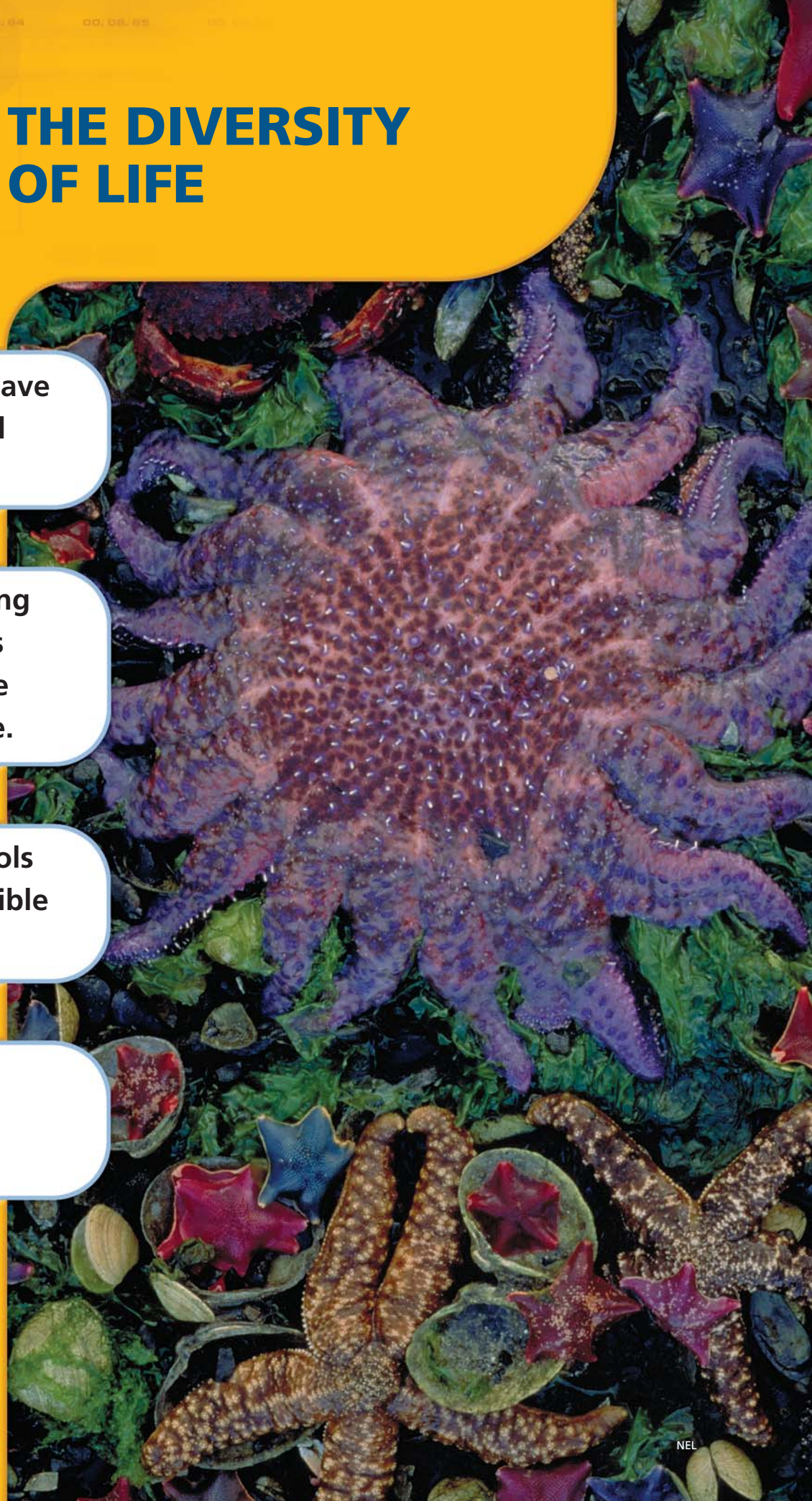
UNIT A

THE DIVERSITY OF LIFE



CHAPTER 1 Living things have similarities and differences.

CHAPTER 2 Classifying living things helps us understand the diversity of life.

CHAPTER 3 Magnifying tools make the invisible world visible.

CHAPTER 4 Living things adapt to their environments.

Preview

Welcome to life—the most amazing show on Earth! Our planet is crawling, swimming, hopping, and buzzing with living things. They come in every colour, shape, and size you can imagine, from giant trees that tower over us to tiny bacteria that can only be seen with a microscope. There is life on barren mountaintops, in sunbaked deserts, in the deepest oceans, and in the icy waters of the Antarctic Ocean. In fact, there isn't any place on Earth where life doesn't exist. Even more amazing, Earth is the only place where life does exist—as far as we know.

Look at the photo on this page. How many different living things can you see? Why does life come in so many different forms? Do you know what makes all forms of life alike in some ways? Do you know what makes them like you?

In this unit, you will discover the answers to these questions and many other questions about living things. You will learn how scientists observe living things and classify them into groups. Like a scientist, you will use a microscope to investigate living things that are too tiny for just your eyes to see. As you do these activities, you will follow the same steps that scientists follow as they explore the incredible diversity of living things. What you discover might surprise you!

TRY THIS: MAKE A LIVING WORLD WEB

Skills Focus: questioning, predicting

1. Create a web that shows what you already know about the variety of life on Earth. Write the words "Life on Earth" in the centre. Radiating from the centre, write different questions about the diversity of life on Earth. For example, you could include questions such as these: What does it mean to be living? What kinds of living things exist? How do living things adapt to survive? What do I know about living things?
2. Beside each question, write a "best guess" answer. Do not worry about being correct. Use your imagination!

A tidal pool in Burnaby Narrows, Queen Charlotte Islands, British Columbia, contains a variety of life like these colourful sea stars.

CHAPTER 1

Living things have similarities and differences.

KEY IDEAS

- Living things share characteristics.
- Living things share basic needs.
- Living things are diverse.

It is easy to see how the dolphins and the snorkelling child in the photo are different from each other. The dolphins are in their natural habitat, while the child is using fins and a snorkel to swim in the water. But how are they the same? The dolphins and the child are just two examples of the incredible diversity of living things on Earth. In this chapter, you will discover that dolphins and children, as well as every other living thing, are surprisingly alike in many ways.

The Characteristics of Living Things

1.1

The world around us is made up of both living and non-living things. But how do we tell the difference? Look at **Figure 1**. Which things are living and which are non-living? Are the rocks living things? Is the lake itself a living thing? What is the difference between the twigs growing on the tree's branches and the twigs in the bird nest?

Figure 1
What living things do you see in this picture? What non-living things do you see?

LEARNING TIP

You have already studied living things in earlier grades. Look at the headings in this chapter and review what you know about the similarities among living things.

One way to identify living things, or **organisms,** is to look at the characteristics they have in common.

Living things

- are made of one or more cells
- grow and develop
- reproduce
- respond

Non-living things, such as rocks and buildings, do not have these characteristics.

LEARNING TIP

Important vocabulary words are highlighted. These are words that you should learn and use when you answer questions. These words are also defined in the glossary at the back of this book.

Living things are made of one or more cells. A **cell** is a tiny, microscopic structure that is the basic unit of all living things. Some living things, such as the bacteria shown in **Figure 2**, are made up of only one cell. Other living things, such as the deer shown in **Figure 3**, contain many cells. You are made of trillions of cells.

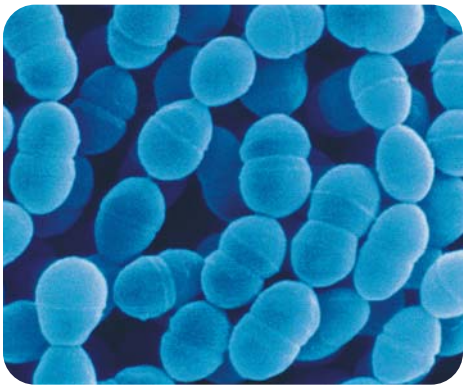


Figure 2
Bacteria

Figure 3
Deer

Living things grow and develop. Some organisms, such as a butterfly, change shape as they grow and develop. **Figure 4** shows the life cycle of a butterfly. Other organisms, such as a cat or a human, are born looking like miniature adults. Most organisms have a life span—the maximum time that they can live. Some bacteria live for only a few hours. A mayfly's life span is one to three days, and a human's life span is over 110 years. Some plants and fungi can live for more than 10 000 years!

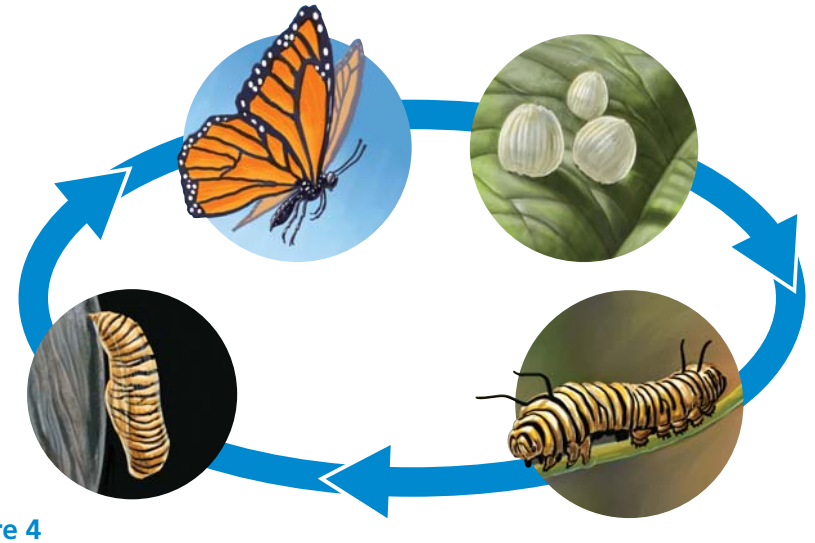


Figure 4
A caterpillar grows and develops into a butterfly.

Living things reproduce to form more of the same kind of organism. These offspring are also able to reproduce. There are many methods of reproduction. Some organisms, such as humans, give birth to live young. Other organisms, such as birds and fish, hatch from eggs. **Figure 5** shows a bald eagle nesting in a tree. Plants develop from seeds or spores. Bacteria reproduce by splitting into two identical cells.

Figure 5
A bald eagle

Living things respond. For example, if you touch something hot, you respond by quickly pulling your hand away. Or if you look into a bright light, you respond by squinting your eyes. Some plants, such as sunflowers, respond to light by turning towards it (**Figure 6**).

Figure 6
Sunflowers take their name from the way they turn to face the Sun.

CHECK YOUR UNDERSTANDING

1. Look at **Figure 1**. What is the difference between the fish in the lake and the fish in the net?
2. Which main characteristic of living things does each statement represent?
   - You are constantly losing skin cells.
   - A rabbit gives birth to babies.
   - Lobsters can live for 50 years.
   - A tadpole develops into a frog.
   - Bacteria divide to form two identical, smaller cells.
   - A sow bug rolls itself into a ball when it is touched.
3. Choose an organism that lives in your community. Use the characteristics of living things to show that it is a living thing.

1.2 The Needs of Living Things

TRY THIS: IDENTIFY A PLANT'S NEEDS

Skills Focus: observing, inferring, communicating

Obtain a geranium or bean plant from your teacher. Cut two pieces of aluminum foil into shapes, such as rectangles or triangles. Attach each foil shape to a leaf using a paper clip, as shown in **Figure 1**. Put the plant in a window, where it will get plenty of sunlight. After three or four days, remove the foil shapes from the leaves. Record your observations in your notebook.

1. What happened to the leaves with the shapes?
2. What does this tell you about the needs of plants?

Figure 1
Make sure that the foil shape covers at least half of the leaf and that it covers both the top and the bottom.

Figure 2
Aphids suck the sap from plants.

All organisms have the same basic needs. They must find these things within their environments, or they will die.

Living things need nutrients and energy. Nutrients are substances that organisms need to keep healthy and grow. Nutrients are found in foods and in the soil. Organisms also need energy to grow and develop, and to reproduce. Different organisms use different types of energy. Plants use the Sun's energy to make their own food. The aphids in **Figure 2** feed on plants. Spiders and birds eat the aphids. In this way, the Sun's energy is passed from one living thing to another.

Living things need water. Water is the main ingredient of the cells of all living things. You, for example, are about two-thirds water! Without water, you could live for only a few days. Some organisms, such as the cactus in **Figure 3**, can live in a very dry environment by storing moisture in their stems or leaves.

Figure 3
A prickly pear cactus in Fraser Canyon, British Columbia.

Living things need air. You, and other organisms that live on land, get oxygen from the air. Fish use oxygen in the water. Marine mammals, such as the orca in **Figure 4**, come to the surface for oxygen. Green plants use carbon dioxide, water, and sunlight to make food.

Figure 4
The orca breathes air at the surface.

Living things need a habitat, or a place to live. A habitat may be a hole in a tree or an isolated mountaintop (**Figure 5**). It is a place where an organism has living space and the right conditions, such as nutrients and energy, water, air, and temperature, to survive. Usually, many organisms share a habitat. For example, coral reefs provide a habitat for many plants, animals, and other marine organisms.

Figure 5
The habitat of the mountain goat includes steep cliffs and rocky slopes.

CHECK YOUR UNDERSTANDING

1. In your notebook, make a table like the one below. Use what you have learned about the needs of organisms to complete your table.

Need of organism	Two examples of how organisms meet this need
nutrients and energy	- Plants get energy from the Sun. -
water	
habitat	

2. How do you meet each of the basic needs listed in the table? (For example, you get energy from the food you eat.)

1.3 Design Your Own Experiment

SKILLS MENU

○ Questioning	● Observing
○ Predicting	● Measuring
● Hypothesizing	○ Classifying
● Designing Experiments	● Inferring
● Controlling Variables	● Interpreting Data
○ Creating Models	● Communicating

What Factors Affect the Growth of a Potato?

All plants need energy from the Sun, water, and a habitat that provides the right temperature to live. Each of these needs is a factor, or variable, in the plant's survival. Design an experiment to test how sunlight, water, and temperature affect the growth of two potatoes.

Question

How does the amount of energy from the Sun, water, or temperature affect the growth of potatoes?

Hypothesis

Write a hypothesis that answers the question. Make sure that you complete your hypothesis with a short explanation of your reasons. Write your hypothesis in the form "If . . . then . . . because . . . ."

LEARNING TIP

For help with this activity, read the Skills Handbook sections "Designing Your Own Experiment," "Hypothesizing," and "Controlling Variables."

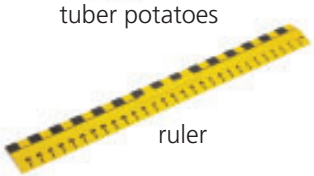
Materials

- apron
- 2 tuber potatoes
- ruler

Decide what other materials you will need. Check with your teacher to make sure that these materials are safe for you to use.

apron

tuber potatoes



ruler

Procedure

- Design a procedure to test your hypothesis. A procedure is a step-by-step description of how you will conduct your experiment. It must be clear enough for someone else to follow your instructions and do the exact same experiment.
- Submit your procedure, including any safety precautions, to your teacher for approval. Also submit a diagram, at least half a page in size, showing how you will set up your experiment.

Data and Observations

Create a table to record your observations. Record your observations as you carry out your experiment.

LEARNING TIP

When you make observations, it is important to be accurate and complete. Read the Skills Handbook section "Observing" to learn about the different types of observations and why each one is important.

Analysis

1. Describe the growth of the potato that received the lesser amount of the variable you tested. How well did it grow?
2. Describe the growth of the potato that received the greater amount of the variable you tested. How well did it grow?
3. How does the variable you tested affect the growth of potatoes?

Conclusion

Look back at your hypothesis. Did your observations support, partly support, or not support your hypothesis? Write a conclusion that explains the results of your experiment.

Applications

1. How could you use what you learned from your experiment when growing plants at home?
2. Why would your conclusions be important information for a garden store or for a grocery store that doesn't want the potatoes to grow?

CHECK YOUR UNDERSTANDING

1. How did your understanding of the needs of living things help you form a hypothesis for your experiment?
2. What was the independent variable in your experiment? What was the dependent variable?
3. Why was it important to change only one variable?

1.4 Living Things Are Diverse

You have learned that all living things are alike in some ways. They share certain characteristics and they have the same basic needs. But aside from these similarities, living things come in an astonishing variety of forms (**Figure 1**). In fact, the most amazing thing about life is the variety, or diversity, of living things on Earth.

Figure 1
What are some of the differences between the scarlet macaw and the whale shark?

For example, living things come in all sizes, from the towering giant sequoia (**Figure 2**) to organisms that are so small they cannot be seen with the naked eye (**Figure 3**). Magnifying tools, such as microscopes, have allowed scientists to identify thousands of tiny organisms, including some that live on and inside our bodies. You will use magnifying tools to look at living things in Chapter 3.

Figure 2
The largest giant sequoias are as tall as a 26-storey building.

Figure 3
A bacterial cell can only be seen under a microscope.

Organisms also get their food in different ways. Plants can make their own food. They use sunlight to turn carbon dioxide and water into food in a process called photosynthesis [foh-toh-SIN-thuh-sis]. However, there are some plants, like the Venus flytrap, that capture and eat small insects (**Figure 4**). Fungi, such as mushrooms, live right on their food source. Animals have to look for their food sources. For example, think about how you get your food. You have to search for your food, even if it's just in the kitchen. In general, animals eat plants, other animals, or the remains of living things (**Figure 5**).

Figure 4
The Venus flytrap is able to make its own food and feed on insects that it captures.

Figure 5
The great blue heron eats fish, turtles, and frogs.

LEARNING TIP

Look at the three pairs of photos in this section. Think about what is being compared in each pair of photos.

Organisms move in every imaginable way. Some move along on legs (**Figure 6**). Those with wings, such as robins and bats, are able to fly overhead. Some organisms, such as fish and marine mammals, swim through the water using fins or flippers. Plants, on the other hand, remain in one place for their entire lives.

There is a great diversity of organisms on Earth and new organisms are discovered every day. Scientists have now identified over 1.7 million different organisms; however, they believe there may be more than 10 million organisms that have not yet been identified. In the next chapter, you will look at how all these diverse organisms can be organized.

Figure 6
Although this giant desert centipede doesn't have 100 legs (as its name implies), it does have two legs on each of its body segments.

CHECK YOUR UNDERSTANDING

1. What are some of the ways that organisms differ from one another?

Awesome SCIENCE

The living world is full of strange and wonderful creatures—and lots of surprises!

SPIDERS BY THE MILLION!

Scientists were amazed to discover a 24-hectare spider web covering a field of clover east of McBride, British Columbia. When they took a closer look, they found tens of millions of spiders (about two spiders per square centimetre), frantically engaged in the mystery building project. The scientists don't believe that the monster web was meant to be a giant insect trap because the spiders did not seem interested in the insects caught in it. But they still don't know what it was. One scientist joked that maybe the spiders were trying to catch a sheep! How could the scientists find out more about this strange phenomenon? What would you want to find out?

GREAT IMPOSTERS

With eyes like these, it's no wonder that the swallowtail caterpillar scares off predators. Or are they eyes? In fact, they're eyespots—markings that look like the eyes of a much larger creature. Eyespots are an example of mimicry. They are an effective way to keep from becoming someone's lunch!

The hawk moth is another great mimic. The snake-like appearance of the hawk moth caterpillar scares predators looking for a tasty feast. As a mature moth, its brown wings and shape easily blend into the bark of a tree. This makes it nearly impossible to see. Can you find other examples of organisms that use mimicry to survive?

REALLY SMALL-SCALE FARMING AND RANCHING

Humans are not the world's only farmers, or even the world's first farmers. In fact, the world's first farmers were leaf-cutter ants. These tiny ants cut out small pieces of leaves, chew them up, and leave them to decompose. The fungus that grows on the decaying mass is harvested and used as the ants' main food supply.

Other ants are ranchers, herding aphids onto young, sap-rich plants. The ants protect the aphids from predators to get their "milk"—the honeydew that the aphids excrete. The ants feed this milk to their young. What other characteristics do ants and humans share?

JUST GROW IT AGAIN!

What would you get if you cut a flatworm into four pieces? Wait two weeks and you'll have four new worms! A flatworm can regenerate, or grow back, a lost part of its body.

