UNIT 9

DNA and Modern Genetics

This crop of soybeans has been genetically modified to make them herbicide resistant.

FLORIDA BIG IDEA 16

Heredity and Reproduction

What Do You Think?

We can change the genetic make up of organisms to have traits that we desire, such as better flavor or nutrition. Should foods from genetically modified organisms be labeled accordingly? As you explore this unit, find evidence to make and support a claim.

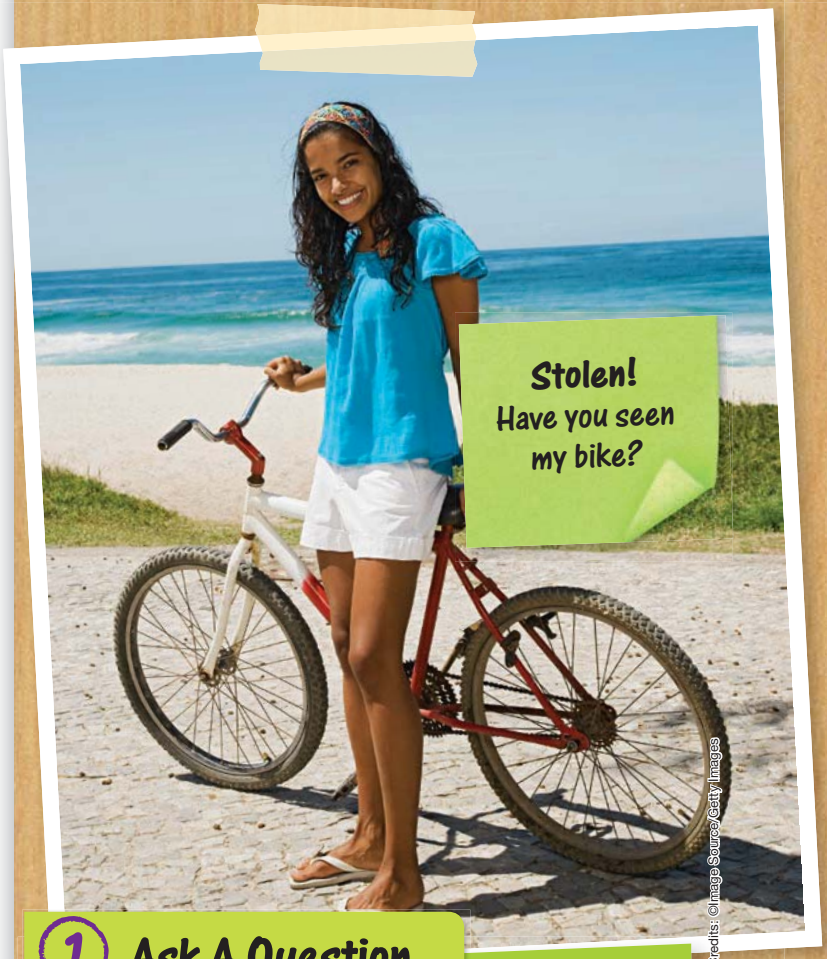
UNIT 9

DNA and Modern Genetics

CITIZEN **SCIENCE**

Solved with Forensics

Modern crime labs use genetics, the study of how traits are inherited, to interpret evidence found at the scene of a crime. In the following scenario, a bike has been stolen and you will use genetic evidence to figure out what happened.



1 Ask A Question

What should a detective at a crime scene look for?

Determine what types of evidence a detective could find at a crime scene. Consider that some evidence might be microscopic! In this case, you have found an empty juice box and a lock of hair.

2 Think About It

List some of the traits (like fingerprints) that are unique to every individual.

What biological evidence might be found on the juice box and lock of hair left behind at the crime scene? What could they tell you about the crime?

3 Apply Your Knowledge

A The hair sample you gathered is in a sealed bag. Why is it important to protect samples?

B When lab technicians analyze DNA, it doesn't have a name on it. How can you match your sample to an individual and solve the crime?

C Can forensics determine for sure that the person identified by the evidence committed the crime? Explain your reasoning.

Take It Home!

Find out how DNA forensics is applied in our justice system. How accurate is it? Has it been used to reverse any court decisions or overturn any convictions?

LESSON 1

DNA Structure and Function

ESSENTIAL **QUESTION**

What is DNA?

By the end of this lesson, you should be able to describe the structure and main functions of DNA.

SC.7.N.1.1 Define a problem from the curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.
SC.7.L.16.1 Understand and explain that every organism requires a set of instructions that specifies its traits, that this hereditary information (DNA) contains genes located in the chromosomes of each cell, and that heredity is the passage of these instructions from one generation to another.
HE.7.C.1.3 Analyze how environmental factors affect personal health.

Lesson Labs

Quick Labs
- Modeling DNA
- Mutations Cause Diversity

Exploration Lab
- Extracting DNA

Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

T	F	
☐	☐	DNA is found in the cells of all living things.
☐	☐	All DNA mutations are harmful.
☐	☐	The cell can make copies of its DNA.

2 Describe DNA is sometimes called the *blueprint of life*. Why do you think that is?

ACTIVE READING

3 Synthesize Many English words have their roots in other languages. Use the Latin words below to make an educated guess about the meanings of the words *replication* and *mutation*.

Latin word	Meaning
mutare	to change
replicare	to repeat

Example sentence
DNA can undergo mutation.

mutation:

Example sentence
Before cell division, DNA replication occurs.

replication:

Vocabulary Terms

- **DNA**
- **mutation**
- **nucleotide**
- **RNA**
- **replication**
- **ribosome**

4 Identify This list contains the key terms you'll learn in this lesson. As you read, circle the definition of each term.

Cracking the CODE

A T T A G C G A T C A C T A A A T T A G C G A

ACTIVE READING

5 Identify As you read, underline the meaning of the word *code*.

What is DNA?

The genetic material of a cell contains information needed for the cell's growth and other activities. It also determines the inherited characteristics of an organism. The genetic material in cells is contained in a molecule called deoxyribonucleic (dee•OK•see•ry•boh•noo•KLAY•ik) acid, or **DNA** for short. You could compare the information in DNA to the books in your local library. You might find a book describing how to bake a cake or complete your favorite video game. The books, however, don't actually do any of those things—you do. Similarly, the "books" that make up the DNA "library" carry the information that a cell needs to function, grow, and divide. However, DNA doesn't do any of those things. Proteins do most of the work of a cell and also make up much of the structure of a cell.

Scientists describe DNA as containing a code. A *code* is a set of rules and symbols used to carry information. For example, your computer uses a code of ones and zeroes that is translated into numbers, letters, and graphics on a computer screen. To understand how DNA functions as a code, you first need to learn about the structure of the DNA molecule.

DNA Timeline

Review this timeline to learn about some of the important scientific contributions to our understanding of DNA.

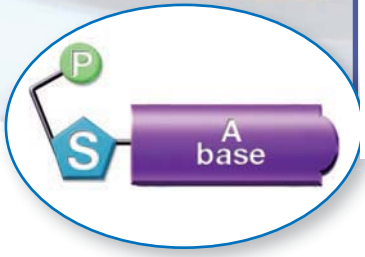
1875

1869 Friedrich Miescher identifies a substance that will later be known as DNA.

1900

1919 Phoebus Levene publishes a paper on nucleic acids. His research helps scientists determine that DNA is made up of sugars, phosphate groups, and four nitrogen-containing bases: adenine, thymine, guanine, and cytosine. Bases are often referred to by their first letter: A, T, C, or G. Each base has a different shape.

1925



6 Support Your Claim In this model, what do *P*, *S*, and *A bases* represent?

_____

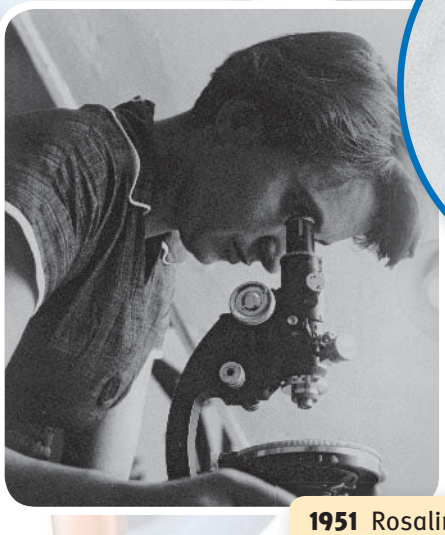
_____

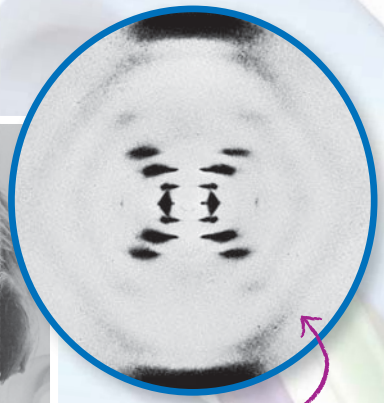
How was DNA discovered?

