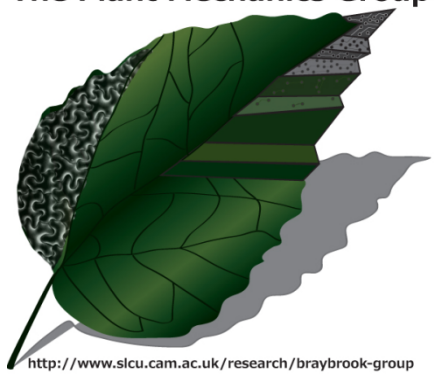
ARABIDOPSIS:
THE ONGOING GREEN
REVOLUTION

The Plant Mechanics Group



Understanding the physical basis of growth from the top down.

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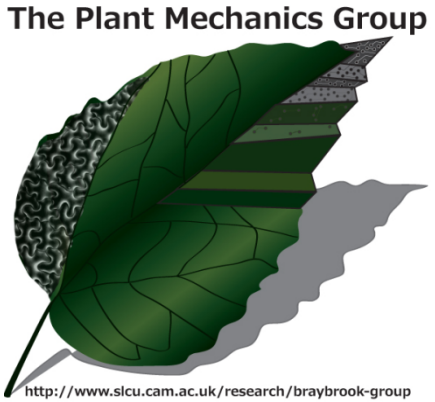
The Plant Mechanics Group



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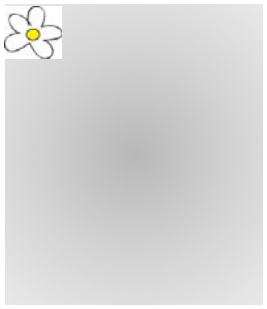
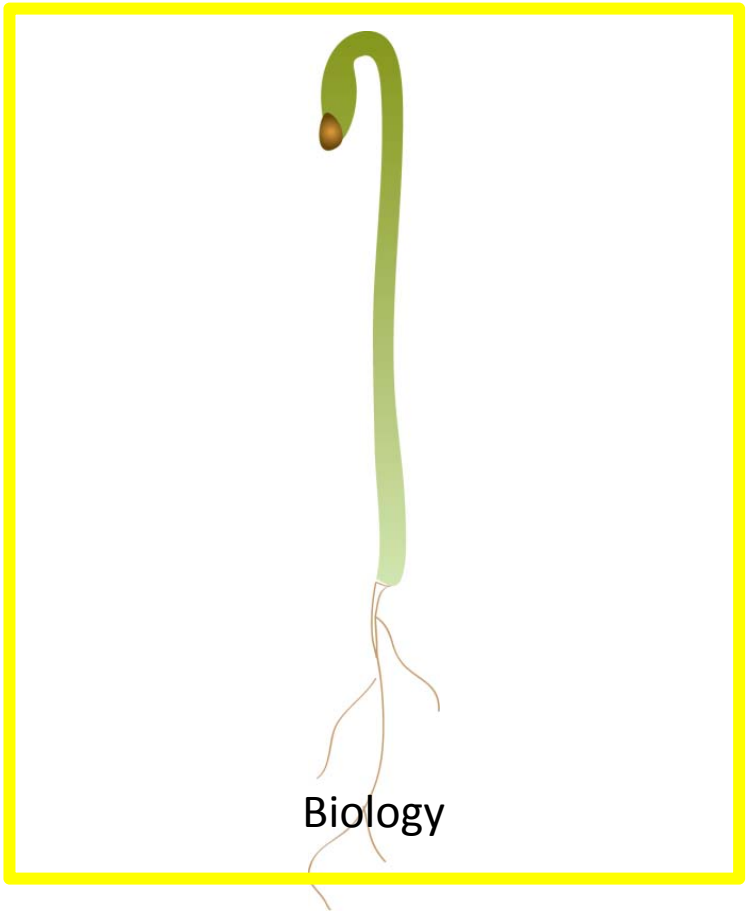


Tom Torode

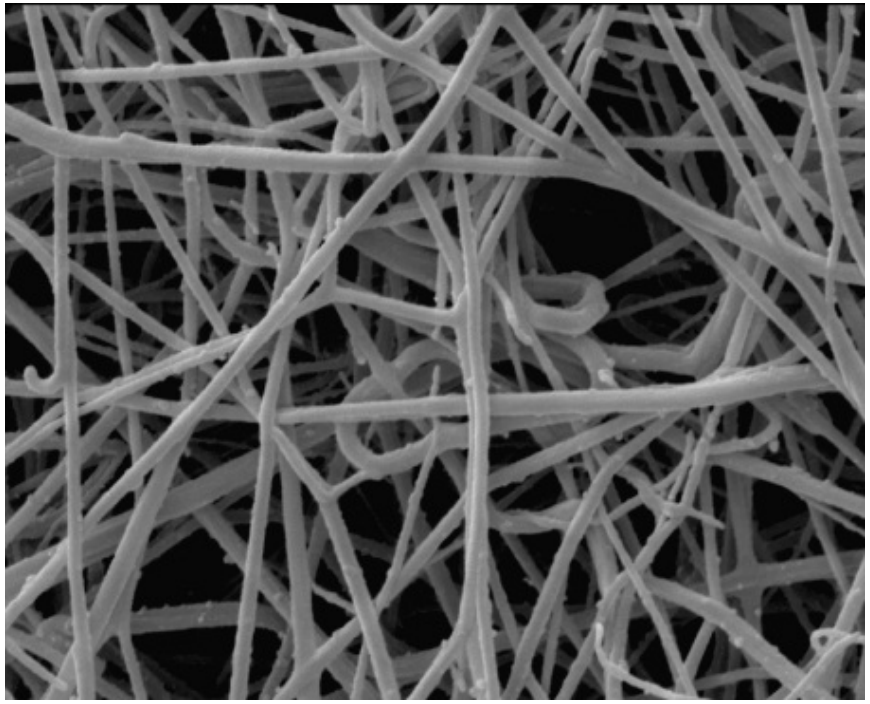
www.plantmechanome.org

How do plants grow shapes?

