Wood Anatomy

Microscopic structure of softwoods

presentation

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Wood microstructure

Plant organism

- basic structure unit: cells of different type

- *tissue* = cells of the same origin, function and morphology

- tissues form anatomic structures (e. g. rays)

Wood = system of tissues

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Wood microstructure

Evolution of woody species

Ginkgophyta
- *gink-go* = silver fruit
- 355 million years ago: *Paleozoikum* (Lower *Carboniferous* period)

***Pinophyta, Gymnospermae* (softwoods)**
- *Paleozoikum* – Upper *Carboniferous* period

***Magnoliophyta, Angiospermae* (hardwoods)**
- *Mesozoic Era* – *Cretaceous* period (135 million years ago)

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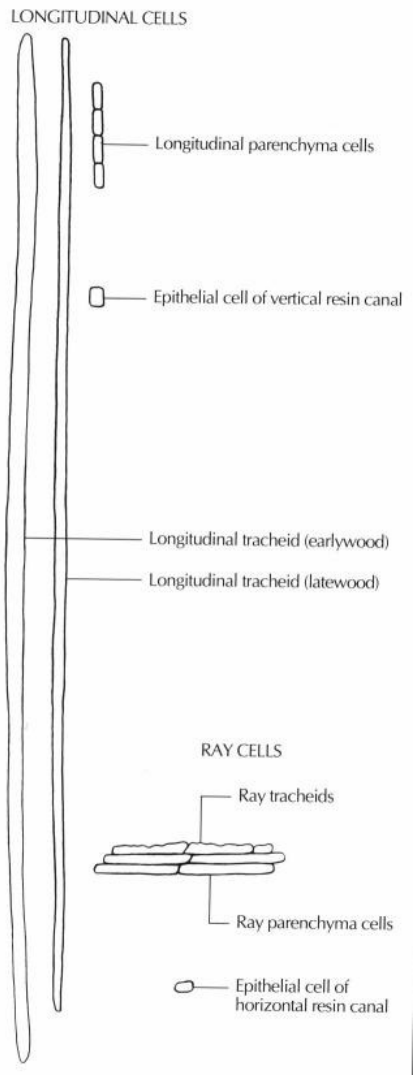
Structure of softwood

- older than hardwoods → very primitive (simple) structure of wood
- only two types of anatomical elements (i. e. cell types):
  - tracheids
  - parenchyma cells



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Structure of softwood

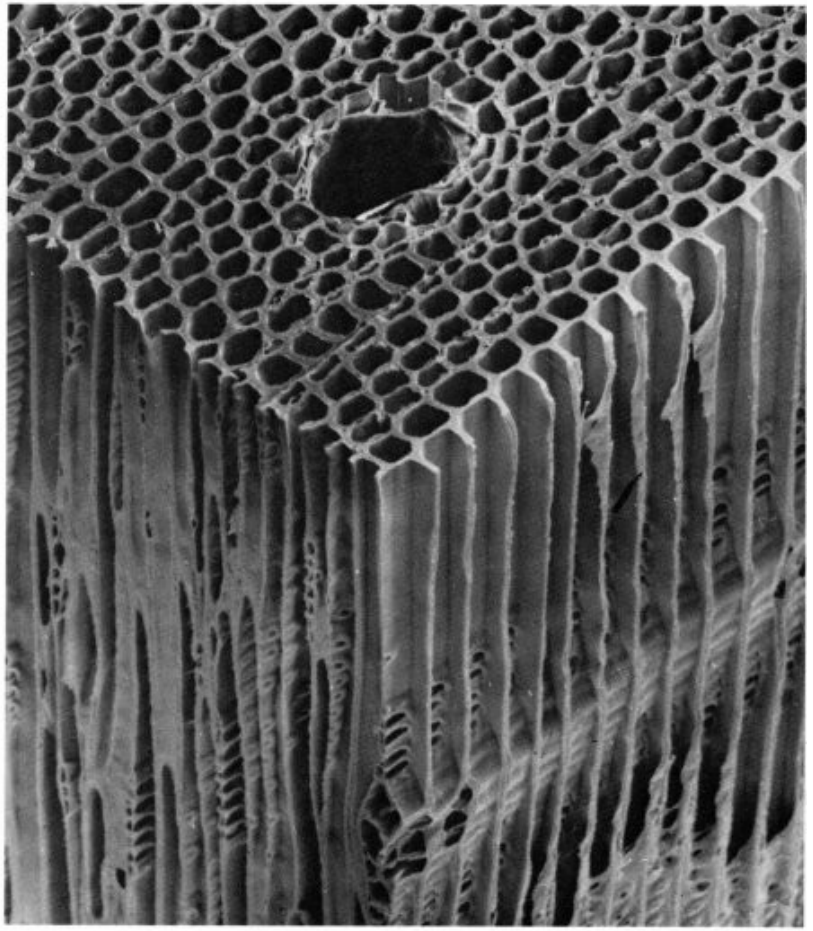

Figure 4-1 Eastern white pine (*Pinus strobus* L.) wood as viewed with the scanning electron microscope. (150×) The structures visible are noted in Fig. 4-2. (*Courtesy of Center for Ultrastructure Studies, State University of New York, College of Environmental Science and Forestry, Syracuse, N.Y.*)

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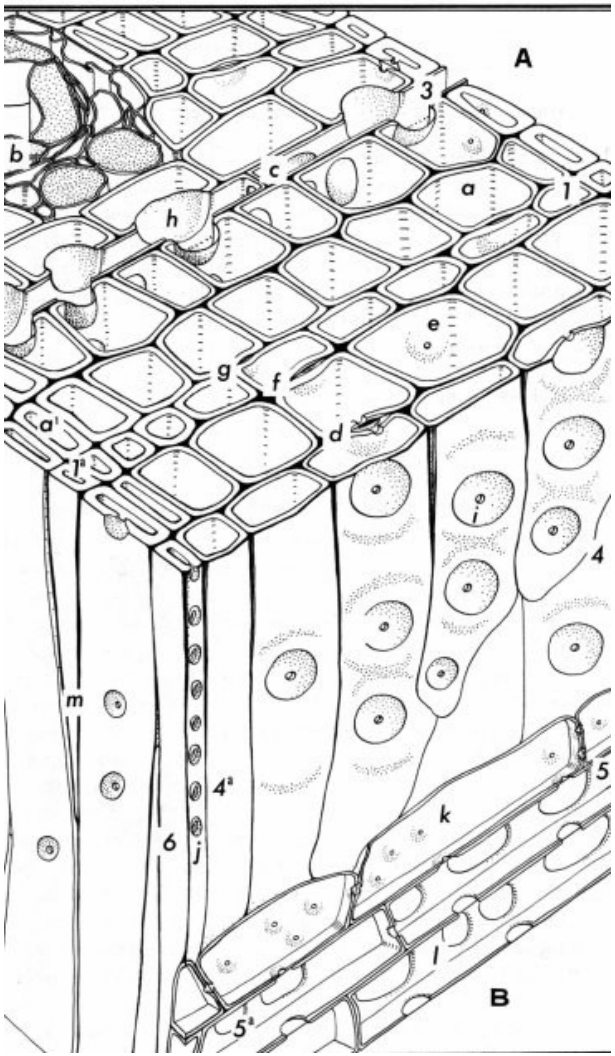
Wood microstructure



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Tracheids

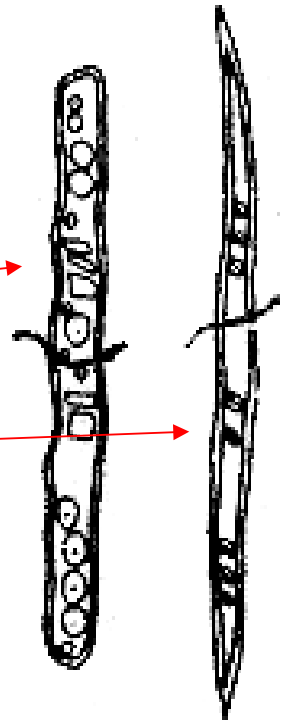
shape
Long cells with closed endings. Four- to six-sided when cut transversally. Pitting: bordered pits. Dead cells.

tracheid volume
- varies from 90 to 97 %

types
early wood tracheids – thin-walled, shorter, bigger diameter, function: water transport
late wood tracheidd - thick-walled, longer, smaller diameter, function: mechanical support

vertical – parallel to the long axis of the stem
horizontal (ray tracheid) – perpendicular to the long axis

dimensions
transverse: 0.02–0.1 mm
length: 4–6 mm



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Parenchyma cells

shape

Thin-walled cells with simple pits on their cell walls. Square-like shape. Living cells (only in sapwood).

