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The Nature and Characteristics of Wood
And Related Observations of Chinese Hardwood Furniture

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Since ancient times the Chinese, with their reverence for nature, have loved trees and beautifully figured woods. A late second-century B.C. poem by Liu Sheng, prince of Zhongshan, entitled "Ode to Fine-Grained Wood," has fantastic descriptions of the natural abstractions found in wood grain. According to legend, his friend, Prince Lu Gongwang, had obtained a piece of particularly fine figured wood from which he had fashioned beautiful pieces of furniture, vessels, and musical instruments. Prince Lu's affection for his lovely wooden objects stirred Liu Sheng to write this poem for him:

A beautiful tree stands solitary on a mountaintop.
Its leaves sweep the Milky Way,
its boughs stretch into the sun's orbit.
Hundreds of birds—young and old, male and female—
hover, gather, and sing around it.
Even under ponderous snow its branches
are powerful enough to play with violent gales.
The tree will live as long as heaven and earth endure.

No carpenter knows the value of this tree,
but with a mere glance the prince sees it all
and orders Lu Ban to chop down the giant of nature
to the earth.
When the tree collapses, heaven opens its doors
and stark light and crushing sounds pour out
like an earthquake.
Flowers and leaves fly apart and limbs and boughs
crack asunder.

When the bark is stripped and the trunk cut clean,
its patterns of fine grain are revealed:
a coiling dragon or a crouching tiger
or pairs of soaring phoenixes,
and a colorful ribbon is tied to jade rings.

There are mountain ranges and enormous waves spreading
with billows.
Some grains are lightning through overcast skies,
some thin mist or thick fog.
A lordly buck and a far-galloping stallion
take over the wood
and also small chickens and pheasants.
We see silk embroidery with mandarin ducks,
lotus flowers, algae and water chestnuts.

Its colors are mellower than gold,
Its surface exactly like jade.

When cut into utensils and vessels,
the patterns of grain, circular or straight,
assume their natural place
like slender bamboo mirrored in a pool
or a pine tree growing on a mountain.
When shaped into a musical instrument,
the sound is delightful and harmonious
like the song of a phoenix in the firmament
or a dragon roaring from the waters.
When cut into a screen, it creates another canopy
for the sky.

When formed into a staff and armrest,
they exhaust the notion of beauty, rendering beauty
by comparison poor.
When made into a wooden pillow and a table,
the excellent fine grain is a guarantee of splendid
poems
and the composition of perfect documents.
When shaped into a basin or a bowl,
how can one bear to release it from one's hands?

So I say to you, my good prince, enjoy it!

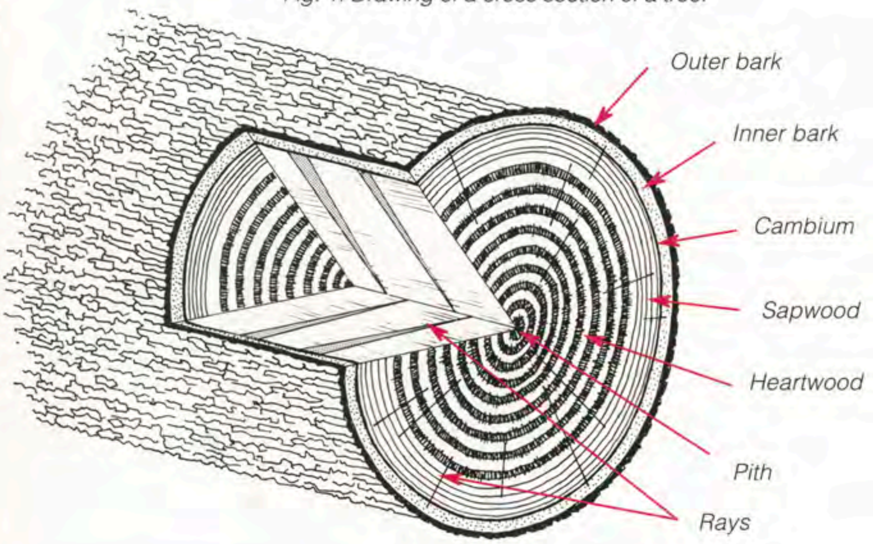
(From Lidai fuhi, *translated by Chou Ping and Willis Barnstone.)*

After reading the poem, Prince Lu looked around at his cherished belongings and laughed heartily. In return, he made a present of two horses to Liu Sheng (*Lidai fuhi).*

By combining this aesthetic approach to wood grain with a more analytical one characteristic of the twentieth century, we can increase our appreciation and understanding of beautifully figured wood. The term "grain" can refer to a number of physical attributes in wood. To arrive at a better understanding, it is first necessary to look at grain in terms of the direction or orientation of the wood cells that make up its fibrous elements. And this requires one further step back to examine the tree itself.

