Apple blossoms. The Mormon pioneers brought apple seed and cuttings with them from the East. From this early beginning until the present, Utah growers have continually been conscious of quality fruit and have strived to plant the better varieties. An apple variety evaluation program was initiated soon after the Experiment Station was organized in 1888. During this period a large number of varieties have been evaluated. Many have been discarded; others have been adopted by the industry. At the present time 134 varieties are being evaluated at the Howell Research Station at North Ogden. A number of dwarf apple tree rootstocks and interstocks are also being studied. New apple selections and varieties released by breeders throughout the country and in many foreign countries are obtained each year for evaluation under Utah environmental conditions. These varieties are discussed and exhibited at the field days, state fair, and at the Utah Horticulture Society meetings.

—David R. Walker

Results of experiments to determine how the essential amino acids should be proportioned in a chick ration to make a well-balanced mixture indicate that such a ration should contain: 1.28 percent arginine, 0.43 percent histidine, 1.15 percent lysine, 1.30 percent leucine, 0.80 percent isoleucine, 0.95 percent valine, 1.33 percent phenylalanine and tyrosine, 0.20 percent tryptophan, 0.73 percent methionine and cystine, and 0.178 percent threonine. Chicks fed a ration with the essential amino acids at these levels gained weight 25 percent faster and used their feed 15 percent more efficiently than chicks fed a similar ration containing the essential amino acids at the levels given as minimum requirements by the National Research Council.—Jay O. Anderson

Studies show that control of western x-disease in sweet cherries by removal of diseased trees is not possible. Observations of natural spread suggest that an adequate insect control program might be more effective in preventing natural spread of the western x-disease virus. Growers should topwork new plantings of sweet cherries on mahaleb framework trees.—Bryce N. Wadley

UTAH FARM AND HOME SCIENCE

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

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FARM AND HOME SCIENCE
what about utah's STARLINGS?

EDGAR P. BAILEY and A. W. STOKES

A recent addition to the agricultural scene in Utah is the exotic starling (fig. 1). Stockmen are most aware of this bird because it occurs in ever-increasing numbers in feedlots during the winter. Turkeys growers are also concerned. To learn more about the relation of starlings to agriculture, we studied these birds during winter in Box Elder County from 1960 through 1962. We hoped to find the weak link in their life history that might lead to their control where necessary.

The starling reached Utah in 1939

The starling was introduced to America from Europe in 1890 but did not reach Utah until 1939, where it has increased steadily ever since. In eastern United States, starlings reached peak numbers 20-25 years after their introduction. If our birds follow the same pattern, they should be approaching peak numbers now. Our birds are almost entirely winter residents and few remain to breed. They arrive in numbers in October and leave again for their breeding grounds to the northeast in April. Starlings in Box Elder County were most numerous in December; presumably some of these were migrants passing through. By February we saw only half as many birds but these probably were residents. How far south the birds move seems to depend on the severity of the weather. In the severe winter of 1961-62, we observed considerably fewer birds in Box Elder County than in the previous, milder winter. However, our southern counties reported more starlings in 1961-62 than in the previous winter. Hence, the colder the weather, the more likely starlings are to move further south.

EDGAR P. BAILEY was a graduate student in wildlife resources, now with the National Park Service, Middlesboro, Kentucky. DR. A. W. STOKES is professor of wildlife resources.

The starling is really a southerner

The starling is really a southerner by origin with a scanty plumage that does not make it well adapted for Utah's winters. Many of the bird’s habits in winter can be explained by its efforts to conserve heat. When they first arrive in the fall, starlings roost primarily in cattail marshes, because the air over the water remains warmer than over the surrounding land at night (fig. 2). A secondary advantage lies in the defense against surprise attack by ground predators. These roosts are easy to locate, for starlings habitually fly in dramatic aerial displays while approaching them, periodically alighting in treetops before resuming their flight. These flocks become steadily larger as groups nearer the roost fly up to join the others.

When the marshes freeze over

(Continued on page 48)
SUGAR-BEET, ALFALFA-STEM, their distribution and importance in Utah

E. C. JORGENSEN
G. D. GRIFFIN

THE toll exacted by nematodes from the gardens, farms, greenhouses, orchards, small fruit plantings, lawns, ornamental plantings, ranges, and forests is staggering. Three of the most prevalent of these nematodes in Utah are the sugar-beet nematode, Heterodera schachtii, the stem nematode, Ditylenchus dipsaci, and the root-knot nematode, Meloidogyne hapla.

Plant disease problems associated with nematode parasitism have been known in Utah since the turn of the century. In 1905 the sugar-beet nematode, Heterodera schachtii, which had plagued sugar beet producers in Europe for half a century, was discovered in fields near Lehi in Utah County.

The stem nematode Ditylenchus dipsaci was found at several places in the irrigated regions of the Intermountain West in 1919. A few years later (1924) Gerald Thorne noted that both the alfalfa and clover strains of this nematode existed in Utah. His survey indicated the alfalfa strain was then present in Salt Lake County and the clover strain in Utah County.

Only one species of root-knot nematode, Meloidogyne hapla, is known in Utah. It was first reported from Weber County as H. marioni in the late 1920's.

These three nematodes cause damage which is characteristic for each and is easily recognized. Excessive proliferation of roots and over-all stunting is caused by the sugar-beet nematode; root galls and general malformation of the roots by the root-knot nematode; and a gross distortion of the leaves and stems by the stem nematode.

Sugar-beet nematode

The sugar-beet nematode is found in all beet growing areas of Utah. In many of these areas, it is considered the most important factor limiting sugar-beet production. It is
AND ROOT-KNOT NEMATODES

a threat to efficient and maximum production, not only because of the actual damage caused to the growing crop, but also because the necessity of rotation with non-susceptible host crops reduces the potential acreage for growing sugar beets.

The life history of the sugar-beet nematode is fascinating because of the type of development and the adaptations to adverse environmental conditions it demonstrates.

In common with other plant-parasitic nematodes, it has three life stages, egg, larval, and adult. There is one embryonic molt. The infective, or free-living stage is the second stage larva. After entering the roots of a suitable host plant, the larvae molt three more times before becoming adults. Sex can be distinguished after the second molt. The females have two ovaries, the males a single testis. After entering the root and molting, the females develop from third stage larvae slender in appearance, through a flask-shaped stage to the typically lemon-shaped adult stage. These remain attached to the roots by the-anterior portion of the body. They continue to feed and increase in size and are fertilized by the males. A gelatinous matrix into which the eggs are deposited forms an egg mass at the posterior end of the body. Not all eggs produced by the females are deposited in the matrix. Most are retained within the body, which hardens to form what is called the brown cyst. Some of the eggs within the cyst hatch immediately, as do those which are deposited in the gelatinous fluid. Others remain unhatched until stimulated by diffusates of hosts or other plants, known to produce substances that stimulate hatching. Some eggs will hatch even if plants are not present. Using this information, it is possible to manipulate the environment to the detriment of the nematode, and induce the larvae to hatch more rapidly than normally by alternately wetting and drying the soil, thereby reducing the potential infective population. Without manipulating the environment, a period of at least four or five years is necessary to bring about this reduction in sugar-beet nematode numbers. With manipulation, it may be possible to shorten this period by at least two and perhaps three years.

The traditional method of controlling sugar-beet nematodes is by crop rotation. If nonhost plants are grown, a good crop of beets can be produced every three to five years provided all other factors are favorable and no weed hosts are permitted to grow during the rotation period. If weed hosts are present, the

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(Continued on page 51)
Brisket disease has been diagnosed as a heart condition that occurs in cattle on the high mountain ranges in Utah. The right side of the heart enlarges, partly because of reduced oxygen at high altitudes which increases the work load of the right heart ventricle. As a consequence circulatory failure occurs and body fluids become imbalanced. In this respect the disease is similar to heart disease of humans.

Why the name “brisket disease”?

One of the prominent signs of the circulatory disturbance is an accumulation of fluid which causes a swelling of the brisket (lower part of the neck, near the front legs). The name emerged from common usage among cattle owners who observed certain of their cattle with this swelling. In some cases the swelling becomes so extensive that the front legs are forced apart making walking difficult.

