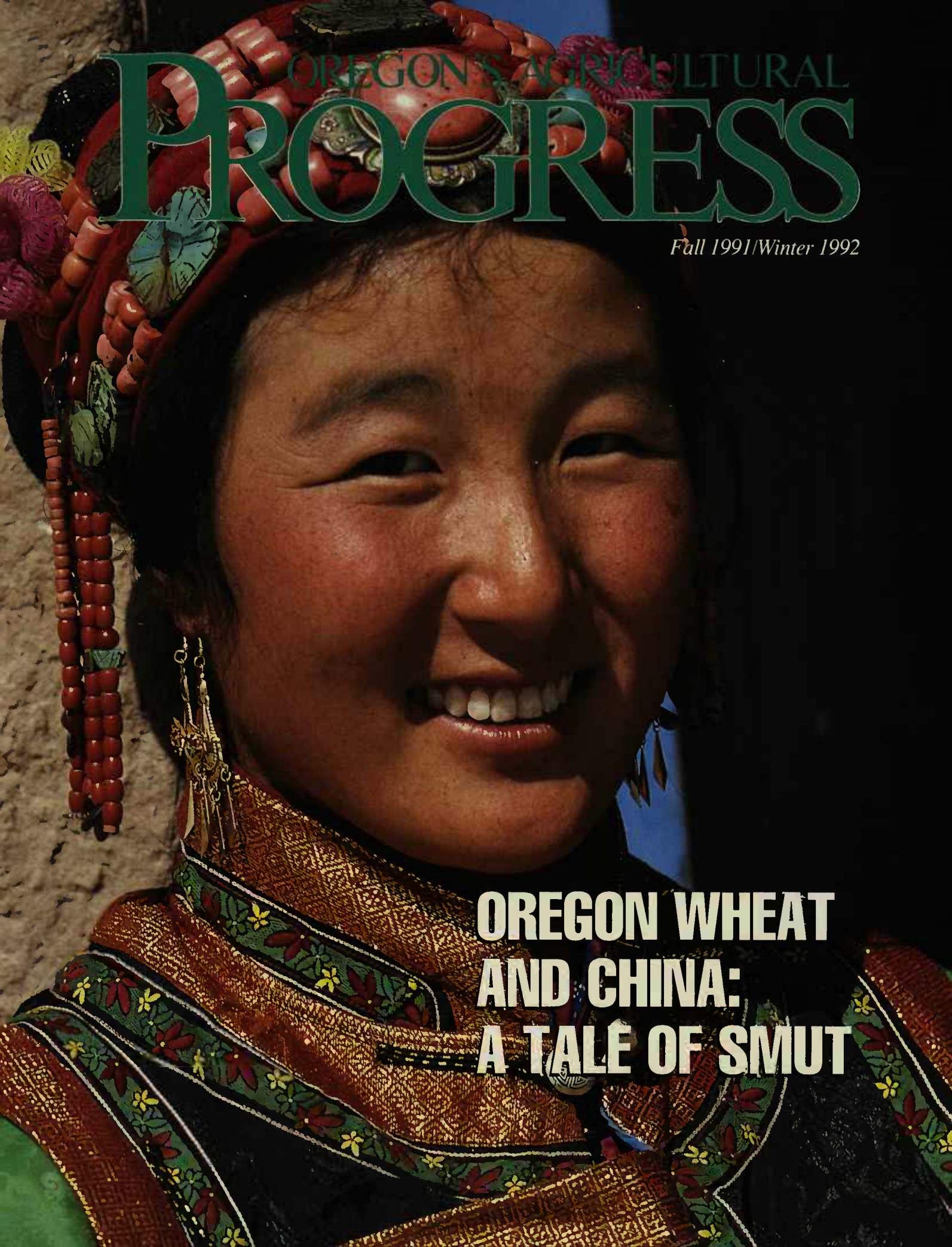
OREGON'S AGRICULTURAL
PROGRESS
Fall 1991/Winter 1992



OREGON WHEAT AND CHINA: A TALE OF SMUT

THE EDITOR'S NOTE

"Even if you're on the right ack," Will Rogers said, "you'll get in over if you just sit there."

I'm pretty sure Conrad J. "Bud" Veiser, the new dean of OSU's ollege of Agricultural Sciences, ould agree. The former head of e campus horticulture department asn't been bashful about saying the llege can't rest on its laurels.

Thumbing through this issue, I an't help thinking a lot of scientists nd Extension agents would agree ith Will Rogers and with Weiser. he researchers are working on sues that affect a lot of Orego-ans, in urban and rural areas.

Many consider "PCR" staggeringly powerful.

Carol Savonen's article, "The ecipe for Revolution," tells us bout campus scientists using a new enetic technique. Many of them onsider "PCR" staggeringly owerful. They're using the process explore bacteria linked to the greenhouse effect, new crops, how thinning of the ozone layer might affect plants and animals, how to improve microorganisms beneficial in food processing and in cleaning up the environment, and lots more.

Other topics in this issue:

Over at Burns a scientist, graduate students and an Extension agent are investigating a use for the Willamette Valley's controversial grass seed straw.

In Malheur County local residents, Extension agents, branch experiment station scientists and others are tackling a groundwater problem.

At Pendleton and on campus, researchers from several disciplines are trying to solve a problem blocking wheat sales to the world's most populous country.

Finally, writer/photographer Bob Rost looks at an animal sciences doctoral student's study of how geese, chickens, ducks and other creatures digest food. The work led Al Hollister to some free-wheeling speculation about fiber and the helpful bacteria in yogurt and other milk products.

I hope you enjoy reading about all these efforts.

Andy Duncan

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Cover: A young woman in northern China's Inner Mongolian Autonomous Region. Related story, page 12. (Front cover photo: Andy Duncan; back cover photo, Bob Rost)

UPDATE

RODENT RANCHING

Dan Edge is getting into rodent ranching to study how small mammals respond to chemicals introduced to the environment. The research could help the U.S. Environmental Protection Agency (EPA) protect wildlife that live in and near areas where herbicides and pesticides are used, according to the OSU scientist.

"The main point is to test, under field conditions, some critical assumptions the EPA makes in registering pesticides and herbicides, particularly about whether they pose hazards to wildlife," says Edge, a professor in OSU's fisheries and wildlife department. "The EPA now makes those assumptions on the basis of small-scale laboratory tests with animals such as rats, mice and quail.

"Our study will be unusual because of its large size," adds Edge. "Most literature on small mammal population responses to disturbance is based on research with four to eight enclosures."

LYNN KETCHUM

Graduate student Bob Carey with a vole, a type of meadow mouse.

Edge is directing the construction of 24 half-acre enclosures at OSU's Hyslop Farm just north of Corvallis. The galvanized steel fences will be 3 feet high and go 3 feet under the ground. That's to corral 100 to 200 individual voles, the grayish brown meadow mice that will live in each enclosure.

"Voles don't climb but they are diggers," says Edge.

Testing will start next summer. In the meantime, Edge's challenge is to establish alfalfa crops and healthy populations of voles in the enclosures.

In the experimentation, Edge will apply six rates of pesticides to alfalfa to study the impact on the small mammals. The 24 enclosures will allow him to replicate each treatment four times to assess system variation. Findings will be compared to laboratory results the EPA uses in evaluating pesticides and herbicides for registration.

Edge is a wildlife specialist for the OSU Extension Service and a researcher for the Agricultural Experiment Station. Several students working on graduate degrees in wildlife science will participate in the Hyslop research, he says. The project is funded by an EPA grant.

TAMING THE WILD

The path to commercial success isn't greased yet, but Steve Knapp has moved forward in turning wild plants into crops Oregon farmers can grow to give us valuable oils, including a substitute for the petroleum in some products.

The Agricultural Experiment Station crop geneticist says he's making progress in trying to reverse 14 million years of evolution with cuphea, an unruly group of wildflower plants. Also, Knapp has developed a self-pollinating variety of meadowfoam, another wildflower, and long-studied as a potential oil seed crop.

If cuphea became a viable crop it would give the United States a new and renewable source of fatty acids that are important ingredients in shampoos, detergents, medicines and foods, according to Knapp. All of the fatty acids used in soaps and many other products in this country come from petroleum or from imported tropical palm kernel and coconut oils.

But developing a new crop often takes decades, he says. He and colleagues in the U.S. Department of Agriculture and private industry have been working together to domesticate cuphea since 1984. They've been crossing different species and looking for important traits.

Until the 1960s, cuphea was a group of obscure purple, red and pink wild flowers growing in the eastern United States, Mexico and Central and South America. Then botanical researchers found unusually high levels of useful fatty acids in the plant's seeds.

"Wild plants have characteristics that help them survive in nature. But these same qualities make them impossible to grow in large-scale commercial ventures," says Knapp.

Wild cuphea blooms and sets seed throughout the growing season, making single harvest yields low. Its seed shatters and falls to the ground before harvest. Some seed may stay dormant for years before germinating.

Knapp and colleagues have made headway toward domesticating the plant. They've crossed strains to get a hybrid with better seed germination. They've introduced genes for self pollination, and they are studying yield, oil-bearing properties and plant hardiness.

In a lucky breakthrough last year, the OSU researcher some found non-shattering seed pods. "It was a once in a lifetime kind of thing," he says.

Meadowfoam research is progressing, too. This wildflower was identified in the 1950s as a potential crop because its seeds contain oil with potential for use in lubricants, cosmetics, paints and foods. One of Knapp's most dramatic accomplishments has been developing a self-pollinating variety.

STEVE KNAPP

Cuphea, a wildflower under study as an oil-seed crop.

That's very significant, he says, because low seed yields have kept the cost of meadowfoam oil prohibitively high. The low yields are partially related to previously necessary insect pollination.

Knapp moved genes among species adapted to the Willamette Valley to produce self-pollinating meadowfoam. He plans to grow self-pollinating strains in large-scale plantings this summer to find out if they yield enough to make production costs competitive with those of other oils.

Large-scale industrial users "won't even think about" finding uses for meadowfoam until there's the potential to have oil available at 30 cents to 40 cents per pound, he says. The present cost is about $1.25 per pound. The crop is considered to be a possible alternative to annual ryegrass grown in the Willamette Valley.

Cuphea oil has a more clearly identified market than meadowfoam oil, noted Knapp.

WETLAND TEST

Researchers working near OSU's campus dairy center are testing whether a new way to treat milking parlor waste water is cheaper and more efficient than current methods.

"Every dairy farmer in the state has to deal with dairy parlor waste water," explains Jim Moore, an OSU bioresources engineer. It's a task that often involves expensive tanks and filters, says Moore.

In the search for a cheaper method, workers are installing eight small cattail- and bulrush-filled wetland ponds behind the campus dairy barn. Cattails and bulrush provide a place for beneficial bacteria to live. The bacteria digest organic matter in waste water.

"Other than land costs, it's extremely cheap and low maintenance when you compare it to the tanks and systems that dairy farmers now have to use," says Moore. "We hope we can show that a farmer can treat milking parlor water on one-tenth of an acre and then discharge clear water.

The project also will study treatment of waste water from barns, which is more contaminated than milking parlor wash water. Barn waste water requires pretreatment before going into wetlands.

He and Mike Gamroth, a dairy specialist with the OSU Extension Service, are overseeing the project.

THEY'RE FAMOUS

James Dryden and Lady MacDuff have been dead for decades, but people are still crowing about their achievements.

Dryden, the first head of OSU's poultry science department, now part of the Department of Animal Sciences, has been named to the Agricultural Hall of Fame in Bonner Springs, Kansas.

Lady MacDuff helped put him there. In 1913 the hen, part of a breeding experiment Dryden was conducting, became the first chicken to lay more than 300 eggs in a year.

A few years later Dryden recorded another first when a hen named Oregona layed more than 1,000 eggs in its lifetime.

In the Agricultural Hall of Fame, Dryden joins such giants as plant breeders Luther Burbank and George Washington Carver and Jerome Increase Case, the "threshing machine king," notes retired OSU poultry scientist George Arscott.

Dryden was an early advocate of breed hydridization and one of the first poultry researchers to investigate artificial incubation, according to Arscott.

SCIENCE SMELLS

Often these days the odor of garlic hangs heavy in the air around Fred Crowe.

