1

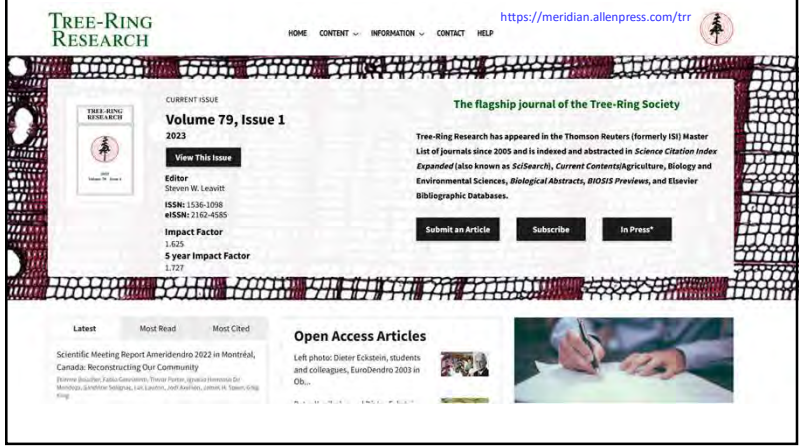
Learn/review a little about:

- Cambium
- Differentiation (cell division, enlargement, maturation)
- Xylem
- Phloem
- Vessels
- Tracheids
- Rays
- Resin ducts
- Earlywood ("springwood")
- Latewood ("summerwood")
- Heartwood
- Sapwood
- Juvenile wood
- Reaction wood

2

Historical aside……

the journal called



3

A Product of the Tree-Ring Society

Formed 89 years ago (established 1934)

ca. 225 members including institutions

Supports international meetings and fieldweeks

Membership $55 regular, $25 students & developing country
[information at http://www.treeringsociety.org]

Publishes 2 issues of a journal each year
Current (2022) Impact Factor: 1.625
5-year Impact Factor: 1.727

http://treeringresearch.org/

4

TREE-RING RESEARCH

An International Journal

First issue (Volume 1, No. 1) published in 1934 as "**TREE-RING BULLETIN**"

Volume 57 (2001), name changed to "**TREE-RING RESEARCH**"

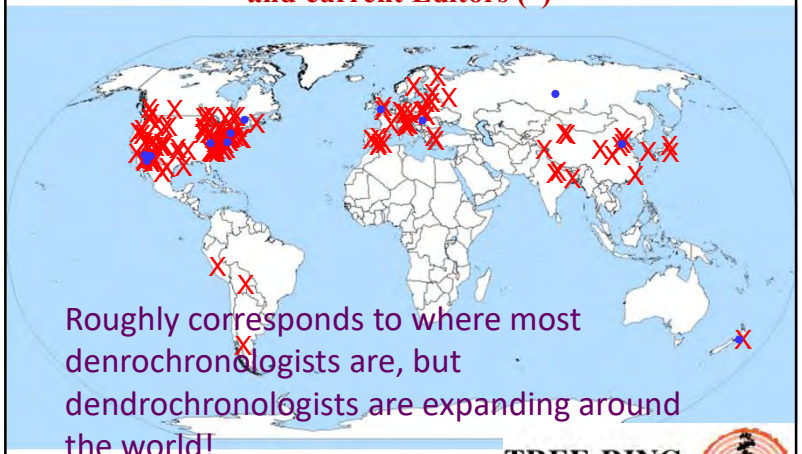
Volume 79 now being published in 2023

~160 manuscripts submitted over the last 10 years

Rejection rate ≈ 27% in last 10 years

5

Tree-Ring Research First Authors (X), 2002-Jan 2023, and current Editors (●)



Roughly corresponds to where most denrochronologists are, but dendrochronologists are expanding around the world!

