chapter 4

Cell Reproduction

section 1 Cell Division and Mitosis

What You'll Learn

- why mitosis is important
- the steps of mitosis
- the similarities and differences between mitosis in plant and animal cells
- examples of asexual reproduction

Before You Read

List five living things on the lines below. Then write one thing that these items have in common with each other and with you.

_____

_____

_____

Read to Learn

Mark the Text

Identify Details Highlight each question head. Then use another color to highlight the answer to that question.

Why is cell division important?

All living things are made up of cells. Many organisms start as one cell. The cell divides and becomes two cells, two cells become four, four become eight, and so on. Through the process of cell division, the organism grows.

Cell division is still important after an organism stops growing. For example, every day billions of your red blood cells wear out and are replaced through cell division. During the time it takes you to read this sentence, your bone marrow produced about six million red blood cells.

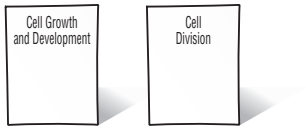
Cell division is the way a one-celled organism makes another organism of its kind. When a one-celled organism reaches a certain size, it reproduces by dividing into two cells.

The Cell Cycle

Every living organism has a life cycle. A life cycle has three parts. First, the organism forms. Next, it grows and develops. Finally, the life cycle ends when the organism dies. Right now, you are in a part of your life cycle called adolescence (a doh LEH sence), which is a time of active growth and development.

FOLDABLES™

A Describe Use quarter sheets of notebook paper, as shown below, to describe cell growth and development and cell division.



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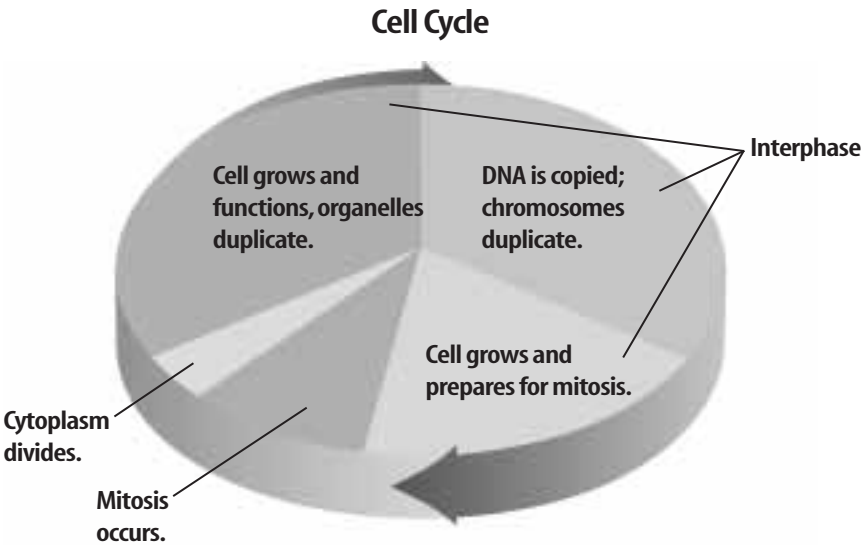
How long is the life cycle of a cell?

Every cell has a life cycle. A cell's life cycle is called a cell cycle, as shown in the figure below. A cell cycle is not completed in the same amount of time in all cells. For example, the cell cycle of some human cells takes about 16 hours. The cell cycle of some plant cells takes about 19 hours. A cell cycle has three parts—interphase, mitosis, and cytoplasm division.

Picture This

1. **Identify** Draw an outline around the interphase part of the cell cycle to the right. Approximately how much of the cell cycle is interphase?

_____



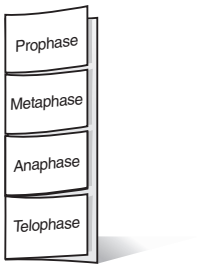
What is the longest part of the cell cycle?

For cells that have a nucleus, the longest part of the cell cycle is a period of growth and development called **interphase.** Cells in your body that no longer divide, such as nerve and muscle cells, are always in interphase.

During interphase, an actively dividing cell, such as a skin cell, copies its DNA and prepares for cell division. DNA is the chemical code that controls an organism's growth and operation. A copy of a cell's DNA must be made before dividing so that each of the two new cells will get a complete copy. Each cell needs a complete set of hereditary material to carry out life functions.

FOLDABLES™

B Sequence Make a four-tab book, as shown below. Use the Foldable to identify facts about the four steps of mitosis.



Mitosis and Cell Division

After interphase, cell division begins. Mitosis is the first step in cell division. **Mitosis** (mi TOH sus) is the process in which the cell's nucleus divides to form two nuclei. Each new nucleus is identical to the original nucleus. The steps of mitosis are called prophase, metaphase, anaphase, and telophase.

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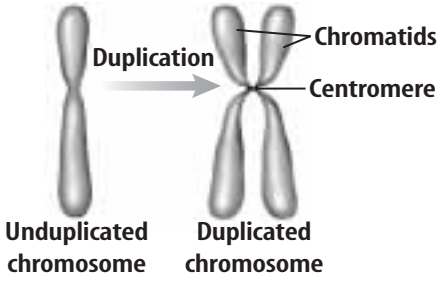
What happens to chromosomes during cell division?

A chromosome (KROH muh sohm) is a structure in the nucleus that contains DNA. During interphase, each chromosome is copied. When the nucleus is ready to divide, the two copies of each chromosome coil tightly into two thickened, identical DNA strands called chromatids (KROH muh tidz). In the figure to the right, the chromatids are held together at a place called the centromere.



