Basic Information About Wood

What should you, as a leader, know about wood that will help your 4-H'ers better understand it and its use?

Where Does Wood Come From?

We all know that wood comes from trees, but where in the trees, and how does it get there? Most of the wood that you and your 4-H'ers will use in your wood science projects will come from the trunks of trees. However, wood from large branches is similar in structure.

Wood, itself, is composed of woody tissue, which is made up of individual wood fibers. An individual wood fiber is very, very small. Tear a piece of paper and look at the torn edge. You should be able to see an individual wood fiber. (You can see it better when magnified.) Paper is made of wood fibers which have been separated from each other and then matted together in a rather random fashion. The original wood grows with these fibers all attached to each other and all aligned in one direction, parallel with the trunk.

If you could look at the end of a piece of wood magnified to 1,000 times its actual size, you would see something that looks quite similar to a box full of soda straws. Each individual straw resembles a wood fiber. Each straw is hollow; so is each individual wood fiber. If you dumped the soda straws out of the box, scattered them about and flattened them, they would look like the magnified surface of paper. Then, if you tore them apart, you could look at one individual straw, just as when you tore the paper, you looked at one individual wood fiber.

What does this have to do with wood science, you may be asking? It is important because so many of the properties of wood are best understood by understanding wood structure.

Wood structure helps explain the strength and weakness of wood. If you wanted to support a concrete block using a couple of boxes of soda straws, you could if you set the soda straws on end. Similarly, you could support a loaded box car with two pieces of wood on end. If you try to support the concrete block with soda straws on their side, you would probably crush them. Similarly, if you tried to support the loaded box car with the wood on its side, you would probably crush it. The point is that wood, like the soda straws, is very strong in the direction of the wood fibers and less strong in the other direction. Many other wood properties depend upon the direction of the wood fibers.

Before leaving the soda straw illustration, there is one additional point which needs to be made. If you took just a few soda straws and stood them on end, they would not support very much weight. If you glued a few together and stood them on end, they would support more weight, but they would probably bend before they compressed. If you glued many straws together and stood them on end, the structure would be strong enough for you to stand on. You can likewise support a very heavy load with a short section of 2×4 (on end) but a full length 2×4 will not support that same load because it will bend. (If you can somehow keep the 2×4 from bending throughout its length, it will support the heavy load.) This demonstrates that the ultimate strength of wood in its strongest direction often cannot be utilized because of a number of factors.

Where Wood Fibers Come From

Now that you know wood is composed of fibers, which are essentially parallel to each other and held together, you might wonder how they get that way. Obviously, they grow that way when a tree is forming wood. In temperate climates, trees grow only during the warmer part of the year. The trunk and branches of trees are covered with a layer of bark. All growth of wood fibers takes place at the junction between the wood and the bark. This junction is called the cambium layer. The cambium is the growth layer, and it allows the tree to grow larger in diameter. Each year a sheath of new wood is formed that completely covers all of the older wood in the trunk and branches. Each new sheath fits snugly over the layer of wood formed the year before.

The wood formed during the early part of each growing season (called springwood or earlywood) is usually lighter in weight and coarser in texture than the summerwood or latewood, formed near the end of the growing season. After most trees have reached a moderate age, the wood near the center of the trunk and branches undergoes further changes. It changes from sapwood into heartwood. Sapwood is usually light in color while heartwood is usually darker in color. Early in the life of the tree, the heartwood was sapwood; but, as the tree grew older, the inner sapwood died and turned to heartwood. Heartwood may be more resistant to decay than sapwood. Often a decayed log in the woods will contain all heartwood, the sapwood having rotted away. Very young trees may be all sapwood. But in most species, the band of sapwood which surrounds the heartwood accounts for a relatively small proportion of the total trunk. The rich colors of furniture woods, like cherry and walnut, are the colors of the heartwood of these species.

(Refer to the Unit III 4-H member manual, *Building Bigger Things,* "Structure of Wood.")

