Advances in Genetics

Reading Preview

Key Concepts
• What are three ways of producing organisms with desired traits?
• What is the goal of the Human Genome Project?

Key Terms
• selective breeding
• inbreeding
• hybridization
• clone
• genetic engineering
• gene therapy
• genome

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a question for each heading. As you read, write answers to your questions.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is selective breeding?</td>
<td>Selective breeding is...</td>
</tr>
</tbody>
</table>

What Do Fingerprints Reveal?

1. Label a sheet of paper with your name. Then roll one of your fingers from side to side on an ink pad. Make a fingerprint by carefully rolling your inked finger on the paper.
2. Divide into groups. Each group should choose one member to use the same finger to make a second fingerprint on a sheet of paper. Leave the paper unlabeled.
3. Exchange your group’s fingerprints with those from another group. Compare each labeled fingerprint with the fingerprint on the unlabeled paper. Decide whose fingerprint it is.
4. Wash your hands after completing this activity.

Think It Over

Observing Why are fingerprints used to identify people?

Would you like to have your picture taken with a 9,000-year-old family member? Adrian Targett, a history teacher in the village of Cheddar in England, has actually done that. All that’s left of his ancient relative, known as “Cheddar Man,” is a skeleton. The skeleton was discovered in a cave near the village. DNA analysis indicates that Targett and Cheddar Man are relatives.

Like your fingerprints, your DNA is different from everyone else’s. Because of advances in genetics, DNA evidence can show many things, such as family relationships.

FIGURE 12
Distant Relatives
Adrian Targett visits his distant relative, Cheddar Man. Unfortunately, Cheddar Man cannot respond to questions about life 9,000 years ago.
Selective Breeding

Genetic techniques have enabled people to produce organisms with desirable traits. Selective breeding, cloning, and genetic engineering are three methods for developing organisms with desirable traits.

The process of selecting organisms with desired traits to be parents of the next generation is called selective breeding. Thousands of years ago, in what is now Mexico, the food that we call corn was developed in this way. Every year, farmers saved seeds from the healthiest plants that produced the best food. In the spring, they planted those seeds. By repeating this process over and over, farmers developed plants that produced better corn. People have used selective breeding with many different plants and animals. Two selective breeding techniques are inbreeding and hybridization.

Inbreeding The technique of inbreeding involves crossing two individuals that have similar characteristics. For example, suppose a male and a female turkey are both plump and grow quickly. Their offspring will probably also have those desirable qualities. Inbred organisms have alleles that are very similar to those of their parents.

Inbred organisms are genetically very similar. Therefore, inbreeding increases the probability that organisms may inherit alleles that lead to genetic disorders. For example, inherited hip problems are common in many breeds of dogs.

Hybridization In hybridization (hy brid ih ZAY shun), breeders cross two genetically different individuals. The hybrid organism that results is bred to have the best traits from both parents. For example, a farmer might cross corn that produces many kernels with corn that is resistant to disease. The result might be a hybrid corn plant with both of the desired traits.

Reading Checkpoint

What is the goal of hybridization?

McIntosh  Red Delicious  Empire

McIntosh  Red Delicious  Empire
Changing Rice Production

The graph shows how worldwide rice production changed between 1965 and 2000. New, hybrid varieties of rice plants are one factor that has affected the amount of rice produced.

1. **Reading Graphs** According to the graph, how did rice production change between 1965 and 2000?
2. **Reading Graphs** How many metric tons of rice per hectare were produced in 1965? How many were produced in 2000?
3. **Calculating** Calculate the approximate difference between rice production in 1965 and 2000.

Cloning

For some organisms, a technique called cloning can be used to produce offspring with desired traits. A **clone** is an organism that has exactly the same genes as the organism from which it was produced. It isn’t hard to clone some kinds of plants, such as an African violet. Just cut a stem from one plant, and put the stem in soil. Water it, and soon you will have a whole new plant. The new plant is genetically identical to the plant from which the stem was cut.

Researchers have also cloned animals such as sheep and pigs. The methods for cloning these animals are complex. They involve taking the nucleus of an animal’s body cell and using that nucleus to produce a new animal.

**Cloned Goats**

These goats were produced by cloning.
Genetic Engineering

Geneticists have developed another powerful technique for producing organisms with desired traits. In this process, called genetic engineering, genes from one organism are transferred into the DNA of another organism. Genetic engineering can produce medicines and improve food crops.

Genetic Engineering in Bacteria  One type of genetically engineered bacteria produces a protein called insulin. Injections of insulin are needed by many people with diabetes. Recall that bacteria have a single DNA molecule in the cytoplasm. Some bacterial cells also contain small circular pieces of DNA called plasmids. In Figure 16, you can see how scientists insert the DNA for a human gene into the plasmid of a bacterium.