Prophase During prophase, the chromatid pairs can be seen. The nuclear membrane breaks apart. Two small structures called centrioles (SEN tree olz) move to opposite ends of the cell. Between the centrioles, threadlike spindle fibers stretch across the cell. Animal cells have centrioles, but plant cells do not.

Metaphase In metaphase, the chromatid pairs line up across the center of the cell. The centromere of each pair usually becomes attached to two spindle fibers—one from each side of the cell.

Anaphase In anaphase, each centromere divides. The spindle fibers become shorter, and each chromatid separates from its partner. The separated chromatids begin to move to opposite ends of the cell. They are now called chromosomes.

Telophase The final step of mitosis is telophase. During telophase, the spindle fibers start to disappear. The chromosomes start to uncoil, and a new nucleus forms.

How does the cytoplasm divide?

For most cells, after the nucleus divides, the cytoplasm separates and two new cells are formed. Each new cell contains one of the new nuclei. In animal cells, the cell membrane pinches in the middle, like a balloon with a string tightened around it. The cell divides at the pinched area to form two new cells. Each new cell contains half the cytoplasm from the old cell.

After the division of the cytoplasm, most new cells begin interphase again. Use the figure on the next page to review the cell division of an animal cell.

Picture This

2. **Identify** Circle the place where the chromatids are held together.

Reading Check

3. **Explain** what happens to the centrioles during prophase.

_____

_____

_____

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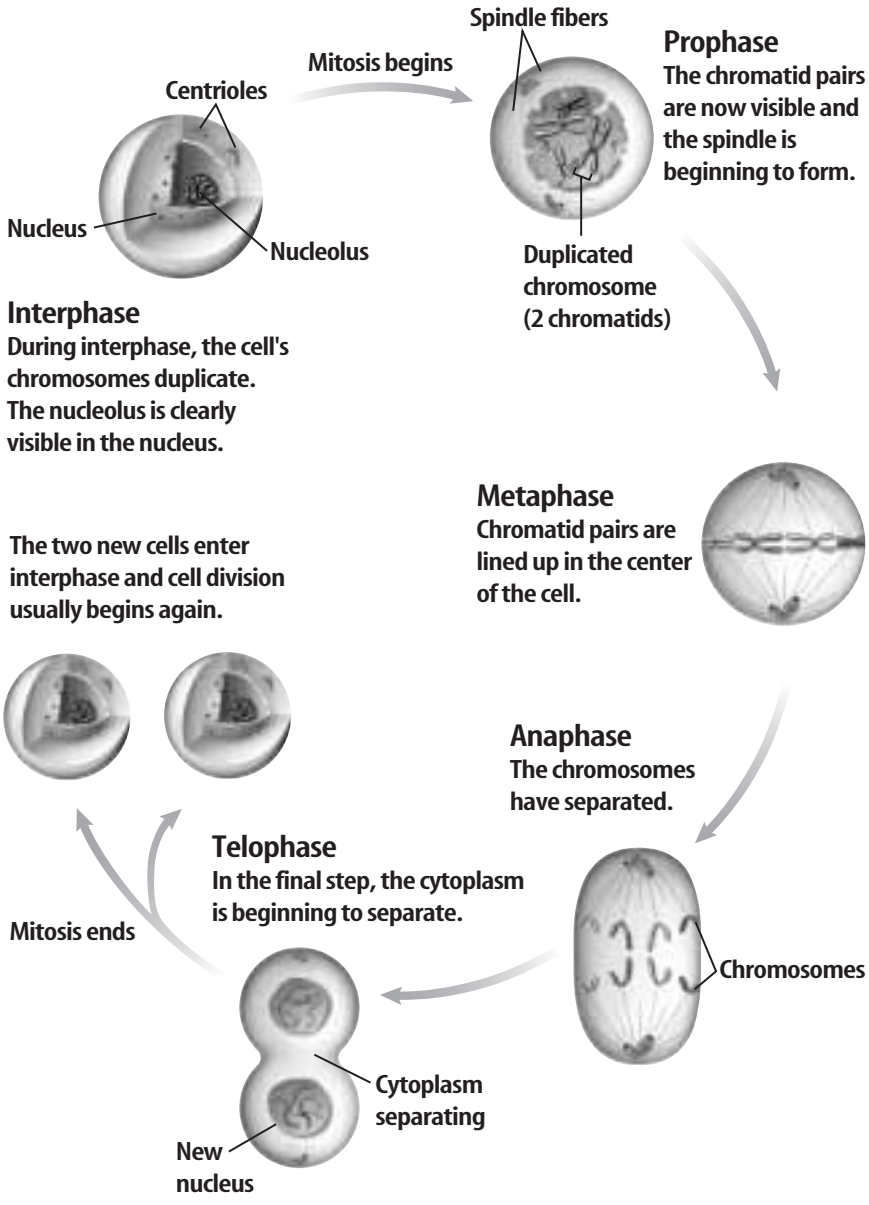
Picture This

4. **Describe** Highlight the chromosomes in each phase of mitosis. As you highlight the step, explain to a partner what is happening to the chromosome.

Cell Division for an Animal Cell



Reading Check

5. **Explain** In plant cells, what divides the cytoplasm into two parts?

_____

How do plant cells divide after mitosis?

