Why is cell division important?

What do you, an octopus, and an oak tree have in common? You share many characteristics, but an important one is that you are all made of cells—trillions of cells. Where did all of those cells come from? As amazing as it might seem, many organisms start as just one cell. That cell divides and becomes two, two become four, four become eight, and so on. Many-celled organisms, including you, grow because cell division increases the total number of cells in an organism. Even after growth stops, cell division is still important. Every day, billions of red blood cells in your body wear out and are replaced. During the few seconds it takes you to read this sentence, your bone marrow produced about six million red blood cells. Cell division is important to one-celled organisms, too—it’s how they reproduce themselves, as shown in Figure 1. Cell division isn’t as simple as just cutting the cell in half, so how do cells divide?

The Cell Cycle

A living organism has a life cycle. A life cycle begins with the organism’s formation, is followed by growth and development, and finally ends in death. Right now, you are in a stage of your life cycle called adolescence, which is a period of active growth and development. Individual cells also have life cycles.
**Length of Cycle** The cell cycle, as shown in Figure 2, is a series of events that takes place from one cell division to the next. The time it takes to complete a cell cycle is not the same in all cells. For example, the cycle for cells in some bean plants takes about 19 h to complete. Cells in animal embryos divide rapidly and can complete their cycles in less than 20 min. In some human cells, the cell cycle takes about 16 h. Cells in humans that are needed for repair, growth, or replacement, like skin and bone cells, constantly repeat the cycle.

**Interphase** Most of the life of any eukaryotic cell—a cell with a nucleus—is spent in a period of growth and development called interphase. Cells in your body that no longer divide, such as nerve and muscle cells, are always in interphase. An actively dividing cell, such as a skin cell, copies its hereditary material and prepares for cell division during interphase.

Why is it important for a cell to copy its hereditary information before dividing? Imagine that you have a part in a play and the director has one complete copy of the script. If the director gave only one page to each person in the play, no one would have the entire script. Instead the director makes a complete, separate copy of the script for each member of the cast so that each one can learn his or her part. Before a cell divides, a copy of the hereditary material must be made so that each of the two new cells will get a complete copy. Just as the actors in the play need the entire script, each cell needs a complete set of hereditary material to carry out life functions.

After interphase, cell division begins. The nucleus divides, and then the cytoplasm separates to form two new cells.
Mitosis and Cell Division

The process in which the nucleus divides to form two identical nuclei is **mitosis** (mi TOH sus). Each new nucleus also is identical to the original nucleus. Mitosis is described as a series of phases, or steps. The steps of mitosis in order are named prophase, metaphase, anaphase, and telophase.

**Steps of Mitosis** When any nucleus divides, the chromosomes (KROH muh sohmz) play the important part. A chromosome is a structure in the nucleus that contains hereditary material. During interphase, each chromosome duplicates. When the nucleus is ready to divide, each duplicated chromosome coils tightly into two thickened, identical strands called chromatids, as shown in **Figure 3**.

How are chromosomes and chromatids related?

During prophase, the pairs of chromatids are fully visible when viewed under a microscope. The nucleolus and the nuclear membrane disintegrate. Two small structures called centrioles (SEN tree olz) move to opposite ends of the cell. Between the centrioles, threadlike spindle fibers begin to stretch across the cell. Plant cells also form spindle fibers during mitosis but do not have centrioles.

In metaphase, the pairs of chromatids line up across the center of the cell. The centromere of each pair usually becomes attached to two spindle fibers—one from each side of the cell.

In anaphase, each centromere divides and the spindle fibers shorten. Each pair of chromatids separates, and chromatids begin to move to opposite ends of the cell. The separated chromatids are now called chromosomes. In the final step, telophase, spindle fibers start to disappear, the chromosomes start to uncoil, and two new nuclei form.

**Cell Division** For most cells, after the nucleus divides, the cytoplasm separates and two new cells form. In animal cells, the cell membrane pinches in the middle, like a balloon with a string tightened around it, and the cytoplasm divides. In plant cells, the appearance of a cell plate, as shown in **Figure 4**, tells you that the cytoplasm is being divided. New cell membranes form from the cell plate, and new cell walls develop from molecules released by the cell membranes. Following division of the cytoplasm, most new cells begin the period of growth, or interphase. Review cell division for an animal cell using the illustrations in **Figure 5**.
**Figure 5**  Cell division for an animal cell is shown here. Each micrograph shown in this figure is magnified 600 times.

