12.2 DNA and Technology

Over a period of thousands of years, Native Americans transformed a type of wild grass into *maize*—better known as corn. Maize was developed from a wild grass originally growing in Central America 7,000 years ago. The seeds of that grass looked very different from today’s kernels of corn. By collecting and growing the plants best suited for eating, Native Americans encouraged the formation of larger kernels on cobs (Figure 12.6).

**Selective breeding**

Native Americans used selective breeding to produce maize. **Selective breeding** is the process of selecting organisms with desired traits to serve as parents for the next generation. Native Americans began by selecting seeds of wild grass that were the best for eating. They grew those seeds and then selected the best seeds from that generation. By repeating this process over many generations of plants, they developed a variety of maize that produced the most food per plant. Today we have many varieties of corn. All are descendents of those early plants.

**VOCABULARY**

*selective breeding* - the process of selecting organisms with desired traits to serve as parents for the next generation.
Genetic engineering

What is genetic engineering?
Since the discovery of DNA, scientists have found new methods of producing organisms with desired traits. One of those methods is called genetic engineering. **Genetic engineering** is the process of transferring genes from one organism into the DNA of another organism. Walk down the produce aisle at your grocery store and you'll find some products of genetic engineering. Supersweet corn and cold-resistant tomatoes are examples.

Genetically engineered bacteria
Another example of genetic engineering is the production of insulin to treat people with diabetes. **Insulin** is a protein that regulates carbohydrates in the blood. People with diabetes can't produce enough insulin. Scientists insert a human gene for insulin into the circular DNA of bacteria (called a *plasmid*). The transformed bacteria are tricked into producing insulin. When the transformed bacterial cells divide, their offspring carry the gene for insulin (Figure 12.7). Because bacteria reproduce rapidly, large amounts of insulin can be produced in a short amount of time.

Treatments for genetic disorders
Scientists routinely insert genes into the plasmids of bacteria, which are prokaryotes. Eukaryotic cells are more complex and usually do not contain plasmids. Therefore it is more difficult to use genetic engineering in eukaryotic cells. One method is to inject new DNA into a cell with a tiny needle. Sometimes the cell accepts the DNA. Other times it destroys the DNA. In one case, scientists were able to insert a cold-water fish gene into a tomato plant, making the plant more cold-resistant.

Important questions
Genetic engineering raises many ethical questions. For example, should we genetically engineer humans to be taller and stronger? Are genetically engineered foods bad for you? Learning genetics can help you make informed decisions about genetic engineering.

Figure 12.7: How genetic engineering is used to make insulin.
DNA fingerprinting

DNA is unique from person to person. The DNA of all organisms contains the same four bases: A, G, T, and C. However, the base sequence varies for all organisms. There are also variations in the base sequence within the same species of organisms. The base sequence in your DNA is different from that of every other person on Earth—unless you have an identical twin. Human DNA is unique from person to person, but the same from cell to cell.

What is DNA fingerprinting? As scientists have learned more about DNA, they have found a way to use it to identify individuals. A technique called DNA fingerprinting produces an image of patterns made by a person's DNA. Using an enzyme, scientists “cut” DNA strands in specific places. The DNA fragments are injected into a gel and an electric current is applied. As the fragments migrate across the gel, they create patterns. Those patterns (DNA fingerprints) are related to the base sequences along the DNA strand.

Each person has a unique fingerprint. Like normal fingerprints, the patterns produced by DNA are unique to each individual person. Therefore, DNA fingerprints can be used to identify suspects in a crime. They can also be used to identify relationships among children and their parents, or among siblings (brothers and sisters). The DNA fingerprints of parents and their offspring show similarities but are not identical.

Using DNA fingerprints to solve a crime. Suppose a serious crime has been committed. There are seven suspects. How can police prove which suspect actually committed the crime? Since blood was found at the crime scene, DNA fingerprints can be produced. Blood is drawn from the six suspects and DNA fingerprints are produced. By comparing the DNA fingerprints of the suspects to the blood from the crime scene, police quickly determine who committed the crime (Figure 12.8).

Figure 12.8: The DNA fingerprints in the middle are from the crime scene. Which one of the suspects committed the crime?
The human genome

What is a genome? Scientists use DNA technology to study the human genome. A genome is the total amount of hereditary material in a single cell of an organism. If you think of a genome as a set of books, each chromosome is a book from the set. Each gene is a paragraph from the book and each base is a letter from the paragraph (Figure 12.9). The Human Genome Project is a study of the human genome. One of the goals of the project was to map the base sequence of the entire human genome.

Using DNA technology to trace human origins Scientists also use DNA technology to trace the origins of humans. In the past, scientists could only analyze the bones and skulls of our human ancestors. Now they have tools to determine the base sequences of their DNA. Most of the ancient DNA scientists can recover is broken into fragments. Recently though, scientists have developed a way to make copies of those fragments, making them easier to analyze. They have also found a way to recover DNA from preserved bones and teeth.

Mitochondrial DNA Not all of your genome is found in the nuclei of your cells. Mitochondrial DNA is DNA that is found in the mitochondria of a cell. Human mitochondrial DNA consists of about 16,000 base pairs contained in 5–10 rings. Unlike nuclear DNA, which is equally inherited from both the father and mother, mitochondrial DNA is inherited only from the mother. That’s because all of our mitochondria are descended from those in our mother’s egg cell. Mitochondria in the sperm cell are destroyed during fertilization.

The origin of humans Mitochondrial DNA is often used to study human origins. Since it is inherited only from the mother, mitochondrial DNA allows scientists to trace human origins along a direct ancestral line. Recent evidence suggests that modern humans descended from Africa about 100,000 years ago.

Figure 12.9: One of the goals of the human genome is to map the base sequence of the entire human genome.

VOCABULARY
genome - the total amount of hereditary material in a single cell of an organism.
mitochondrial DNA - DNA that is found in the mitochondria of a cell.