

## Topic 1.3

# How do cells work together in the human body?

### Key Concepts

- All cells begin alike and differentiate into specialized cells.
- Specialized cells have different structures that allow them to perform unique functions.
- Groups of cells working together form tissues.
- Groups of tissues working together form organs, which work together in systems.

### Key Skills

Inquiry  
Literacy  
Numeracy

### Key Terms

cell specialization  
cell differentiation  
tissue  
organ  
organ system

Life comes in an enormous range of sizes. It can be as small as a bacterium, which is invisible to the unaided eye. Or it can be large enough to fit half a dozen humans in its jaws alone, such as the school-bus-sized, prehistoric Megalodon shark. Scientists can only observe Megalodon through the fossils it left behind. Due to its huge size, however, it was made up of hundreds of trillions of cells.

A single-celled organism relies on the organelles within its one cell to carry out its life functions. A multi-celled organism requires a greater degree of organization to survive. Most of the cells in a multi-celled organism have different structures and abilities that help them carry out specific functions. But even these specialized cells are limited in what they can do on their own. As a result, the survival of a multi-celled organism relies on teamwork. Working together, specialized cells carry out life functions, such as digestion, breathing, and circulation. Such organization is key to developing complex life forms such as Megalodon and you.





## Starting Point Activity

By working together, specialized cells can accomplish tasks they cannot do alone. In this activity, each of your team members will be a specialized cell. Each “cell” will have some abilities but not others. As a result, your team can only complete a given task through teamwork.

1. Assign one student the role of Cell 1 and another student the role of Cell 2. The remaining team members are Cell 3.
  - Cell 1: can move but not talk
  - Cell 2: can talk but not move
  - Cell 3: cannot move or talk other than to tell other cells its birth date
2. Complete the task of lining up all Cell 3 team members in the order of their birth dates, from earliest to latest in the year.
3. Explain how working together as you did enabled you to accomplish a task that each member of your team could not have done alone.

# All cells begin alike and differentiate into specialized cells.

Imagine that you are building a shelving unit. You cut the wood, join the shelves together, and mount the unit on the wall. Now imagine that you have only one tool, such as a hammer, to work with. Will you have a harder time completing the job? After all a hammer is great for pounding nails but is inefficient for cutting wood. To build a shelving unit successfully, you need tools that are specialized for the different tasks you must complete.

As the construction task becomes more complex, such as building a shed, the tools you need become more specialized. In this sense, organisms have a lot in common with construction jobs—as they become more complex, more specialized tools (or cells) are required to perform different functions. **Figures 1.11** and **1.12** help illustrate the difference between organisms made of one or many cells in terms of performing life functions.

▼ **Figure 1.11** Like all single-celled organisms, this amoeba relies on the organelles in just one cell to perform all its life functions.



▲ **Figure 1.13** This cell is specialized to transmit messages to the brain.



▲ **Figure 1.12** The transparent glass frog is found in Venezuela. It is made up of many specialized cells that have different functions. They form different parts of this organism, which are easy to see through its “glass” skin.

## Cell Specialization and Differentiation

We talk about specialized cells and tools, but what does it mean to become specialized? If you are a mechanic who specializes in Harley Davidson motorcycles, you have to learn a lot about these motorcycles and how to fix them. You have to gain the knowledge you need to work on the motorcycles, as well as obtain the tools. Similarly, a cell that transmits messages to your brain, such as the one shown in **Figure 1.13**, has to have both the structures and the ability to perform this task.

**Cell specialization** refers to the fact that different types of cells have different structures and abilities to perform their functions efficiently. All cells start their lives as identical cells called stem cells. Each stem cell has the potential to become a specialized cell, such as a muscle cell or nerve cell, as it matures. During this process, the cell becomes altered to suit its specific functions. The series of events through which stem cells develop into specialized cells is called **cell differentiation**. Scientists are very interested in studying how stem cells differentiate. These cells offer the potential for treating many diseases if scientists can trigger them to develop into cells that can repair damaged tissues.

