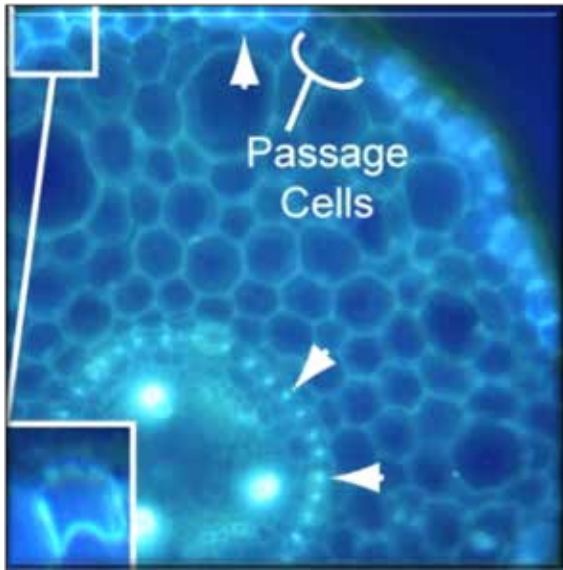


How grapevines use water: a journey through the vine's vascular system

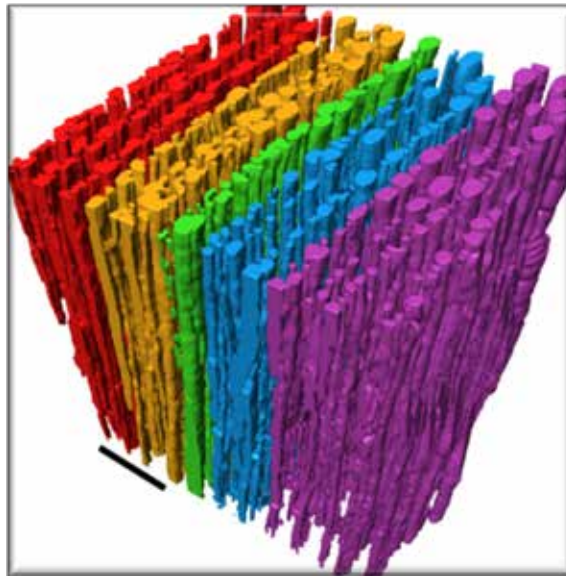
Andrew J. McElrone



Sustainable Water Use in Vineyards



Rootstock
Water Use



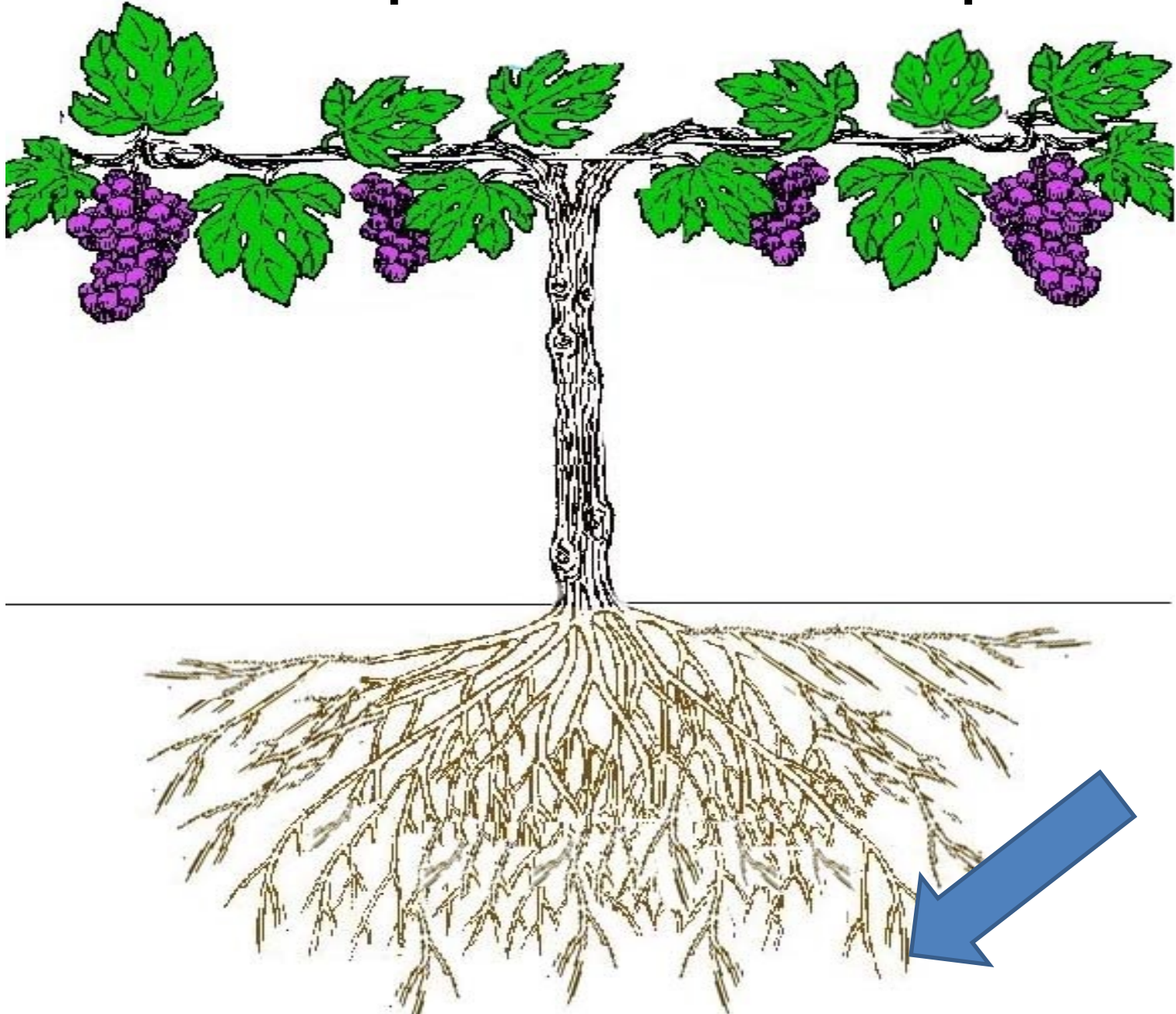
Vascular
Transport



Technology to
Quantify
Water Use

Drought Resistance

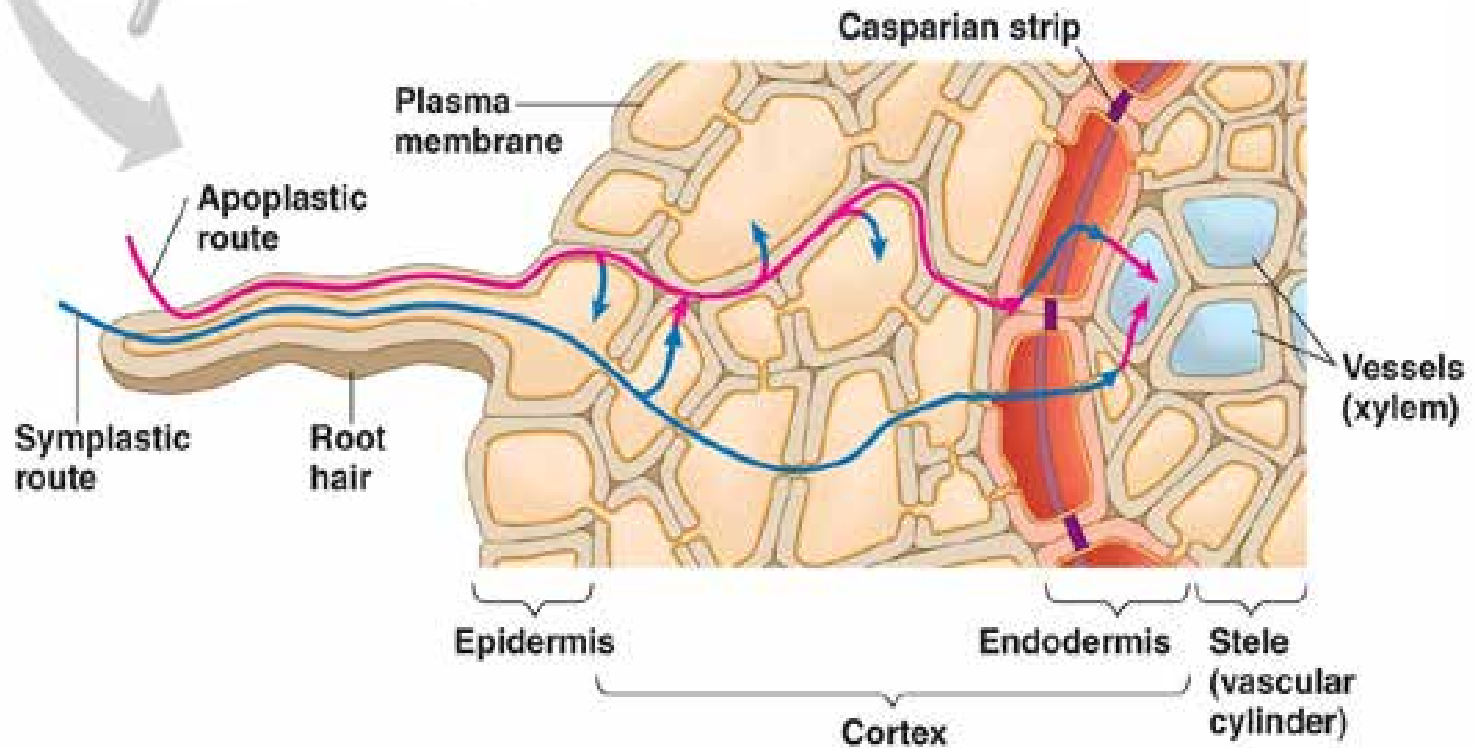
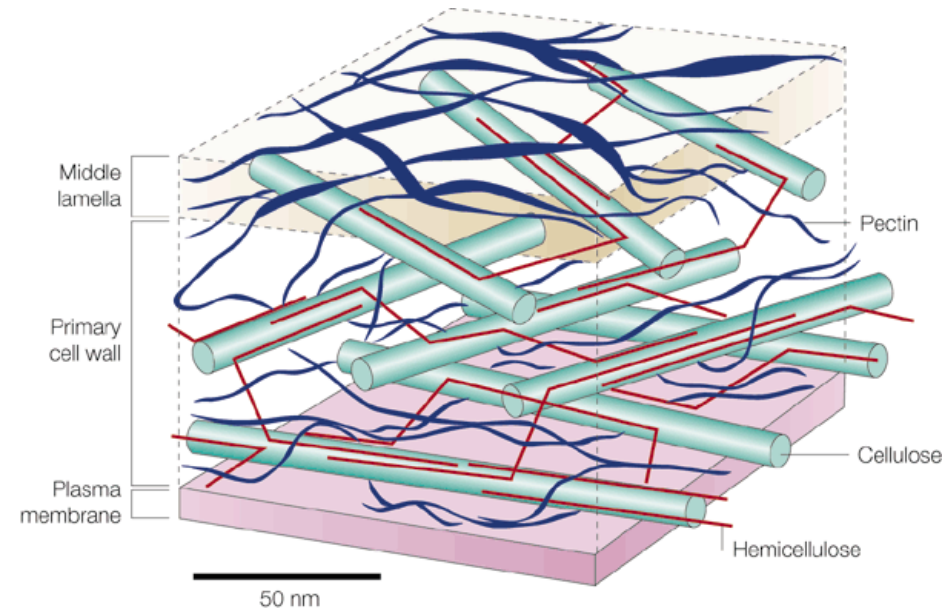
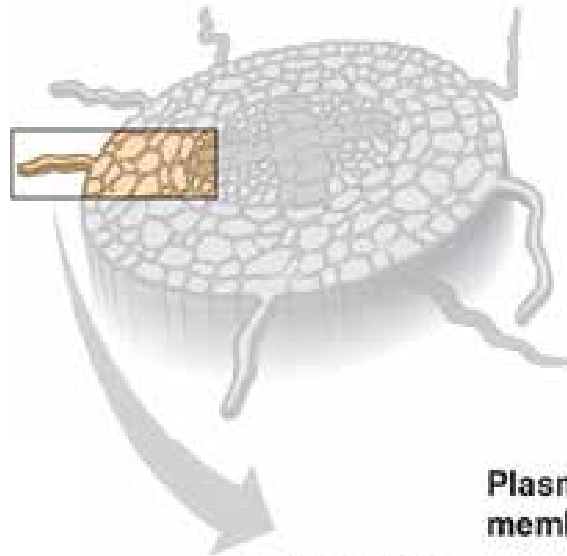
Water uptake and transport



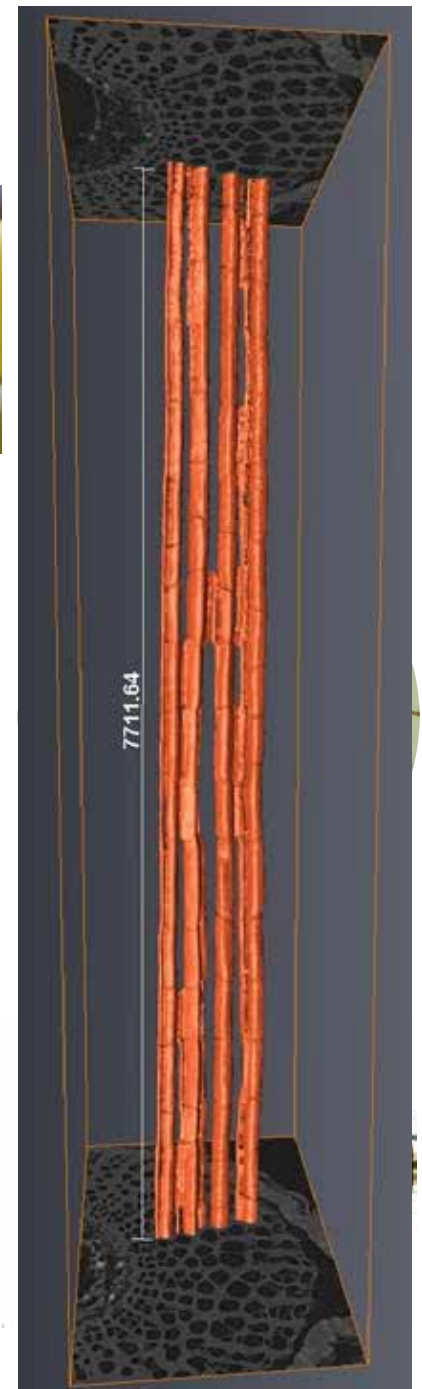
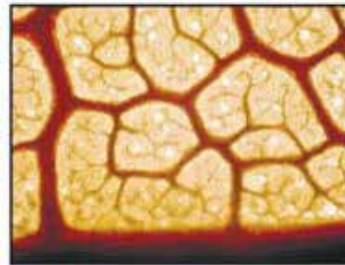
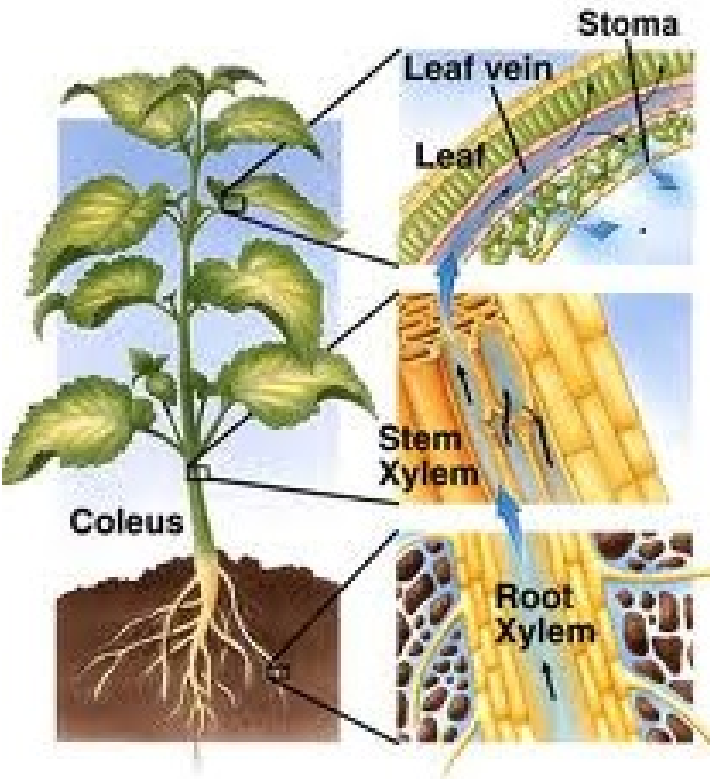