**Figure 16**
Genetic Engineering
Scientists use genetic engineering to create bacterial cells that produce important human proteins such as insulin.

*Interpreting Diagrams*  How does a human insulin gene become part of a plasmid?

1. Scientists remove plasmids, small rings of DNA, from bacterial cells.

2. An enzyme cuts open the plasmid DNA. The same enzyme removes the human insulin gene from its chromosome.

3. The human insulin gene attaches to the open ends of the plasmid to form a closed ring.

4. Some bacterial cells take up the plasmids that have the insulin gene.

5. When the cells reproduce, the new cells will contain copies of the “engineered” plasmid. The foreign gene directs the cell to produce human insulin.
Once the gene is inserted into the plasmid, the bacterial cell and all its offspring will contain this human gene. As a result, the bacteria produce the protein that the human gene codes for—in this case, insulin. Because bacteria reproduce quickly, large amounts of insulin can be produced in a short time.

**Genetic Engineering in Other Organisms** Scientists can also use genetic engineering techniques to insert genes into animals. For example, human genes can be inserted into the cells of cows. The cows then produce the human protein for which the gene codes in their milk. Scientists have used this technique to produce the blood clotting protein needed by people with hemophilia.

Genes have also been inserted into the cells of plants, such as tomatoes and rice. Some of the genes enable the plants to survive in cold temperatures or in poor soil. Other genetically engineered crops can resist insect pests.

**Gene Therapy** Someday it may be possible to use genetic engineering to correct some genetic disorders in humans. This process, called **gene therapy**, will involve inserting copies of a gene directly into a person’s cells. For example, doctors may be able to treat hemophilia by replacing the defective allele on the X chromosome. The person’s blood would then clot normally.

**Concerns About Genetic Engineering** Some people are concerned about the long-term effects of genetic engineering. For example, some people think that genetically engineered crops may not be entirely safe. People fear that these crops may harm the environment or cause health problems in humans. To address such concerns, scientists are trying to learn more about the effects of genetic engineering.
FIGURE 18
The Human Genome Project
Scientists on the Human Genome Project continue to study human DNA.

Learning About Human Genetics
Recent advances have enabled scientists to learn a great deal about human genetics. The Human Genome Project and DNA fingerprinting are two applications of this new knowledge.

The Human Genome Project Imagine trying to crack a code that is 6 billion letters long. That’s exactly what the scientists working on the Human Genome Project did. A genome is all the DNA in one cell of an organism. The main goal of the Human Genome Project was to identify the DNA sequence of every gene in the human genome. In May 2006, the last chromosome in the human genome, chromosome 1, was sequenced. Scientists estimate that human DNA has between 20,000 and 25,000 genes. Analysis of the human genome, such as determining the exact location and function of each gene, could take several decades to complete.

DNA Fingerprinting DNA technology used in the Human Genome Project can also identify people and show whether people are related. DNA from a person’s cells is broken down into small pieces, or fragments. Selected fragments are used to produce a pattern called a DNA fingerprint. Except for identical twins, no two people have exactly the same DNA fingerprint. You will learn more about DNA fingerprinting in Technology and Society.

Target Reading Skill Asking Questions Work with a partner to check your answers in your graphic organizer.

Section 3 Assessment

Reviewing Key Concepts
1. a. Listing List three methods that scientists can use to develop organisms with desirable traits.
   b. Describing Briefly describe each method.
   c. Applying Concepts Lupita has a houseplant. Which method would be the best way of producing a similar plant for a friend? Explain your answer.
2. a. Defining What is a genome?
   b. Explaining What is the Human Genome Project?
3. a. Relating Cause and Effect How might knowledge gained from the Human Genome Project be used in gene therapy?

Lab Zone At-Home Activity

Food and Selective Breeding Go to a grocery store with a parent or other family member. Discuss how fruits and vegetables have been produced by selective breeding. Choose a fruit or vegetable, and identify the traits that make it valuable.
Guilty or Innocent?

**Problem**

A crime scene may contain hair, skin, or blood from a criminal. These materials all contain DNA that can be used to make a DNA fingerprint. A DNA fingerprint, which consists of a series of bands, is something like a bar code. How can a DNA fingerprint identify individuals?

