Lesson 3

DNA Evidence

Reading Preview

Key Concepts

- Why is DNA a valuable tool for forensic scientists?
- What is the process for making a DNA profile?
- Why are DNA profiles accepted as evidence, and how are they used?

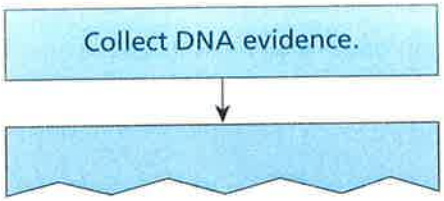
Key Terms

- DNA
- protein
- gene
- DNA profile
- replication
- probability
- cold case
- endangered species

Target Reading Skill

Sequencing As you read, make a flowchart that shows the steps for making a DNA profile. Place each step in a separate box in your flowchart.

Making a DNA Profile



Discover Activity

How Long Can You Make a Match?

1. Your teacher will give you a cup of snap cubes. Select any three cubes and connect them in a 3-cube string. How many students have matching 3-cube strings?
2. Select three more cubes and connect them to the existing string, making a 6-cube string. How many students have matching 6-cube strings?
3. Select three more cubes and connect them to the existing string, making a 9-cube string. How many students have matching 9-cube strings?

Think It Over

Interpreting Data How does the number of cubes in a string affect the number of matching strings?

One fall evening, a deer rancher in Pennsylvania discovered that his prize buck, Goliath, was missing. The stolen buck was worth about $100,000. Someone had cut a hole in the fence. From the drag marks near the fence, the rancher inferred that the thief had drugged the deer before taking it away.

Four years later, the rancher got a tip that Goliath was on a ranch about 50 miles away. When the rancher saw the deer, he was sure it was Goliath. But he needed some way to prove that he was right.

Scientists were able to use DNA to confirm the identity of the deer. DNA tests are expensive. But they are an excellent way to identify individuals, even an individual deer. Why is DNA so useful? The answer lies in the structure of DNA.

DNA Molecules

Do you have curly hair? Brown eyes? These characteristics are traits that are carried from parents to offspring by **DNA,** or deoxyribonucleic acid (dee ahk see ry boh noo KLEE ik). DNA controls the production of proteins in the human body. **Proteins** are molecules that your body uses to build tissues and organs. Proteins also control the chemical reactions that take place in cells.

DNA is found in the nucleus, or control center, of body cells. This nuclear DNA is a combination of the DNA you inherit from each of your parents. It is the same in every body cell—hair, skin, muscle, and so on.

Structure of DNA Figure 8 shows the structure of a DNA molecule. Two long strands of DNA are coiled around one another. Weak chemical bonds between pairs of nitrogen bases connect the strands. The letters A, T, G, and C are used to represent these pairs of bases, or base pairs. **Except for identical twins, no two people have nuclear DNA with the exact same sequence of base pairs.**

Genes DNA strands are divided into sections. A **gene** is a section of DNA that contains information your cells need to make a protein. The order of the bases in a gene is a code that determines which protein is produced. Humans have about 24,000 genes with a total of three billion base pairs.

