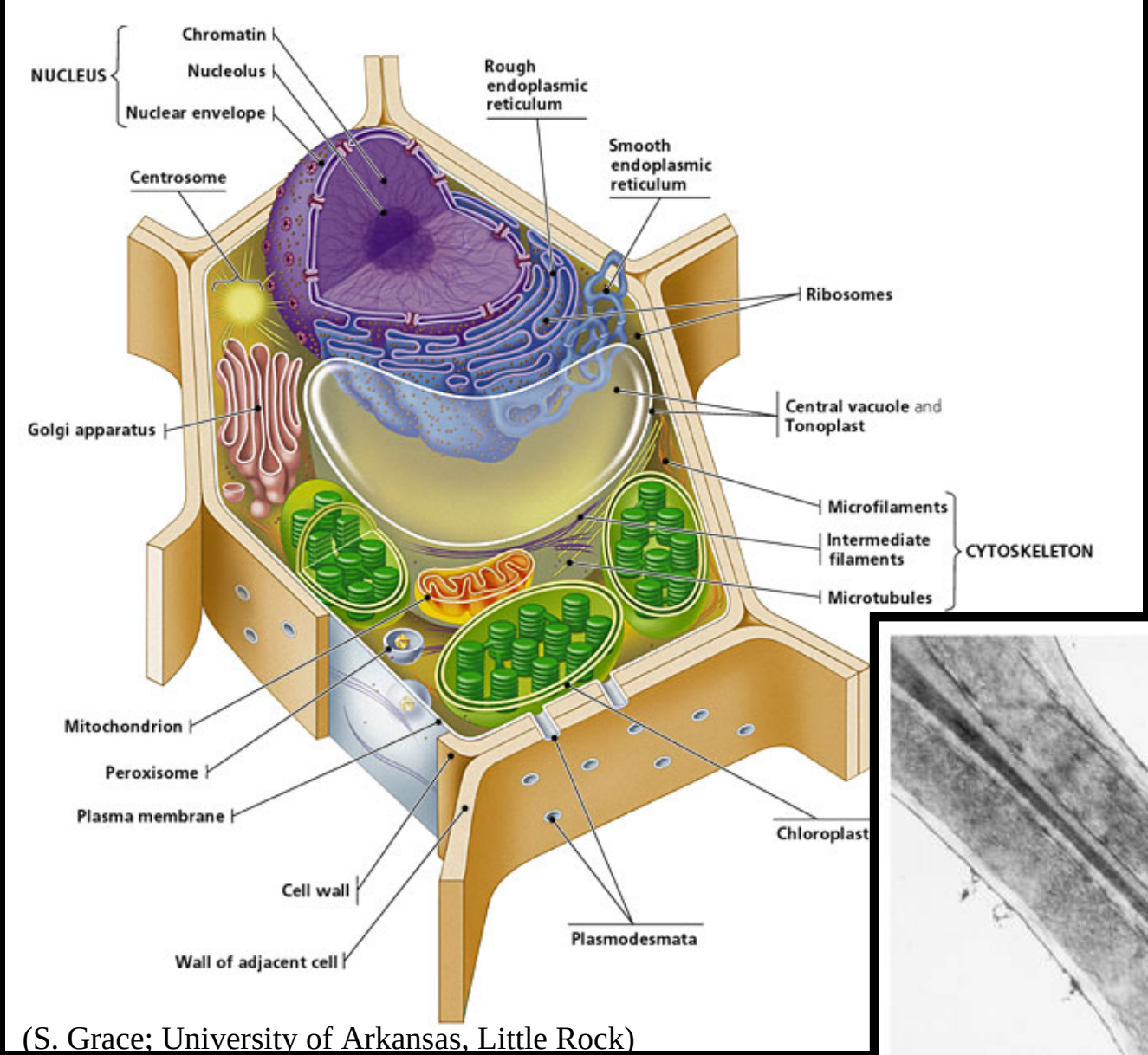
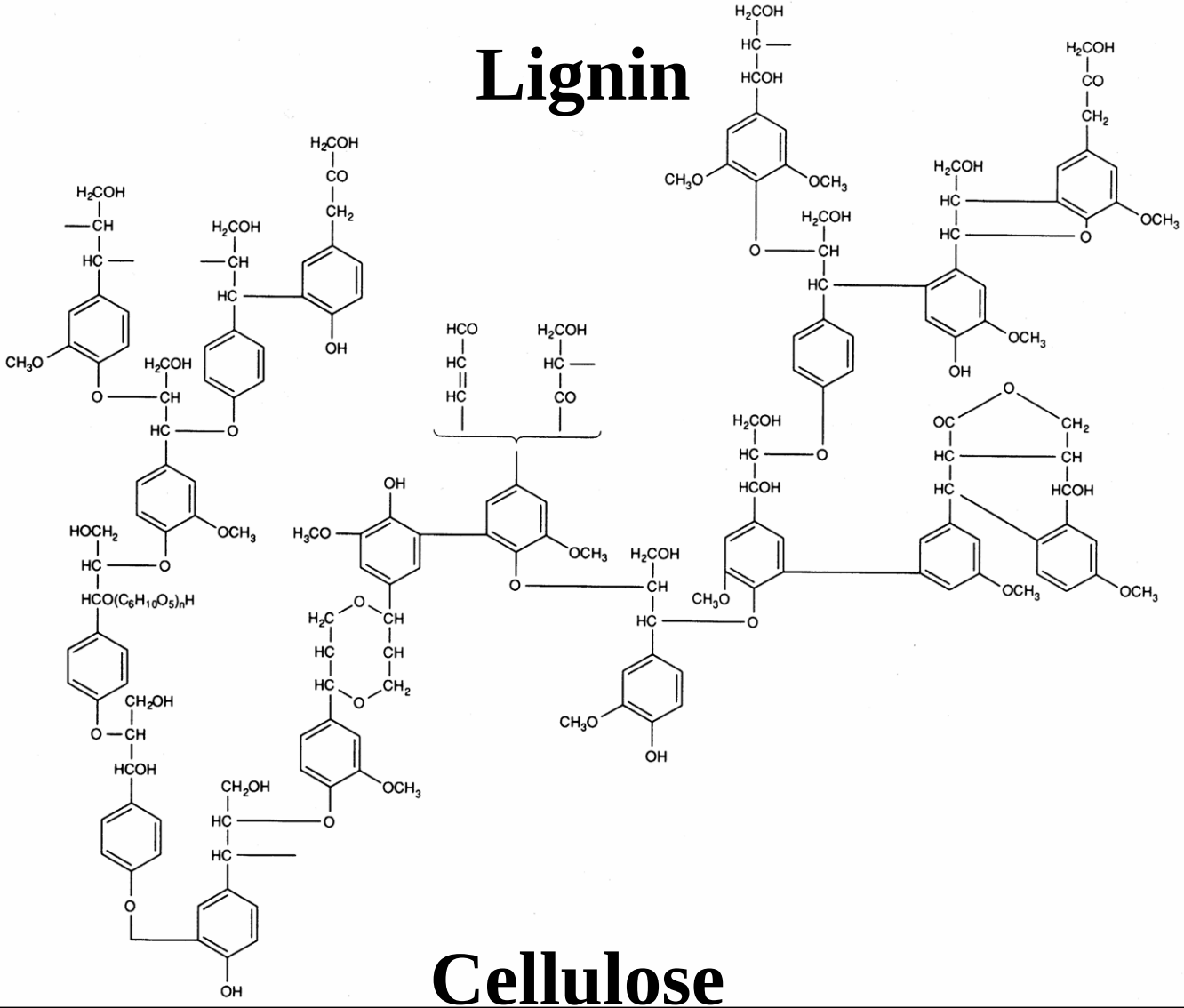


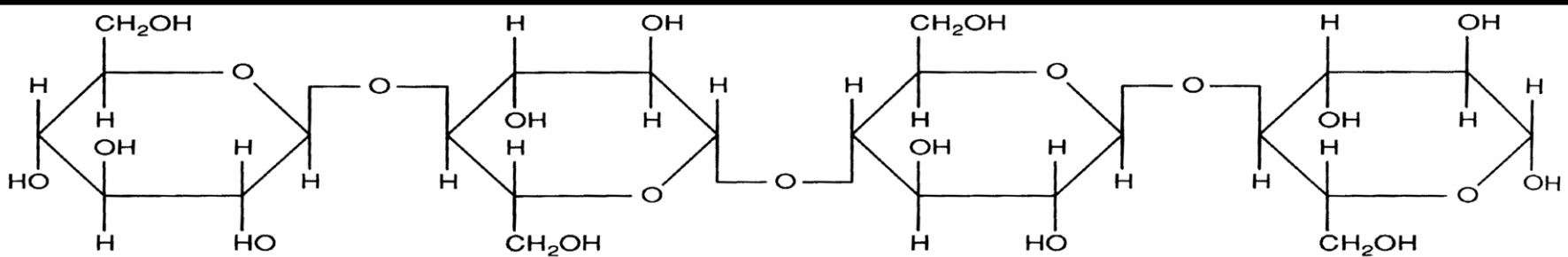
(S. Grace; University of Arkansas, Little Rock)

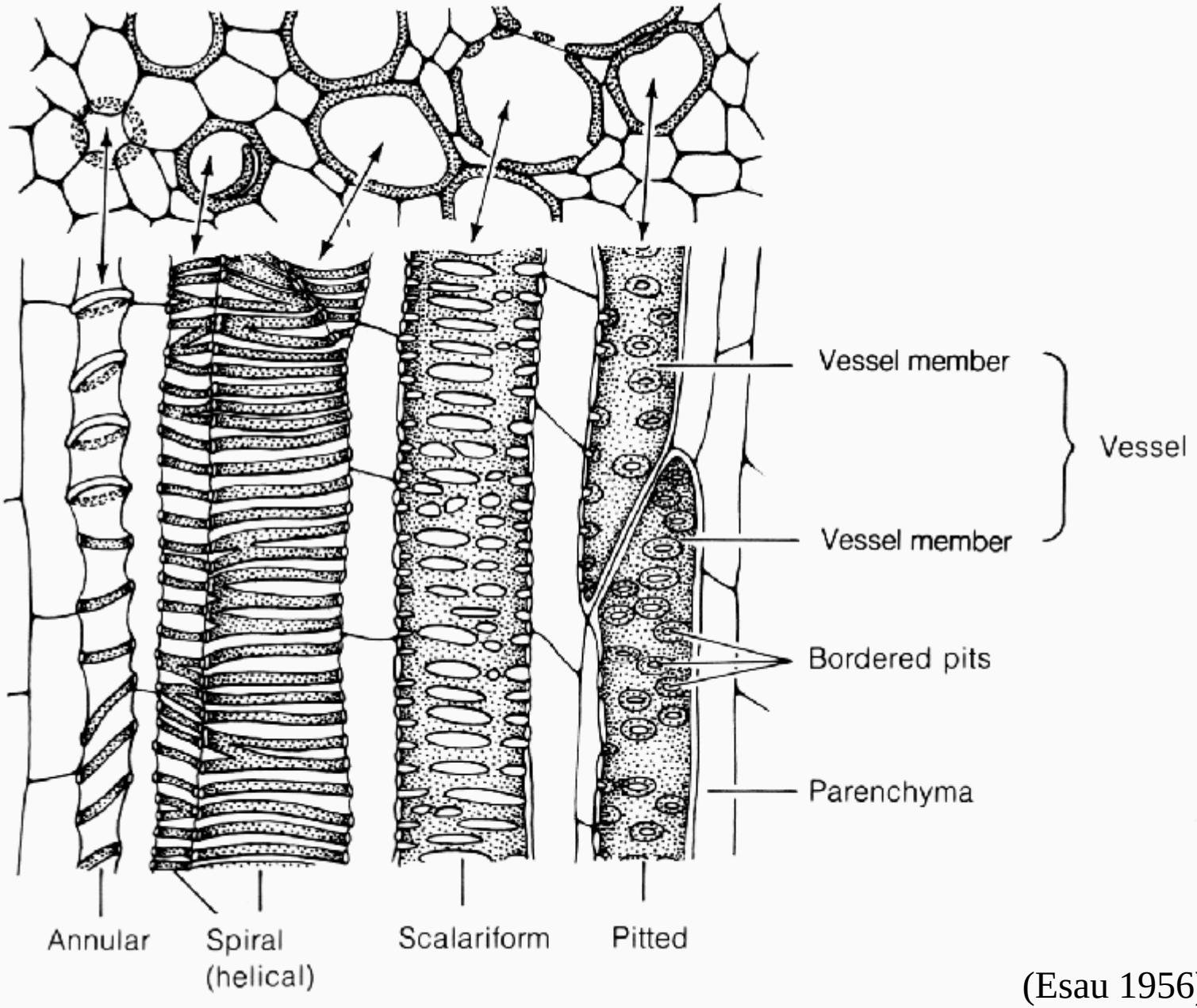
(Pearson Education, Inc.)

Lignin



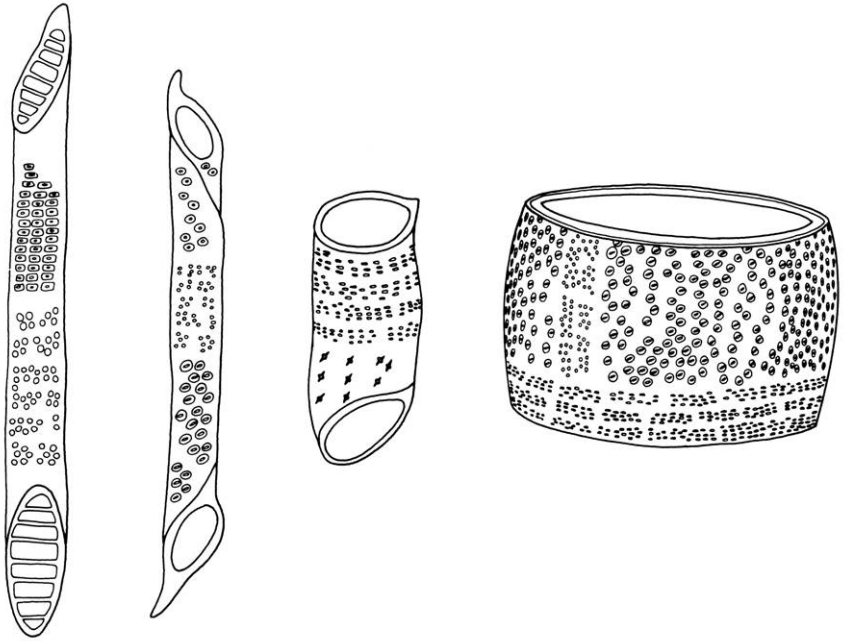
Cellulose



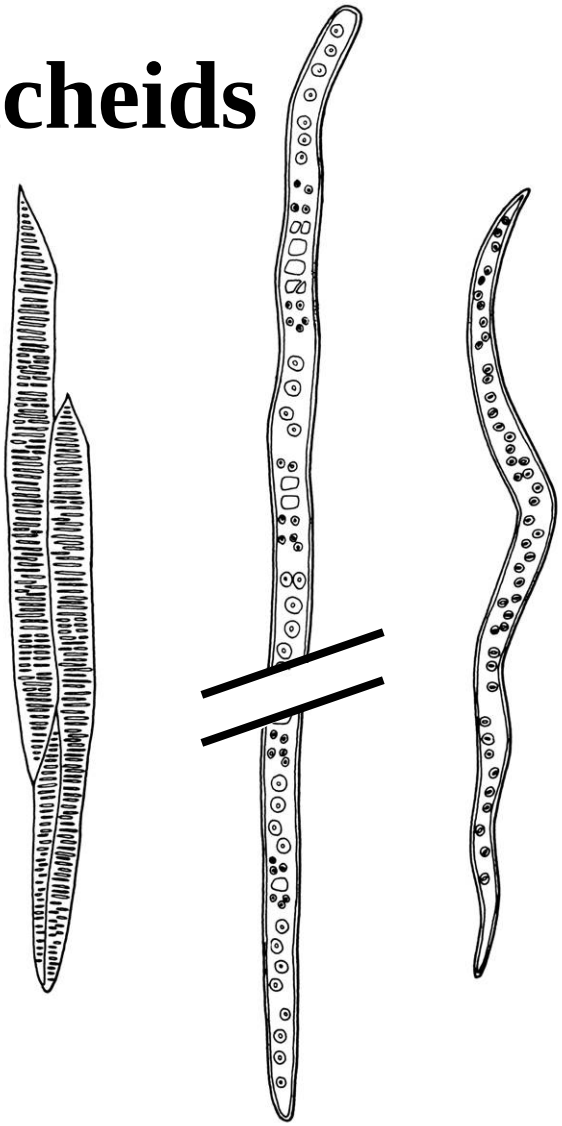

Vessel member
Vessel
Vessel member
Bordered pits
Parenchyma
Annular
Spiral
(helical)
Scalariform
Pitted