The plant pathologist and superintendent of the Central Oregon Agricultural Experiment Station is cooperating with Dan McGrath, county agent for the Marion County office of the OSU Extension Service; Thomas Darnell, county agent for the Umatilla County; and others in testing an innovative way to control an onion-attacking fungus called white rot.

They apply a chemical to unplanted onion fields that's identical to the naturally occurring one that produces the odor in onions and garlic. It's called diallyl disulphide (DADS).

"Our idea is to trick the fungus into germinating and starving to death before onions are planted out into the field," says Crowe. Preliminary results from two years of experiments are limited, but promising, he said.

"We've killed over 99 percent of the white rot fungus in many of our fields with one treatment. But 99 percent probably was not enough. Even 1 percent of the white rot fungus may kill onions. Our second treatment eliminated all detectable levels of the fungus.

"If we can't find a way to solve this problem, it will be a serious situation for both the onion and garlic industries in the Pacific Northwest," he adds.

The Tulelake, Gilroy and Salinas Valley areas in Califomia, once rich onion- and garlic-growing regions, now produce relatively few onions or garlic because of white rot, according to Crowe. In the Pacific Northwest, overwintered crops in Walla Walla, Milton-Freewater, Nevada, Ontario and the Treasure, San Juaquin and Willamette Valleys are especially at risk. Summer onions at Lake Labish can be badly diseased, but summer production in hot regions such as the Treasure Valley of the Boise-Ontario region and the Columbia Basin may be less affected or unaffected, he says.


BOB ROST

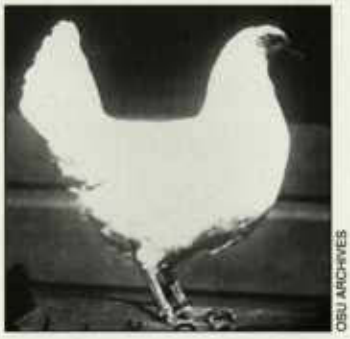
Researcher Fred Crowe eyes onions infected with white rot.

Classic symptoms of white rot include a white cottony fungal growth at the base of onion bulbs from mid to late season, followed by death and decay of the plant. Sometimes infested areas in fields can be spot-treated with soil fumigants, but more typically, a field becomes so infested that onions or garlic can no longer be grown in the field, even after several decades.

Crowe thinks his experimental control method might be more environmentally safe and more easily certified by the EPA than soil fumigants because the effective chemicals occur naturally in onions and garlic.

"The petroleum sources used in these tests have FDA food additive approval, so we assume they're fairly innocuous," he adds. "Furthermore, the amount of material applied to the soil is less than naturally leaks from onion and garlic roots."

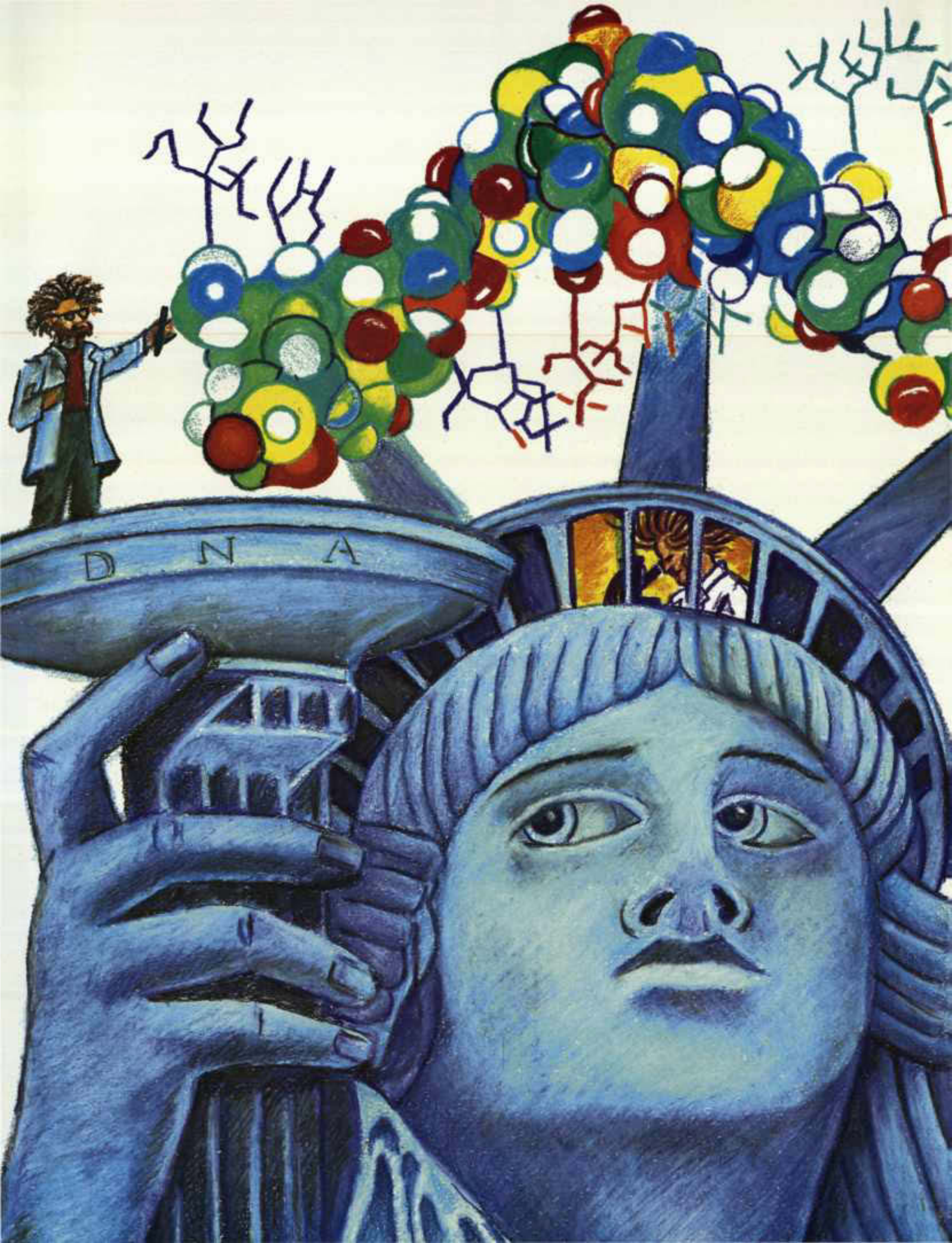
If tests next summer with DADS are successful, the company that manufactures the material may consider applying for EPA registration, says Crowe.


OSU ARCHIVES

Lady MacDuff


OSU ARCHIVES

James Dryden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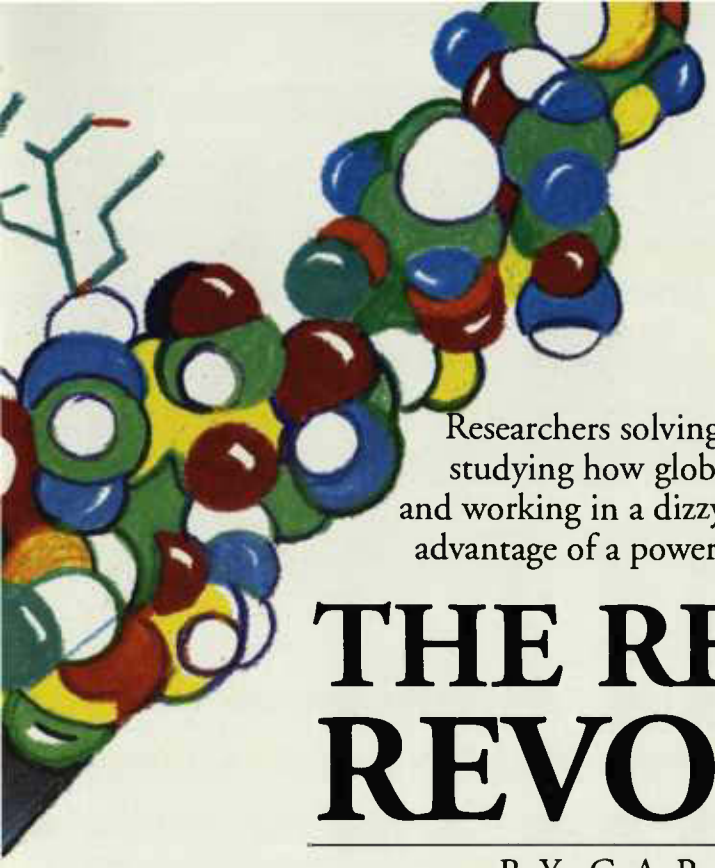


Researchers solving crimes involving rare animals, studying how global warming might affect crops, and working in a dizzying array of other areas are taking advantage of a powerful new process that's been called

THE RECIPE FOR REVOLUTION

BY CAROL SAVONEN

Archaeologists now can take a tiny piece of dried flesh from an Egyptian mummy, extract and make copies of its genetic code and determine its kinship with modern-day humans. Medical researchers are quickly diagnosing and pinpointing the genetics of diseases including hemophilia, cystic fibrosis and sickle-cell anemia. Viral diseases including AIDS and the tick-transmitted Lyme disease are now more easily and surely diagnosed. Crime researchers accurately identify a murderer by analyzing genetic information gleaned from a dried drop of victim's blood on a shoe. Botanists extract genetic information from fossil leaves millions of years old.

The secret is a process called polymerase chain reaction, or PCR.

Science magazine has called PCR "the recipe for revolution." This new, simple-yet-elegant technique for multiplying tiny bits of DNA into substantial amounts of analyzable material is changing the nature of biological research almost overnight. PCR is helping Oregon State University Agricultural Experiment Station researchers study the effects of ozone depletion, develop new crops from wild plants, breed better barley, discover new types of oceanic bacteria, diagnose crop diseases, harness microorganisms to help clean up pollution, make better dairy products and learn more about how cancer develops.

How can one new set of techniques help so many disciplines? PCR allows scientists to get a good DNA sample from almost anything. And PCR is faster, cheaper, more sensitive and more versatile for finding gene sequences than any molecular genetic technique previously available, many scientists say.

"It is to genes what Gutenberg's printing press was to the written word, and promises to be no less revolutionary," said a feature article on PCR in *U.S. News and World Report* last year.

PCR harnesses a process that happens over and over again during natural cell division in any living organism, whether it be a tiny

TOM GENTLE

OSU research assistant Caprice Rosato adds enzymes to a polymerase chain reaction (PCR) machine used to study the genetics of cuphea, a potential oil-seed crop. The device multiples small pieces of DNA (genetic material).

bacterium or a hippopotamus. When a cell divides, its double-stranded DNA unzips and enzymes copy each strand, making two identical DNA molecules, one for each new cell.

In the past, DNA has been hard to study. It has hundreds of thousands of genes, there is usually only one copy of each and it is hard to pinpoint where any given gene is located, much less study it. Until PCR was developed, many genetic discoveries came slowly and tediously .

"With PCR, you are make DNA in a test tube similar to the way a cell would," explained Janine Trempy, assistant professor of microbiology at OSU, who uses PCR to study the genetics of microbes useful to the food industry.

Agricultural Experiment Station researchers study the effects of ozone depletion.

TOM GENTLE

An OSU researcher photographs a gel produced with electrophoresis, a process that helps scientists pinpoint the characteristics of DNA multiplied with the PCR process. In electrophoresis, researchers use electrical charges to group various kinds of DNA. The groupings, marked with florescent dye, glow under ultraviolet light.

Take a piece of DNA and put it in a test tube. Add the right enzymes and nucleotide bases. Heat and cool it just right, and *voila*, you can make a duplicate strand of DNA in a few minutes. Almost cookbook.

And like cooking, there are now fancy machines that automate PCR processes previously done by hand. Looking like a meter with dozens of small wells for test tubes, PCR machines sit on counters in labs all over campus, heating and cooling test tubes full of DNA, enzymes and nucleotides, the building blocks of the genetic code. Again and again. Heat, split, cool, double. Each cycle takes only a few minutes. After an afternoon, about 30 heating and cooling cycles, where once there was a strand of DNA, there are now more than a billion identical pieces of DNA.

