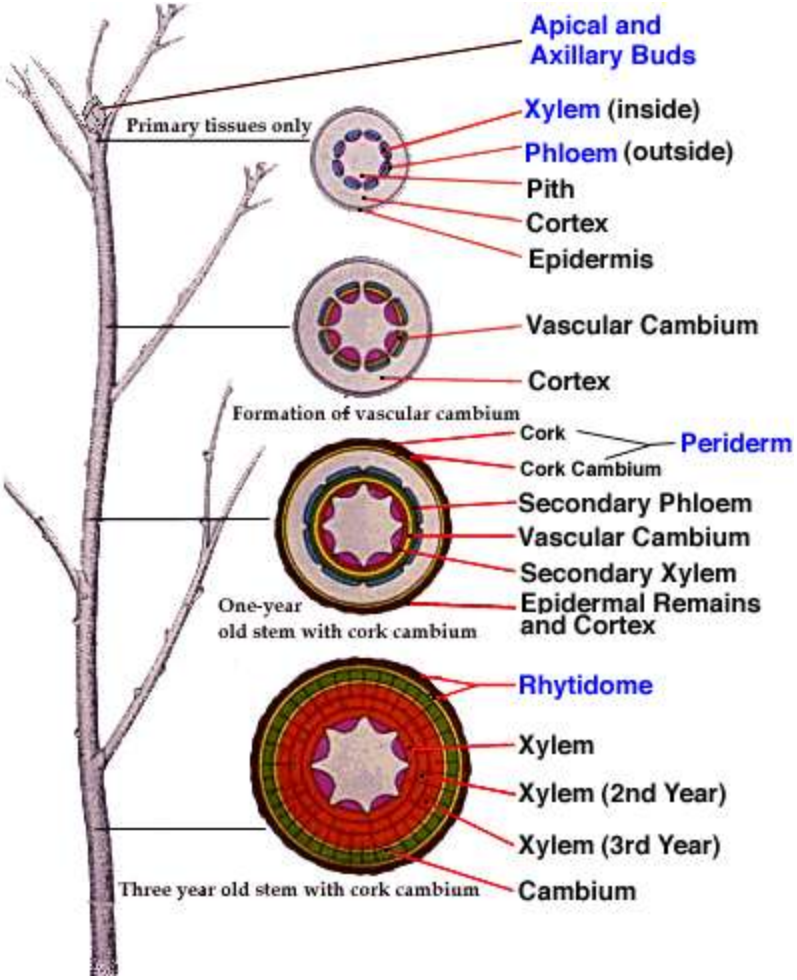
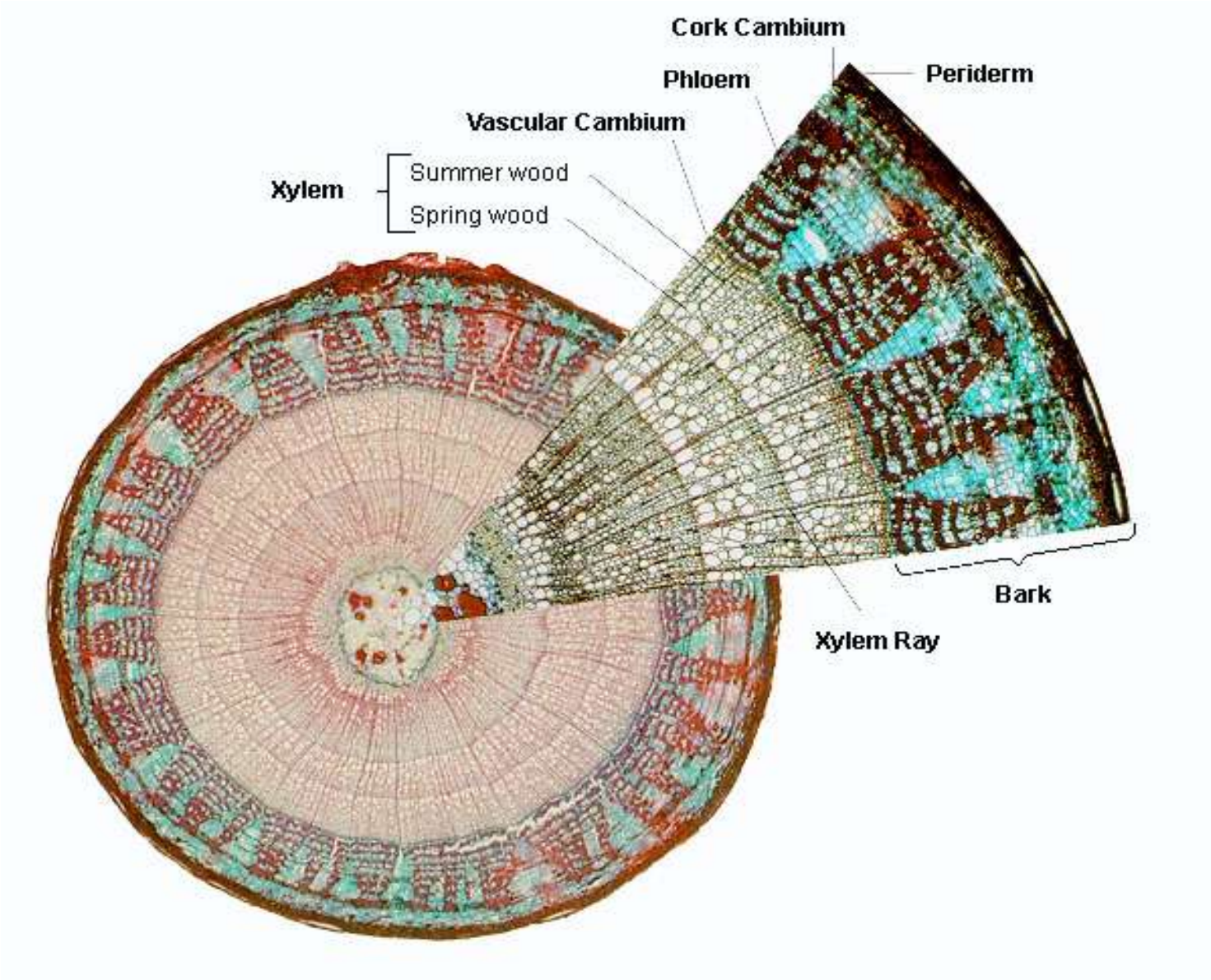
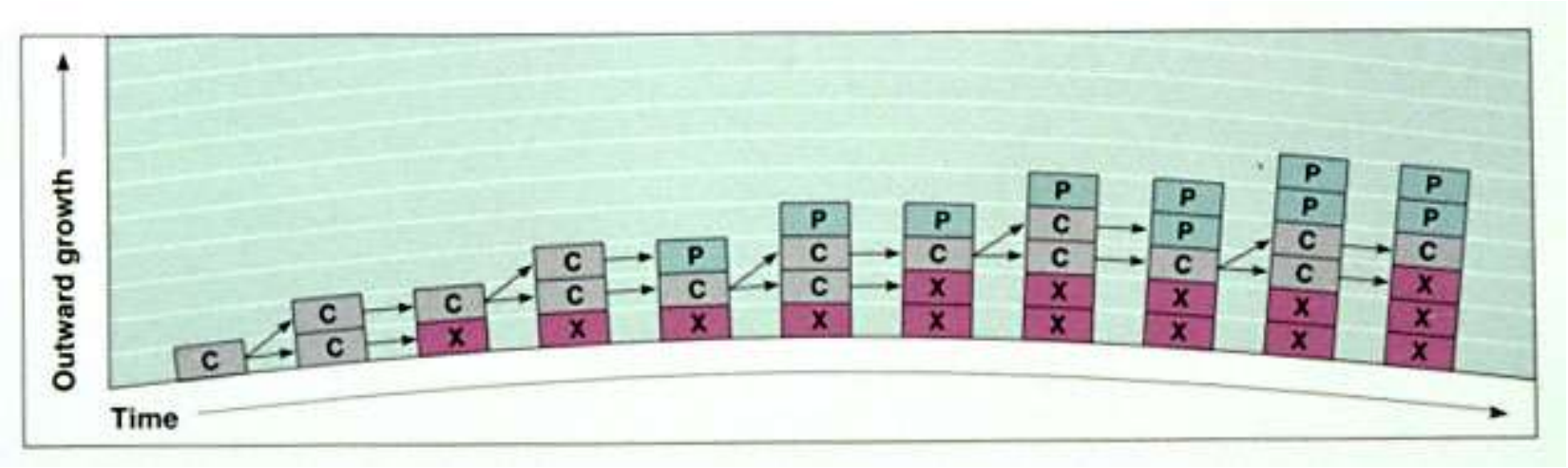
Primary and Secondary Growth



Secondary growth



Secondary growth



Growing Tall – trade-off and compromise

Benefits

Get out of shade

More light for photosynthesis

Disadvantages

More weight, more support needed

Water sugar transport problems

Takes a lot of energy for growth

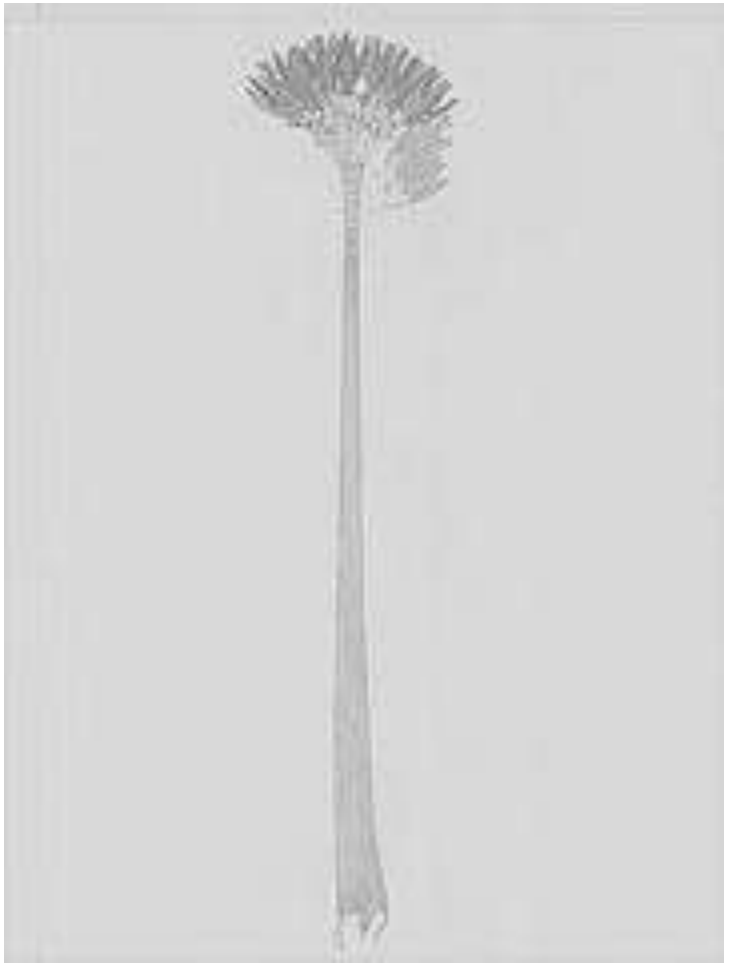
Takes time to grow and flower

Exposure to cold winters

Solution – secondary growth

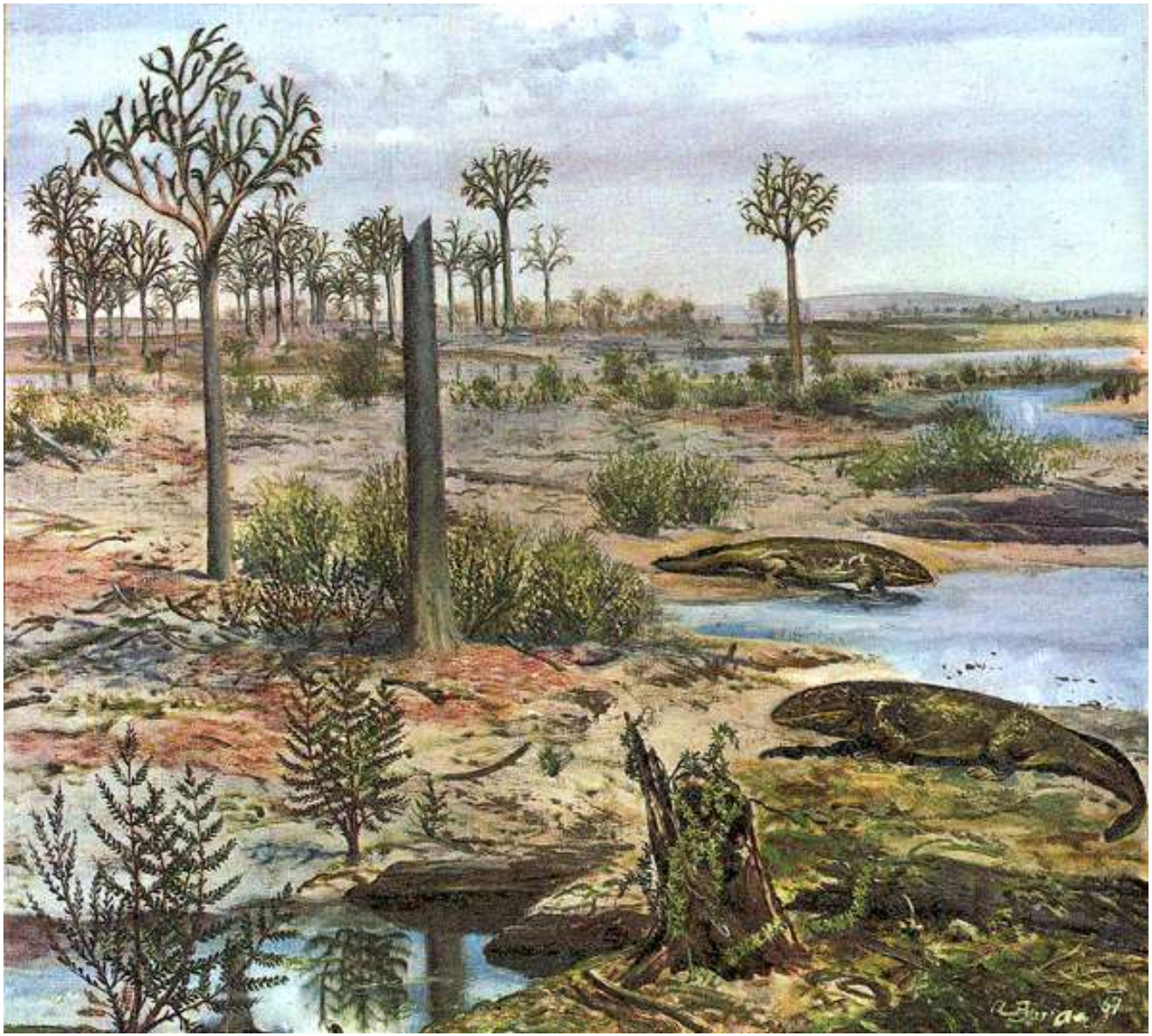
New meristem required – lateral meristem

Eospermatopteris
Devonian
390 to 350 mya
Oldest known tree?



Stein W. E., Mannolini F., VanAller Hernick L., Landing E. & Berry C. M.*et al*. *Nature*, 446. 904 - 907

Devonian Forest Landscape



Carboniferous Forest – 359 – 299 mya

Carboniferous Forest – 300 mya (Field Museum)

Reconstruction of actual site of a peat-forming forest of earliest Permian age that was preserved by a volcanic ash-fall near Wuda, Inner Mongolia, China.

