Wood

Wood is still used to heat more homes and construct more family dwellings than any other material.

Forests are disappearing

-Hardship for underdeveloped countries

-Hardship on developed countries accustomed to consuming vast quantities of wood products such as paper and fiberboard

What is Wood?

•Extensive accumulations of secondary xylem

•Contrast with herbaceous dicots and monocots

•All or almost all of the vascular tissue is produced by terminal meristems

Primary phloem

Primary xylem

•Some dicots with limited secondary phloem and xylem

•Woody dicots and monocots

A cambium (lateral meristem) forms between the primary xylem and phloem

-addition of xylem to the inside and phloem to the outside

-therefore the xylem increases in girth

Twig—from the outside inward toward the center the following tissues are generally recognizable

Epidermis

Cortex

Pericycle

Phloem

Cambium

Xylem

Pith

Epidermis (then periderm + phellogen--2nd lateral meristem), cortex, pericycle, and phloem become part of the bark

Cambium remains meristematic (capable of repeated cell division) and produces additional (secondary) phloem toward the outside and additional (secondary) xylem in great quantities toward the inside.

The primary xylem and pith remain throughout the life of the tree as an inconspicuous central core to the twig or log, the main mass of which is secondary xylem.

Secondary xylem constitutes wood.
It consists of dead cells, except for a shallow zone toward the outside, next to the cambium.

- Heartwood
- Sapwood

Xylem tissue contains several cell types--the frequency and kinds of these cells are distinctive for various species of wood.

- Tracheids—
  - -longitudinally oriented
  - -linear fusiform cells of modest diameter (0.04 mm wide and 1-4 mm long)
  - -bordered pits usually predominating (simple pits connecting with ray parenchyma are the case in softwood)
  - -primarily have pits in the sidewalls and conduct water sideways
  - -supportive and conductive elements.
- Vessels—
  - -longitudinally oriented
  - -much wider, stockier, open-end cells, typically almost barrel-shaped (up to --0.3 mm not infrequently about 1 mm long)
  - -primarily have pits in the endwalls and conduct water vertically
  - -many simple but sometimes bordered pits
  - -chiefly for conduction.
- Fibers—
  - -longitudinally oriented
  - -are like narrow tracheids (0.01 mm wide and 1-2 mm long)
  - -exceptionally thick walls and simple obscure pits
  - -chiefly for support.
- Ray tracheids—
  - -horizontally oriented
  - -in softwoods are typically elongate-rectangular and shorter than the longitudinal tracheids (0.03 mm wide and 1 mm long)
  - -are usually thin walled with bordered pits; for horizontal transport.
- Xylem parenchyma—
  - -mostly horizontally oriented (main component of the rays)
  - -slightly smaller than tracheids,
  - -much like the cambium from which it is derived
  - -with a particularly thin cell wall
  - -used in storage and some transport.

Two major categories of wood

Refers to the kinds of plants that produce the wood, not to the hardness or softness of the wood

- •Hardwood--any wood that comes from an angiosperm
  - -xylem composed of vessels mixed with tracheids and other kinds of cells
  - -comparatively heterogeneous in structure
  - -rays present
  - -resin canals may be present
  - -laticifers may be present
- •Softwood--any wood that comes from a gymnosperm (conifer)
  - -xylem composed primarily of tracheids
  - -comparatively uniform in structure
  - -rays present
  - -resin canals common
  - -laticifers absent

Tree Rings

- •Changes in the appearance of the xylem due to differential activity of the cambium.
  - -In spring in temperate regions or wet season in semiarid tropics cambium produces many big xylem cells
  - -In summer or dry season, only a few small xylem cells
  - -In winter all cell division stops
  - -Affected by annual temperature and seasonal aridity
    - Warm, wet year--cambium active--relatively more xylem produced
    - Cool, dry year--cambium not as active--relatively less xylem produced
- •Dendrochronology--the study of growth patterns of a tree's xylem
  - -"tree-ring dating"--assuming that one tree ring is produced each year one can count backwards to a specific date
    - ex. fires, tornadoes, indigenous people
  - -climatology--size of the ring can indicate temperature and moisture

Characteristics of Woods

Woods differ several characteristics which contribute to their appearance:

- •Color--naturally can range from black to green, yellow, red, white and purple
  - color is produced by the impregnation of the xylem cells by different-colored compounds
- •Porosity--a feature of dicot wood--the way in which large vessels are dispersed within a given part of the year's growth
  - maple and poplar have a few large vessels scattered within a ring
  - oak and ash have large vessels arranged parallel to the annual rings
- •Grain--the alignment of the xylem cells
  - All cells can lie parallel to the vertical axis of the tree
  - the cells can be variously tipped to produce an irregular pattern
  - in some cases the cells are arranged spirally or occur in bands oriented in alternate directions
- •Figure--a complex index of many wood characteristics:

number of rays
porosity (of hardwoods)
grain
arrangement of annual rings
+ or - knots

Density of Wood

The density and mechanical properties of different woods are important considerations for use

- •Density--mass (g) divided by volume
  - -standard is an oven-dried piece of wood 1 cm^3 so mass = weight
  - -since 1 cm^3 of water is 1 g, any wood with a value below 1 is "lighter" than water and will float
    - Ex. balsa is one of the lightest woods--density is 0.13 g/cm^3
      lignum vitae has a density of 1.23 g/cm^3 and sinks in water
      pine=0.35 to 0.50 g/cm^3
      oak=0.60 g/cm^3