All trees are vascular plants, meaning that they contain a system of cells for the conduction of fluids (commonly known as sap). Trees are also perennial plants, capable of adding yearly to their previous growth. Extending into the ground, the roots anchor the tree, searching for water and nutrients. Many deciduous trees have a central taproot that plunges deep into the earth. Others have numerous smaller roots that radiate in all directions close to the surface. Above the ground, the trunk forks into limbs, which in their turn branch and subdivide into leaf-covered twigs. This part of the tree is often referred to as the crown. The trunk increases in size to bear the weight of its widespread crown, which is filled with branches and leaves to obtain the air and light the tree requires. The trunk also serves as a means of communication between the roots and the leaves, and stores food for future use. When the trunk of a tree becomes large enough to be used for timber, it is termed a bole.

Fig. 1. Drawing of a cross section of a tree.



To further understand the complexity of a tree's internal structure, it is necessary to examine the cross section of a trunk (fig. 1). This demonstrates how trees develop in concentric growth rings around the pith, which represents the early growth formed when woody stems or branches elongate. The pith center ceases to grow after this early stage, but it remains until the tree is destroyed or decayed, usually becoming a thin, dark hollow. The pith in *zitan*, however, often forms quite a large hollow, which usually must be filled when left in boards. Brush pots, which are generally cut from a section of the tree trunk or a large branch, frequently require the use of additional inserts to plug the deteriorated pith center.

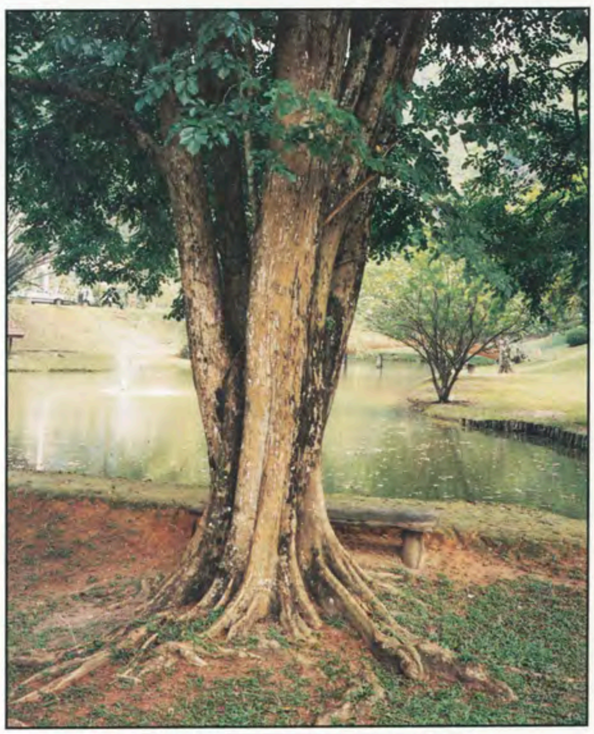
In temperate climates each concentric layer indicates one year's growth. These rings may vary in width as a characteristic of the species and as a result of growing conditions. Visible contrasts within a single growth ring result from seasonal growth. The first growth may be fast, forming a relatively porous layer termed earlywood. The remaining growth may be slower and therefore form a more dense layer called latewood. In hardwoods, latewood can be identified by the smaller diameter of the cells and in softwoods, by the smaller dimension of the rings. Not all woods display a visible distinction between earlywood and latewood. In tropical regions growth may continue with little interruption, or there may be several seasons in a year due to wet and dry conditions. Therefore, visual signs of rings in tropical hardwoods cannot be called annual rings, as they could be indicative of a year with several rainy seasons or possibly of erratic years when extreme conditions of wet and dry existed.

On a microscopic level, the tree stem is made up of countless accumulations of cells, the majority of which are elongated and oriented vertically. Another group of cells radiates outward from the pith center, creating what are known as rays. They can be thought of as a "flattened vertical ribbon" of cells stretching horizontally from the center of the tree to-

ward the bark (Hoadley, *Identifying Wood* 8). In the sapwood, these living cells assimilate and store food. In most woods they are not visible to the naked eye. However, in woods like oak (*zuomu*), beech, sycamore, and lacewood, the rays are much larger and can be distinguished as flecks running across the grain (fig. 2).

Water with dissolved nutrients from the soil is taken up by the fine root hairs and moves upward through the sapwood to the leaves. Here the miraculous process of photosynthesis occurs, producing a basic food sugar for the tree and releasing oxygen into the air. Sap carries this sugar down through the inner living bark to the cambium. The cambium is a thin, fragile layer of reproductive cells between the bark and sapwood that, by cell division, forms new layers of bark cells toward the outside and new layers of wood cells toward the inside.