"Before PCR was available, getting enough of a certain segment of DNA for analysis was incredibly tedious. It took months to get the same answer you now get in a few days;" said Terri Lomax, a molecular biologist in the botany and plant pathology department at OSU. Lomax uses PCR to learn how hormones function in plants.

Until a few years ago, researchers copied DNA fragments by cloning cells from a "gene library," explained Lomax. They inserted a desired DNA sequence into bacteria, allowing them to reproduce, then extracted the DNA and purified it. They used radioactive materials to find gene sequences.

What do researchers do with millions of identical pieces of DNA? George Bailey studies the genetics of cells gone wild with cancer. The director of the Marine-Freshwater Biomedical Science Center in OSU's food science and technology department, and research assistant Kate Mathews, look for clues about the way cancers develop. In one project, they are investigating how compounds called aflatoxins, found in improperly stored grains, seeds and nuts, may cause liver cancer, a major cause of death in the Third World. They take tiny samples from trout liver tumors caused by feeds rich in aflatoxins, then use PCR to increase the amount of tumor DNA. They can then analyze the gene sequences of interest.

"A cancer tumor is not a homogeneous mass of cells," explained Bailey. "There is more than one kind of cancer cell in a tumor. PCR allows me to look at one or a few cells from a particular tumor and to look at the genetics of one specific type of cancer cell. I can even use material from a pathology slide. Before, you couldn't do this. PCR is the key. It has made it possible to do this type of research with reasonable effort."

Arlene Hilger, a doctoral researcher in the crop and soil science department, uses PCR to help her detect an elusive species of nitrogen-fixing bacteria called *Frankia*. Living on the roots of red alder, *Frankia* makes fertilizer from atmospheric nitrogen for the shrubby tree. It is a notoriously difficult bacterium to study because it grows sparsely in soil and is hard, if not impossible, to grow and detect in the lab. With PCR, she can detect both dormant and active populations of *Frankia* by increasing their DNA. She says her research will help forest managers better understand how to manage red alder, an important pioneer species in young western Oregon forests.

PCR's ability to increase minute amounts of DNA is a criminologist's dream come true. The Oregon State Police Crime Lab in Portland is gearing up to use PCR to analyze small bits of evidence left at crime scenes. A hair or a

drop of blood may now be definitive evidence in previously unsolvable crimes, explained Cecilia von Beroldingen, forensic DNA specialist with the Crime Lab in Portland.

"I think PCR-based DNA typing in humans will revolutionize forensic science," said von Beroldingen. "Unlike currently used methods, PCR can handle small and damaged samples."

Von Beroldingen foresees the day when a DNA profile will be used much like fingerprints are now—as a unique pattern that can identify an individual. Using PCR technology, DNA profiles can be easily made from tiny samples containing cells from either a victim or suspect.

PCR also is helping solve crimes involving the poaching, illegal sale or trade of animals such as black bears, eagles and African wildlife.

"Sometimes we just have dried gall bladders, steaks in a freezer or blood stains in the trunk of a car for evidence," said Steven Fain, a molecular biologist and DNA coordinator at the U.S. Fish and Wildlife Service's Forensic Laboratory in Ashland. "PCR makes it possible to use these things for evidence. Proteins degrade, but if DNA degrades, PCR is still a useful tool."

TOM GENTLE

"PCR is a powerful tool," says Terry Lomax, an OSU botanist. Lomax uses the process in locating genes for her studies of how plants grow and adapt to their environments.

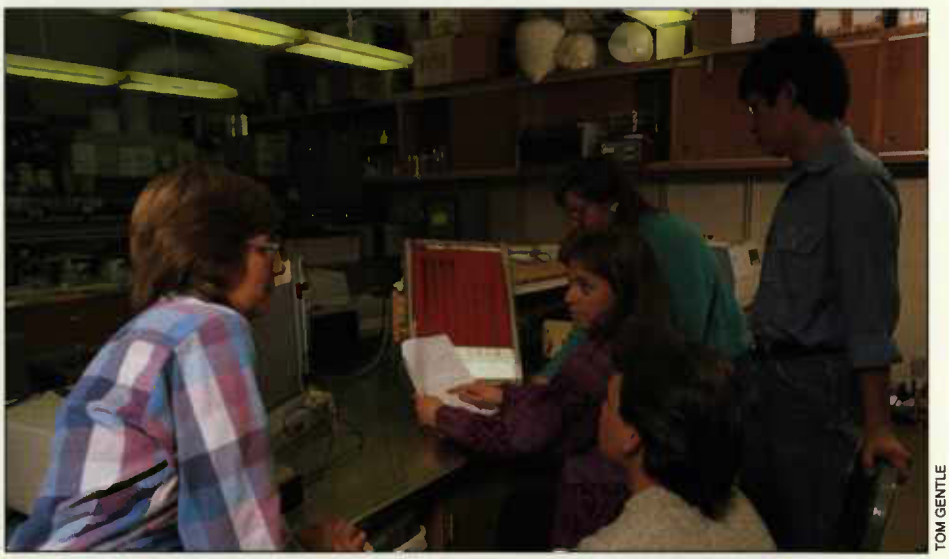
But most amazingly, PCR probes based on known gene sequences from one organism can then be used to "sniff out" similar or identical gene sequences in another species. This comes in particularly handy when trying to learn about the genetics of a new species.

Just as a good map helps a world explorer navigate, a good genetic map helps crop breeders locate genes that control important characteristics such as seed dormancy, height or disease resistance. Experiment Station crop geneticists Steve Knapp and Pat Hayes design PCR probes based on genetic information from well-studied crop varieties and use them to find "marker genes" in a new plants, then compile this information on genetic maps.

"PCR helps me get a more complete genetic map quickly and cheaply," said Knapp, who is mapping the genetics of meadowfoam and cuphea, two relatively wild plants known for the valuable oil in their seeds. "It helps me to look at the genetics of many individuals to see the diversity within a species."

Strange as it may seem, something as small as a DNA molecule is giving OSU scientists insight into global problems

"It is to genes what Guttenberg's printing press was to the written word."



TOM GENTLE

Microbiologist Janine Trempy, in center with paper, is using the PCR process in a search for genes that will help her, and other OSU scientists, develop beneficial microorganisms for the food and environmental cleanup industries. Around Trempy, left to right, are Ph.D. student Karen Dierksen, research assistant Jim Marks, and Ph.D. students Don Chen and T.J. White.

Not only can PCR multiply DNA, it also has the ability to find a molecular needle in a haystack, then make millions of copies of the needle. Kary Mullis, a California biochemist who developed the PCR process in 1983, likens PCR's ability to find a gene sequence on a DNA molecule to being able to find a broken down car on a two-lane highway full of bumper-to-bumper traffic winding 300 times around the earth, in only a few seconds.

Researchers often use PCR's power to locate a certain gene sequence out of thousands or millions on a piece of DNA. First, they study known sequences of genetic code in the area of a trait of interest. Then, in the lab, based on those sequences, they manufacture two small strings of that nucleotide code, called "primers" or "probes," that bracket the section on DNA they are interested in. These are added to the PCR reaction. Like little bloodhounds, the primers go immediately to any identical or nearly alike sequence on the long DNA molecule and stick there, flagging either side of the gene sequence for PCR replication.

like ozone depletion and the greenhouse effect.

To better understand the effects of increased ultraviolet (UV) light from stratospheric ozone depletion, John Hays, professor of agricultural chemistry, and Indira Rajagopal, postdoctoral research associate in agricultural chemistry, are

using PCR techniques to help study DNA exposed to increased amounts of ultraviolet light.

"UV is increasing as stratospheric ozone is decreasing," said Hays. "And it is unknown how resilient plant and animal cells will be if UV keeps increasing."

By studying the genetics of an enzyme called photolyase that repairs UV-damaged DNA in bacteria, plants and animals, including amphibians and crops such as wheat and corn, Hays and Rajagopal hope to learn more about the DNA repair ability of different organisms.

Steve Giovannoni, assistant professor of microbiology at OSU, uses PCR to help identify elusive oceanic bacteria that are thought to be crucial elements at the bottom of the ocean's food chain. These microscopic cells also play important roles in removing carbon dioxide in the atmosphere, he said, and are of vital interest to those studying the "greenhouse effect."

The trouble is, very little is known about the tiny creatures because they are almost impossible to grow and identify in the lab.

"In the open ocean, anywhere near the surface, there are 20,000 to 200,000 bacteria per milliliter of seawater," said Giovannoni. "They are probably among the most abundant species on the planet as a group. Yet no one knows what these bacteria are."


STEVE GIOVANNONI

Technicians on an international cooperative research vessel collect samples from the north Atlantic's Saragasso Sea. Back in his OSU lab, microbiologist Steve Giovannoni uses PCR to study bacteria in such samples. The creatures remove carbon dioxide from the atmosphere and interest scientists examining the so-called "greenhouse effect."

Giovannoni uses PCR to analyze the genetics of these unknown bacteria. New genes prove the existence of new forms, he explained. The genetic information he gets from PCR gives him a way to recognize a species.

"You have to be able to have some way of identifying these bacteria, so when you go back out there in the ocean you can find that kind again," he said. "Only then you can work on their ecology and biology."

"You are making DNA in a test tube."

Disease detection has become faster and more accurate with PCR techniques. HIV (AIDS virus) infections can now be accurately detected in newborns. Genetic diseases such as hemophilia, common cystic fibrosis, and Duchenne muscular dystrophy can now be detected before a baby is born. And degenerative diseases like Huntington's chorea, which strikes

INSIDE THE CELL

The world of genetics is invisible to the human eye. Inside each cell lie chromosomes, where genetic information is stored as long, coiled, double-stranded molecules called DNA (dioxyribonucleic acid). The instructions or genetic code to carry out life is housed in DNA. Here are a few definitions from the world of genetics that may be useful as you read the accompanying article:

NUCLEOTIDE—The building block of the DNA molecule. Like beads on a long DNA necklace, sequences of nucleotides make up genes and the genetic code.

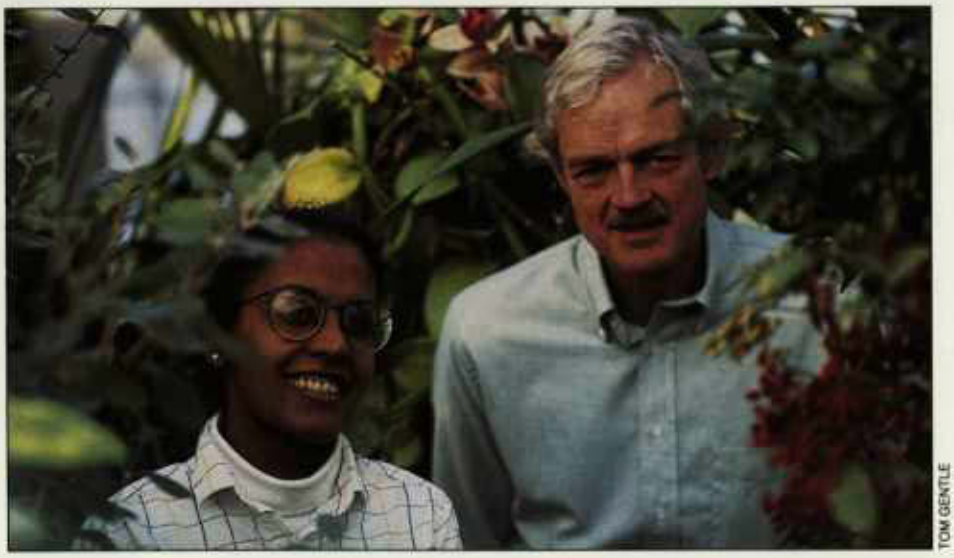
GENE —A short segment of DNA that contains coding (nucleotides) or instructions for a particular protein or function.

GENE SEQUENCE—The particular chain of nucleotides that makes up a gene.

POLYMERASE CHAIN REACTION (PCR)—A new technique that allows researchers to make millions of exact copies of a section of DNA. With millions of copies, scientists can determine more easily the genetic code, gene sequence or the nucleotides that make up a gene. The new technique also helps researchers locate a gene sequence on a piece of DNA and copy it.


Pui Shing Ho

A computer-generated model of part of a DNA molecule. Pui Shing Ho, OSU biochemistry and biophysics professor, designed the image.



