# THESIS.

## THE WINTER HABITS OF PLANTS.

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In all climates there is a period at some time of the year when plants can not continue to live in an active state, but are required, by environmental conditions, to assume a form that will enable them to live through the unfavorable period. Whether a plant must pass through a period of cold, unfavorable to plant activity, or through a periodic drouth, the methods of meeting both these adverse conditions are the same. Since, in the temperate zone, it is the cold against which the plants must protect themselves, the forms assumed by them for protection during the winter are called their winter habits.

If one should take a stroll through the fields or woods in the fall, he would notice that all plants do not succumb to the cold at the same time. Some plants cease activity at the first suggestion of cold, while others continue through a long succession of frosts before they perish. For example, such trees as the Maple, Boxelder, and Ash shed their leaves early, while cottonwood, elms and oaks come somewhat later; many oaks retaining their leaves throughout the winter, shedding them early the following spring.

Other plants yet, such as conifers, mosses, liverworts and lichens, live through the winter with no apparent change. Between the group of plants which are killed by the winter, and the group which survive without apparent change in outward forms, stand the deciduous plants which cast their leaves and the herbaceous plants with thickened underground stems or roots wherein the living substance, withdrawn from the leaves and stems, is able to survive the winter.

The degree of cold necessary to cause the death of any plant depends upon the nature of the protoplasm, i. e. the ability of the protoplasts of that kind of plant to withstand adverse conditions, and also upon the stage

stage of development or activity of the plant at the time it is subjected to the cold.

The excretion of water from the protoplasm of the cell is the primary means possessed by all plants of protecting themselves from cold. Protoplasm contains a large percentage of water, and when the temperature becomes low, part of this water is forced out into the interstices between the cells. The protoplasm being now more concentrated, the temperature must fall still lower in order to freeze it. As the cold increases, more water is forced out until a limit is reached, which varies with different kinds of plants. When this limit is reached, the protoplasm freezes, which act abstracts practically all the water, causing a disorganization of the protoplasm, and consequent death of the plant. When the limit is not reached, as the plant thaws, all the water derived from the melting of the ice in the interstaces of the cells must be returned to the protoplasm from which this water was abstracted, or the death of the plant will result. While it is thus seen that the excretion of water from the protoplasm of the cell is the primary means of protection, plants as a whole provide a means of protection of the cell.

One of the most noticable methods which plants have of protecting themselves from excessive transpiration in cold weather, is the reduction of leaf surface, by means of shedding their leaves. The amount of water given off through the leaves by transpiration is so great that transpiring surface must be greatly reduced in order not to exceed the lessened absorbing ability of the roots at a low temperature. Some plants die at temperatures above freezing, thus colens, melons, and tobacco blacken and die if exposed for a single night to a temperature of three or four degrees above zero C. This is due to the chilling of the roots, making them unable to absorb water from the soil as fast as it is evaporated from the leaves, which blacken and die in consequence.

In some plants, the shoots continue to grow throughout the growing season, giving rise to new nodes and internodes, so that when winter comes, the latest growth, being unripe, dies or buds are weak and the growth is continued the next year from buds farther back on the shoot. In others, such as the cottonwood, hickory and walnut, the elongation of the stem ceases before the end of the growing season. A few of the last formed internodes fail to elongate and the leaves of some of the lower nodes grow up as scales enveloping and protecting the parts above them. Since such buds protect the younger and more delicate parts from mechanical injury and vicissitudes of the weather, they are quite certain to survive the winter and to continue the growth the following year. The leaves formed at the uppermost nodes are ordinary foliage leaves in an embryonic state, and consequently are in need of protection, but the amount and character of protection varies in different plants. The buds of hickory are hard and dry and are adapted to protection from mechanical injury, while the hairs on the scales tend to keep the scales slightly apart, thus forming dead air spaces, preventing the escape of water from the succulent parts and on account of the slight conductivity of air for heat, protect the delicate part of the buds from sudden changes in temperature. The scales of cottonwood buds are held firmly together by a resinous substance which prevents the drying out of the tender parts. The amount of protection required by the buds of different trees depends upon the ability of their protoplasts to withstand adverse conditions.

