Advances and Challenges in Modern Biology

The (Plant) Cell – Vessel for Life

Tomasz Nodzyński

2021.10.04

The (Plant) Cell – Vessel for Life

Can U see a cell..?

Seeing is believing

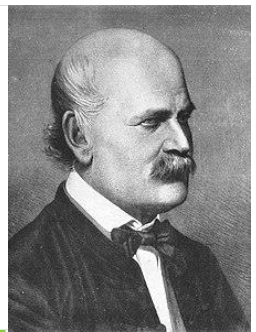
There was no concept a “cell”

What was believed before…

Spontaneous Generation

In the early 1600's and before, living organisms arising from the environment like dust and dirt.

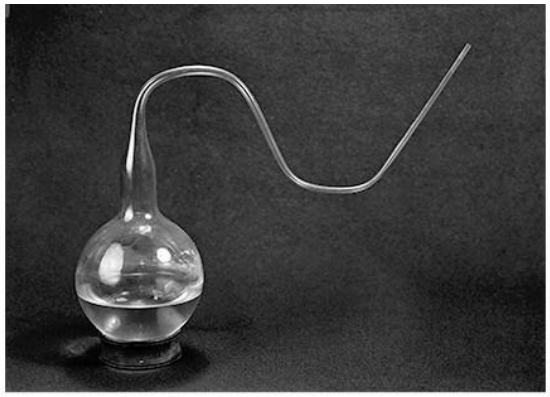
Disproven in 1864



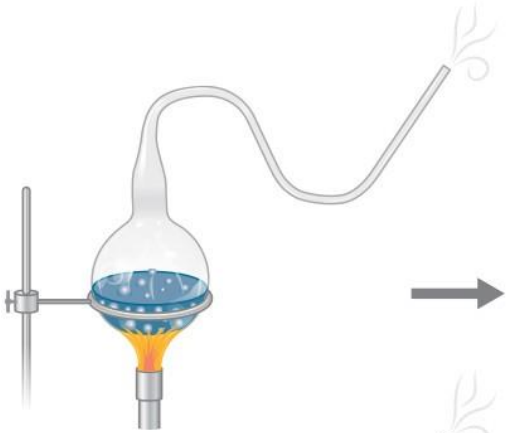
Streptococcus pyogenes

Swan-neck bottle used by Pasteur

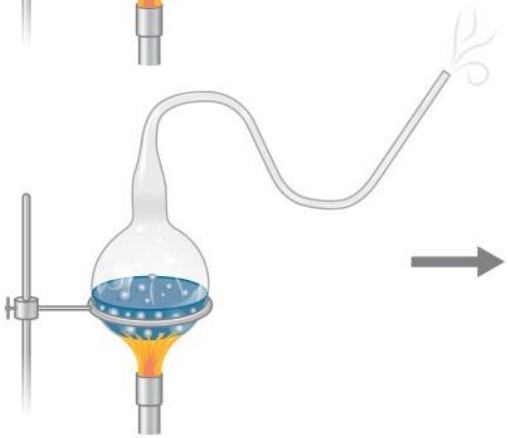
(a)

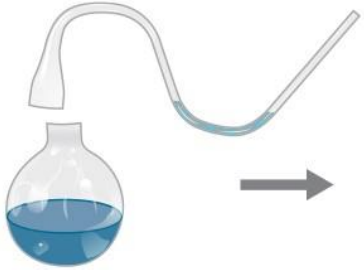


(b)



The curve of the flask prevents outside air from entering the flask. No contamination occurs.



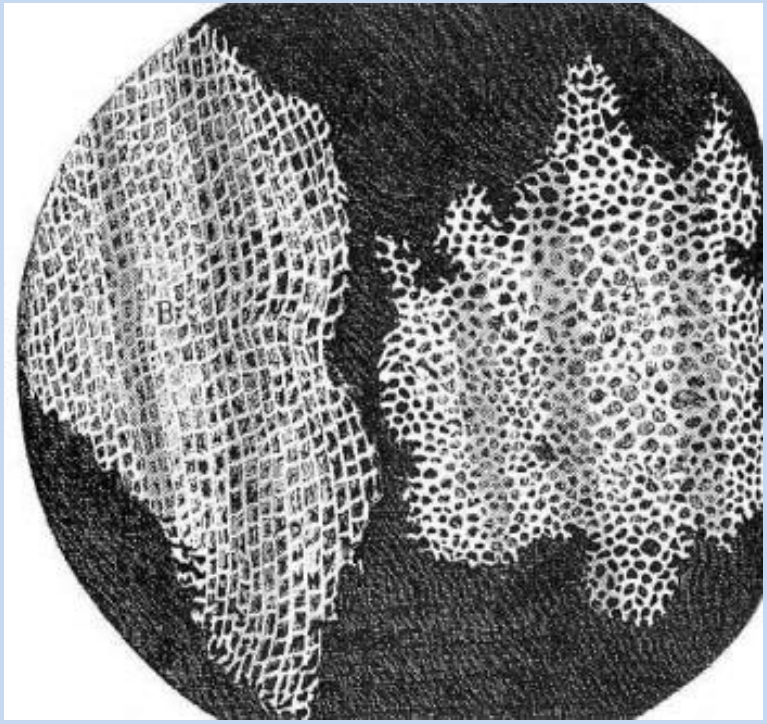


When the neck of the flask is broken off, bacteria reach the sterile broth and organism growth occurs.

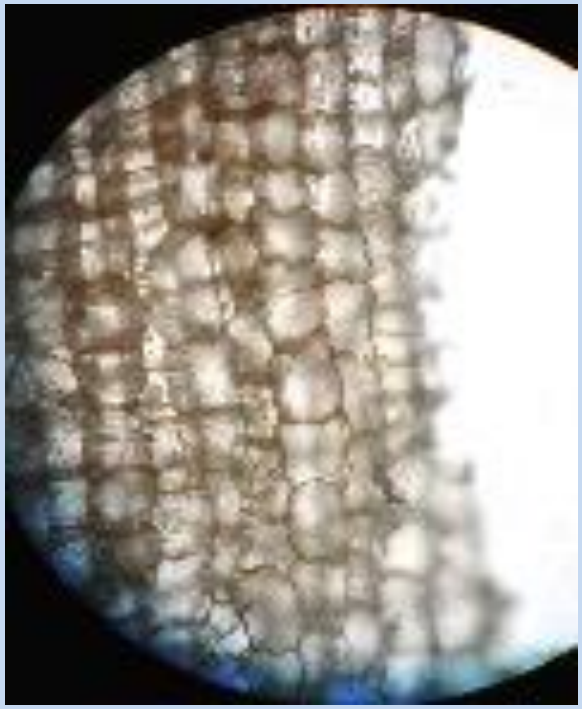
Boiling the broth kills microorganisms.

(c)

Cells were first observed in plants.



Drawing of cork by Robert Hooke, discoverer of “cells”
He coined the tem „cells”



Photograph of cork cells

Little rooms ~ Cells

Photo credit: ©David B. Fankhauser, Ph.D

1665

MICROGRAPHIA:

OR SOME

Physiological Descriptions

OF

MINUTE BODIES

MADE BY

MAGNIFYING GLASSES.

