2.0 Cellular processes sustain living things.

The basic needs of large, small, and microscopic organisms are met at the cellular level.

What You Will Learn

In this chapter, you will:

- examine unicellular and multicellular organisms
- explain cell specialization
- describe plant and animal cell processes

Skills You Will Use

In this chapter, you will:

- demonstrate the proper use of a microscope
- observe and draw organisms observed under a microscope

Why This Is Important

Living things include unicellular and multicellular organisms. Understanding cellular processes helps us to understand how every organism on Earth — from an amoeba to us to a blue whale — meets its basic needs.

Before Reading

Thinking Literacy

Reading and Interpreting Graphical Text

Writers use graphical text forms such as pictures, diagrams, and charts to communicate information in a concise and visual way. Complex ideas and concepts can sometimes be communicated more easily in a picture or diagram. These visual elements provide important clues to the main ideas and concepts in the written text.

Take a "picture walk" through chapter 2. Use what you see to write a prediction about the main idea of this chapter. Consider how most of these pictures are similar to each other but different from pictures you saw in chapter 1.

Key Terms

- unicellular
- multicellular
- specialized cells
- cell division

2.0 Getting Started

Figure 2.1 Blue whales sustain themselves by eating huge quantities of zooplankton.

The blue whale is the largest type of animal on Earth (Figure 2.1). It can grow to be about 25 m long. An adult often weighs more than 150 tonnes. The whale feeds on zooplankton, which is one of the smallest animals on Earth. The blue whale and zooplankton are just two of the estimated 1.75 million different kinds of living things found on Earth. All living things, whether they are plants, animals, fungi, protists, or types of bacteria, are made of cells. It is the activities of cells that allow each living thing to meet its basic needs.

The obvious structures of the living things you see around you — jaws, teeth, eyes, limbs, and wings or fins; leaves, stems, or roots — may appear to be the means of meeting basic needs. In fact, these structures are working together to supply the organism's cells with the water, oxygen, and nutrients that the cells need to carry out their activities.

The visible structures of organisms may look very different. They make it possible for the organism to get what it needs to live from its environment. They also ensure that the necessities of life are processed to get to the cells. The real work of survival happens within the cells.

The co-ordinated activity involved in getting the oxygen, water, and nutrients to the cells happens without any awareness on the part of the organism. This is true when these activities take place in your own body. While you may taste the food you eat, or notice that the water you drink is hot or cold, you rarely breathe consciously. Once the oxygen, water, and food are inside your body, the various parts of your body take care of the processing. You are unlikely to notice any of this activity unless something goes wrong. Yet without it, you would not be able to survive.

A20 *Quick Lab*

Meeting Basic Needs for Survival

Living things must perform certain functions in order to stay alive. These functions may include moving, responding to stimuli, gathering food, taking in oxygen, and building a home.

Purpose

To decide what structure each organism uses to perform the activities that keep it alive

Materials & Equipment

- pen and paper

Procedure

1. Prepare a chart with five columns.
2. Down the left-hand column, list the functions that living organisms perform in order to survive. Name the organisms shown on the right in the headings for the remaining columns. (Note: A **microorganism** is an organism that can only be seen with a microscope.)
3. Fill in your chart to indicate which structure you think each organism uses to perform each function. (Some functions may not be applicable.)
4. Compare your chart with one prepared by a classmate.

Questions

5. Did your classmate list functions that you did not? Which ones?
6. Which functions did most people name?
7. Did each organism shown have a structure for each of the functions you listed?

Figure 2.2 Microorganism

Figure 2.3 Plant

Figure 2.4 Mammal

Figure 2.5 Fish

2.1 Unicellular Organisms

Here is a summary of what you will learn in this section:

- Unicellular organisms are essential for the continuance of life on Earth.
- Unicellular and multicellular organisms carry out many of the same activities to meet their basic needs.
- Unicellular organisms are varied in structures and adaptations.

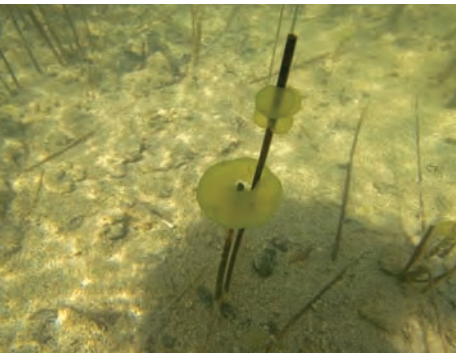


Figure 2.6 Phytoplankton are unicellular organisms that supply most of Earth's oxygen.

Unicellular organisms are living things made of a single cell. They are usually smaller than a speck of dust, and they live everywhere that can sustain life: in water, in soil, and in or on multicellular organisms. There are millions of species. Scientists believe these organisms could have been on Earth for as long as 3.8 billion years.

While some unicellular organisms, such as some forms of bacteria, are harmful, many more are essential for life on Earth to continue. Phytoplankton are unicellular organisms that live in the oceans (Figure 2.6). They contain chlorophyll to convert the Sun's energy into food. Phytoplankton provide most of the oxygen in Earth's atmosphere and are the foundation of the ocean food chain.

Unicellular decomposers, such as bacteria, are another group of single-celled organisms that are essential for life on Earth. They complete the cycling of matter by converting nitrogen in soil into a form of nitrogen that can support plant life and the terrestrial food chains.

A21 *Starting Point*

Skills A C

What is going on in the Composter?

Have you ever looked inside a composter after the decomposers have been at work for a while? What did it look like in there, and how did it smell? Did you turn away in disgust? Or were you fascinated?

What to Do

1. List the conditions decomposers need to do their work.

Consider This

With a classmate or as a whole class, discuss the following questions.

2. List the basic needs of decomposers. Are these needs the same or different from the basic needs of other living things?
3. What should be done with the contents of a composter? Explain your reasoning.

A Single Cell Is a Living Thing

Most unicellular organisms, such as the diatom, paramecium (pl. paramecia) and the amoeba, are microscopic, although some can be seen with the unaided eye. Diatoms (Figure 2.7) live inside glass-like shells, which they make themselves. Like plants, diatoms make their food through photosynthesis.

