Into the woods (木)

G30 for everyone

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Contents

Use of wood　木材の利用

- Construction
- Furniture
- Art
- Lute-making

Uwajima Castle - 宇和島城

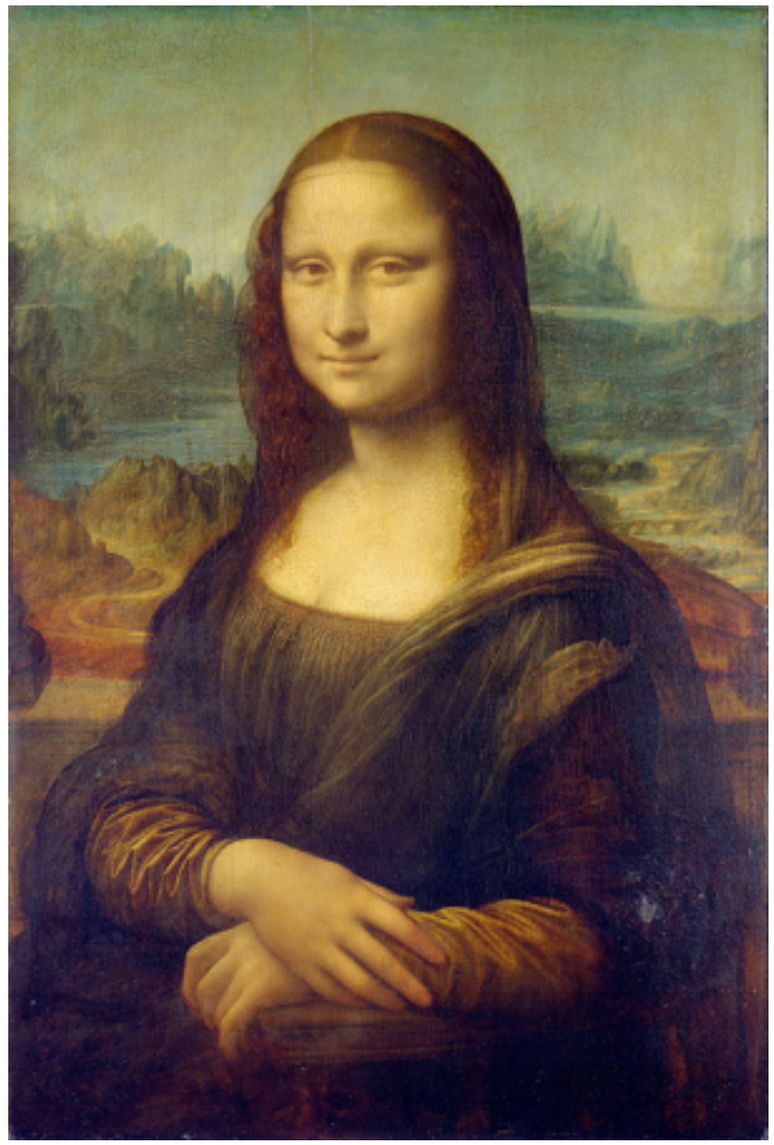
Use of wood

- Construction
- Furniture
- Art
- Lute-making

Bonheur du jour - Charles Topino (1725-1789), assembly in oak and poplar; marquetry of sycamore, roses wood, buxus and ilex aquifolium. Musée des Arts Décoratifs © AnticStore

Use of wood

- Construction
- Furniture
- Art
- Lute-making



Mona Lisa, painted on Populus

Use of wood

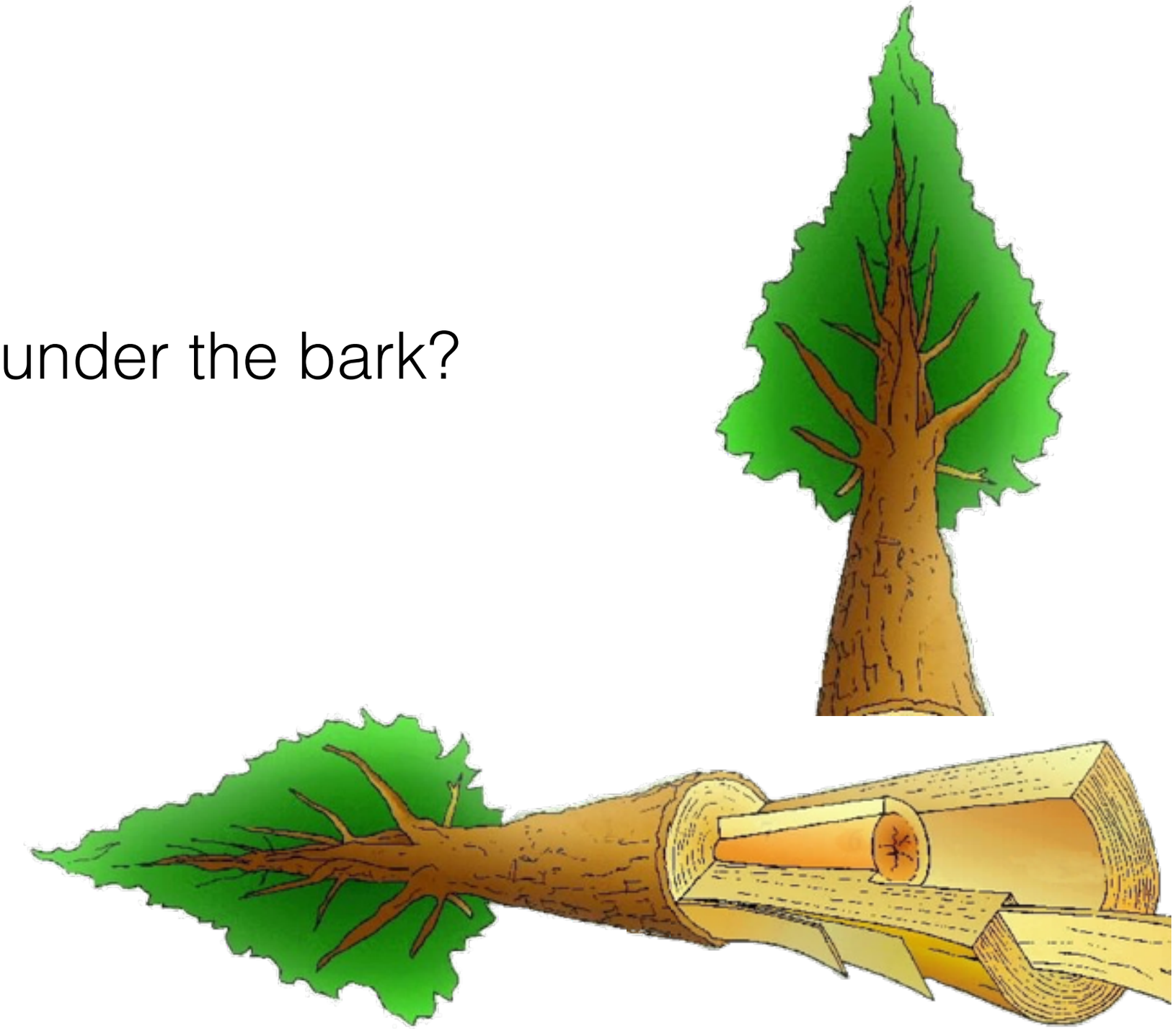
- Construction
- Furniture
- Art
- Lute-making

Few steps of violin making

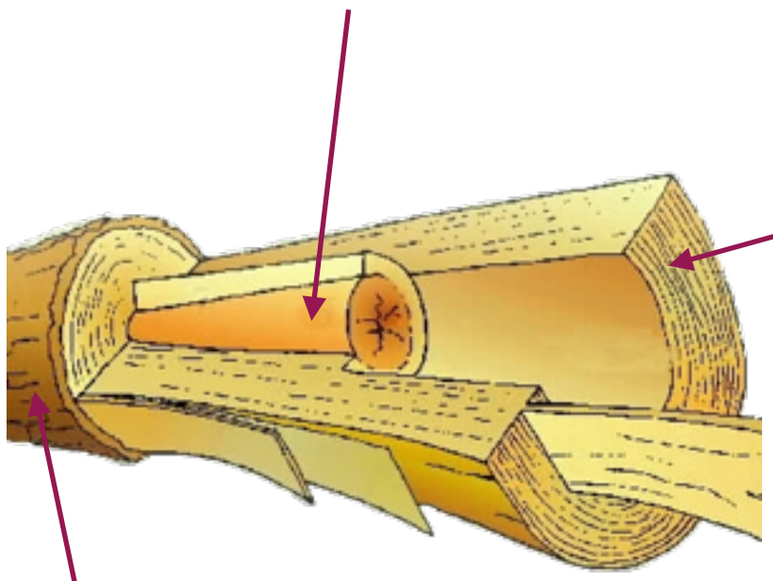
Biwa (琵琶)

Wood architecture

- What is under the bark?



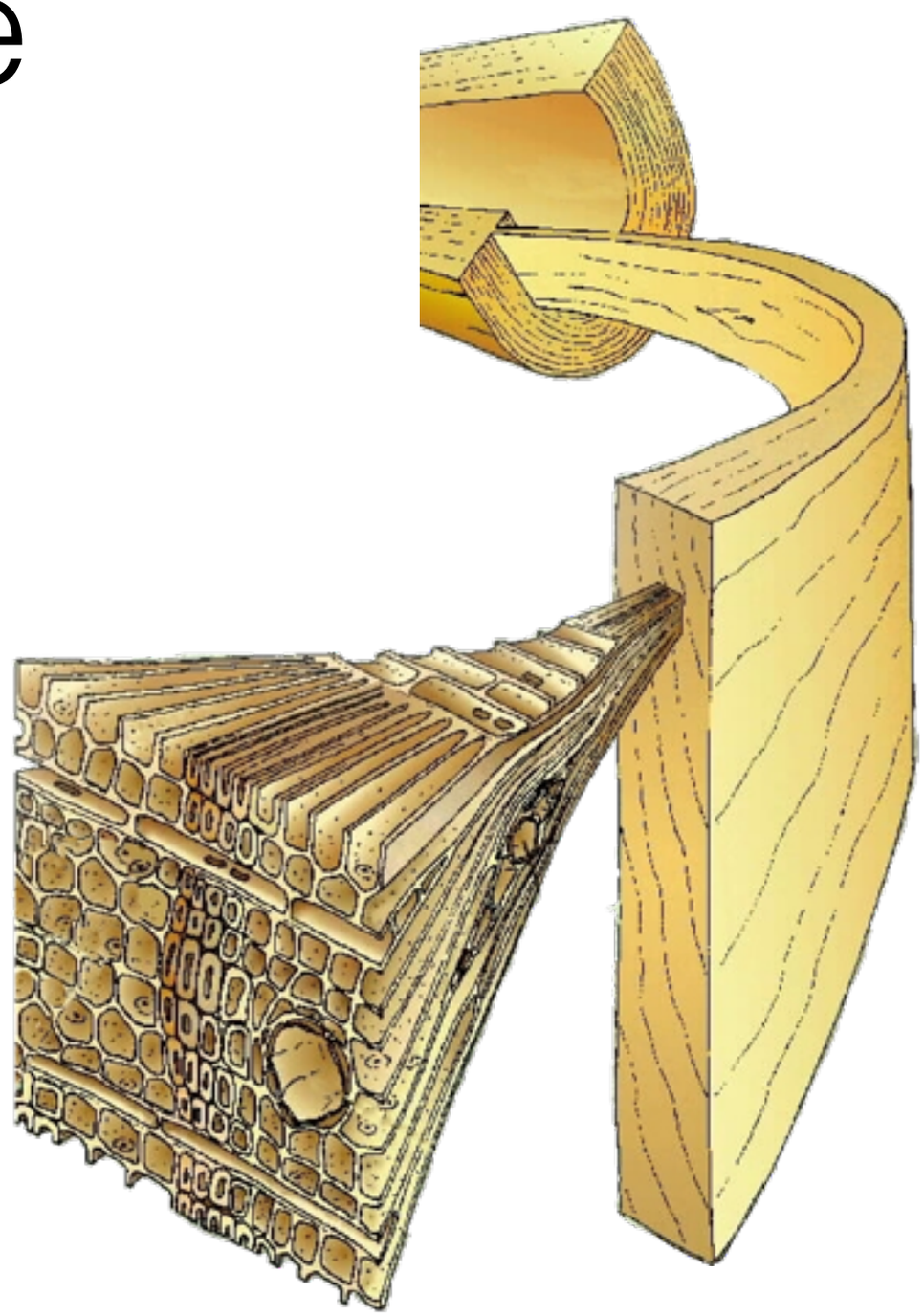
Under the bark, we can observe two zones:



Wood at the microscopic scale

- Different kinds of cells composed wood

- What is the anatomy of wood?



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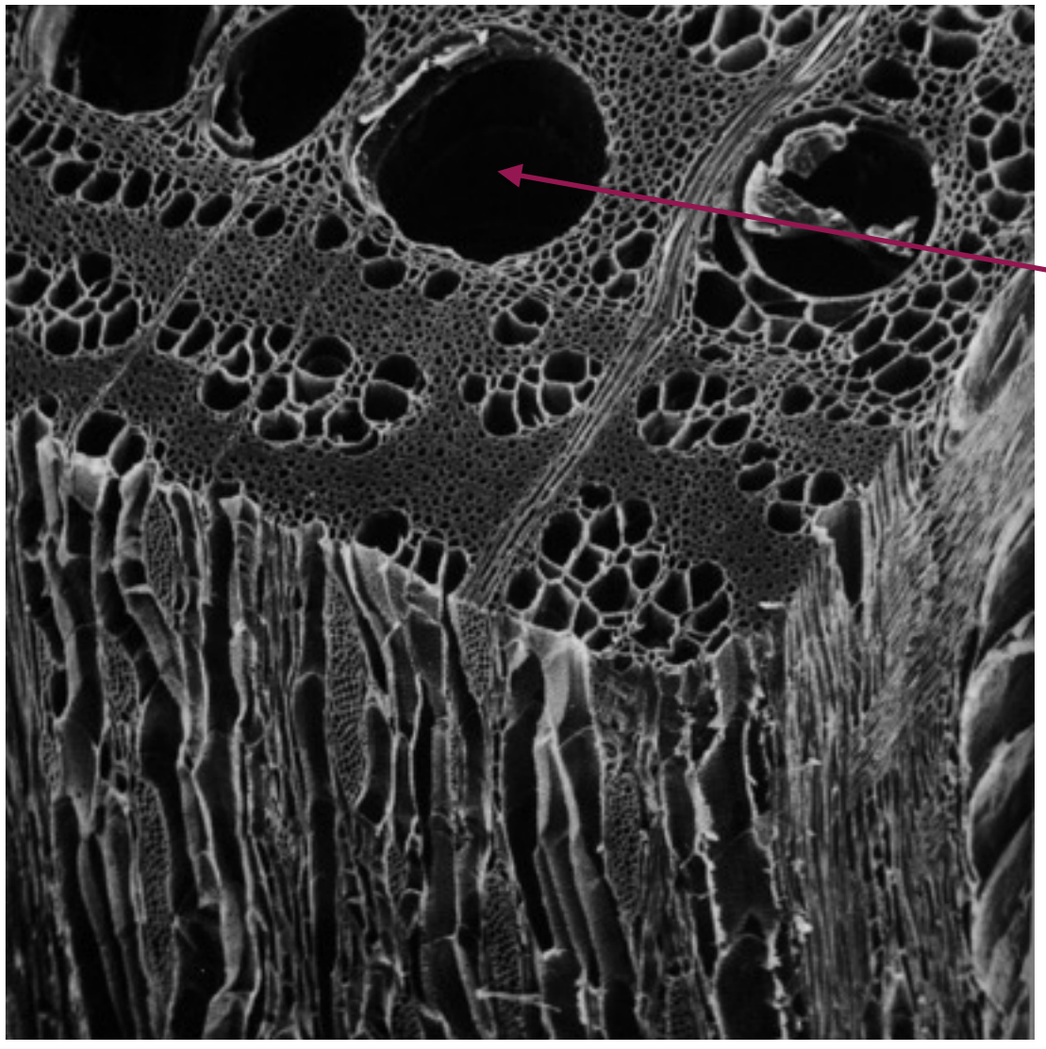
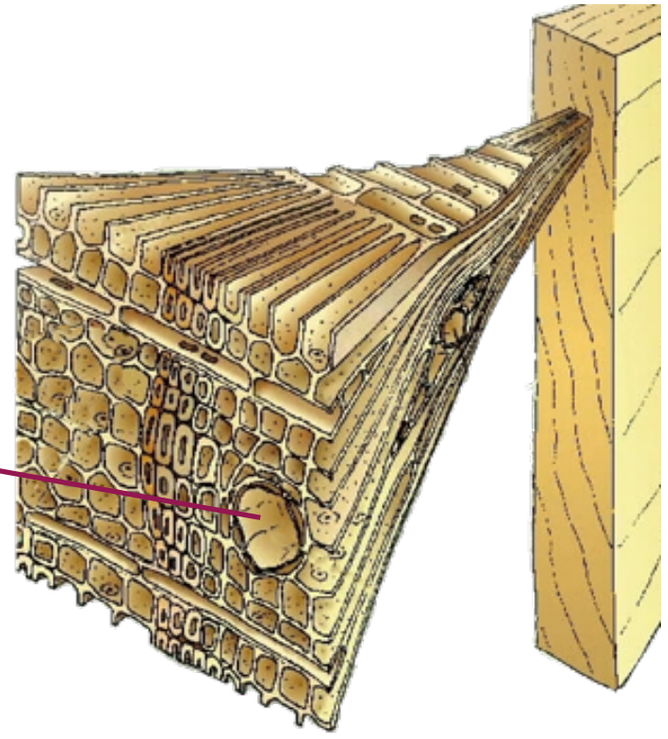
Artwork by Mark Harrington