In plant cells, a cell plate forms in the middle of the cell. The cell plate divides the cytoplasm into two parts. New cell walls form along the cell plate, and new cell membranes develop inside the cell walls. ☑

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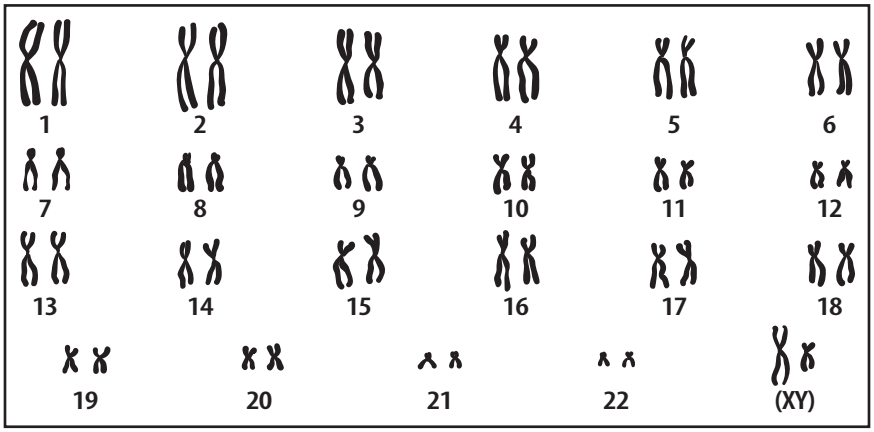
What are the results of mitosis?

There are three important things to remember about mitosis and cell division. First, mitosis is the division of a nucleus. Second, it produces two new nuclei. These nuclei are identical to each other. They have the same number and type of chromosomes as the original nucleus. Every cell in your body, except sex cells, has a nucleus with a copy of the same 46 chromosomes—23 pairs. This is because you began as one cell with 46 chromosomes in its nucleus. Third, the original cell no longer exists.

The 46 chromosomes of a human cell are shown below. Notice that the last pair is labeled XY. This is the chromosome pair that determines sex. The XY label indicates a male. Females have XX chromosome pairs.

Chromosomes of a human cell



_____ (No. of chromosome pairs) × 2 = _____ (No. of chromosomes)

Each of the trillions of cells in your body, except sex cells, has a copy of the same DNA. All of your cells, however, use different parts of the DNA to become different types of cells. Skin cells and blood cells contain a copy of the same DNA. They use different parts of the DNA to perform their different functions.

Cell division allows growth and replaces worn out or damaged cells. You are much larger than you were when you were a baby. This is possible because of cell division. If you cut yourself, the wound heals because cell division replaces damaged cells.

Picture This

6. Solve Complete the equation at the bottom of the figure using the information in the figure.

Reading Check

7. Explain What is the purpose of cell division?

_____

_____

_____

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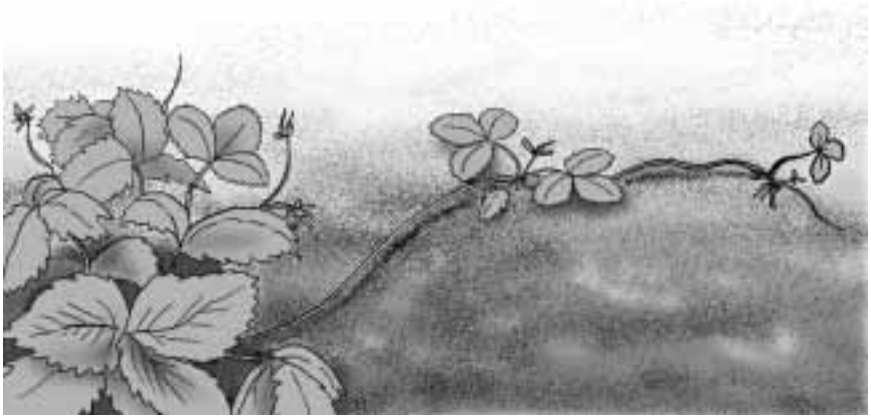
Asexual Reproduction

The way an organism produces others of its kind is called reproduction. Among living organisms, there are two types of reproduction—sexual and asexual. Sexual reproduction usually involves two parent organisms. In **asexual reproduction,** a new organism (sometimes more than one) is produced from only one parent organism. The new organism has the same DNA as the parent. New strawberry plants can be reproduced asexually from horizontal stems called runners. The figure below shows the asexual reproduction of a strawberry plant.



Picture This

8. Identify How many organisms were needed to produce the strawberry runner?

_____

How do cells divide using fission?

Remember, mitosis involves the division of a nucleus. A bacterium does not have a nucleus, so it cannot use mitosis. Instead, bacteria reproduce asexually by a process called fission. During fission, a bacteria cell's DNA is copied. The cell then divides into two identical organisms. Each new organism has a complete copy of the parent organism's DNA.

How do organisms reproduce using budding?

Budding is a type of asexual reproduction in which a new organism grows from the body of the parent. When the bud on the adult becomes large enough, it breaks away to live on its own.

Reading Check

9. Explain budding, which is a form of asexual reproduction.

_____

_____

_____

How do some organisms regrow body parts?

Some organisms, such as sponges and sea stars, can regrow damaged or lost body parts. The process that uses cell division to regrow body parts is called regeneration. If a sea star breaks into pieces, a whole new organism can grow from each piece.

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After You Read

Mini Glossary

asexual reproduction: the way a new organism is produced from one organism

chromosome (KROH muh sohm): a structure in the nucleus that contains hereditary material

