UNIT 8

Reproduction and Heredity

FLORIDA BIG IDEA 16

Heredity and Reproduction

The seeds of a papaya allow it to reproduce more papayas with similar traits.

What Do You Think?

Every organism— such as these papayas—that reproduces shares traits with its offspring. How are qualities passed on from generation to generation? As you explore this unit, gather evidence to help you state and support your claim.

UNIT 8

Reproduction and Heredity

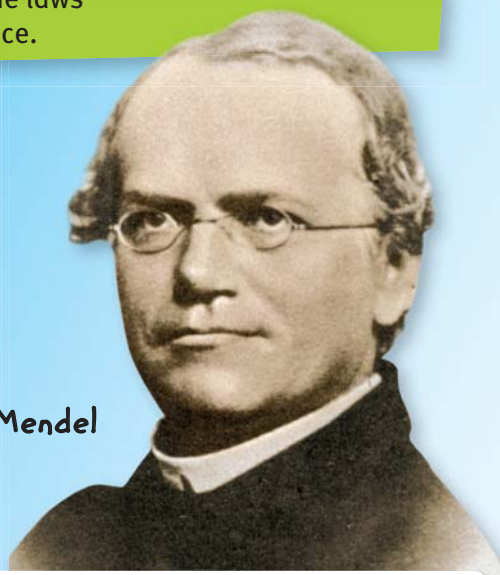
CITIZEN **SCIENCE**

Pass It On

Heredity was a mystery that scientists worked to crack over hundreds of years. The modern field of genetics is vital to the understanding of hereditary diseases. The study of genetics can also predict which traits will be passed from parent to offspring.

1856–1863

Many people consider Gregor Mendel to be the Father of Modern Genetics. His famous pea plant experiments, conducted from 1856–1863, helped to illustrate and establish the laws of inheritance.



Gregor Mendel

Can you predict the traits Mendel might have examined in pea plants? What traits might a fruit or vegetable plant inherit from a parent plant?

Pairs of chromosomes, viewed under a microscope

Fruit fly

DNA samples

1882

Walther Flemming discovered chromosomes while observing the process of cell division. He didn't know it, but chromosomes pass characteristics from parents to offspring.

1908

Thomas Hunt Morgan was the first to actually realize that chromosomes carry traits. Morgan's fruit fly studies established that genes are located on chromosomes. Studies using fruit flies are still happening.

2003

Our DNA carries information about all of our traits. In fact, the human genome is made up of 20,000–25,000 genes! In 2003, the Human Genome Project successfully mapped the first human genome.

Take It Home!

Making Trait Predictions

1 Think About It

Different factors influence appearance. Family members may look similar in some ways but different in others. What factors influence a person's appearance?

2 Ask Some Questions

Can you spot any physical characteristics, like bent or straight pinky fingers, that people in your family share?

3 Make A Plan

Consider the characteristics that are most distinctive in your family. How can you trace the way these characteristics have been passed through the family? Design an investigation of hereditary characteristics in your family.

Describe how these characteristics might be the same or different as they are passed on to offspring. What factors might influence this? Make notes here, and illustrate your descriptions on a separate sheet of paper.

LESSON 1

Mitosis

ESSENTIAL **QUESTION**

How do cells divide?

By the end of this lesson, you should be able to relate the process of mitosis to its functions in single-celled and multicellular organisms.

A human skin cell divides, producing two new cells that are identical to the original cell.

SC.7.L.16.3 Compare and contrast the general processes of sexual reproduction requiring meiosis and asexual reproduction requiring mitosis.

Lesson Labs

Quick Labs

- Modeling Mitosis
- Mitosis Flipbook

Engage Your Brain

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

T	F	
☐	☐	Single-celled organisms can reproduce by cell division.
☐	☐	The only function of cell division is reproduction.
☐	☐	In multicellular organisms, cell division can help repair injured areas.
☐	☐	Cell division produces two cells that are different from each other.

2 Infer An old sequoia tree weighs many tons and has billions of cells. These trees start out as tiny seeds. Predict how these trees get so large.

ACTIVE READING

3 Synthesize You can often define an unknown word if you know the meaning of its word parts. Use the word parts and sentence below to make an educated guess about the meaning of the word *cytokinesis*.

Word part	Meaning
cyto-	hollow vessel
-kinesis	division

Example sentence

When a dividing cell undergoes cytokinesis, two cells are produced.

cytokinesis:

Vocabulary Terms

- **DNA**
- **chromosomes**
- **cell cycle**
- **interphase**
- **mitosis**
- **cytokinesis**

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

Splitsville!

Why do cells divide?

Cell division happens in all organisms. Cell division takes place for different reasons. For example, single-celled organisms reproduce through cell division. In multicellular organisms, cell division is involved in growth, development, and repair, as well as reproduction.

Reproduction

Cell division is important for asexual reproduction, which involves only one parent organism. In single-celled organisms, the parent divides in two, producing two identical offspring. In single-celled and some multicellular organisms, offspring result when a parent organism buds, producing offspring. In multicellular organisms, reproduction by cell division can include plant structures such as runners and plantlets.

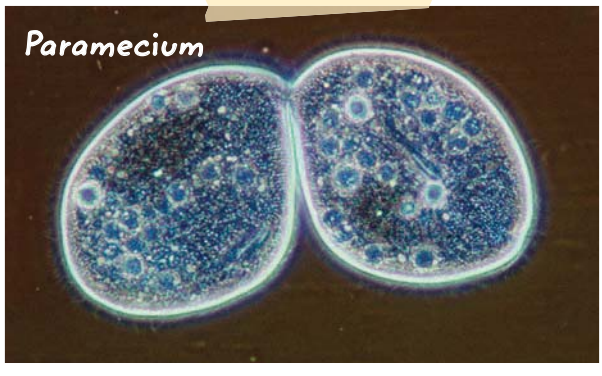
Growth and Repair

One characteristic of all living things is that they grow. You are probably bigger this year than you were last year. Your body is made up of cells. Although cells themselves grow, most growth in multicellular organisms happens because cell division produces new cells.

Cell division also produces cells for repair. If you cut your hand or break a bone, the damaged cells are replaced by new cells that form during cell division.

Visualize It!

5 Claims • Evidence • Reasoning Take a look at the photos below. Underneath each photo, make a claim about how cell devision plays a role in what is taking place. Summarize evidence to support your claim, and explain your reasoning.



Role of cell division:

Role of cell division:

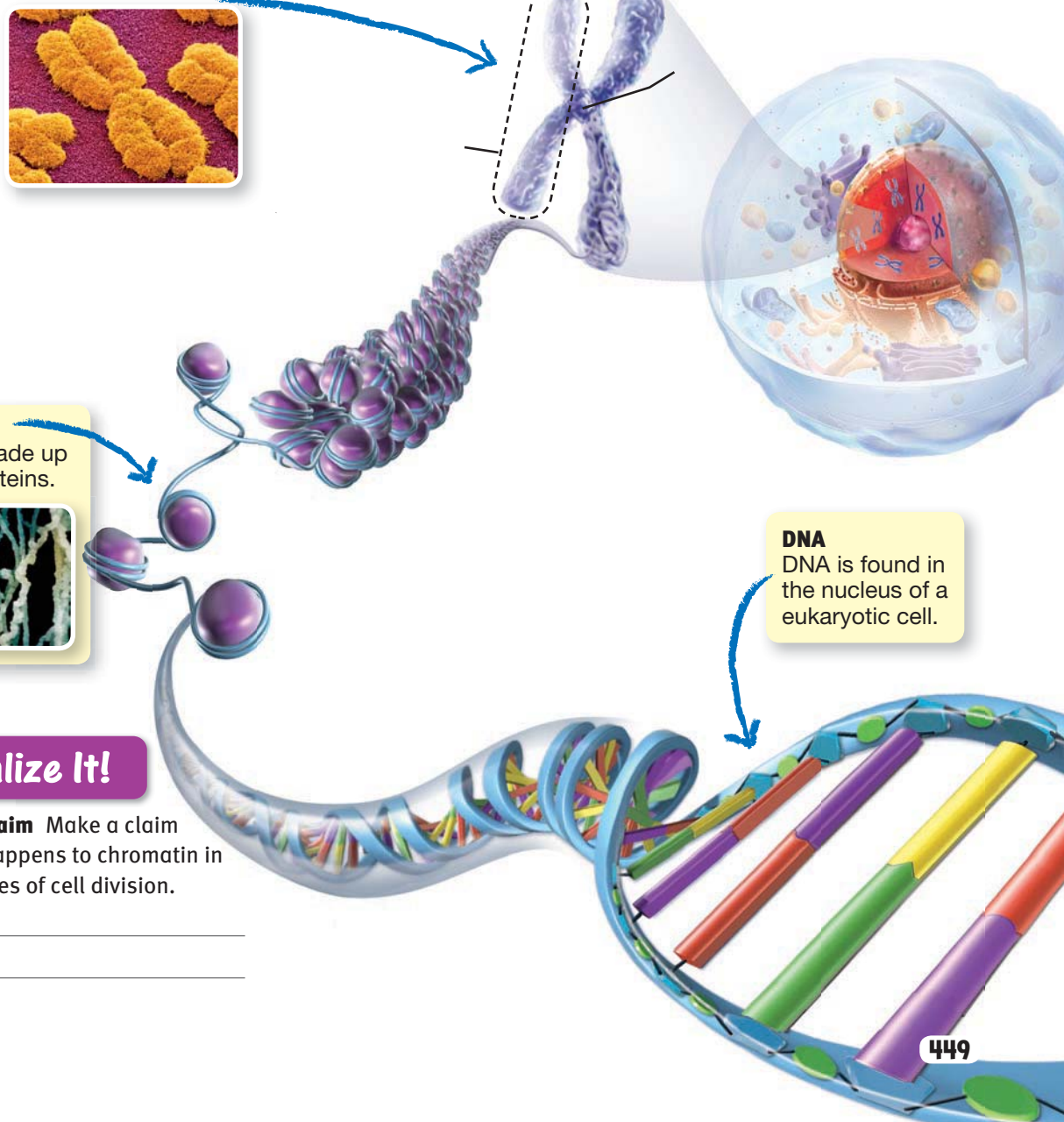
What happens to genetic material during cell division?

The genetic material in cells is called DNA (deoxyribonucleic acid). A **DNA** molecule contains the information that determines the traits that a living thing inherits and needs to live. It contains instructions for an organism's growth, development, and activities. In eukaryotes, DNA is found in the nucleus.

During most of a cell's life cycle, DNA, along with proteins, exists in a complex material called *chromatin* (KROH•muh•tin). Before cell division, DNA is duplicated, or copied. Then, in an early stage of cell division, the chromatin is compacted into visible structures called **chromosomes** (KROH•muh•sohmz). A duplicated chromosome consists of two identical structures called *chromatids* (KROH•muh•tidz). The chromatids are held together by a *centromere* (SEN•truh•mir).

ACTIVE READING

6 Describe What happens to DNA before cell division?



Visualize It!

7 State Your Claim Make a claim about what happens to chromatin in the early stages of cell division.

Around and Around

What are the stages of the cell cycle?

The life cycle of an organism includes birth, growth, reproduction, and death. The life cycle of a eukaryotic cell, called the **cell cycle**, can be divided into three stages: interphase, mitosis, and cytokinesis. During the cell cycle, a parent cell divides into two new cells. The new cells are identical to the parent.

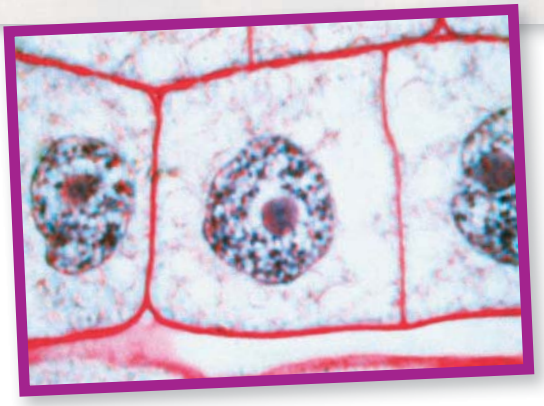
ACTIVE READING

8 Identify As you read, underline the main characteristics of each stage of the cell cycle.

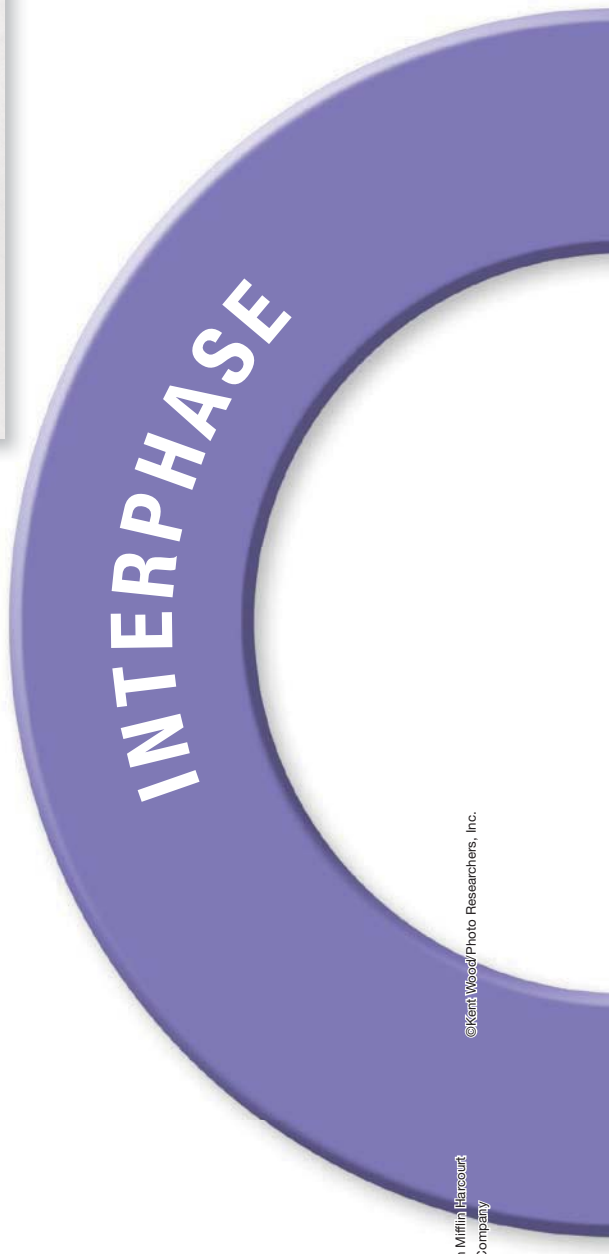
Interphase

The part of the cell cycle during which the cell is not dividing is called **interphase** (IN•ter•fayz). A lot of activity takes place in this stage of the cell's life. The cell grows to about twice the size it was when it was first produced. It also produces various organelles. The cell engages in normal life activities, such as transporting materials into the cell and getting rid of wastes.

Changes that occur during interphase prepare a cell for division. Before a cell can divide, DNA must be duplicated. This ensures that, after cell division, each new cell gets an exact copy of the genetic material in the original cell.



During interphase, the cell carries out normal life activities.

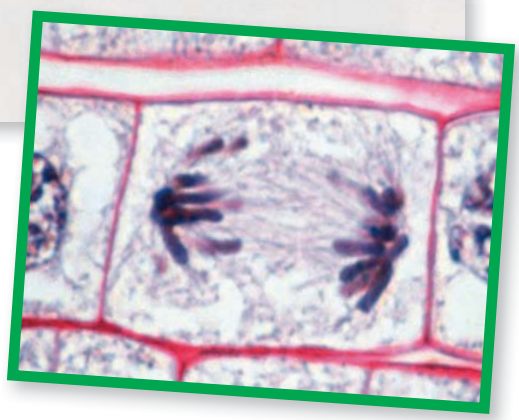


ACTIVE READING

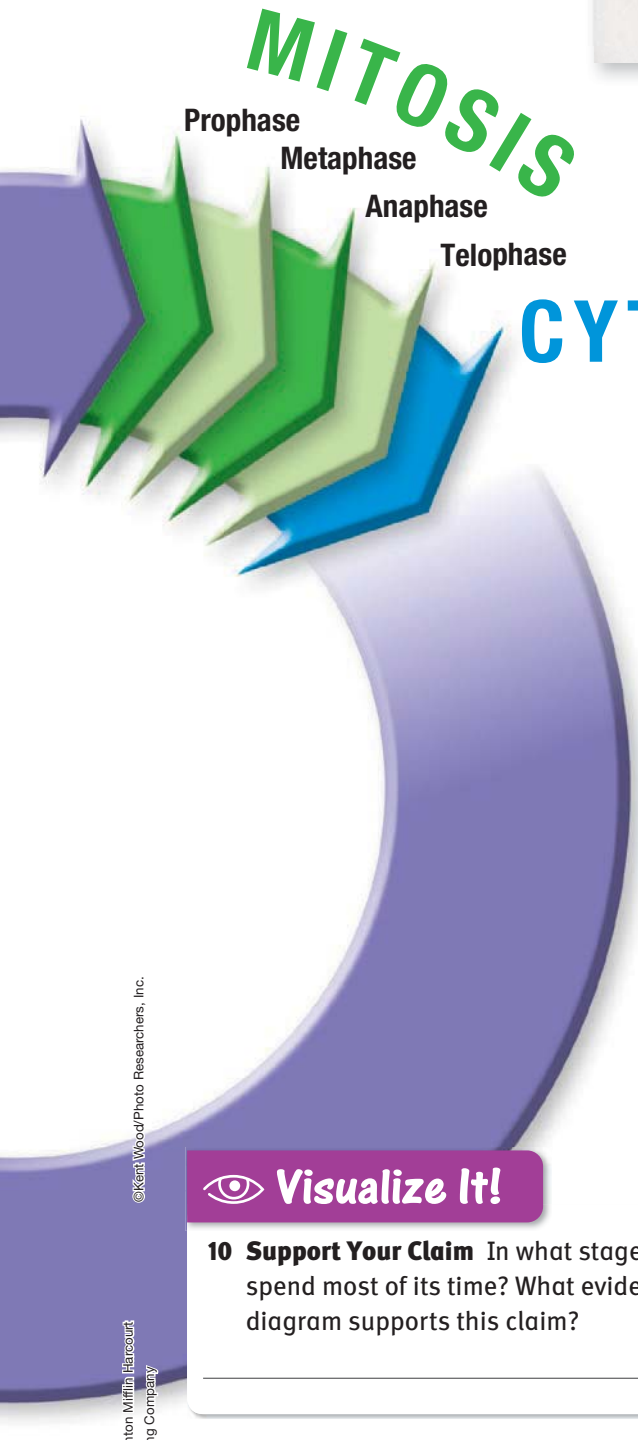
9 Describe What happens during interphase?