Understanding shape growth in plants

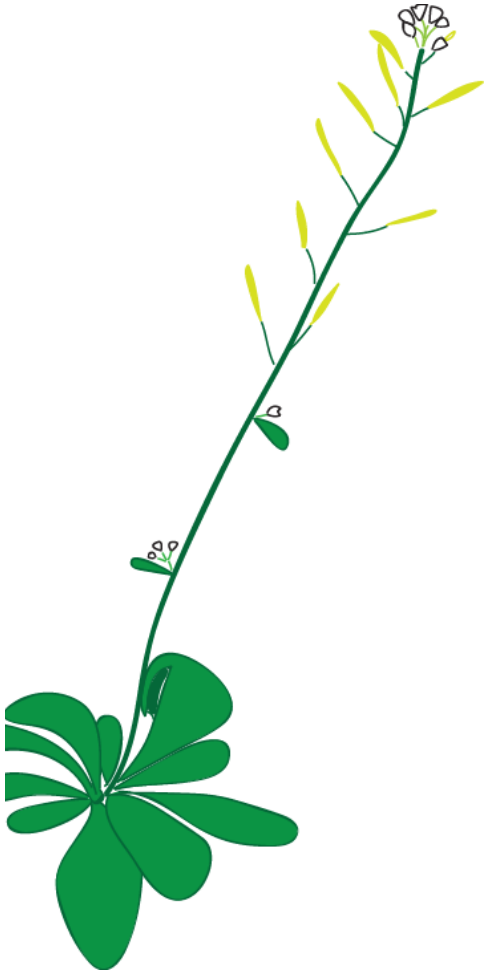


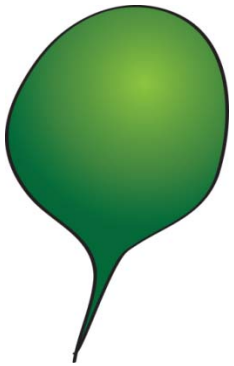
Biology



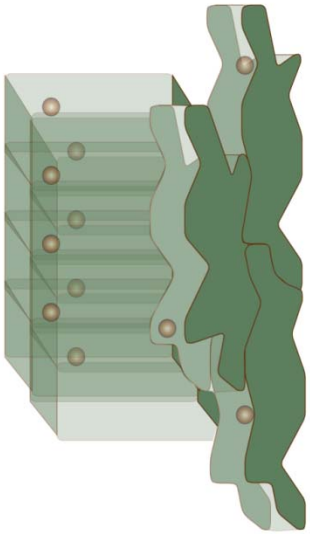
Materials science

Shape growth occurs on many scales because of actions on each scale

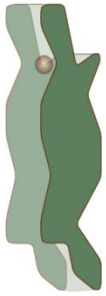




Organ

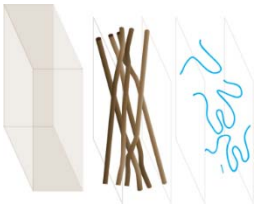


Tissue



Cell

Wall

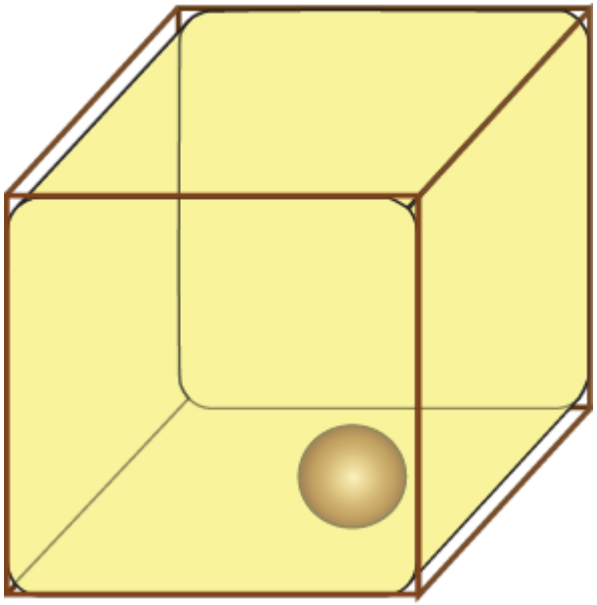


Components

Understanding any given scale is not enough to explain the whole

Biophysics of plant cell growth

Cells grow and change shape by altering 2 parameters:



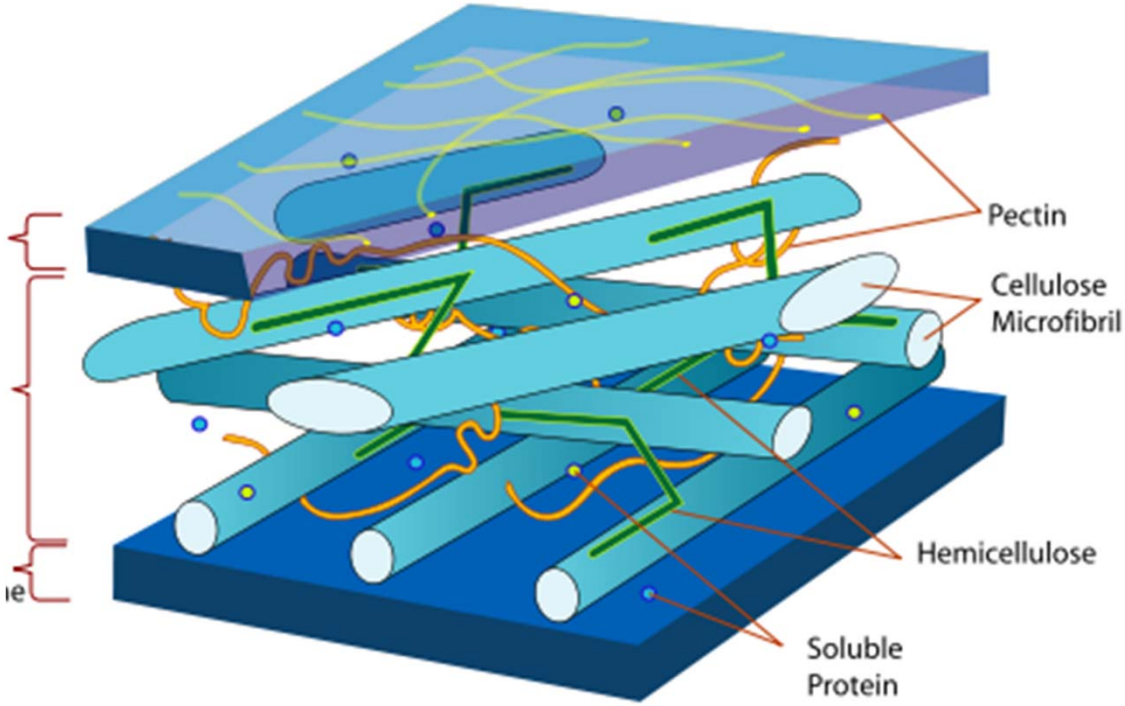
Changes in internal cell pressure

Changes in wall mechanics

Anisotropy
Elasticity
Viscosity

The plant cell wall is a complex biological composite

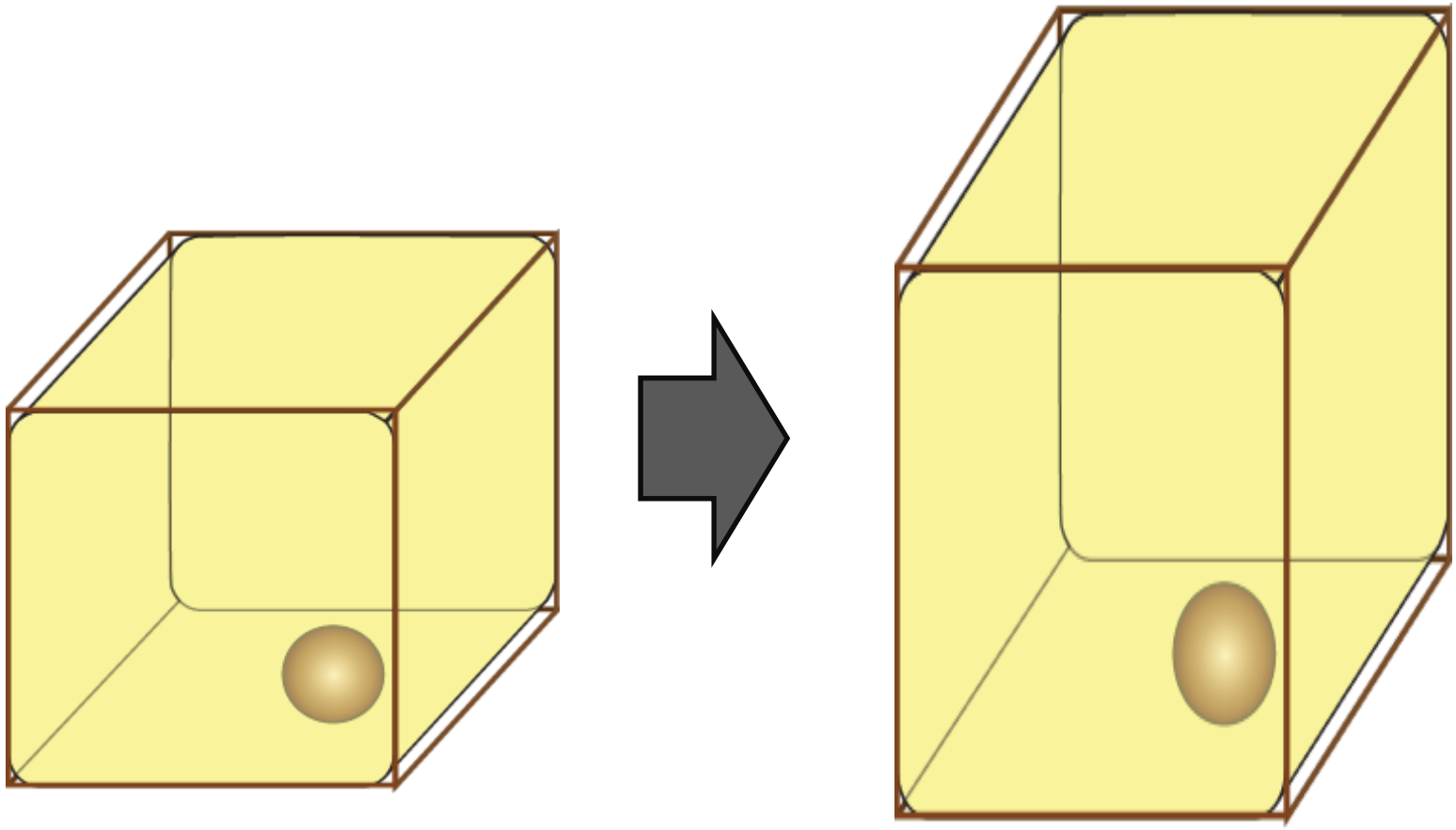
Pectins (gel matrix)
Hemicellulose (tethers/struts)
Cellulose (fibers)



