Figure 9 The cells that make up this young monkey are the same size as those that make up its mother. However, the adult has many more cells in its body.

The Cell Cycle

Think about the cells you learned about in Chapter 1. Each cell contains many different structures, including a cell membrane, a nucleus, mitochondria, and ribosomes. To divide into two equal parts, the cell would need to either duplicate the structures or divide them equally between the two new cells. Both cells would then contain everything they need in order to survive and carry out their life functions.

The regular sequence of growth and division that cells undergo is known as the **cell cycle.** You can see details of the cell cycle in *Exploring the Cell Cycle* on pages 64 and 65. Notice that the cell cycle is divided into three main stages. As you read about each stage, follow the events that occur as one "parent" cell divides to form two identical "daughter" cells.

Stage 1: Interphase

The first stage of the cell cycle is called **interphase.** Interphase is the period before cell division occurs. Even though it is not dividing, the cell is quite active during this stage. **During interphase, the cell grows to its mature size, makes a copy of its DNA, and prepares to divide into two cells.**

Growth During the first part of interphase, the cell doubles in size and produces all the structures needed to carry out its functions. For example, the cell enlarges its endoplasmic reticulum, makes new ribosomes, and produces enzymes. Both mitochondria and chloroplasts make copies of themselves during the growth stage. The cell matures to its full size and structure.

DNA Replication After a cell has grown to its mature size, the next part of interphase begins. The cell makes a copy of the DNA in its nucleus in a process called **replication.** Recall that DNA is a nucleic acid found in the chromatin in a cell's nucleus. DNA holds all the information that the cell needs to carry out its functions. The replication of a cell's DNA is very important, since each daughter cell must have a complete set of DNA to survive. At the end of DNA replication, the cell contains two identical sets of DNA. One set will be distributed to each daughter cell. You will learn the details of DNA replication later in this section.

Preparation for Division Once the cell's DNA has replicated, preparation for cell division begins. The cell produces structures that it will use to divide during the rest of the cell cycle. At the end of interphase, the cell is ready to divide.

Stage 2: Mitosis

Once interphase is complete, the second stage of the cell cycle begins. **Mitosis** (my TOH sis) is the stage during which the cell's nucleus divides into two new nuclei. **During mitosis, one copy of the DNA is distributed into each of the two daughter cells.**

Scientists divide mitosis into four parts, or phases: prophase, metaphase, anaphase, and telophase. During prophase, the threadlike chromatin in the cell's nucleus begins to condense and coil, like fishing line wrapping around a ball. Under a light microscope, the condensed chromatin looks like tiny rods, as you can see in Figure 10. Since the cell's DNA has replicated, each rod has doubled. Each is an exact copy of the other. Scientists call each doubled rod of condensed chromatin a **chromosome.** Each identical rod, or strand, of the chromosome is called a **chromatid.** The two strands are held together by a structure called a centromere.

As the cell progresses through metaphase, anaphase, and telophase, the chromatids separate from each other and move to opposite ends of the cell. Then two nuclei form around the chromatids at the two ends of the cell. You can follow this process in *Exploring the Cell Cycle.*

☑ *Checkpoint During which stage of mitosis does the chromatin condense and form rodlike structures?*

