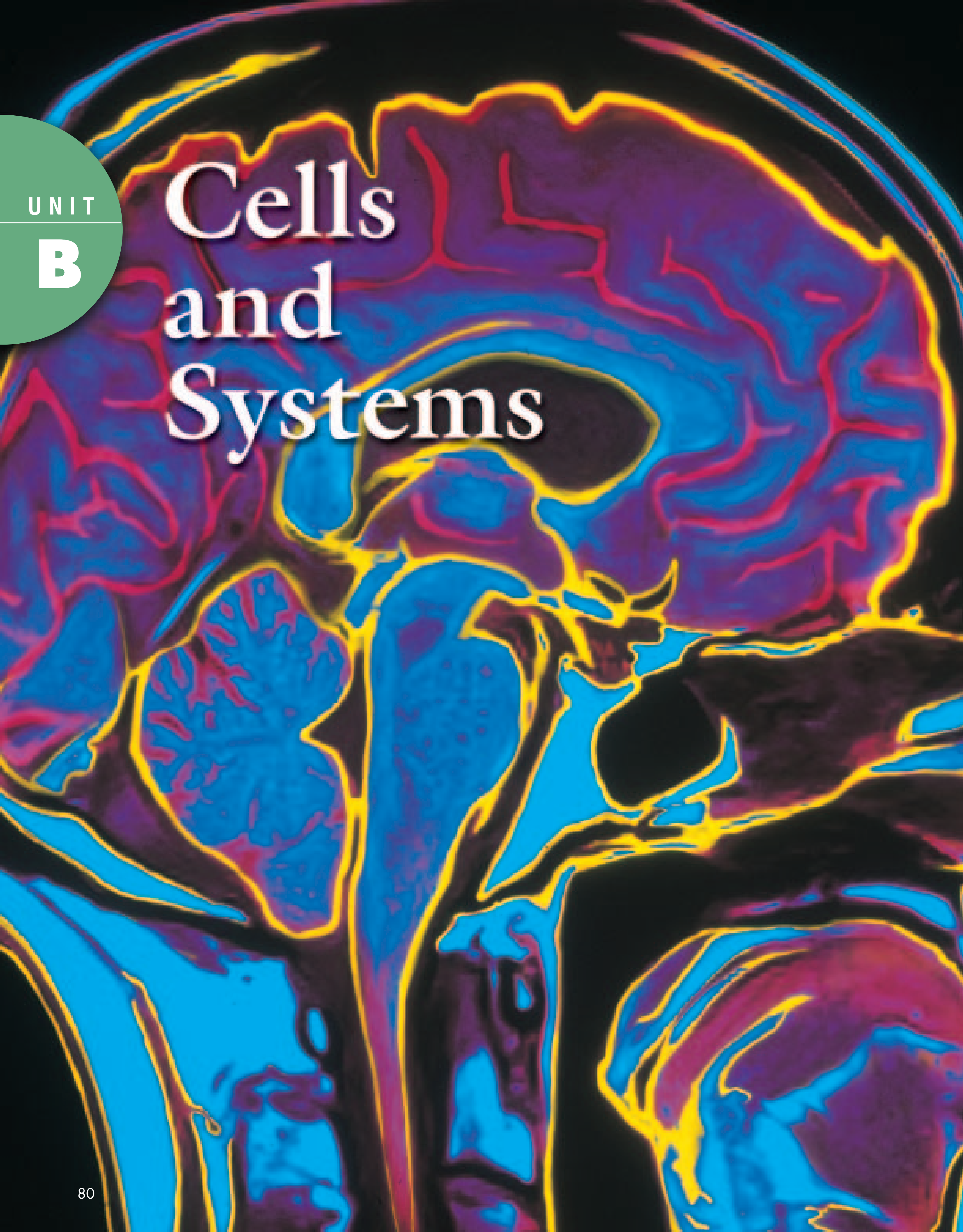
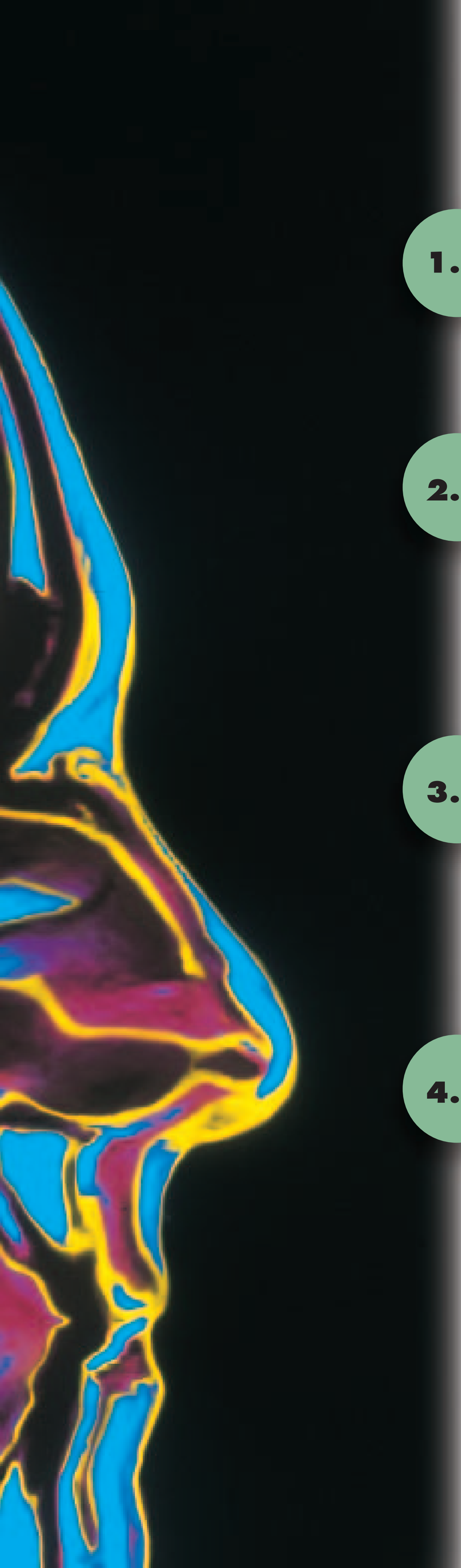
UNIT B

Cells and Systems





In this unit, you will cover the following sections:

1.0

Living things share certain characteristics and have structures to perform functions.

1.1 The Characteristics of Living Things
1.2 Structure and Function
1.3 Organs and Organ Systems

2.0

Cells play a vital role in living things.

2.1 The Microscope Extends the Sense of Sight
2.2 The Cell Is the Basic Unit of Life
2.3 Organisms Can Be Single-Celled or Multicelled
2.4 How Substances Move Into and Out of Cells
2.5 Cells in Multicellular Organisms Combine to Form Tissues and Organs

3.0

Healthy human function depends on a variety of interacting and reacting systems.

3.1 Digestive System
3.2 Respiratory System
3.3 Circulatory System
3.4 Excretory System
3.5 Nervous System

4.0

Scientific investigation leads to new knowledge about body systems and new medical applications.

