Section 5

Cell Division

Reading Preview

Key Concepts

- What events take place during the three stages of the cell cycle?
- How does the structure of DNA help account for the way in which DNA copies itself?

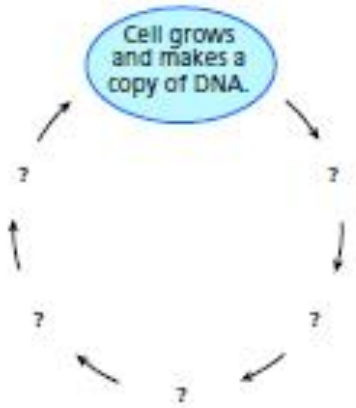
Key Terms

- cell cycle
- interphase
- replication
- mitosis
- chromosome
- cytokinesis

Target Reading Skill

Sequencing As you read, make a cycle diagram that shows the events in the cell cycle, including the phases of mitosis. Write each event in a separate circle.

The Cell Cycle



Lab zone Discover Activity

What Are the Yeast Cells Doing?

1. Use a plastic dropper to transfer some yeast cells from a yeast culture to a microscope slide. Your teacher has prepared the slide by drying methylene blue stain onto it. Add a coverslip and place the slide under a microscope.
2. Examine the cells on the slide. Use low power first and then high power. Look for what appear to be two cells attached to each other. One cell may be larger than the other. Draw what you see.

Think It Over

Developing Hypotheses What process do you think the "double cells" are undergoing? Develop a hypothesis that might explain what you see.

In the early autumn, many local fairs run pumpkin contests. Proud growers enter their largest pumpkins, hoping to win a prize. The pumpkin below has a mass greater than 600 kilograms! This giant pumpkin began as a small flower. How did the pumpkin grow so big?

A pumpkin grows in size by increasing both the size and the number of its cells. A single cell grows and then divides, forming two cells. Then two cells grow and divide, forming four, and so on. This process of cell growth and division does not occur only in pumpkins, though. In fact, many cells in your body are dividing as you read this page.

Prize-winning pumpkin

Discovery CHANNEL SCHOOL

Cell Processes and Energy

Video Preview
▶ Video Field Trip
Video Assessment

Stage 1: Interphase

How do little pigs get to be big pigs? Their cells grow and divide, over and over. The regular sequence of growth and division that cells undergo is known as the **cell cycle.** During the cell cycle, a cell grows, prepares for division, and divides into two new cells, which are called "daughter cells." Each of the daughter cells then begins the cell cycle again. You can see details of the cell cycle in Figure 21. Notice that the cell cycle is divided into three main stages: interphase, mitosis, and cytokinesis.

The first stage of the cell cycle is called **interphase.** Interphase is the period before cell division. **During interphase, the cell grows, makes a copy of its DNA, and prepares to divide into two cells.**

Growing During the first part of interphase, the cell grows to its full size and produces structures it needs. For example, the cell makes new ribosomes and produces enzymes. Copies are made of both mitochondria and chloroplasts.

Copying DNA In the next part of interphase, the cell makes an exact copy of the DNA in its nucleus in a process called **replication.** Recall that DNA is found in the chromatin in the nucleus. DNA holds all the information that the cell needs to carry out its functions. Replication of 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. You will learn the details of DNA replication later in this section.

Preparing for Division Once the DNA has replicated, preparation for cell division begins. The cell produces structures that it will use to divide into two new cells. At the end of interphase, the cell is ready to divide.

Reading Checkpoint **What is replication?**

Lab zone **Try This Activity**

Modeling Mitosis

Refer to Figure 21 as you carry out this activity.

1. Construct a model of a cell that has four 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?

Figure 19
Bigger Pig, More Cells
The mother pig has more cells in her body than her small piglets.

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 nucleus condenses to form double-rod structures called **chromosomes.** Each chromosome has two rods because the cell's DNA has replicated, and each rod in a chromosome is an exact copy of the other. Each identical rod in a chromosome is called a chromatid. Notice in Figure 20 that the two chromatids 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.

