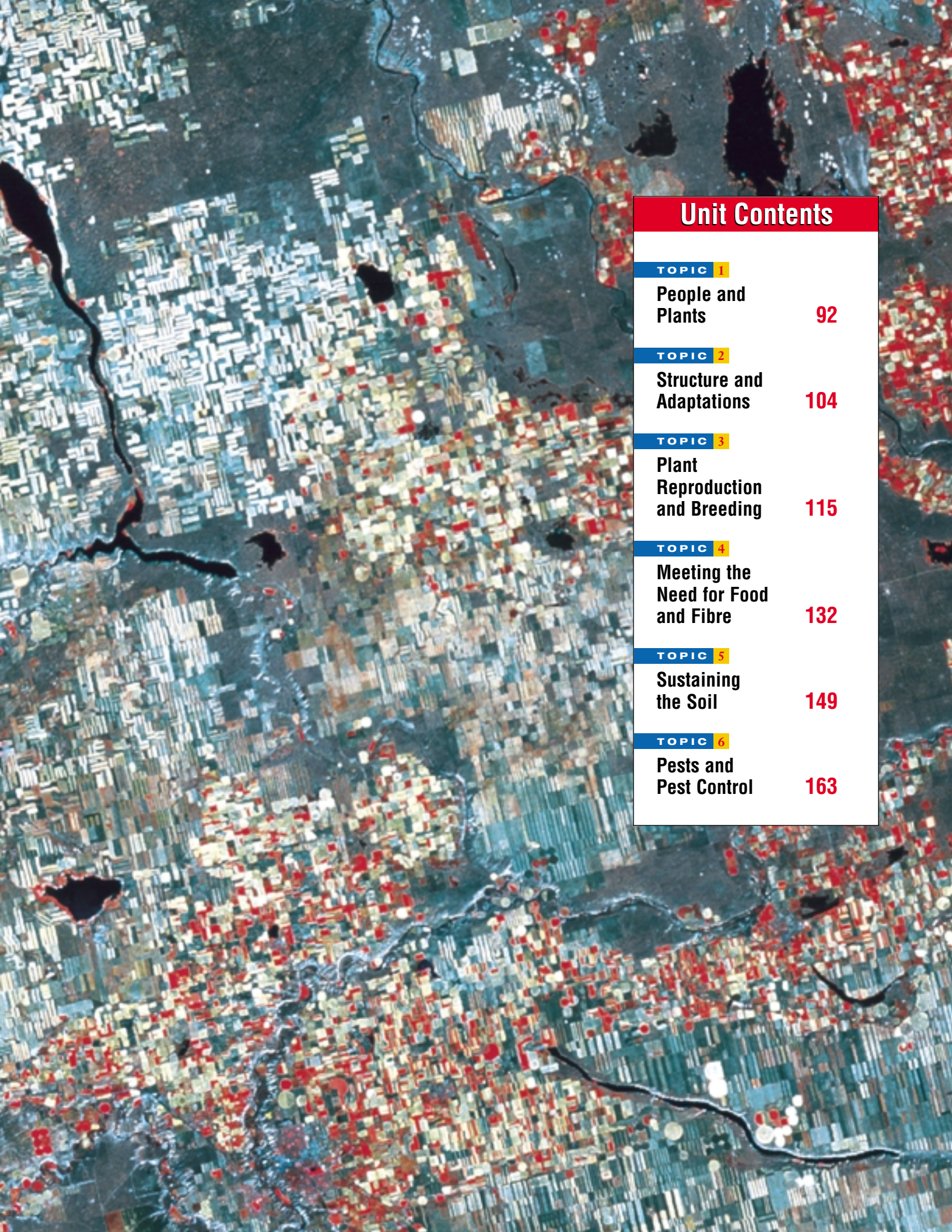
UNIT 2

Plants for Food and Fibre

Imagine for a moment that you are flying over Alberta. What would your first impressions be? Many people are astonished by the vast forests and fields that cover the province. We have used these tremendous natural resources, our knowledge of plants, and various technologies to become important producers of food and fibre. Thousands of people work to produce and process these products, which contribute billions of dollars to our economy each year.

Not long ago some types of farming practices and farm equipment damaged the soil. Scientists and producers of food and fibre are now developing better practices, enabling us to produce and harvest plants while keeping forests and fields healthy. New plant-breeding research, new machinery, and new techniques in farming and forestry are making this possible. In this unit you will explore the many ways that we use plants for food and fibre. Do you know, for example, that all of the items in the small photograph on this page come from plants? You will also grow your own plants under varying conditions to identify the best growing conditions for plants. As well, you will learn how we grow and harvest plants for food and fibre and some of the challenges this presents.



Unit Contents

UNIT 2

Preview

Focussing Questions

- How do we produce products from plants?
- What techniques do we use to grow plants for food and fibre?
- How can we grow plants without harming the environment?

What do Aspirin™, spacesuits, aircraft tires, and movie filmstrips have in common? They all include products that come from plants. Food, fibre, and many other things are made from plants. Each of the plants that we use to make products are adapted to living in different environments and under different conditions.

In Topics 1 and 2 you will learn how we use plants for food and fibre. You will also learn which parts of the plant contribute to the growth and health of plants. In Topic 3 you will learn how plants reproduce and how people can use special techniques to breed plants with particular characteristics.

We plant and harvest crops and trees to supply our need for plant fibre. What are some of the challenges in trying to grow plants for food and fibre while still maintaining healthy soil and water? How do we control pests? You will learn about these issues in Topics 4–6.

Looking Ahead

Get Growing! Read pages 178–179 to find out about the Unit 2 Project. It gives you a chance to use what you learn in this unit to grow some great plants. Begin this project after you have completed Topic 5. See your plants grow before you finish this unit!

- Carefully read the Challenge posed on page 178. Start thinking about the crop you might grow.
- As you work through Topics 1–5, think about how your knowledge of plants and their needs will help you grow your plant.
- Save your ideas for growing plants in a Project Planning file.

TOPIC 1 People and Plants

Science Log

In your Science Log, list five ways that plants help you and five ways that they help the environment. Could we survive in the world as we know it without plants?

Skill FOCUS

For tips on using a Science Log or Science Journal, turn to Skill Focus 3.

DidYouKnow?

It takes four large trees to absorb the excess carbon dioxide put into the atmosphere when a car is driven for 1 h.

How do humans use plants? Your first reaction might very well be "to eat!" Of course, people have always used plants for food. Plants are used for much more than food, however. Plants provide fibre, which humans use for clothing, paper, and building materials. **Fibre** is the tissue of plants from the stem, leaves, seeds, or roots. Plants are used in a wide range of products. Did you know, for instance, that many medicines are made from plants? Imagine a world without plants! In this Topic you will learn about the many ways we use plants. You will also investigate what a plant needs to grow and stay healthy.

Plants in the Environment

Plants are a critical part of ecosystems. They produce the oxygen that most organisms require for life. Industrial activities and automobiles add excess carbon dioxide and pollutants to the atmosphere. Plants help reduce this problem by using carbon dioxide. A hectare of trees, for example, can remove over 10 tonnes of carbon dioxide each year.

Plants are also the basis of most food webs. Whether an animal is a herbivore or a carnivore, it relies on plants for its existence. Plants also provide shelter for countless animals. Plants help clean and filter water and absorb it, thus regulating the flow and storage of water. As well, the roots of plants help keep soil in place and prevent it from being washed or blown away.

Plants for Food

Vegetables and fruits are probably among the first edible plants you think of, but they are not the only plants we eat. Today, nearly 75 percent of the world's food supply is based on seven major crops: wheat, rice, maize (corn), potatoes, barley, cassava, and sorghum. Many of the world's peoples have a diet based on one of these main crops.

Figure 2.1 This meal was made from the leaves, roots, seeds, and stems of many different plants. Which plants were used to make this meal, including the packaging?

From Plant to Final Product

While a peach, a cob of corn, or a walnut are recognizable as parts of plants, many plants look considerably different by the time we eat them. Try to match the plants below, with the products in which they are used.

A Chocolate is made from the fruit of a cocoa tree. Tropical countries in West Africa and South America produce most of the world's cocoa. To harvest cocoa, the beans of a cocoa pod are spread out in the Sun to dry. They are roasted, shelled, and crushed in a factory. A giant press then separates the cocoa butter from the powder in the crushed beans. The powder is mixed with milk to make chocolate.

B Did you know that we get oil from plants? In Canada, over 78 percent of vegetable oil production is from the canola plant. Oil is pressed from canola seeds. Canola oil is sold as a salad and frying oil and is also used in margarine, shortening, baked goods, potato chips, and french fries. Canola was developed from rapeseed by Canadian plant breeders during the 1970s.

C Seaweeds contain traces of important nutrients such as iodine. Seaweed is a valuable food resource in some parts of the world. Hundreds of thousands of tonnes are collected each year in Japan for use in soup broths or dishes such as sushi. Products from seaweeds are also used in ice cream, chocolate milk, yogurt, whipped cream, pies, jellies, and candies. Seaweed products are often used to thicken food. The terms "alginate," "agar," or "carrageenan" on a food label indicate the product contains seaweed.

D Almost half the world's sugar comes from sugar beets. They are grown in northern countries, including Russia, France, Germany, Poland, the United States, and Canada. The sugar is found in the thick plant roots. The roots are first shredded and then heated in running water to remove impurities. The clear liquid that remains is concentrated and crystallized to produce a sugar similar to that made from sugar cane.

Word CONNECT

Are you familiar with the plants cassava and sorghum? Use a dictionary or encyclopedia to find out about these plants and how they are used.

Plants for Fibre

Plants provide fibres for a variety of needs, including clothing, paper, and shelter. How many uses of plants can you see in the photographs below?

People discovered early in history that the fibres of plants, separated out and processed in some way, were very useful for making clothes. Recall in Unit 1 how Aboriginal people from Canada's west coast wove clothing from the bark of the western red cedar. Today, much of our clothing comes from synthetic (manufactured) material such as polyester or nylon. Plants, however, still provide important fibre to make cloth. Cotton, hemp, and flax are all natural fibres that we use.

Cotton

Cotton is a natural fibre that has been grown and used by humans for centuries. In fact, you are probably wearing at least one garment made from cotton right now. Cotton is even used for spacesuits. Cotton fibres are different from synthetic fibres in that cotton absorbs moisture and then allows it to evaporate easily. Cotton is currently the world's most important non-edible plant.

Cotton fibres come from the plant's seeds. The plant uses silky fibres to spread its seeds in the wind. The fibres are strong, flexible, and have a gradual spiral that causes the strands to interlock when twisted. This makes them ideal for spinning into thread. Beneath these long fibrous hairs lies a second layer of shorter fibres known as "fuzzy" fibres. These fibres are used to make cotton batting, rayon, and various types of plastics and paper.

DidYouKnow?

Silk is the most expensive fibre in the world. It is not produced directly from plants, but it could not be made without them. The leaves of mulberry trees provide the staple food for the common silkworm. The white caterpillars of the moth eat these leaves until they start to spin their silk cocoons.

Figure 2.2 The flowers of cotton plants bloom in the morning and by the afternoon begin to wither. The next day they are rose coloured and fall from the plant. Once the petals fall off, a "boll" develops. After four months the boll splits open and at last you can see the cotton inside.

Hemp

If you had one of the first pairs of blue jeans ever made in the late nineteenth century, you would have been wearing jeans made from hemp. Today jeans are made of cotton.

Hemp is the oldest cultivated fibre plant in the world. The first Bible made on a printing press was printed on hemp paper, and early sails and ropes were made of hemp as well.

Figure 2.3 Today you can buy paper, clothing, and even shoes, made from hemp fibre.

Hemp has a less negative effect on the environment than other sources of fibre do. For example, 1 ha of hemp can produce four times more fibre than the same area planted in trees. A hemp crop is ready to harvest in one year, whereas it takes decades until a tree is ready to harvest. As well, hemp paper lasts longer than paper made from wood pulp and it can be recycled up to seven times. (Paper made from wood pulp can be recycled about four times.) Hemp plants also grow quickly and therefore choke out weeds naturally. Hemp is not eaten by most insect pests, so chemicals to control weeds and insects are not needed.