4.1 Developing a Theory for Disease
4.2 Factors That Affect the Healthy Function of Body Systems

Exploring

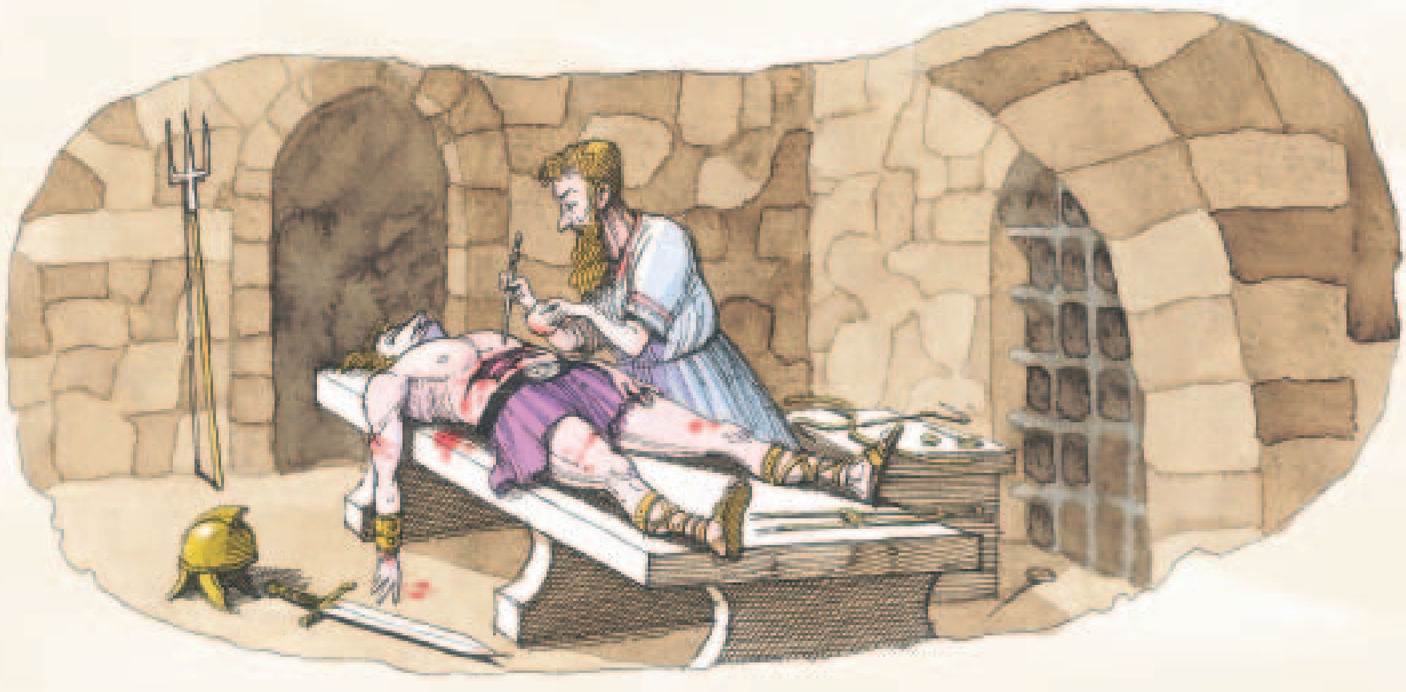
Blood and Guts

One of the first people to observe internal body structures and devise a scheme of how they worked was a Roman called Galen. He was a keen observer, which is an important quality for someone interested in studying the natural world.

Galen wanted to find out how the human body worked, but at the time, there were strict laws against opening up dead human bodies. Luckily, Galen's job allowed him to view the inner workings of the human body. He was the doctor to the gladiators! Roman gladiators had to fight each other to the death. As a result of these combats, the survivors were often injured badly. While he was trying to heal their gaping wounds, he could observe their internal organs. And because these wounds bled so much, he was able to observe how blood flowed in the body.

Through his observations and experiments, he did make some important discoveries. But his ideas about how body parts worked seem quite bizarre today. He mapped the major nerves of the body, but he thought they were hollow tubes through which flowed a "life force." He also thought that the liver was the most important structure in the body because it was so big and had lots of tubes coming out of it. He decided that its purpose was to heat the body.

Galen lived from A.D. 129 to 216. He eventually became the emperor's doctor.



Though these ideas might seem odd today, doctors accepted Galen's theories on how the body worked right up until the sixteenth century.

Give it a TRY ACTIVITY

PIECING TOGETHER THE BODY

You may think Galen's theories were absurd, but what do you know about the body's internal and external parts and how they work together? In this activity, you will have a chance to put your knowledge to the test.

Work with one or two of your classmates. Make a list of all the body parts that you can think of, both internal and external. Write each one on a small piece of paper. Try to figure out how they work together to keep you alive. Once your group has decided that there is a pattern, create a concept map showing how these body parts are linked.

- How many body parts could you name?
- Did you know the functions of the parts you named?
- Did you know how each part related to another?

Focus On THE NATURE OF SCIENCE

As you work through this unit, you will be reading and doing activities about cells and systems. You will encounter three major themes that are important to the study of life science: systems, cells, and structures and functions. You will need an understanding of these themes to do the project about investigating single-celled organisms.

Use the following questions to guide your reading as you learn about cells and systems.

1. **What do all living things have in common?**
2. **What types of systems do living things have, and how are they organized?**
3. **What are the functions of various structures found in living things?**

1.0 Living things share certain characteristics and have structures to perform functions.

Key Concepts

In this section, you will learn about the following key concepts:

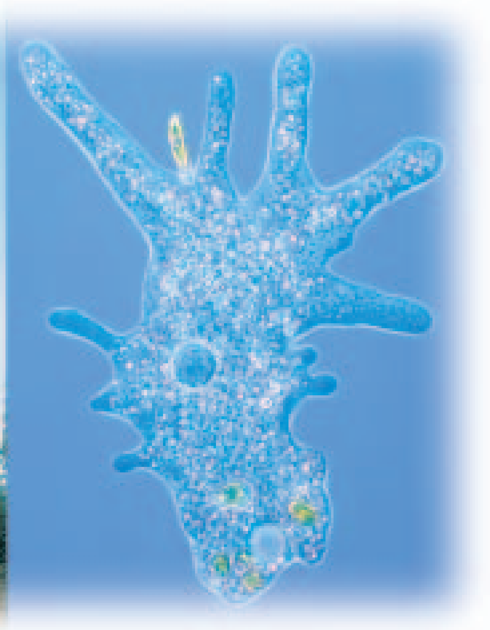
- organisms
- cells
- organs
- structure and function
- systems
- response to stimuli

Learning Outcomes

When you have completed this section, you will be able to:

- describe the characteristics of living things
- analyze the general structure and function of living things
- explain how living things have different structures for similar functions
- show how the body is organized into systems

Giant sequoia



Amoeba

There are about 1.75 million different types of living things on Earth. They come in many different forms—from a single-celled bacteria that can be seen only with a microscope to a giant blue whale over 30 m long, to a giant sequoia tree that's over 100 m tall. Despite the differences among all the different life forms on this planet, there are similarities between them. All living things have features in common that distinguish them from non-living things.

Living things have an amazing variety of functioning parts. For example, some have leaves, some have wings. One way of making sense of this variety is to think about the function of the parts, or what they are used for. What do cats use their claws for? What does a tree use its roots for? Does the structure of these parts tell you something about how they work?

Any single living thing is made up of different structures. These structures work together to keep you, or any other plant or animal, alive. These parts work together as a single unit to keep a plant or animal running smoothly.