Wood anatomy



Clair, (2001), PhD



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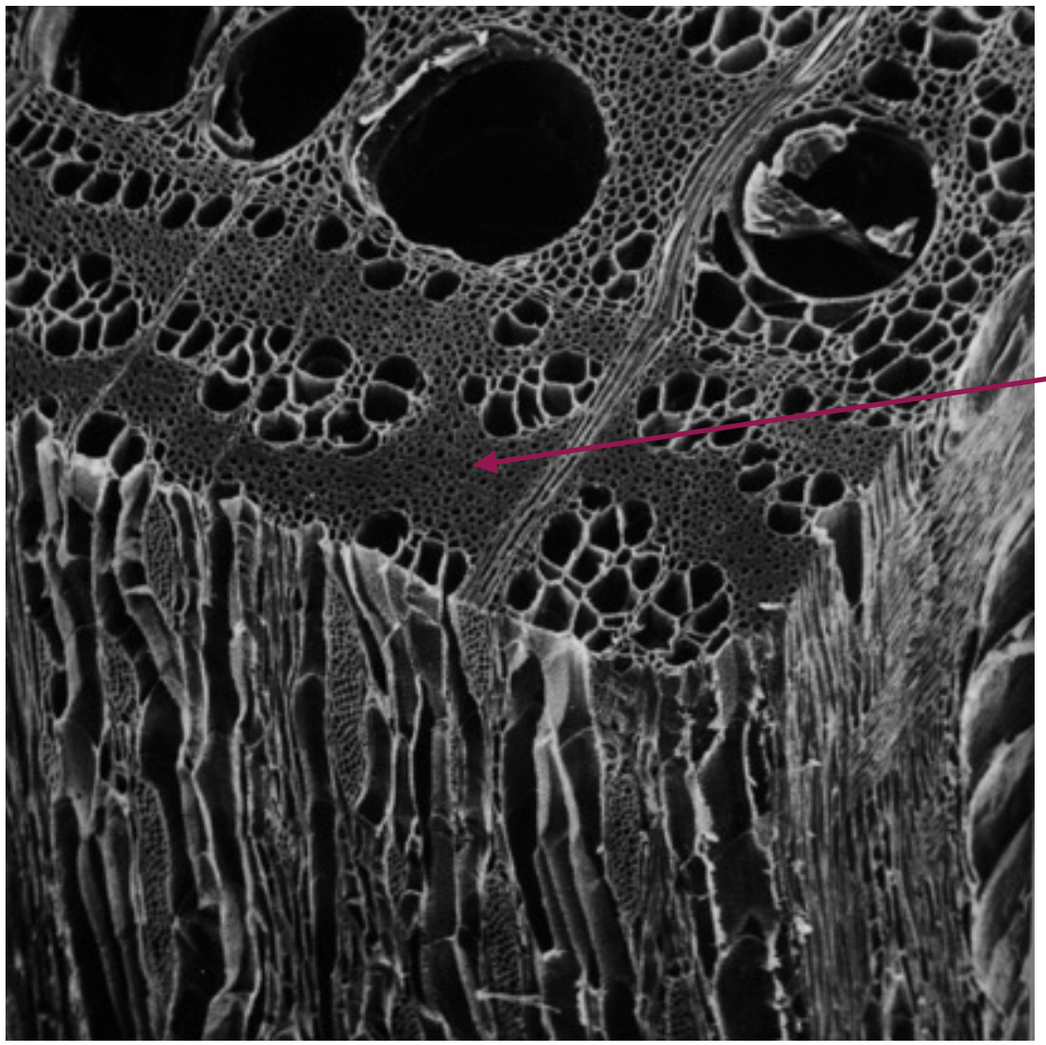
Vessels used for sap flow

Wood anatomy



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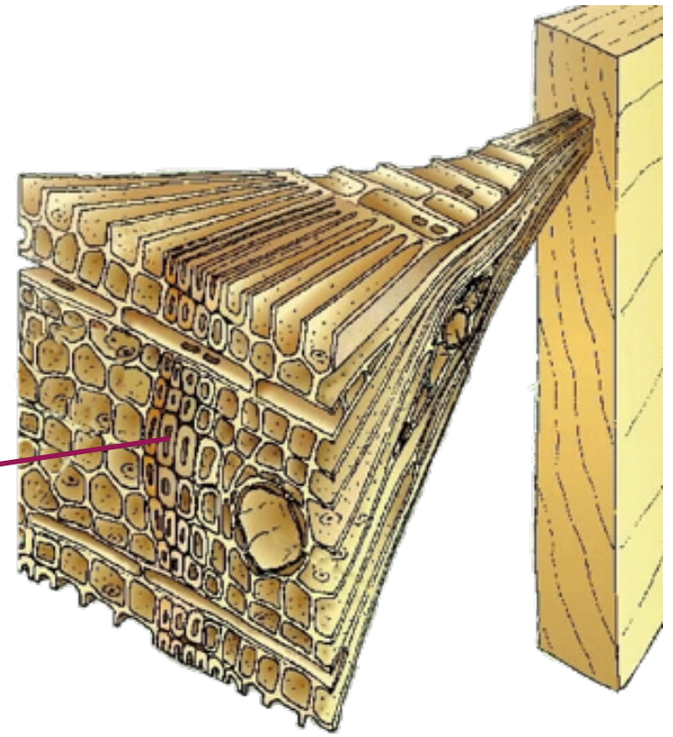

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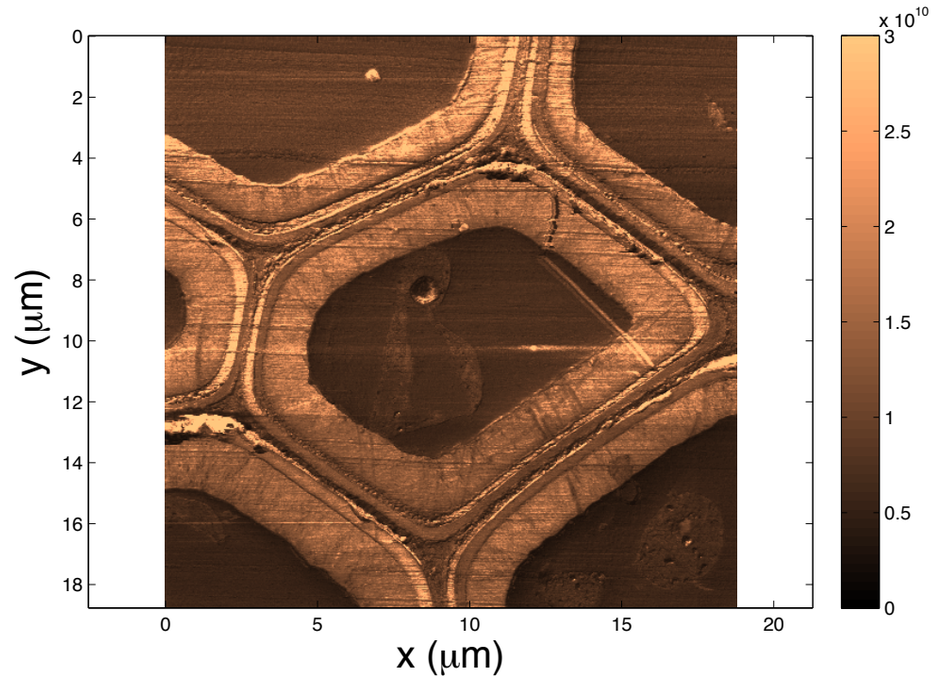
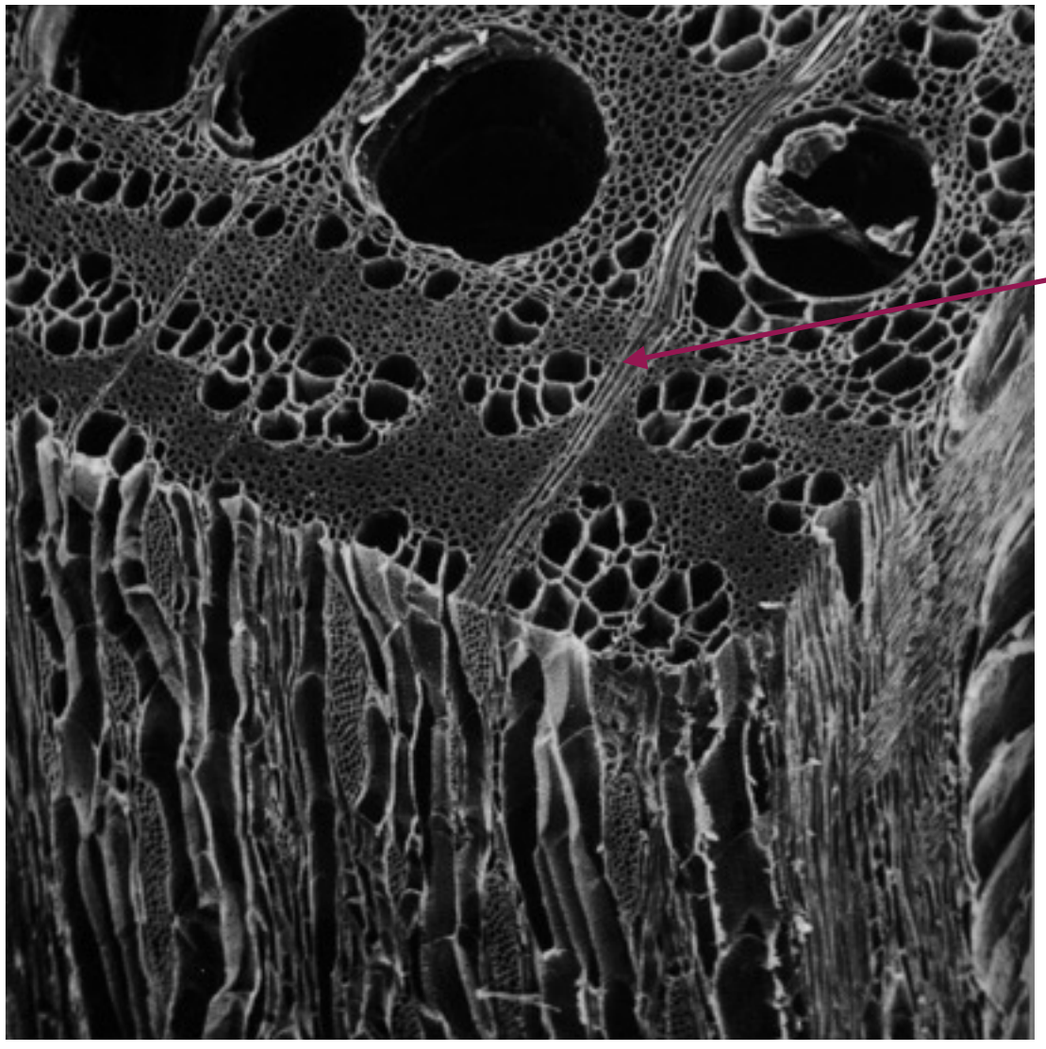


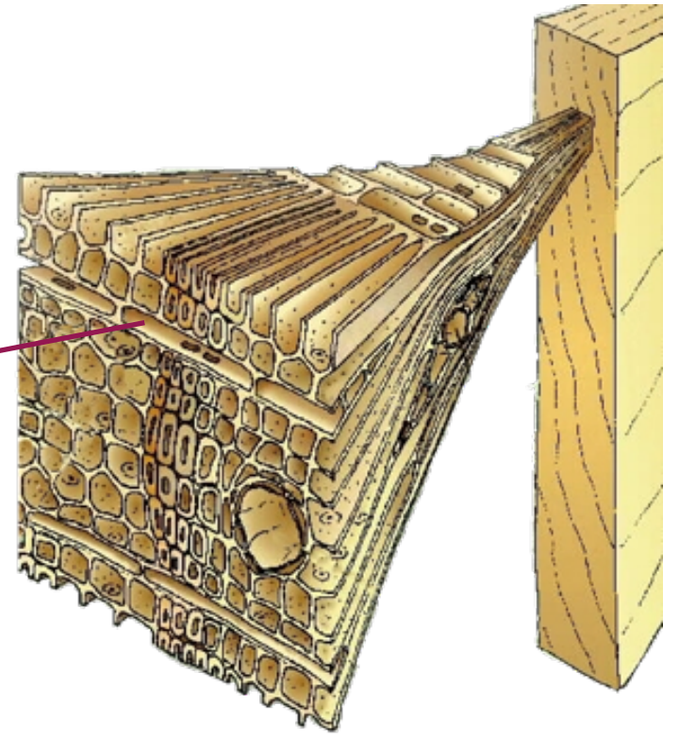
Capron et al., (2015), PBM 8th

Fibers used for supporting stress

Wood anatomy



Clair, (2001), PhD



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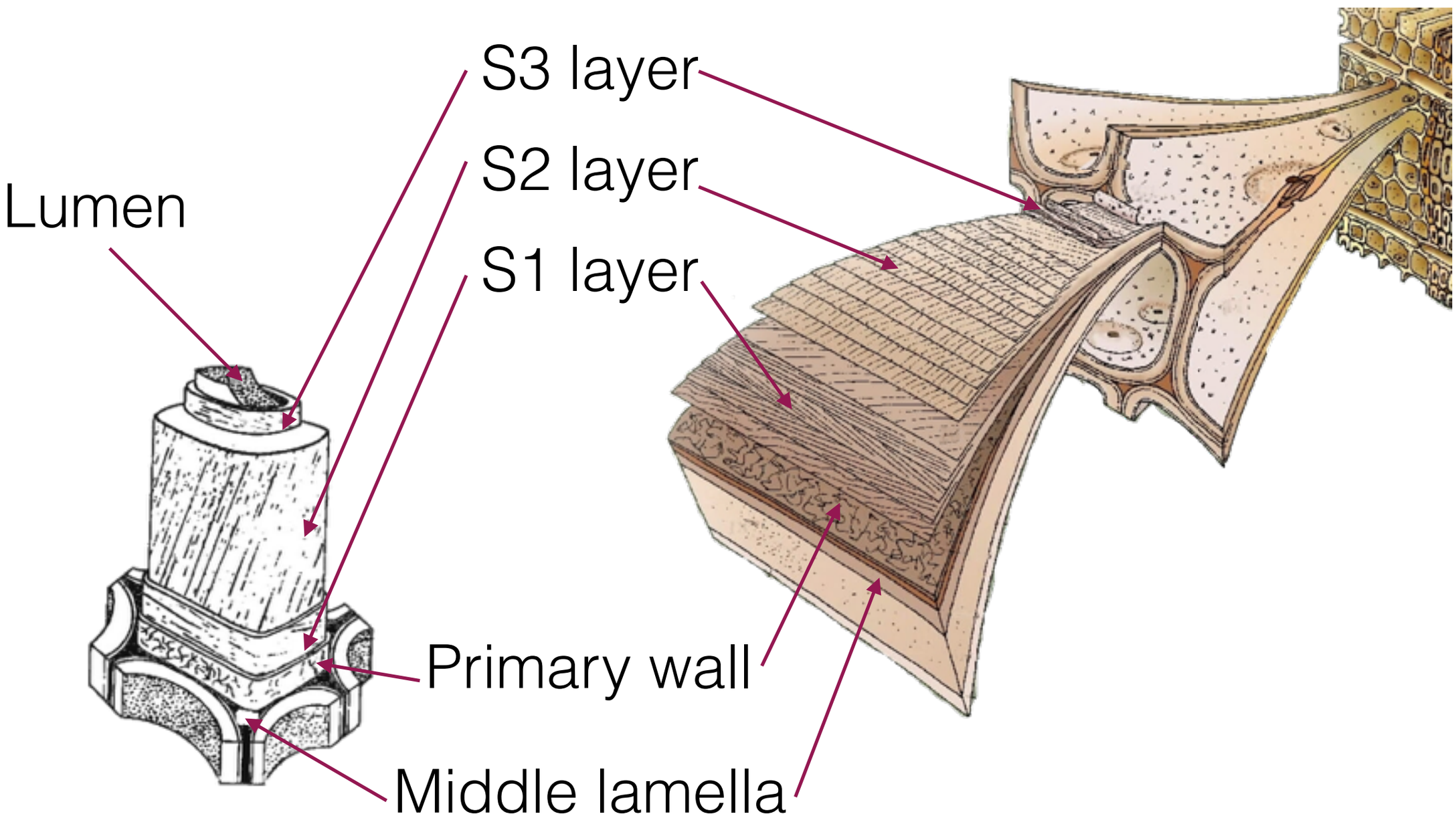
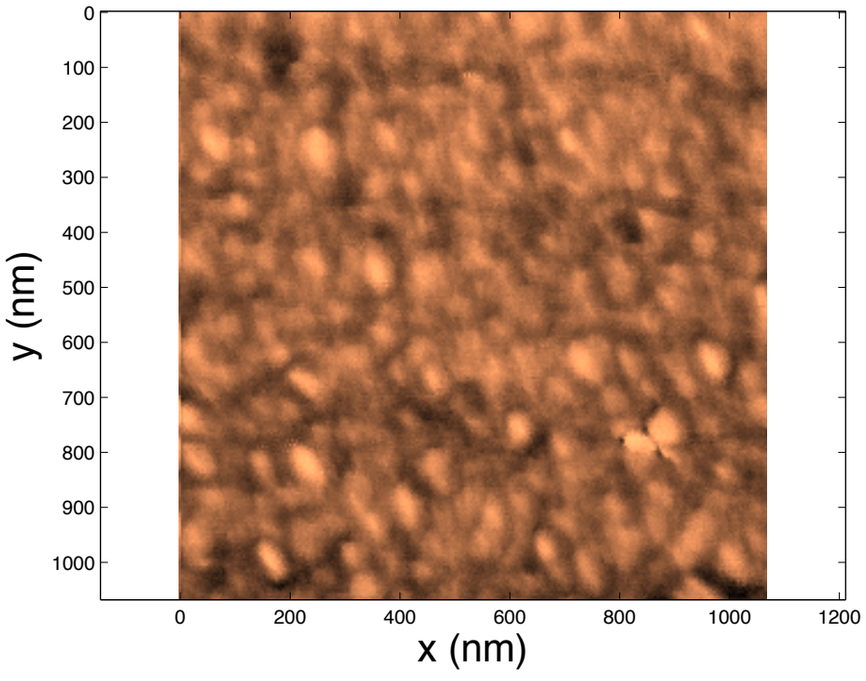
Rays used as a reserve

