PART 2 Continuing the Cycle

LESSON 8

Cell Division: Multiplying by Dividing

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When you look through a microscope like the one you're using in class, cells often appear two-dimensional. But this photo of a dividing cell shows the true three-dimensional quality of cells. It was taken through a powerful electron microscope.

INTRODUCTION

In Lesson 7, you looked at several different types of cells and observed some of their major structures and organelles. In Lesson 9, you will explore sexual reproduction in flowering plants. To bridge the gap between these two lessons, you will now learn how cells reproduce.

The title of this lesson seems contradictory, but in the world of cells it's not. Cell division is one of the most important processes in living things. Its only purpose is multiplication! In this lesson, you will use pipe cleaners to depict what takes place just before and during cell division. Then you will create models to represent specific stages of this process.

OBJECTIVES FOR THIS LESSON

Depict the behavior of chromosomes during interphase and cell division.

Construct models that depict interphase and the key steps of cell division.

Compare and contrast cell division in plant and animal cells.

Update organism photo cards for those organisms whose cells undergo cell division.

Getting Started

1. With your teacher and classmates, read "Multiply, Divide, and Survive."

2. Discuss the reading selection with the class and ask your teacher to clarify any aspect of mitosis and cell division that you don't understand.

Inquiry 8.1
Simulating Interphase, Mitosis, and Cytokinesis

PROCEDURE

1. Work with your partner to cut three pipe cleaners. Follow these steps:

A. Place one end of a pipe cleaner against the zero line of the metric ruler.

B. Place a mark on the pipe cleaner at 4-cm intervals. Repeat this with the two other pipe cleaners.

C. Use your scissors to cut the pipe cleaners at the marks you made. You will use four of these pieces of pipe cleaner for this inquiry. Set the rest aside for Inquiry 8.2.

MATERIALS FOR LESSON 8

For your group

- 1 set of organism photo cards
- 2 copies of Student Sheet 8.2: Interphase and Stages of Mitosis
- 6 pipe cleaners
- 2 pairs of scissors
- 2 metric rulers, 30 cm (12″)
- 2 resealable plastic bags
- 2 black markers
- Transparent tape

2. Watch and listen as your teacher uses a set of transparencies and pipe cleaners to demonstrate the behavior of chromosomes during interphase and mitosis.

3. Now, follow your teacher's example for using your four pipe cleaner pieces to depict the action of chromosomes during interphase and mitosis.

Inquiry 8.2
Creating a Model of Interphase and the Stages of Mitosis

PROCEDURE

1. Work in pairs to create "snapshots" of a pair of duplicated chromosomes during interphase and mitosis. You will use 4-cm pieces of pipe cleaner to represent the single and duplicated chromosomes. To make all the models, you and your partner will need a total of 16 4-cm pieces.

2. On the basis of what you now know about cell division, arrange in order the pages of Student Sheet 8.2: Interphase and Stages of Mitosis. Decide with your group which pages will have no pipe cleaners.

3. Make a model of a duplicated chromosome by twisting two pipe cleaners around each other once near the middle to form a narrow X, as shown in Figure 8.1.

4. Use the remaining pipe cleaners to illustrate how the chromosomes appear in each of the remaining phases.

5. Lay out the pipe cleaners in the appropriate arrangements on the pages of your student sheet. The outlines of the cells and fibers have been drawn to help you place your pipe cleaners. As references, use the reading selection "Multiply, Divide, and Survive" and Figures 8.2 and 8.3, which show cells in the process of dividing. Ask your teacher for approval before you tape the pipe cleaners to the sheet.

