Pulp to Paper

N°. 57

INTERMEDIATE/SENOIR

Science | Social Studies

LESSON SUMMARY

To understand the importance of the chemical lignin to pulp and paper production and to simulate the age-old process of papermaking by making new paper from old.

FORESTS ONTARIO

Focus on Forests

Activity Information

Grade Level: Intermediate/Senior

Estimated Duration: 2 hours to 1-1/2 days

Materials: Activity #1- phloroglucinol stain, ethanol, a piece of woody plant stem, a piece of paper, scalpel or razor blade, forceps, watchglass, a drop of 10% hydrochloric acid, two microscope slides; Activity #2 - scrap paper, plant and vegetable scraps (e.g., flowers, grass clippings, leaves, carrots, or beets), non-toxic fabric dye, fasteners (staples, tacks or waterproof glue), two wooden frames (approximately 20 cm x 15 cm), nylon screening, kitchen cloths (porous type), blender, sponge, iron, large plastic basin, copies of the Papermaking Activity Sheet (one per student or group of students)

Setting: Indoors

Key Vocabulary: Cellulose, cell walls, lignin, pulp

Background Information

In the process of growing, a tree creates new wood tissue using only the energy of the sun, carbon dioxide, water, and traces of minerals. From these simple ingredients, through the process of photosynthesis, the tree builds an amazing material that has the tensile strength of steel, yet is pliable enough to bend in strong winds. The physical and chemical properties of wood give it the extraordinary versatility that has made wood a cornerstone of human civilization - in the form of buildings, furniture, transportation, musical instruments, fuel, paper, and much more.

About half the dry weight of wood tissue is made from the complex chemical cellulose, a large molecule similar to starch. Like starch, **cellulose** is built up from molecules of a simple sugar (glucose) arranged in a long chain. A subtle difference in the arrangement of the glucose subunits, however, means that cellulose, unlike starch, is insoluble in water. The long molecules of cellulose are found mostly in the **cell walls** of wood, where they are arranged in loose bundles like parallel strands of thread. The bundles are twisted together in spirals, like the fibres in a rope. This arrangement is intricate but flimsy. The cellulose on its own could not build a cell structure strong enough to support a tree .

The strength component comes largely from the second most common chemical in wood, called **lignin**. This is another macromolecule, whose characteristic odour can be detected in the smell of freshly cut lumber. Lignin makes up between 15 per cent and 35 per cent of the cell wall in wood tissue, and without it there would be no wood. (The name lignin, in fact, comes from the Latin word lignum, meaning wood.) Lignin provides the "glue" that binds the cellulose molecules together and creates a strong structure.

Cellulose and lignin are the two most common chemicals in wood, but smaller quantities of other chemicals give different woods their particular characteristics. Gums, resins, sugars, mineral salts, and water are all part of the molecular building blocks that make up the wood cells.

Although the most obvious use of wood is as a construction material, or lumber, a very large proportion of Ontario's trees are broken down into their separate fibres and used to make paper products. The mixture of separated fibres and liquids is called **pulp**. In Ontario, most of pulp is made from the wood of spruce and balsam fir. These species have the longest cell fibres and make the strongest paper, because it is difficult to tear across the fibres. Pulp from deciduous trees makes "fine" paper (e.g., writing paper), but this paper is weaker.

In order to make pulp from wood, it is necessary to separate the cellulose from the lignin. This is done by removing the lignin through a combination of chemical solvents, heat, and pressure. When most of the lignin is removed, the cellulose fibres are combined with water to form a thick sludge. This mixture is strained through a fine mesh screen, which lets the water through and leaves the wet, tangled fibres in a thin mat on the surface of the mesh. The remaining water in the fibres is removed by a combination of vacuum action, pressure, and heat. The dry sheet of tangled wood fibres that remains is paper. Even with scientific change and advancement, the basic process of making paper has not changed since its invention.

Teaching Notes

1. Introduce the activities by discussing the similarities and differences between paper and wood. Consider the raw materials needed to make paper and the characteristics of wood that make it an ideal fibre for papermaking.
2. Activity #1 is a teacher demonstration showing the presence of lignin in wood and the absence of lignin in paper (lignin must be removed from wood pulp before paper can be made).
3. As the students conduct Activity #2, encourage them to draw comparisons between this simplified method and the actual process of pulp and paper making.

Advance Preparation

Make copies of the Papermaking Activity Sheet (one per student or group of students) and gather the required materials.

ACTIVITY #1

Demonstrate the lignin test using the instruction sheet.

ACTIVITY #2

Have the class conduct the papermaking exercise on the activity sheet.