The two general winter habits of plants are the deciduous and herbaceous habits. There are many intergradations between these two general forms, but for the purpose of considering their winter habits, these intergrading forms may be considered with that type which it most closely resembles.

The herbaceous habit is the retreat to a cover of earth or in some cases

of dead leaves. In some localities where snow falls early in winter and remains until the following spring, the blanket of snow plays an important part, acting as a non conductor of heat.

One common winter form assumed by plants, is the bulb. In this form, the portion of the plant above ground disappears entirely in the fall so that no evidence of it remains. Down in the ground, from 4-8 inches, one will find the bulb, a structure composed of fleshy scales, stored with food materials and enclosing the bud of the next seasons plant. Early in the spring, the plant begins to grow. Food is readily available, having been prepared and stored up the preceeding season, consequently the plant makes an exceedingly vigorous and rapid growth, and is one of the earliest forms to appear in the spring. After the plant is grown, the old bulb has become exhausted, and during the current season, a new one, in which food is stored for the next years growth, is formed. This formation of a new bulb each year causes such a plant to become more deeply embedded in the ground from year to year.

The corm is similar to a bulb with the exception that a corm, instead of being composed of fleshy scales, is a solid structure. With this exception, all that has been said of the bulb applies equally well to the corm.

Another interesting form is the tuber which is an underground stem modified for storage of food materials. The bud scales on a tuber are minute, and on the potato for instance, form what is called the "eye." As in bulbous plants, so in tuberous, the tuber is exhausted by the growth of the young plant, and a new tuber is formed during the season. This is also one of the early spring forms, although some plants with tuberous roots, such as the artichoke (Helianthus tuberosa) do not bloom until late in the summer.

The rhizome or rootstock is also a form of underground stem and is used for food storage, but may be distinguished from tubers by the fact that root-

stocks are generally longer, more cylindrical and not so thick in proportion to their length as are tubers. Corms, bulbs, tubers and rootstocks are all forms of underground stems, the distinctions in some cases being more arbitrary than real. Rootstocks may or may not be fleshy, and may occur horizontally in the ground, as in Solomonia, or they may be more or less erect, as in the case of violets. An entire new rhizome is not formed each season as are tubers and bulbs, but it increases in length at one end from year to year, and the old portion at the other end dies off with corresponding rapidity. Many plants owe their rapid spread to the formation of rootstocks.

There is another form assumed by plants as a winter habit which is quite distinct from the preceeding forms, in that the survival of the winter is due to thickened and more or less fleshy roots which serve as storage organs. In a great many plants of this type, new leaves are formed in the fall, arranging themselves in a peculiarly compact cluster known as a rosette. The peculiarity is that in some cases the summer form is so different from the rosette form of winter that the two would hardly be recognized as being the same plant. These rosettes may be found in a green condition all during the winter, and upon the first warming up in spring, begin to grow. Some plants of this type, but not forming rosettes, have shoots underground which grow in fall and early spring, sending up numerous new shoots as soon as warm weather comes. Aster oblongifolius, Apocynum hypericifolium, and Solidago serotina are good illustrations of such a form.

A study of the flora of some certain environment with reference to the forms of winter habit assumed and also to the time of flowering, shows some interesting results. The tables following give lists of woodland, swamp and prairie plants, respectively, showing form of winter habit and time of flowering of the various species. Since all trees and shrubs have the deciduous habit, they will not be considered in the following tables.