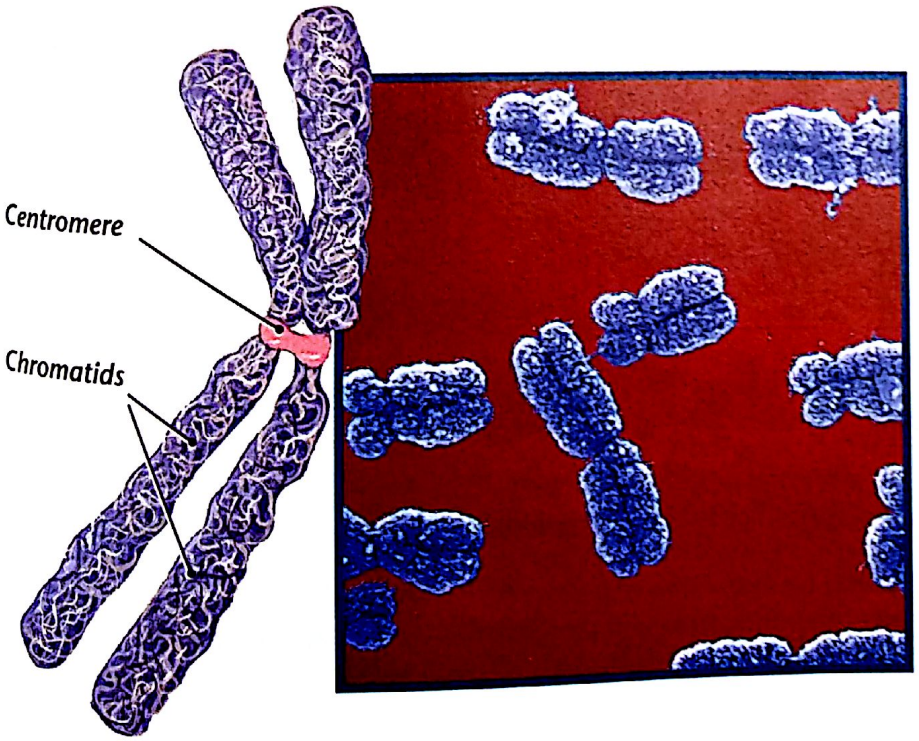


Figure 10 During mitosis, the chromatin condenses to form rodlike chromosomes. Each chromosome consists of two identical strands, or chromatids. *Interpreting Diagrams What is the name of the structure that holds the chromatids together?*

Modeling Mitosis

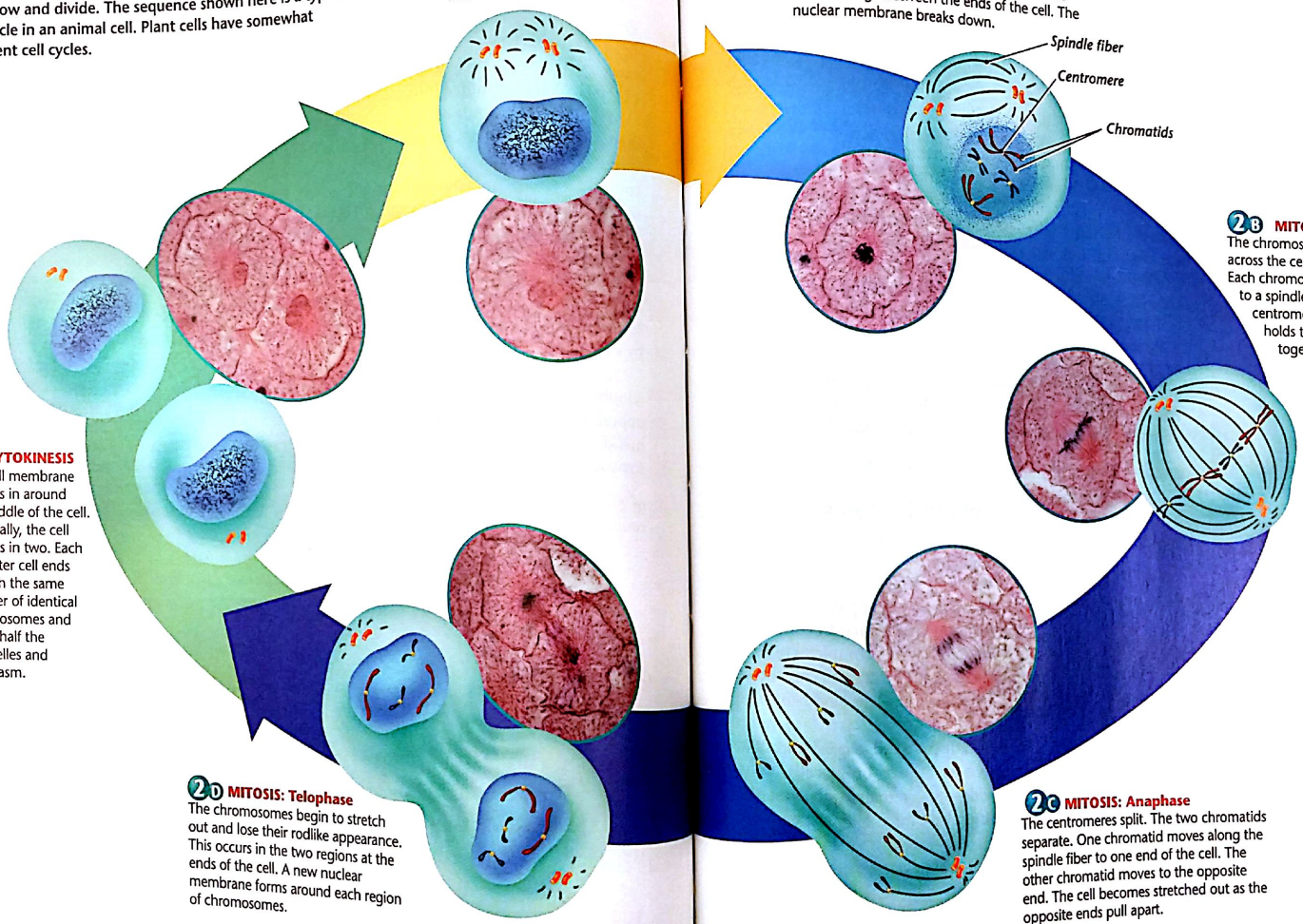
Refer to *Exploring the Cell Cycle* as you carry out this activity.