It is paradoxical that the name “brisket disease” came into being because of the spectacular enlargement of the brisket, yet in many cases of the disease this symptom is not evident, even though death may ensue. Swelling in the brisket region more often occurs in calves than in adult cattle. The explanation offered for absence of a swollen brisket in some animals even though they had the disease is that the right side of the heart enlarged so rapidly that death from heart failure occurred before circulatory disturbances became extensive.

Nature and extent of circulatory disturbances

In Utah, approximately 75 percent of the cattle that develop brisket disease have external signs of fluid imbalance. The data in Table 1 illustrate this. There is a comparable percent wherein abnormal heart sounds and distended jugular veins occur. The first heart sound, during the contraction phase of the heart muscle, is muffled; and the second, during the relaxation phase, is pronounced. Distension of the jugular veins occurs in a wave-like fashion with each heart beat. The distension is due to incomplete closure of the valves between the right atrium and right ventricle which results in a backward flowing of venous blood.

Circulatory disturbances may be manifested in several ways (Table 2). Fluids leave the blood stream by passing through the vessel walls and accumulate between cells in certain body tissues. This condition is called edema. It is most evident in the brisket tissues or in supporting tissues surrounding the kidneys, intestines, lungs, and other visceral organs. Pools of free fluid lying in the bottom of the thoracic cavity, abdominal cavity, or in the membranous sac which surrounds the heart may also occur. The fluid comprising these pools also originates from the blood, as a result of enlargement of the right side of the heart.

Recovery of afflicted animals is slow. Some of the cattle that developed the disease in late summer and were removed to a lower altitude still had evidences of circulatory disturbance the following summer (convalsescent group, Table 1).
CHARACTERISTICS OF BRISKET DISEASE

A circulatory disturbance accompanied by fluid accumulation

JOSEPH T. BLAKE

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Table 2. Incidence and nature of fluid imbalance in cattle with brisket disease

<table>
<thead>
<tr>
<th>Fluid imbalance</th>
<th>Afflicted</th>
<th>Healthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brisket edema</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Visceral edema</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Fluid around heart</td>
<td>6</td>
<td>1*</td>
</tr>
<tr>
<td>Fluid around lungs</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Fluid abdominal cavity</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

* Had liver flukes

Is there a fever?

The body temperatures of cattle afflicted with brisket disease are not any higher than those for healthy cattle living in the same environment. In both healthy and afflicted groups in table 1 temperature averages were from 1 to 2 degrees higher than normal for the species. This is because of the excitable nature of untamed range cattle and the inability to take temperatures without the cattle struggling.

Lesions caused by the shedding of the epithelium of the muzzle mucosa are one of the constant signs of brisket disease. Such lesions could follow and are often associated with body fever. Fever is usually but not always associated with an infectious disease. It occurs as part of an inflammatory reaction and is a sign of tissue irritation. Whether a fever occurs early in the development of brisket disease is not now known. This possibility should be investigated. Efforts to isolate a pathogenic organism from the tissues of animals afflicted with brisket disease have been fruitless.

Why diarrhea?

As evidenced by the data in table 1, diarrhea nearly always accompanies brisket disease. It occurs during the early stages of the disease, then disappears. The reason for diarrhea is not known. It may be the result of an alteration in the composition of the intestinal contents. A change in the amounts and types of proteins and minerals within the intestine could influence the extent to which water is held or reabsorbed. A change in pressure within the

(Continued on page 53)
(1) Virus particles containing DNA are isolated by using a high speed refrigerated centrifuge (2) Viral DNA is prepared for assay of genetic material (3) Level of DNA activity is evaluated by use of an electronic counter.
You just can't judge complexity — nor importance — by size. Modern geneticists are constantly reminded of the truth of that statement as they try to decipher the mechanisms of heredity.

Once upon a time (before the 1940's), genetics was largely a descriptive science. During these early days, geneticists were most often concerned with cataloguing the results of experiments that involved various breedings of reasonably common plants and animals. Rapid developments in technology and steadily growing backlogs of data, however, drastically changed the perspective of geneticists.

Today you find genetic researchers delving more and more deeply into the no-longer private world of the individual cell. One result of such work has been to put DNA (deoxyribonucleic acid) into the vocabulary of everyone who reads newspapers and popular magazines.

Once the scientists discovered that it was DNA that transmitted genetic data between generations of organisms, they naturally set about trying to define its structure and activities. Many vital bits of information have been discovered, but the enigma of why you are you is far from solved.

Some “knowns” about DNA

DNA that has been carefully isolated in the laboratory is a white fibrous material (fig. 1). However, most experimenters do not use the solid DNA. Instead it is dissolved in a chemically buffered solvent. Under such conditions, DNA forms a colorless, highly viscous solution.

Each molecule of DNA is composed of hundreds of thousands of relatively simple building blocks called nucleotides. Each nucleotide (fig. 2) is itself of comparatively high molecular weight. All of these molecules, of course, are invisible to the human eye. The DNA molecule, however, can be seen with the aid of an electron microscope.

Various investigations have proved that DNA actually fulfills its

(Continued on page 53)
Our enigmatic weather, part 4

**PRECIPITATION**

one component of climate

Fig. 1. Probability or chance of receiving .06 inch or more of precipitation (lightly shaded portion of graphs) or .6 inch or more of precipitation (dark portion of graphs) in any 7-day period beginning on indicated dates.

E. A. RICHARDSON
G. L. ASHCROFT
LOIS M. COX

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**LEWISTON**

**U TAH LA KE LEHI**

**DESERET**

**EMERY**

**BLANDING**
Ever consciously think about how much of your life and your way of living are influenced by the weather? Probably not, few of us have.

And yet, climates, which are simply the average daily weather over long periods of time, actually help shape civilizations. The ways in which you and I adapt to this part of our natural environment are symptomatic of our times, our culture, and our individual philosophies.

For example, members of today’s highly mobile labor force may decide for or against a job in a given location as much because of the area’s climate as because of a salary incentive. Entire industries such as construction, air conditioning, heating, and ranching key their operations to climatic conditions.

In this article we begin to explore the history-oriented world of the climatologist. It is a world characterized by a long range approach and a necessarily localized application of information. It is a world that vitally affects our way of life in innumerable subtle ways.

The indispensable records

A climate can be characterized only over long periods of time. This time factor necessitates consistently kept records. And because climates are so drastically affected by topographical features, the records must be accumulated at large numbers of carefully situated stations.

Thousands of unpaid observers around the United States keep daily climatological records for their localities. In Utah alone, over 300 conscientious men and women volunteer their time for this task.

Each month, the records accumulated by these volunteers are sent to the Weather Bureau’s electronic computer center in Asheville, North Carolina. At the center, the data (which include daily maximum and minimum temperatures, rainfall, snowfall, depth of snow on the ground, and sometimes evaporation, wind velocity, relative humidity, and soil temperature) are placed on computer cards. The cards, in turn, have facilitated a wide variety of climatological studies.

Probabilities and planning

Among these studies are the ones that generate climatological forecasts for a specific locality. Such forecasts are based on the pleasant assumption that the weather during the coming 30 to 100 years will resemble that of the past 30 to 100 years.

Basically, a climatological forecast does one of two things. It either indicates the average weather conditions that can be expected to prevail at a certain time of the year in a certain geographic area — or, it assesses the chance (probability) of some particular climatological phenomenon occurring. Thus these forecasts facilitate long range weather-oriented planning by people such as engineers, architects, construction workers — and you and me.

One climatological factor that (Continued on page 55)
ANIMALS normally ingest variable levels of fluorine throughout their lives. So long as they continue to ingest a constant or increasing amount, some of the fluorine accumulates in their bodies. If amounts of fluorine above the threshold or critical level, which varies with factors (1) to (7) listed below, are ingested over long periods of time, fluorine toxicosis may result. This toxicosis may be either acute or chronic, but the chronic form is more common in livestock.

Chronic fluorosis develops gradually, and every affected animal will evidence an individualized manifestation of the typical lesions. It is impossible therefore, to define a precise point at which an instance of normal consumption will become a case of chronic fluorosis. The borderline or threshold point will vary somewhat in individual cases as the seven following interacting factors exert their influence:

1. level or amount of fluoride ingested,
2. duration of ingestion — time,
3. type and solubility of fluoride ingested,
4. age of animal during period of ingestion,
5. level of nutrition,
6. stress factors, and
7. individual biological response.

