2006

Plants & Civilization; An Introduction to the Interrelationships of Plants and People

James P. Smith Jr
Humboldt State University, james.smith@humboldt.edu

PLANTS
&
CIVILIZATION

AN INTRODUCTION TO THE INTERRELATIONSHIPS OF PLANTS & PEOPLE

By

James P. Smith, Jr.
Professor Emeritus of Botany
Department of Biological Sciences
Humboldt State University
Arcata, California

December 2006

[Minor Revisions: February 2017

James Payne Smith, Jr.
Department of Biological Sciences
Humboldt State University
Arcata, California 95521
[707] 826-4802
jps2@humboldt.edu

Acknowledgments

I extend my sincere thanks to a number of students through the years who have pointed out errors of various sorts and who have suggested changes in the text that have led to improvements. I am particularly indebted to Ian Hammon-Hogan for his very thorough list of corrections and inconsistencies in format. Any that remain are, of course, my fault.

Previous Editions:

1971
1988
1989
1991
1992
1993
1995
1997
1998
1999
2000
2002
2003

TABLE OF CONTENTS

SECTION 1 • AN INTRODUCTION

1.1 • SCOPE

University courses in the United States that survey useful plants have been around for only a century or so. I suspect that the first class offered in the United States was at Harvard College in 1876. When I was an undergraduate, such courses were called "Economic Botany" or "Economic Plants." When I joined the faculty at Humboldt State in 1969, I was asked to develop a course in Economic Botany. These titles were rather simple and descriptive, or so they seemed. Students were sometimes surprised to discover that their professors were spending time on more obscure food plants or discussing other plants with little economic importance, such as arrow poisons. The adjective "economic" could certainly suggest that these plants would be those of international commerce – the plants where significant sums of money could be made or lost.

To address this problem, and frankly to come up with names that had more sex appeal, colleges and universities now often use titles such as "Plants and Civilization" or "Ethnobotany." In both instances, however, some confusion and controversy remains. The first suggests emphasis on more highly developed, modern civilizations. Some definitions of ethnobotany restrict it to so-called primitive or aboriginal plant uses.

Here is a sample of how various authors have attempted to define these terms.

Economic plants "... *are those plants utilized either directly or indirectly for the benefit of Man. Indirect usage includes the needs of Man's livestock and the maintenance of the environment; the benefits may be domestic, commercial, environmental, or aesthetic.*" (Wickens, 1990)

Aboriginal botany is the study of "... *all forms of the vegetable world which the aborigines used for medicine, food, textile fabrics, ornamentals, etc."* (Powers, 1874)

Economic botany includes any area "... *where plant science impinges on the economic life of man.... [It] is the simple study and description of economic plants, their culture, products, preparation, uses, occurrences, and distribution."* (Fosberg, 1948)

"... *emphasizes the uses of plants, their potential for incorporation into another (usually Western) culture, and that their benefactors have indirect contact with the plants through their by-products. In the botanical tradition ethnobotany is subsidiary to economic botany...."* (Ford, 1978)

"... *usually concerns such subjects as the production, distribution and consumption of plants useful to people... [It] is ... a subdivision of ethnobotany that is involved when money becomes an important consideration*." (Heiser, 1985)

"...*the study of plants either useful or harmful to people."* (M. Balick, 1985)

"... *the study of the identification, properties, uses, and distribution of economic plants.*" (Wickens, 1990)

"... *the study of human evaluation and manipulation of plant materials, substances, and phenomena, including relevant concepts, in primitive or unlettered societies."* (Schultes & von Reis, 1995)

Ethnobotany is the study of "... *plants used by primitive and aboriginal people.*" (Attributed to Harshberger, 1895)

"... *is concerned with the totality of the place of plants in a culture and the direct interaction by the people with the plants."* (Ford, 1978)

"..."*the study of the direct interrelations between human populations and their botanical environment."* (Ford, 1981)

"... *the study of plants in relation to people."* (Heiser, 1985)

is the subdivision of economic botany that involves "... *the investigation of plants employed by people indigenous to a particular area."* (M. Balick, 1985)

"... *Today, the term denotes the entire realm of useful relationships between plants and man."* (Manilal, 1988)

"... *the study of useful plants prior to their commercial exploitation and eventual domestication.... Unfortunately the term ethnobotany can still contain, especially to the laymen, a slightly derogatory flavour, the implication of racially inferior societies.*" (Wickens, 1990)

"...*the study of the interactive relationships between nonindustrial societies and their floral environment."* (Lipp, 1995)

"... *which concern the mutual relationship between plants and traditional peoples."* (Cotton, 1996)

"... *the study of the interactions of plants and people, including the influence of plants on human culture.... The field of study that analyzes the results of indigenous manipulation of plant materials together with the cultural context in which the plants are used*." (Balick & Cox, 1996)

"*The scientific study of the traditional classification and uses of plants in different human societies."* (Encarta World English Dictionary, 1999)

RELATED FIELDS OF STUDY

About a century ago, fields of study that had once been subsumed under "botany" were carved out as separate disciplines and given their own names, particularly those aspects of botany that had applied, practical applications. Unfortunately, what remained as “botany” then seemed very esoteric and remote from our everyday life.

Because these fields deal with useful plants, they may be seen as portions of the broader designation “Economic Botany.” The second edition of the "Random House Dictionary of the English Language" offers the following definitions for related fields of study:

agriculture: the science, art, or occupation concerned with cultivating land, raising crops, and feeding, breeding, and raising livestock; farming

agronomy: the science of soil management and the production of field crops

forestry: the science of planting and taking care of trees and forests

horticulture: the cultivation of a garden, orchard, or nursery; the cultivation of flowers, fruits, vegetables, or ornamental plants

HOW MANY USEFUL PLANTS?

A good starting point might be to look at the number of described species in each of the major groups of plants and other organisms. In the older literature, algae and fungi were considered plants.

Plants:		
	Mosses/liverworts	16,500
	Fern relatives	1,300
	Ferns	10,000
	Gymnosperms	529
	Flowering plants (dicots)	170,000
	Flowering plants (monocots)	50,000
	Subtotal	248,329
Others:		
	Algae	26,900
	Fungi	47,000
	Bacteria	4,800
	Viruses	1,000
	Protozoa	30,800
	Insects	751,000
	Animals (all other)	281,000
	Total	1,390,829

This summary suggests that botanists and zoologists have described about 1.4 million species. How many undescribed ones are still out there? One estimate is 5 million to 30 million, most of them insects!

We have found some groups of the plant kingdom to be rich sources of useful species, while others have proven less so.

- ☼ The vast majority of the plants that we have exploited to date have been flowering plants. This is not too surprising since there are so many of them.
- ☼ The conifers (gymnosperms) are the source of a number of important timber trees and wood products.
- ☼ The ferns and their relatives provide a few useful plants.
- ☼ We have found very few uses for mosses and liverworts.
- ☼ There are a number of useful fungi and algae.

Just how many economically important plants are there? Surprisingly, there are few estimates that have been published. The following is based on a recent compilation (Wiersema & León, 1999).

Food (human)	1,049
Food (additives)	382
Food (animal: fodder)	269
Food (animal: fForage)	466
Bee Plants (honey)	134
Medicinal	738
Psychoactive (recreational)	39
Gene sources	614
Industrial	1,583
Fuels	145
Agroforestry	52
Shade and shelter	188
Toxic (vertebrates)	1,293
Toxic (pesticides)	28
Ornamentals	4,332
Weeds	1,570
Total	12,882

HOW ARE THEY USED ?

Several uses come immediately to mind, such as plants used for food, fiber for clothing, wood for construction, and a number of our medicines. But, there are many other uses that are perhaps less obvious. Here is a much more comprehensive summary:

Sources of Nourishment

- ☼ Directly as food
- ☼ Fats and oils in cooking
- ☼ Flavorings (sugars, herbs, spices)

Beverages

- ☼ Caffeinated beverages
- ☼ Alcoholic beverages
- ☼ Fruit drinks
- ☼ Herbal teas

Food for Our Domesticated Animals

- Grains
- Fodder
- Silage

Articles of Clothing

- Cover ourselves
- Footwear (made from fibers and latex)
- Masks
- Hats (straw, Panama hats, pith helmets)

Construction Materials

- Dwellings (thatch, framework, etc.)
- Interior walls
- Furniture
- Carpeting, linoleum, mats, etc.
- Bridges
- Scaffolding

Industrial Uses

- Gums
- Resins
- Sizings
- Starches
- Waxes
- Polishes
- Essential oils
- Fixed oils
- Paints
- Plastics
- Dyes
- Tannins
- Fermentation by micro-organisms

Means of Transportation

- Canoes, boats, ships
- Rubber tires
- Engine lubricants
- Fuels

Treatment of Illness & Disorders

- Treat specific illnesses
- Pain killers
- Sedatives and stimulants
- Antibiotics
- Increase or decrease fertility

Cleansing

- Soaps
- Shampoos

Beautification

- Cosmetics
- Lipsticks
- Perfumes
- Hair dyes and conditioners
- Deodorants
- Toothpastes, dental or chewing sticks
- Ornamentation (body painting, etc.)

Recreation and Entertainment

- Paints and ink
- Photography
- Gardening
- Sports (baseball and cricket bats)
- Golf balls
- Musical instruments

Preserve/Transmit Our Heritage

- Even today, paper remains the medium

Sources of Beauty and Inspiration

- Gardens
- Wilderness, etc.
- Florists
- Parks

Objects of Study

- Botany
- Horticulture
- Agronomy
- Forestry
- Agriculture

Spiritual Activities

- Sacred plants as objects of worship
- Myths
- Magical powers (positive and negative)
- Purification rites
- Sanctification rites
- Initiation ceremonies
- Ordeal rituals
- Alter our perception of the world
- Commune with deities, etc.

Abuse and Misuse

- Destruction of natural environments
- Enslavement to grow and process crops
- Destruction of cultures
- Political and economic instability
- Population growth as a result
- Dependence on a few plants
- Victims of poisonings and disease
- Kill people with them

And, plants are not just for our use ...

- Air quality
- Water quality
- Soil maintenance
- Climate
- Food for wild animals
- Habitat for wildlife and fish

BASIC CONCEPTS OF PLANT USE

- All animal life is dependent upon plants (directly or indirectly) because they convert solar energy to food, replenish the oxygen supply, and provide the caloric base for all food chains.

- In addition to satisfying our basic needs for food, clothing, and shelter our interaction with plants has touched almost every aspect of our life on earth.

- We use only a few of the quarter of a million or so plant species that are potentially available.

- We have found only one use for some plants, while others have several uses. A particular plant may have had several very different uses through history.

- Many plants are grown and used locally, and never enter into international trade.

- The vast majority of our economically important plants are flowering plants, probably because of their number and relative commonness.

- ☼ Micro-organisms, especially bacteria and yeast, play critical roles even though we often fail to observe their presence or activities.
- ☼ The search for plants and our desire to control their production and sale have been the cause of great feats of exploration, political intrigue, and wars.
- ☼ The planting, tending, and processing of crops have been among our major preoccupations and we have employed or have been willing to enslave millions of our fellow humans to perform these tasks.
- ☼ While the plant kingdom is the source of a seemingly endless array of products, we appear to be especially interested in starch, protein, sugar, alcohol, and alkaloids.
- ☼ The process of "trial and error" has been critical in discovering what is edible, toxic, medicinal, and psychoactive.
- ☼ The knowledge of indigenous peoples has often been an invaluable source of information about plant uses or it may be pure malarkey. The trick is to distinguish the two.
- ☼ We have long believed (incorrectly and dangerously) that the general appearance of a plant provides us with clues as to its use, especially its curative powers.
- ☼ Several of the most important families of economically useful plants are easily recognized and have been well-known for millennia.
- ☼ Usefulness is a concept found in humans, pre-humans, and perhaps a few other animals. Some plants may never be useful to us. They are simply there.

1.2 • SOME BASIC TERMINOLOGY

"It is a very sad thing that nowadays there is so little useless information." (Oscar Wilde)

☼ ☼ ☼ ☼ ☼

Every field of endeavor has its own specialized vocabulary. Technical terms are required for exactness and brevity. Consider the following set of directions on how to harness a horse in Mark Twain's "A Tramp Abroad," in which he avoids the use of technical terms.

"*The man stands up the horses on each side of the thing that projects from the front end of the wagon, and then throws the tangled mess of gear on top of the horses, and passes the thing that goes forward through a ring, and hauls it aft, and passes the other thing through the other ring and hauls it aft on the other side of the other horse opposite to the first one, after crossing them and bringing the loose end back, and then buckles the other thing underneath the horse, and takes another thing and wraps it around the thing I spoke of before, and puts another thing over each horse's head, with broad flappers to it to keep the dust out of his eyes, and puts the iron thing in his mouth for him to grit his teeth on, uphill, and brings the ends of these things aft over his back, after buckling another one around his neck to hold his head up, and hitching another thing on a thing that goes over his shoulders to keep his head up when he is climbing a hill, and then takes the slack of the thing which I mentioned a while ago, and fetches it aft and makes it fast to the thing that pulls the wagon, and hands the other things up to the driver to steer with. I have never buckled up a horse myself, but I do not think we do it that way.*"

Botany has an extensive vocabulary, much of it necessary because we do not have sufficiently accurate terms in ordinary English to describe what we observe. Much of this terminology is concerned with the details of classification, structure, and functioning of the plant body and it is of interest only to a specialist in these areas. I have attempted in the summary below to review of some basic terms with special reference to economic plants. While it may appear at times to be exhausting, it is by no any means exhaustive.

GROWTH FORM

The following terms describe the general appearance or **habit** of plants. Most plants will fit comfortably into one of these categories, although some are clearly intermediate.

arborescent: tree-like, as in the bananas and palms

herbs: plants with non-woody aerial stems that typically die back to the ground each year

herbaceous: having the features of an herb, a plant with soft, usually featureless stems, with little development of bark or wood

lianas: woody plants with elongate, flexible, non-self-supporting stems

shrubs: woody plants with more than one principal stem

trees: woody plant with a single main stem or trunk; some plants that we commonly call trees, such as the banana, are arborescent

vines: non-woody plant with elongate, flexible, non-self-supporting stems

woody: although not clearly differentiated from the herbaceous plant, a woody plant generally has a much more substantial stem system with well-developed bark and wood; the stem often has clearly identifiable surface features, such as leaf scars, bud scale scars, and air pores (lenticels).

DURATION (LIFE SPAN)

annual: living for one year or less

biennial: living for two years, often flowering and fruiting in the second year

perennial: living for three or more years, often flowering and fruiting each year

ROOTS

Roots, generally speaking, comprise the sub-terranean portion of a plant. It is convenient to recognize four basic kinds of roots:

fibrous roots: many plants, particularly grasses, have a number of roots of about the same size, forming a dense complicated network. No single root is obviously larger than the others. Except for their use in broom and brush making, fibrous roots are of little direct economic importance to us.

tap roots: in many plants there is a single centrally located root that is dominant. Smaller roots branch off this tap root. Common examples include the carrot and dandelion.

tuberous roots: a tap root that becomes swollen with food and water is often referred to as a tuberous root. There is no sharp distinction between the tap root and tuberous root. The sweet potato is a common example.

adventitious roots: any kind of root that arises from a site other than the true root system, as in the aerial roots and prop roots of maize.

STEMS

The stem system is usually the above ground axis of the plant body. Stems bear leaves at a region called the **node**. The region between two successive nodes is called the **internode**. It is basically the nature of the stem system that determines the growth form of a plant. Stems are subject to many modifications:

rhizome: a horizontal stem at or below the surface. It is very often confused with a root, but it has nodes and internodes. It is often covered with scaly leaves. Rhizomes serve a propagative function. They may also store food.

tuber: a thick, fleshy underground horizontal stem. It also functions in food storage and reproduction. Tubers and tuberous roots are not the same thing. Common examples of the tuber are the Irish potato and the Jerusalem artichoke.

bulb: a vertical underground stem that is essentially a bud. The edible portion of a bulb, the portion which makes up the bulk of the structure, is a series of overlapping leaves. Common examples are found in the onion and tulip.

corm: an upright, hard or fleshy underground stem surrounded by dry, scaly leaves, as in the "bulb" of a gladiolus.

stolon or **runner**: an above-ground horizontal stem that bears ordinary foliage leaves. Like the rhizome, it is useful in propagating the plant. Stolons are seen in the strawberry. They are of little direct economic importance to us.

LEAVES

The leaf is usually a flattened photosynthetic outgrowth of the stem. It is composed of two basic parts, the **blade** and the **petiole**, the stalk that supports it. Often the petiole is mistakenly thought of as a stem; the rhubarb "stem" is actually the petiole of the plant.

The leaf blade may be undivided (**simple**) or divided into separate parts (**compound**). Each segment of a compound leaf blade is a **leaflet**. We often confuse leaves and leaflets, as in the children's poem about poison oak and ivy, "Leaves of three -- let it be!" Those three "leaves" are the leaflets of a single compound leaf.

A reduced leaf anywhere on a plant is often called a **bract**.

FLOWERS

A flower is a stem that typically bears four series of modified leaves. The stem axis of the flower is the **pedicel**. The upper end of the pedicel to which these modified leaves are attached is the **receptacle**. The component parts of the four series are the **sepals**, **petals**, **stamens**, and **carpels**. The sepals are usually green. They are of little direct economic importance. The petals are often brightly colored. They may contain aromatic oils that can be extracted. The stamen is composed of a spore-producing area (**anther**) and a supporting stalk (**filament)**. Stamens are of no direct economic importance. The carpel is usually differentiated into a basal seed-bearing portion (**ovary**), a neck region (**style**) and a terminal area that is receptive to pollen (**stigma**). Because the carpels mature into the fruit of the plant, they are of tremendous economic importance.

FRUITS

A fruit is a ripened ovary, along with any other floral or vegetative parts that may be associated with it and that mature at the same time. This botanical definition applies to a long list of what we refer to as fruits in everyday life, but in many cases it does not. The "seeds" of the sunflower, corn, and carrot plants are actually seed-like fruits. And for some strange reason, we call certain fruits "vegetables." Examples include squash, beans, and the dreaded eggplant.

STRUCTURE

When we cut most fruits in cross-section, they reveal the following features:

pericarp: the fruit wall, which may be fleshy, fibrous, woody, or bony at maturity. It consists of an outer layer (**exocarp**), a middle layer (**mesocarp**), and an inner layer (**endocarp**). The three may be clearly differentiated from one another, as in the coconut with its woody exocarp, fibrous mesocarp, and bony endocarp. In many of our common fruits, the skin or rind is the exocarp, while the mesocarp and endocarp are the fleshy portion and they are not distinguishable. In the stone fruits (peaches, plums, etc.) the endocarp is the hard, bony layer that contains the seeds, the mesocarp is the fleshy edible portion, and the exocarp is the skin. The structure of some fruits is very complex and easily misinterpreted. For instance, the skin of an apple and the rind of a squash are not the exocarp of these fruits. They are derived from the receptacle or floral tube (fused calyx and corolla).

locule: the chambers within the fruit. The number of locules is characteristic of a particular plant and varies from one to many.

ovules: the immature seeds

placenta: the region or line where the ovules are borne. Fruits of the grass family and the bean family have one, the mustard family have two, the lily and squash familes have three.

septum: an interior wall that divides the fruit into two or more chambers (locules)

DIFFERENTIATION OF THE FRUIT WALL (PERICARP)

Plant	Exocarp	Mesocarp	Endocarp
Coconut	Woody shell	Fibers (coir)	Bony (= seed ?)
Date	Skin	Sweet edible flesh	Thin, bony (= seed ?)
Grape	Skin	Sweet edible flesh	Not differentiated
Tomato	Skin	Edible flesh	Not differentiated
Avocado	Skin	Edible flesh	Thin, bony (= seed ?)
Orange	Rind	Spongy layer below rind	Fleshy, chambered interior

DEHISCENCE

At maturity, fruits are either **dehiscent** (opening by means of sutures, pores, or caps) or **indehiscent** (not opening by sutures, etc.), the seeds being released by the rotting of the pericarp.

FRUIT TYPES

The classification of fruit types is an unholy mess. The following scheme is a conservative one that is widely used in general botany textbooks. You will note that two major subsets are recognized. **True fruits** are those derived from a single flower, in which the ovary has a single carpel or two or more of them that are fused to one another. **False fruits** have been given that name because they are made up of true fruits arranged in such a way that the whole structure appears to be a single fruit. Conjure up the image of a raspberry or a strawberry. Each of the small, juicy parts of a raspberry is a true fruit; each of the little seed-like structures embedded on the surface of the strawberry is a true fruit. These are common examples of false fruits derived from the separate carpels of a single flower. In other words, it I placed five strawberries or five raspberries in front of you, each would have come from a different flower. There are also false fruits that result from the fusion of fruits from separate flowers. Examples include the pineapple, breadfruit, and fig. More about them when we get to tropical and subtropical fruits.

AN OUTLINE OF FRUIT TYPES

True fruits (dry when mature):

1-seeded; not splitting open at maturity:

achene: fruit wall and seed separate
caryopsis (grain): fruit wall and seed fused
nut: outer fruit wall hard
schizocarp: fruit separates into series of intact segments

2- to many-seeded; splitting at maturity:

capsule: a "pod" that opens by slits, pores, or an apical lid
silique: splits lengthwise to reveal central, papery partition
legume: 1-chambered, splitting along two seams (sutures)
follicle: 1-chambered, splitting along only one seam (suture)

True fruits (fleshy when mature):

drupe: fruit with outer skin, pulpy flesh, and one hard seed
berry: fruit with outer skin and a fleshy interior
pepo: a type of berry with leathery rind as outer layer of fruit wall
pome: fruit surrounded by fleshy stem tissue at maturity
hesperidium: fruit with sections lined with juicy bladders

False fruits (derived from a single flower):

accessory: seed-like fruits on surface of rounded, expanded stem
aggregate: formed from numerous dry or fleshy individual fruits
hip: fruit vase-like, containing several seed-like fruits (achenes)

False fruits (derived from a flower cluster):

multiple:derived from fusion of fruits of many separate flowers
syconium: vase-like fruit with flowers lining interior wall

SEEDS

Most plants reproduce by means of structures called seeds. Flowering plants, conifers, ferns, and fern relatives are collectively known as “seed plants” because they possess them. Mosses, fungi, and algae do not. A seed is a mature ovule. It consists of (1) an embryonic plant, (2) stored nutritive material that will tide the plant over until it can germinate and mature to the stage where it can photosynthesize, and (3) an outer protective layer known as the seed coat. It is sometimes thin and papery; sometimes hard and bony.

Seeds tend to be higher in proteins, fats, and oils than the vegetative parts of the plant. These are often of great economic importance.

Sometimes a seed is more or less covered by a papery to fleshy tissue called an **aril**, as in ackee (a tropical fruit) and mace (a spice).

POLLINATION AND REPRODUCTION

Pollination is the transfer of pollen from an anther to a stigma. It is not synonymous with **fertilization**, the union of egg and sperm in plants and animals that reproduce sexually. Pollen grains may be transferred within the same flower (**self-pollination**) or from one flower to another (**cross-pollination**). Many species of plants have evolved temporal, structural, or physiological mechanisms to insure self-pollination or cross-pollination. In addition, we have imposed artificial conditions in many of our economically important plants to make certain that pollination does not occur or that it comes about in very precisely controlled ways. For instance, we remove the tassels from maize plants to prevent self-pollination. We may also exclude pollinators from particular areas.

Pollen tubes, carrying sperm cells, will grow through the style and into the locules of the ovary. Eventually they will penetrate the immature seed (**ovule**), discharge the male gametes, one of which will fuse with the egg nucleus to form a fertilized egg or **zygote**. In the flowering plants, another male gamete will fuse with other nuclei within the ovule to initiate the formation of **endosperm**, a protective and nutritive tissue. Much or all of the endosperm may be used by the developing embryo. It may also be present in mature seeds, in which case we may consume it. Some kinds of endosperm are starchy; others have high oil content.

Sexual reproduction, which involves the union of egg and sperm nuclei, is not the only mechanism available to plants. Many species, including some of our most important economic ones, reproduce asexually or vegetatively. The essential part that must be used for vegetative propagation is stem tissue. Cuttings, slips, and grafts all consist of a section of stem, with at least one bud. Recall that a bud is a much condensed side shoot that will produce a lateral stem with its own leaves, flowers, or both. We are able to propagate the Irish potato by planting its "eyes" because they are buds. If we were to plant a portion of the skin or starchy interior of the potato, it would not grow into a new plant.

In nature, the various kinds of modified stems (rhizomes, stolons, bulbs, corms, and tubers) serve as means of vegetative reproduction, in addition to being storage organs for the plants. When rhizomes or stolons break apart, each segment is capable of growing into a new adult plant. Keep this in mind when you gleefully attack some weed that bears rhizomes or stolons. Each part that gets left behind or dropped somewhere in the yard can become a new plant. The central or lateral buds can also develop into independent daughter plants.

The products of asexual reproduction will be genetically identical to the parent plants. The particular combination of characteristics (food value, fiber content, oil content, taste, color, medicinal properties, etc.) will be faithfully reproduced, generation after generation. Therefore, it is not surprising to learn that many of our most important crops are vegetatively propagated. We do not plant the seeds of potatoes, bananas, sugar cane, or pineapple to get a new crop. All are the products of asexual reproduction. In fact, a few of our crop plants have not flowered or set seed in hundreds or even thousands of years. We maintain them in a strictly vegetative state.

I should also point out that we are not talking about an "either/or" situation. Many plants, under natural conditions or in cultivation, may reproduce sexually by forming flowers, fruits, and seeds and they may also reproduce asexually by forming rhizomes, bulbs, etc. We purposefully keep some plants that are perfectly capable of sexual reproduction in a vegetative state. For instance, we frustrate the poor pineapple by keeping the required pollinators away from them.

One final complication. You might well assume that if you see fruits on a plant that they must be the result of sexual reproduction. After all, a fruit is the ripened ovary of a flower. However, in plants such as the navel orange and the banana, fruit formation is initiated by the act of pollination. No union of gametes occurred and no seeds were formed. **Parthenocarpy** is the condition of fruits developing without seeds. Not all seedless fruits are parthenocarpic. Some of the seedless grapes are entirely fertile. They lack seeds because of a failure of their embryos to develop.

Of course, you might suspect that something kinky might be going on in seedless fruits. But, if there are seeds in that fruit, then fertilization must have occurred ... right? Wrong! To muddy the waters even further, some plants have seeds that develop from an unfertilized egg or even from vegetative cells.

CHROMOSOME NUMBERS AND SETS

In general, all living plant cells contain nuclei with a specific number of chromosomes. Their number, which varies from 1 to 1000+, appearance, and behavior provide important information in determining the classification and evolutionary history of plants. When you see a chromosome number cited in a text, that count is based upon an examination of nuclei taken either from vegetative cells or from reproductive cells. In most higher plants, the nucleus in each cell of root, stem, or leaf tissue typically contains two complete sets of chromosomes. The total number of paired chromosomes in each of these vegetative cells is variously referred to as its **somatic** or **sporophytic** chromosome number. On the other hand, the specialized sex cells, the egg and sperm nuclei, typically contain only one complete set of chromosomes. When we make reference to their number of chromosomes, we are talking about the **gametic** chromosome number of a plant. If the number appears in terms of **2n**, as in "2n = 14," it is a somatic chromosome number. If it appears in terms of **n**, as in "n = 4," it is a gametic chromosome number.

One complete set of chromosomes is called a **genome**. It is often referred to by a letter, as in the "B" genome of wheat or the "A" genome of the banana. A nucleus with a single genome is said to be **haploid**; a nucleus with two genomes is said to be **diploid**. Another situation, fairly common in plants, but rare in animals, is that of having more than two complete sets of chromosomes present in a nucleus. This condition is called **polyploidy** and plants in which it occurs are called **polyploids**. Many of our most important economic plants are polyploids. It may be a **triploid** with three sets of chromosomes, a **tetraploid** with four sets, a **pentaploid** with five sets, a **hexaploid** with six sets, etc. Plants with an even number of chromosome sets are more common than those with an odd number. Whereas "n" and "2n" are used to tell the gametic and sporophytic chromosome numbers, respectively, **x** is used to tell the number of chromosome sets (genomes) present in a plant. For example, if a plant is a triploid, it is 3x. When you read that the common breadwheat is 6x = 42, the author is telling you that the nuclei contain six genomes or sets, totaling 42 chromosomes. Each basic set (genome) is composed of seven chromosomes ($x = 7$).

Here are the somatic chromosome numbers ($2n$) for a series of economic plants:

Banana:	$3x = 33$
Coffee:	$2x = 22$; $4x = 44$
Coca:	$4x = 24$
Cotton:	$2x = 26$; $4x = 52$
Marijuana:	$2x = 20$
Wheat:	$2x = 14$; $4x = 28$; $6x = 42$
Rice:	$2x = 24$

A FEW GEOGRAPHICAL TERMS

The following terms are frequently encountered in the literature of economic botany:

Old World: the continents of Europe, Asia, and Africa

New World: the continents of North, Central, and South America

Oceania: the islands of the central and south Pacific. i. e. Polynesia, Micronesia, Melanesia, Australia, and New Zealand

tropics: the regions lying between the Tropic of Cancer and the Tropic of Capricorn (from 23.5° north latitude to 23.5° south latitude)

subtropics: bordering on the tropics; nearly tropical

temperate: the region of the earth's surface lying between each of the tropics and the nearest pole

A FEW TERMS RELATING TO TIME

AD: Anno Domini, Latin for "in the year of Our Lord," not "After Death," as commonly believed

BC: Before Christ

BCE: Before the Christian, Current, or Common Era

BP: Before Present (with present defined as 1950)

Bronze Age: a cultural period in Old World human pre-history characterized by the use of bronze in tools, weapons, and ornaments. It occurred after the Stone Age and before the Iron Age.

CE: Current Era

Iron Age: a cultural period in Old World human prehistory characterized by the use of iron in tools and weapons

MYA: million years ago, as in 125 MYA

Neolithic: "New Stone Age," the final portion of the Stone Age characterized by the use of polished stone implements and when farming and domestication became prevalent; it began about 10,000 BCE in the Middle East

Paleolithic: "Old Stone Age," the cultural period, characterized by relatively crude chipped stone tools, that began about 2-3 million years ago and that lasted until the retreat of the glaciers about 12,000 years ago

Pre-Columbian: pertaining to New World cultures and artifacts before the arrival of Columbus in 1492

UNITS OF MEASUREMENT

I believe that the United States is the only country left -- or at least the only one of any size -- that does not use the metric system for measuring length, weight, area, and volume. The "English system" is just as accurate as the metric system, but it is more difficult to understand and to use. A pint of a dry material is not the same volume as one pint of a liquid. We express weight using three different systems -- troy, apothecaries, or avoirdupois -- depending on what we are weighing. etc.

Here are a few useful equivalencies:

- 1 millimeter = 0.04 inches
- 1 centimeter = 0.39 inches
- 1 meter = 1.09 yards
- 1 hectare = 2.47 acres
- 1 gram = 0.035 ounces
- 1 kilogram = 2.20 pounds
- 1 metric ton = 1.10 short ton
- 1 liter = 1.06 quarts

Three quick and dirty approximations:

- 1 gram = weight of 1 regular paperclip
- 1 milligram = weight of 1 grain of salt
- 1 mm = thickness of 1 dime

And, your thought for the day is, *"If God had wanted us to use the metric system, He would have given us ten fingers!"*

1.3 • THE NAMES OF PLANTS

"Order is heaven's first law." (Alexander Pope)

"Yesterday I cut an orchid, for my buttonhole.... In a thoughtless moment I asked one of the gardeners what it was called. He told me it was a fine specimen of Robinsoniana, or something dreadful of that kind. It is a sad truth, but we have lost the faculty of giving lovely names to things. Names are everything."
(Oscar Wilde, "The Picture of Dorian Gray")

"There should be some things we don't name, just so we can sit around all day and wonder what they are."
(George Carlin)

☼ ☼ ☼ ☼ ☼

Plants often have two names -- a common name used by most of us in everyday circumstances when we need to make reference to a plant growing in the yard or something that we might wish to purchase at the market. They also have scientific names or Latin names, as they are sometimes called, used by botanists, agronomists, and by the "serious" amateur, etc. In this course, I will be using both common names and scientific names. **You will not be required to learn the scientific names of any plants and you may use acceptable common names on the examinations.** Many of you will, however, begin using the scientific names more and more as the term goes along.

COMMON NAMES

ADVANTAGES. It would be foolish for me to maintain that common names have no value. They are the only names known to most of us. These names are often simple, easy to remember, descriptive, colorful, pleasing to the ear, and easy to pronounce. Given this impressive list of advantages, why do we not simply use common names for plants and be done with it?

DISADVANTAGES. There are several reasons why botanists and other scientists do not use common names:

- A plant may have more than one common name. The broad-leaved plantain, a common lawn weed, has almost fifty other common names in English alone. In California and Oregon, one of our common trees is called bay, bay leaf, California bay, myrtle, myrtlewood, pepperwood, and Oregon myrtle.

- The same common name may be used for more than one plant. Laurel is a common name applied to trees in five different plant families. We all know what corn is. You may be surprised to learn that in other English-speaking countries, their corn is what we call wheat.

- Many common names are confusing. A pineapple is not a kind of pine, nor is it an apple. Kentucky bluegrass is not blue, nor is it native to Kentucky. Names such as "welcome home husband, no matter how drunk ye be," "kiss me over the garden gate," "spotted arsemart," and "ramping fumitory" certainly make it difficult to maintain that common names have brevity and clarity of meaning.

- Because there are no universally accepted rules for giving common names to plants, we cannot say that one is **the** correct common name. There are certainly instances in which this becomes critical. If you pay $1000 for an ornamental tree at a nursery or take a particular herbal remedy, you want to be very sure of what you are getting.

- Common names do not provide an indication of close relationship among the plants that share the name. Sour-grass, arrow-grass, blue-eyed grass, grass (marijuana), and China-grass are not kinds of grasses, nor are they related to one another.

- Probably the most serious difficulty is that most plants do not have common names. We have used only a small portion of the half million or so kinds of plants to the extent that common names have been applied to them. This is a problem for authors of field guides, for consultants who write environmental impact statements, and for staff members in various state and federal agencies who must prepare material for general consumption. Authors have attempted to compensate for this lack of common names by inventing them, usually by translating the scientific name into English. The advantage of "Milo Baker's cryptantha" over *Cryptantha milobakeri* is not immediately apparent to me.

SCIENTIFIC NAMES

ADVANTAGES. Although scientific names may cause you some discomfort, their advantages to the botanist are compelling.

- There is a single, universally recognized name for each plant. Because they are used by botanists all over the world, scientific names facilitate the free transfer of ideas and information. Consider the difficulties that would arise if the botanists in the United States, England, Germany, Russia, China, etc. each had their own independent set of names for the plants of their countries.

- The same scientific name may not be used for more than one kind of plant. Once it has been published, that name cannot be used again for any other plant.

- Scientific names are given according to an "International Code of Botanical Nomenclature." These regulations are reviewed at International Botanical Congresses.

- Inherent in our system of scientific names is the concept of evolutionary or genetic relationship. When we name the white potato, eggplant, and black nightshade *Solanum tuberosum, Solanum melongena,* and *Solanum nigrum*, respectively, we are indicating that these three plants belong to the same genus, *Solanum*, and that they are related to one another. Because there is a set of botanical features associated with the name, it has predictive value. If you know a plant belongs to the genus *Quercus*, the true oaks, you can predict all kinds of things about it. You can bet good money that it will be a tree or shrub with leaves of a certain shape, and that it will have the familiar acorn as its fruit type.

DISADVANTAGES. There are some difficulties with scientific names.

- They can be difficult to pronounce, especially if you did not learn to divide words into syllables early on in your education. You might note, however, that such familiar and easily pronounced common names as aster, rhododendron, magnolia, chrysanthemum, petunia, and begonia are also the first part of the scientific names of these plants. My own experience in teaching undergraduates to use scientific names is that once you can get past the psychological barrier that these are terribly long words that only those who have had a strong background in Latin and Greek can pronounce, then you will become much more comfortable with them and begin using them rather easily.

- One of the most frustrating features of scientific names, especially for someone who is just learning about them, is that they are changed from time to time. Just when you have learned the scientific names for a particular group of plants, someone will publish a new revision of the group and you discover that some of the names have been changed. These changes come about for several reasons. As new information about the anatomy, chemistry, and genetics of plants becomes known, it may cause botanists to rethink the evolutionary relationships among the plants being studied. These changes may require us to revise the scientific names to reflect the new level of information now available to us. Sometimes names are changed, not for biological reasons, but because someone studying a group may discover that the name given to a particular plant has to be rejected because it violated some provision of the International Code of Botanical Nomenclature.

Both of these examples point out one of the important operating principles in plant classification. As new information becomes available and as errors are discovered, we make adjustments and corrections. What appears to be a fine scheme of classification today may be modified drastically or even discarded completely at some point in the future.

THE CLASSIFICATION OF PLANTS

The branch of the biological sciences that deals with the classification of organisms is **taxonomy** or **systematics**. The purpose of this discipline is to create a system of classification that best reflects our knowledge of the similarities and differences in organisms. In the strictest sense, the classification of plants involves placing them in a series of categories that have been arranged to show relationships to one another. The names and sequence of these categories are set by the International Code of Botanical Nomenclature. When these groupings are so arrayed, they constitute the **taxonomic hierarchy**, the list of categories into which plants are classified. The principal levels of the taxonomic hierarchy and their standard endings, when applicable, are:

division (or phylum): -phyta
class: -opsida
order: -ales
family: -aceae
genus: no single ending
specific epithet: no single ending

PLANT FAMILY NAMES

I will usually refer to a plant family by its common name and its technical one. While all of the families of vascular plants have the standard "**-aceae**" ending, eight of them have equally correct alternative names. They constitute the only exceptions to the rule that at any level in the taxonomic hierarchy, each plant can have only one correct name. They are permitted because these families are so well known to us by virtue of their abundance and usefulness that they were named long before our requirement of standardized endings was adopted. I use the older names; they were the first to be published. The eight families with two equally correct names are:

FAMILY EQUIVALENCIES

First Published Family Name	Alternative
Compositae (Sunflower family)	Asteraceae
Cruciferae (Mustard family)	Brassicaceae
Gramineae (Grass family)	Poaceae
Guttiferae (Garcinia family)	Clusiaceae
Labiatae (Mint family)	Lamiaceae
Leguminosae (Legume family)	Fabaceae
Palmae (Palm family)	Arecaceae
Umbelliferae (Carrot family)	Apiaceae

Let me put your mind at ease. You will not be asked to learn the technical family names of any plants.

COMPONENTS OF SCIENTIFIC NAMES

If we examine the botanical works of the 15th and 16th centuries, we see that the name of a plant was often a lengthy series of descriptive words, typically in Latin, as in "Convolvulus argentateus foliis ovatis divisis basi truncatis: laciniis intermediis duplo longioribus." These **phrase names** or **polynomials** became increasingly awkward because the discovery of a new kind of plant required that the existing polynomial be slightly modified so that it could be distinguished from the older one.

A new way of naming plants was developed over four centuries ago to replace the polynomials. It was popularized in the 17th century by Carolus Linnaeus, the leading botanist of his time. This system was based upon the principle that each plant (or animal for that matter, because they are named according to the same scheme) is given a scientific name that consists of two components, both of them parts of the taxonomic hierarchy mentioned above. The first element of the scientific name is the **genus** (or generic name), as in *Triticum*, the genus of wheat. The plural of genus is **genera**, not genuses. The second element is the **specific epithet**, as in *aestivum*, the particular kind of wheat called bread wheat. This second element of the scientific name is often incorrectly called the "species." It is the genus and specific epithet together that form the species name. *Triticum aestivum* is the species name of bread wheat. Because the name of a plant or animal is the combination of these two words, the scientific name is called a **binomial** and we call this scheme of giving technical names to organisms the **Binomial System of Nomenclature**.

The binomial, for reasons of completeness and accuracy, is followed by the name (typically abbreviated) of the person or persons who first published that name for the plant. For example, in the scientific name *Zea mays* L., the "L." stands for Linnaeus.

It is sometimes necessary to transfer the name of a plant from one genus to another, usually because more recent research has demonstrated that the plant was incorrectly assigned to a particular genus. For instance, Linnaeus called the tomato *Solanum esculentum*. Several years later, Philip Miller determined that the tomato should be in the genus *Lycopersicon*, to separate it from the nightshades of the genus *Solanum*. The scientific name of the tomato becomes *Lycopersicon esculentum* (L.) Miller. The person whose name is in the parentheses first published the specific epithet for the plant. The name after the parentheses is that of the person who transferred it into the genus where it now resides.

It is often useful to recognize variation within a species. The two most widely used are the **subspecies** (abbreviated ssp.) and the **variety** (abbreviated var.). These names also have authorities, as in *Cannabis sativa* L. ssp. *indica* (Lamarck) E. Small & Cronquist. If the subspecies or varietal name is a repeat of the specific epithet, then the authority is not repeated, as in *Zea mays* L. ssp. *mays*.

Since we are focusing our attention on plants of economic importance, an additional explanation is needed for the term variety. For reasons that are obvious, we have developed many different cultivated strains of a particular crop plant or ornamental. There are literally thousands of different kinds of rice. There are probably hundreds of different kinds of tuberous begonias. In general parlance, we often call these varieties. However, for purposes of formal nomenclature, these variations are considered too minor and often too short-lived to warrant giving them a scientific name. The variety of botanical nomenclature is not used in these instances. Instead, we employ the term **cultivar** (cultivated variety). It is abbreviated cv. The "Martha Washington" geranium is technically known as *Pelargonium hortense* cv. 'Martha Washington.'

Many of our economic plants are hybrids that result from the accidental or purposeful crossing of two closely related species or cultivars. This can be reflected in the scientific name of the hybrid by inserting an "x." If the x occurs before the generic name, then the plant is considered the result of a cross between two plants in different genera, as in X *Triticale*, a hybrid between wheat (*Triticum*) and rye (*Secale*).

If the x occurs between the generic name and the specific epithet, then the plant is the product of a cross between two species in the same genus, as in the banana, *Musa* x *paradisiaca*. It is result of a cross between *Musa acuminata* and *M. balbisiana.*

WRITING SCIENTIFIC NAMES

There are a few simple rules that must be followed in writing scientific names.

☼ The genus is always capitalized.

☼ The specific epithet should not be capitalized. The rules allow them to be if they are commemorative, as in *Elymus Smithii* (a relative, no doubt) or if the epithet was once a generic name itself, as in *Acer Negundo*, the box-elder. Even in such instances, however, the rules discourage capitalization.

☼ The generic name and specific epithet are underlined when they appear in handwritten or typed material. They are put in italics or bold-face in printed text.

☼ The authority is always capitalized, but it is not underlined or otherwise set off from the remainder of the text.

THE ORIGIN OF SCIENTIFIC NAMES

Most of the words that make up scientific names are derived from Latin or Greek, although there is no requirement that they must be. Modern names and even nonsensical ones have been used. Many students, however, believe that there must be some requirement that scientific names be as long and unpronounceable as possible. This reveals a certain lack of scholarship. Even a rudimentary knowledge of etymology is very helpful in understanding the composition of scientific names. The following examples may be helpful.

Commemorative Names

Blighia	William Bligh, Captain of the Bounty
Carnegia	Andrew Carnegie, American industrialist
nuttallii	Thomas Nuttall, English botanist
menziesii	Archibald Menzies, surgeon/naturalist

Classical/aboriginal Names

Agrostis	Greek name for grass
Fagus	Latin name for the beech tree
mays	Indian name for corn or maize
cepa	Latin name for the onion

Geographical Names

anglicus	of or pertaining to England
gallicus	of or pertaining to France
canadensis	of or pertaining to Canada
sinensis	of or pertaining to China

Growth Form

arboreus	tree
repens	creeping
scandens	climbing

Habitat

arenarius	growing in sand
campestris	of the fields
fluviatilis	of the rivers
sativus	cultivated

Structural feature

Penstemon	having 5 stamens
Sanguinaria	having a red sap
amabilis	lovely in appearance
foetidus	foul-smelling
tuberosus	having a swollen part

Use

esculentus	edible
officinalis	recognized as medically important
somniferum	sleep inducing
textilis	having useful fibers

PRONUNCIATION

The International Code of Botanical Nomenclature states that scientific names of plants are to be treated as Latin words, regardless of their origin. A few of the more scholastically inclined botanists will argue, therefore, that we ought to pronounce scientific names according to the strict rules of the sounds of vowels and consonants in Latin and that great care should be taken in accenting the proper syllable. But, there are several versions of Latin to choose from, each with its own set of rules for pronunciation.

Most American botanists pronounce the scientific names of plants as though they were English words. Some of us follow the rules in Latin for determining which syllable is accented; most of us do not. Many of us pronounce scientific names the way we were taught as undergraduates (if any formal discussion occurred) or more commonly we imitate the way our professors said them when we took their classes. These become the familiar and "correct" way to pronounce the scientific names of plants.

A Quick and Dirty Guide to Pronunciation

☼ Pronounce each syllable.
☼ Say them as you would in English.
☼ Put the accent where you think it ought to be.
☼ Try to be consistent.

A More Scholarly Approach

The following is an attempt to present a basic guide to pronouncing vowels, consonants, and diphthongs, together with some of the rules for accenting syllables.

- ☼ The letters of the Latin alphabet are the same as ours, except that J, U, and W did not occur in the classical version.
- ☼ Each syllable will contain a vowel or a double vowel combination (ae, au, ei, oe, or ui). The latter are called diphthongs.
- ☼ Pronounce all of the syllables. *Ribes* is "rī-bees," not "rībs."
- ☼ Final vowels are long, with the exception of a. If a word ends in two vowels (unless they are a diphthong), they are sounded separately. The epithet *quinquefolia* is pronounced "kwin-kwe-fo-li-ah."
- ☼ The diphthongs "ae" and "oe" have the sound "e," as in the word beat; "au" has the sound of "aw," as in awful; "ei" usually has the sound "i," as in site; "eu" has the sound of "u," as in neuter; and "ui" has the ui-sound in the word ruin.
- ☼ The "oi" in the ending "-oides" is treated as a diphthong by most American botanists and we give it the sound that "oi" has in the word oil. This habit is considered close to barbaric by English and Europeans who are much more persnickety about such matters. Because these two vowels do not form a diphthong, they should be pronounced separately, so that the ending "-oides" has the sound "-o-e-deez."
- ☼ A single consonant is placed with the following vowel, as in "pa-ter." Double consonants are separated, as in "am-mi." If there are two or more consonants, the first one is usually put with the preceding vowel, as in "an-gli-cus."
- ☼ The letters B, d, f, h, l, m, n, p, qu, and z are pronounced the same in Latin and English.
- ☼ The consonants c and g are soft (that is, have the sounds of "s" and "j") if they are followed by ae, e, i, oe, or y. Otherwise, the c is pronounced like a "k" and the g is also hard, as in "go." The s is always pronounced as it is in the word "so," not as a "z." An initial x is pronounced as a "z," not "ek-z." *Xanthium* is "zan-thi-um," not "ek-zan-thi-um."
- ☼ The first letter is silent in words beginning with cn, ct, gn, mn, pn, ps, pt, and tm.
- ☼ Accenting the proper syllable can be tricky. Sometimes the author of a flora or other manual may provide assistance by including an accent mark. Most do not. If included, they are for the convenience of the reader and they are not part of the scientific name itself. If you must determine which syllable to accent, the following rules may be helpful. Words of two syllables are always accented on the first syllable. In words of three or more syllables, the last syllable is never accented. The stress will fall either on the next to the last syllable (the penultimate syllable), as in "ar-ven-sis," or on the third from the last syllable (antepenultimate), as in "an-gli-cus." No matter how long the word, the accent can never be to the left of the antepenultimate syllable. Deciding between these two options is a difficult choice. Accent the penultimate syllable if it ends in a consonant, diphthong, or in a long vowel.
- ☼ Commemorative names (patronyms) present a special problem because giving them the proper accenting can render the person's name unrecognizable. The epithet *jamesii* is pronounced "ja-me-se-i," not "james-e-i." Most of us in the United States ignore this rule.

THE CODE FOR CULTIVATED PLANTS

The naming of cultivated plants is governed by its own set of rules, the International Code of Nomenclature for Cultivated Plants. The following articles are pertinent:

Article 1. Cultivated plants are essential to civilization. It is important, therefore, that a precise, stable, and internationally accepted system should be available for their naming.

Article 7. Cultivated plants are named at three main levels: genus, species, and cultivar (variety).

Article 10. The international term "cultivar" denotes an assemblage of cultivated plants which is clearly distinguished by any characters (morphological, physiological, cytological, chemical, or others), and which, when reproduced (sexually or asexually), retains its distinguishing characteristics. The term is derived from **culti**vated **var**iety. Note 2. The concept of cultivar is essentially different from the concept of botanical variety, varietas. The latter... are always in Latin form and are governed by the Botanical Code. Note 4. The terms cultivar and variety (in the sense of the cultivated variety) are exact equivalents.

Article 29. A cultivar name, when immediately following a botanical or common name, must be distinguished clearly from the latter, either by placing the abbreviation cv. before the cultivar name, or by some typographical device, preferably by enclosing it within single quotation marks. It should not be printed in italics.

1.4 • CHRONICLE OF ECONOMIC BOTANY

The purpose of this compilation is to identify the dates of various critical discoveries, events, voyages, inventions, publications, etc. that relate to economically important plants. I begin by setting the stage, so to speak, with cosmological considerations -- the formation of the universe, solar system, and our planet. The next several entries relate to the appearance of life on the earth, beginning about 4 billion years ago. The evolution of our immediate ancestors began about 4 million years ago, with the first true human beings appearing in Africa approximately 1.5 million years ago. Our use of plants begins at about that point, with such discoveries as fire-making, the building of shelters, and the cosmetic use of dyes. About 150,000 years ago we began incorporating flowers into ritual burials; there is some evidence that 60,000 years ago we started using various herbs because of their medicinal properties. Farming of cultivated plants began about 16,000 years ago; the domestication of various plants and animals approximately 10,000 years ago. Most of our important crop plants were domesticated over the next few thousand years. Only a handful of plants have been domesticated in the last two millennia.

In about A. D. 800, Irish voyagers reached Iceland, beginning an age of exploration that would last for a thousand years. Among the many notable accomplishments of Marco Polo, Christopher Columbus, James Cook, and others was a dramatic increase in our knowledge of the natural history of our planet and the exchange of plants and plant products around the globe. As the sixteenth century came to a close, newly developed instruments and techniques in the fields of botany and chemistry formed the basis of our modern understanding of the plant kingdom. This was followed by the appearance of a series of inventions designed to extract various products from plants and to process them.

The nineteenth century saw the refinement of chemical extraction procedures that allowed us to isolate and purify a number of economically important materials, especially certain alkaloids with medicinal and psychoactive properties.

In the twentieth century, we have witnessed the growth of giant industries based upon the supplying of a long list of plant products to the consumer. It was a little over a hundred years ago that the field of genetics was founded with the investigations of Strasburger and von Beneden into the mechanisms of mitosis and meiosis. For the last several decades, we have developed the techniques needed to control the genetic heritage of many of our most important crops and to create entirely new ones in our laboratories. Our studies have also shown how dangerous plant products such as alcohol, tobacco, and the opiates can be; how destructive to the natural environment our conversion of land for the growing of crops can be; and how we have become increasingly dependent upon a relatively short list of genetically-impoverished plants.

DATE	EVENT, DISCOVERY, ETC.
Years Ago:	
13,500,000,000	The "Primordial Explosion" or "The Big Bang"
12,500,000,000	Galaxies form
6,000,000,000	Sun forms
5,000,000,000	Solar system forms
4,500,000,000	Earth forms
4,000,000,000	Beginning of life on Earth (bluegreen algae)
1,600,000,000	Multicellular plant life evolves
425,000,000	Terrestrial plant life evolves
395,000,000	Insects evolve
380,000,000	Ferns evolve
350,000,000	Gymnosperms (cone-bearing plants) evolve
216,000,000	Mammals evolve
200,000,000	Continental drift begins
123,000,000	Flowering plants evolve
69,000,000	Primates evolve
67,000,000	Extinction of the dinosaurs
24,000,000	Grasses evolve
14,000,000	*Ramapithecus*, oldest human-like primate, evolves in Africa and India
11,000,000	Grazing animals evolve
7,000,000	*Sahelanthropus tchadensis* ("Toumai man") oldest hominid species, evolves in Africa
4,400,000	*Ardipithecus ramidus* evolves in Africa
4,000,000	*Australopithecus afarensis* ("Lucy") evolves in Africa
3,700,000	Modern horses evolve
3,200,000	Large ice sheets build up over northern continents
2,400,000	Paleolithic (Old Stone Age) begins
2,400,000	Hominids in Africa make first stone tools
2,000,000	*Australopithecus boisei* and *A. robustus* evolve
1,900,000	*Homo habilis* ("Handy Man") evolves in Africa; first hand axes
1,800,000	First stone dwellings (Tanzania)
1,600,000	Apes and prehumans use red ochre as a cosmetic
1,500,000	*Homo erectus*, first true human, emerges in Africa
1,400,000	Discovery of fire (Kenya)
1,000,000	*Homo erectus* migrates through the Old World tropics

800,000	*Homo erectus* populates temperate zones; makes shelters from branches
420,000	First huts (France); first fishermen (France)
200,000	*Homo sapiens* ("Thinking Man") evolves
200,000	Artistic hand axes appear
150,000	Neanderthal Man emerges in Paleolithic Europe; ritual burials there and in Far East
127,000	Last glaciation and associated warming period
79,000	Oil-burning lamps made of stone in use
60,000	Earliest evidence of herbal medicine
50,000	Humans first populate Australia
45,000	Music and oral literature developed (Asia)
35,000	Modern humans evolve in Europe
35,000	Oldest written records
35,000	Asian hunters cross Bering Strait
35,000	Cro-Magnons appear; Neanderthals decline
32,000	Flute, first known musical instrument, invented
30,000	Human settlements in Mexico
27,000	Cave art (France); ceramics and sculpture (Czechoslovakia)
27,000	First humans colonize Japan
21,000	Sewing needle invented
18,000	Bow and arrow invented (Europe)
18,000	Laurentide and Scandinavian ice sheets attain their greatest extent
16,000	Mesolithic begins
16,000	Farming of cultivated plants begins
15,000	Ropes invented (France)
13,000	Grinding stones for grain developed (Egypt)
11,000	Pottery developed (Japan)
11,000	Bottle gourd domesticated (Africa ?)
10,000	Dog domesticated (Iraq/Palestine)
10,000	World population reaches 3 million

B. C. E. (arbitrarily placed here)

9000	Neolithic (New Stone Age) begins
9000	Emmer wheat and barley domesticated (Palestine)
9000	Sheep domesticated (Iran/Afghanistan)
8500	First town built (Jericho, north of the Dead Sea)
8500	Lima bean domesticated (South America)
8000	Flax, the oldest textile fiber, first used
8000	Last Ice Age ends
8000	Bering Land Bridge severed
8000	Dog domesticated (North America)
8000	Goat domesticated (Iran and Iraq)
8000	Potato domesticated (Peru)
8000	Pumpkin domesticated (Mesoamerica)
8000	Sweet potato domesticated (Peru)
8000	Common bean domesticated (South America)
8000	Ulluco domesticated (South America)
8000	World population reaches 5 million
7500	Rice domesticated (Indochina)
7500	Water buffalo domesticated (Indochina)
7500	Pig domesticated (E. Asia)
7500	Rye domesticated (Syria)
7000	Agriculture begins to replace hunting-gathering
7000	Village life in the Near East
7000	Einkorn wheat domesticated (Syria)
7000	Durum wheat domesticated (Anatolia)
7000	Yams domesticated (Indonesia)
7000	Banana domesticated (Indonesia)
7000	Coconut domesticated (Indonesia)
7000	Cattle domesticated (Anatolia)
7000	First metalworking (Anatolia)
7000	Sugar cane domesticated (New Guinea)
6500	Beans and gourds domesticated (Mexico)
6500	Earliest domestication of plants in Andes
6500	Flax domesticated (Silesia)
6500	Weaving and printed textiles developed (Anatolia)
6300	Quinoa domesticated (South America)
6000	Copper Age begins
6000	Bread wheat domesticated (Southwest Asia)
6000	Citrus fruits domesticated (Indochina)
6000	Lentil domesticated (Southwest Asia)
6000	Squashes domesticated (Mexico)
6000	Brewing of malted beer begins
6000	Bulrush millet domesticated (Algeria)
6000	Finger millet domesticated (Ethiopia)
5500	Maize domesticated (Mesoamerica)

5500 Foxtail millet domesticated (Central China)
5500 Peach domesticated (Central China)
5000 Glaciers retreat and Ice Age ends
5000 Maize a major crop in Tehuacan Valley of Mexico
5000 Avocado domesticated (Mexico)
5000 Chicken domesticated (Southern Asia)
5000 Llama and alpaca domesticated (Peru)
4500 Date palm domesticated (India)
4500 Sorghum domesticated (Sudan)
4500 Horse domesticated (Ukraine)
4500 Hunting/gathering and fishing in Japan
4300 Cotton domesticated (Mexico)
4300 Tepary bean domesticated (Mexico)
4004 Year of Creation in the Christian calendar (one estimate)
4000 Bronze Age begins
4000 Grape domesticated (Turkestan); wine making begins
4000 Oil palm domesticated (Sudan)
4000 Silkworm domesticated (China)
3760 Year of Creation in the Hebrew calendar
3641 Year of Creation in the Mayan calendar (10 February)
3500 Wheel invented (Sumeria)
3500 First writing
3500 Olive domesticated (Crete)
3500 Zebu cattle domesticated (Thailand)
3300 Jack bean domesticated (South America)
3300 Coca domesticated (South America)
3000 Cities spread into Nile Valley
3000 Plow invented (Near East)
3000 Accurate stellar calendar invented (Egypt)
3000 Cotton domesticated (India)
3000 Peanut domesticated (Peru)
3000 Donkey domesticated (Palestine)
3000 Two-humped camel domesticated (Iran)
3000 Elephant domesticated (India)
3000 Mule domesticated (Palestine)
3000 Rice under cultivation in China
2800 Hemp rope invented (China)
2800 Major flood covers much of Mesopotamia
2800 Sickle invented (Sumeria)
2800 Emperor Shen Nung publishes “Pen Tsao,” the first herbal
2700 Tea first used in China
2600 Pyramids built in Egypt; cities in the Indus Valley
2600 Egyptian bakers develop more than 50 varieties of bread
2600 Egyptian voyage to Byblos to gather cedar
2500 Cat domesticated (Egypt)
2500 Yak domesticated (Tibet)
2500 Egyptians use papyrus as writing material
2500 Pharaoh Sahure sends fleet to Punt for myrrh
2500 African yam domesticated (West Africa)
2000 Alfalfa domesticated (Iran)
2000 Tea and banana cultivated in India
2000 Apples cultivated in Indus Valley
2000 Figs cultivated in Arabia
2000 Guinea pig domesticated (Peru)
2000 Watermelon cultivated (Africa)
2000 World population reaches 50 million
1750 Code of Hammurabi regulates beer
1700 Rye cultivated in eastern Europe
1680 Egyptians develop leavened bread
1500 Soybean domesticated (Manchuria)
1500 Bronze sickles and scythes used in Europe
1500 African rice domesticated (West Africa)
1495 Queen Hatshepsut sends team to Land of Punt to collect spices
1450 Mesopotamians use seed drill
1400 First alphabet completed
1400 Glass invented
1400 Smelting and forging of iron (Anatolia)
1300 Manioc domesticated (South America)
1300 Sunflower domesticated (North America)
1200 Iron Age begins
1000 Oats domesticated (Central Europe)
1000 Phoenicians terrace hillsides to prevent erosion
1000 Maize with large ears domesticated (Mexico)
1000 Millets domesticated (Korea)
800 Oldest New World pyramids
800 Widespread flood appears to destroy much of Mesopotamia

700 Founding of Rome
700 Hoe invented (North America)
600 Rise of science in Greece, China, etc.
500 Tea domesticated (Tibet)
500 Cloves domesticated (Indonesia)
500 Selection and breeding of maize in South America
500 Currant domesticated
500 Reindeer domesticated (Central Asia)
500 Bronze sickles and scythes in use in Europe
484 Herodotus sees cotton in India
400 Tobacco domesticated (South America)
400 Hippocrates compiles list of uses for herbs and spices
399 Socrates commits suicide, presumably using poison hemlock (*Conium maculatum*)
350 Tobacco first used in North America
300 Turkey domesticated (Mexico)
300 Greek farmers rotate crops to main soil fertility
100 Vertical and horizontal waterwheels in use
100 Chinese use dried chrysanthemum flowers as first insecticide
85 Seed-drill plough invented (China)
50 Herodotus publishes "Histories" of his Mediterranean journeys
40 Rotary winnowing machine invented (China)

Beginning of the Current or Christian Era:

65 Year's supply of cinnamon used at funeral Poppaea Sabina, Emperor Nero's wife
70 Pliny the Elder publishes 37-volume "Natural History"
78 Dioscorides publishes "De Materia Medica"
100 Sieva bean domesticated (Mexico)
105 T'sai Lun invents first true paper from paper mulberry, hemp, and scrap fibers
190 Galen extracts juices from plants for medicinal uses
200 Potato domesticated (Peru and Bolivia)
301 Theophrastus describes caprification of figs
327 Alexander the Great finds bananas growing in Indus Valley
350 First written Greek reference to wheat
350 First written account of tea processing
410 Alaric the Visigoth demands 3000 lbs. of pepper to ransom Rome
432 Earliest recorded use of tobacco (Mexico)
450 Whisky developed (attributed to St. Patrick)
500 Sweet potato domesticated (Polynesia)
590 Epidemic of ergot poisoning hits France
593 Tea introduced into Japan
644 Windmill for grinding grain invented (Persia)
700 Mayan civilization reaches its zenith
700 Achira (*Canna edulis*) domesticated (Mexico)
748 First printed newspaper (Peking)
750 Hops first added to beer (Bavaria)
750 Polynesians begin long range ocean voyages
780 Lu Yu publishes "First Tea Classic"
800 Irish voyagers reach Iceland
850 First reference to use of coffee (Kaffe Province of Ethiopia)
857 Ergot poisoning reported in Germany
900 First shipment of spices from East Indies arrives in England
985 Bjarni Herjulfsson lands in Nova Scotia or Newfoundland
941 Ergot fungus kills 40,000 in France
1000 Iroquois form village communities and cultivate maize and beans
1000 Colonization of Oceania complete
1002 Leif Eriksson lands in New World
1096 First Crusade begins
1099 Crusaders plant sugar cane in Holy Land
1148 Returning Crusaders bring sugar to Europe
1150 First European paper factory opens (Spain)
1191 Tea introduced in Japan from China
1212 Tofu introduced from China to Japan
1227 Oldest extant botanical garden founded (Vatican City)
1250 Roger Bacon invents magnifying glass
1253 Linen first made in England
1271 Marco Polo travels through Asia [to 1295]
1300 Arnau de Villanova discovers distillation of wine to brandy
1328 First sawmill constructed
1347 "Black Death" kills one-third of Europe
1350 Shogun of Japan prohibits drinking of tea
1391 First paper mill opens (Nuremberg, Germany)
1400 Coffee domesticated (Arabia)
1400 Sir John Maundiville publishes accounts of his travels and the plants he encountered
1420 Bottom-fermentation of beer invented in Germany
1470 "The Age of Herbals" begins [to 1670]

1476 Oca domesticated (South America)
1492 Columbus lands in New World, believing it to be India
1492 Jews forbidden to serve as spice dealers
1493 Columbus introduces European grape and sugar cane into New World
1493 Second voyage of Columbus to New World [to 1496]
1493 Columbus founds Isabella, the first European settlement in the New World
1493 Columbus observes Indians using tobacco as medicine
1497 Vasco de Gama sails around Cape of Good Hope (Africa)
1497 Romano Pane describes tobacco and its use by Indians
1498 Third voyage of Columbus [to 1500]
1498 John Cabot explores North America
1499 Amerigo Vespucci makes first written observation of coca use
1500 World population reaches 500 million
1502 Fourth voyage of Columbus to New World [to 1504]
1503 Refinement process for raw sugar developed
1509 Sugar cane first harvested in the New World (Hispaniola)
1510 First Black slaves arrive in the New World (Cuba)
1510 Spanish introduce sunflower to Europe as an oil crop
1511 Portuguese capture Malacca, center of East Indies spice trade
1511 Coffee houses in Mecca closed
1512 Portuguese discover nutmeg trees in Moluccas
1513 Ptolemy's "Geography" recognizes two continents in New World
1513 Juan Ponce de Leon introduces orange and lemon trees in Florida
1514 Pineapple introduced into Europe
1516 Indigo introduced into Europe
1516 Maize first planted in China
1517 Coffee introduced into England
1519 Conquest of Mexico [to 1521]
1519 Ferdinand Magellan sails from Spain in search of Spice Islands
1520 Ferdinand Magellan circumnavigates globe [to 1524]
1520 Spanish bring wheat to New World
1520 Hernan Cortes introduces chocolate into Europe
1523 Sugar first grown in Cuba
1523 Anthony Fitzherbert publishes "Book of Husbandry," first English agricultural manual
1525 Paracelsus develops laudanum (opium dissolved in alcohol)
1525 Portuguese introduce chili peppers to India
1529 Sweet orange introduced into Europe
1530 Spinning wheel in general use in Europe
1531 Conquest of Peru [to 1535]
1532 Sugar cane first grown in Brazil
1534 First written description of tomato published (Italy)
1536 Gonzalo de Oviedo publishes "Historia General y Natural de Las Indias"
1540 Francisco de Orellano explores South America
1540 Francisco Basquez de Coronado explores American Southwest and Great Plains
1540 Benzoni describes cacao preparation
1545 Spanish introduce hemp into New World
1551 William Turner publishes “New Herball”
1556 Tobacco cultivation begins in Europe
1556 Spain's Council of the Indies prohibits plant exploration by foreigners
1556 André Thevet introduces tobacco seeds into Europe
1558 Portuguese introduce cassava into Africa
1561 Jean Nicot sends tobacco to Catherine de' Medici
1562 Witchcraft made capital offense in England
1564 John Hawkins introduces sweet potato into England
1565 Oranges introduced into Florida
1565 John Hawkins introduces tobacco from Florida into England
1566 First European seed drill patented
1568 Alexander Nowell, Dean of St. Paul's Cathedral in London, invents bottled beer
1569 Gerhardus Mercator prepares first comprehensive world map
1569 Bernardino de Sahagun publishes "Historia General de las Cosas de la Nueva Espana"
1575 Sir Francis Drake begins circumnavigation of globe [to 1580]
1579 Sir Francis Drake reaches East Indies by sailing around South America
1580 Prospero Alpino establishes that flowering plants have two sexes
1582 Ergot cited as means for quickening childbirth
1583 Andre Caesalpino publishes "De Plantis"
1587 Thousands die from ergot poisoning in German states
1587 Eggplant introduced into England (now seen as a tragic event!)
1589 Elbert de Veer invents hemp mill
1590 Hans & Zacharias Janssen invent compound microscope
1590 Tomato introduced into England
1595 Dutch establish colonies in East Indies
1596 Li Shih-Chen publishes 52-volume “Catalogue of Medicinal Herbs”
1597 John Gerard publishes "Herbal or General Historie of Plantes"
1597 Ergotism found to be caused by infected rye
1600 East India Company founded
1600 Spanish make rum from molasses (Barbados)

1600 Seeds and unroasted coffee beans smuggled out of the Arabian port of Mocha
1601 The word "coffee" first appears in an English account of William Parry's Persian travels
1602 Oat introduced into the U. S.
1602 Dutch East India Company founded
1604 King James I publishes (anonymously) "Counterblaste to Tobacco"
1610 Tea introduced to Europe by Dutch East India Company
1612 John Rolfe begins tobacco cultivation in Virginia
1615 Coin-operated vending machines for dispensing tobacco leaves appear in English taverns
1615 Chocolate paste from the New World introduced into Europe
1616 Coffee introduced into Europe
1616 Dutch smuggle a coffee tree from Aden to Holland
1616 Schouter and Lemaire discover new route from Europe to Pacific, around Cape Horn
1618 Wheat cultivated in Virginia
1618 David Ramsay and Thomas Wildgoose invent ploughing machine
1619 First Black slaves arrive in Virginia
1619 Burgandy bans the growing of potatoes because they cause leprosy
1620 Pilgrims arrive in Plymouth, Massachusetts
1621 Potato planted in Germany for first time
1621 Potato introduced into North America
1621 European grapes planted on east coast of U. S.
1621 Dutch cut down three-quarters of clove trees in the Moluccas
1621 Jamestown colonists build first American grist mill to process wheat
1623 Dutch establish first commercial brewery
1624 Pope Urban VIII threatens snuff users with excommunication
1630 Lemonade invented
1630 Kikkoman soy sauce invented
1632 Jesuits introduce quinine powder into Spain and Rome
1633 Bananas first sold in London
1635 Jesuits introduce grapes into California
1635 Louis XIII founds Jardin des Plantes in Paris
1635 French restrict tobacco sales to physician's prescription
1636 Tulipmania strikes in the Netherlands
1640 John Parkinson publishes "Theatrum Botanicum"
1641 Dutch sieze Spice Islands from Portuguese
1641 Michael Romanov of Russia forbids sale and use of tobacco
1642 Pope Urban VIII bans tobacco, saying that it causes hallucinations and bad behavior
1642 Abel Tasman reaches New Zealand
1643 Abel Tasman reaches Fiji and New Guinea
1645 Richard Weston publishes first description of crop rotation
1650 First coffee house opens in Oxford, England
1651 Francisco Hernandez publishes "Rerum Medicarum Novae Hispaniae Thesaurus..."
1651 Frederich Wilhelm of Prussia orders cultivation of potatoes
1652 First coffee houses open in London
1653 Nicholas Culpeper publishes "The English Physician, or Herball"
1655 Robert Hook observes structure of cork; first use of "cell"
1656 William Coles publishes “Art of Simpling”
1657 First chocolate shop opens in London
1658 Dutch begin to grow coffee in Ceylon
1658 Dutch oust Portuguese from Ceylon, thereby gaining control over cinnamon
1660 Samuel Pepys notes in his secret diary that he has drunk a "cup of tee...."
1661 Robert Boyle extracts methyl alcohol
1663 Robert Hooke reports microscopic structure of petrified wood
1670 Covent Garden, famous produce market, opens in London
1672 John Josselyn publishes "New England Rarities Discovered," a treatise on herbal cures
1674 Severe outbreak of ergotism in Gatinais, France
1674 "Women's Petition Against Coffee" published
1676 Antoni von Leeuwenhoek discovers microorganisms ("animacules")
1676 Nehemiah Grew determines that higher plants reproduce sexually
1676 British troops poisoned by jimson weed in Jamestown, Virginia
1676 Compaignie de Limonadiers (lemonade vendors) founded in Paris
1677 London Pharmacopoeia recognizes cinchona, jalap, and ipecacuanha
1682 Nehemiah Grew describes function of stamens and carpels in "Anatomy of Plants"
1683 Antoni von Leeuwenhoek discovers bacteria
1686 John Ray develops concept of plant species in "Historia Plantarum"
1688 Dom Pierre Perignon makes champagne
1690 Physick Garden founded in Edinburgh
1692 Witch trials in Salem, Massachusetts
1694 Rudolph Camerarius distinguishes male and female floral parts
1695 Rice introduced (accidentally through shipwreck) into U. S.
1696 Dutch plant coffee trees in Java
1697 Czar Peter of Russia permits open sale and use of tobacco
1701 Jethro Tull invents seed drill
1706 One coffee tree from Java reaches Amsterdam Botanic Garden
1710 British Parliament passes act preserving trees in American colonies for ship’s masts
1712 Cotton Mather publishes 13 letters on natural history and biology
1716 Cotton Mather observes hybridization in maize

1717 Giovanni Lancisi suggests that malaria transmitted by mosquitos
1719 Rem de Reaumer suggests that paper can be made from wood fiber
1720 Coffee introduced into New World
1721 Ergot poisoning prevents Peter the Great's attack on the Ottoman Empire
1724 Paul Dudley describes cross-pollination in maize
1727 Stephen Hales discovers root pressure
1727 Coffee trees planted in Brazil
1728 Vitus Bering sails through Arctic strait, proving Asia and North America not joined
1728 Failure of oat crop in Ireland prompts Jonathan Swift's "A Modest Proposal...."
1730 John Bartram founds first U. S. botanical garden (near Philadelphia)
1733 John Kay invents flying shuttle
1735 French Academy of Sciences sends expedition to South America
1737 Carolus Linnaeus publishes "Genera Plantarum"
1738 Charles Marie de la Condamine sees quinine trees in Ecuador
1739 John Bartram experiments with cross-breeding in flowers
1750 Oat crop failure in Ireland
1741 Elizabeth Pinckney begins indigo cultivation
1743 Charles Marie de la Condamine explores the Amazon
1743 Sir Joseph Banks born in London
1744 Frederich II distributes free potatoes to Prussian peasants
1747 Andreas Marggraf discovers sugar in sugar beets
1750 Brussel sprouts appear as a "sport" (Belgium)
1753 Carolus Linnaeus publishes "Species Plantarum"
1753 Sugar cane first grown in the U. S. (Louisiana)
1753 James Lind discovers that lemon juice cures scurvy
1755 Pierre Poivre smuggles pepper and cinnamon into Mauritius
1756 Joseph Black discovers carbon dioxide
1758 Jedidiah Strutt invents machine to knit hose
1759 Arthur Guinness opens a brewery in Dublin
1760 Royal Botanic Gardens at Kew (England) opens
1761 John Hill notes development of "polypusses" after excessive use of snuff
1763 Josef Kohlreuter discovers pollination
1764 James Hargreaves invents spinning jenny
1765 Date introduced into California
1765 James Baker and John Harmon set up chocolate factory in Massachusetts
1765 Potato now Europe's most widely used food
1765 Lazzaro Spallanzani discovers that food can be preserved in air-tight bottles
1765 James Watt improves steam engine
1766 Louis Antoine de Bougainville begins round-the-world voyage [to 1769]
1767 George Washington plants potato at Mount Vernon
1768 Capt. James Cook begins his first voyage to the South Pacific [to 1771]
1768 Richard Arkwright invents machine to spin cotton
1768 Lazzaro Spallanzani disproves theory of spontaneous generation
1769 Father Junipero Serra plants grapes, olives, oranges, and figs in California
1769 The water frame, for spinning yarn, invented
1769 Baron von Humboldt born in Berlin
1770 Apricot introduced into California
1770 Governor Pierre Poivre smuggles nutmegs from Dutch E. Indies and plants them on Mauritius
1770 Sir Joseph Banks discovers and names Botany Bay in Australia
1771 Joseph Priestley discovers that plants release oxygen
1771 Arkwright opens first spinning factory in England
1771 Faculte de Paris declares potato not only safe to eat, but useful
1772 Second voyage of Capt. James Cook [to 1775]
1772 Daniel Rutherford discovers difference between oxygen and nitrogen
1772 Karl Scheele isolates oxygen
1772 Joseph Priestley ("Father of the soft drink") demonstrates carbonating apparatus
1773 Boston Tea Party
1773 East India Company obtains monopoly on production and sale of opium
1773 Richard Arkwright produces first cloth made entirely of cotton
1773 Tea Act passed by Parliament, allowing East India Co. to export tea to colonies
1774 Andreas Marggraf demonstrates that cane sugar and beet sugar are identical
1775 Frederick the Great prohibits importation of green coffee into Prussia
1775 British Navy replaces French brandy with West Indian rum as its daily grog
1776 Third voyage of Capt. James Cook [to 1779]
1779 Jan Ingenhousz discovers that sunlight essential for oxygen production in leaves
1779 Samuel Crompton invents spinning mule
1780 James Watt develops steam-driven flour mill
1784 Andrew Meikle invents threshing machine
1784 Richard March invents rope-making machine
1784 Karl Scheele discovers citric acid
1785 Cartwright invents power loom
1785 Ransome invents cast iron plow
1785 William Withering publishes "An Account of the Foxglove and Some of Its Medical Uses..."
1785 Louis XVI promotes use of potato in France
1785 Oliver Evans invents automatic grist mill
1786 Sugar beet cultivated in France

1786 Rice riots in Edo (Tokyo)
1787 Lt. William Bligh sails to Tahiti on H. M. S. Bounty to collect breadfruit seedlings
1787 Calcutta Botanic Garden founded
1788 Sir James Edward Smith founds Linnean Society (London)
1789 Johann W. von Goethe suggests that all plant parts are modified leaves
1789 First cotton factory powered by steam opens (Manchester, England)
1789 Eliza Craig distills bourbon whisky
1789 Antoine Laurent de Jussieu publishes "Genera Plantarum"
1789 Ninety percent of Americans engaged in farming and food production
1790 Pineapples introduced into Sandwich Islands (Hawai'i)
1790 Vatican opens its own tobacco factory
1791 First cotton mill in U. S. (Rhode Island)
1791 Samuel Peel patents India rubber cloth
1792 William Bligh sets out on his second "breadfruit voyage" to Tahiti on H. M. S. Providence
1792 Robert Thomas publishes first "Famer's Almanack"
1793 Eli Whitney invents cotton gin
1793 Karl Sprengel establishes that some plants wind-pollinated
1793 Franz Achard extracts sugar from sugar beets
1793 Captain William Bligh arrives in St. Vincent with 722 breadfruit seedlings
1795 Hydraulic press invented
1795 F. A. Chalons-sur-Marne develops sterilization and bottling/canning of food
1795 British Navy eliminates scurvy by supplying sailors with lemon juice
1795 King of Spain grants Don Jose Maria Guadalupe de Cuervo license to produce mezcal wine
1796 J. Lowitz prepares pure ethyl alcohol
1796 Edict of Peking forbids importation of opium into China
1796 British take Ceylon from Dutch, thereby gaining control of cinnamon
1797 United States enters world spice trade by importing Sumatra pepper
1798 Machine for making continuous lengths of paper invented
1798 Thomas Malthus publishes "An Essay on the Principle of Population"
1799 Alexander von Humboldt and Aimée Bonpland explore South America [to 1804]
1799 John Ferriar suggests correlation between digitalis and heart disease
1800 Jute domesticated (India)
1800 Humboldt and Bonpland observe curare preparation on Orinoco
1800 Sugar beet introduced into U. S.
1800 Matthew Koops develops vegetable fiber paper
1801 Sugar beet domesticated (Silesia)
1802 Franz Achard designs first sugar beet factory
1802 Soybean introduced into United States
1803 Friedrich Sertürner isolates morphine from crude opium latex
1803 Andrew Duncan isolates cinchonine
1804 A. D. Thaer develops concept of crop rotation
1804 Meriwether Lewis and William Clark begin exploration of western U. S. [to 1806]
1804 World population reaches 1 billion
1805 Leschenault describes preparation of upas tieute, a Javanese dart poison
1805 J.-M. Jacquard invents draw power loom
1806 Benjamin Thompson invents coffee pot with metal sieve
1806 Partial failure of potato crop in Ireland
1807 Baron von Humboldt publishes first of 30 volume treatise on travels in Spanish America
1808 Joseph-Louis Proust identifies glucose, fructose, and sucrose in plant juices
1808 John Stearns demonstrates efficacy of ergot extracts during child birth
1809 Louis Vaquelin isolates atropine
1809 J. B. Lamarck suggests that organs are improved with use and acquired traits are inherited
1809 Nicholas Appert develops heat-bottled foods
1809 Louis Vauquelin identifies nicotianine as active principle in tobacco
1810 J. L. Gay-Lussac discovers that sugar breaks down into alcohol and carbon dioxide
1810 Philippe de Girard invents hemp and flax spinning machine
1811 Napoleon decrees that sugar beets grown in France and that processing factories be built
1811 Louis Figuier develops bone charcoal filtering technique for sugar purification
1812 Austria passes law allowing for confiscation of contaminated rye
1812 Gottlieb Lorchoff demonstrates that starch breaks down to glucose
1813 Augustin de Candolle coins "taxonomy," for the science of classification of organisms
1813 John Clark invents air and water beds made of India rubber cloth
1813 Humphry Davy publishes "Elements of Agricultural Chemistry"
1814 John Lunan introduces term "grapefruit" in his "Hortus Jamaicensis"
1814 Donkin, Hall, & Gamble introduce first commercially available canned food
1815 J. B. Lamarck, French naturalist, introduces a modern species concept
1817 Robiquet isolates narcotine
1817 P.-J. Pelletier and Magendie isolate emetine
1818 Lane invents harvester/thresher
1818 P.-J. Pelletier and J. Caventou extract a green pigment and call it "chlorophyll"
1818 P.-J. Pelletier and J. Caventou isolate strychnine
1818 British plant tea in India
1818 Johann Siegert formulates Angostura bitters
1819 U. S. government instructs its foreign diplomats to send home seeds of useful plants
1819 François-Louis Cailler produces first commercially available chocolate for eating
1819 P.-J. Pelletier and J. Caventou isolate brucine

1819 Oersted isolates piperine
1820 P.-J. Pelletier and J. Caventou isolate colchicine
1820 P.-J. Pelletier and J. Caventou isolate quinine
1820 Col. Robert Johnson eats tomato before crowd of 2000 people and lives!
1821 Runge isolates caffeine from coffee
1820 U. S. Pharmacopaeia published
1820 Thomas Hancock invents rubber masticator
1820 P.-J. Pelletier and J. Caventou isolate cinchonine
1822 John Chapman (Johnny Appleseed) plants orchards
1823 Charles Macintosh discovers solubility of rubber in naphtha
1823 Royal Horticultural Society sends David Douglas to collect fruit trees in North America
1824 British Navy distributes Cocoa Issue (1 oz. chocolate block) to sailors
1825 David Douglas explores western United States
1825 Coffee cultivation begins in Hawai'i
1826 Otto Unverdorben develops distilled indigo dye (aniline)
1826 Michael Faraday establishes the empirical formula for Pará rubber
1827 Salicin isolated from willow bark
1827 Heinrich Merck begins commercial production of morphine
1828 Coenrad van Houten develops process for removing fat from cacao beans
1829 Sylvester Graham develops the Graham Cracker
1830 Robert Brown discovers cell nucleus while working on orchids
1831 Robiquet and Colin isolate alizarine red from madder
1832 Charles Darwin begins his voyage on H. M. S. Beagle [to 1835]
1832 Pierre Robiquet isolates codeine
1832 Aeneas Coffey invents the alcohol still
1832 Karl von Reichenbach discovers creosote in coal tar
1833 Avocado introduced into Florida
1833 Payen and Persoz isolate first enzyme
1834 Cyrus McCormick invents reaper
1834 John and Hiram Pitts invent an efficient thresher
1834 Anselme Payen extracts cellulose from wood and gives it its name
1835 Thiboumery isolates thebaine
1836 Asa Gray publishes "Elements of Botany," first American botany textbook
1836 Grain combine invented
1836 Theodor Schwann demonstrates sugar fermentation the result of yeast activity
1836 Charles Cagniard de la Tour observes yeast growth during fermentation
1837 John Deere invents the steel-bladed plow
1838 Schleiden and Schwann develop cell theory
1838 Captain Charles Wilkes leads U. S. Navy expedition to Pacific
1839 Charles Goodyear develops vulcanizied rubber
1839 Opium Wars in China begin [to 1842]
1839 Jan Purkinje coins the term "protoplasm"
1839 John Lawes develops artificial fertilizer
1839 U. S. Congress appropriates $1000 to provide free seed to farmers
1839 Assam tea auctioned off in London
1840 Friedrich Keller makes first all-wood paper
1840 Justus von Liebig establishes that some minerals can limit growth in plants
1840 Jean-Baptise-Joseph Dieudonne shows that plants obtain nitrogen from soil nitrates
1840 J. Schweppes Co. develops tonic water
1840 Grapefruit trees from Spain introduced into Florida
1841 William Hooker becomes first official Director of Kew Botanic Gardens
1842 English develop first chemical fertilizers
1843 Franciscans introduce almond into California
1843 Smoking of opium banned in China
1843 Charles Goodyear patents process for vulcanization of rubber
1844 F. Keller invents wood-pulp paper
1845 E. B. Bigelow invents power loom for carpet manufacture
1845 J. Heilman invents machine for combing cotton
1845 Late blight of potato causes famine in Ireland and Europe [to 1848]
1845 Stephen Perry invents rubber bands from vulcanized rubber
1846 Elias Howe invents sewing machine
1846 Christian Schonbein discovers solubility of cotton cellulose
1846 H. von Mohl describes protoplasm
1846 U. S. repeals Corn Laws, imposing import duties
1846 Figuier and Purmarède invent vegetable-based parchment paper
1846 Charles Hancock invents sponge rubber
1847 Sir William Hooker's Museum of Economic Botany opens to public at Kew Gardens
1847 Herbert reports that crossing of some plants yields fertile offspring, but others sterile
1847 Fry & Sons in England develop chocolate for eating
1848 Heinrich Merck isolates papaverine
1849 David Livingstone begins exploration of Africa [to 1871]
1849 Luther Burbank, developer of Burbank potato, Shasta daisy, etc., born in Massachusetts
1849 Magnus Huss coins the term "alcoholism"
1850 Claude Bernard discovers that curare blocks nerve impulses to muscle tissue
1850 John Heath invents the grain binder
1850 Sorghum introduced into U. S. from Africa

1850 Marijuana listed in the U. S. Pharmacopeia
1850 Milo or Kaffir-corn introduced into U. S.
1850 Delicious red apple found in Iowa
1850 American Vegetarian Society founded
1850 William Alcott, a cousin of Louisa May, opens America's first health food store (Boston)
1851 Robert Fortune brings 2000 tea plants and 17,000 seeds out of China
1852 E. W. Bull develops Concord grape, a cross between European and catawba grapes
1852 Nelson Goodyear and Charles Macintosh develop vulcanite and ebonite (hard rubber)
1853 Alexander Wood and Charles Pravaz invent the hypodermic syringe
1853 George Crum develops the potato chip
1853 Concord grape exhibited by Massachusetts Horticultural Society
1854 John Polson develops corn flour
1856 John Dauglish develops aerated bread
1856 Ghirardelli's California Chocolate Manufactory established
1856 Louis Pasteur discovers process now called pasteurization
1856 Second Opium War; Britain and France defeat Manchu armies [to 1860]
1856 N. Pringsheim observes entrance of sperm into ovum
1857 Louis Pasteur publishes "Mémoire sur la Fermentation Appelee Lactique"
1857 Count Agoston Harszthy de Moksa establishes California wine industry in the Valley of the Moon
1858 Remak and Virchow develop theory that cells arise from divisions of pre-existing cells
1858 Hyman Lipman invents the pencil with attached eraser
1858 Mace and nutmeg crops planted on Grenada
1858 J. Schweppes patents quinine tonic water
1858 Treaty of Tientsin legalizes importation of opium into China
1858 Charles Darwin reads paper on plant and animal domestication before Linnean Society
1859 Charles Darwin publishes "The Origin of Species..."
1859 Franz Knop and Julius von Sachs establish that plants can grow in nutrient solutions
1859 Karl von Scherzer isolates cocaine from coca leaves
1860 Richard Spruce and Robert Cross send cinchona seeds from S. America to England
1860 Louis Pasteur publishes "Mémoire sur la Fermentation Alcoolique"
1860 Frederich Walton invents linoleum
1860 Charles Baudelaire publishes "Les Paradis Artificiels..."
1860 Richard Spruce ships plants and seeds of *Cinchona* from Ecuador to London
1861 Louis Pasteur publishes "Mémoire sur les Corpuscles Organisés Qui Existent dans l'Atmosphere"
1862 Julius von Sachs establishes that starch a product of photosynthesis
1862 Ebenezer Stevens invents the bread-making machine
1862 John Leighton invents the rubber stamp
1862 U. S. Congress passes Morrill Land-Grant Act
1862 U. S. Congress prohibits distillation of alcohol without a license
1862 U. S. Navy abolishes rum ration for its sailors
1862 United States Department of Agriculture established
1863 Root louse (*Phylloxera vasatrix*) attacks European vineyards
1863 Emperor Louis Napoleon asks Pasteur to study maladies of wine
1863 Pasteur discovers that heat kills bacteria
1864 Pasteur shows that organism causing fermentation not spontaneously generated
1864 Jobst and Hesse isolate physostigmine from calabar bean (*Physostigma venenosum*)
1865 Gregor Mendel publishes "Experiments in Plant Hybridization"
1865 David Livingstone publishes "Narrative of an Expedition to the Zambesi..."
1865 Adolphus Busch and Eberhard Anheuser open a brewery in St. Louis, Missouri
1866 Richard and George Cadbury sell pure cocoa in Britain
1866 Louis Pasteur publishes "Etudes sur le Vin"
1867 Atropine shown to block effects of vagal nerve stimulation
1867 Britain introduces tea into Ceylon
1868 Charles Darwin publishes "The Variation of Animals and Plants Under Domestication"
1869 Schneider discovers navel orange in Brazil
1869 Digitoxin isolated from foxglove plant
1869 Charles Fleishmann founds yeast-production industry in USA
1869 Thomas Welch pasteurizes Concord grape juice to make unfermented sacramental wine
1870 Thomas Adams develops chicle-based chewing gum
1870 Friederich Miescher discovers DNA
1870 MacIntosh apple propagated
1870 Ground wood paper pulp first made (Germany)
1872 Ebers Papyrus (1500 B. C.) discovered in Thebes
1872 Pará rubber (*Hevea brasiliensis*) domesticated (South America)
1872 Carl Ekman develops the sulphite processing of wood pulp
1872 Luther Burbank develops the Burbank potato
1873 Othman Zeidler develops DDT
1873 Don Cenobia Sauza distillery exports first tequila to U. S.
1873 Asa T. Soule of Rochester, NY invents hop bitters, the most successful patent medicine
1874 Mennonites introduce Turkey red wheat into U. S.
1875 Pilocarpine isolated from jaborandi leaf
1875 Eugen Langen invents the sugar cube
1875 Richard Joshua Reynolds founds tobacco company in Winston, North Carolina
1875 Luther Burbank estalishes experimental garden in Santa Rosa, California
1875 Bing chery developed in Oregon
1875 Ferdinand Tiemann patents process for synthetic vanilla

1875 Machine invented that strips corn kernels from cobs
1875 Henry Wickham delivers Pará rubber seeds from Brazil to Royal Botanic Gardens at Kew
1876 Charles Darwin publishes "The effects of Cross and Self-fertilisation ... "
1876 Henry J. Heinz develops catsup
1876 M. D. Peter develops milk chocolate
1876 Henry Wickam smuggles seeds of Pará rubber out of Brazil
1876 John Henry Kellogg develops flake cereal, to curb sex drive
1876 Eduard Strasburger describes mitosis in plants
1876 Lydia Estes Pinkham patents "Mrs. Lydia E. Pinkham's Vegetable Compound"
1876 Charles E. Hires promotes "Hires Rootbeer Household Extract"
1876 Thomas Johnstone Lipton opens his first tea shop
1876 *Phylloxera* destroys more than 1 million acres of France's vineyards
1877 Wilhelm Pfeffer discovers osmosis
1877 John Harvey Kellogg develops a cereal he calls "Granula"
1878 Caleb Chase & James Sanborn form company specializing in coffee and tea
1879 John Appleby invents grain binder
1879 P.-M.-A. Millardet develops Bordeaux mixture to protect grapes against fungi
1879 Constantine Fahlberg and Ira Remsen invent saccharin
1879 Thomas Edison successfully tests carbonized bamboo filament in incandescent light bulb
1880 Sugar beets raised commercially for first time in U. S.
1880 Rodolfe Lindt invents conching machine used to process cacao beans
1880 Canned fruits become commercially available
1881 James Logan develops loganberry, a raspberry and blackberry hybrid
1882 A. P. De Candolle publishes "L'Origine des Plantes Cultivees"
1882 Albert King discovers that mosquitos transmit malaria
1883 Edouard J. L.-M. von Beneden discovers meiosis
1883 French develop rayon, first synthetic fiber
1883 James Buchanan Duke begins making machine-manufactured cigarettes
1884 William S. Halsted discovers anesthetic property of cocaine
1884 Carl Dahl invents sulfate (Kraft) pulp
1885 Karl Benz invents first gas-powered automobile
1885 John S. Pemberton markets Coca Cola
1886 R. S. Lazenby develops Dr. Pepper
1886 Hires Root Beer marketed
1887 Nagai isolates ephedrine from mahuang (*Ephedra sinica*)
1887 U. S. Congress passes Hatch Act, providing funds for agricultural research
1888 John Boyd Dunlop invents pneumatic tire for bi- and tricycles
1888 Heinrich von Waldeyer-Hartz discovers chromosomes and coins term for them
1888 Angus Campbell invents cotton picker
1889 Gottlieb Wilhelm Daimler invents gasoline-powered automobile
1889 James Buchanan Duke founds American Tobacco Company
1889 United States Department of Agriculture founded
1890 Peanut butter invented
1891 W. Rimpan describes spontaneous fertile wheat x rye hybrids
1892 Asa Chandler founds Coca-Cola Co.
1893 Henry Perky develops Shredded Wheat
1893 Charles Post develops Postum, a coffee substitute
1893 Thomas Lipton takes out a trademark on his tea
1893 O. Hesse develops heroin from morphine and acetic anhydride
1894 W. A. Burpee introduces "iceberg" lettuce
1895 John Harshberger coins the term "ethnobotany"
1895 John and Will Kellogg develop wheat flake cereal
1896 Arthur Heffter isolates mescaline from peyote cactus
1896 Pineapple introduced into Hawai'i
1896 George Washington Carver begins his studies of products made from peanuts
1897 Ronald Ross identifies protozoan as cause of malaria
1897 Felix Hoffmann of Bayer synthesizes stable form of acetysalicylic acid
1898 Richard Willstatter determines structure of atropine and cocaine
1898 M. W. Deijerinck discovers that tobacco mosaic disease caused by virus
1898 Bayer introduces heroin as a cough suppressant
1899 Hermann Dreser and Felix Hoffmann develop aspirin
1899 Mexican boll weevil enters U. S.
1900 United Fruit Company founded
1900 Spinal anesthetic using cocaine developed
1900 Beitter isolates alkaloids from khat
1900 Milton Hershey opens factory to produce chocolate bars
1900 H. de Vries, C. E. Correns, and E. Tschermak von Seysenegg rediscover Mendel's work
1900 David Barrows awarded first doctorate in ethnobotany
1900 David Wesson markets first edible cottonseed oil
1901 Hugo De Vries coins term "mutation"
1901 Gerrit Grijns discovers that berberi caused by nutrient-poor, polished rice
1901 Ludwig Roselius develops 97% caffeine-free coffee
1901 Satori Kato develops soluble instant coffee
1902 Rotenone isolated
1902 U. S. bans use of coca leaf extracts in Coca Cola
1902 James Dole founds Hawaiian Pineapple Co.

1902 Caleb Bradham founds Pepsi Cola Co.
1903 Walter Sutton shows that chromosomes carry hereditary material
1903 Christian Gray and Thomas Sloper invent cross-ply rubber tire
1903 Ludwig Roselius introduces Sanka Coffee
1904 Postum Co. introduces "Elijah's Manna," later to be called "Post Toasties"
1905 A. E. Douglass develops technique of dating tree rings
1905 Heinrich Braun introduces novocaine into clinical use
1905 Vick's Magic Croup Salve introduced
1905 Ludwig Roselius develops decaffination process
1906 U. S. Congress passes Pure Food and Drug Act
1906 William Bateson coins "genetics" for new science
1906 Gerrit Grijns suggests beriberi caused by nutrient deficiency in rice
1906 William Keith Kellogg (brother of J. H. Kellogg) founds W. K. Kellogg
1907 American Spice Trade Association founded
1907 President Theodore Roosevelt declares Maxwell House coffee “good to the last drop”
1908 C. W. Post develops "Post Toasties"
1908 Melita Bentz invents once-through coffee brewing filter using linen towel
1908 MSG (monosodium glutamate) isolated from seaweed
1908 Jacques Brandeneberger, a Swiss chemist, invents cellophane
1909 U. S. prohibits importation of opium
1909 U. S. Bureau of Soils declares soil an indestructible
1909 Pictet and Gams synthesize papaverine
1909 Wilhelm Johannsen coins "gene," "genotype," and "phenotype"
1909 Aaron Levene discovers RNA
1909 Karl Hofmann makes synthetic rubber from butadiene
1909 Sir Thomas Lipton begins blending and packaging of tea leaves
1909 George Washington develops soluble coffee powder
1910 Thomas Hunt Morgan discovers specific genes occur on specific chromosomes
1910 Harvey Firestone invents non-skid tire
1911 A. H. Sturtevant produces first chromosome map
1911 U. S. Supreme Court dissolves American Tobacco Co.
1911 Procter Gamble introduce "Crisco," the first solid vegetable shortening
1911 Henry Ginaca invents the pineapple processing machine
1911 Polish chemist Casimir Funk discovers “vitamines,” a rice hull extract, that cures berberi
1912 J. Suzuki, T. Shimamura, and S. Ohdake extract anti-beriberi substance from rice hulls
1912 Casimir Funk coins the term "vitamin"
1913 Richard Willstatter determines structure of chlorophyll
1914 U. S. Congress passes Harrison Narcotic Act
1914 U. S. Congress passes Smith-Lever Act, establishing agricultural extension service
1915 Absinthe with wormwood banned
1916 Quaker Oats develops instant oatmeal
1917 Donald Jones develops double-cross hybrid maize
1917 Clarence Birdseye develops freezing techniques for preserving foods
1918 Rabe synthesizes quinine
1918 First use of airplane in crop dusting
1920 Alcohol use in U. S. prohibited by 18th Amendment to Constitution
1920 K. Spiro and A. Stoll extract ergotamine
1920 Joseph Krieger invents the tea bag
1920 Rudolf Boysen develops the boysenberry (blackberry x raspberry x loganberry)
1920 George Washington Carver testifies before U. S. Congress on uses for the peanut
1921 Thomas Hunt Morgan develops chromosome theory of heredity
1921 "Nobilized" form of sugar cane produced (Java)
1921 E. M. East and G. M. Shull produce hybrid maize
1922 First U. S. soybean refinery opens (Illinois)
1924 "Wheaties" introduced into U. S. market
1925 W. K. Kellogg develops Rice Crispies
1925 Robert Robinson synthesizes morphine
1925 Automatic potato-peeling machine invented
1926 N. I. Vavilov publishes "Centers of Origin of Cultivated Plants"
1926 Henry Wallace founds Pioneer Hi-bred International
1926 Maize hybrid seed becomes available
1926 H. J. Mueller discovers that X-rays induce genetic mutations
1926 I. G. Farben invents Buna S (synthetic rubber)
1926 Ergot poisoning in U. S. S. R.
1927 John and Mack Rust perfect the mechanical cotton picker
1927 World population reaches 2 billion
1927 Thomas Edison, Henry Ford, and Harvey Firestone found Edison Botanic Research Foundation
1928 Sir Alexander Fleming discovers that *Penicillium* spores kill certain bacteria
1928 Albert Szent-Györgyi isolates Vitamin C from paprika pepper
1928 Josef Stalin orders collectivization of Soviet farms
1928 Windaus reports chemical structure of digitoxin
1929 A. Harden and H. von Euler-Chelpin win Nobel Prize for work on sugar fermentation
1929 E. Murphy and W. Chapman invent foam rubber
1929 Wonder Bread (Continental Bakery) introduces sliced bread
1929 American Maize Products develops first genetically modified maize
1929 General Foods develops Minute Rice

1929 R. T. French develops instant mashed potatoes
1930 U. S. Congress passes Plant Patent Act
1930 Postum Co. markets frozen foods
1930 Castetter establishes masters program in ethnobotany at Univ. of New Mexico
1930 Sydney Smith isolates digoxin from *Digitalis lanata*
1930 Norman Haworth, English chemist, synthesizes Vitamin C
1931 Louis Lewin publishes "Phantastica..."
1931 Indian snakeroot reported as useful in treatment of certain mental disorders
1931 First plant hormone (indole acetic acid) discovered
1931 Wallace Carothers develops Du Prene (later called neoprene), first synthetic rubber
1932 Du Pont markets synthetic rubber
1932 Walter Haworth synthesizes Vitamin C
1932 Germans develop atabrine (quinachrine hydrochloride), a synthetic quinine
1932 Charles King isolates Vitamin C (ascorbic acid) from lemon juice
1933 Prohibition repealed by 20th Amendment to U. S. Constitution
1933 Golden Cross Bantam corn, first widely planted hybrid, introduced
1933 Ernest and Julio Gallo build winery in Modesto, California
1933 Soil Erosion Service established in U. S. Department of Interior
1934 J. P. Lent isolates coumarin from spoiled clover
1934 Wallace Carothers invents nylon, an artificial fiber
1934 Philip White and Roger Gautheret get plant tissue culture to survive
1935 Ergonovine proven effective in obstetrics
1935 Trofim Lysenko's "scientific" views become official Soviet policy
1935 Alcoholics Anonymous founded
1936 Andrei Belozersky isolates pure DNA
1936 Tadeusz Reichstein isolates cortisone
1937 Pierre Givaudon discovers colchicine induces chromosome doubling
1937 U. S. Congress passes Marijuana Tax Act
1937 Michael Sveda and L. F. Audrieth invent the artificial sweetener "Cyclamate"
1937 Albert Szent-Györgyi awarded Nobel Prize (Chemistry) for discovery of Vit. C
1938 Arthur Stoll and Albert Hofman synthesize LSD (lysergic acid diethylamide)
1938 Nestlé Co. develops instant coffee (Switzerland)
1938 Richard Gill discovers that curare made from *Chondrodendron tomentosum*
1939 Paul Müller of Geigy Pharmaceuticals invents DDT, a powerful insecticide
1939 F. H. Muller relates smoking and lung cancer
1939 Japanese beetles threaten U. S. crops
1940 Automatic hay baler invented
1940 T. D. Lysenko becomes Director of Institute of Genetics in Soviet Union
1940 N. I. Vavilov arrested by Soviet government for being British spy
1941 George Beadle and Edward Tatum develop "one-gene, one-enzyme" hypothesis
1941 Stem rust devastates Mexican wheat crop
1942 R. E. Marker synthesizes human sex hormones from Japanese yams
1942 U. S. Congress passes Opium Poppy Control Act
1942 P. H. Mueller of Switzerland describes insecticidal properties of DDT
1943 N. I. Vavilov dies in Soviet labor camp
1943 Albert Hofmann discovers LSD, a powerful hallucinogen
1943 DDT introduced to fight insects in U. S.
1943 Rockefeller Foundation and Mexican government found CIMYTT
1943 U. S. distilleries produce alcohol for synthetic rubber
1944 Robert Woodward and William Doering synthesize quinine
1944 Avery, McCarty, & McLeod identify DNA as molecular basis of heredity
1944 Chiquita banana introduced by United Fruit Co.
1945 2, 4-D introduced for general use
1945 Alton Ochsner relates smoking and lung cancer at Duke Univ. address
1945 Food and Agriculture Organization (FAO) of the United Nations founded in Rome
1945 Samuel Salmon discovers semi-dwarf wheat variety (NORIN 10)
1945 Univ. of California develops long-season strawberry
1946 Self-rising corn meal first marketed in U. S.
1946 Dutcher isolates d-tubocurarine
1947 Thor Heyerdahl's sails on the raft “Kon Tiki” from Peru to an island near Tahiti
1947 NORIN 10 gene introduced into North American wheat
1947 Karl Link develops Warfarin from an anticoagulant in sweet clover
1948 Cortisone found effective in treatment of rheumatoid arthritis
1948 Liberty Hyde Bailey coins the term “cultivar”
1949 Robert Boyer patents vegetable protein fibers derived from soybeans
1950 Barbara McClintock publishes "The Origin and Behavior of Mutable Loci in Maize"
1950 Hoagland and Arnon develop balanced mixture of 11 nutritional salts
1950 Cyclamate introduced
1950 General Mills introduces "Minute Rice"
1950 Richard Doll, British physician, presents first statistical proof linking smoking and lung cancer
1951 Woodward synthesizes cortisone
1951 J. Watson, F. Crick, and M. Wilkins propose DNA structure
1952 Emil Schlitter isolates reserpine from Indian snakeroot
1953 James Watson and Francis Crick publish "Molecular Structure of Nucleic Acids"
1953 Evarts Graham and Ernest Wydner show that cigarette tars may cause cancer
1954 Woodward synthesizes strychnine

1954 Nathan Kline develops resperpine (anti-depressant)
1954 Wheat stem rust destroys 75% of Durum wheat crop
1954 Ernest Sears demonstrates that wheat chromosomes can be substituted
1955 Hurricane Janet destroys 75% of Grenada's nutmeg trees (about 40% of world crop)
1955 Severo Ochoa synthesizes RNA
1955 James Schlatter develops aspartame, an artificial sweetener
1956 Sorghum hybrid seed becomes commercially available
1956 Arthur Kornberg synthesizes DNA
1956 Pincus discovers that wild yams will stop ovulation in humans
1956 U. S. Congress passes Narcotic Drug Control Act
1957 Gibberellins (plant growth hormones) isolated
1957 Vinca alkaloids from periwinkle found effective against leukemia
1957 Eli Lilly releases "Darvon," a codeine alternative
1958 Kiwi fruit domesticated
1958 Vinblastine (vinca alkaloid) isolated
1958 U. S. Congress requires enrichment of rice
1958 Sweet 'n Low introduced
1958 Mass of cultured cells gives rise to complete plants
1958 George Beadle and Edward Tatum win Nobel Prize for one gene-one enzyme work
1959 National Seed Storage Laboratory founded at Fort Collins, CO
1959 Society for Economic Botany founded
1959 U. S. Dept. of Agriculture seizes 25% of cranberry crop, fearing weed-killer contamination
1960 Astroturf, an artificial grass, invented
1960 Georges Morel clones cultured cells
1960 FDA approves Enovid for birth control
1960 World population reaches 3 billion
1961 J. A. Wilson and W. M. Ross develop stable cytoplasmic-male-sterile wheat
1961 Melvin Calvin wins Nobel Prize (Chemistry) for work on photosynthesis
1962 James Watson and Francis Crick win Nobel Prize (Medicine) for DNA work
1962 International Rice Research Institute (IRRI) opens in Philippines
1962 Coby Lorenzen, Jr. invents tomato harvester
1962 Rachel Carson publishes “Silent Spring”
1964 Edwin Mertz develops high-lysine maize
1964 World Health Organization warns of psychological dependence on khat
1964 Mutant opaque-2 gene increases lysine and tryptophan content of maize
1964 IRRI begins "Green Revolution" with new strains of high-yield rice
1964 Surgeon General Luther Terry links cigarette smoking and lung cancer
1965 T. D. Lysenko dismissed as Director of Soviet Institute of Genetics
1965 V. Vasil and A. G. Hildebrant regenerate complete tobacco plant from single cells
1965 Standard Malaysian Rubber grading system comes into use
1965 Tetrahydocannabinols synthesized
1965 U. S. Congress requires warning labels on cigarettes
1965 U. S. Congress passes Drug Abuse Control Amendment
1966 International Rice Research Institute releases IR8 "Miracle Rice"
1966 Michael Sporn and coworkers report highly toxic aflatoxins on peanuts
1966 General Mills introduces flavored protein that tastes like bacon
1967 U. S. D. A. begins tests of irradiating food to kill insects
1967 A. E. Porsild and Charles Arington germinate 10,000 year old lupine seeds
1970 Norman Borlaug receives Nobel Prize (Peace) for development of dwarf wheat
1970 Sanforization of cotton fibers developed
1970 Male sterile strains of maize hit by southern leaf blight
1970 Rust hits Brazilian coffee crops causing $3 billion loss
1970 Barley hybrid seed becomes commercially available
1970 Arber, Smith, and Nathans discover restriction enzymes
1970 “Plants and Man” first taught at Humboldt State College
1971 Centro Internacional de la Papa (CIP) founded
1971 Canadian Int. Development Agency investigates triticale as food for humans
1971 First Starbucks opens
1972 Wild rice domesticated
1972 Black sigatoka fungus attacks Central American bananas
1972 Use of DDT banned in the U. S.
1973 High lysine strains of sorghum developed
1973 Herbert Boyer and Stanley Cohen create DNA with sticky ends
1973 Stanley Cohen and Herbert Boyer recombine and duplicate DNA from two species
1974 Wheat hybrid seed becomes commercially available
1975 Endorphins (naturally occurring morphine-like hormones) discovered
1975 Miller Brewing Company introduces "Lite" beer
1975 Soft drinks now more popular than coffee
1975 World population reaches 4 billion
1975 Schell & Van Montagu find crown gall genes occur in plasmids
1975 Seed Savers Exchange founded
1976 Soft drinks now more popular than milk
1976 HFCS (high fructose corn syrup) developed
1976 Herbert Boyer and Robert Swanson found Genentech, first genetic engineering company
1979 Raphael Guzman discovers perennial teosinte (Mexico)
1980 Coca Cola switches from sugar to high fructose corn sweeteners

1980 U. S. Supreme Court rules that genetically-engineered bacteria may be patented
1981 Castanospermine, useful in HIV treatment, isolated from Moreton Bay chestnut
1981 Whitely & Schnepf find gene in *Bacillus thurgensensis* that kills insects
1982 Horst Binding and Jonathan Gressel develop protoplast fusion
1983 Barbara McClintock receives Nobel Prize for discovery of "jumping genes"
1983 N. Murai inserts protein from bean plant into a sunflower
1983 NutraSweet, a synthetic sugar substitute, introduced
1983 Functioning bacterial plasmid transferred into plant cell
1983 Murray & Szostak construct first artificial chromosome
1985 T. Fujimara regenerates rice protoplasts
1985 U. S. Board of Patent Appeals rules that plants may be patented
1985 Coca Cola replaces its traditional recipe with a new, sweeter version
1986 Coca Cola pulls "New Coke" from market
1986 U. S. D. A. approves irradiation of fruits and vegetables
1986 U. S. D. A. approves field-testing of genetically altered, high-yield tobacco
1986 World population reaches 5 billion
1987 Genetically-engineered, frost-resistant potatoes field-tested in California
1987 Genetically modified tobacco with herbicide-tolerance, gene field-tested
1988 Carol Rhodes inserts foreign gene into maize
1988 U. S. carries out experiments using robots to pick fruits
1988 Monsanto Corporation field-tests Roundup-resistant tomato
1989 Taxol, from the Pacific yew, found effective in treatment of human breast cancer
1991 U. S. Government declares second-hand smoke a health hazard
1991 Sale of salsa in the U. S. exceeds that of ketsup
1992 One hundred ninety-two countries sign Convention on Biodiversity
1994 Food and Drug Administration approves sale of genetically-engineered "Flavr Savr" tomato
1994 First genetically-engineered food goes on sale in California and Illinois
1994 U. S. Congress passes Dietary Supplement Heath & Education Act
1995 Food and Drug Administration declares nicotine a drug
1995 Monsanto introduces Newleaf potato, genetically engineered to kill potato beetle
1995 Environmental Protection Agency approves marketing of genetically-engineered maize
1997 John Pezzato discovers anti-cancer properties of resveratol in grapes and other fruits
1997 The Liggett Group admits that tobacco is addictive
1997 U. S. District judge rules F. D. A. can regulate tobacco as a drug
1998 Delta & Pine Land Co. & U. S. D. A. patent "terminator gene"
1999 Institute of Medicine calls for clinical trials of medical marijuana
1999 Dupont purchases Pioneer Hi-Bred, world's largest seed corn company
1999 Food and Drug Administration approves use of "Olestra" in processed foods
1999 World population reaches 6 billion
1999 John Losey finds Bt corn pollen toxic to butterflies
1999 Plum pox found for first time in North America
1999 Monsanto releases "terminator seeds"
2000 Human genome decoded
2001 Aventis CropScience is ordered to pay millions in compensation for genetically altered corn
2001 Syngenta and Myriad Genetics decode rice genome
2001 U. S. Supreme Court rules that use of medicinal marijuana violates federal law
2001 Environmental Protection Agency renews authorization for use of genetically modified corn
2002 California Supreme Court ruling protects medicinal use of marijuana
2004 Ninth Circuit Court rules D. E. A. lacks authority to ban foods derived from hemp
2004 Food & Drug Administration bans ephedra – first ban of a dietary supplement
2005 Swiss government allows limited production of absinthe

1.5 • TWENTY-FIVE IMPORTANT FAMILIES

There are various ways of surveying useful plants. I will use the structure found in most textbooks on the subject -- arrange the plants according to how we use them, as opposed to some botanical scheme. While this makes good sense, it obscures the fact that some plant families are economically more important than others. Which plant families are high in useful plants? Here is one analysis.

FAMILIES WITH 25+ USEFUL PLANTS

Plant Family	Taxa	%*
01 Grass (Gramineae)	359	15.6
02 Legume (Leguminosae)	323	29.7
03 Rose (Rosaceae)	154	36.4
04 Nightshade (Solanaceae)	100	40.7
05 Sunflower (Compositae)	75	44.0
06 Myrtle (Myrtaceae)	73	47.2
07 Mallow (Malvaceae)	67	50.1
08 Mint (Labiatae)	55	52.5
09 Squash (Cucurbitaceae)	46	54.5
10 Mustard (Cruciferae)	43	56.4
11 Rue (Rutaceae)	43	58.2
12 Spurge (Euphorbiacecae)	41	60.0
13 Carrot (Umbelliferae)	38	61.7
14 Ginger (Zingiberaceae)	32	63.1
15 Palm (Palmae)	30	64.4
16 Goosefoot (Chenopodiaceae)	30	65.7
17 Yam (Dioscoreaceae)	29	67.0
18 Century Plant (Agavaceae)	25	68.0

* The percentages shown are cumulative. In other words, the first 10 families contain 56.4% of all of the useful plants tallied by the authors. Data from Zeven & Zhukovsky (1975).

A PLANT FAMILY SURVEY

I have selected 25 plant families to summarize below. My choice is more subjective than I had originally intended. Even if someone had tallied the number of economic plants per family, I would argue that a family that contains fifty plants of minor economic importance should not rank higher than, for instance, Cannabaceae, which contains only marijuana and hops.

Each of the descriptions below gives you the technical and common name of the plant family, the number of genera and species it contains, a brief statement as to its distribution, the typical growth form (herbs, trees, etc.), the typical number of flower parts, the fruit type, a list of economically important species, and their use(s). I have not included strictly ornamental plants.

Anacardiaceae (Cashew Family)

73 genera and 850 species. Primarily tropical, but extending into the Mediterranean, Europe, Asia, and North America. Trees or shrubs (rarely vines), often with resinous bark. Sepals 5; petals 5; stamens 10; carpels 3 or 5, but only 1 functional. Fruit a drupe. Useful plants include *Anacardium occidentale*, cashew (food, oil, dye); *Mangifera indica*, mango (food); *Pistacia vera*, pistachio (food); *Rhus* spp., sumac, lacquer tree (resins and dyes); *Schinopsis* spp., quebracho (tanning); *Schinus* spp., peppertree (beverage, medicine, flavoring); *Spondias* spp., golden apple, hog plum, mombin, Spanish plum (food); *Toxicodendron* spp., Chinese lacquer tree, poison-ivy, poison-oak, and poison-sumac (resins and dermatitis-producing).

Apocynaceae (Dogbane Family)

215 genera and 2100 species. Cosmopolitan, especially well-represented in the tropics. Trees or shrubs (rarely perennial herbs), typically with a milky sap. Sepals 5; petals 5; stamens 5; carpels 2. Fruit a follicle, berry, or capsule, the seeds sometimes conspicuously hairy. Useful plants include *Apocynum cannabinum*, Indian hemp (fiber, medicine); *Carissa grandiflora*, Natal plum (food); *Landolphia* spp., landolphia rubber (latex); *Catharanthus roseus,* periwinkle (medicine); *Funtumia elastica*, lagos rubber (latex); *Nerium* spp., oleander (medicine, poison); *Rauvolfia* spp., devil pepper or snakeroot (medicine); *Strophanthus* spp., ouabin or kombe (arrow poisons); *Thevetia* spp., yellow oleander (fixed oil, medicine).

Araceae (Aroid or Philodendron Family)

106 genera and 2950 species. Primarily tropical, but with many representatives in the temperate regions. Mostly terrestrial herbs (rarely woody and epiphytic). Plant tissues often contain needle-like crystals of calcium oxalate and enzymes that can inflame and irritate the eyes, mouth, and throat. This means that even the food plants derived from this family must typically be prepared in certain ways to destroy these crystals. Individual flowers very small, unisexual, typically clustered in a showy cylinder or column surrounded by a conspicuous, sometimes brightly-colored bract. Sepals 4-6; petals 4-6; stamens 6; carpels 2-3. Fruit a berry. Useful plants include *Acorus calamus*, sweet flag (flavoring); *Alocasia* spp., alocasia (food); *Amorphophallus* spp., elephant yam (food); *Colocasia esculenta*, taro and dasheen (food); *Monstera deliciosa*, ceriman (food); *Philodendron* spp., philodendron (food, fiber, medicine); *Xanthosoma sagittifolium*, yautia (food).

Bombacaceae (Bombax Family)

30 genera and 250 species. Primarily tropical; none native to the U. S. Trees and shrubs. Sepals 5; petals 5; stamens 5-many; carpels 2-5. Fruit a capsule. Useful plants include *Adansonia digitata*, baobab (food, medicine, industrial); *Bombax ceiba*, red silk cotton (fiber); *Ceiba* spp., kapok, pochote (fiber); *Chorisia* spp., palo boracho, paina de soda (fibers); *Durio zibethinus*, durian (food); *Ochroma pyramidale*, balsa or corkwood (wood).

Chenopodiaceae (Goosefoot Family)

120 genera and 1300 species. Cosmopolitan, especially on soils rich in salts. Herbs and shrubs. Individual flowers unisexual, small and often greenish. Sepals 2-5; petals 0; stamens 2-5; carpels 2. Fruit an

indehiscent nutlet. Useful plants include *Atriplex* spp., saltbush or orach (food); *Beta vulgaris*, beet, chard, sugar beet (food, flavoring); *Chenopodium quinoa,* quinua [-oa] (food); *Kochia scoparia,* summer cypress (food); *Spinacia oleracea,* spinach (food).

Compositae or Asteraceae (Sunflower Family)

1317 genera and 21,000 species, second only to the orchid family in number of species. Cosmopolitan. Vast majority are herbaceous; some are trees, shrubs, vines, and epiphytes. Individual flowers are small and clustered into conspicuous heads of flowers, as in the sunflower. Sepals 0; petals 5; stamens 5; carpels 2. Fruit an achene. Useful plants include *Arctium lappa*, gobo (food); *Artemisia* spp., tarragon, wormwood (flavoring); *Carthamus tinctorius*, safflower (fixed oils); *Chrysanthemum* spp., chrysanthemum (insecticides); *Cichorium* spp., endive, chicory (food and flavoring); *Cynara* spp., cardoon, artichoke (food); *Helianthus* spp., Jerusalem artichoke, sunflower (food and oils); *Lactuca sativa*, lettuce (food); *Parthenium argentatum*, guayule (latex); *Scorzonera hispanica*, black oyster plant (food, beverage); *Tanacetum vulgare*, tansy (medicine); *Tragopogon porrifolius*, oyster plant or salsify (food).

Cruciferae or Brassicaceae (Mustard Family)

390 genera and 3000 species. Common in the cooler regions of the northern hemisphere (rare in the tropics). Mostly herbs (a few somewhat woody). Many contain oil of mustard that imparts a characteristic flavor and aroma. Sepals 4; petals 4; stamens 6 (2 shorter than the other 4); carpels 2. Fruit a silique. Useful plants include *Armoracia rusticana*, horseradish (flavoring); *Brassica* spp., broccoli, Brussel sprouts, cabbage, cauliflower, kale, kohlrabi, mustard, rutabaga, turnip (food); *Camelina sativa*, false flax (fiber); *Crambe* spp. (food, fixed oil); *Isatis tinctoria*, woad (dye); *Nasturtium officinale*, water cress (food); *Raphanus sativus*, radish (food).

Cucurbitaceae (Squash or Gourd Family)

121 genera and 735 species. Common in warmer regions of both the Old and New World. Mostly tendril-bearing, coarse, herbaceous vines. Flowers typically unisexual. Sepals 5; petals 5; stamens 5; carpels 3. Fruit a pepo. Useful plants include *Benincasa hispida*, wax gourd (food); *Citrullus* spp., bitter apple, citron melon, watermelon (food); *Cucumis* spp., cucumber, gherkin, melon (food); *Cucurbita* spp., cushaw, gourd, pumpkin, squash (food); *Ecballium elaterium*, squirting cucumber (medicine); *Lagenaria siceraria*, bottle gourd or calabash gourd (utensils, food, medicine); *Luffa aegyptiaca*, vegetable sponge (fiber); *Sechium edule*, chayote (food); *Trichosanthes* spp., snake gourds (food).

Euphorbiaceae (Spurge Family)

326 genera and 7750 species. Widespread, especially in tropical Africa and tropical America. Shrubs, trees, and herbs (often resembling cacti and confused with them). Plants often with a milky sap that is toxic. Flowers unisexual. Sepals 0 or 5; petals 0 or 5; stamens 1, 5, or many; carpels 3. Fruit a schizocarp. Useful plants include *Aleurites* spp., candlenut tree, tung oil tree (fixed oils); *Cnidoscolus* spp. (food, latex); *Croton* spp., croton (medicine, fish poison); *Hevea* spp., Pará rubber (latex); *Jatropha* spp., physic nut (fixed oil, medicine, food); *Manihot* spp., cassava, ceara rubber (food and latex); *Phyllanthus acidus*, Otaheite gooseberry (food); *Ricinodendron* spp., mongongo nut (fixed oils, food); *Ricinus communis*, castor bean (fixed oil); *Sapium* spp., tallow tree (medicine, fish and arrow poisons, "jumping beans").

Fagaceae (Oak or Beech Family)

7 genera and 1050 species. Common in the temperate and tropical regions of both the New World and Old World. Trees and shrubs. Flowers small, inconspicuous, and unisexual. Sepals 4-6; petals 0; stamens 4-many; carpels 3, but only 1 is functional. Fruit a nut, often inside a cup-like structure. Useful plants include *Castanea* spp., chestnut (food); *Chrysolepis* spp., chinquapin (wood, food); *Fagus* spp., beech (timber); *Nothofagus* spp., southern hemisphere beech (wood); *Quercus* spp., oaks (timber, edible nuts).

Gramineae or Poaceae (Grass Family)

650-900 genera and 10,000 species. Cosmopolitan; the most commonly encountered of the flowering plants. Herbs (rarely shrubby or tree-like in the bamboos). Flowers greatly reduced and inconspicuous, arranged in units called spikelets. Sepals 2-3 (scale-like); petals 0; stamens 3; carpels 3, only 1 of which is functional. Fruit typically a caryopsis (grain). Useful plants include *Agrostis* spp., redtop (pastures, lawns, golf courses); *Arundinaria* spp., cane (construction); *Arundo donax*, reed (reeds for clarinets and organs, fishing poles); *Avena* spp., oats (food and forage); *Bambusa* spp., bamboo (food and building materials); *Bromus* spp. (pastures); *Coix lacryma-jobi*, Job's tears (food and ornamental jewelry); *Cymbopogon* spp., lemon grass and citronella (flavorings); *Dactylis glomerata*, orchard grass (pastures); *Dendrocalamus* spp., giant bamboo (food, construction); *Echinochloa* spp., barnyard grass and millets (food); *Eleusine coracana*, ragi or African millet (food); *Hordeum* spp., barley (food and beverage); *Oryza sativa*, rice (food); *Panicum miliaceum*, proso millet (food); *Pennisetum glaucum*, pearl millet (food); *Phleum pratense*, timothy (pastures); *Phyllostachys* spp. fish-pole bamboo (food, construction); *Saccharum officinarum*, sugar cane (food, flavoring); *Secale* spp., rye (food and beverages); *Setaria* spp., millets (food); *Sorghum bicolor*, sorghum and broomcorn (silage, traditional brooms); *Triticum* spp., wheat (food); *Chrysopogon zizanioides*, vetiver or kush-kush (essential oil); *Zea mays*, maize or corn (food and industrial); *Zizania palustris* (wild rice).

Labiatae or Lamiaceae (Mint Family)

224 genera and 5400 species. Cosmopolitan; chiefly Mediterranean. Herbs (rarely shrubs or trees), often with 4-sided stems and opposite leaves. Plants often pleasantly aromatic because of essential oils. Sepals 5; petals 5; stamens 2 or 4; carpels 2. Fruit a 4-lobed nutlet. Useful plants include *Hyssopus officinalis*, hyssop (essential oil, medicine); *Hyptis suaveolens*, wild spikenard (beverage); *Lavandula* spp., lavender (essential oils); *Majorana hortensis*, sweet marjoram (flavoring); *Marrubium vulgare*, hoarhound (flavoring); *Melissa officinalis*, balm (essential oil, medicine); *Mentha* spp., peppermint, spearmint (essential oils, flavorings); *Monarda* spp., Oswego tea, horsemint (essential oil, flavoring, medicine); *Nepeta cataria*, catnip (flavoring); *Ocimum basilicum*, basil

(flavoring); *Origanum* spp., wild marjoram, oregano (flavoring); *Perilla frutescens*, perilla (essential oil); *Rosmarinus officinalis*, rosemary (essential oil, medicine); *Salvia officinalis*, sage (flavoring); *Satureja* spp., savory (flavoring); *Stachys* spp., betony (food, medicine); *Thymus vulgaris*, thyme (flavoring).

Lauraceae (Laurel Family)

45 genera and 2200 species. Tropical and subtropical. Trees and shrubs. Sepals 3; petals 3; stamens 12; carpels 3. Fruit a berry. Useful plants include *Cinnamomum* spp., camphor, cassia, cinnamon (flavoring, medicinal); *Laurus nobilis*, bay or sweet bay (flavoring); *Lindera benzoin*, spice bush (flavoring, beverage); *Persea americana*, avocado or alligator pear (food); *Sassafras albidum*, sassafras (flavoring); *Umbellularia californica*, California bay (flavoring).

Leguminosae or Fabaceae (Legume, Bean or Pulse Family)

657 genera and 16,400 species; probably the third largest family of flowering plants. Cosmopolitan. Trees, shrubs, herbs, and vines. Plants often with symbiotic, nitrogen-fixing bacteria. Sepals 5; petals 5; stamens 10-many; carpels 1. Fruit a legume. Useful plants include *Acacia* spp., acacia, wattle, gum arabic (dye, gum); *Arachis hypogaea*, peanut or goober (food, industrial uses for oils); *Astragalus gummifer,* gum tragacanth (gum); *Cajanus cajan*, cajan pea (food); *Canavallia ensiformis*, jack bean or horse bean (food); *Cassia* spp., senna (dye); *Ceratonia siliqua*, carob or St. John's bread (food); *Cicer arietinum*, chickpea (food); *Copaifera* spp. copal (resin); *Dalbergia* spp., rosewood (cabinetry); *Cyamopsis* spp., guar, cluster bean (food, gum); *Derris* spp., derris root (fish poison); *Dipteryx* spp., tonka bean (flavoring); *Glycine max*, soybean (food and industrial uses); *Glycyrrhiza glabra*, licorice (flavoring); *Gymnocladus dioica*, Kentucky coffee bean (coffee substitute); *Haematoxylon* spp., logwood (dye); *Indigofera* spp., indigo (dye); *Lablab purpureus*, hyacinth bean (food); *Lathyrus* spp., sweet pea (essential oil, food); *Lens culinaris,* lentil (food); *Lonchocarpus* spp., cube (fish poison); *Lupinus* spp., lupine (food, coffee substitute); *Mucuna* spp., velvet bean (food, medicine, fish poison); *Myroxylon* spp., balsam of Tolu (resin); *Pachyrrhizus* spp., jicama, yam bean (food); *Parkia* spp., locust bean (food); *Phaseolus* spp., bean, common bean, lima bean (food); *Physostigma venenosum*, Calabar bean (ordeal poison); *Piscidia piscipula*, fish poison tree (fish poison); *Pisum sativum*, pea or garden pea (food); *Pithecellobium saman*, saman or rain tree (food, wood); *Pongamia pinnata*, pongam (essential oil, medicine); *Psophocarpus tetragonolobus*, winged bean (food); *Pterocarpus* spp., barwood or rosewood (wood); *Robinia pseudoacacia*, black locust (wood); *Sesbania exaltata*, Colorado river hemp (fiber); *Sophora secundiflora*, mescal bean (narcotic); *Tamarindus indica*, tamarind (beverage); *Tephrosia* spp., tephrosia (fish poison, medicine); *Trigonella foenum-graecum*, fenugreek (flavoring); *Vicia faba*, broad bean, fava bean, or Windsor bean (food); *Vigna* spp., adzuki bean, cow pea, black-eyed pea, mung bean (food).

Liliaceae (Lily Family)

312 genera and 5130 species, treated here in the broad sense that includes plants often assigned to the amaryllis family (Amaryllidaceae), century plant family (Agavaceae), and as many as 40 other segregate families. Cosmopolitan. Mostly perennial herbs (often with bulbs, rhizomes, or corms), sometimes quite large in the century plants and their relatives. Sepals 3; petals 3; stamens 6; carpels 3. Fruit a capsule or berry. Useful plants include *Agave* spp., agave, century plant, henequen, istle, maguey, sisal (fiber, fermented and distilled beverages); *Allium* spp., chives, garlic, leek, onion, shallot (food, flavoring); *Aloë vera*, aloe (medicinal); *Asparagus officinalis*, asparagus (food); *Camassia* spp., camas (food); *Chlorogalum pomeridianum*, California soaproot (fish poison); *Colchicum autumnale*, autumn crocus (mitotic poison); *Cordyline terminalis*, ti (fiber); *Dracaena* spp., dragon's blood (dyes, medicinal); *Furcraea* spp., cabuya, Mauritius hemp (fiber); *Hyacinthus orientalis*, hyacinth (essential oil); *Phormium tenax*, New Zealand hemp (fiber); *Sansevieria* spp., bowstring hemp (fiber); *Scilla* spp., squill (medicine, poison); *Smilax* spp., sarsaparilla (flavoring); *Urginea maritima*, squill (rat poison); *Yucca* spp., yucca (fiber).

Malvaceae (Mallow or Cotton Family)

121 genera and 1550 species. Cosmopolitan, especially well-represented in the New World tropics. Herbs and shrubs (rarely small trees). Plants often with branched hairs and mucilaginous sap. Sepals 3-5; petals 5; stamens many; carpels 5-many. Fruit a capsule or berry. Useful plants include *Abelomoschus esculentus*, okra or gumbo (food); *Abutilon* spp., (fiber, food, medicine); *Gossypium* spp., cotton (fiber, oil); *Hibiscus* spp., hibiscus, kenaf, Deccan hemp, roselle (food, oil, fiber, wood, medicine); *Malva* spp., mallow (food, medicine, beverage); *Sida* spp., Queensland hemp (fiber, medicine); *Thespesia* spp. (fiber, wood); *Urena lobata*, aramina (fiber).

Moraceae (Mulberry or Fig Family)

48 genera and 1200 species. Mostly tropical. Trees and shrubs (rarely herbs). Plants often with a milky sap. Individual flowers unisexual, small, and borne in heads, on flattened disk-like structures on inside a vase-like structure (the syconium of the fig). Sepals 4; petals 0; stamens 4; carpels 2. Fruit an achene, nut, drupe, or false (as in the breadfruit and Osage orange). Useful plants include *Antiaris toxicaria*, upas (arrow and dart poisons); *Artocarpus* spp., breadfruit, jackfruit (food); *Brosimum* spp., breadnut or cow tree (timber, food, fiber, latex); *Broussonetia papyrifera*, paper mulberry (fiber); *Castilla elastica*, Panama rubber (latex); *Ficus* spp., Assam rubber, fig, Banyan tree, strangler fig (food, latex); *Maclura pomifera*, Osage orange, bois-d'arc (timber, dye); *Morus* spp., mulberry (food for us and silkworms).

Musaceae (Banana Family)

2 genera and 42 species. Native to Africa, Asia, and Australia; none is native to the U. S. Large, tree-like herbs. Flowers unisexual. Sepals 3; petals 3; stamens 6; carpels 3. Fruit a leathery berry. Useful plants include *Ensete ventricosum*, Abyssinian banana or ensete (food); *Musa* spp., banana, plantain or platano (food) and Manila hemp (fiber).

Myrtaceae (Myrtle Family)

121 genera and 3850 species. Chiefly native to

Australia and New World tropics. Trees or shrubs. Sepals 4-5; petals 4-5; stamens many; carpels 2-3. Fruit a capsule or berry. Useful plants include *Eucalyptus* spp., gum, karri (timber); *Eugenia uniflora*, pitanga (food); *Feijoa sellowiana*, feijoa (food); *Melaleuca* spp., cajeput (essential oil, medicine); *Pimenta* spp., allspice, bay (flavorings); *Psidium guajava*, guava (food); *Syzygium* spp., clove, jambolan, mountain apple, rose apple (food).

Palmae or Arecaceae (Palm Family)

207 genera and 2675 species. Tropics and subtropics of the Old World and New World. Mostly trees and shrubs (rarely vines). We commonly recognize two groups of palms ("fan palms" and "feather palms") based upon the general appearance of the leaves. Flowers small, but typically aggregated into large, branched clusters. Sepals 3; petals 3; stamens 3; carpels 3, only one of which may be functional. Fruit a berry or drupe. Useful plants include *Areca catechu*, betel nut (narcotic); *Arenga pinnata,* sugar palm (sugar, beverage); *Bactris gasipaes*, peach palm (food, beverage, oil, construction); *Borassus flabellifer*, palmyra palm (timber, fiber, drink, food); *Calamus* spp., rattan (furniture); *Caryota urens*, toddy palm (beverage); *Cocos nucifera* (food, building materials); *Copernicia* spp., carnauba wax palm, Caranday palm (wax); *Elaeis guineensis*, African oil palm (oil); *Metroxylon* spp., sago palm (food); *Phoenix dactylifera*, date palm (food); *Raphia* spp., raffia or wine palm (fiber, beverage); *Sabal* spp., palmetto (food, fiber), *Serenoa repens*, saw palmetto (medicine).

Rosaceae (Rose Family)

107 genera and 3100 species. Cosmopolitan, especially well-represented in Europe, Asia, and North America. Trees, shrubs, and herbs. Sepals 5; petals 5; stamens many; carpels 1 or 5 or many. Fruit an achene, drupe, pome, follicle, or false (as in the strawberry and raspberry). Useful plants include *Cydonia oblonga*, quince (food); *Eriobotrya japonica*, loquat (food); *Fragaria* spp., strawberry (food); *Mespilus germanica*, medlar (food); *Malus domestica*, apple (food); *Prunus* spp., almond, apricot, cherry, nectarine, peach, plum (food); *Pyrus communis*, pear (food); *Quillaja saponaria*, soapbark (soap, medicine); *Rubus* spp., blackberry, dewberry, loganberry, raspberry (food).

Rubiaceae (Madder Family)

637 genera and 10,700 species. Tropical and subtropical regions of both the Old World and the New World. Trees and shrubs, sometimes herbs (as in most of our North American plants). Sepals 4-5; petals 4-5; Stamens 4-5; carpels 2. Fruit a capsule or berry. Useful plants include *Cephaelis ipecacuanha*, ipecac (medicine); *Cinchona* spp., quinine (medicine and flavoring); *Coffea* spp., coffee (beverage); *Morinda citrifolia*, Indian mulberry, noni (dye, food, medicine); *Rubia tinctorum*, madder (dye); *Uncaria gambir*, gambier (tanning, dye).

Rutaceae (Rue or Citrus Family)

161 genera and 1650 species. Tropical and temperate regions, especially well-represented in Australia and South Africa. Shrubs and trees. Plants often aromatic because of essential oils. Sepals 4-5; petals 4-5; stamens 8-10; carpels 4-5. Fruit a drupe, berry, samara, schizocarp, or hesperidium. Useful plants include *Casimiroa edulis*, white sapote (food); *Citrus* spp., bergamot, citron, grapefruit, lemon, lime, mandarin, orange, tangerine (food and flavoring); *Dictamnus albus*, dittany (medicine); *Fortunella* spp., kumquat (food); *Galipea officinalis*, angostura (flavoring); *Pilocarpus jaborandi*, jaborandi (medicine); *Poncirus trifoliata*, trifoliate orange (food); *Ruta graveolens*, rue (medicine).

Solanaceae (Nightshade Family)

90 genera and 2600 species. Tropical and subtropical; center of distribution is New World. Herbs, shrubs, lianas, and trees. A number of species contain highly toxic alkaloids. Sepals 5; petals 5; stamens 5; carpels 2. Fruit a berry or a capsule. Useful plants include *Atropa belladonna*, belladonna (cosmetic, medicine); *Brugmansia* spp., tree datura (narcotic, ritual); *Brunfelsia uniflora*, manaca (medicine); *Capsicum* spp., chilis, peppers (food and flavorings); *Cyphomandra betacea*, tree tomato (food); *Datura* spp., datura, jimson weed, thorn apple (narcotic and ritual use); *Duboisia* spp. (poison); *Hyoscyamus* spp., henbane, black henbane (medicine); *Lycium* spp., matrimony vine (food); *Lycopersicon esculentum*, tomato (food); *Mandragora* spp., mandrake (narcotic, medicine); *Nicotiana* spp., tobacco (poisons, narcotic); *Physalis* spp., ground cherry, husk tomato, tomatillo (food); *Solanum* spp., aubergine or eggplant, potato, naranjilla (food); *Withania* spp. (medicine, narcotic).

**Umbelliferae or Apiaceae
(Carrot or Umbel Family)**

420 genera and 3100 species. Primarily northern temperate region. Herbs, sometimes woody (rarely trees). A characteristic odor and flavor are imparted by a series of essential oils in the plant tissues. Flowers small, but occurring in conspicuous clusters. Sepals 5; petals 5; stamens 5; carpels 2. Fruit a schizocarp. Useful plants include *Anethum graveolens*, dill (flavoring); *Angelica archangelica,* angelica (flavoring); *Apium graveolens,* celeriac, celery (food); *Carum carvi*, caraway (flavoring); *Coriandrum sativum*, coriander (flavoring); *Cuminum cyminum*, cumin (flavoring); *Daucus carota*, carrot (food); *Ferula assafoetida*, asafetida (medicine); *Foeniculum vulgare*, fennel, finochio (flavoring); *Levisticum officinale*, lovage (flavoring); *Pastinaca sativa*, parsnip (food); *Petroselinum crispum*, parsley (flavoring); *Pimpinella anisum*, anise (flavoring).

Zingiberaceae (Ginger Family)

53 genera and 1200 species. Tropics and subtropics; none is native to the U. S. Herbs, sometimes large. Sepals 3; petals 3; stamens 2-3; carpels 3. Fruit a capsule. Useful plants include *Aframomum melegueta*, grains of paradise (food); *Alpinia* spp., galanga (flavoring, medicine); *Curcuma* spp., arrowroot, turmeric, zedoary (flavoring); *Elettaria cardamomum*, cardamon (flavoring); *Kaempferia* spp. (flavoring, medicine); *Zingiber* spp., ginger (flavoring).

1.6 • PLANT KINGDOM RECORDS

I began constructing this section several years ago because these kinds of questions were often asked. What is the biggest, smallest, oldest, most expensive ..., etc. Some of what follows is found in the Guinness Book of World Records; much of it comes from a wide variety of newspaper articles and more obscure sources.

Oldest plant: King's holly (*Lomatia tasmanica*), a member of the protea family growing in southern Australia, is estimated to be 43,000 years old.

Oldest tree: bristlecone pine (*Pinus longaeva*) in California is estimated to be 4700 years old. Some references cite the "Eon" tree, a redwood growing in Humboldt County, California, as 6200 years old.

Tallest living tree: The "stratosphere giant," a redwood (*Sequoia sempervirens*) in Humboldt Redwoods State Park is 112.3 m (368.6 ft.) tall, as determined by Dr. Stephen C. Sillett, a botanist at Humboldt State University.

Tallest tree ever measured: "Ferguson tree" (*Eucalyptus regnans*) in Australia was 470-480 ft. tall.

Tree with the largest canopy: the Great Banyan (*Ficus benghalensis*), growing at the Indian Botanical Garden in Calcutta, has 1775 prop roots and covers about three acres.

Most massive organism (plant or animal): "Pando" aspen clone in the Wasatch Mtns. of Utah. Its 47,000 trunks cover 106 acres and weigh an estimated 13 million pounds.

Plant with greatest coverage: The honey mushroom (*Armillaria ostoyae*), growing in the Malheur National Forest in Oregon, covers about 2000 acres or 3.5 sq. miles. It is estimated to be 2400 years old.

Most massive living tree: "General Sherman," a Sierra redwood (*Sequoiadendron giganteum*) in Sequoia Natl. Park in California. At 274 ft. tall, 36.5 ft. in diameter, 82.3 ft. in circumference, and weighing an estimated 4.5 million pounds, this tree may be the largest single organism that has ever lived on our planet, exceeding by far the size of any known dinosaur or whale. It would yield 600,120 board feet of lumber.

Most massive tree ever measured: The "Lindsey Creek" redwood (*Sequoia sempervirens*), with an estimated weight of 8 million lbs. It was downed by a storm in 1905.

Tree with the lightest wood: *Aeschynomene hispida*, a South American legume, has wood with a specific gravity of 0.044. A cubic foot weighs only 2.75 lbs.

Tree with the heaviest wood: ironwood (*Olea laurifolia*), an African relative of the olive tree. With a specific gravity of 1.49, one cubic foot weighs 93 lbs.

Largest yield of cork bark from a single tree. A single tree produced enough cork for 100,000 bottles of wine. The average yield is closer to 4000 corks.

Fastest growing plant: Chaparral yucca (*Yucca whipplei*). It grew 12 ft. in 14 days.

Largest simple leaf: elephant ear (*Alocasia macrorrhiza*), a member of the philodendron or aroid family growing in Malaysia. One leaf was measured at 9 ft. 11 in. long by 6 ft. 3 in. wide.

Largest compound leaf: raffia palm (*Raphia farinifera*), from tropical Africa, has leaves with a 13 ft. petiole and a 65 ft. long blade.

Largest flower cluster: *Puya raimondii*, a member of the pineapple or bromeliad family, that grows only in Peru and Bolivia. The inflorescence was 35 ft. tall. Plants flower after 80-150 years, which may also be some kind of record. There is a fine specimen at the Botanical Garden at UC, Berkeley.

Largest single flower: stinking corpse flower or bunga patma flower (*Rafflesia arnoldii*), which grows in Sumatra. One flower may be 3 ft. in diameter and weigh up to 15 lbs.

Largest seed: double coconut or coco-de-mer (*Lodoicea maldivica*), a palm from the Seychelles, a group of islands in the Indian Ocean. The record is 40 lbs.

Smallest seed: several epiphytic orchids have very tiny seeds -- 35 million of them to the ounce.

Oldest viable seed: arctic lupine (*Lupinus arcticus*) seeds discovered in Canada that were 8,000-13,000 years old have been germinated.

Smallest flowering plant: duckweed (*Wolffia angusta*), at 0.6 mm by 0.3 mm, is a little larger than the period at the end of this sentence.

Most widely grown crop plant: wheat (*Triticum aestivum*), with 213,816,865 hectares planted in 2001.

Leading crop in world tonnage: sugar cane (*Saccharum officinarum*), with 1,288,403,000 metric tons being harvested in 2002.

Most commonly consumed herb: coriander or cilantro (*Coriandum sativum*), a member of the carrot family.

Largest tree fruit: jackfruit (*Artocarpus heterophyllus*), a tropical member of the mulberry family, can weigh up to 70 lbs.

Most nutritious fruit: avocado (*Persea americana*), with 741 calories per lb.

Least nutritious fruit: cucumber (*Cucumis sativus*), with only 73 calories per lb.

Tallest corn plant: 31 ft., grown in Iowa

Longest gourd: 93.5 in., grown in Missouri

Heaviest sugar beet: 45.5 lbs., grown in Brawley, California

Heaviest cabbage: 124 lbs., grown in England

Heaviest garlic: 2 lbs. 10 ozs., grown in Eureka, California

Heaviest gourd: 196 lbs., grown in England

Heaviest watermelon: 262 lbs., grown in Tennessee

Heaviest pumpkin: 990 lbs., grown in Canada

Heaviest squash: 900 lbs., grown in Canada

Heaviest tomato: 7 lbs. 12 ozs., grown in Oklahoma

Heaviest grapefruit: 61 lbs. 8.5 ozs., grown in Arizona

Heaviest potato: 18 lbs. 4 ozs., grown in England

Heaviest sweet potato: 40 lbs. 12 ozs., grown in Georgia

Heaviest radish: 37 lbs. 15 ozs., grown in Australia

Most expensive spice imported into the United States: saffron (*Crocus sativus*), costing $2600 per lb.

Most paid for a white truffle: $8820 per pound for specimens from Alba, Italy

Most paid for unusual coffee beans: $300 per lb. for Indonesian beans whose special flavor comes from having been passed through the intestinal tract of a civet cat (yes, really!)

Most paid in modern times for a tulip bulb: $480,000 in 1987!

Most paid for a bottle of Scotch: $79,552 for a 50 yr. old Glenfiddich

Most paid for an herbal medicine: $18,678,624 for 1 oz. of ginseng from the Chan Pak Mtn. area in China

Herbal remedy in longest continuous use: ephedra or mahuang (*Ephedra sinica*), a gymnosperm, has been in use for 10,000 years

Most commonly used herbal remedy worldwide: leaf extract of the ginkgo or maidenhair tree (*Ginkgo biloba*).

Most commonly purchased herbal remedy in the United States: echinacea or coneflower (*Echinacea* spp.), a member of the sunflower family.

... and finally, the **ugliest, least nutritious, most distasteful, and generally worthless member of the entire plant kingdom:** the eggplant (*Solanum melongena*), a relative of the much more useful potato and tomato.

SECTION 2 • DOMESTICATION

2.1 - AN OVERVIEW

- ☼ We have domesticated plants and they, in a sense, have domesticated us.
- ☼ In many cultures, if you cultivate plants, you are civilized; if you do not, you are a savage.
- ☼ Agriculture is a relatively recent invention; for 90% of the time that we have been on earth, we have been hunter-gatherers.
- ☼ There are a few regions, most of them in the Old World, where domestication began.
- ☼ Only a few plants (coconut, bottle gourd, sweet potato) were in use in both the Old World and in the New World in Pre-Columbian times.
- ☼ Today most crop plants are not grown commercially where they are native.
- ☼ We have modified plants to meet our needs, with little regard to the biological consequences to the plants themselves.
- ☼ The wild ancestors of several of our most important crops are now extinct.
- ☼ The destruction of wild populations of ancestral forms is endangering the genetic viability of a number of our crop plants.
- ☼ The domesticated forms of some of our most important crops are now incapable of living without our assistance.
- ☼ Many of our crops are reproduced asexually.
- ☼ Asexual reproduction means genetic stability; sexual reproduction means variation. Therein lies the great paradox -- in homogeneity lies productivity; in diversity lies survival.
- ☼ The natural crossing of plants in closely related species or genera has been an important process in the origin and evolution of many of our crops.
- ☼ Many of our crop plants have three or more complete sets of chromosomes in each nucleus, while their wild ancestors typically had only two sets.
- ☼ The domestication of plants is intimately associated with the rise of great civilizations.
- ☼ There have been three great revolutions: agriculture, the Green Revolution, and biotechnology (genetic engineering).
- ☼ We are losing plant species, possible sources of food and cures, at an ever increasing rate.

2.2 • DOMESTICATION

"*Agriculture is the first of all arts. Without it there would exist neither merchants nor poets nor philosophers.*
" [Frederick the Great]

"... *the offspring of the ancient marriage of plants and people are far stranger and more marvelous than we realize."*
[Michael Pollan, "The Botany of Desire"]

"Economic botany is a necessity for human survival but a potential hazard to the survival of Nature."
[G. Kunkel]

"*One day a little band of these odd apes – for apes they were – shambled out upon the grass: the human story had begun. Apes were to become men, in the inscrutable wisdom of nature, because flowers had produced seeds and fruits in such tremendous quantities that a new and totally different store of energy had become available in concentrated form.*

The great Ice Age herds were destined to vanish. When they did so, [a] hand ... would pluck a handful of grass seed and hold it contemplatively.

In that moment, the golden towers of man, his swarming millions, his turning wheels, the vast learning of his libraries, would glimmer dimly there in the ancestor of wheat, a few seeds in a muddy hand. Without the gift of flowers and the infinite diversity of their fruits, man and bird, if they had continued to exist at all, would be today unrecognizable. Archaeopteryx, the lizard-bird, might still be snapping at beetles on a sequoia limb; man might still be a nocturnal insectivore gnawing a roach in the dark. The weight of a petal has changed the face of the world and made it ours."
[Loren Eiseley, "The Immense Journey']

☼ ☼ ☼ ☼ ☼

We have lived on Earth in a recognizably distinct form for about 2 million years. For the vast majority of that time, we have hunted beasts, gathered roots and fruits of various kinds, and eaten wild grasses. Of the estimated 80 billion "cultural people" who have lived on our planet, about 90% have been hunters and gatherers.

Please refer to the "Chronicle of Economic Botany" earlier in the syllabus. You will note that it was about 14 million years ago when the first human-like primate evolved and that it was about 3-4 million years ago that our closest relatives (*Australopithecus* spp.) came on the scene. It was only about 250,000 years ago that we began to make standardized tools.

But the monumental event that is often called the single most significant occurrence in human cultural evolution happened a scant 10,000 years ago. That event is the cultivation and domestication of plants and animals.

To emphasize how recent this was in the scheme of things, I will switch time scales. Assume that the entire history of the universe can be collapsed into a single year.

HISTORY IN A SINGLE YEAR

January 01	Creation of the Universe
September 25	Origin of life on earth
December 20	Plants colonize the land
December 28	First flowering plants appear
December 31 (10:30 p.m.)	First humans
December 31 (11:00 p.m.)	Use of tools
December 31 (11:59 p.m.)	Agriculture

In other words, this monumental event (or process) that has so changed the way we live on this planet occurred one minute before midnight on the very last day of the "Cosmic Year."

THE PROCESS OF DOMESTICATION

"*Domestication is a biological process that invokes changes in the genotype and physical characteristics of plants and animals as they become dependent upon humans for reproductive success.*"

[Price & Gebauer, 1995]

What do we mean by cultivation and domestication of plants and what are the processes involved? To **cultivate** means to care for a plant; to till the soil, water, weed, and prune. To **domesticate** means to bring into the household and in so doing, to alter it from its wild state. We have domesticated a hundred or so plants and 50 or so animals, such as the dog, pig, cattle, horse, water buffalo, goat, sheep, and chicken.

Domestication is really directed evolution, which in turn is based upon two basic phenomena: **variation**, the concept that not all individuals are the same and that some are better adapted for survival than others, and **natural selection**, the view that nature selects for those individuals that are best adapted to reproduce the species. When it comes to our crop plants, natural selection has been largely replaced by **artificial selection** -- by people consciously and unconsciously selecting those individuals that we want to preserve.

Domestication involves three important steps:

(1) moving seeds, tubers, etc. from their native habitats and planting them in new areas;

(2) removing selective pressures and thereby allowing more variants to survive; and

(3) selecting for characteristics that are useful to us, but not necessarily for the plant under its natural conditions.

CHANGES BROUGHT ABOUT BY DOMESTICATION

Some changes in plants that have occurred as a result of domestication include:

Ecological:
- spread into a greater diversity of environments and a wider geographic range

Life History/Reproduction:
- flowering and fruiting simultaneously;
- reduction or loss of dispersal mechanisms;
- conversion from perennials to annuals;
- absence of normal pollinators;
- loss of defense mechanisms (thorns, spines, etc.);
- development of seedless fruits;
- reproduction by vegetative means;
- change in chromosome number;
- increased susceptibility to disease;
- loss of seed dormancy;
- loss of photoperiod controls;
- change from cross- to self-pollination;
- conversion of flower parts

Size of Plants/Plant Parts:
- Increase (as in maize and potato)
- Decrease (as in dwarf wheats)

Chemical Constituents:
- Increase (as in % of corn oil, THC, etc.)
- Decrease (as in % of nicotine, HCN, etc.)

Aesthetics:
- Palatability
- Uniformity
- Color and texture

WHY DID IT TAKE SO LONG?

The overriding question about the domestication of plants is why did it take so long for us to make so simple a "discovery" or to take this step. A number of theories have been put forth:

- While we lived by hunting, fishing, and gathering we had too little time for such cultural luxuries.
- Domestication became a necessity after dramatic shifts in climate.
- For thousands of years, we would be satisfied just to meet our basic needs for food, shelter, and clothing. Domestication occurred as the culmination of an ever increasing differentiation and specialization of human communities.
- Some plants and animals may have been domesticated as parts of religious ceremonies.
- No particular motive or advance was required; only the revelation that seeds can be sown to produce plants when and where desired ("The Eureka! Model").
- There is no single explanation; all of them have contributed to our understanding of the problem ("The No-Model Model").

IDENTIFYING THE ANCESTORS

There are two schools of thought, each championed by a giant figure in this field.

ALPHONSE DE CANDOLLE (1806-1893) was a member of a distinguished family of Swiss botanists. In his two great works ("Géographie Botanique Raisonnée," 1885 and "Origine des Plantes Cultivées," 1882) he attempted to demonstrate that the different kinds of cultivated plants that we now see could be traced back to wild ancestors that were still with us and recognizable as their wild progenitors. De Candolle determined that there were 247 ancestral species: 199 in the Old World, 45 in the New World, 7 now extinct, and 3 whose origin was uncertain.

The following concluding remarks from his "Origin of Cultivated Plants" provide an excellent summary of his thinking:

"Cultivated plants do not belong to any particular category, for they belong to fifty-one different families. They are, however, all phanerogamous [flowering plants] except the mushroom.... The characters which have most varied in cultivation are, beginning with the most variable: a. The size, form, and colour of the fleshy parts...; b. The number of seeds, which is often in inverse ratio to the development of the fleshy parts of the plant; c. The form, size, or pubescence [hairiness] of the floral organs which persist round the fruits or seeds; d. The

rapidity of the phenomena of vegetation -- whence often results the quality of ligneous [woody] or herbaceous plants, and of perennial, biennial, or annual."

"The classification of varieties made by agriculturists and gardeners are generally based on those characters which vary most (form, size, colour, taste of the fleshy parts, beard in the ears of corn, etc.). Botanists are mistaken when they follow this example; they should consult those more fixed characters of the organs for the sake of which the species are not cultivated."

"No distinctive character is known between a naturalized plant which arose several generations back from a cultivated plant, and a wild plant sprung from plants which have always been wild."

"A species may have had, previous to cultivation, a restricted habitation, and subsequently occupy an immense area as a cultivated and sometimes a naturalized plant."

"In the history of cultivated plants, I have noticed no trace of communication between the peoples of the old and new worlds before the discovery of America by Columbus.... Between America and Asia two transports of useful plants perhaps took place, the one by man (the Batata, or sweet potato) the other by the agency of man or of the sea (the cocoa-nut palm)."

CHARLES ROBERT DARWIN (1809-1882) is probably best known for his great work, "The Origin of Species by Means of Natural Selection." Another of his most important contributions to the field of natural history is "The Variation of Animals and Plants under Domestication." In these quotes from the second edition, you will see that Darwin took a very different approach to the problem.

"The subject is involved in much difficulty. Botanists have generally neglected cultivated varieties, as beneath their notice. In several cases the wild prototype is unknown or doubtfully known; and in other cases it is hardly possible to distinguish between escaped seedling and truly wild plants, so that there is no safe standard of comparison by which to judge of any supposed amount of change. Not a few botanists believe that several of our anciently cultivated plants have become so profoundly modified that it is not possible now to recognise their aboriginal parent-forms."

"... M. De Candolle concludes that plants have rarely been so much modified by culture that they cannot be identified with their wild prototypes. But on this view, considering that savages probably would not have chosen rare plants for cultivation, that useful plants are generally conspicuous, and that they could not have been the inhabitants of deserts or of remote and recently discovered islands, it appears strange to me that so many of our cultivated plants should still be unknown or only doubtfully known in the wild state. If, on the other hand, many of these plants have been profoundly modified by culture, the difficulty disappears. The difficulty would also be removed if they have been exterminated during the progress of civilisation; but M. De Candolle has shown that this probably has seldom occurred."

"From innumerable experiments made through dire necessity by the savages of every land, with the results handed down by tradition, the nutritious, stimulating, and medicinal properties of the most unpromising plants were probably first discovered.... We probably owe our knowledge of the uses of almost all plants to man having originally existed in a barbarous state, and having been often compelled by severe want to try as food almost everything which he could chew and swallow."

WHEN DID IT OCCUR?

The answer is reasonably straightforward – at various times in different places around the world. The question also implies that domestication is a past event. We continue to guide the evolution of plants and animals around us.

DOMESTICATED PLANTS

B. C. E.		**Where ?**
9000	Emmer wheat	Near East
9000	Barley	Near East
8500	Lima bean	South America
8000	Potato	Peru
8000	Pumpkin	Central America
8000	Sweet potato	Peru
8000	Common bean	South America
7500	Rice	Indochina
7500	Rye	Syria
7000	Einkorn wheat	Syria
7000	Durum wheat	Anatolia
7000	Yam	Indonesia
7000	Banana	Indonesia
7000	Coconut	Indonesia
7000	Sugar cane	New Guinea
6500	Gourds	Mexico
6500	Flax	Central Europe
6300	Quinoa	South America
6000	Bread wheat	Southwest Asia
6000	Citrus	Indochina
6000	Lentil	Southwest Asia
6000	Squash	Mexico
6000	Finger millet	Ethiopia
5500	Maize	Mexico
5500	Foxtail millet	China
5500	Peach	China
5000	Avocado	Mexico
4500	Date palm	India
4500	Sorghum	Sudan
4300	Upland cotton	Mexico
4300	Tepary bean	Mexico
4000	Grape	Turkestan
4000	Oil palm	Sudan
3500	Olive	Crete
3300	Jack bean	South America
3300	Coca	South America
3000	Cotton	India
3000	Peanut	Peru
2500	African yam	West Africa
2000	Alfalfa	Iran
1500	Soybean	Manchuria
1500	African rice	West Africa
1300	Cassava	South America
1300	Sunflower	North America
1000	Oats	Europe
500	Tea	Tibet
500	Cloves	Indonesia
500	Currant	Eurasia
400	Tobacco	South America
100	Sieva bean	Mexico
C. E.		
200	Potato	Peru/Bolivia
500	Sweet potato	Polynesia
1400	Coffee	Arabia

1800	Jute	India
1801	Sugar beet	Silesia
1958	Kiwi fruit	
1972	Wild rice	North America

DOMESTICATED ANIMALS

B. C. E.

15,000	Dog	East Asia
9000	Sheep	Iran/Afghanistan
8000	Goat	Near East
7500	Water buffalo	Indochina
7500	Pig	East Asia
7000	Cattle	Turkey
5000	Chicken	Asia
5000	Llama	Peru
5000	Alpaca	Peru
4500	Horse	Ukraine
4000	Silkworm	China
3000	Donkey	Palestine
3000	Arabian camel	Iran
3000	Elephant	India
3000	Mule	Palestine
2500	Cat	Egypt
2500	Yak	Tibet
2000	Guinea-pig	Peru
500	Reindeer	Central Asia
300	Turkey	Mexico

WHERE DID IT FIRST OCCUR?

In 1807, Baron Alexander von Humboldt observed, "*The birthplace, the original homeland of plants most useful to man is as impenetrable a secret as the question of the origins of domestic animals... We do not know in what region first appeared in their wild form wheat, barley, oats and rye.*"

Habitat. Since that time, a variety of habitats have been suggested, including (1) arid hillsides or mountainous regions; (2) grasslands; (3) edges of forests; (4) rubbish heaps; (5) stream terraces; and (6) edges of lakes and rivers.

Geography. In attempting to locate the geographic region where domestication arose, attention was first directed to locations in the Old World. Fossil remains, although scanty, were there. The earliest come from present-day Iraq and Iran, from sites in the Zagros Mountains. The fossils have been dated at 8000 B. C. E. They consist of grinding stones, obsidian tools, bones of domesticated sheep and goats, and a few grains of two kinds of domesticated wheat and one of domesticated barley. Three or four thousand years later, a second major center of domestication appeared in China or Southeast Asia. The people of that region first domesticated a small-grained cereal called millet. Rice and the soybean came later.

In the New World, studies have centered on Mesoamerica and South America, especially sites in Mexico and Peru. The great Indian civilizations of these areas were based upon the domestication of maize, squashes, beans, quinoa, and the potato.

CENTERS OF ORIGIN

Nickolay Ivanovich Vavilov (1887-1943) was one of the leading investigators of the origin of cultivated plants. He held several high positions in the Soviet scientific establishment, including President of the Lenin Academy of Agricultural Sciences and Director of the Institute of Plant Industry. Vavilov was in charge of over 400 research units and experiment stations in the U. S. S. R. from 1921 to 1934. He engaged in extensive field work in Afghanistan, Ethiopia, China, Central America, and South America. It was the detailed knowledge from this vast amount of field work that formed the basis of many of his theories.

Much of Vavilov’s work on the origin of cultivated plants is summarized in "Phytogeographic Basis of Plant Breeding" (1951). Vavilov recognized eight independent areas that are now variously referred to as **centers of origin** or as **centers of diversity**. The two concepts are not the same, although the terms are often used interchangeably. These centers are separated from one another by extensive deserts or mountain ranges that acted as barriers to the movement of plants and primitive peoples. Taken as a whole, the eight areas occupy only 1/40th of the land surface of the earth.

Vavilov's early work, resulting in his designating these eight centers of origin, rests on the premise that the place of origin of a particular kind of cultivated plant is that area where we encounter the greatest number of genetic varieties or strains of that plant. This idea was not original with Vavilov, but he did much to substantiate it by collecting tremendous amounts of data on his numerous expeditions. At first, the concept was widely accepted. In recent years, however, Vavilov's work has come under increasing criticism.

Vavilov himself recognized the validity of some of these criticisms and made certain basic changes in his theories. Probably the major improvement in his theories involves recognizing that what he called "centers of origin" should have been called "centers of diversity." The Abyssinian Center of Vavilov contains many plants that had their origins elsewhere. Crops such as wheats, barleys, peas, flax, and lentils have great diversity there, but their sites of origin may well be in the Middle East. None of the wild counterparts of these plants occurs in Ethiopia. This presents a serious problem, unless we accept the idea that domesticated plants arise *de novo*. In an attempt to answer this criticism, Vavilov distinguished between "primary centers" where domestication began and "secondary centers" where cultivated plants may be found after the initial domestication.

A summary of Vavilov's eight centers, their geographic delimitations, and their most important plant species is presented below.

I. The Chinese Center. This is the largest center of origin. It covers the mountainous regions of central and western China and the adjacent lowlands. 136 species, including the peach, apricot, cherry, walnut, kumquat, loquat, persimmon, litchi, water chestnut, taro, soybean, rhubarb, eggplant (now you can see this hideous creature in its true light -- a communist plot against all right-thinking citizens!), cucumber, broomcorn millet, tea, mulberry, paper mulberry, opium poppy, ginseng, sesame seeds, tung nut oil, China berry, cassia, ramie, and hemp.

II. The Indian Center. This center includes Burma and Assam, but it excludes northwest India, the Punjab, and the northwestern frontier region. 117 species, including many peas and beans, mango, orange, jack fruit, betel nut, chaulmoogra oil tree, rice, sorghum, madder, Indian rubber tree, yam, henna, madder, black pepper, cardamon, cumin, cinnamon, coconut, safflower, black mustard, gum Arabic, and sandalwood.

IIa. The Indo-Malayan Center. This area includes the Malay Archipelago, Java, Borneo, Sumatra, the Philippines, and Vietnam. 55 species, including the banana, plantain, mangosteen, durian, air potato, pokeweed, ginger, vetiver, clove tree, nutmeg, black pepper, sugar cane, Manila hemp, gutta-percha, Job's tears, and candlenut tree.

III. The Central Asiatic Center. The area includes northwest India, Afghanistan, the Soviet Republics of Tadjikistan and Uzbekistan, and western Tian-Shan. 42 species, including the pistacio, apricot, pear, almond, Russian olive, grape, English walnut, apple, lentils, mung bean, flax, coriander, carrot, turnip, onion, garlic, spinach, bread wheat, and cotton.

IV. The Near-Eastern Center. This center occupies the Near East. 83 species, including nine endemic wheats, fig, pomegranate, cherry, hazelnut, chestnut, pistachio, Russian olive, rye, oats, cantaloupe, pumpkins, cabbage, carrot, leeks, lettuce, alfalfa, vetch, anise, anisette, sumac, and coriander.

V. The Mediterranean Center. This center occupies the Mediterranean region. 84 species, including the garden beet, turnip, chives, asparagus, celery, chicory, parsnip, salsify, Spanish oyster, caraway, fennel, thyme, hyssop, hops, lavender, peppermint, rosemary, sage, laurel, three kinds of wheat, black and white mustards, carob, madder, and sumac.

VI. The Abyssinian Center. This center includes Ethiopia and Eritrea. It is limited in both size and in the number of endemic species. 38 species, including teff, raggi, pearl millet, fenugreek, cow pea, hyacinth bean, castor bean, khat, coffee, okra, myrrh, and indigo.

VII. South American & C. American Center. In addition to southern Mexico and Central America, this center also includes the Antilles. 49 species, including the prickly pear, soursop, sapodilla, three kinds of sapote, papaya, avocado, guava, star apple, cashew, yam bean, sweet potato, arrowroot, chayote, agave, cherry tomato, cacao, annatto, tobacco, lima bean, tepary bean, upland cotton, sisal, henequen, maize, and various peppers.

VIII. The South American Center. This center includes Peru, Ecuador, and Bolivia. Many of the endemic plants occur in the high mountains. The region is characterized by unusual potatoes and other tuber-bearing plants. 45 species, including potatoes, oka, nasturtium, tomato, tree tomato, ground cherry, pumpkin, peppers, marigold, coca, passion flowers, quinoa, Egyptian cotton, quinine, and tobacco.

VIIIa. The Chiloe Center. This is the smallest center of origin, a small island off southern Chile. 4 species, including the white potato and wild strawberry.

VIIIb. The Brazilian-Paraguayan Center. Although rich in wild plants, this center is poor in its number of cultivated species. 13 species, including manioc, peanut, cacao, the rubber tree, Paraguay tea, pineapple, Brazil nut, and cashew.

NUMERICAL SUMMARY OF CENTERS

Center	Number of Species	% of Total
Chinese	136	20.4
Indian	172	25.8
Central Asia	42	6.3
Near East	83	12.5
Mediterranean	84	12.6
Abyssinian	38	5.7
Mesoamerican	49	7.4
S. American	62	9.3

Certain facts are immediately apparent from these lists. First, the vast majority of the 666 species treated by Vavilov are of Old World origin. Only 111 are New World plants. About 80% of the Old World plants had their origin in southern Asia. The mountains and tropical regions of Asia are the home of many plants that we use today. Second, there are major continental areas that are particularly poor in major endemic cultivated plants. They are North America, Europe, Africa, and Australia. This is not to say that these areas are devoid of cultivated plants that played some role in the ethnobotanical development of peoples. It is just that they are impoverished in major cultivated plants. Can you name, for instance, a major crop plant that is native to the United States?

VAVILOV AND LYSENKO

As Vavilov's fame grew around the world, he found himself the target of scientific and political opposition, especially from one of his staff members, an ambitious charlatan named Trofim D. Lysenko. He claimed that chromosomes did not exist and that the field of genetics was just some silly notion of a Catholic monk (Mendel). His bizarre ideas of crop breeding included the belief that one species of plant could be transformed into another in a matter of months. Unfortunately for Soviet agriculture in general, and for Vavilov in particular, Lysenko had a very powerful patron -- none other than Josef Stalin himself. Lysenko finally decided that his position was strong enough to bring down Vavilov, who was accused of being a British spy, accepting the concepts of western scientists, and rejecting those of Soviet workers, including Lysenko. Vavilov was arrested, tried, and sentenced to death. He was put in one of the infamous Siberian labor camps. He became a "non-person." One of the 20th century's most distinguished scientists simply failed to exist. The circumstances surrounding Vavilov's death remained unclear for many years. Now we know that he died in 1943 of starvation and heart disease.

Lysenko became a dominant figure in Soviet agriculture, which accounts, at least in part, for decades of food shortages as the collective farms were forced to adopt his scientifically discredited procedures. Lysenko fell from grace when Nikita Khrushchev was ousted. A few years later, the Soviet government not only acknowledged that Vavilov had existed, but it restored his reputation and accorded him great honors.

TIMELINE: N. I. VAVILOV

1887 Born in Moscow
1913 Studies in England
1917 Becomes Professor at Univ. of Saratov
1921 Heads All-Union Inst. of Plant Industry
1922 Publishes "Law of Homologous Series"
1926 Publishes "Centers of Origin..."
1932 Visits U. S.
1938 Visits U. S.
1938 Replaced by Lysenko as President of Academy of Agricultural Science
1939 Elected President of International Congress in

Edinburgh
1940 Arrested for being a spy for England
1941 Sentenced to death
1943 Dies in Soviet labor camp at Saratov
1967 Vavilov's rehabilitation begins

TIMELINE: T. D. LYSENKO

1898 Born in Ukraine
1933 Presents paper at All-Union Collective
1936 First public attack on western genetics
1938 President of Agricultural Academy
1939 Appointed Academician
1940 Director of Institute of Genetics
1945 Becomes "Hero of Soviet Labor"
1948 Publishes "Agrobiology"
1948 Begins purge of opposing scientists
1949 Awarded Stalin Prize for "Agrobiology"
1953 Joseph Stalin dies
1955 Awarded Michurin Gold Medal
1956 Forced to resign from some posts
1965 Forced from power
1976 Dies in Moscow

THE NATURE OF THE EVIDENCE

De Candolle, Darwin, Vavilov and other scientists of the 19th and early 20th century used a number of different sources of evidence in their investigations of the origins of our domesticated plants. They include:

☼ comparison of wild and cultivated living forms;

☼ fossil remains, in the form of:

- charred (carbonized) material;
- impressions;
- silica skeletons;
- water-logged material;
- desiccated or mummified grains;
- frozen material;
- petrified material;

☼ art work with botanical illustrations

☼ references to plant use in ancient texts; and

☼ linguistic studies.

We are now able to combine these lines of evidence with genetic data (DNA comparisons) and chemical data from living plants to produce a more complete picture of the ancestors of our modern domesticated plants. This has led to other more recent interpretations of centers of diversity, as seen below.

RECENT VIEWS OF CENTERS OF DIVERSITY

Zhukovsky (1976)

Chinese-Japanese
Indochinese-Indonesian
Australian
Hindustani
Central Asian
Near Eastern
Mediterranean
African
European-Siberian
South American
Central American & Mexican
North American

Hawkes (1983)

Nuclear Centers:
Northern China
The Near East
Southern Mexico
Central to southern Peru

Regions of Diversity:
China
India
Southeast Asia
Central Asia
The Near East
The Mediterranean
Ethiopia
West Africa
Meso-america
Northern Andes

Outlying Minor Centers:
Japan
New Guinea

Northwestern Europe
United States & Canada
The Caribbean
Southern Chile
Brazil

MacNeish (1992)

Andean Area
Mesoamerica
New World Tropics
American Southwest
Eastern United States
Near East
Far East
Europe
Southeastern Asia
Africa

Harlan (1992)

Near Eastern Complex
Africa
Chinese Region
Southeast Asia & Pacific Islands
Mesoamerica & North America
South America

Zohary (2001)

First Old World Territory (Fertile Crescent)
Second Old World Territory (China)
Third Old World Territory (Sub-Sahara Africa)
American Territory
Southwestern Mexico
South America
Eastern North America

CURRENT VIEW OF ANCESTRAL HOME OF OUR MAJOR CROPS

Using the latest information at our disposal, what is the ancestral home of many of our better known domesticated plants?

NORTH AMERICA

Chestnut	*Castanea dentata*
Cranberry	*Vaccinium macrocarpon*
Devil's claw	*Proboscidea parviflora*
Ground nut	*Apios tuberosa*
Jerusalem artichoke	*Helianthus tuberosus*
Jojoba	*Simmondsia chinensis*
Mulberry, red	*Morus rubra*
Pecan	*Carya illinoensis*
Persimmon	*Diospyros virginiana*
Pokeweed	*Phytolacca americana*
Strawberry, Virginia	*Fragaria virginiana*
Sumpweed	*Iva axillaris*
Sunflower	*Helianthus annuus*
Walnut, black	*Juglans nigra*
Wild rice	*Zizania aquatica*

MEXICO AND CENTRAL AMERICA

Aguacate	*Persea* spp.
Amaranth	*Amaranthus hypochondriacus*
Arrowroot	*Maranta arundinacea*
Avocado	*Persea americana*
Bean, common	*Phaseolus vulgaris*
Bean, scarlet runner	*Phaseolus coccineus*
Bean, sword	*Canavalia ensiformis*
Bean, tepary	*Phaseolus acutifolius*
Calabash tree	*Crescentia cujete*
Capulín	*Prunus serotina*
Cassava	*Manihot esculenta*
Castilloa rubber	*Castilla elastica*
Century plant	*Agave* spp.
Ceriman	*Monstera deliciosa*
Chan	*Hyptis suaveolens*
Chayote	*Sechium edule*
Chia	*Hyptis suaveolens*
Chia	*Salvia* spp.
Chiclé	*Manilkara zapota*
Cotton, upland	*Gossypium hirsutum*
Custard apple	*Annona squamosa*
Grain amaranth	*Amaranthus hypochondriacus*
Guava	*Psidium guajava*
Guayule	*Parthenium argentatum*
Henequen	*Agave fourcroyes*
India-fig	*Opuntia ficus-indica*
Jícama	*Pachyrrhizus erosus*
Kapok	*Ceiba pentandra*
Maguey	*Agave atrovirens*
Maize	*Zea mays*
Manioc	*Manihot esculenta*
Marigold	*Tagetes patula*
Mescal	*Agave tequilina*
Mescal bean	*Sophora secundiflora*
Nance	*Byrsonima crassifolia*
Panic grass	*Panicum sonorum*
Papaya	*Carica papaya*
Pepper, aji	*Capsicum frutescens*
Pepper, bell	*Capsicum annuum*
Pepper, chile	*Capsicum annuum*
Pepper, tabasco	*Capsicum frutescens*
Pimento	*Pimento dioica*
Prickly-pear	*Opuntia* spp.
Prickly-poppy	*Argemone mexicana*
Pumpkin	*Cucurbita pepo*
Ramón	*Brosimum alicastrum*
Sapodilla	*Manilkara zapota*
Sapote, black	*Diospyros ebenaster*
Sapote, white	*Casimiroa edulis*
Sea-grape	*Coccoloba uvifera*
Sisal	*Agave sisalana*
Soursop	*Annona muricata*
Squash	*Cucurbita* spp.
Sweet potato	*Ipomoea batatas*
Sweet sop	*Annona squamosa*
Teosinte	*Zea* spp.
Tomate	*Physalis ixocarpa*
Tuna	*Opuntia megacanthos*
Vanilla	*Vanilla planifolia*
Yam, Mexican	*Dioscorea floribunda*
Yam bean	*Pachyrrhizus erosus*

SOUTH AMERICA

Achiote	*Bixa orellana*
Achira	*Canna edulis*
Achis	*Amaranthus caudatus*
Añil	*Indigofera suffruticosa*
Annatto	*Bixa orellana*
Añu	*Tropaeolum tuberosum*
Arracacha	*Arracacia xanthorrhiza*
Arrowroot	*Maranta arundinacea*
Banana passion fruit	*Passiflora mollissima*
Bean, common	*Phaseolus vulgaris*
Bean, jack	*Canavalia ensiformis*
Bean, Lima	*Phaseolus lunatus*
Bottle gourd	*Lagenaria siceraria*
Brazil nut	*Bertholletia excelsa*
Brazilian pepper tree	*Schinus molle*
Caapi	*Banisteriopsis caapi*
Cacao	*Theobroma cacao*
Cañahua	*Chenopodium pallidicaule*
Cashew	*Anacardium occidentale*
Cassava	*Manihot esculenta*
Cherimoya	*Annona cherimola*
Coca	*Erythroxylum coca*
Cotton, sea island	*Gossypium barbadense*
Guaraná	*Paullinia cupana*
Inca-wheat	*Amaranthus caudatus*
Ipecac	*Cephaelis ipecachuana*
Jícama	*Pachyrrhizus* spp.
Lulo	*Solanum quitoense*
Maca	*Lepidium meyenii*
Manioc	*Manihot esculenta*
Maté	*Ilex paraguariensis*
Mesquite	*Prosopis juliflora*
Nasturtium	*Tropaeolum majus*
Oca	*Oxalis tuberosa*
Pará rubber	*Hevea brasiliensis*
Peanut	*Arachis hypogaea*
Pineapple	*Ananas comosus*
Potato	*Solanum tuberosum*
Quinoa	*Chenopodium quinoa*
San Pedro cactus	*Echinopsis pachanoi*
Squash	*Cucurbita maxima*
Tannia	*Xanthosoma sagittifolium*
Tobacco	*Nicotniana tabacum*
Tobacco, Aztec	*Nicotiana rustica*
Tomato	*Lycopersicon esculentum*
Tree-gourd	*Crescentia cujete*
Tree-tomato	*Cyphomandra betacea*
Ulluco	*Ullucus tuberosus*
Yacón	*Polymnia sonchifolia*
Yam, cush-cush	*Dioscorea trifida*
Yaupón	*Ilex vomitoria*
Yautia	*Xanthosoma sagittifolium*
Yoco	*Paullinia yoco*

EUROPE & SIBERIAN ASIA

Asparagus	*Asparagus officinalis*
Barberry	*Berberis vulgaris*
Beach grass, European	*Ammophila arenaria*
Brussel sprouts	*Brassica oleracea*
Buckthorn	*Rhamnus catharticus*
Burdock	*Arctium lappa*
Caraway	*Carum carvi*
Chamomile	*Anthemis nobilis*
Chicory	*Cichorium intybus*
Crested wheat grass	*Agropyron cristatum*
Dame's rocket	*Hesperis matronalis*

Dandelion	*Taraxacum officinale*
Fescue, meadow	*Festuca pratensis*
Fescue, sheep	*Festuca ovina*
Fescue, tall	*Festuca arundinacea*
Foxglove	*Digitalis purpurea*
Good King Henry	*Chenopodium bonus-henricus*
Gorse	*Ulex europaeus*
Gromwell	*Lithospermum officinale*
Hens-and-chickens	*Sempervivum tectorum*
Hops	*Humulus lupulus*
Horse radish	*Armoracia rusticana*
Lamb's quarter	*Chenopodium album*
Madder	*Rubia tinctoria*
Meadow foxtail	*Alopecurus pratensis*
Monkshood	*Aconitum napellus*
Mountain-spinach	*Atriplex hortensis*
Orchard grass	*Dactylis glomerata*
Parsnip	*Pastinaca sativa*
Pear	*Pyrus communis*
Purslane	*Portulaca oleracea*
Reed canary grass	*Phalaris arundinacea*
Rye grass	*Lolium perenne*
Sea kale	*Crambe maritima*
Soapwort	*Saponaria officinalis*
Sweet flag	*Acorus calamus*
Sweet vernal grass	*Anthoxanthum odoratum*
Valerian	*Valeriana officinalis*
Velvet grass	*Holcus lanatus*
Watercress	*Nasturtium officinale*

MEDITERRANEAN COAST

Aloe	*Aloë vera*
Anise	*Pimpanella anisum*
Artichoke	*Cynara scolomus*
Balm	*Melissa officinalis*
Bean, broad	*Vicia faba*
Bean, fava	*Vicia faba*
Beet	*Beta vulgaris*
Belladonna	*Atropa belladonna*
Black henbane	*Hyoscyamus niger*
Borage	*Borago officinalis*
Cabbage	*Brassica oleracea*
Cardoon	*Cynara cardunculus*
Carnation	*Dianthus caryophylleus*
Carob	*Ceratonia siliqua* ??
Carrot	*Daucus carota*
Capers	*Capparis spinosa*
Celery	*Apium graveolens*
Chard	*Beta vulgaris*
Chaste tree	*Vitex angus-caste*
Coriander	*Coriandrum sativum*
Dill	*Anethum graveolens*
Esparto	*Stipa tenacissima*
Fennel	*Foeniculum vulgare*
Garden cress	*Lepidium sativum*
Garlic	*Allium sativum*
Giant reed	*Arundo donax*
Grape	*Vitis vinifera*
Harding grass	*Phalaris tuberosa*
Hyssop	*Hyssopus officinalis*
Laurel	*Laurus nobilis*
Lavender	*Lavandula officinale*
Leek	*Allium porrum*
Lettuce	*Lactuca sativa*
Mangle	*Beta vulgaris*
Marsh mallow	*Althaea officinalis*
Mustard, black	*Brassica nigra*
Myrtle	*Myrtus communis*
Oat	*Avena sativa*
Oleander	*Nerium oleander*
Olive	*Olea europaea*
Onion	*Allium cepa*
Opium poppy	*Papaver somniferum*
Papyrus	*Cyperus papyrus*
Parsley	*Petroselinum crispum*
Psyllium	*Plantago psyllium*
Pyrethrum	*Chrysanthemum cineriaefolium*
Radish	*Raphanus sativus*
Rape	*Brassica napus*
Rosemary	*Rosmarinus officinalis*
Saffron	*Crocus sativus*
Sage	*Salvia officinale*
Salsify	*Tragopogon porrifolius*
Scorzonera	*Scorzonera hispanicus*
Shepherd's purse	*Capsella bursa-pastoris*
Squill	*Urginea maritima*
Squirting cucumber	*Ecballium elaterium*
St. John's bread	*Ceratonia siliqua*
Subterranean clover	*Trifolium subterranea*
Thyme	*Thymus vulgaris*
Turnip	*Brassica rapa*

AFRICA

Abyssinian banana	*Ensete ventricosum*
Abyssinian oat	*Avena strigosa*
African oil palm	*Elaeis guineensis*
Air-potato	*Dioscorea bulbifera*
Akee	*Blighia sapida*
Bambara groundnut	*Voandzeia subterranea*
Baobab	*Adansonia digitata*
Bean, hyacinth	*Lablab niger*
Black-eyed pea	*Vigna unguiculata*
Bottle gourd	*Lagenaria siceraria*
Bowstring hemp	*Sansieveria trifasciciata*
Butter tree	*Butryospermum paradoxum*
Calabar bean	*Physostigma venenosa*
Castor bean	*Ricinus communis*
Coffee, Arabian	*Coffea arabica*
Coffee, Liberian	*Coffee liberica*
Coffee, robusta	*Coffea canephora*
Cowpea	*Vigna unguiculata*
Date palm	*Phoenix dactylifera*
Elephant grass	*Pennisetum purpureum*
Ensete	*Ensete ventricosum*
Fonio	*Digitaria* spp.
Guinea grass	*Panicum maximum*
Gum arabic	*Acacia senegal*
Hottentot-fig	*Mesembryanthemum edule*
Iboga	*Tabernanthe iboga*
Indigo	*Indigofera tinctoria*
Jaragua grass	*Hyparrhenia rufa*
Kafir-potato	*Plectranthus esculentus*
Karité	*Butryospermum paradoxum*
Kenaf	*Hibiscus cannabinus*
Kikuyu grass	*Pennisetum clandestinum*
Kola nut	*Cola acuminata*
Kola nut	*Cola nitida*
Melegueta pepper	*Aframomum melegueta*
Millet, bulrush	*Pennisetum typhoides*
Millet, finger	*Eleusine coracana*
Millet, Guinea	*Brachiaria deflexa*
Millet, pearl	*Pennisetum glaucum*
Molasses grass	*Melinis minutiflora*
Mongongo nut	*Schinziophyton rautanenii*
Musk melon	*Cucumis melo*
Napier grass	*Pennisetum purpureum*
Natal plum	*Carissa grandiflora*
Oyster nut	*Telfairia* spp.
Periwinkle	*Catharanthus roseus*
Pigeon pea	*Cajanus cajan*
Qat	*Catha edulis*
Rhodes grass	*Chloris gayana*
Rice, African	*Oryza glaberrima*
Sesame	*Sesamum indicum*
Sorghum	*Sorghum bicolor*
Tamarind	*Tamarindus indica*
Teff	*Eragrostis tef*
Tree cotton	*Gossypium arboreum*
Watermelon	*Citrullus lanatus*
Weeping lovegrass	*Eragrostis curvula*

Yam, white	*Dioscorea rotundata*
Yam, yellow	*Dioscorea cayenensis*

NEAR EAST

Alfalfa	*Medicago sativa*
Barley	*Hordeum vulgare*
Cabbage	*Brassica oleracea*
Caraway	*Carum carvi*
Coriander	*Coriandrum sativum*
Cumin	*Cuminum cyminum*
Filbert	*Corylus* spp.
Flax	*Linum usitissimum*
Goat grass	*Aegilops ovata*
Garden pea	*Pisum sativum*
Grape	*Vitis vinifera*
Grass pea	*Lathyrus sativus*
Hazelnut	*Corylus* spp.
Hyacinth	*Hyacinthus orientalis*
Indian lotus	*Nelumbo nucifera*
Leek	*Allium porrum*
Lentil	*Lens culinaris*
Licorice	*Glycyrrhiza glabra*
Melon	*Cucumis melo*
Pea	*Pisum sativum*
Plum	*Prunus domestica*
Pomegranate	*Punica granatum*
Quince	*Cydonia oblonga*
Radish	*Raphanus sativus*
Rye	*Secale cereale*
Safflower	*Carthamus tinctorius*
Sloe berry	*Prunus spinosa*
Teasel	*Dipsacum sylvestris*
Vetch	*Vicia sativa*
Walnut, English	*Juglans regia*
Wheat, bread or common	*Triticum aestivum*
Wheat, durum	*Triticum durum*
Wheat, einkorn	*Triticum monococcum*
Wheat, emmer	*Triticum dicoccum*
Wheat, macaroni	*Triticum durum*

SOUTHEAST ASIA & PACIFIC ISLANDS

Banana, common	*Musa x paradisiaca*
Banana, dwarf	*Musa acuminata*
Bean, mat	*Vigna acontifolia*
Bean, mung	*Phaseolus radiata*
Bean, rice	*Vigna calcarata*
Bean, urd	*Phaseolus mungo*
Bean, winged	*Psophocarpus tetragonolobus*
Betel nut	*Areca catechu*
Betel pepper	*Piper betle*
Bilimbi	*Averrhoa bilimbi*
Breadfruit (breadnut)	*Artocarpus altilis*
Carambola	*Averrhoa carambola*
Cardamon	*Elettaria cardamomum*
Chaulmoogra	*Hydnocarpus kurzii*
Citron	*Citrus medica*
Citronella grass	*Cymbopogon nardus*
Clove	*Eugenia caryophyllus*
Croton oil	*Croton tiglium*
Derris root	*Derris elliptica*
Durian	*Durio zibethinus*
East Indian arrowroot	*Tacca leontopetaloides*
East Indian arrowroot	*Curcuma angustifolia*
Elephant-ear	*Cyrtosperma chamissonis*
Elephant-yam	*Amorphophallus campanulatus*
Emblic	*Phyllanthus emblica*
Galanga	*Alpinia galanga*
Gutta percha	*Palaquium gutta*
Henna	*Lawsonia inermis*
Indian-almond	*Terminalia catappa*
Indian-spinach	*Basella rubra*
Jambos	*Eugenia* spp.
Java-almond	*Canarium commune*
Job's tears	*Coix lacryma-jobi*
Kikuyu	*Aleurites moluccana*
Lemon	*Citrus limon*
Lime	*Citrus aurantiifolia*
Longan	*Nephelium lappaceum*
Mandarin orange	*Citrus reticulata*
Mango	*Mangifera indica*
Mangosteen	*Garcinia mangostana*
Manila hemp	*Musa textilis*
Nutmeg	*Myristica fragrans*
Orange, sour	*Citrus aurantia*
Orange, sweet	*Citrus sinensis*
Pommelo	*Citrus maxima*
Pummelo	*Citrus grandis*
Rambutan	*Nephelium lappaceum*
Rice, common	*Oryza sativa*
Rice, red	*Oryza rufipogon*
Sago-palm	*Metroxylon sagu*
Salak palm	*Salacca zalacca*
Sandalwood	*Santalum album*
Senna	*Cassia angustifolia*
Shaddock	*Citrus maxima*
Sugar cane	*Saccharum officinarum*
Sugar palm	*Arenga pinnata*
Tangerine	*Citrus reticulata*
Taro	*Colocasia esculenta*
Vetiver grass	*Vetiveria zizanioides*
Wax gourd	*Benincasa hispida*
Yam, greater	*Dioscorea alata*
Yam, lesser	*Dioscorea esculenta*
Yam, winged	*Dioscorea alata*

HINDUSTANI

Bermuda grass	*Cynodon dactylon*
Black pepper	*Piper nigrum*
Bo tree	*Ficus religiosa*
Cajan pea	Cajanus cajan
Cardamon	*Elettaria cardamomum*
Cotton, tree	*Gossypium arboreum*
Cucumber	*Cucumis sativus*
Eggplant	*Solanum melongena*
Giant taro	*Alocasia macrorrhizos*
Ginger	*Zingiber officinalis*
Hindu datura	*Datura metel*
Indian clover	*Medicago indicus*
Indian rubber tree	*Ficus elastica*
Indian snakeroot	*Rauvolfia serpentina*
Jack fruit	*Artocarpus heterophyllus*
Jungle-rice	*Echinochloa colona*
Jute	*Corchorus* spp.
Luffa	*Luffa aegyptiaca*
Mango	*Mangifera indica*
Marijuana	*Cannabis sativa*
Mat bean	*Phaseolus acontifolius*
Radish	*Raphanus sativus*
Spiny bamboo	*Bambusa arundinacea*
Strychnine tree	*Strychnos nux-vomica*
Sugar cane, wild	*Saccharum spontaneum*
Sunn hemp	*Crotalaria juncea*
Turmeric	*Curcuma longa*
Urd bean	*Phaseolus mungo*
Vegetable sponge	*Luffa aegyptica*
Watermelon	*Citrullus lanatus*
Zedoary	*Curcuma zedoaria*

CENTRAL ASIA

Alfalfa	*Medicago sativa*
Almond	*Prunus dulcis*
Bread wheat	*Triticum aestivum*
Chick pea	*Cicer arietinum*
Durango root	*Datisca glomerata*
Flax	*Linum usititissimum*
Garlic	*Allium sativum*
Grape	*Vitis vinifera*

Jasmine	*Jasminum officinale*
Mulberry, black	*Morus nigra*
Onion	*Allium cepa*
Opium poppy	*Papaver sominferum*
Pistacio	*Pastacia vera*
Rhubarb	*Rheum x hybridum*
Rye	*Secale cereale*
Tamarisk	*Tamarix gallica*
Tarragon	*Artemisia dracunculus*
Walnut	*Juglans regia*

CHINA & JAPAN

Abutilon-hemp	*Abutilon avicinnae*
Apricot	*Prunus armeniaca*
Bamboo	*Arundinaria* spp.
Bamboo	*Bambusa* spp.
Bamboo	*Phyllostachys* spp.
Barnyard grass	*Echinochloa crus-galli*
Bean, adzuki	*Vigna angularis*
Bean, velvet	*Mucuna pruriens*
Buckwheat, common	*Fagopyrum esculentum*
Buckwheat, Tartar	*Fagopyrum tataricum*
Cabbage, Chinese	*Brassica chinensis*
Camphor	*Cinnamomum camphora*
China berry tree	*Sapium sebiferum*
China-grass	*Boehmeria nivea*
Chinese gooseberry	*Actinidia chinensis*
Chinese quince	*Chaenomeles* spp.
Chinese water-chestnut	*Eleocharis dulcis*
Ginkgo	*Ginkgo biloba*
Ginseng	*Panax ginseng*
Ginseng	*Aralia quinquefolia*
Hazelnut, Chinese	*Corylus* spp.
Hemp	*Cannabis sativa*
Hickory, Chinese	*Carya* spp.
Jujube	*Zizyphus jujuba*
Kudzu vine	*Pueraria montana*
Kumquat	*Fortunella japonica*
Leek, Chinese	*Allium ramosum*
Litchi nut	*Litchi chinensis*
Loquat	*Eriobotrya japonica*
Maidenhair tree	*Ginkgo biloba*
Millet, foxtail	*Setaria italica*
Millet, Japanese	*Echinochloa frumentacea*
Millet, proso	*Panicum miliaceum*
Mulberry, white	*Morus alba*
Onion, Welsh	*Allium fistulosum*
Paper mulberry	*Broussonetia papyrifera*
Peach	*Prunus persica*
Ramie	*Boehmeria nivea*
Rhubarb, Chinese	*Rheum palmatum*
Rice	*Oryza sativa*
Shallion, Chinese	*Allium chinense*
Soybean	*Glycine max*
Tea	*Camellia sinensis*
Timber bamboo	*Phyllostachys bambusoides*
Trifoliate-orange	*Poncirus trifoliata*
Tung oil	*Aleurites fordii*
Turnip	*Brassica rapa*
Varnish tree	*Rhus vernicifera*
Walnut, English	*Juglans regia* ??
Wasabi	*Wasabia japonica*
Water chestnut	*Trapa natans*
Wild rice	*Zizania latifolia*
Yam, Chinese	*Dioscorea esculenta*

AUSTRALIA

Beefwood	*Casuarina equisetifolia*
Eucalyptus	*Eucalyptus* spp.
Fe'i banana	*Musa trogodytarum*
Macadamia nut	*Macadamia integrifolia*
New Zealand flax	*Phormium tenax*
Pituri	*Duboisia hopwoodii*
Tea tree	*Leptospermum laevigatum*
Ti tree	*Cordyline fruticosa*

Did you notice that some centers of diversity are rich in species, while others are less so. Which are in the latter category? Consider the array of plants that we use in this country today. Where are they native?

WAS DOMESTICATION A MISTAKE?

Let's end this topic by pointing out that not everyone is convinced that the domestication of plants and animals has been such a fine thing. How is it possible to hold such a position? Are we not better off now than the people in the Middle Ages? The cavemen? The apes? Jared Diamond (1987) argues the following:

☼ We are now much more dependent upon a few high carbohydrate crops, such as rice and the potato.

☼ We are more susceptible to famine and crop failure.

☼ Studies show an increase in tooth enamel defects associated with malnutrition, an increase in iron-deficiency anemia, an increase in bone lesions, and until recently a decrease in life expectancy.

☼ The population densities that are now possible with agriculture encourage the spread of parasites and infectious disease.

☼ Agriculture led to deep class divisions and accentuated the inequality of the sexes.

ORIGIN VERSUS PRODUCTION ?

As we move through our review of useful plants, you will notice an interesting pattern. The places around the world where we now grow these plants is typically far removed from their ancestral home. At first, this may seem to make little sense. Here are some reasons why we grow the crops where we do:

☼ Better growing conditions;

☼ Competition from weeds, pests, and diseases;

☼ Availability of land;

☼ Cost, supply, and efficiency of labor;

☼ Availability of capital;

☼ Existence and proximity of markets;

☼ Economic/governmental stability;

☼ Government subsidies;

☼ Industrial subsidies;

☼ Role of botanical gardens, experiment stations, etc.;

☼ Role of an individual (botanist, politician, monarch, etc.) in identifying a region.

2.3 • WEEDS: OUR COMPANIONS

"What is a weed? A plant whose virtues have not yet been discovered." (Ralph Waldo Emerson, 1878)

"A weed is more than a flower in disguise."
(James Russell Lowell)

A weeds is "... *a plant which has an innate disposition to get into the wrong place."* (Celia Thaxter, 1894)

"... a weed is a plant out of place."
(Willis Blatchley, 1912)

Weeds are *"wild plants that interfere with human objectives."* (Ellstrand, et al., 1999)

"... the history of weeds is the history of Man."
(Edgar Anderson)

☼ ☼ ☼ ☼ ☼

It might strike you as a little peculiar that a discussion of economically important plants would include weeds. They are of great economic importance, mostly in the negative sense. It is estimated that weeds cost the American farmer several billion dollars each year by reducing both the amount and quality of crops produced. Their damage causes a loss as large as insect injury and disease combined. Another reason for studying weeds is their intimate association with our own species. Many of them are essentially our wards and they would perish without our encouragement.

There are many definitions of a weed. Inherent in most of them is the idea that a plant is a weed if it is growing where we do not wish it to be. The picture of a well-manicured lawn dotted with dandelions comes easily to mind. There are problems with this approach. If I am growing irises, then a rose that appears in my garden is a weed. Bermuda grass is a highly prized lawn grass in much of the southern United States. Elsewhere it tends to live in disturbed areas. Is Bermuda grass a weed?

A good botanical definition of a weed is that of the late Herbert Baker, a botanist at the University of California at Berkeley. A plant is a weed, "... *if, in any specified geographical area, its populations grow entirely or predominately in situations markedly disturbed by man (without, of course, being deliberately cultivated plants).*" Remember that disturbed sites include not only relatively undesirable vacant lots and roadsides, but also our prime agricultural lands. Some weeds invade one or the other; some live in both.

Weeds are such a problem in the agricultural states that there is legislation against them. Many states have weed laws that require the farmer to use varying degrees of control against weedy plants. The "primary noxious weeds" are considered so bad that the land owner is required to destroy them if he discovers them on his property.

THE SYNDROME OF WEEDINESS

There are certain biological features that many weedy plants have. These include:

- ☼ persistence from year to year in an area;
- ☼ ability to reproduce vegetatively, thereby allowing plants to spread quickly and efficiently;
- ☼ ability to germinate in many different environments;
- ☼ producing flowers early in its life cycle;
- ☼ long-lived seed;
- ☼ high seed production;
- ☼ setting seed in a wide variety of conditions;
- ☼ rapid seedling growth;
- ☼ having a "general purpose" set of genes that will enable plants to compete very effectively against native plants when they are competing on disturbed sites;
- ☼ self-pollination or some other asexual means of reproduction;
- ☼ if cross-pollinated, then by wind or some unspecialized insect visitor; and
- ☼ being unpalatable or even toxic to livestock or herbivores.

Can we say anything positive about weeds? Yes, indeed. In ruined and abandoned areas, weeds make up much of the flora. Many of the more attractive plants that city folks see these days are weeds. They also retard or prevent erosion along many of our roadsides.

Why have I linked this subject to domestication?

SOME OF OUR COMMON WEEDS*

Aster	*Aster pilosus*
Barnyard grass	*Echinochloa crus-galli*
Bedstraw (cleavers)	*Galium aparine*
Beggar's ticks	*Bidens* spp.
Bind weed, field	*Convolvulus arvensis*
Bind weed, hedge	*Calystegia sepium*
Bindweed, black	*Polygonum convolvulus*
Black berry	*Rubus allegheniensis*
Black medic	*Medicago lupulina*
Blue grass, annual	*Poa annua*
Bouncing bet	*Saponaria officinalis*
Box elder	*Acer negundo*
Bur cucumber	*Sicyos angulatus*
Burdock	*Arctium minus*
Butter weed	*Packera glabella*
Buttercup, small-flowered	*Ranunculus abortivus*
Butterprint (velvet leaf)	*Abutilon theophrasti*
Carolina cranesbill	*Geranium carolinianum*
Cheat grasses (chesses)	*Brtomus* spp.
Cherry, black	*Prunus serotina*
Chickweed	*Stellaria media*

Chicory	*Cichorium intybus*
Cinquefoil	*Potentilla recta*
Clovers, Japanese	*Kummerowia* spp.
Cocklebur	*Xanthium strumarium*
Confederate daisy	*Helianthus porteri*
Crab grasses	*Digitaria* spp.
Daisy	*Chrysanthemum leucanthemum*
Dandelion	*Taraxacum officinale*
Day flower	*Commelina communis*
Day lily	*Hemerocallis fulva*
Dock, curly	*Rumex crispus*
Dodder	*Cuscuta pentagona*
Elderberry	*Sambucus canadensis*
Evening-primrose	*Oenothera biennis*
False nut sedge	*Cyperus strigosus*
Fireweed	*Erechtites hieracifolia*
Fleabane	*Conyza canadensis*
Fleabane	*Erigeron annuus*
Foxtail grasses	*Setaria* spp.
Gama grass	*Tripsacum dactyloides*
Garlics	*Allium* spp.
Goldenrod	*Solidago canadensis*
Goosefoots	*Chenopodium* spp.
Gout weed	*Aegopodium podagraria*
Grape, frost	*Vitis vulpina*
Ground-cherry	*Physalis philadelphica*
Ground-ivy	*Glechoma hederacea*
Henbit (dead nettle)	*Lamium amplexicaule*
Honey vine	*Cynanchum laeve*
Honeysuckle, Japanese	*Lonicera japonica*
Horse-nettle	*Solanum carolinense*
Indian hemp	*Apocynum cannabinum*
Indian-tobacco	*Lobelia inflata*
Ironweed	*Vernonia gigantea*
Jimson weed	*Datura stramonium*
Johnson grass	*Sorghum halepense*
Knotweed	*Polygonum aviculare*
Mexican tea	*Chenopodium ambrosioides*
Milkweed	*Asclepias syriaca*
Mock-strawberry	*Duchesnia indica*
Moonseed	*Menispermum canadense*
Morning glories	*Ipomaea* spp.
Mulberry, white	*Morus alba*
Mulleins	*Verbascum* spp.
Nightshade, black	*Solanum nigrum*
Pepper-grass	*Lepidium campestre*
Pigweeds	*Amaranthus* spp.
Pineapple weed	*Matricaria discoidea*
Pipe vine	*Aristolochia tomentosa*
Plantains	*Plantago* spp.
Poison ivy	*Toxicodendron radicans*
Poke weed	*Phytolacca americana*
Prickly lettuce	*Lactuca serriola*
Prickly sida	*Sida spinosa*
Privet	*Ligustrum vulgare*
Purslane	*Portulaca oleracea*
Quack grass	*Elymus repens*
Queen Anne's lace	*Daucus carota*
Quick weed	*Galinsoga quadriradiata*
Ragweeds	*Ambrosia* spp.
Rose, multiflora	*Rosa multiflora*
Rye grass	*Lolium perenne*
Sassafras	*Sassafras albidum*
Self-heal	*Prunella vulgaris*
Sheep sorrel	*Rumex acetosella*
Shepherd's purse	*Capsella bursa-pastoris*
Smart weeds	*Polygonum* spp.
Snakeroot, black	*Sanicula canadensis*
Snakeroot, white	*Eupatorium rugosum*
Sow thistles	*Sonchus* spp.
Speedwells	*Veronica* spp.
Spring beauty	*Claytonia virginica*
Spurges	*Euphorbia* spp.
St. John's wort	*Hypericum perforatum*
Star-of-Bethlehem	*Ornithogalum umbellatum*
Sumac, smooth	*Rhus glabra*
Sump weed	*Iva annua*
Sunflower	*Helianthus annuus*
Sweet clover, white	*Melilotus albus*
Sweet clover, yellow	*Melilotus officinalis*
Teasel	*Dipsacus sylvestris*
Thistle	*Cirsium vulgare*
Timothy	*Phleum pratense*
Unicorn plants	*Proboscidea* spp.
Venus's looking glass	*Triodanus perfoliata*
Violet, dooryard	*Viola sororia*
Virginia creeper	*Parthenocissus quinquefolia*
Virginia rock cress	*Sibara virginica*
Whitlow-grass	*Draba verna*
Winter creeper	*Euonymus fortunei*
Winter cress	*Barbarea vulgaris*
Witch grass	*Panicum capillare*
Wood sorrels	*Oxalis* spp.
Yarrow	*Achillea millefolium*

* After Heiser, C. B. 2003. Weeds in my garden. Timber Press. Portland, OR. 247 pp.

SECTION 3 • EXPLORATION FOR PLANTS

3.1 - AN OVERVIEW

☼ We have been exploring for plants in an organized way for about 4000 years.

☼ Sometimes the search for useful or precious plants was the principal justification for a voyage; at other times they were incidental.

☼ The early voyages were not well-documented. Those of Columbus marked a turning point.

☼ Sometimes the expeditions were paid for with private funds; mostly they were sponsored by monarchs or government agencies.

☼ Especially since the 1700's, naturalists and artists were often part of the expedition.

☼ These voyages brought back tens of thousands of scientific specimens, principally to the great botanical research centers in Europe and the United States.

☼ The explorers also brought back critical ethnographic data; the first knowledge that Europeans had of many of the world's peoples.

☼ Exploration continues!

3.2 • THE COLUMBIAN EXCHANGE

"*I simply do not know where to go next. I never tire from looking at such luxurious vegetation, which is so different from ours. I believe there are many plants and many trees that could be worth a lot in Spain for use as dyes, spices, and medicines; but to my great sorrow I do not recognize them.... I am the saddest man in the world for not knowing what kind of things these are because I am very sure that they are valuable. I am bringing a sample of everything I can.*"

(Christopher Columbus)

☼ ☼ ☼ ☼ ☼

Christopher Columbus was not the first person in history to be involved in some aspect of botanical exploration. Hatshepsut [1495-1475 B. C. E.], Queen of Egypt, is often cited as the individual behind the first botanical expedition. She ordered a military party to the Land of Punt to bring back myrrh and other aromatic resins used in religious ceremonies. The Venetian, Marco Polo [1254-1324], explored Asia from 1271 to 1295. His memoirs contain many references to pepper, sesame oil, ginger, nutmeg, cloves, and cassia, and to the production of these spices. He also wrote of how people used various plants, such as flavoring wine with rice and spices.

A little over 500 years ago, Christopher Columbus and 80 or so companions left on a long ocean voyage, and the world has not been the same since. Why did he undertake this great adventure? It was not to prove that the earth was a globe. That had been accepted fact for quite some time. Columbus told his potential sponsors that his voyage had three goals:

(1) to find a water route to the Indies;
(2) to bring back precious materials, including the wealth of the Indies themselves (black pepper, cinnamon, nutmeg, mace, etc.); and
(3) to bring the message of Christianity to the heathen.

Somewhat more privately, he suggested that some of this new found wealth could be used to free Jerusalem.

If we look at how well he accomplished his stated goals, we would have to conclude that Columbus was a failure. He did not find the Indies, although he believed that he had until the day he died. He was not able to bring back caravels filled with precious spices. He did not succeed in bringing the message of his religion to the Indians.

Perhaps we are being too harsh. Was he not the first European to travel to the New World? No! Norsemen visited coastal North America in A. D. 900-1000. There may well have been Polynesian voyages to the Pacific side of South America centuries before Columbus.

If he was not the first, at least he did discover a new world. While it was new to him and to his companions, it was not new to the 60-70 million people who were living there at the time. It had been their home for 10,000-60,000 years. They had built great cities in the Americas when London and Paris were little more than dirty little villages.

Why then do we make so much of a failed mission? The voyage of Columbus was the first documented contact. He kept diaries that we can still consult. So far as we know, he was also the first to return to the New World, a second, third, and fourth time. He was also the first person to lay claim to what he had found. He became "Admiral of the Ocean Sea" and the Viceroy and Governor General of various lands.

The true significance of the voyages of Columbus is that he brought two existing worlds into contact with one another. He initiated communication and exchange -- a two-way movement of people, useful plants and animals, harmful ones, ideas, prejudices, and diseases. This commerce has been called "The Columbian Exchange." His voyages and those who came after him did create a New World.

The log of the Santa Maria for 13 October 1492 gives us the first European reference to tobacco. "*In the middle of the gulf ... I found a man in a canoe carrying a little piece of bread ... a gourd of water ... and some dry leaves which must be a thing very much appreciated among them.*"

Other major New World discoveries included maize (corn), the potato, many new kinds of beans, the peanut, vanilla orchid, chocolate, pineapple, horse, and turkey. The Food and Agriculture Organization of the United Nations cites four principal plants that feed our species: wheat, rice, maize, and the potato -- three cereals and a root crop. Two are of New World origin.

A more complete listing of the two-way traffic that constitutes the Columbian Exchange follows:

FROM THE NEW WORLD TO THE OLD

Cereals:
Maize, wild-rice

Root Crops:
Potato, sweet potato, Jerusalem artichoke, cassava

Vegetables:
Beans (lima, scarlet), squash, pumpkins

Spices/Flavorings:
Peppers, vanilla, pimento, allspice, coriander (cilantro), chocolate

Fruits/Nuts:
Pecan, black walnut, blueberry, cranberry, strawberry, persimmon, cashew, pineapple, guava, papaya, avocado, sunflower

Beverages:
Cacao (chocolate)

Medicinal/Psychoactive:
Quinine, coca, tobacco

Miscellaneous:
Rubber, sugar maple, turkey, slaves, syphilis (?)

FROM THE OLD WORLD TO THE NEW

Cereals:
Wheat, barley, rice, oats, millets (a group of small-grained cereals)

Vegetables:
Cabbage, lettuce, onions, watermelon, soybean, peas, lentils

Spices/Flavorings:
Black pepper, cloves, cinnamon, apple, pear, citrus fruits, olive, banana

Beverages:
Coffee, tea

Medicinal/Psychoactive:
Foxglove, opium, marijuana

Miscellaneous:
Sugar cane, sugar beet, horse, cow, pig, chicken, honeybee, slaves, missionaries, smallpox, diphtheria, measles

3.3 • THE POLYNESIAN EXCHANGE

While much has been made, and justifiably so, of the voyages of Columbus and their consequences, less attention is often paid to the cultural and biological importance of the earlier oceanic explorations made by Asians who traveled to the far outposts of what we now call Polynesia. The spread of these Proto-Polynesians and their plants and animals across thousands of miles and taking thousands of years to complete is one of the great events in human history.

THE POLYNESIAN EXPANSION

B. C. E:

50,000	Australia
40,000	New Guinea
8000	Papua New Guinea (agriculture)
1500	Fiji
1200	Samoa
1200	Tonga, Society & Cook Islands

C. E.

0	Marquesas
500	Easter Island, Hawai'i
1000	Eastern Polynesia
1100	Micronesia
1200	New Zealand

Also intriguing is the possibility of Pre-Columbian visits by Polynesians to South America.

One of the natural laboratories where this story has unfolded is the Hawai'ian Island chain. Consider the plants that we call to mind when someone says "Hawai'i." My guess is that every one on your list was brought there hundreds or thousands of years ago during the waves of colonization. They are often collectively known has the heritage plants. Or to put it another way, none of the plants that most of us associate with Hawai'i is native to the island chain.

HAWAI'IAN HERITAGE PLANTS

Hawai'ian	English Name	Scientific Name
Root Crops:		
Ape	Elephant ear	*Alocasia macrorrhiza*
Hoi	Air-potato	*Dioscorea bulbifera*
Pia	Arrowroot	*Tacca leontopetaloides*
Pi'a	Five-leaved yam	*Dioscorea pentaphylla*
Taro	Taro	*Colocasia esculenta*
Uala	Sweet potato	*Ipomoea batatas*
Uhi	Common yam	*Dioscorea alata*
Spices & Flavorings:		
Ko	Sugar cane	*Saccharum officinarum*
Awapuhi	Shampoo ginger	*Zingiber zerumbet*
Fruits:		
Mai'a	Banana	*Musa* x *paradisiaca*
Niu	Coconut	*Cocos nucifera*
Ohi'a al	Mountain-apple	*Syzgium malaccense*
Ulu	Breadfruit	*Artocarpus altilis*
Cosmetics:		
Tiare	Tahitian gardenia	*Gardenia taitensis*
Industrial:		
Hala	Screwpine	*Pandanus tectorius*
Hau	Hawaiian tree hibiscus	*Hibiscus tiliaceus*
Ipu	Bottle gourd	*Lagenaria siceraria*
Kou	Cordia	*Cordia subcordata*

Kukui	Candle nut	*Aleurites moluccana*
Milo	Pacific rosewood	*Thespesia populnea*
Ohe	Bamboo	*Schizostachyum glaucifolium*
Ti, ki		*Cordyline fruticosa*
Wauke	Paper mulberry	*Broussenetia papyrifera*

Medicinal, Psychoactive, & Toxic:

Auhuhu		*Tephrosia purpurea*
Awa	Kava	*Piper methysticum*
Kamani		*Calophyllum inophyllum*
Noni	Indian-mulberry	*Morinda citrifolia*

3.4 • MORE RECENT EXPLORATION

"The discovery of America, and that of a passage to the East Indies by the Cape of Good Hope, are the two greatest and most important events recorded in the history of mankind." (Adam Smith, 1776)

"Wherever the European had trod, death seems to pursue the aboriginal. We may look to the wide extent of the Americas, Polynesia, the Cape of Good Hope, and Australia, and we find the same result." (Charles Darwin, 1839)

☼ ☼ ☼ ☼ ☼

The brief sketches that follow tell of two kinds of explorers. In many cases, the leader of the expedition had no particular training or interest in botany or natural history. However, the exploring party often included specialists in various areas. Charles Darwin served on the H. M. S. Beagle. Joseph Banks was the naturalist on Captain Cook's first voyage to the South Pacific. Other great expeditions were led by scientists, such as Alexander von Humboldt, for the specific purpose of collecting botanical specimens and making detailed observations. The diaries and field notes of the famous explorers often contained information about useful plants, how they were prepared, their aboriginal names, and other ethnographic data.

Vasco da Gama [1469?-1524], Portuguese navigator. His party of about 170 men on four ships explored the coasts of Africa and India. They were especially interested in locating cloves, pepper, and ginger.

Francisco Pizarro [1470-1541], Spanish conqueror of Peru. The dates of his major activities are 1524-1525, 1526-1527, and 1531-1533.

Ferdinand Magellan [1480-1521], Portuguese navigator and explorer. Of particular interest is his voyage to the Spice Islands from 1519-1522.

Hernán Cortés [1485-1547], Spanish conqueror of Mexico (1519-1521).

Francisco de Orellano [1490-1546], Spanish explorer of the Amazon (1541-1542) and usually cited as the first man to go down the Amazon River. Gaspar de Carvajal kept detailed diaries. He wrote of a race of tall, white, naked warrior women who used the bow and arrow much better than did the male Indians. He called them Amazons. A second voyage occurred in 1545-1546.

Jacques Cartier [1491-1557], French explorer. His three voyages (1534-1542) provided an early inventory of the natural products of the New World.

Francisco Hernandez [1515-1578], Spanish physician and natural historian. His work was compiled into 16 folio-sized volumes that were sent to King Philip II. He deposited them in the library at the Escorial. A terrible fire would later destroy most of Hernandez's work.

Jan Pieterszoon Coen [1587-1629], Dutch explorer. He sailed to the Spice Islands, where he attempted to control the sales of cloves, nutmeg, and pepper.

Abel Tasman [1602-1659], Dutch navigator and explorer (1642-1643; 1644) of the South Pacific. He discovered New Zealand and Van Damien's Land, now known to us as Tasmania.

Louis-Antoine de Bougainville [1729-1811], French navigator and explorer who was commissioned by the French to circumnavigate the globe (1766-1769) on the La Boudeuse and the L'Etoile (storeship). He explored Tahiti, Samoa, New Hebrides, Falklands, Great Barrier Reef, New Guinea, and Pitcairn Island. The popular ornamental *Bougainvillea* is named in his honor.

James Cook [1728-1779], English navigator and explorer. First voyage: 1768 to 1771 on H. M. Bark Endeavour. The crew consisted of 71 navy, 12 marines, and 11 civilians. In the party were the botanists Joseph Banks and Daniel Solander, and the artist (botanical draughtsman) Sydney Parkinson. Second voyage: 1772 to 1775 on H. M. S. Resolution and H. M. S. Adventure. George Vancouver and William Bligh were on board. The artists were Johann Forster and his son George. Third voyage: 1776 to 1779 on H. M. S. Resolution and H. M. S. Discovery. George Vancouver and William Bligh on board. The naturalist was William Anderson and the artist was John Webber. Cook was killed in Hawai'i on 14 February 1779.

Timeline: James Cook

1728	Born in Marton-on-Cleveland, England
1755	Joins Royal Navy
1759	Made ship's master
1768	First voyage (to 1771)
1772	Second voyage (to 1775)
1776	Awarded Copley Medal by Royal Society
1776	Third voyage (to 1780)
1779	Dies at Kealakekua Bay, Hawai"i

Charles Marie de la Condamine [1701-1774], French aristocrat and scientist. Commissioned by Louis XV, his was the first scientific expedition to South America (1735-1745). The party of ten consisted of an astronomer, a mathematician, a medical doctor, an artist, and a botanist (Joseph de Jussieu). The principal reason for the trip to South America was to settle an argument between the French and the English as to the shape of the Earth. Newton had argued that our planet was flattened at the poles; Cassini that it was flattened at the equator. While there the party discovered a rubber latex tree, brought out samples of the fever bark tree (later to be named *Quinaquina condamine*), and platinum. When de Jussieu's botanical specimens were lost at sea, he went insane and had to be put away.

Joseph Banks [1743-1820], English botanist, explorer, and long time President of the Royal

Society. Sir Joseph sailed with Cook on the Endeavour, but refused to go on the second voyage to the Pacific because the ship would not be modified to meet his needs. It was Banks who recommended to King George III that William Bligh be sent to Tahiti for breadfruit, and who named Botany Bay in Australia. The genus *Banksia* of Australia is named in his honor.

Friedrich Wilhelm Heinrich Alexander, Baron von Humboldt [1769-1859], Prussian scientist and explorer of Central and South America (1799-1804). The Baron has been described as the "last great universal man." Darwin called him "the greatest scientific traveler who ever lived." As to his mission, von Humboldt said "*I shall make collections of fossils and plants. I intend to institute chemical analysis of the atmosphere and I shall make astronomical observations. My attention will be ever directed to observing harmony among the forces of nature....*" Intense! He and Aimée Bonpland (1773-1858) traveled about 40,000 miles, made 1500 measurements, collected about 60,000 plant specimens in South America and they were the first Europeans to observe the preparation of the curare arrow poisons. He also investigated the connection between the Amazon and the Orinoco rivers and discovered the ocean current that bears his name.

After leaving Central America, the Baron had dinner one evening in Washington, D. C. with another man very much interested in natural history – President Thomas Jefferson! Once back in Europe, von Humboldt spent 23 years preparing the manuscript of his 29 volume narrative!

Samuel Wallis [1728-1795], English navigator and explorer (1766-1768). Sailing on H. M. S. Dolphin, he discovered Tahiti in 1767, naming it King George the Third's Island.

André Michaux [1746-1803], French botanist. He concentrated on eastern North America, sending back some 5000 tree seedlings and thousands of seed packets to Versailles. Michaux delivered gifts of seeds from Lafayette to Washington. He would die of a fever in Madagascar.

William Bligh [1754-1817], English navigator. Bligh was sent by George III to transport breadfruit from Tahiti to England. First voyage: 1787-1789 ("Operation Breadfruit") on H. M. S. Bounty. The botanist was David Nelson. The famous mutiny occurred on 28 April 1789. Nelson sided with Captain Bligh. We botanists are establishment people. A second voyage in 1791 on H. M. S. Providence successfully transported the breadfruit plants back to England. Bligh explored Tahiti, Tasmania, and Fiji. He rose to the rank of Vice Admiral in the Royal Navy and was later appointed Governor of New South Wales in Australia. An edible and toxic fruit tree, *Blighia sapida*, is named in his honor.

Hipolito Ruiz Lopez [1754-1816] and **Antonio Pavon y Jimenez [1754-1840]**, Spanish explorers in South America. They are known in the botanical literature as Ruiz and Pavon. Trained as pharmacists, they collected 55 cases of specimens of economic plants and would coauthor the "Flora Peruviana et Chilensis." A fire destroyed much of their material. Ruiz once complained that he had suffered from "*... heat, fatigue, hunger, thirst, nakedness, want, storms, earthquakes, plague of mosquitos and other insects, continuous danger of being devoured by jaguars, bears and other wild beasts, traps of thieves and disloyal Indians, treason of slaves, falls from precipices and the branches of towering trees, fording of rivers and torrents... and the most touching of all, the loss of manuscripts.*"

Mathew Flinders [1774-1814], English navigator and explorer. He served with Bligh on a second voyage to the Society Islands (1801-1803). Robert Brown, a leading English botanist, accompanied him on his exploration of the coasts of Australia. The artist was Ferdinand Bauer.

Meriwether Lewis [1774-1809], personal secretary to President Thomas Jefferson and American explorer, and **William Clark [1770-1838]**, U. S. soldier and explorer. The Lewis & Clark Expedition (1804-1806) had as its primary goal the discovery of a waterway from the Mississippi River to the Pacific coast. Other, less publicized, objectives were more commercial and military, including finding the best farmland for future settlers in the West. Along the way, the party of 48 collected plant, animal, and geological specimens, and Native American artifacts. Daniel Boone was asked to go along, but he declined. The early plant collections were sent back to Thomas Jefferson, who sorted them. In the Bitterroot Mtns., Lewis found the the plant that was later named after him (*Lewisia rediviva*). The genus *Clarkia*, of the evening-primrose family, commemorates William Clark.

J. S. C. Dumont d'Urville [1790-1842], French naval officer and explorer of the South Pacific and Antarctic (1826-1829; 1837-1840).

George Vancouver [1757-1798], English navigator of the Pacific coast of North America and of the South Pacific (1791; 1792-1794). Dr. Archibald Menzies served as the naturalist. He was the first European to collect the coast redwood and to find the madrone tree (*Arbutus menziesii*). *Vancouveria*, a member of the barberry family, is named after him.

Zebulon M. Pike [1779-1813], American explorer of the headwaters of the Mississippi, Arkansas and Red Rivers, and of the American Southwest (1805; 1806-1807).

Jedediah Smith [1798-1831], American explorer of the Great Basin, Great Salt Lake, California and Oregon (1826-1829).

Charles Wilkes [1798-1877], Rear admiral in the United States Navy. He headed the U. S. Exploring Expedition of 1838-1842. The botanists were William Brackenridge and William Rich. The party visited 280 islands and collected 50,000 botanical specimens. The botanical work of the expedition was published by Asa Gray of Harvard Univ. *Wilkesia gymnoxiphium*, a silver-sword relative known only from Hawai'i, is named after the admiral. It was also on this expedition that *Darlingtonia californica*, the California pitcher plant or cobra-lily, was first collected.

Stephen Harriman Long [1784-1864], American Army officer and explorer of the Great Plains of North America (1820).

Thomas Nuttall [1786-1859], English naturalist who explored the Ozarks, Arkansas River, Hawaii, and California. He was one of the founders of the Philadelphia Academy of Natural Sciences. Most of Nuttall's botanical discoveries were "appropriated" and published by Frederick Pursh. After botanizing in the San Diego area, Nuttall returned to the East

Coast on the Pilgrim, accompanied by one of his former students, Richard Henry Dana. Who was Dana?

David Douglas [1799-1834], indefatigable Scottish collector, especially of horticulturally important plants. By the time he was 28, Douglas had been elected to the Linnean Society, the Zoological Society, and the Geological Society in England. His specimens are deposited at the Natural History Museum in London. Douglas was the first European to collect the California laurel, the sugar pine, chinquapin, Ponderosa pine, and the Douglas-fir. He died under mysterious circumstances, presumably being killed by a wild bull in a pit in Hawai'i.

Charles Darwin [1808-1882], English naturalist and explorer. He served as the naturalist on H. M. S. Beagle (1831-1836), under the command of Robert FitzRoy. Darwin made numerous collections and observations while exploring South America, Galapagos, Tahiti, New Zealand, and Australia.

David Livingston [1813-1873], Scottish missionary and explorer of Africa (1849-52; 1853-56; 1858-64; 1866-71; 1871-73). He became an expert on African arrow poisons.

John Charles Frémont [1813-1890], American soldier, politician, map-maker and explorer (1842; 1843-44; 1845-46) of the Mississippi and Missouri Rivers, and of California. *Fremontodendron*, a California shrub, is named after him.

Richard Spruce [1817-1893], English explorer of South America. He was commissioned by the English government *"to procure seeds and plants of the red bark tree, which contains the chemical ingredient known as quinine."* He went on to collect 30,000 botanical specimens in South America and become one of England's best known field botanists. The spruce tree is not named for him, nor vice versa. Spruce died in obscurity on a tiny government pension.

Alfred Russel Wallace [1823-1913], English naturalist and explorer of South America (1848-1852). In addition to his explorations, Wallace is also credited with originating a theory of evolution similar to the one proposed by Darwin.

John Wesley Powell [1834-1902], American geologist and ethnologist who explored the Rocky Mountains (1869-1879).

Ernest Henry Wilson [1876-1930], an English botanist who became known as "Chinese Wilson" because of his collecting trips to that country. He died, along with his wife, in an automobile accident in the United States.

Frank Kingdon-Ward [1885-1958], English botanist and avid collector in China, Burma, and Tibet. His first job was as a teacher in Shanghai, where he fell in love with the country.

Richard Evans Schultes [1915-2001], American botanist and explorer of South America. He was Director Emeritus of the Botanical Museum at Harvard University. Schultes was the modern day equivalent of Darwin and Wallace. His many expeditions focused on Pará rubber, quinine, and the psychoactive, medicinal, and toxic plants of the New World tropics. See Davis (1996) for an excellent biography.

SECTION 4 • TWO MODERN REVOLUTIONS

4.1 • AN OVERVIEW

- ☼ The first great agricultural revolution occurred thousands of years ago when humans began cultivating and later domesticating plants. Those processes continue.
- ☼ After a few millennia, our understanding of plants had progressed to the point where we had developed two important techniques – grafting and crossing of closely related plants to yield hybrids that combined desirable traits.
- ☼ Two highly significant advances occurred in the 20th century. The Green Revolution and genetic engineering can be thought of as second and third agricultural revolutions.
- ☼ Both are based on recent advances in genetics and technology.
- ☼ Both have already demonstrated great successes in increasing the world's food supplies and the quality of plant resources available to us.
- ☼ The Green Revolution has also been called the "Revolution That Failed" and has been criticized for its negative economic impact, especially in the Third World.
- ☼ Genetic manipulation of plants remains very controversial, with critics expressing concerns about the effects of genetically engineered organisms on the human body, on nutritional quality of foods, and on the environment.

4.2 • THE GREEN REVOLUTION

"It is as if man had been appointed managing director of the biggest business of all, the business of evolution... whether he is conscious of what he is doing or not, he is in point of fact determining the future direction of evolution on this earth. That is his inescapable destiny, and the sooner he realizes it and starts believing in it, the better for all concerned."[Sir Julian Huxley, 1957]

"We are now in a position where we must not only manage our crop plants, our domestic animals, our fisheries, out forests and range lands, but the whole globe is in our care, ready or not, competent or not. We are affecting the atmosphere, the oceans, the forests, rainforests, deserts, and even the climate. We are woefully unprepared for this awesome responsibility. This is an age of great knowledge and little wisdom, but we have no choice; we must blunder on. Who is in charge here? God help us, amen." [Jack Harlan, 1992]

"Twenty-seven years ago, in my acceptance speech for the Nobel Peace Prize, I said that the Green Revolution had won a temporary success in man's war against hunger, which if fully implemented, could provide sufficient food for human-kind through to the end of the 20th century. But I warned that unless the frightening power of human reproduction was curbed, the success of the Green Revolution would only be ephemeral.... The more pertinent question today is whether farmers and ranchers will be permitted to use this new technology. Extremists in the environmental movement from the rich nations seem to be doing everything they can to stop scientific progress in its tracks."

[Norman Borlaugh in a 1997 address]

TIMELINE: GREEN REVOLUTION

1839	U. S. begins to collect plant germplasm
1873	U. S. Commissioner of Agriculture sees dwarf wheat
1898	Section of Seed & Plant Introduction established in U. S. D. A.
1917	Japanese develop dwarf wheat (Norin 10)
1926	Henry A. Wallace founds Hi-Bred Corn Co.
1936	U. S. D. A. warns of genetic uniformity of crops
1940	Henry Wallace visits Mexico
1943	Office of Special Studies established
1944	Norman Borlaug joins wheat research project
1949	Borlaug develops 4 new rust-resistant cvs.
1954	High-yielding varieties (HYVs) of wheat developed
1958	IRRI established in The Philippines
1959	National Seed Storage Laboratory established
1961	Cytoplasmic sterile wheat developed
1964	High lysine maize developed
1966	CIMMYT established in Mexico
1966	"Miracle rice" (IR8) released
1969	Robert S. McNamara urges financial support for network of research centers CGIAR)
1970	Borlaug wins Nobel Peace Prize
1970	Southern leaf blight hits U. S. maize crop ($1B!)

