What's a Tree Done For You Lately?

Some common products we get from trees and how they are made

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Introduction

Products from trees are all around us. Some items are easy to recognize as products we get from trees - lumber, plywood, and paper, for example. Other items such as cellophane, a rayon scarf, and a chocolate bar, may not be as easy to recognize as a product from trees.

This publication will help educators teach students about the variety of products we obtain from trees and how the products are made. It serves as a reference for anyone who wants to know more about products we obtain from trees.

Products from trees may be categorized as:

- products from wood fiber - for example, paper products and purified cellulose products (rayon, cellophane, food additives, and pharmaceuticals);
- products derived from chemicals in trees - for example, soap, turpentine, chewing gum, maple syrup, natural rubber, charcoal, flavorings/ additives and fragrances;
- products from fruits and nuts - for example, spices, edible fruits and nuts, and chocolate;
- products from bark - for example, cork, fuel, and mulch;
- solid wood products - for example, lumber, furniture, doors, flooring, moulding & millwork, pencils; and
- composite wood products – for example, plywood, oriented strand board, and particleboard.

This publication will serve as valuable background material for several activities in the Project Learning Tree (PLT) Pre K-8 *Environmental Education Activity Guide* (1993, American Forest Foundation, Washington, D.C.). In particular, the publication is well-suited to activities 12 and 13, *Tree Treasures*, and *We All Need Trees*, respectively.

Number 12 - *Tree Treasures*
Objectives:
1) identify and categorize products derived from trees,
2) find out which forest products are recyclable or reusable, and
3) recommend actions for conserving forest resources.

Number 13 - *We All Need Trees*
Objectives:
1) examine various products and determine which ones are made from trees,
2) describe ways that trees are used to make products and ways that these products can be conserved, and
3) explore methods for recycling and reusing products.

References are made in the text to other relevant PLT activities.

Products from Wood Fiber

Paper

Think of all the products made from paper. The list includes such items as books, magazines, newspapers, notebook and computer papers, boxes, grocery bags, egg and milk cartons, tissue and toilet paper. According to the American Forest & Paper Association, each year the United States uses paper to publish more than two billion books, 350 million magazines, and 24 billion newspapers. We now recycle approximately 45 percent of all the paper used in the United States.

The exact steps involved in the papermaking process depend on the type of paper being made. Even specific types of paper such as newspaper are made by different processes by different paper companies and with different wood species. A general overview of papermaking is followed by a discussion of the processes used to make specific types of paper.

There are four basics steps involved in making paper from wood:

1. acquire the raw material
2. separate individual fibers in the raw material to create pulp
3. bleach the pulp (for some products)
4. form the pulp into paper

- The raw material - If you look closely (a magnifying glass will help) at a torn piece of paper you can see the individual fibers. Paper is made from cellulose fibers. Cellulose is the main constituent of all plant fibers including wood fibers. Wood fiber, in the form of chips, logs, and recycled paper products, is the raw material for the vast majority (about 90 percent) of worldwide paper production. The remaining 10 percent of paper is made from raw materials such as cotton waste from the clothing industry ("rag" paper), bamboo, straw, flax, kenaf, and bagasse (squeezed sugarcane).

In the United States, sawmill residues (primarily chips) account for about 25 to 30 percent of the raw material source for making paper. In the Pacific Northwest, sawmill residues account for the majority of the raw material used for making paper.

Related Project Learning Tree activities:

Number 51 - *Make Your Own Paper*
Objectives:
1. make recycled paper from scrap paper
2. describe the steps of the papermaking process and identify the elements and outputs of the process
3. compare making paper by hand to the process used in factories

Number 93 - *Paper Civilizations*
Objectives:
1. chronicle the major events in the history of papermaking
2. create a pictorial representation of the history of paper

- Separating individual fibers - Wood is composed primarily of cellulose and a mixture of other related compounds known as hemicelluloses. By itself, cellulose is soft and flexible. However, wood contains another chemical compound, lignin, that "glues" individual fibers together within the tree and makes the fibers rigid. To make paper thin and flexible, wood fibers must be separated into individual fibers. Several different processes are used to separate wood into individual fibers. The processes use either chemicals to dissolve lignin, machines to separate the fibers, or some combination of machines and chemicals.

  The "soup" of separated wood fibers is known as pulp

- ***Bleaching*** - Pulp is bleached to improve its suitability for specific products. For writing papers, bleaching brightens the paper, prevents it from becoming yellow over time, improves the strength and ability to accept ink. For tissue products (for example, toilet paper, facial tissue, and paper towels), bleaching improves the paper's ability to absorb water. For paper used for food packaging, bleaching improves strength and cleanliness so that the packaging does not alter the flavor of the food. Thorough bleaching is also done to create a highly purified form of cellulose that is used for a number of products to be discussed later. Approximately 40 percent of total pulp production in the United States is bleached.

  In addition to making wood fibers rigid and acting as the glue between individual fibers, lignin is also largely responsible for the tan to brown color of wood.

  In fact, the brown color of grocery bags and cardboard boxes is due primarily to lignin. Bleaching is the process of either removing or chemically altering lignin.

- ***Forming the pulp into paper*** - To form paper, pulp is poured onto a moving felt screen. The felt mat allows the water to drain out of the pulp while preventing the fibers from being lost. The pulp is then pressed between a series of smooth rollers (like rolling pins) to create a wet mat of paper. The paper is sent through dryers and rolled onto a large drum for shipping to the customer.

Note: No adhesive is used to hold the fibers together in the papermaking process. Wood fibers bond together naturally in a sheet of paper.

Paper mills are very expensive to build. To build their largest facility from the ground-up, Weyerhaeuser Company spent approximately 1.5 billion dollars. Paper mills are also very expensive to operate. Therefore, to be cost effective, paper mills must use state-of-the-art technology and must produce enormous amounts of paper. Paper mills producing lightweight papers such as newsprint or tissue often create as much as a mile of paper per minute.

Processes used to make specific types of paper:

Newspaper

The most common mechanical process used to make newsprint is thermo-mechanical pulping (TMP). TMP involves pressurizing wood chips with steam and separating the fibers using machines called disk refiners (Figure 1).

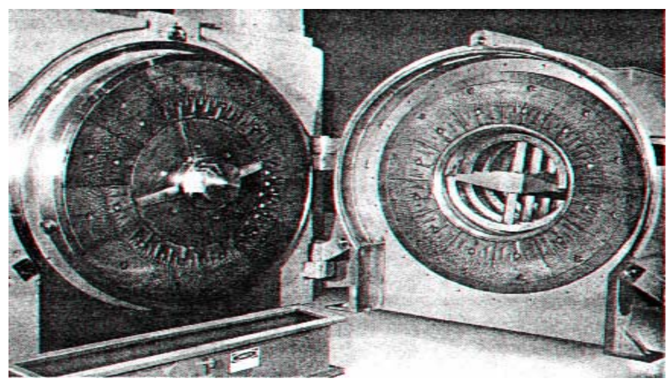

Figure 1. Disk refiner. Photo courtesy of Andritz Sprout-Bauer. Reprinted from *Essentials of Pulping and Papermaking* (1993, Biermann, C.J., Academic Press Inc.), with permission.