TREE-RING RESEARCH

6

Another journal specializing in tree-ring studies is

Dendrochronologia

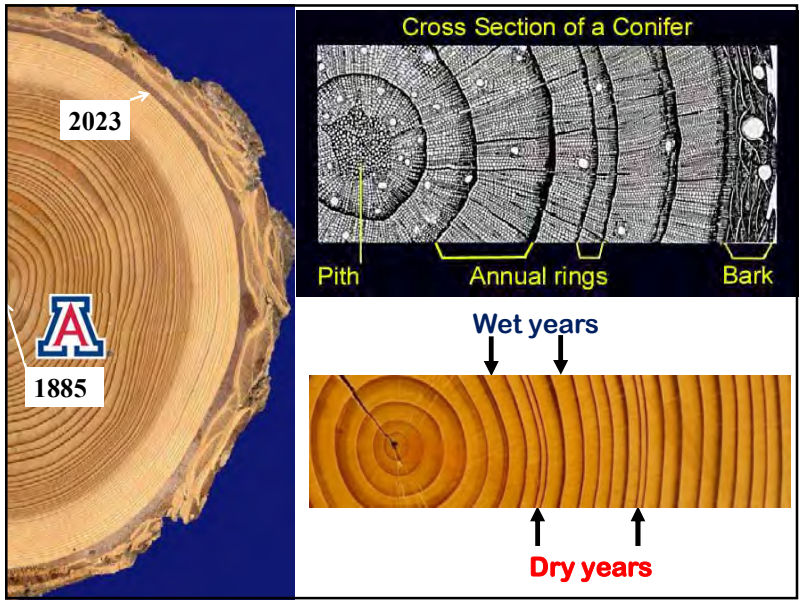
Currently on volume 79

Published by Elsevier as 6 issues per year

Editorial offices in Europe

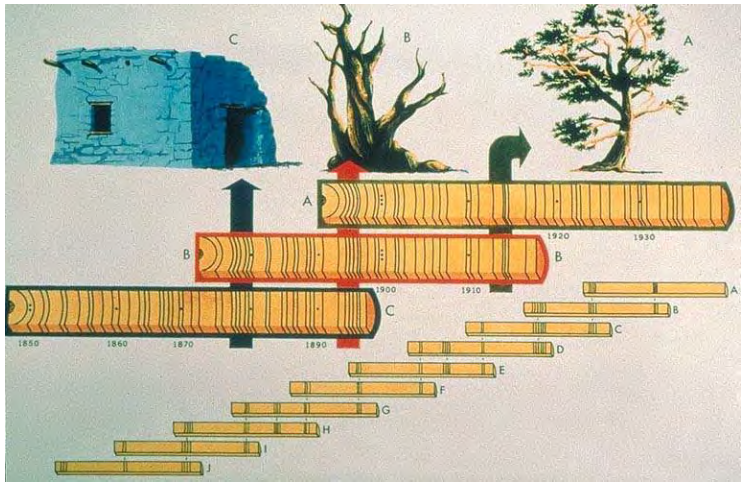
7

8



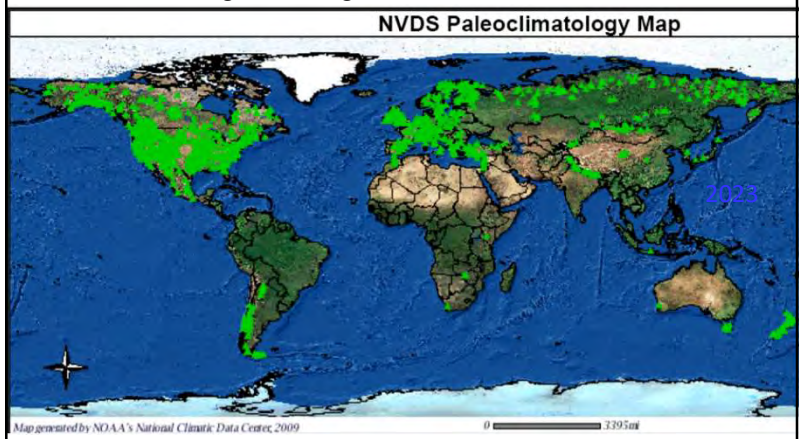
9

Developing Tree-Ring Chronologies



10

Tree-Ring Chronologies Around the World, ITRDB



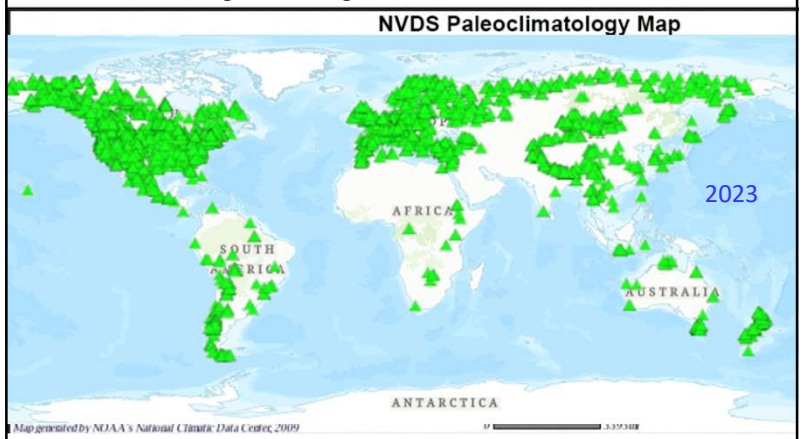
87 chronologies 1000+ years world-wide, of which 59 are in U.S.

http://www.ncdc.noaa.gov/paleo/treering.html

https://www.ncei.noaa.gov/maps/paleo/?layers=0000000000000001

11

Tree-Ring Chronologies Around the World, ITRDB



87 chronologies 1000+ years world-wide, of which 59 are in U.S.

http://www.ncdc.noaa.gov/paleo/treering.html

https://www.ncei.noaa.gov/maps/paleo/?layers=0000000000000001

12

Historical wood

Buildings: churches, castles, houses, barns.

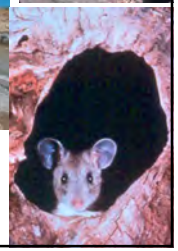
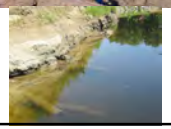
Other: bridges, fences, walkways, tombs, frames, artwork, boats.


Archaeological wood

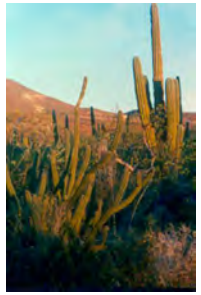
(1) primary and secondary roof support beams
(2) window and door timbers
(3) hearths and firepits (often charcoalized)


Wood from biological and geological deposits

alluvial deposits
lake deposits
bog deposits
packrat midden macrofossils
glacial deposits

13



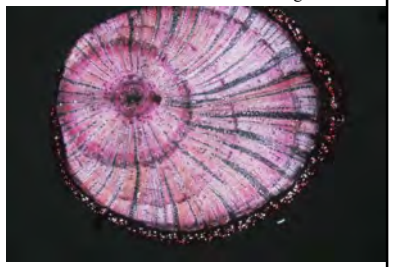
Organ Pipe and Cardon Cactus

Woody Plants Show Growth Rings

Saguaro Rib

Even Some Perennial Herbaceous Plants…..

