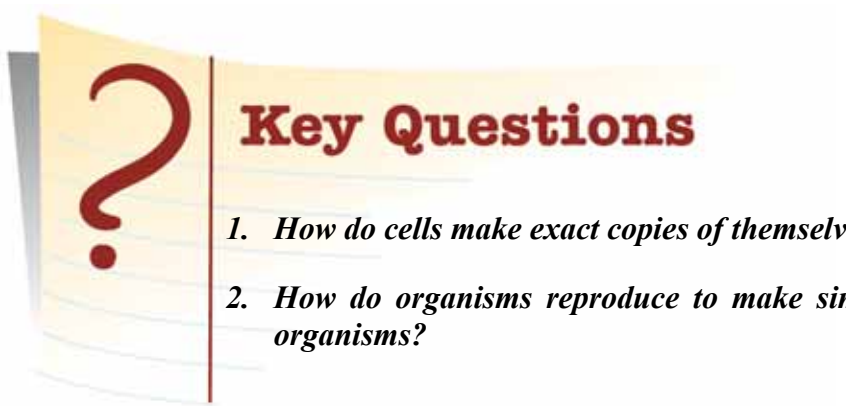
## Chapter 8

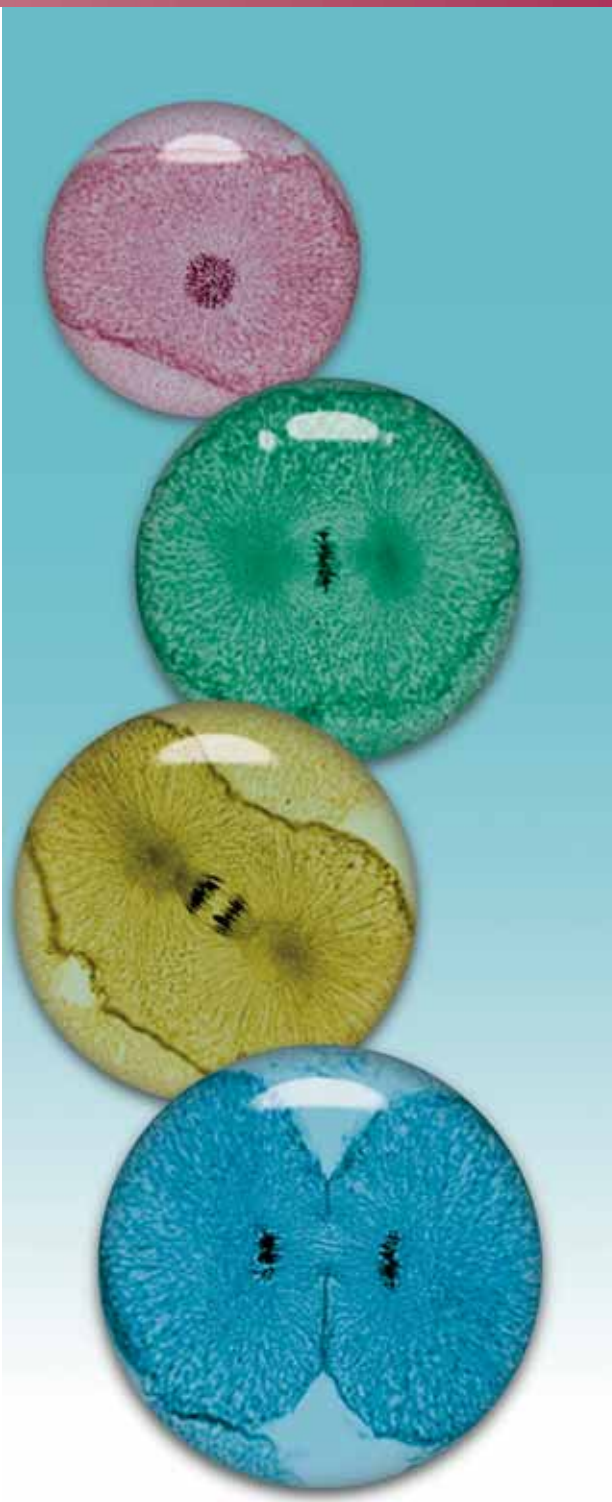
# *Reproduction*

Your school probably has at least one copy machine. When a teacher has a quiz or a letter that she wants each student to have, she runs the pages through the copier. The copier reproduces the pages, making exact copies so each student can have one. Your cells undergo a process that makes exact copies of themselves too, but of course, they don't use a copy machine! You grow because your cells multiply. How did you end up with billions of cells when you started as the union of only two cells? Cells have fascinating ways of making copies of themselves. Take a trip into the world of the cell to learn how organisms can reproduce and grow—the processes are amazing!



## Key Questions

1. ***How do cells make exact copies of themselves?***
2. ***How do organisms reproduce to make similar organisms?***



# 8.1 Growth and Cell Reproduction

Growth is a characteristic of all living things. You started out as a single cell. That cell quickly divided into two cells. Two cells became four and four became eight. Eventually, you grew into an organism made of *billions* of cells. As you continue to grow, your cells will divide to make more and more cells. Also, your cells divide to replace cells that have died, or to repair damaged tissues. Each new cell contains an exact copy of the DNA that's found in all of your body cells. How do cells divide to make exact copies of themselves?

## What is cell division?

**Cells reproduce by dividing**

Most of the cells in your body reproduce by dividing into two cells called *daughter cells*. Each daughter cell contains an exact copy of the DNA found in the original (parent) cell (Figure 8.1). The process of one cell dividing into two daughter cells is called **cell division**. Most cells reproduce by cell division.

***The process of one cell dividing into two daughter cells is called cell division. Each daughter cell contains an exact copy of the DNA found in the parent cell.***

**Cell division in prokaryotic cells**

As you learned earlier, prokaryotic cells like bacteria do not have a nucleus. Their DNA is found bunched up in the cytoplasm. Because of this, their cell division is simpler than the division of eukaryotic cells. Bacteria reproduce by splitting in two. Each daughter cell contains one copy of the DNA from the original cell.

**VOCABULARY**

**cell division** - the process of one cell dividing into two daughter cells.

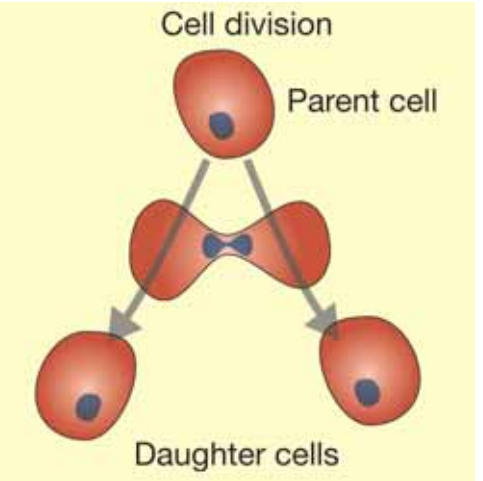



**Figure 8.1:** *Most of the cells in your body reproduce by dividing into two daughter cells.*

**MY JOURNAL**

Most organisms grow by producing more cells. Why couldn't an organism grow simply by allowing its cells to get larger and larger? Write your thoughts on this question in your notebook. You may wish to review Chapter 6 before you answer.

