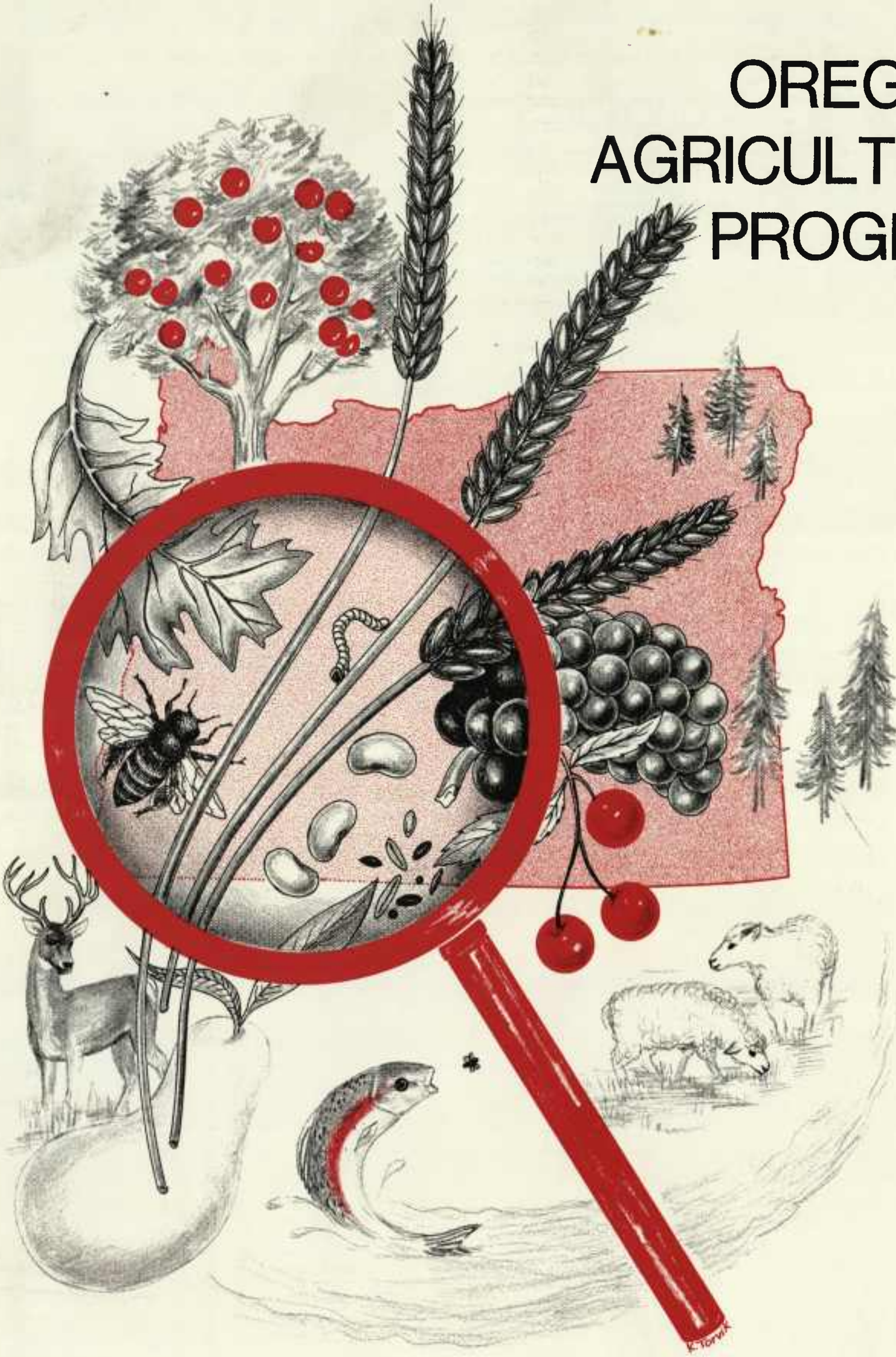
OREGON'S AGRICULTURAL PROGRESS



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OREGON'S AGRICULTURAL PROGRESS

Contents

Face(t)s of agriculture

This issue of *Oregon's Agricultural Progress* presents an expanded look at agricultural research of Oregon State University.

Information for the issue came from a spring quarter seminar sponsored by the Department of Food Science and Technology. Called "The Many Face(t)s of Agriculture," it was the idea of H. W. Schultz of that department who felt that OSU students, and those in food science particularly, needed to learn more about other phases of agricultural research.

Schultz signed 15 OSU speakers for the weekly seminar sessions. Each is a research scientist and a leader in his field. The seminars were open to all.

Information in this issue came from the sessions and from talks with the seminar speakers. The result shows the diversity of Agricultural Experiment Station research in Oregon, work with wide-ranging significance in the push to improve food supplies and lower food costs at home.

It is work we in the Experiment Station can be proud of.

G. BURTON WOOD
Director

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Needed: nature's nitrogen

Nitrogen, comprising nearly 80 percent of the air we breathe, is otherwise useless to man unless it is in a form that he can eat. Only when it is converted to the amino acids and proteins of meat, cereal grains, and other foods is it worthwhile as a nutrient.

With the worldwide population explosion demanding more food from plants and animals, basic research in protein production has assumed increased importance.

One way to boost protein supplies is to learn more about nitrogen fixation or how nitrogen is transformed into substances usable by plants for making protein.

Oregon State University researchers are probing this natural chemical process which may hold the promise of helping to meet the world's protein needs while conserving energy sources.

Looking at nitrogen fixation is a team of plant scientists headed by plant physiologist Harold J. Evans. Their work is part of several continuing National Science Foundation funded projects within the Agricultural Experiment Station.

There are several ways in which nitrogen gas can be combined with hydrogen to form ammonia. Industrial fixation using high temperatures and pressures forces the reaction and represents how nitrogen fertilizers are produced commercially. Energy requirements are high for this process,

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Nitrogen-fixing microorganisms in nodulated roots of alder produce more than 200 pounds of nitrogen per acre per year. Oregon has over one million acres of alder forests.

Azolla filiculoides, a small water fern, has a blue-green nitrogen-fixing alga in its fronds. It is one of nature's more unusual ways of changing atmospheric nitrogen into a form usable by plants.

and fuel must be expended to transport the manufactured product to the farm.

Some nitrogen is fixed in the atmosphere by lightning and a small amount is produced by volcanoes. The resulting compounds are washed by rain into the soil.

But by far the major source of fixed nitrogen today comes from biological fixation.

Primary biological nitrogen fixers are the bacteria that live in the nodules on roots of legumes and such plants as alder. Other kinds of soil bacteria synthesize ammonia at normal temperatures and atmospheric pressure. Some microbes degrade more complex nitrogenous materials into simpler ammonia by decay processes.

In the United States in 1972, approximately nine milion tons of nitrogen at an estimated value of $3.6 billion were manufactured naturally. Comparable figures for Oregon in 1973 were 104,000 tons and $42 million.

Because of new and more sensitive methods of detecting biological nitrogen fixation, estimates of nitrogen's contribution to protein production have increased.

Biological nitrogen fixation is a complex chemical process. Nitrogen gas from the atmosphere is combined with hydrogen atoms from plant sugars to form ammonia. Ammonia is then used by the plant where it undergoes transformations that eventually produce proteins.

This complicated series of events occurs naturally only when certain conditions exist. These include the presence of a nitrogenase enzyme complex from bacteria in the legume nodules, a reaction enhancing agent, and energy.

Energy is provided by sunlight which falls on leaves and which has been converted by photosynthesis into sugars which are used by cells to make the energy storage molecule adenosine triphosphate (ATP).

"The role of nitrogenase enzymes in plants still needs fuller clarification," Evans explains. But the OSU team does know something about its composition.

At least two distinctly different proteins comprise the enzyme. One contains iron and the other, molybdenum and iron. Both are essential to fixation.

Recently Evans' team successfully separated nitrogenase from soybean nodules into its two protein components. One of these, the molybdenum and iron component, has been obtained in pure form.

The scientists are using soybeans in their program because they have large root nodules that are easy to work with. In addition, soybeans, one of the world's most productive protein crops, contain more than 40 percent protein, compared with 15 percent in wheat or corn.

In other research, Evans is looking at non-leguminous plants like wheat and oats which do not contain the root nodules usually associated with the nitrogen fixing ability. Yet laboratory tests show that some of these plants are producing nitrogen products.

The National Academy of Sciences member is examining not only the free living soil bacteria for a clue to these plants' unexpected ability, but also is hoping to get help from plant breeders to look at the genetic make-up of these grasses for any signs of compatibility with nitrogen fixing organisms.

A surprising discovery that has come out of the search for nitrogen fixing plants may have implications for Oregon's lumber industry.

Working with Ramon J. Seidler and Paul Aho, the group discovered bacteria in decaying white fir heartwood that fix nitrogen. Since fungi require nitrogen to cause decay and wood is very low in nitrogen, this finding could explain where the nitrogen comes from.

"In light of worldwide shortages of food to feed people and fuel to run industrial processes," he says, "we are obliged to continue this work which might help alleviate both shortages. In addition, we can minimize environmental contamination from applying excess commercial fertilizers by letting nature produce and regulate the amount of nitrogen needed."

"We are going to need all the nitrogen we can get from fertilizer and from biological nitrogen fixation in order to feed the people of the world," Evans concludes.

Ground level approach

Mixing garbage with desert soil, a potential garbage disposal method, offers new challenges for scientists who must determine effect on the soil and crops grown on the soil-garbage mixture.

Thomas L. Jackson of Oregon State University really digs his work.

In fact, this researcher samples, examines, tests, and evaluates it. The target of his study? Dirt.

But Jackson is not getting his hands soiled unnecessarily. Working with a team of Experiment Station and Extension Service experts, Jackson is studying soil fertility and plant nutrition. He wants to gauge the effects of fertilizers on increasing crop yield and quality.

For more than 20 years, Jackson has been looking at the effect of fertilization on Oregon crops. Commonly used fertilizers are nitrogen, phosphorus, potassium and lime.

"The most obvious effect of fertilization," Jackson observes, "is a straight increase in crop yield. Nitrogen applications to Willamette Valley field crops are a good example."

Farmers have come to rely on nitrogen fertilizer to boost production. But they have suddenly run up against worldwide energy shortages which may drastically reduce nitrogen supplies.

"There is no longer an endless supply of nitrogen fertilizer," Jackson warns, "and Oregon's farmers are likely to experience reduced yields and lower income." Natural gas is used in distilling nitrogen from the air.

One of eastern Oregon's major crops—potatoes—suffers from nitrogen deficiency.

"With increased nitrogen," Jackson points out, "size and yield are improved but grade can sometimes be reduced.

"There is a need," the OSU scientist goes on, "to identify specific combinations of factors which affect soil fertility. We must check beneath the soil surface." Moisture-holding capacity and chemical characteristics must be examined, too.

Various OSU research projects point to the depth of study needed. Land use planning and some solid waste disposal plans are often dependent on soil qualities.

In one test in the Boardman area, OSU soil scientists sought ecologically sound ways to dispose of the solid wastes and garbage generated by the metropolitan areas of the state.

