

## Compound Light Microscope

| Part                            | Function   | Handling Hints  |
|---------------------------------|--|---|
| <b>1</b> eyepiece               | contains the lens that magnifies   | Try keeping both of your eyes open.   |
| <b>2</b> coarse adjustment knob | moves the stage up or down to focus on the object to produce a clear, sharp image                    | Use this only when you're using the lowest-power objective lens.  |
| <b>3</b> fine adjustment knob   | brings the object into sharper focus   | Use this with any objective lens, but mainly with the medium-power and high-power objective lenses.   |
| <b>4</b> revolving nosepiece    | holds the three objective lenses   | When you change any objective lenses, you'll feel or hear a "click" when the lens is in the right position.   |
| <b>5</b> objective lenses       | provide different strengths (power) of magnification   | Avoid getting fingerprints or dirt on the lenses. They should be cleaned with proper lens-cleaning paper only.  |
| <b>6</b> stage                  | supports the slide that holds the object you want to view  | Keep the stage dry.   |
| <b>7</b> stage clips            | hold the slide firmly on the stage   |   |
| <b>8</b> diaphragm              | has different-sized holes that let different amounts of light pass through the object you're viewing |   |
| <b>9</b> lamp                   | supplies the light that passes through the object you're viewing                                     | If your microscope uses a mirror instead of a lamp, be careful <u>not</u> to reflect direct sunlight into the microscope. You could damage your eyes. |
| <b>10</b> arm                   | allows you to carry the microscope securely  | When you carry your microscope from one place to another, hold the arm with one hand. Support the microscope with your other hand under the base.     |
| <b>11</b> base                  | serves as a foundation for the rest of the microscope  | When you carry your microscope from one place to another, support it with one hand under the base. Use your other hand to hold the arm.               |

**TRYING OUT A MICROSCOPE**

Now it's your turn to try out a microscope. For information on using a microscope, refer to Toolbox 11.

- Select a slide and place it on the microscope stage. Make sure that the lens is switched to the lowest power.
- Look through the microscope and focus the image using the coarse adjustment knob.
- When it's in focus, make a sketch of what you see.

**reSEARCH****How Big Is It?**

When you view something through a microscope, you can determine the actual size of the image. Ask your teacher how this is done.

**PEEKING INSIDE**

Microscopes come in many shapes and sizes. Fibre optics is a technology that allows light to travel down a flexible tube. Medical researchers have used fibre optics to create microscopes that can be used inside and outside the body. Some have parts that are tiny enough to be passed through a person's arteries. Other devices are used to help surgeons operate.



**Figure 2.5** The image you see on the screen is actually the patient's eye!

**CHECK AND REFLECT**

- Which of the following could you see without a microscope? Why would you need one to see the others?
    - a liver cell (about 0.02 mm)
    - the head of a pin (about 1 mm)
    - a red blood cell (about 0.007 mm)
  - Did any of these sizes surprise you? Which one, and why?
- In your notebook, make a labelled sketch of a microscope. Briefly explain how you would use a microscope to look at a slide.
- When using a microscope, why should you start with the lens in the lowest position and then move up? What would happen if you didn't?

## 2.2 The Cell Is the Basic Unit of Life

**Cells** are the smallest known functioning units of life. All organisms must be made of at least one cell. In most organisms, cells rarely work alone: cells with a similar structure and function are organized into **tissues**. Tissues that work together for a common purpose form **organs**, and an **organ system** is a group of organs that work together for a common purpose in order to keep you alive.

### LOOKING AT CELLS

When you look at cells using a microscope, even at low power you will probably see more than one cell. So it helps to be able to identify where one cell stops and another starts.

### CELL STRUCTURES YOU CAN USUALLY SEE WITH A CLASSROOM LIGHT MICROSCOPE

Many things can affect your ability to see details of the internal parts of cells. These factors include:

- the type of microscope
- the power of the lenses
- the quality of the prepared slides

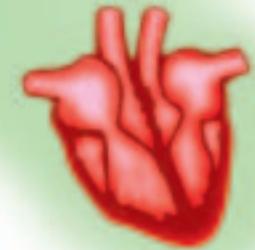
You are likely to find all of the cell structures listed in the table below if you look at slides of plant material as well as animal material. Not all of these structures will be found in any one cell.

| Cell Structure | Feature That Can Help You Identify It  |
|----------------|--|
| cell membrane  | looks like a thin line that surrounds the whole cell                                 |
| cell wall      | a rigid, frame-like covering that surrounds the cell membrane                        |
| cytoplasm      | a liquid inside the cell, which has grainy-looking bits in it                        |
| nucleus        | a fairly large, dark, spherical structure that's usually near the centre of the cell |
| vacuoles       | clear, liquid-filled spaces in various places within the cytoplasm                   |

**cell** = an individual unit of life

**tissue** = a group of specialized cells

**organ** = a group of tissues that perform a special function



**Figure 2.6** How cells, tissues, and organs are related

## COMPARING PLANT AND ANIMAL CELLS

### The Question

How are cells from different living things alike and how are they different?

### Procedure

#### Materials & Equipment

- compound microscope
- one or more prepared slides of plant cells (for example, cells from a lily leaf or hibiscus stem)
- one or more prepared slides of animal cells (for example, skin cells)

- 1 Set up your microscope.
- 2 Get a prepared slide of plant cells, and put the slide on the stage. Position it so that your specimen is above the hole in the stage. Use the stage clips to hold the slide firmly in place.
- 3 When your glass slide is in place, look at the stage from the side. Make sure the low-power objective lens is above the slide.



**Figure 2.7**  
Using the coarse  
adjustment knob



**Figure 2.8** Using the fine  
adjustment knob

- 4 Use the coarse adjustment knob shown in Figure 2.7 to bring the low-power objective lens as close as you can to the slide without touching it.
- 5 Look through the eyepiece. Use the coarse adjustment knob to bring your specimen into focus.
- 6 Use the fine adjustment knob, shown in Figure 2.8, to get a clear, sharp image.
- 7 Keep looking through the eyepiece. Gently move the glass slide in different directions—a bit to the left, to the right, up, down. See what effect this has on the image.
- 8 Move the specimen back to the centre of your view. Refocus using the coarse adjustment knob. Turn the revolving nosepiece to switch to the medium-power objective lens. (A “click” will tell you the lens is in place.) Focus the image with the fine adjustment knob.

- 9 Move the specimen to the centre. Refocus with the fine adjustment knob. Switch to the high-power objective lens.
- 10 Use the fine adjustment knob to focus the image.
- 11 Take your time to get familiar with what you can see at low, medium, and high power. In each case:
  - a) Count or estimate the number of cells you observe in the field of view. The **field of view** is the entire area you can see when you look through the microscope.
  - b) Notice the shapes of cells and how they're arranged.
  - c) In your notebook, draw the view you see.
- 12 Remove the slide. Replace it with a prepared slide of animal cells. Again, observe at low, medium, and high power. Repeat step 11.

### Collecting Data

- 13 Look over all your cell drawings. Choose one plant cell and one animal cell. Then use the information about typical cell structures in the text to help you label your drawings.

### Analyzing and Interpreting

- 14 What do you think are the differences between plant and animal cells? Give examples from what you observed.
- 15 What are the similarities you can identify between plant and animal cells?