☼ ☼ ☼ ☼ ☼

The genetic manipulation of plants and of animals is a fairly recent development. After all, the field of genetics is only about a century old. Gregor Mendel's work on garden peas was published in 1866 in a relatively obscure journal. It was rediscovered in 1900. A few years later, the terms "gene" and "genetics" were first used. This does not mean, however, that our attempts to control and to take advantage of desired traits in plants is also something relatively new. **Grafting** is an ancient technique used to combine the tissues of two or more plants. The plant that provides the root system and lower portion of the stem is called the **stock**; the new section of plant that is added to the stock is called the **scion**. The interaction between the different genetic systems can influence the appearance of the plant (e. g. yield a dwarf fruit tree), affect its hardiness, or modify its resistance to disease. Unlike higher animals, plants have not developed the antibody mechanisms that can lead to tissue rejection. However, if the stock and scion are too structurally and physiologically different, graft incompatibility may occur. Grafting of fruit trees is very common. On your next Napa Valley winery tour, look carefully at the grape vines. You will see where European grape vines have been grafted on to American stocks.

Long before we understood the rudiments of genetics, we had discovered the advantages of cross-breeding or **hybridization**. We learned by trial and error that we could take the pollen from one plant that had its particular set of desirable features and place it on the stigmas of another plant that had features that also suited us. The object of all of this was to produce offspring that combined the desirable features of the two plants. We soon discovered that only closely related plants could be crossed or hybridized -- wheat with barley, but not wheat with rice. In nature, it is the wind, or insects, birds, bees, water, etc. that carries the pollen from one plant to another. The techniques of hybridization require that we control pollen transfer to make certain that it is only the pollen that we want that finds its way on to the stigmatic surface of another flower. We emasculate flowers to prevent self-pollination. We hide flowers behind netting or enclose them in bags to prevent pollinators or the wind from effecting cross-pollination. When we are the agent of pollination, we use little brushes, sticks, or our fingers to dab pollen on receptive stigmas. Then we cover up the flowers to prevent further, natural pollination from occurring. Many of our best known crop plants are the result of many generations of hybridizations and are themselves very complex hybrids that combine the genetic heritage of many different plant varieties.

A quiet agricultural revolution began in the 1930's. Plant breeders in this country and elsewhere in the world perfected the techniques needed to increase dramatically the yield of several of our most important crops, especially cereal grains. The effort was an attempt to provide higher crop yields to feed an ever increasing human population. The technology itself was then made available to the governments in developing countries where the need was acute. In 1943, the Rockefeller Foundation and the Mexican government established the Centro Internacional de Mejoramiento de Maiz y Trigo (International Center for the Improvement of Maize and Wheat).

Several decades later this massive program of crop improvement has become known as the "Green Revolution." Sugar cane, maize, wheat, rice and the soy bean have been the major players. Yields per hectare (1 hectare = 2.471 acres) in the United States increased dramatically: wheat (115%), rice (117%), maize (320%), sugar cane (141%), peanut (295%), soybeans (112%), cotton (188%), and the potato (311%).

If we were to single out a particular crop and a particular person as the "stars" of the Green Revolution, they would be wheat and Norman Borlaug. By 1954, he had developed high-yielding varieties (HYV) of wheat, semi-dwarf forms with immense yields of grain. These cultivars were also more resistant to fungal attacks and had stems better able to bear up under heavy applications of fertilizers without falling over (lodging) in wind or rain. Mexico, which had been able to meet only 1/3 of its needs for wheat, then became an exporter. Similar success was seen in India. In recognition of his efforts, Norman Borlaug received the Nobel Peace Prize in 1970. The Nobel Committee cited his technological advances that would make "... it possible to abolish hunger in the developing countries in the course of a few years." Unfortunately, this would not be the case.

The Ford and Rockefeller Foundations sponsored the International Rice Research Institute in Los Banos, The Philippines. New strains matured earlier, had more than one crop per year, and had more grains per head.

PLANT GERMPLASM CENTERS

A series of agricultural research centers now exists around the world. They are involved in the continuing process of crop improvement and of preserving different genetic strains of particular plants. These units are called germplasm centers because they store samples of the hereditary material – the chromosomes and genes – of various crop plants. The ones that are devoted to plant investigations are listed below.

CIAT (Centro Internacional de Agricultura) in Cali, Colombia. Beans, cassava, rice, and tropical pasture plants.
CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo) in Londres, Mexico. Wheat, maize, and triticale.
CIP (Centro Internacional de la Papa) in Lima, Peru. Sweet potatoes.
IBPGR (International Board for Plant Genetic Resources) in Rome, Italy. A wide variety of useful plants.
ICARDA (International Centre for Agricultural Research in Dry Areas) in Aleppo, Syria. Barley, lentil, faba bean, durum wheat, bread wheat, and chickpeas.
ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). Sorghum, millet, chickpea, pigeon pea, and groundnut.
IITA (International Institute of Tropical Agriculture) in Ibaden, Nigeria. Cassava, maize, plantain, cowpea, soy bean, rice, and yams.
IRRI (International Rice Research Institute) in Manila, The Phillipines. Rice.
WARDA (West African Rice Development Association) in the Cote d'Ivoire. Rice.

SEED BANKS

The need to maintain a collection of germplasm of our crops and their wild ancestors is not a new idea. N. I. Vavilov established a collection of seed samples in his laboratory in St. Petersburg, then called Leningrad. It still exists. Hundreds of thousands of samples gathered on various expeditions around the world were stored there. Today we call such collections **seed banks**. We have 19 seed banks in this country that collectively form the National Plant Germplasm System. The main facility is in Fort Collins, Colorado. The various international research centers listed earlier in this section perform a similar function. To a much more limited extent, certain of our larger botanical gardens also preserve some of this genetic heritage.

THE REVOLUTION THAT FAILED?

"In most developing nations, food is still grown mainly with traditional methods; even where appropriate, the green revolution and its yield-boosting inputs are largely unaffordable or unavailable to subsistence farmers."

[Anne & Paul Ehrlich, 1987]

Even the most enthusiastic supporters of the Green Revolution admit that it has not been an unqualified success. Its harsher critics label it as a major failure. What has cast such a pall over the early optimism?

To begin with, these high yield varieties require a great deal of tender, loving care -- more water, more fertilizer, more pesticides, and more equipment to plant and to harvest them. The newer fertilizers may require two or three times more nitrogen and phosphorus. There has been a three fold increase in the use of pesticides, leading to environmental pollution. Much more irrigation water is required. Massive irrigation projects may be needed. Aquifers, underground water supplies, become depleted. The machinery needed for harvesting crops is technologically advanced and expensive. Developing countries often find themselves deeply in debt to pay for the seed, fertilizer, equipment, etc.

The new cultivars are in some ways nutritionally inferior to those planted before the Green Revolution. The protein content of Kansas wheat declined by 44.7% in the period 1940-1969. Prehybrid maize had 82% more crude protein; 37% more copper; 113% more manganese than current hybrids. In rice, protein content is down from 9-10% to 7-8%. The appearance and taste of bread and other products made from the new cultivars was sometimes disappointing.

The Green Revolution has also favored the practice of **monoculture**, the growing of a single strain of a particular crop year after year, and often over large expanses of farm land. As our plant breeding techniques improved, it was possible to plant seed of these new high yielding strains that produced genetic carbon copies of one another. It was wonderful! The plants all looked alike, came into flower and fruit at the same time, could be harvested at the same time, and they all had the same set of desirable features. This all sounds very positive.

Our increasing reliance on the monoculturing of high yield varieties is dangerous. As the 21st century begins, we find ourselves dependent upon a handful of cultivars for each of our major crops. As Levitin & McMahon (1996) point out, in the United States half our wheat crop is derived from only nine cultivars; 4 cvs. of potato account for 75% of the crop; 3 cvs. yield half of our cotton crop. In this country, we no longer grow about 90% of the different varieties of crops that we grew before the Green Revolution. This means that the genetic variability that was stored away in those thousands upon thousands of cultivars is lost to us.

If we have these spiffy high-yielding varieties, why are we concerned about losing the genes in these cultivars that we are not growing because they are inferior to the HYV's? Because these traditional varieties or **land races**, as they are sometimes called, are the reservoirs of the genetic heritage of the new strains. They are the source of the **germplasm**, the library of the genetic codes needed by plant breeders to maintain, to modify, and to create new strains of these critical crops. Some of the first high yield cultivars of the Green Revolution, such as IR-8 rice, have already shown signs of genetic deterioration. Only an infusion of genes from the very cultivars that they were to replace can save them.

What if something happens to these cultivars? The very genetic uniformity that makes them so useful to us also makes them potentially vulnerable to disaster. If one plant of a particular cultivar is susceptible to a fungal pest, then all of them will be. They are genetically identical. This is not simply a theoretical concern. It has happened. In the 1840's, the potato crop in Ireland was decimated by a fungus, the late blight of potato. In 1892, coffee rust, another fungal infection, wiped out the plantations in Ceylon. The maize varieties in this country that contained the gene for cytoplasmic male sterility were hit badly by the corn leaf blight in 1970. A bacterial infection of citrus trees in Florida killed millions of trees. New resistant cultivars were needed. Where do plant breeders go for the genes they need? To the germplasm reservoir stored in the land races.

SUSTAINABLE AGRICULTURE

Modern agriculture has tended to substitute: (1) continual culture of a single crop for crop rotation and diversification; (2) herbicides and pesticides for biological control; (3) inorganic fertilizers that must be purchased, rather than organic ones or green manure; and (4) larger agricultural fields in place of smaller family farms.

The perils are obvious. What do we do? One solution has been called "organic farming," "alternative agriculture," or "sustainable agriculture." The basic principle underlying this approach is that a plot of land has to be seen as a small ecosystem, not as a factory. It is an ecosystem that must be maintained in balance.

The techniques include:

- switch from monoculture to polyculture;
- switch from annual to perennial crops;
- crop rotation;
- biological pest control;
- working the soil to minimize erosion;
- use of animal manure and green manure; and
- control weeds and disease.

Plant breeders are now developing perennial forms of sorghum by crossing the annual (*Sorghum bicolor*) with the common Johnson grass (*S. halepense*), a perennial weed. Similar efforts may produce a new form of maize by crossing the annual crop (*Zea mays*) with a recently discovered perennial, wild teosinte (*Zea diploperennis*).

Sustainable agriculture sounds like a return to the techniques of long ago, but it is much more than that. For a farm to be sustainable it must produce adequate amounts of high-quality food, it must be environmentally safe, and it may even turn a profit. Such enterprises must minimize what they purchase externally and rely upon the renewable resources of the farm itself. About 90% of the farms that practice these alternative methods are in poorer parts of world.

4.3 • GENETIC ENGINEERING

"*For I have heard it said there is an art which ... shares with great creating nature.... Yet nature is made better by no mean but nature makes that mean: so, over that art, which you say adds to nature, is an art that nature makes.... [T]his is an art which does mend nature, change it rather, but the art is nature.... Then make your garden rich ... and do not call them bastards.*" [Pilixenes and Perdita discussing the crossing of flowers in her garden.

William Shakespeare. The winter's tale, 4:4]

"... in the near future man will be able, by means of crossing, to synthesize forms such as are absolutely unknown in nature." [N. I. Vavilov]

"We, the undersigned delegates of African countries participating in the 5th Extraordinary Session of the Commission on Genetic Resources ... strongly object that the image of the poor and hungry from our countries is being used by giant multinational corporations to push a technology that is neither safe, environmentally friendly, nor economically beneficial to us."
[Representatives of 19 African countries]

"*I personally have no wish to eat anything produced by genetic modification, nor do I knowingly offer this sort of produce to my family or guests.*"
[Charles, Prince of Wales]

To which James Watson, Nobel laureate, responded, "*The Crown Prince is a twit!*"

"*Will 'Frankenfoods' feed the world? Biotech is not a panacea, but it does promise to transform agriculture in many developing countries. If that promise is not fulfilled, the real losers will be their people, who could suffer for years to come.*"
[Bill Gates, Chairman of Microsoft]

TIMELINE: DISCOVERIES IN GENETICS

1580	Prospero Alpino shows plants have two sexes
1590	Hans & Zacharias Janssen invent compound microscope
1655	Robert Hook determines structure of cork; coins "cell"
1716	Cotton Mather demonstrates hybridization in maize
1763	Josef Kohlreuter discovers pollination
1782	Nehemiah Grew discovers function of stamens and pistils
1830	Robert Brown describes cell nucleus
1838	Schleiden & Schwann propose "Cell Theory"
1856	Nathaniel Pringsheim discovers fertilization
1858	Remak & Virchow propose that cells arise from cells
1865	Gregor Mendel publishes results of garden pea experiments
1868	Von Sacks & Pringsheim discover plastids
1870	Friederich Meischer discovers DNA
1876	Eduard Strasburger discovers mitosis
1883	Edouard J. L.-M. von Beneden discovers meiosis
1888	Hugo de Vries proposes mutation theory
1900	De Vries, Corren, & Tschermak find Mendel's paper
1902	Fischer & Hofmeister discover proteins made of amino acids
1903	Sutton & Boveri show chromosomes carry hereditary material
1905	Wilhelm Johannsen coins "gene," "genotype," and "phenotype"
1906	William Bateson coins "genetics"
1909	Aaron Levene discovers RNA
1909	Carl Correns discovers cytoplasmic inheritance
1910	T. H. Morgan postulates specific genes on specific chromosomes
1911	Arthur Sturtevant prepares first chromosome map
1921	T. H. Morgan proposes chromosome theory of heredity
1937	Pierre Givaudon uses colchicine to double chromosome number
1941	Beadle & Tatum propose "one gene - one enzyme" hypothesis
1944	Avery, McLeod, & McCarty show DNA is basis of heredity
1946	Delbrück & Hershey discover recombinant DNA
1947	Congress passes Insecticide, Fungicide, & Rodenticide Act
1948	Alfred Mirsky finds RNA in chromosomes
1953	Watson & Crick publish molecular structure of nucleic acids
1954	George Gamow proposes that genetic code is nucleotide triplet
1960	Georges Morel clones cultured cells
1969	Beckwith isolates single gene
1973	Cohen & Boyer recombine/duplicate DNA from 2 species
1975	Schell & Van Montagu find crown gall genes occur on plasmids
1976	Khorana inserts artificial gene into bacterium
1976	Genetech founded
1981	Whitely & Schnepf find gene in Bt that kills insects
1982	Binding & Gressel develop protoplast fusion
1983	Barbara McClintock wins Nobel Prize for "jumping genes"
1983	Murray & Szostak construct first artificial chromosome
1987	First genetically-altered bacterium released into environment
1988	Carol Rhodes inserts foreign gene into maize
1992	Transgenic cotton patented
1992	192 countries sign Convention on Biodiversity
1995	U. S. D. A. deregulates Bt potato
1995	E. P. A. approves sale of Monsanto's Russet Burbank Bt potato
1998	Delta & Pine Land Co. & USDA patent "terminator gene"
1999	British Medical Association questions safety of GM foods
1999	John Losey finds toxicity of Bt corn pollen to butterflies

THE TECHNIQUES: OLD AND NEW

It is impossible, using the time-honored techniques of cross-breeding to select specifically for the particular trait(s) that you desire. The pollen grains had in them not only the genes for the desirable feature, but many others as well. We may not want them. The techniques were also laborious and time consuming. What plant breeders wanted was the ability to produce offspring that combined specific traits. Once our understanding of basic genetics was in place, we began to realize that someday we ought to be able to control reproduction in plants -- to produce carbon copies of plants that had we found useful to us or to transfer specific genes from one plant to another. We now have a series of new techniques at our disposal to accomplish exactly those goals.

CLONING. The term comes from the Greek word for twig. In this procedure, we use individual cells from a plant with desirable features to produce whole plants with the those traits. These are the "twigs" of the parent plant. The process involves:

Removing tissue from plant
▽
Separating cells from one another
▽
Dissolving cell walls
▽

Putting cells in nutrient solution
∇
Cells clumping together to form callus tissue
∇
Nurturing callus tissue into adult plants

PROTOPLAST FUSION. The cell membrane and all that is inside it is a **protoplast**. In protoplast fusion, we create new forms by combining cells from different plants and then regenerating a hybrid from the fused cells. The result is a **somatic hybrid**. Protoplast fusion occurs naturally or it can be induced by treatment with electrical shock or with certain chemicals, such as polyethylene glycol. One gram of plant tissue may contain as many as 4 million protoplasts that are capable of maturing into adult plants, either one their own or after being fused with other cells. Sometimes the results are a disappointment. The "pomato" is a somatic hybrid of the potato and tomato. It produces both tomato fruits and potato tubers, but both are small and its seed is inferior. On the other hand, when a potato protoplast was fused with one from a triazine-resistant black nightshade (both members of the genus *Solanum*), the somatic hybrid could be grown in soil that had been treated with triazine -- a potent herbicide.

Crops that have been regenerated through protoplast fusion include citrus, the sunflower, cassava, clover, millets, cabbage, and asparagus.

GENETIC ENGINEERING. The most recent and most controversial technique goes by a variety of names, such as genetic engineering, gene splicing, and biotechnology. This highly advanced technology allows us to alter the genetic makeup of plants by introducing single genes from the nucleus of one plant into the nucleus of another. The "host plant" then reproduces new cells that contain the genes that have been transferred into its nuclei. The new forms are often called **transgenic organisms**, or **genetically modified** or **genetically manipulated organisms**. In the popular press, they are often called "GM" plants and animals, or "GMO's."

The process is easy to describe, but it requires rather sophisticated techniques.

Identify desired gene and its location
∇
Isolate gene using restriction enzymes
∇
Insert gene into new host plant
∇
Activate gene in host DNA
∇
Desirable feature appears

First, you must identify the desired gene and its location. Then you isolate the gene and remove it from the donor plant by using enzymes that cut a chromosome at a specific spot. Finally, you must transfer the gene into the host plant. This is accomplished by plucking out the gene with a pair of little tiny tweezers and carrying it across the laboratory to the host plant, hoping that you don't sneeze or stumble or drop the gene on the floor. Well, not exactly.

In most cases, the transfer of the gene is accomplished by using *Agrobacterium tumefaciens*, the soil bacterium that causes crown gall disease in various crop plants. This bacterium has the ability to penetrate host cell nuclei and to introduce fragments of its own DNA, called **plasmids**. The genetic code of the plasmid then instructs the host plant to produce excess hormones. This results in the growth of tumor tissue, the crown gall. The bacterium itself finds this tissue to be a suitable home. These days, we take advantage of the bacterial plasmid by using it as the vector or carrier of the genetic material that we want to transfer from one plant to another. In the laboratory, we culture in a petri dish bacteria that have had the desired gene inserted into their DNA. The bacteria infect pieces of tissue from the host plant -- the one that will be the recipient of the gene. The host cells are now **transformed** or we say that **transformation** has occurred. By the way, the bacterial plasmids have been "disarmed" genetically so that they will not cause the crown gall tumor tissues to form, as they do in nature. The transformed host tissues are then moved to a new growth medium that kills off the bacteria and that induces the formation of callus tissue, shoots, and eventually a whole new plant.

Common examples of crops plants that have been transformed and regenerated by this technique include maize, rice, wheat, barley, rye, cotton, flax, soybean, sunflower, beans, peas, lettuce, potatoes, sugar beet, tobacco, tomato, apples, and walnuts.

Even newer procedures involve injecting genes into a nucleus using microscopic needles and shooting DNA-coated pellets fired into host tissues with DNA particle guns. The latter is the technique favored by the National Rifle Association.

THE MAJOR PLAYERS

THE PLANTS	THE ENGINEERS
Maize Tomato Soy bean Potato Cotton Tobacco Rapeseed Melons/squashes Alfalfa Rice	Monsanto Pioneer Hi-Bred Seed Calgene Upjohn Dupont De Kalb U. S. Dept. Agriculture Frito-Lay DNA Plant Technology

THE RESULTS OF GENETIC ENGINEERING

In 1996, about 7 million acres of transgenic crops were grown around the world; in 1997, 31.5 million acres. In 1998, farmers in this country, Argentina, Canada, Australia, Mexico, Spain, France, and South Africa planted 69.6 million acres of genetically modified crops. In the United States, about 40% of the corn crop is GM; 27% of the soybeans were engineered to be herbicide resistant, as was 27% of the cotton crop. Three percent of our potato crop has been transformed to have a built-in pesticide.

Genetic engineering allows us to produce plants that can fix their own nitrogen, which means that they will use less fertilizer. By increasing their tolerance of heavy metals and salinity, and by increasing drought and frost resistance, we can grow crops in a wider variety of locations. By increasing resistance to herbicides and by manufacturing their own insecticides, the competitive advantage of genetically modified crops is also enhanced.

It is also possible to view crop plants as "molecular farms," living factories that can be genetically manipulated to produce the raw materials of industry

-- starch, essential and fixed oils, enzymes, and even human medicines. Genetic engineers at Michigan State Univ. have produced transformed plants that make a biodegradable plastic that would ordinarily have been manufactured by the bacterium itself. Belgian scientists have developed a procedure for producing human neuropeptides in the seeds of the canola oil plant. In the popular press, the genetic engineering medicines are called **farmaceuticals**.

Genetic engineering to produce biopesticides is still in its infancy. These newer techniques promise to be much more precise than our traditional "spray and pray" approach to pesticide and herbicide application. Another bacterium, *Bacillus thuringiensis*, known to its friends simply as "Bt," makes a protein that is toxic to caterpillars that eat various plants. The gene from Bt that makes that protein has been transferred to another bacterium (*Pseudomonas fluorescens*) that lives in the roots of corn plants. When corn seeds that have been coated with the transformed bacterium germinate, they are protected from the caterpillars that would have eaten their roots! Last year about 1 million acres of Bt corn were planted in the Midwest. Yield went up 10-15%.

AN OVERVIEW

Ecological:
Fix their own nitrogen
Increased tolerance of heavy metals
Increased tolerance of salty soils or salt water
Increased tolerance of drought/water stress
Increased tolerance of freezing temperatures
Detoxification of contaminated soils

Pest and Weed Management by Resistance to:
Herbicides
Insects
Viruses
Fungi
Bacteria

Improved Post-Harvest Qualities:
Delay of ripening
Improved storage capability

Improved Nutritional Qualities:
High starch potatoes
Sweeter fruits and vegetables
Higher amino acid content (lysine)

Plant Cells as Molecular Farms:
Starch
Essential oils
Biodegradable plastics
Fixed oils
Enzymes
Human/veterinary medicines

NEW PLANTS? WHO OWNS THEM?

Those of us who are interested in the naming and classifying of plants will fret over whether these new products of genetic engineering should be recognized as distinct and given their own scientific names. Another group of people who are also very interested in these novelties are patent attorneys. When a corporation or a university has invested millions of dollars in perfecting these techniques and regenerating GMO's, when can it patent this new plant or animal to protect its investment, offer it for sale, and earn a profit? This is a very hot issue. In 1930, The United States Congress passed the Plant Patent Act. It covered plants that were asexually propagated. The 1970 Plant Variety Protection Act dealt with sexually reproducing plants -- but not their seeds. In 1980, the United States Supreme Court ruled on a case that involved four different plasmids transferred into a single bacterial cell. It ruled that "novel life forms" could be patented, including all parts of the plant. That meant the adult plant itself, along with cuttings, seeds, and tissue cultures. European countries have taken a much more conservative approach. The European Patent Convention makes it all but impossible to patent plants or animals or "... biological processes for the production of plants or animals."

Another way to protect your investment has been developed by Monsanto and its partners. It has been dubbed the "**terminator gene**" or the "suicide seed." You purchase the GM seed, you plant it, and it yields the crop that you desired. If you attempt to plant the seeds of the crop you have just harvested, you will discover that they have been engineered to be sterile. You will have to go back to the seed store to buy more seed to replant. Developers of the terminator genes point out that you are not permitted to make copies of videos or books that you have purchased. Why should the fruit of their work be any different. It is a genetic form of intellectual property.

THE OTHER SIDE OF THE STORY

Recent articles in the popular press bear titles such as, "The Great Gene Escape," "Attack of the Gene Splicers," "Agricultural Biotech Faces Backlash in Europe," "The Suicide Seeds," and my personal favorite, "The Curse of Frankenfood." Here, and especially in Europe, we are seeing a backlash against genetic engineering. It is easy to dismiss some of the critics as late-20th century versions of Luddites who oppose new inventions and technologies. However, there are a number of well-informed critics who raise legitimate concerns. These include:

Unexpected products of genetic engineering. GMO's can go ahead (on their own) to produce new pathogenic organisms, especially those that have viruses incorporated into them. We may also be creating "super weeds" without realizing it.

Contamination of traditional strains of crop plants. Pollen from GMO's can be carried by the wind, insects, etc. to non-GMO's in adjacent fields.

Reliance on so few transformed plants. We are heading down the same path of monoculturing of our crops -- millions of acres devoted to one kind of GM corn, GM cotton, etc. Farmers, especially those in the Third World, will become even more dependent on patented seeds, associated pesticides and herbicides, which they cannot afford.

Loss of traditional varieties of crop plants and their wild relatives. We will become so enamored of the GMO's that we will not continue to grow the old style plants or worry about their wild relatives as sources of genetic material. Gene pools of our crops will continue to deteriorate.

There will be unexpected and undesirable consequences. Scientists at Cornell University have just found that corn pollen from plants that have Bt toxin transferred into them will kill monarch butterfly larvae. The pollen had been sprinkled on milkweed plants, a favorite food of the butterfly. A major portion of the butterfly's natural distribution overlaps the "corn belt."

Safety of genetically-engineered foods. The British tabloids call them "Frankenfoods." Are GMO's toxic? Will they produce allergies in consumers?

Nutritional quality. Are they as nutritious as the non-GMO's? Recent articles suggest that the GM version of soybeans is lower in phytoestrogens, compounds that may protect us against heart disease and cancer.

SECTION 5 • FOOD PLANTS

5.1 • AN OVERVIEW

☼ We are heavily dependent on a handful of cereals and root crops as the major sources of our food.

☼ How many plants are critical to feeding the world? From about six to one hundred, depending upon the criteria employed, and which expert you ask.

☼ Most of our food plants are of Old World origin.

☼ While many food plants are important items of international commerce, hundreds of others are grown and consumed locally and are little-known outside the immediate region.

☼ Very few new food plants have come on the scene in the last several thousand years.

☼ Most of the spices and flavorings that we use have been around since ancient times.

☼ We devote most of our land to the growing of cereals.

☼ All great civilizations, past and present, are based upon the cultivation of cereals.

☼ Several plant families that are important sources of food plants are also notorious for their toxic members. In fact, many food plants must be prepared properly to rid them of toxins.

☼ Nor is the category "food plant" entirely distinct from "medicinal plant" or even "psychoactive plant."

☼ Many of our most important food plants have significant nutritional deficiencies and do not, in and of themselves, provide an adequate diet.

☼ Typically, we see in our markets only a narrow segment of the spectrum of food plants potentially available.

☼ We have often been fearful of and resistant to consuming new foods.

5.2 • AN INTRODUCTION

"Tell me what you eat and I will tell you what you are." [J. A. Brittat-Savarin, French epicure]

"Not all foods are equal. Some are relished, others only tolerated, and still others are loathed, being eaten only when necessary." [Paul Minnis, 2000]

☼☼☼☼☼

Food plants are those that provide nourishment. They provide us with the materials needed to maintain life, to make new tissue; to grow. Food plants are also the source of energy needed for the body's various activities.

HOW MANY FOOD PLANTS?

Estimates vary widely. The most recent comprehensive survey by Kunkel (1984) shows about 12,500 species in 400 plant families. Here are the top ten families that are the sources of our food plants.

01. Rose family - Rosaceae
02. Sunflower family - Compositae
03. Yam family - Dioscoreaceae
04. Bean family - Leguminosae
05. Lily family - Liliaceae
06. Mulberry family - Moraceae
07. Ebony family - Ebenaceae
08. Madder family - Rubiaceae
09. Myrtle family - Myrtaceae
10. Nightshade family - Solanaceae

WHAT PORTIONS ARE EDIBLE?

The following outline is adapted from Roecklein & Leung (1987).

Entire plant body: algae, fungi, and delicate annuals.

Roots: The carrot, dandelion, radish, and sugar beet are swollen taproots. Horseradish, licorice, and sarsaparilla are adventitious roots. Cassava, sweet potatoes, and the true yam are tuberous roots. Sassafras comes from root bark.

Stems: Asparagus and bamboo shoots are young sprouts. Sugar cane is whole stem. The potato and Jerusalem artichoke are swollen tubers. Arrowroot, calamus, ginger, turmeric, and galangal are rhizomes. Taro and water chestnut are corms. Sago palm is pith. Cinnamon and angostura bitters come from stem bark.

Root and stem: Beetroot, celeriac, swede, turnip, and kohlrabi are combinations of stem and root.

Leaves: Bay leaf, cabbage, dill, grape, lettuce, and parsley are whole leaves. Cardoon is just from the midrib. Leek is from the base. Celery and rhubarb come from the petiole; fennel from the petiole base. Cabbage and Brussel sprouts are leafy buds. Garlic and onion are leafy bulbs.

Flowers: Capers and cloves are flower buds. The artichoke, broccoli, and cauliflower are entire flower clusters. Roselle is sepals. Saffron comes from just the stigmas and styles.

True fruits: Wheat, rice, wild-rice, maize, oats, barley, and rye are grains (caryopses). Okra, cardamon, and vanilla are capsules. Beans, peas, lentils, peanut, carob, and fenugreek are legumes. Anise, caraway, cumin, dill, and coriander are schizocarps. Allspice, banana, peppers, papaya, tomatoes, and grapes are berries. The grapefruit, lemon, lime, orange, and tangerine are hesperidia. The pumpkin, squash, watermelon, cucumber, and chayote are a kind of modified berry called the pepo. Apples, loquats, pears, and quinces are pomes. The apricot, peach, plum, nectarine, olive, and black pepper are drupes.

False fruits (derived from one flower): The custard apple, sweetsop, and bullock's head are aggregations of berries. The blackberry, raspberry, and loganberry are aggregations of small drupes.

False fruits (derived from several flowers): Hops, breadfruit, jackfruit, mulberry, and pine-apple are produced by the coalescing of many flowers at maturity.

Seeds: Sunflower, acorn, chestnut, Brazil nut, poppy, sesame, beans, peas, nutmeg, almond, coffee, pecan, walnut, and pistachio nut are all seeds.

Sap: Sugar maple, sugar cane, and sugar palms yield sugary sap.

Latex: Chiclé, once the basis of the chewing gum industry, is the latex of a tropical tree.

Gums: Pectins, gum Arabic, guar, gum Karaya, and gum tragacanth are all gums.

TOXIC FOOD PLANTS

It would seem reasonable to assume that the category "food plants" would be quite distinct from the category "toxic plants." Even our pre-human ancestors must have discovered by the process of trial and error that this plant is edible, but that plant will make you sick or even kill you. The summary that follows shows you that there are well-known food plants that have toxic properties. Sometimes it is a matter of processing; in other instances the toxicity is a function of individual sensitivities or even genetic makeup.

Dermatitis: cashew, mango, pineapple

Gastrointestinal: potato, tomato, rhubarb, horse radish, spinach

Circulatory/cardiovascular: fava bean, onions + allies, banana

Skeletal: sweet pea

Cellular (hydrogen cyanide poisoning): apples, peaches, lima bean, chick pea, cassava, flax

Central nervous system: nutmeg

Mutagens/teratogens (aflatoxins): peanut

FOOD PLANT DETOXIFICATION

Many of our food plants contain toxins that must be removed or destroyed before we can eat them. We have discovered a number of methods for accomplishing this goal. According to Johns (1990), we have learned to detoxify plants by:

heating: boiling, stewing, roasting, baking, frying, and steaming;

soaking: in static water, soaking with change(s) of water, soaking in running water, leaching, soaking in salt water, soaking with ashes, lye, acids, and boiling;

fermentation: spontaneous or using an inoculum from earlier preparations;

adsorption: clay, charcoal, and mud;

drying: sun, kiln, or hot-air;

physical processing: peeling, grating or rasping, squeezing, pounding, grinding, and cutting; and

changing pH: lye or lime, acidic substances.

WHICH ONES ARE CRITICAL TO US?

While the question seems simple enough, the answer remains elusive. What follows are attempts by various authors to list the most important food plants, the ones upon which our continued existence depends.

Garrison Wilkes. Barley, maize, millets, oats, rice, rye, sorghum, and wheat. Cassava, potato, sweet potato, taro, and yams. Beans, chickpea, cowpea, pea, peanut, and soybean. Coconut, cottonseed, and sunflower. Sugar beet and sugar cane. Cabbage, onions, squash, and tomato. Apple and banana. Melons, orange, and pear.

Marcus Rhoades. Barley, maize, oats, rice, sorghum, and wheat. Cassava, potato, and sweet potato. Soybean. Sugar cane. Grape.

Oswald Tippo & W. L. Stearn. Maize, rice, and wheat. Cassava, potato, and sweet potato. Beans and soybeans. Coconut. Sugar beet and sugar cane. Banana.

M. J. Chrispeels & D. Sadava. Barley, maize, rice, sorghum, and wheat. Cassava, potato, and yams. Beans, peanut, and soybean. Coconut. Sugar beet and sugar cane. Banana.

Jack Harlan. Barley, maize, millets, oats, rice, rye, sorghum, and wheat. Cassava, potato, sweet potato, and yams. Beans, chickpea, pea, peanut, and soybean. Coconut, cottonseed, oil palm, sesame seed. Sugar beet and sugar cane. Tomato. Apple, banana, cacao, grape, melons, and orange.

Paul Mangelsdorf. Barley, maize, rice, sorghum, and wheat. Cassava, potato, and sweet potato. Beans, peanut, and soybean. Coconut. Sugar beet and sugar cane. Banana.

Norman Myers. Barley, maize, millets, oats, rice, rye, sorghum, and wheat. Cassava, potato, and sweet potato. Peanut, and soybean. Coconut and cottonseed. Sugar beet and sugar cane. Apple, banana, grape, melons, and orange.

National Academy of Sciences. Maize, millets, rice, sorghum, and wheat. Cassava, potato, and sweet potato. Beans, pea, peanut, and soybean. Coconut. Sugar beet and sugar cane. Banana.

Richard Evans Schultes. Maize, rice, and wheat. Cassava, potato, and sweet potato. Bean, peanut, and soybean. Sugar beet and sugar cane. Coconut. Banana.

Prescott-Allen & Prescott-Allen. Wheats, rices, maize, sorghum, millets, rye, barley, oats, and fonio. Quinoa. Potato, cassava, yams, sweet potato, taro, and yautia. Soybean, peanut, beans, cowpea, pea, pigeon pea, chickpea, broad bean, lentil, and lupin. Coconut, sunflower seed, oil palm, cottonseed, olive, rapeseed, sesame seed, melon seeds, and shea nut. Sugar cane and sugar beet. Tomato, cabbages, onions, carrot, cucumber, pumpkins, squash, gourds, lettuce, eggplant, garlic, spinach, and artichoke. Almond, filbert, mustard seed, safflower seed, walnut, Brazil nut, and pistachio nut. Banana, plantain, orange, apple, grape, watermelon, date, avocado, mango, pineapple, tangerine/ mandarin, lemon, lime, grapefruit, melon, papaya, pear, peach/nectarine, plum, fig, strawberry, apricot, cherry, currants, pimento/allspice, star anise, cardamon, pepper, chili pepper, sweet pepper, and cacao. Coffee, maté, and tea.

THE TEN MOST PRODUCTIVE PLANTS

Crop	Area	Yield
Wheat	229,347	2,204
Maize	131,971	3,702
Rice	144,962	3,261
Potato	20,066	14,981
Barley	78,696	2,244
Manioc	14,010	9,676
Sugar	24,676	59,144
Sweet potato	7,880	14,041
Sorghum/millets	91,859	1,139
Soybean	52,683	1,914

Area in 1000 hectares
Yield in kilograms/hectare

[Source: Solbrig & Solbrig,1994]

WHAT ARE THE ESSENTIAL FOOD PLANTS?

Food Plant	JH	PM	NM	NAS	OTS	GW	MR	T&S	C&S	RES
Wheat	√	√	√	√	√	√	√	√	√	√
Rice	√	√	√	√	√	√	√	√	√	√
Maize	√	√	√	√	√	√	√	√	√	√
Sorghum	√	√	√	√	√	√	√	√	√	√
Millets		√		√	√		√			
Rye		√		√			√			
Barley		√	√	√		√	√	√		√
Oats		√		√			√	√		
Potato	√	√	√	√	√	√	√	√	√	√
Cassava	√	√	√	√	√	√	√	√	√	√
Yams	√		√			√			√	
Sweet potato	√	√	√	√	√	√	√	√		√
Taro					√					
Sugar cane	√	√	√	√		√	√	√	√	√
Sugar beet	√	√	√	√		√		√	√	√
Soy bean	√	√	√	√		√	√	√	√	√
Peanut	√	√	√	√		√		√	√	√
Beans	√	√		√		√		√	√	√
Pea	√			√		√				
Chick pea	√					√				
Cow pea						√				
Tomato	√		√			√				
Squash					√					
Banana	√	√	√	√				√	√	√
Apple	√		√							
Pear					√					
Citrus	√		√			√				
Grape	√		√				√			
Watermelon			√							
Coconut	√	√	√	√		√		√	√	√
Oil palm	√									
Cottonseed	√		√			√				
Sesame	√									
Sunflower	√					√				

Key to abbreviations:

JH = Jack Harlan, PM = Paul Mangelsdorf, NM = Norman Myer, NAS =National Academy of Sciences, OTS = Office of Technology Assessment, GW = Garrison Wilkes, MR = Marcus Rhoades, T & S = Tippo & Stearn, C & S = Crispeels & Sadava, RES = Richard Evans Schultes.

5.3 • ROOT CROPS

This category of food plants includes those with edible roots, underground root-like stems, subterranean leaf bases, and combinations of these tissues. In other words, root crops are not limited to just those food plants that have edible roots, as the name might well imply. In general, root crops are:

- mostly water;
- high in starches and/or sugars;
- low in proteins and oils;
- not easily stored, transported, or marketed;
- not the basis of a balanced diet;
- sometimes consumed raw, but often require heating or some other processing to destroy toxins.

The annual tonnage of the major root crops is almost as great as the cereal production. They exceed the major cereals in their nutritional yield in terms of millions of calories per acre: potato = 4.84; rice = 2.77; maize = 2.55; wheat = 1.61.

THE IRISH POTATO

"Two things are too serious to talk about – marriage and potatoes." [Old Irish saying]

"... a scarcely innocent underground stem." [John Ruskin, 1869]

Also known as the Irish or white potato, *Solanum tuberosum* probably originated in the Andean Mountains of Bolivia and Peru. It has been in use there since at least A.D. 200 and it is still in common use. The potato is a tuber, a starchy, underground stem. The eyes are buds; leaf scars are also evident on the surface. The tuber is about 70-80% water, 8-28% starch, and 1-4% protein. The food value varies greatly with cultivar, growth conditions, storage, and handling.

In *Solanum tuberosum*, x = 12 and there are diploids, tetraploids, and hexaploids. The *Tuberosum* Group, to which our cultivars belong, is tetraploid (2n= 4x = 48).

TIMELINE: IRISH POTATO

BCE:

11,000	First archaeological remains (Chile)
5,000	Alkaloid-free diploids evolve
5,000	Domesticated ??

CE:

1533	First seen by Europeans (Pizzaro)
1553	First European reference ("Chronica del Peru")
1570	Introduced into Spain
1585	Introduced into Italy
1586	Introduced into England
1588	Introduced into Ireland
1590	José de Acosta describes chuño making
1597	First printed illustration (Gerard's "Herball")
1601	"It springs from a bulb" (Clusius)
1619	Gaspard Bauhin names it *Solanum tuberosum esculentum*
1622	Governor of Bermuda sends them to Governor of Virginia
1625	Now a food staple in Ireland
1651	German Grand Elector forces their planting and consumption
1662	Royal Society considers planting throughout England
1664	John Forster publishes "England's Happiness Increased..."
1697	Introduced into Russia by Peter the Great
1719	Introduced to U. S. (New Hampshire)
1740	Famine in Ireland (to 1741)
1753	Linnaeus names it *Solanum tuberosum*
1756	Frederick the Great issues pamphlet on planting/storing
1761	A. R. J. Turgot eats potato in public ... and lives
1767	George Washington plants them at Mount Vernon
1171	A. A. Parmentier wins prize for essay on its value
1771	Faculté de Paris declares potato innocuous
1786	A. A. Parmentier establishes test plots for Louis XVI
1832	Dry rot, a fungal disease, hits potato
1845	"A fatal malady has broken out..."
1845	Irish potato famine (to 1851)
1851	Massachusetts legislature offers $10K for potato rot cure
1853	Potato chip invented
1861	De Bary publishes work on potato blight
1871	Luther Burbank develops "Burbank potato"
1824	Colorado potato beetle discovered
1889	Bordeaux mixture (copper sulfate + calcium hydroxide) developed
1972	Cause of serious birth defects in humans?
1974	Blighted potatoes found to cause abortion/birth defects
1994	Resurgence of blight

HISTORY. The potato was brought to Europe in the mid-1500's and was planted extensively in North America by about 1700. The plant was not an immediate success, for a variety of reasons. It was seen to be a member of the nightshade family (Solanaceae), a group of plants long known for their toxic properties. There were also cultural and religious biases against the potato. Later its reputation changed and it became very popular. Often its planting was the result of a royal edict. The potato became a dominant food in the diet of the Irish. The "late blight of potato," caused by the fungus *Phytophthora infestans*, wiped out the Irish crops two consecutive years (1845-1847). It is estimated that 1.5 million died as a result of the famine and that perhaps another million Irishmen immigrated to the U.S.

TOXICITY. When exposed to sunlight, potato tubers make chlorophyll and turn green. They also increase production of a toxin called solanine. It has caused sickness and death in domesticated animals that eat green tubers, but it rarely causes problems in humans because we destroy the toxin during the cooking process.

USES. The potato is not just a food plant for us and for some of our domesticated animals. Its starch is used in textiles, paper, confections, and adhesives, and to make industrial alcohol. **Chicha** is a South American beer made from fermented potatoes. Schnapps is also made from potatoes.

SWEET POTATO

Ipomoea batatas, a relative of the ornamental morning glory and the weedy bindweeds, is a trailing vine of tropical lowlands. The plants are vegetatively propagated; many strains rarely flower. Its origin is still a matter of controversy. It was probably used in both the Old World and New World before Columbus. Current thinking appears to favor New World tropical lowlands as the sweet potato's ancestral home. Note the similarities in common names:

kumar • Quechua Indians (Andes)
kumara • Polynesian islands
umara • Tahiti
umala • Samoa
uwala • Hawai'i

The plant is very popular in the southern U.S., where it is often called a yam. The true yams are entirely different species and are rarely seen in this country. China is the leading producer of sweet potatoes. It has 50% more calories than the Irish potato, usually less protein (1.5-2.0%), and is a good source of Vitamin A. The sweet potato is a polyploid (2n = 4x = 60 and 6x = 90).

Henry VIII loved sweet potato pie. He thought that it was good for his love life, a common belief of the time. William Shakespear makes reference to this when he has Falstaff hoping that the sky would rain potatoes.

CASSAVA

Manihot esculenta has a number of common names, including **manioc** and **yuca** (not to be confused with yucca, an entirely unrelated plant). Cassava is a member of the spurge family, known for its many toxic species. It is a shrubby perennial of the tropical lowlands. It was originally from South America, perhaps eastern Brazil. In Africa and in the West Indies, cassava is cooked and then pounded into a dough to make **fufu**, a traditional African pudding. The plant is not widely known outside of the tropics, although there it is a very important plant. While you may not know a cassava when you see it, you do know a product made from its roots – tapioca. The starch from cassava and maize were used to make postage stamp glue.

The edible part is a series of swollen roots. With little care the plants will yield 10 tons of roots/acre. The roots contain a poisonous glycoside that will yield HCN (hydrogen cyanide or Prussic acid) when it breaks down. We have learned by trial and error that the roots must be heated to drive off this toxic gas. The roots are consumed whole after boiling, or pulverized and dried to a meal called **farinha**. The juices are also used to make alcoholic beverages and as a component in meat sauces (West Indian pepper pot).

YAMS

First, please note that yams and sweet potatoes are not the same thing, and that while all of the sweet potatoes belong to a single species, there are several species of yams. *Dioscorea* spp. are perennial climbing vines of the tropics. Three "Groups" are often recognized: Asian, African, and America. Only one, the cush-cush yam, is native to the New World. The vines have large storage tubers that can weigh up to several hundred pounds. The plants may have aerial tubers as well. The yam is a very important food in the West Indies, much of South America, in Asia, and the South Sea Islands. It is baked, boiled, or ground into flour. The yam is mostly starch. Several million tons are produced each year.

In addition to being an important root crop, the yam has ritual and medicinal uses. I will tell you about that later in the semester.

THE TRUE YAMS (*DIOSCOREA)*

New World:

D. trifida	Cush-cush yam, ajam, yampi

Africa:

D. abyssinica	Rikua
D. cayenensis	Yellow Guinea yam
D. dumetorum	Bitter yam, 3-leaved yam
D. bulbifera	Potato-yam, air-potato
D. elephantipes	Elephant's foot
D. rotundata	White yam, Guinea yam

Asia:

D. alata	Greater yam, water yam
D. bulbifera	Potato-yam, air-potato
D. esculenta	Lesser yam, Asiatic y., Chinese y.
D. hispida	Intoxicating yam, nami
D. japonica	Japanese yam
D. nummularia	Kerung
D. opposita	Chinese yam
D. pentaphylla	Sand yam, buck yam
D. praehensilis	Bush yam, forest yam

Pacific Islands:

D. papuan	
D. spinosa	Spiny yam

TARO

"One man's meal is another man's poi, son."
(Restauranteur in Honolulu Polynesian bistro)

☼ ☼ ☼ ☼ ☼

Colocasia esculenta, a member of the philodendron family, is very widely used by the peoples of Southeast Asia and the Pacific Islands. The plants live in moist to swampy areas, seldom flower, and typically have large leaf blades shaped like elephant ears. The fleshy corms are eaten boiled, baked, or mashed; or they may be dried and pulverized. These treatments destroy the calcium oxalate crystals present in the underground structures. These crystals are quite characteristic of the family.

In Hawai'i, the plant is known as **kalo**. Its leaves are **luau**; the same word is also used for a soup made of taro leaves and for the well known feast. As a soup, "... *it is as delicate, wholesome, and agreeable a one as any in the world."* (Sturvevant, 1919). The leaves are also called **callaloo**, as is a Caribbean soup made from taro leaves, okra, yams, chili peppers, and coconut milk. **Po'i**, the famous Hawai'ian dish, is steamed taro that has been crushed and fermented. So much of it is grown for local consumption that precise production figures are unavailable.

Taro is only one of several important root crops derived from the philodendron or aroid family. There is much confusion as to their common names.

ARROWROOTS

There are several unrelated Old World and New World root crops that are collectively known as arrowroots. They are important starch sources that we use as food in the tropics and for a variety of other purposes. The starch is deposited in tubers or rhizomes.

THE ARROWROOTS

Maranta arundinacea	arrowroot, W. Indian a.
Tacca leontopetaloides	Tahiti a., African a.
Curcuma angustifolia	Bombay arrowroot
Zamia pumila	Florida arrowroot
Manihot esculenta	Brazilian arrowroot, Pará a.
Canna indica	Queensland arrowroot

Arrowroot (*Maranta arundinacea*) is the best known member of the group. Its rhizomes are cleaned, peeled, crushed, grated, and then washed to free the starch. The resulting liquid is then centrifuged or poured on to a flat surface to allow the starch to settle out. The air-dried starch lumps are pulverized to yield a very fine, small-grained starch. The highly-digestible starch is a favorite in foods for infants and invalids. It is also used in various jellies and pastes. The starch is also applied externally as a face powder and to treat wounds, ulcers, insect bites, and snake bites. Most arrowroot comes from St. Vincent, in the West Indies. The United States is the chief importer.

Tahiti arrowroot is a favorite starch crop of the South Pacific. Its tubers are treated to remove taccalin, a bitter chemical. Besides being a food plant, the starch is also processed to make the coating used on carbon-less computer paper. Tahiti arrowroot leaves are used to make hats.

TABLE BEET AND SUGAR BEET

The many cultivars of *Beta vulgaris* that we now use are presumably derived from *B. maritima* of northern Europe. Close relatives include chard (edible leaves) and the mangelwurzel, all of which freely interbreed. Our own production of the sugar beet increased dramatically in the early 1960's, after we boycotted cane sugar from Cuba. The sugar in sugar beets is identical to that of cane sugar. The main ingredient in borsch, a Russian soup, is a puree of beets. Beetroot wine is a popular homemade wine.

CARROT

Daucus carota var. *sativa* is another of our ancient food plants. It is perhaps native to the Afghanistan area. It was highly prized by Europeans and was brought to America by the early colonists. The carrot is a biennial, although the plant is mature after the first year. There are many kinds of carrots, some with enormous root systems three feet long. The carrot is rich in vitamin A and sugar. At first it was considered a medicinal plant, its seeds used as a stimulant and as a diuretic. After many centuries it was considered a food plant. Eating carrots raw is a very recent habit. The early cultivars were purple. The orange ones became popular when they were exported from Holland in the 17^{th} and 18^{th} centuries.

PARSNIP

Pastinaca sativa, a carrot relative, has been cultivated as a food plant since the days of the ancient Romans. However, the development of fleshy roots did not come until the Middle Ages. The parsnip is high in sugars and starch. We also make parsnip wine.

JERUSALEM ARTICHOKE

Helianthus tuberosus is a close relative of our native North American sunflower. The common name would certainly suggest otherwise. According to one explanation, "Jerusalem" is a corruption of the Italian word for sunflower. The plants produce tubers that are somewhat like the potato in appearance. Although native to the New World, the Jerusalem artichoke is better appreciated in Europe and China. In the United States it is most often used as a food for hogs. When eaten by humans it is usually boiled or baked. The Jerusalem artichoke contains inulin, a sugar that may be used by diabetics.

THE BRASSICA ROOT CROPS

Several different root crops are derived from the genus *Brassica*, a member of the mustard family. The **turnip** is a combination of edible stem and root tissue. There is considerable variation in the size, shape, and flesh color in different cultivars. The turnip has been used since prehistoric times. The **rutabaga** is of recent origin, the result of hybridization between the turnip and the cabbage sometime in the 17th century. The **kohlrabi** is a leafy stem base. It can get to be about the size of an orange when fully grown, but it is best eaten before it gets that large.

THREE S. AMERICAN ROOT CROPS

There are several South American root crops that are in wide use there, but which are almost completely unknown to us in this country. Chief among them is **oca** (*Oxalis tuberosa*), a relative of our local redwood sorrel or sour-grass. It is used primarily in Peru, Ecuador, and Bolivia. The tubers are acid when fresh. They are usually dried in the sun so that they get more floury and less acid. If dried for several weeks, oca takes on the flavor of dried figs.

Two other crops of note are the **añu** (*Tropaeolum tuberosum*), a relative of the garden nasturtium, and **ullucu** (*Ullucus tuberosus*), an important Andean food plant with no well known relatives in North America.

SURVEY OF ROOT CROPS

Common Name (Scientific Name)	Plant Family	Comment
añu *(Tropaeolum tuberosum)*	Nasturtium	South American tuber
arracacha *(Arracacia xanthorrhiza)*	Carrot	Used in Peruvian region
arrowroot *(Maranta arundinacea)*	Prayer plant	Starchy rhizomes
arrowroot, African *(Tacca leotopetaloides)*	Tacca	Starch source
arrowroot, Indian *(Curcuma angustifolia)*	Ginger	Starch source
arrowroot, Queensland *(Canna edulis)*	Canna	Starchy rhizome
artichoke, Chinese (*Stachys floridana*)	Mint	See crosne
artichoke, Japanese (*Stachys floridana*)	Mint	See crosne
artichoke, Jerusalem *(Helianthus tuberosus)*	Sunflower	Native to North America
beet *(Beta vulgaris)*	Goosefoot	Relative of sugar beet
carrot *(Daucus carota)*	Carrot	Native to Near East
cassava *(Manihot esculenta)*	Spurge	Important pantropical food
celeriac *(Apium graveolens)*	Carrot	Used in soups and stews
chavar *(Hitchenia caulina)*	Ginger	Used like arrowroot; Indomalaysia
chicory *(Cichorium intybus)*	Sunflower	Coffee flavoring/substitute
chufa *(Cyperus esculentus)*	Sedge	Tubers rich in starch, sugar, oil; pantropical
crosne *(Stachys floridana)*	Mint	Edible tubers; popular in Europe, esp. France
daikon *(Raphanus sativus)*	Mustard	Relative of the radish
dasheen *(Colocasia esculenta)*	Philodendron	Important pantropical food
false yam *(Icacina oliviformis)*	Icacina	Tubers to 50 kg; West Africa
garlic *(Allium sativum)*	Lily	Native to Central Asia
gobo root *(Arctium lappa)*	Sunflower	Old World; contains inulin
groundnut *(Apios americana)*	Bean	Native to North America
hausa-potato (*Solenostemon rotundifolius*)	Mint	See fra-fra potato
horseradish *(Armoracia lapathifolia)*	Mustard	Native to Europe; potent!
jicama *(Pachyrrhizus erosus)*	Bean	Native to Mexico
kohlrabi *(Brassica oleracea)*	Mustard	Fleshy lower stems eaten
leek *(Allium ampeloprasum)*	Lily	Native to Mediterranean
lotus *(Nelumbo nucifera)*	Lotus	Rhizomes; source of Chinese arrowroot
maca *(Lepidium meyenii)*	Mustard	Andean; baked in pits
malanga *(Xanthosoma sagittata)*	Philodendron	Pantropical food plant; = yautia
maloga bean *(Vigna lanceolata)*	Bean	Taproot also edible; Australia
manioc *(Manihot esculenta)*	Spurge	Another name for cassava
nami *(Dioscorea hispida)*	Yam	Also called intoxicating yam
oca *(Oxalis tuberosa)*	Oxalis	Tubers of Andean plant
onion *(Allium cepa)*	Lily	Ancient; origin uncertain
onion, Welsh *(Allium fistulosum)*	Lily	From Asia, not Wales
oyster plant *(Tragopogon porrifolius)*	Sunflower	Dandelion relative
parsley root *(Petroselinum crispum)*	Carrot	Native to Mediterranean
parsnip *(Pastinaca sativa)*	Carrot	Perhaps native to China
potato, fra-fra *(Solenostemon rotundifolius)*	Mint	Tubers; West African
potato, Irish or white *(Solanum tuberosum)*	Nightshade	Native to Andes mountains
potato, Spanish *(Ipomoea batata)*	Morning glory	Another name for sweet potato
radish *(Raphanus sativus)*	Mustard	Now unknown in wild
rutabaga *(Brassica napus)*	Mustard	Turnip and cabbage hybrid
salsify *(Tragopogon porrifolius)*	Sunflower	Another name for oyster plant
salsify, Spanish *(Scorzonera hispanica)*	Sunflower	Native to southern Europe
shallot *(Allium cepa)*	Lily	Produces cluster of bulbs
shoti *(Cucurma zedoria)*	Ginger	Starchy rhizomes; Southeast Asia
skirret *(Sium sisarum)*	Carrot	Tuberous roots
sugar beet *(Beta vulgaris)*	Goosefoot	Native to Europe
swede *(Brassica napus)*	Mustard	Hybrid of recent origin
Sweet potato *(Ipomoea batata)*	Morning glory	Not same as true yam
tannia *(Xanthosoma sagittifolium)*	Philodendron	African tuber plant; = yautia
taro *(Colocasia esculenta)*	Philodendron	Important pantropical food
tiger nut *(Cyperus esculentus)*	Sedge	Native to West Africa
topee tambo *(Calathea allouia)*	Prayer plant	Potato-like tubers; West Indies
turnip *(Brassica rapa)*	Mustard	Perhaps from western Asia
turnip-root chervil *(Chaerophyllum bulbosum)*	Carrot	Carrot-like roots boiled

ullucu *(Ullucus tuberosus)*	Basella	Important Andean root crop
water chestnut *(Eleocharis dulcis)*	Sedge	Old World native; corms
yam, Asiatic *(Dioscorea alata)*	Yam	Native to Southeast Asia
yam, Chinese *(Dioscorea esculenta)*	Yam	Native to Southeast Asia
yam, cush-cush *(Dioscorea trifida)*	Yam	Native to American tropics
yam, elephant *(Amorphophallus campanulatus)*	Philodendron	Tubers; SE Asia & Pacific
yam, white *(Diosocrea rotunda)*	Yam	Native to west Africa
yam, yellow *(Dioscorea cayenensis)*	Yam	Native to west Africa
yam bean *(Pachyrrhizus erosus)*	Bean	Native to American tropics
yam bean *(Sphenostylis stenocarpa)*	Bean	Native to west Africa
yautia *(Xanthosoma sagittifolium)*	Philodendron	Pantropical food plant
ysano *(Tropaeolum tuberosum)*	Nasturtium	Another name for añu
yuca *(Manihot esculenta)*	Spurge	Another name for cassava

5.4 • STEMS, LEAVES, & FLOWERS

This group of food plants is relatively straight-forward. We tend, for obvious reasons, to consume these various leaves and flowers while they are young and tender. The flower clusters are often so immature that you may not realize what you are eating.

ONIONS AND THEIR ALLIES

The edible portion of various *Allium* spp. is the bulb, a modified stem system bearing a series of overlapping, fleshy leaves. The outer leaves are often dry and papery. The stem itself is reduced and is often discarded before the rest of the bulb is eaten.

Chives	*A. schoenoprasum*
Egyptian onion	*A. cepa* var. *proliferum*
Garlic	*A. sativum*
Garlic chives	*A. tuberosum*
Kurrats	*A. ampeloprasum*
Leeks	*A. ampeloprasum*
Onion	*A. cepa*
Potato onion	*A. cepa* var. *aggregatum*
Rakkyo	*A. chinense*
Rocambole	*A. ampeloprasum*
Shallots	*A. cepa* var. *aggregatum*
Tree onion	*A. cepa* var. *proliferum*
Welsh onion	*A. fistulosum*

ONION. The onion *(Allium cepa)* is of uncertain origin. The common name derives from the Latin (unio), the French (oignon), and the Anglo-Saxon (onyon). It was in use by the Egyptians in 3000 B. C. It was a common food in Europe in the Middle Ages. Long ago, the onion had another reputation. It "... *serves no other thing but to provoke and stirre folks to the act of carnal copulation."*

There are numerous cultivars. Yellow onions often have golden-brown skins; red or Italian onions have ruby-red skins; white onions are white. The famous sweet and juicy Vidalia onion is named after the city in Georgia.

Why do we get all teary-eyed when we slice an onion? The cause is propanethial-S-oxide, a volatile sulfur compound. It changes quickly to sulfuric acid, which irritates our eyes and causes the tears. Put the onion under water when slicing it to reduce the effect.

GARLIC. This onion relative is another ancient plant. We have Egyptian inscriptions from 3200 BCE. In those days, garlic had a number of ceremonial uses. The Greeks and Romans ascribed magical properties to the plant. It was offered to the gods. Warriors ate it for added strength. It was also tied around babies necks to ward off evil spirits. Its medicinal uses also date to ancient times. Garlic was used to treat eczema, toothaches, and snake bites.

SHALLOTS. Shallots are not simply baby onions. They are a type of slender onion with a long neck and copper skins. They have a more delicate flavor and they dissolve more easily in liquids during cooking.

LEEKS. This plant was also used by the ancient Greeks, Romans, and Egyptians. It is sometimes called the "King of the soup onions."

CABBAGE AND ITS ALLIES

We have been eating *Brassica oleracea* for thousands of years. It was a favorite of the Greeks and Romans. The Emperor Claudius once asked the Senate of Rome to confirm that corned beef and cabbage was indeed the best dinner dish. Its wild ancestor may still be found along the coasts of Great Britain and Europe.

Today cabbages are cultivated in almost every country, from the Arctic to the subtropics. This single species is the source of an amazing variety of leaf, stem, and root crops. Some yield edible leaves, as in **kale** and **collards**; **kohlrabi** is an aerial stem; **broccoli** and **cauliflower** are edible leafy buds and immature flower clusters, respectively. **Head cabbage** is essentially a large bud made up of numerous broad leaves. It is about 91% water, along with some lime salts and proteins. **Slaw** is merely uncooked cabbage. In this form it is not too easily digested and it is often boiled or steamed. We also eat partially decomposed cabbage leaves in the form of **sauerkraut**.

Cabbage has a characteristic odor when cooked. At about the point when the leaves begin to soften, they give off hydrogen sulfide. This is the smell that we associate with rotten eggs and sewer gases.

OTHER EDIBLE LEAVES

ARUGULA. Also known as rocket, *Eruca sativa* is a member of the mustard family. It is native to Eurasia. I have added it to the syllabus because arugula is showing up in our markets, especially in the fancy salad mixes. For a long time, its bitter, peppery flavor was not that popular with Americans. The ancient Greeks and Romans enjoyed arugula. They ate it as an aphrodisiac, to balance the "dampening" effect of lettuce. Arugula adorned statues of Priapus, son of Aphrodite and Dionysus, and himself the Greek god of fertility. He was also the protector of gardens and herbs.

LETTUCE. *Lactuca sativa*, a member of the sunflower family, is derived from the weedy wild lettuce (*L. serriola*) that is native to southern Europe and Asia. As in the cabbages, lettuce is another ancient plant. Early on it was used for a variety of medicinal purposes. The leaves contain alcohols that have a soporific effect. Lettuce is 95% water; it has little food value. Several hundred cultivars are now in use.

RHUBARB. *Rheum rhabarbaratum* is native to Asia. It is one of the very few food plants in which we eat the leaf stalk (petiole) and throw everything else away. Many people mistakenly believe that the edible portion is the stem and that the leaf is poisonous. It is the leaf stalk that is edible and the leaf blade that must be discarded. The petiole is about 95% water, along with citric and malic acids. The blade contains oxalic acids, soluble oxalates, and other toxic substances in high enough concentrations to cause poisoning and even death in humans.

CELERY. *Apium graveolens*, a member of the carrot family, is native to coastal marshes in Eurasia. Its early history is that of a medicinal plant, touted as a cure for impotence, hangovers, constipation, and for its diuretic effects. Plants contain a family of chemicals called **psoralens**, that can cause severe allergic reactions in sensitive individuals. It is an occupational hazard among celery pickers.

SPINACH. *Spinacia oleracea* is probably the most commonly consumed of the "greens." Spinach is native to Southwest Asia. It was first cultivated in Persia, thousands of years ago. It came to Europe via the Arab world. Italians are said to be especially fond of spinach, which gives rise to the phrase *a la florentine*, which means a dish made with spinach. The amount of soluble oxalate in its tissues can be high enough to cause poisoning under improper dietary conditions. About half of the U. S. crop is grown here in California; Texas is the other leading producer.

NEW ZEALAND SPINACH. *Tetragonia tetragonioides* is a member of the ice plant family and not at all related to spinach. It is native to the islands of the Pacific and to New Zealand. It was named by Captain Cook when he was in that part of the world in 1771. Here in California, you will encounter this plant as a weedy escape along the coast.

EDIBLE AERIAL STEMS

ASPARAGUS. *Asparagus officinalis*, a member of the lily family, is native to the eastern Mediterranean. Its young shoots, spears, are typically boiled or steamed. It has been a favorite food plant since the time of the ancient Greeks and Romans. Originally it was a medicinal plant, eaten for its diuretic effects. Our most popular cultivar, "Mary Washington," was developed by the U. S. Dept. of Agriculture. Asparagus has other uses. Its seeds have been used as a coffee substitute and its stems for paper-making.

And then, there is that little problem associated with eating asparagus. As Lemery noted in 1702, "*They cause a filthy and disagreeable Smell in the Urine, as every Body knows*." As it turns out, some of us secrete this smelly urine, and some of us do not. Perhaps it was under genetic control. It now appears that all of us make this sulfur-containing compound (methyl mercaptan), but we vary in our ability to detect it. In other words, this explains why some of you know what I am talking about in this paragraph and others are scratching their heads.

Caesar Augustus defined haste as "*quicker than you can cook asparagus*."

FLOWER CLUSTERS/HEADS

ARTICHOKE. Cynara scolymus is native to the Mediterranean and to the Canary Islands. Today it is widely planted and grows best along sea coasts. The plant is a member of the thistle tribe of the sunflower family. The edible portion is a head of tiny flowers surrounded by a series of bracts, modified leaves. We like to eat a coating found on the bracts and the artichoke heart, the tissue to which the immature flowers are attached. When the artichoke was first grown, it was the regular foliage leaves that were consumed. The plant has little food value. It has been suggested that, "*Eating an artichoke is like getting to know someone really well!*"

CARDOON. A close relative of the artichoke is the cardoon (*Cynara cardunculus*). The blanched leaves are the edible part of this plant. They are covered with black plastic bags or with newspaper to keep out the sunlight. The pale green leaves are typically harvested in the fall. They taste like artichoke x asparagus x salsify.

CAULIFLOWER. *Brassica oleracea* var. *botrytis* is an Old World plant, probably native to the Near East. We have been eating cauliflower for at least 2500 years. It reached the U. S. in the 17th century, being grown first in Long Island, New York.

The edible portion, the curd, is a mass of undeveloped flower buds that are attached to branches that are, in turn, from a central stalk. They come in white, green, and purple. The surrounding leaves are used to cover the curd in the cvs. that will be white. Cutting off the sunlight prevents chlorophyll and other pigments from forming. The curd may be eaten raw or cooked. **Broccoflower** is a cauliflower x broccoli hybrid.

As Mark Twain noted, "*Cauliflower is nothing more than cabbage with a college education.*"

EDIBLE FLOWERS, LEAVES, AND AERIAL STEMS

Common Name (Scientific Name)	Family	Comments
artichoke *(Cynara scolymus)*	Sunflower	Domesticated in Mediterranean
arugula *(Eruca vesicaria)*	Mustard	Pungent leaves; Mediterranean
asparagus *(Asparagus officinalis)*	Lily	Native to Mediterranean
bamboo *(Bambusa* and other genera*)*	Grass	Young shoots widely used
broccoli *(Brassica oleracea)*	Mustard	Stems, lvs, and flws used
Brussel sprouts *(Brassica oleracea)*	Mustard	Leafy buds eaten
cabbage, Chinese *(Brassica oleracea)*	Mustard	Primarily Oriental crop
cabbage, common *(Brassica oleracea)*	Mustard	In use for 8000 years
cabbage palm *(various genera)*	Palm	Central leafy bud eaten
cardoon *(Cynara cardunculus)*	Sunflower	Blanched leaves eaten
cauliflower *(Brassica oleracea)*	Mustard	Immature flower cluster eaten
celery *(Apium graveolens)*	Carrot	Domesticated in Mediterranean
chard *(Beta vulgaris* var. *cicla)*	Goosefoot	Beet relative without swollen root
chervil *(Anthriscus cerefolium)*	Carrot	Native to Europe and Near East
Chinese-spinach *(Amaranthus tricolor)*	Pigweed	Long use in Orient
chives *(Allium schoenoprasum)*	Lily	Native to Old World
collards *(Brassica oleracea)*	Mustard	Southern U. S. favorite
cress, garden *(Lepidium sativum)*	Mustard	European salad plant
cress, spring *(Barbarea verna)*	Mustard	European salad plant
cress, water *(Nasturtium officinale)*	Mustard	Favorite wild edible plant
dandelion *(Taraxacum officinale)*	Sunflower	Tender, young leaves eaten
endive *(Cichorium endivia)*	Sunflower	Relative of chicory
escarole *(Cichorium endivia)*	Sunflower	Another name for endive
kale *(Brassica oleracea)*	Mustard	Southern U. S. favorite
lettuce *(Lactuca sativa)*	Sunflower	Asiatic; giant leafy bud eaten
mustard, Indian *(Brassica juncea)*	Mustard	Native to Central Asia
mustard, leaf *(Brassica juncea)*	Mustard	Another name for Indian mustard
N. Zealand spinach *(Tetragonia tetragonioides)*	Mollugo	Native to Old World
pak-choi *(Brassica pekinensis)*	Mustard	Also called Chinese cabbage
parsley *(Petroselinum crispum)*	Mustard	Used as garnish and flavoring
pe-tsai *(Brassica rapa)*	Mustard	Autumn and winter vegetable
pokeweed *(Phytolacca americana)*	Pokeweed	Southern U. S. favorite; also toxic
radicchio (radiccio) *(Cichorium intybus)*	Sunflower	Leaves red-purple, white-veined
rhubarb *(Rheum rhabarbarum)*	Knotweed	Petiole eaten; blade toxic!
samphire *(Salicornia* spp.*)*	Goosefoot	Leaves and stems eaten; coastal
sea kale *(Crambe maritima)*	Mustard	European plant
shungiku *(Chrysanthemum coronarium)*	Sunflower	Cooked vegetable and ornamental
spinach *(Spinacia oleracea)*	Goosefoot	Leaves toxic in large amounts
tampala *(Amaranthus tricolor)*	Pigweed	South American favorite
udo *(Aralia cordata)*	Spikenard	Favorite in Japan
water-spinach *(Ipomoea aquatica)*	Morning glory	Native to Old World
witloof *(Cichorium endivia)*	Sunflower	Another name for endive

5.5 • MAJOR CEREALS

"All flesh is grass." (Book of Isaiah, 40:6)

"No civilization worthy of the name has ever been founded on any agricultural basis other than the cereals." (Paul Mangelsdorf)

INTRODUCTION

The great civilizations, past and present, have been based upon agriculture. These agricultural systems, in turn, have been founded upon a handful of cereals or grains. Those of the Near and Middle East, notably those of Greece, Rome, and Egypt, were based primarily on wheat; as were those of Europe and later North America. The well-developed agriculture of the Maya, Aztecs, and Incas rested on maize. The great societies of China, India, and the Far East were based upon rice. While all of the great civilizations cultivated many different kinds of plants for a variety of purposes, it is almost impossible to overestimate the importance of the cereals. We devote 70% of our farmland to growing cereals and we derive about 50% of our calories from them. As a group they are, without question, the most important source of our food and they have been throughout our entire cultural history.

WHY SO IMPORTANT? There are several features of cereals that make them useful to us. They are annuals, which means that we can rely on getting a crop in a relatively short time. They are also adaptable and efficient producers of food. The yield per hectare/acre is high. Cereals are very nutritious. Grains can be easily harvested, cleaned, and processed.

NUTRITIONAL VALUE. The cereal grain contains a carbohydrate-rich tissue called **endosperm**, which serves as food for the germinating embryo. The embryo itself contains oils and about 8-15 % protein. Vitamins and minerals are also present. The amino acids cysteine and methionine occur at levels adequate to meet our needs. Other amino acids, notably lysine and tryptophan, may be insufficient, depending on the cereal consumed. See the table below for amino acid content. Cereals are also deficient in calcium and Vitamin C.

TRUE AND FALSE CEREALS

All of the **true cereals** belong to the grass family. It is common to recognize maize (corn), rice, and wheat as the **major cereals**. Barley, rye, and oats are the better known **minor cereals**. In addition to the true cereals is an artificial group of plants called the **false cereals**. They are characterized by small, grain-like fruits. Sunflower and buckwheat "seeds" are perhaps the best known examples.

The most important part of the cereal plant is its seed-like fruit, the **caryopsis**. It is more commonly known as a **grain** or a **berry**. It contains a single seed whose outer coat is fused to the inner wall of the fruit. The outer layer of the grain (ovary wall and seed coat) are often called **bran**; the embryo within the grain is the **germ**. Hulled and crushed grains are called **groats**.

The caryopsis is found within a very complicated structure called a **spikelet**. It is a highly modified and reduced flower system. The spikelet is composed of a central stalk, a series of tiny overlapping bracts, and very small flowers. Some spikelets, as in those of the rice plant, may yield only one grain; those of oats will produce more than one. The caryopsis is typically enclosed by two bracts, the **palea** and **lemma**. In common parlance they are called **hulls**. These bracts may be fused to the grain or free from it. This is not a trivial matter when it comes to the processing of the cereal grains.

WHEAT

Triticum aestivum is most widely cultivated crop plant. It is the second oldest cereal, after barley. Archeological remains dating to 6700 B. P. have been found in Jarmo, Iraq. These were relatively primitive wheats. But, even the advanced bread wheat is known from 5000 BCE. from the Nile Valley. Wheat was brought to the New World by the Spanish in 1529. It has been in cultivated in the United States since about 1602.

Today there are literally tens of thousands of cultivars of wheat. They are classified informally as follows:

Winter wheats are planted in the fall, remain dormant during the winter, and then mature in the early summer. Winter wheats are grown in the United States from Texas to South Dakota.

Spring wheat is planted in the spring and matures that same summer. It is adapted for growing seasons as short as 90 days. Spring wheat is grown in the northern regions of the U. S. and Canada. It is are hardy as far north as the Arctic Circle.

Hard wheat has a protein content of 13-16%, more than does soft wheat. It is typically used to make long lasting breads. These cultivars are usually grown in areas of low rainfall.

Soft wheat grains have about 8-11% protein and they are often used for pastries and breads that will be consumed quickly, such as French bread. They are grown in more humid regions.

One of the popular cereals is **bulgur wheat.** It consists of kernels that have been steamed, dried, and then crushed. In that sense, it is a kind of cracked wheat; but not all cracked wheat is bulgur wheat. It is a staple in the Middle East countries. We also see it in salads, such as tabbouleh.

Semolina is made from very hard strains of durum wheat. Its flour is tough and it will not become a starchy paste when cooked. Bakery products made from it tend to be of a light texture. It is also used to make a variety of puddings.

Kamut is a relative of durum wheat. The name comes from the ancient Egyptian name for wheat. Its grains are two or three times larger than regular wheat, its protein content much higher, and it also contains significant amounts of other nutrients. Look for it in hippie food stores; otherwise it is not commonly encountered.

SPECIES OF WHEAT (*TRITICUM*)

There are about 14-16 commonly recognized species of wheat. They fall easily into three groups, differing in chromosome number and morphology. In *Triticum*, x = 7. Two of the wheats are diploid (2x = 14); eight are tetraploids (4x = 28); and six are hexaploids (6x = 42). A more detailed summary is presented below. The diploids and tetraploids are of little economic importance, except for durum or macaroni wheat.

Species (common name)	**Chromosome Set**
Diploids [2n = 2x = 14]:	
T. boeoticum (wild einkorn)	AA
T. monococcum (einkorn)	AA
Tetraploids [2n = 4x = 28]:	
T. dicoccoides (wild emmer wheat)	AABB
T. dicoccon (emmer wheat)	AABB
T. durum (durum or macaroni)	AABB
T. turgidum (poulard or rivet)	AABB
T. polonicum (Polish wheat)	AABB
T. carthlicum (Persian wheat)	AABB
T. timopheevii (Timopheevi wheat)	AAGG
T. araraticum	AAGG
Hexaploids [2n = 6x = 42]:	
T. spelta (spelt wheat)	AABBDD
T. macha (macha wheat)	AABBDD
T. vavilovii (Vavilov's wheat)	AABBDD
T. compactum (club wheat)	AABBDD
T. sphaerococcum (shot wheat)	AABBDD
T. aestivum (bread wheat)	AABBDD

* This summary is modified after Simmons, N. W. (editor). 1976. Evolution of crop plants. Longman. London, England. P. 121. The nomenclature for the various wheat species follows Terrell, et al. (1986).

EVOLUTION OF BREAD WHEAT

As you can see from this table, bread wheat and its immediate relatives are hexaploids; they have six complete sets of chromosomes. Each set contains seven chromosomes. Further inspection will show that the six sets are not six different sets, but three of them (A, B, & D) in duplicate. In other words, bread wheat contains three different genomes, each represented twice. The evolutionary process that led to our modern day bread wheat began with a natural, spontaneous crossing of a wild einkorn wheat with a kind of goat grass (*Aegilops speltoides*) that occurred in the same area. Both were diploids (2x = 14). This primitive wheat is the source of the A genome in modern bread wheat; the goat grass is the donor of the B genome. The hybrid that resulted from the natural crossings would be designated AB and it was at least partially sterile because of the differences in the chromosomes in the A and B sets (genomes). Eventually, by a procedure in which unreduced gametes (egg and sperm nuclei that have twice as many chromosomes as they ought to have) combine, the chromosome complement in these primitive hybrids doubled. The result was wild emmer wheat with 28 chromosomes (AABB). The inhabitants of the Near East domesticated this grass and used it along with einkorn wheat.

A few thousand years later, a domesticated form of emmer wheat crossed spontaneously with a second kind of goat grass (*Aegilops squarrosa*). It has been identified as the source of the D genome in modern bread wheat. Again, the immediate result of this hybridization was a sterile grass with three genomes (ABD) and a chromosome number of 21. The union of unreduced gametes would eventually yield offspring that were AABBDD.

Here is the same explanation, this time in the form of a diagram.

PHASE I: DIPLOID TO TETRAPLOID

Triticum boeoticum		*Aegilops speltoides*
(wild einkorn wheat)		(goat grass)
[2n = 2x = 14]	X	[2n = 2x = 14]
[genome: AA]		[genome: BB]

▾
Sterile First Generation Hybrid
[2n = 2x = 14]
[genomes: AB]
▾
Unreduced Gametes
("chromosome doubling")
▾
Triticum dicoccoides
(wild emmer wheat)
[2n = 4x = 28]
[genomes: AABB]
▾
Domestication
▾
▾
Triticum dicoccum
(cultivated emmer wheat)
[2n = 4x = 28]
[genomes: AABB]

PHASE II: TETRAPLOID TO HEXAPLOID

Triticum dicoccum		*Aegilops squarrosa*
(cultivated emmer wheat)		(goat grass)
[2n = 4x = 28]	X	[2n = 2x = 14]
[genomes: AABB]		[genomes: DD]

▾
Sterile Hybrid
[2n = 3x = 21]
[genomes: ABD]
▾
Unreduced Gametes
("chromosome doubling")
▾
Triticum aestivum
(bread wheat)
[2n = 6x = 42]
[genomes: AABBDD]
▾
Domestication
▾
Hulled/free-threshing cultivars
▾
Recent domestication/genetic engineering

BREAD MAKING

"*There is not a thing which is more positive than bread.*" (Feodor Dostoyevsky)

"*Thinkst thou such force in bread?*" (John Milton)

"*Everything is food, but bread is the great mother.*" (Hindu scripture)

"Bread made from wheat, as compared with that made from barley, is more nourishing, more digestible

and in every way superior." (Sophilis of Siphonos, 100 BCE)

"Wheat is stronger and more nourishing than barley, but both it and its gruel are less laxative. Bread made of it without separating the bran dries and passes, when cleaned from the bran it nourishes more, but is less laxative." (Hippocrates, ca. 400 BCE)

☼ ☼ ☼ ☼ ☼

HISTORY. As Hindu scripture suggests, bread is clearly one of our most important foods. Three common English words also speak to its significance. A "lord" is the keeper of the loaf; a "lady" is the kneader of the loaf; a "companion" is a person with whom we eat bread.

To most of us, bread is a dough made from wheat flour and water that is baked in an oven. A broader definition recognizes that bread may be made from carbohydrate sources other than wheat and that it may be deep-fried, cooked on a griddle, or poached and then baked, in the case of the bagel. Bread is an ancient foodstuff, older than our recorded history. In its earliest form, bread was probably a gooey dough of wild cereal grains mixed with water. It evolved out of more watery gruels, grouts, or porridges. The grains had been beaten between two rocks to crack them. The mass was parched and then formed into flat cakes that could be cooked on hot stones. Crushing and parching also separated the grain itself from hulls that adhered to it. The domestication of wheat brought about a critical improvement -- varieties that could be easily husked.

About 6000 years ago, the Egyptians discovered that uncooked dough would begin to bubble and to give off a characteristic sour smell if left alone for a few hours. When cooked, this version of dough made a lighter, more palatable **leavened** bread. They quickly found that a small piece of the soured dough would produce this same effect in freshly made dough. So did soaking crushed wheat grains in white wine for about three days. The relationship between brewing and bread making has always been an intimate one. The Egyptians became master bread makers, adding honey, eggs, and various aromatic substances to their creations. They formed the dough into a loaves of various shapes and baked them in a ovens of their own design. They were a two-chambered oven, shaped like a bee hive. The fire was maintained in the lower compartment and the baking occurred in the upper section.

The Greeks and Romans were also skilled bakers. Because they drank wine, fermented grape juice was their source of yeast. Pliny noted, however, that the barbarians in Spain and France who were beer drinkers managed to make a lighter loaf of bread by using scrapings from the beer vats. The Romans developed the first rotary mill powered by animals, by slaves, or by running water. A thousand years later, Europeans would adopt an Arab invention, the windmill. Cereal grains were crushed between a stationary lower mill stone and an upper one that rotated. Milling does two things. It separates the endosperm from the bran (the outer layers of the grain) and from the germ (the oily embryo). It also reduces the starchy endosperm to a fine powder, the flour. Flour comes from the same root word as "flower," meaning that it is the best part of the grain. The Romans were probably the first to establish commercial bakeries. Large stone bowls with wooden paddles to mix and knead dough allowed large quantities of dough to be processed. Knowledge of these techniques spread with the Roman army. By the way, since the days of the ancient Greeks and Romans white bread made from refined flour has been considered far superior to the coarser, darker breads. The upper class has eaten white bread; the poorer folk and those in prison ate unleavened bread made from barley, oats, or rye.

The invention of the steam engine by James Watt in 1769 allowed for significant technological advancements. In 1834, Jacob Sulzburger developed the steam-powered milling machine that used steel rollers. In 1870, Edmund La Croix invented a way of separating the middlings (bran, germ, and other coarse materials) from the starchy endosperm. Rollers cracked the cereal grain, rather than crushing it. The grains were then passed through a series of screens of increasingly finer mesh. Air currents blew away impurities; the bran and germ were also sifted off.

BIOLOGY AND CHEMISTRY. When the ancient Egyptians noticed that soured dough gave off bubbles and a particular smell, they were observing the activity of air-borne, wild yeasts that had gotten into the dough and were now carrying out their life processes. Yeasts are microscopic, one-celled fungi. The particular species that is important in bread making is the same one used in brewing, *Saccharomyces cerevisiae*. The name translates roughly as "brewer's sugar fungus." The yeast cells convert the starchy endosperm in the dough to carbon dioxide and alcohol. The chemical process is starch --> glucose --> 2 pyruvic acid --> 2 CO_2 + 2 ethyl alcohol. The carbon dioxide is trapped in the dough and forms gas pockets. Baking the dough increased the generation of carbon dioxide. The alcohol (ethanol or ethyl alcohol) escapes from the baking bread and explains, at least partially, the characteristic aroma that we find so pleasing. Of course, at a certain stage during baking, the temperature rises to a point at which the yeasts are killed. One pound of dough contains about three billion yeast cells. Did they suffer?

All carbohydrate sources will be worked on by the yeast cells in the same fashion. One cereal grain, wheat, is especially well suited to bread making because it contains two proteins, **glutenin** and **gliadin**, that combine when moistened to form an elastic substance called **gluten**. When wheat dough is kneaded, gluten will absorb up to twice its weight in water and it will form a three dimensional mesh or matrix that traps carbon dioxide and stabilizes it. Otherwise, the raised dough would collapse at some point during the baking process. Kneading strengthens the gluten structure, increasing its ability to stretch. When you purchase lighter, fluffier breads made from rye or some other grain, these have wheat flour in them to impart this feature. This special feature of wheat helps to explain why breadmaking was not an important aspect of life in regions where rice predominates or starchy root crops are the primary carbohydrate source.

The production of carbon dioxide by yeast cells is not the only mechanism for making raised or leavened breads. Much later, we discovered that ash made from a hardwood, when soaked in water, would yield carbon dioxide when heated. This hardwood ash is, for all practical purposes, lye. In the last century, baking soda was developed. It is sodium bicarbonate ($NaHCO_3$), an alkaline substance that imparts an unpleasant taste to the bread unless it was neutralized by an acid of some sort. Buttermilk and fruit juices have been traditional sources. French bread is made from milk, butter, and beer leavening. Baking powder, sodium bicarbonate combined with cream of tartar to supply the acidic neutralizer, was developed in the 1840's. The chemical process is sodium bicarbonate + tartaric acid --> sodium tartrate + water + carbon dioxide. In 1855, packaged baking soda, cream of tartar, and cornstarch to absorb excess moisture was developed. In 1867, Charles and Maximillian Fleischmann, two Austrian bakers, started the yeast-making industry in the United States. Yeast cells were grown in a sugar solution. Then excess water was removed and the yeast was mixed with starch, compressed into cakes, and packed in balsa wood boxes. Dry yeast cakes, developed during World War II, became available for widespread use after 1945. European scientists had also developed the techniques needed to grow particular strains of yeasts for a variety of special purposes, including those of the baker.

The flour that we use today is typically bleached and aged. Bleaching yields the uniform white color that many of us find aesthetically appealing. Chlorine dioxide is often the bleaching agent. If you allow flour to sit around, the oxygen in the atmosphere will accomplish the same result. Unbleached flour has a yellow cast to it, the result of pigments called xanthophylls. Various products made from semolina wheat, such as pastas, use unbleached flour. The bleaching process also destroys small amounts of Vitamin E. "Aged" or "improved" flour has better baking qualities. Aging allows important changes in gluten to occur.

You might think that bread making is a dull, noncontroversial subject. You would be wrong! In 1861, Eben Horsford, a Harvard professor (there-fore, immediately suspect) warned that yeast cells were poisonous molds and should not be used. After all, they were microbes -- germs. Instead, he suggested a baking powder made from lime and sodium phosphate, both of which are found in the human body. At about the same time, a pamphlet was distributed that argued that the bread of the day was "*... rotted by fermentation or poisoned with acids and alkalis, [so that] the staff of life has well become the staff of death.*" The so-called Boston Water Cure urged use of an oven that was so hot that dough would be puffed up by the sudden expansion of air and vaporized water. The result was a loaf of bread that was amazingly dense and unpopular. In the 19th century, there was also concern abut the adulteration of bakers' bread with alum, chalk, and ground up human bones!

WHITE OR BROWN BREAD? A rephrasing of the quote from Hippocrates cited above suggests that brown bread has a laxative effect on us and that white bread is more nutritious. This is consistent with a view espoused by the ancient Greeks and Romans -- white bread is better than brown bread made from whole wheat grains or from grains other than wheat. This opinion persisted, more or less unchallenged, until the 19th century. The Reverend Sylvester Graham and Dr. John Harvey Kellogg, inventor of the Graham Cracker and one of the brothers who founded Kellogg Cereals, were vocal advocates of the superiority of whole grain cereals. Graham wrote that separating the endosperm from the bran was akin to "... put[ting] asunder what God has joined together...." Kellogg focused his attention on the laxative effects of the bran component. He believed that we ought to have three or more bowel movements each day to prevent the build up of intestinal poisons.

The views of Graham and Kellogg gained credibility with the appearance of studies in the 1970's on dietary fiber. These suggested that the higher the intake of these indigestible cell wall components, the lower the risk of intestinal disorders, hemorrhoids, and cancer of the colon and rectum. Brown bread has more nutrients in it than white bread and it clearly has a higher fiber content. The irony is that, "*... because the cellulosic material of the bran cannot be digested and tends to speed the passage of food through the human digestive tract, the total nutritive contribution of whole wheat flour is less than that found in enriched white flour products.*" (Pomeranz, 1973)

RICE

"Grain upon grain, fresh and delightful as frost
a dazzling jewel
to what can I compare this treasure?"
(Yang Ji, Ming Dynasty poet)

There are 20-25 species in the genus *Oryza*, but only two are of economic significance. Asian rice, *Oryza sativa*, is the principal food for about 60% of the world's population. There is some question as to its nativity. Some experts say it is native to India; others to southwest China or southeast Asia. It has been cultivated in southeast Asia for at least 7000 years. Sealed pots of rice 8000 years old have been found in China. Literally thousands of cultivars have been developed, 8000 of them in India alone. Asian rice was introduced into America in 1647. *Oryza glaberrima*, red rice or African rice, is native to Africa and has been used locally there for about 3500 years.

Unlike wheat, most kinds of rice are diploid ($2n = 2x = 24$). It is usually grown in a swampy field known as a paddy. This helps to explain why so much rice is raised in the monsoon belt where heavy seasonal rainfall is used. In most instances, rice seeds are not planted directly in the paddies. Instead there are nurseries where seedlings are started and then transferred. The seedlings are planted in small bunches, each clump about 4-16" from the next one. Most cultivated strains require flooding, this being accomplished by taking advantage of the monsoons and by the skillful manipulation of dikes in the paddies. There are also cultivars called upland rices that can be grown in drier fields.

At maturity, most rice plants are 4-6 ft. tall; some deep water varieties reach 20 ft. Once the plants have flowered, the water level is reduced and finally the supply is shut off entirely and the fields allowed to dry. When the plants begin to wither, it is time to harvest the crop. In the Old World, the harvesting and threshing processes are done by hand. In the U.S. and other technologically advanced countries, much of this is done by machine. In this country, Arkansas, Louisiana, Mississippi, and California are the main rice growing states.

KINDS OF RICE. We commonly recognize three types of rice based upon the length of the grain: **long**: tropical rices; not too soft nor starchy; grains 7-8 mm long, the length prized by the connoisseur; **medium**: commonly grown in the U. S.; somewhat softer; grains averaging about 6.6 mm long; **short**: grown in the more northern climates, often planted in Japan; even more starchy; grains averaging about 5.5 mm long.

Rice cultivars vary in the "stickiness" of their grains. This is a function of the proportion of **amylose** and **amylopectin**, two types of starch. The higher the amylopectin, the stickier the rice. The range is about 70% in the least sticky to about 83% in the stickiest.

Brown rice has not had its nutrient-rich outer layers removed during processing. In other words, it has not been pearled or polished. Given its nutritional superiority, why do we eat white rice? Because brown rice is harder to cook, tougher, not as sticky, goes rancid more rapidly, is more susceptible to insects, and has been considered aesthetically inferior to white rice since ancient times.

Converted rice has been steeped, steamed, and dried before it is milled. The technique was developed about 2000 years ago in India and Pakistan. Several changes occur, including diffusion of Vit. B from the bran and germ into the endosperm.

In the 1904 World's Fair, Quaker oats introduced **puffed rice**, the "cereal that was shot from guns." They used a canon from the Spanish-American War! Today's puffed rice is prepared in pressure cookers, with the pressure released at the last minute to puff the rice.

Basmati rice was originally grown in the foothills of the Himalayas, where it has been used for thousands of years. It is a long-grained rice that is aged to reduce moisture content. Basmati rice is particularly popular in Middle Eastern and Indian markets. The grains are yellow and have a characteristic sweet, nutty aroma and flavor.

NUTRITIVE VALUE. The intact grain is a good source of iron, calcium, magnesium, selenium, vitamin E, the B vitamins, and an essential fatty acid, alpha linoleic acid. However, people who subsist on polished rice are more likely to suffer from **beriberi**, brought on by a deficiency in vitamin B1 (thiamine). Sensory nerves are affected, starting with the feet and working upward in the body. In one form of the disease, congestive heart failure occurs.

MAIZE OR CORN

"... a sort of grain they called maiz which was well tasted, bak'd, dry'd and made into flour."
(Christopher Columbus, 5 November 1492)

"This Corne is a marveilous strange plante, nothing resembling any other kinde of grayne."
(H. Lyte, 1578)

☼ ☼ ☼ ☼ ☼

First, a word about the common name of *Zea mays*. In this country, we usually call this plant corn or Indian corn. Maize is a better common name (and a perfectly legitimate one) because corn is used by other English-speaking peoples around the world for what we would call wheat, oats, or as a generic term for cereal grains. This explains the use of the word "corn" in the Hebrew Bible and other ancient texts, since what we call corn would have been unknown to them.

There are three features of maize that make it different from wheat, rice, or any other cereal. It is the only important cereal that is native to the New World. Second, maize as we known it today is considerably different in appearance from its wild ancestors. The progenitors of the other cereals are basically the same in general appearance as their modern derivatives. Maize is strikingly distinct. And third, maize is unique among the major cereals in having separate male and female flowers borne on entirely different parts of the plant. The male flowers are found on the branches of the tassel, while the female flowers are clustered in the ear, the complex fruiting structure that bears an even number of rows of caryopses, or kernels as they are commonly called.

Maize has many uses. In this country, about 90% of the crop goes into livestock food. In many other countries, maize is a very important food for humans. It is inferior to wheat and to some other cereals in its protein content. This means that maize flour products are less tasty than those made from rye or wheat. Maize flour, however, has been the mainstay of many peoples in Central and South America. **Hominy** is dried, hulled maize kernels that are cooked in various ways. The word comes from the Algonquian language. Hominy was one of the first Native American foods that was accepted by the early European settlers in the 17th century. Lime (the mineral, not the fruit) or lye (from wood ash) is used to help loosen the hulls. **Grits** is made from finely ground hominy. It is sometimes called hominy grits. Look for it south of the Mason and Dixon Line. I discovered many years ago on my first collecting trip into the South that grits were served with just about anything that you ordered, especially for breakfast.

Other important products from maize include corn starch, corn oil, alcoholic beverages, and silage. As one author noted, maize is with us from cradle to grave – literally. It is in baby powder and in embalming fluid!

TYPES OF MAIZE

There are six main types of maize in use today:

flint: kernel made of hard starch; in use by Native Americans at the time of Columbus; widely used in the northern corn belt;

dent: kernel of hard starch, capped by soft starch that dries to leave a small depression in the top of the grain; economically the most important maize; much used in the corn belt;

flour: kernel consists almost entirely of soft starch; used by the Native Americans of the Southwest and those in South America for hand grinding;

sweet: kernels with high sugar content, consumed while immature; most widely grown for human consumption here and in Europe;

pop: kernels lacking soft starch, cells burst upon heating because of high water content of central cells; related to flint corn;

pod: peculiar type with comparatively little economic importance; kernel enclosed by bracts; considered by some to be the ancestor of modern maize.

THE RELATIVES OF MAIZE

Maize has two close relatives -- gama grass and teosinte. There are about seven species of gama grasses (*Tripsacum* spp.), found from the central portion of the U. S. to southern Brazil. All of them are perennials. The male and female flowers are separate from one another, as in maize, but they are not in the tassel and ear configuration.

There are three kinds of teosinte, all occurring in Mexico and Central America. Traditionally, teosinte has been placed in its own genus (*Euchlaena*), but in more recent works the species have been put in *Zea*. The male flowers are borne in a tassel at the top of the plant; the female flowers are borne on a spike on the lower parts of the plant.

THE ORIGIN OF MODERN MAIZE

For much of the last century, the identity of the grass that gave rise to maize has been the subject of much controversy. Most of the botanists and geneticist who studied the matter belonged to one of two camps. They are either teosinte people, followers of George Beadle, or pod corn people, followers of Paul Mangelsdorf and Richard Reeves. Those who believe that teosinte was the ancestor of modern maize point out how easily it can be crossed with maize. They note that the conversion of the hard bracts surrounding the grains on the teosinte "ear" into soft structures would produce a maize-like ear. Hugh Iltis, a botanist at the Univ. of Wisconsin, has suggested that it was the conversion of male flowers, with their softer bracts, that was actually involved.

The more widely held view was that modern maize originated from a wild form of pod corn and that the variety that we see today in maize is the result of past hybridization between *Zea* and *Tripsacum*, the gama grasses. According to the "Pod Corn Theory," teosinte is not a maize ancestor at all, but the result of natural crosses between maize and gama grasses.

The results of the archeological, botanical, and genetic research into the origin of maize suggest the following:

☼ Maize is native to the New World, more particularly to Mesoamerica. Reports of Pre-Columbian maize from the Old World have not been substantiated.

☼ Domestication of maize began about 10,000 BP.

☼ The ancestor of maize is teosinte, its closest relative.

☼ Teosinte is not a hybrid of maize and gama grass.

☼ Gama grass may have crossed with some primitive forms of maize and thereby contributed to the evolution of modern kinds of maize.

☼ Primitive maize became extinct because it could not compete against more successful cultivated forms and perhaps because of the introduction of grazing animals by the Spanish after the Conquest.

The Beadle school won and the pod corn people, the followers of Paul Mangelsdorf, lost the long battle. He was generous in defeat.

HYBRID MAIZE

One of the great developments in modern agricultural genetics is hybrid corn. The basic principle behind hybrid corn is that stable inbred lines can be crossed with one another to produce more uniform plants with higher yields. Modern hybrid corn involves a double crossing. During the first year, inbred strain A is crossed with B. Self-pollination is prevented during these crosses by removing the male flowers from one strain (detasseling), thereby rendering the plants effectively female. In separate fields, strains C and D are similarly crossed. The seeds from the A x B and from the C x D crosses are planted. These mature into AB and CD individuals. These are then crossed during the second year, yielding the double cross ABCD hybrid seed. It is planted the third year to produce tremendous yields of high-quality seed. The ABCD seed is not true-breeding and must, therefore, be purchased regularly.

CYTOPLASMIC MALE STERILITY

In 1938, Paul Mangelsdorf, a Harvard botanist who devoted his life to the study of maize, discovered a sweet corn variety in Texas that was male sterile. The male flowers of its tassel had shriveled anthers that did not produce fertile pollen grains. Investigation of this plant revealed that the sterility was under genetic control, as opposed to some short-lived environmental problem, such as drought. Sterile sex cells typically result from chromosomal abnormalities, either in their number or structure. However, in this case the corn plant produced sterile pollen when a sterility factor [S] in the cytoplasm of the cell was present at the same time that it had a double recessive gene [rf] in its nucleus. This same kind of phenomenon was first found in onions, and is now known to occur in several crop plants. One possible explanation is that the cytoplasmic sterility is caused by viruses that can survive only if the rf rf condition exists. If the gene is present in the Rf state, fertility is restored. Cytoplasm without the sterility factor is designated N, for "normal." The cytoplasmic factor passes from one generation to the next only via the egg.

Therefore, by using an inbred line that contains the S rf rf genetic combination, male sterile plants are produced. The corn plants are rendered functionally female. The difficulty in finding enough workers and their cost made the male-sterile strains a very attractive alternative to manual detasseling. Within twenty years, practically all of the maize grown in the United States incorporated the male sterility factor first found in the Texas corn plants.

Once again we had made one of our major crop plants more genetically similar to one another, with all of the advantages and disadvantages associated with that uniformity. The bill came due in the summer of 1970. Our corn fields were invaded by a fungus (*Helminthosporium maydis*), which causes the southern leaf blight. The disease spread rapidly, moving from Florida northward at about 150 km per day. By the end of the summer, the blight had covered much of the eastern and central United States. It devastated the Texas male-sterile hybrids, causing more than a $1 billion loss in the corn crop.

"JUMPING GENES"

James Watson, who shared the Nobel Prize with Francis Crick for their discovery of the structure of DNA, said, *"There are really three main figures in the history of genetics -- the three M's: Mendel, Morgan, and McClintock."* Gregor Johann Mendel (1822-1884), an Austrian monk, is often called the father of genetics. His work on the changes that he observed from one generation to the next in pea plants that he grew in the monastery garden is well known -- a standard fixture in all highschool and college texts in biology and genetics. Thomas Hunt Morgan (1866-1945), of Columbia University, along with his wife (Lillian) and his students did research on the fruit fly (*Drosophila melanogaster*). His lab was the first to show that genes were located on chromosomes in the cell nucleus, that genes were located at specific sites on a chromosome, and that traits were passed from parent to offspring through genes. Morgan won the Nobel Prize in 1933 for these fundamental discoveries.

The third "M" is Barbara McClintock (1902-1992). She earned her bachelor's degree in botany from Cornell University, where she was also awarded her master's and doctorate. In 1931, McClintock identified the ten chromosomes of maize, and she co-authored with Harriet Creighton the first paper to describe the genetic phenomenon of crossing-over. In 1944, McClintock identified the seven chromosomes of the bread mold, *Neurospora*, and began her research on mobile genes and controlling elements in maize. She had observed that some plants have leaves with different patterns of pigment in them. In maize, some kernels were white, some solid purple, and some had speckles of purple on otherwise white kernels.

After years of detailed study, McClintock developed a theory to explain what she had seen. The differences in pigmentation of corn kernels was caused by some genes moving from one site on a chromosome to another location, or from one chromosome to another. Further, it appeared to her that other genes acted as switches that turn a gene on and off during plant development. McClintock presented the results of her work in 1951 at a Cold Spring Harbor Symposium. The reaction was mixed. Most of her colleagues failed to understand her work, others rejected it outright, and others thought that poor Barbara had been out in the sun too long playing with her corn plants. One said, that *"... he had never heard anything as ridiculous."* Another, *"I understand that you're doing something that's very strange. I don't want to hear a word about it."* At the other end of the spectrum, the distinguished Caltech geneticist Alfred Sturtevant said, *"I didn't understand one word she said, but if she says it is so, it must be so!"*

What Barbara McClintock had proposed was heresy! Everyone knew that a chromosome was like a necklace and the beads were genes. This bead is always next to that bead in a necklace; this gene is always next to that gene on a chromosome. And she was saying that it ain't necessarily so. In her now classic paper, McClintock concluded that the best explanation for what she was seeing was that a gene did, in fact, actually move from one site on a chromosome to the site of the gene that controlled pigment color. She called it Ds, the dissociator gene. Ds would instruct the color gene. The Ds gene, in turn, was controlled by an activator, Ac.

McClintock called these mobile genetic units **transposons**. Time Magazine called them "jumping genes." It explained McClintock's theory in terms of three characters -- a painter, a boss, and a policeman. The painter is the structural gene that makes a kernel have a particular color. The boss (Ds or dissociator gene) can tell the painter to paint or not to paint. The boss must follow the directions of the police officer (Ac or activator gene), who can tell the boss to let the painter do his job or not. The officer can tell the boss to have the painter stop and then later resume painting. Depending on the interaction of the painter, boss, and policeman, the kernel will be pigmented, speckled, or colorless.

On 10 October 1983, McClintock learned from the radio that she had won the Nobel Prize in Physiology or Medicine. The folks in Stockholm had tried to call her at home, but she didn't have a telephone. She, Marie Curie in 1911, and Dorothy Hodgkin in 1964 are the only three women to receive an unshared Nobel in any field.

McClintock's long-time friend and champion, Marcus Rhoades, said of her work:

"One of the remarkable things about Barbara McClintock's surpassingly beautiful investigations is that they came solely from her own labors. Without technical help of any kind she has by virtue of her boundless energy, her complete devotion to science, her originality and ingenuity, and her quick and high intelligence made a series of significant discoveries unparalleled in the history of cytogenetics. A skilled experimentalist, a master at interpreting cytological detail, a brilliant theoretician, she has had an illuminating and pervasive role in the development of cytology and genetics."

Transposable elements have since been found in many plants and animals. They are best known in maize, fruit flies, yeasts, and humans.

5.6 • MINOR CEREALS

By convention, any true cereal other than wheat, rice, or maize is called a minor cereal. Many of them are unfamiliar to people who live outside the tropics, but in those regions they are very important food plants for us and for our animals.

BARLEY. *Hordeum vulgare* is the fourth leading cereal, in terms of world-wide production. Along with wheat, it was one of the first plants that we domesticated. All of the cultivated species are diploids ($2n = 2x = 14$). Barley differs from wheat, maize, and rice in having three spikelets per node. If all three develop, the spike has the appearance of having six rows of grains, three on each side (the 6-rowed barleys); if the two lateral spikelets are rudimentary, then the spike appears to have two rows of spikelets (the 2-rowed barleys). The two bracts immediately surrounding the grain are fused to it. The grain is pearled, rubbed against abrasive disks to remove the hulls and some of the outer layers of the grain, during the processing for human consumption. The chief use of barley is as animal food. It is a relatively unimportant food for humans. About one-third of the crop is used for making malt used in brewing, flavoring, cereals, icings, coffee substitutes, infant foods, flours, medicinal syrups, candies, and industrial fermentations.

RYE. *Secale cereale* is a plant of cool, non-humid regions. It is grown chiefly in northern Europe. In the U. S., North and South Dakota and Nebraska grow the most rye. The species is diploid ($2n = 2x = 14$). It is now unknown in the wild. Most rye is fed to cattle. We use it to make flour for "rye bread" or the famous blackbread (Schwartzbrot) of Germany, Poland, and Russia. Most of our U. S. ryebread has a very high wheat flour content. Rye is also used to make whisky and industrial alcohol.

Ergot *(Claviceps purpurea)* is an important fungal parasite of rye. It causes tremendous crop losses and poisoning in both cattle and humans. More on that subject when we get to medicinal plants.

SORGHUM. The U. S. is the leading producer of *Sorghum bicolor*. The species is believed to be Asian or African in origin. Sorghum was introduced into the U. S. in the mid-1800's. The grains are small and difficult to process. We use the various species mostly for forage and silage, but in the Old World the grains are often eaten like rice or made into an unleavened bread. All of the speciesof the genus are diploids ($2n = 2x = 40$), except Johnson grass, a very aggressive tetraploid weed.

There are four commonly recognized groups of sorghum species, based upon their use:

- ☼ syrup or sorgos, whose stem juices are abundant and sweet;
- ☼ broom-corn, used to make old-style brooms;
- ☼ grain sorghums, such as kaffir, milo, and durra; and
- ☼ grass sorghums, such as Sudan grass, Tunis grass, and Johnson grass, grown for forage and silage.

OATS. The origin of *Avena sativa* is still obscure. There are few references to it in the ancient literature; none, for instance, in the Hebrew Bible. It may have become domesticated in the cultivated fields of barley or of some other crop. It is now grown in temperate regions, chiefly of Europe and North America. The USSR is the leading producer. As in wheat, there are diploid, tetraploid, and hexaploid oats. We use the hexaploids more than the others.

USEFUL SPECIES OF OATS

Scientific (Common) Name	**Genome(s)**
Diploids [2n = 2x = 14]:	
A. brevis (slender oat)	AA
A. strigosa (sand oat)	AsAs
A. nuda (naked oat)	AA
Tetraploids [2n = 4x = 28]:	
A. barbata (slender oat)	AABB
A. abyssinica (Abyssinian oat)	AABB
A. vaviloviana (Vavilov's oat)	AABB
Hexaploids [2n = 6x = 42]:	
A. fatua var. *fatua* (wild oat)	AACCDD
A. fatua var. *sativa* (cultivated o.)	AACCDD
A. sterilis (wild red oat)	AACCDD
A. byzantina (red oat)	AACCDD

Oats, until quite recently, were not widely appreciated, even though they are very nutritious (protein content of 13.8%). Samuel Johnson, in his 1755 dictionary, defined oats as, *"A grain which in England is generally given to horses, but in Scot-land supports the people."*

Oats are used to make flour, rolled oats, and even as a beverage (avena). The crop is often rotated with corn. Iowa is the leading U. S. producer.

Wild Rice. *Zizania* spp. are native to North America. The common name is confusing, because wild rice is not a kind of rice. The plants are robust aquatics. As in maize, the two sexes are found in separate spikelets on different parts of the plant. Native Americans gathered the grains by boat. Until recently, wild rice has eluded cultivation with most of the crop coming from Minnesota. It is now being grown here in California.

JOB'S TEARS. Although native to southeastern Asia, *Coix lacryma-jobi* is now very common through all of the tropical and subtropical regions of the world where its grains are used as food. It is not highly regarded, even though it has a very high protein content. Many of you will have seen these grains because they are also used to make rosaries and tourist trinkets. The common name may derive from an Old Testament figure named Job who experienced great suffering.

MILLETS. This is the group name for a series of true grasses that have small grains. Most of the common ones belong to the genera *Pennisetum, Setaria, Panicum,* and *Eleusine*. They are also used for forage. Most of us in North America and Europe, except for college students who frequent hippie co-op food stores, have never eaten any of the millets and we probably do not appreciate the role that they play in the diet of about one-third of the world's people. We see their relatives as roadside weeds or as constituents in bird seed mix. This unfortunately causes us to underestimate their importance as human food.

THE MINOR CEREALS

Common Name (Scientific Name)	Comment
acha *(Digitaria exilis)*	African; quite palatable and nutritious
Adlay *(Coix lacryma-jobi)*	See Job's tears
African millet *(Eleusine coracana)*	Widely used in China, India, and Africa
barley *(Hordeum vulgare)*	Old World; one of the ancient cereals
barnyard grass *(Echinochloa crusgalli)*	Known to us also as an agricultural weed
broom millet *(Panicum miliaceum)*	Cultivated especially in the Old World
browntop *(Brachiaria ramosa)*	A relative of the *Panicum* cereals
bulrush millet *(Pennisetum americanum)*	A relative of elephant and Napier grass
channel millet *(Echinochloa turnerianum)*	A relative of our barnyard grass
club wheat *(Triticum compactum)*	Grown mostly in Chile, USA, and India
common millet *(Panicum miliaceum)*	In use since prehistoric times; Eurasia
durum wheat *(Triticum durum)*	High in gluten; used to make spaghetti
einkorn wheat *(Triticum monococcum)*	Primitive diploid, 1-seeded wheat
emmer wheat *(Triticum dicoccon)*	Ancient Mediterranean wheat; still used
finger millet *(Eleusine coracana)*	Important cereal in Africa and India
fonio *(Digitaria elixis)*	Used in tropical Africa
foxtail millet *(Setaria italica)*	Native to India; Near East & China
German millet *(Setaria italica)*	See foxtail millet
guinea grass *(Panicum maximum)*	A perennial grass of tropical areas
hog millet *(Panicum miliaceum)*	See common millet
Hungarian millet *(Setaria italica)*	Old World; now widely cultivated
Italian millet *(Setaria italica)*	See Hungarian millet
Japanese millet *(Echinochloa crusgalli)*	See barnyard grass
Job's tears *(Coix lacryma-jobi)*	SE Asia; ornamental use in jewelry
koda millet *(Paspalum commersonii)*	Old World; relative of Dallis and bahia grass
little millet *(Panicum sumatrense)*	Grown extensively in India
manna grass *(Glyceria* spp.*)*	Used especially in North America
naked oat *(Avena nuda)*	Upland regions of China
oats *(Avena* spp.*)*	Hexaploids most important
pearl millet *(Pennisetum glaucum)*	Highly nutritious; hybrids grown in USA
pod corn *(Zea mays)*	A maize with well-developed bracts around grains; S. America
Polish wheat *(Triticum polonicum)*	S. Europe and n. Africa, not Poland
proso millet *(Panicum miliaceum)*	Ancient; grown mostly in USSR and Asia
ragi *(Eleusine coracana)*	See finger millet
rye *(Secale cereale)*	Probably native to southeast Asia
sanwa millet *(Echinochloa frumentacea)*	Used primarily as cereal in Far East
shama millet *(Echinochloa colona)*	Old World; now also a widespread weed
sorghum *(Sorghum bicolor)*	Ancient cereal of Asia and Africa
tartarian oats *(Avena orientalis)*	One-sided spikelet clusters
teff *(Eragrostis tef)*	Ethiopia & African highlands; pancakes
teosinte *(Zea mays* ssp. *mexicana)*	A close relative of maize
teosinte, perennial *(Zea mays* ssp. *diploperennis)*	Recently discovered in Mexico
triticale *(X Triticosecale)*	Artificial wheat/rye hybrid
wild-rice *(Zizania* spp.*)*	Only recently domesticated

5.7 • PSEUDOCEREALS

A few plants produce fruits that somewhat resemble the true grains of the cereals and may be confused with them, particularly if you are terribly far-sighted and have difficulty distinguishing items that have little in common. Because they are derived from plant families other than Gramineae, they are called **false cereals** or **pseudocereals**.

BUCKWHEAT. *Fagopyrum esculentum* is grown in cool, moist regions. The northeastern United States is one of the major production areas. Buckwheat is related to knotweeds, smartweeds, and docks. All are common weeds over much of the country. The pyramid-shaped, one-seeded fruit makes it easy to identify. We use them to make pancakes, soup, and porridge. We also feed buckwheat to our domesticated animals.

Kasha, in this country, refers to toasted buckwheat groats or to a gruel made from them. In Russia and other countries where kasha is a popular food, the name applies to a gruel made from buckwheat or any of several major/minor cereals.

QUINOA. Also known as quinua, *Chenopodium quinoa,* is a member of the goosefoot family. Its seeds were first cultivated in about 3000 BCE on the high plains of the Andes. It has been and continues to be an important food plant in South America. According to the Baron Alexander von Humboldt, quinoa was to the inhabitants of that region what *"wine was to the Greeks, wheat to the Romans, cotton to the Arabs."* Quinoa seeds are not only rich in protein, but they are high in certain essential amino acids (particularly lysine and methionine) that are deficient in most cereals and legumes. The seeds also contain toxic saponins that must be leached out or removed by a milling process to render them edible.

GRAIN AMARANTHS (*Amaranthus* spp.) are sometimes advertised as the miracle grain of the ancient Aztecs. In North America, we mainly encounter plants of this genus as undesirable weeds, with names such as pigweed and red root. But, in Mexico the small, one-seeded fruits were an important food, especially before the Conquest. Spanish clerics insisted that the growing and use of the grain amaranths cease because the Aztec priests used them, combined with human blood, to form figurines that were part of their religious ceremonies. The seeds are quite nutritious; relatively high in protein, rich in lysine and oils. Seeds must be boiled, baked, or popped to render them edible.

SUNFLOWER. *Helianthus annuus*, of the aster or daisy family, is both a food plant and an industrially important one. The familiar stripped sunflower seed of our markets is actually a 1-seeded fruit. When we crack open the shell, we are discarding the fruit wall to gain access to the seed itself. We consume these seeds and we feed them to our domesticated animals. The seeds are also rich in sunflower oil, which is used in cooking and in various industrial applications. Argentina is the world's leading producer of sunflower oil.

5.8 • PULSES (THE EDIBLE LEGUMES)

"And let them give us pulse to eat, and water to drink." (Book of Daniel 1:12)

☼ ☼ ☼ ☼ ☼

The edible fruits and seeds that we derive from the bean or legume family (Leguminosae) are second only to the cereals in importance as food plants to us. The term **pulse** is the collective noun for these edible products. The word has been part of the English language for hundreds of years, as in the biblical quote above, but it has almost disappeared from current usage. In common parlance, we typically refer to various edible members of the family as beans or peas. While there is no clear botanical distinction between the two, there is a tendency for the seeds of most kinds of bean to be oval or kidney-shaped and for most peas to be spherical, except for the black-eyed pea. A **gram** is a seed or entire legume used for human food or animal fodder that is grown in Asia or on the Indian Subcontinent. Examples include the chick-pea, and the black, green, and golden grams.

It should be noted that not all plants that have "bean" as part of the common name are members of the legume family. The coffee bean is from a plant in the madder family (Rubiaceae); the castor bean and Mexican jumping bean are from plants in the spurge family (Euphorbiaceae).

The domesticated pulses of the Old World include lentils, peas, vetches, and the soybean. The peoples of the New World domesticated a variety of beans. We have good archeological remains from 5000 BP in Mexico and 3000 BP in Peru.

The fruit, generally called a pod, splits open along a seam or suture at maturity. We often eat the fruit before it is fully mature because it can become tough, fibrous, or almost woody. There are usually several seeds inside. Technically the fruit is called a **legume**. Botanists do not recognize "pod" as a fruit type.

NUTRITIONAL VALUE

The primary nutritional significance of pulses lies in their protein content. The immature pods are often about 10% protein; mature pods may be 22-40% protein! There may also be a complementation between the proteins of the cereals and those in legumes. For example, the alpha and beta globulins in black beans complement those of zein, the principal protein in maize. Lysine is the limiting amino acid in zein. The globulins of black beans are high in lysine. The protein of one complements the other.

Although not terribly high in tryptophan (an amino acid), many pulses supplement that found in maize. Tryptophan acts as a precursor of niacin and it successfully replaces the niacin lost in tortilla making. This helps to explain the lack of pellagra in those areas in Central America where the inhabitants eat both beans and tortillas. This disease is brought about by a deficiency in niacin (nicotinic acid). It causes skin lesions, inflammation of the soft tissues of the mouth, diarrhea, and central nervous systems disorders. Maize and beans were not domesticated together.

Many of our legume crops have entered into a symbiotic relationship with bacteria. These microscopic creatures have the ability to fix atmospheric nitrogen. The legume plant uses this nitrogen in the manufacture of protein, an essential part of its life processes. When the plant dies, this protein returns to the soil making it richer.

FLATULENCE

"Beans, beans, the musical fruit. The more you eat, the more you toot!" (Kinky children's verse)

And, of course, there is the social problem associated with eating beans. It is nicely captured in the children's poem quoted above. Bowel gases are composed of nitrogen, oxygen, carbon dioxide, hydrogen, and methane. They are derived from swallowed air, production within the gut itself, and diffusion from the blood into the gut. Hydrogen and methane are combustible and in proper mixtures with oxygen may even be explosive. The unpleasant odors that we associate with other people's bowel gases come from skatole, indoles, ammonia, and hydrogen sulfide.

The cause of flatulence is that many of the beans that we eat are high in raffinose sugars. They escape digestion in our intestinal tract because we lack a necessary enzyme (alpha-galactosidase). Bacteria in the lower portion of our gut act on these sugars to form large amounts of carbon dioxide and hydrogen and to lower the pH of our intestine. Appreciable amounts of methane are also formed. Navy beans seem to have the highest yield: 5-465 cc of gas per hour, with an average of 179 cc. Hot water treatments and alcohol extraction may be useful techniques in lowering gas production.

TOXICITY

"Wretches, utter wretches, keep your hands off beans!" (Empedocles, 5th century BCE)

"I tell you too, as did Pythagoras, withhold your hands from beans, a hurtful food."
(Callimachus, a 3rd century BCE Greek poet)

"Avoid beans as you would matricide."
(Pythagorus, Golden Verses)

"One should abstain from eating beans because they are full of the material of which our souls are made."
(Diogenes Laertius, 1st century, BCE)

☼ ☼ ☼ ☼ ☼

These quotes may surprise you. But since the days of the ancient Greeks, legumes have been regarded as dangerous. Pulses, fresh or dried, are often boiled or cooked for a sufficiently long time before they are eaten. Several experts recommend at least 10 minutes. Not only does this render them more palatable, but the heating process destroys toxins in the legume seeds.

Here are four syndromes of poisoning that can occur from eating improperly prepared legumes, or too many of them:

Lectins are plant proteins that can cause stomach cramps, nausea, and diarrhea. They can also cause red blood cells to clump together. Peas and lentils are relatively low in lectins and it is generally sufficient to bring them to a brief boil before they are cooked. Many beans must be boiled for about 10 minutes before you continue to simmer them.

Hydrogen cyanide is present at toxic levels in some pulses, such as the lima bean and chick pea. The U. S. Department of Agriculture monitors the HCN content of various cultivars and will not allow those above a certain level to be sold in this country. The Minimum Lethal Dose (MLD) for HCN taken orally is estimated at 0.5 to 3.5 milligrams per kilogram in humans. The white Burma cultivar has 100 mg; the black Puerto Rican strain has 300 mg! Cyanide, contrary to popular belief, does not kill its victims by paralyzing the lungs. It works at the cellular level to impair cellular respiration.

Favism comes from eating too many fava or broad beans. It is a form of acute anemia. It occurs especially in males of Mediterranean extraction. The cause is a deficiency of glucose-6-phosphate dehydrogenase (G-6-PD).

Lathyrism, caused by eating too many sweet pea or grass pea seeds, again affects primarily males and causes skeletal deformation and loss of bowel and bladder control. Thousands have died from this disorder, particularly in developing countries after droughts have killed more desirable food plants and people were forced to eat too many seeds.

SURVEY OF PULSES

BEANS. The genus *Phaseolus* is the most important source of many of our beans, such as the lima, scarlet runner, string, shell, white, and black. Most of them are cultivars of *Ph. vulgaris*. The plants typically require hot weather and good moisture. In some cases, we eat the entire fruit; in others we shell away the fruit wall and eat only the seeds. Many of our beans are of New World origin.

FAVA BEAN. Also called broad bean (because of its large, flat seeds), *Vicia faba* is native to northern Africa or to the Near East. It was the only widely cultivated bean in the Old World before the spread of the New World beans after Columbus.

GARDEN PEA. *Pisum sativum*, also called the English pea, is native to central and western Asia. Archeological remains go back to 5700 BCE. An ancient Greek play mentions "pease porridge." A group of cultivars called the marrowfats have large, wrinkled seeds. They are commonly used in canning and in frozen foods.

GARBANZO BEAN. Also called the chick pea, *Cicer arietinum* is native to western Asia where it has been cultivated since ancient times. Its seeds are ground into flour from which a very nutritious bread may be made. **Hummus** is a thick paste made of mashed garbanzo beans, lemon juice, garlic, and tahini oil (from crushed sesame seeds).

BLACK-EYED PEA. *Vigna unguiculata*, also called the cowpea, is native to Africa. It is now grown through much of the tropics and in the southeastern United States, where it is a very popular regional food plant. Sometimes we eat the pods; at other times the seeds. This genus is also the source of the adzuki bean, from India or Japan, and the mung bean, from India.

LENTILS. *Lens culinaris* -- what a wonderful scientific name! -- is native to southwest Asia. It is an ancient pulse, being a favorite food plant of the Greeks and Egyptians. We have fossil remains from 8000-9000 BP. The next time you are preparing or eating lentils, look at the seeds. They are shaped like little optical lenses. Actually, it is the other way around. Glass lenses are called lenses because they are shaped like lentil seeds. *Lens* is the Latin name for the lentil.

MUNG BEAN. *Vigna radiata* is also known as the green, golden, and black gram. Guess what colors its seeds are. It is a tropical crop, often grown in paddies after the rice has been harvested. Its seeds may contain 25% protein. Sprouted bean shoots have long been a favorite in Chinese cooking. Dried seeds have also been ground into a flour and added to various dishes.

PEANUT. Also called the goober or groundnut, *Arachis hypogaea* is native to South America. Its use spread from there to Africa and then to the United States via slaves. The seeds are highly nutritious (1 lb of peanuts yields 2700 calories; 1 lb of beef = 900 calories). Peanut oil and the **cake** that remains after the oil has been extracted are also important, the latter as cattle food.

In recent years, much concern has been expressed about the amount of **aflatoxins** found in peanut butter. These toxins are not made by the plant itself, but by a bread mold fungus (*Aspergillus flavus*) that contaminates it. Aflatoxins cause liver damage and they are carcinogenic, mutagenic, and teratogenic; they cause cancers, mutations, and birth defects. About 5 million Americans suffer from food allergies, including allergic reactions to the peanut. Symptoms include rapid swelling of the breathing passage way, loss of consciousness, and anaphylactic shock, which may be fatal.

At the other end of the spectrum of things to worry about is **arachibutyrophobia**, the fear of peanut butter sticking to the roof of your mouth. This is one of those vocabulary-building words.

SOYBEAN. *Glycine max* is an ancient food plant of the Orient. While we do not have an especially good fossil record, there are references to the plant in literature from 3000 BP. The U. S. is the world's leading producer of soybeans; we supply about 70% of the world's crop. The seeds contain 38% protein and 18% fats and oils. Edible soybean cultivars are becoming popular again. The seeds may be boiled, baked, or roasted. These processes removed trypsin inhibitors that cannot be handled by the digestive system of non-ruminants. The seeds may also be ground into flour. Intact soybean pods and seeds may also be eaten. They are known as **edamame.**

Soybean oil is the leading source of vegetable oils used in margarine, shortening, salad and cooking oils. Its protein is also being used to enrich foods and as a meat substitute. Soybean oil is used in adhesives, enamels, linoleum, printing ink, and soap.

Perhaps 2000 years ago, the Chinese discovered two somewhat elaborate ways to prepare soybeans. **Miso** is a mixture of ground soybean, salt, and a moldy rice preparation. It is a paste that may be used to flavor soups and sauces. Here is the recipe:

Steam beans
▽
Add moldy rice or barley
(or innoculate with bread mold)
▽
Smash beans by foot
▽
Mix beans and cereal
▽
Ferment
(for up to 3 years)

Tofu or bean curd is a soft, bland, more or less inert looking substance made from curdled soybean milk. The procedure is much like that for making cheese.

Soak beans
▽
Grind
▽
Add water, then boil
▽
Filter
▽
Curdle
(add calcium sulfate)
▽
Ladle into boxes
▽
Press to squeeze out whey

WINGED BEAN. *Psophocarpus tetragonolobus* is probably native to southeast Asia. It is well adapted to the humid tropics. The plant, which produces edible tubers and seeds, is the subject of a great deal of current research to develop it as a major food plant. The tubers contain about 13.5% protein -- much more than other tropical root crops. Mature seeds have about 33% protein, 18% oil, 30% carbohydrates, and 8% fiber. They also contain trypsin inhibitors and chemicals that can cause blood to coagulate. Heating destroys these substances.

CAROB. Also known as St. John's bread and the locust bean, *Ceratonia siliqua* is an evergreen tree native to Syria. It has been cultivated in the Old World since antiquity. The dried pods contain about 50% sugar and they are eaten as candy. The ground seeds are used to make a nutritious meal and in bread making. A sweet pulp around the seeds is also eaten. You may have consumed carob without realizing it. It is a common substitute for chocolate in a variety of products.

The ancient Greeks prized the seeds for another reason – their uniform size. They used them to measure the weight of gold and silver. They called the seeds "keration," from which our modern word "carat" is derived. The New Testament story of St. John the Baptist eating locusts in the desert gives rise to two other common names for this plant. Chances are the locust being referred to in that case was not the insect, but a locust-shaped fruit.

EDIBLE FRUITS AND SEEDS OF THE BEAN FAMILY

Common Name (Scientific Name)	Origin; Comment
adzuki bean *(Vigna angularis)*	India or Japan; used mainly in Orient
asparagus bean *(Vigna unguiculata* ssp. *sesquipedalis)*	India or Africa; immature pods, ripe seed
asparagus pea *(Psophocarpus tetragonolobus)*	See winged bean
Bambarra groundnut *(Voandzeia subterranea)*	Africa; consumed like the peanut
bean *(Phaseolus vulgaris)*	See common bean
black bean *(Phaseolus vulgaris)*	See common bean
black gram *(Vigna mungo)*	See urd bean
black-eyed pea *(Vigna unguiculata* ssp. *unguiculata)*	Africa & Asia; seeds and pods eaten
bonavist bean *(Lablab purpureus)*	See hyacinth bean
broad bean *(Vicia faba)*	See fava bean
butter bean *(Phaseolus lunatus)*	See lima bean
Cajan pea *(Cajanus cajan)*	India; very drought resistant
carob *(Ceratonia siliqua)*	Mediterranean; also a chocolate substitute
catjang pea *(Vigna unguiculata* ssp. *u.)*	Used primarily in India and Sri Lanka
chick pea *(Cicer arietinum)*	See garbanzo bean

chili bean *(Phaseolus vulgaris)*	See common bean
cluster bean *(Cyamopsis psoralioides)*	India & Pakistan; eaten like string beans
common bean *(Phaseolus vulgaris)*	Mexico & Guatemala; most widely cultivated
cowpea *(Vigna unguiculata* ssp. *u*.)	See black-eyed pea
cranberry bean *(Phaseolus vulgaris)*	See common bean
crowder pea *(Vigna unguiculata* ssp. *u*.)	See black-eyed pea
Egyptian bean *(Lablab purpureus)*	See hyacinth bean
English pea *(Pisum sativum* ssp. *sativum)*	See garden pea
fava bean *(Vicia faba)*	Near East; seeds very important Mid-East
field bean *(Phaseolus vulgaris)*	See common bean
garden bean *(Phaseolus vulgaris)*	See common bean
garden pea *(Pisum sativum* ssp. *sativum)*	Eurasia; green pods and seeds eaten
garbanzo bean *(Cicer arietinum)*	Middle East; highly nutritious seeds
goa bean *(Psophocarpus tetragonolobus)*	See winged bean
golden gram bean *(Vigna radiata)*	See mung bean
goober *(Arachis hypogaea)*	See peanut
grass pea *(Lathyrus sativus)*	S. Europe & Asia; seeds parched
green bean *(Phaseolus vulgaris)*	See common bean
green gram bean *(Vigna radiata)*	See mung bean
groundnut *(Arachis hypogaea)*	See peanut
haricot bean *(Phaseolus vulgaris)*	See common bean
horse bean *(Vicia faba)*	See fava bean
hyacinth bean *(Lablab purpureus)*	India & SE Asia; pods and seeds eaten
ice-cream bean *(Inga edulis)*	C. & S. America; pods eaten; flavoring
jack bean *(Dolichos ensiformis)*	See hyacinth bean
kidney bean *(Phaseolus vulgaris)*	See common bean
lablab bean *(Lablab purpureus)*	See hyacinth bean
lentil *(Lens culinaris)*	Mediterranean; most nutritious pulse
lima bean *(Phaseolus lunatus)*	Trop. America; some have high cyanide
locust bean *(Parkia filicoidea)*	Africa; seeds also used as a condiment
mani *(Arachis hypogaea)*	See peanut
Manila bean *(Psophocarpus tetragonolobus)*	See winged bean
mat bean *(Vigna aconitifolia)*	Asia; green pods and ripe seeds consumed
moth bean *(Vigna aconitifolia)*	See mat bean
multiflora bean *(Phaseolus coccineus)*	See scarlet runner bean
mung bean *(Vigna radiata* var. *radiata)*	India; ancient Old World pulse
navy bean *(Phaseolus vulgaris)*	See common bean
peanut *(Arachis hypogaea)*	South America; also many industrial uses
pea bean *(Phaseolus vulgaris)*	See asparagus bean
pigeon pea *(Cajanus cajan)*	See Cajan pea
pink bean *(Phaseolus vulgaris)*	See common bean
pinto bean *(Phaseolus vulgaris)*	See common bean
princess pea *(Psophocarpus tetragonolobus)*	See winged bean
red bean *(Phaseolus vulgaris)*	See common bean
rice bean *(Vigna umbellata)*	Asia; widely used there and Pacific Islands
scarlet runner bean *(Phaseolus coccineus)*	Mexico & C. America; seeds & pods eaten
Scotch bean *(Vicia faba)*	See fava bean
shell bean *(Phaseolus vulgaris)*	See common bean
sieva bean *(Phaseolus lunatus)*	See lima bean
snake bean *(Vigna unguiculata* ssp. *sesquipedalis)*	A relative of the asparagus bean
snap bean *(Phaseolus vulgaris)*	See common bean
soybean *(Glycine max)*	Asia; important source of oil and protein
St. John's bread *(Ceratonia siliqua)*	See carob
string bean *(Phaseolus vulgaris)*	See common bean
sugar bean *(Phaseolus lunatus)*	See lima bean
sword bean *(Canavalia gladiata)*	SE Asia; broad bean substitute
tamarind (-indo) *(Tamarindus indica)*	Tropical Africa; seeds, fruit pulp a flavoring
tepary bean *(Phaseolus acutifolius)*	SW USA & Mexico; dry, shelled bean
tick bean *(Vicia faba)*	See fava bean
urd bean *(Vigna mungo)*	India (?); most important pulse in India
velvet bean *(Mucuna deeringianum)*	Asia; fresh pods and seeds toxic !
wax bean *(Phaseolus vulgaris)*	See common bean
white bean *(Phaseolus vulgaris)*	See common bean
white lupine *(Lupinus albus)*	Mediterranean; fresh seeds toxic !

Windsor bean *(Vicia faba)*	See fava bean
winged bean *(Psophocarpus tetragonolobus)*	Mauritius & Malagasy; immature pods eaten
winged pea *(Tetragonolobus purpureus)*	Medit.; young pods eaten, coffee substitute
yam bean *(Pachyrhizus* ssp.*)*	Africa; seeds and tubers eaten
yard-long bean *(Vigna unguiculata)*	See asparagus bean
yawa *(Vigna unguiculata* ssp. *u.)*	Another name for the black-eyed pea

5.9 • FRUITS WE CALL VEGETABLES

In botany, we define a fruit as the ripened ovary of a flower, along with any other floral or vegetative parts that may be attached to it or surround it and that mature at the same time. This definition is not observed in everyday life when we consider that there are a number of fruits that we call "vegetables." In common parlance, we seem to call certain fruits vegetables if:

- ☼ they are eaten along with the main dish;
- ☼ they are put into a side dish;
- ☼ we put salt on them; or
- ☼ they are predominantly green at the stage when we consume them.

This distinction between a fruit and a vegetable might seem a pretty trivial matter, but it went all the way to the United States Supreme Court in 1893. A merchant tried to escape a tax on vegetables (in this case tomatoes) by arguing that they are fruits. The Supreme Court ruled,

"Botanically speaking, tomatoes are the fruit of a vine, just as are cucumbers, squashes, beans, and peas. But in the common language of the people, whether sellers or consumers of provisions, all these are vegetables, which are grown in kitchen gardens, and which are whether eaten cooked or raw, are, like potatoes, carrots, parsnips, turnips, beets, cauliflower, cabbage, celery, and lettuce, usually served at dinner in, with, or after the soup, fish or meats which constitute the principal part of the repast, and not, like fruits generally, as dessert.

The attempt to classify tomatoes as fruit is not unlike a recent attempt to class beans as seeds, of which Mr. Justice Bradley [1889], speaking for the court said: We do not see why they should be classified as seeds, any more than walnuts should be so classified. Both are seeds in the language of botany or natural history, but not in commerce nor in common parlance."

THE CUCURBITS (SQUASHES, PUMPKINS, & MELONS)

Many of the more common fruits that we call vegetables come from the squash or gourd family (Cucurbitaceae). In botany, we also call them **cucurbits**, obviously based on the technical name of the plant family. Most of the plants are coarse vines, sometimes reaching over 100 ft. in length and bearing a few hundred fruits. The vines produce male and female flowers on the same plant. The plants are diploids (2n = 2x = 40).

Common names (squashes, pumpkins, melons, marrows, etc.) are something of a problem because they of their inconsistent use. Also, there is no clear distinction between squashes and gourds. Most gourds have a hard, durable outer rind and are not edible. They have a series of utilitarian uses (cups, containers, ornamentals, etc.). They are discussed elsewhere in the text.

The edible members of the family are prized for their fleshy or fibrous fruit walls and nutritious seeds. **Pepitas** are the shelled and roasted seeds of these squashes. The fruits generally have a very high water content and little food value. We have domesticated different cucurbits in both the Old and New World. Five species of squashes and pumpkins are native here. The oldest fossil remains of seeds and rinds date from about 7000 BCE in Mexico. The earliest forms did not have fleshy interiors; it was their seeds that we ate. Squashes were carried north from Mexico to become a principal food plant of North American agricultural Indians. Along with maize and beans, squashes were one the "three sisters" of the indigenous peoples of this continent. The cucumber, cantaloupe, casaba, and watermelon are native to the Old World and were domesticated there.

SURVEY OF EDIBLE CUCURBITS

Squashes, pumpkins, and marrows. The word squash comes from a Massachusetts Indian term, askutasquash, which means "eaten raw." The squashes are all native to the New World. The distinction between summer and winter squashes is arbitrary. Most of the former have soft skins because they are eaten when the fruits are immature. Winter squashes are stored and their skins harden during storage. These cucurbits belong to the genus *Cucurbita*, as seen in the following list:

> *C. pepo*: summer s., winter s., vegetable marrows, spaghetti s. (noodle s.), crookneck s., yellow custards, pumpkins (some), American pattypan, zucchini (courgette)
>
> *C. maxima*: winter s. (larger ones), Hubbard s., turban s., buttercup s.
>
> *C. moschata*: pumpkins (some), winter s. (smaller ones), winter crooknecks
>
> *C. ficifolia*: ivy-leaved s., Malabar gourd
>
> *C. argyrosperma*: cushaw, silverseed gourd

Cucumber. A relative of the melons, *Cucumis sativus* is native to the Himalayan region, where its has been in cultivation for about 3000 years. It is now unknown in the wild. The cucumber is about 96% water and 2% sugar. The fruits range from a few centimeters to about half a meter in length. They are eaten fresh or variously seasoned to yield the familiar pickle. Samuel Johnson once remarked, "*A cucumber should be well sliced, and dressed with pepper and vinegar, and then thrown out, as good for nothing.*"

Gherkin. *Cucumis anguria* is an Old World relative of the cucumber. It probably arrived in the New World via the slave trade. Most gherkins are pickled and most of what we see in our markets are not really this species, but small cucumbers. Look for real gherkins in the West Indies and in Brazil.

Chayote. Also known as the **vegetable pear** or **christophine**, *Sechium edule* is native to Mexico and Central America where it was widely used by the Aztec people. Its fruit is 1-seeded and it has a greenish flesh. Its tubers are also edible. Once rather uncommon, chayote is now a standard fixture in many of our markets in this country.

Cassabanana. Also known as the **musk cucumber**, **sikana**, or **melocotón**, *Sicana odorifera* is found throughout tropical America. It resembles a very large cucumber, but with orange-yellow flesh. Fresh fruits are added to soups and stews, but it is more popular when made into a jam. The specific epithet suggests that the plant has an odor about it. In this case it is a pleasant one and the fruits have been used to make linens smell better.

Melons. *Cucumis melo*, native to Africa and perhaps also to Southeast Asia, is the source of a number of the "dessert fruits," such as the honeydew, Persian, musk, casaba, cranshaw melons and the cantaloupe. They are not mentioned in ancient Greek and Egyptian texts, but do appear later in Roman works.

TOMATO

[The tomato is an] "*... evil fruit... treacherous and deceitful.*" (Henri LeClerc)

"*... a person who should eat a sufficient abundance of these apples would never die.*"
(Dr. Siccaary)

Lycopersicon esculentum has had several common names through the centuries, including love-apple, mala peruviana, tomatl (an Aztec word from which we derive tomate and tomata), pomi dei Moro, pomme d'amour, and pomi d'oro. It is a New World plant, native to the Andes of Ecuador or Peru. Its fame spread slowly upon its introduction into Europe because it was recognized as a member of the nightshade family (Solanaceae) and, therefore, thought to be toxic. The Europeans were correct -- it is toxic under certain circumstances. Its use as a food plant is relatively recent.

EGGPLANT

Also called the aubergine, mad-apple, spawn of hell, etc., *Solanum melongena* is a relative of the potato, tomato, and other nightshades. It is a native of northern India, near Burma. The fruit is a large egg-shaped berry, typically purple or black in the cultivars that we grow in temperate areas. In tropical regions, yellow- and white-fruited forms are common. The eggplant is a minor crop in the United States, with Florida being the leading producer.

As with the tomato, the eggplant was not always popular as a food plant... and with good reason! Through the centuries, various authors have suggested that it can cause insanity (one of its common names is mala insana), leprosie, cancer, hemorrhoids, melancholy, cancer, pustules, bad breath, changes in skin color, and obstructions in the liver and spleen.

I also encourage you to consider the following items that I have assembled after many years of research. I offer them as part of my continuing effort to bring an unsuspecting world the truth about the hideous purple peril.

- Not a single major religious leader (Moses, Jesus of Nazareth, Mohammed, the Buddha, etc.) ever recommended eggplant to his followers, nor is it mentioned in the sacred writings of any of the world's great religions.
- The country that grows the most eggplants is Communist China. What more needs to be said?
- Adolf Hitler, Joseph Stalin, and Saddam Hussein all ate the eggplant.
- Lord Byron's "Ode to an Aubergine" was so savaged by literary critics that he destroyed all existing copies.
- Martha Stewart was overcome by the fumes of an eggplant as she attempted to prepare it on her nationally syndicated television program. She recovered fully.
- The Central Intelligence Agency once used a toxic extract from the eggplant in an attempt to kill Fidel Castro.
- Mama Cass Elliot did not choke to death on a ham sandwich, as widely reported in the press. An eggplant became lodged in her throat.
- The Monsanto Corporation, using secret techniques of genetic engineering, has developed a polyploid eggplant that can cross with wheat, rice, and maize and replace them in the fields.

As if more evidence were needed, consider the following astounding statistics:

- 100% of all Americans who ate eggplant in 1880 subsequently died!
- 92.6% of all patients in this country's mental hospitals ate eggplant.
- 87.2% of all heroin addicts began by eating eggplants.
- 98.4% of all individuals who listen to Rush Limbaugh on the radio have eaten eggplant.
- 82.1% of all divorces occurred in couples who had consumed eggplant.
- 78.9% of all fatal automobile accidents happened after eating eggplants.
- Only 0.09% of young, innocent children like eggplant on first eating it.

NUTRITIONAL ANALYSIS OF EGGPLANT

Water	80.0 %
Carbohydrates	00.0 %
Sugars	00.0 %
Fat	00.0 %
Calories	00.0 %
Inert material	21.0 %
Purple Peril Death Factor	02.0 %

How does the eggplant compare with other edible and inedible material? Here are the results of a blind taste test conducted on the streets of San Francisco a few years ago.

BLIND TASTE-TEST PREFERENCES

Choice Offered	**Ranking**
Month old pizza	1
Cat litter	2
Cardboard	3
Discarded bathroom sponge	4
Old shoe leather	5
Mud	6
Mold from shower curtain	7
Eggplant	8

BREADFRUIT

"*The bread-tree, which without the ploughshare yields, the unreaped harvest of unfurrowed fields, and bakes its unadulterated loaves, without a furnace in unpurchased groves, and flings off famine from its fertile breast, a priceless market for the gathering guest.*" (Lord Byron)

☼ ☼ ☼ ☼ ☼

Artocarpus altilis, a tree native to Malaya, is now pantropical. It has been cultivated since antiquity. It is a member of the mulberry family (Moraceae). A similar plant, the Osage-orange or bois d'arc, grows in the United States. The breadfruit is a false fruit, being formed by the fusion of many true fruits to produce a single, large, warty "fruit." Unlike most fruits, the breadfruit is high in starch (30-40%). It is not eaten fresh, but is typically baked, boiled, or fried. Although its seeds are edible, the seedless strains are the most commonly used. An eight year old tree can produce 700-800 fruits.

The cultivars with large, edible seeds are called the **breadnut**. Here the surrounding flesh is discarded and the seeds are boiled. They taste like chestnuts.

Most of us in this country have never seen breadfruit, but we have heard of the plant because of a famous event in history. In 1787, Lt. William Bligh was sent to Tahiti to collect breadfruit seedlings for eventual transplanting to feed slaves in the West Indies. As you know, on the return voyage, the crew of H. M. A. T. Bounty mutinied against the captain and put him and eighteen others (including the ship's botanist, David Nelson) into a small boat. They survived a grueling 41 day ocean voyage. The mutineers, led by Fletcher Christian, established their new home on Pitcairn Island. Bligh went on to become a Vice Admiral in the Royal Navy and a Governor in Australia.

Two close relatives of the breadfruit are the **jackfruit**, also spelled jakfruit (*A. heterophyllus*), whose giant fruits can weigh about 70 lbs., and the **marang** (*A. odoratissima*, whose scientific name suggests one of its best known features -- it is highly aromatic.

OKRA

Abelmoschus esculentus [= *Hibiscus e.* in the older literature] is native to Africa, perhaps the Upper Nile Valley. It came to the New World via slaves in the 16th century. They also brought with them dried peas, yams, and ackee, an interesting fruit. Okra is related to hibiscus and cotton. This is fairly evident when you examine the flowers. It is a very popular vegetable, especially in French Louisiana where it is used in soups, stews, etc. Some people object to its slimy, mucilaginous nature. We eat the immature fruit, a capsule. If you let it mature, it gets almost woody and splits open. What is the best way to serve okra? To someone else!

SPAGHETTI TREE

We have become so accustomed to eating artificial spaghetti that many of us are unaware that the natural version grows on plants. *Pastadendron italica*, the spaghetti tree, is native to the hilly regions of the Mediterranean. The edible portion is a stringy outgrowth on the surface of seeds. In the early summer, the tree's woody pods split open to reveal numerous seeds, each with a string of carbohydrate-rich tissue about 30 cm long. It is a curious sight to see hundreds of these trees with their strands of spaghetti dangling gracefully in the wind. Processing is simple, but laborious. Workers, usually of the peasant class, move through the spaghetti tree plantations and harvest the material manually. Attempts to mechanize the process have not been successful. As with cotton, it is necessary to separate the seed, which will be discarded, from the desired portion. This is done by hand, one seed at a time. The tissue is then washed and placed in the sun to dry by carefully arranging the spaghetti on a network of strings or wire drying racks. Almost all of the work is done by women. A few years ago, the BBC produced an award-winning documentary on the harvesting and processing of spaghetti. A particularly touching part of the film showed women singing various harvesting songs as they plucked the spaghetti from the trees.

Historically, the very best spaghetti came from trees grown around Tuscany. Unfortunately, almost all of them were destroyed during World War II. This prompted the research to produce artificial spaghetti, as did a dramatic increase in the popularity of Mediterranean foods. Attempts to improve spaghetti's nutritional quality and the length of the strands through hybridization with other species of *Pastadendron* have not been successful. The Italian government has funded a spaghetti tree germplasm center ("seed bank") in Rome, in an attempt to preserve the genetic heritage of the species. To date, five genomes have been identified.

Real spaghetti is once again available in our local markets, but it is quite a bit more expensive. It is sold under the label "Spaghetti Antigua" or "Spaghetti a la Tuscany." It must be kept refrigerated. Once you have eaten the real thing, you will never go back to the insipid, artificial version.

FRUITS THAT WE CALL VEGETABLES

Common Name (Scientific Name)	Plant Family	Origin
African aubergine (*Solanum macrocarpum*)	Nightshade	East Africa
aubergine (*Solanum melongena*)	Nightshade	Asia
Balsam pear (*Momordica charantia*)	Squash	Old World
beans (Various genera) [1]	Bean	New World
breadfruit (*Artocarpus altilis*)	Mulberry	Malaysia
calabaza (*Cucurbita moschata*)	Squash	North America
chayote (*Sechium edule*)	Squash	C. America
corn (*Zea mays*)	Grass	C. America
courgette (*Cucurbita pepo*)	Squash	Himalayas
cucumber (*Cucumis sativus*)	Squash	India (?)
custard marrow (*Cucurbita pepo*)	Squash	Himalayas
eggplant (*Solanum melongena*)	Nightshade	Asia
gherkin (*Cucumis sativus*)	Squash	India
jackfruit (jak-) (*Artocarpus heterophyllus*)	Mulberry	Malaysia
maize (*Zea mays*)	Grass	C. America
marang (*Artocarpus odoratissima*)	Mulberry	Philippines
marrow (*Cucurbita pepo*)	Squash	Himalayas
okra (*Abelomoschus esculentus*)	Mallow	Ethiopia
peas (Various genera) [2]	Bean	Old World
peppers (*Capsicum* spp.)	Nightshade	C. & S. America
pumpkin (*Cucurbita maxima*)	Squash	C. & S. America
sinkwa (*Luffa acutangula*)	Squash	India (?)
squashes (Various genera) [3]	Squash	Old & New World
tomato (*Lycopersicon esculentum*)	Nightshade	New World
vegetable spaghetti (*Cucurbita pepo*)	Squash	Mexico; USA
zucchini (*Cucurbita pepo*)	Squash	Himalayas

Notes:

1. Most of the common kinds of beans are *Phaseolus* spp., particularly *Ph. vulgaris*. Others belong to genera such as *Vigna* (adzuki bean and mung bean) and *Vicia* (broad bean or fava bean). See the discussion of pulses elsewhere in the syllabus for a more complete listing.

2. The garden or English pea belongs to the genus *Pisum*. The black-eyed pea is a kind of *Vigna*; the chickpea or garbanzo bean belongs to the genus *Cicer*.

3. Most of the commonly encountered squashes (crookneck, banana, summer, scallop, butter, etc.) belong to *Cucurbita* or *Cucumis*.

5.10 • FRUITS OF THE TEMPERATE ZONE

Many of the fruits that we commonly eat, with the exception of the banana, citrus fruits, and the pineapple, come from temperate areas of the world. Most of these fruits are intensively cultivated, rather than being fruits easily available in the wild state. The rose family (Rosaceae) is the single largest source of these species.

Most of the temperate fruits are of Old World origin. Many of them have been in cultivation since ancient times. In more advanced societies, fruits are not a staple. They provide interesting flavors and variety to our table. Some of them are high in vitamins, various organic acids, and mineral content. For the most part, however, they are nutritionally poor. They are mostly water. Because of the high water content and their texture, many fruits are perishable. Pickling, canning, and freezing have allowed their shipment around the world. So has rapid air transportation.

SURVEY OF TEMPERATE FRUITS

APPLE. *Malus sylvestris* probably ranks first in economic importance and extent of cultivation. It is native to the Caucasus Mountains of western Asia. We have perpetuated, and to some extent developed, over 6500 horticultural forms. The Old World species were introduced into the United States by colonists who were dissatisfied with the fruits of the native species.

A ripe apple is about 84% water, 11% sugar, and 0.3% protein. It is usually harvested ripe, because it will not ripen well after being picked. Apples are very sensitive to a variety of insect and fungal pests.

PEAR. *Pyrus communis* is native to Eurasia. The plant is similar to the apple in appearance. It is propagated either by seed or by grafting. The United States produces about one-quarter of the total output. Pears are picked before they reach full maturity.

APRICOT. *Prunus armeniaca* is an Asian species. It has been used in China since about 2000 BC. Because the flowers are sensitive to frost, apricots are grown in warmer climates. They were introduced into California in the 18th century. Sun dried fruits are very popular.

PEACH. *Prunus persica* is native to China. Like the apricot, it is an ancient fruit. It was introduced into the United States by the early colonists. Today it is second only to the apple in importance in this country. The nectarine, sometimes distinguished as *P. persica* var. *nectarina* is a peach without fuzz, often with a richer flavor. It is not a hybrid, as many people believe.

PLUMS AND PRUNES. Several species of *Prunus*, a member of the rose family, are the source of plums. The ones that reach our tables are derived from Europe, Japan, or they are native to North America. The plum industry in this country is centered on the Pacific coast. Prunes are merely plums with a high sugar content. They can be cured without removing the stone inside.

STRAWBERRY. The two most important species in the United States are *Fragaria chiloensis*, which is native to the New World from Chile to the western coast of North America, and *F. virginica*, a wild strawberry native to the eastern part of the continent. Both species are octaploids. The European "ever-bearing strawberry" (*F. vesca*) is a diploid. Except for this species, the cultivated strawberries are all propagated by runners or stolons; they reproduce asexually. The "fruit" is very sensitive to pressure and can be easily bruised. Most strawberries are, therefore, handpicked. Unlike most other temperate fruits, the strawberry is the result of an intensive selection and breeding program.

The edible portion of the strawberry is not the fruit itself, but the expanded, swollen stem tip that bears tiny, hard, seed-like fruits. Most of us would be delighted if breeders could only get rid of those pesky little fruits so that we could better enjoy the succulent, sugary stem.

"Doubtless God could have made a better berry, but doubtless God never did." (William Butler)

BRAMBLES. From the single genus *Rubus*, we derive the raspberry, blackberry, thimbleberry, dewberry, youngberry, loganberry, boysenberry, and a series of lesser known kinds. The berry is not really a berry in the botanical sense, but an aggregation of numerous small, fleshy fruits giving the appearance of a single structure.

CURRANTS AND GOOSEBERRIES. We eat both native and introduced species. Gooseberry plants have bristly branches and 1-3 fruits in a cluster. Currants do not have bristles and typically have 4 or more fruits in a cluster. Often currants are used in the form of jelly. One species, *Ribes nigrum*, is the alternate host for the white pine blister rust. The common name "currant" is also used for a kind of grape grown principally in Greece.

MULBERRY. The mulberry is a false fruit -- an aggregation of many tiny fruits put together in such a way as to simulate a single, larger fruit. The black mulberry (*Morus nigra*) is native to Asia Minor. It has been in use there for thousands of years. The white mulberry (*M. alba*), also from Asia, is used as food for the silkworm. The red mulberry (*M. rubra*) is native to North America.

CRANBERRY. The American cranberry, *Vaccinium macrocarpon*, is a low-growing shrub of the heath family (Ericaceae). It is usually cultivated in a low, acidic bog. It is related to our local huckleberries and salal. At present, the organized cranberry industry is mainly in the United States. Another species, *V. oxycoccus*, is native to the northern portions of Europe, Asia, and North America.

GRAPES. *Vitis vinifera* is native to Southwest Asia, where it has been cultivated for millennia. Many cultivars, literally thousands of them, have been selected. Early attempts by the Colonists to establish a grape industry in the United States were largely unsuccessful until they started to use the native species. The Concord grape is such an example. The wine industry in California is not based upon our native grapes, but on the European *V. vinifera*. I have heard one or two tour guides in the Napa Valley carefully explain (incorrectly) that they use only good, old American grapes! More about this in the lecture on wine making.

TEMPERATE FRUITS

Common Name (Scientific Name)	Family
acorn (*Quercus* spp.)	oak
almond (*Prunus dulcis* var. *dulcis*)	rose
apple (*Malus sylvestris*)	rose
apricot (*Prunus armeniaca*)	rose
barberry (*Berberis vulgaris*)	barberry
beechnut (*Fagus sylvatica*)	oak
bilberry (*Vaccinium myrtillus*)	heath
blackberry (*Rubus* spp.)	rose
blueberry (*Vaccinium* spp.)	heath
boysenberry (*Rubus ursinus*)	rose
bullace (*Prunus insititia*)	rose
butternut (*Juglans cinerea*)	walnut
cherry, sweet (*Prunus avium*)	rose
chestnut (*Castanea sativa*)	oak
cloudberry (*Rubus chamaemorus*)	rose
cowberry (*Vaccinium vitis-idaea*)	heath
crabapple (*Malus* spp.)	rose
cranberry (*Vaccinium macrocarpon*)	heath
currant (*Ribes* spp.)	gooseberry
currant, black (*Ribes nigrum*)	gooseberry
currant, red (*Ribes rubrum*)	gooseberry
damson (*Prunus insititia*)	rose
dewberry (*Rubus* spp.)	rose
elderberry (*Sambucus canadensis*)	honeysuckle
filbert (*Corylus* spp.)	alder
gage (*Prunus insititia*)	rose
gooseberry (*Ribes* spp.)	gooseberry
gooseberry, Chinese (*Actinidia chinensis*)	actinidia
grape (*Vitis vinifera*)	grape
green gage (*Prunus insititia* var. *italica*)	rose
hawthorn (*Crataegus* spp.)	rose
hazelnut (*Corylus* spp.)	alder
hickory (*Carya* spp.)	walnut
huckleberry (*Vaccinium* spp.)	heath
kiwiberry (*Actinidia chinensis*)	actinidia
loganberry (*Rubus ursinus*)	rose
medlar (*Mespilus germanica*)	rose
mirabelle (*Prunus insititia* var. *syriaca*)	rose
morello (*Prunus cerasus*)	rose
mulberry, black (*Morus nigra*)	mulberry
mulberry, red (*Morus rubra*)	mulberry
nectarine (*Prunus persica*)	rose
olive (*Olea europaea*)	olive
peach (*Prunus persica*)	rose
pear (*Pyrus communis*)	rose
pecan (*Carya illinoensis*)	walnut
persimmon (*Diospyros* spp.)	ebony
pistachio (*Pistacia vera*)	cashew
plum (*Prunus domestica*)	rose
plum, American (*Prunus americana*)	rose
plum, cherry (*Prunus cerasifera*)	rose
plum, Japanese (*Prunus salicina*)	rose
prunes (*Prunus domestica*)	rose
quince (*Cydonia oblonga*)	rose
raisin (*Vitis vinifera*)	grape
raspberry, black (*Rubus occidentalis*)	rose
raspberry, red (*Rubus idaeus* var. *idaeus*)	rose
strawberry (*Fragaria* spp.)	rose
strawberry tree (*Arbutus unedo*)	heath
veitchberry (*Rubus ursinus*)	rose
walnut, black (*Juglans nigra*)	walnut
walnut, English (*Juglans regia*)	walnut
wineberry (*Rubus phoenicolasius*)	rose
youngberry (*Rubus ursinus*)	rose

5.11 • EDIBLE NUTS

Edible nuts were among our earliest foods gathered from wild trees. They were easily harvested and nutritious. Many nuts contain about 10-30% protein, 55-70% fat (often highly un- or monosaturated), and they may also be a good source of vitamins. A few are rich in starch. Their water content is low, which means that they will store well if kept cool.

The term **nut** may be defined botanically as a hard, one-seeded fruit that does not dehisce (split open) at maturity. We usually break through a hard shell to get to the seed inside. The nut may also be partially to almost completely hidden by a leathery or spiny cup or husk. The nuts derived from trees in the oak and birch families fit this more restricted definition rather well. Other fruits that are often considered nuts by the general public are technically drupes, as in the almond, coconut, pecan, and walnut. Menninger (1977) suggests the broadest definition. A nut is "any hard shelled fruit or seed of which the kernel is eaten...." In other words, sometimes a nut is a 1-seeded fruit; sometimes a nut is a seed that has been removed from a multi-seeded fruit, as in the peanut or the Brazil nut. Pine nuts represent a special case because these edible seeds are not borne in fruits, but on specialized woody cone scales of the familiar cone. By the way, the Menninger that I just quoted is the brother of the founder of the famous clinic in Topeka, Kansas.

Look for the discussion of the peanut under the legumes and the coconut under tropical fruits.

NUTRITIONAL VALUES

Fruit	% Protein	% Fats	% Water
Almond	20	40-60	4
Brazil nut	17-20	65-70	5
Chestnut	2-4	2-5	52
Filbert	18	68	5
Macadamia	8	70	3
Pecan	18	70	1
Pistachio	18	55	5
Pine nut	12-31	47-68	3
Walnut	15	70	3

SURVEY OF EDIBLE NUTS

ALMOND (*PRUNUS DULCIS*). The almond was domesticated in the Old World about 3000 BCE and is now the world's most important nut tree. California is the leading producer. It has wide uses in foods, candies, etc. The tree is a member of the rose family and therefore related to the cherry and the apricot. There are two varieties of almonds – sweet (var. *dulcis*) and bitter (var. *amara*). The difference between the two is how much hydrogen cyanide they contain!

BRAZIL NUT (*BERTHOLLETIA EXCELSA*). There are no Brazil nut plantations any where in the world. We harvest the seeds from wild trees growing in Amazonia after their heavy wooden pods have fallen to the ground. By the way, these fruits are heavy enough to cause injury and even death if you are hit on the head by one of them! Pods are split open to extract the 1-25 seeds that they contain. Brazil nuts are second only to macadamia nuts in mono-unsaturated oils. They are eaten raw, roasted, or salted.

CHESTNUT (*CASTANEA SATIVA*). This relative of the oaks and beech tree is native to Europe, where it has been popular since ancient times. Chestnuts have less fat and more starch than other nuts. They are roasted (think of street vendors or Nat King Cole's song) or boiled and used in flour, bread, porridge, fritters, and for stuffing the interiors of birds. We have a chestnut that is native to eastern North America (*C. dentata*), but its importance has been much reduced in the 20th century because of a fungal disease (chestnut blight).

FILBERTS AND HAZELNUTS (*CORYLUS* SPP.). These Eurasian shrubs are related to birch trees. The generic name derives from the Greek word for a hood or helmet, a reference to the husk that surrounds the fruit. If that structure extends beyond the fruit, it is a filbert; if not, it is a hazelnut. An unrelated use for the hazelnut is to make divining rods.

MACADAMIA NUT (*MACADAMIA* SPP.). Two species of *Macadamia*, also known as the Queensland nut and the Mac nut, are native to Australia. The macadamia nut is named after a local naturalist, John Macadam. It was domesticated in 1858 and it is the only Australian food plant of world wide economic importance. It is third after the pineapple and sugar cane in the Hawai'ian economy. It is prized as one of the gourmet nuts because of its delicate flavor. So that's why they cost so much!

PECAN (*CARYA ILLINOENSIS*). This tree is native to the central and southern parts of the United States and it is the most important native nut tree in North America. The common name comes from paccan, the Algonquin Indian name. A really good pecan tree can produce 400 lbs. of nuts each year. In addition to the delectable pecan pie, pecan oil is used in cosmetics and pharmaceuticals. The pecan belongs to the same plant family as the walnut. In both cases the fruit (technically a drupe) is enclosed in a husk.

PINE NUTS (*PINUS* SPP.). Pine nuts are also called piñon, pinyon, and pignolia nuts. A number of different pines from both the Old and New Worlds yield these edible seeds. The ancient Romans ate pine nuts; so did the Indians of North America.

PISTACHIO (*PISTACIA VERA*). This relative of the cashew is native to the Middle East and Central Asia. The principal production regions are Iran, Turkey, and California. We eat pistachios raw or salted in brine while still in the shell. The seed itself is usually green (from chlorophyll) and the shell reddish. Here in California, we often dye shells a darker red. The pistachio costs about three or four times what we pay for other nuts.

WALNUTS (*JUGLANS* SPP.). The common or English walnut (*J. regia*) is native to Europe, Asia, and China, where it was domesticated thousands of years ago. The edible portion is the enlarged embryonic leaves (cotyledons), as in the pecan. California is the leading producer. Walnut trees can live for 300-400 years. Walnuts are very popular in France and in Britain, where the Brits like to pickle them in vinegar. The walnut shell is often bleached with chlorine or sulfur dioxide. The black walnut (*J. nigra*) is native to eastern North America. It has a thicker shell that is more difficult to crack open, but the seed inside has a richer flavor than its Old World cousin.

EDIBLE NUTS

Common (Scientific) Name	Production Centers
acorn (*Quercus* spp.)	North America
African walnut (*Coula edulis*)	Africa
almond (*Prunus dulcis*)	North America
American beech (*Fagus sylvatica*)	North America
American chestnut (*Castanea dentata*)	North America
beaked filbert (*Corylus cornuta*)	North America
beech nut (*Fagus* spp.)	Europe, N. America
betel nut (*Areca catechu*)	Old World tropics
bitter almond (*Prunus dulcis*)	Europe, Asia, N. America
black walnut (*Juglans nigra*)	North America
Brazil nut (*Bertholletia excelsa*)	Amazon
butternut (*Juglans cinerea*)	North America
cashew (*Anacardium occidentale*)	Trop. America, Africa
chestnut (*Castanea* spp.)	Europe, Asia, N. America
Chinese chestnut (*Castanea mollissima*)	Asia, N. America
Chinese filbert (*Corylus chinensis*)	China
Chinese walnut (*Juglans cathayensis*)	China, N. America
chinquapin (*Castanea pumila*)	North America
chirauli nut (*Buchanania lanzan*)	India and S. E. Asia
cob (*Corylus avellana*)	Old and New World
coco de mono (*Lecythis minor*)	Honduras
coconut (*Cocos nucifera*)	Pantropical
English walnut (*Juglans regia*)	Europe, Asia, N. America
European beech (*Fagus sylvatica*)	Europe
European filbert (*Corylus avellana*)	Old & New World
filbert (*Corylus* spp.)	Old and New World
giant filbert (*Corylus maxima*)	Old and New World
gbanja kola (*Cola nitida*)	Africa and Jamaica
hazelnut (*Corylus americana*)	North America
heartnut (*Juglans ailanthifolia*)	Japan and U. S.
Himalayan filbert (*Corylus ferox*)	Asia
hickory (*Carya* spp.)	North America
Indian-almond (*Terminalia catappa*)	Pantropical
Japanese walnut (*Juglans ailanthifolia*)	Japan, North America
Japanese chestnut (*Castanea crenata*)	China & Japan
Java-almond (*Canarium indicum*)	Malaysia
jojoba nut (*Simmondsia chinensis*)	North America
kola nut (*Cola acuminatum*)	Africa, Brazil, Caribbean
macadamia nut (*Macadamia* spp.)	Australia, North America
Malabar chestnut (*Pachira aquatica*)	Africa, Florida, W. Indies
mani (*Caryocar amygdaliferum*)	South America
marula nut (*Sclerocarya caffra*)	Africa
Mexican stone pine (*Pinus cembroides*)	Mexico
mongongo nut (*Ricinodendron rautanenii*)	Africa
monkey nut (*Lecythis usitata*)	South America
monkey pod (pot) (*Lecythis ollaria*)	South America
Moreton Bay chestnut (*Castanospermum australe*)	Australia
oysternut (*Telfairia pedata*)	East Africa
peanut (*Arachis hypogaea*)	India, Africa, China
pecan (*Carya illinoensis*)	North America
pequi (*Caryocar* spp.)	South America
pignolia (*Pinus pinea*)	Europe
pili nut (*Canarium ovatum*)	Philippines
pine nut (*Pinus* spp.)	North America
piñon (*Pinus edulis*)	North America
pistachio (*Pistacia vera*)	Mediterranean, India, N. America
quandong nut (*Santalum acuminatum*)	Australia
Queensland nut (*Macadamia tetraphylla*)	Australia, California
saba nut (*Pachira aquatica*)	Africa, Florida, W. Indies
sapucaia (*Lecythis pisonis*)	South America
shagbark hickory (*Carya ovata*)	North America
shellbark hickory (*Carya laciniosa*)	North America
Siberian filbert (*Corylus heterophylla*)	Asia
suari nut (*Caryocar nuciferum*)	South America
sweet almond (*Prunus dulcis*)	North America

sweet chestnut (*Castanea sativa*)	Europe, N. America
Swiss stone pine (*Pinus cembra*)	Europe
terminalia (*Terminalia* spp.)	Tropics
Tahiti chestnut (*Inocarpus fagifer*)	Malaysia, Pacific
Turkish filbert (*Corylus colurna*)	Turkey
walnut (*Juglans regia*)	Europe, Asia, N. America
water chestnut (*Trapa* spp.)	Asia
wingnut (*Pterocarya* spp.)	Asia
yeheb nut (*Cordeauxia edulis*)	Africa

Source: Huxley (1985)

5.12 • TROPICAL & SUBTROPICAL FRUITS

One of the most striking features of tropical and subtropical fruits is their diversity. There are literally hundreds of kinds, belonging to a number of plant families that are relatively unknown to most of us, even to the average temperate botanist. Many of the fruits are used widely. Some of them, such as the banana, coconut, various citrus fruits, and the pineapple, have become quite common in our markets. Hundreds more are used locally and rarely enter into regional or international trade. Common names abound and there is also some confusion in the application of scientific names.

While the various tropical and subtropical fruits are not major portions of our diet, they are often very important daily foods of tropical peoples. The food value is variable. Often the fruit is mostly water and of little value, while others are high in certain vitamins, organic acids, and minerals.

While the rose family (Rosaceae) is the primary source of fruits in the temperate zone, it plays a minor role in tropical and subtropical areas. The major plant families from which tropical fruits are derived include the cashew family (Anacardiaceae), which comes as a surprise to many of us who know only its most common North American representatives -- poison oak, poison ivy, and poison sumac; the custard apple family (Annonaceae); the myrtle family (Myrtaceae), also a source of many ornamental shrubs; the citrus family (Rutaceae); the sapote family (Sapotaceae); and the soapberry family (Sapindaceae).

In the survey that follows, I will devote most of the attention to six of the major tropical fruits and comment briefly on a few others of interest.

BANANA AND RELATIVES

"*There is nothing so delicious as a banana.*"
(Benjamin Disraeli)

The banana was domesticated in Southeast Asia; its wild counterparts can still be found there today. There are about 25-30 species and subspecies in cultivation. The banana of commerce is *Musa* x *paradisiaca*. About 300 cultivars are now planted.

THE BANANA AND ITS ALLIES

Musa acuminata	Cavendish, dwarf, Chinese
Musa balbisiana	
Musa corniculata	horse banana
Musa discolor	
Musa errans	
Musa nana	dwarf banana
Musa oleracea	banana poreté
Musa x *paradisiaca*	banana, plantain, platano
Musa superba	wild plantain
Musa troglodytarum	fe'i
Musa textilis	Manila hemp
Ensete ventricosum	Abyssinian banana

A banana "tree" is actually a large, tree-like herb. It can reach a height of 25 ft. The trunk of a banana plant is a series of overlapping leaf bases, hiding a small central shoot that will later give rise to the flower cluster. The bulk of the stem system is a large, fleshy rhizome that lies underground. The leaves may be 10-12 ft long. They are simple, but often appear pinnately compound because of the fraying of the blade that results from wind damage. The flower cluster is large and drooping, with the growing tip at the bottom end of the inverted cluster. The female flowers, which will eventually produce the fruits, are borne toward the base of the cluster. The male flowers are toward the tip. These unisexual flowers, although conspicuous and attractive, are sterile. A plant will begin to bear fruit in about 8-14 months. A mature fruiting cluster can weigh up to 140 lbs. Individual bananas occur in small bunches, known in the industry as "hands."

By the way, if banana flowers are sterile, where did those fruits come from? Review the brief discussion of parthenocarpy in the introductory section.

Bananas are harvested while green. They are so perishable that if they were picked after maturing, they would spoil before reaching the markets. After a plant has borne fruit, it usually dies back or is cut down. Bananas are loaded on air-conditioned ships for transport to world markets. The hold is usually kept at about 14° C to prevent premature ripening. The temperature will later be raised to begin the maturation process. At that stage, the bananas turn from green to yellow and starch begins to change to sugar.

Many different cultivars are now available, but we see only a few of them in our temperate markets. Our local stores are carrying more than they once did. Until a few years ago, the most common cultivar was "Gros Michel" or "Big Mike." It was wiped out by the dreaded Panama disease. Big Mike has been replaced by "Valery" and "Lacatan."

Modern bananas and their relatives contain five genomes (A, B, E, F, and T). All edible bananas contain either the A (Acuminata) or B (Balbisiana) chromosome sets (AAA, AAB, ABB, BBB). The industry is based upon an AAA triploid [2n = 3x = 33]. Banana fruits are seedless, and therefore sterile, because of the genetic complications that arise from having three identical sets (AAA) of chromosomes competing with one another as they go through meiosis. Bananas are propagated vegetatively by cuttings taken from the mother plant.

A close relative of the banana is the **plantain**, also known as the **platano** or **cooking banana**. It is very widely used in tropical countries as a food plant, but was rarely seen in our markets until recent years. The plantain must be cooked before use because it stores carbohydrates in the form of starch, rather than sugar. The cooking process converts starch to sugar.

The only other economically important species is *Musa textilis*, the Manila hemp. It is not grown for its edible fruits, but for its fibers. They are used in heavy ropes and in very delicate tea bags.

A less known relative is *Ensete ventricosum*, the ensete or Abyssinian banana. It is grown in Africa for fiber and for food – not from nice fleshy fruits. The edible portions are the young shoots, leaf bases, flowers, and seeds.

CITRUS FRUITS

The various citrus fruits, excluding the grapefruit and numerous hybrids, all appear to be native to Southeast Asia. The plants are shrubs or small trees with compound leaves reduced to a single leaflet. The plants have a mycorrhizal relationship with fungi in the soil. Citrus plants are said to lack root hairs and this relationship is probably explained on this basis. All of the species are diploids [2n = 2x = 18].

Most citrus production is in the New World, in both temperate and tropical areas. More oranges are grown than any other citrus fruit. Annual production is about 56 million metric tons; Brazil is the leading producer. Next comes the tangerine, at about 10 million metric tons, mostly from Japan. About 13 million metric tons of lemons, limes, grapefruits, and pomelos are produced each year. The United States is the leading producer.

Citrus fruits are high in vitamin C, just as you have always been told. The rind contains numerous oil glands, the basis of a famous parlor trick that I will tell you about in lecture. The part of the fruit that we eat is a series of thick, juicy hairs that line the papery septations within the fruit. Look very closely next time!

Some citrus fruits, such as the orange and the grapefruit, are allowed to ripen on the tree. Others, such a lemons and limes, are harvested green. Many oranges are artificially colored or treated with gases or other chemicals to destroy the green chlorophylls in the flesh of the fruit to give it a better appearance on the market shelf.

The more familiar citrus fruits are the orange, lemon, lime, mandarin orange, tangerine, kumquat, citron, pomelo, shaddock, and sour orange. The grapefruit appears to be a spontaneous, recent hybrid between the orange and the pomelo. All of them are various species of *Citrus*, except for the kumquat. It belongs to the genus *Fortunella*.

SUMMARY OF THE GENUS *CITRUS*

Subgenus: Scientific/Common Name.	**Nativity**
Subgenus *Papeda:*	
C. celebica (Celebes papeda)	Celebes & Philippines
C. hystrix (Mauritius papeda)	SE Asia and Malaysia
C. ichangensis (Ichang papeda)	China
C. latipes (Khasi papeda)	India and Burma
C. macroptera (Melanesian papeda)	SE Asia/Polynesia
C. micrantha (small-flowered papeda)	Philippines
Subgenus *Citrus:*	
C. aurantifolia (lime)	Southeast Asia*
C. aurantium (sour orange)	Southeast Asia*
C. grandis (pummelo)	Southeast Asia*
C. indica (Indian wild orange)	E. Himalayas
C. limon (lemon)	Southeast Aisa*
C. medica (citron)	East Asia*
C. paradisi (grapefruit)	West Indies*
C. reticulata (Mandarin orange	SE Asia/Philippines*
C. sinensis (sweet orange)	China and Indochina*
C. tachibana (Tachibana orange)	Japan

* Now widely cultivated   Source: Swingle (1967)

Hybridization is rampant among the various citrus fruits. Some common examples include:

tangelo (tangerine x grapefruit)
limequat (kumquat x lime)
orangequat (kumquat x orange)
citrange (trifoliolate orange x orange)
citrangequat (kumquat x citrange)
tangor (orange x tangerine)
ugli (grapefruit x tangerine)

SCURVY ("SAILOR'S DISEASE")

Scurvy is an ancient disease caused by an insufficient intake of Vit. C (ascorbic acid) from fresh vegetables and fruits. Tens of thousands of sailors died from scurvy, especially from the 15th to the 18th centuries. One of the earliest scientific investigations was that of Dr. James Lind, who published "A Treatise on Scurvy" in 1753. He concluded that various citrus fruits were very effective in the prevention and treatment of scurvy. It would take almost a century for the Lords of the Admiralty to approve the use of lime juice on British naval vessels. Now you know why British sailors are called limeys.

Here are typical symptoms of the disease:

☼ Longing for land, greenery, home
☼ Uncontrollable weeping
☼ Depression
☼ Weakening of capillaries
☼ Subcutaneous bleeding
☼ Anemia
☼ Skin "black as ink"
☼ Ulcers on legs
☼ Loose teeth
☼ Gums protruding from mouth
☼ Really bad breath!
☼ Stiffness/soreness of joints
☼ Slow healing of wounds
☼ Difficult breathing
☼ Overwhelmed by stimuli
☼ Death

COCONUT

"*He who plants a coconut tree, plants food and drink, vessels and clothing, a habitation for himself, and a heritage for his children.*"

(Polynesian traditional saying)

☼ ☼ ☼ ☼ ☼

As inhabitants of the temperate zone, it is all but impossible for us to appreciate *Cocos nucifera*, which has been called "one of Nature's greatest gifts to Man," the "tree of life," the "tree of heaven," and "Mankind's greatest provider in the tropics." There it provides food, drink, oil, medicine, fiber, timber, thatch, mats, fuel, and domestic utensils. In addition to these utilitarian aspects, the coconut has also played a prominent role in the customs and beliefs of tropical peoples.

The home of the coconut remains controversial. It appears to have been present in both the Old World and the Americas before 1492. The fruit is able to float for a hundred days or more in salt water; the best ocean currents are from Asia to the New World. It was probably first domesticated in the Indo-Pacific region. There are no reproductive or genetic difficulties here. $2n = 2x = 32$.

The coconut is a kind of palm. The trees can produce 50-100, to as many as 500 fruits per year. The first crop typically comes on in about 6-8 years. The fruit is single-seeded. The fruit wall is clearly differentiated into an outer layer (exocarp) that is woody; a middle layer (mesocarp) that is fibrous; and an inner, bony layer (endocarp) that is more or less fused to the seed coat. When we see coconuts in our markets, the exocarp and mesocarp have been removed during processing. The coconut "seed" is the true seed, plus the innermost layer of the fruit wall, the endocarp.

After harvesting, the fruits are cut in half and the coconut meat is gouged out. It will be cured in the sun or in kilns to yield **copra**. It contains about 60-68% oil. Coconut oil is about 90% saturated and it is one of the "tropical oils" that manufacturers are increasingly proud to say they are no longer using in their foods. Once the oil has been removed from copra, the residue (coconut cake) is used for cattle feed. It is a rich source of protein and carbohydrates. Curiously, it is rarely eaten by humans, even in areas where protein is otherwise deficient.

The middle portion of the fruit wall, the fibrous portion, is the source of **coir**. This fiber, sometimes sold under the name coco fiber, is used for mats, rugs, filters, stuffing, and rope. Various plant parts yield **sennit fiber** used to make ropes, hats, and other items.

DATE PALM

"Honor your maternal aunt, the palm, for it was created from the clay left over after the creation of Adam (on whom be peace and the blessings of God!"

(The Prophet Muhammad)

☼ ☼ ☼ ☼ ☼

We have been cultivating *Phoenix dactylifera* for 6000-8000 years. According to Muslim tradition, the first date palms arose from the dust left over from the creation of Adam. This explains one of the plants common names, the "tree of life." Wild populations with small, inedible fruits may still be found in Saudi Arabia and the Sahara. Today the domesticated forms are found on the fringes of African and Asian deserts. The date palm was introduced into California in 1765 at Mission San Ignacio. This state and Arizona are leading producers in the U. S. The palm trees on the Arcata plaza are *Ph. canariensis*, a relative of the date palm native to the Canary Islands.

The leaves of the date palm are used for thatching and matting, and its trunks for building materials. The fruit is a drupe, with a brown skin (exocarp), a sweet juicy pulp (mesocarp), and a thin, bony layer (endocarp) surrounding a single seed. The fruits have a high sugar content. They may be consumed fresh, dried, or pounded into a paste. In the Arab world, they are often eaten with milk. If properly dried, they will last indefinitely. A single tree can produce about 100 lbs. of dates each year. Trees may continue to bear fruit for 100-200 years. Maturing fruits are often bagged to protect them from birds and insects. We harvest dates the same way that we did in ancient times -- by hand, with a sharp knife.

The Hebrews and Babylonians carried out a ritual ceremony to ensure that a good crop of dates would be produced. Even though the concept of sexuality in plants would not be discovered until the close of the 17th century, they had found that it was necessary to bring pollen-bearing flowers into the oases where the date palms grew. The cultivated date palm is a female plant and it must be fertilized with pollen from a male date palm tree if it is to produce fruit. For thousands of years, we have maintained a few, isolated male trees wherever we cultivate the date palm for this purpose. Although its seeds are fertile, we usually cut off sucker shoots at the base of the trunk to grow new date palms.

We also discovered that we could ferment the sap of the date palm and produce arrak, which one sixteenth century traveler called *"the strongest and most dreadful drink ever invented."*

PINEAPPLE

Ananas comosus, native to the New World, was unknown to Europeans until it was first seen by Columbus in 1493 on Guadaloupe Island. By that time, the inhabitants of tropical America had already selected seedless varieties for their use. Their wild counterparts with numerous seeds could still be seen growing in the vicinity of villages. When the pineapple was introduced to Europe, it was considered an interesting oddity, but certainly not an edible fruit. Leading growers include Costa Rica, the United States (principally in Hawaii), Thailand, Brazil, Mexico, and South Africa.

The pineapple plant is an herb with a basal clump of stiff, sword-shaped leaves. Many of the cultivars have sharp teeth on the leaf margins. The widely used Cayenne cultivar does not. The flowers are borne at the center of the rosette of leaves. At first, the flowers are separate from one another, but as the plant sets fruit, the individual fruits from adjacent flowers fuse with one another to form a false fruit, the familiar pineapple. The hole in the center of canned pineapple represents the area once occupied by the central axis of the fruiting cluster. A plant can bear fruit in about one year. After the first pineapple has been cut from the plant, the growing point divides and the next crop will be two, smaller pineapples per plant. After these are harvested, the growing point divides once again, and four even smaller pineapples are produced. These are often used to make pineapple juice. After the 4-pineapple stage, replanting occurs. Except for handpicking, the pineapple industry is now almost completely automated.

Modern cultivars are also seedless. Unlike the banana, however, there are no genetic difficulties that prevent sexual reproduction from occurring. We see to that by excluding the pollinators needed for cross-polination.

The fruits contain about 15% sugar, some organic acids, minerals, and a proteolytic enzyme called **bromelain**. Because it can digest animal tissue, workers in the pineapple fields and processing plants must wear protective clothing. Test the power of bromelain yourself by allowing the juice of a reasonably fresh pineapple to remain on your lips. Note the tingling sensation as the enzyme begins to dissolve the delicate tissue of your buccal orifice!

FIG

The ancestral home of *Ficus carica* is probably southern Arabia. It spread quickly to the Mediterranean. There are now several kinds of figs in cultivation, notably the common fig, the Capri fig, and the Smyrna fig. As in the pineapple, the sap of the fig contains a proteolytic enzyme that is the cause of an occupational hazard called "fig-pickers disease."

FIG RELATIVES

Banyan tree	*Ficus benghalensis*
Weeping fig	*Ficus benjamina*
Indian rubber tree	*Ficus elastica*
Bo tree	*Ficus religiosa*
Sycamore fig	*Ficus sycamorus*
Creeping fig	*Ficus pumila*
Strangler fig	*Ficus* spp.
Mulberry	*Morus* spp.
Osage-orange	*Metopium toxiferum*
Breadfruit	*Artocarpus altilis*
Jackfruit	*Artocarpus heterophyllus*

FRUIT STRUCTURE

The fig is a false fruit. What appears to be the skin and much of the flesh of the "fruit" is a receptacle, which is stem tissue. If you cut a fig in longitudinal section (down the middle), you can see that it has a hollow interior. At the top of the fig is a small opening (osteole) lined with scales. The inner wall of the vase-like structure is lined with hundreds of unisexual flowers. The upper section is covered with male flowers; the middle and lower portions with female flowers. Figs produce two kinds of female flowers. One type is sterile and the other fertile. The latter will produce a tiny, one-seeded fruit. These are the true fruits of the fig. As in the strawberry, it is easy to assume that the tiny fruits are the seeds of the plant, located within a fleshy fruit.

POLLINATION

Let's focus on the wild form of the edible fig (*Ficus carica*). It will form three different versions of figs during the year. The first one appears during the winter months. It contains male flowers and sterile flowers. Tiny female wasps (*Blastophaga psenes*) will enter the opening at the top of this fig, penetrate the wall of the ovary, and deposit their eggs inside the sterile flowers. When she lays an egg, she also injects a drop of a special secretion that will stimulate the sterile flower to develop gall tissue. This will nourish the newly-hatched wasp larvae. She then dies. The eggs hatch, with male wasps appearing first. They have poorly-developed legs and eyes, and they have no wings. The males roam around in the interior of the fig, looking for flowers that contain female wasps. The males bore through the ovary wall, find the females, and fertilize them right then and there. Talk about cradle-robbing. The males then die. The females emerge from the flowers and find their way to the opening, and exit the fig. The scales around the osteole will often damage their wings and antennae. As they pass through the opening, they are dusted with the pollen of the male flowers, which have just matured. It is June. The gravid female wasps now migrate to a second generation of figs that has been maturing on the tree. They leave behind the earthly remains of their mother and their brothers.

The second generation of figs contains a mixture of female flowers and sterile flowers, or it may contain only female flowers. The wasp will lay her eggs in both types of flowers, but only those laid in the sterile flower type will develop. They have a hollow, short neck (style) that sits on top of the ovary. It is short enough that when the female wasp attempts to lay eggs in the sterile flower, her egg-laying apparatus (ovipositor) is long enough to reach the chamber in the flower's ovary. That location is essential for proper maturation of the wasp's eggs. The female flowers, on the other hand, have a much longer, solid style -- too long for the wasp's ovipositor. However, when the wasp attempts to lay her eggs in the female flowers, she coats the stigma with the pollen that she has brought on her body from the first generation of figs. That pollen will fertilize the female flowers and they will set seed. It is now autumn. Following the same plan, gravid female wasps emerge from the sterile flowers, leave the second generation of figs, and migrate to the third generation of figs. It has a smaller receptacles and it contains only sterile flowers. Egg laying and fertilization occur, as before. A new generation of wasps emerges in the winter and the cycle repeats itself.

FIG POLLINATION

[February]

Gravid female wasp enters fig
▽
Deposits egg + injects special secretion
▽
Gall forms (food for her young)
▽
She dies
▽
Larvae hatch
▽
Male wasp emerges first
▽
Pierces flower - fertilizes female wasp
▽
Male wasps die

[May or June]

Fig has ripened, but tough/bitter
Male flowers shed pollen
Gravid female emerges
▽
She leaves fig - dusted with pollen
▽
Enters 2nd generation of figs

▽
Lays eggs
▽
She dies

[September or so]

Fertilized females emerge
▽
Enter third generation of figs
▽
Insects emerge in winter

In the fig, we see a complex inter-relationship between a plant and its pollinator. Because it involves pollination and fertilization, it is an example -- a complicated one -- of sexual reproduction. In the domesticated figs, many cultivars produce figs with only female flowers that set seed without pollination and fertilization have occurred. These figs, like the bananas, have replaced sexual reproduction with asexual reproduction and have parthenocarpic fruits. We have maintained them through the centuries because we like their predictably tasty figs.

FIG CULTIVARS

Kadota	Self-pollinated or parthenocarpic
Mission	Self-pollinated or parthenocarpic
Smyrna	Figs with ♀ flowers only
Capri	Figs with ♂ flowers only

Capri + Smyrna + rituals and incantations ➙ figs

OTHER TROPICAL FRUITS

MANGO. *Mangifera indica* is native to Asia, where it has been in cultivation for at least 6000 years. It is one of the few tropical fruits that has been significantly improved by cultivation. Some people discover that they are allergic to the skin of the mango fruit. This is not surprising when you realize that the plant is member of the same plant family that contains poison-oak and poison-ivy. The toxin is not in the skin itself, but exudes on to the surface when the fruit is harvested.

PAPAYA. *Carica papaya* is a native of the New World, to the West Indies more specifically. Its flowers are unisexual and occur on separate trees. There are also cultivars with bisexual flowers. The fruits contain **papain**, a digestive enzyme similar to pepsin. Look for it in meat tenderizers.

CASHEW. Also native to the New World, *Anacardium occidentale* is now heavily cultivated in the Old World. India is the leading producer. The familiar cashew nut is attached to a larger swollen structure – the cashew apple. It is also edible, but because it is so perishable it is relatively unknown outside the tropics. The fruits can cause rashes in sensitive individuals. The cashew is also in the poison-ivy and poison-oak family. The toxin is in the shell and it is destroyed when the cashew is roasted.

ACKEE OR AKEE. *Blighia sapida*, a tree of the soapberry family (Sapindaceae), is named in honor of Lt. William Bligh. It is doubtful that he would be pleased, because this is a poisonous plant that produces fruits that are edible only during a short period of their maturation. Fruits can be lethal when too ripe. They cause epidemics of poisoning in the Caribbean, calledthe "Vomiting Sickness of Jamaica."

DURIAN. *Durio zibethinus* is native to western Malaysia. Its green, spiny fruits usually weigh up to 2 kg (5 lbs.) and grow high up on trees 30 m tall. Falling fruits have killed people! We are not the only fan of the durian; elephants, tigers, and monkeys are particularly attracted to its fruits.

The durian may be the world's most notorious fruit. Most people find its smell and taste repulsive. The odor of mature fruits is so strong that they are banned in subways, on airplanes, and in public buildings. What does it smell like?

- French custard passed through a sewer;
- stale vomit;
- a civet cat;
- a fermented papaya after a fruit-eating bat has pee'd on it; and my personal favorite;
- a garbage truck that has run over a skunk in a paper mill town on a damp day!

Others express something akin to adulation when discussing its unique qualities. The great naturalist Alfred Russel Wallace, who described himself as a "confirmed durion eater," put it this way:

" *A rich butter-like custard highly flavoured with almonds gives the best general idea of it, but intermingled with it com wafts of flavor that call to mind cream-cheese, onion-sauce, brown-sherry, and other incongruities. Then there is a rich glutinous smoothness in the pulp which nothing else possesses, but which adds to its delicacy. It is neither acid, nor sweet, not juicy, yet one feels the want of none of these qualities, for it is perfect as it is. It produces no nausea or other bad affect, and the more you eat of it the less you feel inclined to stop. In fact, to eat durions, is a new sensation worth a voyage to the East to experience.*

TROPICAL AND SUBTROPICAL FRUITS

Common Name (Scientific Name)	Family	Comments
abiu (*Pouteria caimito*)	Sapodilla	Andean; used for refrescos
acerola (*Malpighia glabra*)	Malpighia	Same as the Barbados cherry
aguacate (*Persea americana*)	Laurel	Same as the avocado
akee (*Blighia sapida*)	Soapberry	African; lethal at wrong stage
alligator-pear (*Persea americana*)	Laurel	Same as the avocado
amatangula (*Carissa grandiflora*)	Dogbane	Native to Natal
ambarella (*Spondias cytherea*)	Cashew	Polynesian; resembles small mango
assai (*Euterpe oleracea*)	Palm	South American
avocado (*Persea americana*)	Laurel	Tropical Americas
bacupari (*Rheedia brasiliensis*)	Garcinia	Brazil; used for jams
bacuri (*Platonia insignis*)	Garcinia	South American; used for refrescos
banana (*Musa* x *paradisiaca*)	Banana	Southeast Asia; now pantropical
Barbados-cherry (*Malpighia glabra*)	Malpighia	Tropical America; used for refrescos
batjang (*Mangifera foetida*)	Cashew	Native to Malay Archipelago
bignay (*Antidesma bunius*)	Spurge	Native to Southeast Asia
bilimbi (*Averrhoa bilimbi*)	Oxalis	Woody relative our of sour-grass
biriba (*Rollinia deliciosa*)	Annona	Brazil; used for refrescos
borojoa (*Borojoa patinoi*)	Madder	Colombia; used for refrescos
breadfruit (*Artocarpus altilis*)	Mulberry	East Indies; now pantropical
bullock's heart (*Annona reticulata*)	Annona	Tropical Americas; fruit ± insipid
cabelluda (*Eugenia tomentosa*)	Myrtle	Native to Brazil
caimito (*Pouteria caimito*)	Sapodilla	Same as the abiu
caja (*Spondias lutea*)	Cashew	Same as the yellow mombin
canistel (*Lucuma nervosa*)	Sapodilla	Native to West Indies
Cape-gooseberry (*Physalis peruviana*)	Nightshade	North & South America; Eurasia
capulin (*Muntingia calabura*)	Elaeocarp	South America; also a fiber plant
carambola (*Averrhoa carambola*)	Oxalis	Malayan; gooseberry-like fruits
carissa (*Carissa grandiflora*)	Olive	South American; cranberry-like
cashew (*Anacardium occidentale*)	Cashew	Brazilian; also contains a toxin
ceriman (*Monstera deliciosa*)	Philodendron	Central America; philodendron-like
Ceylon-gooseberry (*Dovyalis hebecarpa*)	Flacourtia	Tropical Asia; dark purple fruits
chempedak (*Artocarpus integer*)	Mulberry	Malayan; relative of breadfruit
cherimoya (*Annona cherimola*)	Annona	Native to northern Andes
citron (*Citrus medica*)	Rue	Native to Southeast Asia
clementine (*Citrus reticulata*)	Rue	Related to tangerine
coconut (*Cocos nucifera*)	Palm	Old World native; now pantropical
coco plum (*Chrysobalanus icaco*)	Rose	Same as the icaco
cupuassu (*Theobroma grandiflora*)	Cacao	Relative of cacao
Curaçao-apple (*Eugenia javanica*)	Myrtle	Malayan
curuba (*Passiflora mollissima*)	Passion Flower	Relative of passion fruit
custard apple (*Annona reticulata*)	Annona	Tropical American favorite
date palm (*Phoenix dactylifera*)	Palm	Southwest Asia; source of arrak
deciduous-orange (*Poncirus trifoliata*)	Rue	One of the citrus relatives
downy myrtle (*Rhodomyrtus tomentosa*)	Myrtle	India and Sri Lanka
durian (*Durio zibenthinus*)	Bombax	Malayan; you will love it or hate it!
egg fruit (*Lucuma salicifolia*)	Sapodilla	Central America
emblic (*Phyllanthus emblica*)	Spurge	Tropical Asia, India; acid fruits
Fehi banana (*Musa fehi*)	Banana	Southeast Asia
feijoa (*Feijoa sellowiana*)	Myrtle	Native from Brazil to Paraguay
fig (*Ficus carica*)	Mulberry	Old World; now pantropical
genip (*Melicocca bijugatus*)	Soapberry	Tropical America
genipado (*Genipa americana*)	Madder	South America & West Indies
golden-apple (*Spondias dulcis*)	Cashew	Same as the ambarella
governor's plum (*Flacourtia indica*)	Flacourtia	Madagascar & Southeast Asia
gandaria (*Bouea macrophylla*)	Cashew	Malayan
granadilla, giant (*Passiflora quadangularis*)	Passion Flower	Tropical America; pantropical

granadilla, purple (*Passiflora edulis*)	Passion Flower	Brazil, juice produced comercially
granadilla, sweet (*Passiflora ligularis*)	Passion Flower	Tropical America
granadilla, yellow (*Passiflora laurifolia*)	Passion Flower	Tropical America & West Indies
grapefruit (*Citrus* x *paradisi*)	Rue	West Indies; a pummelo mutant?
groselha (*Phyllanthus distichus*)	Spurge	Oriental; acid fruits for jellies
grumichama (*Eugenia dombeyi*)	Myrtle	Native to sourthern Brazil
guabiroba (*Abbevillea fenzliana*)	Myrtle	Native to Brazil
guanabana (*Annona muricata*)	Annona	West Indies; delightful beverage, too
guava (*Psidium guajava*)	Myrtle	Mexico, Peru, and West Indies
guava, Brazilian (*Psidium guineense*)	Myrtle	Much like the guava
guava, C. Rican (*Psidium friedrichstalianum*)	Myrtle	Central America; used for jellies
guava, Pará (*Campomanesia acida*)	Myrtle	Brazil; used to make jellies
guisaro (*Psidium molle*)	Myrtle	Mexico, Central America; jellies
hill-gooseberry (Rhodomyrtus tomentosa)	Myrtle	India & Malaysia
hog plum (*Spondias purpurea*)	Cashew	Mexico & Central America
hondpara (*Dillenia indica*)	Dillenia	Native to the Far East
husk-tomato (*Physalis ixocarpa*)	Nightshade	Same as the tomatillo
icaco (*Chrysobalanus icaco*)	Rose	South America; plum-like fruits
ilama (*Annona diversifolia*)	Annona	Mexico & Central America
imbé (*Garcinia livingstonei*)	Garcinia	Tanzania to Gambia
imbu (*Spondias tuberosa*)	Cashew	Brazil; acid fruits
inga (Inga spp.)	Bean	Tropical America; fleshy pods
jaboticabá (*Myrciaria cauliflora*)	Myrtle	Brazil; grape-like fruits
jackfruit, jakfruit (*Artocarpus heterophyllus*)	Mulberry	India; breadfruit relative
jambolan (*Syzygium cumini*)	Myrtle	Native to Malay Archipelago
Japanese cherry (*Prunus salicifolia*)	Rose	Subtropical cherry
Japanese medlar (*Eriobotrya japonica*)	Rose	Same as the loquat
Japanese persimmon (*Diospyros kaki*)	Ebony	Same as the kaki
Java plum (*Syzygium cumini*)	Myrtle	Same as the jocote
jobo (*Spondias purpurea*)	Cashew	Same as the hog plum
jocote (*Syzygium cumini*)	Myrtle	A clove relative
jujube (Zizyphus jujuba)	Buckthorn	A major Chinese fruit
kaki (*Diospyros kaki*)	Ebony	Native to China and Japan
karanda/caranda (*Carissa carandas*)	Dogbane	Native to India and Malaysia
kei apple (*Doryalis caffra*)	Flacourtia	Native to South Africa
ketembilla (*Doryalis hebecarpa*)	Flacourtia	Relative of the umkokola
kiwi (*Actinidia chinensis*)	Actinidia	China; fruits high in Vitamin C
kumquat (*Fortunella* spp.)	Rue	E. Asia, Malaysia; citrus relative
kaweni (*Mangifera odorata*)	Cashew	Asia; a mango relative
kuwin (*Mangifera odorata*)	Cashew	Asia; a mango relative
kwai muk (*Artocarpus hupargyrea*)	Mulberry	A breadfruit relative
langsat (*Lansium domesticum*)	Mahogany	Malayan; mangosteen-like fruits
lemon (*Citrus limon*)	Rue	Asian fruit in use since ancient times
lime (*Citrus aurantiifolia*)	Rue	East Indies
lime, Mandarin (*Citrus limonia*)	Rue	Subtropical China
lingaro (*Elaeagnus philippensis*)	Russian olive	Native to Philippines; acid fruits
litchi (*Litchi chinensis*)	Soapberry	Native to China
longan/lungan (*Dimocarpus longan*)	Soapberry	Native to China
loquat (*Eriobotrya japonica*)	Rose	Native to China; apple-like
lovi-lovi (*Flacourtia inermis*)	Flacourtia	Malesia ?
lucumo/lucuma (*Lucuma obovata*)	Sapodilla	Native to Peru and Chile
lulo (*Solanum quitoense*)	Nightshade	Same as the naranjilla
lychee (*Litchi chinensis*)	Soapberry	Native to China
mabolo/mabola (*Diospyros discolor*)	Ebony	Malayan; cream-colored dry flesh
Malay-apple (*Eugenia dombeyi*)	Myrtle	Old World
Malay rose-apple (*Syzygium malaccensis*)	Myrtle	Southeast Asia
mamao (*Carica papaya*)	Papaya	Same as the papaya
mammee/mamey (*Mammea americana*)	Garcinia	West Indies and Central America
mamoneillo (*Melicocca bijugatus*)	Soapberry	Tropical America; plum-like fruits
Mandarin (*Citrus reticulata*)	Rue	Native to Philippines and SE Asia
mangaba (*Hancornia speciosa*)	Dogbane	Native to Brazil; persimmon-like
mango (*Mangifera indica*)	Cashew	Asia; one of the prized fruits
mango, gray (*Mangifera foetida*)	Cashew	Same as the batjang
mangosteen (*Garcinia mangostana*)	Garcinia	Malayan; best tasting fruit for many

manzanilla (*Crataegus* spp.)	Rose	Central America
maracuja (*Passiflora* spp.)	Passion Flower	Same as the granadilla
marang (*Artocarpus odoratissima*)	Mulberry	Southeast Asia; breadfruit relative
Mauritius papeda (*Citrus hystrix*)	Rue	Southeast Asia; citrus relative
mombin, red (*Spondias purpurea*)	Cashew	Central America and Mexico
mombin, yellow (*Spondias purpurea*)	Cashew	West Indies and South America
naranjilla (*Solanum quitoense*)	Nightshade	Native to Andes; used as refresco
Natal plum (*Carissa grandiflora*)	Dogbane	Native to Natal
ohia (*Eugenia malaccensis*)	Myrtle	Same as the Malay apple
olive (*Olea europaea*)	Olive	Mediterranean; now pantropical
orange, king (*Citrus* x *nobilis*)	Rue	Relative of the Mandarin orange
orange, Otaheite (*Citrus limonia*)	Rue	Native to subtropical China
orange, sour/bitter (*Citrus aurantium*)	Rue	Native to Southeast Asia
orange, sweet (*Citrus sinensis*)	Rue	Native to Southeast Asia
Otaheite-apple (*Spondias cytherea*)	Cashew	Same as the ambarella
Otaheite-gooseberry (*Phyllanthus distichus*)	Spurge	Native to India and Malaysia
papaya (*Carica papaya*)	Papaya	Native to tropical America
papaya, mountain (*Carica pubescens*)	Papaya	Native to Colombia and Ecuador
passion fruit (*Passiflora edulis*)	Passion Flower	Same as the purple granadilla
pawpaw (*Carica papaya*)	Papaya	Same as the papaya
peach palm (*Bactris gasipaes*)	Palm	New World tropics; plum-like fruits
pejipaye (*Guilielma utilis*)	Palm	Tropical America; eaten as vegetable
pera do campo (*Eugenia klotzschiana*)	Myrtle	Native to central Brazil
pineapple (*Ananas comosus*)	Bromeliad	Native to New World tropics
pineapple guava (*Feijoa sellowiana*)	Myrtle	Same as the feijoa
pinha (*Annona squamosa*)	Annona	Native to New World tropics
pitanga (*Eugenia uniflora*)	Myrtle	Native to Brazil
pitaya/pitahaya (*Hylocereus* spp. & others)	Cactus	Native to New World tropics
pitomba (*Eugenia luschnathiana*)	Myrtle	Native to Bahia, Brazil
platano/plantain (*Musa* x *paradisiaca*)	Banana	Tropical Asia; must be cooked
pomegranate (*Punica granatum*)	Pomegranate	Asia; seeds with arils
pond-apple (*Annona glabra*)	Annona	Native to North America (Florida)
posh-te (*Annona scleroderma*)	Annona	Central America; thick, hard shell
pulasan (*Nephelium mutabile*)	Soapberry	Native to Southeast Asia
pummelo/pomelo (*Citrus grandis*)	Rue	Native to Malaya
Queensland nut (*Macadamia ternifolia*)	Protea	Also called the macadamia nut
rambutan (*Nephelium lappaceum*)	Soapberry	Malaysia; seeds also roasted
ramontchi (*Flacourtia indica*)	Flacourtia	Asia; used mainly in preserves
rose-apple (*Syzgium jambos*)	Myrtle	Native to East Indies
rukam (*Flacourtia rukam*)	Flacourtia	Madagascar and Southeast Asia
sapodilla (*Manilkara zapota*)	Sapodilla	Central America; also yields a latex
salak (*Zalacca edulis*)	Palm	Native to Malay archipelago
santol (*Sandoricum koetjape*)	Mahogany	Malayan, especially the Philippines
sapote (*Pouteria sapota*)	Sapodilla	Native to Central America
sapote, black (*Diospyros digyna*)	Ebony	Native to Mexico
sapote, green (*Calocarpum viride*)	Sapodilla	Native to Central America
sapote, white (*Casimiroa edulis*)	Rue	Native to Mexico & Central America
sapote, yellow (*Lucuma salicifolia*)	Sapodilla	Native to Mexico & Central America
semarange rose-apple (*Syzgium javanicum*)	Myrtle	Native to Malay archipelago
shaddock (*Citrus grandis*)	Rue	Native to Malaya
soncoya (*Annona purpurea*)	Annona	Native to Mexico & Central America
soursop (*Annona* spp.)	Annona	Tropical America; raw, drinks, soups
Spanish-lime (*Melicocca bijugatus*)	Soapberry	Tropical America; rather acid flavor
Spanish-plum (*Spondias purpurea*)	Cashew	Same as the mombin
star apple (*Chrysophyllum cainito*)	Sapodilla	West Indies and Central America
star fruit (*Averrhoa carambola*)	Oxalis	Same as the carambola
sugar-apple (*Annona squamosa*)	Annona	Native to American tropics
Surinam-cherry (*Eugenia uniflora*)	Myrtle	Same as the pitanga
sweetsop (*Annona squamosa*)	Annona	Tropical America; a dessert fruit
sweet calabash (*Passiflora maliformis*)	Passion Flower	Tropical America; same as curuba
tamarind [-indo] (*Tamarindus indica*)	Bean	Native to India; now in Americas
tangerine (*Citrus reticulata*)	Rue	Native to China
tomatillo/tomatl (*Physalis ixocarpa*)	Nightshade	Native to Mexico

tree-tomato (*Cyphomandra betacea*)	Nightshade	Native to Peru
trifoliate orange (*Poncirus trifoliata*)	Rue	Native to northern China
tunas (*Opuntia* spp.)	Cactus	Native to tropical America
umkokola (*Doryalis caffra*)	Flacourtia	Native to Africa
uvalha (*Eugenia uvalha*)	Myrtle	Native to southern Brazil
vi-apple (*Spondias dulcis*)	Cashew	Cultivated Old & New World Tropics
wampi/wampee (*Clausena lansium*)	Rue	Native to southern China
watery rose-apple (*Syzygium aqueum*)	Myrtle	Native to Malay archipelago
wax-apple (*Syzygium samarangense*)	Myrtle	Malayan; now pantropical use
West Indian-cherry (*Malpighia punicifolia*)	Malpighia	Tropical America & West Indies
zapote (*Manilkara zapote*)	Sapodilla	Same tree also a latex source

5.13 • WILD EDIBLES

If you drop into almost any bookstore and look in the natural history section, you are likely to find a recently published book on the identification and preparation of wild edible plants. There is a tremendous interest in this subject, particularly on the part of impoverished students and others fascinated by a return to a more simple way of living.

We might begin with a simple question. What is an edible plant? The answer is not as easy as you might think. Consider our personal preferences in cultivated edible plants. Are we all in agreement that okra, eggplant, and hominy grits are edible? To many of us they are comparable to slime, cardboard, and wallpaper paste. About all we can do is talk about plants that most of us consider edible, realizing there are many others that we might add to the list.

SOME PRECAUTIONS

Be sure of the identification of any plant that you eat. It is not only important to avoid poisonous plants, but to know the identity of the plant that you are about to consume.

Make certain that you know the toxic plants of your area. Excellent technical and popular references are available to assist you in telling the edible from the poisonous. It can be difficult. The edible plants of the carrot family are amazingly similar to ones that are lethal. The toxic plants of the lily family closely resemble some of the popular wild edible ones. People make these mistakes all the time; some only once!

Eat plants that are growing in uncontaminated areas. Avoid plants growing in stagnant waters, those growing in the immediate vicinity of agricultural areas that might have been sprayed, or those growing in soils high in nitrates or selenium.

In some plants, only certain parts are edible, while in others the entire plant body may be eaten with impunity.

Also, some plants may be eaten without any preparation, while others require cooking, sometimes involving a change of waters. Consult the recipes for details.

Never eat large quantities of any wild plant that you have not tried before. Place a small portion in your mouth, chew it up, and then spit it out. Wait for a few minutes to see if any unpleasant taste or stinging sensation occurs. If not, chew and swallow a small piece of the plant. This time, wait for an hour or so. If the plant passes your personal test, then proceed with some of the fancy recipes.

You should also ignore much of the folklore associated with wild edible plants. One of the most dangerous myths is that you can use other animals' food habits as a guide. After all, if a bird can eat that plant or if you see Bambi browsing on some herb, then it must be safe to eat. The digestive system of birds, other mammals, and insects are sufficiently different from ours that they should not be viewed as reliable guides.

The notion that plants come color-coded (certain colors indicate edibility; others toxicity) is also without foundation. Also be leery of the stories about telling mushrooms from toadstools by the latter's ability to discolor silver spoons or coins.

SOME WILD EDIBLE PLANTS OF CALIFORNIA

Common Name	Scientific name	Comments
	UNDERGROUND PLANT PARTS	
amole	*Chlorogalum pomeridianum*	Bulbs, slightly acid unless cooked
arrowhead	*Sagittaria latifolia*	Tuberous roots; boiled or roasted
balsam root	*Balsamorhiza* spp.	Roots cooked over hot stones
bear grass	*Xerophyllum tenax*	Roots; roasted or boiled
biscuit roots	*Lomatium* spp.	Roots; raw or ground into flour
bistort *Polygonum bistortoides*		Roots; saute with butter and onions
bitter root	*Lewisia rediviva*	Roots; remove bark and cook well; bitter
broomrape	*Orobanche* spp.	Underground parts tender and edible
burdock	*Arctium minus*	Peel off outer layer of root, then boil
bur reed	*Sparganium eurycarpum*	Tubers; cooked
calypso orchid	*Calypso bulbosa*	Bulbs; raw, boiled or roasted
camas *Camassia* spp.		Bulbs; raw, but better cooked
cattail	*Typha* spp.	Roots; boiled or roasted; starchy
century plant	*Agave utahensis*	Roots are roasted
chickweeds	*Stellaria* spp.	Tubers; raw or cooked
chicory	*Cichorium intybus*	Roots; better cooked; bitter taste
cow-lily	*Nuphar luteum*	Rootstocks; raw or baked
cow-parsnip	*Heracleum lanatum*	Roots cooked; ashes for salt substitute
dandelion	*Taraxacum officinale*	Roots
eel-grass	*Zostera marina*	Rootstocks chewed, but do not swallow
evening-primrose	*Oenothera hookeri*	Roots; boil in early spring
false dandelion	*Tragopogon* spp.	Roots; raw or cooked; parsnip-like

false Soloman's seal	*Smilacina racemosa*	Aromatic rootstocks; soak in lye
fawn lilies	*Erythronium* spp.	Bulbs; boiled or dried
fritillaries	*Fritillaria* spp.	Bulbs; raw, boiled or dried
green brier	*Smilax californica*	Roots in soups; also ground into flour
green-gentians	*Frasera* spp.	Roots; raw, boiled or roasted
hedge nettle	*Stachys palustris*	Tubers; raw or cooked
Indian-potato	*Orogenia* spp.	Roots; raw, roasted or baked
lilies	*Lilium* spp.	Bulbs; raw or cooked
mariposa lilies	*Calochortus* spp.	Bulbs; raw or cooked
nodding scrozonella	*Microseris nutans*	Roots; raw
nut grass	*Cyperus esculentus*	Tubers; raw
pondweed	*Potamogeton* spp.	Rootstocks underwater; boil
quack grass	*Elymus repens*	Rootstocks (rhizome) ground into flour
rattlesnake weed	*Daucus pusillus*	Roots; raw or cooked
reed grass	*Phragmites australis*	Roots; raw, roasted or boiled
rein orchid	*Platanthera dilatata*	Roots; raw or cooked
sand-verbena	*Abronia latifolia*	Large roots are eaten
sea rocket	*Cakile edentula*	Roots ground into flour
skunk-cabbage	*Lysichiton americanum*	Roots; roasted, gives starchy flavor
shooting stars	*Dodecatheon* spp.	Roots; raw or boiled
spring beauty	*Claytonia* spp.	Bulbs; raw or cooked
sunflower	*Helianthus* spp.	Tubers; raw, boiled or roasted
sweet cicely	*Osmorhiza* spp.	Roots; anise-flavored
thistle	*Cirsium* spp.	Roots; raw or cooked; rather flat taste
toothwort	*Cardamine* spp.	Bulbs; raw, or cooked in salads
tule (bulrush)	*Scirpus* spp.	Roots; raw or soaked; starchy
waterleaf	*Hydrophyllum occidentale*	Roots; boiled
water shield	*Brasenia schreberi*	Tuberous roots are boiled
wild carrot	*Daucus carota*	Roots; much as in the cultivated carrot
wild-ginger	*Asarum* spp.	Rootstock is used
wild hyacinth	*Brodiaea* spp.	Bulbs; less mucilaginous after boiling
wild licorice	*Glycyrrhiza lepidota*	Sweet succulent roots used as flavoring
wild onion	*Allium* spp.	Bulbs; either raw or cooked
yampa, squawroot	*Perideridia gairdneri*	Roots; raw or cooked

STEMS, LEAVES, AND FLOWERS (SALADS AND POTHERBS)

asparagus	*Asparagus officinalis*	Young shoots; same as cultivated plants
aster	*Aster ledophyllus*	Leaves boiled as greens
balsamroot	*Balsamorhiza sagittata*	Leaves and stems boiled
bee plant	*Cleome serrulata*	Leaves and flowers boiled as potherb
bitter cress	*Cardamine* spp.	Young plant as salad or potherb
black mustard	*Brassica nigra*	Leaves as a salad
bladder campion	*Silene* spp.	Young shoots as potherbs
broomrape	*Orobanche fasciculata*	Raw; better roasted
bulrush	*Scirpus validus*	Stem bases may be eaten raw
burdock	*Arctium minus*	Leaf stalks peeled; raw or cooked
burnet *Sanguisorba occcidentalis*		Leaves used as a salad
burning bush	*Kochia scoparia*	Tips of young shoots as potherbs
carpetweed	*Mollugo verticillata*	Plant as a potherb
cattail	*Typha latifolia*	Young shoots; raw or cooked
cheeseweed	*Malva* spp.	Shoots and leaves as salad or potherb
chicory	*Cichorium intybus*	Leaves; raw or boiled; spinach-like
chickweed	*Stellaria media*	Young plants used as a potherb
chuparosa	*Beloperone californica*	Flowers; raw or cooked
cow parsnip	*Heracleum lanatum*	Inner stem tissue; raw or cooked
curly dock	*Rumex crispus*	Leaves as potherb; boil in two waters
dandelion	*Taraxacum officinale*	Tender young leaves as a potherb
dead nettle, henbit	*Lamium amplexicaule*	Leaves and stems boiled as potherb
desert trumpet	*Eriogonum inflatum*	Young inflated stems as a salad
evening-primrose	*Oenothera* spp.	Leaves and stems as salad; better blanched
false mermaid	*Floerkea proserpinacoides*	Plants make for a spicy salad
field pennycress	*Thlaspi arvense*	Leaves and stems; raw or boiled
filaree *Erodium circutarium*		Young plants as a potherb

fireweed	*Epilobium angustifolium*	Stems and leaves as potherb
glasswort	*Salicornia* spp.	Succulent stems used; salty taste
goldenrod	*Solidago missouriensis*	Leaves used as a potherb
goosefoot	*Chenopodium* spp.	Leaves cooked as salad greens
greasewood	*Sarcobatus vermiculatus*	Tender stems cut into sections; boiled
hedge mustard	*Sisymbrium officinale*	Young plant used as a potherb
hops	*Humulus lupulus*	Young stems as potherb
Hottentot-fig, ice plant	*Carpobrotus edulis*	Leaves and stems as salad
Indian pipe	*Monotropa* spp.	Succulent stems; raw or cooked
Indian-rhubarb	*Darmera peltata*	Leafstalk peeled; eaten raw or cooked
jackass-clover	*Wislizenia refracta*	Potherb
lady's thumb	*Polygonum persicaria*	Leaves in salads
lamb's quarters	*Chenopodium album*	Young plants as potherbs
live forever	*Dudleya saxosa*	Fleshly leaves eaten raw
mignonette	*Reseda lutea*	Young plants as salad
milk thistle	*Silybum marianum*	Prepare as you would the artichoke
miner's-lettuce	*Montia perfoliata*	Young plants as salad or potherb
monkey flower	*Mimulus guttatus*	Young plants as salad; somewhat bitter
mountain-sorrel	*Oxyria digyna*	Leaves and stems raw or boiled
nettle	*Urtica* spp.	Young stems and leaves as a potherb
nipplewort	*Lapsana communis*	Young plants boiled as potherb
patata *Monolepis nuttalliana*		Above ground parts as potherb
pigweed	*Amaranthus* spp.	Young leaves; boil immediately
pipsissewa	*Chimaphila umbellata*	Leaves as a salad
plantain	*Plantago* spp.	Leaves boiled as potherb
prairie mallow	*Sidalcea neomexicana*	Entire plant may be boiled
prickly lettuce	*Lactuca serriola*	Young leaves for salads or potherbs
prince's plume	*Stanleya* spp.	Stems and leaves boiled like cabbage
purslane	*Portulaca oleracea*	Young stems and leaves as potherb
redbud	*Cercis occidentalis*	Fresh flowers good in salads
red maids	*Calandrinia ciliata*	Plants as salad or potherb
reed grass	*Phragmites australis*	Stems and leaves as potherb
Russian thistle	*Salsola iberica*	Leaves and stems; boil for 12-15 minutes
saltbush	*Atriplex* spp.	Stems and leaves boiled
scorpionweed	*Phacelia ramosissima*	Leaves cooked as greens
sea rocket	*Cakile edentula*	Leaves and stems as salad or potherb
seep weed	*Suaeda* spp.	Young plants; raw or boiled; salty taste
shepherd's purse	*Capsella bursa-pastoris*	Tender leaves and stems as salad
sorrel, sour-grass	*Oxalis oregana*	Leaves and stems eaten raw
sow thistle	*Sonchus oleraceus*	Stems and leaves used as a potherb
speedwell	*Veronica* spp.	Leaves as a salad
squaw-cabbage	*Caulanthus inflatus*	Stem requires repeated boilings
stonecrops	*Sedum* spp.	Leaves and stems; raw or boiled
vetch	*Vicia* spp.	Young stems and leaves boiled
violet	*Viola* spp.	Leaves and stems eaten raw or cooked
water cress	*Nasturtium officinale*	Plant as salad or potherb
winter cress	*Barbarea vulgaris*	Leaves; boil in two waters
wintergreen	*Gaultheria humifusa*	Young leaves as greens
yucca	*Yucca* spp.	Flowers and buds; raw, boiled, roasted

EDIBLE FRUITS

bastard toadflax	*Comandra umbellata*	Raw; best when fruits are green
blackberry	*Rubus* spp.	Berries; raw or cooked
buffalo berry	*Shepherdia argentea*	Raw or cooked; tart
bunchberry (dogwood)	*Cornus canadensis*	Raw or cooked
California fan palm	*Washingtonia filifera*	Pulp around seeds edible
California-laurel	*Umbellularia californica*	Parched; ground into flour
catclaw acacia	*Acacia greggii*	Meal made from dried fruits
cheeseweed	*Malva* spp.	Young fruits edible
chinquapin	*Chrysolepis chrysophylla*	Acorns edible
chinquapin, bush	*Chrysolepis sempervirens*	Acorns edible
chokecherry	*Prunus* spp.	Cook! Raw fruits high in cyanide
climbing milkweed	*Sarcostemma* spp.	Raw or cooked

crabapple	*Malus fusca*	Good for jellies
crabgrass	*Digitaria sanguinalis*	Fruits may be ground into flour
datil yucca	*Yucca baccata*	Fleshy fruits edible
dill	*Anethum graveolens*	Seed-like fruits used in flavorings
dropseed	*Sporobolus* spp.	Ground into meal or flour
elderberry	*Sambucus* spp.	Blue or black berries only; pies & jellies
fairy bells	*Disporum trachycarpum*	Berries eaten raw
flax	*Linum perenne*	Eat only after roasting fruits
foxtail *Setaria* spp.		Fruits ground into meal
gooseberry	*Ribes* spp.	Raw or cooked
gooseberry, blite	*Chenopodium capitatum*	Raw or cooked
goosegrass	*Eleusine indica*	Fruits ground into flour
ground cherry	*Physalis* spp.	Purple berries; raw or cooked
hackberry, western	*Celtis douglasii*	Fruits may be eaten raw
hawthorn	*Crataegus douglasii*	Fruits edible; quality varies with species
hazelnut, beaked	*Corylus cornuta*	Fruits ground into meal
Hottentot-fig	*Carpobrotus edulis*	Fruits edible
huckleberry	*Vaccinium* spp.	Raw or cooked; taste varies with species
Johnson grass	*Sorghum halepense*	Ground into meal or flour
juneberry (serviceberry)	*Amelanchier* spp.	Fruits highly prized by the Indians
juniper	*Juniperus* spp.	Raw or cooked; best in late summer
madrone	*Arbutus menziesii*	Berries; raw, boiled, or steamed
mannagrass	*Glyceria* spp.	Fruits parched; ground into flour
manzanita	*Arctostaphylos* spp.	Makes excellent jellies; somewhat acid
mesquite	*Prosopis juliflora*	Fruits may be ground into a meal
mountain-ash	*Sorbus* spp.	Ripe berries; raw or cooked
Nuttall's dogwood	*Cornus nuttallii*	Raw or cooked
oak	*Quercus* spp.	Acorns edible, varies with species
ocean spray	*Holodiscus discolor*	Raw or cooked
Oregon-grape	*Mahonia aquifolium*	Eaten raw or made into jelly
ocotillo	*Fouquieria splendens*	Tender fruits; raw or cooked
organpipe cactus	*Lemairocereus thurberi*	Pulp of fruits edible
oso berry	*Oemleria cerasiformis*	Raw or cooked
panic grass	*Panicum* spp.	Eaten raw or ground into meal
prickly pear cactus	*Opuntia polyacantha*	Fruits peeled; raw or boiled
raspberry	*Rubus leucodermis*	Berries; raw or cooked
redberry	*Rhamnus crocea*	Berries edible
redbud	*Cercis occidentalis*	Fruits may be fried
rice grass	*Stipa hymenoides*	Eaten raw or ground into meal
rose	*Rosa* spp.	Hips edible; varies with the species
sagebrush	*Artemisia tridentata*	Raw or dried; ground into meal
saguaro	*Cereus giganteus*	Pulp of fruits; raw or boiled
salal	*Gaultheria shallon*	Raw or cooked
salmonberry	*Rubus spectabilis*	Berries; raw or cooked
squaw-apple	*Peraphyllum ramosissimum*	Raw, but bitter; also made into jelly
squawbush	*Rhus trilobata*	Berries best when fully ripe
sunflower	*Helianthus annuus*	Seed-like fruits roasted; ground into meal
tansy mustard	*Descurainia* spp.	Fruits and seeds ground into meal
tarweed	*Madia glomerata*	Raw or roasted; also ground into meal
thimbleberry	*Rubus parviflorus*	Berries; raw or cooked
toyon	*Heteromeles arbutifolia*	Raw or roasted
twinberry	*Lonicera involucrata*	Edible raw
twisted stalk	*Streptopus amplexifolius*	Raw or cooked
unicorn plant	*Proboscidea* spp.	Fruits boiled or pickled when young
walnut	*Juglans hindsii*	Nuts edible
walnut, California	*Juglans californica*	Nuts edible
wild grape	*Vitis californica*	Fruits edible
wild oat	*Avena* spp.	Ground into flour
wild strawberry	*Fragaria* spp.	Fruits edible; quality varies with species
wintergreen	*Gaultheria humifusa*	Raw or cooked
wolfberry; boxthorn	*Lycium fremontii*	Fresh or dried in the sun

EDIBLE SEEDS

balsam root	*Balsamorhiza* spp.	Roasted
beach pea	*Lathyrus japonicus*	Raw when immature; best in soups later
bedstraw	*Galium aparine*	Roasted; coffee substitute
black medick	*Medicago lupulina*	Ground into meal
blazing star	*Mentzelia albicaulis*	Red seeds used to make gravy
buttercups	*Ranunculus* spp.	Parched; ground into meal
California fan palm	*Washingtonia filifera*	Dried; ground into meal
chia	*Salvia columbariae*	Parched; ground into meal
cow-lily	*Nuphar luteum*	Roasted; also ground into meal
desert-lavendar	*Hyptis emoryi*	Seeds parched and ground into flour
four-leaf pinyon	*Pinus quadrifolia*	Seeds edible
giant hyssop	*Agastache urticifolia*	Raw or roasted
goosefoot	*Chenopodium* spp.	Ground into meal for gruel or soup
gray pine	*Pinus sabiniana*	Seeds edible
hedge mustard	*Sisymbrium officinale*	Parched; ground into flour
ironwood	*Olneya tesota*	Parched or roasted in late summer
juniper	*Juniperus* spp.	Raw or dried and ground into meal
lacepod	*Thysanocarpus curvipes*	Parched and eaten or ground into flour
palata	*Monolepsis nuttalliana*	Ground into meal
palo verde	*Cercidium* spp.	Ground into meal
peppergrass	*Lepidium* spp.	Mix with vinegar and salt for dressing
pickleweed	*Salicornia subterminalis*	Seeds ground into flour
pinyon pine	*Pinus edulis*	Seeds edible
prince's plume	*Stanleya pinnata*	Parched; ground into flour
purslane	*Portulaca oleracea*	Seeds may be ground into mush
red maids	*Calandrinia ciliata*	Raw or cooked and ground into meal
sagebrush	*Artemisia* spp.	Raw or cooked and ground into meal
saltbush	*Atriplex* spp.	Ground into meal
Scotch broom	*Cytisus scoparius*	Roasted; coffee substitute
screw bean	*Prosopis pubescens*	Seeds ground into meal
seep weed	*Suaeda* spp.	Raw or parched
shepherd's purse	*Capsella bursa-pastoris*	Parched; ground into flour
single-leaf pinyon	*Pinus monophylla*	Seeds edible
squaw cabbage	*Caulanthus inflatus*	Parched; ground into flour
tansy mustard	*Descurainia* spp.	Ground into meal
tarweed	*Madia glomerata*	Raw, boiled or roasted
vervain	*Verbena* spp.	Roasted; ground into flour
vetch	*Vicia* spp.	Seeds boiled and eaten by Indians
wild flax	*Linum perenne*	Roasted, dried and ground; high in oils
winged pigweed	*Cycloloma atriplicifolium*	Ground into mush or cakes

BEVERAGE PLANTS

bird's foot fern	*Pellaea mucronata*	Stems and leaves make an aromatic tea
buffalo berry	*Shepherdia argentea*	Fruits crushed in water
California-lilac	*Ceanothus* spp.	Leaves and flowers; boil 5-10 minutes
creosote bush	*Larrea divaricata*	Leaves as a tea
Douglas-fir	*Pseudotsuga menziesii*	Needles as a tea
elderberry	*Sambucus* spp.	Blue and black berries made into wine
false buckwheat	*Eriogonum umbellatum*	Leaves as a tea
goldenrod	*Solidago missouriensis*	Leaves and mature flowers steeped for tea
ground ivy	*Glechoma hederacea*	Leaves dried; prepared as a tea
hoarhound	*Marrubium vulgare*	Tea/broth from leave; also a laxative
jojoba *Simmondsia chinensis*		Fruits ground, boiled, and liquid strained
lemonade berry	*Rhus integrifolia*	Berries soaked in water
manzanitas	*Arctostaphylos* spp.	Fruits scalded, crushed, added to water
Mormon tea	*Ephedra* spp.	Boil handful of leaves and stems
mountain hemlock	*Tsuga mertensiana*	Steep needles in hot water
mountain mahogany	*Cercocarpus ledifolius*	Bark as a tea
Oregon grape	*Mahonia aquifolium*	Fruits in water
pennyroyal	*Monardella odoratissima*	Makes a refreshing tea
pineapple weed	*Matricaria matricarioides*	Flower heads used as a tea
pipsissewa	*Chimaphila umbellata*	Boil roots and leaves
prairie smoke	*Geum ciliatum*	Roots boiled for a tea
quinine bush	*Cowania mexicana*	Steep handful of leaves for tea

saltbushes	*Atriplex* spp.	Seeds in water
selfheal	*Prunella vulgaris*	Fresh or dried leaves in cold water
sissop; winter fat	*Ceratoides lanata*	Leaves as a tea
spearmint; peppermint	*Mentha* spp.	Fresh or dried leaves in boiling water
squawbush	*Rhus trilobata*	Berries soaked in water
tarweed	*Grindelia* spp.	Leaves as a tea; broth for skin rashes
western hemlock	*Tsuga heterophylla*	Steep needles in hot water
wild strawberry	*Fragaria* spp.	Leaves as a tea
yerba buena	*Satureja douglasii*	Steep leaves 15-20 minutes in hot water
yerba santa	*Eriodictyon californicum*	Leaves as a tea

MISCELLANEOUS USES

California bay; laurel	*Umbellularia californica*	Leaves used as a condiment
chicory	*Cichorium intybus*	Roots provide coffee flavoring
cow parsnip	*Heracleum lanatum*	Leaves dried, burned; salt substitute
false dandelion	*Tragopogon* spp.	Sap chewed as a gum
hawkweed	*Hieracium* spp.	Sap may be chewed as gum
horsetails	*Equisetum* spp.	Peel away tough outer stem; pulp sweet
licorice fern	*Polypodium vulgare*	Leaf axis chewed
pussy's toes	*Antennaria* spp.	Stalks may be chewed as gum
red osier	*Cornus stolonifera*	Inner bark-leaves as tobacco substitute
reed grass	*Phragmites australis*	Stems may be ground into flour
sugar bush	*Rhus ovata*	Sugary covering on berries eaten
sugar pine	*Pinus lambertiana*	Sap sugary; also resinous
willows	*Salix* spp.	Inner bark edible when times are rough

5.14 • FORAGE PLANTS

I will close this section on food plants by pointing out to you that there is another vastly important category of food plants -- those that we feed to our domesticated animals, especially horses, dairy cattle and beef cattle. Another way of looking at it is that we use dairy and beef cattle to transform plants into meat, milk, and other dairy products. In the United States alone, forage crops constitute a multibillion dollar industry. It is estimated that more than half of the earth's land surface is devoted to pastures and meadows used for grazing by farm animals.

