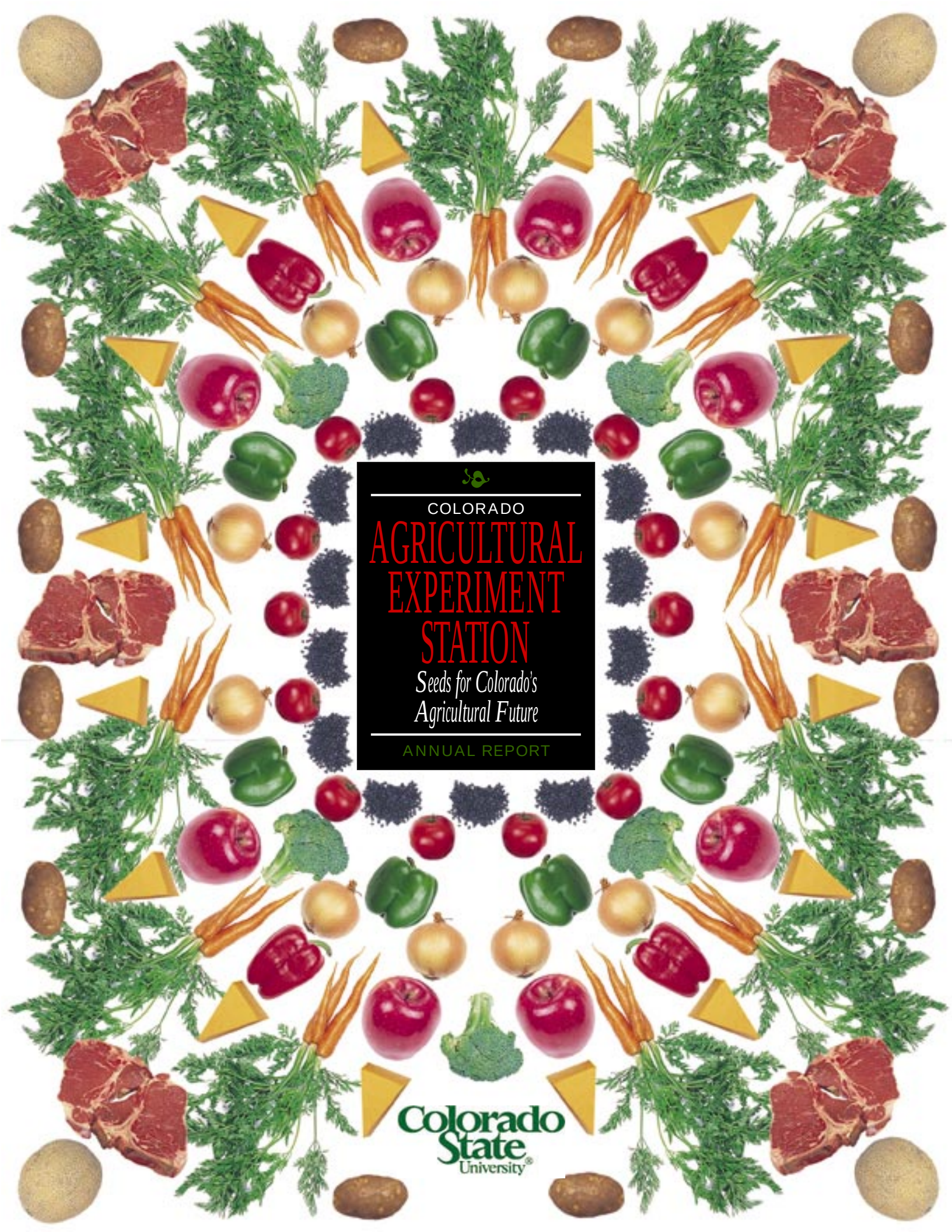

COLORADO

AGRICULTURAL EXPERIMENT STATION

Seeds for Colorado's Agricultural Future

ANNUAL REPORT

Colorado State University

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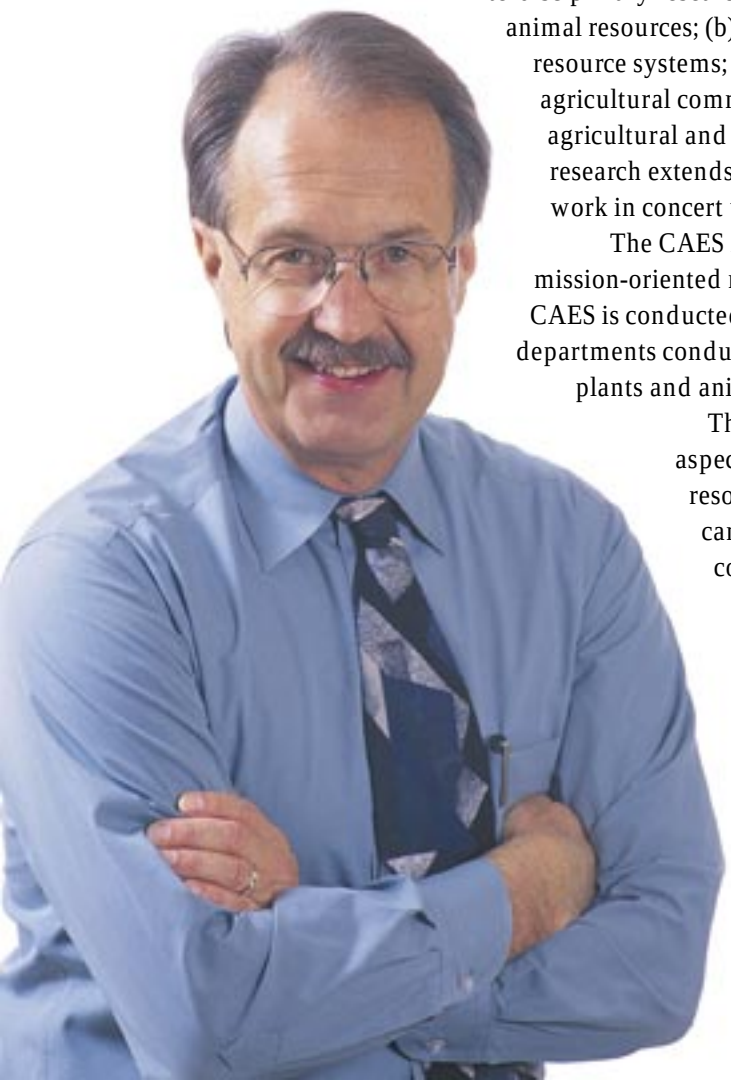
Greetings from the Agricultural Experiment Station at Colorado State University.