Reading Checkpoint **What do proteins control?**

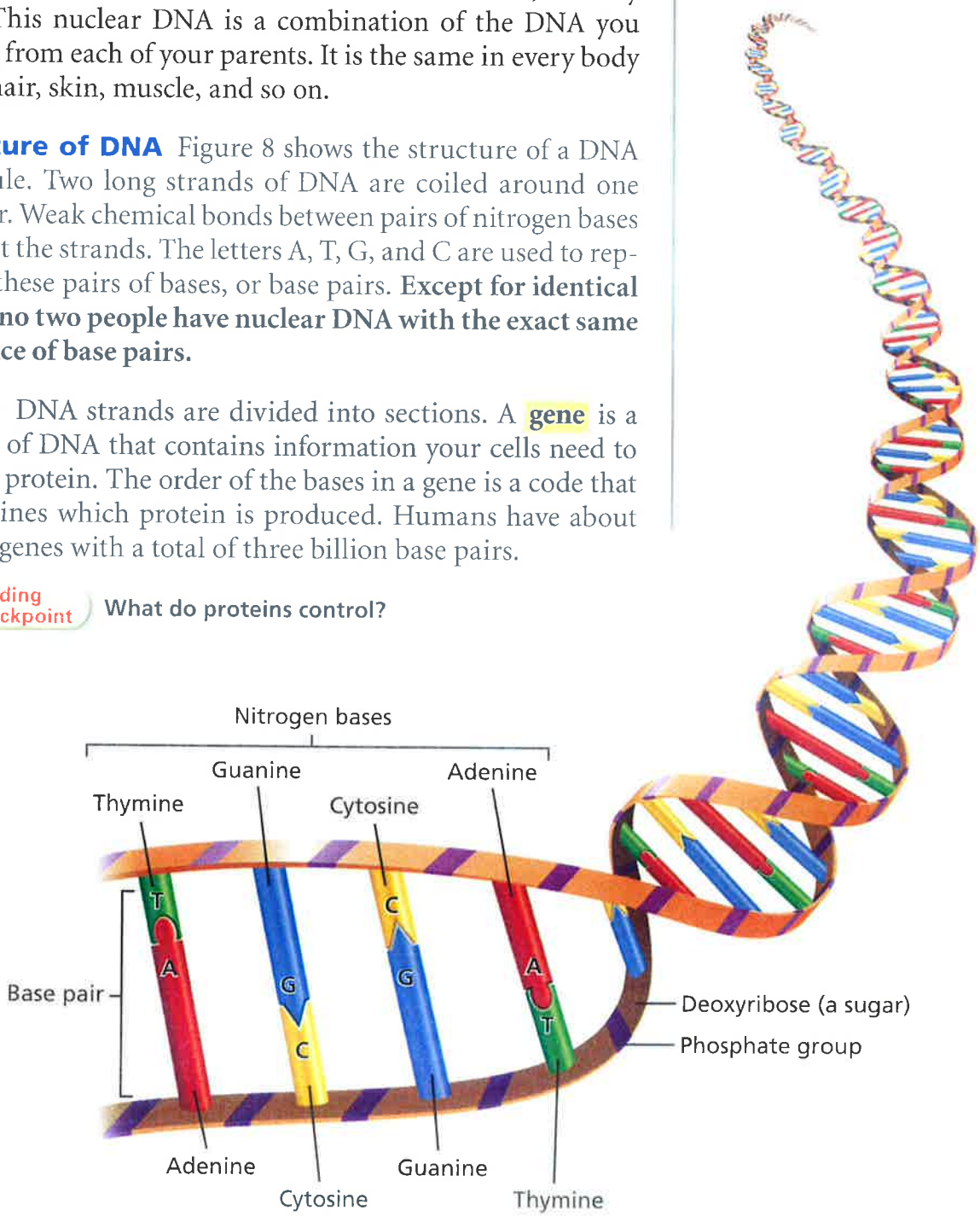


FIGURE 8
Structure of DNA
The DNA molecule is like a twisted ladder. The base pairs form the rungs of the ladder.
Interpreting Diagrams *Which base is paired with thymine? Which is paired with guanine?*

Skills Activity

Drawing Conclusions

Some DNA profiles are like a bar code. Your teacher will give you a partial bar code and a sheet of paper with complete bar codes. Compare your partial bar code to the bar codes on the sheet to find a match. Then explain why it is a match.

Making a DNA Profile

You might expect that a strand of DNA is filled with genes. But this isn't true. Some sections of DNA are non-coding; that is, they do not contain instructions for making a protein. In non-coding DNA, a sequence of bases can be repeated many times. The number of times a sequence repeats is an inherited trait.

The number of repeats for a sequence can vary. Scientists use this variation to make DNA profiles. A **DNA profile** is a distinctive pattern of DNA fragments. The pattern is used to match a biological sample to an individual. **To make a profile, scientists must collect, isolate, multiply, and sort DNA.**

Collecting DNA A CSI may find a suspect's blood or skin under a victim's fingernails. There could be saliva on a pillow or a licked stamp. A discarded facial tissue might contain a suspect's sweat or blood. All of these materials contain DNA.

Investigators may use a swab to take cells from the inside of a suspect's cheek. They can also find DNA on a toothbrush or a comb. A CSI must be careful to avoid contamination when collecting samples for DNA analysis. Tools, such as the swab box in Figure 9, can help.

Isolating DNA DNA must be removed from a biological sample before it can be tested. Suppose a scientist has a sample of blood. She uses a microfuge like the one in Figure 9 to spin the blood at high speed. As the blood spins, the cells separate from the liquid. Then she adds chemicals to release the DNA from the white blood cells. Finally, she adds alcohol, and a sticky blob of DNA settles out of the mixture.