The steam and pressure soften the wood chips so that the fibers are easier to separate. The disk refiners contain large rotating metal wheels (disks) with small metal bars welded on the surface of the disk. The disks rotate at high speeds and are spaced very closely together. Wood chips are fed into the narrow gap between the disks. Pulp is formed as the grinding action of the disks separates the wood fibers. Water is used to cool the disks and wash away the fibers. Disk refiners are also commonly used to grind peanuts into peanut butter and corn into flour. Another common mechanical process for making newspaper is called stone groundwood (SGW). Logs are ground against a large rotating abrasive wheel (the "stone") that works like a wood file. (Figure 2.) The grinding action of the stone against the logs separates the wood fibers. Water is sprayed on the grinding wheel to wash the fibers from the stone and to cool the fibers and the stone.

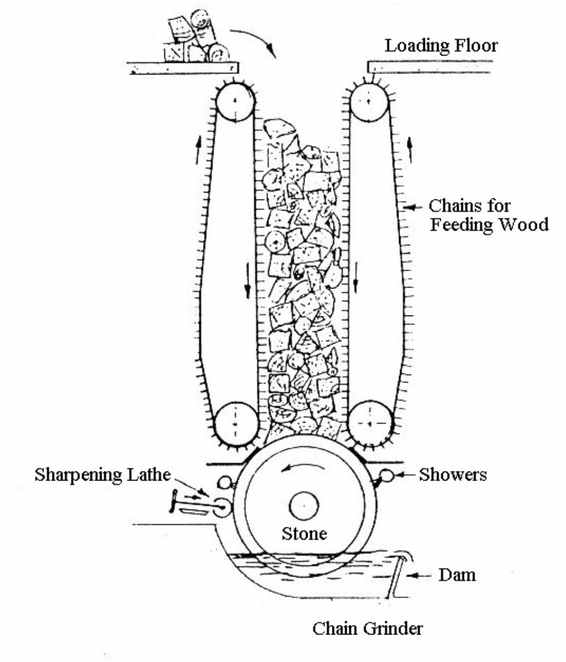

Figure 2. The stonegroundwood process. Reprinted from *Making Pulp and Paper* (1967, Crown Zellerbach Corp.)

Corrugated Containers

Corrugated containers (commonly called "cardboard"), are composed of three layers of paper products. The middle layer is the corrugated material. Corrugated material is made from the short, thick fibers found in hardwood trees such as oak, maple, birch, aspen, and others. These short, thick fibers are preferred because of their strength and resistance to crushing. The smooth top and bottom layers are called linerboard and are a thicker form of the kraft paper used for grocery bags.

Figure 3 shows the process of making linerboard, using chemical pulping. The diagram shows using both wood chips as well as recycled material ("Secondary Fiber"). Recycling paper products is discussed below. The section of the diagram listed as the "Recovery Cycle" demonstrates the process of recovering the chemicals used in the pulping process.

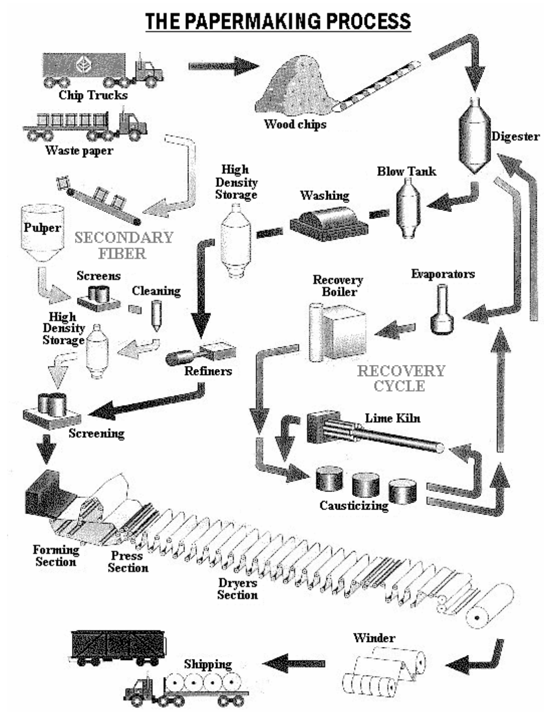

Figure 3. The papermaking process, including recycling ("secondary fiber") and the chemical recovery cycle. Reprinted from Willamette Industries Inc., with permission.

In pure chemical pulping, wood chips are sent to a large tank called a digester. Chemicals within the digester remove the lignin from the chips. This softens the chips and aids in the separation of the wood fibers. The chips are then blown under high pressure into the blow tank. The impact helps to separate the wood fibers. The material is washed and processed by refiners (Figure 1) to further separate the fibers.

After refining, the pulp is screened to remove dirt and other contaminants and formed into a mat at the forming section. The paper is then pressed, dried, and wound into a roll of finished paper.

Notebook paper
The most common process for making higher quality paper, such as notebook paper, is very similar to the process described above for making linerboard with the exception that the pulp is bleached prior to being formed into paper.

Tissue
To make paper soft, such as for facial tissue and toilet paper, the paper is made very thin and is crimped back and forth before being wound onto the drum. The crimping action softens the fibers in a manner similar to folding a piece of notebook paper back and forth. Today, about 60 percent of tissue paper is made from recycled paper products.

Magazine paper
Magazine paper is produced by adding mineral fillers such as calcium carbonate and clay to the pulp. The fillers improve the printing qualities of the paper by making the paper smoother, less absorbent, and more opaque.

Recycling paper products
As stated above, we now recycle approximately 45 percent of all the paper used in the United States. The United Nations Council on Environment and Development (UNCED) estimates that recycled fiber accounts for about 20 percent of total global wood fiber consumption (i.e., 80 percent comes from timber harvesting) and expects the value to increase to 30 percent by the year 2010.

About 80 percent of waste paper comes from three primary sources: corrugated boxes, newspapers, and office papers. Approximately 80 to 90 percent of recycled fiber is not deinked (no attempt is made to remove printing ink) and is used to make products such as roofing paper, corrugated containers, cereal and shoe boxes, and the liner for drywall (also called sheetrock or wallboard). The remaining 10 to 20 percent of recycled fiber is deinked and used to make products such as newsprint, tissue, or other "bright" papers.