### Forming Conclusions

- 16 Write a summary paragraph that answers the question: "How are cells from different living things alike and how are they different?" Include diagrams in your explanation.

### Applying and Connecting

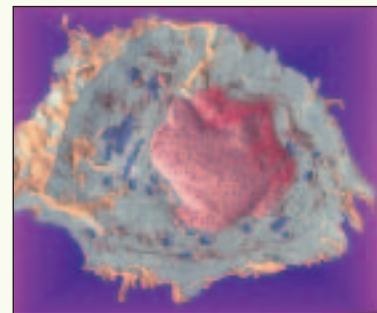
In this activity, you looked at slides that were prepared by taking extremely thin slices of samples. When you look at them through the microscope, you are seeing two-dimensional views of the samples. Another method of preparing samples is called freeze-etching, which gives three-dimensional views of the parts of cells, as seen in Figure 2.9.

#### Caution!

Whenever you use the medium-power and the high-power objective lenses, focus your image using only the fine adjustment knob.

#### Hint!

When your specimen is in focus, try keeping both eyes open. If you concentrate on what you're looking at, all you'll see is your specimen. This method lets you relax your face muscles so you feel more comfortable. As a result, you can observe much longer.



**Figure 2.9** Freeze-etching shows parts of this cell in three dimensions.

## PREPARING SLIDES

So far, you have looked at slides that have been prepared for you. In order to learn more about organisms, scientists have to be able to view living specimens. To do this, they must prepare their own slides. This is how it's done.

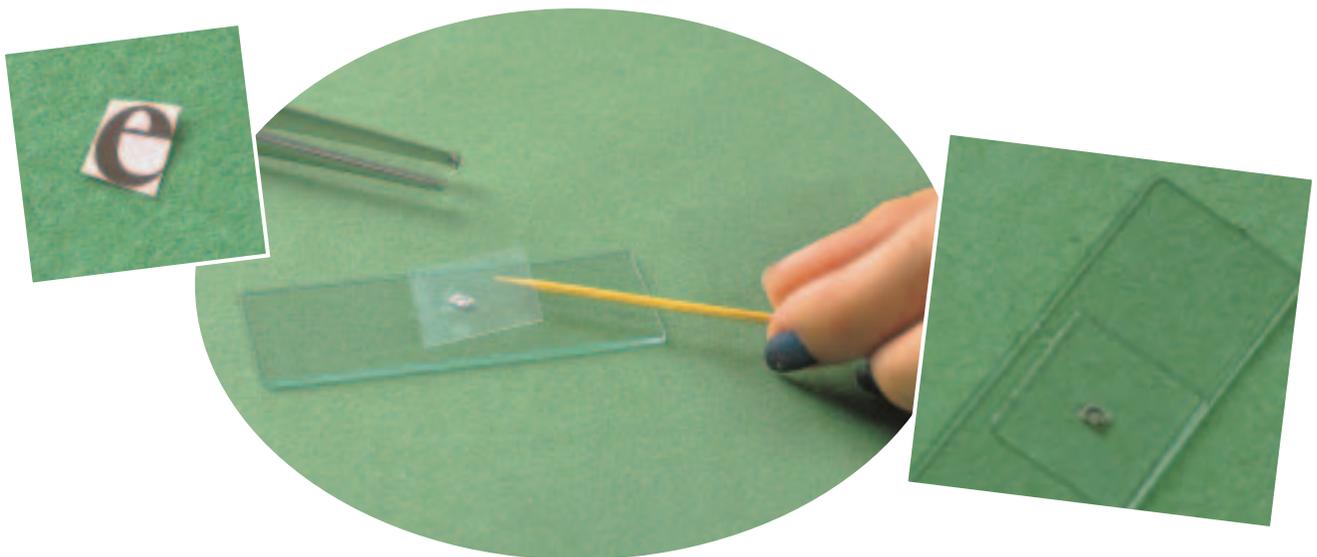
**Figure 2.10** A finished wet mount being positioned on the microscope stage



### Preparing a Wet Mount

Follow these steps to make a wet mount of a lowercase letter “e.”

1. Gather the following: a clean glass slide and cover slip, an eyedropper, tweezers (or a toothpick), a small cup of water, and your specimen—a letter “e” taken from a newspaper page.
2. Pick up the glass slide by the edges and place it in front of you.
3. Using an eyedropper, place one drop of water in the centre of the slide. Then use tweezers or a toothpick to lay your specimen—right side up—on the drop of water.
4. Pick up the cover slip the same way you picked up the glass slide. Slowly lower it over your specimen as shown in Figure 2.11. Try not to trap air bubbles under the cover slip.



**Figure 2.11** Placing a cover slip on a specimen

## Preparing and Viewing a Cell Specimen

If you've ever looked closely at an onion, you may have noticed a thin, semi-transparent skin between the thicker layers. This skin is only one cell thick in most places, which makes it ideal for observing cells.

1. Remove this layer from a section of onion as shown in Figure 2.12 and carefully pick it up using tweezers or a toothpick. Hold the slide at a 45° angle and drape the specimen onto the middle of the slide. Try to avoid trapping air bubbles between the specimen and the slide.
2. Continue to prepare the wet mount as you did above.



**Figure 2.12** Peeling off a thin layer of an onion section

### Give it a TRY

### ACTIVITY

#### TESTING YOUR WET MOUNT

Prepare a wet mount of an “e” following the directions on the previous page. Pick up your wet mount slide by the edges and place it on the microscope stage. Before you view anything, make the following predictions. Then, make sketches to record your predictions.

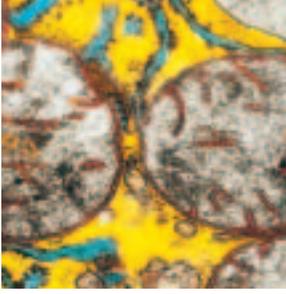
- How will your specimen appear when you observe it with low power?
- How will it change when you move the slide to the left? to the right? up? down?
- How will it change when you view it with medium power? with high power?

View your slide under the microscope to test your predictions. Record your observations in your notebook.

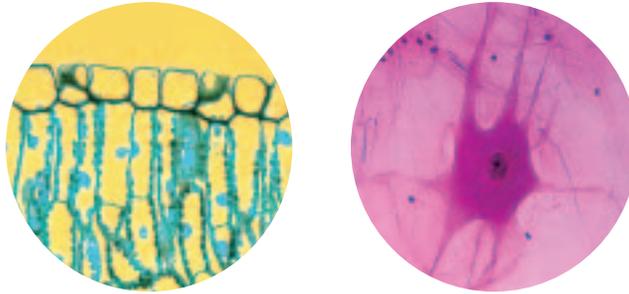
Now, prepare a specimen of onion skin following the directions above. View your specimen under the microscope. Make a sketch of your observations.