**cell specialization:** refers to the fact that different types of cells have different structures and abilities that enable them to perform their functions efficiently

**cell differentiation:** the series of events through which stem cells develop into specialized cells

### Inquiry Focus

## Activity 1.13

### MODEL SPECIALIZED CELLS

Design and build two specialized cells. Each cell will carry out one of these functions:

- move limbs by lengthening and shortening
- provide a protective barrier between the inside and outside of the organism

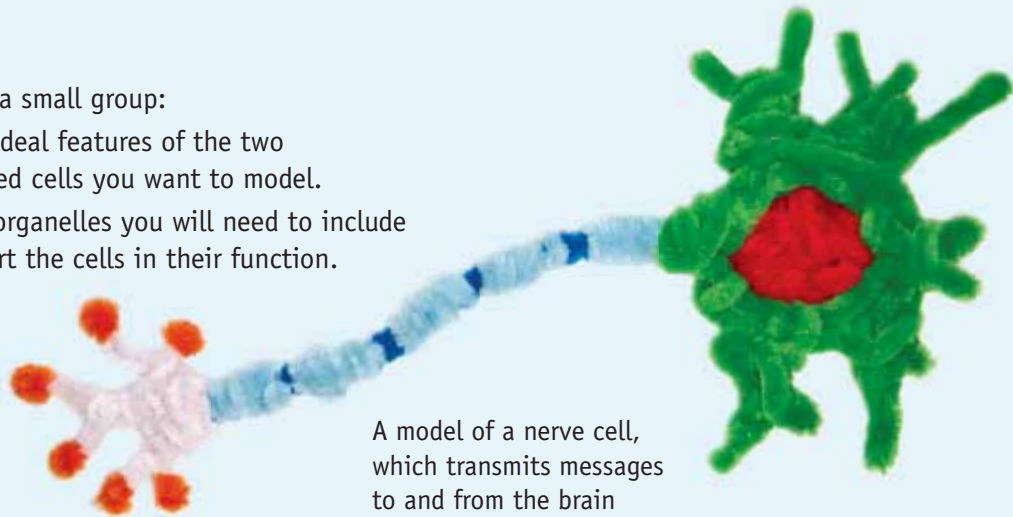
#### What You Need

- a variety of craft materials

#### What To Do

1. Working in a small group:
  - List the ideal features of the two specialized cells you want to model.
  - List the organelles you will need to include to support the cells in their function.

2. Sketch each specialized cell and its organelles. Label the organelles and other features that make the cell specialized.
3. Determine the materials you will use to create each specialized cell.
4. Collect the materials and build your cells. Label the features that make each cell specialized.



A model of a nerve cell, which transmits messages to and from the brain

### LEARNING CHECK

1. Explain why a multi-celled organism such as the glass frog in [Figure 1.12](#) has specialized cells.
2. Use a t-chart to compare cell specialization and cell differentiation.

### INVESTIGATION LINK

Investigation 1B, on page 50

# Specialized cells have different structures that allow them to perform unique functions.



▲ **Figure 1.14** This funnel has a lot in common with a specialized cell.

Pouring a liquid into a bottle can be messy if you do not have a funnel such as the one shown in **Figure 1.14**. A funnel is small on one end to fit into the neck of a bottle and wide on the other end. It is specialized so that you can transfer liquid into a bottle without spilling. Similarly, the structure of each specialized cell is adapted for the task that it performs. **Figure 1.15** shows a variety of specialized human cells. **Table 1.2** describes how the structure of each cell influences its function.



muscle cells



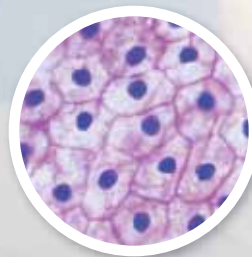
nerve cells



bone cells



blood cells



skin cells

► **Figure 1.15** In total, there are over 200 different types of cells in the human body! Muscle, nerve, bone, blood, and skin cells are shown here.

**Table 1.2 Specialized Cells and Their Functions in the Human Body**

Specialized Cells	How Structure Influences Function
Muscle cells	<ul style="list-style-type: none"><li>• Long and thin structure allows the cells to change size drastically when they contract.</li><li>• Some have a branching pattern that increases muscle strength.</li><li>• High concentration of mitochondria supply the energy required to change shape.</li></ul>
Nerve cells (called <i>neurons</i> )	<ul style="list-style-type: none"><li>• Long, threadlike branches enable the cells to receive and transmit signals from other cells throughout the body.</li></ul>
Red blood cells	<ul style="list-style-type: none"><li>• Doughnut-like shape with a depression in the centre provides a large surface area to carry oxygen.</li></ul>
Bone cells	<ul style="list-style-type: none"><li>• Framework of hard material, which contains minerals that provide strength and support, hold the cells together.</li></ul>
Skin cells	<ul style="list-style-type: none"><li>• Thin, flat, and layered cells form a gap-free barrier to keep out potential invaders and keep in moisture.</li></ul>

**Inquiry Focus** 🔍

### Activity 1.14

#### **DIFFERENT CELLS, DIFFERENT JOBS, DIFFERENT YOU!**

Choose one of the specialized cells shown in **Table 1.2**. Consider what would happen to you if you did not have this type of cell in your body. Imagine that you are looking in a mirror. Would you look like yourself, or like a completely alien life form? Do you think you could survive without this type of cell? Explain your thinking.