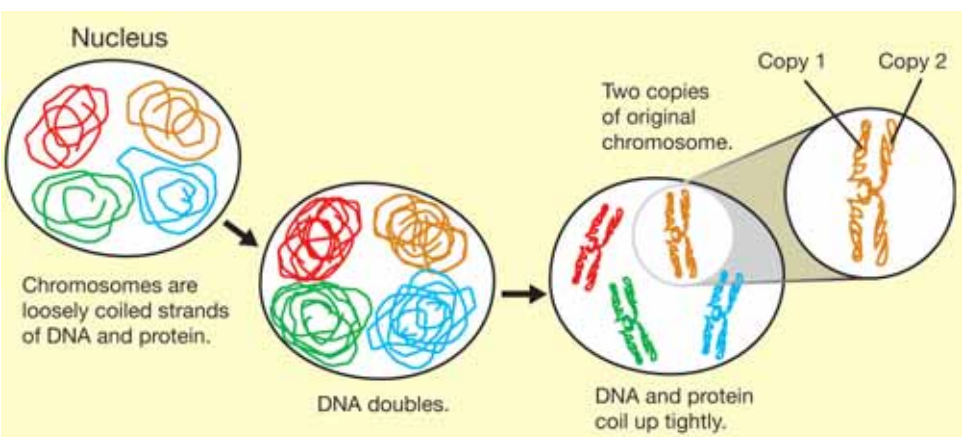
## Chromosomes

**What are chromosomes?**

Eukaryotic cells are usually larger and more complex than prokaryotic cells. The DNA of a eukaryotic cell is found in the nucleus. That DNA is organized into structures called chromosomes. A **chromosome** is a structure made of DNA and protein in the nucleus of a eukaryotic cell. Chromosomes organize DNA into distinct units. Different organisms have different numbers of chromosomes (Figure 8.2). Humans for example, have 46 chromosomes. The proteins in a chromosome help support its structure and function. But the genetic information of the cell is stored in the DNA.

**Chromosome doubling**

Individual chromosomes are not clearly visible under a microscope until just before a cell begins to divide. Before cell division, chromosomes exist as long strands of DNA loosely coiled in the nucleus. Just before cell division begins, the amount of DNA doubles and so do the chromosomes. The DNA and protein in the doubled chromosomes coil up tightly. Each doubled chromosome consists of two copies of the original chromosome joined at the center.




**VOCABULARY**

**chromosome** - a structure made of DNA and protein in the nucleus of a eukaryotic cell.

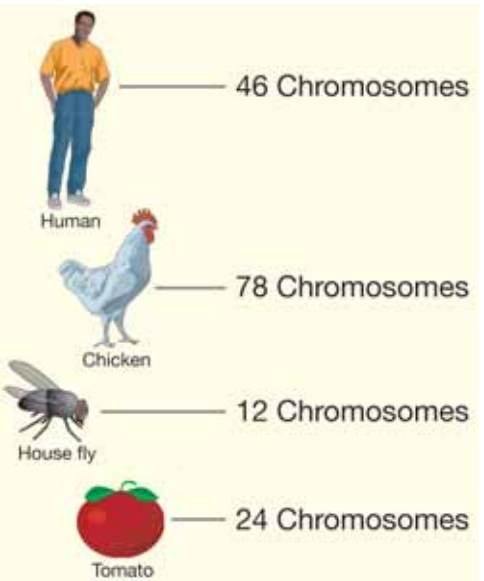



**Figure 8.2:** *Different organisms have different numbers of chromosomes. Does the number of chromosomes have anything to do with the complexity of the organism?*

## The cell cycle

**The life cycle of a cell**

As you grow from an infant to an adult, you pass through different stages of your life cycle. Similarly, a cell passes through different stages of its life. The life cycle of a cell is called the cell cycle. The **cell cycle** is the period of time from the beginning of one cell division to the beginning of the next. It consists of three stages: interphase, mitosis, and cytokinesis (Figure 8.3).

**Interphase**

The longest stage of the cell cycle is called interphase. **Interphase** is the stage that occurs in between cell divisions. During interphase the cell grows and develops and performs its functions. Toward the end of interphase (just before the cell begins to divide), the amount of DNA doubles. Organelles of the cytoplasm (like mitochondria) also double in number.

**Mitosis**

The second stage of the cell cycle is called mitosis. **Mitosis** is the process in cell division where the nucleus divides into two nuclei, each with an identical set of chromosomes. Mitosis is divided into four phases: *prophase, metaphase, anaphase,* and *telophase.* The illustration on the facing page shows what happens during each phase.

**Cytokinesis**

The shortest stage of the cell cycle is called cytokinesis. In **cytokinesis**, the cytoplasm and its organelles divide into two daughter cells. Each daughter cell contains a nucleus with an identical set of chromosomes. The two daughter cells then start their own cycles, beginning again with the interphase stage.

