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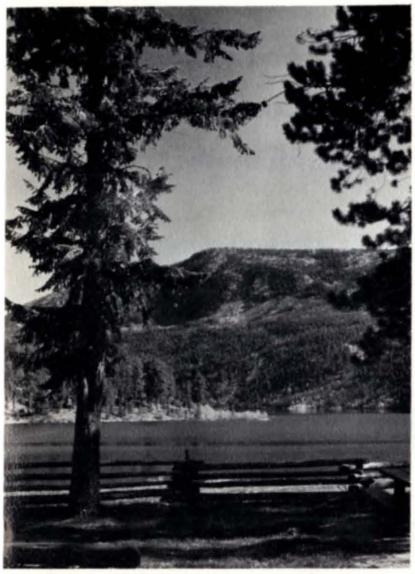

As viewed from its highways, Utah presents a panorama of sagebrush and cattle, striking rocky formations and mountains, and canyons and valleys. Also visible are large areas of pinyon and juniper woodlands — the "pigmy forests," so-called because of the smallness of their trees. Not often seen on their mountain top hideaways, however, are Utah's 4 million acres of commercial forests.

These commercial forests, consisting of spruce, fir, pine, and aspen, are largely under federal administration. These forests, besides providing watershed, recreation and other benefits, also provide the timber which is the life blood of a small but highly interesting group of forest products industries; logging, primary manufacturing, secondary manufacturing, and woodland.

Utah's forest industries employ approximately 1351 persons. This figure includes 853 full-time and 498 part-time employees. Their annual forest-derived payroll is nearly 4.5 million dollars. The annual wholesale value of the products which they produce is conservatively estimated at 16.4 million dollars.

Surprisingly, the majority of Utah-produced lumber is marketed in other states. The largest market is southern California, which absorbs 25.75 million board feet. Other midwest markets consume 13.76 million feet. States adjacent to Utah use 12.73 million and Utah uses 20.67 million board feet of its own product less than the consumption of greater Los Angeles.

Photo by John Hunt.

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UTAH FARM AND HOME SCIENCE

A quarterly devoted to research in agriculture, land and water resources, home and community life, human nutrition and development, and published by the Agricultural Experiment Station, Utah State University, Logan, Utah.

The magazine will be sent free on request.

To avoid overuse of technical terms, trade names of products or equipment sometimes are used. No endorsement of specific products or firms named is intended, nor is criticism implied of those not mentioned.

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Editorial . . .

The Station serves us all

DIRECTOR K. W. HILL

Everyone knows about agriculture. However, it might be difficult to write a definition that would be accepted universally. Certainly agriculture is the oldest industry. To most of mankind agriculture is a primary source of food. To many industrialists it is a primary source of raw materials. To a hungry peasant in India or China agriculture is literally life itself.

American agriculture is the envy of all the world. Nowadays, one of our farmers feeds himself and 33 others (compared to four others in 1830 and nine others in 1930). Furthermore American agriculture is so efficient that the average householder spends only 19 percent of his earnings for food whereas his counterparts in England spend 31 percent, in Japan 51 percent, and in Russia 60 percent.

Furthermore, American agriculture is the nation's largest industry. In 1964 the on-farm value of agricultural products was $41.4 billion. Processing, packaging and distributing these products added another $78 billion to their value. Government services — inspection, grading, provision of marketing information, etc. — added $18 billion more. The value of forest products was $31.5 billion. The total of all these was $159 billion which is more than 25 percent of the gross national product.

In Utah the food processing industry employs more people than the primary metals industry. It has long been an economic mainstay of the state. More than 8,500 people are employed in food processing while the primary metals industry employs 7,500.

Today our Agricultural Experiment Station research includes a number of projects in human nutrition, population changes, recreational needs, conservation of resources and many other areas which would have been considered foreign to agriculture in 1888. When the Experiment Station was established 78 years ago it was charged with the task of providing information to solve the problems of rural people — this meant 68 percent of the population at that time.

If we said "agricultural" people instead of "rural" the percentage would be even higher. Most "city" homes of that day were located on a lot of an acre or two and included barns at the back and a big vegetable and fruit garden in the middle. Nearly every family milked their cows, gathered their eggs, cured their pork, filled their root cellar and canned a winter's supply of fruits and vegetables. When the Experiment Station developed a new spray for the coddling moth it was as warmly welcomed on Main Street as on "Cow Lane."

Is there less interest among city people today in agriculture, the Experiment Station, and the work of the farmers of the State? The answer is probably "Yes" and "No." Most urban people do not take much interest in either agricultural research or production as long as the shelves of the supermarkets are well supplied. But let the peach crop be wiped out by frost or the corn destroyed by insects and city dwellers begin to ask why the scientists or the farmers don't do something about it. In actual fact, urban people are now much more dependent on agriculture than they ever were. When practically all consumers were also food producers the risks were widely spread. Nowadays concentration is the rule. Milk from Utah's Cache Valley makes a daily appearance on the breakfast tables of Denver and Las Vegas. Five percent of the nation's turkeys are grown in Utah, primarily in one county and 90 percent of these are exported from the state. If a serious disease epidemic were to devastate turkey production in Sanpete County, 5 percent of American families would be without Thanksgiving turkeys. One wonders what conditions would reign in urban areas if the supermarket supplies of food suddenly failed.

Thus rural and urban people are inter-dependent and if agriculture is defined as the production of food then it is certainly everybody's business. If successful agriculture depends heavily on scientific research, as has been amply proven, then research becomes the business of everybody. Research is especially the business of this Station — a business of service and the importance of its service increases yearly.

The Agricultural Experiment Station has been serving the people of the state for 78 years. It is still serving the people of the state — *all* of them.

Food is a science at USU

LOIS M. COX

To most of us, food is something to savor rather than study. Fortunately, however, some scientists study as well as enjoy food. The province of these "food scientists" stretches from the point of production to the point of consumption. Their efforts have helped provide people in economically advanced countries with an unprecedented variety of foods, and they are developing ways by which the rest of the world can achieve a comparable status.

At Utah State University, food scientists are scattered primarily among three departments: Animal Science, Plant Science, and Food and Nutrition. Several relevant disciplines such as bacteriology, biochemistry, and physiology, are in other university departments. Despite the limitations imposed by such fragmentation, however, many of the individuals involved have achieved notable research results. In addition, graduate and undergraduate students are being trained to meet the increasingly urgent needs of government agencies, industries, and universities.

Research has led to the development of:

1. A new process of making cottage cheese.
2. New cheeses and betterment of existing types.
3. More tender and moist meat when cheaper cuts are roasted longer at lower temperatures.
4. Superior methods of maintaining freshness in stored fruits and vegetables.
5. Freeze-dried foods, a promising food preservation breakthrough.

PRODUCTION AND MANUFACTURING

Dairy scientists at USU have made valuable contributions to the industry through imaginative research and teaching efforts. Students trained in the department are filling responsible positions ranging through business administration, research, and herd management throughout U.S.A., particularly the West.

•

LOIS M. COX is Technical Writer for the Utah Agricultural Experiment Station and Division of University Research.

COTTAGE CHEESE

Americans consume over 830 million pounds of cottage cheese annually. Conventionally, cottage cheese is made by a batch process in large vats which contain from 10 to 20 thousand pounds of skimmilk. Lactic-acid-producing microorganisms are added to the skimmilk, and as they multiply, sufficient acid is developed to cause the milk proteins to coagulate into a firm curd. The curd must then be cooked and washed. The total process takes from 8 to 16 hours depending upon the amount of culture used.

In a new process developed by USU's Dr. Anthon Ernstrom, working with the C. P. Division of St. Regis Paper Co., microorganisms are no longer needed. They are replaced by the direct addition of food grade acid to the milk at very low temperature. Using special equipment, the cold, acidified skimmilk is warmed to coagulating temperatures without agitation in order to form a firm curd. The curd is then cooked, washed, and drained prior to the creaming. This continuous process is accomplished from start to finish without contact with human hands.

One commercial unit, capable of producing 2000 pounds of dry curd or 3000 pounds of finished cottage cheese per hour, is now in operation on an experimental basis. The lower manufacturing costs, better quality control, and better sanitation will benefit both producers and consumers.

CHEESE FISH BAIT

Processed cheese products are renowned as bait for game fish in the intermountain area. However, the products most often used are greasy, fall apart in warm weather, and are difficult to keep on a hook. Financial support for a research project to solve these problems was contributed to USU by a Utah cheese processor. During the past year the research produced a substance that molds well, has a putty-like consistency, stays on the hook much better than regular processed cheese, and apparently still has ample fish appeal.

SALT MEASUREMENT

Analytical procedures currently used to determine the salt content of processed foods are tedious and

time consuming. The recent development of specific ion electrodes makes it possible to measure sodium ion concentration with good accuracy. One USU research project is using such equipment to measure the salt content of cheese. Early results look very promising, and should lead to a quick, easy method for obtaining accurate salt analyses on large numbers of food samples.

WHEY UTILIZATION

Approximately 600,000 pounds of whey are produced every day by Utah cheese factories. Only about half of this material is used for human or animal food, the rest is wasted. Scientists at USU are trying to find a way to remove the native whey proteins so that they can be properly modified for use by the baking industry as a substitute for egg whites. Whey proteins have excellent foaming properties when they are dissolved in water, but their foams lack the stability that bakers require in sponge cakes and meringues. This partially state-supported work has already developed a way to isolate native whey proteins that are completely soluble in water. Present studies are aimed at increasing the foam stability of these proteins and decreasing the liquid drainage from the foams.

Figure 1. Cottage cheese, usually made in large batches, can now be manufactured in a continuous process by using equipment and methods designed by Dr. Anthon Ernstrom of USU. One commercial unit now in operation on an experimental basis produces 3,000 lbs. of finished cottage cheese per hour.

PRORENNIN ACTIVATION

Rennin is an enzyme formed naturally in the stomach of milk-fed calves. The inactive precursor of rennin is called prorennin. Acidic conditions within the calf's stomach cause a structural change in the precursor which makes it active. Current research has suggested that prorennin may be activated by two different mechanisms. Continuing investigations are expected to define the nature of the chemical change(s) involved in the activation mechanism(s).

Student participation in such research is routine. In this way, the Dairy Science group at USU maximizes the productivity of its teaching and research programs despite antiquated equipment and building facilities.

FOOD AND NUTRITION

Under the direction of Dr. Ethelwyn Wilcox, the USU Food and Nutrition Department is vigorously working to expand its research and teaching capacities. If it can obtain additional scholarship funds and fulfill its research ambitions, the department expects to play a vital role in helping USU become a major training center for food scientists. The department's newly acquired electronic oven is one step towards this goal. It will provide students with first-hand experience in modern cooking techniques, and help researchers to stay abreast of their field.

Figure 2. Dairy research continues with other types of cheese. Here, a graduate student stretches some of his new pizza cheese prior to molding and salting.

Although handicapped by limited funds, the diverse research projects are producing results that are likely to have substantial effects on our cooking and eating habits. The studies include efforts to define: the effects of variety, maturity, fertilizers, and home cooking practices on ascorbic acid (Vitamin C) contents of peas, corn, and lima beans; the effects of feeding sucrose to beef cattle, swine, and poultry relative to dressing percentages and quality of meat; and how different methods of cooking affect the tenderness of turkey. In addition, general quality and nutrition changes are being appraised in gamma irradiated fruits and vegetables.

A primary aim for the future is to do more basic research on the physical and chemical principles involved in food preparation and preservation. The in-progress pilot studies on time-temperature relationships during cooking mark the beginning of this new program.

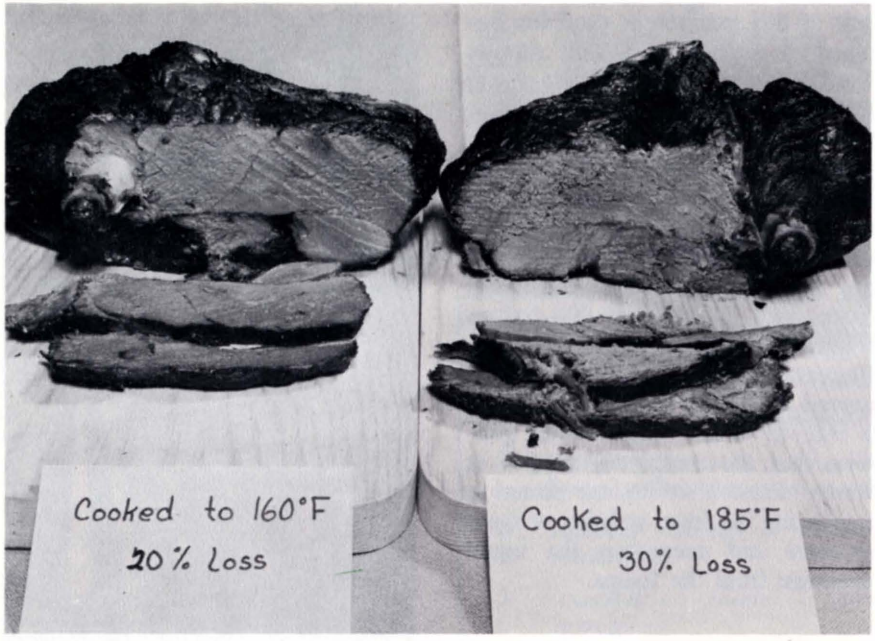

Figure 3. New methods of cooking meats are investigated by Station staff members. Here two roasts, one cooked to 160°F, the other cooked to 185°F, show different degrees of moistness and texture. The one cooked to the lower temperature is more moist and tender and has only a 20 percent loss of juices.

ROASTING MEATS

The patterns of heat transfer and the tenderizing effect of roasting less tender cuts of meat, uncovered, at temperatures as low as 250°F are being determined. Indications are that the meat provides its own moisture to tenderize the connective tissue, and roasts processed this way are tender and moist when cooked to any degree of doneness. The method seems most effective for roasts over 3 pounds in weight. This research is correlated with efforts by Animal Science personnel to produce more tender beef through genetic selection.

In another project, meat was broiled at three temperatures. Under these conditions the intermediate temperature, 350°F, produced the most tender, moist, and flavorful meat. Also, meat cooked to the rare stage was more moist and tender than that taken to the medium or well-done stage. The scientists hope to extend this work to include other meats, additional types of food, and various sources of heat, in order to arrive at accurate basic concepts. Pilot studies have indicated that the commonly accepted idea of a direct correlation between cooking time and temperature is a fiction.

VENISON FLAVOR

Research being done in collaboration with the Utah Cooperative Wildlife Research Unit is identifying the substances that produce the distinctive flavor of venison. Meat, fat, and subcutaneous glands from strong and mild flavored venison are being analyzed using a gas chromatograph. Eventually it should be possible to relate flavor, age, sex, range, and time of year when obtained, so the hunting season can be adjusted to promote good range management and the harvesting of high quality meat.

Other departmental research projects are concerned with interrelating intakes of different foods, nutritional levels, and hormonal interactions in individuals. Consumer preferences and patterns of food consumption are also being investigated.