The Colorado Agricultural Experiment Station (CAES) is an integral component of your land-grant university. This report highlights 10 of the 130 projects supported by CAES at Colorado State University. Our purpose is to show how the research being conducted by CAES scientists addresses issues facing Colorado constituents. The projects were selected to illustrate the diversity of research needs within the agricultural and natural resource sectors of Colorado, as well as the breadth of research interests in the CAES.

The mission of the Colorado Agricultural Experiment Station is to focus and support research leading to an agriculture that is economically viable, environmentally sustainable, and socially acceptable. Areas of disciplinary and interdisciplinary research emphasis for the CAES include: (a) improvement of plant and animal resources; (b) environmental quality — the interaction of agricultural and natural resource systems; (c) integrated agricultural systems; (d) alternative uses for agricultural commodities; (e) foods — their quality and safety; and (f) enhancing agricultural and rural economies. The CAES supports the concept that agricultural research extends across the entire campus and that colleges within the University work in concert with each other to solve problems through interdisciplinary effort.



The CAES is not a single location; rather, it is a statewide system conducting mission-oriented research to meet the needs of Colorado constituents. Work of the CAES is conducted both on and off campus. Currently, CAES supports 22 on-campus departments conducting mission-oriented research that ranges from basic biology of plants and animals to applied field research on crop and animal production.

The CAES program likewise includes research on social and economic aspects of issues as well as research to solve agricultural and natural-resource problems that exist in different regions of the state. The off-campus research centers are staffed with professionals dedicated to conducting locally directed, applied research and outreach programs.

This report marks the first in what will be an annual publication highlighting selected accomplishments of our CAES research program. We appreciate your feedback on our programs and on this report. Many of you have supported our research programs in a variety of ways. A sincere thank you to all for this support.

Lee E. Sommers, Director
Colorado Agricultural Experiment Station
at Colorado State University

Seeking public opinion on environmental issues

THE PUBLIC

It's common for opposing groups to strongly express their opinions on environmental issues such as protection of endangered animals or proper use of natural resources such as streams, rivers, lakes, and forests.

Often, these groups represent small but vocal segments of society that use protest or other means to capture the megaphone of mass media in an attempt to sway legislation. Eventually, these issues escalate until they become a pressure cooker of conflicting information and public attention that make it difficult for policy- and decision-makers to act intelligently, not knowing what the general public really wants and is willing to pay for.

Colorado State University professor John Loomis is focusing on this problem by conducting surveys of the general public and providing results to those who make

DETECTIVE

decisions – elected officials, state and federal agency managers, industry, and interested general public. Since 1993, Loomis, of the Department of Agricultural and Resource Economics, has teamed with graduate students to conduct public surveys to determine the recreational use and non-use values of natural resources such as water, forests, and threatened or endangered species.

"You might call us detectives," says Loomis, who considers his position as an objective investigator at a research institution one of the keys to the perceived validity of his research. His research uses proven methods of social science research such as random sampling and built-in reliability checks. Plus, unlike the groups involved in these issues, Loomis has nothing to gain from the outcome. "We're seeking answers," he says, "and we're impartial."

John Loomis wants to help leaders make informed policy decisions by conducting unbiased scientific research on public opinions.

What's more, Loomis wants the public to put its money where its mouth is. "We want to know what the general public thinks about the value of these issues in terms of dollars," he says.

To do that, Loomis devotes considerable time asking respondents what they would pay for a particular action. For example, in a survey Loomis conducted on federal land use to provide habitat for endangered species in the Four Corners Area of Colorado, respondents were asked how much they would pay to maintain critical habitat for the Mexican Spotted Owl. It may surprise some to learn that the average household said it would pay up to $100 per year.

Another survey focused on establishing a Four Corners Region Threatened and Endangered Fish Trust Fund. The fund would cover nine species of endangered fish. In this case, the average household responded that it would pay up to $200 per year.

Loomis says survey results on these often controversial but critical issues provide important information to those who make decisions about the future of our natural resources. "This information will become even more important in the future as Colorado continues to change," says Loomis. "We're experiencing significant growth with more people, new businesses, and more demand for resources such as land, water, space, and recreation facilities. These changes often result in conflict over natural resources. We think our research and survey tools will play an even more important role in helping the general public inform government officials about how to manage the state's natural resources."

Developing SUPER

Probably since plants were first cultivated, people have wished for ways to build the perfect specimen – a super-plant that

resists most diseases and insects and produces the highest quality crop with fewest resources. The traditional way to create super-plant varieties is through selective breeding, a process pioneered by Gregor Mendel in the 1850s. Selective breeding involves breeding together two plants that have desired traits to produce offspring with the desired qualities of both plants. But this process is time-consuming and inexact. Successful new crop varieties are the result of a wait-and-see strategy that takes several generations and many years to accomplish.

Enter the age of genetics and new high-technology tools that speed things up. When two plants are bred together, geneticists use gene mapping to distinguish whether a desired trait was passed on by looking directly at the DNA of the offspring. Gene mapping is the science of examining the chromosomes of a given organism to find the location of a gene or genes that control a certain trait.

"We follow pieces of DNA on a gel to make a map that is representative of the genes in an organism," says Nora Lapitan, associate professor in the Department of Soil and Crop Sciences at Colorado State University. The tricky part is that even simple plants have tens of thousands of genes, and only small sections of DNA can be examined at one time. To make things easier, geneticists look for visual clues or DNA markers that help them figure out where they are on the DNA strand and which genes they are looking at. "DNA markers are like landmarks on the gene map," Lapitan says.

The Colorado State researcher has used gene

PLANTS

Following pieces of DNA on a gel, geneticist Nora Lapitan has helped growers develop crop varieties with natural resistance to insects and diseases.

mapping since 1989 to produce knowledge that helps plant breeders improve wheat, potato, and barley crops.

For more than a decade, Colorado's multi-million dollar wheat industry has been the target of a tiny, destructive insect called the Russian wheat aphid. Chemical control is costly and may be environmentally threatening. Lapitan worked on the problem with colleague Jim Quick, who identified several wheat genes that allow the plant to generate a natural resistance to the aphid. Lapitan then was able to provide wheat breeding programs with the DNA markers for two of these genes.

"This speeds the process for breeders who want to add natural aphid resistance as they develop new varieties," says Lapitan. "Because they know what to look for, wheat breeders are able to produce desired results much faster than with conventional breeding programs."

Lapitan and colleague Carol Ishimaru used a similar genetic approach to control bacterial ring rot, a common bacterial disease in potatoes. Because the pathogen of this disease often is latent, it will show up in some generations and skip others, making it extremely difficult to work with using traditional selective breeding programs. Though they haven't been able to identify a genetic code for total immunity, Lapitan and Ishimaru have been able to identify markers for several genes that show high levels of resistance.

