Oregon's Agricultural

Spring-Summer 1984

PROGRESS

The Power of Biotech

Agricultural Experiment Station
Oregon State University

comment

Grab the ring . . . and hang on

John R. Davis
Director, Oregon Agricultural Experiment Station

Remember the TV commercial about the hazards of using magarine instead of butter? It ends with the scolding, "You can't fool Mother Nature."

Well, maybe we can't. But we can certainly put her to work for us or encourage her to smile more often on those who work with natural resources. There is no question about it—the future of agriculture will be directed by our ability to manipulate the biological world we live in, and that ability is changing rapidly.

Over the last few years, biologists have found that the genetic chemistry of all living things directs not only the characteristics of the offspring but also the ability of the living things to survive and to grow. Altering that chemistry, or transferring and recombining the chemistry of one plant or cell structure to another plant or structure, represents a tremendous potential for manipulating nature for the benefit of mankind. The research described in this issue of *Progress* illustrates some of the fantastic opportunities in what now is often called "biotechnology."

So, what does all this mean for Oregon's agriculture?

First, Oregon has already cashed in on some benefits of biotechnology. For example, we have developed some strategies for pest management utilizing biotechnology as simple as the introduction of the cinnabar moth and flea beetle for control of tansy ragwort. In a more complex program, the combined use of synthetic pheromones (imitations of insects' chemical sex attractants) and measuring both beneficial and harmful insects to evaluate the best balance of insect control has resulted in substantial savings in costs of chemical pest controls in the Medford Valley.

Second, we stand to gain substantially in the future: in the improvement of crop quality, reduction in costs of production, and stabilization of crop yields from year to year. (Just think of the advantages to Oregon if we could insert the necessary chemistry in wheat to increase disease resistance.)

All these opportunities make it imperative that the Agricultural Experiment Station invest more of it resources in biotechnology research ... if we are to serve Oregon's agriculture properly.

We may not be able to fool Mother Nature. Let's make sure we don't fool ourselves by watching the new technology of biological sciences pass us by. Let's grab the brass ring and hang on—the ride into the future of agriculture will be the thrill of a lifetime! □

Spring–Summer 1984

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Cover: The outer photo is of young coho salmon. OSU researchers hope to protect such valuable fish with a vaccine produced with genetic engineering. The artificially lighted inset photo is of Miriam Gallardo-Ramirez, crop science graduate researcher, holding a disease-free potato "plantlet" grown in a test tube. A roundup article on OSU biotech research in agriculture starts on page 10. (Photos by Dave King)

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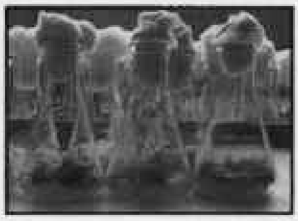

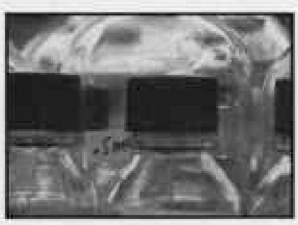

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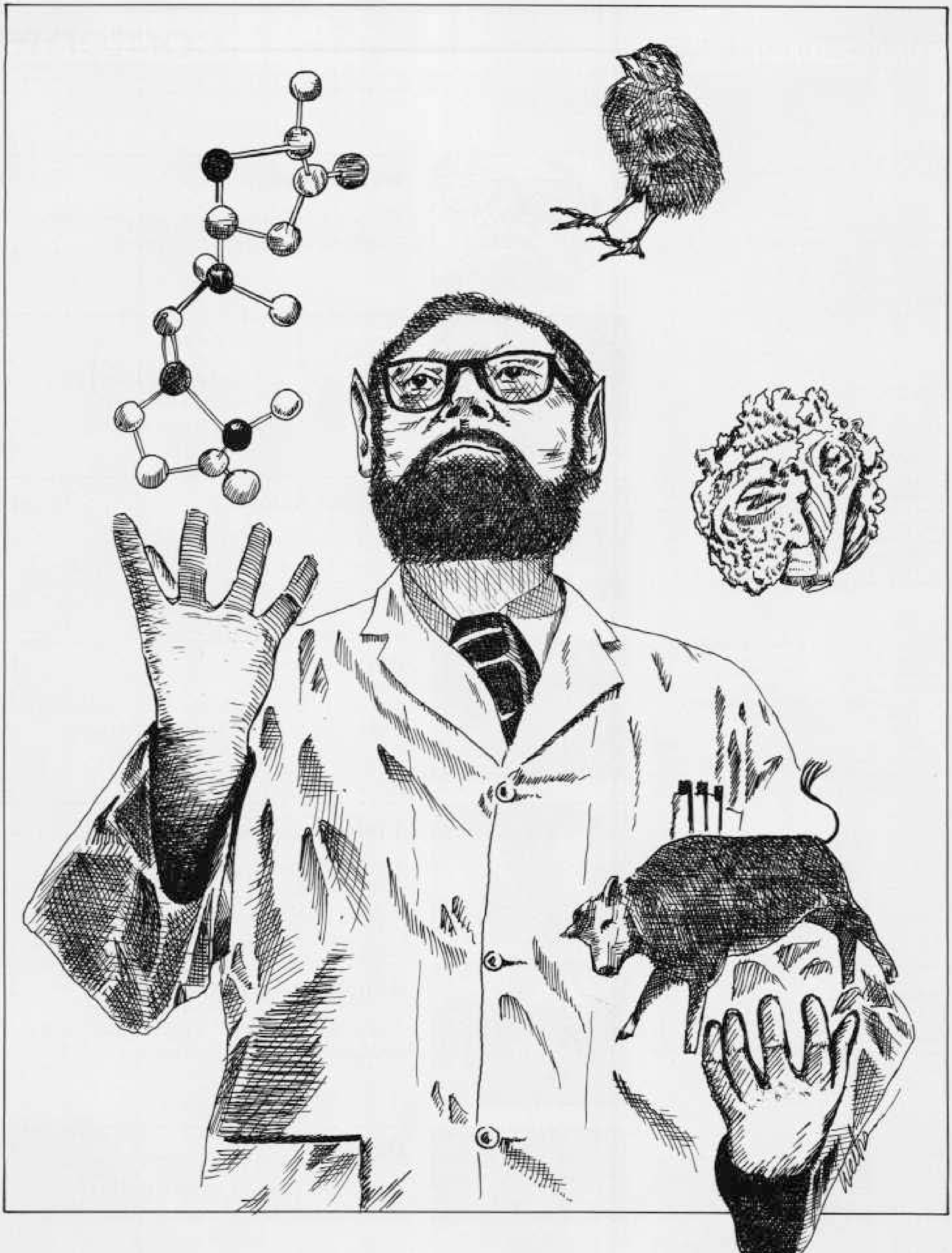


Beam Me Down a Protoplast, Scotty

As biotech spills into their field, agricultural scientists are juggling new concepts and spouting some strange lingo

By Andy Duncan

It's too bad they stopped making "Star Trek," I thought, toying with the idea that the scientist a few feet from me could have been a big hit cast as a being from, oh, say a planet orbiting one of the stars in the Big Dipper.

He looked pretty normal standing by his blackboard talking a mile a minute, drawing diagrams and glancing over occasionally to make sure I was paying attention. It was what he was saying—the weird words.

He was one of the first of 18 scientists I interviewed while I was collecting information for an article about agricultural research at OSU involving biotechnology, which you've probably heard of or read about in connection with some exciting development in medical, industrial, agricultural or other research.

The rest of the women and men looked normal too (short, tall, bald, fuzzy-haired; wearing dresses, suits, blue jeans, white lab coats). But after we'd broken the ice chatting about basketball or the weather or campus politics, most of them shifted into the same alien language as the first fellow.

I got the message.

This biotechnology, which some predict eventually will give farmers and consumers some of the most incredible advances in the history of agriculture—from healthier and more nutritious plants to improved (and nearly identical) livestock—already has spawned a new vocabulary that is spilling into agriculture.

To write about the topic, I was going to have to explain concepts and terminology not usually tossed around by agricultural researchers.

Here goes:

In the first place, the word biotechnology is confusing. In one sense, it

The very word biotechnology is confusing.

apparently refers to nothing more specific than using living things or their parts in processes intended to help humans. Big deal. Most traditional agricultural research fits that description. For example, plant breeding research, where two varieties of a plant can be combined, has produced better cereal grains, vegetables and other crops. Breeding research with animals has produced better livestock. Scientists have helped farmers harness "good bugs" that help keep insect pests in check. And I could go on.

But there's another sense of the word.

What a lot of people are talking about when they speak of biotechnology is what I've seen described as "the new biotechnology." That's where the strange language has arisen. It has many parts. Its biggest influence has been molecular biology, the science of studying life's most basic construction unit, the molecule.