***The cell cycle results in two daughter cells with identical sets of chromosomes.***

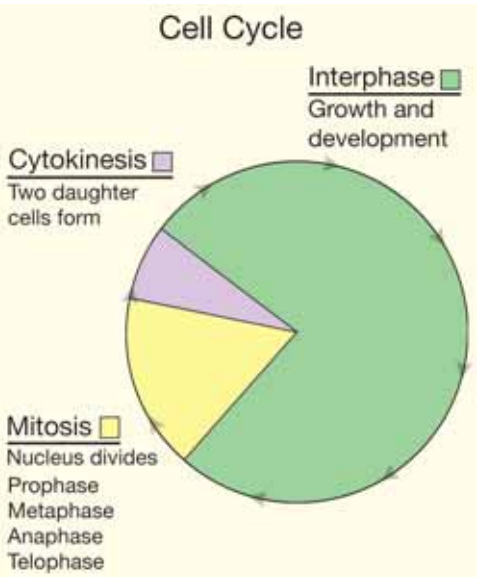



**Figure 8.3:** *The cell cycle consists of three phases.*

**VOCABULARY**

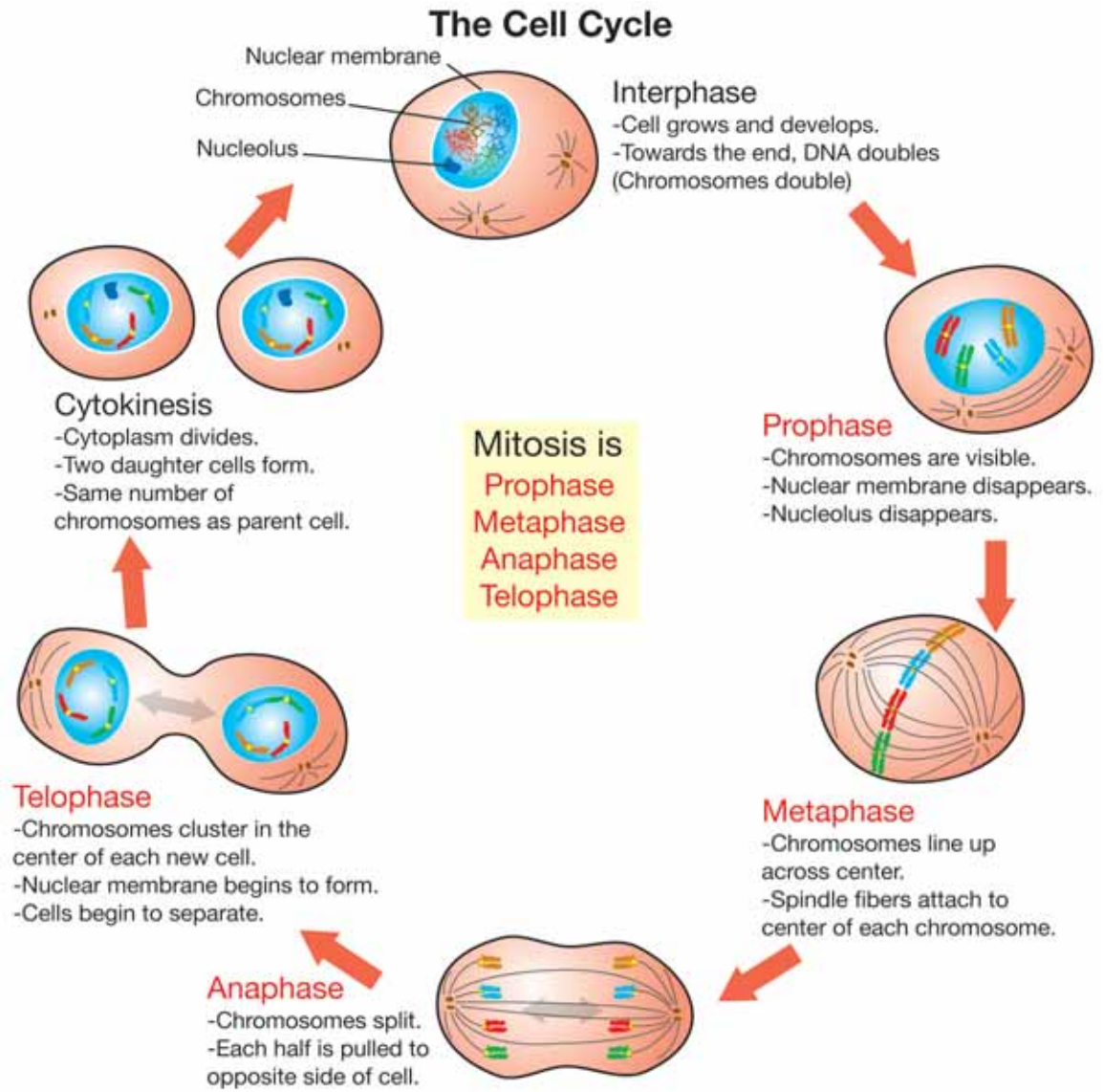
**cell cycle** - the period of time from the beginning of one cell division to the beginning of the next.

**interphase** - the stage of the cell cycle that occurs between cell divisions.

**mitosis** - the process of cell division where the nucleus divides into two nuclei.

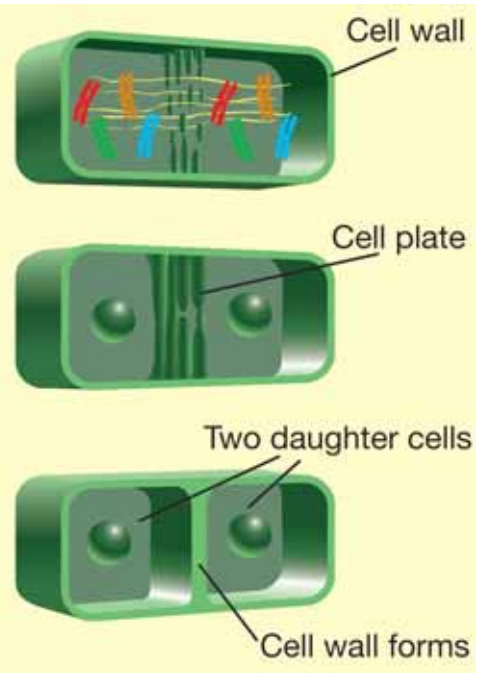
**cytokinesis** - the process where the cytoplasm and its organelles divide into two daughter cells.

You have 46 chromosomes in your body cells. The diagram below shows the cell cycle in an organism with only 4 chromosomes.




**Cytokinesis in plant cells**

In plant cells, a cell plate forms between the two nuclei. The cell plate grows outward until a new cell wall separates the two cells as shown below.



## Observing the cell cycle with a microscope

With a microscope and specially prepared slides, you can observe the cell cycle and identify each part. Figure 8.4 shows pictures of plant cells in each stage of the cell cycle.

**Interphase** During most of interphase, the chromosomes are not visible. They appear as a grainy substance inside of the nucleus. Another way to identify interphase is to look for the nucleolus inside of the nucleus. The nucleolus disappears before mitosis begins.

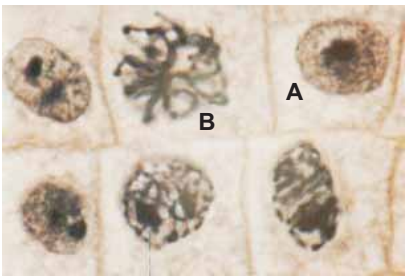
**Prophase** The first clue that mitosis has begun is the appearance of chromosomes. Because the amount of DNA has doubled, each chromosome appears as two identical strands joined at the center. Also, the nuclear membrane breaks down during this phase. You may also be able to see threads of protein called *spindle fibers*.

**Metaphase** In metaphase, you can see the chromosomes lined up across the center of the cell. Each half is pointing in the opposite direction. The spindle fibers are attached to the center of each chromosome.

**Anaphase** In anaphase, the chromosomes split. Each half is pulled toward the point where the spindle fibers come together. Anaphase is the phase of mitosis where the doubled chromosomes separate from each other.

**Telophase** You can identify telophase by finding cells where the chromosomes are clustered at separate ends of the cell. The forming daughter cells begin to separate. A nuclear membrane forms around each cluster of chromosomes.

**Cytokinesis** In cytokinesis, you can see that the cytoplasm is divided. Two separate daughter cells have formed, each with a complete set of chromosomes. Because it is so quick, this stage is hard to catch under a microscope.