Underground stream at 20m depth
Menard, Texas, USA

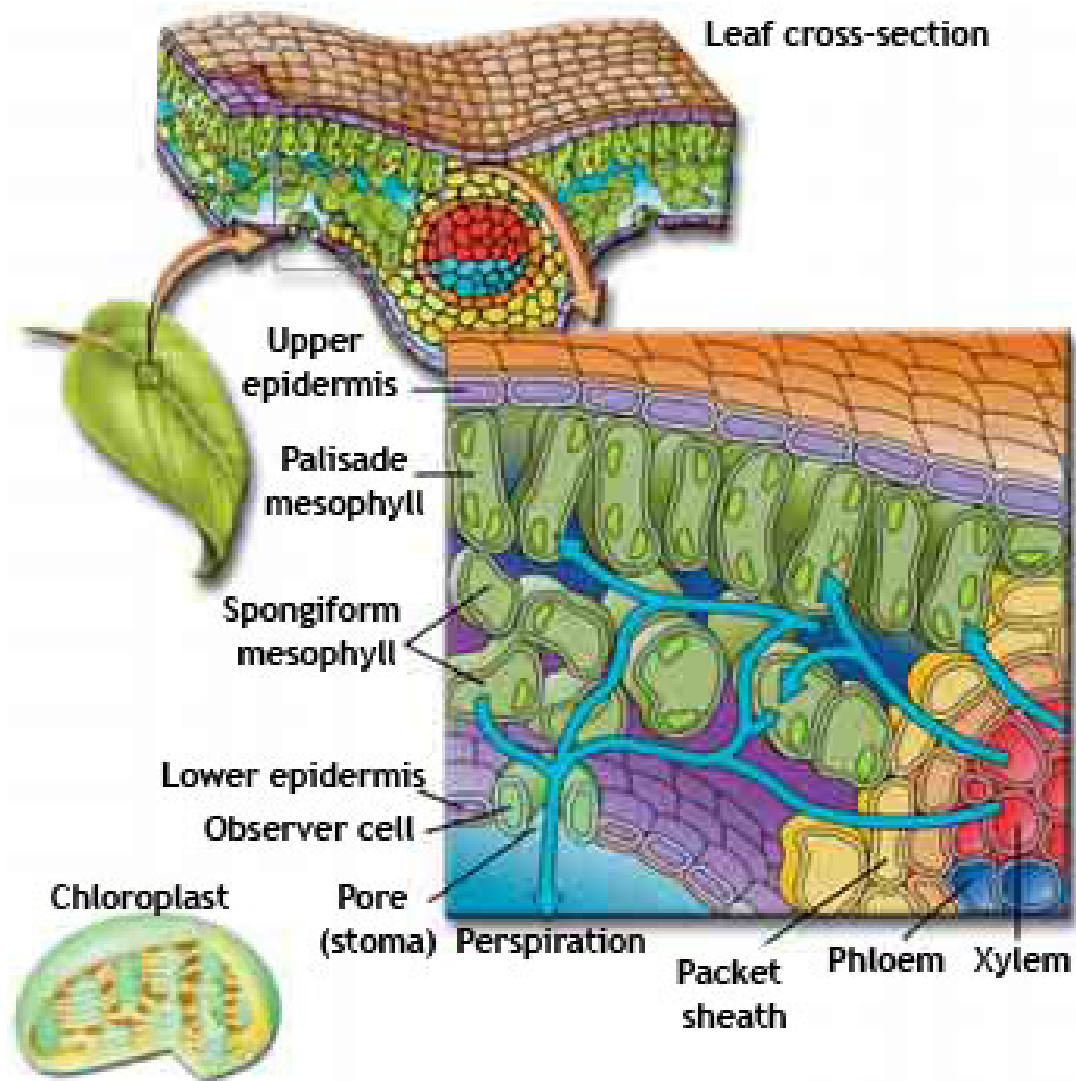
Water absorption by fine roots



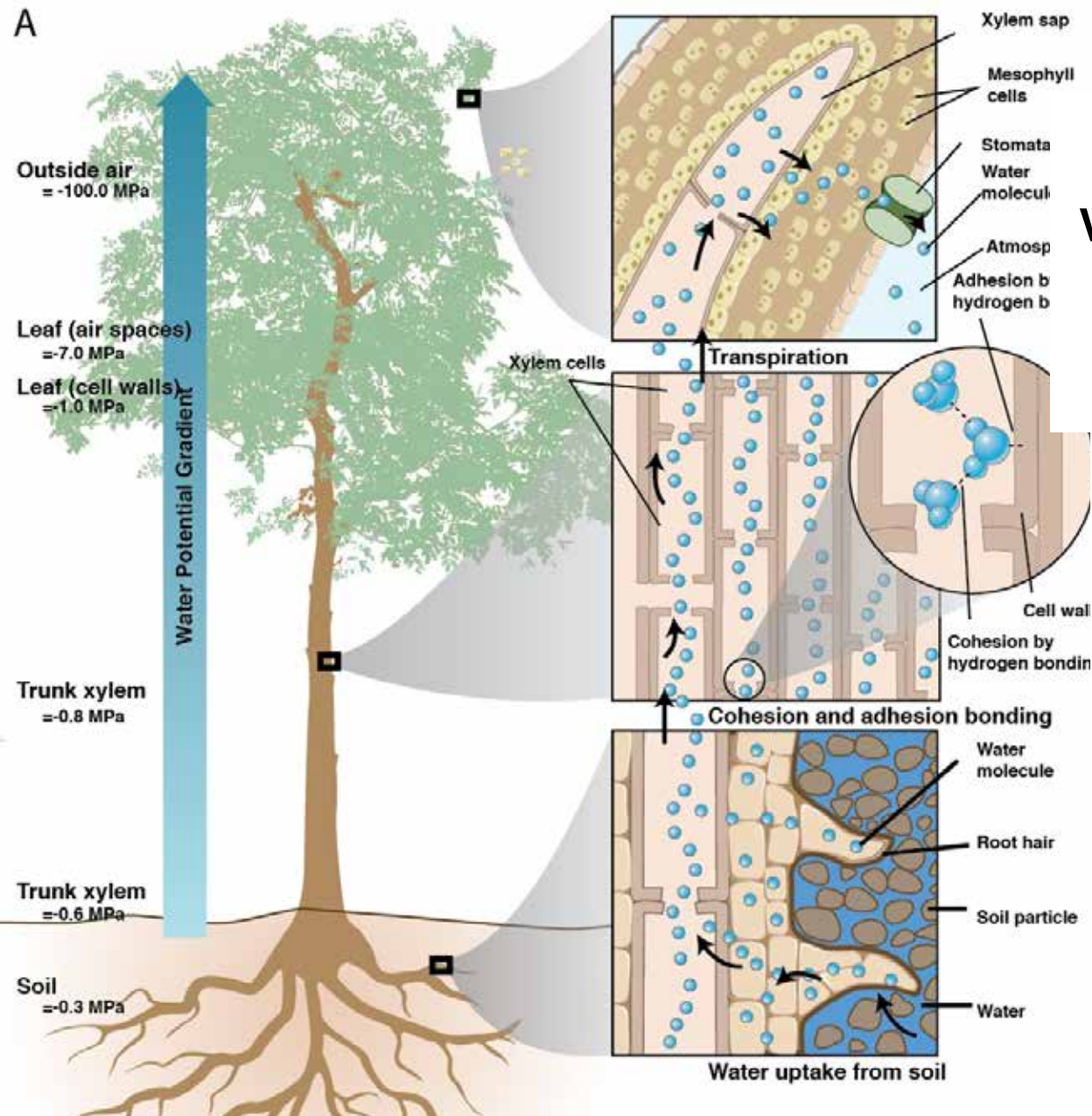
Long distance water transport in xylem



Water loss from leaves by transpiration



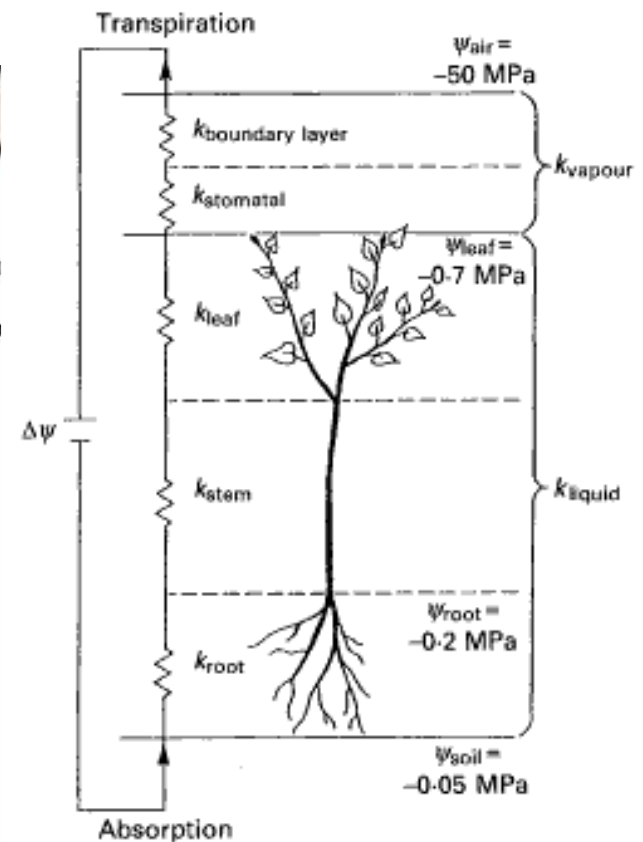
Cohesion-Tension Mechanism

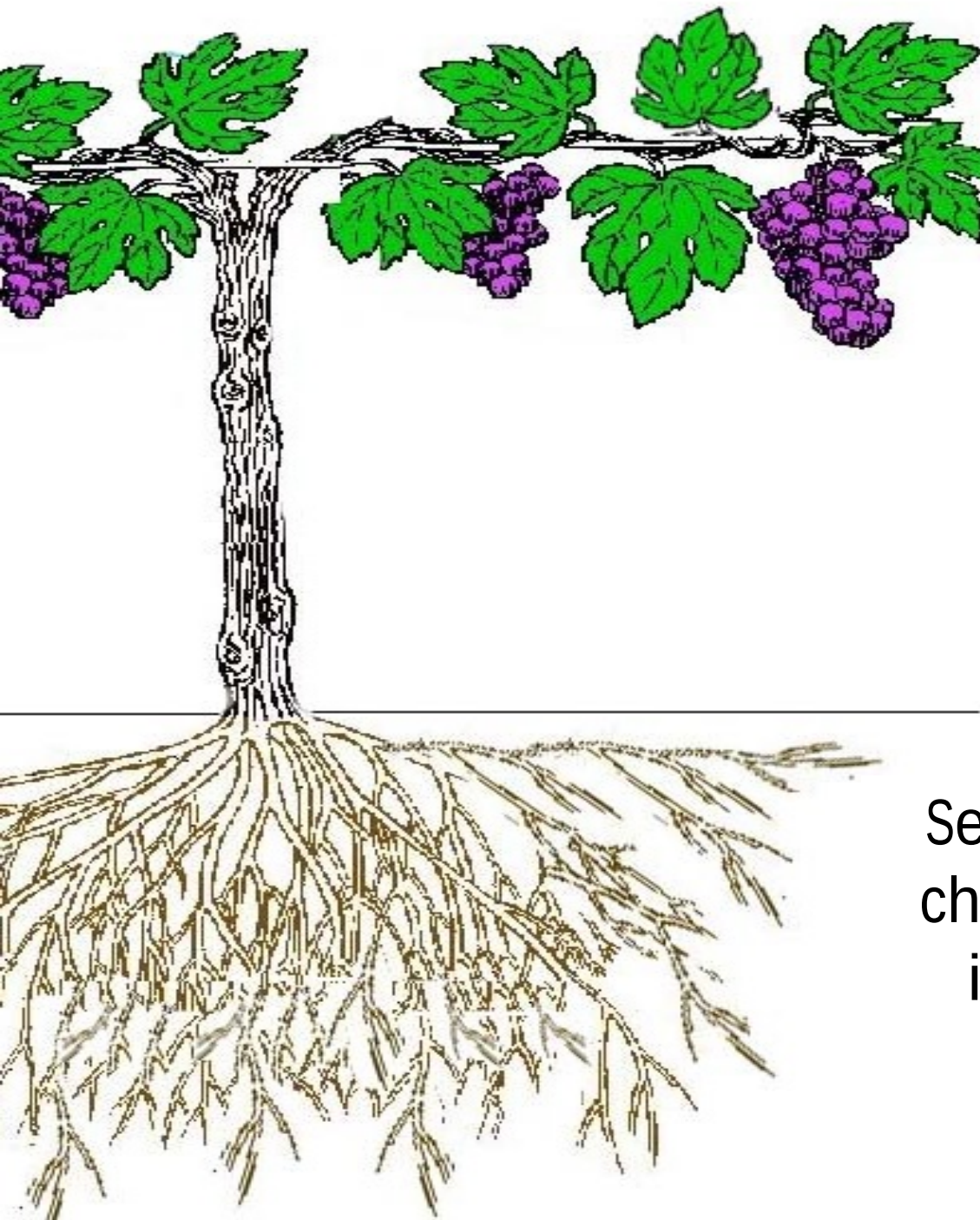


Ohm's Law Analogy

Voltage = Current X Resistance

Flow = $\Delta\psi$ / Resistance





Drought resistance:
the ability of a plant
to continue growth
when exposed to
periods of water
stress

Searching for rootstock
characteristics linked to
improved water use
efficiency

Vitis germplasm collection- Dr. Andy Walker

V. girdiana- Ash Meadows Salt Flats



V. girdiana- Lake Meade



V. arizonica- Zion National Park



V. arizonica- Las Vegas, NV



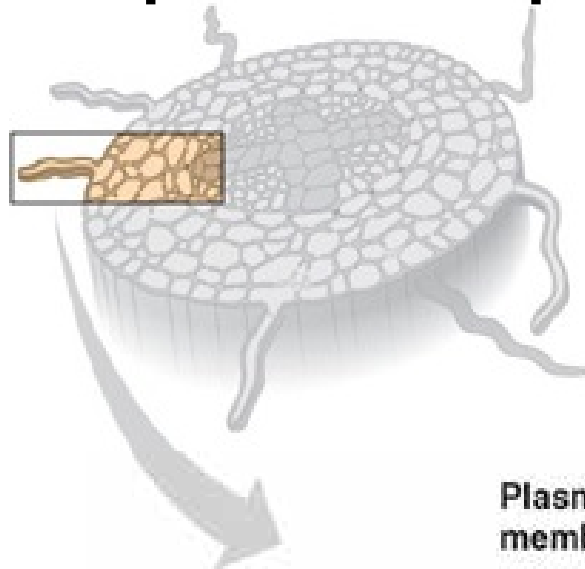
Improved water uptake via extensive and/or efficient root systems

- a. large & active root system
- b. high permeability of fine roots
- c. prevent/promote leakage to soil
- d. efficient xylem transport
- e. cavitation resistance/limit embolism
- f. ability to repair embolism

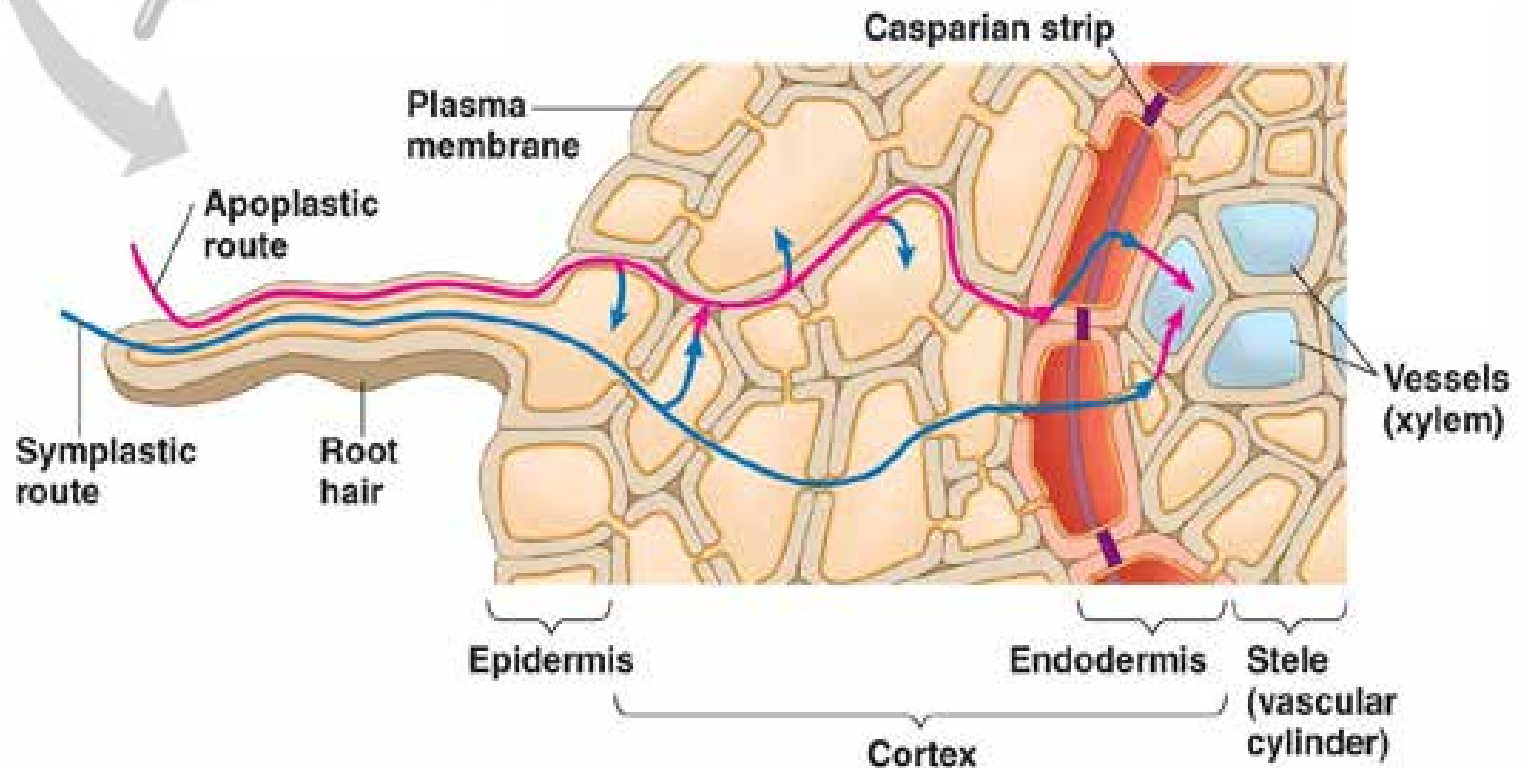
a. Large & active root system



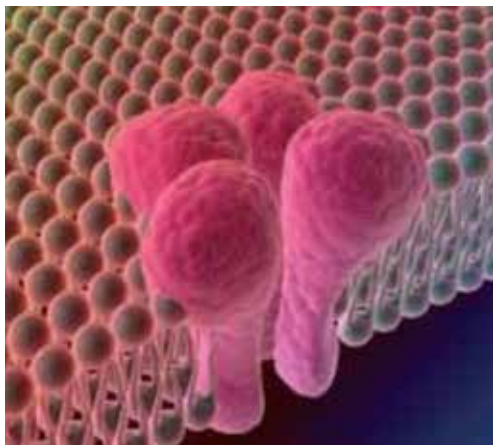
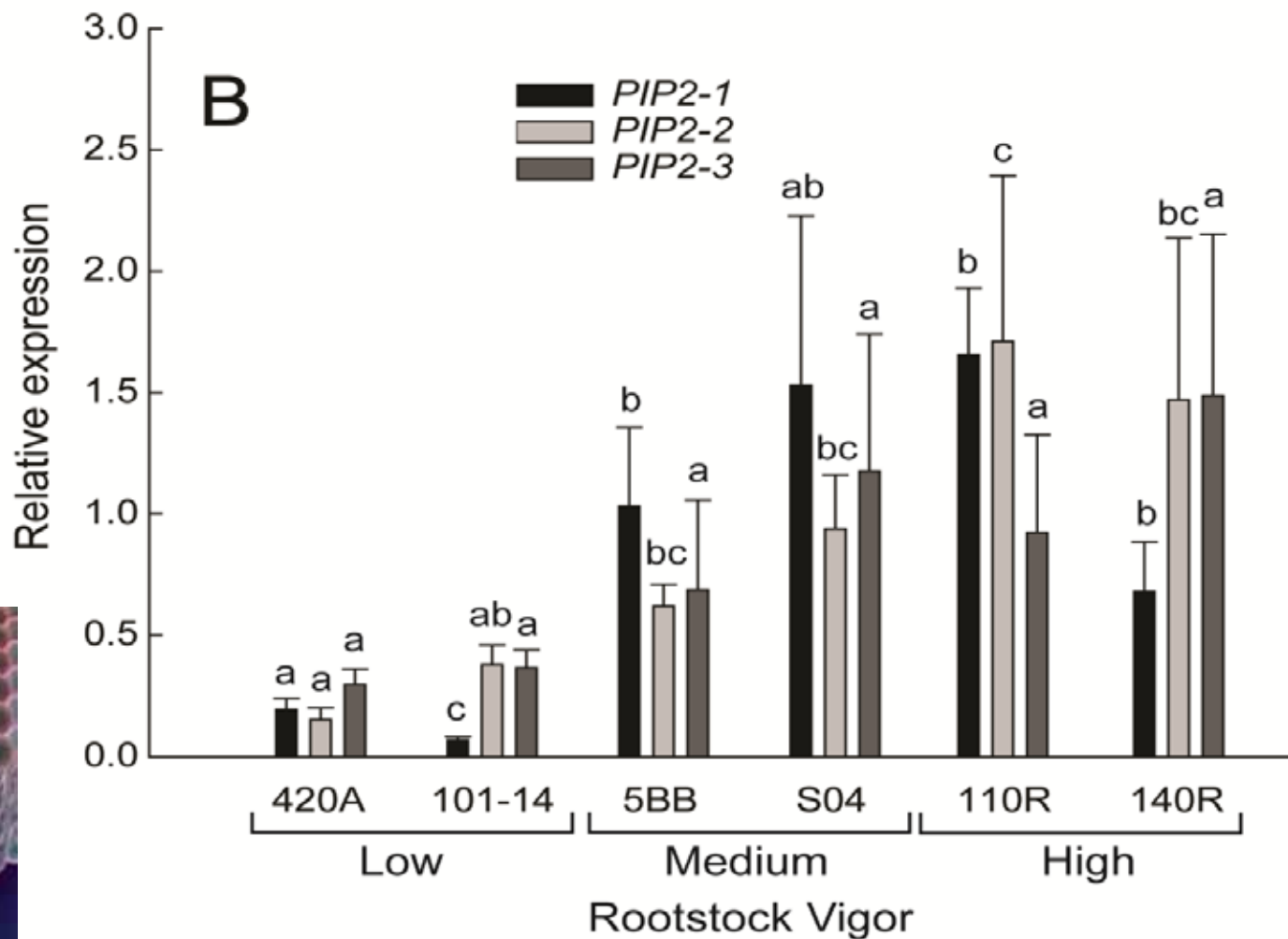
- b. high permeability of fine roots
- c. prevent/promote leakage to soil



Water Uptake by Fine Roots



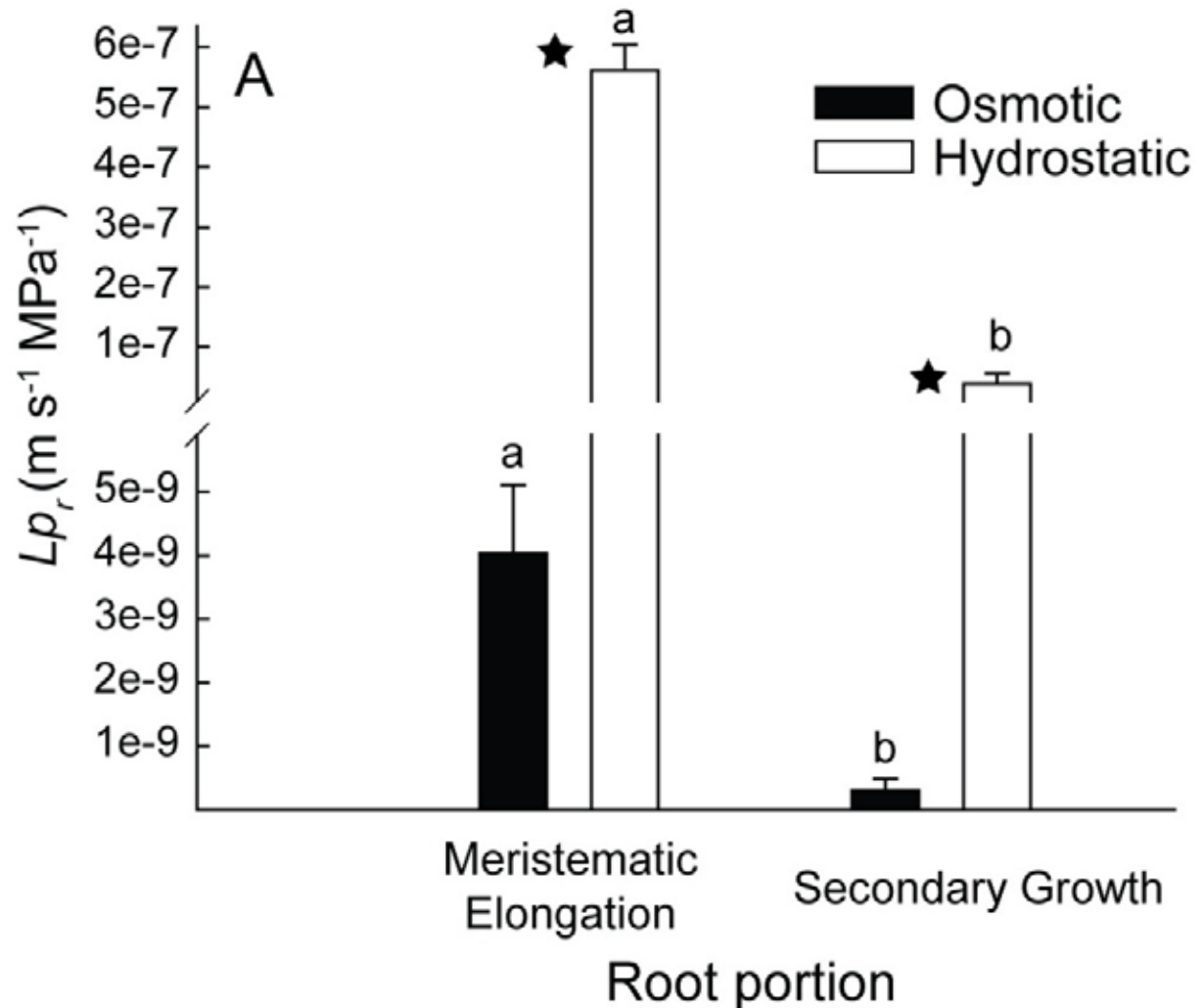
Inherent, Non-Stressed Aquaporin Expression