Since the 1950s, particularly in the last 10 years, scientists studying molecular biology have developed new means of using living things and their parts in processes that help humans. Much of the biotechnology spilling into agricultural research is coming from the medical research field, where considerable public and private funding has been available in recent years to molecular biologists trying to use biotechnology to fight human health problems. Notable results of that effort have been construction of bacteria strains that produce insulin for diabetics and interferon, a drug for cancer patients.

Despite the strange terminology, many of the processes the molecular biologists developed aren't terribly hard to use, I gathered from talking with OSU agricultural researchers. "You could compare it to using a Betty Crocker recipe to bake a cake. Putting together the recipe was the hard part," one told me. The sticky part of using the new biotechnology in agriculture seems to be that lots of information about individual plants, animals and microorganisms, at the molecular level, is going to have to be assembled to show where, and how, the processes can be employed.

With some fascinating exceptions, that seems to be what OSU scientists involved with biotechnology and agriculture are doing: accumulating information they hope will allow them to use biotechnology to improve various types of plants, animals and microorganisms.

That also seems to be a fairly good description of what's happening nationally, although biotechnology has already made a few splashes in agriculture, including providing a much-needed vaccine for foot and mouth disease in livestock and a vaccine for Marek's Disease, which kills poultry.

"You could compare it to using a Betty Crocker recipe."

Curious about the new processes? Want to impress your friends by spouting the lingo? I'll assume you at least answered yes to the first question. Let's take a peek at some of the biotechnology researchers around the world are using, or hope to use, in agriculture. (First, though, a bit of advice—the most important step in biotechnology development was when molecular biologists figured out the system that guides the activities of the cells in all organisms. That allowed them to think of manipulating cells in new ways. If you got a A in high school biology and have kept up with all advances since, keep going. If not, I suggest you read the brief article on the next page about the cell, then continue.)

Recombinant DNA Technology and Gene Transfer

This is the biotechnology biggie. It hinges on scientists being able to identify genes' messages and figure out how the messages are switched on and off. It includes the "genetic engineering" that has been widely publicized.

In genetic engineering, a fragment of DNA (deoxyribonucleic acid) containing a gene can be isolated from surrounding DNA with "biological scissors" called restriction enzymes (thought to be produced by cells so they can slice up invaders like viruses). Once isolated, a gene can be transferred with chemical procedures to the cell of another organism. The transfer can involve putting the gene into the plasmid of a weakened disease bacterium that invades the cells of the organism you want to get the gene into—using the bacterium as a gene carrier, or "vector." If the gene is inserted into reproductive cells, like sperm or egg cells, it will be passed to future generations, altering the organism's natural evolution.

Of course, plant and animal breeding work has the same goal: to move desirable genes from plant to plant or animal to animal. But with breeding, bad genes as well as good ones can be transferred from parents to offspring. If perfected with plants and animals, as it has been with one-celled organisms like bacteria, the new process would be quicker, more precise, and, unlike plant and animal breeding, might allow researchers to move genes among differing creatures—across species and family lines.

Scientists have their eyes on exciting possibilities like transferring genes linked to salt tolerance (in plants), disease resistance, growth, and more efficient use of nutrients, to name just a few desirable characteristics. They also hope to learn to go into the DNA in a plant's or animal's cells and "turn off" genes causing problems.

But don't drop to your knees rejoicing yet. As I said, the successes so far have been with bacteria (for example, the bacteria medical researchers fitted with genes that make them produce insulin). Splicing genes into complex, multicelled organisms like plants and animals is a much bigger challenge. There have been promising experimental results, like transferring a growth hormone into mice from larger mammals, and transferring a gene that controls protein storage in bean cells into sunflower cells.

Protoplast Fusion

In this process, scientists use certain enzymes to "eat away" the walls of two cells, permitting the insides, or protoplasts, to combine. It is a direct method of combining genes and other materials from unrelated cells. Theoretically, these combined cells could be regenerated into a new crop variety (and, in fact, inventive researchers have created the "pomato," a tomato cell-potato cell combination, although they've found no commercial niche for it).

Tissue Culture

The procedure, already used commercially in some plant agriculture, involves growing tiny pieces of tissue in a test tube containing nutrients and other chemicals such as growth hormones. Scientists can screen the tissue for desirable traits, such as being free of various diseases or resistant to certain diseases, and then grow test-tube "plantlets" from the screened tissue.

The plantlets can be used as sources of tissue for growing additional plants, or they can be planted directly in the field. The later use of tissue culturing bypasses the planting of seeds, which is a gamble for farmers growing high-value crops like fruit trees where uniform genetic makeup is especially important (the genes in seeds can vary).

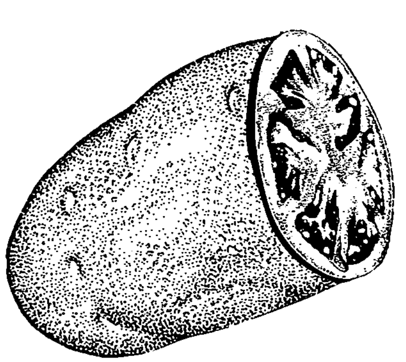
Some culturing has been done with single cells. An offshoot benefit of that has been labeled "somoclonal variation," which means same-body variation. Since cells from an organism have the same genes, you'd expect the cells to be identical. But scientists have found that some, when cultured into a plantlet, have different traits. Somoclonal variations may prove to be another source of desirable genes for the co-called "gene pool" plant breeders and genetic engineers will draw from to construct better crops. Tissue culturing techniques for animal cells are being studied, too.

Monoclonal Antibodies

When the immune system in animals, which fights disease, detects a foreign substance—called an antigen —it stimulates certain cells to produce protein molecules called antibodies that bind to the antigens and neutralize them. Animal antiserums that fight disease are made with antibodies obtained from immunized animals. But sometimes the antibodies are ineffective because they are impure.

Now scientists have discovered a way to produce pure antibodies in the lab. It's called the "hybridoma technique." They fuse fast-growing cancerous cells with antibody-producing cells from an immunized animal. The fused cells multiply rapidly, producing what are called monoclonal antibodies that can be isolated and injected into animals.

This technique may give scientists a new way of protecting livestock and poultry from diseases caused by viruses, bacteria and fungi. The technology also presents some interesting possibilities for diagnosing and preventing diseases in valuable plant crops like potatoes, fruit and wheat.



Embryo and Cell Transplantation

Beef and dairy farmers already transfer embryos from top-quality cows into surrogate mothers so the prized animals can produce more offspring. Scientists are learning to use certain hormones to trigger the production of as many as 25 eggs by a cow (as opposed to the regular one egg). When fertilized with semen from a top-quality bull, the eggs could be transferred to surrogate mothers for gestation, the researchers say. Scientists have demonstrated that they can inject genes into such fertilized eggs with a microscopic device, and they are studying the potential of that.

Ready to move on to how researchers in Oregon are using these techniques? I am, even though we probably haven't viewed all of the fledgling field of "agribiotechnology." The field is racing in many directions, so it's hard to capture a complete picture.

The articles that follow describe the program OSU has set up to promote the use of biotechnology, give some examples of how OSU scientists are applying biotech to agriculture, and discuss OSU researchers' hopes and reservations.

In my investigation, I found people who think the new approach will totally replace much traditional agricultural research, others who think agribiotechnology is being oversold, and still others who expect a melding of old and new will give farmers and others in agriculture new tools for coping with the challenges over the horizon.

I came away totally convinced of one thing—it is too bad they stopped making "Star Trek."□

The Cell: A Factory

What makes cells tick? Think of them as little factories.