Mitosis

In eukaryotic cells, **mitosis** (my•TOH•sis) is the part of the cell cycle during which the nucleus divides. Prokaryotes do not undergo mitosis because they do not have a nucleus. Mitosis results in two nuclei that are identical to the original nucleus. So, the two new cells formed after cell division have the same genetic material. During mitosis, chromosomes condense from chromatin. When viewed with a microscope, chromosomes are visible inside the nucleus. At the end of mitosis, the cell has two identical sets of chromosomes in two separate nuclei.



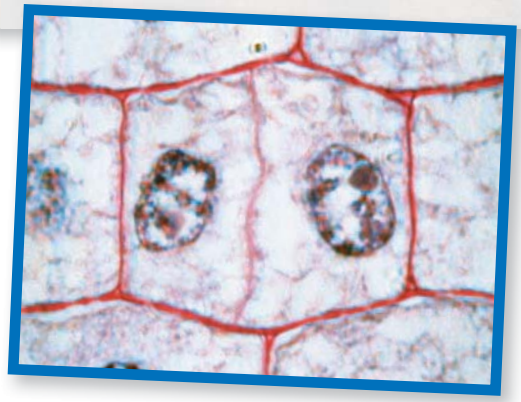
During mitosis, the cell's nucleus divides into two identical nuclei.



Cytokinesis

Cytokinesis (sy•toh•kuh•NEE•sis) is the division of the parent cell's cytoplasm. Cytokinesis begins during the last step of mitosis. During cytokinesis, the cell membrane pinches inward between the new nuclei. Eventually, it pinches all the way, forming two complete cells.

In a cell that has a cell wall, such as a plant cell, a cell plate forms. The cell plate becomes cell membranes that separate the new cells. New cell walls form where the plate was.



During cytokinesis, the cytoplasm divides and two new cells are produced.

Visualize It!

10 Support Your Claim In what stage does a cell spend most of its time? What evidence in the diagram supports this claim?

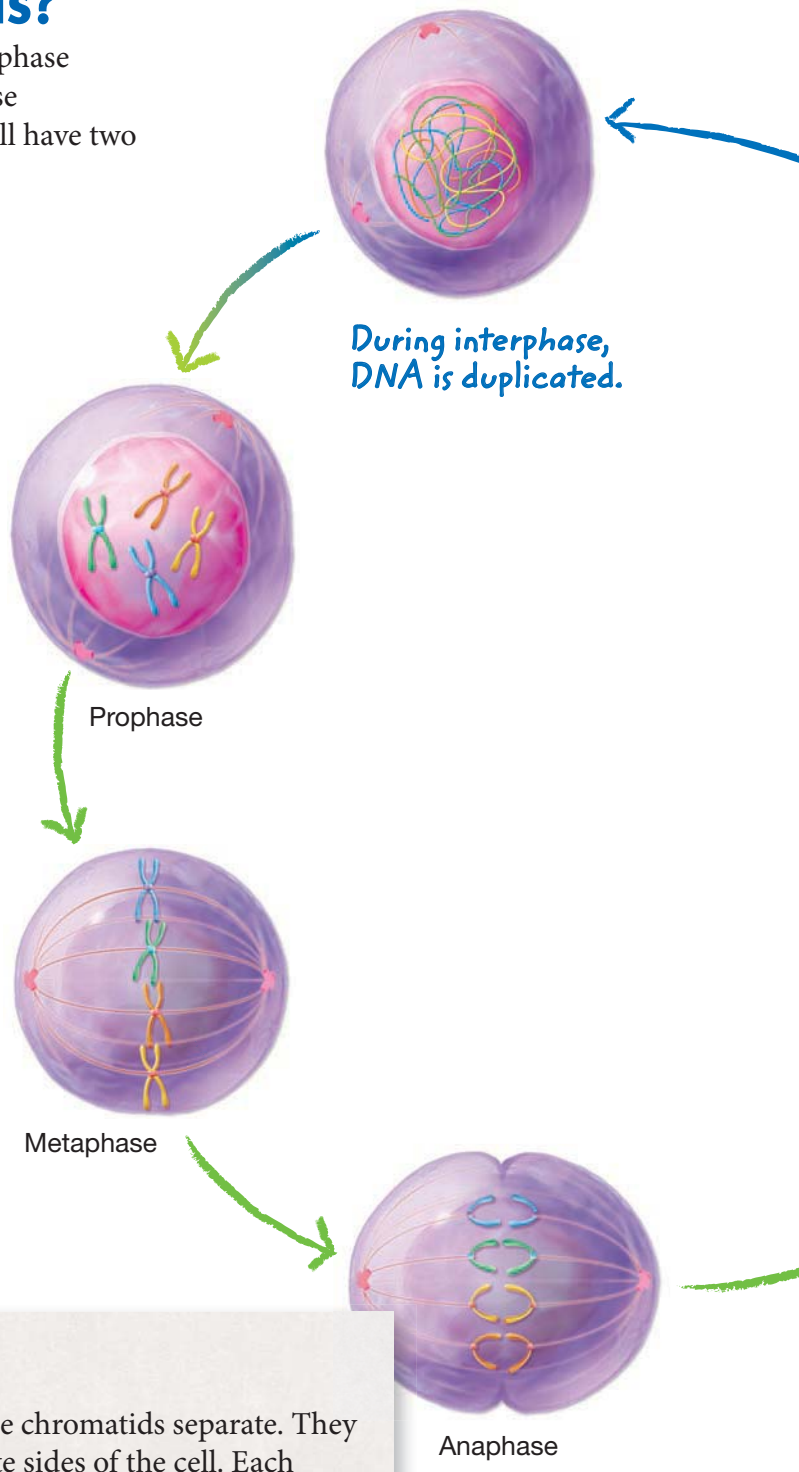
Phasing Out

What are the phases of mitosis?

Mitosis has four phases: prophase (PROH•fayz), metaphase (MET•uh•fayz), anaphase (AN•uh•fayz), and telophase (TEE•luh•fayz). By the end of these phases, the cell will have two identical nuclei and cytokinesis will begin.

ACTIVE READING

11 Identify As you read, underline the major events that take place in each phase of mitosis.



Prophase

During prophase, the chromatin in the nucleus of a cell condenses and becomes visible under a microscope. Each chromosome consists of two chromatids held together by a centromere. The membrane around the nucleus breaks down.

Metaphase

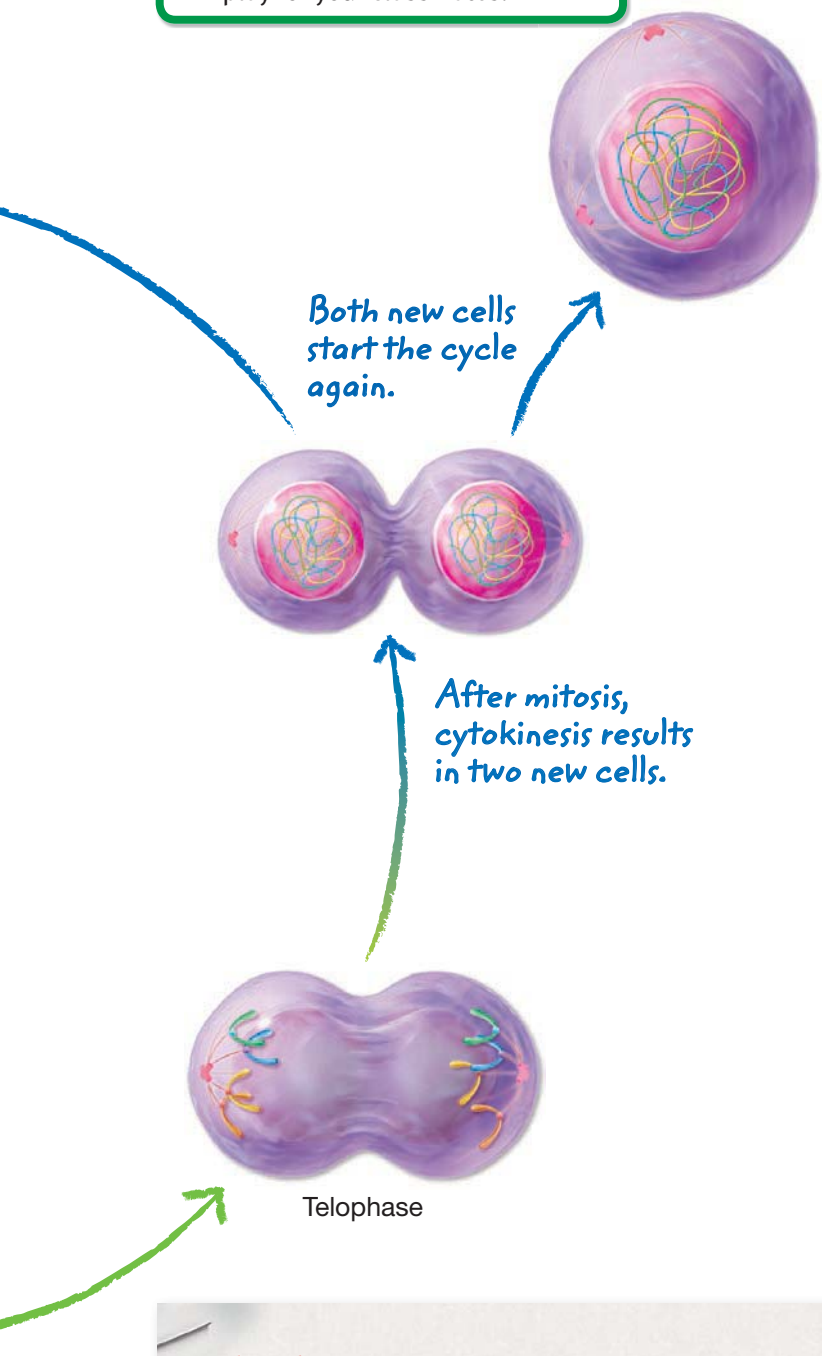
During metaphase, chromosomes line up in the middle of the cell. Centromeres of the chromosomes are the same distance from each side of the cell.

Anaphase

During anaphase, the chromatids separate. They are pulled to opposite sides of the cell. Each side of the cell ends up with a complete set of chromosomes.

Think Outside the Book

12 Model With a small group, write a play that acts out the steps of mitosis. Trade your play with another group, and perform the play for your classmates.



Telophase

The last phase of mitosis is telophase. A new nuclear membrane forms around each group of chromosomes. So, the cell now has two identical nuclei. The chromosomes become less condensed. Cytokinesis begins during this phase.

13 List Use the table below to draw a picture for each step of the cell cycle.

Step	Drawing
Interphase	
Mitosis: Prophase	
Mitosis: Metaphase	
Mitosis: Anaphase	
Mitosis: Telophase	
Cytokinesis	

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.

During the cell cycle, cells divide to produce two identical cells.

14 Three reasons that cells divide are

_____

_____

_____

DNA is duplicated before cell division.

15 Loose chromatin is compacted into _____, each of which has two _____ that are held together by a centromere.

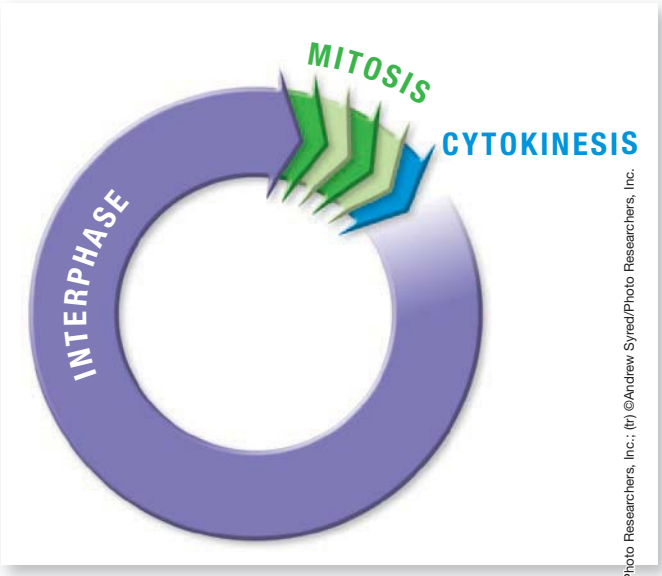
Mitosis

The cell cycle is the life cycle of a cell.

16 They lack nuclei, so prokaryotes do not undergo _____

17 The cell produces organelles during _____

18 _____ results in the formation of two new cells.



19 Claims • Evidence • Reasoning A student claims that the number of chromosomes inside the nucleus of a cell decreases by half during mitosis. Summarize evidence to support or refute this claim and explain your reasoning.

Lesson Review

LESSON 1

Vocabulary

Fill in the blanks with the term that best completes the following sentences.

1 _____ provides the information for cell growth and function.

2 The cell spends most of its time in the _____ stage of the cell cycle.

3 After _____ , the nucleus of the parent cell has divided into two new nuclei.

4 A _____ is the condensed, visible form of chromatin.

Key Concepts

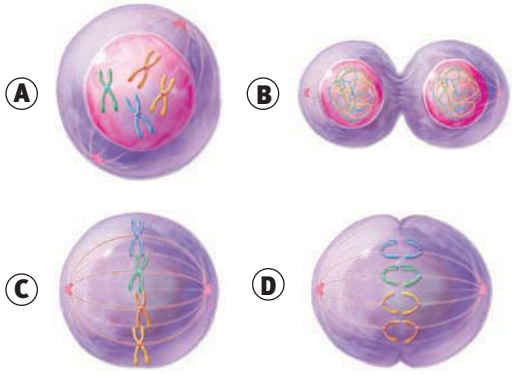
5 **Relate** What happens in a cell during interphase?

6 **Compare** Describe the functions of cell division in single-celled and multicellular organisms.

7 **Claims • Evidence • Reasoning** Why is it important for DNA to be duplicated before mitosis? State your claim. Summarize evidence to support your claim and explain your reasoning.

Critical Thinking

Use the figures below to answer the questions that follow.



8 **Sequence** Starting with prophase, what is the correct order of the four diagrams above?

9 **Identify** What phase is shown in each of the diagrams above?

10 **Describe** What is happening to the cell in diagram B?

11 **Claims • Evidence • Reasoning** Make a claim about what would happen if a cell went through mitosis but not cytokinesis. Summarize evidence to support your claim and explain your reasoning.

LESSON 2

Meiosis

ESSENTIAL **QUESTION**

How do cells divide for sexual reproduction?

By the end of this lesson, you should be able to describe the process of meiosis and its role in sexual reproduction.

The sperm cell and egg cell shown here were produced by a special kind of cell division called meiosis.

SC.7.L.16.3 Compare and contrast the general processes of sexual reproduction requiring meiosis and asexual reproduction requiring mitosis.

Lesson Labs

Quick Labs

- Crossover and Meiosis
- Meiosis Flipbook

Engage Your Brain

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

T	F	
☐	☐	The offspring of sexual reproduction have fewer chromosomes than their parents have.
☐	☐	During sexual reproduction, two cells combine to form a new organism.
☐	☐	Sex cells are produced by cell division.
☐	☐	Sex cells have half the normal number of chromosomes.

2 Calculate Organisms have a set number of chromosomes. For example, humans have 46 chromosomes in body cells and half that number (23) in sex cells. In the table below, fill in the number of chromosomes for different organisms.

Organism	Full set of chromosomes	Half set of chromosomes
Human	46	23
Fruit fly		4
Chicken		39
Salamander	24	
Potato	48	

ACTIVE READING

3 Synthesize You can often define an unknown word if you know the meaning of its word parts. Use the word parts and the sentence below to make an educated guess about the meaning of the term *homologous*.

Word part	Meaning
homo-	same
-logos	word, structure

Example sentence

Homologous chromosomes are a pair of chromosomes that look similar and have the same genes.

homologous:

Vocabulary Terms

- **homologous chromosomes**
- **meiosis**

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

Number Off!

How do sex cells differ from body cells?

Before sexual reproduction can take place, each parent produces sex cells. *Sex cells* have half of the genetic information that body cells have. Thus, when the genetic information from two parents combines, the offspring have a full set of genetic information. The offspring will have the same total number of chromosomes as each of its parents.

This photo shows the 23 chromosome pairs in a human male. Body cells contain all of these chromosomes. Sex cells contain one chromosome from each pair.

ACTIVE READING

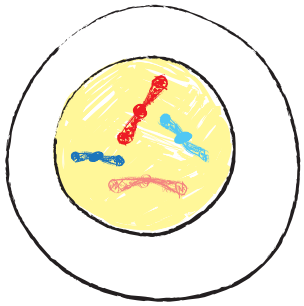
5 Relate Describe sex cells.