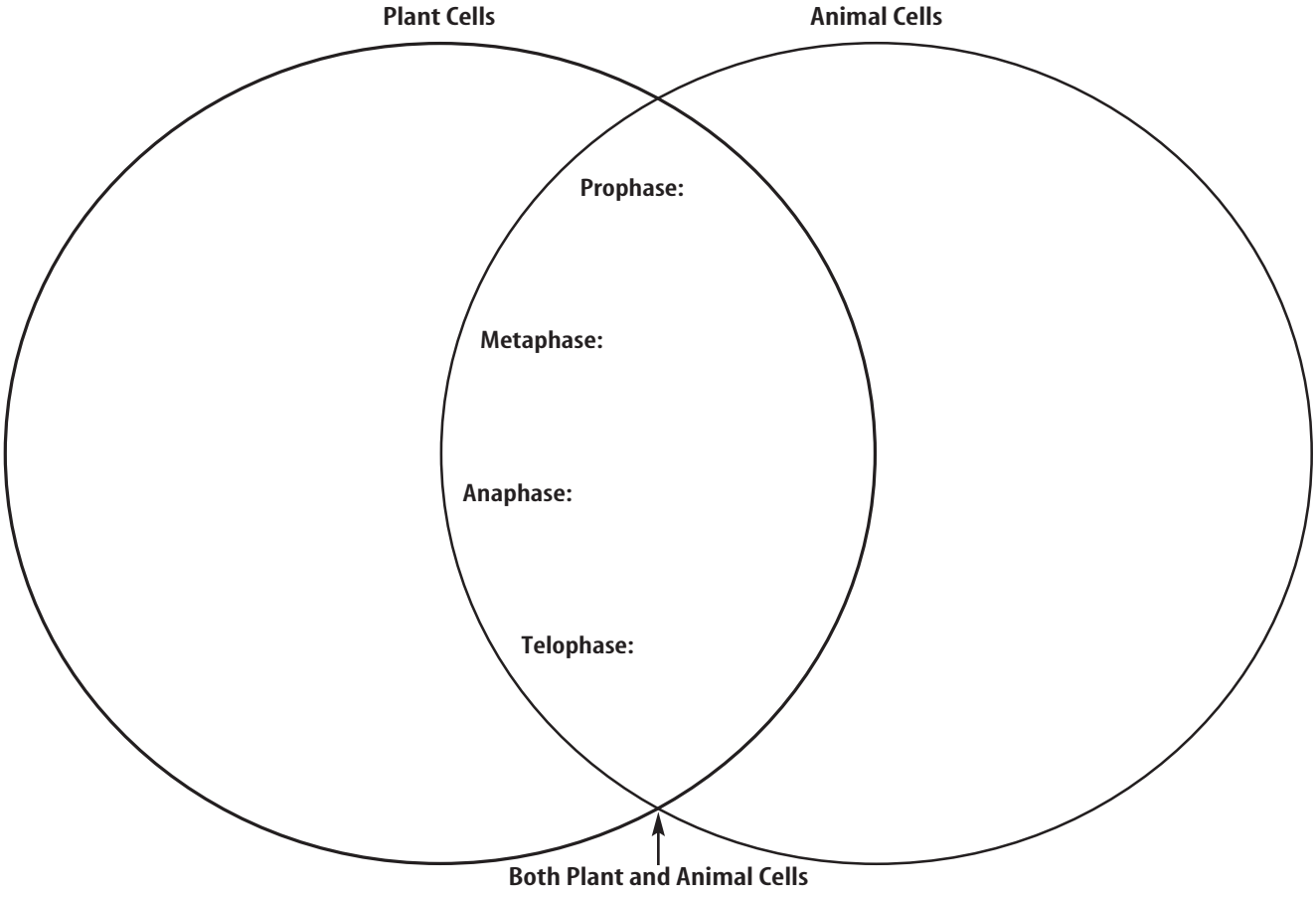
mitosis (mi TOH sus): the process in which the nucleus divides to form two identical nuclei; the four steps include prophase, metaphase, anaphase, telophase

1. Review the terms and their definitions in the Mini Glossary. Write a sentence to explain mitosis using a skin cell as an example.

_____

_____

2. Complete the Venn diagram below to help you compare mitosis in plant and animal cells. Write one similarity at each phase in the overlapping area.



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ScienceOnline Visit **life.msscience.com** to access your textbook, interactive games, and projects to help you learn more about cell division and mitosis.

End of Section

chapter 4

Cell Reproduction

section 2 Sexual Reproduction and Meiosis

What You'll Learn

- the stages of meiosis
- how sex cells are produced
- why meiosis is needed for sexual reproduction
- the names of the cells involved in fertilization
- how fertilization occurs in sexual reproduction

Before You Read

On the lines below, explain what makes you different from anyone else in your class.

_____

_____

_____

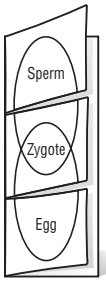
Study Coach

Make Journal Entries

As you read the section, write a question for each paragraph in a journal. Answer the question with information from the paragraph. Make a list of questions you have about the section that are still unclear and then find the answers.

FOLDABLES™

Explain Make a three-tab book, as shown below. Use the Foldable to make a Venn diagram explaining sexual reproduction.



Read to Learn

Sexual Reproduction

A new organism can be produced through sexual reproduction. During **sexual reproduction,** two sex cells, sometimes called a sperm and an egg, come together. Usually the sperm and the egg come from two different organisms of the same species.

Sex cells are formed in reproductive organs. The male reproductive organ forms **sperm.** The female reproductive organ forms **eggs.** The joining of a sperm and an egg is called **fertilization.** The cell that forms from fertilization is called a **zygote** (ZI goht).

What two types of cells does your body make?

Your body makes body cells and sex cells. Body cells form your brain, skin, bones, and other tissues and organs. A human body cell usually has 46 chromosomes. Each chromosome has a mate that is similar in size and shape and has similar DNA, or hereditary information. This means that a body cell has 23 pairs of similar chromosomes. Cells that have pairs of similar chromosomes are called **diploid** (DIH ployd) cells.