DidYouKnow?

Levi Strauss invented blue jeans as tough, protective work clothes. The cloth he used for his jeans was imported from Nîmes in France. The French name for this material, serge de Nîmes, soon turned into the word "denim" in North America.

Flax

Flax is a food and fibre crop that is grown in the northern, cooler regions of the world. Flax fibres are taken from the stem of the plant and are two to three times as strong as those of cotton. As well, flax fibres are naturally smooth and straight. Europe and North America depended on flax for cloth until the nineteenth century, when cotton overtook flax as the most common plant used for making clothes. Flax fibre is also used for making linen paper.

Flax is grown on the Canadian Prairies for linseed oil, which is used as a drying oil in paints and varnish and in products such as linoleum and printing inks.

DidYouKnow?

Wood pulp is the basic raw material for almost all disposable diapers. Aboriginal people in Canada used certain types of moss for baby diapers. Mothers packed absorbent moss between their baby's legs and held it there with a soft strip of animal skin.

INQUIRY

INVESTIGATION 2-A

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Fibre Face-off

Paper is made from the fibre of trees, flax, hemp, or other plants. The fibre is processed into a pulp before it is pressed into sheets of paper.

Question

Which type of plant fibre is the strongest?

Safety Precautions

- Take care not to touch the hot base plate of the iron.
- Wipe up any spills, as wet floors are slippery.

Apparatus

large jar or plastic container
blender or food processor
large rubber tub or sink filled with warm water
1 screen
2 dishcloths
newspapers
sponge
clothes iron
magnifying glass or microscope

Materials

several sheets of linen writing paper or envelopes, newspaper, construction paper, manila envelopes, or photocopy paper
warm water
white glue

Procedure

Part 1

1. **Predict** which paper will be the strongest.
2. Choose one paper to work with from the Materials list.
3. Rip your paper into small pieces and place it in the jar or plastic container. Cover with warm water and leave overnight.
4. Place the fluid from step 2 into a blender and slowly blend until you have a smooth pulp. **Note:** Add more water if necessary.
5. Add five drops of white glue to the pulp and blend well.
6. Add the pulp to the rubber tub or sink filled with 10 cm of warm water.
7. Place the screen into the water and swish it around until your pulp forms a thin, even layer on the screen.

8. Lift the screen out of the water and let the water drain off.
9. Lay a damp dishcloth on a stack of newspapers.
10. Flip the screen, with the pulp, onto the dishcloth. Use the sponge to soak up any excess moisture off the back of the screen.
11. Gently remove the screen so that the pulp stays on the dishcloth.

CAUTION Take care using the iron.

12. Cover the pulp with the second dishcloth and iron at medium temperature for 1–2 min.
13. Gently pull the dishcloth away from the paper and let the paper air dry on a flat surface.
14. When the paper is completely dry, proceed to Part 2.

Part 2

1. **Design** a way to test the strength of the paper you have made.
2. **Discuss** your testing methods with students who have made paper from other materials and agree upon a strategy for testing paper strength.
3. **Review** your testing strategy with your teacher and then conduct your tests.
4. **Examine** the paper fibres in your recycled paper sheets using a magnifying glass or microscope.

Skill FOCUS

For tips on using graphic organizers turn to Skill Focus 2.

For tips on making predictions, turn to Skill Focus 6.

Analyze

1. Which paper was the strongest? Explain your results based on your knowledge of plant fibre.
2. What other variables could you have tested to evaluate your paper? (For example, is strength the only quality to look for when choosing paper?)
3. Does the length of fibre affect paper strength? Explain.

Conclude and Apply

4. Photocopy paper is made from wood pulp and linen paper is made from flax. What do we use these types of paper for?

Extend Your Knowledge

5. Research how paper is actually recycled. Draw a flowchart or other graphic organizer to illustrate this process.

Plants for Medicine

The saying "An apple a day keeps the doctor away" may be closer to the truth than you realize. Many medicines contain ingredients made from plants. In fact, more than 7000 medicines are made from plants, including heart drugs, cancer medicines, antibiotics, and pain medication. Plants were the original medicines. Aboriginal people have known about the medicinal use of plants for centuries. They used the plants around them before the medicines we now have were available. You may even have a plant-based home remedy that you use in your family. For example, some people make tea from ginger root to soothe an upset stomach.

Pain Medication

Plants often give us the "blueprints" for medicines that scientists can then copy in laboratories. For example, for centuries it was well known that the bark of the white willow eased pain. The exact ingredient was isolated through testing, and now these pain medications are manufactured synthetically in laboratories. Aspirin is one example.

Figure 2.4 Tropical rain forests are home to more than 50 percent of plant species on the planet.

Figure 2.5 Morphine, a powerful pain medication, is found only in the thick fluid of the opium poppy's seed pod. It cannot be manufactured.

Opium poppies (Figure 2.5) are the source of morphine, the most powerful natural pain medication of all. Morphine is found in the milky fluid of the poppy's seed pod and also in the stems and leaves. Codeine is also found in the poppy. It is used in cough medicines and for the relief of other cold symptoms.

Quinine comes from cinchona trees (see Figure 2.6). It is used as a prevention for malaria, a deadly disease carried by certain tropical mosquitoes. Until quinine became widely available, malaria killed approximately 2 million people each year.

Off the Wall

A Swedish archaeologist recently found what is probably the world's oldest chewing gum. He found 9000-year-old wads of chewed birch resin (or pitch) on the floor of a hut used by Stone-Age hunter gatherers. The gum might have had a medicinal use as birch resin contains a natural disinfectant. Today, a natural tooth cleaner containing birch resin is sold in Finland. In Canada, the Cree used spruce resin as chewing gum.

Since quinine was discovered in 1820, there has been a steady demand for the drug. In 1944 American scientists devised a way to produce synthetic quinine. However, the malarial parasite has since developed resistance to manufactured quinine and it is no longer effective in some areas of the world. Natural quinine is effective everywhere.

Figure 2.6 The cinchona tree grows in the humid forests of the South American Andes. It is the source of quinine.

Herbal Remedies

Does anyone in your family or someone you know use herbal remedies?

CAUTION Do not use herbal remedies without first checking with your doctor.

Find Out ACTIVITY

Procedure Performing and Recording

1. Link the common herbs below, with their descriptions. Do research in the library and on the Internet if necessary.

A. echinacea
B. feverfew
C. garlic
D. ginkgo biloba
E. ginseng
F. aloe vera

(a) This bulb, a natural antibiotic, has been used to prevent infections. In World War I the juice from this bulb was squeezed onto moss and used to dress wounds.

(b) The leaves of this plant are used to heal skin problems, such as minor burns.

(c) This plant is considered an effective treatment for migraine headaches.

(d) This plant is one of the world's oldest living trees. It is often called the smart herb because it increases the supply of oxygen to the brain.

(e) This root has long been important for health in Chinese culture. It enhances mental activity and is said to stimulate the central nervous system.

(f) This plant is used to combat cold, cough, flu viruses, and sore throats.

2. Choose one of the herbs above or another herbal remedy or medicine to research further. Use the library or Internet resources to prepare a one-page summary of your research, listing important points about the herb's history and claims for its effectiveness.

What Did You Find Out?

Analyzing and Interpreting
Communication and Teamwork

1. How are herbal remedies and many modern medicines similar?

2. How is the use of herbal remedies controlled?

Extension

3. As a class, discuss herbal remedies and why the Western medical profession is sometimes concerned about their use.

Plants for Transportation and Construction

Figure 2.7 Latex being tapped from a rubber tree

Did a plant help transport you to school today? Unless you walked barefoot, one probably did. Rubber is one of the most important plant products that people use. When humans figured out how to turn liquid rubber (called latex) into a hard, yet flexible, material, our world changed dramatically. Without rubber, it is unlikely we would have cars, airplanes, or spacecraft!

Natural rubber comes from the Brazilian rubber tree (see Figure 2.7). This tree is currently the only source of natural rubber. Since the demand for natural rubber is increasing faster than we can grow rubber trees, scientists are researching alternative plants to supply this useful product. Today most vehicle tires contain some synthetic rubber made from coal and oil by-products, but natural rubber is still an important part of them.

Plants have also influenced transportation on water. For instance, Aboriginal people in Canada made canoes from trees (see Figures 2.8 and 2.9).

Figure 2.8 On the west coast of Canada, Aboriginal people hollowed out the huge trunk of the western red cedar with a combination of carving and controlled burning.

Figure 2.9 Aboriginal people of the interior regions of North America used the bark of the white birch to make canoes.

Certain plants are the source of lubricants. Lubricants are used to oil machinery parts to ensure that they work properly. The racing car in Figure 2.10, as well as airplane engines, uses lubricants made partially from coconut and castor bean oils.

Plants are also used for construction all around the world. In North America, 90 percent of all houses are made of wood. Most timber used today for construction comes from softwood trees. Forests of the Pacific Northwest, especially those of British Columbia, provide a large proportion of the softwood timber used around the world.

DidYouKnow?

Softwood trees are conifers, such as hemlock or fir. Conifers have needles and cones.

Plants for Fuel

If you use wood or coal to heat your home you have plants to thank for keeping you dry and warm. In many places in the world, wood is still burned for fuel. In other countries, plants that were growing on Earth millions of years ago provide the energy. These ancient plants died and were covered with sediment. Over many years the layers of sediment built up and the weight compressed the plant tissues. Under intense pressure and heat, they underwent chemical and physical changes to become coal.

The sugar in some plants can be turned into a type of liquid fuel called ethanol. Methanol is another type of liquid fuel that is made from wood. Methanol is also called wood alcohol.

Producing fuel from plants is economical but not very energy efficient. A large amount of energy is required to grow and harvest the crop and a lot of energy is lost when plants are converted to fuel. Still, liquid fuels provide an alternative fuel source in our world where oil and gasoline from traditional sources are limited.

DidYouKnow?

Softwood comes from a coniferous tree and hardwood comes from broad-leaved, or deciduous, trees. The terms can be confusing since some softwood timbers are actually harder than those made from hardwoods. For example, wood from the conifer, the Pacific yew, was used by Aboriginal people for paddles, harpoon shafts, spears, and sewing needles. All of these items need a heavy, tough wood.

Figure 2.10 Many racing cars use lubricants made from coconut and castor bean oils.

Figure 2.11 Will there always be enough plants to support the need of the human population for food and fibre?

Human Needs and Plant Needs

If Canadians and other producers of plants are to meet the growing need for plants, we need to make sure that plants survive and thrive. We need to maintain healthy conditions to support the plants that help support us. What do plants need to survive and stay healthy? You will find out in the next investigation.

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Growing Conditions for Healthy Plants

Plants growing in natural conditions are well suited to their environment and the amount of light, heat, and water they naturally receive. Plants grown by people, however, are often helped a bit so that the health and yield of the plants (how much is harvested) is maximized.

Challenge

Grow the healthiest plants that you can by varying the light, temperature, and water.

Apparatus

thumbtack
graduated cylinder
plant grow lights (optional)
ruler
thermometer
space heater (optional)

Materials

seeds sprouted between layers of moist paper towel
paper cups, or small peat pots
potting soil or garden soil
water

Design Specifications

A. You will be given nine sprouted seeds from one type of plant. Divide your seeds into three groups and plant them at the same depth in the same type of soil and in the same type of container. Use a peat pot or a paper cup with holes poked in the bottom (use a thumbtack).

B. Design an experiment that shows how the amount of light, temperature, and water affects plant growth.

C. You may change only one variable for each group of plants. (For example, if you are varying the amount of light, the temperature and water should stay the same.)

D. Design appropriate graphs and tables for recording your data.

Plan and Construct

1. Design appropriate ways to vary light, temperature, and water.
2. Review the design of your experiment with your teacher. Then proceed with your experiment.
3. Measure and graph the growth of your plants daily for a week or more.
4. Record the temperature, amount of water, and approximate amount of light daily.

Evaluate

1. Why was it important that all of your seeds were planted at the same depth, in the same soil, and in the same type of container?
2. Why was it was important to begin your experiment with sprouted seeds?
3. Which combination of light, temperature, and water would result in the healthiest plant?
4. Is a healthy plant always the tallest plant?
5. Describe and draw the condition of a healthy plant.