The high cellulose levels of grass stems and leaves make these tissues relatively difficult for most animals, including humans, to digest. However, the bacteria that inhabit the intestinal tracts of many animals carry out a fermentation process that reduces the cellulose to simpler compounds. We also create a suitable environ-ment in which anaerobic fermentation can occur when we put silage into a silo -- those cylindrical, observatory-looking structures that you see in farm country. For all practical purposes, chopped up plant material is pickled by being bathed in organic acids that are produced by the bacteria. If done properly, silage can be stored for years. The end product may sound pretty disgusting, but many of us enjoy something that is similarly prepared. It is called sauerkraut. From the German (sour + cabbage), it is chopped cabbage leaves that have been fermented in brine.

Although a great variety of plants can provide palatable food for our domesticated animals, all of the important forage plants are either grasses or legumes.

COMMON FORAGE PLANTS

Common Name	Scientific Name	Comment
GRASSES:		
Bermuda grass	*Cynodon dactylon*	Also an aggressive weed and lawn grass
Brome grasses	*Bromus* spp.	Very important in dry, cool regions
Buffalo grass	*Buchloë dactyloides*	Native grass of cool, dry prairies
Fescues	*Festuca* spp.	Well adapted to warm summers
Kentucky bluegrass	*Poa pratensis*	One of the best and most palatable
Love grasses	*Eragrostis* spp.	Widely used in southern Great Plains
Orchard grass	*Dactylis glomerata*	Does well in cool, humid regions
Redtop	*Agrostis stolonifera*	One of the best wetland forage grasses
Reed canary grass	*Phalaris arundinacea*	Well adapted to wet areas
Sorghum	*Sorghum bicolor*	Also used for grain, silage, and syrup
Timothy	*Phleum pratense*	Eurasian; widely planted
Wheat grasses	*Agropyron* spp.	Good in cool, dry regions
Wild ryes	*Elymus* spp.	Natives of the Pacific Northwest

LEGUMES:		
Alfalfa	*Medicago sativa*	Excellent protein source
Bird's-foot trefoil	*Lotus corniculatus*	Grows well on poor soils
Bush clovers	*Lespedeza* spp.	Plants of poor soils
Clovers	*Trifolium* spp.	Good protein and very palatable
Crown vetch	*Coronilla varia*	Eurasian; also used for erosion control
Sweet clovers	*Melilotus* spp.	Drought resistant; good soil builders
Vetches	*Vicia* spp.	Often used as winter cover crops

SECTION 6 • SPICES, FLAVORINGS, AND SUGAR

6.1 - AN OVERVIEW

- ☼ Most of the spices and flavorings that we use today were also used in ancient times.
- ☼ It is difficult for us now to imagine how precious certain spices were in the Middle Ages and the efforts made then to discover where they grew and to control their sale.
- ☼ Many of them are associated with particular regions of the world and ethnic groups.
- ☼ Some spices are made by grinding up entire plants, but most of them come from a particular part, such bark, leaves, seeds, etc.
- ☼ Spices have little food value.
- ☼ Some spices and flavorings, such as horseradish and wasabi, can be toxic if consumed in excess.
- ☼ In addition to their use in the kitchen, spices also are used in various medicines to impart a pleasant flavor.
- ☼ Before the invention of refrigeration, spices were used to mask the unpleasantness of spoiling meat.
- ☼ Sugars are carbohydrates, with the ratio of hydrogen to oxygen being 2:1, as in water.
- ☼ The effects of refined sugar on the body remain controversial, especially its purported addictive properties.
- ☼ Sugars are not the only sweetening agents found in plants. Some contain proteins or glycosides that are 4000 times sweeter than sucrose.

6.2 • SPICES AND FLAVORINGS

Spices are edible materials that are consumed not so much for their food value as they are for their aromatic, flavor-producing qualities. They are not necessities; spices generally have little nutritional value. Many of them are produced in Central America, northern South America, equatorial Africa, and Southeast Asia. Most spices owe their popularity to the **essential oils** that they contain. These oils are highly aromatic. Chemically they are benzene or terpene derivatives or straight-chain hydrocarbons of intermediate molecular length, seldom more than 20 carbon atoms long. Some may contain sulfur or nitrogen.

FUNCTIONS

The major functions of spices are:

- ☼ to add variety to our diet;
- ☼ to disguise the unpleasant taste of bad meat, an important consideration in warm areas; and
- ☼ to increase perspiration and salivation, thereby cooling the body and perhaps aiding in digestion.

Some not so major, but historically interesting, uses of spices include:

- ☼ as deodorants
- ☼ for prevention of the plague
- ☼ for the fumigation of areas before royal visits
- ☼ for covering up bad breath (once an absolute requirement before an audience with the Emperor of China)
- ☼ for embalming the dead, particularly in ancient Egypt
- ☼ in magical rites of various sorts
- ☼ in religious purification ceremonies
- ☼ as ingredients or cosmetic flavorings in medicines
- ☼ as aphrodisiacs.

HISTORY

Almost all of the spices that we use today have been in use for thousands of years. Until the 14th century, the world spice trade was controlled by the Arabs. In the 15th century, Venice took control and it was at about this time that many spices became known and widely used in Europe. In the late 1400's, Portugal became the leading figure in international spice trade. None of the important spices left the East Indies, except on Portuguese ships. An uprising in 1574 ended their rule of the Moluccas, also known as "The Spice Islands." England soon controlled India and the Spice Islands. This was the era of the founding of the famous East India Company. The Dutch then took control of the East Indies and for almost two centuries they dominated the distribution of pepper, most cinnamon, cloves, ginger, mace, and nutmeg. Today many of the spices are widely planted and no single country has a monopoly.

TIMELINE: SPICE TRADE

BCE:

5000	Spices used in Middle East
3000	Egyptians use spices in embalming
2000	Arabs establish monopoly in spice trade
1500	Queen Hathepshut of Egypt imports spices from the Land of Punt
992	Queen of Sheba brings spices to King Solomon
200	Chinese import cloves from the Spice Islands

CE:

410	Fall of Rome
610	Arab domination begins (to 1096)
812	Charlemagne orders spices planted on imperial farms
1096	First Crusade opens trade routes
1180	Pepperer's Guild founded in London
1271	Nicolo, Marco, & Maffeo Polo sail for Asia

1460	Portuguese bring back grains-of-paradise from Africa
1492	Columbus sails for the Indies in search of its precious spices
1498	Vasco de Gama reaches Calicut, India
1510	Portuguese gain control of Ceylon (Sri Lanka)
1522	Magellan arrives in Spice Islands
1560	Overland trade route to Asia re-established
1574	Uprising against Portuguese in Spice Islands
1579	Sir Francis Drake reaches East Indies
1600	British East India Company founded
1602	United (Dutch) East India Co. founded
1605	Dutch drive Portuguese out of Spice Islands (to 1621)
1641	Dutch capture Spice Islands
1651	Dutch begin destroying nutmeg and cloves
1770	Pierre Poivre smuggles cloves, etc. from Spice Islands
1795	U. S. sails for Sumatra – enters pepper trade
1795	English plant clove trees on Malay Peninsula
1796	English gain control of East Indies
1799	English end control by Dutch East India Co.
1955	Hurricane Janet destroys 90% of Grenada's nutmegs
1983	International Spice Group founded

ROOTS, RHIZOMES, AND BULBS

ONIONS AND THEIR ALLIES

Common Name	Scientific Name
Canadian garlic	*Allium canadense*
Ch'iao t'ou	*Allium chinense*
Chinese chives	*Allium odorum*
Chives	*Allium schoenoprasum*
Egyptian onion	*Allium cepa*
Elephant garlic	*Allium ampeloprasum*
Eschalot	*Allium cepa*
Garlic	*Allium sativum*
Giant garlic	*Allium scorodoprasum*
Kurrat	*Allium ampeloprasum*
Leek	*Allium ampeloprasum*
Levant garlic	*Allium ampeloprasum*
Nodding onion	*Allium cernuum*
Onion	*Allium cepa*
Rakkyo	*Allium chinense*
Ramp	*Allium tricoccum*
Rocambole	*Allium sativum*
Shallot	*Allium cepa*
Tree onion	*Allium cepa*
Welsh onion	*Allium fistulosum*
Wild garlic	*Allium canadense*
Wild leek	*Allium tricoccum*

ONION (*Allium cepa*) is one of our oldest food and flavoring plants. It is the most popular of the group of related species shown in the table. Onions are probably native to southwestern Asia. Their characteristic flavor and aroma come from a sulfur-containing compound, **allicin**. The onion is also held in high regard as a medicinal plant.

GARLIC (*Allium sativum*) is second only to the onion in popularity as a flavoring. It is also native to Asia. Garlic cloves are segments (axillary buds) of the parent bulb, surrounded by a papery sheath. Garlic has a long history of medicinal uses to cure cancer, tuberculosis, athlete's foot, hemorrhoids, and to treat high blood pressure, and as an aphrodisiac.

Sacks of garlic worn about the neck have been considered by some people to be useful in warding off trolls and vampires. All I can say in this matter is that not a single friend of mine who uses garlic has ever been the attacked by either of these creatures.

OTHER "ROOTS"

GINGER (*Zingiber officinalis*) is the most important of the root spices. It is actually the rhizome that contains the spice. Ginger, a member of the ginger family (Zingiberaceae), is native to Southeast Asia.

TURMERIC (*Curcuma longa*) is native to Southeast Asia. It is also a member of the ginger family. The spice is derived from rhizomes with blunt tubers. Turmeric is immensely popular because it is a principal ingredient in curry powder.

HORSERADISH (*Armoracia rusticana*) roots contain a very potent glycoside called sinigrin. The plant, a member of the mustard family (Cruciferae), is native to southeastern Europe, where it can be a weed.

WASABI (*Wasabia japonica*) is related to the horseradish, but it is not a kind of horseradish. It is also known as the Japanese horseradish, which adds to the confusion in common names. This perennial member of the mustard family grows naturally next to mountain streams; it is cultivated in flooded terraces. The roots are ground to make a green powder or paste. Most of the wasabi that we are served is horseradish + mustard + green food coloring. The real wasabi is far too expensive for general use.

It is very pungent! One fellow who did not know about wasabi thought that it was strange that a Japanese restaurant would be serving guacamole. After consuming a hearty bite, he ended up in the hospital.

SARSAPARILLA (*Smilax* spp.) is a trailing, prickly vine native to the New World tropics. The roots yield the spice, once widely used in various health tonics and beverages. The hero in the old western movies always ordered this when he found himself in a saloon. The plant belongs to the lily family (Liliaceae).

BARKS

CINNAMON (*Cinnamomum zeylanicum*) comes from a tree native to Ceylon and India. The volatile agent is cinnamic aldehyde. Bark is removed by hand after the monsoon season. The best material is intact bark sections from which the underlying cells have been removed. These are the "quills" of commerce. Damaged quills and fragments are converted into powdered cinnamon.

CASSIA (*Cinnamomum cassia*), an ancient spice, is often confused with true cinnamon. The tree is native to Burma. Its bark is loosened, stripped off, and dried. Cassia is used in medicine, flavorings, soaps, and candies. A significant portion of the cassia crop is sold as cinnamon.

SASSAFRAS (*Sassafras albidum*) comes from a tree native to eastern North America. It has been used to flavor medicines, root beers, soaps, etc. It has industrial applications in floor oils and polishing oils. The once popular sassafras tea is now rarely encountered because of its recently discovered carcinogenic properties.

LEAVES

BASIL comes from *Ocimum basilicum*, a mint native to India and Africa. It is much used in stews, dressings, and in mock turtle soup.

PEPPERMINT is also derived from a mint, *Mentha piperita*. It grows wild in Europe, Asia, and North America. The plants yield menthol, an essential oil with wide applications.

SPEARMINT is derived from *Mentha spicata*, a mint native to Europe and Asia. It is a widely used flavoring material.

SAGE (*Salvia officinalis*) is a mint native to the Mediterranean region. It has been a popular culinary herb since ancient times. The generic name, derived from the Latin verb "to save," tells us of its reputation as a medicinal plant. The specific epithet indicates that the plant was listed officially and approved for medical use.

WINTERGREEN comes from the leaves of a birch tree, *Betula lenta*. The flavoring derives from a glycoside, methyl salicylate. Originally this popular spice came from *Gaultheria procumbens*, a plant of the heath family.

TARRAGON (*Artemisia dracunculus*) is an Asian herb that belongs to the daisy or sunflower family. It is in the same genus as the sagebrush of our western states. Its distinctive bittersweet flavor has made it one of the most popular culinary herbs. Tarragon's popularity appears to go back only to about the Middle Ages.

FLOWERS AND FLOWER BUDS

CAPERS are the flower buds of a shrub (*Capparis spinosa*) native to the Mediterranean. It is also cultivated in the southern U. S. Caper buds are pickled in salt and strong vinegar.

CLOVES are the unopened flowers and attached section of stem from *Eugenia caryophyllata*, a tree native to the Spice Islands. Most cloves now come from Zanzibar and the Malagasy Republic. Oil of cloves is obtained by distillation. Eugenol is used in the synthesis of vanillin, the artificial vanilla flavoring.

SAFFRON, from the stigmas and styles of *Crocus sativus*, a relative of the garden crocus, is the most expensive of the commonly used spices. It takes about 70,000 flowers to yield one pound of saffron. The material has also been used as a plant dye.

FRUITS

ALLSPICE is derived from *Pimenta dioica*, a tree native to the West Indies and Central America. The common name comes from the fact that the spice tastes as though it were a combination of several flavorings.

PEPPERS is the common name used for the fruits of various species of *Capsicum*, New World members of the nightshade family. Because they can be confused with black and white pepper, some authors prefer to call these plants "capsicums" or "capsicum peppers."

A SUMMARY OF CAPSICUM PEPPERS

Common Name	Scientific Name
Aji	*C. baccatum* var. *pendulum*
Aji	*C. chinense*
Anaheim	*C. annuum* var. *a.*
Ancho	*C. annuum* var. *a.*
Banana	*C. annuum* var. *a.*
Bell	*C. annuum* var. *a.*
Bird	*C. annuum* var. *glabriusculum*
Bird	*C. frutescens*
Cascabel	*C. annuum* var. *a.*
Cayenne	*C. baccatum* var. *baccatum*
Cayenne	*C. frutescens*
Chamburoto	*C. pubescens*
Chile manzana	*C. pubescens*
Chili	*C. frutescens*
Chili	*C. annuum* var. *a.*
Chilipiquin	*C. annuum* var. *glabriusculum*
Chiltepine	*C. annuum* var. *glabriusculum*
Green	*C. annuum* var. *a.*
Habanero	*C. chinense*
Hungarian wax	*C. annuum* var. *a.*
Jalapeno	*C. annuum* var. *a.*
Mango	*C. annuum* var. *a.*
Mirasol	*C. annuum* var. *a.*
Paprika	*C. annuum* var. *a.*
Peperoni	*C. annuum* var. *a.*
Pepperoncini	*C. annuum* var. *a.*
Peter	*C. annuum* var. *a.*
Pimiento	*C. annuum* var. *a.*
Poblano	*C. annuum* var. *a.*
Rocotillo	*C. chinense*
Rocoto	*C. pubescens*
Serrano	*C. annuum* var. *a.*
Squash	*C. annuum* var. *a.*
Tabasco	*C. frutescens*
Tomato	*C. annuum* var. *a.*

[After Andrews, 1984 and others]

The volatile agent is capsaicin. Our tongue can detect concentrations of as little as 1 part per million. Capsaicin can produce burns that are so severe that they require medical attention. The greatest concentration of capsaicin is in the placenta, the tissue where the seeds are attached. Relative "heat" is traditionally expressed in terms of Scoville Heat Units. Wilbur Scoville was a pharmacist. The delicate scientific instrument that he used to quantify "hotness" was his tongue.

RELATIVE INTENSITIES OF PEPPERS

Type of Pepper	Scoville Heat Units
Bell	0
Pimiento	0
Chile con carne	15-30
Paprika (dry, ground)	0-150
Taco sauce	300
El Paso	100-500
Cherry	100-500
Big Jim	500-1000
Anaheim	500-1000

Ancho	1000-1500
Sandia	1500-2500
Rocotillo	1500-2000
Tabasco sauce	4500
Jalapeno	2500-5000
Mirasol	2500-5000
Yellow wax	5000-15,000
Serrano	5000-15,000
De Arbol	15,000-30,000
Santaka	50,000-100,000
Chiltecpin	50,000-100,000
Thai	50,000-100,000
Bahamian	100,000-300,000
Habanero	100,000-300,000
Pure capsaicin	16,000,000

BLACK PEPPER and **WHITE PEPPER** are both derived from *Piper nigrum*, a climbing vine native to Ceylon and India. It is a member of the piper or peperomia family and not at all related to the nightshades. The unripened fruits are hand picked, piled in heaps, and dried in the sun. Natural fermentation causes the fruits to turn black. The hard, berry-like fruits are called "peppercorns." Commercial black pepper is made by grinding up the peppercorns.

White pepper is made by soaking the ripe peppercorns for about two weeks. The outer skins are removed and the smooth, white insides are washed and dried in the sun.

VANILLA beans are the unripened, fermented fruits of *Vanilla planifolia*, a New World tropical vine belonging to the orchid family. The essential oil, vanillin, is extracted with alcohol. The Spanish found vanilla in use by the Aztecs. Bernal Diaz describes Moctozuma using it to flavor a beverage called chocalatl.

THE "SAVORY SEEDS"

Several plants of the carrot family (Umbelliferae) produce small, seed-like fruits that are commonly known as "savory seeds." Some examples are:

ANISE from *Pimpinella anisum*, one of our oldest spices, is used to flavor cakes, pastries, candies, and anisette, a liqueur.

CARAWAY, from *Carum carvi*, is used in baking, medicine, and to make kummel. The plant is native to Europe and Asia.

DILL comes from *Anethum graveolens*, native to Europe and Asia. It is used in cooking and to flavor pickles.

FENNEL, a common roadside weed in our area, comes from *Foeniculum vulgare*, a native of the Mediterranean region. All parts of the plant are aromatic. It is widely used in cooking.

SEEDS

WHITE MUSTARD, from *Sinapis alba*, contains sinalbin, a glycoside. When combined with water, it yields a non-volatile sulfur compound that imparts the characteristic taste. White mustard is used in medicine and as a condiment.

BLACK MUSTARD is derived from *Brassica nigra*, a Eurasian plant. It is now widely cultivated. The seeds contain sinigrin, which will produce a volatile sulfur compound when it breaks down. It is exceedingly powerful and can cause great damage to the sensitive linings of the digestive tract. Black mustard has a stimulating effect on the salivary glands and on the peristaltic action of our gastrointestinal tract. The ground mustard that we typically purchase is often a mixture of black and white mustards.

NUTMEG comes from *Myristica fragrans*, a tree native to the Spice Islands. It was unknown to most of the ancient world. Most nutmeg is now grown on Grenada, an island in the West Indies. The seeds also contain psychoactive compounds.

MACE comes from the very same tree. Whereas nutmeg is the seed, mace is the brightly-colored tissue (aril) that surrounds the seed.

SPICES AND FLAVORINGS

Common Name (Scientific Name)	Part Used	Comments
achiote *(Bixa orellana)*	seeds	See annatto
allspice *(Pimenta dioica)*	fruits	Not a mixture, as commonly thought
angelica *(Angelica archangelica)*	roots	Used to flavor vermouth
angostura *(Galipea officinalis)*	bark	Flavoring in alcoholic/soft drinks
anise *(Pimpinella anisum)*	fruits*	Used in anisette
annatto *(Bixa orellana)*	seeds	From tropical America; also a dye
asafedita *(Ferula assafoetida)*	resin	Used in Worcestershire sauce
balm *(Melissa officinalis)*	leaves	Cultivated for 2000 years
balsam of Tolu *(Myroxylon balsamum)*	stems	From South America
basil *(Ocimum basilicum)*	leaves	Widely used in cooking
bay *(Laurus nobilis)*	leaves	The laurel of classical references
black cherry *(Prunus serotina)*	fruits	A popular flavoring
buchu *(Agathosma* spp.*)*	leaves	A potent flavoring in foods
California bay *(Umbellularia californica)*	leaves	Often sold as bay leaves
capers *(Capparis spinosa)*	flw buds	Buds pickled; used in salads
caraway *(Carum carvi)*	fruits*	Widely used in baking

cardamom *(Elettaria cardamomum)*	seeds	Used in curries, pickles, and cakes
cassia *(Cinnamomum aromaticum)*	bark	Often confused with cinnamon
celery *(Apium graveolens)*	fruits*	Many culinary uses
chervil *(Anthriscus cerefolium)*	leaves	Native to Asia
cilantro *(Coriandrum sativum)*	fruits*	See coriander
cinnamon *(Cinnamomum verum)*	bark	Contains cinnamic aldehyde
cloves *(Syzygium aromaticum)*	flw buds	Contains oil of cloves
coriander *(Coriandrum sativum)*	fruits*	Perhaps most widely used flavoring
cubeb *(Piper cubeb)*	fruits	A black pepper relative; East Indies
cumin *(Cuminum cyminum)*	fruits*	Used in cheeses and pickles
dill *(Anethum graveolens)*	fruits*	Used to "dill" pickles
epazote *(Chenopodium ambrosioides)*	leaves	Also called Mexican tea; medicinal uses
eucalyptus *(Eucalyptus* spp.*)*	leaves	Wide variety of uses
fennel *(Foeniculum vulgare)*	fruits*	Licorice-like flavoring; weedy here
fenugreek *(Trigonella foenum-graecum)*	seeds	Used in artificial maple flavorings
frankincense *(Boswellia carteri)*	resin	Tree of Asia and Africa
galanga *(Kaempferia galanga)*	rhizome	Asiatic; also medicinal uses
galangal *(Alpinia officinarum)*	rhizome	Asiatic; ginger relative
garlic *(Allium sativum)*	bulbs	Pungent leaves also used in medicine
ginger *(Zingiber officinalis)*	rhizome	Sold by the "hand"
grains-of-paradise *(Aframomum sceptrum)*	seeds	Pungent West African flavoring
horseradish *(Armoracia lapathifolia)*	roots	Contains powerful mustard oils
hyssop *(Hyssopus officinalis)*	leaves	Some culinary uses
laurel *(Laurus nobilis)*	leaves	Native to Mediterranean
licorice *(Glycyrrhiza glabra)*	roots	Fifty times sweeter than sucrose
mace *(Myristica fragrans)*	seeds	Derived from tissue covering seeds
marjoram *(Origanum majorana)*	leaves	Used as a flavoring
mustard, black *(Brassica nigra)*	seeds	Contains sinigrin (volatile)
mustard, Indian *(Brassica juncea)*	seeds	Primarily Old World plant
mustard, white *(Sinapis alba)*	seeds	Contains sinalbin (nonvolatile)
myrrh *(Commiphora* spp.*)*	resin	Also used in incense and medicine
nutmeg *(Myristica fragrans)*	seeds	From same plant as mace
onion *(Allium cepa)*	bulbs	Native to Asia and the Mediterranean
oregano *(Origanum vulgare)*	leaves	Prized in Mexican cooking
paprika *(Capsicum annuum)*	fruits	A kind of capsicum pepper
parsley *(Petroselinum crispum)*	leaves	Used as garnish and flavoring
pennyroyal *(Mentha pulegium)*	leaves	Relative of spearmint and peppermint
pepper, black *(Piper nigrum)*	fruits	From the whole fermented fruits
pepper, chili *(Capsicum annuum)*	fruits	Pungency from capsaicin
pepper, Japan *(Zanthoxylum piperitum)*	seeds	Condiment in Japan and China
pepper, red *(Capsicum* spp.*)*	fruits	Native to New World tropics
pepper, tobasco *(Capsicum frutescens)*	fruits	Very acrid; New World tropics
pepper, white *(Piper nigrum)*	fruits	Outer skin of fruit removed
peppermint *(Mentha* x *piperita)*	leaves	Its essential oil widely used
pepper tree *(Schinus molle)*	fruits	Used in baked goods and candies
poppy seeds *(Papaver somniferum)*	seeds	From opium poppy; no opiates
quassia *(Quassia amara)*	bark	A bitter flavoring
rue *(Ruta graveolens)*	leaves	Culinary and medicinal uses
saffron *(Crocus sativus)*	flowers	Only stigmas and styles used!
sage *(Salvia officinalis)*	leaves	Not from sagebrush of the deserts
sarsaparilla *(Smilax aristolochiifolia)*	roots	Used to flavor root beer
sassafras *(Sassafras albidum)*	bark	Used to flavor root beer; poisonous
savory *(Satureja hortensis)*	leaves	Used in dressings and sauces
sesame *(Sesamum indicum)*	seeds	Contains a fixed oil
sloe berry *(Prunus spinosa)*	leaves	Flavoring in gin and liqueurs
spearmint *(Mentha spicata)*	leaves	Widely used flavoring
star anise *(Illicium verum)*	fruits	Not a kind of anise; magnolia relative
tarragon *(Artemisia dracunculus)*	leaves	Flavoring; used in pickles
thyme *(Thymus vulgaris)*	leaves	Contains thymol
Tonka bean *(Dipteryx* spp.*)*	seeds	Contains vanilla-like coumarin
turmeric *(Curcuma domestica)*	rhizomes	Used in making curry powder
vanilla *(Vanilla planifolia)*	fruits	Fermented fruits of an orchid
wasabi *(Wasabia japonica)*	roots	Popular Asian spice
wintergreen *(Gaultheria procumbens)*	leaves	Contains methyl salicylate

zedoary *(Curcuma zedoaria)*	rhizome	Flavoring in liqueurs

* These seed-like fruits from plants of the carrot family (Umbelliferae) are often called savory-seeds.

6.3 • SUGAR & OTHER SWEETENERS

In everyday language, sugar is a sweet, crystalline solid used to flavor food, to hide disagreeable tastes, and in a variety of industrial processes. Within the plant body, sugar is an intermediate, soluble, transportable form of food. Sugars are kinds of carbohydrates. To a chemist, carbohydrates are polyhydroxyaldehydes or ketone alcohols. To the rest of us, they are organic compounds made up of carbon, hydrogen, and oxygen, with the hydrogen and oxygen typically occurring in a ratio of 2:1, as they do in water.

It is convenient to divide carbohydrates into two subgroups: **sugars** and **polysaccharides**. Sugars have simpler structures and lower molecular weights. The simplest sugars are called **monosaccharides**, sugars that cannot be broken down (hydrolyzed) into even simpler sugars. **Dissacharides**, on the other hand, yield two monosaccharide sugars on hydrolysis; **trisaccharides** break down into three, and so on. The polysaccharides are chemically more complex, often represented graphically as long chains of repeating chemical units. Two very common examples of polysaccharides are **starch** and **cellulose**. Starch can be thought of as the principal food storage form in living plants. It can be chemically converted back into simpler, more directly usable sugars. More about starch later. Cellulose is an inert material. It is the chief component of plant cell walls. It, too, is of great economic importance. Cotton fibers are essentially pure cellulose. It is the main constituent in wood.

There are many kinds of sugars, including **dextrose**, also called corn sugar or grape sugar; **fructose** or fruit sugar or levulose, which occurs in honey and in many fruits; **glucose**, the kind found in karo syrups; **lactose** or milk sugar; **sucrose**, also known as cane sugar or beet sugar; and **xylose** or wood sugar, which is made by boiling corn cobs, straw, etc. Far and away, the most economically important of these sugars is sucrose, a disaccharide made up of glucose and fructose. World production is about 111 million metric tons of raw sugar each year, from the processing of about 1 billion metric tons of cane and 282 million metric tons of sugar beets. These two plants concentrate enough sucrose in the jointed stems of the sugar cane and in the swollen taproot of sugar beets to make extraction economically feasible.

TIMELINE: SUGAR & SWEETENERS

BCE:

10000 Sugar cane domesticated
510 Persian tablet provides first account of solid sugar use

CE:

1493 Columbus brings sugar cane to New World
1523 Cane first grown in Cuba
1532 Cane first grown in Brazil
1605 Oliver de Serres discovers beet juice similar to sugar syrup
1751 Sugar cane first planted in U. S.
1786 Sugar beet first cultivated in France
1800 Sugar beet introduced into the U. S.
1801 Sugar beet domesticated in Silesia
1802 Franz Achard designs first beet factory
1810 J. L. Gay-Lussac discovers sugar → ethyl alcohol + carbon dioxide
1811 Louis Figuier develops bone charcoal filtering technique
1875 Eugen Langen invents sugar cube
1879 Fahlberg & Remsen invent saccharine
1929 Haden & von Euler-Chelpin win Nobel for sugar fermentation
1937 U. S. Congress passes American Sugar Act that sets import quotas
1958 Sweet 'n Low introduced
1980 Coca Cola switches to high fructose corn sweetener
1983 NutraSweet introduced

SUGAR-BEARING PLANTS

Common & Scientific Name	Plant Family
Barley (*Hordeum vulgare*)	Grass
Black maple (*Acer nigrum*)	Maple
Coconut palm (*Cocos nucifera*)	Palm
Honey palm (*Jubaea chilensis*)	Palm
Jaggery (*Caryota urens*)	Palm
Manna ash (*Fraxinus ornus*)	Olive
Nipa palm (*Nypa fruticans*)	Palm
Palmyra palm (*Borassus flabellifer*)	Palm
Sago palm (*Caryota urens*)	Palm
Sugar beet (*Beta vulgaris*)	Goosefoot
Sugar cane (*Saccharum officinarum*)	Grass
Sugar maple (*Acer saccharum*)	Maple
Sugar palm (*Arenga pinnata*)	Palm
Sorghum (sorgo) (*Sorghum bicolor*)	Grass
Toddy palm (*Caryota urens*)	Palm
Wild date palm (*Phoenix sylvestris*)	Palm

CANE SUGAR

"The Queen's sugar was a bitch!"
[Simon Schama, "A History of Britain"]

"*... sugar, after the illegal drugs, and tobacco and alcohol, is the most damaging addictive substance consumed by rich, white mankind.*"
(Henry Hobhouse, 1986)

☼ ☼ ☼ ☼ ☼

Cane sugar comes from the jointed, bamboo-like stems of *Saccharum officinarum*, a grass native to the Old World tropics, perhaps in the area of New Guinea. Although it has been in use since ancient times, there are no references to sugar cane in Chinese or Egyptian literature. It spread from its ancestral home to China, then to Java, and to the islands of the Pacific. Sugar cane was brought to the New World by Columbus on his second voyage. It was first planted in the United States in New Orleans in 1751. Now it is grown in warm areas around the world.

Sugar cane is vegetatively propagated by planting sections of stems with buds. It generally takes about 1 to 1.5 years to get a crop. Current production is almost 1 billion metric tons per year worldwide. Cane requires a great deal of water -- 2 metric tons of water to produce 1 kg of sugar. Plants are subject to a number of diseases and pests, including rats.

PROCESSING. The crop was traditionally harvested by hand, often by slaves. Because of the terrible conditions under which they worked, one authority estimated that 1 ton of sugar cost the life of one slave. Today, manual labor is still used, but so is a great deal of specialized equipment.

The processing of sugar cane consists of two phases:

Milling

Stems washed, chopped, shredded, and pressed between giant rollers
▽
Stems chopped more finely
▽
Soaked in hot water squeezed to extract more sugar
▽
Crushed stem fiber remains (**bagasse**) burned to make steam to run mill
▽
Lime added and the mixture heated
▽
Fibers and soil settle out or float to surface
▽
Juice pumped to evaporators
▽
Loss of water yields a thick, dark syrup
▽
Pumped to vacuum pans
▽
More evaporation occurs
▽
Syrup boiled down to form **massecuite** (solid sugar crystals and liquid **molasses**)
▽
Massecuite centrifuged to separate solid and liquid phases
▽
Sugar crystals washed (removes film of molasses)
▽
Spinning and drying (just what it sounds like)

All of the steps so far are accomplished at the mill, often located in a tropical or subtropical area close to the sugar cane plantations. Most of them were built many years ago and they tend to look pretty disreputable. The product at this stage is unrefined **raw sugar**. It is about 96% sucrose, a disaccharide consisting of fructose and glucose. It also contains soil, microbes, and various other contaminants. The Food and Drug Administration says that it is unfit for human consumption. **Turbinado** is a partially refined form of sugar. It is washed with steam during centrifugation. **Molasses**, from the Latin for honey-like, is the syrup that remains after sucrose has been crystallized. Its darker color comes from carmelization and the high temperature during boiling.

Refining

The refining of raw sugar typically occurs in a separate facility, often located somewhere far removed from the mill.

Raw sugar melted to reform syrup
▽
Filtered twice to yield a colored syrup
▽
Boiled in vacuum pans
▽
Centrifuged
▽
Air-dried
▽
Filtered again (diatomaceous earth, carbon black, and ground bone)

Brown sugar is a form of refined sugar. Syrup has been added to the processed sucrose and it is redissolved and recrystallized. A fine molasses film remains on the sugar crystals. The sugar industry once claimed brown sugar was so contaminated that it should never be eaten.

Average consumption of sucrose in the United States is about 136 lbs per person annually or about 450 calories per day. Large amounts of sugar, and some people eat about 4 lbs/week, can meet the body's energy needs. Consuming sugar in this amount can inhibit starch and fiber-converting enzymes. Our stomachs then find it more difficult to digest starch and fiber. Some argue that we can become addicted to refined sugar. Some authorities believe that there is a strong correlation between high sugar consumption that high alcohol intake outside of regular meals.

BEET SUGAR

Beet sugar is derived from the swollen taproots of *Beta vulgaris* var. *altissima*, a relative of the edible table beet. The wild beet of northern Europe, *Beta maritima*, is presumably ancestral to both of them. It was not until the latter part of the 18th century that the potential of the sugar beet was realized. In the following years, the chemical nature of its sugar was found to be identical to that of sugar cane and intensive breeding programs began. In 1993, we grew 282 million metric tons of sugar beets. Sugar beets are grown in the temperate parts of the world. France is the leading producer, which is not unexpected when we recall the edict of Napoleon Bonaparte.

Extraction Process

Topping (removal of the leaf cluster)
▽
Thorough washing
▽
Shredding taproots
▽
Soak material in hot water (most soluble sugar diffuses into water)
▽
Remove impurities (add lime, carbon dioxide, and sulfur dioxide)
▽
Filter
▽

Concentrate clear liquid that results to yield crystalline sucrose.

The residue that remains makes an excellent cattle feed. As in sugar cane, the raw sugar obtained from sugar beets is brown and must be refined to create white sugar. Two hundred years ago, sugar beets contained about 6% sucrose. Today's improved varieties can produce up to 20% sugar.

MAPLE SUGAR

The indigenous peoples of North America had used the sugar maple (*Acer saccharinum*), and to a lesser extent, the black maple, as the source of a sweetening agent. They made cuts in the bark of the trees in the early spring. The sap that oozed out was collected and concentrated by dropping hot rocks into it or by freezing the sap and removing the layer of sugary ice that formed each day. Early European settlers modified the procedure by drilling holes in the trees and by boiling the sap down in iron kettles. Today we use power drills, perhaps even the battery-powered models! Final processing occurs in the "sugar house," where the maple sap is concentrated even more in an evaporator to yield maple syrup. If boiled even further, the product will be the crystalline solid called maple sugar.

Maple sugar is mostly sucrose. The sugar content of the sap is only about 2-6%, much lower than that of cane or beets. One reason why maple sugar is so expensive is that it takes about 40 gallons of sugar maple sap to make one gallon of maple syrup. One of the major users of maple syrup is the tobacco industry, as a flavoring in its products.

OTHER SWEETENERS

Perhaps fueled by the controversy about the health hazards of sucrose, some attention has been turned to plants that yield sweeteners other than ordinary sugars. The West African plant *Thaumatococcus daniellii*, an herb in the prayer plant family (Marantaceae), contains a protein that is up to 4000 times sweeter than sucrose. From that same region, a second plant called *Dioscoreophyllum cumminsii*, yields another protein that is 800-3000 times sweeter than cane sugar. *Stevia rebaudiana*, a South American member of the sunflower family, contains stevioside, a glycoside up to 300 times as sweet as sucrose. A little closer to home, *Lippia dulcis*, of the vervain or verbena family native to Mexico, has a compound in its leaves and flowers that is 1000 sweeter.

SECTION 7.0 • BEVERAGE PLANTS

7.1 • AN OVERVIEW

- ☼ There are three major groups of beverages that we derive from plants: fruit juices and those that contain caffeine or alcohol.
- ☼ Many widely used beverage plants are relatively unknown here in the United States.
- ☼ The ethyl alcohol in beer, wine, and distilled beverages is a byproduct (which sounds better than waste product) of microscopic yeasts.
- ☼ Caffeine acts as a stimulant to the central nervous system.
- ☼ Alcohol is not so easily categorized. It can be a depressant or a stimulant, and has other effects as well.
- ☼ Both caffeine and alcohol fit comfortably within the usual definition of a drug.
- ☼ The ill effects of alcohol abuse are well-established.
- ☼ Linkage of caffeine consumption with heart disease, high blood pressure, etc. remains controversial.

7.2 • CAFFEINATED BEVERAGES

"*It is probably significant that the most widespread words in the world – borrowed into virtually every language – are the names of the four great caffeine plants: coffee, cacao, cola, and tea.*"

(E. N. Andes, "The Food of China")

☼ ☼ ☼ ☼ ☼

We have developed a number of non-alcoholic beverages from plants. There is an almost endless list of fruit juices. They are, however, of rather minor economic importance when compared to the three leading nonalcoholic drinks -- tea, coffee, and chocolate. These drinks contain **alkaloids**, physiologically active compounds containing nitrogen. If you examine a structural representation of their molecules, you will see that they have a ring of carbon atoms.

CAFFEINE & RELATED ALKALOIDS

The principal alkaloid in coffee, tea, and chocolate is **caffeine**, technically known as 1, 3, 7-trimethyl-xanthine. It has been called the most widely used psychoactive material on earth. In the United States, we consume about one quarter of the world's supply, about 211 milligrams per person per day (about three times the world's average).

Two other chemically similar alkaloids may also be found in caffeine-bearing plants. They are **theobromine** and **theophylline**. Collectively they are often called the **xanthine alkaloids.**

CAFFEINE CONTENT

We encounter caffeine in various foods, beverages, medicines, and weight-control aids.

Product	Caffeine in mg
coffee (5 oz) (drip)	115-175
coffee (5 oz) (perked)	60-125
coffee (5 oz) (instant)	40-105
coffee (5 oz) (decaffeinated)	2-5
tea (5 oz) (steeped 3 minutes)	20-50
tea (5 oz) (steeped 5 minutes)	40-100
tea (5 oz) (instant)	12-28
tea (5 oz) (iced)	22-36
maté	25-150
guaraná	58
cocoa (5 oz)	2-8
milk chocolate (1 oz)	1-15
baking chocolate (1 oz)	35
dark chocolate (1 oz)	5-35
"Jolt" cola (12 oz)	72
Coca Cola (12 oz)	46
Dr. Pepper (12 oz)	40
Pepsi Cola (12 oz)	38
RC Cola (12 oz)	36

[Source: Inst. Food Technol., 1987]

PERCENTAGE OF XANTHINE ALKALOIDS

Plant Source	Caffeine	Theobrom-	Theophyl l-
Coffee	0.6-2.2	Trace	Trace
Tea (green)	2.9-4.2	0.15-0.20	0.02-0.04
Cacao	0.1-0.4	2.8-3.5	
Cola nut	0.6-3.7	Trace	Trace
Guaraná	3.6-5.8	Trace	Trace
Maté	0.4-2.4	0.3-0.5	

ACTION OF CAFFEINE. Caffeine acts by inhibiting adenosine, a naturally-occurring tranquilizer in the brain. It appears to dislodge adenosine from receptor sites. A recent paper suggests that the effects of our first cup of coffee in the morning are really those of compensating for the first stages of withdrawal symptoms that began while we were asleep and not replenishing the supply of caffeine to our central nervous system.

In large doses, caffeine can cause:

- ☼ nausea
- ☼ vomiting

☼ insomnia
☼ restlessness
☼ tinnitus (ringing in the ears)
☼ tremors
☼ scintillating scotoma ("island of blindness")
☼ rapid heart action
☼ irregular heart beat, and
☼ diuresis.

Tolerance and habituation may develop from prolonged use. There is considerable debate as to whether caffeine is outright addictive and should be classed as a drug.

CAFFEINE-BEARING PLANTS

Plant Source	Part Used
cassine=*Ilex vomitoria*	leaves and shoots
cocoa=*Theobroma cacao*	seeds
coffee, Arabian=*Coffea arabica*	seeds
coffee, Congo=*Coffea canephora*	seeds
coffee, Liberian=*Coffea liberica*	seeds
coffee, robusta=*Coffea canephora*	seeds
guaraná=*Paullinia cupana*	seeds
khat (qat)=*Catha edulis*	leaves
kola (cola)=*Cola nitida*	seeds
maté (yerba maté)=*Ilex paraguariensis*	leaves
tea (cha)=*Camellia sinensis*	leaves and buds
yaupon=*Ilex vomitoria*	leaves and shoots
yoco=*Paullinia yoco*	bark

TEA

"Tea is better than wine for it leadeth not to intoxication, neither does it cause a man to say foolish things and repent thereof in his sober moments. It is better than water for it does not carry disease; neither does it act like poison does when the wells contain foul and rotten matter."
(Attributed to Shen Nung, Emperor of China)

"There are few hours in life more agreeable than afternoon tea." (Henry James. Portrait of a Lady)

"Thank God for tea! What would the world do without tea? -- how did it exist? I am glad I was not born before tea." (Sydney Smith)

"We had a kettle; we let it leak. Our not repairing it made it worse. We haven't had any tea for a week.... The bottom is out of the Universe."
(Rudyard Kipling. Natural Theology)

☼ ☼ ☼ ☼ ☼

TIMELINE: TEA

B. C. E.

2737 Emperor Shen Nung discovers tea
0500 Domesticated (Tibet)

C. E.

0200 Chinese text cites as substitute for wine
0350 Chinese scholar Kuo P'o cites medicinal uses
0593 Introduced into Japan from China
1484 Tea ceremony introduced by Shogun Yoshimasa
1559 First mention in European text
1610 Introduced into Europe by Dutch East India Co.
1638 Russian Czar receives 140 lbs from Mongolia
1657 First public sale in England
1706 Thomas Twining founds "Tom's Coffee House"
1753 Linnaeus names it *Thea sinensis*
1773 Boston Tea Party boards East India Co. ships
1788 Joseph Banks declares Indian climate favorable
1793 George III sends trade mission to China
1818 British introduce into India
1824 John Cadbury opens tea/coffee house in Birmingham
1833 Earl Grey, British Prime Minister, ends East India Co. monopoly
1834 J. G. Gordon collects 80,000 seeds in China
1840 Anna, Duchess of Bedford establishes afternoon tea ritual
1849 Henry Charles Harrod, tea wholesaler, opens grocery shop
1859 Great American Tea Co. opens in New York; it became the A & P
1867 British introduce into Ceylon
1869 Cutty Sark, English clipper ship, sails to Shanghai
1876 Thomas Johnstone Lipton, Glasgow grocer, opens his 1st shop
1878 Caleb Chase & James Sanborn found coffee/tea company
1889 Thomas Lipton blends/packages tea
1904 Iced tea created at a St. Louis fair
1909 Joseph Krieger invents hand-sewn muslin tea bag
1993 Natl. Cancer Inst. reports inhibitory effects on growth of tumors

Tea or cha, from the leaves of *Camellia sinensis*, was once the most widely consumed caffeinated drink in the world. Now it is second only to the cola beverages. The plant is native to Southeast Asia, perhaps China. Tea has had a long history. At first it was strictly a medicinal plant. It was not until about the 5th century A.D. that tea became popular in Asia as a drink. It remained relatively unknown in Western Europe until the 16th or 17th century. Today China remains the leading producer; India and Ceylon the chief exporters.

The tea plant is a small tree that is usually kept pruned back as a shrub. It is often grown under the shade of some other plant on the hillsides of tropical and subtropical areas. The leaves are produced in **flushes**. After the third or fourth year, the flushes are plucked. This consists of removing a section of the young shoot bearing three or four young leaves and the terminal bud. The plucking stimulates the lateral buds to produce shoots. After about ten years, the plant is cut back to the ground and sucker shoots take over. The harvesting is done by hand in most instances, although machinery is used in some areas. It is important not to bruise the young leaves.

There was, by the way, a version known as "Imperial Plucking." Tea for the Emperor of Japan was plucked by virgin women who wore special gloves and used scissors of gold to remove the bud and youngest leaf. They were placed on a golden platter to dry.

PROCESSING OF BLACK TEA

Withering
▽
Rolling
▽

Sorting
▽
Fermentation
▽
Drying
▽
Sorting
▽
Grading

After the leaves have been removed from the plant, they are spread out on trays to wilt. Once again it is essential to prevent bruising so as to avoid fermentation. Temperature during the withering phase must be precisely controlled. Once the leaves have wilted, they are rolled under pressure to separate them from the stem tips and to crush them. The crushing helps to distribute the sap within the leaf. This also initiates fermentation. A preliminary sizing or sorting also occurs at this point. The partially fermented and sized leaves are placed on screen-bottom trays. During this fermentation phase the temperature is kept between 21-25°C and the relative humidity at about 90%. Many very important bio-chemical changes occur during the fermentation process. The tea leaves are then dried for 20-25 minutes at 90-100°C. The final grading involves judging the aroma, uniformity, and appearance of the leaves along with the taste, color, and aroma of the infusion made from the leaves.

Green tea is processed much the same as black tea, except that the freshly plucked leaves are heated to inhibit fermentation. The oolong teas are partially fermented. Black tea is the most commonly produced type.

Because of local variation in quality, differences in quality over a period of time, and local taste preferences, most of the commonly consumed teas have leaves from a wide variety of sources blended together.

Bubble tea or boba milk tea or tapioca milk tea is a recent fad imported from Taiwan. It is tea, milk, sugar, and black tapioca pearls, served cold.

Tea leaves contain up to 5% caffeine or theine and about 20% tannins. There are also dextrins, pectins, cellulose, and other structural materials. After a five minute infusion the tea leaf yields about half of the tannins, 3/4 of the caffeine, and about half of the other extractable solids.

THE TEA CEREMONY

The Japanese tea ceremony, adapted from an earlier ritual developed by the Chinese, is based on the Zen principle of adoration of the beautiful and the routine. The setting is a tea house in a garden or special room made of specific materials and configuration. Typically there are hanging scrolls, flowers, and a sunken fireplace. Participants enter along path of paving stones, walk silently, and leave behind their worldly concerns. The host extends a silent greeting. A light meal is served. Water is heated over a charcoal stove. The host presents the tea utensils that will be used. Green tea (matcha) is now prepared. Everyone drinks from a communal bowl, usually taking three servings. The teapot, spoon, and other implements are washed and put away. The host now offers cake and a weaker tea. This sets the stage for silent contemplation of the fire and the surroundings. The host now takes guests to threshold of the tea house where there is a ritual rinsing of mouth and hands.

COFFEE

"One need only compare the violent coffee-drinking societies of the West to the peace-loving tea drinker of the Orient to realize the pernicious and malignant effect that bitter brew has upon the human soul."
(Anonymous Hindu dietary tract)

"Coffee should be black as Hell, strong as death and sweet as love." (Turkish proverb)

"They have in Turkey a drink called coffee. This drink comforteth the brain and heart, and helpeth digestion." (Sir Francis Bacon)

"Coffee makes us severe, and grave, and philosophical." (Jonathan Swift, 1722)

The *"...damned infidells [drink] a certaine liquor, which they do call Coffe."* (Anthony Shirley, 1599)

"Everybody is using coffee. If possible, this must be prevented. My people must drink beer."
(Frederick the Great, 1777)

"Wherever it has been introduced it has spelled revolution. It has been the world's most radical drink in that its function has always been to make people think. And when the people began to think, they became dangerous to tyrants."
(William Ukers, 1935)

TIMELINE: COFFEE	
1000	Arabs prepare hot drink from boiled beans
1400	Domesticated (Arabia)
1511	Coffee houses in Mecca closed
1573	Leonhard Rauwolf publishes directions for preparation of Turkish coffee
1601	"Coffee" appears in English for first time
1616	Introduced into Europe
1650	Oxford opens first coffee house
1652	London opens first coffee house
1658	Dutch grow in Ceylon
1674	"Women's Petition Against Coffee" published
1675	Charles II bans coffee houses in London
1688	Edward Lloyd founds "Lloyd's Coffee House"
1689	Paris opens first coffee house
1696	Dutch grow in Japan
1696	New York opens first coffee house
1714	Jardin des Plantes receives coffee tree from Dutch
1727	Coffee trees planted in Brazil
1732	J. S. Bach composes "Coffee Cantata"
1777	Frederick the Great exhorts Germans to drink beer
1821	Friedlieb Ferdinand Runge isolates caffeine
1825	Cultivation begins in Hawai'i
1827	Nicolas Felix Durant invents modern percolator
1878	Caleb Chase & James Sanborn found coffee/tea company
1893	Charles Post invents Postum, a coffee substitute
1901	Satori Kato develops soluble instant coffee
1903	Ludwig Roselius develops Sanka
1905	Ludwig Roselius develops decaffeination process
1908	Melita Bentz invents coffee filter (a linen towel)

1938	Nestlé Co. invents instant coffee
1970	Rust causes $3B loss in Brazilian crop
1971	First Starbucks opens
1975	Soft drinks now more popular than coffee
1984	International Olympic Committee once again declares caffeine as "doping agent"
1985	FDA rules solvent-processed decaffeinated coffee safe
1994	Caffeine Anonymous founded

Coffee is grown in every tropical country, particularly those in the New World. About 80% of all coffee produced comes from South America; half of it from Brazil. Coffee is second only to tea in world popularity. In the U.S. it is a much more popular drink. About 75-90% of all coffee beans processed come from *Coffea arabica*. This shrub is native to Ethiopia, not Arabia as the epithet suggests. Much of the remainder is derived from "Robusta Coffee" (*C. canephora*), which is used principally to make instant coffee. Other species utilized are "Liberian coffee" (*C. liberica*) and "Excelsa coffee" (*C. excelsa*).

Coffee beans were first used as a food, the seeds being eaten on long trips to ward off fatigue. It was not until the 15th century that coffee became popular as a drink.

The coffee plant is a shrub or small tree. Like tea, it is often grown in the shade of other plants. Trees begin to bear fruit after about three years. The fruits are green at first, and after about a nine month maturation period, they turn a bright red. At this stage they are often called **cherries**. The fruit consists of an outer skin (exocarp), a pulpy flesh (mesocarp), and a hard bony inner layer, the **parchment** (endocarp), which surrounds the seeds. The seed coat itself is called the **silverskin**. Processing of the coffee bean involves getting rid of these layers surrounding the seeds.

PROCESSING

There are two methods of processing the cherries. The simplest is the **dry method**. The fruits are spread out in the sun to dry for 15-25 days. They are then dehulled. The more commonly employed **wet method** involves several steps. The cherries are first pulped. This removes the outer skin and much of the mucilaginous flesh. The seeds surrounded by the parchment and some adhering pulp are graded by their specific gravity into various size classes and placed in fermentation tanks for 12-24 hours. The fermentation removes any remaining pulp from the parchments. The coffee beans are then washed carefully and dried. This drying stage is traditionally done on a "coffee drying floor." Sun-drying usually takes 8-10 days. Artificial heaters are also used. The final stage of processing is curing. It consists of removing the parchment from the seeds, polishing, and a final grading.

WET PROCESSING METHOD

"Cherries" pulped
(outer skin and pulp removed)
▽
Sort by size
▽
Ferment
▽
Wash
▽
Dry
(drying floor or oven)
▽
Milling and polishing
(remove parchment and silver skin)
▽
Final grading
▽
Shipped
▽
Roasted

Coffee, like tea, is usually blended to local tastes. The seeds contain 1-1.5% caffeine, not as much as in tea leaves. An essential oil, caffeol, imparts the characteristic aroma and flavor. Coffee seeds also contain glucose, dextrins, and various proteins.

DECAFFEINATION

Making decaffeinated coffee begins with unroasted beans that are steam-softened. They are then flushed with a solvent for about an hour. Until the mid-1970's trichloroethylene was used; now it is methylene chloride or ethyl acetate. The solvent is drained away and the beans are steamed to evaporate the residue. This phase may be repeated as many as 24 times. The final product is about 97% caffeine-free (0.08% vs. 1.0-2.0%).

KINDS OF COFFEE PREPARATIONS

Some people have suggested that we blame Frasier and Niles Crane for the increased interest in exotic, yuppie kinds of coffee. Especially here along the Pacific Coast, we have many opportunities to sample them.

Espresso is a strong, dark-roast coffee that is brewed under pressure.

Cappuccino is an Italian espresso coffee that is topped with steamed, foamed milk. Some of the milk is mixed into the coffee. Cocoa or cinnamon is often added to the foam.

Café latte is similar to cappuccino, except that the steamed and foamed milk is mixed throughout.

Café au lait is made from a strong coffee or espresso; it is about half coffee and half milk.

Café mocha is café latte with chocolate added.

Café con leche is a very strong black coffee to which hot milk is added.

Café amaretto is a black coffee that is flavored with amaretto, cloves, citrus rinds, and cinnamon.

Café brulot is a black coffee that is flavored with sugar, citrus rinds, cloves, cinnamon, and brandy. It is set on fire and allowed to flame briefly. Look for it in New Orleans.

Café macchiato is an espresso with just a dollop of steamed milk foam on the top

Café Normande is black coffee flavored by Calvados, an apple brandy from Calvados, Normandy.

Café royale is like a café brulot, but it is not set on fire. It may also be bourbon- and sugar-flavored coffee.

By the way, café is the French, Spanish, and Portuguese word for coffee and the place where it is sold is called a caféteria.

COFFEE AND YOUR HEALTH

Is coffee good for you? Certainly it can be drunk to excess. What about more moderate consumption – two to four cups a day? Below is an attempt to summarize recent studies, which often seem to contradict one another.

Too much coffee may cause:

1986: Phobias, panic attacks
1990: Heart attacks, stress, osteoporosis
1991: Underweight babies, hypertension
1992: Higher cholesterol
1993: Miscarriages
1994: Intensified stress
1995: Delayed conception
2000: Arthritis

Coffee may also help prevent or treat:

1988: Asthma
1990 Colon and rectal cancer, impotence
1992 Mental sluggishness, heart disease (instant only)
1996 Fatal car accidents, suicide
1999 Gallstones, heart disease
2000 Parkinson's Disease

Source: Time Magazine: 05 June 2000

CACAO

"The divine drink which builds up resistance and fights fatigue. A cup of this precious drink permits a man to walk for a whole day without food."

[Hernán Cortés]

"This cacao, when much is drunk, when much is consumed, especially that which is green, ... makes one drunk,... dizzy, confuses one, makes one sick, deranges one. When an ordinary amount is drunk, it gladdens one, refreshes one, consoles one, invigorates one. Thus it is said: 'I take cacao. I wet my lips. I refresh myself."

[Bernardino de Sahagun, 16th century]

"The beverage of the gods was ambrosia; that of man is chocolate. Both increase the length of life in a prodigious manner."

[Louis Lewin, "Phantastica"]

☼☼☼☼☼

First, a word about easily confused common names. The plant itself is a cacao tree (*Theobroma cacao*). By processing its seeds, we obtain products that we call cocoa and chocolate. The South American shrub that bears the coca leaf, the source of cocaine, is a completely unrelated plant.

Cacao is a small tree native to the New World tropics. The Aztecs made a drink from it called xocoatl; the Mayans made kakaw. These were very popular drinks long before the Conquest. They also used it as a money substitute. The usual Aztec recipe called for cacao, maize, water, and capsicums. The maize was used because the cacao seeds contained so much fat. This concoction was relatively unpalatable to the Spaniards. It was not until the Dutch broke a virtual Spanish monopoly that cacao even became known to most Europeans. Cacao did not become popular in Europe until someone discovered that it could be improved by adding sugar, cinnamon, and vanilla.

PROCESSING

Processing of cacao begins with the harvesting of the fruits. This is done by hand. The fruits are often split open immediately and the seeds removed. The seeds are then fermented, either by placing them in large piles in the open, or by putting them in special fermentation tanks. This process helps to remove pulpy material from around the seeds. They are then washed, dried, and packaged for export. Final processing usually occurs in the U.S. or Europe. This consists of the seeds being cracked open and the meat expressed to yield the oils and fats, the **cocoa butter**. It is used in everything from suntan lotions to hemorrhoid medicines. The remaining **cake** is the source of commercial chocolate. Cacao seeds contain theobromine (3,7-dimethylxanthine), an alkaloid related to caffeine.

Today West Africa is the leading cacao production center. Ghana produces about 35% of the world's supply; Nigeria about 14%. The United States and United Kingdom use about half.

The chocolate industry was helped considerably by two discoveries. In 1828 C. J. van Houten discovered the process for removing the excess fat from seeds. In 1876, M. D. Peter of Switzerland formulated milk chocolate by adding dried milk.

Initial Processing:

Extract seeds
▽
Ferment
▽
Clean/dry seeds
▽
Roast (121° C)
▽
Separate nibs from shells
▽
Grind
▽
Cake + liquor
▽
Second grind
▽
Press
▽
Cocoa butter + cake

Final Processing:

Option 1:

Cocoa butter
▽
Add liquor and sugar
▽
Conch
▽
Sweet chocolate

Option 2:

Cocoa butter
▽
Add liquor, sugar, milk solids
▽
Conch

▽
Milk chocolate

Option 3:

Cocoa cake
▽
Pulverize
▽
Cocoa powder

COLA BEVERAGES

Cola nitida is a tree native to the rain forests of Africa. Its seeds contain caffeine (up to 3.5%), theobromine (less than 1%), and kolanin, a glycoside. Cola nut extracts were once used to flavor the various cola drinks. Now most of these use flavorings, theobromine, and caffeine from other sources. Most of the cola nuts are produced in Africa and Jamaica.

While the chewing of coca leaves never became popular in Europe and North America, various drinks with coca leaf extracts did. John Styth Pemberton was a pharmacist in Atlanta, Georgia. He was also a Civil War veteran who had become addicted to morphine, as had so many of his compatriots. Pemberton was aware of the research that indicated that cocaine could cure morphine addiction and that it had other healthful properties. Earlier he had concocted a series of patent medicines with colorful names, such as Triplex Liver Pills, Globe Flower Cough Syrup, Indian Queen Hair Dye, and my personal favorite, Botanic Blood Balm.

Noting the success of Vin Mariani (see the discussion of cocaine), Pemberton formulated a drink called French Wine Coca, which he described as “an ideal tonic and stimulant.” He placed it on the market in 1881. He claimed that it cured addiction to opiates, was effective in the treatment of alcoholism, and was drunk by thousands of the world’s leading scientists. What a testimonial! In 1885 the good citizens of Atlanta voted to ban the sale of alcoholic beverages, which meant that Pemberton’s coca-fortified wine was now illegal. He came up with a new recipe that was alcohol-free. His accountant, Frank Robinson, suggested that he name the new beverage after its two exotic ingredients – coca leaf and the kola nut. With a little bit of purposeful creative misspelling, Coca Cola was born. In 1891, Pemberton sold his rights and the secret recipe to Asa Griggs Chandler for $2300.

Coca Cola also has a less well known reputation. The company itself claimed that it was “a most wonderful invigorator of the sexual organs,” which led to a strange trial in 1909 when the government charged that the drink caused young boys to masturbate. It was also popular with young women who picked up on the rumor that Coca Cola, when used as a douche after intercourse, was an effective spermicide. The scientific literature on cocaine as an aphrodisiac is murky. Its ability to kill sperm has not been demonstrated.

Modern day Coca Cola does not contain cocaine, but it still has coca leaf flavoring in it. A plant in New Jersey, run by a subsidiary of Coca Cola, processes about 175,000 kg of the trujillo coca leaf each year to remove its cocaine. They refer to the leaves as “Merchandise No. 5” (Streatfeild, 2001). You may recall that in the 1980's, we saw a new version of Coke for sale, but that it failed and it was replaced by “Classic Coke.” The recipe that failed had no coca leaf flavoring in it.

MINOR CAFFEINATED BEVERAGES

MATÉ. *Ilex paraguariensis*, also called yerba maté and Jesuit tea, is a shrub related to English holly. It is probably the world's 4th most popular drink. It is very widely used in South America, where it is native. The leaves contain about 1.5% caffeine. Maté is becoming more popular in the U.S.

GUARANÁ. This is the “Brazilian cocoa” or the "cola" of Brazil. *Paullinia cupana* is a twining shrub that has long been used by the local Indians. It has 3-4 times more caffeine than either tea or coffee. In recent years it has found its way into North American markets, often as one of the ingredients in beverages that health-conscious folks drink.

7.3 • ALCOHOLIC BEVERAGES (FERMENTED)

The use of beverages containing alcohol has always been part of our culture. In addition to the very common social aspects of drinking alcoholic beverages, we have also used them in a ceremonial and religious context. We first encountered alcohol perhaps through the accidental discovery of naturally fermented substances. The fact that yeast was necessary for these natural processes to occur must have been appreciated early on. It has been suggested by some authors that yeast was our first cultivated plant.

THE PLAYERS

Organism	**Where Used?**
Aspergillus oryzeae	Saké, miso, soy sauce
Aspergillus soyae	Soy sauce
Saccharomyces cerevisiae	Beer/bread
Saccharomyces carlsburgensis	Beer
Saccharomyces ellipsoideus	Wine
Saccharomyces sake	Saké
Saccharomyces exiguis	Bread
Saccharomyces beticus	Fino sherries
Saccharomyces theobromae	Cacao
Leuconostoc mesenteroides	Sauerkraut
Lactobacillus plantarum	Sauerkraut
Lactobacillus sanfrancisco	Sour dough bread

FERMENTATION

In the beginning, we had only fermented beverages. **Fermentation** is a biochemical process by which a wide variety of carbohydrate sources are acted upon by naturally occurring or cultivated strains of yeasts (*Saccharomyces* spp.). We use these organisms because they: (1) are efficient producers of alcohol, (2) can tolerate higher levels of ethanol in their environment than many other fungi, and (3) also make other compounds that affect the taste of fermented beverages. They live in an anaerobic (oxygen-free) condition. Yeasts ingest sugar and nitrogenous compounds produced by other organisms. They metabolize 6-carbon simple sugars. They cannot break down starch directly; it must be metabolized for them. This usually means that one or more enzymes must be present.

During fermentation, sugars are broken down into ethanol (ethyl alcohol), carbon dioxide, fusel oils (alcohols of long chain-lengths), acetaldehyde, acetic acid, and various sulfur-containing compounds. About 47% of the sugar is converted into alcohol. With an unlimited supply of sugar, the alcohol level can reach about 14-18%. In a sense, the yeasts are swimming about in alcohol, a waste product of their life processes. When the alcohol concentration reaches approximately 18-19%, the yeasts are killed by it and the fermentation process stops. This is the reason for the comparatively low alcohol content of beer, wine, and other fermented drinks.

FERMENTATION: THE RECIPE
(Joseph Gay-Lussac, 1810)

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

Sugar → ethyl alcohol + carbon dioxide

Much of our modern understanding of fermentation rests on the work of Louis Pasteur (1822-1895), the French chemist and bacteriologist. In a series of experiments, he found that: (1) grape juice will not ferment into wine in the absence of yeast cells, and (2) "... *fermentation by yeast is the direct consequence of ... life.*" Pasteur trapped air-borne yeast cells so that he could examine them under the microscope. **Pasteurization** is the process that he developed for destroying microorganisms and thereby arresting fermentation. It involves heating milk or some other material to about 140° F.

ALCOHOL CONTENT

Beverage	% Alcohol
Fermented:	
Beer	3.5-6.0
Ale	6.0-8.0
Hard cider	8.0-12.0
Wine and fortified wine	10.0-22.0
Distilled:	
Whiskey	40.0-55.0
Brandy	40.0-55.0
Rum	40.0-55.0
Gin	40.0-55.0
Vodka	40.0-55.0

[After Der Marderosian & Liberti (1988), p. 32]

ALCOHOL AND ITS EFFECTS

"*I have made an important discovery... alcohol, taken in sufficient quantities, produces all the effects of intoxication.*" (Oscar Wilde, "In Conversation")

"*An alcoholic is someone you don't like who drinks as much as you do.*" (Dyan Thomas)

"*Alcohol ... enables Parliament to do things at 11 at night that no sane person would do at 11 in the morning.*" (George Bernard Shaw)

☼ ☼ ☼ ☼ ☼

Alcohol is a non-selective depressant of the central nervous system. At first, it has a slightly stimulating effect, but this is followed by a much more prolonged dulling of the senses. In low to moderate doses, there is little evidence of long lasting, harmful effects. What constitutes "low to moderate" remains a matter of debate. Several experts have spoken of the efficacy of one or two glasses of red wine per day.

Ethanol is soluble in water and fats. It moves easily through membranes. Almost all of the alcohol that we imbibe is absorbed in our stomach and large intestine. Typically we drink alcohol faster than our system can break it down to carbon dioxide and water. The alcohol levels in our body simply rise. This leads to a feeling of general numbness, which we perceive as a sense of relaxation.

Drinking can produce disorientation, reduced judgmental ability, and loss of reasoning. It can also lead to permanent physical damage characterized by:

☼ lowering of the body's resistance to disease (especially tuberculosis);

☼ a progressive destruction of liver tissue and accompanying formation of sclerotic tissue (cirrhosis of the liver); hepatic coma;

☼ nervous complications;

☼ physical and psychological dependence; and

☼ an increased chance of having a stroke.

The recently described "fetal alcohol syndrome" highlights the effects of alcohol on the developing young of women who drink during their pregnancies. There can be little doubt that alcohol is a drug -- a legal one.

BEER

"*A meal of bread, cheese and beer constitutes the chemically perfect food.*" [Queen Elizabeth I]

"*Beer is proof that God loves us and wants us to be happy.*" [Benjamin Franklin]

☼ ☼ ☼ ☼ ☼

Beer, in the broad sense, is an alcoholic beverage that is made by fermenting the carbohydrates found a wide variety of plants. In its simplest form:

carbohydrate + water + enzymes → beer

By carbohydrates I mean the starches and sugars found in the roots, tubers, stems, and fruits of a long list of plants. Enzymes are needed to break down the carbohydrate. They occur when wild or cultivated strains of yeast are present. We also found out several millennia ago that the enzymes in our saliva will do the trick.

The brands of beer popular in this country are typically made from a cereal as the carbohydrate source. They are also typically flavored with hops.

PROCESSING OF MALTED BEERS

To prepare the **malt**, a cereal grain (usually barley) is washed and cleaned, then steeped in vats of water for about two days. The grains are then germinated under controlled conditions. This stage usually lasts four to six days. When the primary root has emerged, germination is stopped by drying the grains in kilns. Grains are steeped in water, germinated, ground up, and dried. The result is malt. The enzymes in these sprouted grains break down the carbohydrate material that is added to it.

A carbohydrate source (**adjunct**), such as rice, corn, wheat, or potatoes, is added to the malt. The mixture often consists of about 65% malt and 35% adjunct. This combination is called the **mash**. The liquid portion of the mash is the **wort**. After it is drawn off, the barley grains are collected, dried, and used as cattle feed.

Most American beers are not only malted, but also hopped, which means that the wort is boiled with hops for two or three hours. Hops is made from the bracts surrounding the female flowers of *Humulus lupulus*, a vine in the hemp family (Cannabaceae). California is one of the main producers of hops in the U. S. It imparts the characteristic bitter flavor to beer and helps to clarify it. Clarification is the coagulation of nitrogen-containing materials in the wort. Most of our beers do not have a high hops content; European versions are usually much higher.

The cooled wort is now placed in large tanks where it is inoculated with a select strain of *Saccharomyces cerevisiae*, a yeast. It will act on the wort to produce carbon dioxide, ethyl alcohol, and minor organic constituents. At this stage, the fermented beer is called **green beer**. After a couple of days of initial fermentation, the green beer is transferred to lagering vats where a secondary fermentation occurs. During this several day process, various organic materials coagulate as scum. The beer is then aged for a period lasting from a few weeks to a few months. Young beer may be added just before bottling to bring the carbonation to a desired level or carbon dioxide may be artificially added. The beer is then filtered and usually pastuerized. Draft beer is not pastuerized. The final product is about 5% ethyl alcohol (ethanol), 90% water, along with maltose (a sugar), gums, dextrins, and various nitrogenous substances.

THE BREWING PROCESS

Barley soaked and germinated
▽
Steeped in warm water 2-3 days
▽
Partly germinated grain (malt) heated and dried
▽
Store 20-30 days
▽
Malt + warm water (mashing)
▽
Sweet, brown liquid (wort)
▽
Add adjuncts (cereal, potato, etc.)
▽
Filter
▽
Add hops
▽
Boil (2+ hours)
▽
Cool
▽
Centrifuge
▽
Add cultured yeast
▽
Ferment
(8-11 days for beer)
(5-6 days for ale)
▽
Skim to remove yeast
▽
Green beer
▽
Add yeast, sugar, or fresh wort
▽
Ferment
▽
Clarify
▽
Bottle or can
▽
Pasteurize (keg)
or
Unpasteurized (draft beer)

[After McGee, 1984]

TYPES OF BEER

MALTED BEERS

Ale has a higher hops concentration and a higher alcohol content (4-7%). It is brewed at a higher temperature and it is made by yeasts floating on the surface of the wort, rather than those on the bottom of the tank.

Bock is a potent dark beer. It is often made from the first hops and malt of the season.

Porter is a dark, sweet, bock-like ale. It is usually aged for six to eight weeks. It is often made from an inferior malt and then colored with caramel or licorice.

Stout is a porter-like beer of high alcohol content and with a strong hop flavor. It is heavier than porter beers and it is usually aged for about a year.

Kvass or **quass** is a Russian beer made from barley and rye and flavored with peppermint.

Pombe or **bousa** is an African beer made from millet grains.

Weiss is a light, malty ale made mostly from wheat.

UNMALTED BEERS

Chicha is a very popular South American beer that is practically unknown in the U. S. It can be made from a variety of carbohydrate sources, including maize, potatoes, manioc, plantain, and palms. The enzymes needed for fermentation to occur are provided by human saliva using the ancient "chew and spit" process.

Ginger beer is produced by allowing a sugar solution containing ginger rhizomes to be acted upon by yeast and bacteria.

Hard cider is based upon the fact that many kinds of fruits, especially the apple, ferment quickly. A large proportion of the apple cider that we make is allowed to undergo acetic acid fermentation that will yield commercial vinegar.

Mead is made with fermented honey. It is so concentrated that fungi and bacteria cannot live easily in it, which explains its long shelf life. It played an important role in the 30 day wedding ceremonies, the "honeymoon," of the Scandi-navians.

Pulque is a favorite Mexican beer made from the sap of several different century plants (*Agave* spp.).

Root beer is made from herbs, barks, roots, sugar, and yeast. Sarsaparilla, ginger, and wintergreen are often used. There is, of course, the non-alcoholic version sold by Hires, and others.

Sake (also spelled saki) is a Chinese and Japanese favorite made by fermenting steamed rice. Fermentation is accomplished by *Aspergillus oryzae*, rather than *Saccharomyces*. The alcohol content is higher than that of typical wine or beer. Sake is sometimes treated as a kind of wine.

WINE

"*Wine is the most healthful and hygienic of beverages*." [Louis Pasteur]

☼ ☼ ☼ ☼ ☼

Wine-making is one of our most ancient enterprises. We read in Genesis that the first thing that Noah did after the waters of the Great Flood had receded was to plant a vineyard. We know, with perhaps more certainty, that the ancient Mesopotamians made wine thousands of years ago. The Greeks and Romans were well-versed in the subject. Their wines were stored for 15-25 years in a two-handled, earthenware vessel called an **amphora**. They also used amphorae to store oils.

By the Middle Ages, amphorae had been replaced by wooden casks. The habit at that time was not to fill the casks completely. Contact with air in the barrel made the wines turn to vinegar rather quickly, so most of these wines had to be drunk within a year or so. In 1690, Dom Pierre Perignon rediscovered the use of the cork and began storing champagne in newly developed strong, glass bottles.

The European colonists established vineyards around the world. By the mid-1600's, the Spanish had planted grapes in Mexico, Chile, and Argentina. South Africa had vineyards a century later. California and Australia were planted in the later part of the 18th century; New Zealand followed a few decades later.

In 1863, the vineyards of the Rhone Valley in France were attacked by a root louse (*Phylloxera vastatrix*), imported accidently from the United States. This insect caused the grape vines to loose their leaves and it eventually killed them. The European cultivars were highly susceptible and the plague spread through the vineyards with appalling speed. Many treatments were attempted, but the one that proved to be most successful involved grafting European cultivars onto American strains that were resistant to *Phylloxera*. The insect has never been eradicated from the vineyards. Almost all of today's wines are made from grafted vines.

Algeria, Argentina, Australia, Austria, Chile, France, Germany, Italy, Portugal, the Soviet Union, Spain, and the United States are the leading wine-producing countries. France, Italy, and Spain are the top three, usually in that order.

There are many species of grapes known throughout the world, but only one of them, the European *Vitis vinifera* meets all of the requirements for making an excellent wine. Its fruit contains enough of the right kinds of sugars with the properly low acidity so that the juices can be made into a stable and balanced wine without having to add large amounts of sugar or water. We have domesticated thousands of cultivars of this single species and they provide most of the world's wine.

DEFINITION

Many authorities restrict the term "wine" to fermented grape products. Other fruit sources, such as cherries, blackberries, and elderberries, often referred to as wines, are then considered to be hard ciders. While the definition of "wine" may be a broad one in the study of economically important plants, it often is very narrow in the legal sense. California restricts the term to only those products with a minimum percentage of grapes used in their manufacture.

TYPES OF WINE

There are four commonly recognized categories of wines. In **dry wines**, almost all of the sugar in the grape has been fermented into ethanol and carbon dioxide. The finished wine typically has an alcohol content of about 12%.

In **unfortified sweet wines**, only a portion of the sugar is broken down. These are rich, sweet white wines made from partly dehydrated grapes or from those that have been attacked by the "noble rot," caused by the fungus *Botrytis cinerea*. In either case, the yeasts are killed by the level of alcohol produced (14%) before they can break down the high concentrations of sugar present in the grapes.

In **sparkling wines**, a second fermentation occurs inside sealed containers. More sugar and yeasts are added to the finished wine to set the stage. Because the second fermentation occurs inside sealed vessels, any carbon dioxide produced will remain in the wine, making it effervescent. The best known example of a sparkling wine comes from the Champagne region of France. In the strict sense, it must be made from pinot noir, pinot meunier, or Chardonnay grapes.

Fortified wines have been augmented by wine-based distilled beverages to raise their alcohol content to about 20%. They may be either sweet or dry. The best known examples are:

☼ **Madeira**, named after an island off the coast of Portugal; usually served after a meal or as a dessert wine

☼ **Port** is a fortified sweet, red wine named after the Portuguese city of Oporto. It is usually drunk after dinner. There are also brown and white versions available.

☼ **sherry**, made from white palomino grapes and named after Jerez (Xeres) de la Frontera, a town in southern Spain. Sherries range from very dry to very sweet.

Vermouth is a wine to which aromatic herbs have been added. The name comes from the German word for wormseed (wermut), one of the original flavorings.

VARIETALS. I mentioned earlier that there were thousands of cultivars of *Vitis vinifera*. A few of them, called the "noble grapes," produce the world's best wines.

White Noble Grapes (White Wines):

Chardonnay, makes champagne and our best white wines in California, the Pacific Northwest, and New York;

Chenin blanc, makes both dry and sweet wines;

Gewurtztraminer, produces a highly scented wine;

Riesling, also yields a highly scented grape that produces Germany's finest wines, and its best sweet wines when infected by the noble rot;

Semillon, when infected with the noble rot, yields sweet white wines of the Bordeaux region of France.

Black Noble Grapes (Red Wines):

Cabernet Sauvignon, yields wines that are high in acidity and tannins and that are long-lived;

Gamay, from the Beaujolais district of Burgundy in France, produces wines highly regarded for their fresh, fruity flavors;

Grenache, a black grape that does well in hot climates of France, Spain, North Africa, and California;

Merlot, from the Bordeaux region of France, produces a robust, long-lived wine;

Pinot noir, yields fine red burgundies; and

Syrah, which produces a robust red wine.

Other grapes of note include: **barbera**, made from an Italian black grape; **catawba**, a black grape native to North America; **colombard**, a white grape used in California to make French colombard and, in France, to make some cognac; **Concord**, a black grape native to North America used to make both a dry wine and a sweet kosher wine; **lambrusco**, an Italian black grape; **mission**, the first European grape introduced into the New World and the main one used in California until the late-1800's; **petite sirah**, a black grape introduced into California from France; **sylvaner**, a white grape grown in Germany and in California; and **zinfandel**, a black grape, possibly from Italy, now planted in California where it yields fruity, red wines.

PROCESSING

While the process of wine-making is relatively easy to explain, there is a great deal of art and science required to produce really top quality wines. The juices of the grape are squeezed out (expressed) by large machines (by foot in the olden days) to form the **must**. It is then inoculated with a particular strain of yeast, *Saccharomyces ellipsoideus*. Fermentation begins and it will continue until the alcohol content reaches 10-14%, at which time the yeasts are killed by their own metabolic products. The must may be treated with sulfur dioxide or pasteurized to kill unwanted micro-organisms that could spoil the delicate flavor that is desired. Initial fermentation continues for several days, during which various solids settle and chemical changes occur. The conversion of grape sugar into alcohol and carbon dioxide also generates heat. It and the alcohol itself begin to break down the grape skins. Tannins in the skin are of great importance in the production of many of the red wines.

The stem of the grape is another source of these tannins. Grapes may be fermented with the stems intact, partially removed, or completely absent. Today there are machines that stem and crush the grapes, thereby allowing the skins and juices to be pumped into vats and the stems to be discarded. Vats are made of wood, concrete, or stainless steel. If the grape skins remain in the must, the result is a red wine. Many of them are named after the areas where they were first developed or they are associated with the wine industry of a particular country. Some common examples of red wines are Burgandy, claret, Chianti, Cabernet, and zinfandel.

If the skins are not allowed to remain on the grapes during fermentation, a white wine will result. While the skins may be left on long enough to impart some color and flavor, the juices will lack the tannin content of red wines. These tannins inhibit the growth of bacteria. Sulfur dioxide is used in its place. White wines are typically fermented at lower temperatures than are red wines. Common examples include Chardonnay, Sauvignon blanc, Riesling, Tokay, Chablis, champagne, sauterne, and white burgundy.

Rosé wines are made by leaving the grape skins in the must for a short period of time and then removing them. Really cheap rosé wines may be mixtures of red and white wines.

The high malic acid content of new wine can be reduced by a secondary fermentation or **malolactic fermentation**. The process is mediated by select strains of yeast. It is used extensively in the processing of California chardonnays.

Better wines are then aged in wood for a period of about six months to several years. The casks are typically made of oak and hold 225-228 liters (about 60 gallons). Alcohol and water diffuse into the wood and then evaporate. These processes concentrate the wine at the same time that a number of highly complex biochemical changes are occurring. During maturation, wine is decanted from one vessel to another. **Racking**, as it is known in the trade, allows a clear liquid to be drawn off and for the **lees** (dead yeasts, tartar crystals, small pieces of grape skin, and other solids) to remain behind. Wines may also undergo clarification or **fining**. This process also removes microscopic solids. They coagulate around fining substances, such as egg white, gelatin, or bentonite, a kind of clay.

WINE MAKING

Harvest grapes
▽
Crush
▽
Remove skins/seeds
(white wine)
▽
Squeeze our juices to form must
▽
Add yeast, sugar, & sulfur dioxide
▽
Ferment
▽
Remove skins/seeds
(red wine)
▽
Draw off liquid (rack)
▽
Clarify (fining)
▽
Age in wooden barrel
▽

Filter
▽
Bottle
▽
Sell at an extravagant price

FERMENTED BEVERAGES

Beverage	Plant Source	Part Used
Arrack (arak)	Date (*Phoenix dactylifera*)	Fruits
Beer	Many plant sources	Grains, bracts
Chicha	Various plants	Grains, seeds
Cider	Apple (*Malus* spp.)	Fruits
Ginger beer	Ginger (*Zingiber* spp.)	Rhizomes
Kava (yangona)	Kava (*Piper methysticum*)	Roots, etc.
Kvass (quass)	Cereals + mint (*Mentha* spp.)	Grains, leaves
Palm wine	Various palms	Stem apex
Pombe	Millet (*Eleusine* spp.)	Grains
Pulque	Maguey (*Agave* spp.)	Stem apex
Root beer	Several aromatic plants	Leaves, bark, roots
Saki (sake)	Rice (*Oryza sativa*)	Grains
Sorgo	Sorghum (*Sorghum bicolor*)	Grains
Wine	Grapes (*Vitis vinifera* + *Vitis* spp.)	Fruits

7.4 • ALCOHOLIC BEVERAGES (DISTILLED)

"There's no such thing as bad whiskey. Some whiskeys just happen to be better than others."
[William Faulkner]

☼ ☼☼☼☼

We have not been satisfied with the modest 14% alcohol content afforded us by the natural processes of fermentation by microorganisms. We have evidence that the ancient Egyptians and Greeks knew of methods to increase the alcohol content of a liquid. Aristotle wrote of making seawater drinkable by a distilling process and suggested that it could also be used with wines and beers.

DISTILLATION

Sometime during the late Middle Ages, the Arabs or the Saracens perfected the process by which the percentage of ethyl alcohol in a fermented drink could be increased by a process called **distillation**.

The principle of distillation rests on a very simple fact. Alcohol vaporizes (changes from a liquid to a gas) at 173° F and water vaporizes at 212° F. Therefore if you heat an alcohol + water mixture to just below the boiling point of water, the alcohol will turn to a gas, escape, leaving the water behind in its liquid state. If you were to cook a beer mash or wine in an open pot, the alcohol would simply escape into the atmosphere. We do not want that to happen. We have to figure out a way to trap the alcohol and change it back from being a gas to a liquid.

All of this is accomplished in a place called a distillery, in a device called a distilling apparatus or **still**. The equipment consists of: (1) a boiler, the vessel or container in which the material is heated; (2) a condenser that returns the gas to its liquid phase; and (3) a receiver in which the end product is collected. The boiler may be heated by coal, wood, or steam. On top of the boiler is a hood of some sort, a device for trapping the alcohol vapors. The gas travels through thin metal pipes, often made of copper, to a condensing coil. It is a section of metal tubing bathed in cold water. The temperature of the alcohol vapor drops below 173° F and it changes back to its liquid state. The alcohol now trickles out of the condenser into a receiving pan or vessel of some sort. There are several different kinds of stills. Some of them have the grace and elegance of a large, ugly hot water tank, while others are extremely handsome pieces of equipment.

TYPES OF DISTILLED BEVERAGES

Whiskey (also spelled whisky) comes from two Scottish and Irish words meaning the "water of life." It is a very popular drink made from cereal grains, although potatoes are sometimes used. Whiskey is usually aged in white oak casks. This aging may last for several years. The alcohol content is about 50% (or 100 proof, another way of describing alcohol content). Several different kinds of whiskey are in common use. **Bourbon** or **corn whiskey** is made from at least 51% corn mash. It was first concocted in Bourbon Co., Kentucky by the Rev. Elijah Craig, a Baptist minister. **Irish whiskey** is made from a barley mash. The malt is kiln-dried. **Rye** or **rye whiskey** is made from at least 51% rye mash. **Scotch** or **Scotch whiskey** is made from barley mash that is cured in the smoke of a peat fire.

Gin is distilled to obtain nearly pure alcohol. The mash is usually of maize and rye. Various aromatics, such as the juniper berry (*Juniperus* spp.) or sloe berry (*Prunus spinosa*) are added for flavor.

Vodka is from the Russian word for water. For all practical purposes, it is pure ethanol. It is made from a wheat-malt mash and it is unflavored and unaged.

Rum (rhum or ron) is distilled from sugar-cane juice or from molasses to which water and yeast are added. It is then distilled to yield an alcohol content of about 80-150 proof. It is aged in oak, usually for 1 to 10 years. Various flavorings are often added. Most of our rum comes from the Caribbean.

Tequila, a favorite Mexican drink, is made by distilling the fermented juice from a century plant (*Agave* spp.). The highest quality is obtained by using 100% blue agave, a cultivar of *A. tequileana*. Plants that are about 10-12 years old are harvested. After the leaves have been cut off, what remains is a 75-150 lb. plant part that the locals call a "piña" or "cabeza." It is sometimes called the fruit of the plant, but that is incorrect. The agave heads are cooked in ovens, cooled, and then put through mechanical crushers that separate the juice from the solid material. Yeasts are added to the agave juice to begin the fermentation process. The fermented mash will then be distilled. Tequila is a very popular drink these days. Premium labels sell for as much as $300 a bottle; $20 a shot at your fancy upscale bars down in The City.

Brandy is made by distilling wine or fermented fruits other than grapes. It is usually aged in wood. The alcohol content is about 40-50%. Cognac, named after the French city, is probably the best known brandy.

Absinthe is the most dangerous and notorious of the distilled beverages. It is a green liqueur made of oil of wormwood (from a kind of sagebrush, *Artemisia absinthium*), fennel, star-anise, and other aromatics. Sale of absinthe was banned in France in 1915, with the United States and many other countries adopting similar restrictions. Curiously, in 2005 Switzerland will once again allow limited production.

The toxic principles appear to be l-thujone and d-isothujone. On the other hand, a mixture of absinthe and anisette is reported to be excellent in treating motion sickness. A reformulated version of absinthe, called **pernod**, appeared in 1922. It lacks the wormwood, but retains the anise base.

Over indulgence causes:
- mania;
- convulsions;
- irritation of the gastrointestinal tract;
- stupor;
- hallucinations;
- extreme nervousness;
- loss of hearing and sight;
- coma; and
- death.

Akvavit is a favorite Scandinavian drink made from grains or potatoes flavored with caraway seeds.

Bitters is made from various herbs and flavorings. The alcohol content is about 40%. Angostura bitters contains quinine and several aromatic substances, including the angostura bark from *Galipea*, a member of the citrus family.

Liqueurs or **cordials** are made by combining brandy with a series of flavorings, often by simply adding dried fruits. Common examples include apricot cordials, creme de cacao, and creme de menthe.

DISTILLED BEVERAGES

Product	Plant Source	Comment
absinthe	grape, wormwood	spirit flavored with oil of wormwood
akvavit (aquavit)	potato and caraway	distilled potato starch and caraway fruits
arrack	rice, sugar cane, palm	distillate of fermented grains and palm juice
brandy	grapes	distilled grape wine
cognac	grapes	distilled grape wine
fruit brandy	apples, plums, etc.	distilled fruit wines
gin	maize, rye, juniper	grains malted, fermented, and distilled
guaro	sugar cane	The national drink of Costa Rica
liqueurs	grape and sugarcane	spirits, sweetened and flavored with herbs
mezcal	century plant	distillate of fermented sap and pulp
okolehao (oke)	rice, dasheen	molasses-flavored; aged in charred barrels; Hawai’i
raki (ouzo)	various plants	distillate of wine, grain, potatoes or molasses
rum	sugar cane	juice fermented and distilled
tequila	century plant	distillate of fermented sap and pulp
vermouth	grape and wormwood	fortified wine flavored with herbs
vodka	rye, potato, wheat	distilled potato or grain starch
whiskey	barley, maize, and rye	grains malted, fermented, and distilled

8.0 • INDUSTRIALLY IMPORTANT PLANTS

8.1 • AN OVERVIEW

☼ Many of our great industries are based upon the extraction and processing of various woods, fibers, fixed oils, essential oils, latexes, gums, resins, starches, dyes, etc. from plants.

☼ Still others are involved with a host of products derived from micro-organisms, such as carefully maintained cultures of yeasts needed for bread making and brewing, and other fungi that are used in medicine.

☼ In some instances, a plant is killed during processing to extract a particular product.

☼ In other cases we have developed refined techniques that allow us to remove what we want, but to keep the plant alive.

☼ The importance of some plants, such as Pará rubber, was linked to technological developments; in this case the invention of the pneumatic tire and the internal combustion engine. Before that, it was an interesting curiosity with limited potential.

☼ As the natural sources have been exploited and depleted, we find it increasingly necessary to create synthetic substitutes for these extractives.

8.2 • FIBER PLANTS

"Fiber plants are second only to food plants in terms of their usefulness to humans and their influence on the advancement of civilization. Tropical people use plant fibers for housing, clothing, hammocks, nets, baskets, fishing lines and bowstrings. Even in our industralized society, we use a variety of natural plant fibers.... In fact the so-called synthetic fibers now providing much of our clothing are only reconstituted cellulose of plant origin." [Mark Plotkin, 1988]

☼ ☼ ☼ ☼ ☼

The category "fiber plants" is an artificial one, including not only true fibers based on anatomical origin, but also a number of miscellaneous plants and plant parts that are loosely called fibers. Woody plant tissues also contain fibers, but they are treated in the next section.

GENERAL FEATURES OF FIBER CELLS

☼ Long and slender, with tapering ends;
☼ About 1-250 mm long and about 1/100 to 6/100 mm wide;
☼ Dead at maturity;
☼ Comparatively thick walls;
☼ Central opening (lumen) is typically quite small;
☼ Occur in clusters.

The cell wall of a fiber consists of cellulose, hemicellulose, and lignins. Often, especially in the case of high quality fibers, the cell wall is almost pure cellulose.

TYPES OF FIBERS

Soft, **stem**, or **bast** fibers occur toward the outside of the stem, when viewed in cross-section. For those of you with a general botany background, bast fibers typically lie in the cortex, phloem, and pericycle tissues. Common examples include flax, hemp, ramie, and jute.

Hard, **leaf**, or **structural fibers** usually come from leaves, typically from some kind of monocot, such as those in the century plant family. The leaves are often tough, with the fibers embedded in a pulpy matrix. Common examples include sisal, Manila-hemp, and New Zealand flax.

Surface fibers are derived from surfaces of seeds and interior walls of fruits. The most important of them are fibers derived from the seeds, with cotton being the pre-eminent example. In addition to cotton, kapok, cotton-grass, and several species of milkweeds yield surface fibers.

PROCESSING

Stem or bast fibers usually occur in bundles, cemented together by a middle lamella. The fibers are freed from one another by a process called **retting**. It involves their partial decomposition in water by micro-organisms. The water may be dew or rain, or the fibers may be submerged in lakes, rivers, or tanks. After retting, the fibers may be **scutched**, a process of smashing the stems between fluted rollers. The central core and bark of the stem are separated from one another.

Leaves are scraped and pounded to separate the vascular bundles from a pulpy matrix around them. Traditionally this was done by hand, but now a machine called a **decorticator** is used. Because so much manual labor is involved, hard fibers are often grown and processed in tropical countries where inexpensive labor is available.

The processing of seed fibers involves **ginning**, in which the fibers are caught on toothed disks or combs and are then pulled through openings too small for the seed itself to pass.

Once fibers have been extracted they may be put through additional machines to align them with one another (**combed**), stretched (**attenuated**), and then twisted to interlock them to yield yarn. It is then twisted in the opposite direction to produce cord, which is used to make rope, which is used to make cables.

HOW DO WE USE FIBERS?

Fibers may also be classified according to their uses:

textile fibers are used primarily in the fabric industry. Cotton, flax, ramie, hemp, and jute are common examples.

cordage fibers are used to make twines and ropes. Jute, cotton, hemp, abacá, sisal, and New Zealand flax are common examples.

brush, **plaiting** or **braiding fibers** are used to make brooms, brushes, mats, hats, baskets, rugs, screens, etc. In this category, the fiber strand can be braided or folded. Examples include a variety of palms, bamboos, herbaceous grasses, and sedges.

filling fibers are used for stuffing, caulking, and reinforcing. Kapok, cotton, several of the hard fibers, Spanish moss, and many grasses fall into this category.

paper-making fibers are used to make paper. Who would have guessed it? There are purists, however, who will argue that hemp, paper mulberry, papyrus, kenaf, rice paper, and various bamboos do not give us "paper," but only a writing surface. Real paper, they say, can be made only out of wood fibers and rags that have been reduced to a pulp and then reconstituted. See Section 8.3 for a discussion of paper-making.

FLAX

Flax is one of the oldest fibers. It comes from *Linum usitatissimum*, a member of the flax family (Linaceae). From the time of the ancient Egyptians until about the 19th century, it was the leading fiber plant. Now it is relatively unimportant. Flax seeds are the source of linseed oil.

Flax is retted, either in dew or it is immersed in water for one or two weeks. After retting, the fibers are **scutched**. The central core and bark are separated from one another. Commercial flax is derived from the bark. The fiber is superior to cotton in many ways. Flax fibers can absorb up to 20% of their own weight in water and they are stronger wet than they are dry. For this reason, hey are prized as towels.

HEMP

"Hemp is intertwined with American history. We grew it to rig the great New England sailing ships, traveled west in Conestoga wagons covered in hemp cloth, dressed in homespun hemp cloth when we got there and wound up wearing hemp jeans. We tied our cargo with hemp rope and fed the poultry with hemp seed. We used hemp to help develop this country.... George Washington said, 'Make the most of hemp seed. Sow it everywhere." (Willie Nelson)

☼ ☼ ☼ ☼ ☼

Like flax, hemp (or hempen) fiber is another plant with a long history of use. Its fiber is similar to that of flax and it may be used as a substitute for it. Hemp (*Cannabis sativa*) is native to Asia. The plant is not only the source of a valuable fiber, but it also yields edible seeds (used for birdseed), oils, and psychoactive resins. The stems are allowed to ret for 3-8 weeks, usually in the dew of fields. They are then scutched. Hemp is used in cordage, in rather coarse fabrics, and to caulk wooden sailing ships, a need that seems to be declining. Until the latter part of the 19th century, hemp was a major source of fiber for manufacturing paper. Its present day advocates have launched an educational campaign to grow it once again for that purpose, thereby saving our forests.

A COMPARISON OF HEMP & PINE PAPER PULP

Hemp	Pine trees
80% conversion to pulp	43 % conversion
3-20% lignin	30% lignin
Requires less bleaching	Requires more
3-8 tons dry wt. per acre	2-4 tons

TIMELINE: HEMP FIBER

BCE:

8000	Earliest fiber remains at Çatal Hüyük
4500	Spreads from Central Asia to China
2800	Emperor Shen Nung teaches Chinese to cultivate
2700	Use widespread in Old World
170	Oldest extant specimens of hemp paper

CE:

100	Chinese first to make paper from hemp
1150	Moors open factory in Spain (first in Europe)
1533	Henry VIII requires farmers to grow hemp
1545	Spanish introduce hemp to New World
1563	Elizabeth I renews Henry's decree
1564	Philip I of Spain orders use in Central & South America
1611	King James Bible printed on hemp
1619	Jamestown colonists directed to grow hemp
1637	Families in Hartford, CT ordered to plant 1 tsp. of seed
1645	Puritans introduce into New England
1753	Linnaeus publishes *Cannabis sativa* as scientific name
1776	Drafts of Declaration of Independence written on hemp
1807	Treaty of Tilset controls sale of hemp
1812	U. S. war with England over access to Russian hemp
1812	Napoleon invades Russia to devastate hemp crop
1841	U. S. Congress orders Navy to buy domestic hemp
1850	U. S. census records 8327 hemp farms (2000 + acres)
1916	U. S. D. A. publishes "Hemp ... As Paper-Making Material"
1929	Ford Motor Co. investigates use of hemp in car plastic body
1937	Mechanical Engineering declares hemp a "most ... desirable crop..."
1937	U. S. Congress passes Marijuana Tax Act
1938	Popular Mechanics publishes "New Billion Dollar Crop"
1942	U. S. D. A. distributes 400,000 pounds of hemp seed in war effort
1942	U. S. D. A. releases film "Hemp for Victory"
1957	Last hemp fields planted in U. S. (Wisconsin)
1984	Ralph Lauren begins secret use of hemp in clothing line
1988	European Economic Community subsidizes

seed production

1989 Imported hemp garments once again available in U. S.
1993 Great Britain lifts hemp ban
1994 Presidential Order declares hemp a strategic crop
1995 North American Industrial Hemp Council formed
1997 North Dakota legalizes hemp
1998 Canada legalizes non-drug cultivation
1998 Australia legalizes hemp
1998 Oregon State University publishes feasibility study
1999 Hawai'i Legislature authorizes test plots
2002 California Legislature fails to pass bill to study feasibility

Because of the confusion in many people's minds, hemp fibers contain about 0.1-1.0% psychoactive materials; marijuana has about 3-20%.

Manila-hemp, Indian-hemp, and sunn-hemp are not kinds of hemp. See the "Survey of Fiber Plants" table for more details.

PAPYRUS

"*Papyrus sheets preserve the thoughts and deeds of man.*" (Leonardo Da Vinci)

This writing material of the ancient Egyptians, Greeks, and Romans was prepared from the stems of an aquatic sedge, *Cyperus papyrus*. The plant is native to central Africa and the Nile Valley. It is naturalized in southern Europe. The plant is a typical member of the family, in that its stems are solid, rather than hollow, as in the grasses. The Egyptians perfected the technique of cutting strips of tissue, placing them parallel to one another, smashing them together with a smooth rock and water from the Nile, and then drying them to form papyrus. The process was recorded by the Greek historian Herodotus, in the 5th century B. C. E.

Although our modern word "paper" comes from papyrus, purists on the subject do not refer to papyrus as paper. They restrict the term to writing surface prepared from cloth or wood that has been pulped, which means that the fiber tissues have been smashed and macerated (soaked in water to soften them), and then trapped on a screen to form flat sheets of writing material.

Papyri have amazing durability. Scholars have access to texts from the early dynasties that tell us of ancient wars, political matters, day-to-day life, and that also document their uses of plants. It is customary to give them names. The Ebers Papyrus, discovered in Thebes, Egypt in 1872, lists several hundred medicinal plants, along with how they were prepared and used.

Papyrus fibers were used to make sails, clothing, mats, and cords. In about the 9th century, it was replaced by paper as a principal writing material.

COTTON

"I wish I was in de land ob cotton, old times dar am not forgotten. Look away, look away, look away, Dixie Land." (Daniel Decatur Emmett, 1859)

☼ ☼ ☼ ☼ ☼

King Cotton! This is the world's most important fiber plant. In addition, its seeds yield cottonseed oil and they are used for fodder cake. The mature fruit, the **boll**, splits open to reveal the fibers, outgrowths of the seed surface. These unicellular hairs are essentially pure cellulose. The hairs may be 1000-6000 times longer than they are wide. They occur in two forms: (1) **fuzz**, also called **linters**, that are thick at the base and firmly attached to the seed itself; and (2) **lint**, with a narrow, delicate base that is easily detached. Lint can be spun. The linters are removed by special machinery and they are used to make nitro-cellulose and rayon. What do we use nitrocellulose for? (A hint: it is the N in TNT.)

There are three major groups of cotton species, based on the length of the seed fibers:

- ☼ Long-staple (2.5-6.5 cm long) cottons are the most difficult to grow, but they yield a fine, lustrous fiber. Examples include sea island, pima, and Egyptian cottons.
- ☼ Medium-staple (1.3-3.3 cm long). American upland cotton is an example.
- ☼ Short-staple (1.0-2.5 cm long) yield coarser fibers that end up in blankets and carpets, or blended with better quality material.

PROCESSING. The processing of cotton fibers involves several stages, including:

- ☼ **ginning**, the removal of the lint fibers from the seeds;
- ☼ **carding**, the straightening of fibers;
- ☼ **combing**, which brings the fibers in parallel, equal-sized groups; and
- ☼ **spinning**, which is the twisting of fibers into a continuous thread.

SPECIES OF COTTON. Cottons are derived from various species of *Gossypium*, plants related to okra and the ornamental hibiscus. The genus is represented in both the Old World and in the New World. The leading Asiatic species are *Gossypium arboreum* and *G. herbaceum*. The Old World cottons have 13 pairs of large chromosomes. *Gossypium barbadense* and *G. hirsutum*, the leading New World cottons, have 26 pairs of chromosomes -- 13 pairs of large chromosomes and 13 pairs of small ones.

GENETICS OF COTTON. There is some controversy as to the number of species of cotton. About 30 of them are diploids ($2n = 2x = 26$) and four are tetraploids ($2n = 4x = 52$). Only four of them are of significant economic importance. *Gossypium hirsutum* (cotton, upland cotton) provides about 95% of our cotton fibers; *G. barbadense* (sea island cotton, pima, Egyptian cotton) most of the remaining 5%.

AN OVERVIEW OF COTTON SPECIES

They fall into four groups that are recognized at the subgeneric level:

- ☼ Australian (C-genome diploids)
- ☼ New World (D-genome diploids)
- ☼ African & Arabian (A, B, E, & F genomes)
- ☼ New World (AD tetraploids)

Here is an overview expressed in a little more detail.

Genome(s)	Distribution
Diploids:	
AA	1 (*G. herbaceum*); S. Africa
BB	3 in Africa; Cape Verde Island
CC	7 in Australia
DD	11 in Mexico, U. S., Peru, & Galapagos
EE	4, Africa to Pakistan
FF	1 (*G. longicalyx*) in East Africa
Tetraploids:	
AADD	*G. barbadense* (South America)
AADD	*G. hirsutum* (C. & S. America; Pacific)
AADD	*G. caicoense* (Brazil)
AADD	*G. tomentosum* (Hawai'i)

Have you noticed that we have a little problem with our New World cottons? There are several with the D genome native here. We also have three tetra-ploid cottons with both the D and A genomes. But there are no native New World cottons that could have contributed the A genome! How an Old World seed source got to the New World remains an open question. Recent molecular studies suggest that the event occurred only once, about 1-2 million years ago.

Most of the cotton in the United States is grown exactly where you suspect, in the southern states. Repeated plantings have depleted the soils, forcing the farmer to rotate crops in order to replenish them. Until the development of appropriate insecticides, the boll weevil (*Anthonomus grandis*), introduced from Mexico just prior to the turn of the 20th century, was a major cotton pest. It is a beetle that lays its eggs in the fruit, where its larvae hatch and damage the plant. The fruit of cotton and flax is called a boll. I think that I was in college before I realized that the bug was not called a "bo weevil."

For centuries, the growing of cotton was intimately tied to the institution of slavery. The following data from Mississippi and Louisiana are instructive.

COTTON AND SLAVES

Year	Pounds Exported	# of Slaves
1785	5,000	8,000
1790	25,000	8,200
1800	20,000,000	10,000
1820	125,000,000	32,000
1858	1,100,000,000	450,000

[Source: Kahn, 1985]

THE AGAVE FIBERS

These fibers are derived from plants of the agave or century plant family (Agavaceae). Most are sterile polyploids. They are called century plants based on the mistaken belief that they bloomed every 100 years. The agaves yield about 90% of all of the hard fibers used in commerce. About half is derived from sisal, named after a port city in Mexico. After 3-8 years, depending on the species, the plants will have produced about 300 thick, juicy, sword-shaped leaves that are ready to be harvested by machetes or similar implements.

Leaves are inserted into mechanical **decorticators** that separate the fiber bundles from the softer, pulpy leaf tissues. A decorticator consists of a set of rotating wheels armed with blunt knives. The fibers are typically washed, dried on racks in the sun or by hot air, and cleaned. The various agave fibers are used to make strong, inexpensive ropes and twines. They are also used in paper, matting, and building panel materials. The waste pulp is used as a fertilizer.

The sap of other *Agave* species is fermented to yield maguey or mezcal, or distilled to produce tequila.

SURVEY OF THE AGAVE FIBERS

Bahama-hemp	*Agave sisalina*
Cantala	*Agave cantala*
Henequen	*Agave fourcroydes*
Ixtle	*Agave lecheguilla*
Jaumave ixtle	*Agave funkiana*
Lecheguilla	*Agave lecheguilla*
Letona	*Agave letonae*
Mexican henequen	*Agave lurida*
Mexican sisal	*Agave fourcroydes*
Salvador hemp	*Agave letonae*
Sisal	*Agave sisalina*
Cabuya	*Furcraea cabuya*
Cuba-hemp	*Furcraea hexapetala*
Mauritius-hemp	*Furcraea foetida*
Fique	*Furcraea macrophylla*
Pitre	*Furcraea hexapetala*
Palma fiber	*Samuela carnerosana*
Adam's needle	*Yucca filamentosa*
Aloe yucca	*Yucca aloifolia*
Chaparral yucca	*Yucca whipplei*
Joshua tree	*Yucca brevifolia*
Mohave yucca	*Yucca schidigera*
Soapweed yucca	*Yucca glauca*
Trecul yucca	*Yucca treculeana*

MANILA HEMP

Manila hemp or **abacá** comes from a relative of the banana and plantain, *Musa textilis*. It is native to the Philippines. Historically the fibers were highly prized because they do not deteriorate in salt water. This meant that they were commonly used in marine ropes, ship caulking, and sails. They were also used to make sacks, coarse fabrics, and wrapping paper. While you may not have heard of Manila hemp, it is probably more commonly encountered in your daily life than you realize. It is found in tea bags, cigarette filters, salami wrappers, and in manila folders and envelopes (hence the name). In Japan, the fibers are used in the light-weight interior walls of homes.

The fibers are extracted from the sheaths at the base of the banana-like leaves. They are strong, light, and can be 2-4 meters long! They are the strongest of the structural fibers.

MINOR FIBER PLANTS

BARK CLOTH. Early European explorers of the South Pacific found the natives wearing various article of clothing that they made from bark fibers. The best known of these is **tapa** or **kapa**, which is a Polynesian word meaning "the beaten thing." Tapa can be made from several plants, including the paper mulberry, breadfruit, milo, and hau tree.

PAPER MULBERRY (*Broussonetia papyrifera),* yields the best known of the bark cloths. It is a tree native to southeast Asia. The Polynesians carried the plant with them as they colonized the South Pacific. The inner bark of the plants is used, after the outer layer has been scrapped away. While the fibers are still damp, they are spread evenly into strips. Now they are placed on a smooth surface and beaten with a wooden mallet (hence the name, "beaten thing"). The fibers spread out and mat with one another. Mucilage from plants such as the taro and hibiscus is used to increase adherence of fibers. Sections of tapa are attached to one another by pounding together overlapping edges. In this way, it is possible to create wrap-around garments, mats, and panels of considerable size, and writing materials. Tapa cloth is often elaborately dyed -- brown, red (from annatto), yellow (from turmeric), and black (from the kukui or candlenut tree). The patterns are characteristic of the various islanders who made them and have assisted anthropologists in determining the sequence of inhabiting the islands of the South Pacific.

KAPOK. The kapok tree (*Ceiba pentandra*), native to the American tropics, is the source of valuable stuffing or filling fibers used in life preservers, cushions, mattresses, sleeping bags, and as an insulating material. The fibers line the interior fruit wall and surround the seeds. Relatives of the kapok tree whose fibers are used in a similar fashion include the silk-floss tree and the red silk-cotton tree.

RAMIE. Ramie or China-grass (*Boehmeria nivea*) is native to the Old World, probably to China. The fiber is one of the finest known, but problems in getting it out of the stem and degumming the fibers have made it difficult to process economically. Ramie has about 8X the tensile strength of cotton and 4X that of flax. When you look at our specimen in the subtropical dome, it may remind you of a large nettle. They are in the same plant family. Ramie does not sting, however. Most members of the nettle family (Urticaceae) do not.

JUTE. *Corchorus capsularis* and *C. olitorius*, relatives of our popular basswood tree, come from eastern Asia. The latter has become a widespread tropical weed. About 98% of the world's production comes from Asia. Jute is a very widely used fiber, although it is of poor quality. Much of it will be used for packing material and spun into a coarse yarn. About three-quarters of the crop will be used to make sacks. Although you may not have heard of jute fibers, you know of two products that are made from them -- burlap bags and gunny sacks. By the way, what is a gunny? How many will fit in a sack? Also, look on the underside of carpets and linoleum. You may well find jute fibers in the backing.

KENAF. *Hibiscus cannabinus* is a related to the ornamental hibiscus, cotton, and okra. Plants were domesticated first in Africa, probably before 4000 B.C.E. Through the millennia, kenaf has been used in the Old World as a substitute for jute. Shortly after World War II, production increased dramatically. India, China, and Thailand are the main producers today.

Kenaf is an easily grown, annual crop. One acre of kenaf can yield 7-10 tons of dry fibers -- five times what an acre of pine trees would produce. The fibers are increasingly popular for paper pulp. The newsprint made from kenaf is brighter, requires less ink, and the ink sticks to the paper better. This is a minor blessing to those of us addicted to the Los Angeles and New York Times.

A SURVEY OF FIBER PLANTS

Common Name (Scientific Name)	Family	Comments
abacá *(Musa textilis)*	Banana	Banana relative; cordage, bagging
African-hemp *(Urena lobata)*	Mallow	Used for fishing nets and cordage
aramina *(Urena lobata)*	Mallow	New World; jute-like fiber
basswood *(Tilia americana)*	Basswood	Used by Native Americans; baskets
bolo-bolo *(Clappertonia ficifolia)*	Basswood	Africa; used for mats
bowstring-hemp *(Sansevieria senegambica)*	Century Plant	Africa; nets and bowstrings
broomroot *(Muhlenbergia macroura)*	Grass	North & Central America; brushes
cabbage palmetto *(Sabal palmetto)*	Palm	Found from Florida to N. Carolina
cabuya *(Furcraea cabuya)*	Century Plant	C. America; sisal-like fiber
cadillo *(Urena lobata)*	Mallow	New World; jute-like fiber
cantala *(Agave cantala)*	Century Plant	Used in the Philippines
China-grass *(Boehmeria nivea)*	Nettle	See: ramie
China-jute *(Abutilon theophrastii)*	Mallow	Cultivated in China; used as jute
chuchoa *(Furcraea andina)*	Century Plant	Native to Ecuador
cocuiza *(Furcraea humboldtiana)*	Century Plant	Used in Venezuela
coir *(Cocos nucifera)*	Palm	The only major fiber from a fruit
Colorado River hemp *(Sesbania exaltata)*	Bean	Used by Native Americans
Congo jute *(Urena lobata)*	Mallow	Kenaf-like fiber; tropical
cotton, Arabian *(Gossypium herbaceum)*	Mallow	Unknown origin; fiber quality good
cotton, Egyptian *(Gossypium barbadense)*	Mallow	Tetraploid of New World origin
cotton, Hawaiian *(Gossypium tomentosum)*	Mallow	Of no commercial important
cotton, Jamaican *(Gossypium hirsutum)*	Mallow	See: upland cotton
cotton, Kathiawar *(Gossypium obtusifolium)*	Mallow	Widely used in India
cotton, levant *(Gossypium herbaceum)*	Mallow	See: Arabian cotton
cotton, sea island *(Gossypium barbadense)*	Mallow	Longest cotton fibers (3-5 cm)

cotton, short staple *(Gossypium herbaceum)*	Mallow	See: Arabian cotton
cotton, tree *(Gossypium arboreum)*	Mallow	India and Africa; short fibers
cotton, upland *(Gossypium hirsutum)*	Mallow	Almost all U. S. cotton of this type
crin vegetale *(Chamaerops humilis)*	Palm	Mediterranean; leaves used
Cuba-jute *(Sida rhombifolia)*	Mallow	Tropical; fibers from stem
Cuban-hemp *(Furcraea hexapetala)*	Century Plant	West Indies; lustruous, good fiber
danicha *(Sesbania bispinosa)*	Bean	Mostly Old World; also food and forage
Decan-hemp *(Hibiscus cannabinus)*	Mallow	See: kenaf
esparto *(Stipa tenacissima)*	Grass	Old & New World; fine fiber for paper, etc.
fique *(Furcraea macrophylla)*	Century Plant	Central America; sisal-like fiber
flax *(Linum usitatissimum)*	Flax	Stem fiber finer than cotton
hemp *(Cannabis sativa)*	Hemp	Stem fiber of ancient use
henequen *(Agave fourcroydes)*	Century Plant	Used especially on Yucutan Peninsula
henequen, Salvador *(Agave letonae)*	Century Plant	Used in El Salvador
Indian-hemp *(Apocynum cannabinum)*	Dogbane	Used by Native Americans in e. U. S.
Indian mallow *(Abutilon avicinnae)*	Mallow	China; jute-like fiber
istle *(Agave lecheguilla)*	Century Plant	See: lechiguilla
ixtle *(Yucca funifera)*	Century Plant	Mexico; used to make coarse sacks
jute *(Corchorus capsularis)*	Basswood	Commonly used fiber
jute, nalta *(Corchorus olitorius)*	Basswood	Tropical; used as jute
jute, tossa (tussa) *(Corchorus olitorius)*	Basswood	Tropical; used as jute
jute, white (*Corchorus capsularis)*	Basswood	Commonly used fiber
kapok *(Ceiba pentandra)*	Bombax	Tropical; fibers from seed surfaces
kenaf *(Hibiscus cannabinus)*	Mallow	Used like hemp and jute
kittul *(Caryota urens)*	Palm	Used in Sri Lanka and East Indies
lapulla *(Triumfetta tomentosa)*	Basswood	Africa; cordage, excellent fiber
lechiguilla *(Agave lecheguilla)*	Century Plant	Mexico & Texas; brushes and cordage
lechiguilla, Juamave *(Agave lecheguilla)*	Century Plant	Mexico; used in fine brushes
letona *(Agave letonae)*	Century Plant	Used in El Salvador
linden *(Tilia americana)*	Basswood	Used by Native Americans
maguey *(Agave atrovirens)*	Century Plant	See: sisal
maguey, Manila *(Agave cantala)*	Century Plant	See: cantala
Manila-hemp *(Musa textilis)*	Banana	See: abaca
Mauritius-hemp *(Furcraea foetida)*	Century Plant	Old & New World; twine and cordage
mezcal *(Agave tequilana)*	Century Plant	Also source of alcoholic beverage
muriti *(Mauritia vinifera)*	Palm	South America; cordage
nettle *(Urtica* spp.*)*	Nettle	Long history of use in Europe
New Zealand flax *(Phormium tenax)*	Century Plant	Widely used by Maories
ozone *(Asclepias incarnata)*	Milkweed	Fiber derived from bark
paineira *(Chorisia speciosa)*	Bombax	South America; seeds yield fibers
palma ixtle *(Samuela carnerosana)*	Century Plant	Mexico; fibers from leaves
palmetto *(Sabal palmetto)*	Palm	Used in southeastern U. S.
palmilla *(Yucca elata)*	Century Plant	Used in Mexico and the U. S.
palmyra *(Borassus flabellifer)*	Palm	Used in the East Indies
palo de borracho *(Chorisia insigna)*	Bombax	Seeds yield kapok-like fiber
paper-mulberry *(Broussonetia papyrifera)*	Mulberry	Source of tapa
Panama hat *(Carludovica palmata)*	Cyclanthus	Industry centered in Ecuador
Paroquet bur *(Triumfetta rhomboidea)*	Basswood	Africa; fibers used for binding
piassaba *(Leopoldina piassaba)*	Palm	Used in Amazonia
piassava *(Attalea funifera)*	Palm	Used in Amazonia
piña *(Ananas comosus)*	Pineapple	From leaves of pineapple plant
pita floja *(Aechmaea magdalenae)*	Pineapple	Fiber resistant to salt water
piteira *(Furcraea gigantea)*	Century Plant	See: Mauritius hemp
pitre *(Furcraea hexapetala)*	Century Plant	Used in Cuba and Hispaniola
pochote *(Ceiba aesculifolia)*	Bombax	Mexico; fibers from seeds
Puerto Rican hat *(Sabal causiarum)*	Palm	Leaf fibers for hats and baskets
Queensland-hemp *(Sida rhombifolia)*	Mallow	See: Cuba jute
ramie *(Boehmeria nivea)*	Nettle	Old World; a strong, fine fiber
red silk-cotton *(Bombax ceiba)*	Bombax	Mostly grown in Indonesia; water-resistant
roselle *(Hibiscus sabdariffa)*	Mallow	East Indies; stem fiber
screwpine *(Pandanus tectorius)*	Screwpine	Mostly Polynesia; mats, baskets, housing
silk-cotton tree *(Ceiba pentandra)*	Bombax	See: kapok
sisal *(Agave sisalina)*	Century Plant	Mexico; general purpose ropes
Spanish broom *(Spartium junceum)*	Bean	Wide variety of uses

Spanish moss *(Tillandsia usneoides)*	Pineapple	A stuffing fiber
sunn (san) hemp *(Crotalaria juncea)*	Bean	Ancient fiber; fish nets and canvas
tikus (tikug) *(Fimbristylis umbellaris)*	Sedge	Asia; basketry, mats, bags, and hats
yaray *(Sabal causiarum)*	Palm	See: Puerto Rican hat palm
yucca, banana *(Yucca baccata)*	Century Plant	Southwestern U. S.; basketry
yucca, chaparral *(Yucca whipplei)*	Century Plant	U. S. & Mexico; long, white fibers
yucca, Mohave *(Yucca mohavensis)*	Century Plant	Southwestern U. S.; leaf fibers
yucca, soapweed *(Yucca glauca)*	Century Plant	Soft, fine fibers from leaves
zacaton (zakaton) *(Muhlenbergia macroura)*	Grass	Texas to C. America; brushes
zamadoque *(Yucca funifera)*	Century Plant	Mexico; used in twine and sacks
zapupe *(Agave zapupe)*	Century Plant	Mexico; attractive, but weak fibers

8.3 • WOOD, ITS BYPRODUCTS, & CORK

ANATOMICAL STRUCTURE

When we first attempt to describe or identify a plant, we often note whether it is an herb, a shrub, or a tree. This classification has served us well since prehistoric times. While useful, it is misleading in the sense that herbs, shrubs, and trees are structurally quite similar to one another. They are composed of the same plant tissues. Beginning at the outside and working our way to the center they are the epidermis, cortex, pericycle, phloem, cambium, xylem, and pith. The difference between an herbaceous and a woody plant is not whether one or more of these tissues is present or absent, but the degree to which particular tissues continue to be produced year after year. In a woody plant, the incremental growth of the outer four tissues (epidermis, cortex, pericyle, and phloem) constitute the bark, a tough, protective outer layer. Herbs may have a light covering of bark on their stems and branches, but not to the degree that we encounter in shrubs and trees. These tissues are, for the most part, dead at maturity.

Beneath the bark lies the cambium, a living tissue that continues to undergo repeated cell divisions during the life of the plant. It will produce some additional phloem tissue to the outside and significant additional xylem tissue toward the inside. Plant anatomists refer to these as the secondary phloem and secondary xylem, respectively. Xylem and phloem are the plumbing system of a plant. They are the tissues through which water and nutrients flow. Most of these tissues will also be dead at maturity. The chief difference between an herbaceous plant and a woody one is that the latter continue to build layer upon layer of secondary xylem in annual increments (**annual rings**). In other words, most of what we call wood is secondary xylem. Also note that when you look at a perfectly healthy, mature tree most of its stem system (the trunk and branches) are composed of dead cells. In fact, xylem tissue will not be fully functional as the water plumbing system of the stem until it is dead and its cell contents (cytoplasm) have dissolved. The portion of the xylem tissue that conducts water is called **sapwood**; the portion that is no longer functional is the **heartwood**.

Forestry and lumber industry people recognize two major categories of woody plants -- **hardwoods** and **softwoods**. The terms are confusing, because they suggest some feature of the wood itself; some measure of its density or hardness. Instead, they tell us whether the wood comes from a conifer (softwood) or from a flowering plant (hardwood). While it is true that there are fundamental anatomical differences between the xylem tissues of most conifers and most flowering plants, they do not lead to a soft wood in one group and a hard wood in the other.

CHEMICAL STRUCTURE

From a chemical viewpoint, wood is primarily **cellulose** and **lignins**. Cellulose is a carbohydrate polymer -- a long molecule made of many glucose resides ($C_6H_{10}O_5$) linked to one another. You know of glucose, a monosaccharide sugar ($C_6H_{12}O_6$). The organization of these glucose residues becomes quite complex. The structure of glucose remains an active subject of research. Cellulose is found in other parts of the plant, as well. Grass leaves are high in cellulose. One of the reasons that we have domesticated certain animals is that their digestive systems are able to deal with these molecules, because ours lack the enzymes needed to break down cellulose. Lignin is the other main constituent of wood. A typical wood sample will contain about half as much lignin as cellulose. It is also a high polymer of repeating phenylpropanoid molecules. I do not have the slightest idea what phenylpropanoid molecules are. Lignin breaks down even less easily than cellulose. By the way, much of the foul smell associated with paper pulping mills comes from the lignin residue that is a byproduct of paper making.

CHARACTERISTICS OF WOOD

Color. Woods come in a variety of colors, including yellow, black, red, white, green, purple, and various striped combinations. These result from pigments in the xylem.

Porosity refers to the number, size, and distribution of larger cells (vessels) in the wood. It will determine how readily a kind of wood takes paint or is resistant to decay. Some trees, such as maple and basswood, have their vessels scattered through the wood (diffuse-porous). Other woods, such as those from oaks, walnuts, elms, and ashes have vessels that are parallel to the annual rings (ring-porous).

Grain is the technical term for the alignment of cells that make up the xylem tissue. All of them can be parallel to the vertical axis of the tree, such that a cross-section cuts neatly through all of them. Some lie that angles so that an oblique cut is produced. Others are arranged spirally. Grain is a major feature in determining the aesthetic appeal of a particular wood.

Density of a wood is its weight divided by its volume.

The industry standard calls for measuring an oven-dried cube of wood 1 cm on each side. Because 1 cm^3 of water weighs 1 gram, any wood that has a density of less than 1.0 will float in water; those with a density of greater than 1.0 will sink. Balsa wood is probably the lightest, with a density of 0.13 grams/cm^3. You have probably seen balsa wood without knowing it. Think about the thin, light wood used to make model airplanes. At the other end of the scale are lignum vitae and quebracho with densities of about 1.25 grams/cm^3. Densities for woods from various North American trees include: incense cedar, 0.35; Douglas-fir, 0.45; redwood, 0.41; ponderosa pine, 0.38; white ash, 0.55; black cherry, 0.47; American elm, 0.46; white oak, 0.60; sycamore, 0.46; and black walnut, 0.51.

Durability. Woods vary greatly in the kinds of chemicals, such as phenolic and terpenoid compounds, that they deposit in their heartwood. This determines the durability of the wood. In some trees, such as redwood and bald-cypress, the deposition of various compounds retards the growth of fungi and bacteria that would otherwise decompose the wood over a period of time. On the other hand, basswood and poplar (usually misspelled and mispronounced "popular") decay comparatively rapidly. Because most woods will last much longer if they are kept dry, we have developed a series of preservatives, such as paints, varnishes, creosotes, and tar oils that we apply to their surfaces.

Moisture content. The amount of moisture in wood ranges from about 70% to 7%, with the sapwood having a higher water content than the heartwood. In most instances, woods with a lower water content are preferable to those with more moisture.

Mechanical Properties. Cleavability is an index of how easily wood can be split. When we want to chop firewood, we want a wood that cleaves easily. When we are constructing something that requires us to use nails or screws in the wood, we want low cleavability.

In addition, there are a number of mechanical properties of wood that must be taken into account. They include stiffness, tensile strength, shear strength, crushing strength, and cross-breaking strength. The particular use intended for the wood will determine which of these features is critical.

THE USES OF WOOD

FUEL. Until the development of alternate energy sources, such as coal, oil, gasoline, electricity, and nuclear materials, we burned wood. Even today, about 1 billion m^3 of wood is consumed by burning it as fuel. In North America, only about 10% of our annual timber harvest goes for fuel, but in Latin American and Africa that figure is much closer to 90%. In this country, wood is a primary fuel in some of the more rural areas. Woods vary considerably in the way that they burn. This is a function of their physical and chemical structure. Obviously the density and dryness of the wood are important factors. Most woods will yield about 4 calories of heat for each gram burned. When we burn a piece of wood, the first phase involves evaporation of water. This requires heat. Then comes the vaporization of volatile materials in the wood at we observe as the flame of the fire. Many conifers are a problem in this regard because their wood is impregnated with resins that will form flammable deposits on the interior of stove pipes and chimneys. Once enough heat has been reached, the cell walls of the xylem itself begin to burn or glow. This is the stage of maximum heat production.

For most of us, burning wood is not a necessity, but an option that we enjoy. We buy cords of wood for our fireplaces or we burn charcoal in our cookouts. A cord of wood is a stack 8' wide, 4' high, and 4' deep. A face cord has the same width and height, but the individual logs may be only 16" or 24" long, as opposed to 48" in the full cord. Charcoal is wood that has been burned in a contained area where only enough oxygen occurs for partial combustion, as in an underground pit. In other words, it has gone through the first and second stages of burning that I described in the last paragraph. Charcoal can produce very high temperatures, hot enough to smelt some metals. In this country we see charcoal in the form of briquets. They are molded from wood waste and often contain coal. Before you get too upset about learning that you were cooking with coal at your last picnic, have you ever considered that coal is, for the most part, wood? Yes, very, very old wood. Fossil wood.

LUMBER. About 0.5 billion m^3 of timber are harvested each year as sawlogs for the production of lumber for the construction. The United States and Canada are the leading consumers of timber for this purpose, with Europe close behind. In the U. S., we harvest about 38 billion board feet or almost 0.25 billion m^3 each year for lumber. There is little of this activity in Asia, Africa, and Latin America. Logging and milling operations are often geographically close to one another because 50-70% of the cost of producing lumber is in getting the logs to the mill. In a highly efficient, modern mill about 60-70% of the log will eventually become lumber. The rest is shavings, sawdust, trimmings, etc. In the United States, most of our timber comes from forests in the West and in the Southeast. Lumber production is about 40 billion board feet per year, with about 75% of it being derived from softwoods. The demand of lumber for the housing industry is a major use. A typical frame house contains about 10,000 board feet. Each year about 3 billion board feet of lumber go into the manufacture of furniture, handles, baseball bats, musical instruments, caskets, and an almost endless list of other items. Here both utility and beauty of the wood are critical factors.

A particular piece may be may of solid wood or a **veneer**, a thin (0.25 mm to 1 cm thick) sheet of wood of uniform thickness that is either shaved (sliced veneer) from a flat surface of a log or more commonly peeled from it as the log is revolving (rotary-cut). The techniques may suggest to you that advanced technology is needed to produce veneers, but this is not the case. We find them in the tombs of the Pharaohs who lived 3500 B. P. How they did it is something of a mystery. Yet another example, some would say, of extraterrestrial intervention. Because they can be laminated onto the surface of a cheaper wood or composite material, veneers are very popular. When considering the purchase of some piece of furniture, most of us would select something made from solid wood, as opposed to a veneer. Obviously, solid wood is better than an item where only the surface is the real thing. Perhaps not! An expert veneer cutter can produce an exterior beauty that the vast majority of solid woods cannot match. Furniture made of a solid wood is also more likely to warp, crack, and split. Of course, if the wood is to be carved, then solid wood is the choice.

The most utilitarian use of veneer is in the manufacture of plywood. Douglas-fir is the principal source of plywood veneer in this country. To make plywood, an odd number of sheets of veneer are glued to one another, each so that the grains run at right angles to the sheet immediately above and below it. Recent development of synthetic resins have permitted very effective gluing of the plies to one another. The chances of failure and peeling are much reduced. Pound for pound, modern plywood are stronger than steel.

OTHER USES OF RAW WOOD. Some logs are stripped of their bark, allowed to dry, often after having been impregnated with chemicals. This unmilled material is called round wood. It finds its way into a variety of products, including poles, posts, pilings, and timbers for mines. Over 6 million new poles for telephone and telegraph wires are produced each year; about 300 million new posts annually. We also cut these logs into shingles and shakes. If one end is thicker than the other, it is a shingle.

I have no idea how many railroad ties there are in this country. Because we have been unable to come up with anything better, we still use about 1 billion board feet per year to replace worn out ties. That translates into about 30 million per year.

Most of the need in this country for wooden barrels has disappeared because of metal, plastic, and paper substitutes. But, barrel-making, technically known as **cooperage**, remains as a minor industry. If you need a watertight container, you want a tight cooperage barrel; otherwise a slack cooperage one will do. The best wood for tight cooperage is white oak because the xylem cells of its wood are clogged up so badly that water will not pass through them. The wood also has no undesirable smell or taste to it. The vast majority of the white oak goes for whiskey barrels and to age red wine. Some large redwood tanks have been in use in California wineries for almost a century.

LUMBER BYPRODUCTS. Pieces of wood that are too small, poorly shaped, or simply ugly have their uses, as well. They are made into particle board, fiberboard, and chipboard. The first two require that these pieces of wood be reduced to smaller chips, sorted, and graded. The particles are then mixed with glues, pesticides, fire retardants, etc. and then pressed into the required size and shape. Fiberboard, as the name suggests, are made from wood fibers, not from small wood chips. Pieces of wood are placed in chemical solvents to separate the fibers, resins, and other additives are mixed with them, and the resulting product then pressed into sheets and dried.

Masonite is manufactured by subjecting wood chips to high pressure in a steam chamber and then exploding them by a quick release of the pressure. This change tears the fibers apart and it reactivates the lignin, which will act as a glue to fix and bind the wood fibers in their new orientation. Further application of heat and pressure will produce a grainless, synthetic board that is hard and water resistant.

Rayon, cellophane, and acetate are also wood byproducts, in that they come from wood cellulose. The first two differ only in their final form -- a sheet or a thread. Wood chips are placed in a chemical bath that reduces them to a pulp that is washed, ground up, and oxidized in the air. Carbon bisulfide is mixed in, along with caustic soda. The product sits until it reaches the proper consistency, at which time it is pressed into sheets of cellophane or extruded through small openings to yield threads of rayon. Some of the newer rayon fibers rival natural ones in many of their physical attributes. Acetate is a more synthetic fiber, in the sense that the pure cellulose has been augmented by acetyl groups during the manufacturing process. The cellulose comes from wood or from fibers left on cottonseeds are they have gone through the ginning process. Because the fibers resist wrinkling, they are popular in the manufacture of permanent press clothing. They are also used to make cigarette filters.

Turpentine is a mixture of essential oils and resins. We extract it from a variety of trees in a variety of ways. About one-quarter of what we produce in this country comes from distilling wood, especially old stumps and roots of pine trees. About half is produced as a byproduct of the sulfate paper-making process described above.

PAPER. One of the most important byproducts of the timber industry is paper. Before outlining the manufacturing process, a definition is in order. Various civilizations used plant tissues to create a surface for their writings. We also used animal skins and silk cloth. The Egyptians cut strips of pith from the stems of the papyrus sedge (*Cyperus papyrus*). Our word "paper" comes from papyrus. Asians also used the pith of the rice paper plant (*Fatsia papyrifera*), which is not a kind of rice; and the Polynesians and the Mayans both pounded the bark of the paper-mulberry (*Broussonetia papyrifera*) into sheets. This same species is the source of tapa cloth worn by the Polynesians. Early Spanish colonials in the New World used century plants and fig leaves. However useful these materials might have been, they are not "paper," according to the narrow definition. True paper, a Chinese invention from about A. D. 100, is made by separating plant fibers from one another and then reconstituting them into thin sheets on a mat or screen. It has been suggested that observing the paper-making wasp construct its nest from macerated wood provided a helpful clue! After drying, the sheets of paper are peeled away from the surface of the screen. The earliest true papers were often mixtures of flax, hemp, paper-mulberry, and rags. Until about 200 years ago, paper making was labor intensive and therefore expensive. It comes as a surprise to learn that since Colonial times until the close of the last century, much of our paper in this country was made of hemp (*Cannabis sativa*). Other forms of this same species are the source of psychoactive materials and are called marijuana, etc. Therefore, there is no need to mutilate pre-Civil War books by smoking them. The invention of movable type by Gutenberg and of paper-making machines made it necessary to look for new sources of plant fibers. Those from wood pulp were an obvious choice.

Processing consists of stripping the bark from logs and then turning them into pulp. In mechanical pulping, debarked logs are forcefully pressed against a revolving grindstone to yield a mush of short wood fibers and fragments. Various agents (bleaches, gums, starches, etc.) may be added. These additives, called sizings, will produce a paper with a smoother surface and one that will accept the printer's ink more readily. The mixture is then floated onto the surface of screens. The slurry of fibers begin to interlock with one another, forming a thin mat of plant fibers. After draining and pressing, the paper is wound up in large rolls. One cord of wood will produce about a ton of pulp. The paper that comes out of this mechanical pulping process is inexpensive and of poor quality. It soon acquires a yellow tinge to it and crumbles rapidly. You encounter it daily (at least I hope you do!) in the form of newsprint used to make your favorite newspaper. Most of the books manufactured after about 1850 employed paper made by the sulfite process. The world's libraries are now discovering that their vast holdings of older books are now crumbling as the paper disintegrates. The Library of Congress, probably the world's largest library, is attempting to save its books from this era by moving them into a large chamber where the books are treated with diethyl zinc. This chemical neutralizes the acid residue on the paper.

There are three chemical processes used to produce paper pulp. In the **sulfite process**, wood chips are placed in a large metal digester and heated under pressure with bisulfites and hot acid. The dissolved lignins are drained off. The softened fibers of essentially pure cellulose are then washed and dried. They may be stored in this form or sent on to beaters and the paper-making screens and presses. The strong and durable paper is used in many different products, as in kraft wrapping paper. In the **sulfate process**, wood chips are reduced in an alkaline solution of sodium hydroxide and sodium sulfide. These chemicals are able to remove resins, waxes, and fats from wood chips. This means that a wider variety of woody plants may be used, including the softwoods (conifers). Most of our paper these days is made this way. In the **soda process**, sodium hydroxide is the only digester used. The paper that results here is often used in books and magazines.

Ninety percent of today's paper is made from wood pulp. Cigarette paper and banknotes are still made out of the linen fibers from flax. Paper made from hemp, straw, and other fibers are produced on a very small scale. In the United States, we consume about 600 lbs. of paper and paperboard per person each year; 200 lbs in Britain, under 100 lbs. in France; about 50 lbs. in Japan, and 25 lbs. in Russia, and only 2 lbs. per person per year in The Peoples Republic of China. As our demand for paper increases -- the computer age notwithstanding -- there is renewed interest in traditional pulp sources (hemp, bamboo, etc.) and in new ones. Two new ones of particular interest are kenaf (*Hibiscus cannabinus*), a cotton relative, and sunn (*Crotalaria juncea*), a member of the bean family.

OTHER ODDS AND ENDS. If you subject a piece of wood to rapidly moving knives or teeth, the result is excelsior. These thin, curled strands can be made from almost any light weight, lightly-colored, odorless wood. Basswood is especially prized. We use excelsior for packing and for stuffing mattresses and furniture. One cord of wood will produce about 1500 lbs. of excelsior. Shavings, especially those from white pine, are also used as packing material. Sawdust is used for fuel, bedding, as a packing material, as a soil amendment, and as an ingredient in a number of industrial products. Wood flour is finely ground sawdust, shavings, and wood waste. It finds its way into linoleum, plastic, nitroglycerin, veneer, flooring, and many other products. I am reminded of the old joke about the cow. The only part that isn't used is the moo.

SURVEY OF TIMBER TREES

TEMPERATE WOODS

Scots pine (Scotch pine). *Pinus sylvestris* (Pinaceae) is probably the most important conifer through northern Europe and Asia. It is used in furniture, poles, veneers, and it is pulped for making kraft paper.

Eastern white pine. *Pinus strobus* (Pinaceae) is our most famous pine. It is native from southern Canada through New England across to the Great Lakes. When we were a British colony, this species was protected on royal reserves because the trunks were used to make the masts for sailing ships. After we gained our independence, we set about logging vast tracts of eastern white pine, making it the most often cut timber tree in the New World. Only about 2% of the original forests remain. Today it is relatively unimportant because so little remains and because it has become the victim of the white pine blister rust, a fungal infection introduced from Europe.

Longleaf pine. *Pinus palustris* (Pinaceae) is the best known pine from the southeastern United States. Longleaf pine is the heaviest of the commercial softwoods. It is very important economically because it yields lumber for heavy construction and it is pulped to make paper. This is the world's leading source of rosin and turpentine.

Ponderosa pine. *Pinus ponderosa* (Pinaceae) is the source of more lumber than any other North American pine. It is the most widely distributed and important pine in the West. Its wood is light, hard, and strong.

Douglas-fir. *Pseudotsuga menziesii* (Pinaceae) accounts for about half of the standing timber in the western United States and is the source of about 20% of the timber cut each year. It is native to western North America from British Columbia southward along the Pacific coast and the Rocky Mountains into Mexico. It reaches its greatest size in our local forests (the largest being almost 300 ft. tall and 14 ft. in diameter). The wood is highly prized for all kinds of construction. Much of our plywood is made from this species.

Redwood. *Sequoia sempervirens* (Taxodiaceae) grows along the Pacific coast of southern Oregon and California. Its wood is valuable because it is relatively soft, light, and resistant to decay. Swellings on the trunk (burls) are valuable because they yield decorative lumber that can be turned into table and counter tops, along with a myriad of strange novelty items that tourists love to purchase.

White oak. *Quercus alba* (Fagaceae) is probably the most valuable of several oaks that yield timber. Its wood is used in furniture-making, flooring, and to make staves for tight cooperage for red wines and that most elegant of alcoholic beverages, Scotch whiskey! We import white oak from Europe. It is very expensive.

Black walnut. *Juglans nigra* (Juglandaceae) is native to much of the eastern United States. On favorable sites it can reach a height of 150 ft. and a diameter of 4 ft. The wood is so valuable that I read of walnut tree rustling a few years ago. The lumber is heavy, strong, and durable. It is popular in cabinet making and for interior finishes. The wood from its roots is used to make gunstocks.

Black cherry. *Prunus serotina* (Rosaceae) is native to much of the eastern United States and southeast Canada. It also occurs in North America in Arizona and Texas. While many cherry trees are small, black cherry can reach a height of 60-80 ft. Its wood is valued for high quality furniture and interiors. It is also used in such specialty items as the wooden blocks that support the electrolyte plates used in printing.

Sweet gum. *Liquidambar styraciflua* (Hammelidaceae) is a 50-120 ft tall tree native to the eastern United States. Its wood is used to make a beautiful veneer, lumber, plywood, boats, toys, slack cooperage, and boxes. We also chew its sweet sap.

Tulip tree. *Liriodendron tulipifera* (Magnoliaceae) is native to the eastern portion of the United States. It is commonly used in plywood, veneer, wood pulp, wood flour, and it is a favorite of wood carvers.

TROPICAL WOODS

Teak. *Tectona grandis* (Verbenaceae) is native to the seasonally dry rain forests of southeast Asia. Its wood is one of the world's strongest, most beautiful, most durable, and most stable. It is used in flooring, plywood, veneer, and in a variety of marine situations, including shipbuilding.

Mahogany. *Swietenia mahogani* (Meliaceae) is a large tree native to the West Indies. Soon after its discovery by Spanish explorers, it became popular for shipbuilding and for fine furniture. In fact, its beautifully colored wood is so valuable that we have been using other species of *Swietenia* and other genera in the same family and other families (Leguminosae and Burseraceae) and calling all of them mahogany.

Rosewood. This is a collective common name for various species of *Dalbergia* and *Pterocarpus* of the Leguminosae. Its scarcity these days limits its use for solid wood items, but it is more widely available in the form of a strikingly beautiful veneer. The Brazilian rosewood (*D. nigra*) has a red-brown wood with black streaks.

Ebony. *Diospyros* spp. (Ebenaceae) yields a magnificent black wood or one that combines black with brown, grey, and green. The trees are native to India and southeast Asia. It is an ancient wood. The Romans used to purchase it from the East. In addition to its popularity in luxury cabinets, it shows up in specialty items, such as door knobs, violin finger boards, bagpipe chanters, castanets, and guitar backs.

COMMERCIAL TIMBER TREES

Common Name	Scientific Name
Afara, limba	*Terminalia superba*
Afzelia	*Afzelia* spp.
African teak	*Pericopsis elata*
Ash, American	*Fraxinus americana*
Ash, European	*Fraxinus excelsior*
Ash, Manchurian	*Fraxinus mandschurica*
Ash, red	*Fraxinus pensylvanica*
Aspen, quaking	*Populus tremuloides*
Avodire	*Turraeanthus africanus*
Bald-cypress	*Taxodium distichum*
Balsa	*Ochroma pyramidale*
Basswood	*Tilia americana*
Beech, American	*Fagus grandifolia*
Beech, European	*Fagus sylvatica*
Beech, Japanese	*Fagus crenata*
Beech, Oriental	*Fagus orientalis*
Birch, European or silver	*Betula pendula*
Birch, cherry or black	*Betula lenta*
Birch, white	*Betula pubescens*
Birch, yellow or gray	*Betula alleghaniensis*
Black tulepo	*Nyssa sylvatica*
Blackwood, Australian	*Acacia melanoxylon*
Boxwood	*Gossypiospermum praecox*
Brazilian tulipwood	*Dalbergia frutescens*
Brazilwood	*Caesalpinia echinata*
Cedar, incense	*Calocedrus decurrens*
Cedar, Atlas	*Cedrus atlantica*
Cedar, Chinese	*Toonia sinensis*
Cedar, cigar box	*Cedrela odorata*
Cedar, deodar	*Cedrus deodara*
Cedar, East African pencil	*Juniperus procera*
Cedar, pencil:	See red cedar
Cedar, Port Orford	*Chamaecyparis lawsoniana*
Cedar, red	*Juniperus virginiana*
Cedar, Virginia:	See red cedar
Cedar, West Indian	*Cedrela odorata*
Cedar, western red	*Thuja plicata*
Cedar, white	*Thuja occidentalis*
Cedar-of-Lebanon	*Cedrus libani*
Cherry, black	*Prunus serotina*
Chestnut, sweet	*Castanea sativa*
Cocobolo	*Dalbergia retusa*
Cottonwood	*Populus deltoides*
Douglas-fir	*Pseudotsuga menziesii*
Ebony, black	*Diospyros mannii*
Ebony, Ceylon	*Diospyros reticulata*
Ebony, East Indian	*Diospyros ebenum*
Ebony, Gaboon	*Diospyros dendro*
Elm, American	*Ulmus americana*
Elm, Dutch or Holland	*Ulmus* x *hollandica*
Elm, English	*Ulmus procera*
Elm, rock or hickory	*Ulmus thomasii*
Elm, slippery	*Ulmus rubra*
Fir, balsam	*Abies balsamea*
Fir, Cascade	*Abies amabilis*
Fir, giant	*Abies grandis*
Fir, noble	*Abies procera*
Fir, red	*Abies magnifica*
Fir, silver	*Abies alba*
Gaboon	*Aucoumea klaineana*
Gedu nohor	*Entandrophgrama angolense*
Greenheart	*Ocotea rodiaei*
Gum, blue	*Eucalyptus botryoides*
Hemlock, eastern	*Tsuga canadensis*
Hemlock, western	*Tsuga heterophylla*
Hickory	*Carya ovata*
Horse chestnut	*Aesculus hippocastanum*
Idigbo	*Terminalia ivorensis*
Incense-cedar	*Calocedrus decurrens*
Iroko	*Chlorophora excelsa*
Ironbark	*Eucalyptus* spp.
Jarrah	*Eucalyptus marginata*
Jelutong	*Dyera costulata*
Kapur	*Dryobalanops* spp.
Karri gum	*Eucalyptus diversicolor*
Katsura	*Cercidiphyllum japonica*
Kauri	*Agathis* spp.
Kauri-pine	*Agathis* spp.
Keruing	*Dipterocarpus* spp.
Kingwood	*Dalbergia cearensis*
Koa	*Acacia koa*
Krabak	*Anisoptera* spp.
Larch, eastern	*Larix laricina*
Larch, European	*Larix decidua*
Larch, western	*Larix occidentalis*
Laurel, Chilean	*Laurelia sempervirens*

Laurel, Indian	*Terminalia* spp.
Lignum vitae	*Guaiacum* spp.
Lime, American	*Tilia americana*
Lime, European	*Tilia* x *vulgaris*
Lime, Japanese	*Tilia japonica*
Mahogany, African	*Khaya senegalensis*
Mahogany, Honduras	*Swietenia macrophylla*
Mahogany, Nyasaland	*Khaya nyasica*
Mahogany, red	*Khaya ivorensis*
Mahogany, true	*Swietenia mahagoni*
Mahogany, Venezuelan	*Swietenia candollea*
Maple	*Acer* spp.
Maple, Queensland	*Flindersia brayleyana*
Maple, sugar	*Acer saccharum*
Meranti	*Shorea* spp.
Monkey puzzle	*Araucaria arauana*
Mora (morabukea)	*Mora excelsa*
Moreton Bay-pine	*Araucaria cunninghamii*
Muhimbi	*Cynometra alexandri*
Muninga	*Pterocarpus angolensis*
Oak, bar	*Quercus macrocarpa*
Oak, basket	*Quercus prinus*
Oak, Durmast	*Quercus petraea*
Oak, English	*Quercus robur*
Oak, Mongolian	*Quercus mongolica*
Oak, red	*Quercus rubra*
Oak, Spanish	*Quercus palustris*
Oak, Spanish red	*Quercus falcata*
Obeche (wawa)	*Triplochiton scleroxylon*
Padauk, Andaman	*Pterocarpus dalbergidides*
Padauk, Burma	*Pterocarpus macrocarpum*
Padauk, West African	*Pterocarpus soyauxii*
Parana-pine	*Araucaria angustifolia*
Pear	*Pyrus communis*
Pine, eastern white	*Pinus strobus*
Pine, loblolly	*Pinus taeda*
Pine, longleaf	*Pinus palustris*
Pine, Scots (Scotch)	*Pinus sylvestris*
Pine, sugar	*Pinus lambertiana*
Pine, western white	*Pinus monticola*
Pine, western yellow	*Pinus ponderosa*
Pine, white	*Pinus strobus*
Plane, European	*Platanus hybridus*
Poplar, balsam	*Populus balsamifera*
Poplar, black	*Populus nigra*
Poplar, white	*Populus alba*
Ramin	*Gonystylus bancanus*
Rauli	*Nothofagus procera*
Redwood	*Sequoia sempervirens*
Rewarewa	*Knightia excelsa*
Rosewood, Brazilian	*Dalbergia nigra*
Rosewood, East Indian	*Dalbergia latifolia*
Rosewood, Honduras	*Dalbergia stevensonii*
Rosewood, Malabar	*Dalbergia sissoides*
Rosewood, Nicaragua	*Dalbergia retusa*
Rosewood, Thailand	*Dalbergia cochinchinensis*
Sapele	*Entandrophragma utile*
Sapele, heavy	*Entandrophragma candollei*
Satinwood, Ceylon	*Chloroxylon swietenia*
Satinwood, West Indian	*Zanthoxylum flavum*
Spruce, Engelmann	*Picea engelmannii*
Spruce, Norway	*Picea abies*
Spruce, red	*Picea rubens*
Spruce, Sitka	*Picea sitchensis*
Spruce, white	*Picea glauca*
Stinkwood	*Ocotea bullata*
Sweet gum	*Liquidambar styraciflua*
Sycamore, American	*Platanus occidentalis*
Tasmanian-oak	*Eucalyptus delegatensus*
Teak	*Tectona grandis*
Tulip tree	*Liriodendron tulipifera*
Utile	*Entandrophragma utile*
Wallaba	*Eperua falcata*
Walnut, black	*Juglans nigra*
Walnut, Japanese	*Juglans* spp.
Wenge	*Millettia laurentii*
White peroba	*Paratecoma peroba*
Yew	*Taxus baccata*
Zebrano	*Microberlinia brazzivillensis*

* Based primarily upon Heywood, V. H. & S. R. Chant. 1982. Popular encyclopedia of plants. Cambridge Univ. Press. P. 329.

CORK

Typically, bark is removed during processing to get at the wood that lies beneath it. There is an important exception. The cork oak (*Quercus suber*), native to the Mediterranean, has highly desirable bark several centimeters thick that can be removed from the plant without killing it. Trees are stripped at about age 25 and cork may be harvested again every 9 or 10 years. The first cork removed (virgin cork) is inferior to later strippings. It will be ground up for wall and floor coverings. Later strippings will be used to make stoppers, etc. About half of the world's cork comes from Portugal; most of the rest from Spain and Morocco. Cork has a number of desirable features. Its air-filled cells make cork light (it floats in water) and they are poor conductors of sound and electricity. It can be compressed without rupturing its cells, which will return to their normal size when the pressure is removed. Cork does not burn easily, nor does it absorb odors or flavors readily. While rubber and plastics have replaced cork in some seals and gaskets, it remains popular world-wide because there is no commonly available synthetic substitute.

8.4 • LATEX PLANTS

Most of our familiar herbs and trees have a watery sap. A few have a milky or brightly-colored latex that oozes from the plant when it is wounded. Although not easily defined, latex is a colloidal mixture of water, hydrocarbons, salts, resins, acids, and various organic and inorganic constituents. It is formed in specialized cells in the plant and often moves in its own separate plumbing system. The function of latex is uncertain. Perhaps it serves to close injured plant parts or to store nutrients.

SOURCES

About 2000 species of plants contain latex. Several plant families characteristically have it, including the spurge family (*Euphorbiaceae*), milkweed family (*Asclepiadaceae*), dogbane family (Apocynaceae), sunflower family (*Compositae*), mulberry family (*Moraceae*), and sapote family (*Sapotaceae*).

TYPES OF LATEX

The basic building block of the industrially important latexes is the **isoprene** molecule C_5H_8 -- thousands of them linked to one another to form polyisoprene. The difference in physical linkage is the basis for recognizing the two basic kinds of latex: rubber is cis-polyisoprene and gutta or balata is trans-polyisoprene.

Category	**Rubber**	**Balata**
Resilient	Yes	No
Pliable	Yes	No
Bounce?	Yes	No
Moldable?	No	Yes
Isoprene units	Cis-form	Trans-form

PANAMA RUBBER

We begin our survey of latex-bearing plants by looking at one that is probably unfamiliar to most of us. My reason for doing so is that this tree was the first to be tapped by the indigenous peoples of the New World and it would later be confused with the much better known Pará rubber tree.

When Columbus and other early European explorers came to the New World, they found the indigenous peoples making a variety of useful items from the latex of native trees. Two species of *Castilla*, trees of the mulberry family (Moraceae), were chief among them. Panama rubber, derived from the latex of *C. elastica*, was used since ancient times by Mesoamerican peoples to make solid and hollow rubber balls and figurines, rubber bands, shoes, vessels, and for waterproofing. It also had medicinal and ritual uses.

The famous Mayan ball game used solid rubber balls about 15-30 cm in diameter and that weighed up to 7 kg made from Panama rubber. We have archeological remains as early as 1600 B. C. E.

Trees were tapped by cutting into the inner bark of the tree. Latex flows until the tree is drained. It is not a pretty sight! If the tree lives, it may take months for it to recover. A mature tree can yield up to 50-70 lbs. of latex. Early Spanish chroniclers noted that the latex was coagaulated by mixing it with the sap of a local morning glory, *Ipomoea alba.* The resulting rubber could then be shaped into a desired form and it bounced. Crude rubber could be stored or shipped by forming it into flat cakes.

Panama rubber remained the primary source of rubber until 1850 when it was replaced by Pará rubber. It enjoyed a rebirth of popularity as an emergency source of rubber latex during World War II.

The early history of rubber latex and its sources in the New World is confusing because both Panama rubber and Pará rubber were called “heve” and their latex called “caoutchouc.”

PARÁ RUBBER

“Rubber dazzled them, as gold and diamonds have dazzled other men and driven them forth to wander the waste places of the world. Searching for rubber, they made highways of rivers whose very existence was unknown to the government authorities, or to map-makers. Whether they succeeded or failed, they left everywhere behind them settlers who toiled, married and brought up children. Settlement began; the conquest of the wilderness entered on its first stage.”

[Theodore Roosevelt]

“I can assure you that ... when Mr. Wickham arrived at Kew ... with his precious bags of seeds, not even the wildest imagination could have contemplated its results.” [Sir William T. Thistleton-Dyer, Director of the Royal Botanic Gardens at Kew, England]

“There is probably no other inert substance which so excites the mind.” [Charles Goodyear]

“I should have chosen rubber.” [Andrew Carnegie]

TIMELINE: RUBBER LATEX

BCE:

1600	Oldest Olmec solid rubber balls (Veracruz, Mexico)
1600	Mesoamericans coagulate latex with sap from morning glory

CE:

1493	Columbus records use of tree latex
1530	Pietro d’Anghiera describes Aztec ball games
1736	Charles Marie de la Condamine reports use in torches, etc.
1763	François Fresneau discovers latex dissolves in turpentine
1770	Joseph Priestley describes India rubber
1790	Fourcroy discovers resin coagulation can be retarded with alkali
1813	John Clark invents air and water beds made of India rubber cloth
1820	Thomas Hancock invents rubber masticator
1823	Charles Macintosh discovers latex dissolves in naphtha
1825	Charles Macintosh & Co. manufacturers waterproof clothing
1825	Alexander von Humboldt & A. Bonpland name tree *Siphonia brasiliensis*
1826	World production: 16 metric tons
1826	Michael Faraday publishes formula for Pará rubber
1839	Charles Goodyear discovers vulcanization process
1839	Thomas Hancock discovers vulcanization process
1843	Charles Goodyear awarded U. S. Patent 3633
1843	Thomas Hancock awarded British patent for vulcanization process
1845	Stephen Perry invents rubber band
1846	Charles Hancock invents sponge rubber
1852	Nelson Goodyear & Charles Macintosh invent vulcanite and ebonite
1852	Daniel Webster defends Goodyear against patent infringements
1856	Chevalier de Claussen proposes synthetic rubber from *Hancornia speciosa*
1858	Hyman Lipman invents pencil with attached eraser
1860	Charles Goodyear dies ($200,000 in debt!)
1862	John Leighton invents rubber stamp
1870	World production: 15,000 metric tons
1872	Pará rubber domesticated
1876	Henry Wickham smuggles 70,000 seeds out of Brazil
1885	Gottleib Daimler invents internal combustion

engine

1888 John Boyd Dunlop invents pneumatic tire
1903 Christian Gray & Thomas Sloper invent cross-ply rubber tire
1906 Henry Ford begins mass production of "tin lizzies"
1909 Karl Hofmann invents synthetic rubber from butadiene
1909 Over 40 million trees now planted in Malaya
1912 Kaiser Wilhelm II presented with car with synthetic rubber tires
1919 British establish rubber plantations in Ceylon
1922 Stevenson Plan stabilizes world latex prices
1926 I. G. Farben Co. invents Buna S, a synthetic rubber
1929 E. Murphy & W. Chapman invent foam rubber
1931 Wallace Carouthers invents Duprene (now called Neoprene)
1934 International Rubber Regulation Agreement
1940 President Roosevelt declares rubber a "strategic and critical material"
1942 U. S. government establishes American Synthetic Rubber Research Program
1943 U. S. distilleries produce alcohol for synthetic rubber manufacture
1943 U. S. has 15 synthetic rubber plants
1986 O-rings of natural rubber fail on Challenger space shuttle
2001 Centers for Disease Control warns of latex toxicity

During the rediscovery and conquest of the New World, the Spanish found several Indian tribes using the latex of local trees to make shoes and balls for games. The Spaniards did not seem terribly impressed by all of this and they did not see the potential of the "weeping woods." Perhaps the first reference to rubber in the European literature appeared in "De Orbo Novo," written by Pietro d'Anghiera (1530). He described the Aztec game balls, "*... made of the juice of certain herbs ... (which) being stricken upon the ground but softly (bounced) incredibly into the ayer*." Although there is still some question, the rubber trees that the Spaniards saw and the samples that were later sent back to France were from the Panama rubber plant (*Castilla elastica*), a member of the mulberry family. Uncertainty as to identification and conflicting reports of the latex content of trees were finally settled by later expeditions into South America. We now know that the principal latex trees of the Amazonian basin are various species of *Hevea*, especially *H. brasiliensis*.

Rubber remained relatively unknown in Europe until the French astronomer Charles Marie de la Condamine sent samples of "caoutchouc" from Peru to France in 1736. At first the latex was regarded as nothing more than a curiosity. Joseph Priestley used it to rub out unwanted pencil marks and supposedly gave the latex its common name of rubber.

Although the potentials of rubber latex were realized by workers of the late 18th and early 19th centuries, it remained an unimportant commodity. There were definite drawbacks to the use of rubber. It got brittle and cracked when exposed to the cold, it became somewhat fluid and sticky on hot days, and it had a most unpleasant aroma. Caoutchouc became a household item when Macintosh rediscovered that the latex could be dissolved in naphtha cheaply and efficiently. This made it possible to waterproof garments. In England, a raincoat is still called a mackintosh.

The technological discovery that made rubber critically important was **vulcanization**. Charles Goodyear or Thomas Hancock (accounts vary, depending upon whether you are American or English) discovered that by treating the latex with sulfur at high temperature and pressure, these troublesome changes in its consistency could be overcome. Carbon black and zinc oxide are added, together with antioxidants to retard deterioration caused by oxygen and ozone. It was recently dis-covered that irradiation with cobalt-60 can replace the use of sulfur.

Vulcanized rubber was used in the pneumatic tires reinvented by John Lloyd Dunlop in 1888. André Michelin in France and Benjamin Franklin Goodrich in the U. S. began making automobile and bicycle tires on a commercial scale. The need for rubber latex was now immense!

A few farsighted individuals had seen that the haphazard methods of collecting the latex from wild trees of the Amazon Basin would not be sufficient to meet these new demands. They saw, instead, huge plantations where rubber trees could be grown and harvested under precise control. Starting such an operation would require getting thousands of seeds out of South America. But, the Brazilian government clamped heavy restrictions on the export of rubber trees, seedlings, and seeds in an attempt to keep absolute control of the latex market. They were not altogether successful. Farris sent 2000 seeds back to the Royal Botanic Gardens at Kew in 1872. Four years later Henry Wickham "acquired" 70,000 seeds and sent them home to Kew. They were germinated and the seedlings then sent to the English colonies in the Far East where plantations were begun. A grateful Queen Victoria would make him Sir Henry Wickham.

Today over 90% of all rubber comes from Southeast Asia and rubber's ancestral home in Brazil is of secondary importance.

PROCESSING

Rubber plantations are a marvel of organization and efficiency. Work begins very early each day. The workers tap the trees by making cuts into the trunk, just deep enough to sever the ends of the latex vessels that lie in the inner bark. Cuts made too deeply will damage the underlying tissues of the tree. The herringbone pattern of cuts soon begins to ooze the rubber latex. It is collected and taken to a factory for processing. The latex is cleaned, filtered, and diluted. It is also coagulated in large tanks of formic, acetic, or sulfuric acid. A liquid phase, the **serum** (accounting for about 70% of the latex) is drained off. The latex is then sent to mills to be rolled into sheets.

Processing is far from finished. The latex sheets are washed, freed from impurities, and dried. They are put into large machines called **masticators** that chew them up into small chunks of latex. The next stage involves mixing the latex with a wide variety of fillers, antioxidants, plasticizers, and coloring materials. This stage is critical and the exact proportions are a closely guarded secret of each company. The treated latex is now put into a machine that produces sheets of stock of a desired size and thickness. If strips of rubber or tubes are wanted, then the treated latex is put through an extruder. It is then vulcanized.

PROCESSING OF LATEX

[*Initial Processing*]

Tap trees
▽
Collect latex
▽
Add ammonia to prevent coagulation
▽
Dilute with water, filter
▽
Coagulate
(old: over a fire)
(new: acetic/formic acid)
▽
Concentrate latex
(evaporation or centrifugation)
▽
Roll into sheets
▽
Wash, clean, & dry
▽
Smoke
▽
Grade
▽
Store or transport

[*Final Processing*]

Mastication
(machines reduce stored latex)
▽
Blend
▽
Additives
(carbon black, plasticizers, coloring agents)
▽
Vulcanization

NATURAL RUBBER PRODUCTION
(metric tons)

1826	16
1870	15,000
1900	52,000
1920	302,000
1940	1,127,000
1947	1,275,000
1950	1,750,000
1960	2,095,000
1970	2,986,300
1980	3,748,108
1990	5,223,885
2000	6,825,475
2003	7,437,129

NATURAL ALTERNATIVES TO PARÁ RUBBER

During the Second World War, rubber sources were cut off from us because of the occupation of certain Asian countries. Our government became intensely interested in two alternatives -- other latex sources and the development of synthetic rubber. Other plants investigated were:

guayule (*Parthenium argentatum*), a shrub of the sunflower family native to Texas and adjacent Mexico;

Russian dandelion (*Taraxacum koksaghyz*), of Central Asia, which the Russians had been working on since the 1930's; and the

rubber vine (*Cryptostegia* spp.), native to the Old World, but introduced into Mexico and North America.

MINOR LATEX-BEARING PLANTS

AFRICAN OR RED RUBBER. *Landolphia gummifera* and other species of the same genus yield red rubber. It is also called African and Madagascar rubber. The large woody vines are members of the dogbane family (Apocynaceae). The fact that they produced a latex was discovered in 1850 by T. L. Wilson, a missionary to Africa. By the turn of the century, the profits from these vines would finance the first stage of formal colonial rule in Central Africa.

One of the more horrendous chapters in the history of that continent involves Leopold II, King of the Belgians, who personally owned most or all of tropical west Africa. The region may have been called the Belgian Congo, but the land belonged to the King, not the country. He leased huge portions of it to outside commercial interests. Those folks paid him tribute and taxes. It is estimated that Leopold received 1/5 of all the profits made on ivory tusks and red rubber. Villages had quotas of latex assigned to them. The native Africans who failed to meet their quotas were flogged, tortured, mutilated by having their hands cut off, or simply killed. The wives and children of the male workers were held as hostages. This happened to tens of thousands of Africans. In 1908, the Belgian government, reacting to world outrage, confiscated the holdings of King Leopold.

"The worst feature in connection with this particular rubber industry, however, was the barbarous treatment of the natives. The story of the operations in the Belgian Congo during the reign of Leopold II will always remain one of the bleakest pages in history." (Albert F. Hill, 1952)

GUAYULE. *Parthenium argentatum* is the only native U. S. plant that has been used commercially as a latex source. It was studied intensively during World War II. The latex is much inferior to its competitors, principally because of its resin content. The juice is extracted by macerating the plants.

CHICLÉ. *Manilkara zapota* is native to the New World tropics. It used to be the principal source of chewing gum latex. The industrial demands were so great that other sources were also used. Today's chewing gum uses polyvinyl acetate and microcrystalline waxes instead.

The chewing gum industry is an offshoot of the rubber industry. According to one account, the man responsible for chewing gum is none other than General Antonio Lopez de Santa Ana. A few years after his defeat by Sam Houston, the General went to New York with a piece of chicle that he thought would be a good rubber substitute. There he met Thomas Adams, who was not that impressed by a series of less than successful demonstrations. Adams did note, however, that during their conversations the General chewed the latex. The rest is history.

GUTTA-PERCHA. *Palaquium gutta* is native to the Malayan region. The trees are usually cut down during the extraction process. The latex is hard at room temperature, oxidizes rapidly, and should be kept under water. It is a very poor conductor of electricity. Gutta-percha is used to insulate submarine cables, in golf ball centers, and in dentistry. If you have had root canal work, you probably have some gutta percha in your mouth.

SYNTHETIC RUBBER

No other natural latex source has proven satisfactory. Synthetic rubber, on the other hand, has been a great success. Chemists found that butadiene and styrene can be combined to form a polymer much like that of natural rubber. Both molecules can be obtained from coal, petroleum, and alcohol. Much of what we purchase today is a mixture of natural and artificial rubber. It is often referred to as "SBR," styrene butadiene rubber.

As you will note from the following data, there was a dramatic increase in synthetic rubber production beginning in the 1940's. This was obviously linked to the need for rubber by the U. S. military and the occupation of the plantations of Southeast Asia by the Japanese.

SYNTHETIC RUBBER PRODUCTION (metric tons)

1940	43,000
1945	800,000
1950	583,000
1960	2,021,000
1980	8,690,000
2002	10,880,000

LATEX-BEARING PLANTS

Common Name (Scientific Name)	Family	Comment
Assam rubber *(Ficus elastica)*	Mulberry	Another name for India rubber plant
balata *(Manilkara bidentata)*	Sapote	Especially good for machine belts
Borneo rubber *(Willughbeia coriacea)*	Dogbane	Malaysian; coagulated by salt water
castilla rubber *(Castilla* spp.*)*	Mulberry	C. America; once important source
caucho *(Castilla ulei)*	Mulberry	Amazon; tree cut down and bled
caura *(Micrandra* spp.)	Spurge	Native to Venezuela
ceara rubber *(Manihot glaziovii)*	Spurge	Brazil; widely cultivated
chiclé *(Manilkara zapota)*	Sapote	Once basis of our chewing gums
chilte *(Cnidoscolus spp.)*	Spurge	New World; used to mold small items
chrysil *(Chrysothamnus* spp.)	Sunflower	North American species
cow tree *(Brosimum utile)*	Mulberry	Latex chewed and drunk!
false rubber tree *(Funtumia africana)*	Dogbane	Noncoagulating rubber; Africa
gaucho blanco *(Sapium* spp.)	Spurge	South American species
getah ago *(Hunteria corymbosa)*	Dogbane	Used in the Malaysian region
goldenrod *(Solidago* spp.)	Sunflower	Thomas Edison investigated it
guayule *(Parthenium argentatum)*	Sunflower	Only native commercially exploited
gutta djelutung *(Alstonia eximea)*	Dogbane	Added to gutta percha
gutta gum *(Couma* spp.)	Dogbane	Used in American tropics
gutta malaboeai *(Alstonia grandifolia)*	Dogbane	Added to gutta percha
gutta niger *(Ficus platyphylla)*	Mulberry	Africa; a local chewing gum base
gutta percha *(Palaquium gutta)*	Sapote	Malayan; excellent electrical conductor
India rubber *(Ficus elastica)*	Mulberry	Also a very popular ornamental
intisy rubber *(Euphorbia intisy)*	Spurge	Leafless shrub of Malagasy Rep.
juletong *(Dyera costulata)*	Dogbane	Malayan; now a chiclé substitute
Kirk's rubber vine *(Landolphia kirkii)*	Dogbane	Important African rubber plant
lagos rubber *(Funtumia elastica)*	Dogbane	West Africa; badly exploited
landolphia rubber *(Landolphia heudelotii)*	Dogbane	West African vine
leche-caspi *(Couma macrocarpa)*	Dogbane	S. America; chicle substitute
mangabeira *(Hancornia speciosa)*	Dogbane	S. America; rubber cement
manicoba rubber *(Manihot* spp.)	Spurge	Brazil; latex viscous
milkweed *(Asclepias* spp.)	Milkweed	Several American species used
noire du Congo *(Clitandra orientalis)*	Dogbane	Tropical Africa; good latex
palay *(Cryptostegia* spp.)	Dogbane	Fastest growing of all latex plants
Panama rubber *(Castilla elastica)*	Mulberry	Tropical America; once important
Pará rubber *(Hevea brasiliensis)*	Spurge	S. America; chief latex now in use
rubber vine *(Cryptostegia* spp.)	Milkweed	Latex found in stems, leaves, and seeds
Russian dandelion *(Taraxacum koksaghyz)*	Sunflower	Tuberous root yields latex
serapat *(Urceola esculenta)*	Dogbane	Malaysian area
sirva *(Couma macrocarpa)*	Dogbane	S. America; chicle substitute
tau-saghys *(Scorzonera tau-saghys)*	Sunflower	Grown commercially in Russia
Vogel fig *(Ficus vogelii)*	Mulberry	Africa; high resin content
West African gum vine *(Landolphia owariensis)*	Dogbane	Common West African vine

8.5 • GUMS, RESINS, AND EXUDATES

If there is a more familiar term for gums, resins, and various plant exudates, it would be oozings or gunk. The discussion that follows is not that satisfactory, mainly because it is so difficult to distinguish the categories from one another.

GUMS

Gums are noncrystalline mixtures of carbohydrates and organic acids that exude from plants. They often harden on exposure to air and swell to produce a viscous dispersion or solution when added to water. They are insoluble in alcohol, ether, and many other reagents. They will char, but will not burn freely. Their role within the plant body is not thoroughly understood. Some experts believe that gums help to heal wounded plants and to store water. We are not able to digest gums completely, so to us they are essentially inert substances.

Gums have a variety of uses. Many of them are **sizings**, substances spread on cloth or paper to glaze or coat them. They stiffen and strengthen fibers during processing. We often wash or steam the sizings out of clothing before we wear them.

Four of our most important gums are derived from members of the bean family (Leguminosae). Gum Arabic (*Acacia* spp., especially *A. senegal*) comes from a plant that lives in North Africa, India, and Arabia. The gum exudes from exposed underbark. It is used in adhesives, confections, polishes, inks, and medicines. Gum tragacanth (*Astragalus* spp.), comes from plants native to western Asia and southeastern Europe. It also yields sizings, adhesives, and medicines. Gum from the locust bean (*Ceratonia siliqua*) is used in papermaking and as a stabilizer in foods. Guar (*Cyamopsis tetragonoloba*) is an Indian plant used in salad dressings and ice cream.

RESINS AND OTHER EXUDATES

This assemblage of exudates is not easily characterized. Many resins appear to be the result of reduction and polymerization of starches and other carbohydrates. Others seem to be oxidative products of essential oils. Resins often have high molecular weights. They are typically brittle, and more or less transparent. Resins are insoluble in water and more or less soluble in ordinary reagents. Their function within the plant remains incompletely understood. They are usually seen when it is wounded. Resins are typically found in special ducts or canals within the plant.

Resins have been used since ancient times as a caulking material, in all-weather torches, as embalming agents, medicine, and materials for painting. While resins are found in many plants, they come primarily from species in three families -- the pines (Pinaceae), legumes (Leguminosae), and the dipterocarps (Dipterocarpaceae).

TURPENTINE is a mixture of the resins and essential oils, an oleoresin, found in the resin canals in the bark and sapwood of various conifers. The crude material that exudes from the plant is called **pitch**. It is distilled to separate the resin from the essential oil. The production and processing of pitch is called the **naval stores industry**. Turpentine manufacture in the U. S. started in the Carolinas. Longleaf pine and slash pine were the principal sources. The tapping procedures themselves have remained relatively unchanged. Crude pitch is gathered every week. The pitch is then diluted and filtered. It is then treated with acid to yield a lighter, more valuable grade of resin. Water is added to remove the traces of acid. It is then distilled. Oil or spirit of turpentine boils off first. A heavier residue, **rosin**, remains behind. The rosin is screened, cooled, and hardened. The oil will be used as a solvent. The rosin will be used in soaps, varnishes, inks, waxes, and lubricants. It is also rubbed on violin bows.

AMBER is the resin of an extinct pine (*Pinus succinifer*). Its origin remained a mystery for many centuries. It was once thought to be made by the sun's rays or to be petrified whale sperm. Amber varies from yellow to black. The lighter colors will get darker upon continued exposure to light. Amber polishes up well and is often incorporated into jewelry. When rubbed, it takes on a negative charge. One of the most fascinating aspects of amber is that insects that were flying about when the trees were exuding the resin sometimes became trapped in the viscous material, just as they do today. This means that we have available to us now the amazingly well preserved remains of insects, millions of years old, trapped in the amber. Large chunks of amber are quite expensive. The largest specimen that I know about weighed 18 lbs. and sold for $30 million.

BALSAMS are oleoresins that contain benzoic or cinnamic acid. They are typically highly aromatic. Balsam-of-Peru, the resin found in *Myroxylon balsamum* of the New World tropics, has been used to heal persistent sores, as a fixative in perfumes, as a vanilla substitute, and as an ingredient in arrow poisons, soaps, and consecrated oils.

LACQUER is the resin obtained from *Rhus vernicifera* and other plants of the cashew family (Anacardiaceae). These shrubs are native to China, Japan, and other countries in the Old World. The resin is milky when it comes out of the plant, but it darkens upon exposure to the air. Sometimes as many as 300 layers of lacquer are applied to furniture. Because these resins are from plants closely related chemically to those found in poison ivy-oak-sumac group, some individuals will have an allergic reaction to furniture treated with these lacquers.

MIXTURES OF GUMS AND RESINS. You have perhaps heard of three of them that were once more popular than they are now. **Frankincense** is an exudate scrapped from the trunk and branches of *Boswellia carteri* and *B. fiereana*, trees of the bursera family (Burseraceae). The elephant tree that lives in southern California is one of the few members of this family in our part of the world. Frankincense was once important as a fumigant and it was used in medicine and in embalming. It was also traded. **Myrrh** is a similar material that comes from *Commiphora* spp., African trees in the same family.

Asafetida is a truly foul-smelling, milky juice that exudes from the roots of *Ferula assafoetida*, an herb in the carrot or parsley family (Umbelliferae). It enjoyed limited popularity as a medicine, often by hanging a bag of asafetida around the neck. I suspect that this malodorous gunk did reduce the spread of illness by keeping people from getting too close to someone using it.

GUMS AND RESINS

Product (Source)	Plant Family or Group
GUMS	
Agar (*Gelidium* spp., etc.)	Red algae
Algin (*Ascophyllum* spp., etc.)	Brown algae
Arabic (*Acacia senegal,* etc.)	Bean
Carob (*Ceratonia siliqua*)	Bean
Carrageenan (*Chondrus crispus*)	Red algae
Catechu (*Acacia catechu*)	Bean
Furcellaran (*Furcellaran fastigiata*)	Red algae
Ghatti (*Anogeissus latifolia*)	Combretum
Guar (*Cyamopsis tetragonolobus*)	Bean
Karaya (*Sterculia urens*)	Sterculia
Larch (*Larix occidentalis*)	Pine
Locust bean (*Ceratonia siliqua*)	Bean
Tragacanth (*Astragalus gummifer*)	Bean
RESINS	
Opopanax (*Opopanax chironium*)	Parsley
Pitch (*Pinus australis*)	Pine
Turpentine (*Pinus australis*)	Pine
OLEORESINS	
Balm of Gilead (*Abies balsamea*)	Pine
Canada balsam (*Abies balsamea*)	Pine
Elemi (Several different plants)	Bursera
Mastic (*Pistacia lentiscus*)	Cashew
HARD RESINS	
Amber (*Pinus succinifer*)	Pine
Copals (*Hymenaea* and related genera)	Bean
Dammars (*Hopea* + related genera)	Dipterocarp
Dragon blood (*Dracaena draco*)	Century plant
Lacquer (*Rhus* and related genera)	Cashew
BALSAMS	
Balsam of Peru (*Myroxylon balsamum*)	Bean
Balsam of Tolu (*Myroxylon balsamum*)	Bean
Benzoin (*Styrax benzoin*)	Styrax
GUM RESINS	
Asafetida (*Ferula assafoetida*)	Parsley
Frankincense (*Boswellia carteri*)	Bursera
Gamboge (*Garcinia hanburyi*)	Mangosteen
Myrrh (*Commiphora* spp.)	Bursera

Source: Hill (1952)

8.6 - STARCH PLANTS

Starch may be the most widely distributed organic compound found in plants and it occurs in practically all parts of the plant. Although it is usually produced in the leaves as a temporary storage form for photosynthetic products, it is primarily in seeds, roots, and a few stems where it is stored permanently enough and in sufficiently large quantities to make its extraction economically feasible. Starch occurs within the plant body as insoluble granules that have characteristic sizes, shapes, and striations. Experts in such matters can tell the source of a starch sample by examining these granules under a compound microscope.

The most common sources of commercial starch are maize, the potato, wheat, rice, sorghum, cassava, arrowroot, and the sago palm.

Starch is a glucose polymer. So is cellulose. The difference between the two is the nature of the chemical bond that unites the glucose molecules to one another. In starch they are α-bonds; in cellulose they are β-bonds. Now you know! In starch the individual glucose building-blocks are linked in a linear array (amyloses) or in a branched configuration (amylopectins). Because α-bonds are more easily attacked by enzymes, starch can be broken down more readily than cellulose. Alpha-amylase is the enzyme that occurs in our saliva and pancreatic juice that breaks down starch into simpler sugars. Complete hydrolysis of starch will yield glucose.

Starch has many uses. We produce billions of tons of it each year in the United States, with 95% of the starch coming from maize. You may be surprised to learn that about 60% of the starch used in this country goes into the paper and cardboard industry, as **sizings**. A **size** is a substance used to fill in the pores of paper or cloth to make the surface appear more uniform. In the textile industry, starch is used to strengthen fibers and to make thread easier to weave. Laundries use starch to give a shirt a more finished appearance. In the food industry, starch is a thickening agent. On a much smaller scale, we do the same thing in our kitchens when we thicken gravy. Starch has a number of cosmetic applications, as in various soothing powders.

We manufacture much of our industrial alcohol from starch. The process is essentially the same as that used to produce ethyl alcohol, the kind found in beer, wine, and distilled beverages. The difference is that industrial alcohol has been denatured -- rendered undrinkable -- by adding methyl alcohol to it. Perhaps the least known use of starch is in the manufacture of explosives. Cellulose + nitric acid → nitrocellulose. Starch + nitric acid → nitrostarch. Toward the end of World War II, the United States was using almost 2 million lbs. of nitrostarch a month to make the explosives for hand grenades.

STARCH PLANTS

Common & Scientific Name	Plant Family
Air potato (*Dioscorea bulbifera*)	Yam
American cabbage palm (*Roystonea oleracea*)	Palm
Arrowroot (*Maranta arundinacea*)	Prayer plant
Bread tree (*Encephalartos altensteinii*)	Cycad
Cassava (*Manihot esculenta*)	Spurge
Cocoyam (*Xanthosoma atrovirens*)	Aroid
Corn (*Zea mays*)	Grass
Cush-cush (*Dioscorea trifida*)	Yam
Dasheen (*Colocasia esculenta*)	Aroid
East Indian arrowroot (*Curcuma angustifolia*)	Ginger
Fijian arrowroot (*Tacca leontopetaloides*)	Tacca
Giant swamp taro (*Cyrtosperma chamissonis*)	Aroid
Giant taro (*Alocasia macrorhiza*)	Aroid
Gomuti palm (*Arenga pinnata*)	Palm
Greater Asiatic yam (*Dioscorea alata*)	Yam
Japanese sago palm (*Cycas revoluta*)	Cycad
Kaffir bread (*Encephalartos caffer*)	Cycad
Maize (*Zea mays*)	Grass
Manioc (*Manihot esculenta*)	Spurge
Potato (*Solanum tuberosum*)	Nightshade
Queensland arrowroot (*Canna edulis*)	Canna
Rice (*Oryza sativa*)	Grass
Sago palm (*Arenga pinnata*)	Palm
Sago palm (*Caryota urens*)	Palm
Sago palm (*Cycas circinalis*)	Cycad
Sago palm (*Metroxylon sagu*)	Palm
Tanier (*Xanthosoma atrovirens*)	Aroid
Taro (*Colocasia esculenta*)	Aroid
Wheat (*Triticum* spp.)	Grass
White Guinea yam (*Dioscorea rotundata*)	Yam
Yam (*Dioscorea* spp.)	Yam
Yampee (*Dioscorea trifida*)	Yam
Yellow Guinea yam (*Dioscorea cayenensis*)	Yam

8.7 • ESSENTIAL OILS

In the section on spices and flavorings, I mentioned that spices usually owe their desirable qualities to the essential oils that they contain. They are characterized by their ability to evaporate readily, by their aromatic odors, and by their pleasing taste. These essential or volatile oils are different from the fatty or fixed oils. From a chemical standpoint, essential oils are complex. They are often benzene or terpene derivatives or hydrocarbons of intermediate molecular length. Some contain sulfur and nitrogen. Typically they are liquids. Their function in the plant is still uncertain. Essential oils are often found in flowers, but they may be found in other plant parts. They are typically produced in special glands.

Essential oils are widely used in perfumes, deodorants, and soaps. They also flavor many beverages and tobacco mixtures. Industrial uses include insecticides, solvents for paints, and as an ingredient in glue, paste, and polish. Some have antiseptic properties and are useful in medicine.

EXTRACTION METHODS

DISTILLATION. When an essential oil is not soluble in water (immiscible), steam distillation or boiling may be used. A layer of oil separates from a layer of water. Hot water or live steam is injected into a still filled with the aromatic plant part. Both vaporize and are then condensed into an adjacent receptacle. When the oil and water are miscible, it is necessary to use techniques that take into account the different boiling and volatilization temperatures. In this process, there is a gradual increase in temperature, with the more volatile essential oils distilling off first. Several distillations may be necessary.

ENFLEURAGE (COLD FAT EXTRACTION). Distillation can ruin certain oils by the chemical processes of hydrolysis, polymerization, or the loss of a delicate oil in relatively large quantities of water. Enfluerage is the process of applying fresh flowers or other aromatic plant parts to glass plates covered with pure tallow and lard. These absorb the essential oils from the plant. The saturated fat is then subjected to alcoholic extraction. This dissolves the trapped essential oil, but not the insoluble fat. The essential oil is then concentrated. Much of this process involves laborious hand labor in which women with tweezers remove wilted petals and replace them with fresh ones.

SOLVENT EXTRACTION. Fresh flowers and a solvent, often petroleum ether, are placed in an extractor. The ether dissolves out the essential oil, along with other impurities. The ether is then removed by a vacuum. All of this is done at room temperature. The principal drawbacks of this process are the expensive equipment required and the precise control needed.

EXPRESSION. This process involves the squeezing of plant material under great pressure, either in hand presses or in giant mechanical devices. Oils and other liquids that are expressed are separated from one another by centrifugation.

ESSENTIAL OILS

Essential Oil (Scientific Name of Source)	Family	Part Used
acacia *(Robinia pseudoacacia*)	Bean	Flowers
ambrette *(Hibiscus abelomoschus)*	Mallow	Flowers
angelica root *(Angelica archangelica)*	Carrot	Roots and seeds
anise *(Pimpinella anisum)*	Carrot	Seeds
balsam amyris *(Amyris balsamifera)*	Citrus	Leaves and twigs
balsam fir *(Abies balsamea)*	Pine	Leaves and twigs
basil *(Ocimum basilicum)*	Mint	Leaves
bay (bay-rum) *(Pimenta racemosa)*	Myrtle	Leaves
bergamot *(Citrus aurantium)*	Citrus	Fruit rind
bitter almond *(Prunus amygdalus)*	Rose	Fruits
bitter orange *(Citrus aurantium)*	Citrus	Leaves
bois de rose *(Aniba rosqedora)*	Laurel	Wood
broom *(Cytisus scoparius)*	Bean	Flowers
buchu (bacco) *(Barosma betulina)*	Citrus	Leaves
calamus *(Acorus calamus)*	Philodendron	Rhizome
camphor *(Cinnamomum camphora)*	Laurel	Leaves
carnation *(Dianthus* spp.*)*	Pink	Flowers
cassia *(Cinnamomum cassia)*	Laurel	Bark
cedar *(Thuja occidentalis)*	Cypress	Needles
cedarwood *(Juniperus virginiana)*	Cypress	Wood
champaca *(Michelia campaca)*	Magnolia	Flowers
chia (ghia) *(Salvia hispanica)*	Mint	Seeds
citronella *(Cymbopogon nardus)*	Grass	Leaves
clary *(Salvia sclarea)*	Mint	Leaves
cornmint *(Mentha arvensis)*	Mint	Leaves
eucalyptus *(Eucalyptus* spp.*)*	Myrtle	Leaves
French lavender *(Lavandula stoechas)*	Mint	Leaves and flowers

gardenia *(Gardenia* spp.*)*	Gardenia	Flowers
geranium *(Pelargonium* spp.*)*	Geranium	Leaves
ginger *(Zingiber officinalis)*	Ginger	Rhizome
horehound *(Marrubium vulgare)*	Mint	Leaves
huisache *(Acacia farnesiana)*	Bean	Flowers
hyacinth *(Hyacinthus orientalis)*	Lily	Flowers
hyssop *(Hyssopus officinalis)*	Mint	Leaves
jasmine *(Jasminum grandiflorum)*	Olive	Flowers
labdanum *(Cistus ladaniferus)*	Rockrose	Leaves and twigs
lavandin *(Lavandula hybrida)*	Mint	Flowers
lavender *(Lavandula officinalis)*	Mint	Flowers
lemon *(Citrus limon)*	Citrus	Fruit rind
lemon grass *(Cymbopogon nardus)*	Grass	Leaves
linaloe *(Bursera* spp.*)*	Bursera	Wood
marjoram *(Origanum majorana)*	Mint	Leaves
mignonette *(Reseda odorata)*	Mignonette	Flowers
narcissus *(Narcissus* spp.*)*	Lily	Flowers
neroli *(Citrus* spp.*)*	Citrus	Flowers
orange *(Citrus aurantium)*	Citrus	Leaves, fruit rind
orris root *(Iris florentina)*	Iris	Rhizome
otto of roses *(Rosa damascena)*	Rose	Flowers
palmarosa *(Cymbopogon martinii)*	Grass	Leaves
patchouli *(Pogostemon cablin)*	Mint	Leaves
pennyroyal *(Mentha pulegium)*	Mint	Leaves
peppermint *(Mentha x piperita)*	Mint	Leaves
petitgrain *(Citrus aurantium)*	Citrus	Leaves
pine *(Pinus palustris)*	Pine	Bark
Roman chamomile *(Anthemis nobilis)*	Sunflower	Flowers
rose *(Rosa centifolia)*	Rose	Flowers
rosemary *(Rosmarinus officinalis)*	Mint	Flowers
rosewood *(Aniba perutilus)*	Laurel	Wood
saffron *(Crocus sativus)*	Iris	Stigmas and styles
sandalwood *(Santalum album)*	Sandalwood	Wood and roots
spearmint *(Mentha spicata)*	Mint	Leaves
spikenard *(Nardostachys grandiflora)*	Valerian	Rhizomes
sweet balm *(Melissa officinalis)*	Mint	Leaves
thuja *(Thuja occidentalis)*	Cypress	Leaves and twigs
thyme *(Thymus* spp.*)*	Mint	Leaves
tuberose *(Polianthes tuberosa)*	Lily	Flowers
valerian *(Valeriana officinalis)*	Valerian	Rhizomes
vanilla *(Vanilla planifolia)*	Orchid	Fruits
verbena (vervain) *(Verbena triphylla)*	Vervain	Leaves
vetiver *(Vetiveria zizanioides)*	Grass	Roots
violet *(Viola odorata)*	Violet	Flowers
wintergreen *(Gaultheria procumbens)*	Heath	Leaves
witch hazel *(Hamamelis virginiana)*	Witch hazel	Stems
wormseed *(Chenopodium ambrosioides)*	Goosefoot	Fruits
wormwood *(Artemisia absinthium)*	Sunflower	Leaves
ylang-ylang *(Cananga odorata)*	Annona	Flowers

8.8 • FIXED OIL PLANTS

"The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which will use it."
(Rudolph Diesel, 1911)

☼ ☼ ☼ ☼ ☼

In the last section, we looked at volatile, aromatic oils. Clearly, there are other kinds of oils produced by plants; ones that are not volatile and that are more or less odorless. These are the **fixed oils**. They are also known as vegetable oils and fatty oils. Plants that have high fatty oil content often are rich in proteins as well. Chemically they are very closely related to fats and waxes. Waxes are esters of certain alcohols. Because they are impervious to water, they serve to protect the plant and we use them in the same way.

Fats and oils are glycerides of organic acids. They are typically a mixture of several of these fatty acids. The distinction between the two is rather simple and arbitrary: fats are more or less solid at room temperate, while oils are liquids. A fat on a summer day in Humboldt County may be an oil in Redding.

An important chemical consideration in vegetable oils is the degree of saturation of chemical bonds in the fatty acids. The more double bonds, the more likely it is that the oil will dry to a waterproof film. Less double bonding means that the oil will remain a liquid for a long period of time after exposure to air. The ability of a fixed oil to absorb iodine correlates directly with its drying properties. The higher the number of iodine ions incorporated into the positions of double bonds along the fatty acid chain, the more likely it is that the oil will oxidize to an elastic film. This index is known as the **iodine number**. It is the number of grams of iodine absorbed by 100 grams of fat. The range in iodine numbers is about 7 to 200+.

IODINE NUMBERS OF FIXED OILS

Fixed Oil	Iodine Number
Linseed oil	165-204
Tung oil	160-175
Soybean oil	137-143
Safflower oil	140-150
Sunflower oil	119-135
Corn oil	111-135
Cottonseed oil	108-110
Canola oil	94-105
Sesame oil	103-108
Rapeseed oil	94-102
Peanut oil	84-100
Caster oil	81-89
Olive oil	78-88
Palm oil	51-77
Cacao butter	32-41
Palm kernel oil	13-17
Coconut oil	7-10

Source: Schery (1972) and Simpson & Ogorzaly (1995)

DRYING CAPACITY OF FIXED OILS

Nondrying oils have little or no linoleic or linolenic acid and a low iodine number (less than 100). Examples include: palm oil, peanut oil, olive oil, castor oil, rapeseed oil, almond oil, avocado oil, cacao butter, cashew oil.

Semi-drying oils lack appreciable amounts of linolenic acid, often are rich in linoleic acid, and have intermediate iodine numbers (100-130). Examples include: cottonseed oil, sunflower oil, sesame oil, croton oil, corn oil.

Drying oils are high in both linoleic and linolenic acids and have high iodine numbers (over 130). Examples include: linseed oil, soybean oil, tung nut oil, hemp seed oil, poppy seed oil, safflower oil, perilla oil, Pará rubber oil.

Source: Schery (1972) and Simpson & Ogorzaly (1995)

SATURATION OF EDIBLE OILS

This feature of the degree to which vegetable oils are saturated carries over into dietary concerns. Saturated fats and oils have a hydrogen atom bonded to each carbon atom of its molecule. If there is one unbonded site, the fat or oil is mono-unsaturated; if there are several, it is poly-unsaturated. Saturated fats/oils come mostly from consuming animal products (meat, milk, butter, and cheese), but they also come from the "tropical oils," such as coconut, cocoa, and palm. Common examples of monounsaturated oils include olive, avocado, peanut, and canola. Polyunsaturated fats and oils may be further subdivided into omega-3's that come from flax, seafood, and lean meat; and omega-6's that come primarily from various fruits and seeds.

EXTRACTION AND PROCESSING

A variety of both tropical and temperate plants yield fixed oils. While vegetable oils are found present in various plant organs, most of the important ones are found in seeds. They are extracted in much the same way that we get essential oils out of a plant. The seed coat is removed and the interior reduced to a fine meal. The oil is removed by a solvent or by expressing it under pressure. It is then filtered and often purified further. Higher grades of fixed oils go into food products; the lower grades have a variety of industrial uses. The oils may also be bleached and deodorized.

SURVEY OF FIXED OIL PLANTS

Soybean oil (*Glycine max*). The soybean, native to eastern Asia, is one of our most ancient oil sources. It was one of the five "sacred grains" of China. The oil content is 13-25%. Soybean oil is used in margarine, shortening, salad oils, whipped toppings, and icings. Its industrial uses include paint, linoleum, printing ink, soap, candles, insecticides, disinfectants, cosmetics, and plastics.

Coconut oil (*Cocos nucifera*). The oil is expressed from **copra**, the dried coconut flesh. The oil content is high, 65-70%. The refined oil is used in foods, especially margarines. Lower grades are found in soaps, cosmetics, salves, shaving creams, shampoos, and as an illuminant.

Oil palms. Two other palms are also important sources of fixed oils. The African oil palm (*Elaeis guineensis*) bears fruit after about 4 or 5 years. They are cut from or knocked off the tree and then processed quickly to keep naturally occurring enzymes from destroying the oil. The fleshy meso-carp yields 45-55% oil used in margarine, cooking fats, soaps, and candles. Taxi cabs in some tropical cities run on palm oil. A different fixed oil is found in the endosperm of the seed (palm kernel oil). It is chemically similar to coconut oil and is used in ice creams, mayonnaise, toilet soaps, and detergents. The endosperm is about 50% oil. The cake that remains after expressing the palm oils is used in livestock food. This plant has the highest yield of oil of any crop (3475 kg per hectare per year).

The American oil palm (*Elaeis oleifera*) appears to be native to Central and South America. It is closely related to the African oil palm and the two hybridize freely. It is not as important a source of fixed oil.

Canola oil (*Brassica* spp.). There is no canola plant growing out there. The name derives from the Canadian Oil Low Acid research project that developed it in the 1960's from rapeseed oil. Some cultivars are high in toxic erucic acid. These oils are used in industry, often as lubricants. The strains that are low in erucic acid were approved by the United States Food and Drug Administration in 1985 as a food. Canola low has a long shelf life.

Meadowfoam oil (*Limnanthes* spp.). Various species of meadowfoam are native to valley grasslands and vernal pools in California and Oregon. It is a current subject of much research. It can be cultivated as an annual crop and perhaps grown in rice fields. The plan is to use the oil as a substitute for sperm whale oil. The U. S. once imported about 50 million pounds per year.

Castor oil (*Ricinus communis*). The ornamental castor bean plant is also the source of an important industrial oil. The United States is the largest importer. The oil content of the seed varies from 35-55%. Castor oil is found in soap, synthetic rubber, linoleum, inks, nylons, and as a lubricant in airplane and rocket engines. About 1% of the production goes into a more refined version that is used in medicine, where it is called "oleum ricini." It is a very effective purgative, an agent that causes evacuation of the bowels.

Olive oil (*Olea europea*). The olive tree, native to western Asia, is another of our most ancient plants. It is probably the most important of the non-drying oils. The oil is not extracted from the seed itself, but from the fruit pulp that surrounds it. Two to four pressings are often involved, the first of which yields the greenish-yellow "virgin" oil. If the fruits were from the highest quality trees, processed in a particular way (mechanical vs. chemical extraction), meet certain aesthetic standards, and have less than 1% free oleic acid, then the product can be called "extra virgin" olive oil. Use of the term is regulated by the International Olive Oil Council (IOOC). The U. S. is not a member, but California producers have formed the COOC. Olive oil has a prominent role as a salad and cooking oil. It has a long shelf life. Hippies and Yuppies have been known to get all misty-eyed when discussing the virtues of olive oil. Later pressings find their way into soap, lubricants, and medicines.

Linseed oil (*Linum usitatissimum*). We grow some cultivars of flax for their fibers and others for the oil content in their seeds (32-43%). Linseed oil is used in paint, oilcloth, soft soaps, varnish, ink, linoleum, and to seal various surfaces, including concrete highways.

Safflower oil (*Carthamus tinctorius*). This member of the sunflower family is known only in cultivation. The ancient Egyptians appear to be the first to have used it. The oil content of the seeds is about 40%. It has the highest percentage of linoleic acid. Safflower oil has become a very popular cooking oil because it is low in cholesterol. It is also used in shortening, margarine, salad oils, and mayonnaise.

Peanut oil (*Arachis hypogaea*). The peanut is native to South America, perhaps to Brazil. It has become a major crop in the United States, especially in the South. The seeds have oil content of 30-45%. The higher grades of peanut oil are used in margarine and shortening, and to pack sardines. The inferior grades end up in soap, lubricants, and illuminants.

Corn oil (*Zea mays*). The oil content is about 50%. Corn oil is used in cooking and salads (Mazola oil), and to make margarine. It smokes when heated to high temperatures. Industrial uses include soap, paints, and in rubber substitutes.

Cottonseed oil (*Gossypium* spp.). Cotton seeds contain about 35% oil. Refined oils are used in cooking and salad oils, margarine, and shortening. Processing inactivates **gossypol**, a toxin found in glands within the seed. Inferior grades end up in soaps. Cottonseed oil is the most important of the semi-drying oils.

FIXED (NON-AROMATIC) OIL PLANTS

Fixed Oil	Scientific Name	Family
MAJOR OIL CROPS:		
African palm oil	*Elaeis guineensis*	palm
American palm oil	*Elaeis oleifera*	palm
castor oil	*Ricinus communis*	spurge
coconut oil	*Cocos nucifera*	palm
corn oil	*Zea mays*	grass
cotton seed oil	*Gossypium* spp.	mallow
linseed oil	*Linum usitatissimum*	flax
olive oil	*Olea europaea*	olive
peanut oil	*Arachis hypogaea*	bean
rapeseed (rape) oil	*Brassica* spp.	mustard
sesame oil	*Sesamum indicum*	pedalium
soybean oil	*Glycine max*	bean
sunflower oil	*Helianthus annuus*	sunflower
MINOR OIL CROPS:		
babassu oil	*Orbignya phalerata*	palm
ben oil	*Moringa pterygosperma*	moringa
Brazil nut oil	*Bertholletia excelsa*	Brazil nut
buffalo gourd oil	*Cucurbita foetidissima*	squash
cajeput oil	*Melaleuca leucadendron*	myrtle
candlenut oil	*Aleurites moluccana*	spurge
canola oil	*Brassica napus*, *B. campestris*	mustard
carapa oil	*Carapa guianensis*	mahogany
cashew nut oil	*Anacardium occidentale*	cashew
chaulmoogra oil	*Hydnocarpus kurzii*	flacourtia

China wood oil	*Aleurites fordii*	spurge
cocoa butter oil	*Theobroma cacao*	sterculia
cohune oil	*Orbignya cohune*	palm
colza oil	*Brassica napus*	mustard
croton oil	*Croton tiglium*	spurge
eng oil	*Dipterocarpus tuberculatus*	dipterocarp
gorli oil	*Oncoba echinata*	flacourtia
gurgum (gurjun) oil	*Dipterocarpus* spp.	dipterocarp
hempseed oil	*Cannabis sativa*	hemp
illipe nut oil	*Shorea macrophylla*	dipterocarp
jojoba oil	*Simmondsia chinensis*	simmondsia
kapok seed oil	*Ceiba pentandra*	bombax
licuri oil	*Syagrus coronata*	palm
macassar oil	*Schleichera oleosa*	soapberry
meadowfoam	*Limnanthes* spp.	meadowfoam
murumuru oil	*Astrocaryum murumuru*	palm
mustard oil	*Sinapis* spp. and *Brassica* spp.	mustard
Niger seed oil	*Guizotia abyssinica*	sunflower
oiticica oil	*Licania rigida*	coco plum
peach oil	*Prunus persica*	rose
perilla oil	*Perilla frutescens*	mint
pistachio oil	*Pistacia vera*	cashew
poppy seed oil	*Papaver somniferum*	poppy
safflower oil	*Carthamus tinctorius*	sunflower
tung oil	*Aleurites fordii*	spurge
walnut oil	*Juglans regia*	walnut

8.9 • TANNINS AND DYES

Tannins and dyes are secretion products found almost universally in plants. They are usually not concentrated enough to make extractions worthwhile. Tannins and dyes are combinations of carbon, hydrogen, and oxygen. Nitrogen is present in some cases. Dyes, in particular, have been largely replaced by synthetic derivatives of coal tars. Only about 10% of our currently used dyes are of natural origins.

TANNINS

This term is applied to a wide variety of astringent substances. Generally speaking, they are metabolic breakdown products of sugars. Tannins are water soluble and are chemical reducing agents. The function of tannins within the plant body is obscure. Perhaps they play a protective role. They are usually found in out of the way places, such as heartwood or the cork, rather than sites of active growth or movement of materials.

The principal use of tannins is in the tanning industry. They combine with proteins in animal skin to yield leather, which is resistant to water, air, temperature changes, and bacterial attack. During the tanning process, the animal skin is soaked in a tannin extraction for a period of time ranging from just a few hours to several months. The leather can then be further treated with oils to restore some pliability and dyed.

Tannins also combine with iron salts to form the basis of several inks. Tannins have some medical uses, such as antidotes to alkaloid and heavy metal poisoning, and in reducing gastric bleeding and diarrhea.

SURVEY OF TANNIN PLANTS

Chestnut (*Castanea dentata*). Tannins are extracted from the wood. This source has practically disappeared in the U.S. because of excessive logging and the chestnut blight.

Tanner's dock or **canaigre** (*Rumex hymeno-sepalus*). An annual species of the south-western U.S. The roots contain 25-35% tannins.

Sumac (*Rhus coriaria*). The species is native to Sicily. The leaves contain about 35% tannins. Our native species of *Rhus* also have tannins in them, but they are inferior in their tanning ability.

Hemlock (*Tsuga canadensis*). This coniferous tree largely replaced the chestnut, but now it is also disappearing. The bark contains 8-14% tannins. *T. heterophylla* of the western U.S. has become more important as a tannin source since the decline of the eastern hemlock.

Quebracho (*Schinopsis lorentzii*). This plant is the foremost source of natural tannins. The tree is native to Argentina and Paraguay. The wood contains about 22% tannins. The U.S. imports great quantities of quebracho tannins each year.

Mangrove (*Rhizophora mangle*). The bark contains 55-58% tannins after concentration. This is one of the cheapest tannin sources. The U.S. is the chief importer.

Wattle (*Acacia* spp.). These trees are usually native to Australia. They are now widely planted. The bark contains about 50% tannins.

Gambier (*Uncaria gambir*). This species is native to the East Indies. A resin in the leaves contains 35-40% tannins.

DYES

Whether natural or synthetic, dyes are chemically relatively straightforward. Fustic, for example, has the empirical formula $C_{13}H_{10}O_6$. As with tannins, the function that the dye performs in plants is not well understood.

Dyes have been in use for thousands of years. No one knows how many different dyes there are, but a conservative estimate is at least 2000.

When dyes were first used to color and decorate cloth, they were impermanent and faded rather quickly. The colors would also change with time. It was necessary to fix and bind the dye with the fibers of the cloth. This was done by using a **mordant**. Most of the mordants are salts of metals. By using a different mordant with a specific dye, the color value of the dye may be changed.

SURVEY OF DYE PLANTS

Woad (*Isatis tinctoria*). This plant is perhaps native to southern Russia. Its use spread rapidly, however. The leaves contain a glucoside, indican. The leaves are crushed by rollers to extract a pulpy material. This is rolled into a ball and dried. The balls are later pulverized, wetted, and fermented. The woad is then dried once more and may be stored in this form. When it is to be used, fermentation is once more required. Two uses of woad are of some historical interest. When the Romans invaded Briton, they found the inhabitants using woad to decorate their bodies. Later in English history, woad and a yellow dye were mixed to yield the "Saxon Green" dye worn by Robin Hood and his Merry Men.

Indigo (*Indigofera tinctoria*). This is one of the best known dyes. It is a brilliant blue. Oxidation is required before the color develops. Fresh cut leaves are soaked for about half a day and aerated. The blue precipitate that develops settles out. This is dried and becomes the "indigo cake." When indigo became popular, it met stiff resistance from the woad dyers (the "Woadites"). In 1577, England *"...prohibited under the severest penalties... the newly invented, harmful, balefully devouring, pernicious, deceitful, eating and corrosive dye known as 'the devil's dye'...."*

Madder (*Rubia tinctorum*). The brilliant red dye is extracted from the roots. The roots are washed, dried, and then pulverized. The color of madder will vary with the mordant.

Logwood (*Haematoxylon campechianum*). This tree is native to Mexico and Central America. The dye is extracted from the heartwood. The dark purple dye is used on cotton, leather, furs and silk. Logwood is also the basis of a black ink and the histological stain widely used in biology.

Annatto (*Bixa orellana*). The annatto plant is native to Brazil, but it is now very widely planted. The dye comes from the pulp around the seeds. It may be extracted with water or some solvent, such as chloroform. Annatto is an orange dye that is widely used as a food coloring in cheese, butter, and margarine; as a condiment on rice; as a dye; as a skin paint; and as an ingredient in lipstick.

Saffron (*Crocus sativus*). This was the principal yellow dye of ancient times. It is extracted from the stigmas of the flowers.

Safflower (*Carthamus tinctorius*). This thistle-like plant is native to Asia. The dye is obtained from the flowering heads. This dye has been used as a saffron substitute. Safflower is also the source of an important oil.

DYE PLANTS OF THE U. S.

Common (Scientific) Name	Part Used
BLACK DYES	
alder (*Alnus* spp.)	leaves, bark
black walnut (*Juglans nigra*)	bark, hulls, leaves
bramble (*Rubus* spp.)	ripe fruits
Indian hemp (*Apocynum cannabinum*)	plant
sumac (*Rhus* spp.)	plant
BLUE DYES	
blueberry (*Vaccinium* spp.)	ripe fruits
elderberry (*Sambucus canadensis*)	fruits, leaves
indigo (*Indigofera tinctoria*)	extract
larkspur (*Delphinium* spp.)	flowers
sorrel (*Rumex* spp.)	plant
BROWN DYES	
alder (*Alnus* spp.)	bark, roots
apple (*Malus* spp.)	bark
barberry, common (*Berberis vulgaris*)	roots
bayberry (*Myrica cerifera*)	leaves
beets (*Beta vulgaris*)	"roots"
birch (*Betula* spp.)	bark, leaves
black cherry (*Prunus serotina*)	bark
black walnut (*Juglans nigra*)	leaves
camomile (*Anthemis* spp.)	flowers
cascara, chittim (*Rhamnus* spp.)	bark
cocklebur (*Xanthium pensylvanicum*)	plant
coffee (*Coffea arabica*)	roasted beans
cutch (*Acacia* spp.)	dried leaves
dahlia (*Dahlia* spp.)	flowers, roots
hemlock (*Tsuga canadensis*)	bark
hickory (*Carya* spp.)	bark, hulls
Indian hemp (*Apocynum cannbinum*)	plant
madrone (*Arbutus menziesii*)	bark
maple (*Acer* spp.)	bark
marigold (*Tagetes* spp.)	leaves
oak (*Quercus* spp.)	bark
pear (*Pyrus communis*)	leaves
plum, wild (*Prunus americana*)	bark
privet (*Ligustrum vulgare*)	leaves, twigs
sumac (*Rhus* spp.)	fruits
sunflower (*Helianthus* spp.)	flowers
willow (*Salix* spp.)	bark
GRAY DYES	
bearberry (*Arctostaphylos uva-ursi*)	leaves
blueberry (*Vaccinium* spp.)	fruits
bramble (*Rubus* spp.)	ripe fruits
cascara (*Rhamnus purshiana*)	fruit extract
couch grass (*Elymus repens*)	roots
horsetail (*Equisetum* spp.)	stems
maple (*Acer* spp.)	bark
rhododendron (*Rhododendron* spp.)	leaves
sumac (*Rhus* spp.)	ripe fruits
yarrow (*Achillea millefolium*)	flowers, leaves
GREEN DYES	
alder (*Alnus* spp.)	leaves
black walnut (*Juglans nigra*)	bark
brome, chess (*Bromus* spp.)	spikelets
camomile (*Anthemis* spp.)	flowers
hollyhock (*Althaea* spp.)	leaves
iris (*Iris* spp.)	fresh flowers
mistletoe (*Phoradendron serotinum*)	stems/leaves
morning glory (*Ipomoea* spp.)	fresh flowers
oak (*Quercus* spp.)	bark
parsley (*Petroselinum crispum*)	fresh leaves
plantain (*Plantago* spp.)	leaves, roots
ragweed (*Ambrosia* spp.)	plant
red cedar (*Juniperus virginiana*)	fruits
spinach (*Spinacia oleracea*)	plant
stinging nettle (*Urtica dioica*)	roots, stems, leaves
yarrow (*Achillea millefolium*)	leaves
zinnia (*Zinnia* spp.)	flowers
PURPLE DYES	
black cherry (*Prunus serotina*)	bark, roots
cocklebur (*Xanthium pensylvanicum*)	aerial parts
dandelion (*Taraxacum offincinale*)	roots
elderberry (*Sambucus canadensis*)	fruits
gooseberry (*Ribes* spp.)	fruits
grape, wild (*Vitis* spp.)	fruits, ripe
oak (*Quercus* spp.)	bark, acorns
red cedar (*Juniperus virginiana*)	ripe fruits
RED DYES	
bedstraw (*Galium aparine*)	roots, stems
beet (*Beta vulgaris*)	"roots"
dogwood (*Cornus* spp.)	roots
hollyhock (*Althaea rosea*)	leaves, flowers
madder (*Rubia tinctorum*)	roots
pokeberry (*Phytolacca americana*)	fruits
poppy (*Papaver* spp.)	red flowers
sorrel (*Rumex* spp.)	stems, roots
St. John's wort (*Hypericum* spp.)	flowers, leaves
YELLOW DYES	
alder (*Alnus* spp.)	leaves
aster (*Aster* spp.)	flowers
bayberry (*Myrica cerifera*)	leaves
bedstraw (*Galium* spp.)	roots
beet (*Beta vulgaris*)	"roots"
birch (*Betula* spp.)	leaves
black cherry (*Prunus serotina*)	bark
bloodroot (*Sanguinaria canadensis*)	roots
bread wheat (*Triticum aestivum*)	straw
broom (*Cytisus scoparius*)	plant
broom sedge (*Andropogon virginicus*)	plant
camomile (*Anthemis* spp.)	flowers
carrot, wild (*Daucus carota*)	plant
cascara, chittim (*Rhamnus* spp.)	fruits, twigs
catnip (*Nepeta cataria*)	plant

chrysanthemum (*Chrysanthemum* spp.)	flowers
cocklebur (*Xanthium pensylvanicum*)	st./leaves
dahlia (*Dahlia* spp.)	flowers
dandelion (*Taraxacum officinale*)	roots
dodder (*Cuscuta* spp.)	entire plant
elderberry (*Sambucus canadensis*)	leaves
goldenrod (*Solidago* spp.)	flowers
hickory (*Carya* spp.)	inner bark
horse chestnut (*Aesculus* spp.)	husks, leaves
lily-of-the-valley (*Convallaria majalis*)	leaves
madder (*Rubia tinctorum*)	roots
marigold (*Tagetes* spp.)	flowers
mullein, common (*Verbascum thapsus*)	leaves
oak (*Quercus* spp.)	powdered bark
onion (*Allium cepa*)	onion skins
Osage orange (*Maclura pomifera*)	wood extract
peach (*Prunus persica*)	bark
pearly everlasting (*Gnaphalium* spp.)	plant
privet (*Ligustrum vulgare*)	leaves, twigs
spruce (*Picea* spp.)	cones
St. John's wort (*Hypericum* spp.)	flowers
sumac (*Rhus* spp.)	fruits
sunflower (*Helianthus* spp.)	flowers
tomato (*Lycopersicon* spp.)	vines
tulip tree (*Liriodendron tulipifera*)	fresh leaves
willow (*Salix* spp.)	fresh leaves
zinnia (*Zinnia* spp.)	flowers

Based primarily on Krochmal & Krochmal (1974).

8.10 • BAMBOOS & GOURDS

Plants of industry and technology suggest those that are the basis of large and sophisticated corporate entities, such as rubber, cotton, and timber. There are many other plants that are used locally and individually by peoples around the world. In the realms of economic botany and anthropology, these constitute examples of the material culture or technology of a culture.

To my way of thinking, the bamboos and the cucurbits or squashes, offer us many excellent examples of these "non-corporate" plants of industry.

BAMBOOS

"It is quite possible not to eat meat, but not to be without bamboo." (Su Dongpo, Song Dynasty poet)

"Bamboo is my brother." (Vietnamese proverb)

☼ ☼ ☼ ☼ ☼

Bamboos, or tree grasses as they are sometimes called, constitute one subfamily of the grasses. There are about 1200-1500 species, native to every continent but Antarctica and Europe. They range from modest shrubs to large tropical bamboos over 120 ft. tall and about one foot in diameter. Some of them bloom every year, others on an irregular basis, and still others only after several decades. Bamboos grow more rapidly than any other plant. The record appears to be 47.6 inches in a 24 hour period!

Several authors have stated with some certainty that no other single group of plants has so many different uses – Hans Sporry in 1903 compiled a list of 1048 them. Here are a few, in no particular order of importance:

☼ food (shoots, grains, and animal fodder)
☼ bowls
☼ scoops and ladles
☼ feeding troughs
☼ toothpicks
☼ housing
☼ flag poles
☼ furniture
☼ flooring
☼ brooms and brushes
☼ rakes
☼ fences and walls
☼ fibers
☼ weaving shuttles
☼ paper
☼ writing instruments
☼ cordage
☼ shavings for stuffing
☼ caulking for ships and boats
☼ mats
☼ baskets
☼ sandals & shoe soles
☼ flails
☼ whisks
☼ boats
☼ oars
☼ masts
☼ spear shafts
☼ bows and arrows
☼ ladders
☼ scaffolding
☼ rafts
☼ pails
☼ churns
☼ roofing tiles
☼ carts springs
☼ aqueducts
☼ rain spouts and guttering
☼ beehives
☼ fans
☼ umbrella frames
☼ bird and fish cages
☼ chop sticks
☼ musical instruments
☼ acupuncture needles
☼ medicines
☼ tongue depressors
☼ walking sticks
☼ phongraphic needles
☼ splints (injuries, torture, etc.)
☼ waxes
☼ light bulb filaments (Edison's first bulb)
☼ musical instruments (xylophones, zithers)
☼ ornamentals

Several genera of bamboos are important sources, including:

Arundinaria. Switch cane, Tongking bamboo. Edible shoots, split-cane fishing poles.

Bambusa. Common bamboo, spiny bamboo. Edible shoots, construction, hedging.

Dendrocalamus. Giant bamboos, including the largest of the clump-forming species. Construction, paper pulp, charcoal, edible shoots.

Phyllostachys. Black bamboo, fish-pole bamboo, madake. A major source of edible shoots. Fishing poles, timber, paper pulp, walking sticks, umbrella handles, musical instruments, and furniture.

GOURDS

A gourd is generally defined as the hard-shelled, durable fruit of the squash family (Cucurbitaceae) that is grown for making various utensils, for orna-ment, and for a wide variety of minor uses. Here is a far from complete list of how we have used gourds:

- bottles
- storage containers
- eating utensils
- drinking cups
- snuff boxes
- bird houses
- cricket containers
- pipes
- masks
- hats
- penis sheaths (yes, really)
- decoration
- floats
- artistry (carving, painting)
- musical instruments (rattles, scrapers, etc.)
- grown as curiosities because of size/shape

A KEY TO GOURDS*

1. Trees ➝ **Tree gourd**
1. Vines ➝ **2**

   2. Petals white ➝ **3**
   2. Petals lemon-yellow to orange ➝ **5**

3. Petals fringed ➝ **Snake gourd**
3. Petals not fringed ➝ **4**

   4. Fruit green to white and hard at maturity ➝ **Bottle gourd**
   4. Fruit usually orange and splits open at maturity ➝ **Bitter gourd (balsam pear)**

5. Fruits bristly or spiny at maturity ➝ **6**
5. Fruits smooth, ridged, warty or hairy at maturity ➝ **8**

   6. Fruits bristly or bur-like ➝ **Teasel gourd**
   6. Fruits spiny or warty ➝ **7**

7. Fruit hollow ➝ **Bitter gourd (balsam pear)**
7. Fruit solid ➝ **Hedge-hog gourd**

   8. Male flowers several per stalk; fruit with dry, papery rind and fibrous interior ➝ **Loofah gourd**
   8. Male flowers one per stalk; fruit without papery rind and fibrous interior ➝ **9**

9. Petals separate to their bases; fruit hairy when young, but waxy-coated at maturity ➝ **Wax gourd**
9. Petals united for at least half their length; fruit not especially hairy nor waxy-coated at maturity ➝ **Cucurbita gourds** (Buffalo, fig-leaf, turban, etc.)

*[After Heiser, 1979]

SURVEY OF GOURDS

The **bottle gourd** (*Lagenaria siceraria)* is probably native to Africa. We have good fossil remains from Egypt (3500 BCE), from Peru (12,000 BP), and from Mexico and Thailand (7000 BCE). Was it distributed in Pre-Columbian times by us or by ocean currents? Both views have their advocates. The exterior of this gourd is tough, almost woody, and more or less impervious to water. That explains its ability to float long distances and its use as a container. The bottle gourd is also a favorite of artists who paint on or carve intricate designs in its woody surface.

The **loofa (loofah, luffa) or vegetable sponge** (*Luffa aegyptiaca*) is native to the Old World. Mature fruits the softer outer skin and inner flesh have rotted away. Once the seeds have been removed, the remaining vascular system (the plumbing system of the fruit) is bleached to yield the familiar luffa sponge. You may have one hanging in your bathroom or you know someone who does. The next time that you have the opportunity, turn the luffa on end and notice the three chambers that run the length of the fruit. This is a standard feature of the squash family. They were once filled with seeds.

Recent magazine advertisements taut the virtues of the vegetable sponge as the *"Amazing oriental plant that helps to wipe away ugly cellulite in just minutes a day!"* Oh, really?

Tree-gourd. If you see a gourd growing on a tree, it is not a true gourd. It is probably the fruit of the calabash tree (*Crescentia cejute*) a member of the family Bignoniaceae. Its gourd-like berries are used to make bowls, scoops, etc. Larger fruits have had eye holes cut in them to camouflage fishermen who swim into flocks of birds and pull them underwater without alarming the others.

THE GOURDS

Ash gourd	*Benincasa hispida*
Balsam pear	*Momordica charantia*
Bitter gourd	*Momordica charantia*
Bottle gourd	*Lagenaria siceraria*
Buffalo gourd	*Cucurbita foetidissima*
Calabash gourd	*Lagenaria siceraria*
Chinese snake gourd	*Trichosanthes kirilowii*
Club gourd	*Trichosanthes cucumerina*
Dipper gourd	*Lagenaria siceraria*
Fig-leaf gourd	*Cucurbita ficifolia*
Goar berry gourd	*Cucumis anguria*
Gooseberry gourd	*Cucumis anguria*
Hedge-hog gourd	*Cucumis metuliferus*
Ivy gourd	*Coccinia grandis*
Malabar gourd	*Cucurbita ficifolia*
Ornamental gourd	*Cucurbita pepo*
Pointed gourd	*Trichosanthes dioica*
Prairie gourd	*Cucurbita foetidissima*
Scallop gourd	*Cucurbita pepo*
Serpent gourd	*Trichosanthes cucumerina*
Siamese gourd	*Cucurbita ficifolia*
Silver-seed gourd	*Cucurbita mixta*
Snake gourd	*Trichosanthes cucumerina*
Spine gourd	*Momordica dioica*
Sweet gourd	*Momordica cochinchinensis*
Teasel gourd	*Cucumis dipsaceus*
Texas gourd	*Cucurbita pepo*

Tree gourd*	*Crescentia cejute*
Trumpet gourd	*Lagenaria siceraria*
Turban gourd	*Cucurbita maxima*
Viper's gourd	*Trichosanthes cucumerina*
Wax gourd	*Benincasa hispida*
White-flowered gourd	*Lagenaria siceraria*
Yellow-flowered gourd	*Cucurbita pepo*

* This is the only plant on this list that is not a member of the squash family (Cucurbitaceae).

SECTION 9.0 • POISONOUS PLANTS

9.1 - AN OVERVIEW

☼ The toxic compounds that plants make are probably, in many cases, a defense mechanism against being eaten. In other instances, we are not quite certain.

☼ Curiously enough, we knowingly or unknowingly experience the symptoms of toxicity from plant poisons when we use plant-derived medicines and psychoactive materials.

☼ Many of our most valuable food plants come from plant families that are notorious for their toxicity, such as the carrot family, mustard family, and nightshade family.

☼ A *poisonous* plant is not necessarily a *lethal* one.

☼ There are many factors that influence the toxic effects that a plant will have on its victim.

☼ Many cases of plant poisonings are accidents, often involving misidentification.

☼ Not all cases of poisoning are accidental. We also employ toxic plants in purposeful ways, in the form of arrow, fish, insect, rat, and ordeal poisons. This will be the focus of our look at toxic plants.

☼ The abuse of two toxic plant products, alcohol and tobacco, are leading causes of death in the United States.

9.2 • INTRODUCTION

"What is food to one, is to others bitter poison."
[Lucretius, 99-55 BCE]

"Unfortunately, the illustrations of edible and poisonous mushrooms were reversed on page 14 of the Sunday edition." [Chicago Tribune]

"... there are few more excruciating ways of expiring than to eat a misidentification."
[R. S. Cowan, an American botanist]

☼ ☼ ☼ ☼ ☼

A DEFINITION

A poisonous plant is one capable of disrupting the normal functioning or state of health of its victim -- a person, a wild or domesticated animal, or even another plant. Some toxic plants are lethal. Most of the several hundred that occur in North America are not. What makes a plant poisonous? The majority of them are toxic because they manufacture one or more poisonous substances. They are called **toxic principles** or **poisonous principles**. Some plants do not make a poison, but instead they absorb or accumulate a toxic principle from the environment. The locoweed weeds, for instance, do not manufacture the selenium found in their tissues. They absorb it from the soil in which they grow.

RELATIVE TOXICITY

The amount of toxin required to kill a test animal may be amazingly small. It is typically expressed in terms of an amount of toxin per weight of the victim. The figures below show the MLD (minimum lethal dose) in micrograms (1 million micrograms = 1 gram) of toxin per kilogram of subject. The poison is administered by injection. Notice that such well known poisons as sodium cyanide and strychnine are relatively crude.

TOXICITY OF SELECTED POISONS

Toxin (source)	MLD in micrograms/kilogram
Nicotine (tobacco)	50,000
Ouabain (arrow poison)	14,000
Sodium cyanide	10,000
Amanitin (mushroom toxin)	1,100
Strychnine	500
Curare (arrow poison)	500
BWSP-toxin (black widow spider)	100
Tetradotoxin (puffer fish)	8-20
Rattlesnake toxin	0.2
Ricin (castor bean toxin)	0.02
Tetanus toxin	0.0001
Botulinus toxin A	0.00003

FACTORS INFLUENCING TOXICITY

A number of factors influence the severity of plant poisonings. They include:

☼ the kind of toxin produced;
☼ the quantity of material ingested or contacted;
☼ the part of the plant eaten and its condition;
☼ the time of year;
☼ environmental conditions, such as drought or frost;
☼ the kind of animal, its age, sex, and general health;
☼ personal sensitivities, allergic systems, and
☼ even the genetic background of the victim.

HOW DOES POISONING OCCUR?

People fall prey to poisonous plants in a variety of ways:

☼ curiosity, especially in children;
☼ mistaking a toxic plant for an edible one;
☼ using toxic plant parts in jewelry or as toys;
☼ sucking nectar from flowers;
☼ using leaves for teas;

- misuse of herbal or medicinal preparations;
- abuse of recreational drug plants, such as the jimson weed; and
- direct or indirect contact with toxic plants when camping, weeding the garden, backpacking, or playing.

A few simple precautions will help lessen the chances of poisoning. Know the common toxic plants of your area, including the ornamentals. Keep pets, infants, and small children away from attractive (especially brightly-colored) ornamentals and seeds. Store bulbs, seeds, and rootstocks away from children.

SOME COMMON MISCONCEPTIONS

On the other hand, you can get yourself into a passel of trouble by accepting some widely held beliefs that are without any foundation.

- Discoloration of a silver spoon or coin is not a reliable way of telling a mushroom from a toadstool.
- Poisonous plants do not come color-coded. Not all red fruits are poisonous; not all blue ones are safe.
- Toxic plants do not always have bitter, disagreeable tastes; some are quite pleasant.
- You cannot use the eating habits of birds or wild animals as a reliable guide; birds are quite fond of brightly-colored "fruits" of the yew trees, which will kill us within minutes.
- While cooking will destroy some toxic principles, others are not heat sensitive.

SYMPTOMS OF PLANT POISONING

Symptoms of plant poisoning in humans are manifold and may present themselves in a variety of areas on and in our bodies. They include:

- itching, redness, stinging, burning, blistering of the skin;
- tingling, numbness, burning, swelling of the lips, mouth, tongue, or throat;
- sweating, salivation, and tears;
- nausea, retching, and vomiting;
- stomach/abdominal pains, diarrhea, or constipation;
- changes in pulse rate and blood pressure;
- headache, dizziness, faintness, and weakness;
- difficulty in breathing, speaking, or seeing;
- change in pupil size;
- lack of muscular coordination, trembling, or paralysis;
- convulsions or epileptic-like seizures;
- changes in mental state (nervousness, giddiness, depressions, or signs of hallucinations;
- sleepiness, coma, and
- death.

TREATMENT

It may come as a surprise to learn that there are no effective antidotes for most of the poisons found in plants. Treatment usually consists of providing symptomatic relief -- treating the effects of the poisons, as opposed to neutralizing or destroying the toxin. What can be done in cases of plant poisoning?

- Make the victim vomit, if he or she is conscious.
- Keep the victim warm and quiet, while observing closely.
- Call a physician or take the victim to a hospital.
- Be ready to identify the plant or bring some of it with you. Plant material in vomitus or stools may also be useful in identification.

A word of caution. You and I are not medical doctors. We cannot legally tell a victim that he or she should follow a particular "cure."

9.3 • SURVEY OF PLANTS

There are roughly 30,000 native, naturalized, and ornamental higher plants in North America; but only a few hundred of them are toxic. Perhaps thirty or forty species are known to cause serious instances of poisoning or fatalities. One of them, tobacco [*Nicotiana tabacum*] is far and away the most dangerous toxic plant encountered by most of us in modern society. Its use leads to the death of several hundred thousand people each year in this country and to billions of dollars in health care expenses and lost productivity. It seldom receives the attention that it should in discussions of toxic plants, probably because it is a legal drug plant whose use has been widely accepted and it is the source of tax revenue.

EXPOSURES IN U. S. (1985-1994)

Unidentified plants	84,593
Unidentified berries	11,384
Philodendron spp. (philodendron)	61,200
Dieffenbachia spp. (dumbcane)	35,645
Euphorbia spp. (spurges)	31,414
Capsicum spp. (peppers)	29,461
Ilex spp. (hollies)	23,904
Crassula spp.	22,295
Ficus spp. (figs)	20,450
Toxicodendron spp. (poison-ivy, etc.)	19,395
Phytolacca spp. (pokeweed)	18,552
Schefflera (Brassaia spp.)	17,708
Solanum spp. (nightshades)	17,177
Spathiphyllum spp.	14,380
Epipremum spp.	13,471
Saintpaulia spp. (saintpaulia)	12,238
Pyracantha spp. (firethorns)	11,227

Taxus spp. (yews)	11,217
Rhododendron spp. (rhodondendrons)	9590
Schlumbergia spp.	9423
Chrysanthemum spp. (chrysanthemum)	8058
Quercus spp. (oaks)	7871
Chlorophytum spp. (spider plant)	7790
Begonia spp. (begonias)	7536
Aloe spp. (aloes)	7505
Pelargonium spp. (geraniums)	7021
Eucalyptus spp. (eucalyptus)	7020
Hedera spp. (English ivy)	6982
Taraxacum spp. (dandelions)	6618
Nerium spp. (oleanders)	6581
Aglaonema spp.	6196
Narcissus spp. (narcissus)	6064
Caladium spp.	6053
Lonicera spp. (honeysuckles)	6007
Syngonium spp.	5541
Prunus spp. (chokecherries)	5359
Dracaena spp.	5110
Cornus spp. (dogwoods)	4960
Sorbus spp. (mountain-ashes)	4945
Impatiens spp. (forget-me-nots)	4653
Tulipa spp. (tulips)	4647
Asparagus spp.	4597
Rosa spp. (roses)	4422
Nandina spp. (heavenly-bamboo)	4337
Cactus (unidentified)	4259
Nephrolepis spp. (Boston ferns)	3872
Pinus spp. (pines)	3776
Liriope spp.	3768
Iris spp. (irises)	3699
Juniperus spp. (junipers)	3670

Modified after Krenzelok, E. P. & T. D. Jacobsen. 1997. Plant exposures... A national profile of the most common plant genera. Vet. Human Toxicol. 39(4): 248, 249.

In the descriptions that follow, I have selected plants that are poisonous to humans or animals. Most of them are well known to the general public; one or two were included to demonstrate particular aspects of toxicity.

POISON-OAK AND POISON-IVY

In many ways, it is convenient to treat poison-oak and poison-ivy as though they were one plant. They are very closely related structurally, chemically, and genetically. Western poison-oak (*Toxicodendron diversilobum*) and eastern poison-ivy (*T. radicans*) account for most of the million or so cases of dermatitis reported in the United States each year because most of us do not recognize these plants in the field and unknowingly come into direct or indirect contact with them. The plants may grow as low, much-branched shrubs or they may be robust and erect. They may climb trees by means of aerial rootlets that fasten them to the trunk. The shape of the three leaflets is variable.