Parenchyma cells volume

5–12 %

types

- transversely oriented cells:
  rays and *horizontál resin canals*
- longitudinal oriented cells:
  longitudinal parenchyma and *vertical resin canals*

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Parenchyma cells

Rays

orientation
- perpendicular to the long axis of the stem

Formed by parenchnyma cells of these dimensions:
diameter: 10–15 μm, length: 40–70 μm

seriation
uniseriate – present in all softwoods species
multiseriate (with horizonatl resin canal) – present only in softwoods with resin canals

function
- food storage, (water transport in radial direction)

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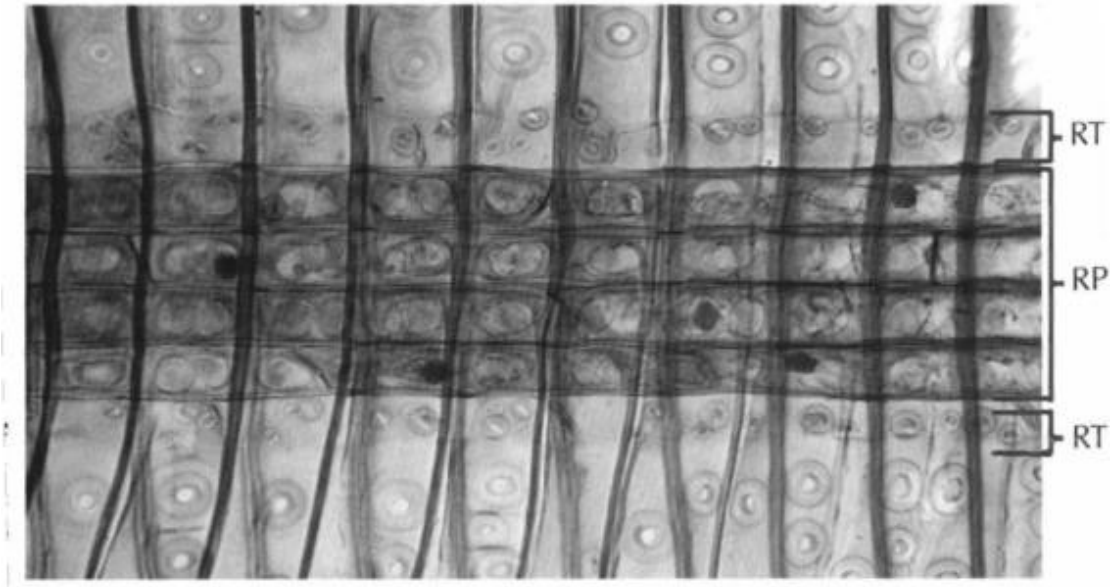
Parenchyma cells

types of rays

homocellular ray
- formed by parenchyma cells only (fir, juniper, yew)

heterocelullar ray
- formed by parenchyma cells (RP) and ray tracheids (RT) (spruce, pine,



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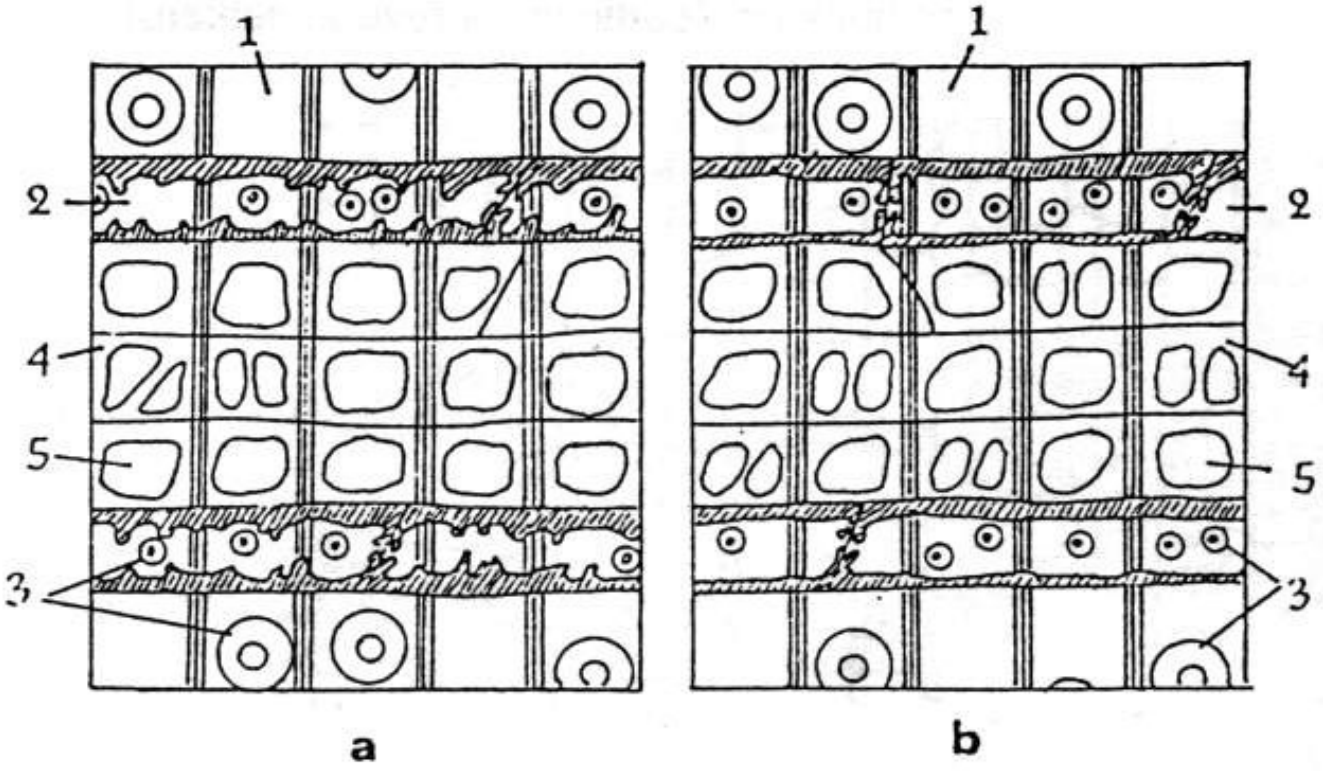
Parenchyma cells