Cell wall scale

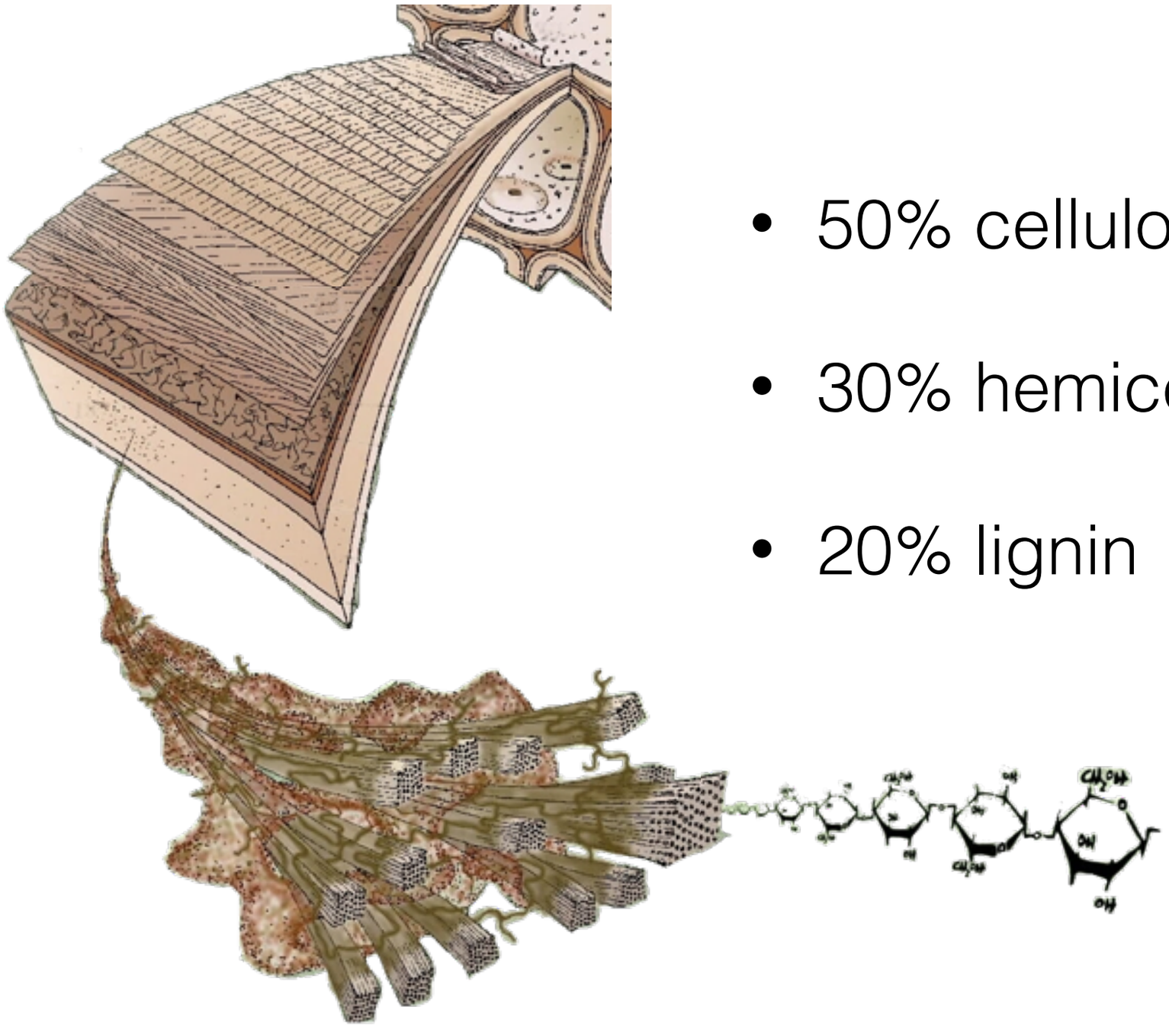


Cell wall scale

- Cell walls = microfibrils + matrix
- Microfibrils = cristallin cellulose
- Matrix = soft mixture of lignin and hemicellulose



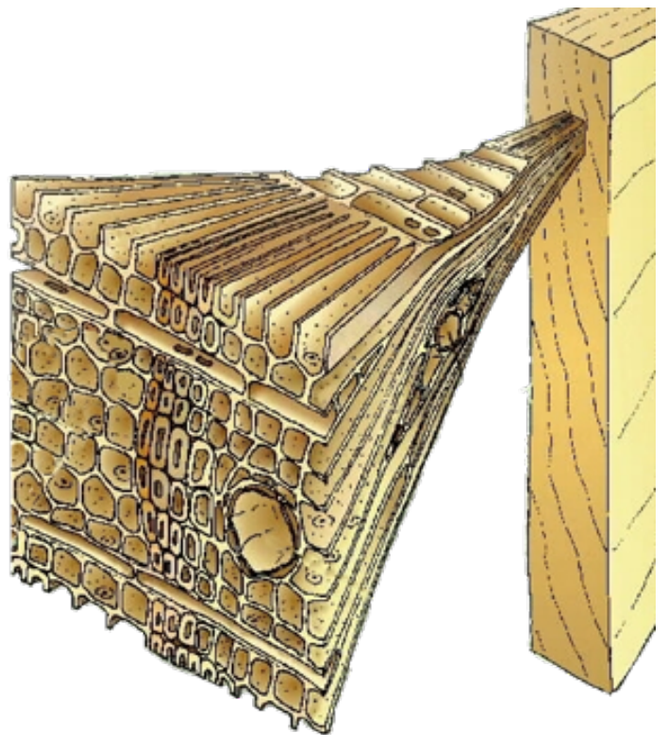
Molecular scale



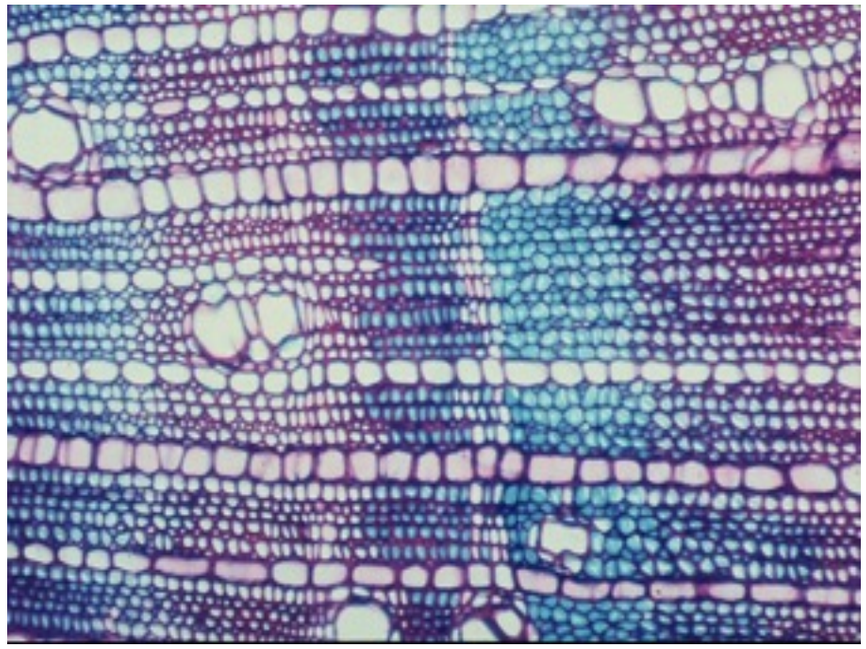
- 50% cellulose
- 30% hemicellulose
- 20% lignin

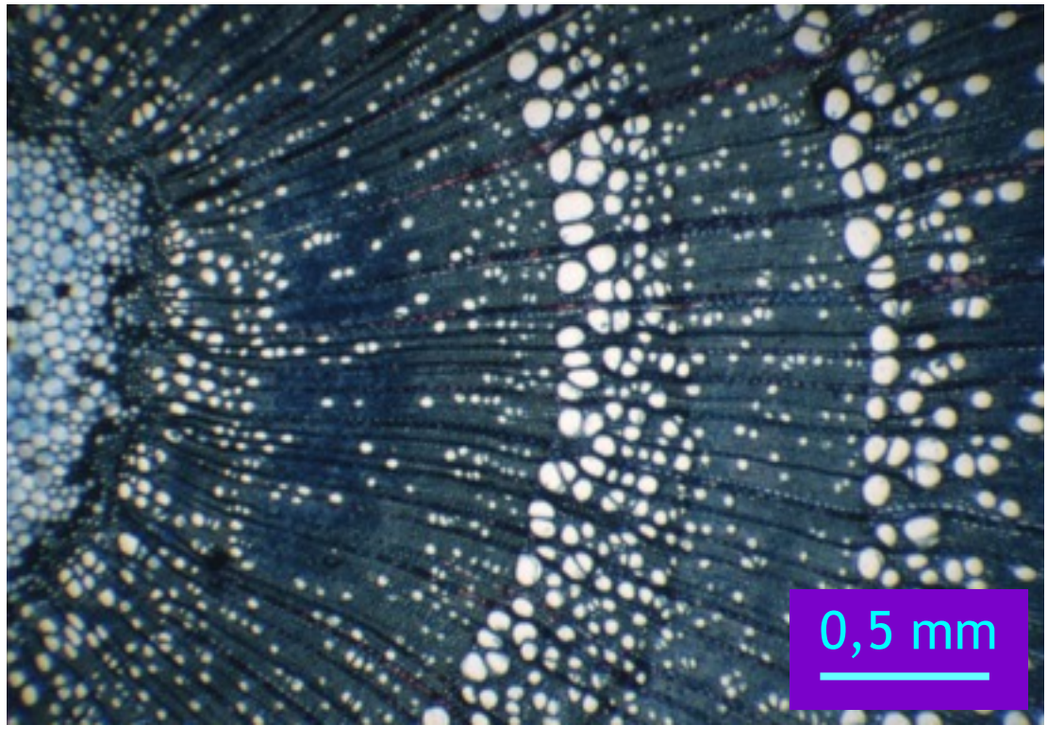
Wood observations

- How to observe wood at the microscopic scale?
- Light microscope
- Scanning Electron Microscope (SEM)
- Atomic Force Microscope (AFM)



Light microscopy

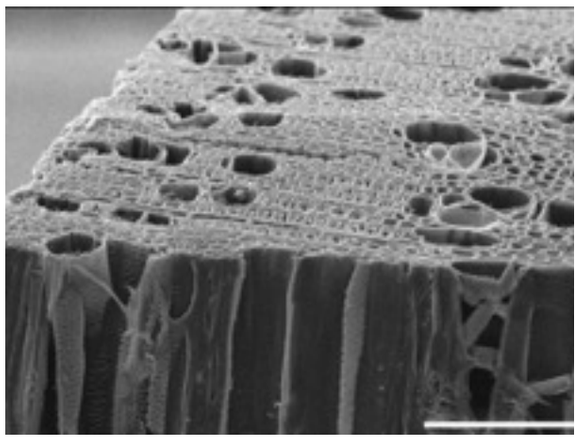


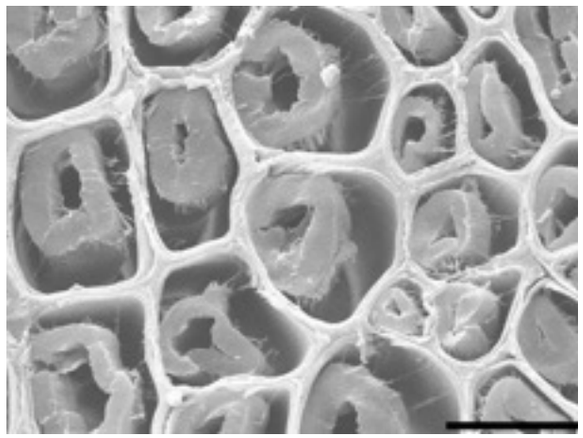


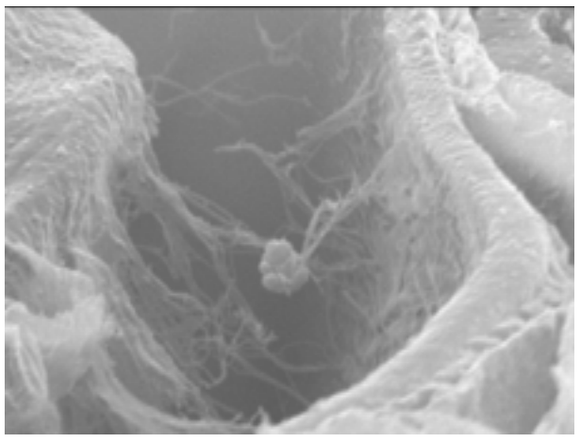
- See the chemical composition between different kind of cells (coloring)

- Observe large areas

Scanning Electron Microscope



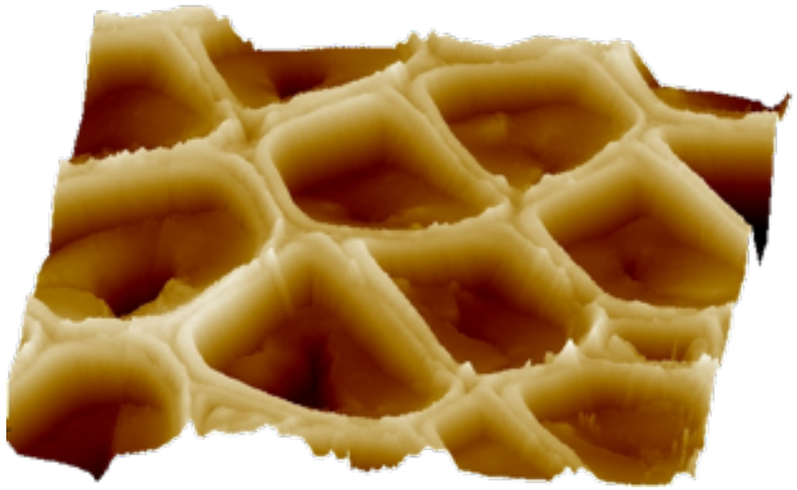




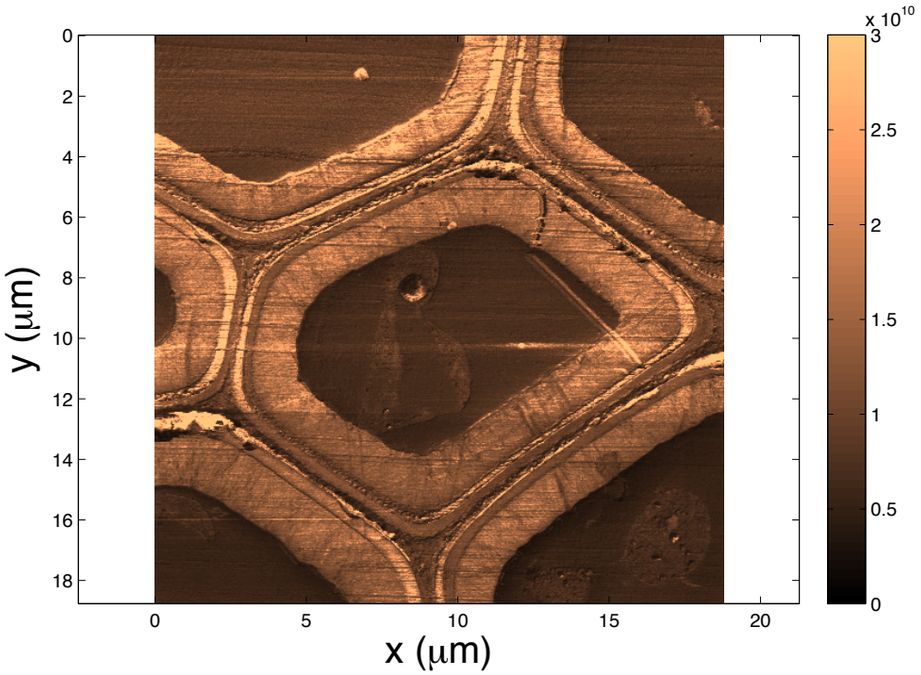
- 3D visualisation
- High magnification

Clair, (2001), PhD

Atomic Force Microscope



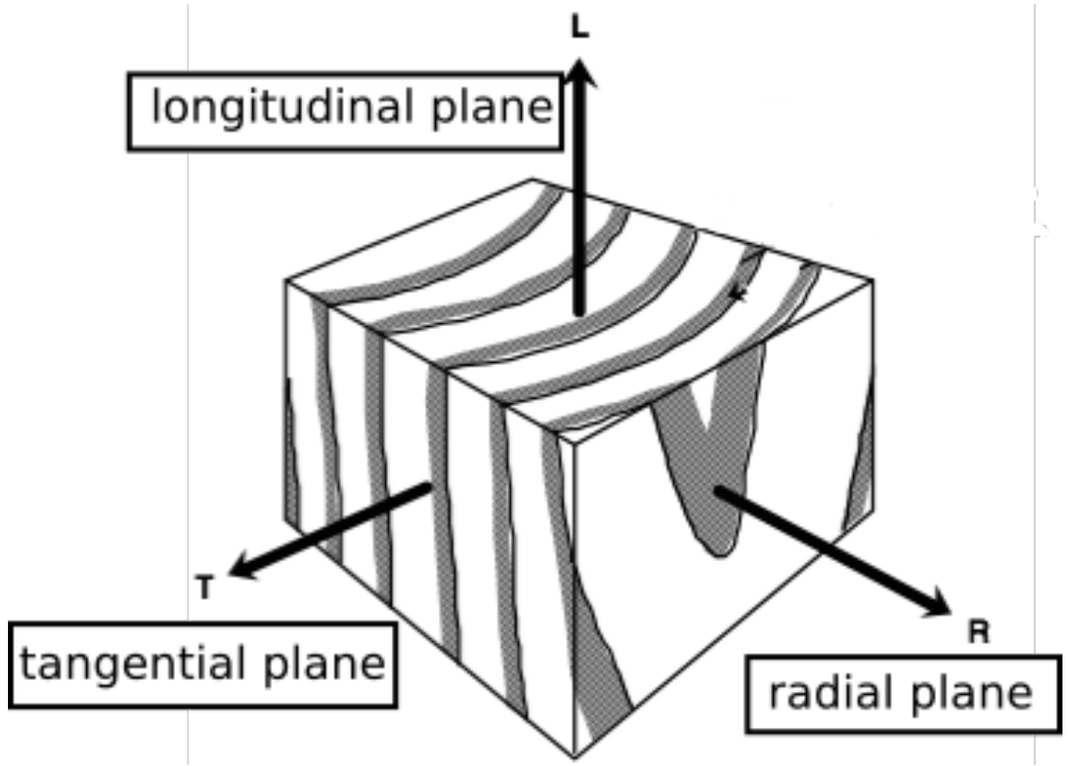
Clair, (2001), PhD



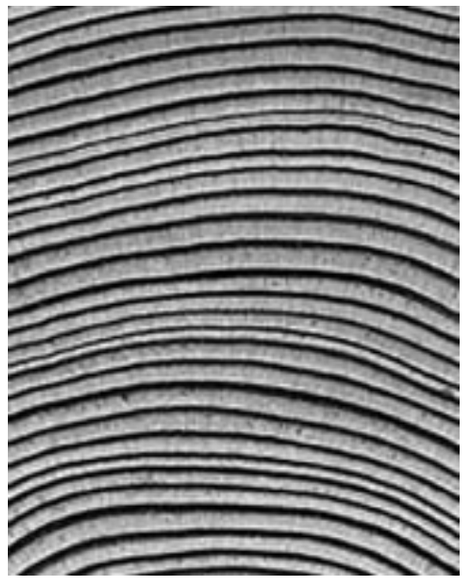
Capron et al., (2015), PBM 8th

- Topography
- High magnification
- Local mechanical properties

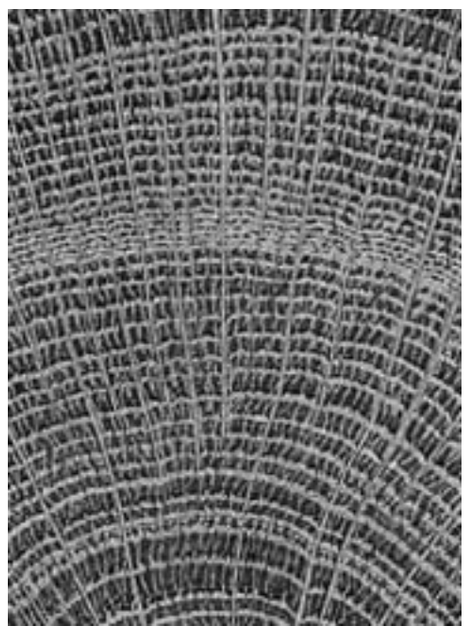
Wood - orthotropic material (異方性材料)