The process of returning waste paper to fiber form is relatively simple (see the "Secondary Fiber" portion of Figure 3). The pulper is really little more than a large blender that churns the old paper products in water to return the material to pulp. The real challenge in recycling waste paper is to remove contaminants (wax from coated boxes, adhesives, fillers, ink, dirt, etc.) from the paper. Contaminant removal is accomplished using numerous different methods.

Large contaminants may be removed during pulping by either settling to the bottom of the pulper or by being caught on a "ragger." The ragger is a chain pulled through the pulper upon which material like wire, plastic, and other stringy materials becomes tangled.

After leaving the pulper, more contaminants are removed by screening. Screening pulp to remove contaminants is analogous to using a sieve in jelly-making to separate the solids from the juice. Following screening, contaminant removal continues by cleaning the pulp. One type of pulp cleaner is known as a centrifugal cleaner. The centrifugal cleaner works by creating a vortex, similar to the vortex that forms as water spirals down the drain in a bathtub or sink. The vortex action causes the heavier particles in the pulp to move to the outside of the cleaner where they eventually move to the bottom of the cleaner and are removed. The cleaned pulp is then concentrated and stored for later use. Figure 3 shows a process where recycled fiber is blended with virgin fiber (fiber that has not been used previously to make paper) to produce linerboard.

Purified Cellulose Products

Purified cellulose is wood pulp from which nearly all the lignin and hemicelluloses have been removed. This form of pulp is often called dissolving cellulose or alpha cellulose. A number of products are made from purified cellulose.

Rayon
Rayon is used to make clothing, curtains, sheets and bedspreads, upholstery, carpet, and tire cord. Rayon is a purified cellulose product made of regenerated (dissolved and reformed) cellulose.

The type of pulp used to make rayon is known as dissolving grade pulp.

Most rayon is made using a series of chemical reactions in a procedure known as the viscose process. In the viscose process, sheets of dissolving grade pulp are saturated with an alkaline (pH above 7.0) solution of caustic soda (sodium hydroxide). The solution is then drained and the pulp sheets are shredded to make the cellulose easier to process. The shredded product is often called "white crumb."

The white crumb is allowed to age in the air to partially dissolve the cellulose. The next step is called xanthation. In this stage, white crumb is mixed with gaseous carbon disulfide resulting in the material turning yellow, hence its new name "yellow crumb."

Yellow crumb is then dissolved in an alkaline solution. At this point, the mixture has very high viscosity (it is thick and doesn't flow well- "like molasses in January"), and hence it is now called "viscose." The viscose is allowed to stand for some time to allow the cellulose to dissolve. The mixture is then filtered to remove any undissolved material.

The filtered viscose is then forced through a spinneret (a device that looks like a showerhead) to form fine filaments of viscose. As the filaments exit the spinneret, they enter an acid bath (a solution of sulfuric acid, sodium sulfate, and zinc ions) where a number of chemical reactions result in the loss of solubility of the cellulose. As the cellulose precipitates from solution it regenerates into fine strands known as rayon.

Before the rayon fibers completely solidify, they are stretched to strengthen the fibers by orienting the cellulose molecules. The rayon fiber is then washed to remove impurities and prepared for shipment.

Cellophane

The process for making cellophane is very similar to the process described above for making rayon. The main difference is, where rayon fiber is produced by forcing the pulp through small holes (spinnerets) and reforming the cellulose into a long fiber, cellophane is made by forcing viscose (dissolved cellulose) through a thin slit and reforming the cellulose into a film.

Other Purified Cellulose Products

In addition to being used to make rayon, viscose pulp is also used to make sausage casings. The solid stage booster rockets in the space shuttle are made using a rayon-type product.

A multitude of products are made from cellulose ethers (also called cellulose gum), derived from purified cellulose. Some products made from cellulose ethers include:

- food additive for low-fat diet products, syrups, toothpaste, and ice cream;
- binder for pills and vitamin tablets;
- cement additive to allow cement to be poured underwater;
- additive for drilling muds for oil wells; and
- thickener for paints and glues.

Products Derived from Chemicals in Trees

Products from Resin

Resin (also called pitch) is the sticky substance you occasionally see oozing from the bark on trees. Coniferous trees ("evergreens") produce resin to defend themselves from insects and wounds. A number of products are made from the chemicals contained in resin. A limited amount of resin is obtained by cutting the bark of trees and collecting the resin that seeps out. The majority of resin-derived chemicals, however, are obtained as by-products of chemical pulping.

Additive for citrus-flavored soft drinks

If you look at the list of ingredients on many citrus-flavored soft drinks you will see "glycerol ester of wood rosin." Many citrus flavors are not water soluble and therefore would not mix in a soft drink. Glycerol ester of wood rosin emulsifies citrus flavorings enabling the flavorings to blend with the beverage.

One interesting method for producing wood rosin uses old pine tree stumps. A facility in Brunswick, Georgia harvests, shreds, and extracts chemicals from pine stumps. The chemicals are separated into a group of compounds known as wood rosin. The wood rosin is reacted with glycerol (a syrupy liquid by-product of chemical pulping) to produce glycerol ester of wood rosin.

In addition to being used in citrus-flavored soft drinks, glycerol esters are one of many materials used to produce chewing gum (the manufacture of chewing gum is discussed below).

Soap

Some soaps are made from by-products of chemical pulping. The chemicals that remove the lignin from the wood during pulping also cause the many waxes and related compounds found in trees to break down to form glycerol and fatty acids. When the strongly alkaline solution (sodium hydroxide, in kraft pulping) reacts with the fatty acids, fatty acid salts[1] are produced. This process is known as saponification.

The material washed from the pulp, including the dissolved lignin, resin, and the fatty acid salts is a dark liquid called "black liquor." When black liquor is concentrated, the resin and fatty acid salts separate and float on the surface where they are skimmed off.

After the fatty acid salts are neutralized, the resulting product is known as tall oil ("tall" is the Swedish word for pine). The tall oil is refined to produce purified rosin acids (used to produce printing inks and adhesives) and fatty acids are sold to soap companies to produce cleaners, detergents, and soaps.

Soap companies produce liquid soap by saponifying fatty acids with sodium and solid soaps by saponifying fatty acids with potassium.

Turpentine

Turpentine is used in paint solvents, cleaning agents (e.g., Pine-Sol®), paints, and varnishes. Turpentine is also used as a raw material to produce fragrance compounds for soaps.

Small amounts of turpentine are produced from extractives from old pine tree stumps. Most turpentine is produced as a by-product of chemical pulping. In chemical pulping, wood chips are "cooked" under high heat and pressure in a digester (Figure 3). Turpentine is made from chemical compounds called terpenes contained in the relief gases from the digester. The pulping industry in the United States recovers about 30 million gallons of turpentine annually (Biermann, 1993).

Sweetener in toothpaste

There is a minor component in turpentine known as trans-anethole. Trans-anethole is the main component that gives licorice its distinctive smell and flavor, however this is not the main use for turpentine-derived trans-anethole.

