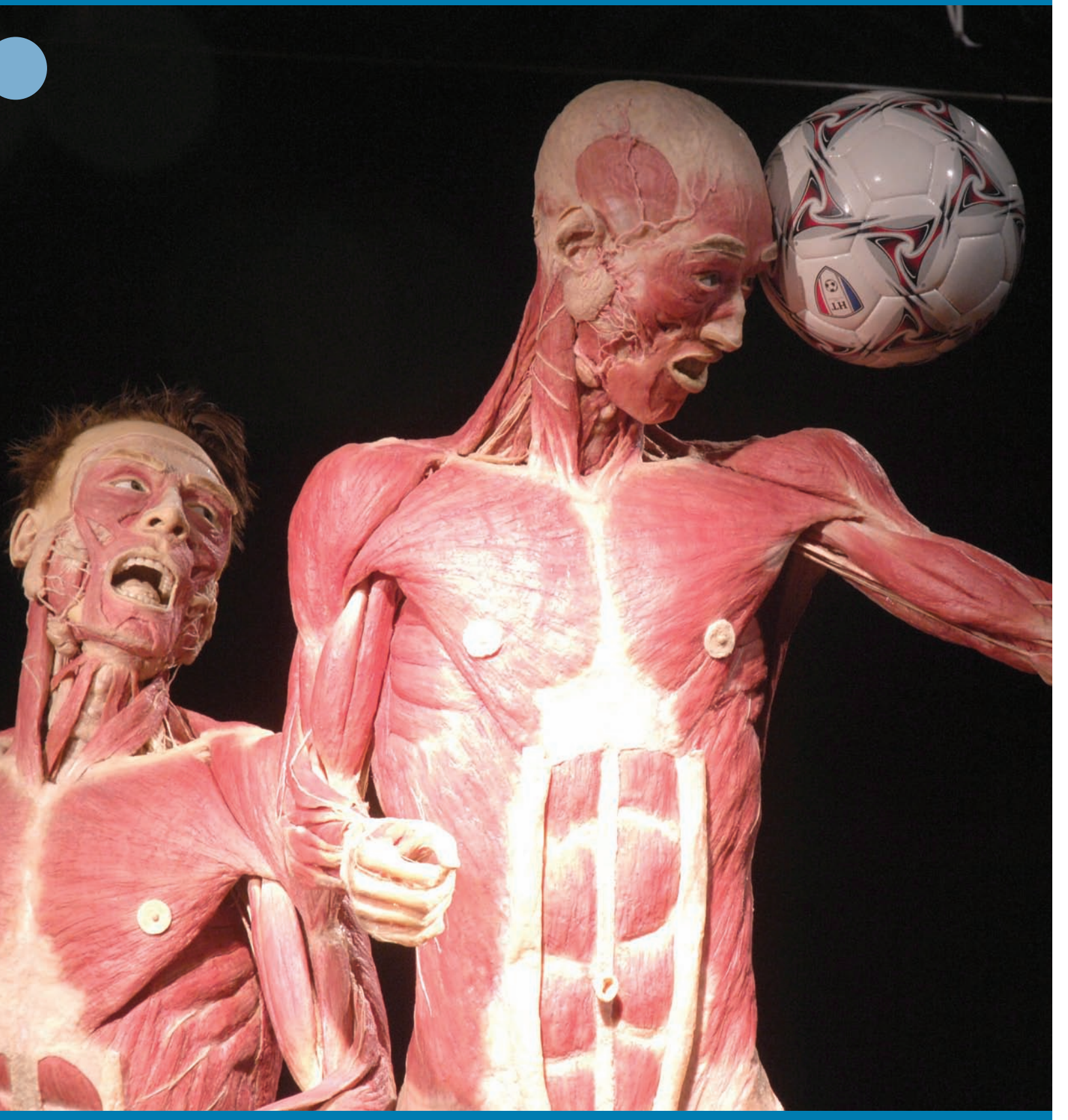
2 An organ consists of groups of tissues and works with other organs to form organ systems.



Our complex movements require the interaction of tissues, organs, and organ systems.

Skills You Will Use

In this chapter, you will:

- investigate, using a microscope, specialized cells in the human body or in plants, focussing on different types of cells, and draw labelled biological diagrams to show the cells' structural differences
- investigate, through laboratory or computer-simulated dissection of a plant, worm, fish, or frog, the interrelationships between organ systems of a plant or an animal
- use a research process to investigate a disease or abnormality related to tissues, organs, or systems of humans or plants

Concepts You Will Learn

In this chapter, you will:

- explain the links between specialized cells, tissues, organs, and systems in plants and animals
- explain the primary functions of a variety of systems in animals
- explain the interaction of different systems within an organism and why such interactions are necessary for the organism's survival

Why It Is Important

In this chapter, you will learn how the tissues in your body work together as organs and how your organs work together as organ systems. Understanding your body will help keep you as healthy as possible.

Before Reading

Thinking Literacy

Synthesizing: Putting the Pieces Together

Good readers know that often they have to read several paragraphs or pages of text to put together a whole picture of a topic. They know that each subtopic is really a piece of the puzzle. Preview the headings and subheadings in section 2.1, and write the ones that seem to go together in your notebook.

Key Terms

• absorption • capillaries • homeostasis • interdependent • organ • organ system

2.1 Organs in Animals and Plants

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

- In animals, tissues combine in special ways to form organs.
- In plants, tissues combine in special ways to form leaves, stems, and roots.

Figure 2.1 The organs were removed from Egyptian mummies before the body was preserved and wrapped.

What Is an Organ?

In ancient times, the Egyptians believed that all parts of a body were required in the afterlife. They developed special procedures to preserve the dead body in the form of a mummy so that it would not decay. They would cleanse the body and remove most of its internal organs because they would decay rapidly. Only the heart was left in place. An **organ** is an organized group of tissues that performs a specific function. The body was preserved with a drying agent and stuffed with linens and sawdust. The body was then wrapped from head to foot in linen (Figure 2.1).

Four organs — the stomach, intestines, liver, and lungs — were placed in special canopic jars, which prevented the organs from decaying (Figure 2.2). The lids of the jars were decorated with four protective spirits known as the four sons of Horus, who was one of the most important Egyptian gods. Each spirit protected a specific organ. Because the ancient Egyptians believed that the heart contained the spirit of the dead person, it was left inside the body. The brain was either left inside the skull or removed through the nose and discarded. The mummy was buried with the canopic jars so that the body could be complete in the afterlife.

Figure 2.2 Four canopic jars contained human organs.

The ancient Egyptians believed that only four organs were important. However, there are many organs in the human body: the kidneys, the eyes, the pancreas, the brain, and the skin are all organs. Each organ is made of a group of tissues that work together to perform a specific purpose. For example, the stomach, liver, and intestines are all organs that are involved with the digestion of food and the absorption of nutrients. The lungs are the site of gas exchange involving the intake of oxygen and the output of carbon dioxide. The skin, which is the largest organ in the human body, serves as a barrier against disease. Your kidneys filter wastes from your blood. All of our organs play a vital role in maintaining the health of our bodies.

It is important to keep our organs healthy and functioning properly. For example, eating a healthy diet and doing about 30 minutes of physical exercise a day strengthens your heart and lungs. Wearing sunscreen protects your skin from damage caused by the Sun.

When an organ does not work properly because of disease or injury, it is sometimes possible to transplant a healthy organ or part of an organ from a donor. Organs that are most often transplanted include the kidney, liver, lungs, and heart.

A13 *Quick Lab*

Mapping the Organs

The human body is made up of many organs that work together to accomplish all of the tasks required in a healthy functioning organism. Some of the organs are located on the outside of the body, while others are found internally. To understand the function of organs, you need to know where they are found in the human body.

Purpose

To predict the location, relative size, and shape of some organs of the human body, and to record your prediction in the form of a diagram

Materials & Equipment

- large piece of paper
- pen and/or pencil
- ruler

Procedure

1. Work with a partner, and obtain a large piece of paper from your teacher.
2. Have your partner trace an outline of your body on the large piece of paper.
3. Brainstorm for two minutes with your partner about the location, relative size, and shape of the following organs of the human body: stomach, lungs, intestines, liver, kidneys, and heart.
4. Draw and label the organs on the traced outline of your body.

Questions

5. Compare your completed labelled diagram with the answer key provided by your teacher. Which organs were the easiest to locate correctly? Which organs were the hardest to locate correctly?
6. Explain how so many organs in the human body fit in such a relatively compact space.

Animal Organs

Suggested STSE Activity
A14 Decision-Making Analysis Case Study on page 61

Recall that there are four types of animal tissues: epithelial, connective, muscle, and nervous tissue. Tissues join together to form organs that have specialized functions. For example, skin is an organ that covers and protects your body, while the heart transports materials around your body. Most organs are made of several different tissues. For example, the heart is made of muscle tissue, connective tissue, nervous tissue, and epithelial tissue.

Skin

WORDS MATTER

The word "epidermis" comes from the Greek word *epi*, which means on the outside, and the word *derma,* which means skin.

The largest organ in your body is the **skin.** The skin protects the inner cells from damage, acts as a defence against disease organisms, insulates, releases heat, and excretes bodily wastes. The skin is made up of two different layers of tissues: the epidermis and the dermis (Figure 2.3). The epidermis is the outer protective layer that is made up of epithelial tissue. The epidermis prevents bacteria and viruses from entering your body. The epidermis is also able to make vitamin D when the skin is exposed to ultraviolet radiation from the Sun. Vitamin D is essential for bone development.

The dermis is the inner layer of the skin and is made up of connective tissue, nervous tissue, and muscle tissue. Connective tissues provide structure and support. Blood and blood vessels are types of connective tissue. When you are hot, the blood vessels in your skin dilate, or become bigger, so that they can release excess heat. Pores in the skin secrete sweat produced in sweat glands to cool the body. Layers of fat, another type of connective tissue at the base of the dermis, provide insulation (Figure 2.4). The dermis contains nerves that sense pain, pressure, heat, and cold and send information to the brain. Muscle tissue in the dermis produces "goosebumps."

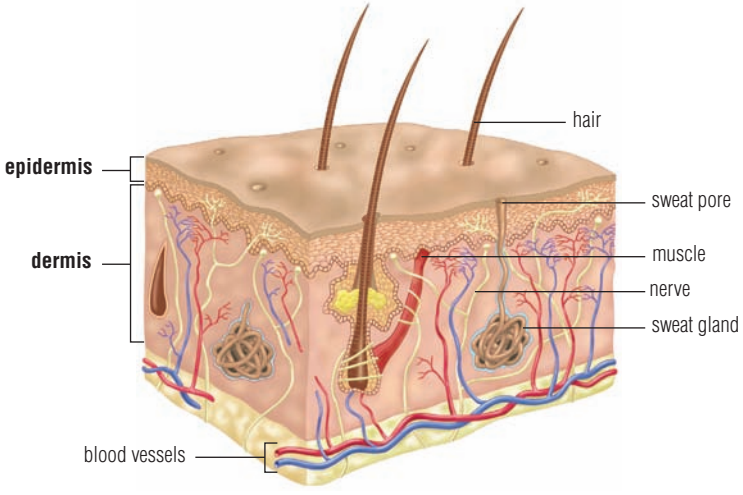


Figure 2.3 A cross section of skin showing the tissues and some of the accessory structures, such as hair and sweat glands.

Figure 2.4 Mammals, like these harp seals, that live in the Arctic have thick layers of fat in the dermis to provide insulation.

Lung

The **lungs** are a pair of organs involved in respiration (Figure 2.5). Your lungs allow you to breathe in oxygen and breathe out carbon dioxide. Cells need oxygen to function. In an adult human, one lung is about 1 kg. The lung is made of connective and epithelial tissue. Humans have two lungs that sit in a cavity in the chest area. The lungs are coated with two sacs of connective tissue separated by a thin layer of fluid. This not only protects the lungs but also reduces the effects of friction when the lungs move.

