Wood Anatomy Lab

Objectives of the Lab:
1) Learn to recognize major cell types and features of wood including:
    tracheids
    vessels
    rays
    axial parenchyma
    pits
    tyloses
    resin canals

2) Look at wood in three dimensions to get a sense of the arrangement of cells and cell types.

3) Distinguish between angiosperm (hard) and gymnosperm (soft) wood.

4) Distinguish between ring porous and diffuse porous wood.

5) Compare wood within a stem at different ages (sapwood versus heartwood). Compare woods of different specific densities.

6) Examine the "wood" of monocots

7) Look at some strange wood (*Drimys*, Bignoniaceae, giant groundsel, *Gnetum*)

What is wood?
Wood is secondary xylem, a highly lignified tissue. Secondary xylem in most woody plants is produced by the vascular cambium, a lateral meristem. Most dicot groups and many gymnosperms (conifers, ginkgos and gnetum) have a vascular cambium.

The lateral meristems
Vascular cambium – phloem produced to the outside, xylem to the inside
Phellogen or cork cambium – cork or outer bark produced to the outside, phelloderm (made up of living parenchyma cells) or inner bark produced to the inside

Cell types

Vessels are made up of many individual cells known as vessel elements stacked end to end. They typically have minimal or holey "end plates" (i.e. cell walls at the short end of the cell) so that water can flow easily from one vessel element to the next. When seen in cross-section, vessels are called pores. They are found only in angiosperm wood (but see *Gnetum* below).

Tracheids are long, narrow cells that make up the xylem in conifers but are also found in angiosperm wood. They tend to give a lot of structural support, and sort of grade into fibers. Theses are not as efficient at transporting water as vessels because they are narrower, are not stacked end to end, and tend to have less porous cell walls at their ends as compared to vessels.

Rays are made up of parenchyma and are oriented radially rather than longitudinally (like vessels, tracheids). These are living cells and are probably responsible for radial transport and repair.

Axial parenchyma is also made up of living cells, but is oriented tangentially or axially instead of radially. It is very distinct in some kinds of wood and absent in others.

Pits are features of the side walls in vessels and tracheids. They are areas where the cell walls are much thinner and allow for "cross-talk" between adjacent cells. They often have distinctive morphology used in wood identification (which we'll talk about next week).

Tyloses are ingrowths in tracheids and vessels that may partially or completely block vessels. These can be very important in choosing woods to use for fluid containment. They can also be important in wood ID. So red oaks lack tyloses, but white oaks have them aplenty. Which do you think is used in constructing wine casks? Why?

Resin canals are specialized sets of cells that contain resins.

The wood cubes and wood sections
So you saw the difference between tangential, radial and cross sections in class. I've reproduced a figure here too. Check out the beautiful cubes of wood micrographs showing these sections.

Gymnosperms versus Angiosperms
It's easy. Gymnosperms have no pores. Angiosperms do. Don't be fooled by resin canals, however! We tend to think of conifers as the main gymnosperm wood, but remember that *Ginkgo biloba* is also a gymnosperm. What does its wood look like?

Ring-porous woods have bigger vessels in the early season. **Diffuse-porous** wood has large vessels scattered relatively evenly throughout the growth ring. Compare oaks to maples. Which groups has diffuse porous wood? Which has ring-porous?

Heartwood versus Sapwood
The sapwood is the living, functional portion of the xylem. Remember that the conducting cells of xylem are dead anyway, but there are parenchyma cells throughout. The width of the sapwood is species- and environment-dependent. The heartwood is often darker, and more susceptible to disease. How big a problem is it for a tree if the entire middles is eaten away?

Density of Wood
Different species vary a lot in the density of their wood (mass per volume). We have a number of samples for you to examine. Compare the samples of balsa wood to those of ebony. Wow!

How to make a monocot tree
Monocots do not have vascular cambia, but many of these have tree-like forms. Palms, bamboos, cabbage trees, and dragon trees are all monocots. How do they do it? Well, in various ways. Some plants (e.g. bananas) build up a strong structure by building up a thick layer of fibrous leaf bases. In palms, there is a "thickening meristem" that adds girth at the base, and then the cells elongate up. This process is described in detail at:
http://www.botany.hawaii.edu/faculty/webb/BOT311/MonoSec/SecGrowMono.htm . Each

vascular bundle, which is clearly visible in the cross-section of a palm stem, adds new cells secondarily. However, there is no organized "ring" of secondary vascular tissues as in dicots. In the cabbage palm *Cordyline*, there is a strange lateral meristem like the vascular cambium of dicots, except that it produces whole vascular bundles (xylem and phloem) into the inside of the stem.
We have here some *Cordyline* and some palm stems (including the coconut, *Cocos nucifera*). Take a look. Check out the enormous and enormously hard vascular bundles in the palms.