Annual Rings

If a tree is cut by sawing through the trunk just above the ground, the surface of the stump reveals the tree's history. The center of the cross section is called the pith. It was formed when the seedling sprang up. In concentric rings around the pith, there are alternate layers of springwood and summerwood. Each ring is made up from the springwood and summerwood formed during one growing season, and the total ring formed in one season is called the annual growth ring or the annual ring. If the tree is cut during the growing season, the last annual ring will not be complete. If the tree is cut early in the growing season, the ring will contain only springwood fibers, since the cambium layer is still producing springwood fibers at that time. If the tree is cut later in the growing season, the cambium layer may or may not have already switched to growing summerwood fibers. However, if the tree is cut in the winter, the outermost annual ring will be complete, having both springwood (earlywood) and summerwood (latewood) fibers present.

The number of annual rings accurately tells the age of the tree. The relative thickness in the proportion of springwood to summerwood can tell much about the local climate during the life of the tree. Fast growing trees have wider rings than slow growing trees. Some fast growing trees have rings up to an inch thick, while some slow growing trees take 100 years or more to grow an inch. In general, wood from fast growing trees, which produce mostly springwood, is weaker than wood with more summerwood.

You cannot tell the age of a tree by counting the rings on a cross section of a cut which is some distance above the ground, because you have no way of knowing how many years it took the tree to reach the height at which the cut was made.

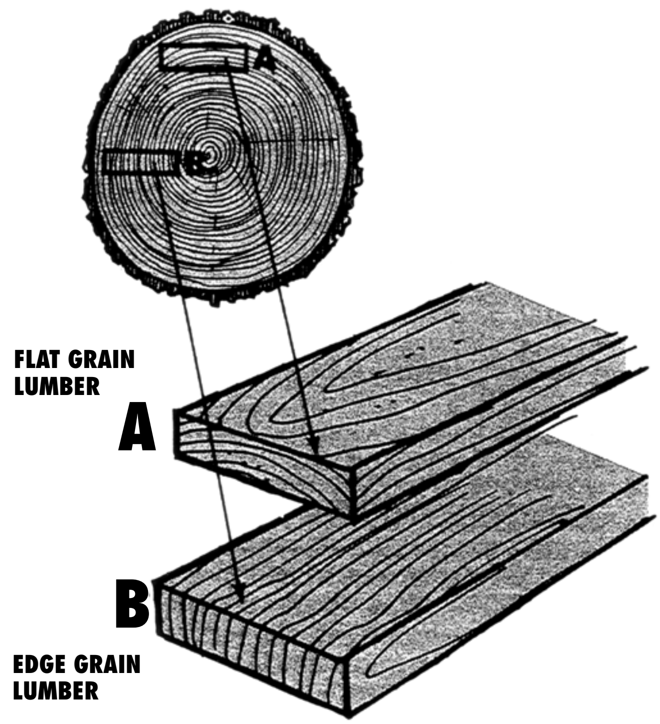
(Refer to the Unit II 4-H member manual, *The Wonderful Wood of Wood,* "Learning to Use Wood"; and to Unit III, *Building Bigger Things,* "Structure of Wood.")

Boards Cut From Logs

When a tree is cut into logs and the logs cut into boards, it may be cut in several ways. If you cut the log off center, closer to the edge like "A," you will get "flat grain" lumber. The grain on the wide face of the board will be large flat bands, long wavy arches or long patches, depending on how the saw cuts through the annual rings of the log. The grain on the edges will be narrow stripes or lines.

If the log is cut through the center, like "B" in the drawing, you will get "edge grain" lumber. In edge grain lumber the grain goes nearly straight across the board from top to bottom and gives a pattern of stripes or lines on the wide face of the board. Lumber cut near the center of the log will have edge grain.

