



Theme IV

Reproduction, Growth, and Development

How Cells Divide

After you have finished reading this chapter, you should be able to:

Discuss the importance of cell division to reproduction, growth, and development, and the negative effect of uncontrolled cell division.

Describe the stages of mitosis and the process of cytokinesis in plant and animal cells.

Compare and contrast different methods of asexual reproduction.

Life is a whim of several trillion cells to be you for a while.

Anonymous

Introduction

Life goes on. Each of us, as an individual, plays a part in the great ongoing process of life on Earth. Each individual organism—as varied in form as a mosquito, an oak tree, or a rhinoceros—is part of this process that began 3.5 billion years ago and continues today.

We have examined what it takes for an individual to remain alive in a constantly changing environment. Now, our focus changes. Staying alive is important for every individual organism. But this is not sufficient to maintain the process of life on Earth. No individual organism lives forever. Every organism has a normal life span—the length of time between when its life begins and when it ends. (See Figure 15-1 on page 320.) So, for life to continue on Earth, individuals must reproduce new individuals.

A group of individuals of the same species living in a particular place makes up a population. Individuals may come and go, but a population continues. For example, a population of squirrels has existed in New York City parks for hundreds of years. Individual squirrels are born, live, and die. However, no squirrel that was alive 100, or even 50, years ago is alive

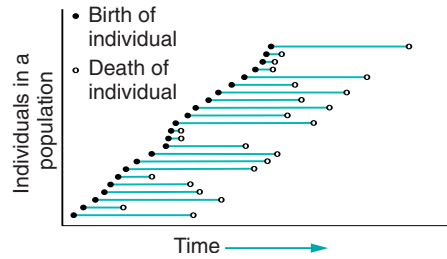


Figure 15-1 Life spans in a population.

today. The squirrel population of New York City will probably continue to exist far into the future. The continuity of life requires **reproduction**, the ability of a species to produce more of its kind. It is reproduction within populations that allows species to survive. It is reproduction that allows life on Earth to continue.

THE LIFE OF A CELL

Every cell has a life of its own. This is as true for single-celled organisms as it is for each of the billions and trillions of cells that make up the bodies of plants and animals—including ourselves. Each cell has a beginning, a period of growth, and then an ending. The series of events that occurs during the life of a cell is called the **cell cycle**. In the first stage of the cell cycle, the cell begins to grow in size. Organic materials such as amino acids and sugars and inorganic materials such as water are moved into the cell. The cell increases in size by adding these materials to itself. The cell also increases the number of its parts. For example, its mitochondria divide in two to make more mitochondria. If it is a plant cell, the same thing happens to its chloroplasts. (See Figure 15-2.)

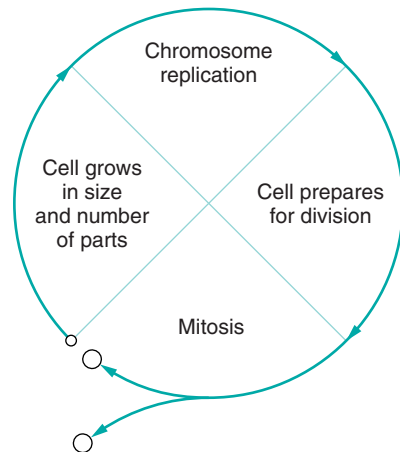


Figure 15-2 The cell cycle—the series of events in the life of a cell.

During the next period in the cycle, the cell stops getting larger. Now, the genetic material in the cell—the set of instructions received from the previous cell—duplicates. The genetic material is the building plan, similar in some ways to the set of blueprints used to build a house. The genetic material contains all the information about how the cell is to be built and how it functions. The genetic material is made up of the chemical called **DNA**, deoxyribonucleic acid. (You will study DNA in detail in Chapter 19.)

In cells that are reproducing, DNA is found in “packages” known as **chromosomes**. Bacterial cells may have a single chromosome. A goldfish has 94 chromosomes in each cell of its body. The number of chromosomes in other organisms varies. A fruit fly has eight chromosomes, a cabbage plant has 18, and a human has 46. The chromosome number is specific for each type of organism. The exact chromosome number must be maintained for the species to continue. This means that as cells reproduce, the new cells must have the same number of chromosomes as did the original cells.

During this middle stage in the life cycle of a cell, the genetic material in the cell is duplicated. This process is called **replication**. It is the most important stage in preparation for reproduction of the cell. Following this stage, some additional cell growth occurs. What is growing here is material needed for the final big event: cell division. This is the way a single cell reproduces: It divides into two cells. (See Figure 15-3.)

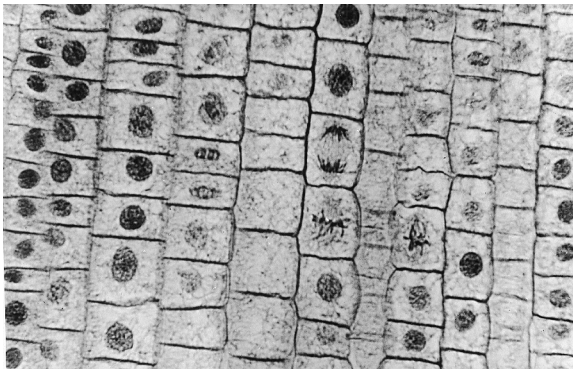


Figure 15-3 Several cells can be seen here preparing for cell division. When cells reproduce, the new cells must have the same number of chromosomes as did the original cells.

