CHAPTER 16

LESSON 1

Changing the Living World

READING TOOL **Make Connections** While you read this lesson, fill in the graphic organizer below. Explain the two ways that scientists carry out selective breeding practices, and the two ways they create increased variation within a population. Use examples from your text to support your explanations.

Selective Breeding

Hybridication: _____

_____

_____

_____

Inbreeding: _____

_____

_____

_____

Increasing Variation

Bacterial Mutation: _____

_____

_____

_____

Polypoid Plants: _____

_____

_____

_____

Selective Breeding

KEY QUESTION *What is selective breeding used for?*

Allowing only those organisms with desired characteristics to produce the next generation is called **selective breeding**. Selective breeding takes advantage of naturally occurring genetic variation to pass desired traits on to the next generation. This is one example of **biotechnology**, which has been practiced for thousands of years in developing animals, such as dog breeds, and plants, such as corn and potatoes. Corn was selectively bred from the wild grass teosinte nearly 10,000 years ago.

As you read, circle the answers to each Key Question. Underline any words you do not understand.

BUILD Vocabulary

selective breeding method of breeding that allows only those organisms with desired characteristics to produce the next generation

biotechnology the process of manipulating organisms, cells, or molecules, to produce specific products

BUILD Vocabulary

hybridization breeding technique that involves crossing dissimilar individuals to bring together the best traits of both organisms

inbreeding continued breeding of individuals with similar characteristics to maintain the derived characteristics of a kind of organism

Suffixes Note that the suffix *-ization* indicates "the making of."

☑ **Scientists use the process of hybridization to make what kind of organisms?**

_____

_____

_____

Hybridization Hybridization is the crossing of dissimilar individuals to bring together the best of both organisms. American botanist Luther Burbank's hybrid crosses combined the disease resistance of one plant with the food-production capacity of another. This resulted in a new line of plants that led to increased food production. In fact, the Russet Burbank potato is one example of a new line of plants.

Inbreeding To maintain desirable characteristics in a line of organisms, breeders will continually breed individuals with similar characteristics. This technique is known as **inbreeding**. Inbreeding helps ensure that the characteristics that make each breed unique are preserved. Many breeds of dogs are maintained this way. Although inbreeding is useful in preserving certain traits, it also brings along some risks. Most of the members of a breed are genetically similar, which increases the chance that a cross between two individuals will bring together two recessive alleles for a genetic defect.

Increasing Variation

KEY QUESTION *How do people increase genetic variation?*

Breeders can increase the genetic variation in a population by introducing mutations, which are the ultimate source of biological diversity.

Bacterial Mutations Mutations, which are heritable changes in DNA, occur spontaneously, but breeders can increase the mutation rate of an organism by using radiation or chemicals. While many mutations are harmful, breeders can select those mutations that produce useful characteristics not found in the original population.

This technique has been very useful with bacteria. Because they are small, millions of bacteria can be treated with radiation or chemicals at the same time. This increases the chances of producing a useful mutant. This technique has allowed scientists to develop hundreds of useful bacterial strains.