Aquaporins

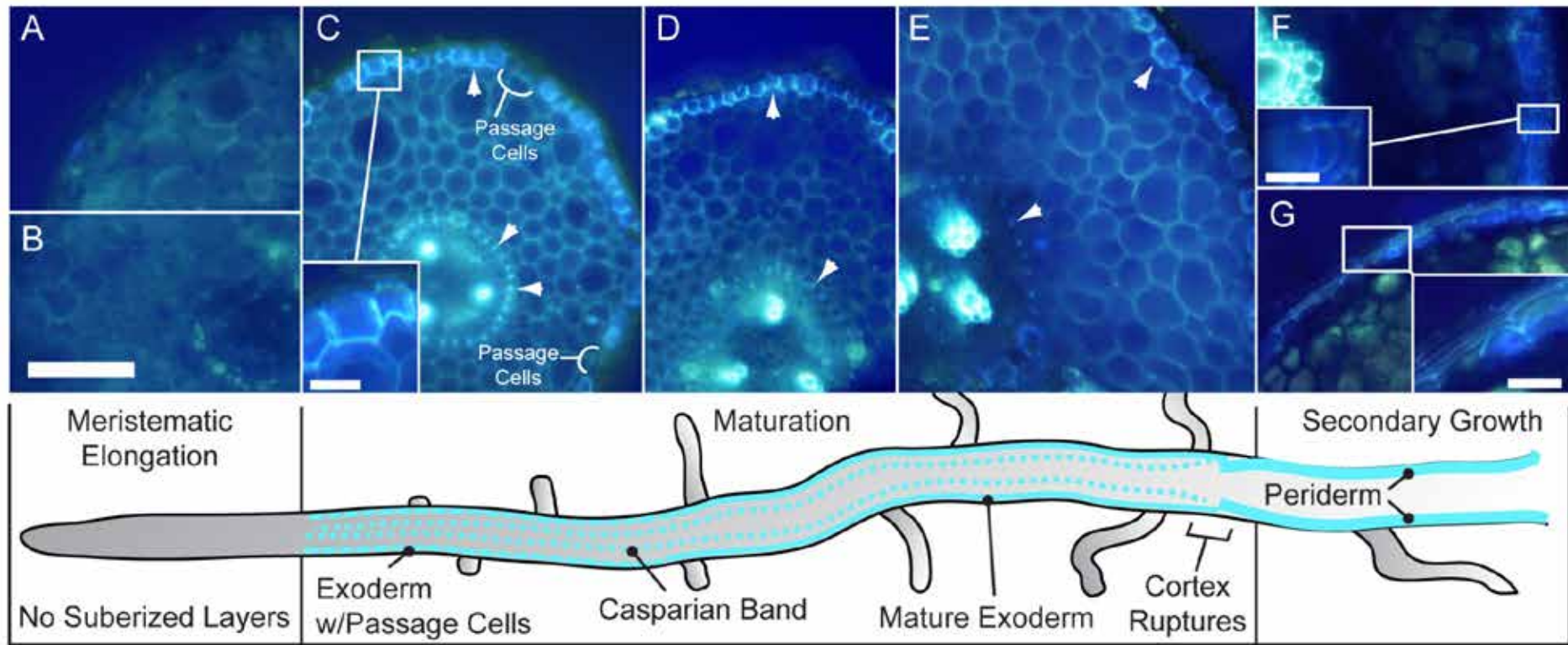
Gambetta et al. 2012 *JXB*

Fine root hydraulic conductivity for 110R = permeability

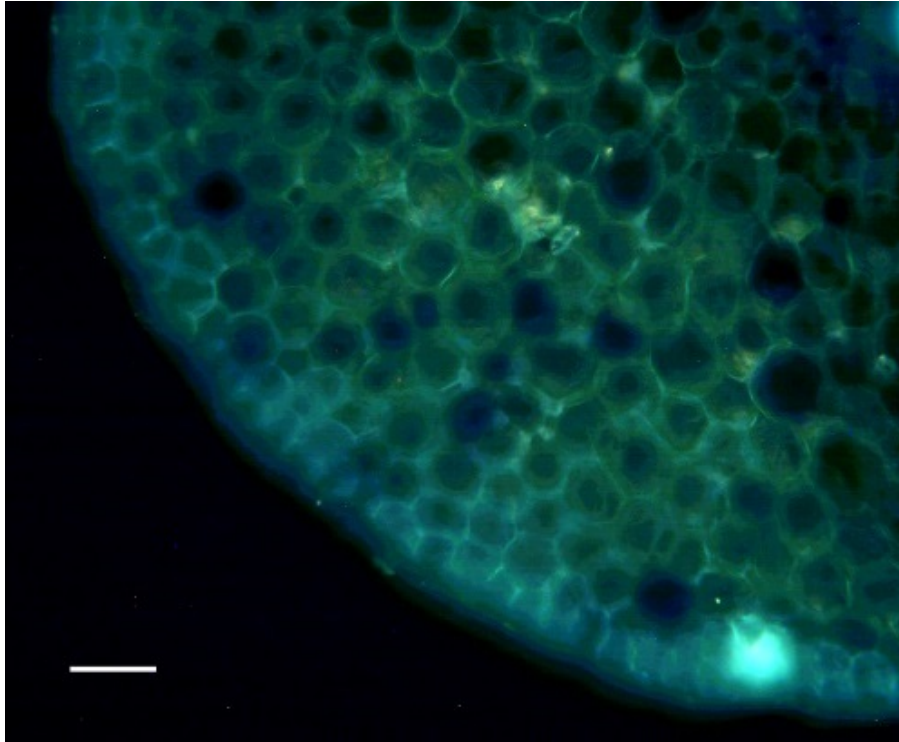


New, white roots more permeable, but old roots are too

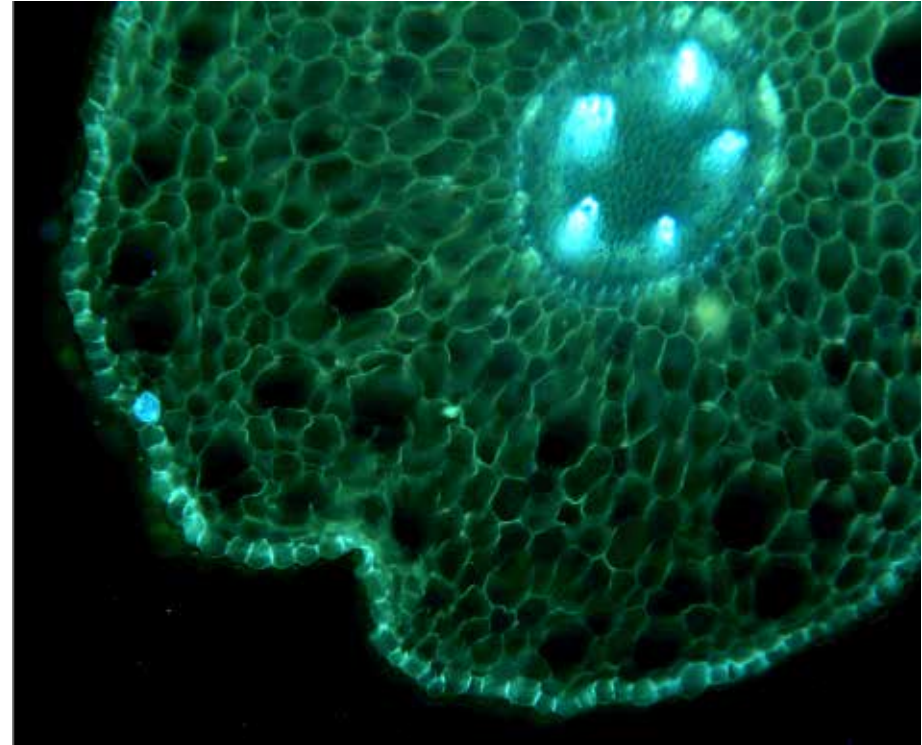
Suberization



Wet

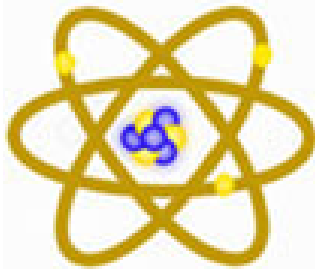


Dry



— Decreasing permeability & leakiness →

- Differential response among rootstocks
- How is this affected by irrigation management?
- How can we manipulate this?



UC DAVIS

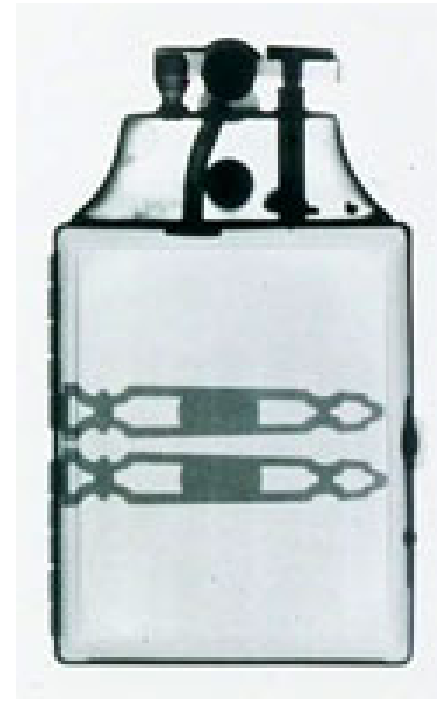
McClellan Nuclear Research Center



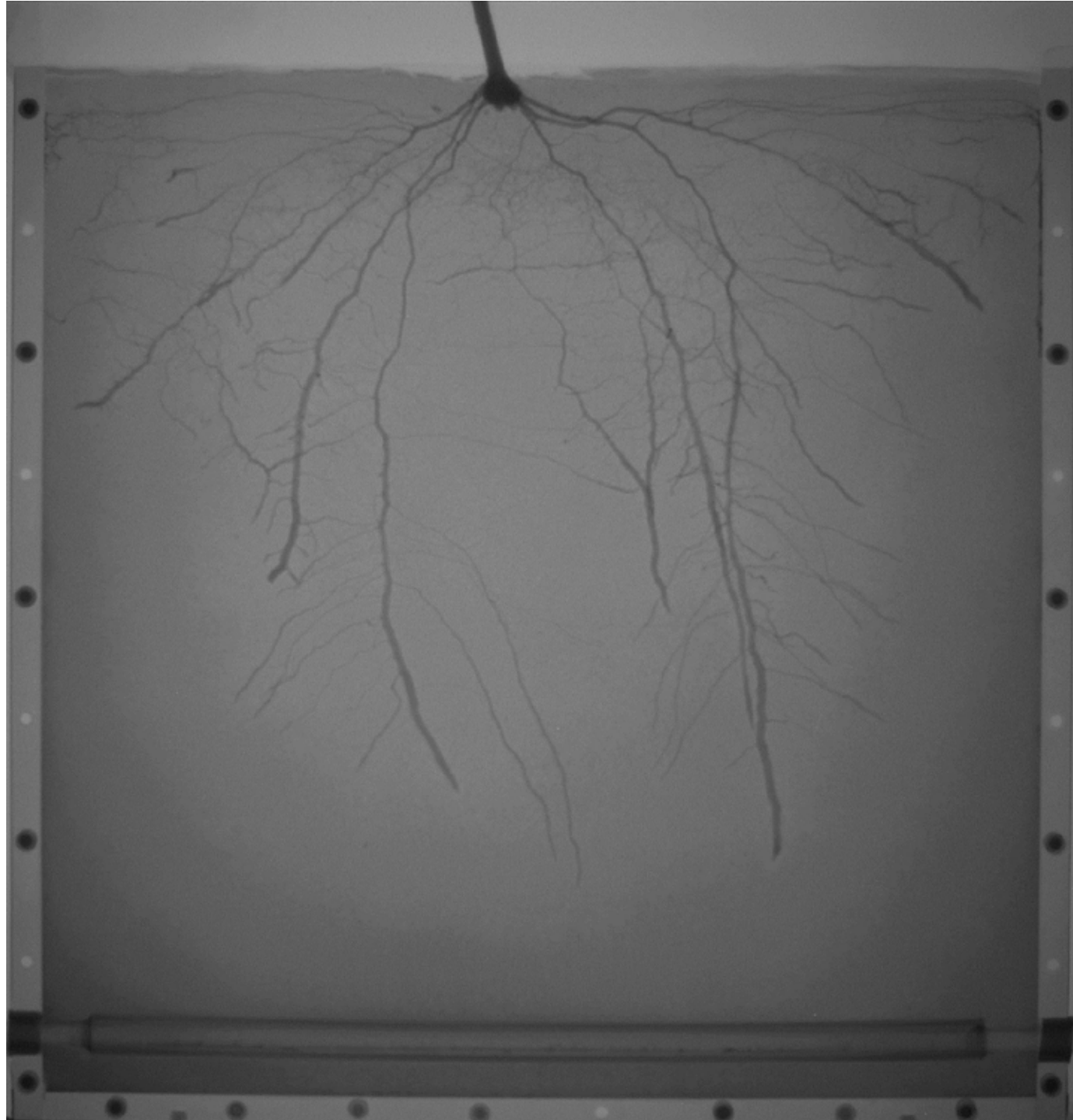
Photograph



**Neutron
Radiograph**



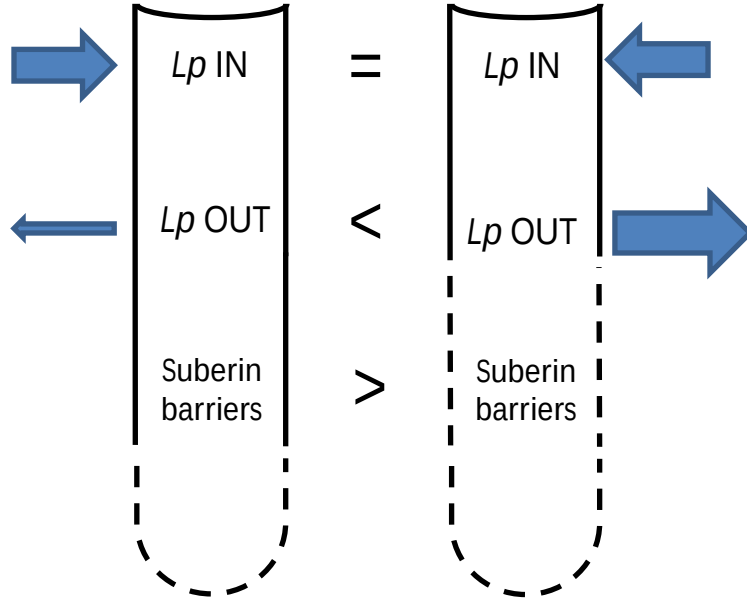
X-Ray



‘Dry’

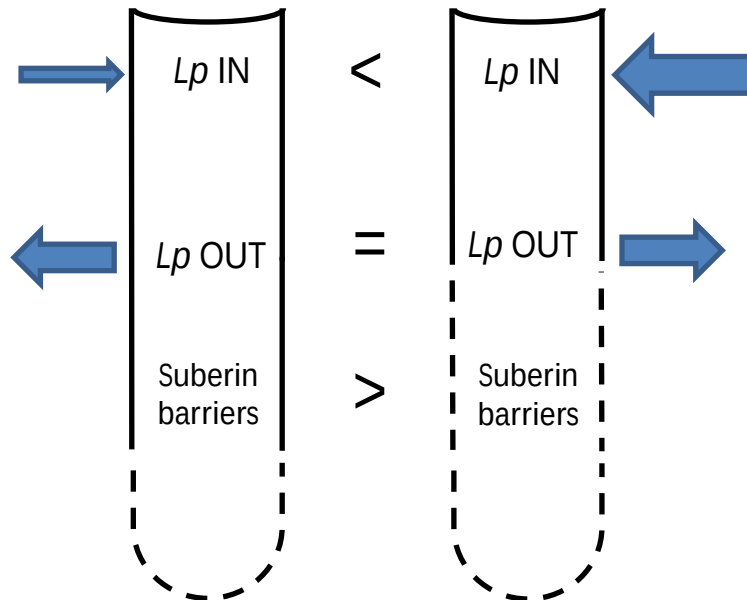
‘Wet’

110R



110R maintains water permeability into roots, but limits leakiness under drought

101-14Mgt



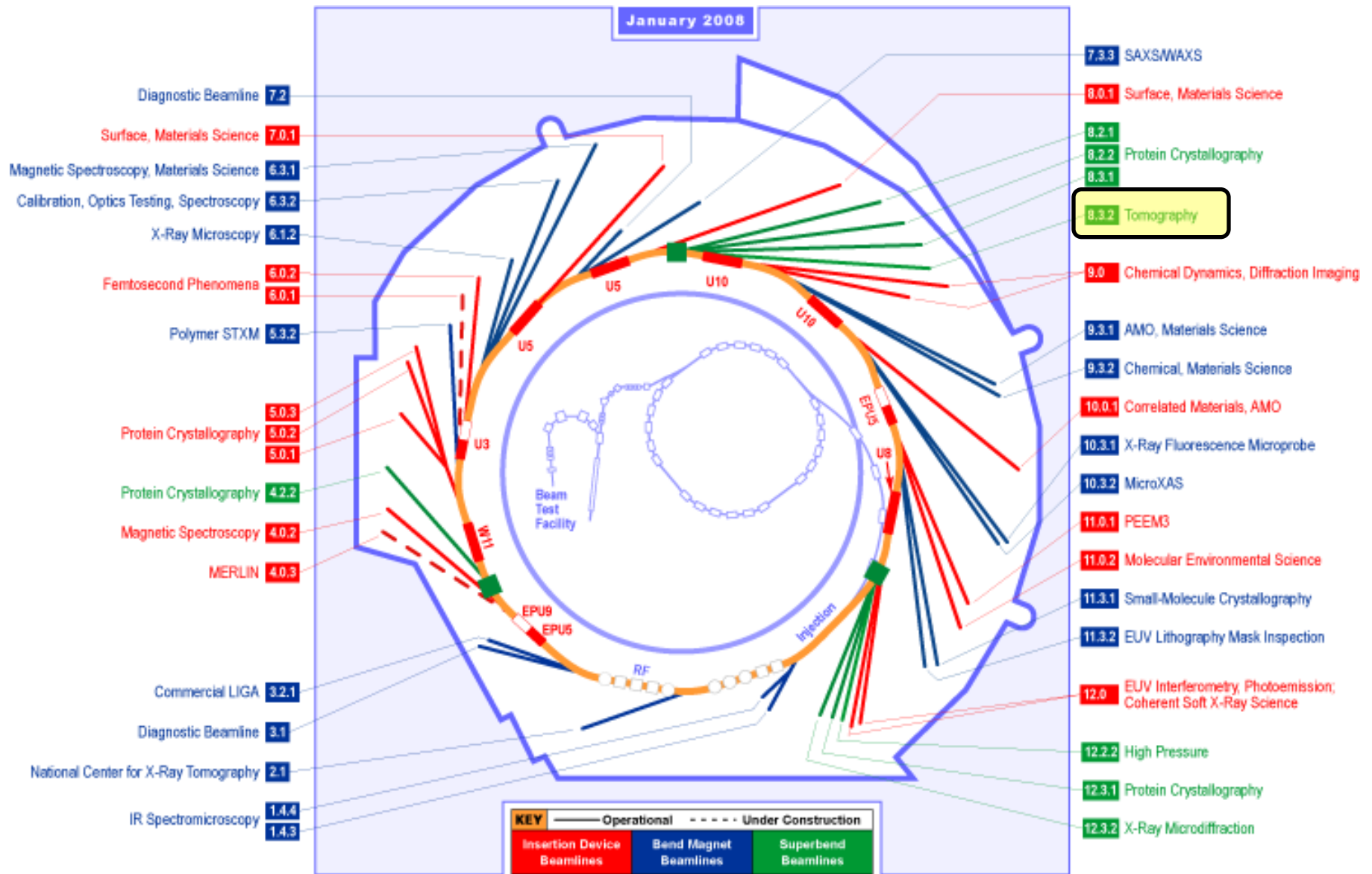
101-14 water permeability decreases into roots, but maintains leakiness under drought

- d. efficient xylem transport
- e. cavitation resistance/limit embolism
- f. embolism repair