The inevitable time lapse between ingestion of elevated levels of fluorides and actual manifestation of the clinical symptoms of chronic fluorosis adds to the complexity of the clinical picture.

Actual instances of fluorosis in livestock may be traced to any of a variety of sources that may act singly or in combination. The most commonly encountered sources include: (1) forages having elevated concentrations of fluorine compounds as a result of airborne contamination in areas near certain industrial plants that heat fluorine-containing materials to high temperatures and expel fluorides, (2) vegetation having a high fluoride content because it grew on soils of high fluoride content, (3) feed concentrates and mineral mixtures high in fluoride and (4) drinking water high in fluoride.

Under field conditions the amounts of fluorine ingested and the lengths of time during which it is ingested are subject to wide variations. In some instances there may be intermittent periods during which no excessive fluorides are ingested. Different levels of nutrition and different management practices can affect manifestations of fluorotic lesions. The usual variability between individual animals within and between herds also can modify manifestations of the disease. Whether an animal consumes elevated levels of fluorine throughout its life, or only after its teeth are formed will determine whether fluorotic dental lesions occur.

About 95 percent of the total fluoride retained in the animal body is found in the bone, and in the
enamel, cementum, and dentine of the teeth. This retention pattern has made possible the establishment of certain criteria that are useful in evaluating the degree of fluorosis.

The information presented here is based primarily on work done over a period of more than 10 years by Utah State University personnel. It represents a correlation of data from controlled experiments and field cases. Technical aspects are being presented in various research journals and in Utah Agricultural Experiment Station Special Report 17.

Diagnosing fluorosis

No single criterion should be relied upon in diagnosing and evaluating fluorosis. All clinical, necropsy, and chemical findings should be carefully evaluated before a definite diagnosis and evaluation of fluorosis are made. Symptoms and lesions of particular importance are: (1) mottling and abrasion of teeth, (2) extent of bone lesions, (3) intermittent lameness, (4) amount of fluorine in the bone, and (5) amount of fluorine in the urine.

Excretion in the urine

When ingestion of elevated levels of fluorides is suspected, but clinical signs are lacking, urine analysis can be used as a diagnostic aid. Fluorine excretion in the urine, however, is affected by several factors such as current rates of absorption from ingested fluorides, the existing level of fluoride saturation of bone tissue, and the type of fluoride ingested. When possible, several animals in a herd should be sampled and the results pooled if a reasonable degree of reliability in diagnosis is to be achieved. Reliability is also enhanced if the sampling is done in the morning. The fluorine:creatinine ratio can be used as a diagnostic aid.

TOLERANCE TO FLUORIDE

In general, the following levels of sodium fluoride (calculated in parts per million for the total dry ration) can be ingested over a normal life span without adverse effects on the normal animal: dairy heifer and cow, up to 30; beef heifer, up to 30; beef cow, up to 40; sheep, up to 50; swine, up to 70; horse, up to 80; turkeys, up to 100; and chickens, up to 150. Tolerances are higher over short time intervals such as normal fattening periods of 180 days for cattle and 70 days for sheep. Under such conditions cattle and sheep can safely ingest up to 110 parts per million.

Fluorosis in livestock can be prevented and controlled but only when the complexity of the disease is realized and the pathogenesis, symptomatology, and lesions are properly correlated, interpreted, and evaluated.

This article is adapted by LOIS M. COX, technical writer, from an article written by DR. JAMES L. SHUPE for the International Encyclopedia of Veterinary Medicine, and based on extensive research by staff members of the Utah Station. Dr. Shupe was formerly professor of veterinary science, he is now with the Animal Disease and Parasite Research Division of the U. S. Department of Agriculture and stationed on the USU campus.

(Continued on page 57)
The amount of phosphorus applied to the alfalfa crop is the significant factor in increased yields as well as in the concentration of phosphorus in the hay and the residual remaining in the soil. The frequency with which the fertilizer is applied to alfalfa is relatively unimportant. These are the conclusions of a six-year study conducted at the Panguitch farm and of field observations throughout the state made over a period of years.

The value of phosphate fertilizer on alfalfa in Utah was first demonstrated by the late D.W. Pittman in 1928. Since then numerous studies have provided considerable information on its role in the nutrition of alfalfa. Some of these studies have shown that time and method of application are relatively unimportant. Broadcast treatments have been as effective with alfalfa as those placed in bands. Fall treatments have been equally as good and sometimes superior to spring treatment.

In 1955 a study at Panguitch was initiated to measure the effect of frequency of application of phosphorus fertilizer. Four levels of phosphorus (P) were used: 33, 66, 132, and 264 pounds per acre. The fertilizer was broadcast on the replicated plots at one, two, and three year intervals during the six-year study. For example, 33 pounds of phosphorus were applied once in the six-year study, 16½ pounds were applied at two intervals, and 11 pounds at three different intervals. This pattern was followed for all rates.

REX F. NIELSON is associate professor of agronomy. GREN OWENS is manager of the Panguitch farm.
The site on the Panguitch farm was seeded to Ranger alfalfa in the spring of 1954. Thirty-five pounds of phosphorus were applied broadcast before seeding. The plot layout was established in the spring of 1955 on the year old stand of plots. Subsequent fertilizer treatments were broadcast on the plots throughout the duration of the six-year study. Two clippings of alfalfa were harvested each year from 1955 through 1960. Samples of the alfalfa from each plot were analyzed for phosphorus content.

The results of the study are shown in the figures. The yield in tons per acre and the percent phosphorus in the alfalfa for the six-year period as a function of frequency of application and rate of fertilizer applied are shown in figures 1 and 2. Yields and phosphorus content of the alfalfa were not significantly affected by the frequency of application. A summation of the total yields and the average phosphorus content of alfalfa irrespective of frequency of fertilization are shown in figure 3. A significant difference in total yield and average phosphorus content was measured between the check plots and the fertilized plots. The data presented in figure 4 show the total amount of phosphorus removed by the alfalfa from the soil during the six-year period. These values were computed by multiplying the percent composition by yield for individual crops.

(Continued on page 59)
they lose their warmth, and starlings then seek more sheltered places. Sheds are favorite sites, but only if they contain cattle; the birds benefit from the heat radiated by the animals. Barns may shelter several hundred birds which perch high up near the ridge in the warmest place. In Europe, starlings tend to seek out the sheltered side of the countless chimney pots that characterize European cities. In eastern United States, many starlings roost in cities, again presumably for the added heat available. It is spectacular to watch, from a city rooftop, the wave after wave of birds arriving just at dusk to settle by countless thousands on the cornices and ledges of tall buildings. This urban roosting has become such a menace to pedestrians below that most large cities wage campaigns against the starling.

The playback of the distress call of starlings has temporarily repelled the birds from specific places; however, electric shocking and screening of ledges have had more long-term success. The ultimate answer lies in designing the buildings of tomorrow with no available roosts. Utah’s starlings have not yet taken up this urban roosting habit, but will undoubtedly do so, especially as our cities grow in size and height. City planners and architects would be wise to bear this in mind now.

In the morning, starlings all leave the roost within a matter of 5 to 10 minutes, radiating out in many directions. The puzzling concentric arcs seen on radar screens during the war are now known to be due to the dense flocks of starlings departing in successive waves from the roost in the morning.

During good weather in the fall, starlings may range at least 10 miles from the roost to feed. Throughout most of the year the birds are insectivorous, hence entirely beneficial to man. Starlings seek out fields where sheep are grazing and will feed in the midst of them, often perching on the backs of the sheep. Sheep tend to graze lower and uproot grass much more than do cattle. This disturbance of the soil by sheep probably makes food available to the birds.