Lythrum salicaria from bog



(Fritz Schweingruber, http://www.wsl.ch/dendro/dendropicdb/index.php?TEXTID=1288&MOD=1)

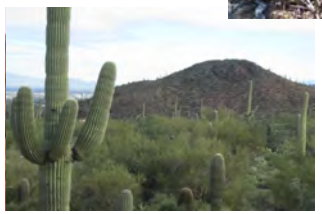
Saguaro and Woody Shrubs

14

Rings

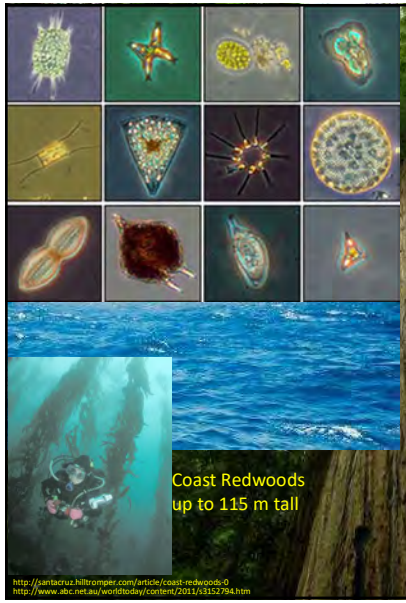
Perennial
s Plants…..
thrum salicaria
om bog

Saguaro and Wood



(Fritz Schweingru

15

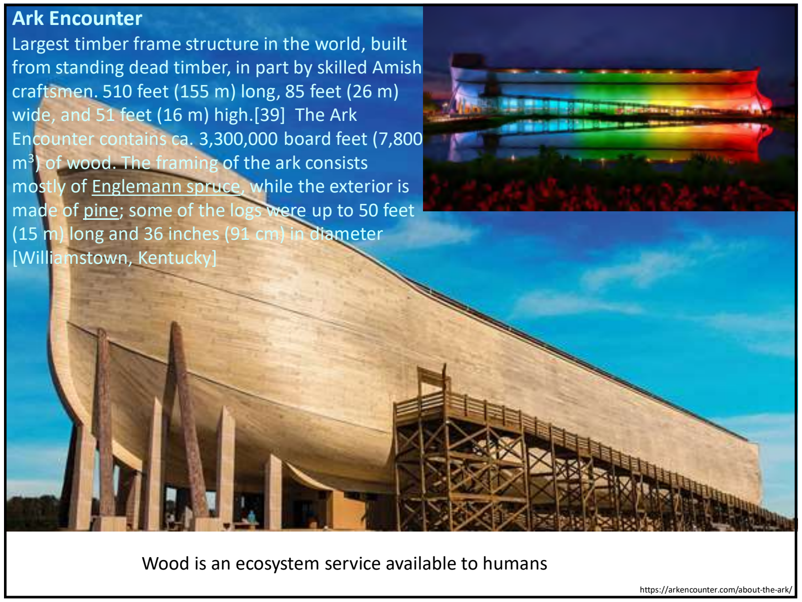


Why wood?

Coast Redwoods
up to 115 m tall

http://santacruz.hilltromper.com/article/coast-redwoods-0
http://www.abc.net.au/worldtoday/content/2011/s3152794.htm
http://slideplayer.com/slide/10073241/

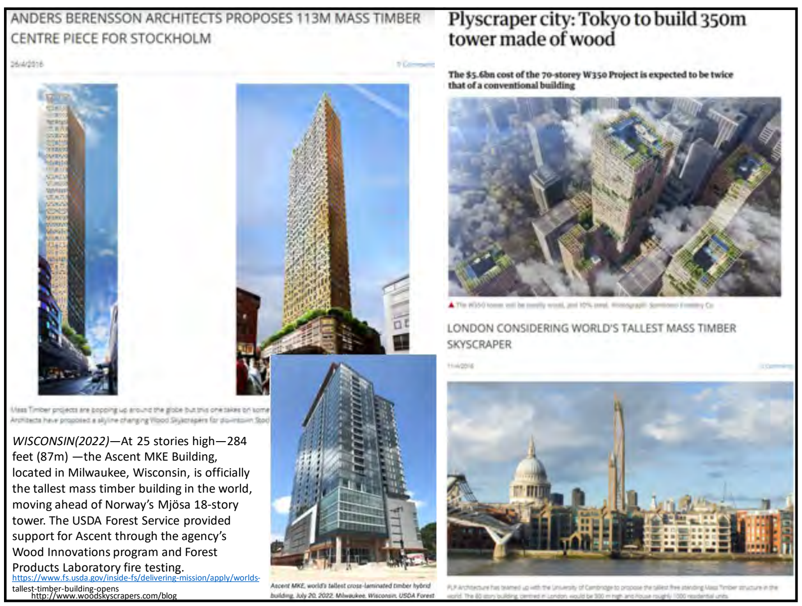
16


Ark Encounter
Largest timber frame structure in the world, built from standing dead timber, in part by skilled Amish craftsmen. 510 feet (155 m) long, 85 feet (26 m) wide, and 51 feet (16 m) high.[39] The Ark Encounter contains ca. 3,300,000 board feet (7,800 m^3) of wood. The framing of the ark consists mostly of Englemann spruce, while the exterior is made of pine; some of the logs were up to 50 feet (15 m) long and 36 inches (91 cm) in diameter [Williamstown, Kentucky]
Wood is an ecosystem service available to humans
https://arkencounter.com/about-the-ark/