Figure 20
Chromosomes
During mitosis, the chromatin condenses to form chromosomes. Each chromosome consists of two identical strands, or chromatids.
Applying Concepts *During which phase of mitosis do the chromosomes form?*

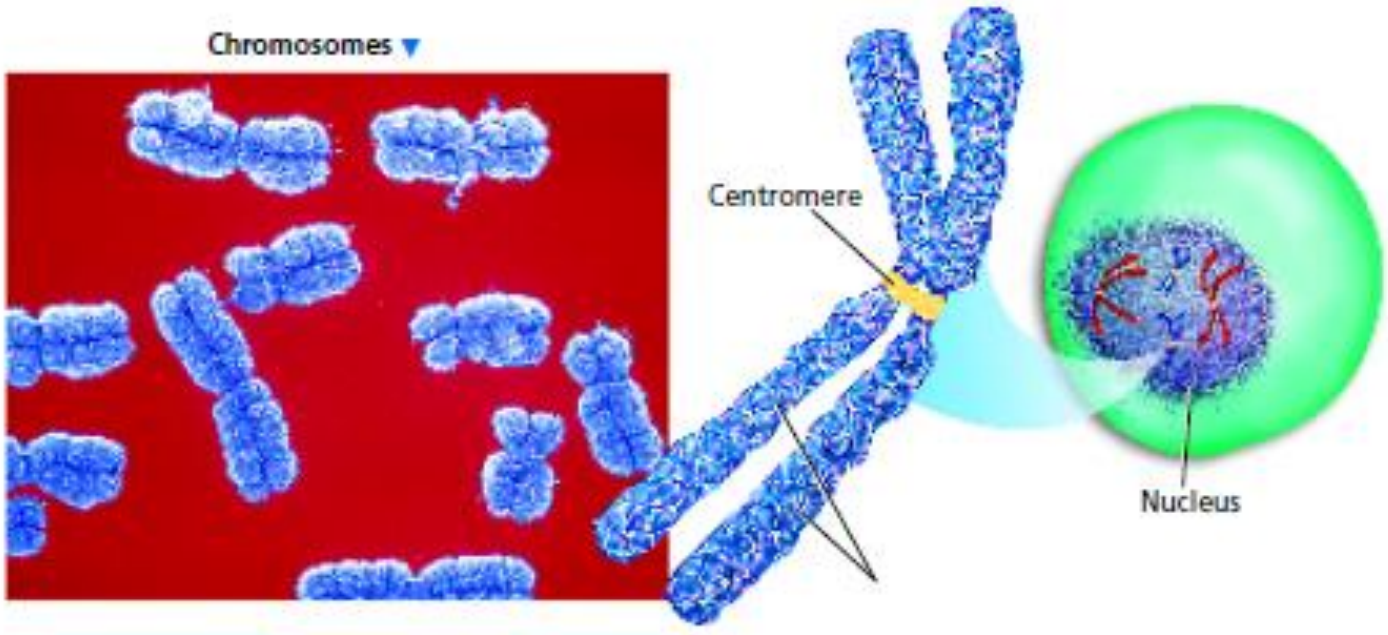
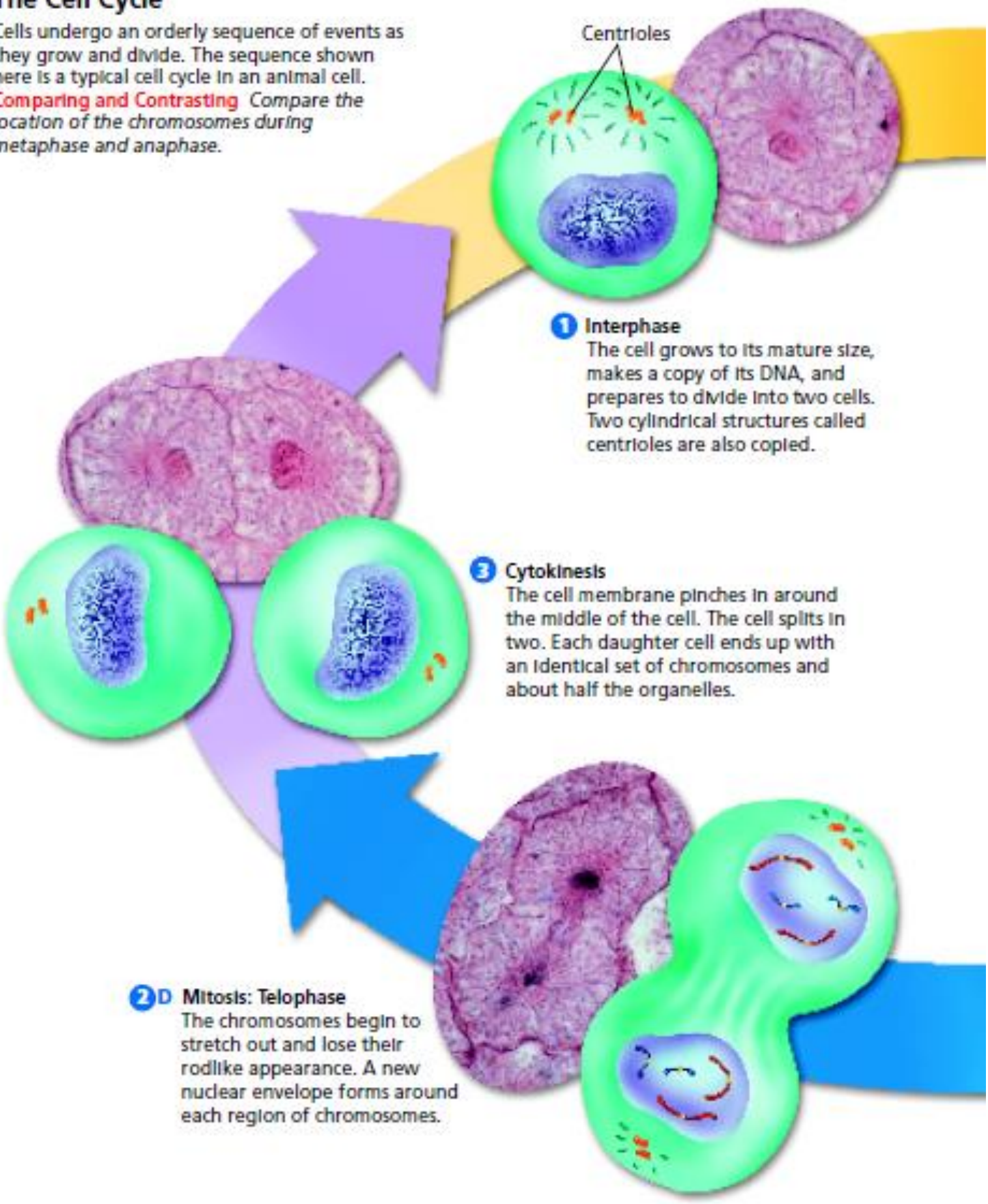


