Recognizing the Role of Biotechnology and Biodiversity

EVER SINCE HUMANS began selective breeding to improve the quality of plants and animals, the genetic diversity of organisms has been influenced by humans. Biotechnology will further influence the change of genetics in organisms and the need to preserve genetic diversity of domestic and wild organisms.

Objectives:

1. Explain the global importance of biodiversity.
2. Describe how biotechnology tools are used to measure biodiversity in a population.
3. Explain some consequences of biotechnology on wild populations.
4. Explain how biotechnology tools can be used to monitor the effects of biotechnology on wild populations.

Key Terms:

Bacillus thuringiensis (Bt)
biodiversity
DNA extraction
gel electrophoresis
polymerase chain reaction
restriction enzymes
transgenic organism

Global Importance of Biodiversity

BIODIVERSITY

Biodiversity is the collective set of differences between all living organisms. Each living organism possesses traits or adaptations that allow it to live in its appropriate environment. Every living organism is a product of its genetic code stored in DNA, which is influenced by environmental factors. Biodiversity exists in both domesticated and wild organisms.

Though biotechnology allows us to create populations of organisms with the same genetic information, we must maintain populations of species with different genetics. The concept can be related to the saying "Don't put all your eggs in the same basket." In case something bad happens, it is important that not all organisms be put in the same "genetic" basket. Each genetic trait may be a tremendous asset for the continuation of the species or may now also be used in creating transgenic organisms. A **transgenic organism** is an organism that contains DNA inserted from another organism.

DOCUMENTING AND PRESERVING BIODIVERSITY

Researchers know that biodiversity is so important that the federal government has developed programs and facilities designed for collecting and storing millions of samples of genetic material from thousands of organisms. The Agricultural Research Service (ARS) of the United States Department of Agriculture (USDA) maintains hundreds of collections around the country, plus some collections in foreign countries. Collections include dead and living samples of plants, animals, insects, bacteria, viruses, and numerous other types of organisms.

Not only is the genetic information stored in these collections a help to us in identifying organisms, but it is also a tremendous resource in developing public policy, medical advances, and new products. It also helps protect national security. As we look to the future, we will need to produce crops in areas with less available water. Scientists will likely look to these collections to find plants that are more drought tolerant to create new drought-tolerant varieties of plants.

The specimen collections can also be used to document genetic history and protect the existence of rare domestic and wild organisms. What are some other potential uses or benefits of the Agricultural Research Service's specimen collections?

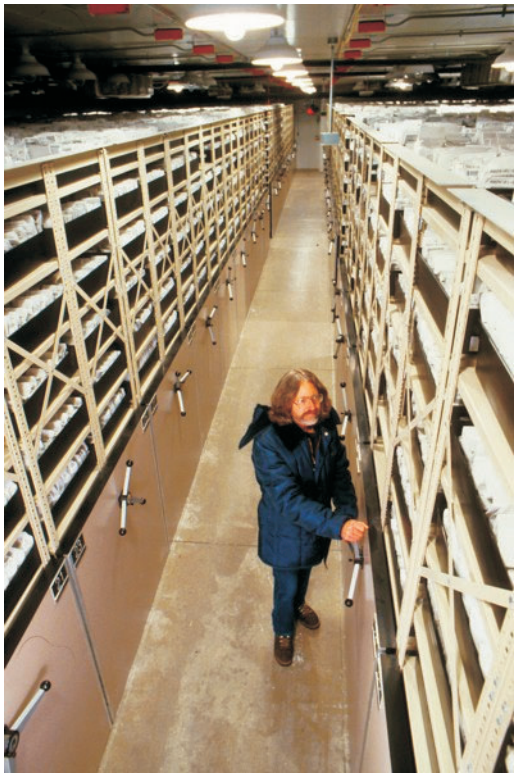

FIGURE 1. The National Seed Storage Laboratory, in Colorado, stores more than 1 million samples of plant material. (Courtesy, Agricultural Research Service, USDA)

FURTHER EXPLORATION...