Some weird wood
Gnetum is a funny tropical tree that has confused many a botanist. It looks an awful lot like a dicot (leaves with reticulate venation, vascular cambium, long open conducting elements in the xylem that look suspiciously porous), but then it has the "naked" seeds. It is clearly a gymnosperm. Take a look at its wood (we have both slides and chunks of wood). Doesn't it look like it has vessels? It turns out these vessels are completely independently derived
For more pictures of *Gnetum*, check out
http://botit.botany.wisc.edu/images/130/Gymnosperms/Gnetophyta_Images/Gnetum/

Drimys is another funny plant. It's an angiosperm, but it has no vessels in its wood! It is considered a "primitive" angiosperm, but it's actually not clear whether this group never had vessels or whether it once had vessels and subsequently lost them. Most species of *Drimys* are vines, but it gets to be a pretty big tree in Chile (where it's called "canelo"- the word for the spice cinnamon – for reasons that are not clear to me. The leaves have a distinctly peppery scent when crushed, but I have not noticed a scent in the bark). Take a look at the slides…no vessels!

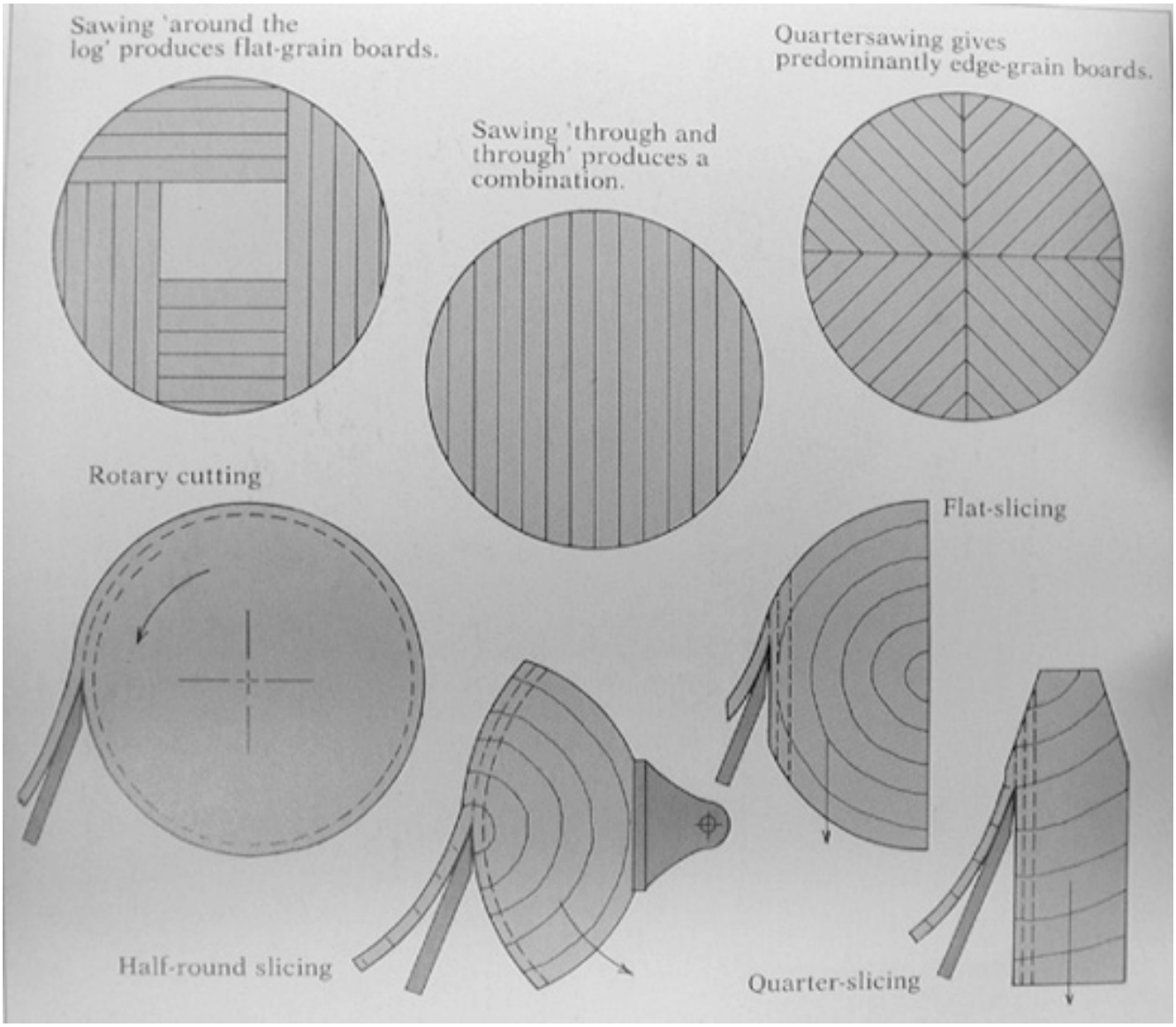
The giant groundsel is just what it sounds like. It's a member of the sunflower family but is a weird "tree" found on Mt. Kiliminjaro. We have a nice stem cross section plus photo of the plant's growth habit. What do you think is going on with the secondary growth here?