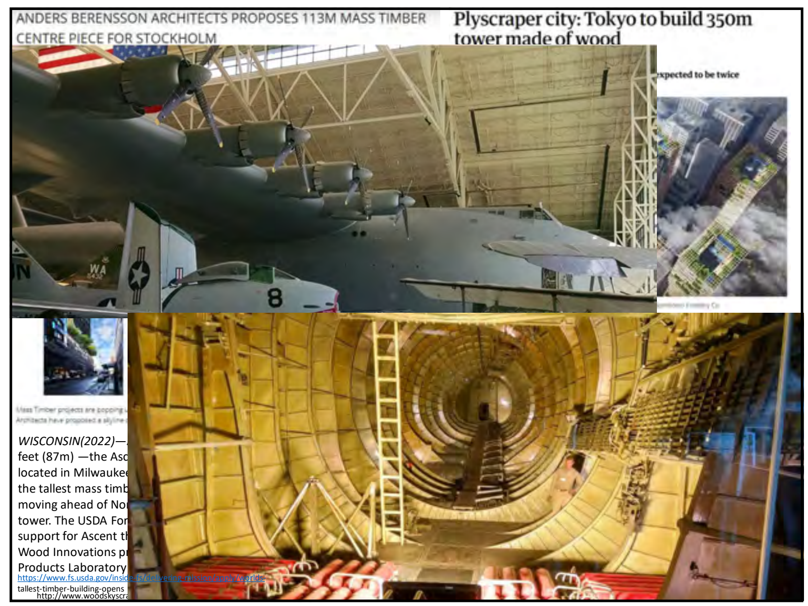
17


Metropol Parasol: The World's Largest Wooden Structure, Seville
http://inhabitat.com/metropol-parasol-the-worlds-largest-wooden-structure-opens-in-seville/
Gliwice Radio Tower: The World's Tallest Wooden Structure, Poland 118 m
https://www.quora.com/What-is-the-worlds-largest-tallest-wooden-structure
Todaiji, the world's largest wooden building, Nara, Japan
http://www.123rf.com/photo_10067487_exterior-of-todaiji-the-world-s-largest-wooden-building-and-a-unesco-world-heritage-site-in-nara-jap.html?fromid=bUdsazcxNW8wbm94cDNiWiQvOU9oZz09

18

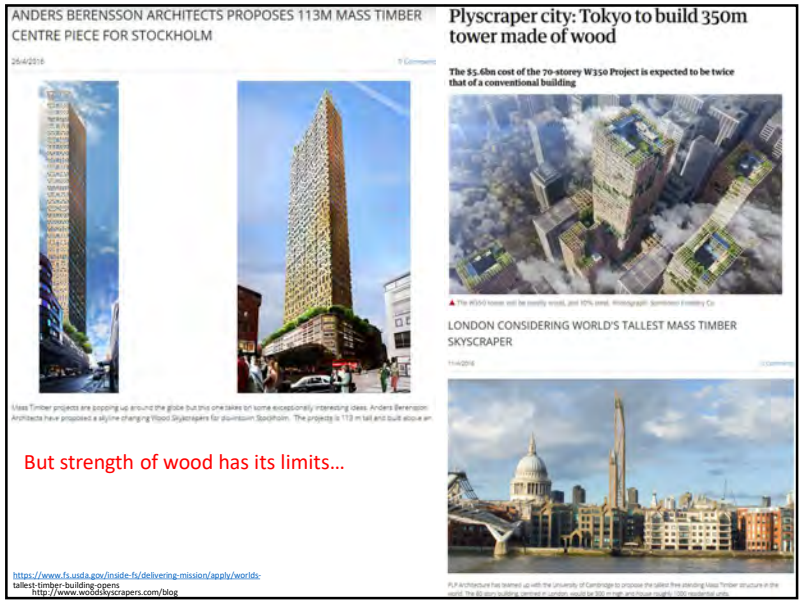

ANDERS BERENSSON ARCHITECTS PROPOSES 113M MASS TIMBER CENTRE PIECE FOR STOCKHOLM
Plyscraper city: Tokyo to build 350m tower made of wood
The $5.6bn cost of the 70-storey W350 Project is expected to be twice that of a conventional building
LONDON CONSIDERING WORLD'S TALLEST MASS TIMBER SKYSCRAPER
WISCONSIN(2022)—At 25 stories high—284 feet (87m) —the Ascent MKE Building, located in Milwaukee, Wisconsin, is officially the tallest mass timber building in the world, moving ahead of Norway's Mjösa 18-story tower. The USDA Forest Service provided support for Ascent through the agency's Wood Innovations program and Forest Products Laboratory fire testing.
https://www.fs.usda.gov/inside-fs/delivering-mission/apply/worlds-tallest-timber-building-opens
http://www.woodskyscrapers.com/blog
Ascent MKE, world's tallest cross-laminated timber hybrid building. July 20, 2022. Milwaukee, Wisconsin. USDA Forest

19


ANDERS BERENSSON ARCHITECTS PROPOSES 113M MASS TIMBER CENTRE PIECE FOR STOCKHOLM
Plyscraper city: Tokyo to build 350m tower made of wood

20

21



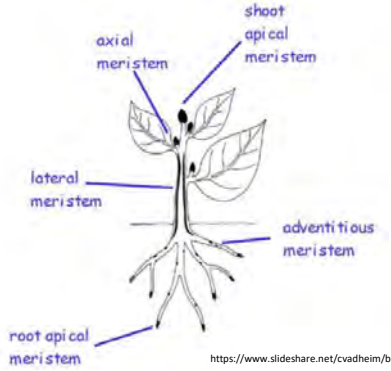
22

23

Tree growth needs wood cells, and cells produced by meristems:

Meristems and gross structure

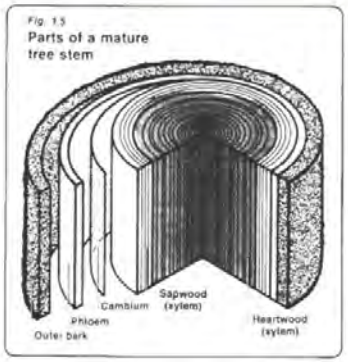
Meristems are tissues whose cells divide and differentiate to form other tissues. Main ones – apical meristem and vascular cambium (this is a lateral meristem).



https://www.slideshare.net/cvadheim/botany-for-gardeners-2014final

24

Major Tissues in the Tree Stem



Outer Bark
- Protection

Phloem (Inner Bark)
- Transport (down)