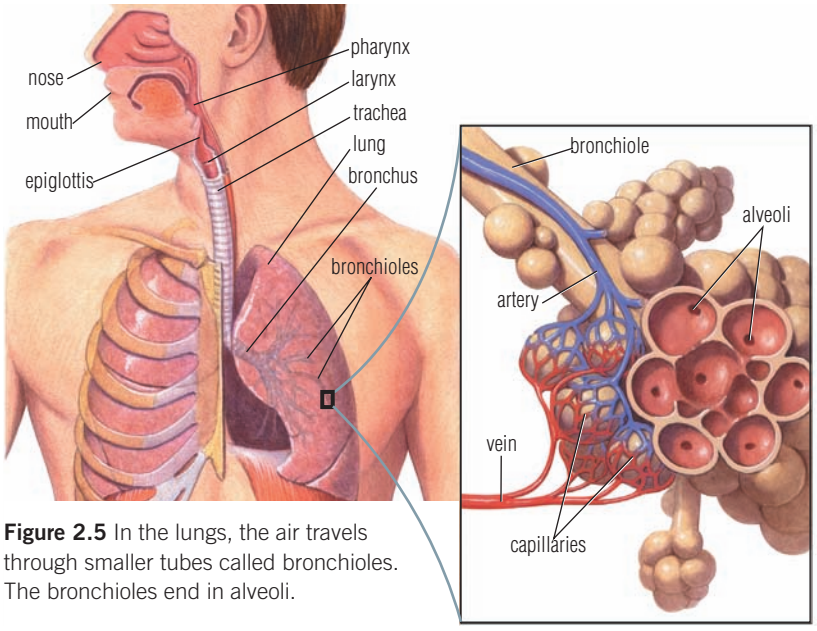


Figure 2.5 In the lungs, the air travels through smaller tubes called bronchioles. The bronchioles end in alveoli.

When you breathe in air through your nose or mouth, the air passes through the pharynx into your trachea. The trachea is a flexible tube that is ringed with cartilage. Air moves down the trachea to the bronchus, into smaller bronchial tubes, and then into tiny air sacs, called alveoli, which are made of a thin layer of epithelial tissue. Alveoli are surrounded by thin-walled blood vessels called **capillaries** (Figure 2.5). Each lung contains about 150 million alveoli. Oxygen travels from the alveoli through the capillaries into the blood. Carbon dioxide travels from the bloodstream across the alveoli to the air in the alveoli.

Heart

The **heart** is a muscular pump that supplies blood to all parts of the body. An adult human heart is about 300 g and is the size of a fist. In an average lifetime, the heart beats about 3.5 billion times. The heart is divided into four chambers: the left and right atria, and the left and right ventricles. The heart serves as a pump to deliver blood to the lungs, to the heart itself, and to the rest of the body (Figure 2.6).

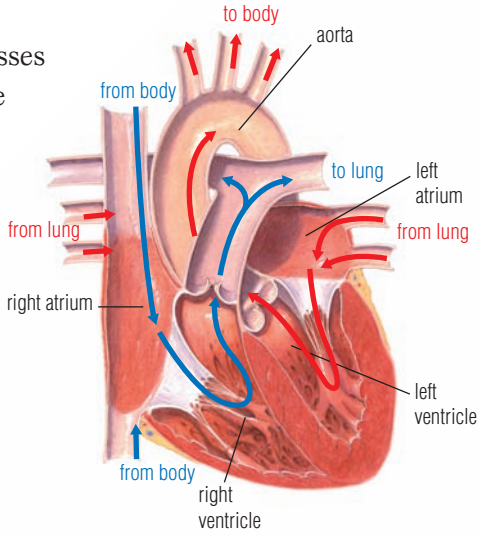


Figure 2.6 The right side of the heart (right atria and right ventricle) pumps blood to the lungs so that the blood can pick up oxygen. The left side of the heart (left atria and left ventricle) pumps the oxygenated blood through the aorta to the rest of the body.

Organs of Digestion

When you eat, various organs assist with the digestive functions to break down the food (Figure 2.7). For example, your mouth takes in food and begins digestion. The mouth is lined with epithelial tissue. There are also glands, made of specialized epithelial cells, that secrete mucus, saliva, and enzymes. The tongue is made of epithelial tissues and glands, connective tissues, and muscle tissue. Once the food enters your body, it travels from the mouth down a tube called the **esophagus**. The food moves along the esophagus because of the rhythmic constriction and relaxation of the smooth muscles that line the esophagus. This movement is known as peristalsis. The esophagus is lined with a protective layer of epithelial tissue. Further down the canal, food enters the **stomach,** which is made of epithelial, connective, nervous, and muscle tissues (Figure 2.8). The stomach churns food and mixes it with digestive juices and enzymes. Finally, the digested nutrients and undigested waste products move into the small and large **intestines**, which are areas of chemical digestion and removal of wastes. Solid wastes are stored in the rectum and exit the body through the anus.

During Reading

Thinking Literacy

Reread to Synthesize

Reread the subtopics about animal organs. Think about how these subtopics fit together and how one organ connects to another. Create a mind map of the organs, using lines and arrows to show which organs connect. Label the arrows with explanations of the connections.

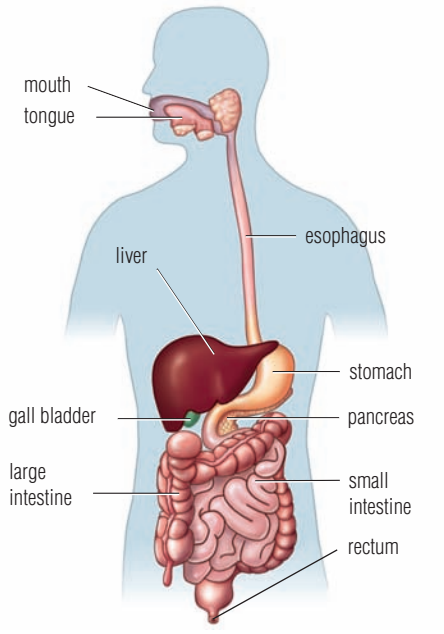


Figure 2.7 Organs of digestion

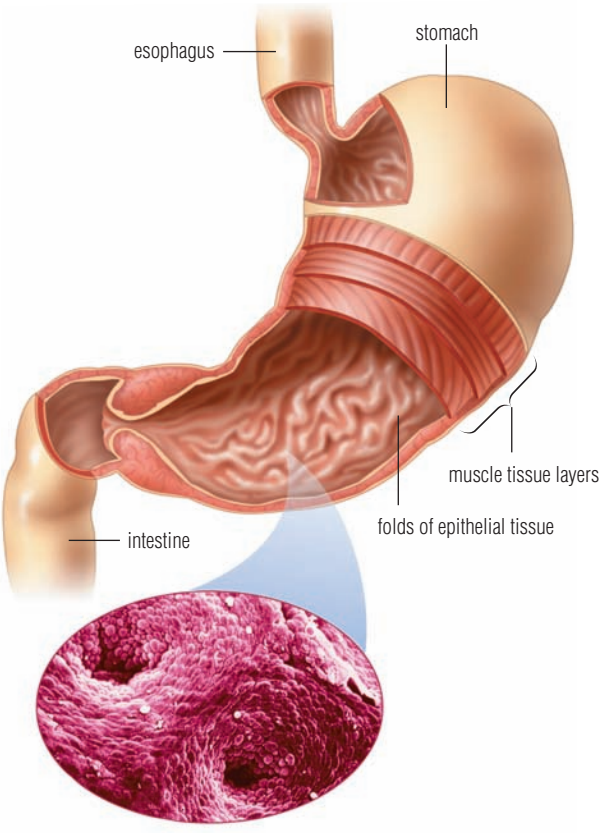


Figure 2.8 The stomach is made of smooth muscle and epithelial tissue as well as connective tissue and nervous tissue (not shown).

Plant Organs

A flowering plant is made up of four types of plant tissues: epidermal, ground, vascular, and meristematic. These plant tissues group together to form organs that perform special functions for the plant. The organs in a plant are the roots, the leaves, the stem, and the flower or fruit (Figure 2.9).

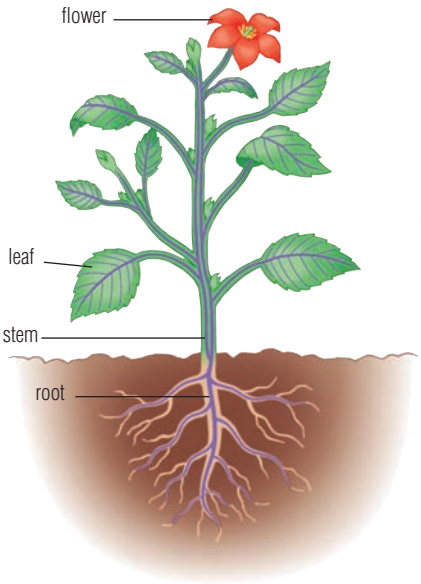


Figure 2.9 Groups of plant tissues form organs that perform specialized functions in a plant.

The Roots

The roots anchor the plant in the soil, which permits the plant to grow above the soil without toppling over. Roots also collect water from the surrounding soil and transport it to the stem, and store food that is made in other parts of the plant. Different tissues in the root work together to accomplish these functions. The bottom of the root is covered with protective epidermal tissue known as the root cap. Just below the epidermal tissue is a layer of meristematic tissue, which allows the root to grow. There are also layers of ground tissue and vascular tissue that make up the centre of the root.

The Leaf

The tissues in a leaf work together to accomplish photosynthesis, a chemical reaction in which carbon dioxide and water are converted into sugar and oxygen. The vascular tissue carries water needed for photosynthesis from the root up the stem to the leaf. The sugar produced is carried by the vascular tissues to the rest of the plant. Carbon dioxide enters, and oxygen and excess water exit through openings in the leaf epidermal tissue called stomata. These openings are controlled by special cells known as guard cells. Most of the leaf is made of a specialized ground tissue called mesophyll. Photosynthesis takes place in the mesophyll. Figure 2.10 shows the tissues in a leaf.

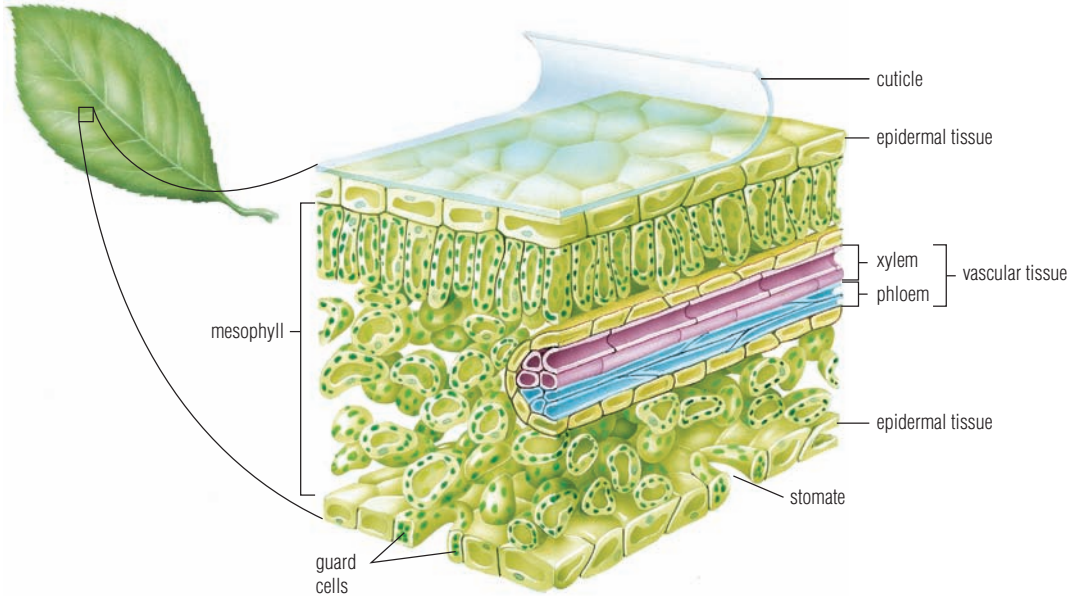


Figure 2.10 A cross section of a leaf showing the tissues

The Stem

The stem performs two major functions:

- transports water and nutrients throughout the plant
- supports the leaves and flowers

Suggested Activity
A15 Inquiry Activity on page 62

The tissues that make up the stem reflect these functions. Epidermal tissue provides a protective covering and allows for the exchange of gases and water vapour. In most plants, the epidermal tissue secretes a waxy substance known as the cuticle that forms a protective coating and reduces water loss. Ground tissue provides the stem with strength and support. Vascular tissue transports substances around the plant.