Wang J et al. PNAS 2012;109:4927-4932

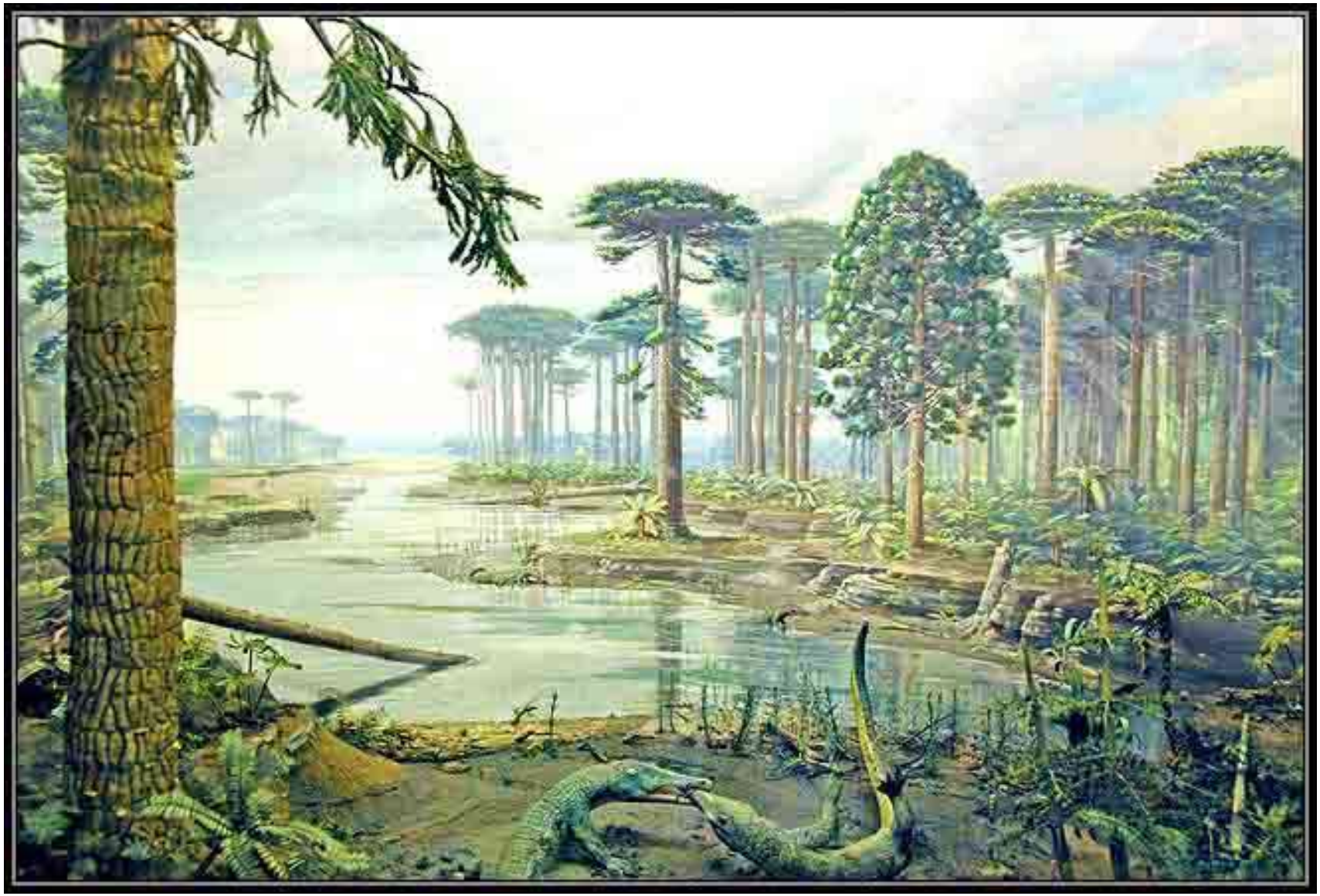
Eon	Era	Period	begin–end (Mya)
Phanerozoic Eon: PH	Cenozoic Era: CZ	Neogene N	23.0–
		Paleogene E	65.5–23.0
	Mesozoic Era: MZ	Cretaceous K	146–65.5
		Jurassic J	200–146
		Triassic T	251–200
	Paleozoic Era: PZ	Permian P	299–251
		Carboniferous C	359–299
		Devonian D	416–359
		Silurian S	444–416
		Ordovician O	488–444
		Cambrian Є	542–488
Proterozoic PR			2500–542
Archean AR			3800–2500
Hadean* HA			3850–4500
Chaotian* CH			–4500

Permian Extinction Survivors

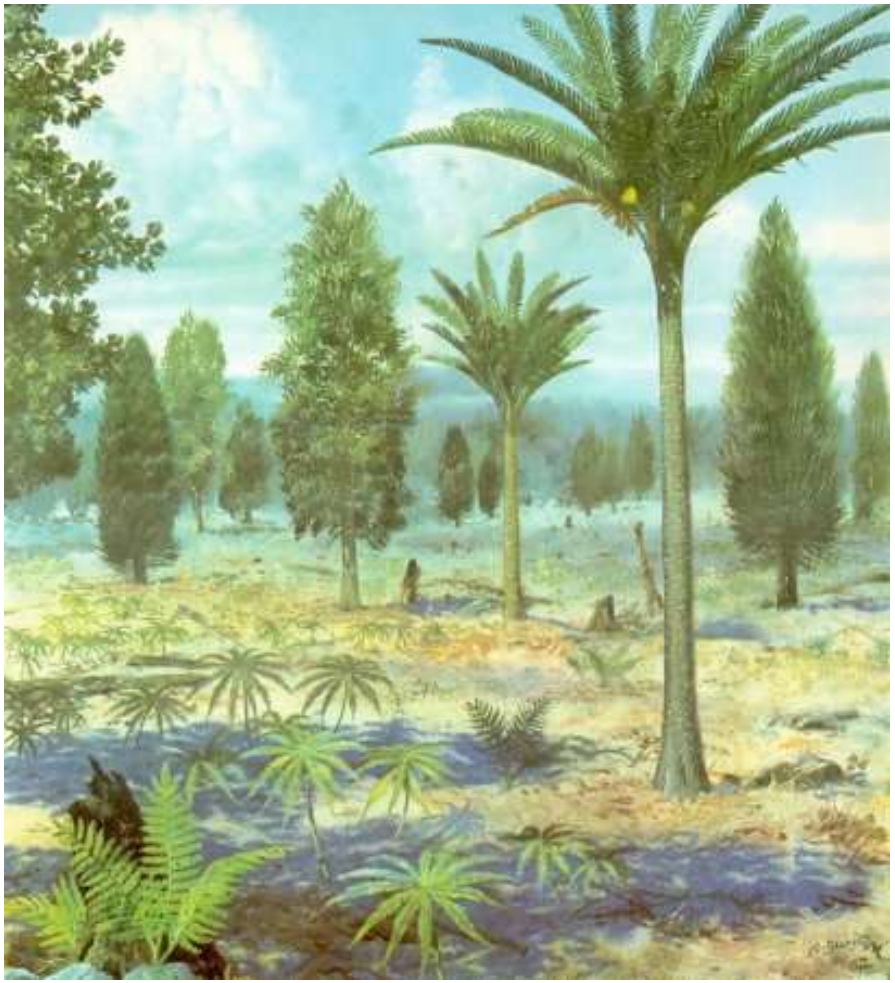
Earth's flora and fauna succumbed to the greatest of all extinctions around 245 MYA. About 95% of all species went extinct.

Lystrosaurus, a relative to mammals, and *Pleuromeia*, a small Isoetalean

Triassic Forest



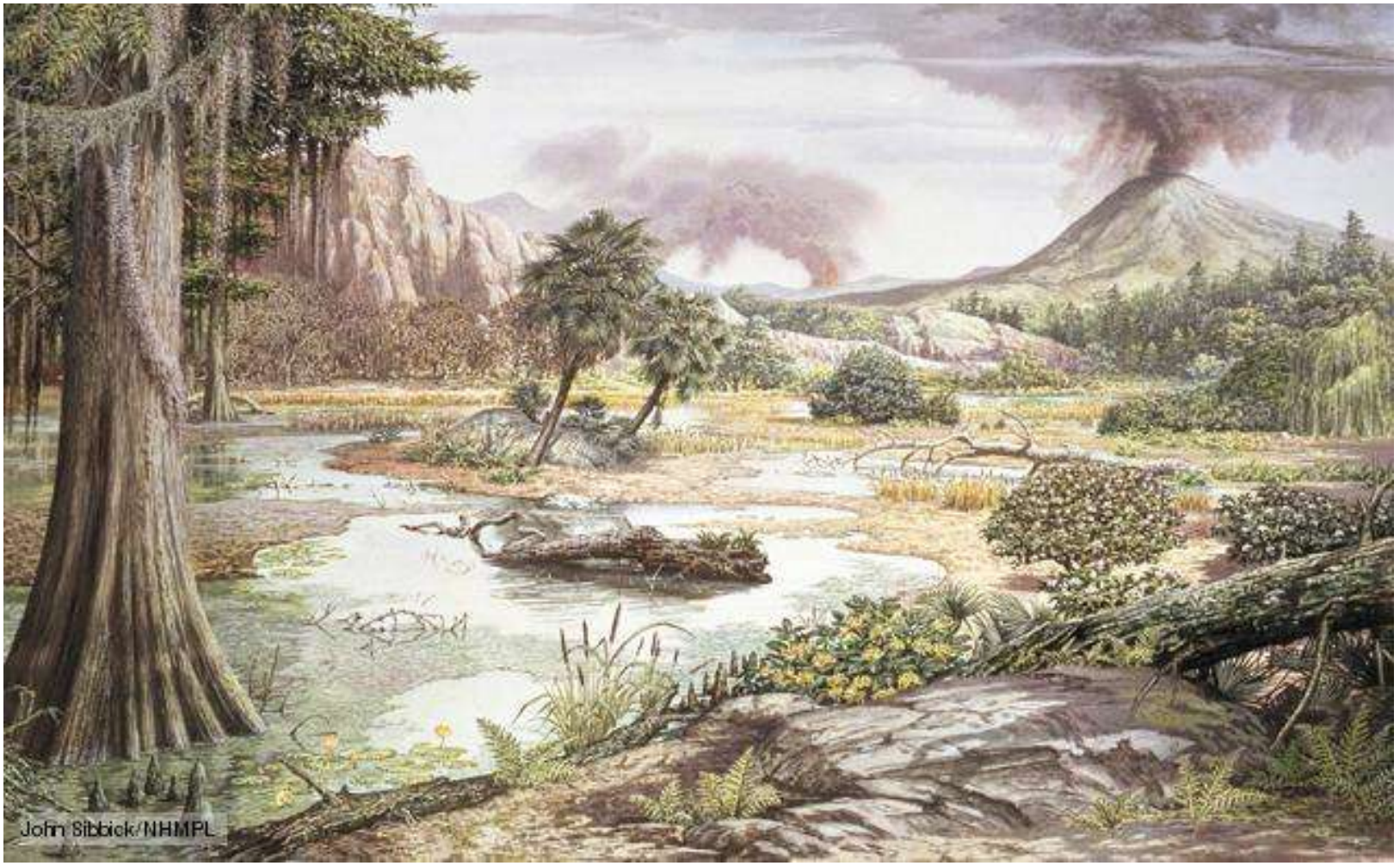
Jurassic Forest



Gingkophytes, Cycadophytes

Sequoias

Cretaceous Vegetation



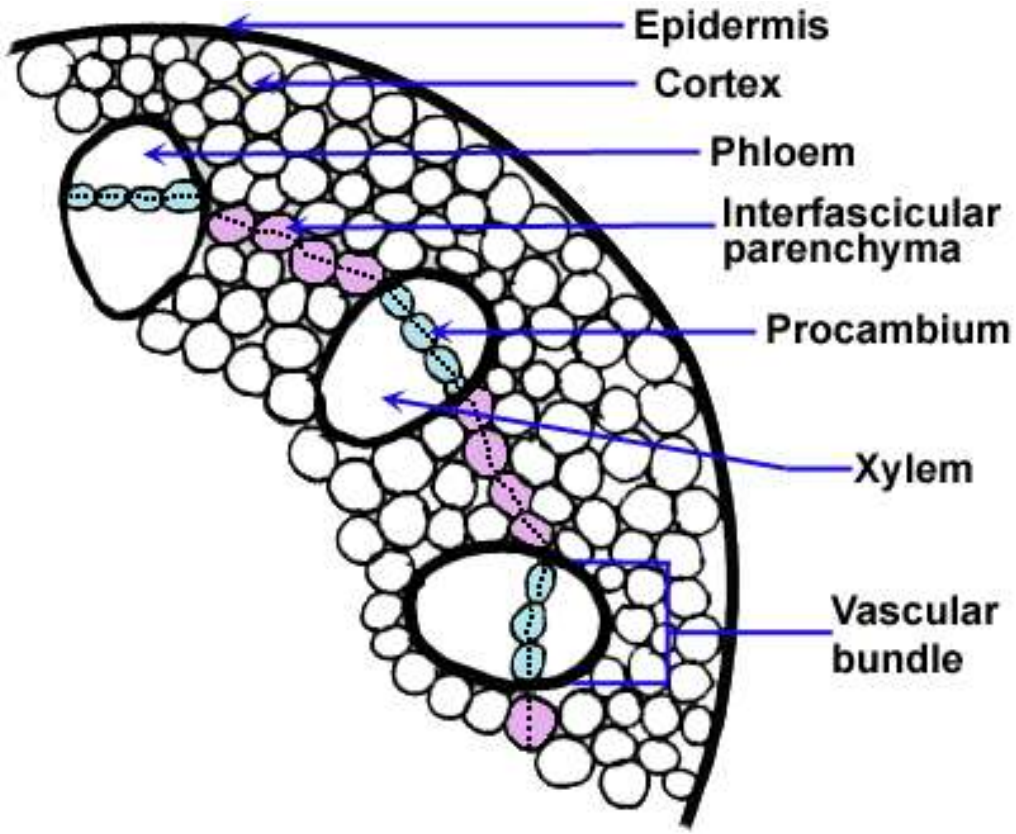
The vascular cambium - Also called just "cambium."

Theoretically a single cylindrical layer of cells

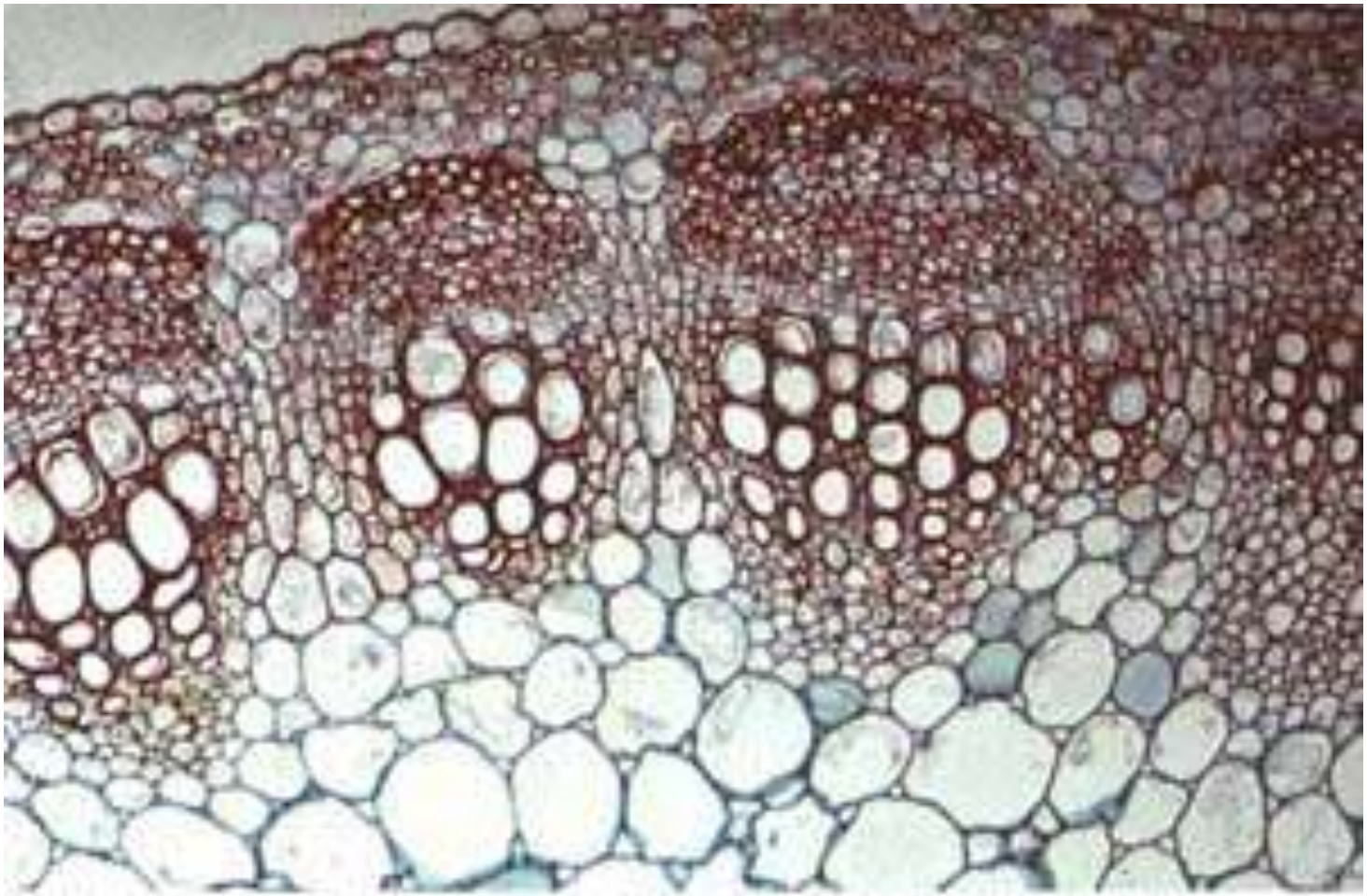
Its derivative cells mature into:

Secondary xylem. From cells produced to the inside.

