WOOD--A SIMPLE EXPLANATION
WHAT IT IS AND HOW WE USE IT

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WHAT IT IS AND HOW WE USE IT

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Wood.--Although woody material is found in plants it is produced by nature in its most familiar form in the trunks and limbs of trees. The green of the leaves of trees harnesses the energy of the sun's rays to make starches, sugars, and cellulose from carbon, hydrogen, and oxygen. The three elements come to the tree in the form of carbon dioxide from the air and water and minerals from the soil. The starches, sugars, and cellulose feed and build the tree.

As a result of its own chemical labors a tree is about 60 percent cellulose, quite like the cotton boll, and 28 percent lignin, a cementing stuff. The other 12 percent is made up of sugars and extractives. Extractives are materials, like the red color in redwood, that can be soaked out of the wood with water or other solvents.

A tree grows from the center outward by forming cells or fibers of wood all around the trunk and limbs under the bark, and at the top of growing shoots and branches. On either side of a thin zone just beneath the bark, wood fibers and corky bark units are formed, the wood fibers on the inner side of the growth line and the bark on the outer side. Limbs of trees grow longer and become thicker, but they always remain at the same distance from the ground.

Wood fibers are long, narrow, and hollow, but very small -- about one-seventh of an inch long and seven-thousandths of an inch thick in the needle-leaved trees and even shorter in the broad-leaved trees. So individually, they are about like the bristles of a man's beard. Every fiber is almost pure cellulose and the fibers are surrounded and bound together by a strong nonfibrous sheath of lignin. Thus the strength of wood is the springy strength of millions of tiny sticks bound into a tight bundle.

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1 Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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The way the fibers of any wood are formed and put together determines the strength, weight, and other properties of that wood. Many kinds of wood can be identified by the shape and arrangement of the fibers as seen on an end surface smoothly cut with a sharp knife, just as the living tree can be named by looking at its bark and leaves.

At the beginning of a year's growth in the spring the wood fibers formed are comparatively large, with thin walls, and large open centers, and light colored when seen on the end of a log or board. This early-grown wood is called springwood. The fibers that grow later in the season are smaller, with thicker walls, and small central openings. They are stronger, and look darker on end surfaces. This later-grown wood is called summerwood. Each pair of light and dark circles on the end of a log or stump, made up of a band of springwood and the band of darker summerwood into which it merges on the outer side, makes up a year's growth and is called an annual ring. Counting these rings is the way to tell the age of a tree.

Generally, only the wood nearest the bark of a tree, called sapwood, takes part in the life activity of the tree, that is, in moving the raw and finished food materials. The rest of the fibers toward the center of the trunk, which is usually darker over both springwood and summerwood bands, merely serves to make the tree stiff and strong. This darker central part of the tree is called heartwood.

There are two main classes into which trees and the wood that comes from them are divided. The common name for one class of trees and lumber is "softwoods." The scientists call these trees "gymnosperms," or "trees with naked seeds," and further describe them as evergreens, or cone-bearing trees, or needle-leaved trees. The most important of the North American softwoods are the cedars, southern cypress, Douglas-fir, true fir, the hemlocks, western larch, eastern white pine, ponderosa pine, the southern pines, sugar pine, western white pine, redwood, and the spruces.

The common name for the other class of trees is "hardwoods." The scientific name for these trees is "angiosperms," meaning "trees with seeds enclosed." In general, these trees have broad leaves and shed them in the autumn. The important North American hardwoods are the ashes, aspen, basswood, beech, birch, cottonwood, the elms, the gums, the hickories, the maples, the oaks, black walnut, and yellow-poplar.

It is well to remember what is really meant by "softwoods" and "hardwoods" as the words are commonly used. Some of the softwoods are quite hard, in fact, and some of the hardwoods are quite soft -- softer than some of the so-called softwoods.

The "basic wood substance" of which the fibers of all woods are made weighs about the same in all woods. But because actual wood has so many tiny internal openings, it is usually much lighter than the fiber wall substance. Because the intermingled openings and fiber walls vary so much from one kind of wood to another the actual weight of various woods also differs over a wide range. Basswood, for instance, weighs about 26 pounds.
per cubic foot when moderately dry. Live oak at the same moisture content will weigh about 62 pounds per cubic foot, so that it will scarcely float in water even when dry. Weight is almost a direct measure of strength in wood. The strength of two different woods will vary almost to the same degree as their dry weights vary, the heavier wood being the stronger.

Wood, either in the tree or in the form of lumber, always contains water. Green wood may have as little as three parts of water to ten parts of wood by weight, or in some trees there may be twenty parts of water to ten of wood. A giant redwood tree contains enough water to fill a backyard swimming pool. Lumber readily absorbs moisture from the air, and gives off or takes on moisture to come to balance with the amount of moisture in the air.