6. When your teacher has approved your layout, attach each pipe cleaner to the student sheet with transparent tape.

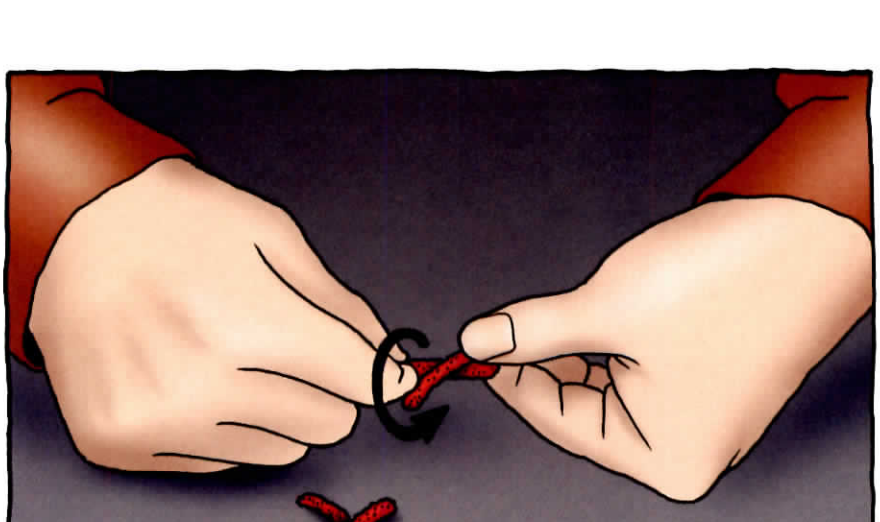


Figure 8.1 *You now have a model of a duplicated chromosome. Notice the narrow area where the duplicated chromosomes are joined. This is called the centromere.*