Another challenge to build a super-plant came from the barley industry. A fungus disease called fusarium head blight, or scab disease, severely curtails production of malting barley, the main feedstock of the beer-brewing industry. This project is national in scope; North Dakota State University and the University of Minnesota do field work while Lapitan and her team at Colorado State handle the laboratory work. Funding is from the U.S. Department of Agriculture, the brewing industry, and the American Malting Barley Industry.

Even though the genetics of barley scab resistance are more complex than for Russian wheat aphid, Lapitan says four chromosome regions have been identified that show promise for genetic resistance to barley scab disease. Further studies are underway.

For all the direct practical application of her research, Lapitan remains modest. "All we're doing through gene-mapping and DNA marking is speeding up the process of identifying and combining genes that produce desired traits in plants. That's what plant breeders have done for hundreds of years through conventional plant breeding."

Ensuring accurate water resource management

GALLON FOR GALLON

Think for a moment how you'd feel if you sold a gallon of bottled water and then discovered your customer got a third more than a gallon. Irrigation water suppliers in the arid West are apt to find themselves in this situation if farmers' open-channel irrigation systems are old and in disrepair.

An important measuring tool in many irrigation systems is a device called the flume, developed more than 60 years ago to measure water delivery to farmers' fields. The most popular flume used in Colorado and much of the West is the Parshall Flume, developed by Ralph Parshall, a Colorado State University (then Colorado A&M) engineer in the 1920s. Flumes are constructed of concrete or sheet metal. When properly installed and maintained, the Parshall flume provides water delivery accurate to plus or minus three percent.

The problem is that age takes its toll. Research by Steven Abt, civil engineering professor at Colorado State University, found that, after long periods of service, flumes can settle into the ground unevenly and cause inaccurate water measurements. It's a serious concern for farmers who rely on precise allocations of water for growing crops, and for ditch companies that have the task of delivering accurate amounts of it. "In this day and age of increasing demand for water resources, accurate water

Steve Abt (right) has found a way to extend the life of the Parshall Flume, developed by Ralph Parshall (left), a Colorado State University (then Colorado A& M) engineer in the 1920s.

measurement through the water conveyance system is vital," says Abt. "We've found flumes in Colorado that have settled enough to cause up to 30-percent measurement errors in water delivery."

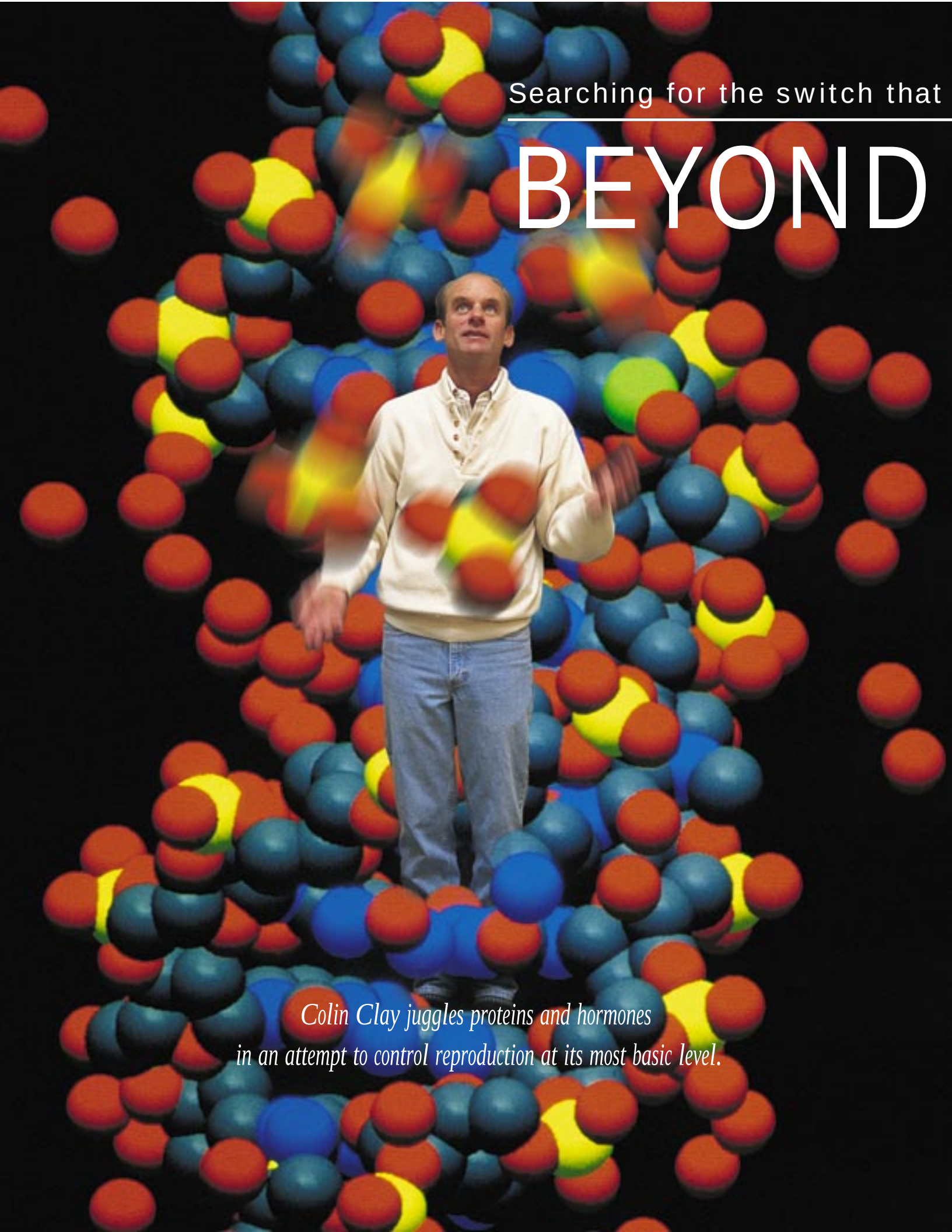
Abt's research team examined 149 flumes on farms in seven different areas of northeast, southeast, south-central, and western portions of Colorado. They found a total of 392 defects at the 149 flume sites. Most are caused by settling, usually the result of years of exposure to the elements — wetting, freezing, thawing, and contact with machinery and equipment. In addition to settlement problems, some of the flumes were corroded or had bent metal components, holes in the floor or sidewalls, siltation and vegetation blockage, and instances where part of the water flow bypassed the flume. None of the flumes had all the gauges needed to perform all the required water flow measurements. Of the 149 flumes examined, only 39 were in good to excellent condition, and of those, most were newer — less than 10 years old.

