2.3 How Cells Reproduce

All organisms, including you, begin life as a single cell. How does one cell produce a multicellular organism? A cell divides itself over and over again to make new cells. Remember that cells can only come from previously existing cells. During cell division, one cell divides to become two cells. Then each of these two cells divides into two more cells, and so on. In this way, with amazing speed, the single fertilized egg cell from which a human develops eventually produces a baby consisting of trillions of cells.

The process does not stop when a baby is born. How do you think you grew to your present size? More cells have been added to your body continually since you were born, making you taller and heavier. Even when you are a fully grown adult, many of your cells continue dividing.

Pause & Reflect

Think of reasons why your cells do not stop dividing when you are fully grown. Write your ideas in your Science Log.

Regeneration

There is a story told in Greek mythology about Hydra, a many-headed monster. If one head was cut off, two heads grew in its place. There are no real monsters like Hydra, but many living things are able to grow new body parts to replace damaged or missing parts (see Figure 2.10). This ability to replace body parts is called **regeneration**.

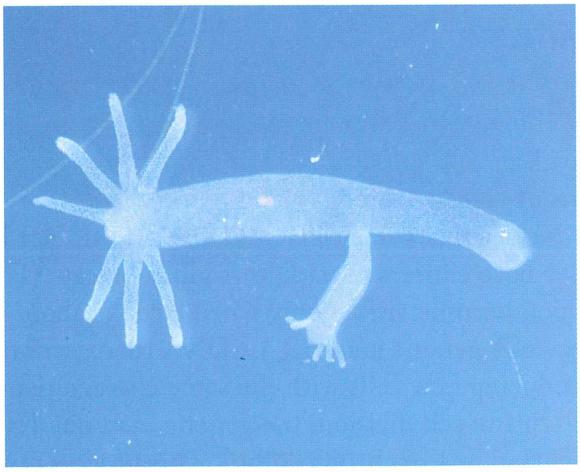


Figure 2.10 The tiny pond organism called hydra was named after the mythical monster. This organism is able to regenerate missing parts.

STRETCH Your Mind

A fertilized egg divides in two. The two cells both divide to make four. The four cells divide to make eight, the eight cells become sixteen, and so on. If a cell divides once every hour, how many hours will it take to make one million cells? Estimate, then calculate!

DidYouKnow?

Your body produces about one million new red blood cells every second. They are made by dividing cells in the bone marrow (the inner core of the bone). In a few weeks' time, all the red blood cells now in your body will have died and been completely replaced by new cells.

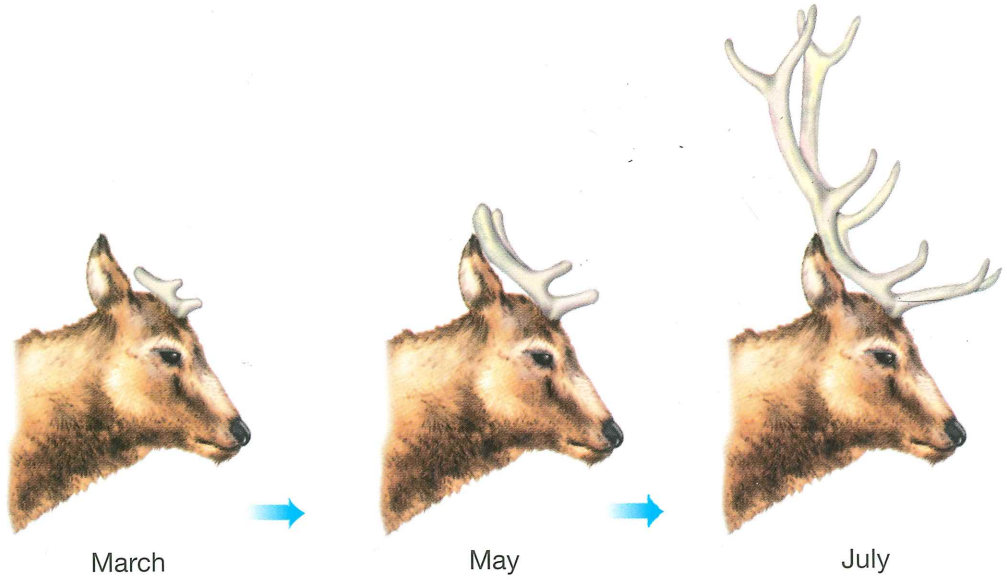


Figure 2.11 Some kinds of deer, such as elk, lose their antlers each year and grow new ones. The new antlers are built up by dividing cells. This is an example of regeneration.