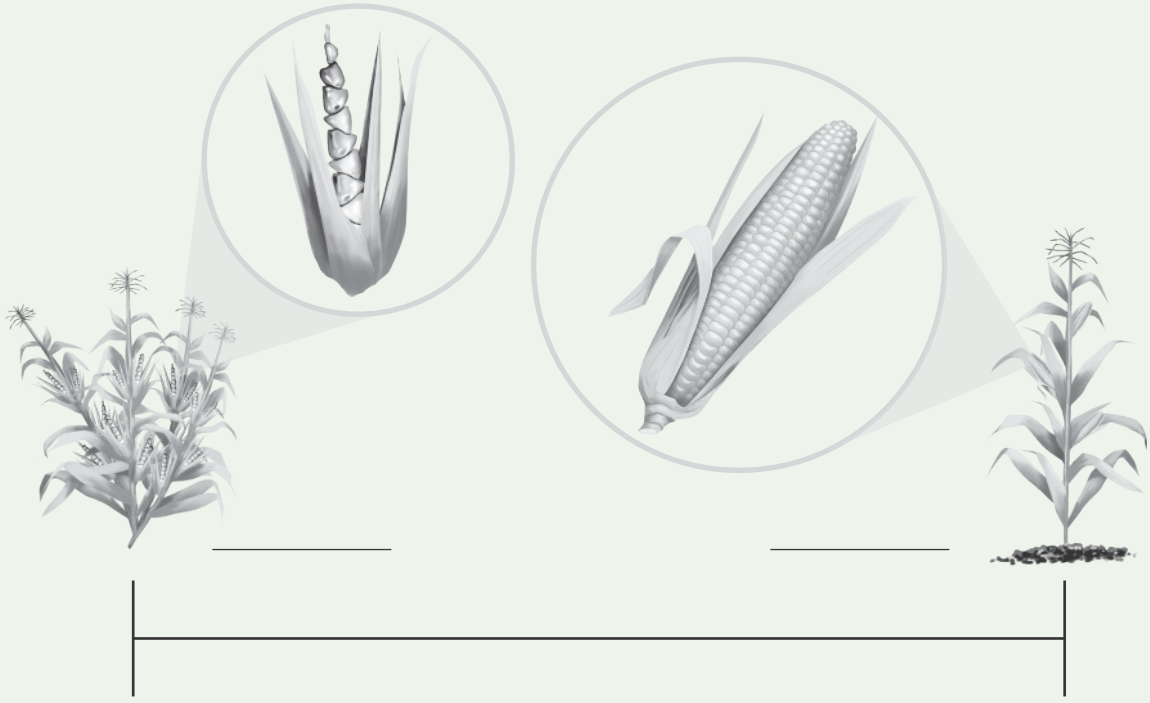
For instance, it is been known for decades that certain strains of oil-digesting bacteria are effective for cleaning up oil spills. Today, scientists are working to produce bacteria that can clean up radioactive substances and metal pollution in the environment.

Polyploid Plants Drugs that prevent the separating of chromosomes during meiosis are useful in plant breeding. These drugs can produce cells that have many times the normal number of chromosomes. Plants grown from these cells are called polyploid because they have many sets of chromosomes. Polyploidy is usually fatal in animals. But, for reasons that are not clear, plants are much better at tolerating extra sets of chromosomes.

Polyploidy can quickly produce new species of plants that are larger and stronger than their diploid relatives. A number of important crop plants, such as bananas and many types of citrus fruits, have been produced in this way.

Visual Reading Tool: Mutations Timeline

Complete the timeline shown by first identifying the two plants shown, and then determining the time when they occurred. Use Figure 16-1 in the textbook to help you.



1. Describe the changes that took place between the two plants.

2. What caused these changes to occur over time?

CHAPTER 16

LESSON 2

The Process of Genetic Engineering

READING TOOL **Use Structure** Before you read, skim through the lesson and fill in the outline below with the section headings. The first one is shown for you as an example. Then, using your outline, answer the questions below.

I. Analyzing DNA

a. Finding a Gene

b. _____

II. _____

a. _____

b. _____

c. _____

III. _____

a. _____

b. _____

c. _____

Next, Use the outline above to help you chose the best answer for each question. There may be more than one possible solution for each question.

1. Which of the following biotechnologies is used to rewrite the human genome?

☐ CRISPR ☐ Recombinant DNA ☐ Polymerase Chain Reaction

2. A Polymerase Chain Reaction is used to do what?

☐ Analyze DNA ☐ Rewrite the Genome ☐ Clone Organisms

3. What does CRISPR do?

☐ Clone Organisms ☐ Rewrite the Genome ☐ Analyze DNA

4. Which of the following combines DNA from two different sources?

☐ CRISPR ☐ Polymerase Chain Reaction ☐ Recombinant DNA

5. What do scientists call the small circular DNA sequences found in bacteria?

☐ Markers ☐ Plasmids ☐ Recombinant DNA

Lesson Summary

Analyzing DNA

KEY QUESTION *How do scientists copy the DNA of living organisms?*

Genes can be engineered to change the characteristics of living organisms. Scientists can isolate single genes from among millions of fragments.

Finding a Gene Scientists analyze the nucleotide sequences of genes to screen for specific genes. The gene for the green fluorescence protein (GFP) in a species of jellyfish was isolated by a method in which DNA fragments are separated by a gel so as to isolate the fragment containing the actual gene for GFP.