Abt and his research team developed a computer program that allows farmers to evaluate their flumes and correct water flow measurements without expensive modifications or installations.

The program is called the Parshall Flume Discharge Correction Program and was developed by the Colorado Agricultural Experiment Station. Available to any producer who has access to an IBM-compatible personal computer, the program asks the water user to make five different field measurements regarding flume performance. The computer program then gives the user correction information for accurate water measurements. The best part is it's free. Research funds provide the computer disks and user instructions. Information and copies of the flume correction program are available from Steven Abt, Professor, Department of Civil Engineering, A227 Engineering Research Center, Colorado State University, Fort Collins, CO 80523; or call (970) 491-8203.

Abt has turned his attention to conducting similar research on another type of flume used in Colorado called the cut-throat flume, again looking for measuring inaccuracies and developing computer software programs to deal with them.

Abt says that although his research may appear to be a high-tech answer to a low-tech problem, the benefits of accurately delivering water to Colorado agriculture are important to everyone, especially as more people compete for this valuable resource.



Searching for the switch that

BEYOND

Colin Clay juggles proteins and hormones in an attempt to control reproduction at its most basic level.

controls animal reproduction

THE PILL

On its most basic level, animal reproduction appears to be very simple. Eggs produced by females are fertilized by sperm produced by males. That's about where simplicity stops. Fully understanding the delicate and often mysterious workings of reproductive systems is a primary goal of many scientists, including Colorado Agricultural Experiment Station researcher Colin Clay, who seeks a better way to control fertility in mammals.

What causes the female to produce the egg? Or the male the sperm? Not to mention the eternal question of what could possibly cause males and females to put aside all the more pressing needs of survival — food, shelter, and avoiding enemies — for the single-minded pursuit of bringing those eggs and sperm together?

Clay, an assistant professor of physiology who works at Colorado State University's animal reproduction and biotechnology laboratory, is seeking clues to the most basic reproductive mystery. Clay is looking for a "switch" or a common factor that turns reproductive fertility in mammals on and off.

Mammal reproductive systems consist of a complicated interacting world of glands, cells, receptors, genes, hormones, and proteins. It begins in a small region inside the brain called the hypothalamus, which produces the hormone GnRH, or gonadotropin releasing hormone. Upon receiving GnRH through the bloodstream, the pituitary, another organ at the base of the brain, releases hormones called gonadotropins. Clay refers to the gonadotropin hormones as the systems' "accelerators" because they stimulate and maintain testicular or ovarian activity.

To keep the system in balance, the gonadotropin hormones also stimulate production of the two primary sex steroid hormones, testosterone in males and estrogen in females. Clay calls these sex steroids the moderators or "brakes." They act in a negative feedback role to inhibit further release of hormones from the hypothalamus and the pituitary. Clay says the sex steroids are such good brakes, in fact, that they are the primary active ingredients found in most oral contraceptives.

Clay wants to go one step better than regulating reproductive activity by using testosterone and estrogen to apply the brakes. These hormones have several well-documented side effects. He seeks to affect testicular or ovarian activity further upstream in the reproductive process by controlling production of the accelerators — the gonadotropin hormones.

"We and others have found that production of the gonadotropin hormones in response from GnRH requires "turning on" about four different genes in receptor cells of the pituitary gland," says Clay. "These genes carry the genetic code that allows receptor cells to make four different proteins that form the building blocks of gonadotropin hormones. What we don't know for certain is what signals the cell to make the proteins."

So Clay is looking for that signal, or "switch" that starts the production of gonadotropin hormones. Thus far, he and his colleagues have uncovered several clues that point to one master switch, another protein called steroidogenic factor-1, or SF-1.

The potential benefits of better, more efficient fertility control are enormous. Animal producers would no longer have to guess when to pair males with fertile females. Further, by controlling the time of year when females become fertile, ranchers could avoid newborns arriving in the dead of winter and could even plan to have the right kind of feed on hand for new mothers who may need more nutrition.

Remote stations provide up-to-date weather data

UNMANNED

Next to baseball, talking about the weather may well be our favorite national pastime. Fact is, we could hardly avoid talking about weather even if we wanted to. Weather directly impacts us every day of our lives. It dictates how we dress in the morning, what activities we plan, and when we can do them. Yet there are those upon whom weather has an even stronger impact — farmers. Colorado farmers plan nearly everything around weather patterns. A quick reaction to the latest turn in weather can mean the difference between success or failure of a whole year.

Thomas McKee, who directs the Colorado Climate Center, is dedicated to gathering and distributing weather information that helps farmers react more effectively to the Colorado's rapidly shifting climate.

"We really can't do much about the weather itself, but we do provide weather-related information that producers must have," says McKee. In addition to moisture, temperature, and humidity information, McKee says crop producers often want timely data about growing-degree days, which relates to temperature conditions suitable for plant growth, and evapotranspiration, which relates to moisture availability and disappearance through evaporation.

"Perhaps the most useful thing we do is gather this weather information from all over the state, compile it, and then deliver it back quickly to producers through high technology," he says.

Most of the data is gathered from a system of 31 unmanned weather monitoring stations located in major crop growing areas throughout the state. Named the Colorado Agricultural Meteorological Network, or COAGMET, the system is jointly funded by the Colorado Agricultural Experiment Station, agricultural commodity groups, and the Agricultural Research Service of the U.S. Department of Agriculture. These solar / battery-powered stations collect and continuously store data on temperature, relative humidity, wind direction and speed, solar radiation, precipitation, and soil temperature. A computer on the Colorado State campus retrieves the information each night by cellular phone. Then it's made available to farmers through a national commercial satellite subscription information service called Data Transmission Network, and through a web page maintained by the Colorado Climate Center. McKee says recent figures show the web page receives about 10,000 visits per month.

Equally important, though, is a long-term look at Colorado's weather, especially precipitation trends. McKee pioneered the application of a Standardized Precipitation Index to monitor dry and wet conditions and establish a history of these conditions in the state. This index tracks moisture accumulations in multiple time scales at 3-, 6-, 12-, 24-, and 48-month intervals. Data is gathered primarily by the Colorado Climate Center and the National Climatic Data Center. Precipitation is measured in snowpack, streamflow, reservoir storage, soil moisture, and groundwater supplies. The index helps Colorado's state government monitor water supplies critical to agriculture and urban areas, and is used at periodic meetings of the State Water Availability Task Force.

Climatologist Tom McKee collects data to help crop producers react more quickly and effectively to changing weather conditions.