For Web links relating to 1.0, visit www.pearsoned.ca/scienceinaction

1.1 The Characteristics of Living Things

Before you can make sense of the millions of different living things on Earth, you have to be able to know what is alive and what is not. When trying to decide what is living and what is non-living, you have to find common characteristics for all forms of life. Although they are still debating, most scientists agree on these six characteristics of living things:

- are made of cells
- need energy
- grow and develop
- respond to the environment
- reproduce
- have adaptations for their environment

All living things, or **organisms**, have all of these characteristics. Non-living things may have some of these characteristics (for example, clouds may grow in size), but they will not have all of them.

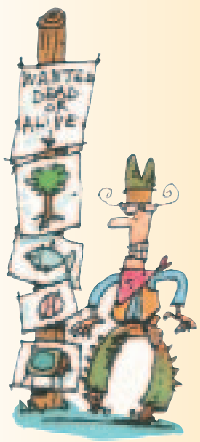
Figure 1.1 What is the energy source for the animal? What is the energy source for the plant?

Give it a **TRY** ACTIVITY

DEAD OR ALIVE?

Draw a table with two columns, one headed *Living*, the other *Non-living*. Place each of the following items under the appropriate heading: radio, tree, mushroom, hair, fish, rain, bicycle, moss, skirt, soil, television, carrot, baseball, rock, seeds, air.

- Do all the things that you placed in the *Living* category meet the six characteristics of living things?
- Were there any items that you had trouble placing in either category?



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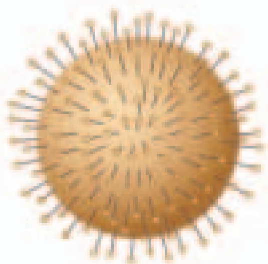
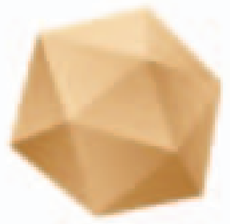
Viruses

Have you ever had a cold? Colds (and many other diseases) are caused by viruses. Viruses are extremely small and come in many different shapes. There is an entire branch of biology devoted to the study of viruses, even though most scientists don't consider them to be alive. This is because viruses can't reproduce by themselves. They depend on living cells of other living things to reproduce.



polio virus



flu virus

Cells

The cell is the basic unit of life. A cell can perform all the processes that life depends on. All organisms are made up of at least one cell, and every cell comes from another cell.

Cells are usually microscopic in size, so a single-celled organism is almost always tiny. A large organism, such as a tree, can be made of trillions of microscopic cells.

Non-living things are not made of cells. However, there are exceptions. Cells are found in non-living material if that material was alive at one time. For example, if you looked at a piece of wood under a microscope, you would see evidence of cells. This is because the wood came from a tree that was once alive.

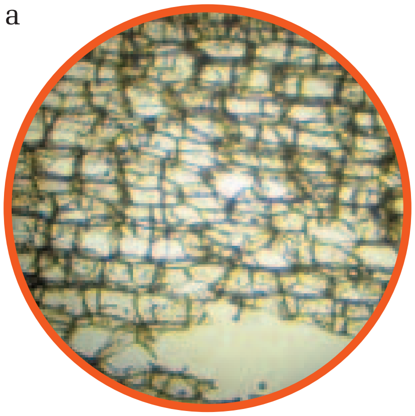


Figure 1.2 Cells from a cork

Energy

Everything an organism does requires energy. Think of all the things you did in the last few hours: you slept, had breakfast, walked to school or ran to catch the bus, and started school. All of these things required energy. Energy is the ability to make things move or change.

Organisms get energy from the environment. Plants and animals differ in how they get their energy. Plants use the energy from the sun to make their own food. Animals get their food from the environment around them. Plants and animals both obtain nutrients from their food and the environment. **Nutrients** are substances that provide the energy and materials that organisms need to grow, develop, and reproduce.

Many different chemical processes happen inside cells. Some of these processes create energy, and some of them use energy. For an organism to stay alive, there has to be a balance between these energy-using processes and the energy-creating processes. The sum of all the different processes that happen in an organism is called the organism's **metabolism**.

Responding to the Environment

You step out onto the street and suddenly you see a moving car barrelling toward you. What do you do? You jump out of the way. The sight of the moving car is actually a stimulus. A **stimulus** is anything that causes a response in an organism. Jumping out of the way of the car is a reaction, or **response**, to a stimulus.

Growth and Development

You may have grown a few centimetres taller in the past year. But growth is not just about getting bigger. It may also involve a change in structure. When you plant a seed, it grows roots and produces a stem and leaves. Once the plant gets to a certain size, it may not get any bigger, just as you will not grow beyond a certain height. But growth doesn't end there. Parts of any living thing wear out or get damaged. Every year, trees produce new leaves. Your skin keeps replacing itself as it gets worn away.

As some organisms grow, they change their body shape quite drastically. This is called development. Think of a frog. Adult frogs release eggs in the water. As each egg develops, it turns into a tadpole with a tail and gills. As the tadpole grows, it loses its gills and tail and develops lungs and limbs. Finally, it moves from the water onto the land.

Reproduction

All living things come from other living things. This process is called reproduction. Reproduction is not actually necessary for an organism to survive. But since all individual organisms die, reproduction is necessary for the survival of each type of organism.

Give it a **TRY** — Activity

Misinterpreting the Evidence

It seems pretty clear to us that living things come from living things, but this wasn't always so obvious. People noticed that mice often appeared from stacks of straw, and that flies and maggots appeared from rotting meat. People then assumed that the piles of straw and the rotting meat could create mice and flies. The idea that living things could come from non-living things was called **spontaneous generation**. But people had misinterpreted the evidence.

However, in the 1600s, an Italian doctor called Francisco Redi performed an experiment to test the idea of spontaneous generation. He put some meat into three jars. One he left open, another he sealed shut with a lid, and a third he covered with a mesh screen. He thought that if spontaneous generation actually happened, maggots would appear on the spoiled meat in all the jars. Figure 1.3 shows the results of the experiment.

Observe the results of the experiment. How did the experiment disprove spontaneous generation?

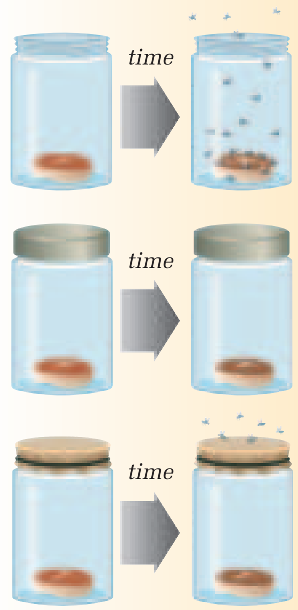


Figure 1.3

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Monarch Development
Monarch butterflies go through an amazing development in their life cycle. What are the stages of development of the butterfly? What happens at each stage?