At low concentrations, trans-anethole loses its licorice flavor and gives a sweet flavor. It is used in very small amounts in many toothpastes to make them sweet without adding sugar.

Food additives to fight heart disease

Products from trees help fight heart disease? Yes, it's true. Phytosterols are a group of chemicals derived from tall oil (see discussion of soap above) that, until recently, had no commercial use. Recent studies have shown that eating foods containing phytosterols (particularly beta-sitosterol) helps prevent the uptake of cholesterol. Phytosterols can therefore help in the fight against heart disease by reducing the level of cholesterol in the blood.

[1] In chemistry, a salt is a compound created by replacing the hydrogen ions in an acid (hydrochloric acid, HCl, for example), with metallic ions (sodium, Na, for example). Common table salt is, in fact, sodium chloride (NaCl).

Chewing Gum

Chewing gum from trees? Yes it's true.

Gum in many forms has been around for many hundreds if not thousands of years. The ancient Greeks chewed mastic gum, the resin of the mastic tree. North American Indians chewed the resin of spruce trees. Strangely enough, the conquering of the Alamo in 1836, and America's introduction to chewing gum are closely related. The Mexican general noted for the conquest of the Alamo, General Antonio López de Santa Anna, was exiled in New Jersey. He brought a substance called chicle (to be discussed later) with him from Mexico.

In 1869, Thomas Adams, an American inventor, attempted to use the chicle as a substitute for rubber. The experiment failed, but Adams noticed that General Santa Anna liked to chew chicle. Adams made a batch of chicle gum in his kitchen and offered it for sale in a local store. By 1871, the gum was selling so well that Adams had produced a machine to mass produce the gum. In December of 1928, Walter Diemer, an employee of the Fleer Corporation, devised the formula for bubble gum.

Most modern chewing gums contain 16% to 30% gum base. Gum base is a blend of different latexes from tropical trees, resins from North American pine trees, and synthetic materials such as polyvinyl acetate, waxes, and imitation rubber. The synthetic materials help give bubble gum its elasticity. Chicle is one of the primary latexes in gum base. Chicle comes from the sap of the sapodilla tree (*Sapota archras*) found in Mexico, Guatemala, and Belize. Chicle and the other latexes are drained from trees by cutting a gash in the tree and collecting the sap in canvas bags. The latexes are then boiled to reduce water content, hardened, and kneaded into blocks. The blocks are shipped to gum factories where they are purified by heating and straining. The other ingredients such as corn syrup, sugar, glycerine and flavorings are mixed into the gum and the mixture is allowed to cool before being cut into sticks of gum.

Maple Syrup

Maple syrup is made from the sap of maple trees. The primary species used is sugar maple *(Acer saccharum*), native to southeastern Canada and the eastern United States. Maple syrup production totaled 1.16 million gallons in the United States in 1998 according to the U.S. Department of Agriculture.

During the growing season, the sapwood[2] of trees conducts water upwards from the roots to the leaves. During the dormant season (fall and winter), trees store sucrose (a sugar) in the roots. In early spring, when the temperature is above freezing during the day but below freezing at night, water is absorbed by the roots forming a concentrated solution of sucrose. As the roots continue to absorb water, the sucrose solution begins to rise up the tree through the sapwood. Maple syrup is made from the early spring sap which has a higher sugar concentration than the sap produced during the growing season.

Maple sap collection occurs between mid-February and mid-April and generally lasts four to six weeks. To collect the sap, a hole is drilled through the bark into the sapwood. A spout is then driven into the hole and either a pail is hung on the spout, or plastic tubing is attached, to collect the dripping sap. The sap is then boiled to produce maple syrup. Each tap (trees larger than two feet in diameter may be tapped in as many as four places at one time) yields about 10 gallons of sap. It takes about 40 gallons of sap to produce one gallon of maple syrup.

Under normal conditions, tapping a maple tree only removes about eight percent of the tree's sugar supply, an amount easily replaced the following

[2] If you look at a stump or the end of a log, the sapwood is the light-colored band of wood closest to the bark, as opposed to the heartwood, which is the darker-colored (in some species) band of wood surrounding the center of the log.

growing season. Therefore, tapping maple trees to produce syrup does not significantly harm the trees. In fact, some have said that farmers are still tapping maple trees planted by the Pilgrims in 1620.

Natural Rubber

Natural rubber is used to make thousands of products including: shoes, balloons, erasers, gloves, weatherstripping, gaskets, conveyor belts, balls (basketball, tennis balls, etc.), inner-tubes, tires, and as foam rubber in products like carpet padding, car seats, pillows, and synthetic sponges.

Approximately 99 percent of natural rubber is produced from the latex of the rubber tree, *Hevea brasiliensis*. Latex is produced by rubber trees and hundreds of other plants as a defense against a wound. Rubber trees are native to Brazil and are grown in Malaysia, Indonesia, Thailand, India, and China. The remaining one percent of natural rubber comes from the guayule bush of Mexico and the southwestern United States.

To collect latex, workers cut shallow gashes into trees and collect latex in cups. Because latex quickly coagulates into lumps, chemicals and water are added to keep it in liquid form.

The process to create crude rubber for shipment to the secondary processor varies according to the end use. One such process, known as smoked sheets, involves adding water and acid to the latex. The acid causes the rubber to coagulate and form into sheets of soft and flexible rubber. The sheets are then compressed to remove some of the water and dried in smoke houses. The sheets are then bundled into bales of crude rubber and sent to the final processor.

The ratio of latex to natural rubber is approximately 3:1, that is, about 3 pounds of latex are required to make 1 pound of rubber. Workers are able to tap rubber trees for approximately 20 years before the tree is no longer suitable for latex production.

Charcoal

Charcoal is formed from the pyrolysis (chemical change caused by heat) of wood. When wood is burned with plenty of air available it burns almost completely, leaving very little residual substance (ash). If air is restricted, however, only the volatile matter burns, leaving carbon. Carbon is the primary component of charcoal. Charcoal is made by cooking wood under a restricted air supply in closed ovens known as retorts.

The ratio of wood to charcoal is approximately 5:1, that is, it takes approximately 5 tons of wood to produce 1 ton of charcoal.

Related Project Learning Tree activity:

Number 49 - *Tropical Treehouse*
(This activity lists numerous products we obtain from tropical forests.)
Objectives:
1. Describe the plants and animals that live in different levels of the tropical rainforest,
2. Examine and discuss a case study that involves the rights of native inhabitants of a tropical rainforest in a national park,
3. Describe the sounds they might encounter when visiting a rainforest

Charcoal briquettes for barbeques are typically made from a binder and filler. The charcoal is crushed into fine particles and screened to remove large pieces. A binder, typically starch and water, is added to the charcoal particles to glue the particles together into briquettes. Charcoal comprises approximately 75 percent of the briquettes, while water and starch comprise approximately 20 percent and 5 percent, respectively.