Applying 400 tons of these wastes to each acre, the research team grew an

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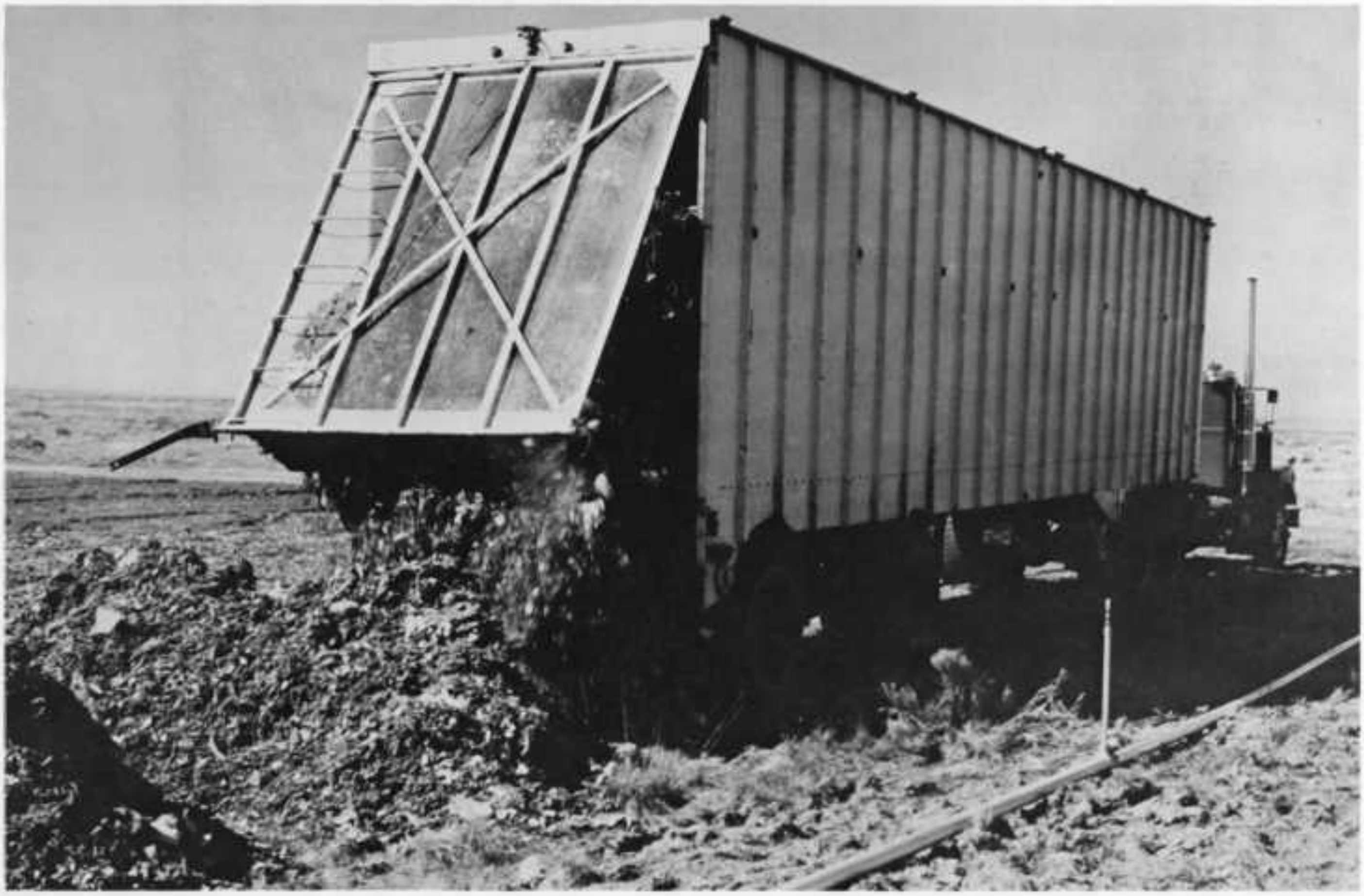

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alfalfa crop on ground previously deemed unproductive.

"These wastes may or may not have helped," Jackson notes. "But this test did show us at least one way to use them."

A cautionary note is sounded, however. The OSU team has found that garbage in fields and landfills produces a high concentration of boron. This chemical element is toxic to some crops.

Other micro-nutrients and their relationships with crops and animals have also come under scrutiny by Experiment Station agricultural chemists.

For instance, copper and molybdenum significantly affect hay and pasture production in Oregon. Hay is the state's top cash crop.

In areas west of the Cascades, lime applications increase hay yields and boost the number of animals that may be grazed on each acre.

"Molybdenum is deficient in a lot of Oregon's hill soils that are acid and respond to lime," Jackson relates. "In many cases, just one-half pound per acre increases forage production for 5-6 years and can substitute for part of the lime need."

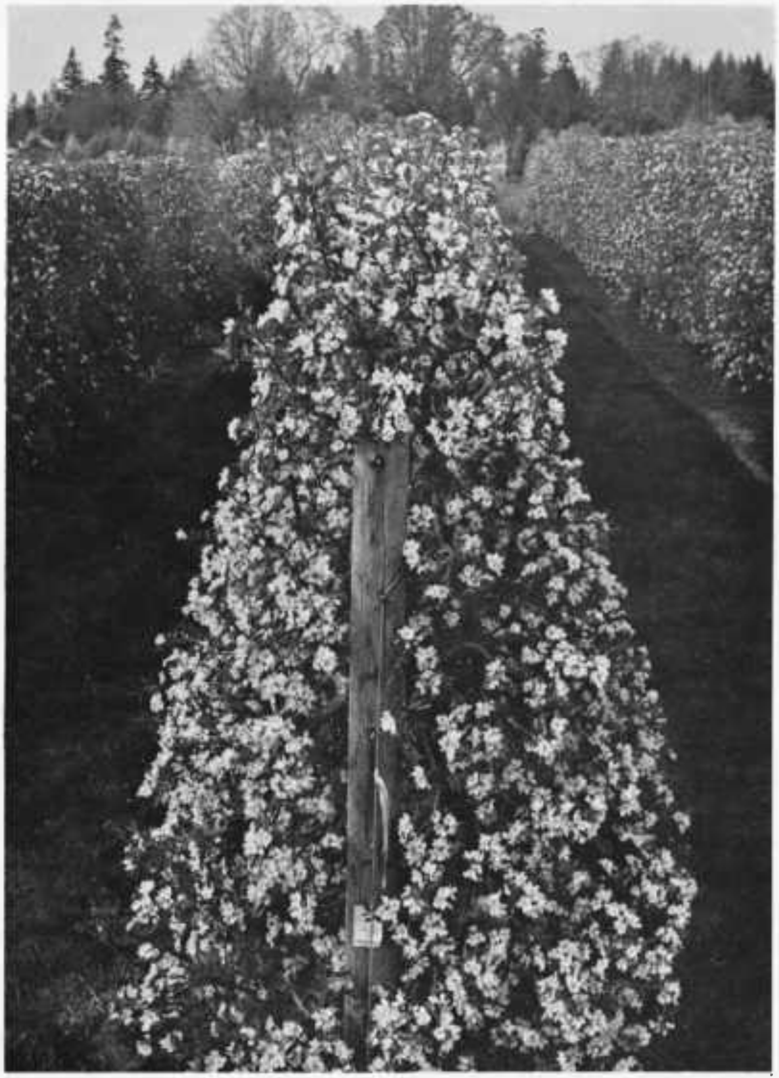
Pasture trials at Klamath Falls have shown that copper is needed to aid growth and improve forage and hay quality. Areas in southeastern Oregon that are low in copper are frequently high in molybdenum. This condition interferes with how well livestock are able to use copper.

"Our soil acidity adjustments and fertilizer applications almost doubled yield," Jackson reports. "More importantly, germination content increased."

Other soil acidity studies have focused on Oregon's garlic seed producers. As a result, acreage devoted to this specialty crop is on the increase.

In an attempt to grow alternate crops on some of Linn County's poorly drained soils, presently suited to growing grass seed only, the OSU team turned to beans. But manganese toxicity problems showed up.

"After tests with different combinations of lime and potassium fertilizers," Jackson concludes, "we found that liming acid soils to reduce manganese toxicity and broadcasting potassium fertilizer or using potassium sulfate for the potassium needed at planting eliminated manganese toxicity."



Densely planted red delicious apple trees form a hedge and are pruned like Christmas trees to provide maximum exposure to the sun.

Density produces fruitful harvest

Imagine having to spend most of your waking hours in search of food to feed yourself and your family.

That is probably what you would be doing if modern, scientific agriculture were not doing it for you.

Natural farming is fine—if you want to spend the time and effort in your home garden. But to feed the world's people, agriculturists need to help nature.

Those are the opinions of Melvin N. Westwood, a leader in Oregon State University's plant research effort. He and his colleagues are trying to develop controlled production systems which will result in the most efficient operation for the grower.

"Today's U.S. farmers do a job that nature could never do alone," Westwood asserts. "Just three percent of our population produces enough foodstuffs to feed the entire country with some left over for export."

Oregon's horticulture industry is throughout the state. Producers raise crops adapted to local climates and growing conditions.

"Each of these production areas," Westwood notes, "is supported by various research and extension arms of OSU."

Over the last 15 years, Westwood's team has concentrated on problems encountered by the fruit grower from planting until harvest. The range of subjects is broad, and experimental work continues.

OSU's horticultural research program operates on the principle that, to develop new and possibly useful methods, researchers must go to the limits of present knowledge and then push beyond.

"We are trying to show the limits of a system," Westwood says. "Then, if the economic climate is right and we can make some adjustments to the controllable variables, it is possible to increase crop yields by two or three times."

Two projects illustrate this philosophy. Both are concerned with converting orchards from extensive to intensive operations.

Extensive orchard culture is the traditional method of raising tree crops. Trees are spaced on 25- to 40-foot squares which translates Into 27 to 70 trees per acre.

In one Intensive culture test, Comice pear trees on quince rootstock were planted on 15 by 4 foot grids, equivalent to 720 trees per acre. The trees grew to about 11 feet tall. Pruning each tree into a modified Christmas tree shape, Westwood sought to increase leaf sunlight interception and improve foliage efficiency.

"We try to get as many leaves illuminated by sunlight for as long as possible each day," explains Westwood. When height of the row does not exceed width, the trees are easier to harvest, too.

Yield from this test planting almost tripled normal production. Compared with 6-8 ton per acre averages, the experimental orchard yielded more than 20 tons per acre of high quality fruit.

Another high density system project featured Golden Delicious apples on an English rootstock.

In this test, tree density reached 3,600 per acre in a 2 by 6 foot pattern. Pyramidal pruning reduced the incidence of one leaf being shaded by another.

"Our target yield for this trial was 50 tons per acre," Westwood says.

In the first year, yield was 1½ tons per acre. By the fourth season, the trees produced 50 tons (2,600 boxes) per acre, and they advanced to 74 tons of fruit in the sixth year.

"We were very pleased with the results," Westwood asserts. "Average yield from traditional extensive plantings is only 500 boxes of fruit per acre."

"However," he cautions, "remember that this is a test planting. Under uncontrolled conditions, yield might not be as high. Besides, crowding may affect fruit quality and size somewhat."

Two major hurdles slow the transition from extensive to intensive cultural practices. One is economic while the other is technological.

The established orchardist has a lifetime investment in his widely spaced trees. To reach full production, low density plantings take 15-20 years. The grower can't afford to pull out his trees and start all over.

Mechanical engineering difficulties are the other problem. Existing farm implements—tractors, cultivators, and harvesters—are designed for widely spaced crops. Agricultural engineers need to develop equipment adapted to high density production systems.