(Esau 1956)

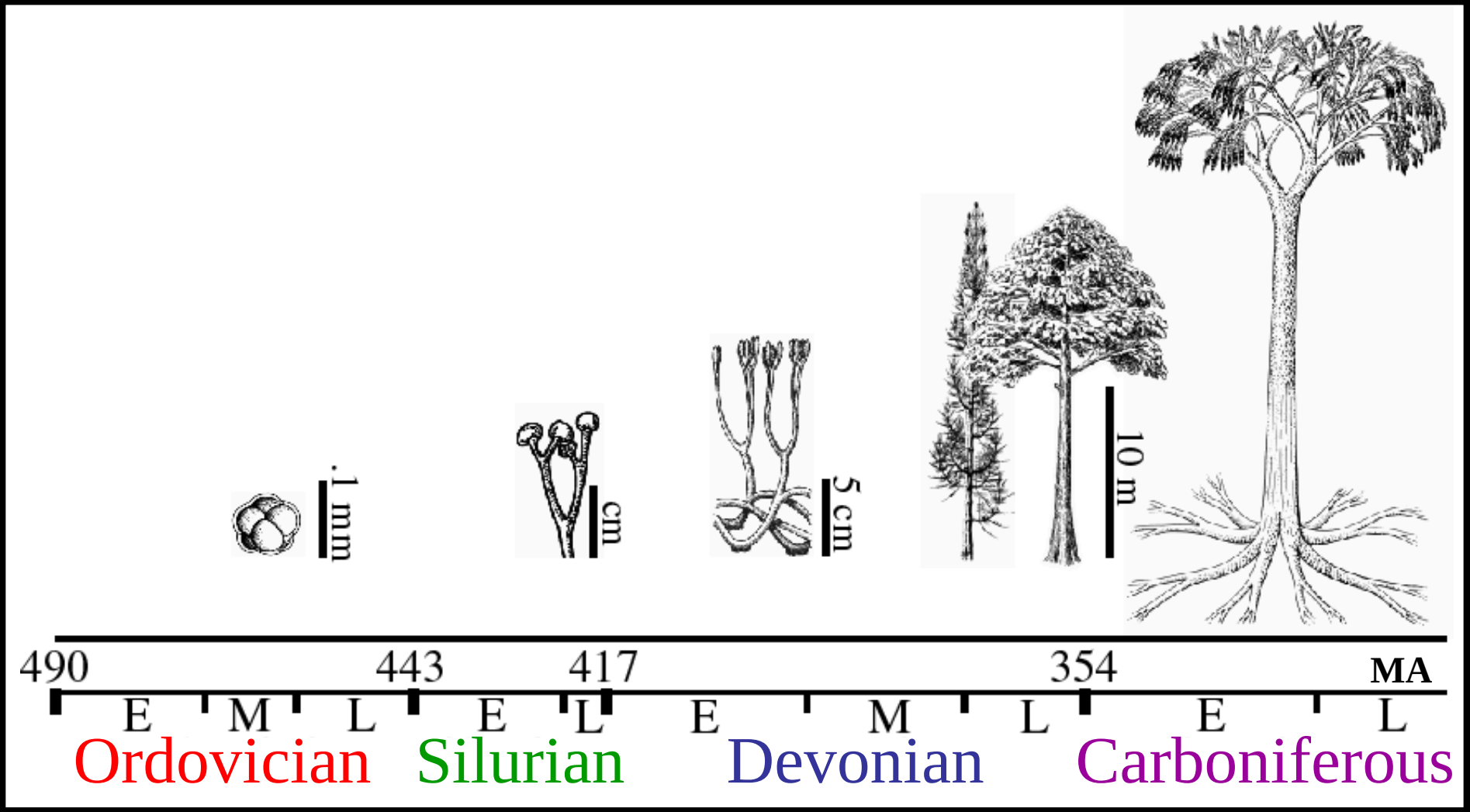
Vessels



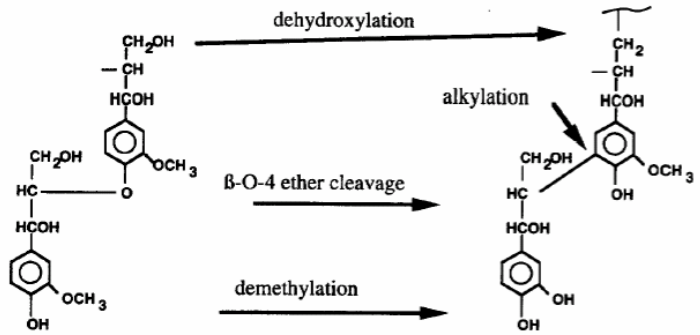
Tracheids



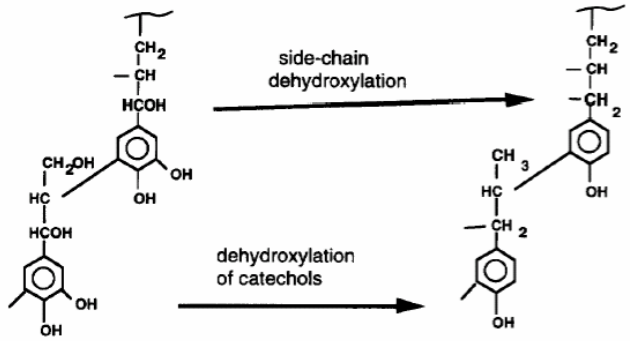
(Eames & MacDaniels 1947)


.1 mm
cm
5 cm
10 m
490
443
417
354
MA
E
M
L
E
L
E
M
L
E
L
Ordovician
Silurian
Devonian
Carboniferous

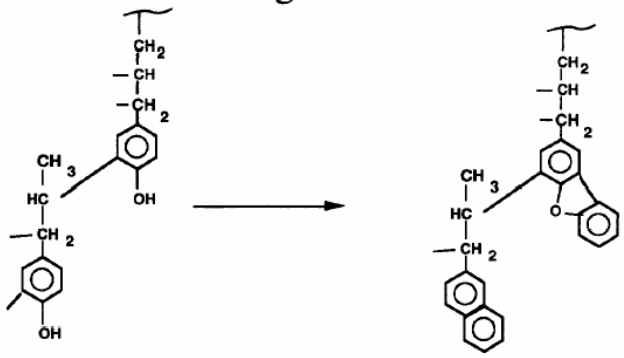
Reactions of lignin to form brown coal and lignite



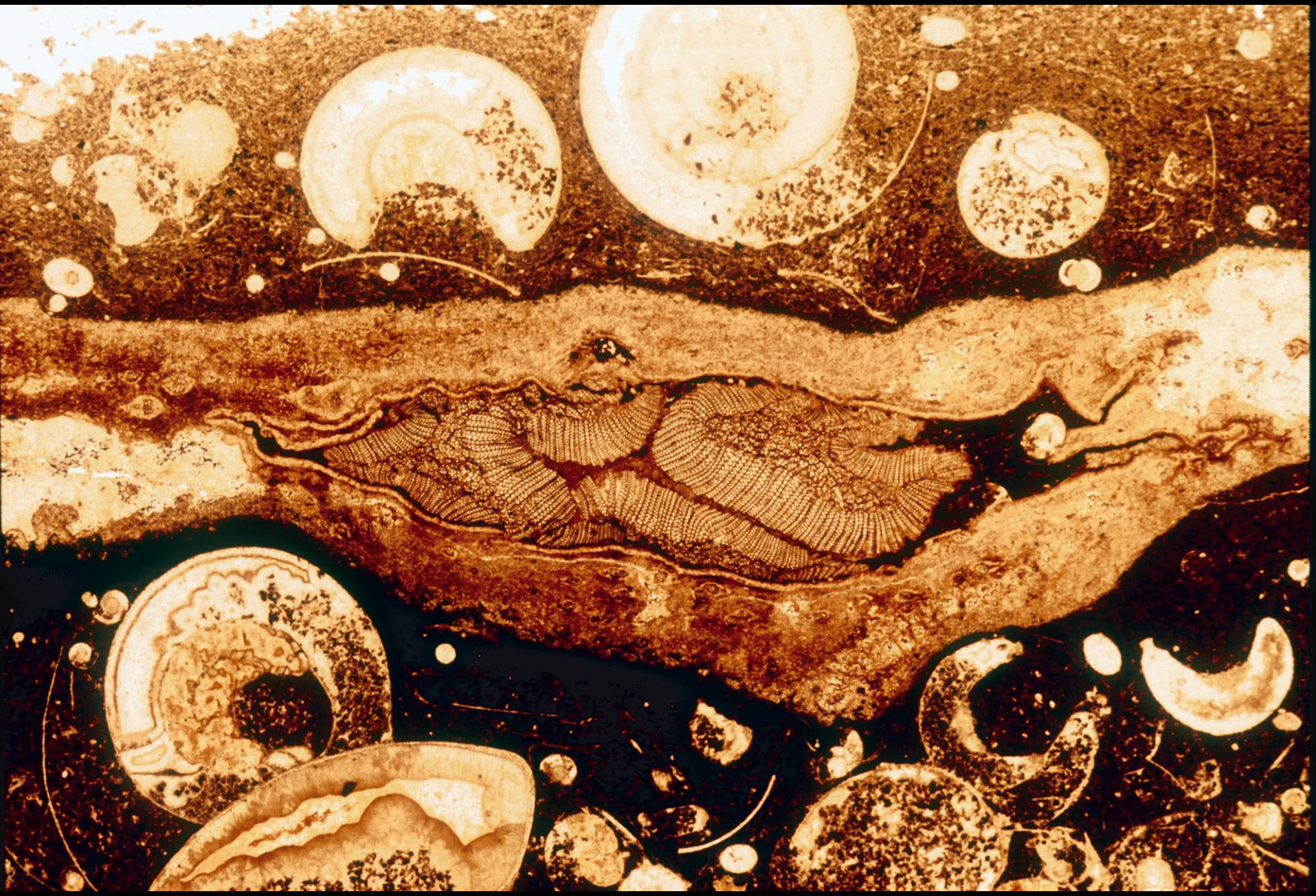
Reactions of lignite to form subbituminous coal