TOM GENTLE

Indira Rajagopal, left, and John Hays of OSU's agricultural chemistry department are using PCR in studies of the effects of ultraviolet light on plants, animals and microorganisms. Their work is part of efforts to learn about the potential impact of thinning of the earth's protective stratospheric ozone layer. Chloroflorocarbons are a major cause of the thinning.

DAVE KING

The capability of increasing minute amounts of DNA with the PCR process is helping government scientists solve crimes involving poaching, illegal sale or trade of animals. Sometimes investigators have only blood stains or small bits of tissue as evidence.

between the ages of 15 and 80, can now be predicted before they manifest themselves.

This same technology is helping agriculturists diagnose diseases in seeds and crops and to identify harmful pathogens, and insect pests of plants and livestock.

Viruses transmitted in crop seeds can now be detected with "unparalleled sensitivity," explained Dick Hampton, research plant pathologist with the USDA and a courtesy professor at OSU.

"We can also distinguish between two closely related plant viruses by means of PCR, which then enables us to identify cultivars susceptible or resistant to each specific virus," said Hampton.

The Oregon Department of Agriculture (ODA) is gearing up to use PCR to diagnose plant diseases and better identify races of insects in their lab, said John Griesback, plant pathologist with ODA.

"PCR offers us cost savings, takes fewer workers, handles more samples in less turn-around time than methods we traditionally use," said Griesback. "Before PCR, we had to have extensive samples to detect a plant virus and had to grow plants in the greenhouse. With PCR, all we need are gene sequence data, primers, and small amounts of sample and we will get better data."

PCR may also help ODA distinguish more effectively between harmful and benign strains of gypsy moths, and diagnose livestock diseases, said Griesback.

"The sky is the limit," he said. "Wherever we can use it we will."

OSU microbiologist Janine Trempy predicts that PCR will help microbiologists develop safer and better food products, better wine and better methods of producing microbes that clean up the environment.

Trempy studies the effects of stress on microbes, especially those used in the food and fermentation industries. To a bacterium in a dairy milk tank, stress might mean a change in temperature, humidity or food source, she explained. Either a microorganism adapts to stress, or it dies.

"Adaptation occurs at the gene level," said Trempy. "I look at those genes expressed in bacteria under stress and ask how these microorganisms protect themselves. What genes turn on or turn off under different environmental conditions."

"Once I've figured out a useful genetic feature in a bacterium, I can isolate it by PCR," she said. "The more copies of a gene we can get, the more likely we can extract it out, put it in a test tube to study it. Our goal is to add or enhance features of microorganisms used in the food fermentation and environmental clean up industries. This is the wave of the future."

Other Experiment Station researchers agree.

"PCR is growing explosively," said John Hays. "Every time you turn around you can think of a new use for it. It's wonderful."

"PCR is a powerful tool," added Terri Lomax. "Many people's success right now is dependent on how quickly they gear up. We don't use it nearly as much as we could because we are so used to the old ways. It's so revolutionary, it's hard to get switched over. Nothing in my career has changed so fast."

Carol Savonen is a science writer in OSU's agricultural communications department.


1000 mL
900
800
700
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9-11-91
REGULAR
BLEACH

THE SMUT PUZZLE

BY ANDY DUNCAN

Scientists are exploring several ways of solving a problem that makes wheat smell fishy and makes Chinese buyers disappear

Suppose you're eating at the new neighbors' house and their spaghetti sauce, an evil-smelling concoction which looks like it might be laced with a summer weight motor oil, drips on the collar of your favorite shirt. Reach for the bleach, right? But that old Don Quixote against clothing stains is tilting at other windmills. Today, lots of us use bleach for jobs like scrubbing the kitchen floor, cleaning moldy shower tiles, or restoring weathered wood. Tom Chastain has something even more ambitious in mind.

Sitting in his small office at the Columbia Basin Agricultural Research Center, just east of Pendleton, Chastain smiles a lot. The young OSU scientist is resisting a visitor who wants to capture, in simple words, the significance of a piece of research. He's like a composer who'd rather let others judge his work; a coach trying to dodge saying how good she figures her team is. But as the fall sun moves west over the surrounding wheat fields, full of golden stalks mowed in half during the summer harvest, he can't duck this: He thinks a heated solution containing plain old bleach can help give the Northwest's wheat industry a billion new customers.

OSU agronomist Tom Chastain at the Columbia Basin Agricultural Research Center at Pendleton. Chastain is among researchers at several universities looking for ways to solve a marketing problem caused by a disease called TCK smut. (Photo: Bob Rost)

Actually, it would be more accurate to say Chastain thinks bleach could contribute to an effort, involving many scientists, to bring a billion wayward customers back to the Northwest. Let's start the explanation of why with the administrator of the Washington Wheat Commission, Tom Mick:

"Recently I was asked what the one thing was we could do through market development efforts that would have major impact on increased export sales," Mick wrote in a magazine article a while back. "I answered without hesitation—to solve the TCK problem with China."

The spores can show up on noninfected wheat.

The problem with the People's Republic of China is simple, at least on the surface: The world's most populous country says it won't buy wheat from the Northwest if our shipments contain a single viable spore of a fungus with the Latin name *Tilletia controversa Kuhn*. TCK smut is what farmers commonly call the disease the fungus causes.

That's a problem because, although only a small percentage of Northwest grain is infected with the fungus, grain of all kinds and from many areas passes through the same trucks, barges, elevator bins and other transportation vehicles and storage areas. The microscopic TCK spores show up on noninfected wheat.

The Chinese government has held to its zero tolerance position on Northwest wheat since announcing it in 1973. China has taken its business to Australia, Canada and other competitors when buying soft white winter wheat, the predominant kind grown in the Northwest.

Most of us in Oregon have lived in ignorant bliss. We didn't know, or didn't care, about an obscure wheat fungus. But it's been frustrating for growers and people in related industries, like the folks who load ships at the Port of Portland. It's been estimated China imports 3 to 6 million metric tons of U.S. wheat a year. If the Northwest could get 50, or just 25, percent of that business it could have a big impact on soft white wheat prices.

It's also been frustrating for economists, government leaders and others who realize about 85 percent of Northwest wheat goes overseas. Lost export sales and related lower prices can affect the pocketbooks and lives of Oregonians who never get near a farm—a dip here in seemingly unrelated retail sales; a drop there in tax revenue that helps pay for schools or senior centers.

DAVE KING

The fungus that causes TCK smut needs exacting environmental conditions—a temperature near 32 degrees Fahrenheit, which results from 30 days of continuous snow cover. That limits the disease to a miniscule percentage of Northwest wheat acreage.

BOB ROST

OSU's Warren Kronstad and other wheat breeders are developing grain varieties resistant to the fungus.

The Chinese's position on TCK smut also has been frustrating for Northwest scientists. They don't think it makes sense. Dwarf bunt is the name researchers use for the disease the TCK fungus causes. Basically, the fungus cuts wheat yields by commandeering nutrients and manufacturing spores to reproduce itself. It stunts wheat plants. Their stalks, called tillers, often are a third as tall as a healthy plant's. At the end of the stunted tillers, seed heads and grain kernels turn black as the fungus replaces them with "bunt balls" that break open when a harvesting combine strikes them, sending up clouds of spores.

Infected grain has a telltale fishy smell caused by a chemical called trimethyl amine. "If a wheat buyer smells that odor coming from a sample it automatically reduces the price of the wheat," says Chastain. "Would you want a cookie with a fish odor?"

But the fungus only thrives under exacting environmental conditions and isn't a major problem for Northwest wheat growers, at least in terms of reducing yields. "TCK needs a temperature near 32 degrees Fahrenheit, a condition which results from 30 days of continuous snow cover," explains Chastain.

In Oregon that seems to boil down to three main areas in the northeastern corner of the state: some high-elevation wheat fields around Flora near the Washington border; a narrow east-west strip roughly from Enterprise to Elgin; and occasionally wheat fields in the valley around Baker City. But the fungus

affects only about a tenth of a percent of Oregon's wheat acreage and isn't spreading. Washington, Idaho, Montana, Utah and a few other states also have small, isolated areas with dwarf bunt disease.

Some Northwest scientists believe environmental conditions in northern China in the general vicinity of Beijing, the part of China that would import Oregon wheat, also would restrict dwarf bunt disease.

Through the years, researchers at OSU and other universities have hosted Chinese scientists who studied the Northwest wheat growing system and the TCK fungus. There have been government and industry missions to China to discuss the embargo. Still, scientific and diplomatic attempts to change the Chinese position have failed.

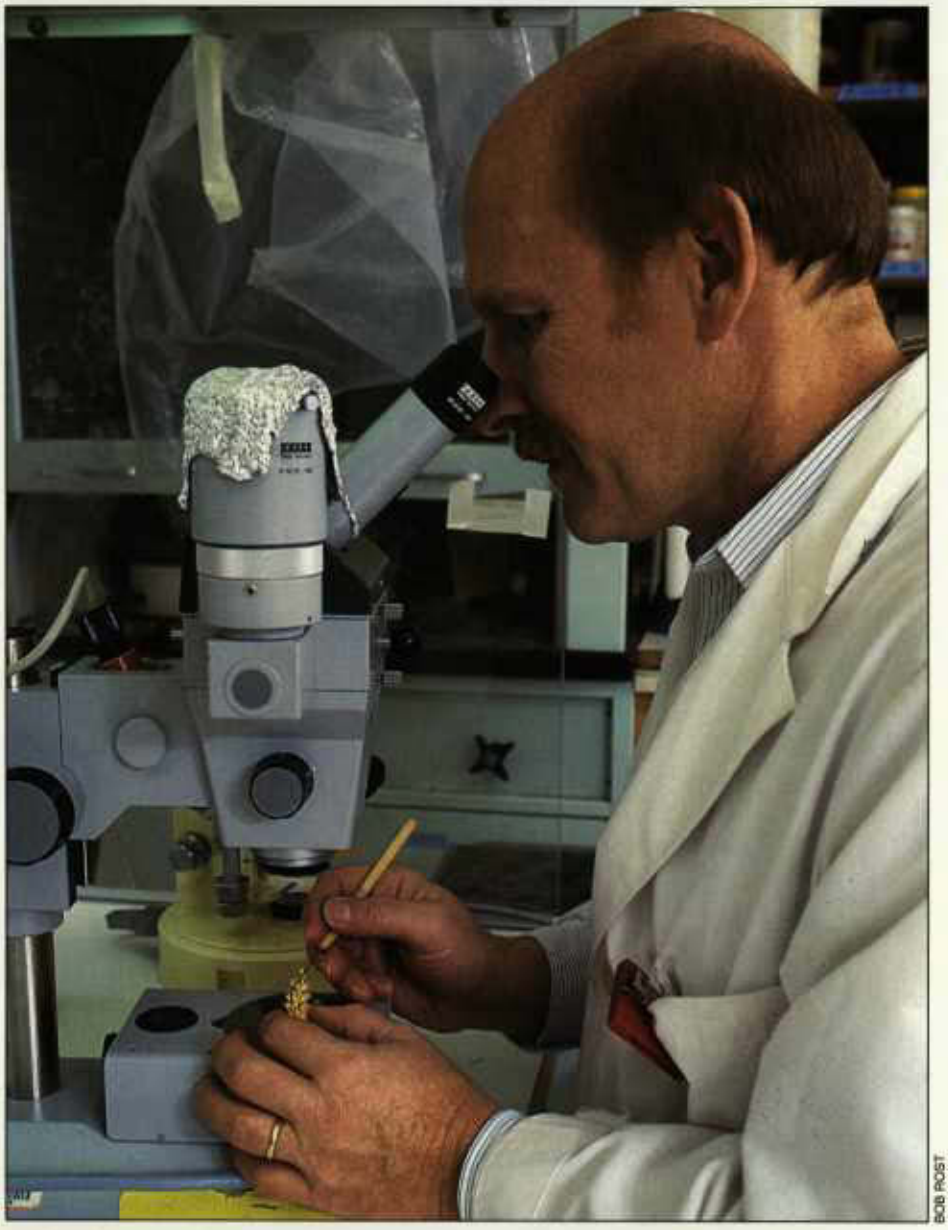
"I've tried to put myself in the shoes of the Chinese to understand how they might look at it," says Chastain. "I guess that's difficult for a westerner. But the world wheat market is a buyer's market. They can do what they want." His current hope, and the hope of many university and government scientists, is to "put the ball back in their court. To have clean wheat, or wheat with dead spores."