Secondary phloem. From cells produced to the outside.

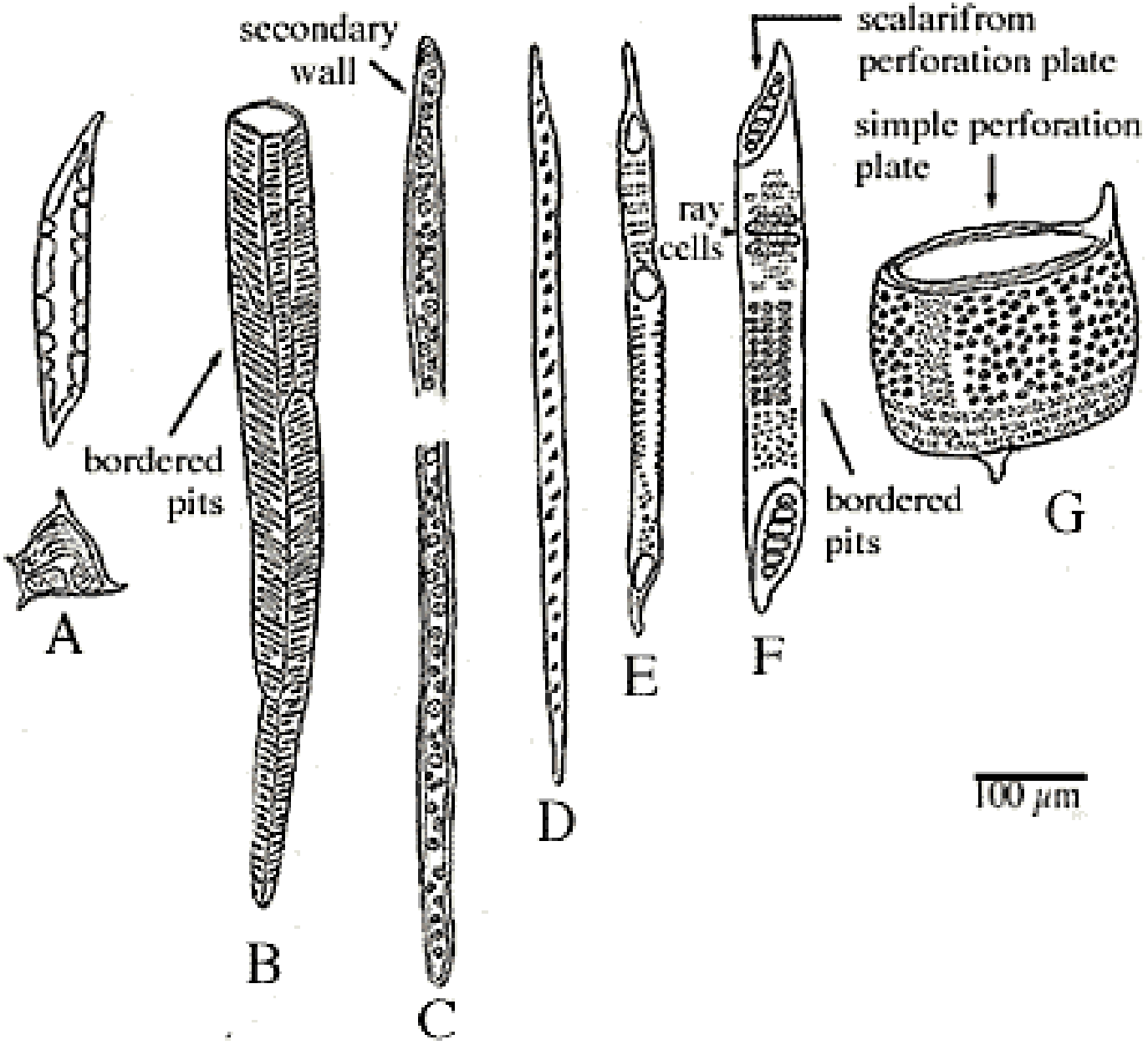


Origin of Cambium in Stems – fascicular and interfascicular

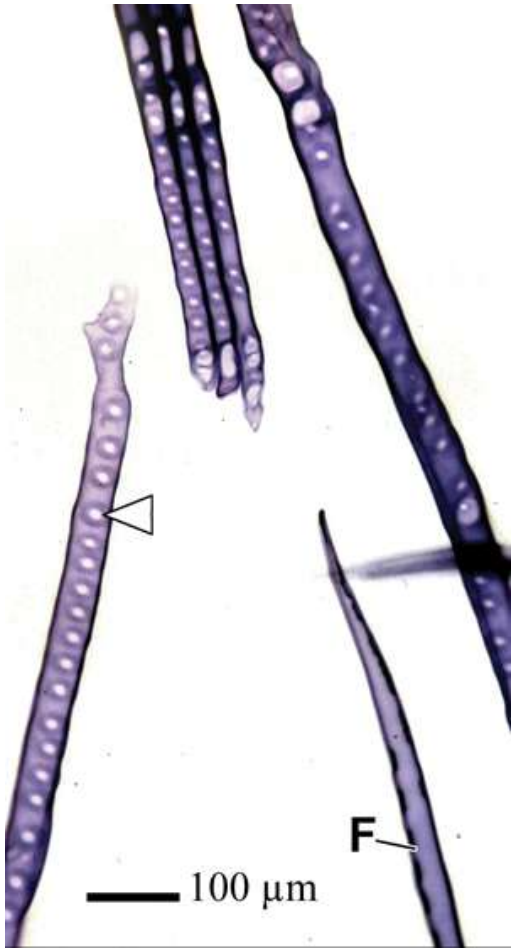


Medicago old stem cross section with fascicular and interfascicular cambia.