Advanced Light Source Synchrotron–LBNL, Berkeley, CA

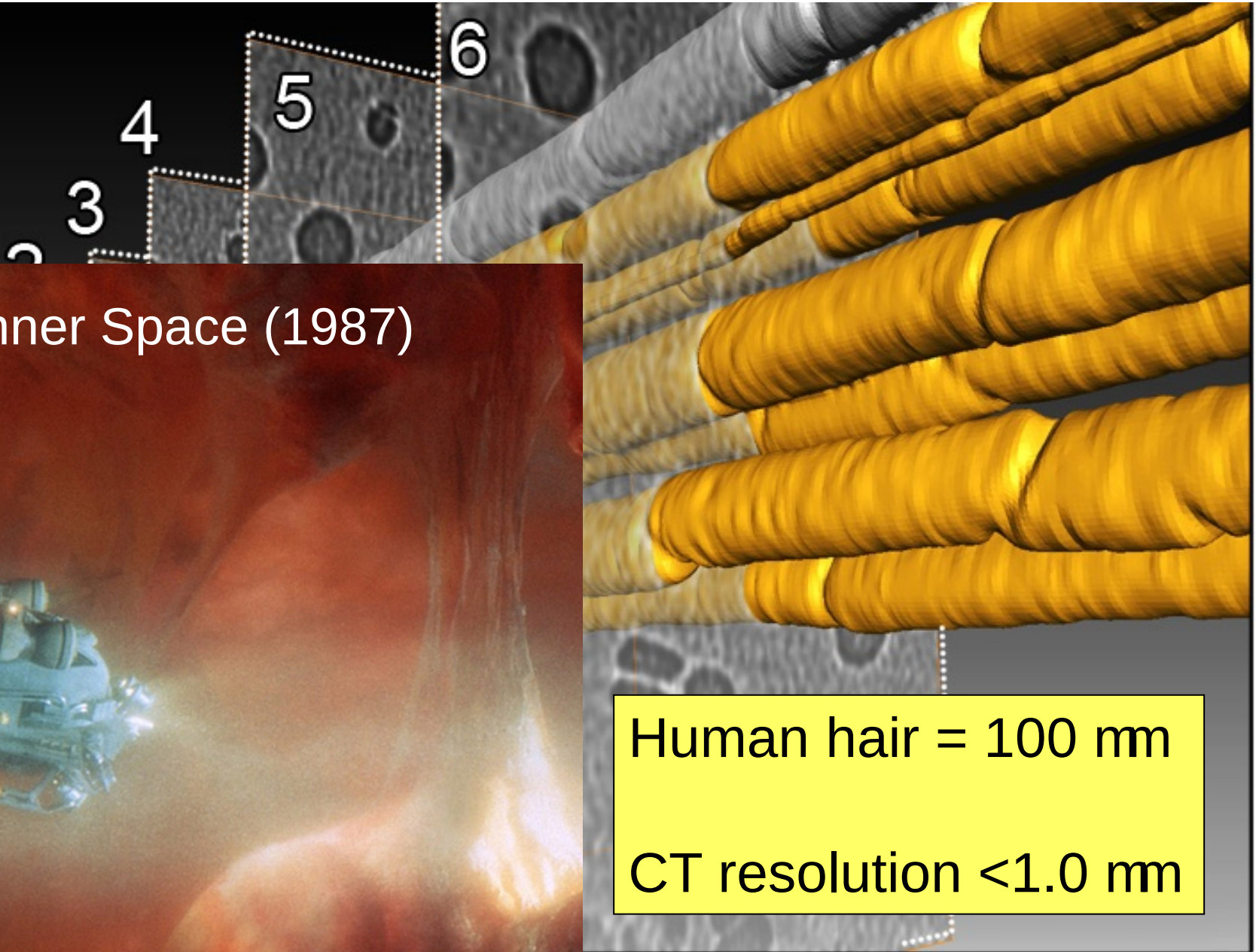


Advanced Light Source Synchrotron—LBNL, Berkeley, CA

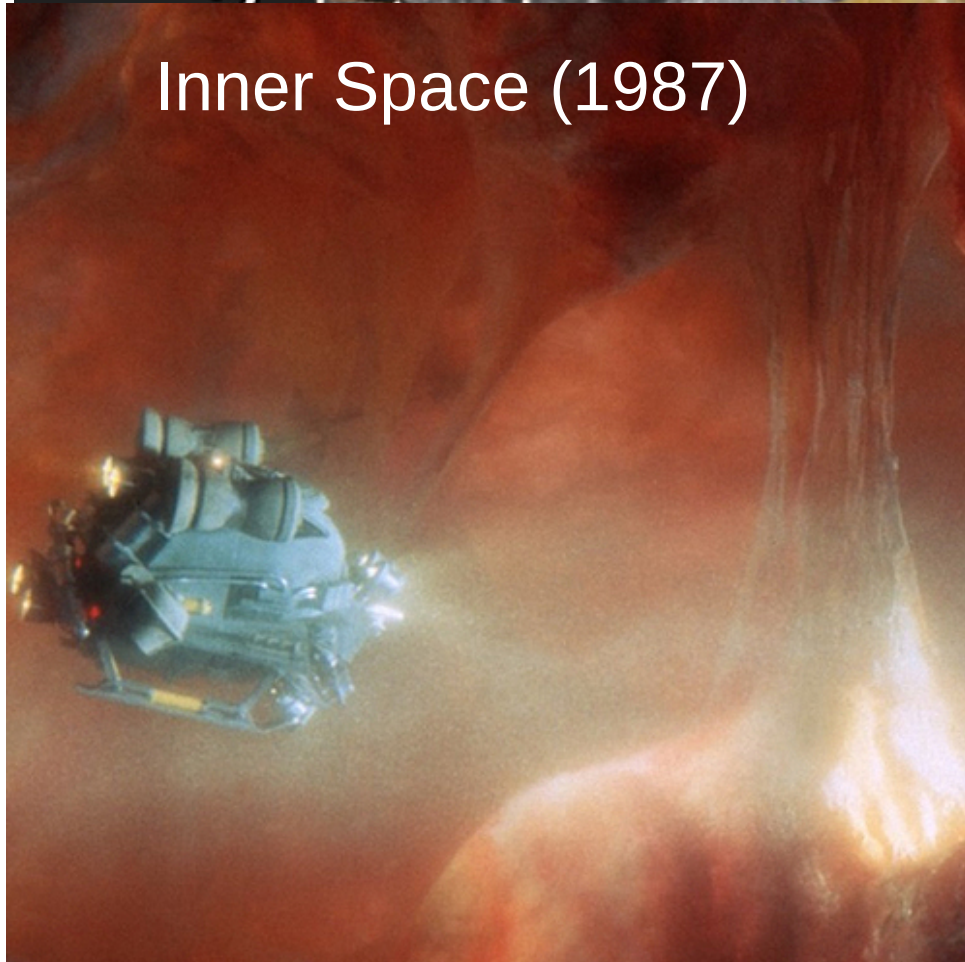


X-ray Micro-Tomography Beamline

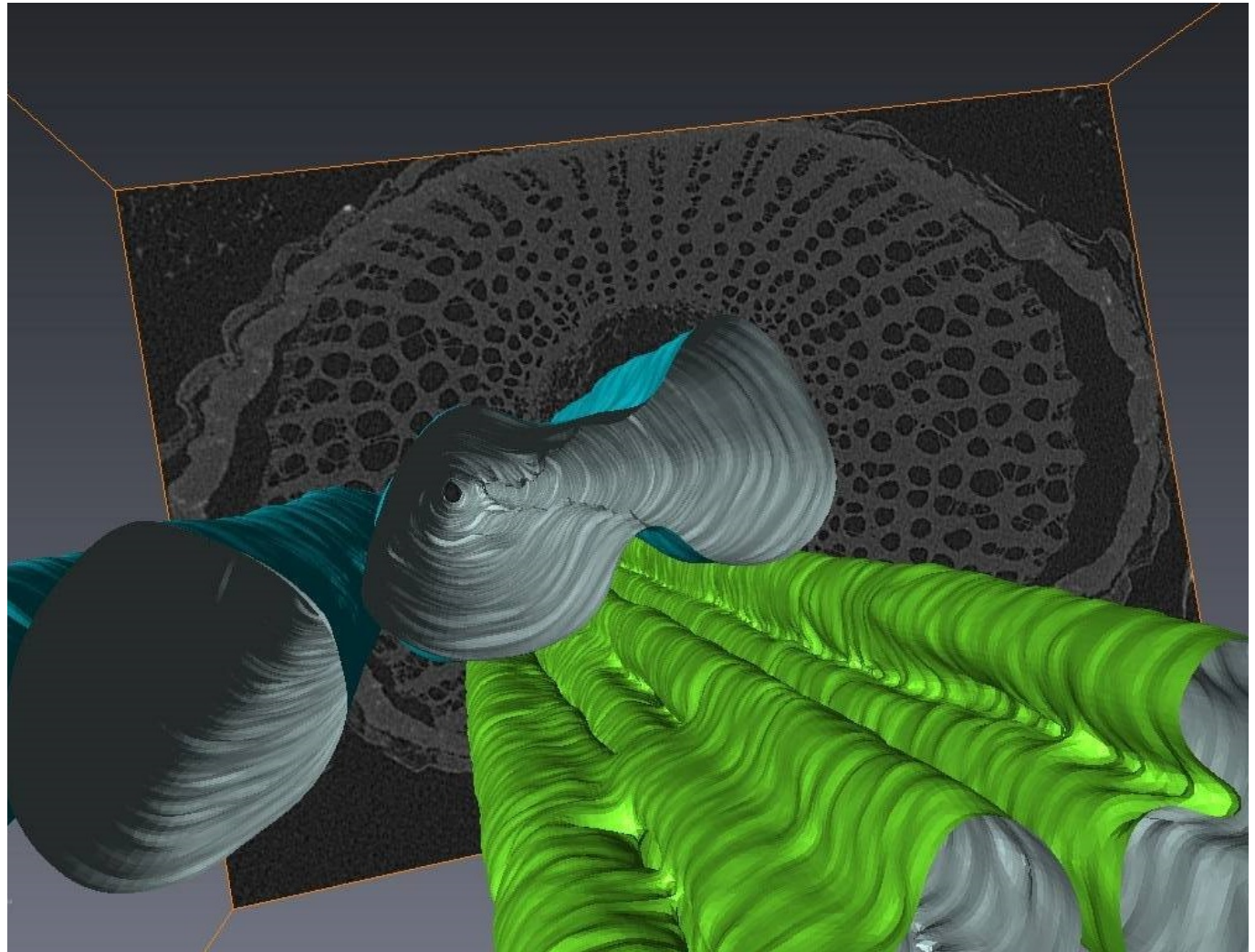
B



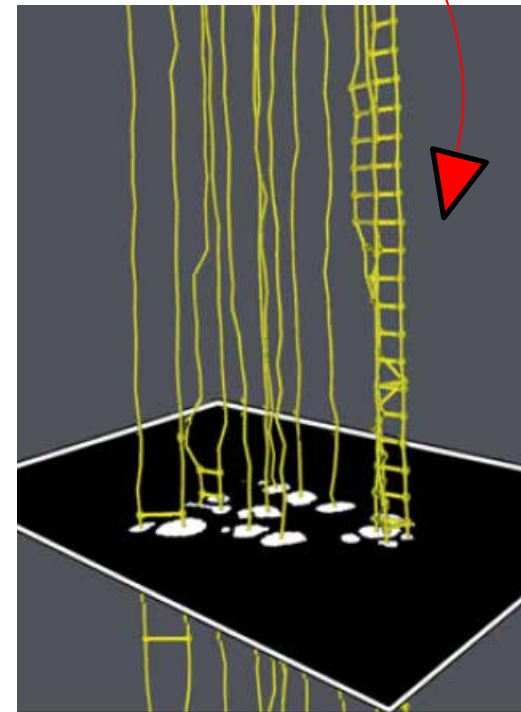
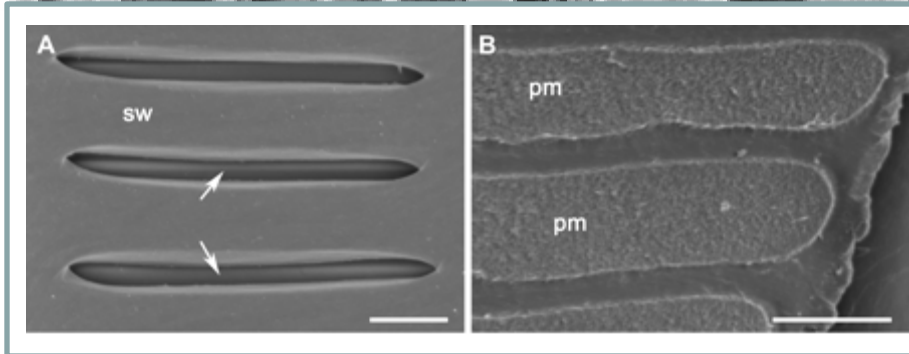
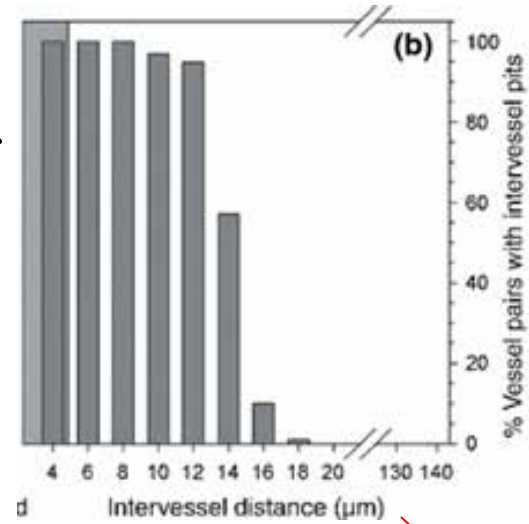
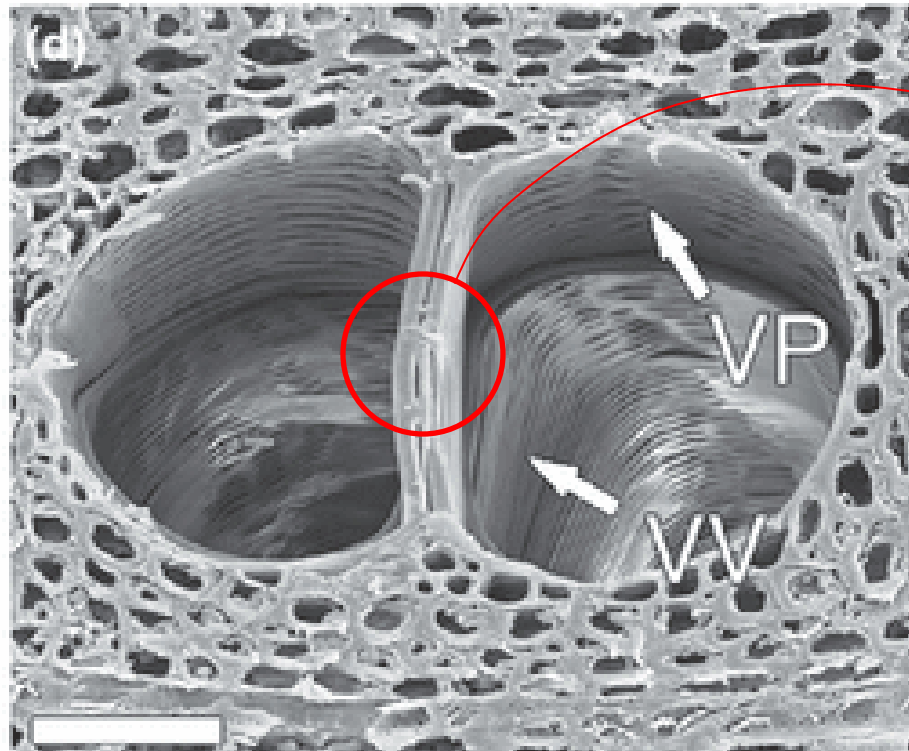
Inner Space (1987)



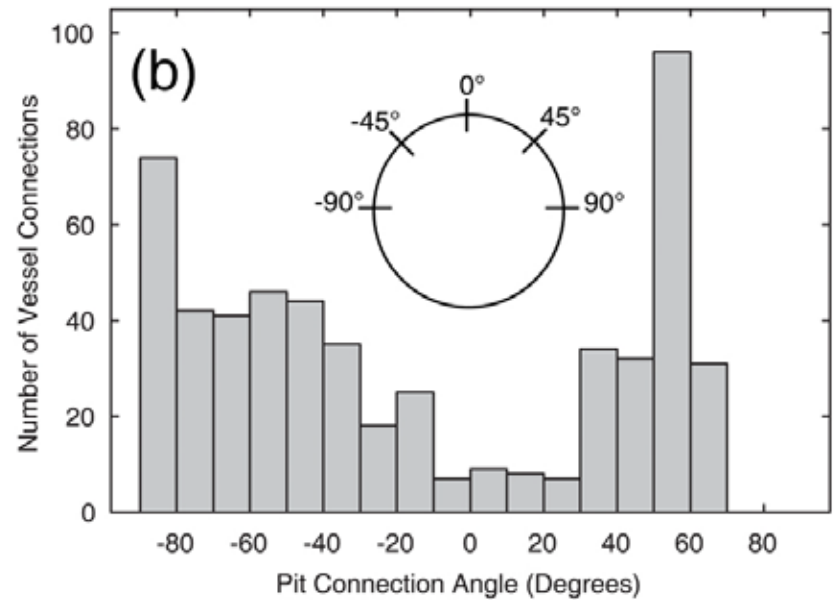
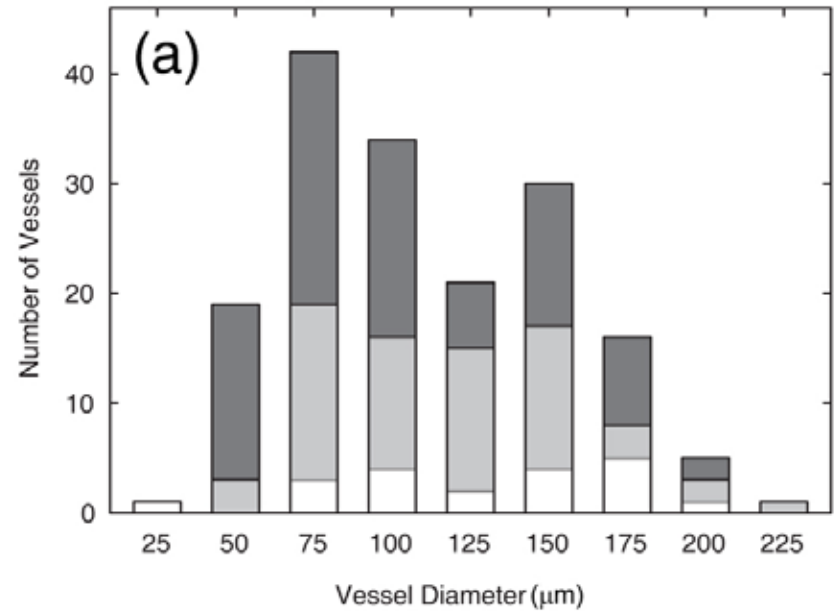
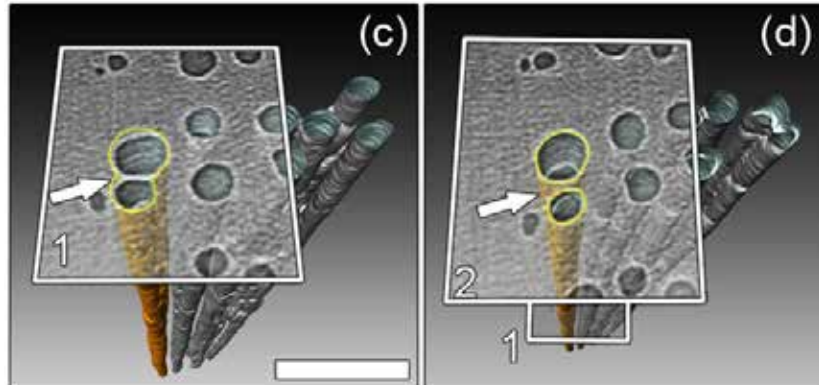
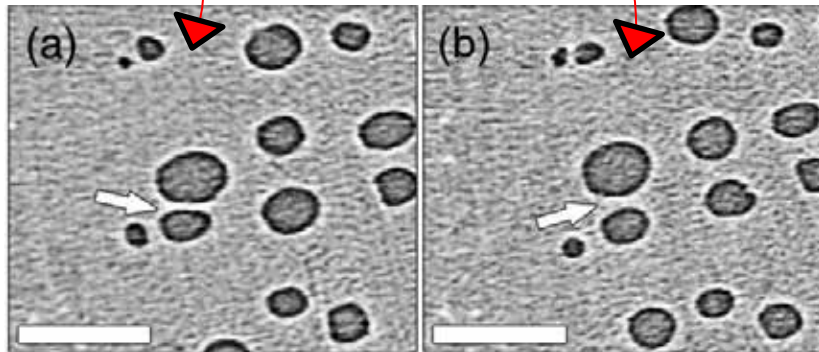
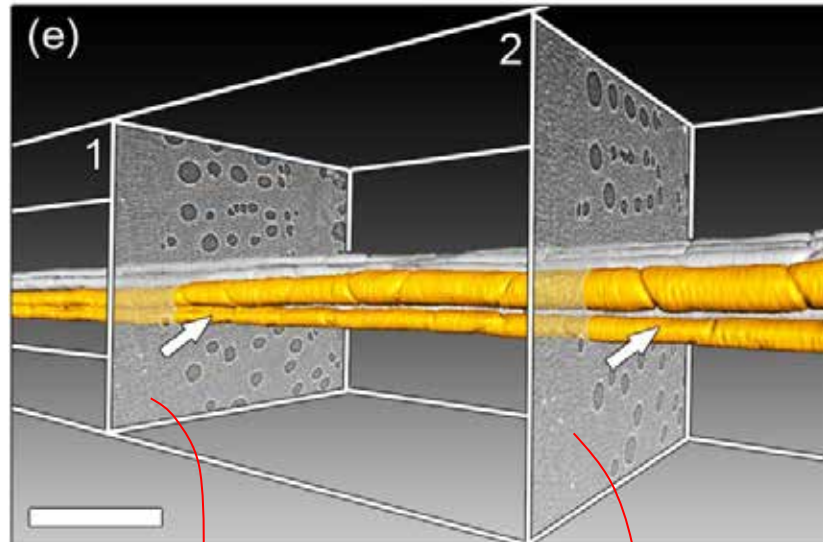
Examples of Grapevine Xylem