rays with dentate or smooth ray tracheids



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Parenchyma cells

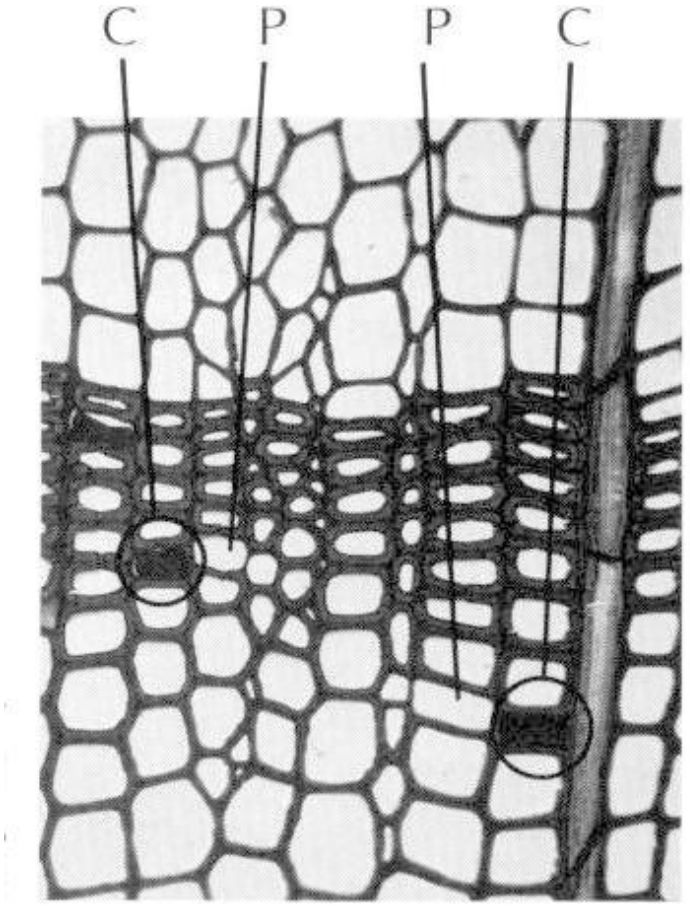
longitudinal parenchyma

orientation
- parallel to the long axis of the stem

dimensions
X – as tracheids
R, T – shorter to tracheids

function
- food storage

occurance
- abundant in *Juniperus*
- absent in *Pinus, Taxus*, *Torreya*



Parenchyma cells (X section).
P – thin-walled cell,
C – cell with a dark content

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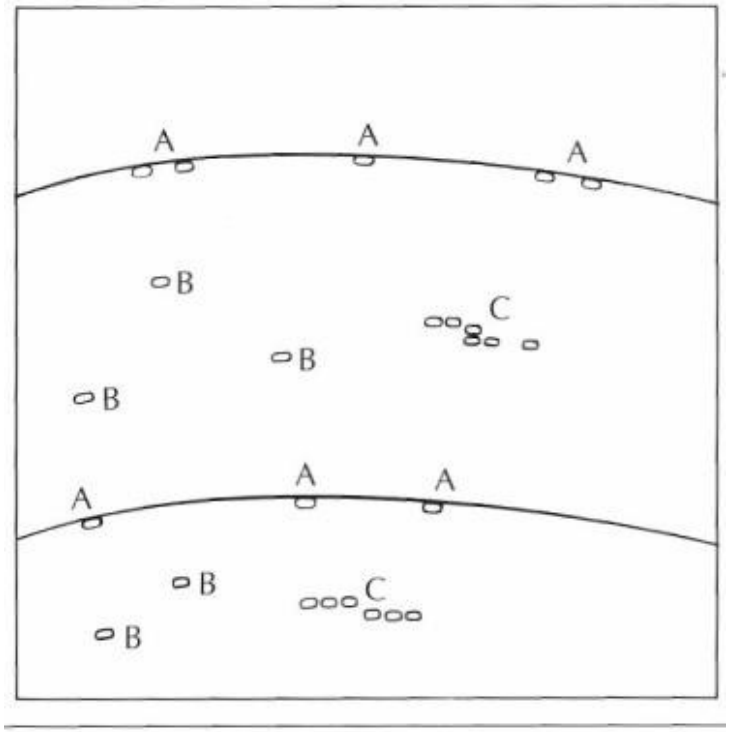
Parenchyma cells

longitudinal parenchyma

Longitudinal parenchyma arrangement in the transverse section.
A – marginal
B – diffuse
C – metatracheal



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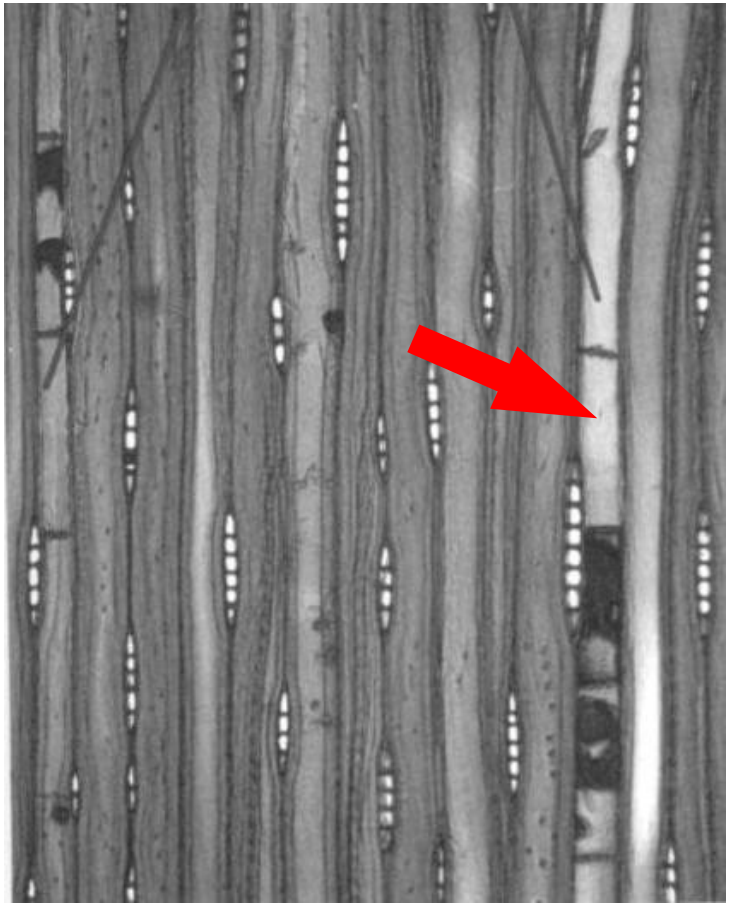
Parenchyma cells

longitudinal parenchyma



Tangential section

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Parenchyma cells

resin canals

- inter cellular spaces or cavities surrounded by parenchyma cells

orientation
Parallel or perpendicular to the long axis of the stem

types
vertical – bigger diameter, numerous
horizontal – smaller diameter, not numerous

diametres
Pinus (V): 135–150 μm, other (V): 50–90 μm (H): do 60 μm

occurance
- only in all species of 4 genus of *Pinaceae* family:
  - pine *(Pinus spp.)*
  - spruce *(Picea spp.)*
  - larch *(Larix spp.)*
  - Douglas-fir *(Pseudotsuga spp.)*