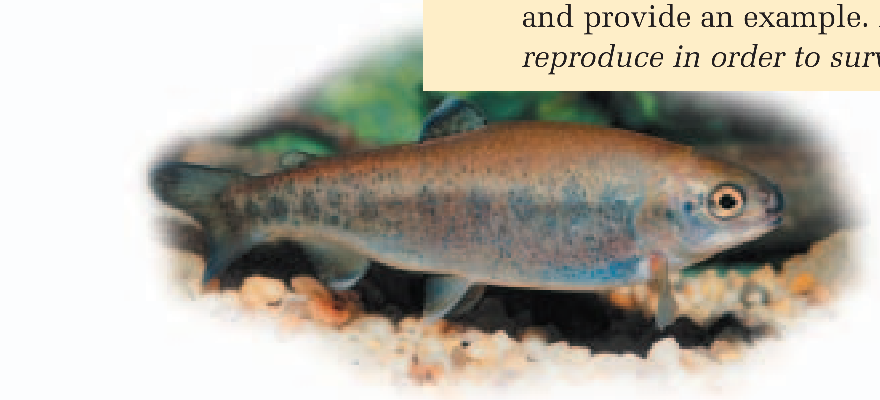
ADAPTATIONS

In the winter, snowshoe hares grow a white coat of fur. This allows them to blend in with their snowy surroundings and avoid being noticed by predators. This coloration is an example of an adaptation. An adaptation is a characteristic that allows an organism to live in its environment. Animals and plants have many adaptations. A cactus has spines to stop animals from eating it. A mountain goat has tiny feet to allow it to perch on steep cliffs.

Figure 1.4 Snowshoe hare in winter

CHECK AND REFLECT

1. List the characteristics of living things. Give an example of each characteristic.
2. What adaptations does a fish have for living in water?
3. Is skin a living thing?
4. Is the following statement true or false? Explain your answer and provide an example. *Each individual organism must reproduce in order to survive.*



1.2 Structure and Function

As well as having certain characteristics, living things have to do certain things to keep themselves alive. Some of the things animals do are to exchange gases, move, and gather food. Plants don't move like animals do, but they do exchange gases and gather nutrients. Organisms have developed many different ways of doing these tasks and have developed different body parts, or **structures**, to do them. Each structure is used for a specific **function**, which means it carries out a specific task.

Give it a **TRY** — ACTIVITY

WHICH STRUCTURE FOR WHAT FUNCTION?

List a number of functions an organism must perform in order to survive. Your list might include movement, food gathering, breathing, and so on. Make a table and place these functions in the first column, and place the organisms pictured in Figure 1.5 in the top row, as illustrated below.

Look at the organisms in Figure 1.5 and decide what structure each organism uses to perform each function. Then, fill in the table. When you are finished, compare your table with those of your classmates.

- Did they list important functions that you did not?
- Which function was listed by the most people?
- Did all the organisms have structures for all the functions you listed?

	Dolphin	Tree	Beetle	Tiger
movement				
food gathering				

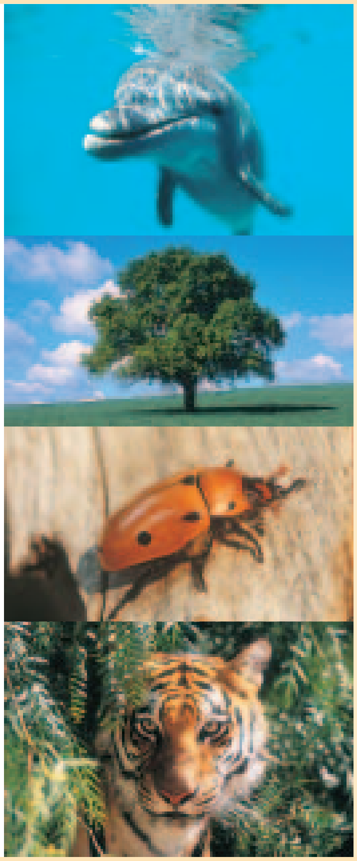


Figure 1.5

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Spiracles

Some animals have unusual ways of breathing! Insects have small holes in the sides of their abdomens called spiracles. Insects adjust the amount of air that enters their bodies by adjusting the size of their spiracles.

Spiracles are the dark spots on the side of the abdomen.

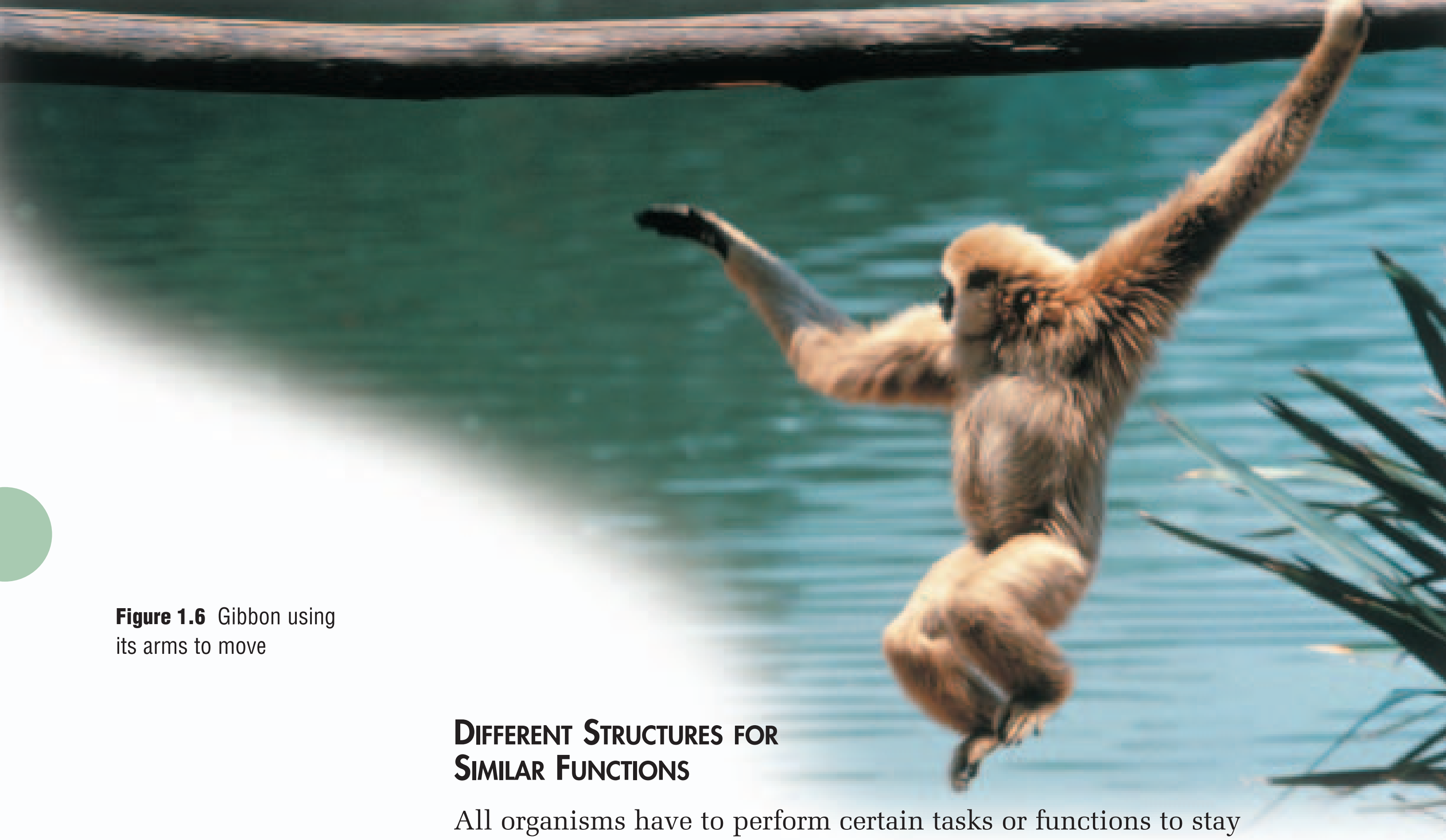

Figure 1.6 Gibbon using its arms to move

Different Structures for Similar Functions

All organisms have to perform certain tasks or functions to stay alive, but different plants and animals have developed different structures for doing similar functions. For example, most animals have to move about in order to find food. But animals have very different structures for performing this function. Birds have wings to fly through the air, and whales have tail flukes and flippers to swim through the water. We humans mostly use our legs to move around, but gibbons mostly use their arms. Can you think of other structures animals have for moving around?

