Microbiology at NDSU — A Look Into the Next Century

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Whenever we speculate about the future outlook of a scientific discipline it is often necessary to glance over our shoulders and remind ourselves where we have been.

Unlike other disciplines in agriculture which have been referenced since written history began, microbiology is a relatively new science. The discipline of microbiology is generally thought to have been established in the late 1800's with the work of Robert Koch and Louis Pasteur. The research discoveries that have come from scientists studying in this field have been so important that since 1910, about a third of the Nobel Prizes in biology have been awarded to microbiologists.

Microbiology covers a wide spectrum of specialized interest areas that show how microbes affect human, plant and animal health, our environment, food technology and the biotechnology industry. In recent years, the field of microbiology has had a major impact upon virtually all other scientific disciplines. Microbiology's importance to these other disciplines was best stated by Dr. Selman A. Waksman in 1942. Dr. Waksman, a microbiologist who won the Nobel Prize for discovering the antibiotic streptomycin, observed that:

> "There is no field of human endeavor, whether it be in industry or agriculture, or in the preparation of food or in connection with the problems of shelter or clothing, or in the conservation of human and animal health and the combating of disease, where the microbe does not play an important and often dominant role."

It is NDSU's distinction to have had a department of microbiology that has been an active participant in teaching and research for 70 years. The earliest specialized courses offered were agriculturally related; soil bacteriology and dairy bacteriology. Over the years, because of increased student needs, the department has been asked to offer an expanded variety of courses. As microbiology has become a more sophisticated science, courses have been added in physiology, immunology, virology, and microbial genetics.

Agricultural research and the training of North Dakota students has been a mission of the department since 1914. Early research dealt with such topics as wilt resistance in flax, home canning safety, poultry diseases and nitrogen fixation. More recently the department has conducted research in several diverse fields such as the microbiology of stripmining reclamation, genetics of symbiotic nitrogen-fixing bacteria, survival of pathogenic bacteria in pasta products, diagnostic methods and vaccine development for animal diseases, microbiology of soil under conservation tillage, and the physiology of rumen bacteria.

During the past 70 years, the Department of Microbiology at NDSU has grown from one faculty member to a high of eight in the late seventies. Currently the Department has five research faculty with 12-month appointments and one teaching faculty with a nine-month appointment.

The department has moved enthusiastically into the new biotechnological era that is upon us. Traditionally, microbiology departments have assumed lead roles in such movements. The ideas for the future that are outlined in the following paragraphs will emphasize this leadership role. Some of the ideas will only require reorganization of our existing human and physical resources. However, other ideas and directions that need to be pursued will required enhanced support from federal, state and private sources to fund additional personnel, supplies and equipment.

I would like to interject a word of caution. As the technology for solving problems in microbiology becomes more sophisticated, the problems we recognize and choose to attack become more complex. Problems that were perceived as technologically difficult 25 years ago are now relatively simple to study. For example, no one was doing gene sequencing and genetic engineering in 1960. Today students can perform these procedures. Likewise the problems we view with frustration today, such as gene regulation, will hopefully be well understood by 2010. This is the nature of scientific progress. Thus we can understandably say that the problems we are investigating today are complex problems and that simple solutions are not immediately apparent. However, the rewards obtained following breakthroughs will be immeasurable.

The Department of Microbiology has three research scientists who are working with soil microorganisms. The general areas of research include *Rhizobium* genetics, ecology of strip-mined land and mycorrhizal fungi, and tillage systems. Although all of these projects are concerned with answering basic science questions, they have direct application to production agriculture. The hope is that research projects will improve production efficiency and therefore increase farm profitability in several ways.

All of us know that for years we have dreamed about improved nitrogen fixation by *Rhizobium* or adapting the microorganism to infect and fix nitrogen in non-leguminous plants. These dreams haven't changed. We still anticipate tremendous decreases in cost of production resulting from this research. However, we now know the problem is more complex than first imagined. In the next 20 years we will see the development of genetically engineered rhizobia and, at some later time, genetically engineered plants containing bacterial nitrogen-fixing genes.