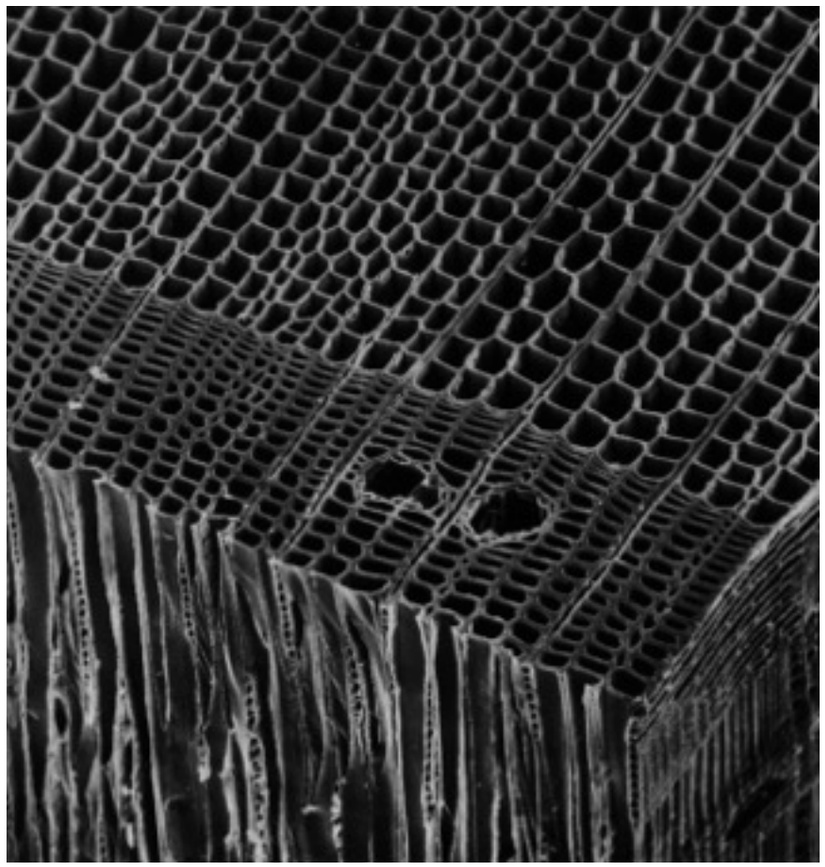
Soft wood



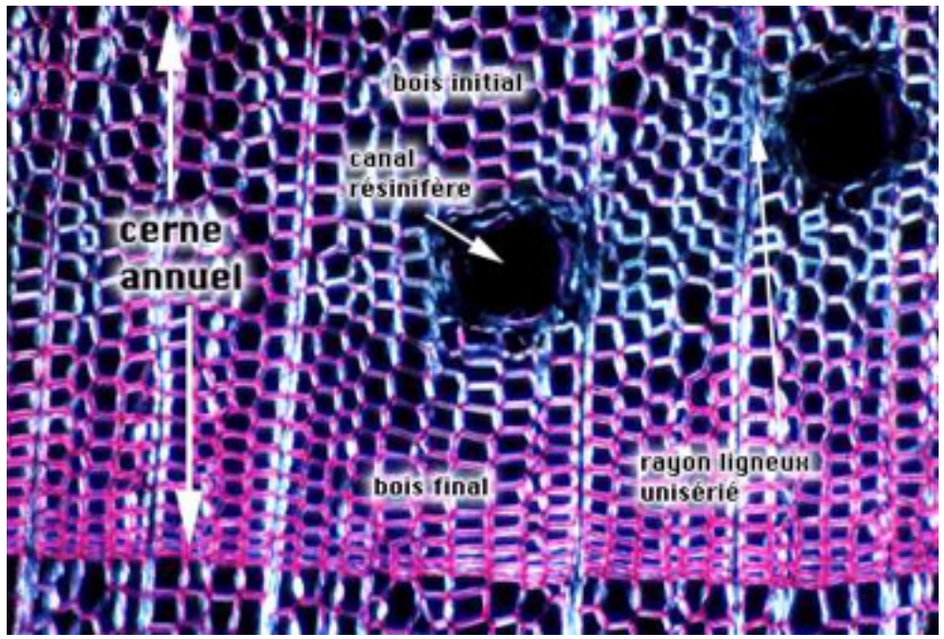
Hard wood



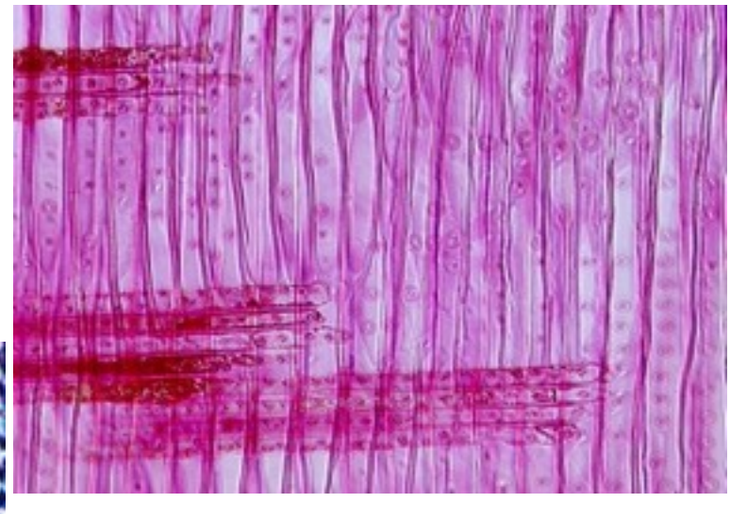
Soft wood　針葉樹

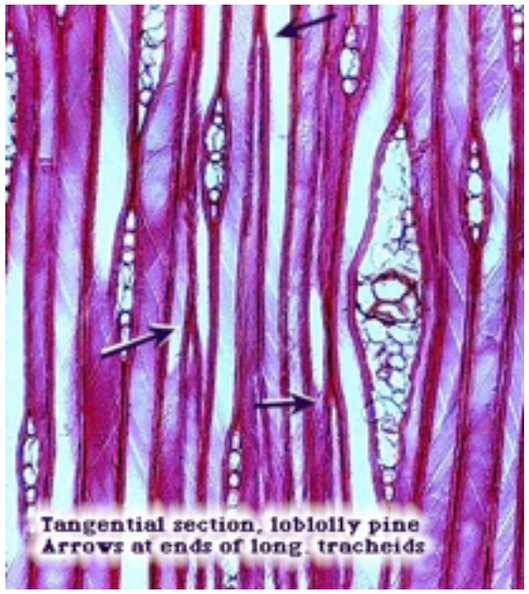


Cross section



Radial section

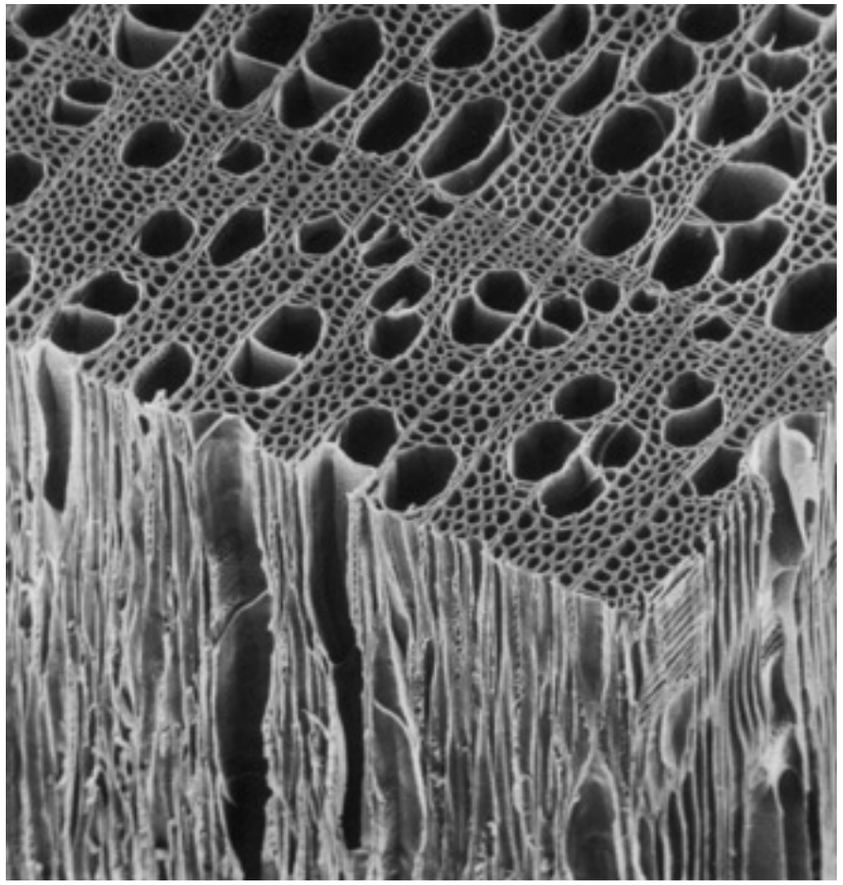




Tangential section

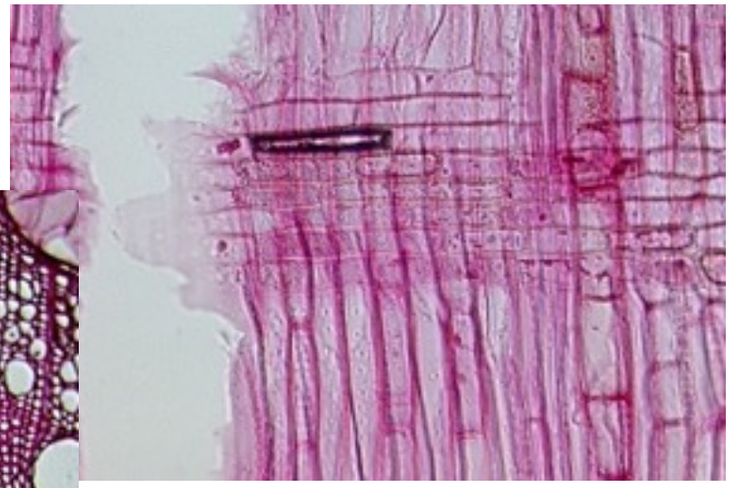
90% of tracheid fiber — support + conduction

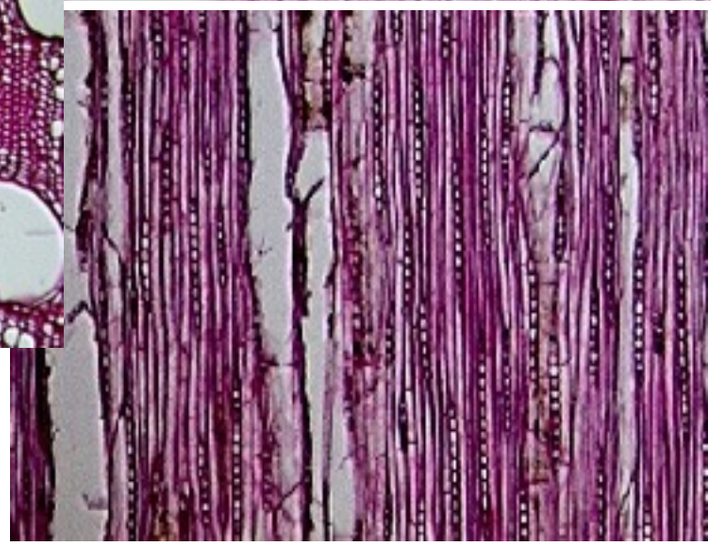
Hard wood　広葉樹



Cross section

Radial section

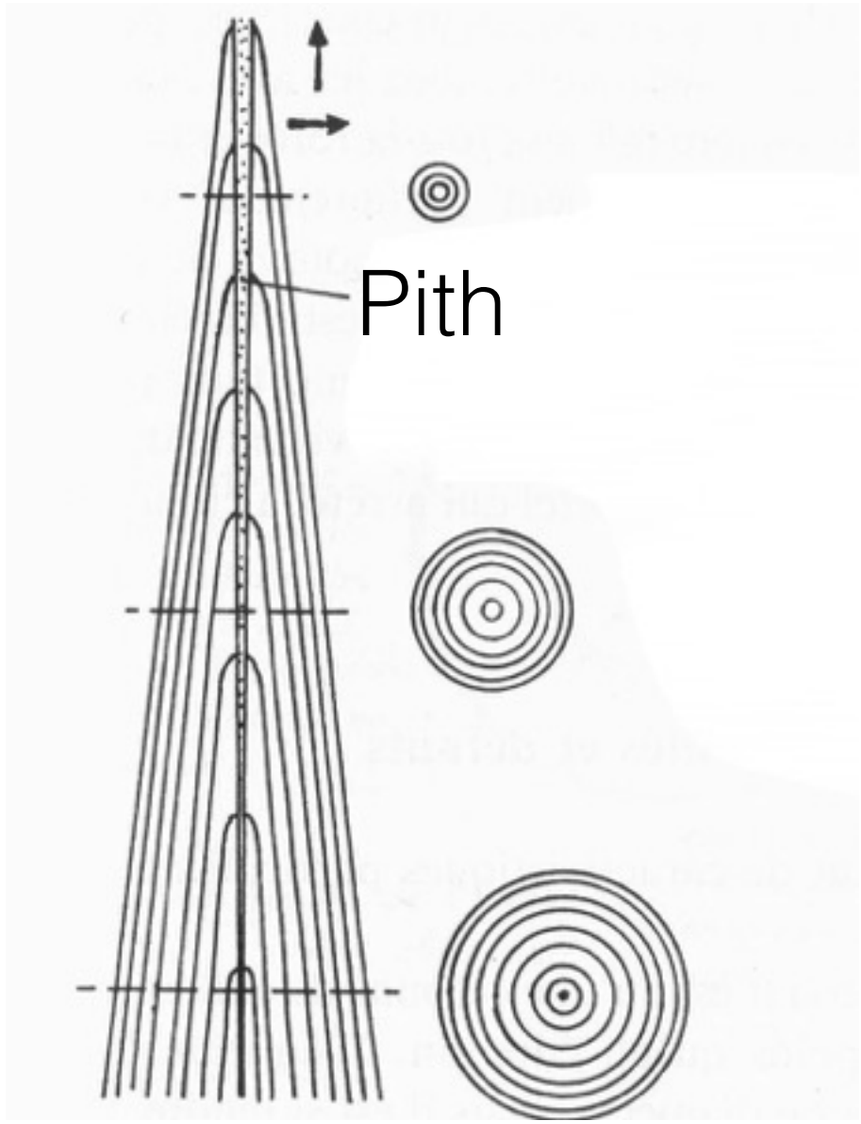


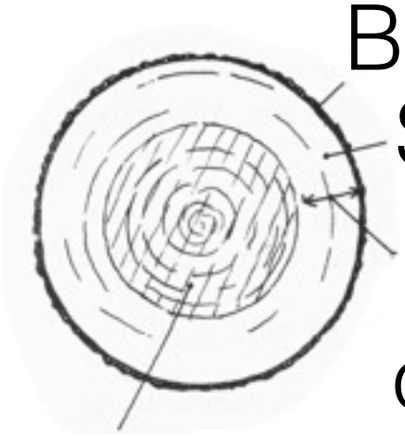


Tangential section

- Fibers — mechanical support
- Vessels — conduction
- Radial parenchyme — reserve storage