It is often assumed that unicellular organisms are simple because of their simple structure. And yet, they perform the same basic activities that complex plant and animal organisms perform. They move, eat, respond to stimuli, reproduce, and expel waste that results from cellular activity.

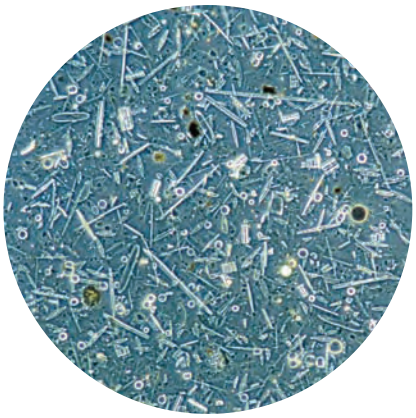


Figure 2.7 Diatoms are unicellular organisms. They live in lakes, oceans, and moist soil and are an important part of the food chain.

How Unicellular Organisms Move

Unicellular organisms move in a variety of ways. Paramecia have cilia, which are tiny hairs that act like oars and propel the organism along (Figure 2.8). *E. coli* bacteria move by rotating a flagellum that looks a bit like a tail (Figure 2.9). These organisms "swim" along. An amoeba moves by changing shape and forcing its cytoplasm into extensions called pseudopods.

WORDS MATTER

Pseudopod comes from two Greek words. *Pseudes* means "false" and *pous* means "foot." So pseudopod means "false foot."

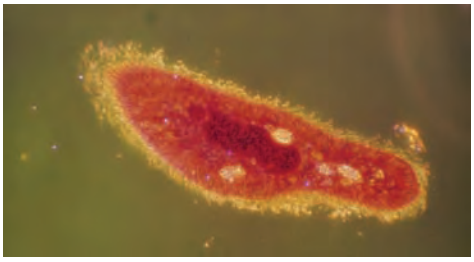


Figure 2.8 Paramecia are unicellular organisms that use cilia to propel themselves.

Figure 2.9 *E. coli* are unicellular organisms that move by rotating a flagellum.

A22 *During Reading*

Thinking Literacy

Visualizing with Combination Notes

Taking notes while reading is a good way to check understanding and clarify thinking. The "combination notes" strategy allows you to record information in a variety of ways, including visually. Draw a line two-thirds of the way down the middle of your page. On the left side of the top two-thirds of the page, record key information as you read "The Amoeba." Use the right side to visually display your understanding in pictures, diagrams, or a web. Use the bottom one-third of the page to record summaries of main concepts.

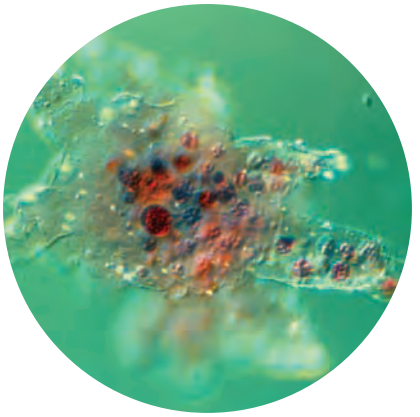


Figure 2.10 Coloured scanning micrograph of *Amoeba proteus*, one of the largest species of amoebas.

The Amoeba

Do not mistake the microscopic amoeba for a mere blob. It is a fascinating organism. Amoebas thrive in water-based environments and are found in both fresh and salt water. They can also live in wet, decaying vegetation on the forest floor, in wet soil, or in other living organisms (including humans). There are many, many species of amoebas (Figure 2.10). Most are harmless to humans, but some cause disease.

Amoebas have many of the characteristics typical of animal cells. The body is surrounded by a selectively permeable cell membrane. Commonly visible organelles include one or more nuclei (depending on the species), cytoplasm, food vacuoles, and a special vacuole that pumps water out of the cell to prevent it from bursting. Water enters the amoeba by osmosis. Oxygen diffuses into the organism, and carbon dioxide waste diffuses out of the organism.

Amoebas can be carnivores, herbivores, or omnivores. Despite their usual microscopic size, amoebas are predators — they prey upon organisms such as algae and bacteria. The amoeba's hunting skills are based on its ability to change shape, a result of having a very soft cell membrane and cytoplasm. (The word "amoeba" comes from the Greek word for change.) The organism changes shape as it moves and captures prey (Figure 2.11).

As the amoeba completes the capture of its prey, the food it has engulfed becomes a vacuole. Chemicals called enzymes digest the food, the nutrients are absorbed by the organism, and the vacuole disappears. Waste products are eliminated through the cell membrane.

Take It Further

Diatoms, paramecia, and bacteria are examples of unicellular organisms. Choose two types of unicellular organisms, and find out how they obtain and digest their food. Prepare a chart comparing the two processes. Begin your research at ScienceSource.

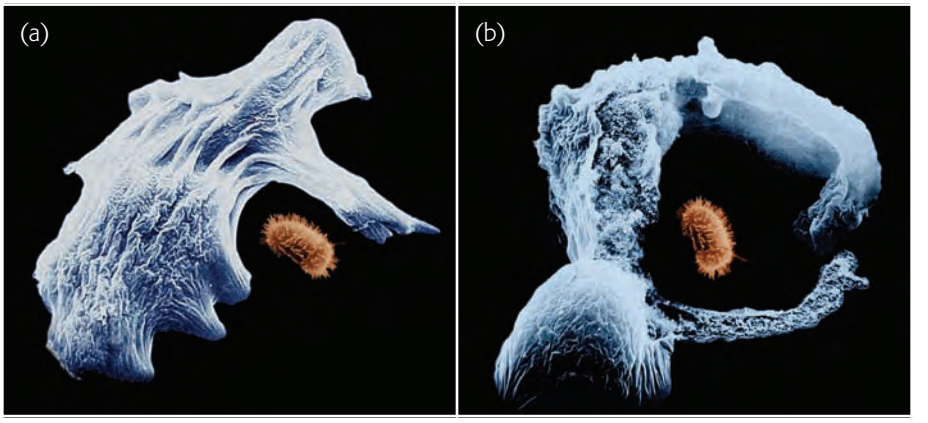


Figure 2.11 When food is detected nearby, an amoeba extends pseudopods to capture it. These images show an amoeba (a) surrounding and then (b) engulfing its prey.