## VIEWING PLANT AND ANIMAL CELLS



**Figure 2.13** Part of a liver cell magnified 11 300× using an electron microscope. The circles are mitochondria.



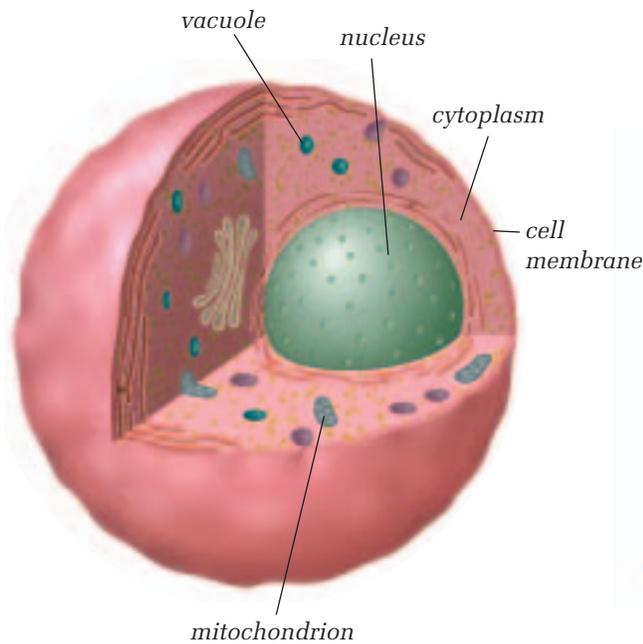
**Figure 2.14** Plant and animal cells viewed through a light microscope. Which is which?

## THE VITAL ROLES THAT CELL STRUCTURES PLAY

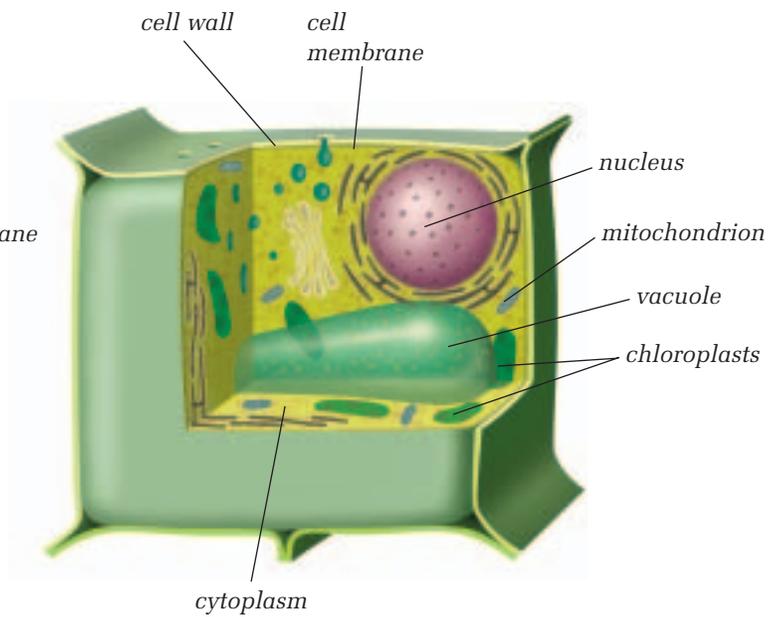
Within each cell there are a number of specialized structures called **organelles** that carry out specific functions. One way to think about cells' organization is to think of them as living factories, making all the things necessary for them to live. These factories have the following specialized areas.

| Structure            | Function   |
|----------------------|--|
| <b>nucleus</b>       | a “command centre” that directs all cellular activities such as movement, growth, and other life functions   |
| <b>mitochondria</b>  | the “powerhouses” of the cell where chemical reactions occur that convert the energy the cell receives into a form it can use  |
| <b>cell membrane</b> | a “controllable gateway” that lets needed materials in and waste materials out   |
| <b>vacuoles</b>      | the “storage rooms” where nutrients, water, or other substances can be stored by the cell. Plant cells tend to have just one big vacuole, and animal cells have many small vacuoles. |
| <b>cytoplasm</b>     | the “kitchen” of the cell. It contains the nutrients required by the cell to maintain its life processes.  |
| <b>cell wall</b>     | the “frame” of the cell. Found in plant cells but not in animal cells, it provides strength and support to plants.   |
| <b>chloroplasts</b>  | the “solar panels” of the cell. They are found in the cells of the green parts of plants. They carry out photosynthesis, converting the sun’s energy into food for the cell.         |

Most cells have these special structures. Because of this, scientists have constructed cell models like the ones shown in Figures 2.15–2.16. How does the function of each cell structure contribute to the overall health of the cell?



**Figure 2.15** Model of an animal cell



**Figure 2.16** Model of a plant cell

## CHECK AND REFLECT

- Design a chart to record the following information:
  - cell structures that you can see with a compound light microscope
  - the functions of these cell structures
  - whether these structures appear in animal cells, plant cells, or both
- Scientists build generalized cell models based on organisms made of many cells. Do you think there's such a thing as a generalized single-celled organism? Make a sketch to record your ideas of what one might look like. Include labels to describe the functions of all the structures you include.
- How would the health of a cell be affected if one or more of its organelles were damaged? Give reasons to support your opinion.

## RESEARCH

### More Organelles

You have observed cell structures using a compound light microscope. Using the higher power of an electron microscope, scientists have discovered many more cell structures. Use print or electronic resources to find out about the following cell structures and their functions:

- endoplasmic reticulum
- Golgi bodies
- lysosomes
- ribosomes



Figure 2.18 Blue whale



Figure 2.17  
Mycoplasma

## 2.3 Organisms Can Be Single-Celled or Multicelled

Figure 2.17 shows the smallest kind of organism scientists have discovered so far. It belongs to a group of organisms known as **mycoplasma**. These are so small that they had to be magnified over 18 000× to make this photo.

The organism in Figure 2.18 is the world's largest kind of animal, the blue whale. The whale is about 30 m in length. It's hard to believe that blue whales and mycoplasma have much in common. But they do. They have something in common with you, too, and with every other organism. They are made up of cells.

Cells are the individual, living units that make up all living organisms. Some organisms are **multicellular**. This means that they are made up of two or more cells. Plants and animals are examples of multicellular (many-celled) organisms.

Other organisms are **unicellular**. They are made up of only a single cell. Most microscopic organisms, or **micro-organisms**, such as mycoplasma, are examples of unicellular (single-celled) organisms.

## UNICELLULAR VS. MULTICELLULAR

The little glass pill-boxes in Figure 2.19 are alive! They are called diatoms, and they are single-celled plants. They have chloroplasts just like the plants you see every day. They live in lakes, oceans, and moist soil, and are an important part of the food chain.

Although there is a tendency to consider unicellular organisms as simple because they lack the tissues and organs of more advanced creatures—they are not. A single-celled organism can do most things that we need trillions of cells to do: eat, move, react to stimuli, get rid of waste products, and reproduce. Unicellular organisms often develop specialized structures to help them perform these functions.

Instead of relying on a single cell to meet all of their needs, multicellular organisms rely on many very specialized cells to perform functions such as feeding, moving, and so on. As a result, all the cells within multicelled organisms react to one another (or interact). For example, in a multicelled animal such as a deer, there are cells specialized for the function of feeding. However, these cells are dependent on other specialized cells, such as muscle cells, to move the deer to new supplies of food.

Whether single-celled or multicelled, all plants and animals have most of the organelles you studied in the cell models.



Figure 2.19 Diatoms

## infoBIT

### Colossal Cell

One of the world's largest unicellular organisms is so big that you can see it with the unaided eye. It's called *acetabularia*, and it's a member of the plant-like algae family. *Acetabularia* measures from 5 cm to 7 cm!



