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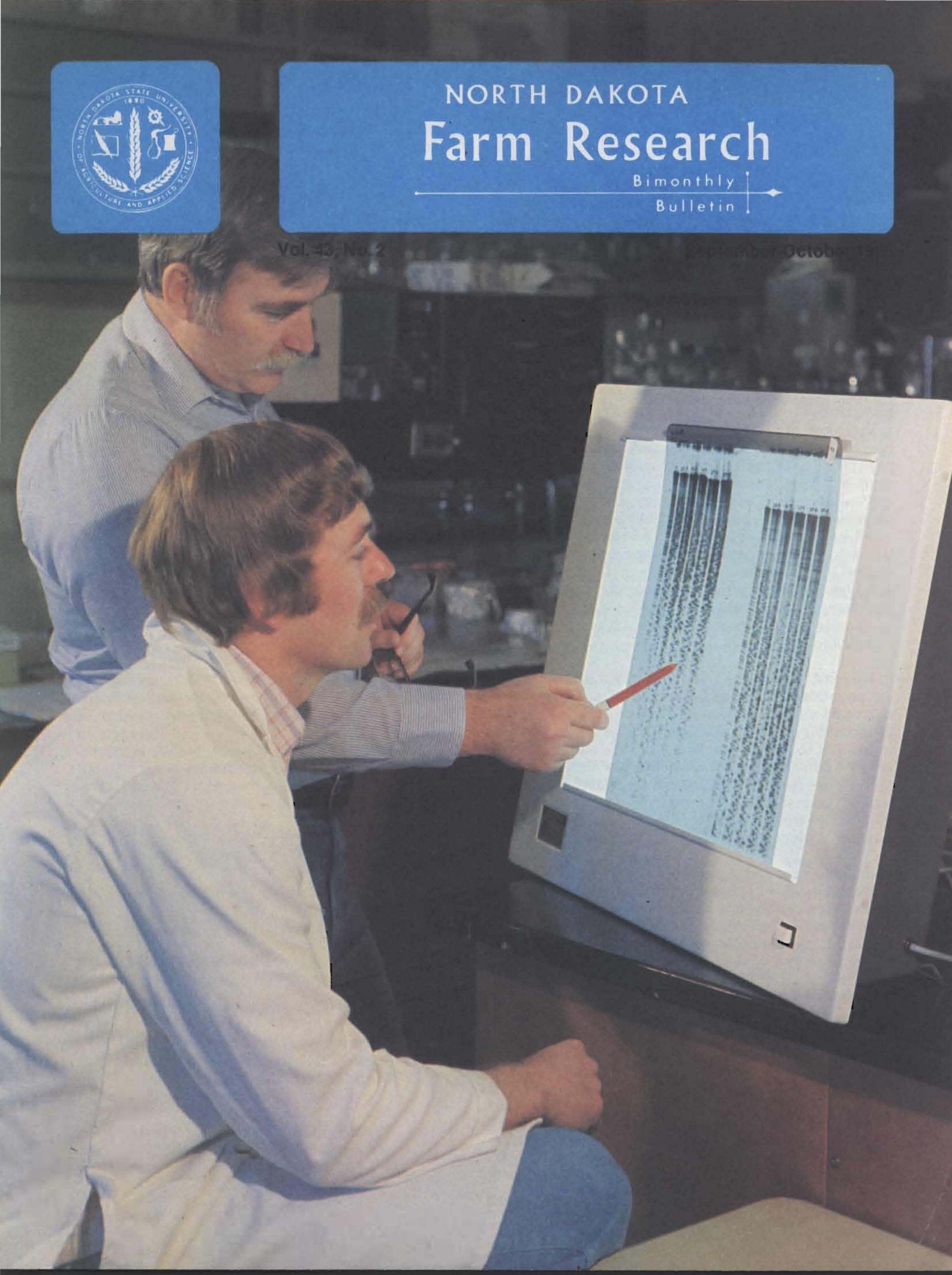

Guest Column

H.J. Klosterman
Chairman, Biochemistry

About a decade ago the scientific world was electrified with the announcement that bacteria had been genetically engineered to produce human insulin in a broth culture, enabling the production of seemingly unlimited supplies of human-type insulin for the treatment of diabetes. With this achievement came the realization that it might now be possible to alter the basic genetic makeup of all types of organisms through the processes of "genetic engineering"—the transfer of a desireable gene from one species to another. In the case noted above, the gene for the production of human insulin was isolated from human pancreas cells and transferred into a bacterium which used this new genetic material to produce human insulin. A variety of new techniques have been developed to accomplish gene transfers and incorporate these genes into useful organisms. These new techniques are collectively known as the "newer biotechnologies" or simply "biotechnology."

We recognize genes by the biochemical substances that are produced in all living tissues and cells. The processes that come together to produce a cell or organism seem to be incredibly complex. It is the challenge of biochemistry to identify the various molecules in cells and tissues and describe how they are produced and how they interact to produce an organism. Altogether an organism may contain tens of thousands of different types of molecules that range in size from a grouping of as few as five or ten atoms to many millions of atoms.