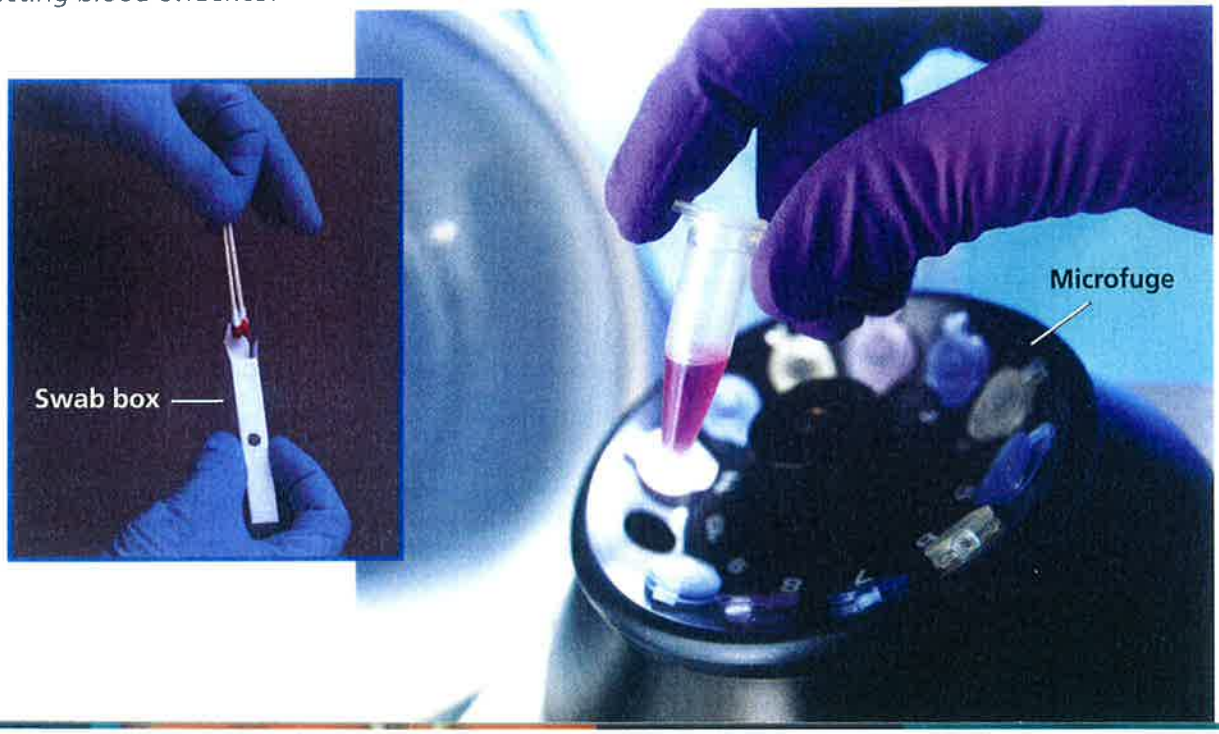


FIGURE 9
Collecting and Isolating DNA
The hole in the swab box allows air to circulate and dry the blood. At the lab, the DNA is isolated.
Applying Concepts *What are two reasons why a CSI wears gloves while collecting blood evidence?*

Multiplying DNA To understand what happens next, you need to know how a DNA molecule makes a copy of itself. This process is called **replication.** The bonds between the base pairs break. The strands begin to separate and unwind, like a zipper unzipping. Nitrogen bases in the nucleus bond to the bases on the single strands. The bases are added according to the rule that A always bonds with T and C always bonds with G. As the bases are added, the original molecule and the copy rewind, as shown below.

FIGURE 10
DNA Replication
The nuclear DNA in a cell must be copied before the cell can divide into two cells. Scientists use this process to multiply DNA samples.

Trace evidence often does not contain enough DNA to make a profile. A forensic scientist can use DNA replication to increase the amount of DNA. The scientist starts with the DNA that was isolated. He doesn't copy all the DNA. He copies only 13 segments of non-coding DNA.

Each time the segments are copied, the amount of DNA doubles. The process can be repeated again and again. In just an hour, a scientist can repeat the process about 30 times. If he does, he will have about a million times as much DNA as he had at the start.

Sorting DNA The result of the DNA "multiplication" is a mass of DNA fragments. These fragments need to be sorted to produce a visual profile. In one method, an electric field pulls the fragments through a thick gel. The fragments travel at different speeds depending on their length. The shorter fragments move more quickly than the longer fragments. The process produces a pattern of bands like the one in Figure 11.

Reading Checkpoint **What is replication?**

FIGURE 11
DNA Profile
The bands on this gel represent different DNA fragments. The DNA is stained so the bands are visible on the profile.