In addition to being used as briquettes for barbeque grills, charcoal is used in water filters, in glass manufacturing, in gunpowder manufacturing, and by artists as chalk. By-products of charcoal production include tar, methanol ("wood alcohol"), acetic acid, and acetone.

Flavorings & Food Additives

Gum arabic

Gum arabic is a common ingredient in many food items including: beverages, breads, candies, condiments, ice cream, yogurt, pet food, salad dressing, and syrups. Gum arabic comes from an exudate of *Acacia senegal*, a tree native to Sudan and neighboring countries in east Africa. Gum arabic is odorless and flavorless and is used to thicken, emulsify, and stabilize foods.

Cola flavoring

Cola flavor originally came from the nut of the cola tree (primarily *Cola anomala* or *Cola nitida*) native to West Africa. Nuts are harvested from the trees from September through June and dried in the sun or piled for "sweating." Today, most companies use synthetic cola flavoring.

Root beer flavoring

The original flavor for root beer came from sassafras oil from the root bark of the sassafras tree (*Sassafras albidum*), native to the eastern United States. The U.S. Food and Drug Administration (FDA) found that safrole, a chemical found in sassafras, is carcinogenic in laboratory animals. Therefore, many companies today use either sassafras oil from which the safrole has been removed or synthetic root beer flavoring.

Artificial vanilla flavoring

<u>Real</u> vanilla flavoring is an extract of the seed pod ("bean") from the vanilla orchid (*Vanilla planifolia*), native to Mexico. <u>Artificial</u> vanilla flavoring is a less expensive substitute for real vanilla that at one time was made as a by-product of chemical pulping known as vanillin. Vanillin is now produced from petroleum-based products.

Fragrances

The oil of the wood, leaves, and fruit of many trees is used to add fragrance to perfumes, soaps, cleaners, candles, insecticidal, pharmaceutical and many other products. Some commonly used oils include:
camphor - oil from the leaves and wood of the camphor tree (*Cinnamomum camphora*) native to eastern Asia.

cedarwood - oil from junipers, cypresses, and true cedars (trees in the genus *Cedrus*) including:

- eastern redcedar (Virginiana cedarwood oil from *Juniperus virginiana*),
- ashe juniper (Texas cedarwood oil from *Juniperus ashei*),
- African pencil cedar (East African cedarwood oil from *Juniperus procera*).
- Chinese cypress (Chinese cedarwood oil from *Cupressus funebris*),
- deodar cedar (Himalayan cedarwood oil from *Cedrus deodara*), and
- atlas cedar (Moroccan cedarwood oil from *Cedrus atlantica*).

Approximately 60 percent of the perfumes and colognes on the world market contain cedarwood oil (Anderson, 1995).

eucalyptus - oil from the wood and leaves of eucalyptus trees native to Australia and New Zealand. There are estimated to be at least 500 eucalyptus species.

sandalwood - oil from the wood of the sandalwood tree (*Santalum album*) native to southeast Asia and the islands of the South Pacific.

Products from Fruits and Nuts

Spices

Some of the many spices we get from trees include:

- **allspice** - made from dried fruits of *Pimenta dioica*, a tree native to the West Indies and Central America. The name "allspice" comes from the fact that the spice tastes like a number of spices - cloves, cinnamon and nutmeg.

- **bay leaves** - dried leaves of *Laurus nobilis* (common names include sweet bay, bay laurel, sweet laurel, and laurel), native to the Mediterranean region. Leaves of *Umbellularia californica* (California-laurel or Oregon-myrtle) native to Oregon and California, are also occasionally used.

- **cinnamon** - made from dried inner bark of *Cinnamomum zeylanicum*, a tree native to Sri Lanka (formerly known as Ceylon), the southwest coast of India (Malabar), and Myanmar (formerly known as Burma). This type of cinnamon is also known as Ceylon cinnamon or "true" cinnamon. Most of the cinnamon we use in North America is actually cassia (*Cinnamomum cassia*), also known as Chinese cinnamon, the dried inner bark of a tree native to southern China.

- **cloves** - dried flower buds of *Eugenia aromatica*, a tree native to the Moluccas, or Spice Islands, of Indonesia.

- **nutmeg** - made from dried seed of *Myristica fragrans*, a tree native to the Moluccas, or Spice Islands, of Indonesia.

Edible Fruits & Nuts

Trees also provide us with food in the form of fruits and nuts. When you eat an apple, pear, plum, peach, nectarine, persimmon, cherry, orange, lemon, lime, grapefruit, tangerine, pecan, walnut, almond, filbert, pistachio, cashew, chestnut, pine nut (seed of pinyon trees), or olive, you are eating either the ovary wall (the flesh of an apple, for instance) or the seeds (filbert, for example) of the tree.

Bananas, however, are <u>not</u> among the fruits we get from trees; bananas grow on large, perennial plants. Banana plants are among the largest plants lacking a woody stem.

Chocolate

Chocolate is made from the seeds (Figure 4) of the cacao (ke-kä′o) tree (*Theobroma cacao*) native to tropical Africa and South America. The chocolate-making process involves:

1. drying the seeds,
2. roasting the seeds,
3. cracking and removing the shell leaving the center of the seed (nib),
4. crushing the nibs,
5. smoothing (conching),
6. hardening (tempering), and
7. forming the chocolate.

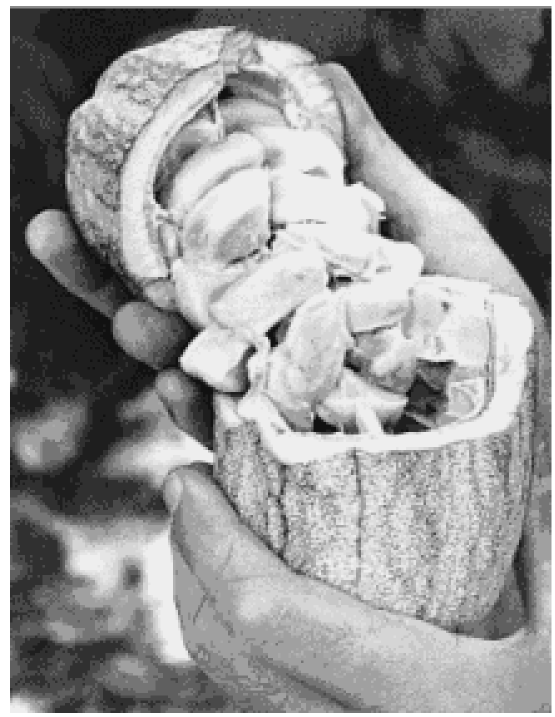

Figure 4. Open cacao pod showing seeds. Reprinted from the Chocolate Manufacturer's Association of the U.S.A., with permission.