CELL DIVISION

During cell division, the genetic material must be equally divided. When a eukaryotic cell divides, it must send one copy of each of its chromosomes to each of the new cells. In addition, the cytoplasm and other cell parts must be divided between the two cells.

The division of the chromosomes occurs first. This division happens during a sequence of events called **mitosis**. Following mitosis, the cytoplasm of the cell divides. This process is called **cytokinesis**. Following cytokinesis, each of the new cells has a complete set of chromosomes, just like the original cell. The new cells are called *daughter cells*. The cell they came from, which no longer exists, is the *parent cell*.

■ WHY MUST CELLS DIVIDE?

Ants are small and elephants are large. Does that mean that ant cells are small and elephant cells are large? Absolutely not! Larger organisms are large because they have more cells, not bigger ones. As a baby, you had blood cells that were exactly the same size as your blood cells are now. The only difference is that now you have a lot more of them.

Why don't cells grow larger and larger? Why must cells divide rather than grow beyond a certain size? Recall how important the cell membrane is in the life of the cell. All materials that enter or leave the cell must pass through the cell membrane. Cells that are too large do not have enough cell membrane in relation to the size of their cytoplasm. The cell membrane is not large enough to permit enough materials to enter and leave the cell in order for the cell to survive. Therefore, rather than increasing beyond a certain size, all cells have built-in instructions to divide instead.

■ THE STAGES OF MITOSIS

Mitosis, we have said, is the sequence of events that produces and separates a cell's chromosomes into two identical sets. The preparation for mitosis is made through the replication of the chromosomes. Let's look more closely at a chromosome. After replication, a chromosome is double-stranded. Each strand of the chromosome is actually an extremely long, twisting molecule of DNA, usually combined with some proteins. The two identical DNA strands are called **chromatids**. They are joined by a structure known as the **centromere**. All the genetic information in one chromatid has been replicated in the other chromatid. (See Figure 15-4.)

Mitosis consists of several different stages. The stage of the life cycle before the actual beginning of mitosis is called **interphase**. Even though this stage is not considered part of mitosis, the cell is far from inactive. Growth of the cell and replication of the genetic material occur during interphase. Interphase is also the longest phase of a cell's life. Mitosis actually begins with **prophase**. During prophase, the long, twisted ribbons of genetic material become shorter and thicker. These are the chromosomes

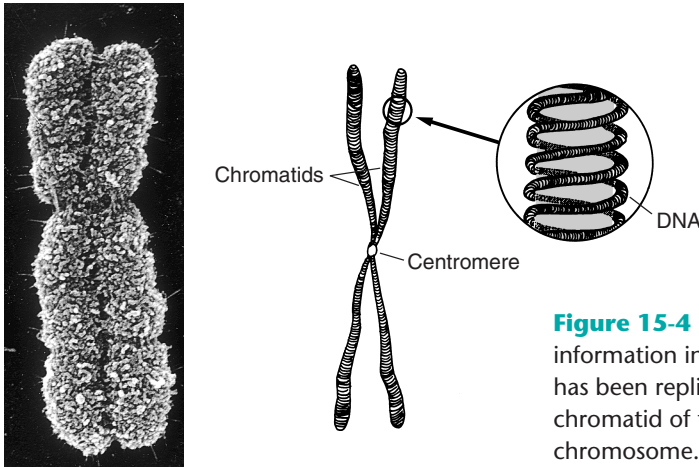


Figure 15-4 All the genetic information in one chromatid has been replicated in the other chromatid of this human chromosome.

that are visible with a microscope. In animal cells, **centrioles**, structures important in cell division, move to opposite ends of the cell. Until now, the genetic material in all eukaryotic cells has been stored inside the nuclear membrane. During prophase, the nuclear membrane breaks down. The double-stranded chromosomes are able to move freely around in the cytoplasm. (See the table below.)

The next stage of mitosis involves the movement of the chromosomes. Cells that are dividing take on a very organized appearance. Mitosis has been called the “dance of the chromosomes.” This dance becomes clear if you use a microscope to observe cells as they begin mitosis. First of all, a series of fine, highly organized fibers begins to appear. The fibers stretch from each end of the cell toward the middle. These fibers, called **spindle fibers**, are made of protein. When fully arranged, the spindle is shaped like a football.

Metaphase is the next stage in mitosis. During this stage, the fibers of the spindle connect to the centromere in the middle of each double-stranded chromosome. In this manner, the chromosomes are lined up in a single file across the middle of the cell.