FIGURE 21

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.

Comparing and Contrasting *Compare the location of the chromosomes during metaphase and anaphase.*



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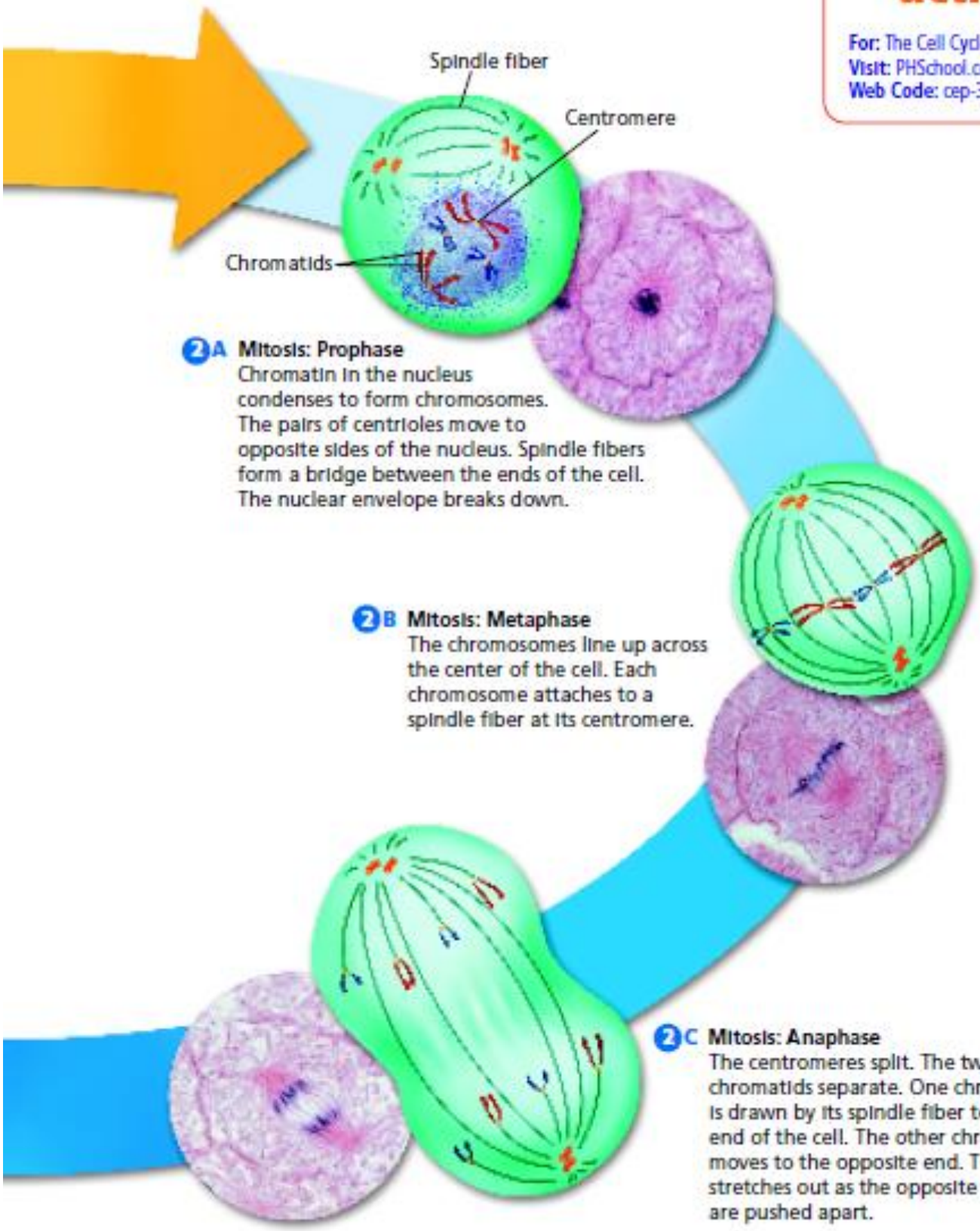


2A Mitosis: Prophase
Chromatin in the nucleus condenses to form chromosomes. The pairs of centrioles move to opposite sides of the nucleus. Spindle fibers form a bridge between the ends of the cell. The nuclear envelope breaks down.

2B Mitosis: Metaphase
The chromosomes line up across the center of the cell. Each chromosome attaches to a spindle fiber at its centromere.

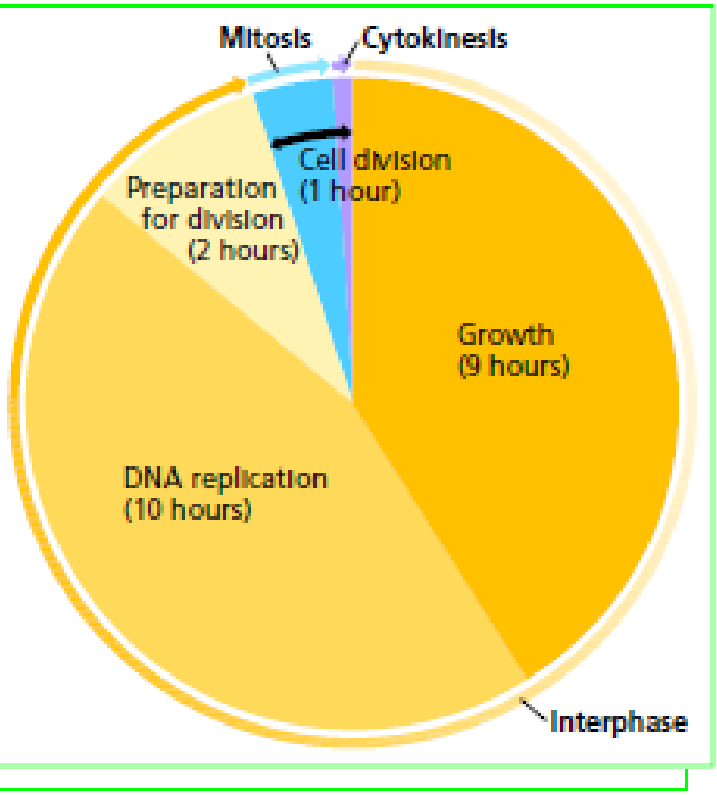
2C Mitosis: Anaphase
The centromeres split. The two chromatids separate. One chromatid is drawn by its spindle fiber to one end of the cell. The other chromatid moves to the opposite end. The cell stretches out as the opposite ends are pushed apart.