Although starlings will use feedlots in the fall, this habit does not become serious until snow covers the ground. Then the normal sources of food are unavailable and the starlings become almost entirely dependent upon man’s farm activities for survival. Some birds may react by moving farther south to find open ground, but many find the copious handouts in the mangers at cattle feedlots (fig. 3) or in the open silage pits sufficient for their needs. Were it not for these sources of food, starlings would be rare in northern Utah, or elsewhere, wherever snow covers the ground for several weeks at a time. The food attainable at feedlots may not be entirely adequate for starlings for they readily entered traps baited with lard cracklings. This high-energy food would undoubtedly help birds maintain their weight during cold weather.

(Carried on page 58)
THE more we learn, the less we seem to know. This could be the lament of scientists in any discipline. Certainly it applies in physiology. Every component of an animal body is interrelated with every other component to some degree. And each thread that is unraveled from the tangle of interrelationships more often than not merely points to new enigmas.

USU researchers are working with two of the most ubiquitous tissues in the human body, trying to discover more about a single type of blood cell. They are concerned with blood and connective tissues, and the cell they are tracking is the eosinophil. The threads are tightly interwoven and resisting solution, but the potentials are exciting enough to warrant preservation.

The basic ingredients

Connective tissue is the most abundant and difficult to characterize material in the body. It includes such things as cartilage, bone, skin, and vascular tissues. Connective tissues are intimately involved with the process of inflammation. And inflammation, in turn, occurs to some degree in virtually every disease at some stage of its development.

The USU group is working primarily with the loose fibrous variety of connective tissue. This type acts as a filler and “packing” tissue throughout the body and is found in almost all of the body organs.

Blood, of course, is also an extremely versatile tissue. The red cells carry oxygen. The various types of white cells operate as part of the body’s defense system against disease. As a unit, the blood transports the body’s wastes and its food.

Eosinophils are one kind of white blood cell. They are characterized by a 2-lobed nucleus and by large spherical granules (fig. 1). The affinity of these granules for the acidic red dye called eosin gave the cells their names. Eosinophils average 10 to 15 microns in diameter (1 micron equals 1/25,000 of an inch), and compose 1 to 3 percent of the total white blood cell population. They increase in number, however, during (a) the recovery phase of acute infections, (b) parasitic conditions, and (c) hypersensitivity (allergic) reactions.

These white blood cells respond to antigenic stimulation. Antigens are the substances that cause antibody production in the body, and they are considered the basis of most allergic reactions. Hypersensitivity and inflammation are always associated to some extent, and this association closely links eosinophils and connective tissues. In fact, eosinophils routinely occur in considerable numbers in loose fibrous tissue during hypersensitivity reactions.

The problem

The unknowns about eosinophils include definition of precisely where and how they originate in the body. The normal supply probably is maintained by production in the bone marrow. But is this the only source? Does the bone marrow also supply the increased numbers of eosinophils that are found during hypersensitivity reactions? Could these “extras” result from the transformation of some other cell type at the site of reaction?

The possibility of cell transformation has intrigued many investigators. It has been proved that lymphocytes, which are usually not normally phagocytic, transform into macrophages during some inflammatory reactions. Macrophages are
blood cells that ingest (phagocytize) and destroy body invaders such as bacteria. Recently developed evidence indicates that macrophages, in turn, sometimes transform into plasma cells. It is the plasma cell that actually manufactures antibody. This transformation of macrophages into plasma cells is believed by some workers to require enzymes supplied by eosinophils.

The USU research, which is still in progress, was designed to clarify questions about the origin of eosinophils during hypersensitivity reactions. Such information is expected to help other researchers develop more effective ways to control these reactions.

The techniques

Defining the point of origin of a single cell type in the living body has proved, not unexpectedly, to be time consuming and patience trying. When the research was first launched, much time was devoted to testing the applicability of a “diffusion chamber technique” for tracking the eosinophils. The porous membranes of the diffusion chambers (fig. 2) permit oxygen and “food” to pass through, but prevent the passage of cells such as eosinophils.

Samples of living connective tissue can be placed inside the diffusion chambers before they are sealed, and the units inserted into an anesthetized “host.” The hosts (and donors) in this research have been guinea pigs. The research group decided to use guinea pigs because of their unusual responsiveness to sensitization. These animals react quickly and measurably to confrontation with an antigen.

Using all possible precautions to assure aseptic conditions, the researchers gradually sensitized a number of young guinea pigs to a specific antigen (horse serum). Horse serum was used because it gives rise to especially large numbers of eosinophils in the blood and other tissues of guinea pigs.

The diffusion chambers (containing connective tissue samples from either sensitized or non-sensitized guinea pigs) were inserted either under the skin or into the abdominal cavities of either sensitized or nonsensitized guinea pigs. After recovering from the operation, these animals were “challenged” with another injection of horse serum.

It was thought that the hypersensitivity response to this challenge might produce a substance(s) which would diffuse into the chambers and cause some connective tissue cells to transform into eosinophils. This hypothesis went unrealized. The diffusion chamber experiments produced some interesting tissue proliferation patterns, but they did little to clarify the question of where eosinophils originate during hypersensitivity reactions.

Another cell-tracking procedure used by the group involved the “skin-window” technique which had been developed by other workers with human volunteers. This technique uses small, extremely thin pieces of glass (cover glasses) placed over artificially produced skin lesions. As various cell types migrate to the wounded area they adhere to the cover glass. The cover glasses are removed and replaced with fresh ones at regular intervals. Microscopic examination of the removed cover glasses after they have been properly stained provides data about the chronological cellular changes that have taken place.

The USU researchers found the guinea pigs to be decidedly uncooperative in this phase of the experiments. Cover glasses were dislodged or broken more often than they were maintained in place for the necessary time intervals. As a result, the researchers had to develop a variation of the technique that would circumvent the perversity of the guinea pigs.

They finally abandoned the cover glasses and resorted to injecting the challenging dose of horse serum just under the skin of sensitized guinea pigs. Samples of connective tissue were removed aseptically from these areas before and at measured intervals after the guinea pigs were challenged. Microscopic examination of the processed and stained samples provided promising insight into the problem.

The propitious results

Some fibroblasts in the connective tissue samples were especially intriguing. Fibroblasts account for more than 90 percent of the cellular population of normal loose connective tissue. These cells are extremely versatile and adapt readily in form and function to the body’s needs.

In examining the tissue samples, the researchers found fibroblasts that contained apparently phagocytized granules which had the staining and size characteristics of typical eosinophil granules. They considered this particularly significant because fibroblasts are not normally phagocytic. Some of these fibroblasts had the granules dispersed throughout their cytoplasm. Others had the granules concentrated in discrete vacuoles. Macrophages in the tissues also contained similar granules. Further observations indicated that degranulated eosinophils were present in greater numbers in the challenged tissues than in control tissues.

The group was also gratified to see two types of eosinophils in the tissue preparations. The more numerous type had the typical 2-lobed eosinophil nucleus. The other type, however, had a non-segmented nucleus and has been tentatively designated a “tissue eosinophil.” It seems quite possible that these tissue eosinophils originate from some sort of cellular transformation.

After these modified “skin-window” experiments had been completed, a new staining procedure became available which the USU researchers are anxious to use. The new technique involves using pyrogallol, a chemical that specifically identifies eosinophil granules in cells in certain species of animals. The USU group has proved that the pyrogallol technique stains guinea pig eosinophil granules a brilliant, distinctive greenish blue.

The road ahead

The researchers are now planning more extensive experiments that will
allow them to explore the diverse potentials demonstrated by the completed research. They want to take samples of challenged tissues over longer time periods after the animals have been challenged. Only by including 24-, 48-, 72-, and 96-hour samples, can they determine unequivocally whether cells in connective tissue do transform into tissue eosinophils during hypersensitivity reactions.

They also have designed new projects using the diffusion chamber technique. They want to investigate more thoroughly the significant differences in tissue proliferation that they observed between chamber-enclosed sensitized and non-sensitized tissues in sensitized animals. Additional experiments will be run to define what happens when sensitized tissues are maintained in diffusion chambers in sensitized animals over extended periods of time. The group is curious about whether such prolonged maintenance will affect the ability of sensitized "grafts" to withstand subsequent challenge.

Obviously there is no way to predict with certainty what results are likely to be realized from the planned research. Even if the stipulated objectives prove elusive, however, the investigations will have broadened our understanding of various facets of hypersensitivity reactions. And only through better understanding can we hope eventually to achieve control.