- ▶ What would you look like if your body were covered with a totally different kind of covering instead of skin cells?



#### **LEARNING CHECK**

1. Why do different specialized cells have different structures?
2. Refer to **Table 1.2** to explain how neurons are specialized to carry out their function.
3. Do you think a fish would have the same types of specialized cells as a bird? Explain your thinking.

#### **ACTIVITY LINK**


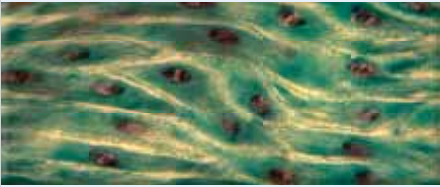
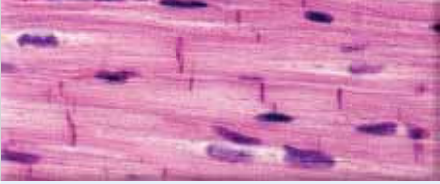

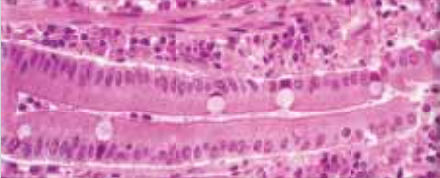
Activity 1.16,  
on page 48


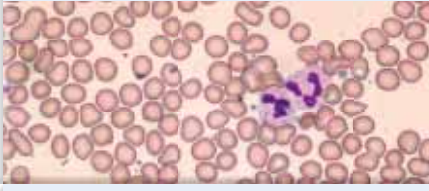

# Groups of cells working together form tissues.

**tissue:** specialized cells working together to perform a function

Cells are the basic unit of life. But even specialized cells can only accomplish so much on their own. This is where teamwork becomes important, as you discovered in the topic opener. When specialized cells work together to perform a specific function, they are known as a **tissue**. There are four basic types of tissues: muscle, epithelial, connective, and nervous tissue. Many different tissues may be classified into these four groups, as shown in **Table 1.3**.

**Table 1.3** Tissues in the Human Body

Tissue	Function	Example
Muscle	<ul style="list-style-type: none"> <li>Enables body parts to move, exert force, or change shape</li> </ul>	Muscle cells in an arm 
		Muscle cells in the stomach 
		Muscle cells in the heart 
Epithelial	<ul style="list-style-type: none"> <li>Covers the external and internal body surfaces</li> </ul>	Epithelial cells in skin 
		Epithelial cells in the small intestine 

Tissue	Function	Example
Connective	<ul style="list-style-type: none"> <li>Strengthens, supports, or connects cells and tissues</li> </ul>	Bone connective tissue 
		Blood connective tissue 
Nervous	<ul style="list-style-type: none"> <li>Senses, conducts, and transmits information</li> </ul>	Nervous tissue 

**Literacy Focus** 🔍

### Activity 1.15

#### TISSUE MODELS

Your class is entering a contest in which the participants model complex materials with everyday items. Your class has chosen to model the four basic human body tissues. The everyday items you can use are a rubber band, a piece of plastic wrap, some electrical wire, and some modelling clay.

1. Refer to the information about tissues in **Table 1.3** and decide which item best models each type of tissue.
2. Choose four other items you could use to model the same four types of tissues. Explain why you chose each item.
3. In what ways were the items that you chose limited in their ability to represent the tissues they were modelling?



#### LEARNING CHECK

1. What are tissues?
2. List the four basic types of tissues.
3. There are four basic types of tissues, but many more types of specialized cells. Why might this be?