FOOD TECHNOLOGY

The USU scientists working most directly with some technical aspects of general food science are affiliated with the Department of Plant Science. Led by Dr. D. K. Salunkhe, this group has emphasized prolonged maintenance of quality in fresh and processed foods. Students from around the world are receiving training through their association with this progressive research.

Successful storage of fresh produce necessitates slowing down the normal aging process and offsetting external factors of deterioration. Microbial contamination, unwanted shrivelling, and improper storage temperatures, are among the primary causes of accelerated deterioration. Researchers at USU have been investigating these problems for more than a decade, primarily using apricots, peaches, and sour cherries.

Various anti-fungal antibiotics have been tested and rated for effectiveness against deterioration on the different fruits. Hydrocooling, a process that almost instantaneously cools the produce from "field temperature" to "storage temperature," has materially extended the storage life of some of the tested produce.

CONTROLLED ATMOSPHERE

Controlled - atmosphere (C - A) storage conditions have also been super-imposed on the other variables. C-A storage involves artificially increasing the carbon dioxide content of the air in the storage room and decreasing the oxygen content. This procedure has considerably lengthened the storage life of some fruits and vegetables. It is currently used on a commercial basis by many apple growers and marketers.

Peaches, apricots, cherries, and beans have been processed in certain types of polyethylene bags as they normally are processed in tin cans. Preliminary results indicate that consumers should eventually benefit by thus actually being able to see the processed food that they buy. The relative economy and ease of "canning" in polyethylene will be especially advantageous to the world's less affluent countries.

Figure 4. Controlled atmosphere storage considerably lengthens the duration of "freshness" in some fruits and vegetables. Dr. Salunkhe examines two crates of apples just removed from a room where the carbon dioxide content of the air was artificially increased.

Freeze-dried foods have over 95 percent of their water content removed (as vapor) while they are frozen. Once processed, the foods require no refrigeration or sterilization as do frozen or canned items. Potential bacterial and fungal contamination is restricted by the limited moisture content. No special costly containers are required. A freeze-dried product retains its normal size, shape, and flavor. And when it is to be used, it will rehydrate faster and to a greater degree than will its oven- or sundried counterpart.

In dehydro-freezing, nearly 50 percent of the water is removed from the produce by a conventional drier before the material is frozen. The USU research so far has been limited to investigations using sour cherries, but the results are promising.

Other USU research is seeking specific information about what initiates the development of flavor in a fruit as it ripens. The investigation is concerned with normal and artificial ripening processes. Different light spectra, growth regulators, chemicals, and magnetic treatments are being tested to see how they may affect the overall aging of certain fruits.

BETTER COORDINATION FOR BETTER PRODUCTION

Teaching and research programs alike are enhanced when scientists sharing a general interest can function with some sense of unity. USU is moving toward this goal with its decision to establish a Food Science Department. Utah's strategic location from a geographic point of view, and USU's unusually competent nucleus of food scientists hold considerable promise for the future of the department.

Food is not likely to go "out of style." But it *is* likely to become more and more of a science — from the field to the table. USU food scientists hope to stay among those leading the way to better nutrition around the world.

NEW TANNING HELPS GOLFERS

Golf gloves — often ruined by perspiration after a few games — can be used by active golfers an entire season if tanned by a new USDA-developed process.

The process, called glutaraldehyde tanning, makes leather more resistant to perspiration and laundering. It is now in wide commercial use. Scientists of USDA's Agricultural Research Service have applied it most recently in tanning glove leather. They had the leather made experimentally into golf gloves where perspiration resistance is especially desirable.

Glutaraldehyde tanning was developed at the ARS Eastern Utilization Laboratory in Philadelphia as part of a continuing research program to find new methods of processing hides and skins into better and more economical leathers. The objective of the work is to increase domestic use of the U.S. hide supply.

Experimental gloves were made from leather tanned conventionally with chrome and then retanned with glutaraldehyde. These gloves were wear-tested by 22 golfers during an 8-month season. Each wearer washed the gloves five to eight times during the season with warm water and soap or detergent. Without exception, the golfers favored the gloves over those worn previously. They reported that a little manipulation of the dried glove after washing restored most of its original softness. They also found that no matter how wet the glove became with perspiration, it would dry without stiffening or cracking.

A good perspiration resistance of the leather, indicated previously by tests made with artificial perspiration, was confirmed under actual use.

Glutaraldehyde is used commercially to make leather for shoe uppers, garments, and other leather products. It is also used in tanning shearlings for hospital bedpans and for paint-roller covers.

HOW TO DEVELOP AND USE WATER — UTAH'S LIFE BLOOD

A. ALVIN BISHOP

The economic growth of Utah has been closely paralled by the development of the water resource of the state. In early days this economic growth was mainly concerned with agriculture. The early pioneers initiated water development even before they began building shelters. The following notes were taken from the diary of Orson Pratt, who accompanied the first party of Mormons into Utah:

> July 23, 1847 - In camp, near the bank of a beautiful creek of pure cold water . . . in about two hours after our arrival, we began to plow and the same afternoon built a dam to irrigate soil.
>
> July 24, 1847 — This afternoon we commenced planting potatoes after which we turned the water upon them and gave the ground quite a soaking.

From that humble beginning, more than 100 years ago, Utah's irrigated land now totals more than a million acres. Large irrigation projects have been built, still larger projects are under construction and vast irrigation schemes to further develop the water resource are under consideration.

The Utah Agricultural Experiment Station has played a major role in maximizing water use under present developments. Research concerned with water measurement, water requirements of crops, stream flow forecasting, water application efficiency, and drainage has resulted in notable progress, yet much remains to be accomplished. It has been estimated that the average annual water supply for Utah coming in the form of precipitation amounts to 59 million acre feet. Of this amount nearly 50 million acre feet is evaporated and transpired where it falls, leaving 9 million acre feet which is subject to regulation and management. Irrigated agriculture consumes about 31 percent of this 9 million acre feet and municipal and industrial uses consume 2 percent. The remaining 67 percent is consumed by nonbeneficial uses. Of this (deep rooted plants which draw directly from the water table), unproductive vegetation along streams, etc., uses 32 percent and evaporation from water surfaces such as lakes uses 35 percent (figure 1).

The agricultural and industrial future of Utah depends upon the degree to which the water resource can be developed and properly managed. The major challenge is to put to use a larger share of the manageable waters than is used at the present time. The development of these water resources will not come easily; many problems must be solved. There are physical, legal, institutional, managerial, social and economic problems. To solve them will require much public effort and the development of new scientific information and techniques as yet unknown. Scientists at Utah State University have found many answers and are attempting to find more. Listed are some of the research projects, and some of the findings.

LINING OF IRRIGATION CANALS AND RESERVOIRS

A wide variety of canal lining materials has been tested by the Agricultural Experiment Station scientists. The advantages and disadvantages of earth materials, membranes, and concrete for the reduction of seepage is well known. Control of seepage is reducing the drainage problem and making more water available for irrigation. Many canals and farm distribution systems are now lined but much remains to be done.

DRAINAGE OF IRRIGATED LANDS

Utah has some 100,000 acres of wet, poorly drained land. Much of this is potentially productive if economical solutions to the drainage

Utah precipitation equals 59 million acre feet.
Only 9 million acre feet are subject to management.
We presently use only 31 percent of this water.
Research has shown how to put wasted water to use:

1. Line irrigation canals and reservoirs.
2. Drain irrigated lands.
3. Forecast stream flows.
4. Better weather data collection.
5. Better understanding of water runoff patterns.

A. ALVIN BISHOP is a Professor and Head of the Department of Agricultural and Irrigation Engineering.

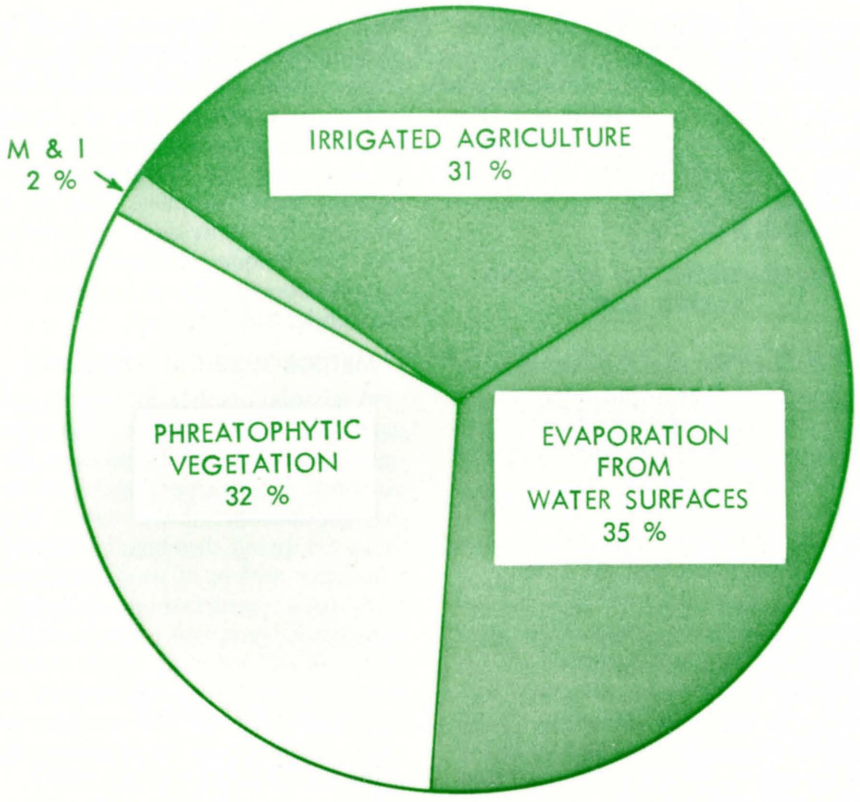

Figure 1. Available water in Utah is about 9 million acre feet annually. Of this, agriculture uses 31 percent, municipal and industrial uses consume 2 percent and 67 percent is wasted by unproductive vegetation along streams, irrigation ditches etc., and evaporation from water surfaces.

problem can be found. Studies of ground water conditions and water table fluctuations have shown the importance of management of irrigation water as a means of preventing or solving many drainage problems. Movement of water toward drains, use of mole drains, soil permeability, and salinity and alkali problems are also under investigation.

STREAMFLOW FORECASTING

The measurement and study of variables which influence streamflow has increased the accuracy of the overall streamflow forecasts.

The value of streamflow forecasting using precipitation measurements and snow surveys was brought sharply into focus in 1934 when a serious drought was forecast. Based on information supplied by the Agricultural Experiment Station farmers reduced their plantings in anticipation of the impending drought and were able to harvest some crop from the limited average. The savings in labor and seed for crops that

Figure 2. Precipitation in the form of snow or rain amounts to 59 million acre feet in Utah. Of this nearly 50 million acre feet are evaporated and transpired where it falls. To more effectively manage the remaining run-off, snow surveys are conducted to forecast available water for the coming irrigation season. Concentrations of snow high in Utah's mountains or quite literally water banks.

never would have matured was estimated at millions of dollars. Since that time the annual streamflow forecasts have been relied upon heavily.

SNOW SURVEYS

Snow surveys are used extensively in connection with the streamflow forecasts. Many problems are encountered in measuring the snow, not the least of which is the problem of getting to the remote high-mountain areas during the winter. This problem led to the development of a snowmobile. One of the most successful of these vehicles was developed at Utah State University and is now being manufactured and sold commercially. Besides snow survey use, the vehicle has many other uses; hundreds are sold for use in ski resorts and for power and telephone line maintenance.

EFFECT OF VARIOUS IRRIGATION TECHNIQUES

The method of water application, water application rate, and saturation level throughout the soil profile during irrigation play a major role in maintaining good soil tilth. Soil structure consolidation and stability in relation to irrigation practices are under study and the information gained will prove useful in selecting irrigation methods and application rates to achieve various soil, plant and water interaction.

IMPROVEMENT OF WET AND SALTED SOILS

Through the use of model studies, it has been shown that, whether reclaiming salty soils or leaching to maintain a salt balance, greater amounts of salt are removed per unit of water if there is intermittent application of water. It also has been established that the amount of leaching water for most efficient salt removal can be ascertained only when the location of the salt in the soil profile is known. If saline waters are used for irrigation, crops should be grown that increase in salt tolerance as the season progresses. This provides for most efficient water use.

ATMOSPHERIC WATER RESOURCES RESEARCH

An experimental project, concerning atmospheric water resources, of both basic and applied research, is co-sponsored by the U.S. Bureau of Reclamation. Weather modification studies by cloud seeding are being carried out along the Wasatch Front to determine the feasibility of increasing water supplies. The areas affected by individual generators and the unique characteristics of water-producing storm systems are also under investigation.

METEOROLOGICAL PROBLEMS

Available weather measuring devices are being studied and new ones are being developed with the objective of implementing fully automated remote weather stations. Devices are being developed to measure water content of snow, temperature, total precipitation, humidity, barometric pressure, wind, radiation, and soil moisture in the mountains and send the information to the laboratory on the campus by radio. Here it will be automatically recorded 24 hours per day.

ELECTRONIC ANALOG MODEL

The electric analog model studies of river basins is a project sponsored by the State of Utah, the U.S. Department of Agriculture, and the Utah Water and Power Board. The basic hydrologic processes of precipitation, snowmelt, surface and subsurface runoff, ground water storage and movement, evapotranspiration, streamflow, etc., are being modeled electronically as a complete hydrologic system. The model will be used to predict performance of various parts of the hydrologic system resulting from proposed water management and water development changes. Plans are now underway to increase its capacity to handle a wider variety of problems.

The projects mentioned are representative of the more than 50 separate research projects concerned with water, now underway at Utah State University. Our present prosperity is soundly based on past research. Since the economy of Utah is tied so closely to water, both from the industrial and agricultural point of view, it is essential that research concerned with water needs be pushed forward and expanded.

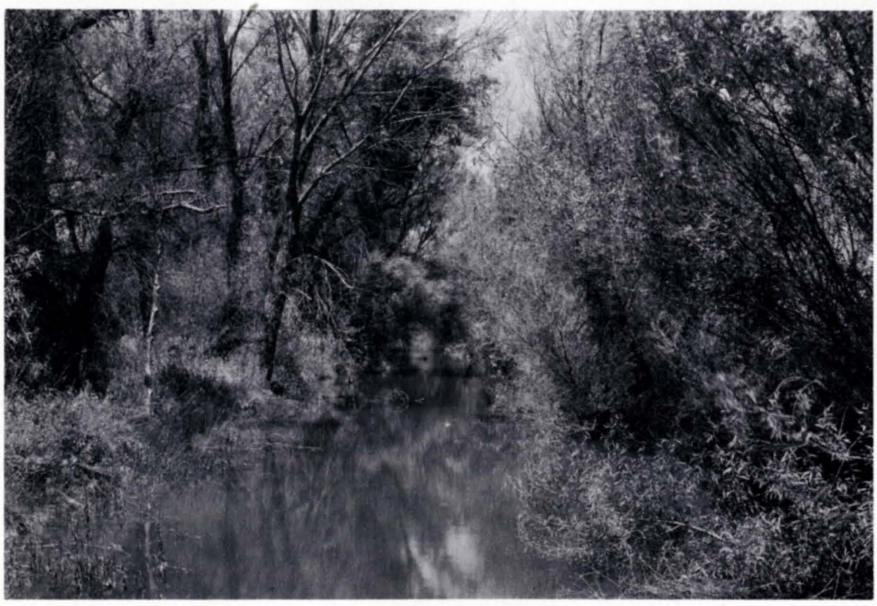

Figure 3. Phreatophytic vegetation (willows, salt cedar, and other woody plants) growing along irrigation ditches, canals, and streams draw off tremendous quantities of water into the air. They also interfere with canal maintenance and usually greatly reduce the flow capacity of the water way.