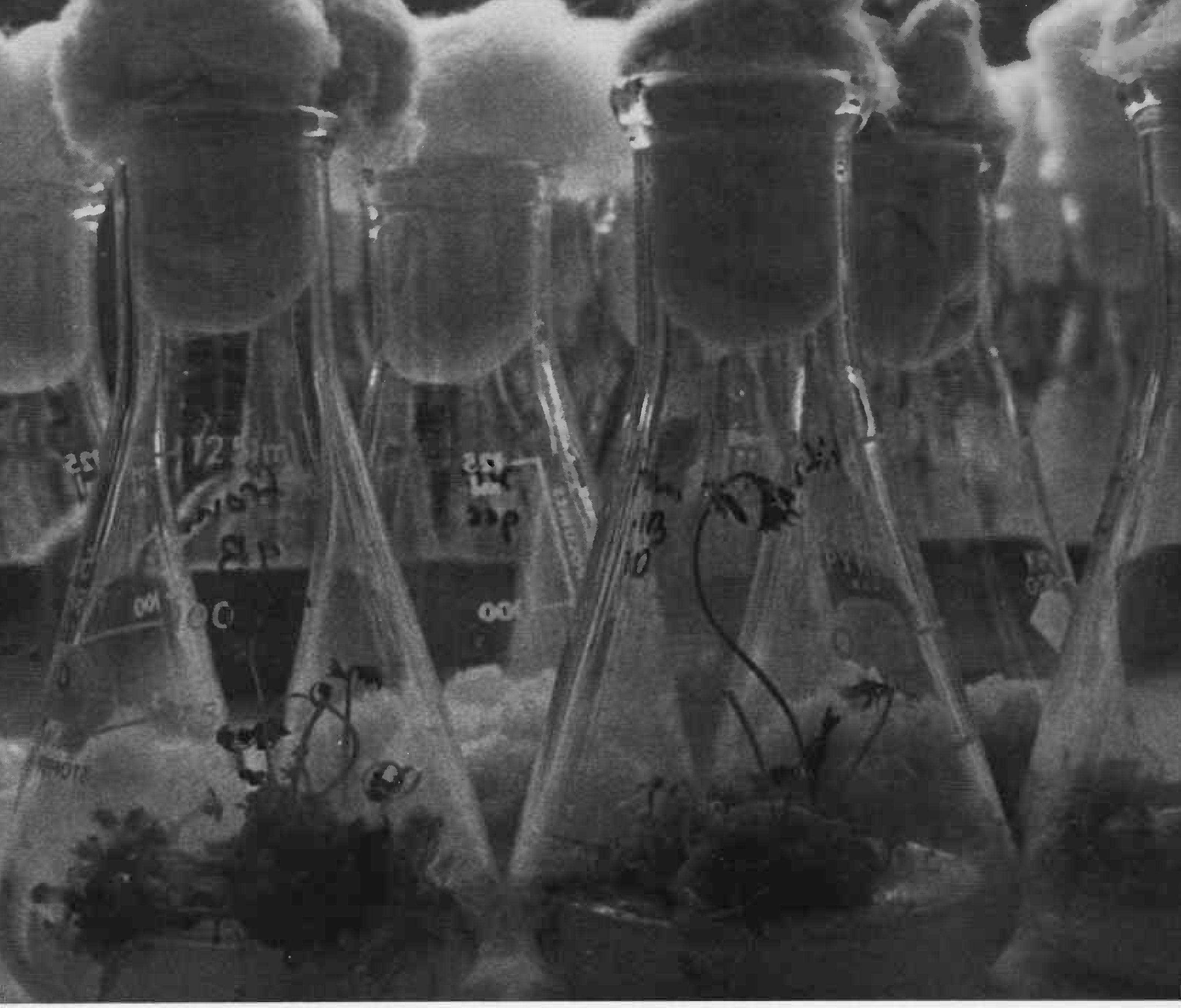
In each one, the control centers are made up of molecules of a substance called DNA (deoxyribonucleic acid) that contain information in chemical coding—the "code of life," some call it. The DNA molecules form strands called genes. Each gene holds the plan, written in its sequence of molecules, for some activity in the cell.

In single-celled creatures like bacteria, genes have two locations. They are in little circular, free-floating DNA molecules called plasmids, and in large strands of DNA called chromosomes (chromosomes can contain all the genes necessary for an entire cell project). In higher organisms like plants and animals, most genes are only in chromosomes in a center section of the cell called the nucleus.

The messengers in cells are RNA (ribonucleic acid) molecules, which are mobile copies DNA makes of itself. RNA can pass from the genes into the manufacturing part of the cell, where raw materials are stored. There, in association with small particles called ribosomes, RNA aligns substances called amino acids for welding into proteins.

There are many types of proteins. Some of the most important are the enzymes, which serve as sort of "straw bosses," regulating functions throughout the cell, including the production of hormones. In plants and animals, hormones can move out of a cell to other regions and influence how cells in those areas behave.

All cells, no matter what kind of organism they are in, contain this machinery. The information in genes is what causes differences: leaf cells and liver cells. Although each gene carries a single message, genes do not act independently. They are affected by surrounding genes. So, to manipulate a cell, researchers must figure out how its genes interact.



How Do You Chew a Test-tube Plant?

Biotechnology will change life in Oregon; the question is how much

If you eat, it's going to affect you.

That's a simple way of saying that the worldwide biotechnology boom is echoing through the OSU campus, including agricultural laboratories.

The question is not if, but how much, biotechnology is going to change production of the home-grown food and fiber we Oregonians consume (and that we produce for export).

OSU researchers are using tiny pieces of plant tissue to grow virus-free "plantlets" in test tubes, improving crops like potatoes and strawberries; they're trying to genetically "engineer" better strains of bacteria that help crops like alfalfa, peas and clover fertilize

themselves; they're studying how cells release hormones that speed up and slow down growth in sheep and other livestock, wondering if they can manipulate the process.

And those are just examples of the work of Agricultural Experiment Station scientists.

Biotechnology, rooted mostly in a deepening understanding of genetics, knows no academic borders or textbook boundaries. What's discovered by a botanist studying the genes of an obscure fungus may help an agronomist trying to improve a valulable crop—and vice versa.

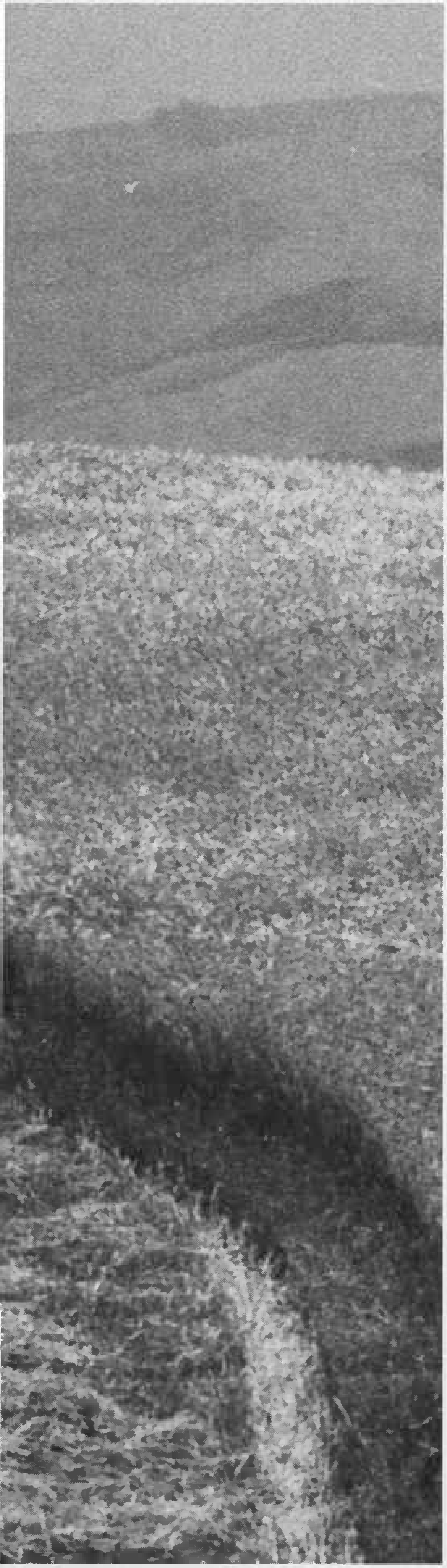
Scientists in OSU's Colleges of Agricultural Sciences, Science, Veterinary Medicine, Forestry and Pharmacy, and in other campus areas, are doing biotechnology-related research while colleagues over the campus perk up their ears listening for spinoff information they might use.

Biotechnology knows no textbook boundaries.

Some of the work has been under way for years. But the first real signal that biotechnology would be part of a clearly defined team effort came last year when OSU President Robert MacVicar announced the university was setting up an interdepartmental program to coordinate and expand gene research and the use of biotechnology. An initial goal, since achieved, was to hire several new faculty members who had expertise in basic gene research and could augment the campus corps of scientists working with biotechnology.

The campus biotechnology boom is quieting somewhat. That is to say, the initial gush over the potential is giving way in many laboratories to the painstaking work necessary to apply biotechnology to researchers' fields of interest. □

OSU botany graduate researcher Barbara Ballo examines wheat grown for gene studies.



Never Say Never

From beans to bovines, the new technology is spreading to many OSU agricultural research areas

It would take an incredibly long article to describe all the ways OSU researchers are applying, or thinking of applying, biotechnology to agriculture. You won't get all that here. But the following rundowns should give you the flavor of what's happening in OSU agricultural research.

You may not be interested in all the work. If not, skip around. Some involves bacteria, some involves viruses, some involves plants, some involves animals, and some involves combinations— for example, several scientists are using bacteria as a tool for improving crops or livestock.

