Objective: 8.L.2.1

Biotechnology

Key Words • biotechnology • genetic modification • genome • cloning

Getting the Idea

You may have eaten pluots. These fruits have only been available for about 30 years. They were developed from plums and apricots. For thousands of years, people have changed plants and animals for human use. But scientists today have new technologies for doing so.

Crossbreeding and Selective Breeding

Biotechnology is the manipulation of living things to make useful products. The use of biotechnology causes changes in organisms. Some of the earliest forms of biotechnology involved breeding plants and animals.

In crossbreeding, two different kinds of organisms are bred together. Pluots were developed by breeding plums and apricots together. Loganberries were developed from blackberries and red raspberries.

Selective breeding is the intentional mating of organisms to produce offspring with specific traits. In this process, organisms with desired traits are bred, in the hope that the traits will be passed to their offspring. Once grown, offspring with the desired traits are bred, continuing the process. Offspring without the desired traits are not bred. This process is repeated over many generations until all offspring consistently show the desired trait. Over time, new varieties of organisms that always show the traits are produced. Many breeds of dogs have been produced in this way.

Genetic Modification

Many traits of organisms are now produced through genetic modification. **Genetic modification** changes the genetic material of a living organism. This practice is used to make medicines and treat diseases. It is also used to improve crops and to produce organisms used in scientific research.

Gene splicing is one form of genetic modification. In gene splicing, a gene from one organism is inserted into the DNA of another organism. For example, scientists have spliced the human gene for making a substance called insulin into the DNA of bacteria. This causes the bacteria to make human insulin. This insulin can be used by some people with diabetes. Their bodies do not produce enough insulin, so they must use insulin from other sources. At one time, insulin for people with diabetes came from the organs of cows or pigs. Now, people can use human insulin manufactured by genetically modified bacteria. Gene splicing has also been used to create bacteria that produce substances such as vitamins and vaccines.

Genetic modification has also been used to develop corn that is resistant to some herbicides. An herbicide is a product used to kill weeds. Farmers who plant this corn can spray their fields with the herbicide to kill weeds, without harming the corn. Scientists are also using genetic modification to develop fruits and vegetables that taste better and stay fresher from farm to market.

To use genetic modification, scientists need to know as much as possible about an organism's DNA. Scientists have developed techniques for mapping an organism's genome. A **genome** is the complete sequence of an organism's DNA. When scientists map a genome, they identify the sequence of certain repeating units in the DNA. They also try to identify all the organism's genes and figure out where on the DNA they are located.

Several sites in North Carolina are involved in genome research, or genomics. North Carolina State University has the Genomic Sciences Laboratory. Its work includes DNA sequencing. The University of North Carolina's Center for Integrated Systems Genetics has performed studies involving genomics and human health. Genome research is carried out at Duke University's Institute for Genomic Sciences and Policy. North Carolina is also home to many corporations that are working in the field of genomics.

DNA Fingerprinting

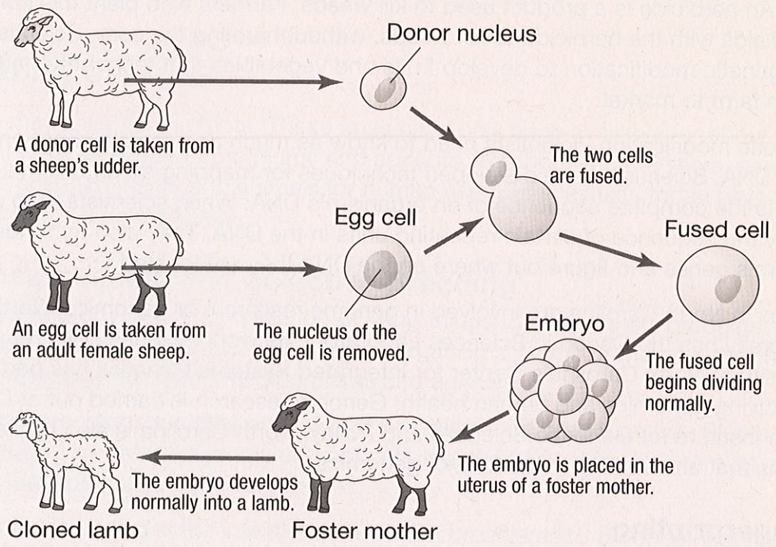
Scientists have worked out the sequence of the human genome. Much of the DNA of all humans is the same. But there are some sections that are different in each person. The sequence of repeating units in these sections can be used as a sort of "fingerprint" to solve crimes.