Utah's Population — Past & Future

THEREL R. BLACK and YUN KIM

Utah is what its poplation is. The number of people, their age and their location within the State may be the best single index to Utah. Periods of fast and slow population growth in the past are reflections of and indications of Utah's history, and projections of Utah's population give us a glimpse at Utah's future.

PAST LOOK

From 1847 to 1910 Utah's population grew rapidly. Its growth slowed from 1910 to 1940, then World War II initiated another fast-growing period which continued until the 1960 Census was taken.

Any change in population is traceable to births, deaths, and migration. In Utah, birth rates were about 30 per 1,000 population before 1922, and declined gradually to about 24 per 1,000 by 1930. They remained at this level up to 1941. Beginning in 1942, birth rates began to increase. By 1947 they were over 34 per 1,000, and they remained above 30 more than a decade. Since 1957, the rates have been declining. By 1963, the rate was below 26. Also, death rates have been declining over the years and in Utah they have been among the lowest in the nation. High birth rates with low death rates have naturally resulted in a high rate of natural increase or population production, as can be seen in Figure 1. The area on the graph between the birth rate and death rate curves shows the extent of natural increase. The rate of natural increase is primarily influenced by the level of the birth rate.

The extent to which the high population production in Utah has been drained off to other States or has been absorbed into the Utah economy constitutes the story of Utah's population change. From 1910 to about 1942, the drain-off of population exceeded the number of people who migrated into the state, which resulted in net out-migration. Utah lost about 30 percent and 46 percent of her natural population increase due to net out-migration in 1920-30 and 1930-40 respectively. However, in 1940-50 and 1950-60, this situation was reversed. The in-migration was not great, however. In the decades of 1940-50 and 1950-60, only 10 percent and 5 percent respectively, of the total population increase was attributable to net in-migration. Thus the great increase in total state population resulted primarily from retention of Utah's own natural increase.

FUTURE LOOK

How fast will Utah's people produce population? To what extent will the population product be exported or retained? To what extent will there be an importation of population? These are the questions that must be considered in making future population projections. Separate projections of the three components — birth, death, and net migration — are therefore necessary.

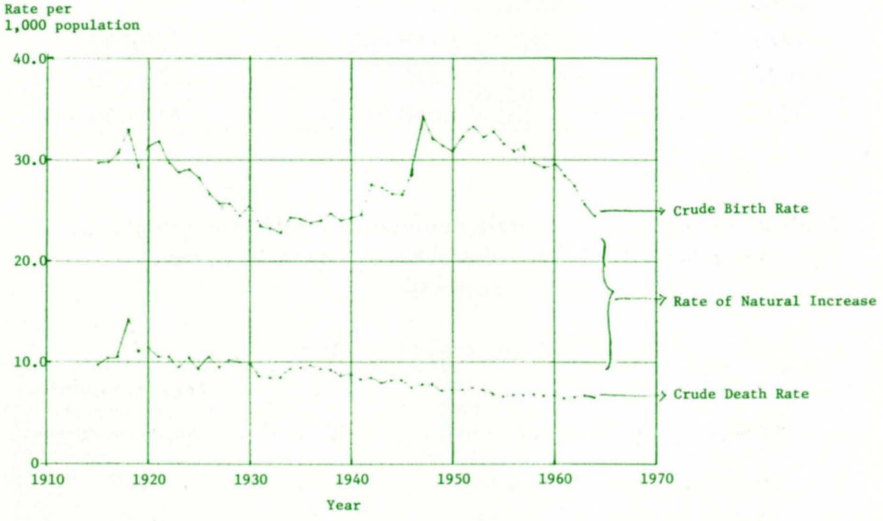

Figure 1. Trend of crude birth rate, crude death rate, and natural rate of population increase in Utah from 1915 to 1964. Source: Utah State Department of Health, Utah Vital Statistics Annual Report, 1964, p. 2.

THEREL R. BLACK is a Professor in the Department of Sociology, Social Work and Anthropology. YUN KIM is an Assistant Professor.

Taking these factors into consideration, Utah Agricultural Experiment Station has published in bulletin form (Bulletins 457 and 459) several possible projections for Utah by 5-year intervals to 1980. One of these projections is presented below. This projection is based upon the assumption that net migration to Utah will be zero, an assumption not out of line with Utah's net migration history mentioned above. The projection is also based upon an assumption of slightly declining death rates, and birth rates that are reduced to the pre war level. For comparative purposes one of the United States Census Bureau's projections is presented alongside the Utah State University projection period (table 1). The Bureau's projection assumes that the Utah 1955-60 net migration rate, with some adjustment to national figures, will continue. It assumes slightly declining death rates and it assumes moderately declining birth rates that in due time will reach an average of all States.

The most striking feature of these figures is the relatively large increase in the population aged 15-44 years between 1960 and 1980. In other words, by 1980 the age structure of Utah's population may be very favorable to economic development if the birth rates decline moderately, as assumed, and Utah manages to prevent the out-flow of population.

COUNTY UNITS IN PLANNING

Another refinement in planning is possible when population projections are seen not only by age and sex but by age and sex on a county-by-county basis. This approach was taken in the USU study, which resulted in the first age-sex projections for all Utah counties.

In that report, the data of which are too voluminous to present here, detailed statistics on the size and the age and sex composition of the future population in each county of Utah were presented. The figures were obtained after making a thorough study of the trend of births, deaths, and net migration.

The assumptions regarding the future course of mortality, birth rates and migration are uncertain and are subject to change primarily because these factors are closely associated with the changes in socio-economic changes and other conditions of society. Therefore, constant refinement on the methods of population projection in small areas is needed, as well as continuous modifications and improvements on the assumptions used in the projections. Nevertheless, the county projections made by Experiment Station staff members offer a base against which current and on-going projections by county can be examined.

To improve on these projections, basic research on the age pattern of marriage in Utah has recently been launched. This marriage pattern has an important effect on the number of births. Also, another investigation is planned to measure the effects of future economic developments (projected) on demographic trends, with particular reference to inter-county net migration.

Table 1. Utah State University and U.S. Census Projections of Utah's future population

Year	USU's Series III Projection	Census Bureau's Series 1-B Projection
1965	1,019,692	
1970	1,168,543	1,139,000
1975	1,372,874	1,271,000
1980	1,668,019	1,417,000

Table 2. Projections of the State population in different age groups made in the Utah Agricultural Experiment Station study Series III

(Numbers in thousands)

Age Groups	April 1, 1960 (U.S. Census)	JULY 1, 1980	Projected Population as percent of original population
0-14	334	565	169
15-44	354	763	216
45-64	142	238	168
65+	60	102	170
Total	891	1,668	187

FUTURE PLANNING

From a 1960 population of 890,-627, the above projected populations indicate significant increases for Utah. Planning to meet the needs of such increases in population constitutes a significant challenge for Utah's citizens.

To effectively conduct this planning, it is necessary to look not only to future total populations for the State, but also to look at the age and sex composition of the projected population.

CLIMATE
the pulse of life

GAYLEN L. ASHCROFT, GEORGE W. REYNOLDS,
and E. ARLO RICHARDSON

All living organisms interact with their environment. Of the many factors which affect organisms, climate is one of the most important. In many environments climate determines whether or not continued life is possible. Man and other organisms have long been subject to the vagaries of weather and climate, but only recently has a significant program of bioclimatic and biometeorological research been developed. These two sciences are concerned with the relationship of living organisms and their atmospheric environment. They have received increased attention of late because of the space program.

CLIMATOLOGY AT UTAH STATE UNIVERSITY

At Utah State University bioclimatology has recently been given added stature. A department of Soils and Meteorology was formed in 1965 and the State Climatologist of the Federal Meteorological Service was stationed at Utah State University as an affiliate of this department. However, there has been interest in this area for many years. Soon after the founding of the University a department of meteorology was created. Most of the research at that time concerned the influence of climate on agricultural plants and animals. Several research bulletins were published and studies on heating orchards were conducted.

This early department later became the Department of Physics, and although purely meteorological research became less prominent, the consideration of climate and weather in biological studies increased and has continued through the years. With the formation of the new Department of Soils and Meteorology the research emphasis will be on biometeorology.

HANDLING WEATHER DATA

Knowledge of climatological and hydrological phenomena is invaluable in a wide variety of design and planning needs that are related to life processes. Agriculturists, recreationists, engineers, architects, foresters, administrators of all kinds, and many other professional and lay people make vital weather-influenced decisions each day.

One of the questions is what to do with the extensive climatological data that have been accumulated for many years by the United States Weather Bureau. In the past, only the raw daily data were available along with computed monthly and annual means and extremes. By use of the University computer, it is possible to reduce this vast amount of data to more useable charts, graphs, and tables. For example, precipitation probabilites have been calculated. From these the chances of receiving selected amounts of precipitation for any weekly period can be determined. The work done in Utah served as a model for similar analysis in all of the eleven western states. Hydrologic data such as stream flow are also being treated in a similar manner.

CLIMATE AND PLANTS

Research is underway on the direct effect of climate on specific plant species. One such experiment is studying the influence of weather and soil moisture conditions on the irrigation needs, growth, quality, and yield of peaches. This is one of the most comprehensive studies that has been undertaken anywhere in the world on the effect of environment on fruit production. It should lead to more effective use of

Climatology at USU is concerned with:

1. The effects of climate on specific irrigated crops.
2. Vegetation modification on Utah water sheds.
3. Increasing the mountain snow pack.
4. Weather modification.
5. More complete weather reporting from remote areas.
6. Orchard heating.

GAYLEN L. ASHCROFT is Associate Professor of Climatology in the Department of Soils and Meteorology. GEORGE W. REYNOLDS is Professor of Meteorology working jointly with Department of Soils and Meteorology and Utah Water Research Laboratory. E. ARLO RICHARDSON is the ESSA State Climatologist for Utah-Nevada.

Figure 1. Firing up to protect fruit blossoms and buds during early spring frosts is usually an annual occurrence in Utah orchards. Research at USU is aimed at studying the effects of various orchard-firing methods, the effects of wind on heating practices and the effects of ground moisture.

irrigation water, higher yields, and better quality fruit.

Another area of vital research is the possibility of modifying the climate to protect fruit crops during critical stages of spring growth. This research may also lead to methods of controlling fall freezes which are very detrimental to such crops as alfalfa seed and tomatoes.

INCREASING SNOW PACK

Under contract with the Bureau of Reclamation, Utah State University is involved in a program to evaluate the effectiveness of attempts to increase the mountain snow pack. An area in the Wasatch Range has been chosen for this study but the results will have applications to many other regions. Clouds will be seeded with ground based generators using a carefully designed method of determining which sites and which storms are to be seeded.

Evaluation of similar experiments in the past have been rather inconclusive because of the limited amount of data that could be collected. To overcome this difficulty, a system has been developed by which precipitation measurements and other data can be sent by radio signals to the campus from remote stations. This telemetry system was developed at Utah State University and is one of the greatest boons to environmental research in recent years. It allows data collection in remote locations with the added asset that the data can be received at a parent station and be available for immediate decisions.

A new type of snow pillow has been developed to determine the

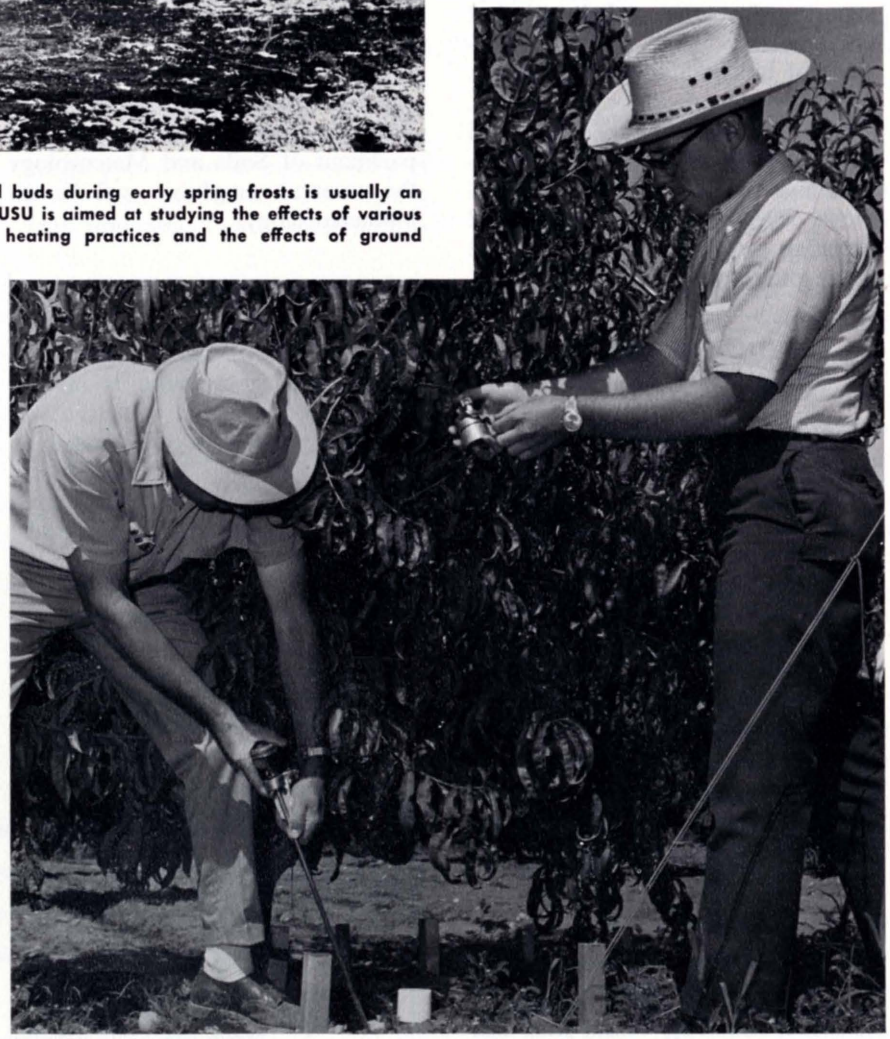

Figure 2. USU Researchers are investigating the influence of climate and soil moisture on the growth yield, and quality of peaches. Here, soil and leaf samples are being taken to measure the physiological effects of irrigation.