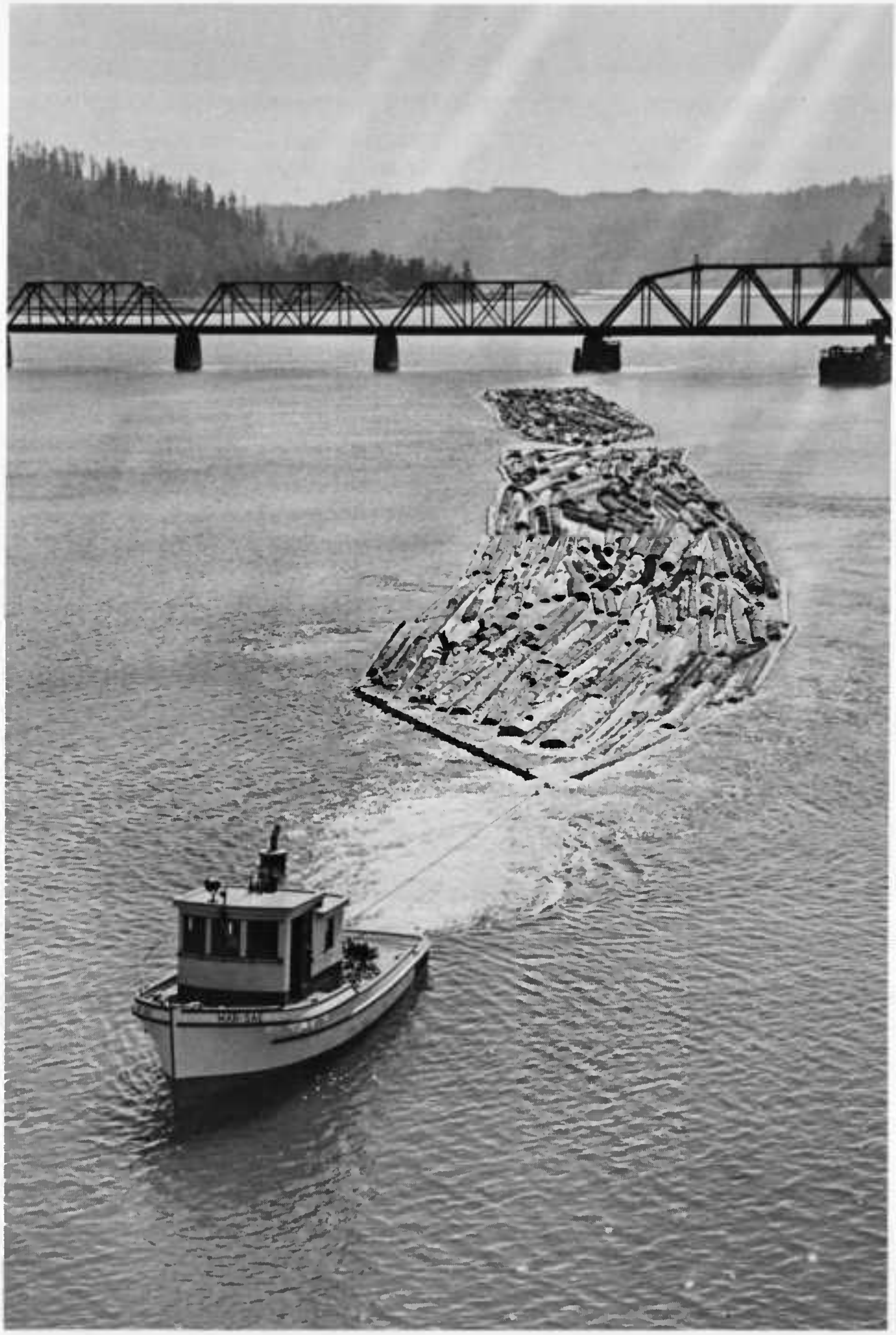
"In recent years, there has been a gradual shift from 70 toward 200-300 trees per acre," Westwood explains. "We consider this good progress toward our goal of higher crop densities."

Efforts by Westwood's staff to conserve energy and natural resources through highly efficient production systems take on greater significance with worldwide shortages.

According to Westwood, the objective of scientific farming should be to convert the maximum amount of sun energy into a usable product. He believes that his controlled, integrated biological systems are effective and efficient ways to meet this requirement.

Horticulturist Melvin Westwood checks the crop on a hedge row of semi-dwarf golden delicious apple trees.

Economists check a new pulse



Rural resource utilization is an expanding area of study by OSU agricultural economists.

If Congress should approve diversion of Columbia River water to the Southwest, would Pacific Northwest residents lose anything besides the water?

What is the best way to develop and protect Oregon's salmon fishery resource?

Knotty questions like these are often handed to Oregon State University's agricultural economists. They must study each and then propose solutions while laying out the possible consequences of each.

But why are agricultural economists studying water and fish resources? Isn't their expertise more concerned with farming and farm policy?

American agricultural economics is broadening its scope. These non-farm resource studies reflect the new directions in agricultural economics research today.

Until several years ago, OSU's agricultural economics program largely mirrored the traditional emphasis on farm management, marketing, agricultural policy, and land tenure.

Research projects studied the application of economic principles to various farming decisions or focused on rural firms and marketing systems. Other work concerned how agriculture serves society and the impact of agricultural resource ownership on farming decisions.

But, beginning about 20 years ago, criticisms were leveled at agricultural economics from inside and outside the profession.

Critics charged that economics researchers had lost sight of the needs of the people, particularly the rural poor, in their preoccupation with agricultural commodities and production efficiency.

In response to these charges, agricultural economists shifted research direction.

"More recent concerns mark a significant trend toward a change in focus at OSU," observes Emery N. Castle, dean of the Graduate School and former head of the Department of Agricultural Economics.

The new emphasis stresses solving people's problems by learning about the social health of the rural environment and how rural resources are used.

For instance, as agriculture commercializes rapidly, rural society fractures into three segments.

One part remains in commercial agricultural production and is in the mainstream of rural life. However, as commercialization proceeds, fewer and fewer people remain in this group.

"This phenomenon," Castle remarks," "illustrates how traditional agricultural economics has focused on smaller and smaller groups."

The second grouping is comprised of small, subsistence farmers. These rural residents are bypassed by the industrialization of agriculture.

Finally, there are those who are forced by economic and social circumstances to move to urban areas.

Studies of rural communities were given national impetus by passage of the Rural Development Act of 1972.

Tillamook County is to be the site for initial Oregon studies under this act. Home economists, Extension Service staff, and agricultural economists are looking at health delivery systems, waste disposal plans, and income sectors operating in this coastal region.

Resource economics, the other new approach, concentrates on land use planning, water resource development, and environmental economics.

Illustrative of this are OSU's continuing studies of how to proceed with development of the state's salmon fishery resource. The question contrasts commercial versus recreational uses of this resource.

"Because the accepted methods of analyzing sports and commercial fisheries differ," Castle explains, "we are presently faced with analyses that are irreconcilable in any satisfactory way."

OSU agricultural economists hope to find a common ground for correlating the research findings.

In the "new" economics, Castle believes researchers are deliberately taking multiple views of each problem. To him, this is the basic difference from traditional economics.

A good example of the shift in outlook is the OSU study of the economic consequences of interbasin water transfer from the Pacific Northwest to the Southwest.

In this study, the United States was divided into four regions. The researchers then tried to analyze the impact of water transfer on each region.

"The really big effect," Castle claims, "would be a transfer of income from the rest of the United States to the Southwest." The Pacific Northwest would benefit slightly, due to stimulation of general economic activity.

These findings have moved arguments for or against interbasin water transfer into the arena of national economic impact. No longer do Northwest residents opposing transfer have to rely on what could be attacked as a regional resource protectionist attitude.

Special problems facing rural communities are a new research focus for agricultural economists.

"It is important to note," concludes Castle, "that this problem was viewed from a non-traditional standpoint. This method of study has given the region's spokesmen much more defendable arguments."

The OSU agricultural economist thinks that there are some dangers in the new approaches, too.

One possible problem, he says, is that traditional agriculture will think that agriculture's interests are not being protected.

"But I would encourage the 'new' approaches," he says, "because they give traditional agriculture a defense against criticism. Besides, public agencies like OSU should be concerned about public interests."

Variety show never ends

Scientific plant breeding holds the key to increased profits for the commercial grower and a better agricultural economy for Oregon.

Hyslop wheat, a variety developed in the plant breeding program at Oregon State University, added $12 million last year to the value of the crop. Not only does Hyslop yield well, but it also has excellent milling and baking qualities. The search for these attributes is a major objective of the breeding program, too.

But to realize such economic gains, plant breeding must be a continuing program.

At OSU's Agricultural Experiment Station in Corvallis and at branch stations from Pendleton to Klamath Falls, plant breeding experts are conducting extensive research to develop plant varieties tailored to Oregon's diverse climate, soils, and plant diseases.

The plant breeding program is geared to improving the state's cereal grain crops. Up to 10 years may be needed to develop and prepare each new variety for release.

Soft white winter wheats, which contribute about $167 million annually to Oregon's economy, receive primary research emphasis at OSU. Also studied are malting barley, feed grains, and other market classes of wheat.

Some of the problems facing plant breeders are climatic. But overriding concern to the state's plant scientists are plant diseases. Resistance to disease attack is mandatory before any variety is released.

Genetic variability is the key to progress in solving these problems. If all plants were alike, little headway would be possible.

The crux of any plant breeding program, says OSU plant breeder Warren Kronstad, is to determine in what combinations cultivars should be crossed. In the case of wheat, there are over 30,000 varieties and many more experimental lines.

To do this, Kronstad and his co-workers utilize information gained throughout the world regarding various varieties, especially their genetic potential as parents. Attempts are made to match the varieties in such a way that subsequent progeny will have the desired attributes of the respective parents.

Once the desired match is selected, the pollen is transferred by hand from one plant to another. OSU's program includes 4,000-5,000 such crosses each year.

Seed from each cross is sown in test plots to see how the blended genes enhance or detract from desirable plant traits.

Six or seven hundred plants per cross are propagated during the second growing season when trait differentiation is marked. Culling is ruthless. Plants with the slightest fault are thrown out of consideration.

Qualitative and quantitative traits are sought. The first kind—color, height, and disease resistance, for example—are relatively easy to detect. They may be sorted out in the early generations of the resulting progeny.

OSU's agronomists have created disease epidemics, for example, to check test plantings for disease resistance. They even put disease spores directly on the test plants to assure that resistance is true for each and every one.

Another qualitative trait is peculiar to western Oregon. Here, plants may be poisoned by minute amounts of aluminum in the soil.

But Experiment Station workers have developed recently a way to select plants unaffected by aluminum in wheat fields.

Quantitative characters such as winter hardiness, yield, and flour quality are more difficult to pick out.

Because the environment exerts great influence on these genetically controlled characters, plant breeders turn to computer models for the probable climatic effects and the environment-genetic interactions needed to evaluate all possible which may influence a trait. Fourth and fifth generation progeny are often required to evaluate these complex traits.

Also compared are different cultural practices to learn how the variety performs under varying crop management systems and climates. The goal is to fit the plant to precise site differences throughout Oregon in order to obtain maximum yields of a high quality product.

Top: Cereals breeder Warren Kronstad checks research plots that contain thousands of new crosses of wheat. Bottom: Individual heads of wheat are prepared for making crosses.

During extended experiments to produce a new wheat variety, Kronstad's staff determines the yield, nutritional properties, and milling and baking traits of the flour, too. A high quality product is demanded in domestic and foreign grain markets where buyers are very selective.

Future research at OSU may produce varieties better able to use moisture and to control erosion. Experiment Stations agronomists will be taking a closer look at plants with extensive root systems and resistance to root diseases.

New emphasis will be placed on development of an improved quality protein through the feed grain breeding program.

Presently, Oregon's livestock producers buy much of their feed grains from other states. In addition, they ship young stock out of the state for finishing. The animals subsequently return as packaged meat.

If the state could become self-sufficient in livestock products, about $104 million could be added to the state's economy annually.

A project funded by the Rockefeller Foundation which could have far-reaching benefits for Oregon is international in scope. Working at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, a team of plant breeders that includes OSU scientists are working with the world's first man-made grain species.

Triticale, the product of this cooperative program, is the result of crossing wheat and rye. It is a better nutritional source than other grains.

Newest thrust of the productive OSU plant breeding program is the launching of a regional effort to adapt triticale to growing conditions in the Northwest.

Capitalizing on climatic differences between Mexico and the northwest states, project agronomists grow two generations of plants each year. This permits more rapid varietal development and an earlier commercial return on the state's investment in this research opportunity.

Their patient's a plant

Oregon's multi-million dollar wheat crop might be less valuable, were it not for the continuing work of Oregon State University's plant epidemiologists.