"We've had great progress on building resistant varieties."

A March gathering to review TCK research included scientists from Washington State University, the University of Idaho, Montana State University, Utah State University, Oregon State University and the U.S. Department of Agriculture's Agricultural Research Service. Samples of their efforts:

• Identifying genes that give resistance to the TCK fungus and breeding the genes into wheat varieties with acceptable yields and other qualities. Wheat from Turkey has yielded the most promising sources of resistance.

• Testing fungicide treatments that would kill TCK spores on wheat seeds or



Dallice Mills, a geneticist in OSU's botany and plant pathology department, is exploring whether the fungus that causes TCK smut is a mutant, geographically limited form of common bunt. That disease is already in most wheat-growing parts of the world.

Near right: Other fungi's spores can be mistaken for TCK smut's. USDA researcher Virginia Stockwell is looking for quick ways to identify spores. Far right: TCK-diseased wheat with telltale darkened grain heads.

spores in the soil attempting to infect a plant.

• Studying TCK resistance in other plants, like pea plants; scientists hope one day to use genetic engineering to place that resistance in wheat.

• Experimenting with methods of killing TCK spores after wheat is harvested.

Lost export sales affect the lives of Oregonians.

Although not all present at the March meeting would agree with the Washington Wheat Commission's Tom Mick, he wrote afterward that "it was the general consensus that agronomic [breeding] research was not going to help the immediate problem, but, at the same time, should not be totally ignored. In addition, diplomatic effort so far has failed. It became obvious that a post-harvest treatment, or a method for eradicating (killing) TCK spores, offered the best choices for an acceptable alternative for the Chinese."

Chastain is one of the scientists exploring the post-harvest approach.

He graduated from OSU in 1987 with a Ph.D. in crop science and took a job at Washington State. "I was a new researcher in an empty lab, looking for something to do," he remembers. "Jim Zuiches, the agricultural experiment station director, wanted a new approach to the TCK problem. He invited people to a mini-conference to brainstorm. Some wanted to ship uncontaminated wheat down the Columbia River in closed packages. The economists said that would be too expensive. I suggested killing the spores in Portland. Nobody necessarily thought it would work, and there was not a quick way at that time to determine viability [if spores had been killed]. But Zuiches took a chance on a young, green Ph.D.'s theory."

The Oregon Agricultural Experiment Station later hired Chastain to do research at Pendleton. He's rewarded both employers. The first payoff was a quick way of finding out if spores are viable (they've been known to "play possum," or stay dormant, more than 10 years).

"In the early 1970s," he explains, "Ed Trione and Te May Ching [Agricultural

DAVE KING

This meal includes cookies made from wheat flour. Selling grain to the People's Republic of China, whose diverse population numbers more than a billion, could have a big impact on Northwest wheat prices. But China won't buy grain contaminated with TCK smut spores.

Research Service and OSU researchers respectively, now retired] showed that fatty acids are an important food source fungal spores use to germinate. Then, when I was in graduate school at OSU, I took a class from Machteld Mok [a horticulture professor] where we learned to test for the presence of lipase, an enzyme that breaks down fatty acids into a food spores can eat. In my later TCK research, I put two and two together. Ph.D.'s can do that sometimes."

Realizing viable spores would contain lipase, what Chastain did was grind TCK spores into an extract and add a substance that caused the extract to change color if lipase was present. "The old spore germination test takes 2 months. We can get you a viability result in about 5 hours," he says.

Another part of Chastain's research focused on how to kill TCK spores. That's where ordinary bleach spilled into the exotic world of international grain marketing.

He tested sodium hypochlorite, the active ingredient in bleach. "I found it took me 20 minutes to kill the spores

TOM GENTLE

Left: A ship loading at the Port of Portland. Though a tiny percentage of Northwest wheat is infected with TCK smut, the microscopic spores contaminate other grain sent through the storage and shipping system.

BOB ROST

Research technician Kathy Ward studies TCK smut spores. Ward works at Pendleton with OSU agronomist Tom Chastain.

with a 20 percent solution of Clorox at room temperature," he says. "I was very excited. I told my scientist friends. They said it took too long. There were hundreds of thousands of tons of wheat at the shipping docks. So I went back to the drawing board."

Clever scientists know adding heat is a good way to speed chemical reactions. With trial and error, Chastain found that a solution containing 1 percent sodium hypochlorite, heated to 131 degrees, killed spores in 15 seconds. His studies show the process doesn't keep seeds from germinating, if you want to plant them instead of using them to make flour.

"What's unknown at this point is the physical and economic viability of the method, and if this would be acceptable to the Chinese," says Chastain, noting that the same questions face other methods under investigation, such as killing spores with gas or gamma radiation. A WSU agricultural engineer, Ralph Cavalieri, is trying to answer questions about the bleach approach. Cavalieri has built and is testing a small prototype device that washes wheat with the bleach solution.

"John Oades of the U.S. Wheat Associates [a marketing organization] estimates you'd have to treat 1,000 tons of wheat an hour to be effective," says Chastain. "I feel I've done what I can—the first step. Now it's up to the engineers and the economists and the wheat people. My next step is to work on how to determine the viability of individual TCK spores, rather than an extract of ground-up spores."

He's far from alone in his desire to probe individual spores. There's a lot of work in that area, quite a bit on the OSU campus. Geneticist Dallice Mills in the botany and plant pathology department is going really small, using molecule-level techniques to explore not only dwarf bunt but common bunt, a fungal disease China definitely has. Mills has strong evidence that argues the fungi are so closely related they shouldn't be considered separate species. The evidence suggests the TCK fungus is a mutant form of common bunt.

There are other fungi that produce spores similar to those of TCK's and can mistakenly signal the presence of dwarf bunt disease, though they don't cause it. Virginia Stockwell, a USDA researcher stationed at OSU, is finding ways to quickly identify spore type. Stockwell also is investigating ways of determining the viability of individual TCK spores, as is Chastain.

"There's a lot of reason for optimism."

There are plenty of outside-the-lab reasons to think the TCK problem can be solved with science. Campus-based OSU wheat breeder Warren Kronstad, who's working with OSU breeder Matt Kolding of the Hermiston experiment station and others, notes "we've had great progress on building resistant varieties at OSU and WSU. And there's data that shows Dividend, a chemical fungicide, gives complete control of the fungus in the field. It's registered for use in Europe but not here, yet.

"Between the variety resistance and the fungicides and killing spores after harvest and viability tests, there's a lot of reason for optimism. But somehow, somebody has to convince the Chinese."

Put another way, Kronstad hopes all the region's researchers aren't Don Quixotes tilting at a perceived enemy while some unfathomable political intrigue is the real foe. Chastain would agree.

"My work is part of an interdisciplinary effort in the Northwest," he says. "I think we've got the ball rolling. I don't care which method works. We just want Northwest farmers to be able to sell their wheat."

TROUBLE NEAR THE TRAIL

PHOTO COURTESY DENVER PUBLIC LIBRARY, WESTERN HISTORY DEPARTMENT

BY ANDY DUNCAN

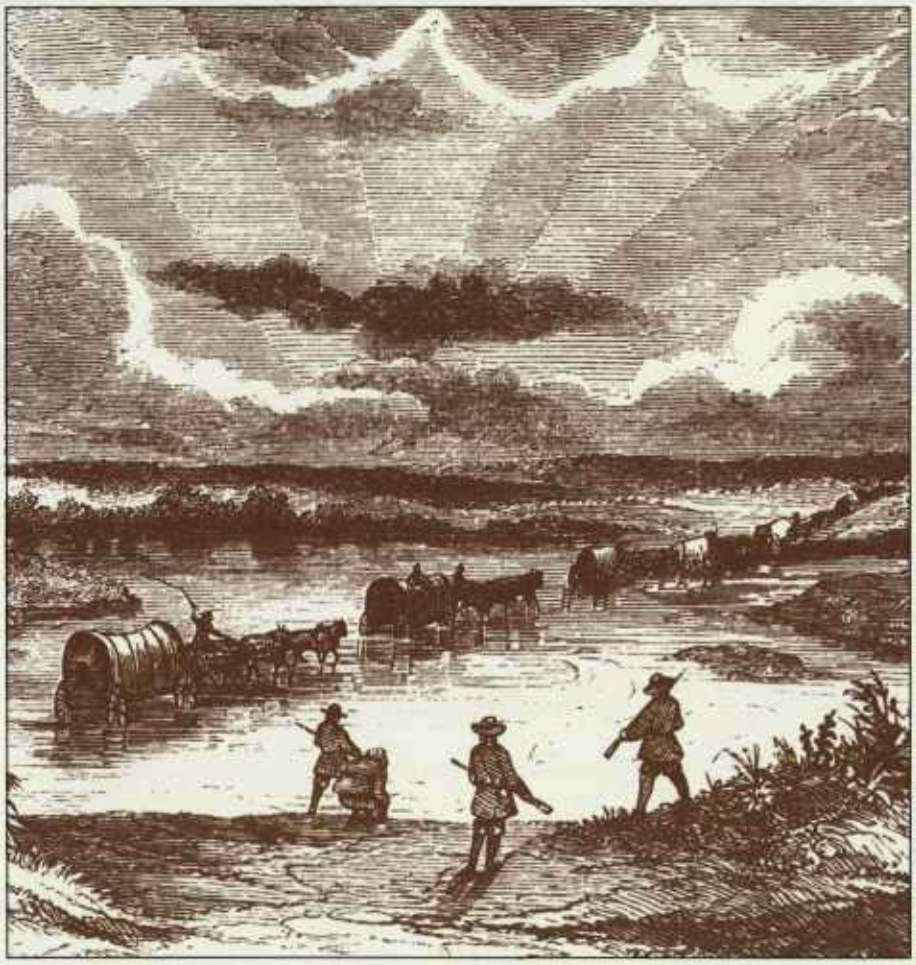
Malheur County finds there's a price for progress

The pioneers who first crossed the Oregon Trail in the early 1840s probably didn't give much thought to settling where Ontario, Oregon, is today. When they forded the Snake River in late summer or early fall they were usually nervous, hurrying to reach the Trail's last major obstacle, the Blue Mountains, before the snows. Angling northwest, they passed a bit west of the basin where Ontario now sits, just across the Snake from the state of Idaho. Any who happened to see the arid basin, dotted with the sagebrush they'd learned to hate, must have thought it was a pitiful sight compared to their lush promised land, the Willamette Valley. How could they know it would become an American oasis?

Local residents aren't throwing up their hands.

Left: Historians haven't been able to confirm the identity, or even the exact location, of these Oregon Trail travelers. The ruggedness of the journey is etched on their faces.

Indians, explorers and trappers lived in what now is the northeast corner of Malheur County before the pioneers showed up. As the wagon trains and the years rolled by, pioneer families occasionally stayed, usually to ranch or operate a ferry or stopover site for other travelers. Eventually, people moved in to raise cattle or sheep. But the Ontario area, which receives less than 10 inches of precipitation a year, didn't really start growing until about 1900. Livestock was the main crop. Gradually, irrigation transformed the basin land, an ancient lake bed. It sprouted high-value crops like lettuce, celery, onions and potatoes. After World War II, the use of synthetic fertilizers, herbicides and pesticides helped farmers make a profit.



OREGON HISTORICAL SOCIETY

Water was critical to pioneers on the often-dry trail to the Oregon country. This illustration of a river crossing appeared in Harper's New Monthly Magazine in September of 1862.

OREGON HISTORICAL SOCIETY

A six-horse team discs land recently cleared of sagebrush in preparation for irrigation from Malheur County's Owhyee Dam project. The photo was taken May 31, 1936.

But now local residents realize there's a price to pay for this transformation. Groundwater contamination has been found in northeastern Malheur County. Samples from private wells documented nitrate contamination and detected breakdown products of the herbicide Dacthal, according to an "action plan" developed by Malheur County's state-appointed groundwater management committee. Chemical fertilizer application practices are the main source of the contamination, according to the report.

