

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

- Unspecialized cells can become specialized through interactions with their environments.
- Specialized cells group together to function as a tissue.
- Specialization of cells allows for diversity of function in multicellular organisms.
- Current research is focussed on the function and use of unspecialized cells, known as stem cells, in treating disease.



**Figure 1.37** The axolotl is a type of salamander that has an amazing ability to regenerate missing limbs.

## Regeneration

In scientific laboratories around North America, scientists study the superstar of regeneration — the salamander (Figure 1.37).

**Regeneration** is the process whereby a body part is replaced or regrown. The salamander has the unique ability to regrow not only limbs that have been amputated but also tails, lenses in eyes, and parts of the heart (Figure 1.38). In the salamander, the process of mitosis is responsible for regenerating the cells that will eventually specialize and create a newly formed limb.

Although regeneration has been studied in organisms such as the salamander, it is not often thought to occur in humans. However, examples of regeneration in humans do exist. The human liver is the only human organ that has an ability to naturally regenerate. Additionally, human fingertips have a limited ability to regenerate. In young children, an amputated fingertip that is cleaned and covered with a simple dressing can regenerate. The new fingertip has the same fingerprint pattern and sensations of the original fingertip.

## Research into Regeneration

In 2008, scientists reported some astonishing progress in the field of regeneration. A powder stimulated a human adult fingertip that had been severed to regrow. The powder, made from pigs' bladders, is called

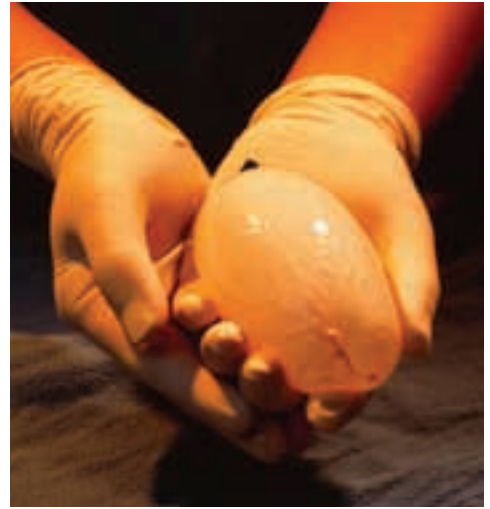


**Figure 1.38** The regeneration of a newt's limb over 6 to 8 weeks. The newt is a type of salamander. The lighter colour represents the newly formed forelimb.

an extracellular matrix. Although regenerating a fingertip is not the same as regenerating a limb, scientists hope that the knowledge they gain from researching the extracellular matrix will lead to further developments.

Another development in the field of regeneration is the creation of body parts in the lab. In one example, a patient's bladder cells were isolated and grown on a prepared surface called a scaffold. In two months, the cells had formed a functioning bladder that was implanted into the patient (Figure 1.39). This technology has also been used to create functioning blood vessels and heart valves. In the future, scientists believe it may be possible to grow a functioning human heart.

Scientists do not fully understand why a salamander can regenerate certain body parts but not others, even though all salamander cells contain the same DNA. With the success in developing technologies to regenerate human bladders or blood vessels, it may be possible to grow all body parts through regeneration in the future.



**Figure 1.39** An artificial bladder held by gloved hands. The bladder was grown from cultured bladder cells.

## **A10** **STSE** *Quick Lab*

### **Tailor-Made Body Parts**

In 2008, Dr. Anthony Atala, from Wake Forest University, North Carolina, reported that he and his team had successfully grown 18 different tissues outside of the body using the techniques of regeneration. One particularly successful experiment involved the creation of a human bladder that was grown in the lab from the patient's own bladder cells and then transplanted into the patient. Growing replacement organs in the lab would meet the needs for replacement organs. Some businesses have recognized the opportunities that this new technology provides. For example, in the future, if you were in need of a replacement organ, you could simply order a tailor-made replacement body part made using your own cells.

#### **Purpose**

To consider the social and ethical issues connected with using technology to make human body parts

#### **Procedure**

1. Work with a partner. Prepare a T-chart with the headings "Social Issues" and "Ethical Issues."
2. Brainstorm about how the production of human body parts using regenerative technologies could affect society. Think about both the positive and negative ways. List your ideas in the T-chart under the heading "Social Issues."
3. Continue to brainstorm about the ethical issues related to the production of body parts using regenerative technologies. List your ideas in the T-chart under the heading "Ethical Issues."