- Drying the seeds - After harvesting, cacao seeds are stacked in bins for several days to dry. During this time, the color of the seeds changes from purple or creamy white to dark brown and the seeds begin to take on the familiar aroma of chocolate. When the seeds are dry enough to lessen their susceptibility to spoilage, they are bagged and shipped to chocolate makers.

- Roasting the seeds - The first step for the chocolate maker is to roast the seeds. Roasting dries the shells and makes them easier to remove.

- Cracking and removing the shell - The next step, “cracking and fanning” cracks the shells on the cacao seeds and uses fans to blow away the shells. The part of the cacao seed that remains is the center of the seed, known as the nib. The nib is approximately 50% cocoa butter.

- Crushing the nibs - The nibs are crushed by large grinding machines. These machines melt the cocoa butter and grind the hard parts of the nibs into powder. The result is a dark brown liquid called chocolate liquor (chocolate liquor does not contain alcohol). To make milk chocolate, milk and sugar must be blended and condensed (a process to remove most of the water). This mixture is then added to the chocolate liquor and blended until a powder is formed. Extra cocoa butter is then added to make liquid chocolate.

- Smoothing - The liquid is then stirred in large tanks for a period ranging from several hours to several days. This process is known as conching and serves to make the chocolate smoother and creamier.

- Hardening and Forming - Finally, the chocolate is tempered (heated to high temperatures) and pumped into moulds to form chocolate bars.

Products from Bark

Cork

Cork is used in many ways. Some examples are bottle stoppers, gaskets, soles for shoes, floor and wall coverings, centers of baseballs (Figure 5) and bulletin boards. Cork comes from the bark of cork oak (*Quercus suber*) native to Europe (primarily Spain and Portugal) and North Africa.

Figure 5. Cutaway section of a baseball showing cork center.

Bark protects trees from moisture loss, fire, freezing, and mechanical damage. Cells in the cork cambium (phellogen) divide to produce the cork layer (phellem) of bark (Figure 6). Cork oak is unique because of the thickness of its bark’s cork layer.

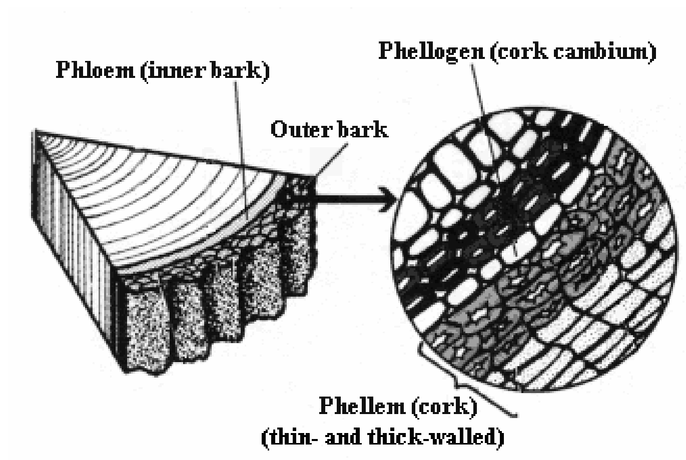

Figure 6. The structure of bark. Reprinted from *Forest Products and Wood Science – An Introduction: Second Edition* (1989, Haygreen, J.G. and J.L. Bowyer, Iowa State University Press), with permission.

If done improperly, stripping the bark will kill a tree. As done by skilled cork harvesters, stripping the bark does not kill the tree. During harvesting, the bark separates at the cork cambium, which dies, leaving the inner bark (also called phloem, the vascular tissue that transports sap downward in trees) intact. The tree then forms a new cork cambium and produces new bark the following year.

The outer bark is stripped from the tree twice during the first 34 years of growth at which time the bark is too woody and coarse to be valuable. A third stripping occurs after another nine years when the tree is about 43 years old. By this time the cork oak tree is fully mature and yields a layer of high quality cork. A tree 50 years old produces only about 100 pounds of cork, but one that is 80 or more years old produces 500 pounds or more. Cork oak trees usually live about 150 years and the bark can generally be harvested every nine years after the tree reaches maturity.

The bark is stripped from the tree during July and August. Harvesters make a horizontal cut around and through the bark layer just above the ground and another just below the lowest branches. One or more vertical cuts are made between the horizontal cuts, and the cork is peeled away.

The stripped bark is dried for a few days, weighed, and boiled to remove tannic acid and sap. Boiling also makes the bark soft enough to be pressed into flat sheets. The flat sheets are trimmed, baled, and shipped to manufacturers.

Mulch

Many wood product manufacturers remove bark before processing logs into lumber or other products (see Figure 7 and the discussion of lumber production below). The bark is often burned to produce energy to power manufacturing facilities. However, many manufacturers also sell bark for use as mulch. Gardeners use bark mulch to help prevent weeds and to keep the soil moist and cool.

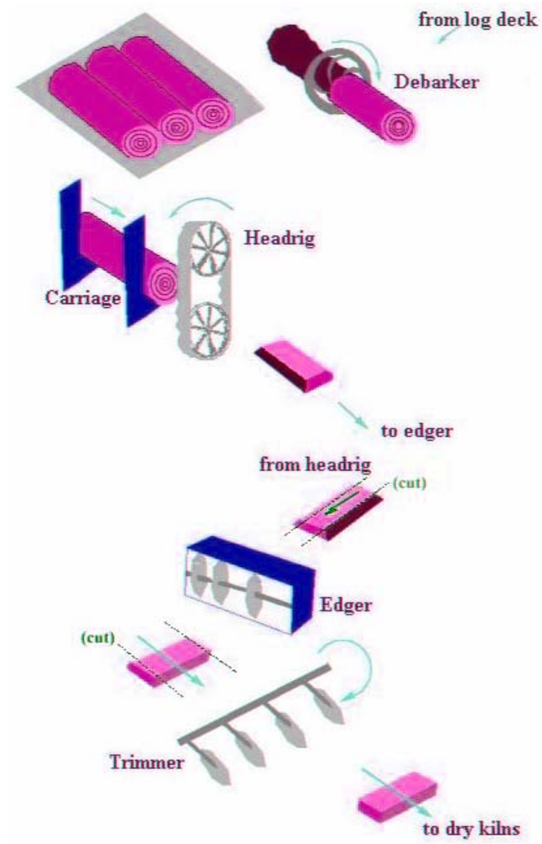

Figure 7. Lumber Manufacturing

Solid Wood Products

Lumber

The process and equipment used for producing lumber varies according to a number of factors including: tree species, size and quality of the logs, available technology, and desired end product. Examples of end products include:

- applications emphasizing strength - wall studs, floor joists, trusses, glue-laminated beams, decks, pallets, upholstered furniture frames, etc.;
- applications emphasizing appearance - siding, shelving, fascia; and
- remanufactured products - moulding, doors, windows, furniture, flooring, paneling, cabinets, etc.