Ultimately the production of each type of molecule in a cell is the result of the expression of many or even hundreds of genes found in the chromosomes in each cell. With the realization that genes can be isolated selectively and transferred into foreign cells, almost at will, it has become conceivable that organisms can be changed and made more useful by taking a desirable gene from an organism of species "A" and adding that gene to the chromosomes of an organism from species "B" in order to give B some unique properties borrowed from A.

Genes have been manipulated for many years by plant, animal and microbial geneticists to improve yield, disease resistance, growth rate or crop quality. Generally this has involved use of hybridization or cross-fertilization between closely related species or breeds, or varieties within a single species. The general concept in these experiments is to start with promising traits and try to find offspring that show

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In This Issue

On the Cover: Biotechnology researchers Arland Oleson and Brad Mogen examine audioradiograms from DNA sequencing determinations. In this issue Harold Klosterman, chairman of biochemistry, discusses biotechnology as a new tool for agricultural research. Photo by Kent Mattson.

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the best combination of desirable traits. However, when the cross-fertilization is attempted between more distantly related species, the experiment is generally unsuccessful. A common example is the crossing of a horse and a donkey to give a mule, which is usually sterile and cannot reproduce. To take a more extreme example, no one has ever succeeded in producing a cross between a plant and an animal. However, with the new biotechnology, it is now feasible to extract the gene from one species and transfer it to another species, perhaps between a carrot and a cabbage, or even between plants, animals and bacteria. It is now feasible to genetically engineer new organisms that show properties never before found in this particular combination. The barriers between species have been lowered! The mechanism for gene transfers now exists.

The recent scientific literature records numerous instances of gene transfers between species. Some of the more spectacular achievements to date involve transfer of genes to bacteria to produce insulin, a variety of hormones, human growth factors, vaccines, and diagnostic agents to detect diseases (including AIDS). During the past two years there have been examples of gene transfers into yeasts, higher plants and animals. With these published successes, scientists have been encouraged to design increasingly more complex experiments involving multiple gene transfers into and between higher life forms, including both plants and animals. The experimental techniques associated with these non-conventional gene transfers and manipulations are often exceedingly complex and involve the combined effort of scientists in a variety of disciplines, including geneticists to identify the gene or genes, molecular biologists and biochemists to isolate the genes and devise schemes for cloning the genes and inserting them into appropriate recipient cells; physiologists must learn how to culture the altered cells and produce whole viable organisms from that altered cell; and, finally, plant, animal or microbial geneticists must incorporate that new genetically altered organism into the breeding program to produce useful economic crops or animals with improved characteristics. Most experiments will fail, but a few will succeed and produce beneficial results.

It is still too soon to reliably estimate the overall impact of genetic engineering and the use of the newer biotechnologies on agriculture and society. Many of the products of biotechnology are already in the market place and are being taken for granted, such as new vaccines, growth hormones and improved fermentation processes. On the horizon in the developmental stage are such things as resistance by plants to specific herbicides; rapid and efficient propagation of horticultural plants; resistance to drought and saline soils in plants; resistance to the corn root worm; nitrogen fixation by non-legumes; invitro fertilization to improve reproduction in farm animals; whole animals from embryo culture; and increased milk production by use of genetically engineered growth hormones. In addition to these more practical examples, these biotechnologies are opening the door to a better understanding of the molecular aspects of the basic biological processes involved in cell growth and reproduction. Very significant discoveries have already been made as to the molecular nature of the complex processes of photosynthesis and nitrogen fixation in plants. In the area of human health, information is being obtained about the exact molecular basis of how a healthy cell becomes transformed into a tumor-producing cell. With this information, the cure and prevention of a variety of cancers will become possible.

The agricultural experiment stations and the United States Department of Agriculture have taken strong supportive positions regarding the application of biotechnology to the improvement of agriculture. At NDSU, a Genetic Engineering Study Group was established in 1982 to coordinate research in the use of the newer biotechnologies. Faculty scientists, research assistants and graduate students are working in the life science departments, including animal science, biochemistry, agronomy, bacteriology, botany, horticulture, plant pathology and veterinary science. The extent of this activity grows as retired faculty are replaced by new faculty trained in the newer biotechnologies. The investigations range from the isolation and cloning of genes to improved animal reproduction, rapid propagation of plants, and the development of disease and stress resistant crops. These studies complement the longstanding breeding programs based on conventional gene transfer techniques and will make available new sources of genetic variations for use in the breeding programs.

We are also concerned about our teaching mission. Graduate students working for their master's and doctorate degrees in several of the life sciences are learning to utilize the new biotechnologies in their research programs with plants, animals, bacteria and insects. In addition the College of Agriculture and the College of Science and Mathematics have combined their extensive strength in the biological sciences to offer an undergraduate training program leading to a major in biotechnology. New courses have been developed in the areas of molecular biology, use of recombinant DNA, gene isolation and structure, plant and animal cell and tissue culture, and a unique course in the isolation of products produced by genetically engineered organisms using new industrial biochemical approaches.

It is still too early to predict where all of this will lead and the impact that the new biotechnologies will have on agriculture. The joining together of capable scientists and teachers in the life sciences at NDSU with their colleagues in universities and research institutes around the world is almost certain to have a major impact on agricultural research for decades and provide new options for agriculture for the future.

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