Probability

Some people refer to a DNA profile as a DNA "fingerprint." But most forensic scientists do not. They don't like to imply that a profile is unique the way a fingerprint is. It is possible that two people could have the same profile. It just isn't probable.

Probability is a measure of the chance that an event will happen. When you toss a coin, it can land heads up or tails up. The probability of either event is 1 in 2 or 50 percent. Suppose you select any two people in the world. Scientists can calculate the probability of their having the same number of repeats in a given DNA segment.

Here is an example. The DNA segment known as TH01 contains the base sequence A-A-T-G. There are 7 variations of TH01 with from 5 to 11 repeats. Figure 12 shows the one with 6 repeats and the one with 8 repeats. A person could inherit both variations. She could inherit the one with 6 repeats from her mother and the one with 8 repeats from her father. About 3.6 percent of people in the world have this combination.

Scientists often test at least 13 different segments. **As the number of segments tested increases, the probability of two people having the same DNA profile decreases.** What is the probability when 13 segments are tested? It is less than 1 in 500 trillion (500,000,000,000,000). With odds like this, courts are likely to accept DNA evidence.

Reading Checkpoint **What is the repeating base sequence in TH01?**

Go Online
SCILINKS NSTA

For: Links on DNA fingerprinting
Visit: www.SciLinks.org
Web Code: dan-1033

First segment

Second segment

Figure 12
DNA Variations
In one non-coding segment of DNA, the sequence A-A-T-G can repeat from 5 to 11 times.
Interpreting Diagrams *How many times does the sequence repeat in the first segment? How many times does it repeat in the second segment?*

Uses of DNA Profiles

DNA is rarely the only evidence in a case. But it is often the most persuasive evidence. **DNA profiles are used to connect a suspect to a crime. They also help solve cold cases, free the innocent, identify human remains, and protect endangered species.**

Connecting a Suspect to a Crime Newer methods for making DNA profiles are faster than earlier methods. But they are still expensive. So DNA profiles are used most often to solve very serious crimes. If police have a suspect, the lab can compare a profile of the suspect's DNA to one prepared with evidence from the crime scene. Figure 13 shows one way profiles are compared.

Police can also search for a suspect in a DNA database. Every state has a DNA database. These databases store profiles of offenders who were convicted of certain violent crimes. The profiles are stored as a series of numbers. So finding a match is a fairly quick process, if a match exists.

The FBI keeps a national database called CODIS. That stands for Combined DNA Index System. It has data from the 50 states, the armed forces, and the FBI. CODIS gives every crime lab access to more data. CODIS includes profiles of known offenders and missing persons. It also has data from forensic evidence.

Solving Cold Cases Not every case gets solved. The police may not have enough evidence or any good leads. If a case isn't solved within a year, the case may be filed away. Old, unsolved cases are known as **cold cases.** Many police departments have set up special units to look into cold cases.

Some crimes happened before DNA testing existed. Suppose police have biological evidence from a cold case. They could send the evidence to a lab and ask for a DNA profile. Adding the profile to a database could help solve the crime.

In Ohio, for instance, a man was sent to prison for a robbery. His DNA profile went into a database. It matched the profile of DNA found at the scene of an unsolved murder.