#### **Questions**

4. With the development of regenerative technologies, there has been interest in the mass production and commercialization of human organs. Discuss two positive outcomes and two negative outcomes of this action.
5. Why do you think this technology would be of interest to the military?



**Figure 1.40** Meerkats have different specialized jobs. The sentinel meerkat looks for any dangers to the clan.

## The Process of Cell Specialization

Meerkats are small mammals that live in the desert regions of southern Africa. Meerkats live in groups, called clans or mobs, of 5 to 20 animals. Members of the clan work together to find food, care for the young, and defend themselves against predators. Scientists have observed that there are certain specialized roles that meerkats may play within the clan. In each clan, there is a dominant, or alpha, pair of animals that lead the group. The other adult meerkats are subservient to the alpha meerkats and leave the clan when they are three years old. During the day, there is always at least one adult meerkat acting as a sentinel, or lookout, and watching for predators while the rest of the clan plays or searches for food (Figure 1.40). Using a bark, the sentinel signals to the rest of the clan when danger approaches. Other meerkats serve as babysitters for the young. The success of the meerkat clan depends on each meerkat doing his or her specialized job.

Much like a meerkat clan is a collection of different meerkats doing specialized jobs, a multicellular organism is a collection of different types of cells doing specialized jobs. Although all cells have the same DNA information, they are not all alike. Cells develop in different ways to perform particular functions in a process called **cell specialization**. For example, animal cells may become specialized to form lung cells, skin cells, or brain cells. Plant cells become specialized to form a variety of specialized cells including xylem or phloem in the root, stem, or leaf.

### During Reading



#### Sketch to Stretch Your Understanding

When reading comprehension gets difficult because of unfamiliar terminology, good readers find it helpful to visualize ideas, and they may even draw or sketch as they read to try and understand the text. Choose one paragraph and sketch as you read, then check your understanding. Did the sketches help you to make sense of what you were reading?

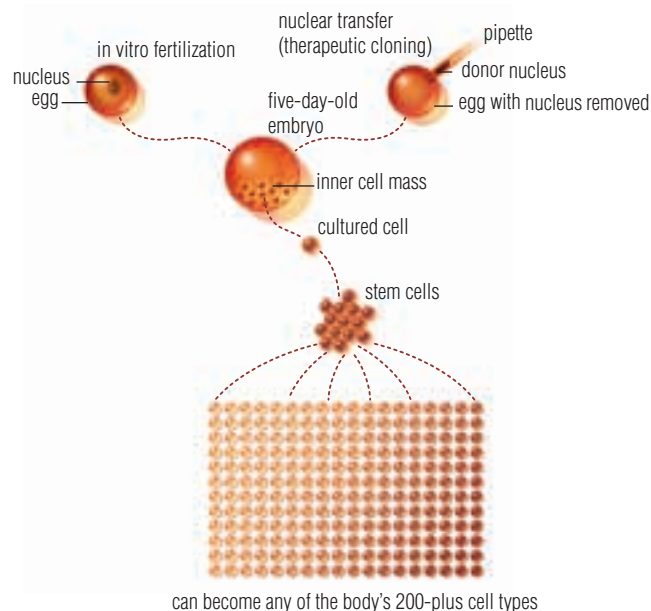
## Stem Cells

Every cell in your body originally came from a small group of stem cells. A **stem cell** is an unspecialized cell. Stem cells can form specialized cells when exposed to the proper environmental conditions, or they can remain unspecialized and actively dividing for long periods.

Scientists are studying stem cells in animals and plants so that they can understand the process of cell specialization. They believe that stem cells may be used to treat injuries and diseases by regenerating organs. Figure 1.41 shows how stem cells are produced in the lab for stem cell research. These stem cells are capable of becoming any cell — including nerve cells, blood cells, or muscle cells — in the human body.

### Embryonic and Adult Stem Cells

There are two types of stem cells: embryonic stem cells and adult stem cells. As the name suggests, embryonic stem cells are found in embryos. Embryonic stem cells are able to undergo **differentiation**, which means that the cells look different from one another and perform different functions. Embryonic stem cells differentiate into other cell types. As these cells divide, further specialization occurs, leaving cells with a limited ability to create a variety of cell types. These cells are called adult stem cells.