1. Construct a model of a cell that has three chromosomes. Use a piece of construction paper to represent the cell. Use different colored pipe cleaners to represent the chromosomes. Make sure that the chromosomes look like double rods.
2. Position the chromosomes in the cell where they would be during prophase.
3. Repeat Step 2 for metaphase, anaphase, and telophase.

Making Models How did the model help you understand the events of mitosis?

EXPLORING *the Cell Cycle*

Cells undergo an orderly sequence of events as they grow and divide. The sequence shown here is a typical cell cycle in an animal cell. Plant cells have somewhat different cell cycles.



1 INTERPHASE
The cell grows to its mature size, makes a copy of its DNA, and prepares to divide into two cells.

2A MITOSIS: Prophase
The chromatin in the nucleus condenses to form chromosomes. Structures called spindle fibers form a bridge between the ends of the cell. The nuclear membrane breaks down.

2B MITOSIS: Metaphase
The chromosomes line up across the center of the cell. Each chromosome attaches to a spindle fiber at its centromere, which still holds the chromatids together.

2C MITOSIS: Anaphase
The centromeres split. The two chromatids separate. One chromatid moves along the spindle fiber to one end of the cell. The other chromatid moves to the opposite end. The cell becomes stretched out as the opposite ends pull apart.

2D MITOSIS: Telophase
The chromosomes begin to stretch out and lose their rodlike appearance. This occurs in the two regions at the ends of the cell. A new nuclear membrane forms around each region of chromosomes.

3 CYTOKINESIS
The cell membrane pinches in around the middle of the cell. Eventually, the cell pinches in two. Each daughter cell ends up with the same number of identical chromosomes and about half the organelles and cytoplasm.

Sharpen your Skills

Interpreting Data

ACTIVITY

Use the circle graph shown in Figure 11 to answer the following questions.

1. How long is the cell cycle shown in the graph?
2. Which stage of the cell cycle would you expect more of the cells to be in at any given time—interphase, mitosis, or cytokinesis? Explain.

Stage 3: Cytokinesis

After mitosis, the final stage of the cell cycle, called **cytokinesis** (sy toh kih NEE sis), completes the process of cell division. **During cytokinesis, the cytoplasm divides, distributing the organelles into each of the two new cells.** Cytokinesis usually starts at about the same time as telophase.