A good place to start is the OSU Laboratory for Nitrogen Fixation, directed by Harold J. Evans, professor of plant physiology. For several years, Evans and fellow researchers and graduate students have been using genetic engineering in their work.

Their goal is fairly simple. They want to improve the cozy — and economically important—relationship of bacteria called rhizobia and Oregon crops like alfalfa, peas and clover, called legumes. It's long been known that rhizobia attach to the roots of these plants, and other legumes like soybeans not grown much in Oregon, and live there in tiny nodules.

The bacteria get materials they need from the plants while collecting atmospheric nitrogen from the soil, converting it to a nutritious form, and providing it to their landlords.

The conversion process , called nitrogen fixation, is becoming more and more important because of the rising cost of nitrogen fertilizer. Some farmers "inoculate" their legume crops with rhizobia to try to ensure good nitrogen fixation, and many farmers rotate legume crops into their fields regularly to add "fixed" nitrogen to the soil and supplement store-bought fertilizer.

In Evans' lab, researchers Mac Cantrell, Rich Haugland, Joe Hanus, Sterling Russell and others have been trying to make nitrogen fixation more efficient. In one effort, they've focused on several strains of rhizobia that live on soybeans roots. The strains recycle hydrogen gas while fixing nitrogen, allowing them to use less energy than rhizobia that don't do the recycling.

The researchers have removed hydrogen uptake (or HUP) genes from soybean rhizobia and inserted the genes into strains of soybean rhizobia that do not have HUP genes. That converted them into more efficient nitrogen fixers. The researchers also have transferred HUP genes from soybean rhizobia into

Jo-Ann Leong, OSU microbiologist, is genetically constructing a vaccine to protect steelhead and salmon from IHN, a deadly virus.

rhizobia that live on alfalfa roots. But that hasn't produced the effect the researchers want, yet.

"Now Cantrell and Haugland have decided we need to isolate additional DNA that has the rest of the genes we need to turn on and turn off the recycling process," said Evans. "We want to transfer the whole banana."

The researchers expect to successfully move the HUP gene to rhizobia that live on alfalfa and other legumes, but they aren't sure how it will affect Oregon agriculture.

"Right now, in soybeans you're talking about a 10 percent maximum increase in nitrogen fixation efficiency in a controlled, lab environment where the plant has no access to nitrogen fertilizer residue (in the field, legumes use man-made fertilizer if they have a choice)," said Evans. "So you can see that it isn't going to revolutionize agriculture."

But it's important to try and take advantage of the process, not only for what it offers but because similar processes may be uncovered, Evans said.

Another scientist with rhizobia on his mind is microbiologist Lyle Brown.

"We want to transfer the whole banana."

Brown has the same goal as researchers in the Laboratory for Nitrogen Fixation. But he's trying to improve nitrogen fixation by studying "transcription" in rhizobia that live on alfalfa roots.

Transcription is when DNA uses a mobile copy of itself called RNA to deliver information within a cell, such as the information needed to manufacture important proteins.

"We know that in some mutants (genetically altered bacteria) we've created, where transcription was improved, nodulation was improved," said Brown.

The researcher also is culturing, or growing, tiny pieces of alfalfa tissue in test tubes and exposing them to rhizobia so he can learn more about how plant and bacteria communicate.

"Nobody knows anything about the signals that go back and forth," he said. "Does the plant tell the bacteria: 'O.K., nodulate me'?"

Cheese is what Bill Sandine, another OSU microbiologist, hopes to improve with genetic engineering.

"Does the plant tell the bacteria: 'O.K., nodulate me'?"

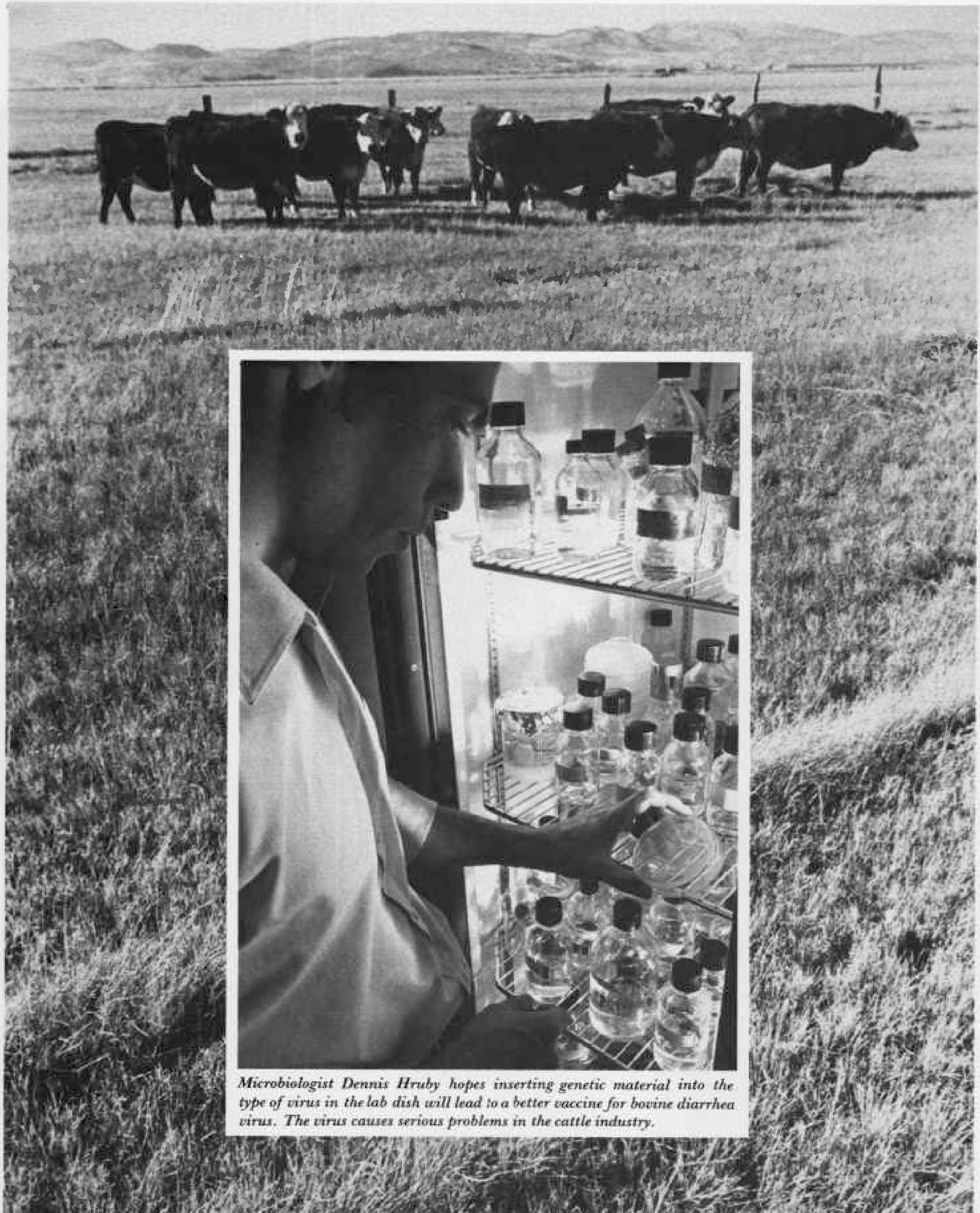
In recent years, Sandine and his graduate students have become popular around Oregon cheese plants by helping plant personnel save money by doing a better job of working with "starter bacteria." The bacteria cause milk to ferment in the first step of cheesemaking.

The Sandine group's contributions include finding and reproducing virus-resistant, fast-fermenting starter bacteria. The bacteria are eliminating a costly and cumbersome starter bacteria rotation system used in cheese plants so cheesemakers can keep ahead of viruses that attack the bacteria and spoil huge vats of milk. With the new system, starter bacteria need only be switched when a new or changed virus appears.

Now Sandine and graduate researcher Paul Orberg are studying the possibility of using genetic engineering to "build" even better starter bacteria.

Sandine would like to move a gene that controls milk sugar fermentation in starter bacterial cells from the plasmid, a circular piece of DNA in the outer portion of the cells, into the chromosomal DNA. That, he thinks, would make future generations of the fast-multiplying organisms more stable (uniformly able to trigger milk fermentation).

He also hopes to construct starter



Microbiologist Dennis Hruby hopes inserting genetic material into the type of virus in the lab dish will lead to a better vaccine for bovine diarrhea virus. The virus causes serious problems in the cattle industry.

bacteria that are permanently resistant to fast-changing viruses because the bacteria contain no "receptor sites" where the viruses can enter.

"Now, I think maybe we're light years away from doing that. But the first step is understanding those receptor sites," he said, "and that's what we're studying."

Dallice Mills, OSU professor of botany and plant pathology, is using biotechnology in three projects.