## reSEARCH

### The World's First Microscope

The person who first observed unicellular organisms was a Dutch amateur scientist named Antony van Leeuwenhoek [pronounced LAY-ven-hook].

Find out about Leeuwenhoek and his microscopic investigations.

- What kinds of organisms did he discover?
- How did he communicate his findings?



## OBSERVING UNICELLULAR ORGANISMS

### Materials & Equipment

- microscope
- glass slide
- cover slip
- eyedropper
- live, unicellular organisms (supplied by your teacher)
- small jar to carry the organisms to your viewing area
- methyl cellulose

### Caution!

Be careful when handling microscopic organisms. Wash your hands thoroughly when you have finished this activity.

### The Question

What cell structures can be seen using a simple light microscope?

### Procedure

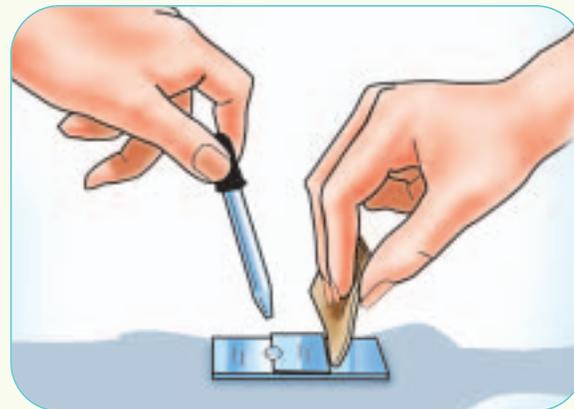
- 1 Prepare a wet mount of the live organisms. Set up your slide on the microscope stage and position the low-power objective lens over your specimen. Observe your organisms.

*Tip:* Some organisms are fast! Take your time and concentrate on getting familiar with what you're observing, and on keeping your specimen in focus. After a little while, switch to medium power and observe. If you wish, try high power. Was this an improvement? Why or why not?

- 2 Observe your specimens. Record any features and actions you find interesting. With a partner, brainstorm some questions you would like answered about your specimens.



**Figure 2.20** A common unicellular organism



**Figure 2.21** Use a piece of paper towel to “pull” the methyl cellulose under the cover slip.

- 3 *To slow down fast-moving specimens:* If you are viewing fast-moving organisms such as paramecia, slow them down by adding a tiny amount—less than a drop—of methyl cellulose. This is a syrupy liquid that thickens the water so it is harder for the paramecia to move rapidly. Figure 2.21 shows how to add methyl cellulose to your wet mount.

- 4 Observe your slowed-down specimen. Follow the instructions in step 5 for recording your observations.

### Collecting Data

- 5 Make an accurate drawing of one organism. Try to draw what you really see, not what you think or imagine might be there. Include labels to identify or describe the following details:
  - shape
  - colour
  - size (how much of your field of view it occupies)
  - all the cell structures and organelles that you recognize
  - any cell structures and organelles that you don't recognize
  - the power of the objective lens you're using

### Analyzing and Interpreting

- 6 Describe how your organisms move. Use an analogy to help you describe their movement.
- 7
  - a) If you observed paramecia, how did the methyl cellulose slow the paramecia's movements?
  - b) Suppose you didn't have any methyl cellulose available. Suggest another method you could use to slow the paramecia without harming them. Explain why you think it will work.

### Forming Conclusions

- 8 Write a short story or draw a cartoon strip about a day in the life of your organism. Use your observations to help you include informative details such as how it moves, where it goes, what you think it eats, and what might eat it! Include as many cell structures and organelles as you can to support the details you include.

### Applying and Connecting

Imagine Antony van Leeuwenhoek or the other microscope pioneers examining their drinking water and seeing unicellular organisms like those you have just observed. What do you think their reaction would be? What would yours be? While many micro-organisms are harmless, some cause disease. Do you know what steps have been taken to ensure your drinking water is safe from micro-organism contamination? Find out, if you don't know.

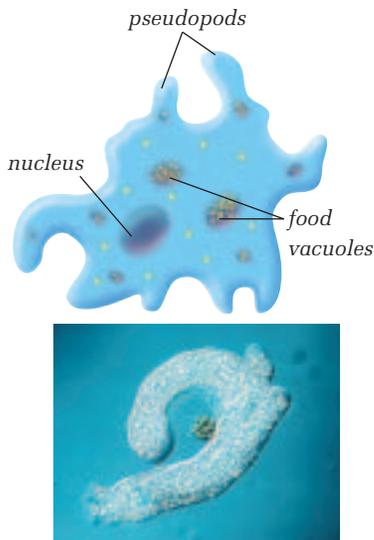


**Figure 2.22** Antony van Leeuwenhoek

## COMMON UNICELLULAR ORGANISMS

### Amoeba

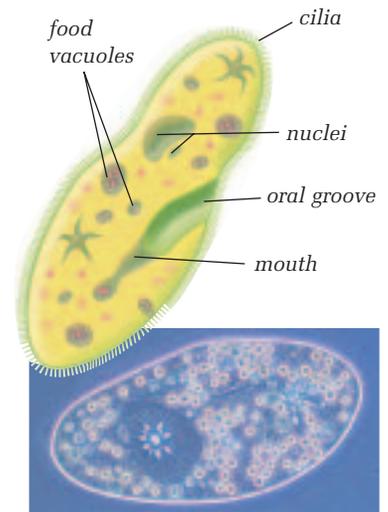
Amoebas are common unicellular organisms that live in water. They move around using foot-like projections called **pseudopods**. They extend a pseudopod and the cytoplasm streams into it. Amoebas also use these pseudopods to capture food. Figure 2.23 shows an amoeba engulfing food between two pseudopods. The ends of the pseudopods fuse together and create a vacuole around the food particle. The food in the vacuole is digested and absorbed into the cytoplasm.



**Figure 2.23** An amoeba keeps changing shape as it creates new pseudopods. Here, an amoeba extends pseudopods around a food particle.

### Paramecium

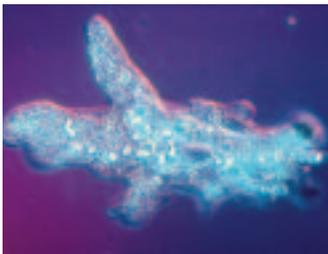
Unlike amoebas, paramecia (plural form of paramecium) move swiftly through the fresh water where they live. They are covered in hair-like structures called **cilia**, which move back and forth like oars to move them through the water. Cilia also help them gather food. On one side of the cell is a channel called an oral groove. It's lined with cilia, which sweep food to the bottom of the groove. There, the food enters a food vacuole, which moves into the cytoplasm, and the food inside is digested.



**Figure 2.24** In the picture, the tiny circles with dark centres are food vacuoles. Can you see the cilia?

## CHECK AND REFLECT

1. Unicellular organisms are simple. Agree or disagree with this statement and fully explain your answer.
2. Why can't the individual cells of a multicellular organism live on their own? Explain your answer.
3. Describe the steps you would follow to prepare amoeba specimens for observation.
4. Identify an amoeba's food-gathering structures and describe how they function.
5. Make up three questions about the behaviours of paramecia. Pick one of your questions and write a hypothesis that answers the question. (Remember: A hypothesis is a possible answer to a question. You usually phrase it so that it implies a way you could test it.)



