

MARKETING THE NEW HYBRIDS

Performance Standard 12A/11A/13A/13B.H

Students will apply the processes of scientific inquiry to compare evolutionary trends between kingdoms and phyla accordingly:

- *Knowledge*: Define the process and products of natural and applied hybridization.
- *Application*: Investigate the implications of hybridization in a societal context.
- *Communication*: Report the findings of the issue investigation of the impact of specific plant or animal hybrids.

Procedures

1. ***In order to know and apply concepts that explain how living things function, adapt, and change (12A), and apply the concepts, principles and processes of scientific inquiry (11A), know and apply the accepted practices of science (13A) and know and apply the concepts that describe the interaction between science, technology and society (13B),*** students should experience sufficient learning opportunities to develop the following:

- Formulate hypothesis for an issue investigation relating to natural and applied hybridization from an informed societal context.
- Preview recent research pertaining to hybridization and current genetic research and its applications.
- Explore policies which affect science and technology issues.
- Design issue investigation on hybridization to use appropriate research, analysis and communication technologies.
- Develop and conduct survey instruments to assess depths of informed opinions.
- Conduct investigation and research on hybridization.
- Distinguish fact from opinion and science from pseudo-science as associated with hybridization research and societal impressions. Interpret and represent analysis of data from surveys and experts, including the context of policy correlation,
- Report, display and defend the process and findings of investigation.
- Generate further questions or issues for consideration.

Note to teacher: This activity relates to knowledge associated with standard 12A, while addressing the performance descriptions for stage H within standard 11A. Connections to scientific research studies and their implications are a focus of standard 13A. The interaction of policies associated with science, technology and society are described in standard 13B.

2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Begin the investigation of the history and foundation of genetics research and hybridization (through natural and applied means, including biotechnology). Introduce the elements of societal acceptance and resistance to scientific research and the ensuing changes that can result from the research. Develop questions for public surveys for depth of informed opinions about the possible impact (positive and negative) of specific hybrids (natural and commercial). Make class decisions about number, composition, specificity and methodology of questions. Students should collect, compile and analyze survey instrument data to explore how the public develops informed opinions.
4. Conduct research about specific examples of plant and animal hybrids (as assigned by teacher or selected by students). Develop a three-fold brochure which explains assigned hybrid and markets its potential impact and addresses public information and acceptability issues. Present research to classroom audience for consideration of correlation of scientific facts and informed opinions.
5. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
 - *Knowledge*: The explanations of the processes and products of natural and applied hybridization were complete and correct.
 - *Application*: The public survey and its analysis were conducted in a well-organized, well-detailed manner; the research on the hybrid included all the required elements.
 - *Communication*: The presentation of the marketing brochure was complete and accurate and incorporated the findings of the surveys for the basis of informing opinions.

Examples of Student Work not available

Time Requirements

- Foundational understanding of hybridization; 1-2 class days for survey instrument development; 3-5 days of out of class time for conducting survey and hybrid research; 1-2 class days for survey analysis; 3-4 days for brochure development (in or out of class); 2 days for class presentations.

Resources

- Copies of the brochure planning assignment sheet
- Resource materials from 'Integrating Science and Foods' from Secondary Science Scientific Literacy Project, ISBE, 1998 (These materials provide background information and suggestions for additional activities)
- Science Rubric

MARKETING HYBRIDS BROCHURE

ASSIGNMENT: Create a tri-fold brochure/pamphlet to market assigned hybrids through informed public opinions. There are six panels to prepare.

The following four items must be a part of your brochure:

1. Cover panel with illustration: Your cover should include the title, your name, and a colorful drawing or picture of a plant and animal hybrid.
2. Historical information: Include information about how the original plant or animal stock was successful in some ways, but displayed some negative factors which were not desirable.
3. Current information: Include information about how the hybridization process is supposed to maintain the existing positive factors and improve the formerly negative factors.
4. Future projections: Include information about the economic and societal impact of the hybrid when released.
5. Pertinent regulations, policies or scientific practices: Include references to applicable scientific or governmental requirements which were considered in the development of the hybrid.

Additional information should also include any pertinent geographic, demographic or commercial details. Provide applicable graphic details. Pictures or sketches may be useful.

Consider Informed Opinion Survey information in order to respond to possible misinformation and uninformed perceptions.