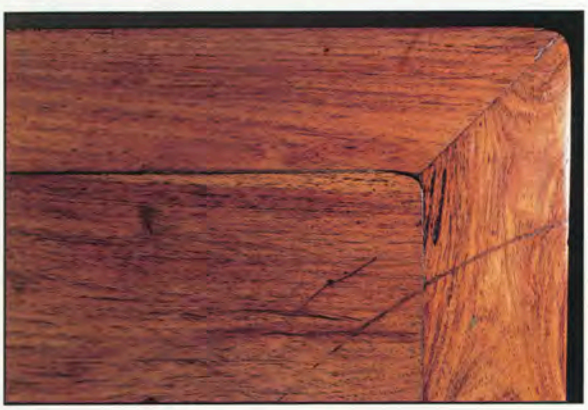
Hoadley explains, "In twigs and small saplings, the entire woody portion of the stem is involved with the vascular activity of sap conduction and is thus called sapwood. As the tree develops the entire trunk is no longer needed to satisfy the leaves' requirements for sap" (*Understanding Wood* 6). The cells nearest the center of the tree lose their vitality and cease their involvement in the life support of the tree. This inactive wood does, however, continue to add to the structural support of the tree's widening crown as new layers are added. This wood is termed heartwood. Heartwood is usually harder, heavier, more stable within conditions of changing humidity, less permeable, and more durable than sapwood. This transformation results from substances called extractives deposited in the heartwood during its transition from sapwood. Extractives also give the heartwood its distinguishing color—the black of *zitan* and ebony, the golden orange tones of *huanghuali* and other rosewoods, the gray-brown of *jichimu*, and so on. Heartwood can be visually distinguished from sapwood by its pigmentation, because in almost all species sapwood is light colored, ranging from whitish or cream to yellow, light tan, or even gray. A cross-sectional slab (fig. 3) sawn from the bottom of a *Pterocarpus indicus* tree (fig. 4) at the Museum of Wood Products at the Forestry Research Institute Malaysia in Kuala Lumpur clearly illustrates the distinction between sapwood



and heartwood. In some trees, however, such as birch, boxwood, and cypress, the extractives have no pigmentation, and thus the heartwood cannot be easily distinguished from the sapwood on the basis of color.

Trees vary considerably in size. In Japan, the Yaku *sugi* or cedar and a similar variety in Taiwan reach over 40 feet in diameter at their base (Nakashima 83, 85). A recent survey of panel sizes in Chinese hardwood furniture conducted by the Museum of Classical Chinese Furniture in Renaissance, California, indicated that the heartwood of *huanghuali* can reach 25 inches in diameter. The heartwood of *zitan*, on the other hand, rarely reaches 12 inches in diameter. Boxwood also grows very slowly, with some varieties only reaching 4 to 5 inches in 100 years. In most mature trees, the thickness of sapwood can also vary considerably, from 1/2 inch to 6 inches, or from another viewpoint, from 1 to 2 annual rings up to 100 or more.

Sapwood is not generally resistant to fungi or insects; therefore the resistance of a species' heart-



wood is due to the toxicity of its extractives. Sapwood is rarely found in a piece of hardwood furniture, but when it is, the easily distinguishable light-colored wood is often riddled with holes from insects. A furniture maker's frugality or lack of sufficient material will occasionally justify the use of some sapwood. It is usually oriented out of the main view, however. Several of the large frame members in a pair of *huanghuali* wardrobes in the collection of the Museum of Classical Chinese Furniture have sapwood on their inside corners. More rarely, a bit of sapwood may be exposed on the corner or edge of a large panel, resulting from a craftsman's attempt to maximize the width of his available material (fig. 5).

Extractives may also give woods their distinctive natural odors, which are released when the wood is freshly worked. Some woods, like camphor and cedar, retain an odor strong enough to repel damaging insects, and thus function well in storage containers for otherwise vulnerable materials. The odor

can be quite varied, ranging from the sweet, fragrant *huanghuali*, to the spicy and peppery cedars, to the sour pungency of *hongmu*. Some modern restorers in Hong Kong and China still use the empirical method of a "burn test" to distinguish *hongmu* and *huanghuali*, which often closely resemble one another. A tiny chip of wood is ignited and then extinguished, leaving a smouldering ember that gives off its distinctive odor.

As already mentioned, the color of wood is mainly a result of the extractives deposited in the heartwood. It may also, however, result from differing soil conditions, and can vary in the same species growing near one another. The color may even vary within the same board due to uneven distribution of extractives (Lincoln 9). The pigment in many woods, including *huanghuali*, *zitan*, and *hongmu*, tends to fade as a result of exposure to light. This feature helps

Fig. 2, facing page, above. Rays in a zuomu *drawer front.*

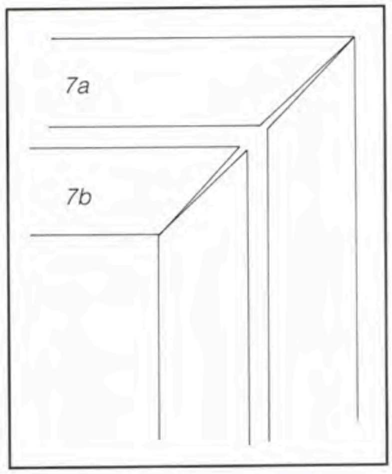
Fig. 3, facing page, center. A slab of wood from a Pterocarpus indicus *at the Forestry Research Institute Malaysia, Kuala Lumpur.*

Fig. 4, facing page, below. Pterocarpus indicus *tree at the Museum of Wood Products in the Forestry Research Institute Malaysia, Kuala Lumpur.*