## Woodland Plants.

| Name. | Time of flowering. | Winter habit. |
|---|---|---|
| Agrimonia mollis | June - Sept. | Multiple fleshy roots. |
| Bicreculla cucullaria | Mar. - Apr. | Bulb. |
| Dentaria laciniata | Apr. - May. | Rootstock (short, thick.) |
| Erythronium albidum | Mar. - Apr. | Corm. |
| Eupstorium ageratoides | July - Nov. | Multiple fleshy roots. |
| Galium circaezans | May - July. | " " " |
| Galium triflorum | June - Aug. | " " " |
| Geum canadense | June - July | " " " |
| Lycopus Americanus | June - Oct. | (forms rosettes.) Multiple fleshy roots. |
| Meibomia Dilleni | June - Sept. | " " " |
| Mimulus ringens | June - Sept. | Rootstocks (not thickened) |
| Penthorum sedoides | July - Sept. | Multiple fleshy roots |
| Phlox divaricata | Apr. - June | " " " |
| Prunella vulgaris | June - Oct. | " " " |
| Ruellia strepens | May - July | " " " |
| Salomonia commutata | May - June | Rootstock (thickened.) |
| Sanicula Marylandica | May - July | Multiple fleshy roots. |
| Triosteum perfolistum | May - July | " " " |
| Viola cucullata | Mar.- May | Rootstock. |

## Swamp Flora.

| Name. | Time of flowering. | Winter habit. |
|---|---|---|
| Acorus calamus | May -- July. | Rootstock. |
| Asclepios incarnata | July - Sept. | Multiple fleshy roots |
| Cicuta maculata | June - Aug. | Simple tuberiforus root |
| Eupatorium perfoliatum | July - Sept. | Multiple fleshy roots |
| Heteranthera reniformis | July - Sept. | " " " |
| Hypericum maculatum | July - Sept. | " " " |
| Lobelia syphilitica | July - Oct. | " " " |
| Lythrum alatum | June - Aug. | " " " |
| Polygonum emersum | July - Sept. | Rootstock |
| Ranunculus sceleratus | May - Aug. | Multiple fleshy roots |
| Sagittaria latifolia | July - Sept. | Rootstock |
| Spartina cynosuroides | Aug. - Oct. | " |
| Typha latifolia | June - July | " |

## Prairie Flora.

| | | |
|---|---|---|
| Achillea millefolium | June - Nov. | Rootstock (not thickened.) |
| Acuan Illinoensis | May - Sept. | Multiple fleshy roots |
| Allionia nyctoginea | May - Aug. | Simple fleshy root |
| Allium stellatum | July - Aug. | Bulb |
| Allium mutabile | Apr. - June. | " |
| Anemone Caroliniana | Apr. - May | Tuber |
| Anemone decapetala | Apr. - May | " |
| Antennaria compestris | March-May | Multiple fleshy roots (rosettes) |
| Argemone alba | May - Aug. | Simple fleshy root |
| Asclepias tuberosa | June - Sept. | " " " |

## Prairie Flora (continued)

| Name. | Time of flowering. | Winter Habit. |
|---|---|---|
| Astragalus crassicarpus | Apr. - May. | Multiple fleshy roots. |
| Baptisis australis | May - June. | " " " |
| Brauneria pallida | June - July | " " " |
| Callirrhoe alceoides | May - July | " " " (rosette) |
| Callirrhoe involucrata | May - July | " " " " |
| Chrysanthemum leucanthemum | June - Nov. | " " " |
| Delphinum tricorne | May - June | " " " |
| Solidago ? | Sept.- Oct. | " " " " |
| Euphorbia marginata | May - Oct. | " " " |
| Grindelia squarrosa | July - Sept. | " " " |
| Hieracium longipilum | July - Sept. | " " " " |
| Houstoria angustifolia | May - July | " " " |
| Kuhnistera candida | July - Aug. | " " " |
| Lacinaria punctata | Aug. - Oct. | Tuberous root |
| Lacinaria sceriosa | Aug. - Sept. | " " |
| Lithospermum linearifolium | Apr. - May. | Multiple fleshy root. |
| Lomatium foeniculaceum | Mar. - Apr. | " " " |
| Megapterium Missouriense | May - July | " " " |
| Meriolix serrulata | May - July | " " " |
| Morongia uncinata | May - July | " " " |
| Nothocalais cuspidata | April- May | " " " |
| Oxalis violacea | April- June | Bulb. |
| Physalis pumila | July - Sept. | Rootstock (not thickened) |
| Psoralea esculenta | May - June | Simple fleshy roots |
| Ruellia ciliosa | June - Sept. | Multiple " " |

