Chapter 13: Plants: Uses, Form, and Function
What is the structure and function of plant organs?

Chapter 14: Plants: Reproduction, Growth, and Sustainability
Bales of straw (dried grain stalks or stems) can be used for support and insulation in the construction of new homes. It is renewable on a short time scale, relatively inexpensive, easily available, and it is an excellent insulator.
13.1 Plants as Valuable Bioresources

Plants provide many services and act as a source of life-sustaining materials, processes, and recreation.

Ecosystem services include:

- photosynthesis
- source of food and habitat
- prevention of erosion

Human services include:

- a cellulose source
- a source of biochemicals
- a fuel source
- a recreation and ecotourism resource
Photosynthesis produces glucose and oxygen gas.

- Glucose is the food that supplies plants and consumers with energy to perform activities.
- Plants use some of the oxygen they produce for cellular respiration, but most of it is released into the atmosphere for other organisms to use.
Plants Supply Cellulose

Cellulose, a large and complex carbohydrate, is the main component in the cell walls of plants.

- Humans use cellulose to make fabric (textiles), paper, and cardboard.
- Wood (including timber for construction) is the most popular building material in the world.
- The heat generated when plant material such as wood is burned comes from the chemical energy stored in cellulose.
Plants Supply Food

Agriculture refers to farming or forestry practices that produce food and goods. Humans consume about 150 of Earth’s 50,000 edible plants. However, the average individual diet is made up of about 20 crop plants. Plants that make up the majority of calories consumed by humans are:

- wheat
- rice
- corn
- sugar cane
- potatoes
- sugar beets
- soybeans
- barley
Canadian Agriculture

The agricultural industry provides Canada’s economy with both food and jobs. 15% of Canadian jobs are related to agriculture or agricultural products for home use or export.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Production (thousands of tonnes)</th>
<th>Food Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>28,611</td>
<td>flour used to make pasta, bread, cereal, cakes, and cookies</td>
</tr>
<tr>
<td>Canola</td>
<td>12,642</td>
<td>canola oil</td>
</tr>
<tr>
<td>Barley</td>
<td>11,781</td>
<td>can be added to soups, salads, and stews</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flour used to make baked goods</td>
</tr>
<tr>
<td>Grain corn</td>
<td>10,592</td>
<td>cornmeal, cereal, and tortilla chips</td>
</tr>
<tr>
<td>Oats</td>
<td>4,272</td>
<td>oatmeal and oat bran</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flour used to make cereal, muffins, and cookies</td>
</tr>
<tr>
<td>Peas</td>
<td>3,571</td>
<td>eaten alone or in soups, salads, and stews</td>
</tr>
<tr>
<td>Soybeans</td>
<td>3,335</td>
<td>soybeans, tofu, and soy milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flour used to make baked goods</td>
</tr>
<tr>
<td>Lentils</td>
<td>1,043</td>
<td>eaten alone or in soups, salads, and stews</td>
</tr>
<tr>
<td>Flaxseed</td>
<td>861</td>
<td>flaxseeds and flaxseed oil</td>
</tr>
<tr>
<td>Rye</td>
<td>316</td>
<td>flour for cereal, bread, and other baked goods</td>
</tr>
</tbody>
</table>
For thousands of years, Aboriginal farmers planted the “three sisters” (corn, climbing beans, and squash) together because they benefit each other. The corn provides a vertical structure for the beans; the bean plants decay after harvest and release a useable form of nitrogen (eliminating the need to fertilize); and the squash provides ground cover and protects the other two plants against dehydration and weeds.
Food security is the state in which all people, at all times, have access to enough safe and nutritious food to meet their dietary needs and preferences and are able to lead active and healthy lives. As the world’s population increases, food security is becoming a concern.

### Farming Solution

<table>
<thead>
<tr>
<th>Monoculture</th>
<th>Benefits</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>simplified crop management; fertilizer</td>
<td>depletes soil nutrients; increases need for pesticides; crops are vulnerable to disease</td>
</tr>
<tr>
<td></td>
<td>increases crop yield</td>
<td></td>
</tr>
<tr>
<td>Sustainable</td>
<td>rotating crops maintain soil; natural</td>
<td>harder to meet needed food quantities; more expensive; appearance of food may be less uniform</td>
</tr>
<tr>
<td>Agriculture</td>
<td>predators keep pests under control; hand-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pulling weeds reduces fuel use and creates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>jobs</td>
<td></td>
</tr>
</tbody>
</table>
Plant chemicals serve plants, for example, by attracting pollinators or repelling threats, but the chemicals are also useful to humans, particularly for medicinal purposes. For example:

- The bark and leaves of willow trees contain a compound that helps relieve pain.
- Blackberry tea can treat diarrhea.
- Evergreen bark and needles make a tea rich in vitamin C.