WHAT IS GENETIC ENGINEERING?

As you have learned in previous units, DNA is the central molecule of the cell, encoding information that is used to make proteins essential to the cell. All of life on this planet is controlled by DNA (or in the case of some viruses, by RNA).

In recent years, scientists have learned new techniques to get at the DNA and, therefore, the genes of organisms. They have learned how to isolate individual genes from a DNA molecule and to transfer them from one kind of organism to another. The ability to change the genetic instructions of an organism has opened the door to many new discoveries, many of which are expected to benefit humans. For example, some rare and expensive disease-fighting hormones can be manufactured in the laboratory using organisms. Some plants and animals that are used for food can be genetically altered to make them easier to grow or more nutritious. Microorganisms that engulf and break down toxic waste materials can be developed. We likely will learn many other possibilities as we learn more about DNA and how the cell functions. The set of techniques used to manipulate DNA is known as genetic engineering.

THE STORY OF B. t. COTTON

In the late '70s, scientists discovered that a bacterium, *agrobacterium tumefaciens*, was capable of inserting its own plasmids (a plasmid is a ring of DNA) into the DNA of plants. *Agrobacterium tumefaciens* proved to be capable of doing its own "natural" genetic engineering on a broad range of host plants, including tobacco, petunias, soybeans, and cotton.

The discovery of *agrobacterium tumefaciens*' ability to insert itself into a plant coincided with increased interest in another group of bacteria - ones that produced insecticides. The insecticides are proteins, the direct products of DNA and RNA. Microbial insecticides usually are considered harmless to people, to organisms other than the larger pests, and to the environment. Microbial insecticides are often applied to crops to control particular insects. Because of this, they have become especially popular among farmers who want to get away from using commercial chemical pesticides.

Many plant scientists began to think, "Here we have one bacterium that can insert its genetic material into many useful plants, and here we have another type of bacterium that can produce insect-killing proteins. What if we could put the abilities of these two bacteria together in one bacterium. The new bacterium would be able to insert its genetic material into a plant, thereby giving the plant the ability to make an insect-killing protein. There you have it--a genetically engineered insect-resistant plant!"

Several groups of scientists in different companies and research centers went to work on the problem. By 1990, a pest-resistant cotton was being field-tested in many places across the country. To produce it, researchers took a gene from the bacterium *Bacillus thuringiensis* (B.t). B.t. produces a protein that is lethal to certain kinds of caterpillars, including the cotton bollworm. (B.t. often is applied directly to cotton crops to control bollworm infestations.) Using *agrobacterium tumefaciens*, they inserted the toxin-producing gene into the cotton plant to make a pest-resistant cotton. As of this writing, B.t. cotton has not been approved for the marketplace, but the field tests are promising.

ACTIVITY

B.t. cotton has been hailed by many as a great advancement. Others have been more cautious about accepting it. They feel that introducing a new, genetically engineered species may have unknown consequences.

Divide the class into groups, each group representing one of the following occupations:

- large cotton farmers
- small cotton farmers
- environmentalists
- chemical pesticide manufacturers
- plant geneticists

Each group should develop answers to the following questions and discuss the questions together from the point of view of their interest group.

1. What are the advantages of using B.t. cotton over the application of pesticides to a cotton crop threatened by the cotton bollworm?
2. What advantage does the use of B.t. cotton have over the direct application of *Bacillus thuringiensis* to a field of cotton threatened by the cotton bollworm?
3. What is likely to happen to the population of caterpillars after a few B.t. cotton growing seasons?
4. How might you expect natural selection to work against the efforts of the B.t. cotton farmers?
5. How might other plants and insects in the environment be affected by the presence of B.t. cotton?

Note: All groups may consult other sources of information provided by your teacher. The plant geneticists should act as the biological experts in solving the problem. As a class, write a recommendation to either approve or reject B.t. cotton for the marketplace, including recommendations for any restrictions on its use.

How Does Genetic Engineering Work?

Genetic engineering refers to a set of techniques used to change the characteristics of organisms. One of these techniques is called recombinant DNA technology.

Recombinant DNA Technology

In recombinant DNA technology, precise sequences of DNA can be removed from the cell, using proteins known as restriction enzymes. Restriction enzymes act a little like a knife or a pair of scissors. They cut up the DNA at specific points along the length of the DNA strand. Many different restriction enzymes exist, and they all have specific points where they cut the DNA.