The nitrate levels exceed the EPA's standard.

So there it is: Practices that created one of Oregon's most productive agricultural areas are part of a threat to its long-term health. Although levels of the Dacthal breakdown products detected are not considered a health threat, nitrate levels in several spots exceed the EPA's standard of 10 parts per million. Levels above that "may represent a serious health concern for infants under 6 months of age and pregnant or nursing women," says the action plan. Nitrate can interfere with the ability of blood to carry oxygen to vital tissues in infants, it explains.

The action plan says no nitrate-related health problems in infants have been documented, but these aren't the kind of things you want to read about your water. Still, like the stubborn settlers who came before them, local residents aren't throwing up their hands. Citizens from many walks of life, including farmers, researchers, extension agents and local, state and federal government representatives, have set out to solve the problem.

A brief look underground will show what they're up against. The contaminated basin is at the convergence of three river valleys, roughly between where the smaller Owyhee and Malheur rivers run into the Snake. If you could dive into the basin in a submarine that penetrated dirt

and rock as well as water, you'd first pass through about 25 feet of silt in most spots. Below that, you'd pass through a sand and gravel aquifer (natural water-holding layer) 10 to 30 feet thick. Under that you'd find several thousand feet of what drillers call blue clay, a fine-textured mix of sand, silt and clay. In some spots in the blue clay you'd find water-containing layers of course sand or gravel. Hydrologists call those layers deep aquifers.

The shallow aquifer is the contaminated one. In pioneer days, the water was lower. But irrigation, made possible by projects such as the damming of the Owyhee River in the 1930s, saturated the aquifer, sending water into the overlying silt.

Records from one continuous water level recorder south of Ontario show that "groundwater levels rise in response to melting snow, to [irrigation] canal leakage and irrigation," says the groundwater committee's action plan. "Groundwater levels decline after the irrigation season is over."

OREGON HISTORICAL SOCIETY

Explorers in the 1800s saw a semi-desert when they passed the basin in northeastern Malheur County where Ontario now sits. In the next century, irrigation helped the ancient lake-bed soils sprout crops like these displayed at the Malheur County fair in 1912.


DAVE KING

This photo, taken in the 1980s, shows an area where irrigation transformed sagebrush land near Ontario into farmland. Nitrogen fertilizers used to grow high-value crops, and nitrates from other sources, gradually moved into groundwater in a shallow aquifer under the basin. Sampling has also identified traces of a herbicide called Dacthal.

ANDY DUNCAN

There are several sources of nitrates in the soil, including runoff from septic tanks, lawns, livestock feedlots, dairy farms and pits where culled onions are discarded. Also, nitrates come from natural organic materials in the soil. But the main sources are nitrogen fertilizers such as ammonium, urea and nitrate. In the soil, the ammonium and urea can be changed into nitrates by bacteria. Area farmers grow several crops in rotation in their fields. They use the fertilizers, in varying combinations and quantities, with almost every one. They use Dacthal to control weeds in fields of onions.

Left: Onions at Ontario. That part of Oregon and Idaho is one of the world's major producers of yellow "Spanish" onions.

EIGHT-FOOT SAGEBRUSH

Studies relating to water quality are only part of the research at OSU's Malheur Agricultural Experiment Station. For many years, scientists have conducted trials to identify improved varieties of sugar beets, onions, potatoes and other crops.

Other research looks for more effective and safer herbicides and pesticides. This work, spearheaded by agronomist Chuck Stanger, is especially important today, says superintendent Clint Shock, because of consumer safety concerns and because government re-registration requirements for herbicides and pesticides are reducing the number of options available to farmers.

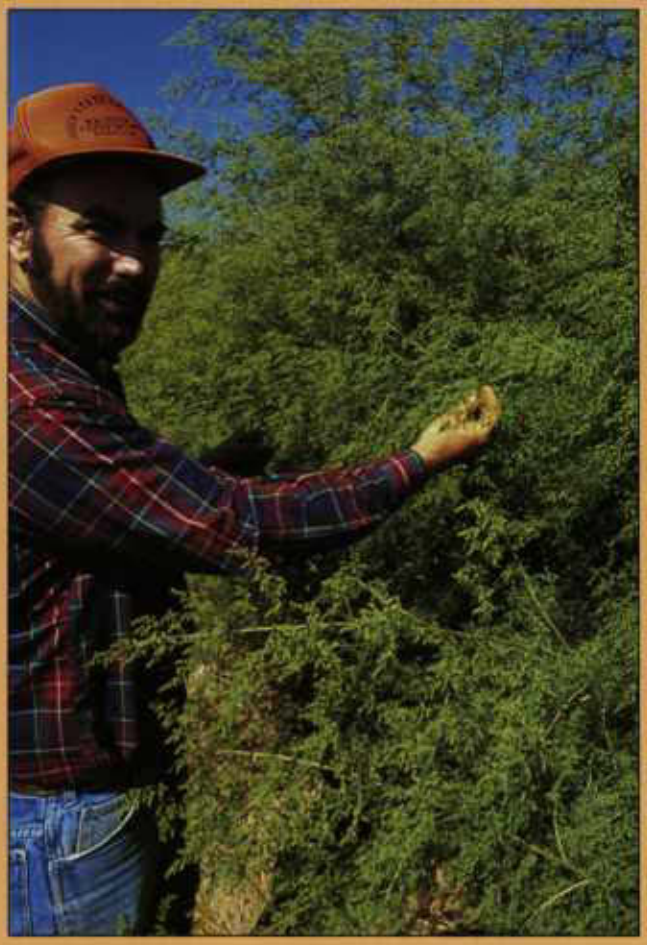
Examples of additional research include scientists' and technicians' experiments with alternative crops (soybeans, gourds and squash) that might be processed in Malheur County and sold in Japan, and a shrub called sweet wormwood. This eight-foot-tall member of the sagebrush family contains a substance used to control malaria, still a problem disease in some parts of the world.

Malheur County, the twelfth largest county in the contiguous United States, has only about 26,000 residents and depends greatly on farming and ranching (nearly 50 crops). In the mid-1980s recession, the area suffered less than parts of the country that depend on just a few crops, according to Shock.

"Our farmers had more choices," he says. "We believe the health of agriculture depends on diversity and on the production of value-added crops, where we process them right here." The potential for local processing is an important factor when evaluating a potential crop, he says.

The county was fourth in the state in farmgate sales in 1991, with a total of $163.5 million, according to OSU Extension Service economist Stanley Miles. Malheur followed Marion County ($335 million), Clackamas County ($205 million) and Umatilla County ($166.6 million).

Shock noted that local processing of onions, potatoes and sugar beets adds "hundreds of millions of additional dollars" to the Malheur County economy.



BOB ROST

Left: Clint Shock, superintendent of OSU's Malheur Agricultural Experiment Station, with an experimental patch of sweet wormwood. The plant contains a substance used to control malaria.

Water from the late spring, summer and early fall irrigation season worked contaminants through the soil into the shallow aquifer, over a period of years. Concentrations of nitrate and Dacthal breakdown products are highest in groundwater below the low, intensively used agricultural land in the area.

That's led the U.S. Department of Agriculture to set up what's called a Hydrologic Unit Area (HUA). It's a narrow strip running from north of Ontario to beyond the city of Nyssa to the south, with a spur running west past Vale. The state of Oregon is involved because the Department of Environmental Quality (DEQ) designated the same lands a state groundwater protection area under the Groundwater Protection Act of 1989. The USDA and DEQ designations led to cooperative efforts among federal, state and local agencies and local citizens.

The state set up the committee that produced the county groundwater management action plan. The committee members were chosen from people recommended by local civic groups, private citizens, agricultural and environmental organizations, and by state, county and city agencies.

"Our families drink this water."

The committee's challenges include (1) identifying both the practices that contribute to the groundwater contamination and those that will reduce the contamination, and (2) setting up a realistic cleanup schedule. The action plan calls for the OSU Agricultural Experiment Station to provide practical information for "best management practices" that will protect and lead to the decontamination of the groundwater. The OSU Extension Service is to develop educational programs to deliver the practices to the right individuals and organizations.

A subcommittee is answering technical questions. Its members include Clint Shock and John Miller of OSU's Malheur branch agricultural experiment station; Lynn Jensen, Ben Simko and Mike Howell of the Malheur County office of

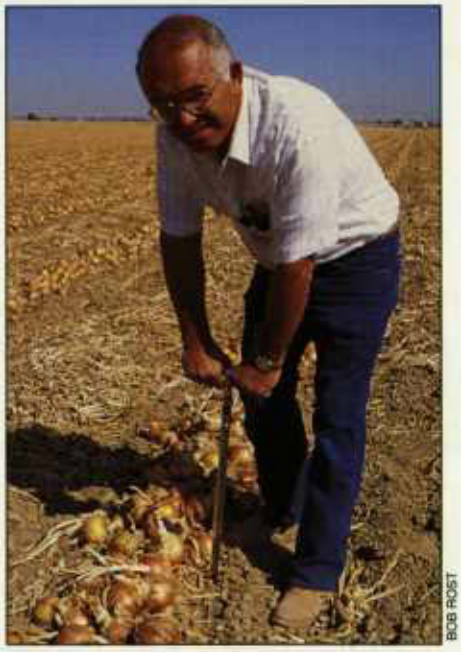
BOB ROST

Former OSU technician Tim Stieber uses a hydraulic probe to collect a sample from deep below the soil surface. Researchers study the samples for clues to how the groundwater contamination process can be reversed.

Right: Water diverted into furrows irrigates most northeastern Malheur County crops. Over a period of years, the water also can work nitrates and other materials down into groundwater.

DAVE KING

Researchers at the Malheur station are experimenting with using deep-rooted crops like wheat to "sop up" fertilizer that's moved below the range of plants like onions and potatoes.



BOB ROST

Lynn Jensen and other agents in the OSU Extension Service's Malheur County Office are linking researchers and farmers in the groundwater cleanup effort.

the OSU Extension Service; Marti Bridges and Herb Futter of the Soil Conservation Service; and Ray Dunten of the Agricultural Stabilization and Conservation Service.

■■■■■

Lynn Jensen steers his well-worn little yellow sedan south from the OSU Extension Office on the campus of Treasure Valley Community College in Ontario, by agricultural fields directly above contaminated groundwater. The Extension agent turns left off the blacktop and follows a familiar gravel lane to the modest headquarters of OSU's Malheur Agricultural Experiment Station. He goes in the back door, sits down, and quickly turns to the topic that dominates his work these days:

"I really thought growers would get their backs up—say we've been drinking this water for 50 years and haven't had any trouble. But I've been surprised. They're concerned. The attitude is, 'Our families drink this water and we want it to be good quality.'

"Ben Simko and I work real closely with the Experiment Station. We come out here and take the things Clint [Shock] and John [Miller] and the others are doing that look good and try to show the growers how they can adapt them to their growing systems."

"For years we simply looked at fertilizer impacts on crop yields, or maybe yield and quality. We didn't account for the environmental costs," says Shock, superintendent of the branch experiment station. "But now we're trying to find solutions that are win-win for producers and the environment. That's a whole new ball game."

Jensen says a lot of the research looks good. The scientists are pinpointing the amount of fertilizer various crops need. That's important—when growers apply too much, the excess begins to work its way down through the soil. The researchers are also examining various methods of applying fertilizer so plants utilize more and fertilizer isn't left in the field with an increased likelihood of it leaching into groundwater.

Another important finding is that unexpected amounts of ammonium fertilizer stay in the soil as ammonium, instead of changing to nitrate. That means there's a significant amount of residual fertilizer in that form that farmers can identify with soil tests and crops can use. "It offers cost savings to growers and will reduce the amount of fertilizer they put into the environment," explains Shock.

A lot of research looks good.

The researchers are also experimenting with "sop up crops," deep-rooted plants like sugar beets and small grains growers can plant to recover fertilizer that's moved below the range of shallow-rooted crops like onions and potatoes. "We're figuring out what it takes to grow crops on residual nutrients—the fertilizer already in the soil," says Shock. "We're not promoting starving a crop. But it may be possible to grow some adding no fertilizer at all. The plots we've had the last 2 years are a testament to the fact that it can be done."