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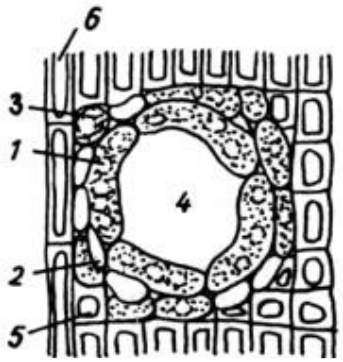
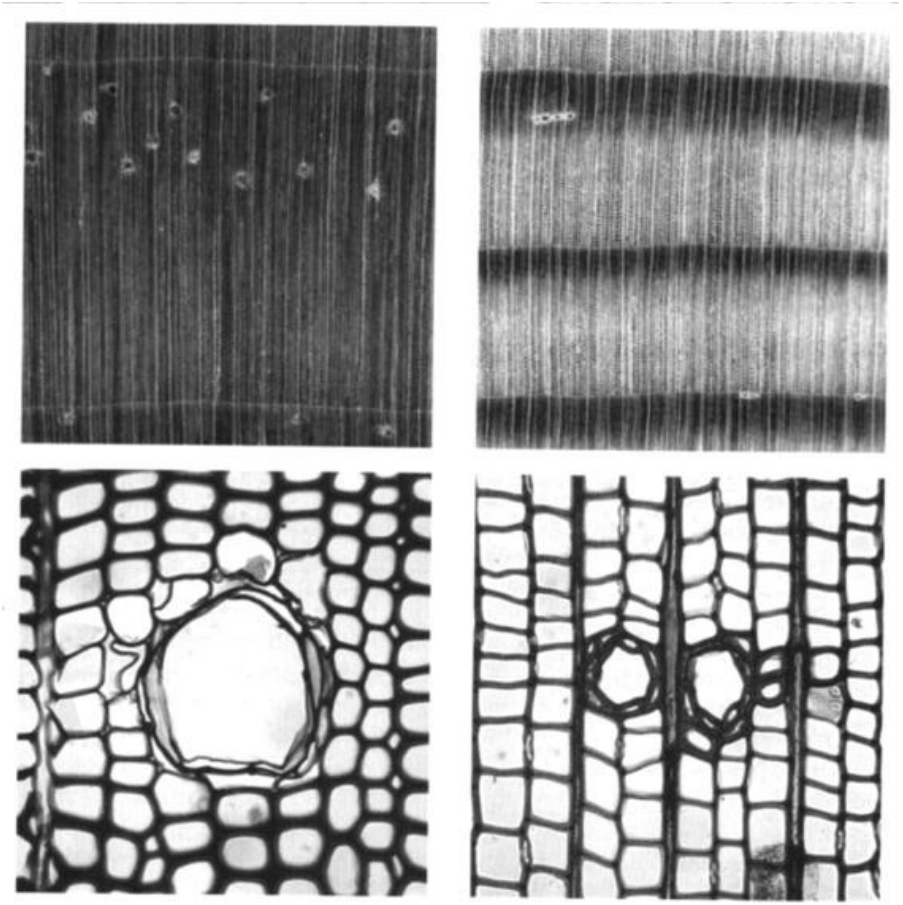
Parenchyma cells

resin canals



1 – epithelial cell, 2 - parenchyma support cell, 3 – dead cell, 4 – canal cavity



types

typ „pine“ (left) – big thin-walled epithelial cells (5)

typ „spruce“ (right) – smaller,thick-walled epithelial cells (8-12)

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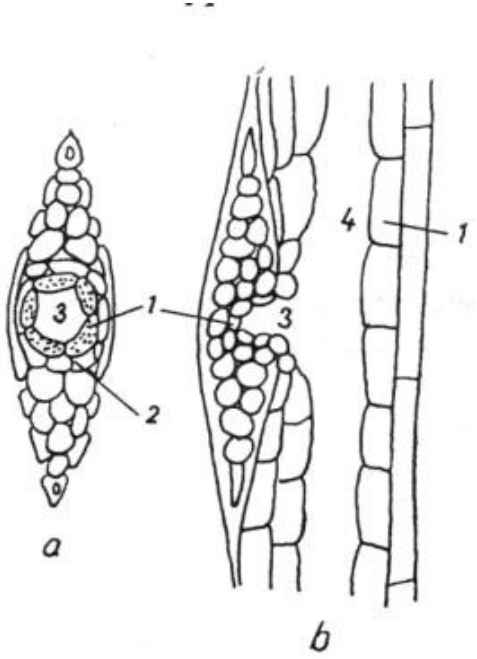
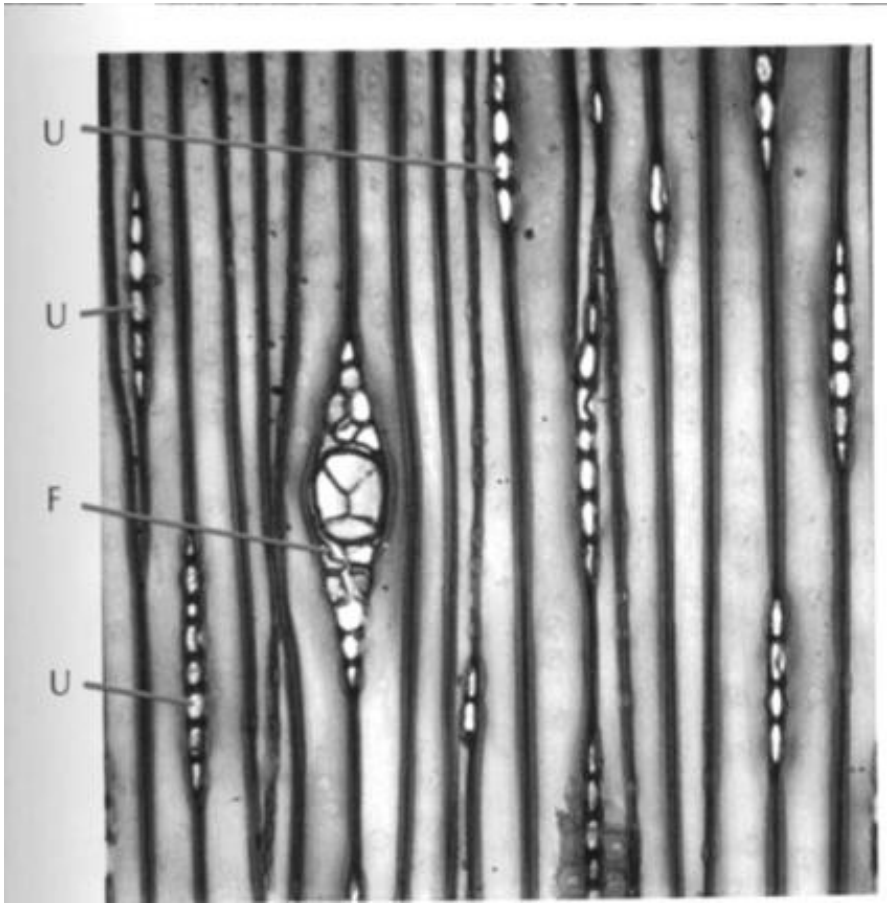
Parenchyma cells

resin canals



Horizontal resin canal in the tangential section



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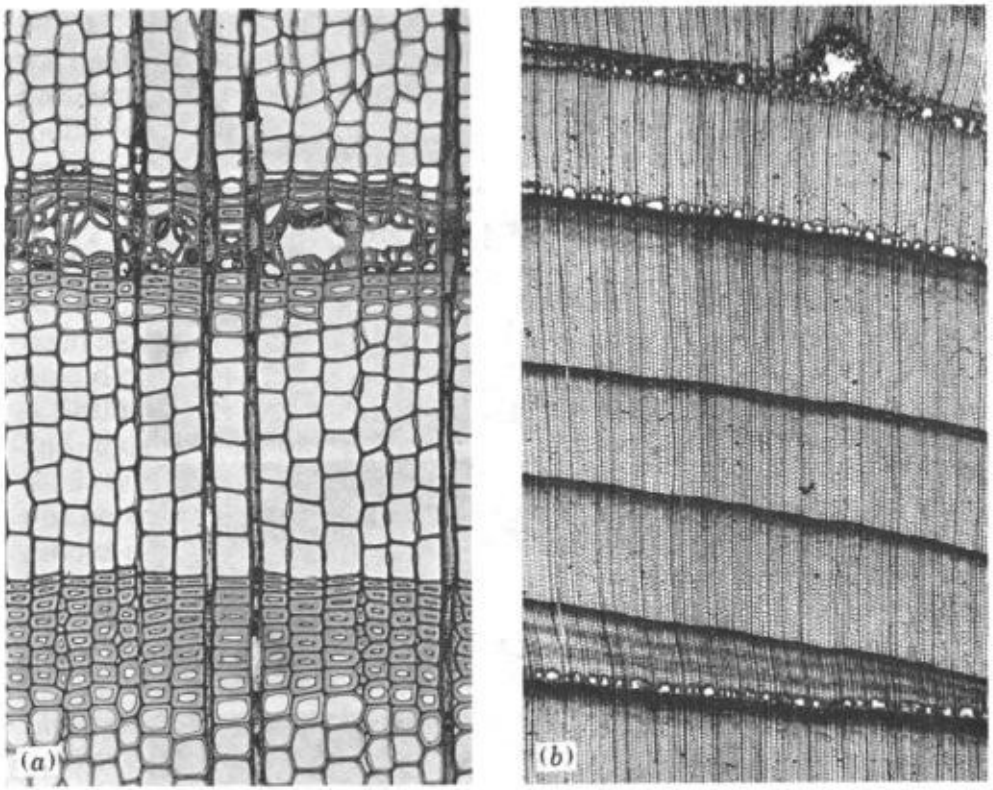
Parenchyma cells