The Flower

The flower is the reproductive structure of the plant. The main function of the flower is to produce seeds through sexual reproduction. The flower contains male organs, called stamens. Each stamen consists of a filament with an anther at the tip. The anther produces pollen, which are the male sex cells. The flower also contains female organs, called the pistil, which consists of the ovary, style, and stigma. Female sex cells, called eggs, are located in the ovary. Figure 2.11 shows the reproductive organs of a plant.

When the pollen and an egg unite, the fertilized egg becomes a seed. Some seeds are surrounded by flesh and are called the fruit. Other types of seeds have no fleshy covering but are encased in a hard shell. Like other parts of the plant, new cells are made from meristematic tissue. As the flower structures develop, the unspecialized meristematic tissue differentiates to form the other parts of the flower, such as the sepals and the stamen.

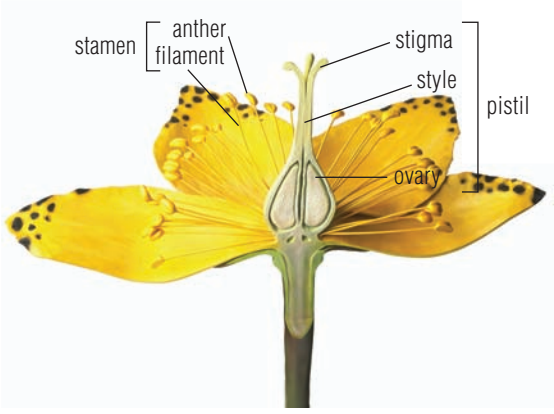


Figure 2.11 A flower's reproductive organs

Take It Further

Carnivorous plants have the unique ability to capture and digest prey. The interactions of the cells, tissues, and organs are intriguing. Select a carnivorous plant to study. Explain how the plant captures, digests, and processes the nutrients in the prey. Report your findings to the class. Begin your research at *ScienceSource*.

Learning Checkpoint

1. What are the three functions of the roots?
2. Describe the major job of the leaf, and explain how two tissues in the leaf work together to accomplish this job.
3. Describe two functions of a stem, and explain how the tissues in the stem work together to accomplish one of the stem functions.
4. What is the major function of a flower?
5. Sketch a plant showing the root, stem, leaves, and flower. Use a system of colour coding or symbols to indicate the location of epidermal tissue, vascular tissue, and ground tissue.

CASE STUDY

A14 STSE *Decision-Making Analysis* Skills Reference 4

SKILLS YOU WILL USE
- Identifying issues to explore
- Justifying conclusions

A Look at Stem Cells

Issue

Over 40 years ago, Canadian researchers Dr. James Till and Dr. Ernest McCulloch discovered the existence of stem cells in the blood. Stem cells are unspecialized cells (Figure 2.13). They have the ability to become any type of cell and, thus, can form skin, bones, and organs. This ability makes stem cells perfect to repair or replace cells that are damaged or defective. Scientists believe that stem cells may be used to cure diseases of tissues and organs, such as Parkinson's and Alzheimer's disease, multiple sclerosis, cancer, diabetes, and heart and lung disease. However, controversy surrounds the use of stem cells because the human embryo is the best source for stem cells.

Background Information

Michael J. Fox is a Canadian actor who is best known for the *Back to the Future* series of movies. In 1998, Fox revealed that he had Parkinson's disease, which affects the nervous system and causes people to lose control over their muscles. In 2001, Fox launched the Michael J. Fox Foundation for Parkinson's Research to raise funds and awareness about Parkinson's disease. Fox is hopeful that embryonic stem cells may cure Parkinson's disease.

Canada has developed strict guidelines surrounding the use of stem cells. Only embryos that are less than 14 days old and that are no longer wanted for reproduction may be used. This means that, in Canada, creating human embryos for stem cell research is not allowed.

So far, stem cell research has been done only on lab animals. Using stem cells has improved stroke recovery in rats, treated a disease similar to Parkinson's in mice, and caused new brain cells to grow in birds. In 2007, a Canadian research team led by Dr. Freda Miller used skin-derived stem cells to repair spinal cord injuries in rats.

Analyze and Evaluate

1. Identify the different types of stem cells (from Chapter 1), and explain how stem cells can be used in the treatment of diseases.
2. There are many different viewpoints about the use of stem cells. Prepare a graphic organizer that presents the position from one of the following points of view:
   - a research scientist
   - Michael J. Fox
   - a pharmaceutical company/biotech company owner
   - a public health official
3. ***ScienceSource*** Research how stem cells are used in the treatment of a specific disease or disorder. Include both the advantages and the disadvantages that are associated with the use of stem cells in the treatment of the disease or disorder.
4. **Web 2.0** Develop your research as a Wiki, a presentation, a video, or a podcast. For support, go to ***ScienceSource***.

Skill Practice

5. Explain how the ethical issues associated with the use of adult stem cells are different than those associated with the use of embryonic stem cells.

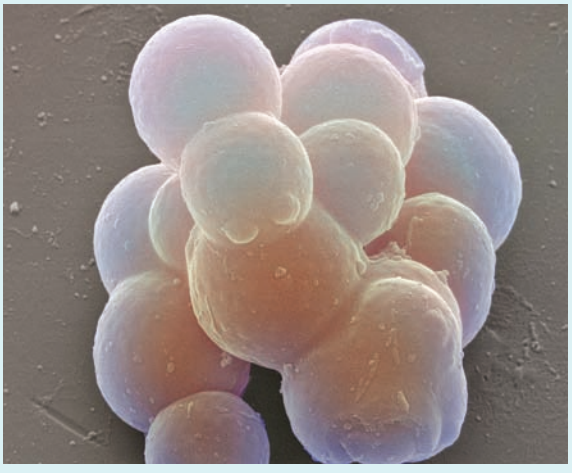


Figure 2.13 Stem cells

A15 *Inquiry Activity*

Skills References 2, 6

SKILLS YOU WILL USE

- Using equipment, materials, and technology accurately and safely
- Observing, and recording observations

Dissecting a Flower

Flowers vary greatly in their structure and appearance. For centuries, flowers have been prized for their beauty and also used as a source of food and medicine. The flower is the reproductive organ of a flowering plant.

Question

How is the flower designed for reproduction?

Materials & Equipment

- flower, such as a lily, tulip, daffodil, or gladiolus
- tweezers
- pen and/or pencil

CAUTION: If you are allergic to plants or pollen, let your teacher know.

Procedure

1. Obtain a single flower, and observe the parts carefully. Compare your flower with the labelled diagram (Figure 2.12). Make a sketch of each part of the flower, and include notes about the appearance of each part.
2. Locate the sepals. Using the tweezers, gently remove the sepals and place them on a paper.
3. Petals are found directly under the sepals. Gently remove the petals, and place them on the paper next to the sepals.
4. Locate the stamens. They may be attached to the ovary or petals. Identify the anther and any pollen sacs that are visible. Make notes about the appearance of each part.
5. Locate the pistil. Identify the stigma, style, and ovary. Make notes about the appearance of each part.
6. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Analyzing and Interpreting

7. Describe the appearance of the petals. Explain how flower petals are adapted to attract pollinators to the plant.
8. The pollen of grasses and trees is usually carried by the wind. Explain how the structure of grass pollen may differ from the pollen of a rose.
9. Describe the appearance of the stigma. Explain how the structure and location of the stigma is important to the process of reproduction.

Skill Practice

10. Explain how dissecting a flower helps you to understand its function.

Forming Conclusions

11. Give evidence from your observations to show how the flower's structure is suited to the task of reproduction.

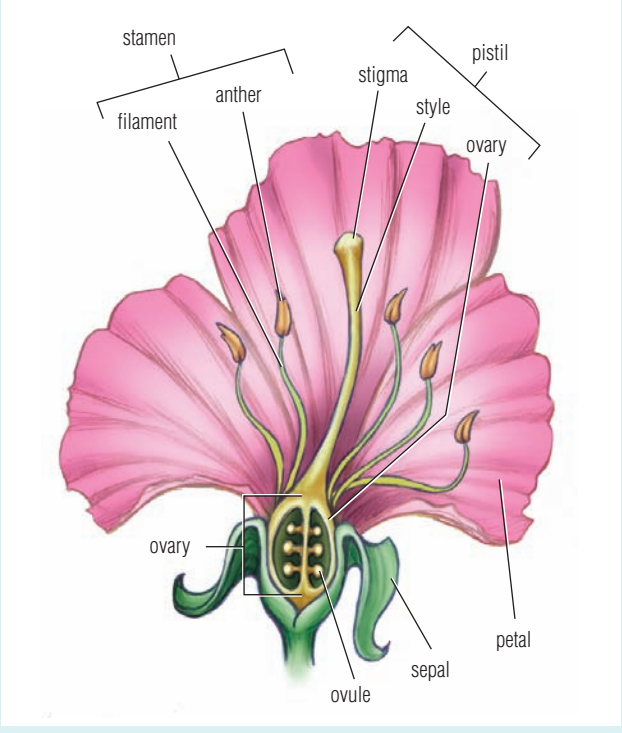


Figure 2.12 The parts of a flower

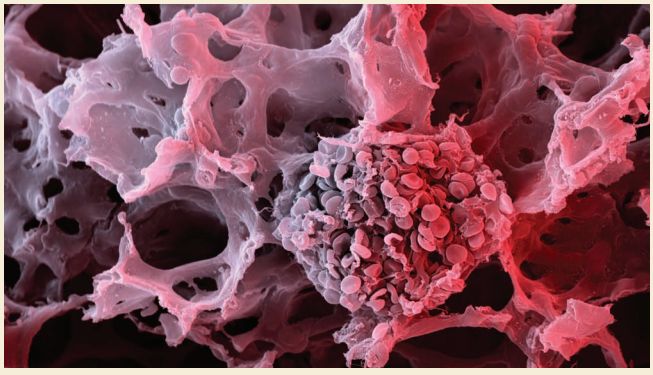
2.1 CHECK and REFLECT

Key Concept Review

1. What is an organ? Give an example of an animal organ and a plant organ.
2. (a) What tissue in the skin provides a layer of protection?
   (b) Explain how the tissues in the dermis work together to permit you to respond to environmental changes.
3. (a) What tissues are found in the lung?
   (b) What is their function in the lung?
4. (a) What is the function of the heart?
   (b) Explain how the heart performs this function.
5. What are the functions of the stomach and intestines?
6. What is a fruit?
7. Describe the function of a flower in a flowering plant.

Connect Your Understanding

8. The photo below shows an electron micrograph of lung tissue. In the upper centre of the micrograph, you can see a capillary filled with red blood cells. The ducts surrounding the capillary are the endings of the bronchioles. Explain how the structure of the lung allows for the exchange of oxygen and carbon dioxide.