How does this happen? The secret is in the cells. A flatworm has stem cells that can be sent into action when its body has been damaged. Stem cells are not specialized. They can become any type of cell. For the flatworm, they develop into tissue for the other half of the worm's body. How could understanding regeneration be helpful to humans?

OPEN WIDE!

The leatherback turtle is the largest and most ancient species of sea turtle living today. Although it does not have any teeth, it can sure bite hard! It uses two upper "fangs" to capture a jellyfish. Then it uses long, backward-facing spines in its mouth to swallow the meal. In fact, the leatherback's mouth protects it so well that it can eat a poisonous Portuguese man-of-war jellyfish without even getting stung!

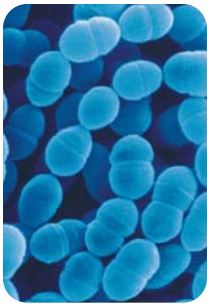
GIANT DRAGONS DO EXIST!

It is 3 m long and has razor-like teeth and poisonous saliva. If that's not bad enough, it can run as fast as a dog for short distances. Fortunately, the Komodo dragon is found on only a few small islands in Indonesia. While it gets the name "dragon" from its fearsome characteristics, it is actually the world's largest lizard. In addition to its speed and its ability to spot objects up to 300 m away, it's the dragon's sense of smell that makes it so deadly. Whipping its long tongue in and out, the Komodo dragon samples the air and can find a meal 4 km away. What can you infer about the sense organs on the Komodo dragon's tongue?

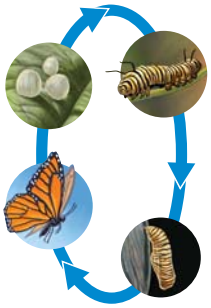
1 Chapter Review

Living things have similarities and differences.

Key Idea: **Living things share characteristics.**



They are made of one or more cells.



They grow and develop.

They reproduce.

They respond to light.

Vocabulary

organisms p. 5
cell p. 6

Key Idea: **Living things share basic needs.**

Nutrients and energy

Water

Air

Habitat

Key Idea: **Living things are diverse.**

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. Create two columns on a piece of paper. Compare a salmon and a tomato plant, based on the characteristics of living things.

2. How is each of the following organisms meeting its needs?
   - Worms burrow into the ground.
   - Mudpuppies are solitary. They build walls around their territory to keep others away.
   - The Gila monster stores fat in its tail.
   - A Venus flytrap snaps shut when it senses an insect on its leaves.
   - A frog soaks up water through its skin.
3. What do scientists mean when they talk about the "diversity of life"?

Use What You've Learned

4. Volcanoes grow over time. Use what you have learned about the characteristics and needs of living things to explain whether or not volcanoes are living things.

5. Look at the photo below. Name an organism that could survive in this environment. How would the organism meet each of its needs?

6. When would it be important to understand the differences between living and non-living things?

Think Critically

7. List at least five benefits of living on a planet that has such a diversity of organisms.

Reflect on Your Learning

8. List three questions that you still have about living things. Glance through the rest of this unit. Do you think your questions will be answered in the topics that are covered? If not, where can you go to find the answers?

CHAPTER 2

Classifying living things helps us understand the diversity of life.

KEY IDEAS

- People use classification systems to organize the diversity of living things.
- Living things can be unicellular or multicellular.
- Scientists classify organisms into groups based on internal and external features.
- Scientists classify living things into five kingdoms: Animalia, Plantae, Fungi, Protista, and Monera.

Have you ever hunted through your bedroom for a favourite T-shirt or CD? If you have, then you know how frustrating it is not to be able to find something you want. You also know that if you sorted things into groups, it would be easier to keep track of them. How are the things grouped in the above photo? How does each system help us find what we are looking for?

Scientists also sort things into groups so that they are easier to understand. There is such an incredible diversity of life on Earth. Living organisms come in all sizes, shapes, colours, and textures. How do scientists classify all these different organisms into groups?

Ways of Classifying Living Things

2.1

When you classify things, such as books or DVDs, you put the things that have similar characteristics together. These characteristics could be topic, author, or size. Sorting things into groups makes it easier to keep track of them.

Organizing things according to their similarities and differences is called classification. You used a **classification system** to sort living and non-living things in Chapter 1. You found that living things share the same characteristics and needs.

But how could you further classify all the thousands of living things around you? People use different systems, depending on what they want to know and what is important to them. For example, if you were on a deserted island, the first thing you would probably want to know is which plants you could eat and which plants you couldn't. Eventually, you would need and want to know much more. Grouping living things according to your observations helps you keep track of your knowledge.

TRY THIS: GROUP ORGANISMS

Skills Focus: observing, classifying

Look at the organisms in **Figure 1**. You can group them in many different ways. For example, you can group them by how they move, what they eat, where they live, and what they look like.

1. Explain how you would group these organisms.
2. What characteristics did you use to group these organisms?

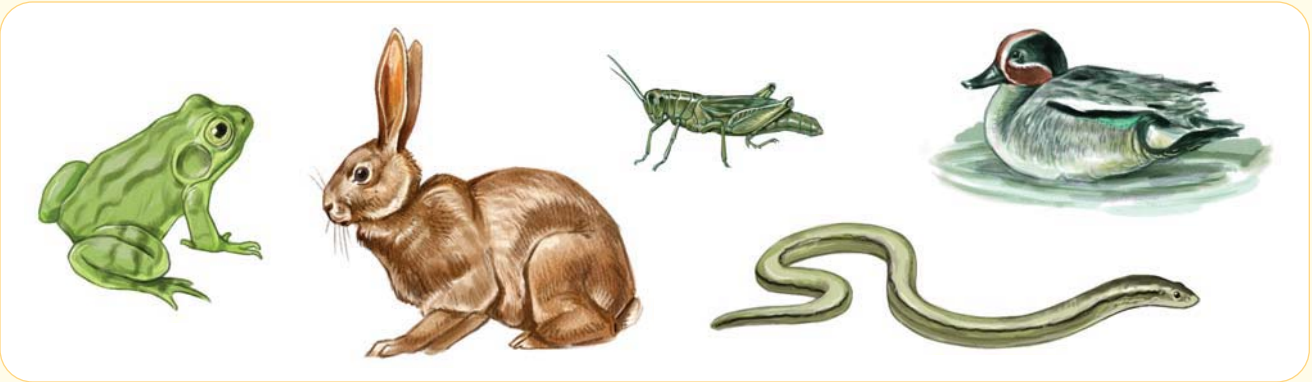


Figure 1

Traditional Ways of Classifying Living Things

All people use classification systems to organize their knowledge of the living things around them. In the past, people relied on their detailed knowledge of living things to help them survive on the plants and animals that were available to them.

Aboriginal peoples, for example, use classification systems that are based on careful observation of the living world. The Aboriginal peoples of the northwest coast of British Columbia, for example, have classified over 200 different plants according to their uses, such as food and medicine (**Figure 2**). This information has been passed from generation to generation.

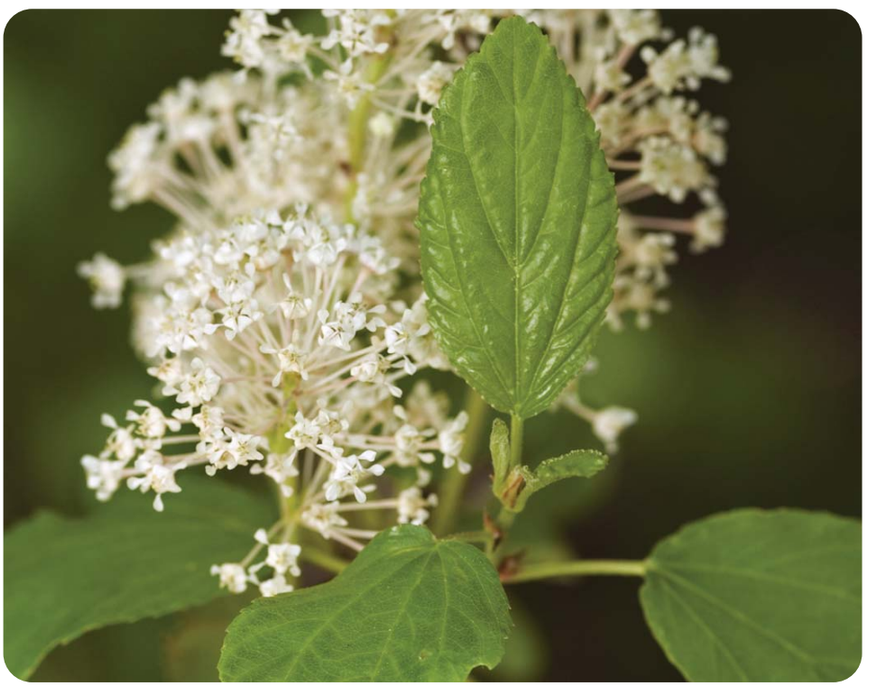


Figure 2
Some Aboriginal peoples use the leaves and twigs of the wild lilac plant to treat pain.

Aboriginal peoples also classify animals according to important characteristics. For example, they classify animals according to which animals are useful and which are dangerous, or where the animals are found. They also classify animals on the basis of helpful information, such as the season in which the animals can be hunted or the animals' use as a source of clothing or food.

Scientific Ways of Classifying Living Things

Scientists use classification systems to help understand the diversity of life on Earth. They examine the internal structures (cells and organs) and external structures (what the organism looks like) of living things to discover how organisms are similar and how they are different. They use microscopes and other forms of technology to compare organisms in a very detailed way (**Figure 3**). For example, they can compare the cell structure of different organisms. They can also compare organisms from around the world to discover how different organisms may be related.

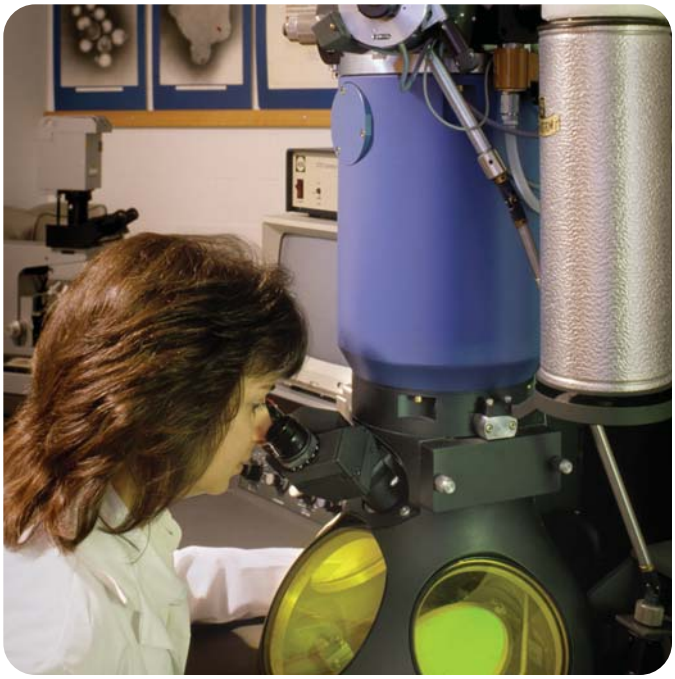


Figure 3
A scientist uses an electron microscope to look at an organism.

CHECK YOUR UNDERSTANDING

1. Copy the following chart into your notebook. List at least five classification systems that you use to organize things. Explain how each classification system makes your life simpler. The first row is filled in for you.

1. Different Classification Systems

Classification system	Use	How it makes life simpler
alphabetical order	telephone book	find names quickly

2. Explain how Aboriginal peoples classify organisms. How does their system differ from the way scientists classify organisms? How is it the same?

2.2 The Key to Classification

Scientists classify organisms by looking at their characteristics. They then develop questions that will help them identify and classify organisms. For example, they might ask whether an organism makes its own food. If the answer is yes, then the organism is probably a plant. If the answer is no, the organism is not a plant. This set of questions is called a classification key. It helps scientists find similarities and differences among a group of organisms. Let's see how a classification key works.

Identifying Berries Using a Key

Aboriginal peoples have learned to recognize edible berries and to avoid poisonous berries and berries that taste bad. They carefully observe the leaves of a plant and the way that the berries grow on the plant. How would you know which berries were safe to eat in the woods?

Which of the berries shown in **Figure 1** would be good to eat? You can use a classification key to help you decide. Look at the key in **Figure 2**.What characteristics are being described?

LEARNING TIP

If you want to know more about how Aboriginal peoples classify things, ask your teacher if it is possible to bring in an Aboriginal Elder as a guest speaker.

Figure 1
Which of these berries would you eat?

1. a	berries grow along the stem	go to 2
1. b	berries grow in one area on the stem	go to 3
2. a	single berries 	huckleberries = edible
2. b	berries in clusters on a stem 	go to 3
3. a	single leaves with teeth 	wild cherry = edible but can taste bitter
3. b	leaves divided into leaflets from a central stalk 	go to 4
4. a	dark velvet red berries	sumac = edible but tastes sour
4. b	powdery blue berries	blue elderberry = edible

Figure 2
A classification key

LEARNING TIP

To use the classification key, choose one of the berries shown in **Figure 1**. Then read statements 1. a and 1. b in **Figure 2** to see which statement describes the berry. Then follow the directions in the next column. Keep following the key until you find the name of the berry.

The key first asks you to look at where the berries are found on the plant (whether they grow along the stem or only on one place on the stem). You then consider whether the berries grow in clusters or as single berries. The next step is to look at the leaves of the plant. Finally, the key uses the colour of the berries. All of these characteristics describe the external, physical structures of the plant.

Use the classification key to name and classify the berries in **Figure 1**. Which berries would you eat?

CHECK YOUR UNDERSTANDING

1. How would you explain a classification key to someone? Write three or four sentences that explain what a classification key is, how it is used, and when it would be a useful tool.
2. Give two reasons why it is important to be able to identify an organism.
3. Can you name another characteristic of berries that could have been used in the key?

2.3 Solve a Problem

How Can Plants be Classified?

LEARNING TIP

To review the steps in problem-solving, see the Skills Handbooks section "Solving a Problem."

Problem

A botanist has just moved into your community. **Figure 1** shows some of the plants that she has classified. She wants to classify the local plants and has asked you to help.

Leafy aster

Deer fern

Western flowering dogwood

Figure 1
Native British Columbia plants

Task

Create an effective classification key to identify five plants based on their leaves and stems.

Criteria

To be successful, your classification key must

- use external, physical characteristics of the leaves and stems
- provide two choices for each of the characteristics in your key
- be accurate and reliable

Plan and Test

1. With a partner, collect a leaf that is attached to a stem from five different plants. Look for specimens that are already on the ground.
2. Label each specimen with a name or a number.
3. Select three or four characteristics that you can use to create a classification key for the five leaves (**Figure 2**).
4. Create a classification key.

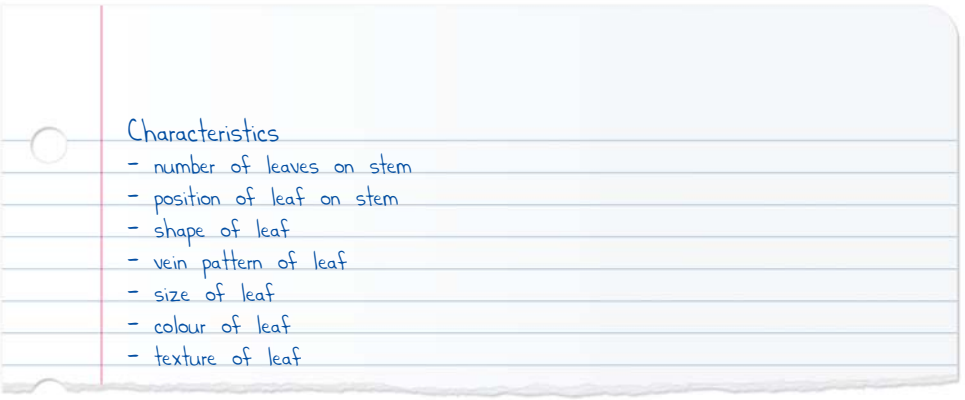


Figure 2

Evaluate

5. Explain your classification key to a classmate. Ask for feedback as to how you could make your key clearer.

Communicate

6. Exchange leaves and keys with a classmate. Ask him or her to use your classification key to identify your five leaves. Was your classmate successful?

CHECK YOUR UNDERSTANDING

1. How did feedback from a classmate help you develop a better classification key?
2. Why are observation skills so important when creating and using a classification key?

Healing with Plants

Long before there were doctor's offices and pharmacies, the Aboriginal peoples of British Columbia were experts on using plants to ease pain and treat illnesses.

The Coast Salish peoples, for example, used the leaves of the stinging nettle plant (**Figure 1**) to treat aches and pains. The Interior peoples brewed a tea from the twigs and leaves of the wild lilac plant to ease rheumatism and arthritis pain and to cure diarrhea. The Shuswap peoples had a different purpose for the wild lilac. When left boiling, it was an excellent insect repellent. The Ulkatcho [ul-GAT-cho] (Williams Lake) peoples used the yarrow plant (**Figure 2**) to treat sore muscles. The leaves of the yarrow plant were used as a mosquito repellent by rubbing them on the skin or tossing them in a fire. The roots were used to make a tea that could cure a stomachache.

Today, there are fewer and fewer people in Aboriginal communities who have detailed knowledge of medicinal plants to pass on to younger generations. Dr. Nancy Turner (**Figure 3**) is working with Aboriginal Elders to preserve this knowledge. For the past 30 years, she has worked closely with Aboriginal Elders in British Columbia to document their knowledge and understanding of plants and ecosystems. Dr. Turner considers the Elders to be teachers and friends. Her hope is that their valuable knowledge will be preserved for the benefit of their communities and the world.

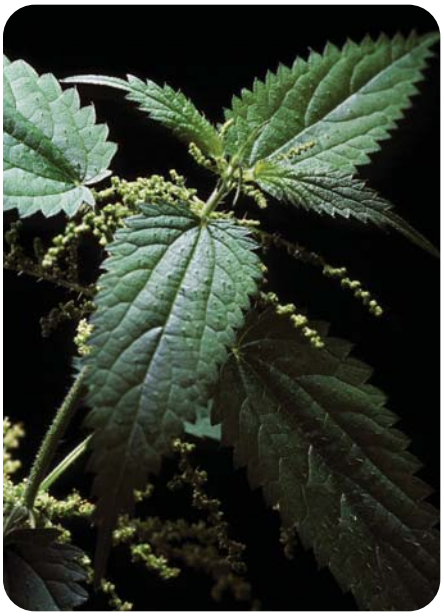


Figure 1
A stinging nettle plant

Figure 2
A yarrow plant

Figure 3
Dr. Turner is an ethnobotanist—a person who studies the classification and uses of plants in different human societies.

How Scientists Classify Living Things

2.4

TRY THIS: CLASSIFY LIVING THINGS

Skills Focus: classifying, communicating

How would you classify living things?

1. As a class, brainstorm all the different types of organisms that live on Earth. Fill the board or a large sheet of paper with the names of organisms.
2. With a partner or in a small group, classify all the organisms into five groups. Explain how or why the organisms in each group belong together.

Scientists use classification to help them understand the diversity of life on Earth. They look at the characteristics of living things and then develop questions to ask. For example, they ask whether the organism is made of one or more cells, how it gets the nutrients and energy it needs, and how it reproduces. The answers allow scientists to identify and classify any organism they discover.

One Cell or More

People have always recognized two groups of living things: plants and animals. However, after the development of magnifying tools, such as microscopes, scientists discovered new organisms that were invisible to the naked eye (**Figure 1**). They also began to study the internal structures of organisms. With this knowledge, scientists had a much better picture of how organisms were alike and how they were different.

Figure 1
Some organisms, such as *Euglena*, cannot be viewed without a microscope.

LEARNING TIP

The prefix *uni-* means "one" or "single." The prefix *multi-* means "more than one." Think of other words you know that use these prefixes.

Using microscopes, scientists discovered that organisms have very different internal structures. One important difference is whether an organism is a single cell or is made of more than one cell. As you learned in Chapter 1, cells are the basic unit of life—the building blocks that make up all organisms. Scientists discovered that some organisms have a very simple structure. Their entire body is just one cell big. They are **unicellular** [YOO-nee-SELL-yur-luhr], or made up of one cell (**Figure 2**).