Math Analyzing Data

Length of the Cell Cycle

How long does it take for a cell to go through one cell cycle? It all depends on the cell. A human liver cell, for example, completes one cell cycle in about 22 hours, as shown in the graph. Study the graph and then answer the following questions.

1. **Reading Graphs** What do the three curved arrows outside the circle represent?
2. **Reading Graphs** In what stage of the cell cycle is the wedge representing growth?
3. **Interpreting Data** In human liver cells, how long does it take DNA replication to occur?
4. **Drawing Conclusions** In human liver cells, what stage in the cell cycle takes the longest time?



Stage 3: Cytokinesis

The final stage of the cell cycle, which is called **cytokinesis** (sy toh kih NEE sis), completes the process of cell division. **During cytokinesis, the cytoplasm divides. The organelles are distributed into each of the two new cells.** Cytokinesis usually starts at about the same time as telophase. When cytokinesis is complete, two new cells, or daughter 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.

Cytokinesis in Animal Cells During cytokinesis in animal cells, the cell membrane squeezes together around the middle of the cell. The cytoplasm pinches into two cells. Each daughter cell gets about half of the organelles.

Cytokinesis in Plant Cells 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.

Reading Checkpoint During what phase of mitosis does cytokinesis begin?

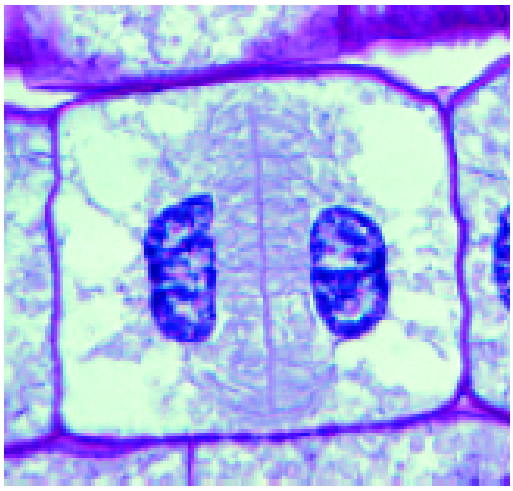


FIGURE 22
Cytokinesis in Plant Cells
During cytokinesis in plant cells, a cell plate forms between the two new nuclei.

Structure and Replication of DNA

DNA replication ensures that each daughter cell will have the genetic information it needs to carry out its activities. Before scientists could understand how DNA replicates, they had to know its structure. In 1952, Rosalind Franklin used an X-ray method to photograph DNA molecules. Her photographs helped James Watson and Francis Crick figure out the structure of DNA in 1953.

The Structure of DNA Notice in Figure 23 that a DNA molecule looks like a twisted ladder, or spiral staircase. The two sides of the DNA ladder are made up of molecules of a sugar called deoxyribose, alternating with molecules known as phosphates.

Each rung is made up of a pair of molecules called nitrogen bases. Nitrogen bases are molecules that contain the element nitrogen and other elements. DNA has four kinds of nitrogen bases: adenine (AD uh neen), thymine (THY meen), guanine (GWAH neen), and cytosine (SY tuh seen). The capital letters A, T, G, and C are used to represent the four bases.

The bases on one side of the ladder pair with the bases on the other side. Adenine (A) only pairs with thymine (T), while guanine (G) only pairs with cytosine (C). This pairing pattern is the key to understanding how DNA replication occurs.