Polymerase Chain Reaction Once a gene has been isolated, scientists can take a small sample and make multiple copies of specific DNA sequences using a technique known as **polymerase chain reaction**.

Rewriting the Genome

KEY QUESTION *How is recombinant DNA used?*

Recombinant DNA Not only can scientists isolate genes but they can make changes in the genome by inserting new or foreign DNA molecules into living cells. The combined molecules are known as **recombinant DNA**, and they change the genetic composition of a living organism.

Plasmids and Genetic Markers Some bacteria contain small circular DNA molecules known as **plasmids**, which are widely used in recombinant DNA studies. Plasmid DNA contains a signal for replication, but it also has a **genetic marker** that makes it possible to distinguish bacteria that carry the plasmid from those that don't. Using plasmids, recombinant DNA technology has been used to transform a bacterial cell so that it can manufacture human growth hormones.

CRISPR and DNA Editing CRISPR (clustered regularly interspersed short palindromic repeats) technology enables scientists to rewrite the base sequence of nearly any gene in a cell, transforming disease-causing genes and reengineering genes to perform new functions.

As you read, circle the answers to each Key Question. Underline any words you do not understand.

BUILD Vocabulary

polymerase chain reaction the technique used by biologists to make many copies of a particular gene

recombinant DNA DNA produced by combining DNA from two or more different sources

plasmid small, circular piece of DNA located in the cytoplasm of many bacteria

genetic marker alleles that produce detectable phenotypic differences useful in genetic analysis

Prefixes

The prefix *trans* means "across," and generally refers to things being moved from one area to another. For example: transporting goods from one side of a country to the other side. ☑ **How does this prefix express the meaning of the word *transgenic*?**

BUILD Vocabulary

transgenic term used to refer to an organism that contains genes from other organisms

clone member of a population of genetically identical cells produced from a single cell

Transgenic Organisms and Cloning

KEY QUESTION *How are transgenic organisms produced?*

The universal nature of the genetic code makes it possible to construct organisms that contain genes from other species. These **transgenic** organisms can be produced by the insertion of recombinant DNA into the genome of a host organism.

Transgenic Plants

Plant cells can be transformed using different methods: inserting a bacterium that contains a small DNA tumor-producing plasmid, removing plant cell walls, or injecting DNA directly into the cell.

Transgenic Animals

Egg cells of many animals are large enough that DNA can be inserted directly into the nucleus. Enzymes normally responsible for DNA repair and recombination may help to insert the foreign DNA into the chromosomes of the cell.