Chromosome Number

In body cells, most chromosomes are found in pairs that have the same structure and size. These **homologous chromosomes** (huh•MAHL•uh•guhs KROH•muh•sohmz) carry the same genes. A homologous chromosome pair may have different versions of the genes they carry. One chromosome pair is made up of *sex chromosomes*. Sex chromosomes control the development of sexual characteristics. In humans, these chromosomes are called X and Y chromosomes. Cells with a pair of every chromosome are called *diploid* (DIP•loyd). Many organisms, including humans, have diploid body cells.

Visualize It!

6 State Your Claim The cell shown is a body cell that has two pairs of homologous chromosomes. Make claim about how it is different than a sex cell by drawing a sex cell.



Body cell

Sex cell

Why do organisms need sex cells?

Most human body cells contain 46 chromosomes. Think about what would happen if two body cells were to combine. The resulting cell would have twice the normal number of chromosomes. A sex cell is needed to keep this from happening.

Sex cells are also known as *gametes* (GAM•eetz). Gametes contain half the usual number of chromosomes—one chromosome from each homologous pair and one sex chromosome. Cells that contain half the usual number of chromosomes are known as *haploid* (HAP•loyd).

Gametes are found in the reproductive organs of plants and animals. An egg is a gamete that forms in female reproductive organs. The gamete that forms in male reproductive organs is called a sperm cell.

How are sex cells made?

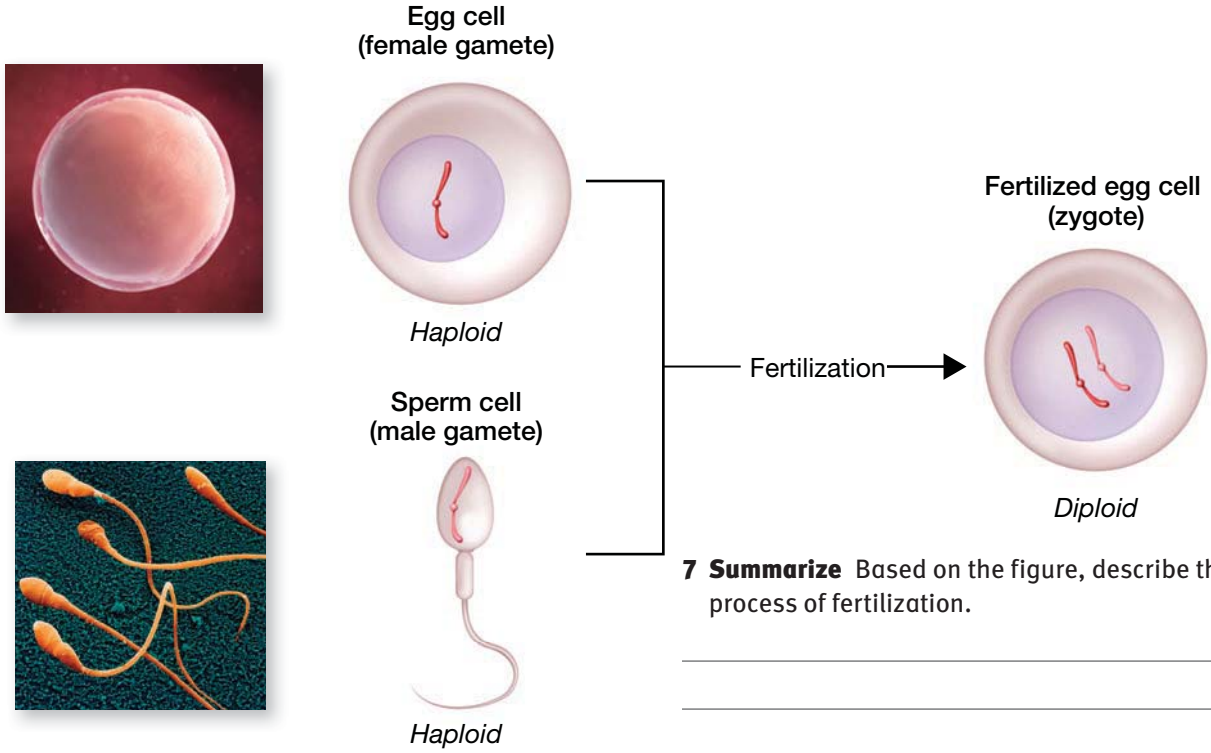
You know that body cells divide by the process of mitosis. Mitosis produces two new cells, each containing exact copies of the chromosomes in the parent cell. Each new cell has a full set of chromosomes. But to produce sex cells, a different kind of cell division is needed.

Meiosis

A human egg and a human sperm cell each have 23 chromosomes. When an egg is joined with, or *fertilized* by, a sperm cell, a new diploid cell is formed. This new cell has 46 chromosomes, or 23 pairs of chromosomes. One set is from the mother, and the other set is from the father. The newly formed diploid cell may develop into an offspring. **Meiosis** (my•OH•sis) is the type of cell division that produces haploid sex cells such as eggs and sperm cells.

Visualize It!

For the example of fertilization shown, the egg and sperm cells each have one chromosome.



7 Summarize Based on the figure, describe the process of fertilization.

One Step at a Time

What are the stages of meiosis?

Meiosis results in the formation of four haploid cells. Each haploid cell has half the number of chromosomes found in the original cell. Meiosis has two parts: meiosis I and meiosis II.

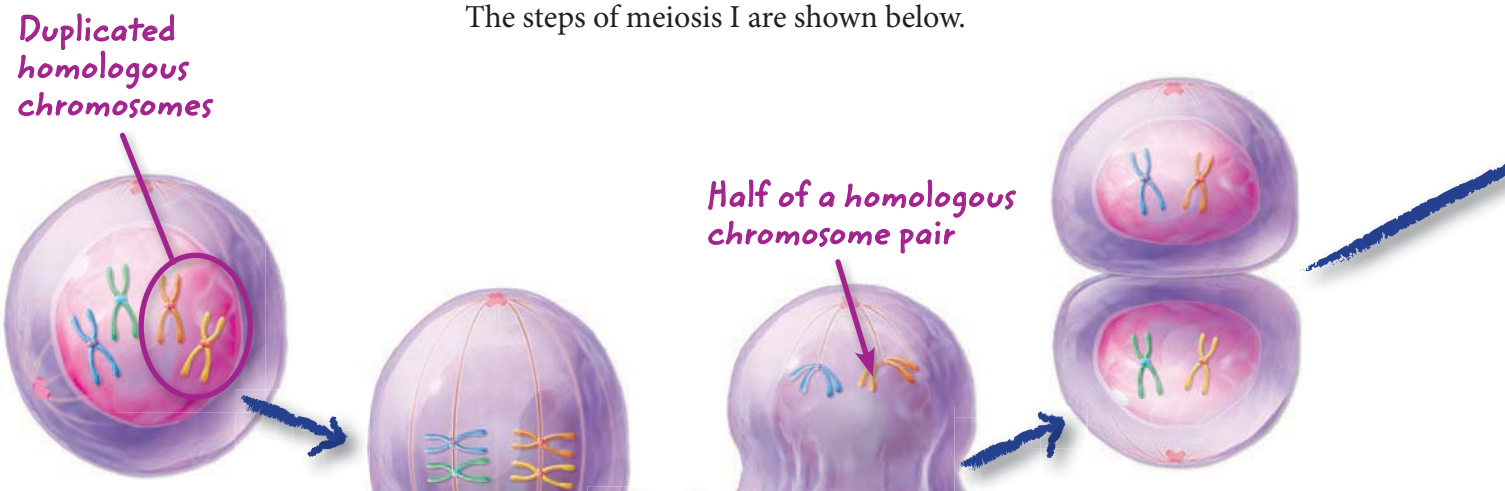
Meiosis I

Remember that homologous chromosomes have the same genes, but they are not exact copies of each other. Before meiosis I begins, each chromosome is duplicated, or copied. Each half of a duplicated chromosome is called a *chromatid* (KROH•muh•tid). Chromatids are connected to each other by *centromeres* (SEN•truh•mirz). Duplicated chromosomes are drawn in an **X** shape. Each side of the **X** represents a chromatid, and the point where they touch is the centromere.

During meiosis I, pairs of homologous chromosomes and sex chromosomes split apart into two new cells. These cells each have one-half of the chromosome pairs and their duplicate chromatids. The steps of meiosis I are shown below.

ACTIVE READING

8 Sequence As you read, underline what happens to chromosomes during meiosis.



Prophase I
The chromosomes are copied before meiosis begins. The duplicated chromosomes, each made up of two chromatids, pair up.

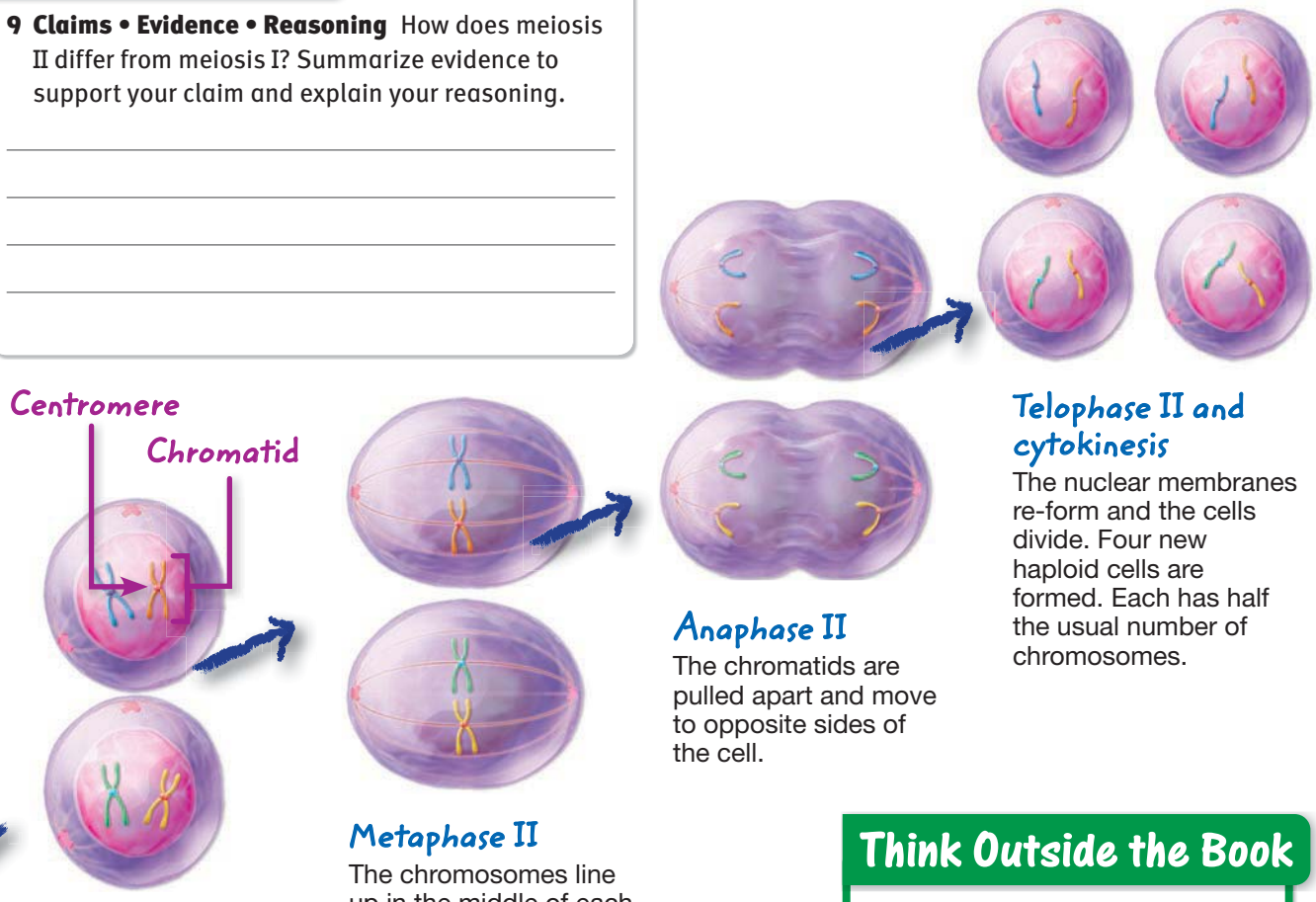
Metaphase I
After the nuclear membrane breaks down, the chromosome pairs line up in the middle of the cell.

Anaphase I
The chromosomes separate from their partners, and then move to opposite ends of the cell.

Telophase I and cytokinesis
The nuclear membranes re-form, and the cell divides into two cells. The chromatids are still joined.

Visualize It!

9 Claims • Evidence • Reasoning How does meiosis II differ from meiosis I? Summarize evidence to support your claim and explain your reasoning.



Prophase II

The chromosomes are not copied again before meiosis II. The nuclear membrane breaks down.

Metaphase II

The chromosomes line up in the middle of each cell.

Anaphase II

The chromatids are pulled apart and move to opposite sides of the cell.

Telophase II and cytokinesis

The nuclear membranes re-form and the cells divide. Four new haploid cells are formed. Each has half the usual number of chromosomes.

Think Outside the Book

10 Summarize Work with a partner to make a poster that describes all the steps of meiosis.

Meiosis II

Meiosis II involves both of the new cells formed during meiosis I. The chromosomes of these cells are not copied before meiosis II begins. Both of the cells divide during meiosis II. The steps of meiosis II are shown above.

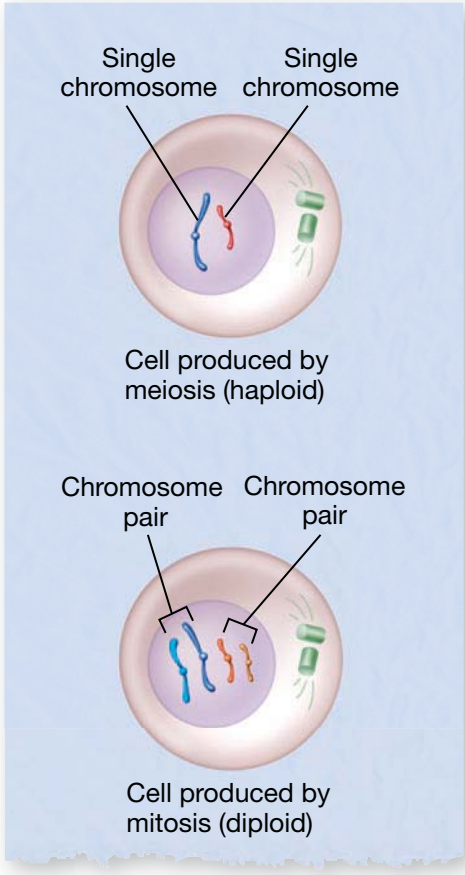
Meiosis II results in four haploid sex cells. In male organisms, these cells develop into sperm cells. In female organisms, these cells become eggs. In females of some species, three of the cells are broken down and only one haploid cell becomes an egg.

11 Identify At the end of meiosis II, how many cells have formed?

How does meiosis compare to mitosis?

The processes of meiosis and mitosis are similar in many ways. However, they also have several very important differences.

- Only cells that will become sex cells go through meiosis. All other cells divide by mitosis.
- During meiosis, chromosomes are copied once, and then the nucleus divides twice. During mitosis, the chromosomes are copied once, and then the nucleus divides once.
- The cells produced by meiosis contain only half of the genetic material of the parent cell—one chromosome from each homologous pair and one sex chromosome. The cells produced by mitosis contain exactly the same genetic material as the parent—a full set of homologous chromosomes and a pair of sex chromosomes.



12 Gather Evidence Using the table below, provide evidence that shows how meiosis and mitosis are alike and different.

Characteristic	Meiosis	Mitosis
Number of nuclear divisions		
Number of cells produced		
Number of chromosomes in new cells (diploid or haploid)		
Type of cell produced (body cell or sex cell)		
Steps of the process		

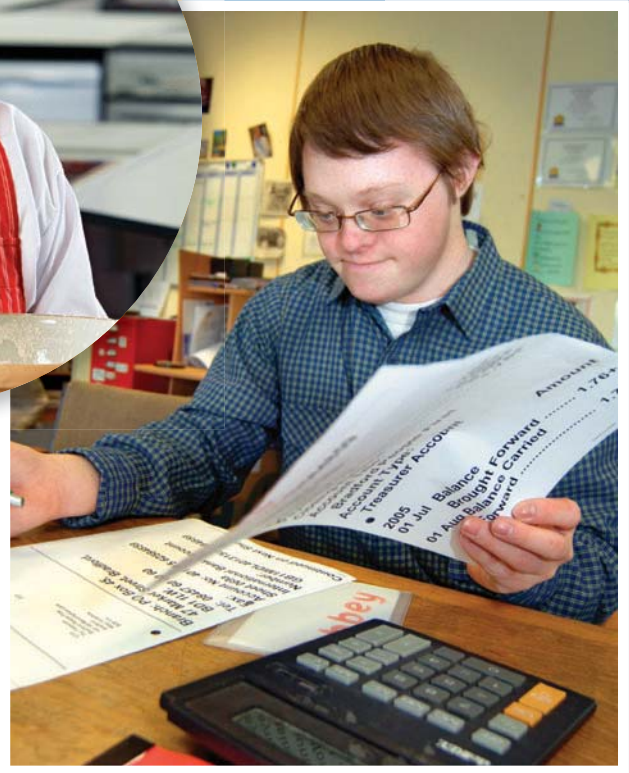
WHY IT **MATTERS**

Down Syndrome

HEALTH WATCH

Down syndrome is a genetic disease. It is usually caused by an error during meiosis. During meiosis, the chromatids of chromosome 21 do not separate. So, a sex cell gets two copies of chromosome 21 instead of one copy. When this sex cell joins with a normal egg or sperm, the fertilized egg has three copies of chromosome 21 instead of two copies.