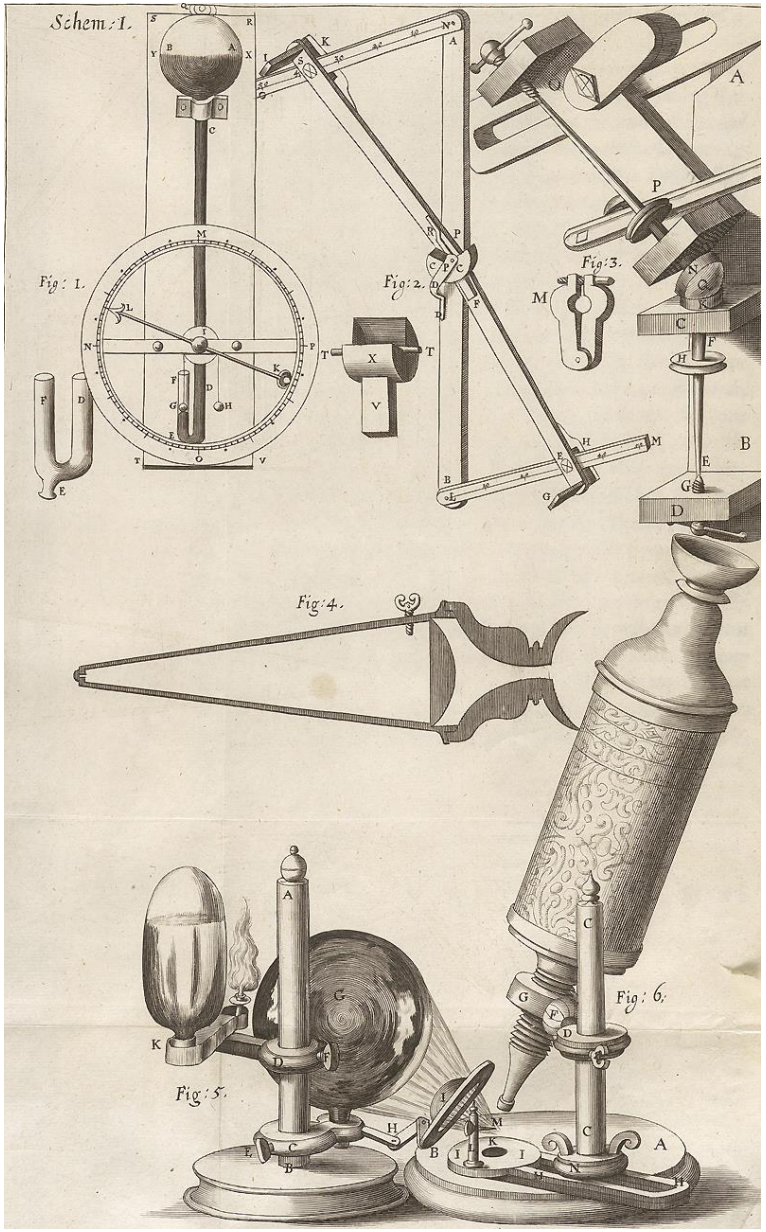
WITH

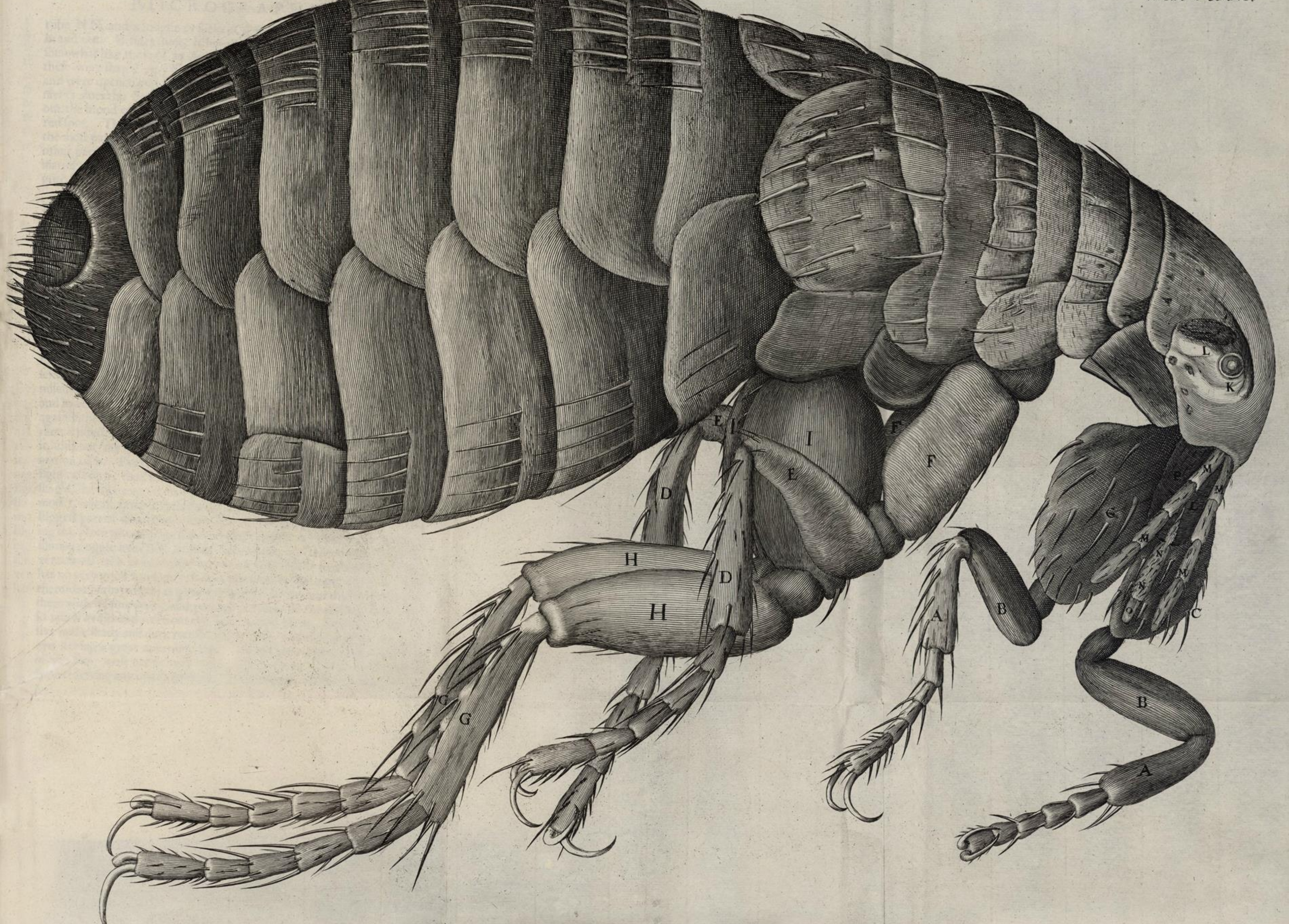
OBSERVATIONS and INQUIRIES thereupon.

By *R. HOOKE*, Fellow of the ROYAL SOCIETY.

Non possis oculo quantum contendere Linceus,
Non tamen idcirco contemnas Lippus inungi. Horat. Ep. lib. 1.

LONDON, Printed by *Jo. Martyn*, and *Ja. Allestry*, Printers to the ROYAL SOCIETY, and are to be sold at their Shop at the *Bell* in S. *Paul's* Church-yard. M DC LX V.