Interphase (A) and prophase (B)


Metaphase


Anaphase

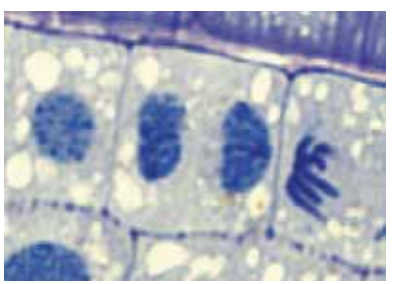

Telophase

**Figure 8.4:** *Photographs of plant cells in different stages of the cell cycle.*

## 8.1 Section Review

1. What is a daughter cell?
2. Why is cell division simpler in prokaryotes than in eukaryotes?
3. What is the major function of cell division and mitosis?
4. What is a chromosome? What are chromosomes made from?
5. Match each term below with the appropriate number on the diagram in Figure 8.5.
   a. cytokinesis
   b. metaphase
   c. interphase
   d. prophase
   e. telophase
   f. anaphase
6. What is the longest stage of the cell cycle? What is the shortest stage of the cell cycle?
7. What is the end result of mitosis and cytokinesis?
8. What is the first clue that mitosis has begun?
9. What happens to the amount of DNA in the nucleus just before the beginning of mitosis?
10. Why are chromosomes called "doubled chromosomes" just before mitosis begins?

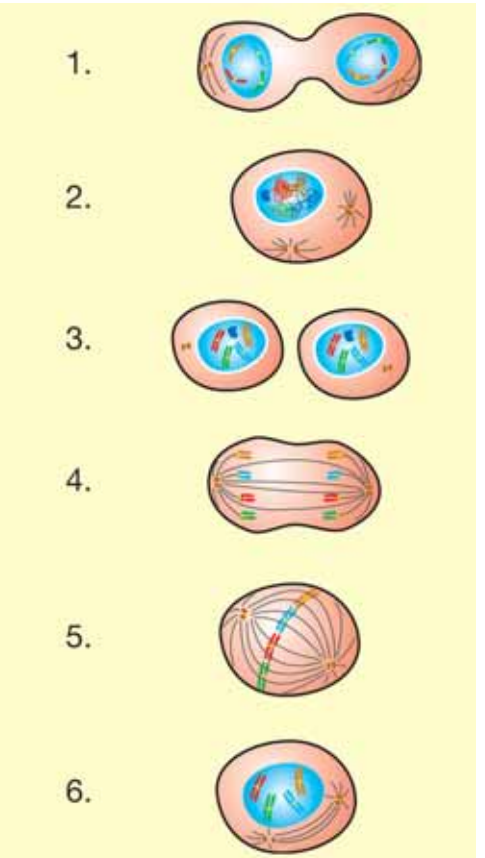



**Figure 8.5:** *Use this diagram to answer question 5.*

# 8.2 Sexual Reproduction and Meiosis

There are thousands of different species of organisms. Each species produces more of its own. A species of bacteria splits to make two identical bacteria. A eucalyptus tree produces more eucalyptus trees. Humans produce more humans. The formation of new organisms of the same species is called **reproduction**. Reproduction is an important life function. In this section, you will learn about the process of reproduction.

## Two types of reproduction

**Asexual reproduction**

There are two types of reproduction: asexual and sexual. **Asexual reproduction** is reproduction that requires only one parent. Most single-celled organisms like bacteria and protozoans reproduce this way. Cell division is a type of asexual reproduction. Your body cells reproduce this way. In asexual reproduction, the DNA and internal structures are copied. Then the parent cell divides, forming two cells that are exact copies of the original.

**Sexual reproduction**

**Sexual reproduction** is a type of reproduction that involves special types of cells called sex cells. **Sex cells** contain half the number of chromosomes as *body cells* (all of the other cells in a multicellular organism). Human body cells have 46 chromosomes. Human sex cells have 23 chromosomes. The male sex cells are called *sperm*. The female sex cells are called *eggs*.

**Homologous chromosomes**

**In body cells, the chromosomes occur in pairs**. The chromosomes in each pair are called *homologous* (equivalent) pairs. Figure 8.6 shows a complete set of chromosomes found in a human body cell. **Each sex cell has only one of the chromosomes from each homologous pair**.

**VOCABULARY**

**reproduction** - the formation of new organisms of the same species.

**asexual reproduction** - a type of reproduction that requires only one parent.

**sexual reproduction** - a type of reproduction that involves special cells called sex cells.

**sex cells** - special cells that contain half the number of chromosomes as body cells.

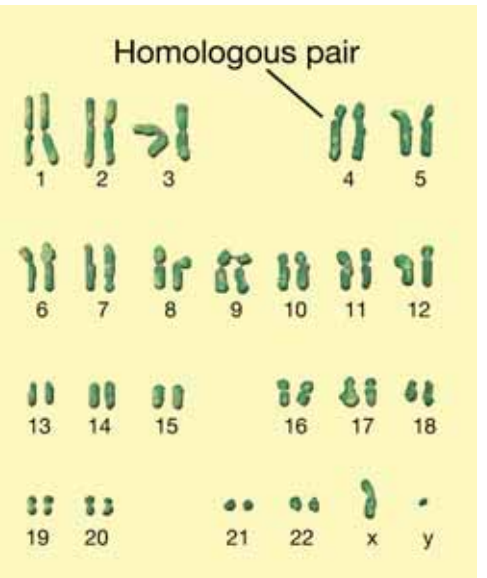



**Figure 8.6:** *A complete set of human chromosomes found in a body cell.*

## Meiosis

**What is meiosis?** A body cell has the same number of chromosomes as its parent cell. How do sex cells end up with only *half* the number of chromosomes? **Meiosis** is cell division that produces sex cells with half the number of chromosomes. During meiosis, a cell undergoes two divisions to produce four sex cells, each with half the number of chromosomes of the parent cell. Figure 8.7 shows slides of meiosis in the part of a plant that produces the male sex cells.

**The first division of meiosis** **In the first division of meiosis, the homologous pairs of chromosomes separate.** Remember, just before a cell divides, the chromosomes double. The doubled chromosome pairs line up along the center of the cell. Spindle fibers attach and pull the pairs apart. Two cells form. Each cell contains one doubled chromosome from each homologous pair.

**The second division of meiosis** **In the second division of meiosis, the doubled chromosomes are split apart.** The doubled chromosomes line up in the center of the cell. Spindle fibers pull the chromosomes apart at the center. The two halves move to opposite ends of the cell.

**The final result of meiosis** **The final result of meiosis is four sex cells, each with half the number of chromosomes of the original parent cell.** Each cell has only one chromosome from each original homologous pair. When male and female sex cells combine to form offspring, each sex cell contributes half the normal number of chromosomes. The offspring has the normal number of chromosomes, half from the male parent and half from the female parent.