Figure 7 shows the general process of converting logs to lumber.

Logs arrive at the mill on log trucks and are unloaded and piled in the log yard. The logs are then loaded onto the log deck, trimmed to length and the bark is removed at the debarker. Figure 7 shows a ring-type debarker. Ring debarkers have large rotating "fingers" that rub and cut the bark from the log. Debarked logs are then rolled onto the carriage where they are held in place and sawn by large saws called headrigs. Figure 7 shows a bandsaw headrig. Large circular saws (some over 5 feet in diameter) are also used for headrigs.

The headrigs create a semi-processed piece called either a cant or a flitch (the terms are often used interchangeably, however, in general, larger pieces are called cants and smaller pieces are called flitches). The rough edges are then removed by machines called edgers. The rough ends are removed and the boards are cut to uniform lengths by trimmers. The green (full of moisture) lumber is then stacked and dried in dry kilns similar to large ovens. Finally, the lumber is planed to create a smooth surface, graded, packaged and bundled for shipment.

In addition to the sawing machines found in sawmills, many modern sawmills use computers, lasers, ultrasonics (similar to sonar used in submarines), video cameras, and even x-ray to process logs into lumber. Sawmills use this modern technology to help them minimize waste and get the most lumber out of every log.

Pencils

The mass production of pencils began in Nuremberg, Germany, in 1662. Today, the pencil capital of the world is Tennessee. The United States produces about 2 billion pencils per year. Approximately one-fourth of the pencils in the world are made from incense-cedar *(Calocedrus decurrens*), a tree native to southern Oregon and northern California. Pencils are also made from tropical hardwoods and plastic.

Related Project Learning Tree activity:

Number 82 - *Resource-Go-Round*
(This activity involves identifying the raw materials used for making pencils)
Objectives:

1. Identify the natural resources from which products are derived,
2. Trace the lifecycle of a product from natural resources, to the raw materials, to the finished product,
3. Describe how energy is consumed in the manufacturing and transportation of products and how it might be conserved.

Figure 8 shows the steps involved in producing pencils. Logs are sawn into 3-inch by 3-inch blocks of wood called "pencil stock." The pencil stock is dried in kilns and cut to short lengths called "pencil blocks" (Figure 8A).

The pencil blocks are sawn into "slats" (Figure 8B) that are one-half the thickness of a pencil. The slats are then saturated with wax and stain to give the pencil a uniform color and to make it easier to sharpen (Figure 8C). Grooves are machined into the slats (Figure 8D) and the graphite (often mistakenly called lead) is then laid in the grooves (Figure 8E).

Another grooved slat is then glued on top of the slat containing the graphite (Figure 8F). The "graphite sandwich" is then machined and sawn into individual pencils (Figure 8G and 8H). Each pencil is sanded, painted, and the metal ferrule and eraser are inserted (Figure 8I and 8J).

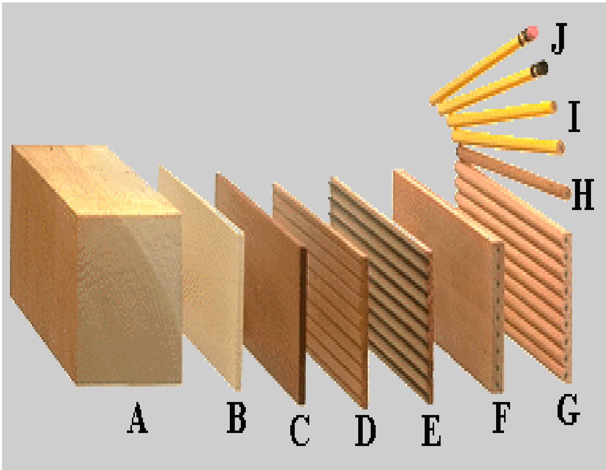

Figure 8. How pencils are made. Reprinted from the Incense Cedar Institute, with permission.

Composite Wood Products

Composite wood products are products made from discrete parts, or in simpler terms, a product made by "taking wood apart and gluing it back together." The "discrete parts" vary by product and include veneer (see discussion of plywood below), flakes or wafers (see discussion of oriented strand board below), chips, sawdust, shavings, and wood fibers. Technically, paper is a composite wood product with the fibers being the discrete parts.

Plywood

Plywood is used for a number of purposes. Plywood made from softwoods, also called conifers or evergreens (pine, hemlock, and Douglas-fir, for example), is used for construction sheathing (roofing, flooring, and walls), concrete forms, packaging (boxes and crates), siding, and more recently for engineered wood products such as wood I-beams. Plywood made from hardwoods, also called broadleaved or deciduous trees (oak, maple, and ash, for example), is generally used for decorative purposes such as paneling, furniture, and doors.

Plywood is made by gluing together sheets of veneer. The grain direction of the sheets (plies) of veneer is oriented perpendicular to the adjacent sheets (except when there are an even number of plies, see Figure 9) to increase the strength and stability of the panel.

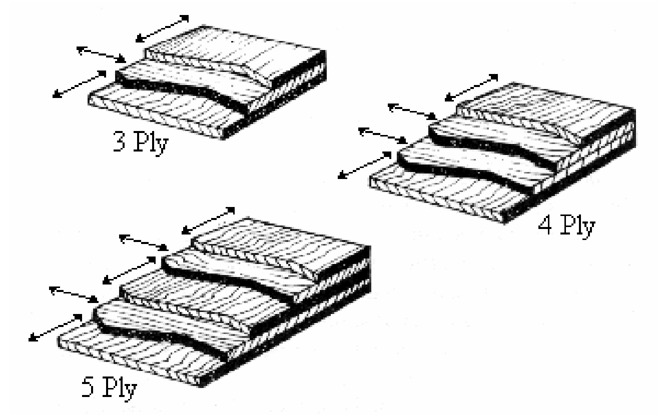

Figure 9. Orientation of sheets of veneer (plies) in the manufacture of plywood. Arrows indicate grain direction. Reprinted from the *Wood Handbook: Wood as an Engineering Material*, 1987, Ag. Handbook #72, USDA Forest Service, Forest Products Laboratory, with permission.

The plywood manufacturing process begins with debarking the logs (Figure 7 shows a ring-type debarker used in lumber manufacturing). Logs are then softened by soaking in hot water or steam baths. A hot log is then held at each end ("chucked") and rotated like a roll of paper towels in a holder. The rotating log is brought into contact with a large steel knife held in a machine called a lathe (Figure 10). The knife cuts a long, thin sheet of wood from the log. The peeling process is analogous to unrolling a roll of paper towels. The long, thin sheet of wood is then clipped to shorter lengths. The clipped sheets of wood are now known as veneer.