Sugar beet growers are leaders in using the residual fertilizer in their fields, he notes. They do it for practical reasons. Too much vegetative growth, which comes from too much nitrogen, reduces

ANDY DUNCAN

OSU agronomist Chuck Stanger eyes alfalfa planted in the search for better crop varieties. Malheur County's economy still depends on agriculture.

the sugar content of the beets. Also, processors find it harder to handle beets with too much nitrate and ammonium.

Shock, Miller and other researchers are trying to determine exactly how much fertilizer is in the areas' irrigation canals, so growers will know how much fertilizer they are delivering to their crops that way. "This is not as simple as it might sound," says Shock. "Growers at the top of the canal system have water without much fertilizer in it. The water is reused many times in the canal system and may pick up nutrients as it goes into fields and returns to the canal system. We need to know what areas have what amounts."

LARRY K. HOFFMAN

Right: An aerial view. The contamination tends to be concentrated below low, intensively used farm land.

BOB ROST

Citizens from many walks of life in northeastern Malheur County, including agriculture, have joined the effort to eliminate nitrate contamination in groundwater. There's a lot at stake.

However, Shock thinks irrigation management (when and how much water crops receive) is the most important groundwater research area at the station. "Irrigation management is an absolutely critical element in keeping fertilizer from moving through the soil profile," he says. "There can be two really contrasting impacts of the same rate of fertilization."

Jensen agrees. He's introducing growers to small devices, called *granular matrix sensors*, that he believes will make it easier to measure the moisture in the soil more accurately, so they irrigate when they should and don't when they shouldn't.

"This spring I had a fellow call and tell me he was having trouble with his potatoes," says Jensen. "I talked him into letting me put in sensors. He told me later he irrigated one side of the field by what he thought he should and the other side by the sensors. Next year he wants all sensors."

"It could take 15 or 20 years."

But even if farmers use every technology and the best management practices, it's going to take longer than many people think it will to clear up the groundwater problem, Jensen believes. He notes that drilling done by OSU agricultural engineer Jack Istok and Kit Kamo of the Soil and Water Conservation District shows buildups of nitrate in the unsaturated soil just above the aquifer (hydrologists call this the "vadose zone."

"Some are saying we need to get this whole problem taken care of in 5 years," says Jensen. "We're saying, 'Whoa!' Right know we do not have the technology to not leach nitrate into the groundwater. We might have the contamination for a while."

"We really don't have good data for before 1983," adds Shock. "But it's a historical problem. It's been developing for a long time, and it could take 15 or 20 years to flush the residual nitrate out of the vadose and the aquifer once efficient practices are developed and implemented.

"What we do have right now is a group of people, from all sorts of disciplines, committed to finding scientific solutions. And we have considerable grower participation. We're trying to take a positive, constructive approach to finding things that work and that people feel good about."

AL'S GOOSE CHASE

A poultry study took this graduate student into the world of fiber, yogurt and microbe wars

Honk, honk. (Translation: Pass the yogurt please.)

Geese don't eat yogurt, but they might be better off—make that more efficient—if they did. It's not yogurt's low calories and vitamin D content that make it good goose food. The average goose probably couldn't care less about gaining weight or getting the required daily nutrients.

It's the lactobacillus (a type of bacteria) in yogurt that appears to benefit geese, according to Al Hollister, who recently completed work on a Ph.D. in poultry science. Hollister's graduate research project focused on making turkeys, chickens, ducks and geese better users of cellulose in their diets. Hollister worked under the guidance of Harry Nakaue, OSU poultry science professor and Agricultural Experiment Station researcher.

Cellulose is important as a potential food source for poultry because it is abundant in the environment, said Hollister. Cellulose is the primary component of the crude fiber in the cell walls of plants.

"Most poultry, such as chickens and turkeys, are primarily seed eaters," said Hollister. "They eat poultry feeds

BY BOB ROST

BOB ROST

Right: OSU graduate student Al Hollister at a Willamette Valley farm with some key subjects in his doctoral degree research.

consisting of corn and soybean meal, all of which are expensive because they are also used directly for human food production. Poultry also consume crude fiber, but they can't digest it very well because they lack the enzymes necessary to break down the cellulose in crude fiber."

Cellulose is important as a potential food source.

Feeding poultry might be cheaper if it were possible for them to digest cellulose more efficiently, Hollister said.

The research included feeding the birds probiotics, commercially prepared products containing concentrated lactobacillus and other bacteria that are often found in milk and in the digestive tract of healthy animals and birds. Commercial probiotics are bacterial cultures.

Lactobacillus, a bacteria found in unpasteurized milk products, turned out to be the cellulose-buster that Hollister was looking for. *Lactobacillus acidophilus* is the most common of several types of lactobacillus found in milk.

Lactobacillus is present in the gastrointestinal systems of all warm-blooded creatures, including humans, said Hollister. It competes with pathogenic bacteria in the gut and produces enzymes that aid digestion. For example, lactobacillus helps geese break down the grasses and other vegetation that they eat.

To study how commercial poultry use cellulose in their diets, Hollister prepared feeds containing varying amounts of crude fiber from various sources. He tested the feeds on experimental lots of ducklings, goslings, turkey poults and broiler chickens.

"I examined the feed consumption, feed conversion, fiber digestion and weight gain of test groups and control groups of different kinds of poultry," said Hollister. "In particular, I was looking for differences in bird health and performance on diets containing different amounts of crude fiber from oat hulls and purified cellulose."

After months of these trials, Hollister found little success with chickens. Even when fed probiotics, chickens were unable to digest significant amounts of purified cellulose.

Geese were a different story. They did well on diets featuring high proportions


BOB ROST

Philomath, Oregon farmer Dave Holderread sells geese around the United States, mostly for breeding. Often, he ships them by express mail.

of crude fiber and even better when probiotics were added in the diet. It didn't take Hollister long to find out why.

Geese, unlike their feathered brethren, are grazers. They feed the same way cattle and sheep do, picking their way across a pasture eating what appeals to them. This makes for a diet high in crude fiber, mostly from grasses, so geese are natural users of high-fiber diets.

These findings left Hollister with a partially successful experiment. He proved geese to be good fiber consumers, but unfortunately these long-necked waddlers aren't much of a commercial enterprise in Oregon. One solution may be to tap the honker's commercial potential. Geese produce meat, and feathers valuable for use in cold weather clothing and blankets. However, valley farmers may appreciate geese most in their role as weed eaters on webbed feet.

"Because they are grazers, geese make great mobile, non-chemical weeders of many types of high-value field crops," he said. "They will eat the grasses and weeds while more or less ignoring other crops such as strawberries. They can also graze on grass without trampling it down as larger livestock do.

"Their grazing habits also make geese inexpensive to feed and they can live in the valley through the winter," Hollister added.

In the past Willamette Valley growers used geese to weed strawberry and mint fields, Hollister said. Owners of geese contracted with crop producers to provide honkers for weeding. At the end of the growing season the owners would conduct a goose roundup and sell the birds for processing.

"This kind of activity was common in the Willamette Valley a few decades ago and is common in the midwest now," Hollister said.

Although broad-scale geese production in the valley may sound appealing, OSU agricultural economist Mike Martin stresses that the economics of such a venture need thorough study.

"The success of producing and using geese in the Willamette Valley is directly dependent on several economic factors


AL HOLLISTER

Geese are grazers and "great, mobile non-chemical weeders of many types of high-value field crops," claims Al Hollister. The birds were a more common sight in Willamette Valley fields a few decades ago, he says.

BOB ROST

Al Hollister's graduate research focused on making poultry better users of cellulose (fiber). Later, the OSU Rabbit Research Center hired Hollister to do feeding trials. He says the trials suggest supplements of lactobacillus, the "good" bacteria in yogurt and some other milk products, would aid digestion in many kinds of livestock.

BOB ROST

Experiment Station poultry scientist Harry Nakaue supervised Hollister's doctoral research.

such as potential markets for geese, availability of marketing and processing services and availability of labor to manage the geese within a particular type of production system," said Martin. "Committing to geese production without knowing the answers to these questions might doom the venture to failure."

Besides becoming an expert on geese, Hollister also learned more about probiotics during his feeding research. The pathogen-inhibiting characteristic of lactobacillus moved Hollister to wonder whether probiotics might make newborn livestock animals less susceptible to diarrhea caused by enteritis and other deadly intestinal diseases.

These illnesses can be brought on by booming populations of potentially pathogenic organisms, such as *clostridium* and *E. coli* bacteria, in the intestines.

Lactobacillus is the weapon Mother Nature provides for fighting these diseases, Hollister said. All newborn warm-blooded creatures receive lactobacillus in mother's milk or in feed. When it settles in the baby's gut, these bacteria begin multiplying and competitively inhibit, or crowd out, pathogenic bacteria.

"All kinds of animals, when they are young, often have problems trying to establish the right kind of bacteria in their digestive tract," said Hollister. "Babies receive lactobacillus from their mothers until they are weaned, but sometimes, for whatever reason, they don't get enough. It's a matter of good bugs and bad bugs competing for living space."

Hollister attempted to prove that extra doses of lactobacillus could help the good bugs triumph by feeding probiotics experimentally to baby rabbits. Although he was among the first agricultural researchers to test lactabacillus' role in gastric bug wars in rabbits, the idea of milk components helping animals overcome diarrhea isn't entirely new.

"There are old stories in the research literature of farmers both here in the United States and in Europe feeding waste milk from dairy cows to pigs and other types of farm animals," said Hollister. "The farmers noticed that these animals seemed relatively free of the kinds of common disease problems like enteritis, which causes scours (diarrhea).

"Babies receive lactobacillus from their mothers."

"Many of these farmers attributed some kind of magical power to the milk, when in fact it was most likely the lactobacillus that made the animals healthier," Hollister explained. "In light of these stories researchers have long suspected that lactobacillus could increase newborn animal survival. Feeding trials conducted with rabbits in the OSU Rabbit Research Center confirmed it."

Hollister chose baby rabbits for his study within a study because they suffer up to 20 percent newborn mortality from diarrhea. He worked with Peter Cheeke, OSU animal scientist and Agricultural Experiment Station researcher.

In tests conducted over a two-year period he fed New Zealand white rabbits varying amounts of probiotics in drinking water or feed and in the process reduced baby rabbit mortality due to enteritis by as much as 50 percent.

The significant increase in newborn rabbit survival indicates that probiotics may benefit other types of newborn livestock as well, Hollister said.

"This may be an especially important finding given the public sensitivity about the use of antibiotics in meat animal feeds," Hollister said. "Probiotics are natural organisms found in the animal. Antibiotics are foreign substances that do not occur naturally in the animal.

"The results of this project strongly suggest that feeding probiotics to livestock can be effective in increasing the numbers of good bugs in the gut of the animal," Hollister said. "And the presence of those good bugs can improve resistance to intestinal problems and feed conversion in the animal."

Bob Rost is an information representative in OSU's agricultural communications department.

A MOVEABLE FEAST

Drive east about 250 miles from the heart of the Willamette Valley, over the Cascades and through the sagebrush to Burns, and you'll find a guy trying to help solve western Oregon's field burning problem.

His office and the lab where he works are a few miles southeast of Burns in a one-story building with a big plastic cow out front—the headquarters of the Eastern Oregon Agricultural Research Center. But animal scientist Tim Del Curto spends a lot of his time in the center's nearby barns, corrals and pastures, where he and his technicians feed cattle from OSU's research herd various concoctions containing Willamette Valley grass seed straw.

"There've been some misconceptions about grass straw. But it does have potential and we're very excited about it," said Del Curto.

That should be good news for quite a few Oregonians:

—Willamette Valley grass seed growers facing a state-mandated phase-down on open burning of grass seed residue, and firms interested in marketing the straw residue left after summer seed harvest.

—Willamette Valley residents who don't like the smoke from farmers' burning of straw residue but don't want to see the seed industry crippled.

—Eastern Oregon ranchers who most years wrestle with high feed costs, and sometimes with forage shortages related to drought and other factors.

He and his technicians feed cattle various concoctions.