The discovery of the structure and function of DNA did not happen overnight. Many scientists from all over the world contributed to our current understanding of this important molecule. Some scientists discovered the chemicals that make up DNA. Others learned how these chemicals fit together. Still others determined the three-dimensional structure of the DNA molecule. The timeline below shows some of the key steps in this process of discovery.

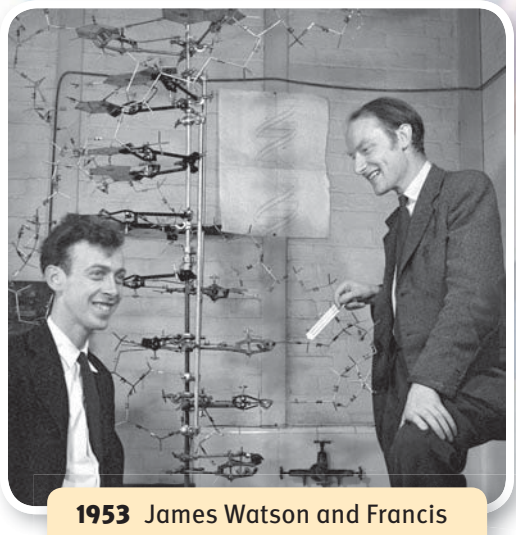
Think Outside the Book

7 Research Use the Internet or library resources to research a scientist who contributed to the discovery of DNA. Then, create a poster about the scientist. Share your findings with your class.





An image of DNA produced by using x-rays.



1951 Rosalind Franklin and Maurice Wilkins make images of DNA using x-rays. When an x-ray passes through the molecule, the ray bends and creates a pattern that is captured on film.

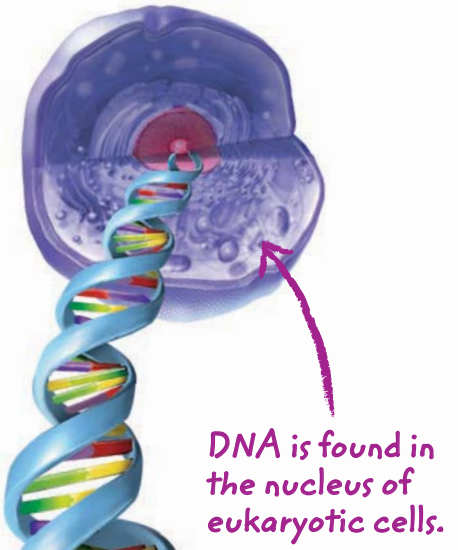
1953 James Watson and Francis Crick use Chargaff's rules and the x-ray images of DNA to conclude that DNA looks like a long, twisted ladder. They build a large-scale model of DNA using simple materials from their laboratory.

1950 — 1975

1950 Erwin Chargaff observes that the amount of guanine always equals the amount of cytosine, and the amount of adenine equals the amount of thymine. His findings are now known as *Chargaff's rules*.

1952 Alfred Hershey and Martha Chase perform experiments with viruses to confirm that DNA, not proteins, carries genetic information.

Unraveling DNA



DNA is found in the nucleus of eukaryotic cells.

What does DNA look like?

The chemical components that make up DNA are too small to be observed directly. But experiments and imaging techniques have helped scientists to infer the shape of DNA and the arrangement of its parts.

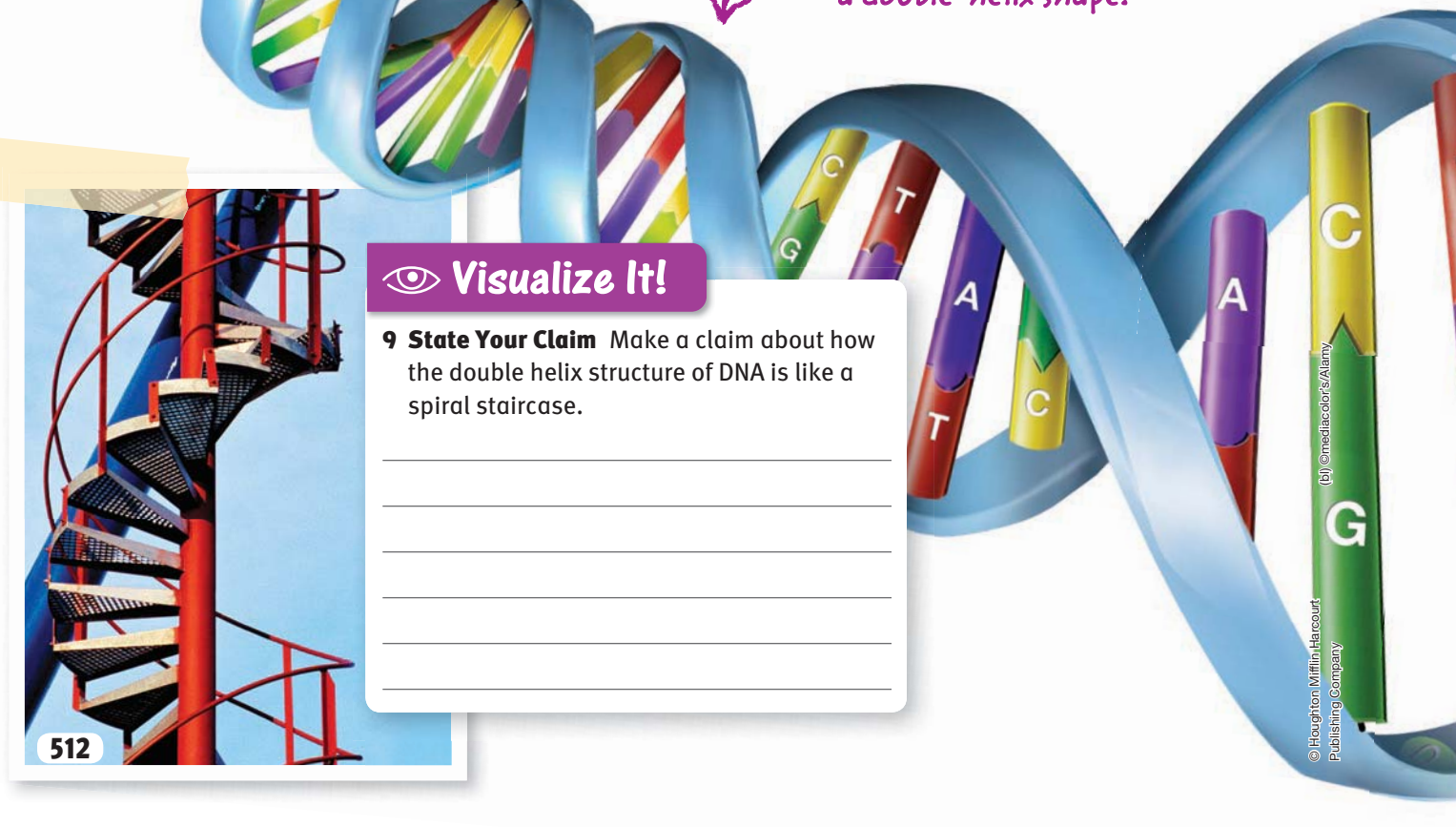
The Shape of DNA Is a Double Helix

The structure of DNA is a twisted ladder shape called a *double helix*. The two sides of the ladder, often referred to as the DNA backbone, are made of alternating sugars and phosphate groups. The rungs of the ladder are made of a pair of bases, each attached to one of the sugars in the backbone.

ACTIVE READING

8 Describe Where are phosphate groups found in a DNA molecule?

The DNA molecule has a double-helix shape.



Visualize It!

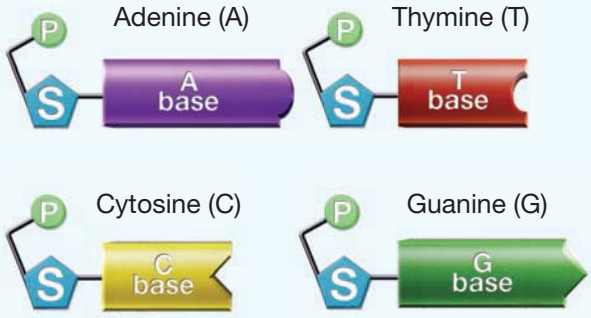
9 State Your Claim Make a claim about how the double helix structure of DNA is like a spiral staircase.