## 2.4 How Substances Move Into and Out of Cells

Right now, every cell in your body is bringing in water, gases, and food inside itself. At the same time, each is removing waste products from inside itself. This bringing in and removal of substances is important to your survival. But it isn't unique to humans. These processes are also happening in the cells of every organism. The cell has a structure that permits this vital exchange of substances. It is the cell membrane. Many substances move through the cell membrane by a process called **diffusion**.

### Give it a TRY

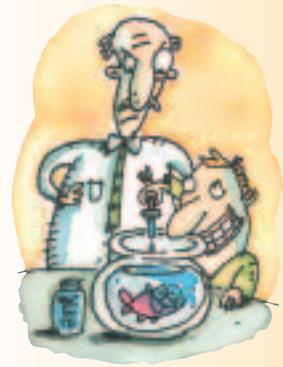
### A C T I V I T Y

#### DIFFUSION IN ACTION

In this activity, you will observe the process of diffusion in action. Place a drop of food colouring into a beaker of room-temperature water. Make sketches in your notebook to show what the drop looks like

- as soon as it is dropped in the water
- about 20 s later
- about 60 s later
- about 10 min later

What happened to the drop of food colouring over time? How did it look after 10 min? Can you think of a sentence to explain diffusion?



### THE CELL MEMBRANE AND DIFFUSION

Diffusion is the movement of particles from an area where there are more of them to an area where there are fewer of them. In other words, diffusion moves particles from a more concentrated area to a less concentrated area. It's a "balancing out" or "evening out" process that continues until the concentration of particles is the same everywhere.

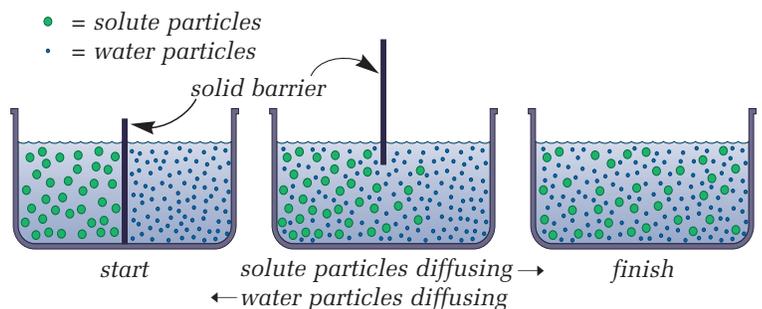


Figure 2.25 The process of diffusion



**Figure 2.26** The tiny openings in this tea bag are large enough to allow water to pass through, along with the substances that make the flavour of the tea, but they are small enough to keep in the tea leaves themselves. How is a tea bag similar to a cell? How is it different?

### infoBIT

#### Vultures Find the Spot

Engineers once used diffusion to find a leak in a gas pipeline. They put a chemical that smells like rotting flesh into the pipeline, and then watched and waited. Turkey vultures can smell even tiny amounts of this gas. The circling vultures led the engineers to the location of the leak in the pipeline.

Particles of many substances move in and out of cells by diffusion. The cell membrane acts like a filter with extremely tiny openings that allow some particles to pass through.

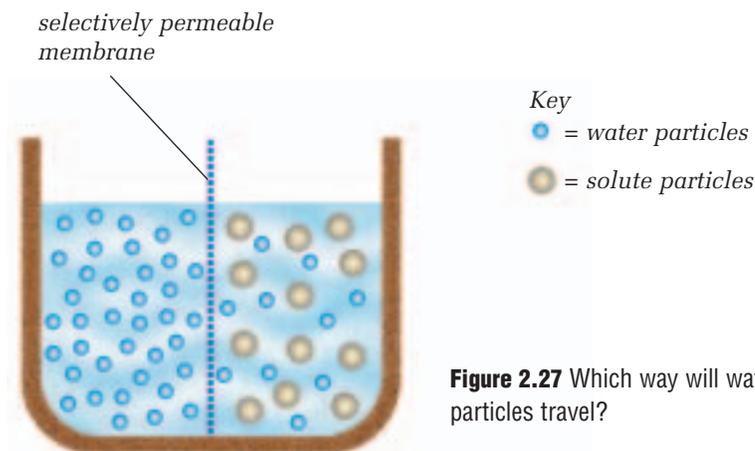
These openings are small enough to keep the cell's cytoplasm and organelles inside. They are also small enough to keep particles of most substances in the cell's external environment out. However, particles of some substances are able to pass from the outside in and from the inside out. So the cell membrane allows the particles of some substances to pass through it, but not others. Because of this fact, scientists say that the cell membrane is **selectively permeable**.

To do their jobs, mitochondria in cells need oxygen. Oxygen particles are small enough to pass through the cell's selectively permeable membrane into the cell. This movement of oxygen happens by diffusion. That's because the concentration of oxygen is usually higher outside the cell membrane than it is inside. As a result, oxygen simply diffuses into the cell. The cell doesn't have to do anything to make it happen.

## THE CELL MEMBRANE AND OSMOSIS

Water is another substance that has particles small enough to diffuse through the cell membrane. The amount of water inside a cell must stay fairly constant. If the water concentration inside the cell gets too low, water from outside the cell diffuses in. If the concentration gets too high, water diffuses out of the cell.

The diffusion of water is vital to the survival and health of cells. For this reason, scientists give it a special name: osmosis. **Osmosis**, then, is the diffusion of water particles through a selectively permeable membrane. The water particles move from an area of higher concentration (where there are more water particles) to an area of lower concentration (where there are fewer water particles).



**Figure 2.27** Which way will water particles travel?

## EFFECTS OF DIFFERENT SOLUTIONS ON CELLS

### Materials & Equipment

- thin slice of onion
- compound microscope
- glass slide
- cover slip
- saltwater solution
- eyedropper
- paper towelling
- distilled (pure) water

### The Question

How will a saltwater solution and pure water affect the appearance of a cell?

### The Hypothesis

Form a hypothesis for this investigation describing the effect a saltwater solution will have on an onion cell. (See Toolbox 2 if you need help with this.)

### Procedure

- 1 Prepare a wet mount of a small piece of onion skin. Lay the skin as flat as possible on the slide.
- 2 Position the slide under the microscope and make a drawing of one or two of the cells you observe. Remove the slide from the microscope.
- 3 Place several drops of saltwater solution on one side of the cover slip. Use a piece of paper towel to “pull” the saltwater solution under the cover slip (as shown in Figure 2.21 on page 112). Wait 30 to 60 s.
- 4 Position the slide under the microscope and make another drawing of one or two of the cells you observe. Remove the slide from the microscope.
- 5 Repeat steps 3 and 4, but this time use distilled water on your specimen.



Figure 2.28 Onion cells

### Collecting Data

- 6 Assemble the three drawings you made in steps 2 to 5.

### Analyzing and Interpreting

- 7 How did the saltwater solution and the pure water affect the appearance of onion cells?