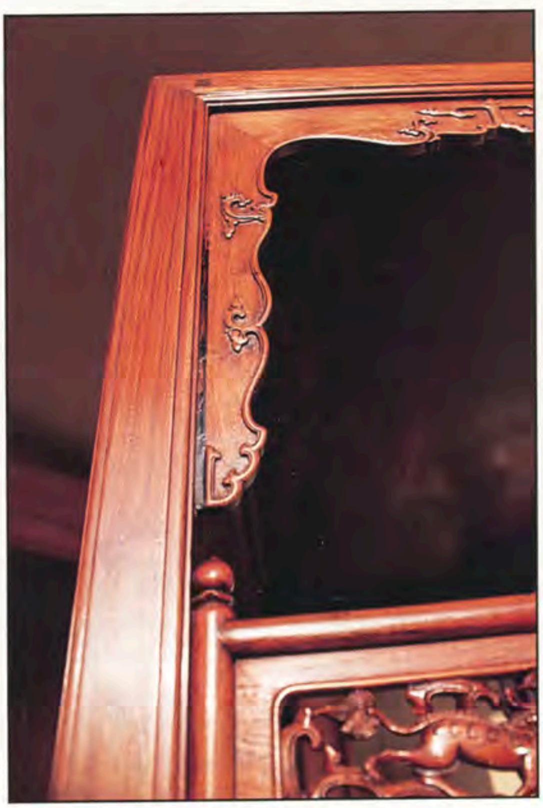
Fig. 5, above left. Sapwood in the panel of a recessed-leg table. Museum of Classical Chinese Furniture, Renaissance, California.

Fig. 6, above right. Interior and exterior views of a display cabinet, showing the difference in color of the huanghuali. *Museum of Classical Chinese Furniture, Renaissance, California.*

to distinguish new or freshly worked wood from that with an old surface patination. This can be particularly noticeable on the interiors of *huanghuali* cabinets, which have normally been protected from the light and thus usually retain their original deeply pigmented surface. By comparison, an undisturbed external surface will appear considerably mellowed by prolonged exposure to light. This phenomenon is clearly illustrated in views of the inside and outside surfaces of two door panels from a *huanghuali* display cabinet in the Museum of Classical Chinese Furniture (fig. 6). Other woods, such as cherry, maple, and mahogany, darken with exposure, their colors deepening in richness.



The oiliness and resins in woods such as teak, satinwood, ebony, and those from the rosewood family are also due to the chemical nature of their extractives. Most people are familiar with the way in which water beads up on oily surfaces. This phenomenon illustrates the difficulty of gluing these woods with traditional water-based adhesives such as fish and animal glues. There is increasing evidence in restoration workshops that a thick red lacquer was used to help adhere joins in sixteenth- and seventeenth-century *huanghuali* furniture, possibly the so-called dragon's blood, a resinous product derived from the *Pterocarpus* genus (Schafer 135).



Luster is a measure of light reflection. Woods with high luster seem to glow from within, giving their surface a translucent quality quite independent of any finishing. Although it has been suggested that translucent resins deposited within the wood cells can impart luster to wood, it is actually the reflectivity of the cell walls themselves that imparts a shimmering surface. This natural luster of *huanghuali* and *zitan* contributes to the high esteem in which they are held.

Density is the relationship of weight to volume. It is measured in terms of specific gravity, i.e., the ratio of the weight of a body to the weight of an equal volume of water. Most woods have a specific gravity of less than 1.0, and therefore float. Woods like ebony, *zitan*, lignum vitae, and pernambuco have specific gravities greater than 1.0; therefore they are heavier than water and sink. A recent testing of samples of *huanghuali* collected by this author indicated a range in specific gravity from .66 to .80. The density of wood can vary considerably due to moisture content, and therefore its density is measured in terms of its oven dry weight. The rate of growth of the tree will also affect a wood's density. A tree found in rugged, mountainous regions will tend to grow much more slowly than one of the same species found in fertile lowlands, yielding a denser wood with more character.

To reduce the weight of timbers and facilitate transportation, the technique of girdling is still used in Southeast Asia to preseason a timber before it is felled. A ring is cut around the base of the tree, penetrating the bark, cambium, and sapwood. This stops all vascular flow and kills the tree in a matter of weeks. Teak timbers from Burma are still girdled and left standing for three years in the heat of the climate, initiating the seasoning process before being felled. (Even today agile elephants outperform modern equipment in their ability to transport these logs to rivers from remote mountainous regions (Kaiser, "Teak" 44)). Many of the denser hardwoods, still heavier than water, are lashed to supporting timbers which float or are loaded onto barges for transport (Drummond 9).