DNA Is Made Up of Nucleotides

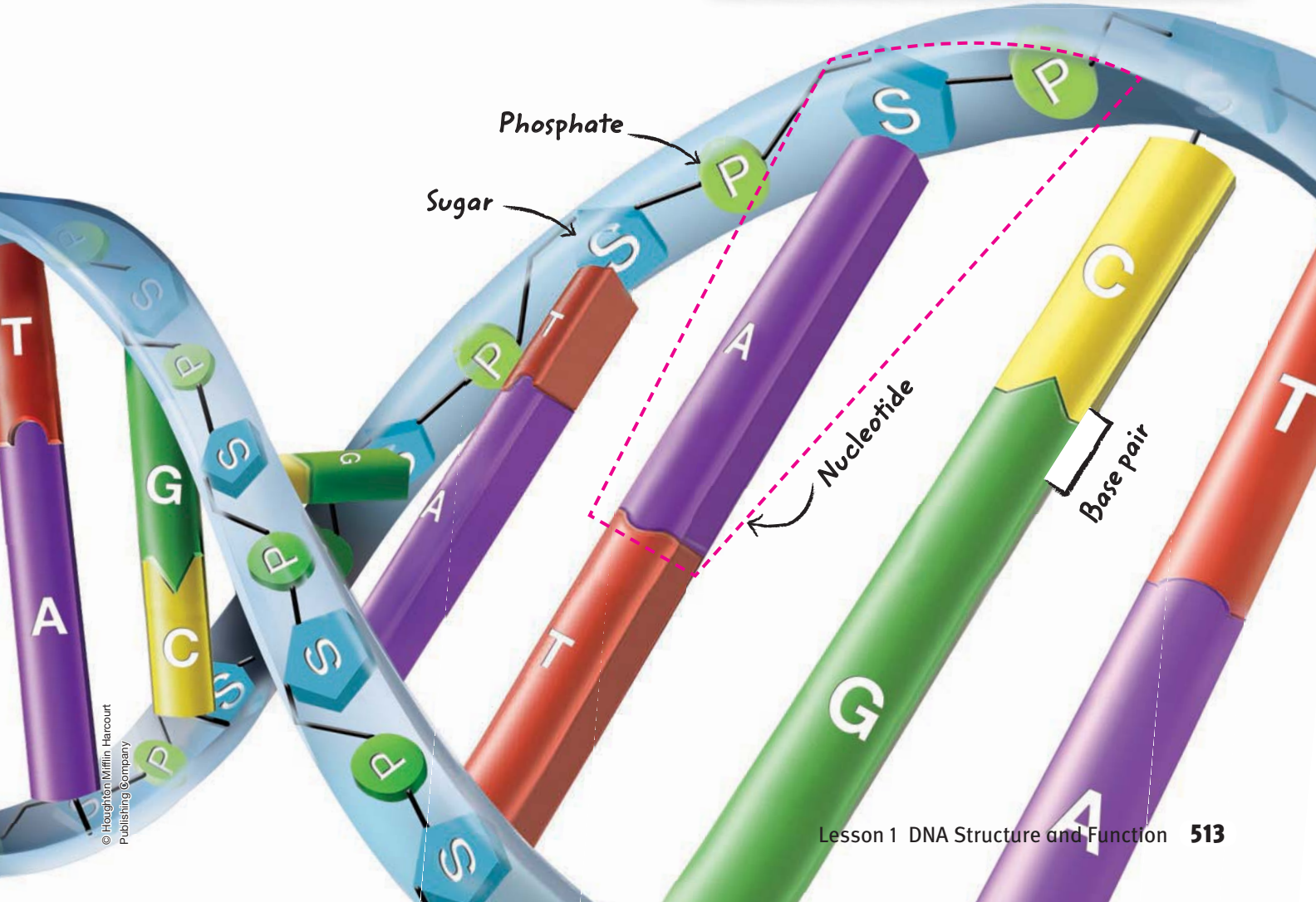
A base, a sugar, and a phosphate group make a building block of DNA known as a **nucleotide**. These repeating chemical units join together to form the DNA molecule. There are four different nucleotides in DNA, identified by their bases: adenine (A), thymine (T), cytosine (C), and guanine (G). Because of differences in size and shape, adenine always pairs with thymine (A-T) and cytosine always pairs with guanine (C-G). These paired, or *complementary,* bases fit together like two pieces of a puzzle.

The order of the nucleotides in DNA is a code that carries information. The DNA code is read like a book. *Genes* are segments of DNA that relate to a certain trait. Each gene has a starting point and an ending point, with the DNA code being read in one direction. The bases A, T, C, and G form the alphabet of the code. The code stores information about which proteins the cells should build. The types of proteins your body makes help to determine your traits.

10 Apply Place boxes around the bases that pair with each other.



11 Devise The bases are often referred to simply by their initials—A, T, C, and G. The phrase "all tigers can growl" may help you remember them. Think of another phrase that uses words starting with A, T, C, and G that could help you remember the bases. Write your phrase below.



Replication and

How are copies of DNA made?

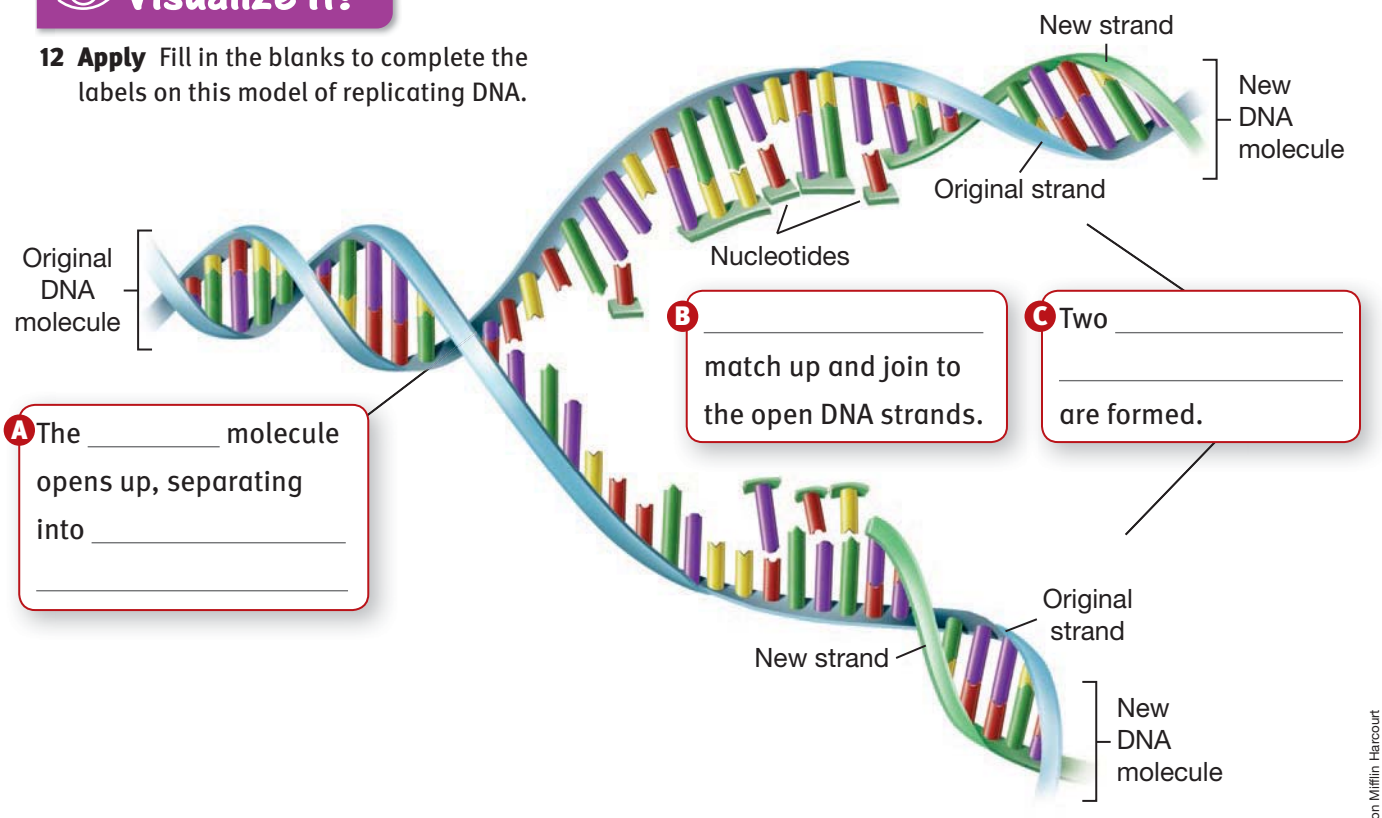
The cell is able to make copies of DNA molecules through a process known as **replication**. During replication, the two strands of DNA separate, almost like two threads in a string being unwound. The bases on each side of the molecule are used as a pattern for a new strand. As the bases on the original molecule are exposed, complementary nucleotides are added. For example, an exposed base containing adenine attaches to a nucleotide containing thymine. When replication is complete, there are two identical DNA molecules. Each new DNA molecule is made of one strand of old DNA and one strand of new DNA.

When are copies of DNA made?

Before a cell divides, it copies the DNA so that each new daughter cell will have a complete set of instructions. Our cells can replicate DNA in just a few hours. How? Replication begins in many places along the DNA strand. So, many groups of proteins are working to replicate your DNA at the same time.

Visualize It!

12 Apply Fill in the blanks to complete the labels on this model of replicating DNA.



Mutation

What are mutations?