Cell wall structure will change dynamically by alteration and addition of new material

Creative Commons, `Ladyofhats`

Simple shape change: anisotropy



Polar organ growth in hypocotyls

Cell wall properties

Wall chemistry

Cytoskeleton

Endo/exocytosis

Regulatory genes

Response to light

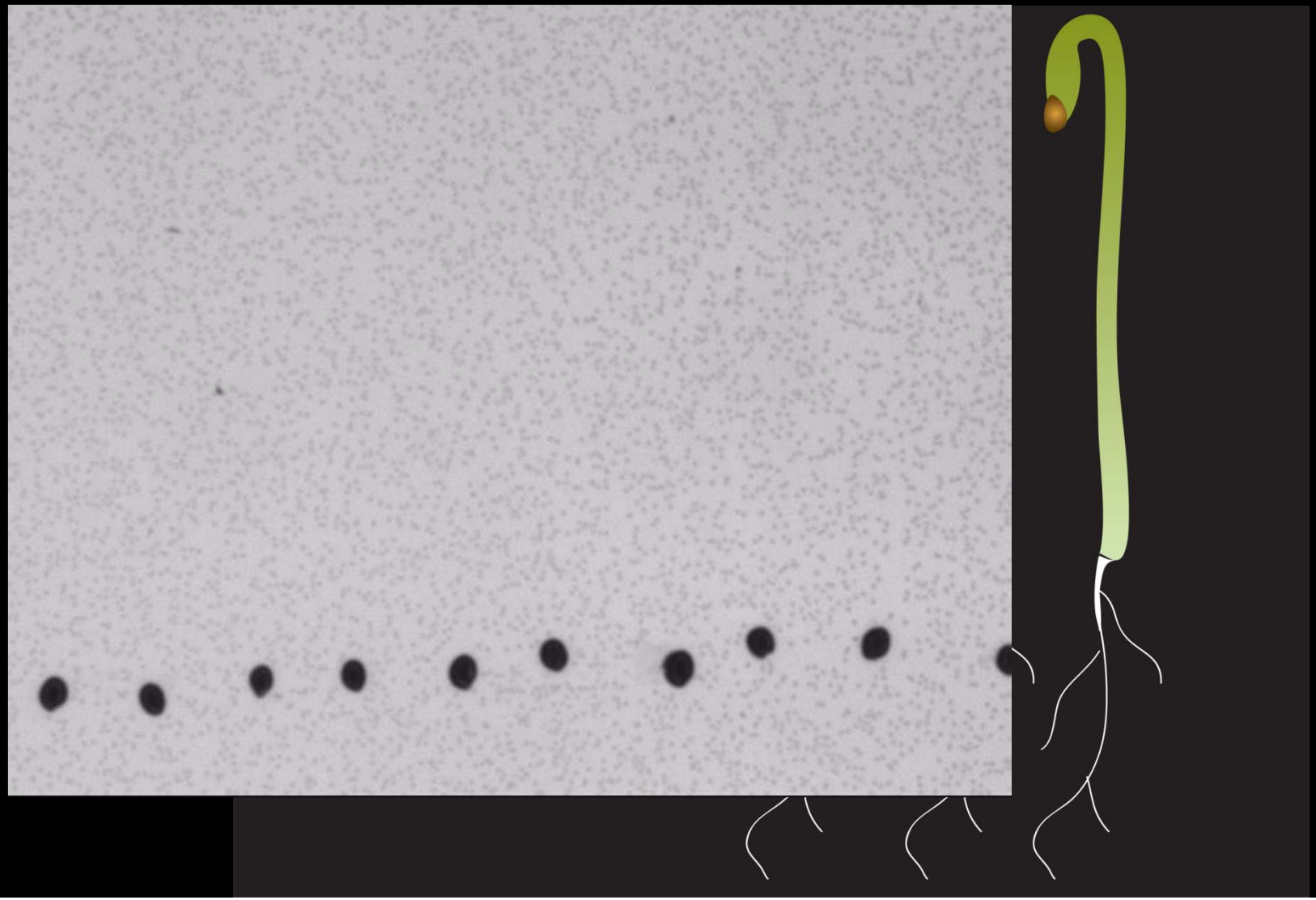
Response to gravity

Hormone biology

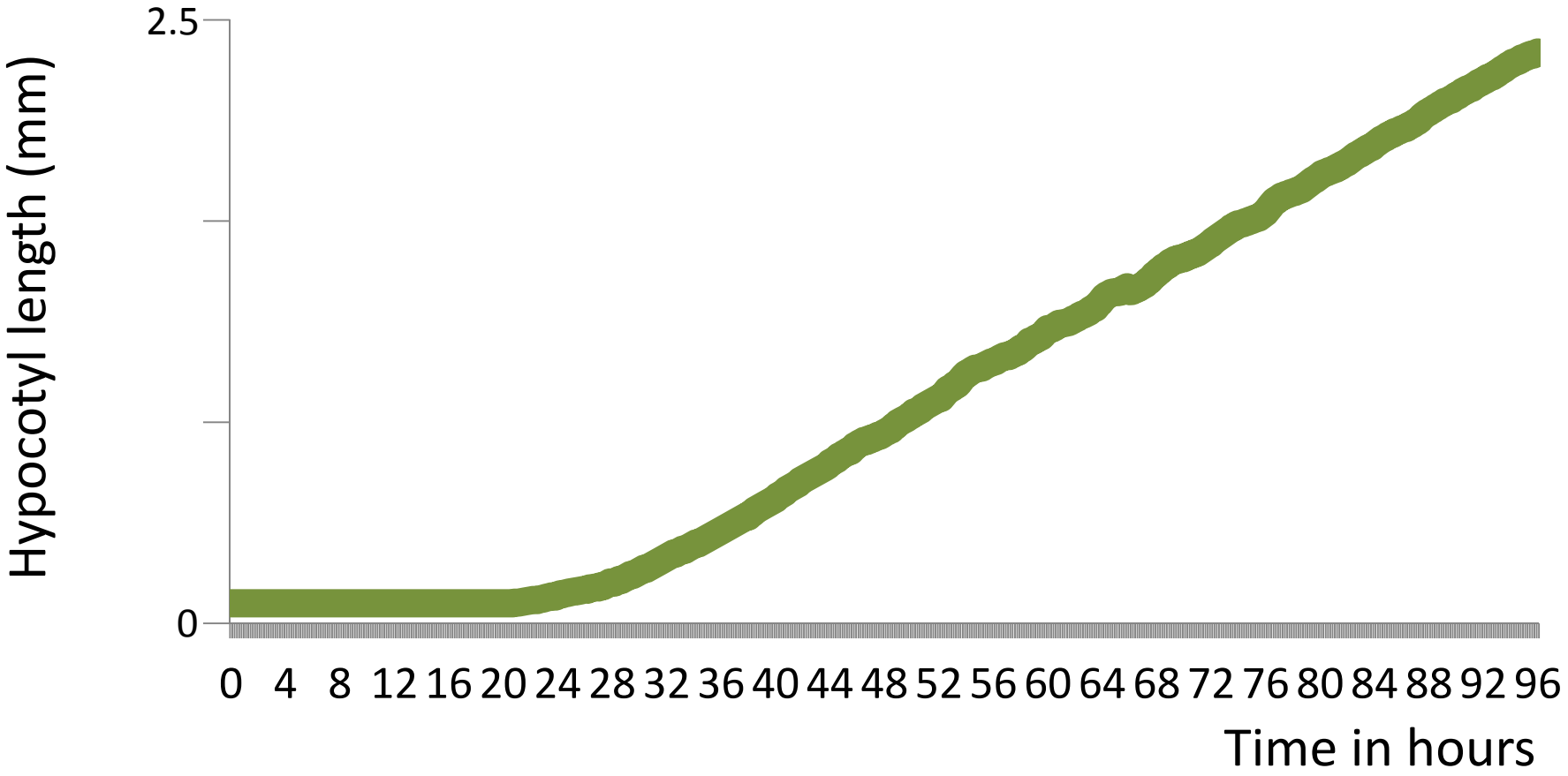