traumatic resin canals



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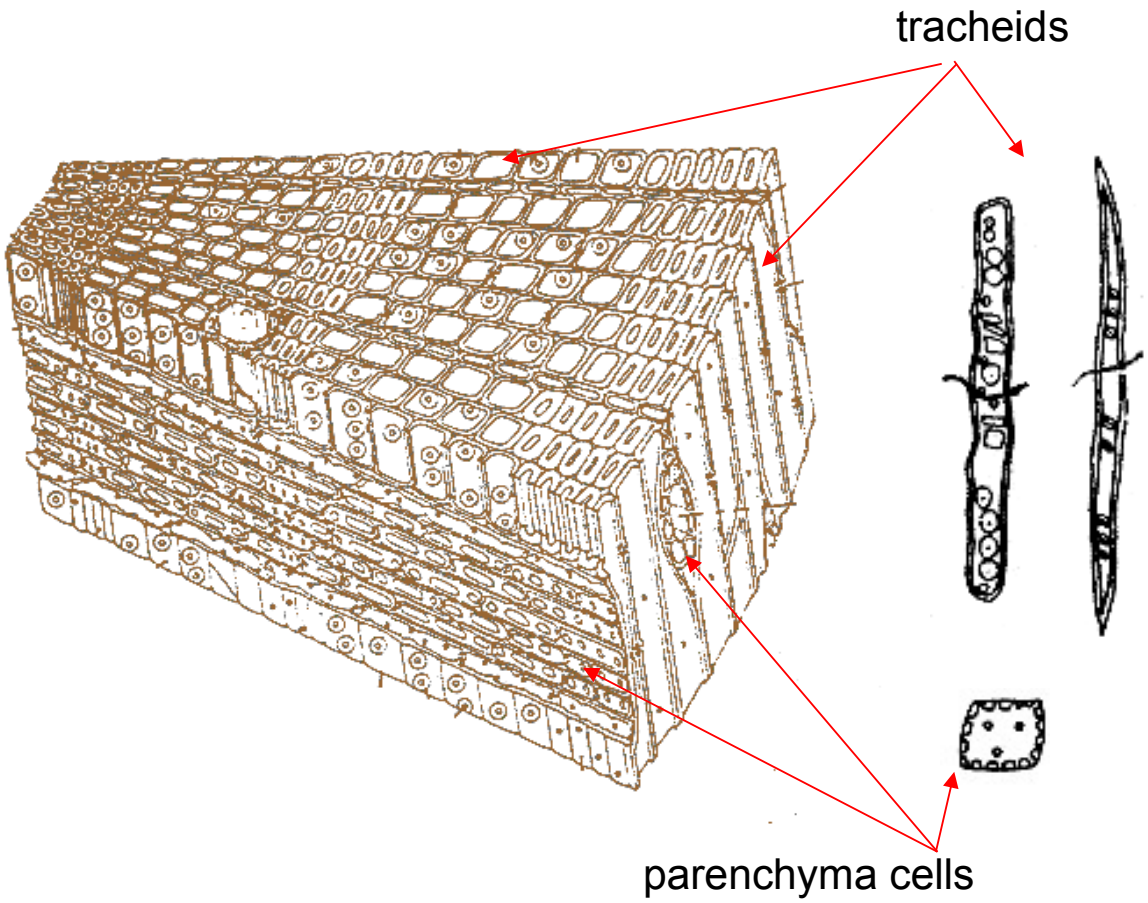
3D structure of softwood



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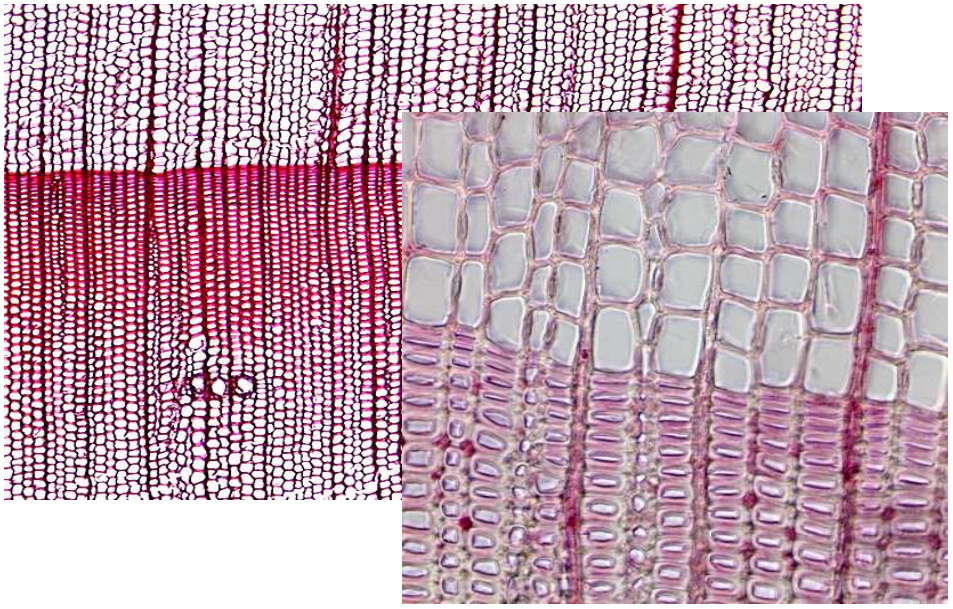
Principal sections

transverse section
- vertical *tracheids* – cut transversely
- *parenchyma cells of rays* – cut along their length
- *parenchyma cells of longitudinal parenchyma* – cut transversely
- epithelial *cells of vertical resin canals* – cut transversely
- epithelial *cells of horizontal resin canals* – cut along their length