Wood that is too wet may shrink and cause trouble when used, and wet wood is also liable to rot. So wood for most uses must be dried or seasoned. Seasoning is done either by piling lumber outdoors where sun and wind can dry it slowly down to a moisture content of about 12 to 14 percent, or by drying it in a lumber kiln. A lumber dry kiln is simply a large drying oven in which temperature, air moisture, and air circulation can be carefully regulated to dry lumber by the truckload without damage.

To give best service wood should be dried to a moisture content as near as possible to the moisture content it will come to in the location where it will be used.

Everyone knows how wood doors and windows sometimes stick in damp weather and loosen in dry weather. The amount by which wood actually gets larger and smaller as it takes on moisture or dries out must be foreseen in making some wooden articles. All swelling and shrinking takes place below 30 percent moisture content. The greatest change, which varies with different woods, may be as small as 4 percent or as great as 14 percent in the width of ordinary boards. It is roughly half as great in thickness, and is too small to worry about when measured lengthwise.

Swelling and shrinking of wood can be controlled by soaking it in solutions of plastics and hardening the plastics in the wood with heat. Several new products treated in this way were introduced for military uses, such as for airplane propellers, during World War II. They have since found use for molds and jigs in aircraft plants, in cutlery handles, and for clarinets.

Wood at moisture contents above 20 percent may decay (rot). Decay is caused by the growth of tiny plants known as fungi (fun'ji), the same class of living things that produces toadstools and mushrooms. Sapwood is more apt to decay than heartwood.

For uses where wood cannot be kept dry enough to protect it from decay, as in railroad ties, the outer layers can be treated in pressure tanks with chemicals that poison fungi. These chemicals prevent the seed-like spores of fungi, always present in the air, from growing on the wood. Merely brushing or soaking wood with wood preserving chemicals is not so satisfactory as forcing the chemicals into the wood under pressure. A good
wood preservative, properly used, should make wood last from 2 to 5 times as long as it would without treatment when it is used in damp locations or near the ground.

Coal-tar creosotes are poisonous to fungi and are much used where their black color and strong tarry odor do not matter. Because the creosotes are mixed with and dissolved in oils they do not wash out seriously with rains or other moisture and hence protect the wood for many years. Railroad ties, bridge timbers, telephone poles, fence posts, and mine timbers are commonly treated with creosote.

Certain metallic salts, such as zinc chloride and sodium fluoride, are good preservatives too, although they dissolve in water and are not so permanent outdoors.

Odorless, colorless, paintable preservatives that will not corrode nails and screws are coming into increasing use for household articles, such as window sash, that are liable to decay.

Wood can also be made resistant to fire by chemical treatment. Ammonium phosphate and mixtures of ammonium phosphate, ammonium sulphate, borax, and boric acid have proved to be good for this purpose, although expensive to use.

Just as for other materials, the strength of wood in various shapes and sizes has been worked out by hundreds of thousands of tests, and strength classes or grades have been set up and widely used in the sale and use of building timbers. As a result the engineers who build bridges, hangars, factories, and other industrial works can plan them surely, safely, and without waste of timber.

Plywood is layered wood, built up from thin sheets into large tough panels having more nearly uniform properties in the length and breadth than ordinary wood. One form of this important modern material is molded plywood, thin waterproof plywood molded for such uses as boat hulls.

Uses of wood.--From some age far back in the history of man comes the habit of knocking on wood for luck, perhaps from a time when men believed that nymphs or less gentle spirits lived in trees or in the forest. Modern man no longer trembles when he knocks on wood, but like his low-browed ancestor, he is a liberal user of wood and never at a loss for a piece to rap with his knuckles for luck. Wood now serves in a wider variety of uses than ever before and in commodities of greater durability and beauty. Five of the most important needs of mankind -- shelter, fuel, clothing, food, and transportation -- can be met in some degree by wood. As wood is quite abundant over large areas of the earth and can be harvested again and again as a crop, it is a raw material which need never be used up.

Because wood can be purchased at reasonable cost, and because it is workable with simple tools, light in weight, and a fine insulator against heat and cold, it is the favorite home building material on the North American
continent. In the United States more than 90 million people live in houses of wood, and wood is an important part of the furnishings of the homes of these and many other millions. Enormous quantities of boards, house timbers, and millwork made in special shapes like moldings and door frames, are needed each year to house the growing population. Farmers use a large amount of lumber for their houses, barns, stock shelters, and other farming equipment.

Since it is light, workable, strong, warm to the touch, and easy to finish and make into attractive designs wood is the most important material for all classes of furniture for use in homes, offices, schools, business places, and public buildings.

Great sections of the population use wood as a fuel for heating and cooking. Except for lumber, more wood is cut for fuel than for any other single use.