Extension

6. What other factors might have affected the growth of your plant other than those tested?

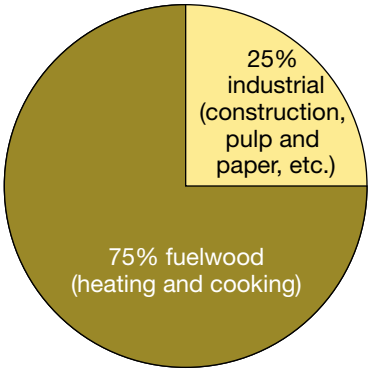
TOPIC 1 Review

1. List ten plant-based products that you have used today. Classify your use of plants into "plants for food" and "plants for fibre." Which type of use is most common for you? Discuss the results as a class.

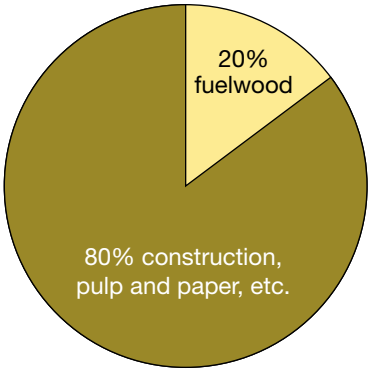
2. Describe the process that is used to create (a) chocolate from cocoa pods, and (b) sugar from sugar beets.

3. Look at these circle graphs. Why do you think the usage of wood in developing countries (such as India or Thailand) differs from the ways it is used in developed countries (such as North America)?

A. Wood use in developing countries



B. Wood use in developed countries



4. Describe the role of plants in the environment.

5. What advantages does hemp have over other fibre plants such as wood and cotton?

6. Name two ways in which plants are used in transportation.

7. **Thinking Critically** Imagine a population of people that depends on only one crop for food, clothing, transportation, and construction needs. What might this plant look like? What would be the effects of depending on only one crop for all human needs?

8. **Thinking Critically** If all the plants on Earth died, what are some of the effects we would face? Which effects would be most immediate and serious?

TOPIC 2 Structure and Adaptations

Word CONNECT

Perennials and annuals have very different survival strategies. Use your dictionary to determine the difference between these two types of plants.

Plants are found in almost all habitats on Earth. Each habitat has a unique set of environmental characteristics, such as temperature, light, water, and soil conditions. A plant's structure helps it adapt to these conditions. For example, a desert plant's roots are adapted to gather moisture from deep in the soil.

We need to understand the structure of plants and how they adapt so that we can match the plants with conditions where they can grow well. We can sometimes use this knowledge to alter growing conditions and improve yield.

Find Out ACTIVITY

Digging into Dandelions

In this activity, examine a dandelion to see what you already know about plant structure.

Materials

trowel
dandelion with roots, leaves, stem, and flower (if possible)
ruler
magnifying glass
scissors

Procedure Performing and Recording

1. Dig up a dandelion from your backyard or schoolyard. Remove the remaining soil on the plant. Be careful not to break the big root. If you do break it, dig out the pieces remaining in the soil.
2. Draw a sketch of the plant and label the roots, stem, flower, and leaves.

3. Use a magnifying glass to examine the dandelion flower or the parachute-like seeds if it has gone to seed. Record your observations.
4. Measure and compare the length of the root with the part of the plant above ground.
5. Use the scissors to cut across the stem and describe what you see. Examine the stem and any fluids under a magnifying glass.
6. Tear the stem lengthwise and describe the kinds of fibres that make up the stem.
7. Examine both sides of the leaves. Are they the same? Describe any differences and indicate them on your drawing.
8. Wash your hands thoroughly.

What Did You Find Out? Analyzing and Interpreting

1. Describe what you know about the functions of the roots, stems, leaves, and flower of a plant. Base your answer on what you observed about the dandelion's structure.
2. How do you think the length of the root helps the plant survive?
3. How are other plants the same or different from the dandelion? Predict how an alpine plant and a rain forest plant might be different from a dandelion.

Roots

When you look at a plant, you see only part of it. As you saw with the dandelion, plants can be a bit like icebergs — there is often much more beneath the surface than what you might think. In many cases, up to one-third of a plant, its root, lies hidden below the ground.

Roots perform several important functions:

- they absorb water and minerals from soil;
- they support and anchor the plant so that it is not blown over by wind or washed away by water; and
- they store food to help the plant survive during times of scarcity.

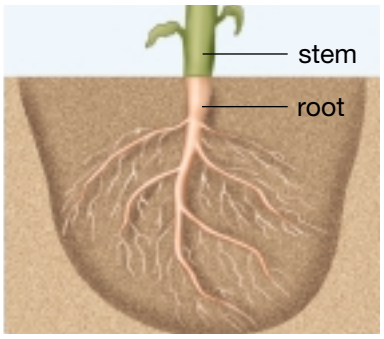


Figure 2.12 A taproot system. It can reach deep into the ground to obtain moisture.

Figure 2.13 A fibrous root system

Many plants have a single, prominent **taproot** with numerous small roots coming out of it (see Figure 2.12). These smaller roots are covered in tiny **root hairs**. The smaller roots and root hairs increase the ability of the plant to absorb water and nutrients from the soil. Most trees and large desert plants grow taproots that reach deep into the ground, as do dandelions. Other plants have **fibrous roots**. This is a shallow system of similar-sized roots that can quickly soak up moisture (see Figure 2.13).

Roots are often specially adapted to a plant's habitat. For example, moss campion, shown in Figure 2.14, is an Alberta plant that grows on mountains where it is high, cold, and dry. The plant grows very low to the ground, thus trapping heat, preventing wind damage, and reducing water loss. When a moss campion seedling begins to grow, its first few years are spent making roots. After five years the taproot can reach 2 m into the mountain, whereas the leaves and stems remain smaller than a bottle cap. Moss campion may take up to 25 years to bloom. In contrast, the duckweed, a common plant found on ponds in spring and summer, has tiny roots that grow off the underside of the leaf and are surrounded entirely by water (see Figure 2.15).

Off the Wall

In 1930 at the University of Iowa, scientists planted a single winter rye plant. They let it grow for four months and then carefully removed the root system from the soil and measured it. They found the total length (including the root hairs) was more than 11 000 km.

Figure 2.14 Moss campion is a common cushion plant found on rocky mountain slopes. Its roots can reach 2 m deep.

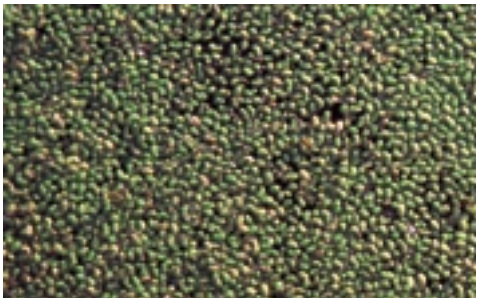


Figure 2.15 The underside of duckweed leaves are covered in tiny roots.

DidYouKnow?

The roots of some desert plants, such as the creosote bush, produce chemicals that kill other plants. In this way they keep other plants away from their source of water.

Root Crops

When you eat the vegetables in Figure 2.16 you are eating a root. Carrots, beets, turnips, radishes, and parsnips are all roots.

Figure 2.16 Root crops generally grow in a short period of time and, since they have deeper roots, can survive where there is less rainfall. These qualities, combined with the length of time they can be stored, make root crops an important part of the diet of many people in the world.

Getting to the Root of Roots

A primary function of roots is to absorb water and minerals and transfer them to the stem. To find out more about how root absorption works, complete this activity using a large root, a carrot.

Materials

water	250 mL beaker
blue food colouring	table knife
carrot with the leaves intact	scale

Procedure Performing and Recording

1. Pour water into the jar and add enough food colouring to turn the water deep blue.
2. Cut off the tip of the carrot. Use care when cutting the carrot. Cut in a direction away from your body. Place the carrot into the dye solution. Set it in bright light for several hours.
3. Remove the carrot from the jar and estimate, then measure the mass of the carrot.
4. Cut the leaves and stem from the root.

Find Out ACTIVITY

5. Estimate, then measure the mass of the carrot root.
6. Estimate, then measure the mass of the carrot leaves and stem.
7. Cut the carrot lengthwise down the middle and observe the location of the dye.

What Did You Find Out? Analyzing and Interpreting

1. Which part of the plant did the food colouring enter? Explain what this tells you about roots.
2. Describe the major functions of the carrot root.
3. Compare the root mass to the total mass of your carrot. What percent of the total mass are the leaf and stem of the carrot? How might this percent differ in a garden crop such as lettuce?

Skill FOCUS

For tips on estimating, turn to Skill Focus 5.

Diffusion and Osmosis

Diffusion and osmosis are two key processes that allow roots to absorb water and dissolved substances such as minerals. **Diffusion** is the tendency of particles in a gas or a liquid to become evenly distributed by moving from areas of greater concentration to areas of lesser concentration. The particles continue to spread until they are evenly spaced in an area. Diffusion occurs, for example, when a perfume bottle is opened in the corner of a room. The scent quickly becomes uniformly distributed throughout the air in the room.

Osmosis is a type of diffusion in which only some types of particles are allowed to pass through a barrier. Imagine a mesh bag filled with marbles and sand. Sand will get through the mesh, but the marbles will remain. The mesh bag is like the cells in the root. The cells are **differentially permeable**. This means that they allow some materials to pass through, such as water and specific nutrients, and keep out other materials. **Osmosis** is the diffusion of water through a differentially permeable membrane. Figures 2.17A, B, and C explain osmosis further.

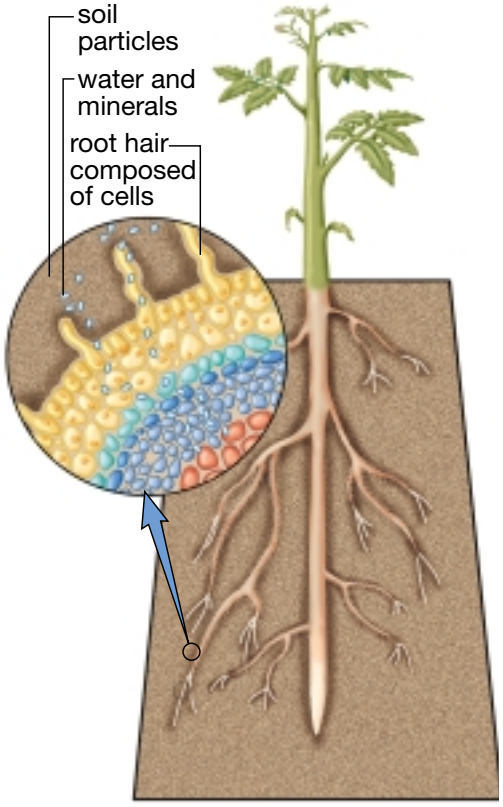


Figure 2.17A Water and dissolved minerals enter the plant by osmosis through cells in the root hairs.

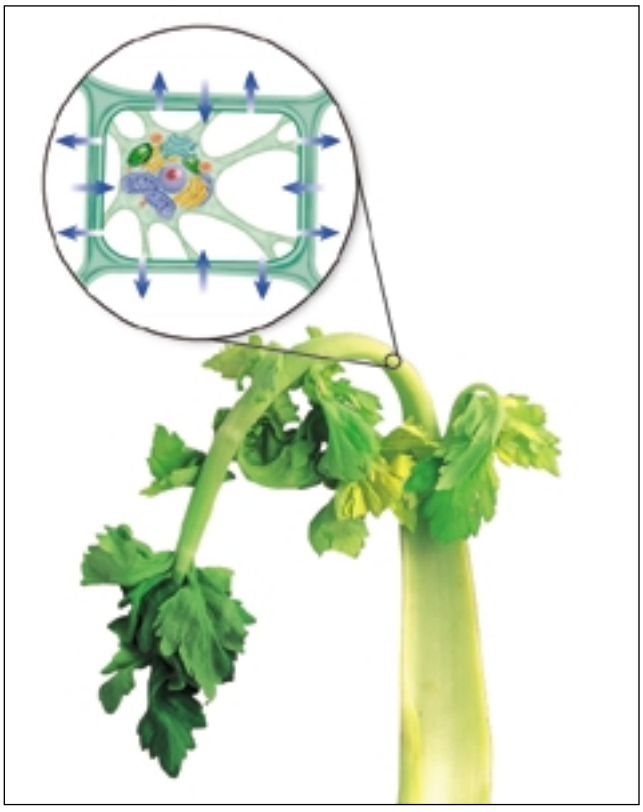


Figure 2.17B Wilting occurs when more water leaves the cells than enters them.

