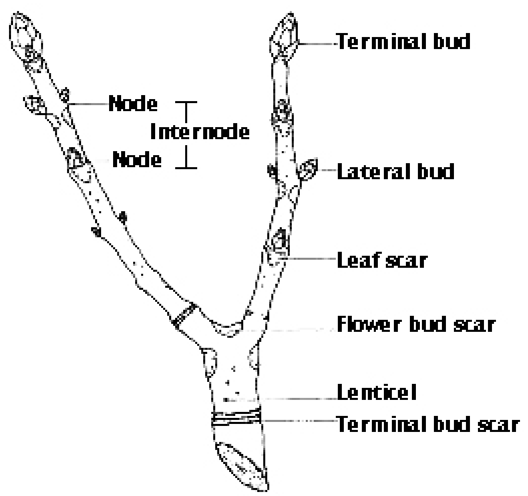
TREE STEMS AND HOW THEY GROW



Horsechestnut Stem

The anatomy of plant stems is a fundamental part of botanical instruction. But the anatomy varies quite a bit, depending on the particular type of stem and its age.

The anatomy of a woody plant is different from that of a herbaceous plant, and that of a dicot is different from a monocot. Roots also have a different anatomy than above-ground stems. Without delving into a complete botany lesson on all stem anatomy, this lesson deals only with stems of our largest woody plants, the trees, and how this anatomy might help us understand and manage the growth of trees.

Herbaceous plants are plants whose above ground growth dies down to the ground each year, but whose root systems remain alive and lie dormant until spring when new growth occurs above the ground. In comparison, woody plants maintain branches over the winter that can tolerate cold temperatures and re-sprout leaves in the spring.

Our next class will address the anatomy of herbaceous plants.

PHASE 1: STARTING WITH THE TWIG

A twig is the current season's growth, as in a seedling, sprout, or branch tip. It holds dormant yet living buds that will initiate new extension and new twigs in the next growing season. Since a twig has resulted from an extending shoot without much time for diameter increase, its tissues are said to me mostly Primary, or formed during the terminal elongation of the shoot. Secondary tissues come later, when the twig needs to add girth, and these tissues will come from the vascular cambium.

Twigs are stems with a thin outer covering, the epidermis- no bark, yet. The epidermis can be green, if chlorophyll is there, or other colors if not. Extending from the epidermis may be hairs, bristles, prickles, or raised openings called lenticels (pores for gas exchange). Underneath the epidermis is the phloem, or part of the vascular system- these will look like fibers if stripped. Under the layer of phloem are xylem vessels, another part of the vascular system. These primary xylem cells are the beginnings of wood. Interior of the xylem, the twig will have a pith. Sometimes, the pith is large, and easily seen. It serves no function in transport of water or nutrients, or support; it is composed of thin-walled cells called parenchyma, but is mostly devoid of free water. It is a primary tissue that fills the center space of a twig, never added to, and it will always be there, unless the stem does not decay in the center.

Interesting patterns of pith account for 5 categories used in tree identification. There is homogenous pith, which is solid or continuous in texture (ex. hickory, maple). Spongy pith is similar but perforated with holes much like the appearance of a sponge (euonymus). Excavated pith is virtually no pith- a hollow tube is seen in the twig center (elderberry, forsythia). Diaphragmed pith is homogenous but with thickened plates or walls scattered throughout (blackgum, tuliptree). Chambered pith is excavated pith except for there being many walls (walnut, sweetspire). All these pith types are seen by splitting the twig in half with a sharp blade. Dull blades can push and pile up the soft pith tissues, not cut them.

PHASE 2: THE 2ND-YEAR STEM

A twig's buds start growth again and the branchlet is underway. A branchlet, or 2nd-year stem, will add new tissues to the girth of the twig using a vascular cambium layer which forms between the phloem and xylem. The cambium is nothing visible to the naked eye- it is merely an area of active cell division where xylem (wood) cells are made to the inside, and phloem (inner bark) cells are made toward the outside. Additionally, a cork cambium (botanists use the word phellogen or periderm) is started by the vascular cambium, and it produces cork cells (true bark). More on bark later.