In one, Mills, graduate student Dirk Anderson and postdoctoral fellow Frank Niepold have identified genes responsible for virulence in bacteria that cause bean and fruit diseases, including "brown spot" and "halo blight" in several types of bush beans.

The researcher has learned how to transfer the virulence genes into bacteria that are free of virulence, giving those organisms the ability to cause the disease.

"What I'm interested in learning," he said, "is how these pathogens (disease-causing organisms) produce the chemical that actually damages the bean plants."

Researchers like Grant Lambert in OSU's nitrogen fixation lab are trying to genetically improve beneficial soil bacteria.

In another study, Mills is examining genes responsible for meiosis (cell division) in yeast cells. He hopes the work will produce clues for how to block reproduction in disease-causing organisms.

Mills also is using his knowledge of genetics to study similarities of TCK smut and common smut, two fungi that cause wheat disease. The mainland Chinese have refused to buy Northwest soft white wheat, claiming is it contaminated with TCK smut spores not present in their wheat. China does have common smut, however. Mills believes TCK smut is a genetic variant of common smut and not a separate species, as the Chinese contend.

"If we could do that . . . it would be a tremendous breakthrough."

Dave Mok and Machteld Mok, a husband-wife research team in OSU's horticulture department, are studying genes linked to hormones that regulate cell division in beans and other vegetables. The work, they say, could provide useful information about how to make plants grow more quickly.

They also are studying new methods of producing hybrid plants, which are combinations of two varieties or species. Variety combinations often are high-yielding in vegetables like lettuce, carrots and corn.

One technique the Moks plan to experiment with is protoplast fusion, where the walls of cells from two varieties are removed so the contents can mix and form a hybrid.

The potential payoff is big, but so are the challenges, for several OSU researchers trying to use biotechnology in research with cereal grains like Oregon's high-value soft white wheat.

One group is directed by Ralph Quatrano, OSU botanist. Quatrano's doctoral students Barbara Ballo and John Williamson are using recombinant DNA technology and gene transfer to study how certain hormones influence genes expressed during wheat embryo development and subsequent germination. They hope the work will provide answers to questions about why a significant amount of Northwest wheat sprouts prematurely, ruining it.

Another member of Quatrano's group, postdoctoral researcher John Proffitt, is studying gliadin, a type of wheat protein. Proffitt and researchers working with him have identified and are studying DNA that contains a gliadin gene. The long-range hope in this type of research is to use gene splicing to alter the amount or type of protein in a kernel of wheat (protein content and quality are crucial factors in determining wheat's nutritional and economic value).

Such work interests Warren Kronstad, an OSU agronomist who directs one of the world's leading traditional wheat breeding programs.

While exchanging information with Quatrano's group, Kronstad's research team is experimenting with tissue culturing — generating wheat plant cells from small clusters of cells, or even single cells, in a laboratory dish containing nutrients and helpful chemicals (called growth media).

Kronstad sees several benefits if tissue culturing can be perfected in cereal grains. One would be the ability to subject cells to disease toxins and other sources of stress and identify, in a lab dish, cells with the resources to overcome the stress . The researchers then could regenerate those cells.

"If we could do that, it would be a tremendous breakthrough," he said, explaining that nowadays researchers have to screen for such desirable qualities by growing entire wheat plants in the field, an expensive and time-consuming process.

"This would be a tool to identify specific traits. Then we'd look at them in a conventional breeding program," said Kronstad, noting that he thinks it will be many years before gene splicing is a viable method of moving around desirable traits in the complicated wheat plant.

Tissue culturing could be a source of desirable genetic variation, the researcher added.

"Indications are that you get some variation from chromosomal breakage and DNA recombination, or maybe the growth media act as a mutagen (cause of genetic change)," he said. "We're always interested in getting variation and looking at new qualities."

Horticulturists Machteld and Dave Mok pose by a slide of leaf protoplasts (cells with their walls removed). The husband-wife team plans to mix vegetable protoplasts in hopes of producing high-yielding hybrid plants.

Te May Ching, one of Kronstad's colleagues in OSU's crop science department, is taking the molecular path to search for why kernels (actually the seeds) of some cereal grains shrivel, reducing their value.

The boom is reaching into fish and livestock research.

Ching and her graduate students are studying a starch-making enzyme called ADP-G Pyrophosphorykase, hoping that will lead them to an understanding of the interplay of genes and other factors that cause shriveling.

''It's very impressive to talk about gene splicing. But you'd better know what the genes and their neighbors are doing before you start,'' she said, pointing out that genetic engineering eventually could help her in trying to increase grain yields.

Agronomist Al Mosely and fellow potato researchers Tom Allen, Jeff McMorron and others are busy trying to improve one use of tissue culturing that has already proved its worth.

The researchers have set up a tissue culturing system that produces virus-free ''plantlets,'' tiny potato plants in test tubes. Quite a few Oregon seed potato growers use the plantlets to produce potatoes that become the seed sources for their crops and eventually improve quality and yields for growers of regular potatoes.

The key to outmaneuvering the viruses is snipping off, and culturing, tissue from new-growth areas where viruses haven't spread. The researchers are experimenting with applying growth hormones to sprouted potato eyes to speed the growth of virus-free shoots they can use as culture tissue.

The work is going to allow OSU researchers to ''clean up''—rid of viruses—experimental potato plants grown at Hermiston, Redmond and other locations in a program designed to develop better potatoes.

''In the past, we just discarded breeding lines infected with the more damaging viruses,'' Mosley said, adding that that was a waste of valuable genetic material.

''You could shoot a person up once and give resistance to four or five diseases.''

OSU horticulturists and plant pathologists are doing similar tissue culture work with crops like lilies, strawberries and caneberries, ridding them of viruses.

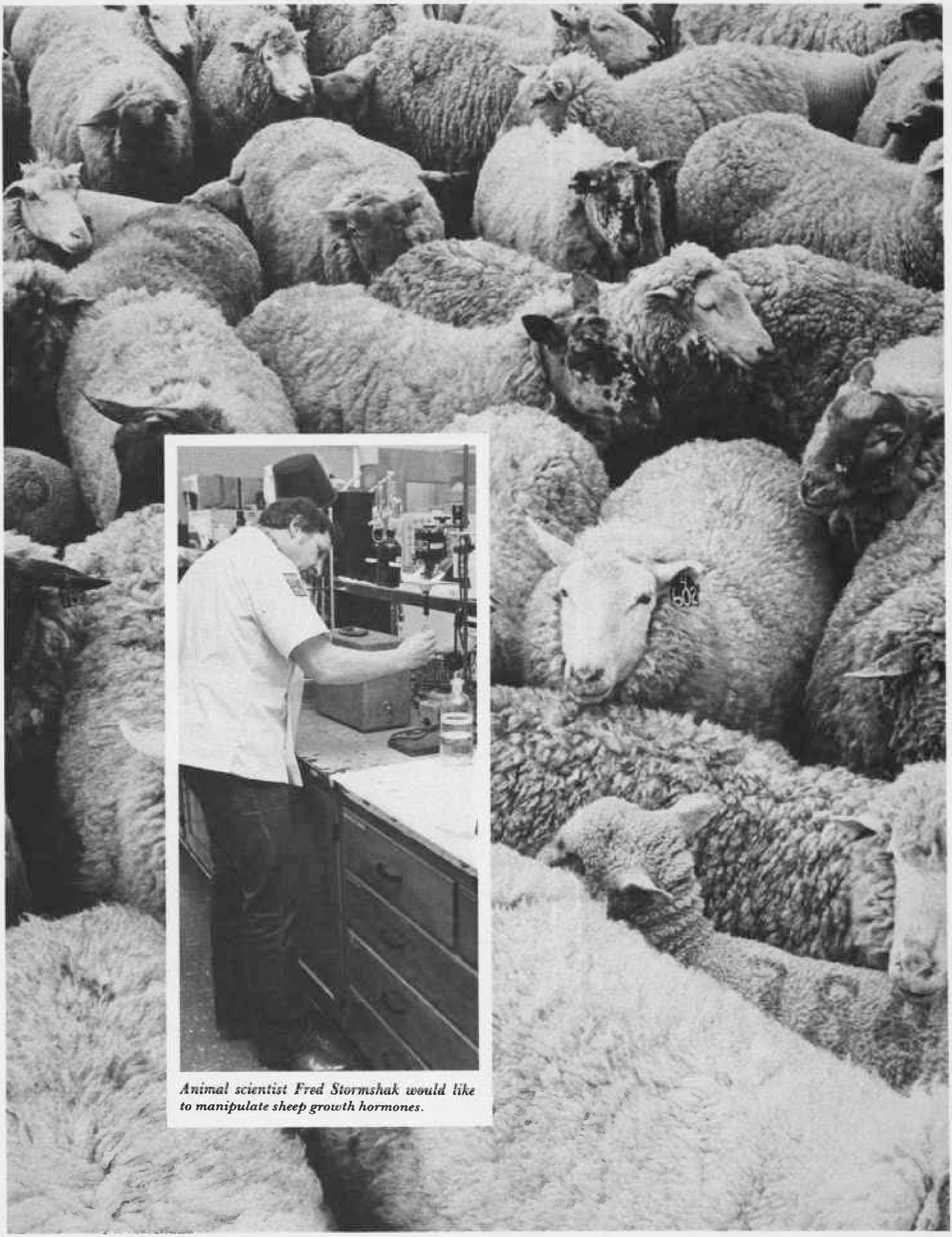
The new biotechnology is reaching into fish and livestock research, too.