Growth of tree　樹木の成長

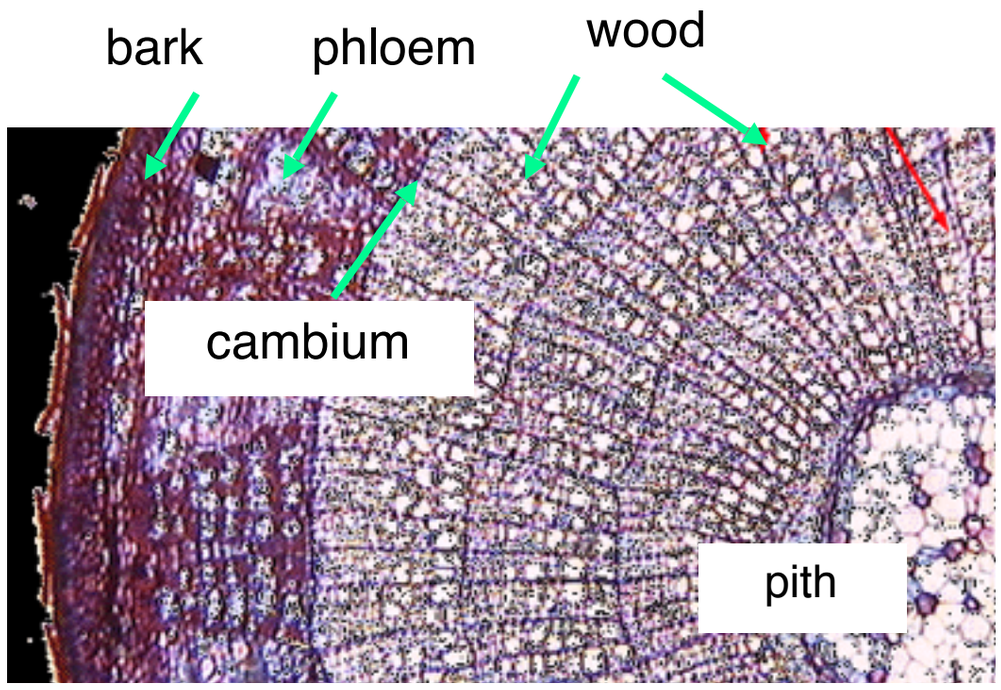


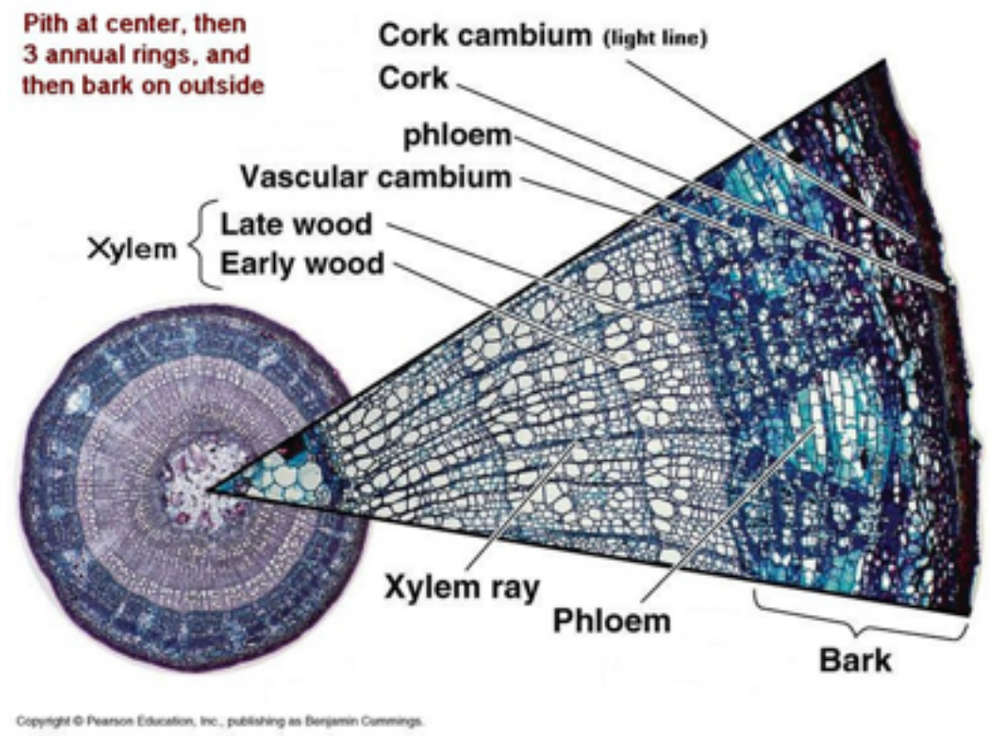


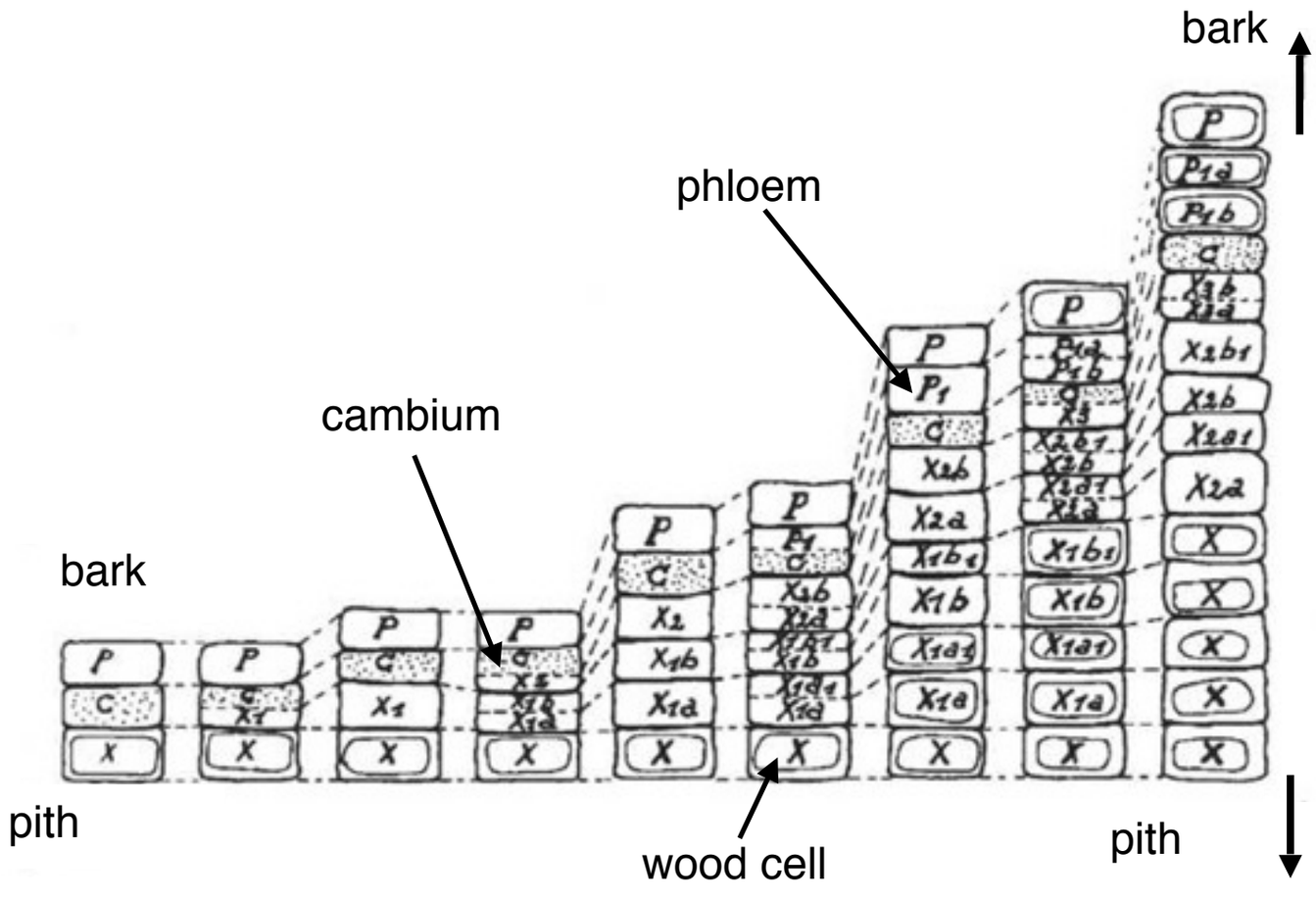
Heartwood =
tree’s skeleton

Hollow tree trunk
with living periphery
parts

Cambium　形成層

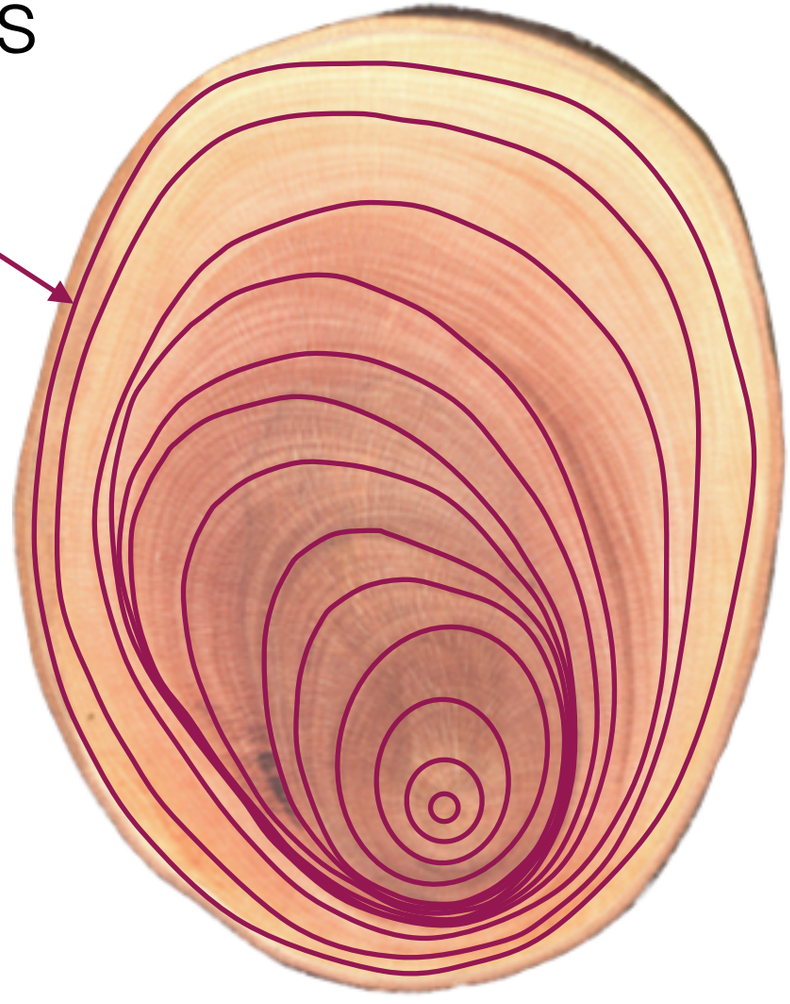






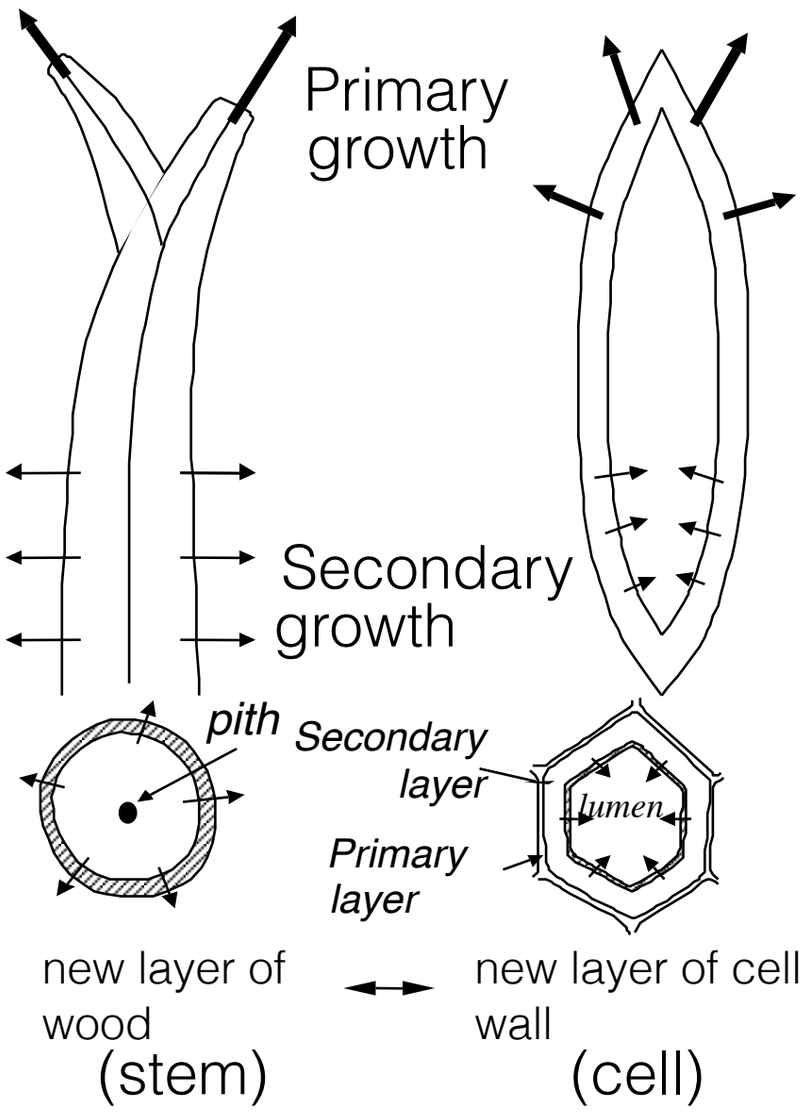
Growth rings 年輪

Growth rings



- Annual rings: Visible rings result from the change in growth speed through the seasons of the year.
- Boundary between « early wood » (rapid growth, less dense) and « late wood » (denser)
- More visible in temperate zones
- Dendrochronology: study of end grain patterns of growth rings, with a view to dating timber

Primary and secondary growth
一次成長と二次成長



- Plants growth — division of meristematic tissue

- Primary growth — cell division at the apical meristem at the tip of the plant (making the shoot longer)

- Secondary growth — cell division at the lateral meristem in a cylinder encasing the shoot (increases the shoot's girth)

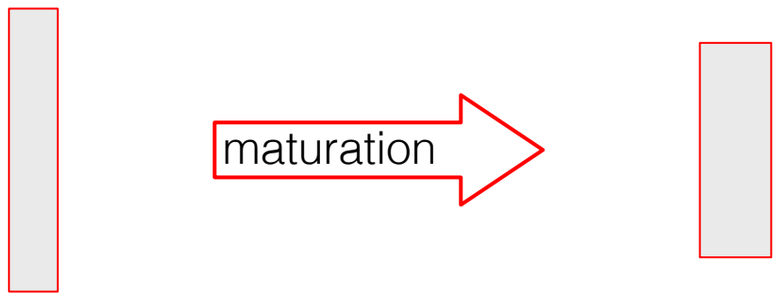
Maturation

- Setting up of secondary growth ended by ligninification (chemical reaction to stiffen cell wall)
- Lignin penetrates between polysaccharides (chemical components of the cell wall) and polymerize

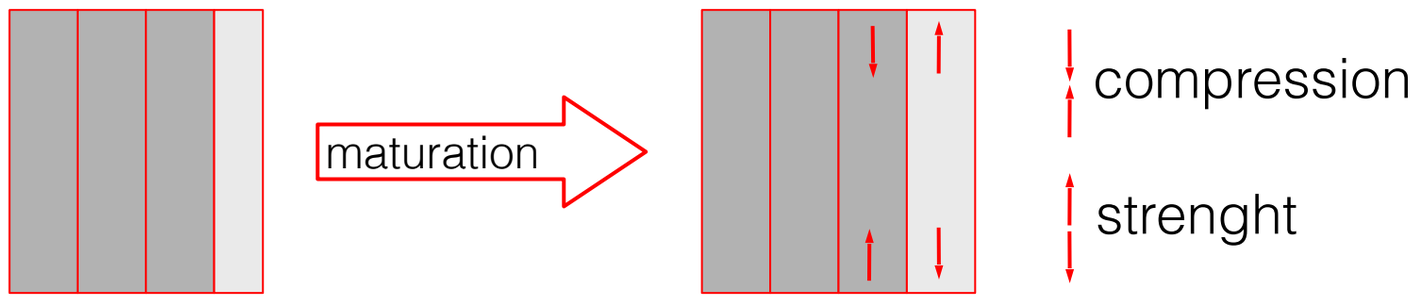
- Mechanical consequences on the cells due to maturation?