Human proteins like insulin can be made using bacteria as miniature factories. Bacteria are used by scientists in genetic engineering because they are relatively simple organisms, and they reproduce rapidly. Also, scientists have ways of inserting human genes into bacteria.

By using a restriction enzyme, researchers can isolate a given sequence of DNA. For example, if a researcher wants to cut out the gene for insulin production, he/she will use a specific restriction enzyme that breaks the bonds of DNA immediately before and after the sequence that causes insulin production.

Once researchers have the gene they are looking for, they can do a number of things with it. In the above example, they take the human gene for insulin production and insert it into the DNA of another organism. Specifically, researchers insert the human gene for insulin into the DNA of bacteria, which is actually a three-step process.

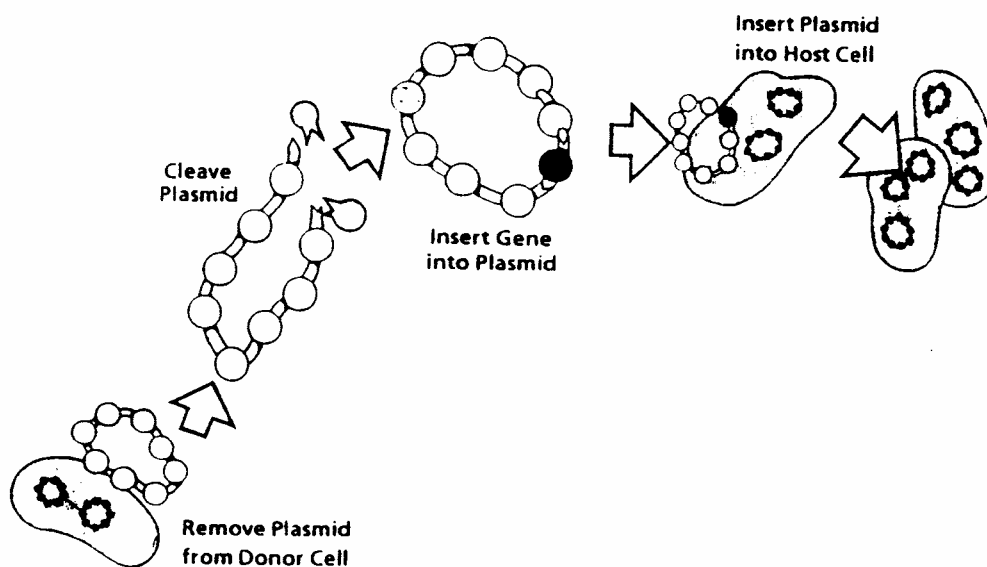
First, using restriction enzymes, they cleave DNA plasmids of bacterial cells at specific sites on the plasmid. (Plasmids are circles of DNA found in bacterial cells that are small enough to pass easily from one cell to another, even if the cells are from two different species.)

Second, they insert the insulin gene into the open plasmid ring.

Third, they insert the plasmids into living bacterial cells. Once the human gene for insulin production is inserted into the bacteria, researchers can grow the bacteria and allow them to reproduce in a nutrient-rich medium. As the bacteria produce their own proteins, the bacteria will synthesize human insulin from the instructions contained in the inserted gene for insulin. Finally, researchers can remove the insulin from the bacteria and use it to treat diabetes.

This process of isolating and inserting a new gene is called gene splicing.

FIGURE 6-1 Three steps involved in recombinant DNA technology



ACTIVITY

Demonstrate insertion of a human gene for insulin production into a bacterial cell.