People cannot grow new arms or legs, but we do show a kind of regeneration. Have you ever scraped off some skin, or broken a bone? The wound is able to heal because dead and damaged cells are replaced by new ones. The new cells, produced by cell division, grow over the injury and repair the wound.

Like organisms, individual cells have a life cycle — they grow, divide, and eventually die. Different cells grow and divide at different rates, depending on their structure and function. For example, the cells in your skin wear out quickly and last only days or weeks. The longest-lived cells in your body are nerve cells, which can last a lifetime.

Regeneration is evidence that organisms can produce new cells throughout their lives. For example, some lizards can grow a new tail after a predator snatches away their old one. Lobsters, newts, tadpoles, and insects can grow new legs. Deer shed their antlers each year, then grow new antlers to replace them (see Figure 2.11). If you cut off a plant stem and place it in water, it will grow new roots, while the part of the plant left behind will grow a new stem. These are all examples of regeneration. Can you think of any other examples?

Mitosis

How does one cell become two? If you look at cells under a microscope, you may be able to observe them in the process of dividing. The best places to look for dividing cells are in parts of an organism that are growing rapidly, such as the root tips of young seedlings (see Figure 2.12).

Notice that some cells in Figure 2.12 do not have a solid, round nucleus. Instead, they have clusters of dark, threadlike objects. These objects are the **chromosomes**, which become visible only when a cell is about to divide. Chromosomes contain the cell's genetic material, or DNA (**d**eoxyribo**n**ucleic **a**cid) — instructions for producing new cells with the same characteristics as the parent cell.

During cell division, the genetic material duplicates and then divides into two identical sets of chromosomes. This process is called **mitosis**. It is very similar in all forms of life, whether the organism is a unicellular micro-organism or a multicellular plant or animal. The two new cells formed by this division are called **daughter cells**. Each daughter cell gets one set of chromosomes. You will learn more about mitosis in later studies.

How Rapidly Do Cells Divide?

All healthy cells have regular rates of dividing. For example, certain bacterial cells divide once every 20 min. Frog embryo cells divide in about an hour, cells lining your intestine take about 48 h to divide, and liver cells divide only once every 200 days.

How can you determine how rapidly different kinds of cells divide? In the next investigation, you will be able to estimate the average rate of cell division in a young plant.

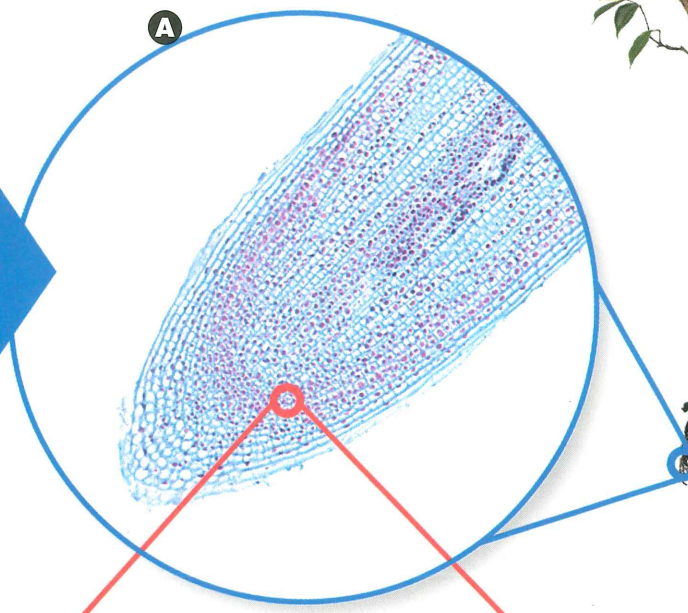
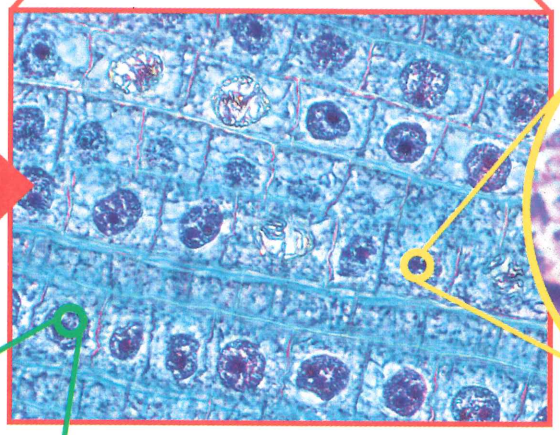
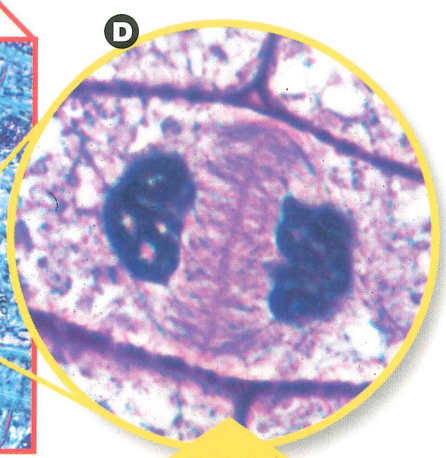