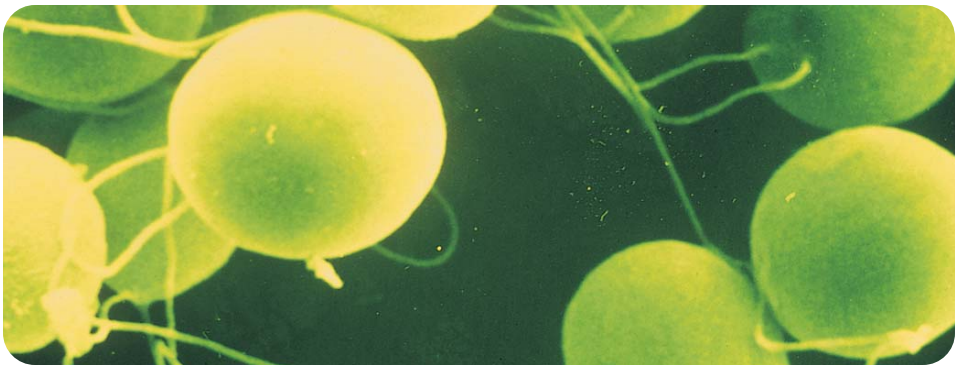


Figure 2
Chlamydomonas is a unicellular green alga.

Other organisms are more complex. They are **multicellular** [MULL-tee-SELL-yur-luhr], or have more than one cell in their bodies (**Figure 3**). In fact, most of these organisms are made up of trillions of cells. Multicellular organisms have different types of cells that perform different functions. Human beings, for example, have bone cells, skin cells, blood cells, and many other types of cells. Each type of cell has its own structure and specific purpose. All the cells of an organism work together to ensure that the organism can perform the functions it needs to survive.

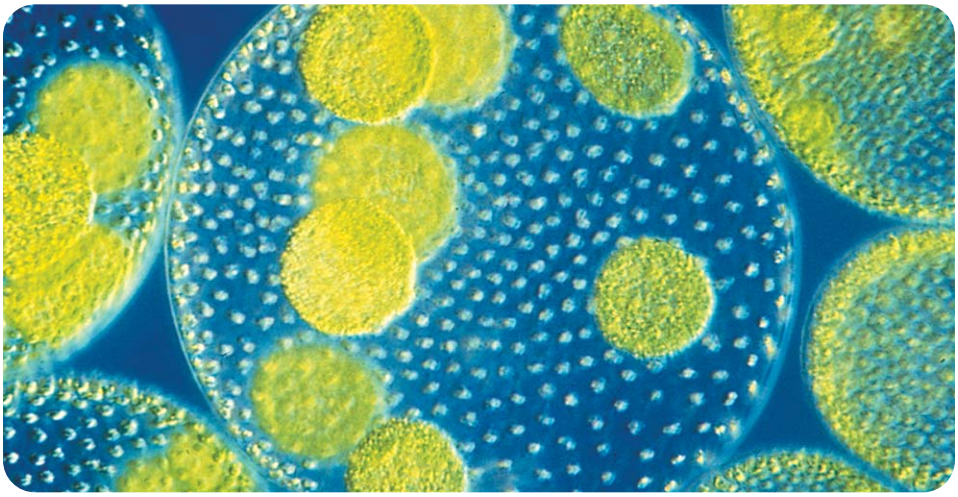


Figure 3
Volvox is a multicellular green alga that is made of thousands of cells.

Plant and Animal Cells

There are many different types of cells. Cells have different sizes, shapes, and functions. Let's look at some of the features of a typical plant and animal cell (**Figure 4**).

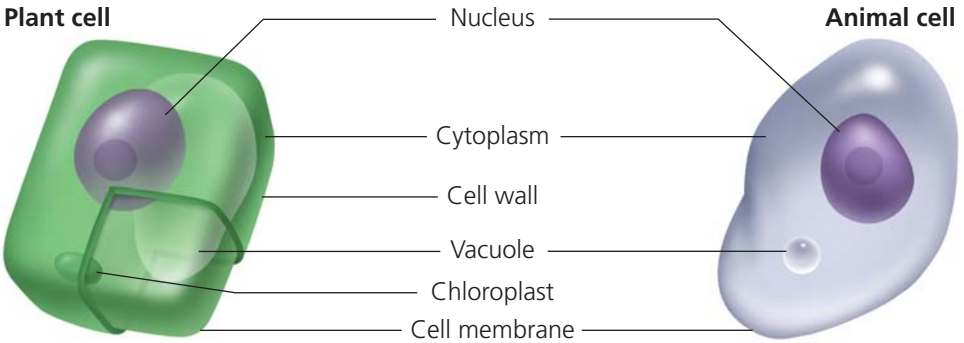


Figure 4
A plant cell and an animal cell

Both plant and animal cells have a **cell membrane.** The membrane is a thin covering around the entire cell. It encloses the cell's contents. It acts like a gatekeeper by allowing useful materials to move into the cell and waste to move out.

The innermost part of a cell is the **nucleus** [NOO-klee-us]. The nucleus acts as the control centre of the cell. It directs all of the cell's activities, such as movement and growth.

Much of a plant or animal cell is filled with a thick liquid called cytoplasm [SIGH-tuh-pla-zum]. The cytoplasm is where the work of the cell is carried out, as directed by the nucleus. Within the cytoplasm are bubble-like vacuoles [VAK-yoo-ole]. Vacuoles store water and nutrients.

Important differences exist between plant and animal cells. Unlike animal cells, plant cells are enclosed by a cell wall. The cell wall helps to protect the cell and provides support for the plant. Plant cells also contain **chloroplasts** [KLOR-uh-plahst], which are the parts of the cell that contain **chlorophyll** [KLOR-uh-fill]. Chlorophyll gives plants their green colour.

LEARNING TIP

Look at each of the highlighted words on the page. To help remember what they mean, find each word in the diagram. Then read the paragraph that describes the term. Now try to define each term using your own words.

TRY THIS: MAKE MODELS OF CELLS

Skills Focus: communicating

Use modelling clay to make a model of a plant cell and a model of an animal cell. Include all of the parts of a cell that were described in this section.

The Five-Kingdom Model of Living Things

As scientists learned more about the internal and external structures of organisms, they discovered that some organisms were like both plants and animals. Others didn't have the characteristics of either plants or animals. Modern scientists realized that there were at least five categories of living things, which they called **kingdoms.** **Figure 5** shows the five kingdoms of life. Each kingdom has important characteristics that all of its members have in common.

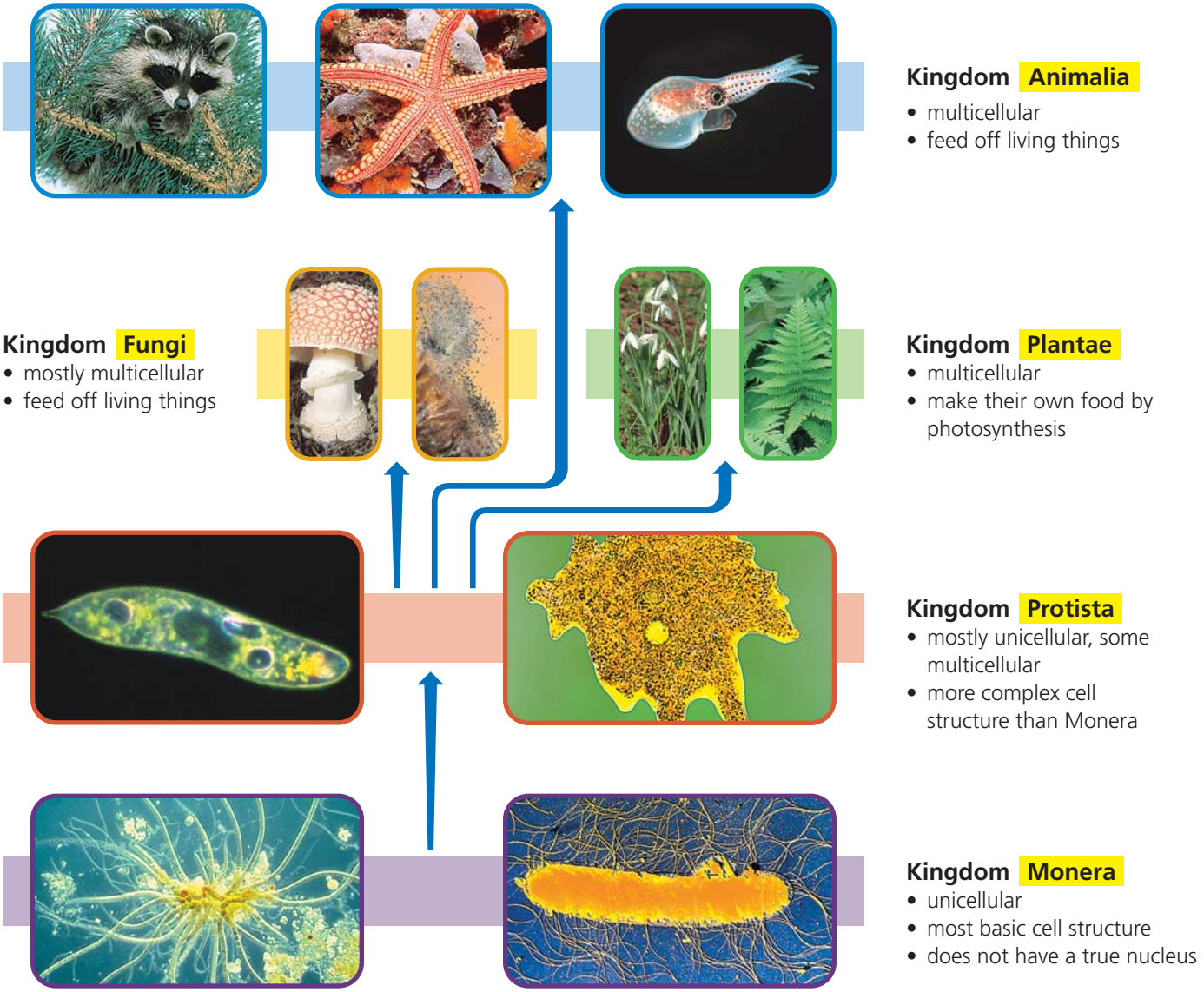


Figure 5
The five kingdoms of life

An International Classification System

Classifying organisms by kingdom is a good beginning. But there are many organisms in each kingdom. For example, there are over one million different types of organisms in the Animal kingdom. Scientists need a way to classify organisms into smaller, more manageable groups. They also need a common way of identifying and naming organisms so that they can describe, compare, and communicate their knowledge about different organisms.

Today, scientists around the world use a single scientific classification system for naming and classifying all organisms. This system was created, in 1735, by Carolus Linnaeus (**Figure 6**). Linnaeus was a Swedish scientist who was very curious about all of the living things he observed. He was the first scientist to divide living things into groups called kingdoms, although he proposed only two kingdoms: plants and animals.

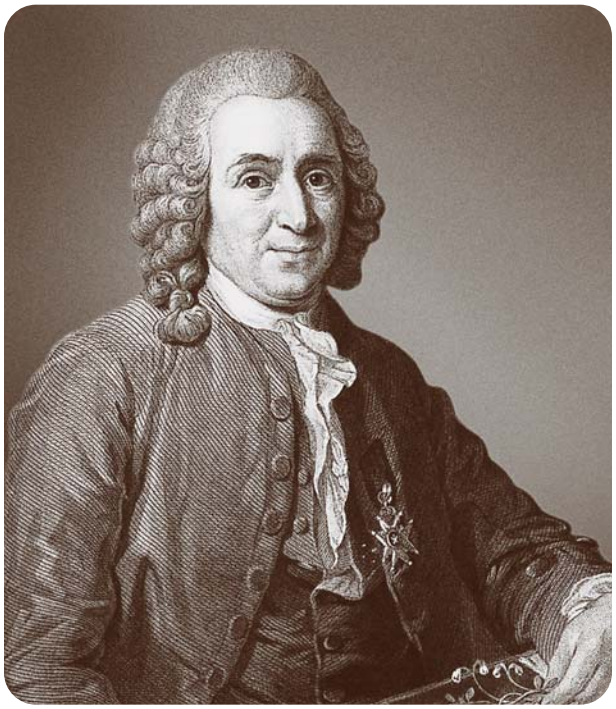


Figure 6
Carolus Linnaeus developed a classification system to organize living things.

Linnaeus proposed that each kingdom could be further classified into a series of smaller categories. His system of classification has seven categories in total. After kingdom comes phylum [FI-luhm], class, order, family, genus [JEE-nuhs], and finally the category of **species.** Organisms that belong to the same species are capable of breeding together and having offspring that can also reproduce.

LEARNING TIP

When you read a diagram, make sure to read the caption for help in understanding what the diagram shows. In **Figure 7**, read each sentence in the caption and check that you can see how the information is shown in the diagram.

Figure 7 shows how the seven-category system works. Follow the mountain lion, shown on the far right of the diagram, down through the levels. The mountain lion is a different species than the tiger, even though they are in the same family. So a mountain lion could not reproduce with a tiger.

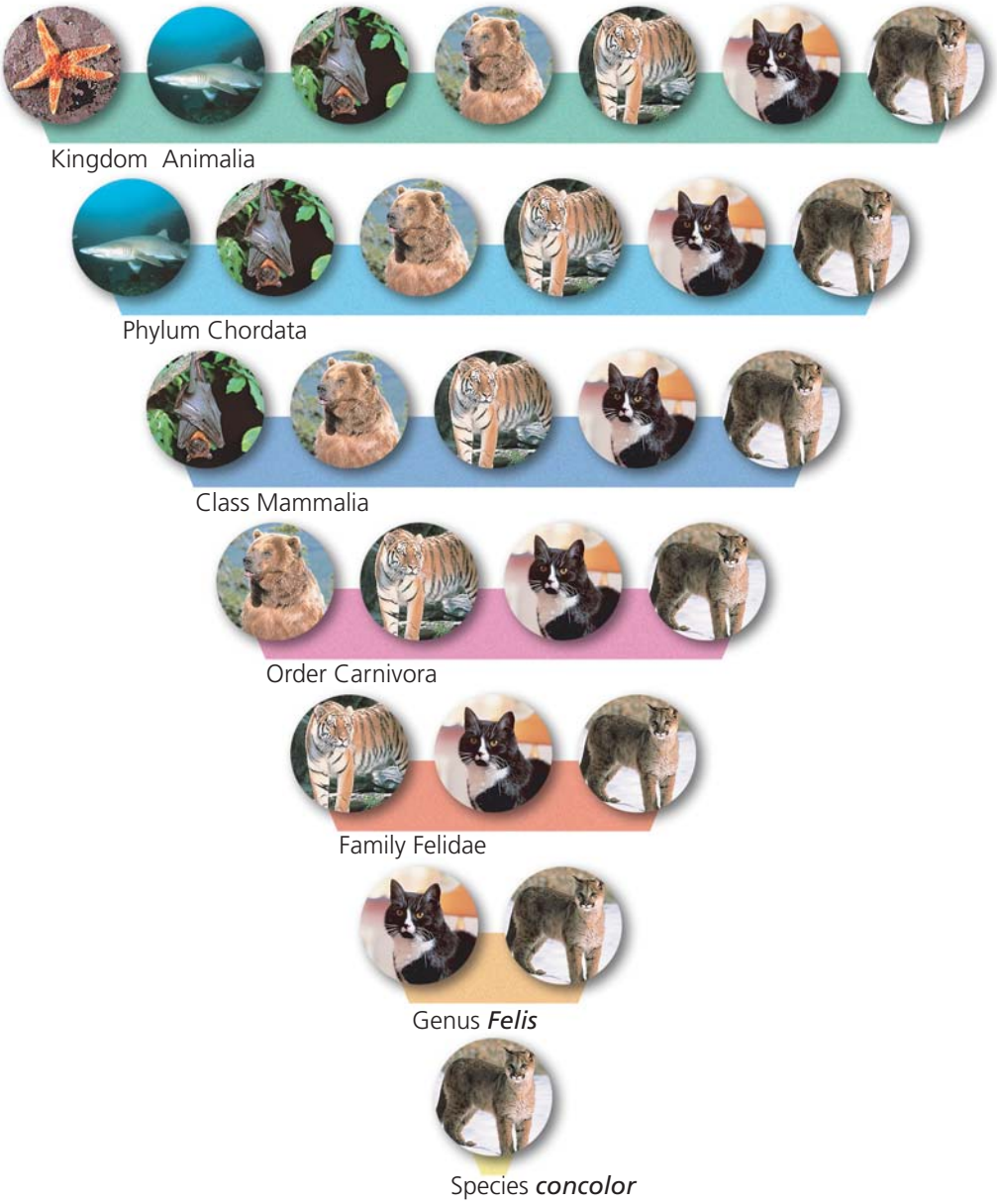


Figure 7

The mountain lion is a multicellular organism that gets its food from other living things, so it is a member of Kingdom Animalia. It has a backbone, so it is in the phylum Chordata. It is a mammal, so it belongs in class Mammalia. It feeds on meat, so it is in the order Carnivora. It is a cat, so it is a member of the family Felidae. It is placed in the genus *Felis*, along with the house cats we keep as pets. Finally, it is a member of the species *concolor*, a mountain lion.

A System of Naming

Linnaeus also developed a two-part system for naming organisms. This naming system made it easier for scientists around the world to communicate about the same organism. In this system, every organism has two Latin names. Just as you have a first and last name, each organism has a first name, called the genus name, and a last name, called the species name. The two-part Latin name for the mountain lion shown in **Figure 7** is *Felis concolor*. The two-part Latin name for humans is *Homo sapiens*.

LEARNING TIP

Linnaeus used Latin for his classification system. Latin is a language that was used by educated people in Europe in Linnaeus' time. Even though Latin is no longer spoken today, scientists around the world still use it as a common language for naming organisms.

CHECK YOUR UNDERSTANDING

1. Are you multicellular or unicellular? Refer to the five-kingdom classification system to explain your answer.
2. Copy the following table into your notebook. Complete the table using information from this section.

2. Structures in Cells

Cell part	Found in plant or animal cells, or both	Function
cell membrane		
cell wall		
nucleus		
cytoplasm		
vacuoles		
chloroplasts		

3. Explain why scientists need at least five kingdoms to group living things.
4. Use what you've learned to classify each of the following organisms into one of the five kingdoms.
   (a) This organism has four sharp claws so that it can climb trees and capture its prey.
   (b) This organism is smaller than the tip of a pin, but its cells can do everything it needs to stay alive.
   (c) This organism cannot move around by itself, but it can make its own food.
   (d) This organism attaches to and feeds off other organisms.
   (e) This organism is only one cell, but it is just as important as other living things.
5. A coyote's two-part name is *Canis latrans*. A dog's name is *Canis familiaris*. Are these two animals closely related? Explain your thinking.

2.5 A Closer Look at the Animal Kingdom

TRY THIS: LOOK AT DIFFERENT ANIMALS

Skills Focus: observing, inferring, classifying

The Animal kingdom is made up of many different organisms. For example, both a spider and an ant belong to the Animal kingdom. Work with a partner to make two specimen boxes that you can use to observe these small animals. Using a hand trowel or a spoon, carefully lift a spider into one of your boxes and an ant into the other. Observe the spider and the ant. When you have finished observing them, gently place them back where you found them.

1. How are these two animals the same? How are they different?
2. Compare the ant and the spider with another animal, such as a dog or a cat. What are some of the similarities and differences? Why do you think all these organisms belong in the Animal kingdom?

There are more than one million different species in the Animal kingdom. All animals are multicellular organisms that get their nutrients and energy by eating other organisms. But animals come in a great variety of forms, from spiders to sparrows to sponges (**Figure 1**). To better understand the diversity of animal life, scientists classify animals into groups based on their internal and external structures.

Figure 1
Although they may look like plants, sponges are simple animals.

Vertebrates and Invertebrates

Scientists divide all the organisms in the Animal kingdom into two main groups: **vertebrates** (animals with backbones) and **invertebrates** (animals without backbones). Vertebrates include birds, fish, and mammals. Invertebrates include insects, worms, squids, sponges, sea anemones, and crabs. Vertebrates are the animals that you're most familiar with, but invertebrates are much more common. Scientists estimate that invertebrates make up more than 95% of all animal species. One group of invertebrates—arthropods—includes all the world's insects, shellfish, and spiders. **Figure 2** shows some of the groups that make up the Animal kingdom.