THE STAGES OF MITOSIS

Interphase	Prophase	Metaphase	Anaphase	Telophase
Growth of the cell and replication of its genetic material	Nuclear membrane breaks down; chromosomes become visible	Spindle fibers appear; chromosomes line up across middle of cell	Double-stranded chromosomes separate; identical chromatids move apart	Chromosomes move to opposite ends; nuclear membranes reappear; cell pinches in

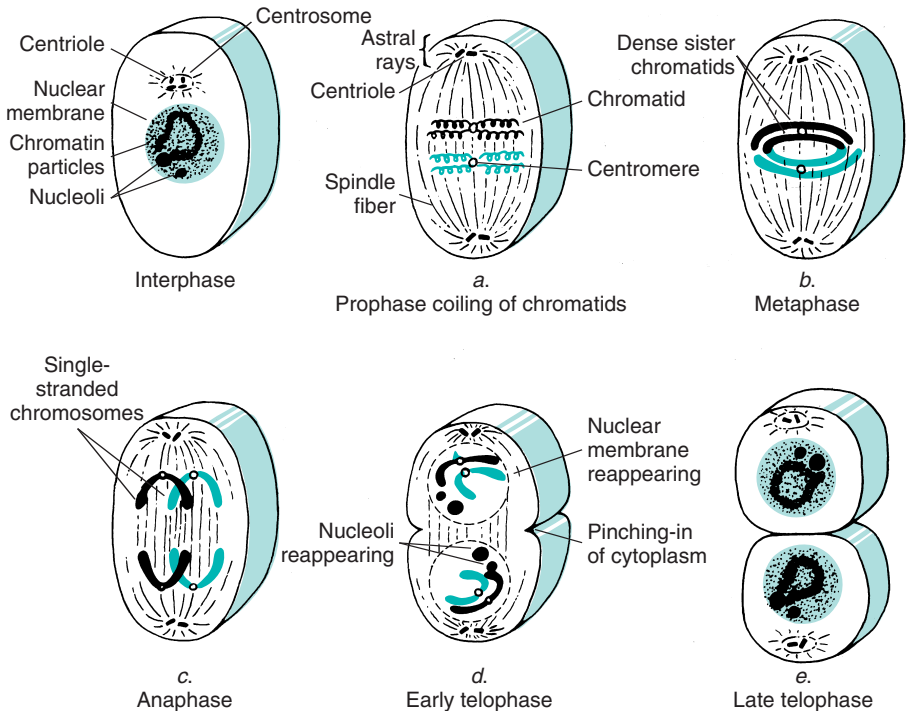


Figure 15-5 The stages of mitosis.

And then it happens! The centromeres that connect the two identical chromatids in each chromosome divide. As a result, the chromatids begin to move apart. The spindle fibers direct the movement of the identical chromatids away from each other. Each chromatid now becomes a separate single-stranded chromosome. This stage of mitosis is called **anaphase**.

The final stage of mitosis is **telophase**. The new chromosomes are pulled toward opposite ends of the dividing cell. There are now two identical, complete sets of chromosomes, one set at each end of the cell. A nuclear membrane forms around each set of chromosomes. Now, the final event in cell division begins. (See Figure 15-5.)

CYTOKINESIS: ONE CELL BECOMES TWO

For a cell to divide, it must produce two identical sets of chromosomes during mitosis. But that is not enough. To complete the division, the cytoplasm of the parent cell must be split in two. Through this process, called *cytokinesis*, two new daughter cells are produced.

The process of mitosis is essentially the same in plant and animal cells. This is one of the great pieces of evidence for evolution. The steps

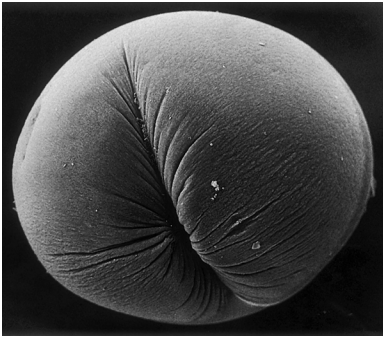


Figure 15-6 The final stage of mitosis—the animal cell “pinches in” to split into two. Each new daughter cell has some of the cytoplasm from the parent cell and an identical set of chromosomes.

involved in mitosis evolved long before organisms became specialized as plants or animals. However, differences can be seen between plants and animals during cytokinesis.

While watching animal cells under the microscope, you will see the cell membrane begin to change as mitosis concludes. The cell membrane begins to tighten in a band around the middle of the cell. This is called “pinching in.” The process seems similar to pulling the drawstring tight on a plastic bag or sweat pants. When the pinching in is complete, the result is two new animal cells. Each new daughter cell has some of the cytoplasm from the parent cell and an identical set of chromosomes. (See Figure 15-6.)

A plant cell divides in a very different manner. The process of separation does not begin at the outside. Instead, a dividing wall begins to grow in the middle of the cell, from the inside out. This dividing wall is called a **cell plate**. It is made of tough polysaccharides. When the cell plate has completed growing, it extends outward to both sides of the cell. It will become a cell wall. The result is two new plant cells. Every growing plant goes through this process again and again as its cells divide. (See Figure 15-7.)

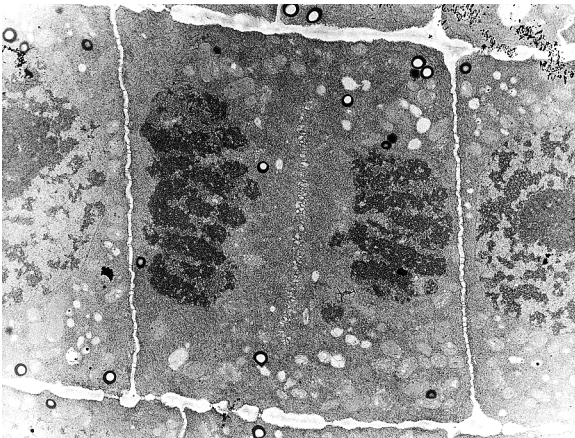


Figure 15-7 When a plant cell divides, a cell plate forms in the middle of the cell, growing from the inside out.