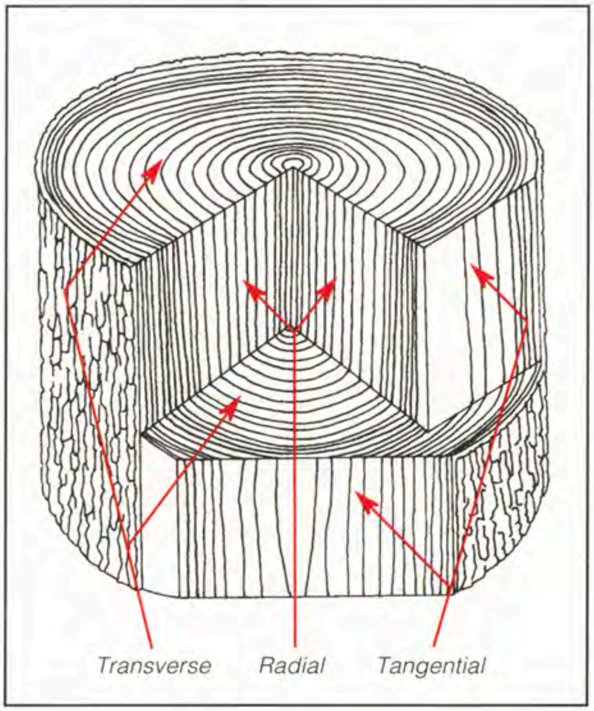
The moisture content in wood can be compared to that found in a common household sponge. Just as a sponge remains damp and limp even after it is wrung dry, so wood remains structurally weak when only the free water contained within its cells has been eliminated. When the cell walls themselves begin to dry out, however, as when after several days our sponge begins to shrink and harden, wood also begins to shrink and increase in strength. How much of this bound water evaporates from the cell walls and to what extent wood shrinks or swells depends on the relative humidity of the air to which it is exposed and to which it will eventually equilibrate.

Relative humidity is the ratio of water vapor present in the air to that which it would be possible to hold at a given temperature. For instance, if the temperature is 70 degrees Fahrenheit and the relative humidity is 50 percent, the air is containing half of the moisture that it is possible for it to contain at that temperature. The warmer the air, the greater its potential for holding water vapor. Therefore when the temperature changes suddenly, the relative humidity changes accordingly. This is important because wood always remains sponge-like in its ability to give off or take in moisture from the surrounding atmosphere. Wooden objects are exposed to daily and seasonal changes, not to mention geographical changes with differing climatic conditions. Thus they are virtually always undergoing gradual changes in moisture content.

An extreme example can be seen in the damage often found on the feet of antique Chinese furniture. This can be attributed to the moisture absorbed from the compacted yet often damp earthen floors to which the furniture was commonly exposed, providing ideal conditions for decay-producing fungus. It is not uncommon to find that the rear legs of tables, chairs, *chuangs*, and canopy beds have lost more height than their front legs, as even more moist conditions are found near the exterior walls. Even in dense hardwoods, repeated saturations will eventually leach out the extractives that prevent damage from insects and fungus.

Wood shrinks almost twice as much in the tangential direction of its annual growth rings as it does radially, and its longitudinal shrinkage is almost negligible. In Chinese hardwood furniture, flat sawn boards are most often seen in the panels of tables and cabinets. It is also in them that one can see the greatest movement, which frequently forms wide cracks between panel and frame. Longitudinally the panel remains virtually unchanged, however, and the joint remains tight.

This difference in dimensional behavior as a result of changes in moisture content can cause problems with joinery. Miters will tend to open on the inside if subjected to drier conditions, as the wood shrinks across the grain yet remains stable along the grain (fig. 7a). The reverse effect occurs under conditions of higher humidity, when gradual swelling across the grain of a mitered joint may open the outside of the miter (fig. 7b). (Modern restorers often recut open miters in antique furniture to tighten up the appearance of a mitered joint, but by removing



Figs. 7a, b, facing page, above. Drawing of miters that have opened on the inside (7a) and the outside (7b).

Fig. 8, facing page, below. Replaced apron of display cabinet, showing the tongue drawn out of the groove. Museum of Classical Chinese Furniture, Renaissance, California.

Fig. 9, right. Drawing of a sectioned log illustrating grain direction.

material they usually weaken the join and subtly alter proportions.) In figure 8 we see a case where a joined miter on a replaced apron (fashioned from improperly seasoned *huanghuali)* did not open, causing the loose fitting tongues of the lower part of the side aprons to be drawn out of their grooves. Swelling within an already tight-fitting joint can cause the fibers to become permanently compressed. Afterwards, having returned to its original moisture content, the joint then fits loosely (Hoadley, *Understanding Wood* 114).

One misconception encountered frequently in classical Chinese furniture literature concerns the use of the terms hardwood and softwood. In China, according to Wang Shixiang, the term hardwood is reserved exclusively for dense tropical hardwoods such as *huanghuali, zitan, jichimu, wumu, hongmu,* and *tielimu.* These tropical hardwoods exhibit hardness and density, deeply pigmented heartwood, impermeability, and a resistance to boring insects. Botanically, however, the terms hardwood and softwood actually refer to types of trees, not to the density or hardness of a wood's surface.

Softwood trees are coniferous, possess needle-like or scale-like foliage (usually evergreen), and have a dominant trunk with lateral side branching. Typical examples include pines, cedars, cypresses, and firs. Asian counterparts include *songmu, nanmu, baimu,* and *shamu.* Because of their long straight trunks, softwood trees are often favored for structural elements in construction. According to recent conversations with Wang Shixiang, until the mid Qing many homes in Beijing were built of *huangsong* (yellow pine), a very straight, strong timber from the northern mountainous regions. When the area was finally deforested, *jumu* (elm) was used, although it does not grow straight and thus is much less satisfactory. Today old pieces of *jumu* salvaged from demolished houses are much in demand by modern manufacturers of reproduction furniture.