Beating the Odds
Down syndrome causes a number of health problems and learning difficulties, but many people with Down syndrome have fulfilling lives.



One Too Many
Someone who has Down syndrome has three copies of chromosome 21 instead of two copies.

Extend

13 Identify What type of error in meiosis causes Down syndrome?

14 Claims • Evidence • Reasoning Research the characteristics of Down syndrome. Make a claim about how a person can overcome some of the difficulties caused by this disorder. Summarize evidence to support your claim and explain your reasoning.

15 Recommend Research the Special Olympics. Then make an informative brochure, poster, or oral presentation that describes how the Special Olympics gives people with Down syndrome and other disabilities the chance to compete in sports.

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.

Meiosis

Meiosis produces haploid cells that can become sex cells.

16 List the steps of meiosis I.

_____

_____

_____

_____

17 List the steps of meiosis II.

_____

_____

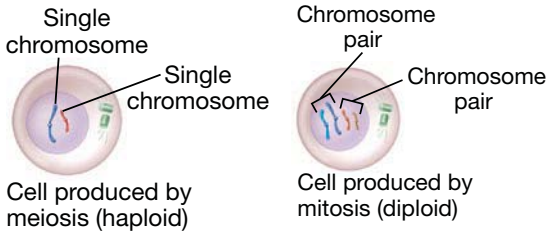
_____

_____

Sex cells have half as many chromosomes as body cells.

18 Sex cells produced by males are called _____, and sex cells produced by females are called _____

Mitosis and meiosis have similarities and differences.



19 During _____, chromosomes are copied once and the nucleus divides twice.

20 During _____, chromosomes are copied once and the nucleus divides once.

21 Claims • Evidence • Reasoning What would happen if mitosis occurred in sex cells instead of meiosis? Summarize evidence to support your claim and explain your reasoning.

Lesson Review

LESSON 2

Vocabulary

Fill in the blanks with the term that best completes the following sentences.

1 _____ chromosomes are found in body cells but not sex cells.

2 The process of _____ produces haploid cells.

Key Concepts

3 **Compare** How does the number of chromosomes in sex cells compare with the number of chromosomes in body cells?

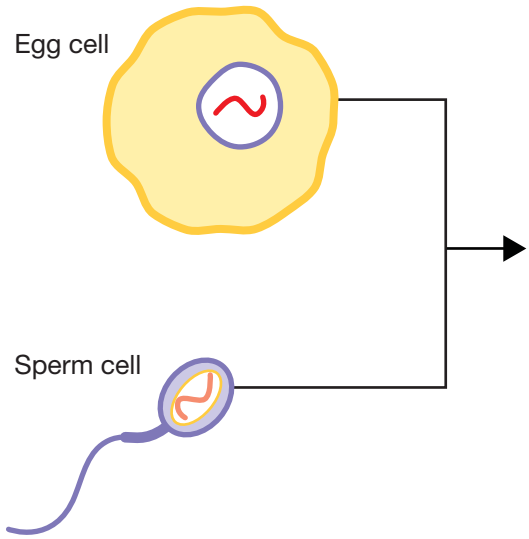
4 **Identify** What is the function of meiosis?

5 **List** Identify the steps of meiosis.

6 **Claims • Evidence • Reasoning** How are mitosis and meiosis alike and different? Summarize evidence to support your claim and explain your reasoning.

Critical Thinking

Use the figure to answer the following questions.



7 **Identify** By what process did these cells form?

8 **Identify** How many chromosomes does a body cell for the organism shown have?

9 **Predict** Draw a picture of the cell that would form if the sperm cell fused with the egg cell. What is this cell called?

10 **Claims • Evidence • Reasoning** What would happen if meiosis did not occur? State your claim. Summarize evidence to support this claim and explain your reasoning.

LESSON 3

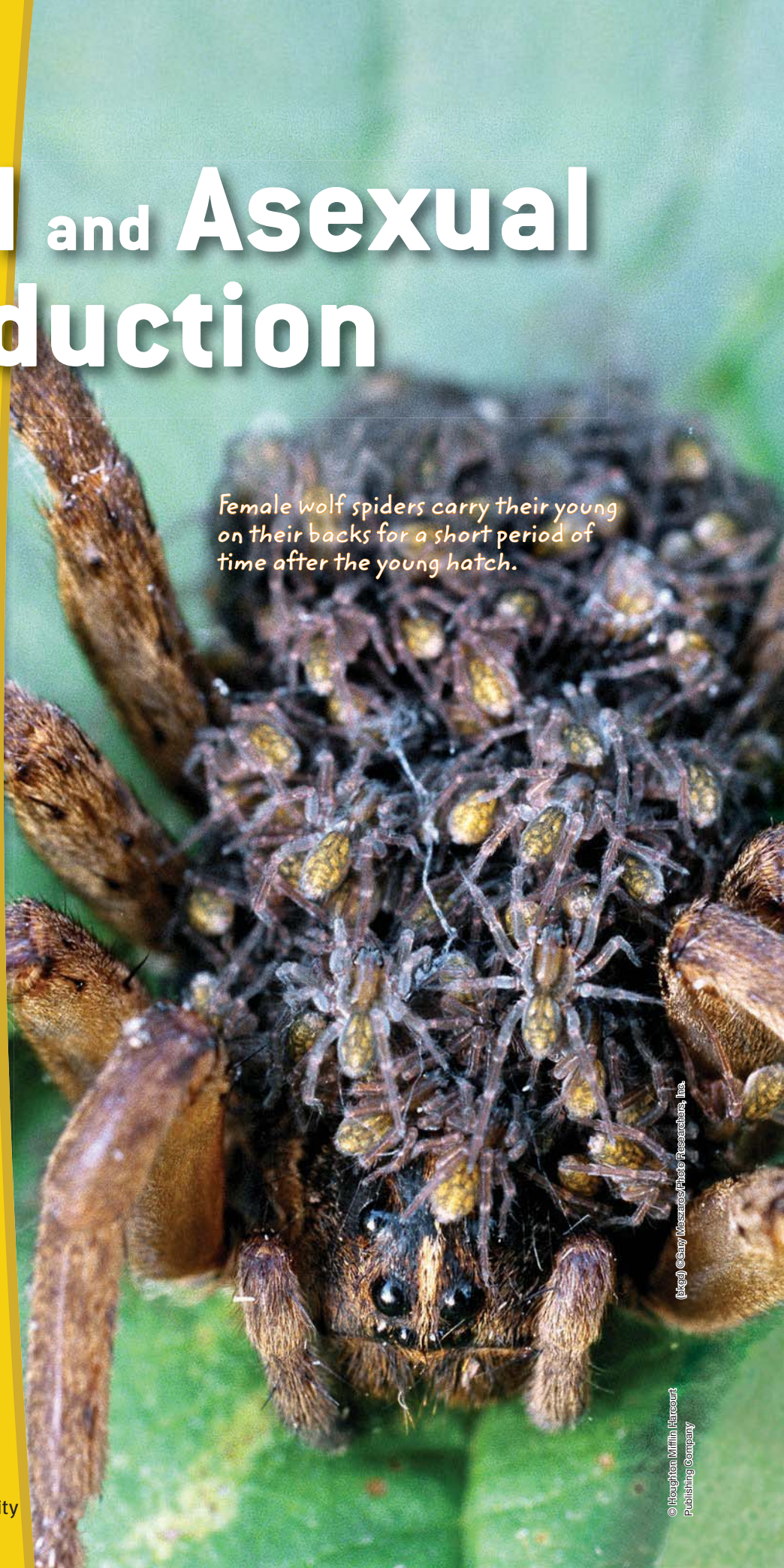
Sexual and Asexual Reproduction

ESSENTIAL **QUESTION**

How do organisms reproduce?

By the end of this lesson, you should be able to describe asexual and sexual reproduction and list the advantages and disadvantages of each.

SC.7.L.16.3 Compare and contrast the general processes of sexual reproduction requiring meiosis and asexual reproduction requiring mitosis.



Female wolf spiders carry their young on their backs for a short period of time after the young hatch.

Lesson Labs

Quick Labs

- Reproduction and Diversity
- Create a Classification System

Engage Your Brain

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

T	F	
☐	☐	Reproduction requires two parents.
☐	☐	Some organisms reproduce by cell division.
☐	☐	New plants can grow from parts of a parent plant, such as roots and stems.
☐	☐	Offspring of two parents always look like one of their parents.

2 Describe How is the young wolf in the photo below similar to its mother?

_____

_____

_____

_____

ACTIVE READING

3 Synthesize You can often define an unknown word if you know the meaning of its word parts. Use the word parts and sentence below to make an educated guess about the meaning of the word *reproduction*.

Word part	Meaning
re-	again
produce	to make
-ion	act or process

Example sentence

Flowers are plant organs that are used for reproduction.

reproduction:

_____

_____

Vocabulary Terms

- **asexual reproduction**
- **sexual reproduction**
- **fertilization**

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

One Becomes Two

What is asexual reproduction?

An individual organism does not live forever. The survival of any species depends on the ability to reproduce. Reproduction lets genetic information be passed on to new organisms. Reproduction involves various kinds of cell division.

Most single-celled organisms and some multicellular organisms reproduce asexually. In **asexual reproduction** (ay•SEHK•shoo•uhl ree•pruh•DUHK•shuhn), one organism produces one or more new organisms that are identical to itself. These organisms live independently of the original organism. The organism that produces the new organism or organisms is called a *parent*. Each new organism is called an *offspring*. The parent passes on all of its genetic information to the offspring. So, the offspring produced by asexual reproduction are genetically identical to their parents. They may differ only if a genetic mutation happens.

ACTIVE READING

5 Relate Describe the genetic makeup of the offspring of asexual reproduction.

_____

_____

_____

Dandelions usually reproduce asexually. The dandelions in this field may all be genetically identical!

Think Outside the Book

6 Summarize Research five organisms that reproduce asexually. Make informative flash cards that describe how each organism reproduces asexually. When you have finished, trade flashcards with a classmate to learn about five more organisms.

How do organisms reproduce asexually?

Organisms reproduce asexually in many ways. In prokaryotes, which include bacteria and archaea, asexual reproduction happens by cell division. In eukaryotes, which include single-celled and multicellular organisms, asexual reproduction is a more involved process. It often involves a type of cell division called *mitosis* (my•TOH•sis). Mitosis produces genetically identical cells.

Binary Fission

Binary fission (BY•nuh•ree FISH•uhn) is the form of asexual reproduction in prokaryotes. It is a type of cell division. During binary fission, the parent organism splits in two, producing two new cells. Genetically, the new cells are exactly like the parent cell.

Budding

During *budding*, an organism develops tiny buds on its body. A bud grows until it forms a new full-sized organism that is genetically identical to the parent. Budding is the result of mitosis. Eukaryotes such as single-celled yeasts and multicellular hydras reproduce by budding.

Spores

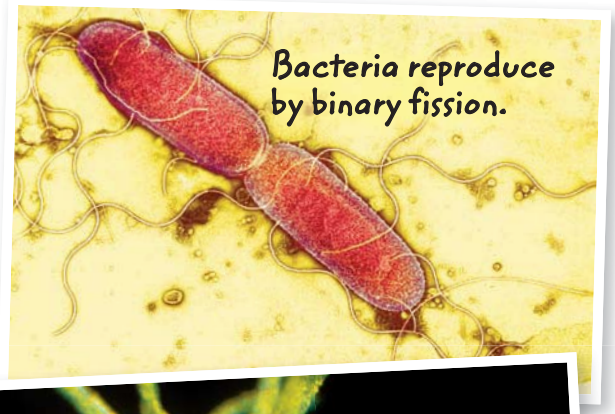
A *spore* is a specialized cell that can survive harsh conditions. Both prokaryotes and eukaryotes can form spores. Spores are produced asexually by one parent. Spores are light and can be carried by the wind. In the right conditions, a spore develops into an organism, such as a fungus.

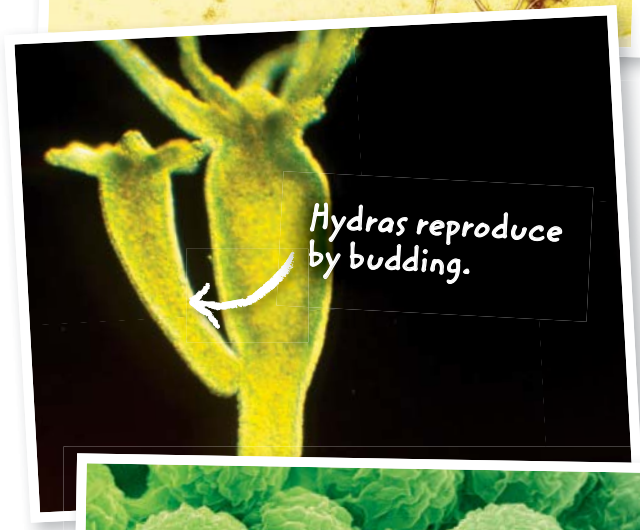
Vegetative Reproduction

Some plants are able to reproduce asexually by *vegetative reproduction*. Mitosis makes vegetative reproduction possible. New plants may grow from stems, roots, or leaves. Runners are aboveground stems from which a new plant can grow. Tubers are underground stems from which new plants can grow. Plantlets are tiny plants that grow along the edges of a plant's leaves. They drop off the plant and grow on their own.

Visualize It!

7 Claims • Evidence • Reasoning Pick one of the pictures below. Make a claim about how the type of asexual reproduction shown can help the organism reproduce quickly. Summarize evidence to support your claim and explain your reasoning.





Two Make One

What is sexual reproduction?

Most multicellular organisms can reproduce sexually. In **sexual reproduction** (SEHK•shoo•uhl ree•pruh•DUHK•shuhn), two parents each contribute a sex cell to the new organism. Half the genes in the offspring come from each parent. So, the offspring are not identical to either parent. Instead, they have a combination of traits from each parent.

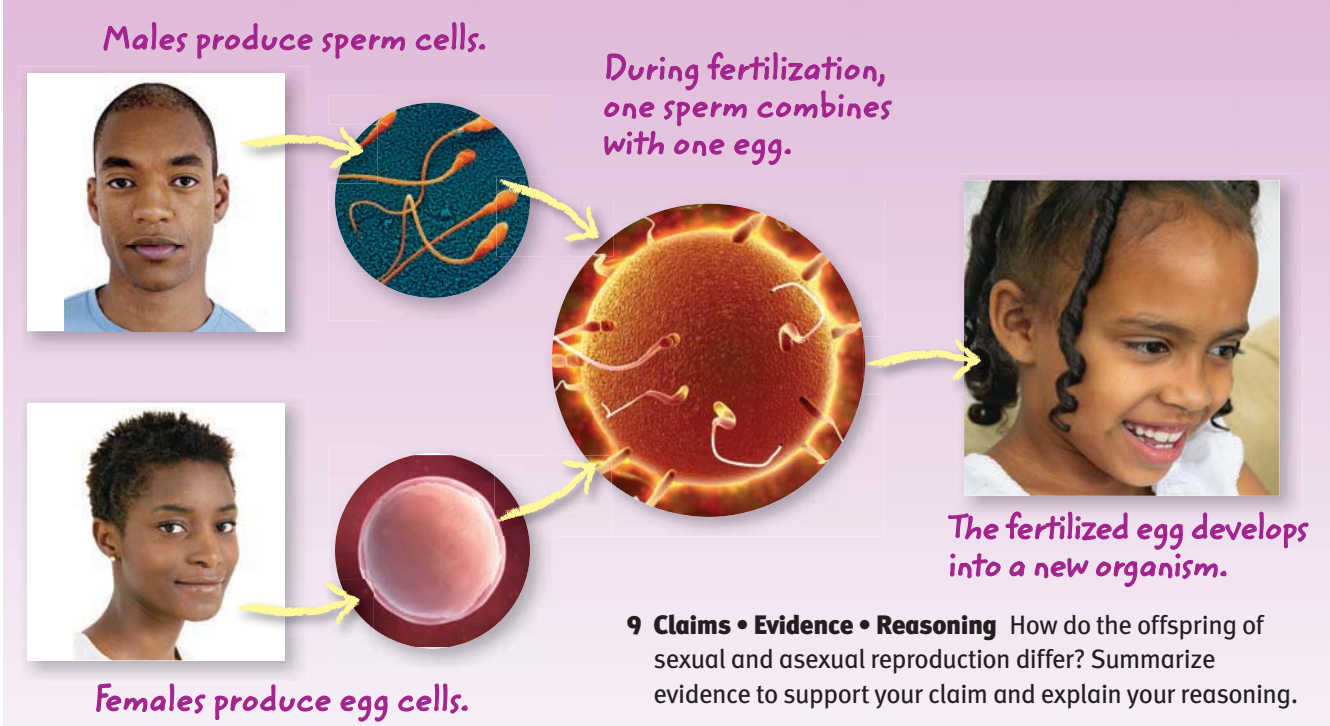
ACTIVE **READING**

8 Identify As you read, underline the male and female sex cells.

Fertilization

Usually, one parent is male and the other is female. Males produce sex cells called *sperm cells.* Females produce sex cells called *eggs.* Sex cells are produced by a type of cell division called *meiosis* (my•OH•sis). Sex cells have only half of the full set of genetic material found in body cells.