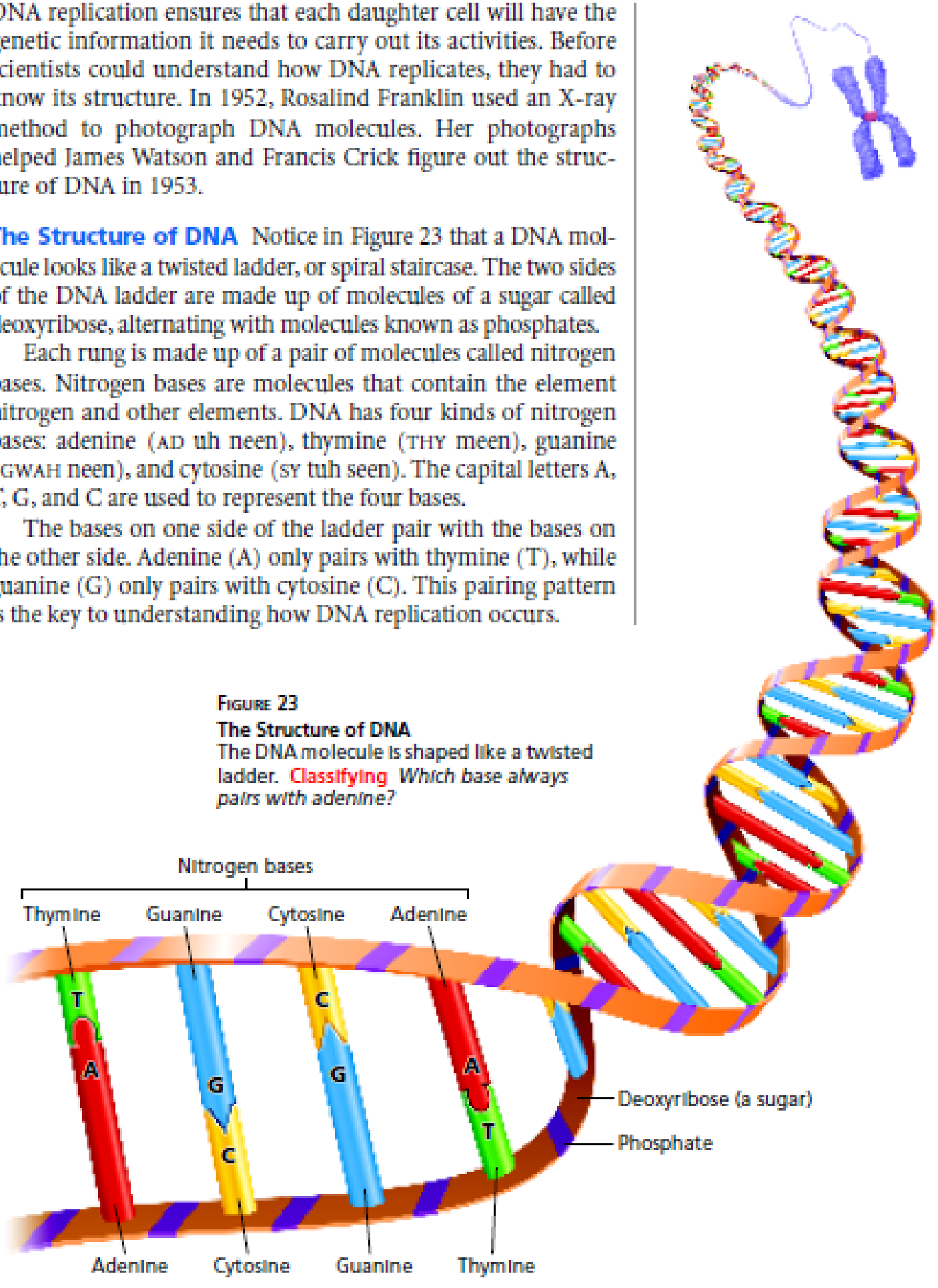


FIGURE 23
The Structure of DNA
The DNA molecule is shaped like a twisted ladder. Classifying *Which base always pairs with adenine?*