Hardwood trees are usually deciduous, that is, their leaves fall off annually at the end of a growing season. They bear covered seeds such as acorns and walnuts and are characterized by a stem that branches and rebranches. Although the normally higher density of hardwoods has probably earned them their name, the very low density balsawood is also classified as a hardwood. Examples of Asian hardwoods that are frequently called softwoods are *jumu* (elm), *huangyang* (boxwood), *zuomu* (oak), and *zhangmu.* (Although camphor is an evergreen, it still is classified as a hardwood.)

Hardwoods have more specialized cells and are generally believed to have evolved later than softwoods. In hardwoods, vessel cells with larger di-

ameters developed to form tubes for conduction, as well as fibers with small diameters for added strength (Hoadley, *Understanding Wood* 14-15). When these vessel cells are cut transversely, their exposed open ends are referred to as pores. Hardwoods are therefore also called porous woods because of their large diameter pores, while softwoods are referred to as non-porous woods. In some hardwood species such as *jumu* (elm) and *zuomu* (oak), these large pores are concentrated in the earlywood while smaller diameter pores occur in the latewood; thus they are termed ring-porous. These woods have an uneven texture and a distinctive figure; carpenters from Suzhou referred to the large layered grain pattern of *jumu* as a "pagoda pattern" (Wang, *Connoisseurship* 152). The uneven uptake of pigment from finishing materials accentuates the figure of ring-porous woods. The variation in pore diameter also affects texture, as woods with large diameter pores such as *tielimu* are of a relatively coarse texture, while *huangyang* (boxwood), with small diameter pores, is quite finely textured and is especially suitable for carving.

With this elementary background in wood anatomy it is possible to return to the idea of grain. Because of the arrangement of the concentric layers of growth in the tree as well as the vertical and horizontal orientation of cell groups, it is appropriate to consider the structure of wood in three-dimensional terms (fig. 9). One plane cuts through the trunk perpendicularly as observed at the end of a log or stump (fig. 3). This cross-sectional plane describes an end

Fig. 10, facing page. Woodblock print of carpenters at work. After Sheng yu xiang jie, *1904 reprint of the Kangxi edition.*

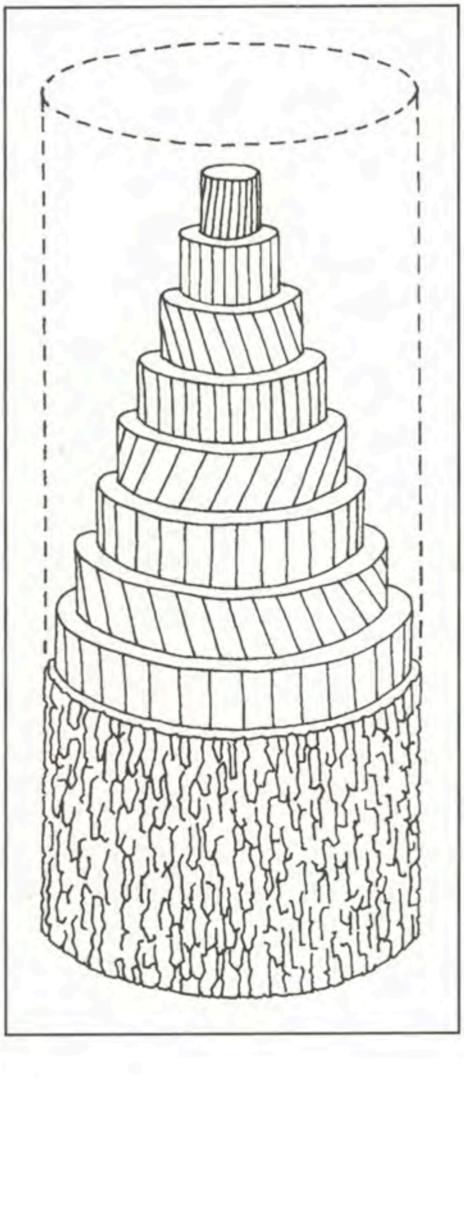
Fig. 11a, above left. The splat panel on a jichimu *yokeback chair, showing radial grain. Museum of Classical Chinese Furniture, Renaissance, California.*

Fig. 11b, above right. The splat panel on a jichimu *yokeback chair, showing tangential grain. Museum of Classical Chinese Furniture, Renaissance, California.*

Fig. 12, below. Crotch-cut panel from one of a pair of huanghuali *wardrobes. Museum of Classical Chinese Furniture, Renaissance, California.*

grain surface or transverse plane. A plane that passes through the pith-center is called a radial plane, and with lumber, a piece whose broad face is more or less within this radial plane is termed quarter-sawn, vertical grain, or edge grain. A plane tangential to the growth ring structure is called a tangential plane. Lumber whose broad face is tangential is called flat-grain or plain-sawn. In figure 11a, the growth rings in the radial plane appear as parallel lines. On a tangential plane or flat-sawn surface, the growth rings appear as layered U-shaped, V-shaped, or elliptical markings.