Changes in the number, type, or order of bases on a piece of DNA are known as **mutations**. Sometimes, a base is left out. This kind of change is known as a *deletion.* Or, an extra base might be added. This kind of change is an *insertion.* The most common mutation happens when one base replaces another. This kind of change is known as a *substitution.*

How do mutations happen? Given the large number of bases in an organism's DNA, it is not surprising that random errors can occur during replication. However, DNA can also be damaged by physical or chemical agents called *mutagens.* Ultraviolet light and the chemicals in cigarette smoke are examples of mutagens.

Cells make proteins that can fix errors in DNA. But sometimes a mistake isn't corrected, and it becomes part of the genetic code. Mutations to DNA may be beneficial, neutral, or harmful. A *genetic disorder* results from mutations that harm the normal function of a cell. Some of these disorders, such as Tay-Sachs disease and sickle-cell anemia, are *inherited*, or passed on from parent to offspring. Other genetic disorders result from mutations that occur during a person's lifetime. Most cancers fall into this category.

Visualize It!

13 Apply Place a check mark in the box to indicate which type of mutation is being shown.

Original sequence

A

☐ deletion ☐ insertion ☐ substitution

B

☐ deletion ☐ insertion ☐ substitution

C

☐ deletion ☐ insertion ☐ substitution

This snake has albinism, a condition in which the body cannot make the pigments that give color to the skin and eyes.

14 Claims • Evidence • Reasoning Albinism is an inherited genetic disorder. Make a claim about what traits you would see in the offspring of this snake. Summarize evidence to support the claim and explain your reasoning.

_____

_____

_____

_____

Protein Factory

What is the role of DNA and RNA in building proteins?

Imagine that you are baking cookies. You have a big cookbook that contains the recipe. If you take the book with you into the kitchen, you risk damaging the book and losing important instructions. You only need one page from the book, so you copy the recipe on a piece of paper and leave the cookbook on the shelf. This process is similar to the way that the cell uses DNA to build proteins. First, some of the information in the DNA is copied to a separate molecule called ribonucleic acid, or **RNA**. Then, the copy is used to build proteins. Not all the instructions are needed all the time. In eukaryotes, the DNA is protected inside the cell's nucleus.

Like DNA, RNA has a sugar-phosphate backbone and the bases adenine (A), guanine (G), and cytosine (C). But instead of thymine (T), RNA contains the base uracil (U). Also, the sugar found in RNA is different from the one in DNA. There are three types of RNA: messenger RNA, ribosomal RNA, and transfer RNA. Each type of RNA has a special role in making proteins.

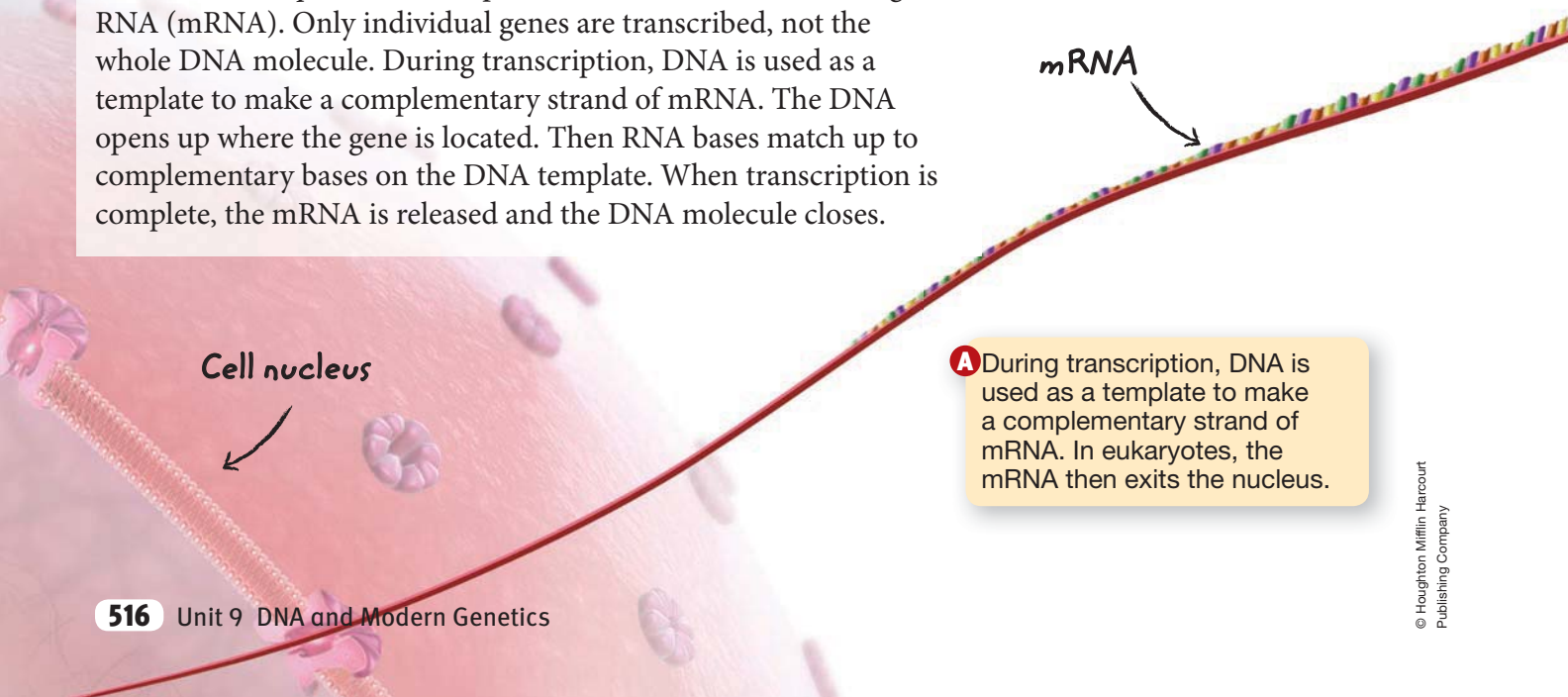
RNA uses the genetic information stored in DNA to build proteins.

ACTIVE READING

15 Identify As you read, number the sentences that describe the steps of transcription.

Transcription: The Information in DNA Is Copied to Messenger RNA

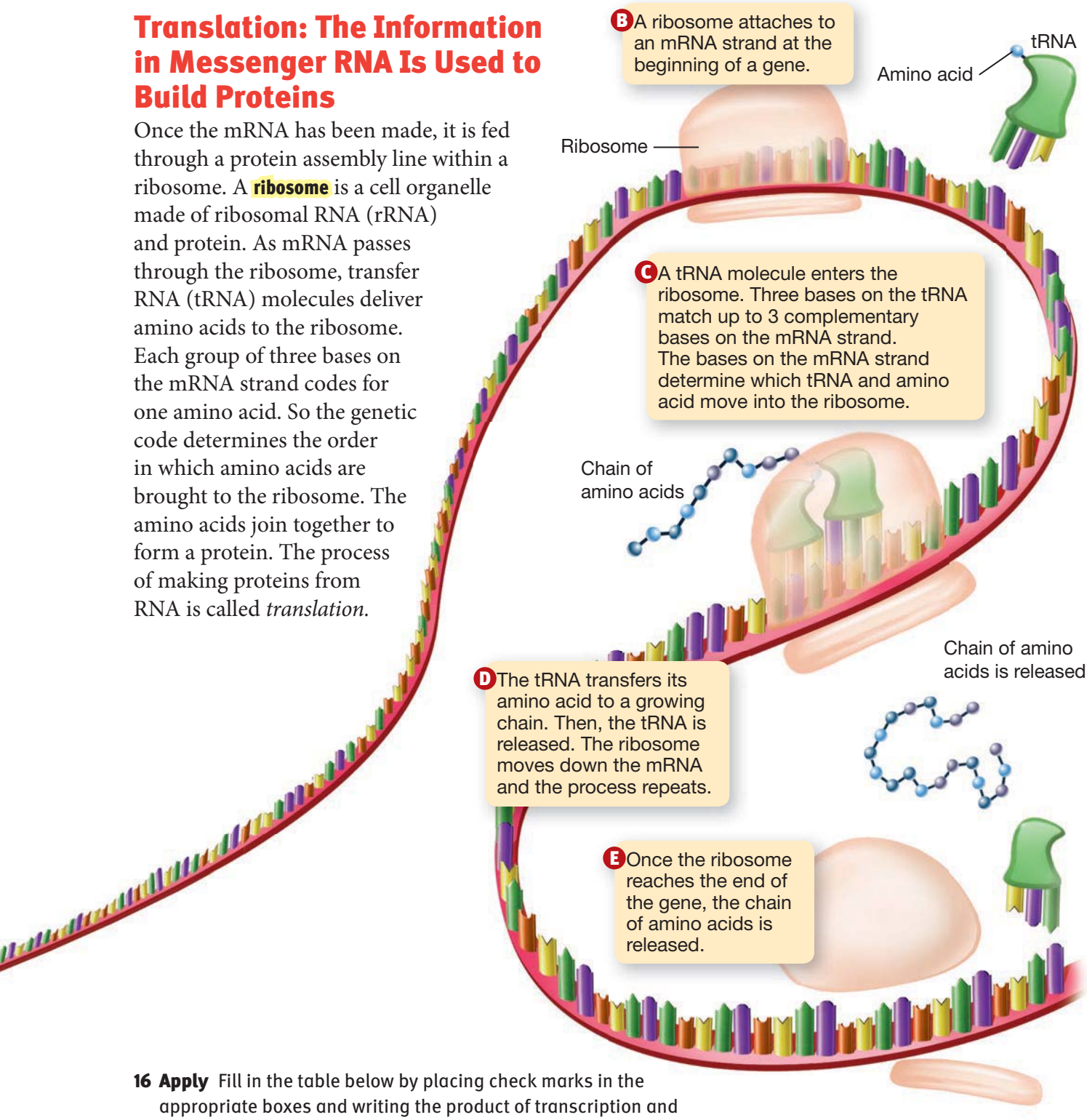
When a cell needs a set of instructions for making a protein, it first makes an RNA copy of the necessary section of DNA. This process is called *transcription*. Transcription involves DNA and messenger RNA (mRNA). Only individual genes are transcribed, not the whole DNA molecule. During transcription, DNA is used as a template to make a complementary strand of mRNA. The DNA opens up where the gene is located. Then RNA bases match up to complementary bases on the DNA template. When transcription is complete, the mRNA is released and the DNA molecule closes.



