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South Dakota Farm and Home Research

South Dakota State University

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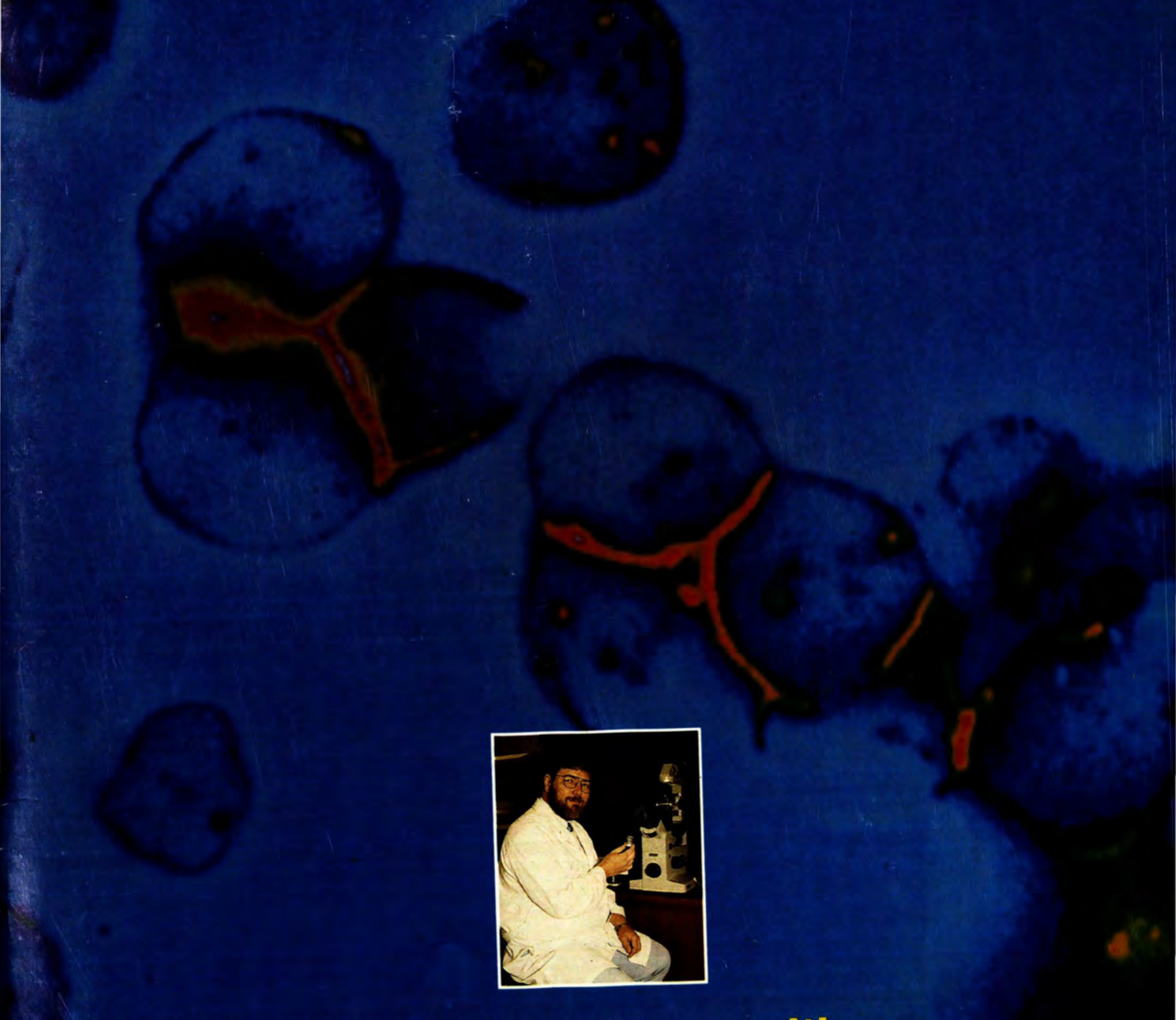

Shaping the future with a new dimension to research

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The answers to some questions become apparent only when we look closely enough. This microscopic view of stressed cells gives scientists like David Hurley (inset photo) information that isn't available from other sources. Hurley believes that molecular biology will provide answers needed to improve crops and livestock, make them more efficient to raise or grow, and make products from them safer and more healthy for consumers.

photos: David Hurley and Tom Bare

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Guest comments

'New way of doing research' in Northern Plains Biostress Laboratory

Dr. David J. Hurley

With the opening of the Northern Plains Biostress Laboratory (NPBL) last September, the scientific community at South Dakota State University moved into not only a new building and a great laboratory facility, but into a building that stands for a new way of doing research in support of agriculture.

The NPBL is an integrated research facility designed to bring together the talents, efforts, ideas, and inspirations of the whole student and faculty community of the University. The building was designed to break down barriers.

We also are knocking down mental barriers. We have done our best to bring together teams of scientists and students from different departments who have common and overlapping interests. Our intent is to integrate teaching with research. Through teamwork, we are building bridges between basic science, applied studies, and agricultural technology.

Using this process, we will bring problems identified in the field into the laboratory in a well focused manner which will encourage solution of those problems in the shortest possible time.

The integrated research team has members from the Extension faculty, applied researchers such as breeders and the veterinary pathologists and from the community of basic scientists including geneticists, physiologists, cell biologists, and molecular biologists. All are in constant communication. This encourages interaction and promotes better focus of the research programs.

Our purpose is a concentrated study of biological stress. We are one big research unit deployed to address the future of agriculture. We are a team, whether we work on better soybeans for food oils or biodiesel, healthier pigs or cattle, better markets for South Dakota livestock and crops, or new and better jobs for the young people of South Dakota.


photo: Tom Bare

Dr. David Hurley believes that integrated research teams bring greater focus to addressing the future of agriculture. The unique blend of talents and skills within each team will allow for quicker reaction and innovative new solutions to agricultural problems.

Here are some examples of this concept in action:

The range research group brings together scientists studying range management, range breeding, forage plant genetics, and forage quality. Because of its vertical and horizontal integration, this group is an excellent example of integrated research.

The animal infectious disease group is another developing cluster of scientists. Scientists from the departments of Biology and Microbiology, Veterinary Science, Dairy Science, and Animal and Range Sciences come together to address problems of health management, disease control, nutritional management, and stress control in cattle and swine.

Another group is the plant tissue culture cluster. Scientists from Biology and Microbiology, Plant Science, and Horticulture have developed a center within the NPBL to prepare the ground work for better crop, tree, shrub, flower, and vegetable variety production in the stressful environment of South Dakota.

Other groups are forming. They include members of other colleges of the University and address a broad range of problems faced by South Dakotans.

The benefits of these realignments are numerous. These groups will provide a better education for South Dakotans attending SDSU. Biostress will be reduced on many South Dakota farms and ranches. The research groups will focus more regional, national, and international attention on the problems we address in South Dakota. The solutions we propose will serve agriculture across the globe in other biostressed areas. Through the integrated model of research the products of our effort will be greater than the sum of its parts.

The NPBL is the proving ground for this model. In its laboratories we are making science work better and harder. We all benefit. ❑

Dr. David J. Hurley is associate professor of microbiology and is a team member of the animal infectious disease group and the cellular biology and molecular biology groups.