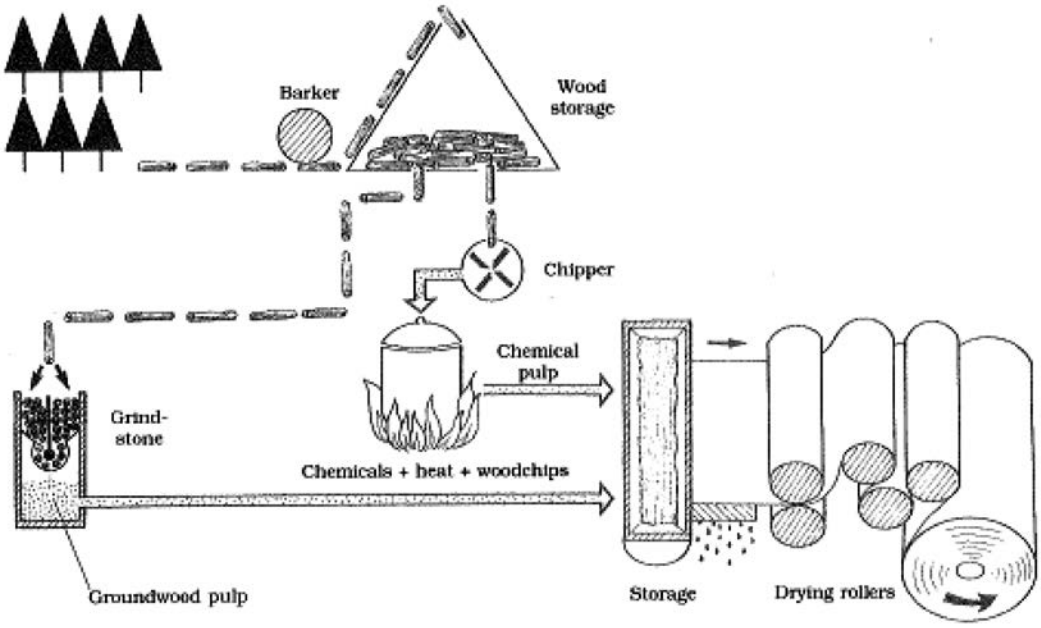
Extensions

1. Have the class investigate and report on the different kinds of paper made throughout history (e.g., papyrus, rice paper, parchment, vellum).
2. Discuss the importance of paper recycling and have students brainstorm on ways to recycle paper at home and at school. Is paper recycling being done in the community/school? Why or why not?

Evaluation

Have students use any method they wish (illustration, models, posters) to describe the basic steps in industrial pulp and paper making today.

From Pulp to Paper



Lignin Test

Instruction Sheet

Purpose

To demonstrate the presence of lignin in wood and its absence in paper.

Materials

phloroglucinol stain, ethanol, a piece of woody plant stem, a piece of paper, scalpel or razor blade, forceps, watchglass, a drop of 10% hydrochloric acid, two microscope slides

Method

1. Make a saturated solution of phloroglucinol stain in ethanol.
2. Carefully cut a piece of stem with a sharp scalpel or razor blade into as thin a section as possible.
3. U sing forceps, soak the section in a watchglass containing the stain for a few minutes.
4. Then rinse away the stain and add a drop of 10% hydrochloric acid to the section on a microscope slide.
5. Examine under the low power of a compound microscope. Lignin should show up stained a bright reddish violet. To show that lignin is not present in paper, follow the above procedure, substituting a small piece of paper for the stem.

Papermaking

Activity Sheet

Purpose

To make new paper from old, using a basic process that has not changed since the invention of papermaking.

Materials

scrap paper, plant and vegetable scraps (e.g., flowers, grass clippings, leaves, carrots, or beets), non-toxic fabric dye, fasteners (staples, tacks or waterproof glue), two wooden frames (approximately 20 cm x 15 cm), nylon screening, kitchen cloths (porous type), blender, sponge, iron, large plastic basin

Method

1. Staple nylon screening tightly to one wooden frame to make a paper "mould". The second frame without the screen is the "deckle", which will help make the edges of the paper more even.
2. Remove any plastic or staples from the scrap paper and tear it into small pieces (about 2 cm). Soak it in hot water for half an hour.
3. Put a handful of the soaked paper into a blender half-full of warm water. Blend at moderate speed until you no longer see pieces of paper. (If you have problems, take out some of the paper.) Add small amounts of plant or vegetable scraps to this mixture (pulp) and blend again. If you want coloured paper, add fabric dye.
4. Pour the mixture into a large plastic basin half full of warm water.
5. Place the deckle on top of your screen. With both hands, dip the mould into the basin and scoop up some of the pulp. (The thickness of your paper will depend on the amount of pulp.) Gently shake the mould back and forth to get an even layer of fibres on the screen. When the water has drained through, place the mould to one side and carefully lift off the deckle, leaving the just-formed sheet on the screen.
6. Lay a clean kitchen cloth on a flat table and lay the screen face down on the cloth. Soak up any extra water from the back of the screen with a sponge. Lift the screen very gently - the paper should remain on the cloth.
7. Cover the paper quickly with another cloth and iron at a medium dry setting. Once dry, pull gently on either side of the cloth to stretch it – this helps loosen the paper from the cloth. Gently peel the paper off.
8. Compare the strength, colour, and texture of homemade paper to that of the different types of paper used in the classroom. Point out similarities and differences.

Note: Be careful not to pour the leftover pulp down the drain. Collect it in a strainer and throw it out or freeze it in a plastic bag for future use.