A During transcription, DNA is used as a template to make a complementary strand of mRNA. In eukaryotes, the mRNA then exits the nucleus.

Translation: The Information in Messenger RNA Is Used to Build Proteins

Once the mRNA has been made, it is fed through a protein assembly line within a ribosome. A **ribosome** is a cell organelle made of ribosomal RNA (rRNA) and protein. As mRNA passes through the ribosome, transfer RNA (tRNA) molecules deliver amino acids to the ribosome. Each group of three bases on the mRNA strand codes for one amino acid. So the genetic code determines the order in which amino acids are brought to the ribosome. The amino acids join together to form a protein. The process of making proteins from RNA is called *translation*.



16 Apply Fill in the table below by placing check marks in the appropriate boxes and writing the product of transcription and translation.

Process	What molecules are involved?	What is the product?
Transcription	☐ DNA ☐ mRNA ☐ tRNA ☐ ribosome	
Translation	☐ DNA ☐ mRNA ☐ tRNA ☐ ribosome	

Visual Summary

To complete this summary, fill in the blanks with the correct word or phrase. You can use this page to review the main concepts of the lesson.

DNA Structure and Function

DNA has a double-helix shape and is made up of nucleotides.

17 The four bases in DNA nucleotides are _____

The cell can make copies of DNA.

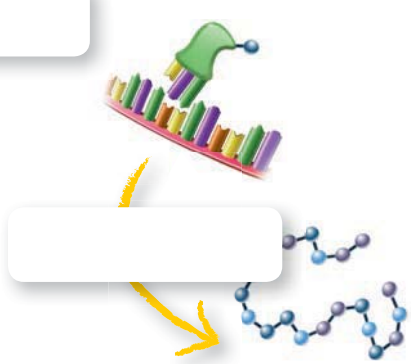
18 DNA replication happens before cells _____

DNA can mutate.

19 Three types of DNA mutations are _____

DNA and RNA are involved in making proteins.

20 The two processes involved in making proteins from the DNA code are _____



21 Claims • Evidence • Reasoning Make a claim about how a mutation in the DNA could affect the proteins made by the cell. Summarize evidence to support the claim and explain your reasoning.

Lesson Review

LESSON 1

Vocabulary

In your own words, define the following terms.

1 A(n) _____ of DNA consists of a sugar, a phosphate, and a nitrogen-containing base.

2 A(n) _____ is a change in the base sequence of a DNA molecule.

Key Concepts

Draw a line to connect the following scientists to their contributions to our understanding of DNA.

3 Erwin Chargaff	**A** took x-ray images of DNA molecule
4 Rosalind Franklin and Maurice Wilkins	**B** proposed a double-helix model of DNA
5 James Watson and Francis Crick	**C** found that the amount of adenine equals the amount of thymine and that the amount of guanine equals the amount of cytosine

6 Identify How does the structure of RNA differ from the structure of DNA?

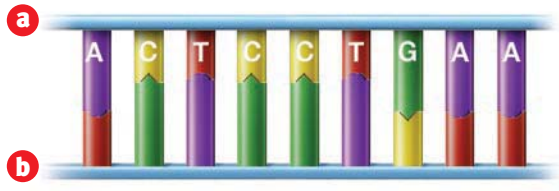
7 Identify When does DNA replication occur?

8 Describe Name the three types of RNA and list their roles in making proteins.

9 Identify What can cause DNA mutations?

Critical Thinking

Use this diagram to answer the following questions.



10 Describe What is the sequence of bases on DNA strand *b*, from left to right?

11 Apply This segment of DNA is transcribed to form a complementary strand of mRNA. The mRNA then undergoes translation. How many amino acids would the RNA code for?

12 Claims • Evidence • Reasoning After many cell divisions, a segment of DNA has more base pairs than it originally did. Make a claim about how this could happen. Summarize evidence to support the claim and explain your reasoning.

13 Explain Your Reasoning Why must DNA replicate?

SC.7.N.1.1 Define a problem from the curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions. **SC.7.N.1.4** Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.

Identifying Variables

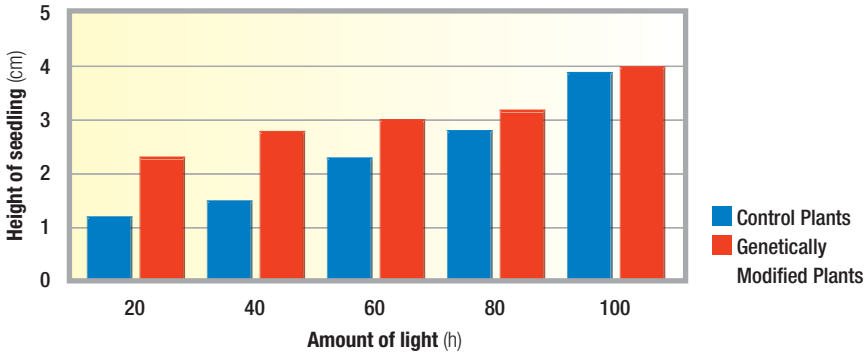
When you are analyzing or designing a scientific experiment, it is important to identify the variables in the experiment. Usually, an experiment is designed to discover how changing one variable affects another variable. In a scientific investigation, the independent variable is the factor that is purposely changed. The dependent variable is the factor that changes in response to the independent variable.

Tutorial

Use the following strategies to help you identify the variables in an experiment.

Summary: We genetically modified corn plants to increase growth in low-light conditions.

Effect of Genetic Modifications on Corn Seedling Growth

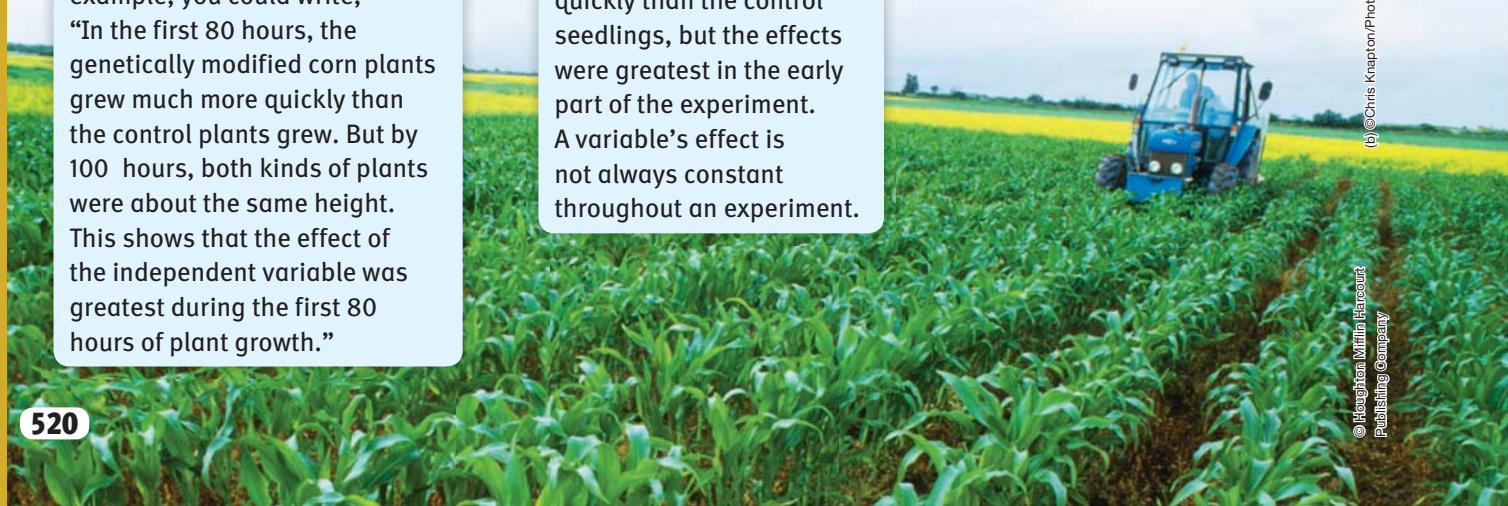


Reading a Summary The published results of an experiment usually include a brief summary. You should be able to identify the variables from it. In the summary to the left, the independent variable is the DNA of the corn plants, and the dependent variable is the height of the plants.