**Figure 1.41** Most stem cells used for research are taken from embryos created by in vitro fertilization. The process occurs when the egg is fertilized under laboratory conditions. Scientists are also working on getting cells from embryos produced by therapeutic cloning, in which the nucleus of a skin cell, for example, is inserted into an egg whose nucleus has been removed. Either way, after five days scientists transfer the embryo's inner cell mass — with its 40 or so stem cells — to a lab dish where the cells can reproduce. After many months, the original stem cells have grown into millions of healthy cells without beginning to differentiate into specialized cells.

As an organism matures, stem cells become specialized. In adult organisms, therefore, there are few examples of stem cells; most adult stem cells are involved in the replacement of damaged tissue. For example, adult stem cells are found in skin, blood, and neural tissue. Recent studies have found that adult stem cells from the tissue of one organ can regenerate tissue in another organ. For example, adult blood stem cells have regenerated liver, kidney, and brain cells.

Current research involves the use of stem cells in the treatment of such diseases as cancer, Parkinson's disease, Alzheimer's disease, stroke, heart disease, diabetes, and rheumatoid arthritis. There is much public debate about the use of embryonic stem cells. It is possible to harvest a few embryonic stem cells from the umbilical cord or placenta, but to collect larger amounts of embryonic stem cells, it is necessary to destroy the embryo.

## Meristematic Cells

Stem cells are also found in plants. Plant stem cells are called **meristematic cells**. They are found in the growing tips of roots (Figure 1.42) and stems and also in a layer in the stem known as the cambium. Plant meristematic cells are active throughout the life of a plant, which means that they continually produce new cells of various types.

### Learning Checkpoint

1. Define the term "stem cell."
2. Explain how stem cells can become specialized.
3. Compare and contrast embryonic stem cells and adult stem cells.
4. State one practical use of stem cell research.
5. What are meristematic cells?



**Figure 1.42** Meristematic cells in an onion root tip (magnification 25×)



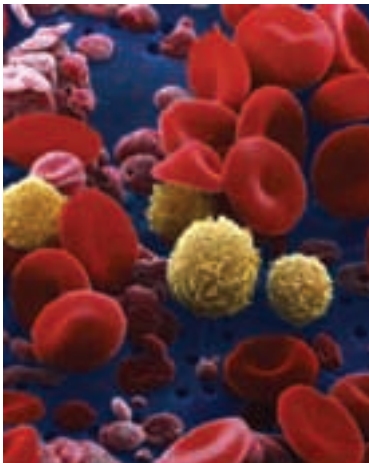
## Specialized Cells and Tissues

Imagine being stranded on a deserted island with a group of your family and friends. You could look out only for yourself and be responsible for all of your own needs, including food and shelter. Or you could work with the other people on the island and form teams: one team may be responsible for building the shelter, while another team would look for food. In the second scenario, each team works for the good of the whole group: everything does not depend on one person.

We can use this analogy to understand how a multicellular organism accomplishes its life processes. A multicellular organism is made of many cells. Since it would be difficult for each cell in a multicellular organism to perform all of the necessary life processes independently, cells group together and become specialized. Just as it makes sense for you to work together as a team on the deserted island, it makes sense for groups of cells to function together. Groups of cells that function together to perform specialized tasks are called **tissues**.

### Animal Tissues

In animals, cells specialize to form four types of tissues (Table 1.5). The cells in each tissue work together to accomplish important tasks.



**Figure 1.43** Scanning electron micrograph showing human red blood cells, white blood cells (yellow), and platelets (pink)

### Epithelial and Connective Tissue

Epithelial tissue is made of cells that are tightly packed together to form a protective barrier. Epithelial tissue may be one cell thick or consist of several layers of cells.

The main function of connective tissue is to join other tissues together. There are different types of connective tissue including tendons and ligaments, bones, cartilage, and blood. Tendons connect muscles to bones, and, ligaments connect bones to bones. Blood is made of plasma, red blood cells, white blood cells, and platelets (Figure 1.43).