SKILLS YOU WILL USE
- Observing
- Communicating

Observing Unicellular Organisms

Question

What cell structures can be seen under a compound light microscope?

Materials & Equipment

- microscope
- microscope slides
- cover slips
- medicine dropper
- pond water sample (supplied by your teacher)
- small jar
- methyl cellulose (optional)
- prepared slides of amoebas (optional)

CAUTION: Handle microorganisms with care. Wear safety gloves, wash your hands thoroughly after the activity, and dispose of the specimens as instructed by your teacher.

Procedure

1. Turn to Toolkit 9 to review how to set up and use a microscope.
2. Prepare a wet mount slide of the pond water.
3. Set your slide up on the microscope stage, and use the low-power objective lens to observe your sample.
4. View the slide systematically for evidence of unicellular organisms.
5. Switch to the medium-power lens. Concentrate on what you are observing, and keep your sample in focus. Try the high-power lens.

   NOTE: If the organisms in your sample are moving too quickly for you to observe them, use the medicine dropper to add a tiny amount (less than a drop) of methyl cellulose. This will thicken the water. Do not touch the sample or the methyl cellulose during this procedure.
6. If you are not successful in locating amoebas, paramecia, or diatoms, use the prepared slides to view these microorganisms.
7. Prepare a drawing of one of the organisms you observe. Indicate the shape, relative size, colour, and any cell structures that you can see. Label your drawing. Note the magnification you are using.

Analyzing and Interpreting

8. If you are observing pond water, describe how your organism moves.
9. If you used the methyl cellulose, what impact did it have on the specimens in your sample?

Skill Builder

10. You have made drawings of your observations. Do you think words would be a better way to communicate your observations? Explain your reasoning.

Forming Conclusions

11. What cell structures did you see?
12. Did all of the organisms you saw move in the same way? Describe any differences.

Figure 2.12 Always wear safety gloves when working with microorganisms.

2.1 CHECK and REFLECT

Key Concept Review

1. Explain why something with only one cell can be considered to be an organism.
2. Name three unicellular organisms.
3. Name three ways in which unicellular organisms can move. Describe one of them.
4. Where did the amoeba's name come from? Explain why it was given that name.

Connect Your Understanding

5. Describe two things that would happen in an ecosystem if there were no unicellular organisms.

Practise Your Skills

6. Describe three things you should do when handling microorganisms.
7. Explain how you would prepare a drop of water containing an amoeba for viewing under a microscope.

For more questions, go to ScienceSource.

A24 *Thinking about Science, Technology, and Society*

Cooking and Freezing

Unicellular organisms such as bacteria thrive in warm temperatures and moist conditions. These conditions are ideal for composting; however, they must be avoided when preserving, storing, or preparing food. Past and present technologies for the preservation and storage of food focus on creating conditions that are cold and/or dry. Cooking raises the internal temperature of foods high enough to kill microorganisms.

What to Do

1. Research one of the following technologies to find out how it preserves food.
   (a) air drying of foods such as fish
   (b) canning of foods such as vegetables
   (c) freezing of foods such as meat
2. Review Health Canada's guidelines for the safe handling of food.

Consider This

With a classmate or as a whole class, discuss the following.

3. Explain how each of the preserving techniques ensures that the food will not contain harmful microorganisms.
4. How do the guidelines for handling food help to ensure that food is free of microorganisms that could contaminate it?
5. What do you think would happen if we did not have these guidelines?

Figure 2.13 Drying racks are a traditional way of preserving fish.

2.2 Multicellular Organisms and Cell Specialization

Here is a summary of what you will learn in this section:

- Diffusion and osmosis limit the size of cells.
- Multicellular organisms use specialized cells to carry out activities to meet basic needs.
- Specialized cells in multicellular organisms interact with and depend on other specialized cells.

You have seen how an amoeba captures a meal. Think of how the frog in Figure 2.14 does it. Unicellular organisms rely on one cell to perform all the functions that meet their basic needs. **Multicellular** organisms rely on a variety of types of cells to perform cellular functions. These types of cells are called **specialized cells**. They perform specific functions, such as digestion or movement. They must interact with other types of cells in the organism in order to carry out their tasks successfully.

Specialized cells in various parts of the frog — including eyes, muscles, and tongue — must work in perfect co-ordination in order to capture an insect for dinner. The average frog performs this task many times each day. Once the frog catches the insect, the cells in the frog's digestive system take over, extracting the nutrients and expelling cellular wastes.

Figure 2.14 The specialized cells in a frog work together to help the organism catch a meal.

A25 *Starting Point*

Skills A C

Specialized Structures to Do Specialized Jobs

Taking in air in order to get oxygen is a function that all terrestrial animals must perform. Look at Figures 2.15–2.17 to see if the structures they use are very similar or very different.

Figure 2.15

Figure 2.16

Figure 2.17

Consider This

1. What key tasks related to getting oxygen into an organism are accomplished by the noses you see?
2. Do you think the structures you see are the same or different? Explain your reasoning.

Figure 2.18 *Acetabularia* is one of the world's largest unicellular organisms.

Figure 2.19 Multicellular organisms have a variety of specialized cells.

More Cells for Bigger Organisms

There are a few unicellular organisms that are so big you can see them with your unaided eye. One of the members of the algae family, *Acetabularia*, can grow to be 5 to 7 cm in diameter (Figure 2.18). Some amoebas may reach 1 cm, but unicellular organisms are usually microorganisms.

Unicellular organisms are usually micro-sized because cellular activities are performed most efficiently at that size. The limitation is related to the processes of diffusion and osmosis. The processes that deliver gases and water to cells and remove wastes are effective across very short distances. For example, an oxygen particle can diffuse over a distance of 0.01 mm in a fraction of a second. To diffuse over a distance of 1 mm would take 100 times as long.

This large increase in distance is because in a bigger cell, even though the surface area of the selectively permeable cell membrane would increase as the cell's size increased, the cell's volume would increase even more. You can imagine the same principle on a bigger scale if you picture the difference between a golf ball and a beach ball. The distance to the middle of the golf ball is many times shorter than the distance to the middle of the beach ball. For a cell to be bigger in the same proportion, gases and water would have to travel much farther to reach all of the organelles in the cytoplasm. If a unicellular organism were many times bigger than 1 mm, diffusion and osmosis could take several minutes instead of fractions of a second.