- •Visual and structural properties vs cost for a given use
  - Ex. construction grade where finished product will be hidden--cost vs structure
    Furniture and visible surfaces--color and figure vs cost
- •Firewood and charcoal
  - -High density woods (us. hardwoods) best but
  - -use what is available
    - Ex. we use much conifer wood here (not in SE)--it burns quickly with flash heat but also has resins that build up in chimney or stove pipe
  - -charcoal is produced from medium to high density wood by burning it slowly in an atmosphere with limited oxygen. This drives off the volatile hydrocarbons leaving a material that can burn at a much higher temperature than wood

- •Mechanical properties include:
  - -tension
  - -cross-breaking
  - -shear
  - -compression strength

What wood is good for what?

White pine

- •softwood used in home construction, masts, matches, boxes, crates.
- •soft, uniform texture and straight grain
- •cuts easily in every direction, polishes well and warps little

Hard Maple

- •bowling pins and flooring for bowling alleys
- •machined or turned into spools, bobbins, cue sticks and croquet balls
- •uniform texture and hardness
- •Romans used maple for spears and lances

Black Walnut

- •choice hardwood for fine furniture and interior paneling (because of the heartwood grain)
- •stays in place after seasoning
- •harder than oak and shock resistant
- •good machining properties

White Oak

- •makes good barrels
- •wood is resilient, durable and impermeable to liquids
- •good flooring and fine cabinetry

Bald cypress

- •weather-resistant without treatment
- •used for railroad ties in the early days
- • tanks, roofing and siding and other applications requiring prolonged contact with water

White Ash

- •perfect for baseball bats, tennis racquets, oars and loon tool handles
- •has straight grain, stiffness, strength, moderate weight, good bending qualities and will become smooth with wear.

Red Spruce

- •a favorite for violin sounding boards because of its high resonant qualities
- •a softwood easy to work
- •light in relation to strength and stiffness
- •good for canoes, paddles, oars and airplanes

Hemlock

- •soft, light, straight grained, resin-free
- •uniformly long fibers
- •one of the most important species for wood pulp
- •structural lumber and plywood, and for boxes, barrels and concrete forms

Hickory

- •unsurpassed for handles of impact tools like axes and hammers
- •skis because of its hardness, strength, toughness and resiliency
- •in horse-and-buggy days it was widely used for wheel spokes and rims, singletrees and buggy shafts

Paper

Paper-like substances used for a long time--not real paper as we know it today

- •Egyptians used leaves of *Cyperus papyrus* pressed together to make papyrus
- •Japanese made rice paper by pounding sheets of *Fatsia papyrifera* pith
- •Mayans and Polynesians both developed paper-like sheets by pounding the bark of *Broussonetia papyrifera*

Paper as we know it today is made from plant fibers which have been separated and then matted together into a thin sheet.

Conifer woods are preferred over hardwoods because the xylem tracheids in conifers are longer than xylem vessels in hardwoods

- •Chinese A.D. 100 credited with the invention
- •it took 1,000 years for papermaking to spread from the orient to Europe
  - -most papers of the time were made by hand from linen, cotton or hemp rags, i.e. 100% rag bond paper
  - -once the process was mechanized, there was a shortage of rags and even mummy wrappings were removed from Egyptian tombs and shipped to Britain

Process of making paper

Paper uses wood fibers--the fibers needed to be separated along with extractives (pectins and lignins) that caused discoloration in paper over time

- •early methods of fiber separation were primitive
  - ex. rubbing logs on stones
- •mechanical methods of pulping essentially grind wood chips to free the fibers
  - -paper produced this way yellows rapidly and eventually crumbles
  - -most cheap newsprint is made by this process
- •several chemical methods of separating wood fibers were developed--essentially chemical digestion of cement that holds tracheids and vessels together
  - -boiling wood chips in caustic alkali
    - bad for the environment
  - -sulfite process (1857)
    - high in acid content that causes brittleness and disintegration after about 100 years
    - we are now facing the loss of most books printed on sulfite paper
    - some are being treated with diethyl zinc to bind to the cellulose and neutralize the acid
  - -sulfate process (1884)
    - produces "acid-free" paper that is not subject to premature disintegration

Cork
Not wood because it is not secondary xylem, but used for woodlike products

- The cork oak (*Quercus suber*) produces a cork that is several inches thick that can be removed without permanently damaging the tree
  - Can first be removed from 25 year old trees
  - Successive crops of cork can be harvested about every 9-10 years and are generally superior in quality to the initial harvest

- The cork is a natural adaptation that provides protection against fire damage

- Mostly grown in areas around the Mediterranean Sea

- Use is expanding because no synthetic material has been produced with all the qualities of natural cork
  - The cells are air filled (useful for stoppers and fishing floats)
  - The cells are resilient (useful for wine corks and shoe soles)
  - Has insulating properties (wood burning tools and the space shuttle)

Bamboo
Not wood because it is not secondary xylem, but used for woodlike products

- The name bamboo is applied to about 1,000 species in one subfamily of grasses

- New growth is only by apical meristems not lateral cambium
- Some bamboos can grow vertically 60-90 cm in a day
- Stems of bamboo consist of segmented hollow tubes
  - This gives a unique combination of flexibility, light weight and strength