Organisms have an amazing variety of food-gathering structures. Barnacles have tentacles that rake the seawater for tiny bits of food. Birds have bills. Insects have very complicated mouth parts. Mammals have different types of teeth to help them chew the food they eat. Teeth can vary from the sharp teeth of a lion to no teeth at all. An anteater has no teeth, just a long, sticky tongue that allows it to gather ants.

Figure 1.7 Feeding structures of barnacles and an anteater

Gills, lungs, spiracles, skin—all of these are breathing structures used by different animals. Plants use their leaves to exchange gases with the surrounding air. Leaves can vary widely in shape, from the tiny needles of spruce trees to enormous flat leaves up to 2 m wide! Conifers, like the spruce, have tiny needles to reduce the amount of water lost in their dry environment.

Figure 1.8 Leaves come in many shapes and sizes.

Variations in Structure

As you have seen, structures used for a certain function can be very different. But they aren't always wildly different. Similar organisms often have slight variations in their structures. These variations are often very easy to see in animals living on islands.

The Galapagos islands are located off the west coast of South America. On the islands, there are 13 closely related species of birds, commonly known as finches. They were discovered by the famous biologist Charles Darwin over 100 years ago. These finches, known as Darwin's finches, as well as many other birds, have different bill structures to perform the function of food gathering.

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Marine Iguanas

There are other species living on the Galapagos islands that have unique features. What structures does the marine iguana have to help it gather food? How is it different from other species of iguana?

Variations in Bill Shape

Three of Darwin's 13 species of finches are pictured in Figure 1.9. Finches are usually seed-eating birds with large bills adapted for crushing hard seeds. However, typical of island organisms, Darwin's finches have different structures for the function of feeding.

Study the different bird bills in Figure 1.9 and decide what kind of food-gathering functions each bill structure would be best suited for. One bird is a warbler-like finch that eats insects hiding within the bark of trees. Another is a ground-dwelling finch that eats seeds and nuts. The third type is a parrot-like finch that eats tree fruit.

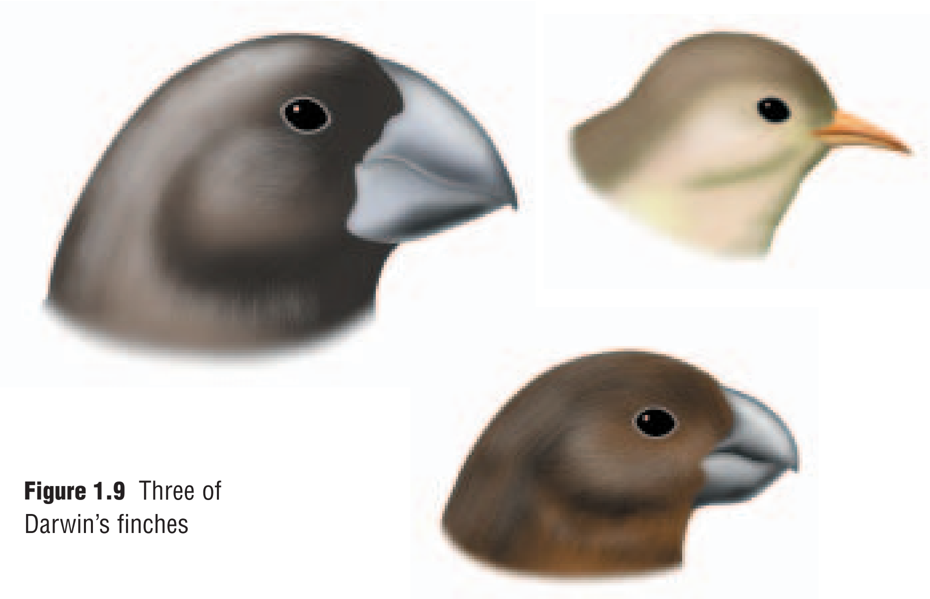

Figure 1.9 Three of Darwin's finches

Check and Reflect

1. Name as many functions as you can think of that an organism must carry out in order to survive.
2. Identify at least one type of structure that an organism would need to perform each of the above functions.
3. Why might similar organisms, such as birds, have different structures to perform the same function such as feeding?
4. What is the function of flowers? Why do you think they come in so many bright colours?

1.3 Organs and Organ Systems

So far, you have seen that you and other organisms have structures that allow you to survive and interact with your surroundings. But you have many other body structures that are constantly in use for other functions. These include your heart, lungs, brain, and kidneys. What other body parts can you think of? None of these body parts functions on its own. Each part is an **organ**. The organs that make up each **organ system** work together to perform a certain task or function. For example, the organs of your digestive system work together to break down food to supply your body with the energy and nutrients you need to survive. The following charts describe some of your body's organ systems.

Give it a **TRY** ACTIVITY

DRAWING SYSTEMS

Notice that some of the organ systems mentioned in the text to follow do not have illustrations. That's your job. On a piece of paper, draw a rough outline of the body. Study the list of structures of the circulatory system. Imagine what they look like and where in the body they are located. Draw these structures in your body outline. Repeat the process for the other organ systems.

CIRCULATORY SYSTEM (see subsection 3.3)

Structure	Function of System
heart arteries veins capillaries blood	• transport oxygen, food, and other substances throughout the body • transport some wastes to other organs for elimination • defend the body against diseases • connect all other organ systems

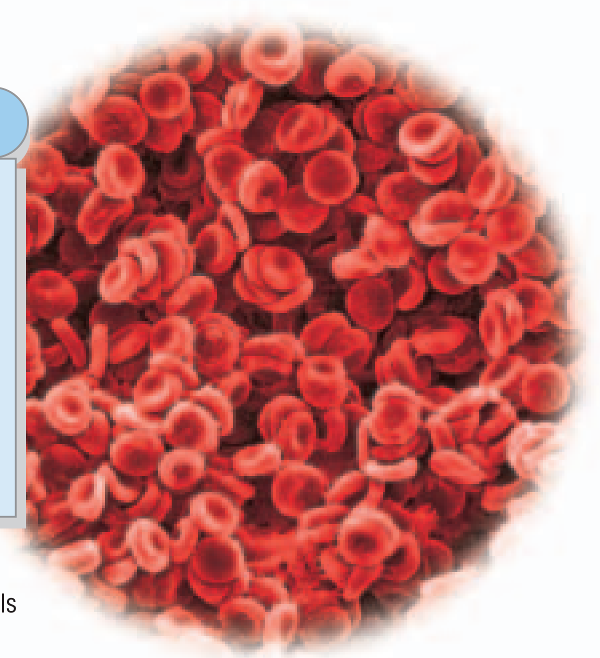

Figure 1.10 Red blood cells

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Only Skin Deep

The largest organ in the human body is the skin! It has a surface area of almost 2 m^2 and it weighs almost 3 kg.