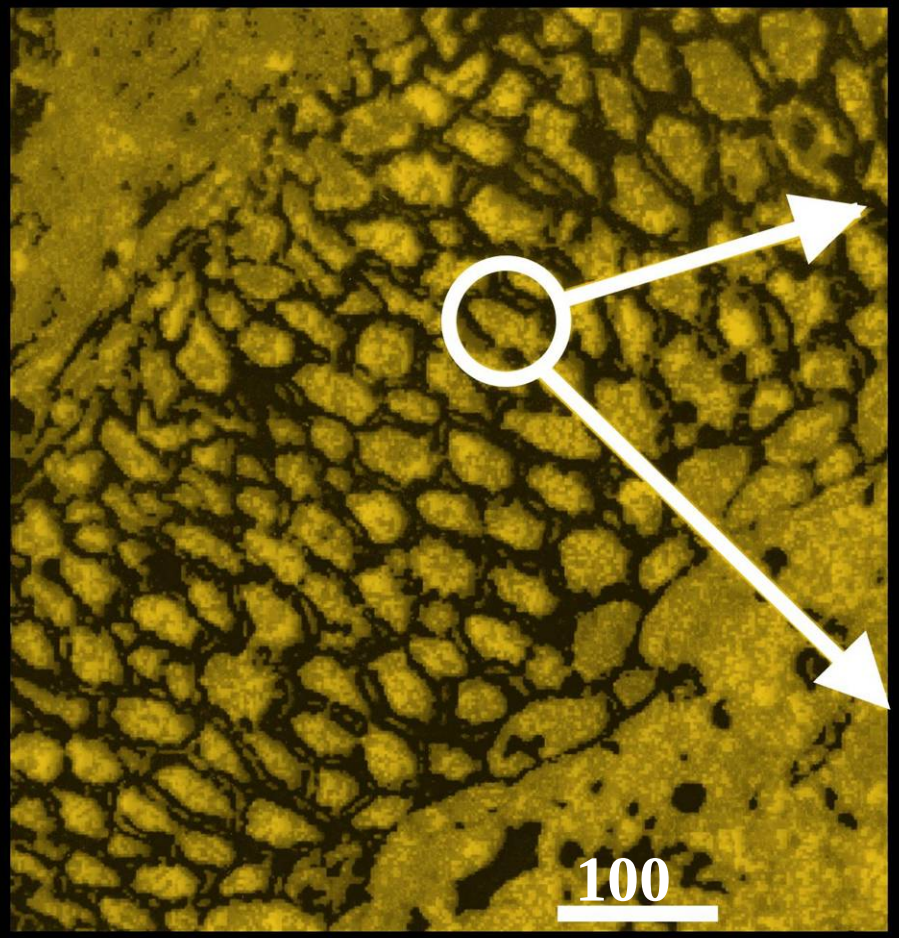


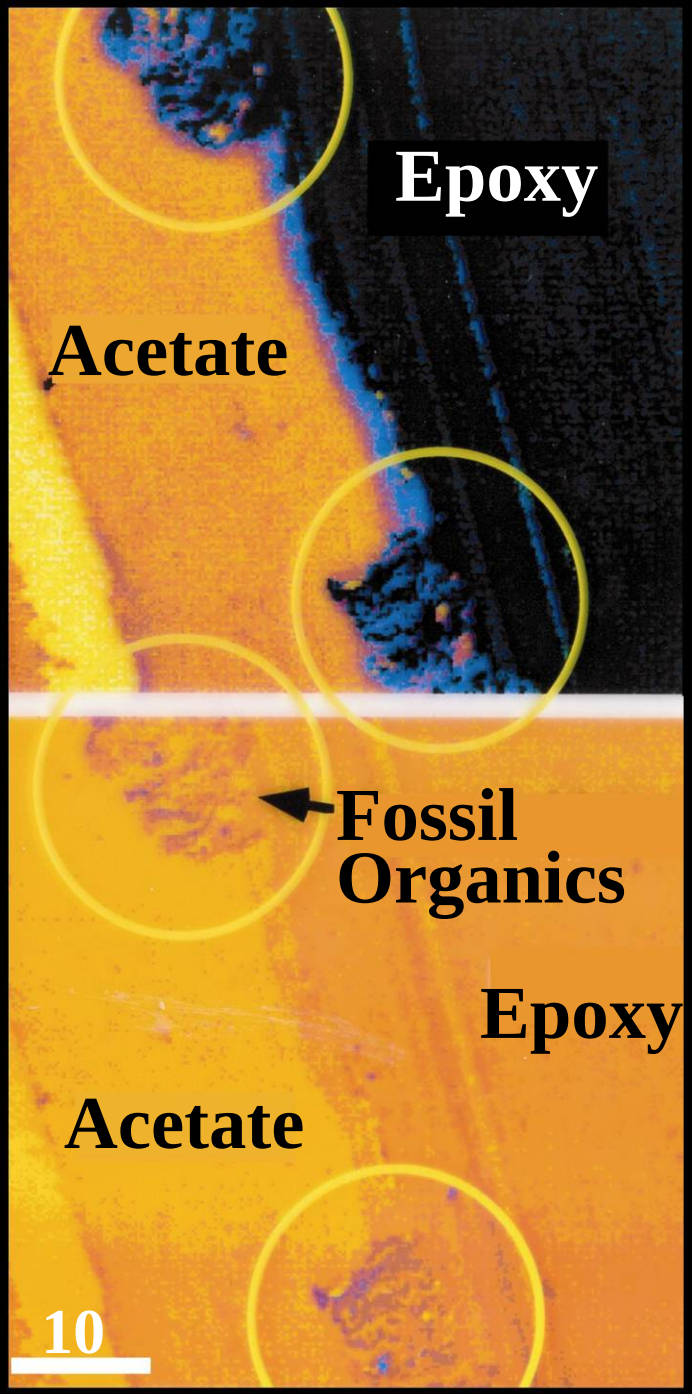
Reactions leading to bituminous coal

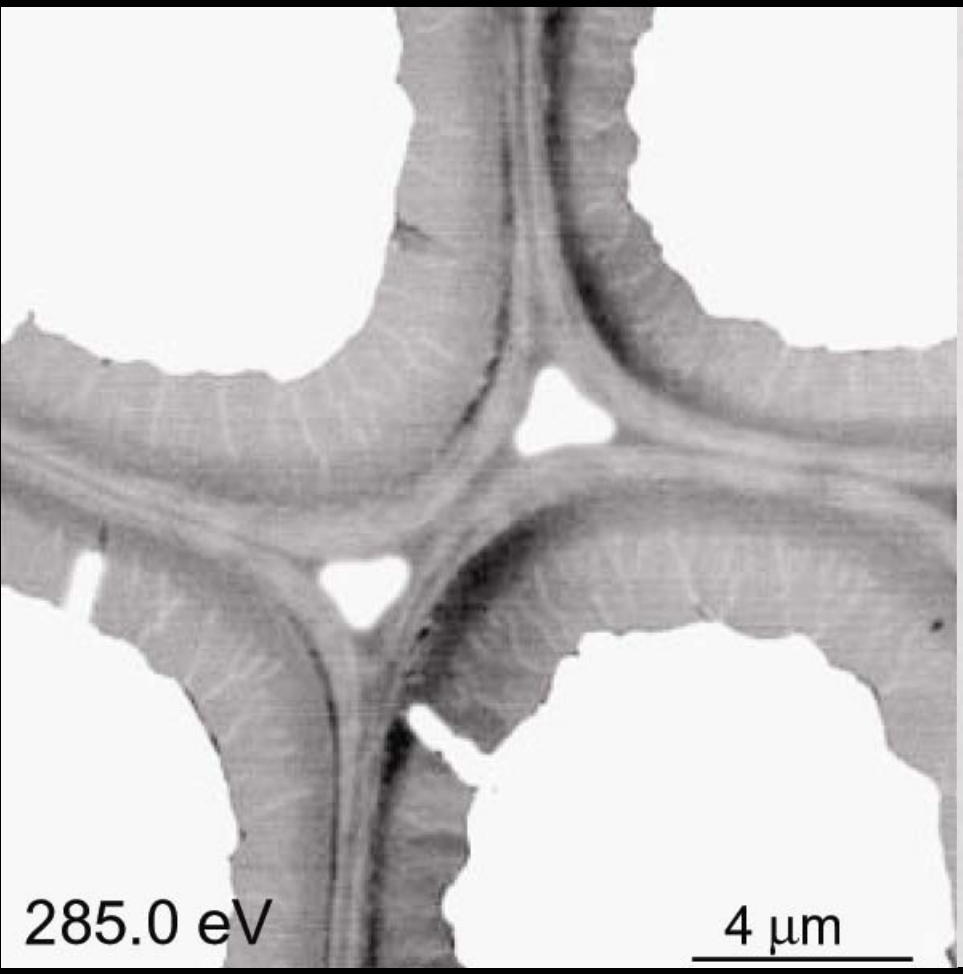


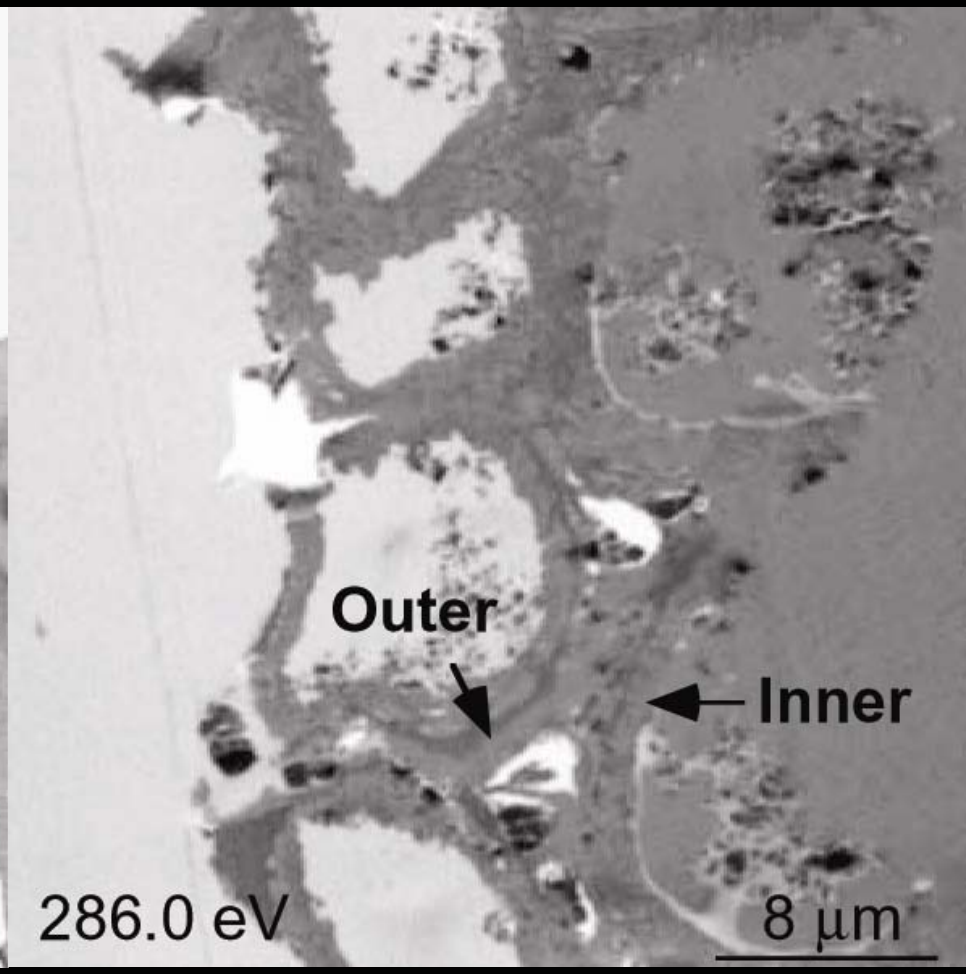
(Hatcher & Clifford 1997)



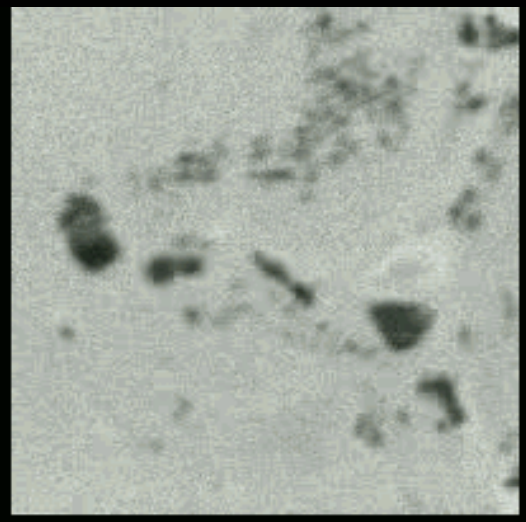

100


285.5 eV
Epoxy
Acetate
287.2 eV
Fossil
Organics
Epoxy
Acetate
10





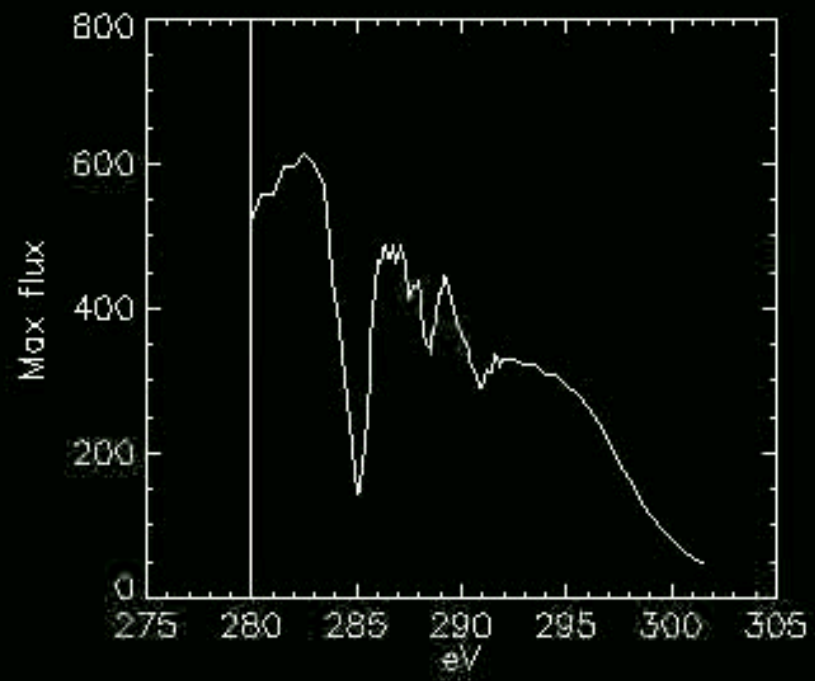
(Boyce et al. 2002)