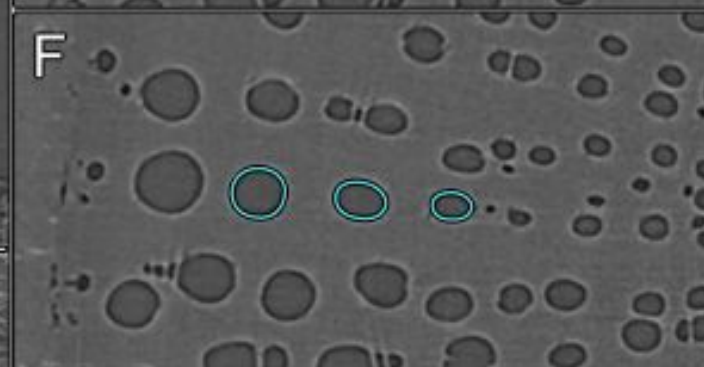
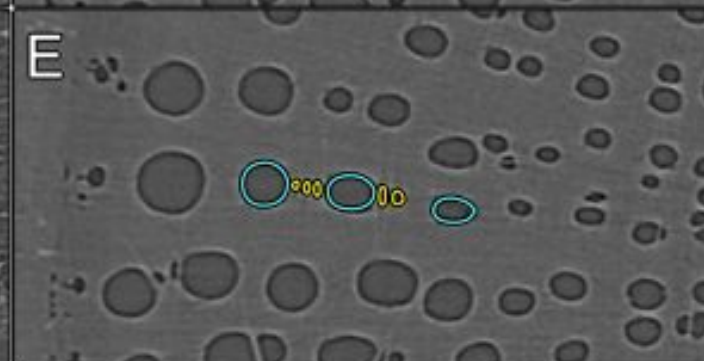
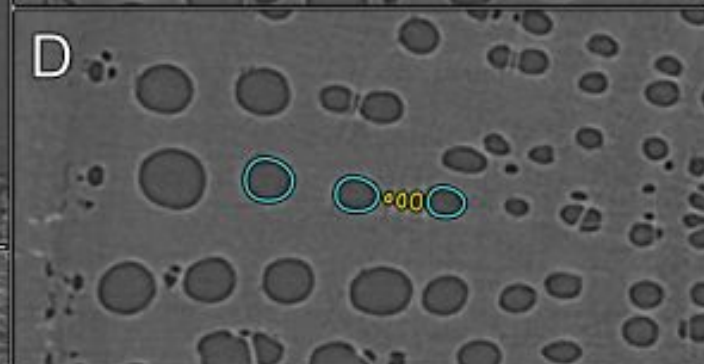
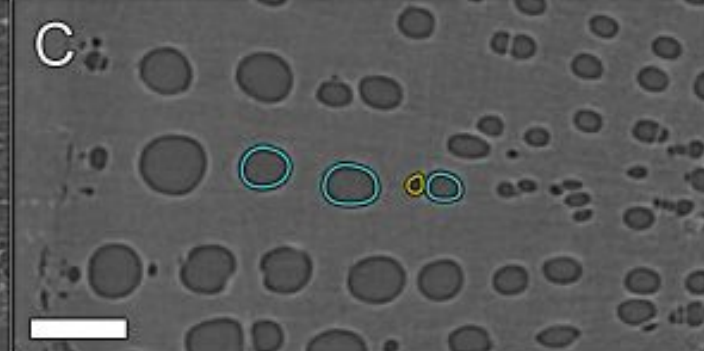
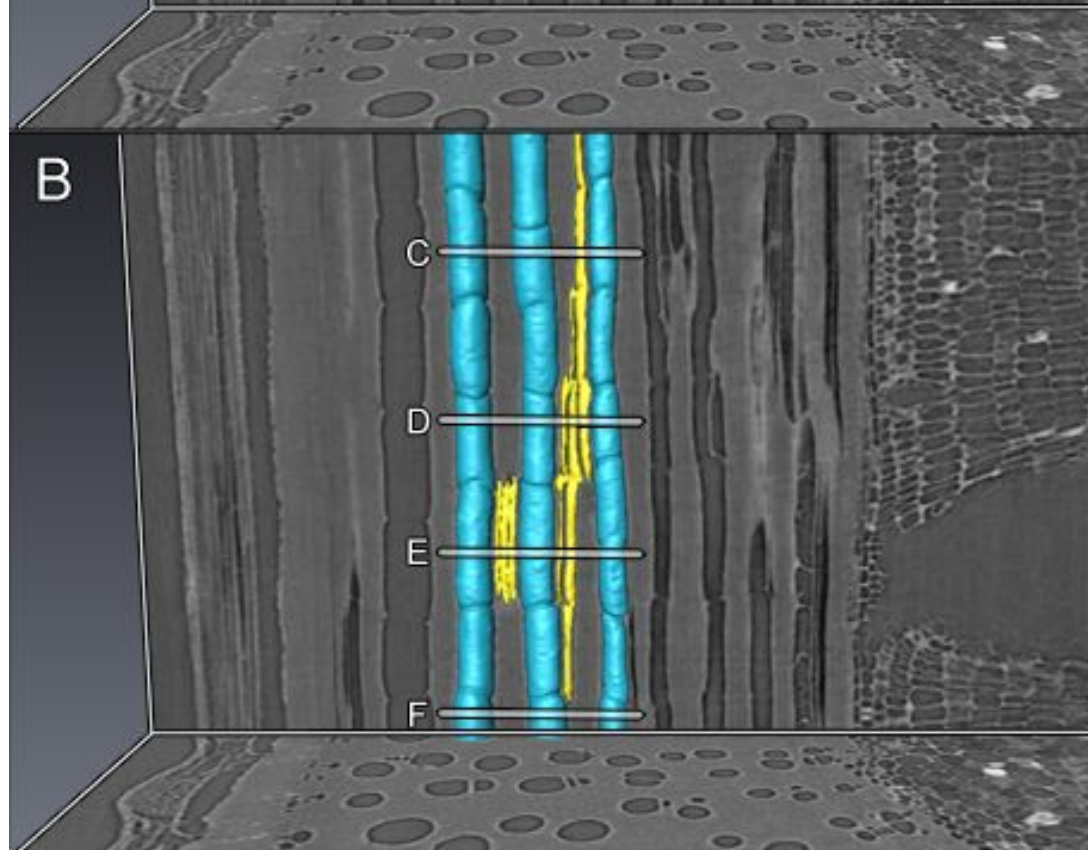
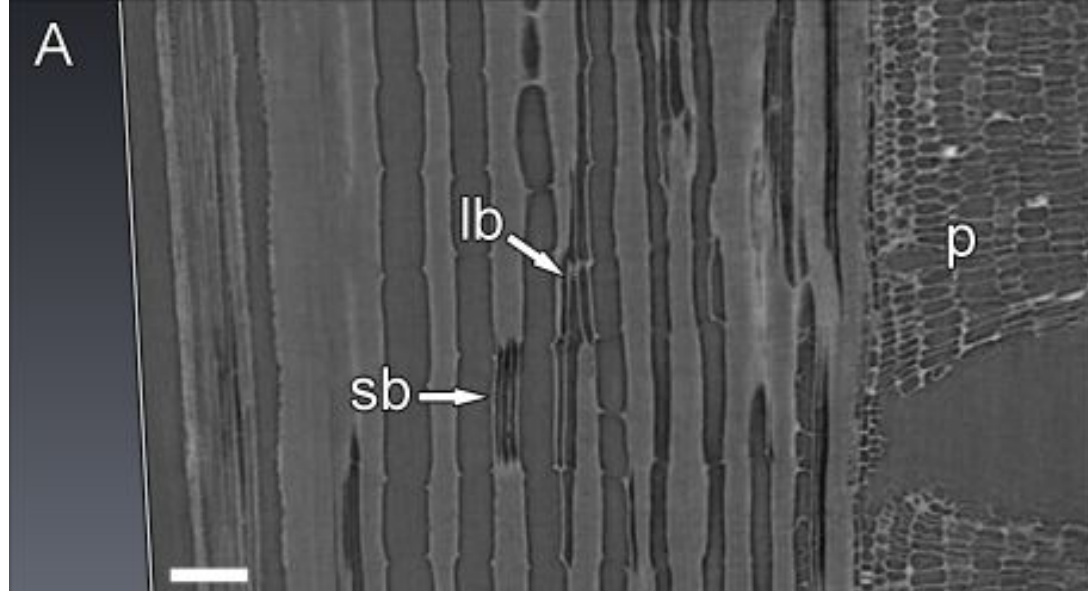


TANAX- Tomography-based Automated Network Analysis for Xylem



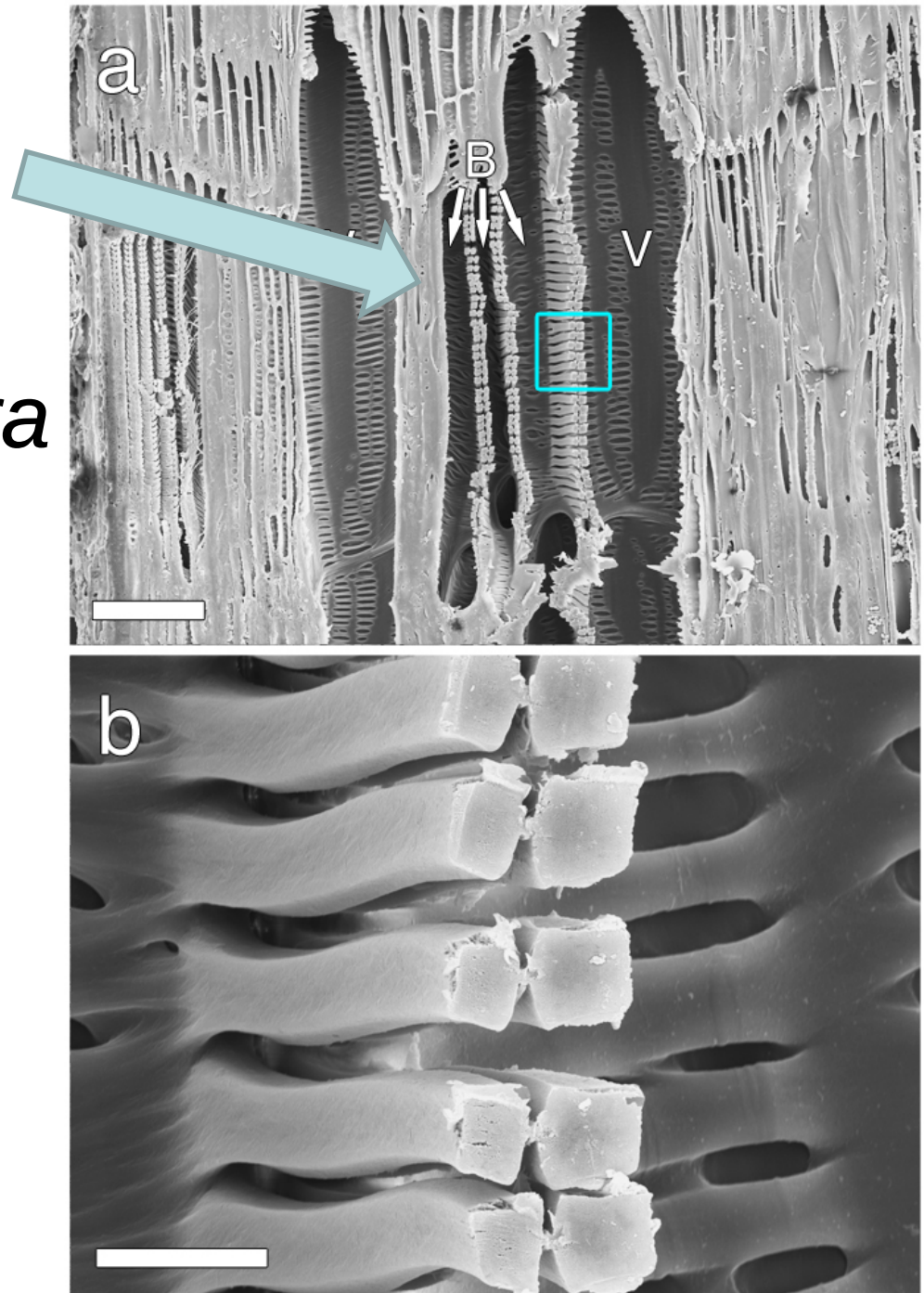
TANAX- Tomography-based Automated Network Analysis for Xylem



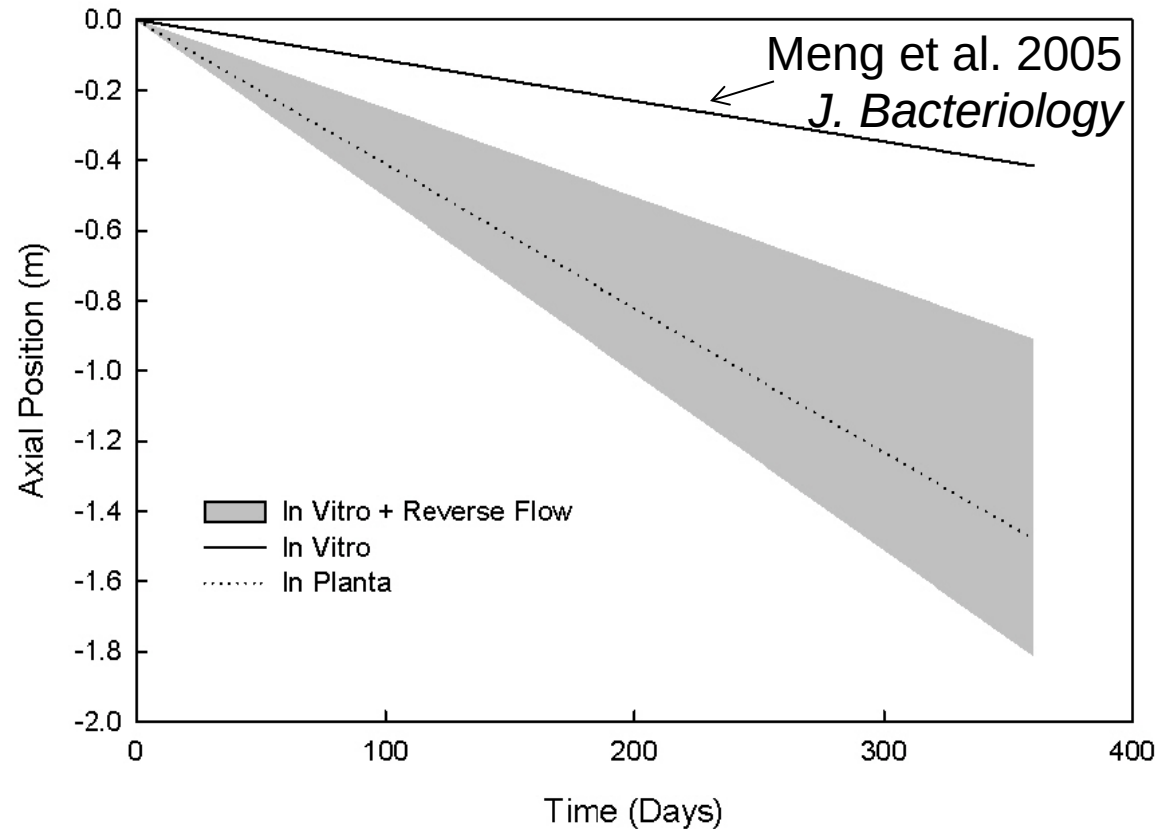
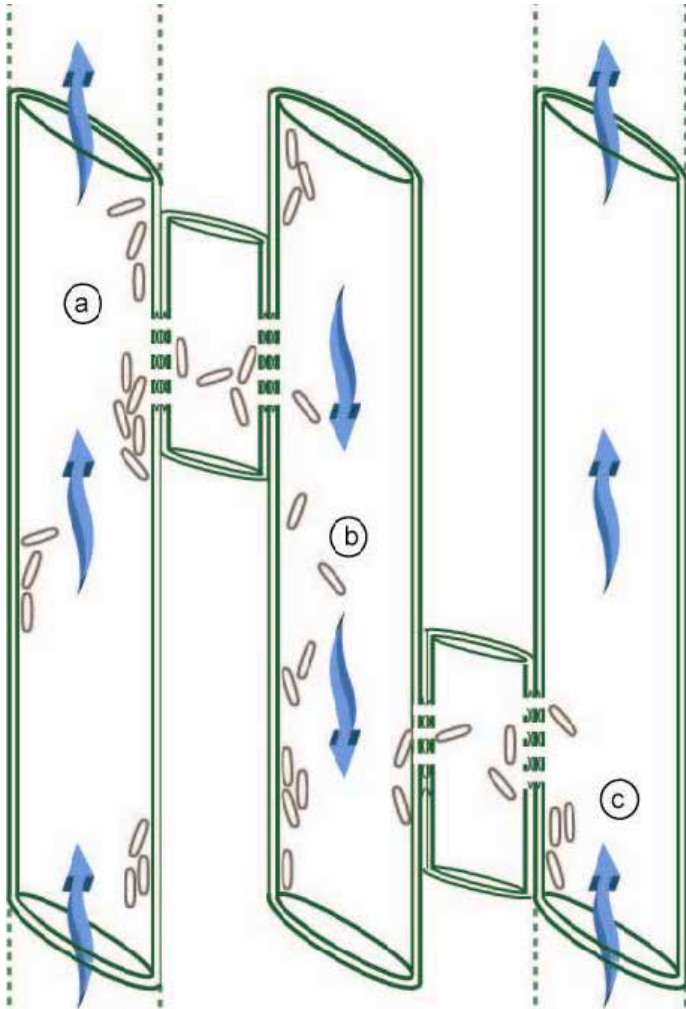


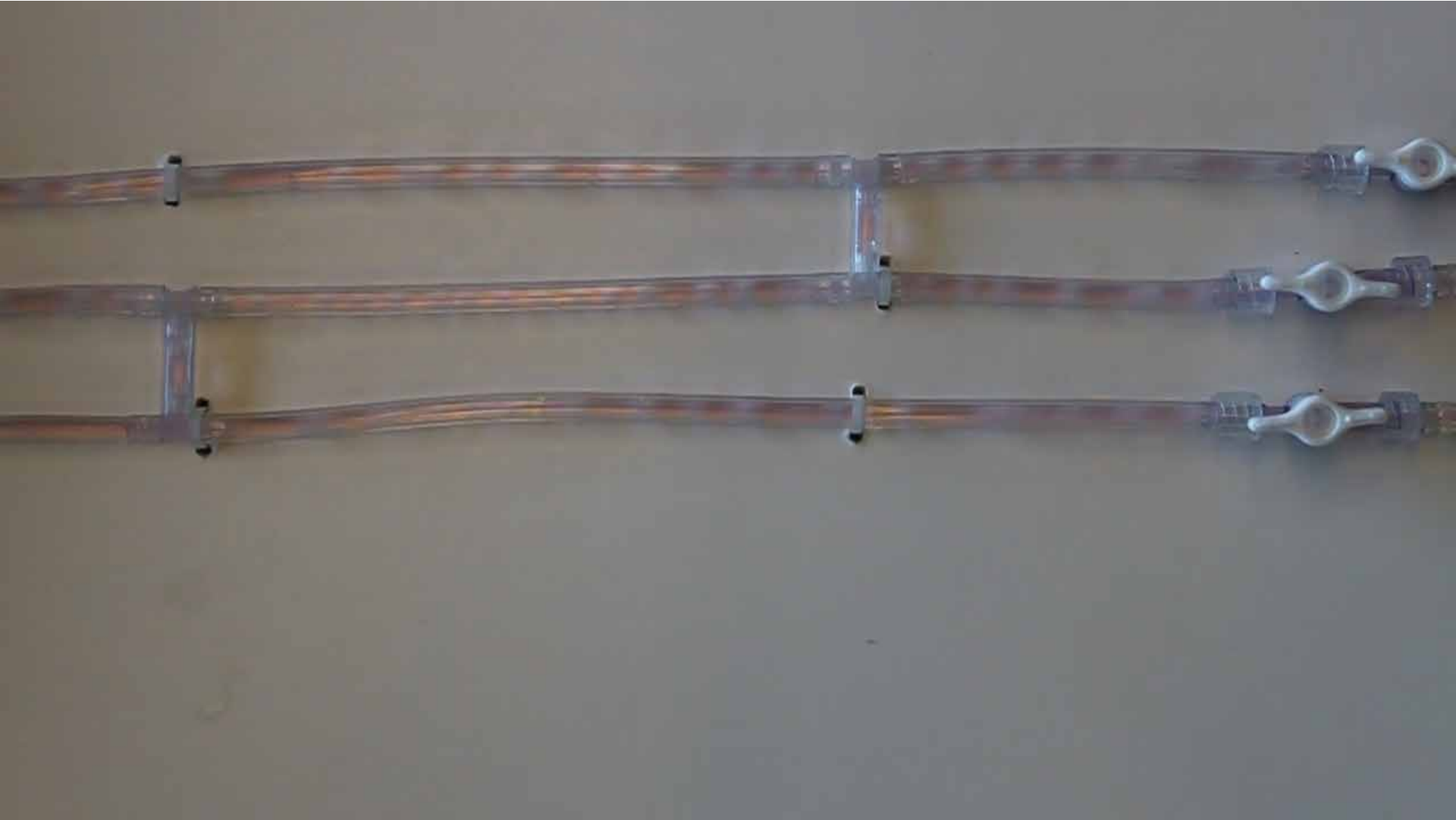
Structure and # of
bridge cells differ
between *Vitis*
arizonica & *V. vinifera*