Today, with sophisticated milling operations, logs can be milled to produce specific surface orientations—from flat-sawn, which exposes the tangential surface, to quarter-sawn, which exposes the radial surface. It is likely, however, that logs in ancient times were hand-split or quartered, yielding radially oriented slabs. With the advent of handsaws, timbers were cut "through and through," which produces a combination of orientations and yields the widest boards. In a Kangxi woodblock print from the Imperial Edicts illustrating carpenters restoring a building, two sawyers can be seen sawing boards from a log in this manner while the others finish the boards with planes and chisels (fig. 10).



An enhanced appreciation of the appearance of wood depends on an understanding of the anatomical structure and physiological functions of the tree. Because of the overuse of the word grain, the term "figure" is actually more appropriate when describing distinctive or characteristic markings, especially in the more decorative woods. Figure results from the interaction of these natural features and from the orientation of grain direction, which is revealed when boards are cut from a timber. The variation of figure as a result of grain orientation is particularly apparent in the radial cuts and tangential cuts of *jichimu*, which impart the impressions of simplicity and severity respectively. Figures 11a and 11b show splat panels from a pair of *jichimu* yokeback armchairs. In figure 11a, the growth rings exposed by the radial cut are accentuated by the deep brown and gray parallel lines of concentric layered tissue. In figure 11b, the tangential surface is exposed. Here the layered effect is maximized, producing the feathered patterns typical of *jichimu* ("chicken wing wood"). Thus, this highly prized figure arises from the characteristic layered tissue of *jichimu* and the orientation to its growth rings.

The more uneven the growth rings, the more distinctive the figure. Although the grain direction of an average tree is more or less straight, wood with irregular grain that deviates from the vertical axis of a tree generally exhibits interesting figure from grain distortion. An extreme example is noted in the crotch, where the trunk forks and secondary branches curve away from the central axis. Within the crotch, an unusually twisted and intergrown structure occurs. Slicing through the crotch produces some of the most extravagant figure found in boards. A pair of *huanghuali* wardrobes in the collection of the Museum of Classical Chinese Furniture feature crotch-cut panels in two of their upper doors (fig. 12). Their fiery figure swirls violently as a straight plane slices through a moment of division and apparent confusion. Yet for the tree, this is a normal and orderly structure fulfilling its purpose of division.

Wavy or curly grain often accompanies the figure in crotch-cut boards, due to inherent internal stresses. Although the reason is not known, this variation also occurs frequently in woods such as *nanmu*, *zitan*, and maple, and is often referred to as tiger-striped or fiddleback. When it is found in *huanghuali*, it is often featured in prominent positions such as the splat of a chair (Ellsworth, pl. 4, 127). The cellular structure of the radial surface of wavy-grained wood can be compared to a washboard (Hoadley, *Understanding Wood* 21). When this surface is cut and polished to a flat plane, the light reflects unevenly off these translucent rippling undulations, producing wave-like stripes across the grain (fig. 13).

Some trees tend to twist as they grow upward, producing a spiral grain. Other trees tend to alternate back and forth in opposite directions every few years. These repeated cycles of growth create an interlocked grain (fig. 14), which is seen as a ribbon or stripe figure when cut radially (Hoadley, *Understanding Wood* 22). Many tropical hardwoods including *huanghuali* have interlocked grain, and when the radial surface is cut and polished to a flat plane, these reversing spirals produce the characteristic long, fuzzy, striped effect (fig. 15). The wood called *xin huali* or new *huali* often has even wider stripes, possibly indicative of a lowland timber with a faster growth, such as the *Pterocarpus indicus* that grows in the coastal areas of the Malay peninsula. This type of wood is frequently used to replace missing parts on antique furniture (fig. 16). The interlocked grain of *huanghuali* also helps to distinguish its tangential and radial surfaces. The tangential cut often exposes long lines of vessel cells, sometimes ten centimeters in length, which are sliced open by the parallel cut (fig. 17). They tend to angle off in opposite directions reflecting the alternating spirals. In the radial cut, however, these same vessel lines are no longer parallel to the surface and decrease in length to two to four millimeters.

Distinctive figure may be obtained not only from wood with irregular grain, but also from curvi-

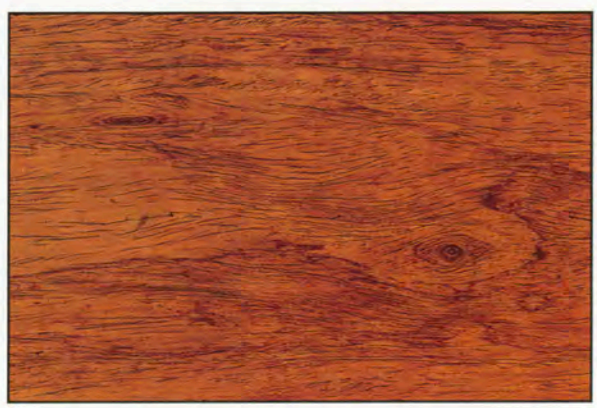


Fig. 13, facing page, above. Wavy grain in a zitan *panel. Double six gameboard. Museum of Classical Chinese Furniture, Renaissance, California.*

Fig. 14, facing page, below. Drawing of spiral grain.