LEARNING TIP

Check your understanding of vertebrates and invertebrates by describing the difference in your own words.

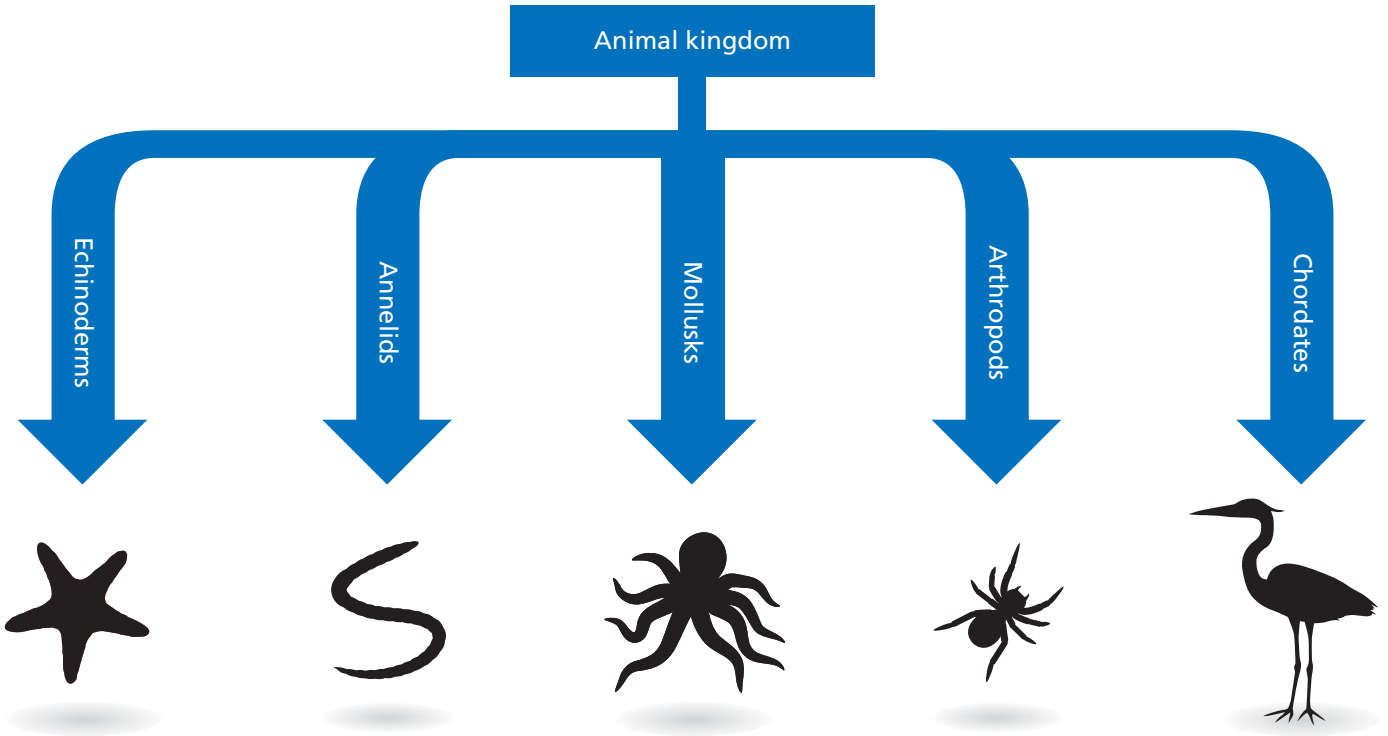


Figure 2
All vertebrates belong to the Chordate group.

Classes of Vertebrates

Scientists divide the vertebrates into classes, based on the internal and external structures they share. There are five main classes of vertebrates: **fish,** **amphibians,** **reptiles,** **birds,** and **mammals.** Each class is defined in **Table 1** on page 36. You are probably familiar with many of the animals in these classes.

Table 1 The Characteristics of Vertebrates

Class	Examples	Characteristics
Fish	salmon, whale shark, ray, seahorse	• live only in water • breathe through gills • use fins to move • lay eggs or give birth to live young • body temperature changes with the environment 
Amphibians	frog, toad, salamander	• young live in water and breathe through gills • adults live mainly on land and breathe with lungs • lay eggs in water • young change form as they grow, for example, growing legs • body temperature changes with the environment 
Reptiles	crocodile, alligator, lizard, snake, turtle	• some live on land; some live in water • breathe through lungs • most have claws that can be used to dig or climb • many lay soft, leathery eggs on land • body temperature changes with the environment 
Birds	eagle, parrot, cardinal, chicken, penguin, puffin	• breathe through lungs • have wings, feathers, and hollow bones • most can fly • lay eggs in a protective shell • hatchlings are cared for by parents • maintain a constant body temperature 
Mammals	dolphin, bat, mouse, kangaroo, lemur, human	• most live on land, some live in water • breathe through lungs • most have hair or fur covering their bodies • most give birth to live babies • mother produces milk to feed her babies • maintain a constant body temperature 

CHECK YOUR UNDERSTANDING

1. Explain why a spider is considered a member of the Animal kingdom.
2. What characteristic can you use to separate all animals into two groups?
3. Look at **Figure 3**. How can you tell that this animal is not a vertebrate?

Figure 3
An earthworm

4. Use **Table 1** as a guide to help you identify which class of vertebrates an organism would belong to if it had the following characteristics:
   - breathes through lungs and lays eggs that have a shell
   - lives in the water and breathes through lungs (**Figure 4**)
   - lives on land and lays eggs in water
   - has a constant body temperature and gives birth to live babies

Figure 4

2.6 A Closer Look at the Plant Kingdom

Figure 1
Grass and other plants provide food for bison and other living things.

The plant kingdom contains about 300 000 different species. Plants provide the food that all other living things depend on to survive (**Figure 1**). Plants also provide the oxygen we breathe. Plants are found everywhere on Earth, including in water, in soil, and even on rocks.

Like animals, plants are multicellular organisms. But unlike animals, plants make their own food. Plants use energy from the Sun to turn carbon dioxide from the air and water from the soil into food for themselves. They also produce oxygen, which other organisms breathe. Through this process, called photosynthesis, plants grow and become food for other living things (**Figure 2**).

Plants differ from animals in another important way. They are made of plant cells, as you learned earlier in this chapter. Plant cells have a cell wall, which helps to protect the cell and to support the plant. Plant cells also contain chlorophyll, which gives plants their green colour. Plants, unlike most animals, are also stationary and are attached to a surface, like soil.

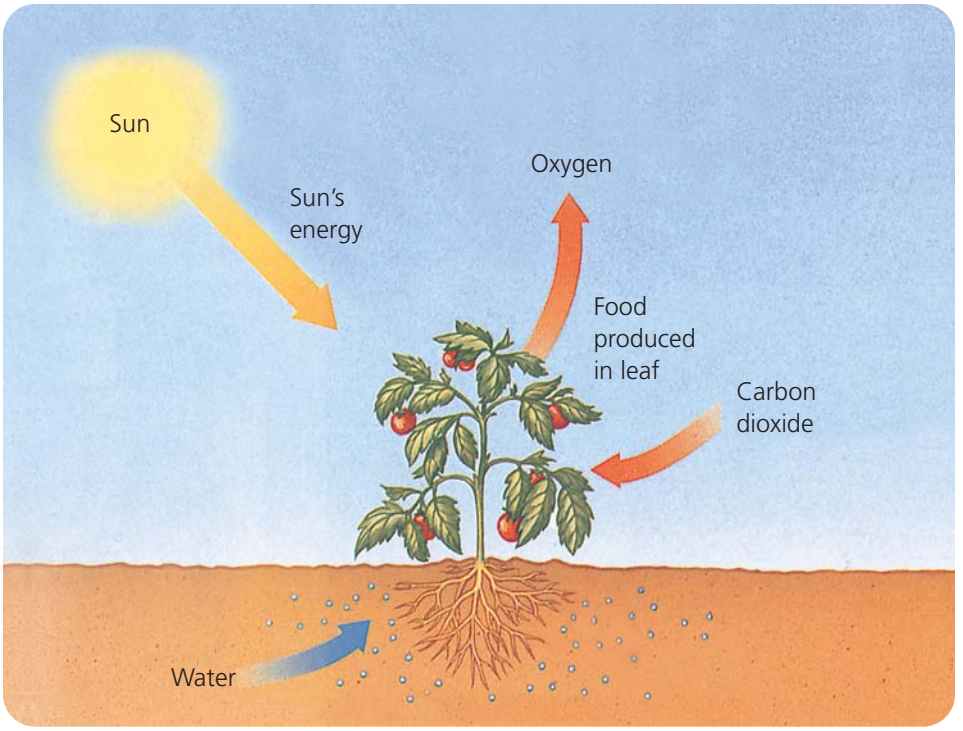


Figure 2
Plants produce their own food and oxygen using energy from sunlight, carbon dioxide from the air, and water from the soil.

Classifying Plants

To classify the thousands of different species of plants, scientists ask three important questions:

- Does it have roots, a stem, and leaves?
- Does it have tube-like structures inside it to help it transport water?
- Does it produce flowers or cones?

On the basis of these three questions, scientists classify plants into four main groups: mosses, hornworts, and liverworts (**Figure 3**); ferns and their relatives; conifers (**Figure 4**); and flowering plants. You are probably most familiar with flowering plants, ferns, and conifers. These three groups of plants have stems, leaves, and roots through which they transport food and water. They also have tubes inside that allow water and food to travel throughout the plant.

Figure 3
Liverworts can be found growing on the ground, on rocks, or even on other plants.

Figure 4
Conifers, such as pine trees, have cones.

TRY THIS: WATER TRANSPORT IN PLANTS

Skills Focus: questioning, observing, inferring, communicating

Look at **Figure 5**. What do you think would happen if you dipped the bottom of a stalk of celery into a glass of coloured water? Try it to find out. For best results, leave the celery in the coloured water overnight.

1. What did you see?
2. Explain your observations.

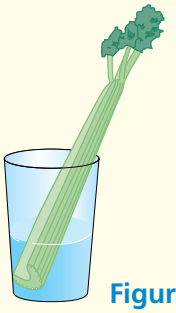


Figure 5

Mosses, hornworts, and liverworts do not have true roots, stems, or leaves, so they depend on their surrounding environment for water. Most of these plants live where it is moist. They are covered in leaf-like structures that allow the plants to absorb the water they require directly into their cells.

TRY THIS: LOOK AT PLANT CHARACTERISTICS

Skills Focus: observing, inferring

Look at a piece of moss and a dandelion plant. Lay the two plants next to each other on your desk so that you can compare them. Use small scissors and tweezers to carefully open the stem or stalk of each plant. Carefully make a cross-section cut in the root of the dandelion plant. Draw a picture of what you see.

Handle scissors and tweezers with extra care.

1. What parts of each plant can you identify? Use **Figure 6** to help you label your drawing.
2. What function does each part play? How does it help the plant live?
3. How are the stem and the stalk the same? How are the stem and the stalk different?
4. How do you think each plant reproduces?

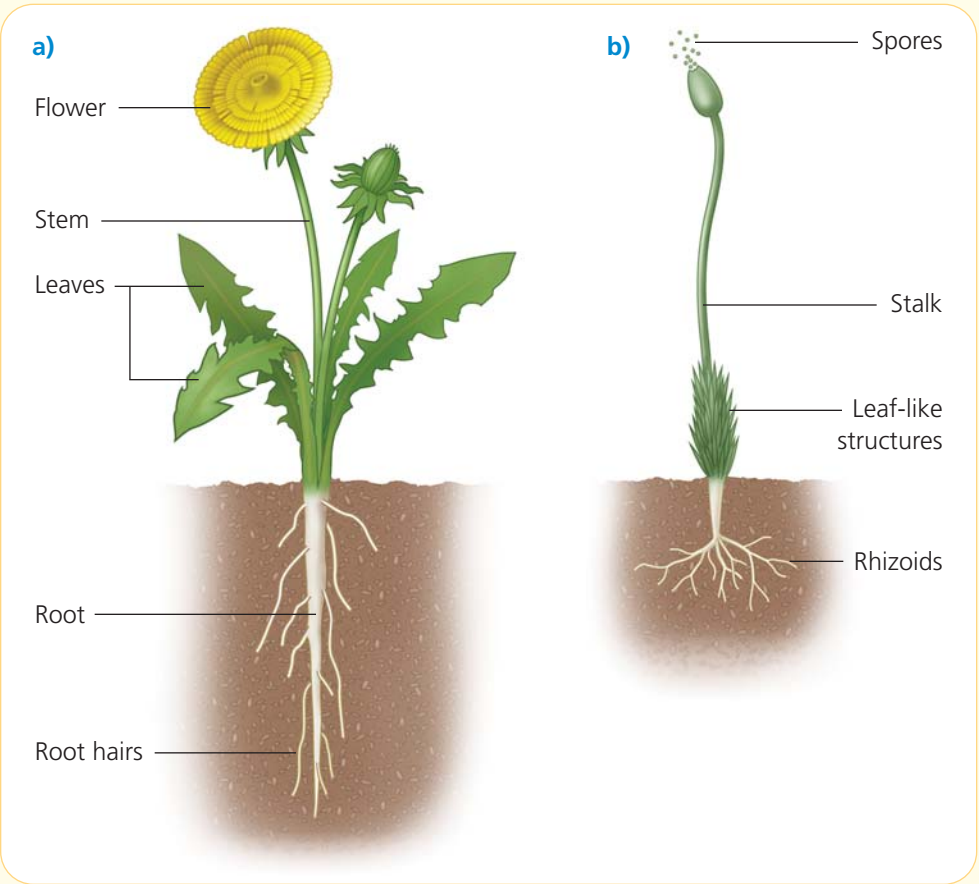


Figure 6
a) A dandelion plant
b) A piece of moss

How Plants Reproduce

Plants are commonly divided into three groups, depending on how they reproduce:

- plants that reproduce with spores
- plants that reproduce with seeds from cones
- plants that reproduce with seeds from flowers

Ferns reproduce by spores. The spores are found on the underside of a fern frond (**Figure 7**). They look like small tufts of soft fluff. The spores are scattered by the wind, fall to the ground, and sprout.

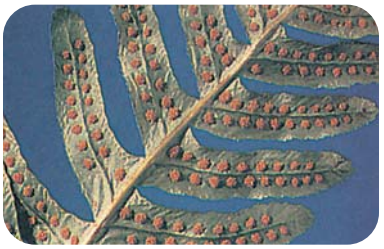


Figure 7
The spores are found under the leaves of a fern plant.

Conifers reproduce with cones. The seeds of the plant are inside these cones. When the cones open, the seeds are scattered by the wind or by animals.

Flowering plants produce seeds in a flower or a fruit. Flowering plants include most trees, shrubs, vines, and flowers. Most fruits and vegetables are also flowering plants.

Look at **Figure 8**. How do you think the seeds are dispersed? Plants that produce fruit have seeds inside the fruit. An animal eats the fruit and scatters the seeds far away. Some plants, such as milkweed, have seed cases that split open and release the seeds. Some plants produce seeds that appear to have wings or parachutes. These structures help the seeds scatter in the wind. Some seeds have tiny hooks that cling to the fur of animals. The seeds are dispersed as the animals move from place to place.

Figure 8

TRY THIS: LOOK AT HOW SEEDS DISPERSE

Skills Focus: observing, inferring

Think about all the ways that seeds can be dispersed. You may want to look in books or survey your neighbourhood. Make a chart to summarize the different methods of seed dispersal. For each method, draw the type of plant and the seed.

CHECK YOUR UNDERSTANDING

1. Discuss why plants are so important to life on Earth.
2. How are plants classified? Into which group would you put the rose?
3. Describe how plants reproduce.

2.7 A Closer Look at the Other Kingdoms

Scientists classify the organisms on Earth that are not plants or animals into three kingdoms of life. These kingdoms are: Kingdom Monera, Kingdom Protista, and Kingdom Fungi. The organisms in these kingdoms are not as familiar to us as plants and animals, but they are important to the lives of other living things, including humans.

Many of the organisms in these kingdoms are so tiny they can only be seen with a microscope. They are called **micro-organisms,** which means "tiny life." Micro-organisms can do everything that other organisms can do. They are made of cells, grow and develop, reproduce, and respond to their environment.

Let's take a look at some of the organisms and micro-organisms in the Kingdom Monera, Kingdom Protista, and Kingdom Fungi.

LEARNING TIP

The prefix *micro-* comes from Greek and means "small" or "tiny." So a micro-organism is just a very small living thing. *Micro-* starts many words in science and technology, such as "*microscope*," "*microprocessor*," and "*microwave*." Can you think of other words that start with *micro-*?

Kingdom Monera

Monerans are the simplest and smallest living things on Earth, but they are also the most widespread. They are unicellular, and do not have a true nucleus. Monerans live only in moist environments. Some Monerans can survive in extremely hot or salty environments, and some can even survive without oxygen! Monerans may also have been the first organisms on Earth.

Kingdom Monera includes one of the most important groups of micro-organisms: bacteria. Bacteria are the most plentiful organisms on Earth. They are present everywhere. **Figure 1** shows the three different shapes of bacteria.

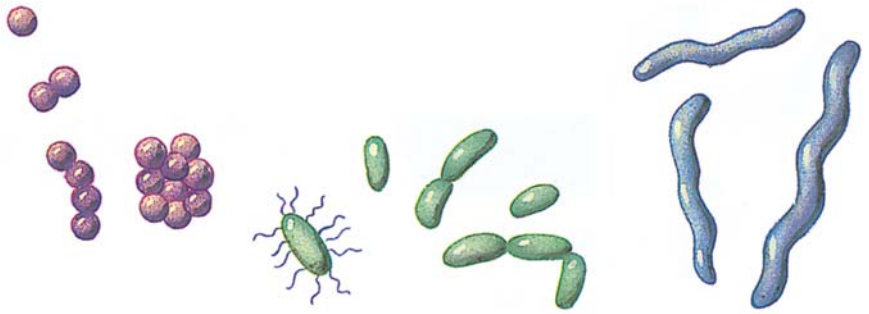


Figure 1
Bacteria come in three shapes: round, rod, and spiral.

Kingdom Protista

Organisms in the Kingdom Protista are more complex than monerans, but most are still only one cell. Protists do, however, contain a true nucleus. This kingdom also includes the simplest multicellular organisms.

Some protists, like algae [AL-jee] and diatoms [DI-uh-toms] (**Figure 2**) are like plants. They contain chlorophyll and they can make their own food through photosynthesis.

Figure 2
There are different types of diatoms. Diatoms make their own food.

Other protists, like paramecia [PAIR-uh-MEE-see-uh] and amoebas [uh-MEE-buhs] (**Figure 3**), are like animals. These organisms are called protozoa [PRO-tuh-ZO-uh]. They feed on other organisms.

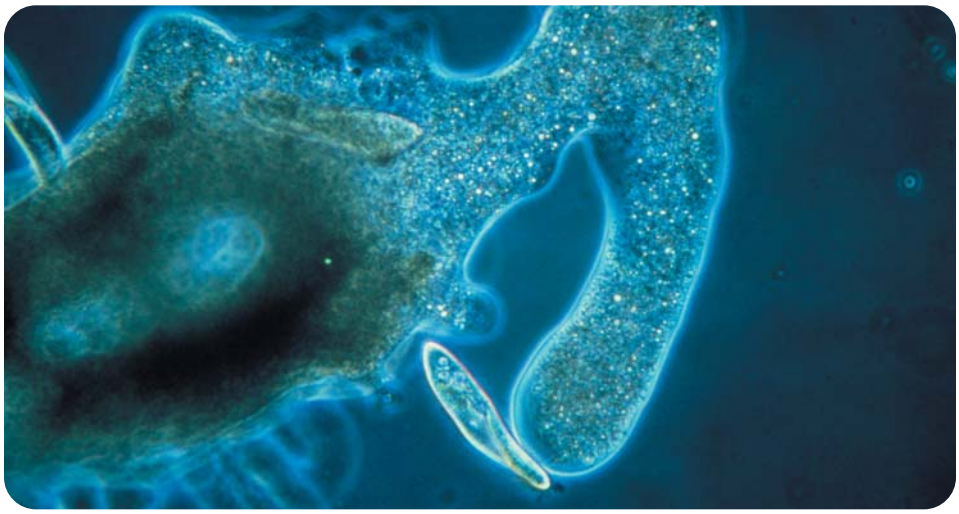


Figure 3
An amoeba engulfs its food.