Weather data collection is vital to many segments of Colorado's economy. McKee says farmers who have up-to-date information are better prepared to deal with changing growing conditions and problems, including those that spur costly diseases (see story, page 12). And for engineers and planners who work with water resources, precipitation and other climatic data are critical.

WEATHERMEN

Technology helps growers deal with mother nature

NO FOOLING

Scientists and farmers often find it difficult to outsmart Mother Nature — or sometimes even understand her. Just when conditions look good for a high-quality bumper crop of vegetables, diseases, insects, weeds, or bad weather can suddenly create a crisis that takes a drastic toll on crop yield or quality. The stakes are incredibly high in Colorado's dry bean and onion industries, worth an estimated $50 million a year each. Both are affected by numerous diseases, as are potatoes, another popular Colorado crop.

But new tools are at hand to swing the balance in favor of producers. Plant pathology professor Howard Schwartz and other Colorado Agricultural Experiment Station scientists have devised a three-fold program to combat crop diseases by drawing on biology, computers, and information technology.

The program begins with biology — selecting the proper variety of crop species. Several years' research at test plots around the state have helped Schwartz and other Colorado State scientists identify pathogens that survive the rigors of winter. These pathogens and the diseases they trigger are likely candidates to cause problems for growers. This knowledge is very useful in selecting and developing crop varieties that exhibit genetic disease resistance, giving growers an important head start in producing healthy plants. Genetic resistance also reduces the need to use chemical sprays as a precautionary measure, lowering overall chemical use.

The next step is to try to understand what types of conditions constitute a warning for different types of threats. For this phase, Schwartz and his colleagues have turned to computers. "We've developed and modified computer models that predict from research and past history many of the likely crop-growing problems producers may encounter," says Schwartz. "That information is combined with regional information about current conditions to help producers, crop consultants, and aerial applicators make timely, more accurate management decisions."

Feedback about current growing, pest, and weather conditions provided by producers, Cooperative Extension professionals, and agricultural consultants is extremely important to the success of this phase, Schwartz says. Another vital component is the daily weather information received from COAGMET, a network of remote electronic weather monitoring stations that retrieves time-sensitive temperature, moisture, and humidity data from sites throughout the state (see story, page 10).

Finally, Schwartz' program must quickly get accurate information back to the producers. Besides the usual newsletters, press releases, field days, and meetings, Schwartz delivers information to a national satellite service for farmers called Data Transmission Network, or DTN. Several thousand Colorado producers subscribe to this service, which allows them to download information instantly through their own satellite receivers. In addition, Schwartz and his colleagues present information on the Internet, and on separate telephone hotline message systems for bean, onion, and potato growers that deliver up-to-date information concerning potential growing problems. These systems also record information about developing and ongoing problems reported by growers and crop consultants.

Howard Schwartz and other scientists have devised a three-fold program to combat crop diseases by drawing on biology, computers, and information technology.

"Continued research combined with efficient technology and fast reaction will help vegetable producers respond quickly to Mother Nature," says Schwartz. "And that translates into a reasonable chance for Colorado growers to profit and for consumers to continue to buy prime quality produce at the prices they have come to expect."

Confirming safety in herbal medications

SNAKE OIL

Picture the old western snake-oil salesman who peddled quack miracle concoctions out of the back of a covered wagon. The wagon is gone now, but there are still plenty of reasons for consumers to be careful when purchasing medicine or any other product they ingest.

Demand for over-the-counter herbal remedies and the like exists among many segments of the American population. In fact, at least three percent of English-speaking adults in the United States use medicinal herbs of one form or another, according to a report in the New England Journal of Medicine. Potential for profit in this business is great, but so are the risks of toxicity for users of some remedies, or the lack of real benefits for others.

That's where Colorado State University chemistry professor Frank Stermitz steps in. He's spent much of his professional career sorting the safe from the dangerous, and the useful from the useless. Stermitz, whose research is funded in part by the Colorado Agricultural Experiment Station, works in a science called phytochemistry, or the study of chemicals derived from plants.

The Rocky Mountain Poison Center in Denver contacted Stermitz in 1993 to analyze an imported Chinese herb called Jin Bu Huan, often sold as tablets for relief of insomnia, pain, and spasm. The center reported three accidental overdose ingestions of the herb by children who suffered neurologic and cardiovascular problems as a result. About the same time, three adults experienced hepatitis associated with sustained ingestion of recommended doses of Jin Bu Huan.

Analysis of the remedy by Stermitz and graduate student John Beck revealed high levels of a toxic chemical it wasn't supposed to have, and none of a primary plant derivative that was listed on the label. These findings led the Food and Drug Administration in 1993 to ban importation of Jin Bu Huan herbal tablets into the United States.

Another interesting case involved Oshá, a medicinal herb widely used in the American southwest. Oshá is derived from the rhizome or underground stem of a plant with the botanical name Porteri that grows wild in western mountains. Hispanic and Native American populations of Colorado, New Mexico, Arizona, and northern Mexico have for many years used the herb as a remedy for colds and flu.

Because the molecular structure of a major component of the herb suggested it could be toxic, Stermitz was asked to investigate. He found no evidence of toxicity. In fact, he confirmed the existence of minor antimicrobial and moderately potent antiviral activity Oshá was purported to have, thus legitimizing some of the folklore claims for its ability to ward off colds and flu. The herb is now being cultivated by CAES researchers in southwestern Colorado.

Not all of Stermitz's research deals with human problems. In 1995, he heard reports that common field bindweed could be toxic to animals. Working with Dr. Anthony Knight of Colorado State's College of Veterinary Medicine and Biomedical Sciences, Stermitz determined that a group of horses consuming bindweed in a pasture near Thornton, Colorado, was indeed being poisoned by toxic compounds produced by the weed. This was the first demonstration that this worldwide problem weed also was toxic.

"The basics of chemistry and chemical analysis can be pretty cold, routine stuff," says Stermitz. "But seeing what I do and knowing that it makes life better for people not only in Colorado but throughout the world is very satisfying and rewarding."

Chemist Frank Stermitz has spent much of his professional career sorting out the safe from the dangerous and the useful from the useless.

A BIG FAT PROBLEM

Certain vegetable fats pose health risks

You are what you eat. Never have Americans been more aware of the truth in this old axiom than they are today. People are changing their diets in all sorts of ways to promote good health. One of the most tried and true diet modifications began in the 1950s when scientists learned that high animal fat consumption may contribute to clogged coronary arteries and heart attacks. Many people have since switched to more vegetarian diets. But the story doesn't end there — new investigations by Colorado Agricultural Experiment Station researcher Kenneth Allen indicate that certain types of vegetable fat could be playing a role in other health problems — particularly for women.