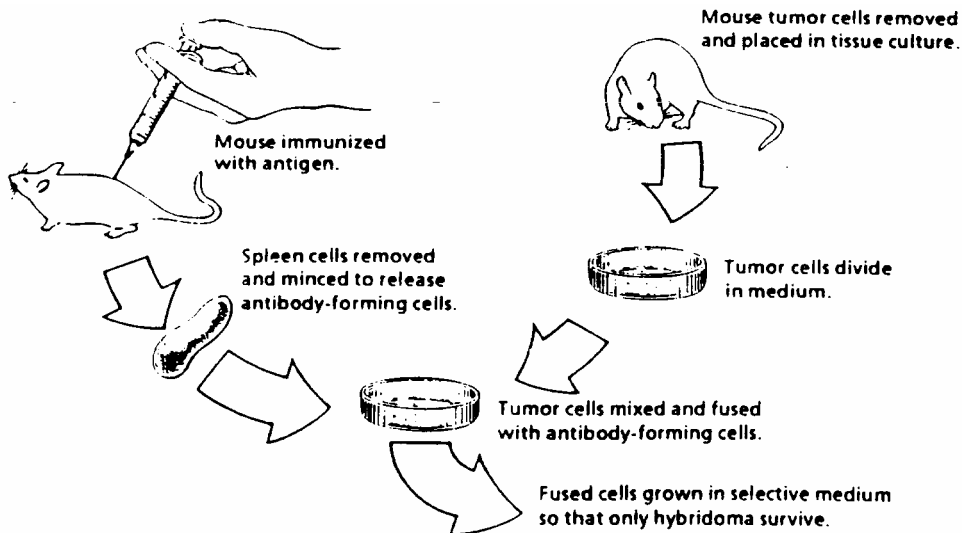
- ◆ Get instruction handouts from your teacher.
- ◆ Using Paper models provided by your teacher, demonstrate the three-step process illustrated above.

Monoclonal Antibody Technology

Monoclonal (cloned all alike) antibody technology involves the process of combining special white blood cells with tumor cells (that have the ability to grow permanently in the appropriate culture medium). These special blood cells produce proteins called antibodies. Antibodies are proteins that respond to antigens. Antigens are foreign substances, such as those produced by disease-causing bacteria, that invade the body. Antibodies are highly specific; each one forms in response to a specific invader.

In monoclonal antibody technology, a mouse is injected with an antigen, which causes specific antibodies to form in the mouse's spleen (an organ that filters and stores blood). The spleen cells then are removed and minced (chopped up into very small pieces) to release the antibody-forming cells. Mouse tumor cells then are mixed in a culture tube with the antibody-forming cells. Tumor cells are used because they reproduce easily. The antibody-forming cells and tumor cells fuse (join) into new cells called hybridomas. The hybridomas can be used to produce antibodies that may be used in disease-preventing vaccines. Monoclonal antibodies also are used to diagnose illnesses and to study cells.

Monoclonal antibody technology



How Can Genetic Engineering Benefit Us?

As you have seen, genetic engineering benefits us by making useful protein products. For example, bacteria are currently being used to make products such as insulin, vaccines, antibodies, and other proteins to prevent or treat disease.

The most current information on biotechnology is available from the USDA at website <http://www.nal.usda.gov/pgdic/>. The Plant Genome Data and Information Center provides access to a variety of information on products and services related to plant and animal genome mapping. Biotechnology for the 21st Century can be accessed through the website <http://www.nal.usda.gov/bic/bio21/>. This site gives examples of new biotechnology including industrial use of recombinant DNA, cell fusion, novel bioprocessing techniques and bioremediation.

Another way genetic engineering can benefit humans is in the development of organisms with the ability to do useful things. For example, the genes of one species of bacterium have been changed to permit it to engulf and break down oil into substances that are less harmful to the environment. Scientists hope that this new "oil-eating" bacterium can help man combat pollution from oil spills. For this purpose, a type of bacterium will be used that dies out quickly after it completes the oil-eating job.

From genetically engineering bacteria that can clean up fuel spills today, we may progress to genetically engineering microorganisms that can make fuel in the future. In Brazil inexpensive alcohol fuel is now being made from sugarcane juice. In the future, scientists might solve the world's energy problems by inserting amylase (the enzyme that breaks down starch into sugar) into yeast, a microorganism. The genetically engineered yeast could help us make great strides toward solving the world's energy problems by enabling us to produce extremely inexpensive alcohol fuel from virtually any plant material.

Alcohol fuel has not yet replaced fossil fuel, but alcohol has been a useful raw material in the chemical industry for decades. Currently alcohol and other industrial organic chemicals such as acetone and glycerol (used in producing such useful products as plastics, fibers, and resins) are derived primarily from fossil fuels. Research dating back to the First World War already has provided the biotechnology to produce these useful raw materials from plant sugar. In the future, industrial chemists hope to genetically engineer enzymes that can produce other useful industrial chemicals.