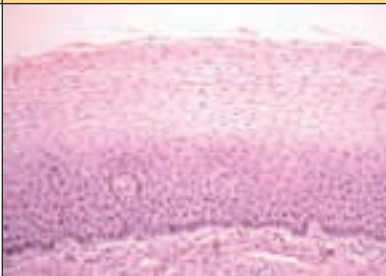
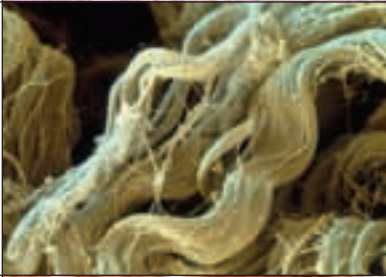
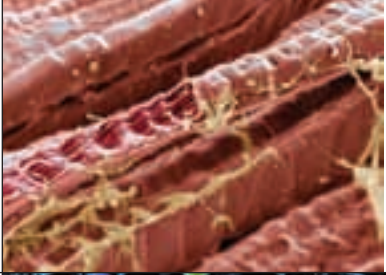
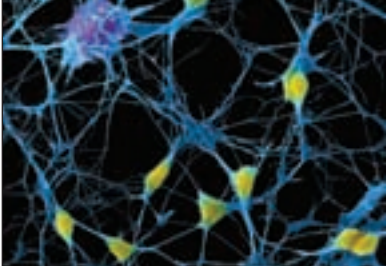
**Red blood cells** contain hemoglobin, a protein that can absorb and release oxygen. White blood cells protect the body from bacteria and viruses and fight infection. Platelets are cells that help in the process of blood clotting.

### Muscle and Nervous Tissue

There are three types of muscle tissue: skeletal, smooth, and cardiac. When you move your arm or leg, you are using skeletal muscle. Smooth muscle occurs in blood vessels, the stomach, and other organs. Cardiac muscle is only found in the heart. Skeletal muscle is voluntary, which means that it is controlled by will. Smooth muscle and cardiac muscle are involuntary, which means they move without conscious control.

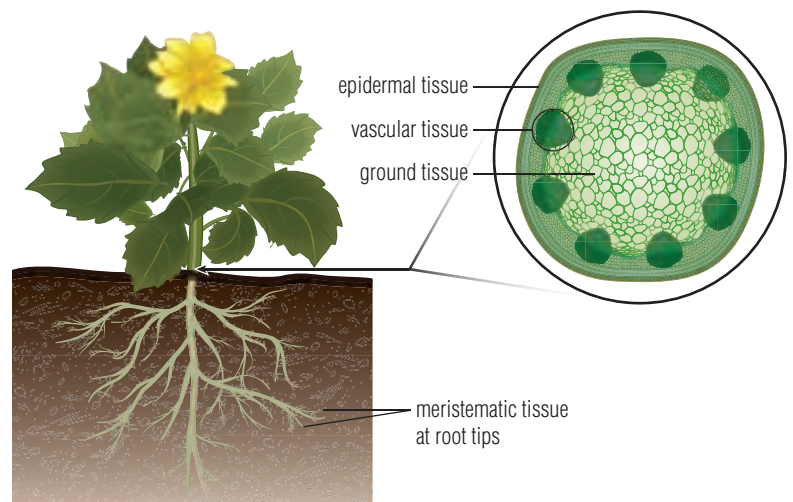
Nervous tissue is made of nerve cells which are capable of creating messages, called impulses, and transmitting them throughout the body. Nerve cells receive information from inside and outside the body.

**Table 1.5** Animal Tissues and Their Functions

Tissue Type	Micrograph	Major Function(s)
epithelial tissue		<ul style="list-style-type: none"> <li>• lines body cavities and outer surface of body</li> <li>• protects structures</li> <li>• forms glands that produce hormones, enzymes, and sweat</li> </ul>
connective tissue		<ul style="list-style-type: none"> <li>• supports and protects structures</li> <li>• forms blood</li> <li>• stores fat</li> <li>• fills empty space</li> </ul>
muscle tissue		<ul style="list-style-type: none"> <li>• allows for movement</li> </ul>
nervous tissue		<ul style="list-style-type: none"> <li>• responds to stimuli</li> <li>• transmits and stores information</li> </ul>