All parts of the plant, with the possible exception of pollen grains, are potentially dangerous at any time of the year. Plants do not have to be in flower or in fruit before they can produce symptoms. The main constituent of the irritating oil in poison-oak and poison-ivy is **urushiol**, a pale-yellow liquid. It is a mixture of catechol derivatives. The vast majority of us appear to be initially immune to urushiol, so that our first encounter with these plants will not produce dermatitis. However, this event does initiate a series of immunological changes that will render the individual much more likely to present symptoms when plants are touched on future occasions. That may be as early as the second encounter. Some of us appear to have much higher threshold levels that must be reached before symptoms appear.

Contrary to popular belief, poison-oak and poison-ivy do not give off mysterious vapors or rays that cause rashes. Direct or indirect contact with plants is required. It is the indirect means that most of us tend to overlook. We gleefully chop down poison-oak or poison-ivy and then carelessly put away the hoe, shovel, and rake. We handle the family pet that has just run through a patch of these plants. We stand in the smoke of burning leaves and stems, not realizing that the toxin may be carried in droplets in the smoke.

The characteristic streaks of red and vesicles are indicative of points of contact with the plant. The signs of itching, burning, and redness are usually seen within a few hours to about five days after exposure, depending upon the sensitivity of the victim. In more severe cases, open running sores may develop. The fluid from these sores is lymph, not the toxin itself. Urushiol binds with the protein of the skin within about ten minutes, so that reinfection from the spread of this lymph is most unlikely. What often passes for the spreading of poison-oak or poison-ivy from running sores is actually caused by reinfection from plant material beneath the fingernails or contaminated clothing. Reactions to urushiol in some individuals may be so severe that hospitalization is required.

There are many time-honored cures for poison-oak and poison-ivy. Most of them cannot withstand close scrutiny. One of the more popular is taking a hot shower with yellow soap immediately after exposure. This does little more than wash off excess toxin. An ancient preventative, supposedly practiced by Native Americans, calls for eating a small piece of poison-oak to bring about a natural immunity. One person who attempted this procedure came down with a serious inflammation of the mouth and of the anus. Most of the creams, lotions, and pills that are available over-the-counter provide only symptomatic relief; they do not cure. Those treatments requiring a physician's prescription have had mixed results.

What follows is taken from a handout for a class on poisonous plants that I once taught. You might also find it helpful.

☼ Poison-oak is not a type of oak, nor is poison-ivy a type of ivy. Both are members of the genus *Toxicodendron* of the cashew family (Anacardiaceae), which includes the pistachio, cashew, pepper tree, and the mango.

☼ There is no poison-ivy in California, only the western poison-oak.

☼ The toxic substance in poison-oak and poison-ivy is called **urushiol**, a complex of four catechols.

☼ The toxin is present in all parts of the plant that contain resin canals.

☼ The toxins are not contracted via mysterious vapors or rays; direct or indirect contact is required.

☼ Urushiol may be present in the smoke of burning plants, because it is trapped in dust or ash.

- ☼ The toxins may be spread by animals. Petting a dog that has run through a patch of poison-oak or poison ivy is a way of contracting it.
- ☼ Toxins may be spread by articles of clothing. It is possible to reinfect yourself by handling the same items you were wearing in the field.
- ☼ The liquid that oozes from broken blisters is lymph and does not contain the toxins.
- ☼ Sensitivity is based upon reactions at the cellular level between the toxins and specialized white blood cells called T-lymphocytes.
- ☼ Sensitivity gradually declines with time, regardless of continued exposure. A minority of persons over 60 are sensitive.
- ☼ Usually one must be sensitized by an initial contact before you will react by producing dermatitis from subsequent exposures.
- ☼ The level of sensitivity to urushiol and related toxins differs from person to person. Once you have surpassed a threshold of sensitivity, you will most likely alter that threshold. In some instances, it appear that a severe case will herald even more serious ones; in others it appears that it precludes future episodes.
- ☼ Strong soap merely removes excess poison from the skin, but it will not remove any that has already reacted, because the toxins have become chemically bound to the skin within minutes after exposure.
- ☼ Eating a leaf as a means of building a natural immunity to poison-oak or poison-ivy can be most dangerous. The internal poisoning likely to occur can be serious, even fatal.
- ☼ There is no evidence to support the widespread belief that the American Indian (or any other racial or ethnic group) is naturally immune to these plants.
- ☼ Medicines used on the skin do not cure the inflammation. They serve only to dry the blisters, to treat secondary infections, and to relieve itching.
- ☼ Injections and over-the-counter remedies are uneven in their effectiveness. They can make matters worse. Their use during an acute attack is hazardous.
- ☼ Corticosteroids are the only agents with a demonstrated ability to benefit dermatitis from poison-oak and poison-ivy.
- ☼ There is some evidence to suggest that in some instances dermatitis from poison-oak and poison-ivy may be psychosomatic in its origin.

HORSE CHESTNUT OR BUCKEYE

Aesculus is a genus of shrubs and trees represented in North America by both native species and those introduced as ornamentals because of their attractive foliage and spikes of flowers. All parts of these plants are potentially dangerous. Children are often the victims of buckeye poisoning, perhaps because of the large, interesting seeds that must be sampled, or because children like to make teas. Cattle have also been poisoned. The toxic principle is **aesculin**, a kind of glycoside. It causes incoordination, sluggishness, vomiting, diarrhea, dilated pupils, and may lead to paralysis and death.

Native Americans realized the toxic properties of the California buckeye [*Ae. californica*]. They used the seeds and other plant parts to stupefy fish. Also, after careful leaching, the seeds were ground up and eaten.

LARKSPUR OR STAGGERWEED

During the spring and summer months, plants of the genus *Delphinium* are among our most attractive wild flowers. Many of them have been brought into cultivation. But, the larkspurs or staggerweeds, as they are known to ranchers, are a leading cause of cattle loss in the western United States. There are many kinds of larkspur and they are difficult to distinguish from one another. Assume that all of them are toxic to one degree or another. When they are in flower, larkspurs are readily identified by the single nectar spur. They are not so easily spotted in the vegetative state because they closely resemble plants of the buttercup, mallow, and geranium families. This is unfortunate, since much of the poisoning occurs in the early spring before plants come into flower.

Several toxic alkaloids have been isolated from larkspurs, the most important being **delphinine**. Toxicity varies from one species to the next, with the age of the plant, with the part ingested, and with the kind and vigor of the animal involved. Symptoms are also variable. Livestock suffer from falling, kicking, severe constipation, vomiting, bloating, and paralysis of the respiratory centers. Most cases of poisoning involve cattle that have been put out to pasture before it is ready, so that the animals have little to eat other than young larkspur plants.

FALSE HELLEBORE

Veratrum californicum, a native member of the lily family, is found in mountain meadows, often on wetter sites. The robust plants have broad leaves with prominent veins and branched clusters of dull white flowers. The toxic principles are alkaloids that may occur singly or in combination with other classes of toxins. Poisoning in humans is rare and it involves gastrointestinal distress with severe vomiting and diarrhea. There is also impairment of motor functions. Cardiovascular involvement is typical, with the heartbeat being noticeably slowed.

Toxicity in pregnant ewes is dramatic. If they feed on false hellebore, the effect of the **veratrum alkaloids** on embryological development is severe and leads to a malformation in lambs called "monkey-face" or "cyclops." The face is shortened, the forehead and jaw protrude, the nose is reduced so that the face is flattened. In cycloptic animals, there may be a single central eye, two eyeballs in the same socket, or two eyes partially fused.

OLEANDER

Nerium oleander, a Mediterranean shrub, is a favorite ornamental in many of the warmer parts of the United States, because of its attractive flowers and penetrating fragrance. It was once believed that the heavy fumes were, in fact, toxic if allowed to accumulate in a closed, poorly ventilated room. While this particular story has no basis, oleander's general reputation for toxicity is well-founded. Cattle and humans have both been killed by this plant. Children have been poisoned by eating the leaves and by sucking nectar from the flowers. Cases of poisoning from eating meat that had been skewered on oleander stems are also in the literature.

All parts of the plant are poisonous. Several cardiac glycosides are present. Symptoms of toxicity in humans include dizziness, drowsiness, irregular and weak heart-beat, coma, and death. Smoke from burning plants is also dangerous.

POISON HEMLOCK

The carrot family (Umbelliferae) is an excellent example of a common and easily recognizable plant family that contains both toxic and edible plants. Most of them vaguely look like, smell like, and even taste like carrots. The species are difficult to tell from one another. Most of the botanical features reside in microscopic features of the fruits. It is mistaken identity that leads most people to eat the poison hemlock (*Conium maculatum*), thinking that it is perhaps a wild carrot of some sort. Plants are common roadside weeds over much of the United States. They have delicate, fern-like foliage and white flower clusters. The best diagnostic feature is purple blotching on the stems and leaf stalks.

Poison hemlock contains a series of nicotine-like alkaloids, the best known of them being **coniine**. Alkaloid concentration is highest in the seeds and lowest in the roots. Their effect is on the central nervous system. The victim experiences progressive depression of vital functions. The tips of the fingers and toes become insensitive; movement of the arms and legs is then impaired. They are finally paralyzed. The heart is weakened and slowed. Death comes as the result of paralysis of the diaphragm and subsequent respiratory failure.

Circumstantial evidence suggests that one of poison hemlock's most famous victims was Socrates. There remains some uncertainty as to the identity of the hemlock used in ancient Greece to dispatch enemies of the state, but the symptoms reported by Plato in Phaedo are consistent with much of what we know about the plant.

"The boy went out, and after spending a long time, came in with the man who was to give the poison carrying it ground ready in a cup. Socrates caught sight of the man and said, 'Here, my good man, you know about these things; what must I do?

'Just drink it,' he said, 'and walk about till your legs get heavy, then lie down. In that way the drug will act of itself.'

... he put the cup to his lips and, quite easy and contented, drank it up.

He walked about, and when he said that his legs were feeling heavy, he lay down on his back, as the man told him to do; at the same time the one who gave him the potion felt him, and after a while examined his feet and legs; then pinching a foot hard, he asked if he felt anything; he said no.

After this, again, he pressed the shins; and, moving up like this, he showed us that he was growing cold and stiff. Again, he felt him, and told us that when it came to his heart, he would be gone. Already the cold had come nearly as far as the abdomen, when Socrates threw off the covering from his face – for he had covered it over – and said, the last words uttered, 'Criton,' he said, 'we owe a cock to Asclepios; pay it without fail.'

... after a little time, he stirred, and the man uncovered him, and his eyes were still. Criton, seeing this, closed the mouth and eyelids.

This was the end of our comrade..."

[Phaedo, Plato]

It has been suggested, however, that Plato knowingly omitted some of the more unpleasant aspects of what occurred in an attempt to make the death of Socrates seem more dignified and heroic.

WATER HEMLOCK

If we had to select the most violently poisonous plant in North America, it would probably be water hemlock. The various species of *Cicuta* occur over much of the continent. Their most unmistakable diagnostic feature is found in the root-like stems, at or below the surface of the ground. When cut lengthwise, the rootstocks reveal cross-partitioning that divides them into small compartments. This is the most toxic part of the plant. One rootstock is sufficient to kill any large animal, including humans.

The toxic principle is **cicutoxin**, an unsaturated alcohol. It is a violent convulsant to the central nervous system. Symptoms appear within 15 minutes to one hour after ingestion. At first, there is excessive salivation, followed by tremors and convulsions. The seizures alternate with periods of relaxation. The tetanic convulsions become more frequent and more violent. In many victims there is an uncontrollable chewing movement that makes it difficult to administer treatment. The tongue may be shredded and teeth forced from their sockets. The poisoning is so traumatic in humans, that survivors often have no recollection of the event.

Here is perhaps the earliest account in English of water hemlock poisoning.

"When about the end of March, 1670, the cattle were being led from the village to water at the spring, in treading the river banks they exposed the roots of this Cicuta [water hemlock], whose stems and leaf buds were now coming forth. A that time two boys and six girls, a little before noon, ran out of the spring and the meadow through which the river flows, and seeing a root and thinking that it was a golden parsnip, not through the bidding of any evil appetite, but at the behest of wayward frolicsomeness, ate greedily of it, and certain of the girls among them commended the root to the others for its sweetness and pleasantness, wherefore the boys, especially, ate quite abundantly of it and joyfully hastened home; and one the girls tearfully complained to her mother that she had been supplied too meagerly by her comrades, with the root.

Jacob Maeder, a boy of six years, possessed of white locks, and delicate though active, returned home happy and smiling, as if things had gone well. A little while afterwards he complained of pain in his abdomen, and scarcely uttering a word, fell prostrate on the ground, and urinated with great violence to the *heighth of a man. Presently he was a terrible sight to see, being seized with convulsions, with the loss of all his senses. His mouth was shut most tightly so that it could not be opened by any means. He grated his teeth; he twisted his eyes about strangely and blood flowed from his ears.... He frequently hiccupped; at times he seemed to be about to vomit, but he could force nothing from his mouth, which was most tightly closed. He tossed his limbs about marvelously and twisted them; frequently his head was drawn backward and his whole back was curved in the form a bow, so that a small child could have crept beneath him the space between his back and the bed without touching him.*

When the convulsions ceased momentarily, he implored the assistance of his mother. Presently, when they returned with equal violence, he could be aroused by no pinching, by not talking, or by no other means, until his strength failed and he grew pale; and when a hand was placed on his breast he breathed his last.

These symptoms continued scarcely beyond a half hour. After his death, his abdomen and face swelled without lividness except that a little was noticeable about the eyes. From the mouth of the corpse even to the hour of his burial green froth flowed very abundantly, and although it was wiped away frequently by his grieving father, nevertheless new froth soon took its place.

DUMBCANE

This popular ornamental (*Dieffenbachia picta*), native to the American tropics, may well be the most toxic member of the philodendron or aroid family (Araceae). The traditional explanation of toxicity in this group is relatively straightforward -- microscopic, needle-like crystals of calcium oxalate (**raphides**) become imbedded in the soft tissues of the mouth and throat. The result is an intense burning sensation, abundant salivation, and a swelling of the lips, tongue, and mouth. There may be impairment of breathing and swallowing. Speech may become unintelligible or lost; hence the common name of the plant. There may also be corrosive effects on the esophagus and stomach. Sap can be very irritating to the eyes, as well.

In recent years, the role calcium oxalate in dumbcane toxicity has been increasingly questioned. One recent study suggests that the raphides do not play a major role in the toxic effects of *Dieffenbachia*. Various researchers have implicated a proteolytic enzyme, histamines, and kinins.

MISTLETOE

Mistletoes are parasitic shrubs that live on woody plants, especially oaks. The European mistletoe [*Viscum* spp.] has a long history of medicinal uses, including to induce abortions. It is known in North America only from introductions in California. The American mistletoe [*Phoradendron* spp.] has enjoyed a reputation for being highly poisonous, with only one or two berries or leaves supposedly being fatal. Extracts from it have been used in herbal teas and its leaves and berries incorporated into Christmas decorations.

Recent studies demonstrate that mistletoe toxicity has been overstated. Ingestion of 1 to 3 berries or leaves appears unlikely to produce adverse reactions. However, herbal tea preparations do put a person at risk and symptoms of poisoning may be severe.

POINSETTIA

Euphorbia pulcherrima, the poinsettia, is named after Joel Poinsett, an American ambassador to Mexico in the 19th century. It is one of this country's most popular ornamentals. Because literally millions of them are raised each year, especially at the Christmas season, the question arises as to the plant's toxicity. It is widely held that the milky latex in the plant can cause irritation to the eyes and blistering of the skin. Ingestion of any portion is commonly thought to produce nausea, vomiting, diarrhea, bleeding, loss of consciousness, and even death.

As with mistletoe, it now appears that the poisonous properties of the poinsettia have been exaggerated. While many standard references on toxic plants have more or less the same litany of deleterious effects, documentation has been meager. The only fatality cited appears to be that of a two-year-old child in Hawaii who died in 1919 after eating a single leaf. The case is now considered hearsay. Recent studies suggest that the latex has a mildly irritating effect on the skin of laboratory rabbits and that it also induces photosensitivity. Rats fed 25 gm/kg body weight of a poinsettia suspension showed no significant toxic effects. Assuming a 50 lb child would react similarly, he or she would have to consume 500-600 leaves to surpass that experimental dose.

ERGOT

I want to end this survey of toxic plants with the ergot fungus because it provides such a fine example of a plant that is toxic, one that has important medicinal uses, and is also well known for its psychoactive properties. The focus in this section will be on its poisonous aspect. For thousands of years we have suffered from a debilitating disease known as **St. Antony's Fire** or **Ignis Sacre**. Its victims were horribly disfigured because of the loss of ears, portions of the nose, fingers, toes, hands, feet, or even the lower portions of arms and legs. Domesticated animals were similarly poisoned. For centuries the cause was assumed to be evil spirits or even God's punishment for wickedness.

We now know that these symptoms are caused by alkaloids produced by the ergot fungus (*Claviceps purpurea* and other species). Poisoning occurs when we consume contaminated food, often bread made from a cereal host of the fungus. The alkaloids cause constriction of blood vessels, leading to the death of tissue and loss of body parts. Extremities of the body are the most likely targets because they are most distant from the heart. This syndrome of poisoning, known as **chronic ergotism**, occurs when the victim consumes relatively small amounts of the **ergot alkaloids** over a long period of time. If the local miller is really sloppy and large doses of toxin enter the body, the effect is not on the circulatory system, but on the central nervous system. The result is **convulsive ergotism**, which produces a syndrome of bizarre behavior that mimics mental illness. I will tell you more about that subject when we get to medicinal plants.

POISONOUS PLANTS OF NORTH AMERICA

Scientific Name [Common Name]	Toxic Part	Toxic Principle. Symptoms

ALGAE AND DINOFLAGELLATES

Anabaena flos-aquae [annie]	All parts	Amines. Neuromuscular disorders
Aphanizomenon flos-aquae [fannie]	All parts	Saxitoxin. Neuromuscular blockage
Gonyaulax spp.	All parts	Saxitoxin. Paralytic shellfish poison
Gymnodinium spp.	All parts	Unknown. Cause of "red tides"
Microcystis spp. [mike]	All parts	Cyclopeptides. Paralysis

FUNGI

Agaricus spp. [grayscales, woollystalks]	All parts	Unknown. GI; most species edible
Amanita bisporigera [destroying angel]	All parts	Cyclopeptides. GI; cellular; liver/kidney
Amanita muscaria [fly agaric]	All parts	Muscimol, etc. "SST Syndrome"
Amanita pantherina [panther mushroom]	All parts	Cyclopeptides. GI; cellular poison
Amanita phalloides [destroying angel]	All parts	Cyclopeptides. GI; cellular poison
Amanita porphyria [porphyry deathcap]	All parts	Indoles. CNS
Amanita verna [death cup, fool's m.]	All parts	Cyclopeptides. GI; cellular; liver/kidney damage
Aspergillus spp. [breadmolds]	All parts	Aflatoxins. Liver; carcinogenic; teratogenic
Boletus spp. [boletus]	All parts	Muscarine, etc. GI; other species edible
Boletus spp. [boletus]	All parts	Muscarine, etc. GI
Chlorophyllum molybdites [green gill]	All parts	Unknown. GI
Claviceps spp. [ergot]	Grain-like beaks	Ergot alkaloids; CNS; gangrene
Clitocybe clavipes [clubfoot funnelcap]	All parts	Coprine. GI; CV
Clitocybe spp. [funnelcaps, clitocybe]	All parts	Muscarine, etc. GI
Collybia dryophila [forest friend]	All parts	Alkaloids (?). GI
Conocybe spp. [conehead mushrooms]	All	Indoles; cyclopeptides. CNS; GI; liver/kidney damage
Coprinus spp. [inky caps]	All parts	Coprine. GI and CV; when consumed with alcohol
Cortinarius spp. [webcaps]	All	Cyclopeptides (?). GI; cellular; liver/kidney damage
Entoloma spp. [pinkgills]	All parts	Unknown. GI
Fusarium spp.	All parts	Zearalenone, etc. GI; reproductive tract
Galerina spp. [skullcaps]	All parts	Cyclopeptides. GI; cellular; liver/kidney damage
Gomphus floccosus [scaly chanterelle]	All parts	Unknown. GI; CNS
Gymnopilus spp. [flamecaps]	All parts	Indoles. CNS
Gyromitra spp. [false morels]	All parts	Monomethylhydrazine. GI; CNS
Hebeloma spp. [poison pies]	All parts	Muscarine (?). GI
Helvella spp. [lorchels]	All parts	Monomethylhydrazine. GI; CNS
Inocybe spp. [fiberhead mushrooms]	All parts	Muscarine, etc. GI
Lactarius spp. [milkcaps]	All parts	Unknown. GI
Laetiporus sulphureus [sulfur shelf]	All parts	Alkaloids. GI
Lepiota spp. [parasol mushrooms]	All parts	Cyclopeptides. GI; cellular; liver/kidney damage
Lycoperdon spp. [puffballs]	All parts	Unknown. GI (when interior discolored)
Naematoloma fasciculare [sulfur cap]	All parts	Indoles, etc. GI; CNS; edible at some sites
Neogyrimitra gigas [false morel]	All parts	Unknown. GI; CNS
Omphalotus spp. [jack-o'lantern fungus]	All parts	Muscarine. GI
Panaeolus subbalteatus	All parts	Indoles. CNS
Paxillus involutus [naked brimcap]	All parts	Muscarine. GI
Penicillium spp. [green molds, blue molds]	All parts	Rubratoxin, etc. CV; hemorrhaging
Pholiota squarrosa [scaly pholiota]	All parts	Unknown. GI; when consumed with alcohol
Psathyrella foenisecii [haymaker's m.]	All parts	Indoles. CNS
Psilocybe caerulipes [psilocybe]	All parts	Indoles. CNS
Ramaria formosa [coral mushroom]	All parts	Unknown. GI
Russula emetica [sickener]	All parts	Muscarine (?). GI
Sarcosphaera crassa [violet star cup]	All parts	Monomethylhydrazine. GI; CNS
Scleroderma citrinum [earthball]	All parts	Unknown. GI
Stropharia hornemannii [Ringstalk]	All parts	Indoles. CNS
Tricholoma spp. [cavaliers]	All parts	Unknown. GI
Verpa bohemica [narrow-capped morel]	All parts	Unknown. GI; muscular incoordination

FERNS AND FERN ALLIES

Equisetum spp. [horsetails]	Stems	Thiaminase. Circulatory failure
Cheilanthes cochisensis [jimmy fern]	Foliage	Unknown. Nervous disorder ("jimmies")
Dryopteris filix-mas [male fern]	Foliage	Thiaminase; GI
Onochlea sensibilis [sensitive fern]	Foliage	Unknown. CNS; lesions in brain
Pteridium aquilinum [bracken fern]	All, esp. rhizomes	Thiaminase. Circulatory; carcinogenic

GYMNOSPERMS

Cedrus deodara [deodar cedar]	Cones, sap	Unknown. Dermatitis
Cupressus macrocarpa [Monterey cypress]	Foliage	Unknown. Abortions in cattle
Cycas circinalis [false sago palm]	Most parts	Cycasin (glycoside). GI; circulatory; CNS
Cycas revoluta [sago palm]	All parts	Glycosides and amino acid. GI and circulatory
Ephedra spp. [mahuang, Mormon tea]	All parts	Ephedrine. CNS disturbances
Ginkgo biloba [maidenhair tree]	Seeds	Phenolic acids. Dermatitis
Pinus ponderosa [ponderosa pine]	Leaves, twigs	Terpene (?). Abortions in cattle; teratogenic
Podocarpus macrophylla [yew pine]	Leaves, fruits	Unknown. GI
Taxus spp. [English and Japanese yew]	All parts	Taxine (alkaloids). GI; circulatory; resp.; CV
Zamia pumila [arrowroot]	Seeds	Cycasin (glycoside). Ataxia ("wobbles"); cancer

FLOWERING PLANTS

Aceraceae [Maple Family]		
Acer rubrum [red maple]	Leaves, twigs	Unknown. Circulatory
Agavaceae [Century Plant or Agave Family]		
Agave spp. [agave, century plant, maguey]	Sap	Volatile oil, oxalates; saponin. Dermatitis; GI
Amaranthaceae [Pigweed Family]		
Amaranthus spp. [pigweeds]	All parts	Nitrates, oxalates (?). GI
Amaryllidaceae [Amaryllis Family]		
Allium spp. [onion, garlic, etc.]	All parts	Sulfides/disulfides. Hemolytic anemia
Amaryllis belladonna [naked ladies]	Bulbs	Lycorine (alkaloid). GI
Clivia spp. [Kaffir lily]	All parts	Lycorine (alkaloid). GI
Cooperia pedunculata [rain lily]	Leaves	Unknown. Photosensitization
Crinum americanum [swamp lily]	Bulbs	Lycorine (alkaloid). GI; respiratory paralysis
Galanthus nivalis [snowdrop]	Bulbs	Lycorine (alkaloid). GI
Hippeastrum spp. [amaryllis]	Bulbs	Lycorine (alkaloid). GI
Hymenocallis spp. [spider lily]	Bulbs	Lycorine (alkaloid). GI
Lycoris spp. [spider lily]	Bulbs	Lycorine (alkaloid). GI
Narcissus spp. [narcissus, daffodil]	All parts	Phenanthridine alkaloids. GI and CNS
Zephyranthes atamasco [atamasco lily]	Bulb	Lycorine (alkaloid). GI
Anacardiaceae [Cashew Family]		
Anacardium occidentale [cashew nut]	Fruits	Anacardic acid. Dermatitis
Cotinus anagyroides [smoke bush]	All parts	Urushiol (catechols). Dermatitis
Mangifera indica [mango]	Fruits	Urushiol (catechols). Dermatitis
Metopium toxiferum [poison wood]	All parts	Urushiol (catechols). Dermatitis
Schinus spp. [pepper tree]	Fruits	Triterpenes. Dermatitis; M & T; GI
Toxicodendron diversilobum [w. poison-oak]	All parts	Urushiol (catechols). Dermatitis
Toxicodendron radicans [poison-ivy]	All parts	Urushiol (catechols). Dermatitis
Toxicodendron toxicarium [eastern p. o.]	All parts	Urushiol (catechols). Dermatitis
Toxicodendron vernix [poison-sumac]	All parts	Urushiol (catechols). Dermatitis
Annonaceae [Annona Family]		
Asimina triloba [paw paw]	Fruits	Unknown. Dermatitis
Apocynaceae [Dogbane Family]		
Acokanthera spp. [Bushman's poison]	All, esp. seeds!	Ouabin and related glycosides. GI and CV
Allamanda cathartica [golden trumpet]	All parts	Glycosides. CV failure; GI
Apocynum spp. [dogbane, Indian-hemp]	All parts	Apocynamarin + glycosides. CV failure; GI
Catharanthus roseus [periwinkle]	All parts	Glycosides. CV failure; GI
Nerium oleander [oleander]	All parts	Oleandrin + glycosides. CV failure; GI
Plumeria spp. [frangipani]	Sap	Unknown. Dermatitis
Thevetia peruviana [yellow oleander]	All parts	Thevetin + glycosides. CV failure; GI

Urechites lutea [yellow nightshade]	Leaves	Urechitoxin (glycoside). GI and CV
Vinca spp. [periwinkle]	All parts	Glycosides. CV failure; GI
Aquifoliaceae [Holly Family]		
Ilex spp. [holly]	Fruits	Ilicin and uncharacterized saponin (?). GI
Araceae [Aroid or Philodendron Family]		
Alocasia spp. [elephant ear]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Anthurium spp. [anthurium]	Stems, leaves	Calcium oxalate; proteolytic enzyme. M & T
Arisaema triphylla [jack-in-the-pulpit]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Arum spp. [lords-and-ladies]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Caladium spp. [caladium]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Calla palustris [water arum]	All, root!	Calcium oxalate; proteolytic enzyme. M & T
Colocasia spp. [elephant ear, taro]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Dieffenbachia spp. [dumbcane]	Stem	Calcium oxalate; proteolytic enzyme. M & T
Epipremnum aureum [pothos]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Monstera deliciosa [ceriman]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Orontium aquaticum [golden club]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Philodendron spp. [philodendron]	Leaves	Calcium oxalate; proteolytic enzyme. M & T
Pistia stratiotes [water lettuce]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Schindapsus spp. [ivy arum]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Spathiphyllum spp. [spathe flower]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Sygonium spp. [sygonium]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Symplocarpus foetidus [skunk cabbage]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Xanthosoma spp. [melanga]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Zantedeschia aethiopica [calla-lily]	All parts	Calcium oxalate; proteolytic enzyme. M & T
Araliaceae [Spikenard Family]		
Aralia spp. [devil's club, Hercules' club]	All parts	Saponins and mechanical. GI
Hedera helix [English ivy, Algerian ivy]	All parts	Hederin (saponin). GI and dermatitis
Oplopanax horridum [devil's club]	Stems, leaves	Unknown. Mechanical only (?) (penetration)
Polyscias spp.	Leaves	Saponin and ?. Dermatitis
Asclepiadaceae [Milkweed Family]		
Asclepias spp. [milkweeds]	All parts	Resinoids. CNS and GI
Calotropis spp. [crown flower]	Latex	Calcium oxalate; cardiac glycosides. Dermatitis
Cryptostegia spp. [rubber vine]	All parts	Digitalis-like glycoside. GI and CV
Berberidaceae [Barberry Family]		
Berberis spp. [barberry]	All	Isoquinoline alks. GI; muscular/uterine contractions
Caulophyllum thalictroides [blue cohosh]	Leaves, seeds	Methylcytisine (alkaloid) and saponin. GI
Mahonia spp. [Oregon grape]	All	Isoquinoline alks. GI; muscular/uterine contractions
Podophyllum peltatum [may apple]	All parts	Lignans. GI; mitotic poison; herbal remedy
Bignoniaceae [Catalpa Family]		
Campsis radicans [trumpet creeper]	Leaves, flowers	Unknown. Dermatitis
Boraginaceae [Borage Family]		
Amsinckia intermedia [fiddleneck]	Seeds	Pyrrolizidine alkaloids. CNS; GI; liver failure
Cynoglossum officinale [hound's tongue]	All parts	Cynoglossine, etc. (alkaloids). GI; respiratory
Echium spp. [viper's bugloss]	All parts	Pyrrolizidine alkaloids. Liver failure; GI
Heliotropium spp. [heliotrope]	All parts	Pyrrolizidine alkaloids. Liver failure; GI
Symphytum spp. [comfrey]	All parts	Pyrrolizidine alkaloids. Liver failure; GI
Bromeliaceae [Bromeliad Family]		
Ananas comosus [pineapple]	All parts	Bromelain (proteolytic enzyme). Dermatitis
Buxaceae [Boxwood Family]		
Buxus sempervirens [boxwood]	All, esp. foliage	Buxine (alkaloid). GI; CNS and respiratory
Cactaceae [Cactus Family]		
Cereus grandiflorus [nightblooming cereus]	All parts	Unknown (digitalis-like). CV
Lophophora williamsii [peyote]	Aerial portion	Mescaline, etc. (alkaloids). CNS and GI
Calycanthaceae [Spice Bush Family]		
Calycanthus spp. [spice bush]	Seeds	Calycanthin (alkaloid). Convulsions; CV
Campanulaceae [Harebell Family]		
Lobelia spp. [lobelia, Indian tobacco]	All parts	Lobeline (alkaloid). CNS and GI; herbal remedy
Cannabaceae [Hemp Family]		
Cannabis sativa [marijuana, pot, hemp]	Leaves, bracts	Resins (THC's). CNS; respiratory
Humulus lupulus [hops]	Bracts	None. Occupational dermatitis in hops pickers

Caprifoliaceae [Honeysuckle Family]		
Lonicera spp. [honeysuckle]	Fruits	Unknown. GI; CV and respiratory
Sambucus spp. [elderberry]	All	HCN glycosides and alkaloids. GI; cathartic
Symphoricarpos spp. [snowberry]	Fruits	Unknown. GI
Caryophyllaceae [Pink Family]		
Agrostemma githago [corn cockle]	Seeds	Saponins. GI
Drymaria spp. [inkweeds]	All parts	Alkaloids. CNS and GI
Saponaria officinalis [bouncing bet]	All parts	Saponins. GI
Celastraceae [Bittersweet Family]		
Celastrus scandens [bittersweet]	Fruit	Alkaloid (?). GI
Euonymus spp. [burning bush, wahoo]	Fruit, bark	Evomonoside (glycoside). GI; CNS; and CV
Chenopodiaceae [Goosefoot family]		
Beta vulgaris [beet, sugar beet]	Leaves	Nitrates. GI; abortions; vitamin deficiency
Chenopodium spp. [goosefoot]	All parts	Nitrates, oxalates. GI
Halogeton glomeratus [halogeton]	All parts	Oxalates. GI and circulatory; death
Kochia scoparia [summer cypress]	All	Unknown. Prostration; photosensitization; liver/kidney
Salsola iberica [Russian thistle]	All parts	Oxalates. GI and circulatory
Sarcobatus vermiculatus [greasewood]	All parts	Oxalates. GI and circulatory; dermatitis; death
Spinacea oleracea [spinach]	All parts	Oxalates. GI and circulatory
Suckleya suckleyana [poison suckleya]	All parts	HCN glycosides. Cellular asphyxiation
Clusiaceae [Clusia Family]		
Clusia rosea [Balsam apple]	Fruit, sap	Unknown. Pronounced diarrhea
Commelinaceae [Spiderwort Family]		
Rhoeo spathacea [oyster plant]	Sap	Unknown. M & T; GI; respiratory
Tradescantia pallida [purple queen]	Sap	Unknown. Dermatitis; eye irritation
Compositae [Sunflower Family]		
Ambrosia discolor [white ragweed]	All parts	Nitrate. GI; vitamin deficiency
Arnica spp. [arnica]	Flowers/roots	Unknown. GI; coma
Artemisia spp. [ssagebrush, wormwood]	All parts	Volatile oils; thujone. CNS; "sage sickness"
Baccharis halimifolia [groundsel tree]	Leaves, flowers	Cardiac glycosides. GI, CV
Baileya spp. [desert marigold]	All parts	Sesquiterpene lactones. CNS and GI
Centaurea solstitialis [yellow star thistle]	All parts	Solstitialin. "Chewing sickness" and mechanical
Dugaldia spp. [sneezeweeds]	All parts	Hymenovin (lactone). CNS; "spewing sickness"
Eupatorium rugosum [white snakeroot]	All parts	Tremetol (alcohol). "Milk sickness"
Florensia cernua [tar bush]	Leaves/fruits	Unknown. GI; respiratory
Grindelia spp. [gumweeds]	All parts	Selenium. Respiratory and cardiac
Gutierrezia spp. [broomweeds]	All parts	Saponins. GI; abortion in cattle
Haplopappus fruticosus	All parts	Tremetol. As in Eupatorium rugosum
Hymenoxys spp. [rubberweeds]	All parts	Hymenovin. GI
Isocoma wrightii [jimmyweed]	All parts	Tremetol. As in Eupatorium rugosum
Lactuca scariola [wild lettuce]	All parts	Unknown. GI; lung, kidney, and liver damage
Osteospermum ecklonis [African daisy]	All parts	HCN glycoside & saponin. Paralysis; respiratory
Oxytenia acerosa [copperweed]	All parts	Unknown. GI; liver and kidney damage
Psilostrophe spp. [paper flowers]	All parts	Psilotropin (lactone). GI and CNS
Senecio jacobaea [tansy ragwort]	All parts	Pyrrolizidine alkaloids. Liver damage
Silybum marianum [milk thistle]	All parts	Nitrate. GI; vitamin deficiency
Tanacetum vulgare [tansy]	All parts	Thujone, etc. (oils). CNS; abortions
Tetradymia spp. [horsebrush]	All	Tetradymol. CNS; photosensitization ("Big Head"); liver
Xanthium spp. [cocklebur]	All parts	Carboxylatractyloside (glycoside). GI; mechanical; dermatitis
Convolvulaceae [Morning Glory Family]		
Ipomoea batatus [sweet potato]	Tubers	Ipomeamarone. Liver; only in spoiled tubers
Ipomoea tricolor [morning glory]	Seeds	Ergot alkaloids. CNS
Coriariaceae		
Coriaria myrtifolia	Fruit	Coriamyrtin (lactone). CNS; death
Cornaceae [Dogwood Family]		
Aucuba japonica [Japanese aucuba]	All, especially fruit	Aucubin (glycoside). GI
Crassulaceae [Stonecrop Family]		
Cotyledon orbiculata [pig's ears]	All parts	Unknown. Paralysis; respiratory; bloating
Crassula arborescens [silver jade plant]	All parts	Unknown. GI
Kalanchoë spp. [kalanchoe]	All parts	Unknown. Respiratory; paralysis; convulsions

Cruciferae [Mustard Family]		
Armoracia lapathifolia [horseradish]	Root	Glucosinolates. Severe GI
Barbarea vulgaris [yellow rocket]	All parts	Glucosinolates. GI
Brassica spp. [mustards]	Various	Glucosinolates. GI
Brassica napus [rape]	Various	Unknown (bacterial ?). Pulmonary emphysema
Brassica napus [rape]	Various	Glucosinolates. GI; liver/kidney damage
Brassica napus [rape]	Various	Glucosinolates. CNS ("rape blindness")
Brassica spp. [mustards]	Various	Glucosinolates. Urinary ("redwater disease")
Descurainia pinnata [tansy mustard]	All parts	Unknown. Blindness; "paralyzed tongue"
Erysimum cheiranthoides [wormseed m.]	All parts	Glucosinolates, HCN (?). GI
Raphanus raphinastrum [wild radish]	All parts	Unknown. As in Brassica spp.
Thlaspi arvense [fanweed]	Seeds	Glucosinolates. GI
Cucurbitaceae [Gourd Family]		
Bryonia spp. [bryony]	Fruits, roots	Cucurbitacins. GI; respiratory paralysis
Momordica charantia [balsam-pear]	Fruits	Saponins & phytotoxin. GI; hypoglycemia
Datiscaceae [Datisca Family]		
Datisca glomerata [Durango root]	All parts	Unknown. CNS; GI; death
Dioscoreaceae [Yam Family]		
Dioscorea bulbifera [air potato]	Tubers	Alkaloid and glycoside. GI
Dioscorea spp. [yams]	Tubers	Alkaloids. CNS paralysis; teratogenic
Ericaceae [Heath Family]		
Kalmia spp. [mountain laurel, lambkill]	All, honey	Grayanotoxins. GI, CNS, and CV
Ledum spp. [Labrador tea]	All parts	Grayanotoxins. GI, CNS, and CV
Leucothoë spp. [Sierra laurel]	All parts	Grayanotoxins. GI, CNS, and CV
Lyonia spp. [fetterbush, male berry]	Leaves, honey	Grayanotoxins. GI, CNS, and CV
Menziesia ferruginea [rusty leaf]	Leaves	Grayanotoxins. GI, CNS, and CV
Pernettya spp.	Leaves, honey, fruits	Grayanotoxins. GI, CNS, and CV
Pieris spp. [pieris, andromeda]	All parts	Grayanotoxins. GI, CNS, and CV
Rhododendron spp. [azalea, rhododendron]	All, honey	Grayanotoxins. GI, CNS, and CV
Euphorbiaceae [Spurge Family]		
Aleurites fordii [tung nut tree]	All parts, esp. seeds	Saponins. Dermatitis; GI
Cnidoscolus spp. [bull nettles]	All parts	Unknown. Dermatitis
Croton spp. [croton]	All parts	Phorbol esters. GI
Eremocarpus setigerus [turkey mullein]	All parts	None. Mechanically injurious (obstruction)
Euphorbia lathyris [gopher spurge]	All parts	Esters. Dermatitis; GI
Euphorbia maculata [spotted spurge]	All parts	Esters. Dermatitis; GI
Euphorbia marginata [snow-on-the-mountain]	All parts	Esters. Dermatitis; GI
Euphorbia milii [crown-of-thorns]	All parts	Esters. Dermatitis; GI
Euphorbia pulcherrima [poinsettia]	All parts	Esters. Dermatitis; GI
Euphorbia spp. [spurges]	All parts	Esters. Dermatitis; GI
Hippomane mancinella [manchineel tree]	All parts	Hippomane A & B (diterpenes). Dermatitis and GI
Hura crepitans [sandbox tree]	Seeds, latex	Hurin (phytotoxin) and esters. Dermatitis; GI
Jatropha spp. [physic nut]	Seeds	Jatrophin (phytotoxin). GI
Manihot esculenta [cassava, yuca]	Root	HCN glycoside. Cellular asphyxiation
Mercurialis annua [mercury]	All parts	Saponins. GI
Pedilanthus tithymaloides [slipper flower]	Latex	Euphorbol and terpenes. Gastritis
Phyllanthus abnormis [spurge]	All parts	Unknown. GI; CNS; prostration
Reverchonia arenaria	All parts	Unknown. Liver and kidney damage
Ricinus communis [castor bean]	Seeds	Ricinine. Dermatitis; edematous swelling
Ricinus communis [castor bean]	Seeds	Ricin. GI; agglutination of red blood cells
Sapium spp. [tallow tree]	Seeds, latex	Unknown. Dermatitis; GI; kidney damage
Stillingia treculeana [Queen's delight]	All parts	HCN glycosides. GI; cellular asphyxiation
Fagaceae [Oak Family]		
Fagus spp. [beech trees]	Seeds	Saponin-like. GI
Quercus spp. [oaks]	Fruits	Tannic acid. GI
Fumariaceae [Fumitory Family]		
Corydalis spp. [fumitory, fitweed]	All	Chelidonine (alkaloid). GI; trembling and convulsions
Dicentra spp. [dutchman's breeches]	All	Chelidonine (alkaloid). GI; trembling and convulsions
Gentianaceae [Gentian Family]		
Centaurium floribundum [centaury]	All parts	Unknown. GI; frequent urinations
Geraniaceae [Geranium Family]		
Erodium spp. [filaree]	All parts	HCN glycosides. Cellular asphyxiation

Gramineae [Grass Family]		
Avena sativa [oats]	All parts	Nitrites. "Grass tetany"
Bromus spp. [ripgut grass]	Awns	None. Mechanically injurious (penetration)
Cynodon dactylon [Bermuda grass]	All parts	Unknown. CNS; photosensitization; dermatitis
Festuca arundinacea [alta fescue]	All parts (fungal endophyte)	Alkaloids. "Fescue foot"
Glyceria spp. [manna grass]	All parts	HCN glycosides. Cellular asphyxiation
Heteropogon contortus [tanglehead]	Callus	None. Mechanically injurious (penetration)
Holcus lanatus [velvet grass]	All parts	HCN. Cellular asphyxiation
Hordeum jubatum [foxtail barley]	Awns	None. Mechanically injurious
Lolium temulentum [darnel]	All parts (fungal endophyte)	Temuline. CNS and GI
Phalaris spp. [canary grass]	All parts	Tryptamine alkaloids; "Staggers"
Setaria spp. [foxtail]	Awns	None. Mechanically injurious (penetration)
Sorghum spp. [Johnson grass, sorghum]	All parts	HCN. Cellular asphyxiation
Stipa robusta [sleepy grass]	All parts	Unknown. Drowsiness and stupor
Stipa spp. [needle grass]	Awns	None. Mechanically injurious (penetration)
Zea mays [corn, maize]	Stem, leaves	Nitrates. Circulatory
Hippocastanaceae [Horse Chestnut Family]		
Aesculus spp. [horse chestnut, buckeye]	All, esp. seeds	Aesculin (saponin). CNS, GI; blindness
Hydrangeaceae [Hydrangea Family]		
Hydrangea spp. [hydrangea]	All, esp. buds/leaves	HCN glycosides. GI; cellular poison
Hydrophyllaceae [Waterleaf Family]		
Phacelia spp. [phacelia]	Leaves, stems	None or unknown. Dermatitis
Turricula parryi [poodle-dog bush]	Leaves, stems	None or unknown. Intense dermatitis
Hypericaceae [St. John's Wort Family]		
Caulophyllum inophyllum [mastwood]	Seeds	Inophyllum, calophylloides, etc. GI
Hypericum perforatum [Klamath weed]	All, esp. leaves/flws	Hypericin (pigment). Photosensitization
Hypericum spp. [St. John's wort]	All, esp. leaves/flws	Hypericin (pigment). Photosensitization
Iridaceae [Iris Family]		
Homeria spp. [Cape-lily]	All parts	Cardiac glycosides. GI and CV
Iris spp. [iris]	All parts	Irisin (resin). GI
Moraea polystachya [Cape blue-tulip]	All parts	Alkaloid. GI, prostration
Juncaginaceae [Arrowgrass Family]		
Triglochin spp. [arrowgrass]	All parts	HCN glycoside. Cellular asphyxiation
Labiatae [Mint Family]		
Glechoma hederacea [creeping charlie]	All parts	Volatile oils (?). CNS
Mentha pulegium [pennyroyal]	All parts	Pulegone (oil). Respiratory; liver damage
Perilla frutescens [perilla mint]	All parts	Ketones. Respiratory
Salvia officinalis [sage]	Leaves	Unknown. GI (only in excess)
Salvia reflexa [annual sage]	All parts	Nitrates (?). GI; muscular weakness
Stachys arvensis [field nettle]	All parts	Unknown. CNS
Thymus vulgaris [thyme]	All parts	Thyme oil. Dermatitis; GI; CNS; CV
Lauraceae [Laurel Family]		
Persea americana [avocado]	All parts	Unknown. Respiratory
Sassafras albidum [sassafras]	Root	Safrole. Carcinogenic; overuse of flavoring
Umbellularia californica [California bay]	Leaves	Irritating oil. Dermatitis; headache; resp.
Lecythidaceae [Brazil Nut Family]		
Lecythis spp. [monkey pot]	Seeds	Cystathionine. GI; loss of hair and nails
Leguminosae [Pea or Bean Family]		
Abrus precatorius [jequirity bean]	Seeds	Abrin. GI; ulcerations; hemorrhaging; death
Acacia berlandieri [guajillo]	Leaves, fruits	Phenylethylamine. CNS; ataxia ("limber leg")
Acacia greggii [catclaw]	Stems, leaves	HCN glycoside. GI; cellular asphyxiation
Astragalus spp. [locoweeds]	All parts	Alkaloids. CNS; respiratory failure
Astragalus spp. [locoweeds]	All parts	Selenium accumulation. Dermatitis; GI; anemia
Astragalus spp. [locoweeds]	Tops, leaves	Miserotoxin. Emphysema, ataxia, "Cracker Heel"
Astragalus spp. [locoweeds]	All parts	Miserotoxins. Circulatory; CNS; paralysis
Baptisia spp. [wild indigo]	All parts	Cytisine, etc. GI
Caesalpinia spp. [bird-of-paradise]	Fruits	Alkaloids. GI
Canavalia spp. [jack bean, sword bean]	Seeds	Unknown. GI; hemolytic anemia; mitogenic
Cassia fistula [golden shower]	All parts	Emodin (glycoside). GI
Cassia occidentalis [coffee senna]	All, seeds!	Several, incl. lectin. GI; organ changes
Crotalaria spp. [rattlebox]	All parts	Alkaloids. CNS and GI
Cytisus spp. [brooms]	All parts	Cytisine and sparteine. CNS; respiratory failure

Dolichos lablab [hyacinth bean]	Seeds	HCN glycoside. GI; cellular poison
Erythrina spp. [coral tree]	Seeds, bark	Curare-like alkaloids. CNS; paralysis
Glottidium vesicarium [bladderpod]	Immature seeds	Saponins. GI; respiratory; CV
Glycine max [soy bean]	Seeds	Lectins. Circulatory (agglutination); goitrogenic
Gymnocladus dioica [coffee bean tree]	Seeds	Cytisine. CNS and GI
Indigofera endecaphylla [creeping indigo]	All	Unknown. Kidney/liver damage; reproductive effects
Laburnum anagyroides [golden chain tree]	Flowers, seeds	Cytisine. CNS and respiratory failure
Lathyrus spp. [sweet peas]	Seeds	Nitriles, etc. CNS; "lathyrism"; teratogenic
Leucaena leucocephala [lead tree]	All parts	Mimosine (amino acid). Hair loss; stunted growth
Lonchocarpus violaceus (violet lancepod)	All parts	Rotenone. GI; circulatory; respiratory failure
Lupinus spp. [lupines]	Seeds, etc.	Alkaloids. CNS; "crooked calf disease"
Medicago spp. [alfalfa]	All parts	Saponins/estrogen. Photosensitization; infertility
Melilotus spp. [sweet clovers]	All parts	Dicoumarin. "The bleeds"
Mucuna deeringiana [velvet bean]	Seeds	Unknown. GI
Oxytropis spp. [locoweeds]	All parts	Alkaloids. CNS and respiratory failure
Pachyrhizus erosus [yam bean]	Seeds	Saponin, rotenone, pachyrrhizin. Catharsis
Phaseolus lunatus [lima bean]	Seeds	HCN glycosides. Cellular asphyxiation
Phaseolus vulgaris [kidney bean]	Seeds	Lectins/enzyme inhibitors. GI
Physostigma venenosum [Calabar bean]	Seeds	Physostigmine (alkaloid). GI; CNS
Pisum sativum [garden pea]	Vine, fruits	Lectin. CNS (ensilage only); mitogenic
Pongamia pinnata [pongam]	Seeds, roots	Saponin. GI
Prosopis juliflora [mesquite]	All parts	Unknown. GI
Robinia pseudoacacia [black locust]	Leaves, seeds	Robin + robatin. GI; agglutination
Samanea saman [rain tree, saman]	Seeds	Saponin. GI
Sesbania spp. [coffeeweed, sesbane]	Seeds	Sesbanine (alkaloid) + saponins. GI; respiratory
Sophora secundiflora [mescal bean]	Seeds	Quinolizidine alkaloids. CNS and GI
Spartium junceum [Spanish broom]	Leaves, seeds	Sparteine. GI and circulatory
Stizolobium deeringianum [Florida velvet b.]	Seeds	Unknown. GI
Trifolium spp. [clovers]	All parts	Isoflavones, coumarins. Resp.; photosensitivity;
Vicia faba [fava bean]	Seeds	Lectins. Anemia ("favism") in genetically sensitive
Vicia spp. [vetch]	All parts	HCN + lectins. "Favism" (hemolytic anemia)
Wisteria spp. [wisteria]	Seeds	Lycorine and wistarine (glycosides) + lectins. GI
Liliaceae [Lily Family]		
Aloë spp. [aloe]	Sap	Barbaloin (anthraquinone glycoside). GI
Amianthium muscaetoxicum [stagger-grass]	Leaves	Alkaloid (?). GI; respiratory
Asparagus officinalis [asparagus]	Stems/fruits	Glycosides and saponin. Dermatitis; GI; and CV
Colchicum autumnale [autumn crocus]	All parts	Colchicine. GI; mitotic poison
Convallaria majalis [lily-of-the-valley]	All parts	Convallatoxin, etc. (glycosides). GI and CV
Galanthus nivalis [snowdrop]	Bulb	Lycorine (alkaloid). GI
Gloriosa superba [glory lily]	All parts	Superbine (alkaloid). GI; convulsions
Hyacinthoides non-scripta [English bluebell]	All parts	Glycosides (?). GI and CV
Hyacinthus orientalis [hyacinth]	All parts	Lycorine (alkaloid). GI
Melanthium virginicum [bunch flower]	Stems, leaves	Unknown. CNS; CV; and respiratory
Ornithogalum umbellatum [star-of-Bethlehem]	All parts	Digitalis-like glycosides. GI
Schoenocaulon spp. [green lily]	All parts	Alkaloids. GI
Scilla spp. [squill]	All, esp. bulbs	Alkaloid and glycoside. GI and CV
Tulipa spp. [tulips]	All parts	Alkaloids. GI
Urginea maritima [red quill]	Bulb	Cardiac glycosides. GI and CV
Veratrum spp. [corn lily, false hellebore]	All	Veratrum alkaloids. CNS; teratogenic effects; GI; CV
Zigadenus spp. [death camas]	All parts	Zygadenine, etc. GI; vasomotor collapse; M & T
Linaceae [Flax Family]		
Linum usitatissimum [flax]	All parts	HCN glycosides. Cellular asphyxiation
Loasaceae [Loasa Family]		
Eucnide spp. [rock-nettles]	All parts	Dermatitis from irritating hairs
Loganiaceae [Logania Family]		
Gelsemium sempervirens [yellow jessamine]	All, incl. honey	Gelsemine, etc. (indole alks). Resp.; CNS
Spigelia spp. [pinkroot]	All parts	Spigeline. GI; convulsions
Strycnhos nux-vomica [nux vomica]	Seeds	Strychnine (alkaloid). CNS (tetanic seizures)
Lythraceae [Loosestrife Family]		
Heimia salicifolia [sinicuichi]	All parts	Cryogenine, etc. (quinolizidine alkaloids). CNS
Magnoliaceae [Magnolia Family]		
Illicium anisatum [star anise]	All parts	Unknown. GI; coma; convulsions

Magnolia grandiflora [bull bay, magnolia]	Wood, leaves	Lactone (?). Dermatitis
Malvaceae [Mallow Family]		
Gossypium spp. [cotton]	Seeds	Gossypol (pigment); GI; cardiac failure; male sterility
Malva parviflora [cheeseweed]	All parts	Fatty acids. CNS disturbances; "shivers"
Meliaceae [Chinaberry Family]		
Melia azedarach [Chinaberry tree]	All, esp. fruits	Triterpenoid neurotoxin. CNS and GI; death
Swietenia mahagoni [mahogany]	Seeds	Unknown. GI and CV
Melianthaceae [Melianthus Family]		
Melianthus spp. [honeybush]	All parts	Bufadienolides (glycosides). CV; death
Menispermaceae [Moonseed Family]		
Cocculus indicus [fish berries]	Fruits	Picrotoxin. GI; convulsions; coma
Menispermum canadense [moonseed]	Fruits	Dauricine. GI
Moraceae [Mulberry Family]		
Ficus spp. [fig]	Sap	Ficin (enzyme). Dermatitis; photodermatitis
Maclura pomifera [Osage orange]	Fruits	None. Mechanically injurious (obstruction)
Morus spp. [mulberry]	Sap	Unknown. Dermatitis; GI and CNS
Myoporaceae [Myoporum Family]		
Myoporum laetum	Leaves, fruits	Ngaione (e. oil). GI; convulsions; coma; death
Myristicaceae [Nutmeg Family]		
Myristica fragrans [nutmeg]	Seeds	Myristicin. GI and CNS; recreational drug use
Myrtaceae [Myrtle Family]		
Eucalyptus spp. [eucalyptus]	Leaves	HCN glyc. & monoterpenes. GI; CNS; respiratory
Melaleuca quinquenervia [cajeput tree]	Stems, leaves	Irritating oil. Dermatitis and respiratory
Nyctaginaceae [Four o'clock Family]		
Mirabilis jalapa [four o'clock]	Seeds, roots	Trigonelline (alkaloid). Dermatitis; GI
Oleaceae [Olive Family]		
Ligustrum spp. [privet]	All parts	Syringin (glycoside). GI; kidney damage; death
Orchidaceae [Orchid Family]		
Cypripedium spp. [lady slipper orchid]	Stems, leaves	Unknown. Dermatitis from irritating hairs
Oxalidaceae [Oxalis Family]		
Oxalis pes-caprae [Bermuda buttercup]	All parts	Oxalates. GI and circulatory
Palmae [Palm Family]		
Areca catechu [betel nut palm]	Seeds	Arecoline, etc. (alkaloids). CNS, GI
Caryota spp. [fishtail palm]	Fruit	Calcium oxalate. Dermatitis; M & T
Papaveraceae [Poppy Family]		
Argemone spp. [prickly poppy]	Seeds	Berberine, protopine. CNS and GI
Chelidonium majus [celandine]	Seeds, root	Isoquinoline alkaloids. CNS; GI; circulatory
Papaver sominferum [opium poppy]	All parts	Isoquinoline alkaloids. CNS and GI
Papaver spp. [ornamental poppies]	All parts	Isoquinoline alkaloids. CNS and GI
Sanguinaria canadensis [bloodroot]	All parts	Isoquinoline alkaloids. CNS and GI
Phytolaccaceae [Pokeweed Family]		
Phytolacca americana [pokeweed]	All	Resin, saponin, alkaloid. GI; mitogenic effects; death
Rivina humilis [rouge plant]	All parts	Saponins. GI reported. Toxicity questionable
Pittosporaceae [Pittosporum Family]		
Pittosporum spp. [pittosporum]	All parts	Saponins. GI
Plumbaginaceae [Leadwort Family]		
Plumbago spp. [plumbago]	All parts	Plumbagin. Dermatitis
Polygonaceae [Smartweed Family]		
Fagopyrum esculentum [buckwheat]	Seeds	Fagopyrin. Photosensitization
Rheum rhabarbarum [rhubarb]	Leaf blade	Anthraquinone glycosides. GI and circulatory
Rumex spp. [docks]	All parts	Oxalates. GI and circulatory
Primulaceae [Primrose Family]		
Anagallis arvensis [scarlet pimpernel]	All	Saponin, glycoside, volatile oil. Dermatitis; GI; death
Cyclamen spp. [cyclamen]	All parts	Cyclamin. Dermatitis, GI irritation
Primula obconica [primrose]	All parts	Primin. Dermatitis; GI irritation

Proteaceae [Protea Family]		
Grevillea spp. [silk-oak]	Sap	Catechols. Dermatitis
Ranunculaceae [Buttercup Family]		
Aconitum spp. [monkshood, wolfsbane]	All parts	Aconitine (alkaloid). Cardiac and circulatory
Actaea spp. [baneberry]	Roots, fruits	Protoanemonin. CNS, GI, circulatory; death
Adonis spp. [pheasant's eye]	All parts	Digitalis-like glycosides. CV
Anemone spp. [windflower, pasque flower]	All parts	Ranunculin. GI irritation
Caltha spp. [marsh marigold]	All parts	Diterpene alkaloids. M & T and GI
Clematis spp. [virgin's bower]	All parts	Protoanemonin. M & T; GI and CNS
Delphinium spp. [larkspur, staggerweed]	All parts	Delphinine, ajacine, etc. GI and respiratory
Helleborus niger [Christmas rose]	All parts	Protoanemonin; saponins. Dermatitis; GI and CV
Hydrastis canadensis [golden seal]	All parts	Hydrastine. CNS and GI
Ranunculus spp. [buttercups]	All parts	Protoanemonin. GI
Rhamnaceae [Buckthorn Family]		
Karwinskia humboldtiana [coyotillo]	Fruit	Anthracenones. Paralysis
Rhamnus purshiana [cascara]	Bark	Anthraquinones. Purgative; medicinal uses
Rhamnus spp. [buckthorn]	Fruit	Anthraquinones. GI
Rosaceae [Rose Family]		
Cercocarpus spp. [mountain mahogany]	Leaves	HCN glycosides. GI; cellular asphyxiation
Eriobotrya japonica [loquat]	Seeds	HCN glycosides. GI; convulsions; coma
Malus sylvestris [apple]	Seeds	HCN glycosides. GI; cellular asphyxiation
Prunus amygdalus [almond]	Seeds	Amygdalin (laetrile). GI; cellular asphyxiation
Prunus armeniaca [apricot]	Seeds	HCN glycosides. GI; cellular asphyxiation
Prunus domestica [plum]	Seeds	HCN glycosides. GI; cellular asphyxiation
Prunus persica [peach]	Seeds	HCN glycosides. GI; cellular asphyxiation
Prunus spp. [wild cherry, etc.]	Seeds, leaves	HCN glycosides. GI; cellular asphyxiation
Pyracantha spp. [firethorn]	Fruits, leaves	HCN glycosides. GI; cellular asphyxiation
Pyrus communis [pear]	Seeds	HCN glycosides. GI; cellular asphyxiation
Rhodotypos scandens [jetbead]	Fruits	HCN glycosides (?). Hypoglycemia; convulsions
Rubiaceae [Madder Family]		
Cephalanthus occidentalis [buttonbush]	All, esp. leaves	Cephalanthin/cephalin. Spasms; paralysis
Coffee arabica [coffee]	Seeds	Caffeine (alkaloid). Mutagenic; CV (?)
Rutaceae [Citrus Family]		
Citrus aurantiifolia [lime]	Fruits	Limonene, etc. Photodermatitis; respiratory
Dictamnus albus [burning bush]	All parts	Furocoumarins. Photodermatitis
Poincirus trifoliata [trifoliate orange]	Fruit	Saponin (?). GI
Ptelea spp. [hop tree, wafer ash]	All parts	Furocoumarins. Photodermatitis
Ruta graveolens [rue]	All parts	Furocoumarins. Photodermatitis
Skimmia japonica [skimmia]	All, esp. berry	Skimmianine (alkaloid). CV and respiratory
Sapindaceae [Soapberry Family]		
Blighia sapida [akee]	Fruits, seeds	Hypoglycin A & B. "Vomiting sickness"
Sapindus spp. [soapberry]	Fruit	Saponin. Dermatitis; GI
Sapotaceae [Sapodilla Family]		
Manilkara zapota [sapodilla]	Bark, seeds	Sapotin (glycoside). GI
Scrophulariaceae [Snapdragon Family]		
Digitalis spp. [foxglove]	All parts	Digitoxin, etc. (glycosides); saponin. GI and CV
Veronica virginica [Culver's root]	Root	Leptandrin. Violent emesis and catharsis
Simaroubaceae [Simarouba Family]		
Ailanthus altissimus [tree-of-heaven]	Leaves, bark, flowers	Ailanthin, etc. Dermatitis; GI
Solanaceae [Nightshade Family]		
Atropa belladonna [belladonna]	All parts	Tropane alkaloids. CNS
Brugmansia spp. [angel trumpets]	All parts	Tropane alkaloids. CNS
Capsicum spp. [chili pepper, etc.]	Fruits, especially placenta	Capsaicin. M & T; GI
Cestrum spp. [jessamine]	All parts	Tropane alkaloids & saponins. CNS
Datura stramonium [Jimson weed]	All parts	Tropane alkaloids. CNS
Datura spp. [datura, thornapple]	All parts	Tropane alkaloids. CNS; recreational drug use
Hyoscyamus niger [black henbane]	All parts	Tropane alkaloids. CNS
Lycium spp. [box thorn]	Leaves	Tropane alkaloids (?). Severe GI
Lycopersicon esculentum [tomato]	All parts	Solanine (glycoalkaloid). CNS and GI
Nicotiana spp. [tobacco]	All parts	Nicotine. CNS; respiratory; and teratogenic
Physalis spp. [ground cherry]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solandra spp. [chalice vine]	All parts	Tropane alkaloids. CNS

Solanum carolinense [horse nettle]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum dulcamara [European bittersweet]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum elaeagnifolium [silverleaf n.]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum gracile [graceful nightshade]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum nigrum [black nightshade]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum pseudocapsicum [Jerusalem cherry]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum rostratum [buffalo bur]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum triflorum [cut-leaved nightshade]	All parts	Solanine (glycoalkaloid). CNS and GI*
Solanum tuberosum [potato]	All, esp. green tuber	Solanine (glycoalkaloid). CNS and GI*
Solanum spp. [nightshade]	All parts	Solanine (glycoalkaloid). CNS and GI*
Strelitziaceae [Banana Family]		
Strelitzia spp. [bird-of-paradise]	Fruits, seeds	Unknown. GI; vertigo
Thymeleaceae [Mezereum Family]		
Daphne mezereum [mezereon]	All parts	Daphnetoxin (diterpene) and mezerein. M & T; GI
Dirca palustris [leatherwood]	All parts	Unknown. Dermatitis
Umbelliferae [Parsley Family]		
Aethusa cynapium (fool's parsley)	All parts	Cicutoxin-like alcohol and coniine. GI
Ammi majus [bishop's weed]	All parts	Furocoumarins. Photodermatitis
Anthriscus sylvestris [cow-parsley]	All parts	Furocoumarins. Photodermatitis
Apium graveolens [celery]	Sap	Furocoumarins. Photodermatitis
Cicuta spp. [water hemlock]	Rootstock	Cicutoxin (alcohol). CNS; GI; tetanic seizures
Conium maculatum [poison hemlock]	All	Coniine. Cardiac and respiratory failure; teratogenic
Cymopterus watsonii [spring-parsley]	Sap	Furocoumarins. Photodermatitis
Daucus carota [carrot, wild carrot]	All parts	Furocoumarins. Photodermatitis
Heracleum lanatum [cow parsnip]	All parts	Unknown. Dermatitis
Oenanthe crocata [water dropwort]	All parts	Oenanthotoxin (alcohol). GI; convulsions
Pastinaca sativa [wild parsnip]	All parts	Furocoumarins. Photodermatitis; dermatitis
Sium suave [water parsnip]	All parts	Unknown. Cardiac and respiratory
Sphenosciadium capitellatum [ranger's buttons]	All parts	Unknown. Respiratory; GI; photodermatitis
Urticaceae [Nettle Family]		
Hesperocnide tenella [western nettle]	Stems, leaves	Histamines (?). Dermatitis
Laportea spp. [wood nettle]	All parts	Acetylcholine, 5-hydroxytryptamine. Dermatitis
Urtica spp. [nettles]	All parts	Histamines. Dermatitis
Verbenaceae [Vervain Family]		
Aloysia lycioides [white brush]	Stems, leaves	Unknown. CNS; prostration; paralysis
Duranta repens [golden dewdrop]	Fruits	HCN glycosides; saponins. CNS; GI; CV; convulsions
Lantana camara [lantana]	Fruits, leaves	Lantadene A & B. GI and liver damage
Viscaceae [Mistletoe Family]		
Phoradendron serotinum [mistletoe]	All parts	Phoratoxin (lectin). GI; CV; abortions
Viscum album [European mistletoe]	Stems, leaves	Viscumin & viscotoxin (lectins). GI and CNS
Vitaceae [Grape Family]		
Parthenocissus spp. [Virginia creeper]	Stems, leaves	Unknown irritant. Dermatitis in gardeners
Zygophyllaceae [Caltrop Family]		
Kallstroemia hirsutissima [carpet weed]	All parts	Unknown. CNS; paralysis
Peganum harmala [African rue]	Seeds	Indole alkaloids. CNS
Tribulus terrestris [puncture vine]	All parts	Saponins. Photosensitization; ataxia Mechanical (penetration)

Notes:

CNS = central nervous system
CV = cardiovascular system
GI = gastrointestinal tract
M & T = mouth and throat
SST Syndrome = sweating, salivation, and tears

Mechanical = penetration by spines, thorns, etc. of softer tissues, leading to infection

TOXIC PLANTS OF CALIFORNIA HOMES AND GARDENS

Common Name [Scientific Name]	Toxic Parts(s)	Symptoms
amaryllis [*Hippeastrum* spp.]	bulb	upset stomach, convulsions
angel trumpet [*Brugmansia* spp.]	all parts	rapid heartbeat, dilated pupils, hot/dry skin
autumn crocus [*Colchicum autumnale*]	all parts	nausea, diarrhea, circulatory collapse
begonia [*Begonia* spp.]	all parts	vomiting, purging, diuretic
bird-of-paradise [*Caesalpinia gillesii*]	pods and seeds	intestinal irritation, vomiting, diarrhea
bird-of-paradise [*Strelitzia* spp.]	fruit and seeds	vomiting, diarrhea, dizziness, drowsiness
bleeding hearts [*Dicentra* spp.]	leaves and roots	trembling, staggering, convulsions
boxwood [*Buxus sempervirens*]	stems and leaves	stomach pains, vomiting, diarrhea
buckwheat [*Fagopyrum sagittatum*]	flour from seeds	allergic rash in sensitive individuals
caladium [*Caladium* spp.]	all parts	irritation of mouth and throat
calla lily [*Zantedeschia aethiopica*]	all parts	irritation of mouth and throat
carrot [*Daucus carota*]	foliage	rash in sensitive individuals
castor bean [*Ricinus communis*]	all parts, esp. seeds	burning in mouth/throat, vomiting, diarrhea
celery [*Apium graveolens*]	foliage	rash in sensitive individuals
chalice vine [*Solandra* spp.]	flowers, leaves	vomiting, diarrhea, pupils dilate
cherry [*Prunus* spp.]	stems, leaves, pits	twitching, difficult breathing, coma
christmas rose [*Helleborus niger*]	rootstocks, lvs.	upset stomach, purging, numbing of mouth
croton [*Codiaeum* spp.]	all parts	rash, irritation of mouth and throat
cyclamen [*Cyclamen* spp.]	tuber	rash in sensitive individuals
daffodil [*Narcissus pseudonarcissus*]	bulb	vomiting, diarrhea, trembling, convulsions
daphne [*Daphne mezereum*]	berries, bark, leaves	vomiting, diarrhea, stupor, convulsions
dumbcane [*Dieffenbachia* spp.]	stems	irritation of mouth and throat, voice loss
elderberry [*Sambucus* spp.]	most parts	nausea, digestive upset
elephant's ear [*Colocasia* spp.]	all parts	irritation of mouth and throat
English ivy [*Hedera helix*]	all parts	excitement, difficult breathing, coma
fig [*Ficus* spp.]	sap	rash
foxglove [*Digitalis purpurea*]	all parts	irregular heartbeat and pulse, digestive upset
four o'clock [*Mirabilis jalapa*]	root and seeds	vomiting, diarrhea, stomach pain
golden chain [*Laburnum anagyroides*]	pods and seeds	incoordination, vomiting, convulsions, coma
holly [*Ilex* spp.]	berries	vomiting, diarrhea, stupor
hyacinth [*Hyacinthus orientalis*]	bulb	intense indigestion
hydrangea [*Hydrangea* spp.]	leaves and buds	nausea, vomiting, diarrhea
iris [*Iris* spp.]	leaves and roots	rash, severe digestive upset, purging
larkspur [*Delphinium* spp.]	all parts	digestive upset, excitement/depression
loquat [*Eriobotrya japonica*]	all parts	vomiting, labored breathing, convulsions
lily-of-the-valley [*Convallaria majalis*]	most parts	heart stimulant, dizziness, vomiting
mistletoe [*Phoradendron* spp.]	berries	severe indigestion, cardiovascular collapse
monkshood [*Aconitum* spp.]	roots, seeds, leaves	tingling lips/tongue, slowing heart rate
morning glory [*Ipomoea violacea*]	seeds	nausea, euphoria, hallucinations
nightshade [*Solanum* spp.]	all parts	nausea, dizziness, pupils dilate
oaks [*Quercus* spp.]	acorns, shoots	constipation, bloody stools, kidney damage
oleander [*Nerium oleander*]	all parts	nausea, irregular pulse, paralysis
parsnip [*Pastinaca sativa*]	foliage	rash in sensitive individuals
philodendron [*Philodendron* spp.]	all parts	irritation of mouth and throat
pieris [*Pieris japonica*]	all parts	vomiting, low blood pressure, convulsions
poinsettia [*Euphorbia pulcherrima*]	most parts	rash, vomiting, abdominal pain, diarrhea
poppy [*Papaver* spp.]	most parts	stupor, coma, slow breathing
potato [*Solanum tuberosum*]	most parts	vomiting, diarrhea, shock, paralysis
primrose [*Primula obconica*]	foliage	rash in sensitive individuals
privet [*Ligustrum vulgare*]	berries	upset stomach, pain, vomiting, diarrhea
red sage [*Lantana camara*]	berries	intestinal upset, muscular weakness
rhododendron [*Rhododendron* spp.]	all parts	vomiting, low blood pressure, convulsions
rhubarb [*Rheum rhaponticum*]	leaf blade	severe abdominal pain, vomiting, weakness
spurge [*Euphorbia* spp.]	sap	mild to severe rash
sweet pea [*Lathyrus odoratus*]	seeds	paralysis (when eaten in large quantity)
tomato [*Lycopersicon esculentum*]	stems and leaves	vomiting, diarrhea, shock, paralysis
tulip [*Tulipa* spp.]	bulb	vomiting, diarrhea, stomach pain
wisteria [*Wisteria* spp.]	pods and seeds	vomiting, diarrhea, abdominal pain

yellow oleander [*Thevetia peruviana*]	all parts	vomiting, diarrhea, abdominal pain, headache
yew [*Taxus* spp.]	all parts	vomiting, diarrhea, circulatory collapse

9.4 • PURPOSEFUL USE OF TOXIC PLANTS

"We did not escape without damage because [the Indians] killed another companion of ours ... and in truth, the arrow did not penetrate half a finger, but as it had poison on it, he gave up his soul to our Lord."
(Francisco de Orellana, 1541)

We have knowingly used poisonous plants as instruments of punishment, torture, murder, and suicide. As interesting as some of these episodes might be, they are not the subject of this section. I want to concentrate instead on our use of plant toxins in arrow poisons, in the little-known ritual known as the "ordeal," and on their use to kill fish, insects, and rodents.

ARROW & DART POISONS

Peoples of both the Old World and the New World have used many different plants in the preparation of these poisons. Native Americans on this continent used relatively few arrow poisons from plant sources, relying instead on rattlesnake venom and the juices of the black widow spider. The Indians of South America and the tribesmen of Africa used arrow poisons both to hunt wild game and in wars against their enemies.

CURARE. This is probably the most famous arrow poison. The name is a phonetic rendering of an Indian phrase meaning, "He, to whom it comes, falls." Other spellings used in the literature are urari, woorari, woorali, and wourali. Curare is the name for a whole group of arrow poisons used in South America. The fact that the ingredients and their relative proportions vary from one location to the next hindered any real understanding of the botanical and chemical nature of the poison.

The Baron Alexander von Humboldt was probably the first European to witness the preparation of curare. He wrote that the Indians shredded bark of certain trees and made an infusion from it. This was further concentrated by boiling it. Several other plant materials were added to the mixture.

The Indians have several different ways of assaying the strength of curare. One is to wound a frog with a poisoned arrow or dart. If it can jump more than eight times without the curare taking effect, then the potion is deemed too weak. Another test involves a monkey jumping from tree to tree. When the curare is at its proper strength, an animal should not be able to jump to more than one tree before the toxin takes effect. And, a final test is that since the honor of preparing curare often falls to the old women of the tribe, if they are not half intoxicated by the fumes of the boiling mixture, the brew is not yet ready.

The exact botanical nature of curare is still in some doubt. The two principal toxic ingredients are *Strychnos* spp. (often *S. toxifera*) of the Logan-iaceae and *Chondrodendron tomentosum* of the moonseed family (Menispermaceae).

Three basic groups or kinds of curare are often recognized, based upon the physical form in which they are prepared. **Tubocurare,** also known as tube curare or bamboo curare, is cylindrical, having been packed in hollow bamboo stems. The two other kinds are **gourd** or calabash curare and **pot** curare. *Chondrodendron* is the principal ingredient in tube curare; it is also used in pot curare. *Strychnos* is used in both calabash and pot curare.

The active ingredient is d-tubocurarine chloride or tubocurarine chloride, a whitish, odorless powder. Poisoning manifests itself in muscular relaxation by blocking of impulses between the nerve and the muscle fiber activated by it. Symptoms include:

☼ impaired vision
☼ bilateral drooping of lips
☼ heaviness of face
☼ relaxation of jaw
☼ weakness of head muscles
☼ inability to raise head
☼ paralysis of spinal muscles, legs, & arms
☼ slowed respiration, and
☼ death.

Curare is rapidly destroyed and excreted. Its action usually lasts for about 15-20 minutes, during which the victim dies. The flesh of animals killed by curare may be eaten.

There are also medicinal uses for curare. Because it is a muscle relaxant, it may be used in the treatment of convulsive mental patients and in certain types of surgery. Curare is also used to diagnose myasthenia gravis, a muscular disorder characterized by an overall deterioration of muscle tone.

KOMBI. The action of this African arrow poison was first described in detail by Dr. David Livingstone, the missionary to Africa of “Dr. Livingstone, I presume” fame. He observed people preparing a poison from the fruits of *Strophanthus*, a member of Apocynaceae, the dogbane family. The action of kombi is much like that of curare. The wounded animal rarely runs more than about a hundred yards before it falls. Kombi contains strophanthin, a glycoside with digitalis-like effects. It must get into the blood stream, which means that the flesh of kombi victims is edible.

Strophanthin also finds limited uses in medicine. It is used on heart attack victims when time is of the utmost importance. It takes effect much faster than digitalis, but it is such a violent poison that the dosages must be carefully controlled.

UPAS. This is an arrow poison used by the natives of Java. The chief ingredient is *Antiaris toxicaria* of Moraceae, the mulberry family.

OUABAIN. The natives of tropical Africa prepare an arrow poison from *Strophanthus gratus*. A somewhat inferior brand can be made from *Acokanthera schimperi* and *A. deflexa*. Ouabain is the most rapidly acting heart-glycoside known.

NEW WORLD ARROW & DART POISONS

Scientific Name (Family)	Area of Use
Aconitum spp. (Buttercup)	North America
Anemone spp. (Buttercup)	North America
Anomospermum spp. (Moonseed)	South America
Capsicum annuum (Nightshade)	South America
Cocculus spp. (Moonseed)	South America
Colliguaja odorifera (Spurge)	South America
Chondrodendron spp. (Moonseed)	South America
Conium maculatum (Parsley)	North America
Cynanchum macrophyllum (Milkweed)	N. America
Delphinium elatum (Buttercup)	North America
Dieffenbachia seguine (Philodendron)	Cuba
Dioscorea spp. (Yam)	West Indies
Ficus atrox (Mulberry)	South America
Gautteria venificiorum (Annona)	South America
Hippomane mancinella (Spurge)	West Indies
Hura crepitans (Spurge)	Central & South America
Jacquinia spp. (Theophrasta)	C. & S.America
Nicotiana spp. (Nightshade)	C. & S. America
Papaver nudicaule (Poppy)	North America
Pedilanthus tithymaloides (Spurge)	West Indies
Piper geniculatum (Pepper)	South America
Piscidia piscipula (Bean)	North America
Ranunculus spp. (Buttercup)	North America
Sapium biloculare (Spurge)	Mexico
Sebastiana palmeri (Spurge)	Mexico
Serjania spp. (Soapberry)	West Indies
Spigelia fruticulosa (Logania)	South America
Strychnos spp. (Logania)	South America
Tabernaemontana spp. (Dogbane)	South America
Yucca glauca (Lily)	North America

FISH POISONS

Many different plants have been used to poison, or more precisely, to stupefy fish. The technique is not complex. It typically involves putting the required part of a particular plant in a still body of water. The plant toxin is released into the water, numbing the fish so that it comes floating to the surface.

The California buckeye *(Aesculus californica)* was used by several tribes of Native Americans. Seeds, sometimes leaves or young stems, were crushed and made into a mash that was floated on the surface of the water. The stupefied fish were then gathered by hand or in nets.

The fish poison tree *(Piscidia piscipula)* of the bean family occurs in Texas, Florida, Mexico, the West Indies, and South America. Its leaves, stems, and root bark are macerated with a rum distillation residue or lime water. The material is then placed in baskets and floated in the water until the stupefied fish surface. The plant contains piscidin, a mixture of two toxic glycosides.

FISH POISONS

Scientific & Common Name	Where Used ?
Aesculus californica (California buckeye)	California
Chlorogalum pomeridianum (soaproot)	California
Clibadium spp. (Cunambi)	Amazon
Conium maculatum (wasia)	Mexico
Croton setigerus (turkey mullein)	California
Derris elliptica (tuba-root)	Asia
Echinocystis fabacea (manroot)	California
Erythrina piscipula	South America
Hura crepitans (oassucú)	South America
Lomatium dissectum	California
Lonchocarpus spp. (barbasco)	Tropical America
Lycopus spp. (horehound)	California
Manihot esculenta (cassava)	Guiana
Patinoa sphaerocarpa	Amazon
Paullinia spp. (timbó)	South America
Phyllanthus spp.	South America
Sapindus saponarius (amolli)	Mexico
Serjania spp. (timbó)	South America
Smilacina sessilifolia (Solomon seal)	California
Tephrosia piscatoria	South America
Thevetia peruviana (jorro-jorro)	Brazil
Trichstema lanceolatum (blue curls)	California
Umbellularia californica (pepperwood)	California
Wikstroemia spp.	Hawai'i

INSECTICIDES

In addition to the more exotic arrow and ordeal poisons, the plant kingdom yields useful poisons for the control of insects. About 1200 different species have been used in this context, although only rotenone, pyrethrum, and nicotine are of any real commercial value. One of these, rotenone, was used for centuries as a fish poison in South America before its use as an insecticide.

Rotenone is a very popular insecticide derived from the roots of *Derris* and *Lonchocarpus*, both members of the bean family. The former is native to the Old World tropics, while the latter is New World in its distribution. Rotenone was first isolated from *Derris* in 1902. It is a colorless, crystalline compound extracted from the dried roots. Rotenone is insoluble in water, but soluble in oil. It is about fifteen times more toxic than nicotine. The toxic principle has no effect on warm blooded animals. Rotenone was isolated from the roots of *Lonchocarpus* in 1926. Its roots are richer in the toxin than those of *Derris*.

Pyrethrum is the name given to the dried flower heads of three species of *Chrysanthemum*. They yield volatile oils that paralyze insects. This came as no surprise to horticulturists who knew that these plants were rarely attacked by insects. Depending upon the species, the pyrethrum is often called "Dalmatian insect powder," "Caucasian insect powder," or "Persian insect powder." Pyrethrum has been used successfully in the control of flies, fleas, malarial mosquitos, and body lice.

INSECTICIDES FROM PLANTS

Scientific Name (Common Name)	Comment
Anabasis ioaphylla	Used in Near East
Annona cherimola (cherimoya)	Used against lice
Chrysanthemum cinerariifolium	Pyrethrum
Croton texensis (croton)	Used in New Mexico
Cymbopogon nardus (lemon grass)	Citronella oil
Delphinium spp. (larkspur)	Seeds used
Derris spp. (tuba-root)	Root source of rotenone
Dolichos pseudopachyrrhizus	Tropical Africa

Duboisia hopwoodii	Leaves contain nornicotine
Eupatorium spp. (boneset)	Eastern N. America
Gardenia lucida	Used in Asia to ward off flies
Ipomoea quamoclit (morning glory)	Seeds used
Liquidambar styraciflua (sweet gum)	Fumigant
Lonchocarpus spp. (barbasco)	Source of rotenone
Macuna spp.	Seeds contain L-dopa
Melia azedarach (China berry)	Used against flies
Nicotiana spp. (tobacco)	Leaf dustings used
Pinus palustris (longleaf pine)	Pine oil used
Ruta graveolens (rue)	Leaves contain volatile oil
Schoenocaulon officinale (sabadilla)	Seeds used
Sesamum indicum (sesame)	Used with pyrethrum
Tanacetum vulgare (tansy)	Used on fleas and lice
Xanthoxylum clava-herculis (prickly-ash)	Bark

RODENTICIDES

These plant toxins are used in poison baits, primarily to kill rats. Therefore, they are sometimes called **raticides**. They are effective in small quantities, and appear to taste just fine.

Squill or **sea-onion** (*Drimia maritima*) is a Mediterranean member of the lily family. Since ancient times, its bulbs and extracts of the bulbs have been used to kill rodents. If you or I eat this material, it will make us sick and we will vomit, thereby ridding the system of the toxin. Rodents, on the other hand, have no "vomit control center" in their brains so that any plant parts consumed will remain in the stomach and be absorbed. The sea-onion contains a series of toxins that affect the heart. They are called cardiac glycosides and they are chemically similar to those found in the foxglove plants. The sea-onion toxins, given by injection in moderation, have medicinal uses as diuretics, emetics, and expectorants.

Sweet clover. One of the most pleasant smells of rural areas is freshly mown pastures. Part of that nice aroma comes from sweet clovers (*Melilotus* spp.), herbs of the legume family. These plants also produce a form of **coumarin**, which inhibits blood clotting. Given in controlled quantities, coumarins are effective as blood thinners. Some years ago, the Wisconsin Alumni Research Foundation discovered that a modified form of coumarin made a very effective rat poison. They named it **Warfarin** (after themselves). The poor little rats go off someplace and die from internal hemorrhaging.

ORDEAL POISONS

The lives of many peoples through the ages have been dominated by a complex pantheon of deities, both good and evil. In many societies, one very important obligation was to placate friendly gods and not to encourage the evil ones. These were not societies that were protected by a single omnipotent god who rewarded good deeds and punished the wicked. In many societies, the people developed procedures for determining guilt and innocence. This was a trial or an **ordeal** to which suspects were subjected. If innocent, the person would be able to pass the ordeal; but, if guilty, he or she would fail.

We have used similar devices in the United States and Europe. Consider the witch trials of the 17th century. A woman suspected of being a witch was bound, placed in a bag, and tossed in a lake. If she floated, it was concluded that she was indeed a witch and she was dispatched in some novel fashion. If the woman sank to the bottom of the lake and drowned, her survivors had the consolation of knowing that she was innocent.

Many of the African tribes employed plant poisons in their own version of the ordeal. No one really knows how the use of ordeal poisons began. One plausible explanation is that food gatherers mistakenly picked a toxic plant, assuming it to be edible. The people of the village ate it; some were poisoned and died, while others lived. Given the philosophical and religious climate, a possible explanation that would come to mind is that those who ate the plant and died were somehow connected with witchcraft or were guilty of some evil and were being punished.

There are several different ways in which the ordeal poisons were employed. One of the most straightforward involves a plant called the **tanghin of Madagascar** (*Cerbera* spp.) All parts of this tree are toxic, the fruits especially so. The toxin is a cardiac glycoside. The person undergoing the ordeal is given a drink of rice water or rice soup. He or she is then given three pieces of chicken skin to swallow without chewing, followed by the crushed tanghin fruits mixed with banana juice and a preparation of cardamom leaves or juice. Incantations are performed. The concoction acts as an emetic, a substance that will cause vomiting. Failure to do so is an immediate sign of guilt. The vomitus is carefully examined by tribal officials to see if all three pieces of chicken skin are present. They must be if the suspect is to be judged innocent. If not, the other members of the tribe kill the person, knowing now that he or she is guilty. The significance of the chicken skin lies in the belief that an evil spirit inhabits the body of a guilty person and that it would devour any flesh presented to it, including chicken skin. Before considering this to be a quaint custom, consider that in 1830 a series of natural disasters and diseases swept Madagascar. This prompted mass ordeal trials to determine who was causing these calamities. As many as 6000 people died in one trial!

Probably the most famous of the ordeal poisons involves the **Calabar bean** (*Physostigma venenosum*), a vine of the legume family named after a town in Nigeria. It has a long history of use in Africa as a means of identifying and killing witches. The trial consisted of the accused drinking water that contained eight smashed Calabar beans. If the person regurgitated the beans or raised his right arm and survived, then he was judged innocent. The fast-acting toxin, **physostigmine**, rarely pro-duced that result.

In recent years this plant has been the object of medical research. This same toxin is now used to treat glaucoma, chronic constipation, and aspects of Alzheimer's disease.

The "**Mauvi tree**" of East Africa is used by the natives of the Lake Nyassa region. The bark is mixed with other substances and given to the suspects. If you are guilty, you will vomit and die. There is a certain simplicity to it. The body of the guilty party is spirited away by relatives who will cremate the remains, grind up the bones, and put the powder on their faces.

In some instances, the suspects at an ordeal will be asked to perform some task. Inability to do so is taken as a sign of guilt. In one tribe, the medicine man draws a line on the ground about ten feet in front of the suspects. If you can walk across the line, you are innocent. In another tribe, the suspect is asked to jump over a stick held about 50 cm above the ground. One tribe that occupied what used to be called the Ivory Coast in Africa used the white latex from a member of the spurge family. A latex-soaked piece of cotton was placed under the eyelid and allowed to remain there for a required period. Damage to the cornea was taken as evidence of guilt.

Many of the ordeal poisons were simple preparations involving a toxic plant and one or two other ingredients. Some were complex preparation of a plant poison, lizards, crushed snakes, toads, hearts from previous victims, miscellaneous human organs, blood, and bile. The various ingredients were then fermented for one year to bring them up to proper strength.

The belief in the accuracy of the ordeal poisons was so powerful that perfectly innocent people who were subjected to the ritual would confess to the most horrible crimes if they felt the toxin taking effect. As with so many useful social institutions, corruption soon tainted the ordeal rituals. The priests and witch doctors found that they could guarantee the outcome of an ordeal by careful preparation of the poisons. Their friends received weak doses; their enemies seldom survived. The witch doctor would make a conspicuous display of drinking a weak dose of the ordeal poison before a large crowd to strengthen his position in the community and to show that the innocent had nothing to fear.

ORDEALS, EXECUTIONS, & SUICIDES

Common/scientific Name	**Where Used?**
Plants used in ordeal rituals:	
Desert-rose (*Adenium obesum*)	Africa/Arabia
Bushman's poison (*Akokanthera venetata*)	Africa
Tanghin of Madagascar (*Cerbera vinenifera*)	Indian/Pacific coasts
Combretum confertum	Africa
Tallow tree (*Detarium senegalense*)	Africa
Sassy bark (*Erythrophleum suaveolens*)	Old World tropics
African pearwood (*Mimusops djave*)	Africa
Calabar bean (*Physostigma venenosum*)	Africa
Securidaca longipedunculata	Tropical Africa
Strychnos icaja	Africa
Strychnos kipapa	Africa
Plants used in executions:	
Monk's hood (*Aconitum napellus*)	Europe
Poison hemlock (*Conium maculatum*)	Greece
Rat's bane (*Dichapetalum toxicaria*)	Africa
Mexican shrubby-spurge (*Euphorbia cotinifolia*)	C. & S. America
Allspice jasmine (*Gelsemium elegans*)	Indomalaysia
Gnidia krausii	Africa
Sago palm (*Metroxylon sagu*)	Malaysia
Oleander (*Nerium oleander*)	Mediterranean
Muavi tree (*Parkia bussei*)	Africa
Timbo (*Paullinia pinnata*)	Mexico/C. America
Rourea glabra	C. & S. America
Pink root (*Spigelia anthelmia*)	Old World tropics
Plants used to commit suicide:	
Kaffir-onion (*Boöphane disticha*)	Africa
Tanghin of Madagascar (*Cerbera vinenifera*)	Indian/Pacific coasts
Allspice jasmine (*Gelsemium elegans*)	Indomalaysia
Glory-lily (*Gloriosa superba*)	India
Mountain-laurel (*Kalmia latifolia*)	E. North America
Engler's leaf-flower (*Phyllanthus engleri*)	Africa
Catchbird tree (*Pisonia brunoniana*)	Tropical Asia/Oceania

SECTION 10 • MEDICINAL PLANTS

10.1 - AN OVERVIEW

☼ Medicinal plants act in two ways. Some actually cure, while many others provide symptomatic relief.

☼ Our most famous medicinal plants are also poisonous ones. We have discovered how to administer the toxin in controlled quantities to achieve the desired result.

☼ The knowledge of indigenous people about the curative powers of plants has been an important source of new drugs.

☼ The power of the mind to effect cures and the placebo effect are important factors in evaluating the medicinal properties of plants.

☼ Even in this era of synthetics, we remain dependent upon the plant kingdom as a source of many critical medicines.

☼ We are experiencing a renaissance of using herbal medicines. It is a multi-billion dollar a year industry in the United States alone.

☼ We are also experiencing concern about the effectiveness of these herbal remedies, their purity, and how they interact with other medications.

☼ Exploration continues to find new cures from plants.

10.2 • HISTORY

"And as there are discovered new Regions, new Kingdoms, and new Provinces by our Spaniards, so they have brought unto us newe Medicines, and newe Remedies, wherewith they do cure many informities, which, if we did lacke them, would bee incurible, and without any remedie..."

[Nicholas Monardes]

"Herbs ... are medical jewels gracing the woods, fields and lanes, which few eyes see, and few minds understand. Through this want of observation and knowledge the world suffers immense loss."

[Carolus Linnaeus]

"Within the infant rind of this small flower poison hath residence, and medicine power."

[William Shakespeare. Romeo and Juliet]

"El venemo de ayer es el medicamento de mañana."

[K. Mezey, 1946]

"The desire to take medicine is perhaps the greatest feature which distinguishes man from animals."

[Sir William Osler]

WHAT IS AN HERB?

The word has several meanings. As a general term used in botany, an herb is a non-woody plant. In the kitchen, an herb is a plant or plant part, such as dill or oregano, used to flavor food. What we are about to examine are the medicinal herbs. Here the term, as defined by Varro Tyler (1994) means "*... crude drugs of vegetable origin utilized for the treatment of disease states, often of a chronic nature, or to attain or maintain a condition of improved health."*

HISTORY

A BRIEF HISTORY OF MEDICINE (SORT OF)

BCE:

2000 Here, eat this root!

CE:

1000 That root is heathen. Say this prayer!
1850 That prayer is superstition. Drink this!
1920 That potion is snake oil. Swallow this pill!
1945 That pill is ineffective. Take this penicillin!
1955 Oops, bugs mutated. Take this tetracycline!
1999 More oops. Take this antibiotic!
2000 The bugs won. Here, eat this root!

(After Nature: 21 October 2004)

Perhaps no other aspect of economic botany is more fascinating than the study of medicinal plants. We have turned again and again to plants as sources of medicines to cure our diseases and disorders. In no other phase of ethnobotany do we find such a strange mixture of fact and fiction, sound medicine and fanciful tale.

Anthropological and archeological studies suggest that we have been using plants for medicinal purposes for about 60,000 years. This date is tied to fossilized plant remains at a Neanderthal grave site unearthed in Iran. Buried with the individual were yarrow, hollyhock, groundsel, grape-hyacinth, St. Barneby's thistle, and joint-fir (*Ephedra*).

Ancient texts reveal to us the **materia medica**, the body of medical knowledge, possessed by various civilizations. Some of the more important ones are:

Pen Tsao Ching, written by the Emperor Shen Nung in about 2700 BC, lists 365 drugs used in ancient China.

Code of Hammurabi, the Babylonian legal code of about 1770 BC, lists cassia, henbane, licorice, and mints.

Ebers Papyrus, an Egyptian text from 1500 BC lists 700 drug plants and 876 formulas in use at the time. This 67 ft. long document was discovered by Georg Ebers in 1874 near Luxor. The papyrus cites hemp, opium, frankincense, myrrh, aloe, juniper, linseed, castor oil, fennel, cassia, senna, thyme, and henna.

De Materia Medica was written about AD 78 by the Greek physician Pedianos Dioskurides, better known to us now as Dioscorides. It lists the medicinal uses of 600 plants, including opium, ergot, black nightshade, and cinnamon. An illustrated version, the Codex Juliana, appeared in AD 512. De Materia Medica remained an authoritative reference for 19 centuries!

Physica is the only ancient herbal that I know of written by a woman, Hildegard of Bingen (1098-1179). It is also the first book on natural history done in Germany. Hildegard established a convent at Rupertsberg and served there as Abbess until her death. She said that God had commanded her to write her herbal.

THE AGE OF HERBALS (1470 to 1670)

An herbal is a compilation of plants used in a medical context. Some had few, if any illustrations. Others had crude drawings; a few were lavishly illustrated.

THE HERBALS

Date	Title	Author
BCE:		
2700	Pen Tsao Ching	Emperor Shen Nung
1500	Ebers Papyrus	Egyptian priests
CE:		
77	Historia Naturalis	Pliny
78	De Materia Medica	Pedianos Dioscorides
1163	Physica	Hildegard von Bingen
1491	[H]ortus Sanitatis	Jacobus Meyenbach
1526	The Grete Herball	Peter Treveris
1539	New Kreüter Büch	Jerome Bock
1542	De Historia Stirpium	Leonhart Fuchs
1552	Badianus Manuscript	Juan Badianus & de la Cruz
1530	Herbarum Vivae Eicones	Otto Brunfels
1551	A New Herball	William Turner
1590	Pen Tsao Kang Mu	Li Shih
1597	Generall Historie of Plantes	John Gerard
1615	Rerum Medicarum Nova Hispaniae	Francisco Hernandez
1629	Paradisi in Sole ...	John Parkinson
1640	Theatrum Botanicum	John Parkinson
1653	English Physitian & Complete Herbal	Nicolas Culpeper
1907	Potter's New Encyclopaedia ...	R. C. Wren
1927	A Manual of Materia Medica	D. M. R. Culbreth
1931	A Modern Herbal	Mrs. M. Grieve
1995	The Honest Herbal	Varro Tyler

A few of the better known herbals include:

Badianus Manuscript, coauthored by Juan Badianus and Martin de la Cruz, appeared in 1552. A compilation of Aztec materia medica, it was the first herbal of the New World. The only surviving copy was discovered in the 1940's in the Vatican Library, where it had been lost for more than four centuries. It listed about 200 plants, along with an illustration and how the plant was used.

Pen Tsao Kang Mu was written in 1590 by Li Shih. This 52 volume catalogue of medicinal herbs contains 1094 plants and about 11,000 recipes.

The English Physician and Complete Herbal, published by Nicholas Culpeper in 1653, is contaminated by his beliefs in astrology and alchemy. It remains popular even to this day, having gone through more than 100 editions.

Rerum Medicarum Novae Hispaniae (1615) was written by Francisco Hernandez (1514-1587), physician to King Philip II of Spain. It first appeared as 16 folio volumes. An illustrated edition was published in 1651.

New Herball was written by William Turner (1510-1568). Part 1 appeared in 1551; Pt. 2 in 1562.

Paradisi in Sole Paradisus Terrestris (1629) was written by John Parkinson (1567-1650), apothecary to King James I of England.

Theatrum Botanicum: the Theater of Plantes, or an Universall and Compleate Herball (1640) was the other major contribution made by John Parkinson.

The Herbal or Generall Historie of Plantes (1597) by John Gerard is perhaps the most monumental classical herbal in the English language. There may be more printed copies in circulation today than when it appeared four centuries ago. Gerard was a member of the Barber-Surgeon's Company in London. Much of what we find in the Herbal was taken from Henry Lyte's translation of another herbal written by Rembert Dodoens.

The Compleat Herbal was written by Joseph Pitton de Tournefort (1656-1708). It was a translation and expansion of his earlier work "Elémens de Botanique" (1694). The work appeared in two volumes, dated 1719 and 1730.

Herbarum Vivae Eicones by Otto Brunfels is a three volume work that was the first to base its illustrations on living plants. Seventy-seven of the original watercolor paintings by Hans Weiditz were found in the attic of the Bern Botanical Institute in 1930.

Charles Singer (1927) noted that, "*Most herbal remedies are quite devoid of any rational basis. It may be taken for granted that the writer of the herbal is unable to treat evidence on a scientific basis.*"

THE DOCTRINE OF SIGNATURES

It was particularly during the Age of the Herbals that the Doctrine of Signatures became a popular belief. If the idea had a special champion, it was the Swiss physician and alchemist Philippus Aureolus Paracelsus (born Theophrastus Bom-bastus von Hohenheim). The concept is captured in the following quotes:

"Though sin and Satan have plunged mankind into an ocean of infirmities, yet the mercy of God which is over all His works has made the grass to grow upon the mountains and herbs for the use of man and He has not only stamped upon these a distinct form, but also has given them particular signatures whereby men may read, even in legible characters, the use of them." (Nicolas Culpeper. English Physician, 1680)

"God [has] imprinted upon Plants, Herbs, and Flowers, as if it were in Hieroglyphics, the very signatures of their vertues." (William Turner, in an herbal dedicated to Queen Elizabeth I).

In other words, the very shape of a plant or portion of a plant gives us a sign as to how it can be used to treat our medical problems. If a plant has a heart-shaped leaf, it is a sign that it is good for the heart; a plant with a scorpion-shaped flower cluster is effective in the treatment of scorpion bites. Kidney beans should be good for the kidneys and walnuts ought to make us smarter. Such nonsense persists today.

MORE RECENT DEVELOPMENTS

Until the early part of this century, the practicing physician derived most of his standard cures from the plant kingdom. Medical botany was a required course in a physician's formal training. The intimate relationship between medicine and botany yielded an interesting side effect. Many of our outstanding botanists, including Linnaeus Himself, were trained in medicine. A number of them gave up their medical practices to go into botany full-time.

The use of drugs of botanical origin began to decline as they were replaced by synthetic substitutes. In 1820, 82% of the drugs listed in the National Formulary were from plants. In 1946, only 38% were of plant origin; 56% were chemical; and 6% animal. Today the plant kingdom is once again a major source of interest to both the major drug houses and the U.S. government. Large screening programs are underway to test thousands of species for their ability to control cancer and leukemia. Other programs are investigating plants, such as the yams of Mexico, that manufacture the chemical components that are vital to the biosynthesis of steroidal hormones. Several are being looked at as useful in the treatment of AIDS.

The shelves of our local bookstores and articles in the popular press provide strong evidence of a renewed interest in herbal remedies. A number of reasons have been suggested, including dissatisfaction with modern health care systems, the costs of commercial drugs, and returning to a more natural way of treating our illnesses. A recent study cited in Brevoort (1994) showed that about half of the people who purchase medicinal herbs use them every day, 70% buy them regularly, and about a third of people have been using herbs for 15 years or more. Regular users of medicinal herbs spend about $30 per month on them.

Herbal remedies constitute a major industry in this country. The following data are from Blumenthal (2001). Total retail sales declined about 15% over the previous year. Of the top ten herbs shown below, only soy and valerian sales were up.

IRRATIONAL HERBALISM

The late Varro Tyler, one of our most respected experts on the use of medicinal herbs, offered some words of caution. He suggests that if we accept any of the following precepts, then we have adopted irrational beliefs about herbal medicine.

☼ A conspiracy by the medical establishment discourages the use of herbs.

☼ Herbs cannot harm, only cure.

☼ Whole herbs are more effective than their isolated active constituents.

☼ "Natural" and "organic" herbs are superior to synthetic drugs.

☼ The Doctrine of Signatures is meaningful.

☼ Reducing the dose of a medicine increases its therapeutic activity.

☼ Astrological influences are significant.

☼ Physiological tests in animals are not applicable to human beings.

☼ Anecdotal evidence is highly significant.

☼ Herbs were created by God specifically to cure disease.

TERMS USED IN HERBAL MEDICINE

astringent: an agent, often rich in tannins, that precipitates proteins and thereby leads to the contraction of tissues and the checking of bleeding;

bitter: an agent that aids in digestion by promoting salivation and the secretion of stomach acids and digestive enzymes;

carminative: an agent that soothes the digestive system by relieving gas, spasms, and distention;

cathartic: an agent with a laxative effect, thereby causing an evacuation of the bowels;

demulcent: an agent, often mucilaginous, that soothes irritated or inflamed tissues, especially mucous membranes;

diaphoretic: an agent that promotes perspiration;

emmenegogue: an agent that stimulates menstrual flow;

emollient: an agent that softens or smooths the skin;

febrifuge: an agent that lowers fever;

galactagogue: an agent that promotes the flow of milk;
nervine: an agent stimulates or depresses the nervous system;

purgative: an agent with strong laxative effect

stomachic: an agent that supports gastric functions and promotes appetite;

tonic: an agent that invigorates specific organ(s) or an entire individual;

vulnerary: an agent that supports the healing of wounds

[After Boon & Smith, 1999]

10.3 • SURVEY OF MEDICINAL PLANTS

There are literally hundreds of plants with medicinal properties, well-documented and otherwise. Many of them have been officially recognized by governments and medical associations for approved use by physicians. Many more reside in the realm of "herbal remedies” with varying degrees of demonstrated effectiveness.

MANDRAKE

Mandrake (*Mandragora officinarum*) is not really a medicinal plant. I have included it because of its long history in folk medicine and its bizarre reputation. From the beginning it has been considered one of the best aphrodisiacs and cures for sterility. A reference to one or both of these uses is found in the Hebrew Bible (Genesis 30:14-16). This is probably the first reference to the plant in western literature. These notions as to the power of mandrake arise from the appearance of its root system, as viewed by someone with a little imagination. The root system is carrot-like, but it is often branched. To many people the branched roots represent tiny humans, complete with sex organs. To others the unbranched root clearly represented a man's penis. In either case, the belief was that the Lord, in His Infinite Wisdom, constructed the root in such a way to give an indication of its use. This view was in keeping with the "Doctrine of Signatures."

In the Middle Ages, mandrake became a cure-all. Preparations were also used in drinks to stupefy the victim. One recent author has also claimed that perhaps Jesus of Nazareth was given a mandrake drink to produce a death-like trance while on the cross. Mandrake wines were used in this fashion in Palestine.

Harvesting such a powerful plant was fraught with peril. The plants were so full of strong magic that they could not be pulled from the ground by mere mortals. One way of extracting a mandrake was to draw three circles around the plant with a sword or stick and dig only while looking west. Stuff your ears before doing this because the plant will produce horrible, deafening screams as it is pulled from the ground. It is also best to stand upwind because of the foul stench the plants give off. The most favorable time for doing all of this was a Friday evening. Apparently so many people were deafened or killed by extracting mandrakes that dogs were later substituted. One end of a rope was tied around the dog, the other end around the mandrake. The dog was struck and it ran away, pulling the mandrake from the ground. Naturally, the dog died.

The sedative properties of mandrake result from a series of alkaloids, principally hyoscyamine, scopolamine, and mandragorine. The aphrodisiac qualities are yet unsubstantiated.

QUININE AND MALARIA

"The great gift of malaria is utter apathy."
(Sir Richard Burton, noted explorer; not the actor)

"Malaria can strike anyone, but history and experience show that it affects primarily the poorest, most peripheral and most marginal groups of a population."
(World Health Organization)

"A tree grows which they call 'the fever tree' in the country of Loxa, whose bark, the color of cinnamon, is made into a powder amounting to the weight of two small silver coins and given as a beverage, cures the fevers and tertians; it has produced miraculous results in Lima." (An Augustinian monk writing in 1633)

☼☼☼☼☼

MALARIA & FEVER BARK: TIMELINE

BCE:

200	“Marshes produce small creatures...”

CE:

1633	“A tree which they call ‘the fever tree’
1717	Lancisi suggests transmission by mosquitos
1807	Crawford suggests malaria caused by eggs
1882	King finds malaria transmitted by mosquitos
1897	Ronald Ross identifies *Plasmodium vivax* as the cause
1820	Pelletier & Caventou isolate quinine
1858	J. Schweppe patents quinine tonic water
1932	Atabrine synthesized
1939	Chloroquine synthesized
1944	Doering & Woodward synthesize quinine
1976	Quinine sulfate synthesized

The World Health Organization estimates that one third of the world's population is constantly endangered by malaria. The annual death toll is about 2 million and another 200-800 million are chronic sufferers. We tend to think of malaria as a disease of the tropics, but until control procedures became effective, 4-6 million people in the southern U.S. were malaria-ridden.

Malaria is caused by several species of the protozoan *Plasmodium*, particularly *P. vivax*. The protozoan is carried in the stomach of a female *Anopheles* mosquito which, in turn, brings the organism to us. *Plasmodium* enters the body when the mosquito pierces the skin. It gets into the blood stream where it attacks red blood cells. Their destruction and the subsequent release of waste products bring on the characteristic "chills-fever-sweat" cycle of malaria.

For centuries there was little known about its cause or possible treatment. The method of choice used by physicians was bloodletting. This only tended to hasten the end because the malaria victim was anemic. Another treatment was to drink wine containing three drops of blood from the ear of a cat. This must be administered by a woman of high birth to be effective. But, even in the days of ancient Rome scholars suggested that malaria was caused by some sort of invisible creature associated with marshes. These suggestions were ignored. They were contrary to the accepted religion and science of the day. In the Middle Ages, malaria was thought to be the result of breathing bad night air. Look again at the word “malaria.” Doctors recommended closing all windows and doors at night to exclude these foul vapors. Closing the house did help, because it kept some mosquitos out.

While the Old World was busy worrying about the bad night air, the Indians in the New World were using the "fever bark" tree or "quina" to control malaria. There is some question as to whether the Indians really knew of the advantages of the bark. Some suggest that they knew quite well that it would control malaria, but were somewhat reluctant to share this knowledge with the Spanish conquerors. After all, “*The only good Spaniard ....”*

The most famous story of how the fever bark became known to the Europeans involves the Countess of Chinchon, wife of the Viceroy of Peru. In 1638 she fell victim to malaria and was on the verge of death when the Governor of Loja heard of this and sent her some of the bark of "quinaquina" (Quechuan for "bark of barks"). This bark effected a miraculous cure and she returned to Spain, extolling the virtue of the Indian cure. Linnaeus, being aware of this popular story of the fever bark tree, named the tree *Cinchona*, after the Countess. He misspelled her name.

Unfortunately, the story is a complete myth. The first Countess died three years before her husband was appointed Viceroy, and the second never had malaria and died of other causes in Colombia, without ever returning to Europe.

The Jesuits played an important role in the spread of knowledge and use of the fever bark tree. They had intimate contact with the Indians who used it regularly and did much to bring it to the attention of Europeans. Some people were convinced that fever bark was actually a Jesuit poison used to kill Protestants. Oliver Cromwell died of malaria in 1685, rather than using the "Jesuit bark."

The active ingredient in the bark is a series of alkaloids. The best known is **quinine**. It is extracted from several species of *Cinchona* and from *Remijia pedunculata*, another member of the madder or coffee family (Rubiaceae). The extraction of the alkaloid allowed standardization of doses. This eliminated much of the trial and error treatment of malaria. The exact mode of action is still incompletely known. One suggestion is that quinine interferes with an enzyme system of the *Plasmodium*. This has not been demonstrated, however.

Although *Cinchona* is native to South America, the chief site of production for most of this century has been Java. At the time of the Second World War, 95% of the world's quinine supply came from Java. This source was eliminated from the Allies by the Japanese occupation. This initiated an intensive search for quinine substitutes and for new sources of high grade material in the New World.

In 1944, Doering and Woodward synthesized quinine. Unfortunately, it cost about $1000 per gram. Atabrine, synthesized by the Germans in 1928, was used by the U.S. Army at the rate of a billion pills per year. During the Korean War, the U.S. used chloroquine. Since then several other quinine substitutes have been developed. Unfortunately, not all malaria strains can be controlled by these alkaloids. New ones are known that are resistant to quinine or any of its synthetic derivatives. Malaria remains our costliest disease.

FOXGLOVE AND HEART DISEASE

"In the year 1775 my opinion was asked concerning a family recipe for the cure of dropsy. I was told it had long been kept a secret by an old women in Shropshire, who had sometimes made cures after the more regular practicioners had failed. I was informed, also, that the effects produced were violent vomiting and purging; for the diuretic effects seem to have been overlooked. This medicine was composed of twenty or more different herbs; but it was not very difficult for one conversant in these subjects to perceive that the active herb could be no other than the Foxglove."

(Dr. William Withering,1785)

☼ ☼ ☼ ☼ ☼

One of the most important heart drugs is obtained from a plant of the snapdragon family, the foxglove (*Digitalis purpurea* + other spp.). For centuries it was a favorite ornamental. In the 1700s, foxglove was used by witches and others to treat dropsy. This disorder was characterized by an accumulation of liquids in the chest and abdomen, and a swelling of the legs and ankles. William Withering, an English doctor, after hearing stories about the success of local witches, experimented with treating dropsy patients with pulverized foxglove leaves and found that they did correct the disorder. In 1785 he published "An account of the foxglove and some of its medical uses: with practical remarks on dropsy and other diseases," which remains one of the most famed monographs in medical history.

The real importance of foxglove was not realized until research showed that dropsy was a symptom of a more serious problem, heart disease. Today foxglove remains an important tool in the treatment of heart patients. The leaves yield cardiac glycosides, known collectively as the **digitalis glycosides**. Two of them are digitoxin ($C_{41}H_{64}O_{13}$) and digitalin ($C_{35}H_{36}O_{14}$).

The digitalis glycosides have not been synthesized. We grow large fields of foxglove plants and use alcohol to extract the glycosides from leaves.

The effects of the digitalis glycosides are:

- ☼ the intervals between cardiac contractions are lengthened;
- ☼ the contractions are stronger and more regular;
- ☼ the pulse is more regular;
- ☼ blood pressure is increased;
- ☼ kidney functioning improves; and
- ☼ urine is passed in copious quantities.

Dr. Withering also recognized the toxic nature of foxglove when he noted, *"... when given in very large and quickly repeated doses, [it] occasions sickness, vomiting, purging, giddiness, confused vision, objects appearing green or yellow, increased secretion of urine with frequent motions to part with it; slow pulse, even as low as 35 in a minute, cold sweats, convulsions, syncope [fainting as a result of depriving the cerebrum of oxygen], and death."*

BELLADONNA

"Belladonna, n. in Italian a beautiful lady; in English a deadly poison. A striking example of the essential identity of the two tongues."

(Ambrose Bierce. The Devil's Dictionary)

☼ ☼ ☼ ☼ ☼

Atropa belladonna, also called the deadly nightshade, has been known for many centuries. For most of this time, belladonna was a favorite poison. The plant is native to central and southern Europe and Asia. The common name comes from the Italian for "beautiful woman," and the generic name from Atropos, the Fate who cuts the thread of life.

The leaves contain a series of alkaloids, known collectively as the **belladonna alkaloids**. These are extracted after the leaves have been dried from 2-15 weeks. Ether or ethyl acetate solvents are often used. The alkaloids are then crystallized. Some of the chief alkaloids are **atropine**, **hyoscyamine**, and **scopolamine**.

Atropine is used to stimulate the sympathetic nervous system, to dilate the pupils of the eye during examinations, to relieve pain, and to reduce muscle spasms. Scopolamine, a depressant, is used as a sedative, in the treatment of insomnia, and to help reduce the symptoms of motion sickness. You may have noticed people wearing scopolamine skin patches behinds their ears.

OPIUM, THE GREAT PAIN KILLER

"Among the remedies which it has pleased Almighty God to give to man to relieve his suffering, none is so universal and so efficacious as opium."

(Sydenham, 1680)

Opium is the name for the crude latex extracted from the opium poppy (*Papaver somniferum*), a relative of the popular garden poppies. The sap that oozes from cut surfaces on the plant contains a series of alkaloids collectively known as **opiates**. They have played an important role in medicine. **Morphine**, in particular, remains a widely used pain-killer and sedative. When administered in small quantities (about 8 mg), morphine produces a drowsiness that soon turns into sleep. When 15-30 mg are used, the patient goes into a dreamless sleep, can easily be awakened, but will return to sleep when left alone. Larger doses produce a deep coma characterized by a slow respiratory rate and contracted pupils. In overdose quantities morphine causes a purple discoloration of the face (cyanosis), extreme respiratory slowness, dilation of the pupils, and finally death. Morphine is used also to control diarrhea and vomiting and to induce perspiration.

Codeine, usually in the form of codeine sulfate, is used orally or subcutaneously to control coughing and as an analgesic. The abuse of the opiates as psychoactive substances is treated in the next section.

COCA LEAF

Cocaine, an alkaloid found in the South American shrub *Erythroxylum coca*, has some medical use as a local anesthetic applied to the surface. It is particularly useful in operations of the eye, nose, throat, and anus. The alkaloid is one of the active ingredients of the coca leaf, the popular masticatory. A discussion of cocaine as a psychoactive material will be found in the next section.

EPHEDRA (MAHUANG)

Ephedra sinica, a relative of the Mormon tea of our western deserts, is probably the oldest medicinal plant in continuous use since ancient times. The Chinese mention its use in 2700 B. C. E. Mahuang contains **ephedrine**, used in the treatment of bronchial asthma and in drug poisoning. It dilates the pupils and it is a spinal anesthetic.

Various herbal preparations containing ephedra appear to be the cause of a number of deaths in the past few years. Some states have already banned its use; others, including California are looking into the matter.

Another ephedrine alkaloid, **pseudoephedrine**, has been the focus of recent attention because various OTC preparations have been used to make methamphetamine.

ERGOT

ERGOT POISONING/USE: TIMELINE

BCE:

600	"A noxious pustule ... of grain"
350	"Noxious grasses that cause women to drop the womb and die in childbed"

CE:

590	Outbreak of ergot poisoning in France
941	40,000 die in France
1000	First precise description of affliction
1129	12,000 die
1582	Lonier cites ergot to quicken childbirth
1597	Infected rye cited as cause of ergotism
1674	Severe outbreak in France
1692	Strange behavior in Salem, MA
1812	Austria confiscates contaminated rye
1818	Desgranges publishes medicinal uses
1824	Hosack writes of stillborn children
1920	Ergonovine isolated
1926	Outbreak in Russia
1935	Ergotamine isolated
1943	Hofmann synthesizes LSD
1943	Ergocristine isolated
1977	Outbreak in Ethiopia

You will recall that the alkaloids produced by the ergot fungus (*Claviceps purpurea*) can have deleterious effects on the circulatory system and on the central nervous system. The poisoning is typically the result of consuming bread products made out of rye contaminated by the ergot fungus. Now we knowingly infect entire fields of rye grass with ergot to get a rich crop of these toxic alkaloids. Why? Because these substances, given in precisely controlled quantities, are highly effective during childbirth and in the treatment of migraine headaches. In both cases, the ability of the ergot alkaloids to constrict blood vessels is the key. During delivery, significant hemorrhaging can occur, especially at the time of expulsion of the placenta. The ergot alkaloids help control post-partum bleeding and they also stimulate the smooth muscle of the uterus.

In the Middle Ages, midwives ground up the beak-like fungal bodies and gave them to women during delivery. They called the beaks "mother seed" or "mutterkorn." It was not until 1920 that the alkaloid ergonovine was isolated. Fifteen years later (1935) ergotamine was isolated. It is the alkaloid that is highly effective in constricting dilated cranial blood vessels, especially in combination with caffeine and the belladonna alkaloids.

GINSENG

Ginseng (*Panax quinquefolia* + other spp.) is another plant highly regarded because of its almost limitless powers. In Asia, it is used to treat anemia, diabetes, insomnia, gastritis, and impotency. It is, "... *a tonic to the five viscera, quieting animal spirits, establishing the soul, allaying fear, expelling evil effluvia, brightening the eye, opening up the heart, benefitting the understanding, and if taken for some time it will invigorate the body and prolong life.*" Not bad!

It is the root that is so highly prized. The United States exports about 200,000 tons of three to six year old plants each year; about 90% goes to Hong Kong. This is nothing new. We have been exporting ginseng root since Colonial times. Recent biochemical studies show that the roots contain a complex mixture of triterpenoid saponins that affect the midbrain, heart, internal secretions, and blood sugar levels.

GINKGO

One of the more important medicinal herbs of the last decade is the maidenhair tree, *Ginkgo biloba*, a widely planted ornamental tree. We use a concentrated extract made from the dried leaves. The extract contains a mixture of flavonoids and diterpenes, the latter known as **ginkgolides** A, B, and C.

Two things make ginkgo exciting. It appears to be effective in the treatment of reduced blood flow to the brain and as a scavenger of free radicals. Some claims suggest that GBE is also effective in the prevention of strokes and of Alzheimer's disease, but these assertions have not yet been properly demonstrated.

ST. JOHN'S WORT

Hypericum perforatum is a European herb of the garcinia family (Guttiferae). The common name is based on the belief that the plant has been observed to release a blood red oil on 29 August, the day that John the Baptist was decapitated. It has long had magical powers associated with it, including the ability to ward off evil spirits. It has been a popular herbal remedy since ancient times. Hippocrates and Dioscorides recommended its use.

The plant contains hypericin, hyperforin, and pseudohypericin. St. John's wort has been used to treat wounds and bruises, warts, hemorrhoids, bacterial infections, influenza A & B, and herpes simplex virus 1 & 2. However, its main claim to fame is as a sedative and antidepressant. One of its current common names, probably of Madison Avenue origin, is "Nature's Prozac." As a mild depressant, it inhibits the uptake of serotonin, norepinephrine, and dopamine, naturally occurring neurotransmitters. Current investigations are focused on its use in the treatment of HIV, psoriasis, and the seasonal affective syndrome.

St. John's wort was once a major weed in this part of the United States, where it is known as Klamath weed. Ranchers noticed that when their animals ate the plant they experienced severe skin blisters. They were caused by an interaction between sun-light and red pigments found in glands on the stems, leaves, and flowers. Humans who have taken excessive amounts of St. John's wort have experienced similar problems when they are exposed to sunlight.

INDIAN SNAKEROOT

Rauvolfia serpentina has been used for thousands of years in India to treat the mentally ill, to rid oneself of intestinal worms, and to cure insect bites. Until recently the plant was largely ignored as just another example of quaint plant mythology. Today it is of great importance in the treatment of hypertension and certain kinds of mental illness, particularly schizophrenia. The roots contain the alkaloid **reserpine**. It is similar to serotonin, a naturally occurring chemical in our brain. It has been suggested that schizophrenia is the result of a serotonin imbalance.

Reserpine occurs in several other species of *Rauvolfia*. In addition to perhaps correcting a serotonin imbalance, reserpine also decreases blood pressure and pulse rate. Its action appears to be on all parts of the central nervous system, particularly the hypothalamus.

ECHINACEA OR CONE FLOWER

Echinacea or coneflower (*Echinacea* purpurea + other spp.) is a 19th century "blood purifier" derived from North American Indian herbal medicine. The term blood purifier was often a euphemism for treating venereal disease. Echinacea's claim to fame is that it stimulates our body's own ability to heal itself. Studies carried out in the last 50 years would seem to show that echinacea does cause a number of changes that could lead to enhanced resistance to disease, particularly colds and flu. It is also sold as a cream or lotion for the treatment of wounds and burns.

FEVERFEW

Tanacetum parthenium, a member of the sunflower family, has been used for over 2000 years to treat headaches. It has been rediscovered and it is now widely used for migraine and the associated nausea and vomiting. The active ingredients include a number of sesquiterpene lactones that are found in the leaves. In the olden days, people simply ate the leaves, but this often resulted in ulcers and inflammation of the mouth and lips. Today it is put up as a tablet or capsule.

VALERIAN

Valerian is the dried underground portions of *Valeriana officinalis*. For a thousand years we have used this plant for its sedative, tranquilizing powers. Studies carried out in the last few decades show that it can depress central nervous system activity. The active ingredients have yet to be identified to everyone's satisfaction.

PERIWINKLE

The periwinkle or Madagascar periwinkle (*Catharanthus roseus*) is a member of the dogbane family (Apocynaceae). The plants contain about 70 or so alkaloids, known collectively as the **vinca alkaloids**. At the time the original research was done, periwinkle was placed in the genus *Vinca*. The most famous of them are **vincristine** and **vinblastine**. They have the ability to inhibit tumor growth and to arrest nuclear division. They have been very successful in treating childhood leukemia, Hodgkin's Disease (a cancer of the lymphatic system), cancer of the testicles, and Kaposi's sarcoma.

PACIFIC YEW

Taxus brevifolia is a coniferous tree of the Pacific Northwest, It contains **taxol**, now considered very promising in the treatment of ovarian and breast cancers. Taxol is found in bark of about 80 year old trees; it is also in the needles.

MEDICINAL PLANTS

Common Name (Scientific Name)	Active Ingredient(s)	Therapeutic Use(s)
agar *(Gelidium cartilagineum)*	Polysaccharide	Bulk laxative; emulsions; lubricants
aloe *(Aloë vera)*	Aloin	Skin-softening; burn treatment
autumn crocus *(Colchicum autumnale)*	Colchicine	Treatment of gout
balsam of Peru *(Myroxylon balsamum)*	Volatile oil	Skin ointments; flavor medicines
belladonna *(Atropa belladonna)*	Atropine*	Dilate pupils for eye exams
benzoin *(Styrax benzoin)*	Benzoin	Loosens phlegm in respiratory passages
betel nut palm *(Areca catechu)*	Arecoline	Destroys tapeworms; treat urinary tract problems
black pepper *(Piper nigrum)*	Piperine*	Reduces gases; stimulates heart
blue cohosh *(Caulophyllum thalictroides)*	Saponin	Rheumatism; promotes menstruation
buckbean *(Menyanthes trifoliata)*	Gentianine*	Pain-killer; lowers blood pressure
Calabar bean *(Physostigma venenosum)*	Physostigmine	Stimulates heart: treatment of glaucoma
camphor *(Cinnamomum camphora)*	Camphor oil	Superficial pain/itching; vapors (asthma)
cascara sagrada *(Rhamnus purshiana)*	Anthraquinone glycosides	Laxative
castor oil *(Ricinus communis)*	Ricinolein	Irrigates intestines
chaulmoogra *(Hydnocarpus wightiana)*	Hydnocarpic/chaulmoogric acids	Treatment of leprosy
Chinese rhubarb *(Rheum palmatum)*	Anthraglycosides/tannins	Treat constipation/diarrhea
cloves *(Syzygium aromaticum)*	Oil of clove	Antiseptic/pain-killer
coca *(Erythroxylum coca)*	Cocaine	Local anesthetic; heart/respiratory stimulant
comfrey *(Symphytum officinale)*	Allantoin	Treat psoriasis/other skin problems
corkwood *(Duboisia myoporoides)*	Scopolamine	Anesthetic/pain-killer
cranberry *(Vaccinium macrocarpum)*	Fructose + unknown	Treat urinary tract infections
echinacea *(Echinacea* spp.*)*	Polysaccharides/chicoric acid	Treat infections
elecampane *(Inula helenium)*	Sesquiterpene lactones	Asthma; chest colds; antibiotic
ergot *(Claviceps purpurea)*	Ergot alkaloids	Uterine contractions; treat migraine
eucalyptus *(Eucalyptus globulus)*	Oil of eucalyptus	Antiseptic; treat bronchial congestion
feverfew *(Tanacetum parthenium)*	Parthenolide	Treat migraine headache, nausea, vomiting
foxglove *(Digitalis purpurea)*	Digitalis glycosides	Regulates heart beat/contractions
garlic *(Allium sativum)*	Disulfide*	Antiseptic; reduces hypertension; antispasmodic
ginger *(Zingiber officinale)*	Volatile oils	Soreness; reduce gas; prevent motion sickness
ginkgo *(Ginkgo biloba)*	Glycosides	Treat cardiovascular disorders
ginseng *(Panax quinquefolia)*	Volatile oils	CNS stimulant; complex tonic effects
goldenseal *(Hydrastis canadensis)*	Hydrastine*	Antiseptic; stops bleeding; treat stomach aches
gum arabic *(Acacia senegal)*	Gum arabic	Treat sore throats, coughs; diarrhea
henbane *(Hyoscyamus niger)*	Hyoscyamine*	Sedative; muscle relaxant; dilates pupils
horehound *(Marrubium vulgare)*	Mucilage	Bring up phlegm from respiratory passage
Indian snakeroot *(Rauvolfia serpentina)*	Reserpine	Treat mental illness; high blood pressure
ipecac *(Cephaelis ipecacuanha)*	Emetine	Induce vomiting; treat persistent coughs
jaborandi *(Pilocarpus jaborandi)*	Pilocarpine	Treat glaucoma; diuretic
Jamaica quassia *(Picrasma excelsa)*	Quassin	Stimulates stomach/intestines; pesticide
karaya *(Sterculia urens)*	Gum karaya	Laxative
kava *(Piper methysticum)*	Methysticin*	Tranquilizer; stimulate appetite
khat *(Catha edulis)*	D-norpseudoephedrine	CNS stimulant
lignum vitae *(Guaiacum officinale)*	Guaiaretic/guaiaconic acids	Anti-inflammatory; local stimulant
Madagascar periwinkle *(Catharanthus roseus)*		Vincristine/vinblastine. Inhibit tumor growth
ma huang *(Ephedra sinica)*	Ephedrine	CNS stimulant; treat low blood pressure
mayapple *(Podophyllum peltatum)*	Podophyllin	Treat testicular/ovarian cancer
opium poppy *(Papaver somniferum)*	Morphine*	Pain-killer; treat intestinal/stomach spasms
Pacifc yew *(Taxus brevifolia)*	Taxol	Treat ovarian cancer
papaya *(Carica papaya)*	Papain	Digest protein; break up blood clots
psyllium *(Plantago psyllium)*	Mucilage	Intestinal lubricant/laxative
quinine *(Cinchona pubescens)*	Quinidine*	Treat malaria; muscle cramps; headaches

rue *(Ruta graveolens)*	Skimmianine	Induce menstruation; produce abortion
saw palmetto *(Serenoa repens)*	Oils, acids, glucosides	Treat enlarged prostate
sea onion *(Urginea maritima)*	Scillaren*	Heart stimulant; powerful emetic
senna *(Cassia senna)*	Sennosides (anthraquinones)	Laxative
Solomon's seal *(Polygonatum officinale)*	Allantoin	Anti-inflammatory; lowers blood pressure
strophanthus *(Strophanthus gratus)*	Ouabain	Heart stimulant
strychnine *(Strychnos nux-vomica)*	Strychnine	Increase muscle activity; antidote for depressants
St. John's wort *(Hypericum perforatum)*	Hypericin*	Treat depression
sweet flag *(Acorus calamus)*	Essential oil	Treat stomach cramps
tansy *(Tanacetum vulgare)*	Tanacetin	Expel worms; induce menstruation; antispasmodic
turmeric *(Curcuma longa)*	Curcumin	Stimulates bile production; antibiotic properties
valerian *(Valeriana officinalis)*	Volatile oil?	Sleep aid/tranquilizer
willow bark *(Salix* spp.*)*	Phenolic glycosides	Treat arthritis
wintergreen *(Gaultheria procumbens)*	Methyl salicylate	Pain-reliever; reduce joint/muscle inflammation
witch hazel *(Hamamelis virginiana)*	Tannins	Liniment; eye wash; reduce blood flow
willow *(Salix alba)*	Salicin	Pain-killer; derivative (acetysalicylic acid) in aspirin
yam *(Dioscorea villosa)*	Diosgenin*	Basis of birth control pills
yohimbe *(Pausinystalia yohimbe)*	Yohimbine	Treat erectile dysfunction

* Other members of same family of chemicals also involved

10.04 • THE GREEN PHARMACY

AGING

Echinacea — *Echinacea* spp.
Evening primrose — *Oenothera biennis*
Camomile — *Matricaria recutita*
Ginkgo — *Ginkgo biloba*
Garlic — *Allium sativum*
Ginseng — *Panax* spp.
Gotu kola — *Centella asiatica*
Horsetail — *Equisetum arvense*
Milk thistle — *Silybum marianum*
Peppermint — *Mentha piperita*
Purslane — *Portulaca oleracea*
Thyme — *Thymus vulgaris*
Willow — *Salix* spp.

ALLERGIES

Garlic — *Allium sativum*
Onion — *Allium cepa*
Ginkgo — *Ginkgo biloba*
Stinging nettle — *Urtica dioica*
Camomile — *Matricaria recutita*
Feverfew — *Tanacetum parthenium*
Horseradish — *Armoracia rusticana*

ALTITUDE SICKNESS

Clove — *Syzygium aromaticum*
Garlic — *Allium sativum*
Horse balm — *Monarda* spp.
Reishi — *Ganoderma lucidum*
Ginkgo — *Ginkgo biloba*

ALZHEIMER'S DISEASE

Club moss — *Lycopodium* spp.
Horse balm — *Monarda* spp.
Rosemary — *Rosmarinus officinalis*
Ginkgo — *Ginkgo biloba*
Sage — *Salvia officinalis*
Stinging nettle — *Urtica dioica*
Willow — *Salix* spp.
Gotu kola — *Centella asiatica*

REDUCTION IN MENSTRUAL FLOW

Chasteberry — *Vitex agnus-castus*
Black cohosh — *Cimifuga racemosa*
Blue cohosh — *Caulophyllum thalictroides*
Carrot — *Daucus carota*
Celery — *Apium graveolens*
Dill — *Anethum graveolens*
Marsh mallow — *Althaea officinalis*
Tumeric — *Curcuma longa*

ANGINA

Hawthorn — *Crataegus* spp.
Angelica — *Angelica archangelica*
Bilberry — *Vaccinium myrtillus*
Garlic — *Allium sativum*
Onion — *Allium cepa*
Ginger — *Zingiber officinale*
Khella — *Ammi majus*
Kudzu — *Pueraria lobata*
Purslane — *Portulaca oleracea*
Willow — *Salix* spp.
Evening-primrose — *Oenothera biennis*
Flax — *Linum usitatissimum*
Sichuan lovage — *Ligusticum chuanxiong*

ARTHRITIS OF SPINAL COLUMN

Ginger — *Zingiber officinale*
Pineapple — *Ananas comosus*
Pigweed — *Amaranthus* spp.

ARTHRITIS

Ginger — *Zingiber officinale*
Turmeric — *Cucurma longa*
Pineapple — *Ananas comosus*
Red pepper — *Capsicum* spp.
Stinging nettle — *Urtica dioica*
Oregano — *Origanum vulgare*
Willow — *Salix* spp.
Brazil nut — *Bertholettia excelsus*
Sunflower — *Helianthus annuus*
Broccoli — *Brassica oleracea*
Rosemary — *Rosmarinus officinalis*

ASTHMA

Coffee	*Coffea arabica*
Tea	*Camellia sinensis*
Cola	*Cola nitida*
Cocoa	*Theobroma cacao*
Ephedra	*Ephedra sinica*
Stinging nettle	*Urtica dioica*
Anise	*Pimpinella anisum*
Fennel	*Foeniculum vulgare*
Licorice	*Glycyrrhiza glabra*
Ginkgo	*Ginkgo biloba*
Tomato	*Lycopersicon esculentum*

ATHLETE'S FOOT

Garlic	*Allium sativum*
Ginger	*Zingiber officinale*
Licorice	*Glycyrrhiza glabra*
Tea tree	*Melaleuca* spp.
Camomile	*Matricaria recutita*
Echinacea	*Echinacea* spp.
Goldenseal	*Hydrastis canadensis*
Lemon grass	*Cymbopogon* spp.
Arrow root	*Maranta arundinacea*
Cinnamon	*Cinnamomum* spp.
Turmeric	*Curcuma longa*

BACKACHE

Red pepper	*Capsicum* spp.
Willow	*Salix* spp.
Peppermint	*Mentha piperita*

BAD BREATH

Cardamon	*Elettaria cardamomum*
Eucalyptus	*Eucalyptus globulus*
Parsley	*Petroselinum crispum*
Anise	*Pimpanella anisum*
Coriander	*Coriandrum sativum*
Dill	*Anethum graveolens*
Peppermint	*Mentha piperita*
Sage	*Salvia officinalis*
Wild bergamot	*Monarda fistulosa*
Clove	*Syzygium aromaticum*

BALDNESS

Saw palmetto	*Serenoa repens*
Licorice	*Glycyrrhiza glabra*
Rosemary	*Rosmarinus officinalis*
Danshen	*Salvia miltiorrhiza*
Sage	*Salvia officinais*
Horsetail	*Equisetum* spp.
Safflower	*Carthamus tinctorius*
Sesame	*Sesamum indicum*
Stinging nettle	*Urtica dioica*

BLADDER INFECTIONS

Blueberry	*Vaccinium* spp.
Cranberry	*Vaccinium macrocarpon*
Parsley	*Petroselinum crispum*
Bearberry	*Arctostaphylos uva-ursi*
Birch	*Betula* spp.
Buchu	*Agathosoma betulina*
Couch grass	*Elymus repens*
Dandelion	*Taraxacum officinale*
Echinacea	*Echinacea* spp.
Goldenseal	*Hydrastis canadensis*
Goldenrod	*Solidago virgaurea*
Lovage	*Levisticum officinale*
Marsh mallow	*Althaea officinalis*
Stinging nettle	*Urtica dioica*

BODY ODOR

Coriander	*Coriandrum sativum*
Licorice	*Glycyrrhiza glabra*

BREAST ENLARGEMENT

Saw palmetto	*Serenoa repens*
Wild yam	*Dioscorea villosa*
Cumin	*Cuminum cyminum*

BREAST FEEDING (LACTATION)

Fenugreek	*Trigonella foenum-graecum*
Garlic	*Allium sativum*
Anise	*Pimpinella anisum*
Chaste berry	*Vitex agnus-castus*
Echinacea	*Echinacea* spp.
Fennel	*Foeniculum vulgare*
Peanut	*Arachis hypogaea*
Alfalfa	*Medicago sativa*
Dandelion	*Taraxacum officinale*
Jasmine	*Jasminum sambac*
Parsley	*Petroselinum crispum*
Sesame	*Sesamum indicum*
Squaw vine	*Mitchella repens*

BRONCHITIS

Eucalyptus	*Eucalyptus globosus*
Garlic	*Allium sativum*
Mullein	*Verbascum thapsus*
Stinging nettle	*Urtica dioica*
Couch grass	*Elymus repens*
English plantain	*Plantago lanceolata*
Horehound	*Marrubium vulgare*
Ivy	*Hedera helix*
Knotgrass	*Polygonum aviculare*
Marsh mallow	*Althaea officinalis*
Primrose	*Primula veris*
Soapwort	*Saponaria officinalis*

BRUISES

Arnica	*Arnica montana*
Comfrey	*Symphytum officinale*
Grape	*Vitis vinifera*
Parsley	*Petrselinum crispum*
Potato	*Solanum tuberosum*
St. John's wort	*Hypericum perforatum*
Witch hazel	*Hamamelis virginiana*

BUNIONS

Calendula	*Calendula officinalis*
Pineapple	*Ananas comosus*
Red pepper	*Capsicum* spp.
Turmeric	*Curcuma longa*
Willow	*Salix* spp.
Arnica	*Arnica montana*
Camomile	*Matricaria recuitita*
Clove	*Syzygium aromaticum*
Ginger	*Zingiber officinale*
Sundew	*Drosera* spp.

BURNS

Aloe	*Aloë vera*
Echinacea	*Echinacea* spp.
Garlic	*Allium sativum*
Gotu kola	*Centella asiatica*
Lavender	*Lavandula* spp.
Plantain	*Plantago* spp.
St. John's wort	*Hypericum perforatum*

BURSITIS/TENDINITIS

Willow	*Salix* spp.
Ginger	*Zingiber officinale*
Echinacea	*Echinacea* spp.
Horsetail	*Equisetum* spp.
Licorice	*Glycyrrhiza glabra*
Pineapple	*Ananas comosus*
Purslane	*Portulaca oleracea*
Stinging nettle	*Urtica dioica*
Turmeric	*Curcuma longa*

CANKER SORES

Myrrh	*Commiphora* spp.
Tea	*Camellia sinensis*
Canker root	*Coptis groenlandica*
Goldenseal	*Hydrastis canadensis*
Licorice	*Glycyrrhiza glabra*
Sage	*Salvia officinalis*
Wild geranium	*Geranium maculatum*

CARDIAC ARRHYTHMIA

Angelica	*Angelica archangelica*
Cinchona	*Cinchona* spp.
Hawthorn	*Crataegus* spp.
Canola	*Brassica* spp.
Khella	*Ammi majus*
Astragalus	*Astragalus* spp.
Barberry	*Berberis vulgaris*
Ginkgo	*Ginkgo biloba*
Horehound	*Marrubium vulgare*
Motherwort	*Leonurus cardiaca*
Purslane	*Portulaca oleracea*
Reishi	*Ganoderma lucidum*
Scotch broom	*Cytisus scoparius*
Valerian	*Valeriana officinalis*

CARPAL TUNNEL SYNDROME

Willow	*Salix* spp.
Camomile	*Matricaria recutita*
Pineapple	*Ananas comosus*
Red pepper	*Capsicum* spp.
Turmeric	*Curcuma longa*
Comfrey	*Symphytum officinale*
Cumin	*Cuminum cyminum*
Sage	*Salvia officinalis*

CATARACTS

Bilberry	*Vaccinium myrtillus*
Catnip	*Nepeta cataria*
Rosemary	*Rosmarinus officinalis*
Brazil nut	*Bertholettia excelsa*
Carrot	*Daucus carota*
Onion	*Allium cepa*
Purslane	*Portulaca oleracea*

CHRONIC FATIGUE SYNDROME

Asian ginseng	*Panax ginseng*
Siberian ginseng	*Eleutherrococcus senticosus*
Maté	*Ilex paraguayensis*
Purslane	*Portulaca oleracea*
Spinach	*Spinacia oleracea*
Wheat grass	*Agropyron* spp.

COLDS AND FLU

Echinacea	*Echinacea* spp.
Garlic	*Allium sativum*
Ginger	*Zingiber officinale*
Black cherry	*Prunus serotina*
Citrus	*Citrus* spp.
Elderberry	*Sambucus nigra*
Forsythia	*Forsythia suspensa*
Honeysuckle	*Loniceera japonica*
Onion	*Allium cepa*
Ephedra	*Ephedra sinica*
Anise	*Pimpanella anisum*
Goldenseal	*Hydrastis canadensis*
Licorice	*Glycyrrhiza glabra*
Marsh mallow	*Althaea officinalis*
Mullein	*Verbascum thapsus*
Seneca snakeroot	*Polygala senega*
Slippery elm	*Ulmus rubra*
Watercress	*Nasturtium officinale*
Willow	*Salix* spp.

CONSTIPATION

Flax	*Linum usitítissimum*
Psyllium	*Plantago ovata*
Aloe	*Aloë vera*
Buckthorn	*Rhamnus cathartica*
Cascara sagrada	*Rhamnus purshianus*
Frangula	*Frangula alnus*
Senna	*Cassia senna*
Fenugreek	*Trigonella foenum-graecum*
Rhubarb	*Rheum officinale*

CORNS

Celandine	*Chelidonium majus*
Fig	*Ficus carica*
Papaya	*Carica papaya*
Pineapple	*Ananas comosus*
Willow	*Salix* spp.
Wintergreen	*Gaultheria procumbens*

COUGHING

Coltsfoot	*Tussilago farfara*
Elderberry	*Sambucus nigra*
Ginger	*Zingiber officinale*
Lemon	*Citrus limon*
Licorice	*Glycyrrhiza glabra*
Slippery elm	*Ulmus rubra*
Anise	*Pimpanella anisum*
Burnet-saxifrage	*Pimpinella major*
Marsh mallow	*Althaea officinalis*
Mullein	*Verbascum thapsus*
Primrose	*Primula veris*
Stinging nettle	*Urtica dioica*
Sundew	*Drosera* spp.

CUTS, SCRAPES, & ABSCESSES

Tea tree	*Melaleuca* spp.
Calendula	*Calendula officinalis*
Comfrey	*Symphytum officinale*
Echinacea	*Echinacea* spp.
Goldenseal	*Hydrastis canadensis*
Gotu kola	*Centella asiatica*
Horse balm	*Monarda punctata*
Aloe	*Aloë* spp.
Arnica	*Arnica montana*
Clove	*Syzygium aromaticum*
Garlic	*Allium sativum*
Marsh mallow	*Althaea officinalis*
Melilot	*Melilotus officinalis*

DANDRUFF

Soybean	*Glycine max*
Burdock	*Arctium lappa*
Celandine	*Chelidonium majus*
Comfrey	*Symphytum officinale*
Ginger	*Zingiber officinale*
Sesame	*Sesamum indicum*

Licorice	*Glycyrrhiza glabra*
Plantain	*Plantago* spp.
Tea tree	*Melaleuca* spp.

DEPRESSION

Licorice	*Glycyrrhiza glabra*
St. John's wort	*Hypericum perforatum*
Ginger	*Zingiber officinale*
Purslane	*Portulaca oleracea*
Rosemary	*Rosmarinus officinalis*
Ginkgo	*Ginkgo biloba*
Siberian ginseng	*Eleutherococcus senticosus*

DIABETES

Fenugreek	*Trigonella foenum-graecum*
Onion	*Allium cepa*
Beans	*Phaseolus* spp.
Bitter gourd	*Momordica charantia*
Garlic	*Allium sativum*
Macadamia nut	*Macadamia* spp.
Marsh mallow	*Althaea officinalis*
Peanut	*Arachis hypogaea*
Tea	*Camellia sinensis*
Bay leaf	*Laurus nobilis*
Gurmar	*Gymnema sylvestre*

DIARRHEA

Agrimony	*Agrimonia eupatoria*
Apple	*Malus domestica*
Bilberry	*Vaccinium* spp.
Blueberry	*Vaccinium* spp.
Blackberry	*Rubus* spp.
Raspberry	*Rubus* spp.
Carob	*Ceratonia siliqua*
Carot	*Daucus carota*
Fenugreek	*Trigonella foenum-graecum*
Oak	*Quercus* spp.
Pomegranate	*Punica granatum*
Psyllium	*Plantago ovata*
Tea	*Camellia sinensis*

DIVERTICULITIS

Flax	*Linum usitatissimum*
Psyllium	*Plantago ovata*
Wheat	*Triticum aestivum*
Slippery elm	*Ulmus rubra*
Camomile	*Matricaria recutita*
Prune	*Prunus dulcis*
Wild yam	*Dioscorea villosa*

DIZZINESS

Ginger	*Zingiber officinale*
Ginkgo	*Ginkgo biloba*
Celery	*Apium graveolens*
Pumpkin	*Cucurbita pepo*

DRY MOUTH

Echinacea	*Echinacea* spp.
Evening-primrose	*Oenothera biennis*
Multiflora rose	*Rosa multiflora*
Red pepper	*Capsicum* spp.
Yohimbe	*Pausinystalia yohimbe*

EARACHE

Echinacea	*Echinacea* spp.
Ephedra	*Ephedra sinica*
Garlic	*Allium sativum*
Goldenseal	*Hydrastis canadensis*
Forsythia	*Forsythia suspensa*
Gentian	*Gentiana officinalis*
Honeysuckle	*Lonicera japonica*
Mullein	*Verbascum thapsus*
Peppermint	*Mentha piperita*
Tea tree	*Melaleuca* spp.

EMPHYSEMA

Mullein	*Verbascum thapsus*
Red pepper	*Capsicum* spp.
Camu-camu	*Myrciaria dubia*
Cardamon	*Elettaria cardamomum*
Eucalyptus	*Eucalyptus* spp.
Licorice	*Glycyrrhiza glabra*
Peppermint	*Mentha piperita*
Seneca snakeroot	*Polygala senega*
Basil	*Ocimum basilicum*
Elecampane	*Inula helenium*
Oregano	*Origanum vulgare*
Tea	*Camellia sinensis*

ERECTILE DYSFUNCTION

Fava bean	*Vicia faba*
Ginkgo	*Ginkgo biloba*
Velvet bean	*Mucuna* spp.
Yohimbe	*Pausinystalia yohimbe*
Anise	*Pimpinella anisum*
Cardomom	*Elettaria cardamomum*
Cinnamon	*Cinnamomum* spp.
Ginger	*Zingiber officinale*
Ginseng	*Panax* spp.
Muira puama	*Ptychopetalum* spp.
Oat	*Avena sativa*
Quebracho	*Aspidosperma quebracho-blanco*
Wolfberry	*Lycium chinense*
Ashwaganda	*Withania somnifera*
Country mallow	*Sida cordifolia*
Guarana	*Paullinia cupana*
Saw palmetto	*Serenoa repens*

FAINTING

Broomweed	*Sida rhombifolia*
Cardamom	*Elettaria cardamomum*
Coffee	*Coffea arabica*
Tea	*Camellia sinensis*
Country mallow	*Sida cordifolia*
Ephedra	*Ephedra sinica*
Eucalyptus	*Eucalyptus* spp.
Roemary	*Rosmarinus officinalis*
Lavender	*Lavandula* spp.
Soursop	*Annona muricata*

FEVER

Willow	*Salix* spp.
Meadowsweet	*Filipendula ulmaria*
Elder	*Sambucus nigra*
Ginger	*Zingiber officinale*
Peppermint	*Mentha piperita*
Red pepper	*Capsicum* spp.

FUNGAL INFECTIONS

Garlic	*Allium sativum*
Licorice	*Glycyrrhiza glabra*
Tea tree	*Melaleuca* spp.
Black walnut	*Juglans nigra*
Camomile	*Matricaria recutita*
Goldenseal	*Hydrastis canadensis*
Henna	*Lawsonia inermis*
Lemon grass	*Cymbopogon* spp.
Pau-d'arco	*Tabebuia* spp.
Turmeric	*Curcuma longa*

GALLSTONES & KIDNEYSTONES

Beggar-lice	*Desmodium styracifolium*
Celandine	*Chelidonium majus*
Couch grass	*Elymus repens*
Ginger	*Zingiber officinale*
Horsetail	*Equisetum arvense*
Peppermint	*Mentha piperita*
Spearmint	*Mentha spicata*
Turmeric	*Curcuma longa*
Goldenrod	*Solidago virgaurea*
Java tea	*Orthosiphon aristatus*
Lovage	*Levisticum officinale*
Milk thistle	*Silybum marianum*
Parsley	*Petroselinum crispum*
Stinging nettle	*Urtica dioica*

GENITAL HERPES & COLD SORES

Lemon balm	*Melissa officinalis*
Echinacea	*Echinacea* spp.
Red pepper	*Capsicum* spp.
St. John's wort	*Hypericum perforatum*
Garlic	*Allium sativum*

GINGIVITIS (GUM DISEASE)

Bloodroot	*Sanguinaria canadensis*
Camomile	*Matricaria recutita*
Echinacea	*Echinacea* spp.
Licorice	*Glycyrrhiza glabra*
Purslane	*Portulaca oleracea*
Sage	*Salvia officinalis*
Tea	*Camellia sinensis*
Calendula	*Calendula officinalis*
Peppermint	*Mentha piperita*
Rhatany	*Krameria triandra*
Stinging nettle	*Urtica dioica*
Tea tree	*Melaleuca* spp.
Watercress	*Nasturtium officinale*

GLAUCOMA

Jaborandi	*Pilocarpus* spp.
Kaffir-potato	*Coleus forskohlii*
Oregano	*Origanum vulgare*
Pansy	*Viola* spp.
Bilberry	*Vaccinium myrtillus*
Shepherd's purse	*Capsella bursa-pastoris*

GOUT

Celery	*Apium graveolens*
Chiso	*Perilla frutescens*
Licorice	*Glycyrrhiza glabra*
Turmeric	*Curcuma longa*
Avocado	*Persea americana*
Cat's claw	*Uncaria* spp.
Cherry	*Prunus* spp.
Devil's claw	*Harpagophytum procumbens*
Oat	*Avena sativa*
Olive	*Olea europea*
Pineapple	*Ananas comosus*
Stinging nettle	*Urtica dioica*
Willow	*Salix* spp.

HANGOVER

Cinchona	Cinchona spp.
Ginkgo	*Ginkgo biloba*
Kudzu	*Pueraria lobata*
Wintergreen	*Gaultheria procumbens*

HEADACHE

Bay leaf	*Laurus nobilis*
Feverfew	*Tanacetum parthenium*
Willow	*Salix* spp.
Evening-primrose	*Oenothera biennis*
Garlic	*Allium sativum*
Onion	*Allium cepa*
Ginger	*Zingiber officinale*
Ginkgo	*Ginkgo biloba*
Red pepper	*Capsicum* spp.
Lemon balm	*Melissa officinalis*
Peppermint	*Mentha piperita*
Purslane	*Portulaca oleracea*
Tansy	*Tanacetum vulgare*
Thyme	*Thymus vulgaris*
Turmeric	*Curcuma longa*

HEARTBURN

Angelica	*Angelica archangelica*
Camomile	*Matricaria recutita*
Licorice	*Glycyrrhiza glabra*
Peppermint	*Mentha piperita*
Cardamom	*Eucalyptus* spp.
Dill	*Anethum graveolens*
Fennel	*Foeniculum vulgare*
Gentian	*Gentiana officinalis*
Papaya	*Carica papaya*
Pineapple	*Ananas comosus*

HEART DISEASE

Pigweed	*Amaranthus* spp.
Willow	*Salix* spp.
Angelica	*Angelica archangelica*
Grape	*Vitis vinifera*
Hawthorn	*Crataegus* spp.
Purslane	*Portulaca oleracea*
Rosemary	*Rosmarinus officinalis*
Chicory	*Cichorium intybus*
Olive	*Olea europea*
Peanut	*Arachis hypogaea*

HEMORRHOIDS

Comfrey	*Symphytum officinale*
Plantain	*Plantago* spp.
Psyllium	*Plantago ovata*
Witch hazel	*Hamamelis virginiana*
Aloe	*Aloë* spp.
Butcher's broom	*Ruscus aculeatus*
Horse-chestunut	*Aesculus hippocastanum*

HIGH BLOOD PRESSURE

Celery	*Apium graveolens*
Garlic	*Allium sativum*
Hawthorn	*Crataegus* spp.
Kudzu	*Pueraria lobata*
Onion	*Allium cepa*
Tomato	*Lycopersicon esculentum*
Broccoli	*Brassica oleracea*
Carrot	*Daucus carota*
Purslane	*Portulaca oleracea*
Saffron	*Crocus sativus*
Valerian	*Valeriana officinalis*

HIGH CHOLESTEROL

Carrot	*Daucus carota*
Avocado	*Persea americana*
Beans	*Phaseolus* spp.
Celery	*Apium graveolens*
Garlic	*Allium sativum*
Onion	*Allium cepa*
Ginger	*Zingiber officinale*
Fenugreek	*Trigonella foenum-graecum*

Safflower	*Carthamus tinctorius*
Sesame	*Sesamum indicum*
Shiitake mushroom	*Lentinus edodes*

HIVES

Jewel weed	*Impatiens capensis*
Stinging nettle	*Urtica dioica*
Parsley	*Petroselinum crispum*
Amaranth	*Amaranthus* spp.
Ginger	*Zingiber officinale*

HIV INFECTION

Licorice	*Glycyrrhiza glabra*
Oregano	*Origanum vulgare*
Self-heal	*Prunella vulgaris*
St. John's wort	*Hypericum perforatum*
Aloe	*Aloë* spp.
Astragalus	*Astragalus* spp.
Black-eyed susan	*Rudbeckia* spp.
Blessed thistle	*Cnicus benedictus*
Burdock	*Arctium lappa*
Echinacea	*Echinacea* spp.
Garlic	*Allium sativum*
Hyssop	*Hyssopus officinalis*
Onion	*Allium cepa*
Pear	*Pyrus communis*
Elderberry	*Sambucus nigra*
Evening-primrose	*Oenothera biennis*
Iceland moss	*Cetraria islandica*

HYPOTHYROIDISM

Gentian	*Gentiana officinalis*
Kelp	*Fucus vesiculosis*
Mustard	*Brassica nigra*
Mustard	*Sinapis alba*
Radish	*Raphanus sativus*
St. John's wort	*Hypericum perforatum*
Walnut	*Juglans* spp.

INDIGESTION

Camomile	*Matricaria recutita*
Peppermint	*Mentha piperita*
Angelica	*Angelica archangelica*
Ginger	*Zingiber officinale*
Marjoram	*Origanum onites*
Coriander	*Coriandrum sativum*
Papaya	*Carica papaya*
Pineapple	*Ananas comosus*
Red pepper	*Capsicum* spp.
Rooibos	*Aspalathus linearis*

INFERTILITY

Cauliflower	*Brassica oleracea*
Ginger	*Zingiber officinale*
Ginseng	*Panax* spp.
Guava	*Psidium* spp.
Jute	*Corchorus olitorius*
Spinach	*Spinacia oleracea*
Sunflower	*Helianthus annuus*
Ashwaganda	*Withamia somnifera*
Bottle gourd	*Lagenaria siceraria*

INFLAMMATORY BOWEL DISEASE

Onion	*Allium cepa*
Psyllium	*Plantago ovata*
Tea	*Camellia sinensis*
Valerian	*Valeriana officinalis*

INHIBITED SEXUAL DESIRE IN WOMEN

Chinese angelica	*Angelica sinensis*
Ginseng	*Panax* spp.
Quebracho	*Aspidosperma quebracho-blanco*
Yohimbe	*Pausinystalia yohimbe*
Anise	*Pimpinella anisum*
Chocolate	*Theobroma cacao*
Cola	*Cola nitida*
Epimedium	*Epimedium* spp.
Fennel	*Foeniculum vulgare*
Ginger	*Zingiber officinale*
Parsley	*Petroselinum crispum*
Saw palmetto	*Serenoa repens*
Wild yam	*Dioscorea villosa*

INSECT REPELLANTS

Mountain mint	*Pycnanthemum muticum*
Pennyroyal	*Hedeoma pulegioides*
Basil	*Ocimum basilicum*
Citronella	*Cymbopogon* spp.
Lemon grass	*Cymbopogon* spp.

INSECT BITES & STINGS

Calendula	*Calendula officinalis*
Garlic	*Allium sativum*
Onion	*Allium cepa*
Plantain	*Plantago* spp.

INSOMNIA

Lemon balm	*Melissa officinalis*
Valerian	*Valeriana officinalis*
Lavender	*Lavandula* spp.
Passion flower	*Passiflora incarnata*
Camomile	*Matricaria recutita*
Catnip	*Nepeta cataria*
Hops	*Humulus lupulus*
Rooibus	*Aspalathus linearis*

INTESTINAL PARASITES

Cinchona	*Cinchona* spp.
Goldenseal	*Hydrastis canadensis*
Ipecac	*Cephaelis ipecacuanha*
Elecampane	*Inula helenium*
Papaya	*Carica papaya*
Sweet Annie	*Artemisia annua*
Cubeb berry	*Piper cubeba*

LARYNGITIS

Cardamomum	*Eucalyptus* spp.
Ginger	*Zingiber officinale*
Horehound	*Marrubium vulgare*
Mallow	*Althaea* spp.
Mullein	*Verbascum thapsus*
Couch grass	*Elymus repens*
Echinacea	*Echinacea* spp.
Elecampane	*Inula helenium*
English ivy	*Hedera helix*
Knotgrass	*Polygonum aviculare*
Plantain	*Plantago* spp.
Primrose	*Primula veris*
Soapwort	*Saponaria officinalis*
Stinging nettle	*Urtica dioica*
Sundew	*Drosera* spp.

LICE

Neem tree	*Azadiracta indica*
Turmeric	*Curcuma longa*
Sweetflag	*Acorus calamus*

LIVER PROBLEMS

Carrot	*Daucus carota*
Dandelion	*Taraxacum officinale*
Indian-almond	*Terminalia catappa*
Milk thistle	*Silybum marianum*
Schisandra	*Schisandra chinensis*
Tamarind	*Tamarindus indica*
Chicory	*Cichorium intybus*
Chinese angelica	*Angelica chinensis*
Javanese turmeric	*Curcuma xanthorrhiza*
Licorice	*Glycyrrhiza glabra*
Bottle gourd	*Lagenaria siceraria*
Ginger	*Zingiber officinale*
Tea	*Camellia sinensis*
Turmeric	*Curcuma longa*

LYME DISEASE

Echinacea	*Echinacea* spp.
Garlic	*Allium sativum*
Mountain mint	*Pycnanthemum muticum*
Licorice	*Glycyrrhiza glabra*

MACULAR DEGENERATION

Bilberry	*Vaccinium myrtillus*
Collard greens	*Brassica oleracea*
Spinach	*Spinacia oleracea*
Ginkgo	*Ginkgo biloba*
Peanut	*Arachis hypogaea*
Clove	*Syzygium aromaticum*
Wolfberry	*Lycium chinense*

MENOPAUSE

Black cohosh	*Cimicifuga racemosa*
Licorice	*Glycyrrhiza glabra*
Alfalfa	*Medicago sativa*
Chaste berry	*Vitex agnus-castus*
Chinese angelica	*Angelica sinensis*
Red clover	*Trifolium pratense*
Strawberry	*Fragaria* spp.

MENSTRUAL CRAMPS

Black haw	*Viburnum prunifolium*
Chinese angelica	*Angelica chinense*
Chaste berry	*Vitex agnus-castus*
Ginger	*Zingiber officinale*
Kava kava	*Piper methysticum*
Red clover	*Trifolium pratense*
Squaw vine	*Mitchella repens*
Strawberry	*Fragaria* spp.
Yarrow	*Achillea millefolium*

MORNING SICKNESS

Ginger	*Zingiber officinale*
Peppermint	*Mentha piperita*
Black horehound	*Ballota nigra*
Cabbage	*Brassica oleracea*
Peach	*Prunus persica*
Raspberry	*Rubus idaeus*

MOTION SICKNESS

Ginger	*Zingiber officinale*

MULTIPLE SCLEROSIS

Stinging nettle	*Urtica dioica*
Black currant	*Ribes nigrum*
Blueberry	*Vaccinium* spp.
Evening-primrose	*Oenothera biennis*
Pineapple	*Ananas comosus*
Purslane	*Portulaca oleracea*

NAUSEA

Ginger	*Zingiber officinale*
Cinnamon	*Cinnamomum* spp.
Peppermint	*Mentha piperita*

OSTEOPOROSIS

Cabbage	*Brassica oleracea*
Dandelion	*Taraxacum officinale*
Pigweed	*Amaranthus* spp.
Avocado	*Persea americana*
Soybean	*Glycine max*
Black pepper	*Piper nigrum*
Horsetail	*Equisetum arvense*
Parsley	*Petroselinum crispum*

OVERWEIGHT

Psyllium	*Plantago ovata*
Red pepper	*Capsicum* spp.
Chickweed	*Stellaria media*
Evening-primrose	*Oenothera biennis*
Pineapple	*Ananas comosus*
Walnut	*Juglans* spp.

PAIN RELIEF

Clove	*Syzygium aromaticum*
Red pepper	*Capsicum* spp.
Willow	*Salix* spp.
Evening-primrose	*Oenothera biennis*
Ginger	*Zingiber officinale*
Kava kava	*Piper methysticum*
Lavender	*Lavandula* spp.
Mountain mint	*Pycnanthemum muticum*
Peppermint	*Mentha piperita*
Sunflower	*Helianthus annuus*
Turmeric	*Curcuma longa*
Eucalyptus	*Eucalyptus* spp.
Rosemary	*Rosmarinus officinalis*

PARKINSON'S DISEASE

Fava bean	*Vicia faba*
Velvet bean	*Mucuna* spp.
Evening-primrose	*Oenothera biennis*
Ginkgo	*Ginkgo biloba*
Passion flower	*Passiflora incarnata*
St. John's wort	*Hypericum perforatum*

PNEUMONIA

Astragalus	*Astragalus* spp.
Baikal skullcap	*Scutellaria baicalensis*
Dandelion	*Taraxacum officinale*
Echinacea	*Echinacea* spp.
Garlic	*Allium sativum*
Goldenseal	*Hydrastis canadensis*
Honeysuckle	*Lonicera japonica*
Onion	*Allium cepa*
Osha	*Lomatium dissectum*
Sundew	*Drosera* spp.

POISON-IVY, -OAK, -SUMAC

Aloe	*Aloë* spp.
Plantain	*Plantago* spp.
Soapwort	*Saponaria officinalis*

PREGNANCY & DELIVERY

Partridge berry	*Mitchella repens*
Raspberry	*Rubus idaeus*

Black haw	*Viburnum prunifolium*
Blue cohosh	*Caulophyllum thalictroides*
Jute	*Corchorus olitorius*
Parsley	*Petroselinum crispum*
St. John's wort	*Hypericum perforatum*
Shepherd's purse	*Capsella bursa-pastoris*
Spinach	*Spinacia oleracea*

PREMENSTRUAL SYNDROME

Chaste berry	*Vitex agnus-castus*
Chinese angelica	*Angelica chinense*
Evening-primrose	*Oenothera biennis*
Stinging nettle	*Urtica dioica*
Burdock	*Arctium lappa*
Raspberry	*Rubus idaeus*
Skullcap	*Scutellaria lateriflora*
Valerian	*Valeriana officinalis*

PROSTATE ENLARGEMENT

Licorice	*Glycyrrhiza glabra*
Pumpkin	*Cucurbita pepo*
Saw palmetto	*Serenoa repens*
Pygeum	*Pygeum africanum*
Stinging nettle	*Urtica dioica*

PSORIASIS

Bishop's weed	*Ammi visnaga*
Red pepper	*Capsicum* spp.
Angelica	*Angelica archangelica*
Avocado	*Persea americana*
Brazil nut	*Bertholettia excelsa*
Camomile	*Matricaria recutita*
Flax	*Linum usitatissimum*
Licorice	*Glycyrrhiza glabra*
Oat	*Avena sativa*
Oregon grape	*Mahonia repens*
Purslane	*Portulaca oleracea*
Fumitory	*Fumaria* spp.
Lavender	*Lavandula* spp.
Milk thistle	*Silybum marianum*

SCABIES

Evening-primrose	*Oenothera biennis*
St. John's wort	*Hypericum perforatum*
Neem tree	*Azadiracta indica*
Turmeric	*Curcuma longa*
Onion	*Allium cepa*
American pennyroyal	*Hedeoma pulegioides*
Mountain mint	*Pycnanthemum muticum*
Oat	*Avena sativa*
Star anise	*Illicium verum*
Tea tree	*Melaleuca* spp.
Walnut	*Juglans* spp.
Aloe	*Aloë* spp.
Five-leaved chaste tree	*Vitex negundo*
Peppermint	*Mentha piperita*
Tansy	*Tanacetum vulgare*

SCIATICA

Stinging nettle	*Urtica dioica*
Willow	*Salix* spp.
Wintergreen	*Gaultheria procumbens*
Chinese angelica	*Angelica chinense*
Country mallow	*Sida cordifolia*
Mustard	*Brassica nigra*
Mustard	*Sinapis alba*
Sciatica cress	*Lepdium* spp.
Ginger	*Zingiber officinale*
Sesame	*Sesamum indicum*

SHINGLES

Lemon balm	*Melissa officinalis*
Red pepper	*Capsicum* spp.
Baikal skullcap	*Scutellaria baicalensis*
Chinese angelica	*Angelica chinense*
Licorice	*Glycyrrhiza glabra*
Passion flower	*Passiflora incarnata*
Bergamot	*Citrus bergamotia*
Pear	*Pyrus* spp.
Purslane	*Portulaca oleracea*
Soybean	*Glycine max*
Watercress	*Nasturtium officinale*

SINUS INFLAMMATION

Garlic	*Allium sativum*
Onion	*Allium cepa*
Goldenseal	*Hydrastis canadensis*
Echinacea	*Echinacea* spp.
Eucalyptus	*Eucalyptus* spp.
Oregano	*Origanum vulgare*
Ginkgo	*Ginkgo biloba*
Horseradish	*Armoracia rusticana*
Pineapple	*Ananas comosus*

SKIN PROBLEMS

Aloe	*Aloë* spp.
Evening-primrose	*Oenothera biennis*
Avocado	*Persea americana*
Calendula	*Calendula officinalis*
Camomile	*Matricaria recutita*
Cucumber	*Cucumis sativus*
Gotu kola	*Centella asiatica*
Wild pansy	*Viola tricolor*
Witch hazel	*Hamamelis virginiana*
Carrot	*Daucus carota*
English plantain	*Plantago lanceolata*
English ivy	*Hedera helix*
Marsh mallow	*Althaea officinalis*
Pineapple	*Ananas comosus*
Purslane	*Portulaca oleracea*
Walnut	*Juglans* spp.

SORES

Calendula	*Calendula officinalis*
Comfrey	*Symphytum officinale*
Dragon's blood	*Croton lechleri*
Camomile	*Matricaria recutita*
Country mallow	*Sida cordifolia*
Ginkgo	*Ginkgo biloba*
Tea tree	*Melaleuca* spp.
Gotu kola	*Centella asiatica*
Tea	*Camellia sinensis*

SORE THROAT

Eucalyptus	*Eucalyptus* spp.
Honeysuckle	*Lonicera japonica*
Licorice	*Glycyrrhiza glabra*
Slippery elm	*Ulmus rubra*
Balloon flower	*Platycodon grandiflorum*
Burnet-saxifrage	*Pimpinella major*
Garlic	*Allium sativum*
Ginger	*Zingiber officinale*
Marsh mallow	*Althaea officinalis*
Wintergreen	*Gaultheria procumbens*
Agrimony	*Agrimonia eupatoria*
Anise	*Pimpinella anisum*
Knotgrass	*Polygnum aviculare*
Myrrh	*Commiphora* spp.
Plantain	*Plantago* spp.

STIES

Echinacea	*Echinacea* spp.
Goldenseal	*Hydrastis canadensis*
Potato	*Solanum tuberosum*
Thyme	*Thymus vulgaris*
Camomile	*Matricaria recutita*
Garlic	*Allium sativum*

STROKES

Garlic	*Allium sativum*
Ginkgo	*Ginkgo biloba*
Pigweed	*Amaranthus* spp.
Willow	*Salix* spp.
Carrot	*Daucus carota*
English pea	*Pisum sativum*
Pineapple	*Ananas comosus*
Scurfy pea	*Psoralea corylifolia*
Bilberry	*Vaccinium myrtillus*
Evening-primrose	*Urtica dioica*
Ginger	*Zingiber officinale*
Spinach	*Spinacia oleracea*
Turmeric	*Curcuma longa*

SUNBURN

Tea	*Camellia sinensis*
Aloe	*Aloë* spp.
Black nightshade	*Solanum nigrum*
Calendula	*Calendula officinalis*
Cucumber	*Cucumis sativus*
Eggplant	*Solanum melongena*
Plantain	*Plantago* spp.
Witch hazel	*Hamamelis virginiana*

SWELLING

Ginger	*Zingiber officinale*
Pineapple	*Ananas comosus*
Turmeric	*Curcuma longa*
Aloe	*Aloë* spp.
Arnica	*Arnica montana*
Cat's claw	*Uncaria* spp.
Maize	*Zea mays*
Dandelion	*Taraxacum officinale*
Multiflora rose	*Rosa mutiflora*
Spanish needles	*Bidens pilosa*

TINNITUS (Ringing in ears)

Ginkgo	*Ginkgo biloba*
Sesame	*Sesamum indicum*
Black cohosh	*Cimicifuga racemosa*
Goldenseal	*Hydrastis canadensis*
Lesser periwinkle	*Vinca minor*
Spinach	*Spinacia oleracea*

TONSILLITIS

Echinacea	*Echinacea* spp.
Garlic	*Allium sativum*
Honeysuckle	*Lonicera japonica*
Sage	*Salvia officinalis*
Citrus fruits	*Citrus* spp.
Blackberry	*Rubus* spp.
Persimmon	*Diospyros virginiana*
Dandelion	*Taraxacum officinale*
Elderberry	*Sambucus nigra*
New Jersey tea	*Ceanothus americanus*

TOOTHACHE

Clove	*Syzygium aromaticum*
Ginger	*Zingiber officinale*
Red pepper	*Capsicum* spp.
Toothache tree	*Zanthoxylum americanum*
Willow	*Salix* spp.
Rhubarb	*Rheum officinale*
Sesame	*Sesamum indicum*

TOOTH DECAY

Tea	*Camellia sinensis*
Bay leaf	*Laurus nobilis*
Bloodroot	*Sanguinaria officinalis*
Licorice	*Glycyrrhiza glabra*
Peanut	*Arachis hypogaea*
Stevia	*Stevia rebaudiana*
Toothache tree	*Zanthoxylum americanum*
Wild bergamot	*Monarda fistulosa*
Creosote bush	*Larrea divaricata*
Myrrh	*Commiphora* spp.

TUBERCULOSIS

Echinacea	*Echinacea* spp.
Forsythia	*Forsythia suspensa*
Garlic	*Allium sativum*
Honeysuckle	*Lonicera japonica*
Licorice	*Glycyrrhiza glabra*
Eucalyptus	*Eucalyptus* spp.
Onion	*Allium cepa*

ULCERS

Ginger	*Zingiber officinale*
Licorice	*Glycyrrhiza glabra*
Yellowroot	*Xanthorrhiza simplicissima*
Banana	*Musa x paradisiaca*
Cabbage	*Brassica oleracea*
Calendula	*Calendula officinalis*
Camomile	*Matricaria recutita*
Garlic	*Allium sativum*
Gentian	*Gentiana officinalis*
Pineapple	*Ananas comosus*
Red pepper	*Capsicum* spp.
Bilberry	*Vaccinium* spp.
Blueberry	*Vaccinium* spp.
Meadowsweet	*Filipendula ulmaria*
Rhubarb	*Rheum officinale*
Turmeric	*Curcuma longa*

VAGINITIS

Garlic	*Allium sativum*
Tea tree	*Melaleuca* spp.
Cardamom	*Elettaria cardamomum*
Goldenseal	*Hydrastis canadensis*
Comfrey	*Symphytum officinale*
Lavender	*Lavandula* spp.
Yellow dock	*Rumex crispus*

VARICOSE VEINS

Horse-chestnut	*Aesculus hippocastanum*
Violet	*Viola* spp.
Witch hazel	*Hamamelis virginiana*
Butcher's broom	*Ruscus aculeatus*
Lemon	*Citrus limon*
Onion	*Allium cepa*
Bilberry	*Vaccinium myrtillus*
Ginkgo	*Ginkgo biloba*
Gotu kola	*Centella asiatica*
Peanut	*Arachis hypogaea*

VIRAL INFECTION

Echinacea	*Echinacea* spp.
Astragalus	*Astragalus* spp.
Dragon's blood	*Croton lechleri*

Garlic	*Allium sativum*
Goldenseal	*Hydrastis canadensis*
Juniper	*Juniperus* spp.
Lemon balm	*Melissa officinalis*
Licorice	*Glycyrrhiza glabra*
Shiitake mushroom	*Lentinus edodes*
Eucalyptus	*Eucalyptus* spp.
Forsythia	*Forsythia suspensa*
Honeysuckle	*Lonicera japonica*

WARTS

Birch	*Betula* spp.
Bloodroot	*Sanguinaria officinalis*
Castor bean	*Ricinus communis*
Celandine	*Chelidonium majus*
Dandelion	*Taraxacum officinale*
Fig	*Ficus carica*
Milkweed	*Asclepias* spp.
Pineapple	*Ananas comosus*
Soybean	*Glycine max*
Willow	*Salix* spp.
Yellow cedar	*Thuja occidentalis*
Banana	*Musa* x *paradisiaca*
Basil	*Ocimum basilicum*
Papaya	*Carica papaya*

WORMS

Ginger	*Zingiber officinale*
Pumpkin	*Cucurbita pepo*
Wormseed	*Chenopodium ambrosioides*
Garlic	*Allium sativum*
Papaya	*Carica papaya*
Pineapple	*Ananas comosus*
Turmeric	*Curcuma longa*
Clove	*Syzygium aromaticum*

WRINKLES

Horse-chestnut	*Aesculus hippocastanum*
Witch hazel	*Hamamelis virginiana*
Carrot	*Daucus carota*
Cocoa	*Theobroma cacao*
Cucumber	*Cucumis sativus*
Purslane	*Portulaca oleracea*
Rosemary	*Rosmarinus officinalis*
Sage	*Salvia officinalis*
Almond	*Prunus dulcis*
Aloe	*Aloë* spp.
Avocado	*Persea americana*
Castor bean	*Ricinus communis*
Grape	*Vitis vinifera*
Olive	*Olea europea*
Pineapple	*Ananas comosus*

YEAST INFECTIONS

Echinacea	*Echinacea* spp.
Garlic	*Allium sativum*
Cranberry	*Vaccinium macrocarpon*
Goldenseal	*Hydrastis canadensis*
Oau-d'arco	*Tabebuia* spp.
Purslane	*Portulaca oleracea*
Goldenrod	*Solidago virgaurea*
English ivy	*Hedera helix*
Licorice	*Glycyrrhiza glabra*
Sage	*Salvia officinalis*
Spice bush	*Lindera benzoin*

Source: Duke, J. A. 1997. The green pharmacy. Rodale Press. Emmaus, PA. 507 pp.

10.05 • PLANTS USED IN NATIVE AMERICAN THERAPEUTICS

USE: COMMON NAME (SCIENTIFIC NAME)	COMMENT
ANESTHETICS:	
Coca (*Erythroxylum coca*)	Used by Inca in skull surgery ?
ASEPSIS (FREE FROM DISEASE-CAUSING ORGANISMS):	
Balsam-of-Peru (*Myroxylon pereirae*)	Antiseptic and for open wounds
ASTRINGENTS (SUBSTANCES THAT CAUSE TISSUES TO CONSTRICT OR DRAW TOGETHER):	
Bayberry (*Myrica cerifera*)	Bark used as powerful astringent
Oak (*Quercus* spp.)	Bark tannins utilized
Persimmon (*Diospyros virginiana*)	Bark and fruits widely used
BURNS AND SCALDS:	
Jimson weed (*Datura stramonium*)	Seeds used
Prairie dock (*Parthenium integrifolium*)	Catawbas used fresh leaves
Tulip tree (*Liriodendron tulipifera*)	Buds used to make soothing ointment
CATHARTICS (SUBSTANCES THAT PURGE THE BOWELS):	
Cascara sagrada (*Rhamnus purshiana*)	Probably the most widely used
Mayapple (*Podophyllum peltatum*)	Dried roots and rhizomes used
CAUTERY AND MOXA (SUBSTANCES FOR SEARING OR BURNING AWAY DISEASED TISSUE):	
Shoestring plant (*Amorpha canescens*)	Omahas burned stems on skin
CONTRACEPTIVES:	
Antelope-sage (*Eriogonum jamesii*)	Roots boiled
Dogbane (*Apocynum androsaemifolium*)	Roots boiled
Deer's tongue (*Frasera speciosa*)	"A half cupful taken once in while"

Indian-turnip (*Arisaema triphylla*)	Powdered roots used
Milkweed (*Asclepias hallii*)	Infusion used
Milkweed (*Asclepias syriaca*)	Roots and rhizomes used
Stoneseed (*Lithospermum ruderale*)	Nevadas used root infusion
Wild ginger (*Asarum canadense*)	Roots and rhizomes boiled

DENTISTRY:

Buttonbush (*Cephalanthus occidentalis*)	Choctaws used bark for toothache
Compass plant (*Silphium* spp.)	Used to clean teeth
Dogwood (*Cornus paniculata*)	Tea made from roots used for toothache
Prickly-ash (*Xanthoxylum americanum*)	Bark widely used to treat toothache
Sweet bay (*Myrica asplenifolium*)	Iroquois remedy for toothache
Tulip tree (*Liriodendron tulipifera*)	Root bark used for toothache

EMETICS (SUBSTANCES THAT PROMOTE VOMITING):

Ipecac (*Cephaelis ipecachuanha*)	Still widely used in patent medicines

EYE PROBLEMS:

Cicimatic (*Canavalia villosa*)	Aztecs used chopped roots
Goldenseal (*Hydrastis canadensis*)	Root infusion used
Osage-orange (*Maclura pomifera*)	Comanches boiled roots
Pepper (*Capsicum* spp.)	Brazilian cure for eye pain
Prickly-poppy (*Argemone* spp.)	Comanches applied sap to eyes

FEBRIFUGES (SUBSTANCES THAT REDUCE FEVER):

Cinchona bark (*Cinchona* spp.)	Bark is source of quinine
Golden Alexander (*Zizia aurea*)	Meswakis used roots
Indian breadroot (*Psoralea argophylla*)	Cheyennes used leaves and stems
Rattlepod (*Astragalus caroliniana*)	Teton Dakotas used root decotion
White crownbeard (*Verbesina virginica*)	Choctaws soaked roots in water

FUMIGATION AND SMOKE THERAPY:

Fleabane (*Erigeron philadelphicus*)	Ojibwas used to relieve head colds
Goldenrod (*Solidago ulmifolia*)	Meswakis used to revive people
Pearly everlasting (*Anaphalis margaritacea*)	Used to aid paralysis victims
Purple cone flower (*Echinacea angustifolia*)	Universal panacea

INSECT BITES AND SKIN CONDITIONS:

Beech tree (*Fagus grandifolia*)	Rappahannocks used to cure poison-ivy
Bedstraw (*Galium trifidum*)	Pillager Ojibwas used for skin disorders
Goldenrod (*Solidago rigida*)	Flowers used to make bee sting lotion
Jewelweed (*Impatiens biflora*)	Used to treat poison-ivy and nettles
Milkweed (*Ascelpias syriaca*)	Rappahannocks used sap for warts
Mulberry (*Morus rubra*)	Rappahannocks used sap for ringworm
Rattlepod (*Astragalus nitidus*)	Cheyenne cure for poison-ivy
Virginia peppergrass (*Lepidium virginianum*)	Cure for poison-ivy
Yiamolli (*Phytolacca octandra*)	Aztec treatment for dandruff

RESPIRATORY AILMENTS:

Red cedar (*Juniperus virginiana*)	Rappahannocks used berries for asthma
Wild ginger (*Asarum canadense*)	Rappahannocks used for asthma

RHEUMATISM AND ARTHRITIS:

False lupine (*Thermopsis rhombifolia*)	Plains Indians used dried flowers
Greasewood (*Larrea tridentata*)	San Carlos Apaches used tops of plants
Ololiuqui (*Turbina corymbosa*)	Mexican Indians used to cure rheumatism

URINARY DISORDERS:

Devil's shoestring (*Tephrosia virginiana*)	Creeks used for bladder trouble
Hop hornbeam (*Ostrya virginiana*)	Ojibwas used as diuretic
Pepper (*Capsicum frutescens*)	Mayan cure for discolored urine
Puccoon (*Lithospermum pilosum*)	Utes used root decoction
Scrub pine (*Pinus virginiana*)	Sap used for kidney ailments

VENEREAL DISEASES:

Blazing star (*Liatris pycnostachya*)	Used to treat gonorrhea
Blue lobelia (*Lobelia siphilitica*)	Famous Iroquois remedy
Guaiacum (*Guaiacum officinale*)	Widely used to treat syphilis
Little bluestem (*Schizachyrium scoparium*)	Ashes used to treat syphilis sores
Prickly-ash (*Xanthoxylum americanum*)	Used to treat gonorrhea
Thistle (*Cirsium undulatum*)	Comanches used roots for gonorrhea
Yerba mansa (*Anemopsis californica*)	Pimas made tea from roots

VEBRMIFUGES:

Horsemint (*Monarda mollis*)	Ojibwas boiled roots
Pinkroot (*Spigelia marilandica*)	Famous Cherokee cure

Turkey-pea (*Tephrosia virginiana*)	Used by several western tribes
Wild plum (*Prunus americana*)	Ojibwas boiled roots
Wormseed (*Chenopodium ambrosioides*)	Used by Nastches and Mayans (?)

[Source: Vogel, V. J. 1970. American Indian medicine. Univ. Oklahoma Press. Norman]

10.06 • SURVEY OF MEDICINAL TEAS

Plant	Active ingredient	Purported use or effect
Alfalfa leaves (*Medicago sativa*).	Vits. A, C, D, E; minerals; saponins.	Analgesic; relieves arthritis
Angelica leaves (*Angelica archangelica*)	Volatile oil, angelic acid; resin	Diuresis; relieves colds, colic, indigestion, bronchitis
Anise seeds (*Pimpinella anisum*)	Volatile oil, anethole, protein	Carminative, flavoring; relieves colds, asthma
Bearberry leaves (*Arctostaphylos uva-ursi*)	Arbutin, tannic & gallic acids, quercitin	Topical antiseptic; astringent; diuretic, relieves bladder inf.
Black willow leaves (*Salix pentandra*)	Salicin, tannins	Analgesic, antipyretic, antimalarial
Blueberry fruits (*Vaccinium myrtillus*)	Tannins, anthocyanins, hydroquinone, myrtillin	Diuretic, antidiarrheal
Boneset leaves (*Symphytum officinale*)	Allantoin, tannins	Improves wound healing, reduces swelling of broken bones, relieves colds, diarrhea
Buchu leaves (*Barosma betulina*)	Volatile oil, diosphenol, glycosides	Diuretic, antiseptic, tonic, gastric remedy
Buckthorn (*Rhamnus frangula*)	Anthroquinone glycosides	Laxative
Catnip leaves (*Nepeta cataria*)	Volatile oil, tannins, geraniol, limonene	Aromatic, antipyretic, calmative
Chamomile flowers (*Anthemis nobilis*)	Volatile oil, anthemide, anthemisine, anthemol, chamazulene, bisabolol	Aromatic, bitter, poultice for inflammations
Couch grass (*Elymus repens*)	Dextrose, levulose glycosides	Diuretic, antirheumatic, relieves cystitis, nutrient drink
Damiana leaves (*Turnera aphrodisiaca*)	Caffeine	Diuretic, aphrodisiac, tonic
Dandelion leaves & roots (*Taraxacum officinale*)	Taraxacin, inulin, levulin, taraxasterol	Diuretic, cholagogic, relieves gastric stress
Eucalyptus leaves (*Eucalyptus globosus*)	Volatile oil containing euca-lyptol, pinene, valeraldehyde	Aromatic, antiseptic, expectorant, relieves colds
Fennel seeds (*Foeniculum vulgare*)	Volatile oil cont. anethol d-pinene, phellandrene	Aromatic, carminative, laxative, flavoring
Foenugreek seeds (*Trigonella foenugraecum*)	Volatile oils, mucilage trigonelline, yellow dye	Antidiarrheal, maple flavor, relieves colds and fevers
Ginseng root (*Panax quinquefolium*)	Panaxoside glycosides, sugars amino acids, sterols, flavonoids	"Adaptogen" and aphrodisiac
Goldenseal root (*Hydrastis canadensis*)	Hydrastine, berberine, canadine, yellow dye	Tonic, laxative, antiinflamatory, dye, stain

Hops flowers (*Humulus lupulus*)	Volatile oil containing humulene, resins, humulon, lupulon	Relieves indigestion, sleeplessness
Horsetails (*Equisetum arvense*)	Silica, aconitic acid, nicotine, equisitine	Diuretic, relieves dyspepsia
Juniper berries (*Juniperus communis*)	Volatile oil containing terpinen, pinene, camphene cadinene, terebene	Diuretic, laxative, flavoring
Licorice roots (*Glycyrrhiza glabra*)	Glycyrrhizin, sugars, glycyrrhetinic acid	Cough suppresant, laxative, flavoring
Linden flowers (*Tilia europaea*)	Volatile oil, glycosides tannins, carotene, Vit. C	Fragrant tea, remedy for indigestion, dyspepsia
Maté leaves (*Ilex paraguariensis*)	Caffeine, tannins	CNS stimulant
Mistletoe berries (*Viscum album*)	Phenylethylamine, tyramine viscotoxin	Narcotic tea, calmative, tonic
Oat straw (*Avena sativa*)	Saponins, fructose, avenin	Nerve stimulant, antispasmodic
Papaya fruits & leaves (*Carica papaya*)	Papain, carpaine, Vits C & E	Protein digestant; back pain
Peppermint leaves (*Mentha piperita*)	Volatile oil containing amyl alcohol, pinene, limonene, menthol, etc.	Digestive aid, prevents flatulence/colic
Rose hips (*Rosa* spp.)	Vit. C, tannins	Perfume, relieves colds
Sassafras root bark (*Sassafras officinale*)	Volatile oil containing safrole, pinene, etc.	Antirheumatic, aromatic
Spearmint leaves (*Mentha viridis*)	Volatile oil containing limonene, carvone, etc.	Diuretic, relieves vomiting, flatulence
Strawberry (*Fragaria* spp.)	Catechins, leucoanthocyanins, etc.	Diuretic, berries for rheumatic gout, roots as astringent, antidiarrheal
Yarrow flowers (*Achillea millefolium*)	Volatile oil, achilleine, achilleic acid, cineol	Hair and scalp care, relieves colds, hemorrhoids
Yerba santa (*Eriodictyon californicum*)	Tannic acid, eriodictyol, pentatriacontane, flavones	Bitter tonic, expectorant, relieves bronchiolar congestion, hemorrhoids, hay fever

*[After Der Marderosian, A. 1977. Medicinal teas -- boon or bane? Drug Therapy February: 178-186]

SECTION 11 • PSYCHOACTIVE PLANTS

11.1 - AN OVERVIEW

☼ The plant kingdom is the source of most of the substances that affect our mental processes, behavior, or that alter our perception of the universe around us.

☼ We have become dependent upon a series of plant products that provide these psychoactive effects.

☼ Many of these plants are used by individuals; others are used more commonly in a ceremonial or ritual context where they have become important elements in our religions, myths, and magic.

☼ These plants contain one or more chemicals (often alkaloids) that stimulate, depress, produce a sense of well-being, or cause us to hallucinate.

☼ This category overlaps with medicinal plants (opiates, cocaine, marijuana), beverages (tea, coffee, cocoa, alcohol), spices (nutmeg), and recreational ones (tobacco).

☼ Only a few of these plants (tobacco, alcohol, tea, coffee, cacao, coca, marijuana, and opium) are of economic significance. Most of the others are used locally.

☼ Most of what we experience from psychoactive plants can be explained by the toxic effects that they have on our central nervous system.

☼ For some yet unexplained reason, the New World has more psychoactive plants than the Old World.

☼ Many psychoactive plants are not as dangerous as their critics suggest, nor are they as risk free as their proponents believe them to be.

☼ Terms such as psychoactive, hallucinogenic, addictive, and narcotic have reasonably precise definitions, but they are often lost in everyday discussions.

☼ Recent research has brought into question the psychoactive properties of several plants with long standing reputations, such as the mescal bean.

11.2 • INTRODUCTION

"If human consciousness is the most wonderful thing on earth, the attempt to fathom the depths of the psychophysiological action of narcotic and stimulating drugs makes this wonder seem greater still.... Such effects are brought about by chemical substances. The most powerful of these are products of the vegetable kingdom, into whose silent growth and creative abundance man has not yet fully penetrated. By the exercise of their powers on the brain, they release marvelous stores of latent energy. They relieve the mentally tortured, assuage the racking pains of the sick, inspire with hope those doomed to death, endow the overworked with new vitality and vigour such as no strength of will could attain, and replace for an hour the exhaustion and langour of the overworked by mental comfort and content." (Louis Lewin, Phantastica)

"Experiences with plant drugs have puzzled and fascinated our species for millennia. They have revealed substances powerful enough to heal or to kill. Yet, whether they help or hurt, these plants are also pursued for their power to intoxicate with stimulating, inebriating, tranquilizing, or hallucinogenic properties. We search our planetary garden for these mind-altering delights with a passion so blinding that the garden becomes a labyrinth, the search becomes the goal, and our passion becomes addiction."
(Ronald Siegel, Intoxication)

"Every kind of addiction is bad, no matter whether the drug be alcohol, morphine or idealism." (Carl Jung)

☼ ☼ ☼ ☼ ☼

There are about 250,000 different kinds of plants. Only a 150 or so have been used as sources of psychoactive substances in either primitive or advanced societies. Siegel (1989) has suggested that if we look at the history of our species we will discover that the use of these intoxicants is one our four basic drives, along with hunger, thirst, and sex. Of these plants, only tobacco, opium, coca, cacao, marijuana, coffee, tea, and alcohol are of any commercial importance.

WHAT TO CALL THEM?

Scholars have found it difficult to come up with an acceptable collective name for this category of plants. Those that have been suggested include: deliriants, delusionegens, eidetics, entheogens, genussmittel, hallucinogens, misperceptinogens, mysticomimetics, phanerothymes, phantastica, phantasticants, psychedelics, psychodelics, psychotica, psychoticants, psychogens, psychosimetics, psychodysleptics, psychotaraxics, psychotogens, psychomimetics, psychotomimetics, psychotropic, and schizogens.

WHY DO WE USE THEM?

Various authors have suggested the following reasons for our use of these plants. They are not in any particular order of importance.

☼ to alter moods
☼ to explore self
☼ to escape boredom and despair
☼ to enhance sensory experiences and pleasure
☼ to stimulate artistic creativity and performance
☼ to improve physical performance
☼ to treat disease
☼ to rebel

- to go along with peers
- to establish an identity
- to aid in religious experiences.

HOW DO WE USE THEM?

We have discovered a variety of ways of introducing psychoactive materials into our bodies. Eating, drinking, and smoking of plant materials come quickly to mind. Less obvious methods include mastication (chewing on plant material without swallowing it), inhaling/snuffing, applying materials to the skin (often mixed with animal fat), putting finely ground powders under our eyelids, injecting via the hypodermic needle (a 19th century invention), and inserting material into the nostrils, rectum, and vagina.

These different approaches have something in common. They are designed to bring the psychoactive substance into contact with capillary-rich tissues or to introduce them directly into the circulatory system. This is their pathway to chemical binding sites in the central nervous system. Depending on the method employed and the chemicals involved, it can take only a few seconds to a few minutes for these psychoactive substances to reach the brain.

THEIR EFFECTS

We are dealing here with plant materials that have profound or significant effects on our mental processes. They affect our mental activity, our behavior, and even our perceptions of the world around us. Many of these substances are **intoxicants** that either dull the senses or stimulate them. Others are **narcotics**. In the popular sense, this term is used for any dangerous drug. In the narrower sense, narcotics are those materials that induce drowsiness, sleep, or anesthesia. Some of these plants can produce **addiction**. You can become enslaved to its use. Addiction is characterized by craving for the material, developing a tolerance to it, and suffering reasonably serious trauma when we attempt to cease using it (withdrawal).

The classification developed by Louis Lewin (1931) may be helpful in understanding the breadth of effects of psychoactive plants. He recognized five classes:

Excitantia. *"Their action, which extends to the brain and particularly to the cerebral cortex, is a purely exciting or stimulating one, which, even if highly concentrated and intense, produces these effects without calling forth serious symptoms of fatigue or inhibition of the functions."* Examples: tobacco, caffeinated beverages

Inebriantia. *"A primary phase of cerebral excitation is followed by a state of depression which may eventually extend to complete temporary suppression of functions."* Examples: alcoholic beverages

Hypnotica. These are the sleep-producing agents. Example: kava

Euphorica. *"These substances diminish or even suspend the functions of emotion and perception in their widest sense, sometimes reducing or suppressing, sometimes conserving consciousness, inducing in the person concerned a state of physical and mental comfort."* Examples: coca and opium

Phantastica. *"... I mean the action of chemical substances capable of evoking such transitory states without any physical inconvenience for a certain time in persons of perfectly normal mentality who are partly or fully conscious of the action of the drug... These phenomena may be accompanied or followed by unconsciousness or other symptoms of altered cerebral functioning."* Examples: marijuana, fly agaric, sacred mush-rooms, nutmeg, Jimson weed, and peyote

You may be surprised to find coffee, tea, chocolate, and the various alcoholic beverages classed as psychoactive. How could it be otherwise? These plants have been discussed elsewhere and will not be treated further here. The remaining three categories constitute the subjects for this section. The last class, the Phantastica, is probably the most interesting. These plants, in particular, have been afforded a very special place in both primitive and advanced societies. They are the plants that bring about hallucinations. We can perceive an external object or stimulus with any of our five senses. There are visual (sight), auditory (hearing), olfactory (smell), tactile (touch), and gustatory (taste) hallucinations.

SOME CHEMICAL CONSIDERATIONS

The chemical basis of the activity of the many plants classed as psychoactive is incompletely understood. Many species have had their active principles analyzed in great detail. Others remain completely unknown. The chemical nature of the Excitantia and Inebriantia have been discussed elsewhere. Kava of the Hypnotica contains methysticin and other components in a series of related substituted 5,6-dihydro-α-pyrones. Coca of the "Euphorica" contains about 25 alkaloids, of which cocaine is the best known. The hallucinogens of Lewin's "Phantastica" contain a variety of active principles, most of them containing nitrogen. A few of the hallucinogens are partly or wholly synthetic. Lysergic acid diethylamide (LSD), for instance, does not occur naturally in plants, although LSD-like substances are found.

CHEMISTRY OF THE PSYCHOACTIVES

Group: Plant	Chemical Group
Excitantia:	
Tobacco	Alkaloids (nicotine)
Coffee	Alkaloids (caffeine)
Tea	Alkaloids (caffeine)
Chocolate	Alkaloids (caffeine)
Khat	Alkaloids (d-norpseudoephedrine)
Inebriantia:	
Alcoholic beverages	Alcohol (ethanol)
Hypnotica:	
Kava kava	Dihydro-α-pyrones
Euphorica:	
Coca leaf	Alkaloids (cocaine)
Opium	Alkaloids (morphine codeine)
Betel nut	Alkaloids (arecoline)
Phantastica (Hallucinogens):	
Ayahusaca	Alkaloids (tryptamine carboline)
Belladonna	Alkaloids (tropane)
Datura (Jimson weed)	Alkaloids (tropane)
Fly agaric	Alkaloids (muscimol)
Marijuana	Resins (tetrahydrocanninols)

Mescal bean	Alkaloids (quinolizidine)
Nutmeg	Phenylpropenes (myristicin)
Ololiuqui	Alkaloids (ergoline)
Peyote	Alkaloids (mescaline)
Sacred mushrooms	Alkaloids (tryptamine)
Snuffs	Alkaloids (tryptamine)

P S Y C H O A C T I V E   P L A N T S

Group: Family	Scientific Name (Common Name)	Part Used	Where Used (Type)
	FUNGI		
Agaricaceae	*Amanita muscaria* (fly agaric, soma)	Sporocarp	Eurasia (H)
Agaricaceae	*Conocybe* spp. (sacred mushroom)	Sporocarp	Mexico (H)
Agaricaceae	*Panaeolus sphinctrinus* (sacred mushroom)	Sporocarp	Mexico (H)
Boletaceae	*Boletus* spp. (kuma mushroom)	Sporocarp	New Guinea (H)
Clavicepitaceae	*Claviceps purpurea* (ergot)	Sclerotium (beak)	Widespread (H)
Lycoperdaceae	*Lycoperdon mixtecorum* (gi-i-wa)	Sporocarp	Mexico (H)
Lycoperdaceae	*Lycoperdon marginatum* (gi-i-sa-wa)	Sporocarp	Europe & N. America (H)
Strophariaceae	*Psilocybe* spp. (sacred mushrooms)	Sporocarp	Mexico (H)
Strophariaceae	*Stropharia cubensis* (sacred mushroom)	Sporocarp	Mexico (H)
	FLOWERING PLANTS		
Acanthaceae	*Justicia pectoralis* (masha-hari)	Leaves (snuff)	South America (H)
Acoraceae	*Acorus calamus* (sweet flag)	Rhizome	Canada (H)
Aizoaceae	*Mesembryanthemum* spp. (kanna, chann)	Roots	Africa (H)
Aizoaceae	*Sceletium tortuosum* (kougued)	Roots	Africa (H)
Apocynaceae	*Tabernanthe iboga* (iboga)	Roots	Western Africa (H)
Apocynaceae	*Voacanga* spp.	Bark/seeds	Africa (H)
Aquifoliaceae	*Ilex paraguariensis* (maté, Paraguay tea)	Leaves (drink)	South America (S)
Aquifoliaceae	*Ilex vomitoria* (yaupon)	Leaves (drink)	North America (S)
Araceae	*Homalomena* spp. (ereriba)	Leaves and bark	tropical Asia (H)
Bignoniaceae	*Tanaecium nocturnum* (koribo)	Leaves (snuff)	Brazil & Colombia (H)
Cactaceae	*Ariocarpus fissuratus* (hikuli sunami)	Stems	Mexico (H)
Cactaceae	*Armatocereus laetus* (pishicol)	Stems	Mexico (H)
Cactaceae	*Coryphantha macromeris* (donana)	Stems	Mexico (H)
Cactaceae	*Coryphantha palmeri* (wichuri)	Stems	Mexico (H)
Cactaceae	*Echinocereus* spp. (‘peyotl’)	Stems	Mexico (H)
Cactaceae	*Echinopsis pachanoi* (San Pedro cactus)	Stems	South America (H)
Cactaceae	*Epithelantha micromeris* (hikuli mulatto)	Stems	N. America & Mexico (H)
Cactaceae	*Lophophora williamsii* (peyote, peyotl cactus)	Stems	North America (H)
Cactaceae	*Mammillaria craigii* (witculiki)	Stems	Mexico (H)
Campanulaceae	*Lobelia tupa* (tupa, tabaca del diablo)	Leaves (smoked)	Andes (H)
Cannabaceae	*Cannabis sativa* (marijuana)	Leaves (smoked)	cosmopolitan (H)
Celastraceae	*Catha edulis* (khat, kat, qat)	Leaves (drink)	Africa & M. East (N)
Compositae	*Calea ternifolia* (thle-pelakano, zacatechichi)	Leaves	Mexico & Costa Rica (H)
Compositae	*Tagetes lucida* (yahutli)	Leaves	Mexico (H)
Convolvulaceae	*Ipomoea violacea* (tlitlilizin)	Seeds (snuff)	Mexico (H)
Convolvulaceae	*Turbina corymbosa* (ololiuqui)	Seeds	Mexico (H)
Coriariaceae	*Coriaria thymifolia* (shanshi)	Fruits	Mexico (H)
Cyperaceae	*Scirpus atrovirens* (bakana)	Tubers	Mexico (H)
Desfontainiaceae	*Desfontainia spinosa* (taique)	Leaves	C. & S. America (H)
Ericaceae	*Gaultheria furens* (hierba loco)	Fruits	Mexico to Chile (H)
Ericaceae	*Gaultheria parvifolia* (taglli)	Fruits	Ecuador (H)

Erythroxylaceae	*Erythroxylum novogranatense*	Leaves	South America (N)
Erythroxylaceae	*Erythroxylum coca* (coca)	Leaves	South America (N)
Gomortegaceae	*Gomortega kuele* (kuele)	Fruits	Chile (H)
Gramineae	*Cymbopogon densiflorus* (lemon grass)	Spikelets	Tanzania (H)
Gramineae	*Phragmites australis* (common reed)	Rootstock	Cosmopolitan (A)
Himantandraceae	*Galbulimima belgraveana* (agara)	Bark/leaves	Malayasia (H)
Labiatae	*Coleus blumei* (coleus, painted-nettle)	Leaves	Mexico (H)
Labiatae	*Lagochilus inebrians* (Turkestan mint)	Leaves	Central Asia (H)
Labiatae	*Leonotis leonurus* (lion's tail)	Leaves	South Africa (H)
Labiatae	*Leonurus sibiricus* (Siberian motherwort)	Leaves	Asia; C. & S. America (H)
Labiatae	*Mentha pulegium* (kykeon)	Leaves	Ancient Greece (H)
Labiatae	*Salvia divinorum* (hojas de la pastora)	Leaves	Mexico (H)
Leguminosae	*Anadenanthera colubrina* (huilca, vilca, sebil)	Seeds (snuff)	South America (H)
Leguminosae	*Anadenanthera peregrina* (yopo, paricá)	Seeds (snuff)	South America (H)
Leguminosae	*Cytisus canariensis* (genista)	Seeds	Mexico (H)
Leguminosae	*Erythrina* spp. (colorines)	Seeds	Mexico (H)
Leguminosae	*Mimosa hostilis* (jurema, vinho do jurema)	Roots	Africa (H)
Leguminosae	*Rhynchosia* spp. (piule)	Seeds	Mexico (H)
Leguminosae	*Sophora secundiflora* (mescal bean, red bean)	Seeds	North America (H)
Lentibulariaceae	*Utricularia minor*	Leaves	India (H)
Liliaceae	*Pancratium trianthum* (kwashi)	Bulbs	Botswana (H)
Loganiaceae	*Desfontainea hookeri* (taique)	Leaves (drink)	Andes (H)
Lythraceae	*Heimia salicifolia* (sinicuichi)	Leaves (drink)	Mexico (H)
Malpighiaceae	*Banisteriopsis caapi* (ayahuasca, caapi, yajé)	Bark, leaves smoked	Amazonia (H)
Malpighiaceae	*Tetrapterys methystica* (caapi-pinima)	Bark	Amazonia (H)
Moraceae	*Helicostylis* spp. (takini)	Sap	C. & S. America (H)
Moraceae	*Maquira sclerophylla* (rape dos Indios)	Seeds (snuff)	Amazonia (H)
Myristicaceae	*Myristica fragrans* (nutmeg)	Seeds	cosmopolitan (H)
Myristicaceae	*Virola* spp. (epena, yakee, nyakwana)	Bark (snuff)	Amazonia (H)
Orchidaceae	*Oncidium cebolleta* (hikuri orchid)	?	New World (H)
Palmae	*Areca catechu* (betel nut)	Seeds (masticatory)	S. Pacific (N)
Pandanaceae	*Pandanus* spp. (screw-pines)	Fruits	New Guinea (H)
Papaveraceae	*Papaver somniferum* (opium poppy)	Latex	Eurasia (N)
Piperaceae	*Piper methysticum* (kava kava)	Roots + (drink)	South Pacific (N)
Rubiaceae	*Coffea* spp. (coffee, café)	Seeds (drink)	cosmopolitan (S)
Rubiaceae	*Mitragyna speciosa* (kratom)	Leaves	Asia (H)
Rubiaceae	*Pagmea macrophylla*	Leaves (snuff)	South America (H)
Rubiaceae	*Psychotria* spp. (nai-kawa)	Leaves	South America (H)
Sapindaceae	*Paullinia cupana* (guaraná)	Seeds (drink)	South America (S)
Sapindaceae	*Paullinia yoco* (yoco)	Seeds (drink)	South America (S)
Solanaceae	*Atropa belladonna* (belladonna)	Leaves and roots	Eurasia (H)
Solanaceae	*Brugmansia amesianum* (culebra borrachera)	Leaves	Colombia (H)
Solanaceae	*Brugmansia candida* (angel trumpet)	Seeds	South America (H)
Solanaceae	*Brugmansia sanguinea* (angel trumpet)	Seeds	South America (H)
Solanaceae	*Brugmansia suaveolens* (angel trumpet)	Seeds	South America (H)
Solanaceae	*Brunsfelsia chiricaspi* (chiric-caspi)	Roots	South America (H)
Solanaceae	*Brunsfelsia grandiflora* (chiric sanango)	Roots	South America (H)
Solanaceae	*Datura ceratocaula* (torna-loco)	Seeds +	Mexico (H)
Solanaceae	*Datura inoxia* (sacred datura, toloache)	Seeds	North America (H)
Solanaceae	*Datura stramonium* (Jimson weed, wyscoccan)	Seeds +	North America (H)
Solanaceae	*Duboisia hopwoodii* (pituri)	Leaves/twigs (mast.)	Australia (N)
Solanaceae	*Hyoscyamus niger* (henbane, black henbane)	Seeds +	Eurasia (H)
Solanaceae	*Iochroma fuchsioides* (borrachera)	Bark and leaves	Colombia (H)
Solanaceae	*Latua pubiflora* (arbol de los brujos, latue)	Fruits	Chile(H)
Solanaceae	*Mandragora officinarum* (mandrake)	All parts	Europe (H)

Solanaceae	*Nicotiana tabacum* (tobacco)	Lvs. (smoked/snuff)	World-wide (S)
Solanaceae	*Petunia violacea* (shanin)	Leaves?	Ecuador (H)
Solanaceae	*Scopolia carniolica* (nightshade-leaved henbane)	Root	Eurasia (H)
Solanaceae	*Solandra grandiflora* (chalice vine)	Sap	Mexico (H)
Solanaceae	*Solandra guerrerensis* (chalice vine, hueipati)	Fruits +	New World tropics (H)
Sterculiaceae	*Cola* spp. (kola nut, cola nut)	Seeds (drink)	cosmopolitan (S)
Sterculiaceae	*Theobroma cacao* (cacao)	Seeds (drink)	New World tropics (S)
Theaceae	*Camellia sinensis* (tea)	Leaves (drink)	cosmopolitan (S)
Zingiberaceae	*Kaempferia galanga* (galanga, maraba)	Rhizomes	New Guinea (H)
Zygophyllaceae	*Peganum harmala* (Syrian rue)	Seeds	Eurasia (H)

Notes on type of psychoactive use:

- A = alcohol
- H = hallucinogen
- N= narcotic/euphoric
- S = stimulant
- \+ = and other plant parts

11.3 • OLD WORLD PLANTS

OPIUM POPPY

"*Oh, jab me with your fine needle a hundred times, and a hundred times I will bless you, Saint Morphine.*"
[Jules Verne]

"*When I got home that night I experienced for the first time the white night of opium. One lies relaxed and wakeful, not desiring sleep. We dread wakefulness when our thoughts are disturbed, but in this state one is calm*...."
[Graham Greene]

"*... The next morning ... I awoke with excruciating rheumatic pains of the head and face, from which I had hardly any respite for about twenty days. On the twenty-first day I think it was ... that I went out into the streets; rather to run away, if possible, from my torments, than with any distinct purpose of relief. By accident, I met a college acquaintance, who recommended opium. Opium! dread agent of unimaginable pleasure and pain! ... After arriving at my lodging (with my purchase of a copper halfpence worth of opium), it may be supposed that I lost not a moment in taking the quantity prescribed. I was necessarily ignorant of the whole art and mystery of opium-taking; and what I took I took under every disadvantage. But I took it; and in an hour, O heavens! what a revulsion! what a resurrection, from its lowest depths, of the inner spirit! what an apocalypse of the world within me! That my pain had vanished was now a trifle in my eyes; this positive effect was swallowed up in the immensity of those positive effects which had opened before me, in the abyss of divine enjoyment thus suddenly revealed. Here was a panacea, a pharmakon nepenthes, for all human woes; here was the secret of happiness, about which the philosophers had disputed for so many ages, at once discovered; happiness might now be bought for a penny, and carried in the waistcoat-pocket; portable ecstasies might be had corked up in a pint-bottle, and peace of mind could be sent down by mail....*"
[Thomas de Quincey]

TIMELINE: OPIUM

BCE:

3400	Sumerians praise "joy plant"
2000	Reference to bhang in Atharva Veda
1300	Egyptians begin cultivation and trade in opium poppies
460	Hippocrates cites usefulness as narcotic
330	Alexander the Great introduces opium into Persia and India

CE:

1000	Opium introduced into China
1499	Amerigo Vespucci observes use of coca
1527	Paracelsus formulates laudanum (opium + alcohol)
1606	English ships bring home finest Indian opium
1680	Thomas Sydenham formulates Sydenham's laudanum
1729	Emperor Yung Chen prohibits sale of opium/closes smoking houses
1753	Linnaeus gives it scientific name (*Papaver somniferum*)
1760	Chinese develop technique for smoking opium without tobacco
1767	East India Co. now exporting 2000 chests per year to China
1793	British East India Co. establishes monopoly on opium trade
1796	Emperor of China prohibits importation of opium/export of silver
1799	Emperor Kia King bans poppy cultivation and trade
1805	Friedrich Sertürner isolates morphium (morphine)
1816	John Jacob Astor's American Fur Co. engaged in opium smuggling
1821	Thomas De Quincey publishes "Confessions of an English Opium-eater"
1827	Heinrich Merck Co. begins commercial production of morphine
1832	Pierre Robiquet isolates codeine
1839	China orders all foreign traders to surrender their opium
1839	First Opium War between England and China [to 1842]
1843	Smoking of opium banned in China
1853	Alexander Wood invents functional hypodermic syringe
1856	Second Opium War [to 1860]

1857 Opium Act of 1857 regulates cultivation and manufacture of opium
1858 Treaty of Tientsin legalizes importation of opium into China
1860 Charles Baudelaire publishes "Les Paradis Artificiels ..."
1874 C. R. Wright synthesizes heroin by boiling morphine
1874 San Francisco restricts smoking opium in city limits
1878 Indian Opium Act attempts to reduce its use in country
1890 U. S. Congress imposes tax on opium and morphine
1898 Heinrich Dressler synthesizes heroin
1905 U. S. Congress bans opium smoking
1909 First International Opium Conference
1909 Congress enacts Smoking Opium Exclusion Act
1910 China and England agree to end India-China opium trade
1942 Congress passes Opium Poppy Control Act
1953 Opium Protocol authorizes seven countries to export opium
1978 U. S. & Mexico use Agent Orange to eradicate "Mexican mud"
1992 Colombian drug lords introduce high-grade opium into U. S.
1995 Golden Triangle now leader in world opium production
2003 Afghanistan once again a major producer of opium poppies

HISTORY

The poppy plant (*Papaver somniferum*), from which opium is derived, is native to Asia. It is now widely cultivated and escaped. The opium poppy is closely related to the ornamental garden poppies and to our state flower, the California-poppy. The history of opium use is an ancient one. By the 16th century, opium was used in several standard medical treatments. The physician Paracelsus concocted **laudanum**, a mixture of opium and alcohol (technically referred to as tincture of opium). English literature is filled with characters who used laudanum for one thing or another. In 1732, Thomas Dover, an English physician, invented a gout remedy, Dover's Powder. In the 18th century a very popular home remedy for diarrhea was paregoric, a mixture of opium and camphor. It remains a popular treatment today, although it must be purchased by prescription since it contains a narcotic. By the end of the 19th century, opium-containing medicinals were so commonly used that it is estimated that 1/400 Americans were addicted, many of them housewives.

THE OPIUM WARS

"... a war more unjust in its origin, a war more calculated to cover this country with permanent disgrace, I do not know and I have not read of."
(William Gladstone)

☼ ☼ ☼ ☼ ☼

Opium has been involved in the statecraft of many great powers. In the 19th century, Great Britain wished to make trade agreements with the Chinese. The English were interested in buying tea from China, and would in turn sell the Chinese opium. The Emperor of China objected strenuously and told his court officials to have no dealings with these foreigners. The British made "informal arrangements" with certain officials in Canton, and soon British and American ships were taking opium into China and bringing out tea. Finally in 1838, the Emperor put a new official in charge of watching over the port at Canton. He immediately confiscated all of the opium on British and American ships and seized thousands of cases in warehouses on docks. The British were infuriated. The result was the "Opium War." Britain, the leading naval power of the world, soon defeated the Chinese. They forced a treaty opening China to trade, creating the British Crown Colony of Hong Kong, and made the Chinese pay about $6,000,000 in damages for destroying the opium. The Opium War is not remembered today by many who associate the problem of opium with China.

In 1839, Lin Zexu, Chinese High Commissioner, wrote the following letter to Queen Victoria. *"The Way of Heaven (Tao) is fairness to all. It does not suffer us to harm others in order to benefit ourselves. Men are alike in this all the world over; that they cherish life and hate what endangers life. Your country lies twenty thousand leagues away; but for all that the Way of Heaven holds good for you as for us, and your instincts are not different from ours.*

We have heard that in your honorable nation, too, the people are not permitted to smoke [opium]... Though not making use of it one's self, to venture nevertheless to manufacture and sell it, and with it to seduce the simple folk of this land, is to seek one's own livelihood by exposing others to death, to seek one's own advantage by other men's injury.... We now wish to find, in cooperation with your honorable sovereignty, some means of bringing to a perpetual end this opium, so hurtful to mankind; we in this land forbidding the use of it, and you, in the nations of you dominion, forbidding its manufacture.

Let us suppose that foreigners came from another country, and brought opium into England, and seduced the people of your country to smoke it. Would not you ... look upon such a procedure with anger, and in your just indignation endeavor to get rid of it? Now we have always heard that Your Highness possesses a most kind and benevolent heart. Surely then you are incapable of doing or causing to be done unto another that which you should not wish another to do unto you.

I now give my assurance that we mean to cut off this harmful drug forever. What is here forbidden to consume, your dependencies [India] must be forbidden to manufacture, and what has already been manufactured, Your Majesty must immediately search out and throw to the bottom of the sea.... The laws against consumption of opium are now so strict in China that if you continue to make it, you will find that no one buys it.

Do not say you have not been warned in time. On receiving this, Your Majesty will be so good as to report to me immediately on the steps that have been taken at each of your ports."

TIMELINE: THE OPIUM WARS

1000: Opium introduced into China
1729: Emperor of China prohibits sale of opium
1793: British East India Co. establishes opium monopoly
1796: Emperor prohibits importation of opium
1799: Emperor bans opium cultivation
1833: British Parliament ends East India Co. monopoly
1838: China confiscates British/American opium at Canton docks
1839: High Commissioner Lin Zexu writes to Queen Victoria

1839: First Opium War: Britain vs. China (to 1842)
1840: Lord Palmerston affirms China's right to prohibit use
1841: British fleet arrives at Canton
1842: Wm. Gladstone writes of a "national iniquity towards China"
1842: China forced to sign Treaty of Nanking ("Unequal Treaty")
1843: Treaty of Bogue opens 5 Chinese ports
1856: Second Opium War: Britain & France vs. China (to 1860)
1858: Treaty of Tientsin (Tianjin) legalizes importation
1910: England and China agree to end India-China opium trade

PROCESSING

Opium is the dried milky latex that exudes from incised fruits of *Papaver somniferum*, the opium poppy. All parts of the plant seem to contain the latex, but the leaves lack the alkaloids that are the active principle. The seeds are essentially devoid of alkaloids as well, so poppy seed rolls may be eaten without fear of addiction.

A few days after the delicate petals have fallen from the poppy flowers, workers enter the fields and make incisions in the fruits. These cuts are not deep and do not pierce the seed chamber. The incisions bleed a latex that hardens in about a day. The latex is then scraped from the fruits, removing some of the epidermis as well. This crude dried exudate is **opium**.

Externally opium is a pale olive-brown or gray, with a coarse surface. It is often covered with poppy leaves or the plant parts from other packing material. Inside it is reddish-brown and granular. It has a very bitter taste. The use of crude opium has declined greatly in recent years, although the tincture and camphorated tincture of opium are still popular.

THE ACTIVE PRINCIPLES

Opium contains about 25 alkaloids. **Morphine** and **codeine** are probably the best known. Their relative percentages vary. Opium may be 5-15% morphine and 0.1-2% codeine. The function of these alkaloids in the plant is uncertain. It has been suggested that the bitter latex may protect the plants against insects or that the alkaloids provide a nitrogen reserve for making proteins.

Morphine is the chief narcotic principle in opium. There are various ways of separating it and purifying it. In one of these, macerated opium is mixed with water and the morphine precipitated by ammonia. The crystals are then purified. A similar process involves ammonia and sulfuric acid. Morphine was first isolated in 1803. The effects of the alkaloid are a state of pleasant drowsiness and muscular relaxation. There is a freedom from anxiety, a shortening of the sense of time, an increased ability to discriminate, a decreased ability to concentrate, a lessening of physical activity, dimness of vision, and lethargy. Finally the subject drifts into a restful sleep. The advantages to medicine of such an alkaloid are immediately apparent. Morphine became one of the chief pain killers, permitting surgery under greatly improved conditions. Unfortunately, morphine exhibits both physiological and psychological dependence. The subject becomes tolerant of it so that increased dosages are required to achieve desired results, and the withdrawal from morphine is especially painful.

Codeine is generally like morphine, but much milder. The effects of codeine are approximately 1/6 to 1/10 those of morphine. Codeine is a common ingredient in cough preparations. It is a narcotic and produces both physical and psychological dependence. Withdrawal symptoms are present, but they are much milder than those associated with morphine. Tolerance to codeine also develops.

THE SYNTHETIC DERIVATIVES

Heroin is a semisynthetic derivative of morphine. It is not, therefore, a naturally occurring alkaloid. Heroin is made by adding acetic anhydride or acetylchloride to morphine. The result is a white, odorless, crystalline powder that is very bitter. It is soluble in water. Heroin was developed in Germany in 1898 as an analgesic more powerful than morphine. An analgesic is a painkiller that does not render the patient unconscious, unless it is administered in large doses. Heroin is three or four times stronger than morphine. Strangely enough, it was widely used to help morphine addicts through their difficult withdrawal periods and was hailed as a cure for morphine addiction. Several years passed before it became apparent that heroin was itself addictive. Today heroin plays no significant role in medicine. It is under strict government supervision. Heroin addicts either inject the material, as with morphine, or they may inhale it. Heroin is the only opiate that has an effect on the mucous membranes of the nose.

Methadone is to heroin what heroin was once thought to be to morphine. Methadone is a synthetic drug used to break addiction to heroin. It is slightly more potent than morphine and it is nearly as effective taken orally as it is by injection. Methadone is both physically and psychologically addictive. Former heroin addicts who are using methadone must continue to use methadone in its place.

THE EFFECTS OF THE OPIATES

The naturally occurring and synthetic derivatives have the following effects in humans:

- pleasant drowsiness
- muscular relaxation
- freedom from anxiety
- shortens sense of passage of time
- increased ability to discriminate
- decreased ability to concentrate
- lessened physical activity
- contracted pupils
- dimness of vision
- lethargy
- slowed respiration
- sleep
- delays in emptying of stomach
- slows peristalsis in small and large intestines
- stimulates, then depresses the central nervous system
- pain-killing, hypnotic, and narcotic effects

ADDICTION & WITHDRAWAL SYMPTOMS

A number of studies have focused on the long term effects of addiction to opiates. One of the best known of these is the "Philadelphia General Hospital Study." It concluded that:

- addiction is not characterized by physical deterioration;
- there is no evidence of changes in circulatory, hepatic, renal, or endocrine functions;
- addiction does not cause emaciation;

- ☼ pale complexions are result of sedentary life styles;
- ☼ 60% had gum disease and carries;
- ☼ chronically-inflamed throats resulted from cigarette use;
- ☼ sexual potency and libido normal;
- ☼ pupils were constricted, which impairs night vision
- ☼ chronic constipation was common.

We have tended to confuse the effects of using opiates over a long period of time with those that occur from withdrawal. They include:

- ☼ constant flow of mucous;
- ☼ chills and sweats;
- ☼ delusions;
- ☼ nausea;
- ☼ diarrhea;
- ☼ hemorrhaging; and
- ☼ death.

MARIJUANA

"They have a sort of hemp growing in this country, very like flax, except in thickness and height; in this respect hemp is far superior.... When therefore the Scythians [inhabitants of a region in southeast Europe and Asia] have taken some seed of this hemp, they creep under the cloths, and then put the seed on the red hot stones; but this being put on smokes, and produces such a steam, that no Grecian vapour-bath would surpass it. The Scythians, transported with the vapour, shout aloud; and this serves them instead of washing, for they never bathe the body in water....

(Herodotus. Ca. 425 B. C.)

☼ ☼ ☼ ☼ ☼

TIMELINE: MARIJUANA

BCE:

2800 Hemp used for rope (China)
2700 First recorded use as medicine (China)
1200 Cited as a sacred plant in Hindu text
500 Zoroaster puts hemp at top of his list of medicinal plants
430 Herodotus observes ritual/recreational uses of hemp by Scythians

CE:

70 Dioscorides writes of widespread use of medicinal hemp in Rome
800 Prophet Mohammed permits its use
1100 Smoking cannabis now widespread in Middle East
1378 Ottoman Emir Soudoun Scheikhouni issues edict against eating cannabis
1430 Joan of Arc accused of using cannabis to hear voices
1484 Pope Innocent VIII condemns use in Satanic masses
1545 Spanish introduce into Chile
1597 John Gerard warns that cannabis will "dryeth up seed" (semen)
1611 British introduce into Virginia
1621 Robert Burton suggests use against depression
1653 Nicholas Culpeper claims cannabis cures a variety of diseases
1753 Linnaeus publishes *Cannabis sativa*
1783 Lamarck publishes *Cannabis indica*
1798 Napoleon bans use by his soldiers in Egypt
1894 Indian Hemp Commission Report
1890 Queen Victoria's physician prescribes its use
1899 T. B. Wood et al. isolate cannabinol
1901 British Royal Commission concludes it is more or less harmless
1924 Janischewsky publishes *C. ruderalis*
1924 Geneva Conference on Opium outlaws cannabis
1928 Dangerous Drug Act outlaws cannabis use in Britain
1937 Congress passes Marijuana Tax Act
1943 U. S. D. A. plants 146,000 acres of hemp for war effort
1944 La Guardia Report
1965 Mechoulan & Gaoni isolate delta-1-THC
1968 Wootton Report
1970 Le Dain Report
1972 Shafer Commission Report
1973 Oregon minimizes penalty for possession of small amounts
1973 Drug Enforcement Agency set up; vows to rid country of cannabis
1974 Frederich Blanton reports use to treat glaucoma
1976 New York Acad. Sci. Conference on Chronic Cannabis Use
1976 Dutch legalizes sale of cannabis
1982 National Academy of Sciences Report
1996 California voters pass Proposition 215
1999 National Inst. of Medicine calls for clinical trials
2000 British P. M. Tony Blair supports use for medicial purposes
2001 Canada becomes first country to allow medical use
2001 U. S. Supreme Court rules medicinal use violates federal law

Marijuana (or marihuana, hemp, Indian hemp, grass, pot, weed, reefer, boo, Maui Wowie, muggles, mooter, greefa, griffo, Mary Warner, Mary Meaver, Mary Jane, Indian hay, loco weed, love weed, joy smoke, giggle smoke, bamba-lacha, mohasky, mu, moocha, etc.) is native to Central Asia, although it is now widely cultivated and escaped. Marijuana does very well in disturbed, nitrogen-rich wastelands near humans. The plant has been used for about 12,000 years as the source of fibers, oils, food, medicine, and it remains one of the most widely used psychoactive plants. Historical references to the use of marijuana abound in the literature. One of the more interesting tales, perhaps an apocryphal one, concerns Hassan-Ibn-Al-Sabbah, the 12th century leader of a band of mountain raiders who swooped down on unsuspecting caravans and Crusaders. According to legend, Hassan used to instill courage and the ability to endure pain by having his men take one of the stronger preparations from the hemp plant. The group became known as Hashishins, from which our modern word assassin is derived.

CLASSIFICATION

Hemp was named by Linnaeus. He recognized only one species, *Cannabis sativa*, a view that is still widely held. Other competent experts in the field of plant systematics argue that there are at least three species of: *C. sativa*, a taller plant of the northern latitudes; *C. indica*, a low-growing plant of more southern distribution; and *C. ruderalis*, a small, unbranched plant native to Russia and Europe. At various times, *Cannabis* has been placed in the mulberry family (Moraceae), the nettle family (Urticaceae), and in its own family (Cannabaceae). The last opinion has prevailed and now most botanists put marijuana in Cannabaceae, along with hops (*Humulus lupulus*).

The plants are large perennials, with male and female flowers occurring on separate plants. The active principle is concentrated in the bracts associated with the female flowers, although the leaves and stems also contain the resinous material.

PREPARATIONS

The marijuana cigarette is the only form known to most users in this country. The leaves, flowering tops, and sometimes the stems are often mixed with tobacco and then smoked. In the Old World, however, where *Cannabis* has been in use for thousands of years, several different preparations and modes of use are employed.

Hasheesh or **hashish**, derived from the resin of recently fertilized female flowers, is popular among the Muslim peoples of northern Africa and western Asia where it is smoked (often through a water pipe), eaten, or drunk.

In India, *Cannabis* is used in a variety of ways. Three preparations are commonly encountered.

Bhang, is prepared from uncultivated plants. The dried parts are powdered and then mixed with water or milk. It is smoked or drunk. It is the weakest preparation.

Ganja or **ganjah** is prepared by gathering the flowering tops of very carefully selected female plants. It is usually smoked with tobacco, but it may be eaten or drunk like bhang. It is considered superior to bhang in its psychoactive effects.

Charas is prepared from pure resinous material collected from especially cultivated female plants. It is normally smoked, but it may be eaten. It is considered the most potent preparation, in that it contains the highest percentage of active resins.

ACTIVE PRINCIPLES

The resin contains a series of active and inactive non-nitrogenous compounds derived from terpenes. They include cannabinol, cannabidiol, cannabigerol, cannabichromene, cannabidiolic acid, tetrahydrocannabinol-carboxylic acid, tetrahydrocannabinol, and its various stereo-isomers. The latter group is collectively called **tetrahydrocanninols** or **THC**. Delta-9-trans-tetrahydrocannabinol appears to be the active principle responsible for producing euphoria. It is also available medically to control the nausea associated with cancer chemotherapy. Some forms have been synthesized recently and are now available for clinical study. Common cultivars average about 1.0-1.5% THC; some of the very potent sinsemilla (Spanish for seedless) and various hybrids now reach 12-13%. "BC Buds" from Vancouver, British Columbia contain 25-30% THC!

PHYSIOLOGICAL EFFECTS

- Dizziness, vertigo, and light-headedness
- Increased heart beat
- Slight rise in blood pressure (sometimes)
- Dryness of mouth and throat
- Impaired coordination (ataxis)
- Hunger and/or craving for sweets
- Nausea and vomiting (sometimes)
- Burning of the eyes
- Ringing or pressure in the ears
- Urge to urinate and defecate (sometimes)

PSYCHOLOGICAL EFFECTS

- Vague dread/anxiety (among inexperienced)
- Disorientation of thinking
- Disturbance to memory
- Euphoria, giggling, hilarity
- Desire to speak more freely
- Depersonalization
- Spatial/temporal distortions
- Floating sensation
- Detachment
- Drowsiness
- Stimulation or depression or both
- Heightened perception of colors, music, etc.

The effects of a single, inhaled marijuana cigarette appear to reach their maximum intensity within about 30 minutes, to be diminished after about 1 hour, and to be dissipated after about 3 hours according to Weil, Zinberg, and Nelson (1968).