A sperm cell and an egg join together in a process called **fertilization** (fer•tl•i•ZAY•shuhn). When an egg is fertilized by a sperm cell, a new cell is formed. This cell is called a *zygote* (ZY•goht). It has a full set of genetic material. The zygote develops into a new organism. The zygote divides by mitosis, which increases the number of cells. This increase in cells produces growth. You are the size that you are today because of mitosis.



9 Claims • Evidence • Reasoning How do the offspring of sexual and asexual reproduction differ? Summarize evidence to support your claim and explain your reasoning.

WHY IT **MATTERS**

Odd Reproduction

WEIRD SCIENCE

It may seem like only single-celled organisms undergo asexual reproduction. However, many multicellular organisms reproduce asexually.

Appearing Act

Some organisms, such as aphids, reproduce asexually by *parthenogenesis*. A female produces young without fertilization.

Falling to Pieces

Tapeworms can reproduce asexually by *fragmentation*. Each segment of the worm can become a new organism if it breaks off of the worm.

Seeing Stars

Organisms such as starfish reproduce asexually by *regeneration*. Even a small part of the starfish can grow into a new organism.

Extend

10 **Identify** Which types of asexual reproduction involve part of an organism breaking off?

11 **Investigate** Research the advantages and disadvantages of a type of reproduction shown on this page.

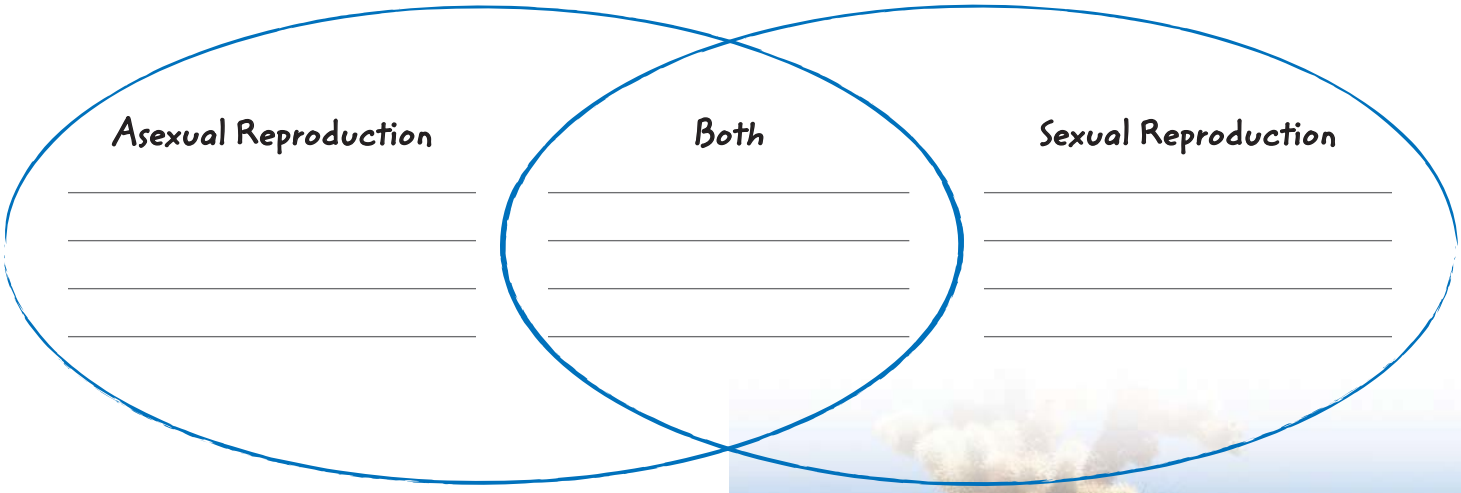
12 **Claims • Evidence • Reasoning** A female shark was left alone in an aquarium tank. She was not pregnant when placed in the tank. Later scientists were surprised to find a baby shark in the tank. Make a claim about what type of reproduction took place in this scenario. Summarize evidence to explain your reasoning.

Added Advantage

What are the advantages of each type of reproduction?

Organisms reproduce asexually, sexually, or both. Each type of reproduction has advantages. For example, sexual reproduction involves complex structures, such as flowers and other organs. These are not needed for asexual reproduction. But the offspring of sexual reproduction may be more likely to survive in certain situations. Read on to find out more about the advantages of each.

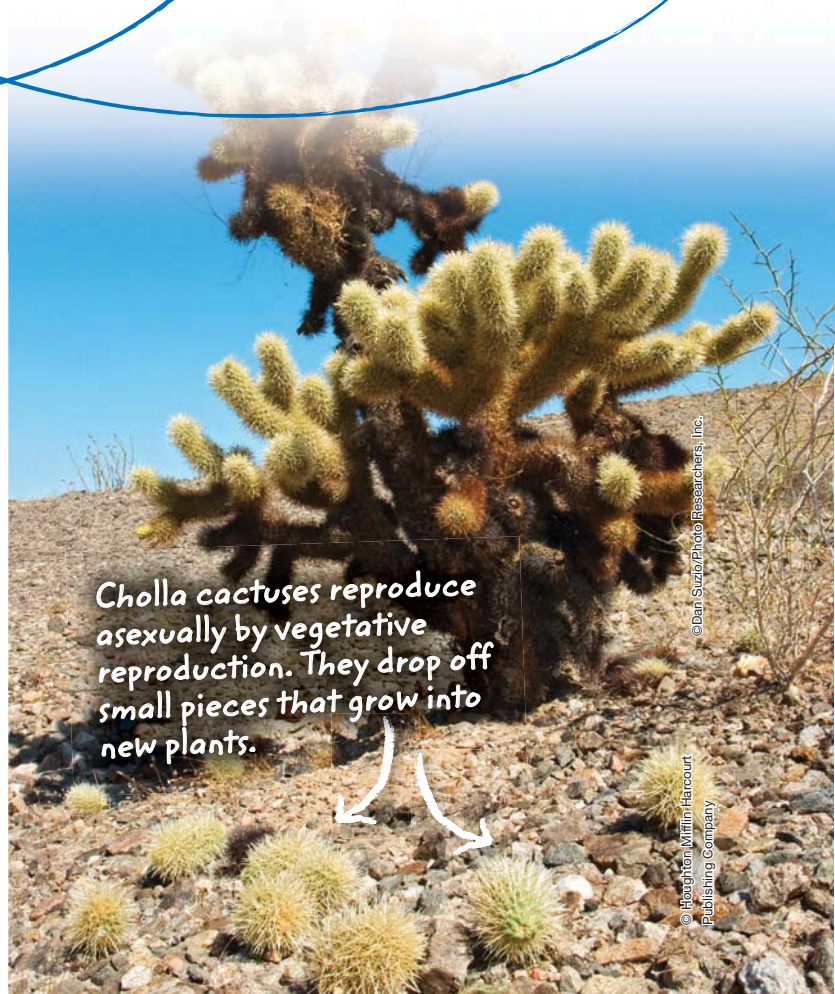
13 Compare Use the Venn diagram below to compare asexual and sexual reproduction.



Advantages of Asexual Reproduction

Asexual reproduction has many advantages. First, an organism can reproduce very quickly. Offspring are identical to the parent. So, it also ensures that any favorable traits the parent has are passed on to offspring. Also, a parent organism does not need to find a partner to reproduce. Finally, all offspring—not just females—are able to produce more offspring.

14 List Identify four advantages of asexual reproduction.



Cats reproduce sexually. Offspring are similar to, but not exactly like, their parents.

Advantages of Sexual Reproduction

Sexual reproduction is not as quick as asexual reproduction. Nor does it produce as many offspring. However, it has advantages. First, it increases genetic variation. Offspring have different traits that improve the chance that at least some offspring will survive. This is especially true if the environment changes. Offspring are not genetically identical to the parents. So, they may have a trait that the parents do not have, making them more likely to survive.

15 Claims • Evidence • Reasoning Make a claim about how increased genetic variation can help some offspring survive. Cite evidence, and explain your reasoning.

Advantages of Using Both Types of Reproduction

Some organisms can use both types of reproduction. For example, when conditions are favorable, many plants and fungi will reproduce asexually. Doing so lets them spread quickly and take over an area. When the environment changes, these organisms will switch to sexual reproduction. This strategy increases the chance that the species will survive. Because of genetic variation, at least some of the offspring may have traits that help them make it through the environmental change.

16 Compare In the table below, place a check mark in the cells that describe a characteristic of asexual or sexual reproduction.

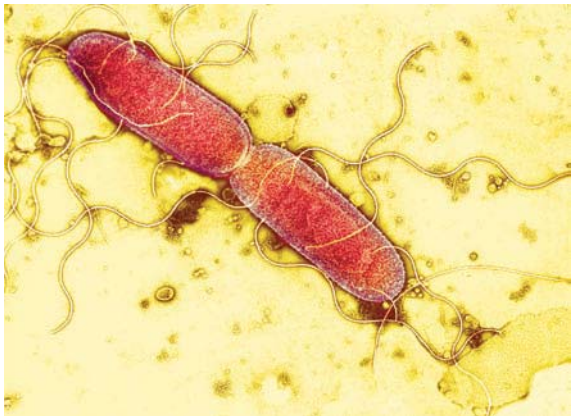
	Quick	Increases chance of survival in changing environments	Produces genetic variation	Doesn't need a partner	Requires complex structures
Asexual reproduction					
Sexual reproduction					

Visual Summary

To complete this summary, circle the correct word that completes each statement. You can use this page to review the main concepts of the lesson.

Reproduction

Asexual reproduction involves one parent.



17 The offspring of asexual reproduction are genetically identical / similar to the parent organisms.

18 Prokaryotes reproduce by budding / binary fission.

19 Specialized reproductive structures called runners / spores can survive harsh conditions.

20 A benefit of asexual reproduction is that it is fast / slow.

Sexual reproduction involves two parents.

21 Male organisms produce sex cells called eggs / sperm cells.

22 Male and female sex cells join during fertilization / meiosis.

23 Sexual reproduction increases genetic variation / similarity.

24 Claims • Evidence • Reasoning How can both asexual reproduction and sexual reproduction allow for the survival of a species? Summarize evidence to support your claim and explain your reasoning.

Lesson Review

LESSON 3

Vocabulary

Fill in the blanks with the term that best completes the following sentences.

1 After _____ , the zygote develops into a larger organism.

2 An advantage of _____ reproduction is the ability to reproduce quickly.

3 The offspring of _____ reproduction are more likely to survive changes in the environment.

Key Concepts

4 Identify What are some advantages of asexual and sexual reproduction?

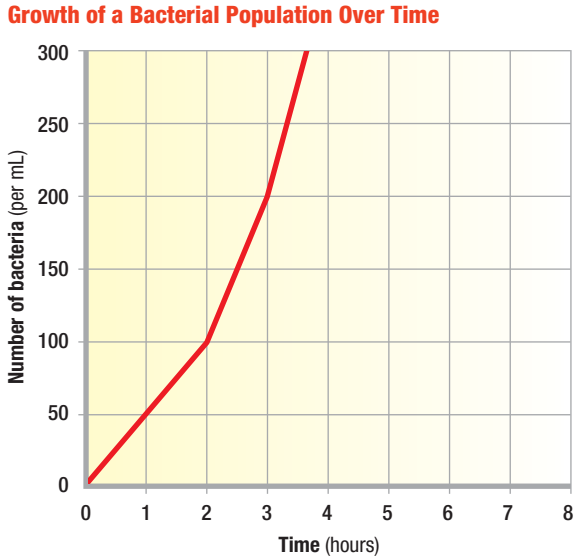
5 Compare In sexual reproduction, how do the offspring compare to the parents?

6 Identify List four types of asexual reproduction.

7 Explain Why do some organisms use both types of reproduction?

Critical Thinking

Use the graph to answer the following questions.



8 Infer What type of reproduction is most likely taking place? Explain your reasoning.

9 Claims • Evidence • Reasoning Which advantage of reproduction does the graph show? Summarize evidence to support your claim, and explain your reasoning.

10 Claims • Evidence • Reasoning Make a claim about how the graph might change if the environmental conditions of the bacteria were to suddenly change. Summarize evidence to support your claim, and explain your reasoning.

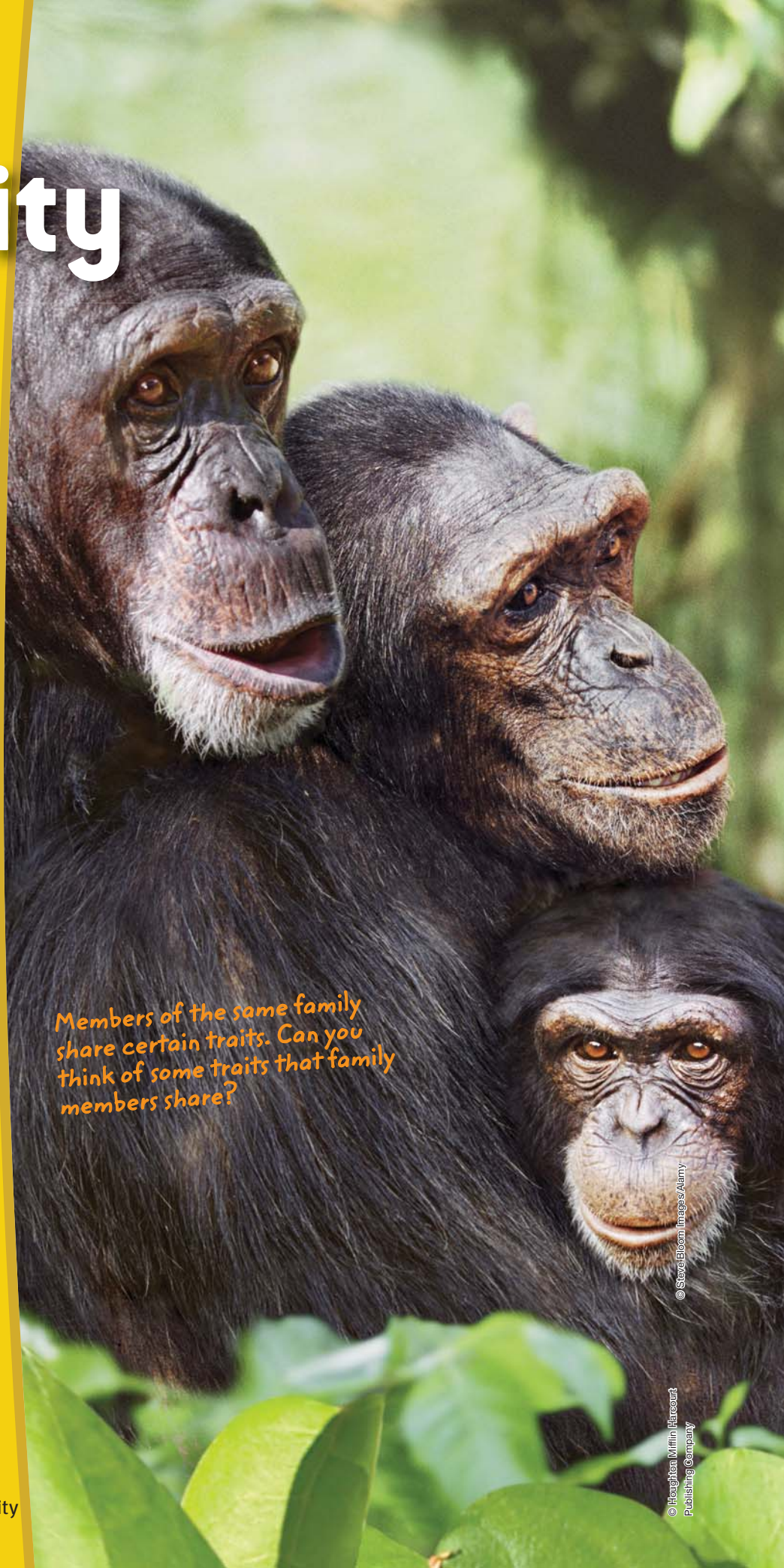
LESSON 4

Heredity

ESSENTIAL **QUESTION**

How are traits inherited?

By the end of this lesson, you should be able to analyze the inheritance of traits in individuals.



Members of the same family share certain traits. Can you think of some traits that family members share?

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. **HE.7.C.1.7** Describe how heredity can affect personal health. **HE.7.C.1.8** Explain the likelihood of injury or illness if engaging in unhealthy/risky behaviors.

Lesson Labs

Quick Labs

- Gender Determination
- Dominant Alleles

Engage Your Brain

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

T	F	
☐	☐	Siblings look similar because they each have some traits of their parents.
☐	☐	Siblings always have the same hair color.
☐	☐	Siblings have identical DNA.

2 Describe Do you know any identical twins? How are they similar? How are they different?

ACTIVE READING

3 Infer Use context clues to write your own definition for the words *exhibit* and *investigate*.

Example sentence
A person with brown hair may also exhibit the trait of brown eye color.

exhibit:

Example sentence
Gregor Mendel began to investigate the characteristics of pea plants.

investigate:

Vocabulary Terms

- **heredity**
- **gene**
- **allele**
- **genotype**
- **phenotype**
- **dominant**
- **recessive**
- **incomplete dominance**
- **codominance**

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

Give Peas a Chance

What is heredity?

Imagine a puppy. The puppy has long floppy ears like his mother has, and the puppy has dark brown fur like his father has. How did the puppy get these traits? The traits are a result of information stored in the puppy's genetic material. The passing of genetic material from parents to offspring is called **heredity**.

What did Gregor Mendel discover about heredity?