Del Curto and Dave Chamberlain, range/livestock agent and head of the Harney County office of the OSU Extension Service in Burns, speculate that there may be enough straw from tall fescue and perennial ryegrass, two types of grass seed crops, to feed about half the 450,000 or so mature cows in eastern Oregon during the winter, when harsh weather and dormant plant life make it very hard for range cattle to fend for themselves.

Bentgrass and bluegrass also show promise as livestock feed, say Del Curto and Chamberlain. They note that grass seed production has increased about 40 percent since 1980 and the current market price of $35 to $60 a ton is competitive with other feed sources.

There are obstacles, though, says Del Curto.

One is that, like the so-called "junk food" some of us eat, Willamette Valley grass seed straw has an image problem. The best grass straw is usually exported to countries such as Japan as livestock feed, but that isn't the main reason for concern over the remaining straw's nutritive quality. "Numerous studies were conducted by OSU during the 60s and 70s," Del Curto said. "During this period of time, the grass seed industry was dominated by annual ryegrass production. Annual ryegrass is of limited nutritive

BOB ROST

Willamette Valley grass seed straw has an image problem, but it's a more nutritious livestock feed than many think, says Tim Del Curto. The OSU animal scientist is doing feeding tests at the Eastern Oregon Agricultural Research Center, headquartered at Burns.

DAVE KING

Willamette Valley farmers swath their fields in July and August, then let the cut grass cure 10 to 14 days before removing seeds for sale. The straw left is baled, mostly by contractors who sell it or turn it over to brokers who sell it. Photo pages 30, 31: Andy Duncan.

value as a livestock feed due to very low crude protein and digestibility values."

The negative results of the feeding experiments "left a lasting impression on the Oregon beef cattle industry," said Del Curto. But annual ryegrass no longer is the dominant seed crop in the Willamette Valley, he points out. The now-significant tall fescue and perennial ryegrass crops are substantially more nutritious and digestible.

There are other reasons for the "junk food" image. People sometimes confuse grass straw with straw left after the harvest of grains such as wheat, which are much less nutritious. Also, an endophyte fungus (a fungus that invades every cell of a plant) infects some types of grasses. The fungus produces toxins called alkaloids that can inhibit circulation in cattle, causing health problems in hot and cold weather.

Del Curto's research is addressing all these obstacles.

Grass straw's protein content is relatively low, so it needs supplementation with alfalfa hay, which can be grown in Oregon, or with imported supplements such as soybean or cottonseed meal. The last three winters Del Curto and others at the Burns research center fed grass straw and supplements to their cattle. They found that with proper supplementation, mature cows eating the straw performed as well as, or better than, mature cows eating average quality meadow hay, a common but limited winter feed.

This fall, Del Curto and technician Roxane Barton evaluated strategies for feeding Willamette Valley tall fescue straw to steers, which have higher nutritional needs than mature cows. Animals ate diets ranging from plain straw to various combinations of straw and a 25 percent alfalfa supplement. The foods were in plain and pelleted form.

The steers preferred eating pellets that were a combination of grass straw and the alfalfa supplement. Studies of samples from the animals' rumens (first stomachs) and feces showed the pellets were easy to digest. The steers that ate them gained weight impressively.

"Essentially what we found is that just by pellitizing the grass straw with the alfalfa we gained about a 50-percent increase in intake compared to feeding just long-stemmed hay," said Del Curto. "We went from a situation where the animals were just getting enough nutrients to sustain them to one where they were eating enough to increase their weight. You'd have to ration out the pellets or they'd eat too much." The Pasco, Washington, firm that produced the pellets for the experiment is interested in expanding into the Willamette Valley, Del Curto noted.

There are other reasons for the "junk food" image.

Another part of his research involves the endophyte fungus that can hurt animal health. Last summer, with the help of the Agricultural Fiber Association, OSU animal science graduate students Michele Stamm and Marc Horney collected more than 300 samples from Willamette Valley grass seed fields, including about 50 samples of turf-type tall fescue, the main type implicated in endophyte poisoning. The graduate students are studying the samples.

BOB RIOST

Del Curto's graduate students are analyzing grass straw samples collected last summer in many Willamette Valley locations.

"Basically, analysis suggests endophyte-produced alkaloids are present in some turf-type varieties of tall fescue," Del Curto said. "However, less than 10 percent of the tall fescue samples had levels that would even be of concern.

"We have a study underway feeding straw from the fourth-highest alkaloid-containing tall fescue field we sampled," he added. "To date we haven't noted any depressions in animal health or performance."

Surprisingly, the graduate students found alkaloids in more samples of perennial ryegrass, which is not generally considered to have an alkaloid problem, than in tall fescue samples, said Del Curto. But "the perennial ryegrass samples had lower levels," he said. He added that research has shown many of the harmful alkaloids move into a grass plant's seeds before harvest, leaving stem and leaves relatively clean, and that alkaloid levels are reduced further when ranchers mix grass straw with protein supplements.

The researchers' interest in what cattle find tasty, and what foods are nutritious and cost-effective, doesn't stop there. This winter, Del Curto is studying the potential of high quality meadow hay as a substitute for alfalfa hay or other expensive protein supplements that could be used with grass straw.

Most ranchers take their cattle off the range and the cattle graze meadows (often near the ranchers' houses) in the

DAVE KING

After grass seed harvest, farmers burn straw residue to clear their fields and kill disease organisms. Objections to the smoke led to a state-mandated phase-down on open field burning. That heated up the study of uses for the straw.

winter. The thought is that some ranchers might come out ahead letting their cattle graze the highly productive meadows in the spring, too. Spring grazing keeps the meadow forage in an earlier vegetative state, increasing protein content and digestibility when it's cut and baled in mid-summer.

"The number one expense of the western beef cattle industry is winter feed cost. That isn't true so much in the Midwest and South," said Del Curto, underlining the importance of such research.

"Also, with the public lands grazing issue, we may see a reduction in cattle on public lands," he added, noting that would make efficient use of private land, especially meadows, more important.

In related research, Del Curto and Steve Brandyberry, another OSU animal science graduate student, are exploring strategies for giving mature cows a winter home not in meadows but on the range. That research is at the Squaw Butte branch of the Eastern Oregon Agricultural Research Center about 45 miles west of Burns.

BOB RUST

These pellets contain tall fescue straw and an alfalfa protein supplement. Cattle in a fall study preferred them, says Del Curto.

DAVE KING

Feeding eastern Oregon cattle in the winter, when forage is less nutritious, is "the number one" production expense, says Del Curto. He and Extension agent Dave Chamberlain hope ranchers can save money with grass straw—and help Willamette farmers in the process.

"This simulates grazing on the public lands in the winter when grazing might have less impact," he said. "Cattle tend to be more widely distributed over the range in the winter and not congregated at water sources."

The idea is to move animals to traditional hay meadows in the summer and return them to the range in the fall. "Quite a few progressive ranchers are already using some form of this system," said Del Curto. "They're in some areas in Lake County, part of Harney County, the Brothers area and in northern Oregon in the Antelope-Shanico area."

Ray Angell, a range scientist with the U.S. Department of Agriculture's Agricultural Research Service, is studying how winter grazing affects plants, Del Curto noted.

There may be enough to feed half the mature cows in eastern Oregon.

But with winter range grazing, just as with winter feeding of animals taken off the range into meadows, cattle still need either high-quality food or supplemental protein, especially during hard winters. So the dietary hunt goes on. This winter, like chefs searching for that special ingredient that will make a dish irresistible, technicians at Squaw Butte are keeping experimental animals in 1,000-acre areas, gathering them for daily feedings. The cattle receive various combinations of hays and protein supplements, or just protein supplements. The researchers study the bovine diners' reactions, hoping to find a supplemental meal that's nutritious, digestible, available and not too expensive.

The Extension Service's Chamberlain points out that for years residue from the relatively small bluegrass seed crop in northeastern Oregon's Grand Ronde Valley has been a "best-kept secret" among the area's ranchers. "They scooped all that was available up and it never got on the market," said Chamberlain.

Some beef producers in other parts of western and eastern Oregon feed their animals grass straw, too, says Chamberlain. "But one thing that shortened its use last year and this year is that the hay situation has been a bit long." The dairy industry used less alfalfa hay, leaving more on the market and driving prices down, he explained. "Most ranchers are going to buy feeder-quality alfalfa for $50 a ton instead of grass straw for $40 a ton," he said. Also, in recent years increased trucking costs made Willamette Valley grass straw less attractive in eastern Oregon, he added.

But alfalfa hay prices won't stay depressed, says Chamberlain. And field burning limitations, along with ups and downs in the grass straw export market, suggest more opportunities in the cattle industry await grass seed straw.

As his research unfolds, Del Curto, too, is becoming increasingly optimistic that grass straw is going to be a more significant part of the diets of the state's beef cattle. If that happens, it won't solve all the problems of western Oregon grass seed growers struggling with field burning restrictions, or eastern Oregon ranchers facing high winter feed costs and the potential of a shrinking land base. But the linking of these two industries with a moveable feast is bound to help both—and Willamette Valley residents who want the smoke to disappear.

—ANDY DUNCAN

(To get "Use of Grass Seed Residues as a Winter Feed Resource for Beef Cattle," a publication by Tim Del Curto and Dave Chamberlain, write Chamberlain at the Harney County Office, OSU Extension Service, 450 N. Buena Vista, Burns, OR 97720. There is no charge.)

A GOOD BALANCE

Diane Carroll has found a place where the pieces of her background fit together like a well-cut jigsaw puzzle.

That's sort of amazing: The new assistant professor has a Ph.D. in dairy science, master's degrees in animal science, library science and ecology, and work experiences ranging from medical research librarian to park ranger. She says it's a good balance of credentials for teaching dairy science and doing applied dairy research in OSU's Department of Animal Sciences.

"I find that the background in ecology is really essential for working in Oregon," Carroll says, offering an example of how her diverse background helps in her new job. She explains that water quality and other concerns of environmentalists and the concerns of dairy producers trying to stay in business overlap more prominently in Oregon than in any other state.

"I understand what the environmentalists are saying and I understand what the (dairy) producers are saying," she adds, "and I think we need people who can provide information to get those groups working together."

But with so many options, just how *did* she come to specialize in dairy science and move here from the heart of dairy country at the University of Wisconsin, where she received her doctorate?

Her work as a medical research librarian helped narrow the career options. "I got tired of doing research background for everybody else," she says. "I wanted to do it for myself. I wanted to change to a field that was a pure science field." That led to dairy science.

As for geography, Oregon, as Carroll explains it, produces more milk per cow than Wisconsin. So there's plenty for a dairy specialist to do here. Carroll got to know the Northwest in 1970 when she worked as a summer volunteer park ranger at Mt. Rainier.

TOM GENTILE

Diane Carroll

While backgrounds in agriculture and ecology help her see a broad picture, the years she spent as the director of a hospital library and as a medical research librarian give her experience she finds important when looking for resources to fund her experiments. Knowing "how to present your product and how to interact with people in order to get the funding you need is real important," she says.

Carroll recently received funding from the Oregon Dairy Farmers Association to do an experiment in dairy nutrition. This project will look at what feeding fishmeal to dairy cows does to improve their reproductive performance.

"A dairy cow calves and within 100 days we expect her to be producing maximum milk, eating the most that she ever does in her yearly cycle, and also [we expect her] to conceive," says Carroll. "Fishmeal has a very high quality of essential amino acids, and we're hoping that by feeding fishmeal with the regular diet we can improve reproductive health."

Such nutrition projects, Carroll explains, will benefit dairy producers by helping them find the most inexpensive ways to feed their animals to make them as healthy and productive as possible.

Her teaching plans go beyond the classroom. She wants to include undergraduate students in projects to give them an idea of what they can do with a research background.

"People have the concept that if they want to work with animals they have to work with sick animals. People have a hard time understanding what an animal scientist does. I always explain that we work with the healthy animals. There are a lot of things we can do—we can feed them, we can breed them, [and] we can manage them."

As someone used to fitting diverse pieces together, Carroll should have no problem finding a place for the activity she considers most important to her new job. "I need to get out on the farms. I need to clearly define what the issues are for Oregon. I need to know what information the dairy producers of Oregon need to be successful dairy producers," she says. "The quality of my grants and the quality of my teaching will be based on my understanding of those things."

—Mollie Mondoux

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GOURMET GANDER

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