EFFECTS FROM CHRONIC USE

There have been numerous studies looking at the long term effects of *Cannabis* on the human body. Here are some of the conclusions reached in two classical studies:

The India Hemp Commission Report (1894):

- no substantial evidence that moderate use will produce mental or moral injury;
- no proof of connection between moderate use of *Cannabis* and disease; and
- no proof that moderate use leads to excess any more than in alcohol.

The Laguardia Report (1944), named after the famous mayor of New York City, concluded that marijuana *does not*:

- cause crime;
- lead to aggressive or antisocial behavior;
- alter basic personality structure;
- cause sexual overstimulation;
- lead to addiction (in strict sense);
- lead to morphine, heroin, or cocaine addiction;
- cause juvenile delinquency.

The most recent research suggests that chronic use of marijuana:

- effects mood, perception, and psychomotor coordination;
- causes reduction in motility – initial sluggishness followed in some cases by almost complete immobility;
- has profound effects on the brain, both in the manner in which sensory inputs are processed and the thinking process itself;
- has little or no effect on the ability to recall previously learned material;
- causes a relatively severe impairment of working memory;
- does not cause structural damage to the brain;
- impairs short-term memory and slows learning;
- may cause transient episodes of confusion or anxiety;
- increases heart rate and initially blood pressure, then lowers blood pressure;
- causes dilation of air passages;
- impairs pulmonary function with prolonged heavy use;
- smoke, because of its tars, is carcinogenic;
- suppresses the number and motility of human sperm;

- does not cause any permanent damage to the male or female reproductive system;
- may affect chromosome segregation during cell division;
- has no effect on the health of offspring;
- can suppress the immune system, but only in doses much higher than humans consume;
- may lead to tolerance and dependence in some users.

MEDICAL USE OF MARIJUANA

One of the controversies raging in the medical and legal communities centers on whether marijuana has any use in the treatment of disease or in providing relief to those suffering from serious, even terminal diseases. As recently as 1995, Governor Wilson vetoed legislation here in California that would have made marijuana legally available to certain individuals. In 1996, the electorate passed Proposition 215 that would permit limited medicinal use. In 2001, the United States Supreme Court ruled that medicinal use of marijuana violated federal law.

Advocates of its medical use argue that it is effective in the treatment of glaucoma, side effects of cancer chemotherapy, epilepsy, multiple sclerosis, AIDS, chronic pain in general, migraine headaches, osteoarthritis, severe itching, premenstrual syndrome, menstrual pain, labor pain, and depression. Less commonly marijuana has been used to treat asthma, insomnia, severe nausea, Adult Attention Deficit Syndrome, schizophrenia, Crohn's Disease, ringing in the ears, violence, post-traumatic stress syndrome, phantom limb pain, alcoholism, scleroderma, and terminal illnesses (Grinspoon & Bakalar, 1997).

FLY AGARIC

"... [This] puts me in mind of a custom among the Tartars.... The Russians, who trade with them, carry thither a kind of mushroom, which they exchange for furs of squirrels, ermines, sables, and foxes. These mushrooms the rich Tartars lay up in large quantities for the winter, and when a nobleman makes a mushroom feast all the neighbors around are invited. The mushrooms are prepared by boiling, by which the water acquires an intoxicating quality, and is a sort of drink which the Tartars prize beyond all other. When the nobility and ladies are assembled, and the ceremonies usual between people of distinction over, the mushroom-broth goes freely round; they laugh, talk double entendre, grow fuddled, and become excellent company. The poorer sort, who love mushroom-broth to distraction as well as the rich, but cannot afford it at the first hand, post themselves on these occasions round the huts of the rich, and watch the opportunity of the ladies and gentlemen as they come down to pass their liquor; and, holding a wooden bowl, catch the delicious fluid, very little altered by filtration, being still strongly tinctured with the intoxicating quality. Of this they drink with utmost satisfaction, and thus they get as drunk and as jovial as their betters."

(Oliver Goldsmith.1762)

"Soma was at the same time a god, a plant, and the juice of that plant. So far as we know, Soma is the only plant that man has ever deified.... In the course of the Soma sacrifice the juice was pounded out with stones on resounding planks and was drunk by the officiating priests. Soma -- the three somas -- inspired hymns vibrant with ecstasy, composed over centuries by priests who lived in centers remote from each other.... Some of the hymns are [of] so exalted, even delirious, a tenor that the modern reader is led to exclaim: 'This surely was composed under the influence of a divine inebriant.' It takes little perception to sense the difference in tone between the awe-inspired hymns to Soma and the rowdy drinking songs of the West prompted by alcohol." (R. Gordon Wasson. 1971. Soma. Divine Mushroom of Immortality)

☼ ☼ ☼ ☼ ☼

Fly agaric (*Amanita muscaria*) is a mushroom that is common in the north temperate zone of both hemispheres. It was once probably widely employed from Siberia through northern Europe. The use of the mushroom by the Siberians came to the attention of Westerners in the 18th century. One of the earliest reports is that of a Swedish officer who was held prisoner by the Siberians for about twelve years. They apparently had no other intoxicant until the Russians introduced alcohol.

The fly agaric is usually eaten by the men of the community. It is not eaten fresh, but only after it has been dried in the sun or over a fire. The dose varies, but often three are eaten; one large mushroom and two small ones. Some have reported consumption of as many as twelve. The fly agaric may be eaten separately or incorporated into soups, stews, reindeer milk, or mixed with the juices of certain plants, such as fireweed. It may even be added to alcohol.

As with all of the psychoactive plants, the mental and physical state of the user plays an important role in determining the effects of fly agaric. Early symptoms include a twitching, trembling, and slight convulsions of the arms and legs. This is followed by a numbness of the feet, euphoria, and a strong desire to dance. Subjects often carry on elaborate conversations with people who are not present and recount fantastic tales of courage and prowess. In some, there is a strong urge to confess misdeeds and sins in general. Some people occasionally become violent and dash about until they are exhausted and fall into a deep sleep.

One of the more fascinating features of fly agaric use is that the intoxicating effect can be obtained by drinking the urine of a person who has eaten *Amanita*. One can only speculate as to how this was discovered. There are stories of poor people waiting outside the huts of the wealthy members of the community who could afford the fly agaric. When a gentleman came out of his hut to urinate, someone was there with a bowl to collect his urine. Fly agaric users also saved their own urine in containers to take with them on long trips.

The psychoactive properties of *Amanita* have been attributed to muscarine, but more recent work by Eugster and Waser indicate the active principle is muscimol(e), unsaturated hydroxamic acid. This is formed by the decarboxylation and loss of water from ibotenic acid.

The late Gordon Wasson, a most respected amateur botanist associated with Harvard University, suggested that the fly agaric is the famous "soma." About 3500 years ago, the Aryan peoples moved into the Indus Valley from the north. They brought with them the cult of soma. To them the plant was divine. The Aryans composed over a thousand hymns to it. The problem is that no one today knows the identity of the plant. The cult is now dead and no physical descriptions of the plant have been uncovered.

Various workers have suggested that it was *Ephedra*, a peculiar gymnosperm; others that the soma is marijuana; still others that the plant is completely mythical. Wasson, using certain linguistic devices and references to urine-drinking believes that soma is *Amanita muscaria*.

NUTMEG

The nutmeg tree, *Myristica fragrans*, is native to the East Indian Archipelago. In addition to providing nutmeg and mace, the seeds have been used for hundreds of years as an hallucinogen. The plant has enjoyed a recent popularity among college students in the United States and Europe. It must certainly be the most easily accessible of the hallucinogens.

One teaspoon or so taken orally will usually produce some response. The effects are variable, but they often include some distortion of space and time and a feeling of detachment. Visual hallucinations are not common, but do occur in some users. Some are disappointed because they get no reactions at all, while others describe illusions similar to those produce by LSD. Users complain of headaches, dry mouth, dizziness, and a general malaise. The oil in the seeds contains safrole, myristicin, and elemicin.

KHAT

Catha edulis is a shrub native to East Africa. It is variously called khat, kat, and qat. It is the least known of the masticatories in the West. Most American had not heard of this stimulant until the "Desert Storm" operation when our newspapers reported that enemy soldiers were getting hopped-up on some exotic drug plant over there. Its leaves have been chewed by the inhabitants of that region and the Arabian peninsula for centuries. It is a stimulant that Muslims are permitted to use. The leaves contain about 1% *d*-norpseudo-ephedrine, a stimulant to the central nervous system.

11.4 • SOUTH PACIFIC

Although the South Pacific is a botanist's delight because of its rich flora, it is relatively poor in psychoactive plants. The three species described here are relatively unknown to those who have not visited the region. They are very popular masticatories.

KAVA

Kava goes by several other names, including kava-kava, yangona, yaqona, and grog. It is prepared from the masticated roots of *Piper methysticum*, a relative of black pepper. The shrub is widely cultivated in the South Pacific. A mildly intoxicating drink is prepared. Outsiders compare its flavor to dirty dish water. Its active principles, a series of pyrones, act on the central nervous system and the skeletal system to produce a feeling of relaxation and reduced irritability, along with localized anesthetic effects. The lips and tongue go numb. The use of kava is often associated with important events in the life of a village, such as a wedding or the visit of an important person. Traditionally, kava ceremonies follow very precise rules. It is important that you know how to sit, when to sing, when to clap your hands, etc.

☼☼☼☼☼

"Kava drinking on Tongariki is a relatively relaxed and unceremonious affair, without the strict adherence to prescribed etiquette characteristic of kava drinking in much of the Pacific. It is prepared entirely by chewing, never by the use of mortars, graters, or other mechanical aids. Boys from pre-adolescent age to young adulthood usually do the chewing for their kinsmen or guests, or out of courtesy to others. Older youths or young men mix, wash, and wring the kava from the chewed pulp. Girls and women may occasionally participate in the chewing, whereas this was not so in the past. Adolescents and, more rarely, women may drink kava without censure. It is drunk in various places within the village proper, usually in a quiet house, and strict exclusion of children and women from the proximity and view of the proceedings has lapsed.

Usually, half of a cocoanut shell or a bowl of the same capacity is used to prepare kava and the full contents -- about 100 ml -- drunk slowly in one draught. Sometimes twice this quantity is drunk. A kava drinker usually eats immediately after taking the kava; the kava is prepared while the evening meal is being cooked. The effects come on in a half our or less, and the drinking is thus usually postponed until food is ready. Those who have drunk kava find a comfortable place to sit, often beside a dying fire in the dark house, where they remain hunched over and avoiding light and sound disturbances of all sorts. Conversation ceases, and slowly they fall into a kava-induced stupor, which is not true sleep. This stage occurs about an hour after drinking. From it they can be aroused by being addressed or gently shaken, but this ruins the effect they are seeking from the kava. A few hours after they have drunk kava they arise and walk to their own houses to fall asleep promptly again; others remain where they have first 'fallen.' In early morning they appear fresh and without any 'hangover-'like sequelae. Those whom we have seen walking a few hours after the drinking are usually somewhat ataxic [loss of motor coordination], photophobic [sensitive to light], and slowed in their reactions. A few who have had a higher dose are extremely ataxic and could return to their homes only with assistance from the children or myself. There is no belligerency or irritability -- only a quiet and friendly somnolence associated with the weakness of the lower limbs and the accompanying ataxia.

The drinkers reply rationally and are well oriented to time, place, and person; they respond intelligently, even sometimes quickly, to complex questions. Bright or moving lights, noise or other sound, touch, and even the subdued bustle of nearby activities annoy them, and the villagers of all ages have extreme respect for this. In discussions the kava users refer to a heaviness and weakness of their extremities, particularly of the feet and legs, and to an earlier paresthesia ascending from their feet to their trunk and described with such words as 'numbness,' 'tingling,' and 'coldness.' ... I have taken pulse rates and blood pressure measurements on a number of kava drinkers at varying intervals from one to three hours after drinking and found no significant change in either from that observed on the same subjects during examinations in the daytime, when they had no kava for the preceding eighteen hours or more. Respiration is shallow and regular; deep tendon reflexes remain intact."

(D. C. Gajdusek in Holmstedt & Kline, 1967)

BETEL NUT

"She had few teeth... and had thin ravines running out from the corners of her mouth... usually filled with betel juice which made her look as if her mouth had been gashed by a rusty razor."
(James A. Michener. Tales of the South Pacific)

"Bloody Mary's chewing betel nuts; She is always chewing betel nuts; Bloody Mary's chewing betel nuts, and she don't use Pepsodent."
(Oscar Hammerstein II. South Pacific)

✡✡✡✡✡

Betel nut is the world's most popular masticatory. It is estimated that about 10% of the world's people use it regularly. In Hindi, it is called **pan**. The betel nut is the seed of *Areca catechu*, a member of the palm family. A sliver of seed is placed on the leaf of *Piper betle*, a close relative of the more familiar black pepper. A layer of lime is sprinkled over this. The whole thing is rolled up and placed in the mouth where we use our tongues to move it around, without being chewed up or swallowed. Early writers claimed that the betel nut would, "... *expel wind, remove phlegm, kill germs, subdue bad odors, beautify the mouth, remove impurities and induce love....*" On the other hand, lime deposits on the teeth of old betel nut users and the revolting habit of spitting red-stained saliva make it fairly easy to spot the habitué.

The seeds contain several pyridine alkaloids, with arecoline being the most common and the most physiological active. The plant is used in human and in veterinary medicine to expel tapeworms.

PITURI

Douboisia hopwoodii is a member of the nightshade family. Plants of the genus are known for their toxicity, and the Australian aborigines have used them as fish and emu poisons, and as insecticides. They are commercial sources of one of the belladonna alkaloids, scopolamine.

Vegetative plant parts are smoked, often after having been mixed with charcoal. Leaves are also formed into a quid and then chewed as a masticatory. The quid is typically passed from one user to another, and stored temporarily in the ear.

11.5 • NEW WORLD

In that we have occupied the Old World for a much longer time, it would be tempting to assume that the list of psychoactive plants is much longer than that of the New World. For reasons that have not been fully explained, just the opposite is true.

TOBACCO

"In the middle of the gulf... I found a man in a canoe carrying a little piece of bread... a gourd of water... and some dry leaves which must be a thing very much appreciated among them..."
[Christopher Columbus, 13 October 1492]

"One of the merveilles of the Hearbe, and that whiche doeth bryng most admiration, is the maner how the priests of the Indias did use it.... [He] toke certain leaves of the Tabaco, and caste theim into the fire, and did receive the smoke of them at his mouthe, and at his nose with a cane, and in takyng of it, he fell doune uppon the grounde, as a dedde manne, and remainyng so, accordyng to the quantitie of the smoke that he had taken, and when the hearbe had doen his woorke, he did revive and awake, and gave theim their aunsweres, accordyng to the visions, and illusions which he sawe.... [Nicolas Monardes. 1557]

"... in this island [Hispaniola], as also in other provinces of these new countries, there are some bushes, not very large, like reeds, that produce a leaf ... which (where it is used) is held in great esteem by the natives, and very much prized by the slaves whom the Spaniards have brought from Ethiopia. When these leaves are in season, they pick them, tie them up in bundles, and suspend them near their fireplace till they are very dry, and when they wish to use them, they take a leaf of their grain (maize) and putting one of the others into it, they roll them round tight together; then they set fire to one end, and putting the other end into the mouth, they draw their breath up through it, wherefore the smoke goes into the mouth, throat, the head, and they retain it as long as they can, for they find a pleasure in it, and so much do they fill themselves with this cruel smoke, that they lose their reason. And there are some who take so much of it, that they fall down as if they were dead, and remain the greater part of the day or night stupefied. Some men are found who are content with imbibing only enough of this smoke to make them giddy, and no more. See what a pestiferous and wicked poison from the devil this must be.... I have entered the house of an Indian who had taken this herb, which in the Mexican language is called tabacco, and immediately perceiving the sharp fetid smell of this truly diabolical and stinking smoke, I was obliged to go away in haste, and seek some other place. In La Española and other islands, when their doctors wanted to cure a sick man, they went to the place where they were to administer the smoke, and when he was thoroughly intoxicated by it, the cure was mostly effected. On returning to his senses he told a thousand stories, of his having been at the council of the gods and other high visions."
[Girolamo Benzoni, 1565]

"And now good Countrey men let us (I pray you) consider, what honour or policie can moove us to imitate the barbarous and beastly maners of the wilde, godlesse, and slavish Indians in so vile and stinking a custome....? Why doe we not as well imitate them in walking naked as they doe? in preferring glasses, feathers, and such tpyes, to golde and precious stones, as they do? yea why do we not denie God and adore the Devill, as they doe....? Have you not reason then to be ashamed, and to forbeare this filthie noveltie, so basely grounded, so foolishly received and so grossly mistaken in the right use thereof? ... A custome lothsome to the eye, hateful to the Nose, harmefull to the braine, dangerous to the Lungs, and the blacke stinking fume thereof, neerest resembling the horrible Stigian smoke of the pit is bottomlesse.
[King James I. 1604. A Counterblaste to Tobacco]

"If I cannot smoke cigars in Heaven, I shall not go!"
[Mark Twain]

"Tobacco is an indispensable as the daily ration; we must have thousands of tons of it without delay."
[General John "Blackjack" Pershing]

☼ ☼ ☼ ☼ ☼

The genus *Nicotiana*, of the nightshade family (Solanaceae), is composed of about 60 species; 45 of them native to the New World, 14 to Australia, and one to the Pacific. The plants are usually small trees. Only two species, both of them tetraploids ($2n = 4x = 48$), are of any economic importance. *Nicotiana tabacum* is the source of smoking tobacco leaves and *N. rustica*, with its higher alkaloid content, is the source of nicotine used as an agricultural insecticide. Both are of hybrid origin. Neither species is known in the wild today.

TIMELINE: TOBACCO

BCE:

5000 Tobacco first cultivated
2500 Reaches northern regions of North America
400 Tobacco domesticated in South America

CE:

500 Shamanistic use (enemas)
1492 Columbus records use of leaves in his diaries
1519 Tobacco introduced into Spain
1542 Tobacco introduced into Japan via a shipwreck
1556 Cultivation begins in Europe
1556 Andre Thevet introduces seeds to Europe
1561 Jean Nicot sends tobacco to Catherine de Medici
1565 John Hawkins introduces tobacco from Florida to England
1565 Nicolas Monardes extols healing properties
1571 Mathias L'Obel describes plant and its use
1588 Ecclesiastical decree forbids use
1598 Ben Johnson satirizes tobacco use in "Every Man in His Humour"
1602 First English anti-tobacco tract published
1604 King James I of England publishes "Counterblaste to Tobacco"
1609 Japan bans tobacco
1612 John Rolfe begins cultivation in Virginia
1615 Coin-operated dispensing machines appear in English taverns
1616 John Rolfe takes first shipment to London
1620 King James I forbids domestic production
1624 Pope Urban VIII threatens users with excommunication
1624 Greek Orthodox Church bans use
1629 Cardinal Richelieu imposes customs duty
1632 Massachusetts bans public smoking
1633 Charles I of England issues proclamation similar to that of his father, James I
1635 French restrict sale to physician's prescription
1636 Tabacalera, world's first tobacco company, founded
1640 Ming Emperor imposes death penalty for use
1641 Czar Michael Romanov forbids sale and use
1642 Pope Urban VIII bans use
1697 Czar Peter permits open sale/use
1753 Linnaeus names plant *Nicotiana tabacum*
1760 P. Lorillard Tobacco Co. founded
1761 John Hill notes abnormal growths after snuffing
1790 Vatican opens its own tobacco factory
1809 Louis Vauquelin isolates nicotianine
1828 Ludwig Reimann & Wilhelm Heinrich isolate nicotine
1875 Richard Joshua Reynolds founds company
1880 James A. Bonsack invents cigarette machine
1889 James B. Duke founds American Tobacco Co.
1907 U. S. government uses American Tobacco under anti-trust, anti-monopoly laws
1911 Supreme Court dissolves American Tobacco Co.
1918 War Department buys entire output of Bull Durham Tobacco for use by American troops
1920 U. S. consumes 100 billion cigarettes for first time
1945 Alton Ochsner correlates smoking and lung cancer
1939 Franz H. Müller links smoking and lung cancer
1950 Morton Levin confirms link between smoking and lung cancer
1954 U. S. tobacco industry publishes "Frank Statement to Cigarette Smokers"
1962 British Royal College of Physicians issues "Smoking & Health"
1964 U. S. Surgeon General issues report on "Smoking & Health"
1966 Congress passes Cigarette Labeling and Advertising Act
1971 U. S. bans cigarette ads on television
1991 FDA declares second-hand smoke dangerous
1995 FDA declares nicotine a drug
1997 The Liggett Group admits tobacco addictive
1998 Master Settlement Agreement reached between tobacco industry and various states
1999 Japan bans tobacco ads on television

☼ ☼ ☼ ☼ ☼

HISTORY

When Europeans arrived in the New World in 1492 they found the indigenous peoples using what the Carib Indians called " tobacco." Whether it was their word for the plant itself or one of the ways that they prepared it is unclear. These uses were largely religious, medicinal, and ceremonial. They either rolled the leaves into cigars and inhaled through the mouth or nostrils, or they inhaled the smoke of burning tobacco leaves through long hollow tubes inserted into the nostrils. The Indians also put tobacco in clay pipes, some of them with other plants in them that acted to filter the smoke. We have extensive archeological remains of these pipes. The Spanish were much amazed at these sights and wrote accounts of the savages who drank fire and whose navels belched smoke.

The fame of tobacco spread quickly to Europe. By 1519 it had been introduced to Spain, and from there it spread to the rest of the continent. It was introduced into France by Jean Andre Thevet in 1557. Three years later it was brought to the attention of the French Court by Jean Nicot, the ambassador to Portugal. It is Nicot who is commemorated in the generic name *Nicotiana*. Tobacco was introduced into England by Sir John Hawkins, who brought it from Florida. Hawkins' tobacco was different from that discovered by the Spanish. Sir Walter Raleigh did much to popularize the use of tobacco in England.

The smoking of tobacco became controversial almost immediately in England and Europe. In 1604, King James I of England wrote an unsigned pamphlet called "Counterblaste to Tobacco," in which he referred to the plant as the "precious stink." (Look at the quote at the beginning of the this section. He also slapped a tax on tobacco to discourage its use. Such taxes continue to this day and have become a most lucrative source of income for many countries.

The English colonies in America, particularly Virginia, were in the tobacco business almost since their founding. The English began with *N. rustica*, a species native to the area, but much inferior to the *N. tabacum* used by the Spanish. In about 1610-12, John Rolfe "procured" seeds of the Spanish tobacco for use by the English colonial planters. This was the beginning of the tobacco industry in the United States. In 1615, Virginia exported 2300 lbs. of tobacco; in 1629, 1,500,000 lbs., and 86,000,000 lbs. at the turn of the century.

The tobacco industry has remained a southern institution. The oldest tobacco company in the U.S. and the world is P. Lorillard, founded in 1760 supposedly with tobacco from George Washington's Virginia plantations. Liggett and Meyers Co. was begun in 1822 and the R. J. Reynolds Tobacco Co. in 1875.

In 1890, W. Duke and Sons combined with four other tobacco companies to form the American Tobacco Company. The company soon absorbed P. Lorillard, Brown and Williamson, Liggett and Meyers, and Phillip Morris. By 1910, 82% of the 8.6 billion cigarettes sold in the U.S. were made by the American Tobacco Company. In 1911, the government declared it a monopoly. Most of today's major companies were carved out of the American Tobacco Co. in the legal settlement that followed.

James Buchanan Duke retained the American Tobacco Co. In 1924, Duke offered Trinity College in Durham, North Carolina, $40 million if it would change its name to Duke University. Trinity College agreed. Duke died in 1925, leaving an additional $40 million to his university.

HOW IS IT USED?

Tobacco is used in several ways. It may be smoked, snuffed, chewed, drunk, or even eaten. Today, only smoking, snuffing, and chewing ("smokeless tobacco") remain popular. Because the leaves are smoked, tobacco is a **fumatory**; because it is chewed, it is also a **masticatory.** Here is a more comprehensive look at how tobacco has been used.

Smoked
Snuffed
Chewed
Dipped
Eaten
Drunk
Licked
Smeared over body
Blown over warrior's faces
Blown over women's faces
Eye drops
Enemas
Offered to the gods
Offered as a gift
Narcotic
Medicine
Initiation ceremony

TOBACCO AS A MEDICINE

You may have been surprised to see tobacco listed as a medicine. Historically, it has been used to treat wounds, rashes, rabies, head injuries, plague, syphilis, insomnia, thirst, hunger, toothache, scorpion bites, and migraines.

PRODUCTION

The United States leads the world in growing tobacco, with most of it grown in North Carolina, Kentucky, South Carolina, Tennessee, and Georgia. Other leading producers include The People's Republic of China, India, and Pakistan.

Tobacco is planted from seed and requires a great deal of care. The seedlings are subject to many diseases with exotic names. At a certain stage in their growth, the plants are "topped" by cutting off the growing point. This prevents flowering and promotes the enlargement of leaves and the accumulation of materials, including nicotine. Individual leaves are harvested from the plants, usually two or three at a time, from the bottom upward. The tobacco leaves are then dried or cured. This process is done is two principal ways. One is to air cure the leaves in ventilated barns, a common sight in the South. The other method is fire curing the leaves in smoke to add flavor. Curing over artificial heat also occurs. After curing the leaves are gathered into "hands" and then sold to buyers. After the purchase they are usually allowed to age for a period of six months to three years. Fermentation occurs during this period, and the characteristic aroma develops. The percentage of nicotine in the leaves also decreases.

NICOTINE

Many of the desirable and undesirable effects of tobacco may be attributed to the alkaloid **nicotine** ($C_{10}H_{14}N_2$). Its effects on the human body are complex. It can:

- stimulate autonomic ganglia;
- stimulate skeletal neuromuscular junctions;
- stimulate sympathetic nervous system;
- increase heart rate (10-20 bpm);
- increase blood pressure (5-10 mm mercury);
- increase cardiac stroke volume/output;
- increase coronary flow;
- produce initial arousal, then relaxation;
- cause changes in brain wave patterns;
- act on midbrain "reward system" region; and
- cause the release of dopamine.

The amount in a cigarette, though not particularly high, is still harmful. Nicotine is a potent poison causing:

- vomiting;
- nausea;
- evacuation of the bowels and bladder;
- mental impairment;
- twitching and convulsions;
- blood to coagulate more easily, which can lead to the formation of thromboses; and
- inflammation and chronic lung disease.

Forty to fifty milligrams taken orally can be fatal in an adult. The dependence of the body on nicotine is still being investigated. Last year the U. S. Food and Drug Administration declared nicotine to be an addictive substance. As you are aware, multi-billion dollar lawsuits are working their way through the courts that rest, at least in part, on that very point. Did the tobacco companies not only know of the addictive nature of nicotine, but engage in practices that would enhance it?

SMOKING AND HEALTH

"Smoking is the largest single cause of chronic disease and premature death in our society."

Recent work indicates that nicotine may be only one part of the problem. Tobacco smoke contains over 4000 combustion products, 400 of them toxic, and 40 of those are carcinogenic. They include: nitrogen, oxygen, carbon monoxide, hydrogen sulfide, ammonia, various resins, essential oils, methyl alcohol, acetone, formic acid, butyric acid, and acetic acid. In December 1997, the Liggett Tobacco Group released additional ingredients used in its L & M cigarettes. They include molasses, patchouli oil, licorice flavoring, valerian root extract, vanilla extract, and cedarwood oil.

Smoking is the leading cause of lung cancer and it is a major factor in deaths from coronary heart disease, chronic bronchitis, emphysema, and other diseases. It is also involved in cancer of the pancreas, esophagus, mouth and throat, larynx, bladder, kidneys, and cervix. Over 400,000 Americans die each year from tobacco-related causes. Another 6000 will die from the effects of second hand smoke. By comparison, 30,000 die each year from sexually-transmitted diseases, 25,000 from motor vehicle accidents, and 20,000 from abuse of illicit drugs.

Bidis (also called beedies or beadies) are cigarettes imported from India. They are very popular with younger smokers. Bidis have the tobacco wrapped in leaves from a relative of the persimmon tree, and tied with colored thread. They are typically flavored with chocolate or strawberry. The Center for Disease Control cautions that bidis have about three times more carbon monoxide and nicotine and about five times the tar found in regular cigarettes.

COCA LEAF

"Which is it today," I asked, "morphine or cocaine?"... It is cocaine," he said ... "would you care to try it?" "No, indeed," I answered brusquely... "Perhaps you are right, Watson... I suppose that its influence is physically a bad one. I find it, however, so transcendently stimulating and clarifying to the mind that its secondary action is a matter of small moment." [Sir Arthur Conan Doyle]

"They may have found a substitute for its [tobacco's] narcotic qualities in the coca ..., or cuca, as called by the natives. This is a shrub which grows to the height of a man. The leaves when gathered are dried in the sun, and, being mixed with a little lime, form a preparation for chewing, much like the betel-leaf of the East. With a small supply of his cuca in his pouch, and a handful of roasted maize, the Peruvian Indian of our time performs his wearisome journeys, day after day, without fatigue, or, at least, without complaint. Even food the most invigorating is less grateful to him than his loved narcotic. Under the Incas, it is said to have been exclusively reserved for the noble orders. If so, the people gained one luxury by the Conquest; and, after that period; it was so extensively used by them, that this article constituted a most important item of the colonial revenue of Spain. Yet, with the soothing charms of an opiate, this weed so much vaunted by the natives, when used to excess, is said to be attended with all the mischievous effects of habitual intoxication." [William H. Prescott. 1847. History of the Conquest of Peru]

"I naturally learned to chew ... toasted coca leaves and, finding it to be a most helpful custom when one must work hard and there is little food, I used coca for eight years while in these remote areas, with absolutely no desire to continue upon my return. Cocaine, the powerful alkaloid extracted from the leaves is, of course, a very dangerous addicting drug. But coca leaves, as they are used by the South American Indians, particularly in the bleak Andean heights, are not addictive and they do serve a useful purpose enabling undernourished, debilitated persons to do a day's work and thus, at least, survive. The energy expended upon punitive international legislation against coca leaves might better be supplanted by an all-out attack upon the basic problems of malnutrition, disease, and a system which in many respects resembles paid slavery."

"A spoonful or two is put into the mouth. Conversation is impossible, until the powder has slowly been moistened and packed with the tongue between the gums and the cheeks. It is not chewed but is allowed gradually to mix with saliva and pass into the stomach. When the amount of powder is thus diminished, it is replenished with an additional supply. Normally, a supply is kept in the mouth throughout the day.... Coca powder has an initial bitter taste which puckers up the mouth. The first noticeable effect is a slight anaesthetizing of the tongue and mouth; this is followed by a general stimulation.... The stimulation and capacity for performance and endurance which coca affords the individual and its ability to suppress hunger pangs gives the drug the role of an indispensable vademecum in the more or less itinerant life of deprivation which many Indians of the northwest Amazon must undergo."
[Richard Evans Schultes, Harvard ethnobotanist]

"Woe to you, my Princess, when I come, I will kiss you quite red and feed you to you are plump. And if you are forward you shall see who is the stronger, a gentle little girl who doesn't eat enough or a big wild man who has cocaine in his body...."
[Sigmund Freud. 1884. Letter to his fiancée]

☼ ☼ ☼ ☼ ☼

TIMELINE: COCA & COCAINE

BCE:

3300 Coca plant domesticated (Peru)

CE:

1533 Francisco Pizarro reports general use in Peru
1567 “appears to give strength only by a deception of the Evil One.”
1565 N. Monardes publishes first European description
1750 Joseph De Jussieu sends first specimens back to Europe
1802 Baron von Humboldt writes of use by his native guides
1859 Paulo Mantegazza recommends use for toothache, etc.
1860 Albert Niemain isolates cocaine
1862 Wilhelm Lossen determines chemical formula of cocaine
1863 Angelo Mariana patents coca/wine drink (Vin/Thé Mariana)
1878 W. H. Bentley recommends use to cure morphine addiction
1880 Cocaine admitted to U. S. Pharmacopeia
1884 William Halsted discovers anesthetic properties
1884 Sigmund Freud uses it for first time
1884 Freud publishes *Über Coca*
1885 John Pemberton markets Coca Cola
1885 Karl Koller discovers local anesthetic property
1885 Louis Lewin & Albrecht Erlenmeyer attack Freud’s paper
1887 Freud publishes *Bemerkungen über Cocaïsucht und Cocaïnfrucht...*

1887 Oregon becomes first state to restrict cocaine use
1888 Arthur Conan Doyle publishes *The Sign of Four* (see first quote)
1890 Angelo Mariana publishes *Coca and Its Therapeutic Application*
1898 R. Willstatter determines chemical structure of cocaine
1901 W. Golden Mortimer publishes *Peru: History of Coca*
1902 R. Willstatter synthesizes cocaine
1903 Cocaine removed from Coca Cola
1904 Procaine discovered
1907 New York State passes law severely restricting medicinal use
1914 The Hauge Opium Convention restricts opium and cocaine production
1922 Congress declares cocaine narcotic and prohibits most imports
1929 C. Ricketts offers plan for cutting cultivation to Peruvian government
1961 Peru & Bolivia sign U. N. convention on abolishing coca cultivation

Coca leaf is a **masticatory**. Mastication, from a Greek word meaning "to gnash the teeth," is the technical term for the chewing of food or other material, thereby rendering it easier to digest. A few psychoactive plants are considered masticatories because we chew the tissues, typically without swallowing them. The process is critical because it brings the enzymes in our saliva into contact with the active principles in the plant.

Leaves are harvested from two shrubs (*Erythrox-ylum coca* and *E. novogranatense*) native to South America. In older literature, the generic name *Erythroxylon* was used for these plants. A person who chews the coca leaf is a **coquero**. The pouch used to carry leaves is a **chuspa**. The gourd that contains the powdered material to stimulate salivation and the action of the alkaloid is an **iscupuru**; the powder itself is called **llipta**.

As Dominic Streatfeild (2001) put it, "*... in its heart, South America runs on Coca Time*." Both distance and time are measured in terms of the amount of coca leaf consumed. The standard unit is the **cocada**, one of which is the amount needed to walk at a comfortable pace on level ground for about 45 minutes or 3 km.

HISTORY

Coca leaves have been chewed by the Andean Indians for centuries to enable them to work harder and to walk longer distances through the mountains. The Great Inca himself once controlled its use. The leaves mature in about three or four years. An average chew is not more than 2 oz. per day. Coca leaves are often chewed in conjunction with powdered lime or ashes, typically carried in a purse or gourd.

Angelo Mariani, a Corsican chemist, was aware of recent research, particularly that of Paulo Mantegazza, on the benefits of the coca leaf. He determined early on that Europeans would not take well to the habit of chewing coca leaves, but that they would drink it. He soaked coca leaves in a pint of Bordeaux wine. Its flavor masked that of coca and the alcohol enhanced the leaching of the alkaloids. He named his new concoction **Vin Mariani** and offered it for sale in 1863. To say that it was an instant success would be an understatement! Mariani was also skilled at advertising his new coca leaf wine, especially at getting endorsements from the rich and famous. A very incomplete list would include Thomas Edison, Henrik Ibsen, Auguste Bartholdi (who built the Statue of Liberty), Jules Verne, H. G. Wells, President William McKinley, Pope Leo XIII, and General U. S. Grant.

Vin Mariana was so successful that he created an entire line of coca leaf products, including a throat lozenge, a non-alcoholic tea, and Elixir Mariana, with added alcohol.

One of the major figures in the history of cocaine is Sigmund Freud (1856-1939), the Austrian physician who developed the theory of psychoanalysis. Early on in his career, he began reading about coca leaves and how they enabled Indians in South America to "resist privations and hardships." He started using it himselfand was so pleased with the results that he not only recommended cocaine to his friends and colleagues, but he supplied them with it. One such recipient was Martha Bernay, his future wife. Freud, who had not seen Martha for over a year, wrote to her in 1864 of his upcoming visit:

"In my last serious depression I took cocaine again and a small dose lifted me to the heights in a wonderful fashion. I am just now collecting the literature for a song of praise to this magical substance."

His "song of praise" was *Über Coca*, published in 1884. Students of Freud's writings say that it was an unusual work for him, in that he wrote so warmly about the subject and that the paper was marred by a series of minor errors. He noted, "*The psychic effect of cocaine consists of exhilaration and lasting euphoria ... which does not differ from the normal euphoria of a healthy person.... Absolutely no craving for cocaine appears after the first, or repeated, taking of the drug*."

In 1885, reports of the dangerous side effects of cocaine use appeared in the scientific literature. This aspect of the drug became very personal for Freud when he saw it destroy the life of his close friend, Ernst von Fleischl-Marxow, who was himself a brilliant and successful physician. Unfortunately, as the result of an accident and subsequent amputation of his thumb, Ernst developed an extremely painful nerve condition. Over a period of time, he became completely addicted to morphine. After seeing his friend in such a terrible straight, Freud offered him cocaine, which had recently been shown to cure morphine addiction. And, it worked! A year or so later, Ernst was now completely dependent on cocaine, taking what Freud estimated to be the equivalent of a gram of pure alkaloid each day. The effects were terrifying. Freud would later spend what he described as "the most frightful night of my life" caring for his old friend. What Freud did not know was that Ernst was not only hooked on cocaine, but that he had gone back to morphine, too. Freud estimated that Ernst would live for only a few more months, but he hung on for six more years. Freud kept a photograph of his friend hanging above his desk for the rest of his life.

MODE OF ACTION

Cocaine, an alkaloid, can be extracted from the leaves with almost any organic solvent. It is chemically related to atropine and the other belladonna alkaloids. Cocaine is a stimulant to all parts of the central nervous system. It produces its effects by increasing the concentration of dopamine in certain regions of our brain, especially those that produce a feeling of pleasure. Dopamine is a naturally occurring neurotransmitter, a category of chemicals that carry messages between nerve cells or between nerve and muscle cells. The intense euphoria that results from these higher concentrations of dopamine is the "rush" that coke users describe. It is followed by the "crash" that comes when cocaine is flushed out of our system. Even natural dopamine levels are reduced, which means that you will feel worse after cocaine wears off than you did before. So what do we do? We soon find ourselves in a feedback loop.

Cocaine was once widely used as a local anesthetic. When applied topically, it paralyzes sensory nerve endings. It can produce a profound feeling of well-being, alertness, increased self-confidence, magnification of normal pleasures, reduction in social inhibitions, and an enhancement of emotions and sexual feelings. Abuse of cocaine, which has become a major health problem in this country, is characterized by:

- headaches
- seizures
- strokes (especially in young people)
- severe complications in pregnancy and childbirth (abortions, fetal death, premature birth, small babies)
- paranoia
- loss of weight and appetite
- pallor
- insomnia, and
- what amounts to an all-consuming focus on its use, to the exclusion of concerns about eating, sleeping, money, responsibilities, and loved ones.

Mood swings may be dramatic -- from elation to mania and delusions. There is reasonably decent evidence that Robert Louis Stevenson wrote "The Strange Case of Dr. Jekyll and Mr. Hyde" while under the influence of cocaine.

Crack is a highly addictive form of smokable cocaine hydrochloride. It is made by adding ammonia or sodium bicarbonate and water, and then heating the mixture. When it cools to room temperature it forms pebble-sized crystals. The term "crack" refers to the sound made when it is smoked. It takes only about 7-10 seconds for the active principles to reach the brain and heart.

PEYOTE

"[There] is another herb, like native tunas [a prickly-pear cactus]; it is called peyotl; it is white; it grows in the north region.... Those who eat or drink it see visions either frightful or mirthful; the intoxication lasts two or three day and then ceases. It is a common food of the Chichimecas, for it sustains them and gives them courage to fight and not to feel hunger nor thirst; and they say that it protects them from all dangers." [Bernardino de Sahagun. General History of Things of New Spain]

"On Good Friday, I found myself entirely alone in the quiet rooms in the Temple which I occupy when in London and judged the occasion a fitting one for a personal experiment. I made a decoction ... of three buttons, the full physiological dose, and drank this at intervals between 2.30 and 4.30 p.m. The first symptom observed during the afternoon was a certain consciousness of energy and intellectual power. This passed off, and about an hour after the final dose I felt faint and unsteady; the pulse was low, and I found it pleasanter to lie down.... The appearance of visions with closed eyes was very gradual. At first, there was merely a vague play of light and shade which suggested pictures, but never made them. Then the pictures became more definite, but too confused and crowded to be described.... Then, in the course of the evening, they became distinct, but still undescribable -- mostly a vast field of golden jewels, studded with red and green stones, ever changing. This moment was, perhaps, the most delightful of the experience...." [Havelock Ellis. 1898]

"A vase containing a rose, iris, and carnation... nothing more, and nothing less than they actually were, a transience that was yet eternal life, a perpetual perishing that was at the same time pure Being, a bundle of minute particulars in which, by some unspeakable and yet self-evident paradox, was to be seen the divine source of all existence."
[Aldous Huxley. 1954. The Doors of Perception]

"*The white man goes into his church house and talks about Jesus; the Indian goes into his teepee and talks to Jesus."*
[Quanah Parker, leader of the Comanche People]

TIMELINE: PEYOTE

BCE:

5000 Earliest use (?)

CE:

1560 Bernardino de Sahagún publishes first description
1591 Juan de Cárdenas describes effects of peyote
1620 Holy Office of Inquisition denounces as act of superstition
1845 Plant described as *Echinocactus williamsii*
1847 Curtis' Botanical Magazine publishes first image
1887 Louis Lewin receives samples of "muscale buttons"
1891 James Mooney participates in ceremony in the Oklahoma Territory
1894 Plant described as *Lophophora williamsii*
1897 Weir Mitchell publishes first account of intoxication
1897 Havelock Ellis publishes account of his use
1897 Arthur Heffter isolates mescaline
1918 Native American Church incorporates in Oklahoma
1919 Ernst Späth synthesizes mescaline
1927 Weston La Barre publishes *The Peyote Cult*
1933 BIA prohibits interference with Indian practices
1953 Aldous Huxley takes mescaline sulfate
1960 Judge Yale McFate sanctions its use
1962 California says peyote has no religious significance
1994 American Indian Religious Freedom Act amended to allow use by Indians for religious purposes

Peyote or the peyotl cactus (*Lophophora williamsii*) is a member of the cactus family. It grows in the deserts of the American Southwest and in adjacent Mexico. Its natural distribution is centered in the Valley of the Rio Grande. Peyote is one of the most fantastic vision-inducing plants of the New World. Perhaps because of this and the associated belief in its therapeutic properties, it is the most sacred hallucinogenic plant of this hemisphere.

The common name of the plant is derived from the Nahautl word "peyotl," meaning a silk cocoon or caterpillar's cocoon, a reference to the hairs present on the upper part of the plant.

HISTORY. No one knows exactly how far back in the history of the New World the peyote use goes. Sahagún suggested that the plant was in use in 300 B.C. The Spanish historians make numerous references to the plant. The missionaries tried to stamp out the peyote cults of Mexico with little success. After almost 400 years of both religious and governmental sanctions, peyote is still widely used. In the past one hundred years its use by American Indians has dramatically increased.

Early opposition to the plant was directed mostly at the pagan connotations that it had, rather than any physical or mental harm that it might be doing to the Indians. In a religious manual of the late 1700's entitled "El Camino del Cielo" the priest is instructed to ask prospective converts if they had eaten the flesh of man, eaten the peyotl, or sucked the blood of others. A "yes" answer to any of the above apparently eliminates one as a serious candidate. Even Indians who were thought to be converted to the new religion still retained remnants of their old ways. It was not uncommon for parents to tie small bags of peyote around the necks of their children to keep them healthy. Older Indians also bowed when passing a plant. Combinations of peyote cults and Christianity appear, as seen in such titles as "El Niño de Peyotl," and "El Santo de Jesus Peyotes."

The earliest uses of peyote in the United States go back to about 1760 in the territory that would become Texas. The plant was in common use by Indians during the Civil War. The spread of knowledge of peyote may have involved the Plains Indians' raiding parties that went into the Mescalero Indian territory of the Southwest. They saw the plant being used and brought the information back with them. In the late 1800's the Kiowa and Comanche Indians had formulated a ceremony that was to become the basis of the peyote cult in more than thirty tribes. They formed semiofficial groups, such as the "Peyote Society," and finally organized into the legally constituted body known as the Native American Church. Present membership of this group is estimated at 250,000, including members from essentially all states and some of the provinces of Canada. At first the Native American Church encountered difficulty from the U.S. government because of the use of peyote during religious ceremonies. In 1933 John Collier, the Head of the Bureau of Indian Affairs, succeeded in getting a regulation passed that "*...prohibited absolutely any interference by the Indian Bureau with the religious practices of the Native American Church.*" In 1962, the State of California decided that peyote had no religious significance and attempted to prosecute the Indians. The American Civil Liberties Union entered the case and the Indians were ultimately victorious.

RITUAL USE. In northern Mexico, the peyote ceremony usually involves a long meeting with lots of dancing. In the U.S., the Indians use a rather standardized ritual patterned after the Kiowa-Comanche ceremony of the late 19th century. There are, of course, certain tribal variations. Often special clothing must be worn and certain taboos must be observed. The peyote ceremony consists of an all night meeting in a special teepee or other specially designated structure. The worshipers sit in a circle around the peyote altar. Special drums, gourd rattles, and a carved staff are passed around after certain purification ceremonies. The worshipers are led in prayer, meditation, and chanting by a cult leader or "roadman." The peyote ceremony ends with a ritual breakfast consisting of parched corn, fruits, water, and boneless meat. In most cases the ceremony combines elements of both Christian worship and Indian belief.

Peyote is usually consumed in the form of **mescal buttons** the dried brown tops of the cactus. The button is the above ground photosynthetic portion of the plant. Much of the plant body is below the surface. The dried buttons may be stored indefinitely. The mescal buttons are usually taken into the mouth and softened by rolling them in saliva. They are swallowed without chewing. Some users prefer to soak them in water and make a drink from the buttons. The number of buttons consumed varies from three or four to about thirty.

EFFECTS. The resulting intoxication is one of the most complex known from any psychoactive plant. It is characterized particularly by brilliant color hallucinations. These are often accompanied by tactile, auditory, and olfactory hallucinations. Many users describe a sensation of weightlessness, doubling of the ego, and depersonalization. Alteration or loss of time is common. Symptoms of hallucinating vary greatly from individual to individual and with the source of material. Injection of any one of the alkaloidal principles can produce some of the sensations, but the effects of intoxication from the entire button should be distinguished from the results of injecting any one of these principles.

ACTIVE PRINCIPLES. The peyote cactus contains at least fifteen different alkaloids. The most famous of these is mescaline (3, 4, 5-trimethoxy-phenylethylamine). It is the alkaloid responsible for the pronounced color visions.

MESCAL BEAN

While I suspect that most everyone has heard of peyote, the mescal bean or red bean is a new plant for most of us. *Sophora secundiflora*, a member of the bean family, is native to the American Southwest and the adjacent regions of Mexico. Early reports by Cabeza de Vaca (1539) indicate that the plant was in trade. The Stephen Long expedition in 1820 reported that the Arapaho and Iowa Indians using it as a medicine and a narcotic. The mescal bean is known from archaeological sites in the Southwest from about A.D. 1000.

Well-developed mescal bean cults were known in many Indian tribes, including the Apache, Comanche, Delaware, Iowa, Kansa, Omaha, Oto, Osage, Pawnee, Ponca, Tonkawa, and Wichita. In most cases the beans were used in initiation ceremonies and for divination. The hallucinogenic effects were apparently not pronounced and much of the mescal bean fervor declined rapidly with the introduction of peyote ceremonies. Today most of the details concerning the nature of mescal bean ceremonies is unknown.

The use of the mescal bean did not completely die when the peyotl cactus cults began. Even today the leaders of the peyote ceremonies sometimes wear necklaces of *Sophora secundiflora*. The Comanche, Oto, and Tonkawa Indians have mixed peyote and mescal beans together, perhaps leading to some of the confusion in names that now exists.

THE SACRED MUSHROOMS

"As I was perfectly well aware that my knowledge of the Mexican origin of the mushrooms would lead me to imagine only Mexican scenery, I tried deliberately to look on my environment as I knew it normally. But all voluntary efforts to look at things in their customary forms and colours proved ineffective. Whether my eyes were closed or open, I saw only Mexican motifs and colours. When the doctor supervising the experiment [Hofmann had ingested Psilocybe mexicana] bent over me to check my blood pressure, he was transformed into an Aztec priest, and I would not have been astonished if he had drawn an obsidian knife. In spite of the seriousness of the situation, it amused me to see how the Germanic face of my colleague had acquired a purely Indian expression. At the peak of the intoxication, about 1½ hours after ingestion of the mushrooms, the rush of interior pictures, mostly changing in shape and colour, reached such an alarming degree that I feared that I would be torn into this whirlpool of form and colour and would dissolve. After about six hours, the dream came to an end. Subjectively, I had no idea how long this condition had lasted. I felt my return to everyday reality to be a happy return from a strange, fantastic but quite really experienced world into an old and familiar home." (Albert Hofmann, Swiss biochemist and discoverer of LSD]

☼ ☼ ☼ ☼ ☼

When the Spanish conquered Mexico, they found the Aztecs using certain mushrooms as a sacrament in their religious ceremonies. The Aztecs referred to the plants as **teonanacatl**, which translates roughly as the "flesh of the gods." The Roman Catholic clergy was strongly anti-mushroom because these fungi presented a stumbling block for the establishment of Christianity in the New World. The Aztecs could see little advantage to this new religion when the use of the sacred mushroom allowed them to speak directly to their deities.

There are ancient references to the use of the sacred mushrooms. Artifacts from Guatemala show clear representations of them. These pieces are about 3000 years old. When first discovered they were thought to be phallic symbols.

Most of our knowledge of the sacred mushrooms has come from investigations done in Mexico in the past few decades. In 1915 William Safford, a noted American ethnobotanist, suggested that the sacred mushrooms were not really fungi at all, but peyote. Safford pointed out that no one had seen any Mexicans eating mushrooms for over four hundred years, but that the peyote cult was well known. Since that time, extensive field work has shown the use of mushrooms by the Indians of the State of Oaxaca.

The Indians of Mexico use at least 24 species of *Psilocybe*, *Stropharia*, *Conocybe*, and *Panaeolus*. Collectively we refer to them as the **sacred mushrooms**.

The chemistry of the mushrooms is not completely known. *Psilocybe mexicana* contains psilocybine (4-hydroxy-dimethyltriptamine), which is allied to bufotenine and serotonin.

THE DATURAS

"Datura stramonium acts very powerfully upon the cerebrospinal system, causing a line of symptoms showing it to be a narcotic-irritant of high degrees. The symptoms collated from many cases of poisoning by this drug are: vertigo, with staggering gait, and finally unconsciousness; stupor and deep sleep, with stertorous breathing; mania, with loquaciousness or melancholia; hallucinations of terrifying aspect, the patient bites, strikes, and screams, and throws the arms about, or picks and grasps at unattainable objects; congestive headaches, with dull beating and throbbing in the vertex. The pupils are dilated, and the patient suffers from photophobia [sensitivity of light], diplopia [double vision], and hemeralopia [day blindness]; the eyes are wide open, staring and set, or are contorted, rolling, and squinting. The face becomes red, bloated, and hot, the mouth spasmodically closed, and the tongue dry and swollen; the patient suffers greatly from thirst, but the sight of water throws him into a spasm and causes great constriction of the throat, foaming at the mouth, but seldom vomiting. The sexual functions are often excited, more especially in women, in whom it causes nymphomania. Spasms of the muscles of the chest are of frequent occurrence; inspiration is slow and expiration quick. Paralysis of the lower limbs and loss of speech, with twitchings and jerkings of the muscles often mark a case. Its action will be seen to be similar to that of Belladonna, yet differing in many respects. [Mitilda Cox Stevenson. 1915. Ethnobotany of the Zuñi Indians....]

"The James Town Weed (which resembles the Thorny Apple of Peru, and I take to be the plant so call'd) is supposed to be one of the greatest Coolers in our World. This being an early Plant, was gather'd very young for a boil'd Salad, by some of the Soldiers sent thither, to pacifie the Troubles of Bacon; and some of them eat plentifully of it, the Effect of which was a very pleasant Comedy; for they turn'd natural Fools upon it for several Days; One would blow up a Feather in the air; anoyther would darts Straws at it with much Fury; and another stark naked was sitting up in a corner, like a Monkey, grinning and making Mows at them; a Fourth would fondly kiss, and paw at his Companions, and snear in their Faces, with a Countenance more antick, than any in a Dutch droll. In this frantick Condition they were confined, lest they should in their Folly destroy themselves; though it was observed, that all their Actions were full of Innocence and good Nature. Indeed, they were not very cleanly; for they would have wallow'd in their own Excrements, if they had not been prevented. A Thousand such simple Tricks they play'd, and after Eleven Days, return'd to themselves again, not remembering any thing that had pass'd." [Robert Beverley. 1705. The History and Present State of Virginia]

☼ ☼ ☼ ☼ ☼

Species of *Datura*, a member of the nightshade family, are native to both the Old World and New World. They have been used since prehistoric times. In the Old World, Chinese and Sanskrit literature make several references to the use of these plants. The generic name is derived from the Hindi word "dhatura." In Asia the seeds of *Datura* are still used by thieves to stupefy their victims. A group of thugs called the Dhatureas once used the plant to kill their victims.

USES OF THE DATURAS

Medicinal:
- "cureth all inflammation whatsoever"
- Treat bruises and wounds
- Asthma preparations
- Anesthetic (surgery)

Aphrodisiac
Toxic plant (stun, punish, stupefy, or kill victims)
Recreational drug use
Ritual/ceremonial use:
- Divination
- Visionary journeys
- Shape-shifting (birds)
- Clairvoyance
- Initiation ceremonies
- Funeral ceremonies

Magic ("herbe aux sorciers")
Discipline unruly children
Zombification (making zombies)

The real ethnobotanical center of *Datura* is the New World. Here the plants assume great medicinal, religious, and magical importance. In North America the plants are used mostly in the American Southwest and in adjacent Mexico. However, the Algonquins and other Indian tribes of the eastern woodlands used the Jimson weed (*Datura stramonium*) in initiation ceremonies for the young males of the tribe.

The species most commonly employed in the Southwest and Mexico is the sacred datura, *D. inoxia* (= *D. meteloides* in the older literature). Among the Zunis, for instance, the plant was used as a narcotic, an anaesthetic, and a poultice for wounds and bruises. The rain priests of the tribe put the powdered root of the sacred datura in their eyes and ate the root to enable them to talk with the dead and ask for rain. Their belief was that the plant was divine and could only be used by members of the priest caste. The use of the plant in Mexico antedates the Conquest. The Aztecs used "toloatzin" as both a medicine and narcotic.

RITUAL USE. In South America, different species are employed in weird and wonderful ways. Several of these plants, belonging to the genus *Brugmansia* (once part of *Datura*), are large shrubs or small trees. In Ecuador the plants are used to produce a deep sleep in children who have been misbehaving. During the sleep the children hear the voices of their ancestors who admonish them for their poor behavior. In Pre-Conquest Bogotá, the wives and slaves of dead chieftains and warriors were drugged with *Brugmansia* before being buried alive with their departed husbands or employers. Among the Jivaro Indians the plant is used as part of an initiation ceremony for the young boys of the tribe. A boy is expected to take a sip of an infusion from the plant from each member of the tribe. Soon he is unable to drink any more. The ritual does not cease, however. He is given an enema of the infusion. During the unconscious period that follows, the boy is supposed to forget all of his boyhood ways and awake a man.

"The Solemnity of Huskanawig is commonly practis'd once every fourteen or sixteen years, or oftener, as their young men happen to grow up. It is an Institution or discipline which all young men must pass, before they can be admitted to be of the number of the Great Men.... The whole Ceremony is performed after the following manner.

[The] principal part of the business is to carry them into the Woods, and there keep them under confinement, and destitute of all Society, for several months; giving them no other sustenance, but the Infusion, or Decoction of some Poisonous Intoxicating Roots [Datura stramonium or wysoccan]; by virtue of which Physick, and by the severity of the discipline, which they undergo, they become stark raving Mad; In which raving condition they are kept eighteen or twenty days.... When the Doctors find that they have drank sufficiently of the Wysocccan, (so they call this mad Potion) they gradually restore them to their Senses again, by lessening the Intoxication of their Diet; but before they are perfectly well, they bring them back to their Towns, while they are still wild and crazy, through the Violence of the medicine. After this they are very fearful of discovering any thing of their former remembrance; for if such a thing should happen to any of them, they must immediately be Huckanaw'd again; and the second time the usage is so severe, that seldom any one escapes with Life. Thus they must pretend to have forgot the very use of their Tongues, so as not to be able to speak, no understand any thing that is spoken, till they learn it again. Now whether this be real or counterfeit, I don't know; but certain it is, that they will not for some time take notice of any body, nor any thing, with which they were before acquainted, being still under the guard of their Keepers, who constantly wait upon them every where, till they have learnt all things perfectly over again. Thus they unlive their former lives, and commence Men, by forgetting that they ever have been Boys...." (Robert Beverly. 1705. The History and Present State of Virginia.)

ACTIVE PRINCIPLES. The daturas manufacture a series of the tropane or belladonna alkaloids. They are responsible for the effects on the central nervous system.

SYMPTOMS OF TOXICITY. Symptoms appear within a few minutes to a few hours after ingestion of plant material. They include:

- intense thirst
- dilated pupils; avoidance of light
- flushed skin
- delirium
- picking at imaginary objects on clothing or in air
- convulsions
- coma
- death from respiratory paralysis

HALLUCINOGENIC SNUFFS

Tobacco leaves are not the only plant that we snuff. The indigenous peoples of South America have discovered that they could reduce dried leaves, bark, and seeds to a fine powder and sniff it into the nostrils, with dramatic effects.

EPÉNA, also known as yakee, parica, and nyakwana, is one of the widely used hallucinogenic snuffs of the Amazonian region. It goes by various names, depending upon the tribe that prepares it. Although the use of snuffs probably goes far back into the history of the New World Indians, detailed botanical and ethnobotanical knowledge is relatively recent. They were first described in detail after an expedition to Colombia in 1954.

In some tribes, particularly those that refer to the snuff as yakee, only the witch doctors are allowed to prepare and use the plant. It is felt that during the hallucinogenic phase they are better able to diagnose disease and to see into the future. Yakee is often prepared from *Virola calophylla* and *V. calophylloidea*, species of the family Myristicaceae. Nutmeg and mace are also derived from this family.

In other tribes, the epéna or nyakwana snuff is prepared from *V. theiodora*. Generally speaking, any male member of the tribe may use epéna. The preparation of the *Virola* snuffs involves removing the bark from trees, scraping off the inner bark that contains a resinous exudate, mixing the resin with water, and boiling it down into a thick syrup. The syrup is sun-dried, pulverized, sifted, and mixed with the ashes of other plants. The exact recipe and choice of supplementary plants varies with the tribe.

The effects of intoxication vary, but usually include an initial phase of excitability, numbness of the limbs, twitching of the facial muscles, loss of coordination, visual hallucinations, including macroscopia, and finally a deep sleep.

The *Virola* plants contain tryptamines in relatively high percentages. These are believed to be the active principle. These same plants are also used to make arrow poisons.

YOPO or **PARICÁ** is a strong hallucinogenic snuff prepared from the seeds of *Anadenanthera peregrina*, a South American legume. Records from 1511 relate the inhaling of the snuff through long tubes. This species is probably the basis of many reports of snuffing by the South American Indians. Many of these reports are now thought to be unfounded and the use of yopo is more restricted than once believed.

Yopo contains various tryptamine derivatives as the psychoactive principle. Bufotenine, once thought to be in the material, is apparently not involved. One of the more pronounced symptoms of hallucination is seeing people and other objects upside down.

AYAHUASCA

"I had scarcely dispatched one cup of the nauseous beverage, which is but half the dose, when the ruler of the feast -- desirous, apparently, that I should taste all his delicacies at once -- came up with a woman bearing a large calabash of caxiri (mandioca beer), of which I must needs take a copious draught, and as I knew the mode of its preparation, it was gulped down with secret loathing. Scarcely had I accomplished this feat when a large cigar, 2 feet long and a thick as the wrist, was put lighted into my hand, and etiquette demanded that I should take a few whiffs of it -- I who had never in my life smoked a cigar or a pipe of tobacco. Above all this, I must drink a large cup of palm-wine, and it will readily be understood that the effect of such a complex dose was a strong inclination to vomit, which was only overcome by lying down in a hammock and drinking a cup of coffee which the friend who accompanied me had taken the precaution to prepare beforehand."

"In two minutes or less after drinking it, its effects begin to be apparent. The Indian turns deadly pale, trembles in every limb, and horror is in his aspect. Suddenly contrary symptoms succeed; he bursts into a perspiration, and seems possessed with reckless fury, seizes whatever arms are at hand ... and rushes to the doorway, where he inflicts violent blows on the ground.... In about ten minutes the excitement has passed off, and the Indian grows calm, but perhaps exhausted. Were he at home in his hut, he would sleep off the remaining fumes, but now he must shake off his drowsiness by renewing the dance." [Richard Spruce, noted explorer of South America]

"My own experiences from participation in many Amazonian Banisteriopsis rituals might be summarized by saying that the intoxication began with a feeling of giddiness and nervousness, soon followed by nausea, occasional vomiting and profuse perspiration. Occasionally, the vision was disturbed by flashes of light and, upon closing the eyes, a bluish haze sometimes appeared. A period of abnormal lassitude then set in during which colours increased in intensity. Sooner or later a deep sleep interrupted by dream-like sequences began. The only uncomfortable after-effect noted was intestinal upset and diarrhoea on the following day. At no time was movement of limbs adversely affected. In fact, amongst many Amazonian Indians, dancing forms part of the caapi-ritual."
[Richard Evans Schultes]

☼ ☼ ☼ ☼ ☼

Ayahuasca, also called **caapi** and **yajé**, is a psychoactive drink made by the Indians of the western Amazon region. One of the earliest written accounts of the use of ayahuasca is that of Villavicencio. He reported that the drink helped the Indians to decipher enemy war plans, to formulate replies to ambassadors in matters of war and peace, to interpret illness, and to help young men endure the physical pain associated with certain initiations into manhood.

Ayahuasca is the bark of *Banisteriopsis caapi* and *B. inebrians*, sometimes fortified with the bark of *B. rusbyana*. These plants belong to Malpighiaceae, a family little known to us in North America. As with so many of the South American preparations, various additives are often included. These confuse the ethnobotanist and chemist and delay a true understanding of the formulae used.

The effects of caapi are an early feeling of nervousness and giddiness, sometimes nausea and vomiting, profuse perspiration, and flashes of light before the eyes. There follows a deep sleep with hallucinations. Early chemical work by Fischer-Cardenas isolated an alkaloid called telepathine. More recent work shows the active principle to be another alkaloid, harmine, and perhaps harmaline.

OLOLIUQUI

The early Spanish historians reported the use of hallucinogenic seeds by Aztec priests who used them as an analgesic. They were commonly employed before making sacrifices on mountain tops and when communication with the gods was required. Today these morning glory seeds may be the most widely used hallucinogen of the Mexican Indians. Until recently, their use was relatively unknown outside ethnobotanical circles.

The identity of ololiuqui remained in doubt for about 400 years. Crude drawings and descriptions gave the strong impression that the plant was a member of the morning glory family. Other experts suggested that it might be the "sacred datura," *Datura inoxia*. In Mexico, botanists and anthropologists working on the problem believed that the plant was *Rivea corymbosa* (now called *Turbina corymbosa*). In 1939, Richard Schultes found it growing next to the doorway of a Zapotec witch-doctor in Oaxaca. This was not accepted as sufficient proof of the identity of ololiuqui until Albert Hofmann (the discoverer of LSD-25) isolated lysergic acid derivatives from the seeds.

Since that time, McDougall discovered the use of *Ipomoea violacea* in conjunction with or as a substitute for *Rivea*. This has helped to clear up some of the botanical confusion.

SECTION 12 • ETHNOBOTANICAL STUDIES

12.1 • AN OVERVIEW

☼ Many of the early ethnobotanical studies were simple in concept. Which plants did a particular people use and how did they use them?

☼ The techniques and methodology used in modern studies are much more sophisticated, showing very clearly their dependence on other disciplines in the natural and social sciences.

☼ Controversy continues as to the focus of ethnobotanical research. Is it just the study of "primitive" peoples?

☼ To what extent do intellectual property rights extend to the fruits of ethnobotanical research?

☼ What is a fair compensation to a people whose knowledge translates into a multi-million dollar product, such as a new medicine?

☼ More than ever, there is a sense of urgency. Everyone has heard of endangered species. What about "endangered knowledge?
"

12.2 • GOALS &TECHNIQUES

"The best ethnobotanist would be a member of an ethnic minority who, trained in both botany and anthropology, would study ... the traditional knowledge, cultural significance, and the management and uses of the flora. And it would be even better -- for him and his people -- if his study could result in economic and cultural benefits for his own community." (A. Barrera)

"Our challenge is to salvage some of the native ... lore before it becomes forever entombed with the cultures that gave it birth." (Richard Evans Schultes)

☼ ☼ ☼ ☼ ☼

We have looked at the scope of economic botany or ethnobotany, its history, the domestication of plants, exploration for useful ones, and the plants themselves, grouped by how they are used. The purpose of this section is to introduce you to how ethnobotanical studies are carried out and in the "Selected References" section to show a reasonably comprehensive list of the published results of this research.

RELATED DISCIPLINES

To a considerable degree, ethnobotany is not a stand alone discipline. In other words, much of the information that it uses, and the analytical approaches that it employs are those of other scientific disciplines. They include traditional botany (especially taxonomy), pharmacology, anthropology, archeology, ecology, economics, and linguistics.

GOALS OF RESEARCH

The early studies were rather straightforward: how do the people of tribe X use plant Y for purpose Z. Those carrying out the studies tended to be from Europe or North America; those studied were often located in remote, poorly known parts of the world. They were characterized as primitive, unlettered, non-industrialized, and non-urbanized.

The earlier procedure of simply preparing a list or a catalogue of useful plants no longer satisfies ethnobotanical enquiry. Current research is characterized by the diversity of its research styles and its objectives.

"Contemporary ethnobotany examines the dynamic interdependencies between humans and plants, recognizing that plants permeate materially, symbolically, and metaphorically every aspect of culture and that nature is by no means passive to human actions. The subject matter of ethnobotany encompasses traditional primitives and prehistoric people as well as literate societies, acknowledging that we have much to learn about our society's folk botany quite apart from the economic botany of modern industry and agrobusiness.... Thus, ethnobotany is more than simply an examination of plants useful to non-Western people, for it is devoted to understanding the limitations and behavioral consequences of human actions on their botanical environment." (Ford, 1981)

QUESTIONS THAT NEED ASKING

Alcorn (1995) suggested the following:

☼ Which plants are available?
☼ Why are they available?
☼ What factors cause a plant to be viewed as a resource?
☼ How is knowledge distributed in the population?
☼ What do the people think about plants?
☼ How do they differentiate and classify elements in their environment?
☼ From which resource zone(s) are plants harvested?
☼ How are they used?
☼ What economic/financial benefits are derived?

- How are the plant populations managed?
- What is the effect of this management on the local vegetation and on local institutions?
- How have human activities influenced the evolution of local plants?

KNOWLEDGE SYSTEMS

In carrying out ethnobotanical research, it is important to realize that although all cultures have studied the natural world around them, they have done so using different values and approaches. The following comparison of knowledge systems is based on the work of Johnson (1992). While useful in drawing a point by point contrast between two world views, I suspect that our scientific methods of conducting ethnobotanical research have been modified in recent years as the result of a better understanding of how traditional knowledge of plants and their uses is generated.

TRADITIONAL KNOWLEDGE SYSTEMS

- All parts of natural world regarded as animate; all life forms as interdependent
- Knowledge transmitted largely through oral media
- Knowledge developed and acquired through observation and practical experience
- Knowledge is holistic, intuitive, qualitative, and practical
- Knowledge generated by resource users on a long-term time scale
- Nature and status of particular knowledge influenced by sociocultural factors, such as spiritual beliefs, and communally held
- Explanations behind perceived phenomena often spiritually-based and subjective
- Knowledge used to make suitable decisions under variable conditions

WESTERN SCIENTIFIC SYSTEMS

- Human life generally regarded as superior, with moral right to control other life forms
- Knowledge transmitted largely through written word
- Knowledge generally learned in situation remote from its applied context
- Knowledge essentially reductionist, quantitative, analytical, and theoretical
- Knowledge generated largely by specialists on a short term time scale
- Nature and status of particular knowledge influenced by peer review, and held by individuals
- Explanations behind perceived phenomena essentially rational and objective
- Knowledge used to put forward hypotheses and to verify underlying laws or constants.

SECTION 13 • PLANTS BY GROUP/FAMILY

This list began as a updating and expansion of one prepared by Albert F. Hill (1952) for his introductory textbook in economic botany... and, I'm afraid it just got out of hand! I also thought it would be useful to add a brief description of how the plant is used and what part yields the product. There are a number of more or less encyclopedic references on this subject. The number of plants and the details of their uses are simply overwhelming. In the list below, I have attempted to focus on plants that are of *direct* economic importance to us, and to present them by groups or families. I have not included ornamentals, weeds, and toxic plants (unless we knowingly use them to kill something or someone). The various dictionaries of economic plants also include, on a hit-and-miss basis, plants that are sometimes eaten only locally or that have been used medicinally in some fashion. I have included only those food plants that enjoy wider use and those medicinal plants that have demonstrated properties. There is an emphasis on plants of the New World.

The listing of nonvascular plants, ferns, and their allies is short enough to scan quickly to find a particular plant. The much more extensive coverage of flowering plants is arranged by plant family.

If you are not familiar with their technical names, look at the end of this section for assistance.

☼☼☼☼☼☼☼☼☼☼

Scientific Name. Common Name	**Use [Plant Part]**

BACTERIA

Acetobacter aceti	Used to make vinegar [all]
Brevibacterium linens	Used to make limburger cheese [all]
Lactobacillus acidophyllus. Milk bacterium	Milk fermentation [all]
Lactobacillus bulgaricus. Yogurt bacterium	Used to make yogurt [all]
Lactobacillus casei. Cheese bacterium	Used to make various cheeses [all]
Propionobacterium freudenreichii	Used to make Swiss cheese [all]
Streptococcus spp.	Used to make yogurt, sour cream, butter, buttermilk [all]
Xanthomonas campestris. Xanthan bacterium	Xanthum gum in food products [all]

ALGAE

Alaria esculenta. Murlin	Food [plant body]
Ascophyllum nodosum. Knotted wrack	Gum (algin) [plant body]
Bangia fusco-purpurea. Cow hair, hair seaweed	Food [plant body]
Chondrus crispus. Irish-moss	Gum (carrageenan) [plant body]
Eisenia bicyclis. Arame	Food [plant body]
Furcellaria fastigiata	Gum (furcellaran) [plant body]
Gelidium spp. Agar-agar	Gum (agar) [plant body]
Gracilaria spp. Gracilaria	Gum (agar) [plant body]
Hijikia fusiformis. Hijiki	Medicine (goiter, high blood pressure) [plant body]
Laminaria digitata. Kelp	Food [plant body]
Laminaria saccharina. Kelp, sugar wrack	Food [plant body]
Laminaria spp. Kombu, oarweed	Gum (algin) [plant body]
Macrocystis pyrifera. Kelp	Food [plant body]
Nostoc spp. Star jelly	Food [plant body]
Palmaria palmata. Dulse	Food, salt substitute [plant body]
Porphyra spp. Nori, laver	Food; wrap sushi [plant body]
Spirulina spp. Spirulina	Food [plant body]
Ulva lactuca. Sea-lettuce, green laver	Food [plant body]
Undaria pinnatifida. Wakame	Food; medicine (suppress tumors) [plant body]

FUNGI

Agaricus bisporus. Button mushroom, field mushroom, portobello mushroom	Food [sporocarp]
Agaricus campestris. Meadow mushroom	Food [sporocarp]
Agrobacterium tumifaciens	Cause of crown gall disease; used in genetic engineering
Amanita muscaria. Fly agaric, soma	Psychoactive [sporocarp]
Aspergillus flavus. Bread mold	Fermentation: sake and soy sauce [all]
Aspergillus oryzae. Miso mold	Fermentation: sake [all]
Auricularia auricula-judae. Wood ear, Judas's ear	Food [sporocarp]
Boletus spp. Boletes	Food [sporocarp]
Botrytis cinerea	Flavoring (wine grapes) [all]
Candida albicans	Disease (yeast infections, thrush) [all]

Cantharellus cibarius. Chanterelle	Food [sporocarp]
Claviceps purpurea. Ergot fungus	Medicine (vasoconstrictor), psychoactive [sclerotium]
Conocybe spp. Sacred mushroom, teonanacatl	Psychoactive [sporocarp]
Cortinellus edodes. Shitake	Food [sporocarp]
Cryphonectaria parasitica	Cause of chestnut blight
Drechslera oryzeae	Cause of southern leaf blight in maize
Flammulina velutipes. Enoki mushroom, velvet shank	Food [sporocarp]
Fusarium oxysporum	Cause of banana wilt and Panama disease
Hemileia vastatrix	Cause of coffee rust
Lactarius deliciosus. Orange agaric	Food [sporocarp]
Lentinus edodes. Shitake mushroom	Food [sporocarp]
Lycoperdon marginatum. Gi-i-sa-wa	Psychoactive [sporocarp]
Lycoperdon mixtecorum. Gi-i-wa	Psychoactive [sporocarp]
Lycoperdon spp. Puffball	Food [sporocarp]
Monilinia fructicola	Cause of brown rot in stone fruits of rose family
Morchella esculenta. Morel	Food [sporocarp]
Mycosphaerella spp.	Cause of sigatoka disease in banana
Ophiostoma ulmi	Cause of Dutch elm disease
Paneolus spp. Sacred mushrooms	Psychoactive [sporocarp]
Penicillium camemberti	Ripening and flavoring of cheese [all]
Penicillium chrysogenum	Antibiotic (penicillin) [all]
Penicillium notatum	Antibiotic (penicillin) [all]
Penicillium roquefortii	Ripening and flavoring of cheese (Roquefort) [all]
Phytophthora infestans	Cause of late blight of potato
Phytophthora palmivora	Cause of pod rot in cacao
Plasmopara viticola	Cause of downy mildew in grapes
Pleurotus spp. Oyster mushroom	Food [sporocarp]
Psilocybe spp. Sacred mushrooms	Psychoactive [sporocarp]
Puccinia graminis	Cause of stem rust in wheat
Rhizobium leguminosarum	Nitrogen fixation symbiont
Russula spp.	Food [sporocarp]
Saccharomyces carlsbergensis. Beer yeast	Alcohol production (brewing) [all]
Saccharomyces cervisieae. Baker's yeast, brewer's yeast	Alcohol production (brewing) [all]
Saccharomyces ellipsoideus. Wine yeast	Alcohol production (wine making) [all]
Saccharomyces theobromae. Cacao yeast	Fermentation process (cacao) [all]
Streptomyces spp.	Antibiotics [all]
Stropharia spp. Sacred mushrooms	Psychoactive [sporocarp]
Taphrina deformans	Cause of peach leaf curl
Tolypocladium inflatum	Medicine (cyclosporin) [all]
Torulaspora delbrueckii. Sherry yeast	Used in fermentation phase in sherry making [all]
Torulaspora holmii	Used in fermentation of sour dough bread [all]
Tuber spp. Truffles	Food [sporocarp]
Ustilago maydis. Corn smut	Cause of corn smut in maize; food
Volvariella volvacea. Straw mushroom	Food [sporocarp]
Zygosaccharomyces soyae	Alcoholic fermentation [all]

LICHENS

Cetraria islandica. Iceland-moss	Food, medicine [all]
Evernia prunastri. Oak-moss	Perfume stabilizer; dye [all]
Evernia sp. Yellow lichen	Arrow poison [all]
Evernia vulpina	Dye [all]
Lecanora esculenta. Manna	Food, sugar [all]
Parmelia conspera. Jevud hiosig	Fumatory/masticatory [all]
Rocella tinctoria. Archil, orseille	Dye (litmus paper); food coloring [all]
Umbilicaria pustulata. Blistered umbilicaria	Dyes (red, purple, brown) [all]
Urceolaria spp.	Dyes [all]
Usnea spp. Old man's beard	Dyes, powder (cosmetic) [all]

BRYOPHYTES

Sphagnum spp. Sphagnum, peat moss	Fuel (peat), insulation, packing material [all]

FERNS & FERN ALLIES

Cyathaea spp. Tree fern	Building material, thatching [frond]
Dryopteris dilatata. Broad shield fern	Medicine (vermifuge) [rhizome]
Dryopteris filix-mas. Male fern	Food; vermifuge [rhizome]
Equisetum spp. Horsetails, scouring-rush	Scouring material [stems]; food [shoot]
Lycopodium alpinum. Club-moss	Yellow dye [all]
Lycopodium clavatum. Club-moss	Flash powder, suppository coatings [spores]

Matteuccia struthiopteris. Ostrich fern — Food [frond]
Osmunda cinnamomum. Cinnamon fern — Food; fibers for orchid growing [frond]
Pteridium aquilinum. Bracken fern, brake fern — Food [rhizome, crozier]

C O N I F E R S

ARAUCARIACEAE (ARAUCARIA FAMILY)

Agathis australis. Kauri, kauri-pine	Timber
Araucaria araucana. Monkey puzzle	Food [seed]
Araucaria columnaris. Cook-pine, New Caledonia-pine	Timber
Araucaria cunninghamii. Moreton Bay pine	Timber
Araucaria excelsa. Norfolk Island pine	Timber

CUPRESSACEAE (JUNIPER OR CEDAR FAMILY)

Calocedrus decurrens. Incense cedar	
Chamaecyparis lawsoniana. Port Orford cedar	Timber
Chamaecyparis nootkatensis. Alaska cedar	Timber
Juniperus communis. Common juniper	Flavoring alcoholic beverages (gin) ["berries"]
Juniperus virginiana. Red cedar	Timber
Sequoia sempervirens. Redwood	Timber
Sequoiadendron giganteum. Big tree, Sierra redwood	Timber
Taxodium distichum. Bald cypress	Timber
Thuja occidentalis. Northern white cedar	Essential oil [leaf]
Thuja plicata. Western red cedar	Timber
Tsuga canadensis. Eastern hemlock	Timber
Tsuga heterophylla. Western hemlock	Timber

CYCADACEAE (CYCAD FAMILY)

Cycas circinalis. Sago-palm	Food (starch) [stem]
Cycas revoluta. Japanese sago-palm	Food (starch) [stem]
Dioon edule. Palma de dolores, palmita	Food [seed]
Encephalartos caffer. Kaffir bread	Food (sago starch) [seed, stem]
Encephalartos altensteinii. Bread tree	Starch [stem]
Zamia floridana. Florida coon-tie, Florida arrowroot	Food [rhizome]

EPHEDRACEAE (EPHEDRA FAMILY)

Ephedra sinica. Ma-huang	Medicine (ephedrine) [stem]
Ephedra trifurca. Mormon tea	Medicine (ephedrine) [stem]

GINKGOACEAE (MAIDENHAIR TREE FAMILY)

Ginkgo biloba. Maidenhair tree	Timber; medicine (vascular), oil, food (sal nut) [seed]

PINACEAE (PINE FAMILY)

Abies alba. White fir	Timber
Abies amabalis. Cascade fir	Timber
Abies balsamea. Balsam fir	Resin (Canada balsam, balm-of-Gilead)
Abies concolor. White fir	Timber
Abies grandis. Giant fir, grand fir	Timber
Abies magnifica. Red fir	Timber
Abies procera. Noble fir	Timber
Cedrus atlantica. Atlantic cedar	Timber
Cedrus deodara. Deodar cedar	Timber
Cedrus libani. Cedar-of-Lebanon	Timber; essential oil [wood]
Larix decidua. European larch	Timber, turpentine, medicine, tannins [bark]
Larix laricina. Eastern larch, tamarack	Timber
Larix occidentalis. Western larch	Resin
Picea abies. Norway spruce	Timber
Picea engelmannii. Englemann spruce	Timber
Picea glauca. White spruce	Timber
Picea rubens. Red spruce	Timber
Picea sitchensis. Sitka spruce	Timber
Pinus cembra. Stone pine, Swiss stone pine	Food [seed]
Pinus cembroides. Mexican stone pine	Food [seed]
Pinus edulis. Piñon pine	Food [seed]
Pinus lambertiana. Sugar pine	Timber
Pinus monophylla. Piñon pine	Food [seed]
Pinus monticola. Western white pine	Timber
Pinus palustris. Longleaf pine	Timber; resin (turpentine, pitch)
Pinus pinea. Pignolia	Food [seed]
Pinus ponderosa. Ponderosa pine, yellow pine	Timber
Pinus strobus. White pine	Timber
Pinus succinifera	Resin (amber)
Pinus sylvestris. Scotch pine, Scots pine	Timber
Pinus taeda. Loblolly pine	Timber
Pinus spp. Pines	Resin, oleoresin

Pseudotsuga menziesii. Douglas-fir	Timber; balsam (Oregon balsam); beverage [leaf]

PODOCARPACEAE (PODOCARP FAMILY)

Podocarpus spp. Podocarp	Timber/wood

TAXACEAE (YEW FAMILY)

Taxus baccata. English yew	Wood
Taxus brevifolia. Pacific yew	Medicine (taxol) [leaf, bark]
Taxus cuspidata. Japanese yew	Timber, dye
Torreya nucifera. Japanese torreya.	Food [seed, oil]

F L O W E R I N G   P L A N T S

ACANTHACEAE (ACANTHUS FAMILY)

Justicia pectoralis. Masha-hari	Psychoactive (snuff) [leaf]

ACERACEAE (MAPLE FAMILY)

Acer nigrum. Black maple	Sugar [sap]
Acer platanoides. Norway maple	Timber; dye [wood]
Acer pseudoplatanus. Sycamore maple	Timber
Acer rubrum. Red maple	Timber; dye [wood]
Acer saccharum. Sugar maple	Timber; sugar [sap]

ACTINIDIACEAE (CHINESE-GOOSEBERRY FAMILY)

Actinidia deliciosa. Kiwi, Chinese-gooseberry	Food [fruit]

AGAVACEAE (CENTURY PLANT FAMILY)

Agave atrovirens. Maguey, pulque	Fiber [leaf]; fermented beverage [sap]
Agave cantala. Cantala, Manila maguey	Fiber [leaf]
Agave fourcryodes. Henequen, Mexican sisal	Fiber [leaf]
Agave lecheguilla. Istle, lechiguilla, tula istle	Fiber [leaf]
Agave sisalina. Sisal	Fiber [leaf]
Agave tequilina. Mezcal	Distilled beverage [sap]; fiber [leaf]
Agave zapupe. Zapupe	Fiber [leaf]
Agave spp. Maguey	Fermented beverage [sap]
Furcraea cabuya. Cabuya, Mauritius hemp	Fiber [leaf]
Furcraea foetida. Mauritius hemp	Fiber [leaf]
Furcraea hexapetala. Cuban hemp, pitre	Fiber [leaf]
Furcraea macrophylla. Fique	Fiber [leaf]
Cordyline terminale. Ti	Fiber [leaf]
Dracaena draco. Dragon tree	Medicine [sap]; resin
Nolina spp. Zacate	Fiber [leaf]
Phormium tenax. New Zealand flax	Fiber [leaf]
Polianthes tuberosa. Tuberose	Essential oil [flower]
Samuela carnerosana. Palma ixtle	Fiber [leaf]
Sansevieria spp. Bowstring hemp	Fiber [leaf]
Yucca baccata. Banana yucca	Fiber [leaf]; food [bud]
Yucca brevifolia. Joshua tree	Fiber [leaf]
Yucca funifera. Ixtle	Fiber [leaf]
Yucca glauca. Soapweed yucca	Fiber [leaf]
Yucca mohavensis. Mohave yucca	Fiber [leaf]
Yucca treculeana. Trecul yucca	Fiber [leaf]
Yucca whipplei. Chaparral yucca	Fiber [leaf], Food [fruit]
Yucca spp. Palma istle	Fiber [leaf]

AIZOACEAE (ICE-PLANT FAMILY)

Tetragonia inexpansa. New Zealand-spinach	Food [leaf]

ALISMATACEAE (ARROWHEAD FAMILY)

Sagittaria latifolia. Arrowhead, wapato	Food [rhizome]
Sagittaria sagittifolia. Arrowhead	Food [rhizome]

AMARANTHACEAE (PIGWEED FAMILY)

Amaranthus caudatus. Achita, jataco	Food [leaf, seed]
Amaranthus gangeticus. Tampala	Food [leaf]
Amaranthus hypochondriachus. Prince's plume	Food [leaf, seed]
Amaranthus tricolor. Chinese spinach, Joseph's coat	Food [leaf]

ANACARDIACEAE (CASHEW FAMILY)

Anacardium occidentale. Cashew	Food [fruit, receptacle]; timber; fixed oil [seed]; dye
Buchanania lanzan. Chirauli nut, almondette	Food [seed]
Cotinus coggygria. Venetian sumac	Dye [wood], tannin [leaf]
Cotinus obovatus. Chittamwood	Dye [wood]

Harpephyllum caffrum. Kaffir-plum	Food [fruit]
Mangifera indica. Mango, mango powder	Food [fruit]; flavoring
Melanorrhoea usitata. Burmese lacquer tree	Lacquer
Metopium toxiferum. Poison wood	Medicine (purgative) [sap]
Pistacia lentiscus. Mastic tree	Resin (mastic)
Pistacia vera. Pistachio, green almond	Food [fruit]; fixed oil [seed]
Rhus coriaria. Sumac	Flavoring [fruit]
Rhus verniciflua. Lacquer tree	Lacquer
Rhus spp. Lemonade berry	Beverage [fruit]
Schinopsis spp. Quebracho	Tannins; wood
Schinus lorentzii. Quebracho	Tannins
Schinus molle. Pepper tree	Flavoring [fruit]
Sclerocarya birrea ssp. *caffra*. Maroola plum, marula nut	Food [fruit]
Semecarpus anacardium. Marking nut	Black ink/dye [fruit]; Food [fruit]
Spondias cytherea. Golden-apple, Otaheite apple, ambarella	Food [fruit]
Spondias dulcis. Vi-apple	Food [fruit]
Spondias mombin. Yellow mombin, hog-plum	Food [fruit]
Spondias purpurea. Red mombin, Spanish-plum	Food [fruit]

ANNONACEAE (SOURSOP FAMILY)

Annona x *atemoya*. Atemoya [cherimoya x sweetsop]	Food [fruit]
Annona cherimola. Cherimoya	Food [fruit]
Annona glabra. Pond-apple	Food [fruit]
Annona muricata. Guanabana, soursop	Food [fruit]
Annona reticulata. Bullock's heart	Food [fruit]
Annona squamosa. Sugar apple, sweetsop	Food [fruit]
Asimina triloba. Pawpaw	Food [fruit]
Cananga odorata. Ylang-ylang	Essential oil [flower]

APOCYNACEAE (DOGBANE FAMILY)

Alstonia congensis. Pattern wood	Wood
Alstonia constricta. Bitter bark	Medicine [bark]
Alstonia scholaris. Dita bark	Vermifuge; wood
Alstonia spatulata	Wood
Apocynum cannabinum. Indian hemp	Fiber [stem]; medicine (emetic, cardiac stimulant) [root]
Apocynum venetum. Kendyr	fiber [stem]
Carissa microcarpa. Natal-plum	Food [fruit]
Catharanthus roseus. Periwinkle	Medicinal glycosides (vincristine & vinblastine) [leaf]
Couma macrocarpa. Milk tree	Food [fruit], latex (chewing gum)
Cryptostegia spp. Palay	Latex
Dyera costulata. Jelutong	Latex
Funtumia africana. False rubber tree	Latex
Funtumia elastica. Lagos silk rubber	Latex
Hancornia speciosa. Mangabeira rubber	Fruit (flavoring); latex
Landolphia kirkii. Kirk's rubber vine	Latex
Landolphia spp. Landolphia rubber	Latex
Plumeria spp. Plumeria, frangipani	Essential oil
Rauvolfia serpentina. Indian snakeroot	Medicinal alkaloid (reserpine) [root]
Strophanthus hispidus. Ouabin, kombe	Arrow poison [seed]
Strophanthus kombe. Kombe	Arrow poison [seed]
Strophanthus gratus.	Arrow poison/medicine (ouabin) [sap]
Thevetia spp. Yellow-oleander	Fixed oil (exile oil) [seed]; medicine (heart, hemorrhoids) [seed]
Urechites suberecta.	Medicine, arrow-poison (wooraia)
Willughbeia coriacea. Borneo rubber.	Latex

APONOGETONACEAE (APONOGETON FAMILY)

Aponogeton dystachyon. Cape asparagus	Food [sprouts]

AQUIFOLIACEAE (HOLLY FAMILY)

Ilex paraguariensis. Maté, yerba m., Jesuit tea, Paraguay tea	Caffeinated beverage [leaf]
Ilex vomitoria. Yaupon, cassine	Caffeinated beverage [leaf]

ARACEAE (AROID OR PHILODENDRON FAMILY)

Acorus calamus. Calamus root, sweet flag	Flavoring [rhizome]
Alocasia macrorrhiza. Giant taro	Food [rhizome]
Amorphophallus campanulatus. Elephant yam	Food [tuber]
Colocasia antiquorum. Taro	Food [rhizome]
Colocasia esculenta. Dasheen	Food [rhizome]
Cyrtosperma chamissonis. Giant swamp taro	Food [rhizome]
Monstera deliciosa. Ceriman, Mexican breadfruit	Food [fruit]
Philodendron spp. Philodendron	Food [rhizome]; fiber; medicine
Xanthosoma atrovirens. Yocoyam, tanier	Food [rhizome]
Xanthosoma sagittifolium. Yautia, tannia	Food [rhizome, leaf]

ARALIACEAE (GINSENG FAMILY)

Aralia cordata. Udo	Food [leaf]

Aralia nudicaulis. Wild sarsaparilla	Beverage (root beer) [root]
Aralia racemosa. American spikenard	Medicinal tea [root]
Eleutherococcus senticosus. Siberian ginseng	Medicine (tonic) [root]
Oplopanax horridus. Devil's club	Medicine (various) [roots, inner bark, berries]
Panax ginseng. Ginseng	Medicine [root]
Panax quinquefolium. American ginseng	Medicine [root]
Tetrapanax papyriferum. Rice paper plant	Fiber [pith]
ARISTOLOCHIACEAE (BIRTHWORT FAMILY)	
Aristolochia spp. Birthwort	Medicine (menstruation, abortifacient) [root/rhizome]
ASCLEPIADACEAE (MILKWEED FAMILY)	
Asclepias curassavica. Tropical milkweed	Medicine (toothache, tooth extraction) [latex]
Asclepias spp. Milkweed	Fiber [seed]; latex
Calotropis gigantea. Madar	Food [leaf]; fiber [bark]
Cryptolepis sanguinolenta	Medicine (various, including malaria) [root]
Cryptostegia grandiflora. Rubber vine	Latex
BASELLACEAE (BASELLA FAMILY)	
Basella alba. Malabar-spinach	Food [leaf]
Ullucus tuberosus. Ullucu	Food [tuber]
BATIDACEAE (SALTWORT FAMILY)	
Batis spp. Saltwort	Food [leaf]
BERBERIDACEAE (BARBERRY FAMILY)	
Berberis vulgaris. Barberry	Food [fruit]
Podophyllum emodi. Indian or Himalayan mayapple	Medicine (podophyllin) [rhizome]
Podophyllum peltatum. American mandrake or mayapple	Medicine (podophyllin) [rhizome]
BETULACEAE (BIRCH FAMILY)	
Alnus glutinosa. Black alder	Wood (Stradivarius violin), tannin, medicine
Alnus oregana. Red alder	Wood (canoes)
Alnus rubra. Alder	Wood
Betula allaghaniensis. Yellow birch	Timber
Betula lenta. Cherry birch	Timber, flavoring (oil of sweet birch)
Betula papyrifera. Paper birch	Timber
Betula pendula. European birch	Timber
Carpinus caroliniana. Blue beech	Timber
Corylus americana. American hazelnut	Food [fruit]
Corylus avellana. European hazelnut	Food [fruit]
Corylus chinensis. Chinese filbert	Food [fruit]
Corylus cornuta. Beaked hazelnut	Food [fruit]
Ostrya spp. Hop hornbeam, ironwood	Timber
BIGNONIACEAE (BIGNONIA FAMILY)	
Catalpa bignonioides. Indian-bean, catalpa	Timber
Catalpa speciosa. Indian-bean, catalpa	Timber
Crescentia cujete. Calabash tree, gourd tree	Utensils, musical instruments [fruit]; timber
Kigelia pinnata. Sausage tree	Medicine (lesions) [bark]
Tabebuia donnell-smithii. Primavera, West Indian boxwood, roble blanco	Timber
Tabebuia serratifolia. Trumpet tree	Timber
BIXACEAE (BIXA FAMILY)	
Bixa orellana. Annatto, urucú, achiote	Food coloring, body paint [pulp around seed]
BOMBACACEAE (BOMBAX FAMILY)	
Adansonia digitata. Baobab	
Bombax ceiba. Red silk cotton	Fiber [fruit wall]
Ceiba pentandra. Kapok, pochote	Fiber [fruit wall]; fixed oil [seed]
Chorisia speciosa. Palo boracho	Fiber [fruit wall]
Durio zibethinus. Durian	Food [fruit]
Ochroma pyramindale. Balsa wood	Specialty wood items
Pachira aquatica. Guiana-chestnut	Food [seed]
BORAGINACEAE (BORAGE FAMILY)	
Alkanna lehmannii. Alkanna, alkanet	Dye [root]
Cordia sebestena. Ziricote, cericote, geiger tree	Medicine, wood (carvings)
Cordia subcordata. Kou	Wood (carving)
Pulmonaria officinalis. Lungwort	Medicine (respiratory) [leaf]
Symphytum officinale. Comfrey	Medicine [leaf]
BROMELIACEAE (BROMELIAD OR PINEAPPLE FAMILY)	
Aechemea magdalanae. Pita floja, ixtle	Fiber [leaf]
Ananas comosus. Pineapple	Food [fruit]; proteolytic enzyme (bromelin); fibers (piña cloth) [leaf]
Tillandsia usneoides. Spanish-moss	Fibers (stuffing) [all]

BURSERACEAE (BURSERA FAMILY)

Boswellia carteri. Frankincense, olibanum	Medicine [sap]
Bursera spp.	Essential oil (linaloe) [wood]
Canarium spp. Pili nut, damar	Food [seed], resins
Commiphora gileadensis. Balm-of-Gilead	Medicine, incense [sap from stem wounds]
Commiphora myrrha. Myrrh	Medicinal , incense (myrrh) [sap from stem wounds]

CACTACEAE (CACTUS FAMILY)

Carnegia gigantea. Saguaro	Food [fruit/seed]
Coryphanthus palmeri. Wichuri	Psychoactive [stem]
Echinopsis pachanoi. San Pedro cactus	Psychoactive alkaloids (mescaline) [stem]
Hylocereus undatus. Dragon fruit, pitahaya	Food [fruit]
Lophophora williamsii. Peyote, peyotl cactus	Psychoactive alkaloids (mescaline, etc.) [stem]
Opuntia ficus-indica. Prickly pear, tuna	Food [fruit]
Stenocereus stellatus. Pityayo	Food [fruit]

CAMPANULACEAE (BLUEBELL FAMILY)

Lobelia inflata. Indian tobacco	Fumatory [leaf]; medicine (emetic) [leaf]
Lobelia tupa. Tupa	Psychoactive [seed]

CANNABACEAE (MARIJUANA FAMILY)

Cannabis sativa. Hemp, marijuana	Fiber [stem], fixed oil [seed], food [seed], medicine [leaf], psychoactive [flowers, buds]
Humulus lupulus. Hops	Flavoring beer [floral bracts]

CANNACEAE (CANNA FAMILY)

Canna edulis. Queensland arrowroot, achira	Edible starch [rhizome]
Canna indica. Indian shot	Ornamentation [seed]

CAPPARACEAE (CAPER FAMILY)

Capparis spinosa. Caper bush	Flavoring [buds]

CAPRIFOLIACEAE (HONEYSUCKLE FAMILY)

Sambucus spp. Elderberry	Beverage [fruit]

CARICACEAE (PAPAYA FAMILY)

Carica papaya. Papaya, pawpaw, mamao	Food [fruit]; medicine/meat tenderizer (papain) [sap]
Carica pentagona. Babaco, mountain papaya	Food [fruit]

CARYOCARACEAE

Caryocarya amygdaliferum. Mani, swarri nut	Food [fruit]

CARYOPHYLLACEAE (CARNATION FAMILY)

Dianthus spp. Carnation	Essential oil [flower]
Saponaria officinalis. Soapwort	Soap-making [root]; medicine (laxative) [root]

CASUARINACEAE (BEEFWOOD FAMILY)

Casuarina equisetifolia. Beefwood	Wood

CELASTRACEAE (BITTERSWEET FAMILY)

Catha edulis. Khat, qat	Caffeinated beverage [leaf]

CERCIDOPHYLLACEAE

Cercidiphyllum japonicum. Katsura	Wood

CHENOPODIACEAE (GOOSEFOOT FAMILY)

Atriplex spp. Saltbush, orach	Food [leaf]
Beta vulgaris var. *cicla*. Chard, Swiss chard	Food [leaf]
Beta vulgaris var. *vulgaris*. Beet, sugar beet, mangel	Food, sugar [taproot]
Chenopodium ambrosioides. Epazote, Mexican tea	Essential oil (wormseed) [leaf, fruit]
Chenopodium anthelminthicum. Wormseed	Medicine (intestinal worms) [leaves, seeds]
Chenopodium quinoa. Quinoa	Food [fruit]
Kochia scoparia. Summer cypress	Food [shoots]
Salicornia spp. Glasswort, samphire	Food [stem, leaf]
Spinacia oleracea. Spinach	Food [leaf]

CHRYSOBALANACEAE (COCO-PLUM FAMILY)

Chrysobalanus icaco. Coco-plum	Food [fruit]; oil [seed]

CISTACEAE (ROCKROSE FAMILY)

Cistus ladaniferus. Rockrose	Essential oil (labdanum) [leaf, twig]

COCHLOSPERMACEAE (ROSE IMPERIAL FAMILY)

Cochlospermum religiosum. White silk cotton	Gum (karaya)

COMBRETACEAE (TERMINALIA FAMILY)

Anogeissus latifolia. Gum ghatti	Industrial gum [stem]; dye (black) [leaf]; timber
Terminalia chebula. Myrobalan	Tannin [root/bark]
Terminalia catappa. Indian-almond	Food [fruit]; oil [seed]
Terminalia superba. Afara	Timber
Terminalia spp. Myrobalan, terminalia	Food [fruit]

COMPOSITAE (ASTER, DAISY OR SUNFLOWER FAMILY)

Anthemis nobilis. Chamomile	Essential oil [flower]
Arctium lappa. Gobo	Food [root, leaf]
Artemisia absinthium. Wormwood	Essential oil (absinthe) [leaf]
Artemisia dracunculus. Tarragon	Flavoring [leaf]; medicine (diuretic, vermifuge) [leaf]
Carthamus tinctorius. Safflower	Fixed oil [seed]; dye [flower]
Chrysanthemum cinerariifolium. Dalmatian insect flower	Insecticide (pyrethrum) [flower]
Chrysothamnus spp. Chrysil rubber	Latex
Cichorium endivia. Endive	Food [leaf]
Cichorium intybus. Chicory	Coffee substitute and flavoring
Cynara cardunculus. Cardoon	Food [root, leaf]
Cynara scolymus. Artichoke	Food [flower cluster]
Echinacea angustifolia. Black sampson	Medicine (immune system) [rhizome]
Echinacea purpurea. Purple cone flower	Medicine (immune system) [rhizome]
Eupatorium berlandieri	Tobacco substitute [leaf]
Eupatorium solidaginifolium. Pihol	Tobacco substitute [leaf]
Guizotia abyssinica. Niger-seed	Oil [fruit]
Helianthus annuus. Sunflower	Food [seed]; fixed oil [seed]
Helianthus tuberosus. Jerusalem artichoke	Food [tuber]
Inula helenium. Elecampane	Flavoring, medicine (respiratory) [root]; dye (blue) [root]
Lactuca sativa. Lettuce	Food [leaf]
Lactuca scariola. Winter lettuce	Food [leaf]
Matricaria spp. Chamomile, pineapple weed	Medicinal tea; insecticide [leaf]
Parthenium argentatum. Guayule	Latex
Scorzonera hispanica. Black oyster plant	Food [root]
Silybum marianum. Milk thistle, holy thistle	Food [stem/leaf]; medicine (hepatitis) [seed]
Solidago spp. Goldenrod	Latex
Stevia rebaudiana. Sweet herb, sweet leaf	Sweetening agent (stevioside) [leaf]
Tanacetum parthenium. Feverfew	Medicine(many ailments, esp. migraine) [inflorescence]
Tanacetum vulgare. Tansy	Medicine (tanacetin) [leaf, flower clusters]
Taraxacum kok-saghyz. Russian dandelion	Latex
Taraxacum officinale. Dandelion	Food, wine [leaf]
Tragopogon porrifolius. Salsify, oyster plant	Food [root]

CONVOLVULACEAE (MORNING GLORY FAMILY)

Convolvulus scammonia. Scammony	Medicine (purgative) [seed]
Dichondra spp. Dichondra	Lawn grass substitute
Ipomoea aquatica. Water-spinach	Food [leaf/shoots]
Ipomoea batatas. Sweet potato, yam	Food [tuber]
Ipomoea orizabensis. Scammony root	Medicine (purgative) [tuber]
Ipomoea pandurata. Indian-potato	Food [tuber]
Ipomoea pes-caprae. Beach morning glory	Food [root]; medicine (cathartic) [seed]
Ipomoea purga. Jalap	Medicine (purgative) [root]
Ipomoea tricolor. Heavenly blue morning glory, tiltilizin	Psychoactive [seed]
Turbina corymbosa. Ololiuqui	Psychoactive [seed]

CORIARIACEAE (CORIARIA FAMILY)

Coriaria myrtifolia. Shanshi	Psychoactive [fruit]; fly-poison

CORNACEAE (DOGWOOD FAMILY)

Camptotheca acuminata	Medicine (leukemia, throat cancer) [wood,bark, fruit]
Nyssa aquatica. Tupelo	Timber
Nyssa sylvatica. Sour gum, black gum	Timber

CRUCIFERAE (MUSTARD FAMILY)

Armoracia lapathifolia. Horse-radish	Flavoring [root]
Barbarea verna. Spring cress	Food [leaf]
Brassica chinensis. Chinese cabbage	Food [leaf]
Brassica juncea. Brown mustard, mustard greens	Flavoring [seed]
Brassica napus. Rape, rutabaga, swede	Food [stem]
Brassica nigra. Black mustard	Essential oil [seed]; fixed oil (Canola oil) [seed]
Brassica oleracea. Broccoli, cauliflower	Food [flower cluster]
Brassica oleracea. Brussels sprouts	Food [buds]
Brassica oleracea. Cabbage	Food [leaf]
Brassica oleracea. Kohlrabi	Food [root/stem]
Brassica oleracea. Kale, collards	Food [leaf]
Brassica rapa. Turnip, pak choi	Food [root/stem]
Camelina sativa. False flax	Fiber [stem]; food, oil [all]
Crambe maritima. Sea kale	Food [petiole]

Eruca vesicaria. Garden rocket	Food [leaf], fixed oil [seed]
Eruca sativa. Arugula	Food [leaf]
Eutrema wasabi. Wasabi, Japanese horseradish	Essential oil [root]
Isatis tinctoria. Woad	Dye and body paint [leaf]
Lepidium meyenii. Maca	Food [root]
Lepidium sativum. Garden cress	Food [leaf]
Nasturtium officinale. Water cress	Food [leaf]
Raphanus sativus. Radish	Food [root]
Sinapis alba. White mustard	Flavoring [seed]

CUCURBITACEAE (SQUASH OR GOURD FAMILY)

Benincasa hispida. Wax gourd	Food [fruit]
Citrullus colocynthis. Colocynth, bitter-apple	Medicine (purgative) [fruit]
Citrullus lanatus. Watermelon, citron	Food [fruit]
Cucumis anguria. Gherkin	Food [fruit]
Cucumis dipsaceus. Teasel gourd	Industrial [fruit]
Cucumis melo. Musk melon, cantaloupe, honeydew, casaba	Food [fruit]
Cucumis metalicerus. Horned melon, kiwano	Food [fruit]
Cucumis sativus. Cucumber	Food [fruit]
Cucurbita ficifolia. Fig-leaved gourd, Malabar gourd	Industrial [fruit]
Cucurbita maxima. Winter squash, pumpkin, marrow	Food [fruit, seed]
Cucurbita moschata. Squash, cushaw, calabaza	Food [fruit]
Cucurbita pepo. Marrow, pumpkin, summer squash, zucchini	Food [fruit]
Ecballium elaterium. Squirting cucumber	Medicine [fruit]
Lagenaria siceraria. Bottle gourd	Utensils/ornamentals [fruit]
Luffa aegyptiaca. Luffa, vegatable sponge	clean skin [fruit]
Marah spp. Man root, wild cucumber	Dye [seed]
Momordica charantia. Balsam pear, bitter melon	Food, medicine [fruit]
Sechium edule. Chayote	Food [fruit]
Sicana odorifera. Cassabanana, musk cucumber	Food, jams [fruit]
Sirartia grosvenorii. Buddha's fruit	Sweetener [fruit]
Telfairia occidentalis. Fluted pumpkin	Food [seed, leaf]
Telfairia pedata. Oyster nut	Food [seed]
Trichosanthes spp. Snake gourds	Food [fruit]

CYCLANTHACEAE (PANAMA HAT FAMILY)

Carludovica palmata. Panama hat palm, paja toquilla	Fibers (hat making) [leaf]

CYPERACEAE (SEDGE FAMILY)

Cyperus esculentus. Tiger nut, chufa	Food [fruit]
Cyperus papyrus. Papyrus	Fiber [pith]
Eleocharis dulcis. Water chestnut	Food [corm]
Fimbristylis umbellaris. Tikus	Fiber (weaving) [stem]
Scirpus californicus. Tortora reed	Fiber (boat-making) [stem]

DILLENIACEAE (DILLENIA FAMILY)

Dillenia indica. Hondpara	Food [fruit]

DIOSCOREACEAE (YAM FAMILY)

Diosocrea alata. Greater Asiatic yam, white yam	Food; medicine (cortical steroids) [tuber]
Dioscorea batatas. Chinese yam, Chinese-potato	Food [tuber]
Dioscorea bulbifera. Air-potato	Food [tuber]
Dioscorea cayenensis. Yellow Guinea yam	Food [tuber]
Dioscorea esculenta. Chinese yam, potato-yam	Food [tuber]
Dioscorea hispida. Nami	Food [tuber]
Dioscorea rotundata. White Guinea yam	Food [tuber]
Dioscorea trifida. Cush-cush yam, yampee, yampi	Food [tuber]
Dioscorea villosa. Yam	Medicine (diosgenin) [tuber]

DIPSACACEAE (TEASEL FAMILY)

Dipsacus sylvestris. Fuller's teasel	Raise nap on cloth [fruit]

DIPTEROCARPACEAE (DIPTEROCARP FAMILY)

Dipterocarpus spp. Dipterocarps	Timber; resins [stem]
Dipterocarpus tuberculatus. Eng tree	Fixed oil [seed]
Hopea spp.	Resin (dammar)
Shorea spp. Borneo tallow, sal, damar	Resin (dammar); timber

EBENACEAE (EBONY FAMILY)

Diospyros digyna. Black persimmon, black sapote, chocolate pudding fruit	Food [fruit]
Diospyros discolor. Velvet apple	Food [fruit]
Diospyros ebenum. Ceylon ebony	Timber
Diospyros kaki. Japanese persimmon, kaki	Food [fruit]
Diospyros marmorata. Zebra wood	Timber
Diospyros mollis. Makua	Dye (black) [fruit]
Diospyros virginiana. Persimmon	Food [fruit]

Fraxinus quadrangulata. Blue ash	Dye [leaf/twig]

ELAEAGNACEAE (OLEASTER FAMILY)

Elaeagnus angustifolia. Russian olive	Food [fruit]
Elaeagnus pungens. Silver berry	Food, beverage [fruit]
Shepherdia argentea. Buffalo berry	Dye [fruit]

ELAEOCARPACEAE (ELAEOCARP FAMILY)

Elaeocarpus grandis. Blue marble tree	Ornamentation [fruit]

ERICACEAE (HEATH FAMILY)

Arbutus menziesii. Madrone, madroño	Wood products; dye [bark]
Arbutus unedo. Strawberry tree	Food [fruit]
Arctostaphylos uva-ursi. Bearberry	Dye [leaf]
Erica arborea. Briarwood	Industrial (pipes) [burl]
Gaultheria hispida. Creeping snowberry	Food [fruit]; beverage [leaf]
Gaultheria procumbens. Wintergreen	Essential oil [leaf]; medicine (methyl salicylate) [leaf]
Gaylussacia baccata. Huckleberry	Food [fruit]
Kalmia latifolia. Mountain-laurel	Medicine [leaf]; toxin (suicide) [leaf]
Ledum glandulosum. Labrador tea	Beverage [leaf]
Vaccinium macrocarpon. Cranberry	Food [fruit]
Vaccinium myrtillus. Bilberry	Food [fruit]
Vaccinium spp. Blueberry, cowberry, huckleberry	Food [fruit]

ERYTHROXYLACEAE (COCA FAMILY)

Erythroxylum coca. Coca.	Psychoactive/medicinal alkaloid (cocaine) [leaf]
Erythroxylum novogranatense. Coca	Psychoactive alkaloid (cocaine) [leaf]

EUPHORBIACEAE (SPURGE OR EUPHORB FAMILY)

Aleurites fordii. Tung-oil, tung-nut tree	Fixed oil [seed]
Aleurites moluccana. Candlenut tree	Fixed oil [seed]; ornamental (necklaces) [seed]
Antidesma bunius. Bignay, Chinese laurel	Food [fruit]
Cnidoscolus aconitifolius. Chaya	Food [leaf]
Cnidoscolus chayamansa. Chaya	Food, medicine [leaf]
Cnidoscolus elasticus . Chilte rubber	Latex [all]
Croton tiglium. Croton	Fixed oil [seed]; fish poison
Cryptostegia madagascariensis. Madagascar rubber vine	Latex (palay rubber)
Euphorbia antisyphilitica. Candellila wax	Polishes, insulation, candles [latex]
Euphorbia intisy. Intisy	Latex
Hevea brasiliensis. Pará rubber	Latex, illuminant
Hippomane mancinella. Manchineel tree	Arrow/dart poison [seed]
Hura crepitans. Sandbox tree, huru	Arrow/dart poison [seed]
Jatropha spp. Physic nut, purge n., Barbados n.	Fixed oil [seed]; medicine [seed]; food [seed]
Manihot esculenta. Cassava, manioc, yuca, tapioca	Food [tuber]; latex
Manihot glaziovii. Ceara rubber	Latex
Micrandra spp. Caura rubber	Latex
Phyllanthus acidus. Otaheite gooseberry, emblic	Food [fruit]
Ricinodendron rautanenii. Mongongo nut	Food [fruit]
Ricinus communis. Castor oil	Fixed oil (industrial/medicinal) [seed]
Sapium sebiferum. Chinese tallow tree	Medicine; fish poison [stem]; arrow poison [sap]; Mexican jumping beans [seed]

FAGACEAE (OAK OR BEECH FAMILY)

Castanea crenata. Japanese chestnut	Food [fruit]
Castanea dentata. American chestnut	Food [fruit]
Castanea mollissima. Chinese chestnut	Food [fruit]
Castanea pumila. Chinquapin	Food [fruit]
Castanea sativa. European chestnut	Food [fruit]
Chrysolepis spp. Chinquapin	Timber; Food [fruit]
Fagus crenata. Japanese beech	Timber
Fagus grandifolia. American beech	Food [fruit]
Fagus sylvatica. European beech, beechnut	Food [fruit]
Lithocarpus densiflorus. Tanoak	Timber; tannin [bark]
Nothofagus spp. Southern hemisphere beech	Timber
Quercus suber. Cork oak	Cork [bark]
Quercus spp. Oak	Timber; Food [fruit]; tannin [bark/galls]

FLACOURTIACEAE (WEST INDIAN BOXWOOD FAMILY)

Dovyalis caffra. Kei-apple	Food [fruit]
Dovyalis hebecarpa. Ceylon-gooseberry	Food [fruit]
Flacourtia indica. Governor's plum, Madagascar-plum	Food [fruit]
Flacourtia inermis. Lovi-lovi	Food [fruit]
Gossypiospermum praecox. Venezuelan boxwood, zapatero	Wood
Hydnocarpus kurzii. Chaulmoogra tree	Medicinal oil (leprosy) [seed]

GENTIANACEAE (GENTIAN FAMILY)

Gentiana lutea. Yellow gentian	Medicine (tonic), flavoring [root]

GERANIACEAE (GERANIUM FAMILY)

Pelargonium odoratissimum. Rose geranium	Essential oil [leaf]

GOMORTEGACEAE

Gomortega keule. Keule	Psychoactive [fruit]

GRAMINEAE (GRASS FAMILY)

Andropogon virginicus. Broomsedge	Dye [leaf]
Anthoxanthum odoratum. Sweet vernal grass	Scent [leaf]
Arundinaria spp. Cane, switchcane	Fishing poles [stem], food [fruit]
Arundo donax. Reed grass	Reeds for musical instruments [stem pith]
Avena spp. Oats	Food [fruit]
Bambusa spp. Bamboo	Building material [stem]; food [young shoots]
Brachiaria spp. Browntop	Food [fruit]
Coix lacryma-jobi. Job's tears, adlay	Food [fruit]
Cymbopogon citratus. Lemon grass	Flavoring [lower shoots]; essential oil [leaf]
Cymbopogon martinii. Lemon grass	Essential oil [leaf]
Cymbopogon nardus. Citronella	Essential oil [leaf]
Cynodon dactylon. Bermuda grass	Lawn grass, forage
Dendrocalamus spp. Bamboo	Building material, chop sticks [stem]; food [fruit]
Digitaria spp. Crabgrass, fonio	Food [fruit]
Echinochloa spp. Millet	Food [fruit]
Eleusine coracana. African millet, finger millet, ragi	Food [fruit]
Eragrostis tef. Teff	Food [fruit]
Gigantochloa spp. Bamboo	Building material [stem]
Glyceria spp. Manna grass	Food [fruit]
Guadua angustifolia. Bamboo	Building material [stem]
Gynerium sagittatum. Uva grass, wild cane	Building material [stem], weaving [leaf]
Hierochloë odorata. Sweet grass, holy grass	Essential oil
*Hordeum vulgare.*Barley	Food [fruit]; flavoring (malt) [fruit]
Muhlenbergia macroura. Zacaton	Fiber [leaf]
Muhlenbergia rigens. Deer grass	Fiber [leaf]
Oryza glaberrima. African rice, red rice	Food [fruit]
Oryza sativa. Rice	Food [fruit]
Panicum miliaceum. Proso millet	Food [fruit]
Pennisetum glaucum. Pearl millet	Food [fruit]
Phragmites australis. Common reed	Food (sugar) [stem]; fiber [stem]
Phyllostachys spp. Fish pole bamboo	Fishing poles; walking sticks [stem]
Phyllostachys spp. Bamboo	Building material [stem]; food [shoots]
Saccharum officinarum. Sugar cane	Sugar [stem]
Secale cereale. Rye	Food [fruit]
Setaria spp. Foxtail millet	Food [fruit]
Sorghum bicolor. Sorghum, milo, Sudan grass, broomcorn	Food [fruit], silage [leaf], sugar [stem], brooms [inflorescence]
Stenotaphrum secundatum. St. Augustine grass	Lawn grass
Stipa tenacissima. Esparto grass	Fiber [leaf]
X *Triticosecale* spp. Triticale [wheat x rye]	Food [fruit]
Triticum aestivum. Common wheat, bread wheat	Food [fruit]
Triticum durum. Durum wheat, macaroni wheat	Food [fruit]
Vetiveria zizanioides. Khus-khus, vetiver	Essential oil [rhizome]
Zea mays. Maize, corn, teosinte	Food; starch; oil [fruit]
Zizania palustris. Wild-rice	Food [fruit]

GROSSULARIACEAE (GOOSEBERRY FAMILY)

Ribes nigrum. Black currant	Food; flavoring [fruit]
Ribes rubrum. Red currant	Food; flavoring [fruit]
Ribes spp. Gooseberry, currant	Food [fruit]

GUTTIFERAE (MANGOSTEEN FAMILY)

Calophyllum inophyllum. Indian laurel, laurel wood	Fixed oil (domba oil) for medicine (neuralgia, skin disease), illuminant [seed]; wood
Garcinia livingstonei. Imbé	Food [fruit]
Garcinia xanthochymus. Gamboge tree	Dye [sap]
Garcinia mangostana. Mangosteen	Food [fruit]
Mammea americana. Mammee-apple	Food [fruit]

HAMAMELIDACEAE (WITCH HAZEL FAMILY)

Hamamelis virginiana. Witch hazel	Medicine; essential oil [stem]
Liquidambar orientalis. Sytrax	Gum (Levant storax) [stem]
Liquiambar styraciflua. Sweet gum	Timber, medicine [stem]; gum (American storax) [stem]
Loropetalum chinese. Razzelberri, razzle berry	Food [fruit]

HIMANTANDRACEAE

Galbulimima belgraveana. Agara	Psychoactive snuff [leaf]

HIPPOCASTANACEAE (BUCKEYE FAMILY)

Aesculus arguta. Western buckeye	Fish poison [seed]
Aesculus californica. California buckeye, horse-chestnut	Food [seed], fish poisons [seed, stem]
Aesculus flava. Yellow buckeye	Timber
Aesculus hippocastanum. Horse-chestnut	Timber; medicine (cardiovascular) [seed]
Aesculus pavia. Red buckeye	Fish poison [seed]

ILLICIACEAE (STAR-ANISE FAMILY)

Illicium floridanum. Florida-anise, purple-anise	Essential oil [fruit/seed]
Illicium parviflorum. Yellow star-anise	Essential oil [fruit/seed]
Illicium verum. Star-anise, Chinese star-anise	Essential oil [fruit/seed]

IRIDACEAE (IRIS FAMILY)

Crocus sativus. Saffron	Essential oil [stigma/style]
Iris florentina. Orris root	Essential oil [rhizome]

JUGLANDACEAE (WALNUT FAMILY)

Carya illinoensis. Pecan	Food [fruit]
Carya spp. Hickory, pignut, mockernut	Food [fruit]
Juglans ailanthifolia. Japanese walnut	Food [fruit]
Juglans cinerea. Butternut	Food [fruit]; dye [bark/husk]
Juglans nigra. Black walnut	Food [fruit]; dye [bark/husk]
Juglans regia. English walnut	Food [fruit]; fixed oil [seed]

JUNCACEAE (RUSH FAMILY)

Juncus bufonius. Toad rush	Fiber [stem]
Juncus effusus. Rush	Fiber [stem]

LABIATAE (MINT FAMILY)

Coleus blumei. Coleus	Psychoactive [leaf]
Hedeoma pulgioides. Pennyroyal	Medicine [leaf]
Hyptis suaveolens. Chia, wild spikenard	Beverage; novelty items [seed]
Hyssopus officinalis. Hyssop	Essential oil, medicine [leaf]
Lavandula officinalis. Lavender	Essential oil[flower]
Lavandula stoechas. French lavender	Essential oil [leaf]
Marrubium vulgare. Horehound	Essential oil; medicine [leaf]
Melissa officinalis. Balm	Essential oil; medicine [leaf]
Mentha piperita. Peppermint	Essential oil [leaf]
Mentha pulegium. Pennyroyal	Essential oil [leaf]
Mentha spicata. Spearmint	Essential oil [leaf]
Monarda spp. Oswego tea, horsemint	Essential oil (flavoring, medicine) [leaf]
Nepeta cataria. Catnip	Essential oil [leaf]
Ocimum basilicum. Basil	Essential oil [leaf]
Origanum majorana. Marjoram	Essential oil [leaf]
Origanum vulgare. Pot marjoram, oregano	Essential oil [leaf]
Perilla frutescens. Perilla	Essential oil [leaf]
Pogostemon cablin. Patchouli	Essential oil [leaf]
Prunella vulgaris. Self-heal	Medicine [leaf]
Rosmarinus officinalis. Rosemary	Essential oil [leaf, flower]
Salvia columbarieae. Chia, chan	Beverage, toys [seed]
Salvia divinorum. Hierba de la pastora, hierba de la virgen	Psychoactive [leaf]
Salvia officinalis. Sage	Essential oil [leaf]
Salvia sclarea. Clary	Essential oil [leaf]
Satureja hortensis. Savory	Essential oil [leaf]
Stachys palustris. Marsh woodwort	Food [tuber], medicine [leaf]
Stachys officinalis. Betony	Medicine [leaf]
Thymus vulgaris. Thyme	Essential oil (flavoring) [leaf]

LAURACEAE (LAUREL FAMILY)

Aniba rosquedora. Rosewood	Essential oil [wood]
Cinnamomum camphora. Camphor	Essential oil (medicine) [wood]
Cinnamomum cassia. Cassia	Essential oil [bark, bud]
Cinnamomum verum. Cinnamon	Essential oil [bark]
Laurus nobilis. Laurel	Essential oil [leaf]
Ocotea rodioei. Greenheart	Timber
Persea americana. Aguacate, avocado, alligator pear	Food [fruit]
Sassafras albidum. Sassafras	Essential oil [leaf]
Umbellularia californica. California laurel, pepperwood	Essential oil [leaf]

LECYTHIDACEAE (BRAZIL NUT FAMILY)

Barringtonia excelsa. Fish-poison tree	Fish poison; medicine [fruit]
Bertholletia excelsa. Brazil nut	Food [seed]; fixed oil [seed]
Lecythis minor. Coco de mono	Food [seed]

Lecythis ollaria. Monkey pod, monkey pot, paradise nut	Food [seed]
Lecythis usitata. Monkey nut	Food [seed]
Lecythis spp. Paradise nut	Food [seed]

LEGUMINOSAE (LEGUME, BEAN, OR PEA FAMILY)

Acacia catechu. Catechu, black cutch	Industrial gum; tannin; dye [wood]
Acacia koa. Koa	Timber
Acacia senegal. Gum arabic	Industrial gum [wood]
Acacia spp. Wattle	Timber
Aeschynomene spp. Shola, sola	Fiber (pith helmets) [stem pith]
Afzelia spp. Afzelia, Malacca-teak	Timber; charms [seed]
Albizzia saman. Rain tree	Timber
Amphicarpaea bracteata. Talet bean	Food [seed]
Anadenanthera colubrina. Huilca, vilca	Psychoactive [seed]
Anadenanthera peregrina. Cohoba, nopo, parica, yopo	Psychoactive [seed]
Apios americana. American potato bean	Food [tuber]
Arachis hypogaea. Goober, ground nut, peanut	Food [seed]; fixed oil [seed]
Aspalanthus contaminatus. Rooibos	Beverage [leaf]
Astragalus gummifer. Gum tragacanth	Industrial gum
Astragalus membranaceus. Astragalus root	Medicine (immune system) [root]
Baphia nitida. Barwood, camwood	Dye [wood]
Caesalpinia coriaria. Divi-divi	Tannin [fruit]
Caesalpinia echinata. Brazil wood	Wood, dye [wood]
Caesalpinia sappan. Sappan wood	Dye [wood]
Cajanus cajan. Pigeon pea, Cajan pea	Food [seed]
Canavalia ensiformis. Jack bean, horse bean	Food [seed]
Canavalia gladiata. Sword bean	Food [seed]
Cardeauxia edulis. Yeheb nut	Food [seed]; purple dye [seed]
Cassia angustifolia. Indian senna	Dye, medicine [leaf]
Cassia fistula. Purging cassia	Medicine (laxative) [seed]
Cassia occidentalis. Coffee weed	Medicine, coffee substitute [seed]
Ceratonia siliqua. Carob, St. John's bread	Gum, food [pulp around seed]
Cicer arietinum. Chick pea, garbanzo bean	Food [seed]
Copaifera officinalis. Copaiba balsam	Resin (medicine, industry) [stem]
Copaifera spp. Copal	Resin (medicine, industry) [stem]
Crotalaria juncea. Sunn hemp	Fiber [stem]
Cyamopsis tetragonolobus. Guar gum	Industrial gum (cosmetic, industrial) [seed]
Dalbergia nigra. Brazilian rosewood	Wood
Dalbergia decipularis. Brazilian tulipwood	Wood
Dalbergia melanoxylon. African blackwood	Wood
Dalbergia retusa. Cocobolo	Wood
Dalbergia sisso. Sisso, sheesham	Wood
Dalbergia stevensonii. Honduras rosewood	Wood
Derris spp. Tuba, derris	Fish poison (rotenone) [root]
Dipteryx odorata. Tonka bean	Flavoring (tobacco/snuff) [seed]
Dipteryx oleifera. Ebor, eboe	Flavoring (tobacco/snuff) [seed]
Entada spp. Sea bean	Abortifacient, fish poison [seed]
Genista tinctoria. Greenwood	Dye [plant]
Glycine max. Soybean	Food [seed/fruit], industrial oil [seed]
Glycyrrhiza glabra. Licorice	Flavoring [rhizome, root]
Gymnocladus dioica. Kentucky coffee bean tree	Timber; coffee substitute [seed]
Haematoxylon campechianum. Logwood	Dye (medical/scientific applications) [wood]
Hymenaea spp. Madagascar copal, Brazilian copal	Resin (varnish, incense), timber, food [fruit]
Indigofera tinctoria. Indigo	Dye [stem, leaf]
Inga edulis. Ice cream bean	Food [fruit]
Inocarpus fagifer. Polynesian chestnut, Tahiti-chestnut	Food [seed]
Lablab purpureus. Hyacinth bean, lablab bean, bonavist bean	Food [seed]
Lathyris sativus. Chickling pea	Food [immature fruit, seed]
Lathyris tuberosus. Tuberous vetch, earthnut pea	Food [tuber]
Lens culinaris. Lentil	Food [seed]
Lonchocarpus spp. Barasco, cubé, timbo	Arrow/dart poisons [root]
Lonchocarpus violaceus. Balché	Ceremonial wine [bark]
Medicago sativa. Alfalfa	Food[leaf, shoot, sprouted seed]
Melilotus spp. Sweet clover	Medicine (coumarins) [stem, leaf]; fodder
Microberlinia brazzavillensis. Zebrano, zebra wood	Wood
Milletia laurentii. Wenge	Wood
Milletia stuhlmanii. Panga-panga	Timber
Mimosa hostilis. Jurema	Psychoactive [root]
Mucuna spp. Velvet bean	Food [seed]; medicine [seed]; fish poison; dye [bark/leaf]
Myroxylon balsamum. Balsam of Tolu	Resin [stem]
Myroxylon pereirae. Balsam of Peru	Medicinal resin [stem wound]
Pachyrrhizus erosus. Yam bean, jicama	Food [tuber]
Pachyrrhizus tuberosus. Tuberous yam bean, potato bean	Food [tuber]
Parkia filcoidea. Locust bean	Food [seed]
Pericopsis spp. False dalbergia	Timber
Phaseolus acutifolius. Tepary bean	Food [seed]

Phaseolus aureus. Mung bean — Food [seed]
Phaseolus coccineus. Scarlet runner bean — Food [seed]
Phaseolus limensis. Lima bean — Food [seed]
Phaseolus lunatus. Butter bean, sieva bean, sugar bean — Food [seed]
Phaseolus vulgaris. Black bean, chili b., common b., cranberry b., garden b., green b., haricot b., kidney b., navy b., pea b., pink b., pinto b., red b., snap b., string b., wax b., white b. — Food [seed, fruit]
Physostigma venenosum. Calabar bean — Ordeal poison/medicinal [seed]
Piscidia piscipula. Fish poison tree — Fish poison [bark, root]
Pisum sativum. English pea, garden pea — Food [seed]
Pongamia pinnata. Pongam — Essential oil; medicine [seed]
Prioria copaifera. Copaiba balsam — Resin, timber
Prosopis glandulosa. Mesquite, algaroba — Wood
Psophocarpus tetragonolobus. Asparagus pea, Goa bean, winged bean — Food [seed, tuber]
Pterocarpus spp. Barwood, rosewood, sandalwood — Wood
Pueraria lobata. Kudzu — Erosion control; medicine (fever, alcoholism) [flower, root]
Robinia pseudoacacia. Black locust — Wood
Sesbania exaltata. Colorado River hemp — Fiber [stem]
Sophora secundiflora. Mescal bean, red bean — Psychoactive [seed]
Sphenostylis stenocarpa. Yam bean — Food [tuber]
Tamarindus indica. Tamarind, tamarindo — Food [fruit, seed, pulp]
Tephrosia spp. Tephrosia — Fish poison, insecticide, medicine [root]
Trifolium spp. Clovers — Fodder [stem, leaf]
Trigonella foenum-graecum. Fenugreek — Essential oil [seed, leaf]
Vicia faba. Broad bean, fava bean, horse bean, Windsor bean — Food [seed]
Vigna acontifolia. Mat bean, moth bean — Food [seed, fruit]
Vigna angularis. Adzuki bean — Food [seed]
Vigna mungo. Black gram bean, urd bean — Food [seed]
Vigna radiata. Golden gram bean, mung bean — Food [seed]
Vigna umbellata. Rice bean — Food [seed]
Vigna unguiculata. Asparagus bean, black-eyed pea, cowpea — Food [seed]
Voandzeia subterranea. Bambara groundnut — Food [seed]

LILIACEAE (LILY FAMILY)
Allium ampeloprasum. Elephant garlic, leek — Food [bulb]
Allium ascalonium. Shallot — Food [bulb]
Allium cepa. Onion — Food [bulb]
Allium sativum. Garlic — Food; medicine (allicin) [leaf]
Allium schoenoprasum. Chives — Food [leaf]
Aloë vera. Aloe vera — Medicine (treat burns) [sap]
Asparagus officinalis. Asparagus — Food [shoots]
Camassia spp. Camas — Food
Chlorogalum pomeridianum. Soaproot — Fish poison [root]
Colchicum autumnale. Autumn crocus — Toxic/medicinal alkaloid (colchicine) [bulb]
Drimia maritima. Squill, sea-onion — Rat poison [bulb]
Hyacinthus spp. Hyacinth — Essential oil [flower]

LIMNANTHACEAE (MEADOW FOAM FAMILY)
Limnanthes alba. Meadow foam — Industrial oil [seed]
Limnanthes douglasii. Meadow foam — Industrial oil [seed]

LINACEAE (FLAX FAMILY)
Linum catharticum. Purging flax — Medicine (purgative); fiber [stem]
Linum usititissimum. Flax — Fiber (linen) [stem]; fixed oil (linseed) [seed]

LOGANIACEAE (LOGANIA FAMILY)
Gelsemium elegans. Allspice jessamine — Poison (criminals, suicide) [leaf]
Gelsemium sempervirens. Yellow jessamine, Carolina j. — Medicine (CNS depressant) [root]
Strychnos nux-vomica. Nux vomica — Medicinal/toxic alkaloid (strychnine) [seed]
Strychnos toxifera. Curare — Arrow/dart poisons [bark]

LYTHRACEAE (LYTHRUM FAMILY)
Lagerstromia speciosa. Banaba tree, crape myrtle — Medicine (lower blood pressure) [leaf]
Lawsonia inermis. Henna — Dye (henna hair rinse) [leaf], medicine [bark]

MAGNOLIACEAE (MAGNOLIA FAMILY)
Liriodendron tulipifera. Tulip tree — Timber
Magnolia officinalis. — Medicine (tonic) [bark]
Magnolia virginiana. Sweet-bay — Timber
Michelia champaca. Champaca, sapu — Timber; essential oil [flower]

MALPIGHIACEAE (MALPIGHIA FAMILY)
Banisteriopsis spp. Ayahuasca, caapi, yajé — Psychoactive [bark]
Bunchosia armeniaca. Ciruela — Food [fruit]
Malpighia glabra. Acerola, Barbados-cherry — Food [fruit]
Malpighia punicifolia. West Indian-cherry — Food [fruit]

MALVACEAE (MALLOW OR COTTON FAMILY)

Abelomoscus esculentus. Okra, gumbo	Food [fruit]
Abutilon esculentum	Food [flower]
Abutilon theophrasti. China jute, Indian mallow, velvet weed	Fiber [stem]
Althaea officinalis. Marsh mallow	Food, medicine [root]
Gossypium arboreum. Tree cotton	Fiber [seed]
Gossypium barbadense. Sea-island cotton, Egyptian c.	Fiber [seed]
Gossypium herbaceum. Arabian cotton, Asiatic c., levant c., short-staple c.	Fiber [seed]
Gossypium hirsutum. Upland cotton	Fiber; fixed oil [seed]
Gossypium nanking. Khaki cotton	Fiber [seed]
Hibiscus cannabinus. Decan hemp, kenaf	Fiber [stem]
Hibiscus tomentosum. Hawaiian cotton	Fiber [seed]
Hibiscus sabdariffa. Roselle, Jamaican sorrel	Fiber; fiber [shoot]
Hibiscus tiliaceus. Majagua, mahoe	Fiber [stem]
Malva spp. Mallow	Food; medicine; beverage [fruit]
Sida acuta. Queensland hemp	Fiber [stem]; medicine [leaf]
Thespesia populnea. Milo, tulip tree	wood, fiber [bark]
Urena lobata. African hemp, aramina, cadillo	Fiber (aramina) [stem]

MARANTACEAE (PRAYER PLANT FAMILY)

Calathea lutea. Balasier	Fiber (baskets) [leaf], wax (cavassú)
Maranta arundinacea. West Indian arrowroot	Food, cosmetics, industrial [rhizome]

MELIACEAE (CHINA BERRY FAMILY)

Azadirachta indica. Neem tree	Timber; oil (margosa o.); insecticide, medicine (spermicide) [bark/leaf]
Carapa guianensis. Andiroba, crabwood	Timber; oil (andiroba oil) [seed]
Cedrela odorata. Spanish cedar, cigar-box cedar	Wood
Khaya senegalensis. African mahogany	Wood
Lansium domesticum. Langsat	Food [fruit]
Melia azedarach. China berry	Insecticide [leaf]
Swietenia humilis. Mexican mahogany	Timber
Swietenia mahagoni. Cuban mahogany	Timber
Swietenia macrophylla. Baywood	Timber
Toona sinensis. Chinese-cedar	Timber

MENISPERMACEAE (MOON SEED FAMILY)

Chondrodendron tomentosum. Curare	Arrow/dart poisons; medicine (tubocurarine) [root]
Cocculus laurifolius. Moonseed	Arrow/dart poisons [bark]
Cocculus spp.	Food, alcoholic beverages [fruit]

MENYANTHACEAE (BOG BEAN FAMILY)

Menyanthes trifoliata. Buck bean, bog bean	Medicinal [rhizome], hops substitute [leaf]

MORACEAE (FIG OR MULBERRY FAMILY)

Antiaris africana. Upas	Timber
Antiaris toxicaria. Upas	Arrow/dart poisons [sap]
Artocarpus altilis. Breadfruit, pan del árbol	Food [fruit]; surf boards [trunk]
Artocarpus heterophyllus. Jack fruit, jak fruit	Food [fruit]
Artocarpus odoratissima. Marang	Food [fruit]
Brosimum alicastrum. Breadnut	Food [seed]
Brosimum utile. Cow tree	Food, chewing gum [latex]
Broussonetia papyrifera. Paper mulberry	Fiber [bark]
Castilla elastica. Panama rubber, Castilla rubber	Latex
Chlorophora tinctoria. Fustic	Dye [wood], medicine [bark]
Ficus benghalensis. Banyan tree	Food [fruit/leaf]; timber; fiber [bark]; medicine [latex]
Ficus carica. Fig	Food [fruit]; medicine [latex]
Ficus elastica. India rubber, Assam rubber	Latex
Ficus platyphylla. Gutta niger, red kano rubber	Latex; fiber, tanning [bark]
Ficus religiosa. Bo tree, peepul tree	Sealing wax [latex]; fiber [bark]; silkworm food [leaf]
Ficus sycomorus. Mulberry fig	Timber; food [fruit]
Maclura pomifera. Bois d'arc, Osage orange	Arrow/dart shafts, timber; dye [wood]
Maclura tinctoria. Toothache tree	Medicine [latex]
Maquira sclerophylla. Rape dos Indios	Psychoactive (snuff); arrow poison [fruit]
Morus nigra. Black mulberry	Food [fruit]
Morus rubra. Red mulberry	Food [fruit]

MORINGACEAE

Moringa oleifera. Horseradish tree	Food [fruit], fixed oil (oil of Ben) [seed]
Moringa pterogyosperma	Fixed oil [seed]

MUSACEAE (BANANA FAMILY)

Ensete ventricosum. Abyssinian banana	Food [seed]; fiber [stem, shoots]
Musa acuminata. Datil, finger banana	Food [fruit]
Musa x *paradisiaca* var. *paradisiaca*. Plantain, platano, cooking banana	Food [fruit]
Musa x paradisiaca var. *sapientum*. Banana	Food [fruit]

Musa textilis. Manila hemp, abacá — Fiber [leaf]

MYRICACEAE (MYRICA FAMILY)

Myrica cerifera. Wax myrtle — Essential oil/wax [fruit]
Myrica pensylvanica. Bayberry — Essential oil/wax [fruit]

MYRISTICACEAE (NUTMEG FAMILY)

Myristica fragrans. Nutmeg — Flavoring [seed]
Myristica fragrans. Mace — Flavoring [aril]
Virola spp. Otoba butter — Fixed oil (candles, soap)
Virola spp. Epena — Psychoactive resins (snuffs) [inner bark]

MYRTACEAE (MYRTLE OR EUCALYPTUS FAMILY)

Eucalyptus diversicolor. Karri — Timber
Eucalyptus globulus. Blue gum — Timber; oil [wood]
Eucalyptus marginata. Jarrah — Timber
Eucalyptus microtheca. Coolibah — Timber
Eucalyptus spp. Eucalypts — Flavoring [leaf]
Eugenia malaccensis. Mountain-apple — Food [fruit]
Eugenia uniflora. Pitanga, Surinam cherry — Food [fruit]
Feijoa sellowiana. Feijoa — Food [fruit]
Leptospermum petersonii — Essential oil [leaf]
Leptospermum scoparium. Manuka — Timber; beverage [leaf]
Melaleuca cajuputi. Cajuput — Fixed oil (medicine) [seed]
Myrciaria cauliflora. Jaboticaba — Food [fruit]
Pimenta dioica. Allspice, bay — Essential oil [fruit]
Pimenta racemosa. Bay leaf, bay-rum — Essential oil [leaf]
Psidium cattleianum. Strawberry guava, purple guava — Food [fruit]
Psidium guajava. Guava — Food [fruit]
Psidium guineense. Guisaro — Food [fruit]
Syzygium aromaticum. Cloves — Essential oil [flower bud]
Syzygium cuminii. Jambolan, Java plum — Food [fruit]
Syzygium jambos. Rose-apple — Food [fruit]
Syzygium malaccense. Rose-apple, Malay-apple, Otaheite-apple — Food [fruit]
Syzygium samarangense. Java apple, wax jambu, wax-apple — Food [fruit]

NELUMBONACEAE (INDIAN LOTUS FAMILY)

Nelumbo nucifera. Sacred lotus, Indian lotus — Food [seed, rhizome, leaf]
Nelumbo pentapetala. Water chinquapin — Food [stem, rhizome, leaf]

NYCTAGINACEAE (FOUR O'CLOCK FAMILY)

Mirabilis jalapa. Marvel-of-Peru — Medicine [root], dye [flower]
Mirabilis multiflora. Four o'clock — Medicine [root]

NYMPHAEACEAE (WATER-LILY FAMILY)

Nymphaea spp. Water-lily — Food [rhizome]

OLACACEAE (AFRICAN WALNUT or OLAX FAMILY)

Coula edulis. Gaboon nut, African-walnut — Food [seed]

OLEACEAE (OLIVE FAMILY)

Carissa grandiflora. Carissa — Food [fruit]
Fraxinus americana. American ash — Wood
Fraxinus excelsior. European ash — Wood
Fraxinus mandschurica. Japanese ash — Wood
Fraxinus pensylvanica. Red ash — Wood
Jasminum officinale. Jasmine — Essential oil [flower]
Olea europaea. Olive — Food [fruit]; fixed oil [seed]
Osmanthus fragrans. Kwei — Flavoring [flower]
Syringa vulgaris. Lilac — Flavoring [flower]

ORCHIDACEAE (ORCHID FAMILY)

Angraecum fragrans. — Beverage, flavoring [leaf]
Vanilla planifolia. Vanilla — Flavoring [fruit]

OXALIDACEAE (OXALIS OR SORREL FAMILY)

Averrhoa bilimbi. Bilimbi — Food [fruit]
Averrhoa carambola. Carambola, cucumber tree — Food [fruit]
Oxalis tuberosa. Oca — Food [tuber]

PALMAE (PALM FAMILY)

Areca catechu. Betel nut — Psychoactive [seed]
Arenga pinnata. Gomuti palm, sugar palm, sago palm — Sugar [sap]; beverage [stem]; food (starch) [stem]; thatch [leaf]
Attalea funifera Bahia piassava — Fiber [leaf]
Bactris spp. Pejibaye, peach palm — Food [fruit]; beverage; fixed oil; building material

Borassus flabellifer. Palmyra palm
Fiber [leaf]; beverage; food; building material; food [fruit]; beverage [fruit]
Butia capitata. Jelly palm — Food [fruit]
Calamus spp. Rattan — Furniture (wicker) [stem]
Caryota urens. Toddy, fish-tail, or sago-palm — Sugar, wine [stem]; food (starch) [stem; fiber [leaf]
Ceroxylon spp. Wax palm — Wax [leaf]
Cocos nucifera. Coconut
Food [seed]; building/thatching [leaf]; fiber [fruit]; fixed oil [seed]; sugar [sap]
Copernicia prunifera. Carnauba wax palm — Industrial wax [seed]
Daemonorops spp. Rattan — Resin (Sumatran dragon's blood) medicine/varnish [fruit]
Elaeis guineensis. African oil palm — Industrial & cooking oil [fruit]
Elaeis oleifera. American oil palm — Industrial & cooking oil [fruit]
Euterpe oleracea. Cabbage palm — Food [palm heart]
Hyphaene ventricosa. Vegetable ivory palm — Industrial [seed]
Jubaea chilensis. Honey palm — Sugar [sap]
Leopoldiana piassaba. Piassaba — Fiber [leaf]
Metroxylon amicarum. Ivory nut palm — Buttons [seed]
Metroxylon sagu. Sago palm — Starch [stem]
Nypa fruticans. Nypa palm — Sugar [inflorescence]
Orbignya cohune. Cohune palm — Oil (cosmetic) [seed]; food [buds]; thatch, fiber (hats) [leaf]
Orbignya phalerata. Babassu palm — Oil (cosmetic, margarine) [seed]
Phoenix dactylifera. Date palm — Food [fruit]
Phoenix sylvestris. Wild date palm — Sugar [stem]
Phytelephas macrocarpa. Tagua nut, ivory nut — Industrial (buttons, dice, etc.) [seed]
Raphia spp. Raffia palm — Fiber [leaf], beverage (palm wine) [stem/inflorescence]
Roystonea oleracea. American cabbage palm — Food (starch) [palm heart]; thatch [leaf]
Roystonea regia. Royal palm — Food (starch) [palm heart]; thatch [leaf]
Sabal palmetto. Cabbage palmetto, palmetto — Fiber [leaf]
Sabal causiarum. Puerto Rican hat palm — Fiber [leaf]
Serenoa repens. Sabal palmetto — Food [fruit]; medicine (prostate) [fruit]

PANDANACEAE (SCREW-PINE FAMILY)
Pandanus spp . Screw-pines, pandanus — Food [seed]; flavoring, perfume [leaf]

PAPAVERACEAE (POPPY FAMILY)
Argemone mexicana. Mexican poppy — Oil [seed]; psychoactive [seed]
Papaver bracteatum. Poppy — Medicinal alkaloid (thebaine) [latex]
Papaver somniferum. Opium poppy, poppy
Medicinal/psychoactive alkaloids [latex]; flavoring [seed]; fixed oil [seed]
Sanguinaria canadensis. Bloodroot — Dye [root]; medicine (expectorant/emetic) [latex]

PASSIFLORACEAE (PASSION FLOWER FAMILY)
Passiflora edulis. Purple granadilla — Food [fruit]
Passiflora laurifolia. Yellow granadilla — Food [fruit]
Passiflora ligularis. Sweet granadilla — Food [fruit]
Passiflora quadrangularis. Giant granadilla — Food [fruit]

PEDALIACEAE (SESAME FAMILY)
Harpagophytum procumbens. Devil's claw — Medicine (analgesic, anti-inflammatory) [root]
Proboscidea spp. Unicorn plant, devil's claw — Food, basketry [fruit]
Sesamum indicum. Sesame — Food [seed]; fixed oil [seed]

PHYTOLACCACEAE (POKE WEED OR POKE BERRY FAMILY)
Phytolacca americana. Poke, poke weed, poke berry — Food [leaf]; dye [fruit]

PIPERACEAE (PIPER OR PEPPER FAMILY)
Piper betle. Betel pepper — Used with betel nut palm seed (masticatory) [leaf]
Piper cubeba. Cubeb pepper — Flavoring [fruit]
Piper longum. Long pepper — Flavoring [fruit, seed]
Piper methysticum. Kava, kava kava, yongona, grog — Psychoactive (masticatory) [root, stem]
Piper nigrum. Black pepper, white pepper — Flavoring [fruit, seed]

PLANTAGINACEAE (PLANTAGO FAMILY)
Plantago afra. Psyllium — Laxative [seed]

PLATANACEAE (SYCAMORE FAMILY)
Platanus occidentalis. Sycamore — Timber
Platanus orientalis. European plane tree — Timber

POLYGALACEAE (POLYGALA FAMILY)
Polygala senega. Senega snakeroot — Medicine (snakebite) [root]

POLYGONACEAE (SMARTWEED OR KNOTWEED FAMILY)
Coccoloba uvifera. Sea-grape — Food, jelly [fruit]
Fagopyrum esculentum. Buckwheat, kasha — Food [fruit]; dye [stem]
Rheum australe. Indian rhubarb — Medicine [root]

Rheum rhabarbarum. Rhubarb	Food [petiole]
Rheum palmatum. Chinese rhubarb	Medicine [rhizome]
Rumex crispus. Dock	Food [leaf]; medicine [root]
Rumex hymenosepalus. Canaigre, tanner's dock	Tannins [root]

PORTULACACEAE (PURSLANE FAMILY)

Lewisia rediviva. Bitter root	Food [root]
Portulaca oleracea. Purslane	Food [leaf]

PROTEACEAE (PROTEA FAMILY)

Grevillea robusta. Silky-oak	Timber
Macadamia integrifolia. Macadamia nut, Queensland nut	Food [seed]
Knightia excelsa. Rewa-rewa	Timber

PUNICACEAE (POMEGRANATE FAMILY)

Punica granatum. Pomegranate	Food [fruit]; flavoring [seed]

RANUNCULACEAE (BUTTERCUP OR CROWFOOT FAMILY)

Aconitum napellus. Monkshood, wolfbane	Medicine [root]
Caulophyllum thalictroides. Blue cohosh	Medicine [root]
Hydrastis canadensis. Goldenseal	Medicine [root]; dye (yellow) [all]
Nigella sativa. Nigella	Flavoring [seed]

RESEDACEAE (MIGNONETTE FAMILY)

Reseda luteola. Dyer’s weld, wild mignonette	Dye (Sherwood Forest green) [all]
Reseda odorata. Mignonette	Essential oil [flower]

RHAMNACEAE (BUCKTHORN FAMILY)

Ceanothus americanus. New Jersey tea	Beverage [leaf]
Rhamnus cathartica. Cascara, cascara sagrada	Laxative [bark]; dye [fruit]
Rhamnus purshiana. Cascara sagrada	Laxative [bark]
Zizyphus jujuba. Jujube, Chinese-date	Food [fruit]
Zizyphus mauritania. Beri, bor, Chinese-date	Food [fruit]

ROSACEAE (ROSE FAMILY)

Agrimonia striata. Agrimony	Dye [rhizome]
Chrysobalanus icacao. Coco-palm, icaco	Food [fruit]
Crataegus spp. Hawthorn	Food [fruit]
Cydonia oblonga. Quince	Food [fruit]
Eriobotrya japonica. Loquat	Food [fruit]
Filipendula ulmaria. Meadowsweet	Medicine (aspirin source); essential oil [leaf]
Fragaria spp. Strawberry	Food [receptacle/fruit]
Malus sylvestris. Apple	Food [receptacle/fruit]; gum (pectin) [fruit]
Mespilus germanica. Medlar	Food [fruit]
Prunus africana. Pygeum tree, red stinkwood	Medicine (treat BPH) [leaf, bark, fruit]
Prunus avium. Sweet cherry	Food [fruit]
Prunus armeniaca. Apricot	Food [fruit]
Prunus domestica. Plum, prune	Food [fruit]
Prunus dulcis. Almond, bitter almond	Food [seed]; essential oil [fruit]
Prunus mahalab. Mahleb	Flavoring [seed]
Prunus persica. Peach, nectarine	Food [fruit]
Prunus serotina. Black cherry	Food [fruit]
Prunus spinosa. Sloe, blackthorn	Flavoring (gin) [fruit]
Pyrus communis. Pear	Food [fruit]
Pyrus pyrifolia. Apple pear, Asian p., Chinese p., sand p.	Food [fruit]
Quillaja saponaria. Soapbark	Saponins (soap substitute) [bark]
Rosa centifolia. Rose	Essential oil [flower]
Rosa damascena. Summer damask rose	Essential oil (otto of roses) [flower]
Rubus chamaemorus. Cloudberry	Food [fruit]
Rubus idaeus. Red raspberry	Food [fruit]
Rubus occidentalis. Black raspberry	Food [fruit]
Rubus ursinus. Boysenberry, loganberry, veitchberry, youngberry	Food [fruit]
Rubus spp. Blackberry, dewberry	Food [fruit]
Sorbus aucuparia. Rowan	Food (jelly) [fruit]; wood

RUBIACEAE (MADDER OR COFFEE FAMILY)

Cinchona spp. Quinine	Medicinal alkaloids (quinine, etc.) [bark]
Coffea arabica. Arabian coffee	Caffeinated beverage [seed]
Coffee liberica. Liberian coffee	Caffeinated beverage [seed]
Coffee canephora. Robusta coffee, Congo coffee	Caffeinated beverage [seed]
Gardenia jasminoides. Gardenia	Essential oil [flower]
Genipa americana. Genipap	Food, dye, drink [fruit]
Morinda citrifolia. Indian mulberry, noni	Dye; food; medicine [fruit]
Pausinystalia yohimbe. Yohimbe	Medicine/aphrodisiatic (yohimbine) [bark]
Psychotria ipecacuanha. Ipecac	Medicine (induce vomiting) [rhizome]
Rubia tinctorum. Madder	Dye [root]

Uncaria gambir. Gambier, white cutch	Dye, masticatory, medicine [leaf]
Uncaria spp. Cat's claw, uña de gato	Medicinal tea [stem, leaves, bark]

RUTACEAE (CITRUS FAMILY)

Aegle marmelos. Bael	Religious rites (India) [leaf]
Angostura febrifuga. Angostura	Flavoring (bitters) [bark]
Barosma betulina. Buchu	Essential oil [leaf]
Casimiroa edulis. White sapote	Food [fruit]; essential oil [leaf]
Citrus aurantiifolia. Lime	Flavoring [fruit]
Citrus aurantium. Sour orange, bitter orange, Seville orange	Flavoring [fruit]
Citrus bergamia. Bergamot orange	Flavoring (Earl Grey tea) [fruit]
Citrus hystrix. Kaffir lime	Flavoring [fruit rind, leaf]
Citrus latifolia. Persian lime, Tahitian lime	Food [fruit]
Citrus limon. Lemon	Flavoring [fruit]
Citrus maxima. Pomelo, shaddock	Food [fruit]
Citrus medica. Citron	Food [fruit]
Citrus x *mitis*. Calomondin, calamandarin	Food [fruit]
Citrus x *nobilis*. Tangor [tangerine x sweet orange]	Food [fruit]
Citrus x *paradisi*. Grapefruit [shaddock x sweet orange]	Food [fruit]
Citrus reticulata. Clementine, Mandarin orange, tangerine	Food [fruit]
Citrus sinensis. Orange, sweet orange	Food [fruit]
Citrus x *tangelo*. Tangelo [tangerine x grapefuit]	Food [fruit]
Clausena lansium. Wampi	Food [fruit]
Dictamnus albus. Dittany, gas plant	Medicine (uterine stimulant) [root]
Fortunella spp. Kumquat	Food [fruit]
Galipea officinalis. Angostura	Flavoring [bark]
Murraya koenigii. Curry leaf	Flavoring [leaf]
Phellodendron spp. Cork tree	Timber
Pilocarpus jaborandi. Jaborandi	Medicine [leaf]
Poncirus trifoliata. Trifoliate orange	Food (marmalade) [fruit]
Ruta graveolens. Rue	Flavoring [leaf]
Zanthoxylum piperitum. Fagara, Sichuan pepper	Flavoring [fruit]

SALICACEAE (WILLOW FAMILY)

Populus alba. White poplar	Timber; medicine [bark]
Populus balsamifera. Balsam poplar	Resin [buds]; wood
Populus grandidentata. Largetooth aspen	Wood
Populus tremula. European aspen	Wood
Populus tremuloides. Quaking aspen	Wood; medicine [bark]
Salix alba. White willow	Medicine (salicin) [bark]
Salix spp. Willow	Fiber (baskets) [stem]

SANTALACEAE (SANDALWOOD FAMILY)

Santalum album. Sandalwood	Essential oil [wood, root]
Santalum acuminatum. Quandong nut	Food [fruit]

SAPINDACEAE (SOAP BERRY FAMILY)

Blighia sapida. Akee, ackee	Food [fruit]
Dimocarpus longan. Longan, lungan	Food [fruit]
Litchi chinensis. Litchi nut, lychee nut	Food [fruit]
Melicoccus bijugatus. Mamoncillo, Spanish-lime	Food [fruit]
Nephelium lappaceum. Rambutan	Food [fruit]
Paullinia cupana. Guaraná	Caffeinated beverage [seeds]
Paullinia yoco. Yoco, cohoba	Psychoactive snuff [bark]
Sapindus saponaria. Soapberry	Soap substitute [fruit]

SAPOTACEAE (SAPOTE FAMILY)

Calocarpum sapota. Sapote, marmalade plum	Food [fruit]
Calocarpum viride. Green sapote	Food [fruit]
Chrysophyllum cainito. Star-apple, caimito	Food [fruit]
Lucuma salicifolia. Yellow sapote	Food [fruit]
Manilkara bidentata. Balata	Industrial latex; timber
Manilkara zapota. Chiclé, sapodilla, zapote, chiku	Latex (masticatory); Food [fruit]
Palaquium gutta. Gutta-percha	Industrial latex
Pouteria caimito. Abiu	Food [fruit]
Pouteria campechiana. Canistel, egg fruit	Food [fruit]
Pouteria sapota. Mammee zapote, marmalade plum, zapote	Food [fruit]
Synsepalum dulcifolium. Miracle berry	Food [fruit]
Vitellaria paradoxa. Shea butter	Flavor food; illuminant [seed]; timber

SCROPHULARIACEAE (SNAPDRAGON FAMILY)

Digitalis purpurea. Foxglove	Medicinal glycosides (digitoxin, etc.) [leaf/root]
Digitalis lanata. Grecian foxglove	Medicinal glycosides (digitoxin, etc.) [leaf]

SIMAROUBACEAE (QUASSIA FAMILY)

Quassia amara. Surinam quassia	Flavoring, medicine (vermifuge), fly-poison [wood]

Quassia cedron. Cedron — Vermifuge [seed]
Quassia indica — Medicine/insecticide [seed]
Quassia simarouba. Acietuna — Vermifuge [seed]

SIMMONDSIACEAE (JOJOBA FAMILY)
Simmondsia chinensis. Jojoba — Industrial wax [seed]

SMILACACEAE (SMILAX FAMILY)
Smilax spp. Sarsaparilla — Beverage, flavoring [roots]

SOLANACEAE (NIGHTSHADE, POTATO, OR TOMATO FAMILY)
Atropa belladonna. Belladonna — Medicinal alkaloid (atropine) [leaf, root]; cosmetic [sap]
Brugmansia spp. Angel trumpet, borrachero, tree datura — Psychoactive alkaloids [bark, seed]
Brunfelsia grandiflora. Fever tree — Psychoactive [leaf/bark], medicinal [fruit]
Brunfelsia uniflora. Manaca — Medicine (syphilis) [leaf, bark]
Capsicum annuum. Anaheim pepper, banana p., bell p., bird p., chili p., green p., jalapeño p., paprika p., peperoni p., pimiento p.,poblano p., serrano p., tomato p. [fruit] — Flavoring, food [fruit]
Capsicum baccatum. Cayenne pepper, aji pepper — Flavoring [fruit]
Capsicum chinense. Aji pepper, habanero p., rocotillo p. — Flavoring [fruit]
Capsicum frutescens. Bird pepper, chili p., cayenne p., Tabasco p. — Flavoring [fruit]
Capsicum pubescens. Rocoto pepper — Flavoring [fruit]
Cyphomandra betacea. Tree-tomato — Food [fruit]
Datura innoxia. Sacred datura, toloache, toloatzin — Psychoactive alkaloids [seed]
Datura stramonium. Jimson weed, thorn apple, wyscoccan — Medicinal, psychoactive [seed]
Duboisia hopwoodii. Pituri — Psychoactive (masticatory) [leaf, stem]
Duboisia myoporoides. Corkwood — Medicine; timber; fish poison [stem/leaf]
Hyoscyamus niger. Black henbane — Medicine, insecticide [leaf]
Latua pubiflora. Latue — Psychoactive; fish poison [fruit]
Lycium spp. Matrimony vine — Food [leaf]; medicine [fruit]
Lycopersicon esculentum. Tomato, love apple — Food [fruit]
Lycopersicon pimpinellifolium. Cherry tomato, currant tomato — Food [fruit]
Mandragora officinarum. Mandrake, hexenkraut — Medicine; psychoactive [all]
Nicotiana rustica. Indian tobacco — Fumatory; alkaloids (nicotine, etc.) [leaf]
Nicotiana tabacum. Tobacco — Fumatory [leaf]
Petunia violacea. Petunia, shanin — Psychoactive [leaf]
Physalis ixocarpa. Husk tomato, tomatillo, tomatl — Food [fruit]
Physalis peruviana. Cape-gooseberry — Food [fruit]
Physalis spp. Ground cherry — Food [fruit]
Solanum melongena. Eggplant, aubergine — Food [fruit]
Solanum muricatum. Pepino, melon pear, tree melon — Food [fruit]
Solanum nigrum. Black nightshade, wonderberry — Food [fruit]
Solanum quitoense. Naranjilla, lulo — Food [fruit]
Solanum tuberosum. Potato, Irish potato, white potato — Food [tuber]
Withania somnifera — Medicine (ashwagandha); psychoactive [fruit]

STERCULIACEAE (KOLA or CACAO FAMILY)
Cola acuminata. Kola nut, cola nut — Essential oil [seed]
Cola nitida. Kola nut, cola nut — Essential oil [seed]
Sterculia urens. Gum karaya — Industrial gum [stem]
Theobroma cacao. Cacao — Essential oils; flavoring (cocoa) [seed]; fixed oil [seed]

STYRACACEAE (STYRAX FAMILY)
Styrax spp. Benzoin — Medicine [resin]

TACCACEAE (ARROWROOT FAMILY)
Tacca leontopetaloides. Tahiti arrowroot, East Indian arrowroot — Food [rhizome]

TAMARICACEAE (TAMARISK FAMILY)
Tamarix gallica. Tamarisk, salt-cedar — Wood; dye [gall]
Tamarix mannifera — Food (manna) [sap from insect damage]

THEACEAE (CAMELLIA OR TEA FAMILY)
Camellia sinensis. Tea — Caffeinated beverage [leaf]

THYMELAEACEAE (DAPHNE FAMILY)
Lagetta lagetto. Lacebark tree — Fiber [inner bark]

TILIACEAE (BASSWOOD FAMILY)
Clappertonia ficifolia. Bolo-bolo — Fiber [bark]
Corchorus spp. Jute — Fiber [stem], food [shoot]
Muntingia calabura. Capulin — Food [fruit]
Tilia americana. Basswood, linden tree — Timber
Tilia cordata. European linden tree, lime tree — Timber
Triumfetta lappula. Cadillo, pega-pega, lapulla — Fiber [bark]

TRAPACEAE (WATER CHESTNUT FAMILY)

Trapa bicornis. Water caltrop	Food [seed]
Trapa natans. Water chestnut	Food [seed]

TROPAEOLACEAE (NASTURTIUM FAMILY)

Tropaeolum majus. Nasturtium	Food [leaf, flower]
Tropaeolum tuberosum. Añu, ysano, tuberous nasturtium	Food [tuber]

TYPHACEAE (CATTAIL FAMILY)

Typha spp. Cattail	Fiber [leaf]; food [rootstock, pollen]

ULMACEAE (ELM FAMILY)

Ulmus alata. Winged elm	Wood
Ulmus americana. American elm	Wood
Ulmus procera. English elm	Wood; medicinal tea [leaf]
Ulmus pumila. Siberian elm	Wood
Ulmus rubra. Slippery elm	Wood
Ulmus thomasii. Rock elm, cork elm, hickory elm	Wood

UMBELLIFERAE (UMBEL OR CARROT FAMILY)

Anethum graveolens. Dill	Flavoring [leaf, fruit]
Angelica archangelica. Angelica	Flavoring, food [leaf, root]
Angelica sinensis. Dong quai	Medicine (tonic) [root]
Anthriscus cereifolium. Chervil	Flavoring [leaf]
Apium graveolens. Celery, celeriac	Food [leaf], rootstock; flavoring [fruit]
Arracachia xanthorrhiza. Arracacha	Food [root]
Centella asiatica. Gotu kola	Food, medicine (skin ointment) [leaf]
Carum carvi. Caraway	Flavoring [fruit]; essential oil [fruit]
Chaerophyllum bulbosum. Turnip-rooted chervil	Food [root]
Coriandrum sativum. Coriander, cilantro	Flavoring [leaf, fruit]
Cuminum cyminum. Cumin	Flavoring [fruit]; essential oil [fruit]
Daucus carota. Carrot	Food [root]
Ferula assafoetida. Asafetida, devil's dung	Medicinal/ culinary resin [rhizome]
Ferula galbaniflua. Galbanum	Medicinal resin [stem]
Foeniculum vulgare. Fennel, finochio	Flavoring (leaf, fruit); essential oil [fruit]
Levisticum officinale. Lovage	Flavoring [leaf]
Opopanax chironium. Opopanax	Gum (opopanax) [root]
Pastinaca sativa. Parsnip	Food [root]
Petroselinum crispum. Parsley	Food [leaf]; flavoring [leaf]
Pimpinella anisum. Anise	Flavoring; essential oil [fruit]
Sium sisarum. Skirret	Food [root]
Trachyspermum copticum. Ajowan	Flavoring [fruit]; essential oil

URTICACEAE (NETTLE FAMILY)

Boehmeria nivea. Ramie, China-grass	Fiber [stem]
Laportea canadensis. Wood nettle	Fiber [stem]
Laportea spp. Wood nettle	Food [leaf]
Urtica dioica. Nettle	Fiber [stem]; food [stem/leaf]; medicine [leaf]
Urtica urens. Dog nettle	Fiber [stem]; food [stem/leaf]; medicine (diuretic) [leaf/flower]
Urtica spp. Nettle	Food [young shoots]

VALERIANACEAE (SPIKENARD FAMILY)

Nardostachys grandiflora. Spikenard	Flavoring [rhizome]
Valeriana officinalis. Valerian	Medicine [rhizome]
Valerianella olitoria. Corn-lettuce	Food [leaf]

VERBENACEAE (VERVAIN OR VERBENA FAMILY)

Tectona grandis. Teak	Timber, wood
Verbena triphylla. Verbena, vervain	Essential oil [leaf]

VIOLACEAE (VIOLET FAMILY)

Viola odorata. Violet	Essential oil [flower]

VISCACEAE (MISTLETOE FAMILY)

Phoradendron flavescens. Mistletoe	Medicine (abortifacient) [plant, leaf, fruit]
Viscum album. Mistletoe	Medicine (immuno-stimulatory) [fruit]

VITACEAE (GRAPE FAMILY)

Cissus javana. Kangaroo vine	Food [leaf, shoot]
Vitis labrusca. Wild grape, Concord grape	Alcoholic beverage (wine) [fruit]
Vitis rotundifolia. Muscadine grape	Food [fruit]; alcoholic beverage (wine) [fruit]
Vitis vinifera. European grape, wine grape, table grape, raisin	Food [fruit, leaf]; alcoholic beverage (wine) [fruit]; grape seed oil [fruit]
Vitis vulpina. Chicken grape, frost grape	Food [fruit]

WINTERACEAE (WINTER'S BARK FAMILY)

Drimys winteri. Winter's bark	Medicine (scurvy) [bark]

XANTHORRHEACEAE (GRASS TREE FAMILY)

Xanthorrhoea spp. Grass tree, yacca	Wood, resin; sugar

ZINGIBERACEAE (GINGER FAMILY)

Aframomum melegueta. Grains-of-paradise	Flavoring [seed]
Alpinia galanga. Greater galangal	Flavoring [rhizome]
Alpinia officinarum. Lesser galangal	Flavoring [rhizome]
Curcuma angustifolia. East Indian arrowroot	Flavoring [rhizome]
Curcuma longa. Turmeric	Flavoring [rhizome]; medicine (curcumin) [rhizome]
Curcuma zedoaria. Zedoary	Flavoring [rhizome]
Elettaria cardamomum. Cardamom	Flavoring [seed]
Kempferia galanga. Kempferia galagal	Flavoring [rhizome]
Zingiber officinale. Ginger	Flavoring [rhizome]

ZYGOPHYLLACEAE (CALTROP FAMILY)

Guaiacum officinale. Lignum vitae	Timber; medicinal resin [stem]
Guaiacum sanctum. Lignum vitae	Wood
Larrea spp. Creosote	Resin; food [bud]
Peganum harmala. Syrian rue	Psychoactive [seed]

PLANT FAMILIES: COMMON NAMES TO TECHNICAL NAMES

Acanthus ➙	Acanthaceae
Actinidia –>	Actinidiaceae
African-violet ➙	Gesneriaceae
Agave ➙	Agavaceae
Akebia ➙	Lardizabalaceae
Alder ➙	Betulaceae
Amaryllis ➙	Liliaceae
Annatto ➙	Bixaceae
Annona ➙	Annonaceae
Aralia ➙	Araliaceae
Araucaria ➙	Araucariaceae
Aroid ➙	Araceae
Arrow-grass ➙	Juncaginaceae
Arrowhead ➙	Alismataceae
Arrowroot ➙	Taccaceae
Ash ➙	Oleaceae
Aster ➙	Compositae
Avocado ➙	Lauraceae
Bald cypress ➙	Cupressaceae
Balsam ➙	Balsaminaceae
Banana ➙	Musaceae
Barberry ➙	Berberidaceae
Basella ➙	Basellaceae
Basswood ➙	Tiliaceae
Bean ➙	Leguminosae
Beech ➙	Fagaceae
Beef wood ➙	Casuarinaceae
Begonia ➙	Begoniaceae
Bellflower ➙	Campanulaceae
Bindweed ➙	Convolvulaceae
Birch ➙	Betulaceae
Birthwort ➙	Aristolochiaceae
Bittersweet ➙	Celastraceae
Bladdernut ➙	Staphyleaceae
Bladderwort ➙	Lentibulariaceae
Bluebell ➙	Campanulaceae
Bogbean ➙	Menyanthaceae
Bombax ➙	Bombacaceae
Borage ➙	Boraginaceae
Box ➙	Buxaceae
Boxwood ➙	Buxaceae
Brazil nut ➙	Lecythidaceae
Bromeliad ➙	Bromeliaceae
Broomrape ➙	Orobanchaceae
Buckeye ➙	Hippocastanaceae
Buckthorn ➙	Rhamnaceae
Bur-reed ➙	Sparganiaceae
Buttercup ➙	Ranunculaceae
Cacao ➙	Sterculiaceae
Cactus ➙	Cactaceae
Caltrop ➙	Zygophyllaceae
Camellia ➙	Theaceae
Canna ➙	Cannaceae
Caper ➙	Capparaceae
Carnation ➙	Caryophyllaceae
Carpet weed ➙	Molluginaceae
Carrot ➙	Umbelliferae
Caryocar	Caryocaraceae
Cashew ➙	Anacardiaceae
Catalpa ➙	Bignoniaceae
Cattail ➙	Typhaceae
Cedar ➙	Cupressaceae
Century plant ➙	Agavaceae
Cinnamon ➙	Lauraceae
Citrus ➙	Rutaceae
Coca ➙	Erythroxylaceae
Coco plum ➙	Chrysobalanaceae
Coffee ➙	Rubiaceae
Corkwood ➙	Leitneriaceae
Cotton ➙	Malvaceae
Crowberry ➙	Empetraceae
Crowfoot ➙	Ranunculaceae
Crucifer ➙	Cruciferae
Currant ➙	Grossulariaceae
Custard apple ➙	Annonaceae
Cycad ➙	Cycadaceae
Cypress ➙	Cupressaceae
Daisy ➙	Compositae
Dillenia ➙	Dilleniaceae
Ditch-grass ➙	Ruppiaceae
Dipterocarp ➙	Dipterocarpaceae
Dodder ➙	Cuscutaceae
Dogbane ➙	Apocynaceae
Dogwood ➙	Cornaceae
Duckweed ➙	Lemnaceae
Durango root –>	Datiscaceae
Ebony ➙	Ebenaceae
Eel-grass ➙	Zosteraceae
Elaeocarp ➙	Elaeocarpaceae
Elm ➙	Ulmaceae
Ephedra ➙	Ephedraceae
Evening primrose ➙	Onagraceae
Fig ➙	Moraceae
Figwort ➙	Scrophulariaceae
Flacourtia ➙	Flacourtiaceae
Flax ➙	Linaceae
Flowering-rush ➙	Butomaceae
Forget-me-not ➙	Boraginaceae
Foxglove ➙	Scrophulariaceae
Frog's bit ➙	Hydrocharitaceae
Four o'clock ➙	Nyctaginaceae
Fumitory ➙	Fumariaceae
Garcinia ➙	Guttiferae
Gardenia ➙	Rubiaceae
Gentian ➙	Gentianaceae
Geranium ➙	Geraniaceae
Ginger ➙	Zingiberaceae
Ginkgo ➙	Ginkgoaceae
Ginseng ➙	Araliaceae
Gooseberry ➙	Grossulariaceae
Goosefoot ➙	Chenopodiaceae
Gourd ➙	Cucurbitaceae
Grape ➙	Vitaceae
Grass ➙	Gramineae
Grass-tree ➙	Xanthorrheaceae
Grass wrack ➙	Zannicelliaceae
Harebell ➙	Campanulaceae
Heath ➙	Ericaceae
Hemp ➙	Cannabaceae
Hickory ➙	Juglandaceae
Holly ➙	Aquifoliaceae
Honeysuckle ➙	Caprifoliaceae
Hops ➙	Cannabaceae
Hornwort ➙	Ceratophyllaceae
Horse chestnut ➙	Hippocastan-
Horsetail ➙	Equisetaceae
Ice plant ➙	Aizoaceae
Indian lotus ➙	Nelumbonaceae
Iris ➙	Iridaceae
Joint-fir ➙	Ephedraceae
Jojoba ➙	Simmondsiaceae
Juniper ➙	Cupressaceae
Knotweed ➙	Polygonaceae
Kola ➙	Sterculiaceae
Laurel ➙	Lauraceae
Leadwort ➙	Plumbaginaceae
Legume ➙	Leguminosae
Lily ➙	Liliaceae
Linden ➙	Tiliaceae
Lizard's tail ➙	Saururaceae
Loasa ➙	Loasaceae
Lobelia ➙	Lobeliaceae
Loosestrife ➙	Lythraceae
Lotus ➙	Nelumbonaceae
Madder ➙	Rubiaceae
Magnolia ➙	Magnoliaceae
Mahogany ➙	Meliaceae
Maidenhair ➙	Ginkogaceae
Mallow ➙	Malvaceae
Malpighia ➙	Malpighiaceae
Mangosteen ➙	Guttiferae
Maple ➙	Aceraceae
Mare's tail ➙	Hippuridaceae
Marijuana ➙	Cannabaceae
Meadow foam ➙	Limnanthaceae
Mignonette ➙	Resedaceae
Milkweed ➙	Asclepiadaceae
Milkwort ➙	Polygalaceae
Mint ➙	Labiatae
Mistletoe ➙	Viscaceae
Moonseed ➙	Menispermaceae
Mormon tea ➙	Ephedraceae
Morning glory ➙	Convolvulaceae
Mulberry ➙	Moraceae
Mustard ➙	Cruciferae
Myrtle ➙	Myrtaceae
Nasturtium ➙	Tropaeolaceae
Nettle ➙	Urticaceae
Nightshade ➙	Solanaceae
Nutmeg ➙	Myristicaceae
Oak ➙	Fagaceae
Ocotillo ➙	Fouquieriaceae
Olax ➙	Olacaceae
Oleander ➙	Apocynaceae
Oleaster ➙	Elaeagnaceae
Olive ➙	Oleaceae
Orchid ➙	Orchidaceae
Orpine ➙	Crassulaceae
Oxalis ➙	Oxalidaceae
Palm ➙	Palmae
Panama hat ➙	Cyclanthaceae
Papaya ➙	Caricaceae
Parsley ➙	Umbelliferae
Passion flower ➙	Passifloraceae
Pawpaw ➙	Caricaceae
Pea ➙	Leguminosae
Pepper ➙	Piperaceae
Persimmon ➙	Ebenaceae
Philodendron ➙	Araceae
Phlox ➙	Polemoniaceae
Pickerel weed ➙	Pontederiaceae
Pigweed ➙	Amaranthaceae

Pine → Pinaceae
Pineapple → Bromeliaceae
Pink → Caryophyllaceae
Piper → Piperaceae
Pipewort → Eriocaulaceae
Pittosporum → Pittosporaceae
Plane tree → Platanaceae
Plantago → Plantaginaceae
Plantain → Plantaginaceae
Podocarpus → Podocarpaceae
Poison-oak → Anacardiaceae
Pokeweed → Phytolaccaceae
Pomegranate → Punicaceae
Poplar → Salicaceae
Poppy → Papaveraceae
Potato → Solanaceae
Prayer plant → Marantaceae
Protea → Proteaceae
Pulse → Leguminosae
Pumpkin → Cucurbitaceae
Purslane → Portulacaceae

Quassia → Simaroubaceae

Rock-rose → Cistaceae
Rose → Rosaceae
Rose imperial → Cochlosperm-
Rue → Rutaceae
Rush → Juncaceae

Salt-cedar → Tamaricaceae
Saltwort → Batidaceae
Sandalwood → Santalaceae
Sapodilla → Sapotaceae
Saxifrage → Saxifragaceae
Screw-pine → Pandanaceae
Scroph → Scrophulariaceae
Sedge → Cyperaceae
Sesame → Pedaliaceae
She-oak → Casuarinaceae
Silk tassel → Garryaceae
Silverbell → Styracaceae
Smartweed → Polygonaceae
Smilax → Smilacaceae
Snapdragon → Scrophulariaceae
Soapberry → Sapindaceae
Sorrel → Oxalidaceae
Soursop → Annonaceae
Spiderwort → Commelinaceae
Spikenard → Araliaceae
Spikenard → Valerianaceae
Spindle tree → Celastraceae
Spurge → Euphorbiaceae
Squash → Cucurbitaceae
Star anise → Illiciaceae
Stinging nettle → Urticaceae
St. John's wort → Guttiferae
Stonecrop → Crassulaceae
Styrax → Styracaceae
Sumac → Anacardiaceae
Sunflower → Compositae
Sweetgale → Myricaceae
Sweetsop → Annonaceae
Sycamore → Platanaceae

Tamarisk → Tamaricaceae
Tea → Theaceae
Teak → Verbenaceae
Teasel → Dipsacaceae
Thrift → Plumbaginaceae
Touch-me-not → Balsaminaceae

Umbel → Umbelliferae
Unicorn plant → Martyniaceae

Verbena → Verbenaceae
Vervain → Verbenaceae
Violet → Violaceae

Walnut → Juglandaceae
Water chestnut → Trapaceae
Water clover → Marsileaceae
Water hawthorn Aponogetonaceae
Waterleaf → Hydrophyllaceae
Water-lily → Nymphaeaceae
Water-lily → Cabombaceae
Water milfoil → Haloragaceae
Water nymph → Najadaceae
Water plantain → Alismataceae
Water poppy → Limnocharitaceae
Water starwort → Callitrichaceae
Waterwort → Elatinaceae
Wax myrtle → Myricaceae
Wild cinnamon → Canellaceae
Willow → Salicaceae
Wintergreen → Pyrolaceae
Winter's bark → Winteraceae
Witch hazel → Hamamelidaceae

Yam → Dioscoreaceae
Yellow-eyed-grass → Xyridaceae
Yew → Taxaceae

SECTION 14 • GLOSSARY & WHO'S WHO

- A -

aboriginal. Inhabiting an area from the earliest times, particularly before the arrival of colonists

abort. To end prematurely, as seen in immature seeds and fruits.

abortifacient. A substance or agent that induces an abortion.

achene. A dry, 1-seeded, indehiscent fruit in which the seed coat and fruit wall are not fused to one another, as in the sunflower "seed."

acid. A chemical substance which in solution liberates hydrogen ions or protons in water and reacts with a base to yield salt and water. All have a pH of less than 7.0 and are sour and corrosive.

adaptation. A feature or trait that allows an organism to survive in or exploit its environment.

adenosine triphosphate (ATP). The principal energy-carrying compound in all living cells.

addict. A person who has become completely dependent upon or devoted to a substance or habit.

adulteration. The process of debasing a food, medicine, etc. by adding other substances to it.

adventitious. Originating from mature tissues of a plant, rather than from meristematic ones, as in aerial roots and tubers arising from older stems.

aerobic. The term applied to organisms and processes that require oxygen to function properly.

aflatoxins. A group of toxins produced by the fungus *Aspergillus*, especially *A. flavus*, from which the name is derived. In animals, aflatoxins can cause cancers and mutations.

agar. A complex polysaccharide found in several kinds of algae. When heated in water and then cooled, agar forms a gel that can be supplemented with nutrients to form a medium suitable for growing bacteria and other micro-organisms.

aggregate fruit. A kind of false fruit in which the separate pistils or carpels of a single flower appear to form a single fruit, as in the raspberry.

agronomy. The science that deals with the theoretical and practical production of crops and with management of soils.

alcohol. A hydrocarbon in which a hydrogen is replaced by a hydroxyl (-OH) group. Most are colorless, volatile, flammable liquids that are used as solvents, fuels, and as the intoxicant in various fermented and distilled beverages.

ale. A fermented alcoholic beverage, similar to beer, but typically with a stronger, more bitter flavor because of its hops content.

alembic. The upper section of a 2-part distilling apparatus.

algal bloom. The sudden and dramatic growth of algal populations in ponds and lakes. Under natural conditions blooms, which may be toxic to fish and other aquatic animals, occur in the late spring or summer. They may occur at other times as the result of nutrient-rich pollution.

alginic acid. A gelatinous substance produced by various brown algae. It has several industrial applications.

alkaloid. A basic, nitrogenous ring compound formed almost exclusively by plants. Most have significant physiological effects and are the active ingredient in many of our medicines, poisons, and psychoactive plants. Names typically end in *-ine*, as in morphine and caffeine.

allelopath. A plant that releases a chemical substance into the soil that prevents seed germination or retards the growth of other plants, as in barley that inhibits weed growth and antibiotic fungi that retard the growth of bacteria.

alternative medicine. The treatment of illness using remedies, such as aromatherapy, homeopathy, and herbology, that are not widely recognized nor accepted by mainstream medicine.

amatoxins. A group of toxic substances produced by *Amanita* mushrooms that can cause severe disturbances to the stomach, intestines, liver, and kidneys, and that can be lethal.

amino acids. The basic building blocks of peptides and amino acids. These organic compounds are composed of an acidic carboxyl (-COOH) group and a basic amino (NH_2) group.

amphora. A clay vessel with a narrow neck and two handles used in ancient Egypt, Rome, and Greece used to store wines and oils.

amylose. A long, unbranched polysaccharide composed of many glucose sugars held together by chemical bonds. They are the building blocks of starches.

anaerobic respiration. The kind of respiration that can occur only in the absence of oxygen.

analgesic. A substance that relieves pain without causing unconsciousness.

anesthetic. A substance that causes partial to complete insensitivity to pain.

angiosperm. The technical name for a flowering plant.

annual. A plant that germinates, flowers, and sets seed in a single growing season.

annual ring. One of the concentric rings in a tree's wood, when viewed in cross-section. It represents the spring-summer cycle of wood tissue growth.

anthocyanins. A class of water soluble, nitrogenous pigments. They account for the colors that we associate with fall foliage.

antibiotic. A substance produced by bacteria, fungi, or higher plants that will prevent or retard the growth of another organism, usually a bacterium or fungus.

antibody. A blood protein produced as a result of the presence of a foreign protein (antigen), such as those found in pollen.

anticonvulsant. A substance that prevents or reduces the severity of convulsions.

anthelmenthic. A substance or agent that expels or kills intestinal worms.

antigen. A molecule, usually a protein but sometimes a polysaccharide, that causes an animal to produce an antibody in reaction to the molecule. The reaction between a particular antibody and antigen is typically very specific.

antihistamine. A substance that counteracts the effects of histamines.

antipyretic. A substance that prevents or reduces fevers.

aphrodisiac. A substance that promotes or arouses sexual desire.

apomixis. Any form of asexual reproduction that plants use in place of sexual reproduction. Many of our crops are propagated asexually because they will have genetically uniform offspring. Plants that demonstrate apomixis are called apomicts.

arboretum. A botanical garden that specializes in woody plants.

aril. A fleshy, often brightly-colored outgrowth of a seed's surface or its stalk. It is often associated with seed dispersal. Examples include the cup-like aril of the yew and the more delicate mace that lies on the surface of the nutmeg seed.

aromatherapy. The practice of using various plant extracts, particularly essential oils, in message treatments and to treat illness.

artificial selection. The procedure that we employ of selecting offspring of desirable kinds of plants and animals that possess traits that we find pleasing or useful in breeding future generations of those forms.

ascomycetes. Those fungi that reproduce by means of sexual spores formed within an ascus, typically a membranous, club-shaped structure. They are often called the sac fungi. The group is of significant economic importance. Common examples include the ergot fungus, bread mold, brewer's yeast, and the penicillin mold.

asexual reproduction. The type of reproduction that does not involve the union of egg and sperm or other sexual spores.

ascorbic acid. A vitamin found in various citrus fruits and green vegetables, a deficiency of which causes scurvy.

astringent. A substance, such as a tannin, that causes tissue contraction in animals. They have medicinal uses, as in the healing of wounds and reducing the flow of blood. They often cause us to "pucker up" when we eat them.

atropine. An alkaloid produced by *Atropa belladonna* and other members of the nightshade family. It is toxic and it has important medicinal properties.

autotroph. A plant that uses atmospheric carbon dioxide as its source of carbon in its life processes.

auxin. A hormone that promotes elongation of cells.

axillary. Of or pertaining to the interior angle formed by a stem and the leaf that it bears. It is derived from the Latin word for armpit.

awn. A substantial hair or bristle that arises from a plant part. The term is most commonly applied to such bristles on grass spikelets.

- B -

backcross. The result of hybridization between a first generation offspring and either one of its parents. The term is also used for the process itself.

bacteriology. The science that deals with the study of bacteria.

bacterium. Any of the microscopic, unicellular organisms that lack nuclei and other subcellular organelles typical of other kinds of plants and animals. Bacteria are of great economic importance because of their role in fermentation, spoilage and decay, and as the source of antibiotics.

bagasse. The dry, fibrous byproduct that remains after juice has been extracted from sugar cane stems. It may be burned as fuel or used to make paper.

balsam. A fragrant, thick, oily or resinous exudate derived from various plants, as in Canada balsam and balsam of tolu. Many are used to make medicinal ointments.

Banks, Sir Joseph (1743-1820). British aristocrat, explorer, botanist, and long-time President of the Royal Society. Banks explored the South Pacific on one of Captain Cook's voyages. His herbarium is at the Natural History Museum in London.

barbasco. A general term for fish poisons.

bark. The tough, dead outer covering on the trunks and branches of woody plants and on the exterior of some roots. It includes the epidermis, cork, cortex, and phloem tissues.

base. A chemical substance that in solution combines with and removes hydrogen and protons, and which reacts with an acid to yield a salt and water; most have a pH of greater than 7.

basidiomycetes. Those fungi that reproduce by means of basidiospores and that form the familiar mushrooms, toadstools, puffballs, and shelf or bracket fungus at some point in their life cycle. They are collectively known as club fungi. The less familiar rust and smut fungi also belong here.

bast fibers. Any of various plant fibers derived from stem tissue. Common examples include hemp and flax.

Beadle, George Wells (1903-1989). American botanist and geneticist. He was one of the leading students of the origin of maize. Beadle won the Nobel Prize in 1958 for his development of the "one gene-one enzyme" hypothesis.

beautiful. Of or pertaining to plants of the grass family (Gramineae).

B. C. E. Before the Current (or Common or Christian) era.

beer. A fermented beverage made from water, yeast, and a carbohydrate. A more restricted definition calls for malt and hops to be used, as well.

belladonna alkaloids. The group name given to atropine, hyoscyamine, scopolamine, and similar alkaloids derived from *Atropa belladonna* and related plants. They are known more technically as the tropane alkaloids.

beri-beri. A disease characterized by inflammation of the nerves. It is caused by a deficiency of vitamin B_1.

berry. A multi-seeded, indehiscent fruit in which the fruit wall is fleshy throughout, as in the tomato and grape. The term is also used for certain cereal grains, as in the wheat berry.

biennial. A plant that lives for two years, often flowering and setting seed during the second year.

binomial system of nomenclature. A system of naming, popularized by Carolus Linnaeus, in which each plant or animal bears a two word name -- the genus and specific epithet.

biotechnology. The use of biological processes, especially genetic manipulation, for industrial or medical purposes.

blight. Any one of a variety of plant diseases caused by fungi or insects, as in the late blight of potato that caused the potato famine in Ireland.

bolting. The premature onset of flowering caused by genetic control or environmental stimulus, such as a change in day length.

Borlaug, Norman (1914-). American agronomist. He developed strains of dwarf wheat and is one of the fathers of the Green Revolution. Borlaug won the Nobel Prize for Peace in 1970.

botany. The science concerned with the study of plants. Ambrose Bierce, in his *The Devil's Dictionary* defined it as "... the science of vegetables -- those that are not good to eat, as well as those that are. It deals largely with their flowers, which are commonly badly designed, inartistic in color, and ill-smelling."

BP. Before the present time, which by convention, is set as 1950.

bract. A much-reduced leaf, particularly one located just below a flower or associated with a flower cluster.

bran. The outer fibrous layers of cereal grains. It is often removed during processing.

brandy. A beverage made by distilling wine or some other fermented fruit.

bromelain. An enzyme found in the pineapple. It is an ingredient in meat tenderizers.

bryophytes. The collective term for mosses and liverworts; multicellular, vessel-less plants with true stems and leaves, but that lack true roots.

Bt. A shorthand notation for *Bacillus thuringiensis*, the bacterium that causes crown gall disease in crop plants and that is now used in genetic engineering as the vehicle for transferring a gene from one plant to another.

bud. An immature shoot, typically covered by protective bracts (bud scales). It will elongate into a stem that bears leaves and, in some cases, flowers.

bulb. An underground structure consisting of a series of overlapping leaf bases inserted on a much-reduced stem axis, as in the onion.

- C -

caffeine. The xanthine alkaloid found in tea leaves, coffee beans, and several other plants.

cake. The solid portion of a fruit, seed, or other plant part that remains behind after oils have been pressed from them.

calabash. A kind of gourd used to store materials or as a drinking vessel.

callus. The undifferentiated plant tissue that forms during tissue culturing. The term is also used for the tissue that forms over a wound.

calorie. The amount of heat needed to raise the temperature of 1 gram of water 1° C. It is often used to measure the energy value in food.

Candolle, Alphonse Louis Pierre Pyramus de (1806-1893). Professor of Natural History at the University of Geneva. Author of numerous important taxonomic works and the author of *Origine des Plantes Cultiveés*, an encyclopedic survey of crop plants and their origins.

caoutchouc. The aboriginal name for the latex from various trees native to Central and South America.

capsaicin. The oleoresin found in the fruits of chili peppers and their relatives (*Capsicum* spp.) that causes the sensation of heat and pain. It also has become popular in the treatment of arthritis pain and as an ingredient in pepper-spray.

capsule. A dry, multi-seeded, dehiscent fruit derived from 2 or more united carpels. It opens by various means to release the seeds.

carbohydrate. An energy producing organic substance composed of carbon, hydrogen, and oxygen, typically in the form of $C_x(H_2O)_y$. Common examples include starch, cellulose, and a wide variety of sugars.

Carboniferous. The portion of the Paleozoic Era that lasted from about 360 to 286 million years ago. It was preceded by the Devonian and followed by the Permian. It is the compressed vegetation of this period that formed coal deposits around the world.

carcinogen. A substance that causes cancer.

carminative. A substance that reduces gas formation and relieves flatulence, as in ginger and peppermint.

carpel. The female reproductive organ in a flower. It is typically differentiated into a terminal stigma, a neck-like style, and a basal ovary where the seeds are borne. A flower typically has 1 or more carpels, which may be separate from one another or united.

caryopsis. A dry, 1-seeded, indehiscent fruit in which the seed coat and fruit wall are more or less completely fused to one another, as in the various cereal grains. This fruit type is characteristic of the grass family (Gramineae).

catalyst. A substance that initiates or speeds up a chemical reaction, but that is not itself consumed during the process.

cathartic. A substance that causes a purging of the bowels, as in castor oil.

C. D. C. Centers for Disease Control.

C. E. Current or common or Christian Era. An alternative to A. D.

cell theory. The fundamental biological principle developed by Schleiden and Schwann that states, in part, that all living organisms are composed of cells and that all cells come from pre-existing cells.

cellulose. An insoluble straight-chain polysaccharide composed of repeating glucose units. It is the basic building material in plants and has been called the most common organic compound on earth.

Cenozoic. The era of geologic time that began about 65 million years ago and continues to the present.

center of diversity. The geographic region of the world where a crop shows its greatest genetic diversity.

center of origin. The geographic region of the world where a crop is thought to have originated. This concept is not distinct from that of "center of diversity," in that the primary criterion for determining site of origin cited by N. I. Vavilov, who developed the concept, is the degree of diversity found there.

cereal. Any kind of grain used for food. The term also refers to any grass, such as wheat, rice, or maize, that yields these grains and to breakfast foods made from these grains.

chaff. The dry, papery bracts (husks) that separate from cereal grains or from seeds during winnowing and threshing.

chicha. A fermented beverage made from various plants, especially maize.

chlorophyll. A green pigment in plants. During photosynthesis, light falling on the plant removes an electron from the chlorophyll molecule. Most terrestrial plants make chlorophyll a and b.

chloroplast. A subcellular organelle that consists of stacks of membranes that bear photosynthetic pigments. It also contains genetic material used to direct its protein synthesis.

chromosome. A thread-like structure found in the cell nucleus. Each contains a series of features, including a linear sequence of genes.

citric acid cycle. See Kreb's cycle.

clarify. To make clear by removing impurities, as in wine making.

clone. A group of genetically identical individuals or cells derived asexually from a single ancestor.

CMS. Cytoplasmic male sterility.

cocaine. An alkaloid present in the leaves of coca plant (*Erythroxylum coca*) and related species of South American shrubs. It is a powerful psychoactive substance and is used in medicine as a local anesthetic.

cocarcinogen. A non-cancer causing substance that activates or enhances the effects of one that does.

codeine. An alkaloid present in the latex of the opium poppy (*Papaver somniferum*). It is used to relieve pain and to control coughing.

codex. An ancient manuscript, usually in book form.

coir. The fiber obtained from the middle layer of the fruit wall (mesocarp) of the coconut. It is used for stuffing and to make ropes, mats, etc.

colchicine. An alkaloid found in the autumn crocus (*Colchicum autumnale*) and related plants. It is a powerful mitotic poisoner and causes hair loss and other symptoms if ingested.

colloid. A mixture of microscopic or ultramicroscopic particles (0.1 to 0.0001 microns) uniformly suspended or dispersed through a second substance, often forming a viscous solution. Examples include milk and the various latexes found in plants.

complementation or complementarity. The principle of nutrition that recognizes that one food or plant may provide one of the eight essential amino acids that is missing in another, such that eating the two will provide the complete set, as in a diet that includes both maize and black beans.

compound. A mixture with two or more ingredients, as in certain medicines.

compound leaf. A leaf in which the blade is divided into two or more discrete segments, as in the walnut and many plants of the bean family.

conifers. The largest and economically most important group of gymnosperms. Most are resinous trees with needle-like leaves. Their wood lacks vessel. Reproductive structures are borne in separate male and female cones. Conifers are the source of timber, paper pulp, and resins. Common examples include pines, spruces, and hemlocks.

convergent evolution. The process of evolving similar features in unrelated plants as an adaptation to living in the same environment. The succulent growth form seen in cacti and spurges offer an excellent example.

Cook, James (1728-1779). English naval captain and one of history's greatest explorers and cartographers. Cook's voyages brought to light new knowledge of the world's plants and its peoples.

copal. A resin derived from a variety of tropical trees used to make varnish.

copra. The dried inner fruit wall (endocarp) of the coconut. It is processed to yield coconut oil. Fresh endocarp is the source of shredded and flaked coconut used in cooking.

coprolite. Fossil poop. Human fecal material often contains seeds or seed-like fruits that reveal what the long dead person ate.

cork. A layer of protective tissue that forms inside the bark of woody plants. At maturity it is composed of dead cells that are impregnated with suberin, which renders them waterproof. Commercial cork comes from the cork oak (*Quercus suber*).

corm. An underground plant structure consisting of a reduced stem axis that bears dry, papery leaves, as in the gladiola "bulb."

cortex. The region of a stem, as seen in cross-section, that lies between the epidermis and the vascular bundles.

cortisone. A steroidal hormone derived originally from yams (*Dioscorea* spp.), used medicinally to treat inflammations and as the basis for oral contraceptives.

cotyledon. An embryonic leaf of a seed plant. Flowering plants typically have one or two, which is the basis for the terms monocots and dicots.

coumarin. An aromatic compound with a vanilla-like odor made by various grasses and legumes. It gives the smell to freshly mown fields. Coumarin is a blood thinner used in medicine and in rat poisons.

crack. The crystalline form of cocaine that is broken into small pieces and inhaled or smoked.

crop. The product of a cultivated plant or the plant itself.

crop rotation. The practice of raising different crops in a field, often to replenish soil nutrients.

cross-pollination. The transfer of pollen from one flower to the stigma of another flower, usually of the same species. The transfer is accomplished by wind, insects, birds, etc.

cultivar. A cultivated strain or variety of plant. The word is a contraction of <u>culti</u>vated <u>var</u>iety.

cultivation. The act or process of caring for a plant, which involves preparing the soil, watering, fertilizing, weeding, pruning, etc.

curandero. A native healer proficient in the use of medicinal herbs.

curare. Any of various arrow and dart poisons containing alkaloids derived from the bark of South American *Chondrodendron* and *Strychnos*. Curare recipes vary with tribe. The toxins paralyze motor nerves, thereby blocking the transmission of impulses to muscles, including the diaphragm.

cure. To preserve by means of drying, salting, etc., as in tobacco leaves and animal skins.

cuticle. The thin, waxy protective covering on stems and leaves.

cv. Cultivar.

cycad. A small group of gymnosperms (about 100 species) that are palm-like in general appearance and that bear male and female reproductive structures in separate cones.

cytology. The science that deals with the study of cells.

cytoplasm. The portion of a cell inside the plasma membrane, but excluding the nucleus.

- D -

dammar. A hard resin derived from various Southeast Asian trees. It is used in oil paints, varnishes, lacquers, and inks.

Darwin, Charles Robert (1809-1882). English naturalist and one of the greatest figures in the history of the biological sciences. He is best known for his book, *On the Origin of Species by Means of Natural Selection*, which set forth his theory of the evolution of life on earth. It remains today the core concept in explaining the diversity of life around us. Darwin contributed significantly to our knowledge of economic plants in his *Voyage of the Beagle* and "*The Domestication of Plants and Animals...*."

dead. In today's politically correct environment, we do not say "dead." The organism is metabolically challenged.

deciduous. Falling from a plant, as in leaves that fall at the end of the growing season.

decoction. The process of boiling down a liquid to extract an essence from it. The term is also used for the material that is extracted.

dehiscent. Opening at maturity by slits, pores, etc. to release seeds, as legumes and various fruit types commonly called "pods."

dendrochronology. The science that deals with the study of tree-rings as a means of determining the age of trees and of past climatic conditions.

denitrification. The conversion by bacteria of nitrate and nitrite to nitrogen and/or nitrous oxide. It occurs typically in the absence of oxygen.

deoxyribonucleic acid (DNA). A nucleic acid composed of a sugar and a series of four bases. It is the genetic material of all living organisms. The exact sequence of the four bases determines the genetic code for that individual.

dermatitis. An inflammation of the skin.

diaphoretic. A substance that induces perspiration.

dicots. The semitechnical name for those flowering plants that typically have two seed leaves on their embryos, net-veined leaf blades, and flower parts in 4's, 5's, or multiples thereof.

digestion. The process by which heat, enzymes, or a solvent decompose a substance. For us, it is the process of breaking down food stuffs in the stomach and bowels.

digitalis. A group name for a series of related glycosides, often called the digitalis glycosides, derived from the leaves and roots of *Digitalis purpurea* and related species. They have powerful effects on the heart.

dioecious. The condition of having male and female flowers on separate plants of a species, as in the papaya.

Dioscorides (Pedanius Dioscorides) (c. 40-c.90). Greek military physician and author of *De Materia Medica*, a compendium of medicinal plants and their uses that remained authoritative for many centuries.

diploid. A nucleus that contains two complete sets of chromosomes. The term is also applied to cells and individuals. Most common animals and birds have diploid nuclei in all of their cells, except for egg and sperm. The non-sex cells of many plants are also diploid, but a significant percentage have three or more sets (polyploids).

disaccharide. A carbohydrate, such as sucrose or maltose, composed of two simple sugars (monosaccharides).

distillation. The process of purifying a liquid by converting it to a vapor, condensing the gas at a colder temperature, and then trapping the resulting liquid in a container. The distillation of fermented beverages is based on the different boiling temperatures of water and alcohol. The term is also applied to the extraction of volatile oils from various plant parts for use in perfumes, etc.

distilled spirit. The alcoholic beverage that results from distillation.

DNA. See desoxyribonucleic acid.

doctrine of signatures. The belief that plants were created with indications (signatures) as to their intended uses. A plant with leaves resembling the lobes of the liver, therefore, is to be used to treat liver disease.

domestication. To tame or modify to meet human needs. Some fully domesticated plants are now unable to live independently of us because of these modifications.

Douglas, David (1798-1834). Scottish botanist and plant collector for the Horticultural Society of London. He is the Douglas of the Douglas-fir. He died under mysterious circumstances while botanizing in Hawai'i.

drug. A medicinal preparation, narcotic or other form of psychoactive substance derived from a plant.

drupe. A fleshy fruit with a bony layer that encloses its single seed, as in the avocado.

dry measure. A system of measuring dry products, such as grains and other fruits, by volume.

dyspepsia. Indigestion, especially when it occurs in the wealthy or well-educated.

Dunlop, John Boyd (1840-1921). Scottish inventor of the pneumatic tire. Its development was a major factor in the growth of the rubber latex industry.

- E -

ecology. The branch of the biological sciences that deals with the relationships of plants and animals to their environment and to one another.

economic botany. The branch of botany that deals with "... production, distribution, and consumption of plants useful to people..." (Charles B. Heiser, 1985).

edaphic. Of, related to, or influenced by soil.

Edison, Thomas Alva (1847-1931). American inventor. Although known primarily for his various electrical devices, Edison also studied useful plants and conducted extensive research on latex plants at his laboratory in Ft. Meyers, Florida.

egg. The female reproductive structure in higher plants. A fertilized egg will develop into a zygote.

eggplant. A reputedly edible plant with no known nutritional or aesthetic qualities. People who like the eggplant should be watched carefully to see if they exhibit other serious personality defects.

embryo. In higher plants, an immature individual contained within a seed.

emetic. A substance that induces vomiting (emesis), such as syrup of ipecac or much of modern popular music.

emmenagogue. A substance that stimulates menstrual flow.

endemic. Restricted to a particular geographic region.

endocarp. The innermost layer of the fruit wall (pericarp). It may be fleshy, fibrous, or bony.

endosperm. The nutritive tissue (often triploid) found within the seed and used by the developing embryo until it is mature enough to produce its own food by photosynthesis. It is typically starchy or oily.

enfleurage. A technique for making perfume by exposing oils to floral scents, typically by using petals.

enology. The study of wine and wine-making.

enzyme. A protein that acts as a catalyst during biochemical reactions, thereby controlling various aspects of cellular metabolism.

ephedrine. An alkaloid derived from ma huang or Mormon tea (*Ephedra* spp.) used to treat asthma by dilation of bronchial tubes and by athletes to enhance physical performance.

epidermis. The outermost layer of cells covering stems, roots, leaves, etc.

epiphyte. A plant that grows on another plant for position or support, but which does not parasitize it.

ergotism. The disease of rye and other grasses caused by the ergot fungus (*Claviceps purpurea* and related species). It occurs in two forms, one that affects the central nervous systems and leads to convulsions, and the other that constricts blood vessels and leads to loss of extremities.

essence. The product obtained by distillation or other extraction procedures.

essential oil. A volatile oil extracted typically from flowers or leaves that bear specialized glands. Because of their pleasant aroma and taste, essential oils are widely used in cooking and the manufacture of cosmetics.

ethanol. Ethyl alcohol, the inebriating principle in beer, wine, etc.

ethnobotany. The branch of botany that deals with the interaction of plants and people.

ethyl alcohol. See ethanol.

ethylene. A gas (C_2H_4) produced naturally by plants that functions as a hormone that controls germination, ripening of fruits, etc.

evolution. The process by which new species of plants and animals arise from earlier pre-existing species over time.

exocarp. The outer layer of the fruit wall (pericarp). It is typically referred to as the skin of the fruit, but it may be hard and woody, as in the coconut.

express. To remove a desired portion of a plant by applying pressure to squeeze it from the tissues.

exudate. Thick, often viscous liquids that ooze from wounds in plants or from slits made in them to allow for industrial extraction, as in rubber latex.

- F -

F_1 generation. Literally, the first filial generation. The first generation of offspring resulting from the crossing of two parents.

false fruit. The structure that results from the fusion of separate true fruits, thereby appearing to be a single fruit, as in the pineapple.

FAO. The Food and Agriculture Organization, a branch of the United Nations. It publishes a number of useful books and pamphlets, and compiles annual reports of world-wide and national crop production data.

fat. A triglyceride that is typically solid at room temperature. Most fats come from animals.

fatty acid. A typically long, unbranched chain of hydrocarbons with a terminal carboxyl group. If the carbon atoms on side chains carry the maximum number of carbon atoms in their structure, the fatty acid is said to be saturated; if fewer, it is unsaturated.

favism. A disease caused by the consumption of fava beans by sensitive individuals. It is characterized by a severe form of anemia.

fermentation. A series of chemical and physical changes resulting from the action of microorganisms and enzymes. It accounts for the change in color, taste, and aroma of tobacco leaves, tea leaves, and coffee beans during processing. Alcoholic fermentation involves the breakdown of a carbohydrate source by microorganisms to produce ethanol and carbon dioxide.

Fertile Crescent. A region of fertile land between Israel and the Persian Gulf. It is one of the earliest sites of plant and animal domestication.

fertilization. The fusion of male and female gametes (egg and sperm in higher plants) to form a zygote. The term is often incorrectly used as a synonym for pollination.

fiber. A type of plant cell, typically many times longer than wide, thick-walled, and dead at maturity. They are typically composed of cellulose, hemicellulose, and lignin. Within the plant body, they provide structural support. We extract fibers from stems, leaves, and the surface of seeds for a number of different industrial uses.

fission. A type of asexual reproduction in which a unicellular organism, such as yeast, simply divides to form offspring.

fixed oil. A type of oil that is not volatile or aromatic, as found in maize, cotton, peanuts, and the castor bean. They are used in cooking and have a number of industrial applications.

floret. A very small flower, particularly one found in a flower cluster (inflorescence), as seen in the sunflower and grass families.

fodder. Dried hay or straw used as animal food.

follicle. A dry, 1- to many-seeded fruit derived from one carpel that opens along a single suture, as in the milkweed "pod."

food. Plant or animal products, especially in solid form, that we consume for maintenance of health and growth.

forage. Food for horses and cattle. The term also means the search for food.

forestry. The science that deals with the theoretical and practical aspects of managing forests.

formication. The sensation that ants or other creatures are crawling over the skin. It is a standard symptom of intoxication from certain psychoactive plants. The term is based on the Latin word for an ant, formica.

fossil. The remains of once-living plants or animals, such as bones or carbonized material, or other evidence of their existence, such as impressions, tracks, etc.

frond. A leaf. The term is used especially for the leaf of a fern, cycad, or palm.

fructose. A simple sugar (monosaccharide) that occurs widely in plants, especially in fruits. It is also called levulose. It combines with another monosaccharide, glucose, to form sucrose.

fruit. A ripened ovary, along with any other structures that mature along with it.

fumatory. A plant material that is smoked for recreational or medicinal purposes, as in tobacco.

fungicide. A substance that kills fungi.

fungus. A microscopic to conspicuous, non-vascular, non-photosynthetic organism that derives its nourishment from organic matter in the soil , or through parasitic or symbiotic relationships. Fungi were once considered to be plants, but now are seen as a distinct form of life. Common examples include molds, rusts, smuts, yeasts, mushrooms, and toadstools. They are of considerable economic importance as causes of human and plant diseases, as players in fermentation, as the source of medicines, and as the source of psychoactive substances.

- G -

gall. A swelling or other abnormal growth in a plant caused by bacteria, fungi, insects, worms, etc. Some galls do little damage to the plant, while others, such as club root and crown gall, cause serious economic losses in crops.

gamete. A sex cell (egg or sperm in higher plants) whose nucleus (and cytoplasm in some cases) fuses with another sex cell of a different type in the process of fertilization.

gene. The basic physical unit of heredity, composed of DNA or RNA, and occupying a specific site on a chromosome or in other subcellular organelles.

gene pool. All of the genes in a particular population of plants or animals.

genetics. The science that deals with the study of genes, heredity, and variation of inherited features.

genome. All of the genetic material contained in a single set of chromosomes in a plant or animal. The term is also used for all of the genetic information carried in all of the sets of chromosomes if they are different from one another.

genotype. The genetic constitution of an organism.

genetic engineering. The purposeful modification of an organism to render it more useful or valuable to humans by manipulation of its DNA or by introduction of DNA from another source.

genus. A rank in the taxonomic hierarchy of closely related species. It is the first component of the scientific name of a plant or animal.

germ. The embryo within a seed. A cereal grain consists of the germ, endosperm, and bran. The term is also used, of course, for any disease causing microorganism.

germplasm. The hereditary material transmitted from one generation to the next. Also spelled germ plasm.

gibberellin. Any of a series of closely related plant hormones that stimulates growth in shoots and leaves. The hormone was first isolated from the fungus *Gibberella fugikuroi*, which caused the "foolish seedling" disease in rice.

gin. A device invented by Eli Whitney to separate cotton fibers from the attached seeds.

glucose. A widely occurring, simple, 6-carbon sugar (monosaccharide) that is a major source of energy required in cellular metabolism. More complex carbohydrates yield glucose on hydrolysis.

gluten. Any one of the proteins in the endosperm of cereal grains. Their chemical and physical properties determine the bread-making properties of flour.

glycoside. The product that results when a sugar reacts with an alcohol or a phenol. Many are physiologically important because of the non-sugar component.

GMO. Genetically modified organism.

Goodyear, Charles (1800-1860). American inventor who developed the process of vulcanization of rubber.

gossypol. The toxic principle found in the seeds of cotton (*Gossypium* spp.).

graft. A shoot or other piece of tissue that is inserted into a slit on a host plant, from which it derives nourishment. The term is also used for the process of uniting two compatible plants.

grain. The fruit type of the grass family. See caryopsis for a more complete definition. The term also refers to the more conspicuous fibers and other tissues in processed wood.

grappa. A brandy made by distilling the remains of grapes after they have been used to in wine making. It is especially popular in Italy.

GRAS. The abbreviation for the phrase, "generally regarded as safe," as applied to foods and medicines.

Green Revolution. The term coined to describe the coordinated effort to increase crop production through genetic development of high-yielding varieties that are pest-resistant.

grist. Grains that will be ground at a mill.

groats. Hulled or crushed cereal grains.

gruel. A soup made of a cereal and water.

guarapo. A Peruvian drink made from fermented sugar cane juice.

gum. The viscous sap from a variety of woody plants that dries to a crystalline solid. Gums are soluble in water and become mucilaginous.

gunny. A coarse fiber, often jute, used to make sacks.

gymnosperm. The semitechnical name for the group of seed plants whose ovules are not enclosed in an ovary. Common examples include the pines, spruces, firs, redwoods, cycads, and the ginkgo or maidenhair tree.

- H -

habit. The general appearance or growth form of a plant, typically expressed as tree, shrub, herb, or vine.

habitat. The home of an individual plant or animal or community of them.

hallucinogen. A substance that causes the mind to perceive the presence of an object or other stimulus that is not actually present. Remember, it is not just the eyes that can be fooled.

haploid. A nucleus, cell, or organism that contains only one set of chromosomes.

hardwood. The kind of wood found in woody flowering plants.

hashish. The purified resin derived from the flowering bracts of female marijuana plants. It is smoked or chewed.

heartwood. The dense wood found toward the middle of a tree trunk, when viewed in cross-section.

hemicellulose. A group of carbohydrates found in plant cell walls that forms a matrix in which cellulose fibers are embedded. It cross-links cellulose chains.

hemolysis. The rupture of blood cells caused by various chemical or physical agents.

herb. A non-woody plant whose aerial portion typically dies back to the ground at the end of a growing season. The term is also used for: (1) aromatic and/or flavorful plants used in cooking and medicine. Some authors distinguish cooking herbs from spices on the basis of geographic origin; spices are from tropical or subtropical regions; and (2) plants with demonstrated or presumed medicinal properties.

herbaceous. Having the features of an herb.

herbal. A book, often lavishly illustrated, that describes the medicinal uses of plants. In earlier times, it was a bound collection of medicinal plant specimens.

herbarium. A collection of dried and pressed plant specimens. The term is used for the specimens themselves or for the room or building that houses them.

herbicide. A substance that is toxic to plants.

herbivore. An animal that feeds on plants.

heroin. A synthetic alkaloid manufactured from morphine, a naturally occurring alkaloid in the opium poppy. It was originally developed as a powerful pain killer, but now has become a major recreational drug.

hesperidium. A fleshy, indehiscent fruit with conspicuous fibrous compartments or segments lined with juicy hairs, as seen in the various citrus fruits.

hexaploid. A nucleus, cell, or individual that contains six sets of chromosomes. Hexaploids are a kind of polyploid.

heterosis. The increased vigor and fertility seen in hybrid offspring when compared to their parents. The phenomenon is also called hybrid vigor.

histamine. A class of substances released by immune cells and producing allergic reactions. Common examples include those produced by our mucous membranes when they are exposed to certain pollen and fungal spores.

Hofmann, Albert (1906-). Swiss biochemist who first isolated LSD from the ergot fungus and later from plants of the morning glory family. Co-author, with R. E. Schultes, of *The Botany and Chemistry of Hallucinogens.*

Hooker, Sir Joseph Dalton (1817-1911). British botanist and author of numerous taxonomic works of great significance. Hooker was a noted explorer and served for many years as the Director of the Royal Botanic Gardens at Kew.

hormone. A naturally occurring regulatory substance, transported via sap throughout the plant, that is stimulates cell and tissue functioning.

horticulture. The science that deals with the cultivation of ornamental plants, vegetables, and fruit trees.

Humboldt, Friedrich Heinrich Alexander, Baron von (1769-1859). German aristocrat, naturalist, and explorer. The Baron von Humboldt may well have been the last of his breed -- a botanist, zoologist, entomologist, geologist, physicist with an encyclopedic knowledge of the natural history of our planet. His extensive exploration in South America uncovered a wealth of botanical information.

hunter-gatherers. The term applied to a people who acquire most or all of their food by hunting animals and gathering edible plants from their surroundings.

hybrid. In the most widely used sense, a plant or animal that is the offspring of two parents that belong to different species, subspecies, or varieties.

hybrid vigor. See heterosis.

hydrolysis. The chemical reaction between water and a substance, resulting in the decomposition of that substance.

hydroponics. The procedure of growing plants in water, sand, or gravel that has had nutrients added, rather than soil.

hyoscyamine. One of the belladonna alkaloids found in *Atropa belladonna* and related plants.

hypnotic. A substance that induces sleep.

HYV's. High yielding varieties.

- I -

ibotenic acid. The substance in the fly agaric (*Amanita muscaria*) that causes hallucinations.

inbreeding. The type of breeding that involves only very closely related individuals, as in members of the same population or cultivated strain.

inbred line. A true breeding line that is homozygous at all (or practically all) of its loci.

indehiscent. The term applied to a fruit or other structure that does not open at maturity by means of sutures, lids, pores, etc.

indigenous. The term applied to a plant or animal species that occurs naturally in a particular area; one that was not accidentally or purposefully introduced by humans.

indole acetic acid (IAA). A substance, with hormone-like properties, that causes cell enlargement and that affects cell division.

inflorescence. The arrangement of one or more flowers on a floral axis. There are many types of inflorescences, such as heads, spikes, etc.

infusion. The process of extracting a substance by steeping it in cold or hot (but not boiling) water, as in the preparation of a cup of hot tea.

inheritance of acquired characters. The theory, developed by the noted French naturalist J. B. P. A. de Monet, chevalier de Lamarck , that evolution proceeds through the inheritance and passing from one generation to the next of features or characteristics acquired during the life of a plant or animal.

insecticide. A substance that kills insects, such as DDT and pyrethrum flowers.

internode. The region on a stem between two adjacent nodes (points of attachment of leaves or bracts).

involucre. A set of bracts that is attached below a flower or an inflorescence.

- J -

jumping genes. See transposable elements.

- K -

kelp. The collective common name for various large, marine brown algae.

kernel. The softer and often edible inner tissues of a seed or hard-shelled fruit. The term is also used for a cereal grain, as in a kernel of corn.

Kreb's Cycle. A series of subcellular reactions that constitute the principal metabolic pathway for producing the hydrogen and electrons needed to generate adenosine triphosphate (ATP), the main energy-carrying substance in living cells.

- L -

land race. A distinct strain or cultivar of a particular crop.

latex. A white or brightly-colored sap found in a variety of unrelated herbaceous and woody plants. It is typically a thick, viscous colloid that is transported in specialized latex ducts or simply oozes through tissues.

lathyrism. The disease caused by consumption of toxic amounts of the sweet pea or chick pea (*Lathyrus* spp.), a member of the legume family. It is characterized by skeletal deformation and loss of bowel and bladder control. Although little-known in the U. S., lathyrism can be a serious problem in Third World countries.

laudanum. An alcoholic solution of opium, once widely used as a pain killer.

leaflet. Any one of the discrete segments of a compound leaf.

lectins. A group of toxic proteins, especially common in plants of the legume family, that causes clumping of red blood cells.

legume. A one- to many-seeded dry, dehiscent fruit that typically opens along two sutures at maturity. It is the characteristic fruit type of the legume family (Leguminosae) and the same term is used to denote its members.

Lewin, Louis (1850-1929). German pharmacologist and toxicologist. Author of important monographs on kava, betel nut, and the classical survey of psychoactive plants, *Phantastica*.

liana. A woody, climbing vine.

lichen. A life form composed of a fungus and an alga living in a symbiotic relationship. They are often seen as brightly-colored crusts on rocks, tree trunks, etc. Others are leafy or resemble small shrubs. Lichens are very sensitive to atmospheric pollution.

lignin. A complex, chemically inert polymer found in the cell walls of plants. It binds cellulose fibers toegether and thereby increases structural support.

Linnaeus, Carolus (1707-1778). Swedish naturalist who is remembered primarily for his naming of literally thousands of plants and animals. Trained as a physician, Linnaeus became the best known scientist of his time. In addition to writing the *Species Plantarum* and *Genera Plantarum*, he was extensively involved in the study of economically important plants.

lipids. A heterogeneous group of small organic molecules that are more or less insoluble in water, but soluble in various organic solvents. The group includes fats, oils, waxes, terpenes, and steroids. They perform a variety of functions within the plant body.

liquor. Any alcoholic drink, especially a distilled one. The term is also used for the liquid phase involved in extraction processes, as in cocoa liquor.

Livingstone, David (1813-1873). Scottish missionary to Africa. European discoverer of the Zambezi River and Victoria Falls. With Henry M. Stanley, searched for source of the Nile. Expert on African arrow poisons of plant origin.

locule. The cavity or compartment within an ovary or fruit.

Lysenko, Trofim Desinovich (1898-1976). Russian agronomist and geneticist. Through political acumen, he became the dominant figure in Soviet agriculture under Josef Stalin, with disastrous results for crop production and for scientists who opposed him.

lysergic acid diethylamide (LSD). A powerful hallucinogen first isolated from the ergot fungus (*Claviceps purpurea*) and later found in morning glory seeds (*Ipomoea violacea*).

lysis. The rupturing or disintegration of a cell.

- M -

macropsia. Seeing objects larger than they actually are.

malaria. A disease caused by a protozoan (*Plasmodium vivax* and related species) and transported by a mosquito (*Anopheles* spp.). It is a recurring disease characterized by chills, sweating, trembling, and damage to internal organs. It is often regarded as the world's most debilitating disease.

malt. A grain, usually barley, that is steeped in water, allowed to germinate, and then dried. Enzymes produced during germination play a critical role in reducing the carbohydrate used during the brewing process. Beers made in this fashion are said to be malted.

maltose. A disaccharide sugar formed from two glucose units. It is the sugar formed when starch is broken down by enzymes in malt, saliva, etc.

Mangelsdorf, Paul (1899-1989). American botanist, associated with Harvard University for many years. He was one of the world's experts on maize and its origin. Along with Richard Reeves, he developed the theory that the ancestor of our modern maize was a primitive pod corn.

mano and matate. Spanish for mortar and pestle.

mash. The mixture of malt or another grain and hot water used in brewing; the fermented material that is distilled.

massecuite. The dense mass of sugar crystals and syrup that forms during crystallization of cane sugar.

masticatory. A plant material that is chewed, ground, or otherwise manipulated by the teeth and tongue, but typically not swallowed. One result is the mixing of plant material with the enzymes in our saliva. Most contain psychoactive substances, as in the coca leaf and the betel nut.

materia medica. The body of medical knowledge developed by a people, including particularly its inventory of medicinal plants and their uses.

McClintock, Barbara (1902-1992). American geneticist who developed the theory of transposable elements or "jumping genes." She was awarded the Nobel Prize for her work in 1983.

Mendel, Gregor Johann (1822-1884). Austrian monk whose experiments with garden peas that he grew at the monastery led to the discovery of several basic principles of genetics. His findings were published in 1865 in a relatively obscure journal and went unnoticed until their rediscovery in 1900.

mercerize. A process, developed by John Mercer, in which cotton fibers are treated with sodium hydroxide to shrink them and to increase their absorption of dyes.

mericulture. The growing of excised growing tip tissue in a sterile culture.

mescal buttons. The dried tops of the peyote cactus.

mescaline. An alkaloid found in peyote (*Lophophora williamsii*) and a few other cacti. It is responsible for the vivid color hallucinations associated with ingestion of this plant.

mesocarp. The middle layer of a fruit wall (pericarp). It is typically seen as the flesh in an edible fruit.

methadone. A synthetic opiate used medicinally to relieve pain and as a substitute for morphine and heroin.

methanol. Methyl alcohol or wood alcohol. It is a toxic solvent and unsuitable for use in alcoholic beverages.

mill. A building that contains the machinery required to crush stems, remove husks from fruits and seeds, or to grind cereal grains into flour. The term is also used for the crushing and grinding processes.

minor cereal. A true cereal, other than wheat, rice, and maize. Common examples include barley, rye, oats, etc.

minute. Small, as in the size of your vocabulary if you found it necessary to look up this word.

monocots. The semitechnical group name for those flowering plants with one seed leaf on the embryo, with parallel-veined leaf blades, and with flower parts in 3's or multiples thereof.

monoculture. The agricultural practice of growing a single crop over a large area.

monoecious. The condition of having male and female flowers on the same plant, as in the banana.

monosaccharide. A sugar, such as glucose, that cannot be broken down to simpler sugars.

mordant. A substance that fixes a dye in cloth.

morphine. An alkaloid found in the latex of the opium poppy (*Papaver somniferum*), widely used in medicine for its pain-killing properties.

morphology. The branch of the biological sciences that deals with the general form or structure of plants and animals, generally without dissecting them.

mortar and pestle. A hard surface or container (mortar), often made of stone or wood, used in conjunction with a grinding implement (pestle) to grind food, herbs and spices, or medicines. Primitive versions were stone slabs and rounded rocks; more elegant are the ceramic vessels and pestles used in pharmacies.

mulch. A mixture of plant materials spread on the ground to enrich or insulate it.

multiple fruit. A type of false fruit in which many true fruits derived from separate flowers fuse at maturity to produce a structure that appears to be a single fruit, as in the pineapple.

mutagen. A substance that causes mutations.

mutation. A change in the structure or amount of genetic material in the nuclei of a plant or animal. Most are structural changes to individual genes and are deleterious.

MV. Modern varieties. Also known as HYV's, high yielding varieties.

mycology. The branch of botany that deals with the study of fungi.

mycorrhiza. A close physical and symbiotic relationship between a fungus and the root system of a vascular plant, as seen in citrus plants. Attempting to grow the citrus without its associated fungal symbiont will fail.

- N -

narcotic. A substance that induces drowsiness, sleep, or unconsciousness. The term is also used for any dangerously addictive drug and for any drug that has been legally listed as a narcotic.

natural selection. The process by which a series of biological and environmental factors determines which plants or animals in a population will survive and reproduce themselves. It is often expressed in the phrase, "survival of the fittest."

naval stores. The various resins and other materials required to caulk sailing ships.

Neolithic. Of or pertaining to the more recent or later Stone Age. It began about 10,000 BCE and is the period of time that saw the development of polished stone tools and the rise of agriculture.

neurotransmitter. A chemical substance that is released at the end of a nerve fiber and that is involved with the passage of an electrochemical impulse to another nerve or a muscle.

New World. North America, Central America, and South America taken collectively.

nibs. Roasted cacao beans (seeds).

nicotine. An alkaloid found in tobacco (*Nicotiana tabacum*) and other related and unrelated species. It is a powerful toxin.

N. I. H. National Institute of Health

nitrogen cycle. The biological process of the interconversion of nitrogen and oxygen to nitrates. Bacteria play the critical role of both fixing atmospheric nitrogen together with oxygen to form nitrates that are used by plants, and later breaking them down into nitrogen and oxygen.

nitrogen fixation. The reduction of atmospheric nitrogen and its incorporation into various nitrogenous compounds. This conversion occurs during thunderstorms, via the electrical energy released by lightning; during certain photochemical processes in the atmosphere; and by the action of nitrogen-fixing microorganisms, especially bacteria that live symbiotically in the root tissue of legumes. The plant derives ammonia from the bacterium and it receives carbohydrates in return. Nitrogen fixation is not limited to legumes and bacteria. A number of other plants are involved in nitrogen fixation with bacteria, and with bluegreen algae and lichens.

node. The point or region on a stem where one or more leaves or bracts are borne.

nodule. A rounded, irregular swelling or growth. Nitrogen-fixing bacteria form nodules on legume roots. They are also seen at sites of infection.

N. S. F. National Science Foundation

nut. A 1-seeded, dry, indehiscent fruit derived from two or more united carpels, as in the walnut.

- O -

Oceania. The islands of the central and South Pacific, including Australia and New Zealand, taken collectively.

oil. A thick, viscous liquid, typically a triglyceride, that is usually flammable, insoluble in water, and soluble in organic solvents.

Old World. Europe, Africa, and Asia as seen collectively.

oleoresin. A plant compound composed of an essential oil and a resin, as in capsaicin.

opiate. A preparation that contains opium.

opium. The crude dried latex found in the opium poppy (*Papaver somniferum*) and related species. It contains a number of physiologically active and inactive alkaloids, such as morphine and codeine.

organic. A substance that contains carbon. The term is also used for a food or crop that is grown without the use of artificial fertilizers, herbicides, pesticides, and without being genetically modified.

ouabin. A potent cardiac glycoside that is the principal active ingredient in various arrow and dart poisons. It acts by retarding the movement of sodium and potassium ions across cell membranes.

outbreeding. Exhibiting cross-pollination on a regular basis.

ovary. The typically swollen, lower, central organ of the flower that contains one or more seeds.

ovule. An immature seed.

oxidation. A chemical reaction in which atoms or molecules gain oxygen or lose hydrogen and electrons.

- P -

paan. A psychoactive mixture made from betel nut, lime, and various flavorings.

paddy. A agricultural field, flooded naturally or artificially, used to grow rice. Hence, rice paddy is redundant.

paleobotany. The study of old dead plants by old dead botanists.

Paleolithic. Of or pertaining to the early or old Stone Age.

papain. An enzyme found in papaya (*Carica papaya*), used in meat tenderizers and to aid digestion.

paper. A thin sheet made of pulped wood or cloth whose surface is suitable for writing and printing.

papyrus. A paper-like writing material made from strips of tissue cut from the stems of papyrus (*Cyperus papyrus*). It was used extensively by the ancient Egyptians, Greeks, and Romans.

parboil. Although the term originally meant to boil thoroughly, it now means to boil partially, typically before frying or roasting.

parasite. An organism that lives in or on another host organism and that derives nourishment or other benefits from it. The word comes from the Greek for, "one who eats at the table of another."

parched. Dried out, as a result of heating.

paregoric. An opium preparation, incorporating camphor and dissolved in alcohol, that is used to relieve pain and to treat diarrhea.

parthenogenesis. Literally "virgin beginning," it is a form of asexual reproduction in which an egg develops into an embryo and adult without being fertilized.

parthenocarpy. The production of fruits in the absence of sexual reproduction. It is one kind of parthenogenesis.

Pasteur, Louis (1822-1895). French bacteriologist who made fundamental discoveries that explained the role of microorganisms in fermenting wine and spoilage of food, and who developed the treatment for rabies.

pathogen. An organism or other agent that causes disease.

pathology. The science that deals with the study of disease.

peat. Partially decomposed and compressed vegetable matter, commonly formed in waterlogged sites where anaerobic respiration occurs. Peat is harvested in many parts of the world to burn for heat.

PDC. Pentadecacatachol. Any one of the several related toxic principles in poison oak and its relatives.

pectins. A group of soluble, gelatinous polysaccharides that are rich in galacturonic acid. They are common in certain fruits. They are used to thicken jams and jellies.

penicillin. An antibiotic derived from the fungus *Penicillium notatum* used to treat bacterial infections.

pepo. A type of berry with a leathery rind, as in the pumpkin. It is characteristic of the squash or gourd family (Cucurbitaceae).

perennial. A plant, woody or herbaceous, that lives for three or more years, often flowering and setting fruit each year.

pericarp. The wall of a fruit, consisting typically of an outer (exocarp), middle (mesocarp), and inner (endocarp) layer. The layers may be easy to distinguish from one another, but not always.

pesticide. A substance that kills insects or other harmful organisms.