Many vines in the family Bignoniaceae (the catalpa and jacaranda family) have a really strange feature, namely a cross or other star-shaped pattern of enormous rays of phloem that are clearly visible in stem cross sections. The origin and function of these is unclear. People have speculated that their thin walls give the vines added flexibility. Alternately, since many phloem cells (unlike xylem cells) are living, it may be that these inclusions give the stem extra regenerative properties when damaged. In any case, look at both the slides and the stem segments. Weird! (Compare this with the green ebony, *Bignonia leucoxylon*, which is also from this family but completely conventional.)

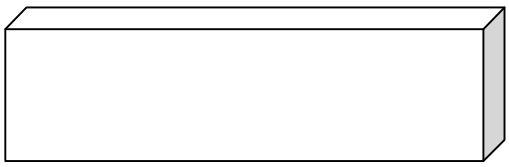
For lots more information about wood (including pretty pictures), see
http://courses.ncsu.edu/WPS202/syllabus.html

Written by Amity Wilczek, 2003

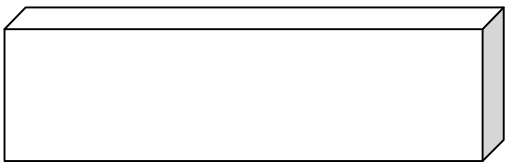
Board Cuts:
Look at the attached figure of different ways to cut lumber. What kind of section do you get when you quarter saw boards? How about sawing around the log? What is meant by "flat-grain" versus "edge-grain?" Draw in the direction of the vessels and rays for the two board types below.