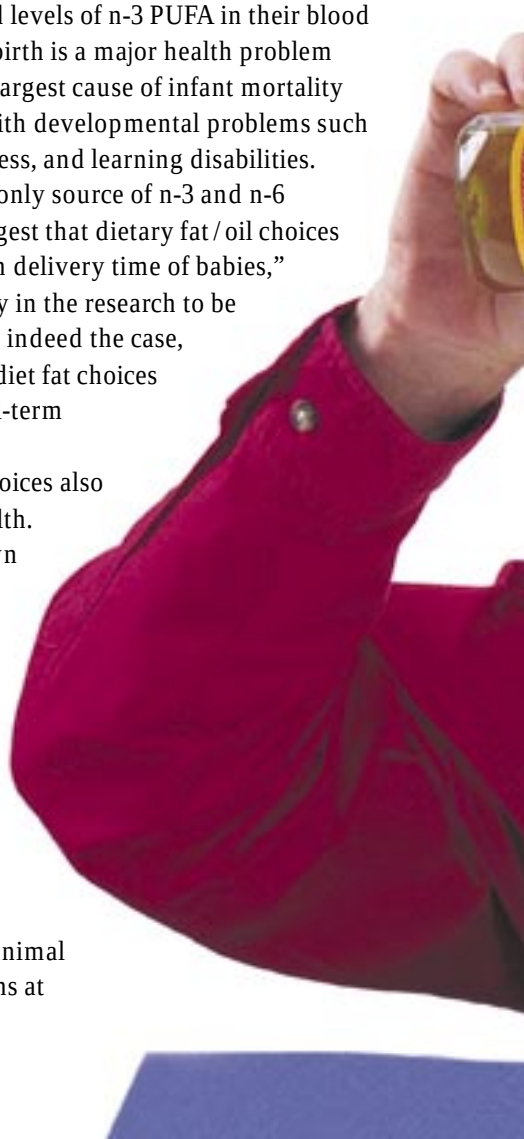
Allen, a faculty member in Colorado State University's Department of Food Science and Human Nutrition, has focused his research on fats contained in vegetable oils, specifically linoleic acid, or n-6 PUFA. PUFA is an acronym for polyunsaturated fatty acid. Allen says another essential fat called linolenic acid, or n-3 PUFA, also is found in most vegetable oils but in much lower amounts. These two fats play a role we don't yet fully understand in premature births and osteoporosis.

Research with Colorado State colleague Mary Harris and with James McGregor at the University of Colorado Medical School shows that women who deliver their babies several weeks early have increased levels of n-6 PUFA and decreased levels of n-3 PUFA in their blood and tissues. Premature birth is a major health problem among infants. It is the largest cause of infant mortality and also is associated with developmental problems such as cerebral palsy, blindness, and learning disabilities.

"Since diet is the only source of n-3 and n-6 PUFA, these results suggest that dietary fat / oil choices may have some effect on delivery time of babies," says Allen. "It's too early in the research to be sure of this, but if that is indeed the case, then simple changes in diet fat choices could help to ensure full-term delivery."

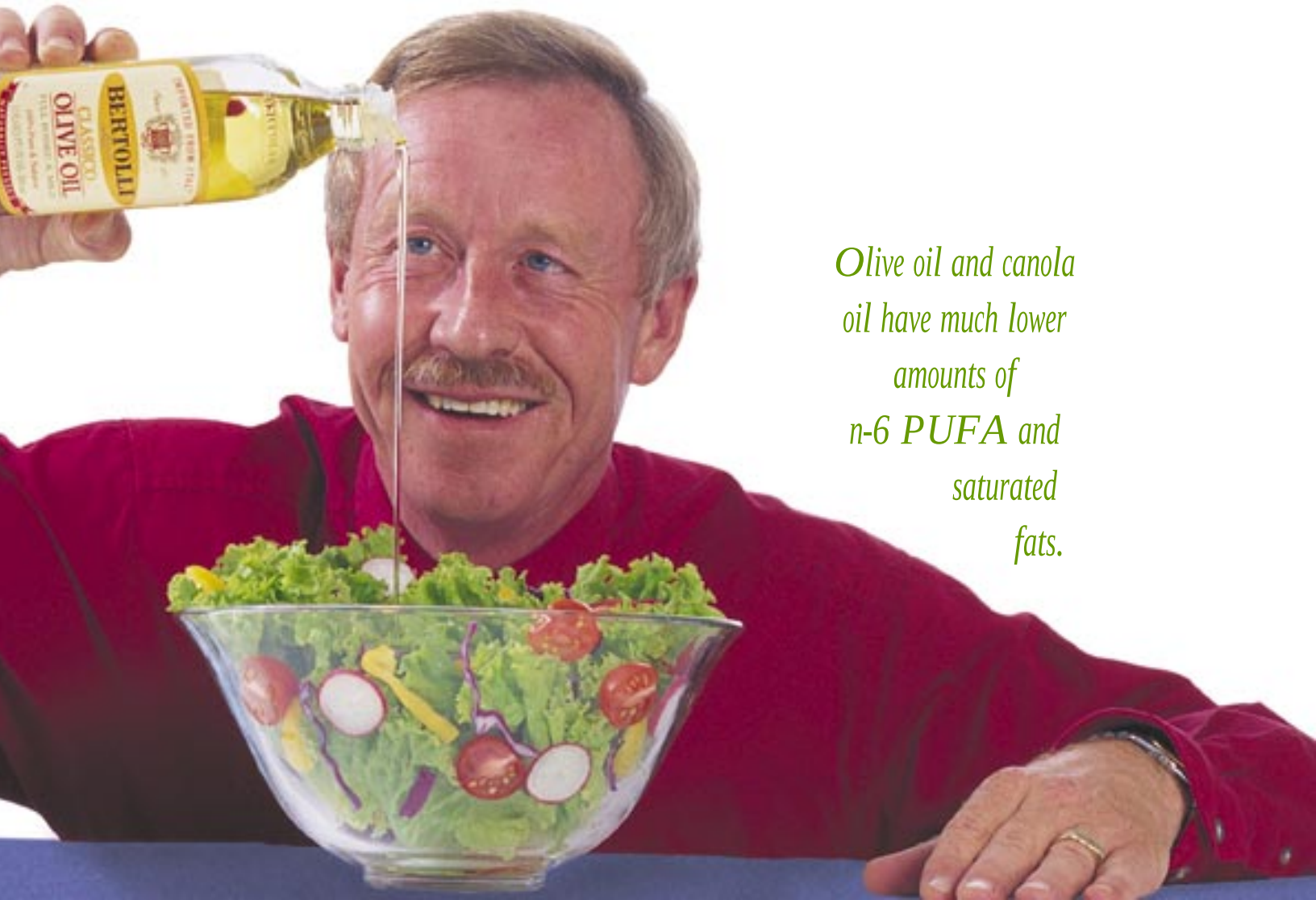
Dietary fat / oil choices also may influence bone health. Osteoporosis, also known as thinning bones, occurs with aging — particularly in women — and is a major contributor to disability of elderly women because it increases their susceptibility to bone fractures.