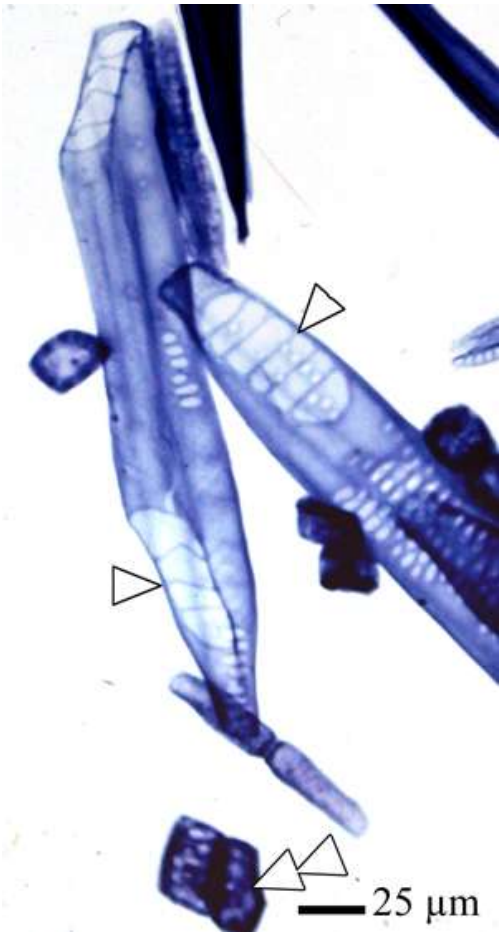
Tracheary Elements



Tracheids and Vessels



Pinus tracheids

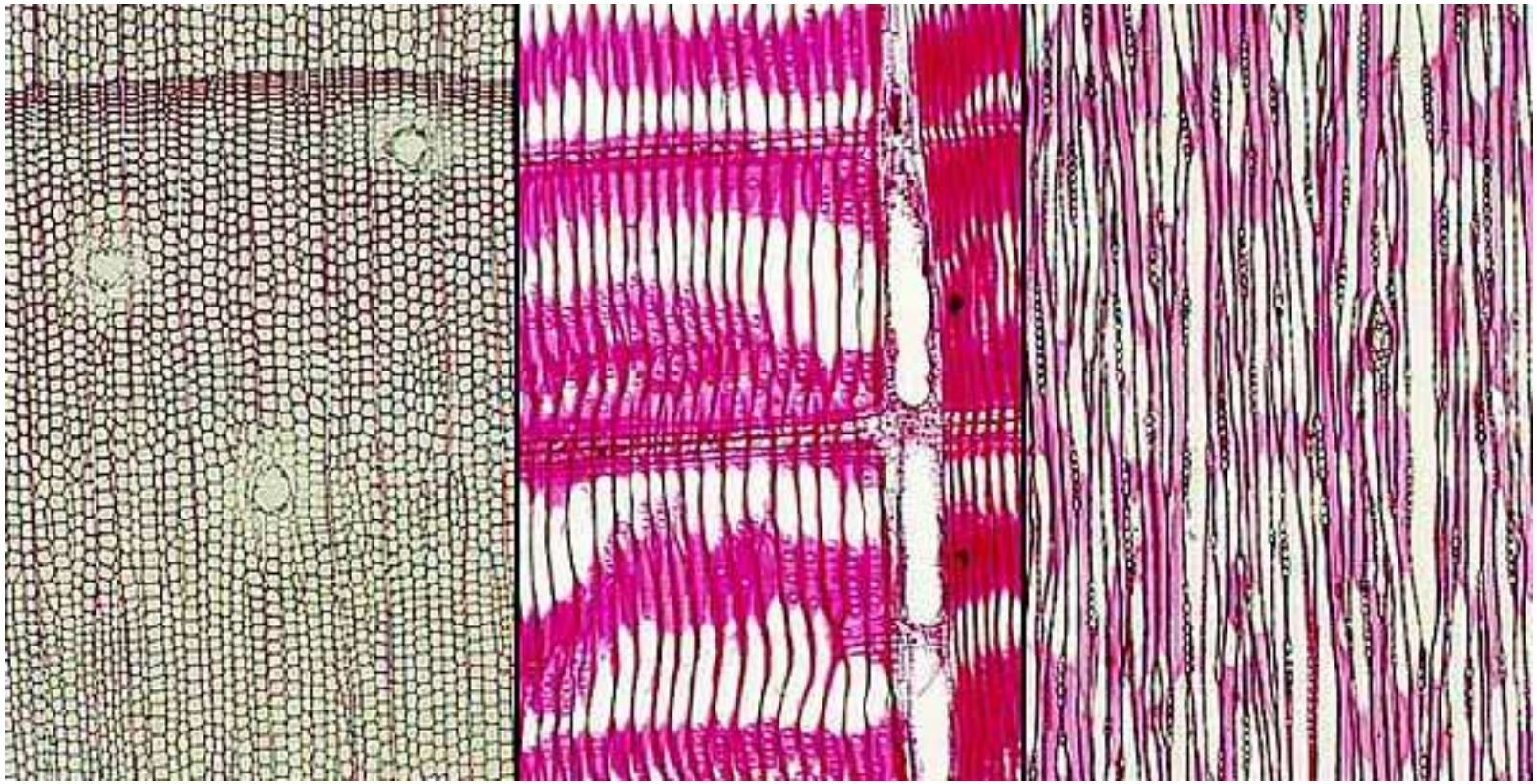


Liriodendron vessels

Quercus vessels

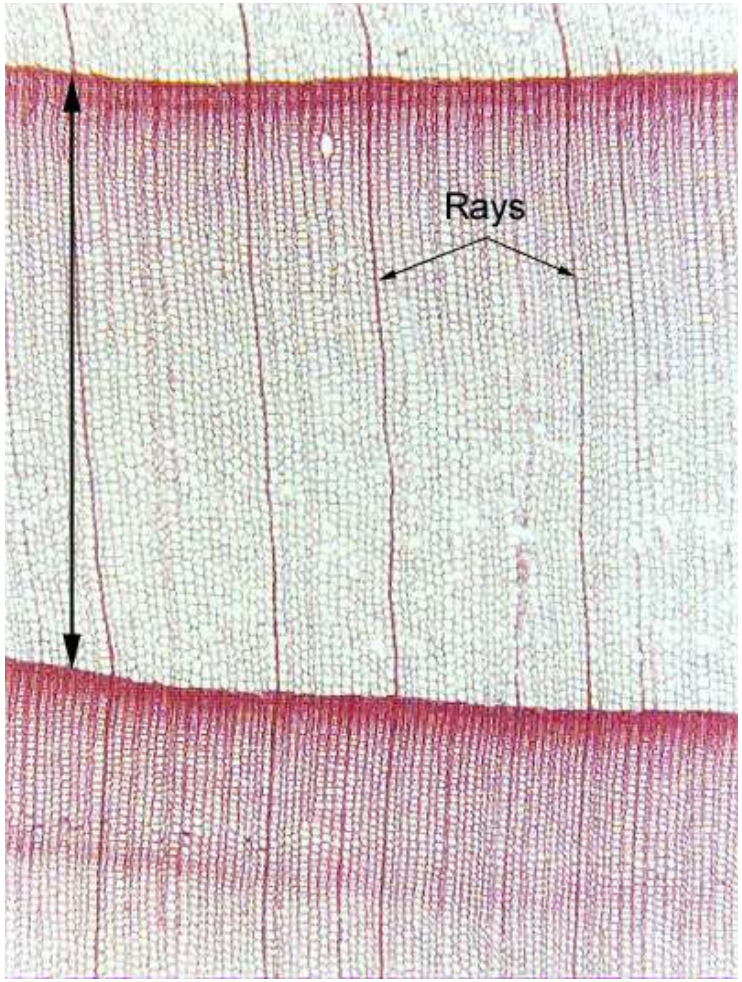
Pinus wood

Transverse Radial Tangential

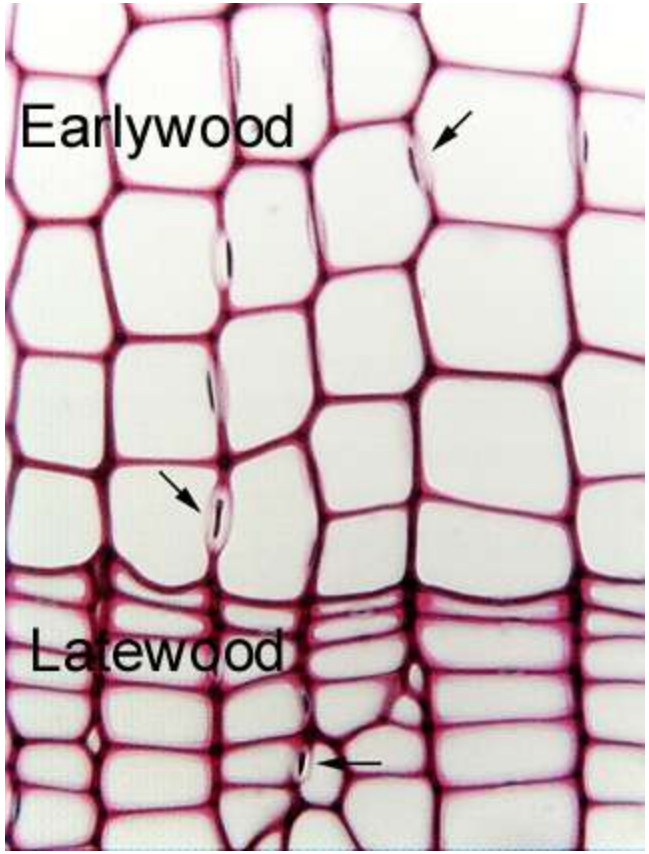


Conifer Wood

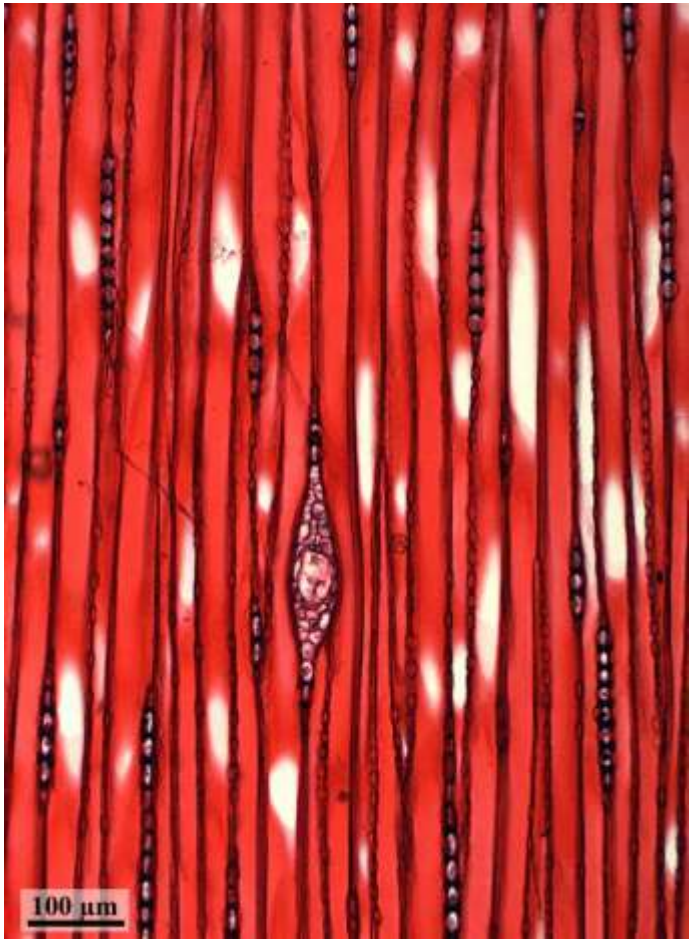
Thuja

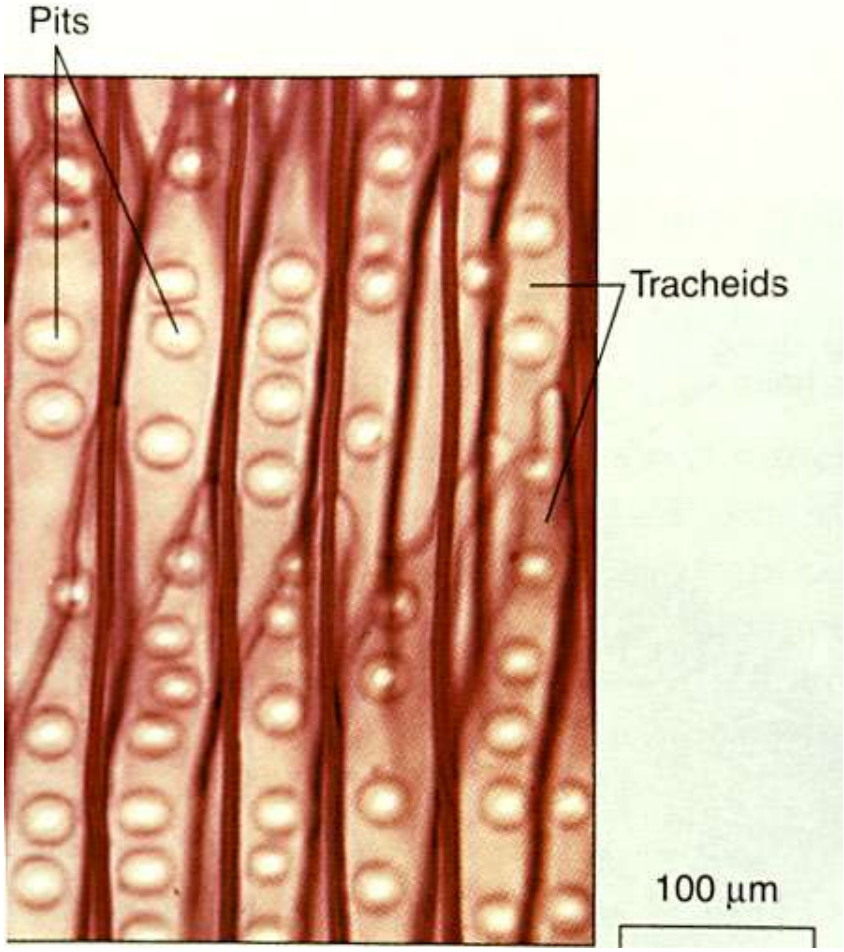


Pinus



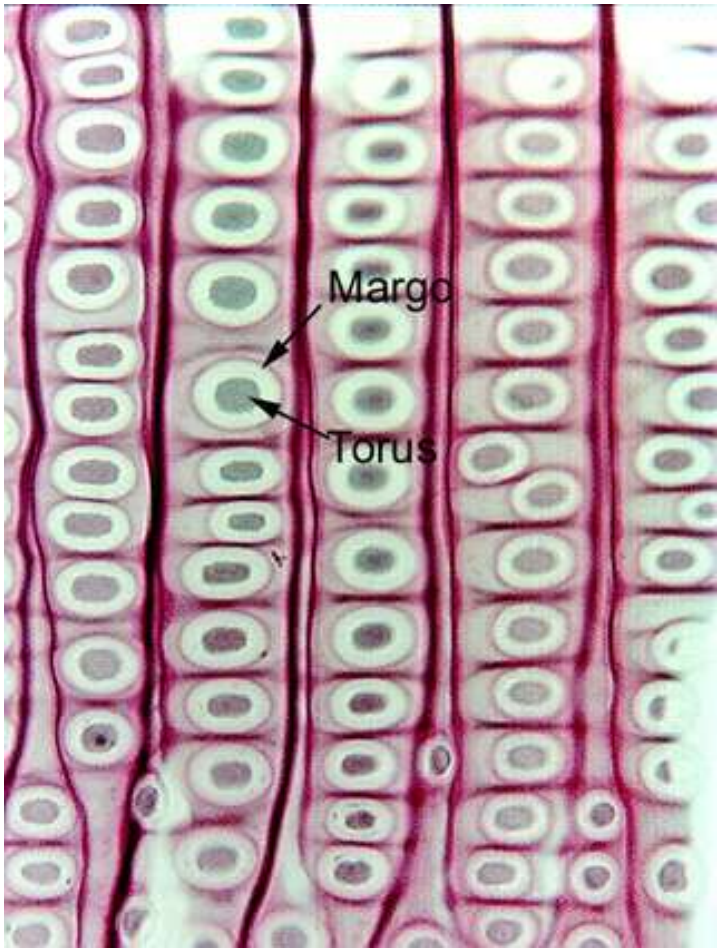
Pine - Tracheids



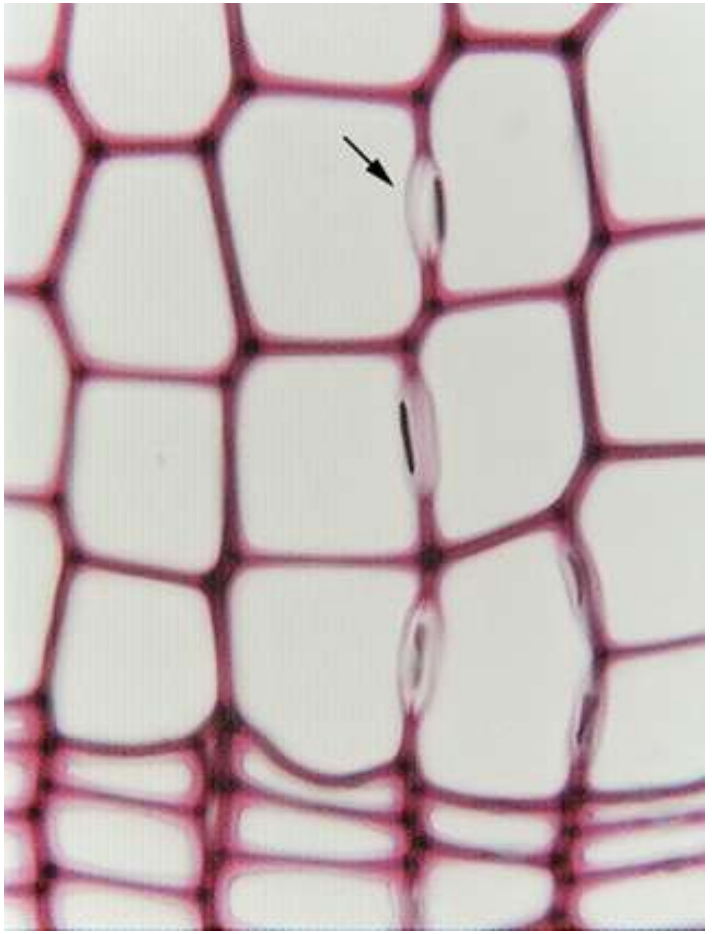


Conifers – circular bordered pits

Radial section

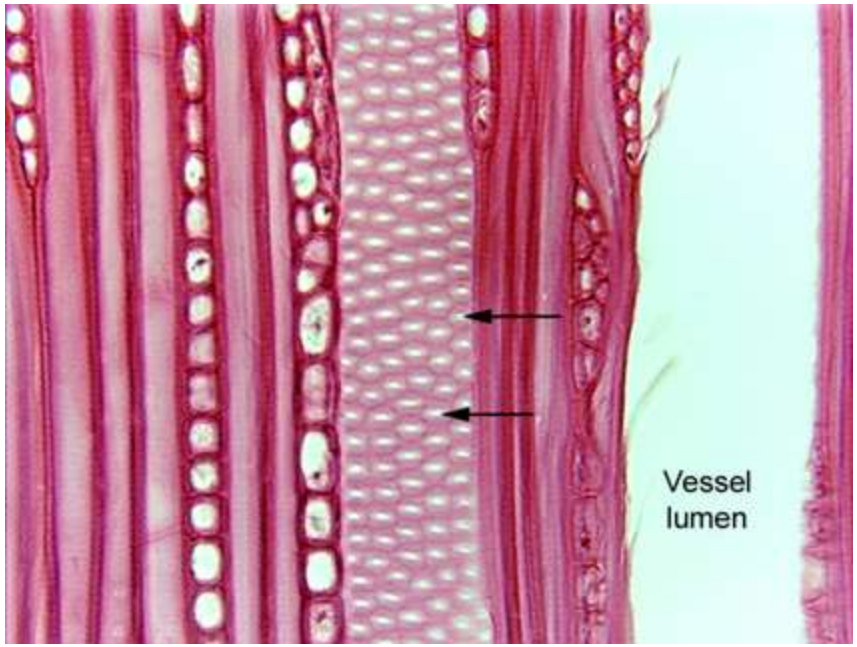


Transverse section