This increase in volume as a cell grows is why the organelles in a huge cell would have trouble accessing the resources they need. Larger living things tend to be made up of more than one cell. In an organism made up of dozens, thousands, or even millions or trillions of cells, diffusion and osmosis can still happen in fractions of a second. The trillions of tiny cells that make up your body are very efficient units when it comes to getting resources to the organelles.

Specialized Cells in Multicellular Organisms

In a community, some people grow food; others deliver it. Some people protect the community from danger, and others help to clean up. One person is not skilled enough to do all of the

different jobs expertly. Nor could one person meet all of the demands of a community.

The same is true for multicellular organisms. One type of cell cannot do all of the different jobs in a complex organism. In the same way that a community needs specialists, multicellular organisms are made up of specialized cells rather than cells that are exactly the same. While the specialized cells have the same kinds of organelles as other plant or animal cells, the organelles may be better adapted to performing the cell's tasks.

Specialized Animal Cells

The number of types of cells in a multicellular organism depends on the complexity of the organism. The hydra is a simple multicellular organism (Figure 2.20). It has "skin" cells on the outside and digestive cells on the inside. The skin cells protect the insides from the outside environment and act as "gatekeepers" to control the substances that can get into and out of the organism in the same way that the cell membrane protects a cell.

Figure 2.20 The hydra is a simple multicellular organism. Hydras are best viewed under a microscope.

A complex organism such as a human has hundreds of different types of cells. We have types of cells that function as protection and gatekeepers (Figure 2.21, skin cells), and cells responsible for digestion. We have cells that make up bones and cells that specialize in converting lots of energy (muscle cells) (Figures 2.22 and 2.23). Humans also have cells that are primarily for transmitting electrical impulses (nerve and brain cells) (Figures 2.24 and 2.25). Eyes have special cells that detect light. Blood cells transport oxygen and carry away wastes of cellular processes. Storage cells keep unused energy on hand in the form of fat, to be released and burned when the need arises (Figure 2.26).

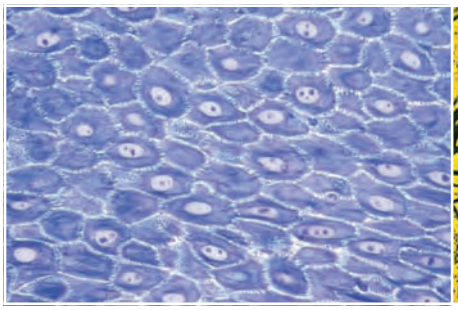


Figure 2.21 Human skins cells make up the largest organ in the human body.

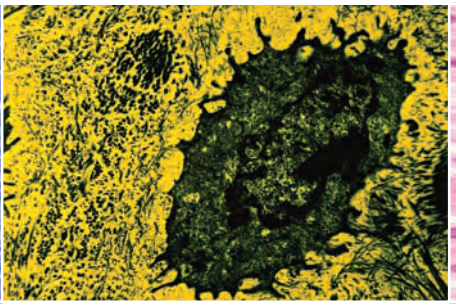


Figure 2.22 Human bone cells make up the structure that supports the body.

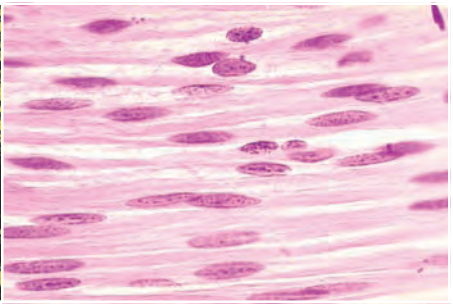


Figure 2.23 Human muscle cells have more mitochondria than other cells, so they can transform more energy.

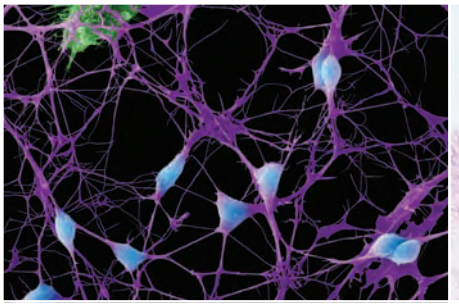


Figure 2.24 Human nerve cells transmit electrical impulses along pathways to the brain.

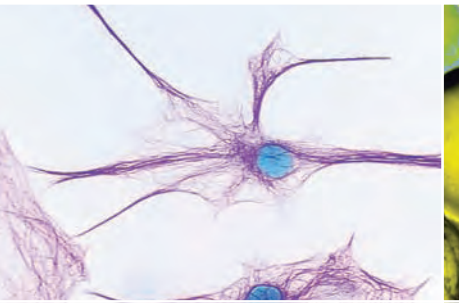


Figure 2.25 Human brain cells receive and transmit electrical impulses.

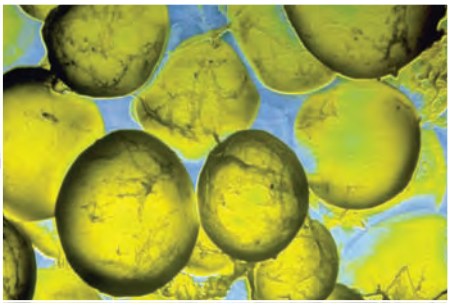


Figure 2.26 Human fat cells store energy in the form of fat, which can be accessed and burned when resources for fuel are low.

A26 *Learning Checkpoint*

Explaining the Size

1. In your own words, explain why diffusion and osmosis limit the size of cells.
2. In your own words, explain why multicellular organisms have specialized cells.

Take It Further

Plants and animals have cells with the special job of defending the organism against invaders. In humans, these cells work in the immune system. Four of these types of cells are called killer T cells, helper T cells, memory T cells, and antibodies. Find out what job two of these types of cells do and how they do it. Report back to the class. Begin your research at ScienceSource.