Fig. 15, top left. Detail of interlocked grain in a radial cut of huanghuali.

Fig. 16, top right. A replaced apron made of new huanghuali.

Fig. 17, above. Detail of long vessel cells in a tangential cut of huanghuali *from a recessed-leg table. Museum of Classical Chinese Furniture, Renaissance, California.*

linear boards cut from relatively straight-grained timber. In the C-curved and S-shaped splats of chairs, Chinese craftsmen exploited the natural characteristics of wood to create the much sought-after abstractions. When cut from the tangential plane, these curvilinear splats slice in and out of the concentric layers of heartwood, producing the characteristic flame and whorling figures (fig. 18).

Figure may also be produced by irregular coloration formed by uneven extractive deposits, whose layered effect may be quite independent of growth-ring layering. This is sometimes referred to as striation or pigment figure and is quite common in rosewoods. *Huanghuali* brush pots are also often quite vigorously figured, especially those with concave surfaces. Here the craftsman exposes the tangential surface, and further enhances it by shaving a concave surface through the pigmented layers until he obtains a satisfying figure (fig. 19).

Although knots are frequently considered to be structural defects, they are often featured in Chinese hardwood furniture. The small, intergrown knots that were particularly prized are the remnants of small branches that died back and became encased by many more years of growth. Because branches grow radially out from the trunk, the encased knots have a radial orientation. In a flat-sawn board the knot appears as a round or oval cross section of the

now encased branch or twig, often resembling a ghostly apparition emerging from the wood (fig. 20).

Burls are abnormal, knob-like projections that bulge out from the trunks (fig. 21) or branches of trees. Their tumor-like growth does not, however, appear to adversely affect the tree's health. What causes them remains unknown, although various theories suggest that they result from a reaction of the cambium layer to inadvertent damage. These injuries could possibly result from falling trees, fire or frost damage, invading fungus or bacteria, or even woodpeckers (Kaiser, "Redwood" 16). It has also been suggested that the sudden exposure to sunlight of a previously shaded area of the trunk can induce them, such as in the falling of a neighboring tree (Boulger 76). It may be possible to intentionally induce them by scarring the cambium. In the garden on the north side of the Forbidden City one can see gnarled and grotesque trees with burls that appear to have been cultivated through repeated heavy prunings. This technique is called pollarding.

Burls have fascinated man for centuries. Records indicate that at the height of the Roman Empire decorative burls were in demand for table tops and other articles of furniture, and particularly fancy or unusual burl patterns commanded especially high prices (Constantine 64). The Tang poet Du Fu wrote a poem (which appears in *Ge Gu Yao Luan*) for the official Wang Chu on burls found in China. In it he compares the delicate and attractive burl of the *hua shu* (birch) from Liao Dong and Shanxi Province with the larger yet coarser pattern of cypress burl, and comments that most of the burl from the north comes from the willow tree. And the Qianlong *jinshi* scholar Li Diao Yuan describes the lychee burl from Guangdong as the best, with a swirling yet delicate

Fig. 18, facing page, left. A huanghuali *yokeback armchair with a splat displaying a whorling figure. Ming dynasty (1368-1644). Height 121 cm, width 68.5 cm, depth 54.5 cm. Museum of Classical Chinese Furniture, Renaissance, California.*

Fig. 19, facing page, right, above. Characteristic pigment figure in a brush pot from a private collection.

Fig. 20, facing page, right, below. Characteristic figure around a knot in a brush pot from a private collection.

Fig. 21, above. Burl growth on a madrone tree in northern California.

Fig. 22, right. A nanmu *burl top on a* huanghuali *table. Museum of Classical Chinese Furniture, Renaissance, California.*

figure and a fine, silk-like textured grain (Li 95).

The wood tissue of a burl is extremely disoriented and is comprised of many small bud formations that often create a figure resembling clusters of round curls. The Chinese describe *nanmu* burl as having a "tight grape seed pattern," a phrase that may describe the tiny bud formations within it. Wang Shixiang, however, believes that this so-called burl comes not from a burl but from the roots of massive *nanmu* trees in the western part of Sichuan province (Wang, *Connoisseurship* I, 152). Wood from the stumpwood—the junction of the trunk and roots—is full of interesting and distorted figure caused by changes in direction of the wood fibers as they branch out as roots, and by the effects of compression from bearing the weight of the tree. Root burls that grow underground can also be cultivated in some species. After a tree is felled, second growth will often sprout up from the perimeter of the original trunk. The repeated lopping off of this second growth forces increased unnatural growth below the ground.

We can now begin to see that wood is a many-faceted and complex material. However, as Hoadley observed, the most important fact to remember in understanding its nature is that "wood comes from trees." By appreciating a tree's functional and physical aspects together with its characteristic features, we can return to Liu Sheng's poem with a greater understanding, sharing his wonder before the swirling abstractions found in the boards cut from the felled "giant of nature." The unknown potential of a tree's internal world is released and given a second life when useful objects are fashioned from it. In the hands of a fine artist-craftsman, the richness and beauty of its *wenmu* (wood grain, or more literally, the "wood's script") are revealed, and the finished piece still displays the harmonious laws of nature.

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