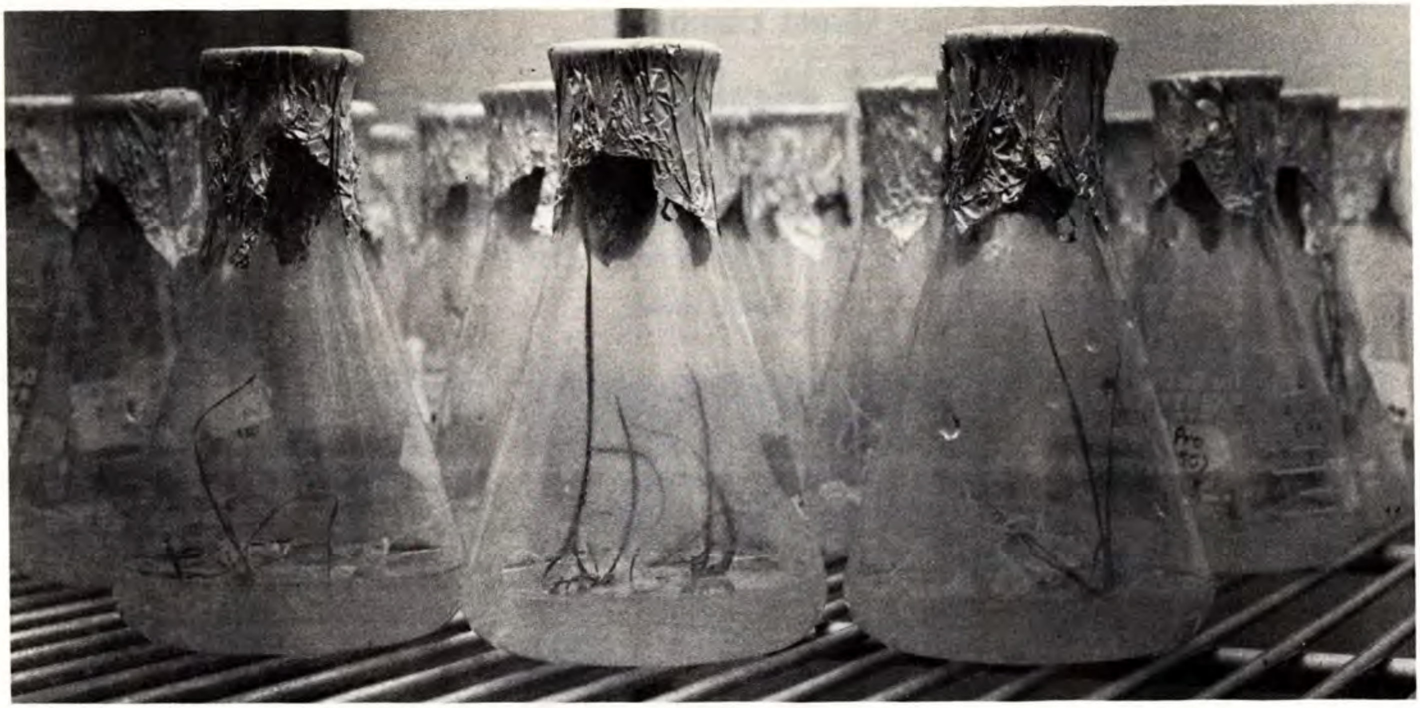


photo: Chen H. Chen

SDSU scientists add a new dimension to research

Jerry Leslie

Seeds of a quiet revolution are taking root on the campus of South Dakota State University.

A new scientific community centering on molecular biology has sprung up in the last 4 or 5 years. The scientists are mostly clustered in the Northern Plains Biostress Laboratory (NPBL).

Core members of the group are molecular biologists. Their associates around the periphery of this specialty are commonly called biotechnologists. They are "basic" scientists, providing the original data that "applied" scientists use in solving particular South Dakota biostress problems. Extension specialists then transfer, through education of producers and consumers, this information to the public. The mission of the scientists, whether in the lab or the field, is to help South Dakota citizens improve their quality of life.

Ways in which they meet that goal include improving crops and livestock, making them more efficient for farmers to raise or grow, and making the products from them safer and more healthy for consumers.

Some specific areas of basic biological research at SDSU are:

- Controlling the virulent *E. coli* bacterium recently implicated in some illnesses from contaminated hamburger on the West Coast.
- Understanding the genetic involvement in stress response that renders cattle and hogs susceptible to disease.
- Creating superior winter-hardy winter cereal grains as a result of transfer of genes for those traits.
- Finding soybean varieties with improved or "prescription" oil and protein content.
- Breeding soybean varieties that don't abort flowers like current varieties but which go on to set seed from all or most of the flowers.
- Designing sunflower plants that produce their own insecticides.
- Developing wheat varieties resistant to greenbug and Russian wheat aphids.
- Using a native South Dakota plant, purple prairie coneflower, as a specialty crop that would yield pharmaceutical products or beneficial genes to transfer to other plants.
- Giving livestock improved vitality and health through selection of genes affecting such things as obesity and fat-to-lean ratios or that reduce susceptibility to immunodeficiency, diabetes, cancer, and other diseases.
- Breeding a wheat variety to be resistant to diseases like tan spot through anther culture, a process faster than traditional crossbreeding.

• Perfecting new techniques and procedures that would lead to a genetically superior beef animal.

• Genetically altering bacteria and fungi to do a better job of producing such things as ethanol, pullulan, calcium-magnesium acetate (de-icer), cheese, lysine, and other commercially valuable products made from common farm commodities or their byproducts.

• Investigating the bovine herpes virus, a major cause of respiratory disease and abortions in cattle, so that it might be either controlled, prevented, or moderated with or without new vaccines. The work could benefit many other food animals, including poultry, swine, and fish that are hosts to the herpes virus.

• Developing genetic markers for various traits in beef cattle.

• Using a technique called flow cytometry to look at alternations of DNA in sperm and assess human and livestock fertility. The same process also notes severity of environmental pollution.

• Replacing some insecticides with predators of those insects, with a goal of more environmentally friendly pest control.

These are among projects under way at SDSU. The new direction in research is an exciting one with promises beyond imagination.

Just how soon these promises will move from discoveries in the laboratory to usable end products in the field or feedlot is hard to estimate. However, the "discovery-to-consumer" process is shortened by the type of comprehensive, interdisciplinary teams that have been developed.

Soybeans and corn product utilization are excellent examples. The soybean team includes basic scientists, applied breeders, and Extension specialists working toward a common goal.

Nationwide on the human health front, people may be familiar with insulin produced from recombinant DNA. This product replaces insulin extracted as a byproduct of the meat processing industry. The new method means that the life-saving drug is available in abundance to diabetics. The thrust of the research at SDSU is similar—to improve the lives of people in South Dakota and the nation. From SDSU, a diagnostic DNA probe for porcine stress syndrome is one benefit already in hand.

photo: Chen H. Chen

New wheat plants resistant to tan spot disease are grown in a flask through a process called "anther culture" (facing page). Inoculating anther cultured wheat cells with tan spot toxin aids in selection for disease resistance. This research project is being tackled by a cooperative team headed by Chen H. Chen from the Biology/Microbiology Department and Jackie Rudd from the Plant Science Department. Above, graduate students Rong Yu (left) and Hong-Kyun Shin, who are working with Chen, examine anther cultured wheat plants in the Northern Plains Biostress Laboratory.

Ray Moore, director emeritus of the South Dakota Agricultural Experiment Station, speculates that the first bioengineered crop to emerge from SDSU may be a soybean variety, simply because more people are at work in that area.

He also has predicted in the long term that corn varieties will fix their own nitrogen fertilizer, either through genetically engineered bacteria or on their own.

He envisions perennial crops from plants that are now annuals. Imagine wheat planted only once, but harvested every year.

Possible benefits have caught the imagination of South Dakota farm commodity groups like the South Dakota Corn Utilization Council, Soybean Council, Wheat Commission, Pork Producers, Cattlemen's Association, and others. Several now direct some of their checkoff dollars to fund SDSU biotech research projects.

Historically, it was considered impossible to cross different species. But occasionally hybrids occurred accidentally in nature, as did mutations.

One of the notable crosses occurred in South Dakota in 1918. Edgar McFadden made an "impossible" cross between Russian spelt and Canadian bread wheat to produce a rust-resistant variety of wheat known as Hope. It became the parent for many later rust-resistant varieties of wheat.

"Mutations occasionally occurred by chance in nature. Now, genetic engineering takes the chance out of it and 'accidents of nature' can be more predictable," Moore said.

Moore also notes a renewed interest "in surveying our native prairies. We know there is a lot of diversity of germ plasm out there. Now with genetic engineering there is some promise of using some of that," Moore said.

Basic scientific research once received little respect from tax critics and pundits. But add the molecular biology component, and

photo: Tom Chase

Tom Chase, right, mycologist and fungal geneticist, works with Ph.D student Zhaowei Liu putting cultures of soybean phytophthora root rot fungi into a Programmable Thermal Controller (PTC) to speed their growth. Chase is examining the genetics of several plant disease organisms to aid in their diagnosis and control.

basic research is faring better at the budget table. Practical applications become more visual, more promising, and quicker to realize.

Some SDSU projects have scored successfully for national competitive grants from the National Institutes of Health, National Science Foundation, USDA, private industry, and others.

A new source of funding for some of this research is state commodity group checkoff dollars.

Charles McMullen, head of the Department of Biology-Microbiology at SDSU, said his department "now has a fair amount of commodity group money for research. That's because commodity groups can see applications that can benefit their particular group."

The funding climate for basic research also has been aided by the practice of teaming up basic scientists with applied scientists, McMullen said. Some molecular biologists have joint appointments with other departments, or have an appointment that is partly basic and partly applied science.

Carl Westby has the longest tenure among molecular biologists at SDSU, having joined the staff in 1973. "I am now fortunate myself to have funding from the Corn Utilization people. They realize the importance of basic theoretical research that has results. They realize that the development of recombinant plant or animals strains can benefit agriculture."