Specialized Plant Cells

Multicellular plants also have specialized cells. Some transform the Sun's energy into sugars. These cells are found primarily in the leaves (Figure 2.27). The job of cells in the stem is primarily to transport food and water to the rest of the plant, store some food, and support the plant (Figure 2.28). The cells in the roots store food, absorb water from the soil, and transport water and nutrients to the stem (Figure 2.29).

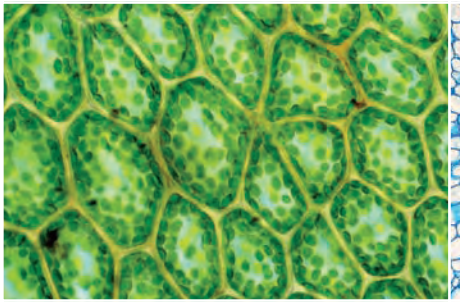


Figure 2.27 These leaf cells contain chloroplasts, which convert the Sun's energy into food.

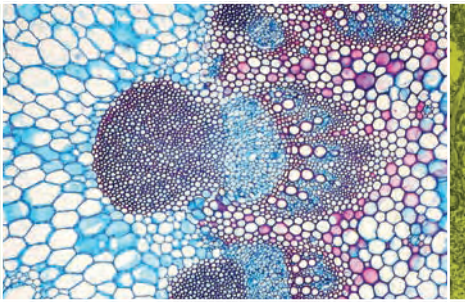


Figure 2.28 The cells in a plant stem transport water and materials throughout the plant.

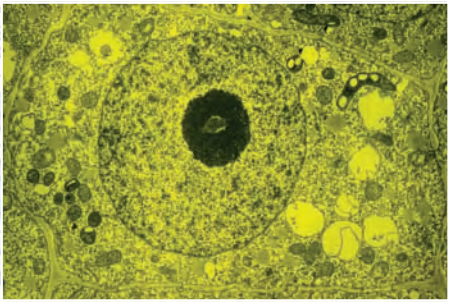


Figure 2.29 The cells in a plant root absorb water and nutrients from the soil and transport these resources to the stem.

A27 *Inquiry Activity* Toolkits 2,9

SKILLS YOU WILL USE
- Observing
- Communicating

Observing Multicellular Organisms

Question

What multicellular organisms can be seen under a compound light microscope?

Materials & Equipment

- microscope
- microscope slides
- cover slips
- medicine dropper
- pond water sample (supplied by your teacher)
- small jar
- methyl cellulose (optional)
- prepared slides of hydras (optional)

CAUTION: Handle microorganisms with care. Wear safety gloves, wash your hands thoroughly after the activity, and dispose of the specimens as instructed by your teacher.

Procedure

1. Turn to Toolkit 9 to review how to set up and use a microscope.
2. Prepare a wet mount slide of the pond water.
3. Set your slide up on the microscope stage, and use the low-power objective lens to observe your sample.
4. View the slide systematically for evidence of multicellular organisms.
5. Switch to the medium-power lens. Concentrate on what you are observing, and keep your sample in focus. Try the high-power lens.

NOTE: If the organisms in your sample are moving too quickly for you to observe them, use the medicine dropper to add a tiny amount (less than a drop) of methyl cellulose. This will thicken the water. Do not touch the sample or the methyl cellulose during this procedure.

6. If you are not successful in locating a hydra, use the prepared slides to view these microorganisms.
7. Prepare a drawing of the multicellular organisms you observe. Indicate the shape, relative size, colour, and any cell structures that you observe. Label your drawing. Note the magnification you are using.

Analyzing and Interpreting

8. If you are observing pond water, describe how the organisms move.
9. How many different organisms did you see in your sample?

Skill Builder

10. Describe the steps you must follow to observe a pond water sample with a compound light microscope.

Forming Conclusions

11. Were the organisms you observed plants or animals? Justify your reasoning.

Figure 2.30 Pond water can supply a number of multicellular organisms.

Toolkits 2,9

SKILLS YOU WILL USE

- Designing an experimental procedure
- Designing a fair test

Cells and Solutions

Question

How will the cells in an onion membrane respond to pure water, salt water, and vinegar?

Design and Conduct Your Investigation

1. Make a hypothesis. Refer to Toolkit 2 for help with this procedure.
2. Decide what materials and equipment you will need to test your hypothesis. For example:
   (a) List the lab equipment you will require to make your observations.
   (b) List the materials such as samples or solutions you will require.
3. Plan the steps in your procedure. Include any safety precautions.
4. Write up your procedure. Include steps to ensure that it will be a fair test of your hypothesis. Explain how you will document your results.
5. Ask a classmate to read the procedure and ask about any steps that are not clear. Show your revised procedure to your teacher.
6. Carry out your investigation. Refer to Toolkit 9 to review how to set up and use a microscope. Refer to "Preparing an Onion Membrane" in the next column for tips on handling your sample.
7. Compare your results with your hypothesis. Did your results support your hypothesis? If not, what possible reasons might there be?
8. Was your investigation a fair test? Justify your answer.
9. Was your procedure complete? How would you change it if you were going to do the investigation again?
10. Share and compare your design and results with your classmates. How were they similar? How were they different?

Figure 2.31 Peel off a single layer of an onion membrane.

Preparing an Onion Membrane

1. Select a clean glass slide and cover slip.
2. Carefully remove a piece of thin, semi-transparent membrane from between two inner layers of the onion.
3. Pick up the membrane with the tweezers. Take the microscrope slide, and hold it at a 45° angle. Carefully drape the membrane onto the middle of the slide. Avoid trapping air bubbles between the membrane and the slide.
4. After you have applied the solution, pick up the cover slip and slowly lower it over the membrane specimen. Avoid trapping air bubbles between the cover slip and the specimen.

2.2 CHECK and REFLECT

Key Concept Review

1. Name five different types of cells that can be found in the human body.
2. Name three different types of plant cells, and describe their key functions.
3. Explain why a tiny cell is a more efficient basic unit of life than a large cell.

Connect Your Understanding

4. What are the advantages of having specialized cells? Are there any disadvantages? Explain your answer.

Practise Your Skills

5. Describe the steps to be followed to make a drawing of organisms observed under a microscope.

For more questions, go to ScienceSource.