**Nematodes**

*(Continued from page 37)*

rotation period is often ineffective.

Crop rotation is practicable because of accurate knowledge of the nematode's host range which includes among the cultivated crops in addition to sugar beets, mangelwurzel, table beet, cabbage, cauliflower, broccoli, brussel sprouts, rape, turnip, rutabaga, tomato, and radish. Weed hosts include mustard, Brassica spp.; lambsquarter, Chenopodium spp.; nightshade, Solanum nigrum; saltbush, Atriplex spp. Occasionally, knotweed, Polygonum minutum; dock, Rumex spp.; red-root, Amaranthus retroflexus; and purslane, Portulaca oleracea, are found infested.

Non-host crops that can be planted during the years the land is out of sugar beets include legumes, potatoes, grains, corn, onions, melons, celery.

The factors which contribute most to insure that the sugar-beet nematode maintains the position of questionable distinction it now occupies are continual cropping of beets year after year, and the accompanying practice of returning dump, or tare dirt, from the loading stations to the farm. When cysts of the sugar-beet nematode are present in the returning tare dirt, a small colony is established where it is dumped and normal cultural practices spread the nematode to other parts of the farm. This is not only the greatest single source but a continuing source of infestations.

In areas where soil types are suitable the sugar-beet nematode is controlled by soil fumigation. Nematocides containing dichloropropene are most effective for this purpose. Fall, plow-sole application gives the most satisfactory results because the beets can be planted earlier than is possible if spring application is used. The extra time gained in the spring is critical since it allows the sugar beets to become established before the nematodes reach their maximum activity. Fumigation at economical rates does not destroy all of the nematodes, and by the end of the season their numbers will have increased to the point where another crop of sugar beets may not be grown without again fumigating the soil.

A variety of sugar beet immune to the attack of sugar-beet nematode is being sought but without much success to date, though use is being made of all the methods at the disposal of plant breeders.

**The stem nematode**

The stem nematode, Ditylenchus dipsaci, is a serious parasite of alfalfa in areas within the state which are climatically suitable for the nematode. Since its discovery in Utah in 1919, it has been transported from limited areas in Salt Lake and Utah Counties to the borders of the state, and is now extensively distributed in Cache and Box Elder Counties in the north, in Uintah and Duchesne Counties in the east, in Millard County in the west, in Sanpete County, and in Washington County in the south. It has not been found in many of the high mountain and central valleys.

This nematode is damaging to alfalfa only within a rather narrow range of climatic conditions, when temperatures in the 50's and high relative humidity prevail for long periods. Since climatic conditions in the state do not consistently combine these factors, the damage from stem nematode varies from year to year, even in areas where it has been established for more than 40 years. However, when conditions are favorable it can be devastating to susceptible varieties. Resistant varieties of alfalfa are attacked by the nematode, but do not develop symptoms characteristic of susceptible varieties.

The life history of D. dipsaci on alfalfa in Utah has been traced. The infective stage is the fourth instar or pre-adult larval stage. These young nematodes enter the primordial buds and penetrate into the developing stems. Heavily infested stems become enlarged and discolored, the nodes swell, and the internodes become shortened. Necrosis results as the nematodes continue to multiply, and if all of the shoots of a plant become infested it may die. Whole stands of susceptible varieties degenerate in as few as three years under conditions favorable for the nematode.

Nematodes in the upper portion of the stems are removed with the first cutting of hay. If temperatures are cool and humidity high, stem nematodes will enter and damage the developing shoots of succeeding crops. This usually does not occur to any great extent, however, since by the time the first crop has been harvested in most areas of Utah,
stem nematode of alfalfa is simply
cations may not react similarly.
52
or strains in other genera has shown
nematode from different hosts and
to plant varieties which are resis­
from similar hosts from different lo­
in quality and should be disregard­
several species apparently indistin­
tistics exhibited by certain popula­
Others
families of plants, have
species have shown the existence of
what have been described as “physi­
range studies have shown repeatedly
that populations from one host
host plants, however, have been revived
heads of teasel stored in the
of races, maintaining the character­
from Iran.
The nature of resistance for all
these varieties is unknown. Tem­
known to be an important
factor in more ways than those pre­
It was recently
shown that the resistance of Lahon­
tan broke down with increases in
temperatures at which the plants
were grown. This may have been due
to a characteristic of the variety of
alfalfa. Earlier work has shown that
populations of the so-called alfalfa
strains from certain locations differ­
ed in their ability to reproduce on
clones of resistant varieties.
Root-knot nematodes
The northern root-knot nematode,
Meloidogyne hapla, is one of several
species of root-knot nematodes that
are important plant parasites. It has
been found in several counties, in­
cluding Box Elder, Davis, Salt Lake,
Washington, and Weber on such
common plants as lettuce, onion,
carrot, tomato, and sugar beets.
The life cycle of M. hapla is simi­
lar to that of the sugar-beet nema­
tode, Heterodera schachtii, except
that females deposit all eggs produc­
and no cyst is formed. Hatched
larvae are in the second or infective
stage, the first, or embryonic molt,
occurring within the egg. Larvae
are approximately 0.40-0.45 milli­
meters long and have a delicate
spur. They penetrate and enter
only the tender plant tissue near
the tip of the root, where they feed
causino cell hypertrophy due to
diffusion of salivary secretions of
the nematode through the cell walls.

The role of the males is not en­
tirely known. They have been found
in large number in the soil, in egg
masses, and occasionally in the roots.
There may be many males present,
or they may be entirely lacking.
Reproduction is known to occur
without the presence of males.

There appears to be a food-sex
relation with root-knot nematodes.
It has been shown, experimentally,
that the percent of male nematodes
increases correspondingly with an
increase in the nematode infestation.

The female continues to grow in
size until becoming pear-shaped. She
lays her eggs in a gelatinous matrix
that adheres to the outer surface of
the root and serves as a protective
covering for the eggs. The posterior
of the female usually protrudes from
the root, though in some instances
it may be deeply embedded, as in
potato tubers. In this case the eggs
are enclosed in a sac-like mem­
brane formed by the plant. The
number of eggs produced may range
from 0-10 on a poor host to 200-500
on a good host. When temperature
and moisture are favorable eggs
 hatch and larvae escape into the
soil. In potato tubers, eggs may hatch and larvae become established in the same tuber. The life cycle of *M. hapla* requires from 17-57 days depending on the temperature. Development takes place at temperatures from 60-90 F with an optimum of 75 F. It is possible for several generations of nematodes to develop in a season under optimum temperature and moisture conditions. Overwintering is generally in the egg or larval stage.

Root-knot nematodes have the widest host range of all known plant-parasitic nematodes, being known to attack more than 2000 species of plants. *M. hapla* is a parasite of several hundred cultivated plants, including such common ones as onion, beet, strawberry, alfalfa, bean, peas, clover, carrot, parsnip, cabbage, turnip, brussels sprout, broccoli, radish, pepper, tomato, potato, cantaloupe, cucumber, squash, and lettuce. Heavily infested plants are usually conspicuous because of unhealthy growth and may wilt severely during hot weather. Plants may regain their turgor and appear almost normal if the weather turns cool and moist, but once the temperatures turn warm again and soil moisture drops, the plants will again wilt.

Root galls incited by *M. hapla* blood vessels which supply the intestines could also influence the fluidity of intestinal contents.

Diagnosis

Diagnosis of brisket disease is complicated. There are no signs which are typical of this disease alone. There are several diseases commonly present in range cattle which can cause heart pathology and resulting circulatory disturbances. Examples are pulmonary emphysema, pulmonary parasitisms, and pneumonia. All these diseases can cause fluid imbalance and some of their symptoms are similar to those of brisket disease. The differential signs of these diseases and brisket disease are small and oval on fibrous roots but large galls may be formed on tuberous roots such as sugar beets and potatoes. Pearly white females can be observed by splitting open the root gall.

Young seedlings attacked by large numbers of larvae may die and the roots fail to show galling. In such cases, the roots are usually covered with attached females and egg masses are covered with adhering soil particles.