pH and Ca++

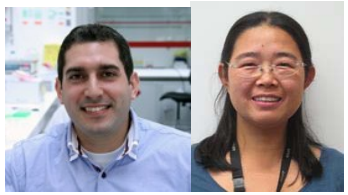
BBSRC

Dark-grown hypocotyls keep reaching for the surface: etiolation

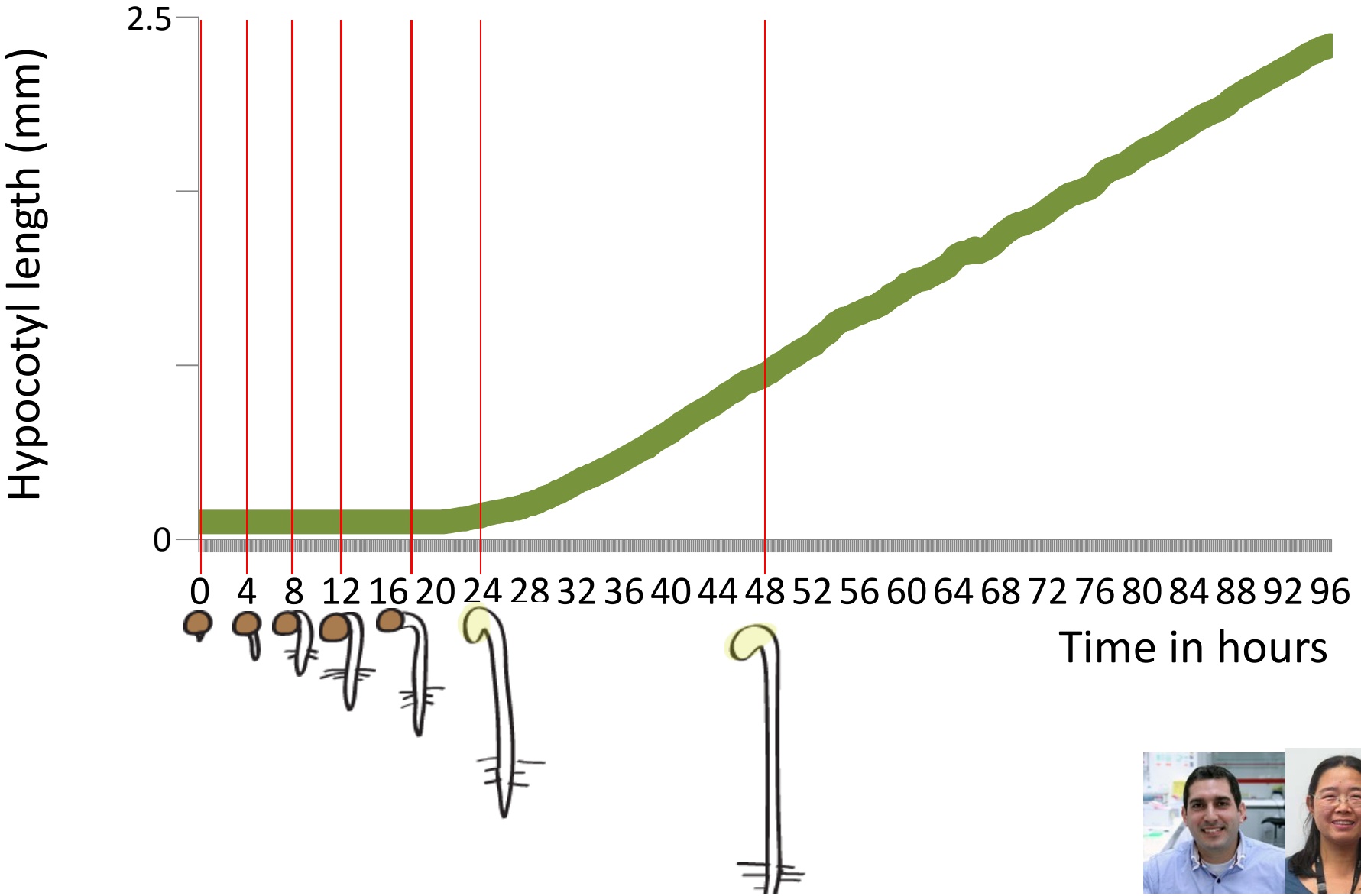


Kinematics of hypocotyl etiolation





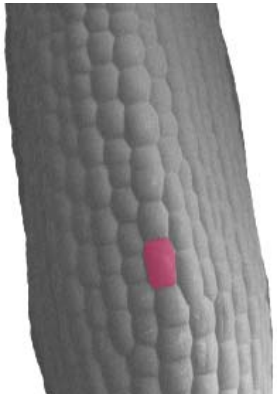
Kinematics of hypocotyl etiolation



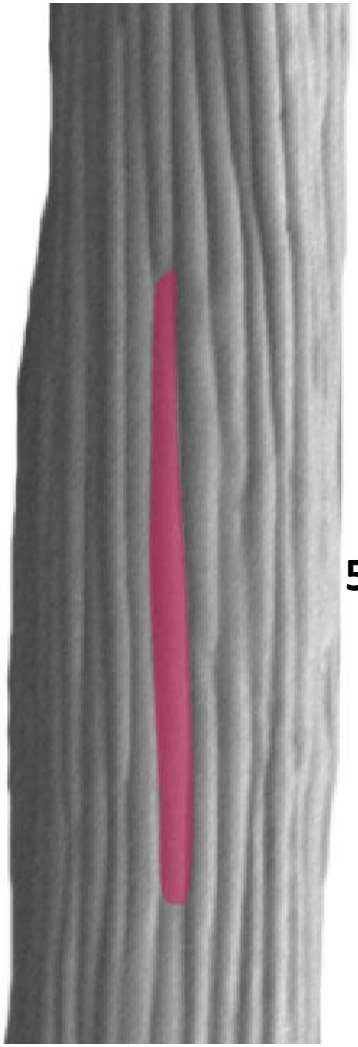
Extreme oriented cell/organ growth during etiolation