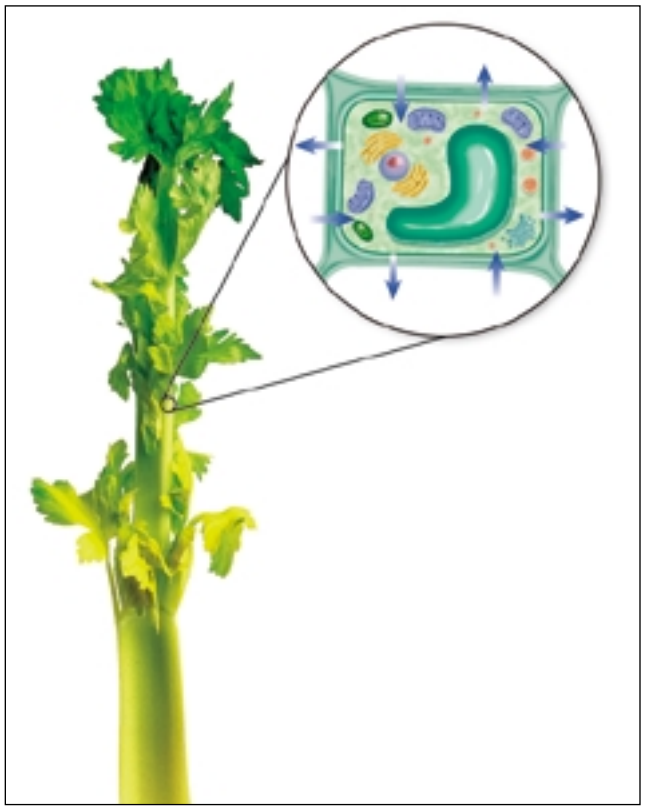


Figure 2.17C When a plant has enough water, no more water will enter the roots until the cells have lost some of their water.

Pause & Reflect

Aboriginal people often harvested the bark of cedar trees in long strips. This practice did not kill the tree because it was done carefully and at the appropriate time of the year. Would cutting one strip of bark 3 mm wide from around the entire tree kill the tree? Explain your answers in your Science Log.

Skill FOCUS

For tips on designing your own experiment, turn to Skill Focus 6.

Stems

Where do the water and dissolved nutrients go after they are absorbed by the roots? One function of stems is to transport water and nutrients between the leaves and roots. Figure 2.18 shows an example of one common type of stem — the trunk of a tree — and the tissues that make it work.

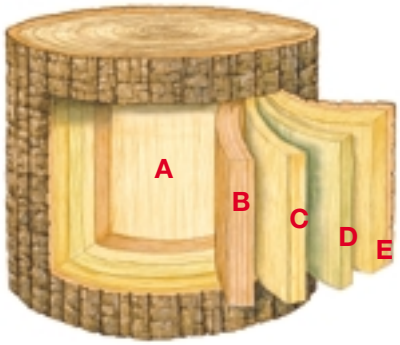


Figure 2.18 The layers of a tree

A. Heartwood is dead wood in the centre of the tree. It gives the tree its strength.
B. Xylem carries water and nutrients from the roots up to the leaves. As new layers develop, the inner layers die and become heartwood.
C. Cambium is the growing part of the trunk. Each year the cambium produces new phloem and xylem.
D. Phloem is the layer of cells that carries sugars from the leaves to the rest of the tree. As these cells die, they become part of the outer bark.
E. Bark is the woody skin that stops a tree from drying out. It protects and insulates the tree.

Find Out ACTIVITY

Celery Superhighway

Complete this activity to find out how water and nutrients travel through stems.

Materials

blue or red food colouring
500 mL beaker
celery stalk with leaves (with 1 cm cut from base)
water
magnifying glass or microscope

Procedure

Performing and Recording

1. Add food colouring to water.
2. Place the celery in coloured water.
3. Set the celery in bright light overnight.
4. The next day observe the cut end of the celery. Record your observations.

What Did You Find Out?

Analyzing and Interpreting

1. What are the coloured tubes in your celery?
2. Why did step 4 instruct you to place a stalk cut from the base of the celery into the water?
3. How might your results change if you bent the celery stalk in half before placing it in the food colouring? Write a prediction for the results of such a trial.

Extension

4. How can you increase the flow of water to the leaves? Rewrite at least one of your ideas as a problem that you could test.
5. **Design Your Own** The celery you used in this activity does not have its roots. Why did water move up the stem? How could you find out if your idea is correct? Design an investigation to answer this question.

Support

A second function of a stem is to support the leaves and to ensure that they receive adequate light, which the plant needs to produce food. To perform this task, most stems grow above the soil. Stems range in size from a few millimetres to over 100 m (see Figure 2.19).

Figure 2.19 Sequoia trees have the tallest stems in the world. They can grow as high as 110 m. The bark of a sequoia tree is more than 50 cm thick.

Food Storage

Some stems also store food for the plant. They store the food produced in the leaves of the plant. Potatoes, for example, are swollen underground stems known as tubers. They store food in the form of starch, which the potato plant uses for growth.

Although plants generally store food in the form of starch, as potatoes do, some plants store food as sugar. The plant best known for storing sugar in its stem is sugar cane. Sugar cane is a grass plant that grows naturally in tropical areas.

Different Types of Stems

Examine Figure 2.20 to see some other types of stems.

Figure 2.20A The stem of the common strawberry plant grows horizontally on the ground and is called a runner. At various spots along the stem, roots begin to grow.

Figure 2.20B Corms are also underground stems. Crocus and gladioli also grow from corms.

Figure 2.20C Cattails have fleshy horizontal stems called rhizomes, which allow the plant to spread underground.

Figure 2.20D Several cacti, like the prickly pear, have flattened stems. This adaptation ensures that part of the plant always faces away from the Sun, helping the cactus to preserve water.

DidYouKnow?

Many trees and plants that grow in dry environments store huge amounts of water in their stems. The barrel cactus, for example, stores enough water to survive more than a year without rain. There are many stories about people lost in the desert who managed to survive on water from the barrel cactus.

Pause& Reflect

In the fall, when many plants stop producing chlorophyll, leaves turn other colours, such as brown, yellow, orange, and red. What happens to the leaves and the plant after this colour change occurs? How is this related to food production in the plant? Write your responses in your Science Log.

Leaves

During spring and summer — the major growing seasons for plants — a pigment called **chlorophyll** makes leaves green. Most of the chlorophyll is in the tops of leaves. Leaves are the part of the plant that use the energy of sunlight and change it to a kind of chemical energy. They do this by combining two simple materials, carbon dioxide (from the air) and water. These combine to make the material that we know as sugar. Sugar is a kind of energy-storing chemical made by plants. This process is called **photosynthesis** (see Figure 2.21).

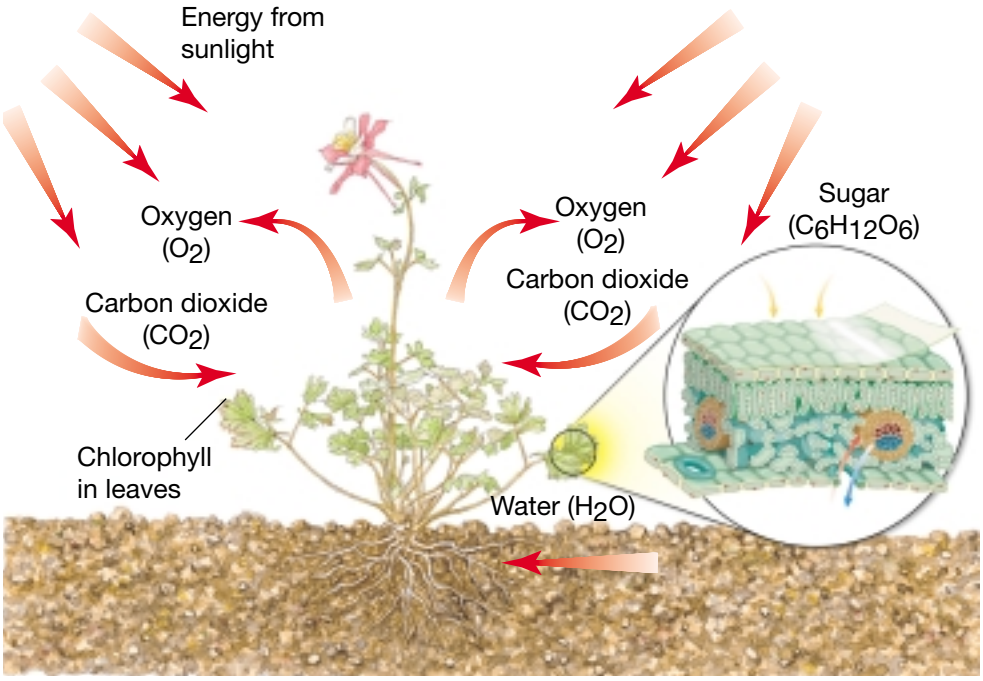


Figure 2.21 During photosynthesis, carbon dioxide from the air, water in the soil, and energy from the Sun react to form sugar and oxygen.

Carbon dioxide enters plants through tiny holes in leaves called stomata (singular: stoma) (see Figure 2.22). Because leaves usually have more stomata on the lower surface, more carbon dioxide reaches the spaces in the spongy layer, as shown in Figure 2.23. The spongy layer is also where much of the leaf's water is stored.

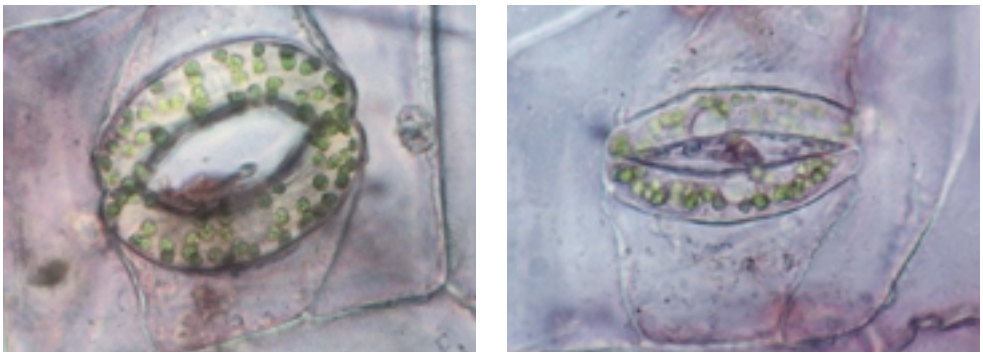


Figure 2.22 These stomata have been magnified many times. Stomata open during the daytime and close at night. Why do you think this is advantageous for the plant?