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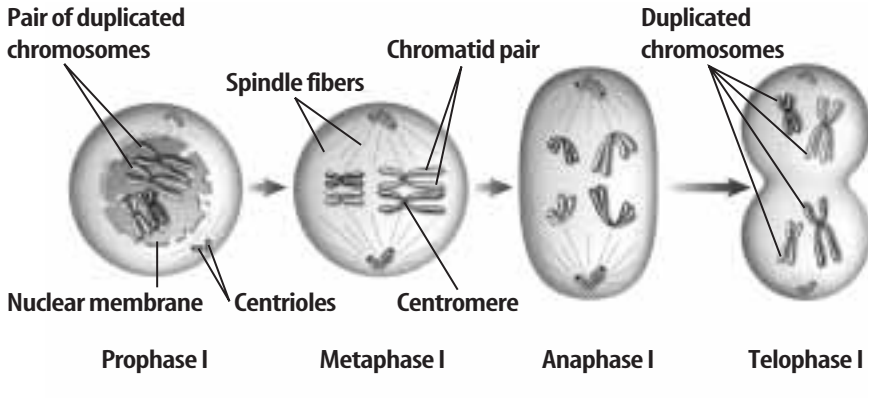
What are haploid cells?

A sex cell has half the number of chromosomes found in a body cell, or 23 chromosomes. A sex cell has only one chromosome from each pair. A cell that does not have pairs of chromosomes is called a **haploid** (HA ployd) cell.

Meiosis and Sex Cells

A process called **meiosis** (mi OH sus) produces haploid sex cells. During meiosis, two divisions of the nucleus occur. These divisions are called meiosis I and meiosis II. The steps of each division of meiosis are named like the steps in mitosis—prophase, metaphase, anaphase, and telophase. The figure below shows what happens during meiosis I.

Meiosis I



What happens to a cell during meiosis I?

Before meiosis begins, each chromosome is copied. When the cell is ready for meiosis, the two copies of each chromosome can be seen under a microscope as two chromatids. Follow the steps in meiosis I in the figure above. Notice that in prophase I, each pair of duplicated chromosomes comes together.

In metaphase I, the pairs of duplicated chromosomes line up in the center of the cell. As you can see, the centromere of each chromatid pair attaches to one spindle fiber.

In anaphase I, the two copies of the same chromosome, the chromatids, move away from each other to opposite ends of the cell. Notice that each duplicated chromosome still has two chromatids.

In telophase I, the cytoplasm divides and two new cells form. Each new cell has one duplicated chromosome from each similar pair.

Picture This

1. **Identify** How many cells form in meiosis I?

_____

Reading Check

2. **Explain** What happens in a cell before meiosis I begins?

_____

_____

_____

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Think it Over

3. Explain how metaphase I and metaphase II differ.

What happens in meiosis II?

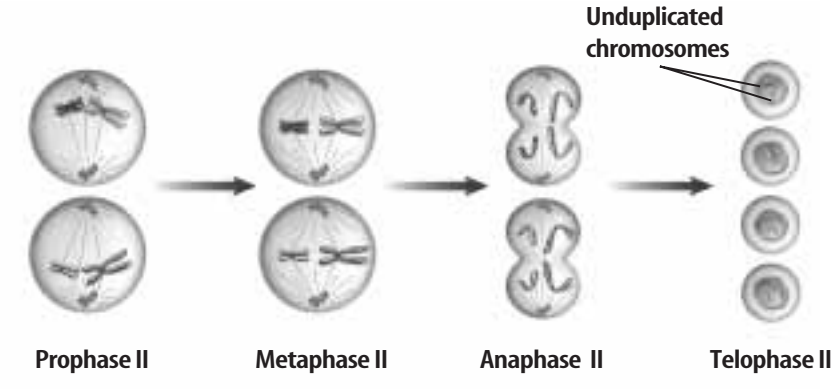
The two cells that formed in meiosis I now begin meiosis II. Follow the steps in meiosis II in the figure below. As you can see in prophase II, the duplicated chromosomes and spindle fibers reappear in each new cell.

In metaphase II, the duplicated chromosomes move to the center of each cell. The centromere of each chromatid pair attaches to two spindle fibers.

In anaphase II, the centromere in each cell divides. Then the chromatids separate and move to opposite ends of each cell. Each chromatid becomes an individual chromosome.

In telophase II, the spindle fibers disappear, and a nuclear membrane forms around the chromosomes at each end of the cell. When meiosis II is finished, the cytoplasm of each cell divides.

Meiosis II



What is the final result of meiosis?

During meiosis I, one cell divides into two cells. During meiosis II, those two cells divide. When meiosis II ends, there are four sex cells. Each sex cell has 23 unpaired chromosomes. This is one-half the number of chromosomes that were in the original nucleus—46 chromosomes.

What can go wrong in meiosis?

Mistakes sometimes occur during meiosis. These mistakes can produce sex cells with too many or too few chromosomes. Zygotes, cells that form from fertilized eggs, produced from these sex cells sometimes die. If the zygote lives, every cell that grows from the zygote will have the wrong number of chromosomes. Organisms with the wrong number of chromosomes usually do not grow normally.