Analyzing a Graph Making a graph can be a very effective way to show the relationship between variables. For a bar graph, the independent variable is usually shown on the *x*-axis, or the horizontal axis. The dependent variable is usually shown on the *y*-axis, or the vertical axis.

Describing the Data When you read a graph, describing the information in complete sentences can help you to identify the variables. For example, you could write, "In the first 80 hours, the genetically modified corn plants grew much more quickly than the control plants grew. But by 100 hours, both kinds of plants were about the same height. This shows that the effect of the independent variable was greatest during the first 80 hours of plant growth."

Identifying the Effects of Variables Look closely at the graph. Notice that the genetically modified seedlings grew more quickly than the control seedlings, but the effects were greatest in the early part of the experiment. A variable's effect is not always constant throughout an experiment.



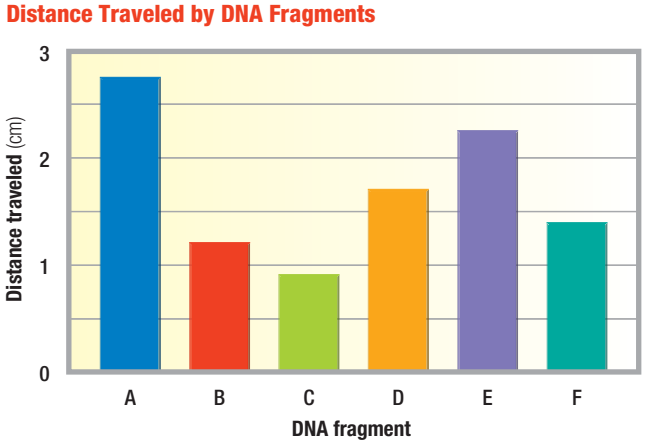
You Try It!

The passage below describes the process of gel electrophoresis. Use the description to answer the question that follows.

During gel electrophoresis, DNA is broken into separate fragments. These fragments are added to a gel. When an electric current is applied to the gel, the fragments travel different distances through the gel. The size of the DNA fragments determines how far they travel. Smaller fragments travel farther than larger fragments do. Scientists can use these data to identify unknown samples of DNA.

1 Reading a Summary Identify the variables described in the passage.

The graph below shows the results of DNA analysis using gel electrophoresis. Look at the graph, and answer the questions that follow.



2 Analyzing a Graph Which variables are shown in the graph? Circle the axis that shows the dependent variable.

3 Analyzing the Data What is the relationship between the size of the DNA fragments and the distance they traveled? Circle the DNA fragment that is the smallest.

4 Applying Mathematics Calculate the average distance that the DNA fragments traveled. How much farther than the average distance did the smallest DNA fragment travel?

5 Claims • Evidence • Reasoning Why is it important to limit the number of variables in an experiment? Summarize evidence to support a claim and explain your reasoning.

Take It Home!

With an adult, plan and conduct a simple experiment that includes an independent variable and a dependent variable. Record your results and graph your data if possible. Then share your results with the class.

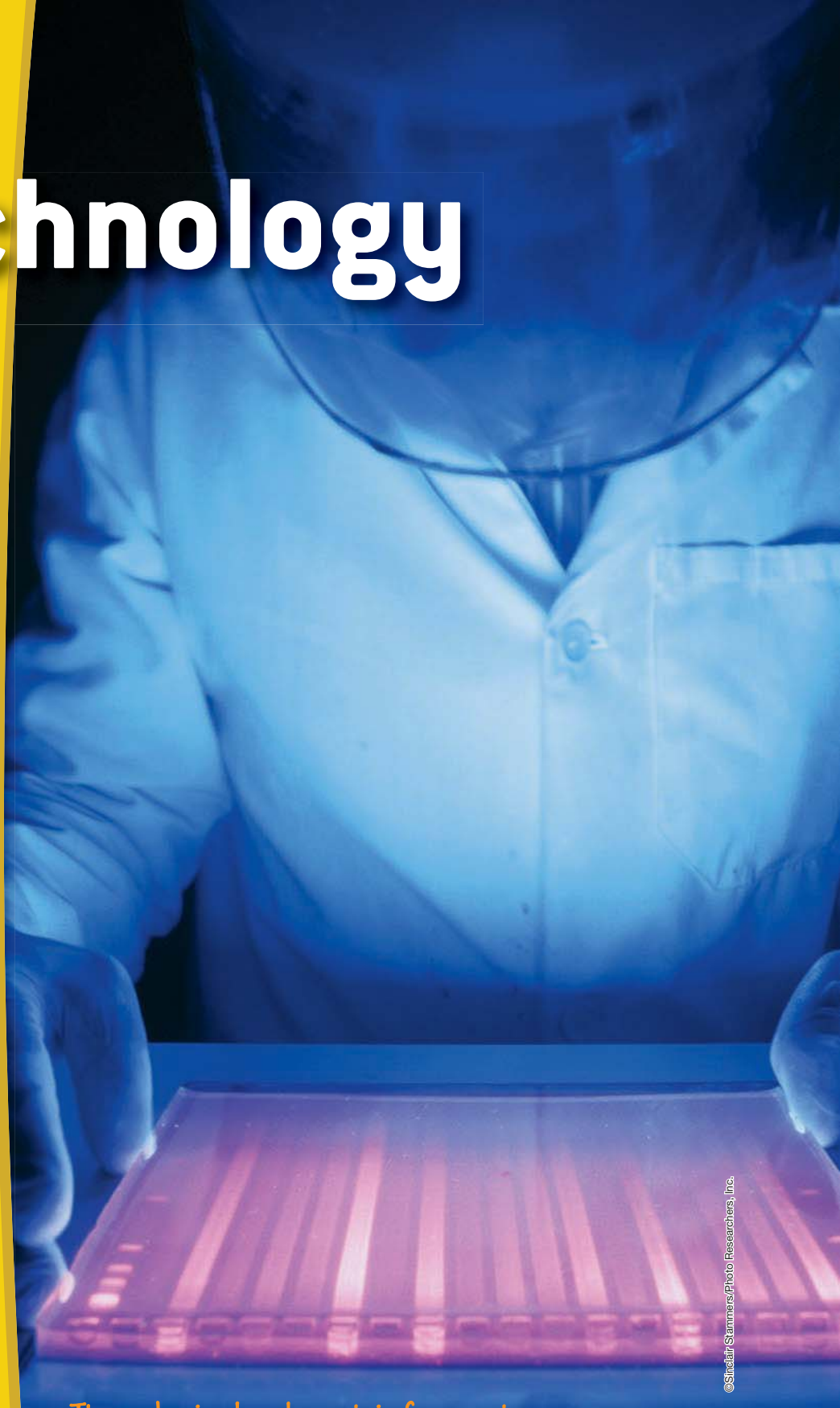
LESSON 2

Biotechnology

ESSENTIAL **QUESTION**

How does biotechnology impact our world?

By the end of this lesson, you should be able to explain how biotechnology impacts human life and the world around us.



These glowing bands contain fragments of DNA that have been treated with a special chemical. This chemical glows under ultraviolet light, allowing scientists to see the DNA.

SC.7.L.16.4 Recognize and explore the impact of biotechnology (cloning, genetic engineering, artificial selection) on the individual, society and the environment.

Lesson Labs

Quick Labs

- Matching Codes
- How Can a Simple Code Be Used to Make a Product?

Engage Your Brain

1 Predict Fill in the blanks with the word or phrase you think correctly completes the following sentences.

A medical researcher might study DNA in order to learn _____

_____

_____

A crime scene investigator might study DNA in order to learn _____

_____

_____

2 Apply *GMO* stands for "genetically modified organism." Write a caption to accompany the following photo.

_____

_____

_____

ACTIVE READING

3 Apply Use context clues to write your own definition for the words *inserted* and *technique*.

Example sentence
Using special technologies, a gene from one organism can be inserted into the DNA of another.

inserted:

_____

_____

Example sentence
Cloning is a technique in which the genetic information of an organism is copied.

technique:

_____

_____

Vocabulary Terms

- **biotechnology**
- **artificial selection**
- **genetic engineering**
- **clone**

4 Apply As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.

BioTECHNOLOGY

Protective clothing keeps this geneticist safe as he works with infectious particles.

This scientist works inside of a greenhouse. He breeds potato plants.

What is biotechnology?

