BRUCE HOADLEY

Wood has to breathe, doesn't it?

"But I was told I shouldn't use varnish because it really doesn't allow the wood to breathe. The wood *should* be allowed to breathe, shouldn't it?"

As I tried to answer the telephone inquiry about a routine finishing problem, I thought to myself, "Oh, oh, the old 'wood has to breathe' thing again." It took another twenty minutes of talk to untangle things. After hanging up, I opened my notebook to a list I once started, called *Common Confusion about Wood.* "Wood has to breathe" had been logged in as Item 2B. It goes with 2A, "Wood is a living substance," and 2C, "You must feed and nourish wood to keep it well." I wonder how these notions get started, or where to begin separating fact from fiction, to clarify the confusion. Wood is such a complicated material, and there is so much vital information to become familiar with, it is truly a shame that the whole subject has been made even more confusing by such wrong ideas as wood somehow being a living, breathing material. Because these misconceptions are so rampant and can be so misleading, a review of some of the more common fallacies will be worthwhile.

A tree is a living organism, which of course it must be in order to grow. It is made up of a myriad of cells, all of which were alive when they formed, some of which are still alive, but most of which (in the wood of the tree) are dead. A cell is considered alive if it contains living protoplasm and a nucleus within the cell cavity. The thin cambium layer, which is the growing interface between bark and wood, is composed of living cells. Cambium cells can divide to produce new bark and wood cells. As the newly divided cambial cells differentiate and transform into various specialized wood cells, they remain alive for several days—long enough to assume their final shape and to develop the full cell-wall thickness.

In newly matured sapwood, however, only a few cells (roughly 10%) remain alive. They are called parenchyma cells. By retaining their living contents, they are able to assimilate and store carbohydrates and perform other metabolic functions. But all the cells other than parenchyma lose their protoplasts after maturing and are therefore non-living. They may still participate in the tree's life functions by providing a means of sap conduction through their now empty cavities (vessels in hardwoods or tracheids in softwoods), or they may simply strengthen and support the tree according to their relative cell-wall thicknesses.

As sapwood eventually becomes heartwood, the parenchyma cells also die. Heartwood is all dead cells. No sap conduction takes place in heartwood either.

When a living tree is cut down, its complicated life system comes to a halt. The parenchyma cells of the sapwood gradually die too. By the time the moisture is dried out of the wood, it is absolutely dead—no more alive than a cotton shirt or a wool necktie.

The "breathing" analogy is often applied to the shrinking and swelling of wood as moisture is gained and lost in response to variations in atmospheric humidity. It has also been applied to the fact that as atmospheric pressure and temperature change, air from cell cavities may be exchanged with the atmosphere by expansion and contraction. If this is breathing, then cellulose sponges and lava stones also breathe. By sealing off the surface of wood, some finishes can virtually eliminate moisture or air exchange, which is usually an advantage. The wood doesn't have to breathe.

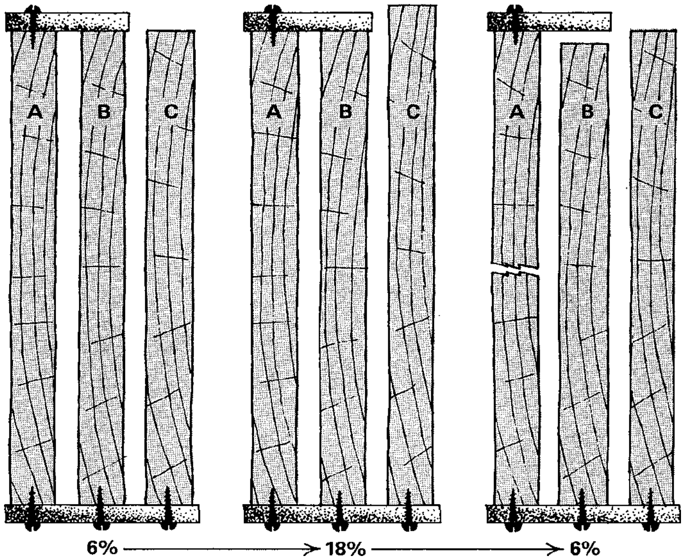
Wood doesn't eat, either, so you don't have to feed it.

When a finish is used on the surface of a piece of wood, the improvement in appearance is mainly an optical effect. When a finished surface becomes ineffective, the finish may be rejuvenated without affecting the wood. The coats of finish put onto wood may enhance its appearance or protect it, but the finish in no way nourishes the wood.

Confusion exists also about agencies or mechanisms that can destroy wood. Item 3A on my list is about dry rot, a misnomer from the beginning since rot is caused by decay fungi whose activity is possible only in the presence of moisture. Item 3B is that wood somehow disintegrates if allowed to dry out. One authority on the care of museum objects declares that a 50% relative humidity (equivalent to about a 9% equilibrium moisture content in wood) is the absolute lower limit of safe humidity, on the meaningless grounds that "dehydration" will take place if the air is dryer, or that wood is susceptible to "damage by desiccation" (whatever that means). In fact, as evidenced by artifacts discovered in the arid Southwest, wood can survive for centuries in extreme dryness. The notion that wood is harmed by dryness may come from the shrinking of wood upon exposure to relatively low humidity. Certainly, the loss of dimension and the uneven shrinkage that causes warping or checks are usually undesirable. But the wood itself does not deteriorate merely by drying and shrinking. Every piece of cabinet wood has already been dried and has already shrunk in the process of getting it from the tree to the shop.