72h post germination

germination

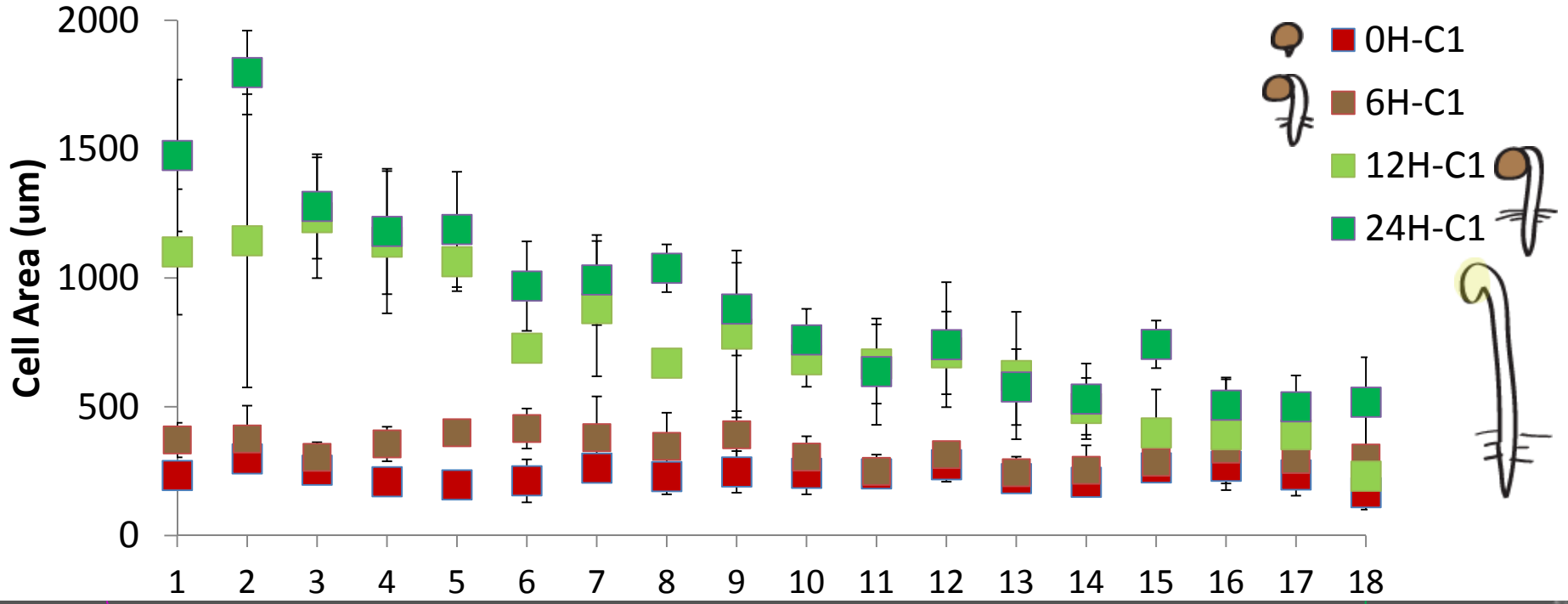


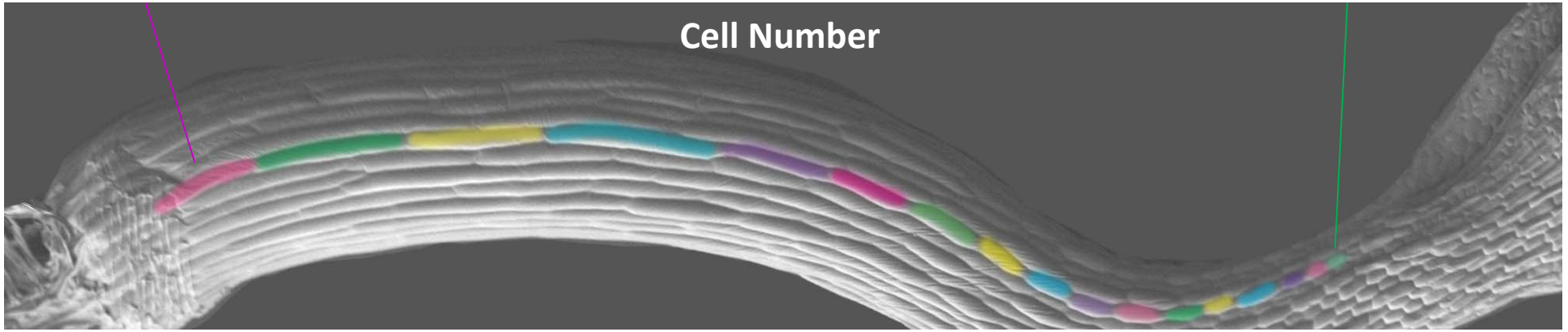
25 um
X
13 um



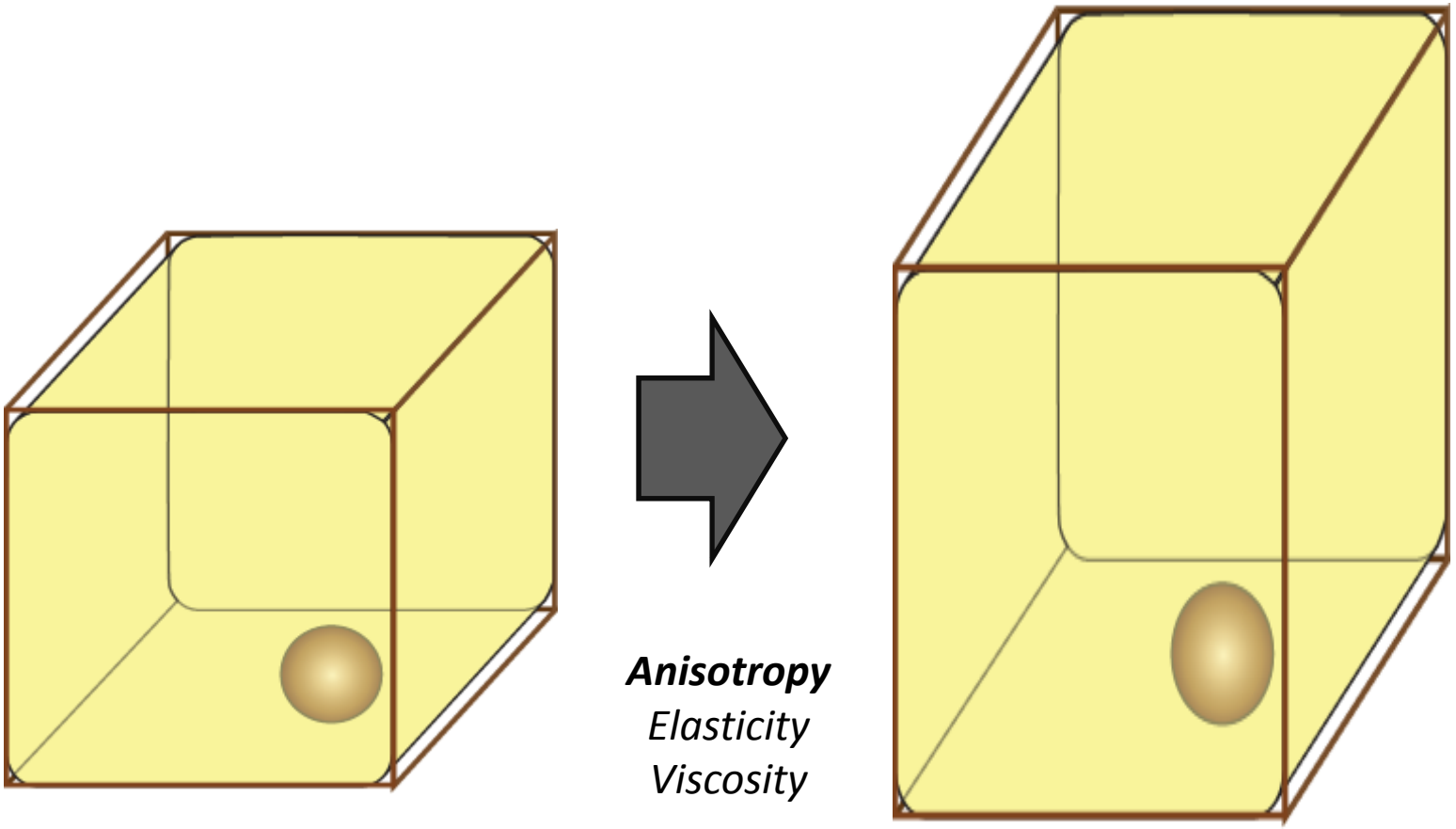
500 um
X
15 um

Cell expansion occurs in a Basal-> Apical wave

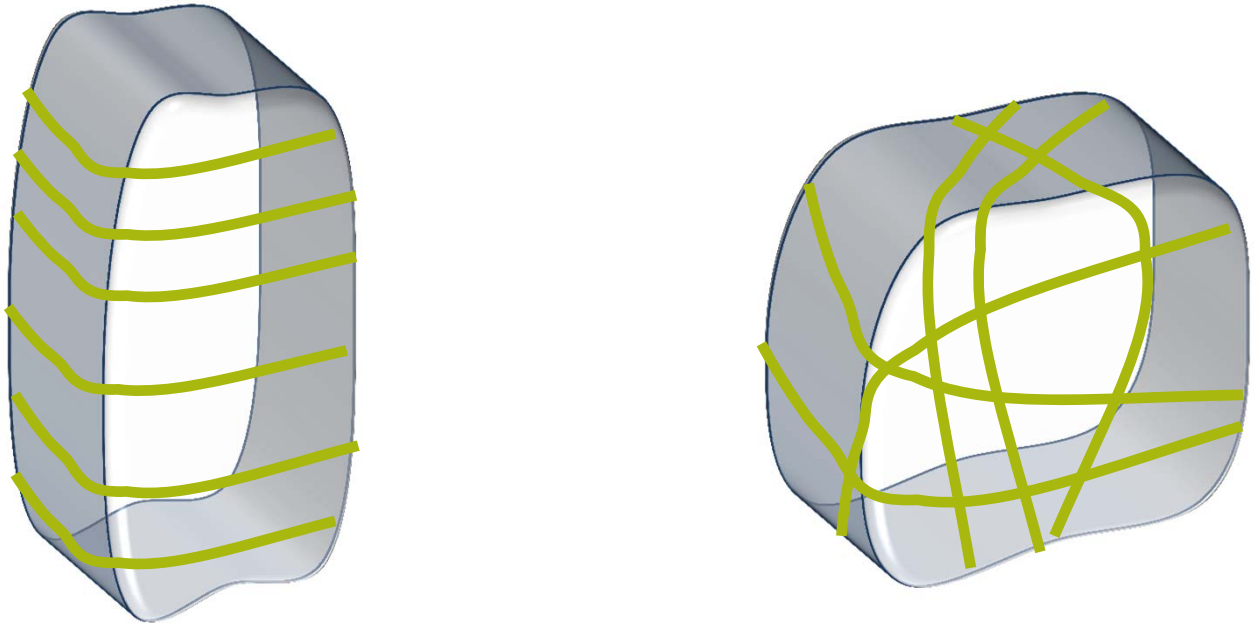




Simple shape change: anisotropy

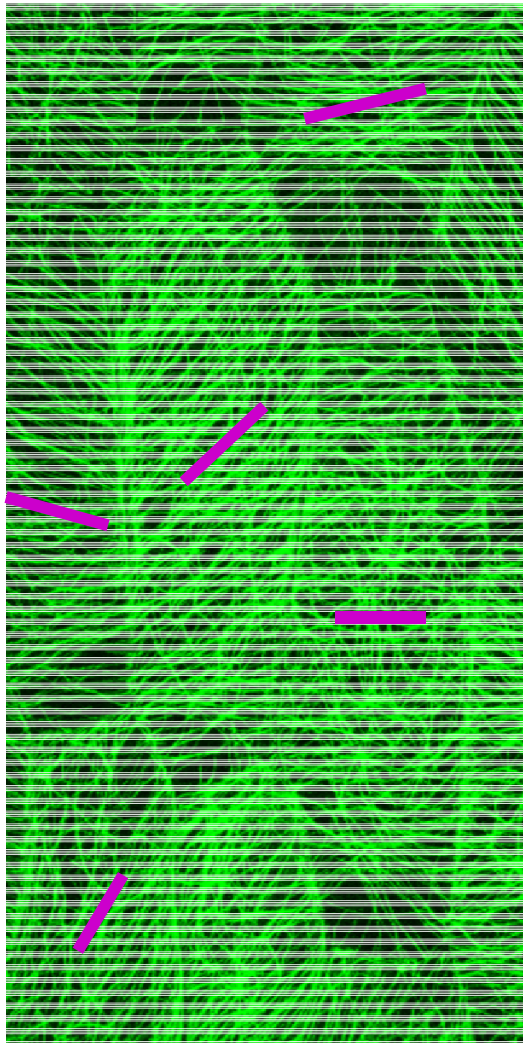


What does MT/CesA orientation look like in isotropic hypocotyl cells?