Research is conducted throughout the state and guided by Robert L. Powelson at Corvallis. It involves investigations on the dynamics of plant diseases, including ways to predict epidemics.

The thrust of this work is best illustrated by studies of the epidemiology of stripe or yellow rust on Oregon's wheat.

Stripe rust is one of three major rusts attacking wheat worldwide, particularly in cooler climates. A fungal disease, it is potentially the most serious problem facing Oregon's wheat growers each year.

Basic to an understanding of plant disease epidemics is the disease triangle concept. Comprising the minimal factors required for an epidemic to occur, this triangle consists of a susceptible host plant, a causative disease agent, and a favorable environment.

A good example of this concept is the severe stripe rust epidemic which struck the state's wheat fields in 1961. Oregon's direct loss amounted to $15-20 million.

In the late 1950s and early 1960s, 70 to 80 percent of Oregon's wheat acreage was planted in the Omar variety.

Couple this wide distribution of one variety to Omar's fatal flaw—its susceptibility to stripe rust—and you have a genetically uniform, susceptible host population.

Enter the second component of the disease triangle, the disease agent. In stripe rust, the pathogen is spread and infection occurs by the yellow spores of the attacking fungus.

Genetic variability allows the pathogen great potential for adapting to new hosts. Thus, when the pathogen encounters a uniform genetic variety being grown extensively and there is an environment favorable for infection, it is free to multiply.

These conditions occurred in the Columbia Basin during 1961, and the pathogen spread throughout the susceptible population of plants.

"Because the Northwest generally has very dry summers," Powelson explains, "how stripe rust spores survive from harvest in late summer until the new crop is up the next spring is an important question. This is a critical period in the rust's life cycle."

Other facets of plant epidemiology under study at OSU are how and where the disease agent is dispersed.

Scientists have learned, for instance, that most stripe rust spores are carried from west to east by prevailing winds. With this knowledge, it is now possible to predict the danger from primary sources of inoculum.

By changing the distribution of the host plant or altering cultural practices at the source of an epidemic, disease outbreaks can be regulated and even cut short down wind from the original infection site.

The OSU plant researchers also have measured the time and duration of dew formation on wheat plants.

"We discovered that at least three hours of dew are required for rust infection to occur," Powelson says, "and eight to twelve hours provide the moisture for maximum infection. If the ideal conditions recur repeatedly and other segments of the disease triangle are present, then an epidemic is almost assured."

However, if dew forms for just one to three hours each night, the rust is killed in the field. The short dew duration allows the spores to germinate, but after drying, they cannot sprout again to cause infection.

OSU researchers are scrutinizing additional epidemiological factors such as the latency period, virulence, and infection rate.

Using special equations, the plant epidemiologists can draw some useful conclusions and make predictions about disease epidemics.

For instance, OSU scientists can predict that the potential for a severe wheat rust epidemic exists if you grow a susceptible wheat variety where there is normal rainfall, and just one infectious rust postule is found on a leaf in five acres of wheat in February.

"The high infection potential from a very small amount of rust pathogen," indicates Powelson, "implies that any practice to eliminate the source of infection in the fall probably will not have much effect on the disease in the spring."

Plant breeding for disease resistance holds great promise in the fight against epidemics, too.

Work on plant disease epidemics has just begun to reach the point of allowing more precise prediction of epidemics and their effects.

"Given the opportunity to develop models which simulate factors in the disease triangle," Powelson observes, "we hope to be able to develop varieties and cultural practices which will improve food production methods and reduce costs to the grower and the consumer."

Fish aid cancer fight

If someone tells you that rainbow trout may help man solve the perplexing question of what causes cancer, don't dismiss it as just another fish story.

Russell O. Sinnhuber has committed more than a decade of his research career to studies of liver cancer (hepatoma) in trout. To date, he has uncovered and documented some pretty interesting facts—there's nothing fishy here.

The food scientist from Oregon State University began his trout hepatoma studies in 1962 when he was called on to learn why many hatchery trout in the Northwest were dying.

Autopsies showed grossly enlarged and tumorous livers. The verdict: hepatoma.

Investigations revealed that almost 95 percent of the trout in certain Northwest hatcheries had hepatoma. Liver cancer was also prevalent in Germany, France, and other parts of the world.

Because of the extent of this hepatoma epidemic, the National

(Continued on next page)

Thousands of trout in tanks at the OSU Food Toxicology and Nutrition Laboratory help food scientists track down possible causes of cancer.

The patient in this operation is a rainbow trout being checked for signs of cancer.

Cancer Institute (NCI) became interested in learning why it was occurring and how to stop it.

Preliminary studies showed that a drastic change of diet had occurred. Formerly, hatchery trout were fed slaughterhouse by-products. But hatchery operators had recently switched to a dry pelleted commercial ration because it was easier to handle, store, and feed.

Working under an NCI grant, Sinnhuber and a team of researchers built an experimental laboratory hatchery east of Corvallis where they could conduct further studies.

This lab is equipped with some 120 circular, fiberglass tanks. Disease-free water can be pumped through them at 500-1200 gallons per minute and is maintained at 52° Fahrenheit, the ideal temperature for trout growth.

Sinnhuber's group stocked the hatchery lab with about 100 trout per tank and then began feeding them measured test rations. Initially fed only the suspect commercial diet, many of the trout developed cancer tumors after six months.

By methodically adding ingredients of the suspect dry pelleted feed to a standard purified diet containing basic fish nutrients, the scientists soon narrowed their search for the carcinogen or cancer-causing agent to cottonseed meal.

Laboratory studies and mention in scientific publications of turkeys fed moldy peanut feed dying from a liver disease led the OSU team to zero in on mycotoxins, poisons produced by molds.

One such mycotoxin is aflatoxin. It is produced by a common mold with the scientific name *Aspergillia flavis*.

"For the first time ever," Sinnhuber reports, "our group was able to isolate aflatoxin from moldy cottonseed meal. We also developed ways to detect its presence."

Then the investigators tried feeding just aflatoxin to trout. When the fish contracted cancer soon afterwards, they knew they had found the sought-after carcinogen.

Subsequent tests led to the conclusion that aflatoxin is the most potent cancer-producing substance known. Less than one part per billion, a very minute amount, produces trout hepatoma.

The presence of aflatoxin is one explanation of why the trout developed cancer. But Sinnhuber wondered whether the cottonseed meal itself had any carcinogenic effect.

Chemical analysis of cottonseed meal shows that it contains two unusual compounds. One is gossypol which is known to be toxic, especially to dogs.

The other components are cyclopropenoid fatty acids. These are chemicals having ringed configurations of carbon atoms in their molecular structure.

When the OSU food scientists fed a combination of cyclopropenoid compounds and aflatoxin, cancer appeared in all of the trout tested at the end of nine months. But the carbon-ring fatty acids alone did not produce hepatoma.

Because the cyclopropenoid fatty acids behave this way, they are termed co-carcinogens or promoting agents. Combined with aflatoxin, these substances cause the liver to "explode" with tumor growth.

"This pair of cancer producing agents," remarks Sinnhuber, "is responsible for liver tumors in fish. And these substances may be important in human health since they may be present in our food."

Aflatoxin's effect on man is unknown. But research is proposed which may shed light on this subject.

"Some of the answers we're getting," Sinnhuber suggests, "can be translated to higher life forms."

In the meantime, an ammonia gas and heat treatment has been developed which may effectively destroy aflatoxin in cottonseed meal. Experiments are under way to determine whether the treated meal is carcinogenic. Preliminary indications are that it does not produce cancer.

A new project that is exciting the OSU team concerns exposing trout eggs to a weak solution of aflatoxin for up to one hour. Exposure begins about fourteen days after fertilization when the embryonic liver bud forms. Hatching occurs about a week later.

Microscopic examination of the liver cells shows that they are enlarged and are being damaged by the aflatoxin. And after eleven months, there was a 40 percent incidence of liver cancer in trout exposed as eggs.

Trials were also run that had the aflatoxin-exposed trout eating a cyclopropenoid supplemented diet after hatching. With just one hour exposure, almost 90 percent of the trout contracted hepatoma.

Sinnhuber cautions that all the answers are not available yet, but he thinks that results of this project point to a promising test procedure.

"This is a very sensitive model," the food scientist says, "to examine a wide variety of potentially carcinogenic agents. Only 50 micrograms of test material are required to induce cancer in about 200 experimental animals."

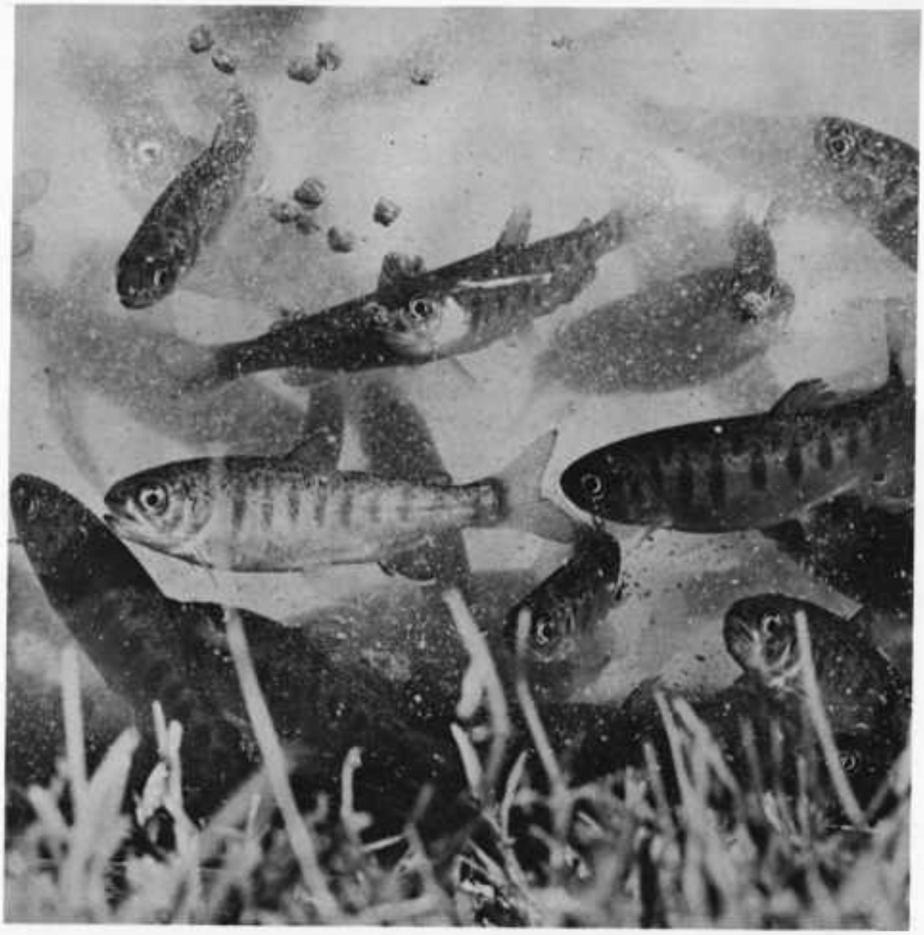
Several additional research topics that have come up in the course of Sinnhuber's trout cancer project are whetting the scientist's curiosity.

One is the effect of water temperature, and oxygen level on tumor growth. To date, very little study has been made of this subject anywhere.

Another revolves around the occasional remission of trout tumors observed by the OSU workers. This apparently is an immunological response, since at some unknown signal, lymphocytes (disease-fighting white blood cells in humans) converge on the tumor site.

"It is one of our great hopes," Sinnhuber remarks, "to be able to identify the substance which signals this response."

A final topic of proposed study concerns fish cataracts. When trout are fed a certain white fish meal for just six weeks, the food science team finds 100 percent incidence of clouding of the lens of the fish eyes. The cause is still subject to speculation.



Environmental research data does not always relate well to the real world, an OSU fisheries biologist claims.