We are also conducting research on how mycorrhizal fungi help improve nutrient uptake and conversion by plants. Once again the hope is that improved efficiency in nutrient conversion by plants will result in showing us how production costs can be lowered. The basic questions that must be answered first, however, are: How do these organisms compete in their environment? How well do they survive following crop rotation? What factors do different tillage systems bring into effect? How can we grow these organisms in pure culture systems?

The advent of conservation tillage systems has led to many questions related to productivity. To help answer some of these questions, we are conducting research to evaluate the effects of tillage systems on soil microorganisms and their biogeochemical cycling of soil nutrients. We are trying to find out what changes occur in the soil ecosystem as a result of tillage system and how these changes affect the ecological balance of microorganisms responsible for soil productivity.

Soil microorganisms play fundamental roles in all terrestrial ecosystems. As farming and ranching methods continue to become more sophisticated through the use of chemicals and feed additives, more attention needs to be focused on how microorganisms can process these new "ingredients." The soil organisms have had thousands of years to "learn" how to safely and efficiently use natural fertilizers (e.g., manure, composts, etc.). Today chemists regularly develop new varieties of pesticides, fungicides, herbicides, etc. to help us farm more efficiently. However, it takes years to understand how soil microorganisms can degrade these compounds to chemical forms that are nontoxic to other living systems. It also takes considerable research to insure that the microbes remain ecologically balanced in nature when these chemicals are added in bulk to their environment.

Although we are learning how to genetically manipulate various bacteria and fungi for these tasks, the problems of testing their safety and survival capacity in our complex agricultural ecosystems are only beginning to be examined. As we look ahead one can predict the development of "safe" organisms that can be used to inoculate land in order to detoxify man-made chemicals as part of our chemical use strategy.

The Department of Microbiology has one faculty member who is studying the physiology of intestinal microorganisms. Studies of this nature are extremely important in understanding biotransformation processes. When animals eat foods, especially ones that have additives present, the digestive process creates many new breakdown products that are then exposed to intestinal microorganisms. The intestinal microbes then metabolize these breakdown products (biotransformation process) and create new end products. These end products may be useful to the animal, e.g., vitamins or peptides, or harmful in the case of toxic or carcinogenic compounds that may debilitate to the host. Detailed understanding of these processes will facilitate animal nutrition by being able to predict which additives will be harmful and which will promote efficient feed conversion. Furthermore, it should be noted that chemically similar biotransformations are carried out by many soil microorganisms that are responsible for metabolizing the man-made compounds described above. This provides an excellent example of how information in one area of microbiology can be applied in often apparently dissimiliar areas.

Microbiology technician Carolyn Maier measures enzyme kinetics on a spectrophotometer, studying microbial metabolism and how microbes change food.

Our department along with the Department of Veterinary Science also has a group of scientists studying animal disease problems. Research interests within this group focus in two general areas: the immune response of the animal to disease (how the animal's body defends itself), and the nature of viral infections in terms of both host and parasite interaction. Current projects involve the use of subunits from microbes (small parts from the original organism) to make safer and less toxic vaccines. Experiments are also being done to examine the use of natural compounds, called immunomodulators, which stimulate the body's immune response against disease. We are also looking at the molecular biology of viral diseases to find clues for stopping infections or to design effective vaccines. The application of these discoveries will enable companies to manufacture safer and more effective vaccines as well as to define more cost-efficient means of administering these products. The net result will be decreased expense for animal health care.

The microbiology department of the future at NDSU will need to focus its efforts into a limited number of general

Continued on page 18

The department must strive to expand its research in biological control. A major multidisciplinary effort directed to the biological control of leafy spurge will continue. Controlled releases of several exotic insect species continue to suggest that some of these species can adapt to the environment of this region and successfully feed and reproduce on the leafy spurge host. Confined releases have recently been expanded from research sites in east-central North Dakota to western North Dakota. Continued success with the insect complex under these varied conditions will hopefully permit larger releases of some of these species. As pathogens are identified that are also deleterious to leafy spurge, the role of the insect in transmission of some of them will be undertaken.