Question 8

9. Why are so many organs made of connective tissue and epithelial tissue?
10. In what three organs would you expect to find muscle tissue?
11. Explain why Canadians may be advised to take a vitamin D supplement during the winter months.
12. Why would a serious lung infection make you feel tired?
13. Explain why it is beneficial to have the heart and the lungs in close proximity.
14. Give a reason why plants have only a few organs while animals have many organs.
15. Use a flowchart to show how gas is exchanged in a leaf. Be sure to name specific tissues.
16. You wish to move a plant from one location in your garden to another location. Explain what would happen to the plant if the roots were damaged during the move.
17. You may be familiar with the job of a security guard or a bodyguard. Explain why the name "guard cell" is appropriate for these cells in the leaf.
18. Explain what would happen if plants were not covered with epidermal tissue.

Reflection

19. State two facts that you learned in this section that will influence your choices and behaviour in the coming year.

For more questions, go to *ScienceSource*.

2.2 Organ Systems in Animals and Plants

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

- Organs function together to form organ systems.
- Organ systems perform one or more functions in the human body.
- Organ systems work together to accomplish movement, support, protection, communication, transport, reproduction, digestion, gas exchange, and waste removal.
- Plants have two organ systems that function in an interdependent fashion.

Figure 2.14 The star-nosed mole is an efficient predator because its organ systems work together.

Organs Working Together

The star-nosed mole (Figure 2.14) may be one of the strangest-looking creatures on Earth, but it is also one of the most efficient predators. It can find and eat prey — including worms and insects — in less than one second!

The mole is built not only to be able to find and obtain food quickly but also to escape from harm and danger quickly. The star-nosed mole can be found in eastern North America. In Canada, the star-nosed mole's range is from Atlantic Canada to eastern Manitoba. In the U.S., the mole ranges along the Atlantic coast to northern Florida. However, people rarely see the star-nosed mole because it lives only in marshes and wetlands. The body of the mole is elongated and covered in dark fur. This body shape is ideal for moving through the soil and the water. The dark colour of fur traps heat and keeps the mole warm while it is swimming in icy water. The limbs of the mole are strong and enable the mole to dig and swim effectively.

The mole finds food by digging tunnels in the soil. While digging, the mole is able to move quickly in complex ways by kicking, brushing, and pushing dirt with its back legs. The unusual star on the nose of this mole is a touch organ, formed from 22 tentacles (Figure 2.15). Each tentacle is covered with sensory receptors, called Eimer's organs. The tentacles are used to touch objects near the mole. When a mole touches something that may be food, it needs less than a quarter of a second to identify it, decide if it is edible, and eat it.

Figure 2.15 A star-nosed mole blowing a bubble from its nose. The mole will then inhale the bubble to smell underwater.

The star-nosed mole is a good example of how different organs work together in an organism to accomplish the many varied tasks needed for survival. Organs that function together form **organ systems**, such as the nervous system or the muscular system. Each organ system consists of a group of organs that work together to carry out specific duties in the body. For example, for the star-nosed mole to find food quickly, the nervous system, which for the mole includes its star appendage, works with its muscular system and its skeletal system to enable the mole to move quickly and efficiently. In other words, the brain coordinates the movements of the muscles and bones so that the mole can react quickly to messages picked up by its star appendage.

A16 *Quick Lab*

Moving Materials

The process of digestion involves several organs. Each of the organs plays a special role in the digestive process (Table 2.1). To understand the digestive process and how materials move through the digestive organs, we can use a model of the digestive system.

Table 2.1 Digestive Organs and Their Functions

Digestive Organ	Function
mouth	• physical digestion through action of teeth, tongue, and saliva • chemical digestion of sugars using salivary enzymes
esophagus	• movement of food in rhythmic waves known as peristalsis
stomach	• physical digestion through churning action and mixing with digestive juices (acids and enzymes) • chemical digestion of protein through the action of enzymes
liver	• secretes bile, which breaks up fat to aid absorption, into the intestine
pancreas	• secretes pancreatic juice, insulin, and enzymes into the intestine
intestines	• completes chemical digestion of food using enzymes • reabsorbs water • absorption of nutrients through large surface area
rectum and anus	• storage of waste material until elimination occurs

Materials & Equipment

- nylon stocking (open at both ends)
- an orange

Purpose

To investigate a model of the digestive system to understand how materials move through the digestive tube

Procedure

1. Form small groups of three to four students. Obtain the materials from your teacher.
2. Review the function(s) of the digestive organs listed in Table 2.1.
3. Place the orange in the stocking, and attempt to move the orange through the stocking efficiently.
4. Record the strategies that you and your group used to move the orange from one end of the stocking to the other.

Questions

5. What problems did you encounter when you were moving the orange from one end of the stocking to the other?
6. The orange and the stocking can be used as a model of how digested food moves through the digestive system. How is this model similar to the movement of materials through the digestive tube? How is this model different?

Animal Organ Systems

You may have gone to a potluck dinner where every guest brings something that contributes to the meal. For example, someone may bring the salad, while another person brings the main dish, and someone else brings the dessert. The success of the dinner depends on everyone bringing something to the dinner.

We can think of an organ system as being similar to a potluck dinner. Just as each person contributes something to the dinner, each organ performs a function in an organ system.

Biologists categorize organ systems according to their main functions. There are 11 main organ systems in the human body (Figure 2.16). Table 2.2 summarizes the basic functions of these organ systems. In this section, we will concentrate on the following five organ systems: integumentary, digestive, respiratory, circulatory, and excretory.

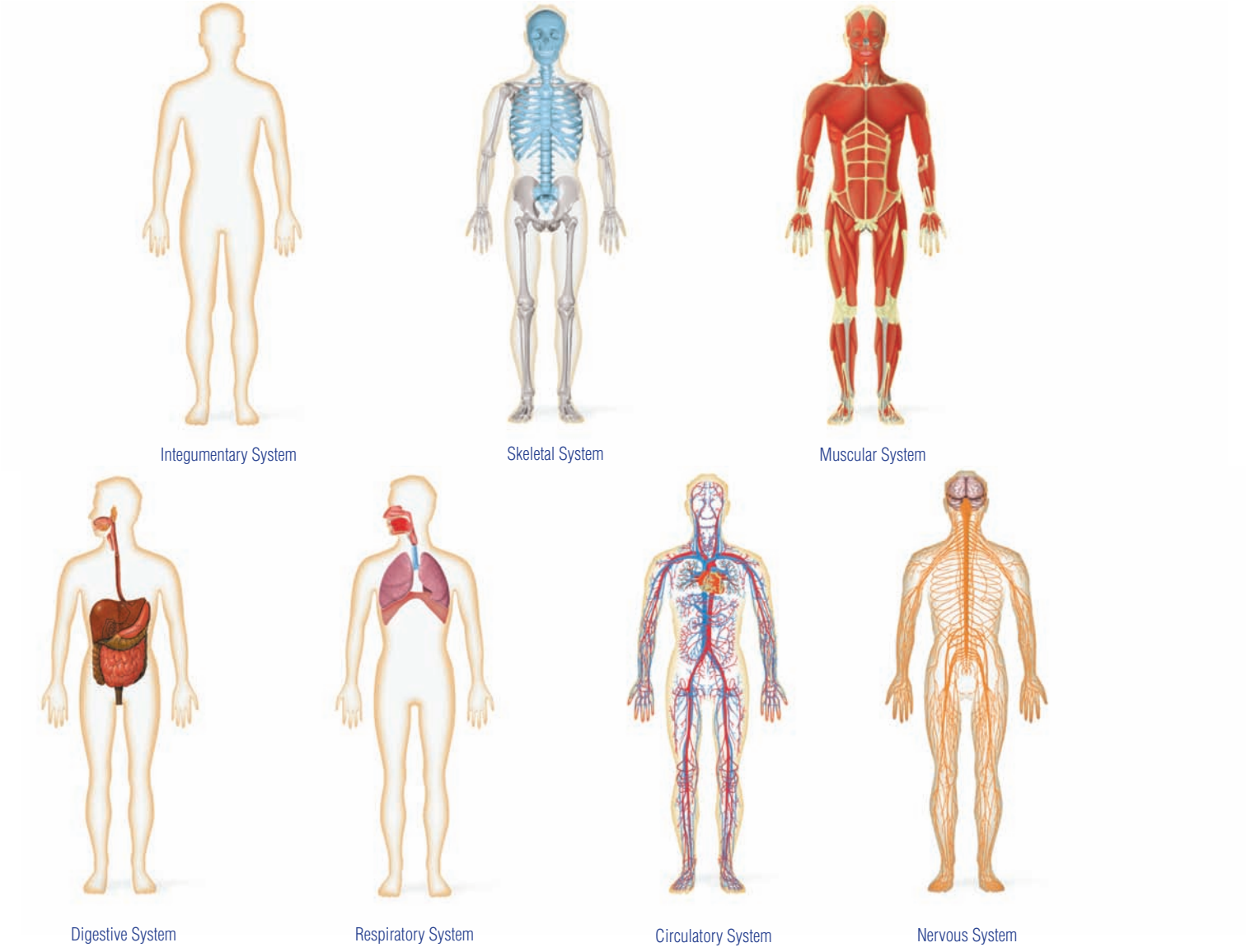
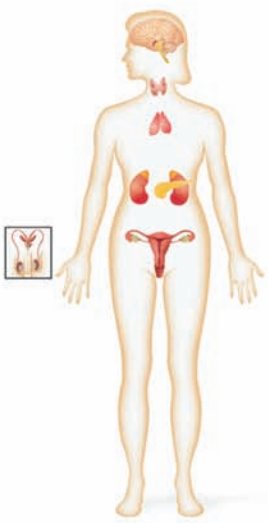


Figure 2.16 The 11 organ systems in the human body

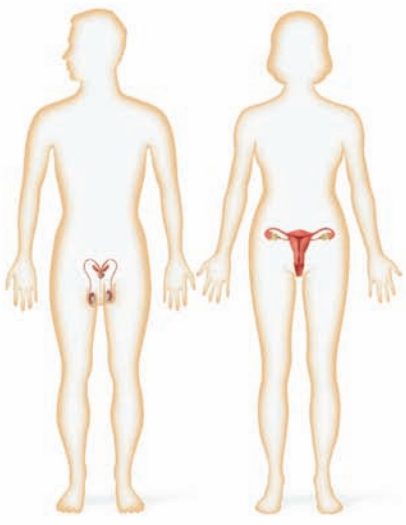
Table 2.2 Basic Functions of Organ Systems

Organ System	Organs Involved	Basic Function
integumentary system	skin, hair, nails, glands	• covers and protects body • glands help control body temperature
skeletal system	bones, cartilage	• supports body • allows movement • protects the body
muscular system	skeletal muscle, smooth muscle, cardiac muscle, tendons, ligaments	• works with skeletal system to provide movement • moves materials within body
digestive system	mouth, esophagus, stomach, pancreas, gall bladder, liver, intestines, rectum	• ingestion • digestion • absorption of nutrients • elimination of solid wastes
respiratory system	nose, mouth, trachea, lungs, bronchi, bronchioles, alveoli, diaphragm	• exchange of gases
circulatory system	heart, blood vessels, blood	• transportation of materials (such as oxygen, nutrients, hormones, and wastes) within body
nervous system	brain, nerves, spinal cord	• controls body functions • coordinates responses and activities
endocrine system	glands (pituitary, hypothalamus, thyroid, adrenals), pancreas, ovaries (in females), testes (in males)	• controls growth and development • controls metabolism
excretory system	skin, kidney, bladder, ureter, urethra	• elimination of wastes
reproductive system	ovaries, fallopian tubes, vagina, uterus (in females); testes, epididymis, vas deferens, penis, urethra (in males)	• reproduction
lymphatic system	white blood cells, thymus, spleen, lymph nodes, lymph vessels	• protects body from disease • circulates fluid called lymph • absorbs and transports fats



Endocrine System

Excretory System



Reproductive System

Lymphatic System

An organ consists of groups of tissues and works with other organs to form organ systems.