Kingdom Fungi

Kingdom Fungi includes mushrooms, moulds, and yeasts. They can be unicellular or multicellular. Members of this kingdom are like plants in certain ways—fungi have a cell wall and are stationary. However, they do not make their own food, as plants do. Instead, they grow on or in their food.

Fungi range in size from large mushrooms and toadstools to micro-organisms like yeast (**Figure 4**). Different types of yeast are found in many natural habitats. They are common on the leaves and flowers of plants, both in water and on land. Yeast can also be found living on and inside the bodies of many other organisms, including you!

Figure 4
Yeast is a unicellular organism.

LEARNING TIP

It is easier to remember information when you connect it to your own life. What are some examples of harmful and helpful micro-organisms from your life?

What Do Micro-organisms Do?

Some people think that micro-organisms are our enemies. Although some micro-organisms are harmful, most are helpful (**Figure 5**). Life would be very different without them. Micro-organisms are everywhere—in the air we breathe, in the soil around us, in the food we eat, and even in our bodies.

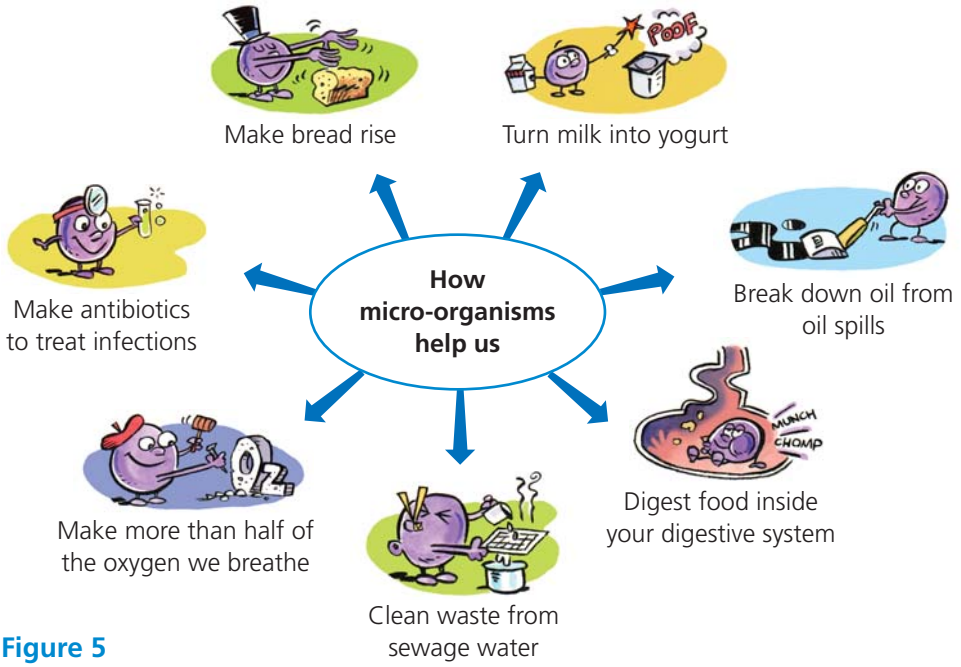


Figure 5

Unfortunately, not all micro-organisms are helpful. They can spoil food by covering it in mould. Some bacteria, such as *Escherichia coli (E. coli)*, can make you very sick. *E. coli* can live in meat products and is killed only if the meat is cooked thoroughly. Other micro-organisms cause diseases such as whooping cough, tetanus, and malaria. Malaria is caused by a micro-organism from the Kingdom Protista. This disease is transmitted when an infected mosquito bites a person.

CHECK YOUR UNDERSTANDING

1. Copy the following table into your notebook. Use information from this section to complete the table.

1. Examples and Characteristics of Micro-organisms

Kingdom	Monera	Protista	Fungi
Example of micro-organism			
Characteristics of micro-organism	1.	1.	1.
	2.	2.	2.

2. If two diatoms were together, would they eat each other? Why or why not?

3. Why are micro-organisms important in our lives?

2 Chapter Review

Classifying living things helps us understand the diversity of life.

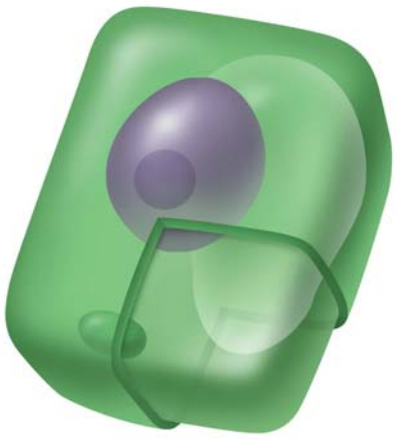
Key Idea: People use classification systems to organize the diversity of living things.

Vocabulary
classification system p. 19

Key Idea: Living things can be unicellular or multicellular.

Vocabulary
unicellular p. 28
multicellular p. 28

Key Idea: Scientists classify organisms into groups based on internal and external features.


Plant cell


Animal cell

Vocabulary
cell membrane p. 29
nucleus p. 29
chloroplasts p. 29
chlorophyll p. 29
vertebrates p. 35
invertebrates p. 35
fish p. 35
amphibians p. 35
reptiles p. 35
birds p. 35
mammals p. 35
micro-organisms p. 42

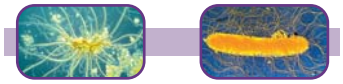
Key Idea: Scientists classify living things into five kingdoms: Animalia, Plantae, Fungi, Protista, and Monera.


Kingdom Animalia


Kingdom Plantae


Kingdom Fungi


Kingdom Protista


Kingdom Monera

Vocabulary
kingdoms p. 30
Animalia p. 30
Plantae p. 30
Fungi p. 30
Protista p. 30
Monera p. 30
species p. 31

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. Give two examples of how people use classification systems to help them organize their knowledge about living things.
2. Give an example of an internal structure and an example of an external structure that scientists use to classify organisms.
3. Every organism is either a single cell or made of more than one cell. What are the names for these two groups of organisms?
4. Name the five kingdoms of living things.

Use What You've Learned

5. Look carefully at **Figure 1**. List three characteristics that you could use to make a classification key for these organisms.

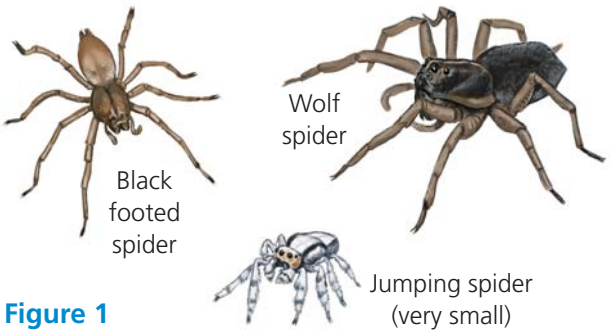


Figure 1

6. Look at the organisms in **Figure 2**. Explain how the organisms are alike. Explain how they are different.

Bracket fungi

Bindweed

Figure 2

7. If you were given an organism that looked like a plant, what characteristics would you look for to find out if it was actually a plant?
8. Imagine that you have discovered a new organism. Draw a picture of the organism. Which kingdom do you think it belongs in? Explain why.
9. Explain how each of the seeds in **Figure 3** are dispersed.

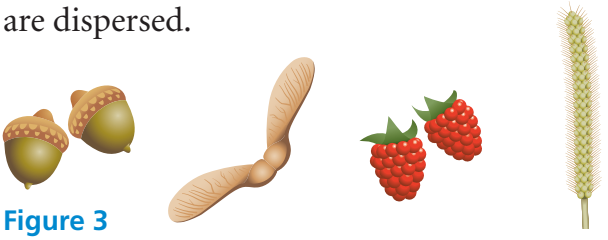


Figure 3

Think Critically

10. How can you distinguish between two species that look very similar? The two owls in **Figure 4** are different species. What external characteristics might a scientist have used to decide that they were not the same species?

Strix occidentalis
(spotted owl)

Strix varia
(barred owl)

Figure 4

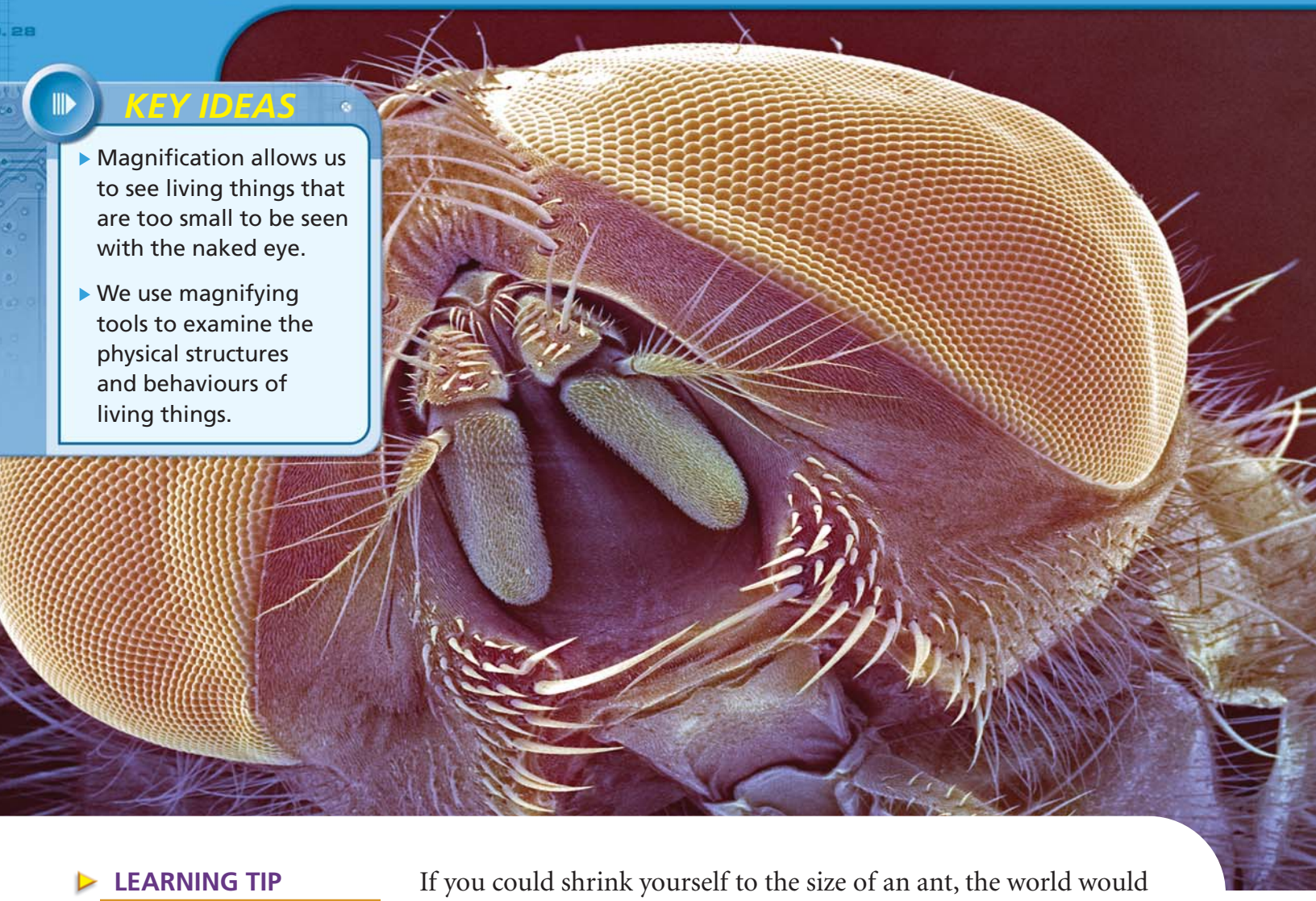
11. Could the five-kingdom classification system change as scientists discover new organisms? Explain your thinking.

Reflect on Your Learning

12. What is the most important idea that you have learned about diversity? Explain why you think this idea is important.

CHAPTER 3

Magnifying tools make the invisible world visible.



KEY IDEAS

- Magnification allows us to see living things that are too small to be seen with the naked eye.
- We use magnifying tools to examine the physical structures and behaviours of living things.

LEARNING TIP

Before you begin this chapter, take a quick look through, noticing the headings and subheadings, photos, and activities. Predict what you will learn in this chapter.

If you could shrink yourself to the size of an ant, the world would look very different. You would be able to observe small things up close. You would be able to see the compound eyes of a fly, as shown in the photo, and many other wonders of nature!

Even though we can't shrink to the size of an ant, we have tools, such as magnifying lenses and microscopes, that help us see tiny things up close. Microscopes make the invisible world visible to us. And what a fascinating world it is! Using different magnifying tools, scientists have discovered an ever-expanding world of tiny creatures living in us, on us, and around us.

Discovering Life Up Close 3.1

TRY THIS: LOOK AT A LEAF

Skills Focus: observing, inferring

Make a tracing of a leaf on graph paper. Then examine the leaf carefully. Add all the details you can see to your tracing. Describe both your qualitative observations (texture and colour) and quantitative observations (length of leaf and number of lobes). Now use a magnifying glass to examine the leaf. Add these details to a section of your drawing. What details can you see that you were not able to see using just your eyes?

Have you ever noticed that when you look closely at something, such as a leaf, you see all kinds of details that you don't see when you look at the object from far away? But even when you look at something very closely, there are limits to what you can see. To see more, we need to **magnify,** or make the object look larger than it really is. Magnifying tools allow us to see very small organisms, like those in the Kingdom Protista and the Kingdom Monera, and also to see structures, such as cells, in larger organisms.

Look at **Figure 1**. The children in the photo are using a magnifying glass to look at objects on a log, just as you used a magnifying glass to look at a leaf in the Try This activity. A magnifying glass is made of one lens in a frame with a handle. A lens is a curved piece of glass that magnifies things so that they appear larger.

Figure 1
Looking through a magnifying glass makes small objects appear larger.

The Romans used magnifying glasses almost 2000 years ago, but different forms of magnifiers were used much earlier. Early magnifiers were given very interesting names. Their names showed how they were used. For example, "reading stones" were laid on top of print to magnify the letters and "flea glasses" were used to study tiny organisms.

TRY THIS: MAKE A MAGNIFIER

Skills Focus: observing, inferring

Make your own magnifying tool. Place two pencils on a printed page, about 2 cm apart. Put a small piece of clear tape across the pencils. Look at the letters through the tape. Then put a drop of water on the tape. Look at the letters on the page through the drop of water (**Figure 2**).

1. Compare what you saw when you looked at the letters through only the tape with what you saw through the tape with the drop of water.
2. What does the drop of water do? What can you call the drop of water?
3. What do you think would have happened if you had used a bigger drop of water? Try it and see. Which size of drop made the best magnifier?

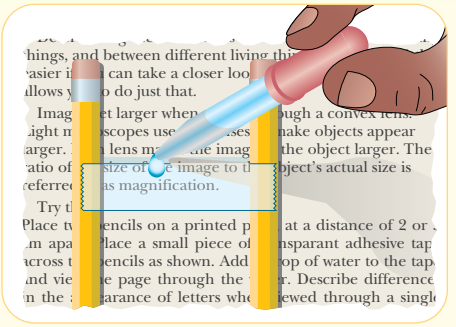


Figure 2

The Development of Modern Microscopes

Using a magnifying glass allowed people to take a closer look at objects. But it wasn't until microscopes were developed that people could see the details in a drop of blood or in a butterfly's wing. A **microscope** is a device that uses a lens or a system of lenses to greatly magnify the image of an object.

The earliest microscopes were made by Anton van Leeuwenhoek in the 1660s. Leeuwenhoek was able to grind and polish glass lenses to magnify objects up to 200 times their real size. Leeuwenhoek's microscopes used one lens to magnify objects. This type of microscope is called a simple microscope. Using his microscopes, Leeuwenhoek saw what he called "animalcules" in pond water (**Figure 3**). These organisms are now known as protozoa and bacteria, which belong to the Kingdom Protista and the Kingdom Monera.

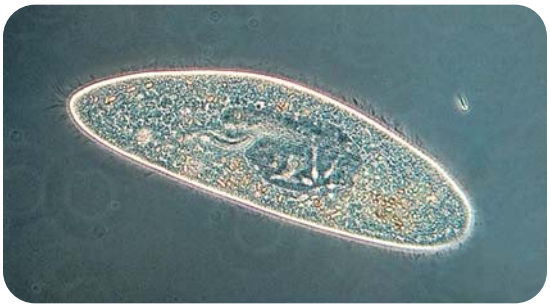


Figure 3
Leeuwenhoek would have seen this protozoan, called a paramecium, when he looked through his microscopes.

The microscopes that we use today have two lenses. Two lenses give much greater magnification than a single lens. Try looking at this page using two magnifiers. A microscope with two lenses is called a compound microscope. Another microscope that is used today is an electron microscope. With an electron microscope, scientists can see much smaller things (**Figure 4**).

Figure 4
A flea and a flea's leg viewed with an electron microscope. An electron microscope is able to achieve magnification of 1 000 000×. This means that an object will look 1 000 000 times larger than it is.

Microscopes are used in many fields. Scientists use microscopes to study organisms. Police investigators use microscopic evidence to solve crimes. Doctors use microscope technology to perform surgeries. Microbiologists use microscopes to identify germs and diseases. Microscopes have greatly increased our knowledge of living things.

CHECK YOUR UNDERSTANDING

1. How does a drop of water act like a magnifier?
2. Why do people continue to work on new technologies for magnifying things?
3. What did Anton van Leeuwenhoek discover with his microscopes? Do you think he would have made this discovery without a microscope? Explain.
4. What is the difference between a compound microscope and the simple microscopes that Leeuwenhoek used?
5. List three ways that microscopes are used today.

LEARNING TIP

Do not guess when you are answering questions. Look back through the section to find the answers. Even if you think you know the answer, it is always a good idea to go back and check the text.

3.2 Learning How to Use a Microscope

The compound microscope uses two lenses—the ocular lens and the objective lens—to magnify an object. **Figure 1** shows the parts of a microscope and explains what they do.

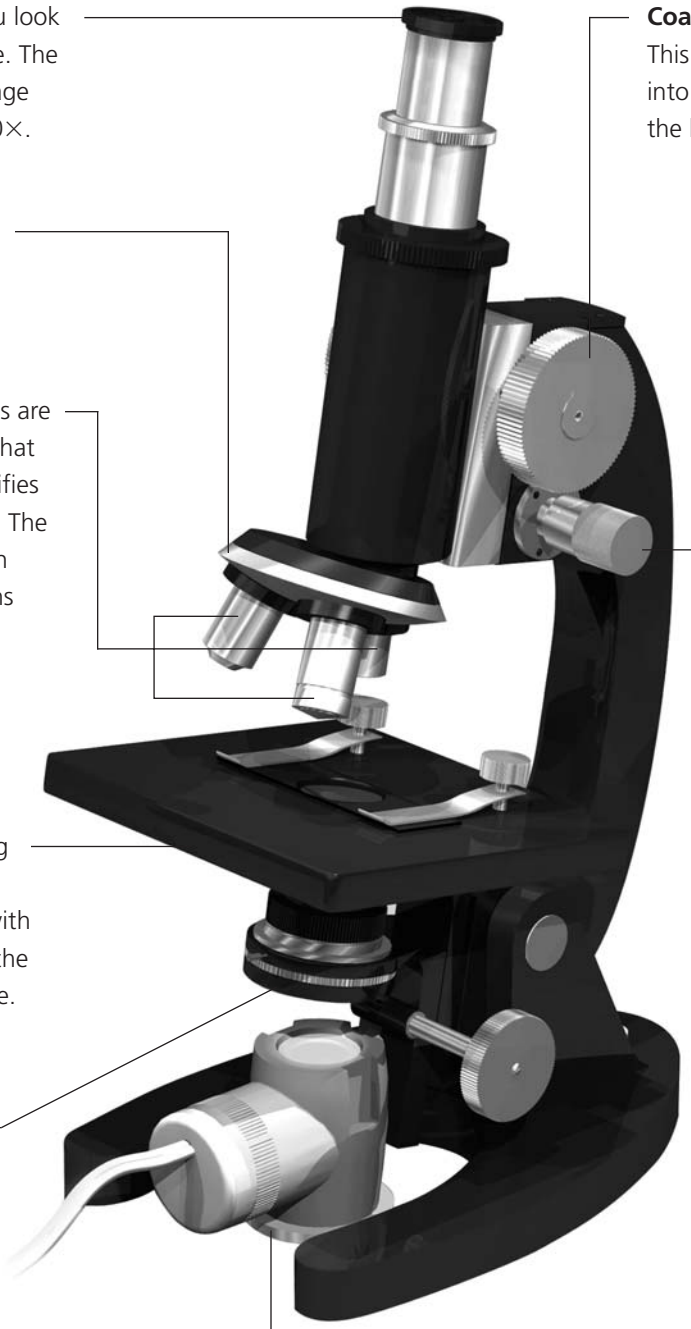
Ocular lens: This is the lens that you look through. It is also called the eyepiece. The ocular lens usually magnifies the image produced by the objective lens by 10×.

