Chapter 6

Inheritance

6.1 How Cells Reproduce

Cells reproduce by dividing. Cell division allows single-celled organisms to reproduce themselves and multicellular organisms to develop, grow, and maintain their tissues (Figure 6.1).

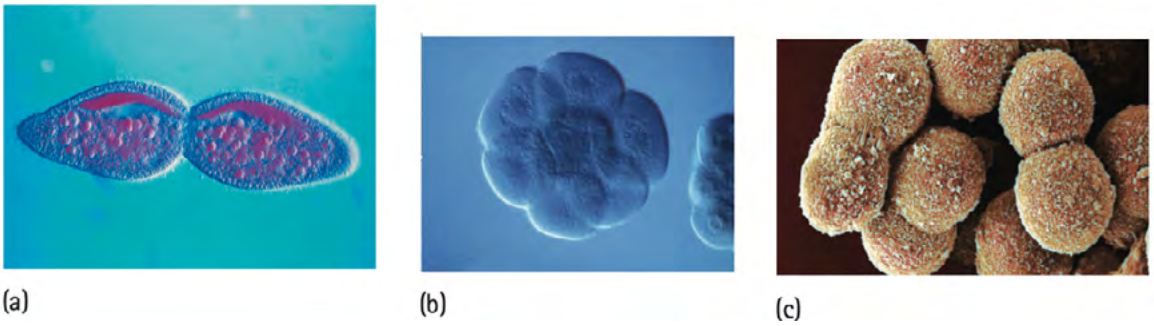

FIGURE 6.1

Cell division is essential for reproduction, growth and development, and maintenance. (a) A paramecium, a single-celled organism, reproduces by dividing into two. (b) The early development of a sea urchin embryo involves multiple divisions of the fertilized egg. A fertilized egg has divided several times to produce this early embryo, which has eight cells. (c) Cell division in the liver produces new cells to replace old, worn-out cells.

Mitosis is a form of cell division in which one parent cell divides into two daughter cells, each of which contains the same genetic information as the parent cell. How does this cell division occur? Cells that are preparing to divide enter the *cell cycle*, shown in Figure 6.2.

The cell cycle is divided into four stages—gap 1, synthesis, gap 2, and mitosis and cytokinesis. (If you need help remembering these in the right order, you can try using the mnemonic phrase "**G**o, **S**ally, **G**o! **M**ake **C**ake!") Gap 1, synthesis, and gap 2 are collectively known as interphase. During interphase, the cell makes the necessary preparations for division. During mitosis and cytokinesis, the cell divides. Let's look at each step in more detail.

During gap 1 (G_1), a cell prepares to divide by growing to approximately double its original size. All the important components of the cytoplasm, including the mitochondria and other organelles, also double in number. You might notice that calling this stage a "gap" is a little misleading in that it suggests that nothing is going on. In fact, important events occur during both "gap" stages.

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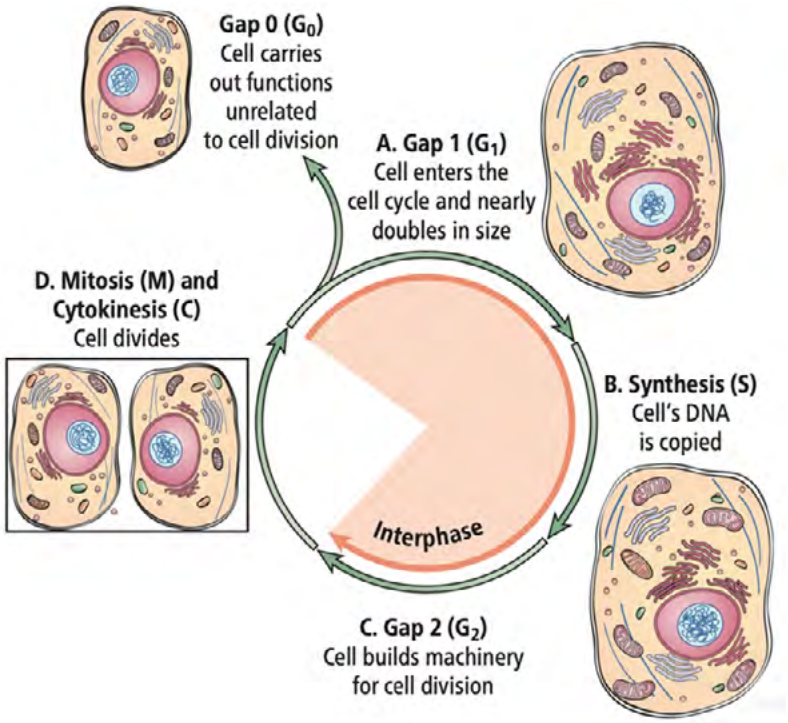

FIGURE 6.2

The cell cycle has four stages. (A) During gap 1, the cell grows to about double its original size. (B) During synthesis, an exact copy of the cell's DNA is made. (C) During gap 2, the cell builds the machinery required for mitosis. (D) During mitosis and cytokinesis, the cell divides.