Check Your Understanding

Why is it important that the chromosomes of a cell replicate before cell division occurs? When does replication occur?

MAKING NEW INDIVIDUALS: ASEXUAL REPRODUCTION

Mitosis and cytokinesis produce two new daughter cells from one parent cell. The daughter cells are identical. They are also genetically identical to the parent cell. But have new individuals been produced? Well, sometimes.

Certainly this is the case if the original parent cell was a single-celled organism. An amoeba, through mitosis and cytokinesis, becomes two new identical organisms. Reproduction in an amoeba involves only one parent. This is **asexual reproduction**. (See Figure 15-8.) The asexual reproduction that occurs in single-celled organisms, including bacteria and protists, is known as **binary fission**, which means “splitting in two.” (For reproduction to be called *sexual*, it must involve two parents.)

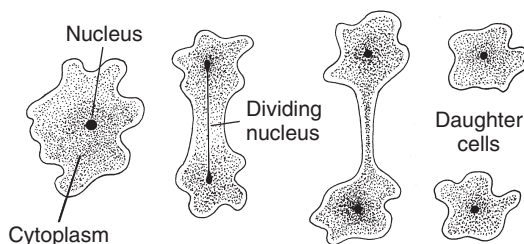
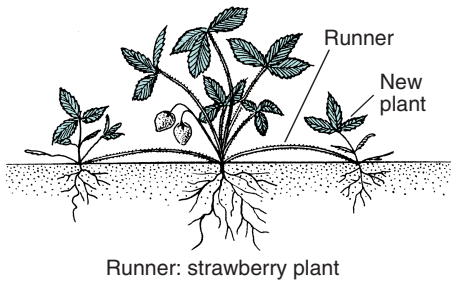


Figure 15-8 Asexual reproduction, as in the amoeba, requires only one parent.

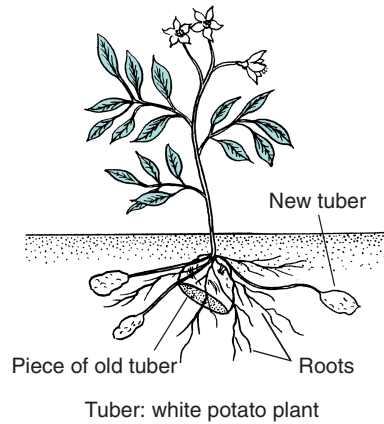
Plants have a variety of types of asexual reproduction. In each type, a plant or a part of the plant reproduces itself through mitosis. As a result, the offspring are identical to the parent plant. For example, strawberry plants send out horizontal stems across the soil. These horizontal stems, called runners, touch the surface of the soil at a new place. At that spot, an entirely new, identical plant with roots and leaves begins to grow. (See Figure 15-9.)

Parts of many plants can be cut off and used to start new individuals. For example, a leaf from an African violet can be placed in soil to begin a new plant. The underground bulbs of daffodils produce new bulbs. All the plants that result are identical to the “parent” plant. Even potatoes can reproduce asexually. Each “eye” on a potato, the point where a shoot



Runner: strawberry plant

Figure 15-9 Strawberry plants can reproduce asexually by means of runners.



Tuber: white potato plant

Figure 15-10 Potatoes can reproduce asexually. Each "eye" on a potato can develop into a new potato plant.

begins to grow, can develop into a new potato plant. All these activities are the result of mitotic cell division. (See Figure 15-10.)

Can animals also reproduce asexually? In some cases, yes. The flatworm, planaria, is able to reproduce from parts of itself. If a planaria is cut into two or three sections, each section can grow into a new worm, replacing the missing sections. If an arm of a sea star is broken off, the arm can sometimes grow into a new sea star. The sea star that lost the arm will regrow one. This process of growth, or regrowth, of an animal from a part is known as **regeneration**. (See Figure 15-11.) Some invertebrates have this ability. However, most vertebrates cannot do this. It is not possible, as you know, for you to regenerate a part of yourself. A severed finger can, in some cases, be reattached; but your body cannot grow a new one.

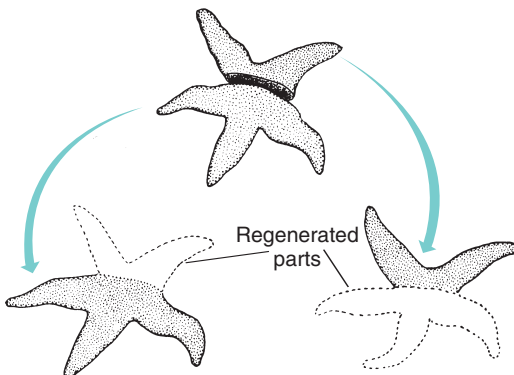


Figure 15-11 Some animals, such as the sea star, can reproduce asexually through the process of regeneration.