7. Follow your teacher's directions for cleaning up and turning in your work.

8. Update your organism photo cards for any organism you have studied whose cells undergo mitosis.

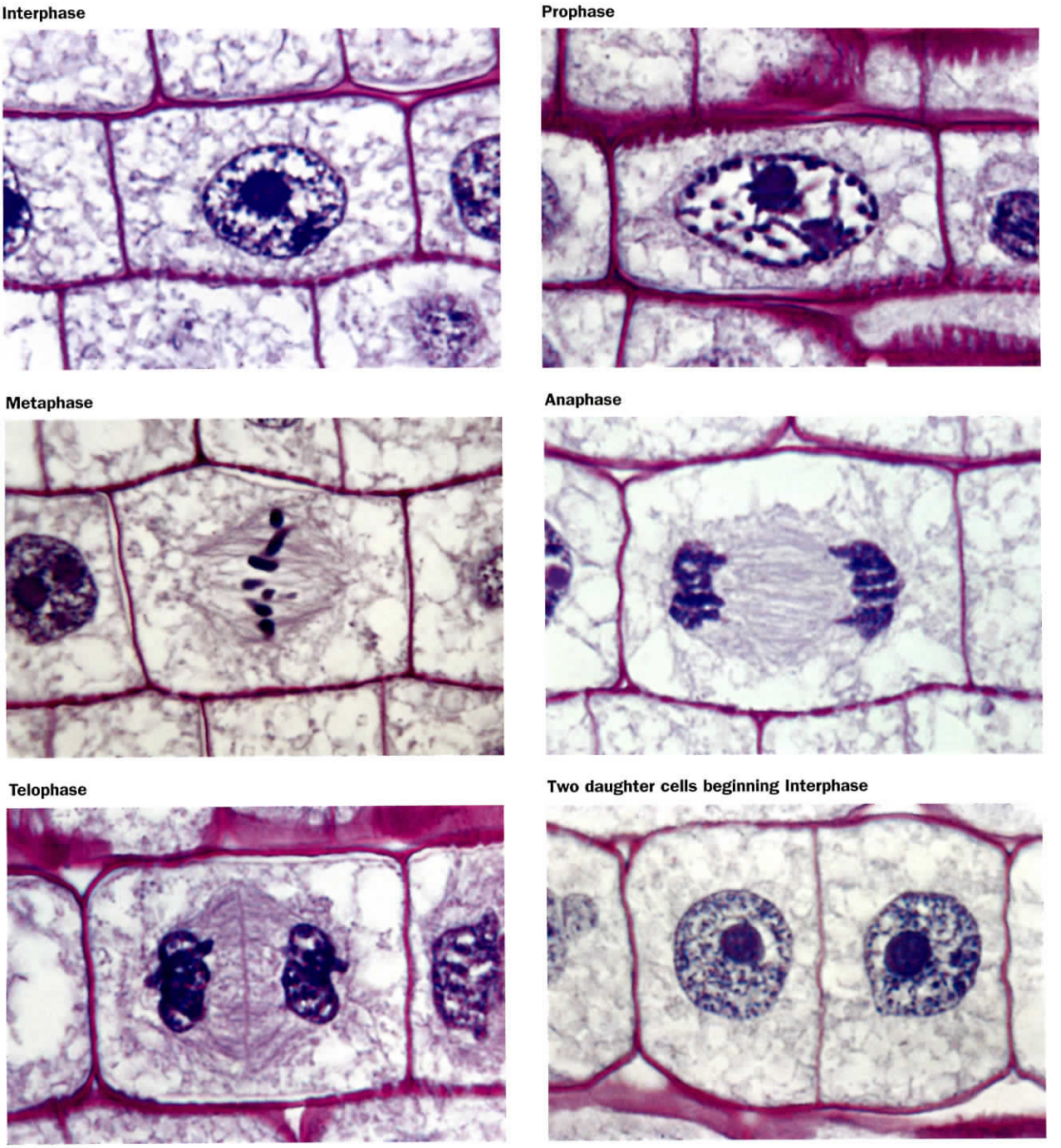


Figure 8.2 *Each stage of mitosis can be identified, as you can see in these photos of the cells of a root tip of an onion plant under high magnification.*