In a cooperative animal study with Bruce Watkins at



Purdue University, Allen found that decreasing n-6 PUFA and increasing n-3 PUFA resulted in increased bone mass and strength. Allen adds that diet calcium and exercise are also important in dealing with osteoporosis.

So how to correct this imbalance of fat types? Allen suggests limiting fat intake to about one third of daily caloric intake and balancing fat types. Pay attention to intake of both saturated fats and PUFA. Allen says one way to do this is to substitute oils such as olive oil and canola oil for other vegetable oils. These oils contain much lower amounts of n-6 PUFA and saturated fats.



Olive oil and canola oil have much lower amounts of n-6 PUFA and saturated fats.

High tech crop production in the age of plastics

PLASTICULTURE

Plastics and vegetable production would seem to be an unlikely combination. But six years of testing and development in southeastern Colorado is proving that this unlikely pairing of organic and synthetic goes together like peanut butter and jelly.

The vegetable production part of this story takes place in the Arkansas Valley where more than ten thousand acres of vegetables are grown each year, including world-famous Rocky Ford cantaloupes and watermelons.

The plastic part of this story is a growing system called plasticulture. Plasticulture uses a lightweight plastic film or mulch that covers the seed bed to control soil temperature, moisture, and weeds. Plants poke their heads through slits in the plastic and are watered by drip irrigation, a network of small plastic tubes placed under the plastic mulch that delivers water to the plants in precise amounts.

Colorado Agricultural Experiment Station scientist Mike Bartolo says experiments at the University's Arkansas Valley Research Center during the past six years show significant advantages for plasticulture-produced vegetable crops. Cantaloupe and tomato yields almost doubled in some test plots and regularly matured as much as two to three weeks earlier than conventionally grown crops.

Bartolo says the plastic mulch keeps weeds from growing while it also warms the soil and promotes early spring plant growth. That's why cantaloupes and tomatoes often go to market earlier than with conventional production. Earlier harvests provide an improved window for marketing at better prices for producers, plus a more uniform supply of high-quality produce for consumers.

Meanwhile, the drip system irrigation saves money and is more environmentally friendly than conventional irrigation. Drip irrigation systems slowly and continually apply small amounts of water to plants. The plant root absorbs as much as it needs in the time it needs to absorb it with little waste. Conventional furrow irrigation results in a lot of water being applied at one time, which means that much is wasted as it runs past the roots and into the ground. The excess water also leaches nutrients such as nitrogen into the groundwater system.

Onion production offers a slightly different challenge in the Arkansas Valley. Some of the onions grown in the valley are started from transplants produced in the milder climates of Texas, Arizona, and California. But Bartolo says they often harbor diseases and insects. This forces growers to use expensive pesticides for control. Using the plasticulture principle of early growth, some producers have begun to grow their own onion transplants locally in greenhouses or under plastic row covers in early spring. Preliminary experiments show little or no evidence of disease or pest problems for transplants grown locally, although more research is needed to make the process cost effective.

So far, high up-front costs to convert to drip irrigation — up to $1,000 per acre for pumping and filtration systems — have made many growers reluctant. But Gary Shane, who raises cantaloupe on the 350-acre family farm near La Junta, says plasticulture is the only way to go. He's among a few larger growers in the valley who have converted to plasticulture techniques. "It uses less water, less fertilizer, fewer pesticides," he says, "and less labor and machinery once the beds are planted and growing." Quality and yields have improved, too. Shane became convinced he needed to change after visiting fruit and vegetable growers in California and Arizona who had converted to plasticulture.

Melons grown in Rocky Ford have a reputation for quality and sweetness that melons from other markets can't match, says Shane. "But we have to make certain they exhibit appearance and shelf quality that melons from other markets have. We can do that with better growing practices that include plasticulture," he adds.

Although Arkansas Valley irrigation water may be relatively inexpensive now, it won't stay that way as more people move to Colorado. "Our crop producers need to demonstrate they can cut water use and produce even better quality than ever before," Shane says. "These new growing techniques with plastic help us do that."

Cantaloupe and tomato yields almost doubled in some test plots and regularly matured as much as two to three weeks earlier than conventionally grown crops.

Turning the worms

Imagine a horde of tiny, ravenous worms moving through the soil, seeking lunch — and lunch is the root system of a corn plant. That's the common story of western corn rootworm in the United States. Rootworms can leave corn roots so riddled that stalks collapse or lodge, causing $1 billion in annual losses due to crop damage and control costs.

Oddly enough, western corn rootworm has a strong preference for corn roots — and almost nothing else. This singular preference piqued the curiosity of Colorado Agricultural Experiment Station researcher Louis Bjostad, who set out to learn why rootworms only eat corn and to see if there was some way to exploit this fact to stop the root-crippling onslaught.

What Bjostad discovered is an interesting process of chemical communication that takes place between corn plants and rootworms. As they grow, corn roots give off carbon dioxide. The CO_2 strongly attracts the larvae to the root systems. Then, like all youngsters, the larvae like to taste their food before they dig in.

"We found that larvae take at least one bite of the roots to see if they like them," says Bjostad.

"If the right stuff is there, they will continue to feed, causing severe damage. If it's something else, they'll move on. The right stuff is a precise mixture of

Chemical misinformation fights rootworm infestation

compounds that only corn roots produce. So far, we have identified a blend of 27 organic acids, monosaccharides, salts, and amino acids that occur in corn roots. We are about to conduct feeding bioassays to find out if this is the complete blend."

While identifying the products in corn roots, Bjostad unexpectedly found something that might prove useful. Corn roots produce small amounts of substances that, in high doses, actually repel the larvae. Unfortunately, the repellents are not strong enough in commercial varieties of corn to overcome the larvae's natural attraction to their favorite food.

Bjostad, a professor in the Department of Bioagricultural Sciences and Pest Management, has teamed up with other researchers to isolate and identify these natural repellents and then figure out ways to synthesize them in strong compounds that could be applied in bands around the corn seed at planting time.

Another approach Bjostad is considering is to use genetic engineering to increase production of the natural repellents in the corn roots themselves.