More bridges & open
bridges in *V. vinifera*



Passive reverse flow even under high transpiration- Lee *et al.* 2013







Pierce's Disease of Grapevines



Lenoir & Blanc du Bois

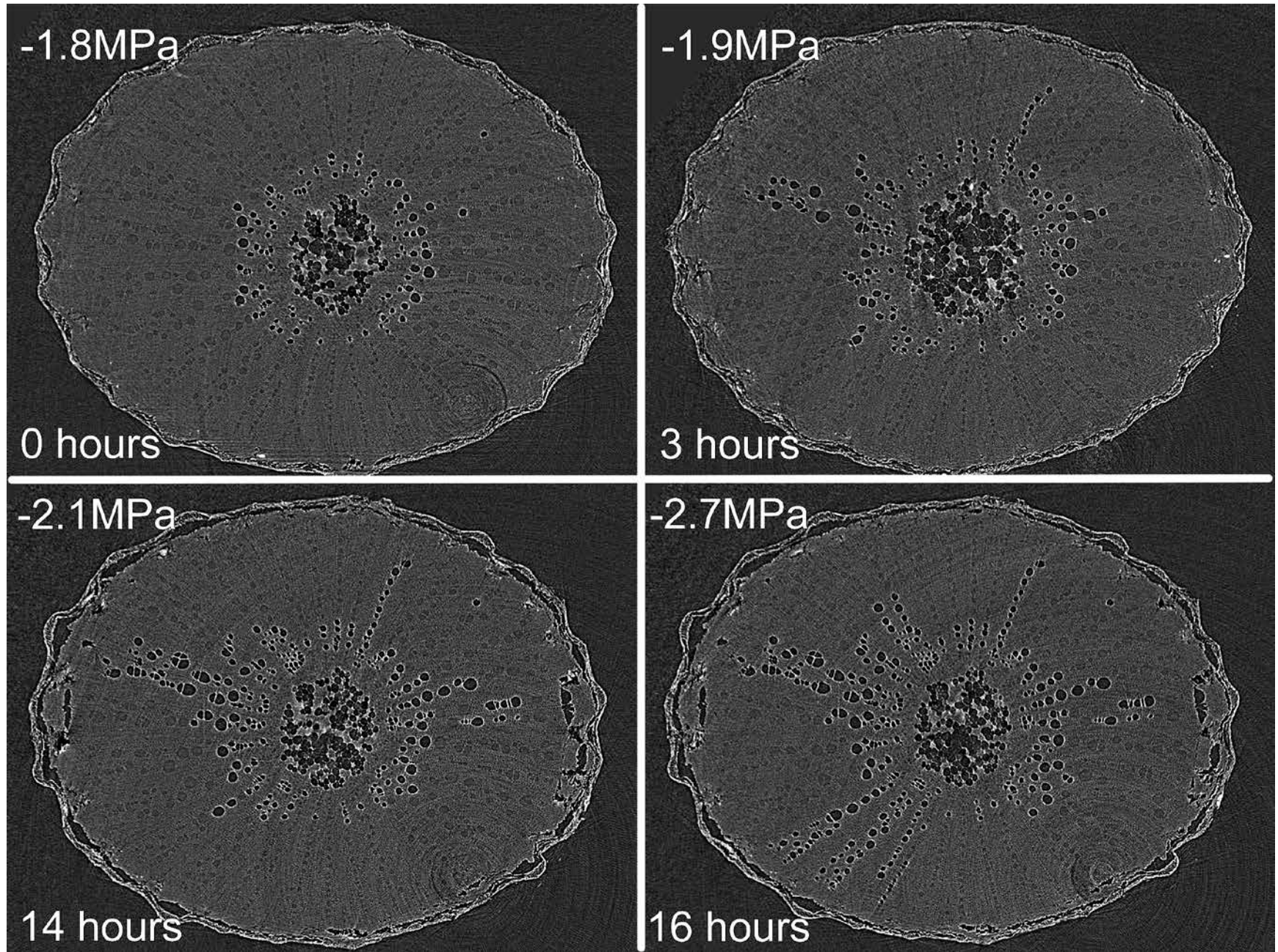
PD resistant winegrapes

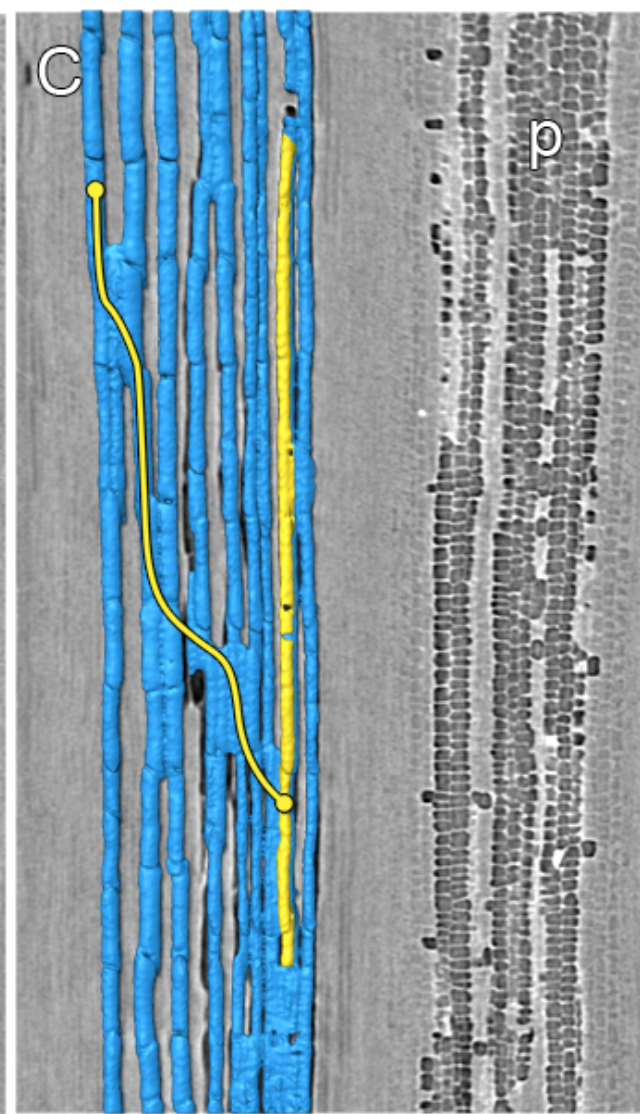
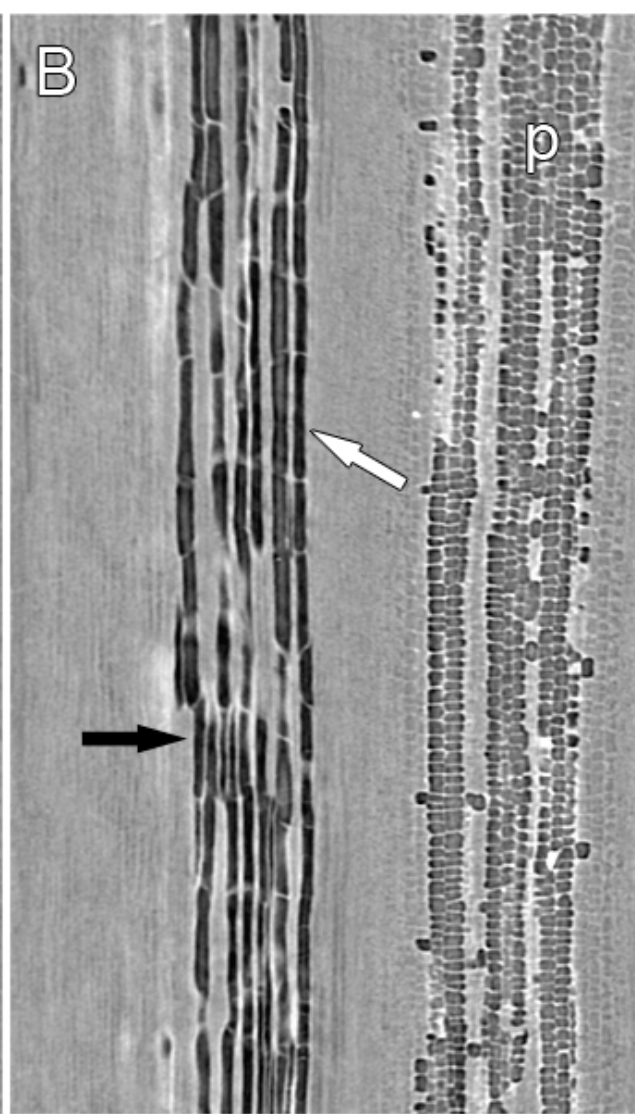
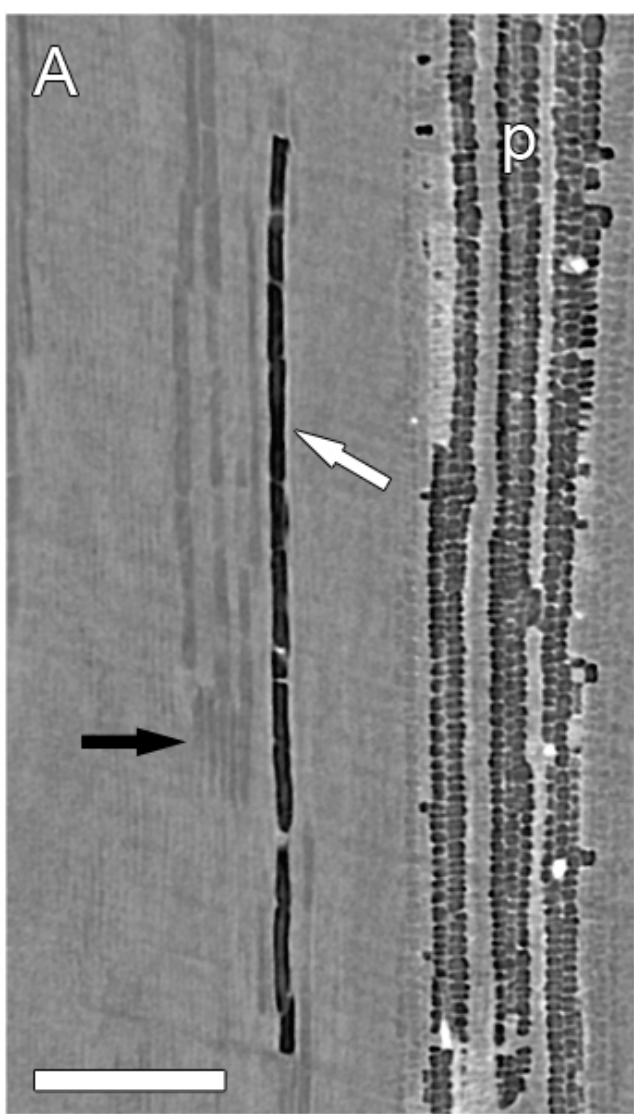
Fritz Westover- Texas A&M

Live, Potted Grapevine in the CT system



Drought-induced embolism- blocks xylem

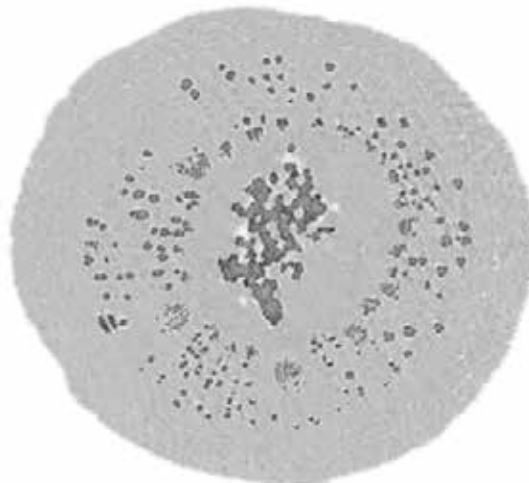




V.riparia
("drought sensitive")

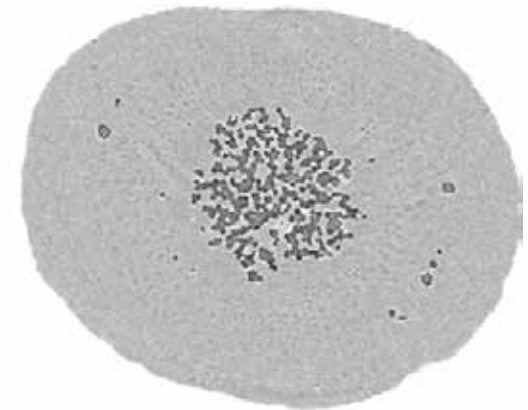


V.champinii (Ramsey)
("drought resistant")