Westby believes one of the factors in gradual acceptance of biotechnology in South Dakota has been the

Research benchmarks in history

1865—Gregor Mendel presents laws of heredity to the Natural Science Society in Brunn, Austria, from his studies of crossing pea plants.

1868—Friedrich Miescher, a Swiss biologist, isolated nucleic acid from white blood cells among discarded bandages.

1880s—Discovery that hereditary factors are transmitted through egg and sperm.

1943—First direct evidence that DNA is the bearer of genetic information.

1940s—Scientists first realize each protein is the end product of a gene.

1953—Scientists James Watson, an American geneticist, and Francis Crick, an English physicist, working at the University of Cambridge, proposed a double helical (spiral) structure for DNA. (Received the 1962 Nobel Prize for Physiology and Medicine).

1970s—Enzymes were discovered that "cut" DNA into smaller pieces, allowing scientists to isolate specific genes and make clones (duplicate copies) of them and to combine genes together into new arrangements (recombinant DNA).

1973—Two California geneticists, Stanley Cohen and Herbert Boyer, plucked a piece of DNA out of an African clawed toad and spliced it into a common bacterium.

1980—Supreme Court ruled that scientists can patent new forms of life created by splicing genes into organisms or cells.

1981—U.S. Ag Secretary John Block announced development of a technology for moving genes from one kind of plant to another, transferring a gene from a French bean seed into a sunflower cell, creating a "sunbean." Scientists from USDA and the University of Wisconsin-Madison used a bacterium to move the gene from one plant to the other. The bacteria was termed a "genetic engineer."

1982—First transgenic mouse survives. It is twice normal mature size and carries extra copies of genes for either rat or human growth hormone. Mouse maintains its larger size through successive generations.

1994—Scientists at George Washington University announced cloning of the first human embryo.

June 3, 1994— USDA approves a biotech soybean tolerant to an environmentally friendly weed killer.

Who's who in molecular biology at SDSU

• **David Benfield**, microbiologist-virologist, Veterinary Science Department. Receptor sites on mucosal surfaces of pigs indicating genetic susceptibility to viruses.

• **Bruce Bleakley**, soil microbiologist, Biology-Microbiology and Plant Science departments. Proteins and nucleic acids of bacteria useful in biological control of tan spot and scab of wheat and in control of corn rootworms, using these molecular "fingerprints" to rapidly identify and track the location of these biological control agents in soil and plant materials.

• **Catherine Carter**, geneticist, Plant Science Department. Sequencing of oil- and protein-controlling genes for transfer in soybeans and sunflowers. Techniques for transformation and for regeneration of transgenic cells. Manages Plant Molecular Biology Laboratory in the NPBL.

• **Christopher Chase,** DVM, virologist-immunologist, Veterinary Science Department. Gene sequences of a herpes virus that causes respiratory diseases in cattle, part of an international project. Polymerase chain reaction technology to look for Mystery Swine Disease virus in boar semen. Virulent *E. coli* in beef animals. Interactions of cattle herpesviruses and the immune system of cattle.

• **Tom Chase**, mycologist and fungal geneticist, Plant Science Department. Genes of fungi infecting crop plants. Molecular techniques, including polymerase chain reaction, to help aid in diagnosis of different races of the pathogen causing phytophthora root rot in soybeans and another pathogen causing charcoal root rot in many plants.

• **Tom Cheesbrough**, molecular biologist, Biology-Microbiology Department. Genes regulating oil synthesis in soybean, modifying to improve oil quality. Transfer of genes for aphid resistance to wheat.

• **Chen H. Chen**, cell tissue culture, Biology-Microbiology Department. Regeneration of plant tissue from cells genetically altered by other scientists in other departments. Anther culture in wheat with a wheat breeder to develop a tan spot-resistant wheat. Elimination of generations of growth in nurseries to speed crop breeding process.

• **Melvin Duvall,** botanist, Biology-Microbiology Department. Evolutionary relationships in grasses, using molecular biology as a tool. A complete phylogeny (evolutionary history) of grass family. Grasses of potential economic importance in South Dakota, such as sorghum, for molecular markers characterizing a variety.

• **Alan Erickson,** protein biochemist, Veterinary Science Department. Intestinal receptors which define the genetic susceptibility of pigs to *E. coli*-induced diarrhea, leading to the development of receptor gene probes that may make it possible to breed pigs that are resistant to some forms of *E. coli* infections.

• **Don Evenson,** biochemist, Station Biochemistry. A very rapid flow cytometer assay to detect abnormal chromosome structure in livestock and human sperm. Direct application for testing fertility potential and genetic damage due to environmental toxicant exposure. Test used internationally.

• **Anne Fennell**, plant physiologist, Department of Horticulture, Forestry, Landscape and Parks. Early induction of cold acclimation in grape vines. Intent is to identify genes for early acclimation response that can be used as markers for selecting winterhardiness in grapes, work has application to many woody plant systems.

• **David Francis**, Veterinary Science Department. Genetic susceptibility of pigs to *E. coli* infections, by finding cell receptor sites in mucosal areas.

• **Bill Gibbons**, applied and industrial microbiologist, Biology-Microbiology Department. Mutant bacterial overproducers of calcium-magnesium acetate (CMA), using corn stillage. CMA is an environmentally friendly road deicer. Production of bacteriocin which inhibits undesirable organisms in ethanol production without inhibiting yeast.

• **Nels Granholm**, developmental geneticist, Biology-Microbiology Department. Genetic material of mutant oversized laboratory mice with the "lethal yellow gene," gene causes obesity (feed efficiency), unthriftiness, diabetes. Same gene found in some humans and other mammals. Broad implications for agricultural efficiency and human health.

• **David Henning**, dairy microbiologist, Dairy Science. Molecular work on bacteria involved in cheese cultures with intent to improve cheese. Virulent *E. coli* in dairy and beef cattle.

• **Jane Christopher-Hennings**, DVM, Veterinary Science. Polymerase chain reaction to look for Porcine Reproductive and Respiratory Syndrome (PRRS) virus in boar semen. Pathogenesis of PRRS virus. Genetic susceptibility of some pigs to scours-causing *E. coli* infections. Evaluation of colostral product.

• **Mike Hildreth**, parasitologist, Biology-Microbiology. Molecular biology to develop diagnostic techniques for identifying parasitic infections in domestic animals.

• **David Hurley**, Biology-Microbiology Department. Components of colostrum responsible for protection against infection. Interaction of herpes virus with immune system of cattle. Reduction of infections in cattle by the virulent form of *E. coli* often associated with human illness. Understanding persistent infection in food animals mediated by "superantigens." Identification of genetic factors causing stress responses.

• **Don Kenefick**, plant physiologist, Plant Science Department. Cold acclimation and freeze-resistance (winter-hardiness) of cereal grains, understanding the cold-acclimation response at the cellular level.

• **Marie Langham**, plant virologist, molecular biologist, Department of Plant Science. Relationship of wheat streak mosaic to freeze-resistant cultivars at the cell level. Behavior of wheat genes in the environment. Immunological diagnostics of plant viruses.

• **Doug McFarland**, muscle biologist, Department of Animal and Range Sciences. Cell biology research. Role of growth factors in skeletal muscle development.

• **Don Marshall**, beef breeding and genetics researcher, Department of Animal and Range Sciences. "Genetic markers" from DNA in breeding beef animals to determine which are related to production efficiency.

• **Eric Nelson**, microbiologist, Veterinary Science. PRRS (mystery swine disease) virus. Evaluation of a polymerase chain reaction assay to detect the virus in boar semen. Monoclonal antibody development and viral receptor studies.

• **Neil Reese**, plant physiologist, Biology-Microbiology Department. Flower abortion in soybeans with eventual intent to transfer genes that will abort fewer flowers and set more seed. Use of nitrogen fixing bacteria to transfer genes. Genetic markers in purple prairie coneflower.

• **Fedora Sutton**, molecular biologist, Plant Science and Biology-Microbiology departments. Sequence and expression of cold-regulated genes in winter cereal grains, with long-range objective to transfer genes for superior winter-hardy cereal grains varieties. Plant growth hormones and animal neurotransmitter receptors for better understanding of how plants and animals respond at the genetic level to the environment.

• **Tom West**, microbial biochemist, Station Biochemistry. Mutant fungi which overproduce pullulan, a polysaccharide gum, from corn byproducts, and one which would overproduce lysine in distillers' grains. Enzyme-based amino acid production.