OSU microbiologist Jo-Ann Leong is using genetic engineering to develop a vaccine to combat infections cause by IHN, a virus which has killed an estimated $109 million worth of steelhead and salmon in the Columbia River system since 1980.

Most virus vaccines for fish and animals work by introducing into the body either weakened live viruses or dead viruses that trigger the production of antibodies that provide immunity.

Leong and others in her lab are working to remove from an IHN virus the gene responsible for production of one of the virus's proteins. They plan to transfer the gene into *Escherichia coli*, a common bacteria, so the bacteria will manufacture the protein. The bacteria then can be killed and used in a vaccine for hatchery salmon.

The beauty of the process is that the vaccine will contain the virus protein and fool the fishes' bodies into producing antibodies, but there will be no need to grow large numbers of the miniscule viruses, which is expensive, or to release into the environment weakened viruses that could change back into a disease-causing form. Leong also is working on producing a vaccine for another salmon and steelhead disease caused by a virus (called IPN virus), and on constructing a ''radioactive DNA probe'' that would help catfish farmers check fish in their



Animal scientist Fred Stormshak would like to manipulate sheep growth hormones.

ponds for a disease-causing viruses. She's collaborating with Ron Hedrick, a University of California at Davis researcher, on that project.

Microbiology professor Dennis Hruby, hired recently through the university's expanded gene research and biotechnology program, is studying vaccines also—but for animals and humans.

Hruby's specialty is working with a form of Vaccinia, a harmless virus—although related to the small pox virus—whose size has attracted attention. Vaccinia is the largest and most complex of viruses. Scientists like Hruby are learning to remove large sections of Vaccinia DNA and replace them with foreign antigen material from disease viruses. That stimulates antibody production (the immune response) when the restructured Vaccinia is injected into an organism. Vaccinia has become a candidate for "multiple vaccine" duty.

"You can think of Vaccinia as a tape recorder and foreign antigens you put into it as cassettes," said Hruby. "Human medical researchers are thinking they can drop in DNA from herpes, influenza, Hepatitis B and other diseases. That multiple approach would be especially important in the Third World. You could shoot a person up once and give resistance to four or five diseases."

Hruby and Al Smith, director of research in OSU's College of Veterinary Medicine, hope to use Vaccinia to develop livestock vaccines, including an improved vaccine for bovine diarrhea virus, which weakens calves and makes them susceptible to other medical problems. An attractive feature of livestock vaccines made with Vaccinia is that they would not spoil easily, Hruby said. The benefits of a multiple vaccine, where one shot would make an animal resistant to several diseases, are obvious, he added.

Hruby also is studying the possibly of putting the genetic ability to produce antibodies directly into vaccines, rather than relying on using foreign antigen material to trigger the immune response.

In OSU's animal science department, scientists are aware of the possibilities for new, biotechnology-related research. "We will be hiring an embryo physiologist in the near future," said Steve Davis, department head. Some research under way may be laying valuable groundwork.

For example, animal scientist Fred Stormshak and his graduate students are studying the growth hormone in sheep and a hormone called somatostatin that acts as a brake on release of the growth hormone.

Piper Klinger, a master's student, has been searching for ways to stimulate release of extra growth hormone in lambs. Now, based on the finding of researchers in England, she and Stormshak are wondering about the possibility of using an antiserum to neutralize somatostatin, allowing the release of more growth hormone.

To lower costs, the antiserum, which seems to work over a long period of time, like a vaccine, probably could be manufactured by common laboratory bacteria outfitted with the proper gene, Stormshak speculates.

You see some fascinatingly different approaches to the use of genetic engineering. For instance, two OSU researchers are studying some species of agrobacteria, bacteria that cause crown gall disease, which produces unsightly tumors that can sap the strength of crops like fruit trees and ornamental bushes. But one researcher is trying to kill the bacteria, while the other sees them as a genetic resource.

"Hypothetically, we may be able to give growers another .45-caliber revolver."

Several years ago, Larry Moore, plant pathologist, began working with a strain of bacteria called *A. radiobacter* K-84 that produces a chemical that kills some strains of the crown gall bacteria. Since then, commercial products containing K-84 have become the best control for crown gall disease. Now Moore has found several strains of bacteria called *Pseudomonas* that kill some agrobacteria strains that K-84 doesn't and also seem to be heartier than K-84.

His research group is trying to move the gene in K-84 responsible for production of the chemical that kills the disease-causing agrobacteria into a strain of *Pseudomonas* and construct a biological control agent that is heartier and toxic to more strains of agrobacteria.

Crop scientist Al Mosley eyes a "test-tube" potato plant grown from virus-free tissue.

"Hypothetically, we may be able to give growers another .45-caliber revolver to use against crown gall—at least we hope so," said Moore.

Roy Morris, agricultural chemist, views the agrobacteria in a more positive light.

The bacteria cause crown gall disease by invading injured plants at the wound site. When they find injured cells, they inject a circular piece of DNA called a Ti-plasmid through the cell's wall. The Ti-plasmid then inserts a small piece of itself, called the T-DNA, into the plant cell's chromosomes.

Once in the chromosomes, the T-DNA seizes control of the production of important growth hormones: cytokinins, which induce shoot growth, and auxins, which influence root growth. In a healthy plant, the hormones are released in a controlled way. But T-DNA switches on their production permanently in the wound area. A tumor develops.

Instead of wasting all that hormone production on tumors, Morris hopes to direct it toward normal plant growth.

"We're working on identifying exactly the gene (in agrobacteria) that controls cytokinin production," he said, noting that would be a big step toward learning to regulate plant growth with genetic engineering. ☐ ***—A.D.***

Some positive views of biotech's future

PRO

"You can just feel the excitement in the air. Here we are sitting on the edge of a technological breakthrough that could be as important as electricity, splitting the atom, or going back to the invention of the wheel or discovery of fire."

What famous scholar said that? An investment analyst for a prominent Wall Street securities firm. That was a couple of years ago and the analyst was talking about genetic engineering, the major cause of the biotechnology boom.OSU agricultural researchers are more subdued when discussing biotechnology's potential in their field. But what are the more enthusiastic of them saying? What's the "up" view? Some sample comments:

"The person who sees no major payoffs coming in agriculture is like the person who looked at the computer chip and said nothing will come of it," says Lyle Brown, OSU microbiology professor. "Some of the animal work is already there. With plants, micropropagation (tissue culturing) payoffs are going to come before payoffs from recombinant DNA work. They're already coming. But the potential is so great (in DNA work)."

"It's (the genetic engineering being used in agriculture) one of the exciting developments in science in our day," says Harold Evans, plant physiology professor. "The human species has sorted out the genetic code—that's a hell of an accomplishment. And much of it was done in the United States."

"People have things in the back of their minds they don't even dare talk about," says Dallice Mills, professor of botany and plant pathology. "Everybody has thought about the corn that fixes nitrogen. You don't see these biotech companies forming so people can waste their money."

"You don't see these biotech companies forming so people can waste their money."

Mills expects private companies to make many of the advances in applying genetic engineering to agriculture. One of the most important roles of universities will be teaching, he thinks.

"We have to be on the research forefront in our laboratories," he said, "so we can train the people private industry will need, and so our graduates can compete in the commercial world.

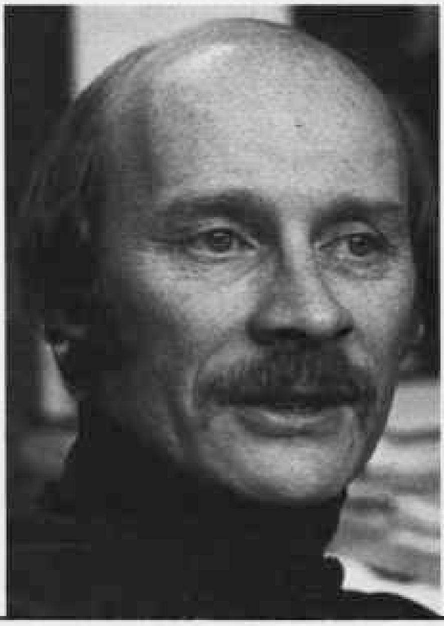
"Many of the techniques we're using in my lab today weren't even known four years ago. But, then, one of my major professors always told me that to work in science you have to be willing to change. I can't imagine doing science any other way."