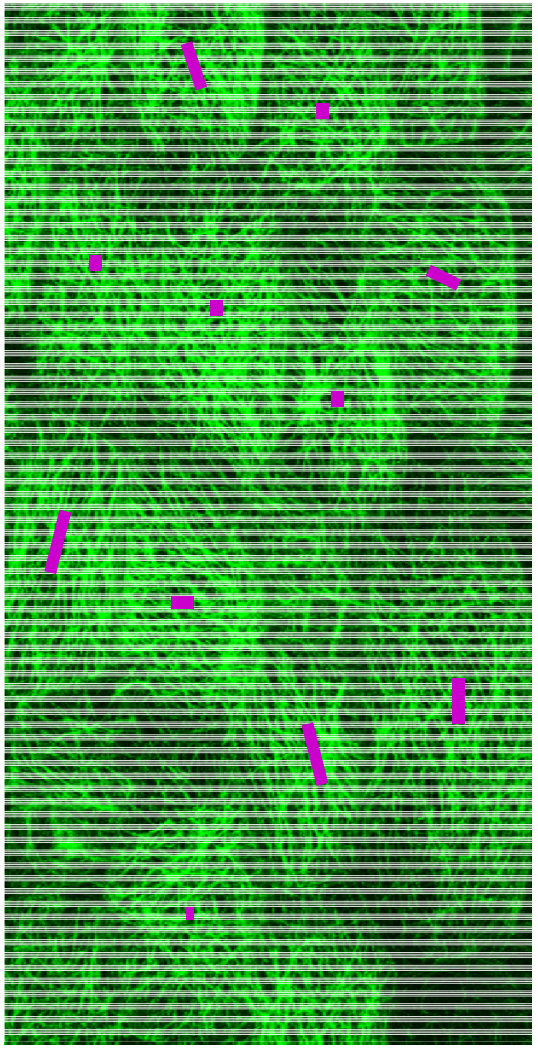


MT orientation *is* correlated with expansion in later stages of etiolation

24h



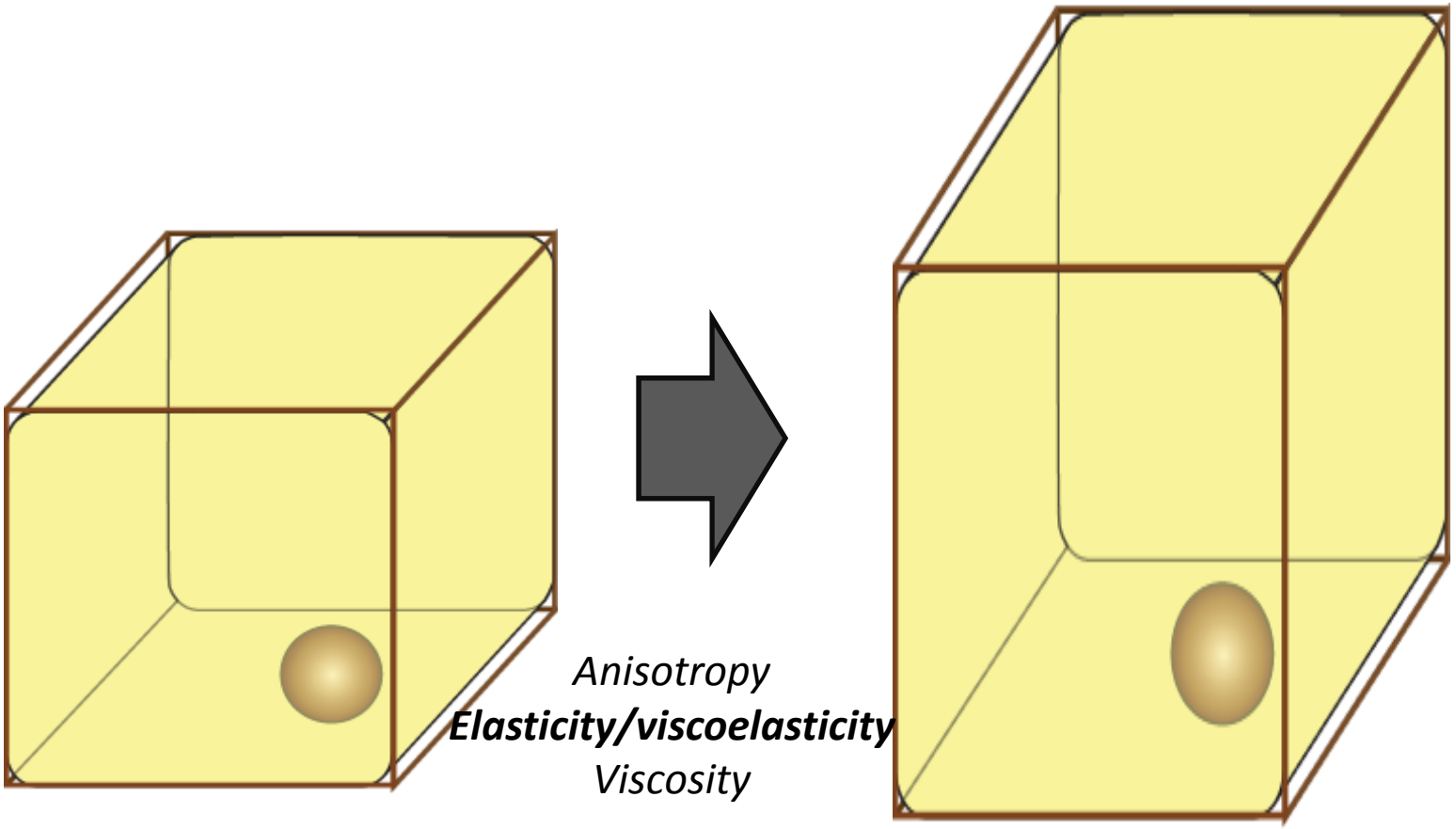
Basal cells, MAP4-GFP



Top cells, MAP4-GFP

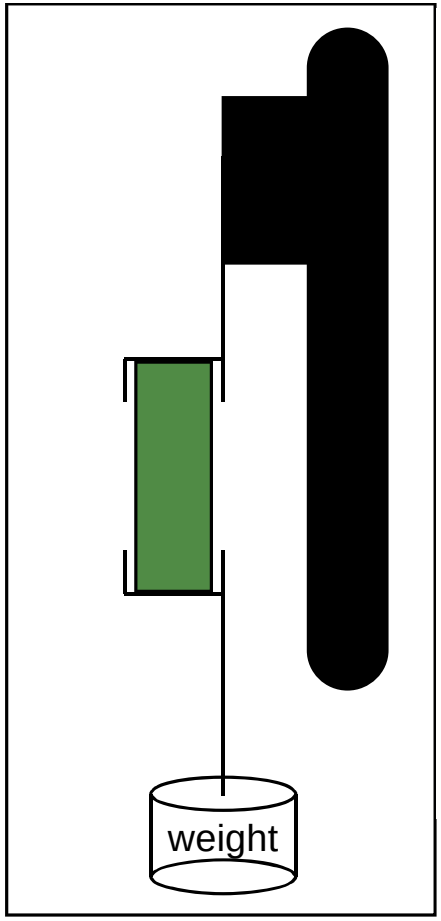
Orientation measured with FibrilTool (A. Boudaoud)