Figure 3. Instruments are set up at tree-top level to measure air currents and temperatures. By better understanding these factors more effective orchard heating methods can be devised.

amount of snow on the ground. This pillow also lends itself to telemetry and is small enough that it can be easily installed and maintained at remote sites.

VEGETATION MODIFICATION

Another project underway at Utah State University deals with the posssibility of producing greater water yields from water sheds. The water use and uptake associated with several vegetative sites on different slopes and aspects are being studied. Results from this study may eventually lead to recommendations for modifying the types of vegetation growing on certain sites. Such modification would reduce the amount of water taken up by the plants and transpired into the air, and thus increase the water yield from the site without appreciably increasing the erosion hazard. A closely related project will study vegetation modification to increase snow drifts on shady protected sites. Thus, the snow pack will last longer. By proper manipulation of the vegetation, it may be possible to increase the snow pack and thus extend the stream flow later into the season, and also to increase the total water yield of the water shed. Greater forage production and greater grazing capacity on mountain ranges should also result.

Figure 4. This remote-controlled silver-iodide generator is used in the weather control studies at USU. Located high in the Wasatch Mountains this generator can be turned on by radio signal when cloud and wind conditions are conducive to cloud seeding.

Ornamentally Yours

BERNARD G. WESENBERG

"Gardening has been the inclination of kings and the choice of philosophers." — SIR WILLIAM TEMPLE

King Nebuchadnezzar's 3 acres of gardens were revered as one of the seven wonders of the ancient world — the Hanging Gardens of Babylon. The Gardens of Versailles similarly paralleled the flowering of mighty France when she was the center of all that was important in the world.

Currently, Mrs. Lyndon B. Johnson, as a symbol of central executive power, is promoting the cause of a more beautiful America. But unlike ancient kingdoms, the emphasis in our day is not toward a fantastic showplace exclusively for the aristocracy. Instead, the effort is greater beauty for everyone throughout the length and breadth of the land. Utah citizens can benefit from better roadsides, parks, and recreational areas and the Utah Agricultural Experiment Station is busy finding, developing, and cultivating plants that will meet these beautification needs.

BEAUTY BUSINESS

The pursuit of beauty is a major business in America. An estimated 4 billion dollars were spent on landscape development in the United States in 1965. One billion dollars of this went for seeds, bulbs and plants; and one-half billion dollars was spent for fertilizers and chemicals. Sales of power lawn mowers jumped 1,600,000 units in 1950 to 4,000,000 in 1963 with a value of 285 million dollars. It is estimated that there are at present 14 million

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Figure 1. Landscaping a yard adds beauty to the neighborhood, offers a sense of well-being to the homeowner, and pays dividends of health, stability, and happiness. Master plans are usually needed when landscaping.

Agriculture also is concerned with the pursuit of beauty.

Americans spent 4 billion dollars last year on landscaping.

Research gave us year-round mums.

Disease free geraniums and carnations are now available.

Utah Station is now testing lawnseed mixtures, annual and perennial flowers, evergreens, woody shrubs, small ornamental trees, and ground cover plants.

acres of lawn in the United States, and the acreage is steadily increasing. When a million housing units are constructed, 100,000 more acres are used for lawns and yards.

Besides the obvious benefits of business volume and wide use, we should recognize other types of dividends from orderly, well-developed physical environments. Gardening is associated with health, stability and happiness. A neighborhood competition for the "best lawn" and the "prettiest yard" reaps the benefit of desirable surroundings for all the competitors. When this competition is between towns and cities or suburban areas, the aesthetic benefits are even greater.

BEAUTY INFORMATION

Nearly anyone with a desire for outward beauty and inner satisfaction should become familiar with the rudiments of ornamental horticulture. Ornamental horticulture concerns itself with the use of plants for aesthetic purposes. Trees, shrubs, evergreens, and lawns are used to develop landscapes, and bright flower beds accent such plantings. Indoor use of cut flowers and potted plants to decorate and accent the house and its furnishings is another facet of ornamental horticulture. Developments in the various sciences, e.g., botany, genetics, biochemistry, are quickly publicized and incorporated into the improvement of landscapes and beautification efforts.

During the past 30 years, a flood of information on the development, planting, culture, care, and propagation of myriad ornamentals has been printed and distributed to the public. Several home and garden-type magazines have circulations in the multi-millions. Home owners are better informed today than ever before.

STATION RESEARCH

Station personnel are involved with research on ornamentals at the Farmington Field Station. They are testing various lawnseed mixtures, annual and perennial flowers, low spreading evergreens, shrubby evergreens, woody shrubs, and small ornamental trees. A project is now underway to collect groundcover plants. Thus far, about 45 varieties have been collected; among them, 5 thymes and 6 sedums.

The sedums are succulents which resemble the mossrose yet are winter-hardy, some are natives of Canada. Thus far, they have adapted well to the Utah environment.

Groundcovers are interesting substitutes for lawns in certain landscape situations. Some of the plants collected thus far adapt well to minimum care conditions.

For the past 8 years the Farmington Field Station has sponsored a Chrysanthemum Day in early October. It is a colorful attraction and Utahns who attend are always impressed with the varieties, diversity of flower forms, colors, and plant sizes which are grown there.

This year four landscaped plots were developed so that the visitors could actually see how various plants can be utilized to develop home grounds.

Minimum maintenance types (evergreens) were featured in one yard while annuals and perennials were emphasized in the other three plots.

Station personnel are also engaged in improving several popular ornamentals. Pyracantha populations are being screened for greater hardiness and redder fruit. Most of the Pyracantha plantings in Northern Utah and Southern Idaho were killed during the severe 1963-64 winter.

Lupines are being crossed to incorporate the best colors with the best plant form and the greatest mildew resistance. In addition, Lupines, common in white, pink, and blue, are now being bred for deeper red colors.

Penstemon is a plant of diverse forms and the different types are now being combined and tailored to produce exciting garden subjects.

MAKING MUMS

An excellent example of a research milestone in ornamental horticulture is the commercial production of chrysanthemums. Dr. Kenneth Post at Cornell University pioneered in the year-round flowering of chrysanthemums. Commercial sales of mums were very minor in the

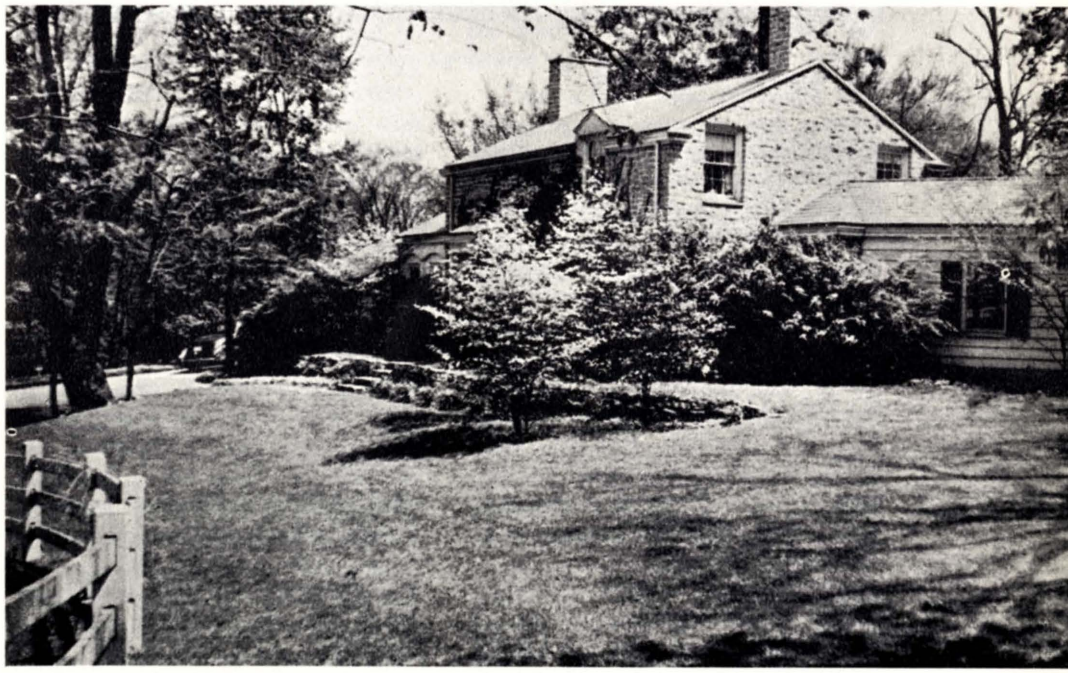


Figure 2. No helter-skelter planning here. This home landscaping was designed with professional help. As each planting season arrives, additional shrubs, annuals, and bulbs can be added.

Figure 3. Dwarf-evergreen penstemon, provides a mass of color when in full bloom and lends itself to dramatic landscape effects.

Figure 4. One of the plots planted at the Farmington Field Station to demonstrate plants which lend themselves to landscaping.

florist industry 25 years ago. Until then the mum was seasonal and never seen except in autumn. Flowering of chrysanthemums is regulated by the length of the day (photoperiod), or more properly, the length of the night. By manipulating the hours of uninterrupted darkness which the plants receive, growers can schedule the blossoms to any date. In the two and one-half decades since 1940, the chrysanthemum has become a major florist crop and now ranks with roses and carnations as the leading flowers.

Chemicals to control the stem length of chrysanthemums already are in regular use. At the USDA laboratories in Beltsville, Maryland, Dr. M. Cathey is currently developing chemical regulators which can prevent the development of axillary flower buds. This eliminates the hand labor for removing (pinching) these axillary buds which is necessary to produce the large, "standard" mums.

Hormone-type chemicals are used in the fruit industry to thin the fruit crop. This results in larger, better quality fruit. Similar chemicals can be used to eliminate fruit-set on trees used for ornamental purposes if such fruit-set is unwanted. Honeylocust pods, catalpa beans, and horsechestnuts are examples of seeds which are objectionable to some people.

The hybrid petunia is an excellent example of a dividend resulting from plant breeding and genetics. About one-half of the spring bedding plant volume consists of petunias, and practically all petunias are hybrids. The production of such hybrids is intricate, and the breeding programs are extensive.

Varieties grown from seed will be better because of the elimination of virus diseases. Geraniums typically are propagated from cuttings and generally carry some virus infection. "Disease-free" is a term now applied to several crops. Virus stunt of chrysanthemum, and fusarium wilt and bacterial wilt of carnations have been essentially eliminated.

The environment around us is an important component of our well-being. The beautiful yard, the interesting roadway, the pleasant park, the useful school grounds and the desirable community can be realized when our values demand them.

DROPPINGS, SALIVA SPREAD LEUKOSIS

Mareks' disease, an acute type of leukosis, can spread from infected to healthy chickens in droppings and saliva.

Dr. Richard L. Witter,Regional Poultry Research Laboratory, East Lansing, Mich., says that study findings imply that farmers should take special care to disinfect or sanitize feeders, waterers, house surfaces and equipment which can harbor droppings and saliva from a previous flock.

Like other forms of leukosis, Marek's disease is a cancer-like infection; it attacks the nervous system, viscera, eyes, muscles, and skin — causing more poultry losses than any other disease. It is not infectious to man or other animals.

In one of a series of trials, healthy birds were placed on litters exposed to droppings from infected birds. All exposed birds contracted the disease. On the other hand, birds kept under similar conditions but on sanitized litters stayed free from the disease. Tests with swabs of saliva transferred from infected to healthy birds showed that this route of infection also is possible.

The mysteries of nutrition

ETHELWYN B. WILCOX

Station researchers have found:

1. Cholesterol isn't necessarily the big villain in hardening of arteries.
2. Other fatty acids may be to blame.
3. Utah's growing population of senior citizens is one reason for investigating the relationship between diet and heart and circulatory diseases.

Human nutrition is one of today's biggest mysteries. Most people love mysteries, and scientists at the Utah Agricultural Experiment Station are no exception.

National interest was stirred when cholesterol was thought to be the villain in hardening of the arteries. Although a high level of cholesterol in the blood may be a factor in the onset of some circulatory diseases, recent research at the Station, as well as other places throughout the United States, has shown that cholesterol cannot now be considered the primary cause of atherosclerosis (hardening of the arteries).

Cholesterol is a normal constituent of almost all animal cells. It is found not only in foods but is manufactured within the body. Station research has shown that girls have significantly higher cholesterol levels than boys in preadolescent and adolescent years. Overweight girls have slightly elevated serum cholesterol levels but no other relationship to body build was observed in either girls or boys. No relations to age were observed. It was found, however, that brothers and sisters of subjects with high cholesterol levels also tended to have high serum cholesterol values.

With newer and more precise methods of lipid and fatty acid analysis, triglycerides seem to be as involved in coronary diseases as is cholesterol. Patterns of the serum fatty acids and the excretion of steroid hormones are under study to determine their relationships.

Polyunsaturated fats (vegetable oils) reduced serum cholesterol more than did saturated fats when each was fed as 35 percent of the total calories in controlled diet studies with Utah State University students. Increased caloric intakes did not significantly affect the serum cholesterol and lipid values of university athletes when compensated by exercise. Also, increasing the protein content of their diets from 10 to 16 percent of the total calories and including up to 2 quarts of whole milk per day did not affect serum cholesterol and lipid values.

If polyunsaturated fats are fed at high levels to reduce serum cholesterol, there is some question as to whether they normally carry sufficient vitamin E (alpha tocopherol). Vitamin E is the natural antioxidant which prevents rancidity of these fats in the human body. A 6-month study now underway involves subjects 35-60 years of age on self-selected diets with 50 percent of the total fat calories as polyunsaturates.

CURRENT RESEARCH

Utah's senior citizens (65 and older) totaled 59,957 in 1960. Demographers predict that this number will increase by about 40,000 in 1980. With a larger percentage of the population in the older age groups, more cases of atherosclerosis and coronary heart disease can be expected. Also, coronary diseases are occurring at an earlier age in men—35 to 50 years of age. Therefore, continued research in the field of lipid metabolism (use of fats by the human organisms) is needed.

The substitution of polyunsaturated fat in the form of corn oil for all the fat used in cooking and on the table did not reduce serum cholesterol values in men and women aged 60 to 95 years. Indications were that, to obtain a real reduction in cholesterol values through the use of polyunsaturated fats, eating habits would need to be drastically changed from the usual self-selected diet, and polyunsaturated fatty acids would have to make up at least 50 percent of the total fat calories.

We can well turn our attention, more than we are doing at present, to basic research on the physical and chemical principles involved in food preparation and preservation. Of particular interest, and opening up a whole new field of research, are the studies on time-temperature relationships during cooking.

Pilot studies have indicated that coagulation of proteins and gelatinization of starches are not instantaneous processes but require time. However, the finished product varies with time or temperature. Varying combinations produce different end products even though the end point internal temperature remains the same.