In peacetimes nearly all merchandise is shipped in fiberboard containers (a wood product) or, in the case of heavy or fragile articles, in wood boxes and crates. In war great numbers of stout, tight, wood boxes and crates are needed to get supplies and ammunition in good condition to armies across the sea. Twelve billion board feet of lumber was used for this purpose in 1942, or a little more than a third of all lumber cut in the United States.

In the upkeep of track, and in the building of cars, small stations, sheds, tool houses, bridges, and fences, and for carrying telephone and telegraph lines the railroads depend on wood. Twenty-five hundred patents have been granted on crossties of various materials, but nothing has been found to equal the wood tie for toughness, cheapness, flexibility, and resistance to pounding by heavy trains. A billion ties are in service and 50 million are used as replacements in an average year.

Some 265,000 miles of telephone and telegraph lines carry our messages over wires hung on wood poles. Far underground 750,000 miners getting out coal, iron, and other minerals are protected from falling earth and rock by heavy wood timbers. Wood piles for piers, wharves, breakwaters, dams, and jetties are cut at the rate of a million a year. To protect food crops and livestock many millions of wood fence posts, in fact 3 to 5 for each person in the United States, are required to keep fences in repair.

The wood products made by freeing, refining, and dissolving wood cellulose and lignin are everyday necessities.

Paper is made from wood by dissolving out the cementing lignin between the fibers (or by grinding the fibers off on a large grindstone), refining them, and forming them into sheets. Paper has been called the lifeblood of civilization because it carries the ideas that cause men's minds to grow. Newspapers, magazines, textbooks, blueprint paper, and legal and business papers, serve this end and also protect and transfer wealth and keep industries operating.

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Men's physical needs are served in many ways by paper -- by surgical papers and absorbents, food wraps, containers for all sorts of goods, building papers, and paper rugs and wovenware. More than 9,000 uses for paper and pulp products have actually been counted.

When wood fibers and wood lignin are dissolved by any one of several processes they may be molded into plastic articles, formed into sheet materials such as cellophane, or spun into yarns for fabrics.

Wood cellulose plastics are used in photographic film, in airplane "dopes," combs and other toilet articles, imitation leather, fountain pen barrels, bottle caps and seals, phonograph records, and in thousands of other familiar articles. Sheet cellulose in various thicknesses, colored or transparent, is a favorite packaging and display material.

Every year wood fibers are dissolved and spun into several hundred million pounds of rayon yarn for stockings and dress goods, undergarments and suits.

In the form of cellulose nitrate, cellulose dissolved in nitric acid, wood is used interchangeably with cotton to make high explosives for big guns.

Small amounts of lignin, which has been discarded by paper mills at the rate of a million tons a year as a waste, have been used as a road binder, as linoleum cements, in electroplating, and in storage batteries. Now more is known about its chemical nature and how it may be used. Its readiness to become plastic when heated has made it possible to produce experimentally general purpose black plastic from sawdust or other wood waste. To make this plastic some of the cellulose of the wood waste is changed to wood sugars and is removed from the wood, and chemicals are added to help soften the lignin.

It has been known for many years that cellulose could be changed by chemical treatment into sugars for human or animal use. During wartime shortages of sugar and stock food in Europe this process has been used to help out the supplies of both.

Ethyl (grain) alcohol can be made from wood by carrying the sugar-recovery process a little further -- by fermenting the sugars with the help of yeasts. Ethyl alcohol is valuable for many industrial uses including the production of butadiene for synthetic rubber. High-protein yeasts for stock food can also be grown on wood sugars.

Methanol (wood alcohol), another important industrial chemical, can be made by heating wood in closed retorts or chambers. However, in normal times wood alcohol can be made more cheaply from other materials.

Gas made from wood or wood charcoal in special tank-like attachments called gas producers or "gasogens" can be used to run the motors of automobiles and trucks. In times of gasoline shortage thousands of gasogens have been used to drive motor vehicles in Europe and Asia with wood as fuel.
Wood turpentine and rosin are called naval stores because in the early days of our Navy they were used for calking the hulls of wooden ships and for lubricating their ropes. Naval stores are made by distilling (boiling) a gum-like material gotten by wounding or chipping the slash and longleaf pines of the South. Turpentine is used as a thinner for paints and varnishes and in making waxes and polishes. Great quantities of rosin are used in paper, varnish, and soap, and lesser amounts in matches, linoleum, oils and greases, rubber, adhesive tape, and printer's ink. In an average year 500,000 barrels of turpentine are produced in the United States and a million and a half barrels of rosin.

Altogether the wood-producing and wood-using industries are an important part of business in North America. In the United States the lumber industry alone makes work for a million people, is fourth in value of its product in peacetimes, and sixth in number of people working.
The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin.

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Note: Since Forest Products Laboratory publications are so varied in subject, no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous 6 months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.