Bjostad says his goal is to create an integrated program of basic research on chemical communication in insects that he can use to develop new, environmentally-desirable technologies for pest control. His approach makes a lot of sense. Using naturally occurring pest deterrents instead of traditional pesticides reduces hazards to farmers who handle pest-control products. It also reduces groundwater contamination and starts a whole string of other environmental benefits that present fewer hazards to animals and beneficial insects. Developing alternative control methods also may prove extremely useful should corn rootworms someday develop resistance to insecticides now being used.

"We know many consumers now favor use of non-toxic approaches to pest control in food production," says Bjostad. "We think this research is a step in that direction."

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Department of Food Science and Human Nutrition
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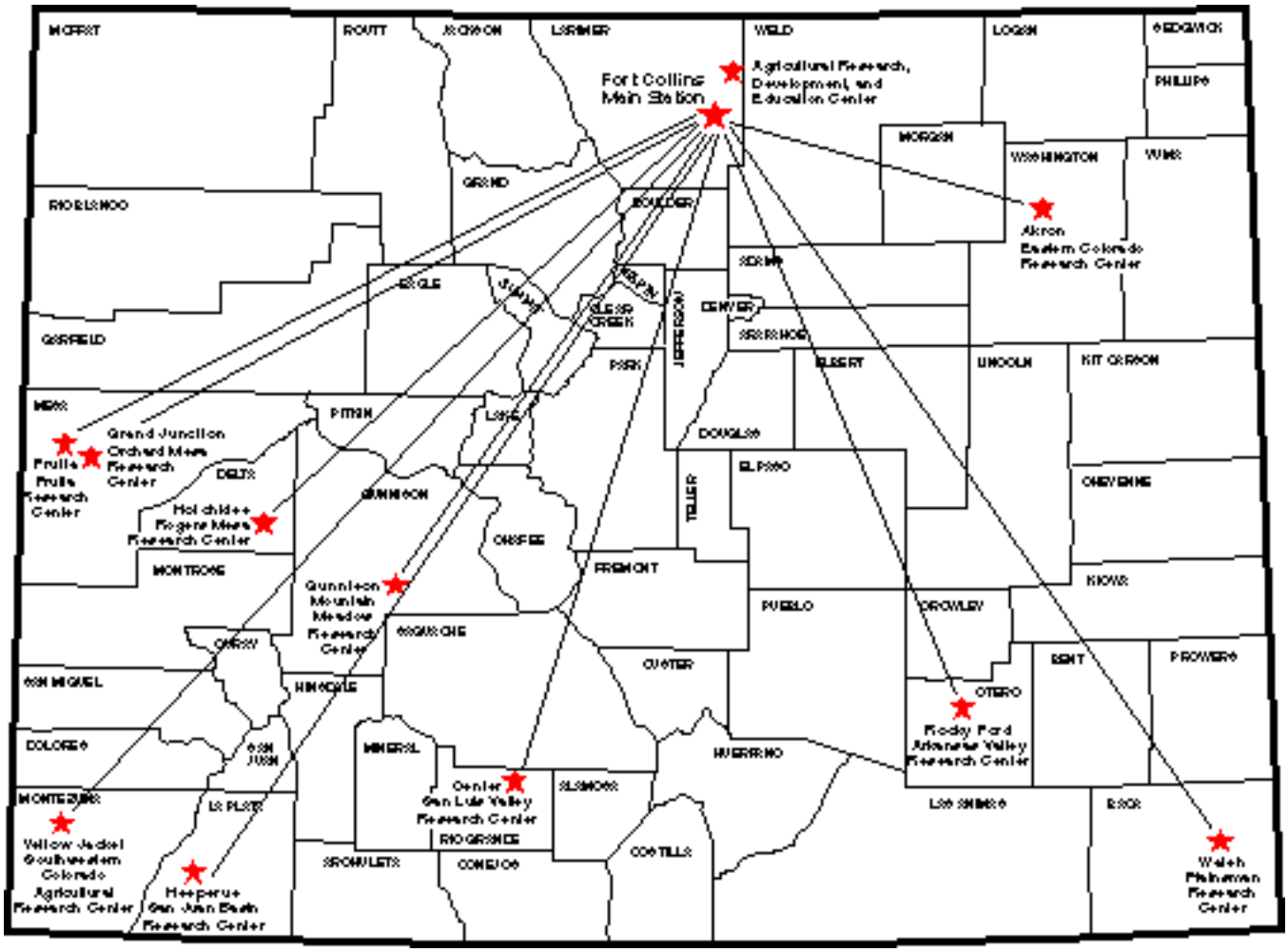
Colorado Agricultural Research System



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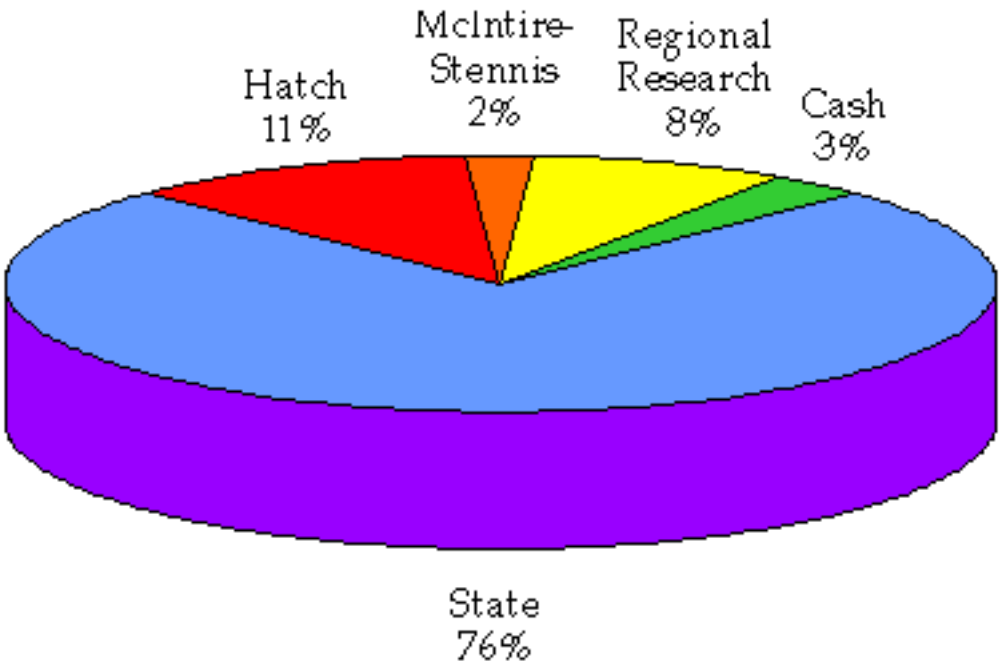

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