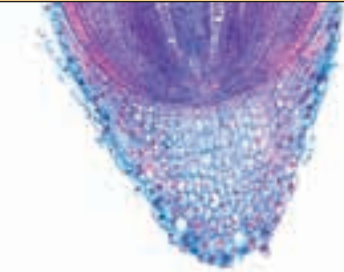
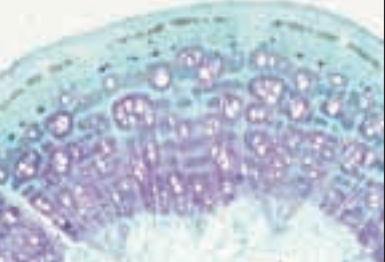
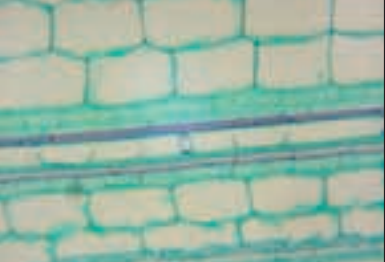
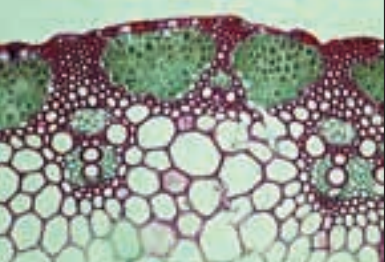
## Plant Tissues

There are four types of tissues in plants: epidermal tissue, vascular tissue, ground tissue, and meristematic tissue (Figure 1.44). All plant tissues are formed from groups of meristematic cells known as **meristematic tissue**. Table 1.6 (on the next page) describes and illustrates the different types of plant tissues.



**Figure 1.44** Location of plant tissues

**Table 1.6** Plant Tissues and Their Functions

Tissue Type	Micrograph	Major Function(s)
meristematic tissue		<ul style="list-style-type: none"> <li>• unspecialized tissue capable of dividing by mitosis</li> <li>• found in several locations in the plant</li> <li>• responsible for growing new parts of the plant</li> </ul>
epidermal tissue*  * The micrograph shows both epidermal and vascular tissues.		<ul style="list-style-type: none"> <li>• forms the protective outer covering</li> <li>• allows the exchange of materials and gases into and out of the plant</li> </ul>
ground tissue		<ul style="list-style-type: none"> <li>• in the stem: provides strength and support</li> <li>• in the roots: stores food and water</li> <li>• in the leaves: where photosynthesis occurs</li> </ul>
vascular tissue		<ul style="list-style-type: none"> <li>• moves substances from the roots to the leaves</li> <li>• transports sugars from the leaves to other parts of the plant</li> </ul>

### Suggested Activity • .....

A12 Inquiry Activity on page 46

## Epidermal and Ground Tissue

The epidermal tissue on both the top and underside of the leaf is clear and very thin. Specialized guard cells form a tiny opening, or pore, called a **stomate**, that allows carbon dioxide, water vapour, and oxygen to move into or out of the leaf easily. Most stomata are found on the underside of the leaf.

Most of the plant is made of ground tissue. The function of the ground tissue depends on where it is found in the plant. For example, in the roots, ground tissue is involved in food and water storage. In the leaves, photosynthesis and gas exchange occurs in specialized ground tissues called **mesophyll**. During photosynthesis, carbon dioxide and water are converted into sugar and oxygen.

## Vascular Tissue

Vascular tissue plays an important role in transporting water and nutrients throughout the plant. There are two types of vascular tissue in the plant: xylem and phloem. **Xylem** is responsible for the movement of water and minerals from the roots up the stem to the leaves, where these substances are used in photosynthesis. **Phloem** transports the sugar produced during photosynthesis from the leaves to other parts of the plant, where it is used to provide energy for all cellular processes.

### WORDS MATTER

“Xylem” comes from the Greek root *xyl*, meaning wood. Phloem comes from the Greek root *phloe*, meaning bark.

### Learning Checkpoint

1. Define the term “tissue.”
2. What is the link between specialized cells and tissues?
3. Compare the structure and functions of epithelial tissue and epidermal tissue.
4. What are four types of animal tissues?
5. What are four types of plant tissues?

### Take It Further

Find out how stem cells are used in the treatment of a disease such as diabetes or Parkinson’s disease. Create a concept map to show the details of your findings. Begin your research at [ScienceSource](#).

## A11 STSE Science, Technology, Society, and the Environment

### Receiving Mixed Messages

We have an almost unlimited access to various sources of information. The Internet gives us the opportunity to interact with others and exchange information on a global scale. Scientific inquiry is now a collaborative international process. The ability to communicate electronically over the Internet using text, sound, and pictures is a powerful tool for the scientist. However, effective and accurate communication of information is important to the success of the process of scientific inquiry.