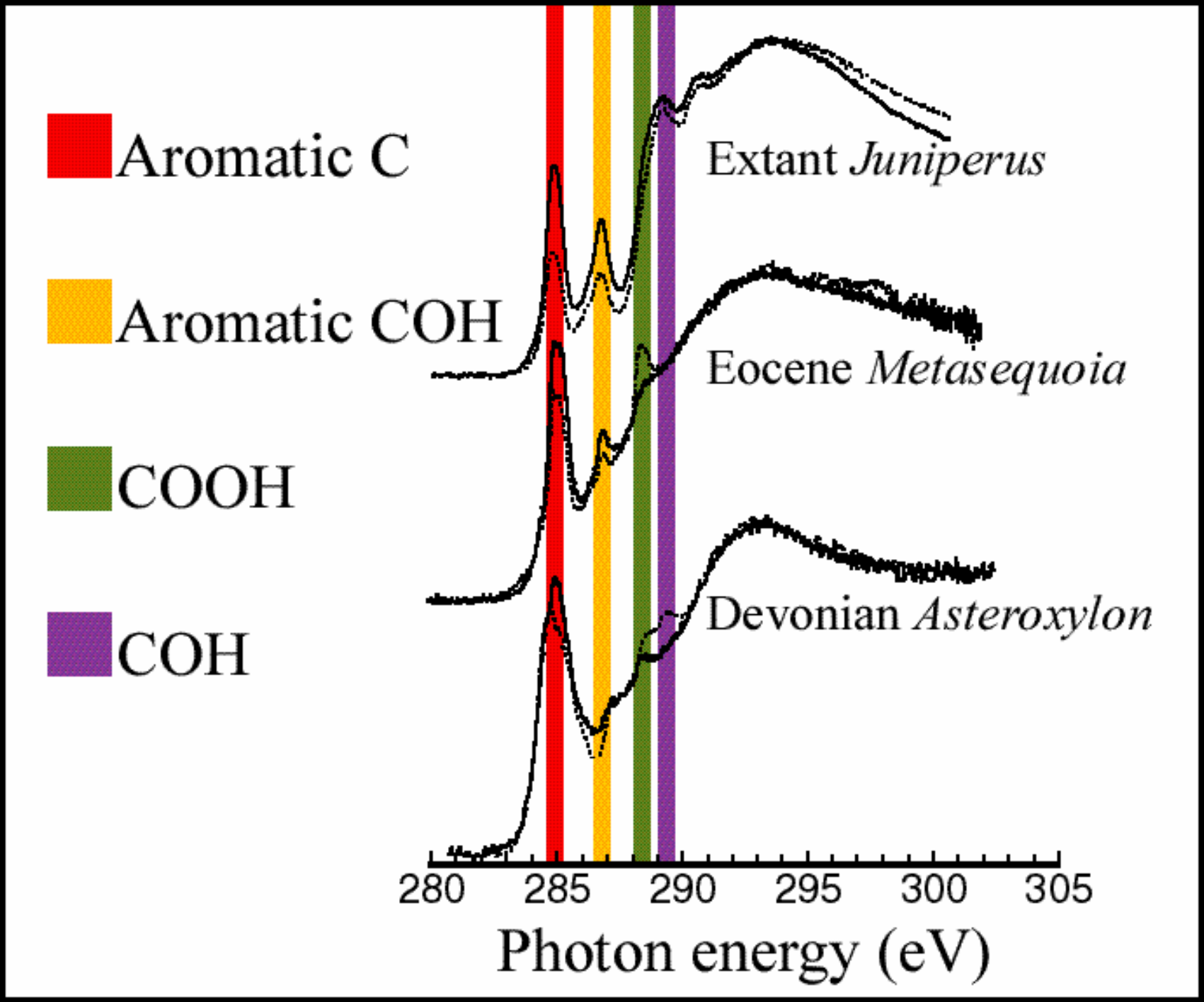


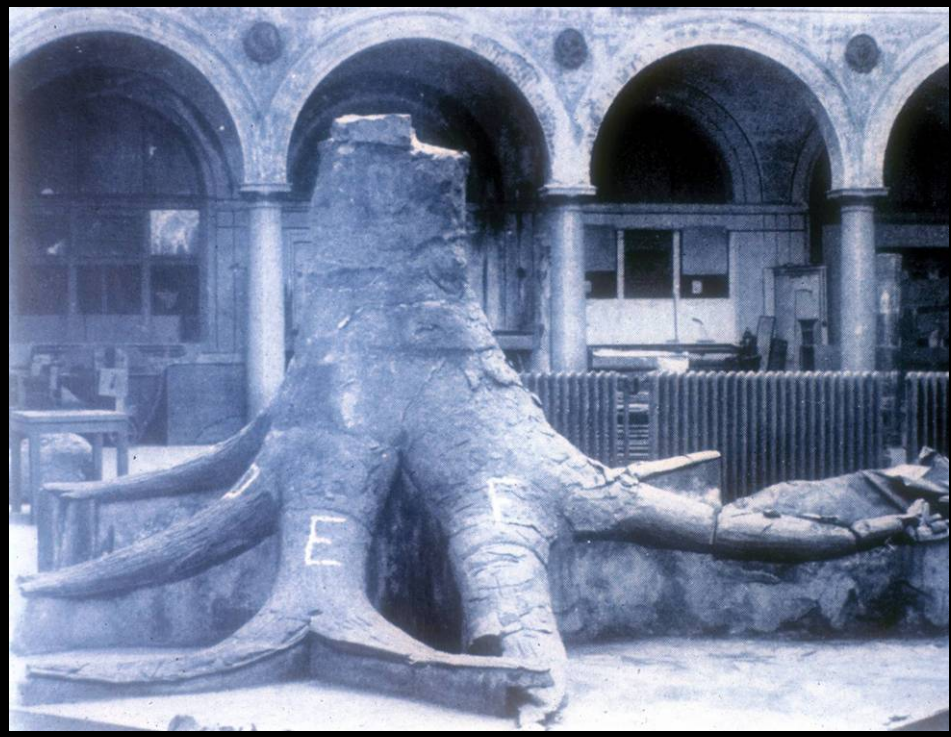
4 microns

280.00 eV

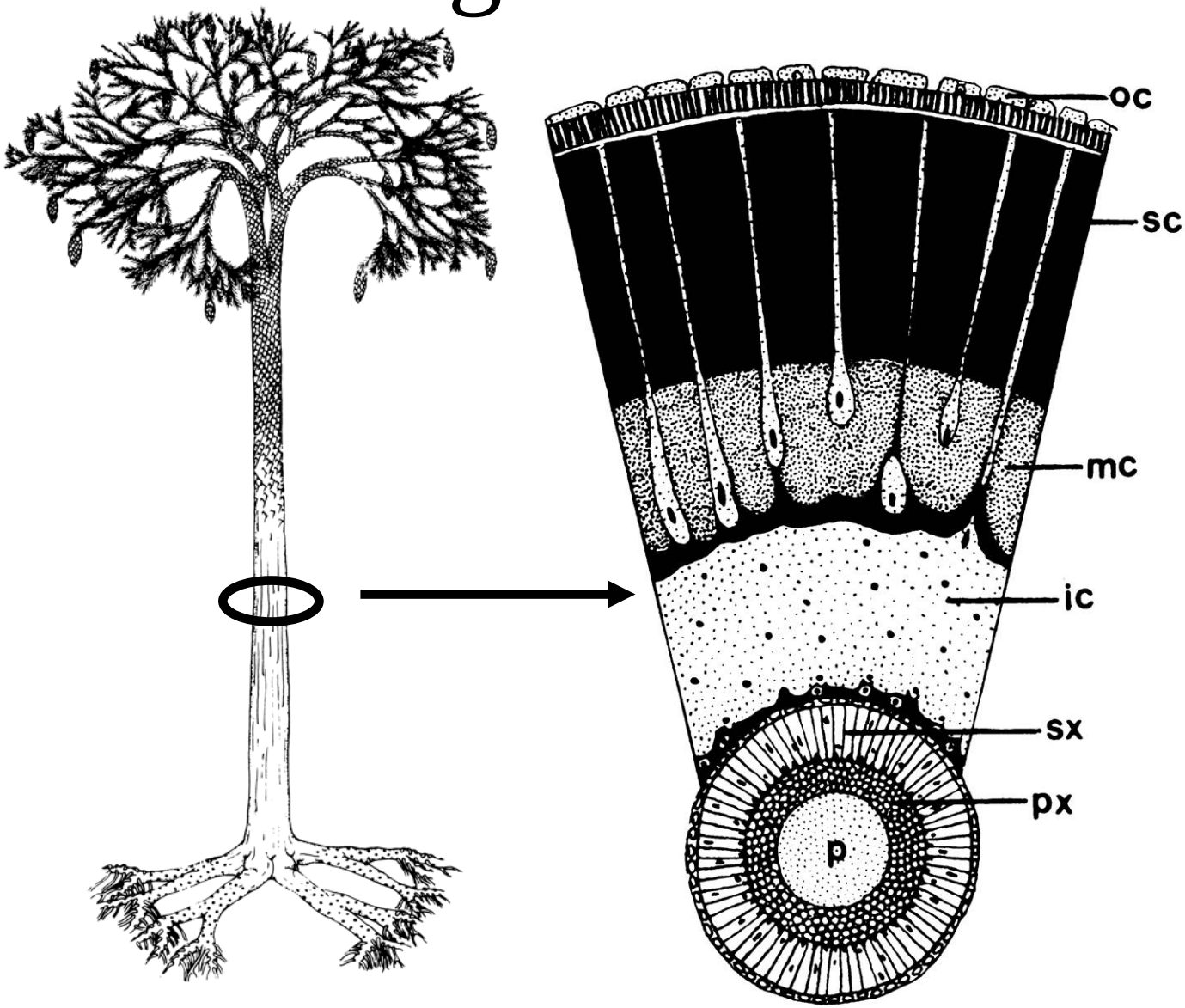
280.00 eV 1 msec




Aromatic C
Aromatic COH
COOH
COH
Extant *Juniperus*
Eocene *Metasequoia*
Devonian *Asteroxylon*
280
285
290
295
300
305
Photon energy (eV)

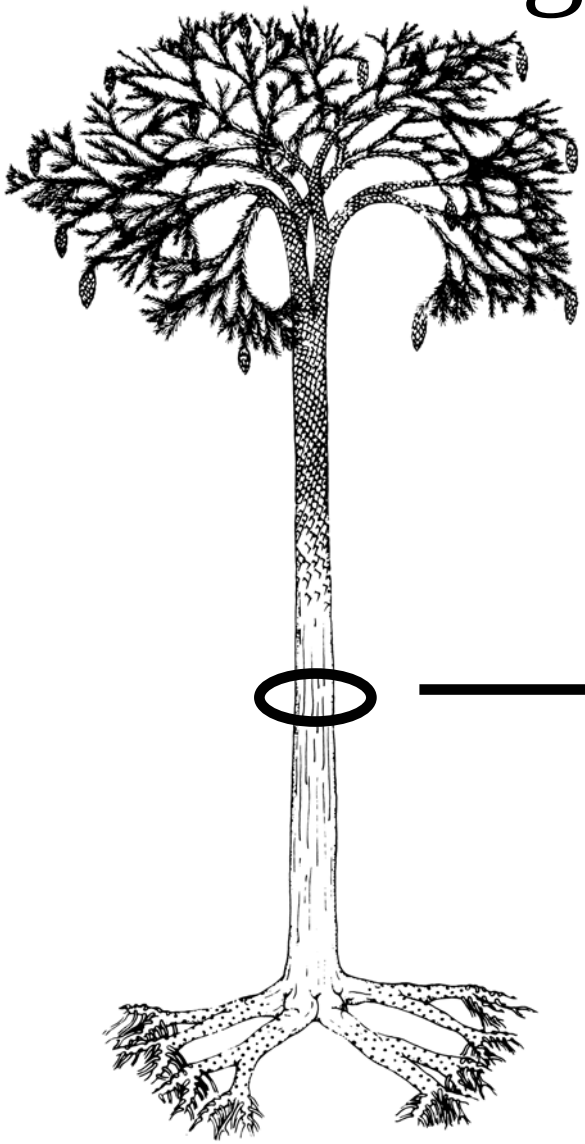


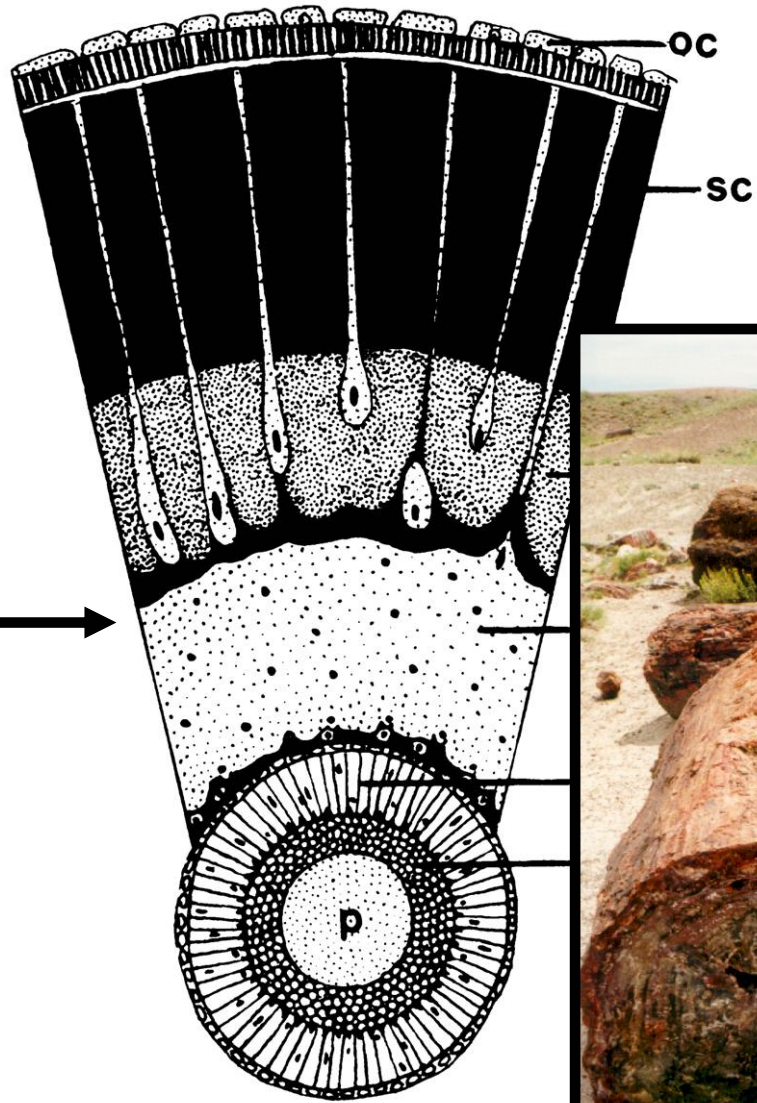
Lignin?

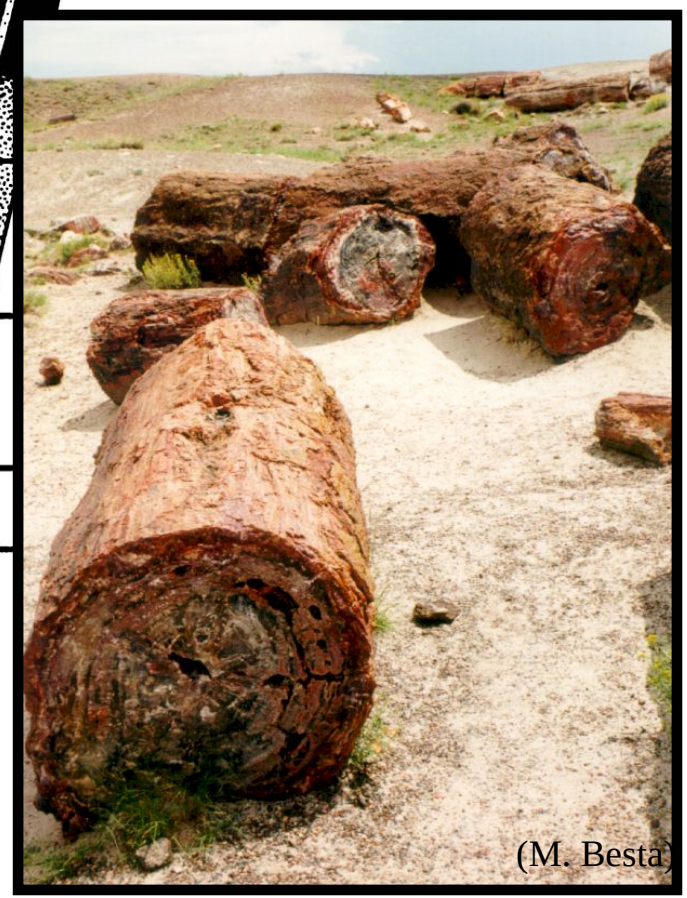


Little wood, a lot of cortex.

Lignin?