Respiratory System (see subsection 3.2)

Structure	Function of System
nose mouth trachea diaphragm bronchi lungs	• transport oxygen from the outside air to the blood • transport carbon dioxide from the blood to the outside air

Digestive System (see subsection 3.1)

Structure	Function of System
salivary glands mouth esophagus stomach liver pancreas gall bladder small intestine large intestine	• break down food pieces into much smaller pieces (particles) so they can be absorbed and transported throughout the body

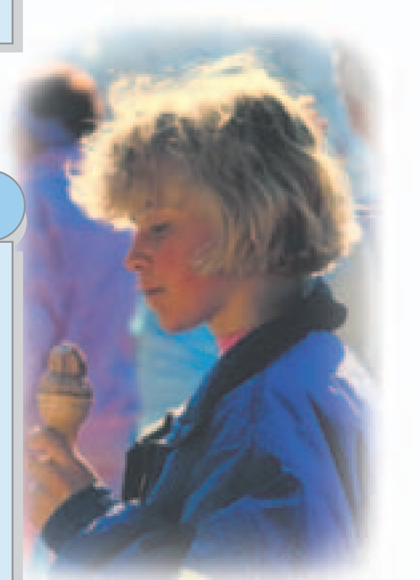


Figure 1.11 The digestion of food begins in your mouth.

Nervous System (see subsection 3.5)

Structure	Function of System
brain spinal cord nerves eyes, ears, and other sensing organs (hands, nose, etc.)	• coordinate and control the actions of all organs and organ systems • detect, process, and respond to changes in external and internal environments

Figure 1.12 The brain controls your nervous system.

Excretory System (see subsection 3.4)

Structure	Function of System
kidneys bladder lungs skin liver	• remove chemical and gaseous wastes from the blood

Skeletal System

Structure	Function of System
bones cartilage	• provide a movable support frame for the body • protect soft-tissue organs such as the heart and lungs

Muscular System

Structure	Function of System
muscles tendons	• move bones • move organs that contain muscle tissue (such as the heart and stomach)

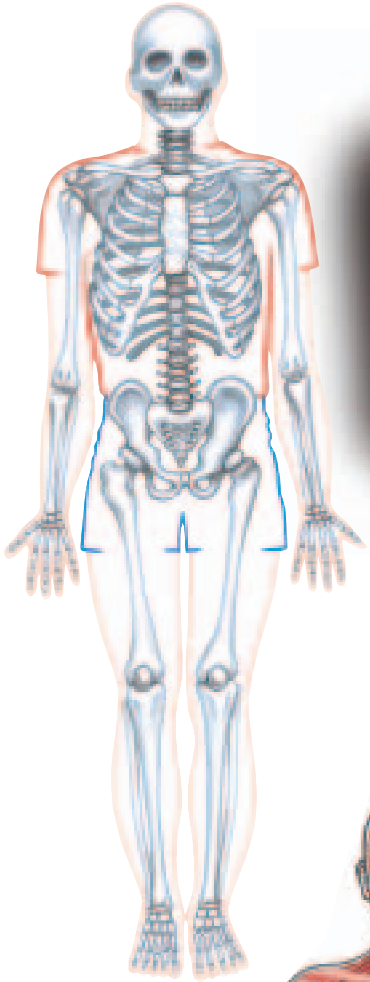
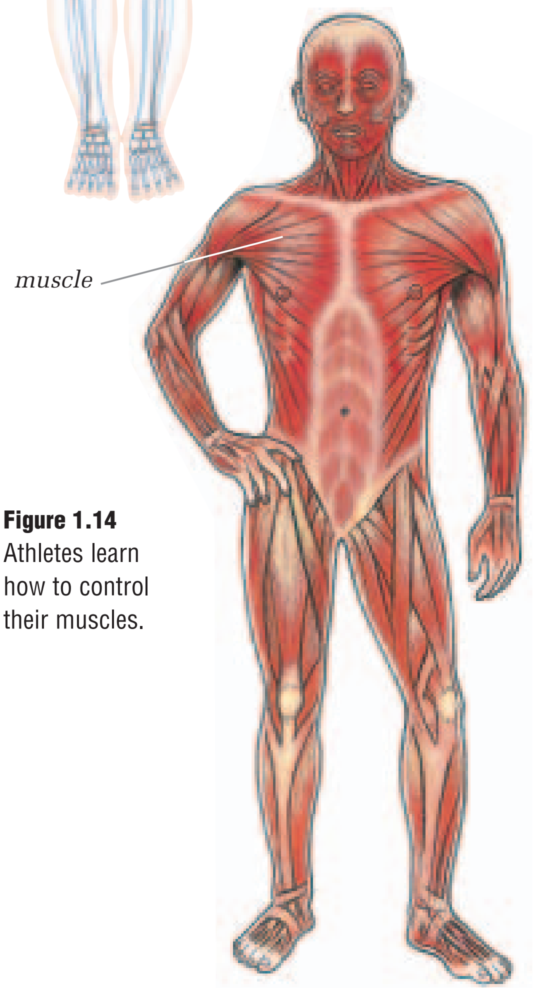


Figure 1.13 You have 206 bones in your body.



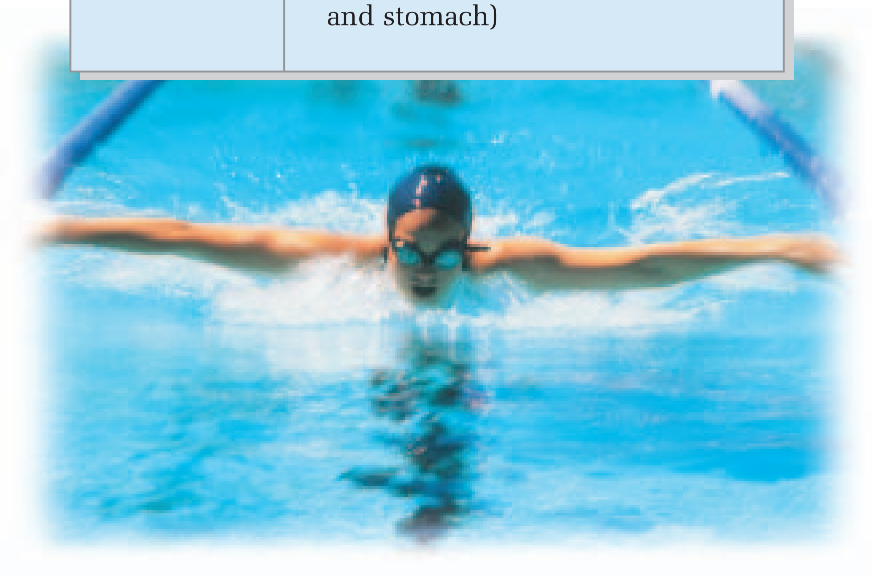


Figure 1.14 Athletes learn how to control their muscles.

INTEGUMENTARY SYSTEM

Structure	Function of System
skin	• protects the body's internal environment from the external environment • senses pain, pressure, and temperature

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Glands

An organ system that has not been mentioned is the endocrine system. Find out what the endocrine system does. What is the role of each of its organs?