# Groups of tissues working together form organs, which work together in systems.

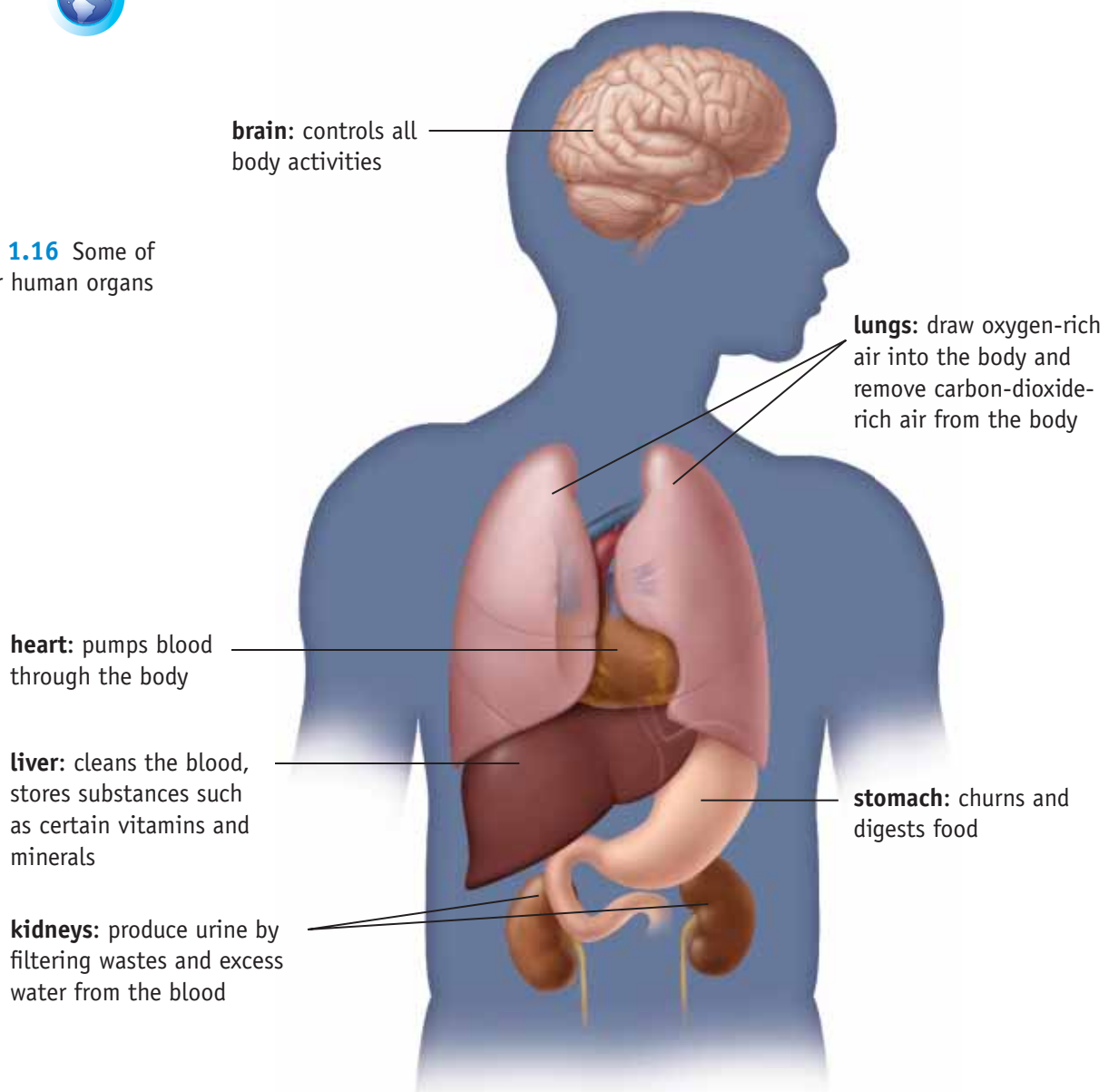
**organ:** different tissues working together to perform a specific task

Go to [scienceontario](#) to find out more



Different tissues perform unique, individual functions. However, like specialized cells, they can only do so much on their own. Tissues working together overcome this limitation to form organs. An **organ** is made up of different tissues working together to perform a specific task. An organ contains at least two different types of tissues. For example, your heart is an organ. Within your heart, muscle tissue contracts and relaxes to pump blood through valves made of connective tissue. The heart also contains nerve tissue and a protective layer of epithelial tissue. **Figure 1.16** shows some of the other organs found in your body along with their functions.