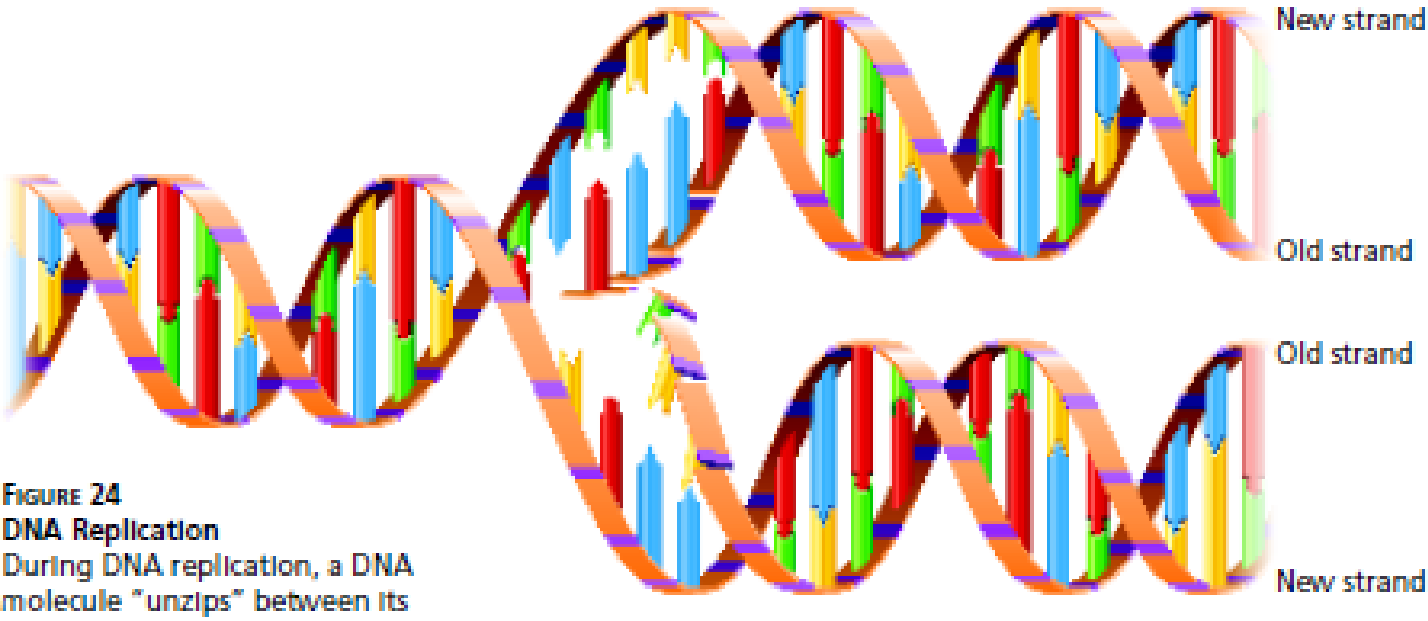


FIGURE 24
DNA Replication
During DNA replication, a DNA molecule "unzips" between its paired bases. New bases pair with the bases on each old strand. As a result, two identical DNA strands form.

The Replication Process DNA replication begins when the two sides of the DNA molecule unwind and separate, somewhat like a zipper unzipping. As you can see in Figure 24, the molecule separates between the paired nitrogen bases.

Next, nitrogen bases that are floating in the nucleus pair up with the bases on each half of the DNA molecule. **Because of the way in which the nitrogen bases pair with one another, the order of the bases in each new DNA molecule exactly matches the order in the original DNA molecule.** Adenine always pairs with thymine, while guanine always pairs with cytosine. Once the new bases are attached, two new DNA molecules are formed.

Reading Checkpoint **During DNA replication, which base pairs with guanine?**

Section 5 Assessment

Target Reading Skill Sequencing Your cycle diagram will help you answer Question 1.

Reviewing Key Concepts

1. a. Reviewing What are the three stages of the cell cycle?
   b. Summarizing Summarize what happens to chromosomes during the stage of the cell cycle in which the nucleus divides. Include the terms *prophase*, *metaphase*, *anaphase*, and *telophase*.
   c. Interpreting Diagrams Look at Figure 21. What is the role of spindle fibers during
2. a. Listing List the nitrogen bases in DNA.
   b. Describing Describe how the nitrogen bases pair in a DNA molecule.
   c. Inferring One section of a strand of DNA has the base sequence AGATTC. What is the base sequence on the other strand?

Writing in Science

Writing Instructions Imagine that you work in a factory where cells are manufactured. Write instructions for newly forming cells on how to carry out cytokinesis. Provide instructions for both plant and animal cells.