The veneer is dried and glue is sprayed on it. Several pieces of veneer are laid on top of each other as shown in Figure 9.

The stack of veneer and glue is placed in a press that applies heat and pressure to dry and set the glue. The plywood is then trimmed to desired width and length (often 4 feet by 8 feet) and bundled for shipment.

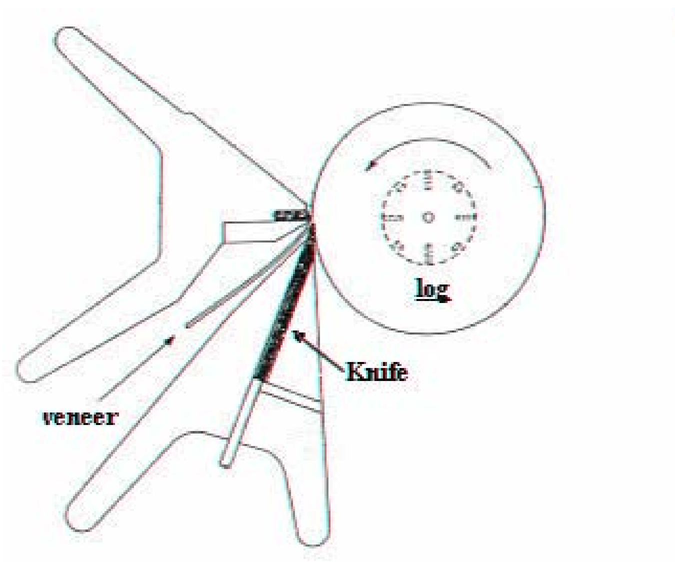

Figure 10. Peeling logs to produce veneer. Reprinted from *Setting veneer lathes with the aid of instruments*, Feihl and Godin, 1967, Publication No. 1206, Dept. of Forestry and Rural Dev. – Forestry Branch, Ottawa, Canada.

Oriented Strand Board (OSB)

As you watch new homes being built you might notice that builders are using less plywood sheathing for roofs, walls, and floors. Structural plywood is gradually being replaced by a product called **O**riented **S**trand **B**oard, or OSB for short. OSB costs less than plywood and can be made from relatively low-grade wood.

Like plywood, OSB is a composite wood product. OSB is made by gluing together flakes or wafers (pieces of wood about the size of potato chips). OSB is also commonly called particleboard, flakeboard, or waferboard. Particleboard (discussed in the next section) is also a composite wood product, however the particles are much smaller than in OSB (Figure 11). Flakeboard is a generic term used to describe composite wood products made from flakes. OSB and waferboard are the two major types of flakeboard. Waferboard looks nearly identical to OSB. In OSB, however, the wood flakes (wafers) are oriented relative to one another (like the veneer in plywood, see Figure 9) to increase the strength and stability of the panel, whereas no attempt is made to orient the wafers in waferboard.

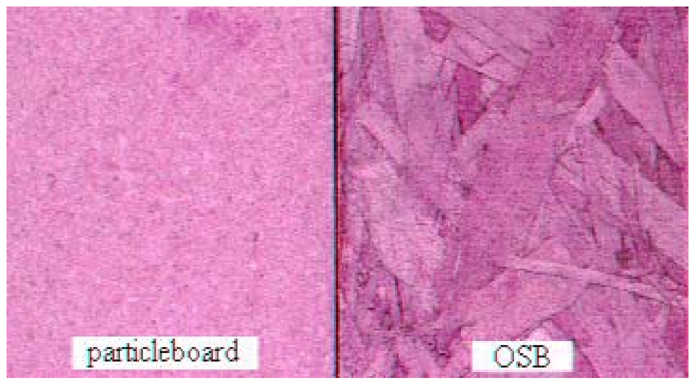

Figure 11. OSB and particleboard.

OSB mills begin by slicing logs into wafers using machines called waferizers. The green (saturated with moisture) wafers are dried and an adhesive is sprayed on them. The wafers are then dropped in layers onto a moving mat. The grain direction of the layers of wafers is oriented perpendicular to the adjacent layers (as with the veneer in plywood shown in Figure 9). The mat of wafers is then fed into large presses that apply heat and pressure to set the glue and create a large panel. After leaving the press, the panels are cut into standard sizes such as 4 by 8 feet, then stacked and bundled for shipment. (Figure 12) presents an artist's rendition of the process of converting logs to OSB.

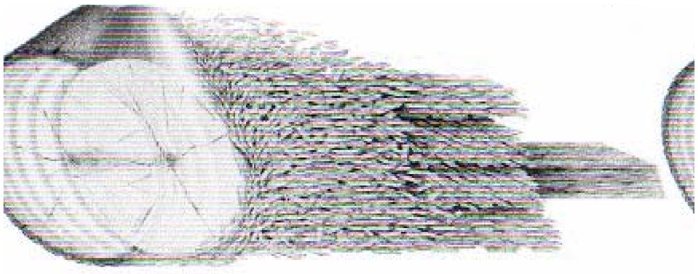

Figure 12. From logs to Oriented Strand Board (OSB). Reprinted from product literature for Sturdi-Wood®, Weyerhaeuser Company, with permission.

Particleboard

Particleboard is a composite wood product, like plywood and OSB. The wood flakes (particles) in particleboard, however, are much smaller than those used to make OSB or waferboard (Figure 11). Particleboard is used for furniture, cabinets, store fixtures, underlayment, and as core material for hardwood plywood (as a substitute for, or in addition to, veneer).

The first particleboard plants were built in 1941 in Germany and Dubuque, Iowa (Haygreen and Bowyer, 1989). The U.S. plant was built in response to large quantities of unused softwood mill residues (sawdust, shavings, etc.). Today, particleboard continues to be made primarily from waste material - the residual shavings and sawdust from other wood products manufacturers.

The process for making particleboard is very similar to that for making OSB. The sawdust and shavings are first screened to segregate them by size. A smooth surface is important and therefore the smaller particles are placed on the surface and the coarser material is placed in the core. An adhesive is sprayed on the particles which are then dropped in layers onto a moving mat. The mat is then fed into large presses that apply heat and pressure to set the glue and create a large panel. After leaving the press, the panels are cut into standard sizes such as 4 by 8 feet, then stacked and bundled for shipment.

Conclusion

There is one product from trees that we have not discussed, and yet this product accounts for the majority of global wood fiber consumption. The product is fuel (firewood). The United Nations Council on Environment and Development (UNCED) estimates that over half of global wood consumption is for fuel. In the industrial world, we think of wood as being used for paper products and to build and furnish homes. In developing nations, however, the primary use for wood is heating and cooking.

There are literally thousands of products made from trees and we have covered but a few. Look around your home or your school and you will be surprised to see all the products that come from trees.

So, what's a tree done for you lately?

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