Current departmental research involves studying the tenderizing effect of roasting less tender cuts of meat, uncovered, at temperatures as low as 250°F. Indications are that the meat provides its own moisture to tenderize the connective tissues; the roasts are tender and moist, and may be cooked to any desired degree of doneness. The method seems most effective for roasts over 3 pounds in weight.

ETHELWYN B. WILCOX is Professor and Head of the Department of Food and Nutrition.

WHERE AND WHY DOES MRS. MURPHY BUY ?

ROICE H. ANDERSON

Women do have definite shopping habits. Grocery "specials" don't really change these habits.

Most shop only one grocery store.

Prices are the chief factor in store choice.

Selection and convenience rank next in the choice of store.

In spite of weekly grocery ads in the newspapers, most shoppers patronize a limited number of stores. This pattern is relatively rigid and seems to persist from week to week.

This conclusion is based on a store-door survey of about 600 shoppers in March 1966 at six stores in Logan, Utah. About equal numbers of shoppers were randomly contacted at each of the stores even though the stores varied in their sales volume. Contacts were made at each store on various days of the week, different times of day, and by various enumerators to eliminate bias in the sample.

SHOPPING PATTERN

Eighty-three percent of shoppers bought more than one-half of their food in one store (table 1). Even though they were contacted at one of six downtown stores, 12 percent of the shoppers purchased most of their groceries in a neighborhood store or shopped in some other Cache Valley city. Seventy percent of all shoppers used one of the six Logan stores as their major store and 16 percent shopped one of the six exclusively. Neighborhood stores were used as a supplementary source of food by 54 percent of all shoppers and they purchased 6 percent of their food from such stores.

STORE POPULARITY

The six stores varied greatly in popularity. An index of popularity was calculated by dividing the number of shoppers using each store as a major point of buying by the number contacted at that store and multiplying by 100. This index varied among the stores from 58 to 115 (table 2).

Shoppers patronizing each of the six stores, whether as a major or supplementary source of purchases varied from 35 to 65 percent. Sixty-five percent or nearly 400 of the 600 shoppers contacted did some shopping at store C whereas only about 200 of the 600 shoppers patronized store B.

PATRONAGE LOYALTY

Patronage loyalty, measured by percent of total purchases made at the major store, varied from 66 to 76. Purchases by the 600 shoppers at store C were double those at store E.

Shoppers were asked to give their reasons for selecting the major store of their choice. Some gave more than one reason but all were included in the analysis on an equal weight basis whether they were the first, second, or third reason given. The importance of various reasons varied considerably among the six stores and are found listed in table 3.

With all stores combined, the non-price factors of product selection and convenience were both more important than price as reasons for selecting the major store. If the sample had been drawn among stores on a basis of sales which would be more representative of the market as a whole, product selection and convenience would have been even more important.

Store E received 35 percent of the votes for lowest price by all shoppers offering an opinion while Stores D and A received 21 and 17 percent of the votes respectively. Stores

Table 1. Distribution of shoppers by shopping pattern (595 shoppers contacted at six Logan food stores, March 1966)

Shopping Pattern	Number of Shoppers		Percent of total	
Those shopping major food store		495		83
Exclusive downtown Logan store	93		16	
Major Logan store	324		54	
Major store at other location	78		13	
No major store		100		17
TOTAL		595		100

ROICE H. ANDERSON is Professor of Marketing in the Department of Agricultural Economics.

B, C, and F which were known for product selection and convenience each received only about 10 percent of the votes for low-priced store. A large percentage of shoppers listed the store of their choice as the store with the lowest prices.

When shoppers were asked which of the stores had the highest prices, store C received 83 percent of the votes with the remainder scattered among the other stores without significant concentration. Distribution of opinions of those shoppers using Store C as their major store were not greatly different than all shoppers. This indicated that they shopped Store C even though they thought its prices were highest in the area.

It should be pointed out that in the opinion of one-fourth of the shoppers there was no difference in overall prices among the six stores.

17% SHOPPED A VARIETY

Those shoppers who patronized a variety of food stores rather than a major grocery store were asked to indicate their reasons for doing so. As would be expected, a large number (71 percent), were motivated by price. Sixty-three percent stated they wanted to get advertised specials of the various stores. It is significant, however, that non-price factors of convenience, acquaintance and product selection were of some importance in motivating some shoppers to shop a variety of stores.

It should be of concern to all who are interested in the production, processing, and marketing of food that 85 to 90 percent of food shoppers feel that the place to buy holds precedence over what to buy. The importance of non-price as well as price considerations used by shoppers in deciding where to buy also has important implications.

Table 2. Some ratios of shopping patterns of food shoppers in Logan, Utah, March 1966

Store	Popularity index*	Percent patronizing each store	Patronage loyalty**	Percent of Purchases by all shoppers
A	58	50	75	13
B	76	35	76	13
C	115	65	72	22
D	60	52	66	12
E	66	37	73	11
F	65	44	72	12
Average all stores	74	47	72	14

* Shoppers using each store as a major in percent of number contacted at the same store.
** Purchases at major store in percent of total purchases.

Table 3. Relative importance of reasons given by shoppers for selecting a major shopping store grouped by major store

Reasons for selecting major store	Distribution of reasons given for shopping at: A Store	B Store	C Store	D Store	E Store	F Store	All Stores
Product selection	19	17	45	15	5	14	24
Convenience	24	19	23	17	16	35	23
Price	27	9	10	33	48	13	20
Acquaintance	10	30	2	17	18	20	14
Service	9	12	7	12	8	8	9
Atmosphere	10	10	12	5	4	8	9
Habit	1	3	1	1	1	2	1
TOTAL	100	100	100	100	100	100	100

NEW YEARBOOK OF AGRICULTURE NOW PRINTED

The giant job of protecting our food against pests, disease, and damege is described in the recently issued 1966 Yearbook of Agriculture, "Protecting Our Food," published by the U.S. Department of Agriculture.

The authors point out that we have to fight 10,000 kinds of insects for our food. We have to combat 1,500 plant diseases and 250 animal diseases. In addition, we must fight spoilage and decay.

The results of this battle to protect our food are evident. In our own country, food quality is high, the abundance great, and the cost relatively low. Overseas, we have supplied 98 percent of food aid received by the less developed nations.

In 416 pages and 105 photographs the Yearbook follows our food supply from the farmer's field to the saucepan on the stove. It describes every stage of safeguarding food from insects, rodents. bacterial contamination, and loss of body-building values.

Men and women in 500 different occupations help protect our food. They include chemists, entomologists, bacteriologists, horticulturists, meat and poultry inspectors, quality control specialists, refrigeration engineers, nutritionists, and food technologists. The housewife, too, plays a key role in proper selection and preparation of food for her family.

Senators and Congressmen each have a limited number of copies of the Yearbook for free distribution to constituents. Copies of "Protecting Our Food," the 1966 Yearbook of Agriculture, may also be obtained for $2.50 each from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

PLANT SCIENCE AND

Agricultural Experiment Station

FRANK B. SALISBURY

The staid old science of botany, once characterized by ladies' clubs counting stamens on a summer afternoon, is on the verge of a revolution hardly precedented in all of its history. In the coming exploration of space, man will not only take plants with him in a sort of super technical agriculture, but he will look for plant-like forms on the surface of Mars. He will also devote a considerable share of his resources to a study of plant (and animal) behavior under the highly exotic and new environments of his space ship and his more or less permanent stations on the moon and on Mars.

There is room for much basic biology here. How can the enzyme systems of living cells tolerate freezing temperatures, high salt concentrations, or high water stress? These are valid questions of exobiology. At the same time, answers to these questions could obviously be of considerable importance to Utah agriculture. Late frosts have been a severe problem in recent years. Much of our land is salty. And drought is always a problem in the arid West. Our researches in exobiology are interesting and even lots of fun, but it is appropriate that they are being carried out in the College of Agriculture and under the auspices of the Agricultural Experiment Station. With a proper amount of good luck, they could easily contribute to better agriculture in the state of Utah.

●

FRANK B. SALISBURY is a Professor of Plant Physiology and Head of the Department of Plant Science.

PROGRAM HAS BEGUN

The program has already begun. Hopefully, about the time this article appears in print the first of a series of three biosatellites will have been launched. This first one will orbit the earth 3 days, the second will stay in orbit 30 days, and the third satellite will remain in space twenty-one days. All are to be recovered. They will contain about 20 fully automated biological experiments. Most are very simple approaches to some classical old biological problems. In spite of the simplicity of the experiments (and many of them are the kind of experiments performed in beginning laboratories at our universities and even high schools), the problem of constructing them so that they will perform automatically and with a high degree of reliability proved to be an extremely difficult one. The entire program cost in the neighborhood of $100,000,000 or about $5,000,000 for each experiment! The Russians are way ahead of us with their program — in the expenditure of funds, that is! Nearly a quarter of a billion dollars has been expended, and yet nearly all of their experiments have been failures! This usually resulted from the difficulties of interpretation which arise in such a complex program, even though the experiments are very simple. Some interesting differences in cell division observed in a *Tradiscantia* plant, for example, might have been caused by the condition of weightlessness or by the vibrations and accelerations present during launch and recovery. We hope to avoid these mistakes in our program. In any case, space biology and even space botany is well under way.

WHERE FROM HERE?

At the moment, the only projects of this type which have been definitely accepted by the United States are the 20 experiments designed for the biosatellite program. Where do we go from here? To answer this question, groups of biologists have been meeting for about 1 year under the financial sponsorship of the National Aeronautics and Space Administration (NASA). The space agency commissioned the American Institute of Biological Sciences (AIBS) to assemble the various groups, coordinate their efforts, prepare the final report, and otherwise administer the program.

In addition to these groups, consisting essentially of "grass roots" biologists, the National Academy of

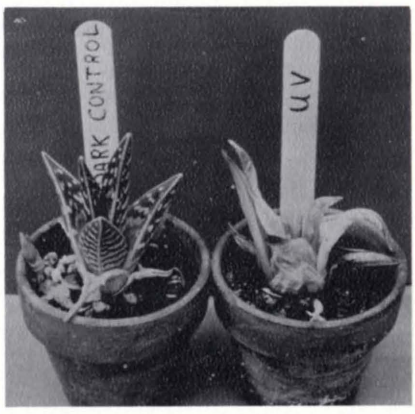


Figure 1. The aloe varrgato on the right was exposed to germicidal ultra-violet rays which simulated the solar conditions thought to exist on Mars.

SPACE EXPLORATION

tools up for the Space age

Sciences has several committees assigned to investigate the problems, and NASA itself has conducted considerable so-called inhouse research on what our future efforts might be. This article does not deal with decisions, since so far, none have been made. This is simply a summary of some of my impressions gained from meeting with one of the AIBS committees, from acting further as a consultant to NASA, and from conducting certain research projects in space biology.

EXTRATERRESTRIAL LIFE

When the decisions are finally made, they are bound to have a significant impact on all of science, including plant science (for once, botanical scientists were well represented). The long-range goals of the NASA life-science program will probably develop along the following lines: The National Academy of Sciences has suggested that the most important objective of the United States space program should be the search for, and, hopefully, the discovery of extraterrestrial life. Mars appears to be the best prospect, and NASA hopes to have a man on the surface of Mars some time during the 1980's. The second goal might concern the study of the response of living organisms to the peculiar characteristics of the space environment, particularly weightlessness. A third goal will have to be the practical one of achieving the technology necessary for the fulfillment of the first two goals.

Consider the impact upon our entire society of the discovery of life on Mars! The simplest forms of Martian life would cause a revision in our current concepts of biology. A well-adapted flourishing life would result in a severe revision of these concepts, and the presence of intelligence on Mars would touch deeply even our social and religious beliefs.

But what if there is no life on Mars? Even if this proves to be the case, all will not have been lost. With a program as ambitious as the one which is envisioned, there is bound to be an extensive and important scientific "fallout." A tremendous amount of background study in earthbased laboratories will be required to support the space program. This will consist of many highly sophisticated and well-funded projects directed by capable scientists. It is bound to result in findings of the utmost importance.

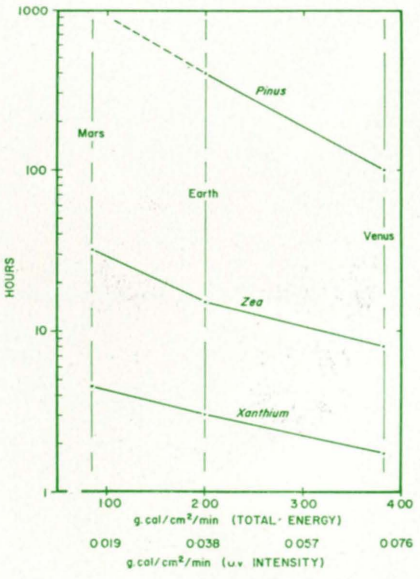


Figure 2. Leaf survival time under different intensities of simulated extraterrestrial solar radiation.

Let us consider some developing areas of scientific interest, each of which is of great potential value in its own right.

THE SPACE LAB

The councils called together by AIBS were assigned the responsibility of discussing the feasibility and the desirability of a space-station laboratory devoted to biological research. Interestingly enough, the councils consisted primarily of hard-headed scientists who were, for the most part, not directly concerned with the space program and who were basically quite skeptical. In spite of this initial "show me" attitude, they became enthusiastic supporters of the program by the time their 1-year study was complete. Many possibilities were considered. One NASA document itemized something like 125 separate experiments which could be conducted in a space station laboratory, and such a laboratory would be an essential preparation for a trip to Mars. We will summarize only a few of the possibilities here.

RESPONSE TO GRAVITY

The greatest interest of all of the council members centered around research on the response of living organisms to gravity. At the earth's surface we can *increase* gravitational force by increasing its equivalent, accelerational force, in a centrifuge, but there is no way that we can *reduce* the pull of gravity on an object on the earth's surface. A satellite

orbiting a planet is in a condition of free fall. That is, it tends to move away from the planet at the same rate that it tends to fall towards the planet. In such a condition, although it is still subject to the gravitational fields caused by the other objects in the universe, it is, nevertheless, weightless.