• **Carl Westby**, molecular biologist, microbial physiologist, geneticist, Biology-Microbiology Department. Identification of genes from laboratory mouse mutants and from cattle, swine, sheep, cats, humans. Bioengineering of bacterium to become an overproducer of pullulan from corn. Bioengineering of soil bacteria to remove pollutants.

photo: Tom Bare

Molecular biology, the science which gave birth to gene transfer, now pervades many other disciplines. The core of a new gene transfer and biotechnology community at SDSU includes, clockwise, molecular biologists Marie Langham, Tom Cheesbrough, Catherine Carter, Carl Westby, and Fedora Sutton. A new soybean plant, regenerated after gene transformation from a single cell, is held to the front by Cheesbrough. It will grow to maturity in a greenhouse and could serve as a parent to many generations.

growing realization that SDSU's research "is focused on agriculture—plants and animals." It also fits in with work at other land-grant universities like University of California—Davis, the University of Wisconsin, and the University of Minnesota.

He predicts that SDSU's efforts will gradually expand. "We have new scientists on board and they all have their own ideas about what should be done and what can be done.

"I see an unfolding of results that, down the line, will produce useful information and recombinant strains that can be used in agriculture."

Westby also reports that SDSU scientists, although resident in separate academic departments, operate almost like a community.

They get together and talk, they have mutual seminars announced around the departments. He cited a "sack lunch" program by the Plant Science Department where the participants discuss their latest findings and journal papers.

Neil Reese, a plant physiologist who joined SDSU in 1988, said the NPBL "is doing what it said it would do," allowing a lot more interaction among scientists. Even before it was built, the promise of facilities to come made it easier to hire. "We now have a critical mass of people. Being together allows us a better sharing of ideas and information," Reese said.

Fedora Sutton is a molecular biologist who gained national attention for isolating cold-regulated genes in winter barley. In addition to her on-going quest to genetically transfer freeze resistance to cereal grains, she now coordinates a graduate-level, year-long course in molecular biology.

The course teaches molecular biology and is team-taught by Sutton, Tom Cheesbrough, another molecular biologist, and Westby. It helps to transfer the new technology to both veteran and aspiring South Dakota scientists.

The "Internet" computer network now links the computers of SDSU scientists by telephone modem with each other and scientists on other university campuses, as well as those in the USDA, Westby pointed out. It helps SDSU scientists share information as part of the "world community" of molecular biologists.

David Benfield, the veterinary researcher involved in solving Mystery Swine Disease, is now acting director of the Agricultural Experiment Station.

Benfield said 10 years ago, not much molecular biology work was occurring on campus. "I think what has happened is that we've been able to recruit people with a good basic background in molecular biology, with a good basic background in science, and also with the capability of using that technology to apply it to a problem important to producers in the field.

"I think we've tried very hard to keep that mission in mind by using that technology to apply some useful and applicable information for producers.

"The investigators we have in the SDSU College of Agriculture and Biological Sciences maintain a constant vision of that mission of applying what we learn to the field.

"They keep in touch with the outside world, and I think the real world has caught up with the technology. Often scientific technology goes on a line without a vision of what the application is and it takes a while for the rest of us to catch up," the research administrator said.

Benfield added that the more a technology is used, "the more it becomes 'cookbook' so more laboratories can use the technology. It becomes less specialized, and it also becomes more economical to use," Benfield said.

Benfield also credited SDSU administrators with "a historic, deliberate effort to hire the best people who fulfill the mission of the Experiment Station and the land-grant institution. And certainly we've looked to individuals to have the molecular background, because it is so important to us and the produc-

photo: Jerry Leslie

Dishes retrieved from a growth chamber contain three stages of sunflower plants regenerated by "cell culture" from a single cell. When the regenerated plants are ready they will leave the culture for the greenhouse where they will grow to maturity. Examining the regenerated sunflower plants is Paula Livingston, an undergraduate lab technician from Salem S.D., working in SDSU's Plant Molecular Biology Laboratory.

ers. That expertise has come along because we've been able to hire good people, good scientists."

Fred Cholick, head of SDSU's Plant Science Department, explained the new trend in SDSU research from a little different perspective. The new molecular research at SDSU is "broader than manipulation of genes," said Cholick. It is the application of molecular biology to the understanding and manipulation of plants, animals, and microorganisms.

"Obviously, the genes are the dominant factor you can manipulate, because they control 100 percent of the mechanism of the plant (or animal)."

What has brought the changes to SDSU and other land-grant universities is technological development, Cholick maintains. "We have abilities and technology at the molecular level we didn't have 10 years ago. The technology developed and we hired people who have the expertise in that area."

The Plant Science Department continues to rely on the traditional plant breeders who use standard selection and crossbreeding techniques. But they are now joined and aided by the "new" scientists.

"Depending on your objectives and what you're trying to change, the two complement each other," said Cholick. "For some traits it is more efficient and cost effective to use conventional means, and for other characteristics we either can't or it is too expensive to use conventional means, then we've got to go to the new molecular techniques."

Cholick, a former spring wheat breeder, said that molecular biology has given plant breeders "a new approach to understanding the plant and ultimately using that plant to meet man's needs."

The SDSU Dairy Science Department has scientists working on the genetics of cheese bacteria in hopes of improving quality of cheeses, according to John Parsons, department head.

The NPBL, which now houses Cholick's plant breeders and a portion of his department, has helped unquestionably, he said. The actual physical space is important, but the focus of the efforts is on biostress research. Cholick pointed out that a lot of the molecular research "is targeted at the stress mechanism."

Benfield, Westby, Moore, McMullen, and Cholick agree the NPBL was influential in attracting staff, even in the idea stage before it was built. It now allows scientists of different disciplines to be located in the same building, share equipment, and collaborate more easily on biotechnological research.

SDSU's Veterinary Science Department has a team that identified a genetic susceptibility of some pigs to scours-causing *E. coli* infections. The discovery promises dollar savings to producers who will one day screen these lines out of their herds, according to John Thomson, department head.

Another team is looking for similar things with viruses. Yet another team is part of an international project that is genetically sequencing a virus causing respiratory diseases in cattle.

Work at SDSU at the gene level, within the nucleus of the cell, has developed within the last 4 or 5 years. In the broader area of biotechnology, the work has been going on longer, perhaps 10 or more years.

In South Dakota and nationwide, new products from the emerging science of molecular biology are just beginning to unfold. South Dakota scientists are contributing to the worldwide body of knowledge, and are among the leaders in several areas.

The years ahead offer an unprecedented excitement in the scientific community. Technological breakthroughs provide optimism about things ultimately to come from the field and feedlot to the dinner table, and benefits for health and the environment. ❑

Jerry Leslie is news and features writer in the Department of Agricultural Communications, SDSU.