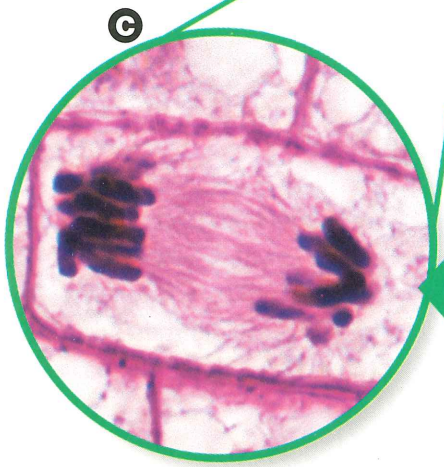
Figure 2.12 Cells in a growing root tip. Roots grow longer as more cells are added at the tip. Root cap cells protect the growing root. They are easily rubbed off by soil particles, but they are constantly replaced by new cells.



Many cells are dividing by mitosis in this enlarged area of the root tip. Note how the appearance of the nucleus changes in cells that are dividing.



The identical sets of chromosomes in a cell have been pulled apart and two new cells are being formed.



The identical sets of chromosomes in this cell are being pulled apart.

Cells and Cancer

Cell division is essential for body growth and repair. What happens if cells begin to multiply and spread in an uncontrolled way? That is what happens in the bodies of people with cancer. Cancer cells divide at a far greater rate than normal cells and they spread to other parts of the body. Cancer has been described as "mitosis gone wild." As the abnormal cancer cells continue to multiply, they spread to other parts of the body and damage them. Cancer is one of the leading causes of death in Canada today.

Cancer can affect many parts of the body and may be caused by many different factors. Factors that produce cancer are called *carcinogens*. They include some types of chemicals, radiation, inherited (genetic) factors, certain viruses, and repeated damage to the body.

People working in some jobs may be exposed to particular types of carcinogens. For example, people working in industries using asbestos have had high rates of lung cancer because they inhaled fine particles of this substance over long periods of time. Some farmworkers have had high rates of cancer after improperly using certain pesticides. The rates of industry-related cancers have been reduced by use of protective clothing, air filters, and banning some harmful chemicals.

Some cancers can be prevented by changing lifestyle habits to reduce exposure to carcinogens. One example is the link between smoking and lung cancer. Smokers are far more likely to die of lung cancer than nonsmokers and they can reduce this risk by not smoking. Another example is the connection between Sun exposure and skin cancer. People who spend many hours in the Sun without protective clothing or sunblock have a high risk of developing skin cancer, caused by ultraviolet radiation from the Sun. The incidence of skin cancer in Canada is on the rise. About 8000 cases of skin cancer are diagnosed each year in Canada.

Although prevention is better than cure, there are some treatments that can slow or stop the spread of cancer in patients who already have the disease. The techniques consist of destroying the cancerous cells while leaving normal cells intact. This can be done by chemicals (chemotherapy) or by radiation treatment — using high-energy particles to kill cells. These treatments are most successful if the cancer is diagnosed in an early stage, before the abnormal cells have spread widely through the body.

New techniques may give better methods of curing cancer in the future. One method is gene therapy, the altering of genes that cause cells to divide and produce cancer. Alternative therapies focus on ways to boost the body's own natural immune system. For example, people may be able to use vaccines or drugs that stimulate their bodies to destroy cancer cells, making them immune to cancer.

Career CONNECT

Just Right for the Job

Read this list of ten personal traits carefully. Then read the career advertisement for a medical technologist. Which traits do you think would be most important if you were interested in this type of career? Why? Rank the personal traits in order from 1 to 10, from most important (1) to least important (10).