Secondary growth

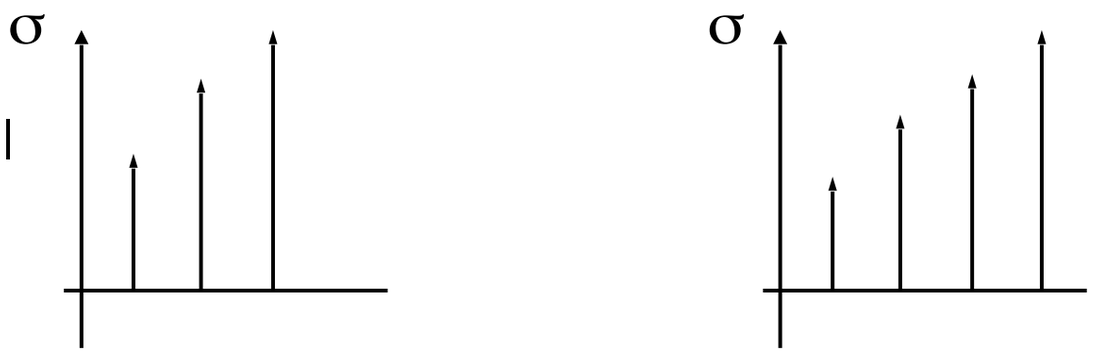
Isolated cell



The same cells attached to older cells



Stress profil



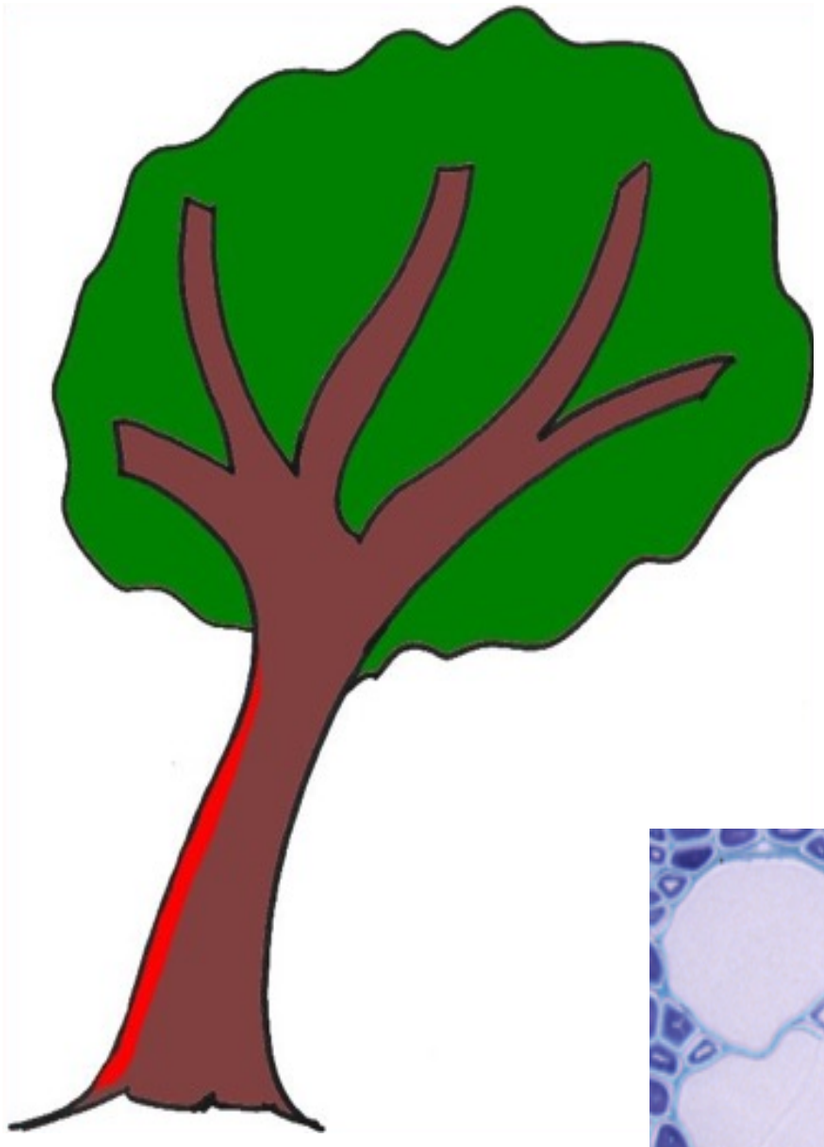
Clair, (2001), PhD

Consequence: Growth stress

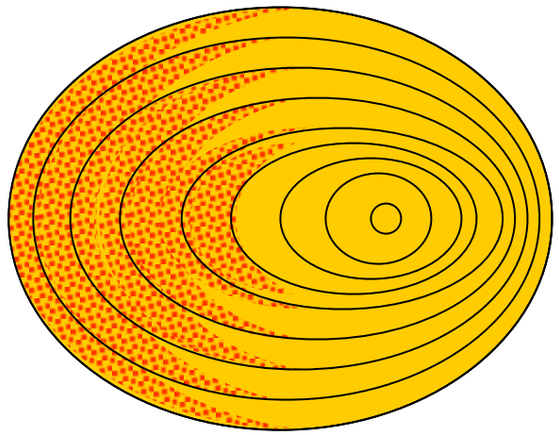
Reaction wood　あて材

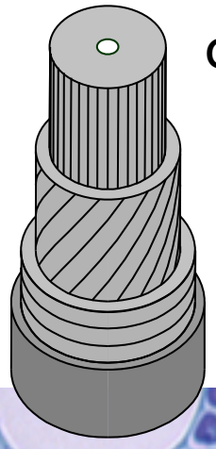
- Trees are able to react to important stresses:
  - fierce unidirectional wind
  - tree-top loss of balance
  - partial lay baring
- Generation of stress strains on the top of the stem or compression strains on the bottom of the stem
- Important changements in the wood cell structure
- Called reaction wood in opposite to normal wood

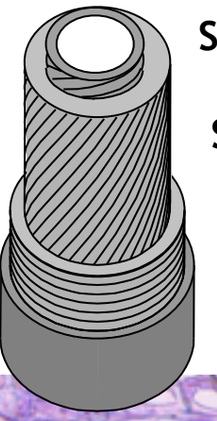
Tension wood

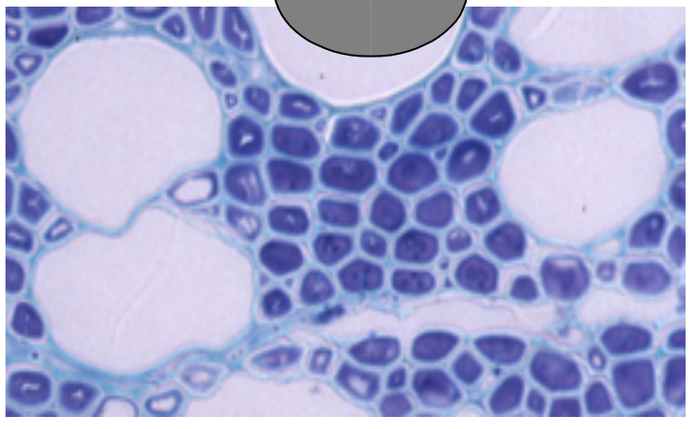


Clair, (2001), PhD

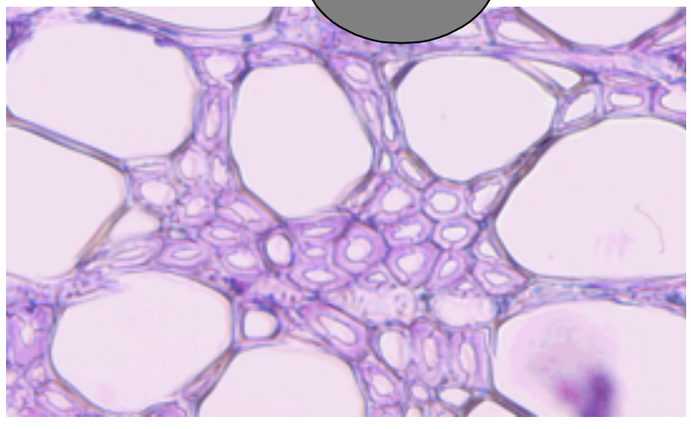






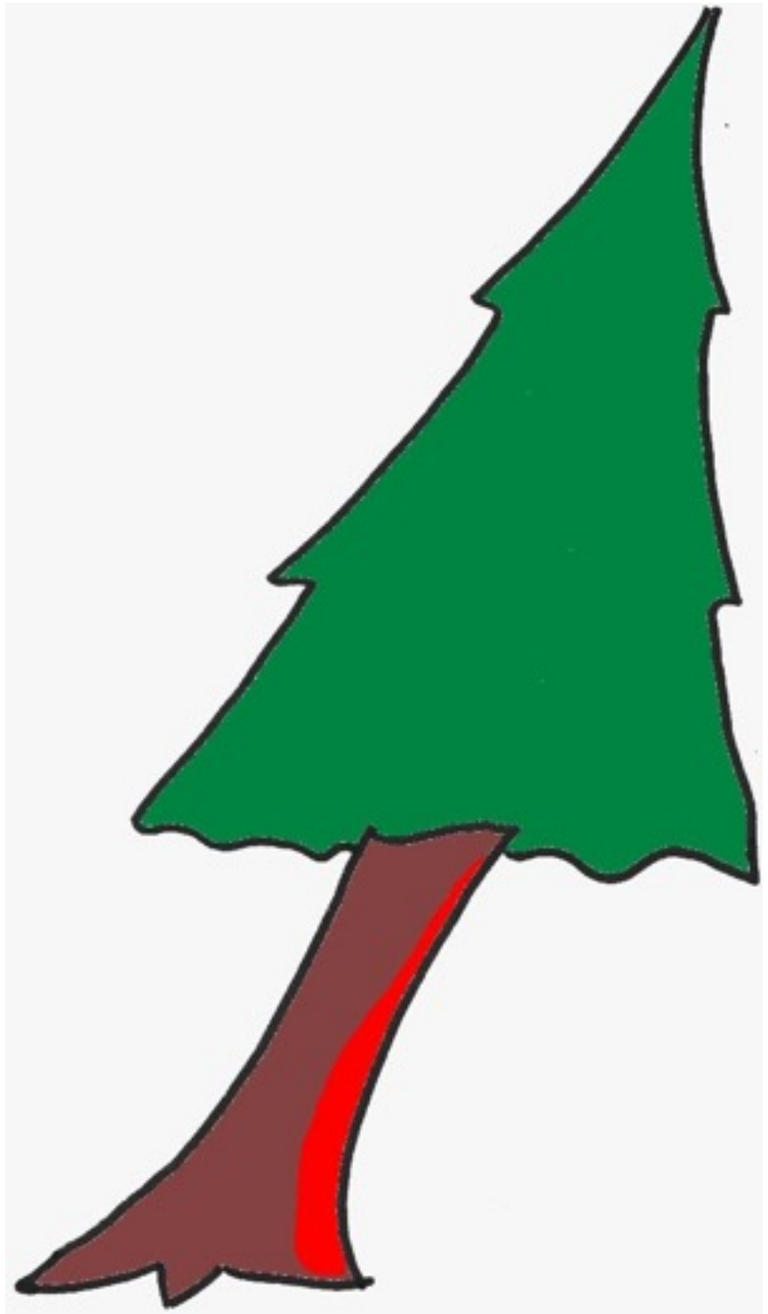


Tension wood

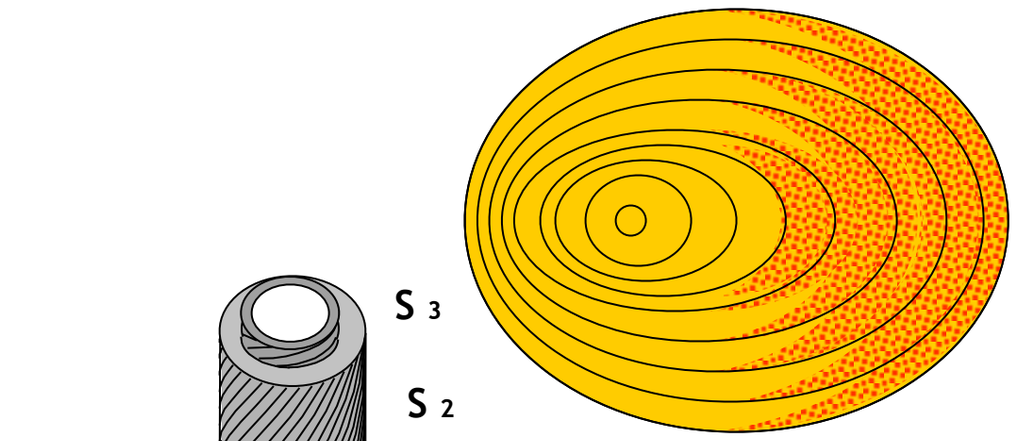


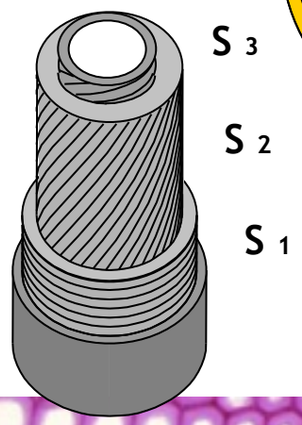
Normal wood

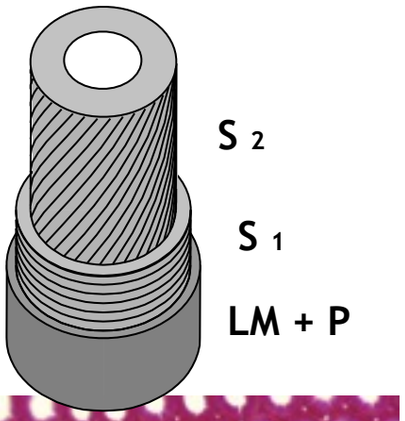
Compression wood

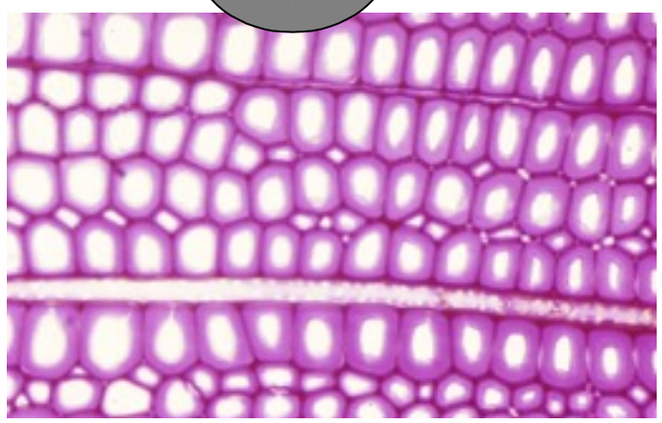


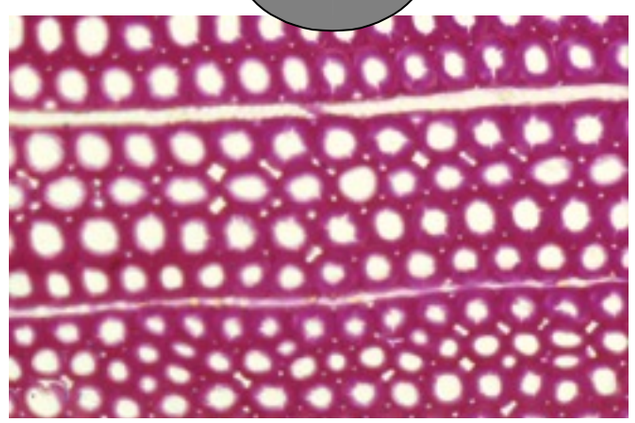
Clair, (2001), PhD











Normal wood

Compression wood

Hydrothermal recovery (HTR)

- HTR is triggered by immersion in hot water at macroscopic and microscopic scales.

- Heating of wood used for rotary cutting or slicing

- Heating of wood induces a complex set of deformation processes at the macroscopic, cellular and microscopic scale

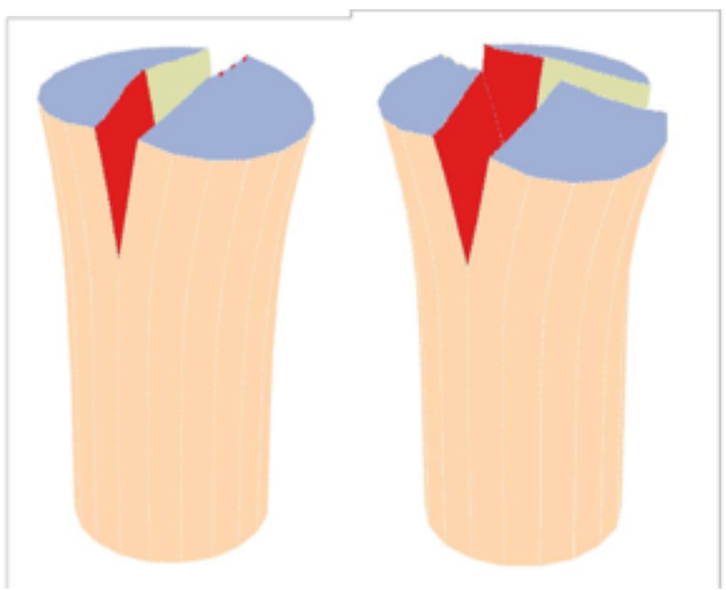
- HTR induced a high tangential expansion, a little radial contraction, a longitudinal contraction in normal and tension wood and a longitudinal expansion in compression wood

Effects of growth stress

Eucalyptus South Africa

Cracks - European Beech

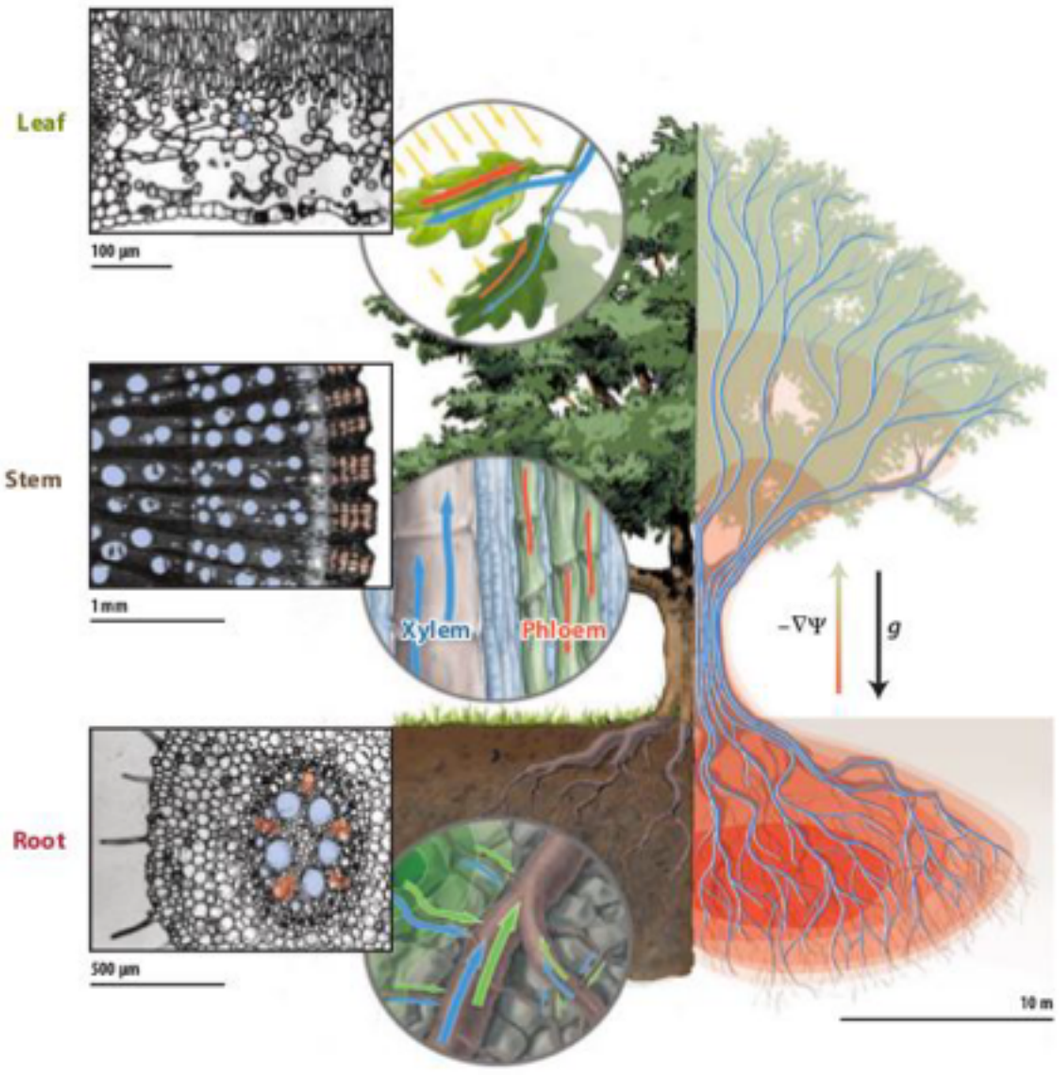
- Cracks appears after the cutting
- Log destruction



Scientific issues

- **Reaction wood**
  - Understanding the mechanism of maturation stress generation in trees used to control the orientation of its axes, to grow in height, maintain its branches at an optimal angle or achieve adaptive reorientations
  - Question of paramount importance in tree physiology
  - Important technological outcomes regarding wood processing and biomimetic inspiration in material design
- **HTR**
  - Understanding the variation of local cell wall properties resulting at different scales
  - Contributing to the basic knowledge required for designing novel preconditioning procedures aiming at increasing both processing yield and quality of wood products

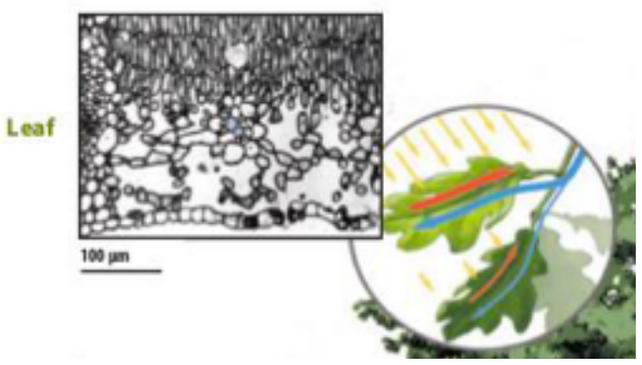
How do you think tree feeds?