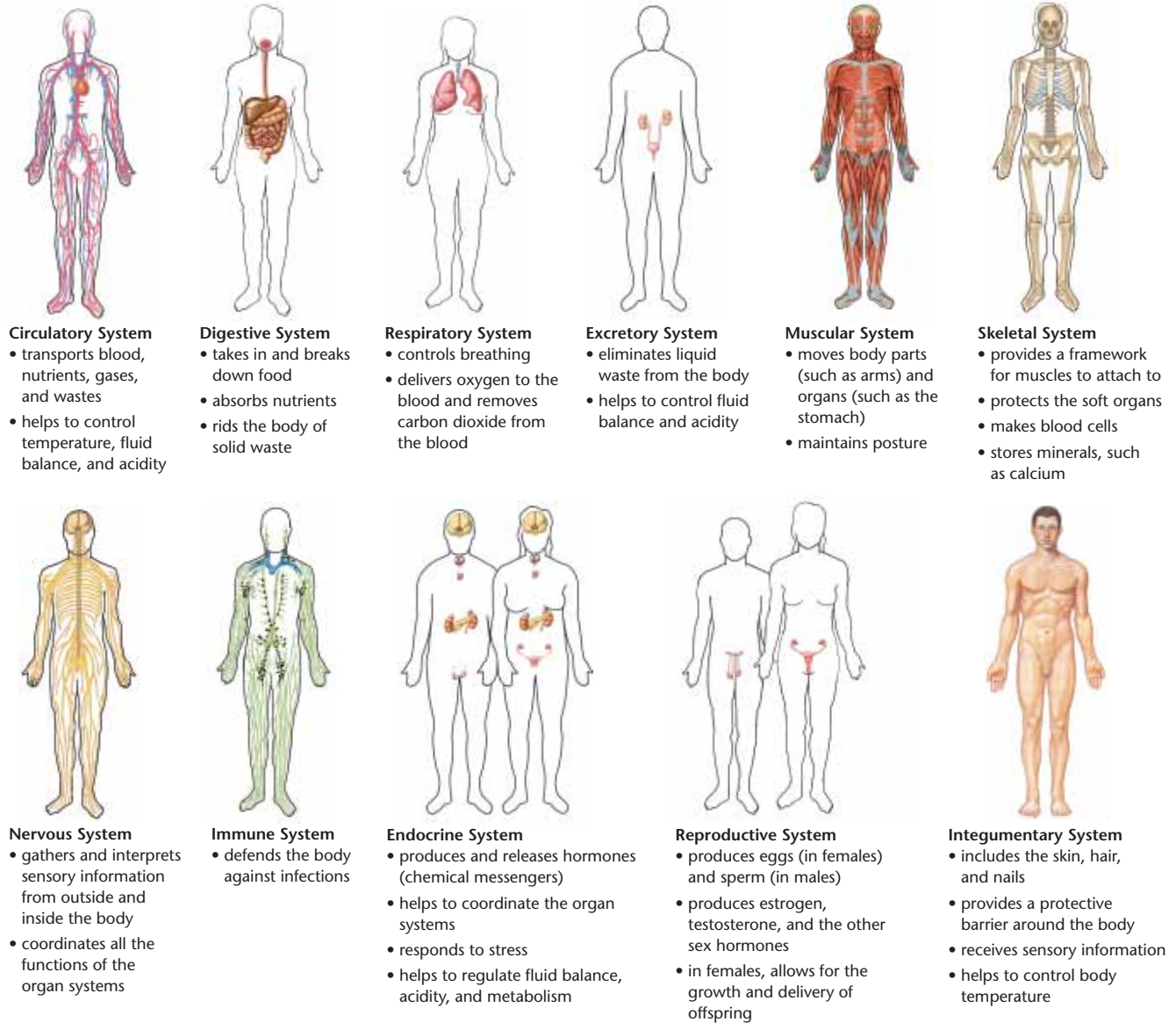
► **Figure 1.16** Some of the major human organs



# Organs Working Together Form Systems

Just as tissues working together form organs, organs working together form **organ systems**. The organs in an organ system interact with each other to perform a common task. **Figure 1.17** shows the different organ systems in the human body and their basic functions.

**organ system:** a group of organs that interact with each other to perform a common task



▲ **Figure 1.17** Human organ systems

## LEARNING CHECK

1. What is an organ?
2. a) What function do the circulatory and respiratory systems work together to perform?  
b) Identify two other examples of two or more organ systems working together to perform a certain function.