New SDSU facilities nearing completion

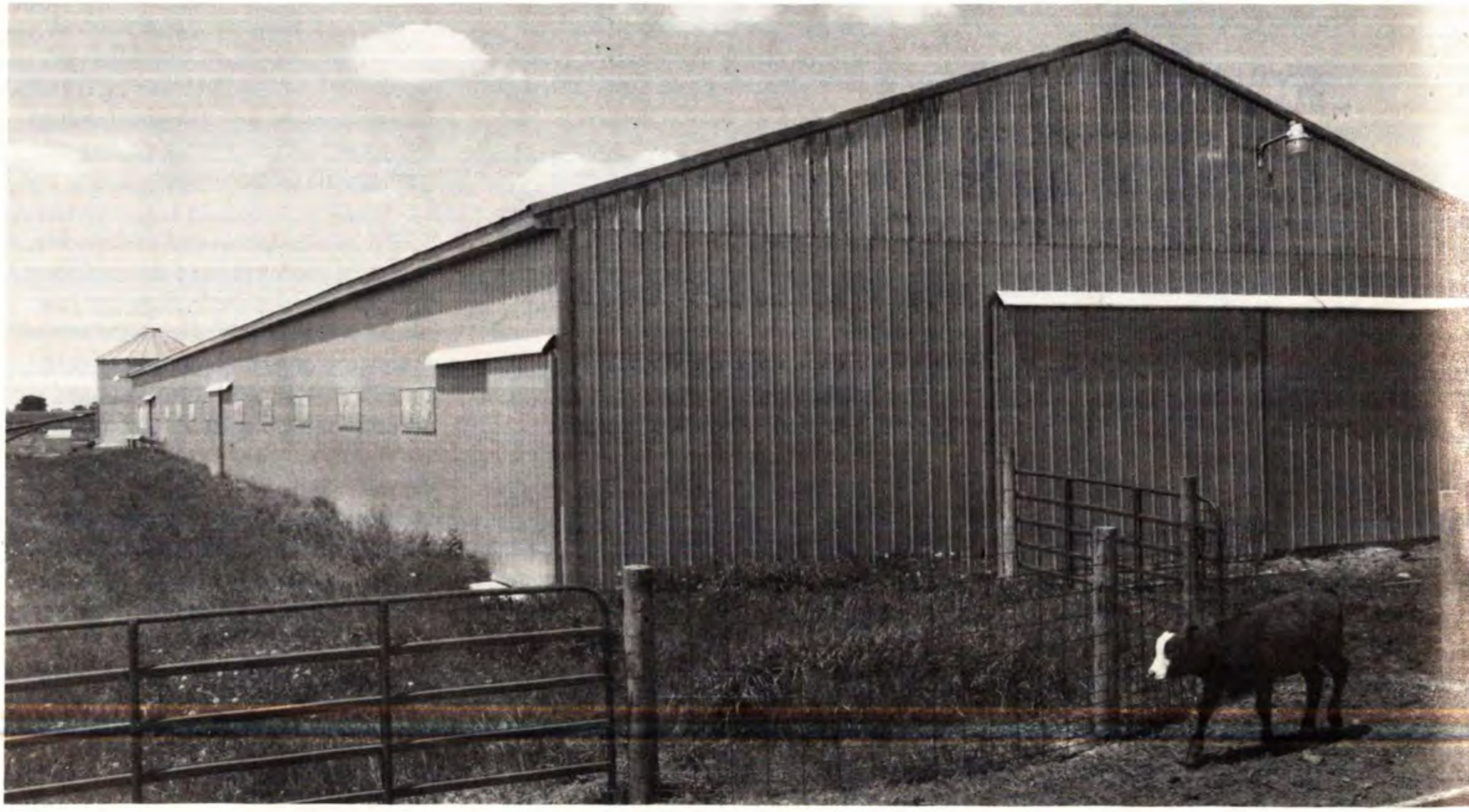
photos by Tom Bare

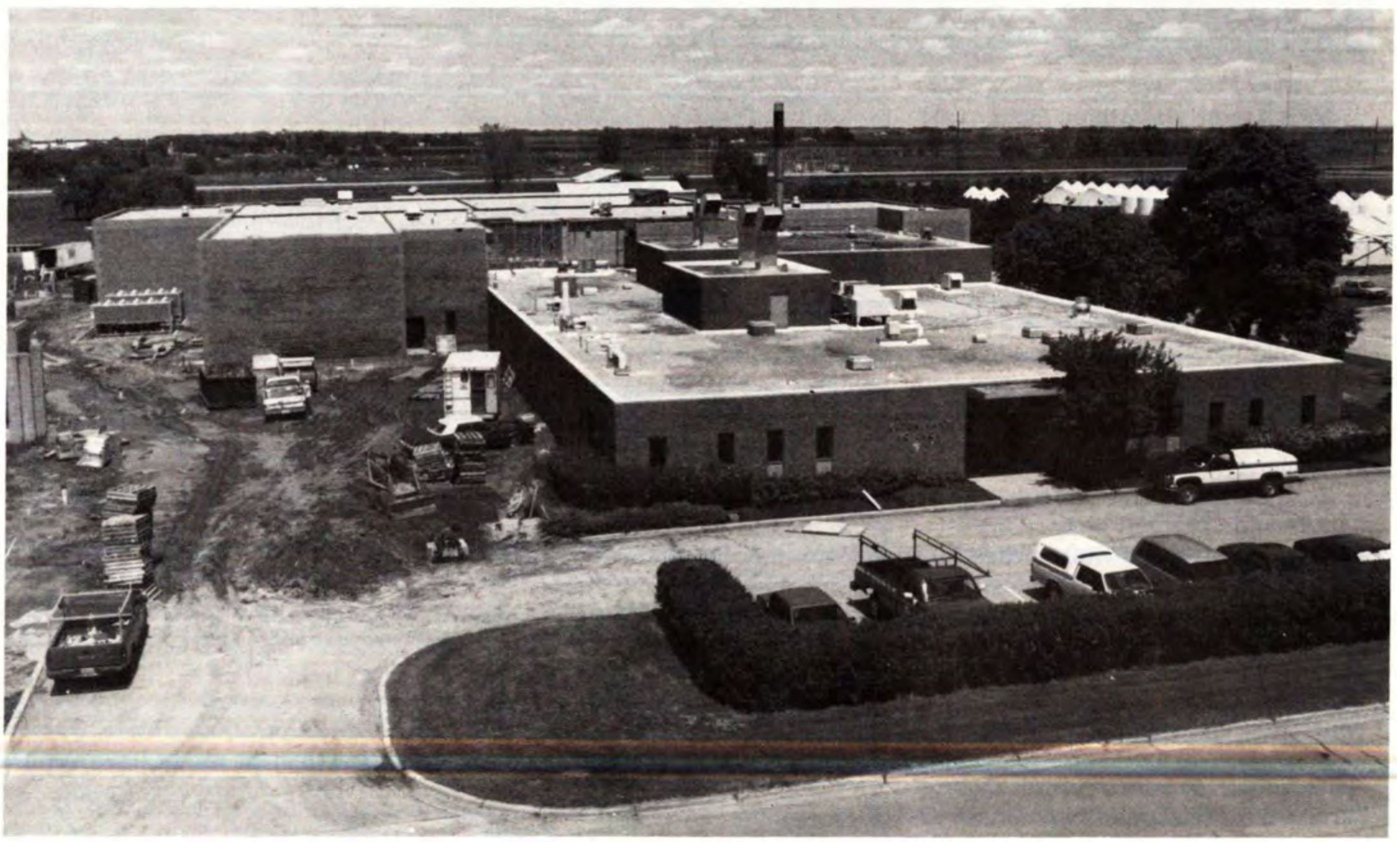
The dedication of the Northern Plains Biostress Laboratory last September signaled the beginning of building projects at SDSU. Three buildings currently under construction will directly benefit the Agricultural Experiment Station and the people of South Dakota.

The expansion and renovation of the Animal Disease and Diagnostic Laboratory (facing page bottom) continues on schedule. Virtually nothing but the outside walls will be spared in the remodeling. When completed in late 1995, the addition will more than double the size of the facility.

The new dairy research and training facility (right) is also on schedule to be completed this September. The new facility emphasizes labor and capital efficiency. It will add to SDSU's national reputation for having the top dairy manufacturing program, as well as an outstanding record for training students.

Also nearing completion and expected to be in use this winter is a new beef breeding research barn (below) located west of the feed unit and old poultry unit. The barn has individual pens to house 72 cows and calves and feed them individually. The old beef breeding barn next to the horse barn near the main campus will now be used to house animals used for teaching purposes. ❑





Wheat first must pass SDSU taste test before it's grown on the moon

Dr. Larry K. Tennyson

First there was orbital flight. Then came the trip to the moon, and the shuttle spaceship. Just ahead is the orbital space station.

And even farther away is the first lunar outpost, when scientists actually will make the 4-day trip to live and work on the moon for extended periods. That's the setting for research being conducted by Dr. Madeleine Rose, an assistant professor of nutrition and food science at South Dakota State University since 1990.

Rose explains that National Aeronautics and Space Administration (NASA) scientists are well on their way to developing the technology required to support a lunar colony. For example, NASA scientists are developing a process for manufacturing breathable air from lunar rocks, which they know contain oxygen.

Living on the moon also requires a "closed loop" system in which the carbon dioxide expelled in human breath is utilized by plants which, in turn, contribute both to the oxygen and food supplies of the outpost. This is what NASA terms a "bioregenerative life support system."

Growing crops on the moon opens up an entirely new area in space research. The reason is that plants simply can't be grown in the weightless conditions of orbital flight, shuttle flights, or the space station.

In the absence of gravity, plant roots simply don't know where to grow. Instead of heading into the soil or other growth medium where the nutrients are, roots are just as apt to grow toward the surface and out of the container.

The moon has gravity, however. Although it's only a sixth of the gravity we have on earth, it's enough to tell plant roots what direction to grow.

One of the crops scientists intend to grow on the moon is wheat, and this decision has provided Rose with a research problem: how much rancidity can humans tolerate in the bread they eat?

Rose explained that dry wheat left in the kernel stage and kept in a proper environment lasts nearly indefinitely. She says kernels of grain found in Egyptian tombs that were thousands of years old were still viable.

However, once wheat kernels are ground into wheat flour for baking, their "shelf life" is dramatically shortened—that is, unless the wheat germ is removed, or unless the product is dried or frozen.

Flour you find on your grocery store shelves contains very little wheat germ. The reason for its removal is that wheat germ contains fat, and fat increases the wheat's susceptibility to rancidity after a short time.