Cambium
- Radial growth

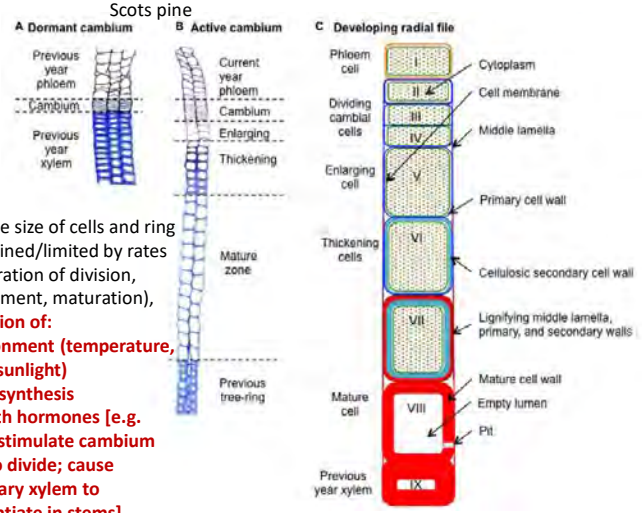
Xylem (Wood)
- Transport (up) and mechanical support

http://slideplayer.com/slide/5225443/

25

Division, Enlargement, Maturation

Scots pine

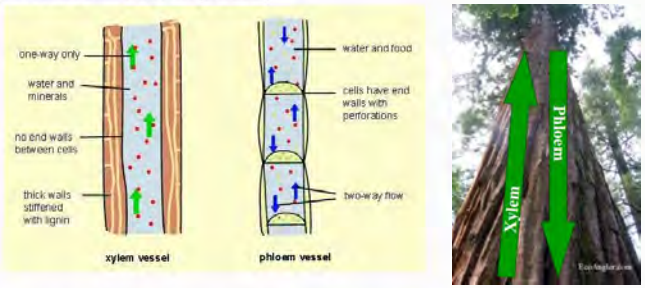


Ultimate size of cells and ring determined/limited by rates and duration of division, enlargement, maturation),
A function of:
***Environment (temperature, water, sunlight)**
***Photosynthesis**
***Growth hormones [e.g. auxins stimulate cambium cells, to divide; cause secondary xylem to differentiate in stems]**

Rathgeber et al. 2016

26

Phloem and Xylem

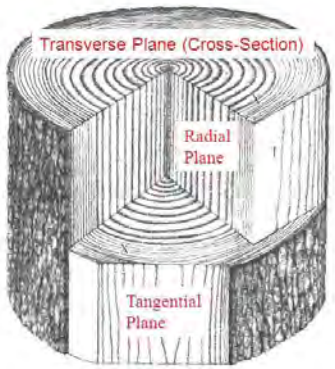


Xylem-System of tubes in a plant that **transport water and dissolved minerals.** The xylem distributes the water throughout the plant.
Phloem-Transport **sugars and molecules created by the plant.** Transports food made during photosynthesis.

http://slideplayer.com/slide/3563770/

27

Planes-of-View in Wood Samples



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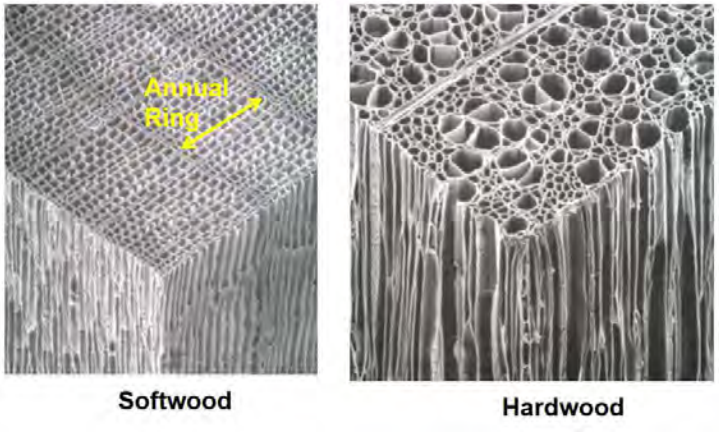
28

Basic Wood Anatomy

Microanatomy



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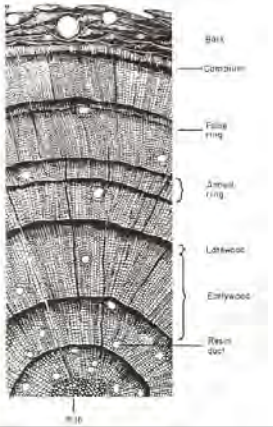
Basic Anatomy of Growth Rings

Terminology



Conifer
"non-porous"

"ring-porous"

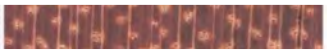
Angiosperms

"diffuse-porous"

30

Thought Question

How many tree rings are in this image?



http://slideplayer.com/slide/5225443/

31

Thought Question

How many tree rings are in this image?

KENTUCKY COFFEETREE
Gymnocladus dioicus

http://slideplayer.com/slide/5225443/

32

Thought Question

How many tree rings are in artist's rendering?

The Big Picture:

33

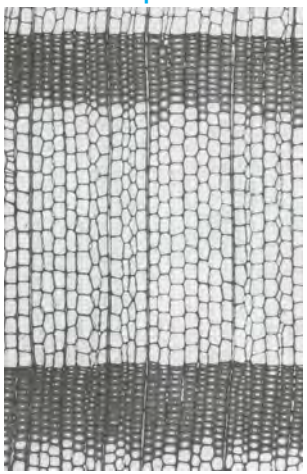
Do all trees have rings?