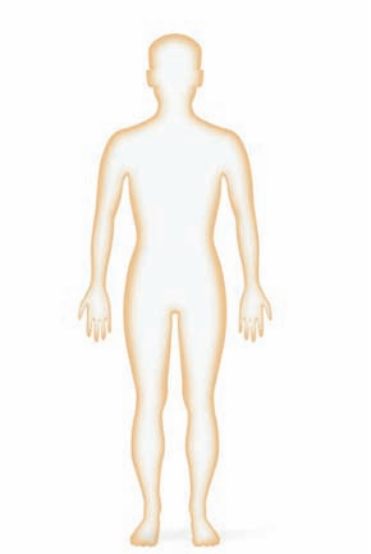


Figure 2.17 The integumentary system

The Integumentary System

The most visible organ system is the **integumentary system**. It is made up of skin (epidermis and dermis) and accessory structures. Accessory structures include horns, antlers, hooves, quills, claws, hair, and nails. Various glands, including sweat glands, sebaceous (oil) glands, and scent glands are also part of the integumentary system. Figure 2.17 shows the human integumentary system.

Skin glands produce fluids that serve different purposes. For example, sweat glands secrete sweat, a clear fluid made of water and body salts. Evaporation of sweat cools the body when it is overheated. Sebaceous glands produce oil that lubricates, waterproofs, and helps prevent skin infections. When the sebaceous glands become plugged with dirt and excess oil, a blackhead forms.

The Digestive System

In humans, the **digestive system** is essentially a tube that extends from the mouth to the anus (Figure 2.18). The digestive system transports nutrients through the body. In humans, the food passes from the mouth, down the esophagus, into the stomach, through the small and large intestine, to the rectum. The major function of the digestive system is the absorption of nutrients. **Absorption** is the process by which food that has already been broken down passes through the walls of the intestine into the bloodstream. Absorption takes place mainly in the small intestine. Refer to Table 2.1 on page 65 to review the roles that the various organs play in human digestion.

Suggested Activity
A18 Inquiry Activity on page 74

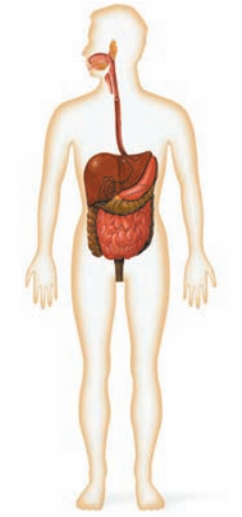


Figure 2.18 The digestive system

The Digestive System of an Earthworm

Not all animals have a digestive system that is similar to humans. For example, earthworms are segmented worms that live in soil (Figure 2.19). As an earthworm moves through the soil, it takes in dirt through its mouth. The food is pushed by muscular contractions through the esophagus to the crop. The food then moves into the muscular gizzard, which grinds the food into smaller pieces. The food is then pushed into the intestines, where digestion and absorption of nutrients occur. Waste material is expelled through the anus.

Figure 2.19 An earthworm

Figure 2.20 Yellow perch

Figure 2.21 North American bullfrog

The Digestive System of a Fish

Fish have a unique digestive system. For example, the yellow perch eats insects and other small organisms (Figure 2.20). The perch's mouth has small sharp teeth that enable it to grasp its prey. Food passes from the mouth down the esophagus into the stomach, where the food is broken down. Some fish have a special pouch, called the pyloric caecum, which further breaks down the food and absorbs the nutrients. Digestion is completed in the intestine.

The Digestive System of a Frog

Adult frogs are carnivores that will eat anything that they can catch (Figure 2.21). A frog's tongue is attached to the front of the mouth so that it can capture flying insects effectively. It has two sets of teeth that it uses to hold prey. When the frog swallows, it closes its eyes and pushes its eyes downward. This action causes pressure on the roof of the mouth, which forces the food to move into the gullet. The food travels down the esophagus to the stomach and then to the intestines. Waste materials exit the body through an opening called the cloaca.

The Respiratory System

Each cell in your body requires oxygen to carry out various life processes including growth, movement, and reproduction. Oxygen is also required to break down food to produce energy: this chemical process is known as cellular respiration.

The function of the **respiratory system** is to obtain oxygen and release carbon dioxide. When you inhale, you take in air through either your nose or mouth. The air passes down the trachea into the bronchus to the bronchioles. The bronchioles empty into the alveoli, which are surrounded by thin-walled blood vessels. The alveoli are the sites of gas exchange. Figure 2.22 shows the organs involved in the human respiratory system.

During Reading Thinking Literacy

A Venn Diagram Synthesizes Similarities and Differences

Every living creature has a digestive system. Create a triple Venn diagram for the earthworm, the fish, and the frog. In the overlapping part of the circles, put the features or actions of the digestive systems that are similar. In the outer parts of the circles, put the features or actions that are different.

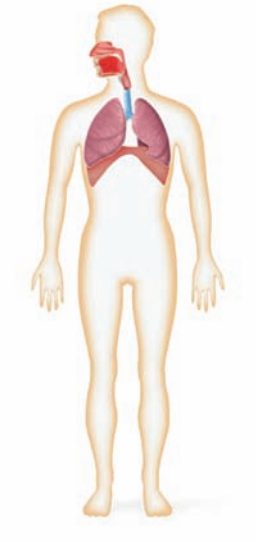


Figure 2.22 The respiratory system

Breathing

Suggested Activities
- A19 Quick Lab on page 76
- A20 Quick Lab on page 76

Your lungs are housed in your chest cavity, which is enclosed by the ribs, chest muscles, and the diaphragm. When you inhale, your rib cage rises and your diaphragm contracts and moves downward, which increases the size of your chest cavity. An increase in the volume of the cavity causes a decrease in the internal air pressure in the cavity. Because the internal air pressure of the cavity is less than the air pressure in the environment, air rushes into your lungs to equalize the pressure.

When you exhale, your rib cage lowers and your diaphragm relaxes and moves upward, decreasing the size of your chest cavity. The decrease in the volume of the cavity causes an increase in the internal air pressure in the cavity. Since the internal air pressure is higher than the pressure in the environment, air moves out of your lungs. Figure 2.23 shows the movement of the diaphragm during breathing.

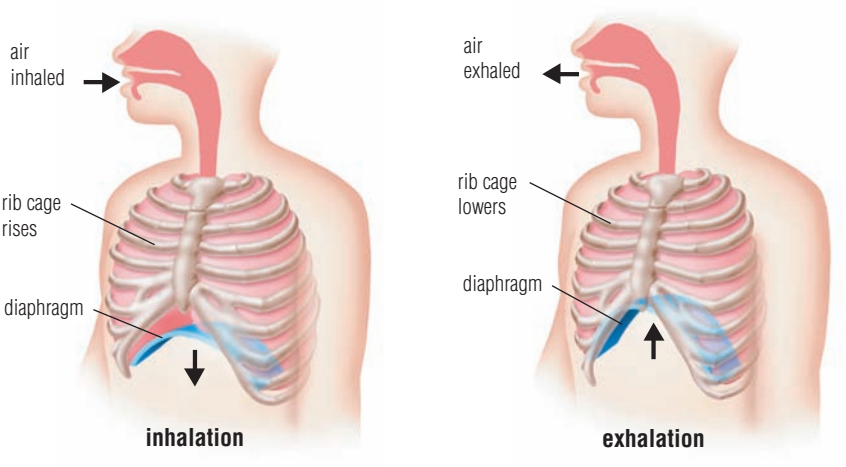


Figure 2.23 During inhalation, the chest cavity expands as the rib cage rises and the diaphragm contracts. During exhalation, the rib cage lowers and the diaphragm relaxes, which decreases the size of the chest cavity.

Figure 2.24 The circulatory system

The Circulatory System

The **circulatory system** is the blood's transportation system (Figure 2.24). The circulatory system includes the heart, blood, and blood vessels. The heart acts as a pump to transport and regulate the flow of blood through a series of blood vessels: arteries, veins, and capillaries.

Arteries are thick-walled vessels that carry blood away from the heart to the tissues. The thickened muscular walls of the arteries allow them to withstand the force of the blood that is pumped from the heart. Veins carry blood back to the heart. The blood flowing through the veins is at a lower pressure than that in the arteries. Therefore, veins have thinner walls than arteries. Veins also contain valves so that the blood does not flow backward. Arteries do not contain valves because the blood flow is pushed along by the blood pumped by the heart. A network of capillaries connects veins and arteries.

Capillaries

Capillaries are the smallest blood vessels in your body; they are about one cell thick. Oxygen (O_2) and carbon dioxide (CO_2) flow in and out of capillaries by the process of diffusion (Figure 2.25). Diffusion is the movement of a substance from an area of high concentration to an area of low concentration. If the blood has more oxygen than the tissues, oxygen will diffuse across the capillary walls and enter the tissues. Carbon dioxide and other wastes are also removed from tissues by diffusion. If the tissues have more carbon dioxide than the blood, the carbon dioxide diffuses across the capillary walls and enters the blood. The blood then carries the carbon dioxide to the lungs, where it is released as you exhale.

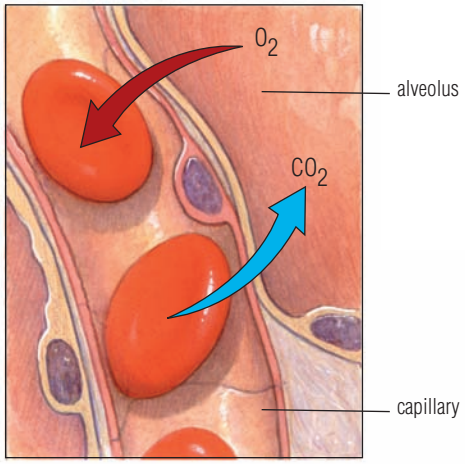


Figure 2.25 Gas exchange between a capillary and the membrane of an alveolus

The Excretory System

The **excretory system** consists of the kidneys, ureters, urinary bladder, urethra, and skin (Figure 2.26). This system filters waste products from the blood and maintains the proper levels of water and electrolytes in the body. As blood flows through your kidneys, wastes such as urea, carbon dioxide, and water are removed by filters called nephrons. These wastes form a fluid called urine. The urine moves out of the kidneys down the ureters to the urinary bladder, where it is stored until it can be eliminated. Elimination occurs when urine travels through the urethra and out of the body. The skin is considered to be part of the excretory system because it excretes water, salts, and urea in sweat.

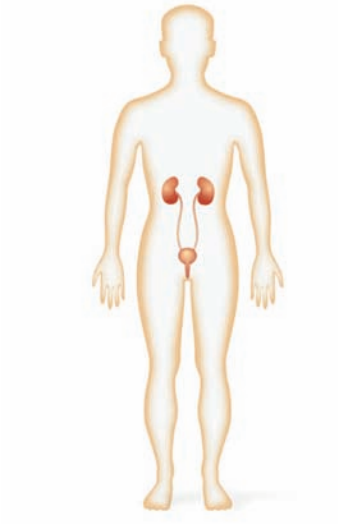


Figure 2.26 The excretory system

Learning Checkpoint

1. What organs in the digestive system are common to the earthworm, perch, and frog?
2. Name one structure that is unique to the digestive system of the earthworm, perch, and frog.
3. What is the diaphragm, and how is it involved in breathing?
4. Explain the role of diffusion in the process of gas exchange.
5. Explain how the excretory system eliminates waste.