Biological systems-Global perspective?

Scientists seek not only ways to apply new findings to everyday needs, but basic knowledge about the world and its processes as well.

Charles E. Warren, Oregon State University fisheries scientist, has been involved in research on the physiology and ecology of aquatic organisms and the application of these areas of knowledge to the solution of water pollution problems.

But the immediate findings from this and other research have, to Warren, provided less than satisfying explanations.

"The data do not always mean what they seem," suggests Warren. "When we try to relate the data to the real world, we are not always sure that we have solved the problems."

This dissatisfaction with the outcome of often complex ecological

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Manure is his bag

J. Ronald Miner has a problem. The Oregon State University agricultural engineer must find ways to manage livestock wastes that are economically feasible for the producer yet which meet stringent anti-pollution standards.

When livestock are kept in small groups or grazed over wide areas, the management of animal manures is of little concern. Any manure deposited in or near streams is diluted by a large quantity of clear water and is quickly assimilated by the environment.

But the advent of large livestock operations in feedlots and other confinement facilities has brought with it the accumulation of large quantities of animal wastes. The potential for pollution has increased greatly.

With the passage of federal water pollution control laws, the pressure for waste management has reached high levels.

"To be successful, a livestock waste management program must do more than just avoid water pollution," Miner asserts. It must be an integral part of the basic livestock production operation, compatible with the rest of the system and sufficiently inexpensive to allow the producer to compete with livestock raisers elsewhere."

The exact management technique is unimportant. But four basic objectives must be met.

First, the system must provide some means of removing manure from the animal's living area. Slotted floors are popular for this purpose.

Second, there has to be some method for transporting manure to a processing site.

Miner thinks that flushing animal wastes away with a water system is the most likely candidate in Oregon, especially if water from the treatment system is recycled.

The third requirement of a waste management system is that a means of storage or treatment be provided. However, this feature is influenced greatly by the fourth objective, the provision for the final disposal or use of the manure.

Current practice is generally to apply animal manures to cropland to boost crop production.

'I feel ridiculus!'

Irrigation disposal of liquid animal wastes is a low-cost, low-labor approach. Frequent sprinkler movement and careful management allow efficient use of the plant nutrients.

When hydraulic manure transport systems are used, reclamation of the flushing water is needed. Reuse of this water is both technologically and economically feasible.

Several solid-liquid separation techniques are available. Vibrating screens, centrifuges, and settling tanks are possible methods. But because each has associated problems, OSU agricultural engineers have been trying to develop alternate systems adapted to Oregon's needs.

One of these consists of a tube mounted on an incline with a spiral fin inside. The water-manure solution flows through this device, encountering a series of small settling pounds formed where the fins contact the walls of the tube.

Trials with the first model of this machine were only partially successful.

A second generation separator consisting of a larger tube and smaller fins has been tested. With these modifications, Miner has obtained better solid concentration. Refinement of the basic technique is continuing.

OSU researchers have studied the special problems of non-roofed livestock production facilities, too. In these instances, runoff water falling on the feedlot as rain or snow carries with it much manure. The runoff is a potential pollutant requiring careful management.

"Runoff control must be designed into the open-air feedlot at the initial planning stage," the agricultural engineer says. "Systems to keep the lot dry usually cannot be added on later without great expense."

Once the amount of feedlot runoff to be managed has been minimized, design and construction of a runoff collection system can proceed. Goals of this system are to keep the lot well drained, to remove the water from feeding areas, and to transport this water to a storage or treatment site.

Research indicates that the application of collected feedlot runoff

Agricultural engineer Ronald Miner designed and built this experimental solid-liquid separator to help solve animal waste disposal problems.

to cropland is compatible with crop production when reasonable quantities are used and good management practices are followed.

Tests now under way at OSU are designed to indicate the maximum amounts of runoff which may be used to obtain crop stimulation without production interference.

Odor pollution is another important aspect of livestock waste management which is receiving research emphasis at OSU. Volatile compounds are released by decomposing wastes in wet feedlots, runoff retention basins, or manure storage tanks.

"The control of these odors presents special difficulties to the livestock producer, particularly to one whose lands are being engulfed by urban sprawl," observes Miner. "Researchers face a continuing challenge from such nuisance pollutants."

Miner believes that the role of the livestock waste researcher must be to find ways to manage wastes that fit into an economically attractive scheme. While progress has been made toward this goal, much work remains.

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experiments led Warren to think about and question how man tries to unravel intricate biological systems. As a result, he has sought to define what he considers to be a more complete approach to biological science.

"Unlike physics," Warren notes, "biology has no broad theoretical basis. Ecology in particular and biology in general are fields in search of a conceptual framework."

The OSU fisheries biologist is more worried about the direction of ecology than its present status. He believes that ecology is a science with the objective of explaining ecological systems.

The explanatory process must be satisfying to the student within the conceptual context that an explanation is offered, Warren believes, or else it is inadequate. It is also lacking if the conceptual framework fails in some sense to capture the nature of the phenomenon being explained. According to Warren, satisfactory explanation presupposes a common language and a conceptual system.

Philosophical and scientific questions arise when one tries to solve some of the problems inherent in efforts to explain. Warren thinks scientists must not only be able to distinguish between reality, observations, and concepts, but they also have to resolve the question of how the study of parts of a system can tell them useful things about the whole.

"We need both part-by-part and overall views of the world," remarks Warren, "to allow us to consider the real nature of life."

The Oregon State researcher illustrates his concern about traditional approaches to explaining biological phenomena with the classical approach to analysis of relationships.

To understand what were believed to be the cyclic population fluctuations of animals, Warren says that some ecologists reduced the relationship to simple mathematical equations. These balanced predator births, deaths, and food supply on the one hand with similar prey population traits on the other.

Yet the OSU biologist objects that the predator-prey relationship does not function as represented by the equations supposedly explaining it. He says that predator-prey populations are, in reality, much more complex. For example, they are density dependent and alternative prey and competitors are usually present. But the equations do not reflect such other important influences.

"The fundamental problem here," Warren points out, "is that we had a 'bad' question, a faulty hypothesis to begin with. The mathematical explanation assumed only one population equilibrium point, when, in fact, there is no single such point."

Warren believes that a broad range of influences exert their individual and interrelated effects on animal populations. For instance, energy input, climate, and other environmentally related forces as well as predation permit the great diversity of biological systems in our world.

There is interaction at all levels between all components of any biological system. The stability and persistence of a biological system, Warren explains, derives from the dynamic nature of its structure and operation, not because anything is fixed.

The equilibrium points of populations are continually shifting, even as populations approach them. Stability does not mean constancy, of which there is very little, but rather means persistence.

"Regardless of historical arguments to the contrary," observes Warren, "there is little local stability in biological systems. What they have is more like global stability."

Relating his thoughts to the determination of the public policy, Warren says public bodies should take the broad view and look at entire systems. He proposes that scientists have to be both analytical and synthetic in outlook, probing detailed subunits of life while bringing it all together in an overall concept of more encompassing systems, including society itself.

"Until biology and ecology find adequate conceptual frameworks" he concludes, "scientists working in these areas will expend a disproportionate amount of their time on non-problems and silly arguments. We must work toward comprehensive frameworks for our research efforts."

Chemicals wear white hats, too

"Without the use of chemicals for the production and preservation of food, protection of health, and prevention of disease, the world's 3.8 billion people would experience mass starvation and severe epidemics."

That is the opinion of Virgil H. Freed, agricultural chemist and director of Oregon State University's Environmental Health Sciences Center. His view adds another dimension to public discussion of environmental concerns.

According to Freed, researchers should take note of the public's concern about chemicals in the environment. He admits that the problems associated with use of chemicals include careless use and handling, accidental poisonings, and abuse.

"I am persuaded," Freed says, "that by misuse and unwise use, we have damaged the environment. But nature may be more forgiving than we had originally thought." He cites Arizona studies showing that since the ban on DDT use took effect, DDT residues have declined much more than predicted.

Freed thinks that the disadvantages of chemical use are difficult to establish with hard data. He suggests that scientists find it difficult to demonstrate the harm to a single species by a particular chemical because there may be a variety of harmful influences working against the species at any one time.

"Nature is never in balance," says the chemist. "The mere presence of man near an endangered species may have a detrimental effect, too."

Freed feels that, in the almost hysterical atmosphere surrounding discussion of chemical uses, it is often forgotten that man has been using chemicals for a variety of purposes for thousands of years.

"Official agencies," Freed says, "have exhibited chemophobia—a fear of chemicals—in response to some pesticide and food additive problems. One gets the impression that chemicals can be divided into two categories: those that are injurious and those that are non-injurious to humans."

The OSU scientist believes the discussion is more complicated than that. He argues that the public must consider not only man's chemical nature when debating chemical usage, but also must distinguish between intrinsic toxicity and hazard.

Although much of the research under Freed's direction emphasizes the effect of pesticides in the environment, what he has to say about pesticides also is applicable to other chemicals.

Several classes of chemicals have been studied by teams of OSU scientists. Among these are the organic chlorine compounds such as DDT, dieldrin, and aldrin; the organic phosphates such as malathion and parathion; and the carbamates—sevin, for example.

Whether chemicals are naturally occurring or synthetic, they have been shown to function similarly throughout the world's biochemical systems. Scientists can describe mathematically the environmental changes caused by chemicals and can diagram chemical behavior in the soil, air, and water.

"There is a metabolism of the environment," Freed notes, "just as

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Pests hold key to selective control

The environmental challenge has produced a new look in entomology worldwide. We in Oregon have a stake in it, too.

The days of non-selective chemical over-kill of crop pests and disease carriers are numbered. Pest management through knowledge of insect biochemistry and behavior is now the key.

A group of scientists at Oregon State University, led by biochemist Leon C. Terriere, is deeply involved in an effort to find better pesticides for agriculture, forestry, and public health use.

They approach the problem from two directions: practical studies of the behavior of pesticides applied to Oregon crops, with the hope of finding better ways to use them; and basic studies of insect biochemistry, with the aim of uncovering special weaknesses which can be exploited with new kinds of pesticides.

What is sought are control agents that meet three essential criteria: effectiveness, selectivity, and safety.

Not only must the insecticides control the pest without harming other organisms or the crop being treated but they must be harmless to the consumer of the harvested crops.

Besides these basic qualities, the ideal insecticides should conform to at least two other criteria.

First, Terriere says, they should feature good pest management without harming non-target species. When you consider that there are about one million kinds of insects, and several thousand birds, fish, and other animals, and only a relatively few—perhaps 10,000—which are pests, meeting this standard is a large order.

Second, pesticides should be non-persistent and bio-degradable. However, they must remain at the application site long enough to do the job they are designed for before they decompose into harmless components.

"Yesterday's pesticides did not fit all of these requirements," suggests Terriere. "But, in the period of transition to newer, safer control methods, some of the old chemicals are useful still."

The development of a new pesticide requires three to seven years and costs several million dollars. The burden is shared by industry, which takes the lead and provides most of the financing. Federal and state agencies also help.

In Oregon, Terriere's team collects residue data on the state's many specialty crops, studies the problems peculiar to Oregon's climate or cultural practices, and prepares technical reports for study by regulatory agencies. This chemical detective work is the basis for the final rules under which the new pesticide is eventually used by Oregon farmers and foresters.

An extensive range of knowledge is required for pesticide development. The expertise of both insect specialists and chemists is vital to the process.

Entomologists must have a complete understanding of the pest's biology—its habits, life cycle, and ecology. They need to know how the pest species is affected by its hormones and pheromones, the internal and external substances which influence biochemical processes and behavior.

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there is in man. The ultimate effect is for the chemical to be broken down. Otherwise, we Northwest residents would have suffocated long ago in the terpenes given off by our evergreen fir forests."