Tropical and subtropical wood

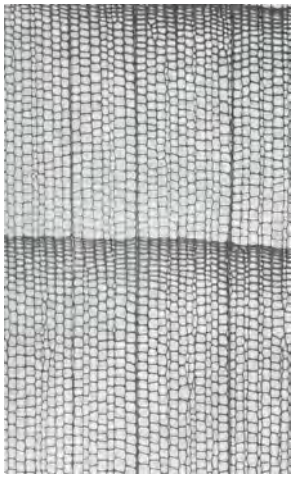
34

Earlywood / Latewood Transition

Abrupt

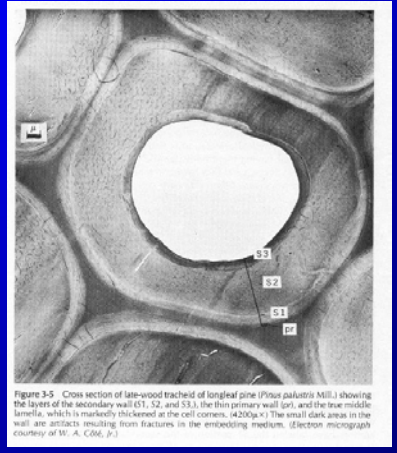


Gradual



35

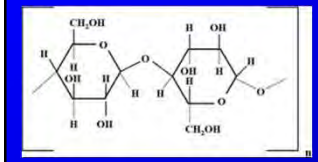
Cell Wall

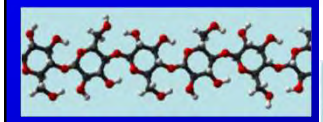


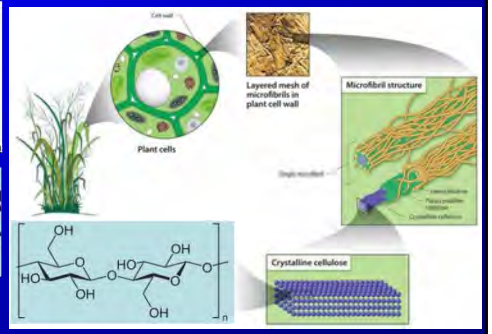
(Panshin & Zeeuw 1980)

36

Cellulose is the dominant constituent of wood:
Long polymers of repeating $C_6H_{10}O_5$ units that are assembled together as **microfibrils**







http://en.wikipedia.org/wiki/Cellulose

http://www.treehugger.com/files/2008/03/zymetis-cellulosic-ethanol.php

37

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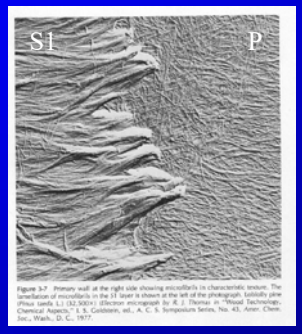
Cell Walls



Wall Layer	Relative Thickness (%)	Avg. Angle of Microfibrils
PW	±1	random
S1	10-22	50-70°
S2	40-90	10-30°
S3	2-8	60-90°

(Panshin& Zeeuw 1980)

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Cell-Wall Chemistry

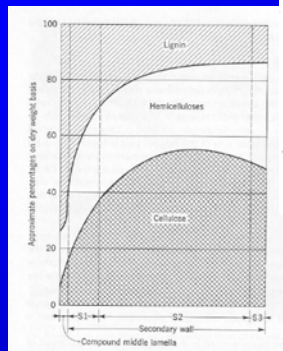


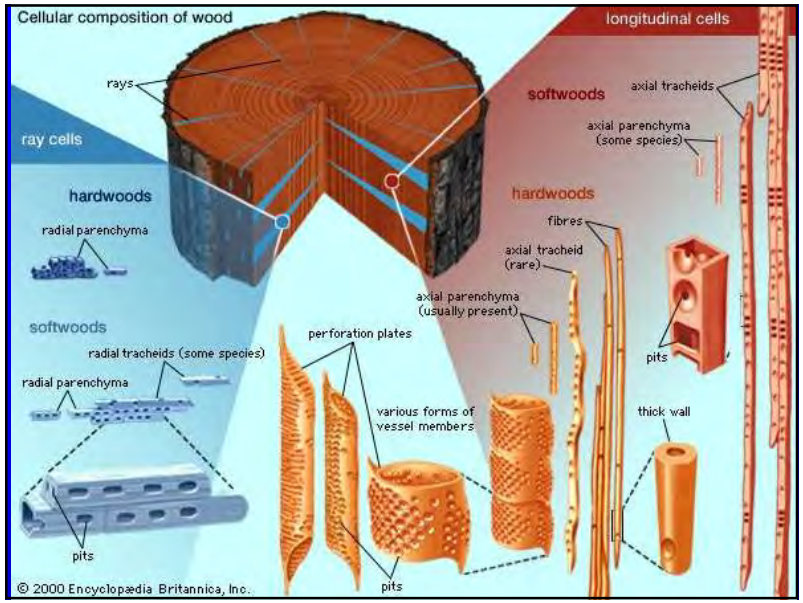
Figure 3-10 Distribution of the principal chemical constituents within the various layers of the cell wall in conifers.