**ACTIVITY LINK**  
Activity 1.17, on page 49

## Activity 1.16

### THINKING ABOUT CHANGES TO ORGANS

In *A Voyage to Arcturus*, a strange novel that is part science-fiction and part fantasy, the main character awakes on an Earth-like planet where he discovers that his body has new organs. One is a tentacle-like limb sprouting from his heart, whose function is to perceive the inner beauty of all things. Another is a plum-sized lump on his forehead that enables him to read minds and communicate telepathically with other beings on the planet.

#### What To Do

1. Imagine that you are the character in a story that you are writing. In your story, one day you find that you have awoken on the Moon, on Mars, or on a planet that you have made up.
  - a) Describe changes to two of your organs that are appropriate to the conditions of the Moon or planet.
  - b) Invent two new organs that you (your character) discovers upon awakening.
2. Now bring your imagination and your ideas back down to Earth. What kinds of changes can happen to real organs and organ systems here, on Earth? Name at least two changes and what could cause them.
3. It is possible for people to live and carry on a healthy, productive life if they lose an organ.
  - a) Identify at least four organs that you know or think a person can live without.
  - b) Describe how the body adjusts to the absence of each of these organs. (In some cases, the adjustment requires the help of technology. Be sure to indicate what, if any, technology is needed.)



## Activity 1.17

### THE BEAT THAT GOES ON AND ON

Do you take your heart for granted? Do you ever pause to think how amazing it is? Your heart pumps approximately 4 L of blood through your body each minute. You know this pumping action as the beating of your heart. Every minute of every day, for your whole life, your heart continues to beat. Determine how many times your heart has beaten from the moment you were born until your last birthday.

#### What To Do

- Determine how many times your heart beats in one minute.
  - Gently place your middle finger and ring finger against either wrist until you find a pulse.
  - Use a stopwatch to keep time while you count the beats you feel in one minute.
- Use the following equation to calculate how many times your heart has beaten from the moment you were born until your last birthday.

$$\text{Beats from birth until last birthday} = \text{number of beats counted in 1 minute} \times 60 \times 24 \times 365 \times \text{your age}$$

number of minutes in one hour

number of hours in one day

number of days in one year

#### What Did You Find Out?

- How many times has your heart beaten since you were born?
- How do you think your answer would compare with the number of beats calculated by a marathon runner who is the same age? Explain.
- How accurate do you think your answer is? (Hint: Think of how your heartbeat changes when you play sports.) Explain your reasoning.
- Why do you think it is recommended that you exercise to make your heart beat faster for at least 20 minutes three times a week?



## Skill Check

initiating and planning

- ✓ performing and recording
- ✓ analyzing and interpreting
- ✓ communicating

## Safety



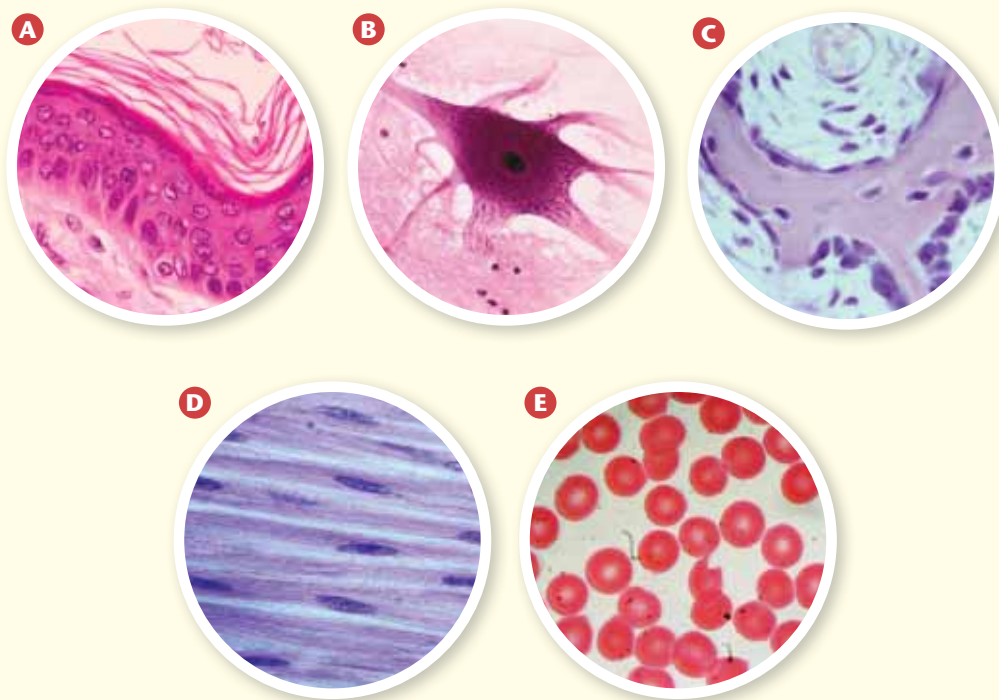
- Microscope slides are made of glass. If they break, put them in the container for broken glass.
- To unplug a microscope, pull on the plug not the cord.