A29 *Thinking about Science, Technology, and Society*

Water for Cells

Two-thirds of the average human body is water. Close to 70 percent of that water is inside the body's cells, 20 percent is in the space surrounding the cells, and the remainder is in the bloodstream. The water moves into and out of cells as necessary through osmosis.

When your body is properly hydrated, it has enough water to maintain cellular activities. When the body does not have enough water, it is dehydrated. Making sure that your body has enough water is one way to keep your body cells healthy.

What to Do

1. Calculate the amount of fluids that you consume in one day.
2. List the fluids you consume regularly. Check the ingredient lists of your favourite commercial drinks, and compile a list of the first three ingredients.
3. Research the most common effects of dehydration. Start your research at ScienceSource.

Consider This

With a classmate or as a whole class, discuss the following questions.

4. Compare the amount of fluids you each consume daily. Calculate the average.
5. Compile a list of the first three ingredients in fluids commonly consumed to find out what is being consumed along with water.
6. Suggest ways in which people are most likely to become dehydrated and what steps can be taken to avoid dehydration.
7. Some people think that bottled water is bad for the environment. They are concerned about the waste of water in unfinished bottles and the plastic bottles that end up in landfill sites. Suggest ways to meet the body's water needs without creating environmental problems.

2.3 Plant and Animal Cellular Processes

Here is a summary of what you will learn in this section:

- Cellular processes are continuous.
- The conversion and transport of energy are key cellular processes.
- Cells are replaced through the process of cell division.

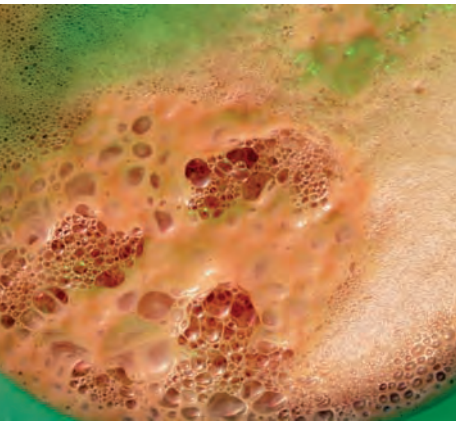


Figure 2.32 When yeast interacts with sugar, it produces carbon dioxide as a waste product.

Whether you are awake or asleep, sitting watching a show or playing soccer, your cells are busy places. Just like a busy factory, materials are arriving in your cells, being used in production, and the waste and final products are being transported out.

The materials entering a cell through diffusion and osmosis and other transport mechanisms are raw materials to be used by the various organelles. Those organelles are breaking materials down to convert energy, transporting energy, building proteins, and sending chemical messages.

Cells also expel waste products. While a tiny cell regularly emits a tiny amount of waste, an organism with a trillion cells finds itself with a lot of waste in its system.

A30 *Starting Point*

Skills A C

Yeast in Action

Yeast is a unicellular fungus used in the preparation of baked goods. Its dried form is mixed with warm water and sugar and added to flour to make light-textured breads and cakes.

How does this work? Yeast cells consume sugar and use the starches in flour to make more sugar. They generate carbon dioxide as a waste product during the process (Figure 2.32). The gas is trapped in the dough, creating small bubbles. The carbon dioxide is eliminated during baking, and the final product is filled with small pockets of air.

You can test for yeast in action.

What to Do

1. Inflate a balloon several times to stretch it out. Set it aside.
2. Pour 250 mL of warm water into a 500-mL recyclable water bottle. Add one package of baker's yeast and about 30 mL of granulated sugar. Swirl the mixture.
3. Stretch the balloon over the mouth of the bottle.

Question

4. What change did you see in the balloon? What is causing this change?

A31 *During Reading*

Thinking Literacy

Visualizing the Cell as a Factory or a City

Visualizing as you read helps you use experiences, senses, and prior knowledge to better understand what you are reading. As you read pages 51 and 52, note the different organelles and their specialized jobs in cells.

What to Do

Using the metaphor "the cell is a factory" or "the cell is a city," visualize how each part of a cell could be represented by a part in a factory or a city. Draw your cell as a factory or city. Use a legend to identify organelles and their visual counterparts, and explain the workings of your cell factory or cell city to a partner. What other metaphors could you create for a cell?

Transforming Energy

All cellular activities such as growth, repair, and reproduction need energy. Mitochondria provide energy for the cell by transforming oxygen and sugar (food) into carbon dioxide and water. This process is called **cellular respiration**, which occurs in both plant and animal cells.

In plant cells, chloroplasts produce the sugar needed by the mitochondria in a process called **photosynthesis**. In photosynthesis, the chlorophyll in chloroplasts captures the Sun's energy so the chloroplast can convert carbon dioxide and water into sugar and oxygen. In this way, energy is transformed from sunlight into sugar in plants (photosynthesis) and then sugar is consumed to release useable energy in both plant and animal cells (cellular respiration).

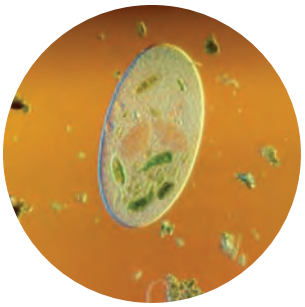


Figure 2.33 This paramecium has ingested (eaten) two smaller organisms, called euglena. The green euglena are visible inside the paramecium near the bottom of the micrograph. Through the process of digestion, the paramecium extracts sugars produced in the chloroplasts of the euglena and provides them to its own mitochondria for energy production.

Processing and Transporting Materials

What happens when water, gases, and nutrients enter cells through the cell membrane? Materials move through the cytoplasm to the various organelles. The endoplasmic reticulum makes proteins from raw materials that come into the cell and passes them to the Golgi apparatus. The Golgi apparatus processes protein molecules and secretes them outside the cell to be used elsewhere in the organism. Lysosomes break down food and digest wastes. All of this cellular activity is controlled by the nucleus.

Reproducing

Cells have a lifespan — amoebas live for approximately two days. Human brain cells live between 30 and 50 years. Human red blood cells live for 120 days. Skin cells live for 20 days. What does this mean? In the case of your skin, it means that your skin cells are replaced approximately every 20 days.