**VOCABULARY**

**meiosis** - cell division that produces sex cells with half the number of chromosomes.

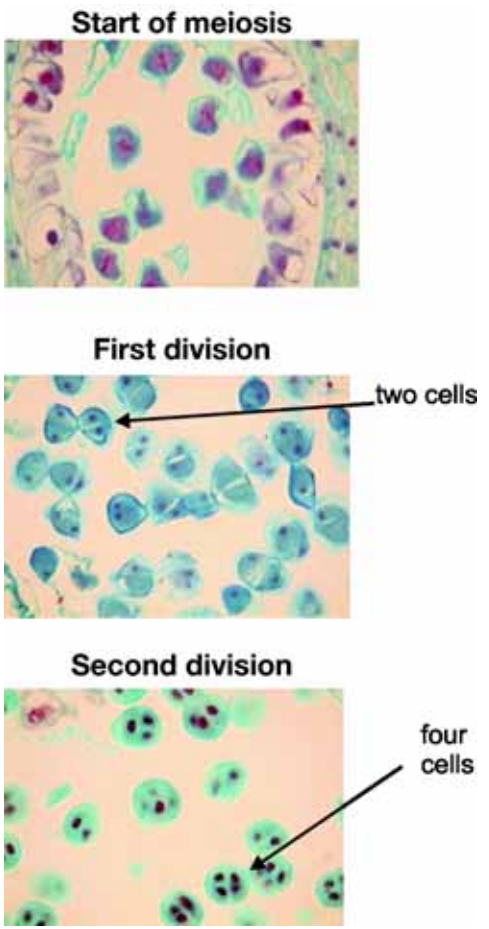
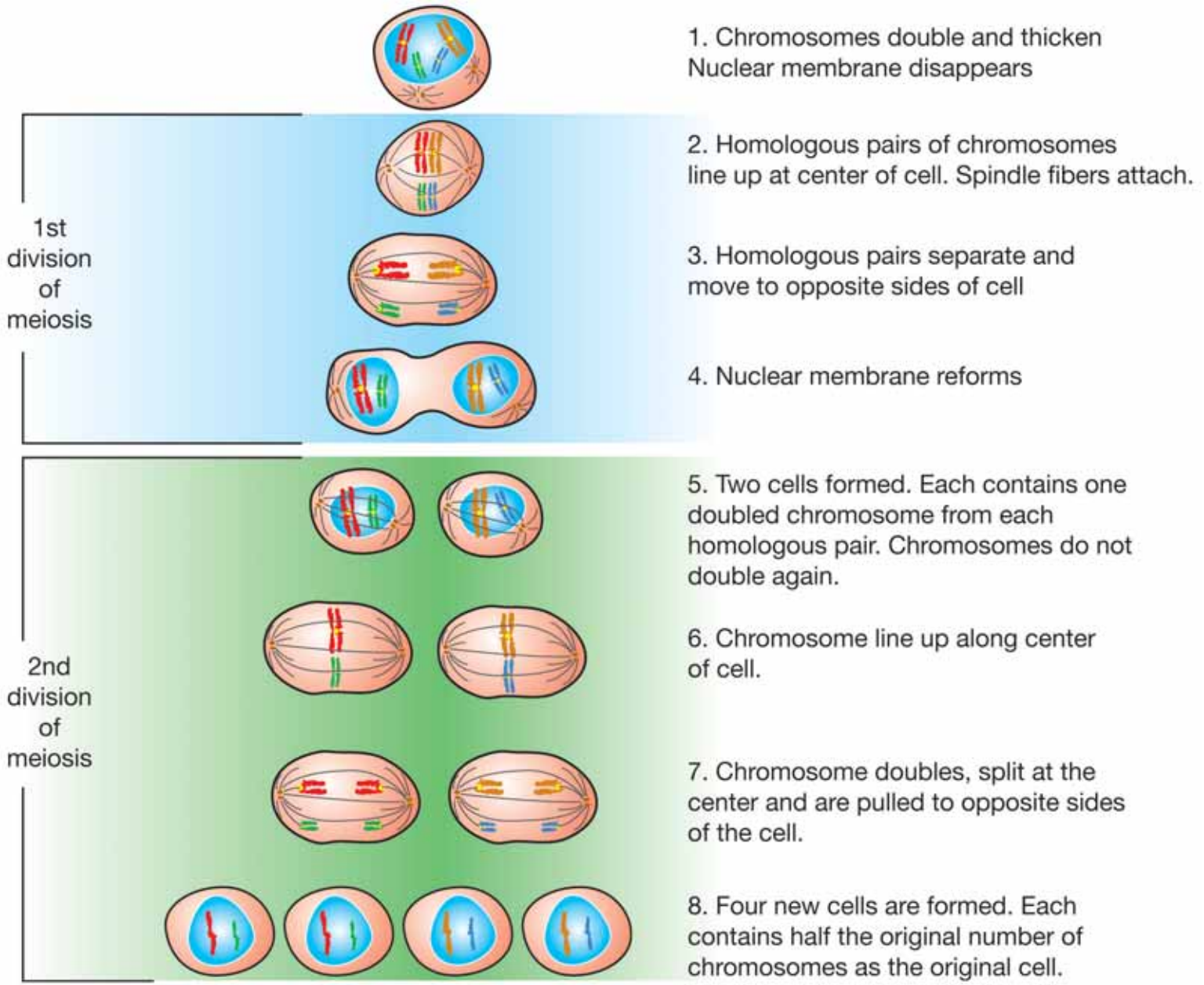



**Figure 8.7:** *Prepared slides showing meiosis in plant tissues.*

## What happens during meiosis?



## Diploid, haploid, and fertilization

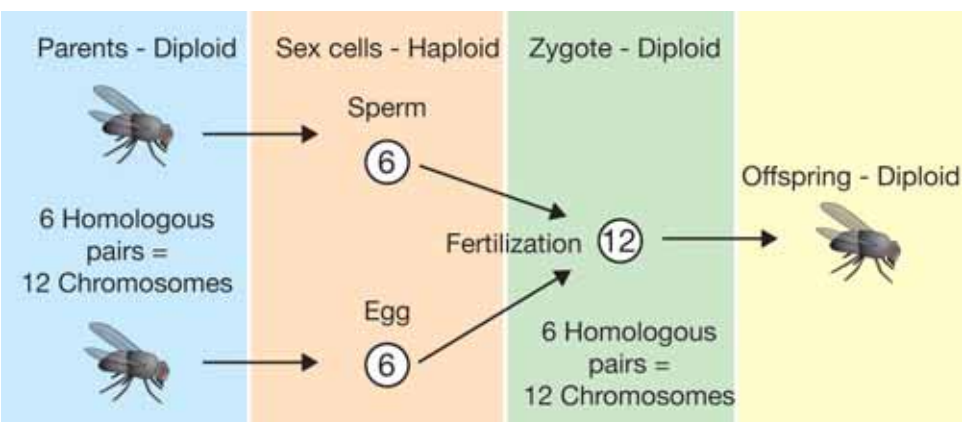
**Diploid and haploid sets**

A complete set of chromosomes is called a **diploid** set. Most animal cells except the sex cells have a diploid set of chromosomes. The diploid human set has 23 *pairs* of chromosomes (a total of 46). Sex cells have half of a complete set of chromosomes, or only one chromosome from each homologous pair. A half set of chromosomes is called a **haploid** set. Humans have 23 chromosomes in their sex cells—a haploid set. Figure 8.8 shows the diploid and haploid number of chromosomes for various organisms.