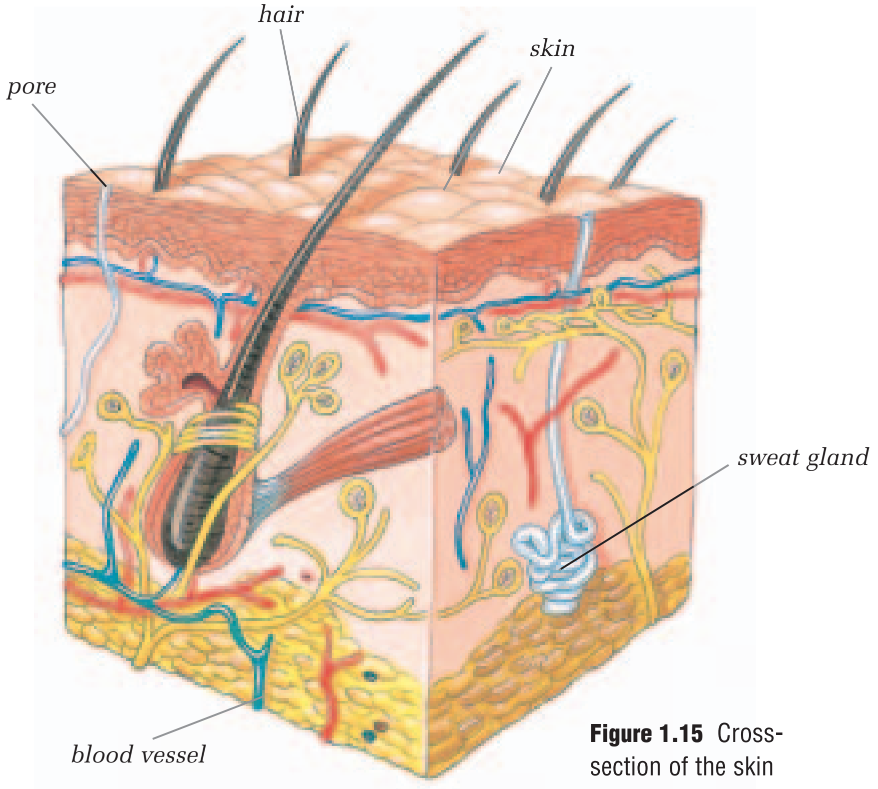
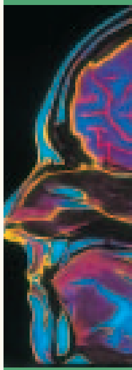


Figure 1.15 Cross-section of the skin

CHECK AND REFLECT

1. Why are organs grouped together into organ systems?
2. Could you do without any of your organ systems? Why or why not?
3. How do you think the systems studied in this subsection might work together to provide the requirements for a living organism?



Assess Your Learning

1. How are living things different from non-living things?
2. As you dive into a pool, you hold your breath. What characteristic of living things are you showing and why?
3. Choose two organisms found in your area and compare the structures each one uses for the same function (e.g., food gathering, breathing).
4. Define *structure* and *function*.
5. Make a labelled sketch of the organs of the digestive system.
6. A doctor has a patient complaining of shortness of breath when climbing stairs. Describe what body systems may be causing this problem and why.

Focus On THE NATURE OF SCIENCE

Scientific knowledge develops through observation, experimentation, and the discovery of patterns and relationships. Think back over what you've learned in this section.

1. What observations have people made about living things? What new information was developed from these observations?
2. What relationship did Redi's experiment establish?
3. Describe one relationship between human body systems that you discovered.

2.0 Cells play a vital role in living things.

Key Concepts

In this section, you will learn about the following key concepts:

- cells
- tissues
- organs
- structure and function

Learning Outcomes

When you have completed this section, you will be able to:

- use a microscope and prepare your own slides
- explain the role of cells as a basic unit of life
- identify plant and animal cells
- identify the differences between one-celled and multicelled organisms
- explain osmosis and diffusion
- recognize the roles of cells, tissues, and organs

For a long time, the circulatory system presented an unsolvable puzzle. People could easily observe the arteries and the veins. They could see that these blood vessels branched out into smaller and thinner vessels. Some observers suspected that blood from the arteries returned to the heart through the veins. However, they could not observe any linking structures between them. They had reached the limits of human sight.

In 1660, an Italian scientist named Marcello Malpighi solved the puzzle. He looked at an intricate network of thin, hair-like vessels connecting arteries and veins in the lung tissues of frogs. These blood vessels were later called **capillaries**, from the Latin word for "hair."

Malpighi's eyesight was no better than that of other scientists of his time. However, he lived during an exciting period in the history of modern science. By the early 1600s, a technological device had been invented that would change our understanding of life and living things. This device was the **microscope**.

The invention of the microscope allowed scientists to view the most basic element of life—the cell—for the first time. Later on in this section, you will learn more about the structure, function, and needs of cells.