We have the opportunity to receive scientific information in various forms of media including journals, newspapers, TV shows, movies, books, lectures, and interviews. Recent scientific advancements are commonly used in the story lines of television programs and movies. The problem is that sometimes these messages about science are not entirely correct. For example, some movies have plots based on a scientific theme but may not be scientifically accurate. Although media with science-based themes may increase the level of public

awareness of an issue, it is also possible that they could misinform the public. In addition, it is also possible that some messages are delivered in a manner that reflects the bias of a particular interest group or corporate sponsor.

In this activity, you will discuss examples in which you received media messages about cell biology.

1. With a partner, make a list of situations where you have received media messages about cells. Remember to consider different types of media including radio, advertisements, newspapers, TV, magazines, websites, blogs, wikis, music, videos, and movies.
2. Share your responses with the whole class and compile a class list.
3. As a class, identify any trends that emerge.
4. As a class, predict how corporate sponsorship of scientific research may affect the nature of the scientific messages that are delivered in the media.



- Justifying conclusions
- Communicating ideas, procedures, and results in a variety of forms

## Examining Plant and Animal Tissues

If you offered to shovel snow for a neighbour, you would be sure to use the proper equipment. You would not use a dustpan or a mop but rather a snow shovel. You would also be sure to be dressed in the appropriate clothing so that you would stay warm and dry while on the job. Groups of cells must also have the proper equipment if they are to perform efficiently as tissues. In this activity, you will observe groups of cells and infer how their structures allow them to perform their specialized tasks.

### Question

How do cell structures enable the tissue to accomplish its function?



### Materials & Equipment

- prepared slides of plant tissue (epidermal tissue, ground tissue, vascular tissue)
- prepared slides of animal tissue (epithelial tissue, nervous tissue, muscle tissue)
- pencil or pen
- paper
- ruler
- compound light microscope

**CAUTION:** Practise proper techniques in handling the microscope and slides.

### Procedure

#### Part 1 — Examining Plant Tissue

1. Review the proper handling and use of the microscope in Skills Reference 10.
2. Set up your microscope, and place a prepared slide of plant tissue on your microscope.
3. View the slide under low power, and scan to see its contents. Adjust the light using the diaphragm so that you can see the cell contents clearly.

4. Find the section of the slide of cells that you wish to examine.
5. Use the low-, medium-, and high-power lenses to study the cells.
6. Draw a labelled diagram of the plant tissue. Remember to include the magnification and scale in your drawing.

#### Part 2 — Examining Animal Tissue

7. Repeat steps 2 to 6 using a prepared slide of animal tissue.
8. 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

9. Describe the structure of the cells in the plant tissue that you examined. How does the structure relate to its function?
10. Describe the structure of the cells in the animal tissue that you examined. How does the structure relate to its function?
11. What information about the tissues could be found through examination using a compound light microscope?

### Skill Practice

12. Was the section of the slide that you chose to examine a good representation of the entire tissue?

### Forming Conclusions

13. Would you expect plant and animal tissues with similar functions to share some common structural features? Support your answer with evidence from your observations.

## 1.3 CHECK and REFLECT

### Key Concept Review

1. What are two characteristics of stem cells?
2. What are stem cells called in plants?
3. Name the four types of specialized animal tissues, and state the general function of each tissue.
4. Name three types of specialized plant tissues, and state the general function of each tissue.
5. Specialized tissues in the cactus, shown below, help it to survive in the harsh desert climate. Why are epidermal tissues so important to plant survival?



Question 5

6. Explain the location and function of ground tissue.
7. Describe the function and importance of mesophyll tissue.
8. Define the term “regeneration,” and give an example of regeneration in animals.
9. In this section, you learned about organ regeneration. Predict two social, political, or economic implications that would result if organ regeneration were possible for every organ in your body.
10. What are some advantages and disadvantages of cell specialization?
11. What is the relationship between specialized cells and tissues in animals?
12. The muscles in the heart are said to be “involuntary.” Explain the meaning of this term, and then state why this characteristic of heart muscle is necessary.
13. Explain how the different types of plant tissues are involved in photosynthesis.
14. (a) Define the term “xylem.”  
(b) Describe how the xylem and phloem work together as a transport system.
15. Plants are often called “nature’s air purifiers.” Explain the meaning of this term.
16. A cross section of a tree trunk reveals rings. These annual rings are made of xylem tissue. Scientists use the size of the tree rings to infer the climate of the year in which the tree grew. Use your knowledge of the function of xylem tissue to explain why wide rings could indicate that the tree grew in an environment with plenty of moisture while narrow rings could indicate that the tree grew in an environment that was unusually dry.
17. Compare animal tissues and plant tissues that have similar functions.