The first major experiments investigating heredity were performed by a monk named Gregor Mendel. Mendel lived in Austria in the 1800s. Before Mendel became a monk, he attended a university and studied science and mathematics. This training served him well when he began to study the inheritance of traits among the pea plants in the monastery's garden. Mendel studied seven different characteristics of pea plants: plant height, flower and pod position, seed shape, seed color, pod shape, pod color, and flower color. A *characteristic* is a feature that has different forms in a population. Mendel studied each pea plant characteristic separately, always starting with plants that were true-breeding for that characteristic. A true-breeding plant is one that will always produce offspring with a certain trait when allowed to self-pollinate. Each of the characteristics that Mendel studied had two different forms. For example, the color of a pea could be green or yellow. These different forms are called *traits*.

Characteristics of Pea Plants

Characteristic	Traits	
Seed color		
Seed shape		
Pod color		
Flower position		

5 Apply Is flower color a characteristic or a trait?

Traits Depend on Inherited Factors

In his experiments with seed pod color, Mendel took two sets of plants, one true-breeding for plants that produce yellow seed pods and the other true-breeding for plants that produce green seed pods. Instead of letting the plants self-pollinate as they do naturally, he paired one plant from each set. He did this by fertilizing one plant with the pollen of another plant. Mendel called the plants that resulted from this cross the first generation. All of the plants from this first generation produced green seed pods. Mendel called this trait the *dominant* trait. Because the yellow trait seemed to recede, or fade away, he called it the *recessive* trait.

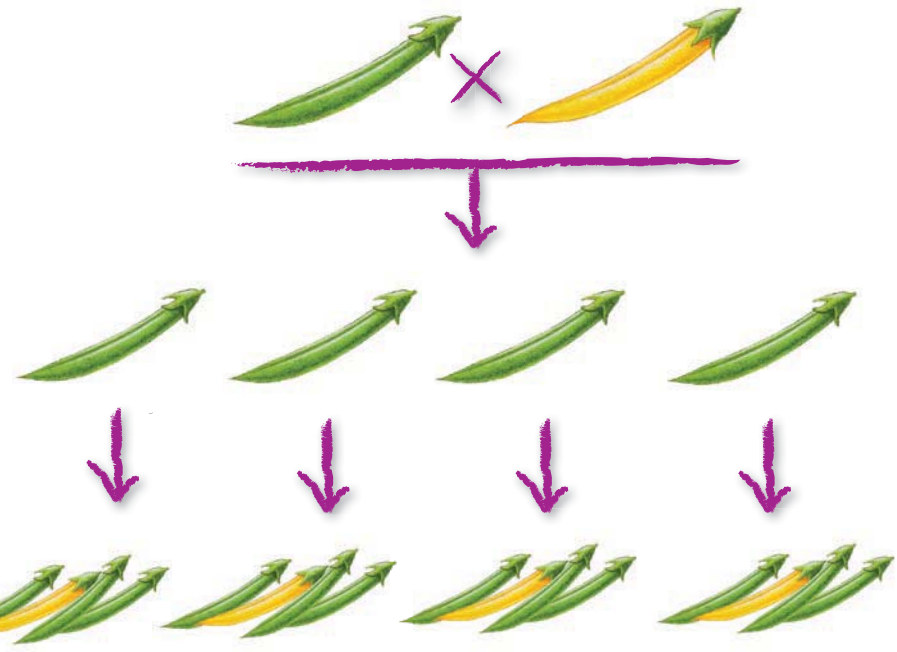
Then Mendel let the first-generation plants self-pollinate. He called the offspring that resulted from this self-pollination the second generation. About three-fourths of the second-generation plants had green seed pods, but about one-fourth had yellow pods. So the trait that seemed to disappear in the first generation reappeared in the second generation. Mendel hypothesized that each plant must have two heritable "factors" for each trait, one from each parent. Some traits, such as yellow seed pod color, could only be observed if a plant received two factors—one from each parent—for yellow pod color. A plant with one yellow factor and one green factor would produce green pods because producing green pods is a dominant trait. However, this plant could still pass on the yellow factor to the next generation of plants.

ACTIVE READING

6 Identify As you read, underline Mendel's hypothesis about how traits are passed from parents to offspring.

Visualize It!

7 Claims • Evidence • Reasoning Which pod color is recessive? Summarize evidence to support your claim, and explain your reasoning.



Parent plants Mendel crossed true-breeding green-pod plants with true-breeding yellow-pod plants.

First generation All of the first generation plants had green pods. Mendel let these plants self-pollinate.

Second generation About three-fourths of the second generation had green pods, and one-fourth had yellow pods.

It's in your genes!

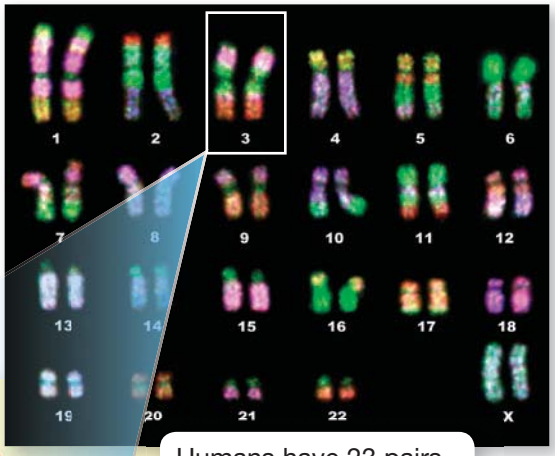
Genes are made up of DNA.

How are traits inherited?

Mendel's experiments and conclusions have been the basis for much of the scientific thought about heredity. His ideas can be further explained by our modern understanding of the genetic material DNA. What Mendel called "factors" are actually segments of DNA known as genes!

Genes Are Passed from Parents to Offspring

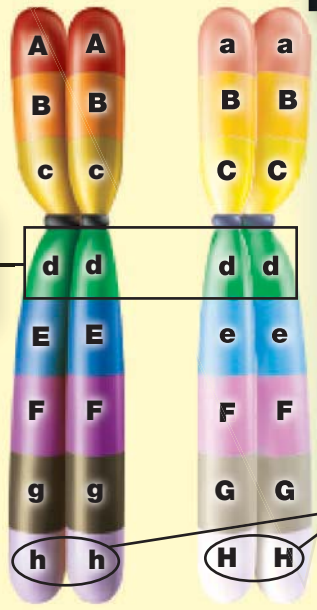
Genes are segments of DNA found in chromosomes that give instructions for producing a certain characteristic. Humans, like many other organisms, inherit their genes from their parents. Each parent gives one set of genes to the offspring. The offspring then has two versions, or forms, of the same gene for every characteristic—one version from each parent. The different versions of a gene are known as **alleles** (uh•LEELZ). Genes are often represented by letter symbols. Dominant alleles are shown with a capital letter, and recessive alleles are shown with a lowercase version of the same letter. An organism with two dominant or two recessive alleles is said to be *homozygous* for that gene. An organism that has one dominant and one recessive allele is *heterozygous*.



Humans have 23 pairs of chromosomes.

In humans, cells contain pairs of chromosomes. One chromosome of each pair comes from each of two parents. Each chromosome contains sites where specific genes are located.

A gene occupies a specific location on both chromosomes in a pair.



Alleles are alternate forms of the same gene.

Visualize It!

8 Apply Circle a gene pair for which this person is heterozygous.

9 Apply The girls in this photograph have different types of hair. Is hair type a genotype or a phenotype?

Genes Influence Traits

The alternate forms of genes, called alleles, determine the traits of all living organisms. The combination of alleles that you inherited from your parents is your **genotype** (JEEN•uh•typ). Your observable traits make up your **phenotype** (FEEN•uh•typ). The phenotypes of some traits follow patterns similar to the ones that Mendel discovered in pea plants. That is, some traits are dominant over others. For example, consider the gene responsible for producing dimples, or creases in the cheeks. This gene comes in two alleles: one for dimples and one for no dimples. If you have even one copy of the allele for dimples, you will have dimples. This happens because the allele for producing dimples is dominant. The **dominant** allele contributes to the phenotype if one or two copies are present in the genotype. The no-dimples allele is recessive. The **recessive** allele contributes to the phenotype only when two copies of it are present. If one chromosome in the pair contains a dominant allele and the other contains a recessive allele, the phenotype will be determined by the dominant allele. If you do not have dimples, it is because you inherited two no-dimples alleles—one from each parent. This characteristic shows *complete dominance,* because one trait is completely dominant over another. However, not all characteristics follow this pattern.

ACTIVE READING

11 Identify What is the phenotype of an individual with one allele for dimples and one allele for no dimples?

Think Outside the Book

10 Summarize Write a short story about a world in which you could change your DNA and your traits. What would be the advantages? What would be the disadvantages?

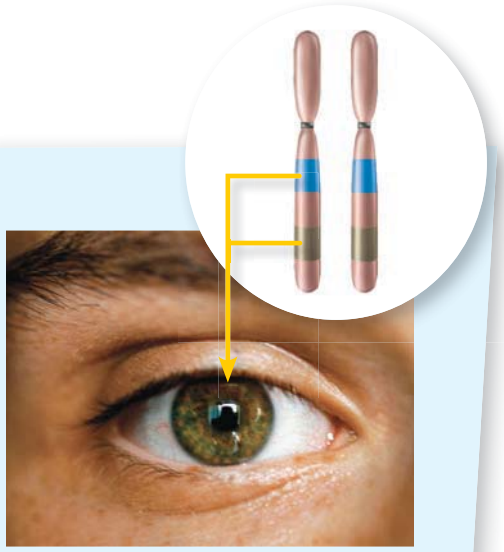
Many Genes Can Influence a Single Trait

Some characteristics, such as the color of your skin, hair, and eyes, are the result of several genes acting together. Different combinations of alleles can result in different shades of eye color. Because there is not always a one-to-one relationship between a trait and a gene, many traits do not have simple patterns of inheritance.

A Single Gene Can Influence Many Traits

Sometimes, one gene influences more than one trait. For example, a single gene causes the tiger shown below to have white fur. If you look closely, you will see that the tiger also has blue eyes. The gene that affects fur color also influences eye color.

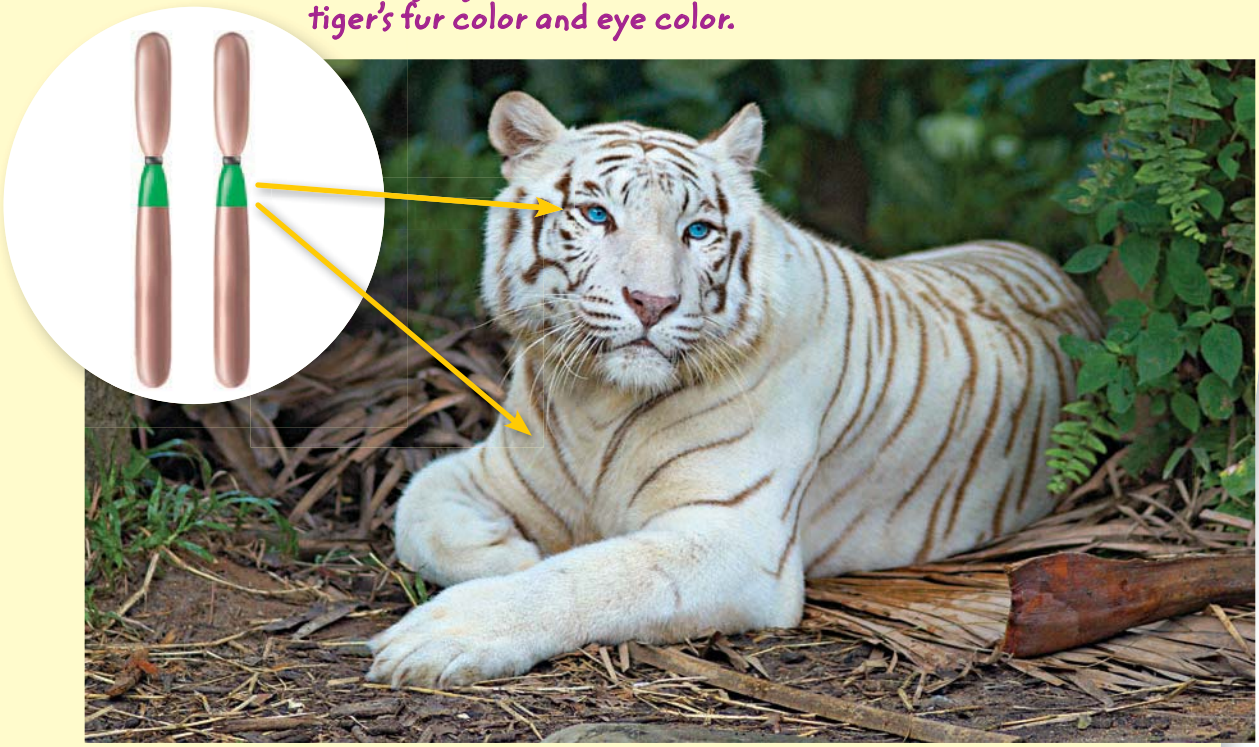
Many genetic disorders in humans are linked to a single gene but affect many traits. For example, the genetic disorder sickle cell anemia occurs in individuals who have two recessive alleles for a certain gene. This gene carries instructions for producing a protein in red blood cells. When a person has sickle cell anemia alleles, the body makes a different protein. This protein causes red blood cells to be sickle or crescent shaped when oxygen levels are low. Sickle-shaped blood cells can stick in blood vessels, sometimes blocking the flow of blood. These blood cells are also more likely to damage the spleen. With fewer healthy red blood cells, the body may not be able to deliver oxygen to the body's organs. All of the traits associated with sickle cell anemia are due to a single gene.



Visualize It!

12 Identify How many genes are responsible for eye color in this example?

This single gene affects the tiger's fur color and eye color.



The Environment Can Influence Traits

Sometimes, the environment influences an organism's phenotype. For example, the arctic fox has a gene that is responsible for coat color. This gene is affected by light. In the winter, there are fewer hours of daylight, and the hairs that make up the arctic fox's coat grow in white. In the summer, when there are more daylight hours, the hairs in the coat grow in brown. In this case, both genes and the environment contribute to the organism's phenotype. The environment can influence human characteristics as well. For example, your genes may make it possible for you to grow to be tall, but you need a healthy diet to reach your full height potential.

Traits that are learned in one's environment are not inherited. For example, your ability to read and write is an acquired trait—a skill you learned. You were not born knowing how to ride a bike, and if you have children, they will not be born knowing how to do it either. They will have to learn the skill just as you did.

ACTIVE **READING**

13 Identify Give an example of an acquired trait.

14 Claims • Evidence • Reasoning What advantage does white fur give the arctic fox in winter? State your claim. Summarize evidence to support your claim, and explain your reasoning.

Bending the Rules

What are the exceptions to complete dominance?

The characteristics that Mendel chose to study demonstrated complete dominance, meaning that heterozygous individuals show the dominant trait. Some human traits, such as freckles and dimples, follow the pattern of complete dominance, too. However, other traits do not. For traits that show incomplete dominance or codominance, one trait is not completely dominant over another.

Incomplete Dominance

In **incomplete dominance**, each allele in a heterozygous individual influences the phenotype. The result is a phenotype that is a blend of the phenotypes of the parents. One example of incomplete dominance is found in the snapdragon flower, shown below. When a true-breeding red snapdragon is crossed with a true-breeding white snapdragon, all the offspring are pink snapdragons. Both alleles of the gene have some influence. Hair texture is an example of incomplete dominance in humans. A person with one straight-hair allele and one curly-hair allele will have wavy hair.

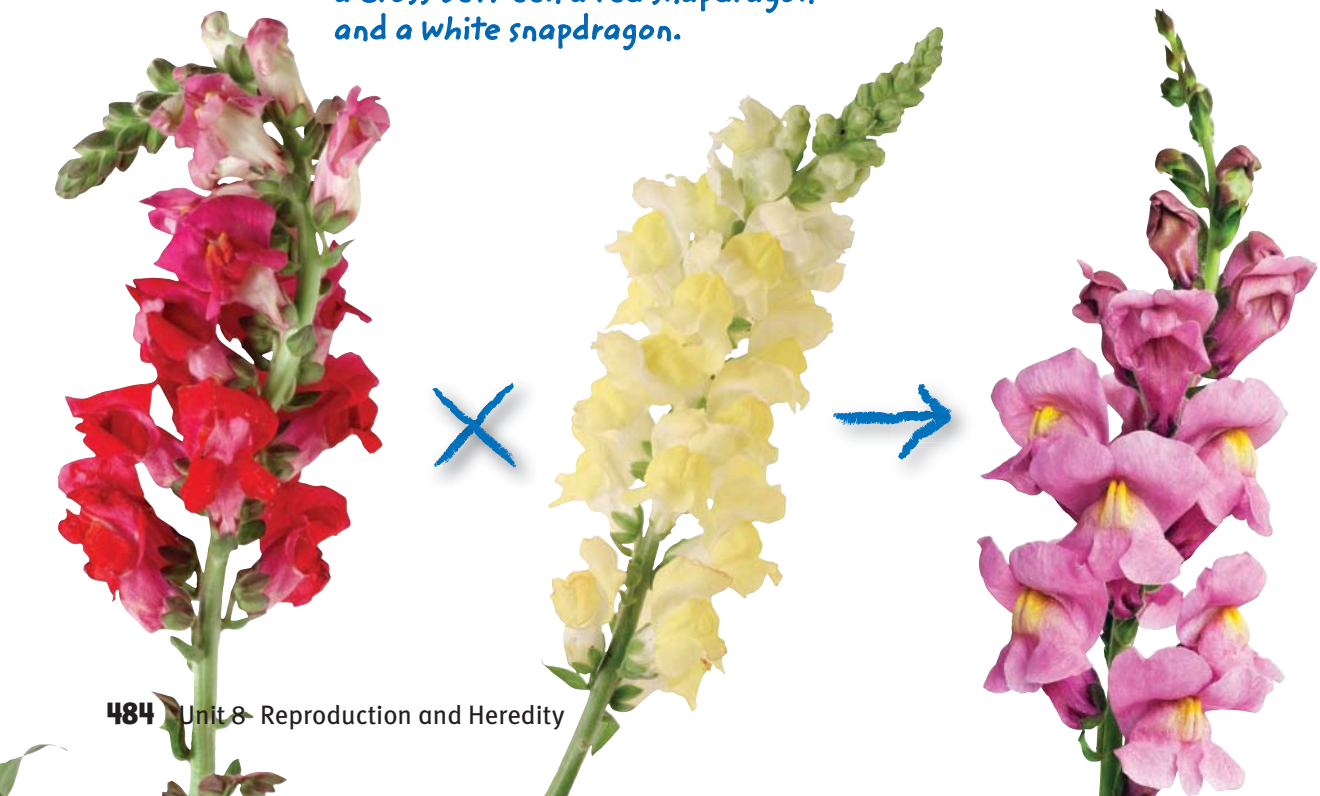
ACTIVE READING

15 Identify As you read, underline examples of incomplete dominance and codominance.

Visualize It!