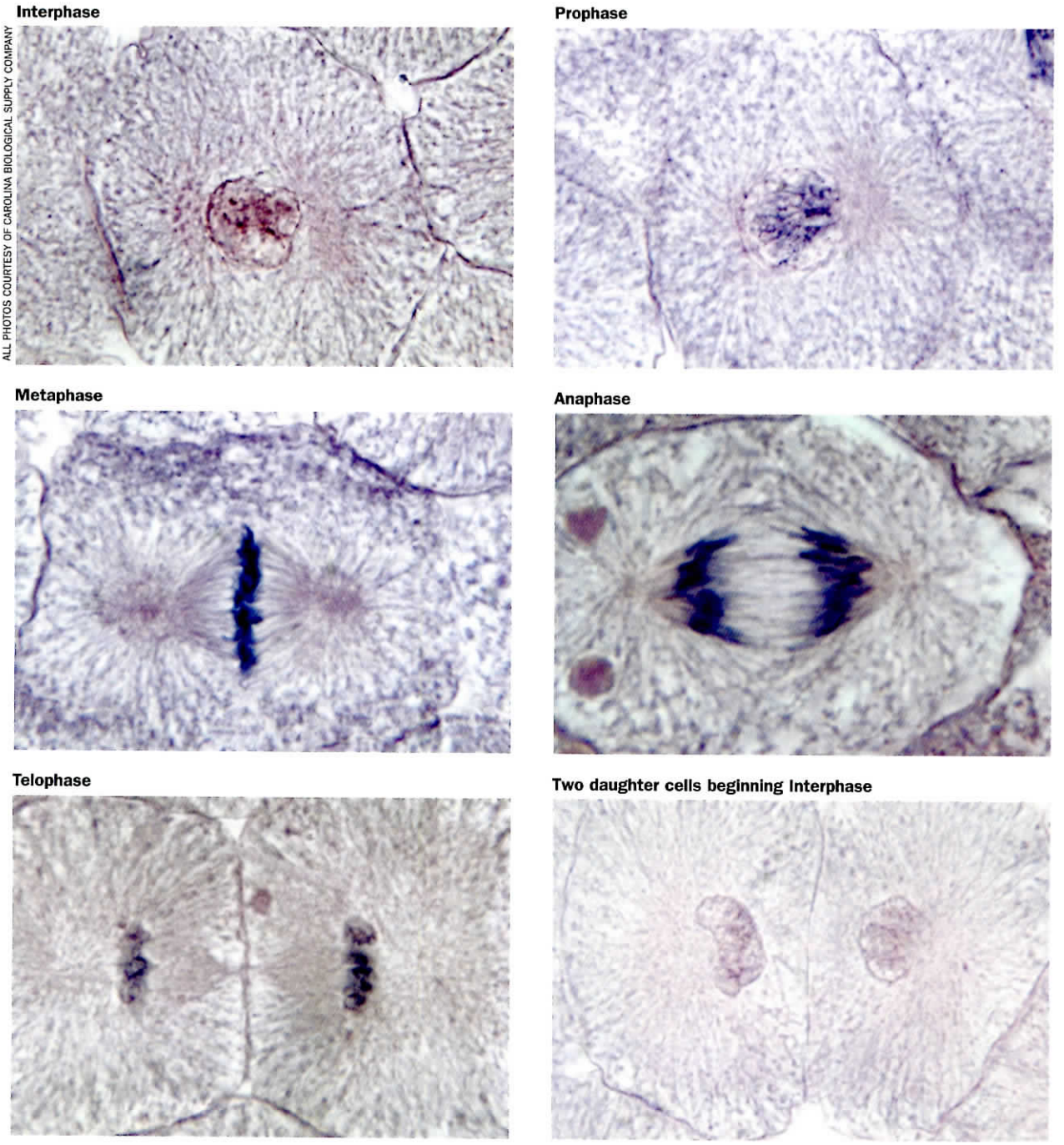


Figure 8.3 *How is cell division of this whitefish cell different from that of the onion root cell in Figure 8.2?*

REFLECTING ON WHAT YOU'VE DONE

1. Respond in your science notebook to the following:

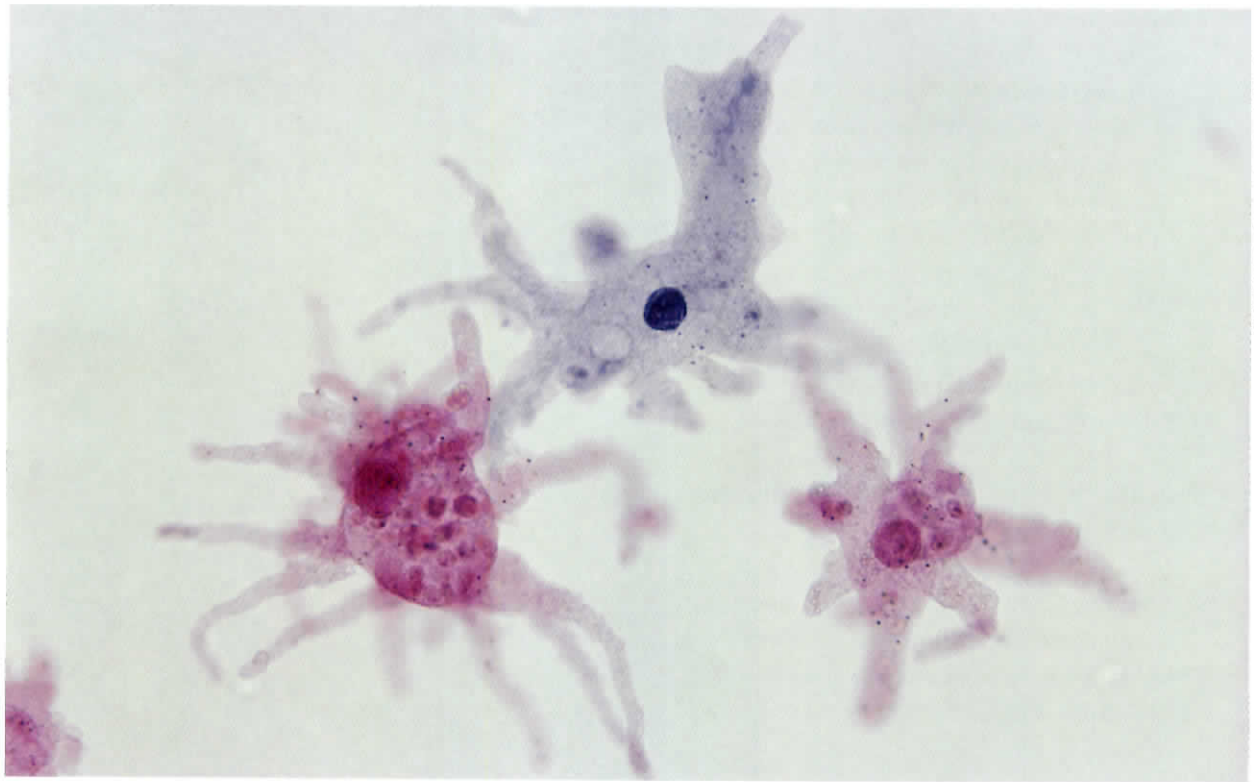
A. Your classmates David and Linda are discussing cell division. David says that this process is important in order for organisms to grow. Linda says that it is important so that organisms can reproduce. Who is right and who is wrong? Why?