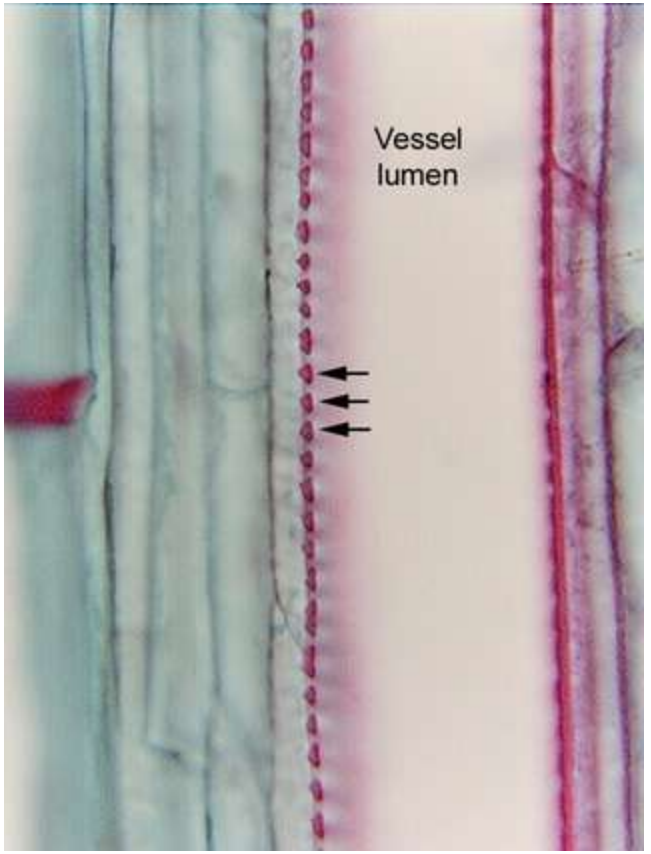


Pits in Dicots

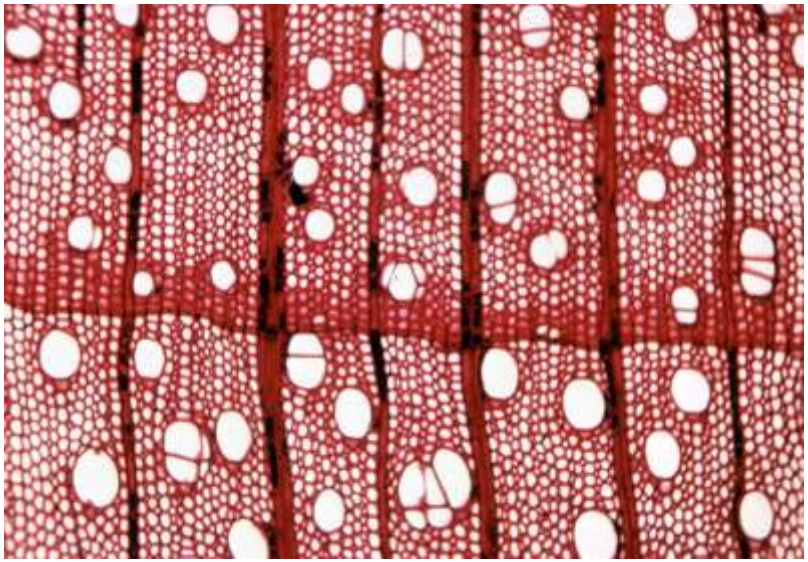
Circular bordered pits - *Carpinus*

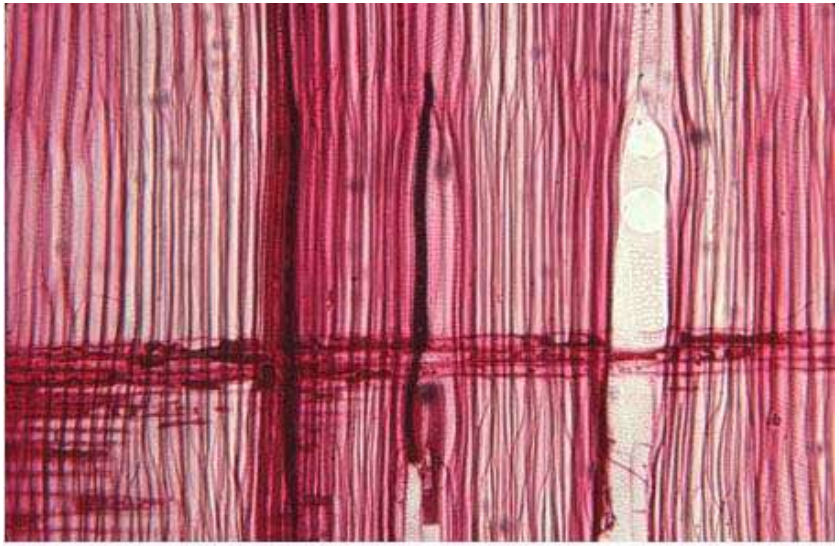


Pits side view



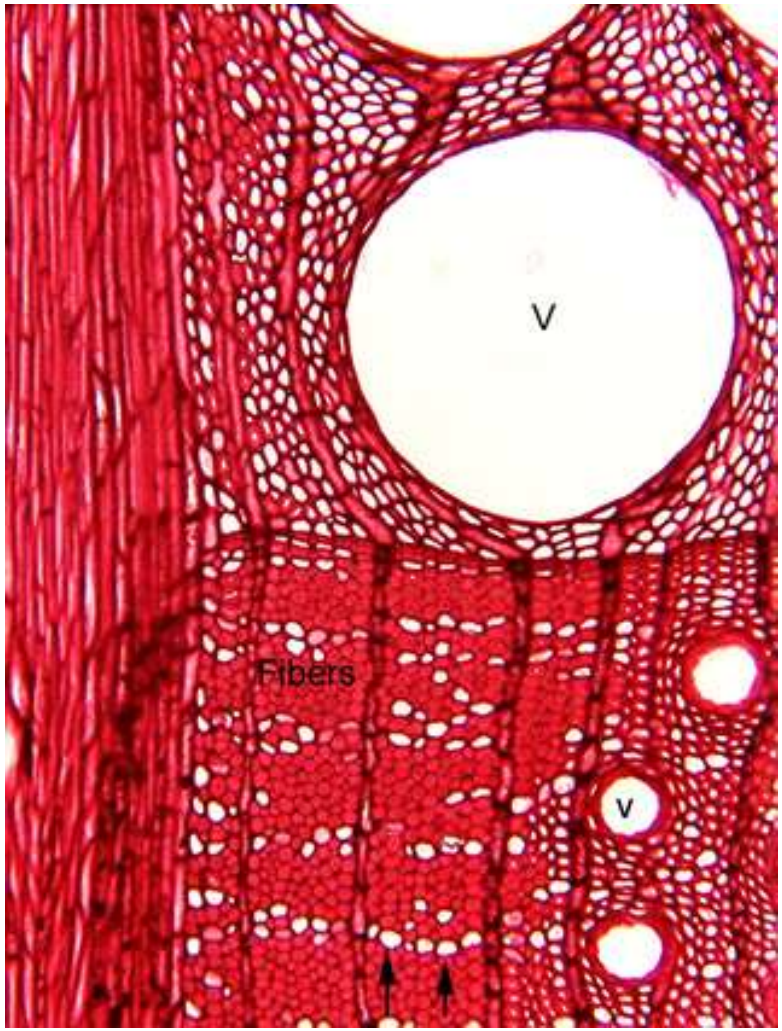
Dicot Wood - Acer

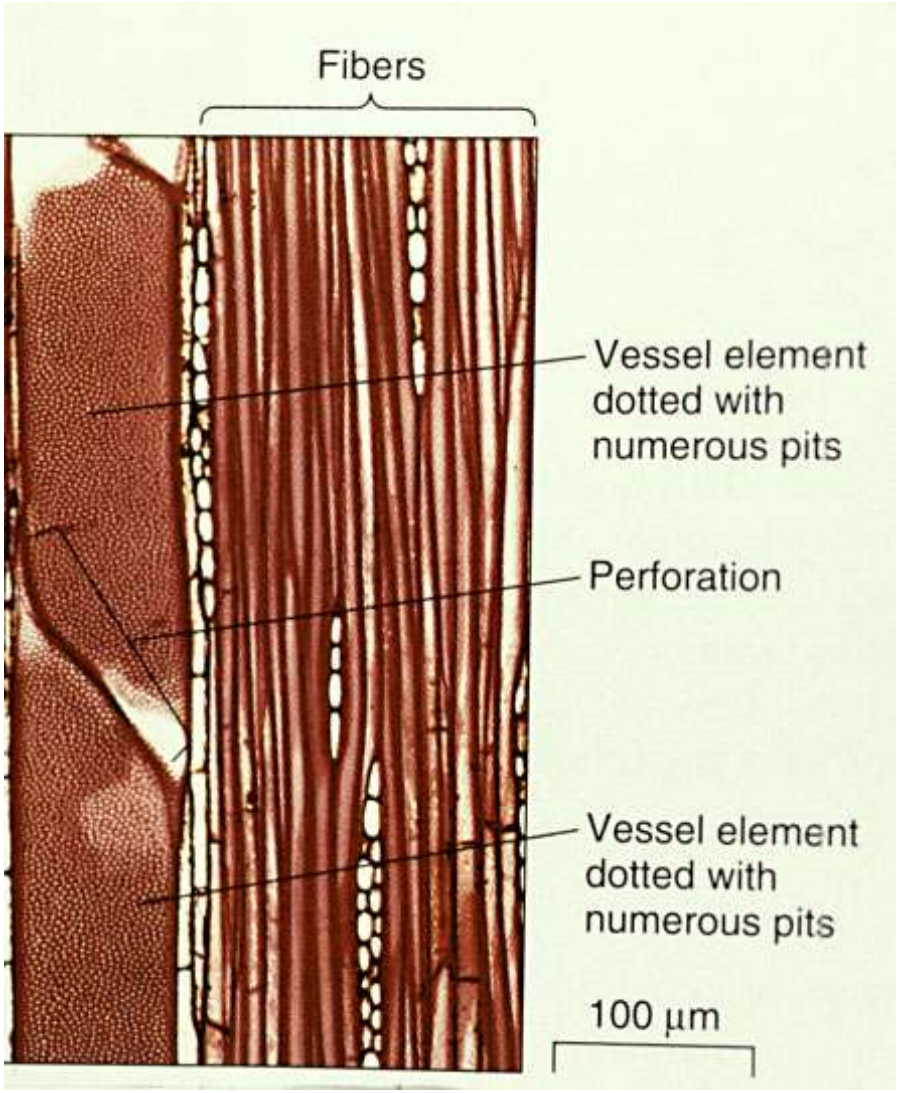




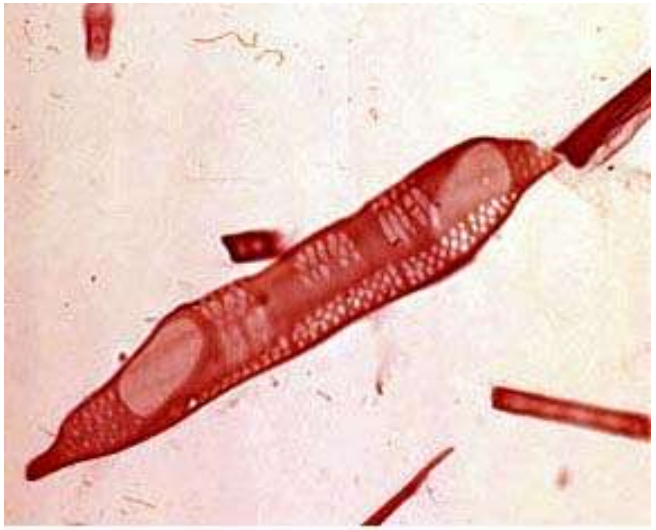
Acer wood radial section.

Vessels

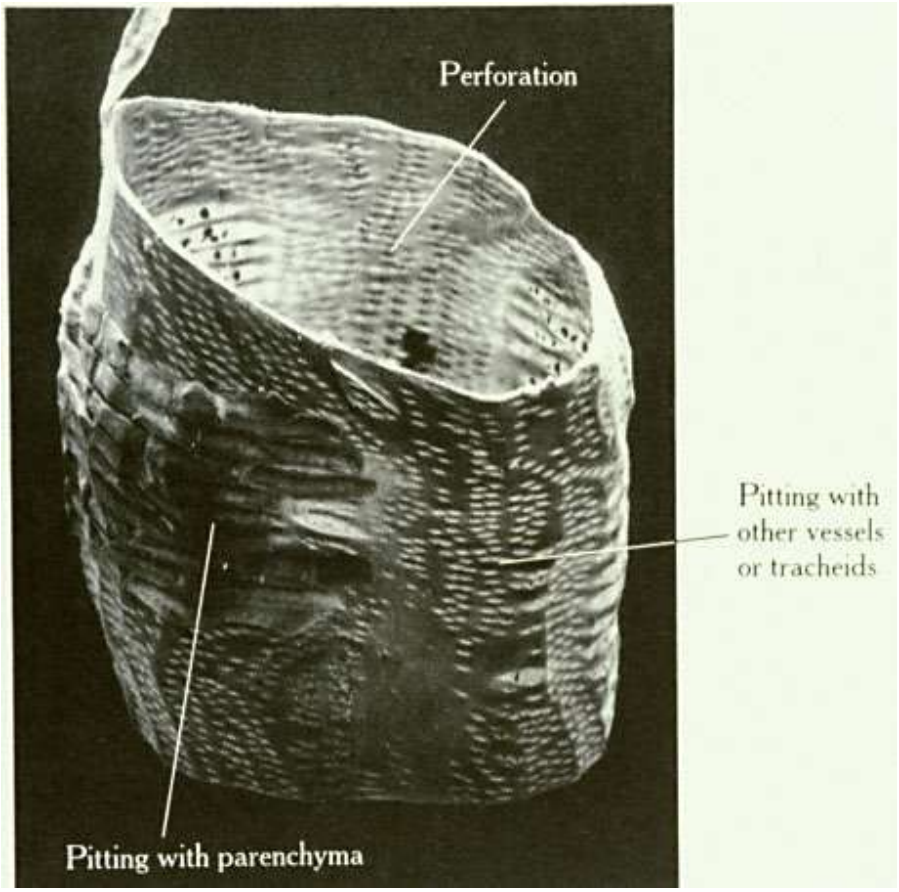

V
Fibers
v


Fibers
Vessel element dotted with numerous pits
Perforation
Vessel element dotted with numerous pits
100 µm

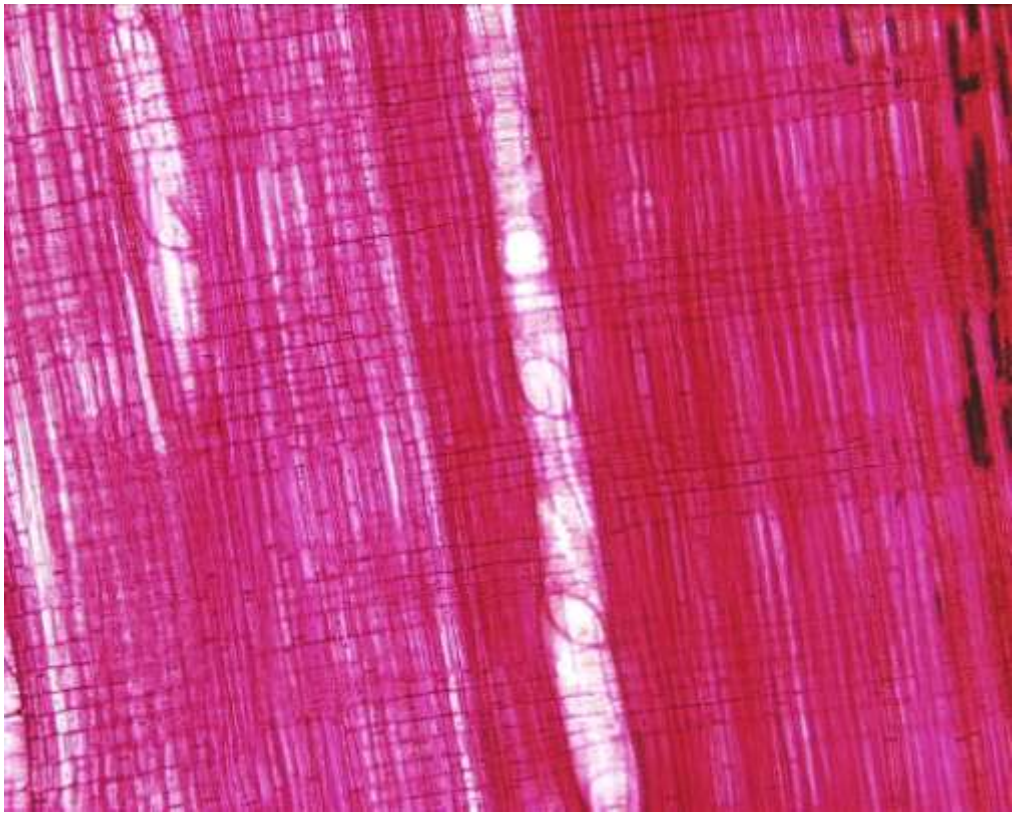
Vessel elements with perforation plates

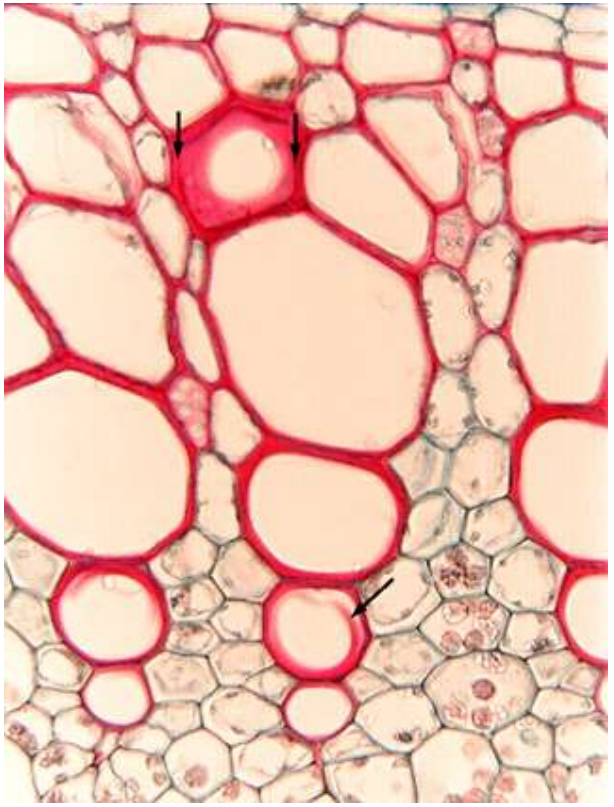


Salix vessel.