Prairie Flora (continued)

| Name. | Time of flowering. | Winter habit. |
|---|---|---|
| Salvia pitcheri | July - Sept. | Multiple fleshy roots. |
| Silphium laciniata | July - Sept. | " " " |
| Solidago rigida | Aug. - Oct. | " " " |
| Verbascum Thapsus | June - Sept. | " " " (rosettes) |
| Viola pedatifida | Apr. - May | Rootstock |
| Zizea aurea | May - June | Simple fleshy root. |
| Zygadenus Nuttallii | May. | Bulb. |

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Of the woodland flowers named, only five bloom in April or before. Of these five, two have rootstocks, one a bulb, and one a corm; these three forms, as has been said before, are modifications of a single type. In all these the amount of stored food is large; and with the exception of the Violet, have a small leaf surface and have finished blooming before the trees have leaved out entirely. The roots of Phlox are not fleshy and hence do not contain a great deal of reserve material, the leaf surface is not so small as in the case of the three other plants just referred to, and it continues to bloom for about two months.

In the swamp flora, there are no early-flowering species, and there are also no species with bulbs, corms, tubers or much thickened rootstocks. Of the five species mentioned having rootstocks, the rootstocks do not become much thickened with food-storage, but are more woody than fleshy.

Of the ten prairie plants which begin to bloom in April or before, three species have tubers, one has a bulb (two species having bulbs bloom later), one a tuber, and four have multiple fleshy roots. Only two of these, however, have a small leaf surface and a short period of flowering; the others have a

greater leaf surface and a longer flowering period. None of the prairie species have thickened, fleshy rootstocks, these, seemingly, being limited to woodland species.

It will be noticed, by a study of the preceeding tables, that a fleshy underground stem in the form of a bulb, corm, tuber or thickened rootstock, is peculiar for the most part to species inhabiting places such that the plant must have a supply of food already prepared in order to develop fruit quickly before being shaded and crowded out by the larger plants growing near by.

The number of species having fleshy underground stems is, proportionately to the whole number of species inhabiting similar locations, greater for woodland flora than for prairie or swamp floras. Most of the plants having bulbs, corms, tubers, and fleshy rootstocks, grow in the more densely shaded parts of the woods and having food stored up from the preceeding season so that they can develop fruit before the trees come into full leaf, are able to live in a situation which would be destructive to other forms. The other woodland species grow in the more open parts of the woods, have greater leaf surface and are able to get sufficient light to carry on the vegetative processes and produce fruit, even after the trees have leaved out fully, and consequently do not need a large supply of quickly available food.

The swamp and prairie plants are nearly all in situations where they can secure unobstructed light during the entire season, and here we find that only a very few species of the great number produce bulbs, corms, tubers or fleshy rootstocks. Many of the grasses, especially, have rootstocks, but these are slender and serve for reproductive rather than storage purposes.

Some species, such as alfalfa, sweet clover, and some grasses do not assume a distinctive winter form, but grow during any warm period in the course of the winter. The length of time necessary for a plant to start to making a new growth, upon the return to warm weather, seems to depend also upon the

time of blooming of that species.

It has already been shown, in the case of woodland plants, that their peculiar adaptations for securing early growth, enables them to live in an environment which is unsuitable to other plants. But even with perennials, having either simple or multiple fleshy roots, and being under the same conditions, there is a succession in the rapidity of change from the winter condition. Antennaria campestris begins growth in March and blooms late in the same month or early in April. The squaw weed (Senecio balsamitae) starts almost as soon, but does not bloom until May. The White Avens (Geum Canadense) which does not bloom until June, does not start to grow until 2 - 3 weeks after Antennaria and Senecio have started, although they may have exactly the same conditions of light, moisture and temperature.

Similarly, other species which bloom successively later in summer, start respectively later in spring. The only explanation is that those species which bloom later in the summer require a higher temperature to start growth than do those which bloom earlier in the season.