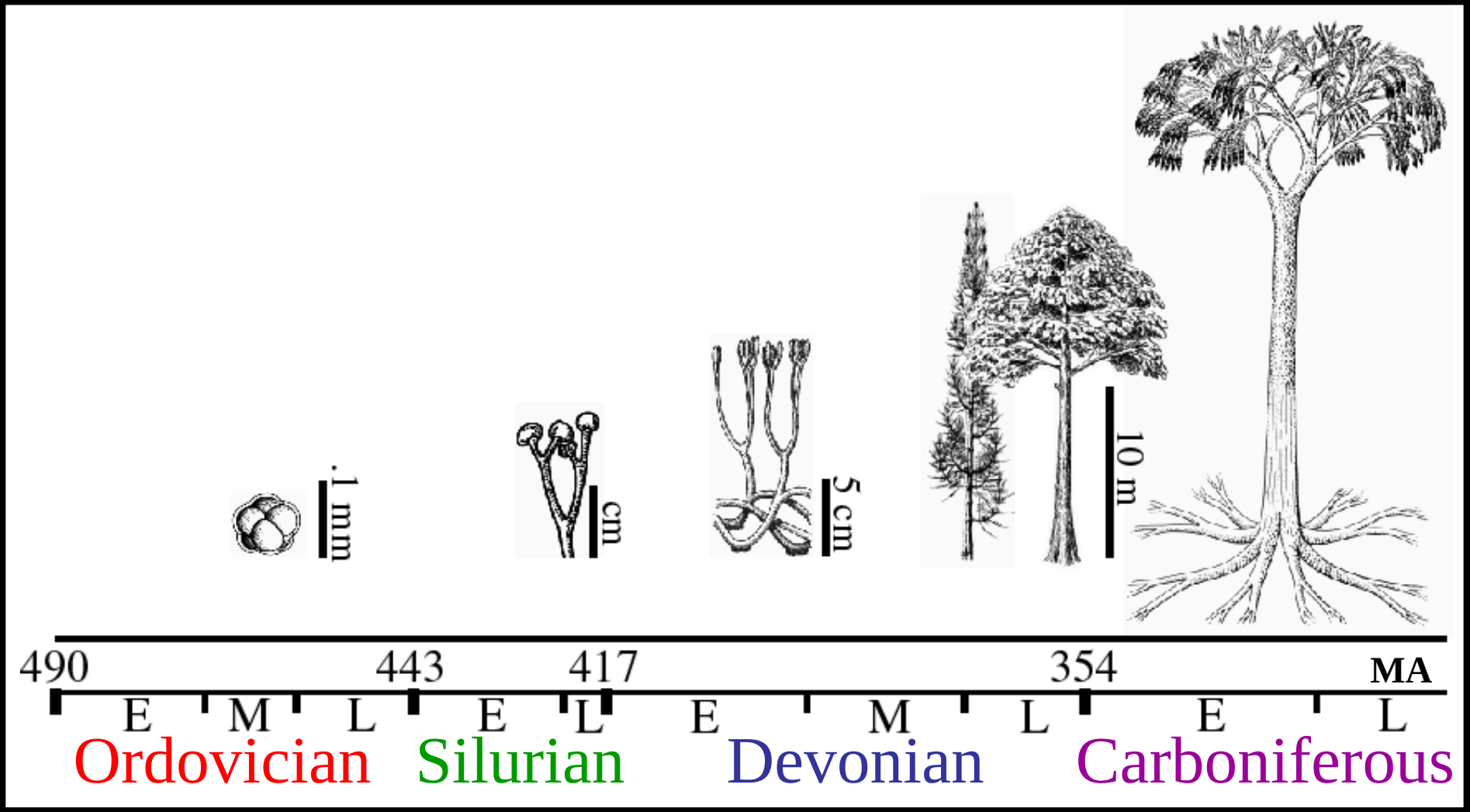


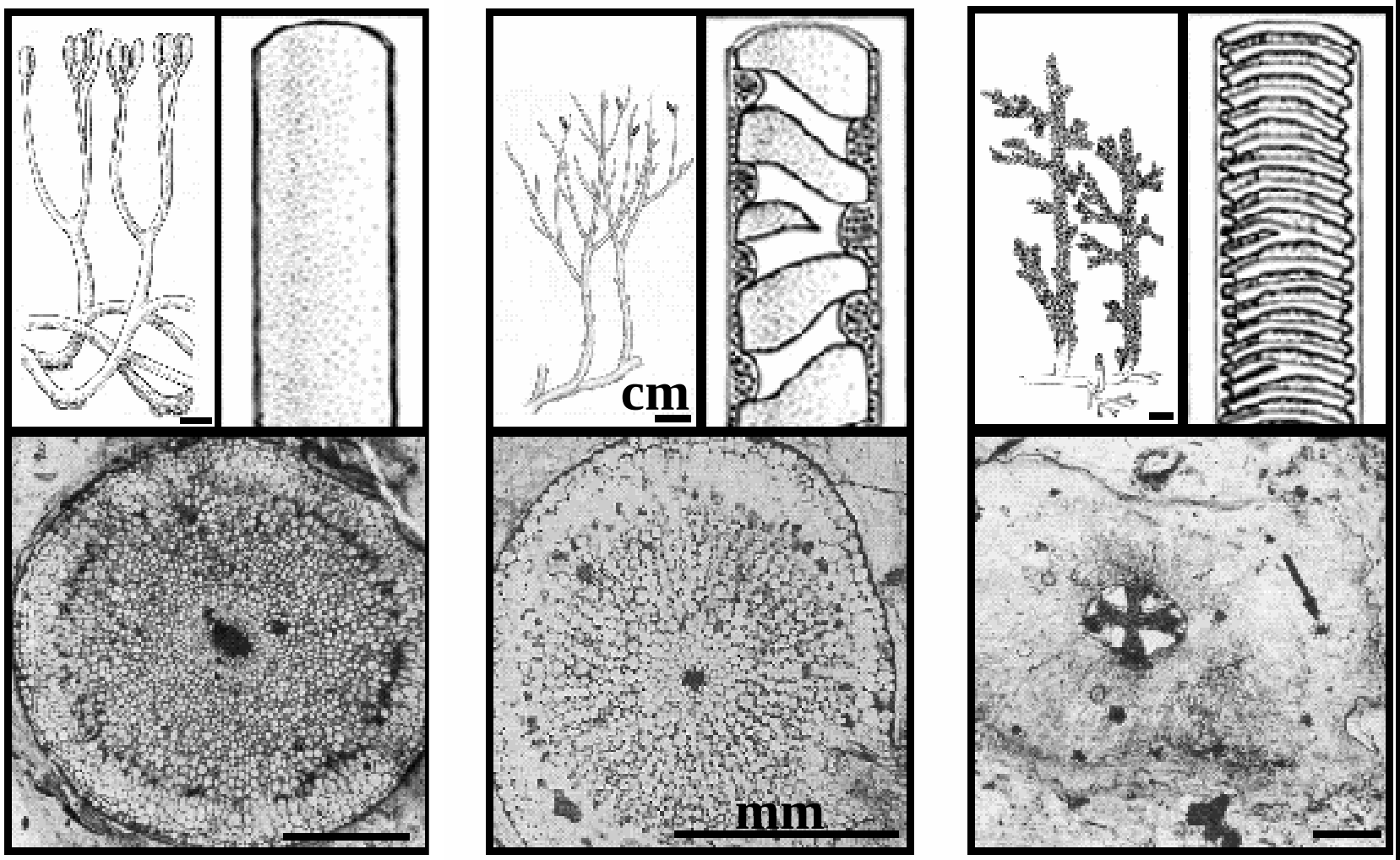




(M. Besta)

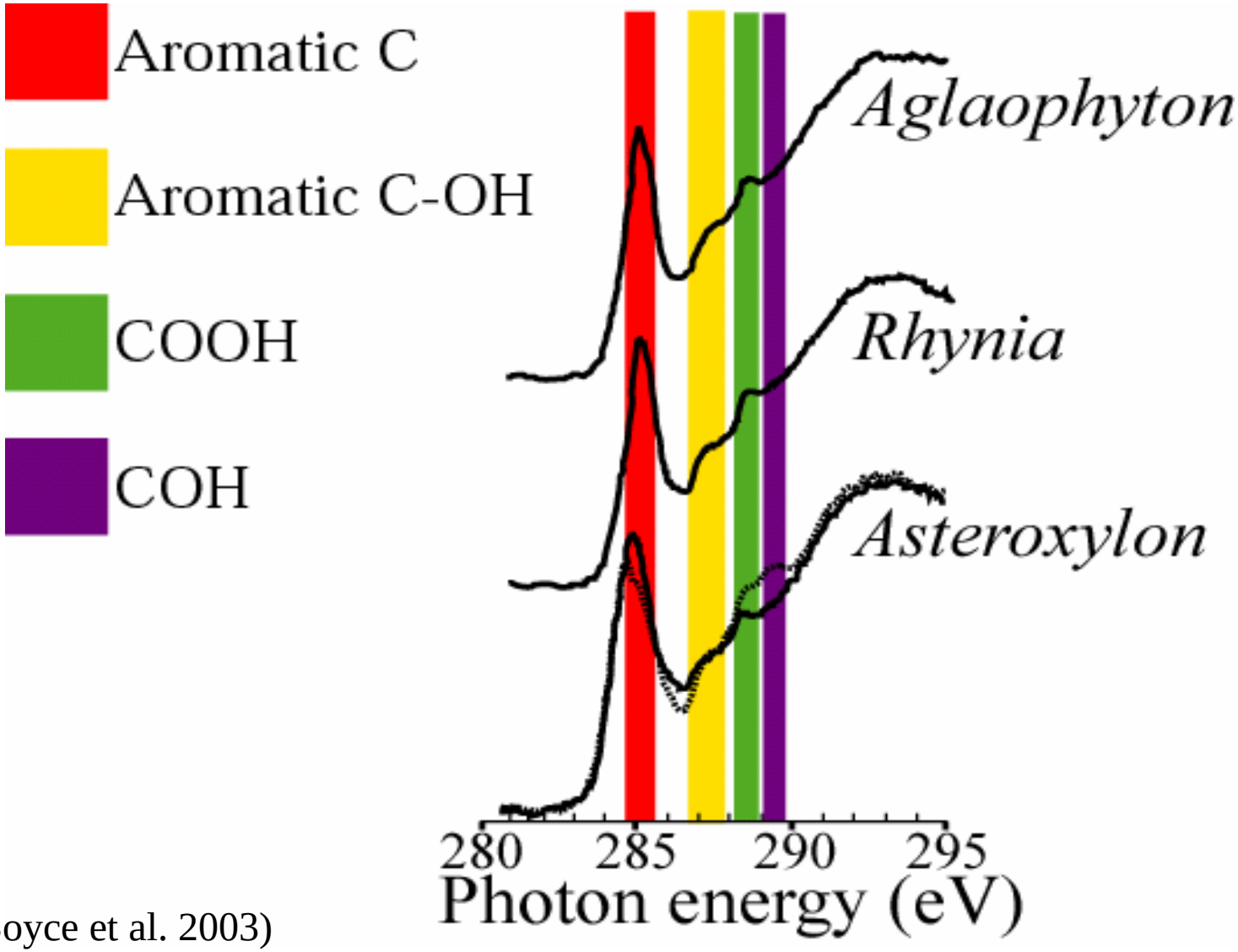
Little wood, a lot of cortex.


.1 mm
cm
5 cm
10 m
490
443
417
354
MA
E
M
L
E
L
E
M
L
E
L
Ordovician
Silurian
Devonian
Carboniferous

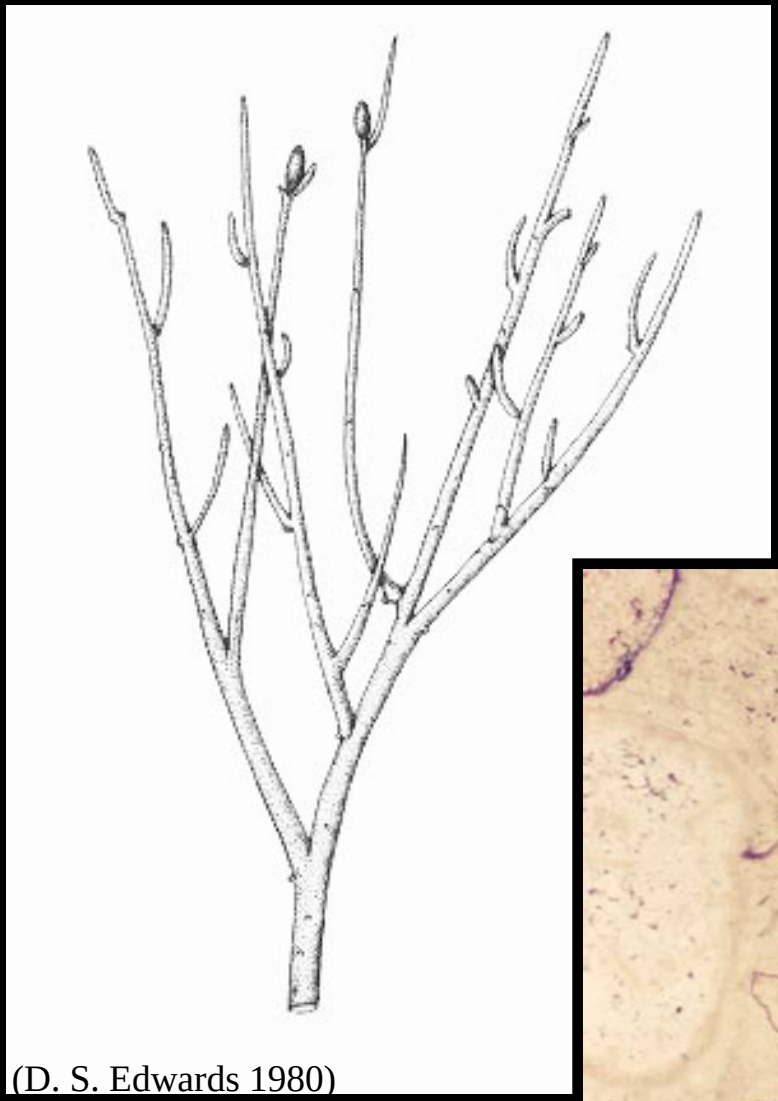


Aglaophyton ***Rhynia*** ***Asteroxylon***

(Boyce et al. 2003)



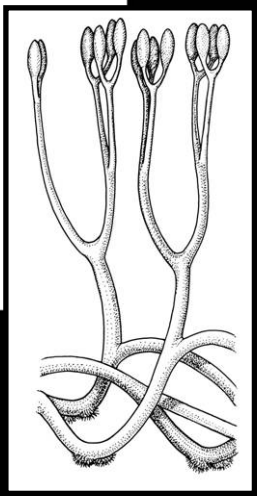
(Boyce et al. 2003)

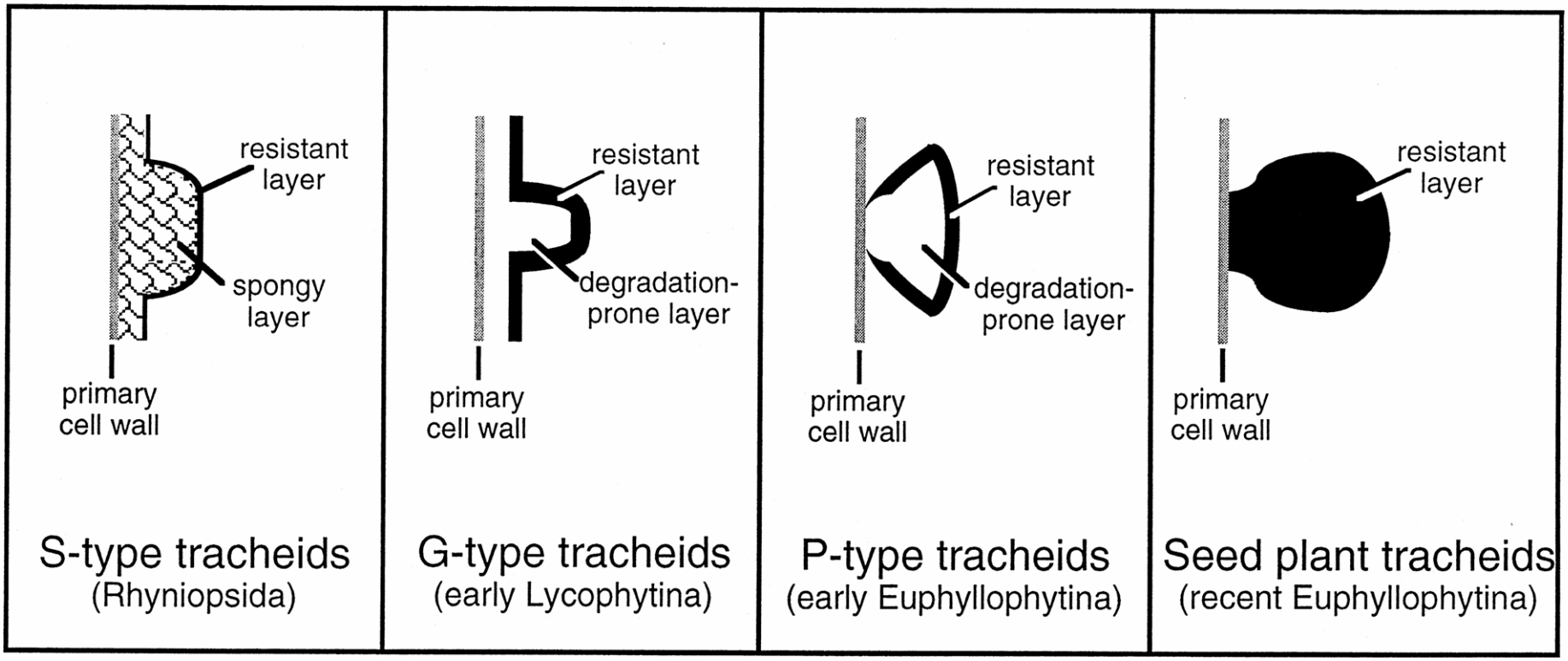


(D. S. Edwards 1980)

(University of Aberdeen)

Lycopods Horsetails Ferns Seed Plants





(Cook & Friedman 1998)

“The primary wall is a thin layer, 0.1-1.0 mm thick, consisting of cellulose, hemicelluloses, pectin, and protein and completely embedded in lignin.”