Knowing this about edge grain and flat grain lumber, you will soon realize that most boards will be something other than pure edge grain or pure flat grain. Few trees are so large that a board cut from the edge will have growth rings that run parallel to the surface of the board. There may be trees which have a nearly flat surface, but growth rings generally curve because the tree is round, so true flat grain is so rare as to almost not exist. True edge grain is relatively easy to obtain from any tree but only in very limited quantities. You could get additional edge grain by first cutting a log into pie shaped pieces and then cutting these into boards. In actual practice, logs are seldom cut this way because it wastes too much wood and would produce more lower grade boards since defects, such as knots, are most common near the center of the tree (and edge grain boards more likely contain wood from the center of the tree). Generally, logs are sawn so that flat grain boards are cut first.



(Refer to the Unit II 4-H member manual, *The Wonderful World of Wood,* "Learning to Use Wood.")

Knots

A knot is a section of a branch embedded in the wood. The wood in the trunk of a tree must curve around the wood of the tree's branches. When the trunk and a branch are both living, a sound knot is formed. If the branch dies and the trunk continues to grow around it, the knot and the trunk will not actually grow together, even though the trunk has grown tightly around the knot. This results in a loose knot in a board. Loose knots sometimes become knot holes. Both loose knots and tight knots cause reduction in strength in wood, but loose knots are generally more objectionable. In fact, tight knots are favored for some special uses, such as in knotty pine paneling or furniture.

As a tree grows, the lower branches are shaded by the upper branches and often die, and eventually drop off. As the tree continues to grow in diameter, clear wood grows over the broken off stubs of the branches so that, after time, a tree may have a clear trunk where once there were branches. Even though the surface of the trunk is clear, the wood underneath the surface still contains branch wood from when the tree was smaller. Clear boards are more valuable than boards with knots. Every log contains some knots near the center of the cross section, and some logs contain knots on all surfaces. The grain of the wood in and around knots is irregular and may interfere with woodworking processes.

(Refer to the Unit III 4-H member manual, *Building Bigger Things,* "Knots."

Softwoods and Hardwoods

Softwood lumber comes from trees which have needles. Hardwood lumber comes from trees which have leaves. Generally, softwood lumber is actually softer than hardwood lumber but there are many exceptions. Softwoods, such as southern yellow pine, are harder than hardwoods, such as cottonwood and yellow poplar. A heavier wood, be it softwood or hardwood, is generally harder and stronger than a lighter wood. Most houses are built from softwood. Most furniture is made from hardwood.

(Refer to Unit II, *The Wonderful World of Wood,* "Learning to Use Wood"; and to Unit III, *Building Bigger Things,* "Identifying Hardwoods and Softwoods.")

Why Wood is an Important Material

Wood comes in many species, sizes, shapes, and conditions. It has a high ratio of strength to weight and a remarkable record for durability and performance. Dry wood has good insulating properties against heat, sound, and electricity. It can absorb and dissipate vibrations. And, it is used in fine musical instruments, such as violins. Because of the variety of grain patterns and colors, wood is also an aesthetically pleasing material. Its appearance may be easily enhanced by stains, varnishes, lacquers, and other finishes. It is easily shaped with tools and fastens easily with adhesives, nails, screws, bolts, and dowels. When wood is damaged, it is easily repaired. Wood structures are easily remodeled or altered. Wood resists oxidation, acid, salt water, and other corrosive agents. It has a high salvage value. It can be made decay and insect resistant with preservatives and can be treated to resist fire.

Moisture Content of Wood

Moisture content of wood is defined as the weight of water in wood expressed as a fraction, usually as a percentage of the weight of oven dried wood. Weight, shrinkage, strength, and other properties depend upon moisture content of wood. In living trees, moisture content may range from 30 percent to more than 200 percent of the weight of wood.

Moisture exists in wood as water or water vapor in the hollow portion of the wood fiber, or as water "bound" chemically within the cell wall. Green wood is wood in which the cell walls are completely saturated with water. Waterlogged wood is wood in which the cell walls and the hollow fibers are completely filled with water. The water contained in the hollow wood fibers adds to the weight of wood but does not affect the other properties very much. The water which is contained within the cell wall greatly influences wood properties. The cell walls in a growing tree are saturated with moisture, and there often is additional moisture inside the hollow wood fibers. Most of the changes that take place in wood due to drying begin to take place as wood dries below 30 percent moisture content, which is the approximate point at which only the "bound" water remains. This is called the fiber saturation point. At moisture contents below the fiber saturation point, wood begins to shrink and gain strength as it loses moisture.