**Interphase**
During interphase, the cell’s chromosomes duplicate. The nucleolus is clearly visible in the nucleus.

**Mitosis begins**

**Prophase**
The chromatid pairs are now visible and the spindle is beginning to form.

**Duplicated chromosome (2 chromatids)**

**Metaphase**
Chromatid pairs are lined up in the center of the cell.

**Anaphase**
The chromatids separate.

**Telophase**
In the final step, the cytoplasm is beginning to separate.

**Mitosis ends**

**New nucleus**

**Cytoplasm separating**

**Chromosomes**

The two new cells enter interphase and cell division usually begins.
Results of Mitosis and Cell Division There are three important things to remember about mitosis and cell division. First, mitosis is the division of a nucleus. Second, it produces two new nuclei that are identical to each other and the original nucleus. Each new nucleus has the same number and type of chromosomes. Each of the trillions of cells in your body, except sex cells, has a nucleus with a copy of the same 46 chromosomes, because you began as one cell with 46 chromosomes in its nucleus. In the same way, each cell in a fruit fly has eight chromosomes and each new cell produced by mitosis and cell division has a copy of those eight chromosomes, as shown in Figure 6.

You probably know that not all of your cells are the same. Just as all actors in a play use the same script to learn different roles, cells use copies of the same hereditary material and become different cell types with specific functions. Certain cells only used that part of the heredity material with information needed to become a specific cell type.

Cell division allows growth and replaces worn out or damaged cells. You are much larger and have more cells than a baby mainly because of cell division. If you cut yourself, the wound heals because cell division replaces damaged cells. Another way some organisms use cell division is to produce new organisms.
Asexual Reproduction

Reproduction is the process by which an organism produces others of its same kind. Among living organisms, there are two types of reproduction—sexual and asexual. Sexual reproduction usually requires two organisms. In asexual reproduction, a new organism (sometimes more than one) is produced from one organism. The new organism will have hereditary material identical to the hereditary material of the parent organism.

How many organisms are needed for asexual reproduction?

Cellular Asexual Reproduction Organisms with eukaryotic cells asexually reproduce by mitosis and cell division. A sweet potato growing in a jar of water is an example of asexual reproduction. All the new stems, leaves, and roots that grow from the sweet potato have the same hereditary material. New strawberry plants can be reproduced asexually from horizontal stems called runners. Figure 7 shows asexual reproduction in a potato and a strawberry plant.

Recall that mitosis is the division of a nucleus. However, a bacterium does not have a nucleus so it can’t use mitosis. Instead, bacteria reproduce asexually by fission. During fission, the one-celled bacterium without a nucleus copies its genetic material and then divides into two identical organisms.

Figure 7 Many plants can reproduce asexually.

A new potato plant can grow from each sprout on this potato.

Infer how the genetic material in the small strawberry plant above compares to the genetic material in the large strawberry plant.

Modeling Mitosis

Procedure
1. Make models of cell division using materials supplied by your teacher.
2. Use four chromosomes in your model.
3. When finished, arrange the models in the order in which mitosis occurs.

Analysis
1. In which steps is the nucleus visible?
2. How many cells does a dividing cell form?
CHAPTER 4

Cell Reproduction

Figure 8  Some organisms use cell division for budding and regeneration.

Budding and Regeneration  Look at Figure 8A. A new organism is growing from the body of the parent organism. This organism, called a hydra, is reproducing by budding. Budding is a type of asexual reproduction made possible because of mitosis and cell division. When the bud on the adult becomes large enough, it breaks away to live on its own.

Some organisms can regrow damaged or lost body parts, as shown in Figure 8B. Regeneration is the process that uses mitosis and cell division to regrow body parts. Sponges, planaria, sea stars, and some other organisms can also use regeneration for asexual reproduction. If these organisms break into pieces, a whole new organism can grow from each piece. Because sea stars eat oysters, oyster farmers dislike them. What would happen if an oyster farmer collected sea stars, cut them into pieces, and threw them back into the ocean?

Summary

The Cell Cycle
- The cell cycle is a series of events from one cell division to the next.
- Most of a eukaryotic cell's life is interphase.

Mitosis
- Mitosis is a series of four phases or steps.
- Each new nucleus formed by mitosis has the same number and type of chromosomes.

Asexual Reproduction
- In asexual reproduction, a new organism is produced from one organism.
- Fission, budding, and regeneration are forms of asexual reproduction.

Self Check
1. Define mitosis. How does it differ in plants and animals?
2. Identify two examples of asexual reproduction in many-celled organisms.
3. Describe what happens to chromosomes before mitosis.
4. Compare and contrast the two new cells formed after mitosis and cell division.
5. Think Critically  Why is it important for the nuclear membrane to disintegrate during mitosis?

Applying Math
6. Solve One-Step Equations  If a cell undergoes cell division every 5 min, how many cells will there be after 1 h?