### Reflection

18. Explain why you think that it is important for you to learn about stem cells and stem cell research.

For more questions, go to [ScienceSource](#).

### Connect Your Understanding

9. In this section, you learned about organ regeneration. Predict two social, political, or economic implications that would result if organ regeneration were possible for every organ in your body.

## Great CANADIANS in Science

## Sheela Basrur



**Figure 1.45** Dr. Basrur calms the fears of the public during the SARS outbreak.

In March 2003, a 44-year-old man went to the emergency room (ER) at Scarborough Hospital with an unknown respiratory illness. During the time he was in the ER, he transmitted the illness to two other patients and sparked a chain of infection that ultimately killed 44 people and sickened 330. Although no one knew it at the time, he had severe acute respiratory syndrome, or SARS.

SARS is a severe pneumonia-like respiratory disease that was first seen in Southeast Asia in late February 2003. By the time the disease had run its course, over 8000 people around the world were sick and 800 had died.

During the SARS epidemic, Dr. Sheela Basrur provided skilled leadership that earned her the respect of the people of Toronto as well as the rest of Canada (Figure 1.45). Dr. Basrur was Toronto's Chief Medical Officer of Health. Dr. Basrur and other medical officials put various procedures in place to control the epidemic. Rigid infection-control procedures were installed in 22 hospitals in Toronto: people who were exposed to SARS were put in quarantine, and people who had the disease were isolated. Dr. Basrur ultimately showed that the epidemic was under control.

In addition to calming a nation's fears about SARS, Dr. Basrur helped develop anti-pesticide and anti-smoking laws. After she showed leadership during the SARS crisis, she was appointed Ontario's Chief Medical Officer of Health and Assistant Deputy Minister of Public Health in 2004. She helped develop a post-SARS action plan for Ontario, which included stockpiling 55 million respirator masks for health-care workers and hiring 10 disease-tracking experts at public health labs. She resigned in 2006 to undergo treatment for cancer. In April 2008, Dr. Basrur received the Order of Ontario (Figure 1.46). On June 2, 2008, Dr. Basrur died; she was 51 years old. The headquarters for the newly formed Ontario Agency for Health Protection has been named in Dr. Sheela Basrur's honour.

**Questions**

1. Describe the role that Dr. Basrur played in controlling the SARS epidemic of 2003.
2. **ScienceSource** Research to learn how Ontario prepared itself for any future pandemic or epidemic.



**Figure 1.46** Dr. Basrur admires the Order of Ontario that she received for her work during the SARS crisis.



**Figure 1.47** A medical technologist draws blood from a patient's arm for testing.

Having the technology to diagnose and treat diseases is useful only if there are people qualified to use the technology. A medical laboratory technologist works individually or as part of a team in a laboratory to analyze specimens taken from a body. Common specimens sampled include blood, urine, fetal tissue, amniotic fluid, bone marrow, and tumours (Figure 1.47). A technologist uses sophisticated techniques and instruments to obtain necessary information about these specimens that will help doctors make medical decisions.

Since technology is constantly changing, a technologist must be capable of learning new information and techniques. Technologists need to be detail oriented and must demonstrate strong critical and creative thinking skills. Technologists must also possess strong motor skills and eye-hand coordination. They must know how to use a great variety of lab instruments and techniques and when to use each appropriately (Figure 1.48).

However, technical skill is not sufficient in itself. Analyzing lab specimens and recording lab results must be done accurately so that the decisions based upon the laboratory work are valid. The technologist must also remember that lab information will affect the present and future medical care of the patient.

Usually, technologist training requires two years at a post-secondary institution. In Ontario, the Michener Institute offers a great variety of specialty courses in medical laboratory technology. Some specialty areas require additional preparation at the university level.

### Questions

1. Describe some of the skills needed to be a successful medical laboratory technologist.
2. **ScienceSource** Research three of the different areas in which medical laboratory technologists can work.



**Figure 1.48** A technologist works with petri dish cultures of amniotic cells. Tests done on the cells will determine if the developing fetus has genetic disorders, such as Down syndrome or cystic fibrosis.