Revolving nosepiece: This rotates so that the objective lenses can be changed.

Objective lenses: These three lenses are just above the object, or specimen, that you view. The low-power lens magnifies the specimen about four times (4×). The medium-power lens magnifies by ten times (10×), and the high-power lens magnifies by forty times (40×).

Stage: This platform has an opening in it just under the objective lenses. You place your slide on the stage, with the object you want to view above the opening. Clips hold the slide in place.

Diaphragm: This controls the amount of light that reaches the object you are viewing.



Coarse-adjustment knob: This is used to move the object into focus. It is only used with the low-power lens.

Fine-adjustment knob: This is used only with the medium-power and high-power lenses. It brings the object into sharp focus. You use it only after you have located the object under low magnification using the coarse-adjustment knob.

Light source: You need light below the object to see it clearly. Some microscopes use a mirror as the light source.

Figure 1
The parts of a microscope

Preparing a Slide of Onion Skin

When you want to view an object under a microscope, you place it on a thin rectangular piece of glass called a **slide.** The object on the slide is then covered with a thin glass square called a **cover slip.** A glass slide and cover slip are shown in **Figure 2**.

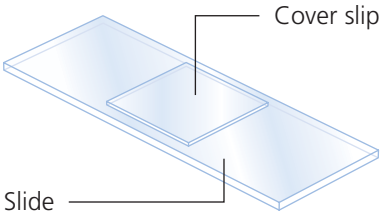


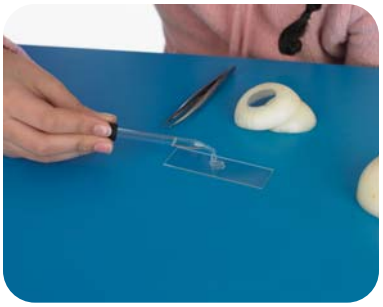
Figure 2

Preparing a slide takes practice. You must learn how to make a specimen thin, so that light can shine through the slide. You must also learn how to place a cover slip over a specimen. Follow these steps to make a slide of a piece of onion skin.

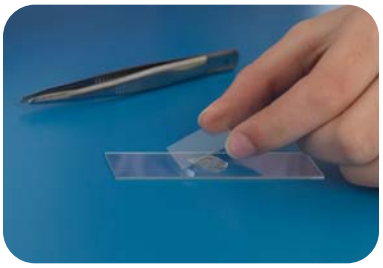
1. Use tweezers to remove the thin skin, or membrane, from the inside of a layer of an onion.

2. Place a small piece of onion skin on a slide. Try not to trap any air bubbles under the skin.

3. Use an eyedropper to place a drop of water on the onion skin.



4. Hold a cover slip between your thumb and forefinger. Place the edge of the cover slip on one side of the skin at a 45° angle. Carefully lower the cover slip to cover the skin. Gently tap the slide with the eraser end of a pencil to remove any air bubbles.



Be careful when handling glass slides and cover slips. The edges of the slides can be rough.

Focusing a Microscope

Every time you look at a slide under a microscope, you need to focus the microscope twice: once with the coarse-adjustment knob and once with the fine-adjustment knob. Follow these steps to learn how to focus, so that you can view an object clearly.

1. Turn the nosepiece so that you are looking through the low-power objective lens.

2. For your safety, pick up your slide by the edges using your thumb and forefinger. This will also ensure that nothing touches your specimen. Place your slide on the stage. Make sure that the specimen is above the opening. Move the clips over the slide to secure it in place.

3. Turn the coarse-adjustment knob slowly until the slide is in focus. Be careful that the lens does not touch the slide. You may need to adjust the diaphragm to increase or decrease the light. What can you see?

Watch the stage as you use the coarse-adjustment knob so that the lens doesn't break the slide and get damaged.

4. Turn the nosepiece to the medium-power lens.

5. Use the fine-adjustment knob to bring the slide into focus. How has the image changed?

Never use the coarse-adjustment knob with the high-power lens as it can break the cover slip or damage the lens.

TRY THIS: *TAKE A CLOSER LOOK*

Skills Focus: observing

Now that you have learned how to use a microscope, you can take a closer look at some of the things around you. Prepare slides of salt, chalk dust, a leaf, and a thin slice of cork, or anything else you think would be interesting. Look at the slides under a microscope. What do you see?

CHECK YOUR UNDERSTANDING

1. Which part(s) of a microscope perform each job described below?
   - holding the slide in place
   - magnifying the specimen you are viewing
   - turning so that you can use the lens you want
   - focusing the specimen
2. Why would you not want air bubbles trapped under or over a specimen?
3. Why should you not allow the lens to touch the slide?

3.3 Conduct an Investigation

SKILLS MENU

○ Questioning	● Observing
○ Predicting	○ Measuring
○ Hypothesizing	● Classifying
○ Designing Experiments	● Inferring
○ Controlling Variables	○ Interpreting Data
○ Creating Models	● Communicating

Observing Pond Water

Many tiny organisms live in pond water. Using a magnifying glass and a microscope, you will see tiny single-celled protists that are plant-like because they make their own food. You will also see some single-celled protists that are animal-like because they hunt and gather other organisms for food. You will also see algae, which look like long chains of cells that contain chloroplasts. Algae belong to the Kingdom Protista. As well, you will see small organisms, such as water fleas, insect larvae, copepods, and hydra that belong to the Kingdom Animalia. **Figure 1**, on the next page, shows some of the organisms you may see in pond water.

You will see that these organisms move in many ways. Some micro-organisms, such as *Euglena* and *Volvox*, move by whipping a tail called a flagellum [fluh-JELL-um]. Paramecia are covered with tiny hairs, called cilia [sill-EE-uh], that wave back and forth to move. Other pond organisms, such as the hydra, can glide or somersault along using tentacles. Water fleas appear to hop along.

In this investigation, you will observe organisms in pond water, using different degrees of magnification. You will also observe the movements and feeding behavior of these organisms. Use **Figure 1** to identify some of the organisms you see.

Question

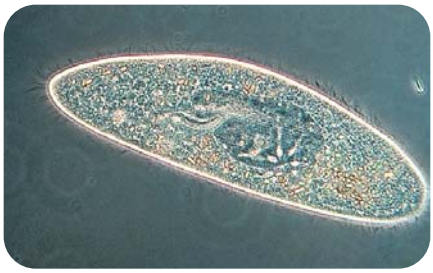
What organisms can you observe in pond water?

Materials

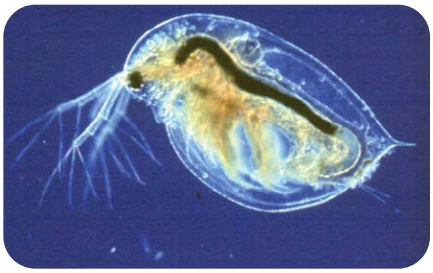
- apron
- pond water in white container (such as a margarine container)
- magnifying glass
- small petri dish
- eyedropper
- microscope
- slide and cover slip
- paper towels

Remember to carry the microscope using both hands, and to adjust the focus and carry the slides carefully.

Hydra

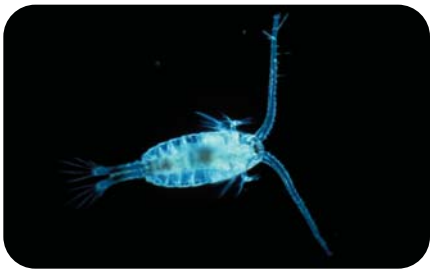


Paramecium



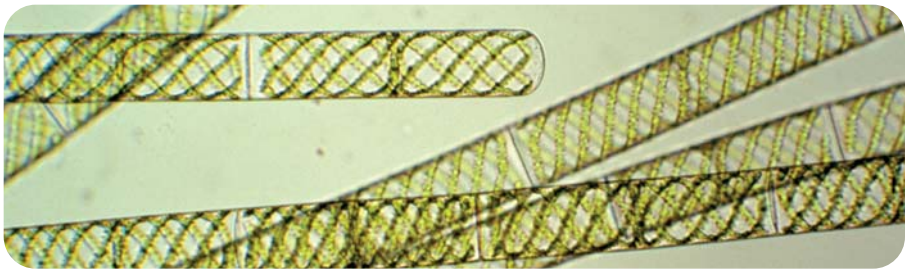
Water flea

Amoeba



Copepod

Mosquito larva



Spirogyra

Figure 1

Procedure

1 Copy the following table in your notebook. Record all your observations in your table.

Observations

Method of observing (naked eye, magnifying glass, microscope)	Drawing of organism and name	Description of structure	Movement	Feeding behaviour

2 Look at the container of pond water. Draw all the organisms that you see and, if possible, write their names in your table. Record details about their structure, movement, and feeding behaviour.

3 Use an eyedropper to pick up any organisms that you cannot see clearly and transfer the organisms to a small petri dish. Put the petri dish on a piece of white paper. Use a magnifying glass to make your observations. Record your observations in your table.

4 Use the eyedropper to place one drop of pond water on the centre of a slide. Touch a cover slip to the slide at a 45° angle. Gently lower the cover slip, being careful not to trap any air bubbles.

Use only the fine-adjustment knob when you focus the high-power lens so you do not break the cover slip.

5 Place the slide on the stage of a microscope. Look for organisms using the low-power lens. If you find organisms that are too small to see clearly, try looking at them using the medium-power lens. The high-power lens is usually not useful for observing pond water organisms, but you can try it.

6 Draw all the organisms you see and write the observations in your table.

7 Wipe your slide clean with a paper towel. Repeat steps 5 and 6 to look for other organisms.

8 Dispose of your slide as directed by your teacher. Wash your hands.

Analyze and Evaluate

1. How many organisms were you able to identify using only your eyes? Using a magnifying glass? Using the low-power lens of a microscope? Using the medium-power lens? Did you see any organisms using the high-power lens?
2. How did the magnifying glass and microscope help you with your observations?
3. What do you think you would be able to see if you used a more powerful microscope?

Apply and Extend

4. Medical lab technicians use microscopes to observe blood samples. Why would a technician need to use a microscope with a high magnification?
5. Can you think of other jobs for which a microscope would be a valuable tool? Explain your thinking.
6. How has the microscope increased our understanding of the diversity of life that exists on Earth?

CHECK YOUR UNDERSTANDING

1. In this investigation, you had to be careful when recording your observations. How could your conclusions about magnification be affected if your observations were not accurate and detailed?

Conduct an Investigation 3.4

SKILLS MENU

○ Questioning	● Observing
○ Predicting	○ Measuring
○ Hypothesizing	○ Classifying
○ Designing Experiments	● Inferring
○ Controlling Variables	○ Interpreting Data
○ Creating Models	● Communicating

Learning about Water Bears

Canada is home to polar bears, black bears, and grizzly bears. But did you know that it is also home to the "bear" shown in **Figure 1**? The scientific name for these organisms is *tardigrades*, but scientists affectionately call them "water bears."

Water bears are tiny multicellular organisms that belong to the Kingdom Animalia. Their favourite home is a moist environment, preferably a clump of moss. They grow to approximately 0.3 mm in length (about the width of a hair) and move along on eight legs. These amazing creatures can survive in harsh conditions. They have been found under ice and in hot springs. In fact, they have been found everywhere on our planet where there is water.

In this investigation, you will use a microscope to study the physical appearance and behaviour of water bears.

Figure 1
A water bear viewed under an electron microscope.

Question

What are the structural and behavioural characteristics of water bears?

Materials

- apron
- moss
- pond water or rainwater
- shallow dish
- small petri dish
- eyedropper or pipette
- slide and cover slip
- petroleum jelly
- microscope

LEARNING TIP

For a review in using a microscope and preparing slides, see Section 3.2, pages 52–55.

Remember to carry the microscope using both hands. Adjust the focus and carry the slides carefully.

Procedure

1 Obtain some moss from your teacher. Look at the moss for evidence of living organisms. Sketch the moss and what you see in it.

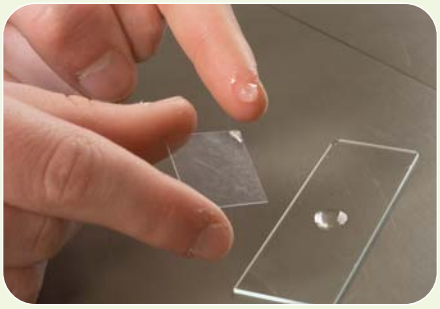
2 Place the clump of moss in a shallow dish. Pour enough pond water or rainwater into the dish to cover the moss by 1 cm. (Do not use tap water.)

3 Let the moss soak overnight. The next day, take the moss out of the water. Pour out the water left in the shallow dish.

4 Squeeze the moss over a small petri dish so that any water in the moss collects in the petri dish. Shake any extra water out of the moss. Look for evidence of living organisms in the water, and sketch what you see.

5 Examine the water in the petri dish under a microscope, using the lowest power. You should be able to see the water bears using this power. Record your observations.

6 Use an eyedropper or pipette to transfer your water bears to a microscope slide for viewing. To avoid crushing your water bears, place a dab of petroleum jelly on the corners of the cover slip before lowering it onto the slide.



7 Look at the slide under the microscope. Record what you see.

8 Dispose of the slide as directed by your teacher. Wash your hands.

Analyze and Evaluate

1. When you looked at the moss without magnification, what life did you observe?
2. When you looked at the petri dish without magnification, what life did you observe?
3. When you looked at the petri dish using the microscope, what organisms could you see?
4. Could you see any physical structures of the water bear when you used the microscope? How do you think these structures help the water bear survive?
5. What behaviours of the water bear did you observe? How do you think these behaviours help the water bear survive?
6. What did you learn about water bears by examining them under the microscope?

Apply and Extend

7. How does your drawing of a water bear compare with the photo at the beginning of this investigation? Are there differences? If so, can you explain why?
8. Water bears can survive in very harsh conditions. Why do you think scientists might study water bears?

CHECK YOUR UNDERSTANDING

1. Why is it important to read and follow the procedure for an investigation carefully?
2. Identify two steps in this procedure that were important for helping you see the water bears.

Microscope Detectives

Forensic scientists find and analyze clues at crime scenes. Criminals usually leave behind some clues about their identity that a forensic scientist can detect using microscopes. Let's look at some of the microscopic clues these scientists might examine.

Fibres

Do you think that the fibres of one red sweater are the same as the fibres of another red sweater? Look at the fibres in **Figure 1**. Do they look the same? A forensic scientist can analyze fibres found at a crime scene and match them to clothing worn by a suspect.

Gather fibres from several different fabric samples. Look at the fibres under a microscope. How are they different? Simulate wear by rubbing each fibre between your fingers. Look at it again under the microscope to see if there is any difference. Rip each fibre into two pieces and look at the edges. What do you notice?

Figure 1
A fibre found at a crime scene came from the sweater of one of these three suspects.

Fingerprints

No one has exactly the same fingerprints as you. You will grow older and bigger, but the pattern of your prints remains the same throughout your life. Each fingerprint has its own pattern of whorls, arches, and loops (**Figure 2**).

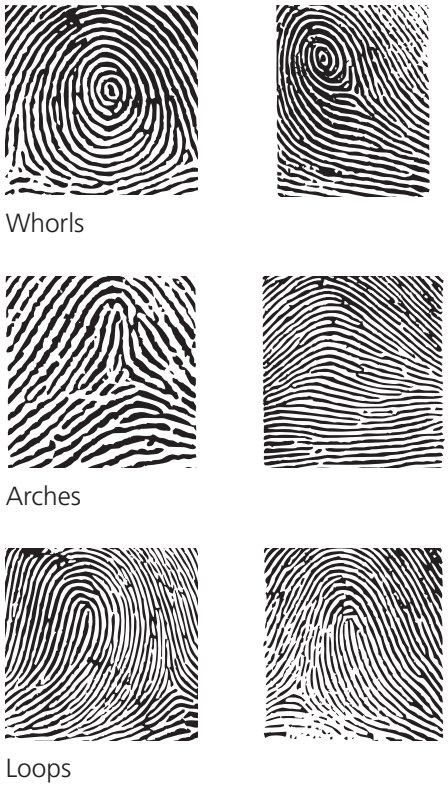


Figure 2
Fingerprints have whorls, arches, or loops. Most people's fingerprints have loops.

Forensic scientists carefully examine fingerprints lifted from a crime scene (**Figure 3**). They look at the patterns and the ridges between the patterns.

Use a hand-held magnifier to examine your own fingerprints. Look for whorls, arches, and loops. Compare your fingerprints with a classmate's fingerprints. How are they similar? How are they different?

Figure 3
A scientist compares the fingerprints of the three suspects with the fingerprint found at the scene of the crime.

Pollen and Spore Analysis

Forensic scientists use microscopes to analyze pollen and spores that are found at crime scenes. Much like fingerprints can be used to identify an individual, pollen grains and spores can be used to identify a specific area, or locale. Scientists can use pollen and spore samples to identify where a crime took place. They can also compare pollen samples, taken from a suspect's clothing or shoes, with pollen samples found at a crime scene to link a suspect to the scene of the crime (**Figure 4**).

Analyzing pollen and spores is not commonly used in Canada. However, because pollen and spores are everywhere—from dust to soil to hair—the analysis of pollen and spores may become a widely used tool to solve crimes.

Using microscopes to compare fibres, identify fingerprints, and analyze pollen and spores are just some of the many things that forensic scientists do. Find out more about forensic scientists on the Internet. Share what you learn with your classmates.

www.science.nelson.com GO

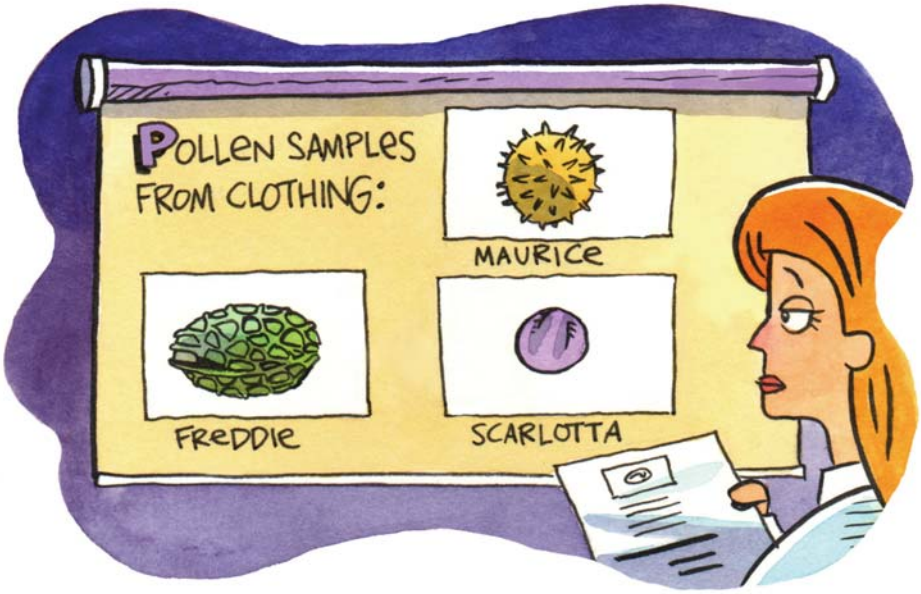
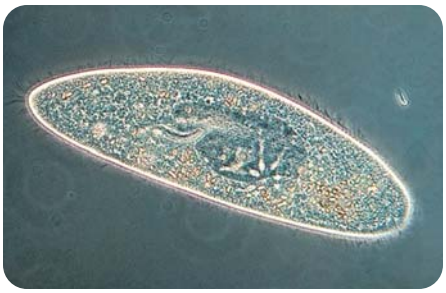


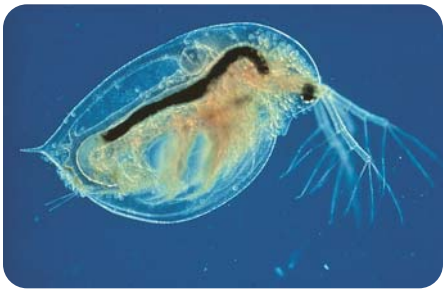
Figure 4
Pollen samples from the three suspects can be compared with pollen found at the crime scene.