**Skills Focus**

drawing conclusions, inferring

**Materials**

- 4–6 bar codes
- hand lens

**Procedure**

1. Look at the photograph of DNA band patterns shown at right. Each person's DNA produces a unique pattern of these bands.
2. Now look at the Universal Product Code, also called a bar code, shown below the DNA bands. A bar code can be used as a model of a DNA band pattern. Compare the bar code with the DNA bands to see what they have in common. Record your observations.
3. Suppose that a burglary has taken place, and you’re the detective leading the investigation. Your teacher will give you a bar code that represents DNA from blood found at the crime scene. You arrange to have DNA samples taken from several suspects. Write a sentence describing what you will look for as you try to match each suspect’s DNA to the DNA sample from the crime scene.
4. You will now be given bar codes representing DNA samples taken from the suspects. Compare those bar codes with the bar code that represents DNA from the crime scene.
5. Use your comparisons to determine whether any of the suspects was present at the crime scene.

**Analyze and Conclude**

1. **Drawing Conclusions** Based on your findings, were any of the suspects present at the crime scene? Support your conclusion with specific evidence.
2. **Inferring** Why do people's DNA patterns differ so greatly?
3. **Drawing Conclusions** How would your conclusions be affected if you learned that the suspect whose DNA matched the evidence had an identical twin?
4. **Communicating** Suppose you are a defense lawyer. DNA evidence indicates that the bloodstain at the scene of a crime belongs to your client. Do you think this DNA evidence should be enough to convict your client? Write a speech you might give to the jury in defense of your client.

**More to Explore**

Do you think the DNA fingerprints of a parent and a child would show any similarities? Explain your thinking.
DNA Fingerprinting

What do you have that no one else has? Unless you are an identical twin, your DNA is unique. Because one person’s DNA is like no one else’s, it can be used to produce genetic “fingerprints.” These fingerprints can tie a person to the scene of a crime. They can prevent the wrong person from going to jail. They can also be used to identify skeletal remains. Today, soldiers and sailors give blood and saliva samples so their DNA fingerprints can be saved. Like the identification tags that soldiers wear, DNA records can be used to identify the bodies of unknown soldiers or civilians.

In the past, identification tags and dental records were the main methods for identifying skeletal remains.

1. After a sample of DNA is extracted from the body, an enzyme cuts the DNA strand into several smaller pieces.

2. The cut-up DNA fragments are loaded into a gel that uses electric current to separate fragments. Larger fragments of DNA move through the gel more slowly than the smaller fragments.
Analyzing DNA

In one method of DNA analysis, DNA from saliva, blood, bones, teeth, or other fluids or tissues is taken from cells. Special enzymes are added to cut the DNA into small pieces. Selected pieces are put into a machine that runs an electric current through the DNA and sorts the pieces by size. The DNA then gets stained and photographed. When developed, a unique banded pattern, similar to a product bar code, is revealed. The pattern can be compared to other samples of DNA to determine a match.

Limitations of DNA Fingerprinting

Like all technology, DNA fingerprinting has its limitations. DNA is very fragile and the films produced can be difficult to read if the DNA samples are old. In rare instances, DNA from the people testing the samples can become mixed in with the test samples and produce inaccurate results. DNA testing is also time consuming and expensive.

Weigh the Impact

1. Identify the Need
   Make a list of at least five situations in which DNA fingerprinting could be useful.

2. Research
   Research the situations you listed in Question 1 to find out if DNA analysis is or can be used in each.

3. Write
   Choose one application of DNA analysis and write one or two paragraphs to explain when the application can be used.

Go Online

For: More on DNA fingerprinting
Visit: PHSchool.com
Web Code: ceh-3040
1 Human Inheritance

Key Concepts

- Some human traits are controlled by single genes with two alleles, and others by single genes with multiple alleles. Still other traits are controlled by many genes that act together.
- The sex chromosomes carry genes that determine whether a person is male or female. They also carry genes that determine other traits.
- Many of a person's characteristics are determined by an interaction between genes and the environment.

Key Terms
- multiple alleles
- sex-linked gene
- sex chromosomes
- carrier

2 Human Genetic Disorders

Key Concepts

- Some genetic disorders are caused by mutations in the DNA of genes. Other disorders are caused by changes in the overall structure or number of chromosomes.
- One important tool that geneticists use to trace the inheritance of traits in humans is a pedigree.
- Today doctors use tools such as karyotypes to help detect genetic disorders. People with genetic disorders are helped through medical care, education, job training, and other methods.

Key Terms
- genetic disorder
- pedigree
- karyotype

3 Advances in Genetics

Key Concepts

- Selective breeding, cloning, and genetic engineering are three methods for developing organisms with desirable traits.
- The main goal of the Human Genome Project has been to identify the DNA sequence of every gene in the human genome.

Key Terms
- selective breeding
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- hybridization
- clone
- genetic engineering
- gene therapy
- genome