As you have seen with B.t. cotton, genetic engineering also can enhance agricultural productivity. Genetically engineered bacteria can help crops resist drought, frost, and such pests as hornworms and cutworms. For example, a frost-resistant strain of bacterium (genetically mutated for that purpose) would be applied to plant surfaces, and a different bacterial mutant (engineered to be a natural pesticide) would be added to plant roots. In the near future, genetic engineering also may improve farm animals and their products. Currently the genetic engineered food projects include genotypes of soybeans, grain and animal genome data, and research on *saccharomyces* or baker's and budding yeast. To learn more about genotypes for some soybean varieties the homepage for SoyBase is helpful at <http://129.186.26.94/>. This site lets you learn more about SoyBase, view graphical genotypes for some soybean varieties, and view maps of the duplicated regions in soybeans. The USDA has a site on graingenes. This site at <http://wheat.pw.usda.gov/graingenes.html> offers information on various types of grains and the current genetic engineering.

Genetic disease is responsible for causing a large number of illnesses in the human population. Many of these illnesses are fatal; some can be treated using medicines. Some genetic diseases can now be detected by a genetic engineering technique. Human DNA sequences put together in the laboratory can be inserted into cells and used as probes. The cells may be those taken during amniocentesis and chorionic villi sampling. Once the DNA probes enter cells, they "look for" natural DNA sequences on the chromosomes with which they can pair. (Remember that the DNA molecule is made up of two strands that are complementary.) Such a DNA probe is being used now to detect sickle-cell anemia in a fetus to be born to carriers. The probe will pair up with the abnormal sickle-cell gene identifying its presence.

Genetic engineering techniques, known as gene therapy, may permit doctors to cure some of these genetic defects in the near future. In the process that scientists are trying to develop, normal genes would be inserted into the cells of

people who suffer from a particular genetic defect. Already, foreign genes are being inserted into animals, and a genetic disease in mice has been cured using gene therapy.

Sampling of Present and Future Benefits from Genetic Engineering

Application	Benefit	In Use Today	Projected for the Future
Medicine	Useful protein	Insulin; vaccines; antibodies	New Vaccines
	DNA probe for detecting genetic diseases	Detection of sickle-cell anemia in fetus to be born to carriers	Curing genetic diseases with gene therapy, such as correcting the defect in phenylketonuria (PKU) patients that prevents them from forming an essential enzyme
Industry	Making raw materials for the chemical industry, such as alcohol, acetone, glycerol	Currently possible with biotechnology techniques	Genetically engineering enzymes for use in producing industrial chemicals
Energy	Inexpensive alcohol fuel	Currently being made from sugarcane juice, a renewable raw material	Genetically inserting amylase into yeast to enable the production of alcohol fuel from starch, a raw material found in virtually all plants
Environment	Cleaning up oil spills and disposing of waste	Genetically engineered oil-eating bacteria; mixtures of natural microbes; and enzymes used for breaking down paper-mill waste and oil	Genetically engineering a microbe that will replace mixtures of several natural microbes

Agriculture	Helps crops resist drought, frost, and pests; enables plants to make their own fertilizer	Currently limited to cross-breeding and grafting to produce hybrids with desirable traits from both plant species	Applying a frost-resistant strain of bacteria to plant surfaces; adding a natural pesticide to plant roots (bacterial mutant); genetically altering plants to be drought-resistant; genetically engineering corn cells with bacterial cells to produce corn plants that self-fertilize
	Improves animals and their products; produces new medical products in cow's milk	Currently limited to selective breeding, using such techniques as <i>in vitro</i> fertilization and artificial insemination	Genetically altering an animal embryo to produce disease-resistance, better milk, bigger animals in a shorter period of time, less fat in hogs, and farm animals whose milk contains medicines such as tPA (used to dissolve blood clots in humans after a heart attack) and blood-clotting Factor IX for use by hemophiliacs; diagnosing disease and improving vaccines

ACTIVITY

- ◆ Using research materials available to you in your school library or community library, research the latest advances being made in genetic engineering. These advances might include the following:

The engineering of new proteins.

The engineering of bacteria with new and useful traits.

The advances being made in gene therapy.

- ◆ Make a poster that explains one of these advances that you think the class will find particularly interesting.
- ◆ Make a display of posters (created by a number of students) to advertise the advances science is making in genetic engineering.