As the buds along the developing branchlet grow into new twigs, the scars where the bud scales fell away will show where one year's growth gave way to another. In many woody plants, you can age the stems by counting each successive growth of buds by the scars left behind, if there was only one growth spurt per year.

PHASE 3: THE 3-YEAR + STEM

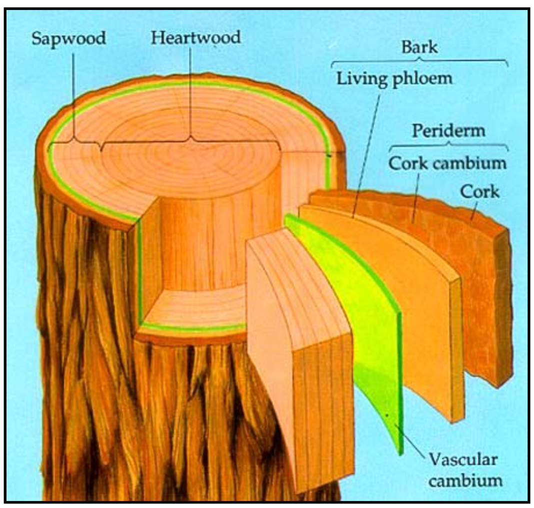
As the vascular cambium makes each new layer of wood to its inside, it must expand itself to accommodate the diameter increases. Likewise, the new layer of phloem made toward the bark side will be stretched by the laying down of wood internally.

Older layers of phloem die and are pushed away and mixed with the bark cells. The cork cambium and cork cells are outside of the phloem, and they too are stretched. Everything outside of the wood must stretch as the wood accumulates.

Xylem tissue mostly transports water (with minerals) from roots toward the tree crown, while phloem transports sap (containing starches or sugars made through photosynthesis of the leaves) to all other parts of the tree. The inner bark is therefore one of the most 'nutritious' parts of a tree, and is a favorite feeding area of many insects. Most flavors we enjoy in sap are concentrated in the inner bark. The fibrous phloem fibers can also be made into cordage, or bast, from some trees.

Spur shoots may appear on the branches, in some trees. These are actually very slow-growing, miniature branches. They usually bear a few clustered leaves, flowers and fruits, and may have either a bud or spine at their tip. Wings may also develop along the branches of some trees, these actually are part of the cork cambium's work.

PHASE 4: THE TRUNK



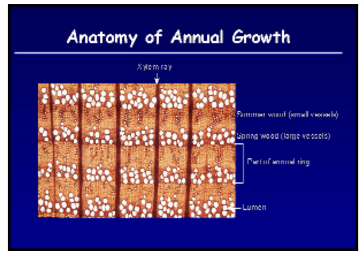
Wood:

A trunk provides the support of potentially a great deal of weight and stress. Lignin, the hardenening ingredient of xylem cell walls in woody plants, stiffens the cell walls and provides much of the strength of wood. The wood accumulating in large trunks will conduct water for a while, but ultimately the older layers will cease in transport of water. These older layers of wood in the interior portions of the tree may become stained by residual resins and sap chemicals, called extractives, which can also help to impart more decay-resistance.

We call this older wood heartwood. The younger layers of wood, lying outside the heartwood and under the cambium, is sapwood. It is still functional in transport of water. A tree, therefore, has only its sapwood and inner bark functional as the circulatory system (vascular system) for its sap. All interior layers of old wood can be lost through decay and it will not affect the vascular workings of the tree. What would be lost, however, is structural support, thus decayed trees usually break under their own weight, without the abundance of old, stiff wood to hold them up.

Annual rings of wood are those layers produced each year by the cambium. When the tree goes dormant, growth of wood essentially ceases and we can see this by the differences in pore sizes of the wood.