Personal Traits

strong artistic abilities
good memory
steady hands
good athletic ability
dramatic talent
concern for accuracy
sense of humour
excellent math skills
good communication skills
love of the outdoors

Add any other personal traits to the list that you think would suit the job of medical technologist.

Mount Kinmore Hospital

has an immediate opening for a medical technologist. The successful applicant must have completed a three-year program in medical laboratory technology and be familiar with advanced laboratory equipment. He or she must be skilled in performing the following tests to assist doctors in diagnosing a patient's condition:

- CBC – a complete blood count of white blood cells, red blood cells, hemaglobin, and platelets
- urinalysis – testing urine samples for blood, protein, white blood cells, sugar, etc.
- microbiological culturing – growing bacteria from throat swabs, wound swabs, urine samples, and stool samples to identify the cause of infections or food poisoning
- tissue typing – matching of donor and recipient tissue types for organ transplants
- blood banking – matching of donor and patient blood types for blood transfusions

Check Your Understanding

1. What are chromosomes?
2. What is mitosis?
3. Give an example of regeneration.
4. Why do the cells of a multicellular organism continue to reproduce even after the organism is fully grown?
5. How is a daughter cell like the original cell from which it formed?
6. How can you tell from a cell's appearance alone whether the cell is undergoing mitosis?
7. What were some of your qualitative observations in Conduct an Investigation 2–C? What were some quantitative observations?
8. **Apply** What evidence do you have that some cells in your body are dividing?

2.4 Specialized Cells

Imagine an orchestra made up of only a hundred trumpet players or a hundred violins. Such an orchestra would be very limited! To play every kind of music, an orchestra needs a variety of musical instruments — some flutes, some oboes, a piano, drums, and so on. In the same way, a multicellular organism cannot be made up only of identical cells. As Figure 2.13 shows, although multicellular organisms grow from single cells that repeatedly divide, their cells are not all the same.

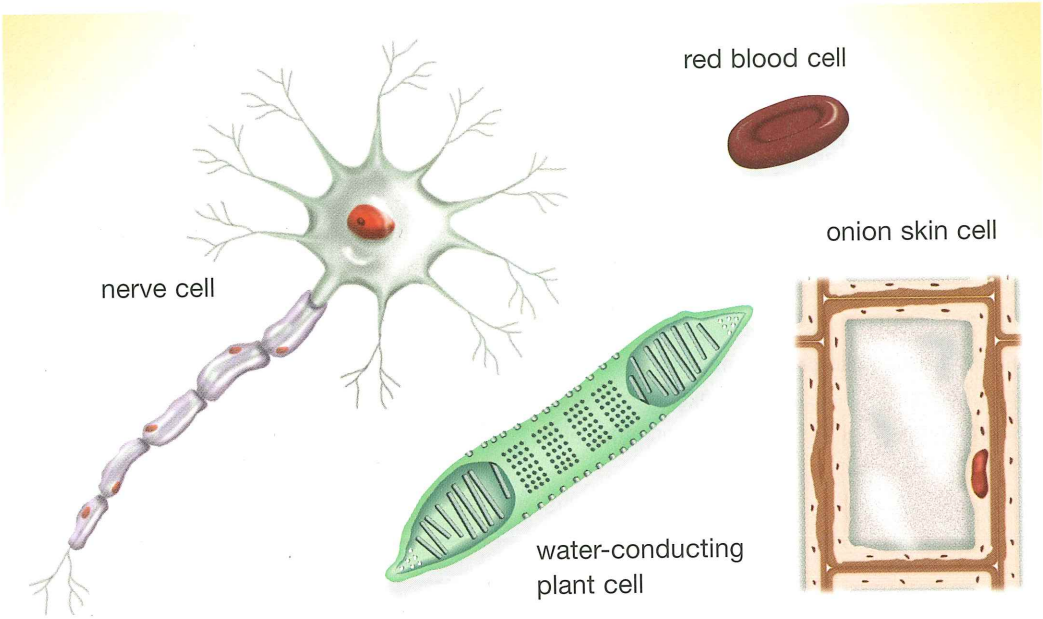


Figure 2.13 Different cells have different shapes and functions.

Like the instruments in an orchestra, different cells have different appearances and perform different jobs. They are said to be **specialized** for particular tasks. For example, your muscle cells are shaped to move parts of your body, and your skin cells are built to protect your body from the drying rays of the Sun. Humans have about a hundred different types of cells, each with their own particular structure and functions.