Equilibrium Moisture Content

The concept of equilibrium moisture content is perhaps the most important wood science concept for a woodworker to know. Equilibrium moisture content is defined as that moisture content at which the wood is neither gaining nor losing moisture. In other words, the wood is in equilibrium with the atmosphere. In actual use, wood almost never reaches a true equilibrium with its surrounding atmosphere, because air temperatures and relative humidities in which wood is used are continually changing.

Wood is constantly either drying or gaining moisture. If you started out with a wet piece of wood and a dry piece of wood of any species and kept them inside an average home, the wet piece of wood would slowly dry to about 8 percent moisture content, and the dry piece of wood would slowly gain moisture to about 8 percent average moisture content. (For the dry Southwest, the figure is closer to 6 percent, and for the humid South and Southeast, it is closer to 11 percent.) The point is that a woodworker should know why it is important to use wood which is already near the moisture content that it will reach while in service or use. This practice should reduce wood shrinkage and swelling by minimizing the change in moisture content of the wood.

Shrinkage

Wood starts to shrink at moisture contents below 30 percent. It swells until it reaches 30 percent. This shrinking and swelling may result in warping, checking, splitting, or performance problems that subtract from wood's usefulness. In your home, you may have experienced a drawer or a door that became difficult to open in humid summer weather due to swelling. Shrinking and swelling can be controlled by controlling the moisture content, but wood is often used where it is not practical to control temperature and relative humidity. Protective coatings can retard (but not prevent) the movement of moisture from the air into and out of wood. The adverse effects of changes in moisture content can often be partially offset by good design and careful selection of materials.

How much does wood shrink? The maximum shrinkage, from fiber saturation point to oven dry, varies in three principal directions. Along the grain, such as along the length of the board, the normal shrinkage is very, very little. This is called longitudinal shrinkage. Infrequently, there are individual pieces of wood which exhibit abnormal longitudinal shrinkage, but for the most part, shrinkage along the grain is no problem.

Flat grain boards shrink more in width than edge grain boards, but less in thickness. The across-the-width shrinkage of a flat grain board is called tangential shrinkage (tangent to the growth rings) while the across-the-width shrinkage of an edge grain board is known as radial shrinkage (in the direction that radiates from the center of the tree). Heavier woods generally shrink more than light woods.

Tangential shrinkage is as much as 12 percent for hickory, a very heavy wood, to as little as 5 percent for redwood, a very light wood. Radial shrinkage for hickory is 7 percent and for redwood is 3 percent. Note that this is the total shrinkage from 30 percent moisture content to oven dry. Most wood in use never shrinks this much because most wood does not dry completely.

If left long enough in the equilibrium moisture content conditions in which it will be used, wood will dry to the proper moisture content. However, this may take an excessively long time, especially for some hard-to-dry woods. Left outside (in most regions of the country), wood will never reach the desired moisture content for interior use. Outside humidities are simply too high most of the year.

Most lumber intended for interior use is dried at high temperatures in controlled humidities, in lumber dry kilns. This removes moisture rapidly. The moisture content of lumber in kilns can be accurately controlled. However, proper care of lumber after drying is also important. Just because lumber has once been kiln dried does not assure that it will be satisfactory for your needs when you go to use it, because it could have regained moisture from the air during the storage period after drying.

It is important that a woodworker learn to use lumber that is at the proper moisture content. In addition to the undesirable shrinkage or swelling which would result from improper moisture content, some other woodworking operations, such as gluing and finishing, can be adversely affected by too much or too little moisture in the wood.

Unfortunately, it is not possible to tell by looking at wood if it is at the proper moisture content. Electrical moisture meters can be purchased to measure moisture content of lumber, but, lacking a meter, the simplest way for a woodworker to check the moisture content of wood is to dry a scrap piece of the wood in an oven.