Phantastica. A name coined by Louis Lewin for plants that cause hallucinations.

pharmacognosy. The branch of pharmacology that deals with medicinally active substances derived from plants.

pharmacology. The science that deals with the study of the action of drugs in humans and other animals.

pharmacopoeia. A book, often officially sanctioned by a government, that lists the medicinal drugs and how they are to be used.

phenol. An aromatic compound that contains one or more hydroxyl groups.

phenotype. The observable features of an organism, as determined by its genotype and environmental influences.

phloem. A type of conductive tissue that transports both organic and inorganic substances throughout the body of vascular plants.

photoperiod. The relative periods of light and dark to which plants are exposed under natural or artificial conditions.

photosynthesis. The process by which green plants use the energy in sunlight, carbon dioxide, and water to make carbohydrates.

phylogeny. The evolutionary relationships among organisms, often expressed in terms of patterns of descent.

physiology. The science that deals with the life processes of organisms or their parts.

physostigmine. The toxic alkaloid in the Calabar bean (*Physostigma venenosum*), used in ordeal rituals and with several applications in modern medicine.

pith. A tissue, typically composed of parenchyma cells, that occurs in the center of a stem, as seen in cross-section.

plantation. An estate on which trees or crops, such as cotton or tobacco, are grown. Historically the plants were raised and harvested by resident workers, often slaves.

plasmid. A ring of DNA that reproduces itself independently of chromosomal DNA, as in bacteria.

plastid. A subcellular organelle that contains pigments or food. One kind of plastid is the chloroplast.

plonk. An inexpensive, poor quality wine.

plywood. A building material made of two or more layers of wood glued and pressed together, one layer alternating with the next in the direction of the grain pattern.

pod. The common name used for fruit types more technically referred to as legumes or capsules.

poison. A substance that disrupts the normal state of health of an organism.

pollination. The transfer of pollen from an anther to a stigma of the same or another flower.

polymer. A compound formed by many repeating units of smaller molecules that are linked together in branched or unbranched chains, as in starch and cellulose.

polyploid. A nucleus, cell, or individual with three or more complete sets of chromosomes.

polysaccharide. A carbohydrate composed of many simple sugars (monosaccharides).

pome. A fleshy, indehiscent fruit with its seeds enclosed in a fibrous core and which is surrounded by a fleshy, edible receptacle, as in the apple and pear.

pomology. The science that deals with the study of fruits.

Pre-Columbian. Of or pertaining to cultures, objects, or events that occurred in the New World before the arrival of Christopher Columbus in 1492.

proof. The standard for judging the strength of a distilled beverage, expressed as twice the percentage of ethanol present. A gin or vodka that is 40% alcohol is said to be 80 proof.

protein. An organic compound composed of one or more chains of amino acids. They are an essential to the structure and functioning of organisms.

protoplasm. The living material in a cell, composed of the cell membrane, nucleus and cytoplasm. It does not include vacuoles and ingested matter.

protoplast. The living substance within a cell, exclusive of the cell wall.

prune. To trim by cutting away dead or unwanted branches, etc.

pseudostem. A false stem formed from overlapping leaf bases, as in the banana.

psychedelic. Of or pertaining to a substance or agent that alters the mental state of awareness or that causes hallucinations.

psychoactive. A general term for a substance that affects the central nervous system and mental processes.

pulp. Crushed or otherwise separated fibers used to manufacture paper.

pulverize. To reduce to a fine powder.

purgative. A substance that acts to evacuate the bowels.

- Q -

quill. A section of dried, rolled bark, especially of cinnamon and cassia.

quinine. An alkaloid found in the bark of the quina-quina tree (*Cinchona* spp.) and related plants. It is used in the treatment of malaria.

- R -

radicle. The embryonic root.

ratoon. A shoot that emerges from a crop plant after the mother plant has been cut back, as in bananas and sugar cane.

rbc. Red blood cell.

receptacle. The more or less expanded stem apex on which the floral parts are inserted. It is typically small, but it may be quite conspicuous, as in the strawberry, apple, and cashew-apple.

red tide. The phenomenon of a red or reddish discoloration of marine waters caused by millions of microscopic organisms called dinoflagellates. They produce toxins that can kill fish, invertebrates, and humans that consume them.

refine. To process with the goal of removing impurities.

resin. A viscous, flammable exudate produced in specialized cells by coniferous trees and a few other plants. It is composed of terpenes and chemically similar compounds. Resins occur in liquid form in the plant, but turn to solids on exposure to the air. They have a variety of industrial applications, as in varnishes.

resperine. An alkaloid found in the Indian snakeroot (*Rauvolfia serpentina*) and related species. It is used to treat hypertension and schizophrenia.

respiration. The cellular metabolic process involving the decomposition of energy-containing compounds to form ATP, carbon dioxide, and water. The term is also used for the subcellular process of transporting oxygen to cells and the removal of carbon dioxide from them.

retting. The process of separating stem fibers from one another through microbial decomposition of substances that bound them to one another. Harvested plant material is spread on the ground or put in ponds to allow naturally occurring bacteria to break down materials that held the fibers together in bundles.

rhizome. An underground horizontal stem that typically bears only scaly leaves.

ribonucleic acid (RNA). A kind of nucleic acid containing D-ribose and uracil. It occurs in three forms (ribosomal-, messenger-, and transfer-RNA), all of which are involved in protein synthesis.

rotenone. A toxin obtained from the roots of *Derris* spp. and other tropical legumes, used to stun fish and as a powerful insecticide.

ruminant. An even-toed mammal with a 3- or 4-chambered stomach. Ruminants chew cuds of food, regurgitate the mass from one compartment to another, and then rechew it. Common examples include the cattle, deer, goats, and sheep.

runner. See stolon.

rust. A rust-colored plant disease caused by fungi, especially those of the order *Uredinales*.

- S -

sago. A kind of edible starch derived from the stem pith of certain palms and cycads. It is used to make a pudding.

saki. A Japanese fermented beverage made from rice. It is considered a wine by some people and a beer by others. The word is also spelled sake.

samara. A type of achene or nut that bears a prominent wing, as in the maple, elm, or tree-of-heaven.

sanforize. A mechanical process by which fabrics are preshrunk to limit later shrinkage.

sap. The fluid found in the conductive tissue of a plant and which appears when it is cut or damaged. Sap may be watery or milky, sugary, or have other useful characteristics.

saponin. A kind of glycoside that forms a soapy colloidal mixture with water and that foams when shaken. They are used to make detergents. Saponins are toxic to many animals, especially cold-blooded ones.

saprophyte. A plant that derives its nourishment from dead organic material in the soil.

sapwood. The outer layer of younger, softer wood formed between the heartwood and bark of a tree, as seen in cross-section.

schizocarp. A dry, indehiscent fruit derived from two or more united carpels that separate from one another at maturity to yield 1-seeded closed segments (mericarps), as seen in the parlsey family (Umbelliferae) and the mallow family (Malvaceae). The condiments known as "savory seeds" are schizocarps.

Schultes, Richard Evans (1915-2001). Long time Professor of Natural History, Director of the Museum of Economic Botany at Harvard University, and botanical explorer par excellence. He was the leading expert on the psychoactive plants of the New World, and author of numerous technical and popular works on that subject. They include, *The Botany and Chemistry of the Hallucinogens, Plants of the Gods, Vine of the Soul,* and *Where the Gods Reign.* Earlier in his career, Schultes was a major figure in natural rubber research in South America.

scion. A shoot intended for planting or use in grafting. A scion is the section of stem inserted into the slit or opening on the rooted plant, the stock.

sclerotium. The structure formed during the life cycle of certain fungi that allows them to go into a dormant, resting phase during unfavorable environmental conditions, as in the grain-like bodies formed by the ergot fungus.

scopolamine. An alkaloid found in belladonna (*Atropa belladonna*) and related plants. It is used in obstetrics and in spy novels to induce a twilight sleep of semi-consciousness. It is also called hyoscine.

Scoville Heat Units. A unit of intensity or "hotness" of capsicum peppers developed by Wilbur Scoville.

scurvy. A disease caused by a shortage of fruits, fresh vegetables, and other sources of vitamin C. It is characterized by bleeding gums and skin, and swellings. It was serious problem on long voyages when sailors were limited to salted meat, beer, and little else.

scutching. The process of beating stems of flax or other fiber sources to separate the useful fibers from undesirable plant parts.

sedative. A substance that has a calming or quieting effect on the nervous system.

seed. A fertilized and ripened ovule. It consists typically of a seed coat, embryo, and stored food.

seed bank. A collection of seed samples intended to preserve living material for future genetic research and breeding. At least some of the samples are held for long periods at very low temperature.

seed plant. The collective term for the gymnosperms and angiosperms, the higher plants that produce seeds at some point in their life cycle.

self-pollination. The transfer of pollen from the anther of a flower to the stigmatic surface of the same flower.

seringueiro. A Brazilian rubber tree tapper.

serotinin. A neurotransmitter derived from tryptophan, an amino acid. It has a variety of physiological effects.

sexual reproduction. The type of reproduction that involves the union of egg and sperm. It is the dominant method of reproduction in vertebrate animals, but only one type found in higher plants.

shaman. An individual who acts as a medium between the real and the spirit worlds and who is seen as skilled at healing, divination, and con-trolling natural events.

sheath. An elongate, tubular structure that surrounds an organ or plant part, as in the lower portion of the grass leaf that wraps around the stem.

shrub. A woody plant with multiple trunks.

shifting cultivation. Also known as "slash and burn agriculture," it is the traditional agricultural regime of a semi-nomadic people who clear an area in the forest, cultivate their crops there for several years, and then abandon it when soil fertility and crop production decline.

silage. Green fodder that is stored in a silo for feeding animals at a later date. Naturally occurring bacteria on the plants begin to ferment silage, which preserves its nutritional value.

silviculture. The branch of forestry that deals with the growing and caring for trees.

sizing. A gelatinous material made from various glues, starches, and varnishes used to fill pores in paper and textile fibers.

slash and burn agriculture. See shifting cultivation.

smut. Any of several plant diseases, caused by fungi of the order Ustilaginales, that can infect cereals and other grasses. Many smut fungi produce black spores that discolor and distort the appearance of the host plant.

snuff. Dried and powdered tobacco or other plant material that is inhaled. The practice is called snuffing. It can be rather simple, but it became the habit of elegant people who developed it into an elaborate ritual with complex rules.

softwood. The type of wood found in conifers.

solanine. A toxic glycoalkaloid found in nightshades (*Solanum* spp.) and related plants.

sp. Species (in the singular)

spp. Species (in the plural)

species. A kind of plant or animal, distinguished by anatomical, morphological, chemical, and genetic differences, and presumably maintained by reproductive isolation.

specific epithet. The second component in the scientific name of a plant or animal. The genus (or generic name) and specific epithet together form the species name of an organism.

specific gravity. The ratio of the density of a solid, liquid, or gas to the density of the standard against which it is compared. Water and air are the standards for a liquid and a gas.

sperm. The male gamete or sex cell in higher plants and animals.

spice. Any of the various fresh or dried plant parts used to flavor and preserve foods because of their aromatic, pungent, and antimicrobial properties. They are typically derived from tropical and subtropical plants.

spikelet. A group of grass or sedge flowers and associated bracts.

spindle fibers. Microscopic fibers formed from microtubules that attach to chromosomes and move them during mitosis and meiosis.

spontaneous generation. The discredited belief that living creatures can arise from non-living sources, such as mice arising from rags left in a closet or worms from horse hairs in a watering trough.

Spruce, Richard (1817-1893). English botanist and explorer. He spent fifteen years botanizing in South America. His best known work is *Notes of a Botanist in the Amazon.*

ssp. Subspecies.

St. Anthony's fire. The popular name for gangrenous ergotism.

starch. A polymer composed of many repeating glucose units, in unbranched or branched chains. It is a very common carbohydrate storage form in plants. Many root crops and cereals are excellent sources of starch. It also has a number of industrial applications, as in making adhesives and stiffening clothing fibers.

steroids. Any of a large heterogeneous group of organic compounds that typically contain four rings of carbon atoms. Many common vitamins, hormones, and alkaloids are steroids. They produce significant physiological effects in the human body.

stimulant. A substance that arouses or increases activity or that produces a sense of well-being.

stock. The rooted plant that is used during the process of grafting.

stolon. A horizontal stem at the surface of the ground that roots at its nodes and is capable of reproducing the plant vegetatively.

stone fruit. A fleshy fruit in which one or more seeds are enclosed in a fibrous to woody endocarp, as in the peach, plum, and apricot.

strychnine. A toxic alkaloid, found in the seeds of *Strychnos nux-vomica*, that stimulates all parts of the central nervous system to produce violent convulsions. It also has limited medicinal uses.

suberin. A waterproof, waxy substance found in plant cells, especially in cork.

suckers. A shoot that originates from the base of a woody plant and that can give rise to new plants.

sucrose. A disaccharide composed of glucose and fructose. It is the most common sugar transported and stored in plants. We extract it commercially from sugar cane and beets.

sugar. Any of various crystalline, sweet-tasting carbohydrates of low molecular weight. They are composed of monosaccharides, either singly or bound together to form disaccharides, etc. There are a number of sweetening agents other than sugars derived from plants.

symbiosis. A mutually advantageous or satisfactory interaction between two different organisms, as an alga and fungus that form a lichen, or between a legume and a bacterium to fix nitrogen and supply carbohydrates.

synapse. The site where a nerve impulse is transmitted from one neuron to another or from a neuron to a muscle fiber.

syndrome. The aggregate of signs or conditions that indicate a disease or poisoning.

- T -

tan. To convert an animal hide to leather by soaking it in a liquid containing tannic acid or various mineral salts.

tannins. A group of complex organic compounds derived from tree barks and oak galls used to tan hide or to make inks.

taproot. The primary, often swollen, descending root, as in the carrot or parsnip.

taxonomy. The branch of biological sciences that deals with the classification and naming of organisms. It is practiced by an eccentric bunch of men and women called taxonomists.

tendril. An elongate, often thread-like structure of stem or leaf origin that climbing plants use for support.

teonanacatl. The Aztec name for the "sacred mushrooms," a group of psychoactive fungi.

teratogen. A substance that causes an embryo to be malformed. The term is based on the Greek word for a monster.

terpenes. A group of unsaturated hydrocarbons found in the essential oils and resins of various plants, such as conifers and citrus fruits.

tetrahydrocannabinol. One of the principal psychoactive agents in marijuana (*Cannabis sativa*).

tetraploid. A nucleus, cell, or individual that has four complete sets of chromosomes. It is one kind of polyploid.

THC. Tetrahydrocannabinol, one of the active principles in marijuana.

thebaine. An alkaloid found in the opium poppy and related species. It can cause severe convulsions. It can be easily converted to codeine.

theobromine. A caffeine-like alkaloid extracted from cacao seeds (*Theobroma cacao*). It has medicinal uses as a stimulant, diuretic, and to dilate arteries.

theophylline. An alkaloid found in the leaves of tea (*Camellia sinensis*). It has medicinal uses as a heart stimulant and to treat bronchial asthma.

thresh. The process of separating cereal grains from their surrounding husks by beating them or having animals walk over them.

tiller. A shoot that emerges from the base of a stem, especially in a grass.

tincture. An alcoholic solution of a plant or animal drug or other chemical, as in tincture of iodine or laudanum, a tincture of opium.

TMV. Tobacco mosaic virus, which infects many different species of plants, and can cause small spots on the leaves that can even kill the plant.

toadstool. A toxic mushroom. The term may be derived from the German for "death's seat."

toxicology. The science that deals with the study of poisons.

tranquilizer. A substance used to reduce anxiety.

transgenic. A plant or animal that has had genetic material from another organism inserted into its chromosomes.

translocation. The movement of dissolved substances within a plant.

transpiration. The loss of water vapor by a plant to the atmosphere.

transposable elements. The region on a chromosome that breaks away and then inserts itself at a different location of the same chromosome or on a different one. They are affectionately known as "jumping genes."

tree. A perennial woody plant, typically with a single trunk that remains unbranched for several feet above the ground.

triploid. A nucleus, cell, or individual that has three complete sets of chromosomes. It is a kind of polyploid. Bananas are triploids; so are the cells of the human liver.

triticale. The common name for the various hybrids between wheat and rye. The name is composed of portions of their generic names, *Triticum* and *Secale.*

tuber. A swollen underground stem or root that functions to store food and water, as in the Irish potato.

tubocurarine. An alkaloid extracted from the stems of South American vines of the genus *Chondrodendron*. It is the principal active ingredient in the various curare arrow and dart poisons, which act by paralyzing neuromuscular transmissions.

Tyler, Varro (1926-2001). Professor of Pharmacognosy at Purdue University. One of the leading experts on medicinal plants. His *Honest Herbal* is now in its fourth edition.

- U -

U. S. D. A. United States Department of Agriculture.

- V -

vacuole. A membrane-bound sac within the cytoplasm of a cell. It is filled with air, liquids, or stored solids.

vascular plant. A plant that has evolved specialized conductive tissue (xylem and phloem) for transporting nutrients and water. Vascular tissue is present in ferns, fern allies, gymnosperms, and flowering plants.

Vavilov, Nikolai Ivanovich (1887-1943). Professor of Botany, University of Saratov and later director of the Lenin All-Union Academy of Agricultural Sciences. Noted geneticist and explorer who assembled one of the world's largest seed collections of economically important plants. Vavilov developed the influential (if flawed) theory of the centers of origins of cultivated plants. After a long scientific and political struggle, he was arrested and eventually died in one of the Soviet Union's infamous Siberian prisons.

vegan. A "real" vegetarian; one who consumes no animal products whatsoever.

vegetable. Any plant, usually an herbaceous one, that is consumed for food. Most are edible roots, stems, and leaves. Some fruits are considered vegetables, usually if they are not brightly colored and are served along with the main course, as in beans and squashes.

vegetative reproduction. Any form of plant propagation or reproduction that does not involve the union of gametes. Common methods include the planting of cuttings, suckers, tubers, rhizomes, etc.

vein. A strand of vascular tissue in a leaf, stem, or other plant part.

vermifuge. A substance that kills worms.

vernalization. The process of germinating seeds or cereal grains at low temperatures to induce flowering at a particular time, as in winter strains of wheat that are planted in the spring, and then exposed to temperatures above freezing to synchronize their flowering with spring wheat. The Soviet agronomist T. D. Lysenko popularized this technique in the 1930's.

vestigial. Reduced in size; atrophied.

vinblastin/vincristine. Two of the vinca alkaloids used to treat childhood leukemia and Hodgkin's disease.

vinca alkaloids. The group name for a series of alkaloids derived from the Madagascar periwinkle (*Catharanthus roseus*). When the alkaloids were first isolated, the periwinkle bore the scientific name *Vinca rosea*.

virus. A microscopic "organism" that straddles the border between the non-living and living. It consists of DNA or RNA enclosed in a protein coat and has no metabolic processes of its own. Viruses can reproduce only by infecting a plant or animal. They cause a variety of diseases in plants and animals.

vitamins. A group of fat- or water-soluble organic compounds that act in small quantities to foster growth and maintenance of health in living organisms. Most vitamins are not manufactured by animals and are derived from plants that they consume.

volatile oil. A type of oil that evaporates quickly. Many are highly aromatic and are used in cooking, perfumes, and medicines, as in lemon oil and oil of peppermint.

vulcanization. The process of combining natural rubber and other substances, heating the mixture and applying pressure to improve the strength of the latex and to reduce its stickiness and odor.

- W -

Wallace, Alfred Russel (1823-1913). English explorer, collector, and early developer of a theory of evolution based on natural selection. His *Travels on the Amazon and Rio Negro* contained much information about the useful plants of that region.

Wallace, Henry Agard (1888-1965). American politician, agriculturalist, and early advocate of hybrid maize and the Green Revolution. He also served as Secretary of Agriculture and Vice President of the United States under Franklin D. Roosevelt.

warfarin. A rodent poison made from anticoagulants derived from sweet clover.

weed. A non-native plant that invades disturbed sites or cultivated fields, competes with native plants or crops for nutrients, and otherwise interferes with human objectives.

Whitney, Eli (1765-1825). American inventor of the cotton gin.

Wickham, Sir Henry Alexander (1846-1928). British explorer who was sent to Brazil in 1876 to acquire seeds of the Pará rubber tree that would become the basis of the plantations in Southeast Asia.

wine. A fermented beverage made from grapes (*Vitis* spp.) or, more broadly, from other fruits.

winnow. The process of separating seeds or cereal grains from unwanted husks, etc. by tossing them in the air and allowing air currents to blow away the lighter husks, while the heavier seeds or grains fall back into a basket.

wood. The hard, fibrous plant tissue occupying much of the interior of the trunk and branches of a tree or shrub. From a technical standpoint, wood is a series of layers of secondary xylem tissue.

wort. An Old English word for plant. It is pronounced as though spelled "wurt." The term is also used in modern times for the infusion of malt that will ferment to become beer.

- X -

xylem. A type of plant tissue that transports water and dissolved material. It is dead at maturity. We refer to significant layers of xylem tissue as wood.

- Y -

yeast. A type of unicellular fungus that reproduces by budding or fission to produce the next generation. Yeasts such as *Saccharomyces cervesieae* are essential in the brewing process.

- Z -

zygote. A fertilized egg of a plant or animal that will develop into an embryo.

15: SELECTED REFERENCES

[Limited updates of some sections available through the HSU Library]

1: INTRODUCTION

THE SCOPE OF STUDY

Alcorn, J. B. 1995. Economic botany, conservation, and development: what's the connection? Ann. Missouri Bot. Gard. 82(1): 34-36.

Balick, M. J. 1996. Transforming ethnobotany for the new millenium. Ann. Missouri Bot. Gard. 83(1): 58-66.

Barrau, J. 1971. L'ethnobotanique au carrefour des sciences naturelles et des sciences humaines. Bull. Soc. Bot. France 118: 237-248.

Barton, J. H. 1994. Ethnobotany and intellectual property rights. Ciba Found. Symp. 185: 214-221.

Bohrer, V. L. 1986. Guideposts in ethnobotany. J. Ethnobiol. 6: 27-43.

Carter, G. F. 1950. Ecology - geography - ethnobotany. Sci. Monthly 70(2): 73-80.

Castetter, E. F. 1944. The domain of ethnobiology. American Nat. 78: 158-170.

Chandra, S. 1991. Foundations of ethnobotany (pre-1900 ethnobotany -- a review and bibliography). Deep Publ. New Delhi, India. 187 pp.

Cotton, C. M. 1996. Ethnobotany: principles and applications. John Wiley & Sons. New York, NY. 424 pp.

Davis, W. 1991. Towards a new synthesis in ethnobotany. In, Rios, M., H. Borgtoft, & H. Pedersen (editors). Las plantas y el hombre. Ediciones Abya-Yala. Quito, Ecuador. Pp. 339-358.

Faulks, P. J. 1958. An introduction to ethnobotany. Moredale Publ. London, England. 152 pp.

Ford, R. I. (Editor). 1978. The nature and status of ethnobotany. Anthrop. Papers No. 67. Museum of Anthropology. Univ. of Michigan. Ann Arbor. 428 pp.

Fosberg, F. R. 1948. Economic botany -- a modern concept of its scope. Econ. Bot. 2(1): 3-14.

Gilmore, M. R. 1932. Importance of ethnobotanical investigation. American Anthrop. 34: 320-327.

Gomez-Pompa, A. 1986. La botanica economica: un punto de vista. Rev. Acad. Columbiana 16(61): 57-63.

Greenfield, S. S. 1969. Economic botany for liberal arts students. Plant Sic. Bull. 15(4): 1, 2.

Harshberger, J. W. 1896. Purpose of ethno-botany. Bot. Gaz. 21(3): 46-154.

Hernández-Bermejo, J. E. 1998. La etnobotanica: una ciencia en expansión. Monogr. Missouri Bot. Gard. 68: 225-234.

Heiser, C. B. 1986. Economic botany: past and future. Econ. Bot. 40: 261-266.

Hodgson, W. 2002. Ethnobotany: origins and relevance. Sonoran Quart. 56(3): 4-10.

Jain, S. K. 1986. A manual of ethnobotany. Scientific Publ. Jodhpur, India. 528 pp.

Jones, V. H. 1941. The nature and status of ethnobotany. Chron. Bot. 6: 219-221.

Martin, G. J. 1994. Ethnobotany and plant conservation. World Wildlife Fund manuals in plant conservation. Series 2. Chapman & Hall. London, England. 240 pp.

Minnis, P. E. 2000. Ethnobotany: a reader. Univ. Oklahoma Press. Norman. 327 pp.

Martin, G. J. 1995. Ethnobotany: a methods manual. World Wildlife Fund manuals in plant conservation. Chapman & Hall. 268 pp.

Montgomery, R. 1989. Ethnobotanical research field kit. Whole Earth Review 64: 30, 31.

Perez, A. F. 1988. La botanica economica: una disciplina necessaria para el desarrallo. Rev. Acad. Colombia Ciencias Ex. 16(63): 27-36.

Portères, R. 1961. L'ethnobotanique: place-objet-méthode-philosophie. J. Agric. Trop. Bot. Appl. 8(4/5): 103-109.

Portères, R. 1966. Aspects de l'ethnobotanique comme discipline scientifique affirmee. J. Agr. Trop. Bot. Appl. 13: 701-704.

Posey, D. A. 1990. Intellectual property rights: what is the position of ethnobiology? J. Ethnobiol. 10: 93-98.

Powers, S. 1873. Aboriginal botany. Proc. California Acad. Sci. 5: 373-379.

Prance, G. T. 1991. What is ethnobotany today? J. Ethnopharm. 32(1-3): 209-216.

Rheingold, H. 1989. Ethnobotany and the search for vanishing knowledge. Whole Earth Review 64: 16-23.

Schultes, R. E. & S. von Reis. 1995. Ethnobotany: evolution of a discipline. Dioscorides Press. Portland, OR. 414 pp.

Wickens, G. E. 1990. What is economic botany? Econ. Bot. 44(1): 12-28.

TEXTBOOKS

Baker, H. G. 1978. Plants and civilization. Third edition. Fundamentals of Botany Series. Wadsworth Publ. Co. Belmont, CA. 198 pp.

Balick, M. J. & P. A. Cox. 1996. Plants, people, and culture: the science of ethnobotany. Scientific American Books. New York, NY. 228 pp.

Berrie, A. M. M. 1977. An introduction to the botany of the major crop plants. Heyden & Son, Ltd. London. 220 pp.

Chrispeels, M. J. & D. E. Sadava. 1994. Plants, genes, and agriculture. Jones & Bartlett. Boston, MA. 478 pp.

Cotton, C. M. 1996. Ethnobotany: principles and applications. John Wiley & Sons. New York, NY. 424 pp.

Edlin, H. L. 1967. Plants & man: the story of our basic foods. American Museum of Natural History. Garden City, NJ. 253 pp.

Faulks, P. J. 1958. An introduction of ethnobotany. Moredale Publ. London, England. 152 pp.

Gill, N. T. & K. C. Vear. 1980. Agricultural botany. Third edition revised by K. C. Vear & D. J. Barnard. Duckworth Publ. Two volumes.

Harshberger, J. W. 1920. Text-book of pastoral and agriccultural botany for the study of the injurious and useful plants of country and farm. Blakiston's Son & Co. Philadelphia, PA. 294 pp.

Hartmann, H. T., W. J. Flocker, & A. M. Kofranek. 1981. Plant science: growth, development, and utilization of cultivated plants. Prentice-Hall. Englewood Cliffs, NJ. 676 pp.

Heiser, C. B., Jr. 1990. Seeds to civilization: the story of food. New edition. Harvard Univ. Press. Cambridge, MA. 228 pp.

Hill, A. F. 1952. Economic botany. A textbook of useful plants and plant products. McGraw-Hill Book Co., Inc. New York, NY. 560 pp.

Hutchinson, J. & R. Melville. 1948. The story of plants and their uses to man. Gawthorn. London, England. 334 pp.

Janick, J., R. W. Schery, F. W. Woods, & V. W. Ruttan. 1981. Plant science: an introduction to world crops. Third edition. W. H. Freeman & Co. San Francisco, CA 868 pp.

Kaufman, P. B. & J. D. LaCroix (Editors). 1979. Plants, people, and environment. Macmillan Publ. Co. New York, NY. 542 pp.

Klein, R. M. 1979. The green world: an introduction to plants and people. Harper & Row. New York, NY. 437 pp.

Langenheim, J. H. & K. V. Thimann. 1982. Botany: plant biology and its relation to human affairs. John Wiley & Sons. New York, NY. 624 pp.

Langer, R. H. M. & G. D. Hill. 1982. Agricultural plants. Cambridge Univ. Press. Cambridge, England. 344 pp.

Levetin, L. & K. McMahon. 1998. Plants and society. Second edition. WCB McGraw-Hill. Dubuque, IA. 477 pp.

Martin, G. J. 1995. Ethnobotany: a methods manual. Chapman & Hall. London, England. 268 pp.

Richardson, W. N. & T. Stubbs. 1978. Plants, agriculture, and human society. W. A. Benjamin. Reading, MA. 353 pp.

Robbins, W. W. 1931. The botany of crop plants. Third edition. Blakiston's Son & Co. Philadelphia, PA. 639 pp.

Robbins, W. W. & F. Ramaley. 1933. Plants useful to man. P. Blakiston's Son & Co. Philadelphia, PA. 428 pp.

Samba Murty, A. V. S. S. & N. S. Subrahmanyam. 1989. A textbook of economic botany. Wiley Eastern Ltd. New Dehli, India. 875 pp.

Schery, R. W. 1972. Plants for man. Second edition. Prentice-Hall. Englewood Cliffs, NJ. 657 pp.

Simpson, B. B. & M. Conner-Ogorzaly. 2001. Economic botany: plants in our world. Third edition. McGraw-Hill Book Co. New York. 529 pp.

Stanford, E. E. 1934. Economic plants. Appleton-Century Co. New York, NY. 571 pp.

Tippo, O. and W. L. Stern. 1977. Humanistic botany. W. W. Norton. New York, NY. 605 pp.

Wickens, G. E. 2001. Economic botany: principles and practices. Kluwer Academic Publ. Dordrecht. 535 pp.

DICTIONARIES, CHECKLISTS, & DATABASES

Agricultural Research Service: http://www.ars.usda.gov/is/graphics/photos/

Beckstrom-Sternberg, S. & J. Duke. EthnobotDB – worldwide plant uses, ACEDB version 4.0.

http://probe.nalusda.gov:8000/related/aboutethnobotdb.html

Brako, L., A. Y. Rossman, & D. F. Farr. 1994. Scientific and common names of 7,000 vascular plants in the United States. APS Press. St. Paul, MN. 295 pp.

Buckingham, J. (Editor). 1994-1996. Dictionary of natural products. Nine vols. Chapman & Hall. London, England. 9500 pp.

Coon, N. 1974. The dictionary of useful plants. Rodale Press. Emmaus, PA. 290 pp.

Economic Research Service: http://www.econ.ag.gov.8o/photos.htm.

Food and Agriculture Organization (United Nations): http://apps.fao.org/

Glasby, J. S. 1991. Dictionary of plants containing secondary metabolites. Taylor & Francis. New York, NY.

Hanelt, P. (editor). 2001. Mansfeld's world manual of agricultural and horticultural crops (except ornamentals). Six vols. 3645 pp.

Harborne, J. B., H. Baxter, & G. P. Moss (editors). 1999. Phytochemical dictionary: a handbook of bioactive compounds from plants. Second edition. Taylor & Francis. London, England. 976 pp.

Hartley, W. 1979. A checklist of economic plants of the world. CSIRO. Melbourne, Australia.

Hocking, G. M. 1997. A dictionary of natural products. Plexus Publ. Medford, NJ. 994 pp.

Hotta, M. et al. (Editors). 1989. Useful plants of the world. Heibonsha Publ. 1499 pp.

Howard, R. A. 1996. An almanac of botanical trivia. Publ. by author. Acton, MA. 52 pp.

Howes, F. N. 1974. A dictionary of useful and everyday plants and their common names. Cambridge Univ. Press. 290 pp.

Jain, S. K., P. Minnis, & N. C. Shah. 1986. A world directory of ethnobotanists. Society of Ethnobotanists. Lucknow, India. 52 pp.

Johnson, T. 1999. CRC ethnobotany desk reference. CRC Press. Boca Raton, FL. 1211 pp.

Johnson, T. 2003. The herbage ethnobotany database. Second edition. CD-ROM.

Kaufman, P. B. et al. 1999. Natural products from plants. CRC Press. Boca Raton, FL. 343 pp.

Leung, A. Y. & S. Foster. 1996. Encyclopedia of common natural ingredients used in food, drugs, and cosmetics. Second edition. John Wiley & Sons. New York, NY. 649 pp.

Moerman, D. E. 1998. Native American ethnobotany. Timber Press. Portland, OR. 927 pp.

Nikolov, H. 1996. Dictionary of plant names in Latin, German, English and French. J. Cramer. Stuttgart, Germany. 925 pp.

Quattrocchi, U.2000. CRC world dictionary of plant names: common names, scientific names, eponyms, synonyms, and etymology. Four vols. CRC Press. Boca Raton, FL. 2896 pp.

Ratsch, C. 1992. The dictionary of sacred and magical plants. Prism Press. Dorset, England. 249 pp.

Rehm, S. (Editor). 1994. Multilingual dictionary of agronomic plants. Kluwer Acad. Publ. Dordrecht. The Netherlands. 286 pp.

Roecklein, J. C. & P.-S. Leung. 1987. A profile of economic plants. Transaction Books. New Brunswick, NJ. 623 pp.

Royal Botanic Garden (Kew, England): www.rbgkew.org.uk/data/econbot-biblio.html

Sanchez-Monge y Parellada, E. 1980. Diccionario de plantas agricolas. Ministerio de Agricultura. Madrid, Spain. 467 pp.

Smith, J. 1882. A dictionary of popular names of the plants which furnish the natural and acquired wants of man, in all matters of domestic and general economy -- their history, products & uses. Macmillan. London, England. 457 pp.

Southon, I. W. & J. Buckingham. 1989. Dictionary of alkaloids. Two vols. Chapman & Hall. London, England.

Terrell, E. E., S. R. Hill, J. H. Wiersema, & W. E. Rice. 1986. A checklist of names for 3,000 vascular plants of economic importance. Agriculture Handbook No. 505. U. S. Dept. of Agriculture. Washington, D. C. 244 pp.

Uphof, J. C. Th. 1968. Dictionary of economic plants. Second Edition. J. Cramer. 591 pp.

Usher, G. 1974. A dictionary of plants used by man. Constable. London, England. 619 pp.

Vickery, R. 1995. Oxford dictionary of plant-lore. Oxford Univ. Press. New York, NY. 437 pp.

Wiersema, J. H. & B. León. 1999. World economic plants: a standard reference. CRC Press. Boca Raton, FL. 749 pp.

JOURNALS

Botanical Museum Leaflets of Harvard University
Bulletin of the Pacific Tropical Botanical Garden
Crop Science
Die Kulturpflanze
Economic and Medicinal Plant Research
Economic Botany
Ethnobotany
HerbalGram
Journal of Economic and Taxonomic Botany
Journal of Ethnobiology
Journal of Ethnopharmacology
Journal of Herbs, Spices & Medicinal Plants
Journal of Natural Products
Lloydia (now Journal of Natural Products)
Phytomedicine
Planta Medica
Principes
Tropical Agriculture
Wood and Fiber Science
World Crops [now called Agriculture International]

ABSTRACTS & BIBLIOGRAPHIES

Bibliography of Agriculture

Biological Abstracts

Botany Subject Index (U. S. Dept. of Agriculture)

Chemical Abstracts

Craker, L. E., A. F. Chadwick, & J. E. Simon. 1986. An introduction to the scientific literature on herbs, spices, and medicinal plants. Recent Adv. Bot. Hort. Pharm. 1: 1-9.

Excerpta Botanica

Index Medicus

Index to American Botanical Literature

Simon, J. E., A. F. Chadwick, & L. E. Craker. 1984. Herbs: an indexed bibliography, 1971-1980: the scientific literature on selected herbs, and aromatic and medicinal plants of the temperate zone. Shoe String Press. 770 pp.

REFERENCES OF GENERAL INTEREST

Altman, N. 1994. Sacred trees. Sierra Club Books. San Francisco, CA. 244 pp.

Ames, O. 1939. Economic annuals and human cultures. Botanical Museum of Harvard Univ. Cambridge, MA. 153 pp. + plates.

Anderson, E. G. 1954. Plants, man, and life. Andrew Melrose. London, England. 208 pp.

Anonymous. 1992. New crops, new uses, new markets. 1992 yearbook of agriculture. U. S. Gov. Printing Office. Washington, D. C. 302 pp.

Archer, T. C. 1853. Popular economic botany; or the botanical and commercial characters of the principal articles of vegetable origins, used for food, clothing, tanning, dyeing, building, medicine, perfumery, etc. Reeve & Co. London.

Archer, W. A. 1945. Collecting data and specimens for study of economic plants. Misc. Publ. No. 568. U. S. Dept. of Agriculture. Washington, D. C. 52 pp.

Ausubel, K. 1994. Seeds of change: the living treasure. The passionate story of the growing movement to restore biodiversity and revolutionize the way we think about food. HarperCollins Publ. New York, NY. 232 pp.

Ayensu, E. S., V. H. Heywood, G. L. Lucas, & R. A. DeFilipps. 1984. Our green and living world: the wisdom to save it.

Balick, M. J. 1990. Botany with a human face. Garden 14(6): 2, 3.

Barrau, J. 1982. Plants and men on the threshold of the twenty-first century. Social Sci. Inform. 21. 1: 127-141.

Berlin, B. 1971. Speculations on the growth of ethnobotanical nomenclature. Working Paper No. 39. Language-Behavior Res. Lab. Univ. California, Berkeley.

Bernhardt, P. 1993. Natural affairs: a botanist looks at the attachments between plants and people. Villard Books. New York, NY. 225 pp.

Bernhardt, P. 1999. The rose's kiss: a natural history of flowers. Island Press. Washington, D. C. 267 pp.

Boom, B. 1990. Giving native people a share of the profits. Garden 14(6): 28-31.

Brooks, R. & D. Johannes. 1990. Phytoarchaeology. Dioscorides Press. Portland, OR. 224 pp.

Brouk, B. 1975. Plants consumed by man. Academic Press. New York, NY. 460 pp.

Brucher, H. 1989. Useful plants of neotropical origin and their wild relatives. Springer-Verlag. New York, NY. 296 pp.

Burke, J. & R. Ornstein. 1995. The axemaker's gift: a double-edged history of human culture. G. P. Putnam's Sons. New York, NY. 348 pp.

Chapman, V. J. 1980. Seaweeds and their uses. Third edition. Chapman & Hall. New York, NY. 334 pp.

Cobley, L. S. 1977. An introduction to the botany of tropical crops. Third edition. Longman. London. 371 pp.

Cook, F. E. M. 1995. Economic botany data collection standard: prepared for the International Working Group on Taxonomic Databases for Plant Sciences (TDWG). Royal Botanic Garden. Kew, England. 146 pp.

Corry, S. 1993. The rainforest harvest: who reaps the benefits? Ecologist 23: 148-153.

Cox, P. A. 2000. Will tribal knowledge survive the millennium? Science 287: 44, 45.

Dash, M. 1999. Tulipomania: the story of the world's most coveted flower and the extraordinary passions it aroused. Crown Publ. New York, NY. 273 pp.

Davis, W. 1998. Shadows in the sun: travels to landscapes of spirit and desire. Island Press. Washington, D. C. 292 pp.

Diamond, J. 1997. Guns, germs, and steel: the fates of human societies. W. W. Norton. New York, NY. 480 pp.

Diamond, J. 1989. The ethnobiologist's dilemma. Nat. Hist. June: 27-30.

Dodge, B. S. 1979. It started in Eden: how the plant-hunters and the plants they found changed the course of history. McGraw-Hill Book Co. New York, NY. 288 pp.

Duke, J. A. 1979. Ecosystematic data on economic plants. Quarterly J. Crude Drug Research 17: 91-110.

Duke, J. A. 1992. Handbook of phytochemical constituents of GRAS herbs, and other economic plants. CRC Press. Boca Raton, FL. 654 pp.

Duke, J. A. 2001. Handbook of phytochemical constituents of GRAS herbs and other economic plants. CRC Press. Boca Raton, FL. 654 pp.

Duke, J. A. & A. A. Atchley. 1986. Handbook of proximate analysis tables of higher plants. CRC Press. Boca Raton, FL. 389 pp.

Duke, J. A. & S. J. Hurst. 1975. Ecological amplitude of herbs, spices, and medicinal plants. Lloydia 38: 404-410.

Duke, J. A., S. J. Hurst, & E. E. Terrell. 1975. Ecological distribution of 1000 economic plants. Agronomia No. 1. IICA-Tropicos. Turrialba, Costa Rica.

Erichsen-Brown, C. 1979. Use of plants for the past 500 years. Breezy Creeks Press. Aurora, Canada. 512 pp.

Fairbairn, N. 2001. A brief history of gardening. Rodale Publ. Emmaus, PA. 256 pp.

Fern, K. 1997. Plants for a future: edible and useful plants for a healthier world. Permanent Publ. Clanfield, England. 300 pp.

Flannery, T. 2001. The eternal frontier: an ecological history of North America and its peoples. Grove Press. New York, NY. 404 pp.

Frisch, R. E. 1969. Plants that feed the world. Van Nostrand. Princeton, NJ. 104 pp.

Gottlieb, O. 1981. New and underutilized plants in the Americas: solution to problems of inventory through systematics. Interciencia 6(1): 22-29.

Gray, W. D. 1959. The relation of fungi to human affairs. Henry Holt & Co. New York, NY. 510 pp.

Gremillion, K. J. 1997. People, plants, and landscapes: studies in palaeoethnobotany. Univ. Alabama Press. Tuscaloosa. 271 pp.

Grime, W. E. 1979. Ethno-botany of the Black Americans. Reference Publ. Algonac, MI. 237 pp.

Groombridge, B. (Editor). 1992. Global biodiversity: status of the earth's living resources. A report compiled by the World Conservation Monitoring Centre. Chapman & Hall. London, England. 585 pp.

Hackett, C. & J. Carolane (Editors). 1983. Edible horticultural crops. A compendium of information on fruit, vegetable, spice and nut species. Four volumes. Academic Press. New York, NY. 674 pp.

Hansen, E. 2000. Orchid fever: a horticultural tale of love, lust, and lunacy. Pantheon Books. New York, NY. 272 pp.

Harborne, J. B. & H. Baxter (Editors). 1993. Phytochemical dictionary: a handbook of bioactive compounds from plants. Taylor & Frances. Bristol, PA. 791 pp.

Harlan, J. R. 1992. Crops & man. Second edition. American Society of Agronomy. Madison, WI. 284 pp.

Haudricourt, A. G. & L. Hedin. 1943. L'homme et les plantes cultivées. Gallimard. Paris, France. 233 pp.

Hawkes, J. G. 1983. The diversity of crop plants. Harvard Univ. Press. Cambridge, MA. 184 pp.

Heiser, C. B., Jr. 1985. Of plants and people. Univ. Oklahoma Press. Norman. 237 pp.

Hobhouse, H. 1999. Seeds of change: six plants that transformed mankind. Revised and expanded edition. Papermac. London, England. 381 pp.

Howard, R. A. 1996. An almanac of botanical trivia. Publ. By author. Acton, MA. 52 pp.

Hutchinson, J. (Editor). 1965. Essays on crop plant evolution. Cambridge Univ. Press. London. 204 pp.

Huxley, A. 1985. Green inheritance: the World Wildlife Fund book of plants. Anchor Press/Doubleday. Garden City, NY. 193 pp.

Hvass, E. 1973. Plants that feed and serve us. Blandford Press. London, England. 200 pp.

Hyams, E. S. 1971. Plants in the service of man. 10,000 years of domestication. J. M. Dent & Sons. London, England. 222 pp.

Jacques, H. E. 1943. Plants we eat and wear: an illustrated key to plants upon which man is directly dependent for his food and clothing, with some essential facts about each plant. W. C. Brown Co. Dubuque, IA. 171 pp.

Janick, J. & J. E. Simon (Editors). 1993. New crops. Proc. Second Inter. Symp. John Wiley & Sons. New York, NY. 710 pp.

Kahn, E. J., Jr. 1985. The staffs of life. Little, Brown & Co. Waltham, MA. 310 pp.

Kaufman, P. B. & P. Dayanandan. 1979. Economic applications of plants. In, Kaufman, P. B. & J. D. LaCroix (editors). Plants, people, and environment. Macmillan. New York, NY. Pp. 53-75.

Kaufman, P. B. et al. 1999. Natural products from plants. CRC Press. Boca Raton, FL. 343 pp.

Kochhar, S. L. 1981. Economic botany in the tropics. Macmillan India, Ltd. Madras. 476 pp.

Kunkel, G. 1984. Plants for human consumption. Koeltz Scientific Books. Koenigstein, West Germany. 393 pp.

Lane, M. A. et al. 1990. Forensic botany: plants, perpetrators, pests, poisons, and pot. BioScience 40(1): 34-39.

Lawler, L. J. 1984. Ethnobotany of the Orchidaceae. Orchid Biol. 3: 27-149.

LeCourteur & J. Burreson. 2003. Napoleon's buttons: how 17 molecules changed history. Tarcher/Putnam. New York, NY. 375 pp.

Lembi, C. A. & J. K. Waaland (Editors). 1989. Algae and human affairs. Cambridge Univ. Press. Cambridge, England. 590 pp.

Leon, J. 1968. Fundamentos botanicos de los cultivos tropicales. Inst. Interamericano de Ciencias Agricolas de la OEA. 488 pp.

Leroy, J.-F. 1967. Un chapitre d'ethnobotanique: la conservacion des especes vegetales. Agric. Trop. Bot. Appl. 14: 511-525.

Leung, A. Y. & S. Foster. 1996. Encyclopedia of common natural ingredients used in food, drugs, and cosmetics. Second edition. John Wiley & Sons. New York, NY. 649 pp.

Lewington, A. 1990. Plants for people. Oxford Univ. Press. New York, NY. 232 pp.

Lindley, J. 1856. Medical and oeconomical botany. Bradbury & Evans. London, England. 274 pp.

Llano, G. A. 1948. The economic uses of lichens. Econ. Bot. 2: 15-45.

Mangelsdorf, P. C. 1961. Biology, food, and people. Econ. Bot. 15: 275-288.

Martin, F. W. 1984. CRC handbook of tropical food crops. CRC Press. Boca Raton, FL. 296 pp.

Miller, K. & L. Tangley. 1991. Trees of life: saving tropical forests and their biological wealth. Beacon Press. Boston, MA. 218 pp.

Minnis, P. E. (editor). 2000. Ethnobotany: a reader. Univ. Oklahoma Press. Norman. 327 pp.

Minnis, P. E. & W. J. Elisens (editors). 2000. Biodiversity and Native America. Univ. Oklahoma Press. Norman. 310 pp.

Moldenke, H. N. 1954. The economic plants of the Bible. Econ. Bot. 8(2): 152-163.

Moore, D. 2001. Slayers, saviors, servants, and sex: an exposé of kingdom fungi. Springer Verlag. Berlin, Germany. 175 pp.

Moore, D. M. (Editor). 1992. The Guinness guide to the plants of the world. Guinness. Enfield, England. 256 pp.

Morton, J. F. 1986. Plants of long ago: being mostly quotations from historical literature. Morton Collecteana Communication 4: 1-35.

Myers, N. 1983. A wealth of wild species: storehouse for human welfare. Westview Press. Boulder, CO. 274 pp.

Nabhan, G. P. 1997. Cultures of habitat: on nature, culture, and story. Counterpoint. Washington, D. C. 338 pp.

National Research Council. Advisory Committee on Technology Innovation. 1975. Underexploited tropical plants with promising economic value. 188 pp.

Ochse, J. J. et al. 1961. Tropical and subtropical agriculture. Two volumes. Macmillan. New York, NY. 1446 pp.

Petersen, R. H. 2001. New World botany: Columbus to Darwin. Koeltz Sci. Books. Königstein, Germany. 638 pp.

Pickering, C. 1879. Chronological history of plants: man's record of his own existence illustrated through their names, uses, and companionship. Two vols. Little, Brown & Co. Boston, MA. 1222 pp.

Pliny (Gaius Plinius Secundus). Natural history, with an English translation. Ten vols. Harvard Univ. Press. Cambridge, MA.

Plotkin, M. & L. Famolare (Editors). 1992. Sustainable harvest and marketing of rain forest products. Island Press. Washington, D. C. 325 pp.

Pollan, M. 2001. The botany of desire: a plant's-eye view of the world. Random House. New York, NY.271 pp.

Posey, D. A. 1990. Intellectural property rights and just compensation for indigenous knowledge. Anthrop. Today 6: 13-16.

Posey, D. A. 1990. Intellectual property rights: what is the position of ethnobiology? J. Ethnobiol. 10: 93-98.

Prance, G. T. & M. J. Balick (Editors). 1990. New directions in the study of plants and people. Research Contributions from the Institute of Economic Botany. Adv. in Econ. Bot. No. 8. New York Botanical Garden. Bronx, NY. 278 pp.

Purseglove, J. W. 1968. Tropical crops: Dicotyledons. Two volumes. John Wiley & Sons. New York, NY. 719 pp.

Purseglove, J. W. 1972. Tropical crops: Monocotyledons. Two volumes. John Wiley & Sons. New York, NY. 607 pp.

Raffauf, R. F. 1996. Plant alkaloids: a guide to their discovery and distribution. Food Products Press. Binghamton, NY.

Rehm, S. 1996. Die Kulturpflanzen der Tropen und Subtropen. Aufbau, wirtschaftliche, Bedeutung, Verwertung. Second edition. Eugen Ulmer. Stuttgart, Germany. 528 pp.

Rhoades, R. E. 1994. Indigenous people and the preservation of biodiversity. Hortscience 29(11): 1222-1225.

Richardson, W. N. & T. Stubbs. 1978. Plants, agriculture, and human society. W. A. Benjamin. Reading, MA. 353 pp.

Rios, M., H. Borgtoft, & H. Pedersen (Editors). 1991. Las plantas y el hombre. Ediciones Abya-Yala. Quito, Ecudaor.

Rios, R. & B. Khan. 1998. List of ethnobotanical uses of Bromeliaceae. J. Bromeliad Soc. 48(2): 75-87.

Rupp, R. 1987. Blue corn & square tomatoes: unusual facts about common garden vegetables. Storey Communications. Pownal, VT. 222 pp.

Sanders, J. 2003. The secrets of wildflowers: a delightful feast of little-known facts, folklore, and history. Lyons Press. Guilford, CT. 304 pp.

Sauer, J. D. 1993. Historical geography of crop plants: a selected roster. CRC Press. Boca Raton, FL. 309 pp.

Schultes, R. E. 1960. Tapping our knowledge of ethnobotanical lore. Econ. Bot. 14: 257-262.

Schultes, R. E. 1990. Gifts of the Amazon flora to the world. Arnoldia 50(2): 21-34.

Schultes, R. E. 1997. The importance of ethnobotany in envir-omental conservation. American J. Econ. Sociol. 53(2): 202-206.

Seigler, D. S. (Editor). 1977. Crop resources. Academic Press. New York, NY. 233 pp.

Smartt, J. & N. Simmons. 1995. Evolution of crop plants. Second edition. Longman Sci. & Tech. New York, NY. 531 pp.

Simoons, F. J. 1998. Plants of life, plants of death. Univ. Wisconsin Press. Madison. 568 pp.

Stearn, W. L. 1994. Linnaeus as an economic botanist. Bot. J. Scotland 46: 702-706.

Stone, J. H. 1962. Economic plants encountered on the voyage of the Beagle. Econ. Bot. 16(2): 116-126.

Styles, B. T. (editor). 1986. Infraspecific classification of wild and cultivated plants. Clarendon Press. Oxford, England. 435 pp.

Swaminthan, M. S. & S. L. Kochhar (Editors). 1988. Plants and society. Macmillan. London, England. 629 pp.

Thames, S., R. Kleiman, & L. D. Clements. 1992. How crops can provide raw materials for the chemical industry. In, 1992 yearbook of agriculture. U. S. Gov. Printing Office. Washington, D. C. Pp. 86-91.

Thieret, J. W. 1956. Bryophytes as economic plants. Econ. Bot. 10(1): 75-91.

Thieret, J. W. 1957. Economic botany of the cycads. Econ. Bot. 12(1): 3-41.

Tseng, C. K. 1947. Seaweed resources of North America and their utilization. Econ. Bot. 1(1): 69-97.

Wagner, H., H. Hikino, & N. R. Fransworth (Editors). Economic and medicinal plant research. Academic Press. Four volumes to date.

Weiner, M . A. 1976. Man's useful plants. Macmillan Publ. Co. New York, NY. 146 pp.

Zohary, M. 1984. Plants of the Bible. Cambridge Univ. Press. 223 pp.

THE NAMES OF PLANTS

Bagust, H. (compiler). 2001. The Hutchinson dictionary of plant names: common and botanical. Helicon Publ. Oxford, U. K. 440 pp.

Baum, B. R. 1981. Taxonomy of the infraspecific variability of cultivated plants. Die Kulturpflanze 29: 209-239.

Berlin, B. 1992. Ethnobiological classification. Principles of categorization of plants and animals in traditional societies. Princeton Univ. Press. Princeton, NJ. 335 pp.

Boorstin, D. J. 1983. The invention of species. In, The discoverers: a history of man's search to know his world and himself. Random House. New York, NY. Pp. 429-435.

Brandenburg, W. A. 1986. Classification of cultivated plants. In, van der Maesen, L. J. G. First international symposium on taxonomy of cultivated plants. Acta Horticulturae No. 182. Wageningen, Netherlands. Pp. 109-115.

Coombes, A. J. 1985. Dictionary of plant names: the pronunciation, derivation and meaning of botanical names, and their common-name equivalents. Timber Press. Portland, OR. 207 pp.

Gledhill, D. 1989. The names of plants. Second edition. Cambridge Univ. Press. Cambridge, England. 159 pp.

Gould, S. J. 1993. The sexual politics of classification. Nat. Hist. 102(11): 20-29.

Gould, S. J. 2002. Linnaeus's luck? In, I have landed. Harmony Books. New York, NY. Pp. 287-304.

Greuter, W. et al. 2000. International code of botanical nomenclature (Saint Louis Code) adopted by the sixteenth International Botanical Congress. Koeltz Scientific Books. Königstein, Germany. 474 pp.

Hawkes, J. G. 1986. Problems of taxonomy and nomenclature in cultivated plants. In, van der Maesen, L. J. G. First international symposium on taxonomy of cultivated plants. Acta Horticulturae No. 182. Wageningen, Netherlands. Pp. 41-47.

Healey, B. J. 1972. A gardener's guide to plant names. Charles Scribner's Sons. New York, NY. 284 pp.

Hetterscheid, W. L. A. & W. A. Brandenberg. 1995. Culton vs. taxon: conceptual issues in cultivated plant systematics. Taxon 44: 161-175.

Hetterscheid, W. L. A. et al. 1996. An annotated history of the principles of cultivated plant classification. Acta Bot. Neerl. 45(2): 123-134.

Holman, F. W. 2002. The relation between folk and scientific classifications of plants and animals. J. Classification 19(1): 131-159.

Hyam, R. & R. Pankhurst. 1995. Plants and their names: a concise dictionary. Oxford Univ. Press. Oxford, England. 545 pp.

Jeffrey, C. 1968. Systematic categories for cultivated plants. Taxon 17: 109-114.

Maesen, L. J. G. van der. 1986. First international symposium on taxonomy of cultivated plants. Acta Horticulturae No. 182. Wageningen, Netherlands. 436 pp.

McNeill, J. 1998. Culton: a useful term, questionably argued. Hortax News 1: 15-22.

Neal, B. 1992. Gardener's Latin. Algonquin Books. Chapel Hill, NC. 136 pp.

Prance, G. T. 1986. La taxonomia y su relacion con las ciencias agricolas. Rev. Acad. Colombiana 16(61): 89-93.

Quattrocchi, U.2000. CRC world dictionary of plant names: common names, scientific names, eponyms, synonyms, and etymology. Four vols. CRC Press. Boca Raton, FL. 2896 pp.

Shevock, J. R. 1993. How plants get their names and why names change. Fremontia 21 (1): 19-24.

Smith, J. P., Jr. 1977. The taxonomic hierarchy and scientific names. In, Vascular plant families. Mad River Press. Eureka, CA. Pp. 12-20.

Sponberg, S. A. 1975. Changes of botanical names. Plant & Garden 30: 45-47.

Stearn W. T. 1992. Botanical Latin: history, grammar, syntax, terminology and vocabulary. Fourth edition. David & Charles. Devon, England. 546 pp.

Stearn, W. T. 1992. Stearn's dictionary of plant names for gardeners: a handbook on the origin and meaning of the botanical names of some cultivated plants. Cassell Publ. London, England. 363 pp.

Stuart, D. 1974. Some problems at the cultivar level. Taxon 23: 179-184.

Trehane, P. et al. 1995. International code of nomenclature for cultivated plants -- 1995. Regnum Vegetabile Vol. 133. Quarterjack Publ. Wimborne, U. K. 175 pp.

Watts, D. 2000. Elsevier's dictionary of plant names and their origin. Elsevier Science. Amsteredam, The Netherlands. 1032 pp.

CHRONICLE OF ECONOMIC BOTANY

Asimov, I. 1989. Asimov's chronology of science and discovery. Harper & Row. New York, NY. 707 pp.

Baker, H. G. 1978. Plants and civilization. Third edition. Fundamentals of Botany Series. Wadsworth Publ. Co. Belmont, CA. 198 pp.

Burne, J. (editor). 1989. Chronicle of the world. Ecam Publications. Longman Group, Ltd. United Kingdom. 1296 pp.

Calder, N. 1983. Timescale: an atlas of the fourth dimension. The Viking Press. New York, NY. 288 pp.

Desmond, K. 1986. A timetable of inventions and discoveries. M. Evans & Co. New York, NY.

Feldman, A. & P. Ford. 1989. Scientists and inventors. Bloomsbury Books. London, England. 336 pp.

Gascoigne, R. M. 1987. A chronology of the history of science, 1450 - 1900. Garland Publ. Co. New York, NY. 585 pp.

Heiser, C. B., Jr. 1990. Seeds to civilization: the story of food. Harvard Univ. Press. Cambridge, MA. 228 pp.

Hellemans, A. & B. Bunch. 1991. The timetables of science: a chronology of the most important people and events in the history of science. Simon and Schuster. New York, NY. 660 pp.

Hill, A. F. 1952. Economic botany. A textbook of useful plants and plant products. McGraw-Hill Book Co. New York, NY. 560 pp.

Hoffman, M. S. 1990. The world almanac and book of facts: 1991. Pharos Books. New York, NY. 960 pp.

Howard, R. A. 1996. An almanac of botanical trivia. Publ. by author. Acton, MA. 52 pp.

Langenheim, J. H. & K. V. Thimann. 1982. Botany: plant biology and its relation to human affairs. John Wiley & Sons. New York, NY. 624 pp.

Lewington, A. 1990. Plants for people. Oxford Univ. Press. New York, NY. 232 pp.

McHenry, R. (editor-in-chief). 1993. Encyclopaedia Brittanica. Fifteenth edition. Encyclopaedia Brittanica. Chicago, IL. 32 vols.

Schery, R. W. 1972. Plants for man. Second edition. Prentice-Hall. Englewood Cliffs, NJ. 657 pp.

Sherratt, G. 1980. Cambridge encyclopedia of archaeology. Cambridge University Press. New York, NY. 494 pp.

Simmonds, N. W. 1976. Evolution of crop plants. Longman. London, England. 359 pp.

Trager, J. 1992. The people's chronology: a year-by-year record of human events from prehistory to the present. Henry Holt. New York, NY. 1237 pp.

Trager, J. The food chronology: a food lover's compendium of events and anecdotes, from prehistory to the present. Henry Holt. New York, NY. 783 pp.

Walker, M. 1978. A concise chronology of science. Published by the author. Univ. Connecticut. 312 pp.

Wallis, F. (editor). 1991. Time lines. World history year by year since 1492. Crescent Books. New York, NY. 128 pp.

Wetterau, B. 1990. The New York Public Library book of chronologies. A Stonesong Press Book. Prentice Hall Press. New York, NY. 634 pp.

Williams, T. 1990. Science. A history of discovery in the twentieth century. Oxford Univ. Press. New York, NY. 256 pp.

2: DOMESTICATION

GENERAL REFERENCES

Alford, J. 1970. Extinction as a possible factor in the invention of New World agriculture. Prof. Geogr. 22(3): 120-124.

Badgley, C. 1998. Can agriculture and biodiversity coexist? Wild Earth 8(3): 39-47.

Baker, H. G. 1971. Human influences on plant evolution. BioScience 21: 108.

Barigozzi, C. 1986. The origin and domestication of cultivated plants. Elsevier Science Publishers. Amsterdam. The Netherlands. 218 pp.

Bray, F. 1994. Agriculture for developing nations. Sci. American 271(1): 30-37.

Burke, J. & R. Ornstein. 1995. The axemaker's gift: a double-edged history of human culture. G. P. Putnam's Sons. New York, NY. 348 pp.

Carter, G. F. 1977. A hypothesis suggesting a single origin of agriculture. In, Reed, C. A. (editor). Origins of Agriculture. Mouton. The Hague. Pp. 89-133.

Carver, G. W. 1894. Plants as modified by man. B. A. thesis. Reprinted in 1981 in the Iowa State J. Research 55: 209-217. [Yes, this is George Washington Carver.]

Cavalli-Sforza, L. L. 1983. The transition to agriculture and some of its consequences. In, Ortner, D. J. (editor). How humans adapt: a biocultural odyssey. Smithsonian Press. Washington, D. C.

Cleveland, D. A. et al. 1994. Do folk crop varieties have a role in sustainable agriculture? BioScience 44(11): 740-751.

Cohen, J. E. 1995. Population growth and earth's human carrying capacity. Science 269: 341-346.

Cohen, M. N. 1977. The food crisis in prehistory. Overpopulation and the origins of agriculture. Yale University Press. New Haven, CT. 342 pp.

Conklin, H. C. 1961. The study of shifting cultivation. Current Anthrop. 2: 27-61.

Crosby, A. W., Jr. 1972. The Columbian exchange: biological and cultural consequences of 1492. Greenwood Press. Westport, Ct. 268 pp.

Crosby, A. W., Jr. 1986. Ecological imperialism: the biological expansion of Europe, 900-1900. Cambridge Univ. Press. Cambridge, England.

Crosby, A. W., Jr. 1993. Native American crops and European history: the influence of American on Europe. In, Natives & newcomers: challenges of the enounter. Cabrillo Hist. Assoc. San Diego, CA. Pp. 45-57.

Crosby, A. 1994. Germs, seeds & animals: studies in ecological history. M. E. Sharpe. Armonk, NY. 214 pp.

Darwin, C. R. 1868. The variation of animals and plants under domestication. Two volumes. Orange Judd & Co. New York, NY. 494 pp. and 568 pp.

De Candolle, A. L. 1886. The origin of cultivated plants. Second edition. Reprinted by Hafner Publ. Co. New York, NY. 468 pp.

Diamond, J. 1987. The worst mistake in human history. Discover 8(5): 64-66.

Diamond, J. 1994. How to tame a wild plant. Discover 15(9): 100-106.

Diamond, J. 1994. Spacious skies and tilted axes. Nat. Hist. 103(5): 16, 18-23.

Diamond, J. 1997. Location, location, location: the first farmers. Science 278: 1243, 1244.

Diamond, J. 1997. Guns, germs, and steel: the fates of human societies. W. W. Norton. New York, NY. 480 pp.

Diamond, J. 2002. Evolution, consequences and the future of plant and animal domestication. Nature 418: 700-707.

Diamond, J. & P. Bellwood. 2003. Farmers and their languages: the first expansions. Science 300: 597-603.

Dimbleby, G. 1967. Plants and archaeology. Humanities Press. New York, NY. 187 pp.

Dressler, R. L. 1953. The Pre-Columbian cultivated plants of Mexico. Bot. Mus. Leaflts Harvard Univ. 16: 115-72.

Ehrlich, P. R. 2000. From seeds to civilization. In, Human natures: genes, cultures, and the human prospect. Penguin Books. New York, NY. Pp. 227-252.

Ellstrand, N. C., H. C. Prentice, & J. F. Hancock. 1999. Gene flow and introgression from domesticated plants into their wild relatives. Ann. Rev. Ecol. Syst. 30: 539-563.

Ember, C. R. 1978. Myths about hunter-gatherers. Ethnology 17: 439-448.

Farrington, I. S. & J. Urry. 1985. Food and the early history of cultivation. J. Ethnobiol. 5(2): 143-157.

Flannery, K. V. 1973. The origins of agriculture. Ann. Rev. Anthrop. 2: 271-310.

Fritz, G. J. 1995. New dates and data on early agriculture: the legacy of complex hunter-gatherers. Ann. Missouri Bot. 82(1): 3-15.

Frost, F. J. 1993. Voyages of the imagination. Archaeology 46(2): 42-51.

Gilbert, R. I. & J. H. Mielke. (editors). 1985. The analysis of prehistoric diets. Academic Press. Orlando, FL. 436 pp.

Gillis, A. M. 1993. Keeping traditions on the menu. BioScience 43(7): 425-429.

Gremillion, K. J. 1997. People, plants, and landscapes: studies in palaeoethnobotany. Univ. Alabama Press. Tuscaloosa.. 271 pp.

Grove, R. H. 1995. Green imperialism: colonial expansion, tropical island Edens and the origins of environmentalism, 1600-1860. Cambridge Univ. Press. New York, NY.

Gunn, S. 1991. Banking for the future [Kew's seed bank]. Friends Kew Mag. Spring: 16-21.

Harlan, J. R. 1971. Agricultural origins: centers and noncenters. Science 174: 468-74.

Harlan, J. R. 1992. Crops & man. Second edition. American Soc. & Crop Sci. Soc. America. Madison, WI. 284 pp.

Harlan, J. R. 1976. The plants and animals that nourish man. Sci. Amer. 235(3): 89-97.

Harlan, J. R. 1976. Plant and animal distribution in relation to domestication. Phil. Trans. Royal Soc. London 275: 13-25.

Harlan, J. R. 1977. The origins of cereal agriculture in the Old World. In, Reed, C. A. (editor). Pp. 357-383.

Harlan, J. R. 1995. The living fields: our agricultural heritage. Cambridge Univ. Press. Cambridge, England. 271 pp.

Harlan, J. R. & J. M. J. de Wet. 1973. On the quality of evidence for origin and dispersal of cultivated plants. Current Anthrop. 14(1-2): 51-62.

Harris, D. R. 1977. Alternative pathways toward agriculture. In, Reed, C. A. (editor). Pp. 179-243.

Harris, D. R. & G. C. Hilman (editors). 1989. Foraging and farming: the evolution of plant exploitation. Unwin Hyman. London, England. 733 pp.

Hawkes, J. G. 1970. The origins of agriculture. Econ. Bot. 24: 131-3.

Hawkes, J. G. 1983. The diversity of crop plants. Harvard Univ. Press. Cambridge, MA. 184 pp.

Hawkes, K. 1993. Why hunter-gatherers work: an ancient version of the problem of public goods. Curr. Anthrop. 34: 341-361.

Hawkes, K. et al. 1997. The behavioral ecology of modern hunter-gatherers, and human evolution. Trends Ecol. Evol. 12(1): 29-32.

Heiser, C. B., Jr. 1985. Seeds, sex, and sacrifice: religion and the origin of agriculture. In, Plants and people. Univ. of Oklahoma Press. Norman. Pp. 190-220.

Heiser, C. B., Jr. 1988. Aspects of unconscious selection and the evolution of domesticated plants. Euphytica 37: 77-81.

Hutchinson, J. et al. 1976. The early history of agriculture. Oxford Univ. Press. 212 pp.

Hyamms, E. 1971. Plants in the service of man: 10,000 years of domestication. J. M. Dent & Sons, Ltd. London. 222 pp.

Jackson, D. L. & L. L. Jackson. 2002. The farm as natural habitat: reconnecting food systems with ecosystems. Island Press. Washington, D. C.

Kimber, C. 1978. A folk context for plant domestication: or the dooryard garden revisited. Anthrop. J. Canada 16: 2-11.

Lee, R. B. & R. Daly (editors). 1999. The Cambridge encyclopedia of hunters and gatherers. Cambridge Univ. Press.

Leonard, J. N. 1973. The emergence of Man: the first farmers. Time-Life Books. New York, NY. 160 pp.

Lewin, R. 1988. New views emerge on hunters and gatherers. Science 240: 1146-1148.

Lewin, R. 1988. A revolution of ideas in agricultural origins. Science 240: 984-986.

Li, J.-L. 1970. The origin of cultivated plants in southeast Asia. Econ. Bot. 24: 3-19.

MacNeish, R. S. 1965. The origins of American agriculture. Antiquity 39: 87-94.

Merrill, E. D. 1938. Domesticated plants in relation to the diffusion of cultures. Bot. Rev. 4: 1-20.

Meyers, J. T. 1971. The origins of agriculture: an evaluation of three hypotheses. In, Struever, S. Prehistoric agriculture. Natural History Press. Garden City, New York.

Monastersky, R. 1998. Paleoscatology: prying DNA from dated dung. Science News 154(3): 38.

Nabhan, G. P. 1979. Cultivation and culture. The Ecologist 9(8-9): 259-263.

Nabhan, G. P. & R. S. Felger. 1985. Wild relatives of crops: their direct uses as food. In, Wickens, G. E., J. R. Goodin, and D. V. Field. Plants for arid lands. George Allen & Unwin. London. Pp. 19-34.

Pearsall, D. M. 1989. Palaeoethnobotany: a handbook of procedures. Academic Press. London, England.

Pickersgill, B. 1972. Cultivated plants as evidence for cultural contacts. American Antiq. 37: 97-104.

Power, J. F. & R. F. Follett. 1987. Monoculture. Sci. American 256(3): 78-86.

Prescott-Allen, R. & C. 1983. Genes from the wild: using wild genetic resources for food and raw materials. An Earthscan Paperback. London. 101 pp.

Prescott-Allen, R. & C. 1990. How many plants feed the world? Conservation Biology 4(4): 365-374.

Price, T. D. & A. B. Gebauer (editors). 1995. Last hunters, first farmers. Advanced Seminar Series. School of American Research. Santa Fe, CA.

Pringle, H. 1998. The slow birth of agriculture. Science 282: 1446-1450.

Raamsdonk, L. W. D. van. 1993. Wild and cultivated plants: the parallelism between evolution and domestication. Evol. Trends in Plants 7(2): 73-84.

Reed, C. A. (editor). 1978. Origins of agriculture. Papers from a conference, 1973. Mouton. The Hague. 1014 pp.

Reinhard, K. J. & V. M. Bryant. 1992. Coprolite analysis: a biological perspective on archaeology. In, Schiffer, M. B. (editors). Archaeological method and theory. Univ. Arizona Press. Tucson, AZ. 4: 245-288.

Renfrew, J. M. 1969. The archaeological evidence for the domestication of plants: methods and problems. In, Ucko, P. & G. W. Dimbleby (editors). The domestication and exploitation of plants and animals. Aldine Publ. Co. Pp.149-72.

Rhoades, R. E. 1991. The world's food supply at risk. Natl. Geogr. 179(4): 74-105.

Rindos, D. 1984. The origins of agriculture. An evolutionary perspective. Academic Press. Orlando, FL. 325 pp.

Rogers, D. & S. M. Wilson (editors). 1993. Ethnohistory and archaeology: approaches to postcontact change in the Americas. Plenum. New York, NY. 237 pp.

Sage, R. F. 1995. Was low atmospheric $C0^2$ during the Pleistocene a limiting factor for the origin of agriculture? Global Change Biol. 1: 93-100.

Sauer, C. O. 1947. Early relations of man to plants. Geogr. Rev. 37: 1-25.

Sauer, C. O. 1952. Agricultural origins and dispersal. American Geogr. Soc. New York, NY. 110 pp.

Sauer, C. O. 1969. Seeds, spades, hearths, and herds: the domestication of animals and foodstuffs. Second edition. MIT Press. Cambridge, MA. 175 pp.

Schultze-Motel, J. 1988. Paleoethnobotanik und ihr Beitrag zue Evolutionsforschung bei Kulturpflanzen. Die Kulturpflanzen 36: 237-246.

Schwanitz, F. 1966. The origin of cultivated plants. Harvard Univ. Press. Cambridge, MA. 175 pp.

Shell, E. R. 1990. Seeds in the bank could stave off disaster on the farm. Smithsonian 20(10): 94-105.

Shepard, P. 1973. The tender carnivore and the sacred game. Charles Scribner's Sons. New York, NY. 302 pp.

Shulman, S. 1986. Seeds of controversy. BioScience 36(10): 647-651.

Smith, B. D. 1995. The emergence of agriculture. Sci. American Library. New York, NY. 230 pp.

Smith, B.D. 1998. Between foraging and farming. Science 279: 1651, 1652.

Smith, C. E., Jr. 1969. From Vavilov to the present. Econ. Bot. 23: 2-19.

Sokolov, R. 1987. Columbus's biggest discovery. Nat. Hist. August: 66, 67.

Solbrig, O. T. & D. J. Solbrig. 1994. So shall you reap: farming and crops in human affairs. Shearwater Books. Washington, D. C. 284 pp.

Solheim, W. G. III. 1982. An earlier agricultural revolution. Sci. Amer. 226(4): 34-41.

Stearn, W. T. 1965. The origin and later development of cultivated plants. J. Roy. Hort. Soc. 90: 279-341.

Struever, S. (editor). 1971. Prehistoric agriculture. Natural History Press. Garden City, NY. 733 pp.

Trepl, L. 1995. Anthropogenic migration of plants and naturalisation. In, Sukopp, H. et al. (editors). Urban ecology. Acad. Publ. The Hague. Pp. 75-97.

Trigg, H. B. et al. 1994. Coprolite evidence for prehistoric foodstuffs, condiments, and medicines. In, Etkin, N. L. (editor). Eating on the wild side. Univ. Arizona Press. Tucson. Pp. 210-223.

Ucko, P. J. & G. W. Dimbleby. 1969. The domestication and exploitation of plants and animals. Aldine Publ. Co. 581 pp.

Vasey, D. E. 1992. An ecological history of agriculture: 10,000 B. C. - A. D. 10,000. Iowa State Univ. Press. Ames. 363 pp.

Vavilov, N. I. 1926. Studies on the origin of cultivated plants. Bull. App. Bot. 16: 139-248.

Vavilov, N. I. 1951. The origin, variation, immunity and breeding of cultivated plants. Translated from the Russian by K. Starr Chester. Ronald Press Co. New York, NY. 364 pp.

Vavilov, N. I. 1992. Origin and geography of cultivated plants. Translated by D. Löve. Cambridge Univ. Press. Cambridge, England. 498 pp.

Wilke, P. J., R. Bettinger, T. F. King, & J. F. O'Connell. 1972. Harvest selection and domestication in seed plants. Antiquity 46: 203-208.

Wright, H. E., Jr. 1977. Environmental change and the origin of agriculture in the Old and New Worlds. In, Reed, C. A. (editor). Origins of agriculture. Pp. 281-318.

Zeist, W. van & W. A. Casparie (editors). 1983. Plants and ancient man. Studies in palaeoethnobotany. Proc. 6th Symp. International Work Group of Palaeobotany. Groningen. The Netherlands. 344 pp.

Zeven, A. C. & P. M. Zhukovsky. 1975. Dictionary of cultivated plants and their centres of diversity. Centre for Agric. Publ. and Documentation. Wageningen. 219 pp.

Zhukovsky, P. M. 1962. Cultivated plants and their wild relatives. Translated from the Russian by P. S. Hudson. Farnham Royal (Commonwealth Agric. Bureau). 107 pp.

Zhukovsky, P. M. 1968. New centres of origin and new gene centres of cultivated plants including specifically endemic microcentres of species closely allied to cultivated species. Bot. Zh. 53: 430-460.

Zohary, D. 1970. Centers of diversity and centers of origin. In, Frankel, O. H. and E. Bennet (editors). Genetic resources in plants -- their exploitation and conservation. Pp. 33-42.

Zohary, D. 1984. Modes of evolution in plants under domestication. In, Grant, W. (editor). Plant biosystematics. Academic Press. Montreal. Pp. 579-586.

Zohary, D. 1999. Monophyletic vs. polyphyletic origins of the crops on which agriculture was founded in the Near East. Genetic Res. & Crop Evol. 46: 133-142.

VAVILOV & LYSENKO

Cohen, B. M. 1991. Nikolai Ivanovich Vavilov: the explorer and plant collector. Econ. Bot. 45(1): 38-46.

Cuvasina, N. P. 1988. N. I. Vavilov -- Personlichkeit und Mensch. Die Kulturpflanze 36: 55-60.

Dobzhansky, T. 1947. N. I. Vavilov, a martyr of genetics. J. Heredity 38(8): 227-232.

Gershenson, S. M. 1990. The grim heritage of Lysenkoism: four personal accounts. IV. Difficult years in Soviet genetics. Quart. Rev. Biol. 65(4): 447-456.

Glass, B. 1990. The grim heritage of Lysenkoism: four personal accounts: I. Foreward. Quart. Rev. Biol. 65(4): 413-421.

Haldane, J. B. S. 1940. Lysenko and genetics. Sci. Soc. 4: 433-437.

Harris, D. R. 1990. Vavilov's concept of centers of origin of cultivated plants: its genesis and its influence on the study of agricultural origins. J. Linnean Soc. 39(1): 7-16.

Hawkes, J. G. 1988. The Vavilov centenary: a personal view of the man and his work. Plants Today 1(4): 107, 108.

Hawkes, J. G. 1990. N. I. Vavilov -- the man and his work. Biol. J. Linnean Soc. 39(1): 3-6.

Johnston, B. A. 1998. Nicolay Ivanovich Vavilov, plant explorer extraordinaire. HerbalGram 44: 14,15.

Joravsky, D. 1970. The Lysenko affair. Harvard Univ. Press. Cambridge, MA. 459 pp.

Krementsov, N. 1996. A “second front” in Soviet genetics: The international dimension of the Lysenko controversy, 1944-1947. J. Hist. Biol. 29: 229-250.

Lysenko, T. D. 1956. Stalin and Michurinist agrobiology. J. Heredity XLVII(2): 56; 104.

Mather, K. 1942. Genetics and the Russian controversy. Nature 149: 427, 430.

Medvedev, Z. A. 1969. The rise and fall of T. D. Lysenko. Columbia Univ. Press. New York, NY. 284 pp.

Popovsky, M. 1984. The Vavilov affair. Shoe String Press. Hamden, CT. 216 pp.

Smith, C. E. 1969. From Vavilov to the present. Econ. Bot. 23: 2-19.

Soyfer, V. N. 1994. Lysenko and the tragedy of Soviet science. Rutgers Univ. Press. New Brunswick, NJ. 379 pp.

Theunissen, B. 1996. A ‘second front’ in Soviet genetics: the international dimension of the Lysenko controversy, 1944-1947. J. Hist. Biol. 29(2): 229-250.

Vitkovskij, V. L. 1988. Leben und Werk N. I. Vavilov. Die Kulturpflanze 36: 43-53.

Zirkle, C. 1956. L'affaire Lysenko. J. Heredity 47(2): 47.

DOMESTICATION: OLD WORLD

Ambrosoli, M. 1997. The wild and the sown: agriculture and botany in western Europe, 1350-1850. Cambridge Univ. Press. Cambridge, England. 512 pp.

Ammerman, A. J. & L.. L.. Cavalli-Sforza. 1971. Measuring the rate of spread of early farming in Europe. Man 6: 674-688.

Burkhill, I. H. 1953. Habits of man and the origins of the cultivated plants of the Old World. Proc. Linn. Soc. 164: 12-42.

Chang, K. C. 1970. The beginnings of agriculture in the Far East. Antiquity 44: 175-185.

Chorley, G. P. H. 1981. The agricultural revolution in northern Europe, 1750-1880: nitrogen, legumes, and crop productivity. Econ. Hist. Rev. 34: 71-93.

Clark, J. D. 1976. Prehistoric populations and pressures favoring plant domestication in Africa. In, Harlan, J. R. et al. (editors). Origins of African plant domestication. Mouton Press. The Hague. Pp. 67-105.

Clark, J. D. and S. A. Brandt. 1984. From hunters to farmers: the causes and consequences of food production in Africa. Univ. California Press. Berkeley. 433 pp.

Harlan, J. R., J. M. J. de Wet, & A. Stemler (editors). 1976. Origins of African plant domestication. Mouton World Anthrop. Series. The Hague. 498 pp.

Harris, D. R. (editor). 1996. The origin and spread of agriculture and pastoralism in Eurasia. Univ. College London Press. London, England.

Helbaek, H. 1959. Domestication of food plants in the Old World. Science 130: 365-72.

Kerr, R. A. 1998. Black Sea deluge may have helped spread farming. Science 279: 1132.

Lee, R. 1979. The !Kung San: men, women and work in a foraging society. Cambridge Univ. Press. Cambridge, England

Lev-Yadun, S., A. Gopher, & S. Abbo. 2000. The cradle of agriculture. Science 288: 1602, 1603.

Murray, J. 1970. The first European agriculture, a study of the osteological and botanical evidence until 2000 BC. Edinburgh Univ. Press. Edinburgh, Scotland. 380 pp.

Renfrew, J. M. 1973. Palaeoethnobotany: the prehistoric food plants of the Near East and Europe. Columbia University Press. New York, NY. 247 pp. + plates.

Solecki, R. 1975. Shanidar IV, a Neanderthal flower burial in northern Iraq. Science 190: 880, 881.

Vavilov, N. I. 1931. The role of Central Asia in the origin of cultivated plants. Bul. Appl. Bot., Genetics and Plant Breeding 26: 3-44. (In Russian).

Wendorf, F. et al. 1992. Saharan exploitation of plants 8,000 years BP. Nature 359: 721-724.

Wright, H. E., Jr. 1976. The environmental setting for plant domestication in the Near East. Science 194: 385-389.

Zhukovsky, P. M. 1965. Main gene centres of cultivated plants and their wild relatives within the territory of the U.S.S.R. Euphytica 14(2): 177-88.

Zohary, D. & M. Hopf. 2001. Domestication of plants in the Old World. Third edition. Oxford Univ. Press. New York, NY. 316 pp.

DOMESTICATION: NEW WORLD

Carter, G. F. 1950. Plant evidence for early contacts with America. Southwest J. Anthrop. 66: 161-82.

Chomko, S. A. and G. W. Crawford. 1978. Plant husbandry in prehistoric eastern North America: new evidence for its development. American Antiq. 43: 405-408.

Clement, C. R. 1989. A center of crop genetic diversity in western Amazonia. BioScience 39: 624-631.

Cook, O. F. 1925. Peru as a center of domestication. J. Heredity 16: 33-46; 95-110.

Denevan, W. M. 1970. Aboriginal drained-field cultivation in the Americas. Science 169: 647-654.

Denevan, W. M. 1992. The pristine myth: the landscape of the Americas in 1492. Ann. Assoc. American Geogr. 82: 369-385.

Erlandson, J. M. 1994. Early hunter-gatherers of the California coast. Plenum. New York, NY. 336 pp.

Heiser, C. B., Jr. 1965. Cultivated plants and cultural diffusion in nuclear America. Amer. Anthrop. 67: 930-49.

Heiser, C. B., Jr. 1979. Origins of some cultivated New World plants. Ann. Rev. Ecol. Syst. 10: 309-26.

Hills, W. H. 1989. Early prehistoric agriculture in the American Southwest. Univ. Washington Press. Seattle. 184 pp.

Hurt, R. D. 1994. American agriculture: a brief history. Iowa State Univ. Press. Ames. 412 pp.

MacNeish, R. S. 1964. The food-gathering and incipient agricultural stage of prehistoric Middle America. In, West, R. C. (editor). Natural environments and early cultures. Handbook of Middle American Indians. Univ. Texas Press. Austin. 1: 413-26.

MacNeish, R. S. 1964. The origins of New World civilization. Sci. American 211(5): 29-37.

Mangelsdorf, P. C., R. S. MacNeish, & G. R. Willey. 1965. Origins of agriculture in Middle America. In, Handbook of Middle American Indians. Univ. Texas Press. Austin. Pp. 427-45.

McLaughlin, S. P. 1985. Economic prospects for new crops in the southwestern United States. Econ. Bot. 39(4): 473-481.

Merrill, E. D. 1950. Observations on cultivated plants with reference to certain American problems. Ceiba 1: 3-36.

Nabhan, G. P. 1985. Native crop diversity in Aridoamerica: conservation of regional gene pools. Econ. Bot. 39(4): 387-399.

Nabhan, G. P. 1989. Enduring seeds: native American agriculture and wild plant conservation. North Point Press. San Francisco, CA. 225 pp.

Pickersgill, B. 1977. Taxonomy and the origin and evolution of cultivated plants in the New World. Nature 268: 591-595.

Pickersgill, B. & C. B. Heiser, Jr. 1977. Origins and distribution of plants domesticated in the New World tropics. In, Reed, C. A. (editor). Pp. 803-835.

Piperno, D. R. & D. M. Pearsall. 1998. The origins of agriculture in the lowland neotropics. Academic Press. San Diego, CA. 400 pp.

Sanders, W. T. 1976. The agricultural history of the Basin of Mexico. In, Wolf, E. (editor). The valley of Mexico. Univ. New Mexico Press. Albuquerque. Pp. 101-160.

Sauer, C. O. 1936. American agricultural origins: a consideration of nature and culture. In, Essays in anthropology, presented to A. L. Kroeber. Univ. California Press. Pp. 279-97.

Sauer, C. O. 1959. Age and area of American cultivated plants. Actas 33d Internationales Congreso Americanistes 1: 215-29.

Sauer, C. O. 1965. Cultural factors in plant domestication in the New World. Euphytica 14(3): 301-6.

Sauer, C. O. 1965. American agricultural origins: a consideration of nature and culture. In, Leighly, J. (editor). Land and life. A selection of the writings of Carl Ortwin Sauer. Univ. California Press. Berkeley. Pp. 121-144.

Smith, B. D. 1989. Origins of agriculture in eastern North America. Science 126: 1566-1571.

Smith, B. D. 1992. Rivers of change: essays on early agriculture in eastern North America. Smithsonian Inst. Press. Washington, D. C. 302 pp.

Smith, C. E., Jr. 1966. Bibliography of American archaeological plant remains. Econ. Bot. 20(4): 446-460.

Smith, C. E., Jr. 1968. The New World centers of origin of cultivated plants and archeological evidence. Econ. Bot. 22: 253-66.

Toll, H. W. (editor). 1995. Soil, water, biology and belief in prehistoric and traditional southwestern agriculture. New Mexico Arch. Council. Albuquerque, NM. 373 pp.

Vavilov, N. I. 1931. Mexico and Central America as the principal centres of origin of cultivated plants in the New World. Bull. Appl. Bot. Genet. Pl. Breed. 26: 135-199. (In Russian).

Weatherford, J. 1988. Indian givers: how the Indians of the Americas transformed the world. Crown Books. New York, NY. 272 pp.

Whitney, G. G. 1994. From coastal wilderness to fruited plain. Cambridge Univ. Press. Cambridge, England. 451 pp.

Wright, K. 1999. First Americans. Discover 20(2): 52-58, 60, 62, 63.

DOMESTICATION: OCEANIA

Barrau, J. 1963. Plants and the migrations of Pacific peoples. Bishop Museum. Honolulu, HI. 136 pp.

Carter, G. F. 1953. Plants across the Pacific. Amer. Antiquity (Mem.) 18(No. 3 pt. 2): 62-71.

Denham, T. P. et al. 2003. Origins of agriculture at Kuk Swamp in the highlands of New Guinea. Science 301: 189-193.

Neumann, K. 2003. New Guinea: a cradle of agriculture. Science 301: 180, 181.

Yen, D. E. 1985. Wild plants and domestication in Pacific islands. In, Miscara, V. N. & P. Bellwood (editors). Recent advances in Indo-Pacific prehistory. Oxford and IBP. New Delhi, India. Pp. 315-326.

W E E D S

Anderson, W. P. 1999. Perennial weeds: characteristics and identification of selected herbaceous species. Iowa State Univ. Press. Ames. 228 pp.

Baker, H. G. 1962. Weeds -- native and introduced. J. California Hort. Soc. 23: 97-104.

Baker, H. G. 1965. Characteristics and modes of origin of weeds. In, Baker, H. G. and G. L. Stebbins (editors). Genetics of colonizing species. Pp. 147-168.

Baker, H. G. 1972. Migrations of weeds. In, Valentine, D. H. (editor). Taxonomy, phytogeography and evolution. Academic Press. London, U. K. Pp. 327-347.

Baker, H. G. 1974. The evolution of weeds. Ann. Rev. Ecology and Systematics 5: 1-24.

Baker, H. G. 1985. What is a weed? Fremontia 12(4): 7-11.

Baker, H. G. 1991. The continuing evolution of weeds. Econ. Bot. 45(4): 445-449.

Barrett, S. C. H. 1983. Crop mimicry in weeds. Econ. Bot. 37: 255-282.

Bridges, D. (editor). 2002. Crop losses due to weeds in the United States. Weed Sci. Soc. of America. Champaign, IL.

Canada Weed Committee. 1975. Common and botanical names of weeds in Canada. Information Canada. Ottawa. 67 pp.

Cox, G. W. 1999. Alien species in North America and Hawaii – impacts on natural ecosystems. Island Press. Washington, D. C. 387 pp.

Crockett, L. J. 1977. Wildly successful plants: a handbook of North American weeds. Collier Books. New York, NY. 268 pp.

Crosby, A. W. 1986. Weeds. In, Ecological imperialism: the biological expansion of Europe, 900-1900. Cambridge Univ. Press. Cambridge, U. K. Pp. 145-170.

Crowe, T. M. 1979. Lots of weeds: insular phytogeography of vacant urban lots. J. Biogeogr. 6: 169-182.

deWet, J. M. J. & J. R. Harlan. 1975. Weeds and domesticates: evolution in the man-made habitat. Econ. Bot. 29: 99-107.

DeWit, M. 2001. Economic impacts of invasive weeds. Noxious Times 4(1): 8-11.

Frankton, C. 1987. Weeds of Canada. Univ. Toronto Press. Toronto. 217 pp.

Frenkel, R. E. 1970. Ruderal vegetation along certain California roadsides. Univ. California Publ. in Geogr. 20: 1-163.

Gunn, C. R. & C. A. Ritchie. 1988. Identification of disseminules listed in the federal noxious weed act. Tech. Bull. 1719. U. S. Dept. Agric. Washington, D. C.

Harlan, J. R. 1965. The possible role of weed races in the evolution of cultivated plants. Euphytica 14: 173-176.

Harlan, J. R. & J. M. J. deWet. 1965. Some thoughts about weeds. Econ. Bot. 19: 16-24.

Holm, L. G. 1971. The role of weeds in human affairs. Weed Sci. 19: 485-490.

Holm, L. G. et al. 1977. The world's worst weeds, distribution and biology. Univ. Press Hawaii. Honolulu. 609 pp.

Holm, L. G. et al. 1997. World weeds: natural histories and distribution. John Wiley & Sons. New York, NY. 1129 pp.

Jenkins, C. N. & S. L. Pimm. 2003. How big is the global weed patch? Annals Missouri Bot. Gard. 90(2): 172-178.

Jones, P. 1994. Just weeds: history, myths and uses. Chapters Publ. Shelburne, VT. 255 pp.

Lorenzi, H. & L. S. Jeffrey. 1987. Weeds of the United States and their control. Van Nostrand Reinhold. New York, NY. 355 pp.

Mack, R. N. 1990. Catalog of woes. Natural History March: 44-53.

Martin, A. C. 1987. Weeds. St. Martin's Press. New York, NY. 160 pp.

Mensing, S. & R. Byrne. 1999. Invasion of Mediterranean weeds into California before 1769. Fremontia 27(3): 6-9.

Muenscher, W. C. 1960. Weeds. Second edition. Macmillan Co. New York, NY. 560 pp.

Pimentel, D. 2002. Biological invasions: economic and environmental costs of alien plant, animal, and microbe species. CRC Press. Boca Raton, FL. 376 pp.

Randall, J. M., M. Rejmanek, & J. C. Hunter. 1998. Characteristics of the exotic flora of California. Fremontia 26(4): 3-12.

Reed, C. F. 1970. Selected weeds of the United States. Agric. Handbook No. 366. U. S. Dept. of Agriculture. Washington, D. C. 463 pp.

Reed, C. F. 1977. Economically important weeds. Agriculture Handbook No. 498. U. S. Dept. of Agriculture. Washington, D. C. 746 pp.

Robbins, W. W., M. K. Bellue, & W. S. Ball. 1951. Weeds of California. State of California. Sacramento. 547 pp.

Royer, F. & R. Dickinson. 1999. Weeds of the northern U. S. and Canada. Lone Pine Publ. & Univ. Alberta Press. Renton, WA & Alberta, Canada. 433 pp.

Schierenbeck, K. A., K. G. Gallagher, & J. N. Holt. 1998. The genetics and demography of invasive plant species. Fremontia 26(4): 19-23.

Sheley, R. L. & J. K. Petroff (editors). 1999. Biology and management of noxious rangeland weeds. Oregon State Univ. Press. Corvallis. 608 pp.

Sokolov, R. 1991. Grasping the nettle. Nat. Hist. August: 72-75.

Stein, B. A. & S. R. Flack (editors). 1996. America's least wanted: alien species invasions of U. S. ecosystems. The Nature Conservancy. Arlington, VA. 31 pp.

Strobel, G. A. 1991. Biological control of weeds. Sci. American 265(1): 72-78.

Weed Science Society of America. 1984. Composite list of weeds. Weed Sci. 32 (Suppl. 2): 1-137.

Whitson, T. D. 1991. Weeds of the West. Western Soc. Weed Sci., in cooperation with the Western Land Grant Univ. Pullman, WA. 630 pp.

Wilkinson, R. E. & H. E. Jacques. 1979. How to know the weeds. Third edition. W. C. Brown Co. Dubuque, IA. 235 pp.

Uva, R. H., J. C. Neal, & J. DiTomaso. 1997. Weeds of the Northeast. Cornell Univ. Press. Ithaca, NY. 416 pp.

3: THE GREAT EXPLORERS

THE COLUMBIAN EXCHANGE

Cohen, J. M. (editor and translator). 1969. The four voyages of Christopher Columbus. Penguin Books. Baltimore, MD. 320 pp.

Cohen, J. B. 1992. What Columbus 'saw' in 1492. Sci. American 267(6): 100-106.

Crosby, A. W., Jr. 1972. The Columbian exchange: biological and cultural consequences of 1492. Greenwood Press. Westport, Ct. 268 pp.

Crosby, A. W., Jr. 1986. Ecological imperialism: the biological expansion of Europe, 900-1900. Cambridge Univ. Press. Cambridge, England.

Crosby, A. W., Jr. 1993. Native American crops and European history: the influence of American on Europe. In, Natives & newcomers: challenges of the encounter. Cabrillo Hist. Assoc. San Diego, CA. Pp. 45-57.

Denevan, W. M. 1992. The pristine myth: the landscape of the Americas in 1492. Ann. Assoc. American Geogr. 82: 368-385.

Dressler, R. L. 1953. The Pre-Columbian cultivated plants of Mexico. Bot. Mus. Leaflts Harvard Univ. 16: 115-72.

Dunn, O. & J. E. Kelley, Jr. (editors). 1989. The diario of Christopher Columbus's first voyage to America, 1492-1493. Univ. Oklahoma Press. Norman. 491 pp.

Ewan, J. 1976. The Columbian discoveries and the growth of botanical ideas with special reference to the sixteenth century. In, Chiapelli, F. First images of America. Univ. California Press. Berkeley. Pp. 807-812.

Ewan, J. 1991. Who conquered the New World? Or four centuries of exploration in an indehiscent capsule. Ann. Missouri Bot. Gard. 78(1): 57-64.

Kingsbury, J. M. 1991. Christopher Columbus as a botanist. Cornell Plantations 45(4): 7-31.

Sokolov, R. 1987. Columbus's biggest discovery. Nat. Hist. August: 66, 67.

Weatherford, J. 1988. Indian givers: how the Indians of the Americas transformed the world. Crown Books. New York, NY. 272 pp.

Wright, R. 1992. Stolen continents: the 'New World' through Indian eyes. Houghton Mifflin Co. Boston, MA. 424 pp.

THE POLYNESIAN EXCHANGE

Barrau, J. 1963. Plants and the migrations of Pacific peoples. Bishop Museum. Honolulu, HI. 136 pp.

Carter, G. F. 1950. Plant evidence for early contacts with America. Southwest J. Anthrop. 66: 161-82.

Carter, G. F. 1953. Plants across the Pacific. American Antiquity (Mem.) 18(3 pt. 2): 62-71.

Heyerdahl, T. 1950. The voyage of the raft Kon-Tiki: an argument for American-Polynesian diffusion. Geogr. J. 115: 20-41.

Heyerdahl, T. 1952. American Indians in the Pacific. The theory behind the Kon-Tiki expedition. Rand McNally. Chicago, IL. 821 pp.

Kirch, P. V. 1982. The impact of the prehistoric Polynesians on the Hawaiian ecosystem. Pacific Sci. 36: 1-14.

Nagata, K. M. 1985. Early plant introductions in Hawai'i. Hawaiian J. Hist. 19: 35-61.

Pickersgill, B. 1972. Cultivated plants as evidence for cultural contacts. American Antiq. 37: 97-104.

Pickersgill, B. & A. H. Bunting. 1969. Cultivated plants and the Kon-Tiki theory. Nature 222: 225-7.

Stone, D. (editor). 1984. Pre-Columbian plant migration. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 76. Harvard Univ. Press. 183 pp.

Whistler, W. A. 1991. Polynesian plant introductions. In, Cox, P. A. & S. A. Banack (editors). Islands, plants, and Polynesians. Dioscorides Press. Portland, OR. Pp. 41-66.

MODERN EXPLORATION: GENERAL

Badger, G. 1996. The explorers of the Pacific. Kangaroo Press. Kenthurst, Australia. 256 pp.

Beaglehole, J. C. 1966. The exploration of the Pacific. Third edition. Stanford Univ. Press. Stanford, CA. 346 pp.

Bellwood, P. 1979. Man's conquest of the Pacific. Oxford Univ. Press. New York, NY.

Bretschneider, E. 1898. History of European botanical discoveries in China. Two vols. K. F. Koehlers Antiquarium. Leipzig.

Brockway, L. H. 1979. Science and colonial expansion: the role of the British Royal Botanic Gardens. Academic Press. New York, NY. 215 pp.

Brosse, J. 1983. Great voyages of discovery: circumnavigators and scientists, 1764-1843. Facts on File. New York, NY. 228 pp.

Brown, D. (editor). 2003. The greatest exploration stories ever told. Lyons Press. Guilford, CT. 396 pp.

Chiappelli, F. (editor). 1976. First images of America. The impact of the New World on the Old. Two vols. Univ. California Press. Berkeley. 957 pp.

Coats, A. M. 1969. The plant hunters. McGraw-Hill Books. New York, NY. 400 pp.

Cooley, M. E. 1940. The exploring expedition in the Pacific. Proc. American Phil. Soc. 82(5): 707-719.

Dodge, B. S. 1979. It started in Eden: how the plant-hunters and the plants they found changed the course of history. McGraw-Hill Book Co. New York, NY. 288 pp.

Ewan, J. 1976. The Columbian discoveries and the growth of botanical ideas with special reference to the sixteenth century. In, Chiapelli, F. First images of America. Univ. California Press. Berkeley. Pp. 807-812.

Ewan, J. 1991. Who conquered the New World? Or four centuries of exploration in an indehiscent capsule. Ann. Missouri Bot. Gard. 78(1): 57-64.

Eyde, R. H. 1985. Expedition botany: the making of a new profession. In, Viola, H. J. & C. Margolis. Pp. 25-41.

Gascoigne, J. 1994. Joseph Banks and the English enlightenment: useful knowledge and polite culture. Cambridge Univ. Press. Cambridge, England. 324 pp.

Goetzmann, W. H. 1995. New lands, new men: America and the second great age of discovery. Texas State Hist. Assoc. Austin. 528 pp.

Goodspeed, T. H. 1961. Plant hunters in the Andes. Univ. California Press. Berkeley. 378 pp.

Gray, W. R. 1981. Voyages to paradise: exploring in the wake of Captain Cook. Natl. Geogr. Soc. Washington, D. C. 215 pp.

Hagen, V. W. von. 1948. South America, the green world of the naturalists: five centuries of natural history in South America. Eyre & Spottiswoode. London, England. 396 pp.

Hagen, V. W. von. 1955. South America called them: explorations of the great naturalists: La Condamine, Humboldt, Darwin, Spruce. Third edition. Little Brown. Boston, MA. 311 pp.

Hepper, F. N. (editor). 1989. Plant hunting for Kew. Royal Bot. Gard., Kew. Her Majesty's Stationary Office. London, England. 222 pp.

Kingdon-Ward, F. 1924. The romance of plant hunting. E. Arnold. London, England. 275 pp.

Kingdon-Ward, F. 1930. Plant hunting on the edge of the world. V. Gollancz. London, England. 383 pp.

Lemmon, K. 1968. The golden age of plant hunters. A. S. Barnes. Cranbury, NJ. 229 pp.

Maslow, J. 1996. Footsteps in the jungle: adventures in the scientific exploration of the American tropics. Ivan Dee. Chicago, IL. 308 pp.

McCracken, D. P. 1997. Gardens of empire: botanical institutions of the Victorian British empire. Leicester Univ. Press. London, U. K. 242 pp.

McKelvey, S. D. 1955. Botanical exploration of the trans-Mississippi West, 1790-1850. Arnold Arboretum. Jamaica Plains, NY. 1144 pp.

Miller, D. P. & P. H. Reill (editors). 1996. Visions of empire: voyages, botany, and representations of nature. Cambridge Univ. Press. Cambridge, England. 370 pp.

Moorehead, A. 1966. The fatal impact: the invasion of the South Pacific, 1767-1840. Harper & Row. New York, NY. 252 pp.

Morison, S. E. 1974. The European discovery of America: the southern voyages A. D. 1492-1616. Oxford Univ. Press. New York, NY.

Musgrave, T., C. Gardner, & W. Musgrave. 1998. The plant hunters: two hundred years of adventure and discovery around the world. Ward Lock. London, England. 224 pp.

Pennington, P. 1979. The great explorers. Facts On File. New York, NY. 336 pp.

Raby, P. 1997. Bright paradise: Victorian scientific travellers. Princeton Univ. Press. Princeton, NJ. 276 pp.

Reveal, J. L. 1992. Gentle conquest: the botanical discovery of North America, with illustrations from the Library of Congress. Starwood Publ. Co. Washington, D. C. 160 pp.

Roberts, G. 1989. Atlas of discovery. Gallery Books. New York, NY. 192 pp.

Sauer, J. D. 1976. Changing perception and exploitation of New World plants in Europe, 1492-1800. In, Chiapelli, F. (editor). First images of America. Univ. California Press. Berkeley. Pp. 813-832.

Sharp, A. 1962. The discovery of the Pacific Islands. Clarendon Press. Oxford, England. 259 pp.

Smith, A. 1990. Explorers of the Amazon. Univ. Chicago Press. Chicago, IL. 344 pp.

Stearn, W. T. 1958. Botanical exploration to the time of Linnaeus. Proc. Linnean Soc. London 169: 173-196.

Tourtellot, J. B. 1987. Into the unknown: the story of exploration. Natl. Geogr. Soc. Washington, D. C. 336 pp.

Wright, R. 1992. Stolen continents: the 'New World' through Indian e yes. Houghton Mifflin Co. Boston, MA. 424 pp.

JAMES COOK & JOSEPH BANKS

Aughton, P. 1999. Endeavour: the story of Captain Cook’s first great epic voyage. Barnes & Noble. New York. NY. 216 pp.

Banks, J. 1896. Journal of the Right Hon. Sir Joseph Banks... during Captain Cook's first voyage in H. M. S. Endeavour in 1768-71.... Edited by Sir Joseph D. Hooker. Macmillan & Co. London, England. 466 pp.

Beaglehole, J. C. (editor). 1955-1967. The journals of Captain Cook on his voyages of discovery. Three vols. Hakluyt Soc. and Cambridge Univ. Press.

Beaglehole, J. C. 1962. The Endeavour journal of Joseph Banks, 1768-1771. Two vols. Public Library New South Wales and Angus & Robertson.

Beaglehole, J. C. 1974. The life of Captain Cook. Hakluyt Soc. and Cambridge Univ. Press.

Blunt, W. & W. T. Stearn. 1968. Captain Cook's florilegium: a selection of engravings from the drawings of plants collected by J. Banks and D. Solander .... Lion and Unicorn Press. London, England.

Cameron, H. C. 1952. Sir Joseph Banks... the autocrat of the philosophers. Angus & Robertson. Sydney, Australia. 341 pp.

Carr, D. J. (editor). 1983. Sydney Parkinson, artist of Cook's Endeavour voyage. British Museum (Natural History) and Croom Helm. London, England. 300 pp.

Cook, J. & G. Forster. 1777. A voyage round the world performed in His Brittanic Majesty's ships the Resolution and Adventure in the years 1772, 1773, 1774, and 1775 and written by James Cook, Commander of the Resolution, and G. Forster, F. R. S. W. Two vols. Whitestone. Dublin, Ireland.

Cook, J. 1784. A voyage to the Pacific Ocean 1776-1780.... Two vols. Strahan. London, England.

Cook, J. & J. King. 1796. A voyage to the Pacific Ocean for making discoveries in the northern hemisphere ... in the years 1776, 1777, 1778, 1779, 1780. Four vols. Tiebout & O'Brien. New York, NY.

Duggard, M. 2001. Farther than any man: the rise and fall of Captain James Cook. Pocket Books. New York, NY. 287 pp.

Ebes, H. 1988. The florilegium of Captain Cook's first voyage to Australia, 1768-1771. Ebes Douwma Antique Prints and Maps and Sotheby's Australia. Melbourne and Paddington. 200 pp.

Ewan, J. 1974. The botany of Cook's voyages. Bull. Pacific Trop. Bot. Gard. 4: 65-75.

Fisher, R. & H. Johnston (editors). 1979. Captain James Cook and his times. Univ. Washington Press. Seattle. 278 pp.

Francis, J. 1972. Sir Joseph Banks, architect of science and empire. Proc. Royal Soc. Queensland 83: 1-19.

Horowitz, T. 2002. Blue latitudes: boldly going where Captain Cook has gone before. Henry Holt. New York, NY. 480 pp.

Hough, R. 1994. Captain James Cook. W. W. Norton. New York, NY. 398 pp.

Joppien, R. & B. Smith. 1985-1988. The art of Captain Cook's voyages. Yale Univ. Press. New Haven, CT. Three vols.

Lamb, C. 1991. Knight to empress. The Garden 116(2): 71-75. [Joseph Banks]

Maclean, A. 1972. Captain Cook. Doubleday Books. Garden City, NJ. 192 pp.

Merrill, E. D. 1954. The botany of Cook's voyages. Chron. Bot. 14: 161-384.

Nicolson, D. H. & F. R. Fosberg. 2003. The Forsters and the botany of the second Cook expedition (1772-1775). Regnum Vegetabile 139. 758 pp.

O'Brian, P. 1993. Joseph Banks: a life. Godine. Boston, MA. 430 pp.

Parkinson, S. 1773. A journal of a voyage to the South Seas in His Majesty's ship the Endeavour. Faithfully transcribed from the papers of the late Sydney Parkinson, draughtsman to Sir Joseph Banks Esq. on his late expedition with Dr. Solander, round the world. London, England.

Robon, J. 2000. Captain Cook's world: maps of the life and voyages of James Cook R. N. Univ. Washington Press. Seattle. 212 pp.

Schiff, B. 1983. A flowering of science: plants from Captain Cook's first voyage. Smithsonian 13(12): 76-82; 84, 85.

Stearn, W. L. 1968. The botanical results of the Endeavour voyage. Endeavour 27: 3-10.

Stearn, W. T. 1969. A Royal Society appointment with Venus in 1769: the voyage of Cook and Banks in the Endeavour in 1768-1771 and its botanical results. Notes and Records Royal Soc. London 24: 64-90.

Stearn, W. L. 1978. The botanical results of Captain Cook's voyages and their later influence. Pacific Studies 1: 147-162.

Watkins, T. H. 1996. The greening of the empire: Sir Joseph Banks. Natl. Geogr. 190(5): 28-53.

Withey, L. 1987. Voyages of discovery: Captain Cook and the exploration of the Pacific. William Morrow. New York, NY. 512 pp.

DARWIN AND THE BEAGLE

Darwin, C. R. 1845. Journal of researches into the natural history and geology of the countries visited during the voyages of H. M. S. Beagle round the world: under the command of Captain Fitz Roy. Second edition. J. Murray. London, England. 519 pp.

Darwin, C. R. 1860. The voyage of the Beagle. Revised edition. Reprinted by Nat. Hist. Library. Doubleday Ancher Books. Garden City, NY. 524 pp.

Moorehead, A. 1969. Darwin and the 'Beagle.' Hamish Hamilton. London, England.

Porter, D. M. 1980. Charles Darwin's plant collections from the voyage of the Beagle. J. Soc. Biblio. Nat. Hist. 9: 515-525.

Porter, D. M. 1982. Charles Darwin's notes on plants of the Beagle voyage. Taxon 31(3): 503-506.

RICHARD SPRUCE

Schultes, R. E. 1953. Richard Spruce still lives. Northern Gardener 7(1-4): 20,27, 55-61, 87-93, 121-125.

Schultes, R. E. 1968. Some aspects of Spruce's Amazon explorations on modern phytochemical research. Rhodora 70: 313-339.

Schultes, R. E. 1976. Richard Spruce and the ethnobotany of the northwest Amazon. Rhodora 78: 65-72.

Schultes, R. E. 1983. Richard Spruce: an early ethnobotanist and explorer of the northwest Amazon and northern Andes. J. Ethnobiol. 3(2): 139-147.

Sledge, W. A. & R. E. Schultes. 1988. Richard Spruce: a multi-talented botanist. J. Ethnobiol. 8(1): 7-12.

Spruce, R. 1908. Notes of a botanist on the Amazon & Andes, being records of travel on the Amazon and its tributaries... during the years 1849-1864. Edited and condensed by A. R. Wallace. Two vols. Macmillan & Co. London, England. 518 pp. + 542 pp.

OTHER EXPLORERS

Ambrose, S. 1996. Undaunted courage: Meriwether Lewis, Thomas Jefferson, and the opening of the American West. Simon & Schuster. New York, NY. 511 pp.

Anderson, B. 1960. Surveyor of the sea: the life and voyages of Captain George Vancouver. Univ. Washington Press. Seattle. 274 pp.

Bartlett, H. H. 1940. The reports of the Wilkes Expedition, and the work of the specialists in science. Proc. American Phil. Soc. 82: 601-705.

Benzoni, G. 1572. La historia del mondo novo. Reprint edition. P. & F. Tini. Venice, Italy. 179 pp.

Bixby, W. 1966. The forgotten voyage of Charles Wilkes. David McKay. New York, NY.

Bligh, W. 1792. A voyage to the South Sea. For the purpose of conveying the breadfruit tree to the West

Indies in H. M. S. Bounty. George Nicol. London, England.

Bligh, W. Bligh and the Bounty: his narrative of the voyage to Otaheite with an account of the mutiny and his boat journey to Timor. E. P. Dutton. New York, NY. 283 pp.

Botkin, D. B. 1995. Our natural history: the lesson of Lewis and Clark. Berkley Publ. Group. New York, NY. 300 pp.

Botting, D. 1973. Humboldt and the cosmos. Harper & Row. New York, NY. 295 pp.

Bougainville, L. 1772. A voyage around the world performed by order of His Most Christian Majesty, in the years 1766, 1767, 1768, and 1769. Translated by J. R. Forster. J. Nourse. London, England. 476 pp.

Burroughs, R. D. 1961. The natural history of the Lewis and Clark Expedition. Michigan State Univ. Press. East Lansing. 340 pp.

Carrington, H. (editor). 1948. A journal of the second voyage of HMS Dolphin round the world under the command of Captain Wallis RN in the years 1766, 1767, and 1768, by her master George Robertson. Hakluyt Soc.

Coues, E. (editor). 1895. The expeditions of Zebulon M. Pike. Three vols.

Cutright, P. R. 1969. Lewis and Clark: pioneering naturalists. Univ. Illinois Press. Urbana. 506 pp.

Davis, W. 1996. One river: explorations and discoveries in the Amazon rain forest. Simon & Schuster. New York, NY. 537 pp.

De Voto, B. (editor). 1953. The journal of Lewis and Clark. Houghton Mifflin. Boston, MA. 504 pp.

Douglas, D. 1914. Journal kept by David Douglas during his travels in North America, 1823-1827.... Reprinted 1959. Antiquarian Press. New York, NY. 364 pp.

Evans, H. E. 1997. The natural history of the Long Expedition to the Rocky Mountains. Oxford Univ. Press. New York, NY. 268 pp.

Ewan, J. 1956. Humboldt and American botany. Rhodora 58: 191-197.

Fisher, R. 1998. Lewis and Clark: naturalist-explorers. Natl. Geogr. 194(4): 76-93.

Gama, Vasco da. 1898. The three voyages of Vasco da Gama and his viceroyalty. Translated and edited by H. E. J. Stanley. Hakluyt Society. London, England.

Graustein, J. E. 1967. Thomas Nuttall, naturalist -- explorations in America 1808-1841. Harvard Univ. Press. Cambridge, MA.

Harvey, A. G. 1947. Douglas of the fir: a biography of David Douglas, botanist. Harvard Univ. Press. Cambridge, MA. 290 pp.

Hernandez, F. 1651. Nova plantarum, animalium et mineralium Mexicanorum historia. B. Deuersini et Z. Masotti. Rome, Italy.

Hooker, J. D. 1844-1860. The botany of the Antarctic voyage of H. M. discovery ships Erebus and Terror, in the years 1839-1843; under the command of Captain Sir James Clark Ross. Pts. 1-3. Reeve Brothers. London, England.

Jayne, K. G. 1970. Vasco da Gama and his successor, 1460-1580. Barnes & Noble. New York, NY.

Johnston, B. A. 1998. Botanical "discoveries" of Lewis & Clark. HerbalGram 44: 30-32; 49-51.

Kahn, E. H., Jr. 1992. Jungle botanist. New Yorker June: 35-58. [Schultes]

Kenihan, G. H. (editor). The journal of Abel Janz Tasman. Australia Heritage Press. Adelaide. 119 pp.

Las Casas, B. de. Historia de las Indias, escrita por fray Bartolome de las Casas.... Impr. de M. Ginesta. Madrid, Spain. Five vols.

Monardes, N. 1577. Joyfull newes out of the newe founde world, wherein is declared the rare and singular vertues of diverse and sundrie hearbes, trees, oyles, plantes, and stones, and their applications... Facsimile edition. D. A. Capo Press. Theatrum Orbis Terrarum, Ltd. Amsterdam. The English Experience No. 251. 109 folios.

Morwood, W. 1973. Traveler in a vanished landscape: the life and times of David Douglas, botanical explorer. C. N. Potter. New York, NY. 244 pp.

Nordhoff, C. & J. N. Hall. 1962. The Bounty trilogy. Little, Brown and Co. Boston, MA. 633 pp.

Oliver, D. (editor). 1988. Return to Tahiti: Bligh’s second breadfruit voyage. Univ. Hawaii Press. Honolulu. 281 pp.

Prance, G. T. 2001. Richard Evans Schultes (12 January 1915-10 April 2001): a tribute. Econ. Bot. 55(3): 347-362.

Ritter, S. A. 2002. Lewis and Clark’s mountain wilds: a site guide to the plants and animals they encountered in the Bitterroots. Univ. Idaho Press. Moscow. 315 pp.

Rossi-Wilcox, S. M. 1993. Henry Hurd Rusby: a biographical sketch and selectively annotated bibliography. Harvard Pap. Bot. 4: 1-30.

Rusby, H. H. 1933. Jungle memories. Whittlesey House. New York, NY. 388 pp.

Sahagún, Fray B. de. 1963. General history of the things of New Spain. Florentine Codex, translated by C. E. Dibble and A. J. O. Anderson. The School of American Research and the Univ. Utah.

Sarton,G. 1943. Aimé Bonpland. Isis 34: 385-399.

Savage, H., Jr. & E. J. Savage. 1986. André and François-André Michaux. Univ. Virginia Press. Charlottesville. 435 pp.

Spence, M. E. & D. Jackson. 1973. The expeditions of John C. Frémont. Univ. Illinois Press. Urbana.

Stanton, W. 1975. The great United States Exploring Expedition of 1838-1842. Univ. California Press. Berkeley.

Stearn, W. T. (editor). 1968. Humboldt, Bonpland, Kunth and tropical American botany. J. Cramer. Stuttgart, Germany. 159 pp.

Stewart, C. S. 1831. A visit to the South Seas in the U. S. ship Vincennes during the years 1829 and 1830.... Two vols. J. P. Haven. New York, NY.

Thrower, N. J. W. (editor). 1984. Sir Francis Drake and the famous voyage, 1577-1580. Univ. California Press. Berkeley. 214 pp.

Thwaites, R. G. 1904-1905. Original journal of the Lewis and Clark Expedition. Eight vols. Dodd, Mead & Co. New York, NY.

Tyler, D. B. 1968. The Wilkes Expedition, the first United States exploring expedition (1838-1842). American Phil. Soc. Philadelphia, PA.

Vancouver, G. 1798. A voyage of discovery to the North Pacific ocean, and round the world..., 1790-95. Three vols. + atlas.

Viola, H. J. & C. Margolis (editors). 1985. Magnificent voyagers: the U. S. exploring expedition, 1838-1842. Smithsonian Inst. Press. Washington, D. C. 303 pp.

Wallace, A. R. 1889. Travels on the Amazon and Rio Negro, with an account of the native tribes, and observations on the climate, geology, and natural history of the Amazon Valley. Ward, Lock, & Co. New York, NY. 363 pp.

Ward, F. K. 1940. Plant hunting through the centuries. Nature 145: 574-576.

Welsh, S. L. 1998. John Charles Frémont, botanical explorer. Missouri Bot. Gard. St. Louis. 450 pp.

Whittle, T. 1970. The plant hunters: being an examination of collecting with an account of the careers and the methods of a number of those who have searched the world for wild plants. Chilton. Philadelphia, PA. 281 pp.

Wilkes, C. 1845. Narrative of the United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842. Five vols. Lea & Blanchard. Philadelphia, PA.

Wilkes, C. 1844-1874. Narrative of the United States exploring expedition. Philadelphia, PA. 24 vols. (Botany, vol. 15).

Williams, D. E. & S. M. Fraser. 1992. Henry Hurd Rusby: the father of economic botany at the New York Botanical Garden. Brittonia 44(3): 273-279.

Woodward, C. H. 1941. Henry Hurd Rusby – explorer, professor, reformer, botanist. J. New York Bot. Gard. 42: 43-46.

4: TWO MODERN REVOLUTIONS

THE GREEN REVOLUTION

Altieri, M. A. Agroecology: the science of sustainable agriculture. Second edition. Westview Press. Boulder, CO 433 pp.

Brown, L. 1970. Seeds of change: the green revolution and development in the 1970's. Praeger Publ. New York, NY. 205 pp.

Burgess, J. 1984. The revolution that failed. New Scientist 104(1428): 26-29.

Cleaver, H. M., Jr. 1972. Contradictions of the green revolution. Monthly Review June: 80-111.

Cleaver, H. 1972. The origins of the green revolution. Ph.D. dissertation. Stanford Univ. Stanford, CA.

Clement, C. R. 1999. 1492 and the loss of Amazonian crop genetic resources. I. The relation between domestication and human population decline. Econ. Bot. 53(2): 188-202.

Clement, C. R. 1999. 1492 and the loss of Amazonian crop genetic resources. II. Crop biogeography at contact. Econ. Bot. 53(2): 203-216.

Cleveland, D., A. Soleri, & S. E. Smith. 1994. Do folk crop varieties in sustainable agriculture? BioScience 44(11): 740-751.

Conway, G. 1999. The doubly green revolution. Cornell Univ. Press. Ithaca, NY. 335 pp.

Conway, G. R. & E. B. Barbier. 1990. After the green revolution. Earthscan. London, England.

Curtin, D. 1995. Making peace with the earth: indigenous agriculture and the green revolution. Env. Ethics 17: 59-73.

Easterbrook, G. 1997. Forgotten benefactor of humanity [Norman Borlaugh]. Atlantic Monthly 279(1): 74-78; 80-82.

Evans, L. T. 1998. Feeding the ten billion: plants and population growth. Cambridge Univ. Press. New York, NY. 264 pp.

Evenson, R. E. & D. Gollin. 2003. Assessing the impact of the Green Revolution, 1960 to 2000. Science 300: 758-762.

Frankel, O. H. et al. 1969. Genetic dangers in the green revolution. Ceres (FAO) 2(5): 35-37.

Gillis, A. M. 1993. Keeping traditions on the menu. BioScience 43(7): 425-429.

Glaeser, B. 1987. The green revolution revisited. Allen & Unwin. London, England.

Guerinot, M. L. 2000. The green revolution strikes gold. Science 287: 241, 242.

Harlan, J. R. 1977. How green can a revolution be? In, Seigler, D. S. Crop resources. Academic Press. New York, NY. Pp. 105-110.

Holmes, B. 1993. A new study finds there's life in the green revolution. Science 261: 1517.

Kaufman, P. B. 1979. The pros and cons of the green revolution. In, Kaufman, P. B. and J. D. LaCroix (editors). Plants, people, and environment. Macmillan Publ. Co. New York, NY. Pp. 210-219.

Klinkenborg, V. 1995. A farming revolution: sustainable agriculture. Natl. Geogr. 188(6): 60-89.

Mann, C. 1997. Reseeding the green revolution. Science 277: 1038-1043.

Manning, R. 2000. Food’s frontier: the next green revolution. North Point Press. New York, NY. 225 pp.

Marini-Bettolo, G. 1987. Towards a second green revolution. Elsevier. New York, NY. 530 pp.

Matson, P. A., R. Naylor, & I. Ortiz-Monsasterio. 1998. Integration of environmental, agronomic, and economic aspects of fertilizer management. Science 280: 112-115.

National Research Council. 1989. Alternative agriculture. National Academy Press. Washington, D. C. 448 pp.

Normile, D. 2000. Hopes grow for hybrid rice to feed developing world. Science 288: 429.

Paddock, W. C. 1970. How green is the green revolution? BioScience 20(16): 892-902.

Pease, A. 1980. Seeds of plenty, seeds of want: social and economic implications of the green revolution. Clarendon Press. Oxford, England.

Plucknett, D. L. & D. L. Winkelmann. 1995. Technology for sustainable agriculture. Sci. American 273(3): 182-186.

Rasmussen, P. E. et al. 1998. Long-term agroecosystem experiments: assessing agricultural sustainability and global change. Science 282: 893-896.

Shell, E. R. 1990. Seeds in the bank could stave off disaster on the farm. Smithsonian 20(10): 94-105.

Sprague, G. F. 1977. Requirements for a green revolution. In, Seigler,D. S. (editor). Crop resources. Academic Press. New York, NY. Pp. 97-104.

Tangley, L. 1987. Beyond the green revolution. BioScience 37(3): 176-180.

Tilman, D. 1998. The greening of the green revolution. Nature 396: 211, 212.

Vandermeer, J. 1995. The ecological basis of alternative agriculture. Ann. Rev. Ecol. Syst. 26: 201-224.

GENETIC ENGINEERING

Abelson, P. H. (editor). 1984. Biotechnology and biological frontiers. American Assoc. Adv. Sci. Washington, D. C. 516 pp.

Abbott, R. J. 1994. Ecological risks of transgenic crops. Trends in Ecol. Evol. 9(8): 280, 281.

Ahmed, I. (editor). 1992. Biotechnology: a hope or a threat? St. Martin's Press. New York, NY. 275 pp.

Aldridge, S. 1996. The thread of life: the story of genes and genetic engineering. Cambridge Univ. Press. Cambridge, England. 270 pp.

Antonsson-Ogle, B. 1984. Wild plant resources. Ceres 17(5): 38-40.

Barton, J. H. 1991. Patenting life. Sci. American 264(3): 40-45.

Benbrook, C. M. & P. B. Moses. 1986. Engineering crops to resist herbicides. Technology Review 89(8): 55-79.

Benson, S. et al. 1997. A growing concern. Mother Jones 22(1): 36-43.

Bliss, F. S. 1984. The application of new plant biotechnology to crop improvement. HortScience 19(1): 43-48.

Brill, W. J. 1985. Safety concerns and genetic engineering in agriculture. Science 227: 381-384.

Brown, K. 2001. Seeds of concern. Sci. American 284(4): 52-57.

Brown, W. L. 1983. Genetic diversity and genetic vulnerability -- an appraisal. Econ. Bot. 37(1): 4-12.

Brown, A. H. D., D. R. Marshall, O. H. Frankel, & J. T. Williams. 1989. The use of plant genetic resources. Cambridge Univ. Press. Cambridge, England. 382 pp.

Bryant, J. A. 1988. Putting genes into plants. Plants Today 1(1): 23-28.

Bud, R. 1993. The uses of life. A history of biotechnology. Cambridge Univ. Press. New York, NY. 299 pp.

Busch, L. et al. 1991. Plants, power, and profit: social, economic, and ethical consequences of the new biotechnologies. Basil Blackwell. Oxford, England. 275 pp.

Buttel, F. et al. 1985. From green revolution to bio-revolution: some observations on the changing technological bases of economic transformation in the Third World. Econ. Dev. and Cultural Change 34(1): 31-55.

Calvin, M. 1977. Green factories. Chemical and Engineering News 56: 30-36.

Cherfas, J. 1991. Transgenic crops get a test in the wild. Science 251: 878.

Comai, L. 1993. Impact of plant genetic engineering on foods and nutrition. Ann. Rev. Nutr. 13: 191-215.

Commoner, B. 2002. Unraveling the DNA myth: the spurious founda-tion of genetic engineering. Harpers 304(1821): 39-47.

Conway, G. B. & E. B. Barbier. 1990. After the green revolution. Earthscan Publications. London, England. 205 pp.

Day, P. R. 1989. The impact of biotechnology on conventional germplasm conservation and use. Beltsville Symp. Agr. Res. 13: 323-336.

Dayan, A. D. et al. (editors). 1988. Hazards of biotechnology: real or imaginary? Elsevier Applied Science. London, England. 138 pp.

Dickson, D. 1983. Chemical giants push for patents on plants. Science 228: 1290-1291.

Dolica, K. 1984. Understanding DNA and gene cloning: a guide for the curious. John Wiley & Sons. New York, NY.

Doyle, J. 1986. Altered harvest: agriculture, genetics, and the fate of the world's food supply. Viking Press.

Duke, J. A. 1981. The gene revolution. Office of Technology Assessment, U.S. Congress, Washington D.C.

Duvick, D. N. 1984. Genetic diversity in major farm crops on the farm and in reserve. Econ. Bot. 38: 161-178.

Enriquez, J. 1998. Genomics and the world economy. Science 281: 925, 926.

Esquinas-Alcazar, J. 1987. Plant genetic resources: a base for food security. Ceres 20(4): 39-45.

Evans, L. T. 1998. Feeding the ten billion. Cambridge Univ. Press. Cambridge, England. 247 pp.

Follett, P. A. 2000. Pandora's picnic basket: the potential and hazards of genetically modified foods. Oxford Univ. Press. New York, NY. 277 pp.

Fowler, C. 1994. Unnatural selection: technology, politics, and plant evolution. Gordon & Breach. Yverdon, Switzerland. 317 pp.

Fowler, C. & P. Mooney. 1990. Shattering. Food, politics, and the loss of genetic diversity. Univ. Arizona Press. Tucson. 278 pp.

Frankel, O. H. 1970. Genetic conservation of plants useful to man. Biol. Cons. 2(3): 162-169.

Frankel, O. H. 1974. Genetic conservation: our evolutionary responsibility. Genetics 78: 53-65.

Frankel, O. H. 1987. Genetic resources: the founding years. Diversity 11: 25-27.

Frankel, O. H. et al. (editors). 1970. Genetic resources in plants. Their exploration and conservation. A conference. Rome, September 1967. Published for the IBP by Davis. Philadelphia, PA. 554 pp.

Gaskell, G. et al. 1999. Worlds apart? The reception of genetically modified foods in Europe and the U. S. Science 285: 384-387.

Gautheret, R. M. 1983. Plant tissue culture: a history. Bot. Mag. Tokyo 96: 393-410.

Gibbs, W. W. 1997. Plantibodies. Sci. American 277(5): 44.

Gilbert, W. 1987. Genome sequencing: creating a new biology for the twenty-first century. Issues in Science and Technology 3(3): 26-35.

Glausiusz, J. 1998. The great gene escape. Discover 19(5): 90-96.

Goldman, K. A. 2000. Bioengineered food – safety and labeling. Science 290: 457-459.

Gould, F. 1988. Evolutionary biology and genetically engineered crops. BioScience 38(1): 26-33.

Gray, A. J. & A. F. Raybould. 1998. Crop genetics: reducing transgene escape routes. Nature 392(6678): 653, 654.

Greenberg, J. 1998. The great gene escape. Discover 19(5): 90-96.

Guarino, L. & R. Rao. 1995. Collecting plant genetic diversity. Technical guidelines. CAB International. Wallingford, U. K. 748 pp.

Gura, T. 2000. Reaping the plant gene harvest. Science 287: 412-414.

Hails, R. S. 2000. Genetically modified plants – the debate continues.Trends in Ecol. Evol. 15(1): 14-18.

Hamilton, N. 1993. Who owns dinner? Evolving legal mechanisms for ownership of plant genetic resources. Tulsa Law Review 28: 587.

Hancock, J. F., R. Grumet, & S. C. Hokanson. 1996. The opportunity for escape of engineered genes from transgenic crops. Hort. Sci. 31: 1080-1085.

Hansen, M., L. Busch, J. Burkhardt, W. B. Lacy, & L. R. Lacy. 1986. Plant breeding and biotechnology: new technologies raise important social questions. BioScience 36(1): 29-39.

Harlan, J. R. 1975. Our vanishing genetic resources. Science 188: 618-621.

Harris, M. 1999. Fresh from the lab: will genetically engineered foods feed a starving planet -- or cause it irrevocable damage? Vegetarian Times August: 58-67.

Hart, K. 2002. Eating in th dark: America's experiment with genetically engineered food. Pantheon. New York, NY. 338 pp.

Hellemans, A. 1999. New genes boost rice nutrients. Science 285: 994, 995.

Hoffman, C. A. 1990. Ecological risks of genetic engineering of crop plants. BioScience 40:434-437.

Holden, J., J. Peacock, & T. Williams. 1993. Genes, crops and the environment. Cambridge Univ. Press. Cambridge, England. 162 pp.

Horsch, R. B. 2001. Does the world need GM foods? Yes. Sci. American 284(4): 62, 63. [See Mellon, M. 2001 for opposing view]

Huang, J. et al. 2002. Plant biotechnology in China. Science 295: 674-677.

Hubbell, S. 2001. Shrinking the cat: genetic engineering before we know about genes. Houghton Mifflin. New York, NY. 256 pp.

Hubbell, S. 2001. Engineering the apple. Nat. Hist. 110(8): 44-53.

Jones, D. D. & S. K. Harlander. 1992. Biotechnology for tailoring old crops to new uses. In, 1992 yearbook of agriculture. U. S. Gov. Printing Office. Washington, D. C. Pp. 176-182.

Jones, H. & M. G. K. Jones. 1989. Direct gene transfer into plant protoplasts. Plants Today 2(5): 175-178.

Juma, C. 1989. The gene hunters: biotechnology and the scramble for seeds. Princeton Univ. Press. Princeton, N. J. 288 pp.

Kling, J. 1996. Could transgenic supercrops one day breed superweeds? Science 274: 180, 181.

Kloppenburg, J. R. 1988. Seeds and sovereignty: the use and control of plant genetic resources. Duke Univ. Press. Durham, NC. 368 pp.

Kloppenburg, J. R., Jr. 1988. First the seed: the political economy of plant biotechnology, 1492-2000. Cambridge Univ. Press. 349 pp.

Kloppenburg, J. Jr & D. L. Kleinman. 1987. Seeds and soverignty. Diversity 10: 29-33.

Kloppenburg, J. Jr. & D. L. Kleinman. 1987. The plant germplasm controversy. BioScience 37(3): 190-198.

Kloppenburg, J. Jr. & D. L. Kleinman. 1987. Seeds of struggle: the geopolitics of genetic resources. Tech. Rev. 90(2): 47-53.

Knee, B. 1999. Farmageddon: food and the culture of biotechnology. New Society Publ. Gabriola Island, Canada. 230 pp.

Lambrecht, B. 2001. Dinner at the new gene café. St. Martin's Press. New York, NY. 383 pp.

Lappé, M. & B. Bailey. 1998. Against the grain: biotechnology and the corporate takeover of your food. Common Courage Press. 163 pp.
Lewis, R. 1987. Agritechnology: building a better plant. In, 1988 Yearbook of science and the future. Encyclopaedia Britannica. Chicago, IL. Pp. 100-117.

Longman, P. J. 1999. The curse of frankenfood. U. S. News & World Report 127(4): 38-41.

Love, S. L. 1994. Ecological risk of growing transgenic potatoes in the United States and Canada. American Potato J. 71: 647-658.

Lowenstein, J. M. 1993. Back to grass roots: chefs against biotechnology. Pacific Discovery 46(4): 42, 43.

Lower, R. L. 1984. Genetic engineering: the relationship between industry, academia, and plant sciences. Hort-Science 19(1): 49-51.

Lurquin, P. E. 2001. The green phoenix: a history of genetically modified plants. Columbia Univ. Press. New York, NY. 173 pp.

Lycett, G. W. & D. Grierson (editors). 1989. Genetic engineering of crop plants. Butterworths. Boston, MA. 293 pp.

Macer, D. 1997. Plant biotechnology, bioethics and food. Nature & Resources 33(2): 2-13.

Maddox, D. & L. E. Morse. 1990. Plant conservation and global climate change. Nature Conservancy Magazine. July/August 24,25.

Mann, C. 1997. Reseeding the green revolution. Science 277: 1038-1043.

Maranto, G. 1986. Genetic engineering: hype, hubris, and haste. Discover June: 50-64.

Martineau, B. 2001. First fruit: the creation of the Flavr Savr tomato and the birth of biotech food. McGraw-Hill. New York, NY.

Marvier, M. 2001. Ecology of transgenic crops. American Sci. 89(2): 160-167.

Marx, J. L. 1985. Plant gene transfer becomes a fertile field. Science 230: 1148-1150.

Mather, R. 1995. Garden of unearthly delight: bioengineering and the future of food. Dutton Publ. New York, NY. 205 pp.

Meadows, D. H. 1999. Are bioengineered potatoes organic? Whole Earth Summer: 106, 107.

Mellon, M. 2001. Does the world need GM foods? No. Sci. American 284(4): 64, 65.

Miller, J. 1973. Genetic erosion: crop plants threatened by government neglect. Science 182: 1231-1233.

Moffat, A. S. 1995. Exploring transgenic plants as a new vaccine source. Science 268: 658, 660.

Moffat, A. S. 1995. Plants as chemical factories. Science 268: 659.

Moffat, A. S. 1997. First nematode-resistance gene found. Science 275: 757.

Moffat, A. S. 2000. Can genetically modified crops go "greener?' Science 290: 253, 254.

Molnar, J. J. & H. Kinnucan (editors). 1989. Biotechnology and the new agricultural revolution. AAAS Selected Symposium 108. Westview Press. Boulder, CO. 288 pp.

Mooney, P. 1983. The law of the seed: another development and plant genetic resources. Development Dialogue 1-2: 7-172.

Mowder, J. D. & A. K. Stoner. 1989. Plant germplasm information systems. Beltsville Symp. Agr. Res. 13: 419-426.

Nestle, M. 1996. Allergies to transgenic foods: questions of policy. New England J. Med. March 14: 726.

Nottingham, S. 1998. Eat your genes: how genetically modified food is entering your diet. Zed Books. London, England. 212 pp.

Pääbo, S. 1999. Neolithic genetic engineering. Nature 398: 194, 195.

Pennisi, E. 1998. Transferred gene helps plants weather cold snaps. Science 280: 36.

Pennisi, E. 1998. A bonanza for plant genomics. Science 282: 652-654.

Powledge, F. 1995. Who owns rice and beans? Patents on plant germplasm. BioScience 45(7)): 440-445.

Plucknett, D. L., N. J. H. Smith, J. T. Williams, & N. M. Anishetty. 1987. Gene banks and the world's food. Princeton Univ. Press. Princeton, NJ. 247 pp.

Prescott-Allen, R. & C. Prescott-Allen. 1983. Genes from the wild: using wild genetic resources for food and raw materials. An Earthscan Paperback. London, England. 101 pp.

Pringle, P. 2003. Food, inc. Mendel to Monsanto – the promises and perils of the biotech harvest. Simon & Schuster. New York, NY. 239 pp.

Purrington, C. B. & J. Bergelson. 1995. Assessing weediness of transgenic crops: industry plays plant ecologist. Trends Res. Ecol. Evol. 10(8): 340-342.

Raeburn, P. 1995. The last harvest: the genetic gamble that threatens to destroy American agriculture. Simon & Schuster. New York, NY. 269 pp.

Raffa, K. F. 1989. Genetic engineering of trees to enhance resistance to insects. BioScience 39: 524-534.

Reichert, W. 1980. Agriculture's diminishing diversity. Environment 24(9): 6-11; 39-43.

Rhoades, R. E. 1991. The world's food supply at risk. Natl. Geogr. 179(4): 74-105.

Rifkin, J. 1986. Biotechnology parallels nuclear energy by playing ecological roulette with environment. Genetic Engineering News 6(6): 4; 29.

Rifkin, J. 1998. God in a labcoat: can we control the biotech revolution before it controls us? Utne Reader 87: 66-71.

Rifkin, J. 1998. The biotech century: harnessing the gene and remaking the world. Tarcher/Putnam. New York, NY. 271 pp.

Rissler, J. & M. Mellon. 1993. Perils amidst the promise: ecological risks of transgenic crops in a global market. Union Concerned Scientists. Cambridge, MA. 92 pp.

Rissler, J. & M. Mellon. 1996. The ecological risks of engineered crops. MIT Press. Cambridge, MA. 168 pp.

Roberts, E. H. 1989. Seed storage for genetic conservation. Plants Today 2(1): 12-17.

Rogoff, M. H. & S. L. Rawlins. 1987. Food security: a technological alternative. BioScience 37(11): 800-807.

Saegusa, A. 1998. Japan may require labels on genetic food. Nature 395: 628.

Schmidt, K. 1994. Genetic engineering yields first pest-resistant seeds. Science 265: 739.

Serageldin, I. 1999. Biotechnology and food security in the 21st century. Science 285: 387-389.

Service, R. F. 1998. Chemical industry rushes toward greener pastures. Science 282: 608-610.

Shell, E. R. 1989. Seed banks -- a growing concern. Smithsonian 20(10): 94-100; 102; 104-105.

Shulman, S. 1986. Seeds of controversy: nations square off over who will control plant genetic resources. BioScience 36(10): 647-651.

Simmonds, N. W. 1983. Engineering of plants. Trop. Agric. 60: 66-69.

Simmonds, N. W. 1983. Conference review: genetic engineering of plants. Trop. Agric. 660(1): 66-69.

Sink, K. C. 1984. Protoplast fusion for plant improvement. HortScience 19(1): 33-37.

Snell, M. B. 2001. Against the grain: why poor nations would lose in a biotech war on hunger. Sierra 86(4): 30-33.

Snow, A. A. & P. M. Palma. 1997. Commercialization of transgenic plants: potential ecological risks. BioScience Feb: 94.

Sokolov, R. 1993. The unknown bioengineers. Nat. Hist. 102(10): 104, 106-108.

Souza Silva, J. De. 1989. Science and the changing nature of the struggle over plant genetic resources: from plant hunters to plant crafters. Ph.D. dissertation. Univ. Kentucky.

Steinbrecher, R. A. 1996. From green to gene revolution: the environmental risks of genetically engineered crops. Ecologist Nov/Dec: 277.

Strange, C. 1990. Cereal progress via biotechnology. BioScience 40(1): 5-9; 14.

Sun, M. 1986. The global fight over plant genes. Science 231: 445-447.

Sun, M. 1986. Fiscal neglect breeds problems for seed banks. Science 231: 329-330.

Szybalski, W. 1985. Genetic engineering in agriculture. Science 229: 112-113.

Tangley, L. 1987. Beyond the green revolution. BioScience 37(3): 176-180.

Tangley, L. 2000. Engineering the harvest: biotech could help fight hunger in the world's poorest nations – but will it? U. S. News & World Report 128(10): 46, 47.

Tanksley, S. D. & S. R. McCouch. 1997. Seed banks and molecular maps: unlocking genetic potential from the wild. Science 277: 1063-1066.

Teitel, M. & K. A. Wilson. 2001. Genetically engineered food: changing the nature of nature. Second edition. Park Street Press. Rochester, VT. 206 pp.

Thacker, J. R. M. 1993-1994. Transgenic crop plants and pest control. Sci. Prog. 77(3/4): 207-219.

Thro, E. 1993. Genetic engineering: shaping the material of life. Facts on File. New York, NY. 121 pp.

Teitel, M. & K. A. Wilson. 1999. Genetically engineered food: changing the nature of nature. Park Street Press. Rochester, VT. 175 pp.

Torrey, J. 1985. The development of plant biotechnology. Amer. Sci. 73: 354-363.

Trevan, M. D. et al. 1987. Biotechnology: the biological principles. Taylor & Francis. New York, NY. 256 pp.

Tudge, C. 1988. Food crops for the future: the development of plant resources. Blackwell. New York, NY. 225 pp.

Tudge, C. 1993. The engineer in the garden. Genes and genetics. From the idea of heredity to the creation of life. Cape Publ. London, England. 398 pp.

Vietmeyer, N. 1979. The greening of the future. Quest, Sept: 25-32.

Walsh, J. 1999. Brave new farm. Time 153(1): 86-88.

Wilkes, H. G. 1977. The world's crop plant germplasm -- an endangered resource. Bull. Atomic Sci. 33: 8-16.

Williams, N. 1998. Agricultural biotech faces backlash in Europe. Science 281: 768-771.

Wilson, E. O. 1985. The biological diversity crisis: a challenge to science. Issues in Science and Technology 2(1): 20-29.

Wolfenbarger, L. L. & P. R. Phifer. 2000. The ecological risks and benefits of genetically engineered plants. Science 290: 2088-2093.

Wright, B. D. 1998. Public germplasm development at a crossroads: biotechnology and intellectual property. California Agric. 52(6): 8-13.

5: FOOD PLANTS

GENERAL REFERENCES

Ableman, M. 1993. From the good earth: a celebration of growing food around the world. Harry N. Abrams. New York, NY. 168 pp.

Allen, S. L. 2002. In the devil's garden: a sinful history of forbidden food. Ballantine Books. New York, NY. 315 pp.

Barer-Stein, T. 1999. You eat what you are. Second edition. Firefly Books. Buffalo, NY. 544 pp.

Beckstrom-Sternberg, S. & J. Duke. The foodplant database, ACEDB version 4.0. http://probe.nalusda.gov:8300/cgi-bin/browse/foodplantdb

Belitz, H.-D. & W. Grosch. 1987. Food chemistry. Translation of the second German edition. Springer Verlag. Berlin, Germany. 774 pp.

Bender, A. E. & D. A. Bender. 1995. A dictionary of food and nutrition. Oxford Univ. Press. Oxford, England.

Bissell, F. 1994. The book of food. A cook's guide to over 1,000 exotic and everyday ingredients. Holt. New York, NY. 276 pp.

Blaxter, K. & N. Robertson. 1995. From dearth to plenty: the modern revolution in food production. Cambridge Univ. Press. New York, NY.

Bonanno, A. et al. (editors). 1994. From Columbus to ConAgra: the globalization of agriculture and food. Univ. Press Kansas. Lawrence. 294 pp.

Brothwell, D. & P. Brothwell. 1969. Food in antiquity: a survey of the diet of early peoples. Thames & Hudson. London, England.

Brouck, B. 1975. Plants consumed by man. Academic Press. New York, NY. 460 pp.

Buishand, T., H. P. Houwing, & K. Jansen. 1986. The complete book of vegetables. An illustrated guide to over 400 species and varieties of vegetables from all over the world. Gallery Books. New York, NY. 180 pp.

Campbell-Platt, G. 1987. Fermented foods of the world: dictionary and guide. Butterworths. Boston, MA. 291 pp.

Camporesi, P. 1989. Bread of dreams: food and fantasy in early modern Europe. Univ. Chicago Press. Chicago, IL. 212 pp.

Chan, H. T., Jr. 1983. Handbook of tropical foods. Dekker. New York, NY. 639 pp.

Chrispeels, M. J. & D. Sadava. 1977. Plants, food, and people. W. H. Freeman. San Francisco, CA. 278 pp.

Coe, S. D. 1994. America's first cuisines. Univ. Texas Press. Austin. 276 pp.

Coenders, A. 1992. The chemistry of cooking: an account of what happens to food before, during and after cooking. Parthenon Publ. Park Ridge, NJ.

Considine, D. M. & G. D. Considine. 1982. Foods and food production encyclopedia. Van Nostrand Reinhold. New York, NY. 2305 pp.

Cummings, R. O. 1970. The American and his food: A history of food habits in the United States. Revised edition. Arno Press. New York, NY. 291 pp.

Darby, W. J. et al. 1977. Food: the gift of Osiris. Vol. 2. Academic Press. London, England. 877 pp.

DeVincenzi, M. & M. R. Dessi. 1991. Botanical flavouring substances used in foods: proposal of classification. Fitotherapia 62(1): 39-63.

Etkin, N. L. (editor). 1994. Eating on the wild side: the pharmacologic, ecologic, and social implications of using noncultigens. Univ. Arizona Press. Tucson. 305 pp.

Fackelmann, K. A. 1993. Food, drug, or poison: cultivating a taste for 'toxic' plants. Science News 143: 312-314.

FAO. 1989. Utilization of tropical foods: trees. Food and nutrition papers no. 47/3. Food and Agriculture Organization of the United Nations. Rome. 52 pp.

Farrington, L. S. & J. Urry. 1985. Food and the early history of cultivation. J. Ethnobiol. 5: 143-158.

Fenton, A. & E. Kisban. 1986. Food in change: eating habits from the Middle Ages to the present day. Humanities Press. Atlantic Highlands, NJ. 166 pp.

Fern, K. 1997. Plants for a future: edible and useful plants for a healthier world. Permanent Publ. Clanfield, England. 300 pp.

Forester, R. & O. Ranum (editors). 1979. Food and drink in history. Johns Hopkins Univ. Press. Baltimore, MD. 173 pp.

Fortin, F. (editor). 1996. The visual food encyclopedia. Macmillan. New York, NY. 685 pp.

Frisch, R. E. 1969. Plants that feed the world. Van Nostrand. Princeton, NJ. 104 pp.

Gilbert, R. I. & J. H. Mielke (editors). 1985. The analysis of prehistoric diets. Academic Press. Orlando, FL. 436 pp.

Gillis, A. M. 1993. Keeping traditions on the menu. BioScience 43(7): 425-429.

Goode, J. & C. Willson. 1987. Fruits and vegetables of the world. Lothian Publ. Melbourne, Australia. 205 pp.

Goodman, D. & M. Redclift. 1991. Refashioning nature: food, ecology and culture. Routledge. London, England. 279 pp.

Grossman, L. 1996. The world on a plate: the history and mystery of the food we eat. BBC Books. London, England. 224 pp.

Hackett, C. & J. Carolane (editors). 1983. Edible horticultural crops. A compendium of information on fruit, vegetable, spice and nut species. Four vols. Academic Press. New York, NY.

Harris, M. & E. B. Ross. 1987. Food and evolution. Temple Univ. Press. Philadelphia, PA. 633 pp.

Herbst, S. T. 2001. The food lover's companion. Third edition. Barron's. Hauppauge, NY. 771 pp.

Heiser, C. B., Jr. 1990. Seed to civilization: the story of food. New edition. Harvard Univ. Press. Cambridge, MA. 228 pp.

Hesseltine, C. W. & H. L. Wang. 1980. The importance of traditional fermented foods. BioScience 30(6): 402-404.

Hopkin, K. 2001. The risks on the table. Sci. American 284(4): 60, 61.

Hu, S.-Y. 2002. Food plants of China: a comprehensive cultural and botanical study of the food plants of China. 800 pp.

Inglett, G. E. & G. Charalambous. 1979. Tropical foods: chemistry and nutrition. Two vols. Academic Press. New York, NY. 701 pp.

Johns, T. 1990. The origins of human diet and medicine. Univ. Arizona Press. Tucson. 356 pp.

Johns, T. 1990. With bitter herbs they shall eat it. Chemical ecology and the origins of human diet and medicine. Univ. Arizona Press. Tucson. 356 pp.

Johns, T. & I. Kubo. 1988. A survey of traditional methods employed for the detoxification of plant foods. J. Ethnobiol. 8: 81-129.

Jukes, T. H. 1977. Organic foods. CRC Rev. Food Sci. & Nutr. 9(4): 395-418.

Kahn, E. J., Jr. 1984. Staffs of life. Little, Brown and Co. Boston, MA. 310 pp.

Kays, S. J. & J. C. Silva Dias. 1996. Cultivated vegetables of the world. Latin binomials, common names in 15 languages, edible parts, and method of preparation. Exon Press. Athens, GA. 170 pp.

King, F. B. 1994. Interpreting wild plant foods in the archaeological record. In, Etkin, N. L. (editor). Eating on the wild side. Univ. Arizona Press. Tucson. Pp. 185-209.

Kiple, K. F. & K. C. Ornelas (editors). 2000. The Cambridge world history of food. Two vols. Cambridge Univ. Press. Cambridge, U. K. 2153 pp.

Kittler, P. G. & K. Sucher. 1989. Food and culture in America. Van Nostrand Reinhold. New York, NY. 384 pp.

Kunkel, G. 1984. Plants for human consumption. An annotated checklist of the edible phanerogams and ferns. Koeltz Scientific Books. Koenigstein, West Germany. 393 pp.

Labensky, S., G. G. Ingram, & S. R. Labensky. 1997. Webster's new world dictionary of culinary arts. Prentice Hall. Upper Saddle River, NJ. 447 pp.

Lane, T. 1997 (editor). Foods that harm and foods that heal: an A-Z guide to safe and healthy eating. Reader's Digest Assoc. Pleasantville, NY. 400 pp.

Langer, W. L. 1975. American foods and Europe's population growth 1750-1850. J. Social Hist. Winter: 51-66.

Leakey, C. L. A. & J. B. Wills (editors). 1977. Food crops of the low-land tropics. Oxford Univ. Press. New York, NY. 345 pp.

Linskens, H. F. & W. Jorde. 1997. Pollen as food and medicine - - a review. Econ. Bot. 51(1): 78-87.

Livingston, A. & H. Livingston. 1993. Edible plants and animals: unusual foods from aardvark to zamia. Facts on File. New York, NY. 292 pp.

Macrae, R. et al. (editors). 1993. Encyclopaedia of food technology and nutrition. Eight vols. Academic Press. London, England.

Mariani, J. F. 1999. The encyclopedia of American food & drink. Lebhar-Friedman Books. New York, NY. 380 pp.

Markle, G. M., J. J. Baron, & B. A. Schneider. 1998. Food and feed crops of the United States. Second edition. Meister Publ. Co. Willoughby, OH. 517 pp.

Martin, F. W. 1984. CRC handbook of tropical food crops. CRC Press. Boca Raton, FL. 296 pp.

McGee, H. 1984. On food and cooking: the science and lore of the kitchen. Charles Scribner's Sons. New York, NY. 684 pp.

Mennell, S. 1985. All manners of food: eating and taste in England and France from the Middle Ages to the present. New York, NY.

Merrill, E. D. 1935. Where our food plants come from. Torreya 35: 25-30.

Muller, H. G. 1988. An introduction to tropical food science. Cambridge Univ. Press. New York, NY. 316 pp.

Nwokolo, E. & J. Smartt (editors). 1996. Food and feed from oilseeds and legumes. Chapman & Hall. London, England.

Perez-Llano, G. A. 1944. Lichens used as food by man. Bot. Rev. 10(1): 33-36.

Poot, W. 1980. Food: an authoritative and visual history and dictionary of the foods of the world. Simon & Schuster. New York, NY. 602 pp.

Prendergast, H. D. V. et al. (editors). 1998. Plants for food and medicine. Royal Botanic Gardens. Kew, England. 438 pp.

Prescott-Allen, R. & C. Prescott-Allen. 1990. How many plants feed the world? Conservation Biology 4(4): 365-374.

Rhoades, R. E. 1991. The world's food supply at risk. Natl. Geogr. 179(4): 74-105.

Roberts, J. 2001. The origin of fruit and vegetables. Universe Publ. New York, NY. 228 pp.

Rose, A. H. 1981. The microbial production of food and drink. Sci. American 245(1): 127-138.

Rupp, R. 1987. Blue corn & square tomatoes: unusual facts about common garden vegetables. Storey Communications. Pownal, VT. 222 pp.

Salunkhe, D. K. & S. S. Deshpande. 1991. Foods of plant origin. Van Nostrand Reinhold. New York, NY. 501 pp.

Schneider, E. 1986. Uncommon fruits & vegetables: a commonsense guide. Harper & Row. New York, NY. 546 pp.

Sheffer, N. & M. Sheraton. 1997. Food markets of the world. Henry N. Abrams. New York, NY. 204 pp.

Simoons, F. J. 1994. Eat not this flesh; food avoidances from prehistory to the present. Second edition. Univ. Wisconsin Press. Madison. 550 pp.

Smil, V. 2000. Feeding the world: a challenger for the twenty-first century. MIT Press. Cambridge, MA. 388 pp.

Smith, C. E., Jr. 1973. Man and his foods: studies in the ethnobotany of nutrition -- contemporary, primitive, and prehistoric non-European diets. Univ. Alabama Press. 131 pp.

Sokolov, R. 1991. Why we eat what we eat. Summit Books. New York, NY. 254 pp.

Tanaka, T. 1976. Tanaka's cyclopedia of edible plants of the world. Edited by S. Tanaka. Keigaku Publ. Co. Tokyo. 924 pp.

Tannahill, R. 1988. Food in history. New, fully revised and updated edition. Crown. Publ. New York, NY. 424 pp.

Toussaint-Samat, M. 1987. History of food. Blackwell Publ. Malden, MA. 801 pp.

Trager, J. 1995. The food chronology: a food lover's compendium of events and anecdotes, from prehistory to the present. Henry Holt and Co. New York, NY. 783 pp.

Tudge, C. 1988. Food crops for the future. Basil Blackwell. Oxford, England. 225 pp.

Vaughan, J. G. & C. A. Geissler. 1997. The new Oxford book of food plants: a guide to the fruit, vegetables, herbs and spices of the world. Oxford Univ. Press. Oxford, England. 239 pp.

Viard, M. 1995. Fruit and vegetables of the world. Longmeadow Press. Ann Arbor, MI. 191 pp.

Vietmeyer, N. 1985. Exotic edibles are altering America's diet and agriculture. Smithsonian 16(9): 34-43.

Voorhees, D. 1995. Why does popcorn pop? and 201 other fascinating facts about food. Barnes & Noble. New York, NY. 250 pp.

Ward, S., C. Clifton, & J. Stacey. 1997. The gourmet atlas: the history, origins, and migration of food of the world. Macmillan. New York, NY. 224 pp.

Welsh, S. O. & R. M. Marston. 1982. Review of trends in food use in the United States, 1909-1980. J. American Diet Assoc. 81: 120-125.

Willett, W. C. 1994. Diet and health: what should we eat? Science 264: 532-537.

ROOT CROPS

GENERAL

Anderson, M. K. 1997. From tillage to table: the indigenous cultivation of geophytes for food in California. J. Ethnobiol. 17(2): 149-169.

Coursey, D. G. & P. H. Hanes. 1970. Root crops and their potential as food in the tropics. World Crops 22: 261-265.

Food and Agriculture Organization. 1989. Utilization of tropical foods: roots and tubers. Food and Nutrition Papers No. 47/2. FAO. United Nations. Rome, Italy. 64 pp.

Hather, J. G. 1993. Archaeological guide to root and tuber identification. Vol. 1. Europe and Southwest Asia. Oxbow Press. 590 pp.

Kay, D. E. 1973. Root crops. TPI Crop and Products Digest No. 2. Tropical Products Inst. London. 245 pp.

Leon, J. 1976. Origin, evolution and early dispersal of root and tuber crops. In, Proc. 4th Int. Symp. Trop. Root Crops. International Development Research Centre. Ottawa.

Montaldo, A. 1972. Cultivo de raices y tuberculos tropicales. Lima. 284 pp.

Moore, P. D. 1998. Getting to the roots of tubers. Nature 395: 330-331.

O'Hair, S. K. 1990. Tropical root and tuber crops. Hort. Rev. 12: 157-196.

Onwueme, I. C. 1978. The tropical tuber crops. John Wiley & Sons. New York, NY. 234 pp.

Pennisi, E. 1999. Did cooked tubers spur the evolution of big brains: Science 283: 2004, 2005.

CASSAVA OR MANIOC

Akinrele, I. A. 1986. Hydrocyanic acid hazard during large scale cassava processing. Trop. Sci. 26(2): 59-65.

Allem, A. C. 1987. *Manihot esculenta* is a native of the neotropics. Pl. Genet. Res. News. 71: 22-24.

Aregheore, E. M. & O. O. Agunbiade. 1991. The toxic effects of cassava (*Manihot esculenta* Grantz) diet on humans: a review. Vet. Human Toxicol. 33(3): 274, 275.

Cock, J. H. 1982. Cassava: a basic energy source in the tropics. Science 218: 755-762.

Dufour, D. L. 1988. Cyanide content of cassava (*Manihot esculenta,* Euphorbiaceae) cultivars used by Tukanoan Indians in northwest Amazonia. Econ. Bot. 42(2): 255-266.

Epstein, H. 1996. Crippling harvest. Nat. Hist. 105(7): 12-15.

Ermans, A. M., N. M. Mbulamoko, F. Delange, & R. Ahluwalia (editors). 1980. Role of cassava in the etiology of endemic goitre and cretenism. IDRC-136e. International Development Research Centre. Ottawa.

Hershey, C. & N. Ocampo. 1989. Yuca. Boletin Informativo 13(1): 1-5.

Hillcocks, R. J., J. M. Thresh, & A. Bellotti (editors). 2001. Cassava: biology, production and utilization. 416 pp.

Jones, W. O. 1959. Manioc in Africa. Stanford Univ. Press. Stanford, CA. 315 pp.

Lancaster, P. A., J. S. Ingram, M. Y. Linn, & D. G. Coursey. 1982. Traditional cassava based foods: survey of processing techniques. Econ. Bot. 36(1): 12-45.

McMahon, J. M., W. L. B. White, & R. T. Sayne. 1995. Cyanogenesis in cassava (*Manihot esculenta* Crantz). J. Exp. Bot. 46: 731-741.

Moran, E. F. 1976. Manioc deserves more recognition in tropical framing. World Crops 28(4): 184-188.

Nambisan, B. & S. Sundaresan. 1985. Effect of processing on the cyanogenetic content of cassava. J. Sci. Food Agric. 36(11): 1197-1203.

Nassar, N. 2001. Cassava, *Manihot esculenta* Crantz, and wild relatives: their relationships and evolution. Genet. Res. & Crop Evol. 48(5): 429-436.

Okezie, B. O. & F. V. Kosikowski. 1982. Cassava as food. CRC Rev. in Food Sci. & Nutr. 17(3): 259-275.

Olsen, K. M. & B. A. Schaal. 1999. Evidence on the origin of cassava: phytogeography of *Manihot esculenta*. Proc. Natl. Acad. Sci. 96: 5586-5591.

Renvoize, B. S. 1972. The area of origin of *Manihot esculenta* as a crop plant -- a review of the evidence. Econ. Bot. 26: 352-360.

Rogers, D. J. 1965. Some botanical and ethnological considerations of *Manihot esculenta.* Econ. Bot. 19: 369-377.

Rogers, D. J. & S. G. Appan. 1971. What's so great about cassava? World Farming 13(6): 14-22.

Sambatti, J. M. B., P. S. Martins, & A. Ando. 2001. Folk taxonomy and evolutionary dynamics of cassava: a case study in Ubatuba, Brazil. Econ. Bot. 55(1): 93-105.

Samways, M. 1979. Alcohol from cassava in Brazil. World Crops 31(5): 181-186.

Smart, H. P. 1938. The cassava industry in British Honduras. Bull. Imp. Inst. Great Britain 36(1): 66-68.

Smith, N. 1985. A plague on manioc. Geog. Mag. 57: 539, 540.

IRISH POTATO

Anderson, E. 1955. How to spend a nice quiet evening with a potato. Bull. Missouri Bot. Gard. 43: 50-53. (Yes, this is a real article!)

Badgley, C. 1998. Romancing the potato. Wild Earth 8(3): 35-38.

Bartoletti, S. C. 2001. Black potatoes: the story of the Great Irish famine, 1845-1850. Houghton-Mifflin. Boston, MA. 184 pp.

Bourke, P. M. A. 1964. Emergence of potato blight, 1843-46. Nature 203: 805-808.

Bourke, A. 1993. The visitation of God? The potato and the great Irish famine. Hill & O'Grada. Dublin, Ireland. 230 pp.

Braa, D. M. 1997. The great potato famine and the transformation of Irish peasant society. Sci. & Soc. 61(2): 193-215.

Brucher, H. 1964. El origen de la papa (*Solanum tuberosum*). Physis 24: 439-452.

Brucher, H. 1975. Domestikation und migration von *Solanum tuberosum* L. Kulturpflanze 23: 11-74.

Brush, S. B., H. J. Carney, & Z. Huaman. 1981. Dynamics of Andean potato agriculture. Econ. Bot. 35: 153-166.

Burton, J. 1963. Introduction of the potato in Ireland and England. Health Educ. J. 21: 71-78.

Burton, W. C. 1989. The potato. Third edition. Longman Scientific & Technical. Essex, England. 742 pp.

Carefoot, G. L. & E. R. Sprott. 1967. Famine on the wind. Rand McNally. New York, NY.

Connell, K. H. 1962. The potato in Ireland. Past and Present 23: 57-71.

Cox, A. E. & E. C. Large. 1960. Potato late blight epidemics throughout the world. ARS-USDA Handbook No. 174. U.S. Government Printing Office. Washington, D.C.

Craig, S. 1998. Flight from famine. Geographical 70(1): 53-56.

Daly, D. C. 1996. The blight is back. Nat. Hist. 105(1): 31.

Daly, D. C. 1996. The leaf that launched a thousand ships. Nat. Hist. 105(1): 24-32.

Dodds, K. S. 1966. The evolution of the cultivated potato. Endeavor 25: 83-88.

Dodge, B. S. 1970. Potatoes and people -- the story of a plant. Little, Brown & Co. Boston, MA. 190 pp.

Elwood, J. H. & G. MacKenzie. 1973. Associations between the incidence of neurological malformations and potato blight outbreaks over 50 years in Ireland. Nature 243: 476.

Faber, H. 1994. A virulent potato fungus is killing the northeast crop. New York Times 12 November 1994 (Metro section).

Fry, W. E. et al. 1993. Historical and recent migrations of *Phytophthora infestans*: chronology, pathways, and implications. Plant Disease 77: 653-661.

Fry, W. E. & S. B. Goodwin. 1997. Resurgence of the Irish potato famine fungus. BioScience 47(6): 363-371.

Garelik, G. 2002. Taking the bite out of potato blight. Science 298: 1702-1704.

Grun, P. 1990. The evolution of cultivated potatoes. Econ. Bot. 44(3:Suppl.): 39-55.

Hawkes, J. G. 1967. The history of the potato. J. Royal Hort. Soc. 92: 207-224; 249-262; 288-302; 364, 365.

Hawkes, J. G. 1988. The evolution of cultivated potatoes and their tuber-bearing wild relatives. Die Kulturpflanze 36: 189-208.

Hawkes, J. G. 1990. The potato: evolution, biodiversity and genetic resources. Columbia Univ. Press. New York, NY. 220 pp.

Hawkes, J. G. & J. Francisco-Ortega. 1992. The potato in Spain during the late 16th century. Econ. Bot. 46(1): 86-97.

Hawkes, J. G. & J. Francisco-Ortega. 1993. The early history of the potato in Europe. Euphytica 70: 1-7.

Hughes, M. S. 1991. Patayto, potahto -- either way you say it, they a'peel. Smithsonian 22(7): 138-149.

Johns, T. A. 1986. Detoxification function of geophagy and domestication of the potato. J. Chem. Ecol. 12(3): 635-646.

Keeler, R. F. et al. 1976. Spina bifida, exencephaly, and cranial bleb produced by the solanum alkaloid solasodine. Res. Commun. Chem. Pathol. Pharmacol. 13: 723.

Keeler, R. F. et al. 1978. Congenital deformities produced in hamsters by potato sprouts. Teratology 17: 327.

Kinealy, C. 1996. How politics fed the famine. Nat. Hist. 105(1): 33-35.

Kinealy, C. 1997. A death-dealing famine: the great hunger in Ireland. Pluto Press. London, England. 192 pp.

Kinlen, L. & A. Hewitt. 1973. Potato blight and anencephaly in Scotland. British J. Prev. Soc. Med. 27: 208.

Knight, R. 1995. Ireland, America, and famine. U. S. News & World Rep. 119(8): 12, 13.

Lang, J. 2001. Notes of a potato watcher. Texas A & M Univ. Press. College Station, TX. 365 pp.

Lu, W. & J. Lazell. 1996. The voyage of the beetle [potato beetle]. Nat. Hist. 105(1): 36-39.

McKay, R. (editor). 1961. An anthology of the potato. A. Figgis. Dublin, Ireland. 92 pp.

McNeill, W. H. 2001. What if Pizarro had not found potatoes in Peru? In, Cowley, R. What if? 2. Berkeley Books. New York, NY. Pp. 415-427.

Mokyr, J. 1983. Why Ireland starved: a quantitative and analytical history of the Irish economy, 1800-1850. London, England.

Moore, P. D. 1998. Getting to the roots of tubers. Nature 395: 330-331.

Morris, S. C. & T. H. Lee. 1984. The toxicity and teratogenicity of Solanaceae glycoalkaloids, particularly those of the potato (*Solanum tuberosum*) -- a review. Food Tech. Australia 36: 118.

Niederhauser, J. S. and W. C. Cobb. 1959. The late blight of potatoes. Sci. Amer. 200(5): 100-102; 107-112.

Nishie, K. et al. 1971. Pharmacology of solanine. Toxicol. Appl. Pharmacol. 19: 81.

Ochoa, C. M. 1999. Las papas de Sudamerica: Perú. Centro Internac-ional de la Papa. Lima, Perú.

Oster, M. 1993. The potato garden: a grower's guide. Harmony Books. New York, NY. 128 pp.

Parmentier, A. A. 1789. Traite sur la culture et les usages des pommes de terres, de la patate, et du topinambour. Paris.

Pennisi, E. 1999. Did cooked tubers spur the evolution of big brains? Science 283: 2004, 2005.

Percival, J. 1995. The great famine: Ireland's potato famine 1845-51. Viewer Books. New York, NY. 192 pp.

Pollan, M. 2001. The potato. In, The botany of desire. Random House. New York, NY. Pp. 181-238.

Rhoades, R. E. 1982. The incredible potato. Natl. Geogr. 161: 668-694.

Ristaino, J. B., C. T. Groves, & G. R. Parra. 2001. PCR amplification of the Irish potato famine pathogen from historic specimens. Nature 411: 695-697.

Safford, W. E. 1925. The potato of romance and of reality. J. Heredity 16: 113-126.

Salaman, R. 1949. The character of the early European potato. Proc. Linnean Soc., London. 161: 71-84.

Salaman, R. N. 1985. The history and social influence of the potato. Revised edition with a new introduction by J. G. Hawkes. Cambridge Univ. Press. Cambridge, England. 752 pp.

Sinden, S. L. 1987. Potato glycoalkaloids. Acta Hort. 207: 41.

Smee, A. 1846. The potatoe (sic) plant, its uses and properties: together with the cause of the present malady. London, England.

Smith, N. 1983. New genes from wild potatoes. New Scientist 98: 558-565.

Smith, O. 1987. Potato processing. Van Nostrand Reinhold. New York, NY. 796 pp.

Sokolov, R. 1975. Potatoes are cheaper... Nat. Hist. 84(3): 78-81.

Stevenson, F. J. 1951. The potato -- its origin, cytogenetic relationships, production, uses and food values. Econ. Bot. 5(2): 153-171.

Ugent, D. 1968. The potato in Mexico: geography and primitive culture. Econ. Bot. 22: 109-123.

Ugent, D. 1970. The potato. Science 170: 1161-1166.

Woolfe, J. A. 1987. The potato in the human diet. Cambridge Univ. Press. New York, NY. 231 pp.

Zimmerer, K. 1991. The regional biogeography of native potato cultivars in highland Peru. J. Biogeogr. 18: 165-178.

Zuckerman, L. 1998. The potato: how the humble spud rescued the western world. Faber & Faber. Boston, MA. 304 pp.

SWEET POTATO

Austin, D. F. 1978. The *Ipomoea batatas* complex. I. Taxonomy. Bull. Torrey Bot. Club 105(2): 114-129.

Bouwkamp, J. C. 1985. Sweet potato products: a natural resource for the tropics. CRC Press. Boca Raton, FL. 280 pp.

Brand, D. D. 1971. The sweet potato: an exercise in methodology. In, Riley, C. L. et al. (editors). Man across the sea. University of Texas Press. Austin. Pp. 343-365.

Cooley, J. S. 1951. The sweet potato -- its origin and primitive storage practices. Econ. Bot. 5(4): 378-386.

Dalton, H. C. 1983. Ethnobotany of the sweet potato in Hawaii. Bull. Pacific Trop. Bot. Gard. 13: 81-84.

Dixon, R. B. 1932. The problem of the sweet potato in Polynesia. Amer. Anthrop. 34: 40-66.

Martin, F. W. 1987. Introducing staple-type sweet potatoes: a potential new food crop for the tropics. Agric. International 39(4): 114-118.

MacDonald, A. S. 1963. Sweet potatoes, with particular reference to the tropics. Field Crop Abstr. 16: 219-225.

Nishiyama, I. 1963. The origin of the sweet potato plant. In, Barrau, J. Plants and the migrations of Pacific people. Bishop Musuem Press. Honolulu, HI. Pp. 119-128.

Nishiyama, I. 1971. Evolution and domestication of the sweet potato. Bot. Mag. [Tokyo] 84: 377-387.

Nishiyama, I. & T. Teramura. 1962. Mexican wild forms of sweet potato. Econ. Bot. 16(4): 305-314.

O'Brien, P. J. 1972. The sweet potato: its origin and dispersal. Amer. Anthrop. 74: 342-365.

Oomen, H. A. P. C. 1961. The sweet potato as the staff of life of the highland Papuan. Trop. Geogr. Medicine 13: 55-66.

Puente, F. de la, D. F. Austin, & J. Díaz. 1996. Common names of the sweet potato (*Ipomoea batata*) in the Americas. Pl. Genet. Res. Newsl. 106: 13-15.

Sokolov, R. 1986. The sweet potato perplex. Nat. Hist. 95(May): 96; 98.

Yen, D. E. 1960. The sweet potato in the Pacific: the propagation of the plant in relation to its distribution. J. Polynesian Soc. 69: 368-375.

Yen, D. E. 1961. The evolution of the sweet potato. Nature 191: 93, 94.

Yen, D. E. 1961. Sweet potato variation and its relation to human migration in the Pacific. Pac. Sci. Congr. Proc. 10: 93-117.

Yen, D. E. 1974. The sweet potato and Oceania. An essay in ethnobotany. Bull. No. 236. Bishop Museum Press. Honolulu, HI. 390 pp.

TARO AND THE TROPICAL AROIDS

Chandra, S. (editor). 1984. Edible aroids. Oxford Univ. Press. New York, NY. 252 pp.

Greenwell, A. B. H. 1947. Taro -- with special reference to its culture and uses in Hawaii. Econ. Bot. 1: 276-289.

Hill, A. F. 1939. Nomenclature of the taro and its varieties. Bot. Mus. Leaflts. Harvard Univ. 7: 113-118.

Hodge, W. H. 1954. Dasheen -- a tropical root crop for the South. U. S. Dept. of Agriculture. Circular No. 950. Washington, D. C.

Merlin, M. 1982. The origins and dispersals of true taro. Native Planters (Ho'okupu kalo) 1(1): 6-16.

Moriarty, D. 1976. Ethnobotany of taro. Bull. Pacific Trop. Bot. Gard. 6: 81-86.

Morton, J. F. 1972. Cocoyams..., ancient root and leaf vegetables gaining in economic importance. Proc. Florida State Hort. Soc. 85: 85-94.

O'Hair, S. K. & M. P. Asokan. 1986. Edible aroids: botany and horticulture. Hort. Rev. 8: 43-99.

Plowman, T. 1969. Folk uses of New World aroids. Econ. Bot. 23: 97-122.

Plucknett, D. L. 1970. The status and future of the major edible aroids: *Alocasia, Amorphophallus, Colocasia, Cyrtosperma,* and *Xanthosperma.* Proc. 2nd Intern. Symp. Trop. Root Tuber Crops. 1: 127-135.

Plucknett, D. L., R. S. de la Pena, & F. Obrero. 1970. Taro (*Colocasia esculenta*). Field Crop Abstr. 23: 413-426.

Rotar, P. P. et al. 1978. Bibliography of taro and edible aroids. Hawaiian Inst. Trop. Agric. Human Resources Misc. Publ. 158: 1-245.

Volin, R. B. & F. W. Zettler. 1976. Cocoyam and taro production in Florida. HortScience 11: 446.

Wang, J.-K. 1983. Taro. A review of *Colocasia esculenta* and its potentials. Univ. Hawaii Press. Honolulu. 400 pp.

TRUE YAMS

Alexander, J. & D. G. Coursey. 1969. The origin of yam cultivation. In, Ucko, P. J. and G. W. Dimbleby. The domestication and exploitation of plants and animals. Aldine Publ. Co. Pp. 405-426.

Ayensu, E. S. & D. G. Coursey. 1972. Guinea yams: the botany, ethnobotany: use and possible future of yams in West Africa. Econ. Bot. 26(4): 301-318.

Burkill, I. H. 1951. The rise and decline of the greater yam in the service of Man. Advancement of Science 7: 443-448.

Coursey, D. G. 1967. Yams: an account of the nature, origins, cultivation and utilisation of the useful members of the Dioscoreaceae. Longmans. London. 230 pp.

Coursey, D. G. 1972. The civilization of the yam: interrelationships of man and yams in Africa and the Indo-Pacific region. Archaeol. and Phys. Anthrop. in Oceania 7: 215-233.

Ingram, J. S. & L. H. Greenwood-Barton. 1962. The cultivation of yams for food. Trop. Sci. 4: 82-86.

Martin, F. W. 1974-1978. Tropical yams and their potential. Parts 1. *Diosocrea esculenta.* Agric. Handbook No. 457. Part 2. *Dioscorea bulbifera.* Agric. Handbook No. 466. Part 3. *Dioscorea alata.* Agriculture Handbook No. 495. Part 4. *Dioscorea rotunda* and *Dioscorea cyanensis.* Agric. Handbook No. 502. Part 5. (with L. Degras). *Dioscorea trifida.* Agric. Handbook 522. Part 6. (with L. Degras). Minor cultivated *Dioscorea* species. Agric. Handbook No. 538. U. S. Department of Agriculture. Washington, D. C.

Waitt, A. W. 1963. Yams, *Dioscorea* species. Field Crop Abstr. 16: 145-157.

MISCELLANEOUS ROOT CROPS

Brewster, J. L. 1994. Onions and other vegetable alliums. CAB International. Wallingford, England. 236 pp.

Emshwiller, E. & J. J. Doyle. 1998. Origins of domestication and polyploidy in OCA (*Oxalis tuberosa*: Oxalidaceae): nrDNA ITS data. American J. Bot. 85(7): 975-985.

Erdmann, M. D. & B. A. Erdmann. 1984. Arrowroot (*Maranta arundinacea*), food, feed, fuel, and fiber source. Econ. Bot. 38: 332-341.

Fenwick, G. R. & A. B. Hanley. 1985. The genus *Allium*. CRC Rev. Food Sci. & Nutr. Pt. I, 22(3): 199-271; Pt. II, 22(4): 273-377; Pt. III, 23(1): 1-73.

Gade, D. W. 1965. Achira, the edible canna, its cultivation and use in the Peruvian Andes. Econ. Bot. 20(4): 407-415.

Haudicourt, A. 1942. Les taccas, plantes utiles. Rev. Bot. Appl. 22: 69-81.

Hayward, W. 1957. The cultivated taccas. Baileya 4: 85-97.

Hermann, M. & J. Heller (editors). 1997. Andean roots and tubers: ahipa, arracacha, macon and yacon. International Plant Genetic Resources Inst. Rome, Italy. 256 pp.

Hill, A. W. 1939. The oca and its varieties. Kew Bull. Misc. Infor-mation 4: 169-173.

Hodge, W. H. 1951. Three native tuber foods of the high Andes. Econ. Bot. 5: 185-201.

Hodge, W. H. 1954. The edible arracacha -- a little known root crop of the Andes. Econ. Bot. 8: 195-221.

Jones, T. 1981. The anu and the maca. J. Ethnobiol. 1(2): 208-212.

King, S. R. & H. H. C. Bastien. 1990. *Oxalis tuberosa* Mol. (Oxalidaceae) in Mexico: an Andean tuber crop in Meso-America. Adv. Econ. Bot. 8: 77-91.

Leon, J. 1964. The "maca" (*Lepidium meyenii*), a little known food plant of Peru. Econ. Bot. 18: 122-127.

Martin, F. W. & E. Cabanillas. 1976. Leren (*Calathea allouia*), a little known tuberous root crop of the Caribbean. Econ. Bot. 30: 249-256.

Morgan, G. R. 1980. The ethnobotany of sweet flag among North American Indians. Bot. Mus. Leaflts. Harvard Univ. 28(3): 235-246.

Ochoa, C. 2001. Maca: a nutritious root crop of the central Andes. Econ. Bot. 55(3): 344, 345.

Rea, J. 1982. El miso (*Mirabilis expansa*). Una contribución de la agricultura preinca de Ecuador y Bolivia. Desde del Surco 5: 23-26.

Rubatsky, V. E., C. F. Quiros, & P. W. Simon. 1999. Carrots and related vegetable umbelliferae. CAB International. Wallingford, U.K. 250 pp.

Spennemann, D. H. R. 1995. Traditional arrowroot production and utilization in the Marshall Islands. J. Ethnobiol. 14(2): 211-234.

Vaughan, J. G. 1977. A multidisciplinary study of the taxonomy and origins of Brassica crops. BioScience 27: 35-40.

EDIBLE AERIAL STEMS, FLOWERS, & LEAVES

Brewster, J. L. 1994. Onions and other vegetable alliums. CAB International. Oxon, England. 236 pp.

Buck, P. A. 1956. Origin and taxonomy of broccoli. Econ. Bot. 10(3): 250-253.

Colbert, T. 1978. New Zealand spinach. Pacific Hort. 39(3): 13, 14.

Fenwick, G. R. & A. B. Hanley. 1985. The genus *Allium*. Part I. CRC Rev. Food Sci. Tech. 22(3): 199-271. II. 22(4): 273-377. III. 23(1): 1-73.

Gray, A. R. 1989. Taxonomy and evolution of broccolis and cauliflowers. Baileya 23(1): 28-46.

Jones, H. A. & L. K. Mann. 1963. Onions and their allies. Botany, cultivation and utilization. Leonard Hill Books. London, England. 286 pp.

Martin, F. W. & R. M. Ruberté. 1979. Edible leaves of the tropics. Second edition. U. S. Dept. Agric. Washington, D. C. 234 pp.

Nieuwhof, M. 1969. Cole crops: botany, cultivation, and utilization. World Crops Books. London, England. 353 pp.

Prakash, S. & K. Hinata. 1982. Taxonomy, cytogenetics, and origin of crop brassicas: a review. Opera Bot. 55: 3-57.

Ryder, E. J. 1999. Lettuce, endive and chicory. CAB International. Wallingford, U.K. 224 pp.

Tucker, J. B. 1986. Amaranth, the once and future crop. BioScience 36: 9-13.

Vaughan, J. C. & J. S. Hemingway. 1959. The utilization of mustards. Econ. Bot. 13: 196-204.

Vries, I. M. de. 1997. Origin and domestication of *Lactuca sativa* L. Genetic Res. & Crop Evol. 44: 165-174.

Whitaker, T. W. 1969. Salads for everyone - a look at the lettuce plant. Econ. Bot. 23: 261-264.

Winters, H. F. 1963. Ceylon spinach (*Basella rubra*). Econ. Bot. 17(3): 195-199.

Zohary, D. & J. Basnizky. 1975. The cultivated artichoke -- *Cynara scolymus*: its probable wild ancestors. Econ. Bot. 29: 233-235.

C E R E A L S

GENERAL

De Wet, J. M. J. 1975. Evolutionary dynamics of cereal domestication. Bull. Torrey Bot. Club 102: 307-312.

Diamond, J. 1997. Location, location, location: the first farmers. Science 278: 1243, 1244.

Dupont, J. & E. M. Osman. 1987. Cereals and legumes in the food supply. Iowa State Univ. Press. Ames. 360 pp.

Food and Agriculture Organization. 1989. Utilization of tropical foods: cereals. Food and Nutr. Papers No. 47/1. FAO. The United Nations. Rome, Italy. 114 pp.

Grubben, G. J. H. & S. Partohardjono. 1996. Plant resources of south-east Asia. No. 10. Cereals. Backhuys Publ. Leiden, The Netherlands. 199 pp.

Henry, R. J. 1985. A comparison of the non-starch carbohydrates in cereal grains. J. Sci. Food Agric. 36(12): 1243-1253.

Kent, N. L. & A. D. Evers. 1994. Technology of cereals. Fourth edition. Pergamon Press. Oxford, England.

Lazenby, A. 1975. The evolution of the temperate cereals. Austr. Field Crops 1: 1-36.

Lee, B. 1989. Cereal transformation. Plants Today 2(1): 9-11.

Moore, G. et al. 1995. Cereal genome evolution: grasses, line up and form a circle. Current Biol. 5: 737-739.

Scade, J. 1975. Cereals. Oxford Univ. Press. London, England. 70 pp.

Williams, J. T. (editor). 1995. Cereals and pseudocereals. Chapman & Hall. London, England.

MAJOR CEREALS

WHEAT

Beardsley, T. 1991. A nitrogen fix for wheat. Sci. Amer. 264(3): 32.

Bell, G. D. H. 1987. The history of wheat cultivation. In, Lupton, F. G. H. (editor). Wheat breeding: its scientific basis. Chapman & Hall. London, England.

Briggle, L. W. 1969. Triticale -- a review. Crop Science 9: 197-201.

Evans, L. T. & W. J. Peacock (editors). 1981. Wheat science: today and tomorrow. Cambridge Univ. Press. 290 pp.

Farbiani, G. & C. Lintas (editors). 1988. Durum wheat: chemistry and technology. Amer. Assoc. Cereal Chemists. St. Paul, MN. 332 pp.

Feldman, M. & E. R. Sears. 1981. The wild gene resources of wheat. Sci. Amer. 244(1): 98-109.

Friggens, P. 1975. Triticale: world's first man-made crop. Reader's Digest 107(Dec.): 33-36.

Hanson, B. 1992. Wheat, new and improved. Discover 13(12): 36, 37.

Harlan, J. R. 1967. A wild wheat harvest in Turkey. Archaeology 20: 197-201.

Harlan, J. R. 1981. The early history of wheat: earliest traces to sack of Rome. In, Evans, L. T. & W. J. Peacock (editors). Wheat science – today and tomorrow. Cam-bridge Univ. Press.Cambridge, England. Pp. 1-19.

Harlan, J. R. & D. Zohary. 1966. Distribution of wild wheats and barley. Science 513: 1074-1080.

Hillman, G. C. & M. S. Davies. 1990. Measured domestication rates in crops of wild type wheats and barley and the archaeological implications. J. World Prehist. 4: 157-222.

Huen, M. et al. 1997. Site on einkorn wheat domestication identified by DNA fingerprinting. Science 278: 1312-1314.

Hulse, J. H. & D. Spurgeon. 1974. Triticale. Sci. Amer. 231: 72-81.

Kimber, G. & M. Feldman. 1987. Wild wheat: an introduction. Univ. Missouri Coll. Agric. Special Report No. 353. Columbia. 142 pp.

Kuckuck, H. 1970. Primitive wheats. In, Frankel, O. H. & E. Bennett. Genetic resources in plants. Pp. 249-266.

Pomeranz, Y. 1973. From wheat to bread: a biochemical study. Amer. Sci. 61: 683-691.

Quisenberry, K. S. & L. P. Reitz (editors). 1967. Wheat and wheat improvement. Amer. Soc. Agron. Madison, WI. 560 pp.

Riley, R. 1965. Cytogenetics and the evolution of wheat. In, Hutchinson, J. (editor). Essays on crop plant evolution. Cambridge Univ. Press. London. Pp. 103-122.

Sears, E. R. 1948. The cytology and genetics of the wheats and their relatives. Adv. in Genetics 2: 239-270.

Sears, E. R. 1977. The origin and future of wheat. In, Seigler, D. S. (editor). Crop resources. Academic Press. New York, NY. Pp. 193-196.

Smith, N. 1983. Triticale: the birth of a new cereal. New Sci. 97: 98, 99.

Sokolov, R. 1993. The good seed. Nat. Hist. 102(7): 72; 74, 75.

Zohary, D. 1970. Wild wheats. In, Frankel, O. H. and E. Bennett (editors). Genetic resources in plants. Pp. 239-248.

RICE

Anonymous. 1973. Rice in the United States: varieties and production. Agric. Handbook No. 289. U. S. Dept. of Agric. Washington, D. C. 154 pp.

Association of Japanese Agricultural Scientific Societies (editors). 1975. Rice in Asia. Univ. Tokyo Press. Tokyo. 600 pp.

Carpenter, K. J. 2000. Berberi, white rice, and vitamin B: a disease, a cause, and a cure. Univ. California Press. Berkeley. 328 pp.

Chang, T.-T. 1976. The origin, evolution, cultivation, dissemination, and diversification of Asian and African rices. Euphytica 25(2): 425-441.

Chang, T.-T. 1984. Conservation of rice genetic resources: luxury or necessity? Science 224: 251-256.

Chen, B. & Q. Jiang. 1997. Antiquity of the earliest cultivated rice in central China and its implications. Econ. Bot. 51(3): 307-310.

Crawford, R. 1991. Gene mapping Japan's number one crop. Science 252: 1611.

Grist, D. H. 1986. Rice. Sixth edition. Longman. London, England. 599 pp.

Hanks, L. M. 1972. Rice and man: agricultural ecology in Southeast Asia. Aldine & Atherton. Chicago, IL. 174 pp.

Hargrove, T. R. et al. 1988. Twenty years of rice breeding. BioScience 38(10): 675-681.

Harris, D. R. 1974. Rice and man in Southeast Asia. Geogr. Rev. 64: 140-142.

Higham, C. & T. L.-D. Lu. 1998. The origins and spread of rice culti-vation. Antiquity 72: 867-877.

Jiang, Q. 1995. Searching for evidence of early rice agriculture at prehistoric sites in China through phytolith analysis: an example from central China. Rev. Palaeobot. Palynol. 89: 481-485.

Normile, D. 1987. Yangtze seen as earliest rice site. Science 275: 309.

Normile, D. & E. Pennisi. 2002. Rice: boiled down to base essentials. Science 296: 32-36.

Oka, H.-I. 1984. Origin of cultivated rice. Elsevier Science Publ. Co. New York, NY. 380 pp.

Ronald, P. C. 1997. Making rice disease-resistant. Sci. American 277(5): 100-105.

Sasaki, T. & G. Moore (editors). 1997. Oryza: from molecule to plant. Klumwer Acad. Publ. Dordrecht, The Netherlands. 254 pp.

Shimamoto, K. 1995. The molecular biology of rice. Science 270: 1772, 1773.

Sokolov, R. 1993. A two-faced grain. Nat. Hist. 102(1): 68-71.

Vaughan, D. A. & L. A. Sitch. 1991. Gene flow from the jungle to farmers. BioScience 41(1): 22-28.

Wenming, Y. 1991. China's earliest rice agricultural remains. Indo-Pacific Prehistory Assoc. Bull. 10: 118-126.

White, P. T. 1994. Rice: the essential harvest. Natl. Geogr. 185(5): 48-79.

Williams, W. W. 1996. From Asia's good earth. Hemispheres Dec: 80-88.

Xiao, J. et al. 1996. Genes from wild rice improve yield. Nature 384: 223, 224.

Yan, W. 1991. China's earliest rice agriculture remains. Bull. Indo-Pacific Prehist. Assoc. 10: 118-126.

MAIZE (CORN)

Anderson, E. 1945. What is *Zea mays?* Chron. Bot. 9: 88-92.

Anderson, E. 1947. Corn before Columbus. Pioneer Hi-Bred Corn Company. Des Moines, IA. 24 pp.

Anderson, E. & H. C. Cutler. 1950. Methods of corn popping and their historical significance. Southwest. J. Anthrop. 6: 303-308.

Anderson, E. & R. H. Barlow. 1943. The maize tribute of Montezuma's empire. Annals Missouri Bot. Gard. 30: 413-418.

Anderson, E. & W. L. Brown. 1952. The history of the common maize varieties of the United States corn belt. Agric. Hist. 26: 2-8.

Balter, M. 1997. Transgenic corn ban sparks a furor. Science 275: 1063.

Barghoorn, E. S., M. K. Wolf, & K. H. Clisby. 1954. Fossil maize from the Valley of Mexico. Bot. Mus. Leaflts. Harvard Univ. 16: 229-240.

Beadle, G. W. 1939. Teosinte and the origin of maize. J. Heredity 30: 245-247.

Beadle, G. W. 1972. The mystery of maize. Bull. Field Mus. Nat. Hist. 43(10): 2-11.

Beadle, G. W. 1977. The origins of *Zea mays.* In, Reed, C. A. (Editor). Origins of agriculture. Mouton Publ. The Hague. Pp. 615-635.

Beadle, G. W. 1978. Teosinte and the origin of maize. In, Walden, D. B. (Editor). Maize breeding and genetics. John Wiley & Sons. New York, NY. Pp. 113-128.

Beadle, G. W. 1980. The ancestry of corn. Sci. American 242(1): 112-119.

Bird, R. M. 1980. Maize evolution from 500 B. C. to the present. Biotropica 12: 30-41.

Brewbaker, J. L. 1979. Diseases of maize in the wet lowland tropics and the collapse of the classic Maya civilization. Econ. Bot. 33: 101-118.

Brush, S. B., M. B. Corrales, & E. Schmidt. 1988. Agricultural development and maize diversity in Mexico. Human Ecol. 16(3): 307-328.

Callen, E. O. 1967. The first New World cereal. American Antiquity 32: 535-538.

Carter, G. F. & E. Anderson. 1945. A preliminary survey of maize in the southwestern United States. Annals Missouri Bot. Gard. 32: 297-322.

Cohen, J. 1995. A Mexican-bred super maize. Science 267: 825.

Cohen, J. 1997. Corn genome pops out of the pack. Science 276: 1960-1962.

Collins, G. N. 1912. The origin of maize. J. Washington Acad. Sci. 2: 520-530.

Comfort, N. C. 2001. The tangled field: Barbara McClintock's search for the patterns of genetic control. Harvard Univ. Press. Cambridge, MA. 352 pp.

Culotta, E. 1991. How many genes had to change to produce corn? Science 252: 1792, 1793.

Curtin, L. S. M. 1968. Preparation of sacred corn meal in the Rio Grande pueblos. Southwest Museum Leaflets No. 32. 15 pp.

Cutler, H. C. & L. W. Blake. 1971. Travels of corn and squash. In, Riley, C. L. et al. (Editors). Man across the sea. Univ. Texas Press. Austin. Pp. 366-375.

de Wet, J. M. J. & J. R. Harlan. 1972. Origin of maize: the tripartite hypothesis. Euphytica 21: 271-279.

de Wet, J. M. J., J. R. Harlan, & C. A. Grant. 1971. Origin and evolution of teosinte (*Zea mexicana*). Euphytica 20: 255-265.

Doebley, J. F. 1985. Maize introgression into teosinte -- a reappraisal. Annals Missouri Bot. Gard. 71: 1100-1113.

Doebley, J. F. 1992. Mapping the genes that made maize. Trends in Genetics 8(9): 302-307.

Dold, C. 1997. The corn war. Discover 18(12): 109-113.

Eddy, F. W. 1964. Metates & manos: the basic corn grinding tools of the Southwest. Popular Series Pamphlet No. 1. Museum of New Mexico Press. Santa Fe. s. p.

Erwin, A. T. 1950. The origin and history of pop corn. Econ. Bot. 4(3): 294.

Eubanks, M. W. 1999. Corn in clay: maize paleoethnobotany in Pre-Columbian art. Univ. Press Florida. Gainsville. 249 pp.

Eubanks, M. W. 2002. The mysterious origin of maize. Econ. Bot. 55(4): 492-514.

Finan, J. J. 1948. Maize in the great herbals. Annals Missouri Bot. Gard. 35: 149-191.

Fine, E. H. 1998. People to know: Barbara McClintock. Enslow Publ. Springfield, NJ. 128 pp.

Galinat, W. C. 1961. Corn's evolution and its significance for breeding. Econ. Bot. 15: 320-325.

Galinat, W. C. 1965. The evolution of corn and culture in North America. Econ. Bot. 19: 350-357.

Galinat, W. C. 1966. The evolution of glumeless sweet corn. Econ. Bot. 20: 441-445.

Galinat, W. C. 1971. The origin of maize. Annual Rev. Genet. 5: 447-478.

Galinat, W. C. 1975. The evolutionary emergence of maize. Bull. Torrey Bot. Club 102: 313-324.

Galinat, W. C. 1977. The origin of corn. In, Sprague, Pp. 1-47.

Galinat, W. C. 1983. The origin of maize as shown by key morphological traits of its ancestor, teosinte. Maydica 28: 121-138.

Galinat, W. C. 1985. Domestication and diffusion in maize. In, Ford, R. I. editor). Prehistoric food production in North America. Univ. of Michigan. Ann Arbor. Pp. 245-282.

Galinat, W. C. 1985. The missing link between teosinte and maize. A review. Maydica 30: 137-160.

Galinat, W. C. 1988. The origin of corn. Agronomy 18: 1-31.

Galinat, W. C. 1992. Evolution of corn. Adv. Agron. 47: 203-231.

Galinat, W. C. 1995. El origin del maiz: el grano de la humanidad. Econ. Bot. 49(1): 3-12.

Goodman, M. M. 1988. The history and evolution of maize. CRC Critical Rev. Plant Sci. 7(3): 197-220.

Gould, S. J. 1984. A short way to corn. Nat. Hist. 93(3): 12-20.

Guzman Mejia, R. 1978. Redescubrimiento de *Zea perennis* (Gramineae). Phytologia 38(3): 177.

Hallauer, A. R. 2001. Specialty corns. Second edition. CRC Press. Boca Raton, FL. 479 pp.

Hardemann, N. P. 1981. Shucks, shocks, and hominy blocks: corn as a way of life in pioneer America. Louisiana State University Press. Baton Rouge. 271 pp.

Harpstead, D. D. 1971. High-lysine corn. Sci. Amer. 225(2): 34-42.

Harshberger, J. W. 1893. Maize, a botanical and economic study. Contr. Bot. Lab. Univ. Penn. 1: 75-202.

Hatt, G. 1951. The Corn Mother in America and Indonesia. Anthropos 46: 853-914.

Iltis, H. H. 1972. The taxonomy of *Zea mays* (Gramineae). Phytologia 23(2): 248, 249.

Iltis, H. H. 1983. From teosinte to maize: the catastrophic sexual transmutation. Science 222: 886-894.

Iltis, H. H. et al. 1979. *Zea diploperennis* (Gramineae): a new teosinte from Mexico. Science 203: 186-188.

Iltis, H. H. & J. F. Doebley. 1984. Zea -- a biosystematic odyssey. In, Grant, W. F. editor). Plant biosystematics. Academic Press. Montreal. Pp. 587-616.

Inglett, G. E. editor). 1982. Maize. Recent progress in chemistry and technology. Papers from a symposium, Prague, June 1982. Academic Press. New York, NY. 252 pp.

Jeffreys, M. D. W. 1967. Pre-Columbian maize in southern Africa. Nature 215: 695-697.

Jeffreys, M. D. W. 1971. Pre-Columbian maize in Asia. E. Anthrop. 9: 21-28.

Jeffreys, M. D. W. 1971. Pre-Columbian maize in Asia. In, Riley, C. L. et al. (editors). Man across the sea. Univ. Texas Press. Austin. Pp. 376-400.

Johannessen, C. L. & A. Z. Parker. 1989. Maize ears sculptured in 12th and 13th century A. D. India as indicators of Pre-Columbian diffusion. Econ. Bot. 43(2): 164-180.

Johannessen, S. & C. A. Hastorf. 1989. Corn and culture in central Andean prehistory. Science 244: 690-692.

Johannessen, S. & C. A. Hastorf (editors). 1994. Corn and culture in the prehistoric New World. Westview Press. Boulder, CO. 623 pp.

Johanessen, C. L., M. R. Wilson, & W. A. Davenport. 1970. The domestication of maize: process or event? Geogr. Review 60: 393-413.

Kahn, E. J. 1984. Profiles: the staffs of life. I. The golden thread. The New Yorker X:46-88.

Katz, S. H., M. L. Hediger, & L. A. Valleroy. 1974. Traditional maize processing techniques in the New World. Science 184: 765-773.

Kempton, J. H. 1919. The ancestry of maize. J. Washington Acad. Sci. 9: 3-11.

Kempton, J. H. 1938. Maize -- our heritage from the Indian. Smithsonian Report for 1937. Smithsonian Institution. Washington, D. C. Pp. 385-408.

Linn, A. 1973. Corn: the New World's secret weapon and the builder of its civilization. Smithsonian 4: 58-65.

MacNeish, R. S. 1955. Ancient maize and Mexico. Archaeology 8(2): 108-115.

MacNeish, R. S. 1985. The archaeological record in the problem of the domestication of corn. Maydica 30: 171-178.

Mangelsdorf, P. C. 1945. The origin and nature of the ear of maize. Bot. Mus. Leaflts. Harvard Univ. 12: 33-88.

Mangelsdorf, P. C. 1947. The origin and evolution of maize. Adv. in Genetics 1: 161-207.

Mangelsdorf, P. C. 1948. The role of pod corn in the origin and evolution of maize. Annals Missouri Bot. Gard. 35: 377-406.

Mangelsdorf, P. C. 1950. The mystery of corn. Sci. Amer. (July): 1-6.

Mangelsdorf, P. C. 1958. Ancestor of corn. Science 128: 1313-1320.

Mangelsdorf, P. C. 1958. Reconstructing the ancestor of corn. Proc. Amer. Phil. Soc. 102: 454-463.

Mangelsdorf, P. C. 1960. Reconstructing the ancestor of corn. Smithsonian Report for 1959. Smithsonian Institution. Washington, D. C. Pp. 495-507.

Mangelsdorf, P. C. 1961. Introgression in maize. Euphytica 10: 157-168.

Mangelsdorf, P. C. 1964. Corn in the Old World. Science 145:659.

Mangelsdorf, P. C. 1965. The evolution of maize. In, Hutchinson, J. Essays on crop plant evolution. Cambridge Univ. Press. Cambridge, England. Pp. 23-49.

Mangelsdorf, P. C. 1974. Corn: its origin, evolution, and improvement. Harvard Univ. Press. Cambridge, MA. 262 pp.

Mangelsdorf, P. C. 1983. The mystery of corn: new perspectives. Proc. Amer. Phil. Soc. 127: 215-247.

Mangelsdorf, P. C. 1983. The search for wild corn. Maydica 28: 89-96.

Mangelsdorf, P. C. 1986. The origin of corn. Sci. Amer. 255(2): 80-86.

Mangelsdorf, P. C. & D. L. Oliver. 1951. Whence came maize to Asia? Bot. Mus. Leaflts. Harvard Univ. 14: 263-291.

Mangelsdorf, P. C. & R. G. Reeves. 1935. A trigeneric hybrid of *Zea, Tripsacum*, and *Euchlaena.* J. Heredity 26: 129-140.

Mangelsdorf, P. C. & R. G. Reeves. 1938. The origin of maize. Proc. Natl. Acad. Sci. 24: 303-312.

Mangelsdorf, P. C. & R. G. Reeves. 1939. The origin of Indian corn and its relatives. Texas Agric. Exper. Station Bull. No. 574. 315 pp.

Mangelsdorf, P. C. & R. G. Reeves. 1959. The origin of corn. I. Pod corn, the ancestral form. Bot. Mus. Leaflts. Harvard Univ. 18: 329-356.

Mangelsdorf, P. C. & R. G. Reeves. 1959. The origin of corn. II. Teosinte, a hybrid of corn and tripsacum. Bot. Mus. Leaflts. Harvard Univ. 18: 357-387.

Mangelsdorf, P. C. & R. G. Reeves. 1959. The origin of corn. III. Modern races, the product of teosinte introgression. Bot. Mus. Leaflts. Harvard Univ. 18: 389-411.

Mangelsdorf, P. C. & R. G. Reeves. 1959. The origin of corn. IV. Place and time of origin. Bot. Mus. Leaflts. Harvard Univ. 18: 413-427.

Mangelsdorf, P. C., R. S. MacNeish, & W. C. Galinat. 1964. Domestication of corn. Science 143: 538-545.

Mangelsdorf, P. C., R. S. MacNeish, & W. C. Galinat. 1967. Prehistoric wild and cultivated maize. In, Byers, D. S. (editor). Prehistory of the Tehuacan Valley. Univ. Texas Press. Austin. 1: 178-200.

Mangelsdorf, P. C. et al. 1978. Fossil pollen and the origin of corn. Bot. Mus. Leaflts. Harvard Univ. 26(7): 237-255.

Morrison, G. 1947. Hybrid corn -- science in practice. Econ. Bot. 1(1): 5-19.

Nault, L. R. & W. R. Findley. 1983. *Zea diploperennis,* a primitive relative, offers new traits to improve corn. Desert Plants 3: 203-205.

Onion, D. K. 1964. Corn in the culture of the Mohawk Indians. Econ. Bot. 18: 60-66.

Ortiz, A. 1989. Some cultural meanings of corn in aboriginal North America. Northeast Indian Quart. 6: 64-73.

Pääbo, S. 1999. Neolithic genetic engineering. Nature 398: 194, 195.

Pearsall, D. M. 1978. Early movement of maize between Mesoamerica and South America. J. Steward Anthrop. Soc. 9: 41-75.

Raloff, J. 1993. Corn's slow path to stardom. Science News 143(16): 248-250.

Randolf, L. F. 1952. New evidence on the origin of maize. Amer. Natl. 86: 193-202.

Randolf, L. F. 1959. The origin of maize. Ind. J. Genet. Plant Breed. 19: 1-12.

Randolf, L. F. 1976. Contributions of wild relatives of maize to the evolutionary history of domesticated maize: a synthesis of divergent hypotheses. I. Econ. Bot. 30: 321-345.

Reeves, R. G. & P. C. Mangelsdorf. 1959. The origin of corn. V. A critique of current theories. Bot. Mus. Leaflts. Harvard Univ. 18: 428-440.

Rhoades, M. M. 1984. The early years of maize genetics. Ann. Rev. Genetics 18: 1-29.

Rhoades, R. E. 1993. The golden grain: corn. Natl. Geogr. 183(6): 92-117.

Shaver, D. L. 1967. Perennial maize. J. Heredity 58: 271-273.

Sprague, G. F. & J. W. Dudley (editors). 1988. Corn and corn improvement. Third edition. American Soc. Agronomy. Madison, WI. 986 pp.

Steinberg, M. K. 1999. Maize diversity and cultural change in a Maya agro-ecological landscape. J. Ethnobiol. 19(1): 127-139.

Tatum, L. A. 1971. The southern corn leaf blight epidemic. Science 171: 1113-1116.

Walden, H. T. 1966. Native inheritance. The story of corn in America. Harper & Row. New York, NY. 199 pp.

Wallace, H. A. & W. L. Brown. 1956. Corn and its early fathers. Michigan State Univ. Press. East Lansing.

Walsh, R. 1999. The unconquerable tostada: five hundred years after Cortes, Zapotec food still offers a taste of antiquity. Nat. Hist. 108(3): 94-97.

Watson, S. A. and P. E. Ranstad (editors). 1987. Corn: chemistry and technology. American Association Cereal Chemists. St. Paul, MN. 605 pp.

Weatherwax, P. 1918. The origin of maize. Bull. Torrey Club 45: 309-342.

Weatherwax, P. 1923. The story of the maize plant. Univ. of Chicago Press. Chicago, IL. 247 pp.

Weatherwax, P. 1935. Phylogeny of maize. Amer. Midl. Natl. 16: 1-71.

Weatherwax, P. 1945. Early contacts of European science with the Indian corn plant. Proc. Indiana Acad. Sci. 54: 169-178.

Weatherwax, P. 1950. The history of corn. Sci. Monthly 71: 50-60.

Weatherwax, P. 1954. Indian corn in Old America. Macmillan & Co. New York, NY. 253 pp.

Weatherwax, P. 1955. History and origin of corn. I. Early history of corn and theories as to origin. In, Sprague, G. F. Corn and corn improvement. Academic Press. Pp. 1-16.

Wilkes, H. G. 1972. Maize and its wild relatives. Science 177: 1071-1077.

Wilkes, H. G. 1977. Hybridization of maize and teosinte, in Mexico and Guatemala and the improvement of maize. Econ. Bot. 31(3): 254-293.

Wilkes, H. G. 1977. The origin of corn -- studies of the last hundred years. In, Seigler, D. S. (editor). Crop resources. Academic Press. New York, NY. Pp. 211-223.

Wilkes, H. G. 1979. Mexico and Central America as a centre for the origin of agriculture and the evolution of maize. Crop Improvement [India] 6: 1-18.

Williams, L. O. 1952. Beans, maize and civilization. Ceiba 3(2): 77-85.

Xolocotzi, E. H. 1985. Maize and man in the greater Southwest. Econ. Bot. 39(4): 416-431.

Yen, D. E. 1959. The use of maize by the New Zealand Maoris. Econ. Bot. 13(4): 319-327.

BREAD MAKING

Dupaigne, B. 1999. The history of bread. Translated from the French by A. & S. Roder. Harry N. Abrams. New York, NY. 256 pp.

Editors of Time-Life Books. 1981. The good cook: breads. Time-Life Books. Alexandria, VA. Pp. 5-10.

Jacob, H. E. 1944. Six thousand years of bread: its holy and unholy history. Reprint edition 1997. Lyons Press. New York, NY. 399 pp.

Katz, S. H. & M. M. Voight. 1985. Bread and beers: the early use of cereals in human diet. Expedition 28(2): 23-34.

McGee, H. 1984. Bread, doughs, and batters. In, On food and cooking: the science and lore of the kitchen. Charles Scribner's Sons. New York, NY. Pp. 273-313.

Panscher, W. G. 1956. Baking in America. Northwestern Univ. Press. Evanston, IL.

Pomeranz, Y. et al. 1970. Molecular approach to breadmaking. Science 167: 944-949.

Pomeranz, Y. 1973. From wheat to bread: a biochemical study. American Sci. 61: 683-691.

MINOR CEREALS

Andrews, D. J. & K. A. Kumar. 1992. Pearl millet for food, feed, and forage. Adv. Agron. 48: 89-139.

Behre, K. E. 1992. The history of rye cultivation in Europe. Vegetation History & Archaeobot. 1: 141-156.

Brunken, J. et al. 1977. The morphology and domestication of pearl millet. Econ. Bot. 31(2): 163-174.

DeWet, J. M. J. 1990. Origin, evolution and systematics of minor cereals. In, Seetharam, A. et al. Pp. 19-.

DeWet, J. M. J. & J. R. Harlan. 1971. The origin and domestication of *Sorghum bicolor*. Econ. Bot. 25: 128-135.

Doggett, H. 1989. Sorghum. Second edition. John Wiley & Sons. New York, NY. 512 pp.

Hayes, P. M. et al. 1989. The domestication of American wild rice (*Zizania palustris*, Poaceae). Econ. Bot. 43(2): 203-214.

Hemmerly, T. E. 1983. Traditional method of making sorghum molasses. Econ. Bot. 37: 406-409.

Hilu, K. W. & J. M. J. de Wet. 1976. Domestication of *Eleusine coracana*. Econ. Bot. 30: 199-208.

Hulse, J. H. et al. 1980. Sorghum and the millets: their composition and nutritive value. Academic Press. London, England. 997 pp.

Jain, S. K. & D. K. Banerjee. 1974. Preliminary observations on the ethnobotany of the genus *Coix*. Econ. Bot. 28: 38-42.

Jenks, A. E. 1900. Wild rice gatherers of the Upper Lakes. 19th annual report. Bureau of American Ethnology. U.S. Gov. Print. Office. Washington, D.C. pp 1013-1137.

Lorenz, K. 1981. Wild rice: the Indian's staple and the white man's delicacy. CRC Rev. in Food Sci. & Nutr. 15(3): 281-319.

Marshall, H. G. & M. E. Sorrells (co-editors). 1992. Oat science and technology. American Soc. Agron. & Crop Sci. Soc. of America. Madison, WI. 846 pp.

Martin, J. M. 1953. Broomcorn -- the frontiersman's cash crop. Econ. Bot. 7(2): 163-181.

Mengesha, M. H. 1966. Chemical composition of teff (*Eragrostis tef*) compared with that of wheat, barley and grain sorghum. Econ. Bot. 20: 268-273.

Sampson, D. R. 1954. On the origin of oats. Bot. Mus. Leaflts. Harvard Univ. 16: 265-303.

Seetharam, A. et al. (editors). 1990. Small millets in global agriculture. Aspect Publ. London, U. K. 392 pp.

Shapley, D. 1973. Sorghum: "miracle" grain for the world protein shortage? Science 182: 147, 148.

Smith, C. W. & R. A. Frederiksen (editors). 2000. Sorghum: origin, history, technology, and production. John Wiley & Sons. New York, NY. 824 pp.

Sokolov, R. 1993. The teff also rises. Nat. Hist. 102(3): 96, 98, 99.

Sokolov, R. 1993. Barley's ghost. Nat. Hist. 102(6): 72; 74, 75.

Standt, G. 1961. The origin of cultivated barleys: a discussion. Econ. Bot. 15: 205-212.

Steeves, T. A. 1952. Wild rice -- Indian food and a modern delicacy. Econ. Bot. 6: 107-142.

Welch, R. W. (editor). 1995. The oat crop: production and utilization. Chapman & Hall. London, U. K. 584 pp.

FALSE CEREALS

Bertero, H. D. 2001 [2002]. Quinoa (*Cheno-podium quinoa*) could become an important crop for Argentinian agriculture. Bol. Soc. Argentina Bot. 36(3-4): 309-314.

Campbell, C. G. 1997. Buckwheat. *Fagopyrum esculentum* Moench. Promoting the conservation and use of underutilized and neglected crops. Vol. 19. Inst. Plant Genetics and Crop PlantResearch. Rome, Italy. 93 pp.

Cusack, D. F. 1984. Quinua: grain of the Incas. The Ecologist 14: 21-31.

Feine, L. B. et al. 1979. Amaranth: gentle giant of the past and future. In, Ritchie, C. A. New agricultural crops. Westview Press. Pp. 41-63.

Galway, N. W. 1984. The *Chenopodium* grains of the Andes: Inca crops for modern agriculture. Adv. Appl. Biol. 10: 145-216.

Lees, P. 1983. The rediscovery of amaranth. World Farming Agriman. 25(6): 6; 24, 25.

Lentz, D. L. et al. 2001. Prehistoric sunflower (*Helianthus annuus* L.) domestication in Mexico. Econ. Bot. 55(3): 370-376.

Sauer, J. D. 1967. The grain amaranths and their relatives: a revised taxonomic and geographical survey. Ann. Missouri Bot. Gard. 54(2): 103-137.

Saunders, R. & R. Becker. 1984. *Amaranthus*: a potential food and feed resource. Adv. Cereal Sci. Tech. 6: 357-396.

Sauer, J. D. 1967. The grain amaranths and their relatives: a revised taxonomic and geographical survey. Ann. Missouri Bot. Gard. 54(2): 103-137.

Saunders, R. M. & R. Becker. 1983. Amaranthus: a potential food and feed resource. Adv. Cereal Sci. Tech. 6: 357-396.

Simmonds, N. W. 1965. The grain chenopods of the tropical American highlands. Econ. Bot. 19: 223-235.

Smith, B. N. 1985. The role of *Chenopodium* as a domesticate in premaize garden systems of the eastern United States. Southeast. Arch. 4: 51-72.

Sokolov, R. 1986. The good seed [amaranth]. Nat. Hist. April: 102-105.

Sokolov, R. 1992. This is quinoa. Nat. Hist. June: 72-75.

THE PULSES

Adler, T. 1995. Black-eyed peas go to Mars? Science News 148(23): 376, 377.

Arie, T. H. D. 1959. Pythagorus and beans. Oxford Med. School Gaz. 2: 75-81.

Aykroyd, W. R. & J. Doughty. 1982. Legumes in human nutrition. Second edition. F. A. O. Rome. 152 pp.

Banks, D. J. 1988. Origin and evolution of the peanut (*Arachis hypogaea* L.) Leguminosae. American J. Bot. 76(2): 158, 159.

Barrow, M. V. et al. 1974. Lathyrism: a review. Quart. Rev. Biol. 49(2): 101-128.

Battle, I. & J. Tous. 1997. Promoting the conservation and use of underutilized and neglected crops. 17. Carob tree. *Ceratonia siliqua*. International Plant Genetic Resources Inst. Rome, Italy. 92 pp.

Bender, A. E. & G. B. Reaidi. 1982. Toxicity of kidney beans (*Phaseolus vulgaris*) with particular reference to lectins. J. Plant Foods 4: 15-22.

Berglund-Brucher, O. & H. Brucher. 1976. The South American wild bean (*Phaseolus aborigineus* Burk.) as ancestor of the common bean. Econ. Bot. 30: 257-272.

Buckles, D. 1995. Velvetbean: a "new" plant with a history. Econ. Bot. 49(1): 13-25.

Buhrow, R. The wild beans of southwestern North America. Desert Plants 5(2): 67-72; 82-88.

Buishand, T. 1956. The crossing of beans. Euphytica 5(1): 41-50.

Burris, R. H. & G. P. Roberts. 1993. Biological nitrogen fixation. Ann. Rev. Nutr. 13: 317-335.

Butler, A. 1995. The small-seeded legumes: an enigmatic prehistoric resource. Acta Palaeobotany 35(1): 105-115.

Carver, G. W. 1940. How to grow the peanut and 105 ways of preparing it for human consumption. Bull. No. 31. Seventh edition. Tuskegee Inst. Tuskegee, AL. 30 pp.

Delwiche, C. C. 1978. Legumes -- past, present, and future. BioScience 28: 565-570.

Dovring, F. 1974. Soy bean. Sci. Amer. 230(2): 14-21.

Duke, J. A. 1980. Handbook of legumes of world economic importance. Plenum Press. New York, NY. 345 pp.

Food and Agriculture Organization. Utilization of tropical foods: tropical beans. Food and Nutrition Papers No. 47/4. FAO. The United Nations. Rome, Italy. 74 pp.

Gentry, H. S. 1969. Origin of the common bean, *Phaseolus vulgaris.* Econ. Bot. 23: 55-69.

Gepts, P. 1990. Biochemical evidence bearing on the domestication of *Phaseolus* (Fabaceae) beans. Econ. Bot. 44(3:Suppl.): 28-38.

Huheey, J. E. & D. L. Martin. 1975. Malaria, favism, and G 6 P D deficiency. Experientia 30: 1145-1147.

Hutchinson, J. B. 1970. The evolutionary diversity of the pulses. Proc. Nutr. Soc. 29: 49-55.

Hymowitz, T. 1970. On the domestication of the soybean. Econ. Bot. 24: 408-421.

Hymowitz, T. & C. A. Newell. 1977. Current thoughts on origins, present status and future of soybeans. In, Seigler, D. S. Crop resources. Pp. 197-209.

Hymowitz, T. & C. A. Newell. 1981. Taxonomy of the genus *Glycine,* domestication and uses of soybeans. Econ. Bot. 35(3): 272-288.

Hymowitz, T. & J. Boyd. 1977. Origin, ethnobotany and agricultural potential of the winged bean -- *Physocarpus tetragonolobus.* Econ. Bot. 31(2): 180-188.

Imhoff, D. & P. Warshall. 1999. Soybean of happiness: a 3,000 year history of our most modern oilseed. Whole Earth Summer: 75-79.

International Legume Database and Information Service. 1995. Legumes of the world. Chapman & Hall. London, England. 1800 pp.

Isely, D. 1982. Leguminosae and *Homo sapiens.* Econ. Bot. 36(1): 46-70.

Kadam, S. S. & D. K. Salunke. 1984. Winged bean in human nutrition. CRC Rev. in Food Sci. & Nutr. 21(1): 1-40.

Kahn, E. J., Jr. 1985. Soybeans, the future of the planet. In, The staffs of life. Little, Brown & Co. Boston, MA. Pp. 251-299.

Kaplan, L. 1965. Archaeology and domestication in American *Phaseolus* (beans). Econ. Bot. 19: 358-368.

Kaplan, L. 1981. What is the origin of the common bean? Econ. Bot. 35(2): 240-254.

Katz, S. H. 1987. Fava bean consumption: a case for the co-evolution of genes and culture. In, Harris, M. & E. B. Ross (editors). Food and evolution. Temple Univ. Press. Philadelphia, PA. Pp. 133-159.

Katz, S. H. & J. Schall. 1979. Fava bean consumption and biocultural evolution. Medical Anthrop. Fall: 459-476.

Kaul, A. K. & D. Combes. 1986. Lathyrus and lathyrism. Third World Med. Res. Found. New York, NY.

Kimball, M. 1982. On farting. Coevolution Quarterly 34: 80-85. [Yes, this is a real article!]

Kirkbride, J. H., Jr., et al. 2000. Legume (Fabaceae) fruits and seeds. CD-ROM. Parkway Publ. Boone, NC.

Kislev, M. E. 1989. Origins of the cultivation of *Lathyrus sativus* and *L. cicera* (Fabaceae). Econ. Bot. 43(2): 262-270.

Kislev, M. E. & O. Bar-Yosef. 1988. The legumes: earliest domesticated plants in the Near East? Current Anthrop. 29(1): 175-179.

Kremer, G. R. 1987. George Washington Carver in his own words. Univ. Missouri Press. Columbia. 208 pp.

Ladizinsky, G. 1989. Pulse domestication: fact and fiction. Econ. Bot. 43(1): 131, 132.

Ladizinsky, G. 1993. Lentil domestication: on the quality of evidence and arguments. Econ. Bot. 47(1): 60-64.

Ladizinsky, G. & A. Adler. 1976. The origin of the chickpea, *Cicer arientinum* L. Euphytica 25(1): 211-218.

Leiner, I. E. 1964. Seed hemagglutinins. Econ. Bot. 18(1): 27-33.

Levitt, M. D. & J. H. Bond. 1980. Flatulence. Ann. Rev. Med. 31: 127-137.

Lumpkin, T. A. & D. C. McClary. 1994. Adzuki bean: botany, production and uses. CAB International. Wallingford, U. K. 268 pp.

Marcus, J. R. & G. Cohen. 1967. The riddle of the dangerous bean. Harpers Monthly Mag. 234(1405): 98-102. [fava bean]

Marx, J. L. 1985. How rhizobia and legumes get it together. Science 230: 157, 158.

Masefield, G. B. 1973. *Psophocarpus tetragonolobus* -- a crop with a future? Field Crop Abs. 26: 157-160.

Matthews, R. H. (editor). 1989. Legumes: chemistry, technology, and human nutrition. Marcel Dekker. New York, NY. 389 pp.

McMurray, L. O. 1981. George Washington Carver: scientist and symbol. Oxford Univ. Press. Oxford, U. K. 367 pp.

Mitchell, R. D. 1971. The grass pea: distribution, diet, and disease. Yearbook Assoc. Pacific Coast Geogr. 33: 29-46.

Morse, W. J. 1947. The versatile soybean. Econ. Bot. 1(2): 137-147.

Morton, J. F. 1976. The pigeon pea (*Cajanus cajan* Millsp.), a high-protein, tropical bush legume. HortScience 11(1): 11-19.

Nabhan, G. B. (editor). 1983. The desert tepary as a food resource. Desert Plants 5(1): 3-63.

Nabhan, G. P. 1984. Mesquite: another great American legume. Organic Gard. April: 114, 115.

Nabhan, G. B. & R. S. Felger. 1978. Teparies in southwestern North America. A biogeographical and ethnohistorical study of *Phaseolus acutifolius.* Econ. Bot. 32(1): 3-19.

National Research Council. 1979. Tropical legumes: resources for the future. National Academy of Sciences. Washington, D. C. 331 pp.

Nwokolo, E. & J. Smartt (editors). 1996. Food and feed from legumes and oilseeds. Chapman & Hall, New York, NY 419 pp.

Peña, F. B. et al. 1999. Use and nutritive value of talet beans, *Amphicarpaea bracteata* (Fabaceae: Phaseoleae) as human food in Puebla, México. Econ. Bot. 53(4): 427-434.

Pickersgill, B. & J. M. Lock (editors). 1996. Advances in legume systematics. Pt. 8. Legumes of economic importance. Royal Botanic Gardens. Kew, England. 143 pp.

Raloff, J. 2000. Detoxifying desert's manna [0sweet pea]. Science News 158: 74-76.

Reynolds, B. F. 2000. The most important food in the world. Mother Earth News 180(June/July): 62-67. [soybean]

Rowlett, R. M. & J. Mori. 1970. The fava bean in English folklore. Ethnol. Europea 4: 98-102.

Sacks, F. M. 1977. A literature review of *Phaseolus angularis* -- the adzuki bean. Econ. Bot. 31(1): 9-15.

Salunkhe, D. K. & S. S. Kadam. 1989. Handbook of world food legumes. CRC Press. Boca Raton, FL. Vol. 1, 310 pp. Vol. 2, 294 pp.

Sauer, J. D. & L. Kaplan. 1969. Canavalia beans in American prehistory. American Antiquity 34: 417-424.

Scarborough, J. 1981-1982. Beans, Pythagoras, taboos, and ancient dietetics. Classical World 75: 355-358.

Schaaffhansen, R. von. 1963. *Dolichos lablab* or hyacinth bean. Econ. Bot. 17(2): 146-000.

Singh, U. & B. Singh. 1992. Tropical grain legumes as important human foods. Econ. Bot. 46(3): 310-321.

Stone, J. 1991. Tooti-frutti. Discover 12(9): 26, 27; 30.

Smartt, J. 1976. Tropical pulses. Tropical Agriculture Series. Longman. New York, NY. 348 pp.

Smartt, J. 1978. The evolution of pulse crops. Econ. Bot. 32(2): 185-198.

Sokolov, R. 1984. Broad bean universe. Nat. Hist. XX(12): 84-85; 87.

Sokolov, R. 1984. The underground pea. Nat. Hist. September: 98-101.

Thompson, R. & R. Casey (editors). 1983. Perspectives for peas and lupins as protein crops. Proceedings of a symposium. Nijhoff. The Hague. 380 pp.

Waines, J. G. 1975. The biosystematics and domestication of peas. Bull. Torrey Bot. Club 102: 385-395.

Wilcke, H. L. et al. 1979. Soy protein and human nutrition. Academic Press. New York, NY. 406 pp.

Williams, J. T. 1993. Pulses and vegetables. Underutilized Crop Series. Chapman & Hall. London, England. 247 pp.

Wolf, W. J. & J. C. Cowan. 1975. Soybeans as a food source. CRC Press. Cleveland, OH. 101 pp.

Wolkomir, R. 1982. It's "coffee," it's "milk," it's superbean! The American Way December: 56-61.

Woodroof, J. G. 1983. Peanuts, production, processing, products. Third edition. AVI Publ. Co. Westport, CT. 414 pp.

Zohary, D. 1972. The wild progenitor and the place of origin of the cultivated lentil: *Lens culinaris.* Econ. Bot. 26: 326-332.

Zohary, D. 1989. Pulse domestication and cereal domestication: how different are they? Econ. Bot. 43(1): 31-34.

Zohary, D. and M. Hopf. 1973. Domestication of pulses in the Old World. Science 182: 887-894.

V E G E T A B L E S

GENERAL

Buishand, T., H. P. Houwing, & K. Jansen. 1986. The complete book of vegetables. Gallery Books. New York, NY. 180 pp.

Ingram, C. 1997. The new guide to vegetables. Hermes House. New York, NY. 128 pp.

Lovelock, Y. 1972. The vegetable book: an unnatural history. St. Martin's Press. New York, NY.

Munro, D. B. & E. Small. 1997. Vegetables of Canada. Natl. Res. Council of Canada. Ottawa. 417 pp.

Phillips, R. & M. Rix. 1993. The Random House book of vegetables. Random House. New York, NY. 270 pp.

Rubatzky, V. E. & M. Yamaguchi. 1997. World vegetables: principles, production, and nutritive values. Second edition. Chapman & Hall. New York, NY. 843 pp.

Schneider, E. 1986. Uncommon fruits & vegetables: a commonsense guide. Harper & Row. New York, NY. 546 pp.

Siemonsma, J. S. & K. Piluek (editors). 1993. Plant resources of South-East Asia. No. 8: vegetables. Pudoc Scientific Publ. Wageningen, The Netherlands. 412 pp.

Yamaguchi, M. 1983. World vegetables: principles, production and nutritive values. AVI Publ. Westport, CT. 415 pp.

BREADFRUIT & JACKFRUIT

Barrau, J. 1957. L'arbre a pain en Oceanie. J. Agric. Trop. Bot. Appl. 4: 117-123.

Morton, J. F. 1965. The jackfruit (*Artocarpus heterophyllus* Lam.): its culture, varieties, and utilization. Florida State Hort. Soc. 78: 336-344.

Oster, G. & S. Oster. 1985. The great breadfruit scheme. Nat. Hist. 94: 34-41.

Ragone, D. 1987. Collecting breadfruit in the central Pacific. Bull. Pacific Trop. Bot. Gard. 17(2): 37-41.

Ragone, D. 1991. Ethnobotany of breadfruit in Polynesia. In, Cox, P. A. & S. A. Banack (editors). Islands, plants, and Polynesians. Dioscorides Press. Portland, OR. Pp. 203-220.

Ragone, D. 1997. Breadfruit. *Artocarpus altilis* (Parkinson) Fosberg. No. 10. Promoting the conservation and use of underutilized and neglected crops. Intern. Plant Genetic Resources Inst. Rome, Italy. 77 pp.

Sokolov, R. 1993. A fruit freely chosen. Nat. Hist. 102(9): 76-79.

Thomas, C. A. 1980. Jackfruit, *Artocarpus heterophyllus* (Moraceae), a source of food and income. Econ. Bot. 34: 154-159.