One of the problems in hauling an entire set of living and working quarters to the moon is weight, obviously. This means that hauling the heavy milling equipment necessary to separate the wheat germ from the flour is out of the question.

Another problem is that flour or bread which contains the germ will begin to become rancid within a few days without refrigeration or freezing. Hauling heavy, bulky refrigerators and freezers to the moon also is out of the question. And even if it weren't, scientists have to consider the power requirements, the need for freon, and the possibility of mechanical failure.

So why not use solar radiation to dry the wheat? Sun drying is the normal method of preserving wheat on Earth, after all.

Wheat normally has a moisture content of 13-20%. But without drying below 14% moisture, wheat starts to deteriorate within a few days. The trouble is, the sun's rays on the moon may be too intense, and other equipment that might be used for drying is too heavy.

And if the wheat kernels instead are ground into flour, it starts to go rancid because of the fat in the germ regardless of its moisture content.

It's a dilemma.

The bottom line is that lunar scientists might have to put up with flour and bread in various stages of rancidity.

So how much of that sour smell and taste can most humans tolerate? And how long would it take for the flour to reach that stage?

That's the research question Rose has answered.

How she approached the problem was to store wheat kernels and flour under conditions expected on the moon. Each week, she would bake bread from the flour and have it evaluated for taste and odor by a panel of volunteers.

This went on for 11 weeks. At that point, the panel was unable to tolerate the smell and taste of the bread, so the experiment was terminated.

To double check the research, Rose used two types of wheat grown under opposite conditions. She used freshly harvested Guard and Pioneer 2371 varieties. One was grown in the drier region of the state, and the other was grown in conditions of extreme amounts of precipitation in the eastern area.

Next, Rose had to duplicate the storage conditions expected on the moon. She mimicked those conditions with a relative humidity of 70% and a constant temperature of about 73 degrees.

In that environment, she kept samples of both kinds of wheat as whole kernels and also as flour.

Rose found that the flour became rancid within 9-10 days after harvest under those conditions. In whole grain form, one wheat also went rancid within 10 days, but after that, its rancidity developed much more slowly than the flour version of the same grain. The other grain stayed at borderline rancidity for about 6 weeks before crossing the threshold.

In testing for odor and taste acceptability, Rose found that the panel could tolerate the flavor of the better of the two grains for as long as 8-10 weeks. After that, acceptability ratings began to drop off rapidly.

Throughout this period, Rose kept testing the fat rancidity level of the product. She discovered that when the product reaches a rancidity score of 120, that's when the acceptability really starts to drop.

Rose says in research there are the occasional findings that really make one's eyebrows raise. There were some of these in the outcomes of her research.

One finding is that a fat rancidity level of 120 seems to be the cutoff point for acceptable flavor and odor.

This is six times the figure that is considered to be the present indicator for unacceptable rancidity. The amount of time to reach that point may vary, but once it has been reached, that's the point where acceptability really tails off.

This finding alone casts a whole new aspect on the problem.

"Finally, good grain that is stored whole will provide totally acceptable bread for 6 weeks without any other preservation techniques," Rose concluded. ❑

Dr. Larry Tennyson is news and features writer in the Department of Agricultural Communications, SDSU.

photo: Larry Tennyson

Dr. Madeleine Rose holds a pouch of freeze-dried ice cream, similar to those taken into space by NASA astronauts. Dr. Rose's research will help determine which foods will be the most practical for scientists living and working in space for extended periods of time.

Dr. Madeleine Rose, a native of Hawaii, comes by her association with NASA and the Johnson Space Center quite naturally.

Rose started her education in the field of dietetics at the University of California, and she enlisted in the U.S. Army at the end of her junior year.

The Army then sent her to the University of Maryland for her master's degree, and to Texas Woman's University for her doctorate.

As a career Army officer, Rose helped test the types of rations that are provided our soldiers. This type of work is very similar to NASA's work in foods for our astronauts.

Upon her retirement from the military in 1990, Rose accepted a position in the Nutrition and Food Science Department of the College of Home Economics at South Dakota State University.

This is the same department where a lot of research has been done on "Meals, Ready to Eat" (MREs) for the U.S. military and also on various food preservation techniques such as freeze drying and on various types of food containers.

Meanwhile, NASA has been accumulating research data faster than it can be analyzed and written into scientific articles. To alleviate part of the crunch, NASA advertised for the help of researchers who were just beginning their careers in an academic setting such as SDSU.

Dr. Virginia Clark, then dean of the College of Home Economics, suggested that Rose apply, and she was immediately accepted.

Rose's relationship with the scientists at Johnson Space Center in Houston will continue into the foreseeable future, she says.

The practical applications of research such as she will conduct for NASA are virtually without limit, she says.

Applications of NASA research already include such everyday innovations as laser surgery to remove fatty deposits in human blood vessels. "Research is a process," she says, "and the spinoffs for use in our everyday lives will continue as long as the process does." ❑

Machines that see

Dr. Larry K. Tennyson

Dr. Dan Humburg and his associates know that machines can be taught to see. In fact, they've already done it.

"Seeing" machines represent one of the newest, most exciting, and potentially most beneficial areas of agricultural research to surface in a long while. "It's an infant technology, but it is exploding fast," says Humburg, an assistant professor of Agricultural Engineering at South Dakota State University since 1991.

Seeing machines? Probably the most common example of machine vision is the optical scanning device that totals your purchases at the local chain store. That flat, red laser beam not only records your purchases; it tells the printer the names of the items you purchased. It also keeps track of how many widgets and doo-dads the store has sold, how many are left in stock, and how many new ones to order.

And this is one of the simpler applications of machine vision, believe it or not.

You're probably also aware of other applications. The "smart" bombs of Desert Storm were machines that saw. There's now a "smart" spray boom

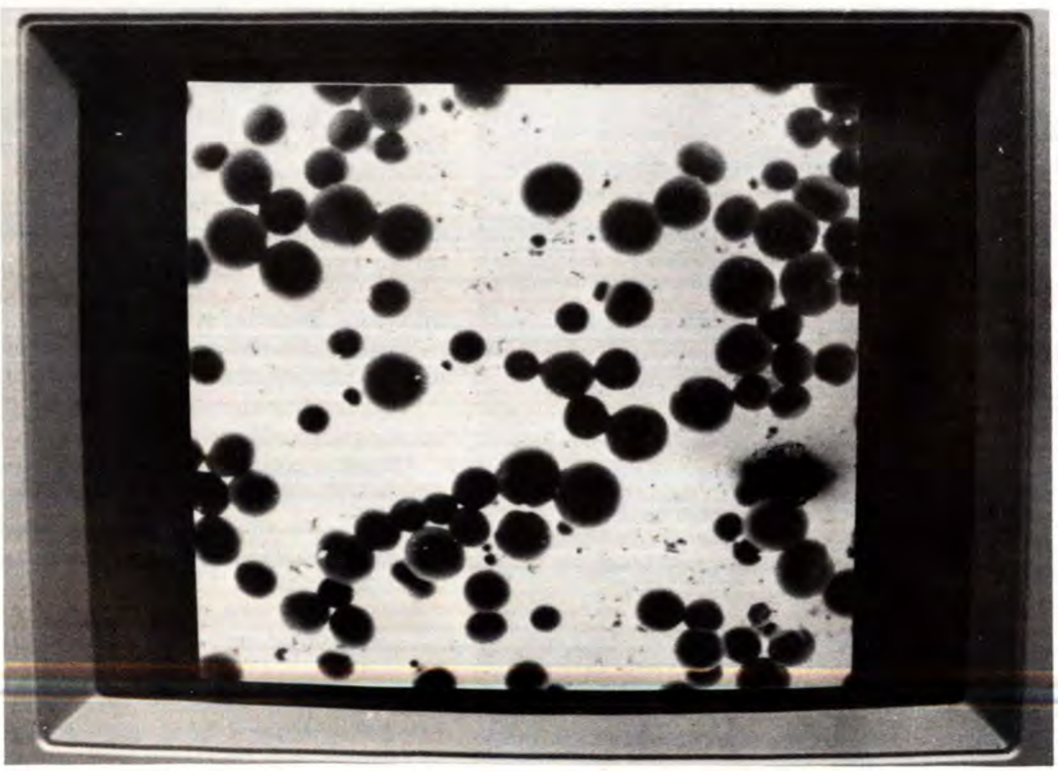


photo:s Larry Tennyson

Left, gray-level images of live plants are subjected to computer analysis which will help determine the optimum time for harvest. A miniaturized CCD black-and-white television camera (above) is used to measure 256 shades of gray.

photo: Larry Tennyson

Yueming "Victor" Li (right) explains a machine vision process to Kevin Impecoven (center), a graduate student in computer science. Li, a PhD candidate at Louisiana State, is here to finish a master's degree in computer science, and he is spending time in the lab to help clarify some of the algorithms he earlier developed for the project. Dr. Dan Humburg (left) believes that the technology currently under development will eventually be used for hundreds of agricultural tasks.

capable of applying herbicide to weeds while shutting off spray nozzles in areas where weeds are not present. Machine vision already is being used to determine the exact stage for harvesting a bacterium being raised for the purpose of destroying certain kinds of insect pests. Machine vision already enables an area potato processor to automatically sort out blemished french fries from the conveyor line.