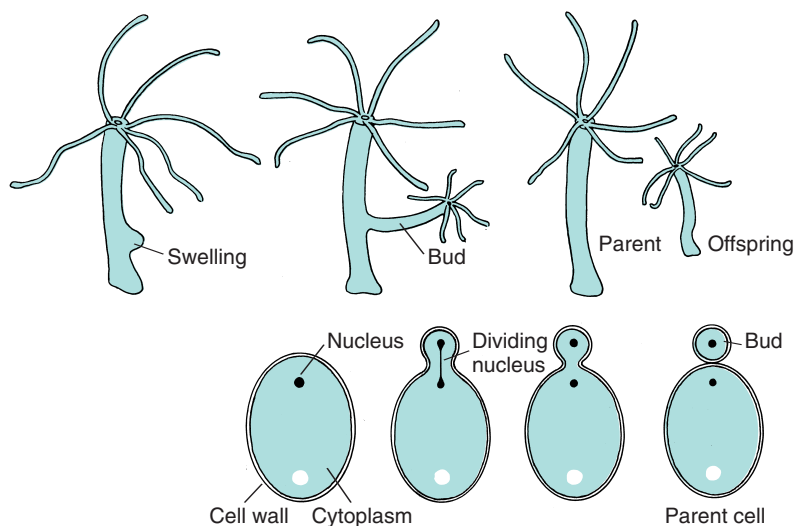


Figure 15-12 Both the hydra and the yeast can reproduce asexually by budding.

Other organisms, such as single-celled yeasts, sponges, and hydra, can produce offspring by **budding**. During the process of budding, a new small individual begins to grow out of the side of the parent. The cells that form this new individual result from mitotic cell division. In time, the bud, large enough to live on its own, breaks free of the parent. (See Figure 15-12.)

■ THE RATE OF CELL DIVISION

When does a cell divide? How long does it take for one segment of cell division to begin and end? Do all types of cells divide at the same rate? What controls the speed at which cells go through the cell cycle? The answers are very important to the process of growth and development in organisms. The answers may also provide the keys that help unlock the secrets of cancer—actually a disease caused by cells whose cycle of growth is out of control.

Every multicellular organism is made up of various types of tissues and cells. For example, the human body contains blood tissue, skin tissue, muscle tissue, bone tissue, and nerve tissue. Controlling the rate at which cells of each particular kind of tissue divide is a necessary part of homeostasis. Red blood cells have a relatively short life span, and we need an enormous number of them. As a result, the cells that develop into red blood cells divide quickly. To maintain the correct number of red blood

cells in our body, about 2.5 million new red blood cells are made each second in the bone marrow. (See Figure 15-13.) Bone cells, on the other hand, divide much more slowly. An even more extreme example is nerve cells, which have almost completely lost the ability to divide. It was long thought that the number of brain cells you have does not increase as you mature. New research is questioning this idea. However, we do know for certain that it is very difficult to repair or replace damaged nerve cells when the spinal cord is damaged.

If conditions in the body change, homeostasis requires that cells change the rate at which they divide. For example, a skin cell normally takes about 20 hours to complete its cell cycle. However, your skin cells speed up their rate of division if you cut yourself. The cell cycle shortens and your cut skin heals faster. Liver cells normally do not divide. However, if part of the liver is removed by surgery, the cells in the remaining part start dividing until the liver returns to its normal size.

How do cells know when to divide and when not to divide? In biology, this is one of the most important current areas of research. Scientists have found internal and external controls for cell division. Substances inside the cell control when, and how rapidly, the cell divides. In addition, external environmental factors affect cell division. Environmental factors include changes in temperature, pH, and the amounts of available nutrients. The presence of other cells is another factor that affects cell division. For example, normal cells keep dividing until they touch other cells. Then cell division stops. This is called *contact inhibition*; it prevents cells from getting overcrowded.

Hormones are another type of external control of cell division. In Chapter 11, you learned that hormones are chemicals produced in one part of the body that affect cells in another part of the body. For example, human growth hormone, from the anterior pituitary gland, controls growth throughout the body. In particular, it stimulates cell division in the long bones of the arms and legs. As the rate of cell division increases, you grow and your clothes no longer fit!

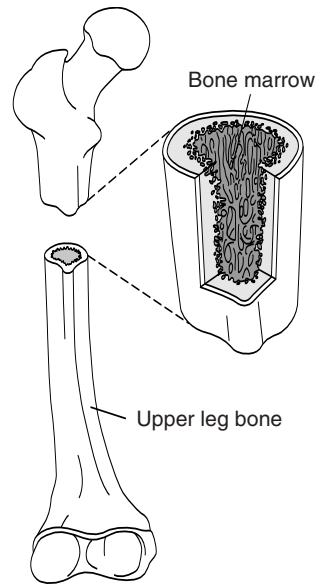


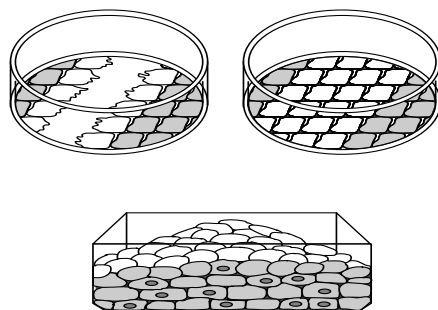
Figure 15-13 Millions of new red blood cells are made each day in the bone marrow.