In fact, man himself can be looked at as a chemical machine. Within his body, man experiences an enormous number of chemical reactions designed to release energy, maintain bodily functions, transform nutrients, and store excess compounds. Temperature and the presence of other chemicals, for instance, determine the reactions that go on in the body.

"Man, a chemical machine, lives in a chemical world and is dependent on chemical processes for life itself," remarks Freed. "His biochemical machinery is capable of coping with moderate amounts of chemicals, regardless of source."

Freed bases this statement on several accepted and experimentally confirmed principles of toxicology.

Briefly, these fundamentals state that any chemical can be toxic in a large enough dose over a period of time. There is a minimum amount of chemical needed before the toxic effect occurs, and as the dose increases, which may vary from minutes for one chemical to years for another, a permanent toxic effect appears. All organisms can resist a limited quantity of chemical, but some organisms are more sensitive to toxic effects than others. Due to individual differences, resistance can develop.

In gaining perspective on the chemical use question, Freed thinks it is important to distinguish between the inherent toxicity of a particular substance and its hazard in use. Toward this end, the agricultural chemist says that the public, armed with an appreciation of toxicological principles, must consider the spectrum of species sensitive to the chemical, the compound's stability, and the probability of exposure.

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Chemists have to explore the species biochemical systems. They seek to uncover any unique systems or chemical defects which can be exploited for control purposes.

Besides their individual research contributions, all team members must have detailed knowledge of the environmental factors involved.

"Non-target species which interact with the pest may be affected by any control procedure," the OSU scientist remarks. "The amount of influence each proposed pest management program has on other organisms, such as bees, birds, and humans, must be weighed."

Certain physical factors like rain or sunlight may change the effect of a control agent. For example, too much rainfall might wash away an insecticide before it has a chance to work. Sunlight can speed up decomposition.

The key to success or failure of the entire pesticide development program rests on the economic factors involved. OSU researchers need to know how much damage can be tolerated.

Therefore, cost-benefit studies are needed. It may not be necessary to kill all the pests infecting the crop or livestock herd to reap the greatest pest management benefit.

The basic research being done by Terriere and his colleagues involves the enzymes with which the insect regulates its hormones as well as detoxifies toxic pesticides.

They operate on the theory that these enzymes are the key to the insect's ability to become resistant to insecticides and to carry on its normal life cycle. If these enzymes could be disrupted, it is reasoned, the insect could not survive.

Using the juvenile hormone as a model, Terriere and his colleagues are testing for the enzymatic chemical processes which influence insect molting. They introduce outside agents into insect biochemical processes and then watch for any unusual effects.

"We want to know why resistant insects have more enzyme activity," explains Terriere. "After several experiments which eliminated possible theories, we determined that a greater source of supply of enzyme is the likely reason."

Because pest management relies heavily on thorough knowledge of all facets of the pest's biology and physiology, a lot of research is needed on each pest species.

But these and future research efforts are basic to meeting tomorrow's insect control needs. By learning how to use a pest's weaknesses to regulate pest populations, the OSU scientists are helping man preserve his environment while assuring the quality of his produce.

Research associate R. D. Schonbrod uses houseflies in a search to determine how insects develop immunity to insecticides.

Calcium deposits in the heart tissue of a sheep are the result of a selenium deficient diet.

Selenium: maddening mineral

It may be a red powder. Sometimes it is glassy and metallic. Each is a different physical form of the same substance.

It sickens and kills if you have too much. Too little produces the same effect. The average American has just 0.2 parts per million (ppm) in his blood stream.

It is a good insulator, but It is also a good heat conductor. It makes clear glass clearer but red glass redder. About three million pounds of it are used annually in the United States to make red paint pigments.

What is this paradoxical substance? It is selenium, a chemical with many properties similar to sulphur. Because it behaves so strangely, some have called selenium "the maddening mineral."

Agricultural chemists at Oregon State University have probed selenium and its contradictory behavior for a number of years.

Paul H. Weswig and his fellow researchers have uncovered much about the effects of selenium on Oregon's livestock and poultry industries. Combining efforts with animal scientists and veterinary medicine researchers, this OSU team continues to develop ways to put selenium to work for Oregon ranchers.

Selenium, a byproduct of iron, lead, copper, and arsenic mining, is an element which occurs abundantly in a belt along the Rocky Mountains.

Other areas of the country are generally deficient in this mineral. Oregon qualifies as one of the most deficient regions although one locality, Rome Valley near the Idaho border, has excess selenium.

Trace amounts occur throughout the state's soils where they are taken up by forage crops. Some species of plants, such as Prince's plume in eastern Oregon, accumulate selenium much more effectively than others.

Selenium poisoning occurs when cows, horses, chickens, and other animals take in an excess of the chemical. OSU's chemists believe that anything over 2 ppm of selenium in the diet is toxic. Others have pegged the poisoning level at 5 ppm.

Whether several human conditions can be attributed to selenium toxicity is uncertain.

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Top: These rats came from the same litter, but the small one was deprived of selenium in his diet. Bottom: A lamb on a selenium deficient diet is losing movement in his legs.

For instance, some researchers have hypothesized that excess selenium causes increased tooth decay. Yet, other experiments have shown that selenium has no effect on the incidence of dental caries.

In the early 1940s, selenium researchers postulated that the mineral was cancer-producing. This was of great concern, since federal law prohibits the addition of any carcinogenic substance to foods.

However, in 1960, OSU researchers proved that the carcinogen tag could not be pinned on selenium. In fact, they showed that selenium may have anti-carcinogenic properties. Subsequent research has produced evidence that selenium may have no effect at all.

Selenium deficiency is of primary concern in Oregon. The naturally low levels of selenium in most of the state's forage crops threatens the livelihoods of livestock and poultry producers.

Too little selenium causes white muscle disease, characterized by calcification of the muscles, particularly in the heart and hindquarters of the affected animal. The circulatory and endocrine systems also are attacked, and cataracts form in the eyes of laboratory rats.

Also known as hepatosi dietetica or mulberry liver in swine, white muscle disease strikes quickly and with little warning. Calves are susceptible, too.

Researchers at OSU are conducting a series of tests to learn how to combat selenium deficiency.

The addition of sodium selenite, a compound of the mineral, to deficient rations cures white muscle disease in sheep. Just one gram of this compound, costing about 1.8 cents, keeps a ewe alive for 12 years with no other dietary source of selenium.

In another experiment, OSU animal scientists are feeding ewes a pellet the size of a dime containing 10 percent selenium and 90 percent iron.

Aim is to see whether a single dose of selenium that is released gradually throughout the animal's lifetime will prevent white muscle disease. To date, results seem successful.

Additional research at OSU has pinpointed other biochemical functions.

"When we injected radioactive selenium into lambs," Weswig reports, "we were able to identify two proteins in the kidney, three in the liver and pancreas, and four in the heart and muscles which contain selenium."

Hearts and skeletal muscle of healthy lambs have been found to contain a protein with selenium that is not present in white muscle diseased lambs.

Even primates, including man, may have a selenium requirement. Tests with squirrel monkeys at OSU have shown that the injection of as little as 0.04 milligrams of selenium every two weeks corrects advanced hair loss, lack of vitality, and other deficiency symptoms terminating in death.

The results of other studies may hold some hope for human infants with protein deficient diets.

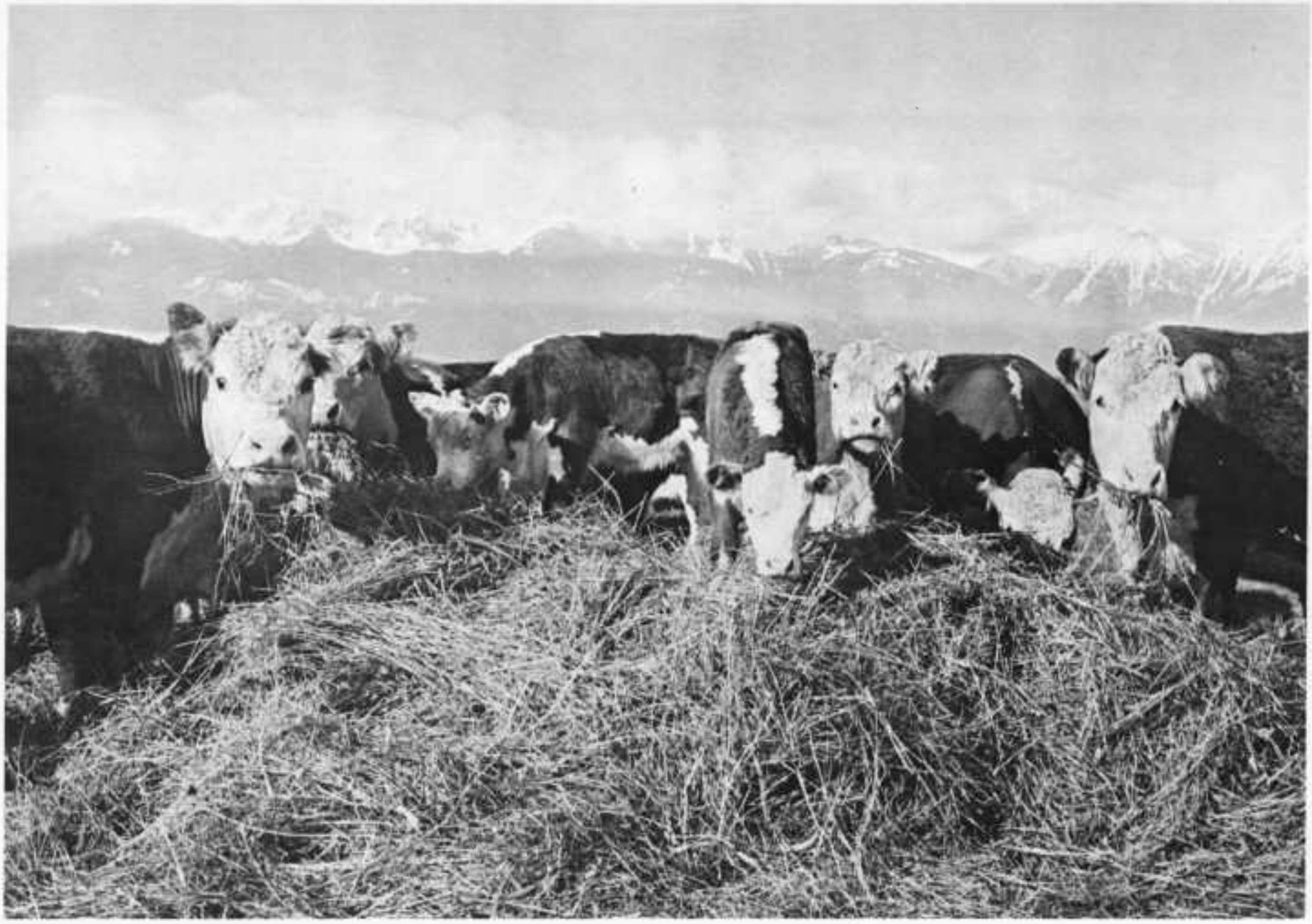
"Adult humans probably need not worry about selenium deficiency," says Weswig. "Even Corvallis residents, in the heart of one of the most deficient areas of the United States, have blood selenium levels on a par with the national average."

Tests have demonstrated that any diet adequate in other essential nutrients will probably be adequate in selenium.

A recent U.S. Food and Drug Administration (FDA) ruling that allows selenium-supplemented feeds for swine, turkeys, and broiler chickens will have a big impact on Oregon's economy.

This one change should add about $500,000 per year to the poultry industry's income. A similar proportional effect is expected for Oregon's swine producers.

However, the FDA directive does not yet apply to lambs, calves, or brooder chickens. With continued funding for research, OSU scientists want to complete studies which they hope will support further liberalization of the FDA policy.


Linking genetics with efficient beef production has been a lifetime job for OSU geneticist Ralph Bogart.

Genes shrink costs

For 26 years, Ralph Bogart has studied muscle building factories. You would call them beef cattle. Some 1,500 have come under his scrutiny.