Table 3 Chemical Constituents of Wood

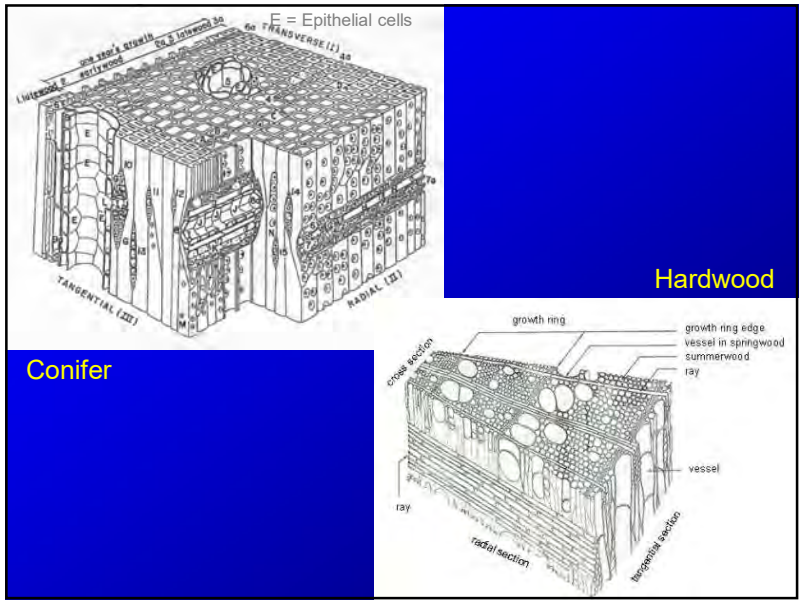
	% Composition	Polymeric nature	Degree of polymerization	Molecular building blocks	Role
Cellulose	45–50	linear molecule crystalline	5,000 –10,000	glucose	framework
Hemicellulose	20-25	branched molecule amorphous	150-200	primarily nonglucose sugars	matrix
Lignin	20-30	three-dimensional molecule	100-1,000	phenolpropane	matrix
Extractives	0-10	polymeric	—	polyphenols	encrusting

(Panshin& Zeeuw 1980)

40

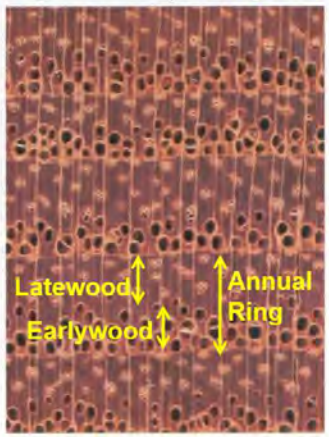


41



42

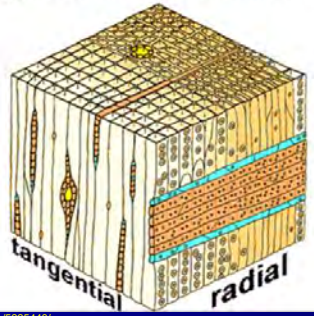
Rays in Wood



KENTUCKY COFFEETREE
Gymnocladus dioicus

Function: Transport from the phloem towards the pith.

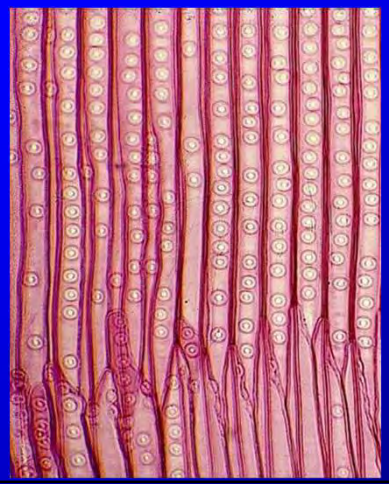
- Ray cells are elongated in the radial direction
- Width, height, density, and appearance vary - useful for ID



http://slideplayer.com/slide/5225443/

43

Longitudinal Tracheids



- Compose the bulk of xylem (90-95%)
- Shape and proportions are similar amongst softwood species
- Radial diameter varies with position in growth ring
- Tangential diameter remains constant and leads to judgements of **texture**
- Conductive and support functions

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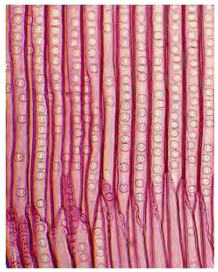
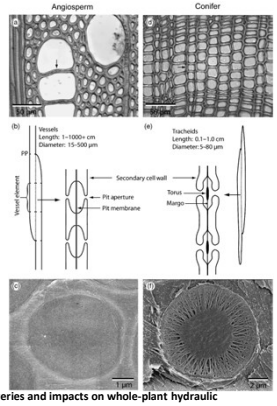
Bordered pits are cavities in the lignified cell walls of xylem conduits (vessels and tracheids) that are essential components in the water-transport system of higher plants. The pit membrane, which lies in the center of each pit, allows water to pass between xylem conduits but limits the spread of embolism and vascular pathogens in the xylem.

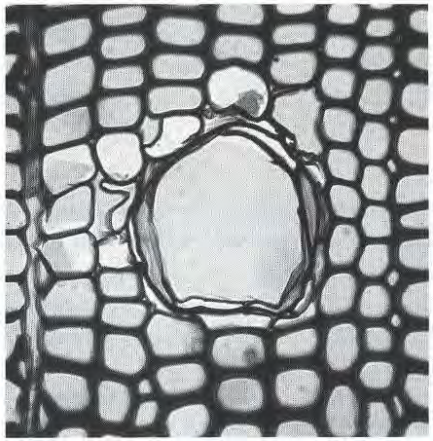




Choat, B., Cobb, A.R., Jansen,S.,2008. Structure and function of bordered pits: new discoveries and impacts on whole-plant hydraulic function.New Phytologist 177: 608–626.

45

Resin Canals



- Conduct resin secreted by specialized parenchyma cells called epithelial cells lining the canal opening
- Seals wounds from insects or mechanical damage
- Occur oriented in the longitudinal direction and in the radial direction (within fusiform rays)

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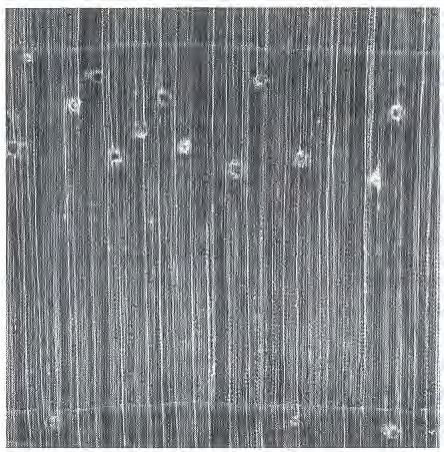
Resin Canals