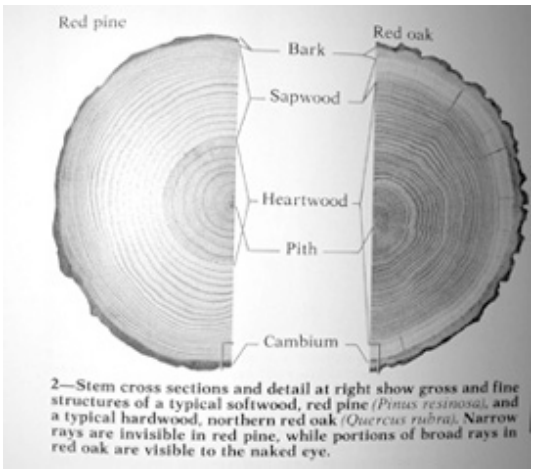


Quarter Sawn

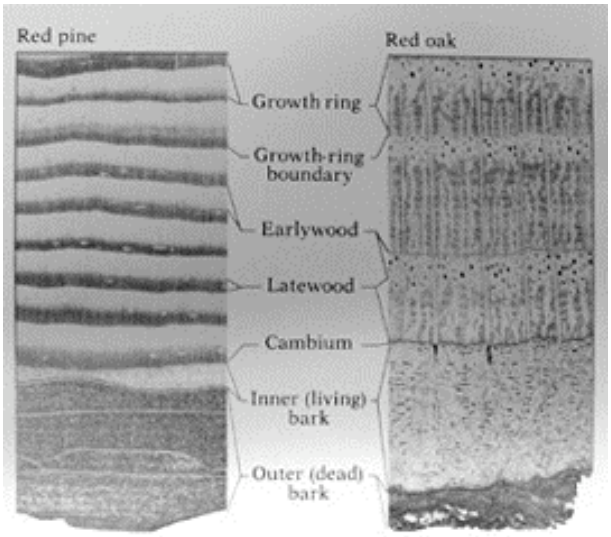


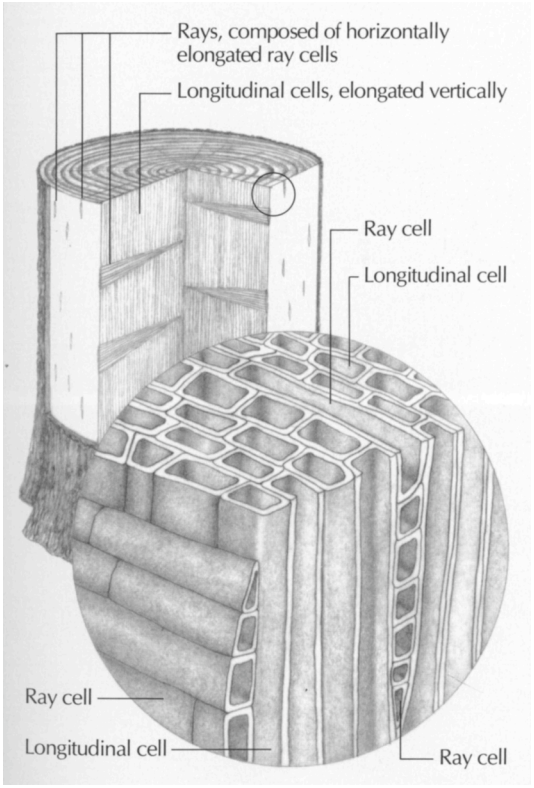
Sawn around the log

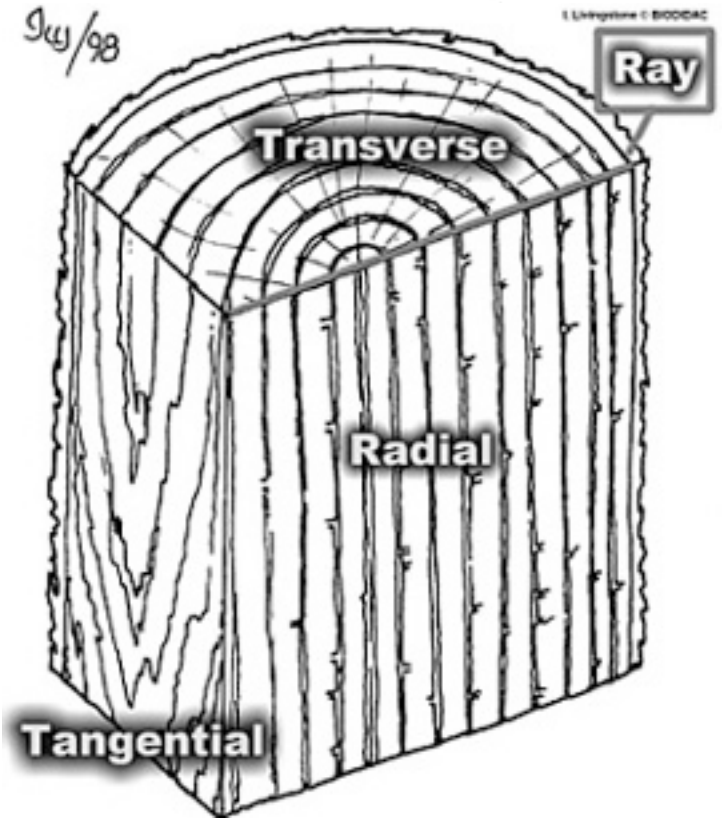




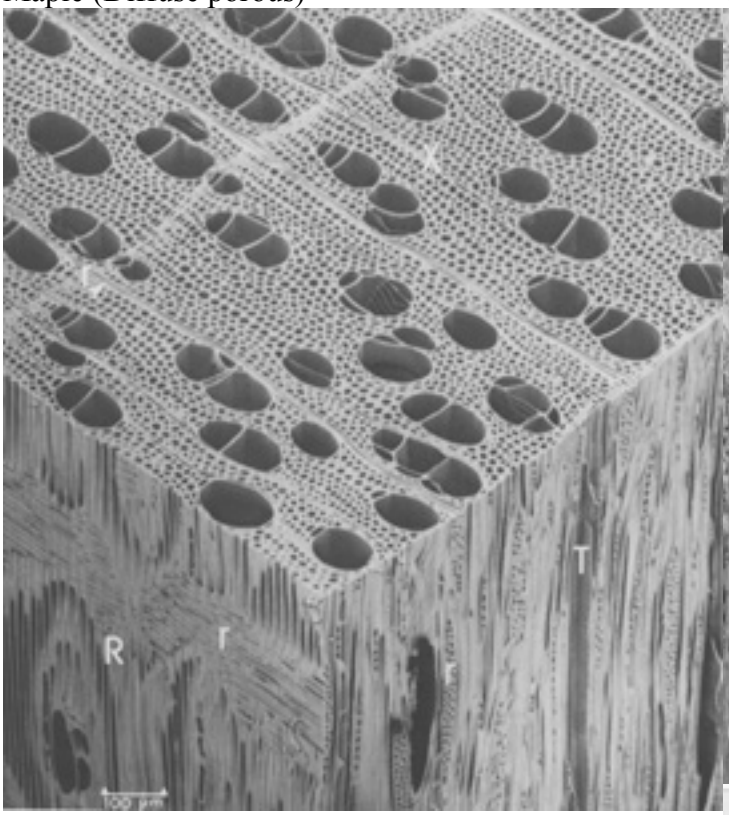
2—Stem cross sections and detail at right show gross and fine structures of a typical softwood, red pine (*Pinus resinosa*), and a typical hardwood, northern red oak (*Quercus rubra*). Narrow rays are invisible in red pine, while portions of broad rays in red oak are visible to the naked eye.