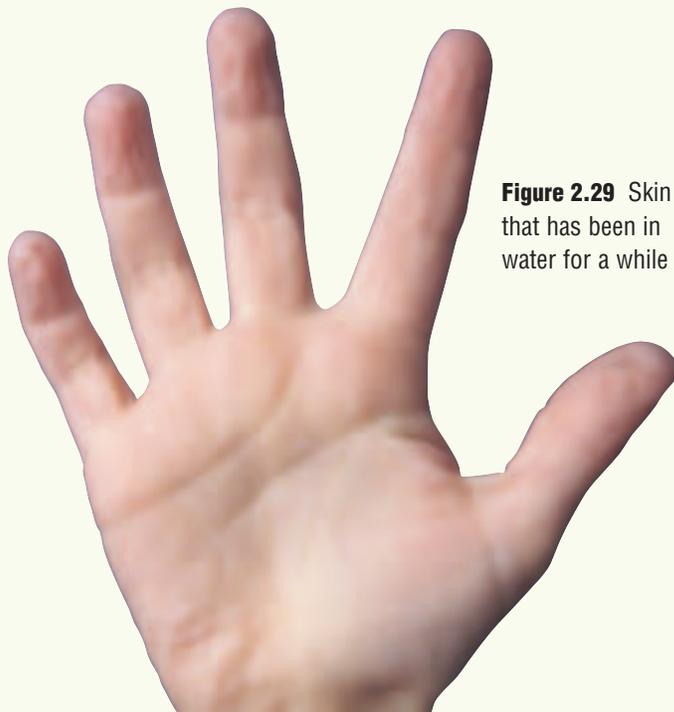


Figure 2.29 Skin that has been in water for a while

### Forming Conclusions

- 8 Explain what happened in this activity.

### Applying and Connecting

Have you ever noticed that when you've been in the water for a long time, your skin wrinkles, as in Figure 2.29? Why do you think this happens?

# Experiment

ON YOUR OWN

## HOW TO STOP THE WILT

### Before You Start ...

Have you ever given or received flowers from someone? How did they look at first? How did they change over time? Why did this happen?

Selling fresh, vibrant cut flowers, as in Figure 2.30, is big business. Flower shops use a variety of methods to keep plants fresh looking for as long as possible. What's the science behind these methods? Use your understanding of plant cells and tissues to help you solve the following problem.

### The Question

Which substance, technique, or both, will keep flowers from wilting for as long as possible?

### Design and Conduct Your Experiment

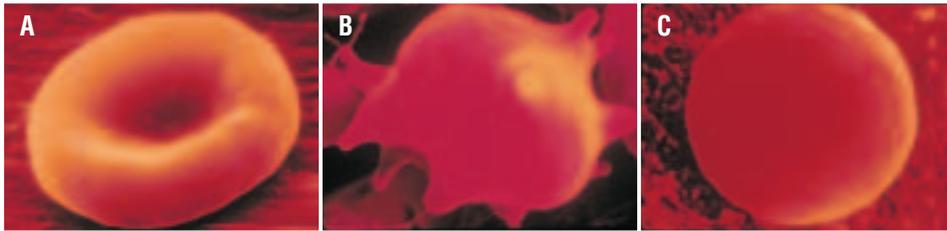
- 1 Make a hypothesis.
- 2 Decide what materials and equipment you'll need to test your hypothesis. For example:
  - a) What kind of plant will you use, and how many will you need?
  - b) What substances do you need to test your hypothesis?
  - c) Where can you find what you need, and what substitutions could you make, if necessary?
  - d) How will you troubleshoot for safety?
- 3 Plan your procedure. For example:
  - a) What evidence are you looking for to support your hypothesis?
  - b) How long will you run your experiment?
  - c) How will you collect your data?
  - d) What variables are you working with, and how would you define them?
  - e) How can you make sure that your test is fair?
  - f) How will you record your results?
- 4 Write up your procedure and show it to your teacher.
- 5 Carry out your experiment.
- 6 Compare your results with your hypothesis. Did your results support your hypothesis? If not, what possible reasons might there be?
- 7 How did you keep water moving through the plant's roots, stems, and leaves? Can you explain your results in terms of water moving through the plant?
- 8 Share and compare your experimental design and findings with your classmates. How do your results compare with theirs?



**Figure 2.30** Fresh cut flowers

## THE EFFECT OF OSMOSIS ON CELLS

In Figure 2.31, photo A shows a normal red blood cell. It has been in a solution in which the concentration of water was the same inside and outside the cell. In photo B, the cell was in a saltwater solution. The concentration of water was higher inside the cell than outside, so the water moved out of the cell by osmosis. This cell now has a shrunken appearance. In photo C, the cell was placed in almost pure water. The inside of the cell contains far less water than the outside of the cell, so the water moves into the cell by osmosis, causing the cell to swell.



**Figure 2.31** Cells can be affected greatly by osmosis.

## RESEARCH

### Reverse Osmosis

A process called reverse osmosis can be used to purify water. It is often used on ships to purify drinking water. Find out how it works.

## CHECK AND REFLECT

- Use the term *selectively permeable* in a sentence that clearly demonstrates its meaning.
  - What is the function of a cell's selectively permeable membrane?
  - How does this function contribute to the health of the cell?
- The terms *diffusion* and *osmosis* seem to have similar meanings. Explain how they are similar. Then give a reason why scientists use two separate terms.
- Martin volunteered to carry drinks to the class hosting a surprise party for a retiring teacher. He isn't sure which classroom is the right one, but he does know the students plan to serve pizza and popcorn. Explain how Martin could use the smell of popcorn and pizza as a clue.
- Alex accidentally left a bag of carrots in the warm car. When he found them, they had wilted and were soft. He decides to place them in a container of water and check on them every half-hour or so for several hours. Predict what will happen to the carrots and why.
- Fish species that live in fresh water have to remove excess water as waste from their bodies. Fish species that live in salt water have bodies that keep as much water as possible. Using what you know about osmosis, explain these observations.

## 2.5 Cells in Multicellular Organisms Combine to Form Tissues and Organs

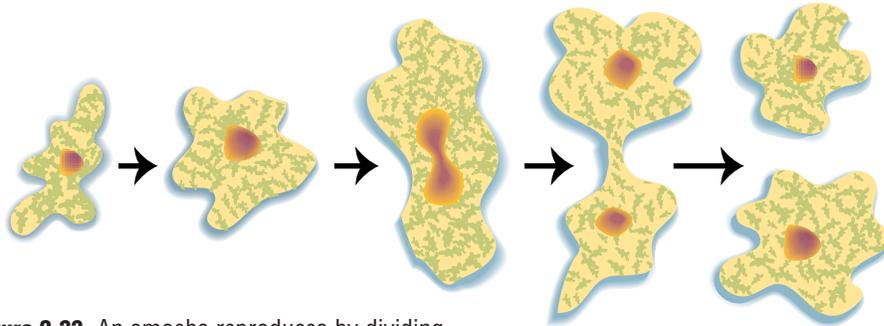


**Figure 2.32** Have you wondered why unicellular organisms are so small? Does it surprise you that there aren't any single-celled creatures the size of a dog or elephant?

Unicellular organisms are tiny because there are limits to how large they can grow. One of the reasons involves diffusion and osmosis. These vital processes work well only over very short distances. For example, it takes an oxygen particle a fraction of a second to diffuse over a distance of  $10\ \mu\text{m}$  ( $0.01\ \text{mm}$ ). To diffuse over a distance of  $1\ \text{mm}$  takes several minutes! Do you see how unicellular organisms benefit by being microscopic?