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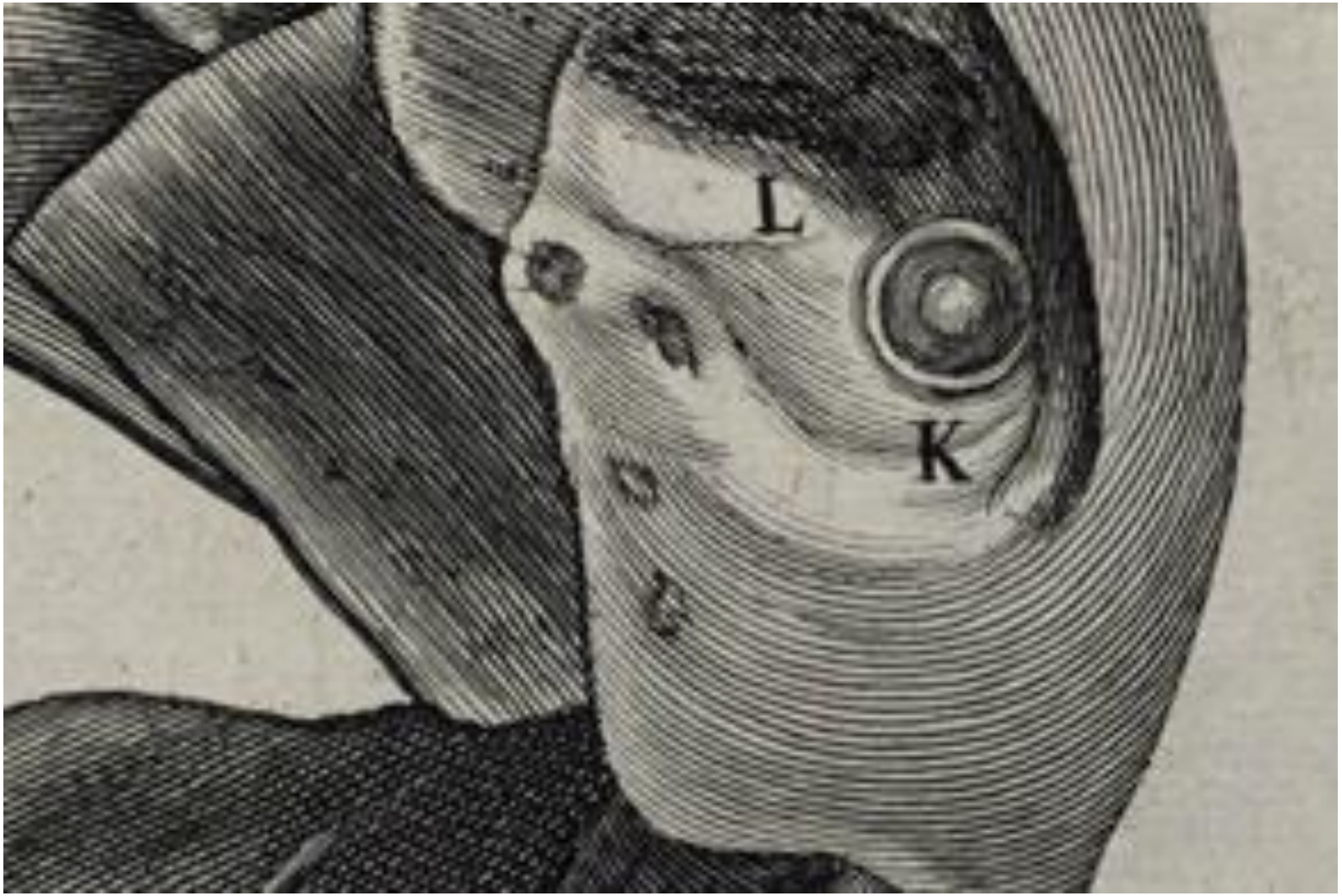
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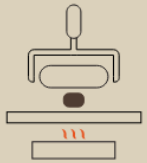
THE TOOLS OF ETCHING

GROUND

Solid hard ground

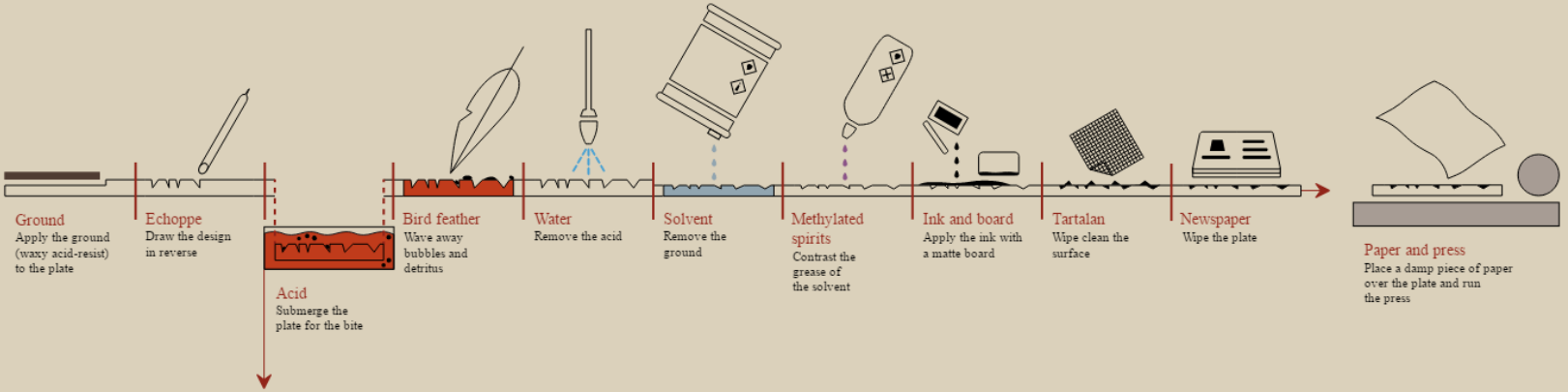
Heat the plate and apply the ground by hand and using a roller



"Smoke" the plate with 3 beeswax tapers

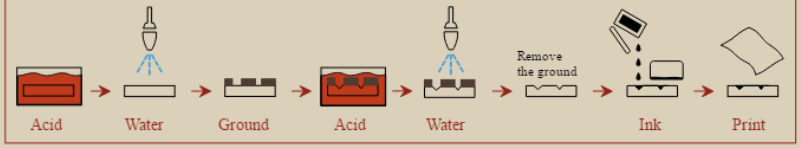
Liquid hard ground and solid ground

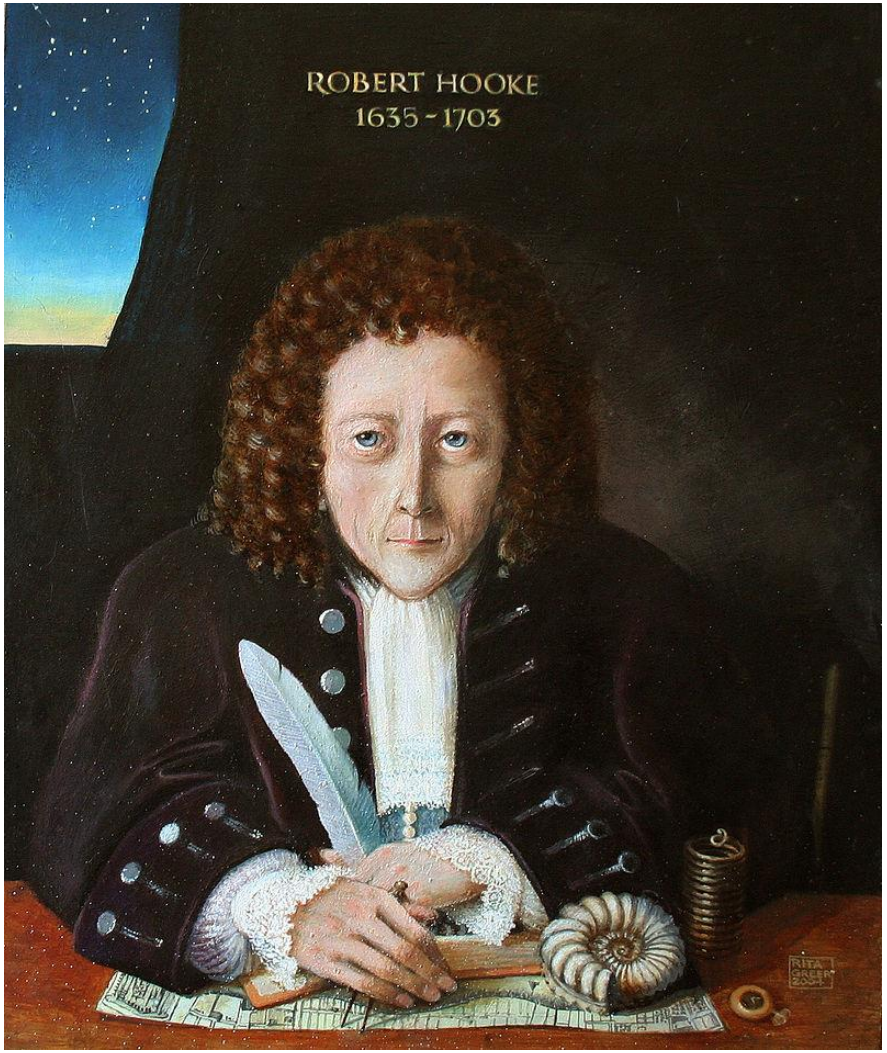
Apply the liquid with a brush upon the plate