**What is fertilization?**

**Fertilization** is the union of egg and sperm to form a new organism. When an egg is fertilized by a sperm, the haploid set of chromosomes from the father unites with the haploid set of chromosomes from the mother. A fertilized egg, called a **zygote**, has a diploid set of chromosomes. For each homologous pair, one chromosome comes from the mother, and one from the father.

***In a diploid set, chromosomes are found in homologous pairs. For each pair, one chromosome comes from each parent.***




**VOCABULARY**

**diploid** - a double set of chromosomes.

**haploid** - a half set of chromosomes.

**fertilization** - the union of egg and sperm.

**zygote** - a fertilized egg.

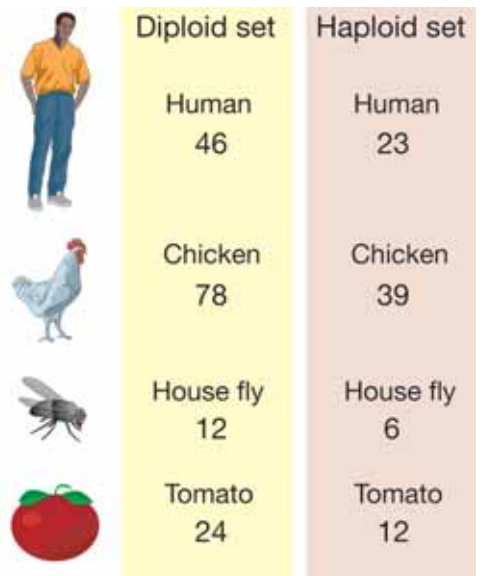



**Figure 8.8:** *The diploid and haploid number of chromosomes for various organisms.*

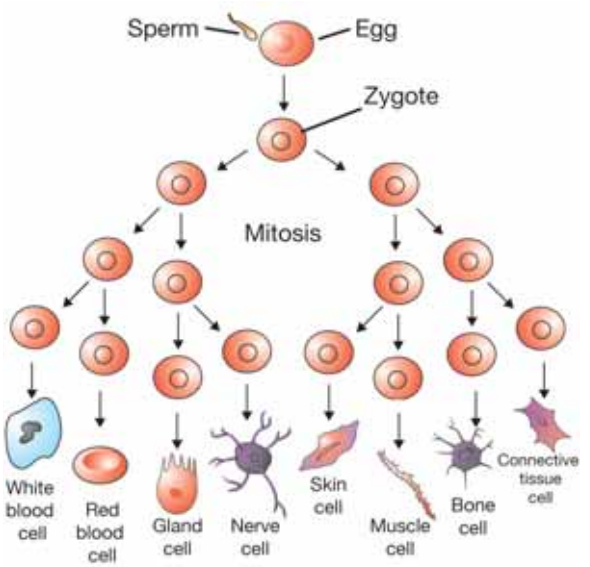
## Cell differentiation

**Specialized cells**

After fertilization, the zygote rapidly divides by mitosis and becomes an embryo. An **embryo** is an organism in its earliest stages of development. Figure 8.9 shows embryo development of a fish, calf, and rabbit. The final outcome is a multicellular organism with many different types of *specialized* cells. You have brain cells, stomach cells, skin cells, and muscle cells to name just a few. All of those cells can be traced back to the zygote.

**Differentiation**

Where do all of the different types of cells come from? An organism that is not fully developed is called an *embryo*. In the developing embryo, cells begin to *differentiate*. **Cell differentiation** is the process of cell specialization. For example, cells that eventually divide to become part of the stomach are different from those that will become part of the nervous system. As cells differentiate, they give rise to different tissues. These tissues eventually form the organs.




**Further specialization**

As the embryo continues to develop, some cells become even more specialized. For example, some cells in the retina of your eye become *rod cells* (for vision in dim light) and others become *cone cells* (for color vision). After differentiation is complete, most cells lose the ability to become other types of cells.

**VOCABULARY**

**embryo** - an organism in its earliest stage of development.

**cell differentiation** - the process of cell specialization.

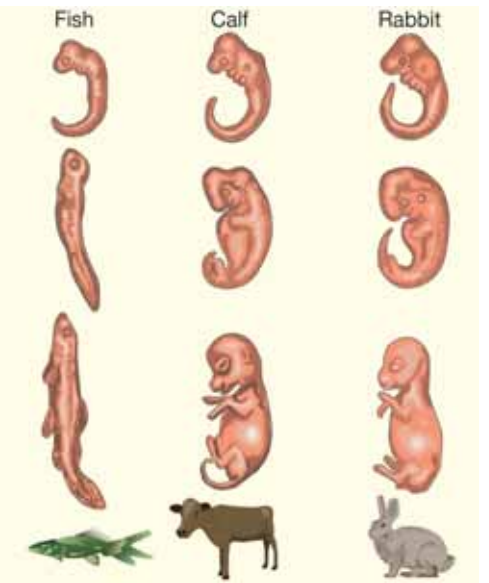



**Figure 8.9:** *An embryo is an organism in its earliest stages of development. The embryos of a fish, calf and rabbit, over time, develop into young organisms.*

## 8.2 Section Review

1. Fill in the table below for a human cell.

| | Mitosis | Meiosis |
|---|---|---|
| Type of cell produced | | |
| Number of cell divisions | | |
| Number of cells produced | | |
| Number of chromosomes in each cell (diploid or haploid) | | |

2. Look at Figure 8.10. Match each number on the diagram to the statements below.
   a. Cells contain half the number of chromosomes.
   b. Homologous pairs of chromosomes are pulled to opposite sides of the cell.
   c. The total amount of DNA is doubled.
   d. Doubled chromosomes are split apart.
3. A chicken has 78 chromosomes in its body cells. How many chromosomes are in its sex cells?
4. What is fertilization?
5. How does the process of fertilization explain the need to have half the number of chromosomes in sex cells?
6. You started out as a single cell and are now made of over 200,000 different types of cells. Explain how this happens.