Wilder, G. P. 1928. The breadfruit of Tahiti. Bull. Bernice P. Bishop Mus. 50: 1-83.

CUCURBITS (GOURDS, ETC.)

Bates, D. M., R. W. Robinson, & C. Jeffrey (editors). 1990. Biology and utilization of the Cucurbitaceae. Cornell Univ. Press. Ithaca, NY. 485 pp.

Cutler, H. C. & T. W. Whitaker. 1961. History and distribution of the cultivated cucurbits in the Americas. American Antiq. 26: 469-485.

Dodge, E. S. 1995. Hawaiian and other Polynesian gourds. Ku Pa'a Press. Honolulu, HI. 190 pp.

Flores, E. 1989. El chayote, *Sechium edule* Swartz (Cucurbitaceae). Rev. Biol. Trop. 37(1): 1-54.

Gathman, A. C. & W. P. Bemis. 1990. Domestication of buffalo gourd, *Cucurbita foetidissima*. In, Bates et al. Pp. 335-348.

Heiser, C. B., Jr. 1973. The penis gourd of New Guinea. Ann. Assoc. American Geog. 63: 312-318. (Yes, this is for real!)

Heiser, C. B., Jr. 1979. The gourd book. Univ. Oklahoma Press. Norman. 248 pp.

Lira, R. & J. Casballero. 2002. Ethnobotany of the wild Mexican Cucurbitaceae. Econ. Bot. 56(4): 380-398.

Lira Saade, R. 1996. Promoting the conservation and use of underutilized and neglected crops. 8. Chayote, *Sechium edule* (Jacq.) Sw. International Plant Genetic Resources Inst. Rome, Italy. 58 pp.

Marr, K. L. 2001. *Benincasa hispida* (Cucurbitaceae): the "pumpkin" of Asian creation stories? Econ. Bot. 55(4): 575-577.

McDermott, M. 1996. The spirit of the gourd. Oklahoma Today 46(4): 32-39.

Morton, J. F. 1967. The balsam pear -- an edible, medicinal and toxic plant. Econ. Bot. 21: 57-68.

Morton, J. F. 1981. The chayote, a perennial climbing, subtropical vegetable. Proc. Florida State Hort. Soc. 94: 240-245.

Nayar, N. M. & T. A. More. 1998. Cucurbits. Science Publ. Enfield, NH. 340 pp.

Nee, M. 1990. The domestication of *Cucurbita* (Cucurbitaceae). Econ. Bot. 44 (3: Suppl.): 56-68.

Newstrom, L. E. 1990. Origin and evolution of chayote, *Sechium edule*. In, Bates et al. Pp. 141-149.

Paris, H. S. 1989. Historical records, origins, and development of the edible cultivar groups of *Cucurbita pepo* (Cucurbitaceae). Econ. Bot. 43: 423-443.

Porterfield, W. M. 1955. Loofah -- the sponge gourd. Econ. Bot. 9: 211-223.

Riley, C. L. et al. (editors). Man across the sea. Univ. Texas Press. Austin. Pp. 320-327.

Robinson, R. W. & D. S. Decker-Walters. 1997. Cucurbits. CAB International. Wallingford, England. 226 pp.

Smith, B. D. 1997. The initial domestication of *Cucurbita pepo* in the Americas 10,000 years ago. Science 276: 932-934.

Whitaker, T. W. 1947. American origin of the cultivated cucurbits. I. Evidence from the herbals. II. Survey of old and recent botanical evidence. Ann. Missouri Bot. Gard. 34(2): 101-111.

Whitaker, T. W. 1971. Endemism and Pre-Columbian migration of the bottle gourd, *Lagenaria siceraria* (Mol.) Standl. In,

Whitaker, T. W. 1990. Cucurbits of potential economic importance. In, Bates et al. Pp. 318-324.

Whitaker, T. W. & H. C. Cutler. 1965. Cucurbits and cultures in the Americas. Econ. Bot. 19: 344-349.

EGGPLANT

Falwell, J. 1994. Eggplants – fruit of the devil! Christian Broadcasting Monthly 35: 43-47.

Gibbon, E. 1780. A lesser known cause of the decline and fall of the Roman Empire. J. British Hist. Soc. 129: 456-471.

Goebbels, P. J. 1936. On limiting the availability of the eggplant to peoples of non-Aryan descent. Zeit. Deutschland. Leben. 4:1-3. [In German]

Hoover, J. E. 1952. Eggplant seen as cause of new wave of youth crime. Misc. Stat. Stud. Federal Bur. Invest. 35: 23-25.

Menninger, K. 1987. Use of narcotics and electric shock therapy to treat eggplant psychosis. Menninger Monographs in Abnormal Psychology. Topeka, KS. 98 pp.

Smith, J. P. 1974. Eggplant toxicity: results of cryptic feeding studies in an upper division botany class at Humboldt State College. Clin. Toxicol. 14(3): 234-242.

Westheimer, R. 1998. That naughty eggplant. Playboy 27(4): 27, 28.

TOMATO

Jenkins, J. A. 1948. The origin of the cultivated tomato. Econ. Bot. 2(4): 379-392.

Rick, C. M. 1978. The tomato. Sci. American 239(2): 77-87.

Smith, A. F. 1994. The tomato in America. Univ. South Carolina Press. Columbia. 224 pp.

Sokolov, R. 1989. The well-traveled tomato. Nat. Hist. June: 84-85; 87-88.

SPAGHETTI TREE

Anonymous. 1944. Aerial bombing of spaghetti tree plantations by Allies brings strong denunciation from Fascist leaders. New York Times Sept. 15: 1.

Molina, G. 1939. The botany, harvesting, and processing of spaghetti. Fourth edition. Food and Agriculture Organization. United Nations. Rome, Italy. 374 pp.

Pacelli, E. 1998. Real spaghetti – it's a good thing! Martha Stewart Living 6: 144-147.

Vavilov, N. I. 1937. Addition of *Pastadendron italica* to the Mediterranean Center of Origin. Trudy Po Prikl. 37(4): 45-48. [In Russian]

FRUITS: TEMPERATE

Browning, F. 1998. Apples. North Point Press. New York, NY. 241 pp.

Darrow, G. M. 1966. The strawberry: history, breeding, and physiology. Holt, Rinehart, and Winston. New York, NY. 447 pp.

Ferree, D. C. (editor). 2003. Apples: botany, production, and uses. XXX. 672 pp.

Frazer Rogers, A. 2002. Chestnuts and native Americans. J. American Chestnut Foundation 16(1): 24-29/

Hancock, J. F. 1999. Strawberries. CAB International. Wallingford, U.K. 250 pp.

Hancock, J. F. & J. F. Luby. 1993. Genetic resources at our doorstep: the wild strawberries. BioScience 43(3): 141-147.

Krochmal, A. & W. Grierson. 1961. Brief history of grape growing in the United States. Econ. Bot. 15(2): 114-118.

Kummer, C. 2003. A new chestnut. The Atlantic Monthly 291(5): 119-122.

Mack, C. A. & R. H. McClure. 2002. *Vaccinium* [cranberry] processing in the Washington Cas-cades. J. Ethnobiol. 22(1): 35-60.

Miller, E. V. 1954. The natural origins of some popular varieties of fruit. Econ. Bot. 8(4): 337-348.

Morgan, J. & A. Richard. 1993. The book of apples. Ebury Press. London, England.

Pollan, M. 2001. The apple. In, The botany of desire. Random House. New York, NY. Pp. 1-58.

Rosenblum, M. 1996. Olives: the life and lore of a noble fruit. North Point Press. New York, NY. 316 pp.

Taylor, J. M. 2000. The olive in California: history of an immigrant tree. Ten Speed Press. Berkeley, CA. 316 pp.

Wilhelm, S. 1974. The garden strawberry: a study of its origin. American Scientist 62: 264-271.

Wilhelm, S. & J. E. Sagen. 1974. A history of the strawberry from ancient gardens to modern markets. Univ. California Div. Agric. Sciences. Berkeley. 298 pp.

EDIBLE NUTS

Cochran, M. F. 1990. Back from the brink: chestnuts. Natl. Geogr. 177(2): 128-140.

Duke, J. A. 2000. CRC handbook of nuts. Second edition. CRC Press. Boca Raton, FL. 368 pp.

Duke, J. A. & M. Fulton. 2000. Handbook of nuts. Herbal Reference Library. 368 pp.

Jaynes, R. A. (editor). 1969. Handbook of North American nut trees. Northern Nut Growers Assoc. Knoxville, TN. 421 pp.

Krochmal, A. & C. Krochmal. 1982. Uncultivated nuts of the United States. U. S. Dept. Agric. Forest Serv. Agr. Infor. Bull. No. 450. 89 pp.

Menninger, E. A. 1977. Edible nuts of the world. Horticultural Books. Stuart, FL. 175 pp. [He is the brother of Karl Menninger of the famous clinic in Topeka, KS.]

Rosengarten, F. 1984. The book of edible nuts. Walker. New York, NY. 384 pp.

Schuster, C. E. 1947. Edible nuts of the Pacific Northwest. Econ. Bot. 1: 389-393.

Sokolov, R. 1977. A Christmastide treat [chestnuts]. Nat. Hist. 86(10): 94-96.

Woodroof, J. G. 1967. Tree nuts. Two volumes. AVI Publ. Co. Westport, CT.

FRUITS: TROPICAL/SUBTROPICAL

GENERAL

Bianchini, F. & F. Corbetta. 1973. The complete book of fruits and vegetables. Crown Publishers. New York, NY. 303 pp.

Clement, C. R. 1991. Amazonian fruits: neglected, threatened and potentially rich resources require urgent attention. Diversity 7: 56-59.

Cobley, L. S. 1956. An introduction to the botany of tropical crops. Longmans, Green, and Co. London, England.

Martin, F. W. et al. 1987. Perennial edible fruits of the tropics: an inventory. U. S. Dept. of Agric. Handbook No. 642. Washington, D. C. 247 pp.

Miller, C. D. et al. 1965. Fruits of Hawaii. Univ. Hawaii Press. Honolulu. 229 pp.

Miller, E. V. 1954. The natural origin of some popular varieties of fruits. Econ. Bot. 8: 337-348.

Morton, J. F. 1987. Fruits of warm climates. Published by author. Winterville, NC. 505 pp.

Nakasone, H. & R. E. Paull. 1998. Tropical fruits. Oxford Univ. Press. New York, NY. 445 pp.

Pijpers, D. et al. 1986. The complete book of fruit: an illustrated guide to over 400 species and varieties of fruit from all over the world. W. H. Smith Publ. New York, NY. 179 pp.

Piper, J. M. 1989. Fruits of south-east Asia: facts and folklore. Oxford Univ. Press. Singapore. 000 pp.

Popenoe, W. 1920. Manual of tropical and subtropical fruits. Macmillan. New York, NY. 474 pp.

Popenoe, W. 1952. Central American fruit culture. Ceiba 1(5): 269-367.

Reich, L. 1991. Uncommon fruits worthy of attention. Addison-Wesley. Reading, MA. 273 pp.

Samson, J. A. 1986. Tropical fruits. Second edition. Longman Scientific & Technical. Essex, England. 335 pp.

Schneider, E. 1986. Uncommon fruit & vegetables: a commonsense guide. Harper & Row. New York, NY. 546 pp.

Shaw, P. E., H. T. Chan, Jr., & S. Nagy. 1998. Tropical and subtropical fruits. Agscience. Auburndale, FL. 569 pp.

Tate, D. 1999. Tropical fruits. Archipelago Press. Singapore. 95 pp.

Van Aken, N. 1995. The great exotic fruit book. Ten Speed Press. Berkeley, CA. 149 pp.

Verheij, E. W. M. & R. E. Coronel (editors). 1991. Plant resources of South-East Asia. No. 2: edible fruits and nuts. Pudoc Scientific Publ. Wageningen, The Netherlands. 446 pp.

Whiteman, K. & M. Mayhew. 1998. The world encyclopedia of fruit. Lorenz Books. New York, NY 256 pp.

THE BANANA & RELATIVES

Breisky, W. 1977. But yes, we had bananas -- out of our ears. Smithsonian 7(12): 96-102.

Daniells, J. 1995. Illustrated guide to the identification of banana varieties in the South Pacific. Australian Centre Agric. Res. Canberra. 39 pp.

Ferguson, J. 1998. A case of bananas. Geographical 70(1): 49-52.

Flinn, J. C. & J. M. Hoyoux. 1976. Le bananier plantain en Afrique. Fruits 31: 520-530.

Gowen, S. R. (editor). 1995. Bananas and plantains. Chapman & Hall. London, England. 612 pp.

Jenkins, V. S. 2000. Bananas: an American history. Smithsonian Inst. Press. Washington, D. C. 210 pp.

Lessard, W. O. 1992. The complete book of bananas. Publ. by author. 119 pp.

Menendez, T. & K. Shepard. 1975. Breeding new bananas. World Crops 27: 104-112.

Robinson, J. C. 1996. Bananas and plantains. CAB International. Wallingford, U.K. 256 pp.

Simmonds, N. W. 1962. The evolution of the bananas. Longmans. London, England. 170 pp.

Stover, R. H. & N. W. Simmonds. 1987. Bananas. Third edition. Longman Scientific & Technical. London, England. 468 pp.

Vincente-Chandler, J. 1973. Plantains -- a versatile crop with commercial potential. World Farming 15(9): 18, 19.

Wainwright, H. 1992. Improving the utilization of cooking bananas and plantains. Outlook on Agric. 21: 177-181.

CITRUS FRUITS

Hume, H. H. 1957. The cultivation of citrus fruits. Revised edition. Macmillan. New York, NY. 444 pp.

Isaac, E. 1959. Influence of religion on the spread of *Citrus.* Science 129: 178-186.

Kumamoto, J. et al. 1987. Mystery of the forbidden fruit: historical epilogue on the origin of the grapefruit, *Citrus paradisi* (Rutaceae). Econ. Bot. 4(1): 97-107.

Mabberley, D. 1997. A classification for edible *Citrus* (Rutaceae). Telopea 7(2): 167-172.

Reuther, W. et al. 1967. The citrus industry. Vol. 1. History, world distribution, botany, and varieties. Revised edition. Univ. California Press. Berkeley. 611 pp.

Saunt, J. 1990. Citrus varieties of the world: an illustrated guide. Sinclair International. Norwich, England. 126 pp.

Scora, R. W. 1975. On the history and origin of *Citrus.* Bull. Torrey Bot. Club 102: 369-375.

Scora, R. W. 1988. Biochemistry, taxonomy and evolution of modern cultivated citrus. Proc. Inst. Soc. Citriculture 1: 277-289.

THE COCONUT

Branton, R. & J. Blake. 1983. A lovely clone of coconuts. New Scientist 98: 554-557.

Bruman, H. J. 1944. Some observations on the early history of the coconut in the New World. Acta Americana 2: 220-243.

Child, R. 1974. Coconuts. Second edition. Longman. New York, NY. 335 pp.

Cook, O. F. 1910. History of the coconut palm in America. Contr. U. S. Natl. Herb. 14(2): 271-342.

Cook, O. F. 1963. History of the coconut palm in America. Principes 7(2): 54-57.

Dennis, J. V. & C. R. Gunn. 1971. Case against trans-Pacific dispersal of the coconut by ocean currents. Econ. Bot. 25: 407-413.

Dransfield, J. & D. Cooke. 1999. *Cocos nucifera*. Curtis's Bot. Mag. 16(1): 2-9.

Fairchild, D. 1951. What do you know about the coconut? Bull. Fairchild Trop. Gard. 6(5): 4-6.

Guzman-Rivas, P. 1984. Coconut and other palm use in Mexico and the Philippines. Principes 28(1): 20-30.

Harries, H. C. 1978. The evolution, dissemination and classification of *Cocos nucifera* L. Bot. Rev. 44: 265-319.

Harries, H. C. 1992. Biogeography of the coconut *Cocos nucifera* L. Principes 36: 155-162.

Moore, O. K. 1948. The coconut palm: mankind's greatest provider in the tropics. Econ. Bot. 2(2): 119-144.

Ohler, J. G. 1984. Coconut, tree of life. FAO Plant Production and Protection Paper No. 57. Rome, Italy. 446 pp.

Oliver, D. S. 1961. Coconut civilization. In, The Pacific Islands. Doubleday & Co. Garden City, NY. Pp. 186-252.

Purseglove, J. W. 1968. The origin and distribution of the coconut. Trop. Sci. 10(4): 190-199.

Rosengarten, F. 1987. Coconut. Principes 30: 47-62.

Sauer, J. D. 1971. A reevaluation of the coconut as an indicator of human dispersal. In, Riley, C. L. et al. (editors). Man across the sea. Univ. Texas Press. Austin. Pp. 309-319.

Spriggs, M. 1984. Early coconut remains from the South Pacific. J. Polynesian Soc. 93: 71-76.

Theobald, W. L. 1980. Ethnobotany of the coconut. Bull. Pacific Trop. Bot. Gard. 10: 8-11.

Ward, R. G. & M. Brookfield. 1992. The dispersal of the coconut: did it float or was it carried to Panama? J. Biogeogr. 19(5): 467-480.

Woodroof, J. G. 1979. Coconuts: production, processing, products. Second edition. AVI Publ. Westport, CT. 307 pp.

Zizumbo-Villareal, D. 1996. History of coconut (*Cocos nucifera* L.) in Mexico: 1539-1810. Genetic Res. Crop Evol. 43(6): 505-515.

Zizumbo-Villarreal, D. & H. J. Quero. 1998. Re-evaluation of early observations on coconut in the New World. Econ. Bot. 52(1): 68-77.

THE DATE PALM

Goor, A. 1967. The history of the date through the ages in the Holy Land. Econ. Bot. 21(4): 320-340.

Hodel, D. R. 1995. *Phoenix*, the date palm. Palm J. 122: 14-36.

Jones, D. L. 1995. Palms throughout the world. Smithsonian Inst. Press. Washington, D. C. 410 pp.

Kraeger, P. 1995. *Phoenix dactylifera* and dates for eating. Palm J. 122: 37-40.

Moore, H. E., Jr. 1963. An annotated checklist of cultivated palms. Principes 7(4): 1-64.

Nixon, R. W. 1951. The date palm -- 'tree of life' in the subtropical deserts. Econ. Bot. 5(3): 274-301.

Popenoe, P. 1973. The date palm. Field Research Programs. Coconut Grove, FL. 247 pp.

OTHER PALMS

Allen, P. H. 1965. Palms in Middle America. Principes 9(2): 44-48.

Balick, M. J. 1976. The palm heart as a new commercial crop from tropical America. Principes 20(1): 24-28.

Dahlgren, B. E. 1944. Economic products of palms. Trop. Woods 78: 10-35.

Gibbons, M. 1993. Palms: the new compact study guide and identifier. Chartwell Books. Edison, NJ. 80 pp.

Johnson, D. (editor). 1996. Palms: their conservation and sustained utilization. IUCN Publ. Cambridge, England. 124 pp.

Kitzke, E. D. & D. Johnson. 1975. Commercial palm products other than oils. Principes 19(1): 3-26.

Moore, J. E., Jr. 1963. An annotated checklist of cultivated palms. Principes 7(4): 119-182.

Siebert, R. J. 1950. The importance of palms to Latin America: pejibaye a notable example. Ceiba 1(2): 65-74.

THE FIG

Anstett, M. C. et al. 1997. Figs and fig pollinators: evolutionary conflicts in a coevolved mutalism. Trends Ecol. Evol. 12(3): 94-99.

Beck, N. G. & E. M. Lord. 1988. Breeding system in *Ficus carica*, the common fig. II. Pollination events. Amer. J. Bot. 75: 1913-1922.

Berg, C. C. 1989. Classification and distribution of *Ficus*. Experientia 45: 605-611.

Condit, I. J. 1947. The fig. Chronica Botanica. Waltham, MA.

Condit, I. J. 1969. *Ficus*, the exotic species. Univ. California Press. Berkeley.

Galil, J. & G. Neeman. 1977. Pollen transfer and pollination in the common fig (*Ficus carica* L.). New Phytol. 79: 163-171.

Gerdts, M. & J. K. Clark. 1979. Caprification: a unique relationship between plant and insect. California Agric. 33(11/12): 12-14.

Gibernau, M. et al. 1996. Consequences of protecting flowers in a fig: a one way trip for pollinators? J. Biogeogr. 23: 425-432.

Goor, A. 1965. The history of the fig in the Holy Land from ancient time to the present day. Econ. Bot. 19(2): 124-135.

O'Brien, T. G. et al. 1998. What's so special about figs? Nature 392(6678): 668.

Sisson, R. F. 1970. The wasp that plays cupid to a fig. Natl. Geogr. 138: 690-697.

Verkerke, W. 1989. Structure and function of the fig. Experimentia 45: 612-622.

Wiebes, J. T. 1979. Co-evolution of figs and their insect pollinators. Ann. Rev. Ecol. Syst. 10: 1-12.

DURIAN

Durian Website:
www.ecst.csuchico.edu/~durian/

Genthe, H. 1999. Durians: smell awful – but the taste, say the brave, is heaven. Smithsonian 30(6): 94-104.

Malo, S. E. & F. W. Martin. 1979. Cultivation of neglected fruits with promise. Part 7. The durian. U. S. Dept. of Agriculture. Science and Education Administration. 16 pp.

Soegeng-Reksodihardjo, W. 1962. The species of *Durio* with edible fruits. Econ. Bot. 16: 270-282.

Walsh, R. 1999. The fruit I can't get past my nose. Nat. Hist. 108(7): 76, 77.

ACKEE

Bressler, R. 1976. The unripe akee – forbidden fruit. New England J. Med. 295(9): 500, 501.

Plimmer, J. R. & C. E. Seaforth. 1963. The ackee: a review. Trop. Sci. 5(3): 137-142.

Rashford, J. 2001. Those that not smile will kill me: the ethnobotany of the ackee in Jamaica. Econ. Bot. 55(2): 190-211.

Wilson, G. F., J. Kerr, & J. Newell. 1993. Jamaican ackee: a safe food. Jamaican Agriculturist 5(1): 10-16.

MISCELLANEOUS FRUITS

Almeyda, A. & F. W. Martin. 1976. Cultivation of neglected tropical fruits with promise. Pt. 1. The mangosteen. U. S. Dept. Agric. ARS-S155. 18 pp.

Burdick, E. M. 1971. Carpaine: an alkaloid of *Carica papaya*. Its chemistry and pharmacology. Econ. Bot. 25: 363-365.

Collins, J. L. 1960. The pineapple: botany, cultivation, and utilization. Wiley Interscience. New York, NY.

Del Tredici, P. 1991. Ginkgos and people -- a thousand years of interaction. Arnoldia 51(2): 3-15.

Hodgson, R. W. 1950. The avocado -- a gift from the Middle Americas. Econ. Bot. 4: 253-293.

Krochmal, A. C. Krochmal. 1987. The cashew. Bull. Pacific Trop. Bot. Gard. 17: 74-77.

Leal, F. 1989. On the history, origin and taxonomy of the pineapple. Interciencia 14: 235-241.

Lee, R. B. 1973. Mongongo: the ethnography of a major wild food resource. Ecol. Food & Nutr. 2: 307-321.

Lewis, T. & E. F. Woodward. 1950. Papain -- the valuable latex from a delicious tropical fruit. Econ. Bot. 4(2): 192, 193.

Litz, R. E. 1997. The mango: botany, production and uses. CAB International. Wallingford, England. 587 pp.

Lyons, G. 1974. In search of dragons or: the plant that roared [dragon fruit]. Cactus & Succ. J. 44: 267-282.

Martin, F. W. & H. Y. Nakasone. 1970. The edible species of *Passiflora.* Econ. Bot. 24: 333-343.

Miller, C. D. et al. 1956. The use of *Pandanus* fruit as food in Micronesia. Pacific Sci. 10: 3-16.

Mitchell, J. D. & S. A. Mori. 1987. The cashew and its relatives (*Anacardium:* Anacardiaceae). Memoirs New York Bot. Gard. 42:1-76.

Mori, S. 2000. Bats, bees, and Brazil nut trees. Nat. Hist. 109(3): 66-69.

Mori, S. A. & G. T. Prance. 1990. Taxonomy, ecology, and economic botany of the Brazil nut.... Adv. Econ. Bot. 8: 130-150.

Poulter, N. H. & J. C. Caygill. 1985. Production and utilization of papain -- a proteolytic enzyme from *Carica papaya* L. Trop. Sci. 25: 123-137.

Singh, L. B. 1968. The mango: botany, cultivation, and utilization. Revised edition. Leonard Hill. London, England.

Sokolov, R. 1975. A matter of taste. Go mango! Nat. Hist. 84: 78-82.

Taussig, S. J. & S. Batkin. 1988. Bromelain, the enzyme complex of pineapple (*Ananas comosus*) and its clinical application. J. Ethnopharm. 22(2): 191-203.

Whiley, A. W., B. Schaffer, & B. N. Wolstenholme. 2002. Avocado: botany, production and uses. CAB International. Wallingford, U.K. 416 pp.

WILD EDIBLE PLANTS

Alderman, D. C. 1974. Native edible fruits, nuts, vegetables, herbs, spices, and grasses of California. II. Small or bush fruits. Plant Science Leaflet 6008. Cooperative Extension, U. S. Dept. of Agriculture. Univ. California, Berkeley.

Angell, M. 1982. A field guide to berries and berrylike fruits. Bobbs-Merrill Co. Indianapolis, IN. 250 pp.

Angier, B. 1966. Free for the eating. Stackpole Books. Harrisburg, PA. 191 pp.

Angier, B. 1969. More free-for-the-eating wild foods. Stackpole Books. Harrisburg, PA. 192 pp.

Angier, B. 1974. Field guide to edible wild plants. Stackpole Books. Harrisburg, PA. 256 pp.

Benoliel, D. 1974. Northwest foraging. A guide to edible plants of the Pacific Northwest. Signpost Publ. 171 pp.

Benson, E. M. 1973. Wild edible plants of the Pacific Northwest. J. American Dietetic Assoc. 62: 143-147.

Berglund, B. & C. E. Bolsby. 1977. The complete outdoorsman's guide to edible wild plants. A comprehensive cookbook and identification guide for North America. Charles Scribner's Sons. New York, NY. 189 pp.

Brown, T. 1985. Tom Brown's guide to wild edible and medicinal plants. Berkeley Books. New York, NY. 241 pp.

Callegari, J. & K. Durand. 1977. Wild edible and medicinal plants of California. Published by authors. El Cerrito, CA. 96 pp.

Clarke, C. B. 1977. Edible and useful plants of California. California Natural History Guides: 41. Univ. California Press. Berkeley. 280 pp.

Couplan, F. 1998. The encyclopedia of edible plants of North America: nature’s green feast. Keats Publ. New Cannan, CT. 583 pp.

Dahl, K. 1995. Wild foods of the Sonoran Desert. Arizona-Sonora Desert Museum Press. Tucson, AZ. 22 pp.

Department of the Army. 2003. The illustrated guide to edible wild plants. Lyons Press. Guilford, CT. 149 pp.

Domico, T. 1979. Wild harvest: edible plants of the Pacific Northwest. Hancock House. Seattle, WA. 88 pp.

Duke, J. A. 2000. Handbook of edible weeds. Second edition. CRC Press. Boca Raton, FL. 256 pp.

Elias, T. S. & P. A. Dykeman. 1990. Edible wild plants: a North American field guide. Sterling Publ. Co. New York, NY. 286 pp.

Farnsworth, K. 1999. Going to seed: edible plants of the Southwest & how to prepare them. Ancient City Press. Santa Fe, NM. 236 pp.

Fernald, M. L. & A. C. Kinsey. 1958. Edible wild plants of eastern North America. Revised by R. C. Rollins. Harper & Brothers. New York, NY. 452 pp. (This is the Kinsey of the famous Kinsey Report.)

Fielder, M. 1983. Wild fruits. An illustrated field guide and cookbook. Contemporary Books. Chicago, IL. 271 pp.

Genders, R. 1988. Edible wild plants: a guide to natural foods. Van der Marck Editions. New York, NY. 208 pp.

Gibbons, E. 1970. Stalking the wild asparagus. Field guide edition. McKay Co. New York, NY. 303 pp.

Gibbons, E. 1973. Stalking the West's wild foods. National Geographic 144(2): 186-199.

Gibbons, E. & G. Tucker. 1979. Euell Gibbon's handbook of wild edible plants. The Donning Co., Publishers. Virginia Beach, VA. 319 pp.

Hall, A. 1976. The wild food trailguide. Holt, Reinhart, and Winston. New York, NY. 230 pp.

Harrington, H. D. 1967. Edible native plants of the Rocky Mountains. Univ. New Mexico Press. Albuquerque. 388 pp.

Harrington, H. D. 1967. Western edible plants. Univ. New Mexico Press. Albuquerque. 156 pp.

Harris, B. C. 1969. Eat the weeds. Barre Publ. Barre, MA. 223 pp.

Hedrick, U. P. (editor). 1919. Sturtevant's edible plants of the world. Reprint edition 1972. Dover Publ. Co. New York, NY. 686 pp.

Hodgson, W. C. 2001. Food plants of the Sonoran Desert. Univ. Arizona Press.Tucson. 410 pp.

Kindscher, K. 1987. Edible wild plants of the prairie: an ethnobotanical guide. Univ. Press Kansas. Lawrence. 276 pp.

Kirk, D. 1975. Wild edible plants of the western United States. Naturegraph Publications. Healdsburg, CA. 307 pp.

Krause, S. A. 1983. In search of the wild dewberry. Making beverages, teas, and syrups from wild ingredients. Stackpole Books. Harrisburg, PA. 276 pp.

Krause, S. A. 1996. Drinks from the wild. Stackpole Books. Mechanicsburg, PA. 276 pp.

McPherson, A. & S. McPherson. 1979. Edible and useful wild plants of the urban west. Pruett Publ. Co. Boulder, CO. 330 pp.

Medve, R. J. & M. L. Medve. 1990. Edible wild plants of Pennsylvania and neighboring states. Pennsylvania State Univ. Press. University Park. 242 pp.

Morton, J. F. 1963. Principal wild foods of the United States. Econ. Bot. 17: 319-330.

Nyerges, C. 1982. Guide to wild foods. Third edition. Survival News Service. Los Angeles, CA. 239 pp.

Nyerges, C. 1982. Wild greens and salads. Stackpole Books. Harrisburg, PA. 204 pp.

Peterson, L. A. 1977. A field guide to edible wild plants of eastern and central North America. Peterson Field Guide Series, 23. Houghton Mifflin. Boston, MA. 330 pp.

Phillips, R. 1986. Wild food. Little, Brown & Co. Boston, MA. 192 pp.

Robson, J. R. K. & J. N. Elias. 1978. The nutritional value of indigenous wild plants: an annotated bibliography. Whitson Publ. Co. Troy, NY. 232 pp.

Schuster, C. E. 1947. Edible nuts of the Pacific Northwest. Econ. Bot. 1: 389-393.

Scully, V. 1970. A treasury of American Indian herbs. Crown Publ. New York, NY. 306 pp.

Shosteck, R. 1979. How good are wild foods? Mother Earth News 60: 110-113.

Sweet, M. 1976. Common edible and useful plants of the West. Naturegraph Co. Healdsburg, CA. 64 pp.

Szczawinski, A. F. & G. A. Hardy. 1962. Guide to common edible plants of British Columbia. British Columbia Prov. Mus. Handbook No. 20. Victoria. 90 pp.

Szczawinski, A. F. & N. J. Turner. 1980. Wild green vegetables of Canada. Natl. Mus. Nat. Sci. Ottawa, Canada. 179 pp.

Thompson, S. & M. Thompson. 1972. Wild food plants of the Sierra. Dragtooth Press. Berkeley, CA. 186 pp.

Tilford, G. L. 1997. Edible and medicinal plants of the West. Mountain Press Publ. Missoula, MT. 239 pp.

Tull, D. 1987. A practical guide to edible and useful plants. Texas Monthly Press. Austin. 518 pp.

Turner, N. J. 1981. A gift for the taking: the untapped potential of some food plants of North America native peoples. Canadian J. Bot. 59: 2231-2357.

Turner, N. J. 1988. Edible wild fruits and nuts of Canada. Fitzhenry & Whiteside. Markham, Canada. 212 pp.

Underhill. J. E. 1974. Wild berries of the Pacific Northwest. Superior Publ. Co. Seattle, WA. 128 pp.

Williams, K. 1984. Eating wild plants. Mountain Press Publ. Co. Missoula, MT. 140 pp.

Wiltens, J. 1988. Thistle greens and mistletoe: edible and poisonous plants of northern California. Wilderness Press. Berkeley, CA. 160 pp.

Yanovsky, E. 1936. Food plants of the North American Indians. U. S. Dept. Agric. Misc. Publ. No. 237. Washington, D. C. 83 pp.

FORAGE PLANTS

Barnes, R. F. et al. 1995. Forages. Vol. 1. An introduction to grassland agriculture. Fifth edition. Iowa State Univ. Press. Ames. 516 pp.

Heath, M. D. et al. (editors). Forages: the science of grassland agriculture. Third edition. Iowa State Univ. Press. Ames.

Hodgson, H. J. 1976. Forage crops. Sci. American 234(2): 61-68.

Janick, J. et al. 1974. Plant science: an introduction to world crops. Second edition. W. H. Freeman. San Francisco, CA. Pp. 443-454.

Judd, B. I. 1979. Handbook of tropical forage grasses. Garland STPM Press. New York, NY. 116 pp.

Looman, J. 1983. 111 range and forage plants of the Canadian prairies. Garland STPM Press. New York, NY. 116 pp.

Phillips Petroleum Company. 1963. Pasture and range plants. Bartlesville, OK. 176 pp.

6: SPICES, FLAVORINGS, & SUGAR

GENERAL REFERENCES

Anonymous. 1989. Utilization of tropical foods: sugar, spices, and stimulants. FAO Food Nutr. Paper 47(6): 1-62.

Billing, J. & P. W. Sherman. 1998. Antimicrobial functions of spices: why some like it hot. Quart. Rev. Biol. 73(1): 3-49.

Bremness, L. 1994. Herbs: the visual guide to more than 700 herb species from around the world. DK Publ. New York, NY. 304 pp.

Charalambous, G. (editor). 1994. Spices, herbs, and edible fungi. Elsevier Science. New York, NY. 764 pp.

Corn, C. 1998. The scents of Eden: a narrative of the spice trade. Kodansha America. New York, NY. 337 pp.

Crockett, J. O. et al. 1977. Herbs. The Time-Life encyclopedia of gardening. Time-Life Books. Alexandria, VA. 160 pp.

Dalby, A. 2000. Dangerous tastes: the story of spices. Univ. California Press. Berkeley. 184 pp.

Dodge, B. S. 1988. Quests for spices and new worlds. Archon Books. Hamden, CT. 236 pp.

Duke, J. A. 1986. Handbook of proximate analysis tables of higher plants. CRC Press. Boca Raton, FL. 389 pp.

Farrell, K. T. 1990. Spices, condiments, and seasonings. Second edition. Van Nostrand Reinhold. New York, NY. 414 pp.

Food and Agriculture Organization. 1989. Utilization of tropical foods: sugar, spices, and stimulants. FAO Food Nutr. Paper 47(6): 1-62.

Garland, S. 1983. The complete book of herbs and spices: an illustrated guide to growing and using aromatic, cosmetic, culinary, and medicinal plants. The Viking Press. New York, NY. 288 pp.

Guzman, C. C. de & J. S. Siemonsma (editors). 1999. Plant resources of South-East Asia. No. 13. Spices. Backhuys Publ. Leiden. 400 pp.

Ilyas, M. 1976. Spices in India. Econ. Bot. 30: 273-280.

Jones, S. E. 1949. Spices, the essence of geography. Natl. Geogr. XCV(3): 401-420.

Kuebel, K. R. & A. O. Tucker. 1988. Vietnamese culinary herbs in the United States. Econ. Bot. 42(3): 413-419.

Landes, P. 1986. An overview of spice marketing in the past 20 years. HerbalGram 3(3): 7-9.

Meares, P. 1987. The economic $ignificance of herbs. HerbalGram 13: 1; 6-8.

Milton, G. 1999. Nathaniel's nutmeg: or, the true and incredible adventures of the spice trader who changed the course of history. Farrar, Strauss & Giroux. New York, NY. 388 pp.

Morton, J. F. 1976. Herbs and spices. Golden Press. New York, NY. 160 pp.

Newcomb, R. M. 1963. Botanical source-areas for some Oriental spices. Econ. Bot. 17(2): 127-132.

Norman, J. 1990. The complete book of spices: a practical guide to spices and aromatic seeds. Viking Studio Books. New York, NY. 159 pp.

Ortiz, E. L. 1992. The encyclopedia of herbs, spices and flavorings: a cook's compendium. DK Publ. 288 pp.

Parry, J. W. 1945. The spice handbook. Chemical Publ. Co. New York, NY.

Parry, J. W. 1953. The story of spices. Chemical Publ. Co. New York, NY.

Parry, J. W. 1962. Spices: their morphology, histology, and chemistry. Chemical Publ. Co. New York, NY.

Peter, K. V. 2001. Handbook of herbs and spices. CRC Press. Boca Raton, FL. 640 pp.

Phillips, R. & N. Foy. 1990. The Random House book of herbs. Random House. New York, NY. 192 pp.

Prakash, V. 1990. Leafy spices. CRC Press. Boca Raton, FL. 114 pp.

Purseglove, J. W. et al. 1981. Spices. Two volumes. Longman Scientific & Technical. New York, NY. 813 pp.

Rosengarten, F., Jr. 1969. The book of spices. Livingston Publ. Co. Philadelphia, PA.

Shelef, I. A. 1984. Antimicrobial effects of spices. J. Food Safety 6: 29-44.

Sherman, P. W. & J. Billing. 1999. Darwinian gastronomy: why we use spices. BioScience 49: 453-463.

Simonetti, G. 1990. Simon & Schuster's guide to herbs and spices. Simon & Schuster. New York, NY. 255 pp.

Smith, P. G. & J. E. Welch. 1964. Nomenclature of vegetables and condiment herbs grown in the United States. Amer. Hort. Soc. Proc. 84: 535-548.

Stella, A. 1998. The book of spices. Flammarion. Paris, France. 192 pp.

Stobart, T. 1982. Herbs, spices, and flavorings. The Overlook Press. Woodstock, NY. 320 pp.

Swahn, J. O. 1991. The lore of spices. Their history, nature and uses around the world. Crescent Books. New York, NY. 208 pp.

Tainter, D. R. & A. T. Grenis. 1993. Spices and seasonings: a food technology handbook. VCH Publ. New York, NY. 226 pp.

Tucker, A. O. 1986. Botanical nomenclature of culinary herbs and potherbs. In, Craker and Simon. Pp. 33-80.

Weiss, E. A. 2002. Spice crops. CAB International. Wal-lingford, U. K. 411 pp.

Wika, L. L. 1988. Spices and herbs: their antimicrobial activity and its determination. J. Food Safety 9: 97-118.

BLACK PEPPER

Atal, C. K. & J. N. Ojha. 1965. Studies of the genus *Piper*. Part IV. Long peppers of Indian commerce. Econ. Bot. 19(2): 157-164.

Creech, J. L. 1955. Propagation of black pepper. Econ. Bot. 9(3): 233-242.

Gentry, H. S. 1955. Introducing black-pepper into America. Econ. Bot. 9: 256-268.

Kay, D. E. 1970. The production and marketing of pepper. Trop. Sci. 12: 201-218.

Ravindran, P. N. (editor). 2000. Black pepper. Medicinal and aromatic plants. Industrial profiles. Vol. 13. 553 pp.

THE CAPSICUM PEPPERS

Adelson, L. 1964. Homicide by pepper. J. Forensic Sci. 9(3): 391-395.

Andrews, J. 1995. Peppers: the domesticated capsicums. New edition Univ. Texas Press. Austin. 186 pp.

Andrews, J. 1998. The pepper lady's pocket pepper primer. Univ. Texas Press. Austin. 192 pp.

Andrews, J. 1999. The pepper trail: history and recipes from around the world. Univ. North Texas Press. 261 pp.

Balboa, S. I. et al. 1968. The capsaicin content of *Capsicum* fruits at different stages of maturity. Lloydia 31: 272-274.

Bosland, P. W. 1994. Chiles: history, cultivation, and uses. In, Charalambous, G. (editor). Spices, herbs, and edible fungi. Elsevier Science. New York, NY. Pp. 347-366.

Bosland, P. & E. Votava. 1999. Peppers: vegetable and spice capsicums. CAB International. Wallingford, U.K. 250 pp.

Bridges, B. 1981. The great American chili book. Rawson and Wade. New York, NY. 219 pp.

Buck, S. H. & T. F. Burks. 1983. Capsaicin: hot new pharmacological tool. Trends Pharmacol. Sci. 4: 84-87.

Cichewicz, R. H. & P. A. Thorpe. 1996. The antimicrobial properties of chile peppers (*Capsicum* species) and their uses in Mayan medicine. J. Ethnopharm. 52(1): 61-70.

Cordell, G. A. & O. E. Araujo. 1993. Capsaicin: identification, nomenclature, and pharmacotherapy. Ann. Pharmacotherapy 27: 330-336.

D'Arcy, W. G. & W. H. Eshbaugh. 1974. New World peppers (*Capsicum*-Solanaceae) north of Colombia: a résumé. Baileys 19(3): 93-105.

De Witt, D. The chile pepper encyclopedia. William Morrow Co. New York, NY. 338 pp.

DeWitt, D. & P. W. Bosland. 1996. Peppers of the world. Ten Speed Press. Berkeley, CA. 219 pp.

Eshbaugh, W. H. et al. 1983. The origin and evolution of domesticated *Capsicum* species. J. Ethnobiol. 3(1): 49-54.

Govindarajan, V. S. 1977. Pepper -- chemistry, technology, and quality evaluation. CRC Rev. in Food Sci. & Nutr. 9(2): 115-225.

Govindarajan, V. S. 1985. Capsicum production, technology, chemistry, and quality. Part I: history, botany, cultivation and primary processing. CRC Rev. in Food Sci. & Nutr. 22(2): 109-176.

Heiser, C. B., Jr. & P. G. Smith. 1953. The cultivated *Capsicum* peppers. Econ. Bot. 7: 214-227.

Heiser, C. B., Jr. 1969. Some like it hot. In, Heiser, C. B., Jr. Nightshades, the paradoxical plants. W. H. Freeman & Co. San Francisco, CA. Pp. 6-27.

Heiser, C. B., Jr. & B. Pickersgill. 1969. Names for the cultivated *Capsicum* species (Solanaceae). Taxon 18: 277-283.

Heiser, C. B., Jr. 1985. How many kinds of peppers are there? In, Heiser, C. B., Jr.. Of plants and people. Univ. Oklahoma Press. Norman. Pp. 142-154.

Maga, J. A. 1975. Capsicum. CRC Crit. Rev. Food Sci. & Nutr. 6(2): 177-196.

McCourt, R. 1991. Some like it hot. Discover 12(8): 48-52.

McLeoad, M. J. et al. 1982. Early evolution of chili peppers (*Capsicum*). Econ. Bot. 35: 361-368.

Miller, M. 1991. The great chile book. Ten Speed Press. Berkeley, CA. 156 pp.

Nahaban, G. P. 1997. Findings: why chiles are hot. Nat. Hist. 106(5): 24-27.

Naj, A. 1992. Peppers: a study of hot pursuits. A. A. Knopf. New York, NY. 245 pp.

Pickersgill, B. 1969. The domestication of chili peppers. In, Ucko, P. J. & G. W. Dimbleby (editors). The domestication and exploitation of plants and animals. Duckworth. London, England. Pp. 433-450.

Pickersgill, B. 1988. The genus *Capsicum*: a multidisciplinary approach to the taxonomy of cultivated and wild plants. Biol. Zentralbl. 107: 381-389.

Robbins, J. 1992. Care for a little hellish relish? Or try a hotsicle. Smithsonian 22(10): 42-46.

Rozin, P. & P. Schiller. 1980. The nature and acquisition of a preference for chili peppers by humans. Motivation and Emotion 4: 77-101.

Sokolov, R. 1985. Hot stuff. Nat. Hist. August: 74-77.

Vogel, G. 2000. Hot pepper receptor could help manage pain. Science 288: 241, 242.

Walsh, R. 1997. Peppers today, sauce tomaly. Nat. Hist. 106(11): 70-73.

Wood, J. N. (editor). 1993. Capsaicin in the study of pain. Academic Press. Orlando, FL. 304 pp.

GARLIC

Blackwood, J. & S. Fulder. 1986. Garlic: nature's original remedy. Javelin Books.

McCaleb, R. 1989. Benefits of garlic. HerbalGram 18/19: 18.

Seligmann, J. & G. Cowley. 1995. Sex, lies and garlic. Newsweek 126(19): 65-68.

Stoker, B. 1932. On the efficacy of garlic in warding off attacks by the Nosfuratu. Proc. Transylvanian Acad. Sci. 92(2): 114-132.

Wolkomir, R. 1995. Without garlic, life would be just plain tasteless. Smithsonian 26(9): 70-76; 78, 79.

MISCELLANEOUS SPICES & FLAVORINGS

Andrews, A. C. 1956. Sage as a condiment in the Graeco-Roman eera. Econ. Bot. 10(3): 263-266.

Calpouzas, L. 1954. Botanical aspects of oregano. Econ. Bot. 8: 222-233.

Carlson, C. 2000. Turmeric – the gold standard of spices. Herbs for Health 5(3): 60-64.

Correll, D. S. 1953. Vanilla -- its botany, history, cultivation, and economic importance. Econ. Bot. 7: 291-358.

Courter, J. W. & A. M. Rhodes. 1969. Historical notes on horseradish. Econ. Bot. 23: 156-164.

Darrah, H. H. 1974. Investigation of the cultivars of the basils (*Ocimum*). Econ. Bot. 28: 63-67.

Ellis, N. K. 1960. Peppermint and spearmint production. Econ. Bot. 14: 280-285.

Fock-Heng, P. A. 1965. Cinnamon of the Seychelles. Econ. Bot. 19(3): 257-261.

Gibson, M. R. 1978. Glycyrrhiza in old and new perspectives. Lloydia 41(4): 348-354.

Hanson, W. I. & G. M. Hocking. 1957. Garden sage. Econ. Bot. 11: 64-74.

Harten, A. M. van. 1970. Melegueta pepper. Econ. Bot. 24: 208-216.

Hodge, W. H. 1974. Wasabi -- native condiment plant of Japan. Econ. Bot. 28: 118-129.

Lees, P. 1981. Fenugreek: a crop that could bring a rise in food supply and a fall in population growth. World Farm. 23(5): 14-18.

Madan, C. L. et al. 1966. Saffron. Econ. Bot. 20(4): 377-385.

Samarawira, I. 1972. Cardamon. World Crops 24: 76-78.

Schulick, P. 1996. Ginger: common spice and wonder drug. Third edition. Herbal Free Press. Brattleboro, VT. 166 pp.

Seabrook, J. 2001. Soldiers and spice [nutmeg]. The New Yorker. LXXVII (23): 60-66; 68-71.

Sokolov, R. 1977. The quality of coriander. Nat. Hist. 86(9): 86-89.

Sokolov, R. 1977. Up from catsup. Nat. Hist. 86(7): 108; 110-113.

Theodose, R. 1975. Traditional methods of vanilla preparation and their improvement. Trop. Sci. 15: 47-57.

Tucker, A. O. et al. 1994. Spicebush ...: a tea, spice, and medicine. Econ. Bot. 48(3): 333-336.

Wood, A. L. 1959. Cinnamon -- spice that changed history. Nat. Hist. 68: 578-591.

SUGAR AND OTHER SWEETENERS

Arceneaux, G. 1965. Cultivated sugarcanes of the world and their botanical derivation. Proc. Int. Soc. Sugar Cane Tech. 12: 844-854.

Artschwager, E. & E. W. Brandes. 1958. Sugar cane (*Saccharum officinale* L.): origin, classification, characteristics and descriptions of representative clones. U. S. Dept. of Agric. Handbook No. 122. Washington, D. C. 307 pp.

Aykroyd, W. R. 1967. The story of sugar. Quadrangle Books. Chicago, IL.

Barnes, A. C. 1974. The sugar cane. Second edition. Wiley Interscience. New York, NY.

Blackburn, F. H. 1984. Sugar-cane. Longman Scientific. London, England.

Brekman, I. I. & I. F. Nesterenko. 1983. Brown sugar and health. Pergamon Press. Oxford, England. 96 pp.

Bremer, G. 1966. The origin of the North Indian sugar canes. Genetica 37: 345-363.

Deerr, N. 1949-1950. History of sugar. Two vols. Chapman & Hall. London, England. 636 pp.

Dillewijn, C. van. 1952. Botany of sugarcane. Chronica Botanica. Waltham, MA. 371 pp.

Dunn, R. S. 1972. Sugar and slaves. Univ. North Carolina Press. Chapel Hill. 359 pp.

Ellis, P. 1995. Overview of sweeteners. J. Chem. Educ. 72(8): 671-675.

Farnsworth, N. R. 1973. Current status of sugar substitutes. Cosmetics & Perfumery 88: 27-35.

Finn, S. B. & R. B. Glass. 1975. Sugar and dental decay. World Rev. Nutr. Diet. 22: 304.

Food and Agriculture Organization. 1989. Utilization of tropical foods: sugars, spices, and stimulants. Food and Nutrition Papers No. 47/6. FAO. The United Nations. Rome, Italy. 62 pp.

Galloway, J. H. 1989. The sugar cane industry. Cambridge Univ. Press. Cambridge, England. 266 pp.

Grenby, T. H. 1991. Intense sweeteners for the food industry: an overview. Trends Food Sci. Tech. 2(1): 2-6.

Harrison, S. G. 1950. Manna and its sources. Kew Royal Bot. Gard. Bull. 3: 407-417.

Henshaw, H. W. 1890. Indian origin of maple sugar. Amer. Anthrop. 3: 341-351.

Hemmerly, T. E. 1983. Traditional method of making sorghum molasses. Econ. Bot. 37(4): 406-409.

Hobhouse, H. 1999. Sugar and the slave trade. In, Seeds of change: six plants that transformed mankind. Revised and expanded edition. Papermac. London, England. Pp. 53-113.

Holloway, H. L. O. 1977. Seed propagation of *Dioscoreophyllum cumminsii*, source of an intense natural sweetener. Econ. Bot. 31(1): 47-50.

Holman, M. B. and K. C. Egan. 1985. Processing maple sap with prehistoric techniques. J. Ethnobiol. 5(1): 61-75.

Hunt, S. R. 1963. Sugar and spice. Pharm. J. 191: 632-635.

Hussain, R. A. et al. 1990. Plant-derived sweetening agents: saccharide and polyol constitutents of some sweet-tasting plants. J. Ethnopharm. 28(1): 103-115.

Inglett, G. E. 1982. Unusual sweeteners of plant origin. Herbalist 48: 67-78.

Khalsa, K. P. S. 2002. Overcome sugar addiction. Herbs for Health 6(6); 46-51.

Kinghorn, A. D. & D. D. Soejarto. 1986. Sweetening agents of plant origin. Critical Rev. Plant Sci. 4: 79-120.

Kinghorn, A. D. 1988. The search for noncarcinogenic sweetening agents from plants. Acta Pharm. Indonesia 13: 175-199.

Kretchmer, N. & C. B. Hollenbeck. 1991. Sugars and sweeteners. CRC Press. Boca Raton, FL. 297 pp.

Mangelsdorf, A. J. 1950. Sugar-cane: as seen from Hawaii. Econ. Bot. 4(2): 150-176.

Miller, S. 1991. Slavery: the high price of sugar. Newsweek (Special Issue Fall/Winter 1991): 70-72; 74.

Mintz, S. W. 1985. Sweetness and power. The place of sugar in modern history. Viking Press. New York, NY. 274 pp.

Morris, J. A. 1976. Sweetening agents from natural sources. Lloydia 39: 25-38.

Munson, P. J. 1989. Still more on the antiquity of maple sugar and syrup in aboriginal eastern North America. J. Ethnobiol. 9(2): 159-172.

Oliver, D. S. 1961. Sugar revolution. In, The Pacific Islands. Doubleday & Co. Garden City, NY. Pp. 253-294.

Owens, H. S., C. L. Rasmussen, & W. D. Maclay. 1951. Production and utilization of sugar beets. Econ. Bot. 5(4): 348-366.

Pennington, N. L. & C. W. Baker. 1990. Sugar: a user's guide to sucrose. Van Nostrand Reinhold. New York, NY. 331 pp.

Price, S. 1963. Cytogenetics of modern sugar canes. Econ. Bot. 17: 97-106.

Richard, S. 1997. Stevia: the sweetest of herbs. The Herb Companion. 10(2): 32-36.

Sheridan, R. 1974. Sugar and slavery. Caribbean Univ. Press. Lodge Hill. Barbados, West Indies.

Sokolov, R. 1975. A matter of taste: the most artificial sweetener of them all. Nat. Hist. 84(4): 86-90.

Stare, F. J. 1975. Role of sugar in modern nutrition. World Rev. of Nutr. and Diet. 22: 239-247.

Stevenson, G. C. 1965. Genetics and breeding of sugarcanes. Longman. London, England. 284 pp.

Tucker, A. O. 1997. Sweet alternatives. Herbs for Health 2(2): 50-54.

Warner, J. N. 1962. Sugar cane, an indigenous Papuan cultigen. Ethnology 1(4): 405-411.

Wilkinson, A. 1989. Big sugar: seasons in the cane fields of Florida. A. Knopf. New York, NY. 263 pp.

Wolraich, M. L. et al. 1995. The effect of sugar on behavior or cognition in children. J. American Med. Assoc. 274(20): 1617-1621.

Yudkin, J. 1986. Refined sugar: pure, white and deadly. Revised and expanded edition. Viking Press. London, England. 200 pp.

7: BEVERAGE PLANTS

GENERAL REFERENCES

Cheney, R. H. 1947. The biology and economics of the beverage industry. Econ. Bot. 1: 243-275.

De Blegny, N. 1687. Le bon usage de thé, caffé, et du chocolat. Paris, France.

Mariani, J. F. 1999. The encyclopedia of American food & drink. Lebhar-Friedman Books. New York, NY. 380 pp.

Marcin, M. M. 1983. The complete book of herbal teas. Congdon & Weed. New York, NY. 224 pp.

Rusby, H. H. 1904. Beverages of vegetable origin. J. New York Bot. Gard. 5: 79-85.

Stewart, H. 1981. Wild teas, coffees, and cordials. Univ. Washington Press. Seattle. 127 pp.

Turner, N. J. & A. F. Szczawinski. 1978. Wild coffee and tea substitutes of Canada. Natl. Mus. Nat. Sci. Ottawa. 111 pp.

Willson, K. C. 1999. Coffee, cocoa, and tea. CAB International. Wallingford, U. K. 300 pp.

CAFFEINE

Benowitz, N. L. 1990. Clinical pharmacology of caffeine. Ann. Rev. Med. 41: 277-288.

Braun, S. 1996. Buzz: the science and lore of alcohol and caffeine. Oxford Univ. Press. New York, NY. 224 pp.

Brecher, E. M. and the Editors of Consumers Reports. 1972. Caffeine. In, Licit and illicit drugs. Little, Brown & Co. Boston, MA. Pp. 193-206.

Bunker, M. L. and M. McWilliams. 1979. Caffeine content of common beverages. J. American Dietetic Assoc. 74(1): 28-31.

Chou, T. 1992. Wake up and smell the coffee: caffeine, coffee, and the medical consequences. West. J. Med. 157: 544-554.

Clark, M., M. Gosnell, D. Witherspoon, and M. Hager. 1982. Is caffeine bad for you? Newsweek 19 July: 62-64.

Dalvi, R. 1986. Acute and chronic toxicity of caffeine. Vet. Human Toxic. 28: 144-150.

Dobmeyer, D. J. et al. 1983. The arrhythmogenic effects of caffeine in human beings. New England J. Med. 308: 814-816.

Evans, S. M. & R. R. Griffiths. 1992. Caffeine tolerance and choice in humans. Physchopharm. 108: 51-59.

Fredholm, B. B. 1985. On the mechanism of action of theophylline and caffeine. Acta Med. Scand. 217: 149-153.

Fredholm, B. B. et al. 1999. Actions of caffeine in the brain with special reference to factors that contribute to its widespread use. Pharmacol. Rev. 51: 83-133.

Garattini, S. (editor). 1993. Caffeine, coffee, and health. Raven. New York, NY. 420 pp.

Gilbert, R. M. 1992. Caffeine: the most popular stimulant. Chelsea House. New York, NY. 154 pp.

Gilbert, R. M. et al. 1976. Caffeine content of beverages as consumed. J. Canadian Med. Assoc. 114: 205-208.

Gladwell, M. 2001. Java man: how caffeine created the modern world. The New Yorker LXXVII(21): 76-80.

Glass, R. M. 1994. Caffeine dependence: what are the implications? J. American Med. Assoc. 272: 1065, 1066.

Goldstein, A. et al. 1965. Psychotropic effects of caffeine in man. II. Alertness, psychomotor coordination and mood. J. Pharm. Exp. Therap. 150: 146-.

Goulart, F. S. 1984. The caffeine book: a user's and abuser's guide. Dodd, Mead & Co. New York, NY. 210 pp.

Grady, D. 1986. Don't get jittery over caffeine. Discover **: 73-79.

Greden, J. F. 1974. Anxiety or caffeinism: a diagnostic dilemma. American J. Psychiat. 131: 1089.

Grilland, K. & D. Anress. 1981. Ad lib caffeine consumption, symptoms of caffeinism, and academic performance. American J. Psych. 138: 512.

Grobbee, D. E. et al. 1990. Coffee, caffeine, and cardiovascular disease in men. New England J. Med. 323(15): 1026-1032.

Hughes, J. R. 1992. Clinical importance of caffeine withdrawal. New England J. Med. 327(16): 1160, 1161.

James, J. 1991. Caffeine and health. Academic Press. New York, NY.

Kuhlman, W. et al. 1968. The mutagenic action of caffeine in higher organisms. Cancer Res. 28: 2375-2389.

Lane, J. D. 1991. Coffee, caffeine, and cardiovascular disease. New England J. Med. 324(14): 991, 992.

Leonard, T. K. et al. 1987. The effects of caffeine on various body systems: a review. J. American Dietetic Assoc. 87(8): 1048-1053.

Looser, E., et al. 1974. The biosynthesis of caffeine in the coffee plant. Phytochemistry 13: 2515-18.

Marx, J. L. 1981. Caffeine's stimulatory effects explained. Science 211: 1408-1409.

Maugh II, T. H. 1973. Coffee and heart disease: is there a link? Science 181: 534-535.

Mikkelsen, E. J. 1978. Caffeine and schizophrenia. J. Clin. Psych. 39: 732-736.

Morrow, P. L. 1987. Caffeine toxicity: a case of child abuse by drug ingestion. J. Forensic Sci. 32(6): 1801-1805.

Robertson, D. et al. 1984. Caffeine and hypertension. American J. Med. 77: 54-60.

Rosenburg, L., A. A. Mitchell, S. Shapiro, and D. Slone. 1982. Selected birth defects in relation to caffeine-containing beverages. J. American Med. Assoc. 247(10): 1429-1432.

Silverman, K. et al. 1992. Withdrawal syndrome after the double-blind cessation of caffeine consumption. New England J. Med. 327(16): 1109-1114.

Spiller, G. A. (editor). 1984. The methylxanthine beverages and foods: chemistry, consumption, and health effects. Liss. New York, NY.

Spiller, G. (editor). 1998. Caffeine. CRC Press. Boca Raton, FL. 374 pp.

Strain, E. C. et al. 1994. Caffeine dependence syndrome. J. American Med. Assoc. 272(13): 1043-1048.

Turner, J. E. and R. H. Cravey. 1977. A fatal ingestion of caffeine. Clin. Toxicol. 10(3): 341-344.

Vandenbroucke, J. P. et al. 1986. Coffee drinking and mortality in a 25-year follow-up. American J. Epidemiol. 123: 359-361.

Weinberg, B. A. & B. K. Bealer. 2001. The world of caffeine: the science and culture of the world's most popular drug. Routledge. New York, NY. 394 pp.

Weiss, B. & V. G. Laties. 1962. Enhancement of human performance by caffeine and the amphetamines. Pharm. Rev. 14: 1-36.

White, B. C. et al. 1980. Anxiety and muscle tension as consequences of caffeine withdrawal. Science 209: 1547-1548.

Wickware, P. 1989. The world's most popular drug [caffeine], and a new way to use it. Biotech Week 4(12): 5, 6.

Wilcox, A., C. Weinberg, & D. Baird. 1988. Caffeinated beverages and decreased fertility. Lancet No. 8626/8627: 1453-1456.

Zimmerman, P. M. et al. 1985. Caffeine intoxication: a near fatality. Ann. Emergency Med. 14(12): 1227-1229.

TEA

Bokuchava, A. E. & N. I. Skobeleva. 1980. The biochemistry and technology of tea manufacture. CRC Rev. in Food Sci. & Nutr. 12(4): 303-370.

Burgess, A. et al. 1992. The book of tea. Flammarion. Paris, France. 256 pp.

Cheney, R. H. 1942. Tea substitutes in the United States. J. New York Bot. Gard. 42: 117-124.

Eden, T. 1976. Tea. Third edition. Tropical Agric. Series. Longman. New York, NY. 236 pp.

Forrest, D. 1973. Tea for the British: the social and economic history of a famous trade. Chatto & Windus. London, England.

Graham, H. N. 1992. Green tea composition, consumption, and polyphenol chemistry. Preventive Med. 21: 334-350.

Greden, J. F. 1976. The tea controversy in Colonial America. J. American Med. Assoc. 236: 63-66.

Harler, C. R. 1963. Tea manufacture. Oxford Univ. Press. London, England. 176 pp.

Harler, C. R. 1964. The culture and marketing of tea. Third edition. Oxford Univ. Press. London, England. 262 pp.

Harler, C. R. 1966. Tea growing. Oxford Univ. Press. London, England. 162 pp.

Harler, C. R. 1970. Propagation of the tea plant. World Crops 22: 375-377.

Harler, C. R. 1970. Tea manufacture. Oxford Univ. Press. Oxford, England. 126 pp.

Hobhouse, H. 1999. Tea and the destruction of China. In, Seeds of change: six plants that transformed mankind. Revised and expanded edition. Papermac. London, England. Pp. 117-172.

Imai, K. & K. Nakachi. 1995. Cross sectional study of effects of drinking green tea on cardiovascular and liver diseases. British Med. J. 310: 693-696.

Jonnes, J. 1982. The tale of tea: a fragrant brew steeped in history. Smithsonian 12(Feb.): 98-106.

Klein, R. M. 1975. The tea mystique. Nat. Hist. 84(10): 12-29.

Kluger, J. 1994. Tea'd off. Discover 15(9): 38-43.

Maity, S. et al. 1995. Acute-ulcer effect of the hot water extract of black tea (*Camellia sinensis*). J. Ethnopharm. 46(3): 167-174.

Manivel, L. 1998. Tea: botany and horticulture. Hort. Rev. 22: 267-295.

Melton, M. 1998. The power of tea: component identified that inhibits cancer. U.S. News & World Report. 125(24): 58.

Morrow, J. 2000. More than sympathy: tea now brews up health benefits and gourmet appeal. U. S. New & World Rept. 128(5): 59.

Schapira, J., D. Schapira, & K. Schapira. 1982. The book of coffee and tea. St. Martin's Griffin. New York, NY. 313 pp.

Scott, J. M. 1965. The great tea venture: the story of how a camellia leaf and a Chinese emperor changed the trade, tempo, and culture of the world. E. P. Dutton. New York, NY. 204 pp.

Smith, W. D. 1992. Complications of the commonplace: tea, sugar and imperialism. J. Interdisciplinary History 23: 259-278.

Sorkar, G. K. 1972. The world tea economy. Oxford Univ. Press. London, England.

Stagg, G. V. & D. J. Millin. 1975. The nutritional and therapeutic value of tea -- a review. J. Sci. Food & Agric. 26: 1439-1459.

Stahl, W. H. 1962. The chemistry of tea and tea manufacturing. Adv. Food Technol. 11: 201-262.

Ukers, W. H. 1935. All about tea. Two volumes. The Tea and Coffee Trade Journal Co. New York, NY.

Ukers, W. H. 1936. The romance of tea. Alfred Knopf Co. New York, NY. 276 pp.

Wickremasinghe, R. L. 1978. Tea. Adv. Food Res. 24: 229-286.

Willson, K. C. & M. N. Clifford (editors). 1992. Tea: cultivation to consumption. Chapman & Hall. London, England. 769 pp.

Yamamoto, T. et al. 1997. Chemistry and applications of green tea. CRC Press. Boca Raton, FL 150 pp.

Zhen, Y.-S. (editor). 2002. Tea: bioactivity and therapeutic potential. XXX. 264 pp.

COFFEE

Anonymous. 1985. Is coffee safe to drink? Consumer Reports 50(5): 267-268.

Anonymous. 1986. Coffee: grounds for concern? Harvard Med. School Health Letter 11(12): 1-4.

Bertrand, C. A. et al. 1978. No relationship between coffee and blood pressure. New England J. Med. 229: 315, 316.

Boublik, J. H. et al. 1983. Coffee contains potent opiate receptor binding activity. Nature 301: 246-248.

Chou, T. 1992. Wake up and smell the coffee: caffeine, coffee, and the medical consequences. Western J. Med. 157: 544-554.

Clarke, R. J. & R. Macrae (editors). 1985. Coffee. Vol. 1. Chemistry. Elsevier Applied Science Publ. London, England. 306 pp.

Clifford, M. N. & K. C. Wilson (editors). 1985. Coffee: botany, bio-chemistry and production of beans and beverage. Avi. Publ. Co. Westport, CT. 457 pp.

Dicum, G. & N. Luttinger. 1999. The coffee book: anatomy of an industry from crop to the last drop. New Press. New York, NY. 196 pp.

Eisele, J. W. 1980. Deaths related to coffee enemas. J. American Med. Assoc. 244(14): 1608, 1609.

Haarer, A. E. 1963. Coffee growing. Oxford Univ. Press. London, England. 122 pp.

Illy, F. & R. Illy. 1986. The book of coffee. Abbeville Press. New York, NY. 188 pp.

Iverson, L. L. 1983. Another cup of coffee? Nature 301: 195.

Meyer, F. G. 1965. Notes on wild *Coffee arabica* from southwestern Ethiopia, with some historical considerations. Econ. Bot. 19(2): 136-151.

Narod, S. et al. 1991. Coffee during pregnancy: a reproductive hazard? American J. Obs. Gyn. 164(4): 1109-1114.

Paige, J. M. 1997. Coffee and power. Harvard Univ. Press. Cambridge, MA. 432 pp.

Roden, C. 1977. Coffee. Faber & Faber. London, England. 136 pp.

Schaefer, V. J. 1971. Observations of an early morning cup of coffee. American Scientist 59: 534-535.

Schapira, J., D. Schapira, & K. Schapira. 1982. The book of coffee and tea. St. Martin's Griffin. New York, NY. 313 pp.

Starbird, E. A. 1981. The bonanza bean -- coffee. Natl. Geog. 159(3): 388-405.

Stavric, B. 1992. An update on research with coffee/caffeine 1989-1990. Food Chem. Toxicol. 30: 533-555.

Stella, A. 1997. The book of coffee. Flammarion. Paris, France. 232 pp.

Sylvain, P. G. 1958. Ethiopian coffee -- its significance to world coffee problems. Econ. Bot. 12(2): 111-139.

Thorn, J. 1995. The coffee companion: the connoisseur's guide to the world's best brews. Running Press. Philadelphia, PA. 192 pp.

Ukers, W. H. 1935. All about coffee. Second edition. The Tea and Coffee Trade Journal Co. New York, NY. 818 pp.

Ukers, W. H. 1948. The romance of coffee. Tea and Coffee Trade Journal Company. New York, NY.

Uribe, C. A. 1954. Brown gold. Random House. New York, NY. 280 pp.

Vaugeois, J.-M. 2002. Positive feedback from coffee. Nature 418: 734-736.

Wellman, F. L. 1961. Coffee -- botany, cultivation and utilization. Leonard Hill. London, England. 488 pp.

Wrigley, G. 1988. Coffee. Longman Scientific. London, England. 639 pp.

CACAO & CHOCOLATE

Bailleux, N. et al. 1996. The book of chocolate. Flammarion. Paris, France. 216 pp.

Baker, W. & Co. 1886. Cocoa and chocolate. Walter Baker. Dorchester, MA.

Beckett, S. T. (editor). 1994. Industrial chocolate manufacture and use. Second edition. Blackie Academic & Professional. London, England. 408 pp.

Brenner, J. G. 1999. The emperors of chocolate: inside the secret world of Hershey and Mars. Random House. New York, NY. 366 pp.

Coady, C. 1993. Chocolate: the food of the gods. Chronicle Books. San Francisco, CA. 120 pp.

Coe, S. D. & M. D. Coe. 1996. The true story of chocolate. Thames & Hudson. London, England. 280 pp.

Cuatrecasas, J. 1964. Cacao and its allies: a taxonomic revision *Theobroma.* Contr. U.S. Natl. Herb. 35(6): 379-614.

Di Tomaso, E. et al. 1996. Brain cannabinoids in chocolate. Nature 382: 677, 678.

Fries, J. H. 1978. Chocolate: a review of published reports of allergic and other deleterious effects, real or presumed. Ann. Allergy 41: 195-.

Fuller, L. K. 1994. Chocolate fads, folklore and fantasies. Haworth Press. New York, NY. 276 pp.

Fulton, J. E. et al. 1969. Effect of chocolate on acne vulgaris. J. American Med. Assoc. 210: 2071.

Galvin, R. M. 1986. Sybaritic to some, sinful to others, but how sweet it is. Smithsonian 16(11): 54-65.

Gómez-Pompa, A., J. S. Flores, & M. A. Fernández. 1990. The sacred caco groves of the Maya. Latin American Antiq. 1(3): 247-257.

Grant, J. D. & P. C. Anderson. 1965. Chocolate as a cause of achne: a dissenting view. Missouri Med. 62: 459-.

Hopley, C. 1991. Chocolate and charity: a Quaker legacy. British Heritage 12(3): 56-68.

Hunter, J. R. 1990. The status of cacao (*Theobroma cacao*, Sterculiaceae) in the Western Hemisphere. Econ. Bot. 44(4): 425-439.

Hurst, W. F. et al. 2002. Cacao usage by the earliest Maya civilization. Nature 418: 289.

Khalsa, K. P. S. 1999. The medicinal benefits of chocolate. Herbs for Health 4(5): 32, 33.

Knight, I. (editor). 2001. Chocolate and cocoa: health and nutrition. XXX. 352 pp.

McFadden, C. & C. France. 1997. The ultimate encyclopedia of chocolate. Smithmark Publ. New York, NY. 256 pp.

Morton, M. & F. Morton. 1986. Chocolate: an illustrated history. Crown Publ. New York, NY. 170 pp.

Ott, J. 1985. The cacahuatl eater: ruminations of an unabashed chocolate addict. Natural Products Co. Vashon, WA. 120 pp.

Potts, L. K. 1996. Chocolate: past, present, and future of cacao. HerbalGram 37: 50-55.

Presilla, M. E. 2001. The new taste of chocolate: a cultural and natural history of cacao. Ten Speed Press. Berkeley, CA. 198 pp.

Raloff, J. 2000. Chocolate hearts: yummy and good medicine? Science News 157: 188, 189.

Rice, R. A. & R. Greenberg. 2003. The chocolate tree. Nat. Hist. 112(6): 36-43.

Schweitzer, J. W. et al. 1975. Chocolate, β-phenethylamine and migraine re-examined. Nature 257: 256.

Szogyi, A. (editor). 1997. Chocolate: food of the gods. Greenwood Press. Westford, CT. 228 pp.

Thompson, J. E. S. 1956. Notes on the use of cacao in Middle America. Notes Middle America Archaeol. Ethnol. Arch. No. 128.

Wagner, G. 1987. The chocolate conscience. Chatto & Windus. London, England. 178 pp.

Walsh, R. 1997. The chocolate bug. Nat. Hist. 106(4): 54-57.

Wood, G. A. R. 1984. Chocolate: food of the gods. Natl. Geogr. 166(11): 664-686.

Wood, G. A. R. 1987. Cocoa. Fourth edition. Longman. London, England. 620 pp.

Young, A. M. 1994. The chocolate tree: a natural history of cacao. Smithsonian Inst. Press. Washington, D. C. 200 pp.

THE COLA BEVERAGES

DeMott, J. S. 1985. Fiddling with the real thing. Time 6 May: 54-56.

Dietz, L. 1973. Soda pop -- the history, advertising, art and memorabilia of soft drinks in America. Simon & Schuster. New York, NY. 184 pp.

Eijnatten, C. L. M. van. 1970. Kola: its botany and cultivation. Comm. Dept. Agr. Res. Royal Trop. Inst. Amsterdam. 59 pp.

Eijnatten, C. L. M. van. 1973. Kola, a review of the literature. Trop. Abstr. 28(8): 1-10.

Kahn, E. J. 1960. The big drink: the story of Coca Cola. Random House. New York, NY.

King, M. M. 1987. Coca Cola. Pharm. Hist. 29: 85- .

Lovejoy, P. E. 1980. Kola in the history of West Africa. Cahiers D'Etudes Africaines 20: 97-134.

Lovejoy, P. E. 1995. Kola nuts: the 'coffee' of the central Sudan. In, Goodman, J. et al. (editors). Consuming habits. Routledge. London, England. Pp. 103-125.

Oliver, T. 1986. The real Coke, the real story. Random House. New York, NY. 195 pp.

Pendergrast, W. 1993. For God, country and Coca-Cola. The unauthorized history of the great American soft drink and the company that makes it. Charles Scribner's Sons. New York, NY. 556 pp.

Riley, J. J. 1972. A history of the American soft drink industry: bottled carbonated beverages, 1807-1957. Arno Press. New York, NY. 302 pp.

GUARANÁ

Beck, H. T. 1990. A survey of the useful species of *Paullinia* (Sapindaceae). Adv. Econ. Bot. 8: 41-56.

Beck, H. T. 1991. The taxonomy and economic botany of the cultivated guarana and its wild relatives and the generic limits within the Paullinieae (Sapindaceae). Ph.D. dissertation. City University. New York.

Bempong, D. K. et al. 1993. The xanthine content of guarana and its preparations. Int. J. Pharmacog. 31: 175-181.

Erickson, H. T. et al. 1984. Guaraná (*Paullinia cupana*) as a commercial crop in Brazilian Amazonia. Econ. Bot. 38(3): 273-286.

Henman, A. R. 1982. Guaraná (*Paullinia cupana* HBK. var. *sorbilis* (Mart.) Ducke): ecological and social perspectives on an economic plant of the Central Amazon basin. J. Ethnopharm. 6: 311-338.

Meurer-Grimes, B., A. Berkov, & H. Beck. 1998. Theobromine, theophylline, and caffeine in 42 samples and products of guarana (*Paullinia cupana*, Sapindaceae). Econ. Bot. 52(3): 293-301.

Schultes, R. E. 1955. El guaraná: su historia y su uso. Agric. Trop. 11: 131-140.

KHAT

Getahun, A. & A. D. Krikorian. 1973. Chat: coffee's rival from Harar, Ethiopia. I. Botany, cultivation, and use. II. Chemical composition. Econ. Bot. 27: 353-389.

Greenway, P. J. 1947. Khat. East African Agric. J. 13: 98-102.

Krikorian, A. D. 1984. Kat and its use. An historical perspective. J. Ethnopharm. 12: 115-178.

Weir, S. 1985. Qat in Yemen: consumption and social change. British Mus. Publ. London, England.

MATÉ

Grondona, E. M. 1953. Historia de la yerba maté. Rev. Argentine Agron. 20(2): 9-24.

Kelch, S. 1998. Yerba mate. Herbs for health. 3(5): 18, 19.

Martinez-Crovetto, R. 1980. Yerba maté: usos no tradicionales y posibilidades. Participar 2(12): 58-61.

Porter, R. H. 1950. Maté -- South American or Paraguay tea. Econ. Bot. 4:37-51.

Vasquez, A. & P. Moyna. 1986. Studies on maté drinking. J. Ethnopharm. 18(3):267-272.

ALCOHOLIC BEVERAGES

GENERAL REFERENCES

Adams, J. F. 1970. An essay on brewing, vintage and distillation, together with selected remedies for hangover melancholia or how to make booze. Doubleday & Co. Garden City, NY. 108 pp.

Braun, S. 1996. Buzz: the science and lore of alcohol and caffeine. Oxford Univ. Press. New York, NY. 224 pp.

Brown, S. C. 1978. Beers and wines of old New England. American Scientist 66: 460-467.

Bruman, H. J. 2000. Alcohol in ancient Mexico. Univ. Utah Press. Salt Lake City. 158 pp.

Cheney, R. H. 1947. The biology and economics of the beverage industry. Econ. Bot. 1(3): 243-275.

Feest, C. F. 1983. New wines and beers of native North America. J. Ethnopharm. 9(2&3): 329-335.

Grossman, H. J. 1983. Grossman's guide to wines, beers, and spirits. Seventh edition. Revised by H. Lembeck. Macmillan. New York, NY. 638 pp.

Holmstedt, B. & R. E. Schultes. 1989. Inebriantia: an early inter-disciplinary consideration of intoxicants and their effects on man. Bot. J. Linn. Soc. 101(2): 181-198.

Heath, D. B. 1983. Alcohol use among North American Indians: a cross-cultural survey of patterns and problems. In, Smart, R. G. et al. (editors). Research advances in alcohol and drug problems. New York, NY.

Jacobson, M. & J. Anderson. 1972. The chemical additives in booze. Center for Science in the Public Interest. Washington, D. C. 38 pp.

Lipinski, R. A. & K. A. Lipinski. 1989. Professional guide to alcoholic beverages. Van Nostrand Reinhold. New York, NY. 548 pp.

Marshall, M. (editor). 1979. Beliefs, behaviors and alcoholic beverages. Univ. Michigan Press. Ann Arbor.

May, P. A. 1977. Explanations of Native American drinking: a literature review. Plains Anthropologist 22: 223-232.

Rose, A. H. (editor). 1977. Alcoholic beverages. Academic Press. New York, NY. 760 pp.

Vallee, B. L. 1998. Alcohol in the western world. Sci. American 278(6): 80-85.

Weiss, P. 2000. The physics of fizz. Science News 157: 300-302.

ALCOHOL

Bertozzi, S. et al. 1986. Alcohol, advertising, counteradvertising and depiction in the public media. J. American Med. Assoc. 256: 1485-1488.

Blume, S. B. 1986. Women and alcohol. J. American Med. Assoc. 256: 1467-1470.

Davis, V. E. & M. J. Walsh. 1970. Alcohol, amines, and alkaloids: a possible biochemical basis for alcohol addiction. Science 167: 1005-1007.

Fleming, A. 1975. Alcohol: the delightful poison. Delacorte. New York, NY. 138 pp.

Friedman, G. D. & A. L. Klatsky. 1993. Is alcohol good for your health? New England J. Med. 329: 1882, 1883.

Galanter, M. (editor). 1995. Alcoholism and women. Plenum Press. New York, NY. 472 pp.

Gibbons, G. 1992. Alcohol: the legal drug. Natl. Geogr. 181(2): 2-35.

Gano, A. J. & C. S. Lieber. 1990. Alcohol and cancer. Ann. Rev. Pharm. & Toxicol. 30: 219-249.

Klatsky, A. L. 2003. Drink to your health? Scientific American 288(2): 74-81.

Klatsky, A. L. et al. 1992. Alcohol and mortality. Ann. Internal Med. 117: 646-654.

Lieber, C. S. 1976. The metabolism of alcohol. Sci. American 234(3): 25-33.

MacGregor, R. R. 1986. Alcohol and the immune system. J. American Med. Assoc. 256: 474-479.

Nellis, M. 1980. The female fix [alcohol and drug abuse]. Houghton Mifflin. Boston, MA. 212 pp.

Seppa, N. 1998. Brain chemical affects alcohol sensitivity. Sci. News 154(22): 341.

Smart, R. G. 1988. Does alcohol advertising affect overall consumption? A review of empirical studies. J. Stud. Alcohol. 49: 314-323.

U. S. Dept. of Health and Human Services. 1990. Seventh report to the U. S. Congress on alcohol and health. Natl. Inst. on Alcohol Abuse and Alcoholism. Rockville, MD. 289 pp.

Vaillant, G. E. 1995. The natural history of alcoholism revised. Harvard Univ. Press. Cambridge, MA. 446 pp.

Victor, R. G. & J. Hansen. 1995. Alcohol and blood pressure -- a drink a day ... New England J. Med. 332(26): 1782, 1783.

Thun, M. J. et al. 1997. Alcohol consumption and mortality among middle-aged and elderly U.S. adults. New England J. Med. 337(24): 1705-1715.

BEER

Bamforth, C. 1998. Beer: tap into the art and science of brewing. Plenum Press. New York, NY. 245 pp.

Baron, S. 1962. Brewed in America: a history of beer and ale in the United States. Little, Brown & Co. Boston, MA.

Braidwood, R. J. et al. 1953. Did man once live by beer alone? American Anthrop. 55: 515-526.

Buhner, S. H. 1998. Sacred and herbal healing beers. Brewers Publ. Boulder Co. 534 pp.

DeLyser, D. Y. & W. J. Kasper. 1994. Hopped beer: the case for cultivation. Econ. Bot. 48(2): 166-170.

Edwardson, J. R. 1952. Hops -- their botany, history, production and utilization. Econ. Bot. 6: 160-175.

Jackson, M. 1993. Michael Jackson's beer companion: the world's great beer styles, gastronomy, and traditions. Running Press. Philadelphia, PA. 288 pp.

Katz, S. H. & F. Maytag. 1991. Brewing an ancient beer. Archaeology 44(4): 24-33.

La Barre, W. 1938. Native American beers. Amer. Anthrop. 40: 224-234.

Marshall, E. 1979. How natural is the science of brewing? Science 203: 731, 732.

Meyer, R. 1971. Beer: how to make it. Stomatopod 1(4): 3-6.

Papazian, C. 1984. The complete joy of home brewing. Avon Publ. Co. New York, NY. 331 pp.

Rhodes, C. P. 1995. The encyclopedia of beer. Henry Holt & Co. New York, NY. 509 pp.

Robertson, J. D. 1978. The great American beer book. Caroline House Publ. Ottawa, Canada. 232 pp.

Salem, F. W. 1972. Beer: its history and its economic value as a national beverage. Arno Press. New York, NY. 275 pp.

Samuel, D. 1996. Archaeology of ancient Egyptian beer. J. American Soc. Brewing Chemists 54: 3-12.

Smith, G. 1998. Beer in America: the early years – 1587-1840. Siris Books. Boulder, CO. 315 pp.

Sokolov, R. 1992. Flower of the vine [hops]. Nat. Hist. January: 80-83.

Williams, N. 1996. How the ancient Egyptians brewed beer. Science 273: 432.

WINE

Allen, H. W. 1961. A history of wine: great vintage wines from the Homeric Age to the present day. Horizon Press. New York, NY. 304 pp.

Anderson, S. F. & D. Anderson. 1989. Winemaking: recipes, equipment, and techniques for making wine at home. Harcourt Brace & Co. San Diego, CA. 284 pp.

Bombardelli, E. & P. Morazzoni. 1995. *Vitis vinifera* L. Fitotherapia 66(4): 291-316.

Bowers, J. et al. 1999. Historical genetics: the parentage of chardonnary, gamay, and other wine grapes of northeastern France. Science 285: 1562-1565.

Editors of Time-Life Books. 1982. Wine. Time-Life Books. Alexandria, VA. 176 pp.

Eisinger, J. 1996. Sweet poison [wine/lead poisoning]. Nat. Hist. 105(7): 48-53.

Foulkes, C. 1995. Larousse encyclopedia of wine. Larousse. Paris, France. 608 pp.

Jackson, R. S. 1994. Wine science: principles and applications. Academic Press. New York, NY.

Johnson, H. 1989. Vintage: the story of wine. Simon & Schuster. New York, NY. 480 pp.

Johnson, H. 1998. Modern encyclopedia of wine. Fourth edition. Simon & Schuster. New York, NY. 592 pp.

Martin, C. 1983. High-tech winemaking. Discover March: 86-88.

McGovern, P. E., S. J. Fleming, & S. H. Katz. 1995. The origins and history of wine. Gordon & Breach, New York, NY.

McGovern, P. E. 1998. Wine for eternity. Archaeology 51(4): 28-32.

McGovern, P. E. 1998. Wine's prehistory. Archaeology 51(4): 32-34.

Philips, R. 2000. A short history of wine. Harper-Collins. New York, NY. 369 pp.

Pinney, T. 1989. History of wine in America from the beginnings to Prohibition. Univ. California Press. Berkeley. 553 pp.

Renaud, S. & M. de Lorgeril. 1992. Wine, alcohol, and the French paradox for coronary heart disease. The Lancet 339: 1523-1525.

Robinson, J. (editor). 1999. The Oxford companion to wine. Second edition. Oxford Univ. Press. Oxford, England. 819 pp.

Sandler, M. & R. Pinder. 2002. Wine: a scientific explo-ration. Taylor & Francis. 336 pp.

Wagner, P. M. 1976. Grapes into wine: a guide to wine-making in America. A. A. Knopf. New York, NY. 302 pp.

Webb, A. D. 1984. The science of making wine. American Sci. 72(4): 360-367.

Winkler, A. J. 1949. Grapes and wine. Econ. Bot. 3(1): 46-70.

MISCELLANEOUS FERMENTED BEVERAGES

Anawalt, P. R. 1997. Flopsy, mopsy, and tipsy [pulque]. Nat. Hist. 106(3): 24, 25.

Bahre, C. J. & D. E. Bradbury. 1980. Manufacture of mescal in Sonora, Mexico. Econ. Bot. 34: 391-400.

Cutler, H. C. & M. Cardenas. 1947. Chicha, a native South American beer. Bot. Mus. Leaflts. Harvard Univ. 13(3): 33-60.

De Barrios, V. B. 1971. A guide to tequila, mezcal, and pulque. Minutiae Mexicana. Mexico, D. F. 64 pp.

Erikson, P. 1990. Near beer of the Amazon. Nat. Hist. August: 52-61.

BEVERAGES: DISTILLED

Arnold, W. N. 1988. Vincent Van Gogh and the thujone connection. J. American Med. Assoc. 260(20): 3042-3044.

Arnold, W. N. 1989. Absinthe. Sci. American. 260(6): 112-117.

Barnaby, C. III. 1988. Absinthe: history in a bottle. Chronicle Books. San Francisco, CA. 160 pp.

Carson, G. 1963. The social history of bourbon: an unhurried account of our star-spangled American drink. Univ. Press Kentucky. Lexington. 280 pp.

Cedeño, M. C. 1995. Tequila production. Critical Rev. Biotech. 15(1): 1-11.

Chandler, R. F. 1987. Wormwood. Canadian Pharm. J. 120(10): 602-604.

Daiches, D. 1978. Scotch whisky: its past and present. Andre Deutsch. London, England. 170 pp.

Emmons, B. 1997. The book of tequila. Open Court Publ. Chicago, IL. 294 pp.

Faith, N. & I. Wisniewski. 1997. Classic vodka. Prion Books. London, England. 190 pp.

Fernandez, S. M. 2000. Tequila's happy hour. Time 155(10):B-26, B-27.

Grossman, H. J. 1983. Grossman's guide to wines, beers, and spirits. Seventh edition. Macmillan Co. New York, NY. 638 pp.

Kretchmer, L. 1998. Guide to tequila. Black Dog & Leventhal. New York, NY. 192 pp.

Jackson, M. 1999. Complete guide to single malt Scotch. Fourth edition. Running Press. Philadelphia, PA. 336 pp.

Limón, E. M. 2000. Tequila: the spirit of Mexico. Abbeville Press. New York, NY.182 pp.

Max, B. 1990. Absinthe. Trends Pharmacol. Sci. 11: 58-

Milne, B. & R. Martine. 1997. Single malt scotch. Friedman/Fairfax Publ. New York, NY. 144 pp.

Montagne, M. & D. D. Vogt. 1982. Absinthe: behind the green mask. Int. J. Addictions 17(6): 1015-1029.

Regan, G. & M. H. Regan. 1995. The book of bourbon and other fine American whiskeys. Chapters Publ. Shelburne, VT. 364 pp.

Reese, K. 1991. One intoxicating impressionist. Today's Chemist Feb: 8.

Valenzuela Zapata, A. G. 1995. La agroindustria del Agave tequilero, *Agave tequilana* Weber. Bol. Soc. Bot. Mexico 57: 15-26.

Vogt, D. D. 1981. Absinthium: a nineteenth-century drug of abuse. J. Ethnopharm. 28(1): 53-62.

Waymack, M. H. & J. F. Harris. 1995. The book of classic American whiskeys. Open Court Publ. Chicago, IL.

Zamora, R. L. 1991. La historia del tequila, de sus regiones y sus hombres. El Consejo Nacional para la Cultura y las Artes. México, D. F.

8: INDUSTRIALLY IMPORTANT PLANTS

F I B E R   P L A N T S

GENERAL

Bally, W. & F. Tobler. 1955. Hard fibers. Econ. Bot. 9: 376-399.

Bell. L. A. 1988. Plant fibers for papermaking. Liliaceae Press. McMinnville, OR. 132 pp.

Berger, J. 1969. The world's major fiber crops, their cultivation and manuring. Centre d'Etude de l'Azote. Zurich, Switzerland.

Brink, M. & R. P. Escobin (editors). 2003. Fibre plants. PROSEA [Plant Resources of South-east Asia]. Vol. 17. Backhuys Pub. Leiden, The Netherlands. 456 pp.

Catling, D. & J. Grayson. 1982. Identification of vegetable fibres. Chapman & Hall. London, England. 106 pp.

Clark, T. F. 1965. Plant fibers in the paper industry. Econ. Bot. 19: 394-405.

Demsey, J. M. 1975. Fiber crops. Univ. Presses Florida. Gainsville. 457 pp.

Gayet, P. 1965. Effect of dew-retting on scutching, yield and fiber quality. Fibra 10: 21-36.

Isenberg, I. H. 1956. Papermaking fibers. Econ. Bot. 10(2): 176-193.

Jarman, C. 1998. Plant fibre processing: a handbook. IT Publ. London, England. 53 pp.

Kirby, R. H. 1963. Vegetable fibers: botany, cultivation, and utilization. John Wiley & Sons. New York, NY.

Lang, C. E. 1996. Natural materials for basketmaking. Publ. by author. Carlsbad, CA. 23 pp.

Lee, J. 1984. Cotton as a world crop. In, Kohel, R. J. & C. F. Lewis (editors). Cotton. American Soc. Agronomy. Madison, WI. Pp. 1-25.

Maiti, R. 1997. World fiber crops. Science Publ. Enfield, NH. 208 pp.

Puterbaugh, H. L. 1965. Plant fibers -- some economic considerations. Econ. Bot. 19: 184-187.

Quian, S.-Z. & Z.-G. Wang. 1984. Gossypol: a potential anti-fertility agent for males. Ann. Rev. Pharmacol. Toxicol. 24: 329–.

Robinson, R. B. 1947. Minor fiber industries. Econ. Bot. 1(1): 4-56.

Smith, C. E., Jr. 1965. Plant fibers and civilization -- cotton, a case in point. Econ. Bot. 19: 71-82.

Weiner, A. B. & J. Schneider. 1989. Cloth and human experience. Smithsonian Inst. Press. Washington, D. C. 431 pp.

COTTON

Endrizzi, J. E. et al. 1985. Genetics, cytology, and evolution of *Gossypium*. Adv. Genet. 23: 271-375.

Fryxell, P. A. 1976. A nomenclator of *Gossypium*: the botanical names of cotton. U. S. Dept. Agric. Tech. Bull. No. 1491. 114 pp.

Fryxell, P. A. The natural history of the cotton tribe (Malvaceae, tribe Gossypieae). Texas A & M Univ. Press. College Station. 245 pp.

Harland, S. C. 1970. Gene pools in the New World tetraploid cottons. In, Frankel, O. H. & E. Bennett (Editors). Genetic resources in plants. Pp. 335-340.

Hobhouse, H. 1999. Cotton and the American South. In, Seeds of change: six plants that transformed mankind. Revised and expanded edition. Papermac. London, England. Pp.175-233.

Hutchinson, J. B. 1962. History and relationships of the world's cottons. Endeavor 21: 5-15.

Munro, J. M. 1987. Cotton. Second edition. Longman. London, England.

Smith, C. E., Jr. & R. S. MacNeish. 1964. Antiquity of American polyploid cotton. Science 143: 675, 676.

Smith, C. W. & J. T. Cothren (Editors). 1999. Cotton: origin, history, technology, and production. John Wiley & Sons. New York, NY. 850 pp.

Stephens, S. G. 1970. The botanical identification of archaeological cotton. American Antiq. 35: 367-373.

Thompson, J. 1994. Cotton: king of fibers. Natl. Geogr. 185(6): 60-87.

Wendel, J. F. 1989. New World tetraploid cottons contain Old World cytoplasm. Proc. Natl. Acad. Sci. (U. S. A.) 86: 4132-4136.

HEMP

Ackerman, E. 1999. The latest buzz on hemp: U. S. Farmers want the ban on cultivating the plant lifted. U. S. News & World Report 126(10): 50.

Ash, A. L. 1948. Hemp -- production and utilization. Econ. Bot. 2: 158-169.

Conrad, C. 1994. The many histories of hemp. In, Hemp -- lifeline to the future. Creative Xpressions Pub. Novato, CA. Pp. 5-21.

De Meijer, E. 1995. Fibre hemp cultivars: a survey of origin, ancestry, availability and brief agronomic characteristics. J. Int. Hemp Assoc. 2(2): 66-73.

Dewey, L. H. 1914. Hemp. In, Yearbook of the Dept. of Agric., 1913. U. S. Gov. Print. Office. Washington, D. C. Pp. 283-346.

Judt, M. 1995. Hemp (*Cannabis sativa* L.) -- salvation for the earth and for the paper makers. Agro Food Ind. Hi-tech. 6(4): 35-37.

Kovacs, L. et al. 1992. Hemp (*Cannabis sativa*) as a possible raw material for the paper industry. Cellulose Chem. Tech. 26(5): 627-635.

McGraw, D. 1997. Hemp is high fashion. U.S. News & World Report. 122(2): 54; 56.

Roulac, J. W. 1995. Industrial hemp: practical products -- paper to fabric to cosmetics. Hemptech. Ojai, CA. 48 pp.

PAPER AND PAPERMAKING

Carter, T. F. 1968. The invention of paper in China. Yale Univ. Press. New Haven, CT. 000 pp.

Hiebert, H. 1998. Papermaking with plants. Storey Books. Pownal, VT. 107 pp.

Alexander, H. H. & M. A. Alexander. 1997. Handcrafted paper and paper products made from indigenous plant fibers. Maralex Studios. Arden Hills, MN.

Toale, B. 1983. The art of papermaking. Davis Publ. Worcester, MA.

MISCELLANEOUS FIBER PLANTS

Bally, W. 1957. Ramie culture and fibre preparation. Ciba Rev. 123: 23-30.

Bell, L. A. 1988. Papyrus, tapa, amate & rice paper: papermaking in Africa, the Pacific, Latin America & southeast Asia. Liliaceae Press. McMinnville, OR. 146 pp.

Bristol, M. L. 1961. *Carludovica palmata* in broommaking. Bot. Mus. Leaflts. Harvard Univ. 19(9): 183-189.

Crane, J. C. 1947. Kenaf -- fiber rival of jute. Econ. Bot. 1: 334-350.

Critchfield, H. J. 1951. *Phormium tenax* -- New Zealand's native hard fiber. Econ. Bot. 5: 172-184.

De Freitas, F. T. 1961. Economic aspects of ramie culture. Agr. 8: 25-36.

Fadiman, M. 2001. Hat weaving with jipi, *Carludovica palmata* (Cyclanthaceae) in the Yucatan Peninsula, Mexico. Econ. Bot. 55(4): 539-544.

Gross, D. R. 1971. The great sisal scheme. Nat. Hist. 80(3): 48-55.

Haller, J. M. 1991. The paper tree: *Broussonetia papyrifera*. Pacific Hort. 52(1): 50-52.

Haun, J. R., T. F. Clark, & G. A. White. 1966. Fiber and papermaking characteristics of bamboo. U. S. Dept. of Agric. Tech. Bull. 1361.

Heinrich, L. 1992. The magic of linen. Orca Book Publ. Victoria, Canada.

Jarman, C. G. et al. 1978. Cultivation, extraction, and processing of ramie fibre: a review. Trop. Sci. 20: 91-116.

Knudsen, H. D. & R. Y. Sayler. 1992. Milkweed: the worth of a weed. In, 1992 Yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 118-123.

Koojiman, S. 1972. Tapa in Polynesia. Bernice P. Bishop Mus. Bull. No. 234. 498 pp.

Kundu, B. C. 1956. Jute -- the world's foremost bast fibre. I. Botany, agronomy, diseases and pests. Econ. Bot. 10: 103-133.

Kundu, B. C. 1956. Jute -- world's foremost bast fibre. II. Technology, marketing, production and utilization. Econ. Bot. 10: 203-240.

Lock, G. W. 1962. Sisal. Longmans. London, England. 355 pp.

McClaughlin, S. & S. M. Schuck. 1991. Fiber properties of several species of Agavaceae from southwestern United States and northern Mexico. Econ. Bot. 45: 480-486.

Miller, T. 2000. The crown of Montecristi [Panama hat]. Nat. Hist. 109(5): 54-63.

Pang, B. K. K. 1992. The making of Hawaiian tapa. Bull. Natl. Trop. Bot. Gard. 22(3): 63-68.

Porterfield, W. M. 1955. Loofah – the sponge gourd. Econ. Bot. 9: 211-223.

Sarma, M. S. 1969. Jute. Field Crop Abstr. 22: 323-336.

Taylor, C. S. & D. E. Kugler. 1992. Kenaf: annual fiber crop products generate a growing response from industry. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 92-97.

Wilson, F. D. 1967. An evaluation of kenaf, roselle, and related *Hibiscus* for fiber production. Econ. Bot. 21(2): 132-139.

Wilson, F. D. & M. Y. Menzel. 1964. Kenaf (*Hibiscus cannabinus*), roselle (*Hibiscus sabdariffa*). Econ. Bot. 18(1): 80-91.

WOOD & CORK

Bell, L. 1981. Plant fibers for papermaking. Fourth edition. Liliaceae Press. McMinnville, OR. 132 pp.

Biermann, C. J. 1993. Essentials of pulping and papermaking. Academic Press. San Diego, CA.

Boutelje, J. B. 1980. Encyclopedia of world timbers: names and technical literature. Swedish Forest Prod. Res. Lab. Stockholm. 338 pp.

Brauns, F. E. 1948. Lignin: a botanical raw material. Econ. Bot. 2(4): 419-435.

Britt, K. W. 1964. Handbook of pulp and paper technology. Reinhold Publ. New York, NY. 537 pp.

Carter, R. G. et al. 1968. Making pulp and paper. Crown Zellerbach. San Francisco, CA. Various pagination.

Chudnoff, M. 1984. Tropical timbers of the world. U. S. Dept. Agric. Handbook No. 607. Washington, D. C. 464 pp.

Clarke, T. F. 1965. Plant fibers in the paper industry. Econ. Bot. 19(4): 394-405.

Cooke, G. B. 1948. Cork and cork products. Econ. Bot. 2: 393-402.

Cooke, G. B. 1961. Cork and the cork tree. Pergamon Press. London, England. 121 pp.

Core, H. A., W. A. Cote, & A. C. Day. 1979. Wood structure and identification. Second edition. Syracuse Univ. Press. Syracuse, NY. 182 pp.

Cox, H. A. 1949 (?). Wood specimens: 100 reproductions in colour. Nema Press. London, England. 206 pp.

Cox, H. A. 1957. A second collection of wood specimens: 100 reproductions in colour. Tothill Press, Ltd. London, England. 205 pp.

Edlin, H. L. 1969. What wood is that? A manual of wood identification. New York, NY. 160 pp.

Edlin, H. & M. Nimmo (Editors). 1981. The illustrated encyclopedia of trees: timbers and forests of the world. Harmony Books. New York, NY. 256 pp.

Fletcher, M. I. 1951. Balsa -- production and utilization. Econ. Bot. 5(2): 107-125.

Fritz, E. 1967. The redwoods of California: largest of economic plants. Econ. Bot. 21(1): 51-56.

Hall, F. K. 1974. Wood pulp. Sci. American 230(4): 52-62.

Harlow, W. M. 1970. Inside wood. American Forestry Assoc. Washington, D. C. 120 pp.

Harrar, E. S. 1947. Veneers and plywood -- their manufacture and use. Econ. Bot. 1: 290-305.

Hess, R. W. Et al. 1950. Properties and uses of tropical woods. Trop. Woods 97: 1-132.

Isenberg, I. H. 1956. Papermaking fibers. Econ. Bot. 10(2): 176-193.

Kribs, D. A. 1968. Commercial foreign woods on the American market. Dover Publ. New York, NY. 241 pp.

Lincoln, W. A. 1991. World woods in color. Macmillan. New York, NY. 320 pp.

Metcalfe, W. 1947. The cork oak tree in California. Econ. Bot. 1: 26-46.

Meyer, J. S. 1960. Paper. World Publ. Co. Cleveland, OH. 91 pp.

Panshin, A. J., E. S. Harrar,, J. S. Bethel, & W. J. Baker. 1962. Forest products: their sources, production, and utilization. Second edition. McGraw-Hill. New York, NY. 538 pp.

Patterson, D. 1988. Commercial timbers of the world. Fifth edition. Gower Technical. London, England. 339 pp.

Perlin, J. 1989. A forest journey: the role of wood in the development of civilization. Harvard Univ. Press. Cambridge, MA. 445 pp.

Record, S. J. 1942-1944. Keys to American woods. Tropical Woods 72: 19-35; 73: 23-42; 74: 17-43; 75: 8-26; 76: 32-47; 77: 18-38; 79: 25-34; 78: 35-45; 80: 10-15.

Record, S. J. & R. W. Hess. 1943. Timbers of the New World. Yale Univ. Press. New Haven, CT. 640 pp.

Rendle, B. J. 1969. World timbers. Vol. I. Europe & Africa. Ernest Benn, Ltd. London, England. 191 pp.

Rendle, B. J. 1970. World timbers. Vol. II. North & South America. Ernest Benn, Ltd. London, England. 150 pp.

Rendle, B. J. 1970. World timbers. Vol. III. Asia & Australia & New Zealand. Ernest Benn, Ltd. London, England. 175 pp.

Ross, P. 1959. Teak in Trinidad. Econ. Bot. 13(1): 30-40.

Stamm, A. J. & E. E. Harris. 1953. Chemical processing of wood. Chemical Publ. Co. New York, NY. 595 pp.

Soerianegara, I. & R. H. M. J. Lemmens (editors). 1993. Plant resources of South-East Asia. No. 5(1): timber trees: major commercial timbers. Pudoc Scientific Publ. Wageningen, The Netherlands. 610 pp.

Sosef, M. S. et al. (Editors). 1998. Plant resources of South-east Asia No. 5(3). Timber trees: lesser known timbers. Backhuys Publ. Leiden, The Netherlands. 859 pp.

Stockwell, P. 1947. The culture of cork oak in Spain. Econ. Bot. 1(4): 381-388.

Titmuss, F. H. 1965. Commercial timbers of the world. Third edition. Technical Press, Ltd. London, England. 277 pp.

Turnbull, R. F. 1950. The taxonomy, harvesting, processing and utilization of eucalyptus trees in Australia. Econ. Bot. 4: 99-131.

Walker, A. (editor). 1989. The encyclopedia of wood: a tree-by-tree guide to the world's most versatile resource. Facts on File. New York, NY. 192 pp.

Wellner, P. & E. Dickey. 1992. The wood users guide. Rainforest Action Network. San Francisco, CA. 67 pp.

Westoby, J. 1989. Introduction to world forestry: people and their trees. Basil Blackwell. New York, NY. 228 pp.

Wheeler, E. A. et al. 1986. Computer-aided wood identification. Bull. No. 474. North Carolina Agric. Res. Service. Raleigh, NC. 160 pp.

Wood, A. D. 1963. Plywoods of the world: their development, manufacture and application. W. & A. K. Johnston & G. W. Bacon, Ltd. Edinburgh, Scotland. 489 pp.

Working Party on Slicing and Veneer Cutting. 1973. Veneer species of the world. Forest Products Laboratory. U. S. Dept. of Agriculture. Madison, WI. 150 pp.

Youngs, R. L. 1967. Present methods of drying and conditioning wood for use. Econ. Bot. 21(1): 46-50.

LATEX-BEARING PLANTS

GENERAL REFERENCES

Anderson, A. B. 1955. Recovery and utilization of tree extractives. Econ. Bot. 9: 108-140.

Balandrin, M. F. 1991. Plant extractives as renewable energy sources. Econ. Med. Plant Res. 5: 21-45.

Boer, E. & A. B. Ella (editors). 2000. Plant resources of South-east Asia. No. 18. Plants producing exudates. Backhuys Publ. Leiden, The Netherlands. 189 pp.

Coppen, J. J. W. 1995. Gums, resins, and latexes of plant origin. Non-wood forest products. 6. Food & Agricul-ture Organization. Rome, Italy. 000 pp.

Kauffman, G. B. & R. B. Seymour. 1990. Elastomers. I. Natural rubber. J. Chem. Educ. 67(5): 422-425.

Metcalfe, C. R. 1966. Distribution of latex in the plant kingdom. Notes Jodrell Laboratory. Royal Botanic Gardens. 3: 1-18.

Metcalfe, C. R. 1967. Distribution of latex in the plant kingdom. Econ. Bot. 21: 115-127.

Rodriguez, E. 1985. Rubber and phytochemical specialties from desert plants of North America. In, Wickens, G. E. et al. (editors). Plants for arid land. George Allen & Unwin. London, England. Pp. 399-411.

Thulesius, O. 1997. Edison in Florida: the green labora-tory. Univ. Press Florida. Gainesville. 150 pp.

Williams, L. 1962. Latificerous plants of economic importance. Econ. Bot. 16: 17-24; 53-70.

PARÁ RUBBER

Bangham, W. N. 1947. Plantation rubber in the New World. Econ. Bot. 1: 210-229.

Barlow, M. E. 1978. The natural rubber industry. Oxford Univ. Press. Oxford, England.

Bauer, P. T. 1948. The rubber industry: a study in competition and monopoly. Longmans, Green, & Co. London, England.

Baukhaus, R. A. 1985. Rubber formation in plants -- a minireview. Israel J. Bot. 34: 283-293.

Baum, V. 1943. The weeping wood. Doran & Co. Garden City, NY. 531 pp.

Coates, A. 1987. The commerce in rubber: the first 250 years. Oxford Univ. Press. New York, NY. 380 pp.

Collier, R. 1968. The river that God forgot: the story of the Amazon rubber boom. Collins. London, England.

Cook, O. F. 1903. The culture of the Central American rubber tree. Bull. No. 49. U. S. Dept. Agric. Bur. Plant Ind. 86 pp. + 18 plates.

Coppen, J. J. W. 1995. Gums, resins, and latexes of plant origin. Non-wood forest products. 6. Food and Agri-culture Organization. Rome, Italy. 000 pp.

Davis, W. 1998. White blood of the forest. In, Shadows in the sun: travels to landscapes of spirit and desire. Island Press. Washington, D. C. Pp. 123-141.

Hosler, D., S. L. Burkett, & M. J. Tarkanian. 1999. Prehistoric polymers: rubber processing in ancient Mesoamerica. Science 284: 1988-1991.

Imple, E. P. 1978. *Hevea* rubber: past and future. Econ. Bot. 32: 264-277.

Klippert, W. E. 1941. The cultivation of Hevea rubber in tropical America. Chron. Bot. 6(9): 199, 200.

Paardekooper, E. C. 1989. Exploitation of the rubber tree. In, Webster, C. C. et al. (editors). Rubber. Longman. London, England. Pp. 349-414.

Sanderson, F. H. 1975. The great Ford fumble. Science 188: 503-509.

Schultes, R. E. 1956. The Amazonian Indian and the evolution of *Hevea* and related genera. J. Arnold Arboretum 37: 123-147.

Schultes, R. E. 1976. Rubber and man – a century of partnership. Horticulture 54(12): 18-26.

Schultes, R. E. 1976. The taming of wild rubber. Horticulture 54(11): 10-21.

Schultes, R. E. 1977. The odyssey of the cultivated rubber tree. Endeavour 1: 378-382.

Schultes, R. E. 1984. The tree that changed the world in one century. Arnoldia 44(2): 2-16.

Schultes, R. E. 1993. The domestication of the rubber tree: economic and sociological implications. American J. Econ. Sociol. 52(4): 479-485.

Sethuraj, M. R. & N. M. Mathew (Editors). Natural rubber: biology, cultivation and technology. Rubber Res. Inst. of India. Kottayam, India. 610 pp.

Taylor, K. W. 1951. Guayule -- an American source of rubber. Econ. Bot. 5: 255-273.

Webster, C. C. & W. J. Baulkwill. 1989. Rubber. Longman Scientific. John Wiley. New York, NY. 614 pp.

Weinstein, B. 1983. The Amazon rubber boom, 1850-1920. Stanford Univ. Press. Stanford, CA. 356 pp.

Whaley, W. G. 1948. Rubber -- the primary sources for American production. Econ. Bot. 2: 198-216.

CHICLÉ

Bolt, A. 1961. Chicle chewing gum from British Honduras. World Crops 13(2): 58, 59.

Egler, F. E. 1947. The role of botanical research in the chicle industry. Econ. Bot. 1: 188-209.

Lundell, C. L. 1933. Chicle exploitation in the sapodilla forest of the Yucatan Peninsula. Field & Lab. 2(1): 15-21.

Lundell, C. L. 1969. La exploitacion del chicle. Hist. Nat. Pro. Nat. 2(6): 29, 30.

Moore, H. E. & W. T. Stearn. 1967. The identity of *Achras zapota* L. and the names for the sapodilla and the sapote. Taxon 16(5): 382-395.

Smith, E. H. G. 1940. Chicle, jelutong and allied materials. Bull. Imp. Inst. Great Britain 38(3): 299-320.

MISCELLANEOUS LATEX PLANTS

Galston, A. W. 1977. Guayule bounces back. Nat. Hist. 86(9): 94-97.

Hochschild, A. 1998. King Leopold's ghost. Houghton Mifflin. Boston, MA. 366 pp. [*Langdolfia*].

Nakayama, F. S. et al. 1992. Guayule has real rubber in it, and it grows in the United States. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 98-104.

Stanfield, M. E. 1998. Red rubber, bleeding trees. Univ. New Mexico Press. Albuquerque. 270 pp.

Twain, M. 1905. King Leopold's soliloquy on the Belgian Congo. American Anti-Imperialist League. [Yes, this is Mark Twain!]

Williams, L. 1964. Laticiferous plants of economic importance. V. Resources of gutta-percha *Palaquium* species (Sapotaceae). Econ. Bot. 18(1): 5-26.

GUMS, RESINS, & RELATED EXUDATES

Anderson, A. B. 1955. Recovery and utilization of tree extractives. Econ. Bot. 9(2): 108-140.

Baumann, B. B. 1960. The botanical aspects of ancient Egyptian embalming and burial. Econ. Bot. 14(1): 84.

Grimaldi, D. A. 1996. Amber: windows to the past. Abrams. New York, NY. 216 pp.

Grimaldi, D. A. 1996. Captured in amber. Sci. American XXX(April): 84-91.

Howes, F. N. 1949. Vegetable gums and resins. Chronica Botanica. Waltham, MA.

Howes, F. N. 1950. Age-old resins of the Mediterranean regions and their uses. Econ. Bot. 4(4): 307-316.

Langenheim, J. H. 1964. Present status of botanical studies of ambers. Bot. Mus. Leaflts. Harvard Univ. 20: 225-288.

Langenheim, J. H. 2003. Plant resins: chemistry, evolution, ecology, and ethno-botany. Timber Press. Portland, OR. 586 pp.

Mantell, C. L. 1949. The water-soluble gums: their botany, sources, and utilization. Econ. Bot. 3: 3-31.

Mantell, C. L. 1950. The natural hard resins: their botany, sources, and utilization. Econ. Bot. 4: 203-242.

Ross, J. F. 1993. Treasured in its own right, amber is a golden window on the long ago. Smithsonian 23(10): 30-41.

Thieret, J. W. 1996. Frankincense and myrrh. Lloydiana 1(4): 6-9.

Tucker, A. O. 1986. Frankincense and myrrh. Econ. Bot. 40(4): 425-433.

Whistler, R. L. (editor). 1973. Industrial gums. Polysaccharides and their derivatives. Second edition. Academic Press. New York, NY. 807 pp.

Whistler, R. L. & T. Hyomitz. 1979. Guar: agronomy, production, industrial use, and nutrition. Purdue Univ. Press. West Lafayette, IN. 124 pp.

STARCH

Whistler, R. L. et al. 1984. Starch: chemistry and technology. Acad. Press. Orlando, FL. 718 pp.

ESSENTIAL OILS

Arctander, S. 1994. Perfume and flavor materials of natural origin. Alloured Publ. Carol Steam, IL. 736 pp.

Calkin, R. & S. Jellnek. 1994. Perfumery: practice and principles. John Wiley & Sons. New York, NY. 287 pp.

Ellis, N. K. & E. C. Stevenson. 1950. Domestic production of the essential oils of peppermint and spearmint. Econ. Bot. 4: 139-149.

Green, T. 1991. Making scents is more complicated than you'd think. Smithsonian 22(6): 52-60.

Guenther, E. 1948-1952. The essential oils. Five vols. Van Nostrand. New York, NY.

Guenther, E. 1952. Recent developments in essential oil production. Econ. Bot. 6(4): 355-378.

Lawless, J. 1995. The illustrated encyclopedia of essential oils: the complete guide to the use of oils in aromatherapy and herbalism. Element Books. Shaftesbury, England. 256 pp.

Lawless, J. 2001. Essential oils: a basic guide. Barnes & Noble. New York, NY. 144 pp.

Linskens, H. F. & J. F. Jackson (Editors). 1991. Essential oils and waxes. Modern Methods of Plant Analysis No. 12. Springer-Verlag. Berlin, Germany. 337 pp.

Maclay, W. D. et al. 1963. Industrial utilization of seed oils. Econ. Bot. 17(1): 23-30.

Morris, E. T. 1984. Fragrance: the story of perfume from Cleopatra to Chanel. Scribner's. New York, NY.

Newman, C. 1998. Perfume -- the essence of illusion. Natl. Geogr. 194(4): 94-119.

Oyen, L. P. A. & N. X. Dung. 1999. Plant resources of south-east Asia: essential oils. Backhuys Pub. Leiden, The Netherlands. 277 pp.

Salunkhe, D. K. et al. 1992. World oil seeds: chemistry, technology, and utilization. Van Nostrand Reinhold. New York, NY. 544 pp.

Svendsen, A. B. & J. C. C. Scheffer (editors). 1985. Essential oil and aromatic plants. Junk Publ. The Netherlands. 246 pp.

Weiss, E. A. 1996. Essential oil crops. Oxford Univ. Press. New York, NY. 608 pp.

F I X E D   O I L S

Bagby, M. 1992. Uses for vegetable oils. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 154-158.

Balick, M. J. 1979. Amazonian oil palms of promise: a survey. Econ. Bot. 33(1): 11-28.

Blackmon, G. H. 1947. Tung oil: a gift of China. Econ. Bot. 1(2): 161-175.

Carlson, K. D. et al. 1992. Nature's abundant variety: new oilseed crops on the horizon. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 124-133.

Corley, R. H. V. & P. B. H. Tinker. 2003. Oil palm. Fourth edition. Oxford Univ. Press. New York, NY. 562 pp.

Cowan, J. C. 1973. Soyabean -- king of the oilseeds. World Crops 15(7): 17-20.

Doty, H. O., Jr. 1983. Economics of oilseed production. Econ. Bot. 37(4): 434-443.

Elder, A. L. & D. M. Rathmann. 1962. Seed oils in human nutrition. Econ. Bot. 16(3): 196-205.

Food and Agriculture Organization. 1989. Utilization of tropical foods: tropical oil seeds. Food and Nutr. Papers No. 47/5. FAO. The United Nations. Rome, Italy. 82 pp.

Gentry, H. S. 1958. The natural history of jojoba (*Simmondsia chinensis*) and its cultural aspects. Econ. Bot. 12: 261-295.

Glaser, L. K. et al. 1992. Castor and lesquerella: sources of hydroxy fatty acids. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 111-117.

Hall, D. D. 1981. Put a sunflower in your tank? New Scientist 89(1242): 524-526.

Hartley, C. W. S. 1988. The oil palm (*Elaeis guineensis* Jacq.). Third edition. Longman Scientific & Technical. Essex, England. 761 pp.

Hodge, W. H. 1975. Oil-producing palms of the world -- a review. Principes 19: 119-136.

Imhoff, D. & P. Warshall. 1999. Soybean of happiness: a 3,000 year history of our most modern oilseed. Whole Earth Summer: 75-79.

Johnson, J. D. & T. W. Hinman. 1980. Oils and rubber from arid land plants. Science 208: 460-464.

Kester, E. B. 1951. Minor oil-producing crops of the United States. Econ. Bot. 5(1): 38-59.

Lusas, E. W. 1983. Comparative processing practices of the world's major oilseed crops. Econ. Bot. 37(4): 444-458.

Maclay, W. D. et al. 1963. Industrial utilization of seed oils. Econ. Bot. 17(1): 23-30.

Princen, L. H. 1983. New oilseed crops on the horizon. Econ. Bot. 37(4): 478-492.

Pryde, E. H. 1983. Utilization of commercial oilseed crops. Econ. Bot. 37(4): 459-477.

Robbelen, G. 1989. Oil crops of the world: their breeding and utilization. McGraw-Hill. New York, NY. 558 pp.

Roetheli, J. et al. 1992. Rapeseed and crambe: developing useful products from oils that high in erucic acid. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 105-110.

Salunkhe, D. K. et al. 1992. World oil seeds: chemistry, technology, and utilization. Van Nostrand Reinhold. New York, NY. 544 pp.

Scarpa, A. & A. Gverci. 1982. Various uses of the castor oil plant (*Ricinus communis* L.): a review. J. Ethnopharm. 5: 117-138.

Weibel, R. O. 1948. The castor-oil plant in the United States. Econ. Bot. 2: 273-283.

Weiss, E. A. 1971. Castor, sesame, and safflower. Leonard Hill. London, England. 901 pp.

Weiss, E. A. 2000. Oilseed crops. Second edition. Black-well Science. Oxford, England. 364 pp.

Wu, C. 1998. Fill 'er up ... with veggie oil. Science News 154(23): 364-366.

Zwingle, E. 1999. Olive oil: elixir of the gods. Natl. Geogr. 196(3): 66-81.

TANNINS & DYES

Adrosko, J. 1968. Natural dyes in the United States. U. S. Nat. Mus. Bull. No. 281.

Adrosko, J. 1971. Natural dyes and home dyeing. Dover Publ. New York, NY. 154 pp.

Armstrong, W. 1994. Natural dyes. HerbalGram 32: 30-34.

Barbour, C. 1997. Natural dyes. Martha Stewart Living 52: 152-159.

Basker, D. & M. Negbi. 1983. Uses of saffron. Econ. Bot. 37(2): 228-236.

Bolton, E. M. 1960. Lichens for vegetable dyeing. Charles T. Branford. Newton Centre, MA.

Cannon, J. & M. Cannon. 2003. Dye plants and dyeing. Revised edition. Timber Press. Portland, OR. 128 pp.

Haslam, E. 1989. Plant polyphenols -- vegetable tannins revisited. Cambridge Univ. Press. New York, NY. 230 pp.

Ingram, J. S. 1969. Saffron (*Crocus sativus* L.). Trop. Sci. 11: 177-184.

Ingram, J. S. & B. J. Francis. 1969. The annatto tree (*Bixa orellana* L.): a guide to its occurrence, cultivation, preparation and uses. Trop. Sci. 9: 97-103.

Krochmal, A. & C. Krochmal. 1974. The complete illustrated book of dyes from natural sources. Doubleday. Garden City, NY. 272 pp.

Kroh, V. F. 1978. Hawaii dye plants and dye recipes. Univ. Hawaii Press. Honolulu. 136 pp.

Madan, C. L., B. M. Kapur, & U. S. Gupta. 1966. Saffron. Econ. Bot. 20(4): 377-385.

Morton, J. F. 1972. Further associations of plant tannins and human cancer. Quart. J. Crude Drug. Res. 12: 1829-1841.

Ohler, J. G. 1968. Annatto (*Bixa orellana* L.). Trop. Abstr. 23: 409-413.

Robertson, S. M. 1973. Dyes from plants. Van Nostrand Reinhold. New York, NY. 144 pp.

Sauer, J. L. 1950. Amaranths as dye plants among the Pueblo peoples. Southwest. J. Anthrop. 6: 412-415.

Wilkins, M. 1976. California dye plants. Thresh Publ. Santa Rosa, CA. 47 pp.

9 : POISONOUS PLANTS

GENERAL REFERENCES

Anderson, D. M. 1994. Red tides. Sci. American 271(2): 62-68.

Arnea, J. M. 1979. Pretty poisonous plants. Vet. Human Toxicol. 21(2): 108-111.

Arena, J. M. 1981. Plants that poison. Emergency Med. 13(11): 24-57.

Arnold, R. E. 1978. Poisonous plants. Terra Publ. Co. Jeffersontown, KY. 141 pp.

Aronow, R. 1979. Toxic reactions to plant products sold in health food stores. Vet. Human Toxicol. 21(3): 193, 194.

Benjamin, D. R. 1995. Mushrooms: poisons and panaceas. W. H. Freeman. New York, NY. 422 pp.

Bernard-Smith, A. 1988. Poisonous plants of all countries. Second edition. Soni Reprints Agency. Delhi, India. 112 pp.

Blackwell, W. H. 1990. Poisonous and medicinal plants. Prentice Hall. Engelwood Cliffs, NJ. 329 pp.

Burrows, G. E. & R. J. Tyrl. 2001. Toxic plants of North America. Iowa State Univ. Press. Ames. 1342 pp.

Cheeke, P. R. & L. R. Shull. 1985. Natural toxicants in feeds and poisonous plants. AVI Publ. Co. Westport, CT. 492 pp.

Colegate, S. M. & P. R. Darling (editors). 1994. Plant-associated toxins. CAB International. 581 pp.

Christensen, C. M. 1975. Molds, mushrooms, and mycotoxins. Univ. Minnesota Press. Minneapolis. 264 pp.

Cooper, M. R. & A. W. Johnson. 1988. Poisonous plants and fungi: an illustrated guide. Ministry of Agriculture, Fisheries, and Food. Her Majesty's Stationery Office. London, England. 134 pp.

D'Mello, J. P. F., C. M. Duffus, & J. H. Duffus. 1991. Toxic substances in crop plants. Royal Soc. Chemistry. Cambridge, England. 339 pp.

D’Mello, J. P. F. 1997. Handbook of plant and fungal toxicants. CRC Prss. Boca Raton, FL. 356 pp.

Der Marderosian, A. H., F. B. Giller, & F. C. Roia, Jr. 1976. Phytochemical and toxicological screening of household ornamental plants potentially toxic to humans. I. J. Toxicol. Env. Health 1(6): 939-953.

DiTomaso, J. M. 1985. Poisonous plants: their impact on livestock and man. 37th Annual California Weed Conf. Pp. 29-37.

DiTomaso, J. M. 1993. Problems associated with the use of common names in the identification of poisonous plants. Vet. Human Toxicol. 35(5): 465, 466.

Dowden, A. O. 1994. Poisons in our path: plants that harm and heal. Harper Collins Publ. New York, NY. 61 pp.

Duke, J. A. 1977. Phytotoxin tables. CRC Critical Rev. Toxicol. 5(3): 190-237.

Ellis, M., W. O. Robertson, & B. Rumack. 1979. Plant-ingestion poisoning from A to Z. Patient Care 13(2): 86-140.

Eshleman, A. 1977. Poisonous plants. Houghton Mifflin Co. Boston, MA. 188 pp.

Fowler, M. E. 1983. Plant poisoning in free living wild animals: a review. J. Wildl. Dis. 19(1): 34-43.

Frohne, D. & H. J. Pfander. 2001. A colour atlas of poisonous plants: a handbook for pharmacists, doctors, toxicologists, and biologists. Second edition. Wolfe Publ. Co. London, ENgland.. 292 pp.

Gadd, L. 1980. Deadly beautiful. The world's most poisonous animals and plants. Macmillan. New York, NY. 208 pp.

Goldfrank, L. & E. Bresnitz. 1979. Toxic emergencies: houseplants. Hosp. Phys. 15(11): 34-38.

Gossel, T. A. & J. D. Bricker. 1990. Plants. In, Principles of clinical toxicology. Second edition. Raven Press. New York, NY. Pp. 219-240.

Haard, R. & K. Haard. 1977. Poisonous and hallucinogenic mushrooms. Cloudburst Press. Mayne Island and Seattle, WA. 126 pp.

Harborne, J. B. H. Baxter, & G. P. Moss. 1996. Dictionary of plant toxins. John Wiley & Sons. Chichester, U. K. 523 pp.

Hardin, J. W. & J. M. Arena. 1974. Human poisoning from native and cultivated plants. Second edition. Duke Univ. Press. Durham, NC. 194 pp.

Harris, J.B. 1987. Natural toxins: animal, plant, and microbial. Clarendon Press. Oxford, England. 353 pp.

Hartman, G. 1977. Pediatrician's advice to parents on poisonous garden plants. Horticult. 55: 18-25.

Hyypio, P. A. An annotated list of books on poisonous plants. Baileya 18: 85-92.

James, L. F. et al. 1988. The ecology and economic impact of poisonous plants on livestock production. Westview Press. Boulder, CO. 428 pp.

James, L. F. et al. 1992. Poisonous plants. Proceedings of the third international symposium, 1989. Iowa State Univ. Press. Ames. 661 pp.

James, W. R. 1973. Know your poisonous plants: poisonous plants found in field and garden. Naturegraph. Healdsburg, CA. 99 pp.

Kakes, P. 1990. Properties and functions of cyanogenic systems in higher plants. Euphytica 48: 25-43.

Keeler, R. F. 1983. Naturally occurring teratogens from plants. In, Keeler, R. F. & A. T. Tu (editors). Plant and fungal toxins. Marcel Dekker. New York, NY. Pp. 161-199.

Keeler, R. F. & A. T. Tu (Editors). 1983. Handbook of natural toxins. Vol. 1. Plant and fungal toxins. Marcel Dekker. New York, NY. 934 pp.

Keeler, R. F., K. R. van Kampen, & L. F. James. 1978. Effects of poisonous plants on livestock. Academic Press. New York, NY. 600 pp.

Kinghorn, A. D. (editor). 1979. Toxic plants. Columbia Univ. Press. New York, NY. 195 pp.

Kingsbury, J. M. 1965. Deadly harvest: a guide to common poisonous plants. Holt, Rinehart & Winston. New York, NY. 128 pp.

Kingsbury, J. M. 1969. Phytotoxicology. I. Major problems associated with poisonous plants. Clin. Pharm. Therap. 10: 163-169.

Kingsbury, J. M. 1969. Phytotoxicology. II. On better methods for dealing with poisonous plants and plant-caused emergencies. Clin. Tox. 2: 143-148.

Kingsbury, J. M. 1975. Phytotoxicology. In, Casarett, L. J. & J. Doull (Editors). Toxicology: the basic science of poisons. Macmillan. New York, NY. Pp. 591-603.

Kingsbury, J. M. 1976. Common poisonous plants. Information Bull. No. 104. Cornell Univ. Ithaca, NY. 19 pp.

Kingsbury, J. M. 1980. One man's poison. BioScience 30(3): 171-176.

Kingsbury, J. M. 1983. The evolutionary and ecological significance of plant toxins. In, Keeler, R. F. & A. T. Tu (Editors). Plant and fungal toxins. Pp. 675-706.

Kunkel, D. B. & G. C. Spoerke. 1984. Evaluating exposure to plants. Emerg. Med. Clin. N. Amer. 2: 123-144.

Kunkel, D. B. et al. 1984. Common toxic plant ingestions. Emerg. Med. Clin. N. Amer. 2(3): 553-562.

Lampe, K. F. 1974. Systemic plant poisoning in children. Pediatrics 54(3): 347-351.

Lampe, K. F. & M. A. McCann. 1985. AMA handbook of poisonous and injurious plants. American Medical Assoc. Chicago, IL. 432 pp.

Lampe, K. F. & R. Fagerström. 1968. Plant toxicity and dermatitis -- a manual for physicians. Williams & Wilkins. Baltimore, MD. 231 pp.

Leopold, A. C. et al. 1972. Toxic substances in plants and the food habits of early man. Science 176: 512-514.

Lerner, C. 1988. Moonseed and mistletoe: the book of poisonous wild plants. William Morrow. 32 pp.

Lovell, C. R. 1993. Plants and the skin. Blackwell Science. 272 pp.

Lucy, J. S. & G. M. Oderda. 1981. 49 poison plants: what to watch for - what to do. Mod. Med. 49(10): 183, 184.

Matossian, M. A. 1989. Poisons of the past: molds, epidemics, and history. Yale Univ. Press. New Haven, CT. 190 pp.

Mickelsen, O. et al. 1966. Naturally occurring toxicants in foods. Fed. Proc. 25(1): 104-123.

Nielsen, D. B. & L. F. James. 1992. The economic impacts of livestock poisonings by plants. In, James, L. F. et al. Poisonous plants. Pp. 3-10.

Panter, K. E. et al. 1990. Natural plant toxicants in milk: a review. J. Animal Science 68(3): 892-904.

Rizk, A.-F. M. (Editor). 1991. Poisonous plant contamination of edible plants. CRC Press. Boca Raton, FL. 183 pp.

Salunkhe, D. K. & M. T. Wu. 1977. Toxicants in plants and plant products. CRC Critical Rev. Food Sci. Nutr. 9: 265-324.

Schmutz, E. M. 1986. Plants that poison. Northland Press. Flagstaff, AZ. 250 pp.

Scimeca, J. M. & F. W. Oehme. 1985. Post mortem guide to common poisonous plants of livestock. Vet. Human Toxicol. 27(3): 189-199.

Seawright, A. A. et al. 1985. Plant toxicology. Animal Res. Unit. Moorooka, Queensland. 625 pp.

Smith, J. P., Jr. 1991. Plants, poisonous. In, Hui, Y. H. (editor). Encyclopedia of food technology. John Wiley & Sons. New York, NY. Pp. 2107-2132.

Spoerke, D. G., Jr. & B. H. Rumack (Editors). 1994. Handbook of mushroom poisoning: diagnosis and treatment. CRC Press. Boca Raton, FL. 456 pp.

Spoerke, D. G., Jr. & S. C. Smolinske. 1990. Toxicity of houseplants. CRC Press. Boca Raton, FL. 244 pp.

Spoerke, D. G. et al. 1990. Plants and mushrooms of abuse. Emerg. Med. Clin. N. Amer. 8(3): 579-593.

Steering Group on Chemical Aspects of Food Surveillance. 1996. Inherent natural toxicants in food. The Stationery Office. London, England. 102 pp.

Taboh, E. 1970. Plant poisons in Shakespeare. Econ. Bot. 24: 81-94.

Tampion, J. 1977. Dangerous plants. Universe Books. New York, NY. 176 pp.

Wagstaff, D. J. 1992. Plant poisoning in humans. In, James, L. F. et al. Poisonous plants. Pp. 340-348.

Williams, M. C. 1980. Purposefully introduced plants that have become noxious or poisonous weeds. Weed Sci. 28(3): 300-305.

Wiltens, J. 1986. Plants your mother never told you about. Interesting, edible and poisonous plants of the Bay Area. Deer Crossing Camp. 160 pp.

Woodward, L. 1985. Poisonous plants: a color guide. Hippocrene Books. New York, NY. 192 pp.

TOXIC FOOD PLANTS

Arnold, R. E. & L. Pearce. 1977. Burgeoning cult of wild food nourishes fatal misconceptions. Smithsonian 8(2): 48-55.

Aronow, R. 1979. Toxic reactions to plant products sold in health food stores. Vet. Human Toxicol. 21(3): 193, 194.

Boyd, C. E. (Editor). 1973. Toxicity of pure foods. CRC Press. Cleveland, OH. 260 pp.

Hall, R. L. 1977. Safe at the plate. Natural toxins in food. Nutrition Today Nov/Dec: 1-9.

Kaplan, H. 1983. Toxicities of natural foods in man: a survey. Trans. Illinois Acad. 76: 181-194.

Klein, A. E. 1982. Were toxic plants or fungi on the menu?PatientCare16(14): 165-236.

Liener, I. E. 1980. Toxic constituents of plant foodstuffs. Second edition. Academic Press. New York, NY. 502 pp.

Mickelsen, O. et al. 1966. Naturally occurring toxicants in foods. Fed. Proc. 25(1): 104-123.

Moreau, C. 1979. Moulds, toxins and food. John Wiley & Sons. New York, NY. 477 pp.

National Research Council. 1973. Toxicants occurring naturally in foods. Second edition. National Academy of Sciences. Washington, D. C. 624 pp.

Ory, R. L. 1981. Antinutrients and natural toxicants in food. Food and Nutrition Press. Westport, CT. 378 pp.

Rechcigl, M. (editor). 1983. CRC handbook of naturally occurring food toxicants. CRC Press. Boca Raton, FL. 319 pp.

Riley, R. T. et al. 1993. Fungal toxins in foods: recent concerns. Ann. Rev. Nutrition 13: 167-189.

Rizk, A.-F. M. (Editor). 1991. Poisonous plant contamination of edible plants. CRC Press. Boca Raton, FL. 183 pp.

Sherman, P. W. & S. M. Flaxman. 2001. Protecting ourselves against food. American Sci. 89(2): 142-151.

Steering Group on Chemical Aspects of Food Surveillance. 1996. Inherent natural toxicants in food. The Stationery Office. London, England. 102 pp.

Wertheim, A. H. 1974. The natural poisons in natural foods. Lyle Stuart. Secaucus, NJ. 198 pp.

SURVEY OF POISONOUS PLANTS

AMANITA MUSHROOMS

Becker, C. E. et al. 1976. Diagnosis and treatment of *Amanita phalloides*-type mushroom poisoning. West. J. Med. 125: 100-109.

Benedict, R. G. et al. 1970. Occurrence of the deadly *Amanita verna* in the Pacific Northwest. Mycologia 62: 597-599.

Chilton, W. S. & J. Ott. 1976. Toxic metabolites of *A. pantherina*, *A. cothurnata*, *A. muscaria* and other *Amanita* species. Lloydia 39: 150-157.

Culliton, B. J. 1974. Destroying angel: a story of a search for an antidote; *Amanita phalloides* poisoning. Science 185: 600, 601.

Faulstich, H. et al. 1980. *Amanita* toxins and poisoning. Koeltz. New York, NY. 246 pp.

Floersheim, G. L. 1985. Treatment of mushroom poisoning. J. American Med. Assoc. 253: 3252.

Floersheim, G. L. 1987. Treatment of human amatoxin mushroom poisoning. Myths and advances in therapy. Med. Toxicol. 2: 1-9.

Floersheim, G. L. & L. Bianchi. 1984. Ethanol diminishes the toxicity of *Amanita phalloides* poisoning. Experienta 40: 1268-1270.

Galler, G. W. et al. 1992. Mushroom poisoning: the role of liver transplantation. J. Clin. Gastroen. 15(3): 229-232.

Genser, A. S. & S. M. Marcus. 1987. *Amanita* poisoning -- an outbreak of 10 cases. Vet. Human Toxicol. 29(6): 461, 462.

Gray, W. D. 1978. Poisonous mushrooms and mushroom poisoning. Drug Therapy 8: 103-112.

Hatfield, G. M. 1979. Toxic mushrooms. In, Kinghorn, A. D. (Editor). Toxic plants. Columbia Univ. Press. New York, NY. Pp. 7-58.

Jaeger, A. 1993. Kinetics of amatoxins in human poisoning: therapeutic implications. J. Toxicol. Clin. Toxicol. 31(1): 63-80.

Mitchel, D. H. 1980. *Amanita* mushroom poisoning. Ann. Rev. Med. 31: 51-57.

Olson, K. R. et al. 1984. *Amanita* phalloides-type mushroom poisoning. West. J. Med. 137(4): 282-239.

Pond, S. M. et al. 1986. Amatoxin poisoning in northern California. West. J. Med. 145(2): 204-209.

Wieland, T. 1968. Poisonous principles of mushrooms of the genus *Amanita.* Science 159: 946-952.

Yocum, R. R. & D. M. Simons. 1977. Amatoxins and phallatoxins in *Amanita* species of the northeastern United States. Lloydia 40(2): 178-190.

Zevin, S. et al. 1997. *Amanita phalloides* mushroom poisoning – northern California, January 1997. Clin. Toxicol. 35(5): 461-463.

CASTOR BEAN

Balint, G. A. 1974. Ricin: the toxic protein of castor oil seeds. Toxicology 2: 77-102.

Brugsch, H. G. 1960. Toxic hazards: the castor bean. New England J. Med. 262: 1039, 1040.

Fox, M. W. 1961. Castor seed residue poisoning in dairy cattle. Vet. Record 73: 885, 886.

Jenkins, F. P. 1963. Allergenic and toxic components of castor bean meal: review of the literature and studies of the inactivation of these components. J. Sci. Food and Agric. 14: 773-780.

Kinamore, P. A. et al. 1980. *Abrus* and *Ricinus* ingestion: management of three cases. Clin. Toxicol. 17(3): 401-405.

Layton, L. et al. 1970. Cross-reactivity in primary respiratory allergy to castorbean (*Ricinus communis*). Int. Arch. Allergy 37: 67-75.

Rauber, A. et al. 1985. Castor bean toxicity re-examined: a new perspecitve. Vet. Human Toxicol. 27(60: 498-502.

DUMBCANE

Arditti, J. & E. Rodriquez. 1982. *Dieffenbachia* -- uses, abuses and toxic constituents: a review. J. Ethnopharm. 5: 293-302.

Drach, G. & W. H. Maloney. 1963. Toxicity of the common houseplant *Dieffenbachia*. J. American Med. Assoc. 184: 1047.

Frochtman, F. W. et al. 1969. Toxicity of the genus *Dieffenbachia*. Toxicol Appl. Pharmacol. 15: 38-45.

Ladeira, A. M. et al. 1975. Studies on *Dieffenbachia picta* Schott: toxic effects in guinea pigs. Toxicol. Appl. Pharmacol. 34(3): 363-373.

Mrvos, R. et al. 1991. *Philodendron/Dieffenbachia* ingestion: are they a problem? Clin. Toxicol. 29(4): 485-491.

Pamies, R. J. et al. 1992. The dieffenbachia plant: case histories. J. Florida Med. Assoc. 79(11): 760, 761.

Pohl, R. W. 1964. *Dieffenbachia* poisoning: a clarification. J. American Med. Assoc. 187: 963.

Rauber, A. 1985. Observations on the idioblasts of *Dieffenbachia*. J. Toxicol. Clin. Toxicol. 23(2-3): 79-90.

Walter, W. G. 1967. *Dieffenbachia* toxicity. J. American Med. Assoc. 201: 140, 141.

Walter, W. G. & P. N. Khanna. 1972. Chemistry of the aroids. I. *Dieffenbachia seguine, amoena,* and *picta*. Econ. Bot. 26: 364-372.

Wiese, M. et al. 1996. Acute poisoning with *Dieffenbachia picta*. Vet. Human Toxicol. 38(5): 356-358.

ERGOT

Anonymous. 1951. "Bread of madness" infects a town. Life 31(11): 25-27.

Berde, B. & H. O. Schild (editors). 1978. Ergot alkaloids and related compounds. Springer. Berlin. 905 pp.

Campbell, C. W. & P. J. Burfening. 1972. Effects of ergot on reproductive performance in mice and gilts. Canadian J. Animal Sci. 52: 567-569.

Caporeal, L. R. 1976. Ergotism: the Satan loosed in Salem? Science 192: 21-26.

Fuller, J. E. 1969. The day of St. Anthony's fire. Hutchinson. London. 310 pp.

Green, S. A. 1982. Salem witchcraft: a biopsychosocial analysis. Pharos 45(3): 9-13.

Hofmann, A. 1958. The chemistry of the ergot alkaloids. Planta Medica 6: 381-394.

Hofmann, A. 1964. Die Mutterkornalkaloide. Fernand Enke. Stuttgart. 218 pp.

Hofmann, A. 1972. Ergot: a rich source of pharmacologically active substances. In, Swain, T. (editor). Plants in the development of modern medicine. Harvard Univ. Press. Cambridge, MA. Pp. 235-260.

Kren, V. & L. Cvak (editors). 1998. Ergot, the genus *Claviceps*. Harwood Academic. 537 pp.

Lorenz, K. 1979. Ergot on cereal grains. CRC Rev. in Food Sci. & Nutr. 11(4): 311-354.

Matossian, M. K. 1989. Ergot and the Salem witchcraft affair. In, Poisons of the past. Yale Univ. Press. New Haven CT. Pp. 113-122.

Spanos, N. P. & J. Gottlieb. 1976. Ergotism and the Salem village witch trials. Science 194: 1390-1394. [Response to the Coporeal article]

Van Rensburg, S. J. & B. Altenkirk. 1974. *Claviceps purpurea* -- ergotism. In, Purchase, I. F. H. (editor). Mycotoxins. Elsevier. Amsterdam. Pp. 69-96.

Youngken, H. W., Jr. 1947. Ergot -- a blessing and a scourge. Econ. Bot. 1(4): 372-380.

FALSE HELLEBORE

Binns, W. et al. 1968. Effects of teratogenic agents in range plants. Cancer Res. 28: 2323-2326.

Bryden, M. M. et al. 1973. Effects of alkaloids of *Veratrum californicum* on chick embryos. Teratology 8: 19-27.

Jaffe, A. M. et al. 1990. Poisoning due to ingestion of *Veratrum viride* (false hellebore). J. Emergency Med. 8(2): 161-167.

Keeler, R. F. 1990. Early embryonic death in lambs induced by *Veratrum californicum.* Cornell Vet. 80(2): 203-207.

Nelson, D. 1954. Accidental poisoning by *Veratrum japonicum*. J. American Med. Assoc. 156: 133.

Quatrehomme, G. et al. 1993. Intoxication from *Veratrum album*. Human Exp. Toxicol. 12: 111-115.

LARKSPUR (DELPHINIUM)

Cronin, E. H. 1971. Tall larkspur: some reasons for its continuing preeminence as a poisonous plant. J. Range Management 24(4): 258-263.

Cronin, E. H. & D. B. Nielsen. 1979. The ecology and control of rangeland larkspurs. Bull. No. 499. Utah Agric. Experiment Station. Logan. 34 pp.

Cronin, E. H. & D. B. Nielsen. 1981. Larkspurs and livestock on the rangelands of western North America. Down to Earth 37(3): 11-16.

Majack, W. & M. Engelsjord. 1988. Levels of a neurotoxic alkaloid in a species of low larkspur. J. Range Manage. 41: 224-226.

Manners, G. D. 1993. Toxicity and chemical phenology of noriterpenoid alkaloids in the tall larkspurs (*Delphinium* species). J. Agric. Food Chemist 41(1): 96-100.

Manners, G. D. et al. 1992. Larkspur chemistry: toxic alkaloids in tall larkspurs. J. Range Manage. 45: 63-66.

Olsen, J. D. 1977. Unlocking the secrets of larkspur. Utah Science 38(2): 35-38.

Olsen, J. D. 1978. Tall larkspur poisoning in cattle and sheep. J. American Vet. Med. Assoc. 173(6): 762-765.

Olsen, J. D. 1978. Larkspur toxicosis: a review of current research. In, Keeler, R. F. et al. (editors). Effects of poisonous plants on livestock. Academic Press. New York, NY. Pp. 535-543.

Ralphs, M. H. et al. 1991. Utilization of larkspur by sheep. J. Range Manage. 44:619-622.

Tucker, J. M. 1960. Poisnous larkspurs: identification and control. Leaflet No. 129. California Agric. Exp. Stat. Unpaged.

MISTLETOE

Hall, A. H. et al. 1986. Assessing mistletoe toxicity. American Emergency Medicine 15(11): 1320-1323.

Harvey, J. & D. G. Colin-Jones. 1981. Mistletoe hepatitis. British Med. J. 6259(282): 186, 187.

Moore, H. 1963. Mistletoe poisoning. J. South Carolina Med. Assoc. 59(8): 269.

Samuelson, G. 1973. Mistletoe toxins. Systematic Zoology 22(4): 566-569.

Wexler, M. 1979. Christmas without mistletoe? Natl. Wildlife Dec-Jan: 18-21.

OLEANDER

Ansford, A. J. & H. Morris. 1981. Fatal oleander poisoning. Med. J. Australia 1: 360-361.

Ansford, A. J. & H. Morris. 1983. Oleander poisoning. Toxicon. Suppl. 3): 15, 16.

Driggeres, D. A. et al. 1989. Acute oleander poisoning: a suicide attempt in a geriatric patient. West. J. Med. 151(6): 660-662.

Galey, F. D. et al. 1996. Diagnosis of oleander poisoning in livestock. J. Vet. Diagn. Invest. 8: 358-364.

Haynes, B. E. et al. 1985. Oleander tea: herbal draught of death. Ann. Emergency Med. 14: 350-353.

Langford, S. D. & P. J. Boor. 1996. Oleander toxicity: an examination of human and animal toxic exposures. Toxicol. 109(1): 1-13.

Shaw, D. & J. Pearn. 1979. Oleander poisoning. Med. J. Australia 2: 267-269.

POINSETTIA

D'Arcy, W. G. 1974. Severe contact dermatitis from poinsettia: status of poinsettia as a toxic agent. Arch. Dermatol. 109: 909, 910.

Krenzelok, E. P., T. D. Jackson, & J. M. Aronis. 1996. Poinsettia exposures have good outcomes ... just as we thought. American J. Emergency Med. 14(7): 671-674.

Runyon, R. 1980. Toxicity of fresh poinsettia (*Euphorbia pulcherrima*) to Sprague-Dawley rats. Clin. Toxicol. 16(2): 167-173.

Stone, R. P. et al. 1971. *Eurphorbia pulcherrima*: toxicity to rats. Toxicon 9: 301, 302.

Walker, J. H. 1972. Poinsettia & mistletoe toxicity -- a witch hunt. Soc. American Florists & Ornamental Horticulturalists. 5 pp.

Winek, C. L. et al. Toxicology of poinsettia. Clin. Toxicol. 13(1): 27-45.

POISON HEMLOCK & WATER HEMLOCK

Anonymous. 1994. Couple perish from poisoning in Willow Creek [California]. Times-Standard 28 September.

Applefeld, J. J. & E. S. Caplan. 1979. A case of water hemlock poisoning. J. American College Emergency Physicians 8(10): 401-403.

Costanze, D. J. & V. W. Hoversten. 1973. Accidental ingestion of water hemlock. California Med. 119: 78-82.

DeBoer, J. 1950. The death of Socrates: a historical and experimental study on the actions of coniine and *Conium maculatum*. Arch. Internatl. Pharm. Therap. 83: 473-490.

Gompertz, L. 1926. Poisoning with water hemlock (*Cicuta maculata*). J. American Med. Assoc. 87: 1277.

Edmonds, L. D. et al. 1972. Poisoning and congenital malformations associated with consumption of poison hemlock by sows. J. American Vet. Med. Assoc. 160: 1319-1324.

Keeler, R. F. 1974. Coniine, a teratogenic principle from *Conium maculatum* producing congenital malformation in calves. Clinical Toxicology 7(2): 195-206.

Keeler, R. & L. Balls. 1978. Teratogenic effects in cattle of *Conium maculatum* and *Conium* alkaloids and analogs. Clin. Toxicol. 12: 49-64.

Keeler, R. F. et al. 1980. Teratogenicity and toxicity of coniine in cows, ewes, and mares. Cornell Veterinarian 70(1): 19-26.

Mutter, L. 1976. Poisoning by western water hemlock. Canadian J. Public Health 67: 386.

Ober, W. B. 1977. Did Socrates die of hemlock poisoning? New York J. Medicine 77(2): 254-258.

Panter, K. et al. 1983. Toxicity and teratogenicity of *Conium maculatum* in swine. Toxicon (Suppl. 3): 333-336.

Panter, K. E. et al. 1985. Induction of cleft palate in newborn pigs by maternal ingestion of poison hemlock (*Conium maculatum*). American J. Vet. Res. 46: 1368-1371.

Robeson, P. M. B. 1965. Water hemlock poisoning. Lancet 2: 1274, 1275.

Rork, L. E. 1969. Plant poisoning in a child. Rocky Mtn. Med. J. 68: 47-49.

Starreveld, E. et al. 1975. Cicutoxin poisoning (water hemlock). Neurology 25(8): 730-734.

Tucker, J. M. et al. 1964. Poisonous hemlocks: their identification and control.Circular 530. California Agric. Exp. Stat. 19 pp.

Withers, L. M. et al. 1969. Water hemlock poisoning. New England J. Med. 281: 566, 567.

POISON-OAK & POISON-IVY

Anderson, T. E. 1995. The poison ivy, oak and sumac book: a short natural history and cautionary account. 138 pp.

Armstrong, W. & W. L. Epstein. 1995. Poison oak: more than just scratching the surface. HerbalGram 34: 36-38, 40-42.

Baer, H. 1979. The poisonous Anacardiaceae. In, Kinghorn, A. D. (Editor). Toxic plants. Columbia Univ. Press. New York, NY. Pp. 161-170.

Baker, S. J. 1979. Poison oak and poison ivy: why it itches and what to do, plus over 100 folk remedies. Publ. by author. Soquel, CA. 40 pp.

Billets, S. et al. 1976. Component analysis of urushiol content of poison ivy and poison oak. Phytochemistry 15(4): 533-535.

Corbett, M. & S. Billets. 1975. Characterization of poison oak urushiol. J. Pharm. Sci. 64: 1715-1718.

Crooks, D. M. & D. L. Klingman. 1977. Poison ivy, poison oak, and poison sumac. Identification, precautions, and eradication. Farmers Bull. No. 1972 (revised). U. S. Dept. Agric. 16 pp.

Daniell, H. W. 1984. Treatment for rhus dermatitis [letter]. West. J. Med. 140(14): 618, 620.

D'Aulaire, E. & P. O. D'Aulaire. 1985. Leaves of three, let them be! Readers Digest July: 45-48.

Dawson, C. 1956. The chemistry of poison ivy. Trans. New York Acad. Sci. II. 18: 427-443.

Duckett, S. 1980. Plantain leaf for poison ivy. New England J. Med. 303: 583.

Epstein. W. L. 1974. Poison oak and poison ivy dermatitis as an occupational problem. Cutis 13: 544-548.

Epstein, W. L. et al. 1981. Induction of persistent tolerance to urushiol in humans. J. Allergy Clin. Immunol. 68(1): 20-25.

Fisher, A. A. 1972. Treatment of rhus dermatitis with nonprescription products. J. American Med. Wom. Assoc. 27: 482-485.

Frankel, E. 1991. Poison ivy, poison oak, poison sumac, and their relatives. Boxwood Press. Pacific Gove, CA. 98 pp.

Gellin, G. A. et al. 1971. Poison ivy, poison oak, and poison sumac. Common causes of occupational dermatitis. Arch. Envron. Health 22: 280-286.

Gillis, W. T. 1971. The systematics and ecology of poison-ivy and the poison-oaks (*Toxicodendron*, Anacardiaceae). Rhodora 73: 72-159; 161-237; 370-443; 465-540.

Gillis, W. T. 1975. Poison ivy and its kin. Arnoldia 35: 93-123.

Goldstein, N. 1968. The ubiquitous urushiols -- contact dermatitis from mango, poison ivy and other "poison" plants. Cutis 4: 679-685.

Gross, M. et al. 1975. Urushiols of poisonous Anacardiaceae. Phytochemistry 14(10): 2263-2266.

Hauser, S. C. 1996. Nature's revenge: the secrets of poison ivy, poison sumac, and their remedies. Lyons & Burford. New York, NY. 111 pp.

Kligman, A. 1958. Poison ivy (rhus) dermatitis. Arch. Dermatol. 77: 149-180.

Markiewitz, K. H. & C. R. Dawson. 1965. On the isolation of the allergenically active components of the toxic principle of poison ivy. J. Organic Chemistry 30: 1610-1613.

Mitchell, J. C. 1990. The poisonous Anacardiaceae genera of the world. Adv. Econ. Bot. 8: 103-129.

National Safety Council. 1975. Poison ivy, poison oak, and poison sumac. Dat Sheet 304. National Safety News. Sept: 99-102.

Vietmeyer, N. 1985. Science has got its hands on poison ivy, oak and sumac. Smithsonian 16(5): 88-90; 92, 94, 95.

POKEWEED

Barker, B. E. et al. 1965. Mitogenic activity in *Phytolacca americana* (pokeweed). Lancet 1: 170.

Barker, B. E. et al. 1967. Haematological effects of pokeweed. Lancet 1: 437.

Kang, S. S. & W. S. Woo. 1980. Triterpenes from the berries of *Phytolacca americana*. J. Nat. Prod. 43(4): 510-513.

Kingsbury, J. M. & R. B. Hillman. 1965. Pokeweed (*Phytolacca*) poisoning in a dairy herd. Cornell Vet. 55: 534-538.

Lewis, W. H. & P. R. Smith. 1979. Poke root herbal tea poisoning. J. American Med. Assoc. 242(25): 2759, 2760.

McPherson, A. 1979. Pokeweed and other lymphocyte mitogens. In, Kinghorn, A. D. (Editor). Toxic plants. Columbia Univ. Press. New York, NY. Pp. 83-102.

Reisfield, R. et al. 1967. Isolation and characterization of a mitogen from pokeweed (*Phytolacca americana*). Proc. Natl. Acad. Sci. 58: 2020-2027.

Waxdal, M. 1974. Isolation, characterization, and biological activities of five mitogens from pokeweed. Biochem. 13: 671-677.

Woo, W. S. et al. 1978. Triterpenoid saponins from the roots of *Phytolacca americana*. Planta Medica 34: 87-92.

ARROW & DART POISONS

Bisset, N. G. 1966. The arrow and dart poisons of South-East Asia, with particular reference to the *Strychnos* species used in them. Part I. Indonesia, Borneo, Philippines, Hainan, and Indo-China. Lloydia 29: 1-13.

Bissel, N. G. 1981. Arrow poisons in China. II. *Aconitum* -- botany, chemistry, and pharmacology. J. Ethnopharm. 4: 247-336.

Bisset, N. G. 1989. Arrow and dart poisons. J. Ethnopharm. 25: 1-41.

Bisset, N. G. 1992. War and hunting poisons in the New World. Pt. 1. Notes on the early history of curare. J. Ethnopharm. 36(1): 1-26.

Bisset, N. G. & A. J. M. Leeuwenberg. 1968. The use of *Strychnos* species in Central African ordeal and arrow poisons. Lloydia 31: 208.

Bisset, N. G. & M. C. Woods. 1966. The arrow and dart poisons of South-East Asia, with particular reference to the *Strychnos* species used in them. II. Burma, Thailand and Malaya. Lloydia 29: 172-.

Blubaugh, L. V. & C. R. Lineger. 1948. Curare and modern medicine. Econ. Bot. 2: 73-82.

Bovet, D. F. Bovet-Nitti, & G. B. Marini-Bettolo. 1959. Curare and curare-like agents. Van Nostrand. Princeton, MA.

Bradley, C. E. 1956. Yerba de la fleche -- arrow and fish poison of the American Southwest. Econ. Bot. 10: 362-366.

Bryn, T. K. 1963. Curare: its history and usage. J. B. Lippincott. Philadelphia, PA.

Burnap, T. K. & D. M. Little, Jr. (Editors). 1968. The flying death. Classical papers and commentary on curare. Inter. Anesthesiology Clinics. Little, Brown, and Co. Boston, MA. 6(2): 399-739.

Cheney, R. H. 1926. The ancient and modern use of plant arrow poisons. Sci. Monthly 23: 552-555.

Cheney, R. H. 1926. Plant arrow poisons: their sources, preparation, and effects. J. New York Bot. Gard. 27: 174-177.

Cheney, R. H. 1931. Geographic and taxonomic distribution of American plant arrow poisons. American J. Bot. 18: 136-145.

Kopp, B. et al. 1992. Analysis of some Malaysian dart poisons. J. Ethnopharm. 36(1): 57-62.

Krukoff, B. A. 1937. Notes on the botanical components of curare. Bull. Torrey Bot. Club 64: 401-409.

Krukoff, B. A. & H. N. Moldenke. 1938. Studies of American Menispermaceae, with special reference to species used in the preparation of arrow poisons. Brittonia 3: 1-74 + suppl. 1-5.

Maitai, C. K. et al. 1973. A survey on the use of poisoned arrows in Kenya during the period 1964-1971. East African Med. J. 50: 100-104.

Reuck, A. V. S. de (editor). 1962. Curare and curare-like agents. Ciba Found. Study Group No. 12. Little, Brown and Co. Boston, MA. 103 pp.

Thomas, K. B. 1963. Curare: its history and usage. J. B. Lippincott Co. Philadelphia, PA. 144 pp.

Vellard, J. 1965. Historie du curare. Gallimard. Paris, France.

FISH POISONS

Acevedo-Rodriquez, P. 1990. The occurrence of piscides and stupefactans in the plant kingdom. Adv. Econ. Bot. 8: 1-23.

Bradley, C. E. 1956. Yerba de la fleche -- arrow and fish poisons of the American Southwest. Econ. Bot. 10: 362-366.

Brandt, A. von. 1972. Fish catching methods of the world. Fishing News (Books), Ltd. London, England. Pp. 22-25.

Heizer, R. F. 1941. The use of plants for fish poisoning by the California Indians. Leaflts. Western Bot. 3(2): 43, 44.

Heizer, R. F. 1949. Fish poisons. In, Stewart, J. H. (Editor). Handbook of South American Indians. The comparative ethnology of South American Indians. Smithsonian Institution Bureau of American Ethnology. Bulletin 143. 5: 565-586.

Heizer, R. F. 1953. Aboriginal fish poisons. Bureau of American Ethnology. Bull. 151. Anthropological Papers, No. 38. Pp. 225-283.

Higbee, E. C. 1947. *Lonchocarpus* -- a fish poison insecticide. Econ. Bot. 1: 427-436.

Howes, F. N. 1930. Fish-poison plants. Kew Bull. Misc. Inform. 4: 129-153.

Kamen-Kaye, D. 1977. Ichthyotoxic plants and the term "barbasco." Bot. Mus. Leaflts. Harvard Univ. 25: 71-90.

Killip, E. P. & A. C. Smith. 1931. The use of fish poisons in South America. Ann. Rep. Smithsonian Inst., 1930. Washington, D. C. Pp. 401-408.

McFarland, J. W. 1951. Poisonous plants used for fishing. Yosemite Nature Notes 30: 14-21.

Neuwinger, H. D. 1994. Fish poisoning plants in Africa. Bot. Acta 107: 264-270.

Nishimoto, S. K. 1969. Plants used as fish poisons. Newsletter Hawaiian Bot. Soc. 8: 20-23.

Pal, D. C. & A. M. Saren. 1986. Some plants used by tribes of India for poisoning/stupefying fishes. J. Econ. Tax. Bot. 8: 13-16.

Pennington, C. W. 1957. Tarahumar fish stupefaction plants. Econ. Bot. 12(1): 95-102.

Quigley, C. 1956. Aboriginal fish poisons and the diffusion problem. American Anthrop. 58: 508-525.

Rickard, P. & P. A. Cox. 1986. Use of *Derris* as a fish poison in the Solomon Islands. Econ. Bot. 40: 479-484.

Stokes, J. F. G. 1921. Fish-poisoning in the Hawaiian Islands with notes on the custom in southern Polynesia. Occas. Pap. Bernice P. Bishop Mus. 7(10): 219-236.

Wilhelm, G. 1974. The mullein: plant piscicide of the mountain folk culture. Geogr. Rev. April: 235-252.

INSECT POISONS

Arnason, J. T. et al. 1989. Insecticides of plant origin. American Chem. Soc. Washington, D. C. 213 pp.

Barnes, D. K. & R. H. Freyre. 1966. Recovery of natural insecticides from *Tephrosia vogelii*. II. Toxicological properties of rotenoids extracted from fresh and oven-dried leaves. Econ. Bot. 20(4): 368-371.

Casida, J. E. & G. B. Quistad. 1995. Pyrethrum flowers: production, chemistry, toxicology, and uses. Oxford Univ. Press. New York, NY. 350 pp.

Crosby, B. G. 1971. Minor insecticides of plant origin. In, Jacobson, M. & D. G. Crosby. Naturally occurring insecticides. Marcel Dekker. New York, NY. Pp. 177-239.

Duffey, S. S. 1980. Sequestration of plant natural-products by insects. Ann. Rev. Entom. 25: 447-477.

Grainge, M. & S. Ahmed. 1988. Handbook of plants with pest-control properties. John Wiley & Sons. New York, NY.

Higbee, E. C. 1947. *Lonchocarpus* -- a fish poison insecticide. Econ. Bot. 1: 427-436.

Isman, M. B. 1994. Botanical insecticides. Pesticide Outlook 5: 26-31.

Jacobson, M. 1958. Insecticides from plants. A review of the literature, 1941-1953. Agric. Handbook No. 154. U. S. Dept. Agric. Washington, D. C. 299 pp.

Jacobson, M. 1975. Insecticides from plants. A review of the literature, 1954-1971. U. S. Dept. Agric. Washington, D. C. 138 pp.

Jacobson, M. & D. G. Crosby (editors). 1971. Naturally occurring insecticides. Marcel Dekker. New York, NY.

Klocke, J. A. 1989. Plant compounds as sources and models of insect-control agents. Econ. Med. Plant Res. 3: 104-144.

Lydon, J. & S. O. Duke. 1989. The potential of pesticides from plants. In, Craker & Simon, Pp. 1-41.

Metcalf, R. L. 1977. Plant derivatives for insect control. In, Seigler, D. S. (Editor). Crop resources. Academic Press. New York, NY. Pp. 165-177.

Nathanson, J. A. 1984. Caffeine and related methylxanthines: possible naturally occurring pesticides. Science 226: 184-187.

Run, P. J. van. 1974. The production of pyrethrum. Trop. Abstr. 29: 237-244.

ORDEAL POISONS

Bisset, N. G. & J. M. Leeuwenberg. 1968. The use of *Strychnos* in Central African ordeal and arrow poisons. Lloydia 31: 208.

Holmstedt, B. 1972. The ordeal bean of Old Calabar. In, Swain, T. (editor). Plants in the development of modern medicine. Harvard Univ. Press. Cambridge, MA. 303-360.

Marwick, M. G. 1963. A note on ordeal poisoning in east central Africa. Man 63: 45, 46.

Robb, G. L. 1957. The ordeal poisons of Madagascar and Africa. Bot. Mus. Leaflts. Harvard Univ. 17: 265-316.

10 • MEDICINAL PLANTS

GENERAL REFERENCES

Aikman, L. 1974. Nature's gifts to medicine. National Geographic 146: 420-440.

Aikman, L. 1977. Nature's healing arts: from folk medicine to modern drugs. National Geographic Society. 199 pp.

Akerele, O. 1990. Medicinal plants in traditional medicine. Econ. Med. Plant Res. 4: 5-16.

Akerele, O. 1993. Guidelines for the assessment of herbal medicines. HerbalGram 28: 17-20.

Akerele, O. V. Heywood, & H. Synge. 1991. Conservation of medicinal plants. Cambridge Univ. Press. Cambridge, England. 362 pp.

Altschul, S. von R. 1973. Drugs and foods from little-known plants. Harvard Univ. Press. Cambridge, MA. 366 pp.

American Botanical Council. 2000. HerbClip on CD-ROM '96-'99.

Anderson, F. J. 1977. An illustrated history of the herbals. Columbia Univ. Press. 270 pp.

Andoh, A. 1986. The science and romance of selected herbs used in medicine and religious ceremonies. The North Scale Institute. San Francisco, CA. 324 pp.

Artuso, A. 1997. Drugs of natural origin. Pharmaceutical Products Press. New York, NY. 201 pp.

Astin, J. A. 1998. Why patients use alternative medicine: results of a national study. J. American Med. Assoc. 279: 1548-1553.

Ayensu, E. 1981. A worldwide role for the healing power of plants. Smithsonian 12(8): 87-97.

Bakhiet, A. O. & S. E. I. Adam. 1995. Therapeutic utility, constituents and toxicity of some medicinal plants: a review. Vet. Human Toxicol. 37(3): 255-258.

Balandrin, M. F., A. D. Kinghorn, & N. R. Farnsworth. 1993. Plant-derived natural products in drug discovery and development: an overview. In, Kinghorn, A. D. & M. F. Balandrin (Editors). Human medicinal agents from plants. Pp. 2-12.

Balick, M. J. 1990. Ethnobotany and the identification of therapeutic agents from the rainforest. Ciba Found. Symp. 154: 22-39.

Balick, M. J. & R. O. Mendelsohn. 1992. Assessing the economic value of traditional medicines from tropical rain forests. Conservation Biol. 6(1): 128-130.

Balick, M. J. et al. 1996. Medicinal resources of the tropical forest: biodiversity and its importance to human health. Columbia Univ. Press. New York, NY. 464 pp.

Bartram, T. 1995. Encyclopedia of herbal medicine. British Herbal Medical Assoc. Bournemouth, England.

Bianchini, F. & F. Corbetta. 1975. Health plants of the world. Atlas of medicinal plants. Newsweek Books. 242 pp.

Bingel, A. S. & H. S. Fong. 1988. Potential fertility-regulating agents from plants. Econ. Med. Plant Res. 2: 73-118.

Bisset, N. G. 1991. One man's poison another man's medicine? J. Ethnopharm. 32(1-3): 71-81.

Bisset, N. G. & M. Wichtl. 2001. Herbal drugs and phytopharmaceuticals. CRC Press. Boca Raton, FL. 565 pp.

Blumenthal, M. (senior editor). 1998. The complete German Commission E monographs: therapeutic guide to herbal medicines. American Bot. Council. Austin, TX. 684 pp.

Blumenthal, M. 1999. Herb market levels after five years of boom...: bad publicity, unreasonable consumer expectations cited as possible reasons. HerbalGram 47: 64, 65.

Blumenthal, M. 1999. Medical journals report on herbal and alternative medicine: articles in AMA journals contrast with NEJM. HerbalGram 46: 29-34; 51, 52.

Blumenthal, M. 2001. Herb sales down 15 percent in mainstream market. HerbalGram 51: 69.

Blumenthal, M., A. Goldberg, & J. Brinckmann. 2000. Herbal medicine: expanded Commission E monographs. American Botanical Council. Austin, TX. 519 pp.

Blunt, W. & S. Raphael. 1979. The illustrated herbal. Thames & Hudson. 191 pp.

Bone, K. 2001. Standardized extracts: neither poison nor panacea. HerbalGram 53: 50-55.

Boom, B. 1990. Giving native people a share of the profits. Garden 14(6): 28-31.

Boyle, W. 1991. Official herbs: botanical substances in the United States pharmacopoeias. Buckeye Naturopathic Press. East Palestine, OH.

Brendler, T. et al. 1997. Herbal remedies. Second edition. CD-ROM. CRC Press. Boca Raton, FL.

Brinker, F. 1998. The role of botanical medicine in 100 years of American naturopathy. HerbalGram 42: 49-59.

Brinker, F. 1999. Variations in effective botanical products -- the case for diversity of forms for herbal preparations as supported by scientific studies. HerbalGram 46: 36-50.

Broadhurst, C. L. 2000. How do plants help prevent cancer? Herbs for Health 4(6): 56-60.

Brown, D. J. 1996. Herbal prescriptions for better health. Prima Publ. Rocklin, CA 349 pp.

Bruneton, J. 1999. Pharmacognosy: phytochemistry - medicinal plants. Second edition. Intercept Ltd. Andover, England. 1119 pp.

Buckle, J. 2003. Aromatherapy: what is it? HerbalGram 57: 50-56.

Cammarata, J. 1996. A physician's guide to herbal wellness. Chicago Review Press. Chicago, IL. 172 pp.

Castleman, M. 2001. The new healing herbs. Rodale Press. Emmaus, PA . 465 pp.

Chevallier, A. 1996. The encyclopedia of medicinal plants: a practical reference guide to more than 550 key medicinal plants and their uses. Dorling Kindersley. London, England. 336 pp.

Collins, M. 2000. Medieval herbals: the illustrative traditions. The British Library and Univ. Toronto Press. 334 pp.

Cox, P. A. 1995. Shaman as scientist: indigenous knowledge systems in pharmacological research and conservation. In, Hostettmann et al. Pp. 1-15.

Cox, P. A. & M. J. Balick. 1994. The ethnobotanical approach to drug discovery. Sci. American 269(12): 82-87.

Cragg, G. M. & D. J. Newman. 2002. Drugs from nature: past achievements, future prospects. Adv. Phytomedicine 1: 23-37.

Crawford, A. M. 1997. Herbal remedies for women. Prima. Rocklin, CA. 291 pp.

Crellin, J. K. & J. Philpott. 1990. Herbal medicine past and present. Vol. II. A reference guide to medicinal plants. Duke Univ. Press. Durham, NC. 549 pp.

Croom, E. M. 1983. Documenting and evaluating herbal remedies. Econ. Bot. 37: 13-27.

Culpeper, N. 1653. The English physician enlarged. George Sawbridge. London, England.

Der Marderosian, A. 1991. The need for cooperation between modern and traditional medicine. HerbalGram 24: 30-37.

Der Marderosian, A. & L. Liberti. 1988. Natural product medicine: a scientific guide to foods, drugs, cosmetics. G. F. Stickley Co. Philadelphia, PA. 388 pp.

Der Marderosian, A., V. E. Tyler, & M. Blumenthal. 1996. Milestones of pharmaceutical botany. Pharmacy in History 38: 15-28.

De Smet, P. A. G. M. 1997. The role of plant-derived drugs and herbal medicines in health care. Drugs 54: 801-840.

Duke, J. A. 1983. Medicinal plants of the Bible. Trado-Medic Books. Division of Conch Magazine, Ltd. 233 pp.

Duke, J. A. 1985. CRC handbook of medicinal herbs. CRC Press. Boca Raton, FL. 696 pp.

Duke, J. A. 1992. Handbook of biologically active phytochemicals and their activities. CRC Press. Boca Raton, FL. 183 Pp.

Duke, J. A. 1997. A guide to herbal alternatives: botanical options for treating 50 common ailments. Herbs for Health 2(5): 45-48.

Duke, J. A. 1999. Herbs of the Bible: two millennia of healing wisdom. Herbs for Health 4(5): 38-41.

Duke, J. A. 2000. Nature's medicine: the green pharmacy. Mother Earth News 177: 22-33.

Duke, J. A. 2002. Handbook of medicinal herbs. Second edition. CRC Press. Boca Raton, FL. 870 pp.

Duke, J. A. 2002. CRC handbook of medicinal spices. CRC Press. Boca Raton, FL. 348 pp.

Duke, J. A. & J. D. McChesney. 1992. New medicines from old crops. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 183-188.

Ebadi, M. 2001. Pharmacodynamic basis of herbal medicine. CRC Press. Boca Raton, FL. 726 pp.

Editors of Pharmacist's Letter and Prescriber's Letter. 2000. Natural medicines comprehensive database. 1310 pp.

Eisenberg, D. M. et al. 1993. Unconventional medicine in the United States. New England J. Med. 328: 246-252.

Eisenberg, D. M. et al. 1998. Trends in alternative medicine use in the United States, 1990-1997. J. American Med. Assoc. 280(18): 1569-1575.

Farnsworth, N. R. et al. 1975. Potential value of plants as sources of new antifertility agents. J. Pharm. Sci. 64: 535-598; 171-754.

Farnsworth, N. R. & R. W. Morris. 1976. Higher plants -- the sleeping giant of drug development. American J. Pharm. 148:46-52.

Farnsworth, N. R. & C. J. Kass. 1981. An approach utilizing information from traditional medicine to identify tumor-inhibiting plants. J. Ethnopharm. 3: 85-99.

Farnsworth, N. R. et al. 1985. Medicinal plants in therapy. Bull. World Health Organ. 63(6): 965-981.

Farnsworth, N. R. 1993. Ethnopharmacology and future drug development: the North American experience. J. Ethnopharm. 18(2-3): 145-152.

Fetrow, C. W. & J. R. Avila. 2000. The complete guide to herbal medicines. Springhouse Corp. Springhouse, PA. 618 pp.

Fleming, T. (editor). 2000. PDR for herbal medicines. Medical Eco-nomics Co. Montvale, NJ. 858 pp.

Flynn, R. & M. Roest. 1995. Your guide to standardized herbal products. One World Press. Prescott, AZ. 100 pp.

Foster, S. 1994. Herbal renaissance. Gibbs-Smith. Salt Lake City, UT. 234 pp.

Foster, S. 1995. Drug discovery and commercial opportunities in medicinal plants. HerbalGram 33: 52-54.

Foster, S. 1996. Herbs for your health. Unicorn Books. Petaluma, CA. 121 Pp.

Foster, S. 2000. Healing resins. Herbs for Health 5(5): 46-50.

Foster, S. & V. E. Tyler. 1999. Tyler's honest herbal: a sensible guide to the use of herbs and related remedies. Fourth edition. Haworth Herbal Press. New York, NY. 442 pp.

Gerard, J. 1597. The herball or generall historie of plantes. John North. London, England. 1392 pp.

Gold, J. & W. Gates. 1980. Herbal abortifacients. J. American Med. Assoc. 243: 1365, 1366.

Goldberg, A. et al. (Editors). 1997. American Herbal Products Association's botanical safety handbook. CRC Press. Boca Raton, FL. 256 pp.

Gorman, C. 1998. Is it good medicine? Time 152(21): 68, 69.

Greenwald, J. 1998. Herbal healing. Time 152(21): 58-67.

Grieve, M. 1959. A modern herbal. Two vols. Hafner Publ. Co. 888 pp.

Griggs, B. 1981. Green pharmacy, a history of herbal medicine. Viking Press. 379 pp.

Grover, N. 1965. Man and plants against pain. Econ. Bot. 19(2): 99-112.

Grünwald, J. 1995. The European phytomedicines market: figures, trends, analyses. HerbalGram 34: 60-66.

Hansen, H. A. 1978. The witch's garden. Unity Press. 128 pp.

Hartnell, J. L. 1984. Plants used against cancer. Quarterman Publ. Lawrence, MA. 710 pp.

Hedberg, I. 1993. Botanical methods in ethnopharmacology and the need for conservation of medicinal plants. J. Ethnopharm. 38(2/3): 121-128.

Hobbs, C. 1997. Medicinal mushrooms. Herbs for Health 1(4): 52, 53.

Hobbs, C. 1998. Herbal remedies for dummies. IDG Books. Foster City, CA. 352 pp.

Hoffmann, D. 1993. An elder's herbal: natural techniques for promoting health & vitality. Healing Arts Press. Rochester, VT. 266 pp.

Hoffmann, D. (editor). 1994. The information sourcebook of herbal medicine. Crossing Press. Freedom, CA.

Holland, B. K. 1994. Prospecting for drugs in ancient texts. Nature 369: 702.

Holmstedt, B. & J. G. Bruhn. 1983. Ethnopharmacology -- a challenge. J. Ethnopharm. 8: 251-256.

Hultkrantz, A. 1993. Interaction between native and Euroamerican curing methods. Shaman's Drum 31: 23-26.

Iwu, M. M. & J. C. Wootton (editors). 2002. Ethnomedicine and drug discovery. Adv. Phytomedicine 1: 1-330.

Jellin, J. M. (editor). 1999. Natural remedies – comprehensive database. Second edition. Therapeutic Rsearch Faculty. Stockton, CA. 1310 pp. See also: http://www.naturalDatabase.com

Johnson, B. A. 1997. One-third of nation's adults use herbal remedies. HerbalGram 40: 49.

Joyce, C. 1994. Earthly goods: medicine-hunting in the rainforest. Little, Brown & Co. Boston, MA. 304 pp.

Karch, S. B. 1999. The consumer's guide to herbal medicine. Advanced Research Press. Hauppauge, NY. 240 pp.

King, S. R. et al. 1999. Issues in the commercialization of medicinal plants. HerbalGram 47: 46-51.

Kinghorn, A. D. & M. F. Balandrin. 1993. Human medicinal agents from plants. American Chem. Soc. Washington, D. C. 356 pp.

Kiple, K. F. (editor). 1997. Plague, pox & pestilence. Barnes & Noble Books. New York, NY. 176 pp.

Kreig, M. B. 1964. Green medicine -- the search for plants that heal. Rand McNally Co. 462 pp.

Krutch, J. W. 1976. Herbal. Putnam. New York, NY. 255 pp.

Ladadie, R. P. 1986. Problems and possibilities in the use of traditional drugs. J. Ethnopharm. 15: 221-230.

Lambert, J. J. Srivastava, & N. Vietmeyer. 1997. Medicinal plants: rescuing a global heritage. World Bank Tech. Paper No. 355. Washington, D. C. 61 pp.

Lane, T. (Editor). 1997. Foods that harm and foods that heal: an A - Z guide to safe and healthy eating. Reader's Digest Assoc. Pleasantville, NY. 400 pp.

Lawless, J. 1995. The illustrated encyclopedia of essential oils: the complete guide to the use of oils in aromatherapy and herbalism. Element Books. Shaftesbury, England. 256 pp.

Lehane, B. 1977. The power of plants. McGraw-Hill Book Co. 288 pp.

Le Strange, R. 1977. A history of herbal plants. Arco Publ. Co. 304 pp.

Lewis, W. H. 2000. Ethnopharmacology and the search for new therapeutics. In, Minnis, P. E. & W. J. Elisens (editors). Biodiversity and Native America. Univ. Oklahoma Press. Norman. Pp. 74-96.

Lewis, W. H. 2003. Pharmaceutical discoveries based on ethnobotanical plants: 1985 to 2000 and beyond. Econ. Bot. 57(1): 126-134.

Lewis, W. H. & M. P. F. Elvin-Lewis. 1977. Medical botany: plants affecting man's health. John Wiley & Sons. New York, NY. 515 pp.

Lewis, W. H. & M. P. F. Elvin-Lewis. 1995. Medicinal plants as sources of new therapeutics. Ann. Missouri Bot. Gard. 82(1): 16-24.

Lipp, F. J. 1989. Methods for ethnophamacological field work. J. Ethnopharm. 25: 139-150.

Malo, N. N. & R. Roy. 1996. Do medicinal plants have a place in today's medicine? Global Biodiversity 6(3): 16-18.

Mann, J. 2000. Murder, magic, and medicine. Second edition. Oxford Univ. Press. Oxford, England.

Marini-Bettolo, G. B. 1980. Traditional medicine: a world survey on medicinal plants and herbs. J. Ethnopharm. 2: 1-196.

Marles, R. J. & N. R. Farnsworth. 1994. Plants as sources of antidiabetic agents. Econ. Med. Plt. Res. 6: 149-187.

Mars, B. 1997. Herbal teas: health in a cup. Herbs for Health 2(5): 32-37.

Marwick, C. 1995. Growing use of medicinal botanicals forces assessment by drug regulators. J. American Med. Assoc. 273: 607-609.

Mathias, M. E. 1994. Magic, myth and medicine. Econ. Bot. 48(1): 3-7.

McCaleb, R. S., E. Leigh, & K. Morien. 2000. The encylopedia of popular herbs: your complete guide to the leading medicinal plants. Prima Publ. Roseville, CA. 451 pp.

McChesney, J. D. et al. 1992. Plants and plant products as sources of pharmaceuticals. In, 1992 yearbook of agriculture. U. S. Gov. Print. Office. Washington, D. C. Pp. 134-141.

McDonald, J. A. 1995. Medicinal plant exploraation – past and present. Arnoldia 55(2): 3-11.

McGuffin, M., C. Hobbs, R. Upton, & A. Goldberg (editors). 1997. American Herbal Products Association's botanical safety handbook. CRC Press. Boca Raton, FL. 231 pp.

McIntyre, A. 1995. The complete woman's herbal. Henry Holt. New York, NY. 287 pp.

McKenna, D. J., K. Hughes, & K. Jones. 2002. Botanical medicines: the desk reference for major herbal supple-ment. Second edition. Haworth Press. Binghampton, NY.

Meares, P. 1987. The economic significance of herbs. HerbalGram 13: 1, 6-8.

Meyer, G. G. et al (editors). 1981. Folk medicine and herbal healing. C. C. Thomas. Springfield, IL.

Miller, A. 1998. Botanical influences on cardiovascular disease. Alternative Medicine Review 3(6): 422-431.

Mills, S. Y. 1992. Out of the earth. The essential book of herbal medicine. Viking Arkana. Middlesex, England. 677 pp.

Moerman, D. E.., R. W. Pemberton, D. Kiefer, & B. Berlin. 1999. A comparative analysis of five medicinal floras. J. Ethnobiol. 19: 49-67.

Mors, W. B. 1991. Plants active against snake bite. Econ. Med. Plant Res. 5: 353-373.

Morton, J. F. 1977. Major medicinal plants: botany, culture, and use. C. C. Thomas. Philadelphia, PA. 431 pp.

Mowrey, D. B. 1986. The scientific validation of herbal medicine. Keats Publ. New Canaan, CT. 316 pp.

Murray, M. T. 1995. The healing power of herbs: the enlightened person's guide to the wonders of medicinal plants. Second edition. Prima Publ. Rocklin, CA. 410 pp.

Newall, C. A. et al. (editors). 1998. Herbal medicines: a guide for health-care professionals. Pharmaceutical Press. London, England. 296 pp.

Ody, P. 1993. The complete medicinal herbal: a practical guide to the healing properties of herbs, with more than 250 remedies from common ailments. Dorling Kindersley. London, England. 192 pp.

O'Hara, M. A. et al. 1998. A review of 12 commonly used medicinal herbs. Arch. Fam. Med. 7: 523-536.

Okuda, T. et al. 1991. Chemistry and biological activity of tannins in medicinal plants. Econ. Med. Plant Res. 5: 130-165.

O'Neill, M. J. & J. A. Lewis. 1993. The renaissance of plant research in the pharmaceutical industry. In, Kinghorn, A. D. & M. F. Balandrin (editors). Human medicinal agents from plants. Pp. 48-55.

Owen, D. J. 2001. The herbal internet companion: herbs and herbal medicine online. Haworth Press. New York, NY. 194 pp.

Parkinson, J. 1640. The theater of plants -- an universal and compleate herbal. Cotes. London, England.

Pasquale, A. de. 1984. Pharmacognosy, the oldest modern science. J. Ethnopharm. 11: 1-16.

Pendell, D. 1995. Pharmako/poeia: plant powers, poisons, and herbcraft. Mercury House. San Francisco, CA. 287 pp.

Pendergast, W. R. 1995. FDA and the herbal industry: problems, antagonisms and a possible solution. HerbalGram 33: 23-27.

Penso, G. 1980. The role of WHO in the selection and characterization of medicinal plants (vegetable drugs). J. Ethnopharm. 2: 183-188.

Perdue, R. E., Jr. & J. L. Hartwell. 1976. Plants and cancer. Cancer Treatment Reports 60:973-1215.

Phillipson, J. D. 1984. Herbal preparations used in sedative and antirheumatic preparations. Pharm. J. 233: 80-82; 111-115.

Phillipson, J. D. 1984. Pharmacologically active compounds in herbal remedies. Pharm. J. 232: 41-44.

Phillipson, J. D. & L. A. Anderson. 1989. Ethnopharmacology and western medicine. J. Ethnopharm. 25: 61-72.

Pisha, E. & J. M. Pezzuto. 1994. Fruits and vegetables containing compounds that demonstrate pharmacological activity in humans. Econ. Med. Plant Res. 6: 189-233.

Plotkin, M. J. 2000. Medicine quest: in search of nature's healing secrets. Viking Press. New York, NY. 224 pp.

Porter, R. & M. Reich. 1995. Drugs and narcotics in history. Cambridge Univ. Press. 227 pp.

Prance, G. T., D. Chadwick, & J. Marsh. 1994. Ethnobotany and the search for new drugs. John Wiley & Sons. Chichester, England. 280 pp.

Prendergast, H. D. V. et al. (editors). 1998. Plants for food and medicine. Royal Botanic Gardens. Kew, England. 438 pp.

Principe, P. P. 1989. The economic significance of plants and their constituents as drugs. Econ. Med. Plant Res. 3: 1-17.

Raffauf, R. F. 1996. Plant alkaloids: a guide to their discovery and distribution. Food Products Press. New York, NY. 279 pp.

Reader's Digest. 1986. Magic and medicine of plants. Reader's Digest Assoc. 464 pp.

Riddle, J. M. 1985. Dioscorides on pharmacy and medicine. Univ. Texas Press. Austin. 298 pp.

Riddle, J. M. 1997. Eve's herbs: a history of contraception and abortion in the West. Harvard Univ. Press. Cambridge, MA.

Roach, M. 1993. Secrets of the shamans. Discover 14(11): 58-65.

Robbers, J. E. & V. E. Tyler. 1999. Tyler's herbs of choice: the therapeutic use of phytochemicals. Revised edition. Hawworth Press. New York, NY.

Robbers, J. E., M. K. Speedie, & V. E. Tyler. 1996. Pharmacognosy and pharmaco-biotechnology. Williams & Wilkins. Baltimore, MD. 337 Pp.

Ross, I. A. 2003. Medicinal plants of the world: chemical constituents, traditional and modern medicinal uses. Second edition. Humana Press. Totowa, NJ. 487 pp.

Ross, I. A. 2001. Medicinal plants of the world. Vol. 2. Humana Press. Totowa, NJ. 487 pp.

Saxe, T. G. 1987. Toxicity of medicinal herbal preparations. Amer. Fam. Phys. 35: 135-142.

Scarborough, J. 1978. Theophrastus on herbals and herbal remedies. J. Hist. Biol. 11: 353-386.

Scarborough, J. 1991. Introduction to folklore and folk medicines. HerbalGram No. 24: 24-29.

Schauenberg, P. & F. Paris. 1974. Guide to medicinal plants. Lutterworth Press. 349 pp.

Schultes, R. E. 1962. The role of the ethnobotanist in the search for new medicine plants. Lloydia 25: 257-266.

Schultes, R. E. 1963. Widening panorama in medical botany. Rhodora 65: 97-120.

Schultes, R. E. 1968. The plant kingdom and modern medicine. Herbalist No. 38: 18-26.

Schultes, R. E. 1983. From ancient plants to modern medicine. Yearbook of science and the future, 1984. Encyclopedia Brittanica. Chicago, IL. Pp. 172-187.

Schultes, R. E. 1987. Ethnopharmacological conservation: a key to progress in medicine. Opera Bot. 92: 217-224.

Schulz, V. et al. 1998. Rational phytotherapy: a physician's guide to herbal medicine. Third edition. Springer-Verlag. 306 pp.

Seidman, B. F. 2000. Medicine wars: will alternative and mainstream medicine ever be friends? Skeptical Inquirer 25(1): 28-35.

Shamon, L. A. & J. M. Pezzuto. 1994. Plant anti-mutagens: a review and strategy for the identification of therapeutically useful agents. Econ. Med. Plant Res. 6: 235-297.

Sheldon, J., M. Balick, & S. Laird. 1997. Medicinal plants: can utilization and conservation coexist? New York Bot. Gard. Bronx, NY. 104 pp.

Skidmore-Roth, L. 2004 [2003]. Mosby's handbook of herbs & natural supplements. Second edition. Mosby. St. Louis, MO. 1073 pp.

Soejarto, D. D. et al. 1978. Fertility regulating agents from plants. Bull. World Health Organ. 56: 343-352.

Souza Brito, A. R. M. 1996. How to study the pharmacology of medicinal plants in underdeveloped countries. J. Ethnopharm. 54: 131-138.

Spinella, M. 2000. Psychoactive herbal medications: how do we know they work? Skeptical Inquirer 25(1): 43-49.

Spinella, M. 2001. The psychopharmacology of herbal medicine. MIT Press. Cambridge, MA. 578 pp.

Spoerke, D. G., Jr. 1980. Herbal medications: a practical, descriptive guidebook to the active principles of more than 200 medicinal herbs. Woodbridge Press Publ. Co. 192 pp.

Stannard, J. 1969. The herbal as a medical document. Bull. Hist. Med. 43: 212-220.

Stannard, J. 1985. The theoretical bases of medieval herbalism. Medical Heritage 1: 186-198.

Stepp, J. R. & D. E. Moerman. 2001. The importance of weeds in ethnopharmacology. J. Ethnopharmacol. 75(1): 19-23.

Stern, W. L. 1974. The bond between botany and medicine. Bull. Pacific Trop. Bot. Gard. 4(3): 41-60.

Stuart, M. 1979. The encyclopedia of herbs and herbalism. Crescent Books. 304 pp.

Sullivan, G. 1981. Herbs available to the public. In, Meyer, G. G. et al (Editors). Folk medicine and herbal healing. C. C. Thomas. Springfield, IL. Pp. 179-196.

Sumner, J. 2000. The natural history of medicinal plants. Timber Press. Portland, OR. 252 pp.

Swain, T. (editor). 1972. Plants in the development of modern medicine. Harvard Univ. Press. Cambridge, MA. 367 pp.

Swerdlow, J. L. 2000. Nature's medicines: plants that heal. A chronicle of mankind's search for healing plants through the ages. National Geographic Soc. Washington, D. C. 400 pp.

Swerdlow, J. L. 2000. Nature's Rx. Natl. Geogr. 197(4): 98-117.

Taylor, N. S. 1965. Plant drugs that changed the world. Dodd, Mead & Co. 275 pp.

Thomson, W. A. R. 1978. Medicines from the earth: a guide to healing plants. McGraw-Hill Book Co. 208 pp.

Tilford, G. L. 1998. An earth-conscious guide to medicinal plants. Mountain Press Publ. Missoula, MT. 249 pp.

Tomlinson, T. R. & O. Akerele (editors). 1998. Medicinal plants: their role in health and biodiversity. Univ. Pennsylvania Press. Philadelphia. 221 pp.

Torkelson, A. R. 1995. The cross name index to medicinal plants. Three vols. CRC Press. Boca Raton, FL.

Turner, W. 1568. New herball. Arnold Birckman. Cologne, Germany.

Tyler, V. E. 1987. Plant drugs in the twenty-first century. HerbalGram No. 11: 6-11.

Tyler, V. E. 1993. Natural products and medicine. HerbalGram No. 28: 40-45.

Tyler, V. E. 1993. The honest herbal: a sensible guide to herbs and related remedies. Third edition. Pharmaceutical Prod. Press. New York, NY. 375 pp.

Tyler, V. E. 1994. Herbs of choice: the therapeutic use of phytomedicinals. Haworth Press. New York, NY. 209 pp.

Tyler, V. E. 1995. Plant drugs, healing herbs, and phytomedicinals. HerbalGram 33: 33--46.

Tyler, V. E. 1996. "Pharmacognosy"! What's that? You spell it how? Econ. Bot. 50(1): 3-9.

Tyler, V. E. 1996. What pharmacists should know about herbal remedies. J. American Pharm. Assoc. 36: 29-37.

Tyler, V. E. 2002. Herbal medicine at the cross-roads: the challenge of the 21st century. HerbalGram 54: 52-61.

Wagner, H. & P. Wolff. 1977. New natural products and plant drugs with pharmacological, biological or therapeutical activity. Springer-Verlag. New York, NY. 286 pp.

Waller, D. P. 1993. Methods in ethnopharmacology. J. Ethnopharm. 38(2/3): 189-195.

Weert, C. J. de, H. P. R. Bootsma, & H. Hendriks. 1996. Herbal medicines in migraine prevention. Phytomedicine 3: 225-230.

Weil, A. 1989. A new look at botanical medicine. Whole Earth Review 64: 54-61.

Weiner, M. A. 1984. The people's herbal. Putnam Publ. Co. New York, NY. 307 pp.

Weiner, M. A. 1992. The herbal bible. Quantum Books. San Rafael, CA. 307 pp.

Weiner, M. A. & J. A. Weiner. 1994. Herbs that heal: prescription for herbal healing. Quantum Books. Mill Valley, CA. 436 pp.

Weiss, R. F. & V. Fintelmann. 2000. Herbal medicine. Second edition. Thieme Publ. New York, NY. 438 pp.

White, L. B. & S. Foster. 2000. The herbal drugstore. Rodale. 610 pp.

Winslow, L. C. & D. J. Kroll. 1998. Herbs as medicines. Arch. Int. Med. 158(20): 2192-2199.

Wong, A. H. C. et al. 1998. Herbal remedies in psychiatric practice. Arch. Gen. Psychiatry 55: 1033-1044.

World Health Organization. 1999. WHO monographs on selected medicinal plants. Vol. 1. World Heath Organization. Geneva, Switzerland. 289 pp.

Wren, R. C. 1988. Potter's new cyclopaedia of botanical drugs and preparations. Revised by E. M. Williamson & F. J. Evans. C. W. Daniel Co. Essex, England. 362 pp.

RISKS ASSOCIATED WITH USE

Allen, J. M. 2000. Herbal medicines and dietary supplements: a risky health gamble. Skeptical Inquirer 25(1): 36-42.

Angell, M. & J. P. Kassirer. 1998. Alternative medicine: the risks of untested and unregulated remedies [editorial]. New England J. Med. 339(12): 839-841.

Anonymous. 1995. Herbal roulette. Consumer Reports 60 (11): 698-705.

Blumenthal, M. 1999. Medical journals report on herbal and alternative medicine: articles in AMA journals contrast with NEJM. Herbal-Gram 46: 29-34; 51, 52.

Blumenthal, M. 2000. Interactions between herbs and conventional drugs: introductory considerations. HerbalGram 49: 52-63.

Brinker, F. 2000. The toxicology of botanical medicines. Third edition. Electric Medical Publ. Sandy, OR. 296 pp.

Der Marderosian, A. 1977. Medicinal teas -- boon or bane? Drug Therapy Feb:178-186.

DeSmet, P. A. G. M. 1991. Is there any danger in using traditional remedies. J. Ethnopharm. 32(1-3): 43-50.

De Smet, P. A. G. M. 1992-1997. Adverse reactions to herbal drugs. Three vols. Springer-Verlag. New York, NY.

Ernest, E. 1998. Harmless herbs? A review of the recent literature. American J. Med. 104: 170-178.

Goldfrank, L. et al. 1982. The pernicious panacea: herbal medicine. Hosp. Physician Oct: 64-75.

Jonas, W. B. 1998. Alternative medicine – learning from the past, examining the present, advancing the future [editorial]. J. American Med. Assoc. 280(18): 1616-1618.

Larkin, T. 1983. Herbs are often more toxic than medical. FDA Consumer. Oct: 5-10. [Lists herbs that should not be used in foods, beverages, etc.]

Miller, L. G. 1998. Herbal medicinals: selected clinical considerations focusing on known or potential drug-herb interactions. Arch. Int. Med. 158(20): 2200-2211.

Phillipson, J. D. & L. A. Anderson. 1984. Counter prescribing of herbal remedies. Pharm. J. 233: 235-238; 272-274.

Phillipson, J. D. 1981. The pros and cons of herbal remedies. Pharm. J. 227: 387-392.

Ridker, P. M. 1987. Toxic effects of herbal teas. Arch. Environ. Health 42: 133-136.

Ridker, P. M. 1989. Health hazards of unusual herbal teas. Amer. Fam. Phys. 39: 153-156.

Vukovic, L. 2001. Should your herbalist be certified? Herbs for Health 6(3): 54-57.

PLANTS: NORTH AMERICA

Angier, B. 1978. Field guide to medicinal wild plants. Stackpole Press. 320 pp.

Balick, M. J. et al. 2000. Medicinal plants used by Latino healers for women's health conditions in New York City. Econ. Bot. 54(3): 344-357.

Beckstrom-Sternberg, S. & J. Duke. The medicinal plants of native America database, ACEDB version 4.0. http://probe.nalusda.gov:8300/cgi-bin/browse/mpnadb

Bigelow, J. 1817-1820. American medical botany, being a collection of the native medicinal plants of the United States. Cummings & Hilliard. Three vols. Boston, MA.

Bolyard, J. L. 1981. Medicinal plants and home remedies of Appalachia. C. C. Thomas. Springfield, IL. 187 pp.

Boyle, W. 1991. Official herbs: botanical substances in the United States pharmacopoeias, 1820-1990. Buckeye Naturopathic Press. East Palestine, OH. 77 pp.

Brill, S. 1994. Identifying and harvesting edible and medicinal plants in wild (and not so wild) places. Hearst Books. New York, NY. 317 pp.

Brown, T., Jr. 1985. Tom Brown's guide to wild edible and medicinal plants. Berkley Books. New York, NY. 241 pp.

Chandler, R. F. et al. 1979. Herbal remedies of the Maritime Indians. J. Ethnopharm. 1(1): 49-68.

Chandler, R. F. 1983. Vindication of Maritime Indian herbal remedies. J. Ethnopharm. 9: 323-327.

Chatfield, K. Medicine from the mountain: medicinal plants of the Sierra Nevada. Range of Light Publ. South Lake Tahoe, CA. 219 pp.

Cheney, R. H. 1946. Medicinal herbaceous species in the northeastern United States. Bull. Torrey Bot. Club 73(1): 60-72.

Conway, G. A. & J. C. Slocumb. 1979-80. Plants used as abortifacients and emmenagogues by Spanish New Mexicans. J. Ethnopharm. 1: 241-246.

Cowen, D. L. 1984. The impact of the materia medica of the North American Indians on professional practice. Veröff Int. Gesell. Gesch. Pharm. 53: 51-63.

Duke, J. A. 1986. Handbook of northeastern Indian medicinal plants. Quarterman Publ. Lincoln, MA. 212 pp.

Eisenberg, D. et al. 1993. Unconventional medicine in the United States. New England J. Med. 328(4): 246-252.

Eisenberg, D. M. et al. 1998. Trends in alternative medicine use in the United States, 1990-1997. J. American Med. Assoc. 280(18): 1569-1575.

Erichsen-Brown, C. 1989. Medicinal and other uses of North American plants: a historical survey with special reference to the eastern Indian tribes. Dover Publ. New York, NY. 544 pp.

Farnsworth, N. R. & D. D. Soejarto. 1985. Potential consequence of plant extinction in the United States on the current and future availability of prescription drugs. Econ. Bot. 39: 231-240.

Foster, S. 1989. Phytogeographic and botanical considerations of medicinal plants in eastern Asia and eastern North America. Herbs Spices Med. Pl. 4: 115-144.

Foster, S. 1995. Forest pharmacy -- medicinal plants in American forests. Duke Univ. Press. Durham, NC. 64 pp.

Foster, S. 1998. 101 medicinal herbs – an illustrated guide. Interweave Press. Loveland, CO. 240 pp.

Foster, S. & C. Hobbs. 2002. A field guide to western medicinal plants and herbs. Houghton Mifflin. Boston, MA. 442 pp.

Foster, S. & J. A. Duke. 2000. A field guide to the medicinal plants and herbs of eastern and central North America. Second edition. Houghton Mifflin. Boston, MA. 512 pp.

Heatherley, A. N. 1998. Healing plants: a medicinal guide to native North American plants and herbs. 252 pp.

Henkel, A. 1906. Wild medicinal plants of the United States. Bull. No. 89. Bureau of Plant Industry. U. S. Gov. Printing Office. Washington, D. C.

Herrick, J. W. 1995. Iroquois medical botany. Syracuse Univ. Press. Syracuse, NY. 278 pp.

Hershenson, B. R. 1964. A botanical comparison of the United States pharmacopeias of 1820 and 1960. Econ. Bot. 18: 342-356.

Hoffmann, D. 1995. Some challenges facing herbalism in North America: a phytotherapist's perspective. HerbalGram 33: 28, 30-32, 50, 61.

Hutchens, A. R. 1986. Indian herbology of North America. 12th edition. Merco. Windsor, Canada. 382 pp.

Huxtable, R. J. 1983. Herbs along the western Mexican-American border. Proc. West. Pharm. Soc. 26: 185-191.

Johnson, C. H. 1960. Important medicinal plants of Florida. Dept. Agric. Bull. No. 14. State of Florida.

Kay, C. & N. Billington. 1997. Medicinal plants of the Heartland. Cache River Press. Vienna, IL. 344 pp.

Kay, M. A. 1996. Healing with plants in the American and Mexican West. Univ. Arizona Press. Tucson. 315 pp.

Kindscher, K. 1992. Medicinal wild plants of the prairie. Univ. Press Kansas. Lawrence. 340 pp.

Krochmal, A. 1968. Medicinal plants in Appalachia. Econ. Bot. 22: 332-337.

Krochmal, A. & C. Krochmal. 1984. A field guide to medicinal plants. Time Books. New York, NY. 274 pp.

Linares, E. & R. A. Bye, Jr. 1987. A study of four medicinal plant complexes of Mexico and adjacent United States. J. Ethnopharm. 19(2): 153-183.

Miller, A. B. W. 1998. Shaker medicinal plants: a compendium of history, lore, and uses. Storey Books. Pownal, VT. 215 pp.

Millspaugh, C. F. 1892. American medicinal plants. An illustrated and descriptive guide to plants indigenous to and naturalized in the United States which are used in medicine. Dover Publ. New York, NY. 806 pp.

Moerman, D. E. 1977. American medical ethnobotany: a reference dictionary. Garland Publ. New York, NY. 527 pp.

Moerman, D. E. 1986. Medicinal plants of native America. Two vols. Tech. Rep. No. 19. Univ. Michigan Mus. Anthrop. Ann Arbor. 910 pp.

Moerman, D. E. 1991. The medicinal flora of native North America: an analysis. J. Ethnopharm. 31: 1-42.

Moerman, D. E. 1996. An analysis of the food and drug plants of native North America. J. Ethnopharm. 52(1): 1-22.

Moore, M. 1977. Los remedios de la gente. Publ by author. Santa Fe, NM. 20 pp.

Moore, M. 1979. Medicinal plants of the mountain West. Mus. New Mexico Press. Santa Fe. 200 pp.

Moore, M. 1989. Medicinal plants of the desert and canyon West. Mus. New Mexico Press. Santa Fe. 184 pp.

Moore, M. 1990. Los remedios. Traditional herbal remedies of the Southwest. Red Crane Books. Santa Fe, NM. 108 pp.

Moore, M. 1993. Medicinal plants of the Pacific West. Red Crane Books. Santa Fe, NM. 359 pp.

Price, E. 1960. Root digging in the Appalachians: the geography of botanical drugs. Geogr. Rev. 50: 1-20.

Snow, A. M. & S. E. Stans. 2001. Healing plants. Medicine of the Florida Seminole Indians. Univ. Press Florida. Gainesville. 135 pp.

Still, C. C. 1998. Botany and healing: medicinal plants of New Jersey and the region. Rutgers Univ. Press. New Brunswick, NJ. 261 pp.

Stuhr, E. T. 1947. The distribution, abundance and uses of wild drug plants in Oregon and southern California. Econ. Bot. 1(1): 57-68.

Tilford, G. L. 1997. Edible and medicinal plants of the West. Mountain Press Publ. Missoula, MT. 239 pp.

Tyler, V. E. 1987. Herbal medicine in America. Planta Med. 53: 1-4.

Tyler, V. E. 1993. Phytomedicines in western Europe: potential impact on herbal medicine in the United States. In, Kinghorn, A. D. & M. F. Balandrin (Editors). Human medicinal agents from plants. Pp. 25-38.

Viereck, E. G. 1987. Alaska's wilderness medicines: healthful plants of the Far North. Alaska Northwest Publ. Edmonds, WA. 107 pp.

Vogel, V. J. 1970. American Indian medicine. Univ. Oklahoma Press. Norman. 533 pp.

Vogel, V. J. 1976. American Indian foods used as medicines. In, Hand, W. (editor). American folk medicine: a symposium. Univ. California Press. Berkeley, CA. Pp. 125-142.

Weiner, M. A. 1980. Earth medicine - earth food. Plant remedies, drugs, and natural foods of the North American Indians. Collier Books. 230 pp.

Westrich, L. 1989. California herbal remedies. Gulf Publ. Houston, TX. 180 pp.

Youngken, H. W. 1924-25. Drugs of the North American Indians. American J. Pharm. 96: 485-502; 97: 158-185, 257-271.

PLANTS: MEXICO & CENTRAL AMERICA

Argueta Villamar, A. (coordinator). 1994. Atlas de las plantas de la medicina tradicional Mexicana. Inst. Nac. Indigenista. Mexico, D. F. Three vols.

Arnason, T. et al. 1980. Maya medicinal plants of San Jose Succotz, Belize. J. Ethnopharm. 2(4): 345-364.

Arvigo, R. & M. Balick. 1993. Rainforest remedies: one hundred healing herbs of Belize. Lotus Press. Twin Lakes, WI. 221 pp.

Barrett, B. 1997. Herbs and healing on Nicaragua's Atlantic coast. HerbalGram 41: 35-48.

Benedetti, M. 1989. Earth and spirit: medicinal plants and healing lore from Puerto Rico. 268 pp.

Browner, C. H. 1985. Plants used for reproductive health in Oaxaca, Mexico. Econ. Bot. 39(4): 482-504.

Bye, R. A., Jr. 1986. Medicinal plants of the Sierra Madre: comparative study of Tarahumara and Mexican market plants. Econ. Bot. 40(1): 103-124.

Cruz, M. de la. 1552. The Badianus manuscript: an Aztec herbal of 1552. Codex Barberini. Latin 241. Vatican Library. Facsimile edition (1940). The Johns Hopkins Press. Baltimore, MD. 341 pp.

Felger, R. S. & M. B. Moser. 1974. Seri Indian pharmacopoeia. Econ. Bot. 28: 415-436.

Foster, S. 1992. The Badianus manuscript: the first herbal from the Americas. HerbalGram 27: 12-27.

Foster, S. 1994. America's first herbal: the Badianus manuscript. Herb Companion 7(1): 27-33.

Gupta, M. P. 1990. Plants and traditional medicine: case of Panama. Econ. Medicinal Plant Res. 4: 95-122.

Heinrich, M. 1998. Indigenous concepts of medicinal plants in Oaxaca, Mexico: lowland Mixe plant classification based on organoleptic characteristics. J. Applied Bot. 72: 75-81.

Hirschhorn, H. H. 1981. Botanical remedies of South and Central America, and the Caribbean: an archival analysis. Part I. J. Ethnopharm. 4(2): 129-158.

Leonti, M. et al. 2003. Medicinal flora of the Popoluca, Mexico: a botanical systematical perspective. Econ. Bot. 57(2): 218-230.

Lozoya, X. 1990. An overview of the system of traditional medicine currently practiced in Mexico. Econ. Med. Plt. Res. 4: 71-93.

MacPherson, B. 1997. The healing herbs of Belize. Herb. Quart. 76: 42-46.

Mellen, G. A. 1974. El uso de las plantas medicinales en Guatemala. Guatemala Indigena 9(1/2): 99-179.

Mendieta, R. & S. del Amo R. 1981. Plantas medicinales del Estado de Yucutan. 428 pp.

Montellano, B. O. de. 1975. Empirical Aztec medicine. Science 188: 215-220.

Morton, J. 1977. Some folk medicine plants of Central American markets. Qtr. J. Crude Drug Res. 15: 165-192.

Morton, J. F. 1981. Atlas of medicinal plants of Middle America, Bahamas to Yucatan. C. C. Thomas. Springfield, IL. 1472 pp.

Nicholson, M. S. & C. B. Arzeni. 1993. The market medicinal plants of Monterrey, Nuevo Leon, Mexico. Econ. Bot. 47: 184-192.

Nunez-Melendez, E. 1978. Plantas medicinales de Costa Rica y su folklore. Second edition. Editorial de la Univ. de Costa Rica. San José. 322 pp.

Nunez-Melendez, E. 1982. Plantas medicinales de Puerto Rico: folklore y fundamentos cientificos. Universidad de Puerto Rico. Rio Pedras. 498 pp.

Ortiz de Montellano, B. R. 1975. Empirical Aztec medicine. Aztec medicinal plants seem to be effective if they are judged by Aztec standards. Science 188: 215-220.

Ortiz de Montellano, B. R. & C. H. Browner. 1985. Chemical bases for medicinal plant use in Oaxaca, Mexico. J. Ethnopharm. 13(1): 89-103.

Seaforth, C. E. et al. 1987. A guide to the medicinal plants of Trinidad and Tobago. Second edition. Commonwealth Secretariat. London, England. 221 pp.

Weniger, B. et al. 1982. Plants of Haiti used as antifertility agents. J. Ethnopharm. 6: 67-84.

Winkelman, M. 1986. Frequently used medicinal plants in Baja California Norte. J. Ethnopharm. 18: 109-131.

PLANTS: SOUTH AMERICA

Arbelaez, E. P. 1990. Plantas medicinales y venenosus de Colombia. Ediciones Triangulo. Medellín, Colombia. 285 pp.

Arenas, P. & R. M. Azorero. 1977. Plants of common use in Paraguayan folk medicine for regulating fertility. Econ. Bot. 31(3): 298-301.

Balee, W. 1993. Footprints of the forest: Ka'apor ethnobotany -- the historical ecology of plant utilization of an Amazonian people. 396 pp.

Balick, M. J. & R. O. Mendelsohn. 1992. Assessing the economic value of traditional medicines from tropical rain forests. Conservation Biol. 6(1): 128-130.

Balick, M. et al (Editors). 1996. Medicinal resources of the tropical forest. 440 pp.

Bandoni, A. L. et al. 1976. Survey of Argentine medicinal plants. Folklore and phytochemical screening. II. Econ. Bot. 30: 161-185.

Bennett, B. C. & G. T. Prance. 2000. Introduced plants in the indigenous pharmacopoeia of northern South America. Econ. Bot. 54(1): 90-102.

Brando, M. G. L. et al. 1992. Survey of medicinal plants used as antimalarials in the Amazon. J. Ethnopharm. 36: 175-182.

Brito, S. A. R. M. & A. A. S. Brito. 1993. Forty years of Brazilian medicinal plant research. J. Ethnopharm. 39(1): 53-68.

Castner, J. L., S. L. Timme, & J. A. Duke. 1998. A field guide to medicinal and useful plants of the Upper Amazon. Feline Press. Gainesville, FL. 154 pp.

Corry, S. 1993. The rainforest harvest: who reaps the benefits? Ecologist 23: 148-153.

Davis, E. W. & J. A. Yost. 1983. The ethnomedicine of the Waorani of Amazonian Ecuador. J. Ethnopharm. 9(2-3): 273-298.

DeFeo, V. 1992. Medicinal and magical plants in the northern Peruvian Andes. Fitoterapia 63(5): 417-440.

DeFilipps, R. A. (editor). 2000. Medicinal plants of Brazil. Reference Publications. Algonac, MI. 550 pp.

Elizabetsky, E. & L. Wannmacher. 1993. The status of ethno-pharmacology in Brasil. J. Ethnopharm. 38: 137-143.

Garcia-Barriga, H. 1992. Flora medicinal de Colombia. Three vols. Tercer Mundo Editores. Bogotá, Colombia.

Gentry, A. H. 1993. Tropical forest biodiversity and the potential for new medicinal plants. In, Kinghorn, A.D. & M.F. Balandrin (Editors). Human medicinal agents from plants. Pp. 13-24.

Guillén, J. E. L. & I. K. de Cornello. 1973. Plantas medicinales del Peru. Biota Pt. 1, 9: 283-313. Pt. 2, 9: 347-376.

Heras, B. de las et al. 1998. Anti-inflammatory and antioxidant activity of plants used in traditional medicine in Ecuador. J. Ethnopharm. 61(2): 161-166.

Jackson, D. D. 1989. Searching for medicinal wealth in Amazonia. Smithsonian 19(11): 94-103.

Joyce, C. 1994. Earthly goods: medicine-hunting in the rainforest. Little, Brown, & Co. Boston, MA. 304 pp.

Luna, L. E. 1984. The concept of plants as teachers among four mestizo shamans of Iquitos, northeastern Peru. J. Ethnopharm. 11: 135-156.

Martin, A. J. 1983. Medicinal plants in central Chile. Econ. Bot. 37(2): 216-227.

Plotkin, M. J. 1988. Conservation, ethnobotany, and the search for new jungle medicines: pharmacognosy comes of age ... again. Pharmacotherapy 8(5): 257-262.

Plotkin, M. J. 1993. Tales of a shaman's apprentice: an ethnobotanist searches for new medicines in the Amazon rain forest. Viking Penquin. New York, NY. 318 pp.

Rodrigues de Almeida, E. 1993. Plantas medicinais Brasileiras. Hemus Editora. Sao Paulo, Brazil. 341 pp.

Schultes, R. E. 1972. From witch doctor to modern medicine: searching the American tropics for potentially new medicinal plants. Arnoldia 32(5): 198-219.

Schultes, R. E. & A. F. Joy. 1955. Twelve years in a green heaven. Nat. Hist. 64: 120-127; 165.

Soejarto, D. D. & N. R. Farnsworth. 1989. Tropical rain forests: potential source of new drugs? Persp. in Biol. and Med. 32: 244-256.

Soraru, S. B. & A. L. Bandoni. 1978. Plantas de la medicina popular Argentina. Guia ilustrada de las cincuenta plantas indigenas mas empleadas. Editorial Albatros. Buenos Aires, Argentina. Pp. 153

Taylor, L. 1998. Herbal secrets of the rainforest: the healing power of over 50 medicinal plants you should know about. Prima Publ. Rocklin, CA. 313 pp.

Villegas, L. F. et al. 1997. Evaluation of the wound-healing activity of selected traditional medicinal plants of Peru. J. Ethnopharm. 55: 193-200.

Wade-Davis, A. & J. A. Yost. 1983. The ethnomedicine of the Waorani of Amazonian Ecuador. J. Ethnopharm. 9: 273-299.

PLANTS: EUROPE

Jashemski, W. F. 1999. A Pompeian herbal: ancient and modern medicinal plants. Univ. Texas Press. Austin. 107 pp.

Lawson, L. D. & R. Bauer (editors). 1998. Phytomedicines of Europe: chemistry and biological activity. American Chem. Soc. Washington, D. C. 324 pp.

PLANTS: ASIA

Anonymous. 1990. Contemporary sources of information on Chinese medicinals. HerbalGram 23: 29-31.

Bensky, D. & A. Gamble. 1993. Chinese herbal medicine. Eastland Press. Seattle, WA. 56 pp.

Buntapraphatsara, N. 1990. Traditional medicine and medicinal plants in Thailand. Econ. Medicinal Plant Res. 4: 141-159.

Chin, W. Y. & H. Keng. 1992. An illustrated dictionary of Chinese medicinal herbs. CRCS Publ. Sebastopol, CA. Pp. 184

Duke, J. A. & E. S. Ayensu. 1985. Medicinal plants of China. Two vols. Reference Publ. Algonac, MI. 670 pp.

Foster, S. & Y. Chongxi. 1992. Herbal emissaries: bringing Chinese herbs to the West. Healing Arts Press. Rochester, VT. 356 pp.

Ghazanfar, S. A. 1994. Handbook of Arabian medicinal plants. CRC Press. Boca Raton, FL. 265 pp.

Guoshi, T. (editor). 1992. Pharmacopoeia of the People's Republic of China. People's Medical Publ. House. Beijing, China. 536 pp.

Hirschhorn, H. H. 1982. Natural substances in currently available Chinese herbal and patent medicines. J. Ethnopharm. 6: 109-119.

Hsu, H.-Y. et al. 1982. The chemical constituents of Oriental herbs. Two vols. Oriental Healing Arts Inst. Los Angeles, CA. 829 pp.

Hsu, H.-Y. et al. 1986. Oriental materia medica: a concise guide. Oriental Healing Arts Inst. Long Beach, CA. 933 pp.

Huang, K. C. 1993. Pharmacology of Chinese herbs. CRC Press. Boca Raton, FL. 388 pp.

Keung, A. 1990. Chinese herbals. HerbalGram 23: 21-28.

Keys, J. D. 1976. Chinese herbs -- their botany, chemistry, and pharmacodynamics. Charles Tuttle. 388 pp.

Kong, Y. C. 1976. Potential anti-fertility plants from Chinese medicine. American J. Chinese Med. 4: 105-128.

Kong, Y. C. et al. 1986. Fertility regulating agents from traditional Chinese medicine. J. Ethnopharm. 15: 1-44.

Lemmens, R. M. J. & N. Bunyapraphatsara (editors). 2003. Medicinal and poisonous plants. Vol. 12, pt. 3. Plant resources of south-east Asia. Backhuys Pub. Leiden, The Netherlands. 664 pp.

Leung, A. Y. 1988. Chinese herbal remedies. Universe Books. New York, NY. 192 pp.

Li, C. P. 1974. Chinese herbal medicine. Publ. No. 75-732. U. S. Dept. Health, Educ., Welfare. Washington, D. C. 120 pp.

Li, T. S. C. 2002. Chinese and related North American herbs: phyto-pharmaceutical and therapeutic values. CRC Press. Boca Raton, FL. 598 pp.

Monachino, J. 1956. Chinese herbal medicine -- recent studies. Econ. Bot. 10(1): 42-48.

Namba, T. et al. 1983. Dental caries prevention by traditional Chinese medicines. Planta Med. 44: 100-106.

Padua, L. S. et al. (editors). 1999. Medicinal and poisonous plants. Vol. 12, pt. 1. Plant resources of south-east Asia. Backhuys Pub. Leiden, The Netherlands. 711 pp.

Parrotta, J. A. 2001. Healing plants of peninsular India. Oxford Univ. Press. New York, NY. 944 pp.

Peigen, S. & H. Luyi. 1983. Ethnopharmacologic investigations on tropane-containing drugs in Chinese solanaceous plants. J. Ethnopharm. 8: 1-18.

Peigen, X. 1990. The role of traditional medicine in the primary health-care system of China. Econ. Medicinal Plant Res. 4: 17-26.

Peng, Y. & P. G. Xiao. 1993. A review of the resource utilization of Chinese medicinal plants. J. Plant Resources and Environ. 2(1): 49-55.

Perry, L. M. 1980. Medicinal Plants of east and southeast Asia: attributed properties and uses. MIT Press. Cambridge, MA. 620 pp.

Rister, R. 1999. Japanese herbal medicine. Avery Publ. Group. Garden City, New York. 412 pp.

Satyavati, G. V. 1990. Use of plant drugs in Indian traditional systems of medicine and their relevance to primary health care. Econ. Medicinal Plant Res. 4: 39-56.

Smith, F. P. & G. A. Stuart (Translators). 1975. Chinese medicinal herbs. Georgetown Press. San Francisco, CA. 512 pp.

Tschanz, D. 1998. Islamic plant medicine. Herbs for Health 3(5): 56-61.

Valkenburg, J. L. et al. (editors). 2001. Medicinal and poisonous plants. Vol. 12, pt. 2. Plant resources of south-east Asia. Backhuys Pub. Leiden, The Netherlands. 782 pp.

Wu, C. 1995. Yin and yang: western science makes room for Chinese herbal medicine. Science News 148(11): 172, 173.

Zhou, Z. Y. & H. D. Jin. 1997. Clinical manual of Chinese herbal medicine. Churchill Livingstone. New York, NY. 585 pp.

Zhu, Y.-P. 1998. Chinese materia medica: chemistry, pharmacology and applications. Harwood Academic. 528 pp.

PLANTS: AFRICA

Arnold, T. H. et al. 2002. Medicinal and magical plants of southern Africa: an annotated checklist. National Bot. Inst. Pretoria, South Africa. 203 pp.

Boulos, L. 1983. Medicinal plants of North Africa. Reference Publ. Algonac, Mich. 286 pp.

Boye, G. L. & O. Ampofo. 1990. The role of plants and traditional medicine in primary health care in Ghana. Econ. Medicinal Plant Res. 4: 27-37.

Bryan, C. P. 1930. The Papyrus Ebers. Appleton. New York, NY. 167 pp.

Hutchings, A. et al. 1996. Zulu medicinal plants. Univ. Natal Press. Pietermaritzburg. 450 pp.

Iwu, M. M. 1990. A handbook of African medicinal plants. CRC Press. Boca Raton, FL. 435 pp.

Kaido, T. L. et al. 1997. Preliminary screening of plants used in South Africa as traditional herbal remedies during pregnancy and labour. J. Ethnopharm. 55: 185-191.

Neuwinger, H. D. 2000. African traditional medicine: a dictionary of plant use and applications, with supplement: search system for diseases. Medpharm Sci. Publ. Stuttgart, Germany. 589 pp.

Sofowora, A. 1993. Recent trends in research into African medicinal plants. J. Ethnopharm 38: 209-214.

Veale, D. J. H. et al. 1992. South African traditional herbal medicines used during pregnancy and childbirth. J. Ethnopharm. 36: 185-191.

Wyk, B.-E. van et al. 1997. Medicinal plants of South Africa. BRIZA Publ. Arcadia, South Africa. 304 pp.

PLANTS: OCEANIA

Abbott, I. A. & C. Shimazu. 1985. The geographic origin of the plants most commonly used for medicine by Hawaiians. J. Ethnopharm. 14(2 & 3): 213-222.

Cambie, R. C. & Brewis, A. A. 1997. Anti-fertility plants of the Pacific. CSIRO. Collingwood, Victoria. 181 pp.

Bushnell, O. A., M. Fukudu, & T. Makinodan. 1950. The antibacterial properties of some plants found in Hawaii. Pacific Sci. 4: 167-183.

Cambie, R. C. & J. Ash. 1994. Fijian medicinal plants. CSIRO Australia. East Melbourne, Australia. 365 pp.

Collins, D. J. et al. 1990. Plants for medicines: a chemical and pharmacological survey of plants in the Australian region. CSIRO. East Melbourne, Australia. 303 pp.

Cox, P. A. 1990. Samoan ethnopharmacology. Econ. Med. Plt. Res. 4: 123-139.

Fletcher, J. E. 1971. Notes on herb medicine in Guam. Econ. Bot. 25: 60-62.

Krauss, B. H. 1981. Native plants used as medicine in Hawaii. Harold L. Lyon Arboretum. Univ. Hawaii. Honolulu, HI. 50 pp.

Krauss, B. 2001. Plants in Hawaiian medicine. XXX. 150 pp.

Nagata, K. M. 1971. Hawaiian medicinal plants. Econ. Bot. 25: 245-254.

Parham, H. B. R. 1943. Fiji native plants with their medicinal and other uses. Polynesian Soc. Mem. 16: 1-160.

Riley, M. 1994. Maori healing and herbal. Viking Sevenseas N. Z. Ltd. 528 pp.

Salsedo, C. A. & D. G. Smith. 1987. Medicinal plants of Palau. Phytologia 64: 62-76.

Ube, G. 1974. Medicinal plants of Samoa. Econ. Bot. 28: 1-30.

Weiner, M. A. 1971. Ethnomedicine in Tonga. Econ. Bot. 25: 423-450.

Whistler, W. A. 1991. Herbal medicine in the Kingdom of Tonga. J. Ethnopharm. 31(3): 339-372.

Whistler, W. A. 1992. Polynesian herbal medicine. National Tropical Bot. Garden. Lawai, Hawaii. 238 pp.

Whistler, W. A. 1992. Tongan herbal medicine. Isle Botanica. Honolulu, HI. 122 pp.

SURVEY OF PLANTS

ALOË VERA

Davis, R. 1997. Aloe vera: a scientific approach. 320 pp.

Foster, S. 1997. *Aloë vera*: easy to grow, easy to use. Herbs for Health 1(4): 55-57.

Grindlay, D. & T. Reynolds. 1986. The *Aloë vera* phenomenon: a review of the properties and modern uses of the leaf parenchyma gel. J. Ethnopharm. 16: 117-151.

Hecht, A. 1981. The overselling of *Aloë vera*. FDA Consumer Jly-Aug: 27-29.

Heggers, J. P. et al. 1993. Beneficial effects of Aloë in wound healing. Phytotherapy Res. 7: S48-52.

Koo, M. W. L. 1994. *Aloë vera*: antiulcer and antidiabetic effects. Res. 8: 461-464.

Morton, J. F. 1961. Folk uses and commercial exploitation of *Aloë* leaf pulp. Econ. Bot. 15: 311-319.

Reynolds, T. 1985. The compounds in Aloë leaf exudates. Bot. J. Linnean Soc. 90: 157-177.

Reynolds, T. 1985. Observations on the phytochemistry of the Aloë leaf-exudate compounds. Bot. J. Linnean Soc. 90: 179-199.

Ship, A. G. 1977. Is topical *Aloë vera* plant mucus helpful in burn treatment? J. American Med. Assoc. 238: 1770.

Spoerkle, D. G. & B. R. Ekins. 1980. *Aloë vera* -- fact or quackery. Vet. Human Toxicol. 22(6): 418-424.

BELLADONNA

Hess, E. H. 1975. The tell-tale eye. Van Nostrand Reinhold. New York, NY.

Hess, E. H. 1975. Attitude and pupil size. Sci. American 212(4): 46-54.

ECHINACEA

Anonymous. 1997. Echinacea: a user's guide. Herbs for Health 2(4): 24-28.

Barrett, B. 2003. Echinacea: a safety review. HerbalGram 57: 36-39.

Bauer, R. & H. Wagner. 1991. Echinacea species as potential immunostimulatory drugs. Econ. Med. Plant Res. 5: 253-321.

Facino, R. M. et al. 1995. ... a potential use of Echinacea extracts in the prevention of skin photodamage. Planta Med. 61: 510-514.

Flannery, M. A. 2001. From Rudbeckia to Echinacea: the emergence of the purple cone flower in modern therapeutics. HerbalGram 51: 28-33.

Foster, S. 1990. Echinacea: beauty and medicine for your garden. Herb Companion Oct/Nov: 33-38.

Foster, S. 1991. Echinacea: nature's immune enhancer. Healing Arts Press. Rochester, VT. 150 pp.

Foster, S. 1991. Echinacea: nature’s immune enhancer. Healing Arts Press. Rochester, VT. 150 pp.

Kindscher, K. 1989. Ethnobotany of purple coneflower (*Echinacea angustifolia*, Asteraceae) and other Echinacea species. Econ. Bot. 43: 498-507.

Melchart, D. et al. 1998. Echinacea root extracts for the prevention of upper respiratory tract infections: a double-blind, placebo-controlled randomized trial. Arch. Family Med. Nov/Dec: 541-545.

Parnham, M. J. 1996. Benefit-risk assessment of the squeezed sap of the purple coneflower (*Echinacea purpurea*) for long-term oral immunostimulation. Phytomed. 3: 95-102.

EPHEDRA

Blumenthal, M. & P. King. 1995. Mahuang: ancient herb, modern medicine, regulatory dilemma. HerbalGram 34: 22-26, 43, 56, 57.

Chen, K. K. 1974. Half a century of ephedrine. American J. Chinese Med. 2: 359-365.

Israelsen, L. 1997. Ephedra ... an insider's perspective. Herbs for Health 2(3): 50, 51.

Mahdihassan, S. 1988. Ephedra, the oldest medicinal plant with a history of uninterrupted use. Ancient Sci. Life 7: 105-109.

McCaleb, R. S. 1995. Perspective on *Ephedra*, ephedrine, and caffeine products. HerbalGram 34: 27, 42.

Turk, M. P. 1997. Ephedrine's deadly edge. U. S. News & World Report 123(1): 79, 80.

White, L. M. et al. 1997. Pharmacokinetics and cardiovascular effects of ma-huang (*Ephedra sinica*) in normotensive adults. J. Clin. Pharm. 37: 116-122.

ERGOT

Barger, G. 1931. Ergot and ergotism. Guerney & Jackson. London, England. 279 pp.

Bennett, J. W. 1999. Pride and prejudice: the story of ergot. Perspective in Biol. and Med. 42(3): 333-355.