TEST STRIP

The test on a small metal strip is useful to show the different degrees of depths of the etch





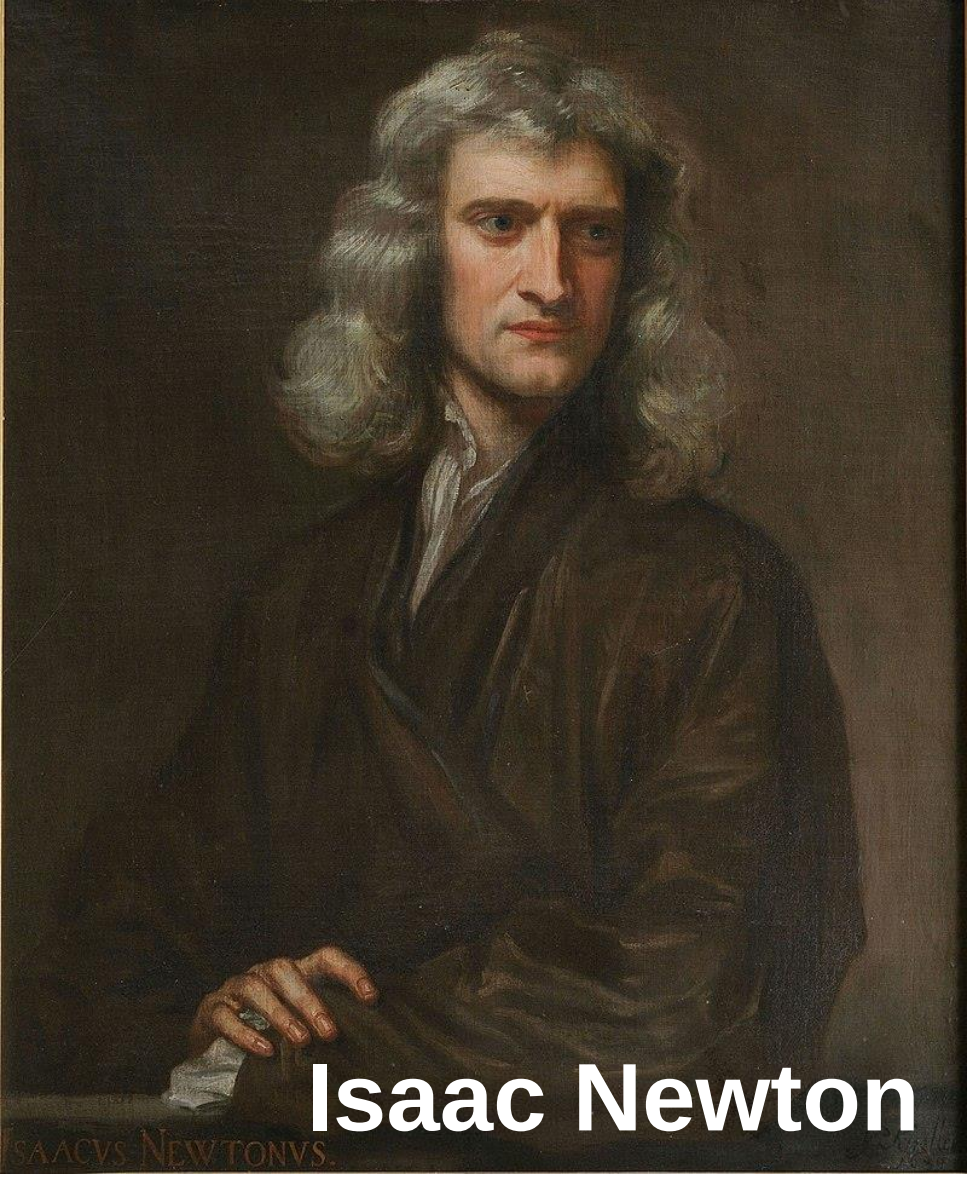
1635 -1703

1678:

ut tensio, sic vis

"as the extension, so the force" or „

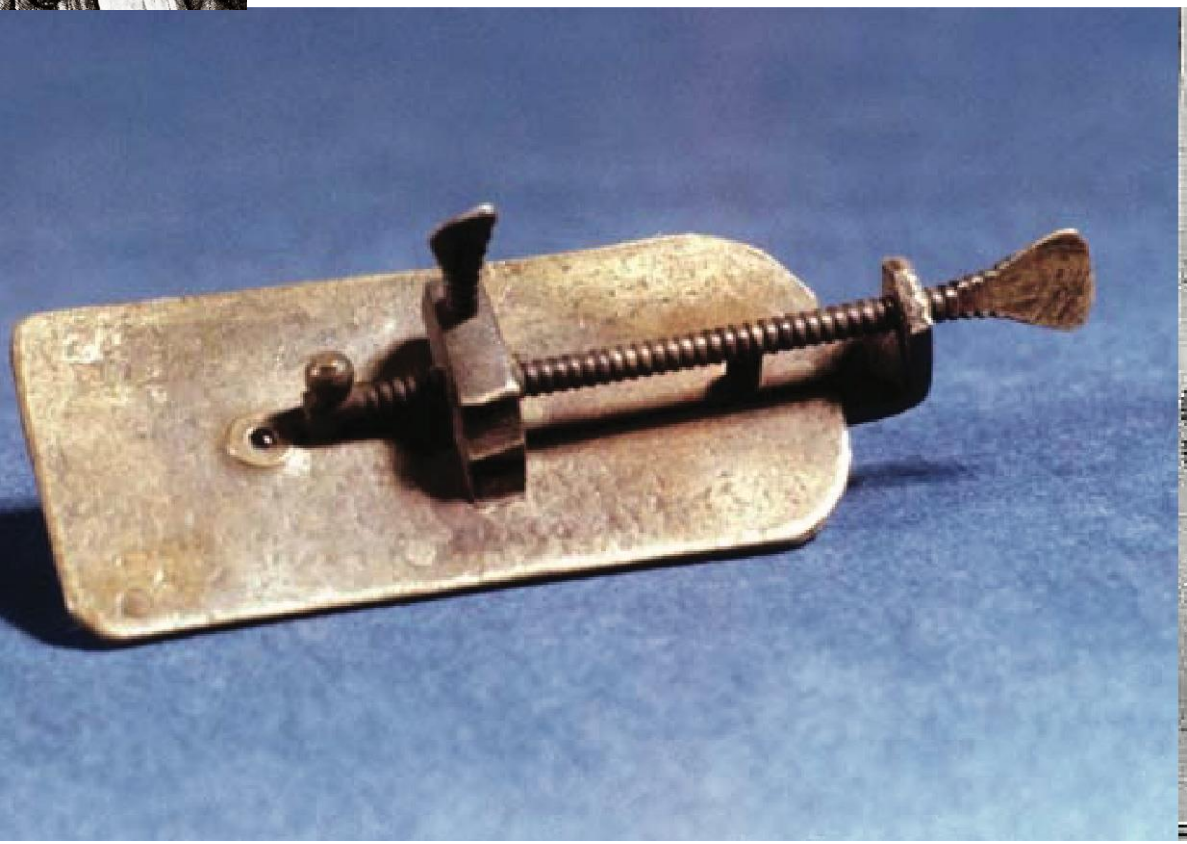
the extension is proportional to the force"