## What You Need

- microscope
- prepared slides of specialized human cells

## Viewing Specialized Human Cells

In this investigation, you will observe specialized human cells under a microscope and sketch what you observe. Then you will compare what you observed under the microscope with the photographs shown below.



## What To Do

1.
  - a) Study the shape, size, and number of cells in each photograph above.
  - b) Based on what you have already learned, identify the type of specialized cell in each photograph.
  - c) Check your answers with your teacher to make sure you have correctly identified the five cells in the photos.
2. Set up a microscope and a slide of a specialized human cell.
3. Sketch what you see, including the structures inside the cell. Refer to the Science Skills Toolkit at the back of your textbook for information about drawing scientific diagrams.
  - Label all the structures you can see.
  - Record the magnification.

4. a) Identify the type of specialized cell you sketched by matching your sketch with one of the photographs. Compare the similarities and differences.
- b) Label the type of specialized cell you sketched.
5. Repeat steps 2 to 4 for each slide.

### What Did You Find Out?

1. Which cell was the easiest to identify? Explain why.
2. Which cell was the most difficult to identify? Explain why.
3. How similar were the specialized cells you observed under the microscope to the specialized cells in the photographs? Provide a possible reason for any differences you observed.
4. In your notebook, make a table similar to the one below. Give your table an appropriate title. Include a row for each type of specialized cell you viewed.
  - In the first column, write the name of each type of specialized cell you viewed.
  - In the second column, describe the main features of each type of specialized cell.
  - In the third column, explain how these features help the cell perform its function.

**Title** \_\_\_\_\_

Specialized Cell	Features	Function

5. Do all of your sketches of specialized cells include the same organelles? Explain why or why not.

### Inquire Further

There are many other types of specialized cells. Use print or electronic resources to identify at least two more types of specialized human cells. Ask your teacher for microscope slides of these cells and compare the photographs with the slides. Make a labelled sketch of each type of specialized cell and describe its function.

# STRANGE TALES OF SCIENCE

## STOMACH for SCIENCE

In the early 1800s, the stomach was an unknown frontier for scientists. Little was known about the digestive system or what happened to food once it was swallowed. Until one fateful day in 1822, that is, when an unfortunate accident provided a unique "window" into the world of digestion. The following story is pieced together from actual notes and letters from the 1800s. Read it and see if you have the stomach for the price one man paid in the name of science.



June 6, 1822. This trading post on Mackinac Island in Lake Huron was about to witness the creation of the most famous stomach in scientific history.



A musket.  
I would...  
OH!

An accidental discharge of a musket blew open the stomach and chest wall of unsuspecting French-Canadian canoe guide, Alexis St. Martin.



Not over three feet from him—I think not more than two!

He is a dead man.

Make way, a doctor is coming.

Luckily, Dr. William Beaumont was stationed at the nearby US military camp. He reached St. Martin within minutes of the blast.



The man cannot live thirty-six hours. I will come and see him by and by.

Dr. Beaumont has cleaned the wound as best he can. Still, it does not look good for St. Martin. But wait...

Amazing. Your wound has healed in weeks. But it has joined to the chest wall, leaving a hole the size of a chestnut. The bandage will keep food from escaping.

Upon my word, what an opportunity. If I can just get him to agree to...

It could not have been easier. Get the illiterate woodsman to sign a document that he will work as my servant for scant wages. And his stomach will be mine to experiment with day in and day out.

What have I done?



...to the surprise of all, St. Martin recovers. But is that good news or bad? It seems Dr. Beaumont has plans for that hole in Alexis's stomach.

One year later, St. Martin has agreed to travel to Dr. Beaumont's new post in the U.S.