- Occur in:
  - *Pinus* spp.
  - *Larix* spp.
  - *Picea* spp.
  - *Pseudotsuga menziesii*
- Useful for wood ID
- May need hand lens to see
- Appearance varies with presence/absence of resin

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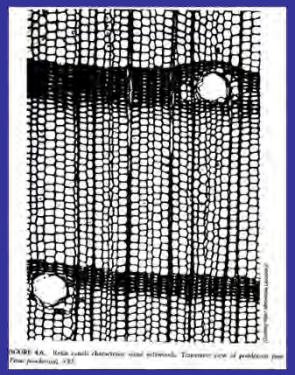

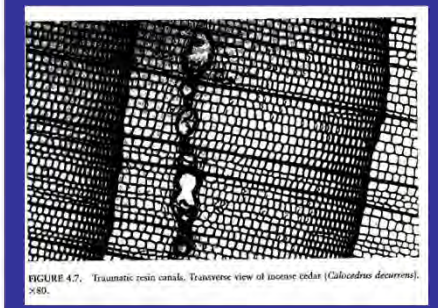

FIGURE 4.7. Traumatic resin canals. Transverse view of incense cedar (*Calocedrus decurrens*). ×80.

Lecture notes and graphics by V. Trouet, with contributions from M.K. Hughes and T.W. Swetnam

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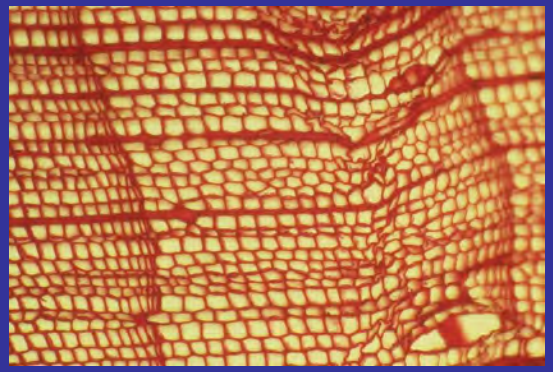
Frost rings



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Heartwood vs. Sapwood

Sapwood

- only living (parenchyma) cells in xylem
- Not all sapwood cells are living
- Conduction function
- Size is relative to size of tree crown

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Heartwood vs. Sapwood

Heartwood

- Reduced water and oxygen availability: death of parenchyma cells
- Mechanical support only
- Does not follow tree-ring contours
- Extractives
  - Coloring
  - Decay resistance
  - Low water permeability

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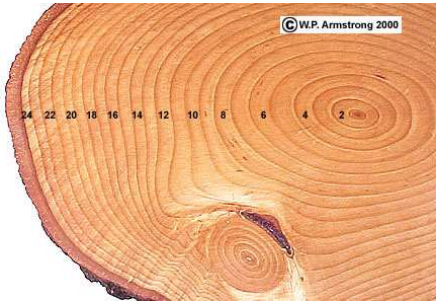
Juvenile Wood



- Short fibered xylem with high microfibril angles and low specific gravity.
- Wood produced during the first 5-15 years of growth
- As tree grows, the SG increases and the fibers lengthen.
- Gradual transition from juvenile wood to mature wood
- Caused by effects of hormones from apical meristems on cambium
- As cambium in stem becomes farther from and less influenced by the apical meristem, transition to mature wood

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Physical Characteristics of Juvenile Wood that Affect its Use

- Cells are shorter than mature wood
- Thin cell walls and less latewood
  - Leads to lower density and strength
- More spiral grain

For Softwoods in Particular:

- Density
  - 10-15% lower than mature wood
- Strength
  - 15-50% lower than mature wood

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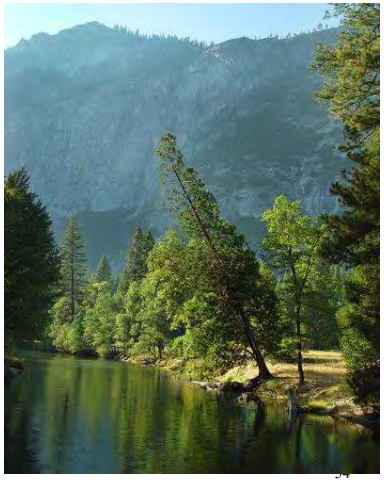
Reaction Wood



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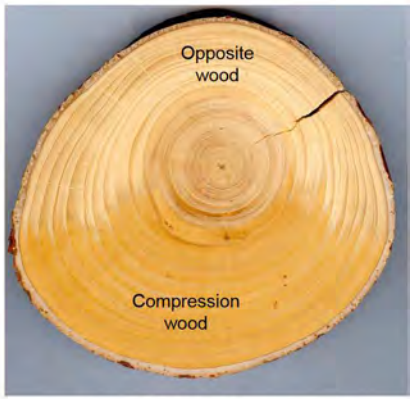
Reaction Wood

White Oak (*Quercus alba*)



Eastern White Pine (*Pinus strobus*)

https://ag.purdue.edu/fnr/associations/IAA/Documents/BiomechanicsOfTreesTelewski.pdf

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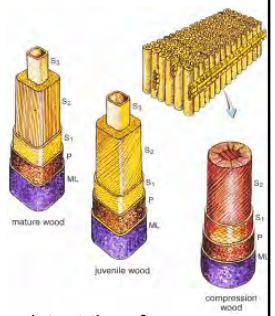
Reaction Wood in Softwoods and Hardwoods

- **Compression Wood**
  - Softwoods
  - Underside of branches or leaning stem
  - Commonly in juvenile wood
  - Appearance is similar in most species
- **Tension Wood**
  - Hardwoods
  - Top of branches or leaning stem
  - Common in juvenile wood also
  - Appearance and microanatomy is less consistent than for compression wood



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Wound formation

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