-Eero Sjöström

Wood Chemistry: Fundamentals and Applications, 1993.

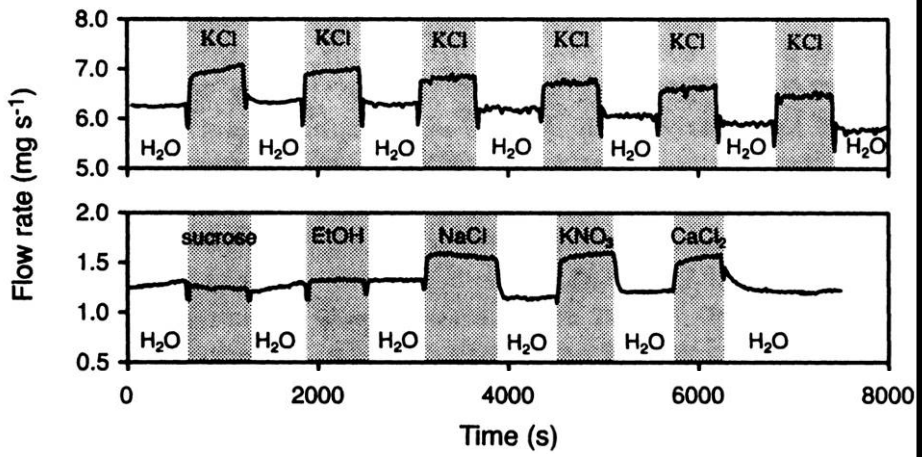
- Paleobotanists, developmental and molecular biologists:
  - Lignin is in the secondary wall.

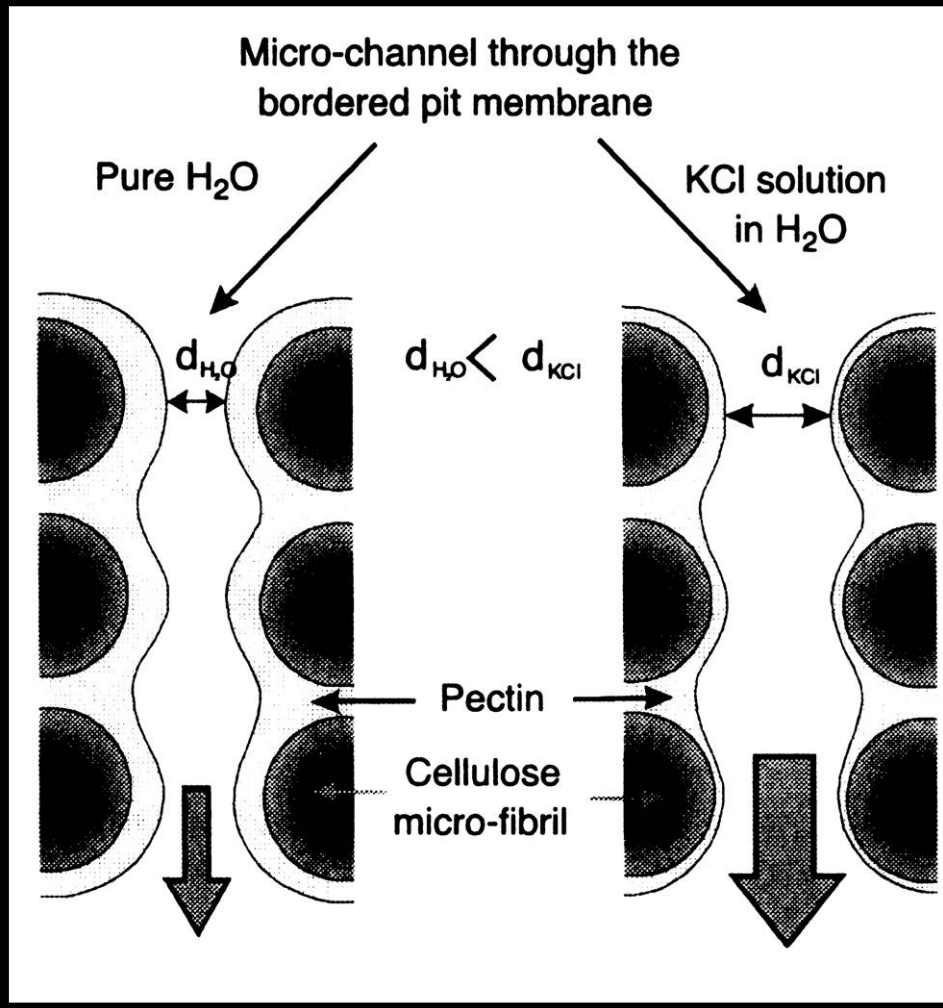
- Wood and paper chemists:
  - Lignin is in the primary wall and middle lamella.

Why does it matter?

Function

- Hydraulics
  - –Short distance distribution
  - –Long distance transport
  - –Refilling after cavitation
  - –Hydrogel transport regulation
- Support
  - –Mechanical strength
  - –Cell-cell adhesion
  - –Withstanding growth stresses

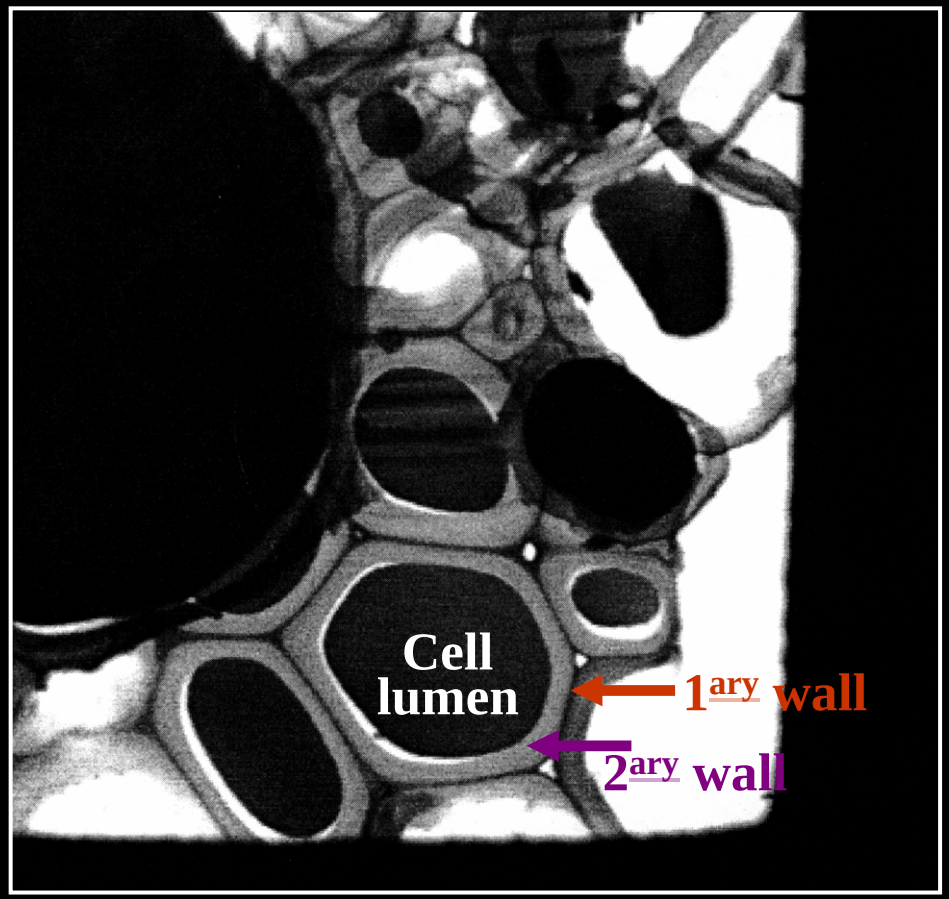




(Zwieniecki et al. 2001)

Why does it matter?

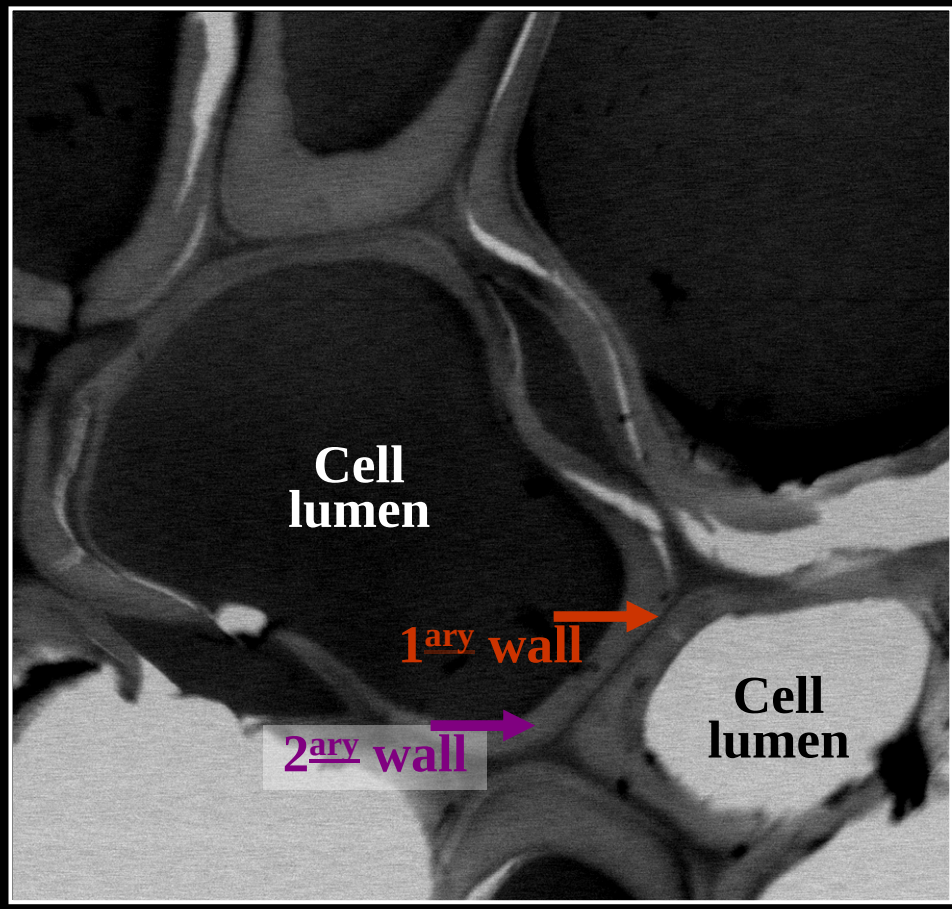
Function	Optimal lignin Placement
• Hydraulics	
–Short distance distribution	2^{ary} wall
–Long distance transport	1^{ary} wall
–Refilling after cavitation	2^{ary} wall
–Hydrogel transport regulation	2^{ary} wall
• Support	
–Mechanical strength	1^{ary} wall
–Cell-cell adhesion	1^{ary} wall
–Withstanding growth stresses	2^{ary} wall