Tuberous roots may be infested without showing external galling symptoms. Potatoes may appear normal but contain nematodes. Egg masses in potatoes may be identified by brown spots of dead plant cells that have become discolored by contact with the gelatinous fluid of the mass.

Control of *M. hapla* is practically the same as for most soil inhabiting nematodes. They can be controlled for one season with 20-40 gallons dichlororopropene or 4-15 gallons ethylene dibromide per acre depending on soil type and the host plant, or by a 3-5 year crop rotation with a nonhost crop such as grain. Care should be taken if crop rotation is used since *M. hapla* has been known to attack and reproduce on grain although no galls were produced.

Brisket disease can occur at a sub-clinical level and, therefore, not be evident in the living animal. Cattle showing no external signs of the disease can have early stages of heart pathology and edema. This has been determined by postmortem examination of cattle living at high altitudes. When subjected to some physical stress, animals with these lesions will die in the same manner that cattle afflicted with brisket disease die. From the data in table 1 it is evident that a percentage of apparently healthy cattle, residing in cohabitation with afflicted cattle on the high mountain ranges, showed some degree of heart pathology, circulatory disturbances, and diarrhea. It may be that these cattle had sub-clinical cases of brisket disease. This could have been determined only by sacrificing the animals and examining the organs and tissues.

Research on brisket disease is continuing at Utah State University. Many of the physiopathological characteristics have been defined in recent years. More need to be defined. One of the major deterrents in solving the disease condition is a lack of understanding of the cause. Oxygen deficiency at high altitude can be only part of the explanation. This is evident when one considers the various high altitude areas within Utah inhabited by cattle with no history of brisket disease.

With brisket disease the cause can best become known by first learning the sequence of development. In a similarly indirect manner several diseases of man and animals, which at one time appeared to be unconquerable, have been or are now in the process of being resolved.

Simplification

(Continued from page 41)
the enzymes are composed of amino acids rather than nucleotides.

It is virtually certain that DNA transmits its genetic instructions by stipulating the order of the amino acid building blocks in the enzyme molecules. This ordering is accomplished through a special biological alphabet in which combinations of nucleotides make up the letters of the alphabet. In the last two years, scientists have made impressive progress towards understanding this alphabet, but the mechanics of its functioning remain relatively obscure.

Seeking simplicity

Obviously it would be extremely helpful if the researchers could somehow isolate a single unit of DNA that controls the conformation of one enzyme, or at most a very few. But such isolation is proving inordinately difficult to achieve. This is because every cell in a given organism, be it man or mouse, contains all the DNA determiners of all the enzymes that characterize that organism. In some cases this means enough pattern-determining DNA in each cell to account for several thousand enzymes.

Thus, if the scientist tries to use our more familiar animals or plants as sources of DNA, he at best obtains an exceedingly complex mixture. For example, each sperm cell from a bull contains 6 billion of the nucleotides that go to make up bovine DNA. The complexity of such a conglomeration has precluded isolating the comparatively few nucleotides (perhaps 300 to 1000) that determine one specific protein. To circumvent this problem, the scientists turned to organisms that operate at relatively simple levels of activity.

Bacteria and viruses

Escherichia coli is one bacterium that is widely used in diverse scientific investigations. Each cell of an E. coli bacterium contains only 12 million nucleotides rather than 6 billion. A definite improvement from the geneticists' viewpoint.

Virus are potentially even more promising as sources of DNA. Though viruses are so small that they can be seen only under the very high magnifying power of the electron microscope, they use the same DNA code to determine hereditary traits as do more complex organisms. And a virus may contain 100,000 or fewer nucleotides.

A few years ago, some Stanford University scientists found that one strain of the virus called lambda was especially well suited to studies probing the genetic functioning of DNA. Their "find" is a virus that infects bacteria, which makes it comparatively easy to use in the laboratory.

Under certain circumstances, lambda was found to carry the genetic instructions that determined the formation of galactose enzymes by the bacteria. These enzymes control the bacteria's use of the sugar galactose. Closely similar enzymes occur in virtually all animals, including man.

By isolating the DNA from the virus rather than the host bacteria, the researchers gained access to DNA information for galactose enzymes that is 100 times more pure than if it had been isolated from the bacteria. This is because of the relative numbers of nucleotides involved (approximately 100,000 for the virus versus 12 million for the bacteria).

The Stanford workers eventually developed a method for assaying isolated lambda DNA for the presence of this particular genetic information. Even though lambda is a relatively simple organism, it still contains far more DNA than that required for genetic control of galactose enzymes. As a result, no one has yet achieved the ideal of segregating the one unit of DNA that controls the one enzyme.

Scientists in the Biochemical Genetics Laboratory at Utah State University are currently working with lambda DNA trying to devise a way to come closer to the ideal.

Fracturing molecules

To date, the USU work has been directed toward breaking the long, rigid, typical lambda DNA molecules in a consistent, predictable fashion. It was discovered early that the long, more or less rigid structure of DNA molecules could be broken by rapid stirring when they were in solution. Furthermore, theoretical calculations, now supported by experimentation in various laboratories, indicated that the rod-like DNA molecules would tend to break first in the middle and give half molecules.

Numerous experiments were necessary to demonstrate that if the proper stirring speed was used, the molecules would indeed break into exact halves. By increasing the speed of stirring, the half molecules themselves can then be broken in half. Under certain experimentally determined conditions and with a great deal of care, the scientists can consistently break the molecules in equal quarters.

Purifying the fragments

The fragmentation, however, was just the starting point for really intensive investigations. The problem now in the process of being solved necessitates somehow separating the fragments of DNA molecules into identifiable fractions. What the scientists are seeking specifically, of course, is to isolate the fragments that do carry the genetic information about galactose enzymes from those that do not. The USU researchers have found two different techniques useful in solving the isolation puzzle.

One procedure utilizes the centrifugal forces of an ultracentrifuge (fig. 3). Materials placed in plastic test tubes in the machine are whirled at tremendous speeds. The forces generated effect separation of the constituents of the materials.

Fragmented DNA, in solution, is floated on the surface of sucrose solutions in the ultracentrifuge tubes. The heaviest DNA molecules move most rapidly to the bottoms of the tubes. Eventually the researchers learned that by stopping the centrifuge after 120 minutes,
functions in the forecasts, and is of prime importance to many of Utah’s citizens, is precipitation. Scientists at Utah State University have been determining precipitation probabilities in 30 representative locations in the state. Their investigations have been facilitated by a grant from Kennecott Copper Corporation and by access to the pertinent Weather Bureau computer cards.

Interpreting the graphs

Five examples of the results of the work at Utah State University are shown in fig. 1. You can determine the chance of receiving measurable precipitation (.06 inch or more) during any given week from the lightly shaded portion of the individual graphs. For example, at Lewiston, measurable precipitation probably will be observed any 7-day period in January in slightly more than 8 years out of 10. In July the chance is reduced to less than 4 years in 10.

The probabilities simply indicate the chance of occurrence. For example, .5 on the probability scale means that, on the average, rainfall will occur in a given week during one-half of the years graphed. There is no way of knowing in advance, however, in which particular years the rainfall can be expected.

The probability of receiving appreciable precipitation (.6 inch or more) in a given 7-day period is derived from the darkly shaded portion of each graph (fig. 1). For a given week in February, the rainfall will be .6 inch or more at Lewiston in only about 2 years out of 10. In July the chance of receiving .6 inch precipitation at Lewiston is only one in 20 years.