Berde, B. & H. O. Schild (editors). 1978. Ergot alkaloids and related compounds. Springer. Berlin, Germany. 905 pp.

Bové, F. J. 1970. The story of ergot. S. Karger. New York, NY. 297 pp.

Hofmann, A. 1958. The chemistry of the ergot alkaloids. Planta Med. 6: 381-394.

Hofmann, A. 1964. Die Mutterkornalkaloide. Fernand Enke. Stuttgart, Germany. 218 pp.

Hofmann, A. 1972. Ergot -- a rich source of pharmacologically active substances. In, Swain, T. (editor). Plants in the development of modern medicine. Harvard Univ. Press. Cambridge, MA. Pp. 235-260.

Kren, V. & L. Cvak (editors). 1998. Ergot, the genus Claviceps. Harwood Academic. 537 pp.

Rehacek, Z. & P. Sajdl. 1993. Ergot alkaloids: chemistry, biological effects, biotechnology. Elsevier Science Publ. New York, NY. 383 pp,

Spanos, N. P. 1983. Ergotism and the Salem witch panic: a critical analysis and an alternative conceptualization. J. Hist. Behav. Sci. 19(4): 358-369.

Van Dongen, P. W. J. & A. N. J. A. De Groot. 1995. History of ergot alkaloids from ergotism to ergometrine. European J. Obs. Gyn. Reprod. Biol. 60: 109-116.

Youngken, H. W., Jr. 1947. Ergot -- a blessing and a scourge. Econ. Bot. 1(4): 372-380.

FEVERFEW

Awang, D. V. C. 1989. Feverfew. Canadian Pharm. J. 122(5): 266-270.

Baldwin, C.A. 1987. What pharmacists should know about feverfew. Pharm. 3. 239: 237, 238.

Foster, S. 1991. Feverfew: *Tanacetum parthenium*. American Bot. Council. Austin, TX. 8 pp.

Foster, S. 1998. Researchers find feverfew does help migraines. Herbs for Health 3(1): 17.

Groenewegen, W. A. & S. Heptinstall. 1986. Amounts of feverfew in commercial preparations of the herb. Lancet 1: 44, 45.

Hobbs, C. 1989. Feverfew: a review. HerbalGram 20: 26-25; 47.

Johnson, E. S. et al. 1985. Efficacy of feverfew as prophylactic treatment for migraine. British Med. J. 291: 569-573.

Knight, D. W. 1995. Feverfew: chemistry and biological activity. Natural Prod. Rep. 12: 271-276.

Murphy, J. et al. 1988. Randomized double-blind placebo-controlled trial of feverfew in migraine prevention. Lancet July 23: 189-192.

Vickers, H. R. 1985. Feverfew and migraine. British Med. J. 291: 827.

Waller, P. C. & L. Ramsay. 1985. Efficacy of feverfew as prophylactic treatment of migraine. British Med. J. 291: 1128.

FOXGLOVE

Antman, E. M. & T. W. Smith. 1985. Digitalis toxicity. Ann. Rev. Med. 36: 357-367.

Aronson, J. K. 1985. An account of the foxglove and its medical uses, 1785-1985. Oxford Univ. Press. London, England.

Cagin, N. A. et al. 1977. Digitalis: new knowledge about an old drug. Cardiovascular Medicine. Pp. 183-192.

Estes, J. W. & P. D. White. 1965. William Withering and the purple foxglove. Sci. American 212(6): 110-117.

Krikler, D. M. 1985. Withering and the foxglove: the making of a myth. British Heart J. 54: 256.

Krikler, D. M. 1985. The foxglove: the old woman from Shropshire and William Withering. J. American Coll. Cardiol. 5: Suppl: A3.

Lee, T. C. 1981. Van Gogh's vision, digitalis intoxication? J. American Med. Assoc. XX: 727.

Marullaz, P. D. 1991. Digitalis: is there a future for this classical ethnopharmacological remedy? J. Ethnopharm. 32(1-3): 111-115.

GARLIC

Adetumbi, M. A. & B. H. S. Leu. 1983. *Allium sativum* (garlic) -- a natural antibiotic. Med. Hypotheses 12: 227-237.

Anonymous. 1998. Garlic goodness and how to get it. Herbs for Health 3 (5): 63-65.

Bergner, P. 1996. The healing power of garlic -- the enlightened person's guide to nature's most versatile medicinal plant. Prima Publ. Rocklin, CA. 290 pp.

Bleumink, E. et al. 1972. Allergic contact dermatitis to garlic. British J. Dermatol. 87: 6-9.

Foster, S. 1997. Curbing cholesterol with garlic. Herbs for Health 1(4): 28, 29.

Jain, A. K. et al. 1993. Can garlic reduce levels of serum lipids? A controlled clinical study. American J. Med. 94: 632-635.

Jain, R. C. et al. 1973. Hypoglycaemic action of onion and garlic. Lancet 2: 1491.

Kendler, B. S. 1987. Garlic (*Allium sativum*) and onion (*Allium cepa*): a review of their relationship to cardiovascular disease. Prev. Med. 16: 670-685.

Kleijnen, J. et al. 1989. Garlic, onions and cardiovascular risk factors. A review of the evidence from human experiments with emphasis on commercially available preparations. British J. Clin. Pharm. 28: 535-544.

Koch, H. P. & L. D. Lawson (editors). 1996. Garlic: the science and therapeutic application of *Allium sativum* L. and related species. Williams & Wilkins. Baltimore, MD. 340 pp.

Morien, K. 1998. Modest cholesterol effect with garlic. HerbalGram 44: 17.

Reuter, H. D. 1995. *Allium sativum* and *Allium ursinum*. Part 2. Pharmacology and medicinal application. Phytomed. 2(1): 73-91.

Seligmann, J. & G. Cowley. 1995. Sex, lies and garlic. Newsweek CXXVI(19): 65-68.

Silagy, C. A. & H. A. Neil. 1994. A meta-analysis of the effect of garlic on blood pressure. J. Hypertension 12: 463-468.

Silagy, C. A. & H. A. Neil. 1994. Garlic as a lipid lowering agent: a meta-analysis. J. Royal Coll. Phys. (London) 28: 39-45.

Tolton, S. et al. 1982. The medical uses of garlic -- fact and fiction. American Pharm. 22: 448-451.

Webb, G. 1996. Conference report: garlic symposium of the 6th annual phytotherapy congress. Berlin. HerbalGram 36: 62, 63.

Wolkomir, R. 1995. Without garlic, life would be just plain tasteless. Smithsonian 26(9): 70-76, 78, 79.

GINGER

Foster, S. 1999. Ginger: a multicultural remedy. Herbs for Health 4(4): 60-63.

Fulder, S. & M. Tenne. 1996. Ginger as an anti-nausea remedy in pregnancy: the issue of safety. HerbalGram 38: 47-50.

Mowrey, D. B. & D. E. Clayson. 1982. Motion sickness, ginger, and psychophysics. Lancet 1: 655-657.

Mustafa, T. et al. 1993. Pharmacology of ginger, *Zingiber officinale*. J. Drug Devel. 6: 25-39.

Schulick, P. 1996. Ginger: common spice and wonder drug. Third edition. Herbal Free Press. Brattleboro, VT. 166 pp.

Stewart, J. J. et al. 1991. Effects of ginger on motion sickness susceptibility and gastric function. Pharmacology 42: 111-120.

GINKGO

Beek, T. A. 2000. Ginkgo biloba. Harwood Acad. Amsterdam, The Netherlands. 548 pp.

Braquet, P. 1988-89. Ginkgolides: chemistry, biology, pharmacology and clinical perspectives. Two vols. J. R. Prous. Barcelona, Spain.

Crowley, G. & K. Springen. 1997. Brain boosters. Newsweek 130(18): 58, 59.

DeFeudis, F. V. 1991. *Ginkgo biloba* extract (EGB 761): pharmacological activities and clinical applications. Elsevier. Paris, France.

De Feudis, F. 1998. Ginkgo biloba extract (EGB 761): from chemistry to the clinic. 401 pp.

Elden, H. R. 1990. Ginsenosides -- new uses for an old root. Drug Cosmetic Indust. Apr: 36-40.

Gorman, C. 1997. More than a funny name. Time 150(18): 94.

Halpern, G. 1998. Ginkgo: a practical guide. Avery Publ. Garden City Park, NY. 172 pp.

Hori, T. et al. (editors). 1997. *Ginkgo biloba*: a global teasure: from biology to medicine. Springer. Tokyo. 427 pp.

Itil, T. M. et al. 1996. Central nervous system effects of *Ginkgo biloba*, a plant extract. American J. Therapeutics 3: 63-73.

Jones, K. 1998. Computer helps measure ginkgo's brain benefits. Herbs for Health 3(1): 65.

Kleijnen, J. & P. Knipschild. 1992. Drug profiles: *Ginkgo biloba*. Lancet 340: 1136-1139.

Kleijnen, J. & P. Knipchild. 1992. *Ginkgo biloba* for cerebral insufficiency. British J. Clin. Pharm. 34: 352-358.

Le Bars, P. L. et al. 1997. A placebo-controlled, double-blind, randomized trial of an extract of *Ginkgo biloba* for dementia. J. American Med. Assoc. 278(16): 1327-1332.

Oken, B. S. et al. 1998. The efficacy of *Ginkgo biloba* on cognitive function in Alzheimer disease. Arch. Neurol. 134(11): 1409-1415.

Purkh, K. & S. Khalsa. 1997. Survival skills: ginkgo and conditions associated with aging. Herbs for Health 2(2): 37-39.

Smith, P. F. et al. 1996. The neuroprotective properties of the *Ginkgo biloba* leaf: a review of the possible relationship to platelet-activating factor (PAF). J. Ethnopharm. 50(3): 131-139.

GINSENG

Awang, D. V. C. 2003. What in the name of Panax are those other "ginsengs?" HerbalGram 57: 30-35.

Baldwin, C. 1971. Green gold from the forest. American Forests 77(4): 40-43.

Baldwin, C. A. et al. 1986. What pharmacists should know about ginseng. Pharm. J. 237: 583-586.

Baranov, A. 1966. Recent advances in our knowledge of the morphology, cultivation and uses of ginseng (*Panax ginseng* C. A. Meyer). Econ. Bot. 20(4): 403-406.

Baranov, A. L. 1982. Medicinal uses of ginseng and related plants in the Soviet Union: recent trends in Soviet literature. J. Ethnopharm. 6: 339-353.

Barna, P. 1985. Food or drug? The case of ginseng. Lancet 2: 548.

Bilger, B. 2002. Wild sang: rangers, poachers, and roots that cost a thousand dollars a pound. New Yorker LXXVIII(19): 38-45.

Carlson, A. W. 1986. Ginseng: America's botanical drug connection to the Orient. Econ. Bot. 40(2): 233-249.

Chong, S. K. & V. G. Oberholzer. 1988. Ginseng: is there a use in clinical medicine? Postgrad. Med. J. 64: 841-846.

Dharmananda, S. 2002. The nature of ginseng. HerbalGram 54: 34-51.

Duke, J. A. 1989. Ginseng: a concise handbook. Reference Publ. Algonac, MI. 273 pp.

Foster, S. 1997. Roots of steel: increase stamina with Siberian ginseng. Herbs for Health 2(3): 31-35.

Fulder, S. 1977. Ginseng: useless root or subtle medicine. New Scientist 73: 138-.

Goldstein, B. 1975. Ginseng: its history, dispersion, and folk tradition. American J. Chinese Med. 3(3): 223-234.

Hemmerly, T. E. 1977. A ginseng farm in Lawrence County, Tennessee. Econ. Bot. 31(2): 160-162.

, C. 1997. Ginseng: facts and folklore. Herbs for Health 2(1): 34-38.

Hou, J. P. 1979. The myth and truth about ginseng. A. S. Barnes & Co. South Brunswick, NJ. 245 pp.

Hu, S. Y. 1976. The genus *Panax* (ginseng) in Chinese medicine. Econ. Bot. 30: 11-28.

Hu, S. Y. 1977. A contribution to our knowledge of ginseng. American J. Chinese Med. 5: 1-23.

Li, T. S. C. & G. Mazza. 1996. Ginsenosides in roots and leaves of American ginseng. J. Agric. Food Chem. 44: 717-720.

Liu, C.-X. & P.-G. Xiao. 1992. Recent advances on ginseng research in China. J. Ethnopharm. 36(1): 27-38.

McCaleb, R. 1988. Ginseng conference report. HerbalGram 16: 8-12.

Persons, W. S. 1994. American ginseng: green gold. Revised edition. Bright Mountain Books. Asheville, NC. 203 pp.

Phillipson, C. D. 1984. Ginseng -- quality, safety, and efficacy. Pharm. J. 232: 161-165.

Proctor, J. T. A. & W. G. Bailey. 1987. Ginseng: industry, botany, and culture. Hort. Rev. 9: 188-236.

Roberts, C. R. 1980. American ginseng/*Panax quinquefolia*. Acta Hort. 96: 85-90.

Rodale, R. 1973. Ginseng: a plant worth knowing. Organic Gard. Farm. 20: 34-39.

Shibata, S. et al. 1985. Chemistry and pharmacology of *Panax*. In, Wagner, H. et al. (Editors). Economic and medicinal plant research. Academic Press. New York, NY. Pp. 217-284.

Siegel, R. K. 1979. Ginseng abuse syndrome: problems with the panacea. J. American Med. Assoc. 241: 1614, 1615.

Smith, R. G. et al. 1996. Variation in the ginsenoside content of American ginseng, *Panax quinquefolius* L., roots. Canadian J. Bot. 74(10): 1616-1620.

Sorensen, H. & J. Sonne. 1996. A double-masked study of the effects of ginseng on cognitive functions. Current Therapeutic Research -- Clinical and Experimental 57(12): 959-968.

Williams, L. O. 1957. Ginseng. Econ. Bot. 11: 344-348.

Williams, P. M. 1972. The ginseng mystique. Bull. Field Mus. Nat. Hist. 43(2): 10-12.

MARIJUANA

Brainard, J. 1998. Marijuana chemical tapped to fight strokes. Science News 154(2): 20.

Brown, D. T. 1998. The therapeutic potential for cannabis and its derivatives. In, Brown, D. T. Pp. 175-222. [Extensive bibliography]

Brown, D. T. 1998. The therapeutic potential for cannabis and its derivatives. In, Brown, D. T. Pp. 175-222. [Extensive bibliography]

Calignano, A. et al. 1998. Control of pain initiation by endogenous cannabinoids. Nature 394: 277-281.

Conrad, C. 1997. Hemp for health: the medicinal and nutritional uses of *Cannabis sativa*. Healing Arts Press. Rochester, VT. 280 pp.

Consroe, P. F., G. C. Wood, & H. Buchsbaum. 1975. Anticonvulsant nature of marijuana smoking. J. American Med. Assoc. 234: 306, 307.

Cotts, C. 1999. Marijuana made easy: armies of experts sell a little white pill. The Nation 269(8): 44, 45.

Formukong, E. A., A. T. Evans, & F. J. Evans. 1989. The medicinal uses of cannabis and its constituents. Phytother. Res. 3(6): 219-231.

Gray, C. 1995. Cannabis -- the therapeutic potential. Pharm. J. 254: 771-773.

Green, K. 1998. Marijuana smoking in cannabinoids for glaucoma therapy. Arch. Ophthal. 116: 1433-1437.

Hobbs, C. 2000. Fabulous hemp. Herbs for Health 5(1): 33, 34.

Hollister, L. E. 1992. Marijuana and immunity. J. Psychoactive Drugs 24: 159-164.

Hollister, L. E. 1986. Health aspects of cannabis. Pharm. Rev. 38(1): 1-20.

Joy, J. E., S. J. Watson, Jr., & J. A. Benson, Jr.. 1999. Marijuana and medicine: assessing the science base. National Academy Press. Washington, D. C. 267 pp.

Lemberger, L. 1980. Potential therapeutic usefulness of marijuana. Ann. Rev. Pharmacol. Toxicol. 20: 151-172.

Levy, E. 1998. Cannabis for migraine treatment: the once and future prescription? An historical and scientific review. Pain 76: 3-8.

Levy, B. 1999. U. S. and U. N. studies support medicinal marijuana research. HerbalGram 46: 14, 15.

Lowry, C. 1999. 'Medical' marijuana is a dangerous fraud. 21st Century Sci. Tech. 12(2): 16, 17.

Mack, A. & J. Joy. 2001. Marijuana as medicine? The science beyond the controversy. National Acad. Press. Washington, D. C. 199 pp.

Meng, I. D. et al. 1998. An analgesic circuit activated by cannabinoids. Nature 395: 381-383.

Nahas, G. G. et al. (editors). 1999. Marihuana and medicine. Humana Press. Totowa, NJ. 826 pp.

Pollan, M. 1998. Medical marijuana. Herbs for Health 3(1): 42-48.

Price, M. A. P. & W. G. Notcutt. 1998. Cannabis and cannabinoids in pain relief. In, Brown, D. T. Pp. 223-246.

Rätsch, C. 2001. Marijuana medicine: a world tour of the healing and visionary powers of cannabis. Healing Arts Press. Rochester, VT. 204 pp.

Rosenthal, E. et al. 1997. Marijuana medical handbook: a guide to therapeutic use. Quick America Archives. Oakland, CA. 270 pp.

Russo, E. 1998. Cannabis for migraine treatment: the once and future prescription? An historical and scientific review. Pain 76: 3-8.

Steinherz, K. & T. Vissing. 1997-1998. The medical effects of marijuana on the brain. 21st Century Sci. Tech. Winter: 59-69.

MUSHROOMS

Hobbs, C. 1995. Medicinal mushrooms: an exploration of tradition, healing and culture. Botanica Press. Santa Cruz, CA. 252 pp.

Hobbs, C. 1997. Medicinal mushrooms. Herbs for Health 1(4): 52, 53.

Jones, K. 1997. Shitake: medicine in a mushroom. Herbs for Health 1(4): 48-51; 54.

Larone, D. H. 1995. Medically important fungi: a guide to identification. Third edition. ASM Press. Washington, D. C. 274 pp.

Wasser, S. P. 2002. Review of medicinal mushrooms advances: good news from old allies. HerbalGram 56: 28-33.

Wasser, S. P. & A. L. Weis. 1999. Medicinal properties of substances occurring in higher Basidiomycetes mushrooms: current perspectives. Int. J. Med. Mushrooms 1: 31-62.

NEEM TREE

Puri, H. S. 1998. Neem, the divine tree. Harwood Academic. 259 pp.

Schmutterer, H. (editor). 1995. The neem tree: *Azadirachta indica* A. Juss. and other meliaceous plants. VCH. New York, NY. 696 pp.

OPIUM POPPY

Bernáth, J. 1998. Poppy: the genus *Papaver*. Harwood Academic Publ. 352 pp.

Booth, M. 1998. Opium: a history. St. Martin's Press. New York, NY. 381 pp.

Duke, J. A. 1973. Utilization of *Papaver*. Econ. Bot. 27: 390-400.

Grove, M. D. 1976. Morphine and codeine in the poppy seed. J. Agric. Food Chem. 24: 896, 897.

Hogshire, J. 1994. Opium for the masses. Loompanics Unlimited. Port Townsend, WA. 112 pp.

Kapoor, L. D. 1995. Opium poppy: botany, chemistry, and pharmacology. Haworth Press. New York, NY. 326 pp.

Kramer, J. C. 1980. The opiates: two centuries of scientific study. J. Psychedelic Drugs 12: 89-103.

Nyman, U. & J. G. Bruhn. 1979. *Papaver bracteatum* -- a summary of current knowledge. Planta Med. 35: 97-117.

Palevitch, D. & A. Levy. 1990. Domestication of *Papaver bracteatum* as a source of thebaine. Acta Hort. 306: 33-52.

PACIFIC YEW

Amato, I. 1992. Chemists vie to make a better taxol. Science 256: 311.

Daly, D. 1992. The tree of life. Audubon. 94(2): 76-84.

Denis, J. N. et al. 1988. A highly efficient, practical approach to natural taxol. J. American Chem. Soc. 110: 5917-5919.

Goodman, J. & V. Walsh. 2001. The story of taxol: nature and politics in the pusuit of an anti-cancer drug. Cambridge Univ. Press. New York, NY. 296 pp.

Hartzell, H., Jr. 1991. The yew tree: a thousand whispers. Hulogosi. Eugene, OR. 319 pp.

Huxtable, R. J. 1995. Regional sources of natural products: *Taxomyces andreanae*. Proc. West. Pharm. Soc. 38: 1-4.

Joyce, C. 1993. Taxol: search for a cancer drug. BioScience 43(3): 133-136.

Kingston, D. G. I. 1993. Taxol, an exciting anticancer drug from *Taxus brevifolia.* In, Kinghorn, A. D. & M. F. Balandrin (Editors). Human medicinal agents from plants. Pp. 138-148.

Kingston, D. G. et al. 1990. The chemistry of taxol, a clinically useful anticancer agent. J. Nat. Products 53(1): 1-12.

McGuire, W. P. et al. 1989. Taxol: a unique antineoplastic agent with significant activity in advanced ovarian epithelial neoplasms. Ann. Int. Med. 111(4): 273-279.

Nicolaou, R., K. Guy, & P. Potier. 1996. Taxoids: new weapons against cancer. Sci. American 274(6): 94-98.

Stone, R. 1993. Surprise! A fungus factory for taxol? Science 260: 154, 155.

Suffness, M. (Editor). 1995. Taxol: science and applications. CRC Press. Boca Raton, FL. 426 pp.

PEPPERS (CAPSICUM)

Cichewicz, R. H. & P. A. Thorpe. 1996. The anti-microbial properties of chile peppers (*Capsicum* species) and their uses in Mayan medicine. J. Ethnopharm. 52(2): 61-70.

Cordell, G. A. & O. E. Araujo. 1993. Capsaicin: identification, nomenclature, and pharmacotherapy. Ann. Pharmacotherap. 27: 330-336.

Hori, T. 1984. Capsaicin and central control of thermoregulation. Pharm. Therap. 26: 389-416.

Monsereenusorn, Y. et al. 1982. Capsaicin: a literature review. CRC Critical Rev. Toxicol. 10: 321-339.

Surh, Y. J. & S. S. Lee. 1995. Capsaicin, a double-edged sword: toxicity, metabolism, and chemopreventative potential. Life Sciences 56: 1845-1855.

PERIWINKLE

Svoboda, G. H. 1969. The alkaloids of *Catharanthus roseum* G. Don (*Vinca rosea* L.) in cancer chemotherapy. In, Gunckel, J. E. (Editor). Current topics in plant science. Pp. 303-335.

Taylor, W. I. & N. R. Fransworth. 1975. The catharanthus alkaloids. Dekker. New York, NY. 312 pp.

QUININE & MALARIA

Brandao, M. G. L. et al. 1992. Survey of medicinal plants used as antimalarials in the Amazon. J. Ethnopharm. 36(2): 175-182.

Butler, D. 1997. Time to put malaria control on the global agenda. Nature 386: 535, 536.

Collins, F. H. & N. J. Besansky. 1994. Vector biology and the control of malaria in Africa. Science 264: 1874, 1875.

Diamond, J. 1989. Blood, genes, and malaria. Nat. Hist. Feb: 8-18.

Duran-Reynals, M. L. 1946. The fever bark tree -- the pageant of quinine. Doubleday. New York, NY. 275 pp.

Fosberg, F. R. 1947. *Cinchona* plantation in the New World. Econ. Bot. 1(3): 330-333.

Harrison, G. 1978. Mosquitos, malaria & man: a history of the hostilities since 1880. E. P. Dutton. New York, NY. 314 pp.

Hobhouse, H. 1999. Quinine and the White Man's burden. In, Seeds of change: six plants that transformed mankind. Revised and expanded edition. Papermac. London, England. Pp. 3-50.

Hodge, W. H. 1948. Wartime *Cinchona* procurement in Latin America. Econ. Bot. 2(3): 229-257.

Hoffman, S. L. 1991. Prevention of malaria. J. American Med. Assoc. 265(3): 398, 399.

Honigsbaum, M. 2002. The fever trail: in search of the cure for malaria. Farrar, Straus & Giroux. New York, NY. 307 pp.

Jaramillo-Arango, J. 1949. A critical review of the basic facts in the history of cinchona. J. Linnean Soc. London 53: 272-309.

Jarcho, S. 1993. Quinine's predecessor. Francisco Torti and the early history of cinchona. Johns Hopkins Univ. Press. Baltimore, MD. 354 pp.

Joy, R. J. T. 1999. Malaria in American troops in the south and southwest Pacific in World War II. Medical History 43: 192-207.

Klayman, D. L. 1989. Weeding out malaria. Nat. Hist. 98(10): 18-29.

Klein, R. 1976. The 'fever bark' tree. Nat. Hist. 85(4): 10-19.

Mansell Prothero, R. 1995. Malaria in Latin America: environmental and human factors. Bull. Latin American Res. 14(3): 357-365.

Marwick, C. 1989. Long struggle continues to find new weapons against an old foe -- the malaria parasite. J. American Med. Assoc. 263: 2718.

Miller, L. H. et al. 1994. Malaria pathogenesis. Science 264: 1878-1883.

Millikem, W. 1997. Plants for malaria. Plants for fever: medicinal species in Latin America – a bibliographic survey. Royal Botanic Garden. Kew, England. 116 pp.

Nagel, R. L. 1991. Malaria's genetic billiards game. Nat. Hist. Jly: 59-61.

Nielsen, L. T. 1991. Mosquitos unlimited. Nat. Hist. Jly: 4-6.

Phillipson, J. D. & C. W. Wright. 1991. Antiprotozoal agents from plant sources. Planta Med. 57(Suppl.): 53-59.

Pennisi, E. 2002. Malaria's beginnings: on the heels of hoes? Science 293: 416, 417.

Poser, C. M. 2000. An illustrated history of malaria. CRC Press. Boca Raton, FL. 172 pp.

Rainey, F. 1946. Quinine hunters in Ecuador. Natl. Geogr. 89: 341-363.

Rocco, F. 2003. The miraculous fever-tree: malaria and the quest for a cure that changed the world. Harper Collins. 348 pp.

Sachs, J. & P. Malaney. 2002. The economic and social burden of malaria. Nature 415: 680-685.

Snow, R. W. et al. 1999. Malaria mortality, morbidity and disability in Africa. Bull. World Health Organ. 77(8): 624-640.

Spencer, C. F. et al. 1947. Survey of plants for antimalarial activity. Lloydia 10: 145-174.

Steere, W. C. 1945. The botanical work of the *Cinchona* missions in South America. Science 101: 177, 178.

Taylor, N. 1945. *Cinchona* in Java. The story of quinine. Greenberg. New York, NY. 87 pp.

Wilson, S. M. 1991. Pandora's bite: mosquitoes and disease shaped the European conquest of the New World. Nat. Hist. Jly: 26--29.

SAW PALMETTO

Bennett, B. C. & J. R. Hicklin. 1998. Uses of saw palmetto (*Serenoa repens*, Arecaceae) in Florida. Econ. Bot 52(4): 381-393.

Braeckman, J. 1994. The extract of *Serenoa repens* in the treatment of benign prostatic hyperplasia: a multicenter open study. Current Therap. Res. 55: 776-785.

Foster, S. 1999. Saw palmetto: good news for men with prostate problems. Herbs for Health 3(6): 42-44.

ST. JOHN'S WORT

American Herbal Pharmacopoeia and Therapeutic Compendium. 1997. St. John's wort. Published as separately paged insert in HerbalGram No. 40.

Berman, J. 1999. Compound may hold key to the power of St.-John's-wort, studies show. Herbs for Health 3(6): 76.

Bombardelli, E. & P. Morazzoni. 1995. *Hypericum perforatum*. Fitoterapia 66(1): 43-68.

Ernst, E. 1995. St. John's wort: an anti-depressant? A systematic, criteria-based review. Phytomedicine 2: 67-71.

Hahn, G. 1992. *Hypericum perforatum* (St. John's wort) -- a medicinal herb used in antiquity and still of interest today. J. Naturopathic Med. 3(1): 94-96.

Hobbs, C. 1989. St. John's wort: a review. HerbalGram 18/19: 24-33.

Hobbs, C. 1997. St. John's wort: the mood enhancing herb. Botanica Press. Loveland, CO. 176 pp.

Hobbs, C. 1997. St. John's wort: the mood enhancing herb. Interweave Press. 96 pp.

Hypericum Depression Trial Study Group. 2002. Effects of *Hypericum perforatum* (St. Johns wort) in major depression disorders: a randomized controlled trial. J. American Med. Assoc. 287(14): 1807-814.

Miller, S. 1997. A natural mood booster. Newsweek 129(18): 74, 75.

Rosenthal, N. 1998. St. John's wort: the herbal way to feeling good. HapperCollins. New York, NY 235 pp.

Sirvent, T. M. et al. 2002. Variation in hyoericins from wild populations of *Hypericum perforatum* L. in the Pacific northwest of the U. S. A. Econ. Bot. 56(1): 41-48.

Vickery, A. R. 1981. Traditional uses and folklore of *Hypericum* in the British Isles. Econ. Bot. 35(3): 289-295.

TEA

Imai, K. & K. Nakchi. 1995. Cross sectional study of effects of drinking green tea on cardiovascular and liver disease. British Medical J. 310: 693-696.

Ji, B. T. et al. 1997. Green tea consumption and the risk of pancreatic and colorectal cancers. International J. Cancer. 70: 255-258.

Knight, J. 1998. Reading the tea leaves: green tea provides clues to preventing cancer, heart disease and more. Herbs for Health 3(2): 40-45.

Leigh, E. 1997. Green and black teas show antioxidant activity. HerbalGram 41: 20.

Maity, S. et al. 1995. Acute-ulcer effect of the hot water extract of black tea (*Camellia sinensis*). J. Ethnopharm. 46(3): 167-174.

Oppliger, P. 1997. Green tea: the delicious everyday health drink. C. W. Daniel. Essex, England. 96 pp.

Snow, J. 1995. Herbal monograph: *Camellia sinensis* (L.) Kuntze (Theaceae). Protocol J. Bot. Med. 1: 47-51.

VALERIAN

Foster, S. 1990. Valerian: *Valeriana officinalis*. American Bot. Council. Austin, TX. 8 pp.

Foster, S. 1998. Calm down. Valerian offers mild relief from insomnia, anxiety. Herbs for Health 2(6): 40-43.

Hobbs, C. 1990. Valerian: a literature review. HerbalGram 21: 19-34.

Morrazzoni, P. & E. Bombardelli. 1995. *Valeriana officinalis*: traditional use and recent evaluation of activity. Fitotherapia 66(2): 99-112.

WILD YAMS

Applezweig, N. 1977. *Dioscorea* -- the pill crop. In, Seigler, D. S. (editor). Crop resources. Academic Press. New York, NY. Pp. 149-164.

Correll, D. S. et al. 1955. The search for plant precursors of cortisone. Econ. Bot. 9(4): 307-375.

Martin, F. W. 1969. The species of *Dioscorea* containing sapogenin. Econ. Bot. 23: 373-379

11: PSYCHOACTIVE PLANTS

GENERAL REFERENCES

Altman, J. et al. 1996. The biological, social and clinical bases of drug addiction: commentary and debate. Psychopharmacology 125: 285-.

Ashton, H. 1992. Brain function and psychotropic drugs. Oxford Univ. Press. New York, NY. 426 pp.

Austin, G. A. 1979. Perspectives on the history of psychoactive substance use. Res. Issues Nat. Inst. Drug Abuse 27: 1-280.

Barinaga, M. 1992. Pot, heroin unlock new areas of neuroscience. Science 258: 1882, 1884.

Barre, W. L. 1988. Old and New World hallucinogens. Rev. Acad. Colombia Ciencias Exp. 16(63): 91-98.

Barron, F. et al. 1964. The hallucinogenic drugs. Sci. Amer. 210(4): 29-37.

Bibra, E. von. 1855. Die narkotischen Genussmittel und der Mensch. W. Schmidt. Nuremberg, Germany. Reprinted in 1955, with additional explanatory test, as "Plant Intoxicants" by Healing Arts Press. Rochester, VT. 269 pp.

Brecher, E. M. & Editors of Consumer Reports. 1972. Licit and illicit drugs. Little, Brown & Co. Boston, MA. 623 pp.

Brown, F. C. 1972. Hallucinogenic drugs. Thomas. Springfield, IL. 154 pp.

Brown, J. K. & M. H. Malone. 1978. Legal highs -- constituents, activity toxicology, and herbal folklore. Clin. Toxicol. 12(1): 1-31.

Buckley, W. F., Jr. et al. 1996. The war on drugs is lost. Nat. Rev. 48(2): 34-48.

Burnham, J. C. 1993. Bad habits. Drinking, smoking, taking drugs, gambling, sexual misbehavior, and swearing in American history. New York Univ. Press. New York, NY. 385 pp.

Clouet, D. H. 1971. Narcotic drugs. Biochemical Pharmacology. Plenum. New York, NY. 506 pp.

Courtwright, D. T. 2001. Forces of habit: drugs and the making of the modern world. Harvard Univ. Press. Cambridge, MA. 288 pp.

Davenport-Hines, R. T. P. 2002. The pursuit of oblivion: a global history of narcotics. W. W. Norton. New York, NY. 576 pp.

Davis, W. 1998. Plants of the gods. In, Shadows in the sun: travels to landscapes of spirit and desire. Island Press. Washington, D. C. Pp. 155-168.

DeKorne, J. 1994. Psychedelic shamanism. Loompanics Unlimited. Port Townsend, WA.

Der Marderosian, A. 1967. Hallucinogenic indole compounds from higher plants. Lloydia 30(1): 23-38.

De Smet, P. A. G. M. 1996. Some ethnopharmacological notes on African hallucinogens. J. Ethnopharm. 50(3): 141-146.

Efron, D. H., B. Holmstedt, & N. S. Kline (editors). 1969. Ethnopharmacologic search for psychoactive drugs. Raven Press. New York, NY. 468 pp.

Emboden, W. A. 1979. Narcotic Plants. Revised and enlarged. Macmillan Co. New York, NY. 206 pp.

Farnsworth, N. R. 1968. Hallucinogenic plants. Science 162: 1086-1092.

Furst, P. T. 1972. Flesh of the gods. The ritual use of hallucinogens. Praeger Publ. New York, NY. 304 pp.

Furst, P. T. 1976. Hallucinogens and culture. Chandler & Sharp. San Francisco, CA. 194 pp.

Gjerstad, G. 1972. Naturally occurring hallucinogens. Qtr. J. Crude Drug Res. 12: 1849-1864.

Goldstein, A. 1994. Addiction: from biology to drug policy. W. H. Freeman. New York, NY.

Goodman, J. 1995. Excitantia: or, how Enlightenment Europe took to soft drugs. In, Goodman, J. et al.

(editors). Consuming habits. Routledge. London, England. Pp. 126-147.

Goodman, J., P. E. Lovejoy, & A. Sherratt. 1995. Consuming habits: drugs in history and anthropology. Routledge. London, England. 244 pp.

Grinspoon, L. & J. B. Bakalar. 1997. Psychedelic drugs reconsidered. Reprint of the 1979 edition. Lindesmith Center. New York, NY. 385 pp.

Haard, R. & K. Haard. 1977. Poisonous and hallucinogenic mushrooms. Cloudburst Press. Mayne Island and Seattle, WA. 126 pp.

Harner, M. J. (editor). 1973. Hallucinogens and shamanism. Oxford Univ. Press. New York, NY. 200 pp.

Heim, R. 1963. Champignons toxiques et hallucinogenes. N. Boubee & Cie. Paris, France.

Heizer, R. F. 1944. The use of narcotic mushrooms by primitive peoples. Ciba Symposium 5: 1713-16.

Hoffer, A. & H. Osmund. 1967. The hallucinogens. Academic Press. New York, NY. 626 pp.

Hofmann, A. 1961. Chemical, pharmacological and medical aspects of psychotomimetics. J. Exp. Med. Sci. 5: 31-51

Hofmann, A. 1967. Psychoaktive Stoffe aus Pflanzen. Therapie Woche 17: 1739-1746.

Hofmann, A. 1970. Struktur und Synthese der Halluzinogene. J. Mond. Pharm. 3: 187-205.

Holmstedt, B. & R. E. Schultes. 1989. Inebriantia: an early interdisciplinary consideration of intoxicants and their effects on man. Bot. J. Linnean Soc. 101(2): 181-198.

Jacobs, B.L. 1987. How hallucinogenic drugs work. American Sci. 75: 386-392.

Kilham, C. 2001. Psyche delicacies: coffee, chocolate, chiles, kava, and cannabis, and why they're good for you. Rodale. 221 pp.

Krane, B. D. & M. Shamma. 1982. The isoquinoline alkaloids. J. Nat. Prod. 45: 377-384.

LaBarre, W. 1970. Old and New World narcotics: a statistical question and an ethnological reply. Econ. Bot. 24: 73-80.

La Barre, W. 1975. Anthropological perspectives on hallucination and hallucinogens. In, Siegel, R. K. & L. J. West (editors). Hallucinations, behavior, experience, and theory. John Wiley. New York, NY. Pp. 9-52.

Lemonick, M. D. 1997. The mood molecule (serotonin). Time 150(13): 75-82.

Leshner, A. I. 1997. Addiction is a brain disease, and it matters. Science 278: 45, 46.

Lewin, L. 1998. Phantastica. Translated from the second German edition (1927) by P. H. A. Wirth. Pzark Street Press. Rochester, VT. 288 pp.

Lincoff, G. & D. H. Mitchel. 1977. Toxic and hallucinogenic mushroom poisoning: a handbook for physicians and mushroom hunters. Van Nostrand Reinhold, New York, NY. 267 pp.

McKenna, D. J. 1995. Bitter brews and other abominations: the uses and abuses of some little-known hallucinogenic plants. Integration 5: 99-104.

McKenna, D. J. & G. H. N. Towers. 1984. Biochemistry and pharmacology of tryptamines and beta-carbolines: a minireview. J. Psychoactive Drugs 16(4): 347-358.

McKenna, T. 1992. Food of the gods. The search for the original tree of knowledge: a radical history of plants, drugs, and human evolution. Bantam Books. New York, NY. 311 pp.

McKenna, T. 1993. True hallucinations: being an account of the author's extraordinary adventures in the devil's paradise. HarperCollins. New York, NY. 237 pp.

Morgan, A. 1995. Toads and toadstools. Celestial Arts. Berkeley, CA. 208 pp.

Nash, J. M. 1997. Addiction. Time. 149(18): 68-72; 74; 76.

Neese, R. M. & K. C. Berridge. 1997. Psychoactive drug use in evolutionary perspective. Science 278: 63-66.

Ott, J. 1993. Pharmacotheon: entheogenic drugs, their plant sources and history. Natural Products Co. Kennewick, WA. 639 pp.

Ott, J. 1997. Pharmacophilia or the natural paradises. Natural Products Co. Kennewick, WA. 191 pp.

Ott, J. 1998. The delphic bees: bees and toxic honey as pointers to psychoactive and other medicinal plants. Econ. Bot. 52(3): 260-266.

Palmer, C. & M. Horowitz (editors). 1982. Shaman woman, mainline lady: women's writings on the drug experience. William Morrow. New York, NY.

Perrine, D. M. 1996. The chemistry of mind-altering drugs: history, pharmacology, and cultural context. American Chemical Society. Washington, D. C. 480 pp.

Porter, R. & M. Teich (editors). 1995.Drugs and narcotics in history. Cambridge Univ. Press. Cambridge, England. 227 pp.

Riedlinger, T. J. (editor). 1990. The sacred mushroom hunter: essays for R. Gordon Wasson. Dioscorides Press. Portland, OR. 303 pp.

Rios, M. D. de. 1975. Man, culture and hallucinogens: an overview. In, Rubin, V. (editor). Cannabis and culture. Mouton Publ. The Hague. Pp. 401-438.

Rudgley, R. 1994. Essential substances: a cultural history of intoxicants. Kodansha International. New York, NY. 196 pp.

Russo, E. 2001. Handbook of psychotropic herbs. Haworth Press. Binghamton, NY. 352 pp.

Schultes, R. E. 1966. The search for new natural hallucinogens. Lloydia 29: 293-308.

Schultes, R. E. 1967. The place of ethnobotany in the ethnopharmacologic search for psychotomimetic drugs. In, Efron, D. H. (editor). Ethnopharmacologic search for psychoactive drugs. Public Health Service Pub. 1645. Pp. 33-58.

Schultes, R. E. 1969. Hallucinogens of plant origin. Science 163: 245-254.

Schultes, R. E. 1969-70. The plant kingdom and hallucinogens. Bull. on Narcotics. Part I. 21: 3-16. Part II. 21: 15-27. Part III. 22: 25-.

Schultes, R. E. 1970. The botanical and chemical distribution of hallucinogens. Ann. Rev. of Plant Physiol. 21: 571-598.

Schultes, R. E. 1975. Present knowledge of hallucinogenically used plants: a tabular study. Recent Adv. Phytochem. 9: 1-28.

Schultes, R. E. 1976. Hallucinogenic plants. Golden Press. New York, NY. 160 pp.

Schultes, R. E. 1976. Indole alkaloids in plant hallucinogens. Planta Medica 29: 330-342.

Schultes, R. E. 1979. Hallucinogenic plants: their earliest botanical descriptions. J. Psychedelic Drugs. 11(1-2): 13-24.

Schultes, R. E. 1988. Where the gods reign: plants and peoples of the Colombian Amazon. Synergetic Press. Oracle, AZ. 306 pp.

Schultes, R. E. 1993. The virgin field in psychoactive plant research. Ethnobot. 5(1/2): 5-61.

Schultes, R. E. 1996. The plant kingdom -- a theasurus of biodynamic constituents. Ethnobotany 8(1 & 2): 2-13.

Schultes, R. E. & N. R. Farnsworth. 1982. Ethnomedical, botanical, and phytochemical aspects of natural hallucinogens. Bot. Mus. Leaflets. 28: 123-214.

Schultes, R. E. & A. Hofmann. 1980. The botany and chemistry of hallucinogens. Revised and enlarged second edition. C. C. Thomas. Springfield, IL. 437 pp.

Schultes, R. E., A. Hofmann, & C. Rätsch. 2001. Plants of the gods: their sacred, healing, and hallucinogenic powers. Second edition. Healing Arts Press. Rochester, VT. 208 pp.

Seymour, R. & D. E. Smith. 1987. Guide to psychoactive drugs. Harrington Park Press. New York, NY.

Siegel, R. K. 1977. Hallucinations. Sci. American 237(4): 132-140.

Siegel, R. K. 1984. The natural history of hallucinogens. In, Jacobs, B. L. (editor). Hallucinogens: neurochemical, behavorial, and clinical perspectives. Raven Press. New York, NY. Pp. 1-18.

Siegel, R. K. 1989. Intoxication: life in pursuit of artificial paradise. E. P. Dutton. New York, NY. 390 pp.

Siegel, R. K. & L. J. West. 1975. Hallucinations, behavior, experience, and theory. John Wiley. New York, NY.

Smith, A. H. 1977. Comments on hallucinogenic agarics and the hallucinations of those who study them. Mycologia 69: 1196-1200.

Smith, H. 2000. Cleansing the doors of perception: the religious significance of entheogenic plants and chemicals. Penguin Putnam. New York, NY. 173 pp.

Stafford, P. 1992. Psychedelics encyclopedia. Third expanded edition. Ronin Publ. Co. Berkeley, CA. 420 pp.

Starks, M. 1981. The fabulous illustrated history of psychoactive plants. Loompanics Unlimited. Mason, MI. 194 pp.

Svendsen, A. B. 1985. Hallucinogenic substances in plants and the analysis of them. Norv. Pharm. Acta 47: 37-50.

Szasz, T. 1975. Ceremonial chemistry: the ritual persecution of drugs, addicts, and pushers. Doubleday/Anchor. Garden City, NY. 243 pp.

Taylor, N. 1963. Narcotics: nature's dangerous gifts. Dell Publishing Co. New York, NY. 212 pp.

Tyler, V. E., Jr. 1966. The physiological properties and chemical constituents of some habit-forming plants. Lloydia 29(4): 275-292.

Wasson, R. G., A. Hoffman, & C. Ruck. 1978. The road to Eleusis. Harcourt Brace Jovanovich. New York, NY.

Weil, A. T. 1969. Nutmeg and other psychoactive groceries. In, J. E. Gunckel (editor). Current topics in plant science. Academic Press. New York, NY. Pp. 355-366.

Weil, A. T. 1986. The natural mind: a new way of looking at drugs and the higher consciousness. Revised edition. Houghton Mifflin. Boston, MA.

Weil, A. & W. Rosen. 1993. From chocolate to morphine: everything you need to know about mind-altering drugs. Revised and updated. Houghton Mifflin. Boston, MA. 240 pp.

Wickelgren, I. 1997. Getting the brain's attention. Science 278: 35-37.

Wilson, S. M. 1993. Coffee, tea, or opium? Nat. Hist. 102(11): 74-79.

OLD WORLD PLANTS

GENERAL REFERENCES

Harner, M. J. 1974. The role of hallucinogenic plants in European witchcraft. In, Harner, M. J. (editor). Hallucinogens and shamanism. Oxford Univ. Press. New York, NY. Pp. 125-150.

Li, H.-L. 1977. Hallucinogenic plants in Chinese herbals. Bot. Mus. Leaflts. Harvard Univ. 25: 161-181.

Peeters, A. 1968. Les plantes masticatoires d'Australie. JATBA 15: 157-171.

Smet, P. A. G. M. de. 1996. Some ethnopharmacological notes on African hallucinogens. J. Ethnopharm. 50(3): 141-146.

Vossen, H. M. van der & M. Wessel (editors). 2000. Plant resources of South-East Asia. No. 16. Stimulants. Backhuys Publ. Leiden. 201 pp.

Winkelman, M. & M. Dobkin de Rios. 1989. Psychoactive properties of !Kung Bushman medicine medicine plants. J. Psychoactive Drugs 21(1): 51-60.

OPIUM AND THE OPIATES

Africa, T. W. 1961. The opium addiction of Marcus Aurelius. J. Hist. Ideas 22: 97-102.

Bernáth, J. 1998. Poppy: the genus *Papaver*. Harwood Acad. Publ. 352 pp.

Berridge, V. & G. Edwards. 1981. Opium and the people: opiate use in nineteenth century England. Allen Lane. London, England.

Booth, M. 1998. Opium: a history. St. Martin's Press. New York, NY. 381 pp.

Courtwright, D. T. 1982. Dark paradise: opiate addiction in America before 1940. Harvard Univ. Press. Cambridge, MA. 000 pp.

Courtwright, D. T. 1983. The hidden epidemic: opiate addiction and cocaine use in the South, 1860-1920. J. Southern Hist. 49: 57-72.

Courtwright, D. T. 2001. Dark paradise: a history of opiate addiction in America. Harvard Univ. Press. Cambridge, MA. 320 pp.

Dessaint, A. Y. 1972. The poppies are beautiful this year. Nat. Hist. 81(2): 31-36; 92, 93; 95, 96.

Duke, J. A. 1973. Utilization of *Papaver*. Econ. Bot. 27: 390-400.

Duke, J. A. et al. 1973. Annotated bibliography on opium and Oriental poppies and related species. Agric. Res. Service. U. S. D. A. Beltsville, MD. 349 pp.

Durlacher, J. 2000. Heroin: its history and lore. Carlton Books, London, U. K. 96 pp.

Fay, P. W. 1997. The opium war. Univ. North Carolina Press. Chapel Hill. 406 pp.

Grove, M. D. 1976. Morphine and codeine in the poppy seed. J. Agric. and Food Chem. 24: 896, 897.

Hayter, A. 1968. Opium and the romantic imagination. Univ. California Press. Berkeley. 388 pp.

Inglis, B. 1976. The Opium War. Hodder & Stroughton. London, England. 223 pp.

Kapoor, L. D. 1995. Opium poppy: botany, chemistry, and pharmacology. Food Products Press. New York, NY. 326 pp.

Kramer, J. C. 1979. Opium rampant: medical use, misuse and abuse in Britain and the West in the 17th and 18th centuries. British J. Addiction 74: 377-389.

Kramer, J. C. 1980. The opiates: two centuries of scientific study. J. Psyched. Drugs 12: 89-103.

Krikorian, A. D. & M. C. Ledbetter. 1975. Some observations on the cultivation of opium poppy (*Papaver somniferum* L.) for its latex. Bot. Rev. 41(1): 30-103.

Lamour, C. & M. R. Lamberti. 1974. The Second Opium War. Allen Lane. London, England.

Latimer, D. & J. Goldberg. 1981. Flowers in the blood. The story of opium. Franklin Watts. New York, NY. 306 pp.

Levinthal, C. F. 1985. Milk of paradise/milk of hell -- the history of ideas about opium. Persp. Biol. and Med. 28(4): 561-577.

Merlin, D. M. 1984. On the trail of the ancient opium poppy. Fairleigh Dickinson Univ. Press. Cranbury, NJ. 324 pp.

Musto, D. F. 1991. Opium, cocaine, and marijuana in American history. Sci. Amer. 265(1): 40-47.

Newsinger, J. 1997. Britain's opium wars. Monthly Review 49: 35-42.

Nyman, U. & J. G. Bruhn. 1979. *Papaver bracteatum*: a summary of current knowledge. Plant Medica 35: 97-117.

Palevitch, D. & A. Levy. 1990. Domestication of *Papaver bracteatum* as a source of thebaine. Acta Hort. 306: 33-52.

Pollan, M. 1997. Opium made easy. One gardener's encounter with the war on drugs. Harper's 294(1763): 35-58.

Schmitz, R. 1985. Fredrich Wilhelm Sertürner and the discovery of morphine. Pharm. in Hist. 27: 61-74.

Scott, J. M. 1969. The white poppy: a history of opium. Funk & Wagnalls. New York, NY. 000 pp.

Snyder, S. H. 1977. Opiate receptors and internal opiates. Sci. American 236(3): 44-56.

Tétényi, P. 1997. Opium poppy (*Papaver somniferum*): botany and horticulture. Hort. Rev. 19: 373-408.

Theuns, H. G. et al. 1986. Search for new natural sources of morphinans. Econ. Bot. 40(4): 485-497.

Westermeyer, J. 1982. Poppies, pipes, and people: opium and its use in Laos. Univ. California Press. Berkeley.

MARIJUANA

Abel, E. L. 1971. Marihuana and memory: acquisition or retrieval? Science 173: 1038-1040.

Abel, E. L. 1971. Effects of marihuana on the solution of anagrams, memory, and appetite. Nature 231: 260, 261.

Abel, E. L. 1979. A comprehensive guide to the *Cannabis* literature. Greenwood Press. Westport, CT. 699 pp.

Abel, E. L. 1980. Marihuana: the first twelve thousand years. Plenum Press. New York, NY. 289 pp.

Abel, E. L. 1981. Marihuana and sex: a critical survey. Drug Alcohol Depend. 8: 1-22.

Abel, E. L. 1970. Marihuana and memory. Nature 227: 1151, 1152.

Abel, E. L. 1976. The scientific study of marihuana. Nelson-Hall. Chicago, IL. 302 pp.

Adams, I. B. & B. R. Martin. 1996. Cannabis: pharmacology and toxicology in animals and humans. Addiction 9: 1585-1614.

Agurell, S. T. et al. 1984. The cannabinoids. Chemical, pharmacologic, and therapeutic aspects. Academic Press. Orlando, FL. 909 pp.

Andrews, G. & S. Vinkenoog (editors). 1967. The book of grass: an anthology on Indian hemp. Grove Press. NY. 242 pp.

Ball, J. C. et al. 1968. The association of marijuana-smoking with opiate addiction in the United States. J. Criminal Law 59: 171-182.

Barinaga, M. 2001. How cannabinoids work in the brain. Science 291: 2530, 2531.

Bates, M. N. & T. A. Blakely. 1999. Role of cannabis in motor vehicle crashes. Epidermiological Rev. 21: 222-232.

Baudelaire, C. 1950. The poem of hashish. In, My heart laid bare and other prose writings. Weidenfeld & Nicholson. London, England. Pp. 75-123.

Bennett, C., L. Osburn, & J. Osburn. 1995. Green gold the tree of life: marijuana in magic and religion. Access Unlimited. Frazier Park, CA. 485 pp.

Bernstein, J. G. 1980. Marijuana -- new potential, new problems. Drug Therapy 10(12): 38-48.

Bey, D. R. & V. A. Zeccinelli. 1971. Marihuana as a coping device in Vietnam. Military Med. 136(5): 448-450.

Bialos, D. S. 1970. Adverse marijuana reactions: a critical examination of the literature with selected case material. American J. Psychiatry 127: 819-823.

Bloom, A. S. 1985. Cannabinoids and neurotransmitter receptors. Brain Res. 235: 370-375.

Boire, R. G. 1993. Marijuana law. Ronin Publ. Berkeley, CA. 171 pp.

Bromberg, W. 1934. Marihuana intoxication: a clinical study of *Cannabis sativa* intoxication. American J. Psychiatry 91: 303-330.

Bromberg, W. 1939. Marihuana, a psychiatric study. J. American Med. Assoc. 113: 4-12.

Brown, D. T. 1998. Non-medical uses of Cannabis sativa. In, Brown, D. T. Pp. 115-124.

Brown, D. T. 1998. Cannabis: the genus *Cannabis*. Harwood Acad. Publ. Amsterdam, The Netherlands. 286 pp.

Brown, D. T. 1998. Non-medical uses of *Cannabis sativa*. In, Brown, D. T. Pp. 115-124.

Brown, D. T. 1998. The therapeutic potential for cannabis and its derivatives. In, Brown, D. T. Pp. 175-222.

Brownell, G. S. 1988. Marijuana and the law in California: a historical and political overview. J. Psychoactive Drugs 20(1): 71-74.

Brunner, T. F. 1977. Marijuana in ancient Greece and Rome? The literary evidence. J. Psychedelic Drugs 9(3): 221-225.

California Narcotic Officer's Association. 1999. Position paper: use of marijuana as "medicine." Available at: http://www/cnoa.org/marijuana.html

Campbell, A. M. G. et al. 1971. Cerebral atrophy in young *Cannabis* smokers. The Lancet II: 1219-1226.

Carlson, B. R. & W. H. Edwards. 1990. Human values and marijuana use. Intern. J. Addictions 25: 1393-1401.

Casto, D. M. 1970. Marijuana and the assassins – an etymological investigation. Int. J. Addictions 5: 747-757.

Chopra, G. S. 1969. Man and marihuana. Inter. J. Addict. 4: 215-247.

Chopra, I. C. & R. N. Chopra. 1957. The use of *Cannabis* drugs in India. Bull. on Narcotics 9(1): 4-29.

Chopra, G. S. 1971. Marihuana and adverse psychotic reactions. U. N. Bull. on Narcotic 23(3): 15-22.

Clarke, R. C. 1977. The botany and ecology of *Cannabis*. Pods Press. Ben Lomond, CA.

Clarke, R. C. 1998. Hashish! Red Eye Press. Los Angeles, CA. 387 pp.

Cloud, J. 2002. This bud's not for you. Time 159(7): 60, 61.

Co, B. Et al. 1977. Absence of cerebral atrophy in chronic cannabis users by computerized transaxial tomography. J. American Med. Assoc. 237: 1229, 1230.

Colbach, E. 1971. Marijuana use by GIs in Viet Nam. American J. Psychiatry 128: 204-207.

Connell, P. H. & N. Dorn (editors). 1975. Cannabis and man: psychological and clinical aspects and patterns of use. Churchill Livingstone. Edinburgh, Scotland. 236 pp.

Conrad, C. 1994. Hemp: lifeline to the future. Creative Xpressions Publ. Los Angeles, CA. 312 pp.

Crancer, A. et al. 1969. Comparison of the effects of marijuana and alcohol on simulated driving performance. Science 164: 851-854.

Deahl, M. 1991. Cannabis and memory loss. British J. Addict. 86: 249-252.

Devane, W. A. et al. 1992. Isolation and structure of a brain constituent that binds the cannabinoid receptor. Science 258: 1946-1949.

Dewey, W. L. 1986. Cannabinoid pharmacology. Pharmac. Rev. 38(2): 151-178.

Doorenbos, N. J. et al. 1971. Cultivation, extraction, and analysis of *Cannabis sativa* L. Annals New York Acad. Sci. 191: 3-14.

Dornbush, R. L. et al. 1971. Marihuana, memory and perception. American J. Psychiatry 128(2): 194-197.

Drake, B. 1970. The cultivator's handbook of marijuana. First edition (revised). Publ. by the author. 91 pp.

Earleywine, M. 2002. Understanding marijuana: a new look at the scientific evidence. Oxford Univ. Press. New York, NY. 326 pp.

Emboden, W. A. 1974. *Cannabis* -- a polytypic genus. Econ. Bot. 28: 304-310.

Emboden, W. A. 1972. Ritual use of *Cannabis sativa* L.: a historical-ethnographic survey. In, Furst, P. T. (editor). Flesh of the gods. Praeger. New York, NY. Pp. 214-236.

Emboden, W. A. 1981. The genus *Cannabis* and the cor-rect use of taxonomic categories. J. Psychoactive Drugs 13(1): 15-21.

Erdolu, C. et al. 1985. The effects of marihuana and tranquilizers on male sexual functions. Bull. Gulhane Mil. Med. Acad. 27: 77-82.

Farnsworth, N. R. 1969. Pharmacognosy and chemistry of *Cannabis sativa*. J. American Pharm. Assoc. NS9: 410-440.

Frazier, J. 1991. The great American hemp industry. Solar Age Press. Peterstown, WV. 110 pp.

Fullerton, D. W. 1975. Winning strategies for defense of marijuana cases: chemical and botanical issues. Natl. J. Criminal Def. 1: 487-543.

Fullerton, D. W. & M. G. Kurtzman. 1974. The identification and misidentification of marijuana. Contemp. Drug Problems Fall: 291-344.

Gieringer, D. H. 1988. Marijuana, driving, and accident safety. J. Psychoactive Drugs 20(1): 93-101.

Godwin, H. 1967. The ancient cultivation of hemp. Antiquity 41: 42-50; 137, 138.

Graham, J. D. P. (editor). 1976. Cannabis and health. Academic Press. New York, NY. 428 pp.

Grinspoon, L. 1971. Marihuana reconsidered. Harvard Univ. Press. Cambridge, MA. 443 pp.

Grinspoon, L. 1969. Marihuana. Sci. American 221(6): 17-25.

Grinspoon, L. et al. 1997. Marijuana addiction (letter). Science 277: 750.

Grinspoon, L. & J. B. Bakalar. 1993. Marihuana, the forbidden medicine. Yale Univ. Press. New Haven, CT. 296 pp.

Grotenhermen, F. & E. Russo (editors). 2002. Cannabis and cannabinoids: pharmacology, toxicology, and therapeutic potential. Haworth Press. Binghampton, NY. 000 pp.

Halikas, J. A. et al. 1971. Marihuana effects: a survey of regular users. J. American Med. Assoc. 217: 692-694.

Halikas, J. A. et al. 1982. Effects of regular marijuana use on sexual performance. J. Psychoactive Drugs 14(1-2): 59-70.

Haun, J. 1997. Medical marijuana. Osprey (Humboldt State Univ.) Spring: 24, 25; 29.

Herner, J. 1990. Hemp & the marijuana conspiracy: the emperor wears no clothes. Hemp Publ. Co. Van Nuys, CA. 181 pp.

Hoffmann, D. et al. 1975. On the carcinogenicity of marijuana smoke. Recent Adv. Phytochem. 9: 63-81.

Hollister, L. E. 1986. Health aspects of Cannabis. Pharm. Rev. 38(1): 1-20.

Hollister, L. E. 1992. Marijuana and immunity. J. Psychoactive Drugs 24: 159-164.

Hornback, R. 1986. *Cannabis*: botanical black sheep. Pacific Horticulture. 48(2): 50-55.

Howlett, A. C. 1995. Pharmacology of cannabinoid receptors. Ann. Rev. Pharm. & Toxicol. 35: 607-634.

Iversen, L. L. 2000. The science of marijuana. Oxford Univ. Press. New York, NY. 283 pp.

Johnson, S. & E. F. Domina. 1971. Some cardiovascular effects of marihuana smoking in normal volunteers. Clinical Pharm. and Therap. 12(5): 762-768.

Jones, R. T. 1983. *Cannabis* and health. Ann. Rev. Med. 34: 247-258.

Joyce, C. R. B. & S. H. Curry (editors). 1970. The botany and chemistry of *Cannabis*. Churchill. London, England. 218 pp.

Kabelik, J. et al. 1960. *Cannabis* as a medicament. U. N. Bull. on Narcotics 12(3): 5-23.

Kalant, H. 1969. Marihuana and simulated driving. Science 166: 640.

Kandel, D. 1973. Adolescent marijuana use: role of parents and peers. Science 181: 1067-1070.

Keeler, M. H. & C. B. Reifler. 1967. Grand mal convulsions subsequent to marihuana use. Dis. Central Nerv. Syst 28: 474, 475.

Kleiman, M. A. 1989. Marijuana: costs of abuse, costs of control. Greenwood Press. Westport, CT. 197 pp.

Kolansky, H. & W. T. Moore. 1971. Effects of marijuana on adolescents and young adults. J. American Med. Assoc. 216(3): 486-492.

Li, H.-L. 1974. The origin and use of *Cannabis* in eastern Asia: linguistic-cultural implications. Econ. Bot. 28: 293-301.

Li, H.-L. 1974. An archaeological and historical account of *Cannabis* in China. Econ. Bot. 28: 437-448.

Ludlow, F. H. 1857. The hashish eater: being passages from the life of a Pythagorean. Harper & Bros. New York, NY. 371 pp.

Lutz, E. G. 1979. Marijuana and paranoid disperception. J. Med. Soc. New Jersey 76(4): 253-259.

MacCoun, R. & P. Reuter. 1997. Interpreting Dutch cannabis policy: reasoning by analogy in the legalization debate. Science 278: 47-52.

Malingré, T. et al. 1975. The essential oil of *Cannabis sativa*. Planta Med. 28: 56-61.

Mason, A. P. & A. J. MacBay. 1985. Cannabis: pharmacology and interpretation of effects. J. Forensic Sci. 30(3): 615-631.

Masood, E. 1998. Cannabis laws 'threaten validity of trials.' Nature 396: 206.

Maykut, M. 1984. Health consequences of acute and chronic marihuana use. Pergamon Press. New York, NY. 328 pp.

Mechoulam, R. 1973. Marijuana. Chemistry, pharmacology, metabolism and clinical effects. Academic Press. New York, NY. 410 pp.

Mechoulam R. 1995. Pharmacology of cannabinoid receptors. Ann. Rev. Pharm. Toxicol. 35: 607-634.

Mechoulam, R. (editor). 1986. Cannabinoids as therapeutic agents. CRC Press. Boca Raton, FL. 186 pp.

Mendel, J. 1988. Is marijuana law enforcement racist? J. Psychoactive Drugs 20(1): 83-91.

Meng, I. D. et al. 1998. An analgesic circuit activated by cannabinoids. Nature 395: 381-383.

Meriwether, W. F. 1969. Acute marijuana toxicity in a dog. Vet. Med. 64: 577, 578.

Merlin, M. D. 1972. Man and marijuana. Some aspects of their ancient relationship. Fairleigh Dickinson Univ. Press. Cranbury, NJ. 120 pp.

Metzger, M. H. 1975. Notes on marijuana identification in criminal cases. Clin. Toxicol. 8(4): 465-473.

Miller, L. (editor). 1974. Marijuana: effects on human behavior. Academic Press. New York, NY. 468 pp.

Mirin, S. M. et al. 1971. Casual versus heavy use of marihuana: a redefinition of the marihuana problem. American J. Psychiatry 127: 1134-1140.

Musto, D. F. 1991. Opium, cocaine, and marijuana in American history. Sci. American 265(1): 40-47.

Musty, R. E. & L. Kaback. 1995. Relationship between motivation and depression in chronic marijuana users. Life Sci. 56: 2151-2158.

Myerscough, R. & S. Taylor. 1985. The effects of marijuana on human physical aggression. J. Personality and Social Psych. 49: 1541-1546.

Nahas, G. G. 1974. Marihuana: toxicity, tolerance, and therapeutic efficacy. Drug Ther. 4(1): 33-35; 38-39, 43, 46-47.

Nahas, G. G. 1973. Marihuana -- deceptive weed. Raven Press. New York, NY. 334 pp.

Nahas, G. G. 1976. Keep off the grass. A scientist's documented account of marijuana's destructive effects. Reader's Digest Press. New York, NY. 206 pp.

Nahas, G. G. 1982. Hashish and Islam: 9th to 18th century. Bull. New York Acad. Med. 58: 814-831.

Nahas, G. G. & C. Latour. 1992. The human toxicity of marijuana. Med. J. Australia 156: 495-497.

Nahas, G. G. & C. Latour (editors). 1993. Cannabis physiopathology, epidemiology, detection. CRC Press. Boca Raton, FL. 415 pp.

Nahas, G. G. & W. Paton (editors). 1979. Marihuana: biological effects. Pergamon Press. New York, NY. 777 pp.

Nahas, G. G. et al. 1976. Marijuana: chemistry, biochemistry, and cellular effects, Proceedings of a symposium, Matinkyla, Finland, July 1975. Springer Verlag. 556 pp.

Neumeyer, J. L. & R. A. Shagoury. 1971. Chemistry and pharmacology of marijuana. J. Pharm. Sci. 60: 1433-1457.

Novak, W. 1980. High culture: marijuana in the lives of Americans. A. A. Knopf. New York, NY. 289 pp.

Paris, M. et al. 1975. The constituents of *Cannabis sativa* pollen. Econ. Bot. 29: 245-253.

Paton, W. D. M. 1975. Pharmacology of marijuana. Ann. Rev. Pharmacol. Toxicol. 15: 191-220.

Paton, W. D. & J. Crown (editors). 1972. Cannabis and its derivatives. Pharmacology and experimental psychology. Oxford Univ. Press. Oxford, England. 198 pp.

Perna, D. 1969. Psychotogenetic effect of marihuana. J. American Med. Assoc. 209: 1085, 1086.

Peterson, R. C. (editor). 1972. Marihuana and health. Second annual report to Congress from the Secretary of Health, Education, and Welfare. U. S. Gov. Printing Office. Washington, D. C. 276 pp.

Phillips, G. F. 1998. Analytical and legislative aspects of cannabis. In, Brown, D. T. Pp. 71-113.

Pollan, M. 1995. How pot has grown. New York Times Magazine. 19 February: 30-35; 44, 50, 56, 57.

Pollan, M. 2001. Marijuana. In, The botany of desire. Random House. New York, NY. Pp. 59-110.

Pope, H. G., Jr. 2002. Cannabis, cognition, and residual confounding. J. American Med. Assoc. 287(9): 1172-174.

Pope, H. G. & D. Yurgelun-Todd. 1996. The residual cognitive effects of heavy marijuana use in college students. J. American Med. Assoc. 275(7): 521-527.

Price, M. A. P. & W. G. Notcutt. 1998. Cannabis and cannabinoids in pain relief. In, Brown, D. T. Pp. 223-246.

Quimby, M. W. et al. 1973. Mississippi-grown marihuana -- *Cannabis sativa*: its cultivation and morphological variations. Econ. Bot. 27: 117-127.

Rafaelsen, O. J. et al. 1973. Cannabis and alcohol: effects on simulated car driving. Science 179: 920-923.

Raman, A. & A. Joshi. 1998. The chemistry of cannabis. In, Brown, D. T. Pp. 55-70.

Raman, A. 1998. The cannabis plant: botany, cultivation and processing for use. In, Brown, D. T. Pp. 29-54.

Ritzlin, R. S. et al. 1979. Delta-9-tetrahydrocanninol levels in street samples of marijuana and hashish: correlation to user reactions. Clin. Tox. 15(1): 45-53.

Robbe, H. W. J. 1994. Influence of marijuana on driving. International Hemp Assoc. Amsterdam, The Netherlands. 232 pp.

Robinson, R. 1996. The great book of hemp: the complete guide to the environmental, commercial, and medicinal uses of the world's most extraordinary plant. Park Street Press. Rochester, VT. 247 pp.

Rosenthal, E. (editor). 1994. Hemp today. Quick American Archives. Oakland, CA. 444 pp.

Rosenthal, E. & S. Kubby. 2003. Why marijuana should be legal. Second edition. Thunder's Mouth Press. New York, NY. 174 pp.

Roulac, J. W. 1997. Hemp horizons: the comeback of the world's most promising plant. Chelsea Green Publ. White River Junction, VT. 211 pp.

Rubin, V. (editor). 1975. Cannabis and culture. Mouton Publ. The Hague. 598 pp.

Rubin, V. & L. Comitas. 1976. Ganga in Jamaica: the effects of marijuana use. Anchor Press. Garden City, NY.

Samler, R. T. et al. 1985. Illicit traffic and abuse of *Cannabis* in Canada. Bull. Narcotics 37(4): 37-49.

Schlosser, E. 1994. Marijuana and the law. Atlantic Monthly 274(3): 84-89.

Schlosser, E. 1994. Reefer madness. Atlantic Monthly 274(2): 45-63.

Schultes, R. E. 1970. Random thoughts and queries on the botany of *Cannabis*. In, Joyce & Curry. The botany and chemistry of Cannabis. Pp. 11-38.

Schultes, R. E. et al. 1974. *Cannabis*: an example of taxonomic neglect. Bot. Mus. Leaflts. Harvard Univ. 23: 337-367.

Schultes, R. E. 1973. Man and marijuana. Natural History 82(7): 58-63;80, 82.

Schwartz, R. H. 1987. Marijuana: a review. Pediatr. Clin. North Amer. 34(2): 305-317.

Seth, R. 1991. Chemistry and pharmacology of cannabis. Progr. Drug Res. 36: 71-115.

Sharma, G. K. 1979. Significance of eco-chemical studies of *Cannabis*. Science & Culture 45(8): 303-307.

Sherman, C. & A. Smith. 1999. Highlights: an illustrated history of cannabis.Ten Speed Press. Berkeley, CA. 159 pp.

Sloman, L. 1998. Reefer madness: a history of marijuana. St. Martin's Griffin. New York, NY. 173 pp.

Small, E. 1975. American law and the species problem in *Cannabis:* science and semantics. U. N. Bull. on Narcotics. 27: 1-20.

Small, E. 1975. On toadstool soup and legal species of marihuana. Plant Sci. Bull. 21: 34-39.

Small, E. et al. 1976. A numerical taxonomic analysis of *Cannabis* with special reference to species delimitation. Syst. Bot. 1(1): 67-84.

Small, E. et al. 1975. The evolution of cannabinoid phenotypes in *Cannabis*. Econ. Bot. 29: 219-232.

Small, E. & A. Cronquist. 1976. A practical and natural taxonomy for *Cannabis*. Taxon 25: 405-435.

Small, E. 1978. The species problem in *Cannabis:* science and semantics. Corpus. Two vols. Toronto, Canada. 218 pp. and 156 pp.

Small, E. 1976. The forensic taxonomic debate on *Cannabis:* semantic hokum. J. Forensic Sci. 21: 239-251.

Smith, D. E. & R. B. Seymour. 1998. Cannabis addiction and withdrawal: attitudes and implications. In, Brown, D. T. Pp. 247-252.

Smith, D. E. & R. B. Seymour. 1998. Cannabis addiction and withdrawal: attitudes and implications. In, Brown, D. T. Pp. 247-252.

Snyder, S. H. 1971. Uses of marijuana. Oxford Univ. Press. New York, NY. 128 pp.

Solowij, N. 1995. Do cognitive impairments recover following cessation of cannabis use? Life Sci. 56: 2119-2126.

Solowij, N. 1998. Cannabis and cognitive functioning. Cambridge Univ. Press. Cambridge, England.

Sommer, R. 1988. Two decades of marijuana attitudes: the more it changes, the more it stays the same. J. Psychoactive Drugs 20(1): 67-70.

Stephanis, C. et al. 1977. Hashish. Studies of long-term use. Raven Publ. New York, NY. 182 pp.

Thomas, H. 1993. Psychiatric symptoms in cannabis users. British J. Psychiat. 163: 141-149.

Thornton, J. I. & J. Nakamura. 1972. Identification of marijuana. J. Forensic Sci. 12: 461-519.

Tinklenberg, J. R. 1975. Marijuana and health hazards -- methodological issues in current research. Academic Press. New York, NY. 178 pp.

Trebach, A. & J. Inciardi. 1993. Legalize it? Debating American drug policy. American Univ. Press. Washington, D. C. 230 pp.

Turner, C. E. et al. 1980. Constituents of *Cannabis sativa* L. XVII. A review of the natural constituents. Lloydia 43(2): 169-234.

Valle, J. R. & N. P. Silva. 1973. Ichthyotoxicity of cannabinoids. Cienc. e Cult. 25: 647.

Wall, M. E. 1975. Recent advances in the chemistry and metabolism of the cannabinoids. Recent Adv. Phytochem. 9: 29-61.

Waller, C. W. et al. 1976. Marihuana: an annotated bibliography. Macmillan Information. New York, NY. 560 pp.

Warner, R. 1986. Invisible hand: the marijuana business. Wm. Morrow. New York, NY. 288 pp.

Weil, A. T. 1970. Adverse reactions to marijuana. New England J. Med. 282: 997-1000.

Weil, A. T. & N. E. Zinberg. 1969. Acute effect of marijuana on speech. Nature 222: 434-437.

Weil, A. T. et al. 1968. Clinical and psychological effects of marijuana in man. Science 162: 1234-1242.

Wickelgren, I. 1997. Marijuana: harder than thought? Science 276: 1967, 1968.

Wikler, A. 1970. Clinical and social aspects of marihuana intoxication. Arch. Gen. Psychiatry 23: 320-325.

Wills, S. 1998. Cannabis use and abuse by man: an historical perspective. In, Brown, D. T. Pp. 1-27.

Wills, S. 1998. Side effects of cannabis use and abuse. In, Brown, D. T. Pp. 253-277.

Wills, S. 1998. Cannabis use and abuse by man: an historical perspective. In, Brown, D. T. 1998. Pp. 1-27.

Wilson, R. I. & R. A. Nicoll. 2002. Endocannabinoid signaling in the brain. Science 296: 678-682.

World Health Organization. 1971. The use of cannabis. Tech. Rep. Series No. 478. World Health Organization. Geneva, Switzerland. 47 pp.

Wu, T.-C. et al. 1988. Pulmonary hazards of smoking marijuana as compared with tobacco. New England J. Med. 318(6): 347-351.

Wu, T.-Z. et al. 1988. Pulmonary hazards of smoking marijuana as compared with tobacco. New England J. Med. 318:

Zias, J. et al. 1993. Early medical use of cannabis. Nature 363: 215.

Zimmer, L. & J. P. Morgan. 1997. Marijuana myths, marijuana fact: a review of the scientific evidence. Lindesmith Center. New York, NY. 245 pp.

Zinberg, N. E. & A. T. Weil. 1970. A comparison of marijuana users and nonusers. Nature 226: 119-123.

Zinberg, N. E. 1976. The war over marijuana. Psychology Today. 10(7): 45-47; 51-52; 102; 104; 106.

FLY AGARIC (SOMA)

Arehart-Treichel, J. 1976. Hallucinations and illusion producing plants, fly agaric: an exotic toadstool trip. Science News 107: 77.

Crunwdell, E. 1987. The unnatural history of the fly agaric. Mycologist 1(4): 178-181.

Lowy, B. 1974. *Amanita muscaria* and the thunderbolt legend in Guatemala and Mexico. Mycologia 66: 188-191.

Ott, J. 1976. Psycho-mycological studies of *Amanita*: from ancient sacrament to modern phobia. J. Psychedelic Drugs 8(Jan-Mar): 27-35.

Riedlinger, T. J. 1993. Wasson's alternative candidates for soma. J. Psychoactive Drugs 25(2): 149-156.

Wasson, R. G. 1969. Soma - divine mushroom of immortality. Harcourt, Brace & Jovanovich. New York, NY. 381 pp.

Wasson, R. G. 1970. Soma of the Aryans: an ancient hallucinogen? Bulletin on Narcotics 22: 25-30.

Wasson, R. G. 1978. Soma brought up-to-date. Bot. Mus. Leaflts. Harvard Univ. 26(6): 211-223.

Wasson, R. G. 1979. Traditional use in North America of *Amanita muscaria* for divinatory purposes. J. Psychedelic Drugs 11(1-2): 25-31.

NUTMEG

Forrest, J. E. & R. A. Heacock. 1972. Nutmeg and mace, the psychotropic spices from *Myristica fragrans*. Lloydia 35: 440-449.

Green, R. C., Jr. 1959. Nutmeg poisoning. J. American Med. Assoc. 171: 1342-1344.

Joseph, J. 1981. The nutmeg: its botany, agronomy, production, composition, and uses. J. Plant Crops 8: 61-72.

Painter, J. C. et al. 1971. Nutmeg poisoning: a case report. Clin. Toxicol. 4: 1-4.

Payne, R. B. 1963. Nutmeg intoxication. New England J. Med. 269: 36-39.

Weil, A. T. 1965. Nutmeg as a narcotic. Econ. Bot. 19: 194-217.

Weil, A. T. 1966. The use of nutmeg as a psychotropic agent. Bull. Narcotics 18(4): 15-23.

Weil, A. T. 1969. Nutmeg and other psychoactive groceries. In, J. E. Gunckel (editor). Current Topics in Plant Science. Academic Press. New York. Pp. 355-366.

Weiss, G. 1960. Hallucinogenic and narcotic-like effects of powdered *Myristica* (nutmeg). Psychiatr. Quart. 34: 346-356.

Williams, E. Y. & F. West. 1968. The use of nutmeg as a psychotropic drug. Report on two cases. J. Nat. Med. Assoc. 60: 289-329.

KHAT

Brooke, C. 1960. Khat (*Catha edulis*): its production and trade in the Middle East. Geogr. J. 126: 52-59.

El-Guindy, M. K. et al. 1971. Effects of *Catha edulis* (khat) chewing on the human body. J. Egyptian Med. Assoc. 54: 230-234.

Giannini, A. J. et al. 1986. Khat: another drug of abuse? J. Psychoactive Drugs 18(2): 155-158.

Kalix, P. 1991. The pharmacology of psychoactive alkaloids from *Ephedra* and *Catha*. J. Ethnopharm. 32(1-3): 201-208.

Kalix, P. & O. Braenden. 1985. Pharmacological aspects of the chewing of khat leaves. Pharm. Rev. 37: 149-164.

Krikorian, A. D. 1984. Kat and its uses: an historical perspective. J. Ethnopharm. 12: 115-178.

Margelts, E. L. 1967. Mirea and myrrh in East Africa -- clinical notes about *Catha edulis*. Econ. Bot. 21: 358-362.

Nordal, A. 1980. Khat: pharmacognostical aspects. Bull. on Narcot. 32(3): 51-64.

Pantelis, C. et al. 1989. Use and abuse of khat (*Catha edulis*): a review of the distribution, pharmacology, side effects and a description of psychosis attributed to khat chewing. Psychol. Med. 19(3): 657, 658.

Peters, D. W. A. 1952. Khat: its history, botany, chemistry, and toxicology. Pharm. J. 169: 17-37.

Rushby, K. 1999. Eating the flowers of paradise: a journey through the drug fields of Ethiopia and Yemen. St. Martin's Press. New York, NY. 322 pp.

Szendrei, K. 1980. The chemistry of khat. Bull. on Narcot. 32(3): 5-35.

United Nations Division of Narcotic Drugs. 1956. Khat. Bull. Narcotics 8: 6-13.

NEW WORLD PLANTS

GENERAL REFERENCES

Bennett, B. C. 1992. Hallucinogenic plants of the Shuar and related indigenous groups in Amazonian Ecuador and Peru. Brittonia 44(4): 483-493.

Booth, W. 1988. Voodoo science. Science 240: 274-277.

Castaneda, C. 1968. The teachings of Don Juan: a Yaqui way of knowledge. Univ. California Press. Berkeley. 276 pp.

Cooper, J. M. 1949. Stimulants and narcotics. In, J. M. Steward (editor). Handbook of South American Indians. Smithsonian Institution, Washington, D.C. 5: 525-558.

Cordy-Collins, A. 1982. Psychoactive painted Peruvian plants: the Shamanism Textile. J. Ethnobiol. 2: 144-153.

Costantini, E. S. 1975. El uso de alucinogenos de origen vegetal por las tribus indigenas del Paraguay actual. Cuadernos Cientificos CEMEF 4: 35-48.

Cuerrier, A. 2002. Les plantes hallucinogènes des premières nations du Canada. Quatre-Temps 26(3): 26-29.

Davis, E. W. 1983. The ethnobiology of the Haitian zombie. J. Ethnopharm. 9: 85-104.

Davis, E. W. 1983. Sacred plants of the San Pedro cult. Bot. Mus. Leaflts. Harvard Univ. 29(4): 367-386.

Davis, W. 1985. The serpent and the rainbow. Simon & Schuster. New York, NY. 297 pp.

Davis, W. 1988. Passage of darkness: the ethnobiology of the Haitian zombie. Univ. North Carolina Press. Chapel Hill. 344 pp.

Davis, E. W. & J. A. Yost. 1983. Novel hallucinogens from eastern Ecuador. Bot. Mus. Leaflts. Harvard Univ. 29(3): 291-295.

De Mille, R. 1979. The shaman of academe: Carlos Castaneda. Horizon 22(4): 64-70.

Diamond, J. 2001. Anatomy of a ritual [ritual enemas]. Nat. Hist. 110(6): 16; 17-20.

Diaz, J. L. 1977. Ethnopharmacology of sacred psychoactive plants used by the Indians of Mexico. Ann. Rev. Pharmacol. Toxicol. 17: 647-75.

Elferink, J. G. R. 1988. Some little-known hallucinogenic plants of the Aztecs. J. Psycho. Drugs 20(4): 427-436.

Emboden, W. A., Jr. 1976. Plant hypnotics among the North American Indians. In, Hand, W. D. (editor). American folk medicine. Univ. California Press. Berkeley. Pp. 159-167.

Furst, P. T. 1974. Hallucinogens in precolumbian art. In, King, M. E. & I. F. Traylor (editors). Art and environment in Native America. Spec. Publ. No. 7. Mus. Texas Tech. Univ. Lubbock.

Furst, P. T. & M. D. Coe. 1977. Ritual enemas. Nat. Hist. 86: 88-91.

Guerra, F. 1967. Mexican phantastica: a study of the early ethnobotanical sources on hallucinogenic drugs. Brit. J. Addict. 62: 171-187.

Guzmán, G., et al. 1976. Psychoactive mycoflora of Washington, Idaho, Oregon, California and British Columbia. Mycologia 68(6): 1267-1271.

Heim, R. & R. G. Wasson. 1962. Une investigation sur les champignons sacres des mixteques. Comptes Rend., Acad. Sci., Paris 254: 788-791.

McKenna, D. J. & G. H. N. Towers. 1985. On the comparative ethnopharmacology of malpighiaceous and myristicaceous hallucinogens. J. Psychoactive Drugs 17(1): 35-39.

Menser, G. P. 1997. Hallucinogenic and poisonous mushrooms field guide. Ronin Publ. Berkeley, CA. 14 pp. + 24 plates.

Naranjo, P. 1969. Etnofarmacologia de las plantas isicotropicas de America. Terepia 24: 5-63.

Naranjo, P. 1979. Hallucinogenic plant use and related indigenous belief systems in the Ecuadorian Amazon. J. Ethnopharm. 1(2): 121-145.

Ott, J. 1976. Hallucinogenic plants of North America. Wingbow Press. Berkeley, CA. 162 pp.

Prance, G. T. & A. E. Prance. 1970. Hallucinations in Amazonia. Garden J. 20: 102-107.

Safford, W. E. 1917. Narcotic plants and stimulants of the ancient Americans. Annual Report of the Smithsonian Institution. 1916. Pp. 387-424.

Schleiffer, H. (editor). 1973. Sacred narcotic plants of the New World Indians. Hafner Press. New York, NY. 156 pp.

Schultes, R. E. 1957. The identity of the malpighiaceous narcotics of South America. Bot. Mus. Leafl. Harvard Univ. 18: 1-56.

Schultes, R. E. 1961. Native narcotics of the New World. Texas J. Pharm. 2: 141-167.

Schultes, R. E. 1963. Botanical sources of the New World narcotics. Psyched. Rev. 1: 145-166.

Schultes, R. E. 1963. Hallucinogenic plants of the New World. Harvard Rev. 1: 18-32.

Schultes, R. E. 1965. Ein halbes Jahrhundert Ethnobotanik amerikanisher Halluzinogene. Planta Med. 13: 125-157.

Schultes, R. E. 1970. The New World Indians and their hallucinogenic plants. Bull. Morris Arbor. 21: 3-14.

Schultes, R. E. 1972. De plantis toxicariis e mundo novo tropicale commentationes XI. The ethnobotanical significance of additives to New World hallucinogens. Plant Science Bulletin. 18: 34-40.

Schultes, R. E. 1972. Ethnotoxicological significance of additives to New World hallucinogens. Plant Sci. Bull 18: 34-41.

Schultes, R. E. 1976. Richard Spruce and the ethnobotany of the northwest Amazon. Rhodora 78: 65-72.

Schultes, R. E. 1977. Mexico and Colombia: two major centers of aboriginal use of hallucinogens. J. Psychedelic Drugs 9(2): 173-176.

Schultes, R. E. 1979. Evolution of the identification of the major South American narcotic plants. J. Psychedelic Drugs. 11(1-2): 119-134.

Schultes, R. E. 1979. Solanaceous hallucinogens and their role in the development of New World cultures. In, Hawkes, G. et al. (editors). The biology and taxonomy of the Solanaceae. Academic Press. New York, NY. Pp. 137-160.

Schultes, R. E. 1981. Iconography of New World hallucinogens. Arnoldia 41(3): 80-127.

Schultes, R. E. 1982. The beta-carboline hallucinogens of South America. J. Psychoactive Drugs 14(3): 205-220.

Schultes, R. E. 1987. Antiquity of the use of New World hallucinogens. Archeomaterials 2: 59-72.

Schultes, R. E. 1988. Where the gods reign: plants and people of the Columbian Amazon. Synergetic Press. London, England. 306 pp.

Schultes, R. E. & R. F. Raffauf. 1992. Vine of the soul. Medicine men, their plants and rituals in the Colombian Amazonia. Synergetic Press. Oracle, AZ. 282 pp.

Smet, P. A. G. M. de. 1983. A multidisciplinary overview of intoxicating enema rituals in the western hemisphere. J. Ethnopharm. 9(2/3): 129-166.

Smet, A. G. M. de. 1985. Ritual enemas and snuffs in the Americas. Latin American Studies. FORIS Publ. Cinnaminson, NJ. 276 pp.

Spruce, R. 1873. On some remarkable narcotics of the Amazon Valley and Orinoco. Ocean highways. Geogr. Rev. 1: 184-193.

Tyler, V. E. 1982. Hallucinogenic drug hoaxes of the American hippies. In, Beal, J. L. & E. Reinhard (editors). Natural products as medicinal agents. Hippokrates Verlag. Stuttgart, Germany. Pp. 339-350.

Wasson, R. G. 1963. The hallucinogenic fungi of Mexico. Psyched. Rev. No. 1: 27-42.

Weil, A. T. 1977. The use of psychoactive mushrooms in the Pacific Northwest: an ethnopharmacologic report. Bot. Mus. Leafl. Harvard Univ. 25(5): 131-149.

Wellmann, K. F. 1978. North American Indian rock art and hallucinogenic drugs. J. American Med. Assoc. 239(15): 1524-1527.

TOBACCO

Akehurst, B. C. 1968. Tobacco. Longman. New York, NY. 552 pp.

Anonymous. 1992. Tobacco or health. Status in the Americas. Sci. Publ. No. 536. Pan American Health Organization. Washington, D. C. 387 pp.

Anonymous. 1995. Secondhand smoke: is it a hazard? Consumer Report 60(1): 27-33.

Anonymous. 1995. Hooked on tobacco: the teen epidemic. Consumers Report 60(3): 142-147.

Balfour, D. J. K. (editor). 1984. Nicotine and the tobacco smoking habit. Pergamon Press. Oxford, England. 221 pp.

Bartecchi, C. E. et al. 1994. The human costs of tobacco use (first of two parts). New England J. Med. 330(13): 907-912.

Bartecchi, C. E. et al. 1995. The global tobacco epidemic. Sci. American 272(5): 44-51.

Brownlee, S. & S. V. Roberts. 1994. Should cigarettes be outlawed? U. S. News & World Rep. 116(15): 32-36.

Buchannan, R. 1994. A short history of tobacco, the most provocative herb. The Herb Companion 7(1): 34-38.

Castigilioni, A. 1943. The use of tobacco among the American Indians. Ciba Symposium 4: 426-435.

Darkis, F. R. 1965. Tobacco as a product of commerce. Econ. Bot. 19(1): 63-67.

Eckholm, E. 1977. The unnatural history of tobacco. Nat. Hist. 86(4): 22-24; 26; 28; 31, 32.

Elferink, J. G. R. 1983. The narcotic and hallucinogenic use of tobacco in Pre-Columbian Central America. J. Ethnopharm. 7(1): 111-122.

Ember, L. R. 1994. The nicotine connection. Chem. & Engr. News 72(48): 8-18.

Fahs, J. 1996. Cigarette confidential: the unfiltered truth about the ultimate addiction. Berkley Books. New York, NY. 304 pp.

Furst, P. 1974. Archaeological evidence for snuffing in prehispanic Mexico. Bot. Mus. Leaflts. Harvard Univ. 24: 1-28.

Gately, I. 2001. Tobacco: a cultural history of how an exotic plant seduced civilization. Grove Press. New York, NY. 403 pp.

Glantz, S. A. & W. W. Parmley. 1995. Passive smoking and heart disease. J. American Med. Assoc. 273(13): 1047-1053.

Gold, M. S. 1995. Tobacco. Drugs of abuse. Vol. 4. Plenum Medical. New York, NY. 211 pp.

Goodman, J. 1993. Tobacco in history: the cultures of dependence. Routledge, NY. 280 pp.

Gray, P. B. 1987. Tobacco goes on trial. Readers Digest 131(786): 225, 226, 228, 230.

Haberman, T. W. 1984. Evidence for aboriginal tobaccos in Eastern North America. American Antiq. 49: 269-287.

Haddon, A. C. 1946. Smoking and tobacco pipes in New Guinea. Phil. Trans. Royal Soc. London, Series B, Bio. Sci. 232(586): 1-278.

Harley, D. I. 1993. The beginning of the tobacco controversy: Puritanism, James I, and the royal physicians. Bull. Hist. Medicine 67: 28-50.

Harrison, L. 1986. Tobacco battered and the pipes shattered: a note on the fate of the first British campaign against tobacco smoking. British J. Addiction 81: 553-558.

Janiger, O. & M. Dobkin de Rios. 1973. Suggestive hallucinogenic properties of tobacco. Medical Anthrop. Newsletter 4(4): 6-11.

Janiger, O. & M. Dobkin de Rios. 1976. Nicotiana an hallucinogen? Econ. Bot. 30(2): 149-151.

Johnson, S. 1988. Tobacco use and shamanism in Mesoamerica. California Anthrop. 15: 20-26.

Kamen-Kaye, D. 1975. Chimo -- why not? A primitive form of tobacco still in use in Venezuela. Econ. Bot. 29: 47-68.

Kluger, R. 1996. Ashes to ashes: America's hundred-year cigarette war, the public health, and the unabashed triumph of Philip Morris. A. A. Knopf. New York, NY. 807 pp.

Koop, C. E. 1987. Non-smokers: time to clear the air. Readers Digest 130(780): 110-113.

Koop, C. E. 1988. The health consequences of smoking: nicotine addiction. A report of the Surgeon General. U. S. Dept. of Health and Human Services. Rockville, MD. 639 pp.

Krogh, D. 1991. Smoking: the artificial passion. W. H. Freeman. New York, NY. 176 pp.

MacKenzie, T. D. et al. 1994. The human costs of tobacco use (second of two parts). New England J. Med. 330(14): 975-980.

Manning, W. G. et al. 1989. The taxes of sin: do smokers and drinkers pay their way? J. American Med. Assoc. 261(11): 1604-1609.

Marshall, E. 1987. Tobacco science wars. Science 236: 250, 251.

Massing, M. 1996. How to win the tobacco war. New York Rev. Books XLIII(12): 32-36.

McCullen, J. T. 1967. Indian tobacco myths concerning the origin of tobacco. New York Folklore Quart. 23: 264-273.

Meyer, J. A. 1992. Cigarette century. American Hert. 43(8): 72-80.

Ochsner, A. 1971. The health menace of tobacco. American Sci. 59: 246-252.

Peto, R. et al. 1992. Mortality from tobacco in developed countries: indirect estimation from national vital statistics. The Lancet 339: 1268-1278.

Pomerleau, O. F. 1986. Nicotine as a psychoactive drug: anxiety and pain reduction. Psychopharm. Bull. 22: 865-869.

Price, J. M. 1995. Tobacco use and tobacco taxation: a battle of interests in early modern Europe. In, Goodman, J. et al. (editors). Consuming habits. Routledge. London, England. Pp. 165-185.

Pringle, P. 1998. Cornered: big tobacco at the bar of justice. Henry Holt. New York, NY. 352 pp.

Rabin, R. L. & S. D. Sugarman (editors). 1993. Smoking policy. Oxford Univ. Press. New York, NY. 243 pp.

Rand, M. J. & K. Thurau. 1987. The pharmacology of nicotine. IRL Press. Oxford, England. 418 pp.

Ricer, R. E. 1987. Smokeless tobacco use. A dangerous nicotine habit. Postgrad. Med. 81(4): 89-94.

Rogozinski, J. 190. Smokeless tobacco in the Western World, 1550-1950. Praeger. New York, NY.

Schmeltz, I. (editor). 1972. The chemistry of tobacco and tobacco smoke. Plenum Publ. New York, NY. 186 pp.

Seely, J., E. Zuskin, & A. Bouhuys. 1971. Cigarette smoking: objective evidence for lung damage in teenagers. Science 172: 741-743.

Setchell, W. A. 1921. Aboriginal tobaccos. American Anthrop. 23: 397-414.

Springer, J. W. 1981. An ethnohistoric study of the smoking complex in eastern North America. Ethnohistory 28: 217-235.

Stewart, G. G. 1967. A history of the medicinal use of tobacco 1492-1860. Med. Hist. 11: 228-268.

Tate. C. 1989. The butt of controversy. Smithsonian 20(4): 107, 108; 110-112; 114-117.

Turner, N. J. & R. L. Taylor. 1972. A review of the Northwest Coast tobacco mystery. Syesis 5: 249-257.

U. S. Dept. of Health and Human Services. 1990. Smoking and health: a national status report. A report to Congress. Second edition. Office on Smoking and Health. Rockville, MD. 390 pp.

von Gernet, A. 1995. Nicotian dreams: the prehistory and early history of tobacco in eastern North America. In, Goodman, J. et al. (editors). Consuming habits. Routledge. London, England. Pp. 67-87.

Warner, K. E. et al. 1997. The emerging market for long-term nicotine maintenance. J. American Med. Assoc. 278(13): 1087-1092.

Wickelgren, I. 1998. Drug may suppress the craving for nicotine. Science 282: 1797, 1799.

Wilbert, J. 1988. Tobacco and shamanism in South America. Yale Univ. Press. New Haven, CT. 294 pp.

Wilbert, J. 1991. Does pharmacology corroborate the nicotine therapy and practices of South American shamanism? J. Ethnopharm. 32: 179.

Winter, J. C. (editor). 2001. Tobacco use by native North Americans: sacred smoke and silent killer. Univ. Oklahoma Press. Norman. 379 pp.

Witschi, H. et al. 1997. The toxicology of environmental tobacco smoke. Ann. Rev. Pharm. & Toxicol. 37: 29-52.

COCA & COCAINE

Andrews, G. & D. Solomon (editors). 1975. The coca leaf and cocaine papers. Harcourt Brace Jovanovich. New York, NY. 372 pp.

Anonymous. 1979. Coca-leaf chewing and public health. The Lancet 8123: 963.

Ashley, R. 1975. Cocaine: its history, use and effects. Warner Books. New York, NY. 254 pp.

Barnett, G. et al. 1981. Cocaine pharmacokinetics in humans. J. Ethnopharm. 3: 353-366.

Bolton, R. 1976. Andean coca chewing: a metabolic perspective. American Anthrop. 78(3): 630-634.

Boucher, D. H. 1991. Cocaine and the coca plant. BioScience 41(2): 72-76.

Buck, A. A. et al. 1970. Coca chewing and health: an epidemiological study among residents of a Peruvian village. Bull. Narcotics 22: 23-32.

Byck, R. 1974. Cocaine papers. Sigmund Freud. New American Library. New York, NY. 402 pp.

Ciba Foundation. 1992. Cocaine: scientific and social dimensions. Ciba Found. Symp. No. 166. John Wiley. New York, NY. 306 pp.

Cohen, S. 1984. Recent developments in the abuse of cocaine. Bull. Narcotics 36(2): 3-14.

Courtwright, D. T. 1983. The hidden epidemic: opiate addiction and cocaine use in the South, 1860-1920. J. Southern Hist. 49: 57-72.

Courtwright, D. T. 1995. The rise and fall and rise of cocaine in the United States. In, Goodman, J. et al. (editors). Consuming habits. Routledge. London, England. Pp. 206-228.

Duke, J. A. et al. 1975. Nutritional value of coca. Bot. Mus. Leaflts. Harvard Univ. 24: 113-119.

Flynn, J. C. 1991. Cocaine: an in-depth look at the facts, science, history and future of the world's most addictive drug. Birch Lane Press. New York, NY.

Freud, S. 1884. Ueber Coca. Centralblatt f. d. Ges. Therapie. 2: 289-314.

Freud, S. 1887. Bemerkungen uber Kokainsucht und Kokainfurcht. Weiner Mediz. Wochenschrift 28: 929-932.

Gawin, F. H. 1991. Cocaine addiction: psychology and neurophysiology. Science 251: 1580-1586.

Gawin, F. H. & E. H. Ellinwood, Jr. 1989. Cocaine dependence. Ann. Rev. Med. 40: 149-161.

Gold, M. 1993. Cocaine. Plenum Press. New York, NY. 238 pp.

Grabowski, J. (editor). 1984. Cocaine: pharmacology, effects, and treatment of abuse. NIDA Research Monograph 50. U. S. Printing Office. Washington, D. C. 135 pp.

Grinspoon, L. & J. B. Bakalar. 1976. Cocaine: a drug and its social evolution. Basic Books. New York, NY. 308 pp.

Grinspoon, L. & J. B. Bakalar. 1981. Coca and cocaine as medicines. An historical review. J. Ethnopharm. 3: 145-159.

Gutierrez-Noreiga, C. 1952. El habito de la coca en Sud America. America Indigena 12(2): 111-120.

Gutierrez-Noreiga, C. & V. W. von Hagen. 1951. Coca -- the mainstay of an arduous life in the Andes. Econ. Bot. 5: 145-152.

Hobhouse, H. 1999. Coca. In, Seeds of change: six plants that transformed mankind. Revised and expanded edition. Papermac. London, England. Pp. 293-363.

Holmstedt, B. & A. Fredga. 1981. Sundry episodes in the history of coca and cocaine. J. Ethnopharm. 3: 113-147.

Holstedt, B. et al. 1979. Cocaine in blood of coca chewers. J. Ethnopharm. 1(1): 69-78.

Jeri, F. R. 1984. Coca-paste smoking in some Latin American countries: a severe and unabated form of addiction. Bull. on Narcotics 36: 15-31.

Karch, S. B. 1998. A brief history of cocaine. CRC Press. Boca Raton, FL. 202 pp.

Kennedy, J. 1985. Coca exotica: the illustrated story of cocaine. Assoc. Univ. Presses. Cranbury, NJ.

Lakoski, J. M. et al. (editors). 1992. Cocaine: pharmacology, physiology, and clinical strategies. CRC Press. Boca Raton, FL. 443 pp.

Lester, B. M., L. L. LaGasse, & R. Seifer. 1998. Cocaine exposure and children: the meaning of subtle effects. Science 282: 633, 634.

MacGregor, F. E. (editor). 1993. Coca and cocaine: an Andean perspective. Greenwood Press. Westport, CT. 155 pp.

Martin, R. T. 1970. The role of coca in the history, religion, and medicine of South American Indians. Econ. Bot. 24: 422-438.

Morrell, V. 1993. Enzyme may blunt cocaine's action. Science 259: 1828.

Mortimer, W. G. 1974. History of coca, "The divine plant of the Incas." Reprint of the 1901 edition. And/Or Press. San Francisco, CA. 576 pp.

Moser, B. & D. Taylor. 1965. The cocaine eaters. Longmans. London, England. 204 pp.

Musto, D. F. 1989. America's first cocaine epidemic. Wilson Quart. 13: 59-65.

Musto, D. F. 1991. Opium, cocaine, and marijuana in American history. Sci. American 265(1): 40-47.

Naranjo, P. 1981. Social function of coca in Pre-Columbian America. J. Ethnophram. 3: 161-172.

Novak, M. et al. 1984. Biological activity of the alkaloids of *Erythroxylum coca* and *E. novogranatense*. J. Ethnopharm. 10: 261-274.

Pacini, D. & C. Franquemont (editors). 1986. Coca and cocaine: effects on people and policy in Latin America. Cultural Survival Report 23. Cultural Survival. Cambridge, MA. 169 pp.

Plowman, T. 1979. Botanical perspectives on coca. J. Psyched. Drugs 11: 103-117.

Plowman, T. 1981. "Amazonia coca." J. Ethnopharm. 3: 195-225.

Plowman, T. 1982. The identification of coca, *Erythroxylum* species: 1860-1910. Bot. J. Linnean Soc. 84: 329-353.

Plowman, T. 1984. The ethnobotany of coca (*Erythroxylum* spp., Erythroxylaceae). Adv. Econ. Bot. 1: 62-111.

Plowman, T. 1984. The origin, evolution, and diffusion of coca, *Erythroxylum* spp., in South and Central

America. In, Stone, D. (editor). Pre-Columbian plant migration. Papers of the Peabody Mus. Archaeol. Ethnol. 76: 125-163.

Rowbotham, M. C. & D. H. Lowenstein. 1990. Neurologic consequences of cocaine use. Ann. Rev. Med. 41: 417-422.

Scheidt, J. von. 1973. Sigmund Freud und das Kokain. Psyche (Stuttgart) 27(1-6): 385-430.

Schober, S. & C. Schade (editors). 1991. The epidemiology of cocaine use and abuse. Res. Monograph No. 110. U. S. Dept. Health and Human Services. U. S. Gov. Print. Office. Washington, D. C.

Schultes, R. E. 1957. A new method of coca preparation in the Colombian Amazon. Bot. Mus. Leaflts. Harvard Univ. 17(9): 241-246.

Schultes, R. E. 1980. Coca in the northwest Amazon. Bot. Mus. Leaflts. Harvard Univ. 28(1): 47-59.

Schultz, M. G. 1971. The "strange case" of Robert Louis Stevenson. J. American Med. Assoc. 216: 90-94.

Siegel, R. K. 1978. Cocaine hallucinations. American J. Psychiat. 135: 309-314.

Siegel, R. K. 1982. Cocaine and sexual dysfunction: the curse of Mama Coca. J. Psychoactive Drugs 14: 71-74.

Siegel, R. K. 1982. Cocaine smoking. J. Psychoactive Drugs 14: 321-337.

Siegel, R. K. et al. 1986. Cocaine found in herbal tea. J. American Med. Assoc. 255: 40.

Spillane, J. F. 2000. Cocaine: from medical marvel to modern menace in the United States, 1884-1920. Johns Hopkins Univ. Press. Baltimore, MD. 214 pp.

Stamler, R. T. et al. 1984. Illicit traffic and abuse of cocaine. Bull. Narcotics 36(2): 57-63.

Streatfeild, D. 2002. Cocaine: an unauthorized biography. St. Martin's Press. New York, NY. 510 pp.

Turner, C. E. et al. 1988. Cocaine, an annotated bibliography. Two vols. Univ. Press Mississippi. Jackson. 1364 pp.

Vogel, G. 1997. Cocaine wreaks subtle damage on developing brains. Science 278: 38, 39.

Weil, A. T. 1981. The therapeutic value of coca in contemporary medicine. J. Ethnopharm. 3: 367-376.

Weil, A. T. 1995. The new politics of coca. New Yorker LXXI(12): 70-80. [Someone cut out this article from the HSU Library's copy. This practice causes me to rethink my position on capital punishment.]

Weiss, R. D., S. M. Mirin, & R. L. Bartel. 1994. Cocaine. Second edition. American Psychiatric Press. Washington, D. C. 204 pp.

White, F. J. 1998. Drug addiction: cocaine and the serotonin saga. Nature 393(6681): 118, 119.

White, P. T. 1989. Coca -- an ancient herb turns deadly. Natl. Geogr. 175(1): 3-47.

Young, K. R. 1996. Threats to biological diversity caused by coca/cocaine deforestration in Peru. Environ. Conserv. 23(1): 7-15.

PEYOTE, OTHER CACTI, & MESCAL BEAN

Aberle, D. F. 1991. The peyote religion among the Navajo. Second edition. Univ. Oklahoma Press. Norman.

Anderson, E. F. 1969. The biogeography, ecology, and taxonomy of *Lophophora* (Cactaceae). Brittonia 21: 299-310.

Anderson, E. F. 1996. Peyote: the divine cactus. Second edition. Univ. Arizona Press. Tucson. 272 pp.

Bergman, R. L. 1971. Navajo peyote use: its apparent safety. America J. Psychiatry. 128: 695-699.

Bittle, W. E. 1960. The curative aspects of peyotism. Bios 31: 140-148.

Bravo, H. H. 1967. Una revisión del género *Lophophora.* Cactus Succ. Mex. 12: 8-17.

Bruhn, J. G. 1973. Ethnobotanical search for hallucinogenic cacti. Planta Medica 24: 315-319.

Bruhn, J. G. & B. Holmstedt. 1974. Early peyote research: an interdisciplinary study. Econ. Bot. 28: 353-390.

Bruhn, J. G. & C. Bruhn. 1973. Alkaloids and ethnobotany of Mexican peyote cacti and related species. Econ. Bot. 27: 241-251.

Campbell, T. N. 1958. Origin of the mescal bean cult. American Anthrop. 60: 156-160.

Collier, J. 1952. The peyote cult. Science 115: 503, 504.

Csordas, T. J. 1997. On the peyote road. Nat. Hist. 106(2): 48, 49.

Davis, W. 1999. San pedro, cactus of the four winds. Shaman's Drum 52: 50-60.

Dorrance, D. L., O. Janiger, & R. L. Teplitz. 1975. Effect of peyote on human chromosomes. J. American Med. Assoc. 234: 299-302.

Ellis, H. 1898. Mescal: a new artificial paradise. Ann. Rept. Smithsonian Inst. Washington, D. C. Pp. 537-548.

Ellis, H. 1902. Mescal: a study of a divine plant. Pop. Sci. Monthly 61: 52-71.

Fischer, R. 1958. Pharmacology and metabolism of mescaline. Rev. Canadian Biol. 17: 389-409.

Hill, T. W. 1990. Peyotism and the control of heavy drinking: the Nebraska Winnebago in the early 1900s. Human Organization 49: 255-265.

Howard, J. H. 1957. The mescal bean cult of central and southern plains: an ancestor of the peyote cult? American Anthrop. 59: 75-87.

Kapadia, G. J. & M. B. E. Fayez. 1973. The chemistry of peyote alkaloids. Lloydia 36: 9-35.

Keller, W. J. 1975. Alkaloids from *Sophora secundiflora.* Phytochem. 14: 2305, 2306.

Kluever, H. 1928. Mescal: the divine plant and its psychological effects. Kegan Paul, Trench, Trubner & Co. London, England. 111 pp.

LaBarre, W. 1947. Primitive psychotherapy in native American cultures: peyotism and confession. J. Abnormal Soc. Psychol. 43: 294-309.

LaBarre, W. 1957. Mescalism and peyotism. American Anthrop. 59: 708-711.

LaBarre, W. 1960. Twenty years of peyote studies. Current Anthrop. 1: 45-60.

LaBarre, W. 1991. The peyote cult. Fifth edition. Univ. Oklahoma Press. Norman. 352 pp.

LaBarre, W. et al. 1951. Statement on peyote. Science 114: 582, 583.

Laycock, D. 1989. Peyote, wine, and the First Ammendment. Christian Cent. 106: 876-880.

Leonard, I. 1942. Peyote and the Mexican Inquisition. American Anthrop. 44: 324-326.

Marriott, A. & C. K. Rachlin. 1971. Peyote. Thos. Crowell. New York, NY. 111 pp.

McLaughlin, J. L. 1973. Peyote: an introduction. Lloydia 36: 1-8.

Merrill, W. L. 1977. An investigation of ethnographic and archaeological specimens of mescal beans (*Sophora secundiflora*) in American museums. Tech. Rept. No. 6. Mus. Anthrop. Univ. Michigan. Ann Arbor.

Morgan, G. R. 1983. The biogeography of peyote in south Texas. Bot. Mus. Leaflts. Harvard Univ. 29(2): 73-86.

Myerhoff, B. G. 1970. The deer-maize-peyote symbol complex among the Huichol Indians of Mexico. Anthrop. Quart. 43: 64-78.

Myerhoff, B. G. 1974. Peyote hunt. The sacred journey of the Huichol Indians. Cornell Univ. Press. Ithaca, NY. 285 pp.

Paul, A. G. 1973. Biosynthesis of the peyote alkaloids. Lloydia 36: 36-45.

Robert, V. 2002. Sacré peyotl! Quatre-Temps 26(3): 30-33.

Safford, W. E. 1915. An Aztec narcotic (*Lophophora williamsii*). J. Heredity 6: 291-311.

Schaffer, S. B. & P. T. Furst (editors). 1996. People of the peyote: Huichol Indian history, religion, and survival. New Mexico Univ. Press. Albuquerque. 560 pp.

Schultes, R. E. 1936. Peyotl intoxication: a review of the literature on the chemistry, physiological and psychological effects of peyotl. Unpublished undergraduate thesis. Harvard Univ. Cambridge, MA.

Schultes, R. E. 1937. Peyote and plants used in the peyote ceremony. Bot. Mus. Leaflts. Harvard Univ. 4: 129-152.

Schultes, R. E. 1937. Peyote (*Lophophora williamsii*) and plants confused with it. Bot. Mus. Leaflts. Harvard Univ. 5(5): 61-88.

Schultes, R. E. 1937. Peyote and the American Indian. Nature Magazine 30: 155-257.

Schultes, R. E. 1938. Peyote -- an American Indian heritage from Mexico. El Mexico Antiguo 4: 199-208.

Schultes, R. E. 1938. The appeal of peyote (*Lophophora williamsii*) as a medicine. American Anthrop. 40: 698-715.

Schultes, R. E. 1940. The aboriginal therapeutic uses of *Lophophora williamsii*. Cactus Succ. J. 12: 177-181.

Schwartz, R. H. 1988. Mescaline: a survey. American Family Physc. 37: 122-124.

Shonle, R. 1925. Peyote: the giver of visions. American Anthrop. 27: 53-75.

Shulgin, A. T. 1973. Mescaline: the chemistry and pharmacology of alkaloids. Lloydia 36: 46-58.

Slotkin, J. S. 1955. Peyotism: 1521-1891. American Anthrop. 57: 202-230.

Smet, A. G. M. de & J. G. Bruhn. 2003. Ceremonial peyote use and its antiquity in the southern United States. HerbalGram 58: 30-33.

Stewart, O. C. 1974. Origin of the peyote religion in the United States. Plains Anthrop. 19: 211-223.

Stewart, O. C. 1980. Peyotism and mescalism. Plains Anthrop. 25: 297-309.

Stewart, O. C. 1987. Peyote religion: a history. Univ. Oklahoma Press. Norman. 454 pp.

Troike, R. C. 1962. The origin of Plains mescalism. American Anthrop. 64: 946-963.

SACRED MUSHROOMS

Badham, E. R. 1984. Ethnobotany of the psilocybine mushrooms, especially *Psilocybe cubensis*. J. Ethnopharm. 10(2): 249-254.

Heim, R. 1957. Notes preliminaires sur les agarics hallucinogènes du Mexique. Rev. de Mycol. 22: 1-46.

Heim, R. & R. G. Wasson. 1958. Les champignons hallucinogènes du Mexique. Mus. d'Hist. Nat. Paris.

Heim, R. & R. G. Wasson. 1962. Une investigation sur les champignons sacrés des Mixtèques. Comptes Rend. Acad. Sci., Paris 254: 788-791.

Kripper, S. & S. Winkelman. 1983. Maria Sabina: wise lady of the mushrooms. J. Psychoactive Drugs 15(3): 225-228.

Lowy, B. 1971. New records of mushroom stones from Guatemala. Mycologia 63: 983-993.

Mayer, K. H. 1977. The mushroom stones of Mesoamerica. Acoma Books. Ramona, CA.

McGuire, T. 1982. Ancient Maya mushroom connections: a transcendental interaction model. J. Psychoactive Drugs 14(3): 221-238.

Menser, G. P. 1997. Hallucinogenic and poisonous mushrooms field guide. Ronin Publ. Berkeley, CA. 124 pp. + 24 plates.

Ott, J. & J. Bigwood (editors). 1978. Teonanacatl: hallucinogenic mushrooms of North America. Madrona Publ. Seattle, WA. 175 pp.

Pike, E. & F. Cowan. 1959. Mushroom rituals versus Christianity. Practical Anthrop. 9(4): 145-150.

Riedlinger, T. J. (editor). 1990. The sacred mushroom seeker. Essays for R. Gordon Wasson. Dioscorides Press. Portland, OR. 283 pp.

Rubel, A. J. & J. Gettelfinger-Krejci. 1976. The use of hallucinogenic mushrooms for diagnostic purposes among some highland Chinantecs [Oaxaca, Mexico]. Econ. Bot. 30: 235-248.

Sanford, J. 1973. In search of the magic mushroom. Clarkson N. Potter. New York, NY. 176 pp.

Schultes, R. E. 1939. Plantae Mexicanae. II. The identification of teonanacatl, a narcotic basidiomycete of the Aztecs. Bot. Mus. Leaflts. Harvard Univ. 7: 37-56.

Schultes, R. E. 1940. Teonanacatl -- the narcotic mushroom of the Aztecs. American Anthrop. 42: 429-443.

Wasson, R. G. 1959. The hallucinogenic mushrooms of Mexico: an adventure in ethnomycological exploration. Trans. New York Acad. Sci., Ser. II, 21: 325-339.

Wasson, R. G. 1961. The hallucinogenic fungi of Mexico: an inquiry into the origins of the religious idea among primitive peoples. Bot. Mus. Leaflts. Harvard Univ. 19(7): 137-162.

Wasson, R. G. 1963. The hallucinogenic mushrooms of Mexico and psilocybin: a bibliography. Bot. Mus. Leaflts. Harvard Univ. 20: 25-73.

Wasson, R. G. 1963. The hallucinogenic fungi of Mexico. Psyched. Rev. 1: 27-42.

Wasson, R. G. 1963. Mushroom rites of Mexico. Harvard Rev. 1(4): 7-17.

Wasson, R. G. 1965. The "mushroom madness" of the Kuma. Bot. Mus. Leaflts. Harvard Univ. 21: 1-36.

Wasson, R. G. et al. 1974. Maria Sabina and her Mazatec mushroom velada. Harcourt, Brace, Jovanovich. New York, NY. 268 pp.

Weil, A. T. 1977. The use of psychoactive mushrooms in the Pacific Northwest: an ethnopharmacologic report. Bot. Mus. Leaflts. Harvard Univ. 25(5): 131-149.

PSYCHOACTIVE SNUFFS

Brewer-Carias, C. & J. A. Steyermark. 1976. Hallucinogenic snuff drugs of the Yanomamo Caburiwe-Teri in the Cauaburi River, Brazil. Econ. Bot. 30: 57-66.

Furst, P. T. 1974. Archaeological evidence for snuffing in prehispanic Mexico. Bot. Mus. Leaflts. Harvard Univ. 24(1): 1-28.

Good, K. 1997. Amazon grace [ebene snuff use]. Nat. Hist. 106(2): 44, 45.

McKenna, D. J. & G. H. N. Towers. 1985. On the comparative ethnopharmacology of malpighiaceous and myristicaceous hallucinogens. J. Psychoactive Drugs 17(1): 35-39.

McKenna, T. & G. H. N. Towers. 1985. On the comparative ethnopharmacology of malpighiaceous and myristicaceous hallucinogens. J. Psychoactive Drugs 17(1): 35-39.

Plotkin, M. J. & R. E. Schultes. 1990. *Virola*: a promising genus for ethnopharmacological investigation. J. Psychoactive Drugs 22(3): 357-361.

Schultes, R. E. 1969. *Virola* as an orally administered hallucinogen. Bot. Mus. Leaflts. Harvard Univ. 22(6): 229-240.

Schultes, R. E. 1984. Fifteen years of study of psychoactive snuffs of South America, 1967-1982. J. Ethnopharm. 11(1): 17-32.

Smet, P. A. G. M. de. 1985. A multidisciplinary overview of intoxicating snuff rituals in the western hemisphere. J. Ethnopharm. 13: 3-49.

Torres, C. M. et al. 1992. Botanical, chemical, and contextual analysis of archaeological snuff powders from San Pedro de Atacama, northern Chile. Current Anthrop. 32: 640-649.

Wassén, S. H. & B. Holmstedt. 1963. The use of paricá, an ethnological and pharmacological review. Ethnos 28(1): 5-45.

AYAHUASCA (CAAPI)

Bristol, M. L. 1966. The psychotropic *Banisteriopsis* among the Sibundby of Colombia. Bot. Mus. Leaflts. Harvard Univ. 21: 113-140.

Burroughs, W. S. & A. Ginsberg. 1953. The yage letters. City Lights Books. San Francisco, CA. 68 pp.

Creedon, J. 2001. Ayahuasca. Utne Reader 107(Sept/Oct): 56-60.

De Alverga, A. P. 1999. Forest of visions: ayahuasca, Amazonian spirituality, and the Santo Daime tradition. 254 pp.

Dean, K. 2000. Amazonian shamans confront the U. S. Patent Office on South American plant [*Banisteriopsis caapi*]. HerbalGram 48: 28-30.

Dobkin de Rios, M. 1970. *Banisteriopsis* in witchcraft and healing activities in Iquitos, Peru. Econ. Bot. 24: 296-300.

Friedberg, C. 1965. Des *Banisteriopsis* utilisés comme drogue en Amérique du Sud. J. Agric. Trop. Bot. Appl. 12: 403-437; 550-594; 729-780.

Lewin, L. 1928. Untersuchungen über *Banisteria caapi* Spruce. Archiv für Exp. Path. und Pharm. 219: 133-149.

McKenna, T. & G. H. N. Towers. 1985. On the comparative ethnopharmacology of malpighiaceous and myristicaceous hallucinogens. J. Psychoactive Drugs 17(1): 35-39.

Morton, C. V. 1931. Notes on yajè, a drug plant of southeastern Colombia. J. Washington Acad. Sci. 21: 485-488.

Ott, J. 1994. Ayahuasca analogues: pangaean entheogens. Natural Products Co. Kennewick, WA. 127 pp.

Pinkley, H. 1969. Plant admixtures to ayahuasca, the South American hallucinogenic drink. Lloydia 32(3): 305-314.

Schultes, R. E. 1957. The identity of the malpighiaceous narcotics of South America. Bot. Mus. Leaflts. Harvard Univ. 18: 1-56.

Schultes, R. E. 1972. *Ilex guayusa* from 500 A. D. to the present. Etnologiska Studier 32: 115-138.

Schultes, R. E. 1985. De plantis toxicariis e mundo novo tropical commentationes XXXVI. A novel method of utilizing the hallucinogenic *Banisteriopsis*. Bot. Mus. Leaflts. Harvard Univ. 30(3): 61-63.

Schultes, R. E. et al. 1969. De plantis toxicarris e mundo novo tropicale commentationes. III. Phytochemical examination of Spruce's original collection of *Banisteriopsis caapi*. Bot. Mus. Leaflts. Harvard Univ. 22: 121-164.

THE DATURAS (JIMSON WEEDS)

Applegate, R. 1975. The Datura cult among the Chumash. J. California Anthrop. 2(1): 7-17.

Bristol, M. L. 1966. Notes on the species of tree daturas. Bot. Mus. Leaflets Harvard Univ. 21(8): 229-248.

Bristol, M. L. 1969. Tree datura drugs of the Colombian Sibundoy. Bot. Mus. Leaflts. Harvard Univ. 22(5): 165-227.

Bye, R. A., Jr., R. Mata, & J. Pimentel. 1991. Botany, ethnobotany and chemistry of *Datura lanulosa* (Solanaceae) in Mexico. Anales Inst. Biol. Univ. Nac. Auton. Mexico. Ser. Bot. 61: 21-42.

Davis, E. W. 1983. The ethnobiology of the Haitian zombi. J. Ethnopharm. 9(1): 85-104.

Furst, P. T. and B. Myerhoff. 1966. Myth as history: the jimson weed cycle of the Huichol. Anthropologia No. 17: 3-38.

Guharoy, S. R. & M. Barajas. 1991. Atropine intoxication from the ingestion and smoking of jimson weed (*Datura stramonium*). Vet. Human Toxicol. 33: 588, 589.

Jacobs, K. W. 1974. Asthmador: a legal hallucinogen. Int. J. Addict. 9: 503-512.

Johnston, T. F. 1972. *Datura fastuosa*: its use in Tsonga girls' initiation. Econ. Bot. 26(4): 340-351.

Karnick, C. R. & M. D. Saxena. 1970. *Datura* Linn. -- the famous narcotic from the East. Quart. J. Crude Drug Res. 10: 1493-1516.

Litzinger, W. J. 1981. Ceramic evidence for prehistoric Datura use in North America. J. Ethnopharm. 4(1): 57-74.

Lockwood, T. E. 1973. A taxonomic revision of *Brugmansia* (Solanaceae). Ph.D. dissertation. Harvard Univ. Cambridge, MA.

Lockwood, T. E. 1979. The ethnobotany of *Brugmansia*. J. Ethnopharm. 1(2): 147-164.

Nicholson, R. 2002. Flowers of evil. Nat. Hist. 111(1): 20-24.

Safford, W. E. 1920. Daturas of the Old World and New: an account of their narcotic properties and their use in oracular and initiatory ceremonies. Smithsonian Inst. Report, 1920, Pp. 537-567.

Safford, W. E. 1921. Synopsis of the genus *Datura*. J. Washington Acad. Sci. 11: 173-189.

Schultes, R. E. 1979. Solanaceous hallucinogens and their role in the development of New World cultures. In, Hawkes, G. et al. (editors). The biology and taxonomy of the Solanaceae. Academic Press. New York. Pp. 137-160.

Tiongson, J. & P. Salen. 1998. Mass ingestion of jimson-weed by eleven teenagers. Delaware Med. J. 70: 471-476.

Weil, A. T. 1977. Some notes on *Datura*. J. Psychedelic Drugs 9(2): 165-169.

OLOLIUQUI (MORNING GLORIES)

Der Marderosian, A. 1967. Psychomimetic indoles in the Convolvulaceae. American J. Pharm. 139: 19-26.

De Riosa, M. D. 1972. Visionary vine. Chandler Publ. Co. San Francisco, CA. 161 pp.

Hofmann, A. 1955. Die Gesschichte des LSD-25. Triangel Sandoz-Zeitsch. Mediz. Wissen. 2: 117-124.

Hofmann, A. 1963. The active principles of the seeds of *Rivea corymbosa* and *Ipomoea violacea*. Bot. Mus. Leaflts. Harvard Univ. 20: 194-212.

Hofmann, A. 1971. Teonanacatl and ololiuqui, two ancient magic drugs of Mexico. Bull. Narcotics 23(1): 3-14.

Hofmann, A. 1979. How LSD originated. J. Psychedelic Drugs 11(1-2): 53-68.

Hofmann, A. 1980. LSD: my problem child. McGraw-Hill. New York, NY.

MacDougal, T. 1960. *Ipomoea tricolor*: a hallucinogenic plant of the Zapotecs. Bol. Centro Investig. Antropol. de México. No. 6.

Osmond, H. 1955. Ololiuqui: the ancient Aztec narcotic: remarks on the effects of *Rivea corymbosa* (ololiuqi). J. Mental Sci. 101: 526-537.

Reko, B. P. 1929. Das mexikanische Rauschgift Ololiuqui. El Méx. Ant. 3(3/4): 1-7.

Schultes, R. E. 1941. A contribution to our knowledge of *Rivea corymbosa*, the narcotic ololiuqui of the Aztecs. Bot. Mus. Leaflts. Harvard Univ.

Schultes, R. E. 1953. A narcotic morning-glory. Rev. Soc. Cuban Bot. 10: 61-68; 101-107.

Wasson, R. G. 1963. Notes on the present status of ololiuqui and the other hallucinogens of Mexico. Bot. Mus. Leaflts. Harvard Univ. 20: 161-193.

PLANTS: OCEANIA

GENERAL REFERENCES

Cawte, J. 1985. Psychoactive substances in the South Seas: betel, kava and pituri. Australia New Zealand J. Psychiat. 19(1): 83-87.

KAVA

Anonymous. 1997. Kava-kava: a calming herb from the South Pacific. Herbs for Health 1(4): 42-44.

Barrau, J. 1957. A propos du *Piper methysticum*. J. Agric. Trop. Bot. Appl. 4: 270-273.

Brunton, R. 1979. Kava and the daily dissolution of society on Tanna, New Hebrides. Mankind 12: 93-103.

Brunton, R. 1989. The abandoned narcotic: kava and cultural instability in Melanesia. Cambridge Univ. Press. Cambridge, England.

Cawte, J. 1988. Macabre effects of a "cult" for kava. Med. J. Australia 148: 545, 546.

Collocott, E. E. V. 1927. Kava ceremonial in Tonga. J. Polynesian Soc. 36: 21-47.

Cox, P. A. & L. O'Rourke. 1987. Kava (*Piper methysticum* Forst.). Econ. Bot. 41: 452-454.

Davis, R. I. & J. F. Brown. 1999. Kava (*Piper methysticum*) in the South Pacific: its importance, methods of cultivation, cultivars, diseases and pests. Australian Centre Internal. Agric. Res. Canberra. 32 pp.

Deihl, J. R. 1932. Kava and kava-drinking. Primitive Man 5: 61-68.

Duffield, P. H. & D. Jamieson. 1991. Development of tolerance to kava in mice. Clin. Exp. Pharmac. Physiol. 18: 571-578.

Ford, C. S. 1967. Ethnographical aspects of kava. Publ. No. 1645. U. S. Publ. Health Service. Washington, D. C. Pp. 162-173.

Frater, A. S. 1952. Medical aspects of yaqona. Trans. Proc. Fijian Soc. 5: 31-39.

Gajdusek, C. 1967. Recent observations on the use of kava in the New Hebrides. Publ. No. 1645. U. S. Publ. Health Service. Washington, D. C. Pp. 119-125.

Garner, L. F. & J. D. Klinger. 1985. Some visual effects caused by the beverage kava. J. Ethnopharm. 13(3): 307-311.

Gatty, R. 1956. Kava -- Polynesian beverage shrub. Econ. Bot. 10(3): 241-249.

Geatz, R. 2000. Roots of tradition [*Piper methysticum*]. Nature Conservancy 50(6): 20- 28.

Hansel, R. 1968. Characterization and physiological activity of some kava constituents. Pacific Sci. 22: 369-373.

Holmes, L. D. 1961. The Samoan kava ceremony: its form and functions. Sci. of Man 1: 46-51.

Holmes, L. D. 1967. The function of kava in modern Samoan culture. Publ. No. 1645. U. S. Publ. Health Service. Washington, D. C. Pp. 107-118.

Kilham, C. 1996. Kava: medicine hunting in paradise. Healing Arts Press. Rochester, VT. 176 pp.

Lebot, V. 1989. L'historie du kava commence par su découverte. J. Soc. des Océanistes 88/89: 89-114.

Lebot, V. 1991. Kava (*Piper methysticum* Forst. f.): the Polynesian dispersal of an oceanic plant. In, Cox, P. A. & S. A. Banack (editors). Islands, plants, and Polynesians. Dioscorides Press. Portland, OR. Pp. 169-201.

Lebot, V. 1992. Kava: the Pacific drug. Yale Univ. Press. New Haven, CT. 255 pp.

Lebot, V. & J. Levesque. 1989. The origin and distribution of kava...: a phytochemical approach. Allertonia 5(2): 223-281.

Lebot, V. et al. 1992. Kava: the Pacific elixir. The definitive guide to its ethnobotany, history, and chemistry. Healing Arts Press. Rochester, VT. 255 pp.

Lehmann, E. et al. 1996. Efficacy of a special kava extract (*Piper methysticum*) in patients with states of anxiety, tension and excitedness of non-mental origin -- a double-blind placebo-controlled study of four weeks treatment. Phytomed. 3(2): 113-119.

Lester, R. H. 1941. Kava drinking in Viti Levu, Fiji. Oceania 12: 97-124.

Lewin, L. 1866. Ueber *Piper methysticum* (kawa). Verlag von August Hischwald. Berlin, Germany.

Malauulu, J. et al. 1974. Kava: legends, ceremony, how-to-make and serve it. Faasamoa Pea 1(2): 20-37.

Nevermann, H. 1938. Kawa auf Neu Guinea. Ethnos 3: 179-192.

Newell, W. H. 1947. Kava ceremony in Tonga. J. Polynesian Soc. 56: 364-417.

Norton, S. A. & P. Ruze. 1994. Kava dermopathy. J. American Acad. Dermatol. 31: 89-97.

Schelosky, L. 1995. Kava and dopamine antagonism. J. Neurology, Neurosurgery & Psychiat. 58(5): 639, 640.

Shulgin, A. T. 1973. The narcotic pepper -- the chemistry and pharmacology of *Piper methysticum* and related species. Bull. Narcotics 25(2): 59-74.

Singh, Y. N. 1981. A review of the historical, sociological and scientific aspects of kava and its uses in the South Pacific. Fiji Med. J. 9: 61-64.

Singh, Y. N. 1983. Effects of kava on neuromuscular transmission and muscle contractility. J. Ethnopharm. 7(3): 267-276.

Singh, Y. N. 1992. Kava: an overview. J. Ethnopharm. 37(1): 13-45.

Singh, Y. N. & M. Blumenthal. 1997. Kava: an overview. HerbalGram 39: 33-55.

Singh, Y. N. & M. Blumenthal. 1998. Kava culture, then and now. Herbs for Health. 2(6): 56-60.

Titcomb, M. 1948. Kava in Hawaii. J. Polynesian Soc. 57: 105-171.

Turner, J. W. 1986. The waster of life: kava ritual and the logic of sacrifice. Ethnology 25: 203-214.

BETEL NUT

Burton-Bradley, B. 1979. Arecaidinism: betel chewing in a transcultural perspective. Canadian J. Psychiatry 24: 481-488.

Ghandi, A. R. & N. M. Sial. 1952. Pan (*Piper betle* Linn.): a review and bibliography. Pakistan J. Sci. 4: 153-165.

Gowda, M. 1951. The story of pan chewing in India. Bot. Mus. Leaflts. Harvard Univ. 14(8): 181-214.

Lewin, L. 1889. Ueber *Areca catechu*, Chavica Betle und das Betelkauen. Monographie. F. Enke. Stuttgart, Germany.

Raghaven, V. & H. K. Baruah. 1956. Areca-nut: India's popular masticatory -- history, chemistry and utilization. Econ. Bot. 12: 315-345.

Sen, S. et al. 1989. Betel cytotoxicity. J. Ethnopharm. 26(3): 217-247.

PITURI

Watson, P. L. 1983. The precious foliage: a study of the aboriginal psychoactive drug pituri. Univ. Sydney Press. Sydney, Australia. 65 pp.

12: ETHNOBOTANICAL STUDIES

GENERAL REFERENCES

Alexiades, M. N. (editor). 1996. Selected guidelines for ethnobotanical research: a field manual. New York Botanical Garden. Bronx, NY. 306 pp.

Barton, J. H. 1994. Ethnobotany and intellectual property rights. In, Ethnobotany and the search for new drugs. CIBA Foundation Symp. No. 185. John Wiley & Sons. Chichester, England. Pp. 214-227.

Berlin, B. 1992. Ethnobiological classification: principles of categorization of plants and animals in traditional societies. Princeton Univ. Press. Princeton, NJ.

Brown, C. H. 1986. The growth of ethnobiological nomenclature. Current Anthropol. 27(1): 1-19.

Browner, C. H., B. R. Ortiz de Montellano, & A. J. Rubel. 1988. A methodology for cross-cultural ethnomedical research. Current Anthropol. 29: 681-702.

Brush, S. B. & D. Stabinsky. 1996. Valuing local knowledge: indigenous people and intellectual property rights. Island Press. Washington, D. C.

Cotton, C. M. 1996. Ethnobotany: principles and applications. John Wiley & Sons. Chichester, England. 424 pp.

Croom, E. M., Jr. 1983. Documenting and evaluating herbal remedies. Econ. Bot. 37: 13-27.

Cunningham, A. B. 2001. Applied ethnobotany: people, wild plant use & conservation. Earthscan. London, U. K. 300 pp.

Food and Agriculture Organization. 1991. Draft international code of conduct for plant germplasm collecting and transfer. Comm. Plant Genetic Resources. Fourth session. 15-19 April 1991. Food and Agriculture Organization. United Nations. Rome, Italy.

Friedberg, C. 1968. Les methodes d'enquete en ethnobotanique. J. d'Agric. Trop. Bot. Appl. 15(7/8): 297-324.

Godoy, R. A., R. Lubowski, & A. Markandaya. 1993. A method for the economic valuation of non-timber forest products. Econ. Bot. 47(3): 220-233.

Hays, T. E. 1976. An empirical method for the identification of covert categories in ethnobiology. American Ethnol. 3: 489-507.

Hunn, E. S. 1982. The utilitarian factor in folk biological classification. American Anthropol. 84: 830-847.

Jain, S. K. (editor). 1989. Methods and approaches in ethnobotany. Soc. of Ethnobotany. Lucknow, India.

Johnson, M. (editor). 1992. Research on traditional environmental knowledge and its role. In, Lore: capturing traditional environmental knowledge. Dene Cultural Inst. Fort Hay, Canada. Pp. 3-22.

Lewis, W. H. & M. P. Elvin-Lewis. 1994. Basic, quantitative and experimental research phases of future ethnobotany with reference to the medicinal plants of South America. In, Ethnobotany and the search for new drugs. CIBS Foundation Symp. No. 185. John Wiley & Sons. Chichester, England. Pp. 60-76.

Lipp, F. J. 1989. Methods for ethnopharmacological fieldwork. J. Ethnopharm. 25: 139-150.

Martin, G. 1994. Conservation and ethnobotanical exploration. In, Ethnobotany and the search for new drugs. CIBA Foundation Symp. No. 185. John Wiley & Sons. Chichester, England. Pp. 229-245.

Meil, J. 1993. New World plants and their uses: a guide to selected literature and genetic resources 1980-1993. National Agric. Library. Beltsville, MD. 38 pp.

National Germplasm Resources Laboratory. 1990. Code of conduct for foreign plant explorations. National Germplasm Resources Laboratory. U. S. Dept. Agriculture. Beltsville, MD.

Paye, G. D. 2001. Cutural uses of plants: a guide to learning about ethnobotany. New York Bot. Gard. Bronx, NY. 211 pp.

Pearsall, D. M. 2000. Palaeoethnobotany: a handbook of procedures. Second edition. Academic Press. San Diego, CA. 736 pp.

Peters, C. M., A. H. Gentry, & R. O. Mendelsohn. 1989. Valuation of an Amazonian rainforest. Nature 339: 655, 656.

Posey, D. A.1990. Intellectual property rights and just compensation for indigenous knowledge. Anthropology Today 6(4): 13-16.

Posey, D. A. 1990. Intellectual property rights: what is the position of ethnobiology? J. Ethnobiol. 10: 93-98.

Posey, D. A. & W. L. Overal (organizers). 1990. Ethnobiology: implications and applications. Proc. First International Congress of Ethnobiology. Two vols. Museu Paraense Emilio Goeldi. Belem, Brazil.

Prance, G. T. et al. 1987. Quantitative ethnobotany and the case for conservation in Amazonia. Conservation Biol. 1: 296-310.

Souza Brito, A. R. M. 1996. How to study the pharmacology of medicinal plants in underdeveloped countries. J. Ethnopharm. 54: 131-138.

Toledo, V. M. 1992. What is ethnoecoology? Origins, scope and implications of a rising discipline. Etnoecol. 1(1): 5-21.

Waller, D. P. 1993. Methods in ethno-pharmacology. J. Ethnopharm. 38: 189-195.

NORTH AMERICA

Anderson, M. K. 1990. California Indian horticulture. Fremontia 18(2): 7-14.

Anderson, J. P. 1939. Plants used by the Eskimo of the northern Bering Sea and Arctic regions of Alaska. American J. Bot. 26: 714-716.

Anderson, J. R. 1925. Trees and shrubs, food, medicinal, and poisonous plants of British Columbia. Dept. of Education. Victoria.

Applegate, R. B. 1975. The Datura cult among the Chumash. J. Calififormia Anthrop. 2:7-17.

Arnason, T., R. J. Hebda, & T. Johns. 1981. Use of plants for food and medicine by native people of eastern Canada. Canadian J. Bot. 59: 2189-2325.

Austin, D. F. & D. M. McJunkin. 1978. An ethnoflora of Chokoloskee Island, Collier County, Florida. J. Arnold Arbor. 59(1): 50-67.

Baker, M. A. 1981. The ethnobotany of the Yurok, Tolowa, and Karok Indians of northwest California. Master of Arts thesis. Humboldt State Univ. Arcata, CA. 141 pp.

Balls, E. K. 1962. Early uses of California plants. Univ. California Press. Berkeley. 103 pp.

Bank, T. P. 1952. Botanical and ethnobotanical studies of the Aleutian Islands. II. The Aleuts. Papers Michigan Acad. Sci., Arts, Letters 38: 415-431.

Banks, W. H. 1953. Ethnobotany of the Cherokee Indians. Univ. Tennessee Press. Knoxville.

Barlow, K. R. & D. Metcalfe. 1996. Plant utility indices: two Great Basin examples. J. Archaeol. Sci. 23: 351-371.

Barrett, S. A. 1910. The material culture of the Klamath Lake and Modoc Indians of northeastern California and southern Oregon. Univ. California Publ. American Archaeol. Ethnol. 5(4): 239-292.

Barrett, S. A. & E. W. Gifford. 1933. Miwok material culture. Bull. Public Mus. City Milwaukee. 2(4): 117-376.

Barrows, D. P. 1900. The ethno-botany of the Coahuilla Indians of southern California. Univ. Chicago Press. Chicago, IL. 82 pp.

Bean, L. J. & K. S. Saubel. 1963. Cahuilla ethnobotanical notes: aboriginal uses of mesquite and screwbean. Archaeol. Surv. Ann. Rpt. Univ. California, Los Angeles. Pp. 51-78.

Bean, L. J. & K. S. Saubel. 1972. Temalpakh: Cahuilla Indian knowledge and usage of plants. Malki Mus. Press. Banning, CA. 225 pp.

Bean, L. J. & K. S. Saubel. 1961. Cahuilla ethnobotanical notes: the aboriginal uses of oak. Archaeol. Surv. Ann. Rpt. Univ. California, Los Angeles. Pp. 237-245.

Beck, B. M. 1994. Ethnobotany of the California Indians. Vol. I. A bibliography and index. Koeltz Scientific Books. Champaign, IL. 165 pp.

Bell, W. H. & E. F. Castetter. 1937. The utilization of mesquite and screwbean by the aborigines in the American Southwest. Univ. New Mexico Bull. No. 314, Biol. Series 5(2).

Bell, W. H. & E F. Castetter. 1941. The utilization of yucca, sotol and beargrass by the aborigines in the American Southwest. Univ. New Mexico Bull. No. 372, Biol. Series 5(3).

Binford, L. B. 1968. An ethnohistory of the Nottoway, Meherrin, and Weanock Indians of southeastern Virginia. Ethnohistory 14(3-4):

Bird, J. 1948. America's oldest farmers. Nat. Hist. 57: 296-303; 334, 335.

Black, M. J. 1978. Plant dispersal by native North Americans in the Canadian subarctic. Anthrop. Pap. Mus. Anthrop., Univ. Michigan 67: 255-262.

Blankinship, J. W. 1905. Native economic plants of Montana. Montana Agric. Coll. Exp. Sta. Bull. 56. Bozeman.

Bocek, B. R. 1984. Ethnobotany of Costanoan Indians, California, based on collections by John P. Harrington. Econ. Bot. 38(2): 240-255.

Bohrer, V. L. 1973. Ethnobotany of Point of Pines Ruin, Arizona. Econ. Bot. 27: 423-437.

Bohrer, V. L. & K. R. Adams. 1977. Ethnobotanical techniques and approaches at Salmon Ruin, New Mexico. Contr. Anthrop. Eastern New Mexico Univ. 8: 1-220.

Bohrer, V. L. 1970. Ethnobotanical aspects of Snaketown, a Hohokam village in southern Arizona. American Antiq. 35(4): 413-429.

Bohrer, V. L. 1962. Nature and interpretation of ethnobotanical materials from Tonto National Monument. Southwestern Monuments Assoc. Tech. Series 2: 79-114.

Brown, R. 1868. On the vegetable products used by the northwest American Indians, as food and medicine, in the arts, and in superstitious rites. Trans. Bot. Soc. Edinburgh 9: 378-396.

Budrow, J. T. 1895. Some useful native plants of Colorado. Courier Publ.

Bye, R. A., Jr. 1985. Botanical perspectives of ethnobotany of the Greater Southwest. Econ. Bot. 39(4): 375-386.

Bye, R. A., Jr. & E. Linares. 1986. Ethnobotanical notes from the Valley of San Luis, Colorado. J. Ethnobiol. 6(2): 289-306.

Callen, E. O. & P. S. Martin. 1969. Plant remains in some coprolites from Utah. American Antiq. 34: 329-331.

Carlson, G. G. & V. H. Jones. 1940. Some notes on uses of plants by the Comanche Indians. Papers Michigan Acad. Sci., Arts, & Letters 25: 517-542.

Carter, G. F. 1944. Plant geography and culture history in the American Southwest. Viking Fund Publ. Anthrop. No. 5. Johnson Reprint. New York, NY. 140 pp.

Castetter, E. F. 1935. Ethnobiological studies in the American Southwest. I. Uncultivated native plants used as sources of food. Univ. New Mexico Bull. Biol. Series 4: 1-62.

Castetter, E. F. & R. M. Underhill. 1935. The ethnobiology of the Papago Indians. Univ. New Mexico Ethnobiol. Bull. No. 275.

Castetter, E. F. & W. H. Bell. 1942. Pima and Papago Indian agriculture. Univ. New Mexico Press. Albuquerque.

Castetter, E. F. & M. E. Opler. 1936. The ethnobiology of the Chiricahua and Mescalero Apache. The use of plants for foods, beverages and narcotics. Univ. New Mexico Ethnobiol. Studies Bull. No. 297. 63 pp.

Chamberlain, L. S. 1901. Plants used by the Indians of eastern North America. American Nat. 35: 1-10.

Chamberlin, R. V. 1909. Some plant names of the Ute Indians. American Anthrop. 11: 27-40.

Chamberlin, R. V. 1911. The ethno-botany of the Gosiute Indians of Utah. Mem. American Anthrop. Assoc. 2(5): 329-405.

Cheatham, S., M. C. Johnston, & L. Marshall. 2000. The useful wild plants of Texas, the southeastern and southwestern United States, the southern plains, and northern Mexico. Vol. 2. Useful Wild Plants. 599 pp.

Chestnut, V. K. 1902. Plants used by the Indians of Mendocino County, California. Contr. U. S. Nat. Herb. 7(4): 295-408.

Clark, C. B. 1977. Edible and useful plants of California. California Natural History Guides: 41. Univ. California Press. Berkeley. 280 pp.

Core, E. L. 1967. Ethnobotany of the southern Appalachian aborigines. Econ. Bot. 21(3): 198-214.

Cornett, J. W. 1995. Indian uses of native plants. Palm Springs Desert Mus. Palm Springs, CA. 38 pp.

Coville, F. V. 1897. Notes on plants used by the Klamath Indians of Oregon. Contr. U. S. Nat. Herb. 5(2): 37-108.

Culley, J. The California Indians: their medicinal practices and their drugs. J. American Pharm. Assoc. 25: 332-339.

Curtin, L. S. M. 1957. Some plants used by the Yuki Indians of Round Valley, northern California. Southwest Museum. Los Angeles, CA. 24 pp.

Davis, B. J. & M. Hendrix. 1991. Plants and the people: the ethnobotany of the Karuk Tribe. Museum Series No. 5. Siskiyou County Museum. Yreka, CA. 182 pp. + bibliography.

Densmore, F. 1928. Uses of plants by the Chippewa Indians. Ann. Rep. American Bur. Ethnol., 1926-1927. U. S. Gov. Printing Office. Washington, D. C. Pp. 275-397.

Duncan, J. W. 1961. Maidu ethnobotany. M. S. thesis. Sacramento State Univ. Sacramento, CA.

Dunmire, W. W. & G. D. Tierney. 1995. Wild plants of the Pueblo Province: exploring ancient and enduring uses. Mus. New Mexico Press. Santa Fe. 290 pp.

Dunmire, W. W. & G. D. Tierney. 1997. Wild plants and native peoples of the Four Corners. Mus. New Mexico Press. Santa Fe. 312 pp.

Dunn, M. E. 1983. Coquille flora [Louisiana]: an ethnobotanical reconstruction. Econ. Bot. 37(3): 359.

Ebeling, W. 1986. Handbook of Indian foods and fibers of arid America. Univ. California Press. Berkeley. 971 pp.

Edwards, E. E. & W. D. Rasmussen. 1942. A bibliography of the agriculture of the American Indians. Misc. Publ. No. 447. U. S. Dept. Agric. Washington, D. C. 107 pp.

Elmore, F. H. 1944. Ethnobotany of the Navajo. Univ. New Mexico and School American Research.

Elsasser, A. B. 1981. Notes on Yana ethnobotany. J. California Great Basin Anthrop. 3(1): 69-77.

Felger, R. S. & M. B. Moser. 1985. People of the desert and sea: ethnobotany of the Seri Indians. Univ. Arizona Press. Tucson. 435 pp.

Fewkes, J. W. 1896. A contribution to ethnobotany. American Anthrop. 9: 14-21.

Ford, R. I. 1985. Anthropological perspective of ethnobotany in the Greater Southwest. Econ. Bot. 39(4): 400-415.

Forde, C. D. 1931. Ethnography of the Yuma Indians. Univ. California Publ. American Archaeol. Ethnol. 28(4): 83-278.

French, D. H. 1965. Ethnobotany of the Pacific Northwest Indians. Econ. Bot. 19(4): 378-382.

French, D. H. 1981. Neglected aspects of North American ethnobotany. Canadian J. Bot. 59: 2326-2330.

Gallagher, M. V. 1977. Contemporary ethnobotany among the Apache of the Clarkdale, Arizona, Coconino and Prescott National Forest. U. S. Forest Service. Archaeol. Rep. No. 14.

Gill, S. J. 1983. Ethnobotany of the Makah and Ozette People, Olympic Peninsula, Washington (U. S. A.). Ph. D. dissertation. 445 pp.

Gilmore, M. R. 1919. Uses of plants by the Indians of the Missouri River region. Ann. Rep. Bur. American Ethnol., 1911-1912. U. S. Gov. Printing Office. Washington, D. C. Pp. 43-154.

Gilmore, M. R. 1913. A study in the ethnobotany of the Omaha Indians. Coll. Nebraska State Hist. Soc. 17: 314-357.

Gilmore, M. R. 1913. Some native Nebraska plants with their uses by the Dakota. Coll. Nebraska State Hist. Soc. 17: 358-370.

Gilmore, M. R. 1931. Vegetal remains of the Ozark Bluff-dwellers culture. Michigan Acad. Sci., Arts, & Letters 14: 83-103.

Gilmore, M. R. 1977. Uses of plants by the Indians of the Missouri River region. Enlarged edition. Revision of author's 1914 thesis. Univ. Nebraska Press. Lincoln. 125 pp.

Ginter, P. L. 1941. Some wild plants used by the American Indians. U. S. Forest Service. U. S. Dept. Agric. Denver, CO.

Goodrich, J., C. Lawson, & V. P. Lawson. Kashaya Pomo plants. Heydey Books. Berkeley, CA. 176 pp.

Gorman, M. W. 1896. Economic botany of southeastern Alaska. Pittonia 3: 64-85.

Gottesfeld, L. M. J. 1992. The importance of bark products in the aboriginal economies of northwestern British Columbia, Canada. Econ. Bot. 46(2): 148-157.

Grime, W. E. 1979. Ethno-botany of the Black Americans. Reference Publ. Algonac, MI. 237 pp.

Grinnell, G. B. 1923. The Cheyenne Indians: their history and ways of life. Vol. 2. Yale Univ. Press. New Haven, CT.

Gunther, E. 1973. Ethnobotany of western Washington. Revised edition. Univ. Washington Press. Seattle. 71 pp.

Hamel, P. B. & M. U. Chilktoskey. 1975. Cherokee plants: their uses -- a 400 year history. Herald Publ. Co. Sylva, NC. 72 pp.

Harrington, M. R. 1924. The Ozark Bluff-Dwellers. American Anthrop. 26: 1-21.

Hart, J. A. 1981. The ethnobotany of the northern Cheyenne Indians of Montana. J. Ethnopharm. 4(1): 1-55.

Hart, J. 1976. Montana: native plants and early peoples. Montana Hist. Soc. Helena. 76 pp.

Hart, J. A. 1979. The ethnobotany of the Flathead Indians of western Montana. Bot. Mus. Leaflts. Harvard Univ. 27(10): 261-307.

Harvey, C. L. 1979. Agriculture of the American Indian. A selected bibliography. U. S. Dept. Agric. Biblio. and Literature of Agric. No. 4. 64 pp.

Hedges, K. & C. Beresford. 1986. Santa Ysabel ethnobotany. Ethnic Technology Notes No. 20. San Diego Mus. Man. San Diego, CA. 58 pp.

Heffner, K. 1984. Following the smoke: contemporary plant procurement by the Indians of northwest California. Unpubl. ms. Six Rivers Natl. Forest. Eureka, CA.

Heizer, R. F. & A. B. Elasser. 1980. Plants commonly used by California Indians. In, The natural world of the California Indians. California Natural History Guides: 46. Univ. California Press. Berkeley. Pp. 239-252.

Hellson, J. C. & M. Gadd. 1974. Ethnobotany of the Blackfoot Indians. Canadian Ethnology Service Paper No. 19. National Museum of Man. Ottawa, Canada.

Hodge, F. W. 1907. Handbook of the American Indians north of Mexico. Bull. Bur. American Ethnol. Bull. No. 30., Pt. 1.

Holmes, G. K. 1909. Aboriginal agriculture: the American Indians. In, Bailey, L. H. (editor). Cyclopedia of American agriculture. Macmillan Co. 4: 24-39.

Holmes, W. C. 1990. Flore Louisiane: an ethno-botanical study of French-speaking Louisiana. Univ. Southwestern Louisiana. Lafayette. 145 pp.

Hoover, R. L. 1971. Industrial plants of the California Indians. Pacific Discovery 25: 25-31.

Hoover, R. L. 1977. California Indian uses of native plants. In, Walthers, D. R. et al. (editors). Native plants: a viable option. Special Publ. No. 3, California Native Plant Society. Berkeley, California. Pp. 131-162.

Hoover, R. L. 1973. Tobacco and the California Indians. Pacific Discovery 26(5): 23-27.

Hoover, R. L. 1974. Anthropologische Bemerkungen zue Ethnobotanik der Indianer Kaliforniens. Anthropos 69: 505-516.

Hoover, R. L. 1974. Aboriginal cordage in western North America. Occasional Paper No. 1. Imperial Valley Coll. Mus. El Centro, CA.

Hough, W. 1897. The Hopi in relation to their plant environment. American Anthrop. 10: 33-44.

Hussey, J. S. 1974. Some useful plants of early New England. Econ. Bot. 28: 311-337.

Johnston, A. 1970. Blackfoot Indian utilization of the flora of the northwestern Great Plains. Econ. Bot. 24: 301-324.

Jones, V. 1931. The ethnobotany of the Isleta Indians. M. A. thesis. Univ. New Mexico.

Jones, V. 1936. The vegetal remains of Newt Kash Hollow shelter. Univ. Kentucky Rep. Anthrop. & Archaeol. 3(4): 147-167.

Kaplan, L. 1963. Archeoethnobotany of Cordova Cave, New Mexico. Econ. Bot. 17(4): 350-359.

Kari, P. R. 1987. Tanaina plantlore. Dena'ina K'et'una. An ethnobotany of the Dena'ina Indians of southcentral Alaska. Second edition. Natl. Park Service. Lake Clark Natl. Park and Preserve. Anchorage, AK. 205 pp.

Kindscher, K. & D. P. Hurlburt. 1998. Huran Smith's ethnobotany of the Hocak (Winnebago). Econ. Bot. 52(4): 352-372.

Krochmal, A. & C. Krochmal. 1977. Useful plants of the Blue Ridge. Southeastern Forest Exp. Stat., in cooperation with Blue Ridge Parkway, Natl. Park Serv.

Krochmal, A., S. Paur, & P. Duisberg. 1954. Useful native plants in the American southwestern deserts. Econ. Bot. 8(1): 3-20.

Kroeber, A. L. 1939. Cultural and natural areas of native North America. Univ. California Publ. American Archaeol. Ethnol. 38: 1-242.

Kroeber, A. L. 1925. Handbook of the Indians of California. Bull. No. 78. Bur. American Ethnol. Washington D. C. 995 pp.

Lawton, J. W., P. J. Wilke, M. DeDecker, & W. M. Mason. 1976. Agriculture among the Paiute of Owens Valley. J. California Anthrop. 3(1): 13-50.

Lloyd, R. M. 1964. Ethnobotanical uses of California pteridophytes by western American Indians. American Fern J. 54(2): 76-82.

Marles, R. J. 1984. The ethnobotany of the Chipewyan of northern Saskatchewan. Master of Science thesis. Univ. Saskatchewan. Saskatoon, Canada.

Marles, R. J. et al. 2000. Aboriginal plant use in Canada's northwest boreal forest. Univ. British Columbia Press. Vancouver, Canada. 368 pp.

Matthews, W. 1886. Navaho names and uses for plants. American Nat. 20(9): 767-777.

McAndrews, J. H. 1969. Paleobotany of a wild rice lake in Minnesota. Canadian J. Bot. 47: 1671-1679.

Mead, G. R. 1971. The Indians of the Redwood Belt of California: an ethnobotanical approach to culture area. Ph. D. dissertation. Washington State Univ. Pullman. 141 pp.

Mead, G. R. 1972. The ethnobotany of the California Indians. A compendium of the plants, their users, and their uses. Occasional Publ. Anthrop. and Ethnol. Series No. 30. Mus. of Anthrop. Univ. N. Colorado. Greeley. 138 pp.

Merrill, W. L. & C. F. Feest. 1975. An exchange of botanical information in the early contact situation: Wisakon of southeastern Algonquins. Econ. Bot. 29: 171-184.

Moerman, D. E. 1994. North American food and drug plants. In, Etkin, N. L. (editor). Eating on the wild side. Univ. Arizona Press. Tucson. Pp. 166-181.

Moerman, D. E. 1998. Native American ethnobotany. Timber Press. Portland, OR. 928 pp.

Moerman, D. E. American Indian ethnobotany database: food, drugs, dyes, and fibers of native North American peoples. http://www.umd.umich.edu/cgi-bin/herb/

Morrell, J. M. H. 1901. Some Maine plants and their uses "wise and otherwise." Rhodora 3(29): 129-132.

Murphey, E. 1959. Indian uses of native plants. Mendocino County Hist. Soc. Fort Bragg, California. 81 pp.

Nabhan, G. P. 1989. Enduring seeds: native American agriculture and wild plant conservation. North Point Press. San Francisco, CA. 225 pp.

Nabhan, G. P. 1985. Gathering the desert. Univ. Arizona Press. Tucson. 209 pp.

Naegele, T. A. 1996. Edible and medicinal plants of the Great Lakes region. Wilderness Adventure Books. 423 pp.

Newberry, J. S. 1887. Food and fiber plants of the North American Indians. Pop. Sci. Monthly 32: 31-46.

Nickerson, G. S. 1966. Some data on Plains and Great Basin Indian uses of certain native plants. J. Idaho State Univ. Mus. 9: 45-51.

Niethammer, C. 1974. American Indian food and lore. Collier Books. New York, NY. 191 pp.

Norton, H. H. et al. 1979. Vegetable food products of the foraging economies of the Pacific Northwest. Ecol. Food Nutr. 14: 219-228.

O'Neale, L. M. 1932. Yurok-Karok basket weavers. Univ. California Publ. American Archaeol. Ethnol. 32(1): 1-184.

Oswald, F. W. 1956. The beginner's guide to useful plants of eastern wilds. Anderson Press. Hawthorne, NJ.

Palmer, E. 1878. Plants used by the Indians of the United States. American Nat. 12: 593-606; 646-655.

Palmer, G. 1975. Shuswap Indian ethnobotany. Syesis 8: 29-81.

Powers, S. 1976. Aboriginal botany. In, Tribes of California. Reprint of the 1877 text. Contr. U. S. Ethnol. 3: 420-431.

Radin, R. 1923. The Winnebago tribe. Ann. Rep. Bur. American Ethnol., 1915-16. U. S. Gov. Printing Office. Washington, D. C. Pp. 35-560.

Rea, A. M. 1997. At the desert's green edge: an ethnobotany of the Gila River Pima. Univ. Arizona Press. Tucson. 430 pp.

Rea, M.-A. F. 1975. Early introduction of economic plants into New England. Econ. Bot. 29: 333-356.

Reagan, A. B. 1928. Plants used by the Bois Fort Chippewa (Ojibwa) Indians of Minnesota. Wisconsin Archaeol. 7(4): 230-248.

Reagan, A. B. 1934. Various uses of plants by West Coast Indians. Washington Hist. Quart. 25: 133-137.

Reagan, A. B. 1934. Plants used by the Hoh and Quileute Indians. Trans. Kansas Acad. Sci. 37: 55-70.

Reagan, A. B. 1929. Uses of plants by the White Mountain Apache Indians of Arizona. Wisconsin Archaeol. 8: 143-161.

Rhode, D. 2002. Native plants of southern Nevada: an ethnobotany. Univ. Utah Press. Salt Lake City. 188 pp.

Riley, T. J., R. Edging, & J. Rossen. 1990. Cultigens in prehistoric eastern North America. Curr. Anthrop. 31(5): 525-541.

Robbins, W., J. P. Harrington, & B. Freire-Marreco. 1916. Ethnobotany of the Tewa. Bur. American Ethnol. Bull. No. 55.

Romero, J. B. 1954. The botanical lore of the California Indians, with side lights on historical incidents in California. Vantage Press. New York, NY. 82 pp.

Russell, F. 1908. The Pima Indians. Ann. Rep. Bur. American Ethnol. U. S. Gov. Printing Office. Washington, D. C. Pp. 3-391.

Rydberg, P. A. 1924. Plants used by ancient American Indians. J. New York Bot. Gard. 25: 204, 205.

Safford, W. E. 1917. Food-plants and textiles of ancient America. Proc. Congr. Int. Amer. Session No. 19: 12-30.

Safford, W. E. 1927. Our heritage from the American Indians. Ann. Rep. Smithsonian Inst., 1926. U. S. Gov. Printing Office. Washington, D. C. Pp. 387-424.

Saunders, C. F. 1934. Useful wild plants of the United States and Canada. R. M. McBride. New York, NY.

Schenck, S. M. & E. W. Gifford. 1952. Karok ethnobotany. Univ. California Anthrop. Records 13: 377-392.

Schmidt, J. G. 1990. Ethnobotany of contemporary northeastern "woodland" Indians: its sharing with the public through photography. Adv. Econ. Bot. 8: 224-240.

Schneider, A. 1906. The medicinal plants of the California Indians. Merck's Report 15: 63-128.

Scully, V. 1970. A treasury of American Indian herbs: their lore and their use for food, drugs, and medicine. Crown Publ. New York, NY. 306 pp.

Simmons, A. H. 1986. New evidence for the early use of cultigens in the American Southwest. American Antiq. 51: 73-89.

Smith, C. E., Jr. 1950. Prehistoric plant remains from Bat Cave. Bot. Mus. Leaflts. Harvard Univ. 14: 157-180.

Smith, H. H. 1923. Ethnobotany of the Menomini Indians. Bull. Publ. Mus. City Milwaukee 4(1): 1-174.

Smith, H. H. 1928. Ethnobotany of the Meskwaki Indians. Bull. Publ. Mus. City Milwaukee 4(2): 175-326.

Smith, H. H. 1932. Ethnobotany of the Ojibwe Indians. Bull. Publ. Mus. City Milwaukee 4(3): 327-525.

Smith, H. H. 1933. Ethnobotany of the Forest Potawatomi Indians. Bull. Publ. Mus. City Milwaukee 7(1): 1-230.

Smith, H. I. 1928. Materia medica of the Bella Coola and neighbouring tribes of British Columbia. Bull. Natl. Mus. Canada 56: 47-68.

Spinden, H. J. 1908. The Nez Perce Indians. Mem. American Anthrop. Assoc. 2: 165-274.

Springmeyer, F. 1996. Willow bark and rosehips: an introduction to common edible and useful wild plants of North America. Falcon. Helena, MT. 80 pp.

Standley, P. C. 1912. Some useful native plants of New Mexico. Ann. Rep. Smithsonian Inst., 1911. U. S. Gov. Printing Office. Washington, D. C. Pp. 447-462.

Steedman, E. V. 1929. The ethnobotany of the Thompson Indians of British Columbia. Bur. American Ethnol. 45th annual report, 1927-1928. Smithsonian Inst. Washington D.C. Pp. 441-522.

Stevenson, M. C. 1915. Ethnobotany of the Zuni Indians. Ann. Rep. Bur. American Ethnol. 1908-1909. U. S. Gov. Printing Office. Washington, D. C. Pp. 31-102.

Strike, S. S. 1994. Ethnobotany of the California Indians. Vol. 2. Aboriginal uses of California's indigenous plants. Koeltz Scientific Books. Champaign, IL. 210 pp.

Struever, S. 1962. Implications of vegetal remains from an Illinois Hopewell site. American Antiq. 27: 584-586.

Sturtevant, W. C. 1960. The significance of ethnological similarities between southeastern North America and the Antilles. Yale Univ. Publ. Anthrop. 64: 1-58.

Sweet, M. 1976. Common edible and useful plants of the West. Naturegraph Co. Healdsburg, CA. 64 pp.

Timbrook, J. 1984. Chumash ethnobotany: a preliminary report. J. Ethnobiol. 4(2): 141-169.

Turner, N. J. 1973. The ethnobotany of the Bella Coola Indians of British Columbia. Syesis 6: 193-220.

Turner, N. J. 1974. Plant taxonomic systems and ethnobotany of three contemporary Indian groups of the Pacific Northwest (Haida, Bella Coola, and Lillooet). Syesis 7. Supplement I. 104 pp.

Turner, N. J. 1975. The ethnobotany of the Okanagan Indians of British Columbia and Washington State. The British Columbia Indian Language Project.

Turner, N. J. 1979. Plants in British Columbia Indian technology. Handbook No. 38. British Columbia Provincial Museum. Victoria. 304 pp.

Turner, N. J. 1988. The importance of a rose: evaluating the cultural significance of plants in Thompson and Lilloet Interior Salish. American Anthropologist 90: 272-290.

Turner, N. J. 1988. Ethnobotany of coniferous trees in Thompson and Lillooet Interior Salish of British Columbia. Econ. Bot. 42(2): 177-194.

Turner, N. J. 1989. "All berries have relations:" midlevel folk plant categories in Thompson and Lillooet Interior Salish. J. Ethnobiol. 9(1): 69-110.

Turner, N. J. 1998. Plant technology of First Peoples in British Columbia. Univ. British Columbia Press. Vancouver. 256 pp.

Turner, N. C. & B. S. Efrat. 1982. Ethnobotany of the Hesquiat Indians of Vancouver Island. Cultural Recovery Paper No. 2. British Columbia Provincial Mus. Victoria. 101 pp.

Turner, N. C. & M. A. M. Bell. 1971. The ethnobotany of the coast Salish Indians of Vancouver Island. Econ. Bot. 25: 63-104.

Turner, N. C. & M. A. M. Bell. 1973. Ethnobotany of the southern Kwakiutl Indians of British Columbia. Econ. Bot. 27(3): 257-310.

Turner, N. J., R. Bouchard, & D. I. D. Kennedy. 1980. Ethnobotany of the Okanagan-Colville Indians of British Columbia and Washington. British Columbia Prov. Mus. Occas. Paper No. 21. Victoria. 179 pp.

Turner, N. J., J. Thomas, B. F. Carlson, & R. T. Ogilvie. 1983. Ethnobotany of the Nitinaht Indians of Vancouver Island. British Columbia Provincial Museum Publ. Victoria. 166 pp.

Turner, N. J., L. C. Thompson, M. Terry Thompson, & A. Z. York. 1990. Thompson ethnobotany: knowledge and usage of plants by the Thompson Indians of British Columbia. Mem. No. 3. Royal British Columbia Mus. Victoria, B. C. 335 pp.

Underhill, R. 1944. Indians of the Pacific Northwest. U. S. Dept. Interior. Bur. Indian Affairs. U. S. Gov. Printing Office. Washington, D. C.

Vestal, P. A. & R. E. Schultes. 1939. The economic botany of the Kiowa Indians as it relates to the history of the tribe. Bot. Mus. Harvard Univ. Cambridge, MA. 110 pp.

Vestal, P. A. 1952. Ethnobotany of the Ramah Navajo. Pap. Peabody Mus. American Archaeol. Ethnol. Harvard Univ. 40(4): XXX.

Wheat, M. M. 1967. Survival arts of the primitive Paiutes. Univ. Nevada Press. Reno. 117 pp.

White, L. A. 1944. Notes on the ethnobotany of the Keres. Pap. Michigan Acad. Sci., Arts, & Letters 30: 557-568.

Whiting, A. F. 1933. Ethnobotany of the Hopi. Bull. No. 15. Mus. Northern Arizona.

Whiting, A. F. 1936. Hopi Indian agriculture. I. Background. Mus. Notes Mus. Northern Arizona 8(10):

Whiting, A. F. 1937. Hopi Indian agriculture. II. Seed source and distribution. Mus. Notes. Mus. Northern Arizona 10(5):

Whiting, A. F. 1966. The present state of ethnobotany in the Southwest. Econ. Bot. 20(3): 316-325.

Willey, G. R. 1955. The prehistoric civilization of nuclear America. American Anthrop. 57: 571-593.

Yarnell, R. A. 1969. Palaeo-ethnobotany in America. In, Brothwell, D. & E. Higgs (editors). Science in archaeology. London.

Yarnell, R. A. 1977. Native plant husbandry north of Mexico. In, Reed, C. A. (editor). Origins of agriculture. Mouton. The Hague. Pp. 861-874.

Yarnell, R. 1987. A survey of the prehistoric crop plants in eastern North America. Missouri Archaeol. 47: 47-60.

Yarnell, R. A. 1964. Aboriginal relationships between culture and plant life in the Upper Great Lakes region. Anthrop. Pap. No. 23. Mus. Anthrop. Univ. Michigan. Ann Arbor.

Yohe, R. M., II. 1997. Archaeological evidence of aboriginal cultigen use in late nineteenth and early twentieth century Death Valley, California. J. Ethnobiol. 17(2): 267-282.

Young, S. 1938. Native plants used by the Navajo. U. S. Dept. Interior. Office of Indian Affairs.

Young, S. B. & E. S. Hall, Jr. 1969. Contributions to the ethnobotany of the St. Lawrence Island Eskimo. Anthrop. Pap. Univ. Alaska 14: 43-53.

Zigmond, M. L. 1941. Ethnobotanical studies among California and Great Basin Shoshoneans. Ph. D. dissertation. Yale Univ. New Haven, CT. 297 pp.

Zigmond, M. L. 1981. Kawaiisu ethnobotany. Univ. Utah Press. Salt Lake City. 102 pp.

MEXICO & CENTRAL AMERICA

Berlin, B. et al. 1974. Principls of Tzeltal plant classification: an introduction to the botanical ethnography of a Mayan-speaking people of highland Chiapas. Academic Press. New York, NY. 660 pp.

Blake, S. F. 1922. Native names and uses of some plants of eastern Guatemala and Honduras. Contr. U. S. Natl. Herb. 24(4): 87-100.

Breedlove, D. E. & R. M. Laughlin. 1993. The flowering of man. A Tzotzil botany of Zinacantan [Chiapas, Mexico]. Smithsonian Contr. Anthro. No. 35. Smithsonian Inst. Press. Washington, D. C. Two vols. 706 pp.

Brieger, F. G. 1967. The main ethnobotanical regions of Central and South America. Ciencias Cult. (Sao Paulo) 19: 547-553.

Bukasov, S. M. 1930. The cultivated plants of Mexico, Guatemala, and Colombia. Bull. Appl. Bot. Genet. Plant Breed. Suppl. 47:1-553. [In Russian with English summary pp. 470-553.]

Bukasov, S. M. 1965. Las plantas cultivada de Mexico, Guatemala y Colombia. Inst. Interamericano de Ciencias Agricolas de la OEA. Publ. Misc. No. 20. Lima, Peru. 261 pp.

Bye, R. A., Jr. & E. Linares. 1983. The role of plants found in the Mexican markets and their importance in ethnobotanical studies. J. Ethnobiol. 3(1): 1-13.

Cardenas, M. 1969. Manual de plantas economicas de Bolivia. Imprenta Icthus. Cochabamba.

Casas, A. et al. 2001. Plant resources of the Tehuacán-Cuicatlán Valley, Mexico. Econ. Bot. 55(1): 129-166.

Christensen, B. 1963. Bark paper and witchcraft in Indian Mexico. Econ. Bot. 17(4): 360-.

Coe, F. G. & G. J. Anderson. 1997. Ethnobotany of the Miskitu of eastern Nicaragua. J. Ethnobiol. 17(2): 171-214.

Conklin, H. C. 1967. Ifugao ethnobotany 1905-1965: the 1911 Beyer-Merril report in perspective. Econ. Bot. 21: 243-272.

Cook, O. F. & G. N. Collins. 1903. Economic plants of Porto Rico. Contr. U. S. Natl. Herb. 8: 57-269.

Covich, A. P. & N. H. Nickerson. 1966. Studies of cultivated plants in Choco clearings, Darien, Panama. Econ. Bot. 20: 285-301.

De Filipps, R. A. 1998. Useful plants of the Commonwealth of Dominica, West Indies. Publ. by author. Washington, D. C. 554 pp.

Dahlgren, B. E. & P. C. Standley. 1944. Edible and poisonous plants of the Caribbean region. U. S. Gov. Print. Office. Washington, D. C. 102 pp.

Dressler, R. L. 1958. The pre-Columbian cultivated plants of Mexico. Bot. Mus. Leaflts. Harvard Univ. 16: 115-172.

Duke, J. A. 1975. Ethnobotanical observations on the Cuna Indians. Econ. Bot. 29(3): 278-293.

Duke, J. A. 1986. Isthmian ethnobotanical dictionary. J. Econ. Taxon. Bot. Addt. Ser. 3: 1-205.

Ford, R. I. 1979. Human uses of plants: don't walk on the grass! Ethnobotany in Middle America. In, Kaufman, P. B. & J. D. LaCroix (editors). Plants, people, and environment. Macmillan. New York, NY. Pp. 281-288.

González, R. J. Zapotek science: farming and food in the northern Sierra of Oaxaca. Univ. Texas Press. Austin. 000 pp.

Guzman, D. J. 1980. Especies utiles de la flora Salvadoreana. Fourth edition. Ministerio de Educacion. San Salvador, El Salvador. 472 pp.

Harper, R. M. 1932. Useful plants of Yucatan. Bull. Torrey Bot. Club 59(5): 279-288.

Heiser, C.B., Jr. 1984. The ethnobotany of the neotropical Solanaceae. Adv. Econ. Bot. 1: 48-52.

Hill, A. F. 1945. Ethnobotany in Latin America. Chron. Bot. XX: 176-181.

Hodge, W. H. 1942. Plants used by the Dominican Caribs. J. New York Bot. Gard. 43: 189-201.

Hodge, W. H. & D. Taylor. 1956. The ethnobotany of the Island Caribs of Dominica. Webbia 12: 513-644.

Honychurch, P. N. 1986. Caribbean wild plants and their uses. Macmillan. London, England. 166 pp.

Jain, S. K. et al. 1997. Ethnobotanical aspects of some plants in Latin America. Ethnobot. 9(1-2): 16-23.

Kingsbury, J. M. 1988. 200 conspicuous, unusual, or economically important tropical plants of the Caribbean. Bullbrier Press. Ithaca, NY.

Latorre, D. L. and F. A. Latorre. 1977. Plants used by the Mexican Kickapoo Indians. Econ. Bot. 31(3): 340-357.

Lentz, D. L. 1986. Ethnobotany of the Jicaque of Honduras. Econ. Bot. 40(2): 210-291.

Lentz, D. L. 1993. Medicinal and other economic plants of the Paya of Honduras. Econ. Bot. 47: 358-370.

León, J. 1987. Botánica de los cultivos tropicales. IICA. San José, Costa Rica.

Lipp, F. J. 1971. Ethnobotany of the Chinantec Indians, Oaxaca, Mexico. Econ. Bot. 25: 234-244.

Lipp, F. J. 1976. A heritage destroyed: the lost gardens of ancient Mexico. Garden J. 26: 184-188.

Lundell, C. L. 1939. Plants probably utilized by the Old Empire Mayas of Peten and adjacent lowlands. Pap. Michigan Acad. Sci. 24: 37-56.

Lundell, C. L. 1976. Ethnobotanical notes from Guatemala. Wrightia 5(8): 299, 300.

MacNeish, R. S. 1964. Ancient Mesoamerican civilization. Science 143: 531-537.

Martinez, M. 1928. Las plantas mas utiles que existen en la Republica Mexicana. Linotipograficos de H. Barrales Sucr. Donceles, Mexico. 395 pp.

Martinez Alfaro, M. A. et al. 1995. Catalogo de plantas utiles de la Sierra Norte de Puebla México. Inst. de Biol. U. N. A. M. México, D. F. 304 pp.

Martinez-Crovetto, R. 1964. Estudios etnobotanicos I. Nombres de plantas y su utilidad, segun los indios tobas del este del Chaco. Bonplandia Rev. Fac. Agron. Vet. Univ. Nac. Nordeste 1: 279-333.

Patino, V. M. 1963. Plantas cultivadas y animales domesticos en America equinoccial. Vol. 1. Imprenta Departmental. Cali, Colombia.

Pittier, H. 1978. Plantas usuales de Costa Rica. Second edition. Editorial Costa Rica. San José. 329 pp.

Prance, G. T. & J. A. Kallunki (editors). 1984. Ethnobotany in the Neotropics. Adv. Econ. Bot. No. 1. 156 pp.

Reko, B. P. 1919. De los nombres botánicos Aztecas. El México Antiguo 1(5): 136-152.

Rose, J. N. 1899. Notes on useful plants of Mexico. Contr. U. S. Natl. Herb. 5(4): 209-259.

Roys, L. 1931. The ethnobotany of the Maya. Tulane Univ. Middle American Res. Ser. Publ. 2: 1-359.

Safford, W. E. 1917. Food plants and textiles of ancient America. Proc. 19th Intern. Congr. Americanists. Washington, D. C. Pp. 12-30.

Sandweiss, D. H. 1993. Ethnobotany of the lower Chamelecón mestizos, northwest Honduras. Ann. Carnegie Mus. 62(2): 131-150.

Sauer, C. O. 1950. Cultivated plants of South America and Central America. Bull. 143. Bur. American Ethnol. Handbook of South American Indians. Smithsonian Institution. Washington, D. C. 6: 487-543.

Schlesinger, V. 2002. Animals and plants of the ancient Maya: a guide. Univ. Texas Press. Austin. 351 pp.

Schultes, R. E. 1941. Economic aspects of the flora of northeastern Oaxaca, Mexico. Two vols. Ph. D. dissertation. Harvard Univ. Cambridge, MA.

Smith, C. E., Jr. 1965. Agriculture, Tehuacan Valley. Fieldiana: Botany 31(3): XXX.

Smith, C. E., Jr. 1967. Plant remains. In, Byer, D. S. (editor). Environment and subsistence: the prehistory of the Tehuacan Valley. Univ. Texas Press. Austin. 1: 220-255.

Smith, C. E., Jr. & M. L. Cameron. 1977. Ethnobotany in the Puuc, Yucatan. Econ. Bot. 31(2): 93-110.

Smith, C. E., Jr. & P. Tolstoy. 1981. Vegetation and man in the Basin of Mexico. Econ. Bot. 35(4): 415-433.

Thompson, J. E. 1930. Ethnology of the Mayas of southern and central British Honduras. Publ. Field Mus. Nat. Hist., Anthropology Ser. 17(2): 27-213.

Toledo, V. M. et al. 1995. La selva util: etnobotánica cuantitativa de los grupos indígenas del trópico húmedo de México. Interciencia 20: 177-187.

Turner, B. L. & C. H. Miksicek. 1984. Economic plant species associated with prehistoric agriculture in the Maya lowlands. Econ. Bot. 38(2): 179-193.

Ventocilla, J., H. Herrera, & V. Nunez. 1995. Plants and animals in the life of the Kuna [Panama]. Univ. Texas Press. Austin. 160 pp.

Williams, L. O. 1981. The useful plants of Central America. Ceiba 24(½): 3-342.

Woodworth, R. H. 1943. Economic plants of St. John, U. S. Virgin Islands. Bot. Mus. Leaflts. Harvard Univ. 11: 29-56.

Yetman, D. & T. R. van DeVender. 2002. Mayo ethnobotany. Univ. California Press. Berkeley. 340 pp.

SOUTH AMERICA

Balée, W. L. 1994. Footprints of the forest. Ka'apor ethnobotany -- the historical ecology of plant utilization by an Amazonian people. Columbia Univ. Press. New York, NY.

Bennet, B. C. 1992. Plants and people of the Amazonian rainforests. BioScience 42: 599-607.

Bennett, B. C., M. A. Baker, & P. Gomez Andrade. 2002. Ethnobotany of the Shuar of eastern Ecuador. Adv. in Econ. Bot. Vol. 14. 299 pp.

Berlin, B. 1984. Contributions of Native American collectors to the ethnobotany of the neotropics. Adv. Econ. Bot. 1: 24-33.

Bodenbender, G. 1940. Nombres vulgares en orden alfabetico y nombres cientificos de plantas Argentinas silvestres y cultivadas. Rev. Univ. Nac. Cordoba. 27:

Boom, B. M. 1987. Ethnobotany of the Chacobo Indians, Beni, Bolivia. Adv. Econ. Bot. 4: 1-68.

Boom, B. M. 1990. Useful plants of the Panare Indians of the Venezuelan Guyana. Adv. Econ. Bot. 8: 57-76.

Cárdenas, M. 1989. Manual de plantas económicas de Bolivia. Second edition. Editorial Los Amigos del Libro. La Paz, Bolivia. 333 pp.

Castner, J. L., S. L. Timme, & J. A. Duke. 1998. A field guide to medicinal and useful plants of the Upper Amazon. Feline Press. Gainsville, FL. 154 pp.

Correa, M. P. 1926-1974. Diccionario das plantas uteis do Brasil. Six vols. Rio de Janeiro, Brazil.

Cruz, G. L. 1995. Diccionário das plantas úteis do Brasil. Bertand Brasil. Rio de Janeiro. 599 pp.

Davis, E. W. & J. A. Yost. 1983. The ethnobotany of the Waorani of eastern Ecuador. Bot. Mus. Leaflts. Harvard Univ. 29(3): 159-217.

Duke, J. A. 1975. Ethnobotanical observations on the Cuna Indians. Econ. Bot. 29: 278-293.

Duke, J. A. 1994. Amazonian ethnobotanical dictionary. CRC Press. Boca Raton, FL. 224 pp.

Fosberg, F. R. 1945. Principal economic plants of tropical America. In, Verdoorn, F. Plants and plant science in Latin America. Chronica Botanica. Waltham, MA. Pp. 18-35.

Gade, D. W. 1975. Plants, man, and the land in the Vilcanota Valley of Peru. Junk. The Hague. 240 pp.

Guallart, J. M. 1975. Contribucion al estudio de la etnobotanica Aguaruna. Biota 10: 336-351.

Herrara, F. L. 1942. Plantas endemicas domesticadas por los antiguos peruanos. Rev. Mus. Nac. Lima 11: 25-30.

Hodge, W. H. 1947. The plant resources of Peru. Econ. Bot. 1(2): 119-136.

Kvist, L. P. & L. B. Holm-Nielsen. 1987. Ethnobotanical aspects of lowland Ecuador. Opera Bot. 92: 83-107.

León, J. 1968. Fundamentos botánicos de la cultivos tropicales. IICA/OEA. San José, Costa Rica.

Levi-Strauss, C. 1950. The use of wild plants in tropical South America. In, Stewart, J. H. (editor). Handbook of South American Indians 6: 465-486.

Levi-Strauss, C. 1952. The use of wild plants in tropical South America. Econ. Bot. 6(3): 252-270.

Milliken, W. et al. 1992. Ethnobotany of the Waimiri Atroari Indians of Brazil. Royal Bot. Gard. Kew, England. 160 pp.

Mors, W. B. & C. T. Rizzini. 1966. Useful plants of Brazil. Holden-Day. San Francisco, CA. 166 pp.

National Research Council. 1989. Lost crops of the Incas: little-known plants of the Andes with promise for worldwide cultivation. Natl. Acad. Press. Washington, D. C. 415 pp.

National Research Council. 1990. Lost crops of the Incas. Arnoldia 50(4): 2-15.

Parodi, J. 1959. Enciclopedia Argentina de agricultura y jardinería. Vol. 1. ACME. Buenos Aires, Argentina.

Parodi, L. R. 1912. Las plantas indigenas no alimentacias cultivadas en la Argentina. Rev. Argentina Agron. 1: 165-212.

Patiño, V. M. 1969. Plantas cultivadas y animales domésticos en América equinoccial. Tomo IV. Plantas introducidas. Imprenta Departmental. Cali, Colombia.

Perez Arbelaez, E. 1978. Plantas utiles de Colombia. Libreria Suramericana. Bogota. 831 pp.

Pio Correa, M. 1926, 1931. Diccionario das plantas uteis do Brasil. Imprensa Nacional, Min. de Agric. Rio de Janeiro. Two vols.

Pittier, H. 1926. Manual de las plantas usuales de Venezuela. Litografica del Comercio. Caracas, Venezuela.

Prance, G. T. 1972. An ethnobotanical comparison of four tribes of Amazonian Indians. Acta Amazonica. 2(2): 7-27.

Prance, G. T. 1983. The ethnobotany of Amazon Indians: a rapidly disappearing source of botanical knowledge for human welfare. Bull. Bot. Surv. India 25: 148-159.

Prance, G. T. et al. 1977. The ethnobotany of the Paumari Indians. Econ. Bot. 31(2): 129-139.

Rizzini, C. T. & W. B. Mors. 1976. Botanica economica Brasileira. Editora Pedagogica Universitaria. Sao Paulo. 207 pp. + plates.

Rossato, S. C., H. de F. Leitao-Filho, & A. Begossi. 1999. Ethnobotany of Caiçaras of the Atlantic forest coast (Brazil). Econ. Bot. 53(4): 387-395.

Rutter, R. A. 1990. Catalogo de plantas utiles de la Amazonia Peruana. Communidades y Culturas Peruanas No. 22. Centro Amazonico de Lenguas

Autoctonas Peruanas "Hugo Pesce." Yarinacocha, Peru. 349 pp.

Sauer, C. O. 1950. Cultivated plants of South and Central America. In, Stewart, J. H. Handbook of American Indians. Bur. American Ethnol. Bull. No. 143. 6: 487-543.

Schmeda-Hirschmann, G. 1994. Plant resources used by the Ayoreo of the Paraguayan Chaco. Econ. Bot. 48(3): 252-258.

Schultes, R. E. 1986. Recognition of variability in wild plants used by Indians of the northwest Amazon: an enigma. J. Ethnobiol. 6(2): 229-238.

Smith, N. 1998. The Amazon River forest: a natural history of plants, animals, and people. Oxford Univ. Press. 256 pp.

Spruce, R. 1908. Notes of a botanist on the Amazon and Andes. Macmillan Co. London. Two vols.

Stewart, J. H. (editor). 1946-1959. Handbook of South American Indians. Bull. No. 143. Bur. American Ethnol. U. S. Gov. Printing Office. Washington, D. C.

Towle, M. 19--. Ethnobotany of Pre-Columbian Peru. Viking Fund Publ. Anthrop. No. 30. Aldine Publ. Chicago, IL.

Towle, M. A. 1952. Plant remains from a Peruvian mummy bundle. Bot. Mus. Leaflts. Harvard Univ. 15: 223-246.

Turner, J. B. 1965. Ethnobotanical notes on Simaba in central Brazil. Bot. Mus. Leaflts. Harvard Univ. 21: 59-64.

Vargas, C. C. 1962. Phytomorphic representations of the ancient Peruvians. Econ. Bot. 16: 106-115.

Vickers, W. T. & T. Plowman. 1984. Useful plants of the Siona and Secoya Indians of eastern Ecuador. Field Mus. Nat. Hist. 63 pp.

Williams, L. O. 1962. South Brazil: its vegetation, natural resources, research centers, and other economic aspects. Econ. Bot. 16(3): 143-160.

Williams, R. O. 1951. Useful and ornamental plants in Trinidad and Tobago. Fourth edition. Guardian Commercial Printing. Port-of-Spain, Trinidad. 335 pp.

Wittmack, L. 1888. Die Nutzpflanzen der alten Peruanes. Congres International de Americanistes 7: 325-349.

Yacovleff, E. & F. L. Herrera. 1934, 1935. El mundo vegetal de los antiguos peruanos. Rev. del Mus. Nac. (Lima) 3: 241-322; 4: 29-102.

BRITISH ISLES & EUROPE

Heer, O. 1866. Treatise on the plants of the Lake Dwellings. In, Lee, J. E. (editor). The Lake Dwellings of Switzerland and other parts of Europe. Trans. by F. Keller. London.

Helbaek, H. 1950. Tollund mandens sidste maaltid. Aarboger for Nordisk Oldkyndighed go Historie. Copenhagen. Pp. 311-341.

Helbaek, H. 1954. Prehistoric food plants and weeds in Denmark. Danmarks Geol. Unders., Series 2, No. 80: 250-261.

Helbaek, H. 1955. The botany of the Vallhagar Iron Age field. In, Stenberger, M. (editor). Vallhagar, a migration period site on Gotland, Sweden. Stockholm.

Helbaek, H. 1956. Vegetables in the funeral meals of pre-urban Rome. In, Gjerstad, E. (editor). Early Rome. Acta Inst. Roman Suerciae. Series 4. 27: 287-294.

Johnson, C. P. 1862. The useful plants of Great Britain: a treatise upon the principal native vegetables capable of application as food, medicine, or in the arts and manufactures. Wm. Kent. London, England.

Lechler, G. 1944. Nutrition of Paleolithic man. Pap. Michigan Acad. Sci., Arts, & Letters 30: 499-510.

Rougemont, G. M. de. 1989. A field guide to the crops of Britain and Europe. Collins. London, England. 367 pp.

Tringham, R. 1971. Hunters, fishers, and farmers of eastern Europe, 6000-3000 B. C. Hutchinson Univ. Library. London, England. 240 pp.

Van Zeist, W. & S. Bottema. 1971. Plant husbandry in early Neolithic Nea Nikomedeia, Greece. Acta Bot. Neerlandica 20(5):

Waterbolk, H. T. & W. van Zeist. 1967. Preliminary report on the Neolithic bog settlement of Niederwil. Palaeohistoria 12: 559-580.

ASIA

Agarwal, V. S. 1986. Economic plants of India. Kailash Prakashan. Calcutta, India. 419 pp.

Ambasta, S. S. P. (editor). 1986. The useful plants of India. Publications and Information Directorate. Council of Scientific and Industrial Research. New Delhi, India. 918 pp.

Anderson, E. F. 1993. Plants and people of the Golden Triangle: ethnobotany of the hill tribes of northern Thailand. Dioscorides Press. Portland, OR. 272 pp.

Atkinson, E. T. 1980. The economic botany of the Himalayas. Cosmo Publ. New Delhi, India. Pp. 672-923.

Bhatt, D. D. 1970. Natural history and economic botany of Nepal. Ministry of Information and Broadcasting. 160 pp.

Brown, W. H. 1951-1958. Useful plants of the Philippines. Tech. Bull. No. 10. Rep. Philippines Agric. Comm. Three vols. 590 pp.

Burkhill, I. H. 1966. A dictionary of the economic products of the Malay Peninsula. Ministry of Agriculture and Cooperatives. Kuala Lumpur, Malaysia. Two vols. 2444 pp.

Chadra, Y. R. (editor). 1972. The wealth of India: raw materials. Vol. 9: Rh-So. C. S. R. I. New Delhi, India.

Chadra, Y. R. (editor). 1976. The wealth of India: raw materials. Vol. 10: Sp-W. C. S. R. I. New Delhi, India.

Chadra, Y. R. (editor). 1976. The wealth of India: raw materials. Vol. 11: X-Z. C. S. R. I. New Delhi, India.

Cheng, T.-H. 1965. Utilization of wild plants in Communist China. Econ. Bot. 19: 3-15.

Dastur, J. F. 1964. Useful plants of India and Pakistan. Taraporevala. Bombay, India. 260 pp.

Duke, J. A. 1986. Isthmian ethnobotanical dictionary. Scientific Publ. Jodhpur, India. 205 pp.

Ertug, F. 2000. An ethnobotanical study in Central Anatolia (Turkey). Econ. Bot. 54(2): 155-182.

Friedberg, C. 1963. Les plantes, les dieux et les hommes dans l'Ile de Bali. Science & Nature (Paris) 59: 3-12.

Helbaek, H. 1960. The palaeoethnobotany of the Near East and Europe. In, Braidwood, R. J. & B. Howe (editors). Prehistoric investigations in Iraqi Kurdistan. Univ. Chicago Press. Chicago, IL. Pp. 99-118.

Helbaek, H. 1961. Late Bronze Age and Byzantine crops at Beycesultan in Anatolia. Anatolian Studies 11: 77-97.

Jacquat, C. & G. Bertossa. 1990. Plants from the markets of Thailand: descriptions and uses of 241 wild and cultivated plants, with 341 colour photographs. Editions Duang Kamol. Bangkok, Thailand. 251 pp.

Jain, S. K. 1991. Dictionary of Indian folk medicine and ethnobotany: a reference manual of man-plant relationships, ethnic groups and ethnobotanists in India. Deep Publ. New Delhi, India. 311 pp.

Maheshwari, J. K. (editor). 1996. Ethnobotany of south Asia. Scientific Publ. Jodhpur, India. 459 pp.

Maheshwari, P. 1965. Dictionary of economic plants in India. Indian Council of Agric. Research. New Delhi, India. 197 pp.

Manandhar, N. 2002. Plants and people of Nepal. Timber Press. Portland, OR. 599 pp.

Manjunath, B. L. (editor). 1948. The wealth of India: raw materials. Vol. 1: A-B. C. S. R. I. New Delhi, India. 254 pp.

Norton, H. H. 1981. Plant use in Kaigani Haida culture: correction of an ethnohistorical oversight. Econ. Bot. 35(4): 434-449.

Penhallow, D. P. 1882. Note on a few of the useful plants of northern Japan. American Nat. 16:

Rajbhandari, K. R. 2001. Ethnobotany of Nepal. Ethnobotanical Soc. of Nepal. Kathmandu. 000 pp.

Sastri, B. N. (editor). 1950. The wealth of India: raw materials. Vol. 2. C. C. S. R. I. New Delhi, India. 427 pp.

Sastri, B. N. (editor). 1952. The wealth of India: raw materials. Vol. 3. D-E. C. S. R. I. New Delhi, India. 236 pp.

Sastri, B. N. (editor). 1956. The wealth of India: raw materials. Vol. 4. F-G. C. S. R. I. New Delhi, India. 287 pp.

Sastri, B. N. (editor). 1959. The wealth of India: raw materials. Vol. 5. H-K. C. S. R. I. New Delhi, India. 332 pp.

Sastri, B. N. (editor). 1962. The wealth of India: raw materials. Vol. 6. L-M. C. S. R. I. New Delhi, India. 483 pp.

Shah, N. C. & M. C. Joshi. 1971. An ethnobotanical study of the Kumaon region of India. Econ. Bot. XX: 414-422.

Shiang-Hua, W. 1995. The ethnobotany of Sheting Village, Henchun. Taiwan Forestry Res. Inst. 79 pp.

Siemonsma, J. S. & K. Piluek (editors). 1993. Plant resources of South-East Asia. No. 8: vegetables. Pudoc Sci. Publ. Wageningen, The Netherlands. 412 pp.

Singh, U., A. M. Wadhwani, & B. M. Joshi. 1990. Dictionary of economic plants in India. ICAR. 287 pp.

Soerianegara, I. & R. H. M. J. Lemmens (editors). 1993. Plant resources of South-East Asia. No. 5(1): timber trees: major commercial timbers. Pudoc Sci. Publ. Wageningen, The Netherlands. 610 pp.

Solecki, R. S. 1975. Shanidar IV: a Neanderthal flower burial in northern Iraq. Science 190: 880, 881.

Sterly, J. 1997. Simbu plant-lore: plants used by the people in the central highland of New-Guinea. Dietrich Reimer. Berlin, Germany. Three vols. 239 pp. + 323 pp. + 275 pp.

Stewart, R. B. 1976. Paleoethnobotanical report -- Cayonu 1972 [Turkey]. Econ. Bot. 30: 219-225.

Verheij, E. W. M. & R. E. Coronel (editors.). 1991. Plant resources of South-East Asia. No. 2: edible fruits and nuts. Pudoc Sci. Publ. Wageningen, The Netherlands. 446 pp.

Vidal, J. E. 1960. Plantes utiles du Laos. II. Gymnospermes. J. Agric. Trop. Bot. Appl. (Paris) 6: 589-594.

Vidal, J. E. 1961. Plantes utiles du Laos. III. Monocotyledones. J. Agric. Trop. Bot. Appl. (Paris) 7: 417-440.

Vidal, J. E. 1961. Plantes utiles du Laos. IV. Monocotyledones. J. Agric. Trop. Bot. Appl. (Paris) 7: 560-587.

Vidal, J. E. 1962. Plantes utiles du Laos. V. Monocotyledones. J. Agric. Trop. Bot. Appl. (Paris) 8: 356-385.

Vidal, J. E. 1962. Plantes utiles du Laos. VII. Dicotyledones. J. Agric. Trop. Bot. Appl. (Paris) 9: 502-524.

Vidal, J. E. 1962. Plantes utiles du Laos. VIII. Dicotyledones. J. Agric. Trop. Bot. Appl. (Paris) 11: 18-50.

Vidal, J. E. 1971. Recent French ethnobotanical research in Southeast Asia. Econ. Bot. 25: 312-316.

Vidal, J. E., G. Martel, & S. Lewitz. 1969. Notes ethnobotaniques sur quelques plantes du Cambodge. Bull. Ec. Fr. E.-O. (Paris) 55: 171-232.

Walker, E. H. 1944. The plants of China and their usefulness to man. Ann. Rep. Smithsonian Inst., 1943. U. S. Gov. Printing Office. Washington, D. C. Pp. 325-361 + 12 plates.

Watt, G. 1972. A dictionary of the economic products of India. Reprint of 1892 edition. Six vols. 3988 pp.

Yen, D. & H. Gutierrez. 1974. The ethnobotany of the Tasaday: the useful plants. Philippine J. Sci. 103: 97-139.

Zingg, R. M. 1934. American plants in Philippine ethnobtany. Philippine J. Sci. 54: 221-274.

AFRICA

Abbiw, D. K. 1990. Useful plants of Ghana: West African uses of wild and cultivated plants. Intermediate Tech. Publ. London, England. 337 pp.

Acland, J. A. 1971. East African crops. An introduction to the production of field and plantation crops in Kenya, Tanzania and Uganda. Longman. New York, NY. 252 pp.

Adam, J. G. 1971. Some uses of plants by the Manon of Liberia (Nimba Mountains). J. Agric. Trop. Bot. Appl. 18(9/10): 372-378.

Arnold, T. H. & J. Musil. 1983. A preliminary survey of primitive crops cultivated in the northern Transvaal of South Africa. Bothalia 14(3/4): 595-601.

Ascherson, P. 1879. Botanisch-ethnographische notizen aus Guinea. Zeitschr. Ethnol. 11: 231-258.

Baron, R. 1890. Notes on the economic plants of Madagascar. Kew Bull. Misc. Inform. 1890: 203-215.

Baumann, B. B. 1960. The botanical aspects of ancient Egyptian embalming and burial. Econ. Bot. 14: 84-104.

Bedigian, D. & J. R. Harlan. 1983. Nuba agriculture and ethnobotany, with special reference to sesame and sorghum. Econ. Bot. 37(4): 384-395.

Binns, B. L. 1976. Ethnobotany of plant names in Malawi: their origins and meanings. Soc. Malawi J. 29(1): 46-57.

Bocquillon-Limousin, H. 1895. Les plantes utiles de la Tunisie. Mnde des Plant 4: 241-244, 260, 276-279, 288-289, 305-312.

Boiteau, P. 1971. Notes on Madagascan ethnobotany. III. Bitter barks of Madagascar: Simaroubaceae. J. Agric. Trop. Bot. Appl. 18(7/8): 205-221.

Bokdam, J. & A. F. Drogers. 1975. Ethnobotanical study of the Wagenia of Kisangani, Zaire. Meded. Landbouwhogesch. Wageningen 75(19): 1-74.

Brewer, D. J., D. B. Redford, & S. Redford. 1994. Domestic plants and animals: the Egyptian origins. Aris & Phillips. Warminster, England. 149.

Burkill, H. M. 1985. The useful plants of west tropical Africa. Vol. 1, Families A - D. Second edition. Univ. Press Virginia. Charlottesville. 960 pp.

Burkill, H. M. 1994. The useful plants of west tropical Africa. Vol. 2. Families E - I. Second edition. Royal Bot. Gard. Kew, England. 636 pp.

Burkill, H. M. 1995. The useful plants of west tropical Africa. Vol. 3. Families J - L. Second edition. Royal Bot. Gard. Kew, England. 857 pp.

Burkill, H. M. 1997. The useful plants of west tropical Africa. Vol. 4. Families M - R. Second edition. Royal Bot. Gard. Kew, England. 969 pp.

Burkill, H. M. 2000. The useful plants of west tropical Africa. Vol. 5: families S - Z. Koeltz Sci. Books. Koenigstein, Germany. 686 pp.

Burkill, H. M. 2001. The useful plants of west tropical Africa. Vol. 6. Indexes. Royal Bot. Gard. Kew, England. 000 pp.

Busson, F. 1965. Plantes alimentaires de l'Ouest Africain. Leconte. Marseille, France. 568 pp.

Chavelier, A. 1900. Nos connaissances actuelles sur la geographie botanique et la flore economique du Senegal et du Soudan. In, Lasnet, A. et al. (editors). Une messionau Senegal. Paris, France. Pp. 197-267.

Dalziel, J. M. 1910. Notes on the botanical resources of Yola Province, northern Nigeria. Kew Bull. Misc. Inform. 1910: 133-142.

Dalziel, J. M. 1916. A Hausa botanical vocabulary. London, England. 119 pp.

Dalziel, J. M. 1948. The useful plants of west tropical Africa. The Crown Agents for the Colonies.

Dalziel, J. M. 1955. The useful plants of west tropical Africa. Second edition. Crown Agents for the Colonies. London, England.

Dewevre, A. 1894. Les plantes utiles du Congo. Bruxelles. 65 pp.

Drake-Brockman, R. E. 1917. The economic resources of British Somaliland. Trans. Third Intl. Congr. Trop. Agric. 2: 488-500.

Durkop, E. 1903. Die Nutzpflanzen der Sahara. Beih. Tropenpfl. 4: 157-304.

Elliot, G. F. S. 1893. Sierra Leone. Reports on botany and geology. Colonial Rep. Misc. Great Britain 3: 1-78.

Fleuret, A. 1980. Nonfood uses of plants in Usambara [Tanzania]. Econ. Bot. 36(4): 320-333.

Greenway, P. G. 1941. Dyeing and tanning plants in East Africa. Bull. Imp. Inst. 39: 222-245.

Greenway, P. G. 1944-1945. Origins of some East African food plants. East African Agric. J. 10: 34-39; 115-180; 251-256.

Greenway, P. G. 1950. Vegetable fibers and flosses in East Africa. East African Agric. J. 15: 146-153.

Greenway, P. G. 1941. Gum, resinous, and mucilaginous plants in East Africa. East African Agric. J. 6: 241-250.

Heinz, H. J. & B. Maguire. 1973. The ethnobiology of the !Ko Bushmen: their ethnobotanical knowledge and plant lore. Botswana Soc. Occas. Paper 1: 1-53.

Holland, J. H. 1908-1912. The useful plants of Nigeria. Kew Bull. Misc. Inform., Add. Series 9(1-4): 1-963.

Irvine, F. R. 1969. West African crops. Third edition. Oxford Univ. Press. London, England.

Jacot Guillarmod, A. 1966. A contribution towards the economic botany of Basutoland. Bot. Not. 119(20): 209-212.

Jain, S. K. 1966. Observations on ethnobotany of Purulia, West Bengal. Bull. Bot. Surv. India 8: 237-251.

Johnson, E. J. & T.J. Johnson. 1976. Economic plants in a rural Nigerian market. Econ. Bot. 30(4): 375-381.

Kitembo, M. 1983. Contribution a l'ethnobotanique des Warega (Maniema, Kivu, Zaire). Bothalia 14(3/4): 607-611.

Kunkel, G. 1983. Plants Africa gave to the world. Bothalia 14(3/4): 465-469.

Laydevant, F. 1942. Les plantes et l'ethnographie au Bautoland. Ann. Latern. 6: 237-283.

Lely, H. V. 1925. The useful trees of northern Nigeria. London, England. 128 pp.

Lemordant, D., K. Boukef, & M. Bensalem. 1977. Plantes utiles et toxiques de Tunisie. Fitoterapia 48: 191-214.

Liengme, C. A. 1983. A survey of ethnobotanical research in southern Africa. Bothalia 14(3/4): 621-629.

Liengme, C. A. 1981. Plants used by the Tsonga people of Gazankulu. Bothalia 13(3/4): 501-518.

Malan, J. S. & G. L. Owen-Smith. 1974. The ethnobotany of Kaokoland. Cimbebasia, Series B 2(5): 131-178.

Melville, R. 1973. L'importance scientifique et le potentiel economique de la flore de la Reunion. Info-Nat. Numero Special: 56-59.

Miller, O. B. 1923. A list of some native names of trees, shrubs, etc. in use in the Transkeian Territories. Bull. For. Dept. Union South Africa. 8: 1-23.

Morgan, W. T. W. 1981. Ethnobotany of the Turkana: use of plants by a pastoral people and their livestock in Kenya. Econ. Bot. 35(1): 96-130.

National Research Council. 1996. Lost crops of Africa. Vol. 1. Grains. Natl. Acad. Press. Washington, D. C. 383 pp.

Neuwinger, H.-D. 1996. African ethnobotany: poisons and drugs. Chapman & Hall. New York, NY.

Neuwinger, H. D. 1998. African ethnobotany – poisons and drugs: chemistry, pharmacology, toxicology. HerbalGram 43: 65-67.

Nigel Hepper, F. 1990. Pharaoh's flowers: the botanical treasures of Tutankhamun. Her Majesty's Stationery Office. London, England. 80 pp.

Okigbo, B. N. 1975. Neglected plants of horticultural and nutritional importance in traditional farming systems of tropical Africa. Acta Hort. 53: 131-150.

Okigbo, B. N. 1980. Plants and food in Igbo culture and civilization. Gov. Printer. Oweeri, Nigeria.

Oliver, B. 1958. Nigeria's useful plants. I. Plants yielding fibres, fats, and oils. Nigerian Field 23(4): 147-171.

Oliver, B. 1958-1961. Nigeria's useful plants. Pts. I - V. Nigerian Field 23(4): 147-171, 24(1): 13-34, 24(2): 54-71, 24(3): 121-143, 24(4): 160-182, 25(4): 174-192, 26(2): 70-90, 26(4): 170-180.

Oliver, B. 1959. Nigeria's useful plants. II(1-3). Medicinal plants. Nigerian Field 24(1): 13-34; 24(2): 54-71; 24(3): 121-143.

Oliver, B. 1960. Nigeria's useful plants. III. Plants yielding essential oil. Nigerian Field 25(9): 174-192.

Oliver, B. 1961. Nigeria's useful plants. IV. Plants yielding gums, resins, and rubber. Nigerian Field 26(2): 70-90.

Oliver, B. 1961. Nigeria's useful plants. V. Plants yielding dyes. Nigerian Field 26(4): 170-180.

Phillips, E. P. 1927. Economic plants of South Africa. Official Yearbook, Union of South Africa 8: 47-53.

Rodin, J. R. 1985. The ethnobotany of the Kwanyama Ovambos [Namibia]. Monographs Syst. Bot. Missouri Bot. Gard. St. Louis. 163 pp.

Sauer, J. D. 1967. Plants and man on the Seychelles coast. Univ. Wisconsin Press. Madison.

Seibire, A. 1899. Les plantes utiles du Senegal: plantes indigenes, plantes exotiques. Paris, France. 341 pp.

Steyn, H. P. 1981. Nharo plant utilization: an overview. Khoisis 1:

Story, R. 1958. Some plants used by the Bushmen in obtaining food and water. Mem. No. 30. Bot. Surv. South Africa.

Story, R. 1958. Plant lore of the Bushmen. In, Davies, D. H. S. (editor). Ecological studies in southern Africa. Junk. The Hague. Pp. 87-99.

Trotter, A. 1915. Flora economica della Libia. Tipgrafia dell'Unione Editrice. Rome, Italy.

Vickery, M. L. & B. Vickery. 1979. Plant products of tropical Africa. Macmillan. London, England.

Wehmeyer, A. S. & E. F. Rose. 1983. Important indigenous plants used in the Transkei as food supplements. Bothalia 14(3/4): 613-615.

Wells, M. J. 1979. The role of economic botany in the development of South Africa. Bothalia 12(4): 751-754.

Wild, H. 1953. A southern Rhodesian botanical dictionary of native and English plant names. Government Printer. Salisbury, Southern Rhodesia. 139 pp.

Williams, R. O. 1949. Useful and ornamental plants of Zanzibar and Pemba. Government Printer. Zanzibar. 497 pp.

Williamson, J. 1955. Useful plants of Nyasaland. Edited by P. J. Greenway. Government Printer. Zomba, Nyasaland. 168 pp.

Williamson, J. 1955. Useful plants of Malawi. Second edition. Montfort Press. Limbe, Malawi.

Wirth, F. 1974. Parfumpflanzenbau in Tunesien. Entw. Landl. Raum. 8(6): 14-16.

Woenig, F. 1897. Die Pflanzen in alten Aegypten. Albert Heitz. Leipzig, Germany. 425 pp.

Wyk, B.-E. van & N. Gericke. 2000. People’s plants: a guide to useful plants of southern Africa. Briza. Pretoria, South Africa. 351 pp.

Yellen, J. E. 1990. Transformation of the Kalahari !Kung. Sci. American 262(4): 96-105.

OCEANIA

Abbott, I. A. 1992. L'au Hawai'i: traditional Hawaiian uses of plants. Bishop Mus. Press. Honolulu, HI. 163 pp.

Abbott, I. A. 1996. Limu: an ethnobotanical study of some Hawaiian seaweeds. Fourth edition. Natl. Trop. Bot. Gard. Lawaia, HI. 39 pp.

Abbott, I. A. 2002. Interpreting pre-western Hawaiian culture as an ethnobotanist. Econ. Bot. 56(1): 3-6.

Alexander, W. B. et al. 1920. Lists of the principal indigenous West Australian plants of economic importance and of naturalized aliens and weeds established in the state, with their vernacular names. J. & Proc. Royal Soc. West Australia 6: 41-46.

Bailey, F. M. 1888. A sketch of the economic plants of Queensland. Queensland Comm. Cent. Inter. Exhib. Brisbane, Australia.

Barrau, J. 1961. Subsistence agriculture in Polynesia and Micronesia. Bull. No. 223. Bernice P. Bishop Mus. Honolulu, HI.

Barrau, J. 1963. Plants and the migrations of Pacific peoples: a symposium. Bishop Mus. Press. Honolulu, HI.

Barrau, J. 1965. Witnesses of the past: notes on some food plants of Oceania. Ethnology 4(3): 282-294.

Barrau, J. 1965. Historie et prehistorie horticoles de l'Oceanie tropicale. J. Soc. Ocean. 21: 55-78.

Barrau, J. 1965. Quelques notes a propos de plantes utiles des Hautes Terres de la Nouvelle-Guinee. JATBA 12: 44-57.

Barrau, J. 1971. Useful plants of Tahiti. Soc. Oceanistes, Pamphlet on Tahiti 8: 1-32.

Barrau, J. 1973. The Oceanians and their food plants. Trans. by R. Roberts and C. Roberts. In, Smith, C. E. (editor). Man and his foods. Univ. Alabama Press. Pp. 87-117.

Beaglehole, E. & P. Beaglehole. 1938. Ethnology of Pukapuka. Bull. No. 150. Bernice P. Bishop Mus. Honolulu, HI. 419 pp.

Blackwood, B. 1940. Use of plants among the Kukukuku of south eastern central New Guinea. Proc. Sixth Pacific Sci. Congr. Univ. California Press. Berkeley. 6: 111-134.

Briggs, L. H. 1947. Plant products of New Zealand. J. Royal Soc. New South Wales 80: 151-177.

Brooker, S., C. Cambie, & R. Cooper. 1988. Economic native plants of New Zealand. Bot. Div. D. S. I. R. Christchurch, New Zealand. 130 pp.

Brooker, S., C. Cambie, & R. Cooper. 1989. Economic native plants of New Zealand. Econ. Bot. 43(1): 79-106.

Buck, P. H. 1932. Ethnology of Tongareva. Bull. No. 75. Bernice B. Bishop Mus. Honolulu, HI. 697 pp.

Buck, P. H. 1930. Samoan material culture. Bull. No. 75. Bernice P. Bishop Mus. Honolulu, HI. 724 pp.

Chock, A. T. K. 1968. Hawaiian ethnobotanical studies. I. Native food and beverage plants. Econ. Bot. 22(3): 221-238.

Colenso, W. 1881. On the vegetable food of the ancient New Zealanders before Cook's visit. Trans. New Zealand Inst. 13: 3-38.

Cooper, R. C. & R. C. Cambie. 1991. New Zealand's economic native plants. Oxford Univ. Press. New York, NY. 234 pp.

Cox, P. A. 1994. Wild plants as food and medicine in Polynesia. In, Etkin, N. L. (editor). Eating on the wild side. Univ. Arizona Press. Tucson. Pp. 102-113.

Cox, P. A. & S. A. Banack. 1991. Islands, plants, and Polynesians: an introduction to Polynesian ethnobotany. Dioscorides Press. Portland, OR. 228 pp.

Crawford, D. L. 1937. Hawaii's crop parade: a review of the useful products derived from the soil in the Hawaiian Islands, past and present. Advertiser Publ. Honolulu, HI. 305 pp.

Dosedla, G. C. 1974. Etnobotanische grundlagen der materiellen kultur der Mount Hagen Staemme im zentralen Hochland vn Neuguinea. Tribus 23: 155-174.

DuBois, M. J. 1971. Ethnobotany of Mare, Loyalty Islands, New Caledonia. JATBA 18(7/8): 222-273; 18(9/10): 310-371.

Emory, K. P. 1947. Tuamotuan plant names. J. Polynesia Soc. 56: 266-277.

Funk, E. 1978. Hawaiian fiber plants. Newsletter Hawaiian Bot. Soc. 17: 27-35.

Goulding, J. H. 1971. Identification of archaeological and ethnological specimens of fibre-plant material used by the Maori. Rec. Auckland Inst. Mus. 8: 57-101.

Guillaumin, A. 1954. Les plantes utiles des Nouvelles Hebrides. JATBA 1: 293-297; 453-460.

Handy, E. S. & E. G. Handy. 1972. Native planters in old Hawaii, their life, lore and environment. Bull. No. 233. Bernice P. Bishop Mus. Honolulu, HI. 641 pp.

Handy, E. S. C. 1940. The Hawaiian planter, his plants, methods and area of cultivation. Bull. No. 161. Bernice P. Bishop Mus. Honolulu, HI. 227 pp.

Harris, D. R. 1976. Aboriginal use of plant foods in the Cape York Peninsula and Torres Strait Islands. Newsl. Australian Inst. Aboriginal Studies 6: 21, 22.

Hartley, W. 1979. A checklist of economic plants in Australia. Commonwealth Scientific and Industrial Research Organization. Melbourne, Australia. 214 pp.

Harwood, L. W. 1938. Native food crops of Fiji. Agric. J. (Fiji) 9(3): 8-11.

Hays, T. E. 1974. Mauna: explorations of Ndumba [Papua New Guinea] ethnobotany. Ph. D. dissertation. Univ. Washington. Seattle.

Hyam, G. N. 1939. The vegetable foods of the Australian aborigines. Victorian Nat. 56(Oct/Nov): 95-98; 115-119.

Irvine,, F. R. 1957. Wild and emergency foods of Australian and Tasmanian aborigines. Oceania 28(2): 113-142.

Jackson, D. L. & S. W. L. Jacobs. 1985. Australian agricultural botany. Sydney Univ. Press. Sydney, Australia. 377 pp.

Jouan, H. 1876. Les plantes industrielles de l'Oceanie. Mem. Soc. Natl. Sci. Nat. Cheerbourg 20: 145-240.

Judd, A. F. 1965. Trees and plants. In, Handy, E. S. C. et al. (editors). Ancient Hawaiian civilization. C. E. Tuttle. Rutland, VT. Pp. 277-285.

Kaikainahaole, M. 1968. Hawaiian uses of herbs -- past and present. Newsletter Hawaiian Bot. Soc. 7: 31-38.

Kato, S. S. 1969. The role of plants in the kapu system of Hawaii. Newsletter Hawaiian Bot. Soc. 8: 1-6.

Kirch, P. V. 1978. Indigenous agriculture on Uvea [western Polynesia]. Econ. Bot. 32(2): 157-181.

Krauss, B. H. 1974. Ethnobotany of Hawaii. Dept. Bot. Univ. Hawaii. Honolulu. 248 pp.

Krauss, B. H. 1975. Ethnobotany of the Hawaiians. Harold L. Lyon Arboretum. Univ. Hawaii. Honolulu. 32 pp.

Krauss, B. H. 1993. Plants in Hawaiian culture. Univ. Hawai'i Press. Honolulu. 345 pp.

Lazarides, M. & B. Hince (editors). 1993. CSIRO handbook of economic plants of Australia. CSIRO Publ. Victoria, Australia. 330 pp.

Lepofsky, D. 2003. The ethnobotany of cultivated plants of the Maohi of the Society Islands. Econ. Bot. 57(1): 73-92.

Lessa, W. A. 1977. Traditional uses of the vascular plants of Ulithi Atoll, with comparative notes. Micronesia 13(2): 129-190.

Levitt, D. 1981. Plants and people: aboriginal uses of plants on Groote Eylandt. Australian Inst. Aboriginal Studies.

Luomala, K. 1953. Ethnobotany of the Gilbert Islands. Bull. No. 213. Bernice Bishop Mus. Honolulu, HI. 129 pp.

Maclet, J.- N. & J. Barrau. 1959. Catalogue des plantes utiles aujord'hui presentes en Polynesie Francaise. JATBA 6: 1-21; 160-184.

Maiden, J. H. 1899. Native food plants. Misc. Publ. No. 282. Dept. Agric. New South Wales. 69 pp.

Maiden, J. H. 1888. Australian indigenous plants providing human foods and food adjuncts. Proc. Linnean Soc. New South Wales 13: 481-556.

Maiden, J. H. 1889. Useful plants of Australia. Turner & Henderson. Sydney, Australia. 696 pp.

Maiden, J. H. 1889. The useful native plants of Australia (including Tasmania). Reprint 1975. Compendium. Melbourne, Australia.

Merrill, E. D. 1945. Plant life of the Pacific world. Macmillan. New York, NY. 295 pp.

Merrill, E. D. 1954. The botany of Cook's voyages and its unexpected significance in relationship to anthropology, biogeography and history. Chronica Botanica 14(5/6): 161-384.

Merrill, E. D. 1947. A botanical bibliography of the islands of the Pacific. Contr. U. S. Natl. Herb. 30(1): 1-322. [See also Walker, E. H. 1947].

Metraux, A. 1971. Ethnology of Easter Island. Bull. Bernice P. Bishop Mus. Honolulu, HI. 160 pp.

Murai, M. et al. 1958. Some tropical South Pacific island foods. Univ. Hawaii Press. Honolulu. 159 pp.

O'Connell, J. F. et al. 1983. Traditional and modern plant use among the Alyawara of central Australia. Econ. Bot. 37(1): 80-109.

Palmer, J. 1989. Lesser known crop plants of the South Pacific: an annotated bibliography. D. S. I. R. Rep. No. 133. 134 pp.

Palmer, E. 1884. On the plants used by the natives of northern Queensland, Flinders and Mitchell Rivers for food, medicine, etc. J. & Proc. Royal Soc. New South Wales. 17: 93-113.

Parham, B. E. V. 1972. Plants of Samoa: a guide to their local and scientific names with authorities; with notes on their uses, domestic, traditional and economic. New Zealand Dept. Sci. Indust. Res. Infor. Serv. 85: 1-161.

Parham, H. B. R. 1943. Fiji plants: their names and uses. J. Polynesian Soc. Mem. 16: 129-143.

Pétard, P. 1984. Plantes utiles de Polynésie: Raau Tahiti. Editones Haere Po No Tahiti. Papeete, Tahiti.

Pétard, P. 1986. Quelques plantes utiles de Polynésie Française et Raau Tahiti. Editiones Haere Po No Tahiti. 354 pp.

Reid, E. J. & T. J. Betts. 1979. Records of western Australian plants used by aboriginals and medicinal agents. Planta Medica 36(2): 164-173.

Safford, W. E. 1905. The useful plants of the Island of Guam, with an introductory account of the physical features and natural histry of the island, of the character and history of its people, and of their agriculture. Contr. U. S. Natl. Herb. 9: 1-416.

Safford, W. E. 1921. Cultivated plants of Polynesia. Proc. Pan Pacific Sci. Confr. 1: 183-187.

Schattenburg, P. 1976. Food and cultivar preservation in Micronesian voyaging. Univ. Hawaii Pacific Islands Progress. Misc. Work Papers 1: 25-32.

Setchell, W. A. 1924. American Samoa. Pt. II. Ethnobotany of the Samoans. Publ. No. 341. Carnegie Inst. Washington. 20: 1-244.

Seurat, L. G. 1905. Flore economique de la Polynesie francaise. Bull. Soc. Natl. Acclim. France 52: 310-326; 355-359; 369 --.

Sillitoe, P. 1983. Roots of the earth: crops in the highlands of Papua New Guinea. Manchester Univ. Press. Dover, NH. 285 pp.

Smith, M. & A. C. Kalotas. 1985. Bardi plants: an annotated list of plants and their use by the Bardi aborigines of Dampierland in northwestern Australia. Rec. West. Australia Mu. 12: 317-359.

Sterly, J. 1974-1975. Useful plants of the Chimbu Papua New Guinea. Ethnomedizin 3(3/4): 353-394.

Sterly, J. 1977. Research work on traditional plant lore and agriculture in the upper Chimbu region, Papua New Guinea. Bull. Intl. Comm. Urgent. Anthrop. Ethnol. Res. 19: 95-105.

Stone, E. L. 1951. The agriculture of Arno Atoll, Marshall Islands. Atoll Res. Bull. No. 6. National Research Council. Washington, D. C.

Straatmans, W. 1967. Ethnobotany of New Guinea in its ecological perspective. JATBA 14: 1-20.

Tagashi, M. 1977. Wild edible plants used by Shoichi Yokoi on Guam Island. J. Japanese Bot. 52(6): 189-192.

Treide, B. 1967. Wildpflanzen in der Ernahrung der Grundbevolkerung Melanesiens. Veroff. Mus. Volkerkunde zu Leipzig 16: 1-267.

Uhe, G. 1974. Wayside plants of the South Pacific: a guide to some common and interesting herbs, shrubs and trees found in Hawaii, Tahiti, Marquesas, Samoa, Tonga, Niue, Rarotonga, Fiji and New Caledonia. Stockton House. Auckland, Australia. 144pp.

Vieillard, E. 1862. Plantes utiles de la Nouvelle-Caledonie. Ann. Sci. Nat. IV, Bot. 16: 28-76.

Waimea Arboretum & Botanical Garden. 1983. Checklist of Hawaiian endemic, indigenous food plants and Polynesian introductions in cultivation in Hawaii. Waimea Arbor. Educ. Series 2: 1-29.

Walker, E. H. 1947. A subject index to Elmer D. Merrill's 'A botanical bibliography of the islands of the Pacific.' Contr. U. S. Natl. Herb. 30(1): 323-404.

Whistler, W. A. 1984. Annotated list of Samoan plant names. Econ. Bot. 38(4): 464-489.

Whistler, W. A. 1988. Ethnobotany of Tokelau: the plants, their Tokelau names, and their uses. Econ. Bot. 42(2): 155-176.

Whistler, W. A. 1990. Ethnobotany of the Cook Islands: the plants, their Maori names, and their uses. Allertonia 5(4): 347-424.

Whistler, W. A. 1991. The ethnobotany of Tonga: the plants, their Tongan names, and their uses. Bishop Mus. Bull. in Bot. No. 2. Bishop Mus. Press. Honolulu, HI. 155 pp.

Whistler, W. A. 2000. Plants in Samoan culture. The ethnobotany of Samoa. Isle Botanica. Honolulu, HI. 000 pp.

Yen, D. E. 1973. The origins of Oceanic agriculture. Archaeol. Phy. Anthrop. Oceania 8: 68-85.

Yen, D. E. 1973. Ethnobotany from voyages of Mendana and Quiros in the Pacific. World Archaeol. 5: 32-44.

Yen, D. E. 1980. The southeast Asia foundations of Oceanic agriculture. J. Soc. Ocean. 66/67: 140-146.

Yen, D. E. 1991. Polynesian cultigens and cultivars: the questions of origin. In, Cox, P. A. & S. A. Banack (editors). Islands, plants, and Polynesians. Dioscorides Press. Portland, OR. Pp. 67-95.

Yuncker, T. G. 1959. Plants of Tonga. Bernice P. Bishop Mus. Bull. No. 220. Honolulu, HI. 283 pp.

Zepernick, B. 1972. Arzneipflanzen der Polynesier. Baessler Archiv. Beih. 8. 369 pp.

13: PLANTS BY GROUP AND FAMILY

GENERAL REFERENCES

Hill, A. F. 1952. Systematic list of species discussed. In, Economic botany. McGraw-Hill. New York, NY. Pp. 495-520.

Kunkel, G. 1984. Plants for human consumption. Koeltz Sci. Publ. Koenigstein, Germany. 393 pp.

Mabberley, D. J. 1997. The plant-book: a portable dictionary of the vascular plants. Cambridge Univ. Press. Cambridge, U. K. 858 pp.

Roecklein, J. C. & P. Leung. 1987. A profile of economic plants. Transaction Books. New Brunswick, NJ. 623 pp.

Usher, G. 1974. A dictionary of plants used by man. Constable. London, England. 619 pp.

Terrell, E. E. 1986. A checklist of names of 3,000 vascular plants of economic importance. Agric. Handbook No. 505. U. S. Dept. Agric. Washington, D. C. 241 pp.

Uphof, J. C. Th. 1968. Dictionary of economic plants. J. Cramer. Würzburg, Germany. 591 pp.

Wiersema, J. H. & B. León. 1999. World economic plants. CRC Press. Boca Raton, FL. 749 pp.

Willis, J. C. 1973. A dictionary of the flowering plants and ferns. Cambridge Univ. Press. Cambridge, England. 1245 + lxvi pp.

GROUPS & FAMILIES

Allen, O. N. & E. K. Allen. 1981. The Leguminosae: a source book of characteristics, uses and nodulation. Univ. Wisconsin Press. Madison.

Chang, S. T. & W. A. Haynes (editors). 1978. The biology and cultivation of edible mushrooms. Academic Press. New York, NY. 820 pp.

Conniff, R. 1987. How the world puts gourds to work. Int. Wildlife 17(3): 18-24.

Coradin, L. & E. Lleras. 1988. Overview of palm domestication in Latin America. In, Balick, M. J. The palm – tree of life. Adv. Econ. Bot. 6: 175-189.

Culberson, C. F. 1969. Chemical and botanical guide to lichen products. North Carolina Univ. Press. Chapel Hill. 000 pp.

Gentry, A. H. 1992. A synopsis of Bignoniaceae ethnobotany and economic botany. Ann. Missouri Bot. Gard. 79(1): 53-64.

Jeffrey, C. 1980. A review of Cucurbitaceae. Bot. J. Linnean Soc. 81: 233-247.

Jury, S. L. et al. 1987. The Euphorbiales: chemistry, taxonomy and economic botany. Academic Press. London, England. 326 pp.

Lawler, L. J. 1984. Ethnobotany of the Orchidaceae. Orchid Biology 3: 27-149.

Lawton, B. P. 2002. Mints: a family of herbs and ornamentals. Timber Press. Portland, OR. 239 pp.

McClure, F. A. 1956. Bamboo in the economy of Oriental peoples. Econ. Bot. 10(4): 335-361.

Miller, M. A. 1959. Orchids of economic use. American Orchid Soc. Bull. 28: 157-162; 268-271; 351-354.

Moore, H. 1973. The major groups of palms and their distribution. Gentes Herb. 11: 27-141.

Morris, B. 2003. Bio-functional legumes with nutraceutical, pharmaceutical, and industrial uses. Econ. Bot. 57(2): 254-261.

Perez-Llano, G. A. 1944. Lichens: their biological and economic significance. Bot. Rev. 10: 33-36.

Piper, J. M. 1992. Bamboo and rattan: traditional uses and beliefs. Oxford Univ. Press. New York, NY. 88 pp.

Renvoize, S. 1995. From fishing poles and ski poles to vegetable and paper, the bamboo genus *Phyllostachys.* Curtis's Bot. Mag. 12(1): 8-15.

Rios, R. & B. Khan. 1998. List of ethnobotanical uses of Bromeliaceae. J. Bromeliad Soc. 48(2): 75-87.
Rizk, A.-F. M. 1987. The chemical constituents and economic plants of theEuphorbiaceae. In, Jury, S. L. et al. Pp. 239-326.

Schultes, R. E. 1987. Members of Euphorbiaceae in primitive and advanced societies. J. Linnean Soc. Bot. 95(1-2): 79-95.

Simpson, D. A. & C. A. Inglis. 2001. Cyperaceae of economic, ethnobotanical and horticultural importance: a checklist. Kew Bull. 56(2): 257-360.

Singer, R. 1962. Mushrooms and truffles: botany, cultivation and utilization. Interscience Publ. London, England. 272 pp.

Southon, I. W. (compiler). 1994. Phytochemical dictionary of the Leguminosae. Chapman & Hall. New York, NY. Two vols. 748 pp.

Thieret, J. W. 1957. Economic botany of the cycads. Econ. Bot. 12(1): 3-41.