Simple shape change: anisotropy

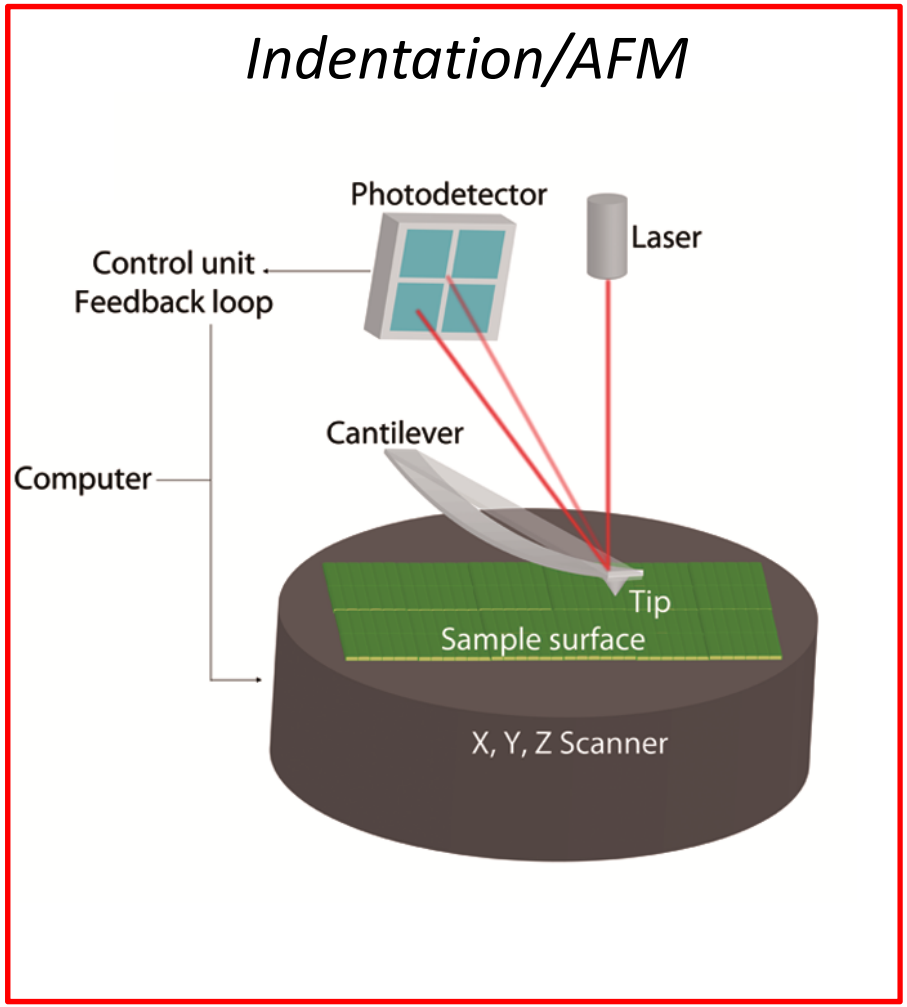


Current methods for examining biophysical changes in plants

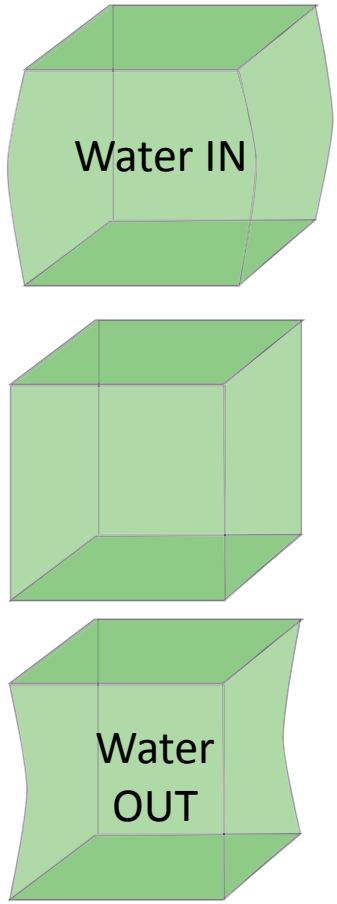
Extensometer



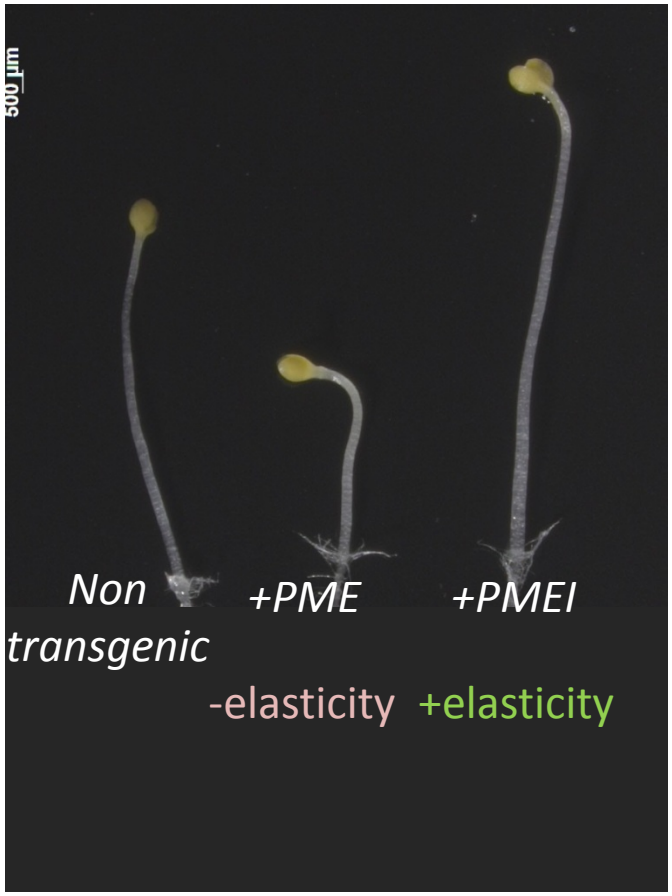
Indentation/AFM

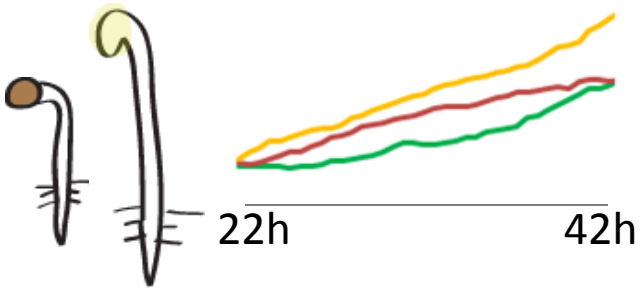


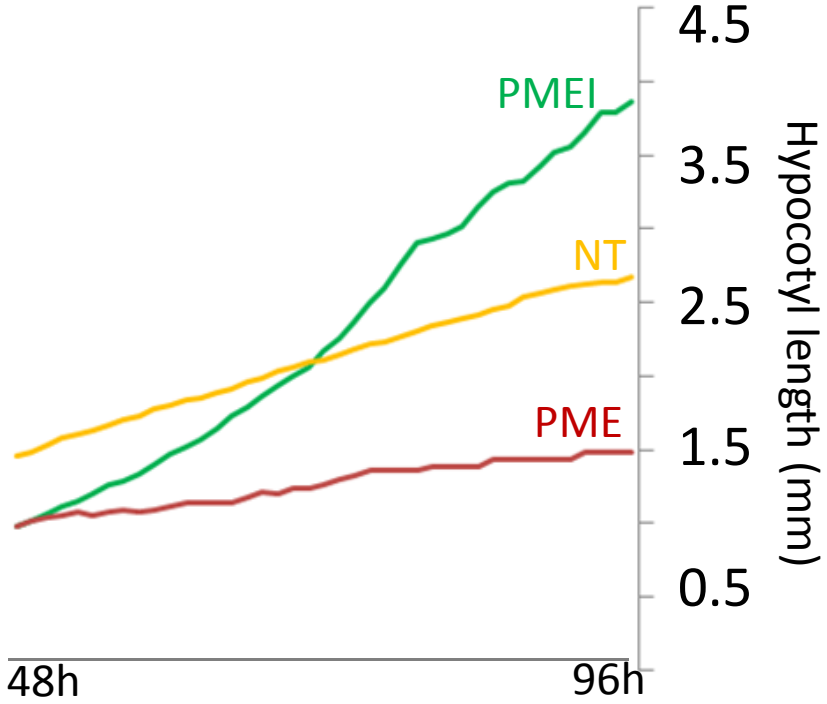
Swell/Shrink



Changes in pectin matrix affect growth magnitude and character but not anisotropy





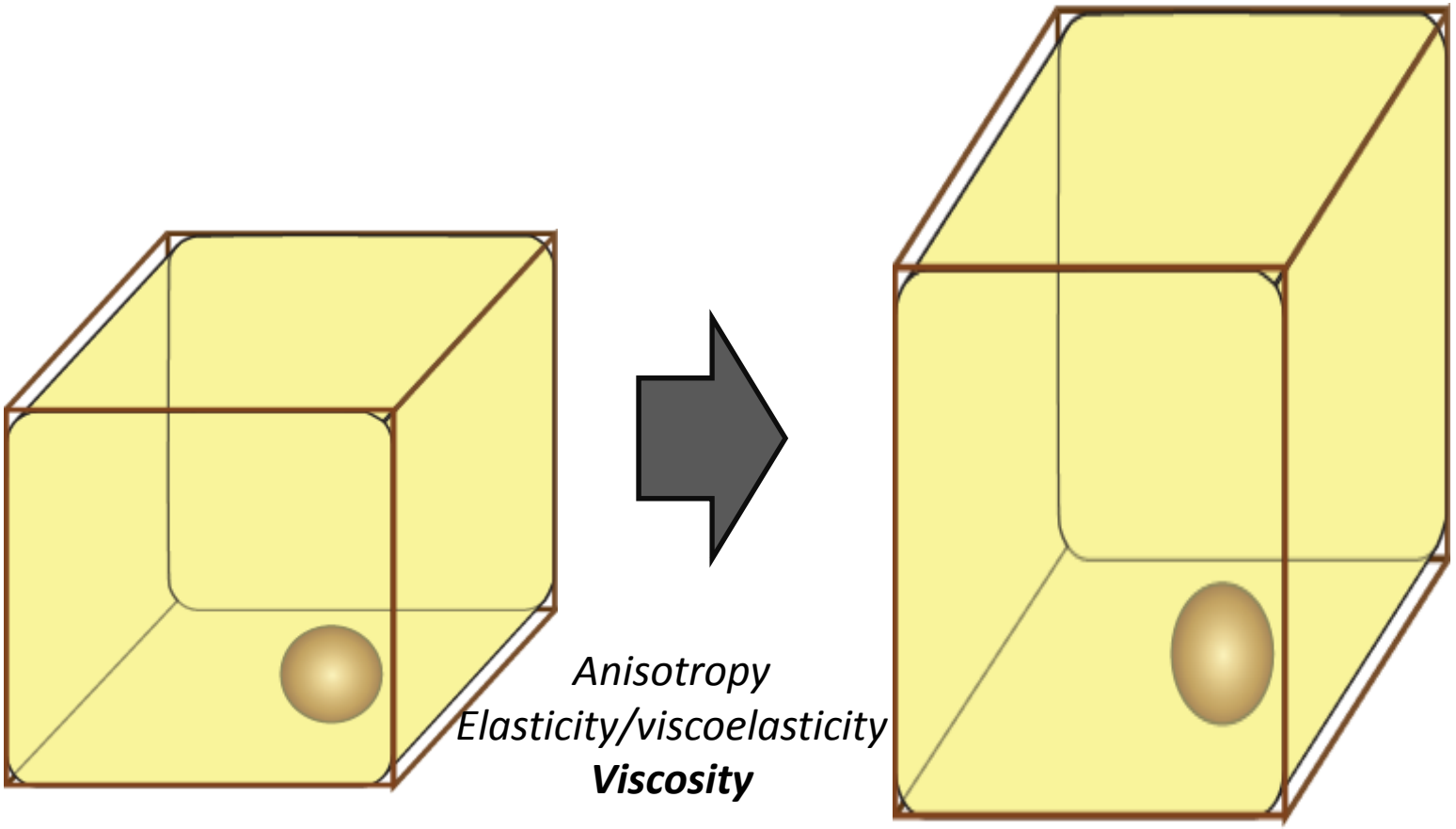


If not pectin, then who?

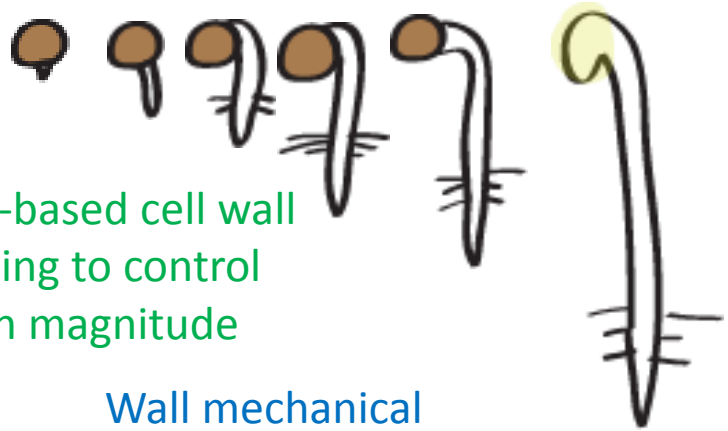
We do not know yet…….

- Developing better testing/modelling methods for viscoelasticity (hemicellulose? expansins?)
- Immunolocalizations for chemical changes in the cell wall
- RNA profiling of transcripts associated with growth changes

Simple shape change: anisotropy



What's going on under there?



Pectin-based cell wall softening to control growth magnitude

Wall mechanical asymmetry occurs before MT orientation

Viscoelasticity?
Hemicellulose?

MT reorient and provide material anisotropy for extreme growth

Exposure to light quickly effects elasticity of the cell wall to halt expansion

So far, all of our information pertains to the epidermis……is that enough?

Acknowledgments

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UNIVERSITY OF CAMBRIDGE

The Plant Mechanics Group

plantmechanome.org

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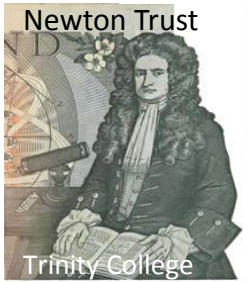

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