(A) The rosy periwinkle is the source of breakthrough medicines that have changed the survivor rates for some cancers. This plant is at risk from the effects of deforestation. Herbal plants such as ginseng (B) and goldenseal (C) are the sources of natural remedies that are available without a prescription. Ginseng is used to improve the function of the immune system. Goldenseal is used to fight colds and to treat sore gums and sore throats.
Plants Supply Fuel

There are many ways to use plant material (biofuel) to produce energy for heating and cooking:

- burning wood
- burning coal, formed over millions of years from partially decomposed plant material buried deep below Earth’s surface
- burning biofuels (renewable crops)
Plants play a key role in controlling erosion and reducing the negative effects of flooding, as well as keeping water in the soil, and preserving topsoil.
Plants are an important part of environments that humans rely on for recreational and educational use. People come from around the world to enjoy the ecotourism industry of Canada.

Plants Provide Opportunities for Recreation and Ecotourism

Hiking in the deciduous forests of Ontario is a pastime enjoyed by many Canadians.
### Section 13.1 Review

#### Plants as Valuable Bioresources

For thousands of years, humans have used plants as sources of food, fibres, fuel, and medicines.

**KEY TERMS**
- agriculture
- biofuel
- cellulose
- food security
- photosynthesis
- sustainable agriculture
- textile
- timber

**KEY CONCEPTS**
- Plants are important because they transform the Sun’s energy into glucose and release oxygen into the atmosphere through the process of photosynthesis.
- Cellulose is an important molecule found in the cell walls of plants, and it is used by humans in many ways.
- Plants are a source of food, fibres, building materials, biochemicals, fuel, flood and erosion control, recreation, and ecotourism.
13.2 The Vascular Plant Body

Vascular plants have two organ systems: shoots and roots.

Shoot system:

• above ground
• stems provide structural support and bear the reproductive structures
• leaves perform photosynthesis
The Vascular Plant Body

Root System:
• below ground
• roots anchor the plant
• roots absorb the water and minerals required
Plant Cells

Typical plant cells have some structures that animal cells do not:

- a cell wall to provide support
- a large central vacuole to store materials such as food and enzymes
- chloroplasts to enable photosynthesis
Plant Cell Types: Parenchyma Cells

- flexible, thin-walled spherical cells found throughout the plant
- cell walls flatten when packed together
- vary greatly in structure and function

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Example</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parenchyma [pah-RENG-keh-muh]</td>
<td>With chloroplasts</td>
<td>• storage</td>
</tr>
<tr>
<td></td>
<td>Without chloroplasts</td>
<td>• photosynthesis</td>
</tr>
<tr>
<td></td>
<td>Magnification: 50×</td>
<td>• gas exchange</td>
</tr>
<tr>
<td></td>
<td>Magnification: 350×</td>
<td>• protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• tissue repair and replacement</td>
</tr>
</tbody>
</table>
Plant Cell Types: Collenchyma Cells

- often elongated and occur in long strands or cylinders to provide support
- growth pattern of unevenly thickened walls allows for flexibility

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Example</th>
<th>Functions</th>
</tr>
</thead>
</table>
| Collenchyma [kohl-ENG-keh-muh] | ![Cell Wall](image) | • support surrounding tissues  
• provide flexibility for plant  
• tissue repair and replacement |

Magnification: 100×
Plant Cell Types: Sclerenchyma Cells

- contain lignin in secondary cell walls, which makes them strong
- most die once they have completed growth; primary function is support
- two types:
  - sclereids are short with an irregular shape; distributed randomly
  - fibre cells are needle-shaped; form tough, elastic tissue when stacked end-to-end