## CELLS REPRODUCE

Like all organisms, unicellular organisms grow and develop. When they reach the limits of their size, like the amoeba shown here, they reproduce. Amoeba do this by dividing into two, which results in two smaller, identical copies of each organism.



**Figure 2.33** An amoeba reproduces by dividing.

Your cells reproduce this way, too. That's how, for example, your body replaces the 50 000 000 or so skin cells that it naturally loses each day! Your body cells also reproduce to repair tissues that get damaged. For example, if you scrape your elbow, your skin cells reproduce to form new skin tissue.

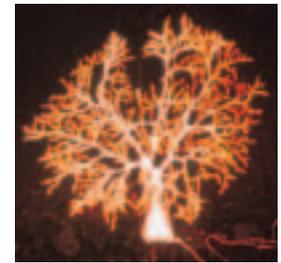
## MULTICELLULAR ORGANISMS HAVE SPECIALIZED CELLS

Your skin cell can do this because it's specialized for this function. You and most other multicellular organisms are made up of **specialized cells**. This means that there are various kinds of cells, and each kind carries out a specific function or functions needed to support life. Each kind of cell has specific structures that enable it to carry out its function. For example, the function of your **red blood cells** is to carry oxygen to all cells of your body. To do this, the red blood cells often must travel through extremely small blood vessels. Their thin, pliable disc shape enables them to do this.

Red blood cells do not reproduce in the same way as skin cells. When red blood cells mature into the shape shown here, they lose their nucleus. Since the nucleus controls cell division (among other functions), red blood cells can't reproduce by simply dividing to make more of themselves. The only way your body can make more red blood cells is by relying on specialized tissues in another body system. Most bones of the skeletal system contain a type of connective tissue called **marrow**, with specialized cells that make red blood cells.

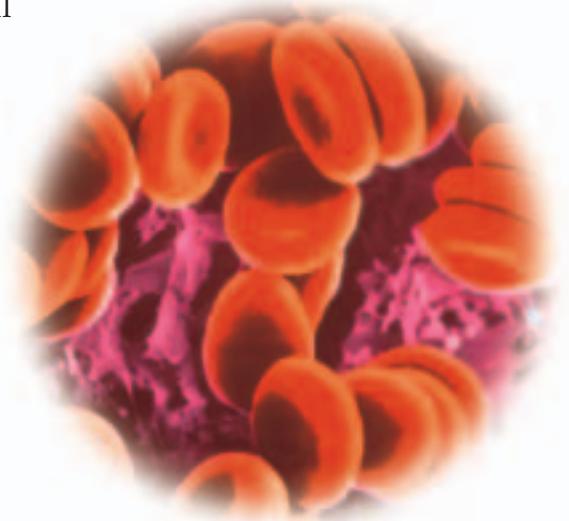
## infoBIT

### The Body's Nerve Centre



This strange-looking tree is actually a nerve cell. It's called a *purkinje cell*, and it is a very specialized cell from a part of your brain called the cerebellum. Your brain and nervous system are made of billions of nerve cells. These cells are what let you think, touch, taste, move, and see.

**Figure 2.34** Red blood cells

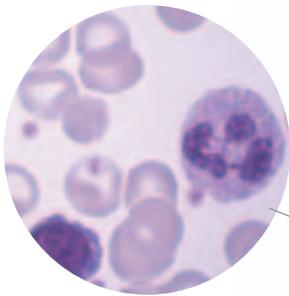


Specialization means that the cells of a multicellular organism must work together to support their own lives, as well as the life of the whole individual. For example, the cells that make up the tissue of your liver rely on other organ systems to provide them with oxygen and nutrients by diffusion.

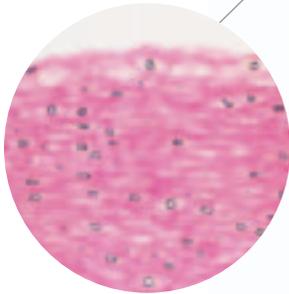
## SIMILAR CELLS COMBINE TO FORM TISSUE

In humans, as well as in many other animals, the cells are organized into four different tissue types: connective, epithelial, nervous, and muscle tissues.

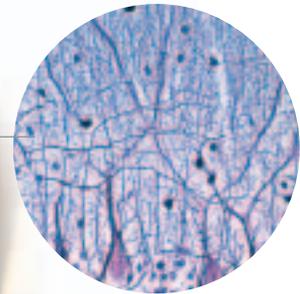
As you may recall, organs are made of tissues. Almost all of your organs are made up of different combinations of these four types of tissue.



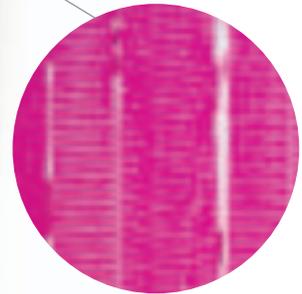
**Connective tissue** supports and connects different parts of the body. Blood is a connective tissue and so are fat, cartilage, bones, and tendons.



**Epithelial tissue** covers the surface of your body and the outside of your organs. It also lines the inside of some of your organs such as the intestine.



**Nervous tissue** makes up the brain, spinal cord, and nerves.



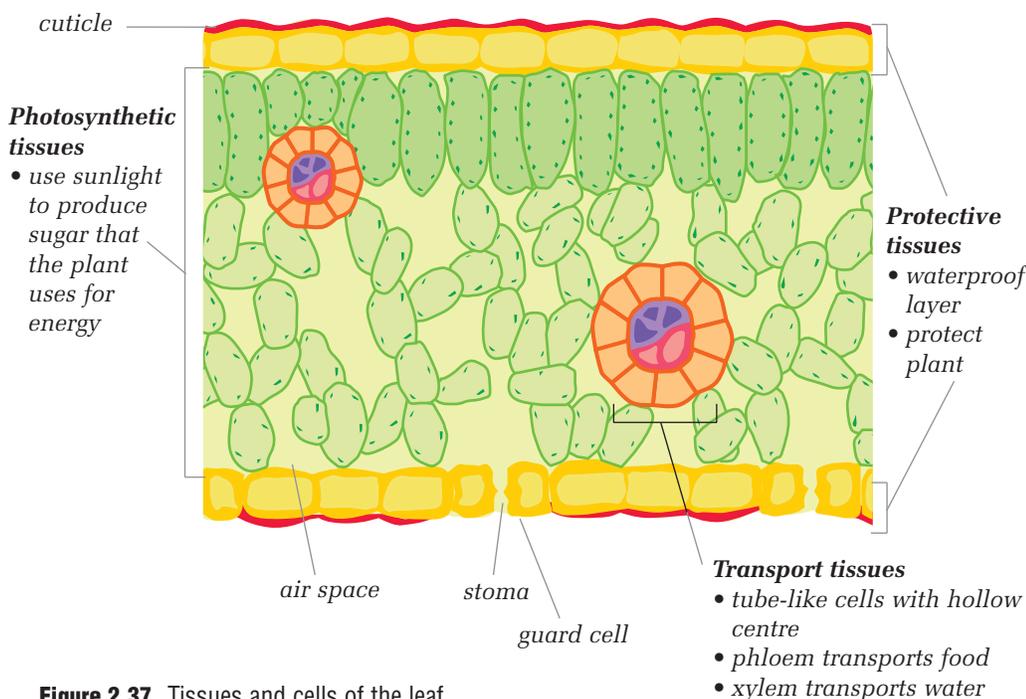
**Muscle tissue** allows you to move. One type of muscle allows you to move your body. Cardiac muscle tissue pumps blood through your heart, and smooth muscle moves food along your intestine.