B. Explain why cell division is a rather misleading name for the process.

C. How is cytokinesis different in plant and animal cells?

2. Visit the NSRC Web site (http://www.si.edu/nsrc) and follow the appropriate links for more information about mitosis. Be sure to check out the animations of mitosis.

Multiply, Divide, and Survive



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Cells sometimes require different stains to highlight various organelles. This often results in a colorful slide.

Late in the 19th century, scientists developed dyes to stain cell structures so they could be seen more clearly through a microscope. This technique, called "staining," allowed scientists for the first time to observe cells in different stages of their life cycles. They could see what happens as cells grow and divide.

As a result of these studies, scientists now know that most cells containing nuclei undergo a series of steps, called "mitosis" and "cytokinesis," to divide into two cells. The stages of mitosis and cytokinesis are collectively called "cell division."

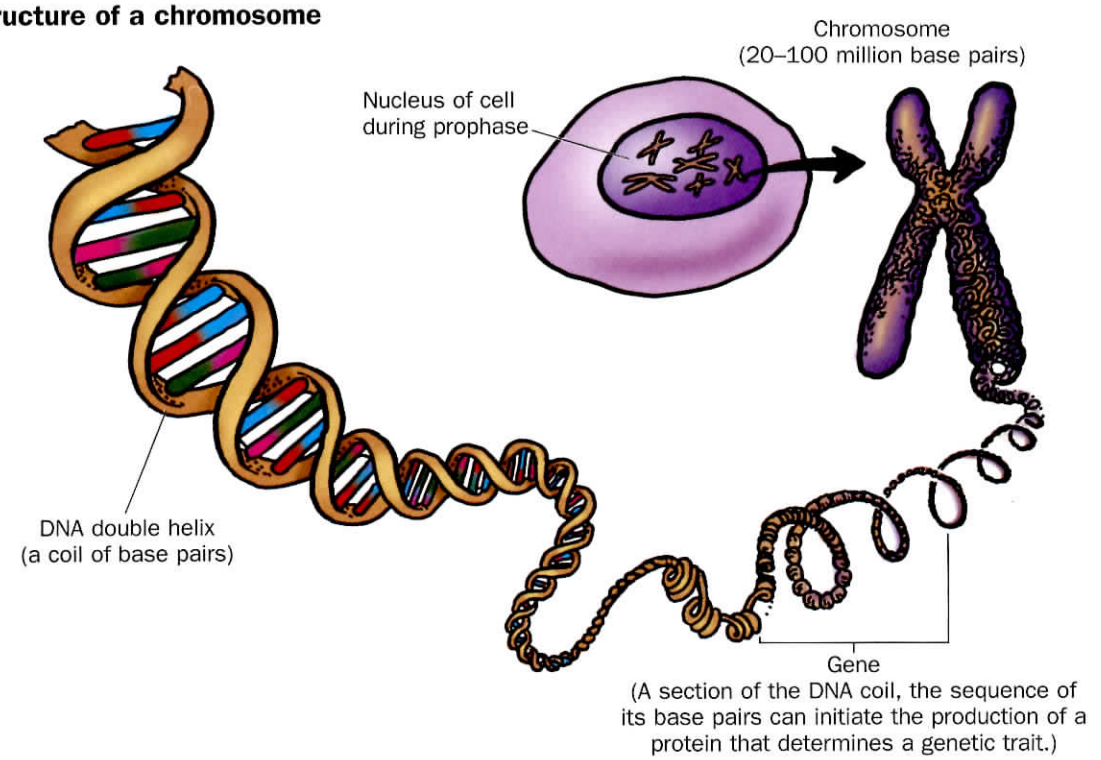
Using their newly developed dyes, those 19th-century scientists also were able to observe some rod-shaped structures in the nuclei that became noticeable just before the cells began to split. Those structures are called "chromosomes." Chromosomes, composed of a substance called "DNA" (deoxyribonucleic acid), are very important because they contain all of the hereditary information for each organism.

Pairing Up

Chromosomes occur in pairs. Although the number of chromosome pairs varies among organisms, all members of the same species have a unique number.

You might expect that complex organisms would have a greater number of chromosomes than simpler organisms. This is not the case. For example, humans have 23 pairs of chromosomes in each body cell, while rose plants, which are less complex, have 35 pairs. Wisconsin Fast Plants have 10 pairs of chromosomes. Fruit flies have 4 pairs. Hereditary units called "genes" appear in the same locations on both chromosomes of each pair.