■ CANCER: CELL DIVISION OUT OF CONTROL

Normal cells from vertebrates can also be grown outside the body. By giving them nutrients and the correct temperature and pH, the cells will begin to divide in a smooth glass dish. They will divide until they touch each other and cover the bottom of the dish. Then cell division stops. The cells remain alive and very “well behaved.”

On occasion, however, scientists have observed that something very different happens. The cells divide, cover the dish, touch each other, and then continue to divide. The cells begin to pile up in the dish, crowding each other, and still they divide. It seems that nothing will stop the cell division. It is like an uncontrolled “blob” in a science fiction movie. Only when all nutrients are used up does the growth cease. (See Figure 15-14.)

Figure 15-14 When normal cells are grown in a glass dish, they continue to divide until they touch each other. Occasionally the cells continue to divide even after they touch, resulting in the type of uncontrolled cell growth seen in cancer.



This phenomenon is the type of cell behavior that characterizes the disease cancer. Cancer results from uncontrolled cell division. Cancer cells seem to no longer follow the rules. They do not recognize the signals that control normal cell division. When this happens in the body, the growing mass of cells may become a **tumor**. The tumor steals energy and nutrients from other normal tissues. The results can be deadly.

Tumors steal energy from surrounding tissues by growing many blood vessels to bring nutrients to them. Some of the most exciting cancer research is now aimed at finding substances that will stop this growth of blood vessels (a process called *angiogenesis*). Two of these substances, angiostatin and endostatin, have in fact recently been found to destroy tumors in mice. Will a cure for cancer in humans actually be found? There is hope that the answer may indeed be yes. However, only time—and further research—will tell.

Humans are not the only organisms that develop cancer. Frogs, chickens, mice, and even plants can develop cancer. In fact, almost all multi-cellular organisms can develop cancer. You may have seen a tree with a

Cancer Treatment in the Twenty-First Century

Non-Hodgkin's lymphoma (NHL) is a cancer of the lymph system. This system collects intercellular fluid from throughout the body, returning it in tubes to the bloodstream. The tiny lymph vessels join together to eventually form large ones that empty into veins in the neck. Enlargements along these lymph vessels are known as lymph nodes. These nodes, or glands, are involved in the body's defenses against diseases. However the lymph system is also the site for NHL cancer—one of the few cancers that is occurring with greater frequency. No one knows why the incidence of NHL is increasing, but it now accounts for more than 4 percent of cancer deaths in this country.

Chemotherapy, the traditional use of drugs to treat cancers such as NHL, was developed during the twentieth century. These anti-cancer drugs use a variety of methods to attack cancer cells: by attacking DNA; by shutting down protein synthesis; or by stimulating the immune system. In the mid-1990s, trials began for the use of a very different type of drug—monoclonal antibodies. These drugs are actually designer-made antibodies that have been produced to find and attack cell-surface targets that exist only on cancer cells. The monoclonal antibody drugs are therefore referred to as *targeted drugs*; they search out the cancer cells. The cutting-edge capability of these twenty-first-century drugs is to attach radioactivity or some other cancer-fighting drug to the monoclonal antibody. The targeted drug will go find the cancer cells, deliver its deadly payload, and then kill the cancer cells. This treatment is now being used against NHL with some success.

Doctors currently stress that the best approach is to use both methods—twentieth-century and twenty-first-century cancer treatments. Well-respected experts are optimistic about the chances for real progress in the years ahead. For example, Dr. Andrew Zelenetz, chief of the lymphoma services at Memorial Sloan Kettering Cancer Center in New York City has said, "This is a very exciting time. We didn't have new important agents for the treatment of lymphoma for many years. Now we're seeing the emergence of these targeted therapies that are very exciting, and in fact, we're starting to see the emergence of other chemotherapeutic agents that actually have activity in lymphoma. We're entering a new era where we have both the traditional tools as well as these new targeted tools, and we're going to be seeing more of them coming down the pike. There are a number of new agents that are in development that are being tested that I think have real promise."

Hopefully these new cancer-fighting agents will be developed in time to fight the increase in incidence of NHL and other potentially deadly cancers.

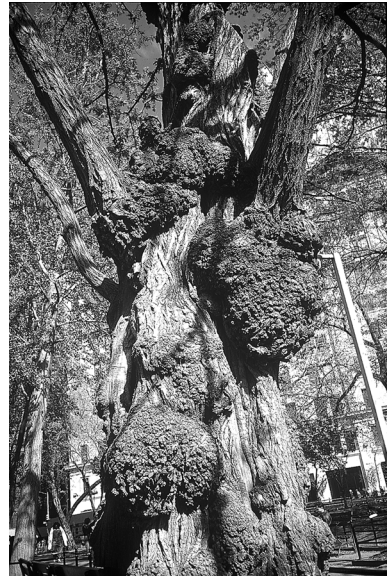


Figure 15-15 Even trees can develop cancers. The tumors on this tree were caused by a virus.

strange, large swelling partway up its trunk. Most likely, that swelling was a cancerous tumor. (See Figure 15-15.)

Sometimes, after the dividing cells form a tumor, nothing else happens. Cells do not break off from the tumor and travel to other places in the body. The tumor causes no further damage and is said to be **benign**. What is dangerous is when cancer cells have the ability to break away from the tumor. These cells may get into the blood system. The blood can carry the cells to other parts of the body where they can start new tumors. The spread of a cancer in this way is known as **metastasis**. A tumor that metastasizes is said to be **malignant**. Malignant cancers can lead to death. (See Figure 15-16.)