<table>
<thead>
<tr>
<th>Month</th>
<th>Station</th>
<th>Inches</th>
<th>Day</th>
<th>Year</th>
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<tbody>
<tr>
<td>January</td>
<td>Tropic</td>
<td>4.50</td>
<td>23</td>
<td>1943</td>
</tr>
<tr>
<td>February</td>
<td>Deer Creek Dam</td>
<td>5.08</td>
<td>1</td>
<td>1963</td>
</tr>
<tr>
<td>March</td>
<td>Manila</td>
<td>4.20</td>
<td>20</td>
<td>1932</td>
</tr>
<tr>
<td>April</td>
<td>Tremonton</td>
<td>3.30</td>
<td>11</td>
<td>1914</td>
</tr>
<tr>
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<td>Silver Lake, Brighton</td>
<td>3.00</td>
<td>19</td>
<td>1957</td>
</tr>
<tr>
<td>June</td>
<td>Escalante</td>
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<td>28</td>
<td>1910</td>
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<td>31</td>
<td>1915</td>
</tr>
<tr>
<td>August</td>
<td>Ranch (Kane County)</td>
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<td>31</td>
<td>1909</td>
</tr>
<tr>
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<td>4.09</td>
<td>11</td>
<td>1939</td>
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<tr>
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<td>Monticello</td>
<td>4.10</td>
<td>5</td>
<td>1911</td>
</tr>
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<td>Moab-Minesville</td>
<td>4.50</td>
<td>27</td>
<td>1919</td>
</tr>
<tr>
<td>December</td>
<td>Moab-Minesville</td>
<td>3.30</td>
<td>31</td>
<td>1915</td>
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<table>
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<tr>
<td>December</td>
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<td>1041.78</td>
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FOR JUNE 1964
The graphs illustrate striking differences among the 5 representative locations as to precipitation distribution through the year. At Lewiston, the probability of getting at least a small amount of precipitation (lightly shaded area) is highest from January through April. The probability drops sharply in June with the lowest value occurring during the first part of July. The probability rises considerably in October and again in December. These Lewiston interpretations indicate what can be derived from the other graphs.

Utah's multifarious precipitation picture

The differences in precipitation patterns through the state are attributable to topography and the general circulation of air.

Frontal activity. Most winter precipitation in Utah results from frontal activity. These are the fronts that develop in the Gulf of Alaska and eventually move across the United States in a west to east direction. Places such as Lewiston and Utah Lake at Lehi receive some precipitation from such fronts almost every week during the winter, but heavy storms are infrequent.

The west slopes of the Wasatch Mountains and the Wasatch Plateau receive moisture from these eastward moving fronts as the air rises and cools in passing over the mountains. Stations such as Emery, which are on the east slopes, receive little winter precipitation because the descending air has been milked of its moisture. Blanding, which is on a plateau about 130 miles southeast of Emery, receives more winter precipitation than Emery, but much less than Utah Lake.

Thunderstorms. Thunderstorms are common in Utah during the three summer months. This is the period when warm moist air from the Gulf of Mexico flows across Arizona and New Mexico and into Utah and Nevada. Most of the moisture delivered in this way comes from a few intense storms.

Blanding is subject to considerable summer thunderstorm precipitation. As the air comes in from the southeast, it rises over the Wasatch Plateau in the vicinity of Emery. Hence, summer storms also account for a large share of the yearly precipitation in Emery. Summer precipitation is less at Utah Lake Lehi than at Emery and Blanding and is further reduced at Lewiston.

Closed lows. Several times during the year a cutoff, counterclockwise circulation develops aloft over Nevada or Utah. This circulation, called a Nevada low, is most common during May and October, when the predominant general air circulation over the region is changing between that from the Gulf of Alaska and that from the Gulf of Mexico.

The characteristic circulation around a closed low pressure center aloft produces an upward displacement of lower level air as it is sucked into the center of low pressure. Quite general and heavy precipitation often results, and this phenomenon accounts for a fair percentage of the total moisture recorded in Utah during many years. In fact, the probability of receiving appreciable precipitation in a 7-day period is at or near its greatest in either May or October (during the closed lows seasons) for all Utah stations.

Orographic precipitation. Orographic precipitation is possible throughout the year. It results when moisture-laden air moves up a slope, cools, and releases precipitation.
The orographic effect generally is superimposed upon other causes of precipitation in the Intermountain Region. This means that the amount of precipitation obtained from a given storm usually increases as the altitude of the reporting station increases. For example, Utah Lake at Lehi has an annual precipitation of about 10 inches, whereas the top of Mt. Timpanogos only 12 miles away receives more than 50 inches. The orographic effect is illustrated by the precipitation map (fig. 2).

Extremes and averages

Probability studies such as those just described were virtually impossible until 1948 when computers began to provide the necessary speed and volume capacity. Even before the computers eased the time element of data processing, however, Weather Bureau personnel routinely summarized the climatological records. Then, after the summaries were prepared, data were extracted on extremes and averages of the various climatic factors. Some of this information relative to Utah is given in table 1.

The greatest monthly precipitations ever reported in Utah (13.70 inches) was recorded during January 1956 at the Alta station. Other record amounts of precipitation received in Utah are compared with United States and world records in table 2.

The average annual precipitation in Utah from the 1890's to 1963 is charted in fig. 3. The values indicated were averaged from data accumulated at various stations over the entire state.

Periods when the precipitation was generally high (such as 1905-23 and 1936-47) and when it was generally low (such as 1924-35 and 1948-63) can be determined. But the "dry" 1942, which occurred during a wet cycle, is an example of the lack of consistency between years that prevails within any given cycle. It was this very lack of consistency that limited the predictive value of climatic averages and emphasized the need for probability studies.

The next installment of this series will illustrate how climatological records are used to gain a better understanding of the temperature component of our climate.

FLUOROSIS

(Continued from page 45)

The teeth

The teeth are reliable indicators of fluorine toxicosis. Fluorotic dental lesions, however, only indicate fluorine intake during the period of tooth development. The characteristic dental lesions will not appear in animals brought into endemic fluorosis areas after their permanent teeth have erupted. Dental fluorosis has not been observed in deciduous teeth of domestic animals.

Depending upon the amount of fluorine ingested, affected teeth erupt with characteristic markings, Mottling, staining, defective or incomplete development, deficient mineralization, and abrasion are associated with dental fluorosis.

The extent and degree of such lesions depend upon the seven factors cited previously. After defective development or a certain degree of mottling occurs, the teeth are subject to increased rates of wearing which can be intensified by abrasive feeds. Incisors and molars should be examined and evaluated since positive relations exist between the dental fluorosis of certain incisors and the degree of abrasion of certain molars. Standards have been developed to facilitate clinical diagnoses (fig. 1).

The degree of dental fluorosis in an animal can be correlated with the amount of fluorine in the bones, the extent of fluorotic bone lesions, the duration of exposure, the age of animal during exposure, the amount of fluoride ingested, and other reactive processes of the body. Such correlation is essential to accurate evaluation of the degree of fluorosis.

The bones

The level of fluorine storage in the bone can increase within limits over a period of time without eliciting any demonstrable changes in structure and function. Eventually, however, if levels of fluorine ingestion are higher than normal for sufficient lengths of time, structural changes will become evident. Characteristic fluorotic bone lesions may develop and function may be adversely affected. The most characteristic bone lesions are increased density or excessive bone growth (fig. 2). Other gross, microscopic, and radiographic lesions, however, are also associated with the bone involvement. Structures within the joints are not primarily affected.

Different bones from a given animal and different anatomical areas of a specific bone vary in amount of fluorine retained and in degree of abnormal reactive change. In taking bone samples, therefore, it is important to use bones for which standards have been established (metacarpal, metatarsal, rib, pelvic, and mandibular) and to consistently select the same anatomical regions.

Intermittent lameness and stiffness are usually seen in advanced cases of fluorosis. The degree of the bone lesions and the mineralization of structures around the joints and of tendon insertions on the bones influence the degree of disability. In turn, the intermittent lameness and stiffness are likely to discourage the affected animals from standing at the manger or grazing. The subsequently reduced feed intake then fosters reduced levels of performance of the animals.

Other effects

Ingestion of high levels of fluorides (93 parts per million) by dairy
No substances are known to prevent completely the toxic effects of ingested elevated levels of fluorides. Some products, however, can counteract and lessen the damage that fluorides cause. Aluminum sulfate, aluminum chloride, calcium carbonate, and de-fluorinated phosphate have been successfully used in reducing the toxicity of fluorine.

Potential adverse effects of hay that is high in fluoride content can be offset by mixing it with hay of low fluoride content. If the animals’ drinking water is high in fluoride content, their feed should have a low fluoride content. If a farm’s forage-producing land has a high fluoride content, it can be used to grow cereal or nonroughage crops which do not accumulate fluoride from the soil as readily as do forage crops. In such cases, hay or roughage with low fluoride content should be imported from low fluoride areas. All mineral mixtures fed should contain de-fluorinated phosphate.