Mills predicts barriers to using genetic engineering in agriculture will fall more quickly as more research is done—a "snowball effect" with the growing mass of information bowling over research obstacles.

Will the rush to biotechnology leave people who are doing traditional agricultural research feeling sort of lonesome, perhaps not "with it"?

Lyle Brown addressed that question in terms of plant research.

"The plant breeders and others will never be out in the cold. We have to interconnect. They know what's happening out in the field. They have specialized knowledge the gene-level people need. The challenge is to get everyone together. Then you'll have something very powerful." □



Left to right: Dallice Mills, botany and plant pathology professor; microbiologist Lyle Brown

CON

The critics cite two old problems

Is there a dark side to the force of the "agribiotechnology" movement?

Yes, some OSU researchers seem to think. It includes the old problems in science of creating false hopes and of limited funding.

"Wheat farmers grow varieties, not recombinant DNA," says Warren Kronstad, OSU wheat breeder. "Promising too much just cuts off your nose to spite your face. I think all of us in agriculture have to be excited about what we're seeing. The potential is quite great. But one has to ask that the story of gene research and biotechnology be told in proper perspective."

"My own feeling is that, with plants, we won't see many commercial payoffs in the next five to 10 years. We're a long way off. The work deserves support. But don't oversell. You're talking about additional tools, not and end-all. And let's not forget other valuable research. You can't turn that off and on."

Peter Bottomley, microbiology and soil science professor, agrees with Kronstad, at least in terms of research with his specialty, alfalfa.

"We've got people getting USDA research grants who a few years ago had all these aggie jokes up their sleeves. And that's great," he says. "They bring a new approach, new knowledge. But there's a certain naivete in some of them that bothers me. What they can say is that maybe they will hit upon something that will start the yield curve moving again. Anything beyond that is motor-mouthing, in my opinion."

"A certain naîveté in some of them . . . bothers me."

Bottomley adds that his field studies of alfalfa production in Oregon, and his knowledge of the bacteria that fix nitrogen in alfalfa, suggest to him that pinpointing flaws in the way growers manage their crops has more potential for boosting yield than does using genetic engineering to improve nitrogen-fixing bacteria.

One problem facing agribiotechnology—controversy over the safety of genetic engineering and releasing altered organisms into the environment—is unfortunate, some OSU researchers contend.

Nationally, there has been an effort to block field testing of a type of bacteria researchers altered because they were reducing crops' resistance to cold weather.

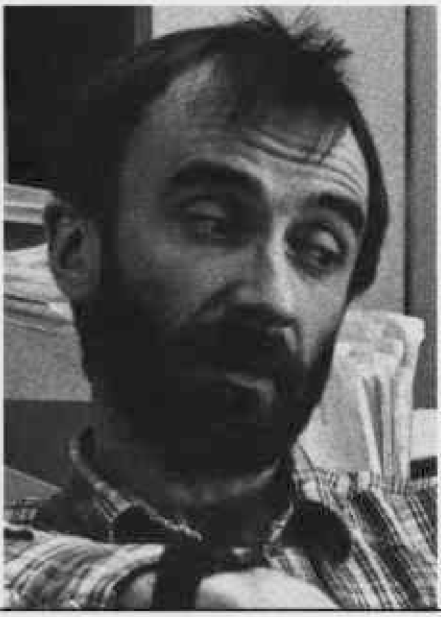
"But I think that comes from a misguided individual," says Roy Morris, an OSU agricultural chemist active in gene research. "All they've done is take bacteria that are already in the environment and delete one gene. I believe you would find similar, natural gene deletions if you looked for them in the environment."

Tightly controlled testing has shown that genes that might be dangerous—like genes from mammal tumor viruses—are not expressed when spliced into microorganisms like bacteria, says George Pearson, a biochemist who is head of OSU's biosafety committee.

Today, genetic engineering research at OSU is monitored by Pearson's committee, he points out, and researchers follow the procedure of first using high-containment testing to prove the safety of work they think might be dangerous.

"I think the safety question really is obsolete," he says.

But some researchers do not agree. They say the consequences of releasing altered organisms into the environment have yet to be determined scientifically—that the jury is still out. □



Left to right: Peter Bottomley, microbiologist; Warren Kronstad, crop scientist

Bob Spotts, Hood River experiment station plant pathologist, stands by his orchard computer.

The electronic orchard

There's a "real" apple computer in Hood River.

The device, the size of a large transistor radio, is in a little wooden stand in an orchard behind OSU's Mid-Columbia Agricultural Experiment Station just south of town.

"It's called an Apple Scab Predictor. The company back in Ohio that makes them gave it to me two years ago so I could test it under Hood River Valley growing conditions," said Bob Spotts, a plant pathologist at the facility.

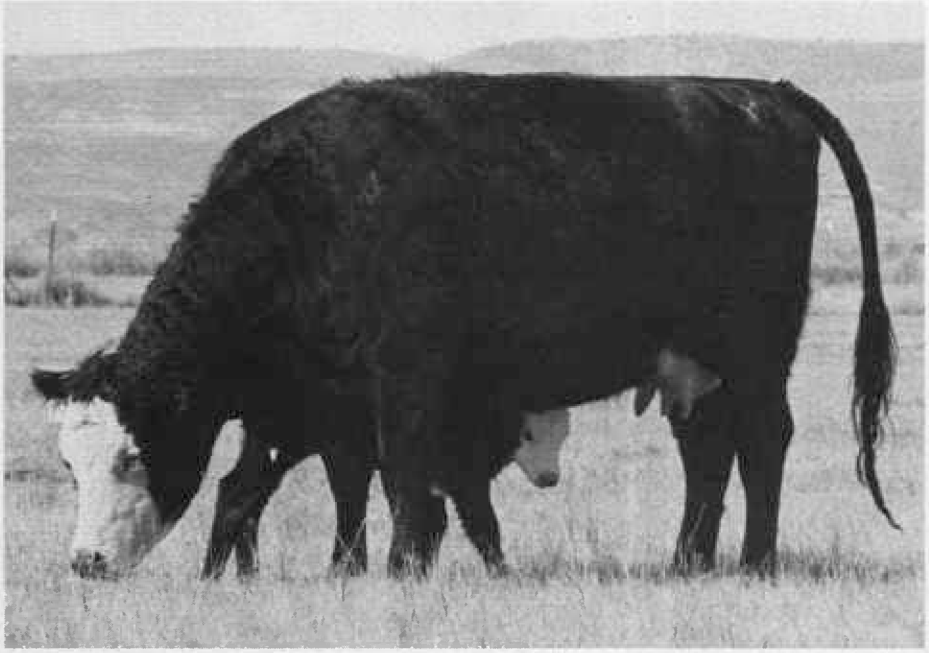
Apple scab, the researcher explained, is a major disease of apples in the Hood River Valley. The fungus that causes it puts black, scabby spots on apple trees, leaves and fruit.

The Apple Scab Predictor is made up of a set of sensors and a microcomputer. The sensors monitor orchard conditions like temperature, relative humidity and wetness on leaves and fruit. A program in the computer is full of data about apple scab disease—including information about fungicides that can be used to combat the disease.

"You just quiz the thing by pushing buttons and it'll give you everything from the time to whether you're in an infection period and when the infection period started," Spotts said.

"The neat thing is spray options," said the researcher. "After giving the history of the current infection, when it started and what the conditions have been like and so on, it will give you the class of fungicides that will be effective."

The device, whose prototype was developed at Michigan State University, is used widely in apple-growing areas of the East such as in New York State but not in the generally arid West, according to the researcher. □



Near Burns, OSU range scientists are studying a new short-duration cattle grazing system.

Home, home on the paddocks

Scientists at OSU's Eastern Oregon Agricultural Research Center at Burns plan to divide the range into "cells" and "paddocks" this spring to study high-density, short-duration grazing.

"The concept was introduced to the United States by a ranch consultant from Rhodesia and really is a hot topic, especially in the South and Southwest. Proponents claim you can get higher carrying capacities on the land. But others say it requires a higher level of managerial skill," said Ray Angell, a range scientist at the facility, operated jointly by OSU and the U.S. Department of Agriculture's Agricultural Research Service.

The idea behind the system is that by dividing the range where you plan to graze a herd of cattle, referred to as the cell, into smaller units called paddocks, and rotating large numbers of cattle from paddock to paddock, you can get uniform grazing and give plants a rest periodically.

Angell, who works for USDA, and OSU range scientist Rick Miller hope to find out if the system could improve the grazing season in Eastern Oregon for crested wheatgrass, a popular forage.