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Example</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sclerenchyma</td>
<td>Fibres</td>
<td>• support mature plant</td>
</tr>
<tr>
<td>[skleh-RENG-keh-muh]</td>
<td><img src="image1.png" alt="Magnification: 50x" /></td>
<td></td>
</tr>
<tr>
<td>Sclereids</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Magnification: unavailable" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plant Tissues

Plants have four main types of tissue:

- **Meristematic**: areas where new cells are produced by mitosis
- **Dermal**: outer layers of cells that form a protective covering
- **Ground**: multi-functional tissue inside a plant; includes all three types of cells (parenchyma, collenchyma, sclerenchyma)
- **Vascular**: internal system of tubes that transports water, minerals, and other substances; two types are xylem and phloem
Meristematic tissue is undifferentiated embryonic plant tissue from which all other tissues develop. Meristems are areas of rapidly dividing cells found where primary growth occurs, such as the tips of roots and stems (apical meristem) and along stems and at the base of leaves (intercalary meristem). Secondary growth, an increase in the circumference of roots and stems, results from the division of cells into two types of lateral meristems: in the vascular tissue of stems and roots (vascular cambium) and in the tough cell walls outside of some stems and roots (cork cambium).
Plant growth results from the cells produced by the meristematic tissues. Stems and roots increase in length due to the division of cells in the apical meristems and the subsequent lengthening of cells. The vascular cambium and the cork cambium are meristematic tissues that increase the diameter of roots and stems.
Dermal tissue makes up the outer covering of the plant and includes the primary growth epidermis (a single layer of cells in non-woody and young woody plants) and secondary growth periderm (found in mature woody plants). Specialized epidermal tissue includes paired guard cells that surround a stoma, root hairs that increase surface area to aid absorption, and trichomes that cool surfaces and prevent evaporation.

Guard cells regulate the size of stomata, which allows gas exchange. On hot and/or dry days, stomata are closed in order to avoid too much water loss.

Trichomes (A) and root hairs (B) are specialized extensions on epidermal cells.
Ground tissue forms most of the plant’s internal and external material with all cell types. Ground tissue functions include storage, photosynthesis, and support. In some stems, roots, and seeds, ground tissue cells store starch and oils.

What are the three types of cells that make up ground tissue?
Vascular Tissue

Vascular tissue is made up of tubes that run throughout the stems, connecting roots and leaves. It transports water and dissolved substances. **Xylem** transports water and minerals from roots to leaves. **Phloem** transports sugars to where they are needed, often from leaves to the roots for storage.

In non-woody plants, the vascular bundles (xylem and phloem) are randomly arranged, whereas in woody plants they are arranged concentrically.
A Closer Look at Xylem

In gymnosperms, xylem consists of cells called *tracheids*. In angiosperms, xylem consists of two types of cells: tracheids and *vessel elements*. Both types of cells die at maturity, leaving their walls as continuous tubes that can be used for transport.

Vessel elements are long, continuous tubes formed from dead, hollow, cylindrical cells arranged end to end. Tracheids are dead cells that taper at the ends and overlap one another.
A Closer Look at Phloem

Phloem consists of two types of cells: *sieve tube elements* and *companion cells*. Both types are alive at maturity, but sieve tubes do not have nuclei. (Each sieve tube cell has a companion cell that carries out life functions for both.) Phloem transports food (sugars).

Companion cells and sieve tube elements make up phloem. Food produced in the leaves of plants is carried to the rest of the plant through the phloem.
### Section 13.2 Review

#### The Vascular Plant Body

**Vascular plants have specialized tissues and cells that perform many functions needed for growth and survival.**

<table>
<thead>
<tr>
<th>KEY TERMS</th>
<th>KEY CONCEPTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>dermal tissue</td>
<td>• Different types of plant cells include parenchyma cells,</td>
</tr>
<tr>
<td>epidermis</td>
<td>collenchyma cells, and sclerenchyma cells.</td>
</tr>
<tr>
<td>ground tissue</td>
<td>• Meristems are areas of rapidly dividing cells that can develop into</td>
</tr>
<tr>
<td>guard cell</td>
<td>different types of specialized cells throughout the plant.</td>
</tr>
<tr>
<td>meristematic tissue</td>
<td>• The outer covering of a plant is called the epidermis and is made up of</td>
</tr>
<tr>
<td>phloem</td>
<td>dermal tissue.</td>
</tr>
<tr>
<td>root hairs</td>
<td>• Plants are made up mostly of ground tissue.</td>
</tr>
<tr>
<td>root system</td>
<td>• Vascular tissue is an internal transport system that runs throughout the</td>
</tr>
<tr>
<td>shoot system</td>
<td>plant, carrying water and dissolved nutrients and minerals.</td>
</tr>
<tr>
<td>stoma</td>
<td></td>
</tr>
<tr>
<td>xylem</td>
<td></td>
</tr>
</tbody>
</table>
13.3 Plant Organs and Their Functions