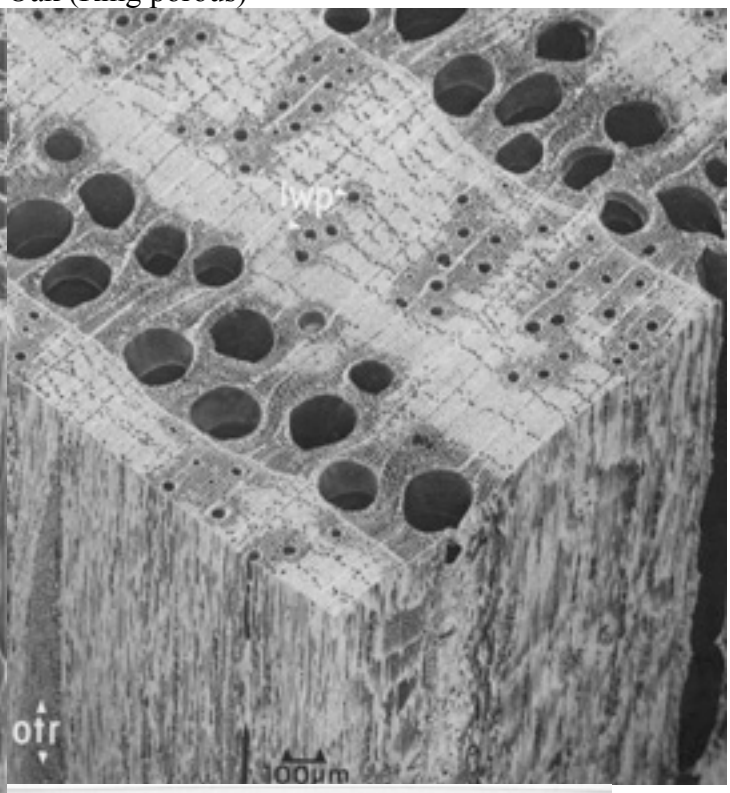


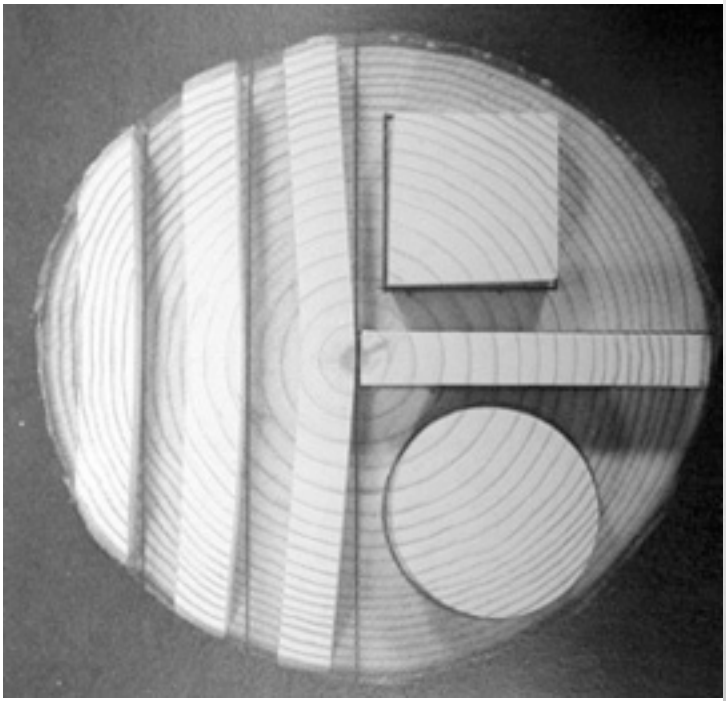


Maple (Diffuse porous)



Oak (Ring porous)





Which areas of the wood shrink most?