Cyclic humidity, not dryness only, is probably at the bottom of these misunderstandings. People say, "Oh, we don't have any trouble from high humidity. Low humidity causes all our problems." Most of the time, damage to wooden furniture which has been in use for a long time is due to seasonal moisture cycles, usually associated with some sort of restraint in the construction. When the humidity goes up, the wood expands. It may be restrained, for example, by a tenon that tightly fits a mortise. The fibers are compressed, but the joint remains tight with no apparent damage. Inside the joint, though, the fibers may have been compressed beyond their ability to recover. The assembly dries again, and the wood either checks or the tenon shrinks smaller than its original dimension. Although the wood has only returned to an originally low level of moisture content (at which the wood was in

This diagram summarizes an experiment Hoadley conducted to illustrate the effect of variations in moisture content when wood is prevented from shrinking and expanding. All three sections were cut across the width of the same board, whose moisture content was 6%—equivalent to a relative humidity of around 20%, normal for interiors during the Northeastern winter. Heavy screws fixed one end of each piece of wood to a metal plate. The other end of board A was also screwed down tight, equivalent to a tabletop tightly secured to an apron frame. Board B was prevented from expanding by the metal plate, but not attached to it—equivalent to a panel fitting tightly into grooves in the stiles of a frame. Board C was unrestrained. Hoadley slowly raised the humidity to 80%, typical for summer. The moisture content of the wood increased to 18%. Board C expanded, as you would expect, while the metal plates prevented boards A and B from expanding. You can't see it, but the elastic limit of the wood has been exceeded and the wood cells are permanently deformed: compression set. When he reduced the moisture content to the original 6%, the unrestrained board C returned to its original size. Board B became smaller than it had been during the previous "winter," and board A cracked because it wasn't allowed to shrink. It's neither the high humidity nor the low—it's the annual cycle, combined with restraint in construction.



good condition), people conclude that the damage occurred because the wood "dried out." The point is, the variation in moisture content, not simply drying out or dryness, caused the damage. The weathering of wood outdoors is the perfect case in point: The wood gradually breaks up due to cyclic swelling and shrinkage, although the moisture level remains fairly high all year around. This also suggests that finishing is helpful and "breathing" would actually be bad for the wood's "health." Severe dryness may also harm some finishes and adhesives. The finishes may dry out, or veneers may separate as a result of dryness, but such problems must be blamed on the degradation of the chemicals or on associated shrinkage stresses, not on deterioration of the wood itself.

Item No. 4 is listed as "Sapwood is weaker than heartwood." This frail idea collapses when we realize that every mass of wood cells was once sapwood, and the cell walls were formed when it was sapwood. Transformation into heartwood may deposit extractives which may ever-so-slightly increase the wood's density and perhaps its abrasiveness to cutting tools, or possibly its hardness, but strength differences are usually insignificant. The confusion is entangled with decay resistance. Because sapwood never has noteworthy decay resistance and heartwood may be very decay-resistant, the sapwood may be weakened in wood exposed for a period of time to conditions favoring decay. Hence the conclusion that heartwood is stronger.

Few subjects can evoke more controversy than the drying of wood. My list reads "No. 5: drying in general" with many sub-headings. It contains notions that seem strangely illogical, even though they cannot all be flatly disproven.

The lore of woodcraft seems rich in rules for when to cut trees to produce the best lumber for various purposes. The supportive reasons involve such nebulous explanations as "when the sap is up" (or down, depending on whom you ask) or "atmospheric influences." Such recommendations probably date back to the difficulties of harvesting and seasoning timber by muscle power. The tree had to be cut down, sawn into lumber, stickered and the drying initiated before it could begin to rot. Logically then, "Beech should be cut in November"—to take advantage of the cold months to get it cut and stacked, and of the dry, windy spring months to get air-drying well under way. Oak was harvested in late spring and summer because an important by-product was bark for tannin, and the bark won't come off an oak tree cut during its dormant season. These days, logs can be harvested, hauled, sawn and the drying begun in a matter of days. Lumbering goes on year round.

Controversy also exists over the comparative qualities of air-dried lumber and kiln-dried lumber, or new wood and old wood. Some people believe kiln-dried wood is permanently shrunk and stable. Not so. Others believe that very old wood becomes stabilized and loses its ability to shrink and swell. Not so. In fact, tests of wood of known ages up to several thousand years have shown that it remains quite hygroscopic and dimensionally responsive, apparently forever. Whether air-dried lumber or kiln-dried lumber is superior is another unending dispute. For such questions the answer may be in the qualification. Not all kiln-dried lumber is dried properly—lumber can easily be ruined in a dry kiln. Carelessly air-dried lumber can be equally useless. But kiln-dried lumber is pretty hard to beat when moisture content and stress are properly controlled.

I have heard claims and counter-claims by the most reputable and accomplished woodworkers to the effect that if wood is air-dried it has better "working properties" or "richer color." I have also been told that kiln-drying, after a period of air-drying, "sets" the fibers, enhancing workability. I can neither substantiate nor disprove these opinions, and there are countless other such grey areas. This is probably what makes wood so fascinating to deal with. As hard as I strive to learn about wood, I somehow hope that all the answers are never found—and I'm sure they never will be.

This brings me back to the top of my list of misconceptions. Item No. 1 was entered when I received a letter written to me on the advice that I am an expert and know everything about wood. The writer went on to ask many questions, and I couldn't answer any of them. So the biggest misconception is that somewhere there are "experts" like me who know everything there is to know about wood. □

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