There are three plant organs:

- roots
- stems
- leaves

Together they work to absorb water and minerals from the ground and take in carbon dioxide and light from above.
Plant Tissues

Root morphology depends on how the roots must extend to access water in the soil. Roots:

- take in and transport water and dissolved minerals
- anchor the plant
- store carbohydrates made during photosynthesis

The tip of a root is covered by a **root cap** made of parenchyma cells that:

- protect the growing root
- secrete a slimy substance to reduce friction while growing

Under the tip, the apical meristem cells differentiate into the various cell types.
Root Structure and Function

The first layer of outer dermal cells is the epidermis, which has root hairs that maximize the surface area that absorbs water. Water then moves to the cortex, which transports substances between the vascular tissue and epidermis. The next layer is the endodermis, which is surrounded by a waterproof band that controls the absorption of water and minerals.

Continued...
Root Structure and Function

Inside the endodermis are the vascular bundles. The arrangement of the bundles depends on whether the plant is a monocot or a dicot.

In monocot roots (A), xylem tissue forms a ring around the pith. In dicot roots (B), xylem tissue forms a central star or X shape.
In addition, some aquatic plants have **aerenchyma**, a special tissue in their roots that has large air spaces through which oxygen can move.

### Types of Root Systems

<table>
<thead>
<tr>
<th>Type</th>
<th>Example</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taproot</td>
<td><img src="image1.png" alt="Taproot Image" /></td>
<td>- anchors plant&lt;br&gt;- absorbs water and minerals&lt;br&gt;- food and water storage</td>
</tr>
<tr>
<td>Fibrous root</td>
<td><img src="image2.png" alt="Fibrous root Image" /></td>
<td>- anchors plant&lt;br&gt;- absorbs water and minerals</td>
</tr>
<tr>
<td>Modified root</td>
<td><img src="image3.png" alt="Modified root Image" /></td>
<td>- food and water storage</td>
</tr>
</tbody>
</table>
Stems

Stems vary from herbaceous, flexible ones to hard, woody ones covered with bark.

(A) Tubers, like potatoes, are underground stems. (B) Bulbs, like onions, are compressed stems surrounded by leaves. (C) Stolons are stems that run horizontally above ground. (D) Rhizomes are stems that run underground. (E) Irises are plants that have rhizomes.
The stem’s main function is to provide support for leaves, flowers, and seeds. With the growth of shoot apical meristem, stems can increase in length and width, as in the case of woody plants with the growth of bark. In addition, new vascular tissue is produced each year. The bark contains tissue from the xylem, phloem, cork, and the tough outer coating.

Annual growth rings form in the stems of woody plants. This pattern occurs because seasonal variations in moisture and other environmental conditions influence the production of new vascular tissue.
Leaves show such great diversity that they can be used to identify a plant. Characteristics include leaf type, the pattern of veins (venation) and leaf arrangement. Dicots usually have palmate or pinnate leaf venation, while venation in monocots is usually parallel.
Leaf Structure and Function

- The flat leaf blade is attached directly to the stem or via a petiole.
- Epidermal cells produce a waxy cuticle to prevent evaporation.
- Veins are made up of vascular tissue.
- Palisade mesophyll cells are made up of parenchyma cells that perform photosynthesis.
- Spongy mesophyll cells are made up of parenchyma cells loosely packed to allow gases to flow between them.