Reading Check

4. Explain What is the usual result of too many or too few chromosomes?

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After You Read

Mini Glossary

diploid (DIH ployd): cells that have pairs of similar chromosomes

egg: sex cell formed in the female reproductive organs

fertilization: the joining of a sperm and an egg

haploid (HA ployd): cells that do not have pairs of chromosomes, such as sex cells

meiosis (mi OH sis): a process that produces haploid sex cells

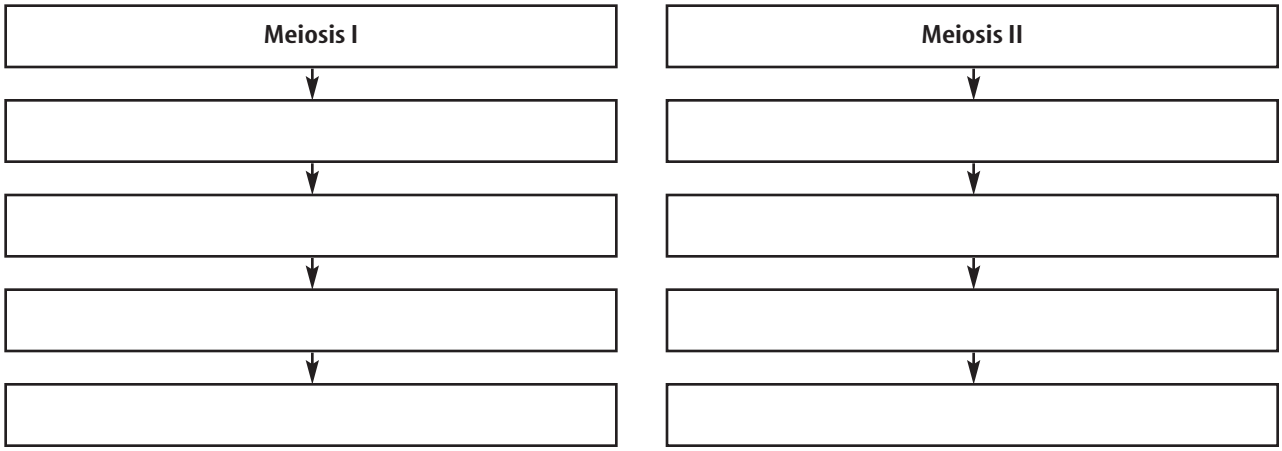
sexual reproduction: two sex cells come together to produce a new organism

sperm: sex cell formed in the male reproductive organs

zygote (ZI goht): the cell that forms from fertilization

1. Review the terms and their definitions in the Mini Glossary. Choose the terms that explain the process of sexual reproduction and write one or two sentences explaining how the process works.

2. Complete the graphic organizer below to label the steps that occur during meiosis I and meiosis II.



3. How do your journal entries help you understand sexual reproduction and meiosis?

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End of Section

chapter 4 Cell Reproduction

section 3 DNA

What You'll Learn

- the parts of a DNA molecule and its structure
- how DNA copies itself
- the structure and role of each kind of RNA

Before You Read

Write on the lines below how police departments use DNA to solve crimes.

_____

_____

_____

Study Coach

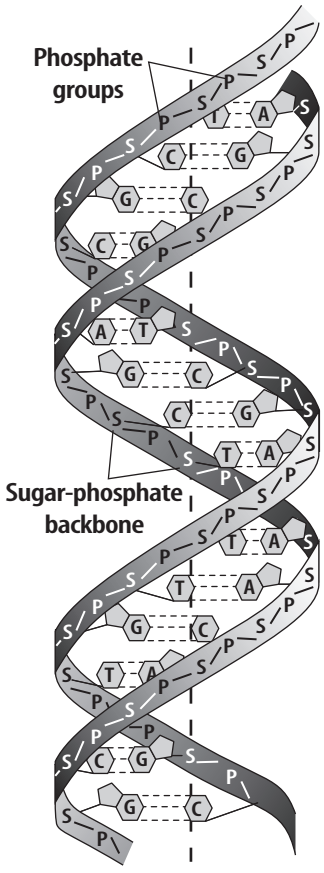
Discuss Read a paragraph to yourself, then take turns with your partner saying something about what you have learned. Continue your discussion until you and your partner understand the paragraph. Then repeat the process with the remaining paragraphs in the section.

Read to Learn

What is DNA?

Before you could learn to read, you learned the alphabet. The letters of the alphabet are a code you needed to know before you could read. A cell also uses a code. That code contains information for an organism's growth and function. It is stored in a cell's hereditary material. The code is a chemical called deoxyribonucleic (dee AHK sih ri boh noo klay ihk) acid, or **DNA.** The figure to the right shows the spiral-shaped structure of DNA.

When a cell divides, the DNA code is copied and passed to the new cells. New cells get the same DNA code that was in the original cell. Every cell that has ever been formed in your body or in any organism has DNA.



Picture This

1. **Infer** Examine the DNA strand in the figure. What do the letters "P" and "S" represent?

_____

_____

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What does DNA look like?

In 1952, scientist Rosalind Franklin discovered that DNA is two chains of molecules. As you can see in the figure on the previous page, DNA looks like a twisted ladder. Each side of the ladder is made up of sugar-phosphate molecules. The sugar in each molecule is called deoxyribose (dee AHK sih ri bohs). In 1953, scientists James Watson and Francis Crick made a model of a DNA molecule.

What are the four nitrogen molecules that make up DNA?

The rungs, or steps, of the DNA ladder are made up of molecules called nitrogen bases. DNA has four kinds of nitrogen bases: adenine (A duh neen), guanine (GWAH neen), cytosine (SI tuh seen), and thymine (THI meen). In the DNA model on the previous page, the first letters of the name of each base, A, G, C, and T, are used to stand for the bases. Also notice that adenine (A) always pairs with thymine (T), and guanine (G) always pairs with cytosine (C).

How is DNA copied?

When chromosomes are copied before mitosis or meiosis, the amount of DNA in the nucleus is doubled. The figure below shows how the DNA copies itself. The two sides of DNA unwind and separate. Each side then becomes a pattern on which a new side can form. The new DNA pattern is exactly the same as the original DNA pattern.