16 Claims • Evidence • Reasoning How can you tell that these snapdragons do not follow the pattern of complete dominance? Summarize evidence to support your claim, and explain your reasoning.

Pink snapdragons are produced by a cross between a red snapdragon and a white snapdragon.



Codominance

For a trait that shows **codominance**, both of the alleles in a heterozygous individual contribute to the phenotype. Instead of having a blend of the two phenotypes, heterozygous individuals have both of the traits associated with their two alleles. An example of codominance is shown in the genes that determine human blood types. There are three alleles that play a role in determining a person's blood type: *A*, *B*, and *O*. The alleles are responsible for producing small particles on the surface of red blood cells called antigens. The *A* allele produces red blood cells coated with A antigens. The *B* allele produces red blood cells coated with B antigens. The *O* allele does not produce antigens. The *A* and *B* alleles are codominant. So, someone with one *A* allele and one *B* allele will have blood cells that are coated with A antigens and B antigens. This person would have type AB blood.

Think Outside the Book

17 Research Blood type is an important factor when people give or receive blood. Research the meanings of the phrases "universal donor" and "universal recipient." What are the genotypes of each blood type?

ACTIVE READING

18 Identify What antigens coat the red blood cells of a person with type AB blood?

_____

Visualize It!

19 Predict The color of these imaginary fish is controlled by a single gene. Sketch or describe their offspring if the phenotypes follow the pattern of complete dominance, incomplete dominance, or codominance.

Complete dominance (Blue is dominant to yellow.)	Incomplete dominance	Codominance

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.

Heredity

Gregor Mendel studied patterns of heredity in pea plants.

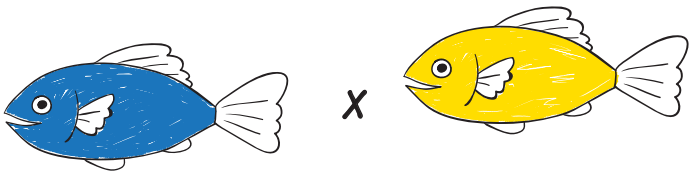
20 Traits that seemed to disappear in Mendel's first-generation crosses were dominant / recessive traits.

Inherited genes influence the traits of an individual.

21 An individual with the genotype BB is heterozygous / homozygous.

Phenotypes can follow complete dominance, incomplete dominance, or codominance.

22 When these imaginary fish cross, their offspring are all green. This is an example of codominance / incomplete dominance.



23 Claims • Evidence • Reasoning A child has blonde hair and both of her parents have brown hair. Make a claim about the allele for blonde hair. Summarize evidence to support your claim and explain your reasoning.

Lesson Review

LESSON 4

Vocabulary

Draw a line to connect the following terms to their definitions.

1 heredity

2 gene

3 phenotype

A an organism's appearance or other detectable characteristic

B a section of DNA that contains instructions for a particular characteristic

C the passing of genetic material from parent to offspring

Key Concepts

4 Describe What did Mendel discover about genetic factors in pea plants?

5 Describe What is the role of DNA in determining an organism's traits?

6 Apply Imagine that a brown horse and a white horse cross to produce an offspring whose coat is made up of some brown hairs and some white hairs. Which pattern of dominance is this an example of?

7 Identify Give an example of a trait that is controlled by more than one gene.

Use this diagram to answer the following questions.

8 Identify What is the genotype at the Q gene?

9 Apply For which genes is this individual heterozygous?

Critical Thinking

10 Claims • Evidence • Reasoning Consider a person who has Marfan syndrome, which is a genetic disorder. This person has only one allele for this disorder in their genotype. What does this mean about the allele for Marfan syndrome? Summarize evidence to support your claim, and explain your reasoning.

11 Describe Jenny, Jenny's mom, and Jenny's grandfather are all good basketball players. Give an example of an inherited trait and an acquired trait that could contribute to their skill at basketball.

SC.7.N.1.1 Define a problem from the seventh grade 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.

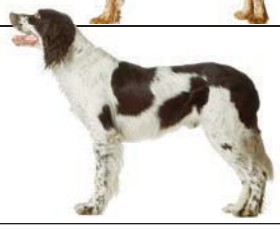
Interpreting Tables

Visual displays, such as diagrams, tables, or graphs, are useful ways to show data collected in an experiment. A table is the most direct way to communicate this information. Tables are also used to summarize important trends in scientific data. Making a table may seem easy. However, if tables are not clearly organized, people will have trouble reading them. Below are a few strategies to help you improve your skills in interpreting scientific tables.

Tutorial

Use the following instructions to study the parts of a table about heredity in Brittanies and to analyze the data shown in the table.

Offspring from Cross of Black Solid and Liver Tricolor Brittanies

Color	Pattern	Number of Offspring
orange and white 	solid	1
black and white 	solid	1
	tricolor	3
liver and white 	solid	1
	tricolor	3

Reading the Title
Every table should have an informative title. By reading the title of the table to the left, we know that the table contains data about the offspring of a cross between a black solid Brittany and a liver tricolor Brittany.

Summarizing the Title
Sometimes it is helpful to write a sentence to summarize a table's title. For example, you could write, "This table shows how puppies that are the offspring of a black solid Brittany and a liver tricolor Brittany might look."

Analyzing the Headings
Row and column headings describe the data in the cells. Headings often appear different from the data in the cells, such as being larger, bold, or being shaded. The row headings in the table to the left organize three kinds of data: the coat color of the puppies, the coat pattern of the puppies, and the number of puppies that have each combination of coat color and pattern.

Describing the Data
In complete sentences, record the information that you read in the table. For example, you could write, "There are five different kinds of offspring. Tricolor puppies are most common, and puppies with a solid coat pattern are least common. There are twice as many tricolor puppies as solid puppies."

Analyzing the Data
Now that you have seen how the table is organized, you can begin to look for trends in the data. Which combinations are most common? Which combinations are least common?

You Try It!

The table below shows the characteristics of Guinea pig offspring. Look at the table, and answer the questions that follow.

Characteristics of Guinea Pig Offspring from Controlled Breeding			
Hair Color	**Coat Texture**	**Hair Length**	**Number of Guinea Pigs**
black	rough	short	27
		long	9
	smooth	short	9
		long	3
white	rough	short	9
		long	3
	smooth	short	3
		long	1

1 Summarizing the Title Circle the title of the table. Write a one-sentence description of the information shown in the table.

2 Analyzing the Headings Shade the column headings in the table. What information do they show? How many combinations of hair color, coat texture, and hair length are shown?

3 Analyzing the Data Circle the most common type of Guinea pig. Box the least common type of Guinea pig. Write sentences to describe the characteristics of each.

4 Applying Mathematics Calculate the total number of Guinea pig offspring. Write this total at the bottom of the table. What percentage of the total number of Guinea pigs has short hair? What percentage of the total number of Guinea pigs has long hair?

5 Claims • Evidence • Reasoning Based on your data from Step 4, which characteristic is dominant in Guinea pigs: long hair or short hair? Summarize evidence to support your claim and explain your reasoning.

6 Applying Concepts What is one advantage of displaying data in tables? What is one advantage of describing data in writing?

Take It Home!

With an adult, practice making tables. You can categorize anything that interests you. Make sure your table has a title and clearly and accurately organizes your data using headings. If possible, share your table with your class.

LESSON 5

Punnett Squares and Pedigrees

ESSENTIAL **QUESTION**

How are patterns of inheritance studied?

By the end of this lesson, you should be able to explain how patterns of heredity can be predicted by Punnett squares and pedigrees.

These cattle are bred for their long, curly hair, which keeps them warm in cold climates. This trait is maintained by careful breeding of these animals.

SC.7.L.16.2 Determine the probabilities for genotype and phenotype combinations using Punnett Squares and pedigrees. **HE.7.C.1.3** Analyze how environmental factors affect personal health. **HE.7.C.1.7** Describe how heredity can affect personal health.

Lesson Labs

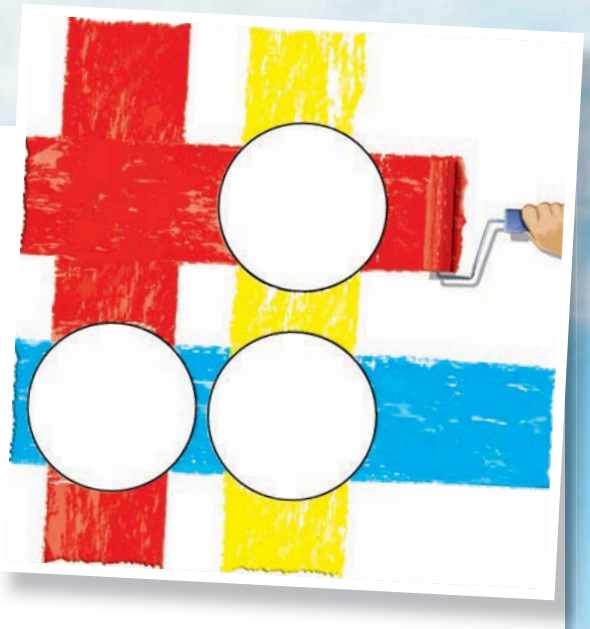
Quick Labs
- Completing a Punnett Square
- Interpreting Pedigree Charts

Exploration Lab
- Offspring Models

Exploration/S.T.E.M. Lab
- Accuracy of Punnett Square Predictions

Engage Your Brain

1 Infer Why do you think that children look like their parents?



2 Apply Color or label each circle with the color that results when the two paints mix. As you read the lesson, think about how this grid is similar to and different from a Punnett square.

ACTIVE READING

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

Example sentence
Tools can be used to predict the likelihood that a particular genetic combination will occur.

occur:

Example sentence
A Punnett square can be used to predict the outcome of a genetic cross.

outcome:

Vocabulary Terms

- **Punnett square**
- **ratio**
- **probability**
- **pedigree**

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.

Squared Away

How are Punnett squares used to predict patterns of heredity?

When Gregor Mendel studied pea plants, he noticed that traits are inherited in patterns. One tool for understanding the patterns of heredity is a diagram called a *Punnett square*. A **Punnett square** is a graphic used to predict the possible genotypes of offspring in a given cross. Each parent has two alleles for a particular gene. An offspring receives one allele from each parent. A Punnett square shows all of the possible allele combinations in the offspring.

The Punnett square below shows how alleles are expected to be distributed in a cross between a pea plant with purple flowers and a pea plant with white flowers. The top of the Punnett square shows one parent's alleles for this trait (*F* and *F*). The left side of the Punnett square shows the other parent's alleles (*f* and *f*). Each compartment within the Punnett square shows an allele combination in potential offspring. You can see that in this cross, all offspring would have the same genotype (*Ff*). Because purple flower color is completely dominant to white flower color, all of the offspring would have purple flowers.

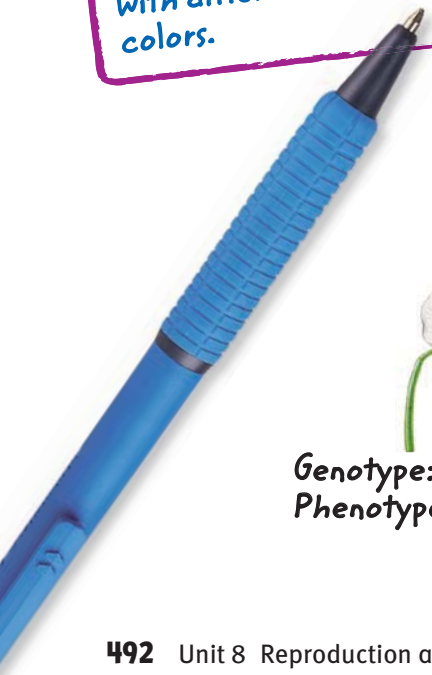
ACTIVE READING

5 Identify In a Punnett square, where are the parents' alleles written?

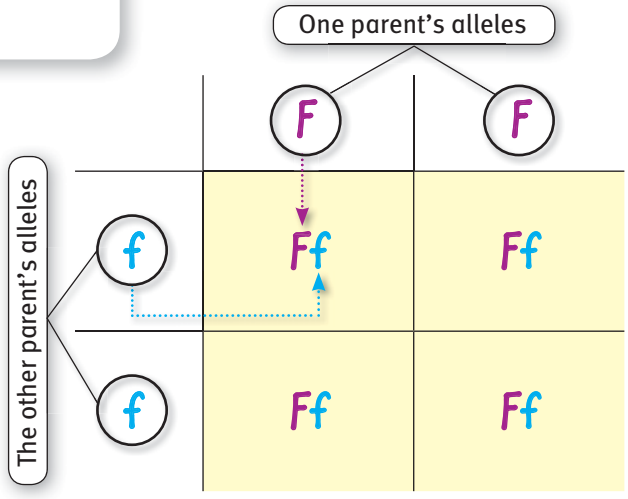
This Punnett square shows the possible offspring combinations in pea plants with different flower colors.

Key:
- F Purple flower allele
- f White flower allele

Genotype: FF
Phenotype: purple flower



Genotype: ff
Phenotype: white flower



Visualize It!

6 Apply Fill in the genotypes and phenotypes of the parents and offspring in this Punnett square. Sketch the resulting offspring possibilities in the white boxes below. (Hint: Assume complete dominance.)

Key:

R Round pea allele

r Wrinkled pea allele

Genotype: _____

Phenotype: _____

Genotype: _____

Phenotype: _____

	R	r
R	Genotype: _____ Phenotype: _____	Genotype: _____ Phenotype: _____
r	Genotype: _____ Phenotype: _____	Genotype: _____ Phenotype: _____

7 Explain Your Reasoning What does each compartment of the Punnett square represent? Explain your reasoning.

_____

_____

_____

_____

_____

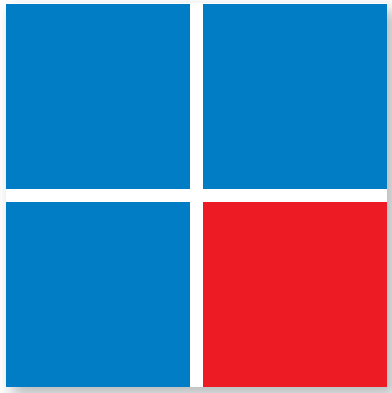
_____

_____

How can a Punnett square be used to make predictions about offspring?

A Punnett square does not tell you what the exact results of a certain cross will be. A Punnett square only helps you find the probability that a certain genotype will occur. **Probability** is the mathematical chance of a specific outcome in relation to the total number of possible outcomes.

Probability can be expressed in the form of a **ratio** (RAY•shee•oh), an expression that compares two quantities. A ratio written as 1:4 is read as "one to four." The ratios obtained from a Punnett square tell you the probability that any one offspring will get certain alleles. Another way of expressing probability is as a *percentage*. A percentage is like a ratio that compares a number to 100. A percentage states the number of times a certain outcome might happen out of a hundred chances.



1:4 is the ratio of red squares to total squares.

Do the Math

Sample Problem

In guinea pigs, the dominant *B* allele is responsible for black fur, while the recessive *b* allele is responsible for brown fur. Use the Punnett square to find the probability of this cross resulting in offspring with brown fur.

	B	b
b	 Bb	 bb
b	 Bb	 bb

Identify

A. What do you know?

Parent genotypes are Bb and bb. Possible offspring genotypes are Bb and bb.

B. What do you want to find out?

Probability of the cross resulting in offspring with brown fur

Plan

C. Count the total number of offspring allele combinations: 4

D. Count the number of allele combinations that will result in offspring with brown fur: 2

Solve

E. Write the probability of offspring with brown fur as a ratio: 2:4

F. Rewrite the ratio to express the probability out of 100 off spring by multiplying each side of the ratio by the same number (such as 25): 50:100

G. Convert the ratio to a percentage: 50%

Answer: 50% chance of offspring with brown fur

Do the Math

You Try It

8 Calculate This Punnett square shows a cross between two *Bb* guinea pigs. What is the probability of the cross resulting in offspring with black fur?