This potential of weightlessness seems to provide the biologist with a new tool to solve some old problems. It is quite evident that all living things on the surface of the earth are strongly influenced in one way or another by gravity. The orientation of plant growth is determined by gravitational force: the

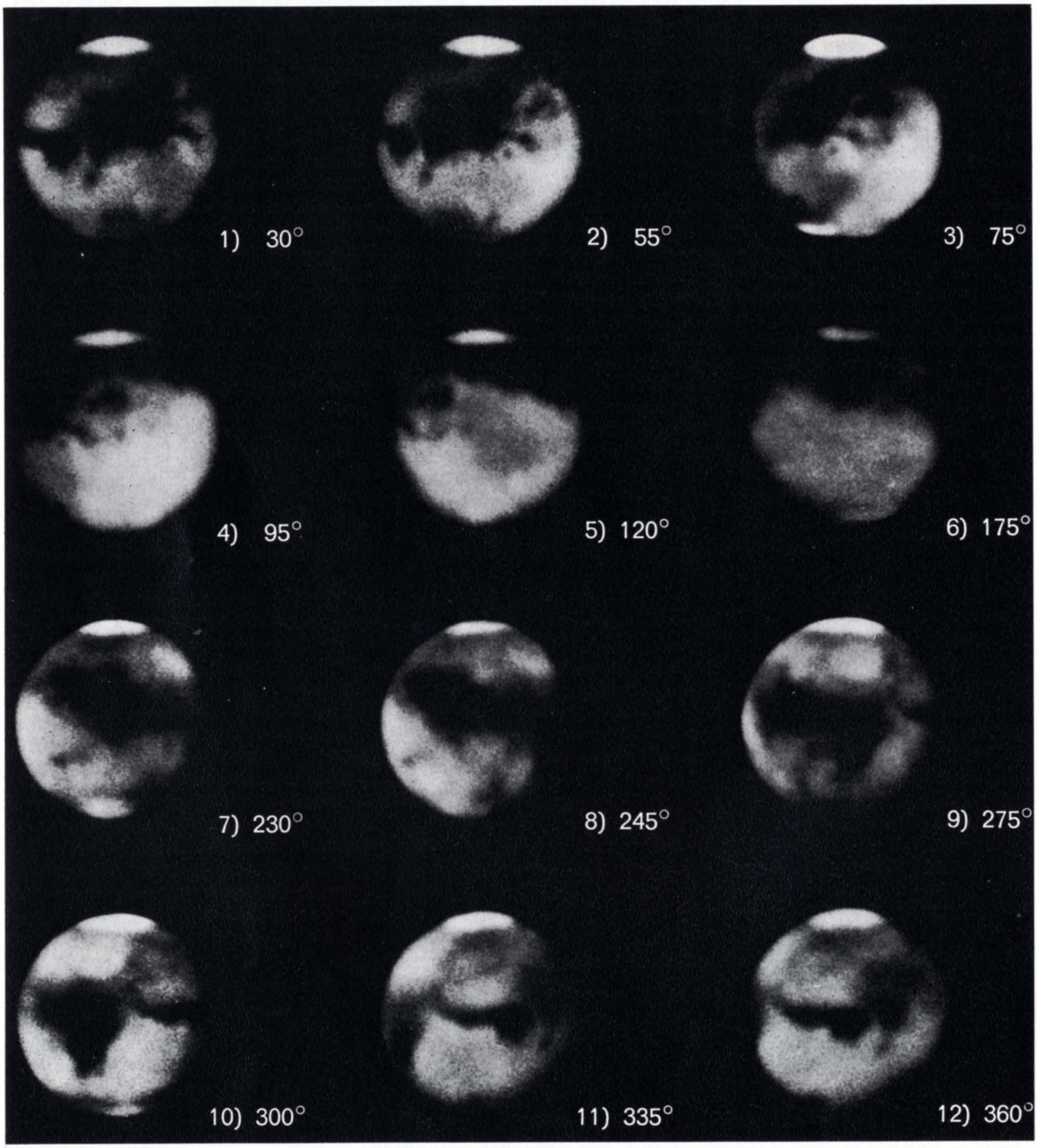


Figure 3. These pictures of Mars were taken in 1939 by E. C. Slipher at the Lowell Observatory in Arizona. They show the different aspects of the planet as it turned on its axis. There is belief that the dark areas represent vegetation because they show seasonal color changes.

roots grow downward and the shoots upward. The bone structure of an animal constitutes a physical means of resisting gravitational force. Animals always move in relation to gravity. The biologist wonders about the mechanisms which are involved in all of these responses.

MECHANISMS KNOWN

In some cases the mechanisms are already fairly well known. A man senses that he is upright because of the fluid in the tubes of his inner ears and the forces exerted upon his muscles and internal organs. But how does a plant respond? It is an old question, and, interestingly enough, we still completely lack a solution. We did learn, in the early 1930's, that a stem turns away from the center of the earth because a growth promoter becomes more concentrated on the bottom side. But why should it? It consists of molecules in solution, and in such a condition the molecular motions are more powerful than the relatively weak gravitational forces (the atomic sized particles of salt dissolved in a glass of water never settle to the bottom but remain evenly distributed throughout the liquid). There has to be something in the plant large enough to respond to gravity and yet capable of causing the redistribution of the growth hormone. So far we have completely failed to find it. All of the councils suggested that this would be a project of primary importance in an orbiting laboratory.

GROWTH AND BEHAVIOR

They were also impressed with the idea that growth in general should be studied in such a laboratory. What initiates the polarity of a developing organism, for example? As a typical fertilized egg begins to divide and grow, one end of the developing organism, be it plant or animal, is soon distinguishable from the other. Does gravity influence this? Some people think so, and if this should be the case, then we might expect a newly fertilized egg in our space laboratory to grow only into a mass of disorganized cells rather than into an organized plant or animal.

We do not expect to discover marked effects on processes such as cell division, since our astronauts and the Russian dogs have now survived for fairly long periods in the weightless condition without any ill effects. The production of red corpuscles in the blood is a cell division process, and if it were strongly influenced by weightlessness, something should have become apparent in the astronauts and other creatures. It is possible, however, that the fundamental processes of growth will be influenced by weightlessness. These have not yet been studied, and most of the councils agreed that they should occupy a high place on the priority list.

There are also several aspects of animal behavior which might well be influenced, at least in secondary ways, by weightlessness. Studies of this sort have, of course, been initiated with the astronauts as subjects. They could be expanded by utilizing all kinds of animals in a manned orbiting laboratory.

OTHER SPACE FEATURES

There are features of the space environment other than weightlessness which could be of importance in a space biology program. Radiation conditions in space are unique compared to the earth's surface, and several workers propose to study them. These are not high on the priority list, however, since for the most part, they could be duplicated in earth-based laboratories or at least in laboratories raised to great heighths by balloons. The high vacuum of space and the high intensities of light might also be used, but again these could be fairly well duplicated in earth-based laboratories. The one aspect of these other factors which stands high on the priority list concerns the interaction of these environmental parameters with weightlessness. Here we have reason to believe that results might be forthcoming, and such experiments will surely be conducted in the space laboratory.

BIOLOGICAL CLOCKS

An orbiting satellite is not subject to the 24-hour periodicity in environmental factors which is present at the earth's surface. A periodicity may be present in an earth satellite below the Van Allen belts, but it will not be equal to 24 hours. In recent years considerable study has been devoted to the phenomenon of the biological clock. It is clear that many different kinds of living organisms are capable of measuring time. Sometimes this is manifest by rhythmical cycles of activity or leaf movement, and sometimes it is manifest in the phenomenon of photoperiodism in which, for example, a plant may produce flowers only when it is exposed to nights which exceed some minimum length such as 8.5 hours.

In any case, how does the organism measure time? Does it have an internal clock analogous to the clocks which men build? Or does it respond to some subtle fluctuation in the external environment? Most biologists believe that the clock is internal, since time is measured even when the organism is removed from environmental fluctuations such as changes in temperature, light intensity, and humidity. A few, however (notably Professor Frank Brown at Northwestern University in Chicago), believe that a plant or animal is measuring time by responding to some very subtle 24-hour fluctuation in the environment which the scientist is unable to control — perhaps a change in cosmic ray flux or magnetic field strength.

The satellite provides an obvious place to test this idea, and such a test will be performed in a biosatellite long before the manned laboratory has been launched. Even if time measurement is not a matter of the organism's response to some subtle environmental factor, the biological clock will influence other satellite experiments, and there might even be an interaction between the biological clock and gravity.

Certain preliminary experiments seem to indicate that this could be the case. Although it is impossible to reduce the force of gravity at the earth's surface, it appears possible to compensate for it in plants which respond slowly by laying the plant on its side and rotating it along its long axis so that the force of gravity is applied over an interval of time equally from all sides. The apparatus which does this is called a clinostat, and it has been used for a century by a few experimenters in an effort to study reduced gravity effects on the earth's surface. We will only know if the approach is a logical one after the proper satellite experiments have been performed. Anyway, the biological clock of a plant on a clinostat did seem to be upset.

REMOTE OBSERVATIONS

One other potentially very important use for the orbiting laboratory has been suggested. It might be utilized as a platform for remote observations of the earth. Using high quality telescopes and cameras, it is possible to observe fairly small objects (only a few inches in size) on the earth's surface. Of course, it is also possible using a different lens system to observe a large portion of the earth's surface at once. These possibilities have suggested many approaches which the biologist might apply. He could begin to study plant geography in a more meaningful way. The orbiting satellite would take him over all of the earth's surface at least once a day. He could follow, for example, the migration of schools of whales or even small herds of elk or deer (this would not be so simple, but it would be possible). He could study the agricultural production of the world, and he could look for infestations of plant disease (photographic techniques for this have already been developed). He could study problems of pollution. There are many difficulties which may not be apparent in such a brief discussion, but the potential for good of the "big eye in the sky" is not to be minimized.

To me, one of the most exciting prospects is not looking in at the earth but out at Mars. It is the markings on Mars and their seasonal color changes which make the prospects of extraterrestrial life in our solar system so exciting. The orbiting laboratory, at least a decade in advance of direct Mars exploration, would provide an opportunity finally to observe these markings without the interference of the earth's atmosphere.

SPACE LIFE SUPPORT

An impression given early in the game of space exploration was that biology would play its biggest role by purifying the air for the astronaut and possibly by providing him with food. This was the concept of the "closed system ecology." The energy source was light, either sunlight or artificial light, produced perhaps by a rocket ship's atomic engines. Green plants, in the familiar process of photosynthesis, would remove the carbon dioxide produced by the astronaut and combine it with water (perhaps also produced by the astronaut) to produce free oxygen and food materials. It was thought that systems could be developed in which all of the waste produced by the astronaut could be purified and recycled by a combination of bacteria, perhaps lower animals, and photosynthesizing plants. Most workers thought that single-celled green algae would play the role of the photosynthesizers, but NASA has supported research into the use of higher plants in such a system. It was found that higher plants would not be practical in a space ship, but they might far outperform the algae in a moon station. After all, anyone would sooner eat tomatoes or even sugar beets than green algae!

In recent years the biological-life-support systems have appeared to be somewhat less interesting. Closed systems are delicately balanced and readily subject to disturbance. Furthermore, for the missions foreseen within the next decade or so, it will not be difficult to carry food and oxygen supplies and to dispose of the wastes chemically or even by jettisoning them from the space craft. A bacterial system has been developed which utilizes hydrogen, giving rise to the possibility that oxygen might be obtained by the electrolysis of water (which produces hydrogen and oxygen), allowing the bacteria to utilize the hydrogen and carbon dioxide in the production of foodstuffs. Such a system is far more efficient than one using green algae.

Eventually, the closed system approach will be recognized again as being highly important. A trip to Mars and back, with our foreseeable rocket technology, will require 2 or 3 years, and a moon station may become a reality within our lifetimes. In such situations, the super-concentrated agriculture of the closed system ecology will have to be utilized. The idea will be to obtain the highest possible yields of food materials and oxygen for a given input of energy. This will take much of the talents and knowledge of our present agricultural scientists, and, again, the findings of the concentrated effort which must be applied in this field could be of considerable importance to more mundane problems such as terrestrial agriculture.

EXOBIOLOGY

It has been estimated, in a very careful and reputable study, that there are 635,000,000 planets in our galaxie with environments suitable for the support of man. There must be countless millions more which, like Mars, are so different from our planet that we could not survive there without special protection but which might, nevertheless, support some other form of life. These figures must then be multiplied by many more millions to account for the countless galaxies besides our own. In the universal sense, then, life could be an extremely prevalent and common occurrence. Such a thought is in itself sufficient grounds for a science of life in its broadest conceivable sense. Even if we can't visit any of these

billions upon billions of planets, we can imagine in an academic way what might be there and thus formulate the science of *exobiology*. It is a science of life in environment. It asks the questions: What limits life? How far can life adapt? What can we ultimately expect to encounter?

To me, the broad science of exobiology is so exciting that it keeps me awake nights thinking about it. Yet, if we can never visit the planets where it exists, it could hardly seem to be of any real importance to us. There is Mars, however. The billions and billions of distant planets in the universe will probably remain inaccessible to us, but Mars is now almost within our grasp. And as indicated above, there are signs of life even on Mars where the atmosphere is a hundred times as thin as our own, where night temperatures drop to tens of degrees below zero every night, where oxygen is absent and water is present only in the most minute amounts. Yet the signs of life are clearly there, and so our science of exobiology could become more than theoretical even in our own lifetimes. What will we find when we get there? What sort of organisms could possibly live in such an environment?

TWO THINGS TO DO

There are two things that we can do to try to answer these questions. First, our technologists can devise ways to get there and experiments which might be performed upon arriving. The Voyager, hopefully to be launched in the early 1970's, will land on the surface of Mars and radio back information relative to the environmental conditions there. The Automated Biological Laboratory (ABL) should land there shortly thereafter, performing a battery of carefully constructed automated experiments designed to detect and evaluate the presence of life there. Within the following decade, man himself should arrive to make first-hand observations.

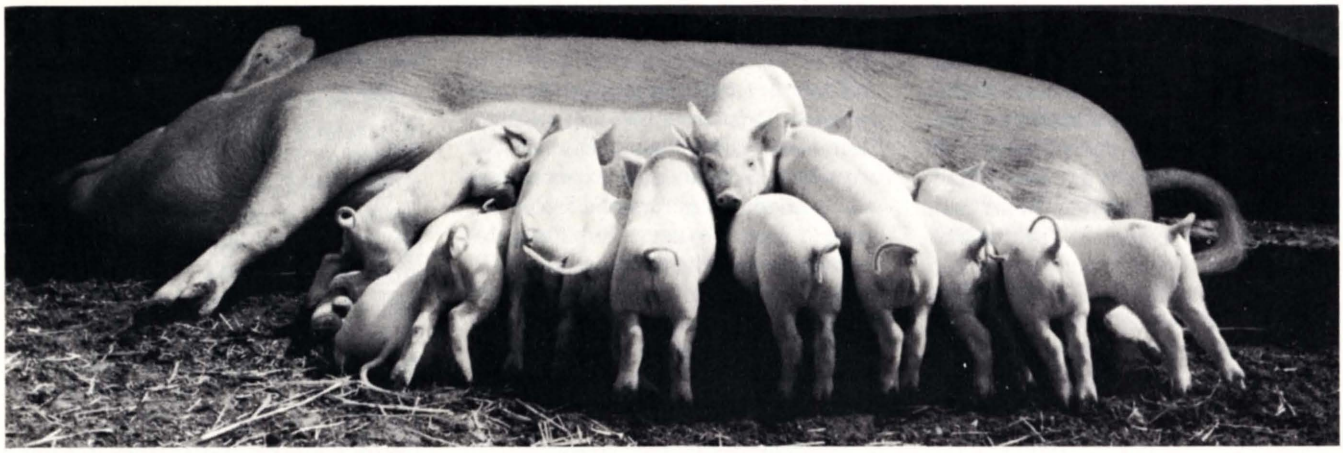
Second, we can study intensively the properties of life on earth, particularly those properties which may allow life as we know it to exist under extreme conditions, even conditions which might approach those on the surface of Mars. NASA is supporting several projects of this type. We have one at Utah State University, entitled "The Response of Higher Plants to Ultraviolet Light and Other Stress Factors." It is based upon work which I have been doing for the past 5 or 6 years before coming to Utah last June.