Continued...
Leaf Structure and Function

Continued…
Monocots and Dicots

Flowering plants can be divided based on the number of cotyledons (seed leaves) in the embryo. Plant organs can be used to compare monocots and dicots.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Monocots</th>
<th>Dicots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of embryonic seed leaves</td>
<td>One</td>
<td>Two</td>
</tr>
<tr>
<td>Organization of vascular tissue in roots and stems</td>
<td>Roots have vascular tissue arranged in a ring. Vascular bundles in stem are scattered throughout ground tissue.</td>
<td>Roots have vascular tissue arranged in a star shape. Vascular bundles in stem are arranged in a distinct ring.</td>
</tr>
<tr>
<td>Venation</td>
<td>Veins are usually parallel to each other along the length of the leaf.</td>
<td>Veins are palmate or pinnate.</td>
</tr>
<tr>
<td>Number of flower parts</td>
<td>Flowers are in three parts, or multiples of three.</td>
<td>Flowers are in four or five parts, or multiples of four or five.</td>
</tr>
<tr>
<td>Presence of wood (secondary growth)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Root system</td>
<td>Typically fibrous</td>
<td>Typically taproot</td>
</tr>
<tr>
<td>Common examples</td>
<td>• asparagus&lt;br&gt;• banana tree (shown below)&lt;br&gt;• lily</td>
<td>• almond tree&lt;br&gt;• beans and other legumes&lt;br&gt;• olive tree (shown below)</td>
</tr>
</tbody>
</table>
### Section 13.3 Review

#### Plant Organs and Their Functions

**The root and shoot systems of plants have structures that enable plants to survive in their unique environments.**

<table>
<thead>
<tr>
<th>KEY TERMS</th>
<th>KEY CONCEPTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>aerenchyma</td>
<td>• The root system anchors the plant and absorbs water and nutrients from the surrounding soil.</td>
</tr>
<tr>
<td>cortex</td>
<td>• Stems provide support for the plant's leaves and reproductive structures.</td>
</tr>
<tr>
<td>cuticle</td>
<td>• Stems and roots have many different forms, some of which are modified to store food or water.</td>
</tr>
<tr>
<td>endodermis</td>
<td>• Leaves perform photosynthesis, and their internal structure is specialized to maximize the amount of sunlight they can capture and convert to chemical energy.</td>
</tr>
<tr>
<td>fibrous root</td>
<td></td>
</tr>
<tr>
<td>mesophyll</td>
<td></td>
</tr>
<tr>
<td>palisade mesophyll</td>
<td></td>
</tr>
<tr>
<td>root cap</td>
<td></td>
</tr>
<tr>
<td>spongy mesophyll</td>
<td></td>
</tr>
<tr>
<td>taproot</td>
<td></td>
</tr>
<tr>
<td>venation</td>
<td></td>
</tr>
</tbody>
</table>

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**UNIT 5**

Chapter 13: Plants: Uses, Form, and Function

Section 13.3
Two critical transport processes ensure the survival of plants:

- Sugars made by photosynthesis are carried to all other living cells by the phloem.
- Water and dissolved minerals are taken from the ground and brought to all cells by the xylem.

Water and minerals move from the roots upward in the xylem tissue of vascular plants. Organic molecules, such as carbohydrates, are transported upward and downward in the phloem tissue.
Diffusion, osmosis, and active transport are all processes working to move water and nutrients around in a plant. *Diffusion* and *osmosis* are the result of the random movement of particles down a concentration gradient. *Active transport* requires energy to move sugars and nutrients across cell membranes.

Active transport moves xylem fluid against gravity in two ways:

- positive root pressure (pushing)
- negative pressure (transpirational pulling)
Xylem Transport Processes

Root Pressure (pushing)

Water enters the roots by osmosis, drawn by the higher concentration of dissolved nutrients. Water creates positive pressure as it enters the intercellular spaces and pushes upward in the xylem. Minerals continue to move across the membrane by active transport. The “push” of water and minerals is aided by the adhesion (sticking) of water molecules to the xylem cell walls. The water and minerals move into the stem and eventually enter the leaves, moving through the veins. At the end of the veins, the water and minerals diffuse into the cells of the leaves. Much of the water that reaches the leaf (up to 90%) then returns to the atmosphere, evaporating through the stomata (transpiration).

Root pressure can raise water approximately 10 m against gravity. How is water transported through large trees?
Xylem Transport Processes

Transpirational Pull

Negative pressure (pulling) from above is the force for long-distance transport.