\section*{Starlings (Continued from page 48)}

Maintaining body heat important need
That maintaining body heat in winter is of increasing importance to starlings was clearly shown by the change in their feeding habits as winter advanced. We regularly drove along a prescribed census route to count birds and their activities. When the maximum daily temperatures were above 60 degrees F, we observed only half the birds feeding at a given time. As the temperature dropped, the percent of birds feeding rose steadily until at temperatures below 20 degrees more than 90 percent of the birds were seen feeding. This means that in such cold weather a bird must spend virtually all of the daylight hours feeding in its attempt to maintain body heat. At the same time, the use of feedlots increased. When maximum daily temperatures exceeded 60 degrees, only 10-15 percent of starlings were seen in feedlots, but below 30 degrees this increased to 60 percent. Birds also fed more on windy days than on calm days; this again was probably in response to greater food requirements, since wind increases heat loss from the body. Hence wind, cold, and snow all increase the use of feedlots.

The sight of several thousand starlings eating all day long every day at a feedlot gives a farmer cause for concern. We found a starling ate about ½ ounce of mash a day during cold weather. This means that a flock of 6,000 birds could eat 250 pounds of mash a day. When kept up week after week, such feed losses are substantial to the feedlot operator working in a competitive market. Equally serious may be the contamination of feed by starlings, making the food less palatable to livestock. For this reason, the U. S. Fish and Wildlife Service is trying to find an efficient means of control where starlings are causing undue damage.

Control of starlings
Poisons are most readily used, but they are dangerous to livestock and other domestic animals. In addition, dogs or cats eating the poisoned starlings may in turn die. Likewise, starlings quickly avoid areas where dead birds occur. The Fish and Wildlife Service made extensive tests at the large feedlots west of Ogden this past winter with good success. However, it does not yet feel that any poison is safe enough to turn over to general use by farmers or government agents.

A proposal still waiting full-scale field testing is “birth-control.” Placing of a chemical in bait taken by starlings has been shown to kill the sperm of males without eliminating the sexual behavior of the birds. The result is that starlings go through courtship and normal nesting, but the eggs are sterile. The female sits...
on her eggs so long that her chance of laying a second clutch and eventually bringing off a brood is slight. This would, of course, require the sterilization of large numbers of birds before farmers would benefit from the results.

Much more successful have been various methods of capturing starlings. Fish and Wildlife Service biologists working in the Boise Valley have succeeded in capturing thousands of starlings by spotlight. By shining powerful searchlights toward the roosts and then scaring the birds up, thousands have been caught in the nets placed between roost and lights. This method requires large concentrations of birds to be worthwhile, probably much higher numbers than we now have in Utah. Besides, the birds that one might catch at roosts in cattail marshes may mostly migrate through that area. The large flocks that cause the damage in midwinter are by that time roosting in warmer and more secure places. Although thousands of starlings have been trapped by spotlighting, they still represent only a small fraction of the birds present.

During our study we trapped several hundred starlings at a single feedlot using the so-called Australian crow trap, baited with lard cracklings (fig. 4). The trap is most effective during cold weather with snow on the ground. Because such traps need considerable adjusting and frequent tending, we doubt if stockmen would find their use satisfactory.

The above methods of controlling starlings all suffer from having to be repeated regularly year after year. Hence, any method that would be more permanent in effect would be valuable. The strong dependence of starlings on feedlots suggests a possible method. Since in the coldest weather starlings rely heavily on feedlots and must feed virtually from dawn to dusk, any method of disrupting their feeding could lead to loss in weight and subsequent death of substantial numbers of birds. So, any modification of design of mangers that would make it more difficult for starlings to reach the food might be successful. Alternatively, a device to frighten birds at the feedlots long enough to disrupt their feeding could bring the same result. The Fish and Wildlife Service is not overlooking any of these possibilities and farmers should expect more concrete help in the future.

PHOSPHORUS

(Continued from page 47)

for each year. A significant difference exists between the amount of phosphorus removed from the check plots and the various treated plots. Significant differences were also measured among the 66, 132, and 264 pound rates. The total amount of phosphorus removed by the crop was closely related to the amount applied.

research reports

Food technology and research grant

AROMA and flavor are among the most important factors in consumer acceptance and satisfaction of edible farm produce. The mechanism of today's agricultural marketing system is such that a large portion of the produce in retail markets has been artificially ripened. Because our producing areas are remotely located from consuming areas, the produce has to be harvested in the green state so that it will stand a transcontinental journey. Other types of produce may have to undergo long periods of storage before being placed on the market. In both of these situations the flavor and aroma of the product reaching the consumer may be inferior to the fresh product. Just what happened inside the product to produce this deterioration is not well understood at the present time. Nor have the precise factors that produce aroma and flavor been delineated.

Recently USU has received two grants to conduct research into factors controlling the flavor of fruits and vegetables. The National Institute of Health has awarded $85,832 for a study of the biosynthesis and degradation of flavor and aroma components of certain fruits. The specific aim of this research is to determine what substances are responsible for the flavor and aroma of fresh fruits and what changes take place during the development and eventual deterioration of the mature fruit. This research is possible because the Experiment Station has acquired a gas chromatograph.

Drs. Olson and Salunkhe examining the recently installed gas chromatograph to be used in the study of the biosynthesis and degradation of aroma and flavor components of fruits
which separates volatile compounds into their various components and an infrared spectrophotometer which aids in the identification of the separated compounds in minute quantities. Once the characteristic compounds are known, the agents responsible for undesirable changes can be determined and attempts can be made to find ways to control their action.

Another grant of a Tectrol generator worth $20,000 and of $2,600 for a research assistantship from Whirlpool Corporation, St. Joseph, Michigan, will permit studies to be conducted on the effects of a controlled atmospheric environment containing increased carbon dioxide and decreased oxygen on the storage life, quality, and biochemical changes of fruits and vegetables.

Understanding how flavors and aroma of fruits change during ripening and storage should facilitate control of these changes to the eventual advantage of the consumer.

D. K. Salunkhe, project leader, and L. E. Olson, both of the Department of Horticulture, will conduct the research.

New Publications


In this publication, the author points out that because of the economic disadvantages in transfer costs of both feed and finished product, Utah is not likely to increase her relative position in turkey production. Experienced producers with physical facilities and satisfactory tie in arrangements for raw materials and turkey processing will continue in turkey production. Net returns will be slim and will accrue only to better than average producers.


This report cites data gathered over a period of 12 years from various controlled experiments that have been correlated with thousands of field observations and examinations in an effort to evaluate fluorosis in cattle more effectively.


This circular describes equipment for making holes for nesting sites for the leaf-cutting bee, which is effective in pollination of alfalfa.


This report describes the significant changes in the dairy industry in Utah in recent years and predicts the continuing importance of the industry in the state.

Utah Res. Ser. 21. Sugar beet production in Utah: cost and net returns 1945-63, by E. M. Morrison, Department of Agricultural Economics. 9 p.

In this report costs of producing sugar beets and net returns based on yield from 1945 to 1963 are given. Size of enterprise and yield as they affect returns are also considered.

CONTRIBUTIONS TO RESEARCH

February 1, to May 1, 1964

| National Institutes of Health | $17,100 for study on the role of estrogen in corpus luteum function |
| U. S. Army Research Office | $11,064 for study of thermochemistry of organic molecules |
| Merck & Company, Inc. | $2,000 for study on use of amproluim in coccidiiosis of cattle |
| Birds Eye Division General Foods Corporation | $1,650 for study of endocrine interrelations in female reproduction |
| Shell Company | $1,500 for study of induction and analysis of eye mutations in Drosophila |
| Stauffer Chemical | $8,070 for study of alkaloids of some rare papaveraceae plants |
| Phillips Petroleum Company | $1,150 for insect studies |
| J. R. Simplot Company | $500 for fertilizer studies |
| Agricultural chemicals for research purposes have been provided by the following companies: American Cyanamid Company, California Chemical Company, Chemagro Corporation, Niagara Chemical Division, Shell Development Company, Stauffer Chemical Company, Velsicol Chemical Corporation. |