Stroock et al (2014), Ann. Rev. Fluid Mech.

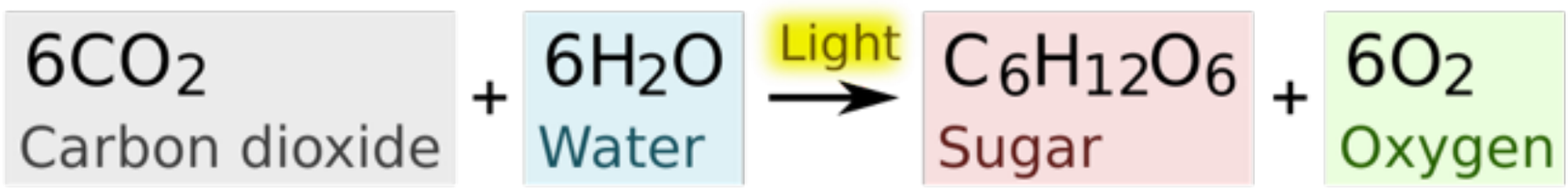
- Global view of transport processes in a vascular plant.
- **Photosynthetic reaction** in the leaves
- Sap transport in **xylem** and **phloem**
- Water exchanges in **roots**

Photosynthesis — 光合成



- Green plants are machines that run on sunlight, carbon dioxide, and water

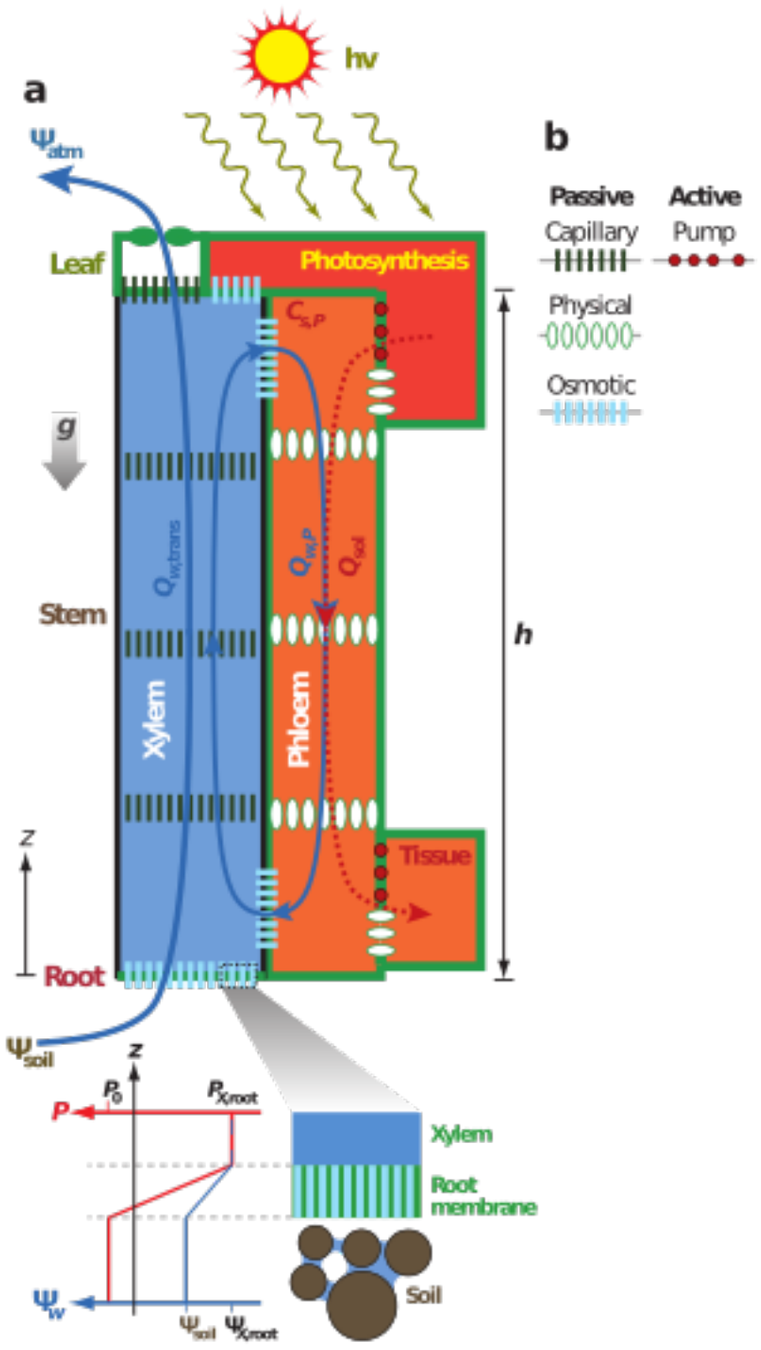
- Photosynthetic reaction:



- Plants generate all of the photosynthetic products in their leaves

- Photosynthetic products are exported to the rest of their tissues for growth and storage

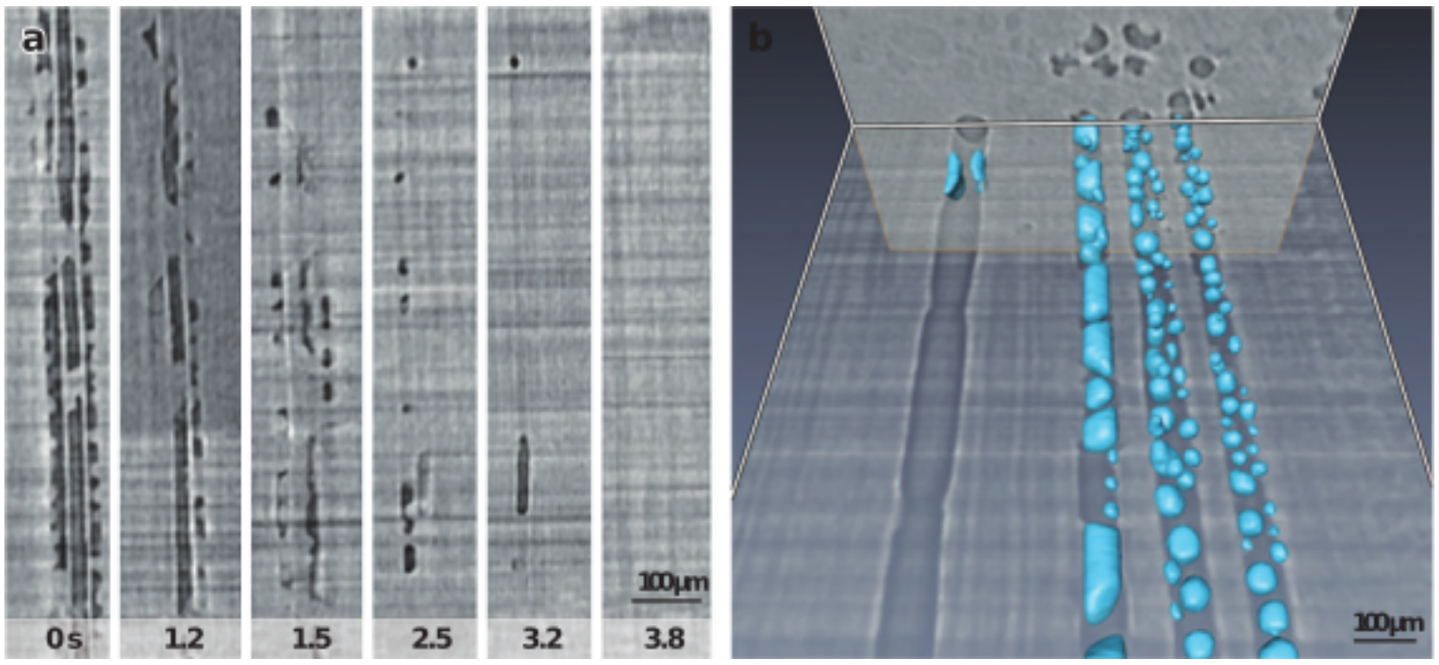
Sap flow



Stroock et al (2014), Ann. Rev. Fluid Mech.

- Efficient convective transport over long distances
- Leaves behave like a pump (capillary pressure)
- **Phloem** : movement from the leaves to the roots — composed of sugars in water
- **Xylem** : movement from the roots to the leaves — mostly composed of water
- Water enters in the roots due to osmotic pressure

Cavitation (キャビテーション)

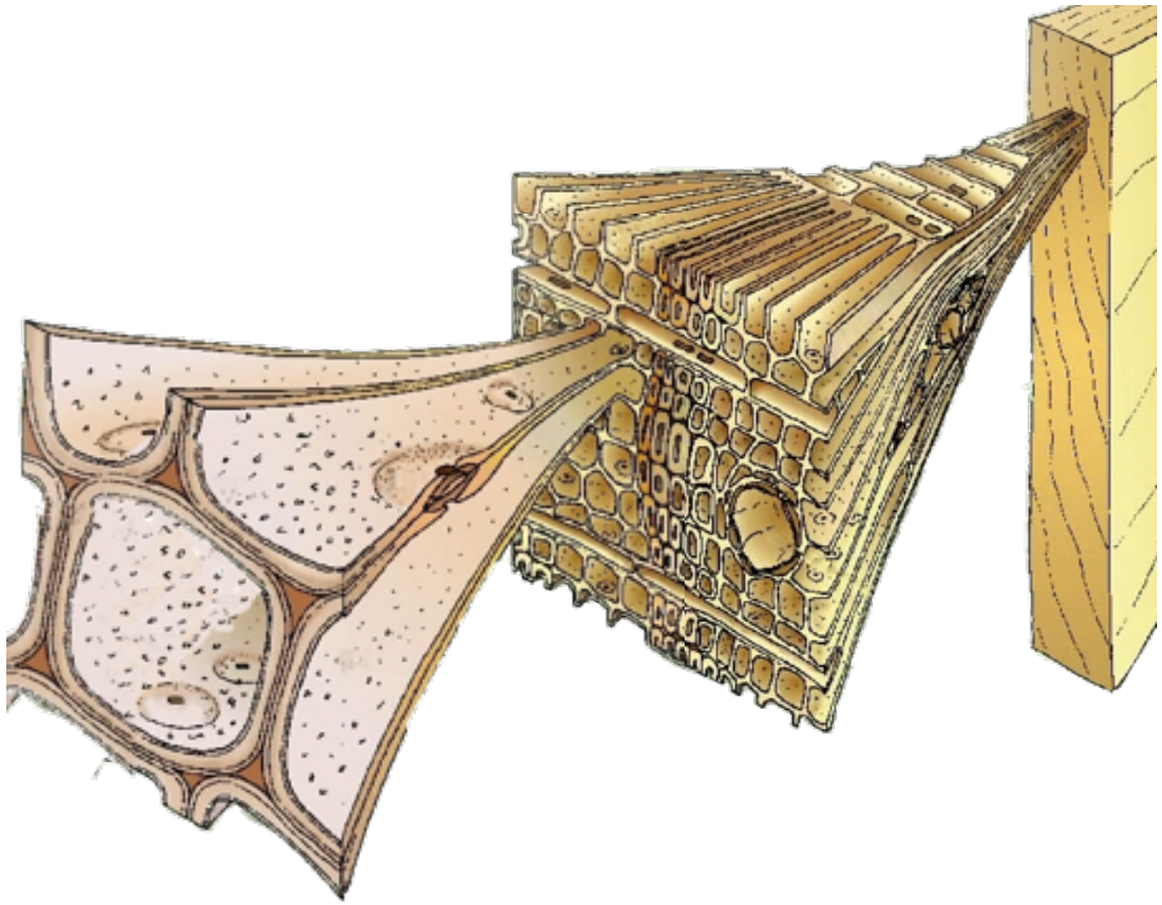


Stroock et al (2014), Ann. Rev. Fluid Mech.

- Liquid are at negative pressures in the xylem during transpiration
- The breakage of the liquid (cavitation columns in the xylem does occur
- Important consequences for plant function and viability —> death of tree

How to prevent cavitation?

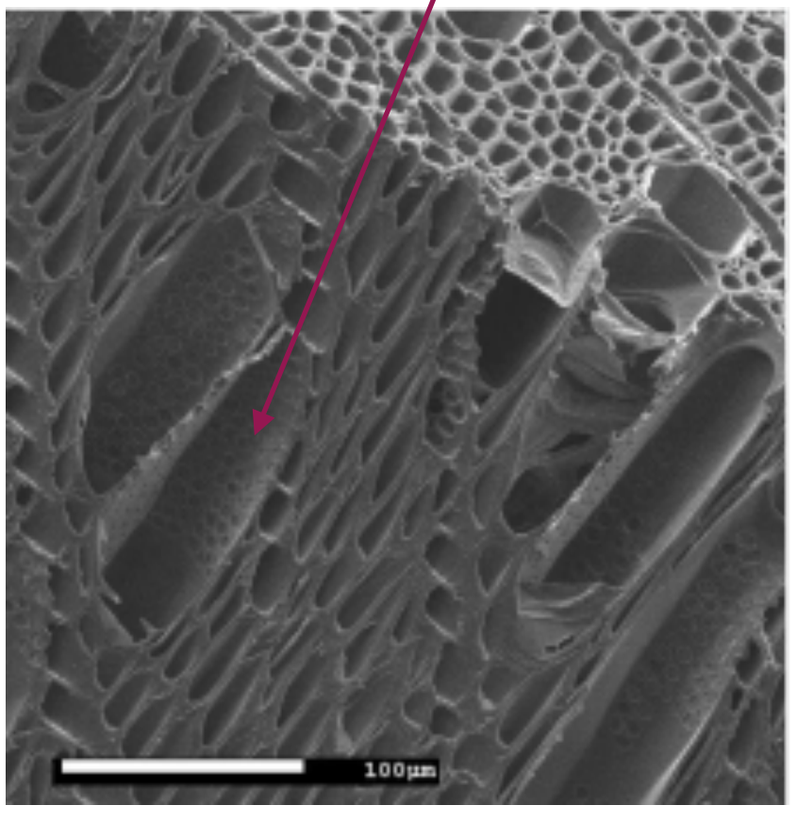
- Xylem fibers composed of death cells connected by pits

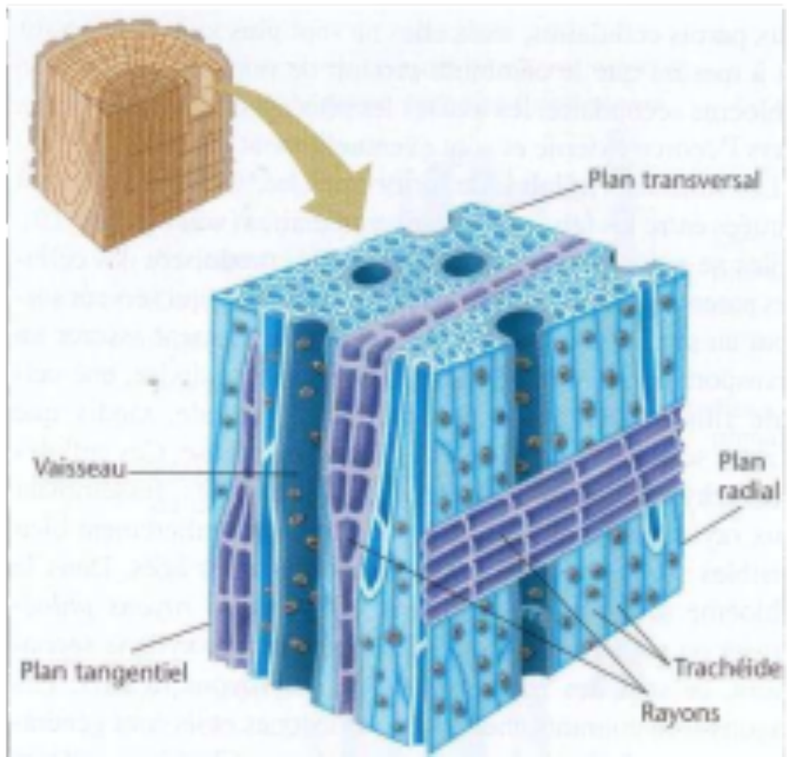


- **Pits** = parts of the cell walls composed of a membrane able to stop gaz spreading and to allow the exchange of liquid