The stomach experiments begin. Food is lowered into St. Martin's stomach and observed. Digestive chemicals are removed and analyzed. Slowly, over several years, the secrets of the stomach are revealed.



"I consider myself but a humble inquirer after truths...a simple experimenter."



"The gastric juice is such a powerful solvent. Even the hardest bone cannot withstand its action."



This doctor cares only for my stomach and little about me. He could have closed this hole long ago, but he has not. I travel everywhere with him, but what I would give to be home again.



But all is not well in scientific paradise...

The loneliness is unbearable. Oh Canada, soon I will see you again.



Then one night when no one suspects, St. Martin leaves the doctor in the lurch.

St. Martin! I am published. Your stomach has brought us fame!... **GASP!** He is gone!



Science has so much more to learn! I must get him back, I will get him back!



But how?

So... What do you think?

1. Did Beaumont convince St. Martin to return? Create a graphic novel that tells how this story might end.
2. Beaumont achieved fame when he published a book about St. Martin's stomach. The book contained 240 of the experiments he completed. Find out three things Beaumont learned about digestion from his experiments.
3. Years later, Dr. Beaumont was quoted as saying that St. Martin left in part because of "unwillingness to submit himself for public experiments." Would you have been willing to take part in these experiments as St. Martin did? Explain why or why not.
4. Beaumont could have closed the hole in St. Martin's stomach with simple surgery, yet he chose not to. In your opinion, was this acceptable? Explain your reasoning.

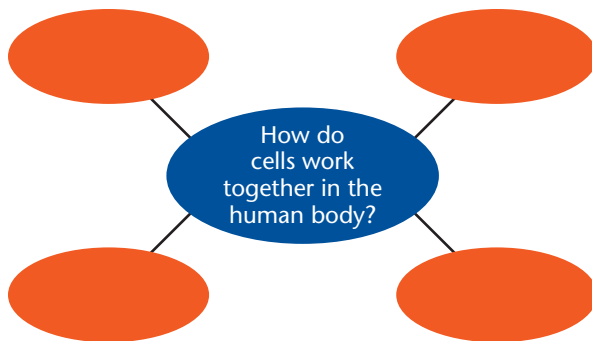
# Topic 1.3 Review

## Key Concept Summary

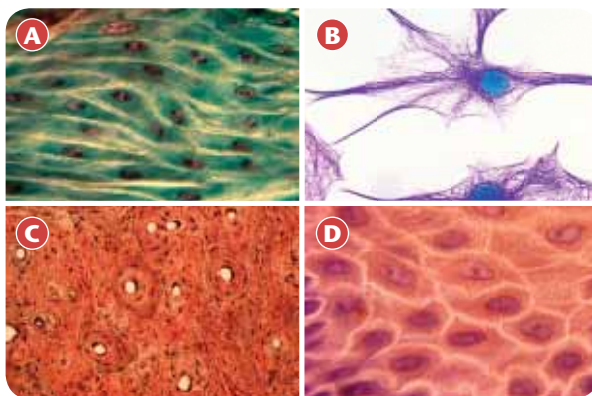
- All cells begin alike and differentiate into specialized cells.
- Specialized cells have different structures that allow them to perform unique functions.
- Groups of cells working together form tissues.
- Groups of tissues working together form organs, which work together in systems.

## Review the Key Concepts

1. **K/U** Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. **K/U** a) What are stem cells?  
b) Why are stem cells important for a multi-celled organism?
3. **K/U** Identify two organs and describe the function of each.
4. **T/I** a) Identify each tissue shown below.  
b) For each tissue, describe its function.



5. **K/U** Draw a flowchart that shows the following terms in order of their complexity, from least complex to most complex: organs, tissues, systems, cells.
6. **T/I** Choose two specialized cells you have studied. Use a Venn diagram to compare the similarities and differences between the two cells.
7. **C** You are the science writer for a community newspaper. Write an article describing one organ system and the role it plays in the body.
8. **A** Think of a human-made system not discussed in this textbook—for example, a computer network, a sewage system, a post office, or a train station. Compare your system to one of the human organ systems shown in **Figure 1.17**.
9. **A** Multiple sclerosis (MS) is a disease that affects the brain and spinal cord, impairing their ability to communicate with each other. Which type of tissue is affected by MS?
10. **C** Use a creative medium of your choice, such as a skit or drawing, to describe how one of the following human cells is adapted for its function: neuron, muscle cell, red blood cell, bone cell, skin cell.