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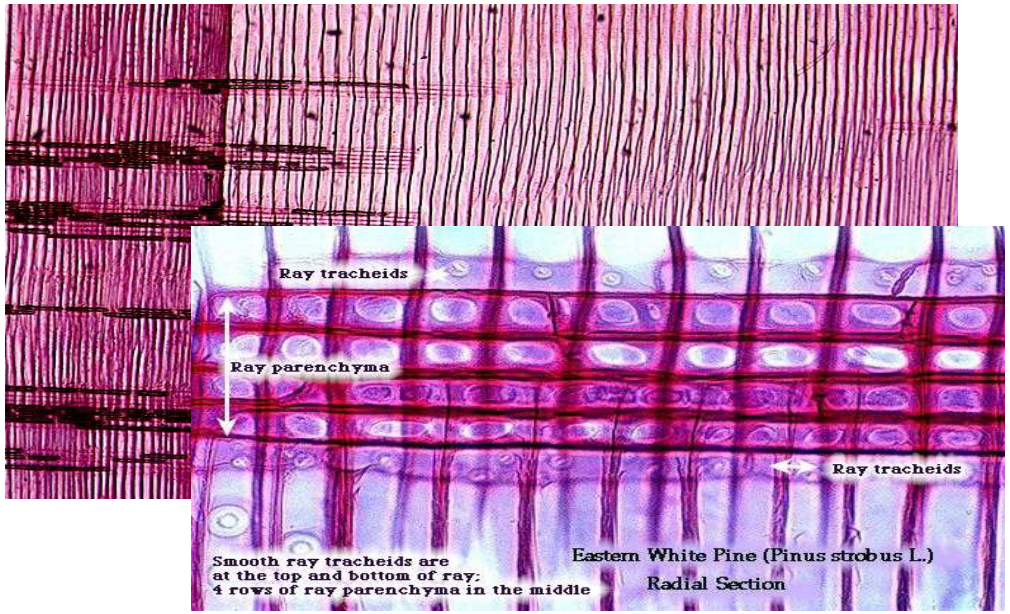
Principal sections

radial section

- *vertical tracheids* – cut along their length
- *parenchyma cells of rays* – cut transversely
- *parenchyma cells of longitudinal parenchyma* – cut along their length
- epithelial *cells of vertical resin canals* – cut along their length
- epithelial *cells of vertical resin canals* – cut along their length



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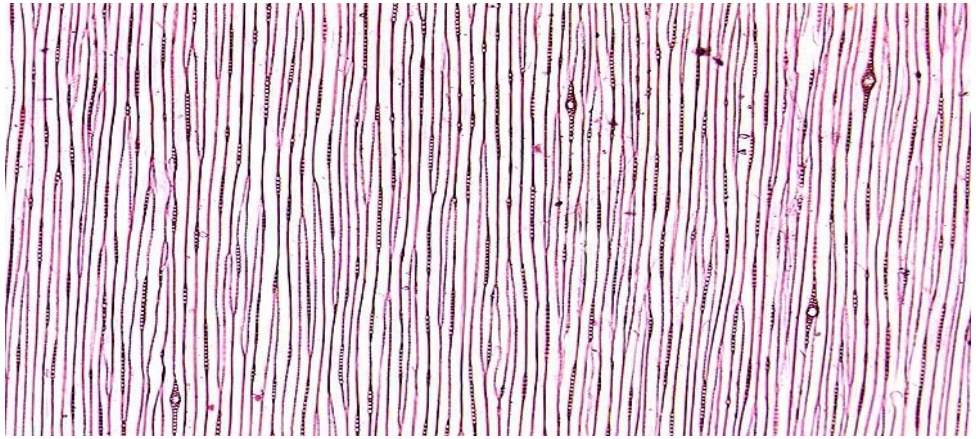
Principal sections

tangential section

- vertical *tracheids* – cut along their length
- *parenchym*. *b. dř. p.* – řezány v příčných rozměrech
- *parenchyma cells of longitudinal parenchyma* – cut along their length
- epithelial *cells of vertical resin canals* – cut along their length
- epithelial *cells of vertical resin canals* – cut transversely



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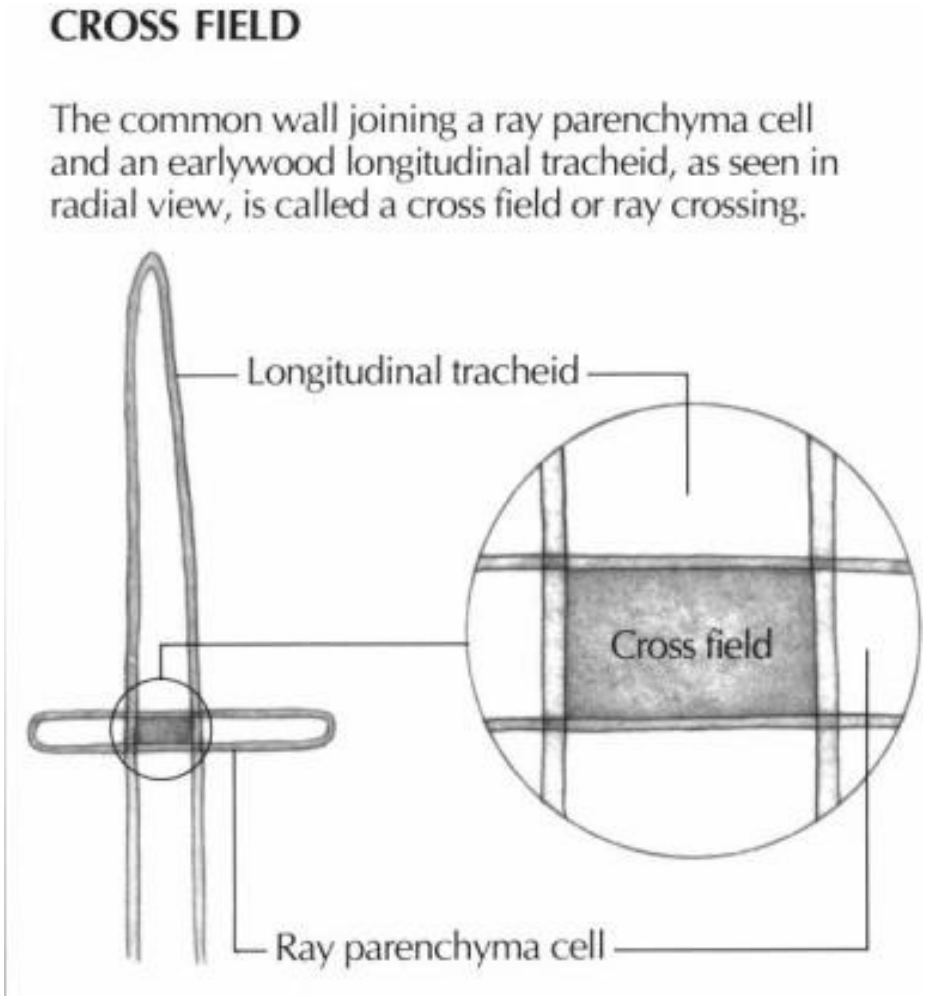
Features of microstructure