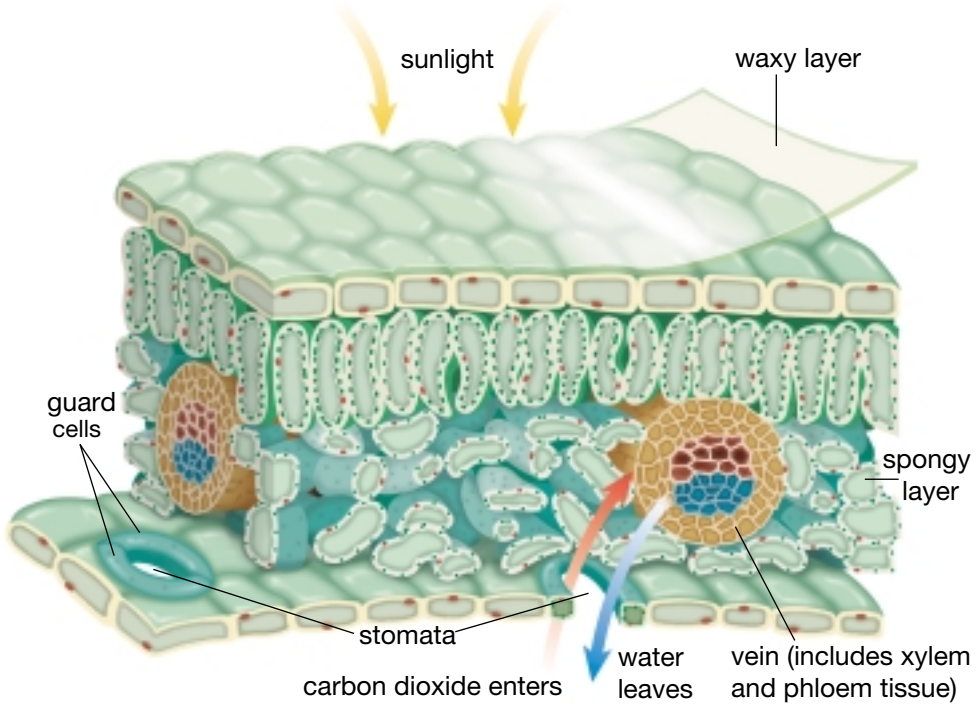


Figure 2.23 Photosynthesis takes place near the top surface of the leaf where the sunlight is strongest. Gas exchange occurs through the stomata.

Along with sugar, plants produce oxygen during photosynthesis. Sugar is carried throughout the plant for the food it needs to live and grow. Oxygen gas escapes through the stomata. Photosynthesis is the source of all food on Earth. Plants convert the Sun's energy into plant tissues, which animals use for food. The oxygen produced by photosynthesis in plants is the source of all oxygen in our atmosphere.

Plants need oxygen as well. At night, when photosynthesis does not occur, respiration does. **Respiration** is a process by which plants release carbon dioxide and let oxygen into their cells.

Guard cells are cells on the leaf surface that surround each stoma, controlling the size of the opening. Water moves in and out of the guard cells by osmosis. When guard cells absorb water, they swell and the stoma opens, letting in carbon dioxide and letting out water vapour. This loss of water from a plant through evaporation is called **transpiration**. When guard cells lose water, they relax and the stoma closes.

Moving Water in Plants

Water loss through transpiration is part of an important system that ensures water moves throughout the plant. Think of the water network in a plant as a series of thin, hollow tubes. Water drawn into the root hairs by osmosis pushes thin columns of water up the plant. At the same time, water lost from the leaves by transpiration pulls water up the xylem tissues from the roots. Both these actions, pushing and pulling, move water to the top of plants, even the world's tallest trees!

DidYouKnow?

Bulbs are modified leaves. Onions, garlic, tulips, and daffodils grow from bulbs. Bulbs store food for plants.

Off the Wall

For St. Patrick's Day, some florists dye white carnations green. They put white flowers in green dye and let the principle of water movement in plants do the work for them. Water is pushed and pulled up the stem by transpiration. You just did something similar when you put a stalk of celery in a glass of water dyed with food colouring.

INVESTIGATION 2-C

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Design a Plant for Its Habitat

Use your problem-solving skills to design a useful plant with adaptations to survive in an extreme environment.

Challenge

Use your knowledge of plant structure and adaptation and your understanding of human needs for plants to design a plant. Your plant must be able to help a human population living in either a dry alpine environment, a desert, a temperate forest where winters are long and cold, or a tropical rain forest.

Materials

poster paper pencils art materials

Design Specifications

A. Your design must include details about how your plant's roots, stems, and leaves will be able to perform their jobs.

B. Your plant must be useful for the human population living near your extreme environment. Use what you learned in Topic 1 to provide details about the ways that your plant is useful.

C. Your group must produce a drawing of the plant with labels.

D. Your group must present its design to the class. As part of your report, you must include at least three problems your plant faces.

E. Your plant must be able to grow naturally in its environment without help from humans.

Plan and Construct

1. With your group and teacher, select the environment you wish your plant to grow in. Brainstorm with your group about the challenges this environment will pose to your plant.
2. Each member of your design team should sketch a possible design for your plant.
3. Evaluate the designs and as a group choose the best design or come up with a new design that will best achieve the specifications of this activity. Be as creative as you like! Your presentation should include other adaptations such as how long your plant lives, any special relationships it may have with insects or other animals, or any other characteristics of your plant.
4. Assign one person to draw, one to label, and two or more to prepare and give the oral presentation.
5. After groups are finished preparing, give your presentation to the class.

Evaluate

1. What would happen to your plant if you put it in a different environment?
2. Suggest ways you might help the plant survive in its new home. Would your suggestions be practical? Explain.

Extend Your Skills

3. Make a model of your plant out of materials such as papier-mâché, wire, cardboard, or modelling clay.

Skill FOCUS

For tips on scientific drawing, turn to Skill Focus 11.

For tips on using models in science, turn to Skill Focus 12.

INVESTIGATION 2-D

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Food and Fibre Plants in Alberta

Think About It

Although Alberta is often known for its field crops of flax or canola, this province grows a variety of crops for food and fibre. Some of these plants are shown here. Different plants are harvested for their stems, leaves, root, or fruit. Crops are chosen by farmers because of their suitability to the local environment and the needs of consumers.

What are the special conditions for growing crops in Alberta? Are some parts of Alberta better than others for growing certain plants for food and fibre? What do these plants need to stay healthy and produce a maximum yield? Finally, what are these plants used for? In this investigation you will answer some of these questions.

What to Do

1. Choose one Alberta plant that is grown for its roots, one that is grown for its stem, and one that is grown for its leaves, fruit, or flower. Using resources in the library or on the Internet, find the following information:
   - The region in Alberta where the plant is grown.
   - How the plant is suited to grow in Alberta.
   - What special environmental conditions, if any, make that area of Alberta better for growing this plant.
   - Whether the environment is changed or enhanced to make it possible to have a more successful crop. (For example, are greenhouses used?)
   - What the plant is used for and who uses this plant.

Analyze

1. Based on your research and the information presented by your classmates, are certain regions of Alberta better suited for growing certain plants?
2. Explain why it is important for a farmer or other person who grows plants to understand a plant's needs as well as the environmental conditions of the area in which the plant will grow.
3. Name two ways that the environment can be altered to enhance the growth of plants.

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus7

Learn more about the crops grown in Alberta by going to the above web site. Click on **Web Links** to find out where to go next. Use the information you find on this site to help you prepare your presentation.

Skill FOCUS

For tips on researching on the Internet, turn to Skill Focus 9.

Did You Know?

The snow willow is the smallest tree in the Rocky Mountains. This woody tree grows in areas where snow remains late in the year. It is only 8 cm tall when fully grown. A willow growing in a river valley can be 10 m high or more. How do you think the snow willow's size is an adaptation to life in the harsh alpine environment?

Career Connect

Sowing and Growing

There are many careers that tie in with plants. A few are noted below. How is each of these careers related to plants? What others can you think of?

crop farmer nursery or lawncare worker landscape gardener

Choose one of these careers or another plant-related career that interests you. What qualities or experience do you already have that might help you in this career? Imagine that you are applying for a related summer volunteer position. What work experience can you list? Do you belong to a club? Have you studied plants on your own, perhaps in your own yard or while on vacation? Perhaps you have items that record your interest or experience: a letter of recommendation, a badge of achievement, a ribbon for growing a prize-winning vegetable. Write a letter outlining why you would be the best candidate for the position.

TOPIC 2 Review

1. Explain the primary function of roots, stems, and leaves using a diagram of a plant.
2. Describe how osmosis works, using the example of a model if you like. Why is osmosis an important process for plants?
3. What is the advantage of having most of the chlorophyll in cells near the top of the leaf?
4. Explain the relationship between the following pairs of words:
   - **(a)** xylem and phloem
   - **(b)** diffusion and osmosis
   - **(c)** chlorophyll and photosynthesis
   - **(d)** root crop and tuber
5. Explain the role of stomata in photosynthesis.
6. Name two Alberta plants that are harvested for their roots, stems, leaves, seeds, or fruit.
7. **Apply** The shape and structure of the leaves of many desert plants reduce their rate of water loss. In cacti, for example, the leaves have been drastically reduced and modified into spines. Many of the adaptations that are found in plants in the desert are also found in plants growing in northern countries. Explain how an evergreen tree has adapted to life in a cold climate.
8. **Apply** In cities with few green spaces, people sometimes have rooftop gardens or patio gardens. How can this improve the air quality?

TOPIC 3

Plant Reproduction and Breeding

Early humans met their nutritional needs by collecting wild plants and hunting wild animals. Eventually people began to grow and tend plants near their home. They even began to adapt plants to meet their needs through selective breeding. **Selective breeding** means that people choose specific plants with particular characteristics and encourage these plants to reproduce. For example, the modern corn plant does not resemble the plant from which it was bred. People encouraged the growth of corn with large "ears" and removed weaker, smaller plants until only the corn that grew large ears remained. They were able to do this because they learned how plants reproduce. In this Topic you will study plant reproduction.

Look at the varieties of apples in Figure 2.25A. Plants are also bred for their ability to withstand certain environmental conditions (hardiness), how much food or fibre they produce (yield), and their resistance to disease. Today, how well a food stores and ships are other factors that may be considered when breeding new plants. Look at the cherries in Figure 2.25. This variety has recently been developed by the Summerland Research Centre in British Columbia. Sweetheart cherries have firm flesh, split-resistant skin, and strong, green stems. Why do you think these are desirable characteristics?

Figure 2.24 Wild roses (top); cultivated roses (bottom)

Figure 2.25A Each variety of apple above has a different taste and use. For example, some are great baking apples, while others are best (and tastiest) eaten raw.

Figure 2.25B Sweetheart, a new variety of cherry.

Find Out ACTIVITY

Apple Varieties

For what characteristics are apples bred?

CAUTION Use thermal gloves or oven mitts to remove pans from the oven.

Materials

knife
baking pan
several varieties of apples
small paper lunch bags (1 per apple)
oven (optional)
thermal gloves or oven mitts

Procedure

1. Make a data table like the one below. Give your table a suitable title. You will be testing your apples for flavour, juiciness, appearance, storage, and other characteristics of your choice.

Apple Variety	Properties Tested				
	Appearance	Flavour		Juiciness	Storage
		Fresh	Baked		

2. Cut the apples into slices. Taste the apples and rate their flavour and juiciness on a scale from 1 to 5 (with a score of 5 being the tastiest or juiciest).
3. If you have access to a stove, test the texture and appearance of apple slices after they have been baked at 200°C for 1 h.
4. Place one of each variety of apple in a small paper bag. Place in a cool place and monitor how well the apples store over one week.

What Did You Find Out?

1. For which characteristics was each apple variety bred?
2. How did apples grown in home gardens or market gardens, differ from apples you bought in the grocery store?
3. Where were most of the apples grown? Are any of the varieties you tested grown in Alberta? in Canada?
4. Does the time of year in which you are doing your study affect the varieties of apples that might be available for testing?

DidYouKnow?

There are over 7500 varieties of apples grown in the world. Approximately over 2500 varieties are grown in North America. How many varieties are there in a supermarket? Why do you think there are so few?

Across Canada

Dr. Thomas Li

In 1992, Agriculture and Agri-Food Canada asked Dr. Thomas Li, horticulturist and plant breeder, to begin developing alternative crops — things besides the traditional crops such as wheat and apples — for the country's farmers to grow. Dr. Li was up to the challenge. Since then he has researched, selected, and introduced to Canada many alternative crops including vegetable soybean, Asian pears, echinacea, ginseng, and winter kiwi.

Dr. Li begins by researching plants that will grow in Canada's environment. He chooses the most appropriate species of a plant, and uses selective breeding to propagate varieties that have desirable characteristics — maximum yield, for example. This new, high-quality plant can then be produced and grown by farmers across the country.