In fact, in the average human body, with its several hundred trillion cells, approximately three billion cells die every day. Cells die because they have been damaged, because they have not received enough water or food, or because they have reached the end of their lifespan. Given these losses, you might expect that multicellular organisms are constantly shrinking. This does not happen, however, because before the cells die, they create a replacement for themselves through cell division.

During cell division, cells split in half to form two smaller cells. The nucleus splits into two first. The rest of the cell then divides.

Cell division is easiest to see in a unicellular organism. Figure 2.34, below, shows the process. First, the cell's nucleus splits in two. Then the membrane begins to pinch near the middle to divide the cytoplasm, including its organelles, and ensure that each new cell has a nucleus. The two new cells are identical. The same process occurs in the cells of your body.

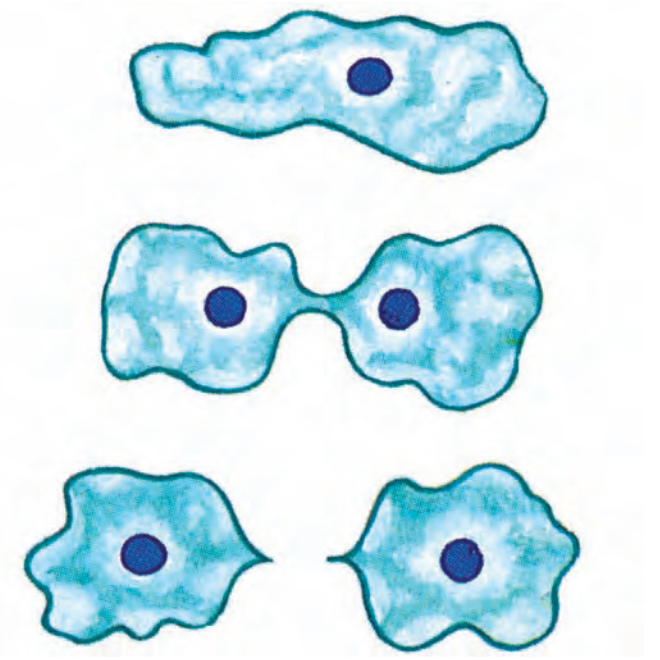


Figure 2.34 First, the nucleus divides into two. Then the cell membrane pinches to divide the cytoplasm. Two new, identical cells result from cell division.

Take It **Further**

Using your muscles frequently and with increased intensity will increase the number of mitochondria in your muscle cells. Find out more about how using your muscles will increase your ability to transform energy. Begin your research at ScienceSource.

In the case of a plant cell, instead of pinching in half after the nucleus divides, a new cell plate develops across the cell to create a new cell wall between the two nuclei (Figure 2.35).

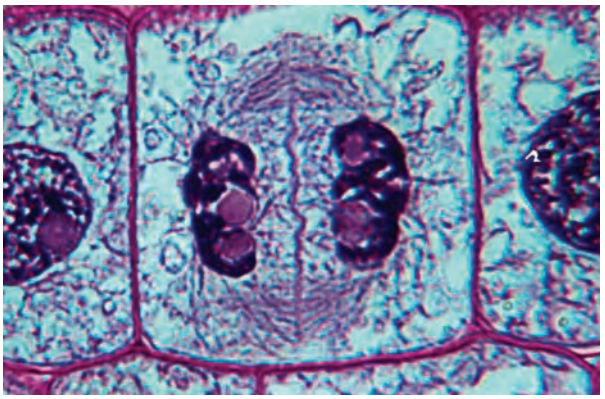


Figure 2.35 Plant cells divide by developing a new cell wall.

A32 Quick Lab

Modelling Diffusion

Purpose

To model the diffusion of molecules through a selectively permeable membrane

Materials & Equipment

- 600-mL beaker
- 250-mL beaker
- water
- cornstarch
- measuring spoons
- non-resealable plastic sandwich bag
- twist tie
- iodine

CAUTION: Iodine will stain skin and clothing.

Procedure

1. Put approximately 200 mL of water in the large beaker. Add about 10 drops of iodine, and set the beaker aside. Note the colour of the solution.
2. Put approximately 100 mL of water in the smaller beaker. Measure 2 tablespoons of cornstarch into the water and mix it thoroughly. Pour the solution into the bag. Seal it with a twist tie. Note the colour of the solution.
3. Submerge the bag with the cornstarch solution in the iodine water bath. Keep the twist tie above the level of the liquid. Leave the bag in the bath for approximately 10 min.
4. Remove the bag from the iodine bath, taking care not to drip the iodine solution onto clothes or other surfaces.
5. Observe the cornstarch solution in the bag.
6. Follow your teacher's instructions in cleaning up everything you used.

Questions

7. What colour was the cornstarch solution at the beginning of the activity? What colour was the cornstarch solution at the end of the activity?
8. What colour was the iodine bath at the beginning of the activity? What colour was the iodine bath after the bag with the cornstarch solution was submerged in it?
9. Did the cornstarch diffuse out of the bag into the iodine solution? How do you know?
10. Did the iodine diffuse through the bag into the cornstarch solution? How do you know?
11. Explain your results.

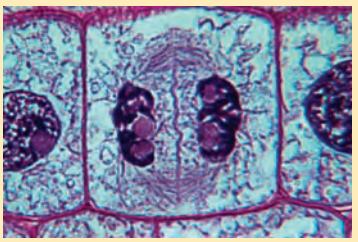
2.3 CHECK and REFLECT

Key Concept Review

1. Name three cellular processes.
2. What time of the day or night is best for cellular activities?
3. Describe the process of cell division in your own words.
4. Name three reasons why cells die.

Connect Your Understanding

5. Explain how cell division is linked to cell theory.
6. This is a picture of a plant cell. Describe what is happening in this picture.



Practise Your Skills

7. Explain how building a model can help you understand scientific processes.

For more questions, go to ScienceSource.

A33 *Thinking about Science, Technology, and Society*

Helping Cells, Harming Cells

Healthy human cells divide to produce new cells on a regular basis. When cancer develops, cells are dividing uncontrollably, and the body is harmed. Some cancers are hard to detect and result in premature death.

Finding technology to stop the cancer process is a goal of cancer research. Current treatment is based on two key therapies: chemotherapy and radiation therapy (Figure 2.37). Both therapies are expensive.