CONCERNS RELATED TO GENETIC ENGINEERING

Concerns about genetic engineering range from fear of potential misuse, such as biological warfare, to concerns about the consequences of genetic therapy on human sperm and ova. The website <http://home1.swipnet.se/~w-18472/indexeng.htm> addresses the safety problems of genetically engineered foods. This site also gives a beginners guide to biotechnology.

Environmental Concerns

Some fears relate to possible unknown consequences of introducing mutants such as dangerous microbes into natural environments. So far, however, genetic engineering has proved to be a safe technology, mainly because laboratory microbes have lived in a protected environment that makes them weak competitors in harsher natural environments. In addition, many microbes are engineered to die out after they have accomplished the task for which they were designed.

Legal Concerns

In addition to environmental concerns, legal questions have led to court action. In 1980, a United States court ruled that genetically engineered microbes may be patented. This has opened the door for patented animals.

Also, the legal rights of people have to be considered when biotechnology is applied to them. For instance, if your blood or tissue samples are taken for a routine purpose and during their analysis it is found you have a genetic disease such as Huntington's, should you be told? Should insurance companies have the right to refuse to insure you or your potential offspring?

Ethical Issues

Gene therapy and other uses of genetic engineering raise some moral questions for our society. As humans perfect the techniques of genetic engineering, we soon may be able to insert genes into human cells to produce all kinds of traits. It may become possible to insert genes that would affect traits such as athletic agility or physical appearance. We surely want to use genetic engineering to cure illness, but what about other uses of genetic engineering? The ability to alter our genes gives us the ability to alter ourselves.

Researchers in the Human Genome Project already are taking the first step toward enabling us (humans) to alter ourselves. They have begun a generation-long intensive effort to map the complete blueprint for making a human. At the beginning of the project scientists estimated that human DNA contains as many as 100,000 genes. At that time, they had assigned labels to only a few thousand human genes and accurately mapped even fewer. The latest information on the Genome Project can be accessed using a search engine on the Internet.

Scientists believe the large-scale effort and financial burden of the project will pay off in many gains for humans and other species. Specifically, they hope the knowledge they gain will enable them to correct flaws in the human genetic system, to solve some mysteries of human heredity, and, indirectly, to save some endangered nonhuman species from extinction. However, the Human Genome Project presents its own special ethical issue: "Do we have the right to tamper with the human blueprint?"

ACTIVITY

In class, discuss or debate ethical or moral issues associated with the advances in genetic engineering and other biotechnologies as follows:

- ◆ Divide the class into groups of three or four students.
- ◆ Each group will be presented with several reports of the ethical issues involved with the various advances being made in biotechnology.
- ◆ Have each group make a list of the important points raised by the articles that they reviewed.
- ◆ Within each group, debate the ethical issues raised by the articles.

LOOKING BACK

Genetic engineering refers to certain procedures used to manipulate the DNA of various organisms to benefit mankind. One technique of genetic engineering, known as recombinant DNA technology, relies on restriction enzymes, molecules which cut up the DNA, to get at needed genes. Once these genes are isolated, scientists can insert them into various organisms to get desired results. In another technique of genetic engineering, known as monoclonal antibody technology, antibody-producing cells are fused with tumor cells to form new cells that make large quantities of antibodies (disease-fighting proteins).

Some of the ways genetic engineering can benefit mankind include the production of medically important proteins such as insulin and the manufacture of special bacteria that may help us clean up the environment. Genetic engineering also is being used to develop plants that grow more easily under difficult conditions or agricultural animals that grow faster. One day, perhaps the techniques of gene therapy--the insertion of normal genes into the cells of human beings suffering from genetic disease--can be used to treat the wide variety of genetic diseases.

Legal, environmental, and ethical issues surround the use of genetic engineering. The ability to manipulate the DNA gives humans tremendous power to change nature. By changing our genes, we are becoming able to change who we are. In addition, the manufacture of genetically engineered organisms conceivably could affect the environment in a negative way. In summary, the techniques of genetic engineering can be used in many different ways. They create difficult decisions about how we want to control our very nature and the world around us.