One of Dr. Li's most recent successes is the shrub Indian-Summer, a variety of sea buckthorn originally imported from Russia. It has very high amounts of vitamins A, C, and E in its fruit, protein in its leaves, and medicinal oils in its seed and pulp. Because of its many marketable traits, Dr. Li says it is Canada's "most promising crop right now." So superior is this variety, it is known around the world and grown in every province in Canada.

New Genes?

Canadian research and development teams are responsible for developing canola, a name that comes from the words "Canadian" and "oil." (See Figure 2.26.) Canola was developed using selective breeding and originated from a plant called rapeseed. The new variety yielded seeds that created a good-tasting oil. Work on canola has continued, and breeders have developed canola crops that are resistant to disease, drought, and even certain chemicals.

DidYouKnow?

In Canada, about 20 percent of soybeans, 35 percent of corn, and 50 percent of canola harvested is genetically modified.

Figure 2.26 Canola was developed from rapeseed. Rapeseed oil was in demand during World War II as an engine lubricant. Edible oil from rapeseed was not very successful, however, so breeders created canola. Modern varieties of canola are genetically modified to make them immune to many herbicides.

Plant scientists now have the ability to make changes to plants by going inside an individual plant cell and changing some of its material. They do this by first removing the parts of the cell that control its characteristics. This material is called the genetic material or **genes** of the plant. It is then combined with genetic material from another plant. When this new combination of genetic material is put back into the cell, the cell can be used to start a new plant. This new plant will have characteristics that come partly from one kind of plant and partly from another. This process is usually called genetic modification but is sometimes called genetic engineering.

Other examples of genetically modified plants include grains and fruit that resist viruses; tomatoes that ripen more slowly (resulting in better flavour and colour); rice with high levels of Vitamin A; and peanuts that do not cause allergic reactions in humans.

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus7

Go to the above web site to find out about genetically modified organisms. Click on **Web Links** to find out where to go next. Genetic modification is controversial. Try to find out why and discuss this issue with a partner.

Types of Plant Reproduction

Plants can reproduce in two quite different ways. **Sexual reproduction** involves the production of seeds and fruits from specialized cells of two plants. **Asexual**, or **vegetative reproduction**, occurs when a "parent" plant grows new plants from its roots, stems, or leaves. People use both methods to grow and selectively breed plants.

Vegetative Reproduction

Vegetative reproduction is a useful technique for farmers or gardeners. When a plant reproduces vegetatively, the young plants are identical to the parent. If farmers have a plant with characteristics they like, they can reproduce it knowing that each young plant it produces will have the same characteristics. Many trees spread by producing new plants from their roots.

Growers also use layering, in which plants reproduce from stems. Blackberry, raspberry, and rosebushes can be grown from a parent plant using this technique. A branch of the parent plant is bent down to the ground and part of it is covered with soil (see Figure 2.27). Roots will grow from the buried stem and eventually a new plant will grow. This new plant can then be cut away and replanted.

Figure 2.28 A grafted stem

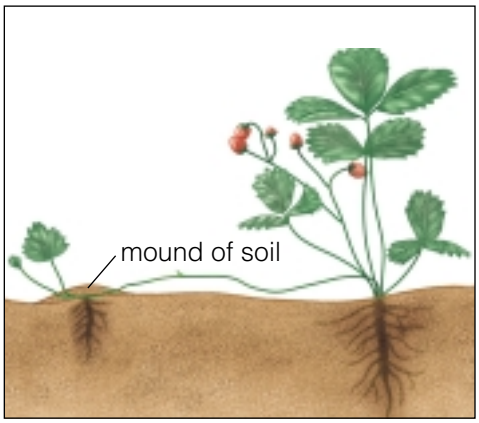


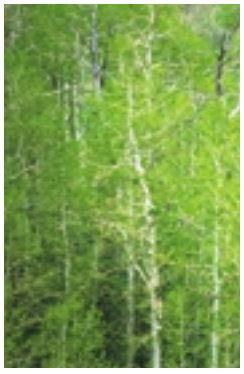
Figure 2.27 A new plant is produced by layering. What advantage does the offspring have by remaining attached to its parent while it develops?

Grafting means to take a branch from one tree and attach it to another tree. This technique is often used with fruit trees and roses (see Figure 2.28). Soon the branch begins to grow on the tree and in several years will produce fruit or flowers.

Plant growers who produce plants commercially will often use cuttings — small sections of leaf and stem cut from a parent plant — to grow new plants. This guarantees that the plants they want to produce will always be the same as the parent plant.

Off the Wall

Trembling aspens reproduce vegetatively by producing new plants from their roots. All the trees in this photograph are part of the same plant. This single male aspen is in the Wasatch Mountains of Utah in the United States. Researchers estimate that this plant has been growing for tens of thousands of years. In the fall you can tell which trembling aspen belong to the same plant because their leaves always turn colour at exactly the same time.



INQUIRY

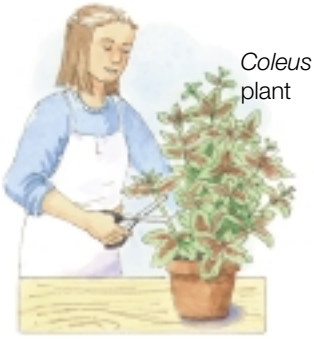
INVESTIGATION 2-E

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Grow a Plant from a Cutting

What are the best types of cuttings to take? Find out in this investigation.



Coleus plant

Your cutting should include two to three leaves.

Problem

How well will plant cuttings with one leaf, two leaves, three leaves, and no leaves grow?

Hypothesis

Make and test a hypothesis about how well different types of cuttings taken from a parent plant will grow.

Apparatus

scissors (or utility knife)
ruler
small flowerpot or plastic cup

Materials

4 plastic cups
labels (or grease pencil)
aluminum foil
several large *Coleus* plants
water

Procedure

1. Prepare a table to record your results.

Cutting	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
No leaf						
1 leaf						
2 leaves						
3 leaves						

2. Label each cup with your name, the cutting type and fill the cup with water. Cover the top of the cup with foil, and use a pencil to punch a small hole in the centre of the foil.
3. Use the scissors to take four small cuttings about 5 cm long. Take one cutting with no leaves, one with one leaf, one with two leaves, and one with three leaves. Ensure that your group's cuttings all come from the same plant.
4. Insert the cut end of the cuttings through the hole in the foil, ensuring the bottom 3 cm of the cutting dips into the water.
5. In the table, **record** the date, and **draw** the cut end of each cutting.
6. **Observe** any changes in the cuttings each day for the next week.
7. **Record** the date in your table when you first see roots, and draw what you see. Repeat this in two or three more days. Use your ruler to **measure** root growth. With your group, decide when the cuttings are ready to plant in potting soil.

Analyze

1. Compare cuttings taken from the same plant with other groups. In what ways are they similar? In what ways are they different?

Conclude and Apply

2. Explain how leaves affect root growth.
3. What advantage might there be to planting the cuttings in soil rather than leaving them in water?

Seed Plant Reproduction

In vegetative reproduction, plants produce new plants identical to themselves. In sexual reproduction — when plants reproduce using seeds — however, the resulting plants are all slightly different from their parents. These differences help plants to adapt to changes in their environment.

Cones

Figure 2.29 Cones come from a variety of conifers, not just pine trees.

Have you ever collected tree cones in the fall? The **cone** is the part of the tree that has a series of woody scales. Cones come in different shapes and sizes and many cone-bearing trees can be identified by their cones (see Figure 2.29).

Pine trees and other cone-bearing trees produce male and female cones. Female cones contain **ovules** (eggs); they are in the small bumps you see at the end of the scale in a cone. Pollen grains containing sperm develop on the smaller male cone. Wind carries pollen grain to the female cones. At certain times of year you can even see wafts of yellowish pollen floating through the air.

Most of this pollen never reaches the female cones because the wind blows it onto other plants, water, and the ground. When a pollen grain does get blown between the scales of a female cone of the same species, it gets caught in a sticky fluid near the ovule (see Figure 2.30). A pollen tube then grows down from the pollen grain to the ovule and sperm swims down the pollen tube and fertilizes the egg. As a result, the tiny fertilized seed begins to grow. The process of pollen travelling to the female cone is called **pollination**.

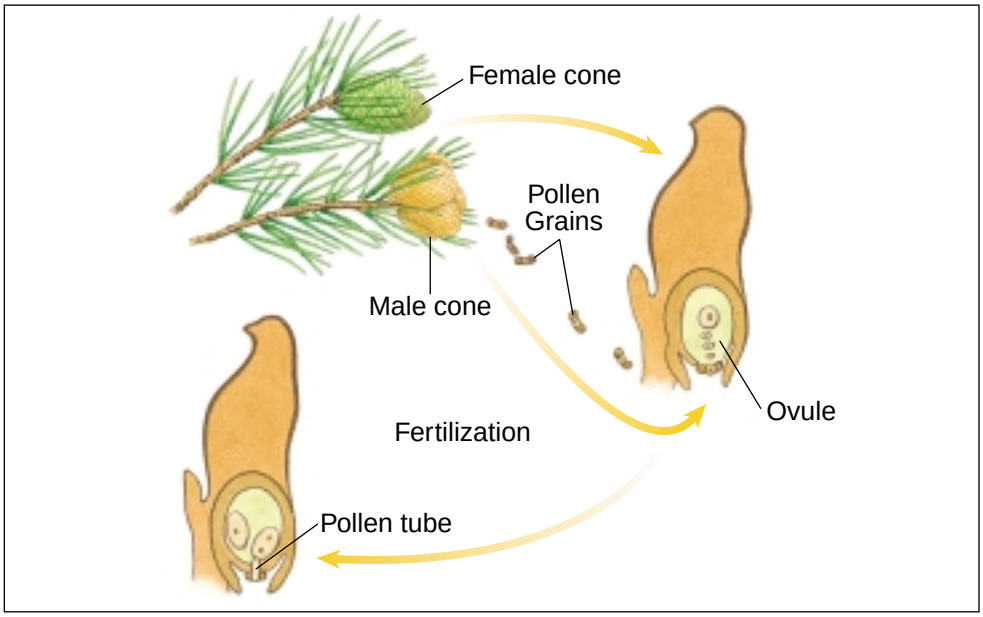


Figure 2.30 Fertilization in pine trees

Female cones of pine trees mature, open, and release their seeds during the fall or winter months. It may take a long time for seeds to be released from a pine cone. From the moment a pollen grain falls on the female cone until the time the seeds are released takes at least two years, depending on the species. Once seeds are released from a pine cone, they can be carried away, eaten, or buried by animals. The buried seeds will eventually sprout and grow into new pine trees.

STRETCH Your Mind

There are over 285 000 plant species that produce flowers. Approximately 20 000 of these are found in Canada. What percentage of the world's flowering plants are found in Canada?

Flowers

Flowers also play an important role in sexual reproduction. Large flowers with bright-coloured petals often attract insects and other animals. These animals pollinate the flowers while feeding on the flower's nectar and pollen. Flowers aren't all large and showy as you can see in Figure 2.31. Flowers that aren't brightly coloured often depend on wind to spread their pollen. Their petals may be small, or they may have no petals at all. Flowers that open at night often have strong scents to guide insects and other pollinators to them (see Figure 2.32).

Figure 2.31 Why do you think there is such variety among flowers?

Figure 2.32 Some flowers bloom at night. Those that do are usually light coloured or white, and they also have a strong scent. Aside from bats, what other animals might pollinate plants at night?

Parts of a Flower

As you read this paragraph, look at each numbered part in the diagram. Most flowers have male and female parts that are needed for reproduction. The male part is called the **stamen** (1) and the female part is known as the **pistil** (2). The stamen and pistil are surrounded by petals and sepals. **Petals** (3) are usually the brightly coloured parts of the flower. They are the flower's banner to advertise its tasty nectar or pollen. **Sepals** (4) are usually green and are underneath the flower. They protect the flower before it opens. When you look at a flower bud, you usually can see the sepals enclosing the tightly bound petals.

When you look in the middle of a flower, you can see most parts of the pistil and the stamen. The pistil has three main parts. The sticky tip is called the **stigma** (5). The tube connecting the stigma and ovary is called the **style** (6). At the bottom of the style is a tiny chamber called an **ovary** (7). Inside the ovary is the plant's ovule (eggs)(8). Each stamen has two parts, a stalk called the **filament** (9) and a tip called the **anther** (10). The anther produces pollen (11). The number of stamens on a plant can vary.