Figure 2.37 Radiation therapy can harm both cancer cells and healthy cells.

What to Do

Go to ScienceSource to research the topics in steps 1 and 2.

1. Find out how the two therapies work, and write an explanation of each in terms of what you know about cells.
2. Find out and describe the effect of each of the two therapies on cancer cells and on healthy cells.

Consider This

With a classmate or as a whole class, discuss the following points.

3. Use what you know about cells and cellular processes to explain how cancer patients can recover from these therapies.
4. As the number of cases of cancer increases, how can society make sure that all patients can get the treatment they need?

Microbiologists at Work

Figure 2.36 Microbiologists study cells and cellular processes, as well as other microorganisms.

Many early researchers studying "things too small to be seen with the unaided eye" were inspired by a desire to understand what caused disease. The earliest suggestion that microorganisms were a factor was published in 1835 after a study of fungi affecting silkworms. The theory that germs were responsible for many illnesses was being discussed by 1847. Louis Pasteur published the theory in 1857.

As the germ theory gained acceptance, the medical profession began to change their practices to include more attention to cleanliness and sterilization. Many more of their patients survived as a result.

The Role of Improved Technology

German electrical engineer Ernst Ruska constructed the first electron microscope in 1931. Since Ruska's innovation, microscopes and techniques for studying cells have become more advanced. At the same time, the discoveries by microbiologists have become increasingly influential in the way diseases are diagnosed and treated.

Careers in Microbiology

The study of microbiology has expanded steadily since the 1930s and has become increasingly specialized. There are now a variety of careers in a variety of fields.

- **Bacteriologists** study bacteria.
- **Environmental microbiologists** study microorganisms in the environment.
- **Food microbiologists** study microorganisms that spoil food and cause illness.
- **Industrial microbiologists** study microorganisms in order to make useful products (biotechnology).
- **Medical microbiologists** are doctors studying diseases caused by microbes.
- **Microbial epidemiologists** study the role of microorganisms in illnesses and health.
- **Mycologists** study fungi.
- **Protozoologists** study protists.
- **Virologists** study viruses.

Questions

1. Research a career in microbiology. Start your reseach at ScienceSource.
2. Prepare a report that includes the following information:

   (a) the education required

   (b) a place of work

   (c) a description of possible main duties

   (d) a recent important discovery in the field

2.0 Chapter Review

Assess Your Learning

After Reading

Thinking Literacy

Reflect and Evaluate

The study of science is often a study of similarities and differences or comparisons and contrasts. A study of ecosystems, for example, is about biotic and abiotic factors. A study of fluids can be about fast or slow, thick or thin. This study of cells is about same or different, unicellular or multicellular, plants or animals.

Research tells us that our brains work in the same way. They store information based on similarities and retrieve information based on differences.

With a partner summarize what you have learned from this chapter in the form of a 5-4-3-2-1 organizer.

List:

- 5 new learnings
- 4 similarities and differences between plant and animal cells
- 3 key differences between unicellular and multicellular organisms
- 2 ways visualization helps you as a reader
- 1 question you still have

Key Concept Review

1. Define the term "cell specialization" in your own words. (k)
2. How do diffusion and osmosis help amoebas survive? (k)
3. How do diffusion and osmosis limit the size of a cell? (k)
4. Explain why visible structures, such as fins, beaks, and tails, look so different on different organisms. (k)
5. Unicellular organisms move in many different ways. Use words and pictures to explain how each of the following organisms moves: (k)
   (a) paramecium
   (b) *E. coli* bacteria
   (c) amoeba

Connect Your Understanding

6. Phytoplankton are unicellular organisms that live in the ocean. How is their existence important to your survival? (t)
7. A unicellular organism is a living thing that meets all of its basic needs with just one cell. A multicellular organism can require up to several trillion cells to do the same thing. Which one do you consider to be more advanced? Explain your reasoning. (t)
8. You need to collect a live sample of an amoeba for study in class. Where would be the best natural environment to collect this sample? Why? (a)

Practise Your Skills

9. What is the correct procedure for handling a sample of pond water? (k)
10. Some algae reproduce every 24 hours if conditions are ideal. If it takes 15 days for the algae to half-fill a pond, how long will it take to fill the whole pond? What assumption did you make in order for this to happen? How likely is this to occur? Explain your reasoning. (a)

ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

11. You are examining a sample of pond water, and you notice organisms passing through your field of view. You are out of methyl cellulose, so your teacher suggests making a new wet mount and adding a few threads of cotton from a cotton ball to the slide before adding the cover slip. What effect will this have? t

12. Sean and Krista were working on the Modelling Diffusion activity (A32) in class. They observed no change in the cornstarch solution. Suggest and explain two possible reasons why this might have happened. t

Unit Task Link

Review the list of key features and functions that you made at the end of Chapter 1. Use the list to make notes on the cellular processes you learned about in this chapter. Remember to include diffusion and osmosis.

A34 Thinking about Science, Technology, and Society

Protecting Cells in the Environment

Synthetic chemicals are chemicals that are produced in a laboratory. Synthetic chemicals are used for cleaning, preserving, and decorating as well as for fuelling our machines. Think of the bleaches, soaps of all kinds, hair gels, make-up, polishes, perfumes, varnishes, paints, gasoline, and oil you use or come into contact with during your regular activities. Synthetic medicines help treat illnesses. All of these synthetic materials are helpful to society.

Many of the chemicals that make up these materials have entered the soil and water systems and are now found in the cells of plants and animals. Some synthetic chemicals are suspected of disrupting cell processes in one of two ways: either by causing uncontrollable cell reproduction (cancer) or by interfering with the reproductive processes of organisms and causing sterility or physical deformities.

What to Do

1. Create a two-column chart. In the first column, list the synthetic chemicals and medicines you have used or have been in contact with in the past week.

2. In the second column, note how the materials are disposed of. For example, are they thrown in the garbage or put into the water system?

Consider This

With a classmate or as a whole class, discuss these questions.

3. Do you think new chemicals should be made available for use before their effects on cells are known? Explain your reasoning.

4. Many people think that the disposal of chemicals should be regulated carefully. Suggest ways in which this could be done.