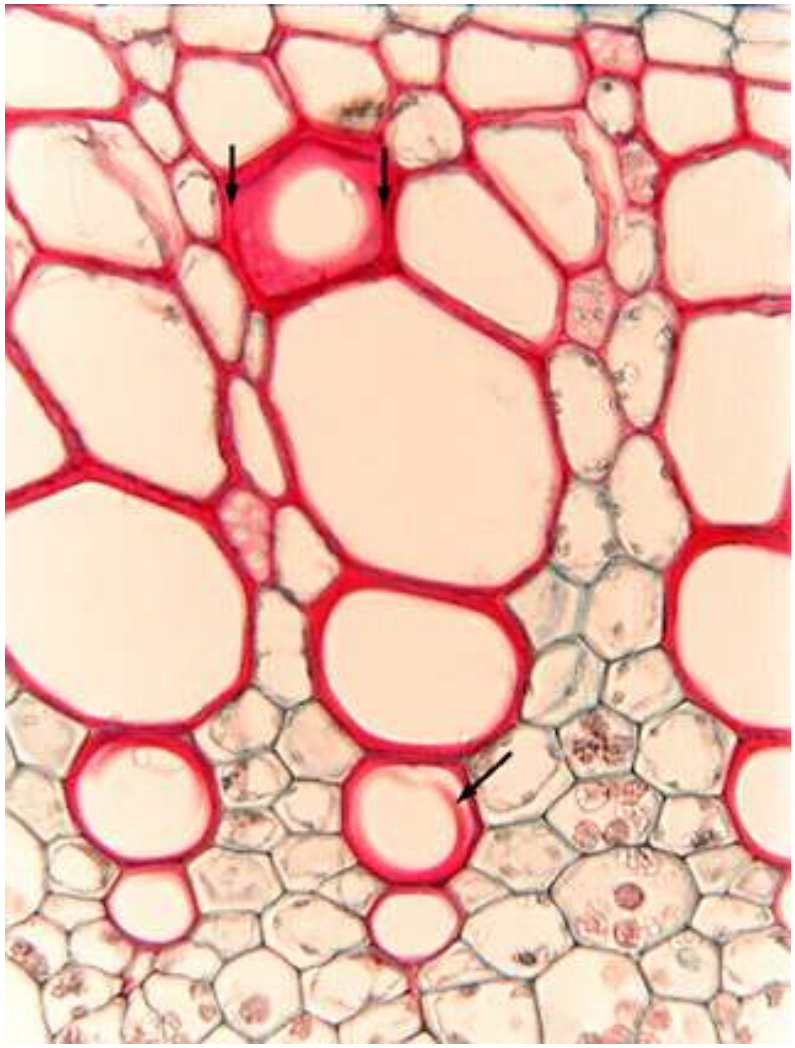
Vessels – simple perforation plates

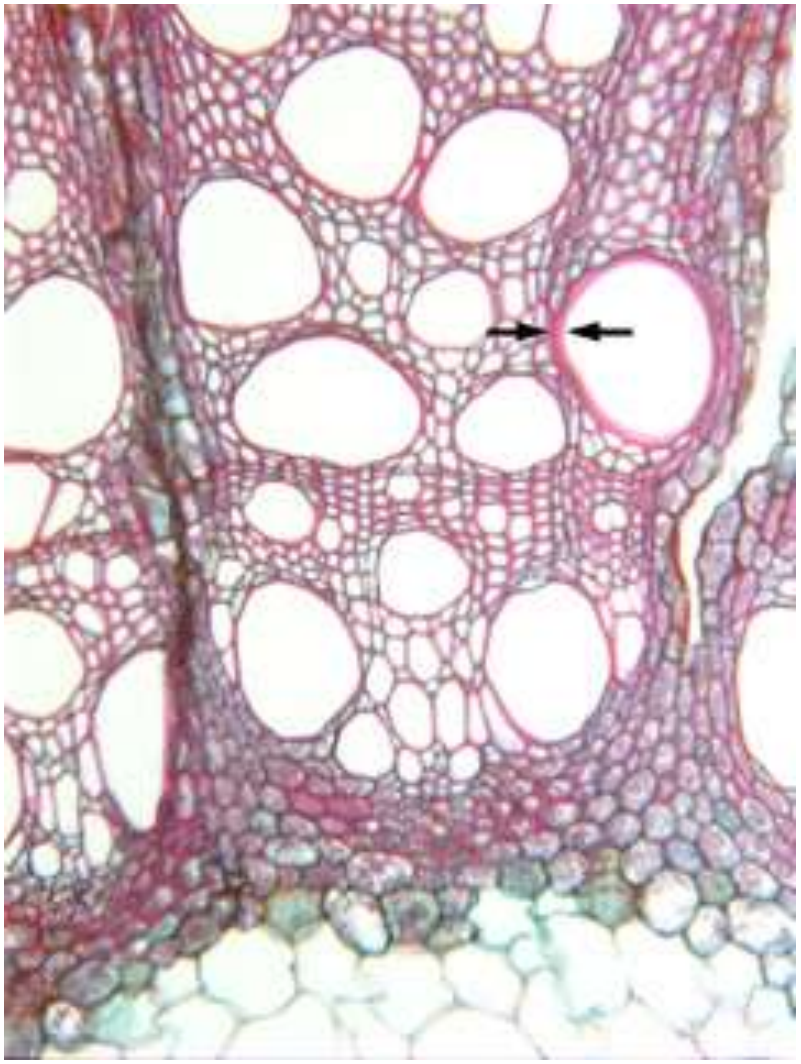




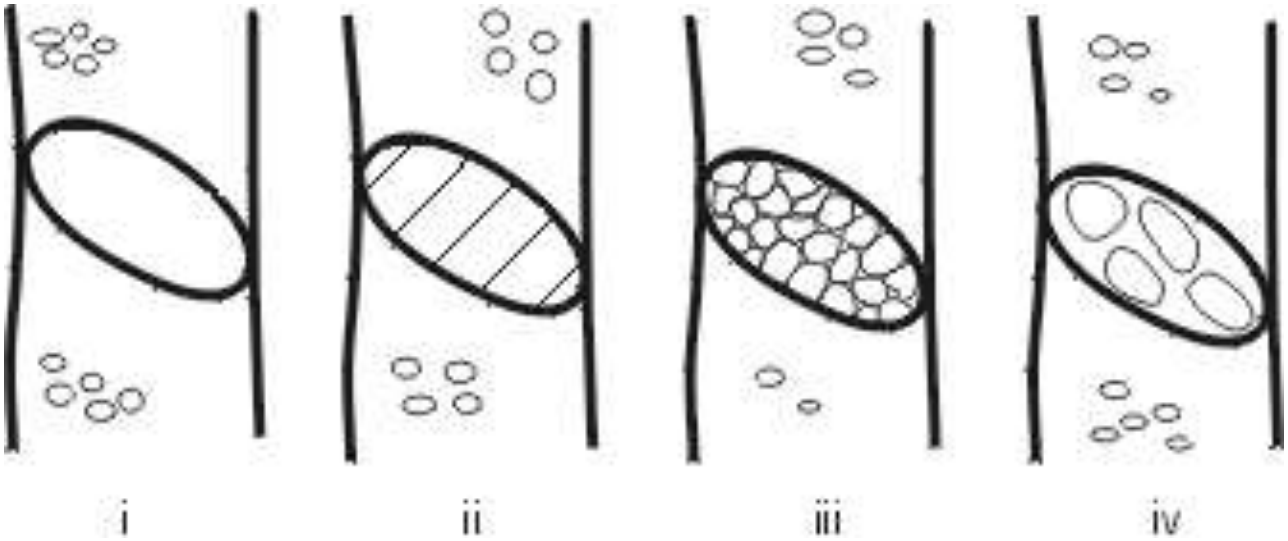
Juglans

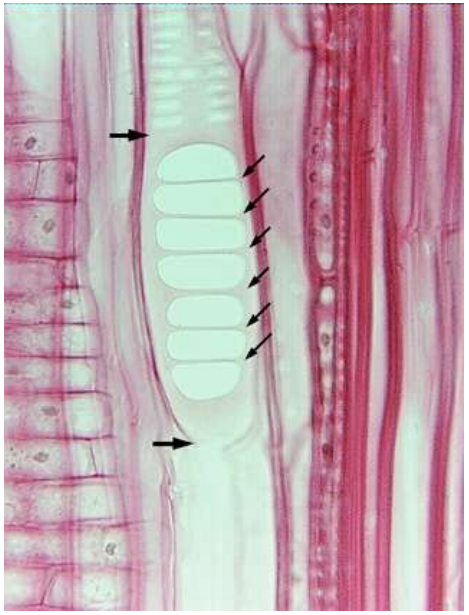
Simple Perforation



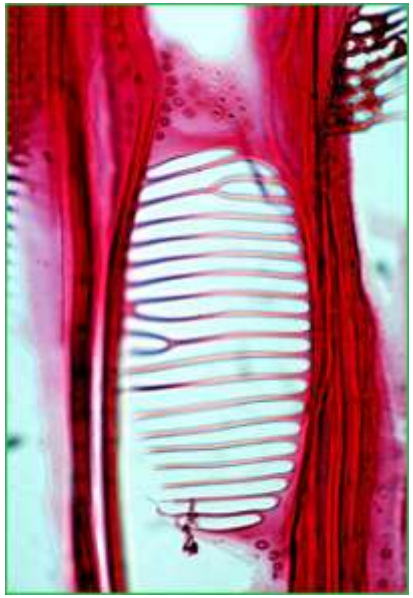


Perforation Plates



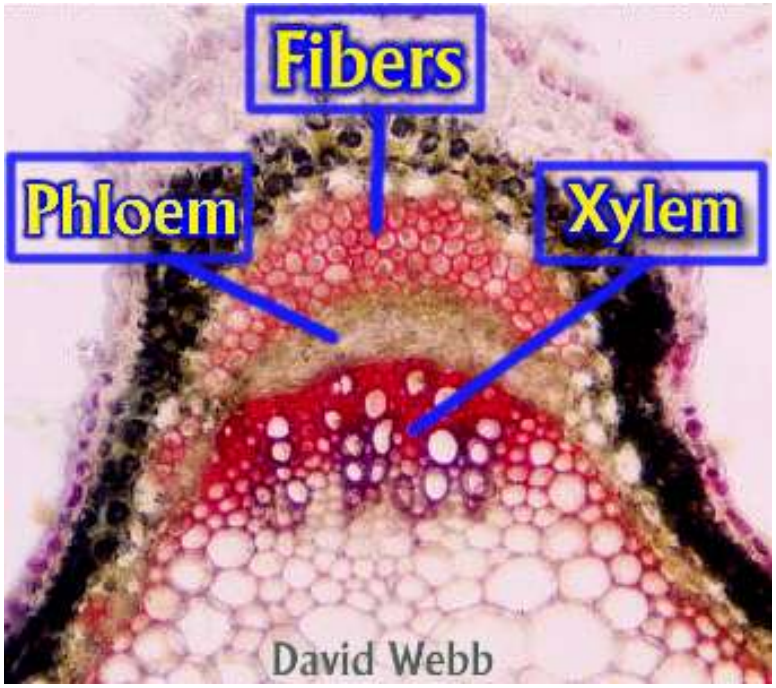


Magnolia tripetala

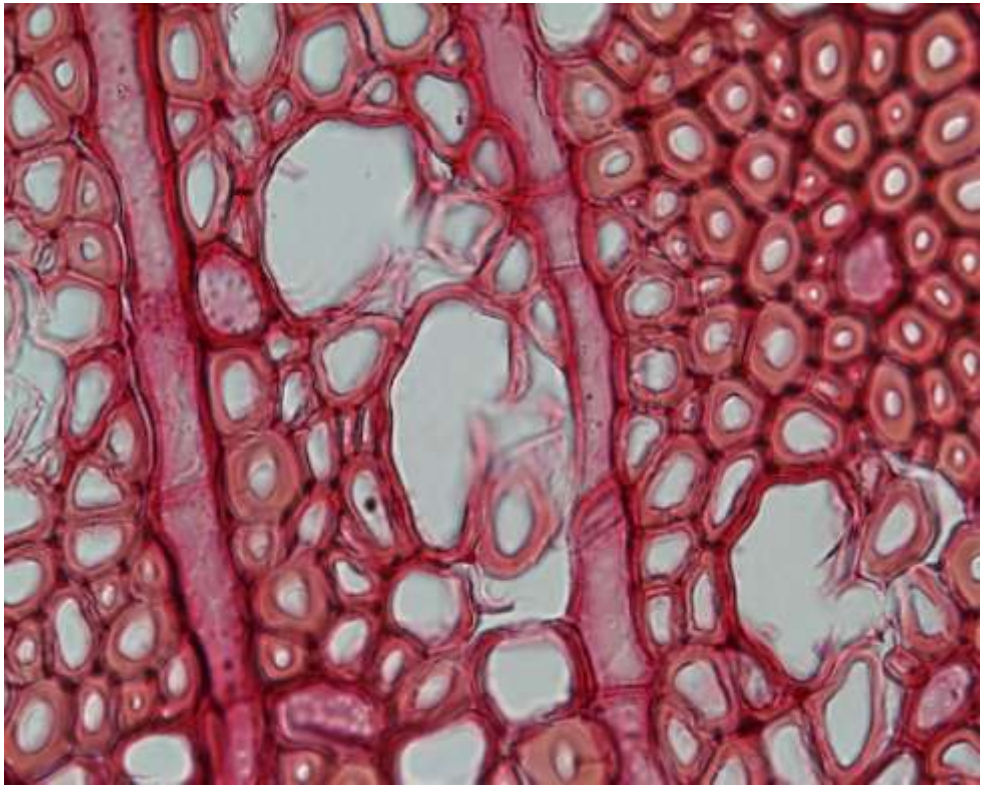


Alnus

Fibers



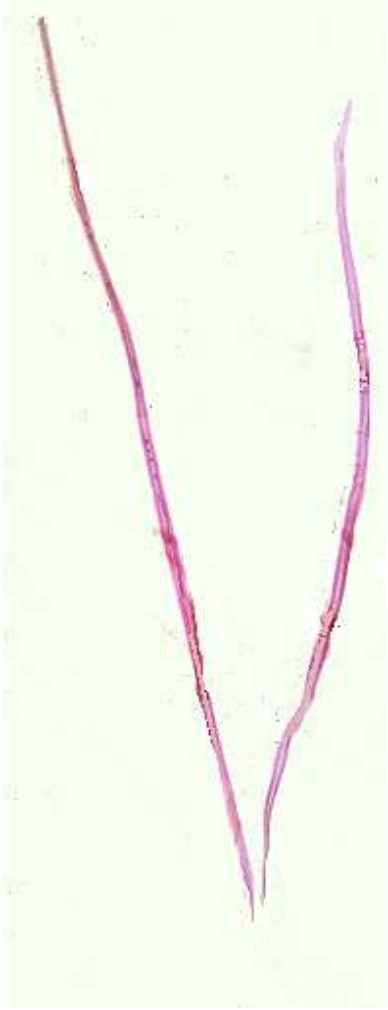
Coleus



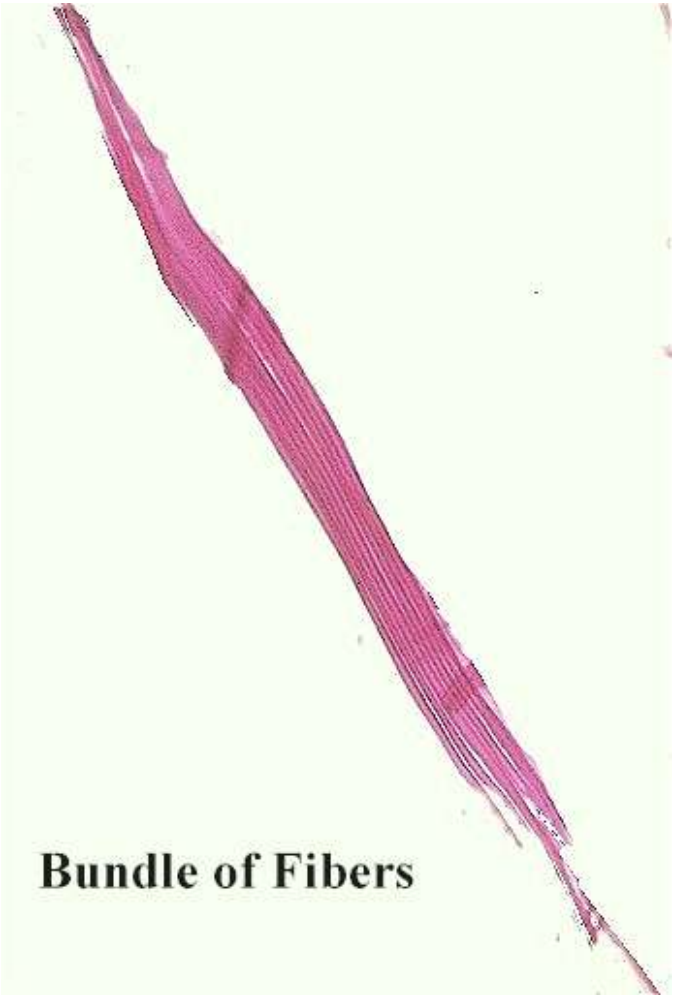
Quercus wood

Fibers - long cells with secondary walls, commonly lignified