In DNA fingerprinting, DNA is collected at a crime scene. Even small amounts of blood or other body fluids left at the crime scene may be enough to provide a sample of DNA. Cells attached to the root of a hair can also provide a DNA sample. When a suspect is found, a DNA sample is taken from the suspect. The sequences of the DNA samples are compared. If the DNA from the crime scene matches the DNA of the suspect, this may be evidence that the suspect was at the crime scene. If the sequences are not the same, it shows that the DNA came from someone else.

Animal Cloning

The chromosomes in the nucleus of a fertilized egg cell have all the information needed to produce an entire organism. A single fertilized egg can develop into an adult. Scientists wondered if a body cell could do the same thing. To find out, they used a technique called cloning. **Cloning** produces an organism that is an exact genetic copy of another.

In one experiment, scientists took the nucleus from an adult sheep cell. They put that nucleus into a sheep egg cell, replacing the original nucleus. When the cell started dividing, it was implanted into a female sheep. The dividing cell grew into a lamb named Dolly. Born in 1997, Dolly was genetically identical to the adult whose chromosomes were used to create her. Therefore, Dolly was a clone. The diagram shows how Dolly was cloned.



Since Dolly was created, scientists have cloned other animals. Cloning animals is difficult and expensive. It often takes many tries to create one clone. However, cloning might be used to duplicate animals with desirable traits. For example, scientists might clone cows that give a lot of milk. Or scientists might clone animals to help preserve endangered species. Clones can give birth normally. So, like other animals, they pass their desirable traits to their offspring.

Bioremediation

Some forms of biotechnology do not change an organism's genes. Bioremediation uses existing kinds of bacteria to clean up the environment. After a large oil spill in 1989, workers saw that some areas were becoming cleaner on their own. They discovered that bacteria were consuming the oil. These bacteria were not added by anyone. They were in the water naturally. The fact that they could consume oil was unknown before this. Scientists found that the bacteria need nitrogen to function. So now, nitrogen-containing fertilizers are added to oil spills to help the bacteria clean up.

Other microorganisms have been used to clean up toxic wastes in soil and water. Different kinds of bacteria work on different substances. Bioremediation scientists know which bacteria to use for each kind of chemical spill. They also know what nutrients must be supplied to keep the bacteria working.

So far, bioremediation has used naturally occurring bacteria. Researchers are working to develop genetically modified bacteria that can clean up chemical spills even faster.

Not all uses of one-celled organisms are new. For example, yeasts have been used for thousands of years in making bread. Yeasts are also used to make some fermented drinks. Bacteria are used in making yogurt. Molds are often used to add flavoring to cheese.

Risks of Biotechnology

Biotechnology has been very beneficial to humans. However, some people have concerns about its use. For example, the entire human genome has been mapped. This new knowledge may lead to treatments or cures for some diseases. But some people worry about how information about an individual's genes could be used. For example, a health insurance company might refuse to cover a person who carries a gene for a specific disease. Cloning is also a controversial issue. Some people worry that scientists might try to clone humans.

Another concern is that genetically modified organisms could spread to places where they are not wanted. Such organisms might cause disease or have unexpected and negative effects on the environment. Crop plants that are genetically modified to resist herbicides could spread beyond the fields where they are planted. These plants could be difficult to remove. Genes bred into some crop plants may also cross over into wild populations.

Genetically engineered food plants may come with other risks. One risk is that genes moved from one species to another may cause allergic reactions. Genetically engineered foods are not currently labeled in ways that would let people avoid this danger. Some crops, such as corn, are used in many different foods. Altering those crops could affect millions of people.

Discussion Question

Not everyone agrees that biotechnology should be used to modify crop plants. What is your opinion? Explain your reasoning.

Lesson Review

1. A genome is
   - **A.** a sequence of units in a short segment of DNA.
   - **B.** a gene inserted into a bacterial chromosome.
   - **C.** the complete sequence of an organism's DNA.
   - **D.** part of a chromosome.

2. Which of these is an example of genetic modification?
   - **A.** use of herbicides
   - **B.** crossbreeding
   - **C.** heart surgery
   - **D.** gene splicing

3. Which process uses a body cell to create a new organism?
   - **A.** crossbreeding
   - **B.** cloning
   - **C.** genetic modification
   - **D.** gene splicing

4. Which of these is **not** a way in which biotechnology can benefit agriculture?
   - **A.** increasing crop production
   - **B.** reducing the loss of crops to insects
   - **C.** producing better-tasting fruits
   - **D.** improving farm machinery