A forensic scientist makes copies of DNA from a crime scene. A botanist breeds flowers for their bright red blooms. A geneticist works to place a human gene into the DNA of bacteria. What do these processes have in common? They are all examples of biotechnology. **Biotechnology** is the use and application of living things and biological processes. In the past 40 years, new technologies have allowed scientists to directly change DNA. But biotechnology is not a new scientific field. For thousands of years, humans have been breeding plants and animals and using bacteria and yeast to ferment foods. These, too, are examples of biotechnology.

Think Outside the Book

5 Research Research careers in biotechnology. Choose a career that you might like to have and share it with your class. You may choose to present your findings in one of the following ways:

- a poster
- a computer presentation
- a play
- a short essay

ACTIVE READING

6 Identify Name three examples of biotechnology.

_____

_____

_____

Different dog breeds are produced by artificial selection.

What are some applications of biotechnology?

Biotechnology processes fall into some broad categories. Artificial selection, genetic engineering, and cloning are some of the most common techniques.

Artificial Selection

For thousands of years, humans have been carefully selecting and breeding certain plants and animals that have desirable traits. Over many generations, horses have gotten faster, pigs have gotten leaner, and corn has become sweeter. **Artificial selection** is the process of selecting and breeding organisms that have certain desired traits. Artificial selection is also known as *selective breeding*.

Artificial selection can be successful as long as the desirable traits are controlled by genes. Animal and plant breeders select for alleles, which are different versions of a gene. The alleles being selected must already be present in the population. People do not change DNA during artificial selection. Instead, they cause certain alleles to become more common in a population. The different dog breeds are a good example of artificial selection. All dogs share a common ancestor, the wolf. However, thousands of years of selection by humans have produced dogs with a variety of characteristics.

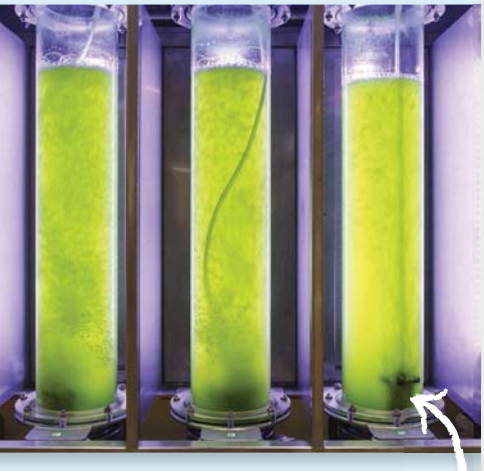
Visualize It!

These vegetables have been developed through artificial selection. Their common ancestor is the mustard plant.

7 Claims • Evidence • Reasoning Why might farmers use artificial selection to develop different types of vegetables? Make a claim, summarize evidence to support the claim, and explain your reasoning.

Genetic Engineering

Within the past 40 years, it has become possible to directly change the DNA of an organism. **Genetic engineering** is the process in which a piece of DNA is modified for use in research, medicine, agriculture, or industry. The DNA that is engineered often codes for a certain trait of interest. Scientists can isolate a segment of DNA, change it in some way, and return it to the organism. Or, scientists can take a segment of DNA from one species and transfer it to the DNA of an organism from another species.



Scientists have engineered algal cells to contain more energy-storing fats. As a result, they may serve as a biofuel alternative to fossil fuels in the future.

ACTIVE READING

8 Describe For what purposes can genetic engineering be used?

These genetically modified plant cells produce tiny, biodegradable plastic pellets. The pellets are then collected to make plastic products.

9 Claims • Evidence • Reasoning Traditional plastics are made from petroleum, a nonrenewable resource. Make a claim about the benefits of plastic made by plants over traditional plastic. Summarize evidence to support the claim, and explain your reasoning.

Cloning

A **clone** is an organism, cell, or piece of genetic material that is genetically identical to the one from which it was derived. Cloning has been used to make copies of small traces of DNA found at crime scenes or on ancient artifacts. Also, cloning can be used to copy segments of DNA for genetic engineering.

In 1996, scientists cloned the DNA from one sheep's body cell to produce another sheep named Dolly. The ability to clone a sheep, which is a mammal, raised many concerns about the future uses of cloning, because humans are also mammals. It is important that people understand the science of genetics. Only then can we make informed decisions about how and when the technology should be used.

Dolly was cloned from a body cell of an adult sheep.

10 Apply Review each of the examples of biotechnology below. Then classify each as artificial selection, genetic engineering, or cloning.

	Scientists have introduced a gene to the DNA of these fish that causes the fish to glow.	☐ artificial selection ☐ genetic engineering ☐ cloning
	A scientist is gathering DNA from clothing found at a crime scene. Then many copies of the DNA sample will be made. This will allow the scientist to better study the DNA. Then the scientist might be able to confirm the identity of the person at the crime scene.	☐ artificial selection ☐ genetic engineering ☐ cloning
	Wild carrots have thin, white roots. Over time, carrot farmers have selected carrots that have thick, bright orange roots.	☐ artificial selection ☐ genetic engineering ☐ cloning
	Diabetes can be treated in some people with injections that contain the hormone insulin. The gene responsible for producing insulin in humans has been inserted into the DNA of bacteria. These bacteria then produce the human insulin that is used in the injection.	☐ artificial selection ☐ genetic engineering ☐ cloning

Feel the **IMPACT!**

How does biotechnology impact our world?

Scientists are aware that there are many ethical, legal, and social issues that arise from the ability to use and change living things. Biotechnology can impact both our society and our environment. We must decide how and when it is acceptable to use biotechnology. The examples that follow show some concerns that might be raised during a classroom debate about biotechnology.

11 Evaluate Read the first two examples of biotechnology and what students had to say about their effects on individuals, society, and the environment. Then complete Example 3 by filling in questions or possible effects of the technology.

Example 1

Editing Genes

Many diseases are caused by harmful bacteria. Antibiotics are substances that fight bacteria. Over time, however, many bacteria undergo changes that make them resistant to antibiotics. Scientists are using a technology known as CRISPR to change, or edit, the genes of organisms. By altering the DNA of bacteria such as those shown, scientists may be able to cause harmful bacteria to destroy their own genes.

Effects on Individuals and Society

"If harmful bacteria can be engineered to destroy their own DNA, many lives could be saved."

Effects on Environment

"While targeting one organism, other changes might arise that have unpredictable effects on other organisms."

Think Outside the Book

12 Claims • Evidence • Reasoning As a class, choose a current event that involves biotechnology. Then hold a debate, making claims and providing evidence about the benefits and risks of technology. Explain your reasoning.

Example 2

Cloning of Pyrenean ibex

The Pyrenean ibex, or bucardo, is an extinct species of mountain goat. In 2009, scientists produced a cloned burcardo. The newborn died within minutes of being born.

Effects on Individuals and Society

"How will we decide when it is appropriate to clone other types of organisms?"

Effects on Environment

"Cloning could restore extinct species and increase populations of endangered species."

Example 3

Tough Plants!

Much of the corn and soybeans grown in the United States is genetically engineered. The plants have bacterial genes that make them more resistant to plant-eating insects.

Effects on Individuals and Society

Effects on Environment

Visual Summary

To complete this summary, circle the correct word or phrase. You can use this page to review the main concepts of the lesson.

Biotechnology

Biotechnology is the use of living things and biological processes.

13 Modern biotechnology techniques can change an organism's DNA / environment.

Aritifical selection, genetic engineering, and cloning are three types of biotechnology.

14 The DNA of the algae on the right has been modified through a technique called cloning / genetic engineering.

Biotechnology impacts individuals, society, and the environment.

15 Creating a clone / gene of an extinct species could impact the environment.

16 Claims • Evidence • Reasoning Both artificial selection and genetic engineering produce organisms that have traits that are different from the original organism. Make a claim about how these two techniques differ. Summarize evidence to support the claim and explain your reasoning.

Lesson Review

LESSON 2

Vocabulary

In your own words, define the following terms.

1 biotechnology

2 artificial selection

3 clone

Key Concepts

4 Identify Wheat has been bred by farmers for thousands of years to improve its ability to be ground into flour. This is an example of what kind of biotechnology?

A artificial selection

B genetic engineering

C cloning

D PCR

5 Identify Which of the following statements correctly describes why society must carefully consider the use of biotechnology?

A Biotechnology is a relatively new scientific field.

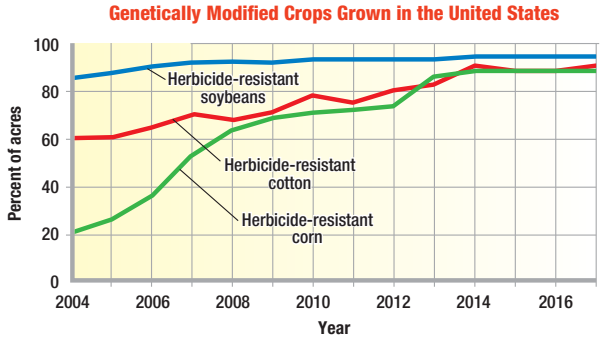
B Biotechnology can impact individuals and the environment.

C The methods of genetic engineering are not well understood.

D Artificial selection is an example of biotechnology.

Critical Thinking

Use this graph to answer the following questions.