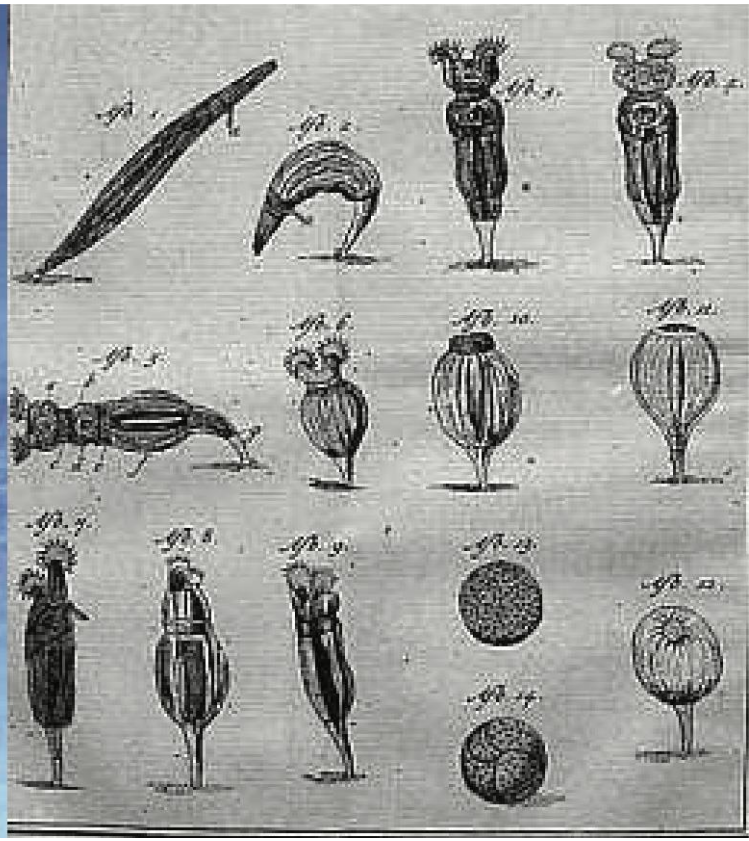


Isaac Newton

1643 - 1727

Antony van Leeuwenhoek



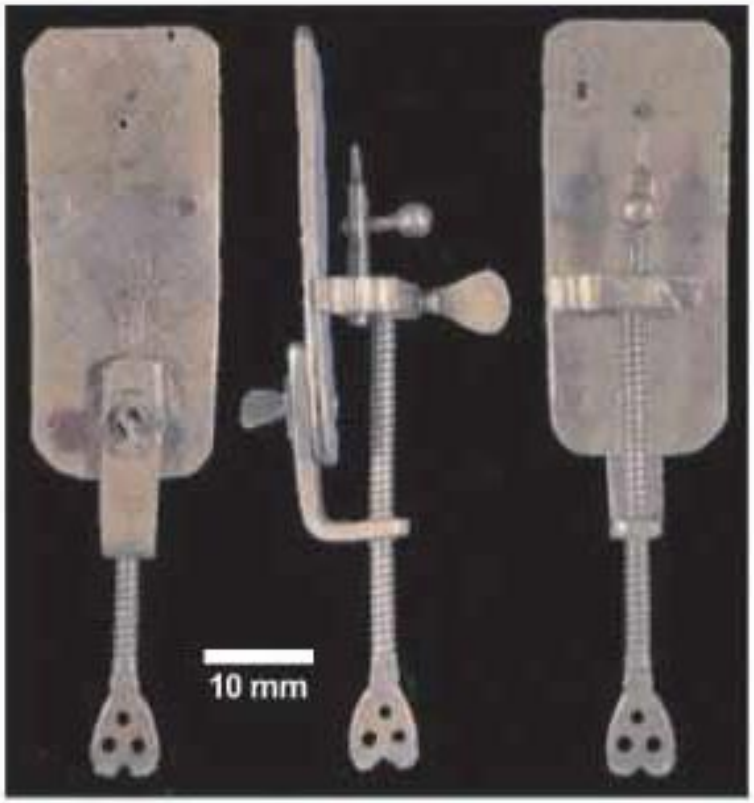


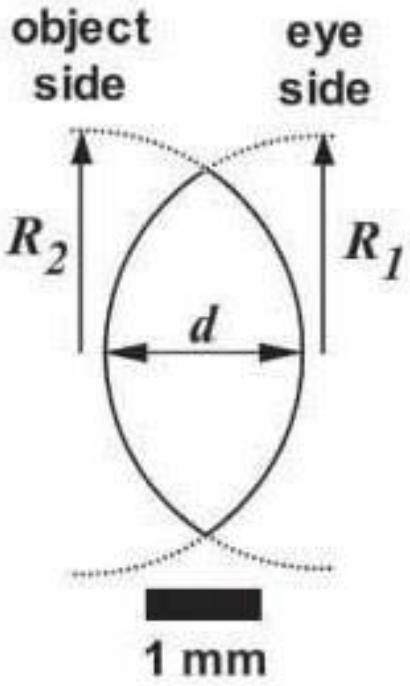
Diaries Diarrhoea

Dierkens

Sperm cells observation helped to abolish the spontaneous generation theory

Optical Properties of a van Leeuwenhoek Lens