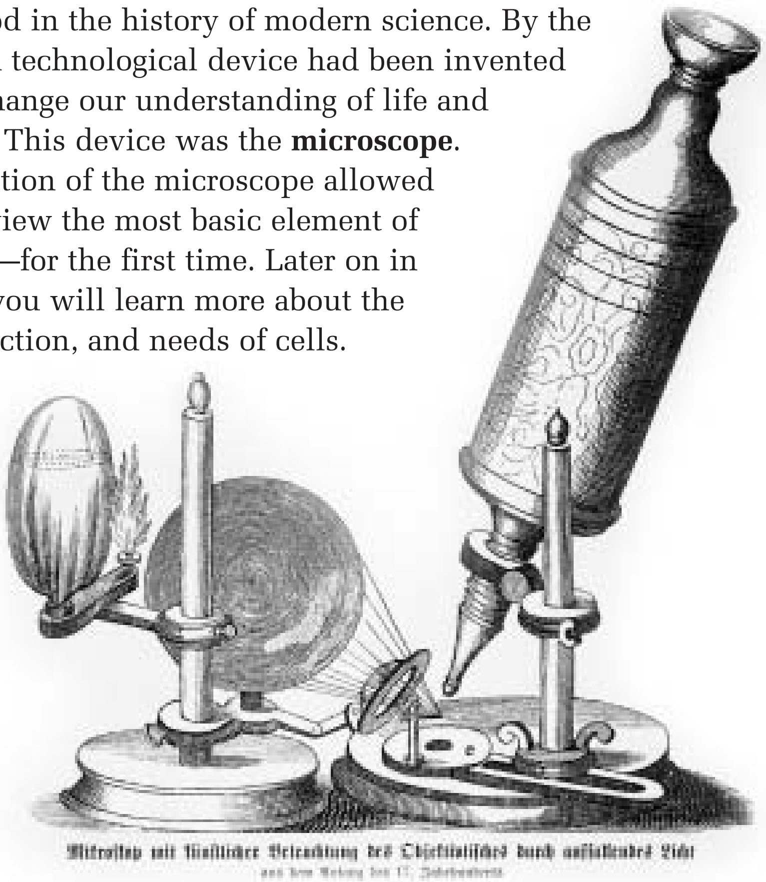


Figure 2.1 One of the earliest microscopes

2.1 The Microscope Extends the Sense of Sight

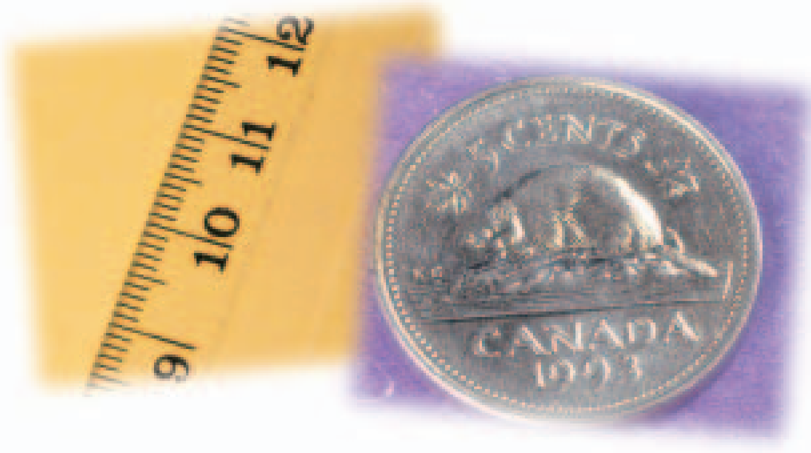


Figure 2.2 How close can your eyes come to an object and still see it clearly? Try it with a ruler and a coin.

Give it a **TRY** ACTIVITY

How Small Can It Be?

How small an object can you see with just your eyes? In your notebook, draw a line 1 mm long (or try making a circle that has a diameter of 1 mm). Have you ever seen an organism this small? Can you think of any organisms that are this small? Can you draw a line half a millimetre long?

Look closely at the dot pictures in Figure 2.3. All the dots in picture A are 1 mm in diameter. They are also 1 mm apart. (Use your ruler to verify this.) You can probably see each dot clearly. Can you see the dots in picture B clearly? What about in pictures C and D?

You probably can't see individual dots in picture D. This is normal. Most people with good eyesight can see only clear, defined images of things that are 0.1 mm or larger. This is a limitation of the human eye. To overcome this limitation and extend our sense of sight, we need the help of technology. We need a microscope.

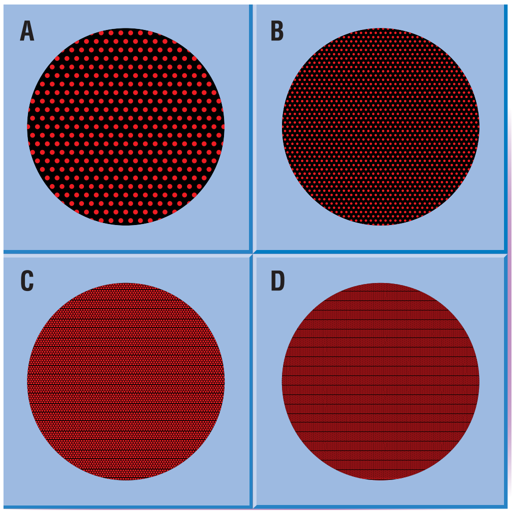


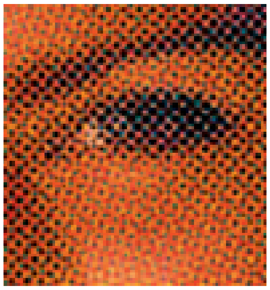
Figure 2.3 Dot pictures

*info***BIT**

A Closer Look

Look at this image close up. What do you see? Now look at it from a distance. What do you see?

Photographs in books, magazines, and newspapers are made up of tiny dots of colour and shade. This example has been exaggerated. The dots on a printed page are usually too small to see without magnification.



Introducing the Compound Light Microscope

A microscope magnifies (enlarges) the images of small objects. This magnification gives a clear, defined image that the human eye can see. The microscope you'll be using in class probably looks like the one shown in Figure 2.4. Take some time to study its parts and how they function. Then you'll be ready to take a closer look for yourself.

Microscope Parts and Their Functions

Any microscope that has two or more lenses is a *compound microscope*.

When you view an object with a microscope, you are looking through a thin slice of the object. You will see a lamp or other light source under the microscope's stage. That's why the full name for your microscope is **compound light microscope**. The light must travel through the thin object for you to see the object properly.

Microscopes are valuable precision instruments. Like all scientific equipment, they must be handled with care. As a class, develop a chart to summarize the proper care and handling of your microscopes. Use these questions as a starting point for your ideas.

- How should you prepare your work area before bringing the microscope to it?
- How should you carry the microscope to your work area?
- In what position (upright, tilted) should you keep the microscope? Why?
- What parts of the microscope should you keep clean? Why?
- How and where should you store the microscope when you've finished using it?

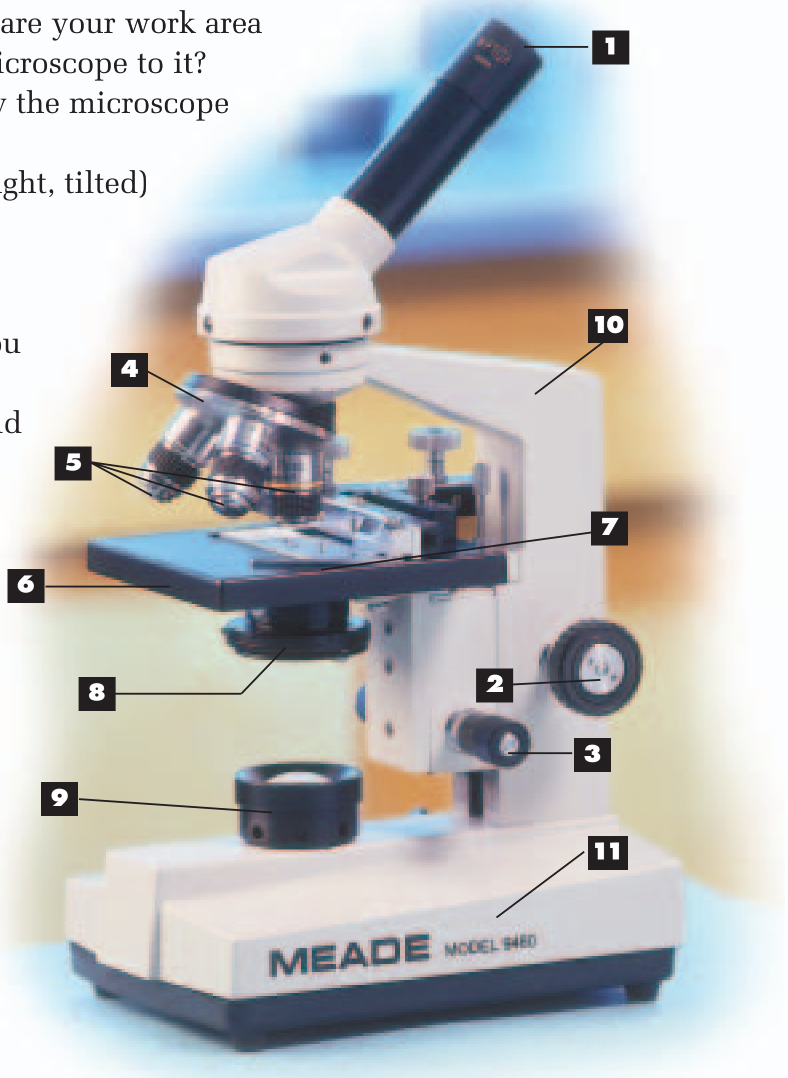


Figure 2.4
Compound light microscope