8μ

Selaginella

285.2 eV

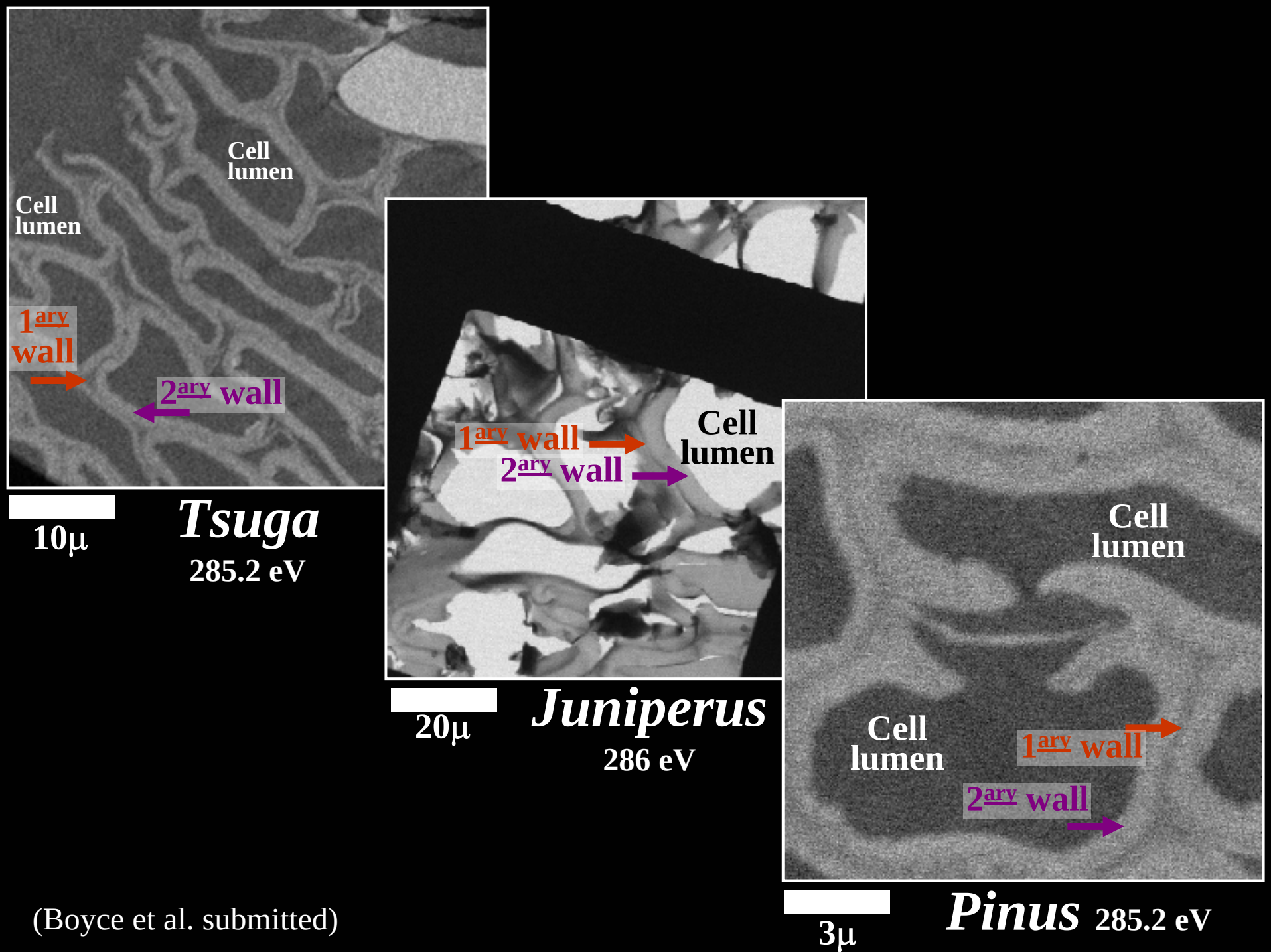


8μ

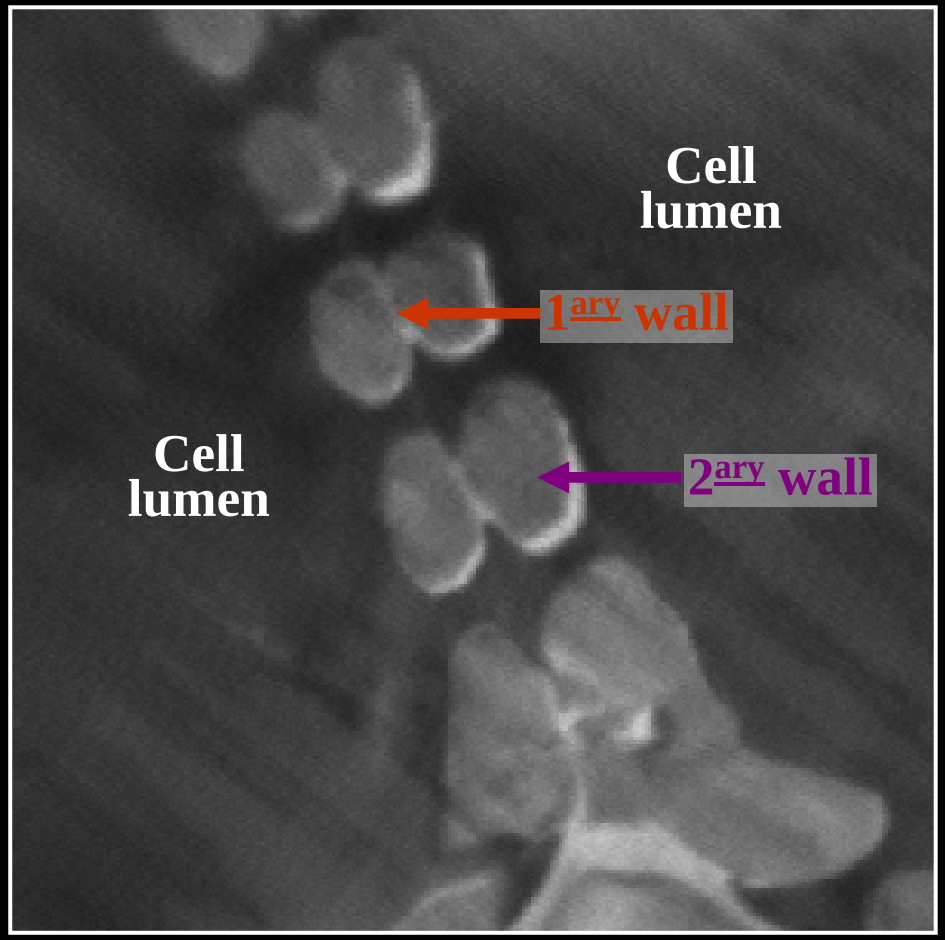
Ginkgo

286 eV

(Boyce et al. submitted)



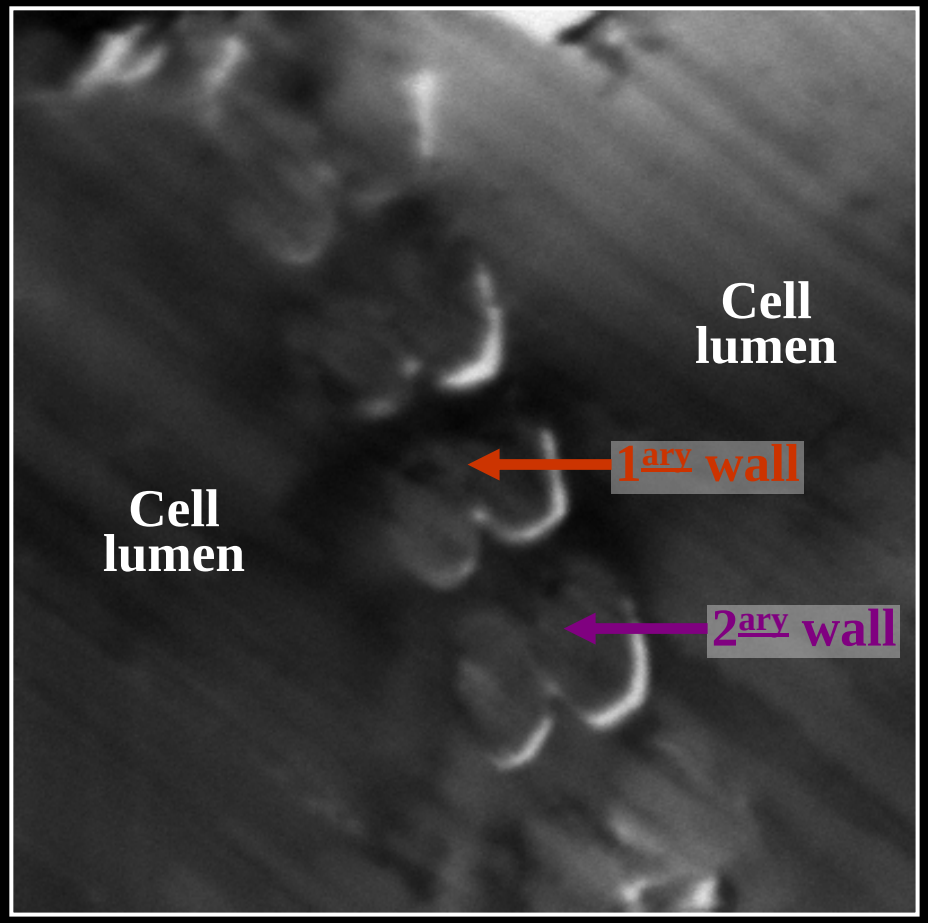
(Boyce et al. submitted)



285.2 eV

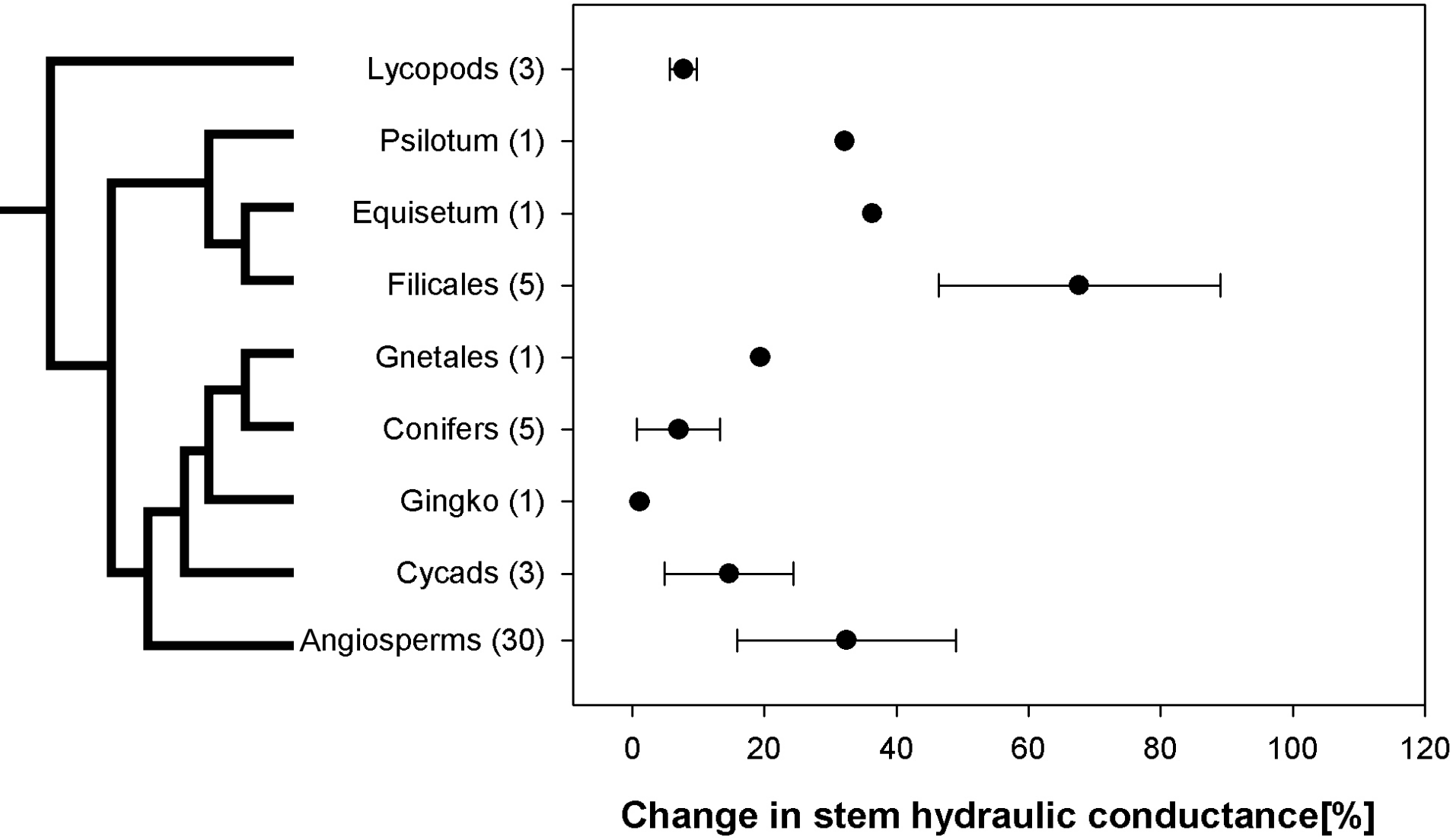
Acer

2μ

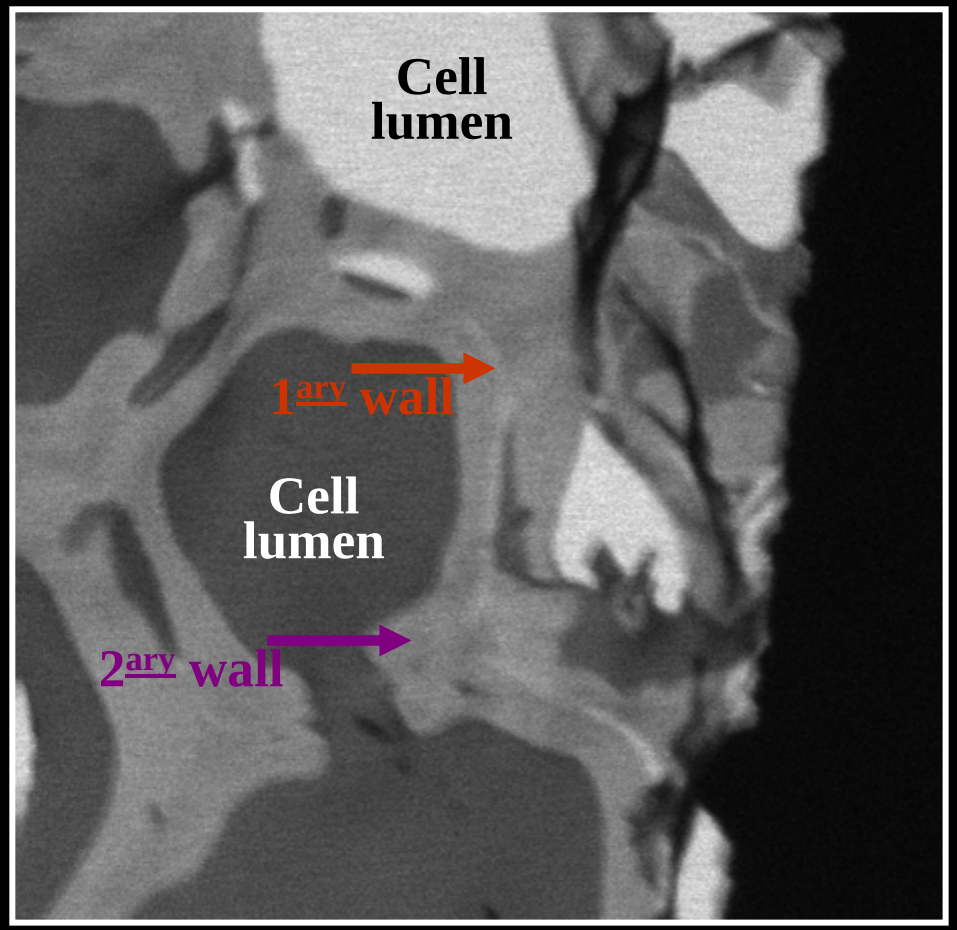


288.5 eV

(Boyce et al. submitted)



(Boyce et al. submitted)