**Figure 2.35** Your body contains four types of tissue.

## TISSUES IN PLANTS

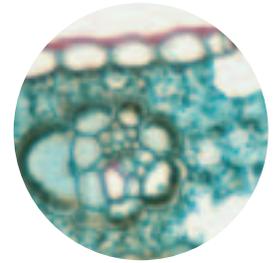
Plant cells are also organized into tissues, but plants have three tissue types: photosynthetic/storage, protective, and transport. These tissues are organized into the three organs that make up plants: the leaves, the roots, and the stems. Unlike animals, though, the organs of a plant are not organized into organ systems. However, the organs of a plant still interact—one organ, such as the leaf, cannot live without the substances provided by the other two organs.

As you look at Figures 2.37, 2.38, and 2.39, observe how each of the tissues are organized in each of the organs.

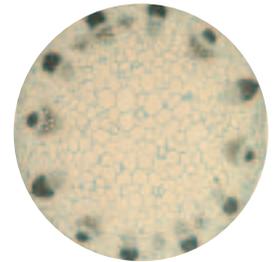


**Figure 2.37** Tissues and cells of the leaf

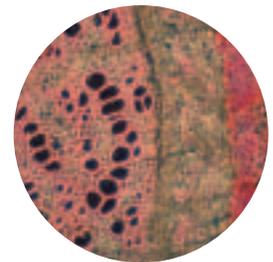
**Figure 2.36** Cross-sections of a leaf, stem, and root seen through a microscope



leaf



stem



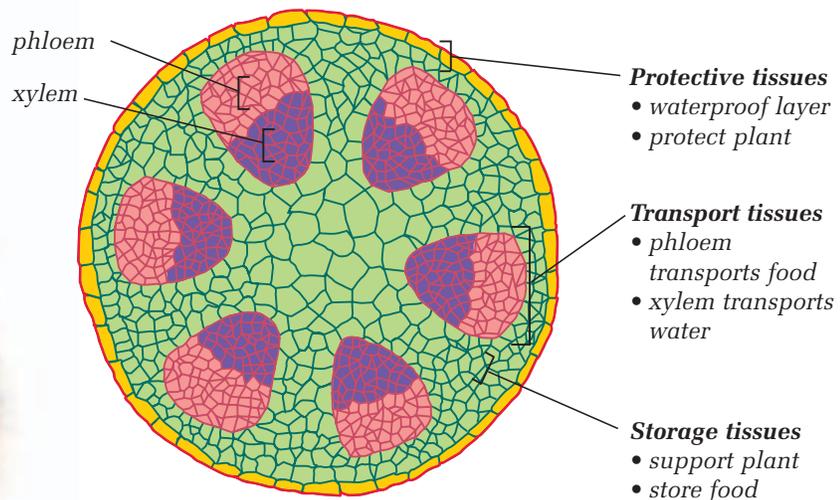
root

## RESEARCH

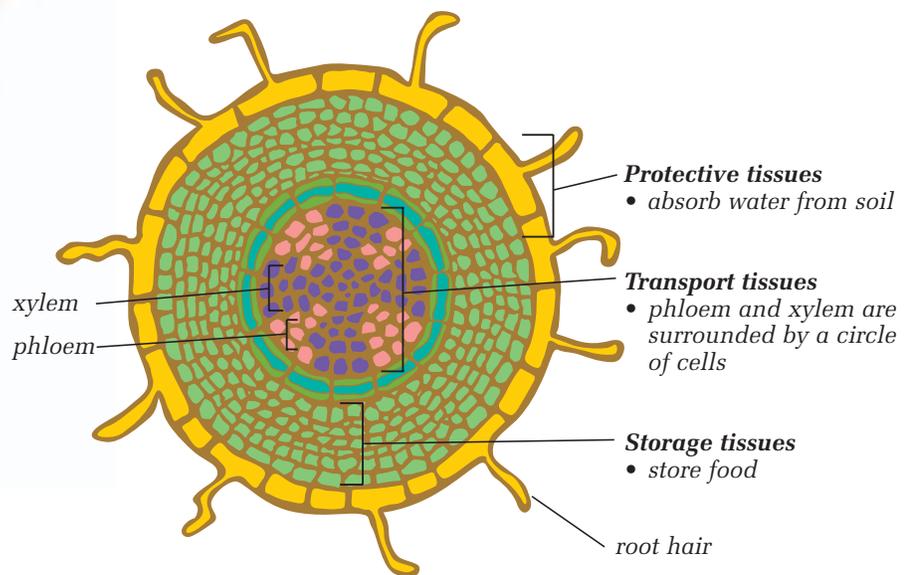
### Water Bears

Not all multicellular animals are large. For example, the members of one group of microscopic animals fondly referred to as “water bears” are multicellular. They range in size from 0.05 mm to 1.2 mm. (So the largest water bears are just in the range of your unaided sight.) These animals are amazing survivors. Find out more about water bears. How do they withstand extreme conditions?





**Figure 2.38** Tissues and cells of the stem



**Figure 2.39** Tissues and cells of the root

## CHECK AND REFLECT

1. For what reasons do the cells that make up multicellular organisms need to reproduce?
2. Is a red blood cell more specialized than an amoeba, or is it the other way round?
3. What are the advantages of having specialized cells? Are there any disadvantages? Explain your answer.
4. a) Name a plant organ.  
b) Identify the tissues that make up this organ.  
c) Describe the cells that make up each of the tissues in these organs.

## Assess Your Learning

1. Identify the organisms in Figure 2.40 as unicellular or multicellular. Give reasons for your answers in each case.



Figure 2.40

2. a) Sketch a plant cell and identify, using labels, the organelles and other cell structures.  
b) Do the same for an animal cell.  
c) Describe the key differences between plant cells and animal cells.
3. What is the function of a compound light microscope?
4. In your opinion, which structure or organelle is the most important to the health of a cell? Give reasons for your answer.
5. Choose one of the items below. Using words, pictures, or both, explain how you would prepare it to view with a microscope. Also, make a sketch showing what you think it would look like under low, medium, and high power. (Ask your teacher if you can set up a microscope to verify, and, if necessary, modify your sketches.)  
a) a hair from your hand  
b) a fleck of dandruff  
c) a grain of pepper  
d) a grain of salt
6. Imagine that an amoeba is placed in a solution of salty water. The concentration of salt in the solution is greater than the salt concentration of the amoeba's watery cytoplasm. What will happen, and why? Be sure to use the proper science terms to communicate your understanding.

### Focus On

## THE NATURE OF SCIENCE

A goal of science is to provide knowledge of the natural world. Think back on what you have learned about cells.

1. Why do you think it's important to know how cells work?
2. How has the microscope helped us to improve our understanding of the natural world?
3. What do plants and animals have in common?