And just consider what other applications lie ahead: Machine vision could enable the rancher to determine the exact grade of a beef animal without having to dress it out.

Machine vision can be used to determine the exact stage of maturity of a crop. It also can enable machine harvesting of crops that now can be picked only by hand.

Machine vision works by image processing in a computer. Image processing often means enhancing a picture for human viewing. Machine vision also can mean digitizing a picture for the exclusive use of a computer.

A black and white video camera sees a picture in dots. Each dot is one of 256 shades of gray. Black is 0, and white is 255. A computer can analyze what the camera sees and assign the proper number from the gray scale to each dot. This "picture" is just a big list of numbers, not the kind of picture that we'd recognize with the naked eye.

The outline or shape of a one-color object seen against a contrasting background has gray-scale numbers that the computer recognizes as representing that object.

The computer then can be programmed to tell the operator the exact size of the object, whether it is leaning one way or another, how big around it is, and other kinds of measurement.

But pictures are flat and only have one dimension. How is it that the computer can give three dimensional information like that?

One way this is made possible is by projecting sheets of flat-shaped laser light onto the object. When the flat sheet of light hits a curved part of the object, it also shows up as being curved. The machine sees this distortion in the light that it knows is ordinarily flat.

The process is a bit like triangulation, in which the location of an object is determined in three-dimensional space by the use of radio waves, line of sight, or other sensing techniques. In this case, three planes of laser light provide the necessary constraints to enable the sensing of three-dimensional locations by the machine vision system. The difference is that the search is not just for the "location" of the object, but rather for the "location" of its outline or shape in a known space.

So, that's basically how a machine sees the height, shape, and thickness of an object.

And why is it important for machines to see color too? Building a machine that knows what to do in response to seeing a certain color is certainly a more complicated aspect of this technology.

The usual way is to have the machine take three "pictures" of each dot in the image. As you know, all colors in the spectrum are derived from the three primary colors of light—green, blue, and red. Just about every color in the image seen by the machine contains some combination of these colors. So, by comparing which one of the 256 shades of each primary color are represented in each dot, the machine can recognize just about any color that exists.

Humburg recently acquired a new type of circuit board for one of his computers that measures hue, intensity, and saturation of color. Hue indicates which color the object is. Saturation indicates the richness of the color—that is, whether it is pale or rich. Intensity indicates how light or how dark the color is similar to the gray level of a black and white image.

But what's the point? Consider this: You could tell your machine to identify every apple that is a certain shade of red, or every square meter of wheat that is a certain shade of gold, or every steak that contains more or less of a certain shade of red.

Humburg cites sweet corn as one example for applying this part of the technology. An entire field of sweet corn is picked at one time. When a truckload comes to a canner like Green Giant, a sample is taken and the load is processed for a particular use based on its grade. Older, more mature corn goes to cream-style. Younger, more ideal corn goes into a premium brand.

Now the grade of the corn can be determined by slight differences in its color, which ranges from a pastel yellow to almost gold as the corn matures.

Machines that can see the differences could conceivably separate the corn ear for ear, instead of by the present method which separates it truckload for truckload.

The result would be an undreamed of level of optimizing the value of that field of corn.

Applications like these are not possible until the hard work of research is done, Humburg said.

Humburg has been working in research for most of his career. After earning a degree in agriculture from the University of Wisconsin at River Falls, Humburg, a farm boy from Blue Earth, Minn, came to SDSU for his master's degree in agricultural engineering.

His master's research involved testing an automatically guided electric field vehicle. During a later conversation with a friend from Green Giant, Humburg was told that if he were to develop a robot that could pick asparagus, he'd really have something. Asparagus is a hand-picked crop, and this makes it a tremendously expensive vegetable. Humburg discussed the challenge with others in the SDSU Agricultural Engineering Department, and they helped him narrow his search down to a relatively new field called "digital image processing," later to be known as "machine vision."

It was then that Humburg left to pursue his doctorate at the University of Illinois. His doctoral research was in building a machine that could see which asparagus spears were ready to pick, exactly where they were located, and whether they were leaning one way or another.

"My purpose was just to demonstrate a technique that later could lead to the construction of a harvesting machine," he explained. His work succeeded to the point where spears ready for harvest could be identified with 95% accuracy.

photo: Duane Hanson

"Machines that see" are already all around us. We encounter them every time we visit the grocery store. These optical scanners are only a simple use of the available technology, and represent only the tip of the iceberg of the possibilities of machine vision. Each advance opens up hundreds of new uses and multiplies potential benefits for both producers and consumers.

Humburg then accepted an appointment on the faculty of the SDSU Agricultural Engineering Department. Asparagus is not a commercial crop here so he concentrated on adapting his research to build a machine that could see when other crops were ready to harvest. Humburg emphasizes that the purpose of the research is not teaching a machine how and when to pick crops.The seeing machines that result will be able to do hundreds of other tasks besides. ❑

The writer is Dr. Larry Tennyson of the Department of Agricultural Communications, SDSU.

photo: Duane Hanson

Wake-up call for South Dakota communities

Mary Brashier

"We're great at pulling together when there's a flood, a fire, or drought," says Jim Satterlee, head of South Dakota State University's Department of Rural Sociology. "It's now time to unite and pull together to shape our future. This time the threat isn't a natural disaster. It's outmigration of our people."

Although the time left to many rural commmunities is growing short, Satterlee is optimistic.

"I do expect this to happen. Our small towns have an amazing array of dedicated and concerned leaders, They know that if they don't work together, they go down together."

He points out that one solution to high out-migration of young adults and the decline in the number of family farms is found in increased off-farm employment. This would subsidize farm income, in many cases making the difference between surviving and selling out—and moving out. It would allow many young families to return to the farm when sources of off-farm employment become available.

"I make the point that if we want business or industry that's already in place to expand, or if we want to entice industry in, we have to show a sense of community vitality in rural South Dakota. Vitality shows in adequate health and medical facilities, public safety, efficiencies in government, good education, and cultural amenities."

To stress the need, Satterlee documents rural decline.

- Hyde County lost 72 percent of its 20 to 24-year-olds in the 1980s.
- The state lost 52,000 residents to other states in the same period.
- Of that 52,000, nearly 40,000 were in the 18 to 40 age group. If Rapid City and Sioux Falls had not contributed their holding power, the state would have lost 63,400 people, 12.4 percent of all South Dakotans, or one in eight people.
- Only 66 of the total 316 incorporated communities in South Dakota experienced any increase in population; those increases were minor.

Satterlee presents these facts, collected by the SDSU Census Data Center in his department, to gatherings of local leaders around the state. Then he offers a plan to stop the decline of rural South Dakota, describing a "new community."

It is like no community his listeners have ever seen.

He starts with the familiar, suggesting to development groups they

photo: Duane Hanson

Statistics packed in the shelves and computers of the Rural Sociology Department tell Jim Satterlee that many small towns are in trouble, unable to afford the full gamut of services necessary for their citizens. Satterlee suggests re-drawing community boundaries, committing loyalties to an affiliated cluster of counties rather than to a home town, and consolidating, re-directing, and re-scaling services to benefit a larger "neighborhood" and assure a brighter future for South Dakotans.

think of a community the size of Sioux Falls.

Its neighborhoods are distinct, usually defined by elementary schools, churches, or small shopping centers. But while the neighborhood may be "home," Sioux Falls citizens do not expect to find everything they need within it.

"They leave the neighborhood to go to work. They leave to go to senior high, the courthouse, the ball diamonds, and big shopping malls. They expect to fight some traffic and experience some hassles in getting around; and they don't expect all their services to be in their own neighborhood."

Rural South Dakota residents also know all too well that miles can separate them from all the services they need.

"At least the traffic is a little lighter," Satterlee quips.

In the model he offers, the "community" is a grouping of counties. The individual counties themselves are the "neighborhoods."

Satterlee tells his audiences that the new community involves "throwing in with nearby towns and counties. Consolidating some services. Re-directing others. Scaling up in some areas; scaling down in others. You must change your sense of commitment, build a loyalty to a cluster of counties instead of to only your home town.