$M = 117.92$

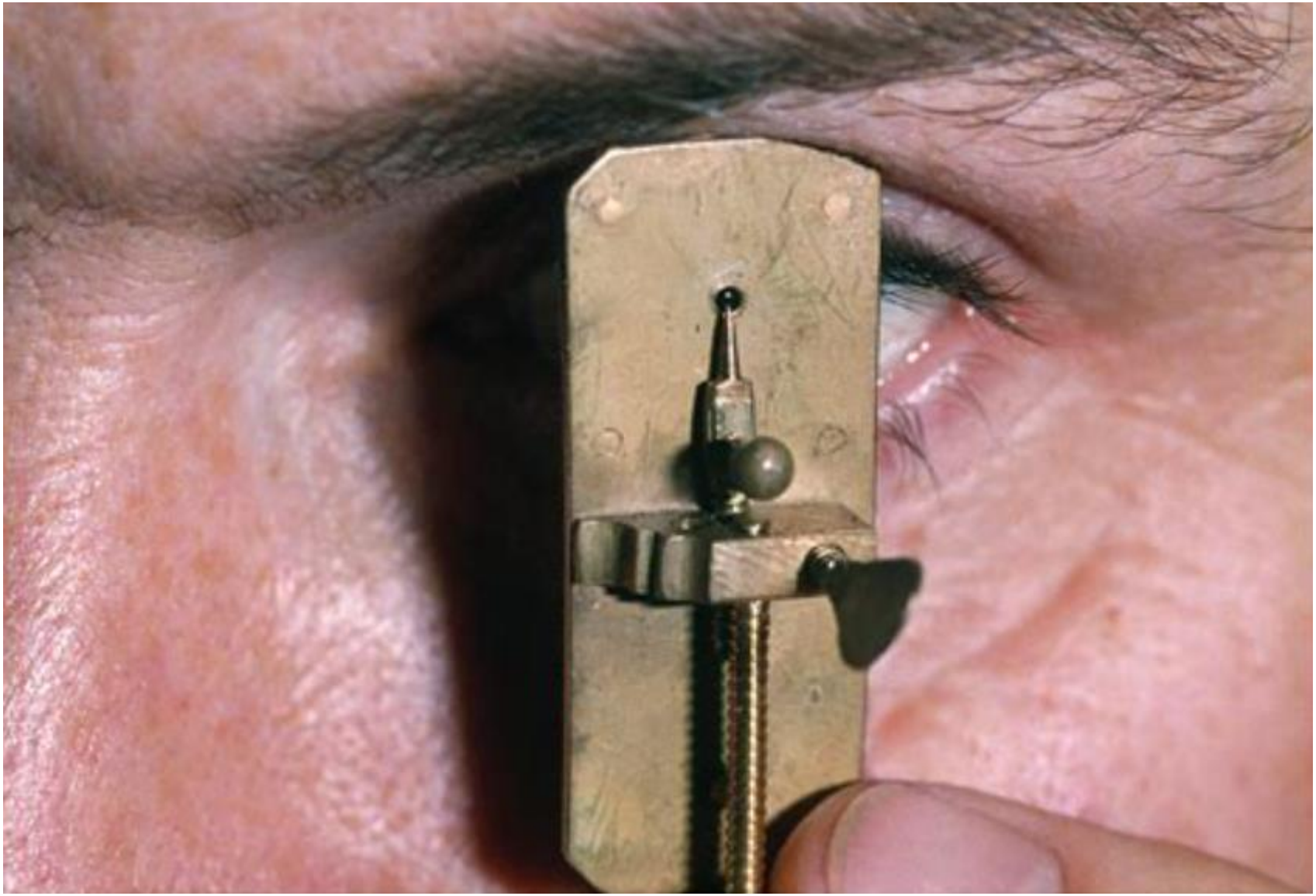
$f = 2.12$ mm

$R_1 = 1.91$ mm

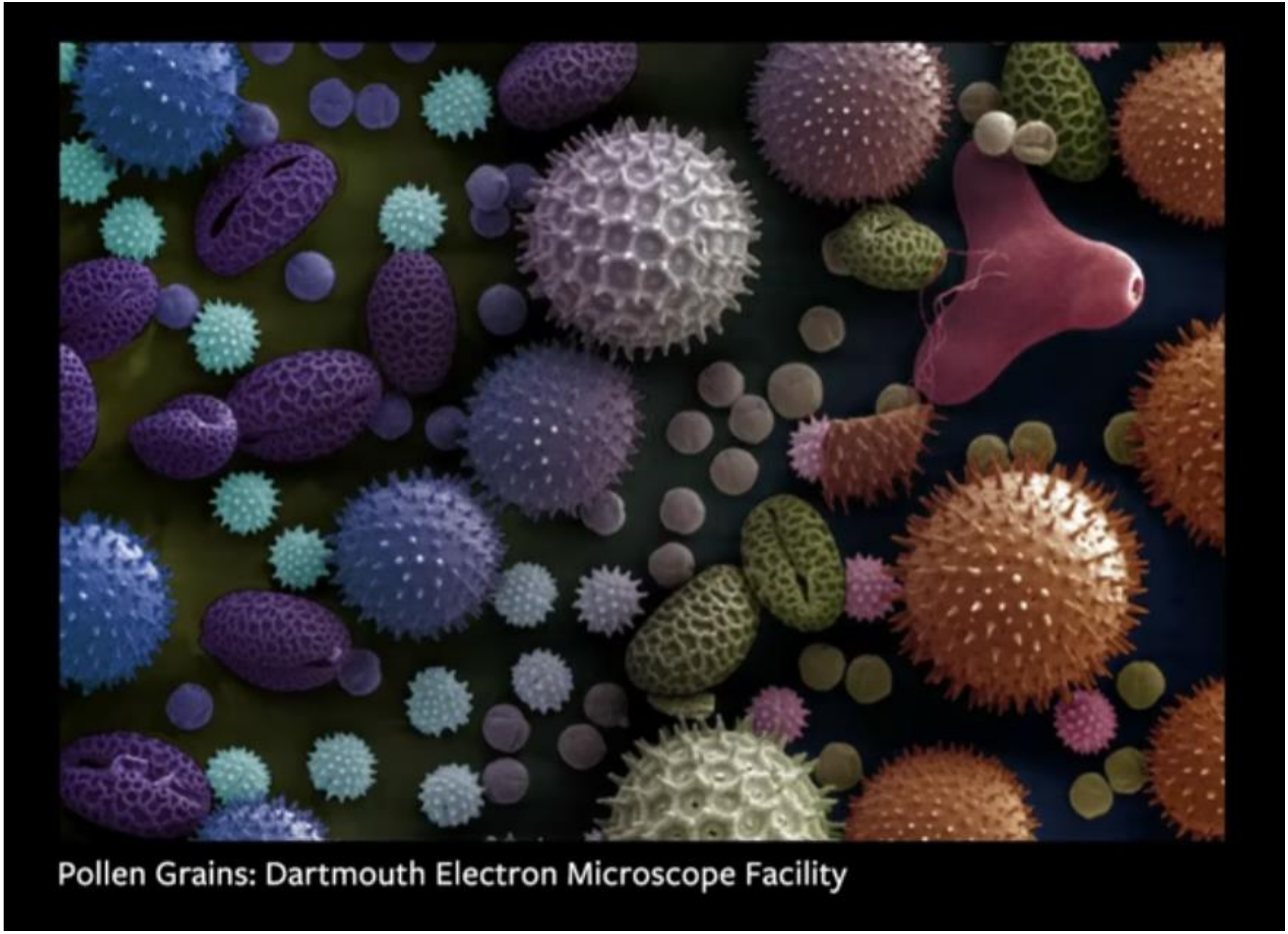
$R_2 = 1.96$ mm

$d = 1.74$ mm

$n = 1.54$

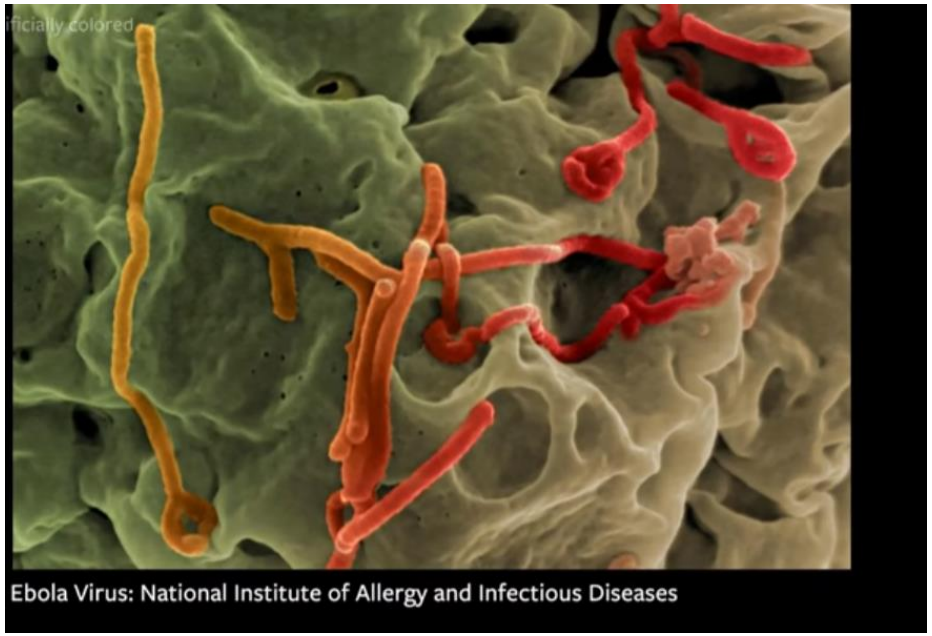



Max Knoll
Ernst Ruska
CLICK TO
SUB



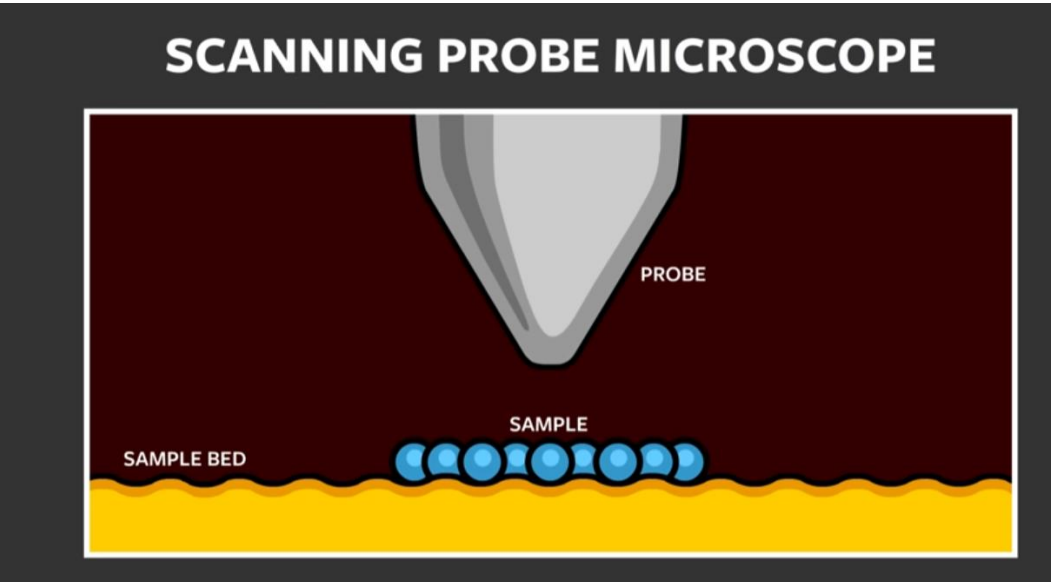
Pollen Grains: Dartmouth Electron Microscope Facility