Look at the examples of plant and animal cells in Figure 2.13. How do their shapes relate to their functions? Nerve cells have long, branched fibres running from the main part of the cell, shaped to carry nerve signals from one part of the body to another. Red blood cells, which carry oxygen in the bloodstream, have a thin, disk-like shape. This gives them a large surface area to pick up large amounts of oxygen. The water-conducting cells of a plant are tubelike, with thick walls and a network of holes that lets water pass easily through them. Onion skin cells are flat and brick-shaped, so they can fit closely together to form a continuous protective layer.

Off the Wall

A nerve fibre in the neck of a giraffe can be up to 1 m in length. However, the main part of the cell from which it comes is about the same size as a human nerve cell.

INVESTIGATION 2-D

Different Cells, Different Jobs

If you were to design a human body, what different cells would you need? What jobs must these cells do in your body? What characteristics would be needed for each job? In this investigation, you will work with groups in your class to discover the variety of different cells and to think about their functions and importance to the body as a whole.

Think About It

What is the structure and function of various cells in the human body?

What to Do

1. The class will divide into five groups. Each group will represent a different part of the body from the following list:

   blood in heart
   bone in leg
   nerve in toe
   skin on head
   muscle in arm

2. Imagine your classroom is a giant body. Go with your group to the approximate location of your part of the body.

3. Prepare a brief presentation about the specialized cells you might expect to find there. Your report should answer the following questions:

   (a) What is the main type of cell found in this part of the body?

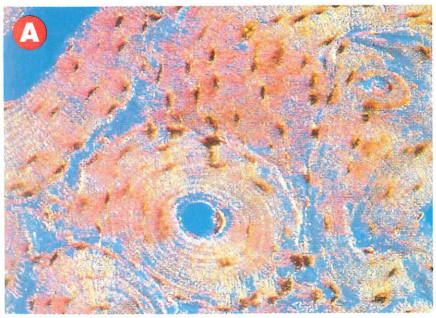
   (b) What is its main function?

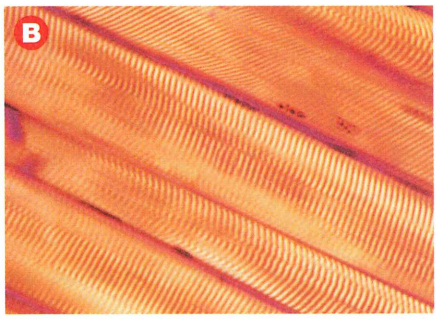
   (c) What type of structure would help it carry out this function? (For example, consider the cell shape, size, use of energy, and other characteristics.)

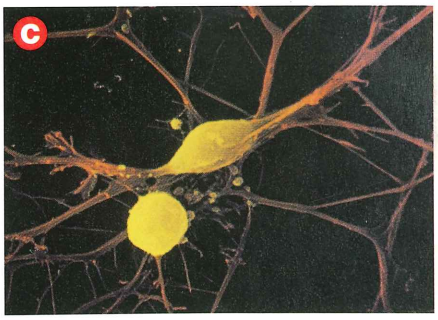
   (d) Could the body as a whole survive if it had none of these cells?

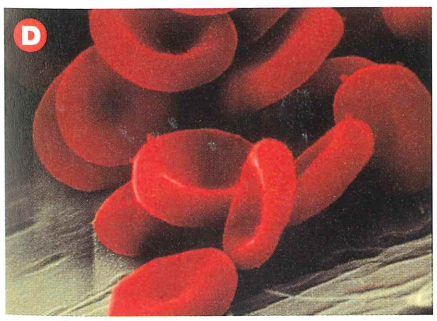
Analyze

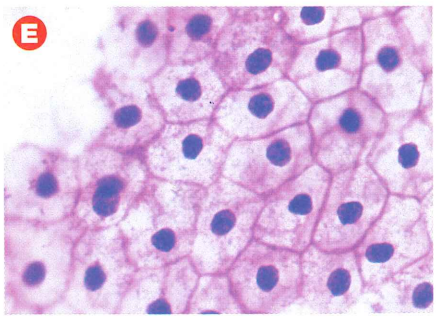
The photographs below show several types of human cells with descriptions of their characteristics. Match each photograph to one of the cell types described by your class. (Answers are found on page 560.)











DidYouKnow?

Most household dust is made up of dead human skin cells. You and everyone around you are continually shedding parts of the thin outer layer of skin. Your entire outer layer of skin is completely replaced by the growth of new cells approximately every 28 days.