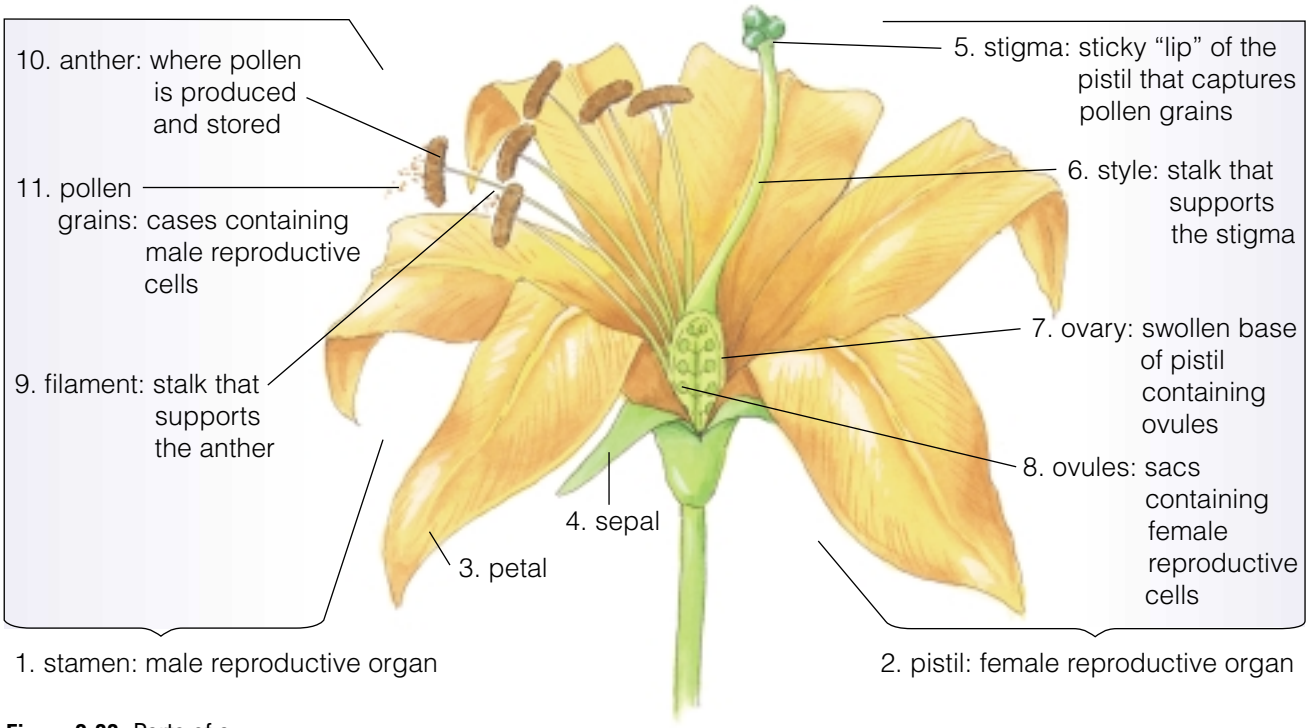


Figure 2.33 Parts of a flower

Pause & Reflect

Flowers function to attract specific insects or other animals (such as hummingbirds). Think of some flowers you know and predict what type of insects or other animal pollinates them. For example, flowers with long tubelike flowers are pollinated by insects with long "tongues," such as butterflies.

Find Out ACTIVITY

The Role of the Flower

Most flowers contain both male and female reproductive parts. In this activity, you will identify the parts of the flower that have a role in reproduction: stamen, anther, filament, pollen grains, pistil, stigma, style, ovary, petals, and eggs.

Materials

a flower
dark-coloured paper
pencil
magnifying glass
paper

Procedure Performing and Recording

1. Make a sketch of your flower showing the different parts.
2. Make a table with the following headings.

Name of part	Location of part	Function of part

3. Refer to Figure 2.33 as you examine your flower and complete your table.
4. Examine the stamens. Remove one anther and brush it against a piece of dark-coloured paper. Use the magnifying glass to observe the pollen grains.
5. Locate the pistil. Look for its three parts. Break open the ovary and look for the ovules (eggs).
6. Without referring to your table or textbook, label as many reproductive parts as you can on your diagram. Include a short definition of each part.

What Did You Find Out? Analyzing and Interpreting

1. How similar was your flower to Figure 2.33? How did it differ?
2. **(a)** What features of the stigma make it suited for capturing pollen grains?
   (b) What features of the pollen grain make it suited for being brushed off on insects or blown away by air currents?
3. Where do you think the seeds are formed?

Skill Focus

For tips on making a scientific drawing, turn to Skill Focus 11.

Off the Wall

Corn on the cob is actually the giant female flower of the corn plant. On the corn plant, the male pollen-making flowers are at the top of the plant. The large "tassel" on the corn are the stamens. (One corn plant can produce 50 million pollen grains!) The female flowers are lower down on the stalk and appear to be dense clusters of succulent strands of corn silk. These are the stigma of a long pistil. Each long strand ends at an ovule, an immature seed. If a pollen grain lands on the tip of a strand of silk, the pollen will grow down and fertilize the ovule at its base, creating a seed. The seeds that have been fertilized are the plump kernels that you eat. The ovules that are not fertilized remain small and undeveloped.

DidYouKnow?

To produce alfalfa seed, farmers require the help of the alfalfa leaf-cutter bee. No other bee is able to open the alfalfa flower and successfully pollinate it.

Pollination

Pollination can happen in several ways. Some plants, such as wheat and barley, self-pollinate. This means the sperm fertilizes the eggs in the same plant. In cross-pollination the eggs of one plant are fertilized by sperm from another plant of the same species. In the wild, cross-pollination can occur when the wind or animals carry pollen from one flower to another. Figure 2.34 shows what happens once the pollen grain lands on a stigma.

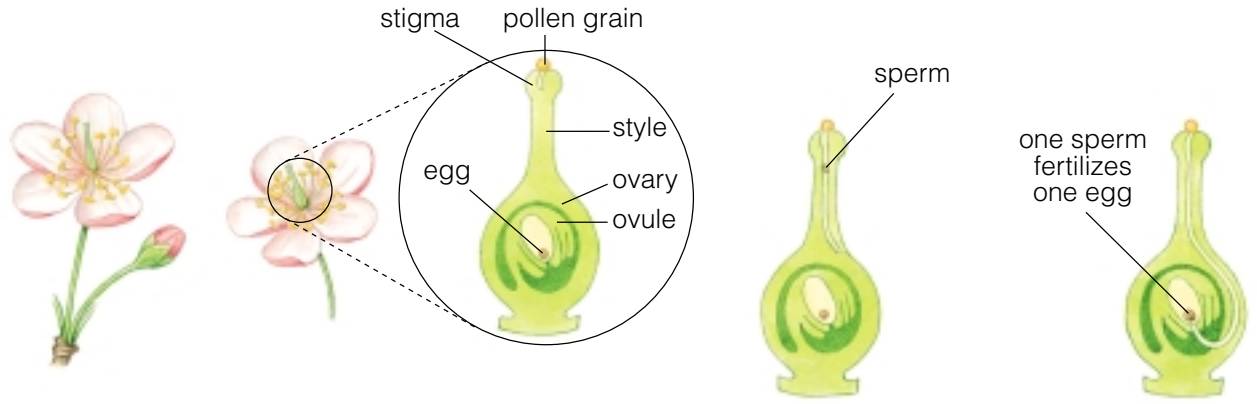


Figure 2.34 Seed formation

Figure 2.35 A bee's work of spreading pollen is so important that some farmers put hives in orchards, fields, and gardens so the bees and flowers can be close together.

For farmers who depend on pollination to produce fruits and vegetables, one pollinator stands out above the rest — the bee. Bees pollinate more crops than any other insect. Each time a bee visits a flower in search of nectar and pollen, some pollen gets caught in the hair on its body. The bee spreads this pollen from flower to flower. Without bees, farmers would produce one-third less fruits and vegetables than they do today.

Artificial pollination can also be used to breed varieties of plants for specific purposes. In many cases, the plant breeders are trying to produce a crop that has a better yield or that is resistant to environmental conditions such as cold winters. For example, people believed that cold temperatures killed seeds. Recent scientific research indicates that it is long exposure to these cold temperatures that kills seeds, not the temperatures alone.

From Seed to Fruit

Once a plant has been pollinated, a seed is formed (see Figure 2.36). Inside the seed is a tiny living plant called an **embryo** and a food reserve to keep it alive. The plant and its food are protected inside a seed coat. Some seeds stay alive only a few days after they mature. Other seeds need a rest or dormant period before they sprout. In what environment would you expect seeds to be adapted to surviving long periods of time without sprouting?

DidYouKnow?

The record for the longest-lasting seed is held by the Arctic lupine. Its seeds were sprouted (and one even flowered) after being frozen underground for 10 000 years!

Fruit

When you bite into a pear, or peach, or slice of watermelon, have you ever thought about the function of fruit for a plant? A **fruit** is the growing ovary of the plant that swells and protects the developing seeds of a plant until they are ripe. You know that apples, raspberries, and cherries are fruits, but so are cucumbers, green beans, tomatoes, and pumpkins. They all have seeds inside them, so they are all fruits. Not all fruits can be eaten — at least by humans. A cotton boll is a fruit, for example. Can you think of others?

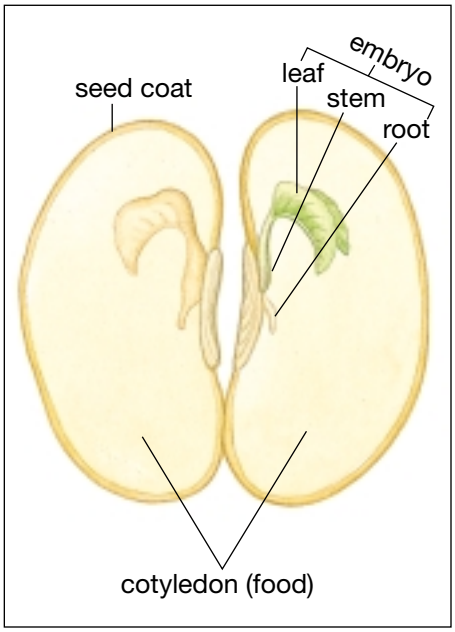


Figure 2.36 The seed is a plant in storage. What conditions do you think it needs to be able to grow?

Find Out ACTIVITY

Inside Seeds

What's inside a seed? To see for yourself, complete this activity.

Materials

dried lima beans
water
jar or a glass
magnifying glass

Procedure

1. Observe a dried lima bean. Try to remove its outer coating or break it open with your finger.
2. Soak two lima beans in a jar of water overnight.
3. Remove the beans from the water. Sketch and label the part of the bean you can identify.
4. Peel off the outer coat of the seed and carefully break the seed into two halves. Sketch and label the parts of the bean you can identify.

What Did You Find Out?

1. Which takes up more space — the seed, the embryo, or the plant's food?
2. How did water affect the seed? What role do you think water might play in growing a plant from a seed?

Find Out ACTIVITY

Classifying Fruits

There are many different kinds of fruits. Some, like peaches and apricots, contain just one big seed. Others, like watermelon, pumpkins, and peas have many seeds inside them. Some fruits are soft, such as apples and oranges, and others like acorns or walnuts are hard. In this activity you will take a look at different kinds of fruits and the seeds inside them to develop a useful classification system.

Materials

6–10 different fruits such as apples, squash, beans, tomatoes, blackberries, grapes, or cucumbers.

paper — pencil

knife — magnifying glass

Safety Precaution

Use care when handling sharp knives. Always be sure to cut away from you and use a cutting board or other surface to protect the counter or desk.