They are gaps only from the point of view of someone focused exclusively on whether the cell's DNA is doing anything obvious, such as replicating or being divided up.

During synthesis (S), the cell creates an exact copy of its genetic material—its DNA. This occurs through the process of DNA replication, which was described in Chapter 5.

During gap 2 (G_2), the cell builds the machinery necessary for cell division. This includes the structures that will separate the two copies of the genetic material and divide the cell into two daughter cells.

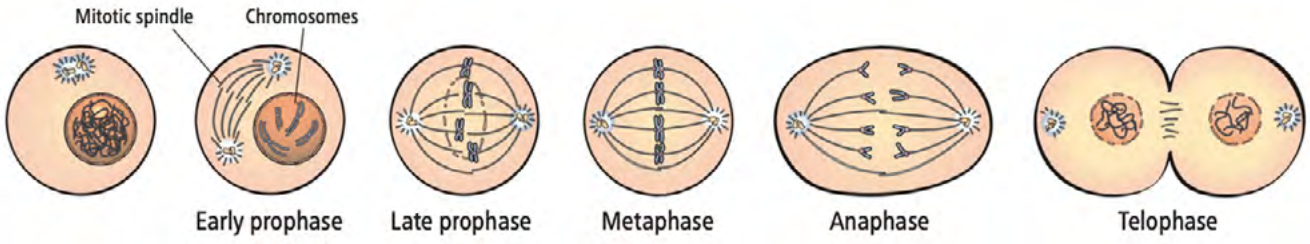

FIGURE 6.3

There are four phases of mitosis: prophase, metaphase, anaphase, and telophase. During cell division, mitosis is followed by cytokinesis.

During mitosis and cytokinesis (M), the cell divides. Mitosis describes the division of the nucleus, which takes place in four steps, or "phases" (Figure 6.3). During *prophase*, the normally loosely packed chromosomes condense and the membranes surrounding the nucleus break down. The condensed chromosomes each consist of two identical sister chromatids attached at a point called the centromere (Figure 6.4).

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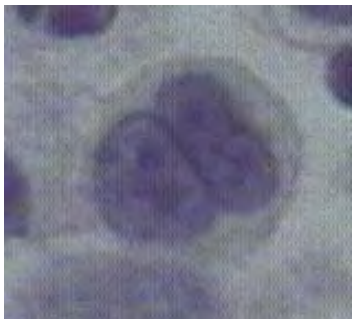

FIGURE 6.4

This closeup of a chromosome as seen during mitosis shows that the DNA replicated during the synthesis phase becomes condensed. Each chromosome at this point is made up of two genetically identical chromatids connected to each other at a point called the centromere.

The *mitotic spindle* forms during prophase. The mitotic spindle consist of a series of fibers that attach to the chromatids and split the identical genetic material between the two daughter cells. This happens during *metaphase*, which begins when the chromosomes line up at the equatorial plane—the plane that passes through the imaginary "equator" of the cell. Then, during *anaphase*, the two sister chromatids are pulled apart by the shortening of the mitotic- spindle fibers and move to opposite poles of the cell. During *telophase*, new nuclear membranes form around each set of chromosomes, and the chromosomes return to their loosely packed state. The division of the nucleus is followed by *cytokinesis*, the division of the cytoplasm to yield two separate daughter cells. There is a mnemonic for the phases of mitosis, too: "**P**eople **M**eet **A**nd **T**alk **C**ars."

Note that cells are not always in the cell cycle. Many cells are neither dividing nor preparing to divide; they are simply carrying out their regular functions. These cells are said to be in gap 0 (G_0). Some cells are in G_0 temporarily and will eventually re-enter the cell cycle. Other cells, such as many neurons, are in permanent G_0 and will never divide again.

READING CHECK

During which stages of the cell cycle does the cell have twice its normal amount of genetic material?

CHECK YOUR ANSWER

The cell has twice the normal amount of genetic material during G_2 and mitosis, M, stages—that is, after synthesis, S, stage and continuing up until cytokinesis, C, is complete. The cell has double the amount of genetic material after synthesis, S, because it copies its genetic material during synthesis, S. During mitosis, M, all that genetic material is still in one big cell. Only after cytokinesis, when two new cells are formed, does each new cell have the normal amount of genetic material.

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