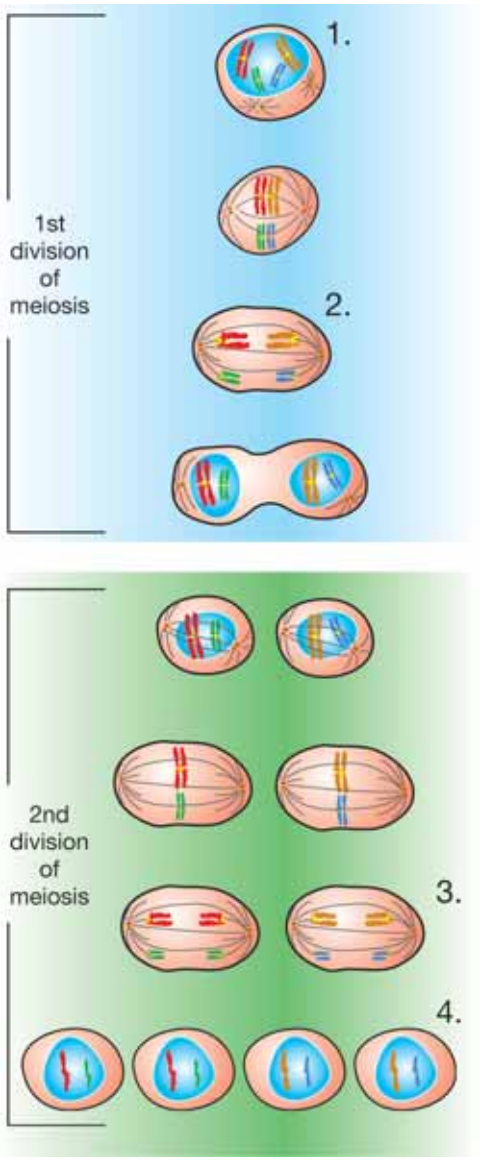



**Figure 8.10:** *Use this diagram to answer question 2.*

MEDICINE CONNECTION

# Differences Between Twins Start With Cells

You are a completely unique individual. No one is just like you. Yet what if there was an exact duplicate of you? Same hair, nose and size. You look exactly the same. No one can tell the two of you apart. You even have the same genes. There is only one way that can happen. If you and another person have the same genes, you are identical twins.

**Identical Twins**

Identical twins develop from an egg that has been fertilized by a single sperm. The zygote divides into two separate zygotes.

Out of every thousand births in the United States, about 25 will be twins. Of these, some are identical twins. The rest are fraternal twins. The difference comes from how the twins formed.

## Fraternal twins start as two

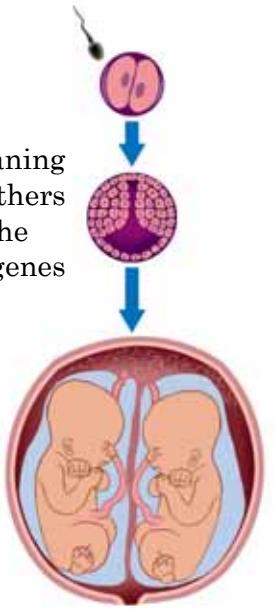
The word fraternal comes from a word meaning "brother." Fraternal twins are like any brothers and sisters, except that they are born on the same day. They each have some the same genes as their parents. But they do not share an identical genetic makeup. Fraternal twins may resemble each other, but they usually will not be mistaken for each other. Fraternal twins might both be girls. They could both be boys, or one girl and one boy.

How do fraternal twins happen? It's simple. Two different sperm cells fertilize two different eggs. Each fertilized egg develops into an embryo. Each embryo becomes a fetus. The mother gives birth to both babies on the same day.

Fraternal twins are also called dizygotic twins. When an egg cell and a sperm cell join, the resulting cell is called a zygote. It is a fertilized egg. The prefix *di* means "two." Dizygotic twins develop from two zygotes, or two fertilized eggs. In other words, the mother has produced two eggs. Each joins with a sperm cell. Each becomes a fetus. The two babies are born one right after the other.

**Fraternal Twins**

Fraternal twins develop from two different eggs that have been fertilized by two different sperms.




## Identical twins start as one

Identical twins are not like other brothers and sisters. Other brothers and sisters share half of their genes. Identical twins have the same genetic makeup. Like fraternal twins, they are born on the same day. But that's where the similarity to fraternal twins ends. Identical twins are always the same sex. They will always be either two boys or two girls. The twins usually look very much the same. Many people cannot tell them apart at first.

Fraternal twins come from two eggs. Identical twins develop from a single fertilized egg. Shortly after the egg cell and sperm cell join, the zygote splits into two parts. Each new part is an identical copy of the original. Each has identical genetic material. After the split, each new

part develops into an embryo. From that point on, each fetus grows just like fraternal twins. Finally, two babies are born. With identical twins, the births are usually just minutes apart. The two babies have the same genes. As they grow, they usually appear to be identical to each other. People who know identical twins well can tell who is who, but a stranger may not be able to tell identical twins apart.

Identical twins are also called monozygotic twins. The prefix mono means "one." These twins develop from one zygote.

## The same genes

What does it mean to have the same genes? It means that identical twins have the same genetic potential. Other factors affect how individuals develop. The environment plays a part. For example, identical twins may have different weights at birth. This is because each fetus may develop in slightly different conditions inside the mother. Identical twins that grow up in different homes often develop differently. Their diets may be different and they might not get the same exercise. If these twins come together later in their lives, they may not look alike. They may not seem to be identical twins at all.

Scientists want to know more about how our environment affects the way we develop. For this reason, identical twins are often studied. They start out with the same genes. However, differences that occur may be caused by environmental factors.

## Transplants and tissue matching

Organ transplants save many lives. The science of transplants has benefited by the study of identical twins. In the early 1950s, scientists observed that most donated organs were rejected. Then in 1954, a kidney transplant was done between identical twins.

Richard Herrick was dying of kidney disease. Ronald, his identical twin brother gave one of his kidneys to him. Both twins had the same genetic makeup. Richard's body recognized Ronald's kidney as being the same tissue as itself. It did not reject the kidney and the transplant was a success.

The Herrick twins and members of the first successful kidney transplant team after the 1954 surgery. Standing from left, Drs. Joseph Murray, John Merrill and J. Hartwell Harrison. Seated, from left: Richard (recipient) and Ronald Herrick (donor). Credit: Courtesy of Brigham and Women's Hospital

This case was very important in the understanding of organ transplants. It helped scientists know more about matching tissue. Since then, many of the problems of organ rejection have been overcome with the use of tissue matching.

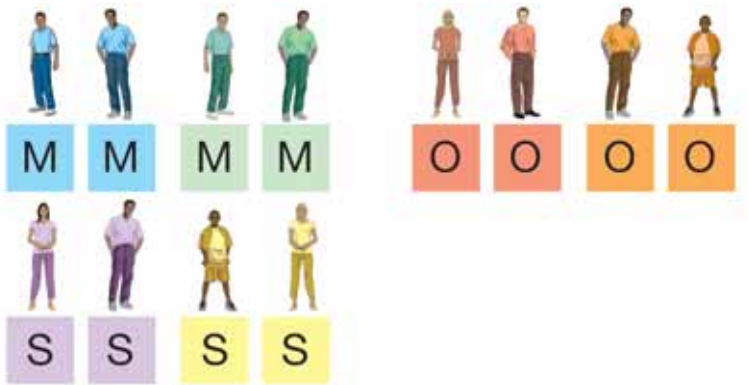
**Questions:**

1. What is a zygote?
2. In terms of zygotes, how are fraternal twins and identical twins different?
3. How does the genetic makeup of fraternal and identical twins differ?
4. What could explain differences in appearance between 50-year old identical twins?

# CHAPTER ACTIVITY Chromosome Square Dance

It's sometimes easier to visualize a process like meiosis using people to act out the parts. In this activity, you will imagine you and your classmates are chromosomes at a square dance. In a square dance, a "caller" calls out orders. The dancers follow the caller's orders.