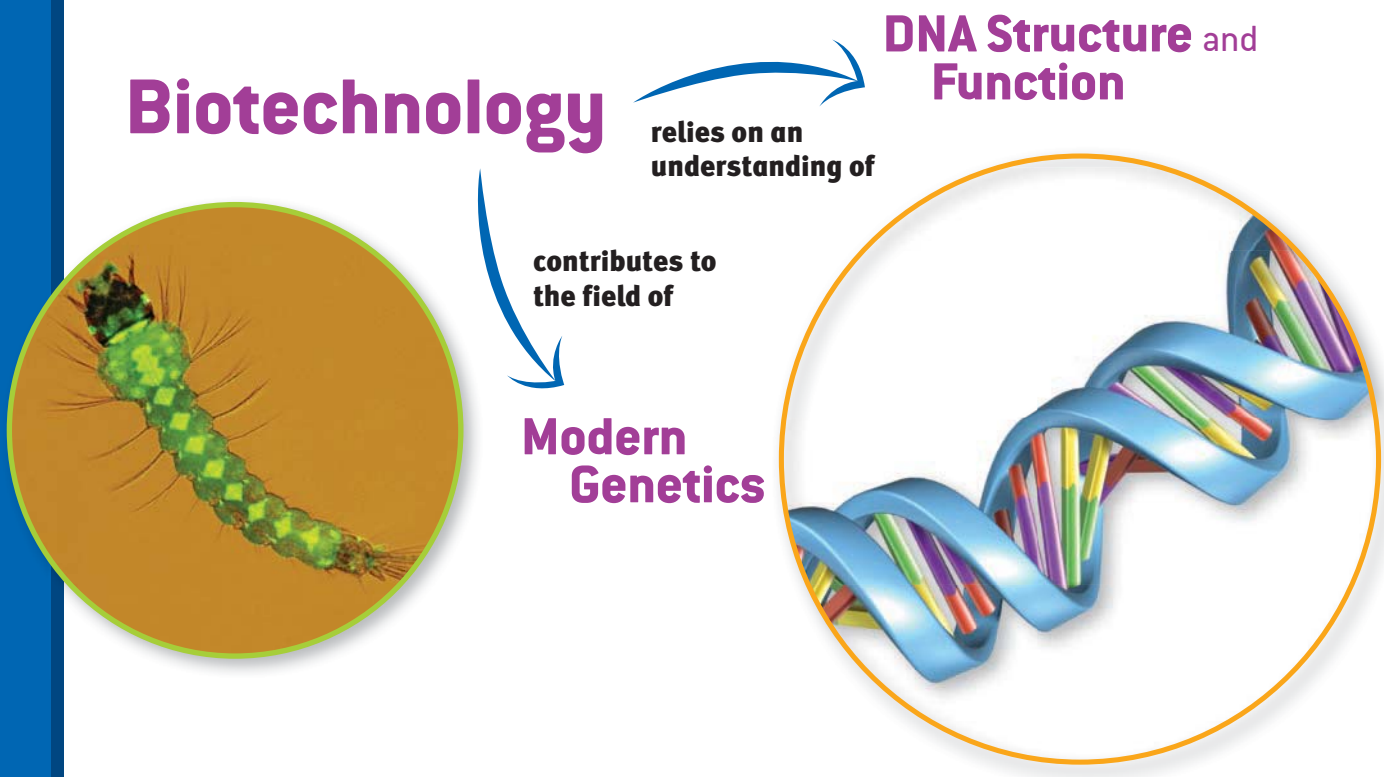
Source: *USDA, 2017*

6 Analyze In 2004, what percentage of soybean crops in the United States were genetically engineered to be herbicide resistant?

7 Analyze From 2004 to 2010, which genetically engineered crop had the greatest increase in acreage?

8 Claims • Evidence • Reasoning Some salmon have been genetically engineered to grow more quickly. The salmon are raised in pens set in rivers or in the sea. Make a claim about how these salmon might impact society and the environment. Summarize evidence to support the claim and explain your reasoning.

UNIT 9 Summary



1 Interpret The Graphic Organizer above shows that biotechnology relies on an understanding of the structure and function of DNA. Explain your reasoning.

2 Compare How are DNA replication and DNA cloning similar? How are they different?

3 Claims • Evidence • Reasoning The variety of traits seen in house cats is due in part to artificial selection. What contribution do mutations make to artificial selection? Make a claim about the role of mutations. Summarize evidence to support the claim and explain your reasoning.

Benchmark Review

UNIT 9

Name _____

Vocabulary

Fill in each blank with the term that best completes the following sentences.

1 The genetic material of all cells is _____

2 _____ is the use and application of living things and biological processes.

3 A(n) _____ is an organism, cell, or piece of genetic material that is genetically identical to the one from which it was derived.

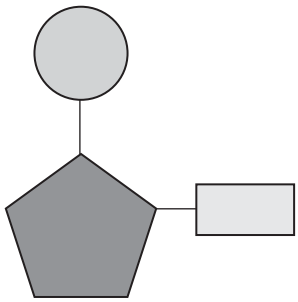
Key Concepts

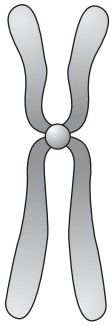
Identify the choice that best completes the statement or answers the question.

4 Terrie is creating a model of DNA. Which of these shapes illustrates how her model should look?

A 

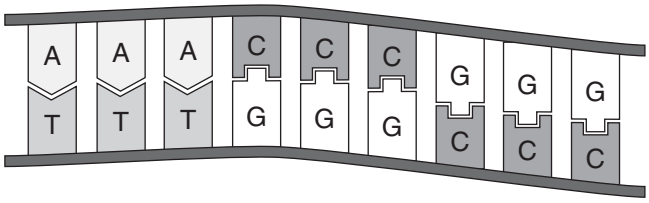
C 

B 

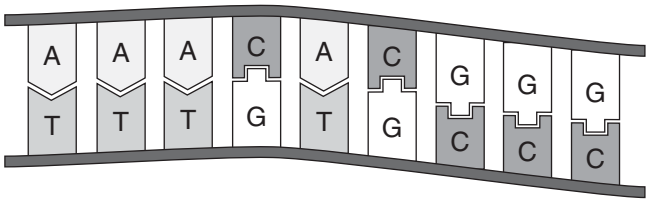
D 

5 The diagram below shows an original sequence of DNA and then a mutated sequence of DNA.

Original sequence



New sequence



Which type of mutation took place?

F deletion

G insertion

H substitution

I translation

6 Sickle cell anemia is an inherited disorder. Which of the following is **a true** statement about sickle cell anemia?

A It is never inherited from a parent.

B The mutation occurs during a person's lifetime.

C It is an infectious disease.

D It is caused by a change in the bases in DNA.

7 Alice is studying biological molecules. She isolated a molecule and identified the nucleotide bases adenine, cytosine, guanine, and thymine. Which molecule did Alice isolate?

F DNA

G mRNA

H rRNA

I tRNA

Name _____

8 Cloning is one type of biotechnology. Which of these choices is an example of cloning?

A Certain chickens are bred for their distinctive feather color.

B Several copies of a fruit fly gene are produced in a laboratory.

C Plants with red flowers are bred with plants with blue flowers.

D Yeast cells are placed under an ultraviolet lamp, causing their DNA to mutate.

9 Luis wants to interview someone who has a career in biotechnology. Which of the following **best** describes a career in biotechnology?

F Athena uses a sophisticated telescope to observe stars.

G Zach tracks the number of fish that inhabit a certain coastal area.

H Vincent modifies the DNA of bacteria to study the function of their genes.

I Lindsey writes computer programs that model the three-dimensional structure of chemical compounds.

10 Dylan is listing the substances that make up DNA. Which of these substances should he list as a nucleotide base found in DNA?

A adenine

B phosphate

C sugar

D uracil

11 A scientist transfers a fragment of genetic material from one organism to another organism of a different species. What is this process called?

F artificial selection

G selective breeding

H genetic engineering

I asexual reproduction

12 Rachel is analyzing a DNA sample to identify its base pairs. Her results show that 40% of the sample is adenine. Which other base makes up 40% of the sample?

A cytosine

B guanine

C thymine

D uracil

13 The following sequence of letters represents the order of bases in a single strand of DNA.

C-T-T-A-G-G-C-T-T-A-C-C-A

Which of these sequences would be the complementary strand that forms during replication?

F G-A-A-T-C-C-G-A-A-T-G-G-T

G C-T-T-A-G-G-C-T-T-A-C-C-A

H T-C-C-G-A-A-T-C-C-G-T-T-G

I A-G-G-C-T-T-A-G-G-C-A-A-C

Critical Thinking

Answer the following questions in the space provided.

14 Describe the major steps of gene transcription and translation. What molecules and organelles are involved in the processes?

15 Rachel's class is debating the impact of biotechnology on people, society, and the environment. Do you think that biotechnology has a positive or negative impact? Provide specific evidence to support your claim and explain your reasoning.