Vocabulary

The words and phrases below are important to understanding and applying the principles and concepts in this subunit. If you don't know some of them, find them in the text and review what they mean. They're listed in the order in which they appear in the subunit.

genetic engineering	antibody
recombinant DNA technology	monoclonal antibody
insulin	antigen
diabetes	spleen
restriction enzymes	hybridoma
plasmid	gene probe
gene splicing	gene therapy
food engineering	genetically modified food
cell fusion	bioprocessing
bioremediation	genetic code
genetic manipulation	

Further Discussion

- ◆ Research career opportunities in the field of biotechnology. List specific job titles and describe both the duties and the level of education and training associated with each, using “Science in the Shopping Cart” booklet, for example.
- ◆ Discuss concerns you have about the application of genetic engineering on microorganisms, higher animals, and humans. What guidelines would you set for approval of genetic engineering projects?

ACTIVITIES BY OCCUPATIONAL AREA

GENERAL

Need for Genetic Engineering

- ◆ Divide into groups and brainstorm ways that genetic engineered food might solve current food problems.
 - For a period of time designated by your teacher, brainstorm as many problems as you can that you think might be solved by genetic engineered food.
 - When the time is up, rank the problems you listed, from most important to least important.
- ◆ Compile all of the group lists into a master list and, through class discussion, form a consensus on the following:
 - Eliminate from the list problems that you determine cannot be solved by genetic engineering.
 - Rank the remaining problems from most important to least important.
- ◆ Try to apply the procedure you just completed to a business or industrial setting, and evaluate it on that basis.

AGRICULTURE AND AGRIBUSINESS

Agricultural Applications of Genetic Engineering

- ◆ Contact your county or state Agriculture Extension Service, or the agriculture department of a local university, and ask for materials or information on how either genetic engineering (altered at the gene level) or biotechnology (using organisms or natural or synthetic parts thereof--to make or modify commodities or provide services) is currently being applied to the field of agriculture.
- ◆ Report to the class on one or more of these applications that you think are particularly important or interesting.
- ◆ The website <http://wheat.pw.usda.gov/graingenes.html> contains current information on genetically engineered grain.

Self-Fertilizing Corn

- ◆ Research is being conducted on transferring the genes from nitrogen-fixing bacteria into corn cells.
- ◆ Review information that your teacher will provide on this research.
- ◆ Survey local farmers to learn the percentage that is aware of this research and the percentage that understands the specific genetic-engineering process.
- ◆ As a class, discuss the following questions relating to that specific research:
 - What type of benefit(s) would the genetically engineered corn provide the farmer?
 - How would they help the environment?

FAMILY AND CONSUMER SCIENCE

A Solution for World Hunger

- ◆ As background research for this activity, read accounts in newspapers and popular magazines about the problem of world hunger.
- ◆ Envision a new food item or an altered version of an existing food that:
 - might be created with the help of some application of either genetic engineering or biotechnology (see definitions in the Agriculture and Agribusiness activities.)
 - might be processed into forms that would appeal to the tastes of people from a variety of ethnic backgrounds.
- ◆ Share your new food idea with other students in your class or others working on the same activity.
 - Ask for opinions about any political, economical, ethical, or social problems they foresee with your idea.
 - If more than one student is working on the activity, vote on the best idea.

Historical Application of Biotechnology to Food Production

- ◆ Choose an application of biotechnology in food production that has been used for many centuries (for example, processing the many varieties of cheese or using fermentation to produce bread).
- ◆ Research the history of the process in the library.
- ◆ Share your findings with the class in an oral report accompanied by either a demonstration or a poster illustration of the process. (For example, demonstrate making yeast bread or making cheese.)

HEALTH OCCUPATIONS

Diagnosing Hereditary Diseases

- ◆ Research and illustrate on pasteboard the biotechnique that is used for diagnosing hereditary diseases. (On the Internet, research topics such as recombinant DNA technology, PKU, cholesterol and diabetes.)
- ◆ Explain your illustration for the class, and ask the following questions:
 - In what health-care procedure would this process be applied?
 - Do you think the procedure could lead to ethical or social problems? Explain.

Large-Scale Genetic Engineering of Insulin

- ◆ Research the process of producing insulin with genetic engineering techniques. (In the library, look in indexes on science and technology under subjects such as insulin, genetic engineering, diabetes, etc.)
- ◆ Pretend that you want to use the technique you researched to manufacture insulin on a large scale, and illustrate with a flowchart the process you would use to get from the laboratory development stage to a marketable product.