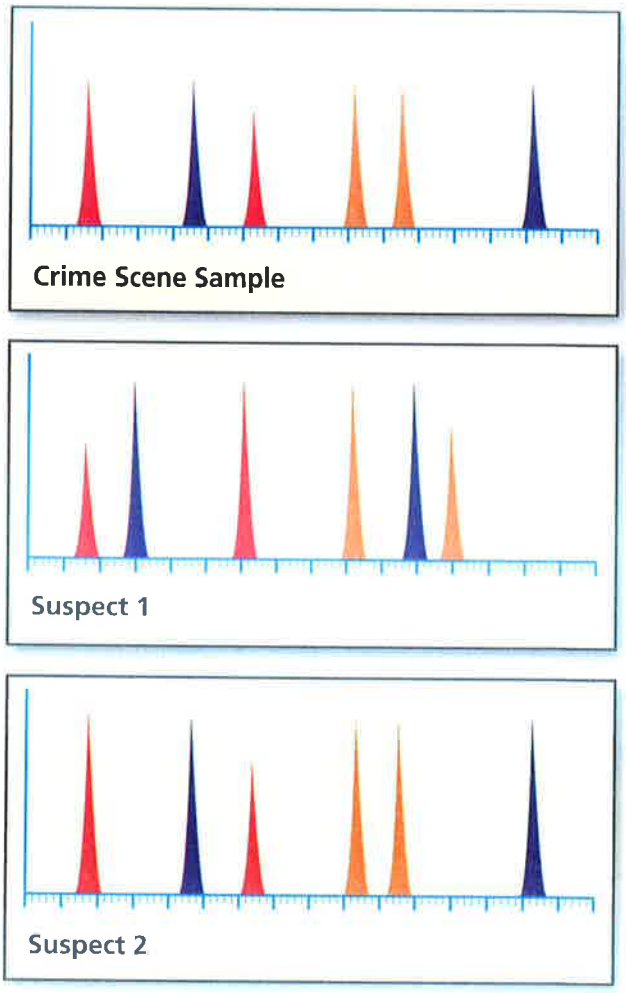


FIGURE 13
Comparing DNA Profiles
With one method for making DNA profiles, the result is a graph. Each peak on the graph represents a different DNA segment.
Interpreting Graphs *Look at the DNA profiles. Based on the profiles, was one of the suspects at the crime scene? Explain.*

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Forensic Science Video

DNA to the Rescue

Freeing the Innocent Many people who are in prison claim that they are innocent. Most are guilty of the crime for which they are being punished. Some, however, are innocent.

In 1992, some lawyers in New York City set up a free legal service. Its goal was to defend prisoners whose claims of innocence could be proven by DNA testing. The idea spread. Law students, journalism students, and lawyers who defend poor clients set up similar services in other states.

Sometimes a DNA test shows that a prisoner's claims of innocence are false. But many times, the evidence has helped free innocent people. In 1997, for instance, Ryan Matthews was accused of shooting a man during a robbery. He was found guilty and sentenced to death. In 2004, Matthews was released from prison. The key was DNA found on the inside of a ski mask left at the crime scene. The DNA profile matched the DNA profile of another man.

Identifying Human Remains Most DNA tests use nuclear DNA. But sometimes it is not possible to get DNA from the nucleus. Some cells don't have a nucleus. Also, nuclear DNA can be damaged when a body decays or is burned.

To identify human remains, scientists can turn to DNA that is found outside the nucleus. This DNA, which is found in all cells, comes only from a person's mother. It is more abundant than nuclear DNA and is less likely to decay. This method was used to identify the bones of Tsar Nicholas II. Figure 14 shows the tsar, his wife, and their children. They were all murdered in 1918 during the Russian Revolution.

Reading Checkpoint **How did DNA testing free Ryan Matthews?**

FIGURE 14
Tsar Nicholas II and His Family
After the family was murdered, their bodies were thrown into a pit and covered with acid. Their bones were dug up in 1991.
Applying Concepts *Why did scientists have to use DNA from outside the nucleus to identify the bones?*

Protecting Endangered Species DNA is not just used to identify human beings. It can be used to identify other species. Some species have been classified as endangered. An **endangered species** is a species whose numbers are so small that the species may disappear from the world.

Some people work hard to protect endangered species. But other people try to use them to make a profit. They may sell protected animals to restaurants. Or they sell specific parts of an animal's body—an elephant's tusk or the skin from a tiger like the one in Figure 15. Some people will buy rare animals, especially birds, to keep as pets.

How can DNA tests help? In Florida, scientists were able to show that the "tuna" on some restaurant menus was really sailfish. Sailfish is protected by federal law. Tests also showed that whale meat being sold in Japan came from species that were protected by international law.

FIGURE 15
Endangered Tigers
Bengal tigers are an endangered species. If a person tried to sell the skin of this tiger, a DNA test could prove that the person had committed a crime.

Lesson 3 Assessment

Target Reading Skill Sequencing Use your flowchart to help you answer Question 2.

Reviewing Key Concepts

1. a. Describing What is the general structure of a DNA molecule?
   b. Summarizing How is the information your cells need stored in a DNA molecule?
   c. Applying Concepts Do a child and a parent have the same nuclear DNA? Explain your answer.
2. a. Describing What feature of non-coding DNA do scientists use to make a DNA profile?
   b. Sequencing List the four general steps scientists follow to obtain a DNA profile.
   c. Relating Cause and Effect What property determines which DNA fragments travel most quickly through a thick gel?
3. a. Explaining Why do scientists use 13 DNA segments instead of just one segment to make a DNA profile?
   b. Summarizing How do forensic scientists use DNA profiles?
   c. Problem Solving Scientists have a DNA profile for a suspect. What are two ways they can use the profile to connect the suspect to a crime?

Math Practice

4. Probability There are 7 variations of DNA segment TH01. A person inherits one from each parent. Figure out how many possible combinations there are of two variations. Then show why the probability of having any one combination is about 3.6 percent.