Individual Fibers



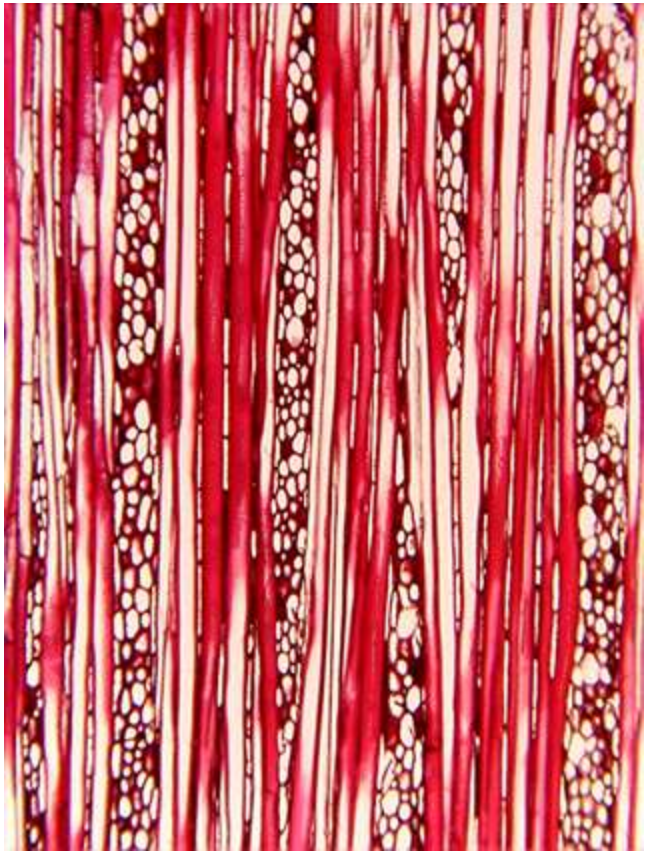
Bundle of Fibers



Vessel with Fibers

Fibers

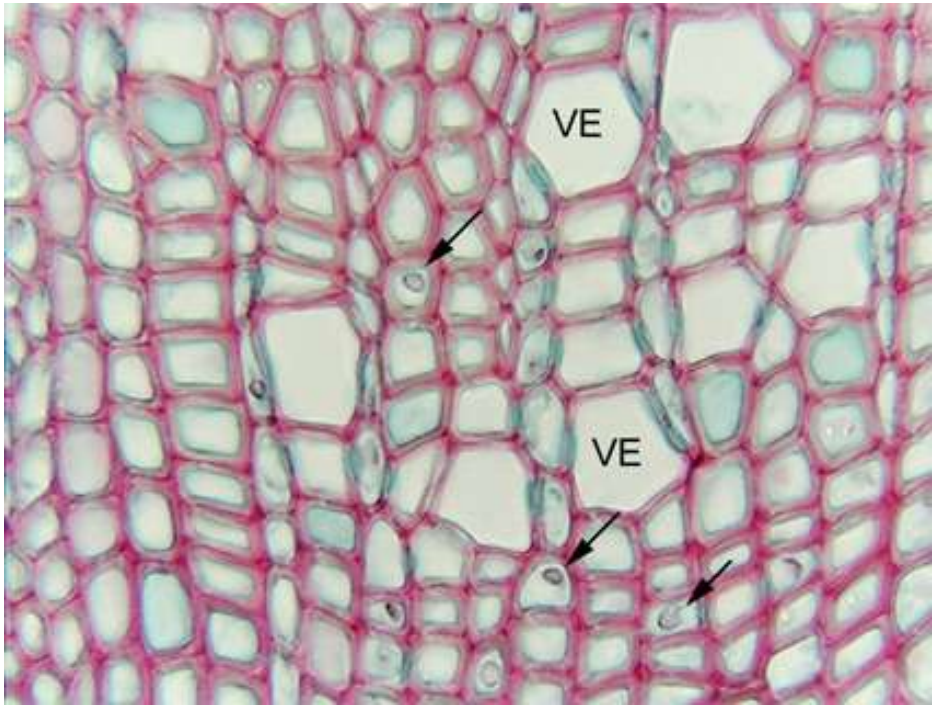
Zygogynum – libriform fibers



Boxelder maceration – libriform fiber

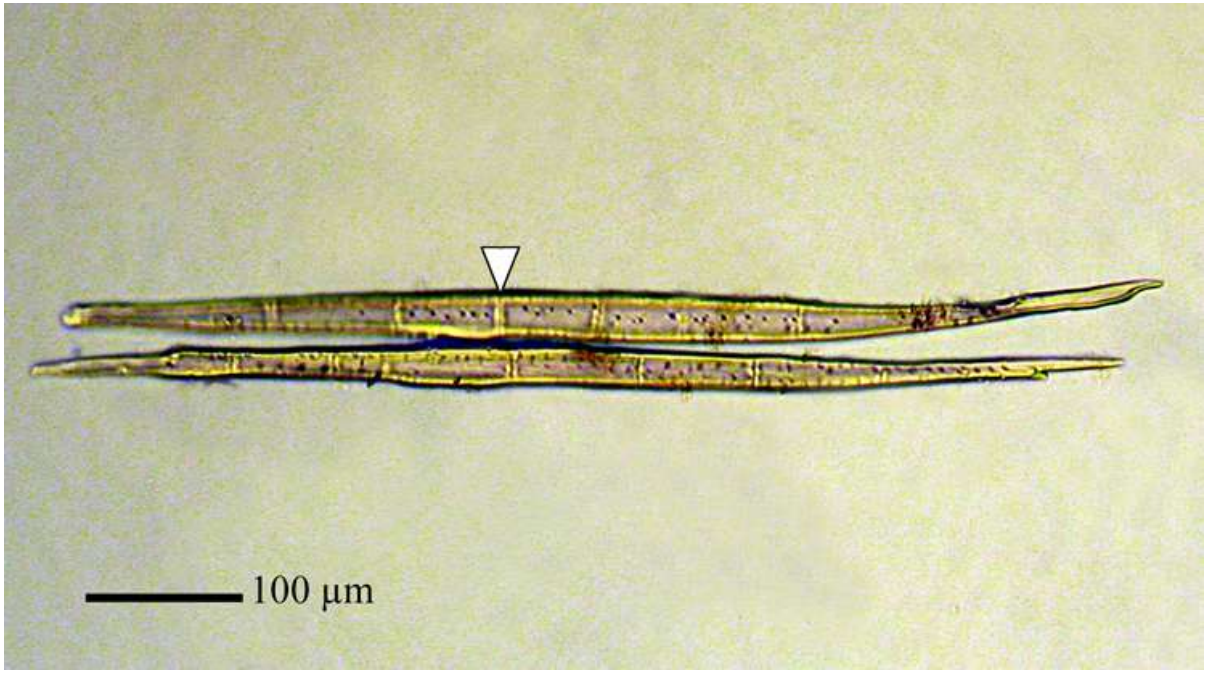
Fibers

Ivy – living fibers, septa

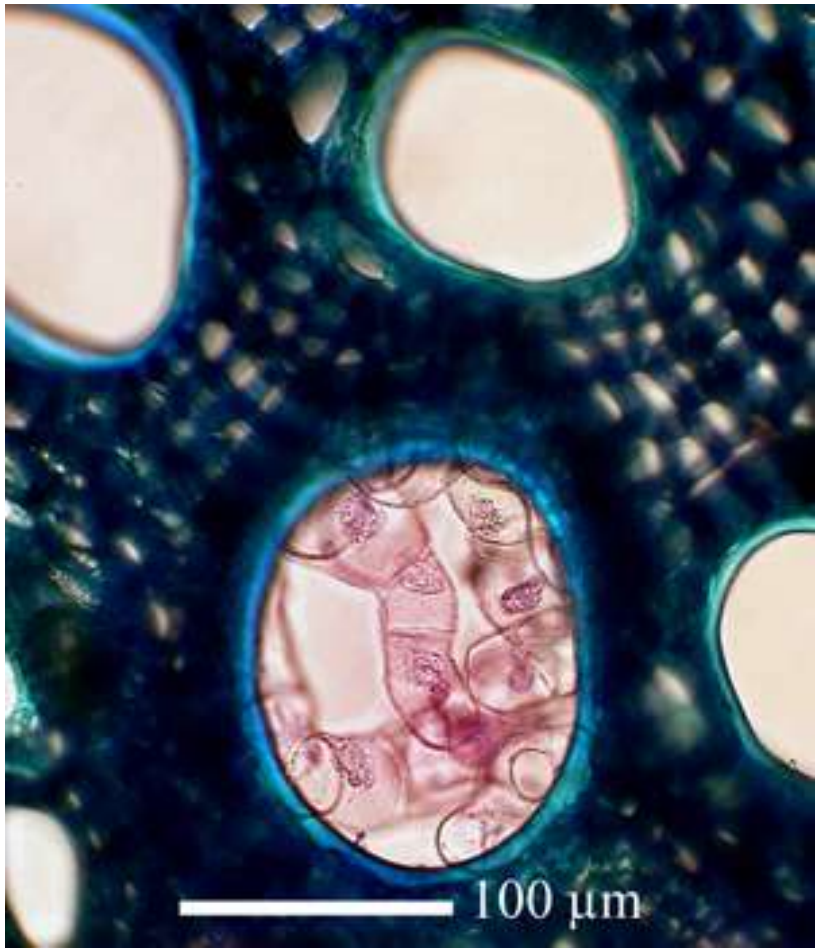


Poa – leaf fibers

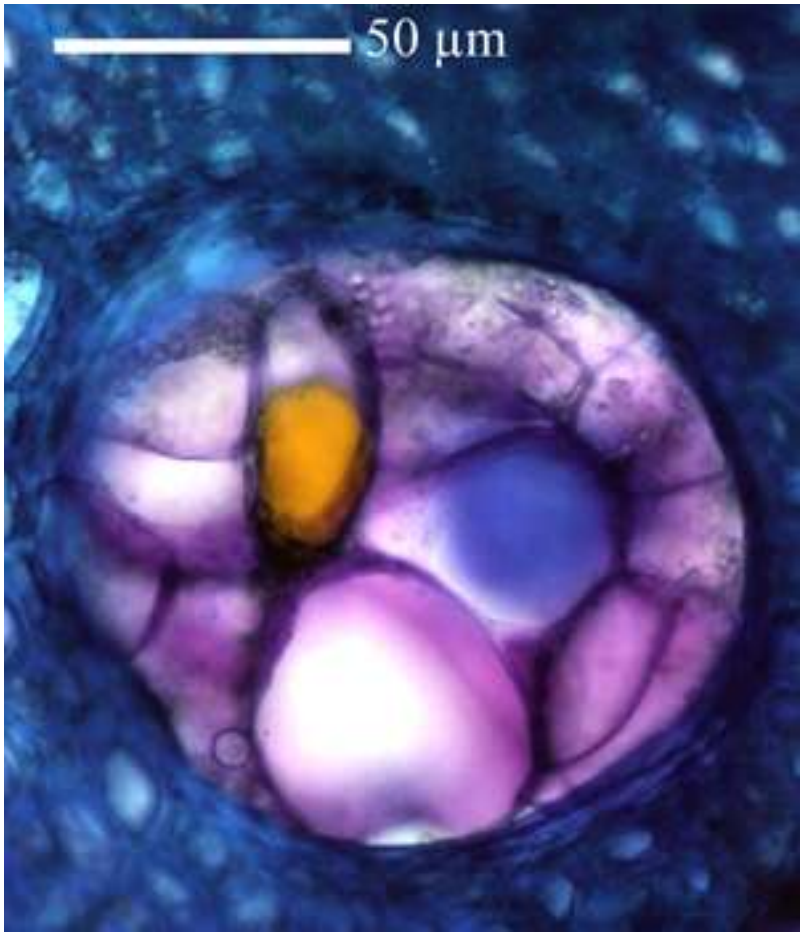
Septate Fibers - Vitis



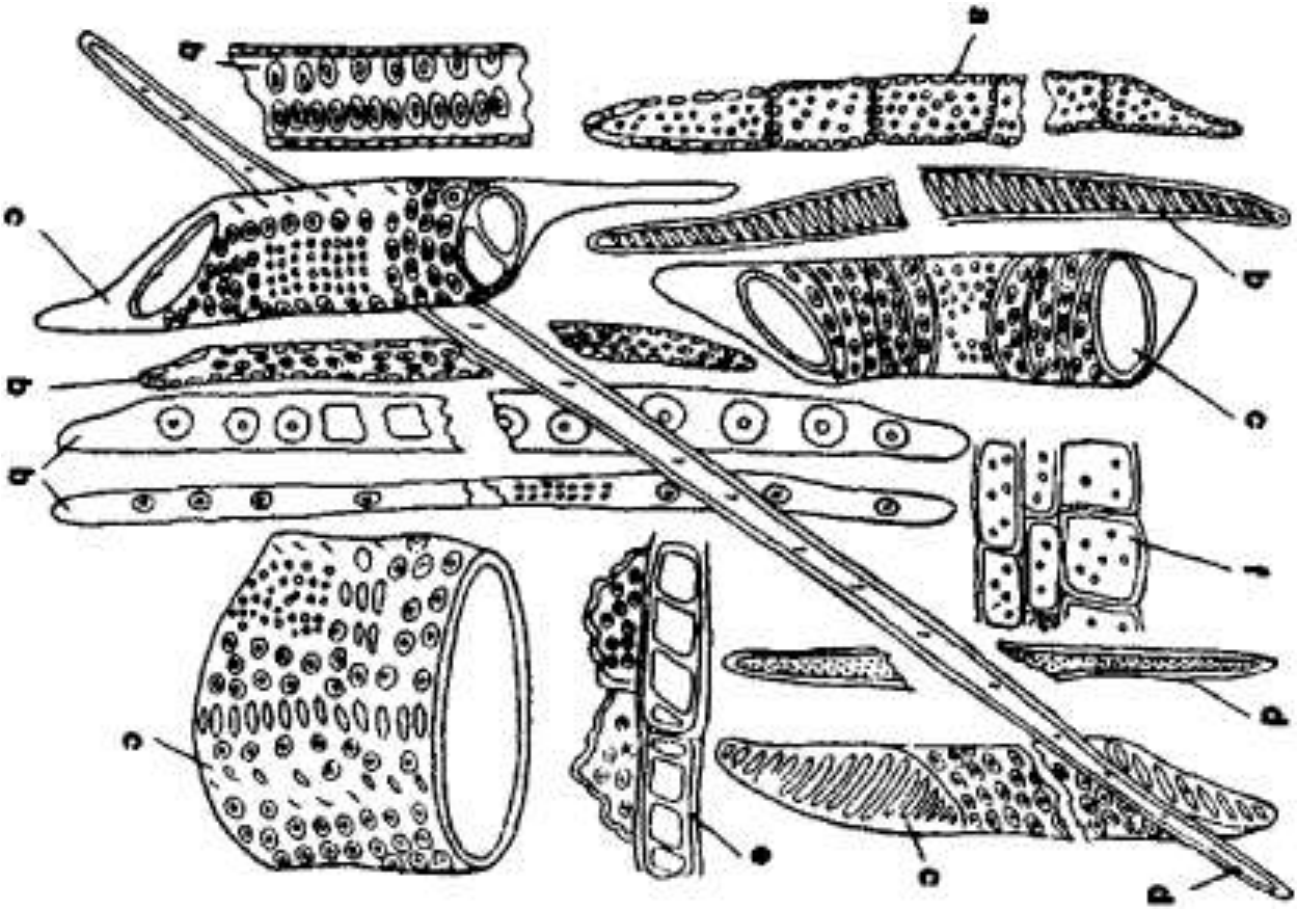
Tyloses – parenchyma cells that invade lumen of tracheary elements