"We're trying to devise a means of using crested wheatgrass earlier in the spring and later in the fall to reduce the amounts of hay ranchers have to feed in the winter, and we're wondering if short-duration grazing could help," said Angell.

More uniform grazing of crested wheatgrass, a hearty plant imported from Russia in the early 1900s, would reduce the number of so-called "wolf plants," ungrazed plants that enter the reproductive stage of development and become less palatable, said the researchers.

This spring, the scientists are dividing a 120-acre range into eight equal-sized paddocks. Using a portable electric fence, the researchers will let cattle herds of several densities graze in the paddocks.

"Our primary interest at the start will be how the crested wheatgrass responds to the increased grazing pressure. Later, we'll study how it affects the livestock, too," said Angell.

Several Oregon ranchers already are using short duration grazing but the system has not been employed enough to allow a useful evaluation of its worth, said the researcher, who has one reservation.

"I feel it carries the potential to do considerable damage to the land if not implemented properly. That's another reason we're going to study it," he said. □

Mongoose trappings

How many persons have trapped the wily mongoose?

Now there are two more, both wildlife scientists from OSU.

Bruce and Brenda Coblentz were asked by officials of the Virgin Islands National Park on St.John to study a mongoose problem. The ferret-sized mammals were eating an estimated 23 percent of the eggs and hatchlings of hawksbill turtles and causing other damage.

The mongooses had nearly driven the ground nesting quail dove to extinction and did wipe out a ground lizard in the Virgin Islands. The mongoose is from India. It feeds on, among other things, snakes and rats, and was introduced into the Caribbean in 1872 to control rats which were damaging sugar cane. Where mongooses have been introduced, native wildlife species have been effected.

"Seemingly, any vertebrate or invertebrate that can be captured and subdued by the mongoose is eaten," said Bruce Coblentz, an Agricultural Experiment Station researcher who was on sabbatical leave for the study.

The OSU scientists were asked to develop a control program after determining the population structure and seasonal patterns of reproduction and condition.

The husband-wife team trapped 1,009 mongooses from January through November 1983—871 adults and 138 juveniles. The animals, killed by asphyxiation or drowning, were studied for body fat, reproductive histories and other aspects.

Their recommendation for control was simple.

"The only total and lasting solution to mongoose predation is to completely eradicate them, a monumental task," said Bruce Coblentz. "As a second choice, we recommended a program of high-intensity, short duration trapping since the mongoose is one of the easiest of mammals to trap." □

1983 Publications Index

Oregon Agricultural Experiment Station scientists conduct a lot more research than *Oregon's Agricultural Progress* has the space to report. Most readers know that. But some of you may not know of other Experiment Station publications available to Oregonians. The scientists write reports—called Circulars of Information, Station Bulletins, Technical Bulletins and Special Reports—about their research findings. Also, the scientists have reprints—called Technical Papers—of articles they write for scientific journals and papers they present at scientific meetings. Usually, Oregonians can obtain single copies of the circulars, bulletins, reports and reprints free.

Following is an index of publications that were printed in 1983. They are categorized by the departments of the OSU College of Agricultural Sciences and by branch experiment stations. Copies of Circulars of Information, Technical Bulletins and Station Bulletins may be obtained by writing the OSU Bulletin Mailing Service, Industrial Building, OSU, Corvallis 97331. Copies of Special Reports and reprints may be obtained by contacting the scientists who wrote them through the scientists' campus departments or branch experiment stations. When requesting a publication, refer to the number preceding the title.

Circulars of Information

Southern Oregon Experiment Station
- CI 694, Alfalfa Production Practices and Variety Performance in Southern Oregon.

Station Bulletins

Agricultural and Resource Economics
- SB 660, Design and Selection of Cooperative Market Pools.

Eastern Oregon Agricultural Research Center
- SB 659, Adjusting and Forecasting Herbage Yields in the Intermountain Big Sagebrush Region of the Steppe Province.

Special Reports

Agricultural and Resource Economics
- SR 693, Estimating Oregon's Private Nonfarm Gross State Product: A Review of Literature and Methodological Extension.

Animal Science
- SR 677, OSU Annual Swine Day.

Columbia Basin Agricultural Research Center
- SR 680, Columbia Basin Agricultural Research Center Research Report.
- SR 684, Irrigated Crop Research in Oregon's Columbia Basin.

Crop Science
- SR 668, Tunisia Cereal Breeding and Production Symposium.
- SR 675, Results of the Ninth International Winter x Spring Wheat Screening Nursery (1981-82).
- SR 681, Wheat Cultivar Abbreviations.

Eastern Oregon Agricultural Research Center-Squaw Butte
- SR 678, 1983 Progress Report, Research in Beef Cattle Nutrition and Management.

Malheur Experiment Station
- SR 683, Malheur Agricultural Experiment Station Research.

North Willamette Experiment Station
- SR 679, Vegetable Research at the North Willamette Agricultural Experiment Station, 1981-82.

Rangeland Resources
- SR 682, Research in Rangeland Management, 1983.

Soil Science
- SR 686, Statistical Analysis of Climatological Data to Characterize Erosion Potential: 1. Precipitation Events in Western Oregon.
- SR 687, Statistical Analysis of Climatological Data to Characterize Erosion Potential: 2. Precipitation Events in Eastern Oregon and Eastern Washington.
- SR 688, Statistical Analysis of Climatological Data to Characterize Erosion Potential: 3. Freezing Events in Western Oregon.
- SR 694, Results of Some Northeast Oregon Potato Soil Fertility Studies.

Technical Bulletins

Crop Science
- TB 145, Quantified Evaluation for Decisions.
- TB 146, Fallow-Cropping Systems in the Pacific Northwest.

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- 5644, "Effect of Temperature on the Chemical Composition of Pink Salmon (*Oncorhynchus gorbuscha*) Muscle," B.M. Kepshire, Jr., I.J. Tinsley and R.R. Lowry, Aquaculture, Volume 32, pages 295-301, 1983.
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- 6273, "Inducibility and Amounts of Metallothionein as Influenced by Cadmium and Zinc in the Developing Rat," J.W. Ridlington, D.E. Goeger, D.C. Chapman and P.D. Whanger, Biological Trace Element Research, Volume 5, pages 175-187, 1983.
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profile

Harold Evans

He's become a student again

He's just "an incredibly hard-working scientist," says one colleague. "Everybody knows he's a workaholic," says another.

Whatever the reason, Harold J. Evans isn't resting on his laurels, although he could probably use them as a bed and most people wouldn't object.

Evans, the only OSU professor ever elected to membership in the prestigious National Academy of Sciences, is at that twilight stage of a productive career when more than a few scientists have been content to sit back, bestow occasional words of wisdom on students and young faculty members, and reel in the awards and praise.

Instead, the 63-year-old Evans is headed out to meet a new challenge—the fast-changing genetic engineering invading agricultural research.

"It's late in the game for me. I'm only two years from retirement. But I find it terribly exciting," says the plant physiologist, director of OSU's Laboratory for Nitrogen Fixation.

Evans points out that he wasn't trained as a geneticist. And the professor isn't ashamed to admit he's become something of a student again, "learning by osmosis" some of the fine points of gene splicing from the researchers and graduate students he brings in to work in his lab.

New technology is where the schooling stops, though. Evans is the master when it comes to overall knowledge of the object of research—rhizobia, bacteria that live on the roots of legume plants like peas, alfalfa, clover and soybeans and convert nitrogen in the soil into a form the plants can use.

Evans has studied rhizobia, discovered in 1888 by a Dutch scientist, through most of his career. Associate Joe Hanus and Evans showed the scientific world a few years ago that some strains of the bacteria not only can fix nitrogen but also carbon, an essential element of life.

"This means they have metabolic flexibility, an additional way of getting food," says Evans. "Nobody wanted to believe it. They'd been thinking another way for 100 years. But we proved it beyond any doubt."

And that was only one of several major contributions Evans—and colleagues, he consistently emphasizes—have made to scientific understanding of the biochemistry of how rhizobia fix nitrogen.

Now researchers in his lab are trying to use gene splicing to transfer the ability to fix nitrogen more efficiently, by recycling hydrogen during the process, from strains of rhizobia that can recycle hydrogen to strains that can't.

The work is a logical extension of the research Evans has done for many years. That means Evans has his foot in two worlds: classical agricultural research and genetic engineering. Which holds the greater potential?

"You don't want to dampen the enthusiasm of the new genetic researchers. Only enthusiastic people get things done. But the advances will be a blending of new and classical," predicts Evans, noting that in his opinion recruiting "the best minds" is the most important direction you can take in an agricultural research program.

"There's room for everybody," he adds. "Good work is good work, wherever it is." □