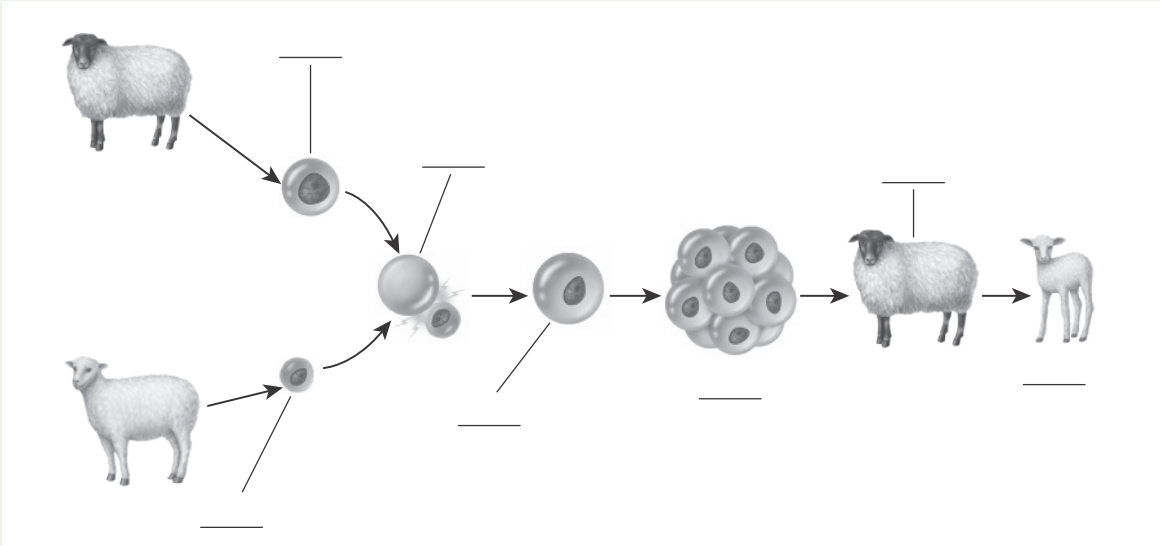
Cloning

A **clone** is a population of genetically identical cells produced from a single cell. The technique of cloning uses a single cell from an adult organism to grow an entirely new individual that is genetically identical to the organism from which the cell was taken.

Cloned colonies of bacteria and other microorganisms are easy to grow, but this is not always true of multicellular organisms, especially animals.

Visual Reading Tool: Analyze a Sequence: Cloning

Use the steps listed below to explain the process of creating a cloned sheep. Match each step or description with the appropriate letter on the diagram.



Cloned Lamb
Donor Nucleus
Egg Cell
Embryo
Foster Mother
Fused Cell
Nucleus of Egg Cell is Removed

Lastly, circle the two sheep on the diagram that represent two genetically identical sheep.

CHAPTER 16

LESSON 3

Applications of Biotechnology

READING TOOL **Main Idea and Details** As you read, identify the main idea and supporting details under each main heading from the text.

Main Idea	Evidence and Details
Agriculture and Industry	
GM Crops	
GM Animals	
Health and Medicine	
Genetic Testing	
Medical Research	
Preventing and Treating Disease	
Examining Active Genes	
Personal Identification	
Forensic Science	
Fallen Heroes	
Establishing Relationships	

Lesson Summary

As you read, circle the answers to each Key Question. Underline any words you do not understand.

READING TOOL

Make Connections Scientists can modify the DNA of plants or animals. **What are two ways that scientists use genetically modified animals to benefit humans?**

Agriculture and Industry

KEY QUESTION *How can genetic engineering benefit agriculture and industry?*

Genetic engineering can benefit agriculture by producing better, less expensive, and more nutritious foods as well as making manufacturing processes less harmful.

GM Crops Since their introduction in 1996, genetically modified (GM) plants have become an important component of our food supply. For example, corn is often modified with bacterial genes that produce a protein called Bt toxin. The Bt toxin inserted in plants makes them resistant to insects, making spraying with pesticides unnecessary, and often produces higher crop yields. Resistance to insects is just one useful characteristic being engineered into crops. Others include resistance to viral infections and herbicides, resistance to rotting, and the production of plastics.

GM Animals Transgenic animals can be made larger and faster growing, which also makes them more productive. Cows have been injected with hormones produced by recombinant-DNA techniques to increase milk production. Pigs can be genetically modified (GM) to produce more lean meat or higher levels of healthy omega-3 acids.

Health and Medicine

KEY QUESTION *How can biotechnology improve human health?*

Genetic Testing Genetic tests diagnose hundreds of disorders, such as cystic fibrosis. Because the CF allele has slightly different DNA sequences from its normal counterpart, genetic tests using labeled DNA probes can distinguish the presence of CF. Like many genetic tests, the CF test uses specific DNA sequences that detect the complementary base sequences found in the disease-causing alleles.

Medical Research Transgenic animals are often used as model test subjects in medical research, simulating human disorders, such as Alzheimer's disease and arthritis.

Preventing and Treating Disease Bioengineering can prevent and treat human diseases in a variety of different ways, from making our food more nutritious to creating strains of mosquitos that are incapable of transmitting particular pathogens.

Examining Active Genes Although each cell in a person contains the same genetic material, the same genes are not active in every cell. Scientists use **DNA microarray** technology to study hundreds or thousands of genes at once, to understand their activity levels.

Personal Identification

KEY QUESTION *How is DNA used to identify individuals?*

The variation of the human genome ensures that no individual is exactly like any other, except in the case of twins. **DNA fingerprinting** analyzes sections of DNA that may have little or no function but that vary widely from one individual to another. Because only identical twins share the same genome, DNA can be used to determine a person's identity.