Measuring moisture content would be a good class exercise. You will need an accurate scale. See the activity called "Measuring the Moisture Content of Wood" in Appendix X ("Suggested Wood Science Experiments") in this leader's guide.

Specific Gravity of Wood

Specific gravity of wood, like that of any other substance, is its weight compared to the weight of an equal volume of water. None of the domestic woods when dry are as heavy as water, although some foreign woods are heavier than water. Any wood, if wet enough, will sink rather than float. Specific gravities of U.S. woods range from about 0.30 for northern white cedar to about 0.88 for live oak (based on 12% moisture content). In general, the higher the specific gravity, the stronger the wood, and the lower the specific gravity, the easier the wood is to work.

(See the activity called "Specific Gravity and Strength of Wood" in Appendix X ("Suggested Wood Science Experiments.")

Other Characteristics of Wood

Each wood has some unique working qualities. Woods weather differently. Woods have differing degrees of decay resistance. There are substantial differences in mechanical properties that are not explained by differences in specific gravity alone. The mechanical properties of wood are explained and values given for American species in Chapter 4 of the 1974 U.S.D.A. Wood Handbook (see "Reference Materials").

Renewability—A Most Important Property

Forests are renewable. Wood products can be produced without expending large quantities of energy. Wood scientists have improved the efficiency in using forest resources so that the same quantity of raw material goes further. Knowledge of how to use wood properly is a scarce resource. Well designed wood products, carefully made, can extend this valuable wood resource even further. 4-H youth can play an important role in this important process.

Tools and Machines

The beginning 4-H'er should use simple tools. As he or she continues in the wood science program, each should learn to use a wider variety of tools and materials. Simple and easy-to-use tools are described in Unit 1. Additional tools and their uses are described in other project manuals.

Members should be encouraged to acquire their own set of tools; however, inability to do so should not be a deterrent to anyone. Local donors, individuals or groups, probably can be found to purchase tools and materials which will remain club property.

Many leaders will allow members to use their personal tools. Remember, youngsters are active, energetic, inexperienced, and need guidance. Encouraging wise and safe use of tools moves 4-H'ers toward increasing opportunities. Even beginning woodworkers can safely use instruments like the short stroke, finetooth jig saw; the oscillating electric sander; and the light duty quarter-inch drill, if properly instructed and supervised in their use. Other power tools and machinery are illustrated in Units II and III; however, the member may satisfactorily complete his or her project work without the use of power tools.

Safety Tips for Using Woodworking Tools, Machines, and Processes

1. Dress appropriately for work in the shop. Wear protective clothing and equipment. Eye protection is always recommended, especially when power tools are being used; and, in many states, eye protection is mandatory.
2. Tools such as screwdrivers, wrenches, and chisels should be of the proper shape and size to fit snugly. Worn tools with rounded corners and blunted edges are dangerous.
3. Electrical equipment grounds on power tools should be properly connected before the machines are started.
4. Never depend upon back muscles in lifting heavy objects. Get help, if necessary, and lift with leg and arm muscles.
5. A sharp cutting tool is less dangerous than a dull one.
6. Lay tools on benches in an orderly fashion. Protect cutting edges and keep sharp surfaces pointed away from the work area.
7. Fasten materials securely in a vise when practical.
8. Keep the work area clean, especially the floor. Put waste stock in the scrap box and oily rags in closed metal containers.
9. Maintain order. No running or playing in the work area!
10. Keep the work area well lighted. Fifty footcandles of illumination is recommended for detailed work.
11. Follow directions and instructions for tools, machines, and materials.
12. Be sure members can successfully pass both written and practice tests before operating machines.
13. Take care of accidents promptly. Apply first aid for any cut or scratch. Keep first-aid equipment readily available.
14. Keep up to date on safety information. Secure posters and visual materials from sources such as the National Safety Council, as constant reminders for 4-H'ers.

NOTE: The leader will note the special emphasis placed on safety in each member's manual.