Starting with little previous research to build on, the Oregon State University animal breeder has tried to learn how genes affect the production characteristics of beef cattle.

Aim of the program is to find ways for the Oregon beef producer to raise animals that will gain most efficiently and produce the most desirable carcass when marketed.

Bogart's genetics team has had to try to change the popular notion that the producer can tell how an animal will do by just looking at it.

Basic to the continuing project are controlled feeding tests which place each animal under regulated barn conditions and on the same feed and water basis.

Then the researchers choose a series of regimens to test the herd and measure individual effects. They are looking for ways to single out the best animals, using physiological differences rather than physical appearance alone.

Comparing the blood constituents of cattle of varying ages, Bogart has learned that the more efficient animals have a lower amount and concentration of hemoglobin than the poorer animals. Older cattle have increased red blood cell pigment levels.

Therefore, Bogart concluded that, contrary to popular belief, anemia is not the reason why some beef animals grow more slowly than others. There had to be some other cause.

To try to find it, the OSU scientists embarked on two lines of study. One emphasized the animal's nitrogen metabolic system; the other, its fat metabolism.

They checked nitrogen usage by measuring the levels of urea and amino acids in the blood. They found

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that as the animal grows, blood urea levels increase. Bulls had relatively lower urea than cows in the test herd.

"As the animal gets heavier," Bogart asserts, "feed intake increases and feed efficiency, measured as pounds gained for each pound of feed, decreases. While bulls and cows eat almost the same amount of feed, the male animals are more efficient meat producers."

Turning to blood amino acid levels, Bogart and his associates are learning that the more efficient animals can withdraw these protein building blocks from the bloodstream to form muscle.

Poorer cattle break down the complex amino acids into simpler parts. They use the carbon portion as an energy source and excrete the nitrogen component through the urine. As a result, the less efficient animal produces more fat and less lean meat.

Fat metabolism is also under investigation. Specifically, two coenzymes closely associated with how the animal burns up fat are being studied.

Using animal breeding studies as a starting point, the Experiment Station researchers have confirmed that inbreeding can be detrimental to efficient meat production. As the degree of inbreeding increases, animals display slower growth rates, and carcasses are more fatty with less lean tissue.

Breed of cattle also has an effect on growth efficiency. Production experiments showed that the Angus line gains at a lower rate after weaning than three Hereford lines used.

However, Angus cows are better milk producers. Although their calves are generally smaller at birth, they gain more rapidly during the nursing period.

Nevertheless, other maternal effects on calves are variable. Weight gain before weaning is most affected by inbreeding.

Another OSU finding is that calving time is important. Early calves outdo late season offspring. This difference exists because pastures start to dry up just when the late calves are beginning to need green forage for growth. Earlier calves have a head start because their forage needs coincide with seasonal pasture conditions.

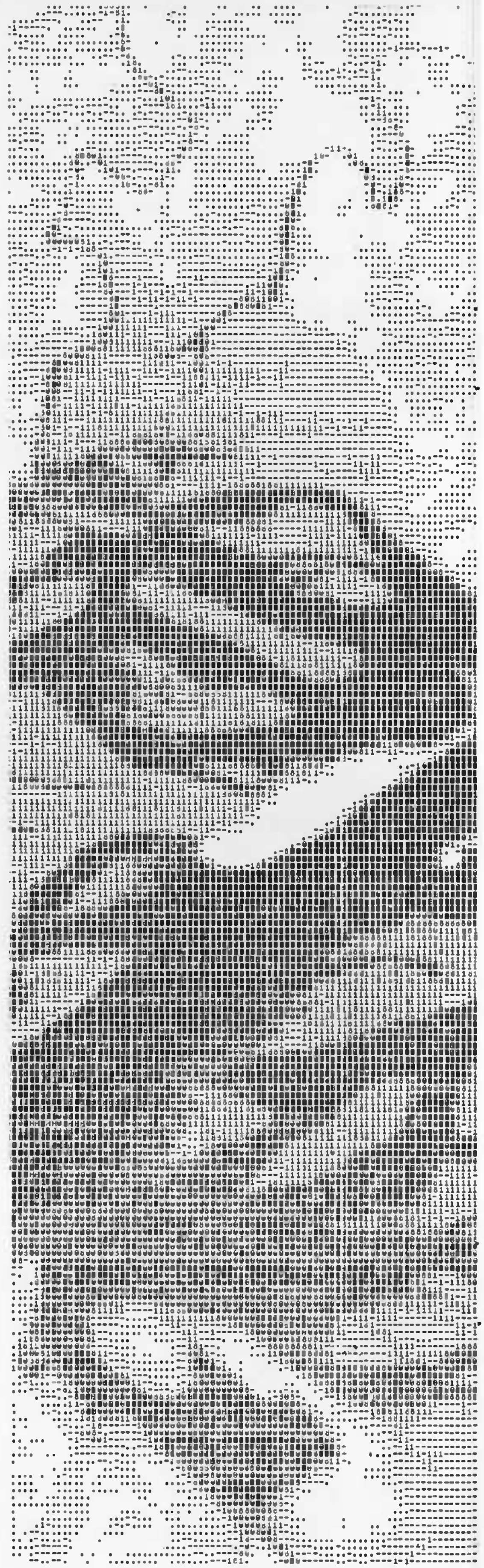
From this group of studies, Bogart has drawn several conclusions. "If the cattleman wants the most efficient meat-producing animal, he should try to raise animals having a metabolic system similar to young animals." Such cattle are the most efficient energy converters.

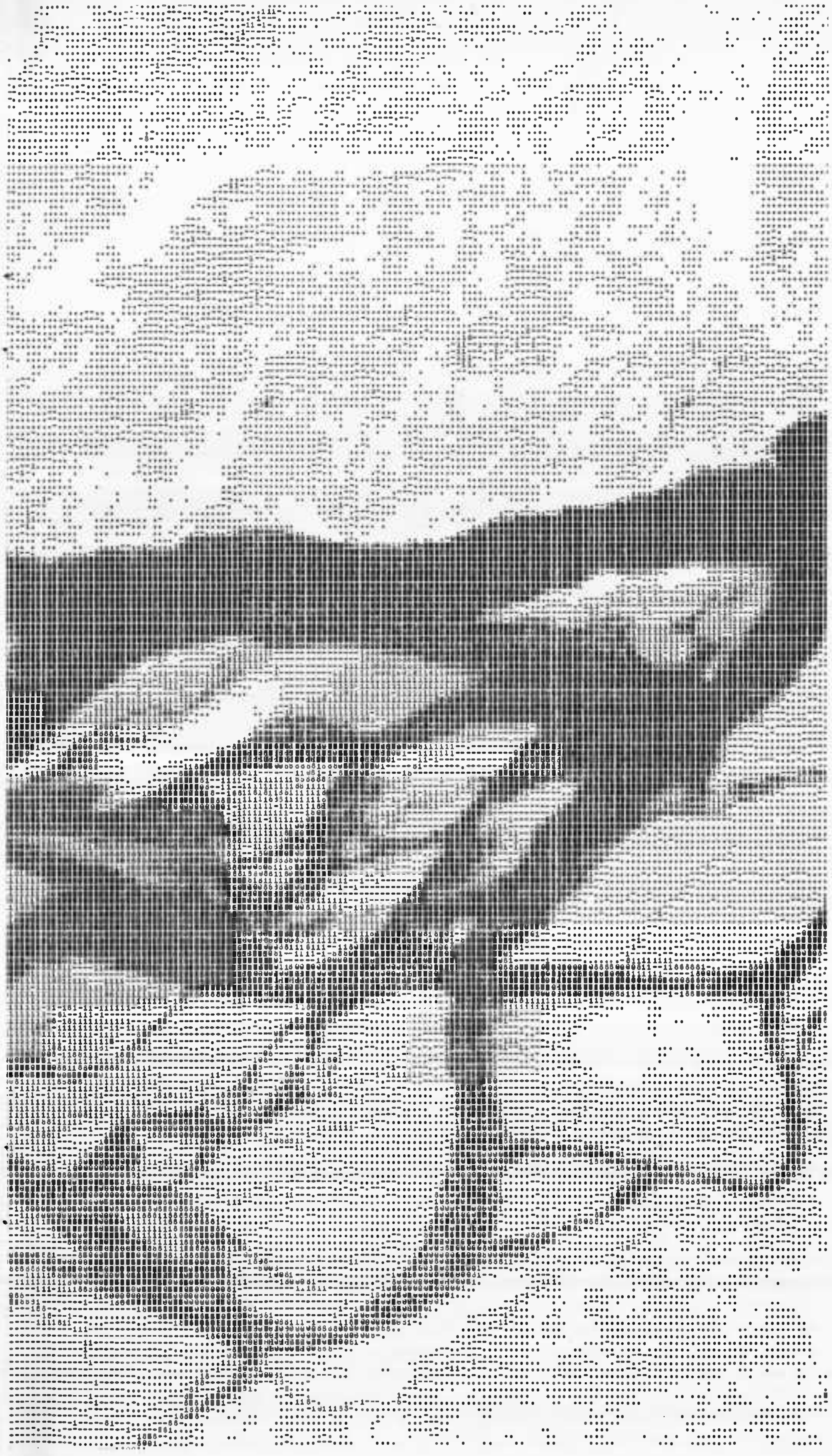
Second, the better animals are those having low blood urea and amino acid levels as well as low urine urea. Carcasses should show a high amount of lean and low quantity of fat. In addition, special studies have shown that a larger thyroid gland is desirable.

One major implication of Bogart's work with blood constituents is the possibility of a blood test for selection of herd sires with the best meat production efficiency potential. Development of this idea is hindered, however, by lack of information about environmental variables.

To date, all of Bogart's research has been with herds raised under carefully controlled conditions. A range herd probably would perform differently.

To allow scientists to follow-up on this and other trends which promise to improve Oregon's agriculture, continuing research is necessary. Bogart and his colleagues already have a headstart on meeting the challenge.





Space 'shots' fill in picture

About 9:45 a.m. every 18 days, look up and smile. You're on camera.

The photographer is an Earth Resources Technology Satellite—ERTS for short—and the camera is a sophisticated multi-spectral scanner.

You do not really have to worry about combing your hair, though. The smallest object that this camera can detect from its orbit 500 miles above earth measures 176 by 261 feet, about 1.1 acre.

ERTS was launched in July 1972 by the National Aeronautics and Space Administration (NASA). Its purpose is to map and monitor the earth's resources by remote sensing techniques. A second, identical ERTS is scheduled for launch during the winter of 1974-75.

J. Ralph Shay, an Oregon State University botanist, headed a National Academy of Sciences committee that was instrumental in convincing NASA to include remote sensing in its experimental satellite program.

Remote sensing is the use of electronic detection and measurement devices in airborne and space vehicles to perform earth surveys. Information obtained is transmitted to receiving stations on the ground by highly refined communications systems for data processing, use, and storage.

Input from the ERTS program flows to three agencies on the OSU campus as well as to some 300 investigators worldwide. Foresters, soil scientists, geologists, geographers, range management specialists, and other researchers receive information for use in studies geared to meeting Oregon's needs.

Barry J. Schrumf directs ERSAL—Environmental Remote Sensing

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Satellite data displayed by OSU computers is helping researchers characterize the ever-changing Columbia River by providing information on channel depth, location of shoals and other features.

Application Laboratory—in Withycombe Hall at Corvallis. Electrical engineer James H. Herzog heads the Pictorial Information Extraction and Enhancement Laboratory (PIXEL). Data processing support comes from R. Jay Murray in the Computer Center.

ERTS is equipped with two major sensor systems. One malfunctioned soon after launch and has not been repaired. The other is a multi-spectral scanner—the camera you pose for every two and one-half weeks.

The scanner views the earth through one aperature. The Incoming light is divided into four wavelength groups so that readings can be taken in the visible green, yellow, and red spectra, as well as in the invisibe infrared range.