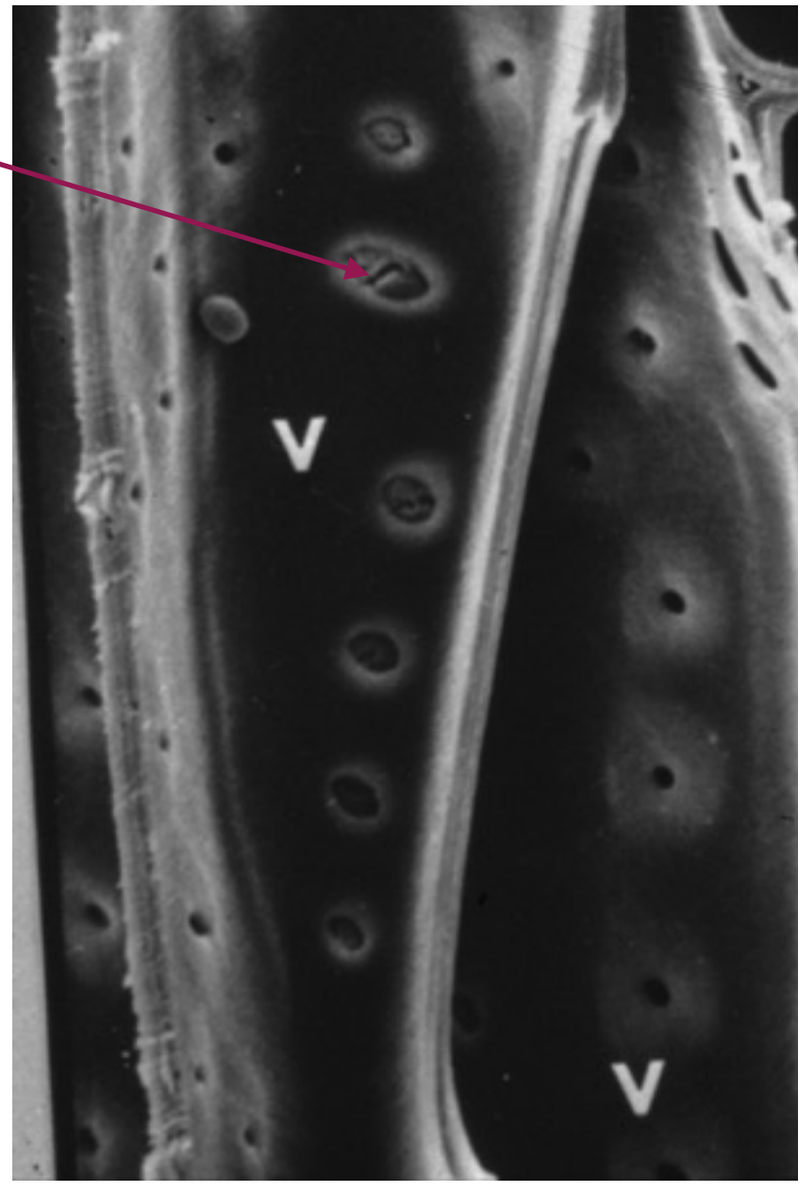
Pit localisation

Vessel



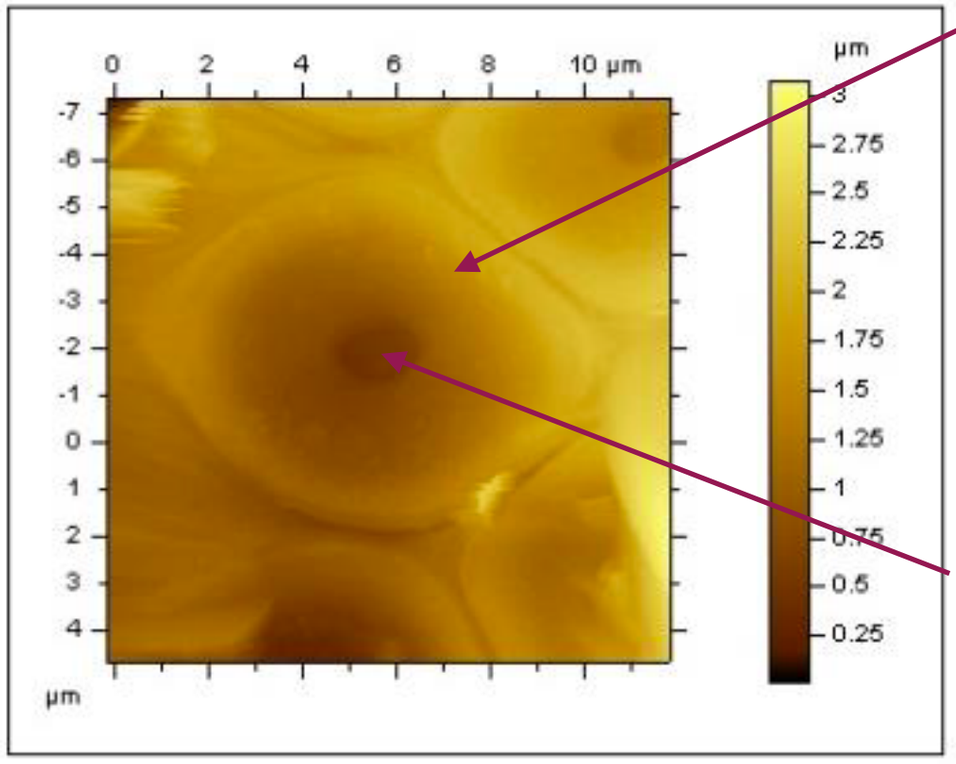


Pit (壁孔)



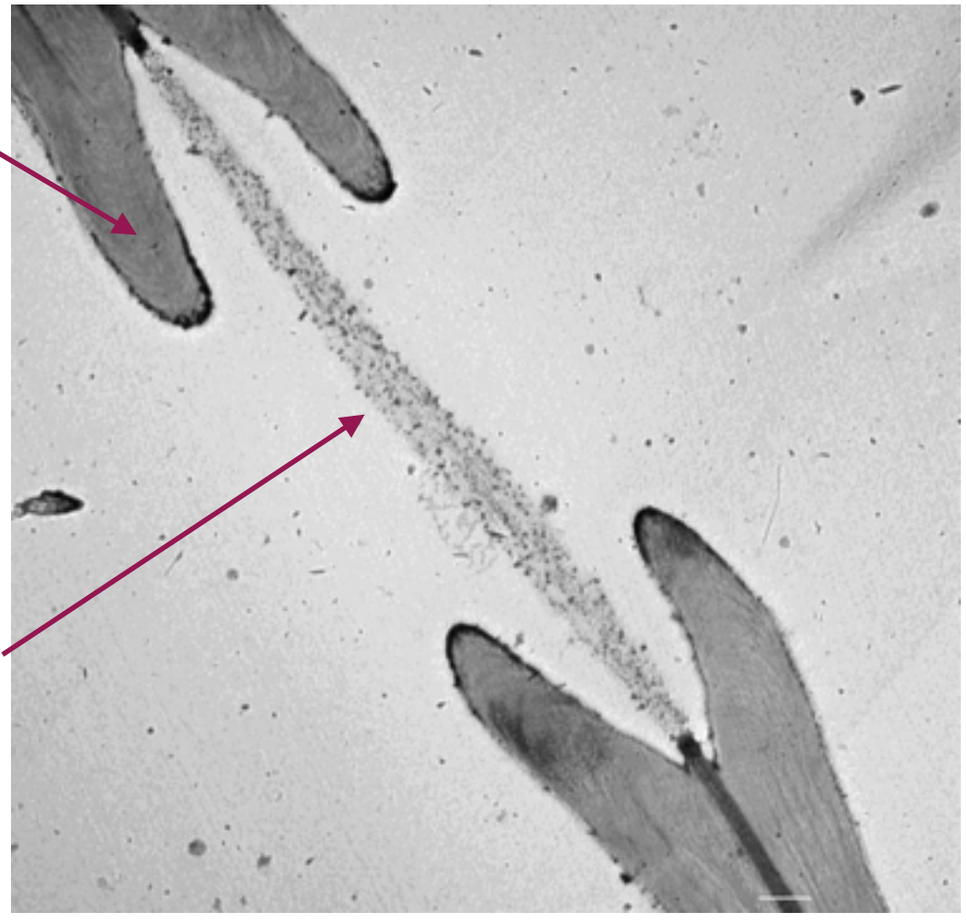
Bouchet et al. (2012)

Pit architecture



Pit border

Pit membrane



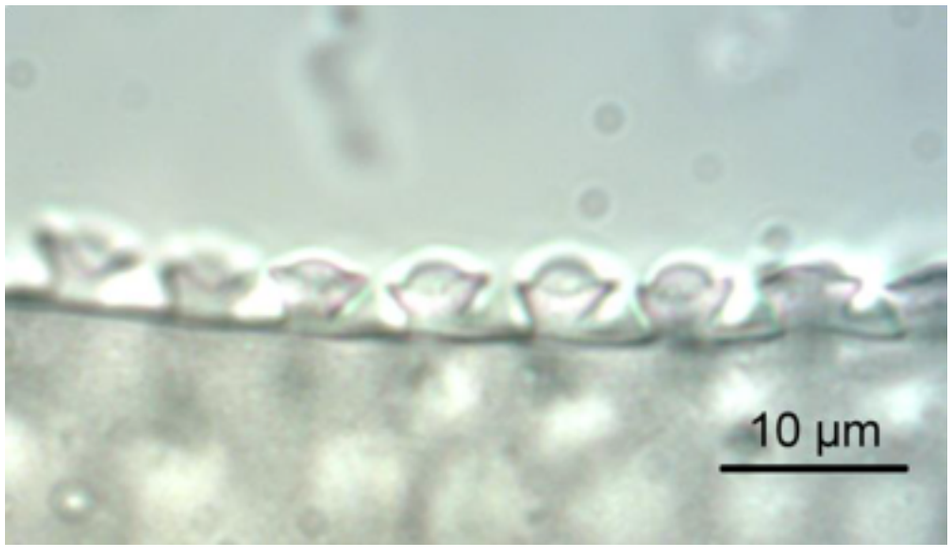
- **Pit membrane** (PM) allows liquid transfert and stops gaz spreading due to its porosity.
- **Pit border** (PB) uses for mechanical structure.

Capron (2014), PhD

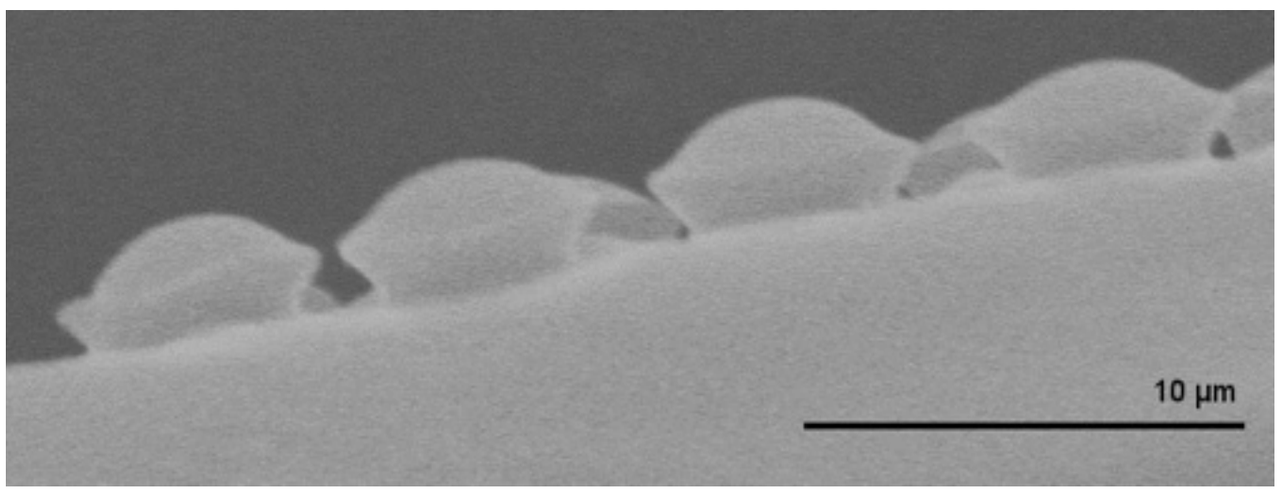
Pit deformation

How pits behave during gaz spreading?

Silicon micro-molding

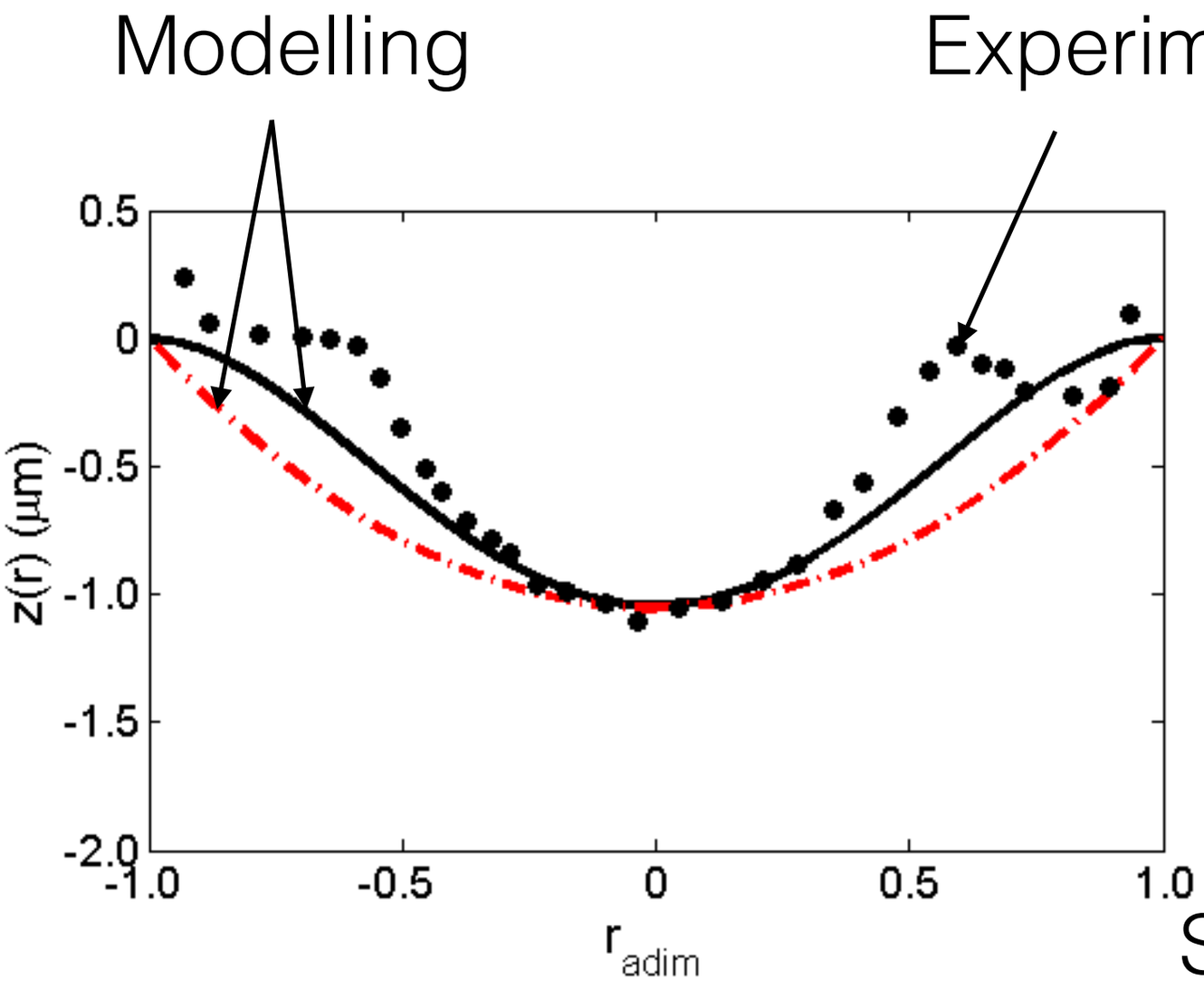


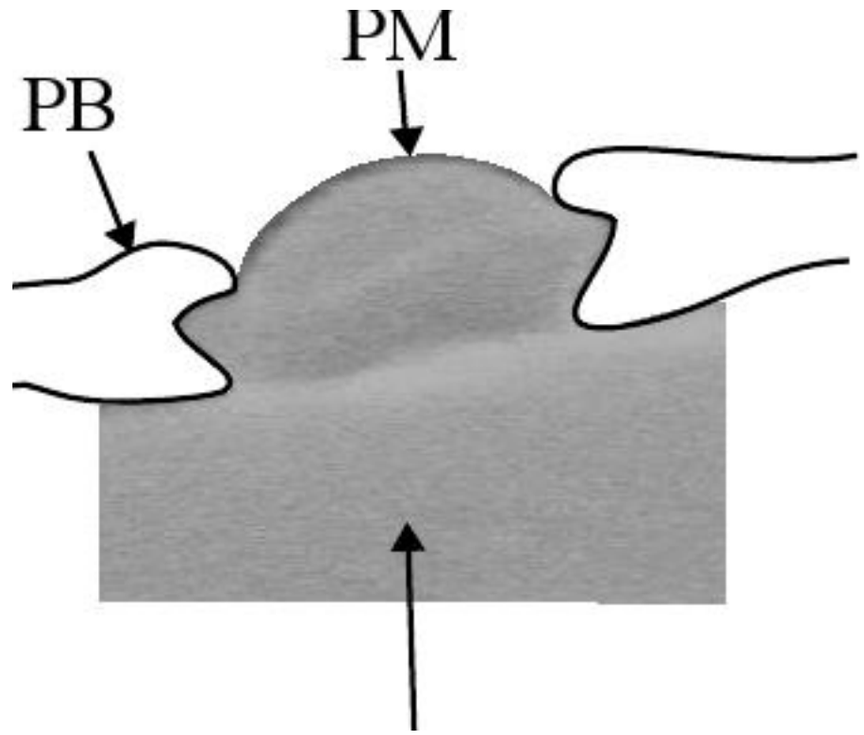
Deformed pit membrane due to increase of pressure



Capron (2014), PhD

Pit deformation





Silicon micro-molding

Capron (2014), PhD

Scientific issues

- Climatic changes and access to water will have an effect on forestry ecosystems

- Find pertinent and operational selection criteria in order to identify stronger genotypes able to resist to climatic changes

- Understating the genetics of the embolism resistance

Thank you for your attention

Any questions?