During cytokinesis in animal cells, the cell membrane squeezes together around the middle of the cell. The cytoplasm pinches into two cells with about half of the organelles in each daughter cell.

Cytokinesis is somewhat different in plant cells. A plant cell's rigid cell wall cannot squeeze together in the same way that a cell membrane can. Instead, a structure called a cell plate forms across the middle of the cell. The cell plate gradually develops into new cell membranes between the two daughter cells. New cell walls then form around the cell membranes.

There are many variations of the basic pattern of cytokinesis. For example, yeast cells divide, though not equally. A small daughter cell, or bud, pinches off of the parent cell. The bud then grows into a full-sized yeast cell.

Cytokinesis marks the end of the cell cycle. Two new cells have formed. Each daughter cell has the same number of chromosomes as the original parent cell. At the end of cytokinesis, each cell enters interphase, and the cycle begins again.

Checkpoint *When in the cell cycle does cytokinesis begin?*

Length of the Cell Cycle

How long does it take for a cell to go through one cell cycle? The answer depends on the type of cell. In a young sea urchin, for example, one cell cycle takes about 2 hours. In contrast, a human liver cell completes one cell cycle in about 22 hours, as shown in Figure 11. The length of each stage in the cell cycle also varies greatly from cell to cell. Some cells, such as human brain cells, never divide—they remain in the first part of interphase for as long as they live.

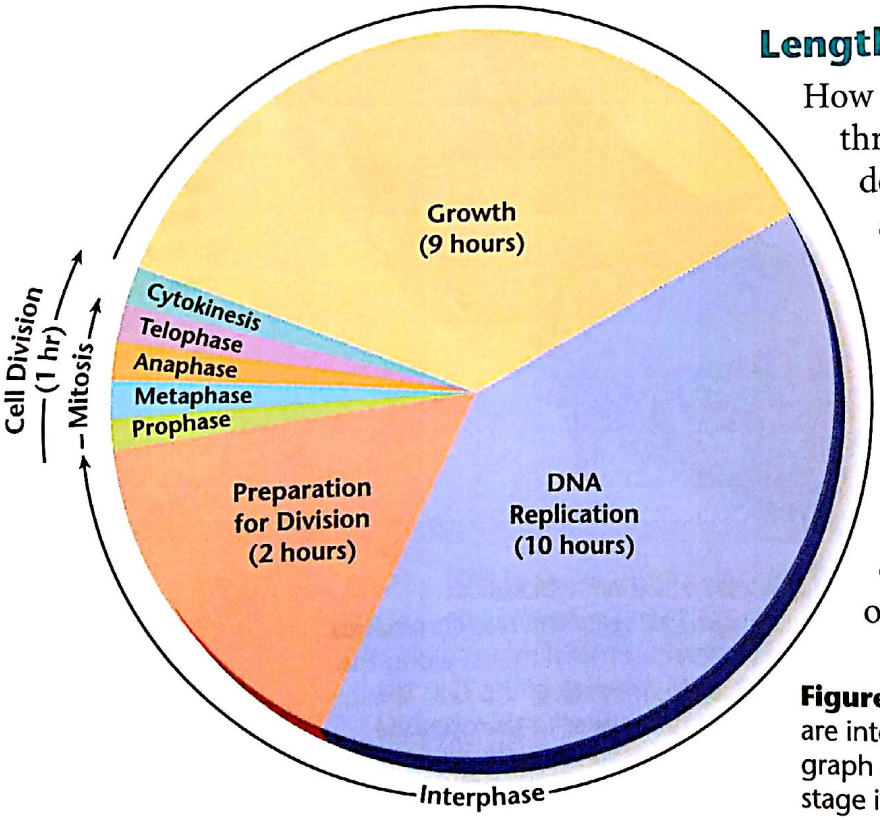


Figure 11 The main stages of the cell cycle are interphase, mitosis, and cytokinesis. This graph shows the average length of each stage in a human liver cell.