Plant Organ Systems

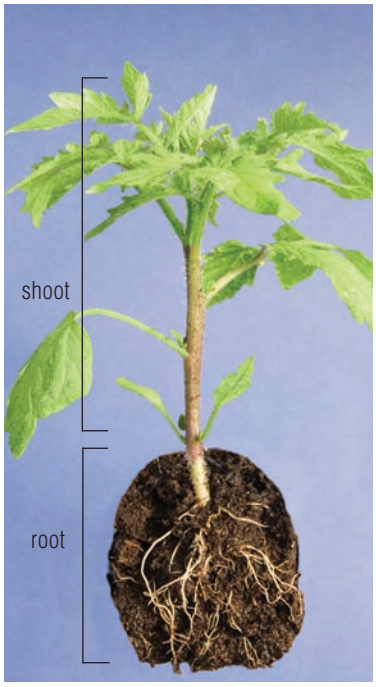


Figure 2.27 A tomato plant's organ systems

A plant has two organ systems: a shoot system and a root system (Figure 2.27). The shoot system is everything that is above ground: the stem, leaves, buds, flowers, and fruits. The root system is everything underground, as well as aerial roots even though they are above ground.

To understand the interdependence between the shoot and root system, consider how water is transported through the plant. Both the roots and the shoots play a role in moving water through a plant.

A plant's roots can push water up the stem. However, the roots can only push the water a few metres and many plants are over 100 m tall. Water enters the root hairs and travels to the xylem. Once the water is in the xylem, it is moved against gravity up the stem to the leaves through transpiration. **Transpiration** is the evaporation of water through the stomata in the leaves. As each water molecule evaporates, it creates a transpiration pull on the adjacent water molecules, which pulls the water up the xylem to the leaves. Once the water reaches the leaf, the transpiration pull is enough to move the water from the xylem into the ground tissue. The leaves lose a high proportion of the water because of evaporation through the stomata. This evaporation maintains the transpiration pull, and water is continuously drawn up the stem. Figure 2.28 shows the direction of water movement.

The organs of a plant also work together to ensure that the plant survives changes in the environment. For example, some specialized cells record changes in the exposure to light. When the length of daylight increases, chemical messages are delivered to tissues to stimulate the production of a flower. Sometimes, in times of drought and excessive heat, a plant may decrease its production of leaves.

Take It **Further**

The tobacco mosaic virus is responsible for severe damage to many Ontario crops. The virus causes changes to a plant's shoot system including the formation of a mosaic pattern on the leaves. The damage to the leaves stresses the plant and results in stunted plant growth. The study of this virus has helped scientists to learn about diseases of plant organ systems and viruses. Learn more about which Ontario food crops are affected by this virus and how this virus affects Ontario food crops. Report back to the class. Begin your research at ***ScienceSource***.

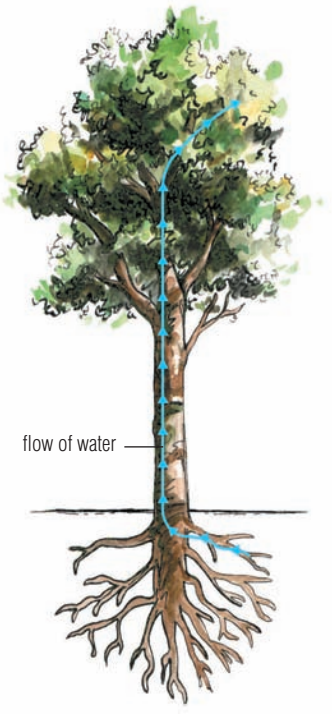


Figure 2.28 Water in a tree flows from the roots to the leaves.

A17 Skill Builder Activity

Dissection Essentials

There are some important terms that are used in dissection. You will learn these terms while dissecting a vegetable.

Materials & Equipment

- cucumber
- paper towel
- paper
- pen and/or pencil
- scalpel

CAUTION: If you are allergic to plants or pollen, let your teacher know. To avoid injury, use proper techniques when using the scalpel.

Procedure

1. Obtain a cucumber, and cut out two holes in one side. These holes represent the eyes. The top of the cucumber is known as the anterior, or cranial. The other end of the cucumber is the posterior, or caudal. Refer to Figure 2.29(a).
2. The front-facing side of the cucumber is the ventral side. The back side of the cucumber is called the dorsal side. We can think of the ventral side as the stomach side. Refer to Figure 2.29(b).
3. Locate the anterior end, and use a scalpel to make a shallow cut along the ventral side of the cucumber to the posterior end. This is known as a sagittal cut. If you cut the cucumber all the way through, you would make a sagittal section.
4. Make a shallow cut that is midway on the ventral side. Extend the cut from left to right. This type of cut is known as transverse. If you were to cut all of the way through the cucumber, you would make a transverse section of the cucumber.
5. Make a sketch of your cucumber, and label with the terms that you have learned.
6. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

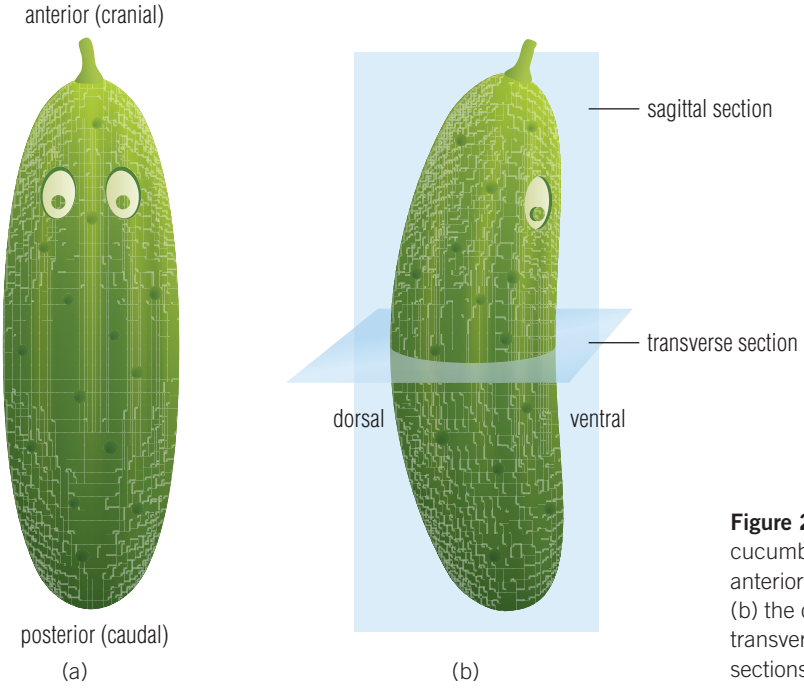


Figure 2.29 A view of a cucumber showing (a) the anterior and posterior end and (b) the orientation of the transverse and sagittal sections.

A18 Inquiry Activity

Skills References 2, 6

SKILLS YOU WILL USE

- Adapting or extending procedures
- Interpreting data/information to identify patterns or relationships

The Digestive System of an Animal

An animal is able to process and absorb nutrients in the food using its digestive system. Digestive systems vary in animals. Biologists have found that particular animals, such as the earthworm, perch, and frog, are good representatives of the increasing complexity in digestive systems.

In this activity, you will study these three digestive systems through dissection. You may do the dissection with preserved specimens of an earthworm and perch or use a virtual dissection program. You may choose to do only one dissection, or you may do all three to compare the systems.

Question

How does the digestive system of the earthworm, the perch, and the frog accomplish the process of digestion?

Materials & Equipment

- paper towels
- preserved specimens of earthworm and perch
- hand lens
- scalpel or dissecting scissors
- probe
- dissecting tray
- dissecting pins
- forceps
- virtual dissection program for earthworm, perch, and frog
- pen and/or pencil
- paper

CAUTION: To avoid injury, use proper techniques when using the scalpel.

Procedure

Part 1 — Digestive System of the Earthworm

1. Since the organs are small, it is helpful if you are familiar with their position in the earthworm before you begin your dissection. Complete a diagram of the earthworm digestive system based on Figure 2.30. When you are finished with your diagram, complete a virtual dissection of an earthworm by following the instructions in the program, or obtain a preserved specimen of an earthworm, dissection tools, and dissection pan. Rinse your specimen with water, and pat dry.
2. Using the hand lens, examine the external structure of the earthworm so that you can identify the prostomium, clitellum, setae, and anus. The prostomium is in front of the mouth. The clitellum looks like a saddle and is on the dorsal side of the earthworm. The setae are tiny bristles found on the ventral side. The anus is found on the ventral side of the last segment of the worm.
3. Place the earthworm so that the dorsal side is facing up. Using your scissors, make a shallow cut on the dorsal side from the clitellum to the prostomium.

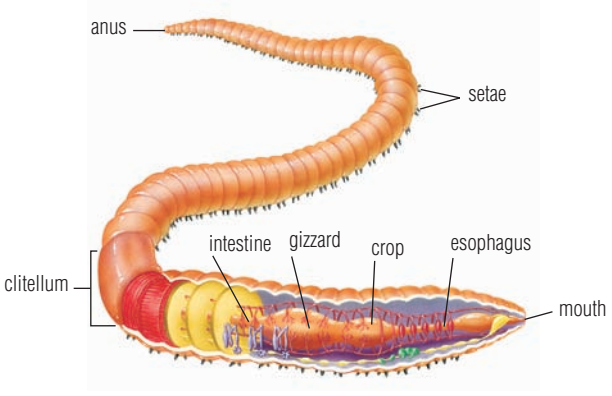


Figure 2.30 The external and internal anatomy of the earthworm

4. Separate the tissue, and use dissecting pins to pin the body wall down to the tray. You may need to cut through the tissue that holds the body wall.
5. Locate the mouth, esophagus, crop, gizzard, intestine, and anus using Figure 2.30.
6. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Part 2 — Digestive System of the Perch

7. Complete a diagram of the perch digestive system based on Figure 2.31. When you are finished with your diagram, complete a virtual dissection of a perch or obtain a preserved specimen of a perch, dissection tools, and dissection pan. Rinse your specimen with water, and pat dry.
8. Observe the external structure of the perch. Note the position and number of fins. Find the lateral line, and locate the gill cover and anal opening.
9. Examine the mouth of the perch.

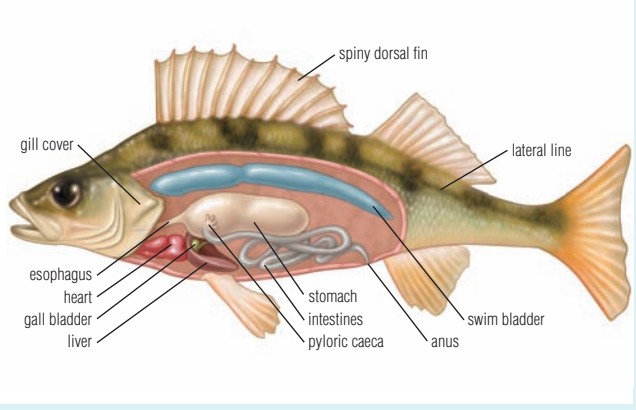


Figure 2.31 The external and internal anatomy of the perch

10. Create a flap through the muscle wall. Make an incision from the bottom of the gill cover along the ventral side to the anal opening. Continue the incision up from the anal opening to the lateral line and then along that line to the head of the fish. Finish your flap by extending your incision back to the base of the gill cover.
11. Lift the flap of muscle wall to look at the organs of the perch. If you have a female perch, the area may be filled with eggs. If this is the case, you should remove the mass of eggs before proceeding. If the perch is male, the testes will be smaller and lighter in colour. Locate the liver (light brown), gall bladder (olive colour), esophagus, stomach, pyloric caeca, and intestines.
12. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Part 3 — Digestive System of the Frog

13. Complete a virtual dissection of a frog. Identify the mouth parts, liver, gall bladder, stomach, pancreas, small and large intestine, and cloaca.

Analyzing and Interpreting

14. How is the mouth specialized?
15. Explain how the structure of the intestines is related to their role in digestion.
16. Why do you think the gall bladder is located so close to the liver? Explain your answer.