The diagram below shows students playing homologous pairs of chromosomes just before the first division of meiosis. The amount of DNA has doubled so each chromosome is doubled. Therefore, for each homologous pair, you will need four students. Look at the diagram then answer the questions below it.




a. How many homologous pairs are in the diagram?
b. What is the diploid number of the organism?
c. What is the haploid number of the organism?

## What you will do

1. Your class will choose one person to be the caller. He or she will read from the orders (right).
2. Your teacher will assign students as chromosomes. You will be given a colored sign to wear around your neck. The letter and color on the sign indicates the chromosome to which you belong. Place your sign around your neck and wait for instructions from your teacher to begin.

| Meiosis event | Caller orders |
|---|---|
| Before meiosis begins, the chromosomes double. But they are randomly arranged in the nucleus. | "Two people with the same letter and sign color link arms and move around at random. You are now doubled chromosomes. Dance!" |
| Just before the first division, homologous pairs find each other and pair up. | "Each doubled chromosome find another doubled chromosome with the same color sign. You are now homologous pairs. Group together!" |
| Homologous pairs of chromosomes line up along the center of the cell. | "Now find your way to the center line. Homologous pairs line up along the center!" |
| Spindle fibers attach and pull the pairs apart. Two cells form. Each cell has one double chromosome from each homologous pair. The first division is complete. | "Homologous pairs—you are being pulled apart. Move to opposite sides of the center line. Doubled chromosomes should stay together!" |
| The second division starts. The doubled chromosomes line up in the center of each new cell. | "Doubled chromosomes—line up along the center line of the cell." |
| Spindle fibers pull the doubled chromosomes apart. Each half moves to opposite ends of the cell. | "Doubled chromosomes—you are being pulled apart. Release arms and move to opposite ends of the cell. Drift apart!" |
| Four cells form. Each cell has a haploid set of chromosomes—one chromosome from each homologous pair. The second and final division is complete. | "You are now single chromosomes. Get together with the other single chromosomes in your cell. Congratulations—you are now haploid! The dance is over." |

## Applying your knowledge

a. Why were there two students for each chromosome in the beginning?
b. Why were there four students per homologous pair?
c. Which letters and sign colors ended up in each cell after the second division?
d. How many chromosomes ended up in each cell after the second division?

# Chapter 8 Assessment

## Vocabulary

Select the correct term to complete the sentences.

| | | |
|---|---|---|
| cell cycle | cytokinesis | sexual reproduction |
| sex cells | fertilization | meiosis |
| differentiation | chromosomes | interphase |
| mitosis | reproduction | asexual reproduction |
| | cell division | |

***Section 8.1***

1. _____ is the process of cell reproduction.
2. Made up of protein and DNA, _____ contain genetic information within a eukaryotic cell.
3. The continuous sequence of events from the beginning of one cell division to the next is the _____.
4. During _____, the cell grows and develops.
5. _____ is the process of eukaryotic nuclear division in which two nuclei with identical sets of chromosomes are formed.
6. A cell whose cytoplasm and organelles divide in two is in the stage of _____.

***Section 8.2***

7. _____ is the process of producing offspring.
8. _____ involves a single parent producing identical offspring without the aid of sex cells.
9. In _____, sperm and eggs unite to form new offspring.
10. _____ contain half the number of parental chromosomes.
11. Sex cells are formed during _____, when the nucleus divides twice, forming cells with half the original chromosome number.
12. In the process of _____, egg and sperm cells unite.
13. As cells develop they specialize in different functions, this is the result of _____.

## Concepts

***Section 8.1***

1. Distinguish between mitosis and cell division.
2. Chromosomes
   a. are structures made of DNA and protein in the nucleus of prokaryotic cells.
   b. are only visible during mitosis.
   c. are doubled along with their DNA prior to cell division.
   d. within two daughter cells contain half the original DNA after mitosis.
3. A researcher has discovered a way to disrupt the cell cycle by allowing cytokinesis to take place before mitosis. What would be the result if a cell with four chromosomes underwent this cycle?
4. Which does not occur during prophase.
   a. The nuclear membrane breaks down.
   b. Chromosomes can be seen for the first time.
   c. Threads of spindle fibers are visible.
   d. Doubled chromosomes separate to opposite ends of the cell.
5. Mitosis
   a. increases the number of cells without changing genetic information.
   b. alters the information passed down to daughter cells.
   c. creates four daughter cells containing half the number of original chromosomes.
   d. is the stage where cells grow and develop.
6. Create a diagram illustrating the stages during mitosis. Include a short explanation of each step in your own words.

***Section 8.2***

7. There are 38 chromosomes in the liver cells of a cat. The sperm of male cat would contain ___ chromosomes.
   a. 38  b. 19  c. 24  d. 56
8. Explain two major differences between mitosis and meiosis.
9. Describe what happens to homologous chromosomes during each division of meiosis.
10. What are homologous pairs of chromosomes? How are these different than the doubled chromosomes in the second division of meiosis?
11. A fertilized egg
    a. contains only half the number of parental chromosomes.
    b. divides into new cells by mitosis.
    c. divides into new cells by meiosis.
    d. cannot undergo cell divisions.

## Math and Writing Skills

1. Specialized cells in within the body divide at different rates. A researcher studying the rate of two different cells has determined cell A divides once every 1.5 minutes while cell B divides every 30 seconds. The researcher places one of each dividing cell in culture, how many cells should he expect in each dish after 4.5 minutes? Create a table like the one below that goes up to 270 seconds and fill in your answers.

| Time (seconds) | Cell A (# of divisions) | Cell B (# of divisions) |
|---|---|---|
| 30<br>60<br>up to 270 | | |

2. Explain how chemicals that disrupt mitosis could be potentially used as an herbicide (weed killer). How would the mechanism of these chemicals differ if they disrupted meiosis instead?

## Chapter Project

**Cell Division Flip Book**

A flip book is a stack of at least twenty pages with individual drawings that change position slightly on each page. When you flip through the pages quickly, the individual drawings look like they are moving!. Here's how to create your own flip book of cell division.

1. Plan a sequence of at least twenty drawings on scrap paper before starting to draw the flip book. The drawings should take one cell completely through the stages of cell division, with slight changes from one drawing to the next. Start with Interphase and draw the stages all the way to cytokinesis. It's easiest to limit your chromosome count to 4 pairs. Color coding works nicely.
2. Begin your flip book by drawing the first picture on the LAST page of the book. Draw the next picture on the second-to-the last page and so on. When the next page is placed on top of the previous, you will be able to see the drawing on the previous page as it shows through the post-it paper. Trace or redraw most of that image, changing a small part of it only slightly.
3. Continue to flip, cover, trace, and change slightly until the action sequence is complete. Keep the figure as close as possible to the edge of the page.
4. Flip through the booklet and watch the animation. Hold the flip book in your right hand and flip the pages from back to front (start to finish) with your left thumb.