Forensic Science In **forensics**—the scientific study of crime scene evidence—DNA fingerprinting has been used to solve crimes, convict criminals, and even overturn wrongful convictions. DNA forensics has also been used to conserve wildlife. Officials can use DNA fingerprinting to identify the African elephant herds where the animals were poached for their tusks to help stop the illegal ivory trade.

Fallen Heroes The U.S. military requires all personnel to provide a sample of their DNA when they begin their service. Those DNA samples are kept on file and used, if needed, to identify the remains of individuals who perish in the line of duty.

Establishing Relationships DNA fingerprinting can also be used to establish paternity and trace ancestry. For example, DNA fingerprinting makes it easy to find alleles carried by the child that do not match those of the mother. Any such alleles must come from the child's biological father, and they will show up in his DNA fingerprint.

BUILD Vocabulary

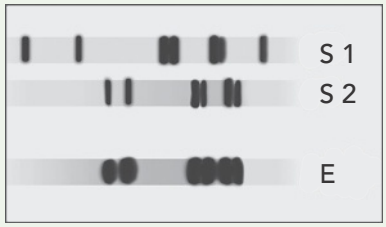
DNA microarray glass slide or silicon chip that carries thousands of different kinds of single-stranded DNA fragments arranged in a grid. A DNA microarray is used to detect and measure the expression of thousands of genes at one time

DNA fingerprinting tool used by biologists that analyzes an individual's unique collection of DNA restriction fragments; used to determine whether two samples of genetic material are from the same person

forensics scientific study of crime scene evidence

Visual Reading Tool: Compare and Contrast: DNA Fingerprints

Compare Suspect 1 (S1) and Suspect 2 (S2) to the DNA evidence sample (E). Based upon the DNA fingerprints, which suspect was likely at the crime scene and why?



DNA fingerprint

CHAPTER 16

LESSON 4

Ethics and Impacts of Biotechnology

READING TOOL **Benefits and Drawbacks** As you read, identify the opposing views on each ethical issue. Take notes in the two-column chart shown below.

Issue	Benefits	Drawbacks
Patenting life		
Genetic privacy		
GM foods		
New biology		

Lesson Summary

As you read, circle the answers to each Key Question. Underline any words you do not understand.

Profits and Privacy

KEY QUESTION *What privacy issues does biotechnology raise?*

Private biotechnology and pharmaceutical companies do much of the research involving genetically modified (GM) plants and animals. They have often sought to protect their research by placing a patent on their discoveries. A patent is a legal tool that gives an individual or a company the exclusive right to profit from innovations for a number of years.

Patenting Life Patents have been used for years for new machines and devices. Now patents are also being used for molecules and biotechnology procedures. At times, disputes over biotechnology procedures arise—and these disputes have slowed the research of other biotechnological advancements.

One such dispute was brought to the United States Supreme Court. In 2013, the U.S. Supreme Court unanimously ruled that genes found in nature cannot be patented. Altered, or synthetic genes, however, could be patented, allowing companies to protect novel biotechnology products.

Genetic Privacy DNA can reveal personal information, including ethnic heritage, the chances of developing certain diseases, and evidence for criminal cases. The revelation of this information does raise questions of privacy. For example, it may be considered unfair for an employer to pass on a possible candidate if certain conclusions were made based on information from the candidate's DNA. As science advances, legal experts will debate ways to keep personal genetic information safe and confidential.

READING TOOL

Academic Words

novel new or unusual in an interesting way.

What type of genes are allowed to be patented?

Safety of Transgenic Organisms

KEY QUESTION *What are some of the pros and cons of transgenic organisms?*

The presence of GM products in the marketplace has raised concerns from consumers. While nearly half of the GM crops today are grown in the United States, farmers around the world are now using GM technology. Many public-interest groups have argued that GM foods should be labeled. The U.S. Department of Agriculture is currently attempting to develop guidelines for this labeling. There are supporters and opponents of GM foods, with each side having very important points to support its opinions.