We have found in the past 2 years of research that while most plants are killed by an exposure to a mere 3 or 4 hours of ultraviolet light, equivalent to that falling on the surface of Mars (the Martian atmosphere fails to filter it out), a few species can tolerate exposures of literally hundreds of hours. So far as the ultraviolet light goes, these species could survive on the Martian surface. Dr. Sanford Siegel of the Union Carbide and Carbon Chemical Company has even found species (e.g., winter rye) which could tolerate the low oxygen levels on Mars, providing that these are combined with freezing night temperatures! In his experiments, plants in a simulated Martian atmosphere (low pressure, no oxygen) survived nightly temperatures of —20°C and day temperatures of +20°C. If oxygen was present, the plants would freeze to death at night, and if the plants were not frozen every night, they would be damaged by the absence of oxygen! Studies such as these open up numerous possibilities for our speculations in exobiology.

We hope in our study to investigate certain other problems besides those relating to ultraviolet light. For one thing, we expect to study the plants of our mountains which grow under the edge of a melting snowbank. We expect to look further into the resistance of plants to conditions of extreme drought or very high salt concentrations.

CONTRIBUTIONS TO RESEARCH

United States Steel Corporation	**$2,700 for air pollution studies**
Utah Travel Council	**$4,428 for a study of consumer decisions effecting vacation patterns**
Canada Dept. of Agriculture	**$3,244 for compilation of data on livestock feed composition**
G. D. Searle & Company	**$3,500 for study of role of estrogen in corpus luteum function** **$2,712 in drugs furnished to aid study of brisket disease**
Ogden Grain Exchange	**$1,200 for research in wheat breeding**
Utah Canners Association	**$833 for tomato varietal studies**
Smith-Kliene and French	**$200 for studying the effect of temperature stress factors on beef cattle**
American Cyanamid Company	**$1,000 for turkey disease studies**
Upjohn Company	**$3,700 for studying role of estrogen in corpus luteum function**
Esso Company	**$2,500 for canal lining studies**
U.S Dept. of Agriculture — Agricultural Research Service	**$69,000 for Cytological, histological and anatomical effects of herbicides**



MEAT

for an expanding population

JAMES A. BENNETT

Feature nearly 10,000 new hungry mouths at the breakfast table each morning. That is what the population expansion means to the United States. The necessity for increased production efficiency has never been greater. Therefore, an increasing level of animal products must be made available to provide nutritionally adequate diets for these people. Research has repeatedly proved the importance of animal foods as rich sources of nutrients essential for good health. American consumers spend nearly 33 percent of their food budget for meat, poultry, and fish; 14 percent for milk, cheese, and ice cream; and 4 percent for eggs. To continue to supply animal products at the same relative volume and at the same bargain prices will require increased efficiency.

EFFICIENT PRODUCTION

American livestock and poultry producers have made an outstanding record for efficient volume production. United States farmers, who represent less than 1 percent of the world's population, produce 26.6 percent of the meat, 29.6 percent of the eggs and 41.7 percent of the fluid milk for the world. Because of this efficient production, the average American wage earner must now work only 19 minutes to buy 1 pound of beef, the most preferred meat, while in 1929 he had to work 29 minutes, nearly double the time. This is strong evidence that meat is a bargain and that American meat is produced efficiently.

Increasing pressures for other uses of land now used in livestock production, higher comparative prices for the supplies used in production, and higher wages for farm workers will put extreme stress upon livestock and poultry producers in the immediate future. The ingenuity of enterprising producers along with the application of research findings have brought about the present high level of efficient meat production. These same two factors hold the keys to meet the demands of an expanding population.

More efficient production can come about largely through the following ways: (1) higher reproduction levels, (2) more efficient rations, (3) more optimal environment, (4) more efficient animals, and (5) less wastage in marketing

Agriculture's problem:

10,000 new mouths to feed each day in U.S.

Agriculture's answers:

1. Three lamb crops in 2 years.
2. More efficient rations.
3. Selective breeding of animals for more rapid gains.
4. Environment control for animals.
5. Less waste in marketing and processing.

JAMES A. BENNETT is Professor of Beef Cattle and Sheep Genetics and Head of the Department of Animal Science.

Figure 1. Most people like thick red steak and as the world population grows the demand for beef cattle will increase. Performance testing bulls or rapid gains in their off-spring, breeding for less fatty carcasses, cross-breeding for faster gains and greater resistance to disease and new types of ration and forages are just some of the methods now being used to get more pounds on the hoof and thus more pounds for the table.

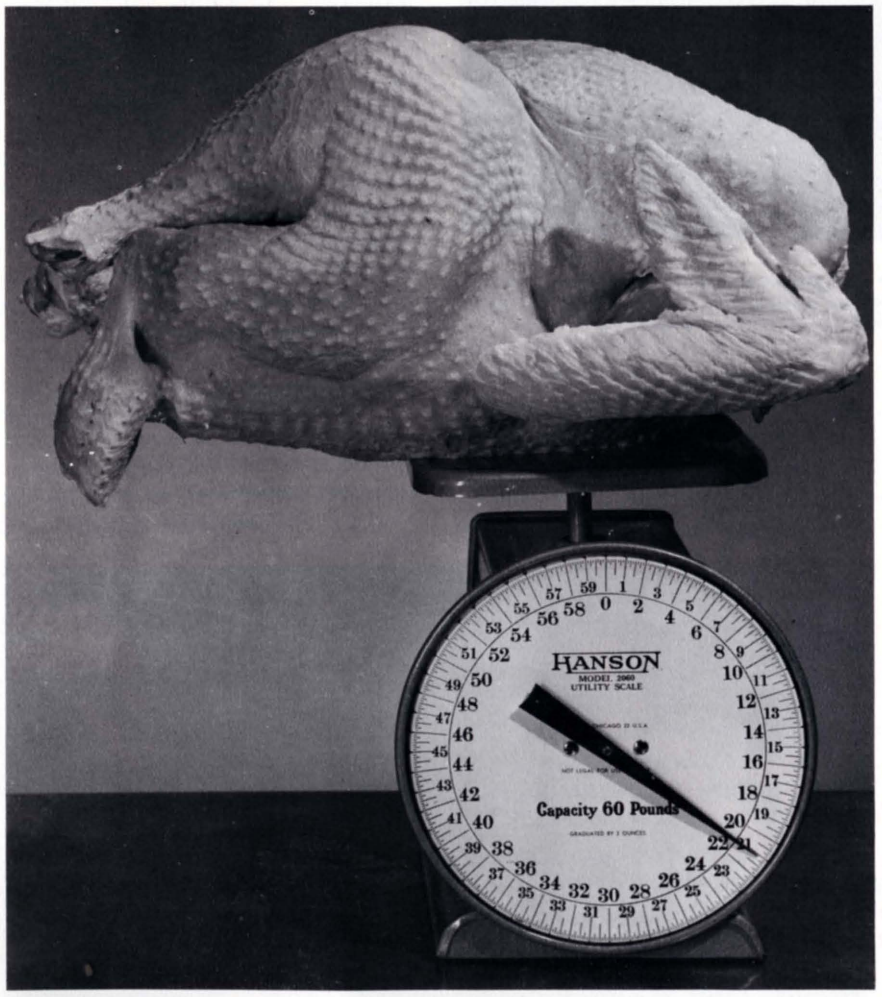


Figure 2. Turkey used to be seen only at Thanksgiving. They are now available year round and more and more American families are enjoying this flavorsome meat many times throughout the year. Research has developed more complete feeding rations, faster gaining birds with smaller and more tender carcasses. Poultry broilers, fryers and turkey are one of the meat bargains available year round.

and processing. The Utah Agricultural Experiment Station has research underway in all these areas.

INCREASED PRODUCTION

It seems evident, for example, that higher levels of reproduction in sheep must be obtained if sheep are to remain competitive. In Utah, domestic sheep are seasonal breeders and drop only one crop of lambs in the springtime. Where good feed is available, ewes are fully capable of rearing three or more lamb crops in a 2-year period if they can be made to conceive outside of the natural breeding season. Recent research at the Station has supplied more information on the relationship of environment and hormones in the regulation of reproduction. The prospects for successfully regulating sheep reproduction with resultant out-of-season lamb production are excellent. Further research is needed but success appears within reach.

EFFICIENT RATIONS

More efficient rations can be formulated only through intensive basic research. Protein is very important in animal diets and the quality of protein is especially critical for poultry and swine. Present basic

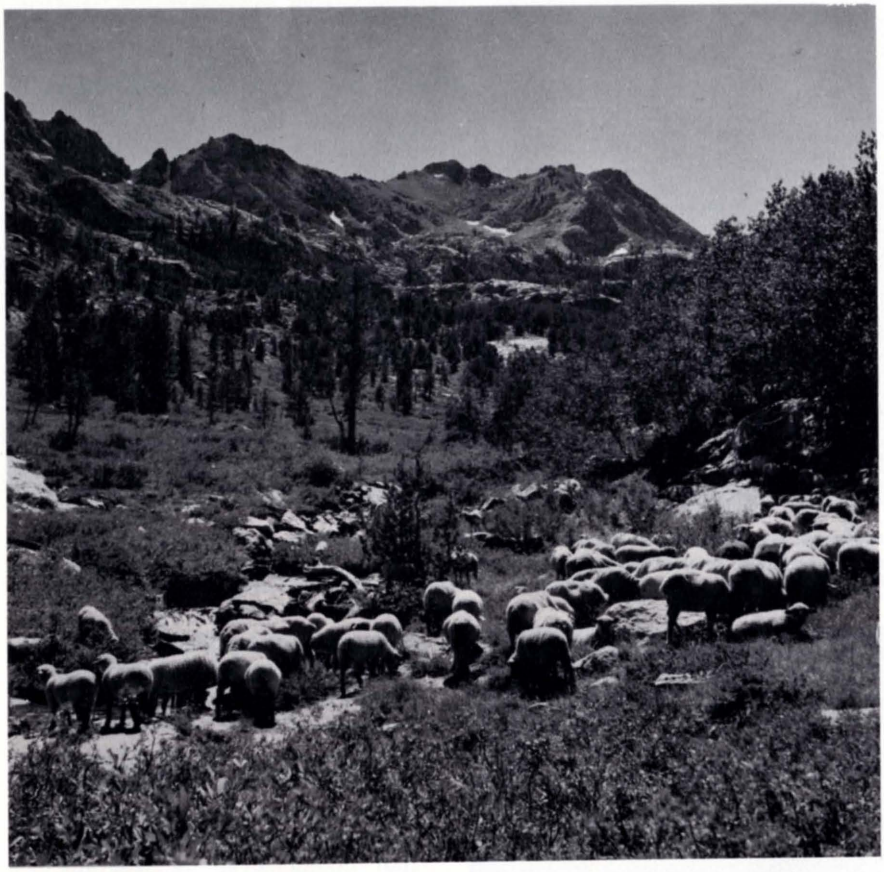


Figure 3. Sheep, once grown mainly for wool are now gaining in popularity as meat producers. Lamb roasts and chops, thanks to active advertising, are gracing more and more American tables. Sheep reproduction levels must be increased if they are to remain competitive, however.

studies indicate that greater gains can be obtained through more precise balancing of the amino acids (the "building blocks" that make up protein) for young chicks and turkeys. Large scale trials involving thousands of turkeys under field conditions test the favorable leads found in the basic studies. Application of the results of these studies is part of the reason Utah, with a production of 4 million turkeys, ranks eleventh in the nation. Less costly rations and amino acid supplementation in swine feeding are under test to give information that could lead to more economical pork production.

More than 250,000 chemical determinations, to learn more of the composition and nutritive value of range forage, have been made in the Animal Industry Laboratories at Utah Agricultural Experiment Station. These determinations and digestibility trials form the basis for recommending proper supplementation of cattle and sheep grazing Utah ranges. Proper supplementation based on the results of research has increased wool production 1 pound per ewe, increased the lamb and calf crop 15 to 20 percent and increased weaning weight of calves 50 pounds. Further information on nutritive value of forages, animal diet, composition of and on ration digestibility can provide the basis for even further gains.

ENVIRONMENT

Animal performance is related to environment. Much of the progress in increased production has resulted from man's manipulation of the environment. It is not economically feasible to completely control environment in most cases and animals must, therefore, endure stress-producing environmental variations. Studies now in progress are measuring the influence of stress upon performance. In poultry, the relationship of high atmospheric temperature to blood components and physiological function including reproduction is measured in detail. Daytime temperatures of 100°F. have resulted in general depression of performance and lowering of egg quality. The extent of stress in cattle and sheep exposed to low temperature and given drinking water of varying temperatures is under study.

Insecticides and herbicides are widely used in animal and plant production and in many instances can be considered as part of the

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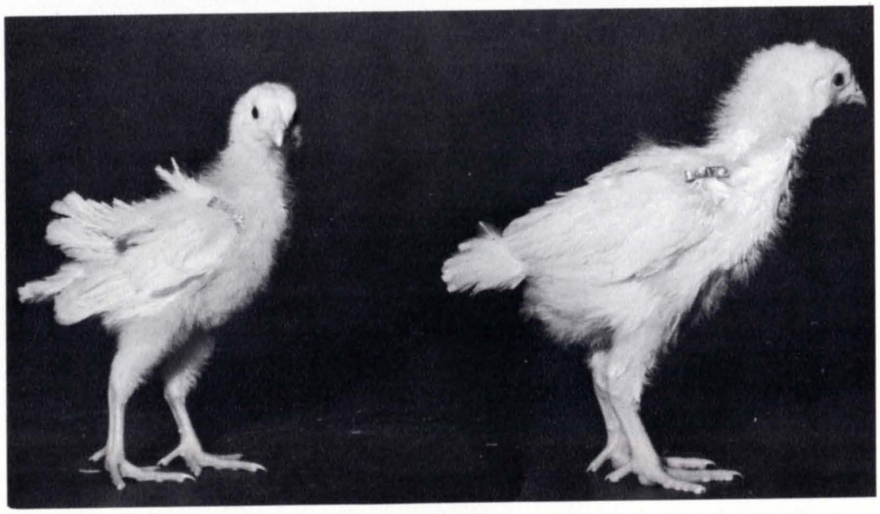

Figure 4. Poultry-rations research has shown that balanced levels of amino acids produce faster growth and better feathering.

Utah's Range Resources and Their Management

L. A. STODDART

Utah ranks eleventh in the Union in land area. 93 percent is in natural vegetation. Of this area, some is too steep, too dry, or too sparsely vegetated to support livestock. Some is national park, city watershed, etc. from which livestock are excluded. Thus, only 78 percent of the state is grazed by livestock. However, another 12 percent is grazed by big game animals so that, in total, 90 percent of Utah can be called range or grazing land — almost 75 thousand square miles!