ONLINE CONNECTION: Science Careers in Government

The United States Department of Agriculture (USDA) employs many people who use science as a regular part of their jobs. The Agricultural Research Service is one agency of the USDA where you can find a career that combines agriculture and science. Learn more about careers in the Agricultural Research Service by visiting the following Web site:

http://www.ars.usda.gov/Careers/Careers.htm

VALUE OF BIODIVERSITY

In production agriculture, biodiversity of our crops and animals is critical in protecting the quality and quantity of our food supply. Our environment is constantly changing, and the threats to our crops and livestock are also changing. Imagine the effect of a new, rapid-spreading disease that would decrease corn production by 50 percent. The economic impact would reach far and wide, from farmers to consumers. Genetic diversity, it is hoped, would provide some corn varieties resistant to the new threat. The genetic information stored in the resistant varieties would be critical in controlling the new threat.

The animal agriculture industry has used selective breeding practices to produce high-performing animals. These selective breeding practices have reduced genetic diversity in some breeds and even threatened the existence of some rare breeds. Artificial insemination in cattle has led to livestock bloodlines that often trace back to the same sires multiple times on the same pedigree. The duplication of sires has helped enhance the quality of traits in cattle, but it could also have a negative impact if the common genetics become susceptible to a disease. The existence of certain breeds of livestock has been threatened because of their inability to compete with other breeds in production levels. Agriculture is taking measures to preserve the existence of rare breeds. Though the rare breeds may not possess traits contributing to high production levels, they may still possess genetic traits, such as disease resistance, that will become important, or necessary, in the future of animal production.

Measuring Biodiversity in a Population

Biotechnology tools and techniques, such as DNA extraction, polymerase chain reaction, and gel electrophoresis, can all be used to identify and measure biodiversity in a population. Scientists can collect genetic information from various species and compare and contrast their genetics with those of other organisms.

DNA EXTRACTION

DNA extraction is the process of separating and removing DNA from a cell's nucleus. DNA extraction allows scientists to collect DNA samples from organisms for DNA analysis.

POLYMERASE CHAIN REACTION

Polymerase chain reaction is a process that makes copies of DNA samples. If the quantity of DNA is limited, polymerase chain reaction (PCR) can be used to amplify or increase the amount of DNA by creating copies of the original DNA. Polymerase chain reaction is a tool that allows us to create a continual supply of identical DNA.

GEL ELECTROPHORESIS

Gel electrophoresis is a technique that uses electricity to move pieces of DNA through a gel. The pieces of DNA move through the gel at different speeds based on particle size. Larger strands of DNA move slower than smaller strands. Before gel electrophoresis is performed, the DNA must be processed using restriction enzymes. **Restriction enzymes** are proteins that "cut" the DNA into desired lengths and segments at specific locations along the DNA strand. Once the DNA is processed, gel electrophoresis can be performed to separate the segments of DNA based on DNA segment size. Gel electrophoresis allows researchers to create a DNA fingerprint of an organism. The DNA fingerprint can then be compared with the DNA fingerprints of other organisms.

FIGURE 2. A dye is used to highlight the DNA segments as they pass through the gel in gel electrophoresis. (Courtesy, Agricultural Research Service, USDA)

Consequences of Biotechnology on Wild Populations

Biotechnology has sparked many debates about the positive and negative impacts it will have on the environment and wild organisms. Biotechnology can offer many benefits to wildlife, such as disease prevention and population enhancement. However, before a product of biotechnology is approved for use, certain concerns must be addressed.