Ipomoea purpurea



Aristolochia durior


a
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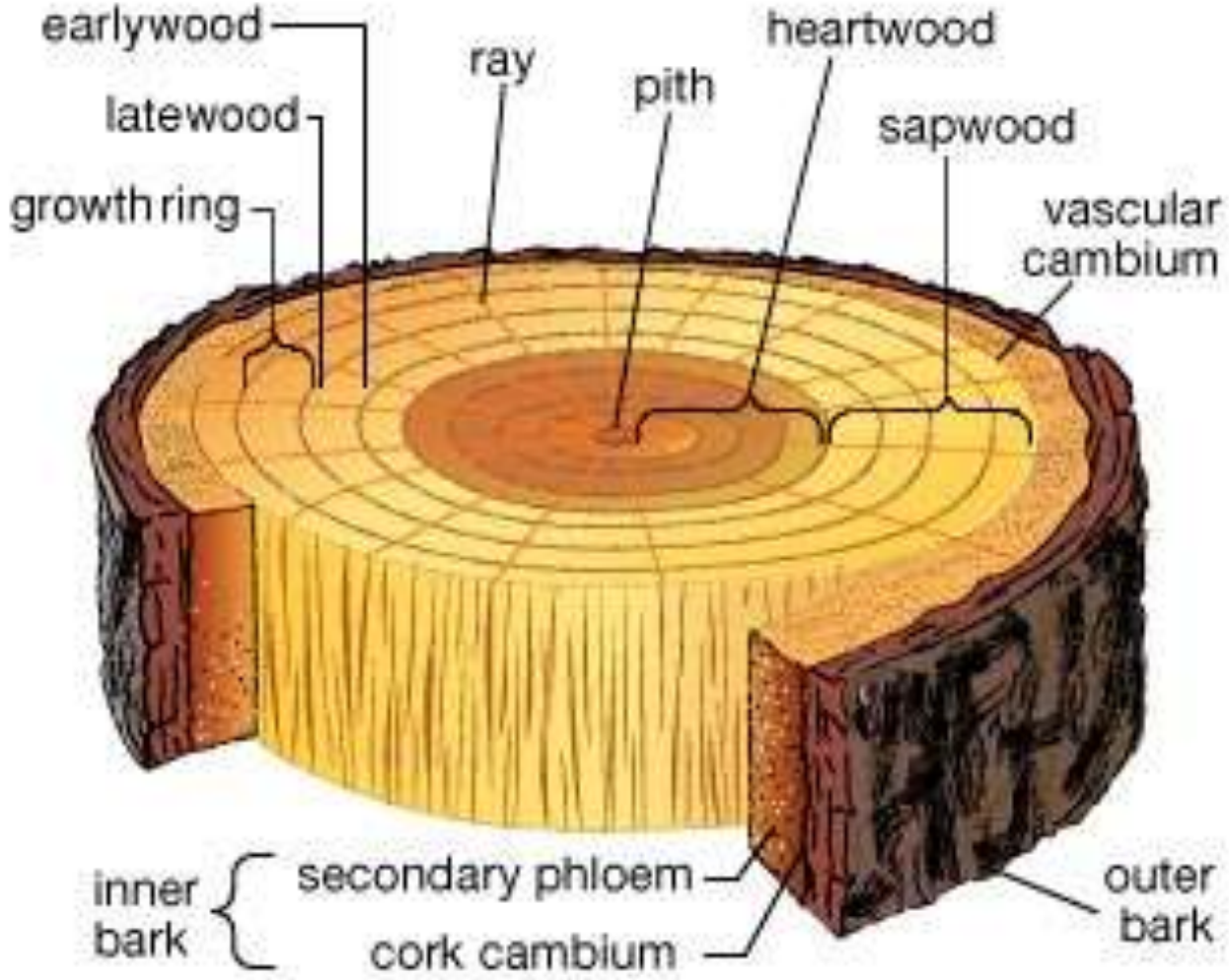
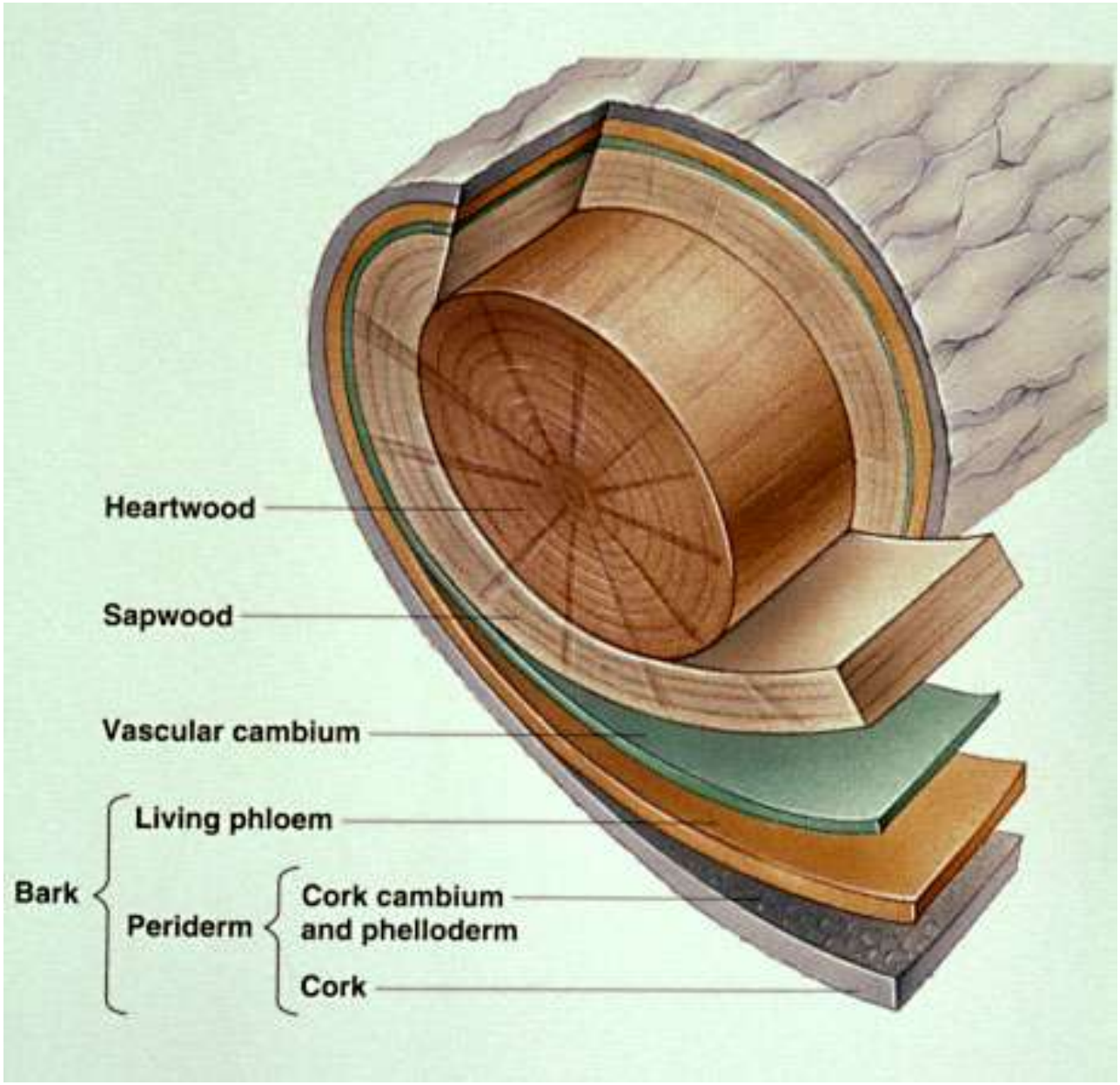
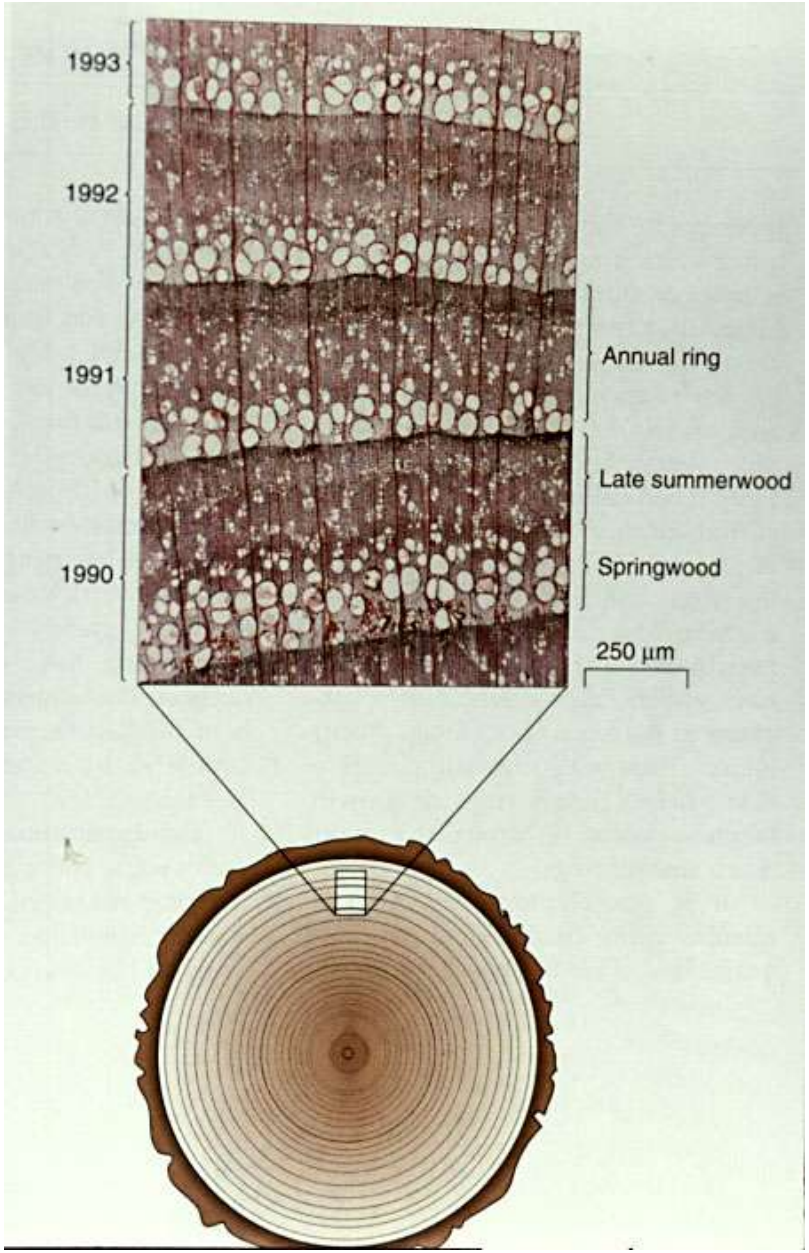


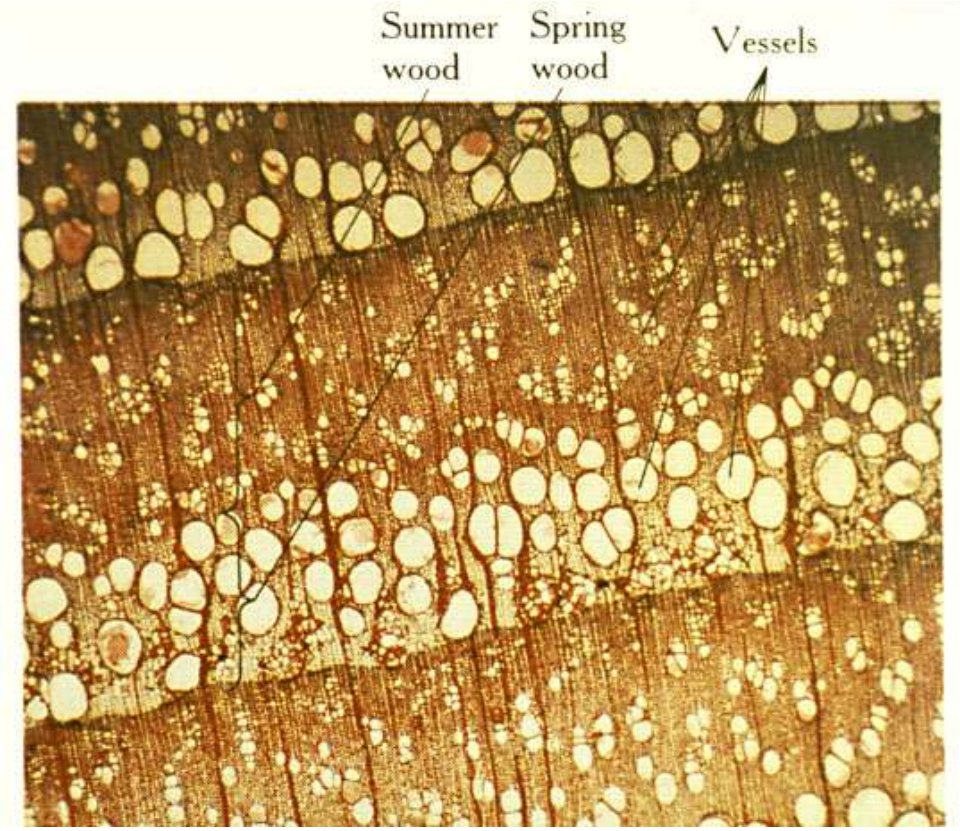

Heartwood
Sapwood
Vascular cambium
Bark
Living phloem
Periderm
Cork cambium and phelloderm
Cork

Growth Rings

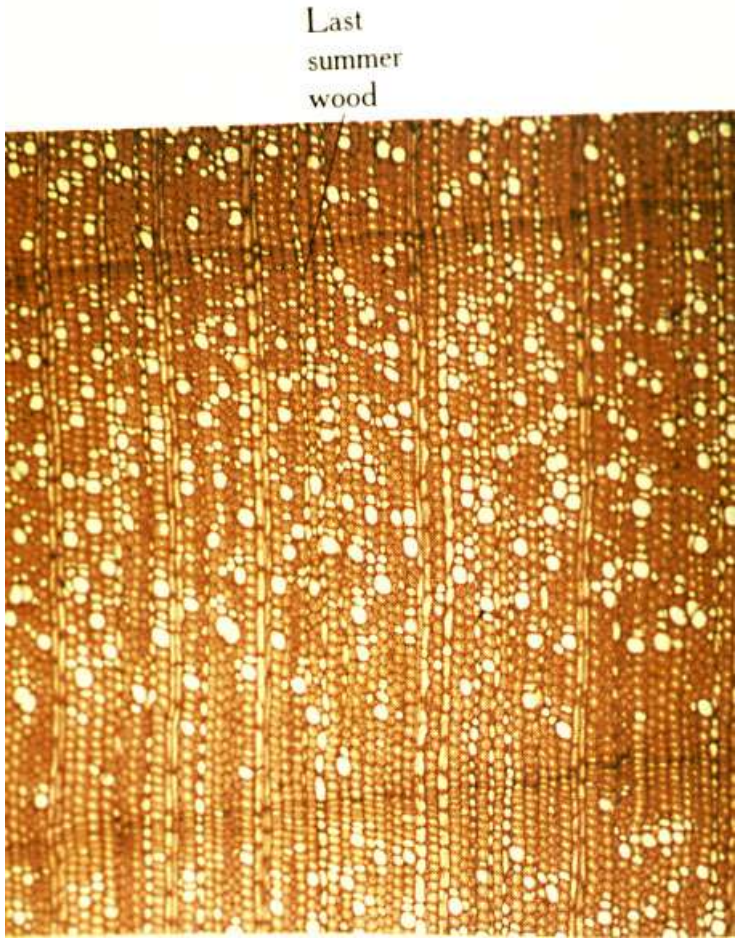


Growth Rings

Ring Porous

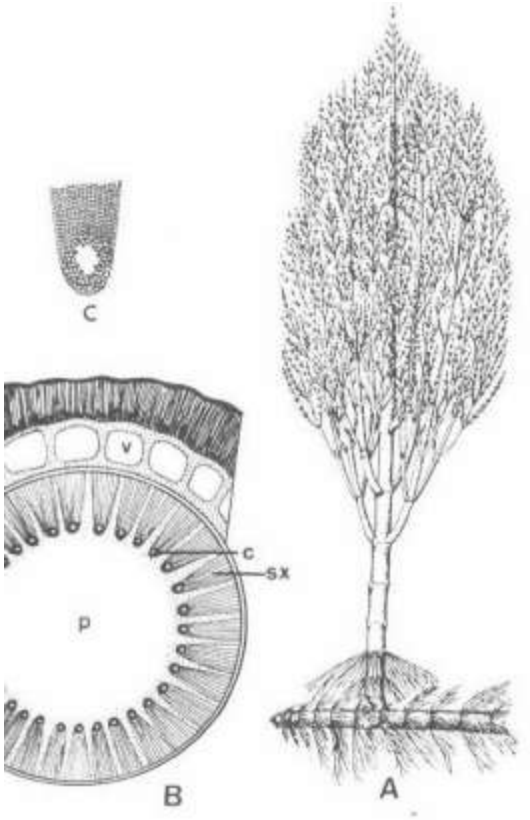


Diffuse Porous



Lycopods - *Lepidodendron*

Horsetails - *Calamites*

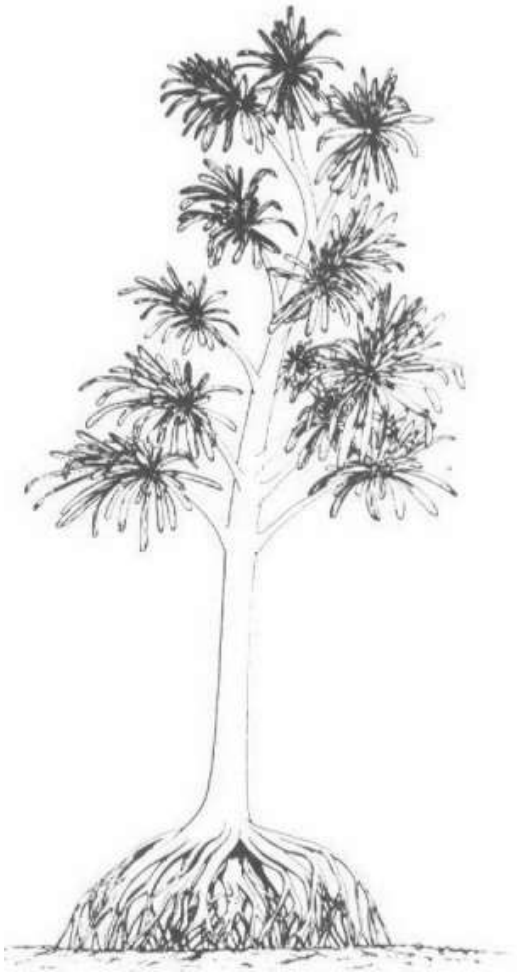


Tree Ferns - *Psaronius*

Seed Ferns - *Medullosa*

Early Conifers - appear in late Carboniferous

Cordaites



Voltzia