Called the **cohesion-tension model**, the loss of water through transpiration in the leaves creates the pull that moves water and minerals up to replace the lost water. As the water is being pulled up the plant by transpiration, cohesion (attraction between water molecules), and adhesion (attraction between water molecules and xylem walls), more water enters the roots. This strong pull against gravity can transport water up to 100 m vertically.
Translocation is the transport of sucrose (made from the glucose product of photosynthesis) and other organic molecules through the phloem. Translocation moves nutrients wherever they are needed for growth, metabolism, or storage. Sucrose moves down to the roots for winter storage and back up to the trunk and branches in the spring. The compounds move quickly through the conducting cells (sieve tube elements) in the phloem.

Continued...
The **pressure-flow model** hypothesizes how sucrose moves from a source (where sugars are produced) to a sink (where sugars are used or stored).

- Sucrose moves into the phloem from the source and increases in concentration.
- Water moves into the phloem through osmosis. Pressure in the phloem increases.
- A pressure gradient between the source and the sink causes a flow of solution through the phloem. Water moves in and out of the phloem according to the concentration. Positive pressure at the source pushes the solution from the source to the sink.
- Sucrose is removed from the phloem at the sink tissue. Water also moves out and pressure decreases.

*Continued...*
Phloem Transport Processes

- **A** Sucrose enters the phloem in the leaf, increasing the concentration of sucrose solution in the phloem.

- **B** Water moves into the phloem as a result of the increased concentration of sucrose. The movement of water leads to an increase in pressure in the phloem.

- **C** The pressure gradient between the source and the sink causes a flow of solution through the phloem from the source to the sink. Water moves into and out of the phloem along the way.

- **D** Sucrose is removed from the phloem by tissues in the plant stem and root. This causes the concentration of sucrose solution to fall, and therefore water moves out of the phloem. Pressure in the phloem decreases.
## Section 13.4 Review

<table>
<thead>
<tr>
<th>Section 13.4</th>
<th>Transport in Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water, minerals, nutrients, and sugar are transported throughout a plant in the xylem and phloem.</strong></td>
<td></td>
</tr>
</tbody>
</table>

**KEY TERMS**
- cohesion-tension model
- pressure-flow model
- root pressure
- translocation
- transpiration

**KEY CONCEPTS**
- Water and minerals are transported through the plant in xylem. Organic nutrients—carbon-based molecules that are produced by the plant—are transported in phloem.
- Active transport, osmosis, and diffusion move water short distances through plants.
- The cohesion-tension model explains how water is moved long distances from a plant’s roots to its leaves, driven mainly by transpiration.
- The pressure-flow model explains how translocation moves organic molecules from a source, where they are entering the phloem, to a sink, where they are being used or stored.
Could Canada Rely on Biomass to Meet Energy Needs?

We are running out of biofuels and the hunt for alternative fuels is underway! Biomass has been a small-scale source of heat since humans began using fire. Could it be practical to use biomass or fuels derived from biomass to meet the energy needs of the modern world? Bob McDonald asked several university researchers, as well as people from private companies, about the prospects for biofuels.

Researchers looked for non-food sources of biomass. For example, significant wood residue exists in Canada, especially in British Columbia, where the pine beetle infestation could create 1 billion cubic metres of dead pine by 2013. This amount of biomass could run an estimated twenty 300 MW power plants for 20 years, thus supplying half of that province's energy production.

In Ottawa, a company is producing an enzyme that can break down cellulose. This process also produces ethanol. The demonstration project used straw to produce over 1 million litres of ethanol between 2004 and 2010. Successful commercial production requires at least 100 million litres of ethanol per year. Sources of cellulose, such as wood chips and agricultural waste, are bulky and much less energy-dense than coal or oil, so the power plant must be located close to the supply.

Renewable Energy from Plants

Biomass from sugar cane and corn has been used to make ethanol, an alcohol distilled from plant sugars. Brazil has an ethanol industry based on sugar cane that supplements and reduces the use of gasoline for transportation. In North America, corn has been the crop of choice to make ethanol. Both ethanol work well in vehicles. However, closer examination revealed that, as of 2006, it took 1 litre of fossil fuel to produce 1.25 litres of corn ethanol. Therefore, the fossil fuel “savings” were not significant. In addition, corn is a food crop. Competition from the fuel market was driving corn prices beyond what many families in countries such as Mexico could pay.