How does a plant, a multicellular organism, obtain food, water, and minerals? How does it respond to its environment? Most plants take up water and minerals through their roots and produce food in their leaves. In winter, some plants lose their leaves, and if they do not receive enough water, some plants may wilt. These actions are complex. What exactly are the structures that allow plants to perform these activities? How are these structures organized and how do they function?

In single-celled organisms, one cell must be able to perform all the functions of life. Each organelle in the cell carries out a specific set of activities. By functioning together, the organelles meet all of the cell's needs.

In multicellular organisms, similar specialization takes place at the level of the cell. Many cells working together meet the needs of the organism. Groups of specialized cells, often with particular structures, perform specific tasks. For example, the cells lining the intestines are specialized to transport nutrients across their membranes and into the bloodstream. Other specialized cells of the body include muscle cells, nerve cells, and skin cells. Plants also show specialization of cells, as you can see in Figures 9.1 and 9.3.

Specialized cells have particular traits that help them to carry out their activities efficiently. Those traits can include a particular cell shape, size, and location within the organism, as well as the types of organelles within the cell.

**Cell Specialization in Leaves**

Leaves contain several types of specialized cells that function in one of the leaf's most important activities: photosynthesis (see Figure 9.2). Light energy powers this biochemical process, in which carbon dioxide from the air and water from the soil are combined to create glucose. Glucose is a carbohydrate that both plant cells and animal cells use as a source of energy. Oxygen gas, an essential component of the air for plants and animals, is produced as a by-product during photosynthesis.

As shown in Figure 9.3, different types of leaf cells have different structures and arrangements. How does a specific structure enable a leaf cell to perform specific activities? How does the location of a leaf cell within a leaf affect that cell's function? Discover the answers to these questions in the Find Out Activity on page 322.
A Epidermal Cells
Just as skin cells protect your inner tissues, a protective layer covers a plant's leaf. This layer, called the **epidermis** (also the scientific name for skin), is made up of epidermal cells. The epidermis covers the upper and lower surfaces of the leaf. The epidermal cells are flat and arranged in a tightly knit sheet that is one cell layer thick. A waxy substance (the cuticle) coats the cells to prevent evaporation of water from the leaf. Because their main function is to protect the leaf, rather than to perform photosynthesis, the epidermal cells do not have chloroplasts. They are mostly transparent to allow solar energy to pass through them to the layers of photosynthetic cells underneath.

B Palisade Tissue Cells
One of the main types of photosynthetic cells of plants are **palisade tissue cells**. This cell type forms a distinct layer within the leaf. The palisade tissue cells are long and narrow, like columns, and are packed closely together. Their shape and organization make photosynthesis within the palisade tissue cells very efficient. These cells lie just under the leaf's upper surface, where they are exposed to sunlight striking the leaf. Palisade cells are packed with chloroplasts, thus, this is where most of leaf's photosynthesis occurs.

C Spongy Tissue Cells
**Spongy tissue cells** also contain chloroplasts and carry out photosynthesis. The spongy cells are layered just below the palisade tissue cells. These cells are round and loosely packed and have many air spaces between them, like a sponge. Their structure helps the cells to exchange gases and water with the environment.

D Stomata and Guard Cells
The epidermis provides leaf cells with valuable protection from the environment. However, if the epidermis prevented carbon dioxide from entering the leaf, photosynthesis could not occur. Small openings in the epidermal layer, called **stomata** (singular, “stoma”), allow gases in and out of the leaf. Carbon dioxide comes in to the leaf and oxygen is released from the leaf through the stomata. Water vapour also diffuses out of the leaf through these openings. Most stomata are on the underside of the leaf. Each stoma is flanked by two **guard cells** that regulate the stoma's size. The shape of the guard cells can change to open or close the stomata.

E Vascular Tissue Cells
In addition to carbon dioxide and light energy, leaves need water to perform photosynthesis. **Vascular tissue cells** form a series of tubes that transport fluids throughout the plant. In the leaves, these are visible as leaf veins. Two kinds of vascular tissue, called **xylem** and **phloem**, make up the tubes. Xylem carries water and minerals from the roots to the leaves. Phloem carries sugars produced by the leaves to various parts of the plant. The tissues are arranged together in **vascular bundles**.

Word Connect
A palisade is a fence made of sharpened poles or stakes that forms a defensive barrier. Canada's early forts were surrounded by palisades. In your notebook, write a few sentences comparing the appearance of a palisade fence to the appearance of palisade tissue cells. Include drawings, if you like.
**Turn Over a New Leaf**

In this activity, you will use a microscope to examine the specialized cells of leaves.

**Materials**
- prepared slides of leaves in cross section
- compound light microscope
- *Tradescantia* (Spiderwort) or *Kalanchoe* (Bryophyllum) leaves
- tweezers
- 2–3 microscope slides
- medicine dropper
- tap water
- 2–3 cover slips

**Safety Precautions**
- Handle microscope slides and cover slips carefully so they do not break and cut you.
- Be careful when using sharp objects such as tweezers.