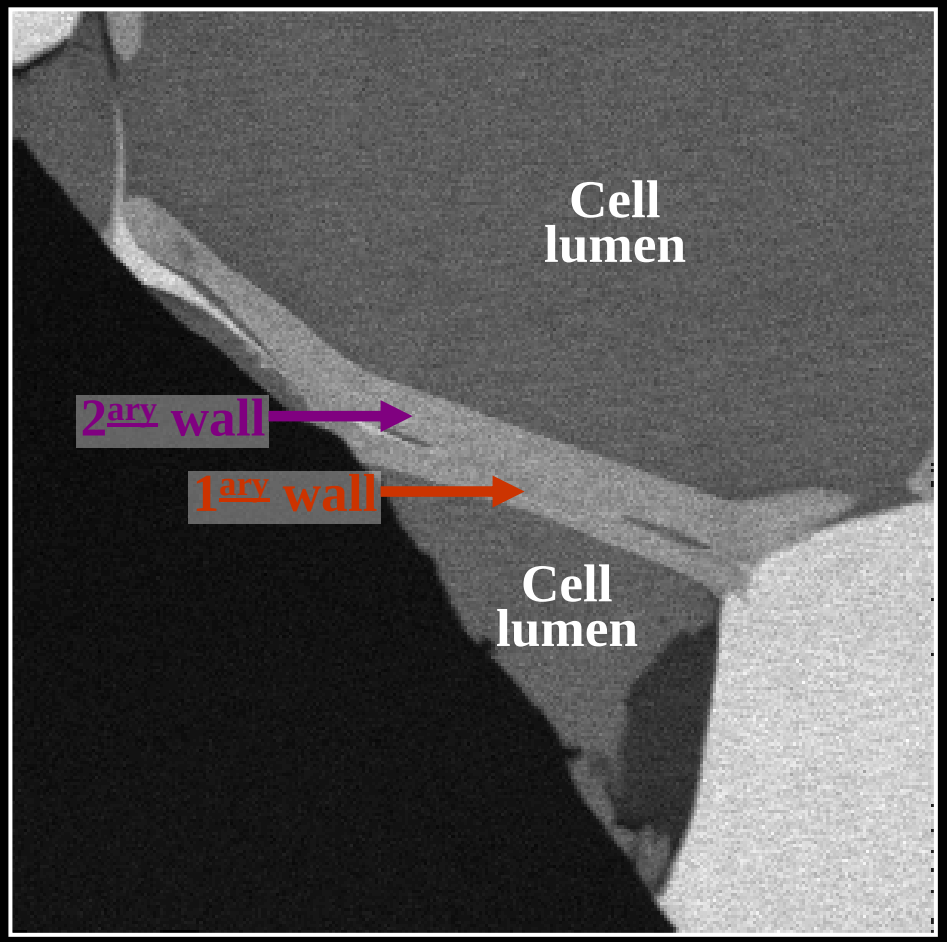


Psilotum

8μ

285.2 eV

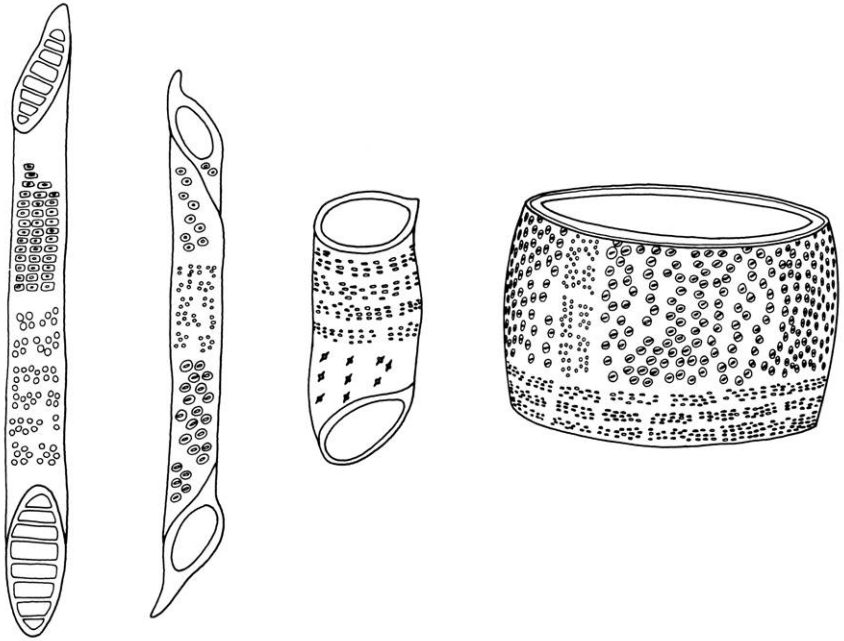
(Boyce et al. submitted)



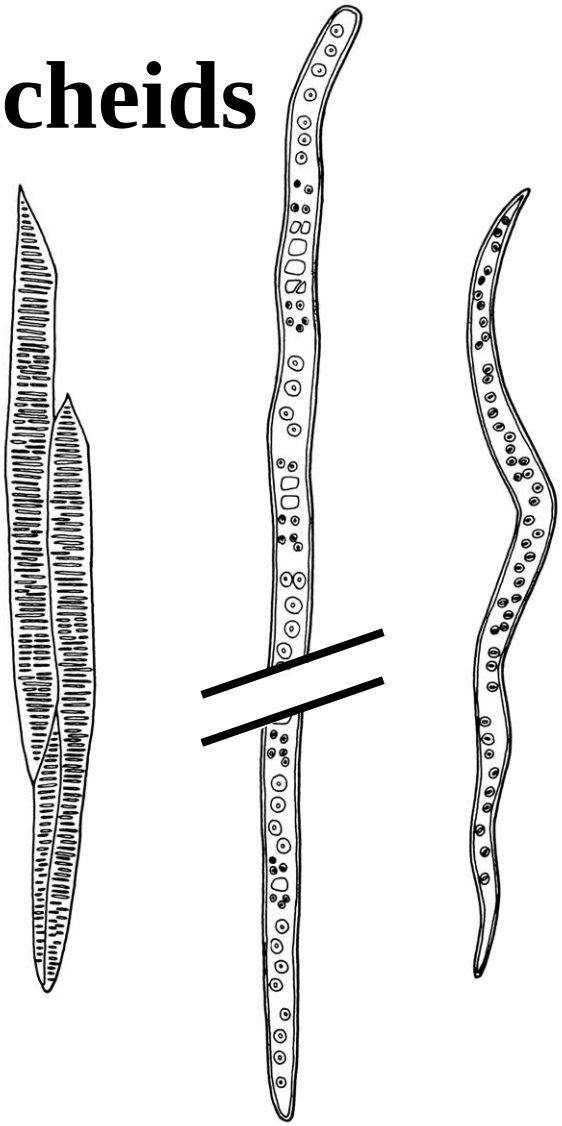
Pteridium

10μ

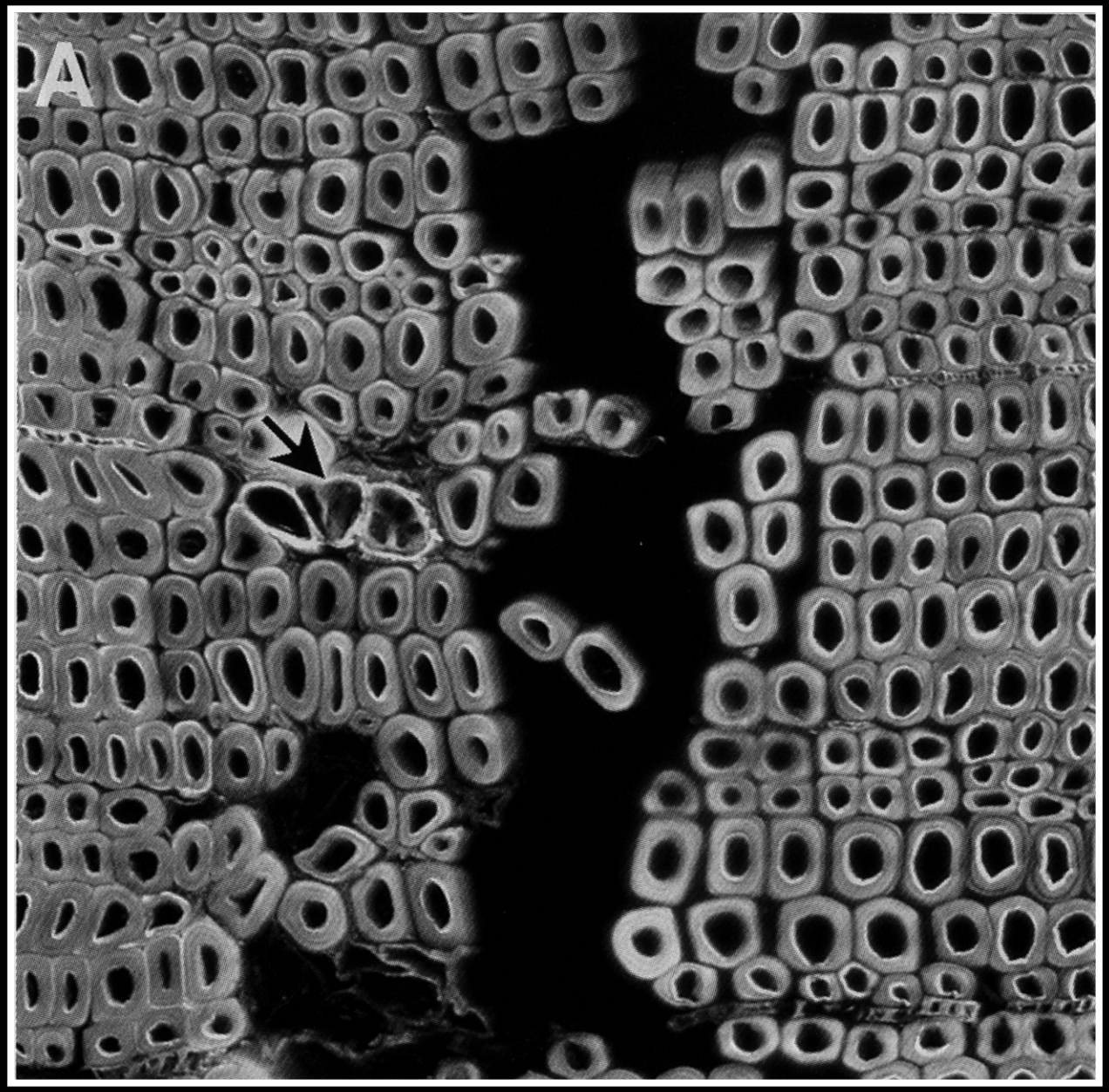
Vessels



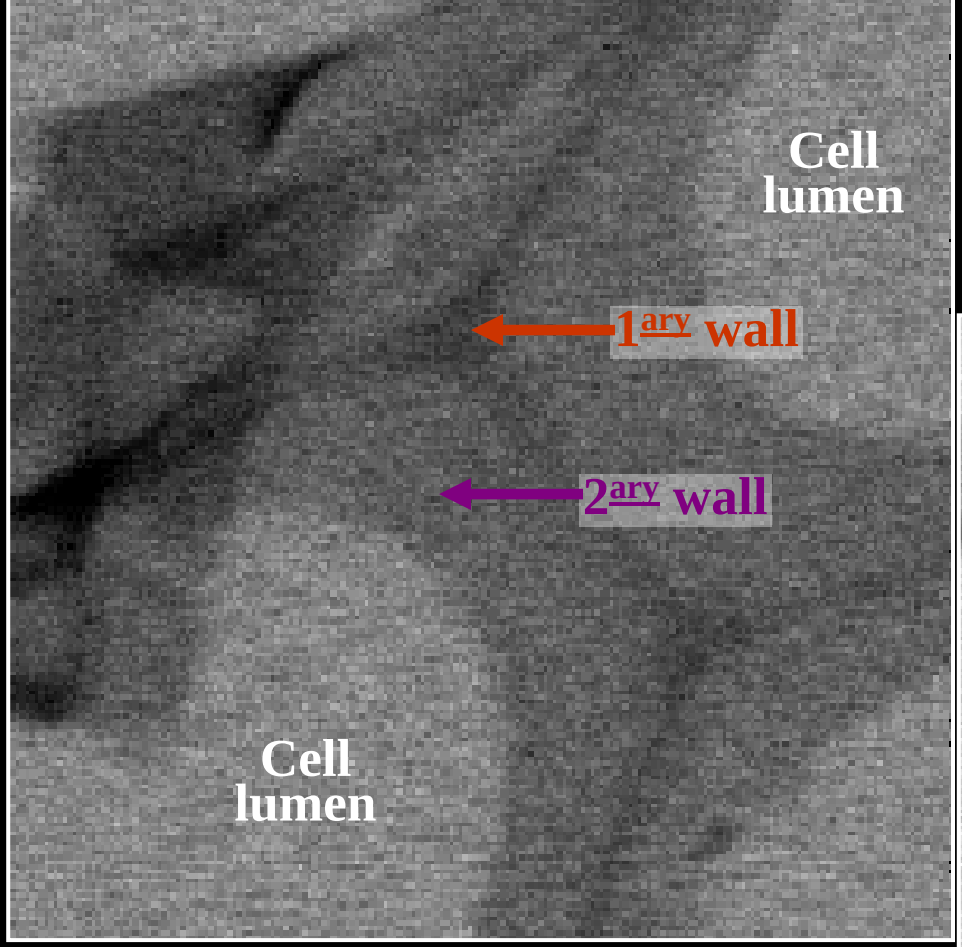
Tracheids



(Eames & MacDaniels 1947)

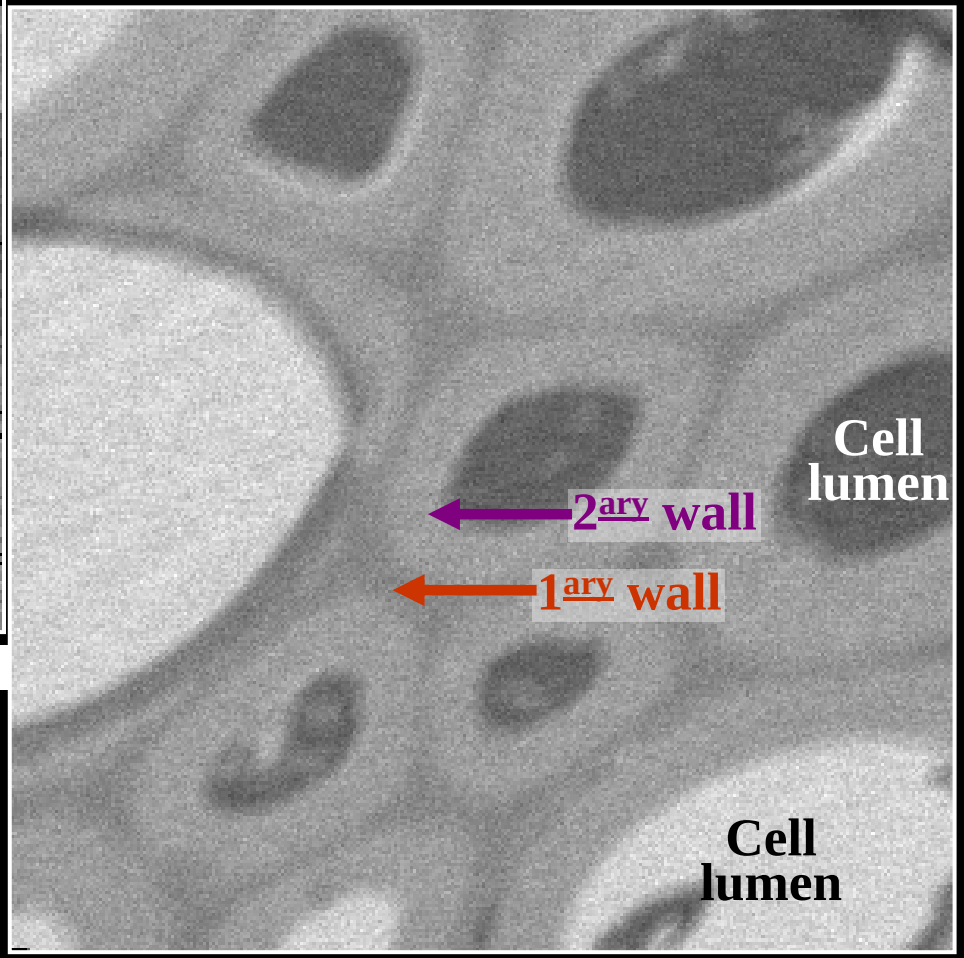


(Donaldson 2002)



Acer

2μ



Pteridium

6μ

285.2 eV

(Boyce et al. submitted)

Divergence of lignification patterns

Lycopods	Ferns	Seed Plants	
		Conifers & Ginkgo	Angiosperms
Primary wall lignification	Secondary wall lignification (tracheids) Primary wall lignification (sclerenchyma)	Primary wall lignification	Secondary wall lignification (vessels) Primary wall lignification (fibers)

Eutracheophytes

Primary wall lignification

Rhyniophytes

Secondary wall lignification

Unlignified tracheids

Collaborators:

Maciej Zwieniecki

Missy Holbrook

Andy Knoll

Harvard University

Sue Wirick

Chris Jacobsen

National Synchrotron Light Source

George Cody

Marilyn Fogel

Bob Hazen

Carnegie Geophysical Laboratory