Uncontrolled cell growth can occur in many different types of cells. As a result, there are different types of cancer. There is skin cancer, breast cancer, prostate cancer, lung cancer, leukemia (a cancer of the blood), and

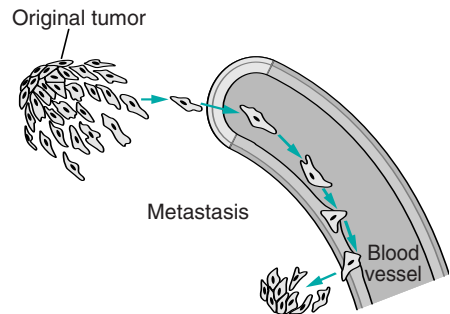


Figure 15-16 Metastasis is the spread of cancer cells through the body.

many others. It does not seem that there is a single cause for all types of cancer. Currently, a great deal of research is being done to try to learn the causes of each type of cancer.

Even though there are differences, it is quite certain that all types of uncontrolled cell division involve the cells' genetic instructions. In Chapter 20, you will learn much more about how these genetic instructions work in cells. We have already seen that these instructions, the genes, are made of DNA. Internal and external factors that cause cancer do so by damaging or changing the DNA. For example, some skin cancers result from DNA damage caused by exposure to ultraviolet (UV) rays that reach Earth from the sun. Physicians recommend limiting exposure to the sun and encourage the use of creams or lotions that contain chemicals to block UV rays from reaching the skin. Tobacco smoke contains several types of chemicals that are known to act as **carcinogens**. These carcinogens cause mutations in the DNA of lung cells, which result in the formation of cancer. It seems that breast cancer, rather than resulting from external factors, sometimes results from internal causes. Some physicians suggest that there are hereditary factors (genes) that make a person more likely to form cancers in breast tissue. This would explain why women in certain families are more likely to develop this disease. If the cancer has also occurred in relatives, it is likely that an inherited factor is the cause.

No matter what the cause of cancer is, it has been said that one of the most important ways to reduce the risk of cancer is to maintain good health habits. The immune system constantly attacks not only invading cells but also abnormal cancerous cells from our own body. Much of the time, the immune system is successful. It destroys cancer cells before they can develop and cause problems. In fact, many biologists describe cancer as being the result of the rare times when abnormal cells get past the immune system. It is no surprise that many people who die from AIDS, a disease of the immune system, actually die from some type of cancer. The patient's damaged immune system is not able to protect the person from cancerous cells. A healthy body, meaning a healthy immune system, is therefore one of the best protections against cancer.

LABORATORY INVESTIGATION 15

How Do Plant Cells Change During Cell Division?

INTRODUCTION

As plants grow, new cells are produced by cell division. Cell division includes the process of mitosis, the rearrangement and regrouping of chromosomes in cells. The stages in plant cell division can be observed in cells from the tips of roots. In this activity, you will examine prepared slides of root-tip cells. To make this kind of slide, a thin slice of tissue is cut from the tip of a root of an onion plant. This tissue is stained, and a permanent slide is made. Through a microscope, you can observe the cells trapped in various stages of mitosis. Your task is to make observations and conclusions about how mitosis occurs in plants.

MATERIALS

Compound microscope, prepared slide of onion root tips, lens paper

PROCEDURE

1. Look at the slide of the onion root tip. How many root tips are on your slide? Look closely at one of the root tips. Decide which end of the root is the bottom and which end was cut from the end of the root. Make a labeled drawing of your observations.
2. Now observe the slide under the low-power objective on your microscope. Observe the cells at the cut end and at the rounded end of the root. List the differences you observe in the two areas.
3. Observe the end of the root where the cells are showing the most evidence that mitosis is occurring. Which end did you choose? Why?
4. Change to the high-power objective. Choose five cells that are in different stages of mitosis. Draw these cells. Label as many structures as possible. Number the drawings from the earliest stage of mitosis to the latest.
5. If time permits, survey the cells throughout the zone where mitosis is occurring. Record the number of cells in each of the stages you numbered in step 4. Prepare a data table of your results.

INTERPRETIVE QUESTIONS

1. Which part of the root, the round end or the cut end, contains the youngest cells? What evidence do you have to support this conclusion?
2. In step 4, how did you decide the order of the stages you observed?
3. Once mitosis is completed, how are the daughter cells similar to the parent cell? How are they different?
4. From your survey of the cells in step 5, draw a conclusion about the length of time it takes to complete each of the five stages observed in step 4. Explain your reasoning.
5. Use your knowledge of the structure and functions of chromosomes to explain why it is necessary for mitosis to produce a complete, new, and identical set of chromosomes for the cells produced by cell division.

CHAPTER 15 REVIEW

Answer these questions on a separate sheet of paper.