BIOTECHNOLOGY AND OTHER ORGANISMS

What impact will the biotechnology product have on other living organisms? **Bacillus thuringiensis (Bt)** is a bacterium naturally found in soil that is toxic to certain insect species. *Bt* pesticide sprays have been used on crops, such as corn and soybeans. Through genetic engineering, the genetics of *Bt* have been inserted into corn to produce corn plants that produce the *Bt* toxins. It is hoped that the transgenic corn crop will require fewer chemical insecticide applications, since it provides its own resistance. In this example, researchers will likely address the following questions:

- When a genetically engineered plant produces a toxin to resist one organism, is it also toxic to desired organisms?
- Because of the biodiversity of the pests, some of the pests may be resistant to the toxin. Will these resistant pests reproduce and create an entire pest population that is resistant to the toxin?
- What impact will the biotechnology product have on the food chain and ecosystem?

Genetically modified salmon have been created to increase the growth rate of salmon raised on fish farms. This idea sounds logical for aquaculture producers, but what will happen if the genetically modified fish escape or are released into the wild? Will the genetically modified fish breed with wild fish and outcompete the wild fish or other organisms in the environment? There is significant concern that the release of genetically modified fish will disrupt the ecological balance, potentially causing the endangerment or extinction of certain wildlife species. Although there is no intent to release genetically modified fish into the wild, the biotechnology industry must address and answer questions about the potential impact of a new product on the environment.

GENETIC TRANSFER

What is the potential for genetic transfer from one generation to the next generation? Is genetic transfer desirable or undesirable? Revisit the example of transgenic *Bt* crops, such as corn. What will happen if a transgenic crop is allowed to reproduce? The same concerns apply to genetically modified animals, such as genetically modified salmon.

Monitoring Effects of Biotechnology on Wild Populations

Once biotechnology products and processes are introduced to the environment, there needs to be a system for monitoring their agricultural, economic, and ecological impact. Just as we can use biotechnology tools to measure biodiversity, we can use those same tools to monitor

the effects of biotechnology on wild populations. Biotechnology tools can also be used to monitor and even help manage wild populations.

Some researchers see biotechnology as a tool to aid in reproductive programs for threatened or endangered species. Cloning may very well become a tool to assist reproduction programs of endangered species.

Genetic comparisons using tools such as gel electrophoresis can be used to identify the amount of genetic diversity in small animal populations. If research shows a significant amount of inbreeding within a wild population, wildlife managers may work to incorporate other animals into the breeding population to increase the genetic diversity of the group. The endangered Florida panther and the timber wolf are both examples of wild animals that have benefited from research in monitoring genetic diversity.

Summary:

Biodiversity is the collective set of biological differences between all living organisms. The genetic differences of organisms allow each organism to survive in its environment. As selective breeding and other biotechnology tools are used to improve the genetics of organisms, it is important to maintain a level of genetic diversity. Researchers recognize that genetic diversity of all organisms is a tremendous resource and are continuously working to build collections of organisms. Biotechnology will affect wild populations of organisms, and biotechnology tools will be used to monitor changes in wild populations.

Checking Your Knowledge:

1. What does biodiversity mean?
2. Explain how collections of the Agricultural Research Service can be used to benefit humans.
3. Why is it important to preserve rare breeds of livestock?
4. What are three biotechnology tools that can be used to monitor biodiversity?
5. Where is *Bacillus thuringiensis* naturally found?

Expanding Your Knowledge:

Research a genetically engineered plant or crop. Develop a list of positive and negative impacts of the crop. Share your observations with the class.

Research a rare breed of livestock. Identify characteristics of the breed that could be used in a popular breed of the livestock species.

Web Links:

Biodiversity: The Impact of Biotechnology
http://www.botanischergarten.ch/EFB/UNESCO-Biodiv-Biotech-Final.pdf

Biotechnology and Conservation of Endangered Species
http://www.science.mcmaster.ca/biology/CBCN/genetics/khan.htm

Conversations About Plant Biotechnology
http://www.monsanto.com/biotech-gmo/asp/default.asp

Council for Biotechnology Information
http://www.whybiotech.ca/

Agricultural Career Profiles
http://www.mycaert.com/career-profiles