	B	b
B	 BB	 Bb
b	 Bb	 bb

Identify

A. What do you know?

B. What do you want to find out?

Plan

C. Count the total number of offspring allele combinations:

D. Count the number of allele combinations that will result in offspring with black fur:

Solve

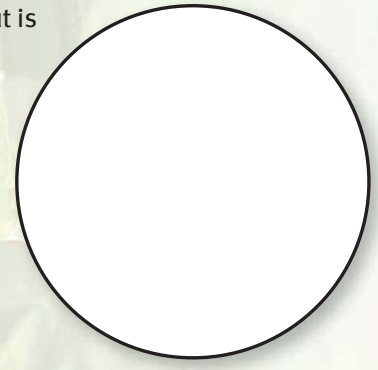
E. Write the probability of offspring with black fur as a ratio:

F. Rewrite the ratio to express the probability out of 100 offspring by multiplying each side of the ratio by the same number:

G. Convert the ratio to a percentage:

Answer:

9 Claims • Evidence • Reasoning In the cross above, what is the ratio of each of the possible genotypes? Make a claim by filling in the pie chart at the right. Fill in the key to show which pieces of the chart represent the different genotypes.



How can a pedigree trace a trait through generations?

A pedigree is another tool used to study patterns of inheritance. A **pedigree** traces the occurrence of a trait through generations of a family. Pedigrees can be created to trace any inherited trait—even hair color!

Pedigrees can be useful in tracing a special class of inherited disorders known as *sex-linked disorders*. Sex-linked disorders are associated with an allele on a sex chromosome. Many sex-linked disorders, such as hemophilia and colorblindness, are caused by an allele on the X chromosome. Women have two X chromosomes, so a woman can have one allele for colorblindness without being colorblind. A woman who is heterozygous for this trait is called a *carrier,* because she can carry or pass on the trait to her offspring. Men have just one X chromosome. In men, this single chromosome determines if the trait is present.

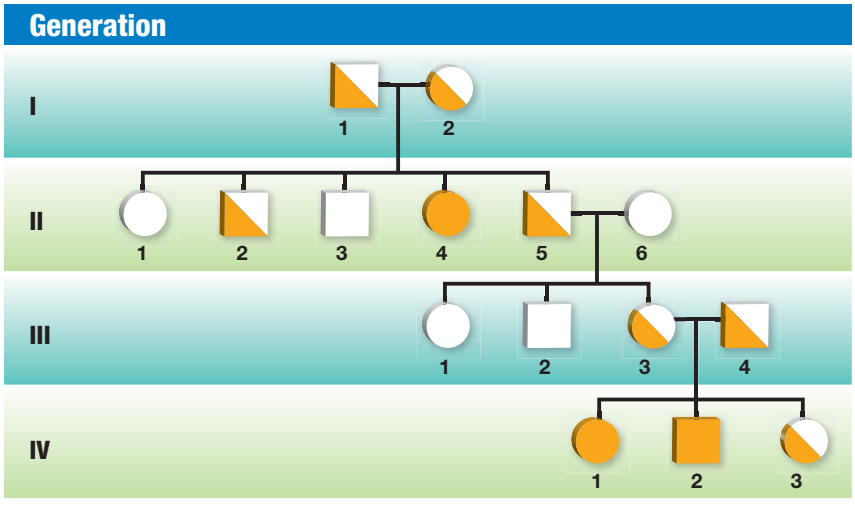
The pedigree below traces a disease called *cystic fibrosis*. Cystic fibrosis causes serious lung problems. Carriers of the disease have one recessive allele. They do not have cystic fibrosis, but they are able to pass the recessive allele on to their children. If a child receives a recessive allele from each parent, then the child will have cystic fibrosis. Other genetic conditions follow a similar pattern.

Think Outside the Book

10 Design Create a pedigree chart that traces the occurrence of dimples in your family or in the family of a friend. Collect information for as many family members as you can.

Visualize It!

Pedigree for Cystic Fibrosis



Males Females

Vertical lines connect children to their parents.

or A solid square or circle indicates that the person has a certain trait.

or A half-filled square or circle indicates that the person is a carrier of the trait.

11 Claims • Evidence • Reasoning Does anyone in the third generation have cystic fibrosis? Summarize evidence to support your claim and explain your reasoning.

12 Calculate What is the probability that the child of two carriers will have cystic fibrosis?

WHY IT **MATTERS**

EYE ON THE ENVIRONMENT

Saving the European Mouflon

The European mouflon is an endangered species of sheep. Scientists at the University of Teramo in Italy used genetic tools and techniques to show how the population of mouflon could be preserved.

Maintaining Genetic Diversity

When a very small population of animals interbreeds, there is a greater risk that harmful genetic conditions can appear in the animals. This is one issue that scientists face when trying to preserve endangered species. One way to lower this risk is to be sure that genetically-similar animals do not breed.

Genetics to the Rescue!

Researchers combined the sperm and egg of genetically-dissimilar European mouflons in a laboratory. The resulting embryo was implanted into a mother sheep. By controlling the combination of genetic material, scientists hope to lower the risk of inherited disorders.

Extend

13 Claims • Evidence • Reasoning Why are small populations hard to preserve? Summarize evidence to support your claim and explain your reasoning.

14 Research Research another population of animals that has been part of a captive breeding program.

15 Describe Describe these animals and the results of the breeding program by doing one of the following:

- make a poster
- write a short story
- write a song
- draw a graphic novel

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.

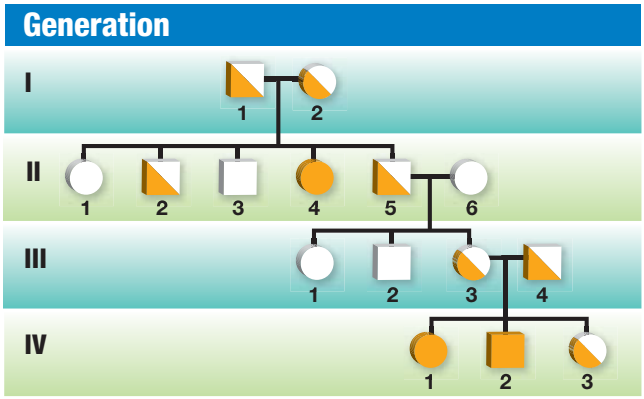
Predicting Patterns of Inheritance

Punnett squares can be used to make predictions about possible offspring.

	F	F
f	Ff	Ff
f	Ff	Ff

16 A Punnett square shows combinations of different _____ received from each parent.

Pedigrees trace a trait through generations.



17 An allele responsible for a _____ is found on a sex chromosome.

18 Claims • Evidence • Reasoning How is a heterozygous individual represented in the Punnett square and pedigree shown above? Summarize evidence to support your claim and explain your reasoning.

Lesson Review

LESSON 5

Vocabulary

Circle the term that best completes the following sentences.

1. A *Punnett square / ratio* is a tool that can be used to predict the genotypes of potential offspring in a given cross.
2. The results from a Punnett square can be used to find the *pedigree / probability* that a certain allele combination will occur in offspring.
3. A mathematical expression that compares one number to another is called a *pedigree / ratio.*

Key Concepts

Use this diagram to answer the following questions.

	G	G
g	Gg	Gg
g	Gg	Gg

4. **Analyze** What is gene G responsible for in these fruit flies?

5. **Analyze** What is the ratio of heterozygous offspring to total offspring in the Punnett square?

6. **Define** What is a sex-linked disorder?

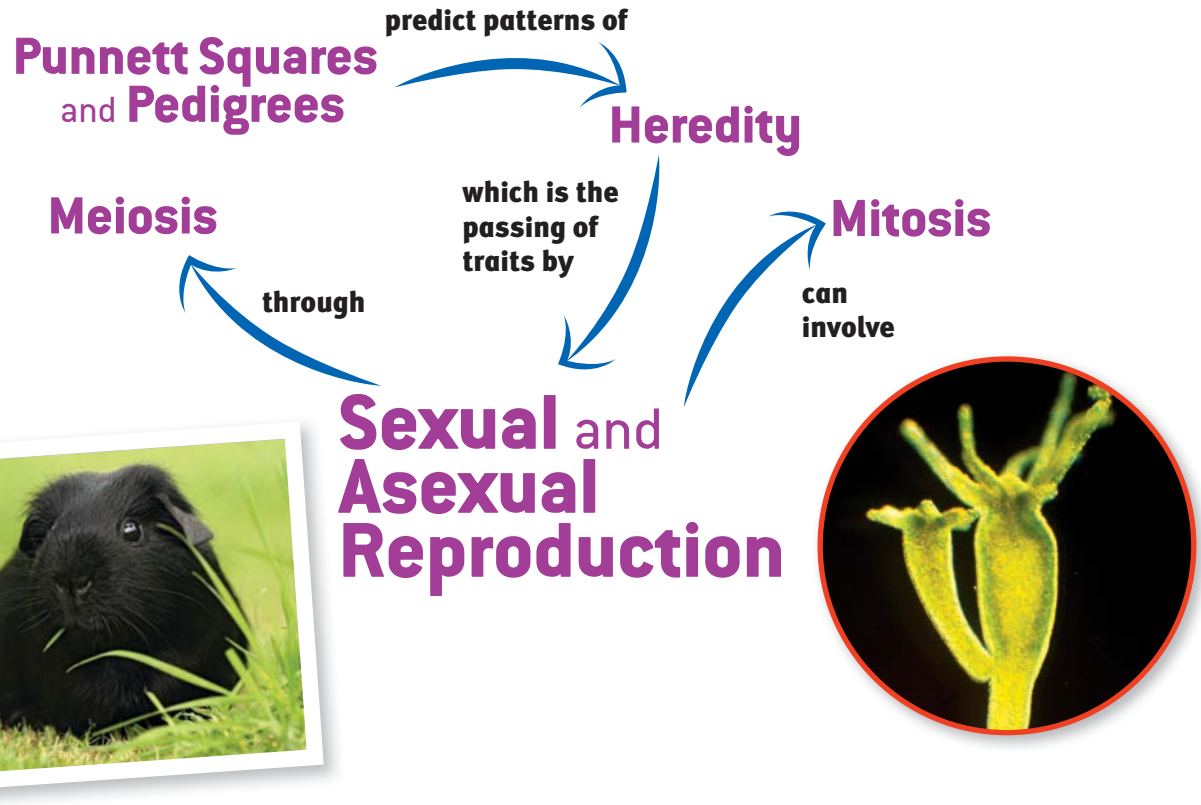
Critical Thinking

7. **Claims • Evidence • Reasoning** Imagine a pedigree that traces an inherited disorder found in individuals with two recessive alleles for gene D. The pedigree shows three siblings with the genotypes *DD, Dd,* and *dd.* Did the parents of these three children have the disorder? Summarize evidence to support your claim and explain your reasoning.

8. **Explain** A *Bb* guinea pig crosses with a *Bb* guinea pig, and four offspring are produced. All of the offspring are black. How could this happen? Explain your reasoning.

9. **Synthesize** You are creating a pedigree to trace freckles, a recessive trait, in a friend's family. You find out which of her family members have freckles and which do not. When you complete the pedigree, what can you learn about members of your friend's family that you could not tell just by looking at them?

UNIT 8 Summary



1 Claims • Evidence • Reasoning The Graphic Organizer above shows that Punnett squares are used to make predictions about heredity. Are Punnett squares more useful for predicting the results of sexual or asexual reproduction? State your claim. Summarize evidence to support your claim and explain your reasoning.

2 Compare How are meiosis and mitosis similar? How are they different?

3 Relate Compare the phenotype and genotype of a parent to the phenotype and genotype of its offspring produced by asexual reproduction.

Benchmark Review

UNIT 8

Name _____

Vocabulary

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

1 The genetic material of all cells is _____

2 A(n) _____ compares or shows the relationship between two quantities.

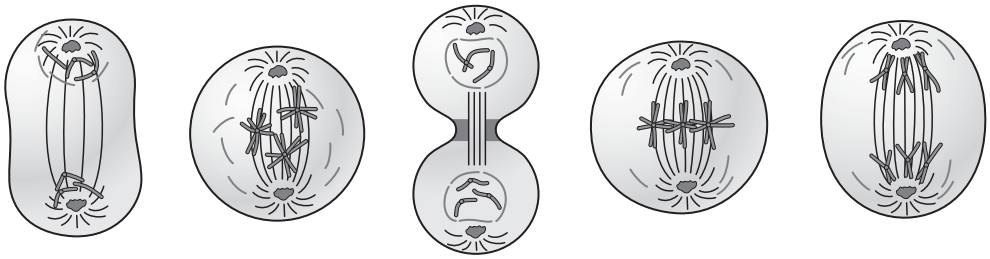
3 _____ is the process of cell division that results in the formation of cells with half the usual number of chromosomes.

4 The type of reproduction that results in offspring that are genetically identical to the single parent is known as _____ reproduction.

Key Concepts

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

5 Cassie draws flashcards for each phase of mitosis and cytokinesis. Before she can label the backs of the flashcards, Cassie drops them onto the floor. The flashcards get mixed up as shown below.



1 2 3 4 5

In what order should Cassie place the cards to show mitosis from start to finish?

A 1 → 2 → 3 → 4 → 5

B 2 → 4 → 5 → 1 → 3

C 3 → 1 → 5 → 2 → 4

D 4 → 2 → 1 → 5 → 3

6 Brandy knows that chromosomes behave differently in meiosis and mitosis. What do chromosomes do in meiosis but **not** in mitosis?

F Each chromosome makes an exact copy of itself.

G The homologous chromosomes form pairs.

H Chromosomes line up in the middle of the cell.

I Chromosomes condense, becoming visible under a microscope.

7 Noriko is studying a plant species she found in a forest. She collects leaf samples from a large parent plant and from the smaller offspring that are growing next to it. After running some tests, she finds that the offspring are genetically identical to the parent plant. Which of these statements is **true** about Noriko's find?

A The offspring were produced sexually, and two parents were required.

B The offspring were produced asexually, and two parents were required.

C The offspring were produced sexually, and only one parent was required.

D The offspring were produced asexually, and only one parent was required.

8 Examine the Punnett square below.

	B	***B***
B	***BB***	***BB***
b	***Bb***	***Bb***

Which of the following choices gives the alleles of the parents shown here?

F *BB* and *BB*

G *BB* and *Bb*

H *Bb* and *Bb*

I *Bb* and *bb*

9 Delia is teaching her sister about important molecules in the body. She tells her sister that one molecule provides a set of instructions that determines characteristics, such as eye color or hair color. Which molecule is Delia describing?

A DNA

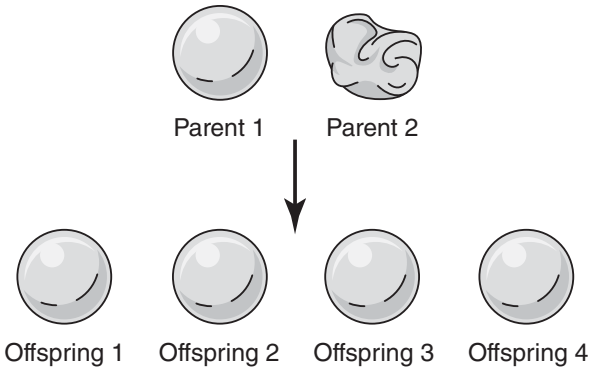
B glucose

C gamete

D spore

Name _____

10 The diagram below shows the results of crossing a pea plant with smooth seeds and a pea plant with wrinkled seeds.



What can be determined from the results of the experiment?

F Smooth shape and wrinkled shape are both recessive traits.

G Smooth shape and wrinkled shape are both dominant traits.

H Smooth shape is a dominant trait, and wrinkled shape is a recessive trait.

I Smooth shape is a recessive trait, and wrinkled shape is a dominant trait.

11 Lucinda decides to investigate what would happen if there is an error at different stages of the cell cycle. She examines interphase, mitosis, and cytokinesis. Which of these statements describes what is **most likely** to happen if DNA is not duplicated during interphase?

A The new cells would be more numerous.

B The new cells would have too many chromosomes.

C The new cells would have too many nuclei.

D The new cells would have too few chromosomes.

12 A species of rabbit can have brown fur or white fur. One rabbit with two alleles for brown fur (*BB*) has brown fur. A second rabbit with two alleles for white fur (*bb*) has white fur. Which statement is true about the alleles *B* and *b*?

F They are on two different genes.

G They result in the same phenotype.

H They are two different versions of the same gene.

I They provide identical instructions for a characteristic.

13 Leah cuts a small stem from an azalea plant and gives it to John. John takes the cutting home and plants it in his garden. In a few months, the small stem has grown into a full-sized, new plant. Which of these choices correctly describes this situation?

A Leah's plant reproduced by budding and is genetically different than the plant in John's garden.

B Leah's plant reproduced by binary fission and is genetically different than the plant in John's garden.

C Leah's plant reproduced by spore formation and is genetically identical to the plant in John's garden.

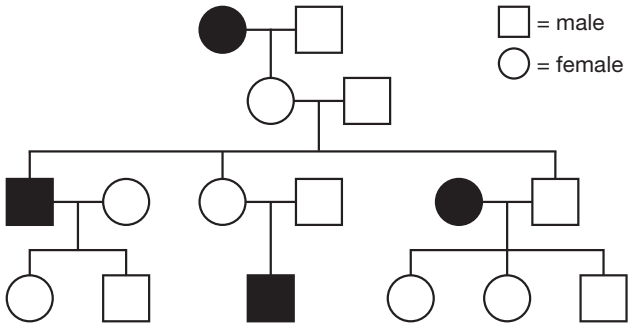
D Leah's plant reproduced by vegetative reproduction and is genetically identical to the plant in John's garden.

Critical Thinking

Answer the following question in the space provided.

14 Describe two advantages and disadvantages of asexual reproduction.

15 Jake made a pedigree to trace the traits of straight and curly hair in his family.



A shaded circle or square in Jake's pedigree represents a person with straight hair. Make a claim about whether straight hair is controlled by a dominant allele or a recessive allele. Use evidence to support your claim and explain your reasoning. How do you know that straight hair is not sex-linked?