Structure of a chromosome

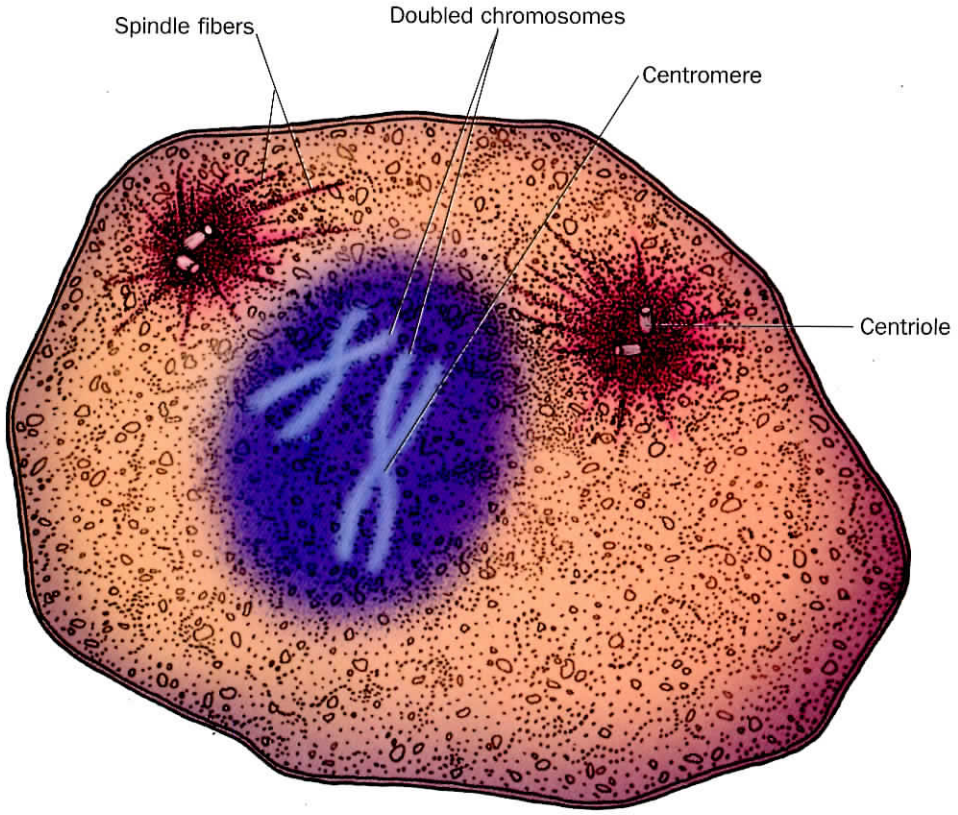


Going in Circles

Like humans, cells have a life cycle. The cell's life cycle has stages, or phases. When cells are not dividing, they are in a stage called "interphase." During this phase, cells are busy carrying on their life processes, which include growing. The chromosomes are not visible because they are elongated and blend into the rest of the nuclear material. In this condition, they are referred to as "chromatin." The DNA, which makes up the threads of chromatin, duplicates during this phase. Near the end of interphase, the cell makes its final preparations for mitosis by producing the necessary organelles for each daughter cell. Because the chromatin threads are still elongated at this point, they are not yet recognizable, even under a compound microscope. A cell in this stage might look like the one shown here.

(continued)

By the end of interphase, the chromosomes have duplicated. At this point human cells have 46 doubled chromosomes in their nuclei.



This is how an animal cell might look toward the end of prophase. Only two of the doubled chromosomes are shown.

Mitosis consists of a series of phases during which the DNA, which duplicates during interphase, first coils and condenses into chromosomes. Then the chromosomes detach from each other and separate into the nuclei of what will soon become two new cells. These new cells are known as "daughter cells." Although scientists describe the process of mitosis as having four phases—prophase, metaphase, anaphase, and telophase—it is actually continuous. Each phase passes smoothly into the next. Dividing mitosis into phases is comparable to viewing a movie, then selecting individual frames, or "snapshots," that best represent each part of the movie.

During prophase, the chromatin threads begin to coil. They shorten and become much thicker. At this point they are referred to as chromosomes and can be observed through a compound microscope. A mesh-like structure of fine, spindle fibers develops. As the nuclear envelope disintegrates, these fibers guide the movements of the chromosomes. As though they were being tugged along by the fibers, the duplicated chromosomes begin to move toward the middle of the cell.

During metaphase, the chromosomes line up in the middle of the cell. Their centromeres, which are the places where the duplicated chromosomes are attached, align in the exact middle of the cell.

At the beginning of anaphase, the duplicated chromosomes separate. Each becomes an individual chromosome. The fibers shorten, drawing the chromosomes to opposite ends of the cell.

As soon as the chromosomes reach the ends of the cell, telophase begins. This phase is almost the opposite of prophase. The chromosomes uncoil and elongate and begin to blend into the nuclear material. A nuclear envelope forms around each new nucleus. The fibers break down and disappear. Mitosis is now complete. The daughter cells are considered to be in interphase. The two nuclei that result are identical. This means that their DNA, or genetic material, is identical.

Now, the final step in the process, cytokinesis, must occur. During this process, the daughter cells split from each other. There is a major difference between cytokinesis in plant and in animal cells. In an animal cell, the cell membrane pinches inward and forms two separate daughter cells. In a plant cell, a cell plate begins forming in the middle of the cell and grows outward until it becomes a part of the cell wall between the daughter cells. Cell walls help give the plant support. Animal cells have no cell walls.

The illustration below summarizes the stages in the cell cycle. □

The cell cycle