Extensive cloud cover renders the data practically useless. Haze has less effect on picture quality.

"But because our agricultural mapping interests come primarily during the summer in Oregon," explains Shay, "the state's cloudy winter weather has little effect on the usefulness of the ERTS system here."

In nearly polar orbit, ERTS makes 14 daylight passes in each 24-hour period.

The scanner's eye passes over all points on the earth between 80 degrees north and 80 degrees south latitude at the same time every 18 days. Therefore, it is sun synchronous.

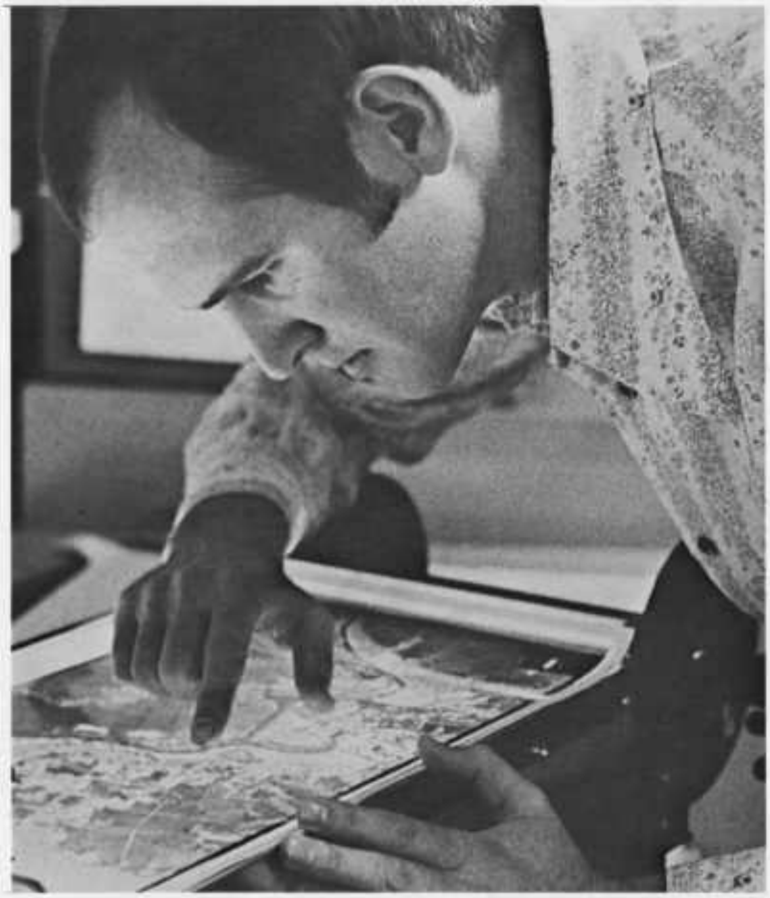
Except for seasonal variations, all pictures are taken with the sun at the same angle to the scanner. The differing effects of shading are thus reduced.

Seven passes are needed for ERTS to cover the state of Oregon. Moving from east to west, the satellite scans a band about 115 miles wide with each orbit.

Data received from ERTS are originally beamed to earth in digital form. These numerical values are translated by computer into various alternate forms. Up to 83 digital values can be detected on each 1.1 acre resolution unit.

"Machine-assisted data interpretation," Shay asserts, "greatly enhances the value of remote sensing. The digital tapes and the reconstituted images represent a major advance in remote sensing technology."

Using a single reference site where physical features have been verified by ground mapping methods,



Researcher Barry Schrumpf helps interpret satellite imagery for an Oregon land use study.

scientists develop computer programs which allow them to analyze similar traits in the same general vicinity, based on satellite data alone.

Several other capabilities of the ERTS system are being exploited to facilitate resource data gathering for Oregonians.

These include near-shore and river surveying and resource monitoring. The time required to survey an area by satellite sensing is drastically reduced from traditional ground methods. Man-hour savings are often 90 percent.

OSU scientists have used ERTS data to plot the extent and progression of Tussock moth damage in forests near LaGrande. With digital analysis, up to four levels of moth damage are detectable.

Another project, proposed by nearly a dozen state and federal agencies, calls for mapping two coastal Oregon counties from space.

"If successful," Shay comments, "this project will show the important contribution that remote sensing can make to unifying data gathering, simplifying interpretation, and reducing storage complexities."

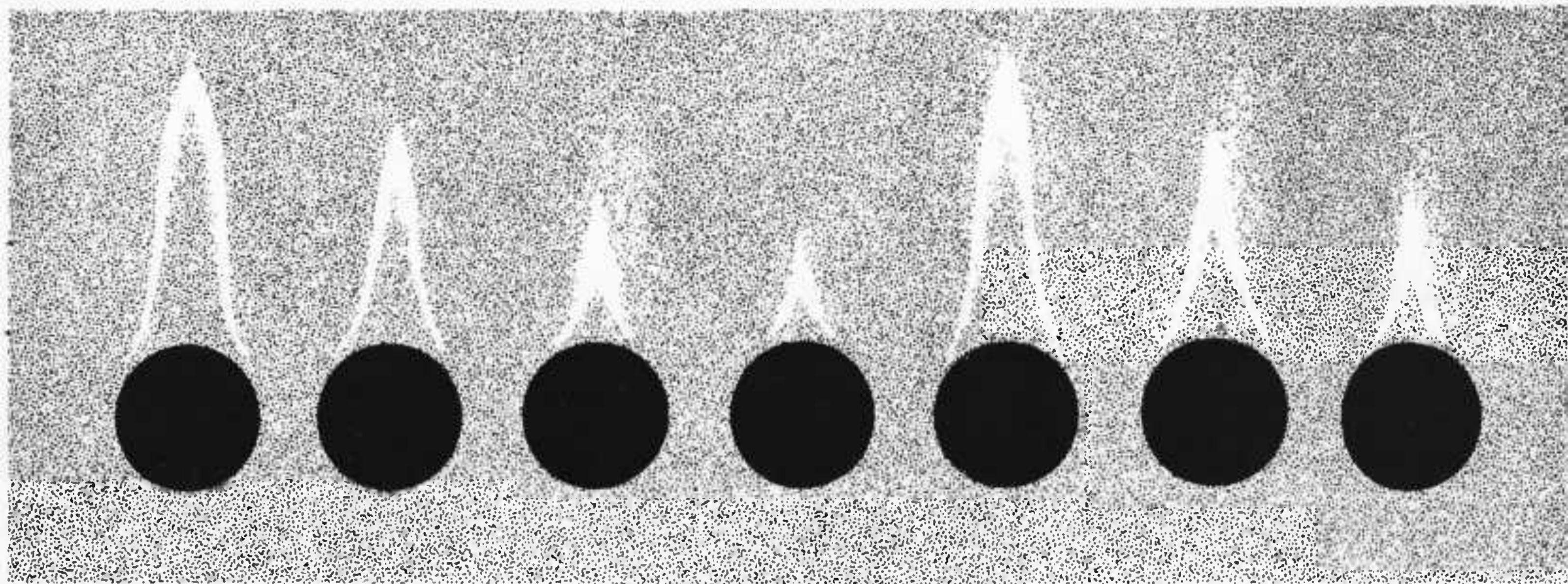
The success of crop identification and mapping efforts here and in other ERTS laboratories will be used in worldwide surveys of the major crops as the world food budget tightens. Weather data from meteorological satellites will help surveyors predict crop yields, especially in arid areas.

Besides these practical applications, Shay thinks the ERTS system is intrinsically valuable.

"For the first time," the botanist points out, "we are able to map the same location repetitively."

Changes in physical features of crops can be noted and used to identify and characterize the crops as they grow and develop.

"It is an unbiased system," concludes Shay. "ERTS' major contribution may be its ability to see earth resources 'as they are' without the interference of personal, political, or national self-interest."



Tests tell if it's food poisoning

No one wants to get food poisoning, but if it does happen, you and your doctor want to know immediately the exact cause so proper treatment can begin.

Work going on at Oregon State University may give your physician and food processors, too, better methods of rapidly identifying the microbial toxins which cause food poisoning.

Microbiologist Arthur W. Anderson heads the OSU research team. The team's efforts, spanning almost a decade, are directed toward finding toxin identification and measurement techniques which are faster, simpler, less objectionable, and more specific than present methods.

Food poisoning is usually caused by three kinds of microbes. These are *Clostridium botulinum* which produces botulism, *Staphlococcus*, and *Salmonella*.

Current methods of identifying botulism organisms in food are slow, non-specific, and often difficult or cumbersome to perform.

Tests for staphlococcal microbes are long (6-8 days) and involved. A skilled chemist may be needed to complete some of the steps.

There is no satisfactory method to tell whether salmonella bacteria are the culprits in a food poisoning case.

To help remedy this situation, Anderson's team began several years ago to investigate better ways to pinpoint and quantify toxins.

They started with botulism toxin and went through all the known procedures, one by one. None produced consistently accurate results that a physician could rely on, and there were other problems, too, even when controls were used.

Then, in 1968, two techniques were found that were adaptable to the team's needs. One is called the Laurell technique after its Swedish developer. The other is a real tongue-twister—reverse immuno-osmophoresis.

"The Laurell method had to be changed somewhat," Anderson notes, "since it had not been used with bacterial toxins before."

The modified Laurell technique involves imbedding a serum containing antitoxin (antiserum) in a gelatinous substance. Photographic, microscopic, or cover slides can be used to support the gel.

Then the toxin (antigen) is placed in a well on the slide. An electrical field is applied which causes the electrically charged particles to migrate across the gel.

Growth cones form above each toxin well. The electrical force is continued until each of the cones forms a sharp peak.

Migration stops when equivalent concentrations of antiserum and toxin are reached. This boundary is marked by the formation of a precipitate.

"What is so handy about this technique," observes Anderson, "is that the relative amounts of antigen and antiserum are unimportant. A precipitate will form, even when there is an excess of either substance."

The height of each cone depends on the quantity of toxin as well as the amount of antiserum in the gel.

"This modified procedure," Anderson reports, "reduces the

(Continued on next page)

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detection time for botulism toxins from 2-3 days to a matter of hours."

Reverse immuno-osmophoresis, the second technique, is very fast, highly specific, and very sensitive. However, it does not permit measurement of how much toxin is present.

This procedure requires only a small amount of toxin and antiserum for accurate test results.

First, scientists remove globulin, water-insoluable protein matter, from the antiserum. Then, by a chemical reaction, they reverse the electrical charge on the antiserum.

"In effect," Anderson explains, "this changes the migration pattern. Then test results are available within a matter of minutes."

With further development and refinement of this procedure, Anderson believes that the results can be amplified and more widely applied to commercial food processing and medical needs.

Staphlococcal enterotoxin also has come under Anderson's scrutiny.

"Our objective," the microbiolgist relates, "was to develop a faster and simpler technique that was as sensitive and specific as the currently accepted Casman method."

Producing their own antiserum in test goats from the OSU herd, the researchers tried different types and concentrations of gels. They finally settled on an agarose gel with a barbital buffer.

The gel is mounted under a lucite plastic cover having four holes to allow addition of the toxin. After the wells are filled with the poison samples, the gel slide is covered with plastic wrap to prevent evaporation.

Then an electric field is applied for up to four hours, depending on the amount of toxin believed present.

"To be able to quantify the results," Anderson points out, "you have to pay particular attention to every detail of the technique. We usually put a known amount of toxin in one of the wells to allow us to estimate the quantity of unknown toxin."

Among other advancements made by the OSU microbiology team are ways to concentrate and separate toxins.

Using a molecular sieve, these scientists can recover about 90 percent of the toxin present, as compared with a known sample.

Another research subject of interest to Anderson and his colleagues are radio-immune assay techniques.

"These detection procedures are more sensitive than present methods," Anderson says, "but there is more chance for error. Further study is needed to remove potential pitfalls."

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