HIV: National Institute of Allergy and Infectious Diseases



Ebola Virus: National Institute of Allergy and Infectious Diseases

COVID-19 virus (SARS-CoV-2): U.S. National Institutes of Health



SILICON ATOMS

(colors assigned artificially)

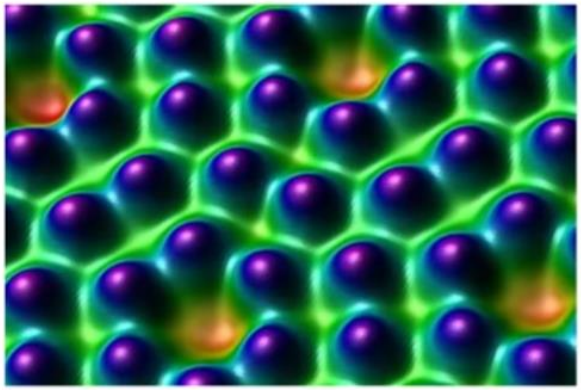
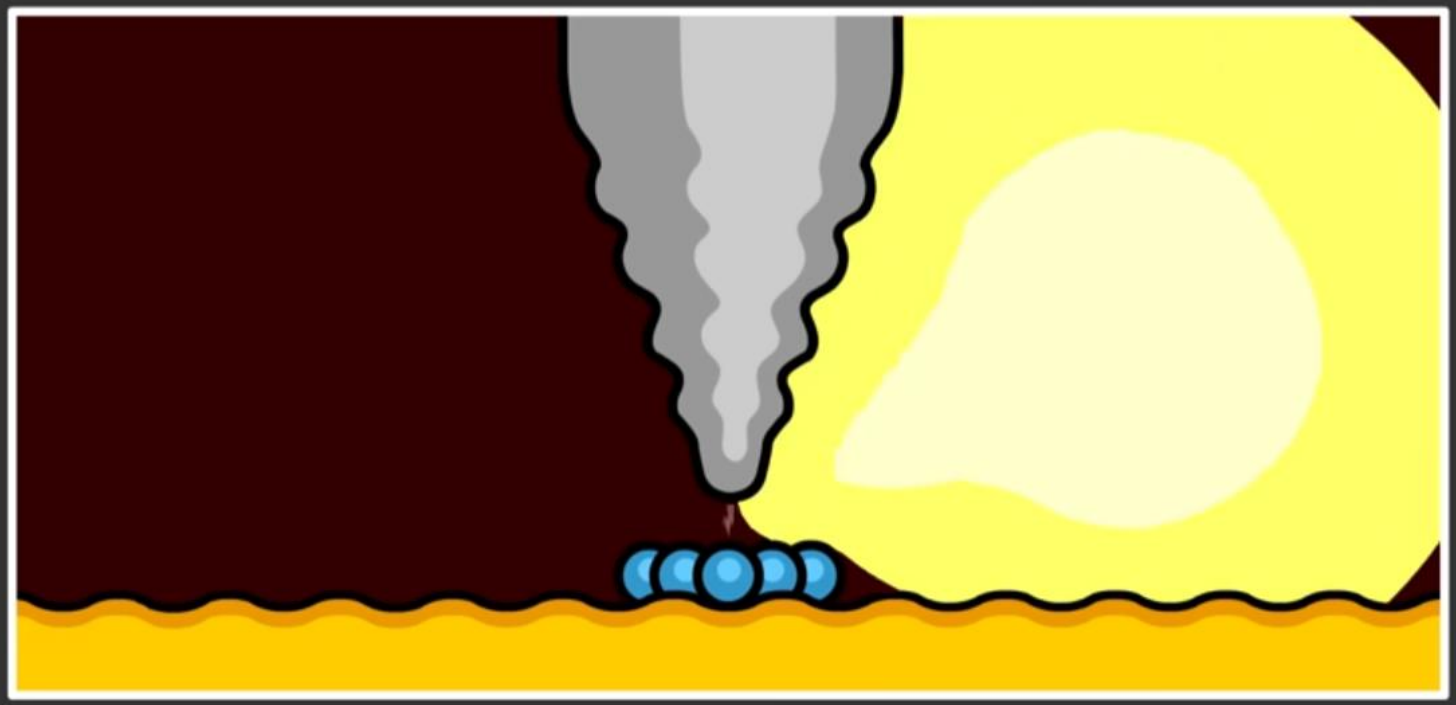
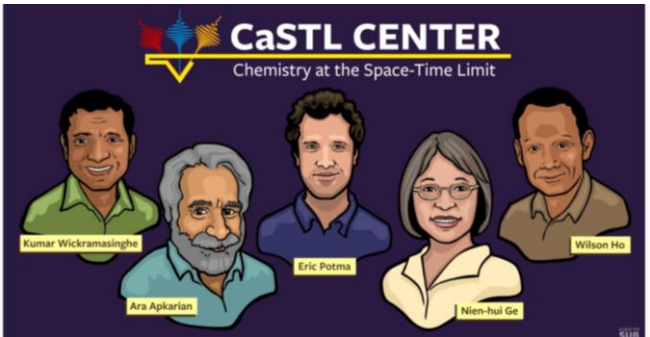


Image produced by lab of Dr. Wilson Ho
Scanning Tunneling Microscope

Scanning line by line concept.