Spring growth normally needs a flood of sap coming up from roots, so the xylem vessels that are made first in spring are larger (springwood). In some trees called ring-porous hardwoods (ex. oaks), the larger spring pores look quite different from the smaller pores produced when the sap flow slows (summerwood), and we can easily see the annual ring of both pore sizes. In diffuse-porous hardwoods (ex. maple, birch), the larger spring pores are scattered, with smaller pores between- in these it is not quite so easy to see the annual ring. Other cells seen in wood sections include parenchyma cells, which can look like whitish bands or spots, and as rays. Rays are ribbons of parenchyma cells radiating from one annual ring to the next, and beyond. Oaks have distinct rays, which also cause weak areas in which splitting of wood is made easier. Parenchyma cells in rays and elsewhere can serve as food storage, where sugars or starches made by the plant are held for needs of growth.

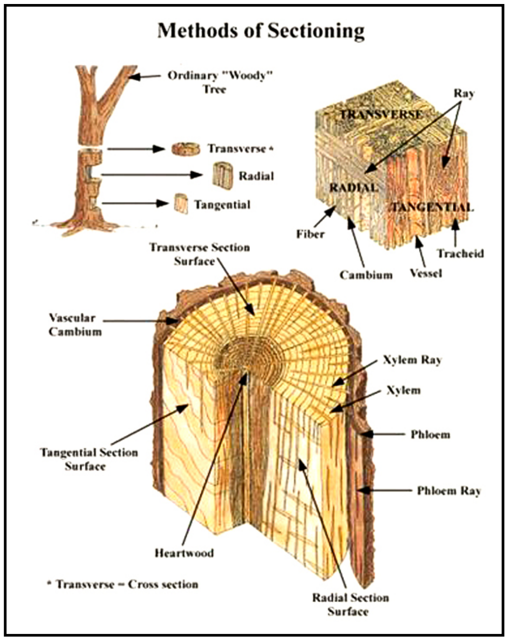


Hardwood is a term used to describe broad-leaved trees like oak, poplar, or ash, though it really has nothing to do with wood anatomy. Softwoods are the coniferous or needle-leaved trees. Anatomically, the conifers have as their xylem tissue a great many tracheids, a slender, smaller xylem cell rather than vessel elements like the big-pored hardwoods. Tracheids yield more cellulose fibers when processed than vessel elements, thus conifer wood is preferred in paper-making. Some hardwoods, however (ex. cottonwood) may also have high cellulose content that is specially suited to particular types of paper manufacture.

Reaction wood is a problem in sawing and seasoning of lumber, as it causes excessive shrinkage, twists, crooks, or splits. This type of wood is formed in trees corresponding to growth stresses. In leaning hardwood trunks, tension wood may develop on the uphill sides- the wood cells have extra amounts of cellulose, in response to the tension imposed by the leaning weight. In conifers, a leaning trunk develops compression wood on the downhill side, which is denser and with higher amounts of lignin. These two different ways of dealing with growing stresses both cause lumber problems. The darker layer of compression wood is harder and tends to split when drying or with driven nails; tension wood shrinks more, has a "fuzzy grain", and is difficult to saw without binding. Young leaning conifers may be able to straighten themselves slightly by the addition of compression wood on the lower side, but leaning hardwoods rarely can straighten any lean with tensionwood- they merely resprout vertically.

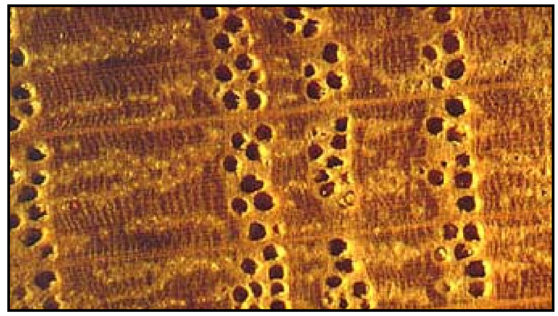
Bark:

Bark is the outer protective layer of a tree's trunk, a collection of non-living cells that have only one purpose- to stretch and seal. Bark is cork cells (cork itself is bark harvested from the cork oak), and cork cells are formed by a cork cambium that is not always continuous around the circumference of the trunk. The cork cambium may be patchy, resulting in discontinuous ridges, plates, or protruding patches of thick bark. It may produce thick-walled cork cells, thin-walled cork cells, and various shades of coloring and stretchy consistency because of the amount of suberin in the cells. Cork cells that weather quickly through actions of wind and water don't accumulate, so the bark stays thin in these type trees. Bark cells that weather more slowly will accumulate for years and form thick bark patterns. Various ways of splitting in older bark layers are seen, as the wood accumulates to the interior of the trunk and the bark must give way to the increase in girth. Scaly bark breaks away in curly plates. Papery bark exfoliates in thin, flexible sheets. Smooth bark remains thin and unbroken due to a more even cork cambium and fast weathering of older bark cells. Furrowed bark bears ridges and grooves, and blocky bark has squarish sections of cork cambium beneath. In all cases, we are looking at outer bark that is produced a little bit annually, from underneath, by a cork cambium. The cork cambium is continuously rejuvenated by the vascular cambium, as it too is pushed outward by the addition of wood and girth, and must be replaced.

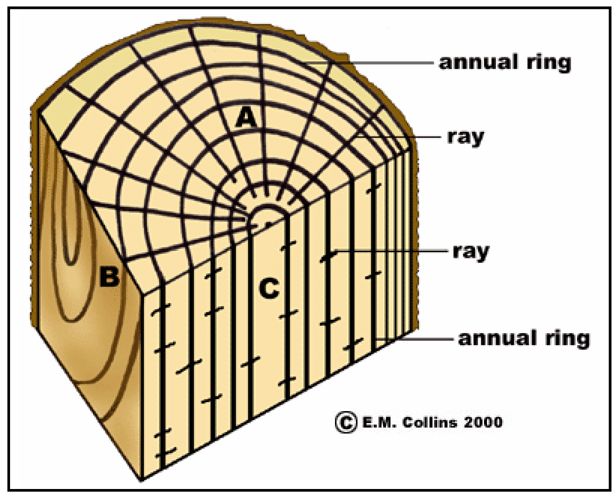


The inner bark is the phloem tissue; it is fibrous because it is actually a system of tubes, and it is aromatic or "sappy" because it contains important energy reserves made by the tree. Old, dead phloem tissue is pushed out with cork cells and replaced by the vascular cambium to the inside. If stripped off, it cannot be replaced except by the cambium. If cut or girdled along with the cambium, the tree can only transport temporarily through its sapwood, and no more phloem can be replaced- death will ultimately occur. Any removal of outer bark in thin trees with thin layers of cork (like white birch) will often result in visible cracking caused by the inner bark losing too much moisture through a loss of its "sealant", and subsequent dying and shrinking.

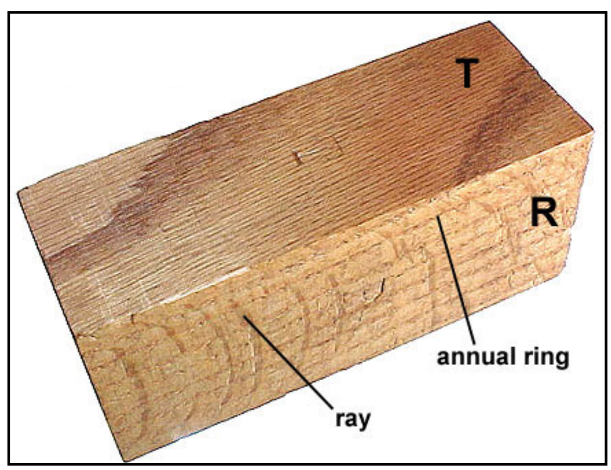
The inner bark can be a useful product itself, yielding food, medicines, and fiber. For example, pine and hemlock bark was used as food; birch and sassafras bark as flavor tinctures; oak and chestnut bark for tanning hides because of tannic acids (also used medicinally for hemorrhoids); witch-hazel bark for facial astringents; slippery elm for throat ailments; leatherwood and basswood bark for bast (cordage).



Section of 3 complete annual rings of a ring-porous hardwood



Three planes of wood:
A. Transverse, B. Tangential, and C. Radial



A block of oak wood showing the tangential plane (T) and the radial plane (R). The parallel lines on the radial side are annual rings. The blotches of cells at right angles to the annual rings are rays.