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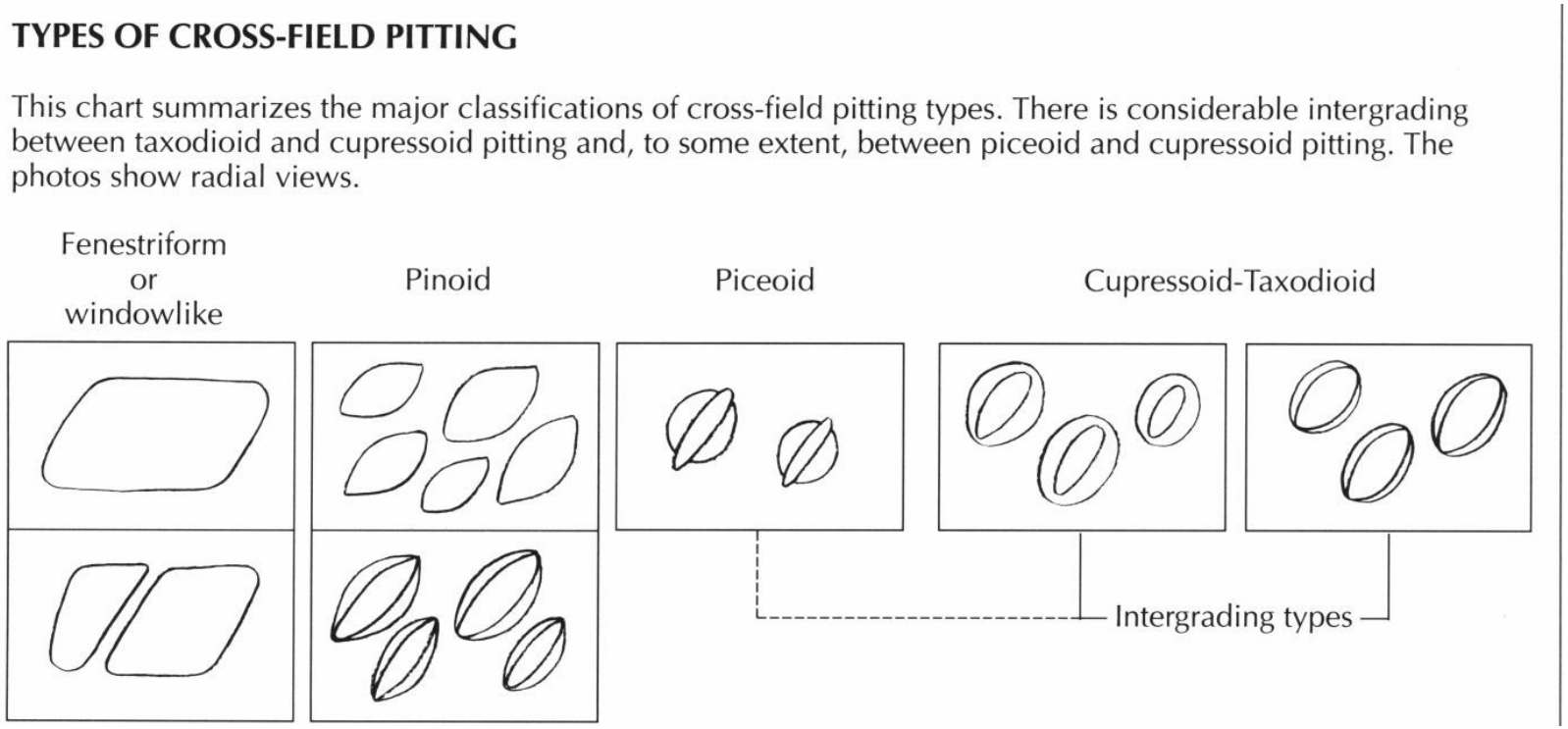
Features of microstructure



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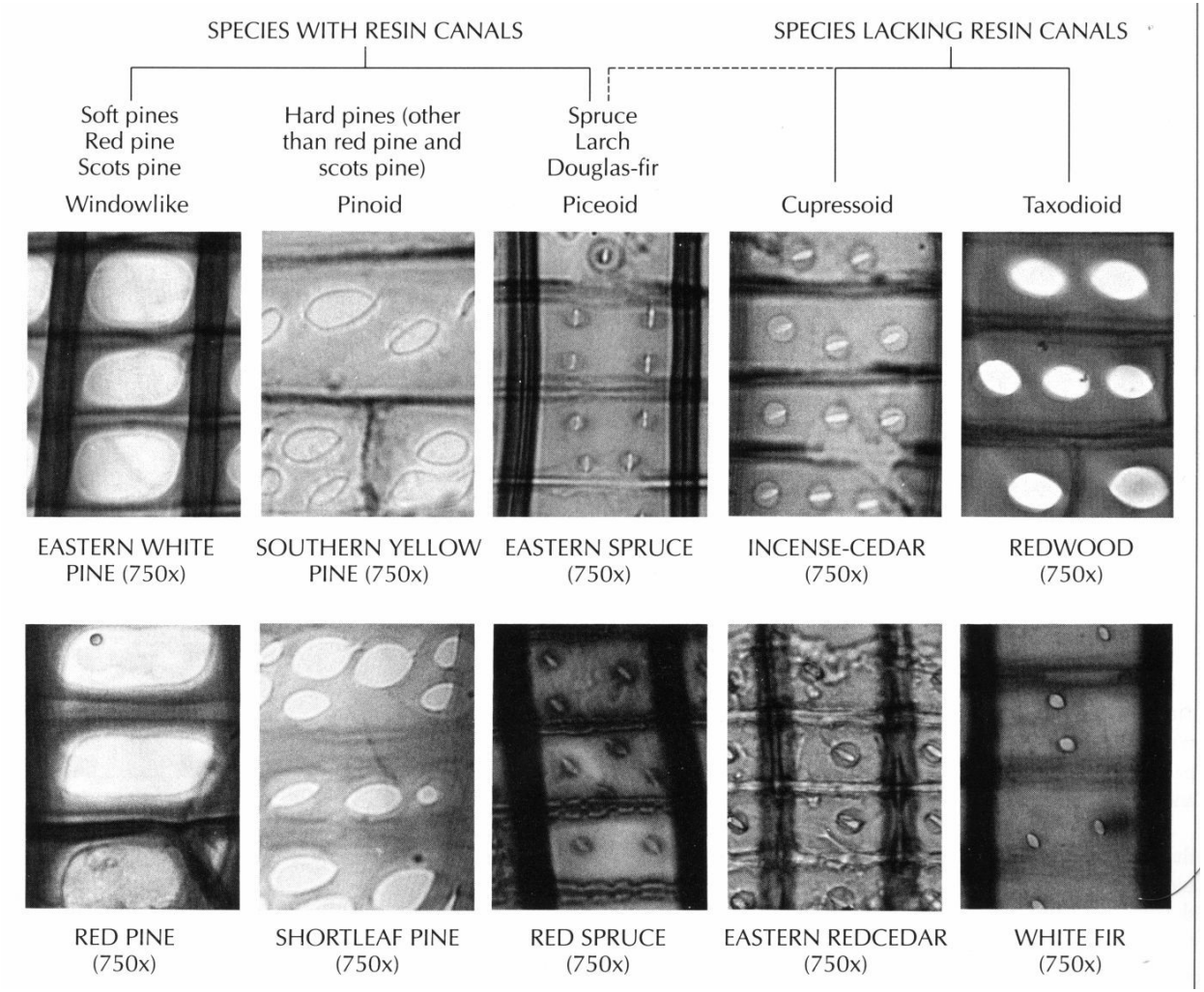
Features of microstructure



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Features of microstructure

Cross-field pitting

window-like
- *Pinus sylvestris, P. resinosa, P. strobus, P. monticola, P. lambertiana*

pinoid
- other *Pinus* species

piceoid
- *Picea, Larix, Pseudotsuga*

taxodioid
- Taxodiaceae: *Sequoia* a *Taxodium*
- Pinaceae: *Abies*
- Cupressaceae: *Thuja*

cupressoid
- Cupressaceae: *Chamecyparis, Calocedrus a Juniperus*
- Pinaceae: *Tsuga*
- Taxaceae: *Taxus*

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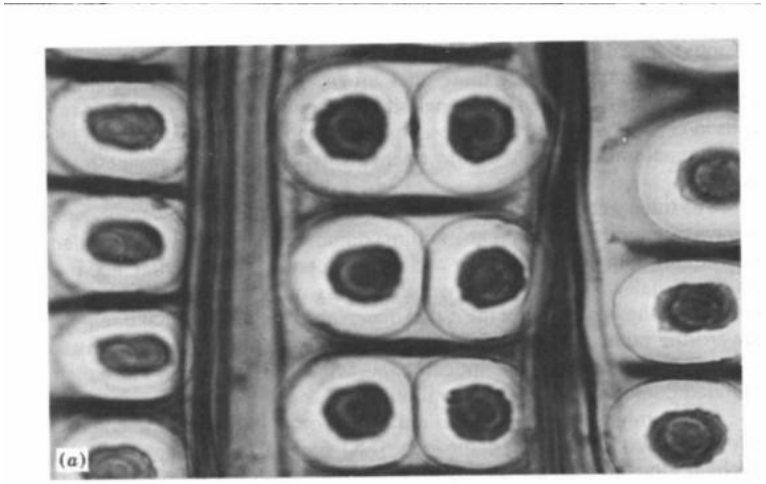
Features of microstructure