Environmental and economic considerations associated with pesticide use and the potential development of resistance by insects to currently used insecticides are critical concerns. A research effort to achieve methods of biological suppression of grasshoppers has been and will continue to be a major thrust in the department. Our current work is focused on a fungal pathogen, *Entomophaga grylli*. While the more common pathotypes of *E. grylli* can now be successfully cultured and will attack selected species of our grasshopper complex, the moisture (humidity) requirements needed to trigger epiphytotics of the disease in grasshopper populations preclude effective use of these pathotypes in arid areas such as western North Dakota. Current and future research on an acquired Australian pathotype, with adaptation to more arid areas, may ultimately permit its introduction into areas where our incipient grasshopper problems exist.

Research directed to the ectoparasitic flies which attack livestock has focused on both biting and non-biting fly complexes. These studies have concentrated on the behavior, ecology, physiology and management of these species. Recent evidence of fly resistance to chemicals used in cattle eartags, which have been widely used for control of this complex, suggests the management is assuming greater complexity and will likely require other approaches to lessen the dependency on the chemical-impregnated eartag.

Similarly the department's recent research thrust to better understand the North Dakota mosquito complex, their behavior, ecology and disease transmission, is aimed at better definitions of the ecological parameters which regulate incipient populations. These studies, which involve interactions with established mosquito abatement districts as well as other state and federal agencies, will be expanded in the forthcoming years.

The decade ahead for we in entomology will be more challenging than ever as we attempt to understand, manage and live with those insect species that are considered deleterious to our food, fiber and quality of life. Management of noxious species must embrace economic efficiency yet be consistent with a need to preserve our environment as a natural resource and the beneficial biota which coexist with our pest species. The department's basic and applied research activities on many fronts recognize those needs and are addressing them. We will continue to do so through development and utilization of new technology in concert with proven methods.

Continued from page 14

areas of interest to North Dakota because costs continue to rise and funding increases are not easily obtained. The key to future success in solving problems will be to integrate research activities with other departments to attack problems through team efforts. Integrated projects are expected to develop with plant science departments as we begin to unravel the pathogenic mechanisms of plant disease and continue to explore ecological questions. Biological control of plant pests using "safe" microorganisms will become increasingly more important as fossil fuel reserves continue to decline and agri-chemicals continue to increase in cost.

Integrated research with food processing departments will be enhanced as we begin to explore new uses for traditional agricultural products. Microbes are critical sources of enzymes and food additives necessary to the food and beverage industry. Genetic engineering has the capability to produce a variety of organisms with improved production efficiency.

A third area of emphasis will be in the area of animal sciences in terms of both health care and animal nutrition. Research in this area will focus on finding ways microbiologists can improve livestock operation efficiency and thereby decrease production costs.

To help keep NDSU on an aggressive and progressive path during the era of applied biotechnology, the Department of Microbiology must see two things happen. First, our research must have avenues to efficiently move from laboratory test facilities into test production facilities. This will happen by developing linkages with other departments at NDSU that have greater production orientation as well as nurturing biotechnology industry contacts to evaluate the production potentials of basic research discoveries. Second, there must be continued commitment from local, state and federal agencies to support the "high tech" basic research of a department of microbiology. Our department plans to add four faculty as resources become available to facilitate research efforts. This commitment is sometimes difficult to maintain since the rewards are often so long in coming. We are continually exploring the variety of options we have to establish partners in industry to help bring laboratory discoveries to the consumers more quickly. We also anticipate that these "business" relations have the potential to help provide future fundings for research projects. Our hope is that dedicated and visionary leadership will insure continued progress in these areas by seeing that adequate resources and unwavering commitment remain available to our department.