Procedure

Performing and Recording

1. Read over the instructions and prepare a data table to record your observations. Be sure you leave space for labelled diagrams.
2. Take a close look at your collection of fruits. Can you tell which end of the fruit was attached to the plant? Record your observations using labelled diagrams.
3. Cut open the fruits. Observe how the seeds are arranged. How many seeds does each fruit have? Some fruits have so many seeds that you can't count all of them. Count the seeds in one section and estimate the number of seeds in the whole fruit.
4. Use the magnifying glass to observe the seeds closely. Sketch the different type of seeds.
5. Measure the size of each type of seed.
6. With your group, review your observations and classify the fruits into groups. You might use shape, size, number of seeds, colour, or any other categories that might work for your collection of fruits.

What Did You Find Out?

Analyzing and Interpreting

1. Why do you think some fruits have so few seeds and some have so many?
2. When you cut open your fruit, did you see any ovules that were not fertilized? How could you tell?
3. Does a large seed always mean the plant has a large fruit? Explain your answer using the data you collected in this activity.
4. Do you think your classification system for fruits would be useful? If so, explain how it could be used. If not, explain what further information or questions you would need to answer to make it useful.

DidYouKnow?

The size of a seed is no clue to how big the plant will be. The tallest plant in the world, the giant redwood, starts out as a seed smaller than your thumbnail.

Seed Dispersal

How do seeds get from the flower to the ground so they can begin to grow? In many plants, the fruit helps in the seed's dispersal. Dispersal is the transport of seeds away from the parent plant. Figure 2.37 shows some ways that seeds are dispersed.

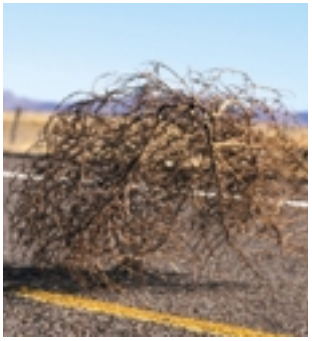


Figure 2.37A After flowering, tumbleweeds snap off at their roots in strong winds and bounce along at speeds of up to 80 km/h, spreading their seeds as they go!

Figure 2.37B Coconuts grow on palm trees that drop their fruits into rivers or the sea. This enables the young palms to sprout thousands of kilometres away from where they started.

Figure 2.37C Some seeds pass almost unchanged through fruit-eating birds and bats. In this way they can be sown many kilometres from the parent plant. Feces, which is full of nutrients, will help the seed grow.

Off the Wall

Have you ever eaten a seedless grape? How are these grapes produced? Growers manipulate the plant by changing special chemicals, called hormones, as the plant grows. The chemical stops the seed from growing when it is tiny, and the fruit around the seed continues to grow to a normal size without seeds that you can notice.

Figure 2.37D Seeds such as burdock may "hitch a ride" on the furry coats of mammals, where they stick until they are rubbed off or removed.

Figure 2.37E The seeds of the lodgepole pine are sealed inside the cone by sticky pitch. Fire or intense heat is required to release the seeds. This is why lodgepole pine is usually the first tree to grow after a forest fire.

Figure 2.37F Seeds, such as these milkweed seeds, are blown about by the wind.

Figure 2.38 Combines gathering grain

Spreading and Harvesting Seeds in the Field

Farmers use machines to spread seeds. Seeds from field crops such as wheat, canola, and barley are usually harvested in two steps. First, a swather cuts the plants about 10–20 cm from the ground and lays them in rows in the field. The stubble (the part of the plant still in the ground) keeps the plants off the soil so that seeds can ripen further. Once the seeds are dry enough, a combine separates the grain from the rest of the plant. If the seeds are ripe and dry enough, both of these operations can be done at the same time.

The combine in Figure 2.38 carries out several steps. The machine first picks the grain off the ground. Next, the seeds are separated from the straw. The straw is then baled or spread evenly over the field.

Germination

Once the seed is dispersed and reaches the ground, it stays inactive until conditions are right for its growth. **Germination** is the development of a seed into a new plant. Study Figure 2.39 to see how a bean seed germinates and grows into a young plant. When the young bean plant grows and develops its own flowers, it is mature and ready to produce the next plant generation.

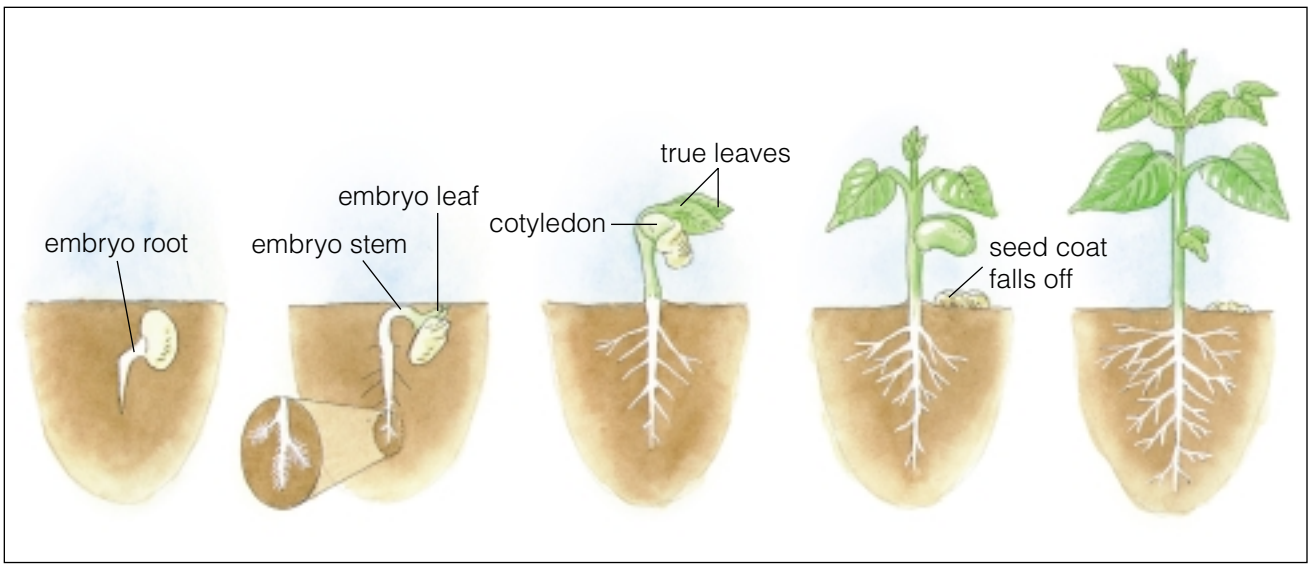


Figure 2.39 Germination of a bean seed.

INQUIRY

INVESTIGATION 2-F

Speeding Up Germination

Many factors in the environment can affect the germination of seeds. Among these are soil temperature, air temperature, moisture content of the soil, and salt content of the soil. What happens to the germination rate when one of these variables is changed?

Question

How does seed germination vary with environmental changes?

Hypothesis

Make and test a hypothesis about how seeds germinate when one environmental factor changes.

Safety Precautions

Wash your hands after working with soil.

Apparatus

plant trays or plastic cups
thermometer
seedling warming cables (optional)
graduated cylinder
250 mL beakers
ruler

Materials

bean seeds
distilled water
salt
potting soil
paper towels
other materials of students' choice

Procedure

1. List the steps that you need to take to test your hypothesis.
   Describe:
   – the variable you will test
   – the measurements you will take
   – the data you will collect
   – the frequency of data collection
2. List your materials. If you need a data table, design one.
3. Have your teacher approve your procedures and materials.

4. Set up the experiment. You will need to **observe** your experiment over several days.

Skill FOCUS

For tips on designing your own experiment, turn to Skill Focus 6.

For tips on making graphs and data tables, turn to Skill Focus 10.

Analyze

1. What are the controlling variables in your experiment? What is the responding variable?
2. Graph your results using a bar graph, placing the growth on the *y*-axis and the environmental variable on the *x*-axis.

Conclude and Apply

3. What happened to the germination of your seeds when you changed a variable?
4. Discuss experimental results and compare graphs with other students in your class who changed a variable that was different from the one you changed. What are the best conditions for germinating bean seeds?

Helping Plants Grow

As you have seen, there are many steps involved in producing seeds and fruit, and ultimately growing a crop. There are many stages at which a new plant might have a problem that might prevent its reproduction. For example, birds might eat seeds before they can germinate, or there might be a drought, preventing the seed from sprouting. Perhaps there is a cool spring and very few bees are around to pollinate flowers. How might growers help to prevent these problems during the plant's life cycle?

Materials

large sheets of paper felt pens

Procedure

Performing and Recording
Communication and Teamwork

1. As a group, draw the life cycle of a plant on the large sheet of paper.

Find Out ACTIVITY

2. Brainstorm some problems that a growing plant might have that will prevent it from completing its life cycle.

3. Do some research in the library or on the Internet to determine how farmers and fruit growers try to ensure that their crop survives. You could also get information directly from farmers or growers, or from garden shops.

What Did You Find Out

Analyzing and Interpreting

1. Describe three situations in a plant's life cycle that may prevent it from completing its life cycle.

2. Explain how people can help ensure that plants will grow.

Looking Ahead

Keep careful notes on what you have learned in the previous two activities. Think about how you could use your knowledge to complete your Unit 2 Project, Get Growing!

TOPIC 3 Review

1. Give two examples of how growers can use vegetative reproduction to cultivate plants.

2. Explain how keeping bees might help a farmer.

3. Describe two problems a plant might encounter during reproduction. Explain how growers might intervene in the plant's life cycle to solve these problems.

4. **Apply** When you go to a grocery store to buy apples, how do you choose your fruit? List characteristics of apples that you want to buy. What are characteristics of apples that are less appealing? Imagine that you are an apple grower participating in a research project to breed new varieties of apples. How would your list of desirable and less desirable characteristics of apples affect your research goals? Write a question your research will investigate based on consumer demands.

5. **Thinking Critically** A corn plant produces thousands of pollen grains on top of the plant in flowers that have no odour or colour. The pistils grow from the cob lower down on the plant. Write a hypothesis for how a corn plant is probably pollinated.

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

fibre
taproot
root hairs
fibrous roots
diffusion
differentially permeable
osmosis
chlorophyll
photosynthesis
transpiration
respiration
selective breeding
genes
sexual reproduction
asexual reproduction
vegetative reproduction
ovules
pollination
stamen
pistil
petals
sepals
stigma
style
ovary
filament
anther
embryo
fruit
germination

Reviewing Key Terms

1. In your notebook, fill in the blanks in the sentences below.

(a) _____ is the loss of water from a plant by evaporation. (2)

(b) The large, single root in a plant is called the _____. (2)

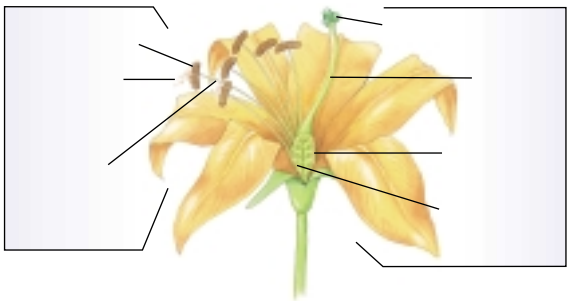
(c) _____ is a type of diffusion that occurs when two solutions are separated by a barrier through which only some materials can pass. (2)

(d) _____ is the tissue of plants from the stem, leaves, seeds, or roots. (1)

(e) In _____ _____ a grower chooses and breeds plants with particular characteristics. (3)

(f) Layering is a form of _____ reproduction. (3)

2. Copy these terms into your notebook: pistil, stigma, style, ovary, ovule, stamen, filament, and anther. Briefly describe the role of each part of the flower. (3)



3. Describe how water moves through a plant using the terms diffusion, osmosis, root hairs, and transpiration. (2)

Understanding Key Concepts

4. Describe two functions of each of the following plant parts: roots, leaves, stem, and flowers. (2)

5. List four plants grown in Alberta that are used for food and/or fibre. Which part(s) of each plant is (are) used? (1, 2, 3)

6. Describe three ways that plants can reproduce asexually. (3)

7. List three ways, other than as food, that Aboriginal people used plants. (1)

8. What adaptations of dandelions make them such difficult plants to get rid of? (2)

9. Describe the process of photosynthesis. Use sketches or equations if you wish. (2)