**Procedure**

1. Place a prepared slide of a cross section of a leaf under the microscope. Examine the specimen under low power, and gradually increase the magnification as necessary.

2. Use the photomicrograph of stained cells below to help you identify the following cell types and structures:
   - epidermal cells
   - palisade tissue cells
   - spongy tissue cells
   - stomata and guard cells
   - vascular tissue cells

3. Prepare a wet mount of epidermis from a *Tradescantia* or *Kalanchoe* leaf. Tear one leaf at an angle perpendicular to the leaf veins.

4. Find a section of the torn leaf edge where a thin layer of the epidermis has been pulled away from the tissue beneath. Using tweezers, place a bit of the epidermis on a clean microscope slide. Using a medicine dropper, put a drop of water on the tissue. Cover the sample with a cover slip.

5. Examine the epidermal tissue under the microscope. Start at low power, and then gradually increase to high power, until the stomata and guard cells are visible.

**What Did You Find Out?**

1. On which part of the leaf did you observe stomata?

2. If you observed both closed and open stomata, describe the difference in appearance of the guard cells in each case.

3. (a) What were the colours and shapes of the cells that you observed?
   
   (b) Explain how the colours and shapes of the cells relate to their functions.

4. (a) What was the arrangement of cells in the leaf?
   
   (b) Explain how the arrangement of cells in the leaf contributes to the efficiency of photosynthesis.
A carnivorous plant plays the leading role in the musical *Little Shop of Horrors*. In this fictional tale, the plant, which resembles a Venus’s-flytrap, has a taste for human blood. As it gobbles up its fellow cast members, it grows from a modest houseplant into a people-eating giant intent on world domination. If such a plant really existed, what kinds of specializations would it have? Describe some of the features its cells and systems would require to be able to stalk and eat prey the size of humans.

**Cell, Tissue, Organ, System**

Being a multicellular organism has many advantages. Compared with single-celled organisms, multicellular organisms can have:

- a larger size
- a variety of specialized cells
- an ability to thrive in a broader range of environments

However, multicellularity also creates a new demand: organization. The human body, for example, contains an estimated 100 trillion cells. For so many cells to function in a co-ordinated way, a high degree of organization is needed.

Within a cell, different functions are performed by specialized organelles. In multicellular organisms, groups of specialized cells are organized so that they can perform their functions efficiently. There are multiple levels of organization in organisms: cells, tissues, organs, and systems (see Figure 9.4). Cells are the most basic level of organization, while systems are the most complex.

**A Cells**
Cells are the most basic unit of organization in organisms.

**B Tissues**
Cells that are similar to each other are often clustered together to form tissues. For example, vascular tissue is formed from bundles of many vascular tissue cells. The epidermal tissue pictured here is made from layered sheets of epidermal cells. The cells making up a particular tissue share the same structure and function.

**C Organs**
Multiple tissues can be arranged in combination to form organs. An example of an organ is your heart, which contains muscle tissue, nerve tissue, and connective tissue. Plant organs include roots, stems, and leaves. The different tissues forming an organ work together to enable the organ to perform a specific function.

**D Systems**
Organs, too, can function together at an even higher level of organization. In a system, organs and tissues throughout the body perform a shared complex function. For example, your teeth, tongue, stomach, and intestines are all part of your digestive system. The vascular system of plants, which carries water to all of the plant’s tissues, makes use of the roots, stem, and leaves.

There are successive levels of organization in multicellular organisms.
Section 9.1 Summary

In a multicellular organism, cells are specialized and work together to meet the needs of the organism. For example, a leaf has epidermal, palisade tissue, spongy tissue, and vascular tissue cells. Epidermal cells make up a thin sheet that protects the leaf's interior. Most photosynthesis takes place in the palisade tissue cells, which are packed with chloroplasts. Much of the leaf is filled with round, loosely packed spongy tissue. Vascular tissues, the xylem and phloem, transport fluids throughout the plant.

Multicellular organisms can grow larger and survive in a wider range of environments than unicellular organisms. However, multicellular organisms must also organize their cells in a co-ordinated way. Cells are organized into tissues, organs, and systems.

Check Your Understanding

1. How are the activities of single-celled organisms similar to the activities of a specialized cell within a multicellular organism?
2. Explain how a plant tissue differs from a plant organ.
3. The epidermal cells of most leaves are transparent. Why is this beneficial to the plant?
4. Describe the roles of the two types of leaf cells that perform photosynthesis.
5. Thinking Critically Some leaf cells specialize in the exchange of water and gases with the environment. Other leaf cells do the opposite and prevent exchange of materials with the environment. Explain why leaves need both types of cells to survive and grow.
6. Apply Consider the following materials: a flowering African violet, a light, and an opaque piece of cloth. How could you demonstrate which plant organ is responsible for photosynthesis in the African violet? Indicate your controls, and the manipulated variable in your procedure.
7. Apply Some people wipe a thin layer of petroleum jelly on the leaves of houseplants to make the leaves shiny. What would be the effects of using petroleum jelly to cover: (a) the entire surface of each leaf; (b) the underside of the leaves; (c) the upper surface of the leaves. Explain your reasoning.