$33.5 \pm 8.5\%$ ^{a,x}
 $(-1.66 \pm 0.22 \text{ MPa})$ ^{b,x}

Drought
stress

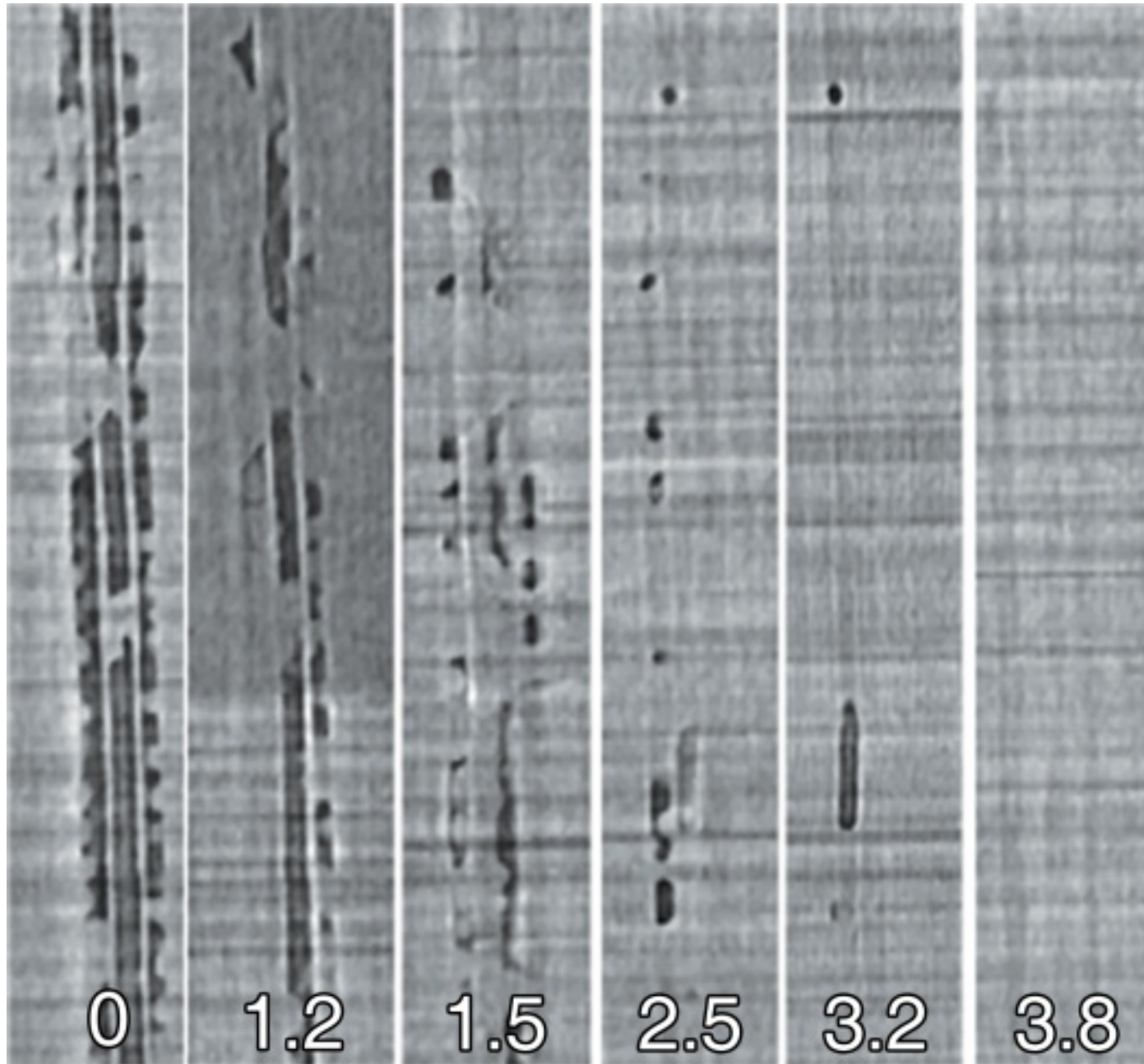


Embolism

$11.5 \pm 3.6\%$ ^{a,y}
 $(-1.76 \pm 0.24 \text{ MPa})$ ^{b,x}

Water Potential

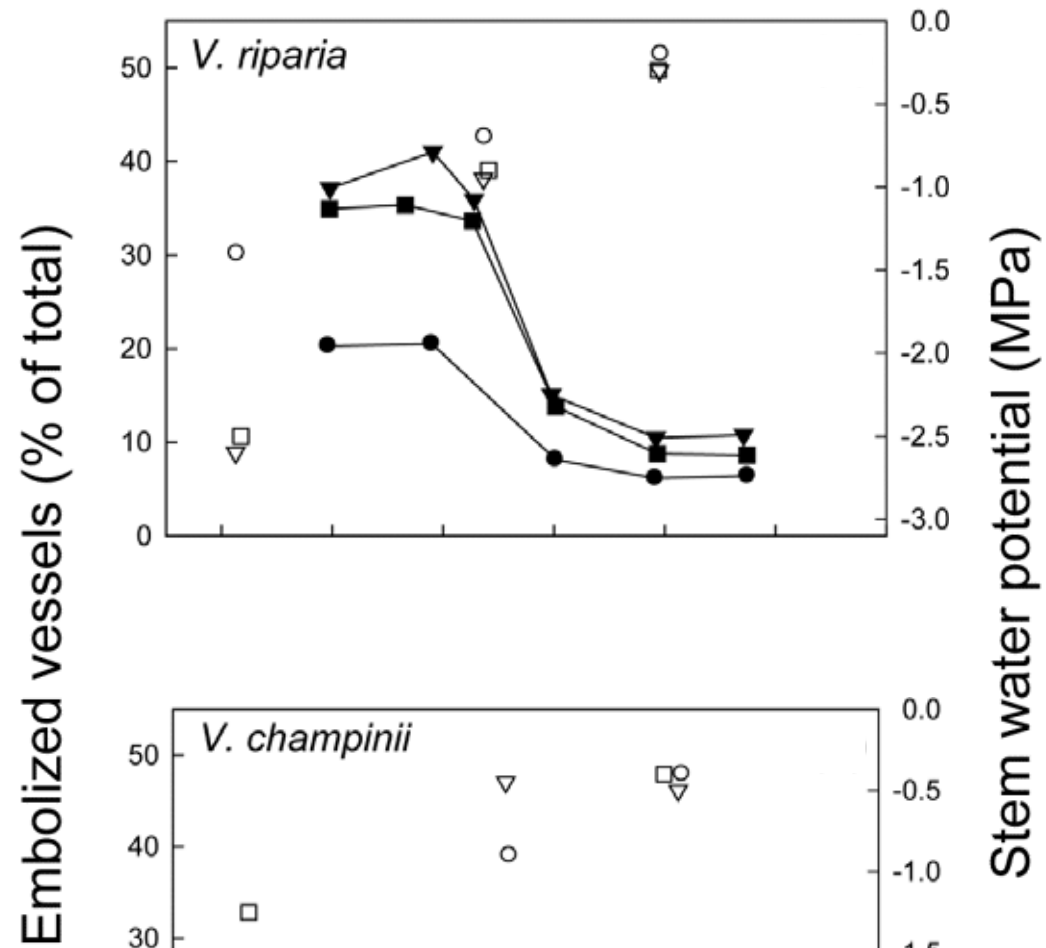
Embolism repair in grapevines



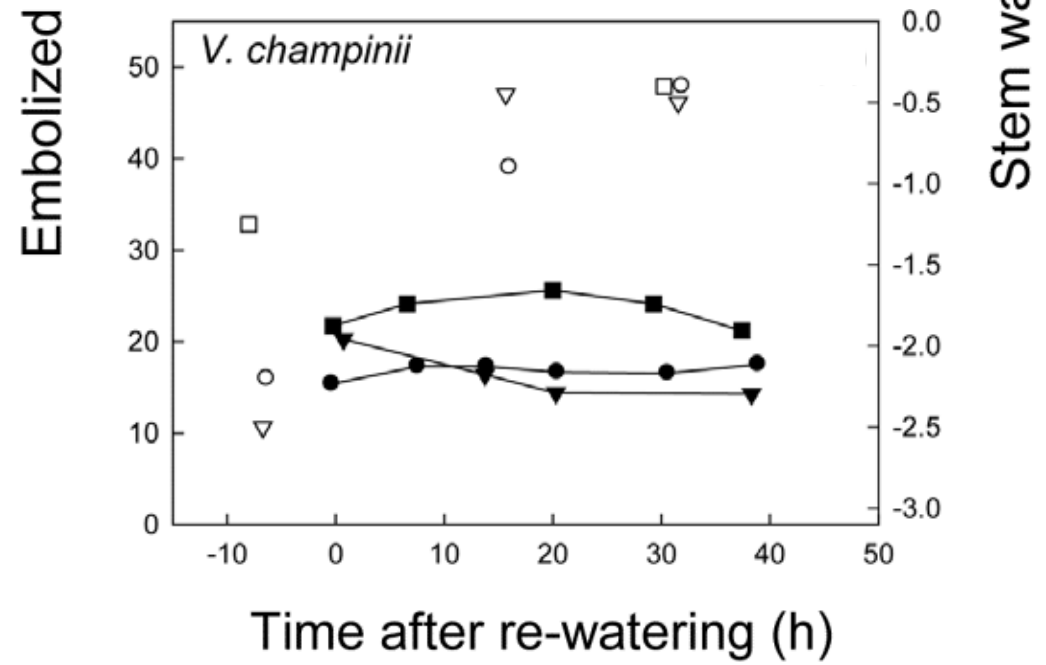
Brodersen et al
2010



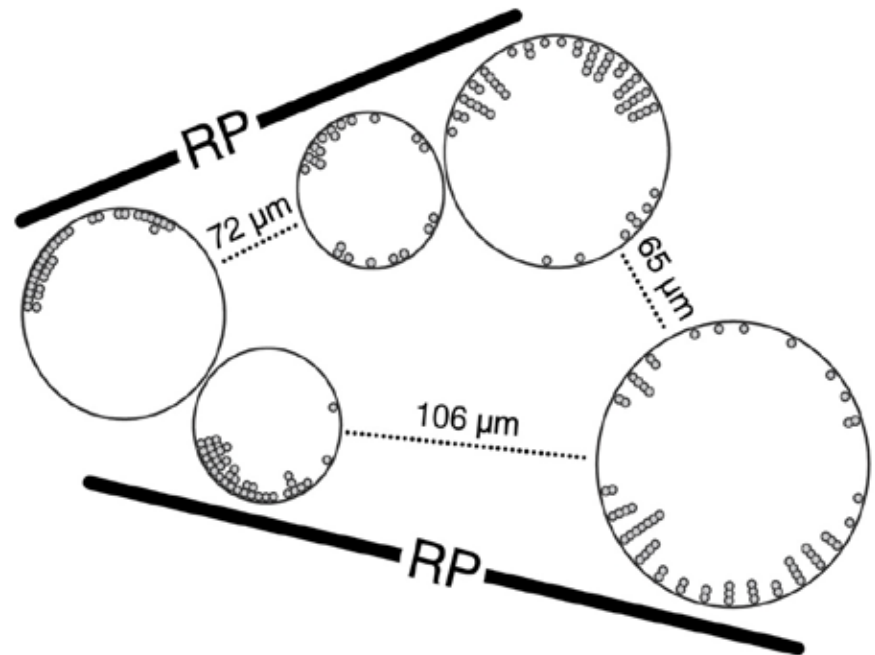
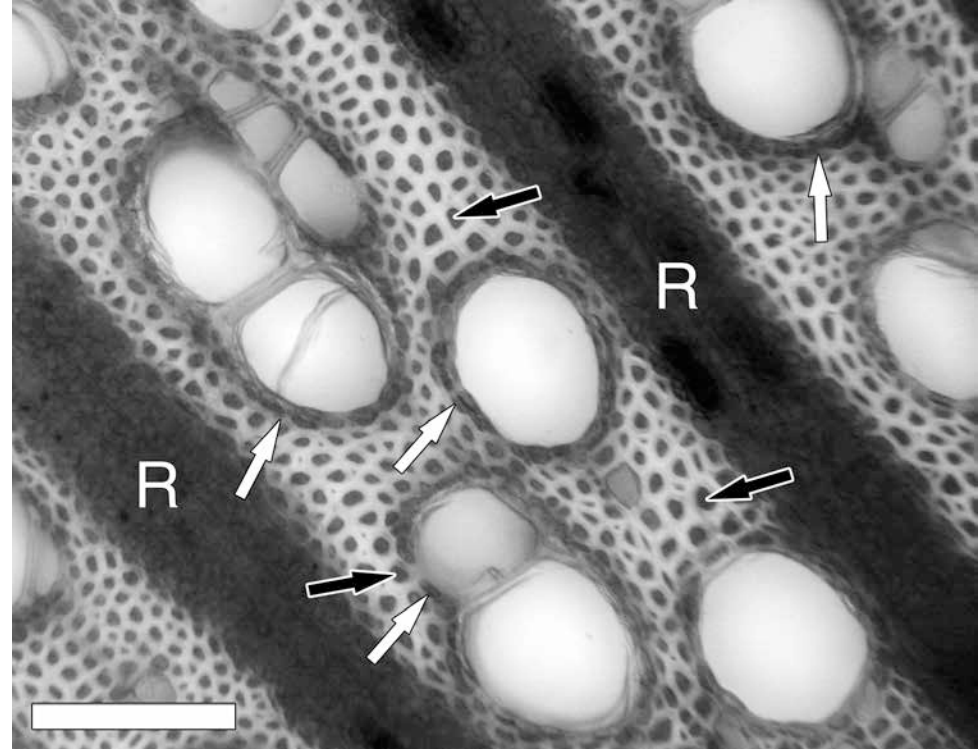
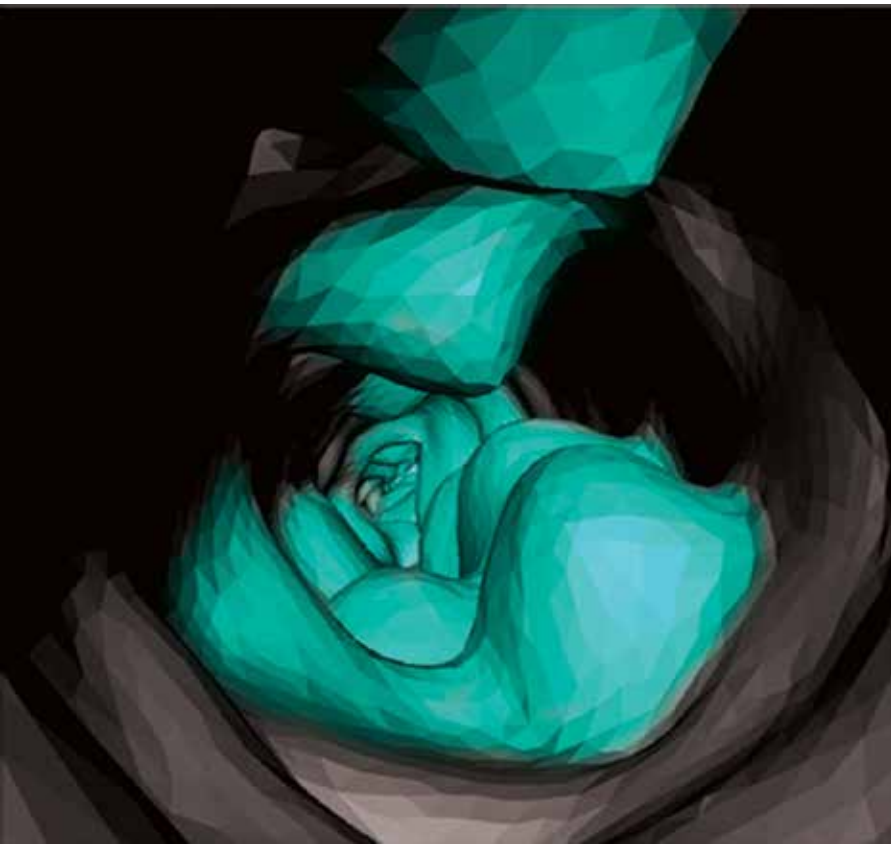
V. riparia



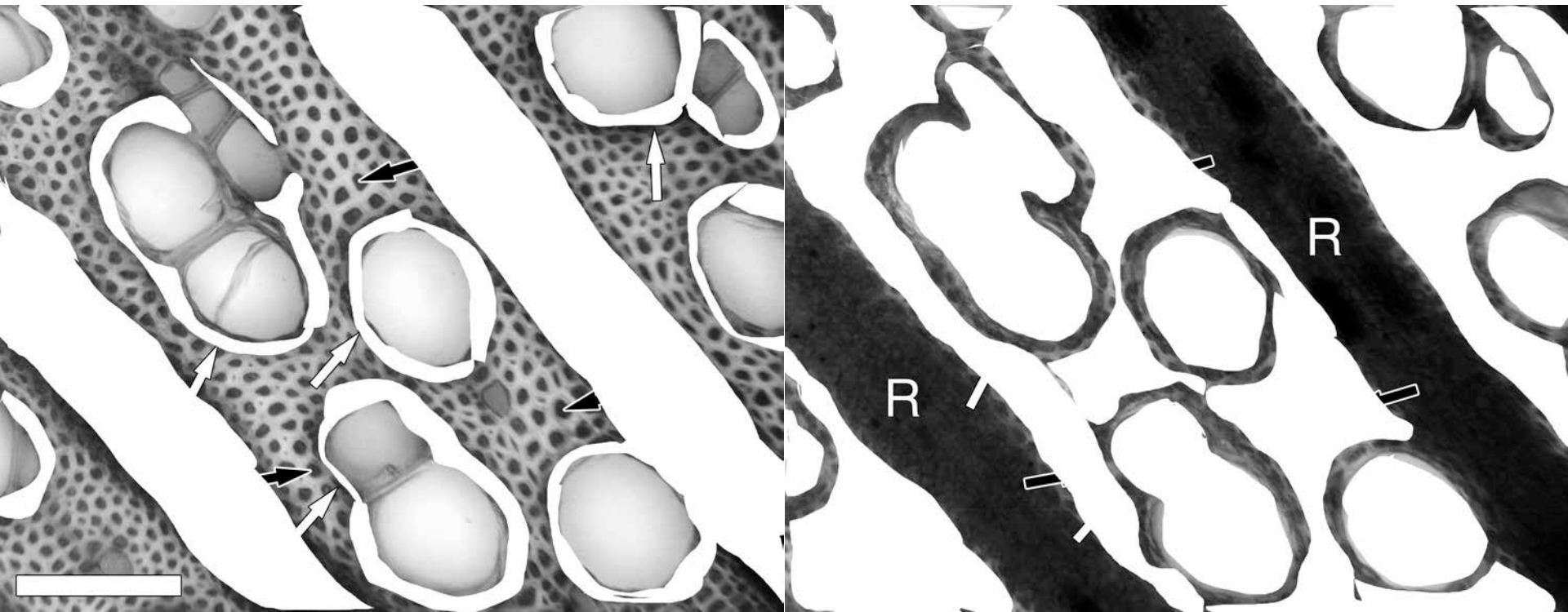
V. champinii



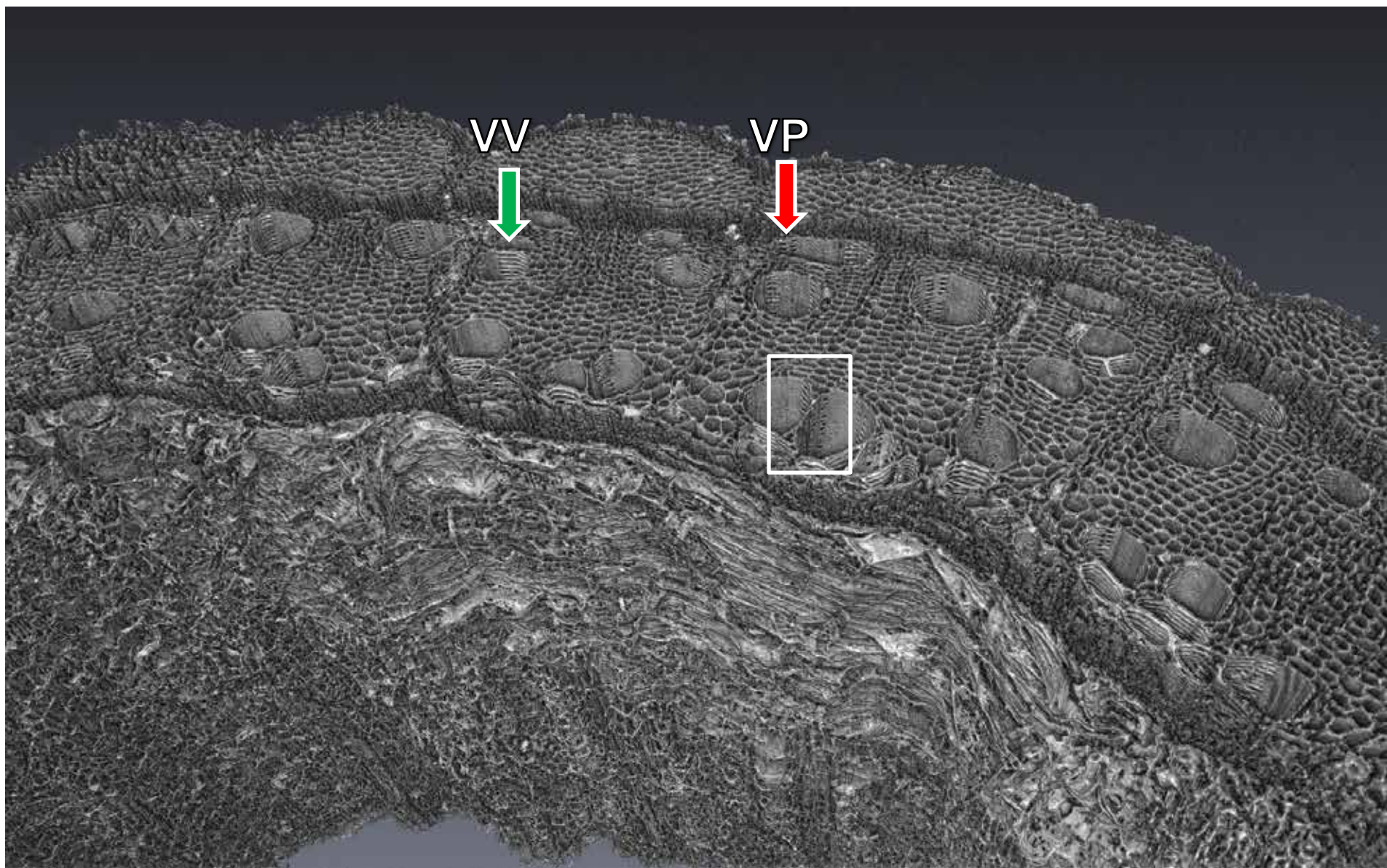
Living cells responsible for embolism repair in *V. vinifera*



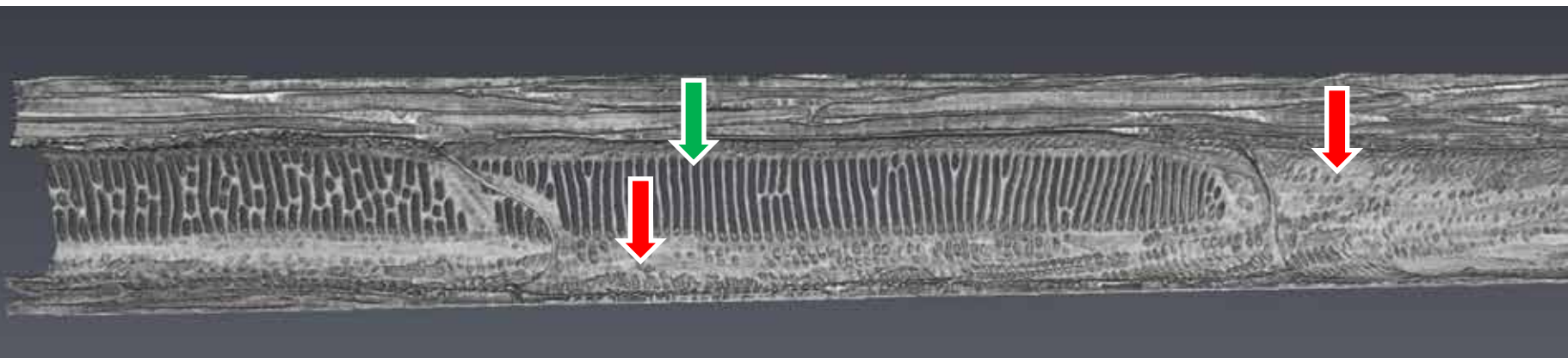
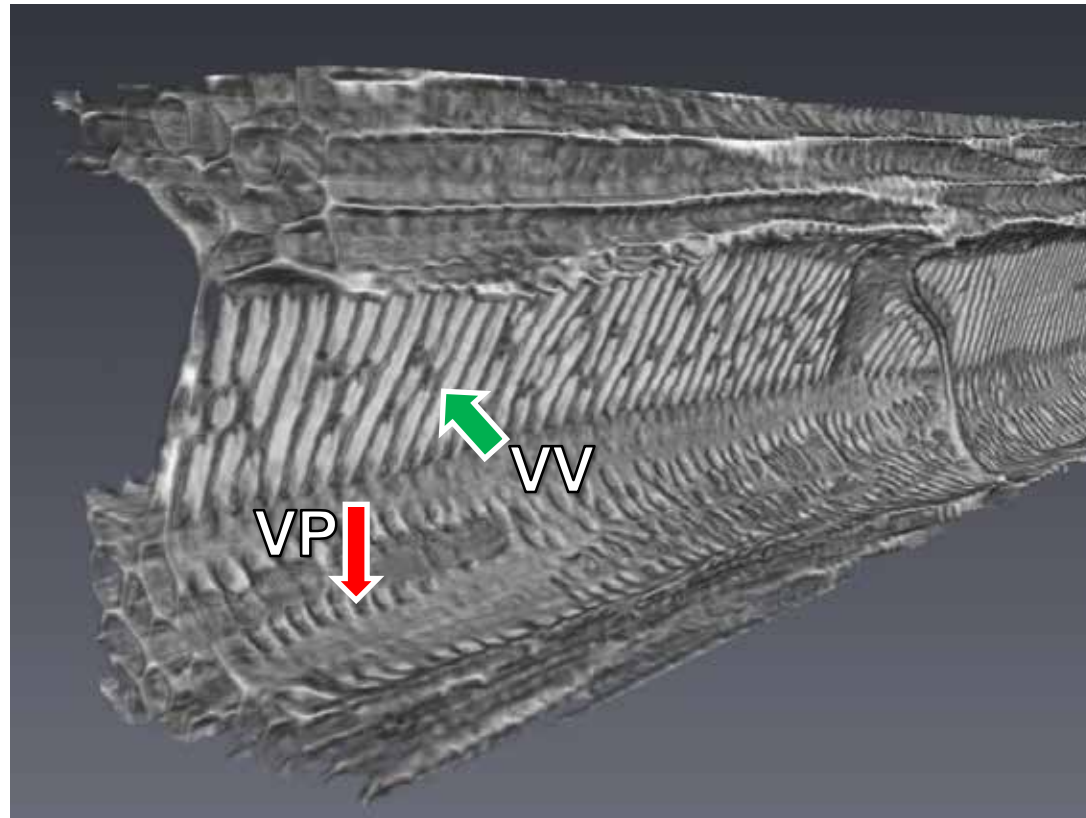
Currently combining: Laser Capture Microdissection, RNA seq, and HRCT



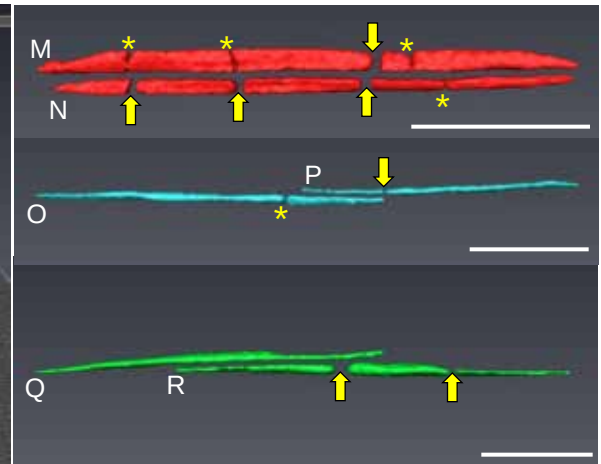
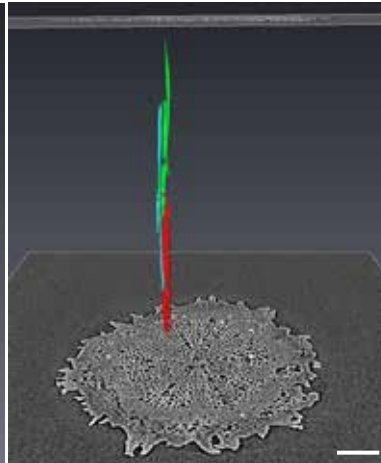
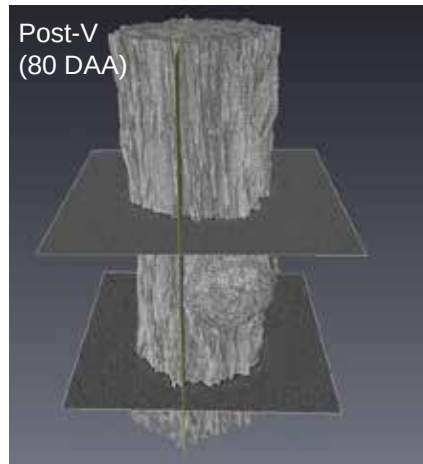
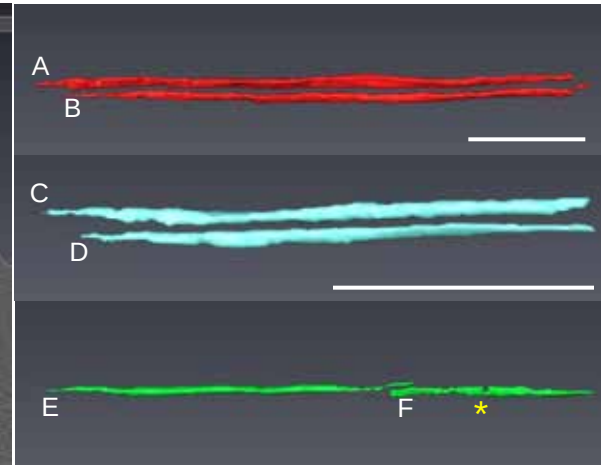
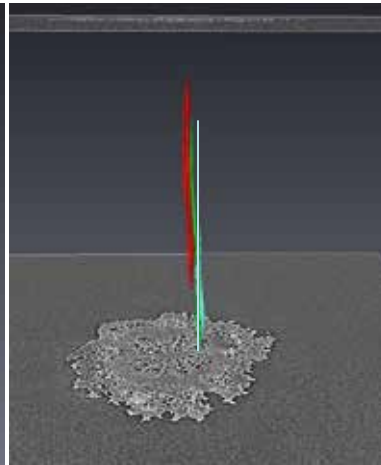
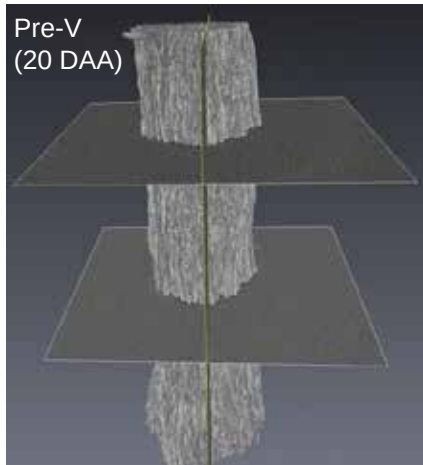
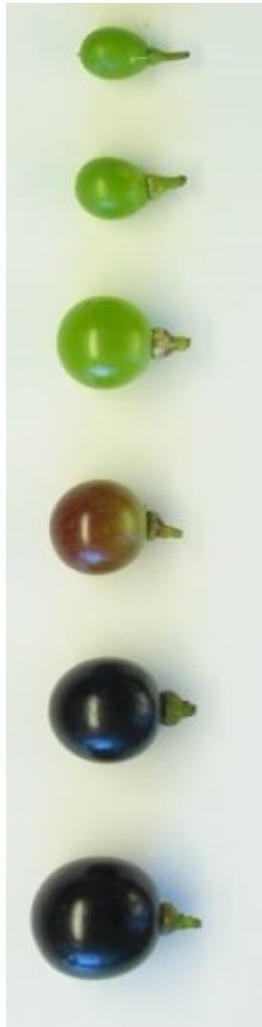
High resolution scans (5X) of grapevine stem