Skill Practice

17. Describe one problem that you encountered in performing the dissection, and explain how you solved the problem.

Forming Conclusions

18. How is the digestive system of the worm, the perch, and the frog each suited to its habitat?

A19 *Quick Lab*

A Look at Breathing

When you breathe, you move about 500 mL of air in and out of your lungs. Usually we are not aware of our breathing. What can you learn about how you breathe if you concentrate on your breathing?

Materials & Equipment

- pen and/or pencil
- stopwatch

Purpose

To observe the movements of your body as you breathe and to count the number of breaths that you take when you breathe normally

Procedure

1. Work in pairs. One partner sits in a chair and breathes normally. The other person observes and records any breathing movements that occur in the chest, shoulders, and abdomen.
2. While breathing normally, your partner counts the number of breaths that you take in one minute and records the number.
3. Change places with your partner, and repeat steps 1 and 2.

Questions

4. Explain how the chest and abdomen change during breathing.
5. Explain why the number of breaths per minute may change when exercising.

A20 *Quick Lab*

Inquiring about Heart Disease

Heart disease is a major cause of death in Canada. There are several known risk factors for heart disease, including high blood pressure, high blood cholesterol, stress, being overweight, diabetes, excessive alcohol consumption, smoking, physical inactivity, and unhealthy diets.

Purpose

To research the risk factors associated with heart disease

Procedure

1. Work in a group of 3–4 students.
2. Each member of the group should select one of the risk factors for heart disease to research.
3. ***ScienceSource*** Research to learn about heart disease and how your chosen risk factor increases the risk of heart disease. Record your information in a table.
4. Share your information with your group so that every member will understand the relationship between risk factors and heart disease.

Questions

5. Describe any common features that exist between the risk factors discussed in your group. Does this suggest that there is a common approach to reducing the risk of heart disease?
6. Your research focusses on the risk factors that can be controlled. Describe one way in which society influences an individual's ability to control his or her risk factors for heart disease.

2.2 CHECK and REFLECT

Key Concept Review

1. Define and give an example of an organ system.
2. What organ system is involved in transporting materials around the body?
3. Name and describe the function of two organs of the digestive system.
4. Name the organ system involved in breathing.
5. Describe the role of muscle tissue in the digestive system of the earthworm.
6. Name and describe the function of three accessory structures of the integumentary system.
7. Look at the organs and job descriptions given in the following table. Match each organ to its proper job description.

Organs and Their Job Descriptions

Organ	Job Description
heart	• filters and cleans blood
teeth	• controls whole body
intestines	• grinds food
skin	• breaks down food and absorbs nutrients
kidney	• exchanges gases
esophagus	• covers and protects surface
bladder	• pumps blood
brain	• stores urine
lungs	• passes food from the mouth to the stomach

8. List the two organ systems that are found in plants.

Connect Your Understanding

9. Explain why the crop and gizzard are important parts in the digestive system of the earthworm.
10. Why is it important to maintain a healthy integumentary system?
11. Using the star-nosed mole as an example, write a paragraph that explains how organs interact with each other to help accomplish the tasks needed for survival.
12. Write a paragraph that explains how chest muscles, ribs, and the diaphragm work together to help you to breathe efficiently.
13. The circulatory system is a transportation system. Use an analogy of a roadway to explain how this system functions.
14. There is a puppet master controlling the puppets shown below. Is there an "organ master" controlling the actions of all the organs in the body? Explain your answer using an example.

Question 14

Reflection

15. Choose an organ system. Identify two questions you have about how that organ system works in your body.
16. Describe three facts that you found most interesting in this section that you did not know before.

For more questions, go to *ScienceSource*.

2.3 Interdependent Organ Systems

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

- Organ systems are interdependent groups of tissues and organs.
- Healthy organ systems work together to maintain homeostasis.
- Healthy organ systems respond to changes in the environment.
- Simple medical tests can provide information about the health of organ systems.

Figure 2.32 Our bodies obtain nutrients from the foods that we eat.

Body Systems Working Together

Each day, your body's cells, tissues, and organs work together to keep you responsive to the environment. Consider the example of eating your lunch. The lunch buzzer sounds just as your stomach is making some rumbling noises. Your brain records the information that the buzzer and time of the day mean you should eat. You proceed down the hall and enter the school cafeteria.

In the cafeteria, your eyes see a poster advertising the daily specials, and your nose senses the odour of freshly made pizza. The message is sent to your brain, and you decide that you should eat pizza for lunch (Figure 2.32). While in the line, you decide to reach out and select a slice of pizza from the warming oven. The muscles in your hand and arm contract and relax, which enables you to pick up the slice of pizza without dropping it.

Once in your seat, you chew and swallow a bite of pizza using your teeth and tongue (Figure 2.33). As the muscles in your digestive system push the food along, a variety of glands add juices to assist in breaking down the food into the necessary nutrients. In several hours, the nutrients in the pizza are absorbed into your bloodstream and carried through your body to the cells. In this example, several organ systems, including the circulatory, digestive, and nervous systems, interact to enable you to obtain, digest, and transport essential nutrients from the pizza to all cells of your body.

Figure 2.33 Eating a piece of pizza involves the interaction of different organ systems.

Maintaining a Steady State

Our body systems function in a way to maintain **homeostasis**, which means "steady state." Generally, this means that there is an acceptable range of physical and chemical conditions in which body cells, tissues, and organs can operate efficiently. To keep the body within this acceptable range, different organ systems must work together to maintain homeostasis in the body.

WORDS MATTER

The word "homeo" is from the Greek word *homoios*, which means similar. The word "stasis" is from the Greek word meaning standing.

A21 *Quick Lab*

How Do They Do It?

Athletes must be able to perform tasks consistently to be successful at their sports (Figure 2.34). For example, to make a successful shot on goal, all the organ systems in an athlete's body must work together in harmony.

Purpose

To identify organs and organ systems that work together

Procedure

1. Think about a particular sport or athlete. Identify the organs and organ systems that work together when an athlete plays sports.
2. Record your ideas in the form of a graphic organizer or mind map.

Questions

3. Explain what would happen to an athlete's performance if the organ systems were not working together effectively.
4. How do you think that athletic training affects the working relationships of the organs or organ systems? Explain.

(c) Wheelchair racing

(b) Hockey

Figure 2.34 (a) Soccer

How Organ Systems Work Together

Organ systems are **interdependent** because the action of one system contributes to the action of another system. For example, the circulatory system, made up of the heart, blood, and blood vessels, works to supply the body with oxygenated blood. The body cannot survive for more than six minutes if the heart stops beating. However, it is the respiratory system, made of the nose, trachea, and lungs, that supplies the blood with oxygen. Thus, the circulatory system and the respiratory system are interdependent.

We can see the complexity of connections between organ systems by considering what happens to your body when you play a sport outside on a sunny day (Figure 2.35).

Suggested Activity •
A23 Design a Lab on page 85

Figure 2.35 Your organ systems work together to maintain homeostasis — even when you are outside playing sports.

Integumentary System

As you play in the Sun, you may begin to feel hot. Your skin begins to turn red because the blood vessels dilate so that excess heat can be released to the environment. You also produce sweat that cools your body and keeps you within the acceptable temperature range so that your body cells function efficiently.

Circulatory System

To keep you moving, your muscles use oxygen and glucose and produce carbon dioxide. Your heart rate increases so that more oxygen-rich blood is brought to your muscles and carbon dioxide is removed. The rate at which the blood moves to the lungs also increases. Blood flow to other organs may be reduced. As well, stored glucose is released from the liver and enters the bloodstream to be taken to muscles so that the cells will have the necessary energy.

Respiratory System

To make sure that your muscles receive oxygen and get rid of excess waste products, your rate of breathing increases. At the same time, the blood circulates around the body faster because your heart rate increases. This means that more gas can be exchanged in the alveoli and more oxygen can be picked up by the red blood cells and carried to the tissues of the body.

Skeletal System

As you exercise in the sunshine, the weight placed on your bones causes them to become stronger, assuming that the appropriate nutrients — calcium and vitamin D — are present. Calcium is essential for the formation and maintenance of healthy bones. Vitamin D is formed naturally in the skin after exposure to sunlight. Your body needs vitamin D to absorb calcium.

Muscular System

Your muscles require extra oxygen to provide the energy needed to move. The oxygen is carried to the muscles by the blood. Exercise causes an increase in the flow of blood so that more oxygen is delivered to the muscles. As you play the game vigorously, your muscles generate heat, which your body does not need. To rid the body of the excess heat, blood vessels in the skin dilate so that this heat can be lost quickly. The skin also releases sweat, which cools the body as it evaporates.

Nervous System

When you exercise, your nervous system stimulates an increase in your heart rate. Nervous signals also travel to blood vessels in various parts of the body, causing them to get smaller so that blood flow to those areas will decrease. This diverts blood flow from tissues that do not need it, such as your stomach, to the muscles where it is needed, such as your arms and legs.

Learning Checkpoint

1. Define the term “homeostasis.”
2. Explain, using an example, how organ systems function in an interdependent way.
3. Explain how the integumentary system and the circulatory system work together to maintain homeostasis while you are playing outside.
4. Explain how the respiratory, circulatory, and nervous systems maintain homeostasis while you are playing outside on a sunny day.
5. Explain how the muscular and skeletal systems work together to maintain homeostasis while you are playing outside on a sunny day.

Diagnosing Problems in Organ Systems

The organ systems in our body interact with each other in very complex ways. This makes it difficult to diagnose and treat problems in organ systems. When you go to the doctor's office for a physical examination, you may undergo a few medical tests (Figure 2.36). The doctor may check your eyes and ears and look at your skin, the largest organ. Often the doctor taps your chest and abdomen to determine the size and density of your organs. Using a stethoscope, the doctor listens to sounds made by the heart and the lungs to determine if they are working properly (Figure 2.37). These tests provide information about how well your organs and organ systems are working.

Figure 2.36 During a physical exam, the doctor may look into your eyes for signs of hemorrhage (blood spots) or reduced blood flow.

Figure 2.37 To measure blood pressure, a sphygmomanometer, also called a blood pressure cuff, is used. The cuff is inflated so that the blood flow in the artery is restricted. As the cuff deflates, the doctor listens with a stethoscope to the sounds of the blood pumping through the artery.

Checking on the Circulatory System

Your doctor can determine how well your circulatory system is working by checking your pulse and blood pressure. Your pulse indicates how often your heart is beating. The average pulse ranges from 60 to 80 beats/min, although there are factors that can alter that rate.

Blood pressure is a measure of the pressure of blood against the walls of the arteries and is represented as two numbers, for example 124/84 mm Hg. The first number indicates the pressure when the heart contracts and pushes blood out (systolic). The second number indicates the pressure when the heart relaxes between beats and fills with blood (diastolic). If the numbers are too high — more than 135/85 mm Hg — there is too much blood pressure in the arteries. High blood pressure can cause damage to the arteries, which can lead to heart attacks and heart failure.

Sometimes, samples of blood are taken for testing the levels of red and white blood cells and the amount of sugar in the blood. Hormone levels may also be tested. Hormones are chemicals that carry messages through the body to regulate cells, tissues, or organs. Samples of blood can be taken to check levels of particular hormones to determine if there is an infection or a problem with the function of a gland or organ.

Learning Checkpoint

1. Describe two ways in which doctors can obtain information about the health of your organs during a routine physical examination.
2. What information is provided by the measurement of a pulse?
3. How can the measurement of the blood pressure be used to determine the health of the circulatory system?
4. Use an example to explain what is meant by the term "blood pressure."
5. What information can be gained from analysis of a blood sample?