A third of the livestock range is desert range which is grazed December through March. A fourth is mountain range grazed June through September and another fourth is foothill range grazed primarily in spring. A sixth is grazed variously, but mostly yearlong by cattle and in winter by sheep.

Only about half the forage consumed in Utah comes from range — the rest is produced on the 3.3 percent of the land that is cultivated. Beef cattle obtain half their feed from ranges while sheep get 90 percent.

The quantity of feed eaten by one cow in one month is called an Animal Unit Month (AUM). In Utah one AUM is produced on each 7½ acres of livestock range. Beef cattle and sheep eat 5 million AUM from the range, big game eat 1.1 million AUM, and dairy cows and horses eat .5 million — a total harvest of 6.6 million AUM. If an AUM is worth $2.00, then this is an annual value of $13 million and the value of the range resource which gives this annual yield is $250 million for grazing alone. Its other uses for watershed, recreation, timber, etc. greatly increase this value.

Considering the great area involved, it is not surprising that Utah's range lands are marked by great diversity. Often plant growth is restricted by low temperature, hot winds, soil salt, shifting sand, excess rodents and insects, and, more than any other factor, drought. In addition, before modern management techniques were developed and introduced, range production was greatly reduced by improper livestock uses. Because of the size and value of our range lands and because of their precarious forage balance, it is important that we learn by research more about how to get the most from this land. An entirely realistic objective of range research would be a doubling of present production — another 13 million dollars a year! The impact of this increase upon game and livestock production is obvious and all Utahns would be benefitted.

INCREASING PRODUCTION

Research by the Department of Range Science shows reseeded range to have an average forage production four times that of unseeded range. Spraying undesirable weeds and brush increases grazing capacity of some ranges as much as 1 AUM per year on each acre at a cost of about 2 dollars. Similar increases have been obtained by fertilizing certain kinds of range. Increased capacity alone doesn't tell this whole story. The stock gain faster, the sheep produce more wool and the lamb and calf crop increases. For example, calves gained .6 pounds more per day and each ewe produced 20 pounds more lamb per year on seeded range compared to sagebrush range.

Unfortunately, less than 20 percent of our range can be given these intensive treatments economically. But this by no means discourages range scientists. Actually, better management of less productive range land offers great potential forage increase. For example, physiological studies have shown that desert ranges will give twice as much forage under a management system range land offers great potential which avoids repeated heavy grazing in spring and summer. On mountain ranges, correct cattle herding, judicious water development,

Utah has 75,000 square miles of grazing land.
Its grazing value is $13 million annually.
Research has shown that this figure can be doubled by:

1. Reseeding ranges.
2. Limiting grazing of certain ranges to certain seasons.
3. Correct methods of herding, salting, and developing water.
4. Watershed studies.

L. A. STODDART is a Professor and Head of the Department of Range Scienece.

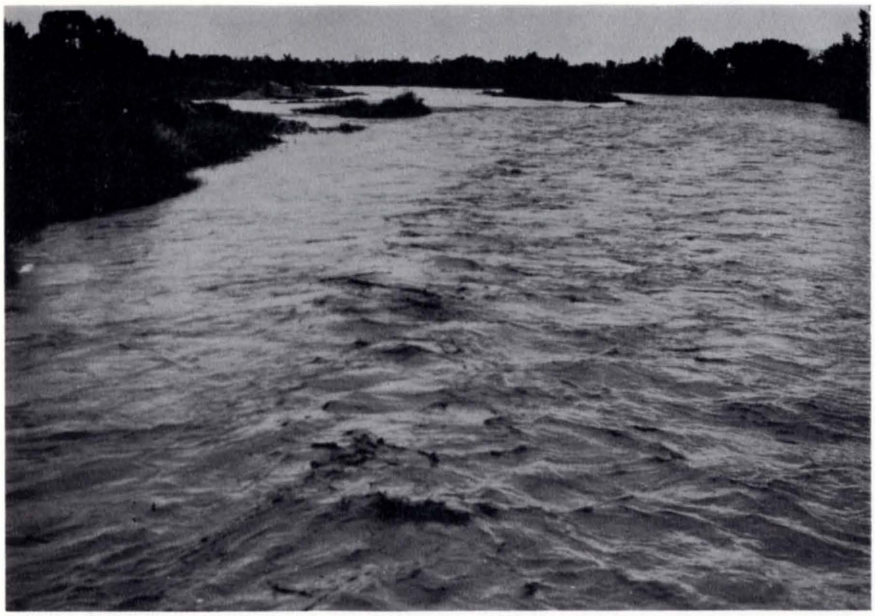

Figure 1. Increased production from Utah's rangeland can result from improved range management practices. If a watershed is properly managed, flood water such as this running down the Duchesne River might instead enter in the soil and produce forage.

Figure 2. Cloud bursts which fall on sagebrush and juniper ranges may cause floods. The rapidly falling water hits the earth, seals the surface, and therefore, runs off.

Figure 3. Current research seeks to find whether seeding grasses on these lands will reduce water run-off and erosion. We already know that such grasses increase livestock production.

and salting practices have increased grazing capacity more than 100 percent. Our range economist finds that these improved management procedures often are the cheapest source of more feed — cheaper than new land and often cheaper than introducing grasses.

In developing better management methods for range land, we find more and more need for sound basic research in the physiology and ecology of individual range plant species. Present studies are answering the perplexing problems of just how grazing affects the food storage and future growth of plants. This work already shows that plants differ in response to grazing and that they can be grazed at certain seasons and frequencies with much less damage.

Ecological studies are trying to find what plants naturally grow on each range. This will indicate what we can expect from proper management — *i.e.,* what is the forage production potential of the land. All individual ranges and all individual plant species differ. Our range ecologists are becoming more familiar with these ranges and their plants. We are learning their reproduction methods, how they resist drought, and make maximum growth of highest nutrient content. This is a challenging and difficult job, but, some day it will pay the state many-fold in terms of high quality feed at the lowest cost.

WATERSHED RESEARCH

Our range watershed scientists are now launching important new research as to how range management influences water flow and erosion from pinon-juniper and sagebrush lands. As the accompanying table shows, these types occupy almost half our state. Extensive areas already have been planted to grasses to increase forage production. The results, in terms of grazing capacity, are obvious, but the effects on the soil and water resources are not so easily discernible. Whereas ordinarily we didn't think of these dry lands as important water sources, their size alone dictates the need to know

Table 1. The types of range found in Utah

Type	Percent of the naturally vegetated land
Pinon-juniper	27½
Sagebrush	18½
Saltbush	18
Blackbush	8
Mountain brush	7
Coniferous trees	5
Mixed desert shrubs	4½
Aspen Trees	5
Grasses	3
Greasewood	3
White sage or winterfat	½
	100%

Figure 4. To effectively measure cattle and sheep gains on various types of range the animals must be weighed, released to a pasture, and then reweighed. The cattle above have just been released from weighing corrals.

Figure 5. Another phase of range management concerns big game. Utah's ranges support large populations of mule deer.

how they affect water flow and dam silting.

Other range watershed research is concerned with such diverse problems as (1) the evaluation of the effects of mechanical treatments such as contour furrows and gully plugs on soil and water resources of saltbush ranges; (2) the effects upon soils and vegetation of cattle grazing on steep mountain slopes; (3) the effects of different intensities and times of grazing on soil water storage; and (4) the use of chemicals to reduce water use of range vegetation.

Full development of Utah's water resources well may depend on our knowledge of how to manage the range lands which contribute the water to rivers and threaten dams with siltation.

BIG GAME RANGES

As with livestock, the key to producing big game animals is range management. Our game range specialist not only investigates ways to produce the best forage for game but he studies how game and livestock can best be grown together with a minimum of competitive interference. We know now how much forage the deer eat, which species they prefer, and how their diet changes with season. We also know the nutritive content and digestibility of important deer feeds. Much has been learned on how to measure range utilization by deer so that their numbers can be balanced with the forage supply.

An important new study now underway deals with factors affecting production and survival of antelope on our winter ranges. These animals may be the source of greatly increased sport and meat in Utah if we can find what it is that presently prevents their normal reproduction.

(*Continued next page*)

Figure 6. Over-population of deer can damage their habitat. The "highlining" of this aspen grove is an example.

FEED LOT LIGHTING HELPS CATTLE GAIN

Cattle definitely like a midnight snack. The reason for lighting feed lots at night and how it often raises financial returns to livestock producers has been clarified by research on cattle feeding habits. Steers will do about one-fourth of their feeding throughout the night, even without lights. But with continuous lighting, they space their time at the feeder more evenly throughout a 24-hour day. No increase in overall feed intake was noticed by researchers, but it is possible that evenly spread feedings improve the efficiency of converting feed to meat.

Dr. Paul A. Putnam, an Agricultural Research Service beef cattle nutritionist at Beltsville, Maryland, summarized other conclusions about the feeding habits of cattle derived from the 6-year study:

1 — *Competition.* When two steers were supplied all the feed they wanted but had to share a feed bunk with just enough room to accommodate one of them at a time, they tended to eat faster — but ate no more total pounds than if they had separate bunks.

2 — *Preferences.* Like humans, cattle have food preferences, depending on the feedstuff and its preparation. The "feeding" appeal of a high-grain ration was compared with that of a high-hay ration, offering both feeds either coarsely ground or pelleted.

With all four choices available at the same time, cattle spent three-quarters of their time eating the coarsely-ground high-grain ration. This confirms the belief that cattle will eat more grain than forages and that they dislike high-grain pellets, Dr. Putnam said.

Pelleting makes an all-forage ration more acceptable, however. With only one feed available at a time, cattle ate twice as fast and consumed 20 percent more total feed per day when fed pelleted, instead of ground hay.

3 — *Hormone implants.* Steers implanted with stilbestrol tended to feed during daylight hours even more than non-implanted steers.

4 — *Lighting pattern.* Reversing the normal lighting pattern reversed feeding habits of both steers and heifers. For this trial, windowless stalls were artificially lighted during the night and kept dark while the sun was up. About 3 weeks after the treatment started, cattle switched from spending most of their time at the feeder during normal daylight hours to feeding mostly during the artificial "daylight."

EXPANDING POPULATION

(*Continued from page* 146)

environment. Much of the increased production in plants and animals has come about from successful use of these chemicals. Factors which influence tissue storage of insecticides in animals are being examined at Utah Agricultural Experiment Station. This is important because excessive carryover into edible tissue could endanger human health. Recently, our researchers found that, at certain levels of administration, dieldrin storage in sheep was reduced by 45 percent in the presence of DDT. This finding is of high significance. Basic studies of other suggested interactions are in progress. They give promise of yielding effective practical methods of reducing retention of insecticides and their metabolites by animals. If this can be accomplished, producers can reap the benefit of effective pest or weed control through the use of chemicals without endangering human health.

FASTER GAINS

Individual feeding tests with beef cattle at this station show that some animals will gain up to 26 percent faster and on 16 percent less feed than other beef animals under similar conditions. As part of a regional project, the Utah Station is measuring the value of mild inbreeding accompanied by selection for producing fast gaining, efficient beef cattle with high reproductive ability. The performance evaluation of cattle from crossing carefully developed lines and strains has now commenced. Crossbred white-faced sheep as well as crosses of black-faced and white-faced sheep are being compared with straight bred sheep for lamb and wool production under range conditions. Black-face crosses give strong evidence of hybrid vigor but there is no regular evidence of hybrid vigor in the white-faced crosses. Ways of further capitalizing on the hybrid vigor of the black-faced crosses are being evaluated.

Paper pulp waste product prevents insect development

A chemical compound that keeps certain insects from developing into adults has been isolated and identified.

Dr. William S. Bowers and Edward C. Uebel and Milton J. Thompson of USDA's Agricultural Research Service isolated the hormone-like compound, called juvabione, from the wood of the balsam fir tree and determined its structure. Cooperating in the work was Dr. Henry M. Fales of the National Institutes of Health.

Isolation and identification of juvabione by the USDA-NIH research team followed a discovery by scientists at Harvard University that something in wood of the balsam fir keeps certain immature Hemipteran bugs from becoming normal adults. With the new information as a basis, scientists at the Insect Physiology Pioneering Research Laboratory in Beltsville, Md., will be able to determine the effects and potential uses of the pure chemical against insects.

The scientists will also determine if juvabione, a monocyclic sesquiterpenoir ester, can be man-made inexpensively in adequate quantities for continued research. Substantial quantities would be needed for large-scale field tests. Small amounts of juvabione are adequate for laboratory studies, however, since a particle smaller than a pinpoint prevents an insect from maturing.

Previously, only the *Pyrrhocoridae* family of the *Hemiptera* order of insects was known to be affected by juvabione. This family includes the cotton stainer, an important pest of South America, African, and Asian cotton crops. ARS scientists now know that it also prevents metamorphosis of a representative of another *Hemiptera* family, the box elder bug. In tests, the box elder bug developed into an overgrown nymph and subsequently perished instead of undergoing its normal transformation into an adult. This indicates that juvabione may work against many insects of the *Hemiptera* order, such as bedbugs and chinch bugs, and of other orders.

Even more promising is evidence that juvabione affects an even larger group of insects unrelated to the bugs. For example, the scientists found that juvabione prevented mealworms — important pests of stored grain, flour, and livestock feed — from becoming normal adults. If it triggers the same abnormal development in other important insect pests, it may become a useful pest control weapon.

Juvabione is one of a number of compounds being studied by ARS scientists that affect insect growth. A man-made hormone — *trans trans* 10, 11-epoxyfarnesenic acid methyl ester — prepared by Dr. Bowers and co-workers is even more potent as a growth arrester than juvabione. And natural hormone extracted from silkworm moths produces smiliar effects on mealworms.

Unlike the other two materials, juvabione is found widely in nature. It exists in large quantities in the balsam fir, one of America's most common pulp trees, and can even be extracted from waste balsam-pulp paper.

NATURAL CHEMICAL SPEEDS LEAF DROP

A natural chemical in plants that makes them "grow old" faster has been isolated and structurally identified — thereby opening the door to many practical applications in agriculture.

This hormone-like chemical promotes the dropping of leaves, flowers, and fruits in a process called abscission. Because of this role, the chemical has been named abscisin II by scientists of United States Department of Agriculture's Agricultural Research Service and the California Agricultural Experiment Station.

Synthetic abscisins might be used to defoliate plants at all stages of growth and in any weather, thin fruit at blossom stage, and eliminate after-harvest growth of such perennial crops as cotton. They also might be used to block flowering in some plants, and make buds stay dormant to escape winter damage.

The scientists isolated and crystallized 1/3,160th of an ounce of abscisin II from about 500 pounds of cotton bolls, 4 to 7 days old. They determined the structure of the compound by elemental analysis, and by comparing it with known chemical compounds through mass and magnetic-resonance comparisons. They are now attempting to synthesize it.

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