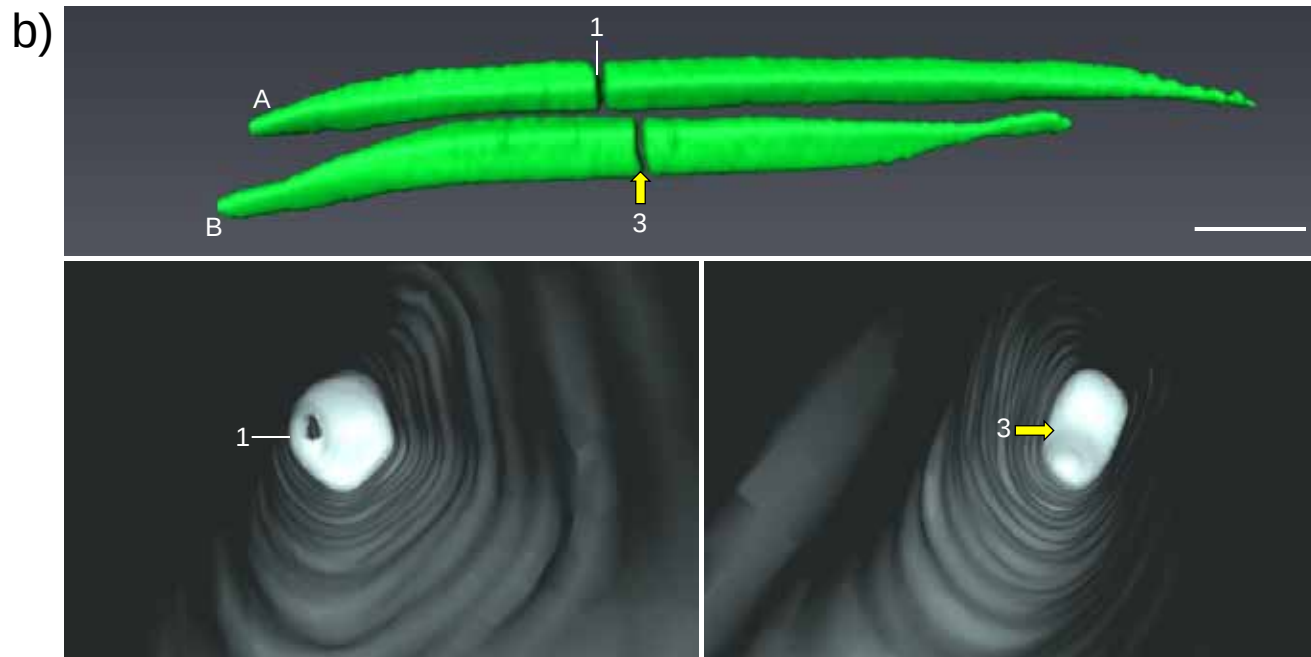
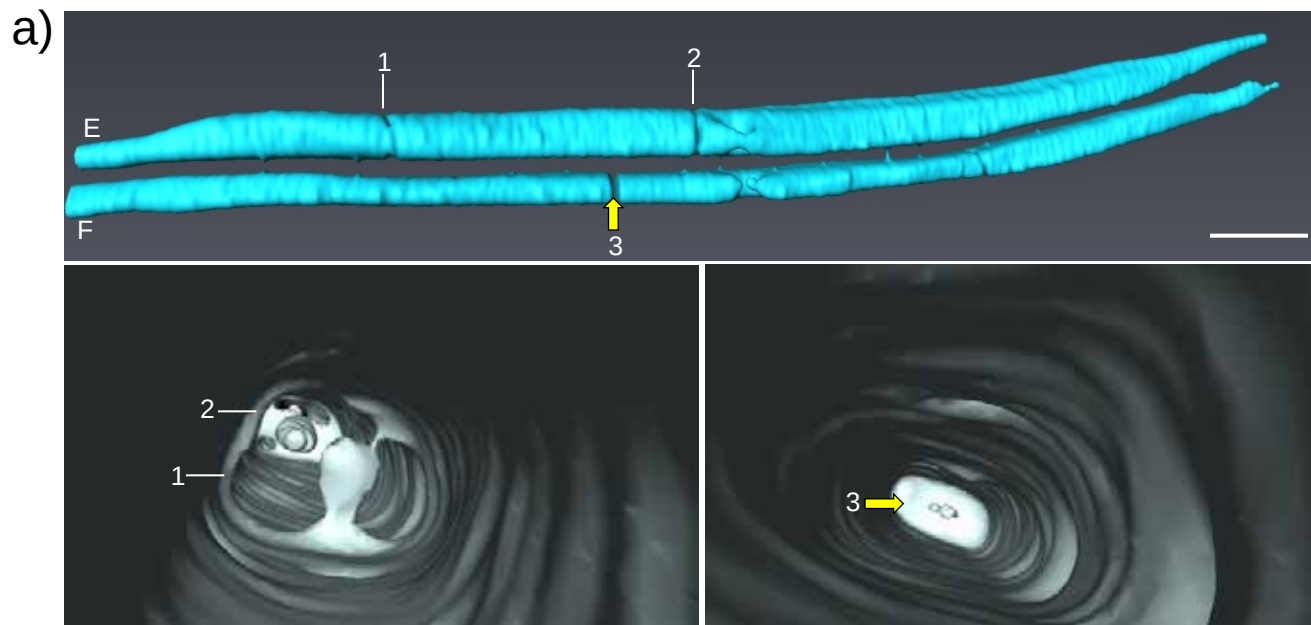


Visualization of vessel connections



Pedicle: Vessel structure over berry ripening





This concludes your journey

Acknowledgements

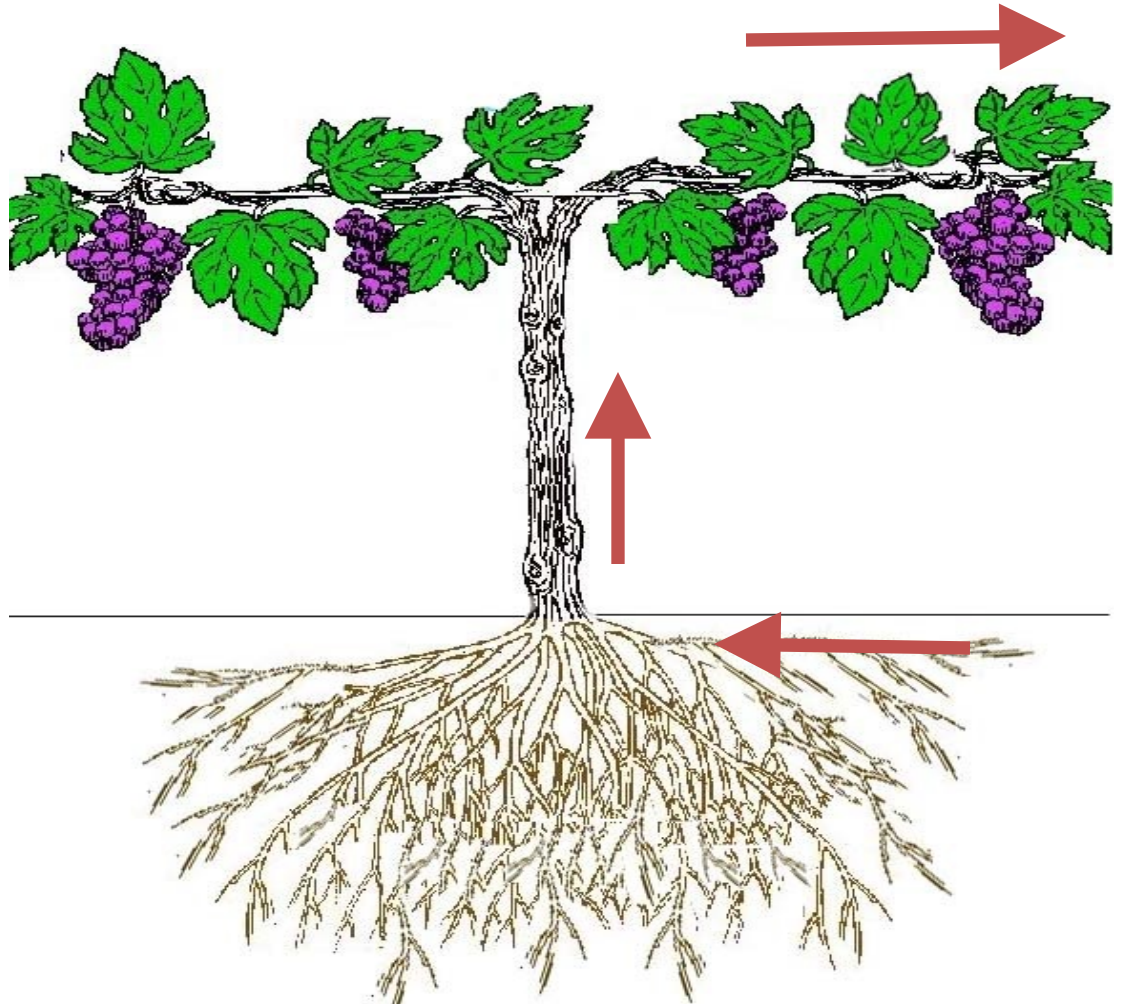
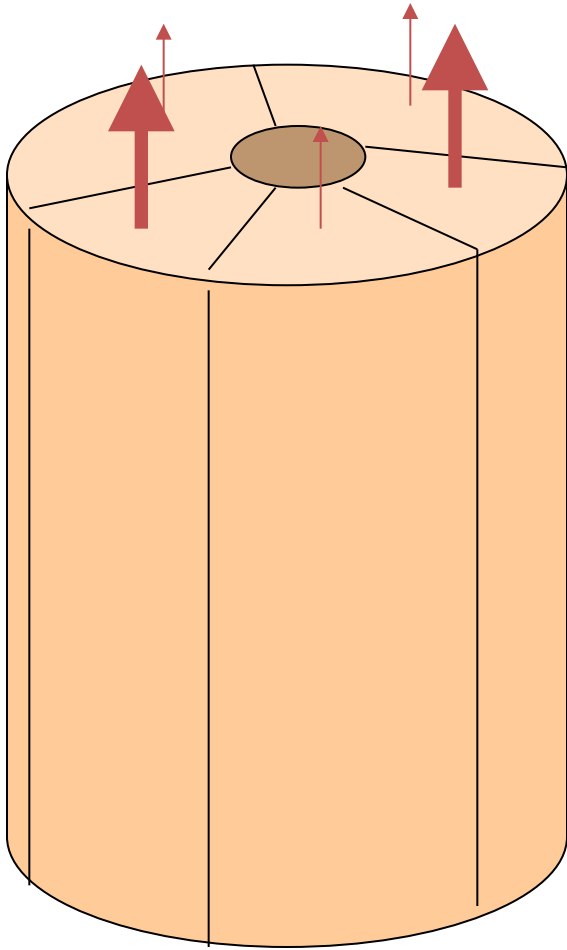
- **Funding Sources:**

- J. Lohr Vineyards and Wines
- American Vineyard Foundation
- National Grape and Wine Initiative
- NIFA-Specialty Crops Research Initiative
- USDA-ARS Sustainable Vit CRIS

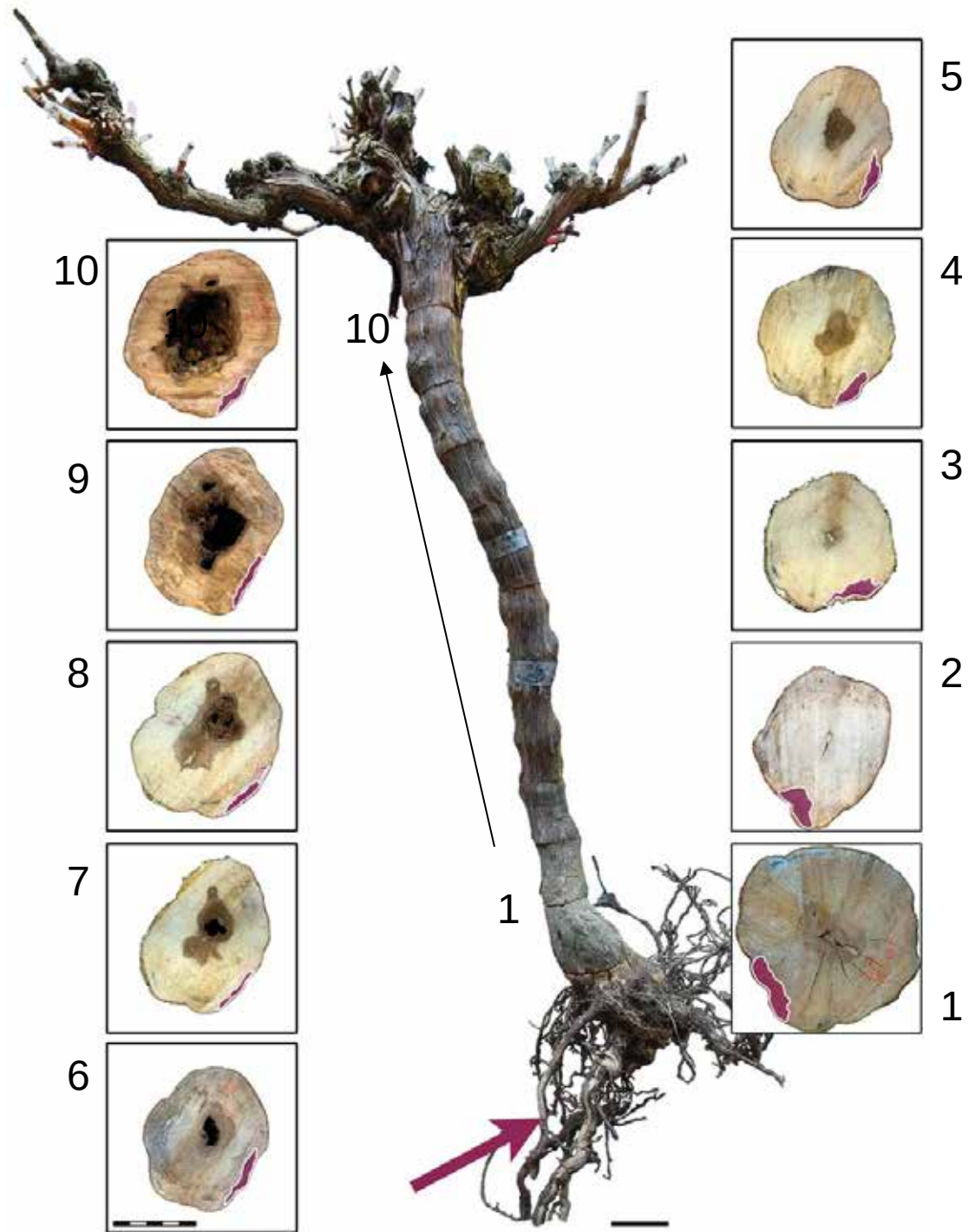


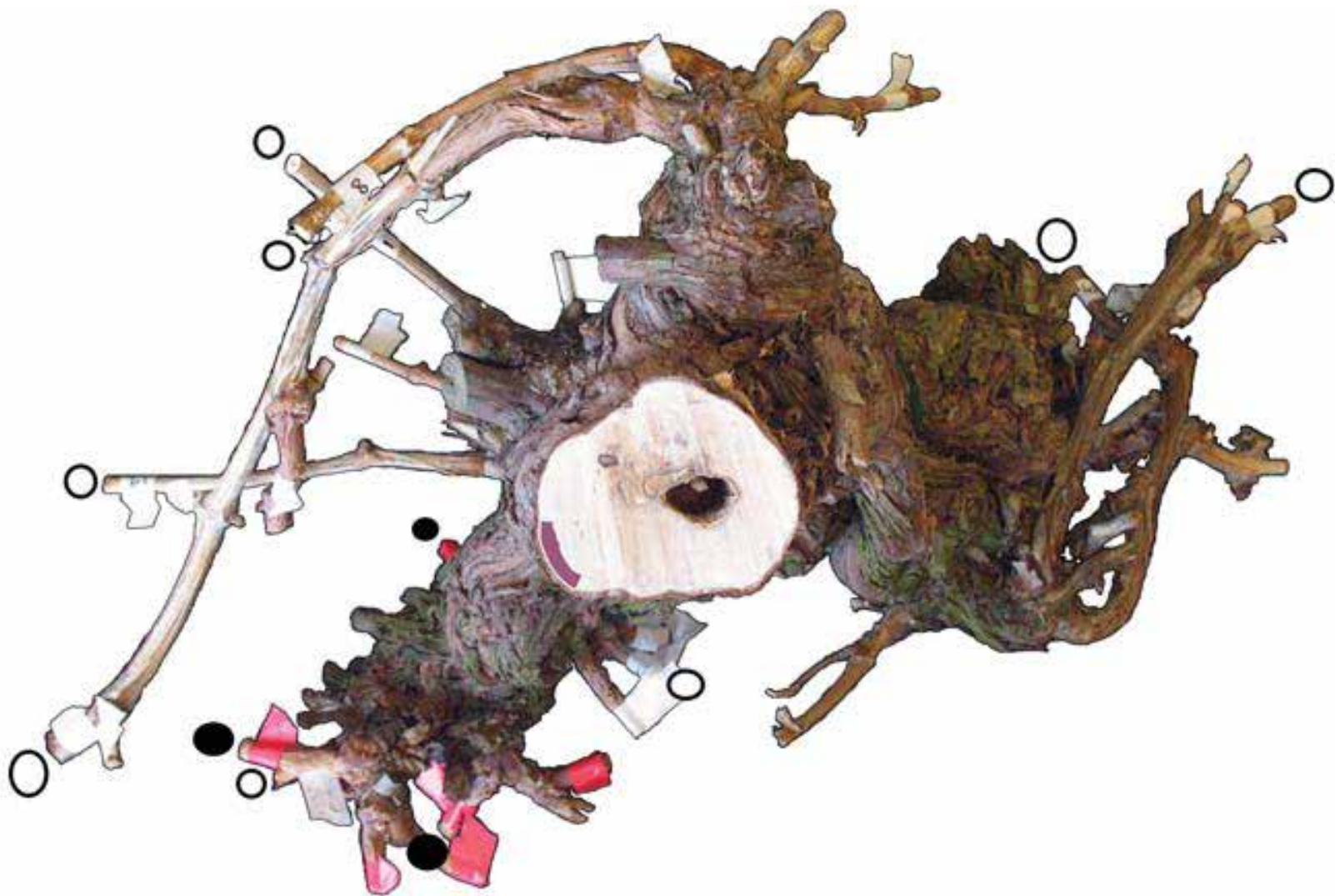
- Jim Ayars- USDA-ARS
- Felipe Barrios Masias- UC Davis
- Mark Battany- UC ANR
- Tim Bleby- Univ of Western Oz
- Daniel Bosch- Constellation Brands
- Craig Brodersen- Yale Univ
- Arturo Calderon- UC Davis
- Sean Castorani- ARS Davis
- Nick Dokoozlian- E&J Gallo
- Ashley Eustis- USDA-ARS
- Kevin Fort- UC Davis
- Thorsten Knipfer- UC Davis
- Jerry Lohr- Grower Cooperator
- Mark Matthews- UC Davis
- Kyaw Tha Paw U- UC Davis
- Kyle Pearsall- UC Davis
- Jean Mari Peltier-NGWI
- Anji Perry- J Lohr V&W
- Eva Pilar Pérez Álvarez
- Rod Scheaffer- Constellation Brands
- Ken Shackel- UC Davis
- Tom Shapland- UC Davis
- Ruby Stahel- USDA-ARS
- Rick Snyder- UC Davis
- Gwen Tindula- UC ANR
- Yannis Toutountzis- Constellation Brands
- Andy Walker- UC Davis
- Larry Williams- UC Davis
- Andrew Zaninovich- Sunview Vineyards

Hydraulic sectoriality?

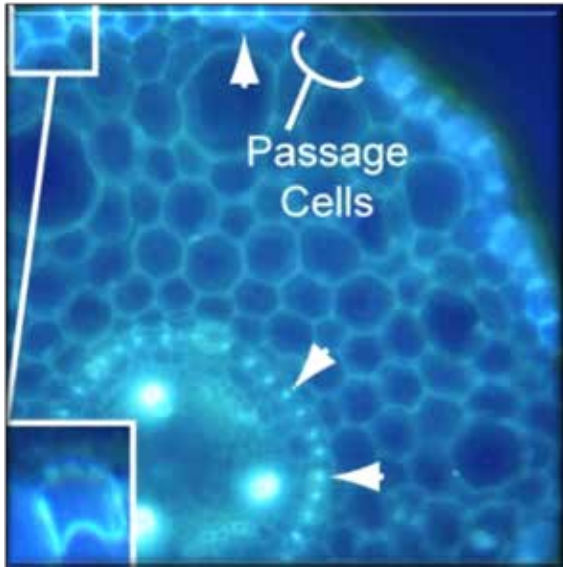


Single Root Injections

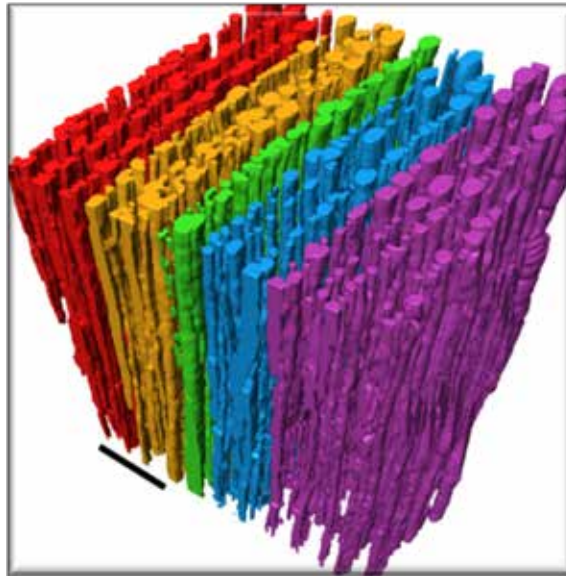




Sustainable Water Use in Vineyards



Rootstock
Water Use



Vascular
Transport



Technology to
Quantify
Water Use

Surface Renewal

Surface Renewal Summary

- Prototypes complete and deployed
- Validated against gold standards
- Economically viable, site specific ET
 - Patented, LLC formed
- Amount and potentially timing
- Research systems = less expensive

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