Checking on the Excretory System

Your doctor can determine how well your excretory system is working by testing a sample of urine. As blood enters your kidneys, the kidneys remove urea, excess water, and other waste products from the blood. These waste products include the by-products, or chemical products, that are left over after you have metabolized nutrients, poisons, or drugs that you have ingested. In other words, what you eat and drink, as well as how well your kidneys are working, affects what is in your urine. The filtered blood leaves the kidneys and returns to circulation in the body. The waste material, called urine, is stored in the bladder until it can be released from the body. Urine is yellow because it contains bile pigments from the liver.

Doctors can check urine to see if it contains different components. For example:

- If there are white blood cells in the urine, there is probably an infection in the excretory system.
- If too little urine is being produced, it may be possible that the kidneys are not working effectively to clean the blood of wastes.
- If too much urine is being produced, it may indicate that the pancreas is not working properly. Excessive urine production is a symptom of a type of diabetes.

During Reading — Thinking Literacy

Revise to Synthesize

Good readers revise their ideas as they read and learn about new puzzle pieces. They think about the knowledge they had before reading about a topic, add the new information, and let the puzzle reveal a revised picture. Before you read this chapter, what would you have said was the most important organ or organ system? What do you think now that you have read and studied about these organs and systems?

Take It Further

Diabetes is the fourth leading cause of death in the world after heart disease, cancer, and influenza. The increase in cases of diabetes is attributed to the rising levels of obesity. Learn about the two types of diabetes, the history of diabetes, and how it is treated. Begin your research at ***ScienceSource***.

Drugs, including prescription drugs, cannabis, cocaine, and methamphetamine, can be detected in the urine for a period of time. For some jobs and at some sporting events, urine is tested for the presence of drugs, both legal and illegal (Figure 2.38).

Figure 2.38 A technician prepares a urine sample for testing at the Swiss Laboratory for Doping Analysis in Epalinges, Switzerland. Urine testing was conducted during the 2008 Beijing Olympic Games.

A22 STSE Science, Technology, Society, and the Environment

Green Livers

Scientists have found that environmental toxins can accumulate in our tissues and organs. A build-up of toxins can cause disease, allergies, environmental sensitivities, and even asthma.

Researchers have found that certain plants can be used to remove environmental toxins from the soil. In fact, the roots of some grasses have been called "green livers" because they store toxins in much the same way as a liver stores toxins in the human body. In one example, plants were grown in soils that contained a high concentration of metals. Over time, the plants absorbed and concentrated the metals in their root systems. At the same time, the plant itself was apparently unaffected by the high concentration of metals. When the plant's roots were removed, the metal was also removed from the environment.

The process whereby plants are used to remove contaminants from their environment is known as phytoremediation. Scientists have been researching different types of plants that can be used in this process (Figure 2.38). They are also looking for ways to engineer plants that can do the job.

1. Working in a small group, list some environmental toxins that you have heard discussed in the media.
2. Discuss some strategies that are used to lessen our exposure to these toxins.
3. Go to ***ScienceSource*** and find out about how plants are genetically engineered to work as "detoxifiers."

Figure 2.39 Indian mustard is a plant used for phytoremediation. It has demonstrated an ability to tolerate and accumulate a range of different metals.

A23 Design a Lab

Skills Reference 2

SKILLS YOU WILL USE

- Making predictions, developing hypothesis
- Defining and clarifying the inquiry problem

Responding to Environmental Changes

The heart pumps blood throughout the body. The blood carries necessary nutrients and gases to the cells and takes waste materials away from cells. Several systems of the body interact together to obtain, transport, and process nutrients, gases, and waste. If the environment in the body changes, the body systems respond quickly. The heart responds to meet the new needs of its cells by increasing or decreasing the rate of pumping of blood. The pulse is a measure of the pumping action of the heart. We can use the pulse as a measure of the heart's reaction to environmental changes in the body system.

Question

How does the pulse change with a change in physical activity level?

CAUTION: Do not perform this activity if you are not well or if you have respiratory or cardiovascular problems. Perform this exercise in an open area.

Design and Conduct Your Investigation

1. Determine your resting pulse. To determine your "resting pulse," you need to have been at rest for 10 min. Select your wrist or your neck as the source of your pulse. Place your index and middle finger on the underside of your wrist near to the base of your thumb or on the hollow of your neck (Figure 2.40). You will need to use a firm pressure. Count the pulse beats for 1 min, or count the beats for 30 s and multiply by 2 to get the number of beats per minute. Note that one pulse is equal to one heartbeat.
2. Identify the experimental variables that could affect the outcome of your experiment.
3. Decide on the variable that you would like to test. Write a hypothesis that indicates how a change in that variable would affect the outcome of the experiment. It may be helpful to write your hypothesis statement in an "if... then..." format.
4. Design a method to test your hypothesis. Remember that you need to indicate how you will measure your results.
5. Prepare a list of your materials, equipment, and safety precautions needed for the experiment.
6. Have your method approved by your teacher before you begin the experiment.
7. Perform the experiment and record your results in an organized and effective manner.
8. Include a discussion of the sources of experimental error.

Figure 2.40 You can feel your pulse in your wrist or your neck.

2.3 CHECK and REFLECT

Key Concept Review

1. Explain why it is important for your body to maintain homeostasis.
2. What organ systems interact together to supply your cells with needed nutrients?
3. Look at the following photo. Describe two things that the doctor would check to determine the health of the young woman's respiratory system and circulatory system.

Question 3

4. (a) What is the typical range for the pulse rate of an average teenager?
   (b) Explain what the term "pulse rate" means.

Connect Your Understanding

5. Explain how organ systems are interdependent. Give an example not used in the textbook to illustrate your answer.
6. Explain why a doctor may order a blood test to check the function of your thyroid gland.
7. Explain how some organ systems work together to maintain homeostasis. Give an example to illustrate your answer.
8. Show how measurements of systolic pressure and diastolic pressure may be used to determine the effectiveness of the circulatory system.
9. Sometimes, we are embarrassed when we sweat on a hot day. Explain why sweating is a healthy and necessary response.
10. Explain the interactions that occur between the nervous system and the circulatory system during exercise.
11. Explain how weight-bearing exercise, such as walking outdoors, can build the skeletal system.
12. Describe the interactions that occur between the circulatory system and the muscular system during exercise.
13. Give an example that shows how proper amounts of vitamins and minerals are critical to the health of organ systems.
14. In previous science courses, you learned how water is treated in water treatment plants to produce fresh drinking water. Explain how the kidney functions in a similar way to a water treatment plant.
15. Think about the importance of homeostasis. Why do you think that people who were climbing high altitude mountains, such as Mount Everest, would need to stay at a base camp for a period of time before continuing their climb?
16. Give an example in which your body systems were placed under stress. How did your body respond to maintain homeostasis?

Reflection

17. Your body is designed to function in a healthy manner and maintain a steady state known as homeostasis. What actions do you take that can affect the healthy functioning of your organs or organ systems?

For more questions, go to ***ScienceSource***.

Organ Transplants: Promise or Peril?

People have always been fascinated with organ transplants. In 1818, Mary Shelley wrote the novel **Frankenstein**, a story about Dr. Victor Frankenstein, who created a monster made from selected body parts. The actual transplantation of different tissues and organs has been attempted for over 100 years.

Organ transplants occur when all other means of medical treatment have not worked. Organs can be donated after death or through a living donation, in which an organ or a piece of organ is donated by a living person. In 2007, over 2000 organ transplants were performed in Canada. Kidneys are the most transplanted organ, but transplants of livers, heart, lung, and pancreas also occur. Even limbs can be transplanted. In 2008, a German farmer who had lost both arms in a farming accident became the world's first person to receive a double-arm transplant.

During an organ transplant, an organ or part of an organ is taken from a donor and placed into a recipient. Survival rates are higher for recipients who receive living donations than for recipients who receive an organ from a diseased donor. The most common living donation is a kidney, although it is also possible to transplant a part of the liver, small intestine, and pancreas in a living donation. In a living liver donation, a portion of the liver is taken from the donor. Over a few months, the liver portion grows to form a fully functioning liver.

2 CHAPTER REVIEW

ACHIEVEMENT CHART CATEGORIES

- (k) Knowledge and understanding
- (t) Thinking and investigation
- (c) Communication
- (a) Application

Key Concept Review

1. Prepare a table with two headings: "Salad Ingredient" and "Plant Organ." Look at the following photo or think about the last salad that you ate. List the ingredients in a salad in the left-hand column in your table and write the name of the organ that corresponds to each ingredient (leaf, root, stem, or flower/fruit) in the right-hand column. (k)

Question 1

2. Describe how vascular tissue is involved in the functions of the root and leaf of a plant. (k)
3. Describe the role of meristematic tissue in the root, stem, and flower of a plant. (k)
4. Describe the function of a flower in a plant. (k)
5. What role does connective tissue play in the human lung? (k)
6. What are the general functions of the skin? (k)
7. Compare and contrast the structure and functions of the dermis and the epidermis. (t)
8. Trace the movement of air from the environment to the alveoli in the human lung. (k)
9. Describe the process of breathing. (k)
10. Explain how diffusion is involved in the process of gas exchange. (k)
11. Using your knowledge of the digestive system, identify structures in the digestive system of the earthworm that are similar to those in humans. (t)
12. Explain how three structures of the respiratory system work together to accomplish the task of breathing. (t)
13. Compare and contrast the structure and functions of the stomach and intestines in the human digestive system. (t)
14. Describe the role of the kidney. (k)
15. State the name and function of the organs in the excretory system. (k)
16. State the primary functions of the following organ systems: integumentary system, circulatory system, and respiratory system. (k)

Connect Your Understanding

17. How are different flowers suited for different environments? (t)
18. Explain how the tissues in the roots work together to collect and transport water for the growing plant. (t)

19. Give an example to show how the root and shoot systems of a plant act in an interdependent fashion. (t)

20. Explain why a person with a low red blood cell count would be likely to experience tiredness and fatigue. (t)

21. (a) Define the term "homeostasis." (k)

(b) Give an example of how an organ system acts to maintain homeostasis in the human body. (t)

22. Explain how the body releases excess body heat built up during exercise. (a)

23. Explain how the structures of two organs in the digestive system are uniquely suited to the functions they perform. (t)

24. Explain why the human heart is called a double pump. (t)

25. The terms cell, tissue, organ, and organ system are often said to be in a biological hierarchy. A hierarchy is an arrangement of things based on their importance or complexity moving from least important or simplest to the most important or most complex. Explain the meaning of this idea in a short paragraph. (t)

26. Explain how specialized tissues in the mouth work together to perform the first phase of the digestion of a sandwich. (t)

27. Write a paragraph that explains the interrelationship between the following terms: oxygen, cellular respiration, carbon dioxide, food, and energy. (c)

28. Give an example of how your body systems act in an interdependent fashion to sustain your life. (a)

29. Create a concept map that shows how your organ systems respond when you play a vigorous game outside on a sunny day. (t)

30. A person who has worked for many years as a miner underground is diagnosed with weak bones. What may have contributed to the cause of this condition? Explain your thinking. (t)

31. Use an example to show how the respiratory and circulatory systems interact, and explain why the interaction is necessary for the survival of the organism. (a)

32. Use an example to explain the links between organs and organ systems in a plant. (a)

33. Use an example to explain the links between organs and organ systems in a human. (a)

34. Blood doping is an illegal practice in many amateur and professional sports. Explain how blood doping affects two organ systems in the human body. (a)

Reflection

35. Describe an analogy that helps you understand the meaning of homeostasis. (c)

After Reading

Thinking Literacy

Reflect and Evaluate

Create a tips sheet for someone who gets easily frustrated by large amounts of reading. Recommend strategies that will help the person to synthesize — or put together — the whole puzzle of a chapter topic. Compare your tips with a partner.

Unit Task Link

In this chapter, you learned about the organs and organ systems of animals and plants. Create a table in which you identify an organ and describe the major functions of the organ. Research to learn about some technological advancement or health issue relating to that organ.