"Any suspicion that somebody will get the better of you must be overcome. That's where many small towns are today: suspicious and resentful of their neighbors. We've got to put that aside."

Satterlee sticks to county boundaries in his six-county example of a new community.

"It's easier than using a trade area," he says. "In a sense, county commissioners hold the purse strings when it comes to funding the various programs, offices, and agencies."

He thinks that one centralized "community government center" housing the consolidated county, state, and federal program offices and a central law enforcement facility would provide equal if not better services at less cost per capita.

Instead of six county treasurers or six county auditors, there would be one of each, with a person from all these offices out in public service centers in each neighborhood at least one day a week, much like the driver licensing people are now.

Each neighborhood would have at least one full-time sheriff's deputy and probably unaltered fire departments.

"When I have talked to groups around the state, their greatest concern has been for fire safety. The volunteers and their fire trucks would probably stay right where they are now."

In his model community, the distance from any outside corner of the county cluster to the community government center is no greater than 40 miles.

"Do we need our local government any closer?" he asks.

"If you absolutely must transfer that car title today you can drive to the government center. But if you can wait until Tuesday, you can take care of it locally in your neighborhood public service center," he says.

Major medical and retirement facilities would be centrally located in the "new community," with paramedics and nurse practitioners housed in outlying neighborhoods.

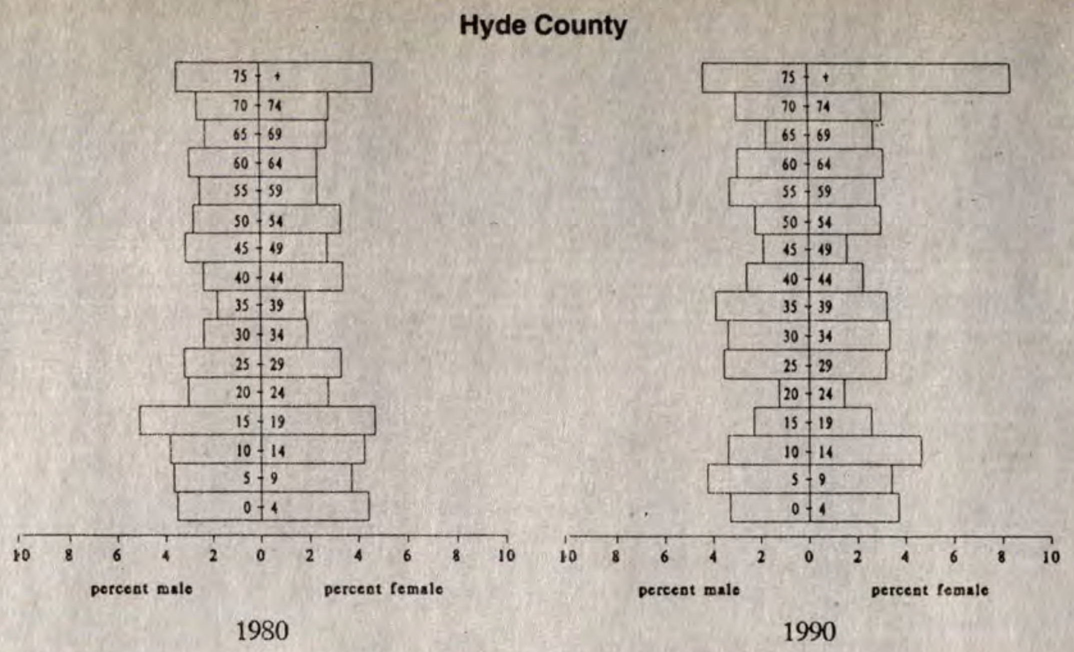
"The community could work out a deal in which doctors or specialists made calls at neighborhood 'first-response' centers on a regular basis," Satterlee said. "That's up to them. This concept is worked out locally by the people involved."

Elementary schools would be dispersed throughout the county neighborhoods, with one or more fairly central high schools. Bus routes would probably take no more than 45 minutes.

"Shorter than some routes are now," Satterlee says.

But rivalry between schools may slow down community development.

"There's a belief in rural South Dakota that if a town lets its high school go, it starts the slide down," Satterlee says. "Couple that with the popular sentiment on Main Street, 'Anybody who wallops our football



During the 1980s, Hyde County lost 72 percent of its 20 to 24-year-olds (right). During the same period, South Dakota lost 52,000 residents to other states. For people to stay, employment opportunities must be available. To entice new industry or convince current industry and businesses to expand, community vitality must be evident in rural South Dakota. This means adequate health and medical facilities, public safety, efficient government services, and good educational and cultural opportunities must be in place.

team on Friday night better not expect us to cooperate with them at a Monday morning development meeting."

Turn that argument around, urges Satterlee: "Say instead, 'If we combine into one school, with all that extra talent we just might win state finals.'"

Satterlee believes that agribusinesses are ready to commit to a "new community."

"They all say the same thing, that they can't afford to keep a dealership in every county. But if the producers in the neighborhoods make a commitment to support a central dealership, they will put local service centers in the neighborhoods.

"Those satellite centers might not have on hand the exact combine part the producer needs, but they would guarantee it will be there within a half day from the central dealership."

The model is flexible. It is meant to be adapted by local leaders. For example:

"The central government and central hospital can be anywhere, and not necessarily together," Satterlee says. They probably will indeed be 'central,' but that's the community's choice.

"In the neighborhoods, not everything needs to be in the old county seat. The more spread out the services are, the better the chances that more towns will survive."

He doesn't force his model on rural development groups, but he does cite the benefits of cooperation.

In the Aberdeen area, county governments have bought road equipment together, getting better prices. School districts cooperate to buy supplies in bulk. Special ed teachers work across district boundaries.

Satterlee's primary role, sponsored jointly by the Agricultural Experiment Station and the Cooperative Extension Service, is to impress upon rural development groups the magnitude of the population reshuffle. Neither he nor SDSU has any vested interest in which counties cluster or where the central government offices will be.

"But I do have to describe the situation as realistically as I can," Satterlee adds.

"Solid waste disposal is mandated, number of nursing home beds is mandated, minimum size of schools is mandated. And more rules and regulations are coming. But there is still a small window of opportunity for us to take charge and participate in our own destiny."

"It's up to the people themselves. If we want business and industry to come in or to expand, we have to show that sense of vitality that indicates we are alive and willing to fight for a future. That vitality will become apparent to industries, both big and small, when they see a sound infrastructure—high-quality schools, medical services, responsive government.

"That infrastructure can't be provided by the system we have in place now. Rural towns don't have the money, the political clout, the population base to attract industry if they continue to 'go it alone.'"

"Sit down together," he tells South Dakotans. "Be honest with yourselves and with your neighbors, and talk through your mutual problems. You can find some answers.

"Many communities can and will benefit through consolidation. Surely that's better than doing nothing to curb the continued loss of our brightest and most productive people." ❑

Dr. Jim Satterlee is director of the SDSU Census Data Center, supported by the Agricultural Experiment Station and Cooperative Extension Service at SDSU. For information about your community, call (605) 688-4132. Mary Brashier is Agricultural Experiment Station publications editor.

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Calendar of Events

Date	Event	Person to Contact
August		
10	CRP Demonstration Plot Tour, Rapid City	Clair Stymiest, Agronomist, Rapid City
19	McCrory Gardens Garden Party, Brookings	C.W. Johnson, Horticulture/Forestry, SDSU
27-Sept. 4	South Dakota State Fair, Huron	Mary E. Aamot, 4-H, SDSU
September		
8	Northeast Research Station, Fall Tour, N of Watertown	Jim Smolik, Plant Science, SDSU
12-15	CRM (Coordinated Resource Management) Training, Brookings, Mitchell	Jim Johnson, Range Specialist, Rapid City
14	SESD Research Farm Fall Tour, Beresford	Bob Berg, Farm Manager, Beresford
14	Antelope Range Field Day, Buffalo	Don Marshall, Animal and Range Sciences, SDSU
15	Cottonwood Field Day, Philip	Dick Pruitt, Animal and Range Sciences, SDSU
22	Eminent Farmer & Homemaker Event	Lloyd Hansen, Ag Hall, SDSU
24	Beef Bowl, SDSU	Dan Gee, Animal and Range Sciences, SDSU
29	Dakota Lakes Fall Field Day	Dwayne Beck, Plant Science, SDSU
October		
2-8	National 4-H Week	Rich Howard, 4-H, SDSU
27-31	Western 4-H Round Up, Denver	
28-29	S.D. Sheep Growers Annual Meeting, Huron	Jeff Held, Animal and Range Sciences, SDSU