Arguments for GM Foods Those who support the use and growth of GM foods and crops argue that GM plants are actually better and safer than other crops. Farmers choose GM plants because they produce higher yield reducing the amount of land and energy that must be devoted to agriculture and lowering the cost for everyone. Supporters also argue that insect-resistant GM plants need little, if any, insecticide to grow successfully. Thus, GM crops could reduce the chance of chemical residue entering our food supply and lessen the effects of or damage to the environment. Finally, supporters point to the fact that the scientific community generally regards foods made from GM plants as safe to eat.

Visual Reading Tool: Analyzing Crop Yield Data

Below, use your own words to describe what the graph shows about the use of genetically modified crops between 1996 and 2016.

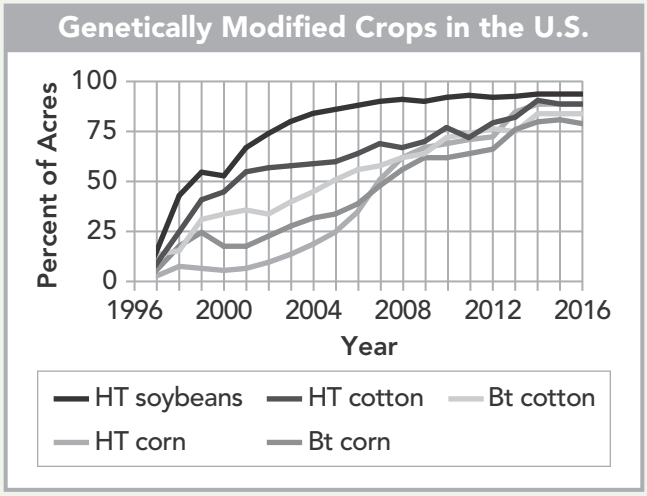
_____

_____

_____

_____

_____



Data for each crop category include varieties with both HT and Bt (stacked) traits.
Sources: USDA, Economic Research Service using data from Fernandez-Cornejo and McBride (2002) for the years 1996–1999 and USDA, National Agriculture Statistics Service, *June Agriculture Survey* for years 2000–16.

Arguments Against GM Foods On the other hand, opponents of GM foods have raised concerns about the possible unintended consequences for agriculture of a shift to GM farming and ranching. One concern is that insect resistance may threaten beneficial insects (such as honeybees) as well as crop pests. Another concern is that patents held on GM seeds may raise the cost of seeds to the point that small farmers would go out of business, especially in the developing world.

In the United States, many public interest groups have argued that GM foods should be identified and labeled so that consumers would be fully aware of what they are eating. In 2016, Vermont passed a law that required labeling on GM foods. However, Congress later overrode that law, but did request that the United States Department of Agriculture develop rules for GM food labeling. The rules would then be implemented across all of the United States.

Ethics of the New Biology

KEY QUESTION *What are some of the ethical issues around new biotechnology?*

With the new knowledge we gain about ourselves using biotechnology, there is also a great responsibility. We can alter life forms for any purpose, scientific or nonscientific. Scientists could cure diseases such as cystic fibrosis or hemophilia. But should they try to engineer taller people or change their eye color, hair texture, sex, blood group, or appearance? The goal of biology is to gain a better understanding of the nature of life. Everyone is responsible for ensuring that the tools science has given us are used wisely.

16 Chapter Review

Review Vocabulary

Choose the letter of the best answer that defines the word.

1. Biotechnology

- ☐ A. the science of computers
- ☐ B. the evolution of animal species
- ☐ C. manipulation of organisms or cells to produce desired products
- ☐ D. computer programs for creating life

2. Hybridization

- ☐ A. creation of mutations for gene modification
- ☐ B. crossing of dissimilar organisms to combine the best traits of each
- ☐ C. development of transport using alternative fuels

Match the vocabulary term to its definition.

3. _____ small, circular piece of DNA located in the cytoplasm of many bacteria

4. _____ use of DNA in the study of crime scene evidence

5. _____ member of a population of genetically identical cells produced from a single cell

a. clone

b. plasmid

c. forensics

Review Key Questions

Provide evidence and details to support your answers.

6. Why do scientists, farmers, and animal breeders use selective breeding practices?

7. What is recombinant DNA and how is it used?

8. How is DNA used in forensics?

9. List some of the benefits and drawbacks of GM organisms.