VOCABULARY

The following list contains all of the boldfaced terms in this chapter. Define each of these terms in your own words.

anaphase, asexual reproduction, benign, binary fission, budding, carcinogens, cell cycle, cell plate, centrioles, centromere, chromatids, chromosomes, cytokinesis, DNA, interphase, replication, malignant, metaphase, metastasis, mitosis, prophase, regeneration, reproduction, spindle, telophase, tumor

PART A—MULTIPLE CHOICE

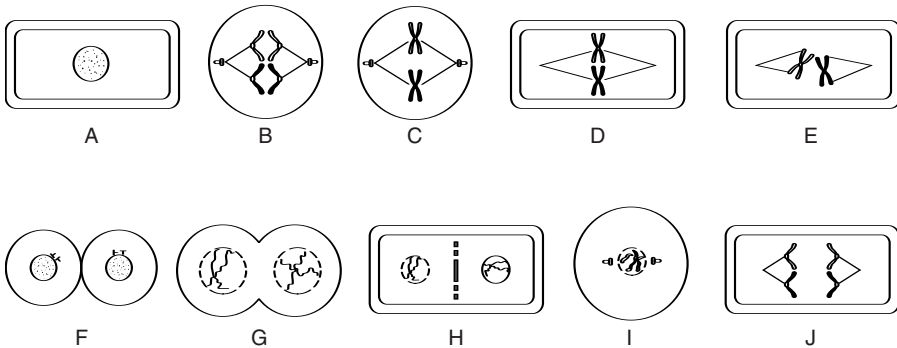
Choose the response that best completes the sentence or answers the question.

1. How many chromosomes are found in a human body cell?
a. 8 b. 18 c. 46 d. 94
2. The duplication of the genetic material in a cell is called
a. reproduction b. replication c. binary fission d. metastasis.
3. Bacteria reproduce by
a. binary fission b. budding
c. metastasis d. meiosis.
4. The process by which the cytoplasm of a cell divides is called
a. mitosis b. meiosis c. cytokinesis d. regeneration.
5. Under normal circumstances, which body cells divide most quickly?
a. bone marrow cells b. liver cells c. bone cells
d. brain cells
6. Chromosomes line up in a single file across the middle of the cell during
a. anaphase b. metaphase c. prophase d. telophase.
7. A tumor that spreads is said to be
a. benign b. malignant
c. carcinogenic d. leukemic.
8. Which of the following statements is correct?
a. A chromosome consists of two chromatids joined by a centriole.
b. A chromatid consists of two chromosomes joined by a centriole.
c. A chromatid consists of two chromosomes joined by a centromere.
d. A chromosome consists of two chromatids joined by a centromere.
9. A group of individuals of the same kind living in a particular place is a
a. population b. genus c. crowd d. species.

10. Geckos, a type of lizard, can detach their tails to fool predators. The gecko later grows a new tail. This is an example of *a.* asexual reproduction *b.* binary fission *c.* budding *d.* regeneration.
11. The series of events that occurs during the life of a cell is called *a.* mitosis *b.* metastasis *c.* binary fission *d.* the cell cycle.
12. During cell division in a plant cell, you would *not* expect to see a *a.* centriole *b.* spindle *c.* cell plate *d.* chromosome.
13. A twig from a willow tree placed in a bucket of water will soon sprout roots and can be planted to produce a new tree. This is an example of *a.* asexual reproduction *b.* sexual reproduction *c.* budding *d.* binary fission.
14. The genetic material is made up of *a.* centromeres *b.* DNA *c.* NADP *d.* proteins.
15. Cell division is affected by *a.* contact inhibition *b.* hormones *c.* nutrient availability *d.* all of these.

PART B—CONSTRUCTED RESPONSE

Use the information in the chapter to respond to these items.



16. The diagram shows the stages of two versions of a process in the incorrect order. Identify the process and put the stages in the proper sequence.
17. Name the stages of the process and briefly describe the major events associated with each stage.
18. Although movies like *The Blob* can be entertaining, they rarely portray cell biology accurately. Explain why a giant human-eating amoeba is not biologically possible.
19. What is cancer? What are some possible causes of cancer? What are some ways of reducing the risk of cancer?
20. Why is asexual reproduction important to people who grow plants?

PART C—READING COMPREHENSION

Base your answers to questions 21 through 23 on the information below and on your knowledge of biology. Source: *Science News* (December 14, 2002): vol. 162, p. 382.

Zapping Bone Brings Relief from Tumor Pain

By unleashing radio waves inside bone, researchers have stopped intractable pain in people with cancer that has spread to their skeletons.

Tumors that form inside bone when cancers spread can be especially painful. The new technique, called radio-frequency ablation, unleashes energy via a needle inserted into bone to reach the edge of the tumor. The radio waves create intense heat that kills nearby tumor cells within about 10 minutes, says study coauthor Matthew R. Callstrom of the Mayo Clinic in Rochester, Minn.

Targeting the surface where the tumor meets the bone seems critical, he says. “Our thought is that nerve fibers in that area—where tumor cells are eroding bone—are the pain generators,” he says. Bone itself appears unaffected by the procedure.

The researchers treated 62 patients in whom conventional cancer therapy had failed. Of these, 59 reported significant pain relief, and 28 said they experienced total pain relief at some times, Callstrom says.

“We’re not curing cancer with this treatment,” he says. “But we’re affecting the pain that patients have. The most important [concern] for all these patients is their quality of life.”

21. Explain why researchers are using a new technique on cancer tumors inside bone.
22. State the process by which radio waves are being used to treat pain in cancer patients.
23. Why are the surfaces where tumors meet the bone considered important in this study?