Reading Check

2. Identify What did Rosalind Franklin discover?

_____

_____

_____

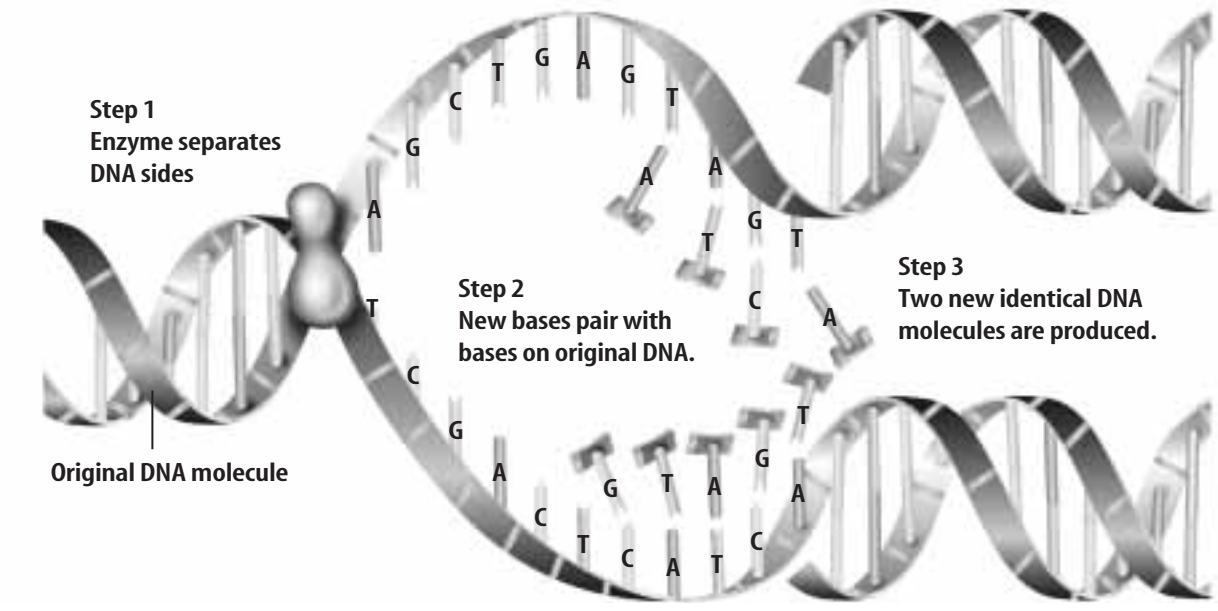
Picture This

3. Determine Write one quiz question in the space below based on one of the steps in this figure.

_____

_____

_____



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Genes

What color are your eyes? How tall are you? The answers to questions like these depend on the kinds of proteins your cells make. Proteins build cells and tissues or work as enzymes. The instructions for making certain proteins are found in genes. A **gene** is a section of DNA on a chromosome. Each chromosome has hundreds of genes.

Reading Check

4. **Explain** where the instructions for making certain proteins are found.

What are proteins?

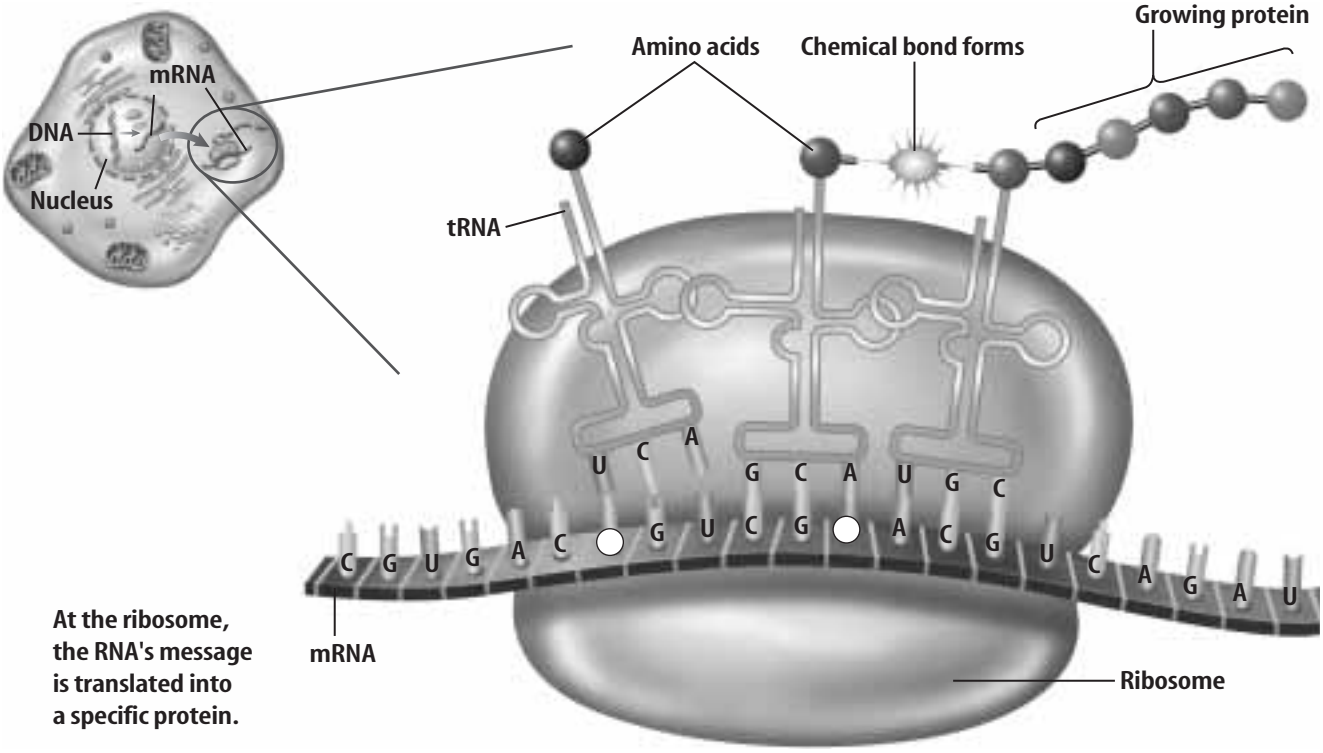
Proteins build cells and tissues. Proteins are made of chains of many amino acids. The gene decides the order of amino acids in a protein. Changing the order of the amino acids makes a different protein. Genes are found in the nucleus, but proteins are made on ribosomes in cytoplasm.