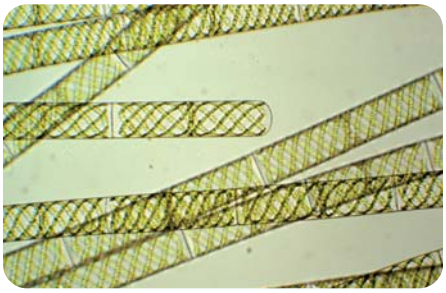
3 Chapter Review

Magnifying tools make the invisible world visible.

Key Idea: Magnification allows us to see living things that are too small to be seen with the naked eye.







Vocabulary

magnify p. 49

Key Idea: We use magnifying tools to examine the physical structures and behaviours of living things.

Vocabulary

microscope p. 50

slide p. 53

cover slip p. 53

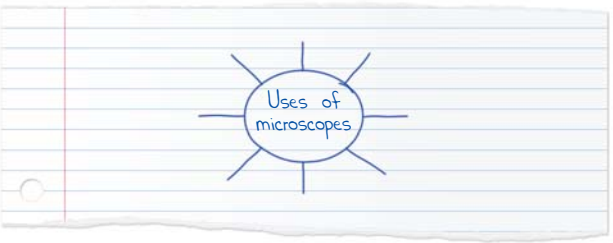
Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. Why are magnifying tools so useful?
2. How do microscopes help scientists understand the organisms on Earth?

Use What You've Learned

3. How is a drop of water similar to a magnifying glass or a microscope?
4. A thick, syrupy substance called methyl cellulose is often used when preparing a slide of moving micro-organisms. Why do you think a biologist would want to watch a micro-organism in this syrupy substance?
5. Write a letter to Anton van Leeuwenhoek explaining how important microscopes are to us today.
6. Create a web, using words and pictures, that shows how microscopes are used today.



7. Create a poster or a comic strip that shows how to use a microscope properly and how to prepare a specimen on a slide.

Think Critically

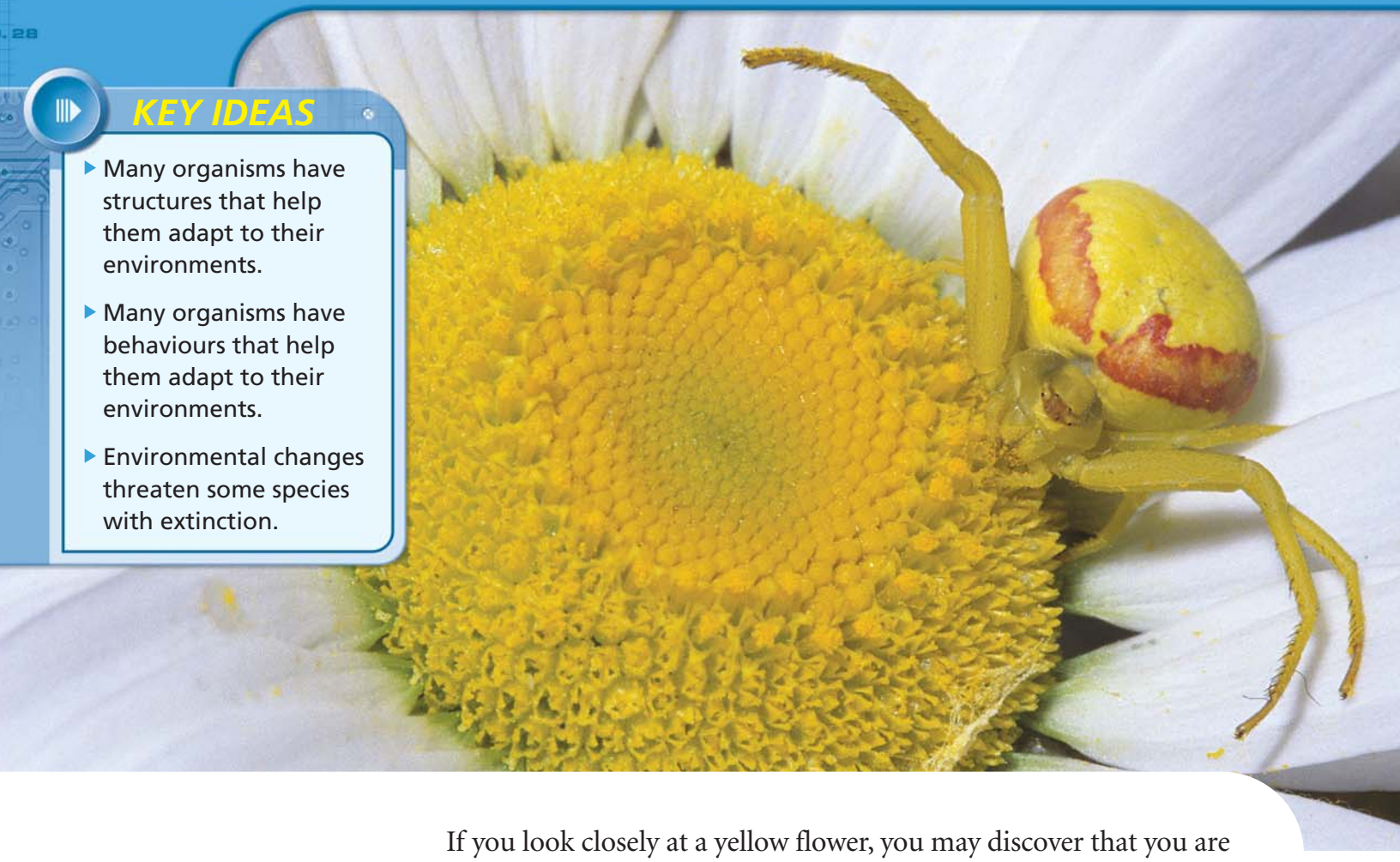
8. Today, scientists use scanning tunnelling microscopes to look at molecules and large atoms. What kinds of research do you think scientists use these microscopes for? What do you think they might discover?
9. How would our understanding of organisms be different without magnification?

Reflect on Your Learning

10. Suppose that you could look at anything you wished up close. What would you choose? What do you think you would be able to see? How could looking up close change the way you normally think about the object?

CHAPTER 4

Living things adapt to their environments.



KEY IDEAS

- Many organisms have structures that help them adapt to their environments.
- Many organisms have behaviours that help them adapt to their environments.
- Environmental changes threaten some species with extinction.

If you look closely at a yellow flower, you may discover that you are also looking at a yellow crab spider. These tiny spiders live on yellow flowers, where they are invisible both to the birds and wasps that feed on them, and to the insects they rely on for their own food.

All living things have structures and behaviours that allow them to meet their needs and to survive in their environment. Like the crab spider's yellow colour, these adaptations help an organism live long enough to reproduce.

In this chapter, you will look at some of the fascinating ways in which living things are adapted to their environment. You will also look at what happens to organisms that cannot adapt to changes in their environment.

Characteristics for Survival 4.1

All organisms have characteristics that help them survive in their environments. These characteristics are called adaptations. Some adaptations are structures. For example, some plants have brightly coloured flowers to attract birds and insects for pollination. Cacti, which grow in dry areas, have fleshy stems to store water and short prickly leaves to reduce water loss.

Some adaptations are behaviours that help organisms survive. **Behaviours** are what organisms do, whether it is swimming, flying, or sleeping. Hibernation is an example of a behaviour that helps some organisms survive cold winter temperatures. The great variety of structures and behaviours of organisms is responsible for the diversity of life on Earth.

LEARNING TIP

Check that you understand the two types of adaptations that help organisms survive by explaining them to a classmate.

TRY THIS: LOOK AT A HUMAN ADAPTATION

Skills Focus: observing, inferring

Take a look at your thumb. It is called an opposable thumb because it can touch all the fingers on the same hand. Your thumb makes it possible for you to do many things that animals without opposable thumbs cannot do.

Have a partner time how long you take to untie one of your shoes, take it off, put it on again, and tie it again. Record your time. Now tape your thumb firmly to the rest of your hand so that you cannot use it. Try the shoe-tying task again. Record how long you take.

1. How useful is having an opposable thumb?
2. Apes, chimpanzees, and other primates (including humans) have opposable thumbs. How is this adaptation useful for helping these animals survive?

Feet for Many Purposes

Animals have feet of many sizes and shapes that are perfect for swimming, perching, climbing, grasping, or walking on mud. These adaptations have allowed the animals to survive in their environments. For example, whales and dolphins have flippers. Ducks and penguins have webbed feet that are great for swimming and for walking in muddy areas or snow without sinking. Sea otters also have webbed feet to help them swim quickly through the water (**Figure 1**).

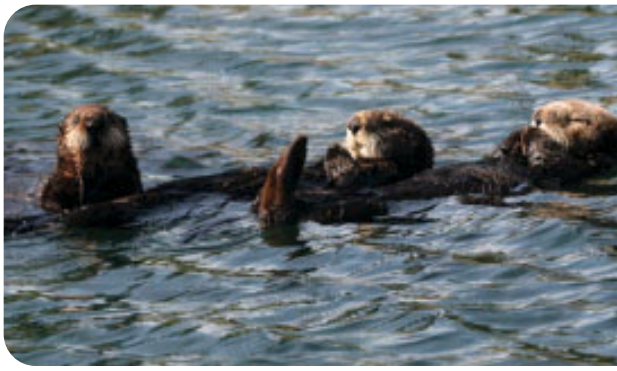


Figure 1
Sea otters use their feet like paddles.

Some feet have special toes. A heron has long, spread-out toes that help it stay on top of mud (**Figure 2**). A thrush has three toes that face forward and one toe that faces backward. This shape allows the thrush to perch safely in trees, even while sleeping! A porcupine has sharp claws on its feet to help it climb.

Figure 2
A heron relies on its feet to keep it from sinking in mud.

What about feet for speed? One of the fastest creatures on Earth is the cheetah (**Figure 3**). How are a cheetah's feet built for speed?

Figure 3
A cheetah can run at speeds of 110 km an hour.

Some Owl Advantages

Owls are adapted to live in a variety of habitats, from the Arctic to the dry regions of southern deserts. There are over 140 species of owls in the world. Owls range in size from the large eagle owl of Eurasia, which grows up to 70 cm in length, to the northern pygmy owl, which is no larger than a sparrow. What adaptations make owls so successful? Let's look at some of the structural adaptations that enable owls to survive in so many different habitats.

Eyesight

Like most birds, owls have very large eyes (**Figure 4**). Unlike other birds, which have one eye on each side of the head, an owl's eyes are at the front. Owls cannot move their eyes. They have to turn their heads to look sideways. Owls can turn their heads almost all the way around to see what is behind them. This adaptation helps to protect owls from possible predators sneaking up on them.

Owls can see well in the daylight, but their nighttime vision is amazing. Most owls are active at night. The pupil in an owl's eye can open very wide, allowing the owl to use all the available light. They can recognize and swoop down on a potential meal in almost complete darkness.

Figure 4
Owls, such as this screech owl, have very large eyes on the front of their heads.

Wings, Feet, and Beaks

Owls have wide wings, powerful feet, and a strong, hooked beak (**Figure 5**). These structures help to make owls very good hunters. Owls also have fine, fringed feathers on the underside of their wings. These feathers help to muffle the sound of the air flowing over their wings, so that owls are almost silent when flying. Consider the advantage that this adaptation gives owls when hunting! This adaptation is not present, however, in the few owl species that hunt during the day.

As an owl sneaks up on an animal, it extends its razor-sharp talons to grip its prey. If the animal is too large to swallow whole, the owl can easily rip the animal into bite-sized pieces with its powerful beak.

Figure 5
The barn owl is an excellent night-time hunter, feeding mostly on rodents.

Colouring

Figure 6
The burrowing owl blends in with its surroundings.

Many species of owls have **colouration** that helps them blend in with their environments. This special colouring is called **camouflage.** For example, the head, wings, and back of a burrowing owl are sandy brown, and its chest is white with large brown speckles (**Figure 6**). This colouring provides excellent camouflage in the dry grassland where the owl lives.

The snowy owl has dappled white colouring—perfect for its snowy surroundings (**Figure 7**). Unfortunately, the colour advantage is lost when summer arrives. As the snow melts in the spring, however, the snowy owl moves to sit on patches of snow or ice. Scientists are unsure whether the snowy owl does this to camouflage itself or whether it is just trying to keep cool.

Figure 7
The colouration of the snowy owl provides camouflage in snow.

LEARNING TIP

The word "symbiosis" comes from the Greek and means "living together."

Symbiosis: A Behaviour for Survival

Symbiosis [SIM-by-O-sis] is an example of a behaviour that helps some organisms survive. In symbiosis, two organisms live together and help each other. Some birds help to keep other animals clean. For example, the oxpecker feeds on ticks and other insects on a rhinoceros' skin. The oxpecker gets food, and the rhinoceros gets rid of the irritating insects.

Lichens [LIE-kuhns] are organisms that result from the symbiotic relationship between a fungus and a green alga (**Figure 8**). The fungus provides the alga with water, while the plant-like alga provides the fungus with food. This relationship allows both the fungus and the alga to survive in environments where they wouldn't be able to survive alone. You will learn more about other survival behaviours in Section 4.3.

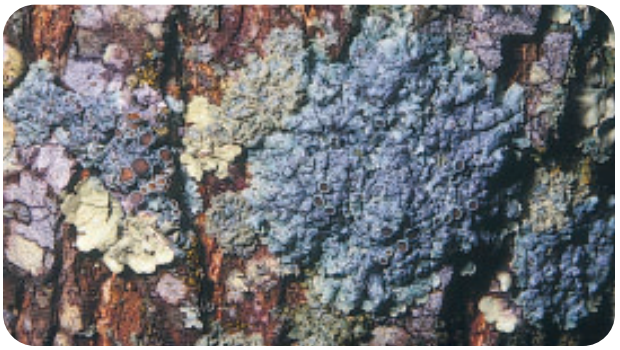


Figure 8
Lichens survive in a wide variety of environments including rocks and tree trunks.

CHECK YOUR UNDERSTANDING

1. Describe four adaptations that show why the owl is a successful organism.
2. Look at the sketches of feet shown in **Figure 9**. Describe how the structure of each foot would be an advantage in a particular environment.

Figure 9

3. Can you spot the fish in **Figure 10**? What adaptation has increased its chances of survival?

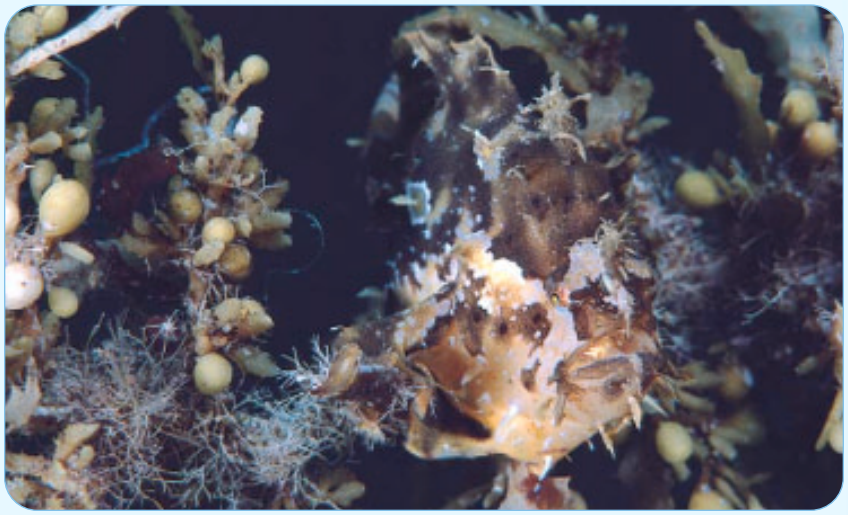


Figure 10

4. A cow has billions of micro-organisms in its stomach to help it digest its food. What is this relationship called? How do the micro-organisms help the cow? How does the cow help the micro-organisms?

4.2 Conduct an Investigation

SKILLS MENU

○ Questioning	● Observing
○ Predicting	○ Measuring
○ Hypothesizing	○ Classifying
○ Designing Experiments	● Inferring
○ Controlling Variables	● Interpreting Data
● Creating Models	● Communicating

Examining Bird Beaks

Birds have a variety of different sizes and shapes of beaks to help them get food (**Figure 1**). Some birds use their beaks to crack open seeds, while other birds spear insects. Still other birds use their beaks to tear plants from mud. Their beaks can also strain food from the mud and water. In this investigation, you will examine how bird beaks are adapted to obtain different types of food.

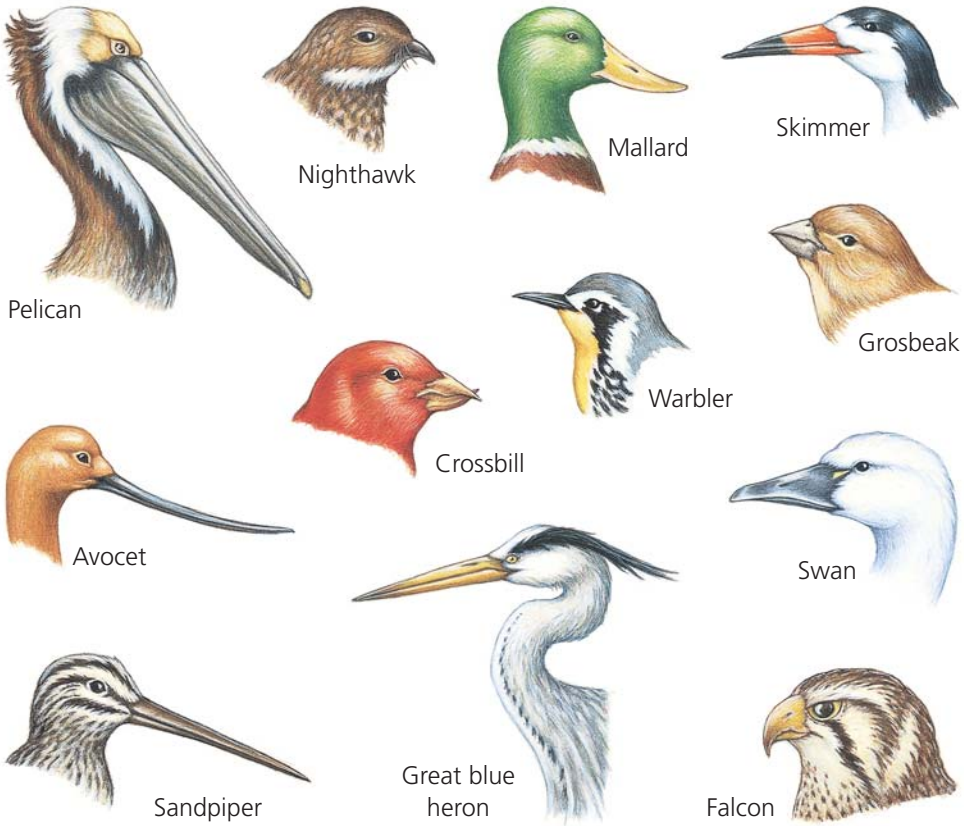


Figure 1


sunflower seeds


clothespin


tongs


pliers


jellybeans


sprouts

Question

How are bird beaks adapted for birds to obtain food from their environments?