Thickenings of cell walls

***crassullae* = "bars of Sanio"**
- the bordered pits on the radial wall of tracheids are bounded above and bellow
by zones of darker subtances



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Features of microstructure

Thickenings of cell walls

Spiral thickenings
- on the wall of vertical tracheids

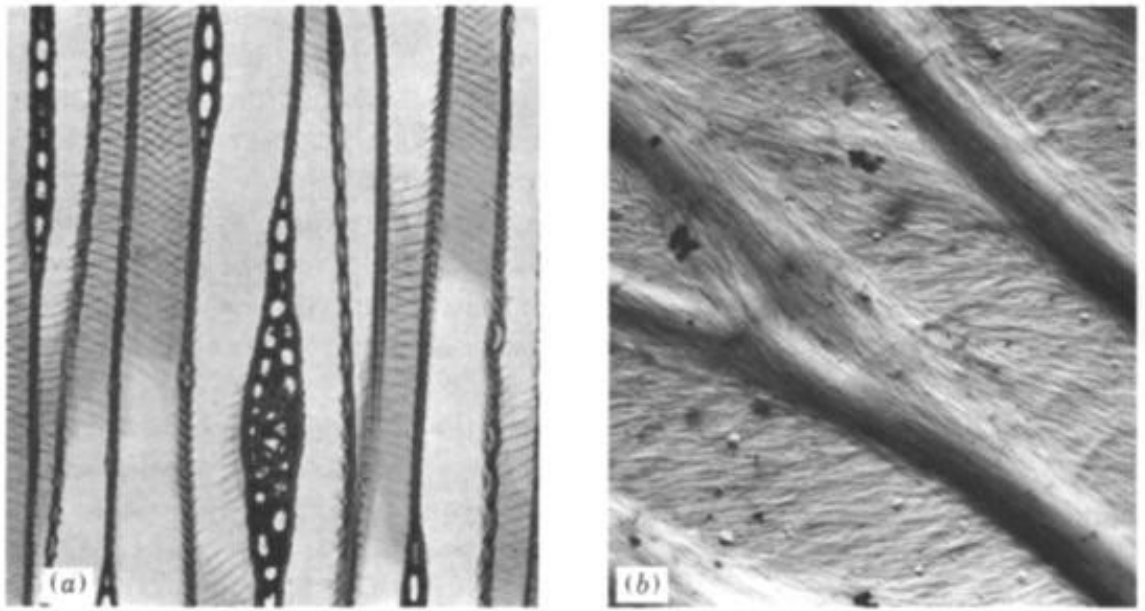

Figure 4-5 Spiral thickening in Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco].
(a) Appearance of spiral thickenings under a light microscope. (110×)
(*b*) Electron micrograph of the surface of a tracheid showing the microfibrillar structure of the spiral thickenings. (6800×) (*Courtesy of W. A. Côté, Jr.*)

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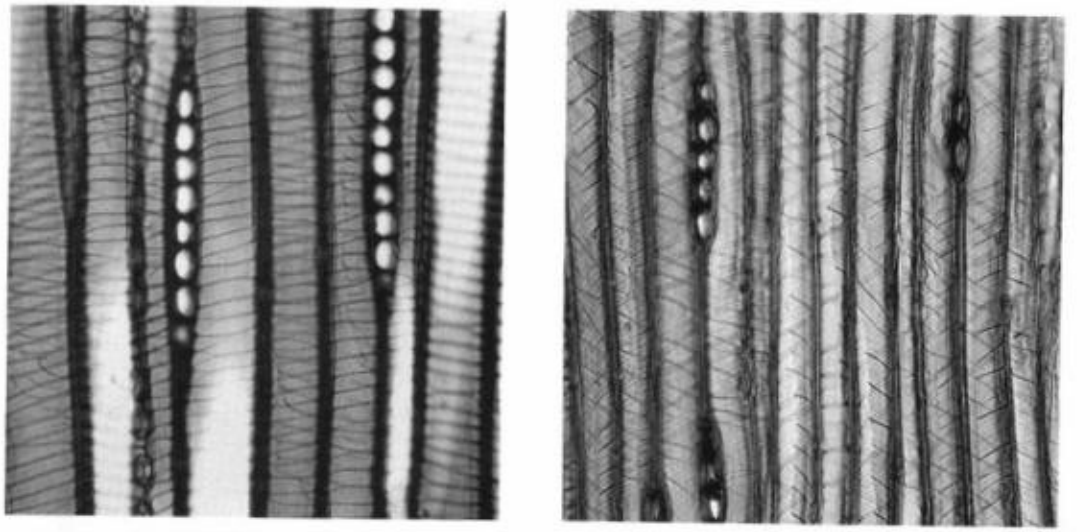
Features of microstructure

Thickenings of cell walls

Spiral thickenings



SPIRAL THICKENINGS
In Douglas-fir (left), which has resin canals, spiral thickenings are nearly perpendicular to the tracheid axis. In yew (right), which lacks resin canals, spiral thickenings form a less regular pattern and a steeper spiral. (200x)

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Features of microstructure

Thickenings of cell walls

trabeculae
- a barlike structure extending cross the lumen of a tracheid from one tangential wall to another

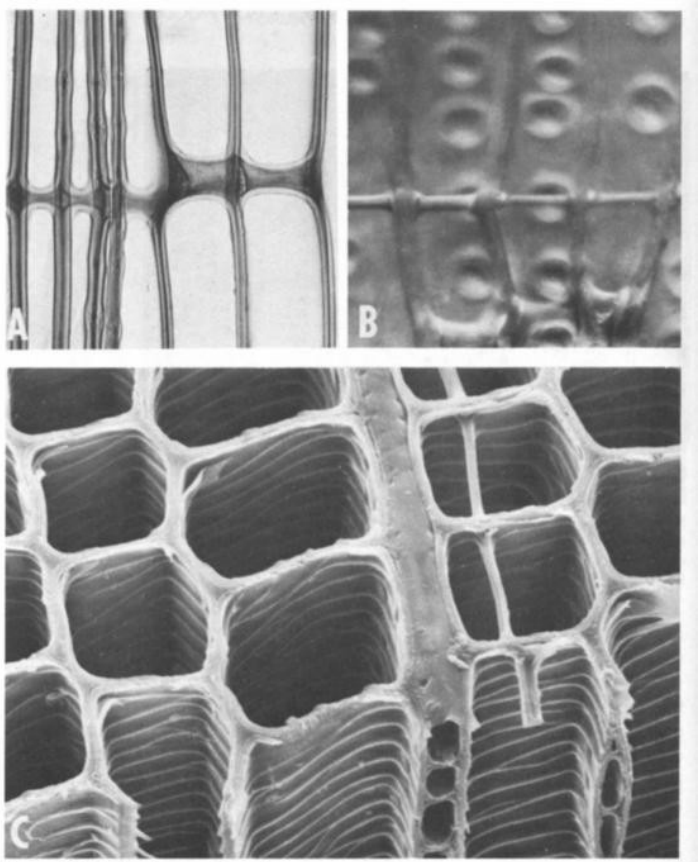

Figure 4-7 Trabeculae in softwoods.
(A) Alaska-cedar [*Chamaecyparis nootkatensis* (D. Don) Spach.]. Radial view. (360×)
(B) Western white pine (*Pinus monticola* Dougl.), radial view photographed with incident light. (430×)
(C) Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco]. Scanning electron micrograph. (700×)
[(B) *photograph by R. E. Pentoney;* (C) *courtesy of Center for Ultrastructure Studies, State University of New York, College of Environmental Science and Forestry, Syracuse, N.Y.*]

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