What is RNA?

The codes for making proteins are carried from the nucleus to the ribosomes by ribonucleic acid, or **RNA.** RNA is made in the nucleus on a DNA pattern, but is different from DNA. Look at the model of an RNA molecule below. Notice that RNA is like a ladder with its rungs cut in half. Like DNA, RNA has the nitrogen bases A, G, and C. But it has the base uracil (U) instead of thymine (T). The sugar-phosphate molecules in RNA contain the sugar ribose.

Picture This

5. **Apply** Fill in the two circles in the figure with the correct letter.



At the ribosome, the RNA's message is translated into a specific protein.

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What does RNA do?

There are three main kinds of RNA made from DNA in a cell's nucleus. They are messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA). Protein is made when mRNA moves into the cytoplasm. In the cytoplasm, ribosomes, which are made of rRNA, attach to the mRNA. The ribosomes get amino acids from tRNA molecules that are already in the cytoplasm. Inside the ribosomes, three nitrogen bases on the mRNA temporarily match with three nitrogen bases on the tRNA. The same thing happens for the mRNA and another tRNA molecule. The amino acids that are attached to the two tRNA molecules connect. This is the beginning of a protein.

How do cells control genes?

Even though most cells in an organism have exactly the same genes, they do not make the same proteins. Each cell uses only the genes that make the proteins that it needs. For example, muscle proteins are made in muscle cells but not in nerve cells.

Cells control genes by turning some genes off and turning other genes on. Sometimes the DNA is twisted so tightly that no RNA can be made. Other times, chemicals attach to DNA so that it cannot be used.

Mutations

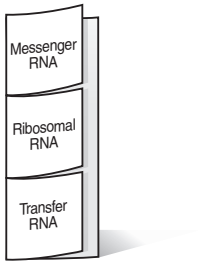
If DNA is not copied exactly, proteins may not be made correctly. These mistakes, called **mutations,** are permanent changes in the DNA sequence of a gene or chromosome.

What are the results of a mutation?

An organism with a mutation may not be able to grow, repair, or maintain itself. A mutation in a body cell may or may not cause problems for the organism. A mutation in a sex cell, however, makes changes to the species when the organism reproduces. Many mutations are harmful to organisms, often causing their death. Some mutations have no effect on an organism. Other mutations can be helpful to an organism.

FOLDABLES™

D Identify Make a three-tab book, as shown below. Use the Foldable to write facts about the three types of RNA.



Reading Check

6. **Explain** What is a mutation?

_____

_____

_____

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After You Read

Mini Glossary

DNA: a chemical in a cell that contains information for an organism's growth and function

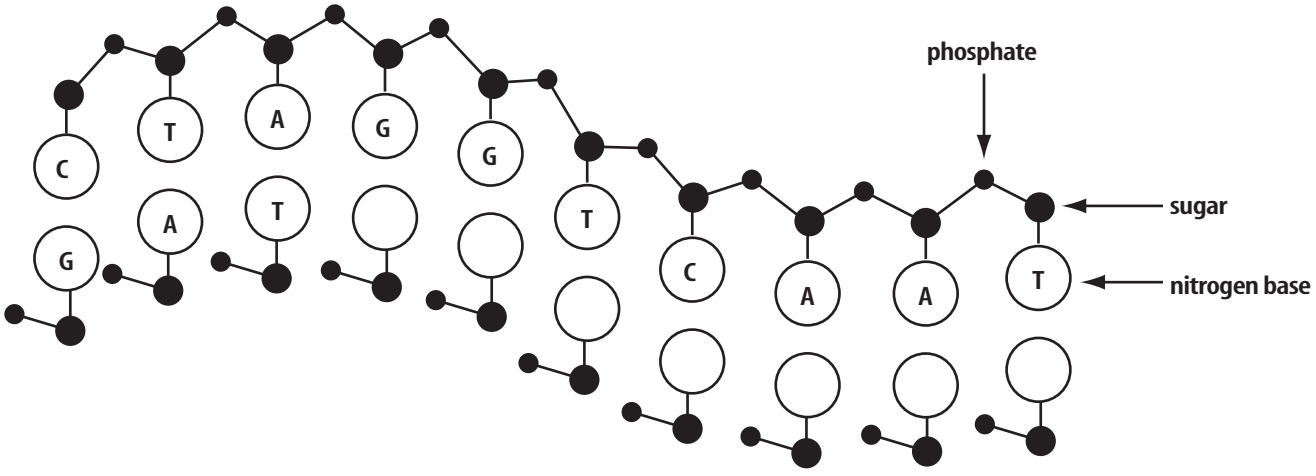
gene: a section of DNA on a chromosome that contains the instructions for making a specific protein

mutations: any permanent change in the DNA sequence of a gene or chromosome of a cell

RNA: a nucleic acid that carries the codes for making proteins from the nucleus to the ribosomes

1. Review the terms and their definitions in the Mini Glossary. Write a short paragraph that contrasts DNA and RNA.

2. Moving from left to right, write the letters (A, T, C, or G) in the empty circles of the bases that will pair with the bases on the top strand to this DNA molecule. The first three pairs have been created for you.



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