Materials

- sunflower seeds
- clothespin
- tongs
- needle-nose pliers
- jellybeans
- patch of grass or bean sprouts

Procedure

1 Copy the following table into your notebook. Record all your observations in your table.

Observations for Investigation 4.2

Tool (beak)	Effect on sunflower seed	Effect on jellybean	Effect on grass
clothespin			
tongs			
needle-nose pliers			

2 Pick up a sunflower seed with a clothespin. Apply force to the seed. Pick up another sunflower seed with the tongs and apply force to the seed. Then pick up a sunflower seed with the pliers and apply force. Record all your observations.

3 Place a sunflower seed in the jaws of the needle-nose pliers in the two positions shown below. Apply pressure until the seed splits or is crushed.

4 Repeat step 3, but this time vary the position of your hand as shown in the photos below.

5 Try to spear a jellybean with the clothespin, tongs, and pliers. Record your observations in your table.

6 Use the clothespin, tongs, and pliers to grab and pull out as many grass shoots or bean sprouts as possible. Record your observations in your table.

Analyze and Evaluate

1. Which tool is best for crushing a sunflower seed?
2. What was the best seed position for crushing it in the pliers—toward the tip or toward the handle? How does this relate to whether birds that eat seeds have a long beak or a short beak?
3. What was the best hand position for crushing a seed in the pliers? Birds that eat seeds need to have strong beaks. Which hand position represents a strong beak?
4. Examine the pictures of bird beaks in **Figure 1**. Which birds have beaks that are suitable for crushing seeds?
5. Which tool is best for spearing a jellybean?
6. Examine the pictures of bird beaks in **Figure 1**. Which bird has a beak that is adapted for spearing insects?
7. Which tool worked best for grabbing and tearing grass shoots or bean sprouts? Which birds in **Figure 1** have beaks that are suitable for pulling grass and straining food from mud?
8. What conclusions can you make about the shape of a bird's beak and its feeding habits?

Apply and Extend

9. How is a beak that is suitable for spearing insects different from a beak that is suitable for spearing fish? Look at the bird beaks in **Figure 1**. Which birds have beaks suitable for spearing fish?
10. Look at the beaks of the pelican, the falcon, and the skimmer shown in **Figure 1**. What do you think each of these birds eat? Explain your thinking.
11. Look at **Figure 2**. This bird sucks the nectar from flowers. How does its beak help with this task?
12. Design a beak that you think would be suitable for picking up insects. Explain your thinking.

Figure 2
A hummingbird

CHECK YOUR UNDERSTANDING

1. What conclusions can you make about the shape of a beak and the size of the food that can be eaten?
2. How did you use your table to help you organize and make sense of your data for this investigation?

4.3 Surviving in Extreme Conditions

LEARNING TIP

Connect new information to what you have already learned. What structures and behaviours do you think would help organisms to survive in extreme conditions?

Some organisms have adaptations that enable them to survive Earth's most extreme conditions. For example, deep in the oceans, organisms can survive with little or no sunlight. Other organisms can live in dry deserts and in regions of extreme cold. What structures and behaviours enable them to survive such harsh conditions?

Canada's Arctic is home to many animals. In the winter, food is hard to find and temperatures may drop to −45 °C. Arctic animals have structures that allow them to survive in the cold. For example, the seal and the walrus have waterproof fur, the arctic grouse has fringed toes that act like a snowshoe, and the arctic fox has a thick white fur coat.

The polar bear has several structures that help it survive the Arctic cold. The polar bear has small, compact ears and a small tail, as well as thick fur. These adaptations help to keep it warm. The polar bear's white fur also helps camouflage the bear in the snow (**Figure 1**). This helps the polar bear sneak up on and hunt seals, as well as escape human hunters. The polar bear also has behaviours that help it survive in the winter. In the spring and summer, it eats as much as it can so that it has a thick layer of blubber when the winter comes. This blubber acts like insulation to protect the bear from the cold. (You will look at how insulation works in Unit C.)

Figure 1
A polar bear is well adapted to live in a snowy environment.

TRY THIS: OBSERVE ADAPTATIONS

Skills Focus: observing, inferring

Look carefully at **Figures 2** and **3**. How have these animals adapted to winter?

Figure 2
A lynx

Figure 3
A snowshoe hare

Migration

Some animals have a behaviour that helps them survive the harsh winter. They move, or migrate, to a warmer place. This **migration** may not be a great distance. For example, the elk moves from the mountains to spend the winter in the lowlands. Other animals migrate great distances. For example, the humpback whale migrates from the Arctic region in the summer to the tropics in the winter. Other animals that take incredible migration journeys include the arctic tern and the Canada goose.

Long-Distance Travellers

The winner of the migration marathon is the arctic tern (**Figure 4**). This bird travels from the Canadian Arctic to Antarctica and back every year. Why does it make such a long journey? Does it need to fly this far for food and shelter? Most biologists believe that ancient relatives of the tern began making the journey when the continents were much closer together. Over millions of years, as the continents gradually shifted farther apart, the tern adapted to the ever-increasing distance of its migration.

Figure 4
The arctic tern migrates over 35 000 km each year.

The Canada goose is another long-distance traveller. It flies all the way to the southern United States and Mexico for the winter. Geese fly in a V-formation when migrating. Why do you think they fly in this formation? Think about the way you might shape your body if you wanted to travel fast. You would try to be streamlined. The lead goose hits the air with the greatest force. It breaks up the wind so that the wind flows with less resistance over the rest of the flock. Since the lead position is very tiring, the geese take turns being in the lead!

Hibernation

Other animals cope with winter by becoming inactive. This behaviour is called **hibernation.** Animals hibernate in burrows in the ground, in tree trunks, and in snow dens. Hibernating animals include chipmunks (**Figure 5**), some bats, and ground squirrels. When an animal hibernates, its body temperature drops and its heartbeat and breathing slow down. This allows the hibernating animal to use less energy so that it can live off the fat reserves it stored during the spring and summer. Some hibernating animals, such as chipmunks, also store food, such as nuts and seeds, to eat during the winter months.

Figure 5
The chipmunk spends the entire winter in its underground burrow. It wakes up now and then to eat part of the food it stored over summer.

Do you think of bears when you think of hibernation? In fact, bears are not true hibernators. Their body temperature does drop a few degrees, but they are easily awakened.

CHECK YOUR UNDERSTANDING

1. Some people travel south for the winter. Are they migrating? Why or why not?
2. How does hibernating help an animal cope with the winter?
3. Draw an imaginary animal that would be well adapted to life in the Arctic. Explain your animal's adaptations.

Adapting to City Life

4.4

Organisms have adapted behaviours that help them to survive. Some animals have even learned how to survive in city environments (**Figure 1**).

Figure 1
What animals live in the city?

Today, humans are moving farther and farther into what used to be wild spaces. Houses, farms, roads, and shopping malls are replacing the natural habitats of animals. The animals have either moved to a new location or learned how to live with humans. Many animals have adapted to life surrounded by concrete, traffic noise, and a lot of people!

City Dwellers

A city is filled with roads with cars zooming by, tall buildings, and lots of people. This can be an advantage for some animals. Wherever there is traffic, buildings, and people, there is heat and food. The daytime heat becomes trapped between tall buildings and provides warmth for animals at night. The discarded food in a trash bin becomes a meal.

The most successful city dwellers are birds (**Figure 2**). Pigeons are so common that in some cities they are considered to be a nuisance. Starlings have also learned to live in cities.

Figure 2
Birds, such as the house finch, have learned to build their nests in crevices of downtown buildings and apartment balconies.

Many four-legged animals, such as squirrels and raccoons (**Figure 3**), have also learned how to live in cities. Raccoons can survive because they are willing to eat just about anything, from fresh vegetables in backyard gardens to waste in garbage cans. Rats and mice have also learned to live on the waste that is so easy to find in urban areas.

Small animals are not the only animals that live in cities. As cities expand, larger animals find themselves in direct contact with buildings and people. Seeing a cougar or a black bear in a backyard is not uncommon in parts of British Columbia.

Coyotes blend into the city so well that many people do not even know they are there (**Figure 4**)! Since coyotes are nocturnal, they roam the streets at night in search of food. Coyotes eat small mammals, such as rats, as well as eggs, fruit, grains, vegetation, and garbage. All these foods are easily found in a city!

Figure 3
Backyard compost bins, garbage cans, and even open back doors provide access to enough food for raccoons.

Figure 4
Coyotes are omnivores—they eat both plants and animals.

CHECK YOUR UNDERSTANDING

1. Name three animals that have adapted to live in cities. Describe how each animal has adapted.
2. What behaviours do pets, such as dogs and cats, learn to help them live in a home?
3. How can a city provide an advantage for an animal?

The Struggle Against Extinction

4.5

The diversity of life on Earth is amazing. Scientists believe that, of the total number of species that ever existed on Earth, most have died out, or have become extinct. Some extinctions are because of extreme environmental changes, such as ice ages and meteorite strikes. Groups of organisms disappear during these mass extinctions and are replaced with new species. This is what scientists believe happened to the dinosaurs 65 million years ago (**Figure 1**). Other species become extinct because they are not able to adapt to changing environments or changing food sources.

LEARNING TIP

Check your understanding of the term extinction by describing in your own words what happens when an organism becomes extinct.

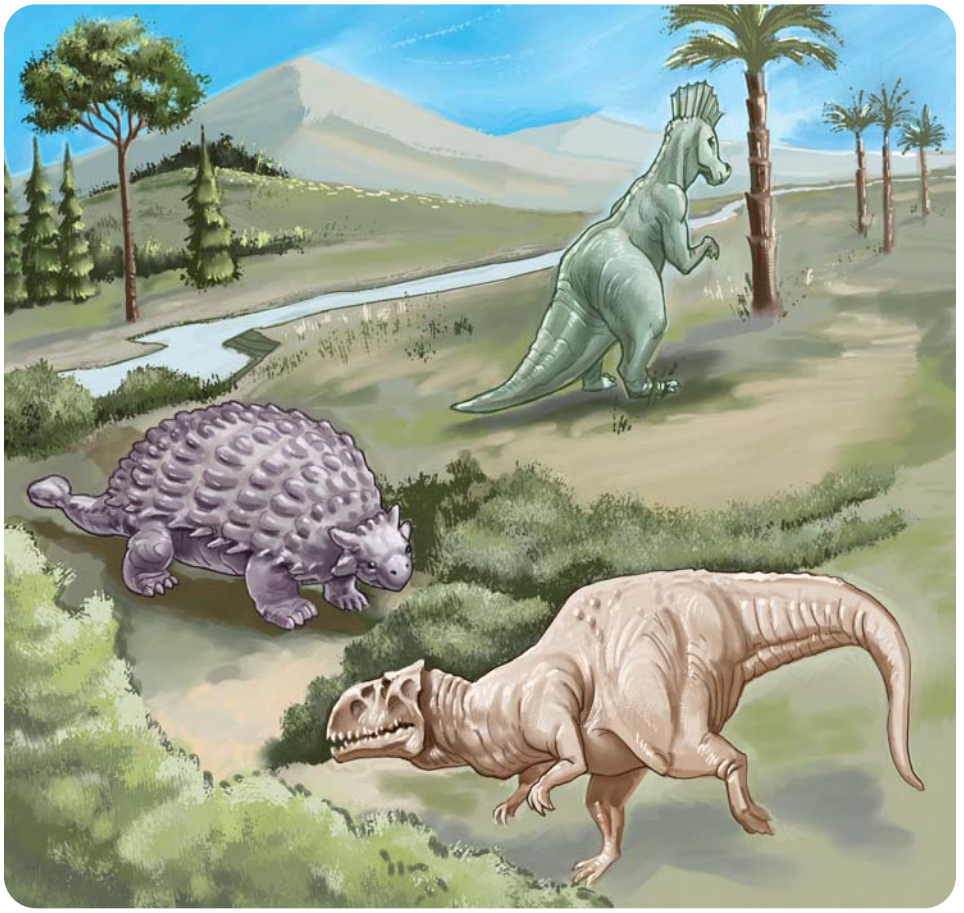


Figure 1
At the end of the Cretaceous Period, 65 million years ago, there was a mass extinction in which half of all life forms died out, including all the remaining dinosaurs.

Endangered Organisms

Many plants and animals are in danger of becoming extinct. These organisms are endangered. In Canada, 72 plant species and 95 animal species are endangered. Habitat destruction, hunting, and pollution are the main causes of species becoming endangered.

In Canada, we keep track of many organisms that are endangered. Environment Canada and the Canadian Wildlife Service are two agencies that help to manage and protect Canada's vast number of creatures. These agencies monitor organisms that seem to be disappearing. They conduct research into wildlife issues and work with other countries to preserve the world's diversity.

Let's look at three endangered species in British Columbia. As you read about these species, think about how their environment has been changed and what impact these changes have had.

Figure 2
The adult tiger salamander has large blotches of black, brown, and grey colouring along its body.

The Tiger Salamander

The tiger salamander (**Figure 2**) lives in the often-dry Southern Okanagan Valley. Its habitat has been changed in two very important ways. First, fish that feed on the salamander have been introduced into some of the lakes where the salamander lives. Second, livestock that live in the area are trampling nearby plant life. This has affected the water quality of the lakes, making it more difficult for the salamander eggs to hatch. Both of these changes have affected the salamander's ability to survive.

The Viceroy Butterfly

The Viceroy butterfly (**Figure 3**) lives in wetlands in southern Canada and throughout the United States. The Viceroy butterfly looks very much like the Monarch butterfly. **Mimicry** is an adaptation where an organism looks like another to help it survive. The Monarch butterfly tastes bitter and birds have learned not to eat it. Since the Viceroy looks like the Monarch butterfly, birds do not eat the Viceroy butterfly either.

Figure 3
The Viceroy butterfly looks like the Monarch butterfly so birds do not eat it.

The Viceroy butterfly feeds on the nectar of fruit trees. The butterfly is endangered in British Columbia because of the pesticides that fruit growers are using in their orchards. The pesticides kill the Viceroy butterfly along with the insects that harm the fruit.

The Vancouver Island Marmot

The Vancouver Island marmot (**Figure 4**) lives in the mountains of Vancouver Island. It likes alpine and sub-alpine areas, which have steep slopes, meadows, and rocky debris at the bases of cliffs. The Vancouver Island marmot is one of British Columbia's most endangered species. There are fewer than 50 left in the wild. The marmot is endangered because of loss of habitat. Although its habitat is now protected, the marmot is not reaching the suitable patches of land. Instead, it is remaining in areas that have been clearcut, where it is an easy target for predators, such as golden eagles, cougars, and wolves.

Figure 4
The Vancouver Island marmot is a small animal that lives in burrows. It eats grasses and other plants, and it hibernates during the winter.

TRY THIS: ***IDENTIFY TRAITS***

Skills Focus: predicting, inferring

Look at the information about the three endangered species.

1. Identify a characteristic that has helped one of the species survive until now.
2. Think of another characteristic that would help this species survive in its changing environment.

CHECK YOUR ***UNDERSTANDING***

1. What is an endangered species?
2. Why do some organisms become endangered?
3. Choose one of the endangered animals discussed in the text. What do you think are some things that can be done to protect this animal?
4. Do you think that humans could become extinct? Explain your answer.

4 Chapter Review

Living things adapt to their environments.

Key Idea: Many organisms have structures that help them adapt to their environments.

Vocabulary

- colouration p. 70
- camouflage p. 70
- mimicry p. 82

Key Idea: Many organisms have behaviours that help them adapt to their environments.

Vocabulary

- behaviours p. 67
- migration p. 77
- hibernation p. 78

Key Idea: Environmental changes threaten some species with extinction.

Pesticides are endangering the Viceroy butterfly.

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. Organisms have adaptations that help them survive in their environments. Describe how each of the following adaptations helps the plant survive.
   - Dandelions have long taproots.
   - Arctic lupines have seeds that can wait for centuries before they sprout.
   - Lodge pole pine cones open only when there is enough heat.
2. Go back to **Table 1** in section 2.5 of Chapter 2, which lists the characteristics of vertebrates. For each class, name one characteristic that helps the vertebrates survive.
3. Which of the following are structures, and which are behaviours?
   - waterproof wings
   - eating berries
   - night vision
   - avoiding traps
4. Explain why the tiger salamander, the Viceroy butterfly, and the Vancouver Island marmot are endangered species. Are there any common reasons?

Use What You've Learned

5. Caribou migrate across the tundra every year. In some areas of the tundra, pipelines have been built to carry oil. These pipelines are barriers to the annual migration of the caribou. Explain how the caribou's behaviour must adapt to survive.
6. Earthworms live all across Canada in their underground environment. As they tunnel through the soil, they eat decaying organisms in the soil. They breathe directly through their thin skin. In dry areas, earthworms spend most of their time inside their burrows. If they didn't, their moist bodies would dry out and they would not be able to breathe. When it rains, earthworms come out of their burrows so they can mate. Explain how earthworms have adapted to their environment.

Think Critically

7. Sandpipers eat insects. Imagine that there is a nest of sandpiper chicks and that one of the chicks has a beak that is longer than the other chicks' beaks (**Figure 1**). How would this affect the chick's chances of survival?

Figure 1

8. List some human activities that may endanger the living things in your community. Which activity has the greatest impact? Explain your choice.

Reflect on Your Learning

9. Look back at the issues that were discussed in this chapter. Select the issue that is most interesting to you. Explain why you find this issue interesting. Describe something that you could do to have an effect on this issue.

UNIT A

Making Connections

Discovering Local Diversity

In this unit, you have learned about the different forms of life that exist on Earth. You have also learned how scientists classify these organisms, based on their similarities. You have used a microscope to examine organisms that seem to be invisible. As well, you have discovered how some organisms have evolved special characteristics and behaviours that help them survive.

Now it's time to apply what you have learned. In this investigation, you will create an inventory of the organisms that live in your community. Choose two different environments, perhaps a forested area and a grassy field.

Part 1: Conduct a Field Study

1. Carefully inspect each environment, and observe each organism you discover. Remember to look closely and use your magnifying glass to see more. Make sure that you look everywhere—on the ground, in trees and shrubs, and above you in the sky. Gently lift rocks and scrape the surface of the soil to look underneath. Make sure that when you are finished, everything has been returned to the way you found it.
2. Record as much information as you can about the organisms you discover. Make descriptive notes about the environment that you find the organisms in and the number of each type of organism that you find.
3. Gather samples from each environment.
   - Collect water, if present.
   - Gather plant samples. Be careful to take your samples from debris on the ground. Do not break them off the plants.

Part 2: Identify Organisms

1. Classify the organisms as unicellular or multicellular. Then classify the organisms into the five kingdoms. Identify any members of the Animal kingdom as fish, amphibians, reptiles, birds, mammals, or insects.
2. Use a magnifying glass and microscope to investigate your samples. Record your observations.
   - Water samples: Prepare a slide to observe the organisms living in the water. Identify the kind and number of micro-organisms you see. What physical adaptations, such as a flagellum or cilia, do they have that help them survive? What behaviours, such as swimming fast or living in groups, do you observe that help them live in their environment?
   - Plant samples: Prepare slides of leaf and stem tissue for each plant. Look closely at the roots. What structures enable the organisms to survive in their environment? How are they able to meet their needs?

Part 3: Analyze Adaptations

1. Create a web for each environment that you investigated. In the centre, write a short description or draw a picture of the non-living parts of the environment (for example, a rocky, dry hill without any shade).
2. Around the centre, create a spoke for each organism that you discovered. Describe how the organism meets its needs in its environment. Give examples of any structures and behaviours the organism has that help it adapt to its environment.
3. Select one change (such as a drought) that could affect the organisms in each environment. Add another spoke to the web for this change, and describe adaptations that would help the organisms survive if this change occurred.

ASSESSMENT

Check to make sure that your work provides evidence that you are able to

CONDUCT A FIELD STUDY

- observe physical features of organisms and their environments
- use magnifying tools appropriately
- record accurate information about organisms and their environments in words and sketches
- conduct a field study without harming the environment

IDENTIFY ORGANISMS

- use magnifying tools appropriately
- classify organisms into five kingdoms
- distinguish among fish, amphibians, reptiles, birds, mammals
- use appropriate scientific terminology

ANALYZE ADAPTATIONS

- use magnifying tools appropriately
- identify structures and behaviours that are adaptations to the environment
- relate adaptations to specific features of an environment
- communicate clearly
- use appropriate scientific terminology