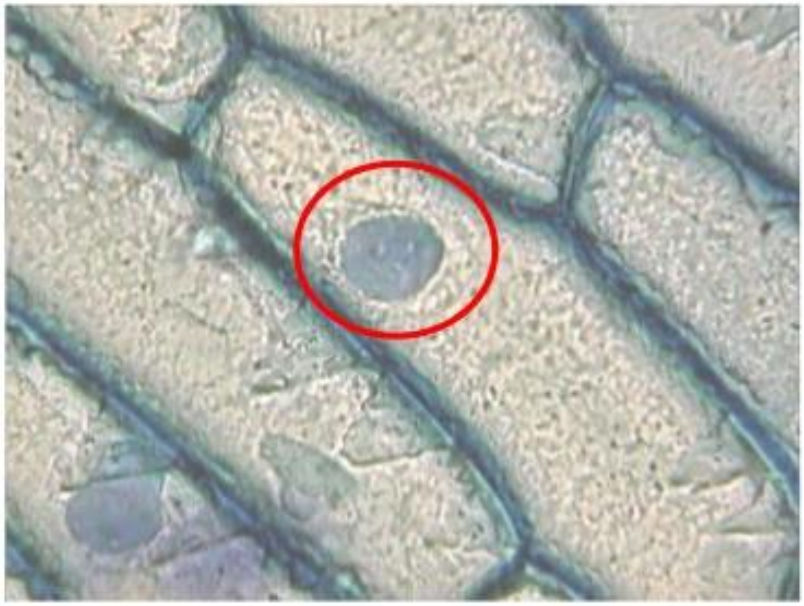
Tip-Enhanced Raman Spectromicroscopy





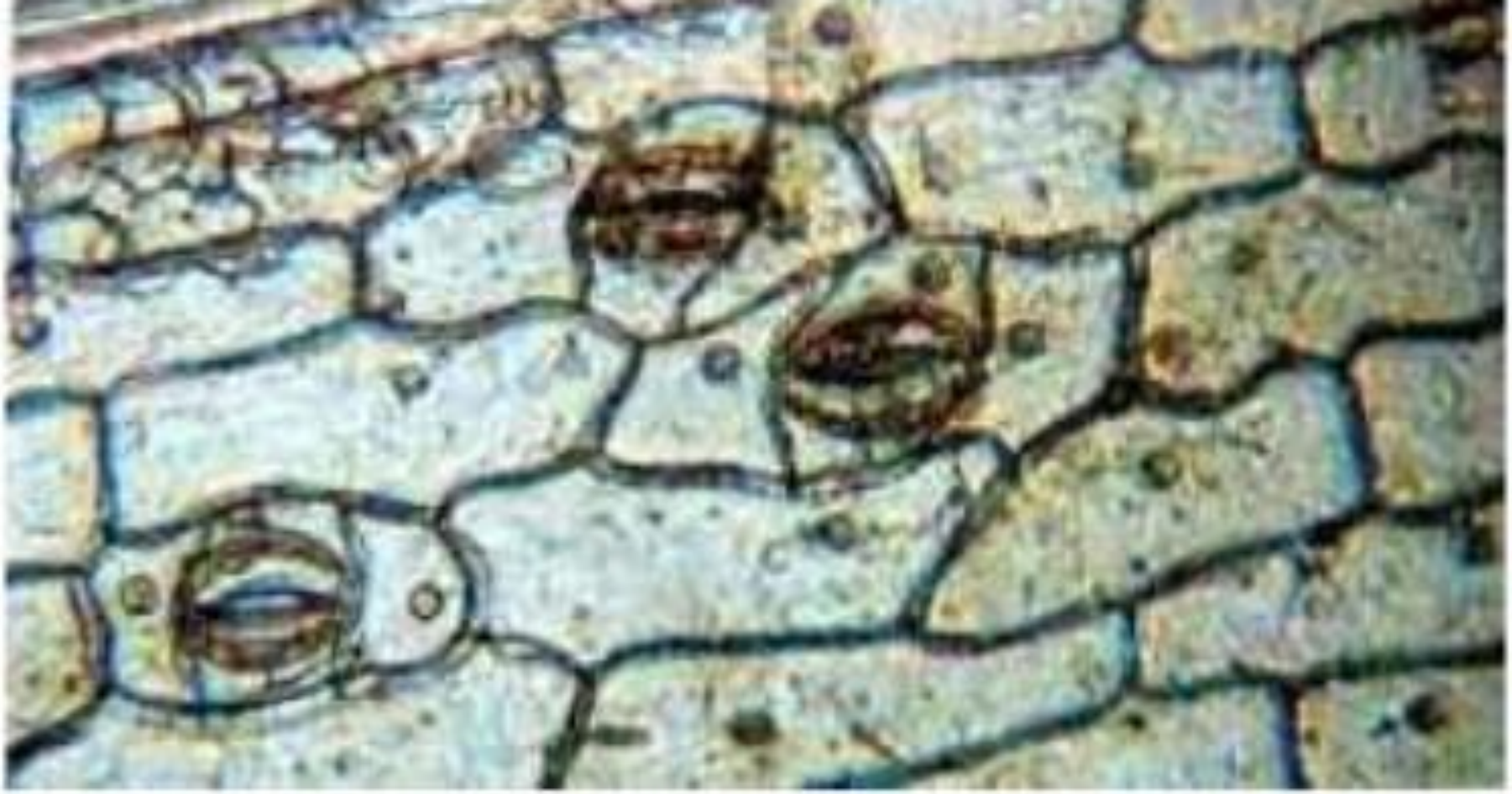
1831 – Robert Brown

- Saw central structure in plant cells, called this structure a nucleus



epidermis of orchid

spot seen also during the early stage of pollen formation



Nucleus - Opaque spot in cells termed **areola**.

The term cell nucleus was used by Robert Brown for the first time in 1831.

Brown sensed that this spot was a key component of cells and called them **"nucleus"** - a term which is still being used today.

Contemporary of Brown 1804-1881

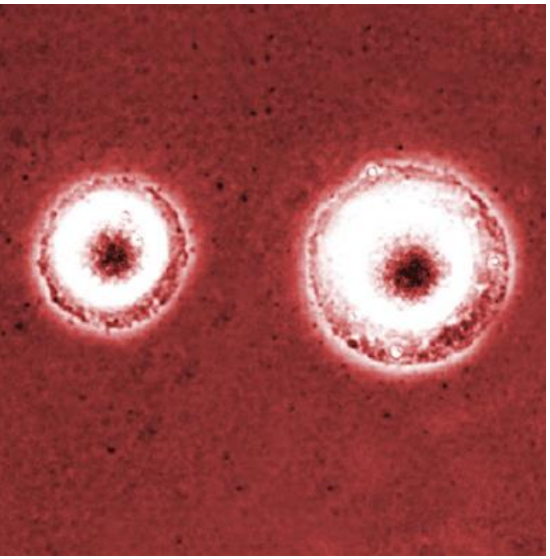
Matthias Jakob Schleiden (botanist) - German botanist and co-founder of the **cell theory**, along with Theodor Schwann (zoologist/med.) and Rudolf Virchow.

He declared that the cell is the *basic building block* of all plant matter.

Cell wall→ nuclei

Botanists of his day who limited themselves to merely naming and describing plants.

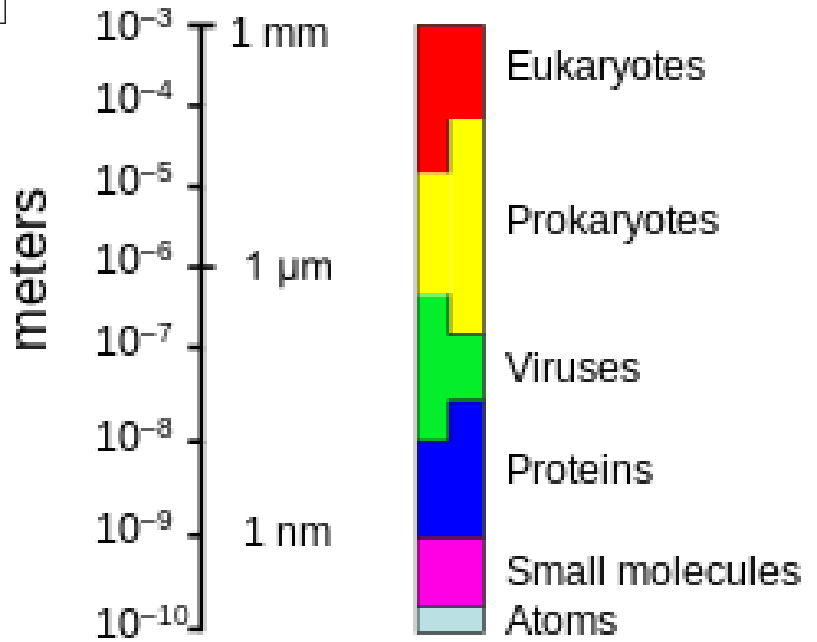
The Small and Big



Mycoplasmas (about 0.25um)

Name of Cell	Size (Length)
Bacteria Mycoplasma (Smallest cell)	0.0001 mm
Red blood Cell	0.009 mm
Liver Cell	0.02
Human egg	0.1 mm
Humming bird egg	13 mm
Hen egg	60 mm
Ostrich egg (Biggest cell)	170mm

Green algae



Resolution for a human eye (naked eye) is between 100 and 200 um (about the diameter of a human hair) then the majority of bacteria cannot be seen with the naked eye.

Stentor Protists

Size: 2 mm in length
Habitat: Freshwater
Year Discovered: 1831

Gromia Sphaerica (ameba)

Size: 3 cm in width

Habitat: Ocean floor

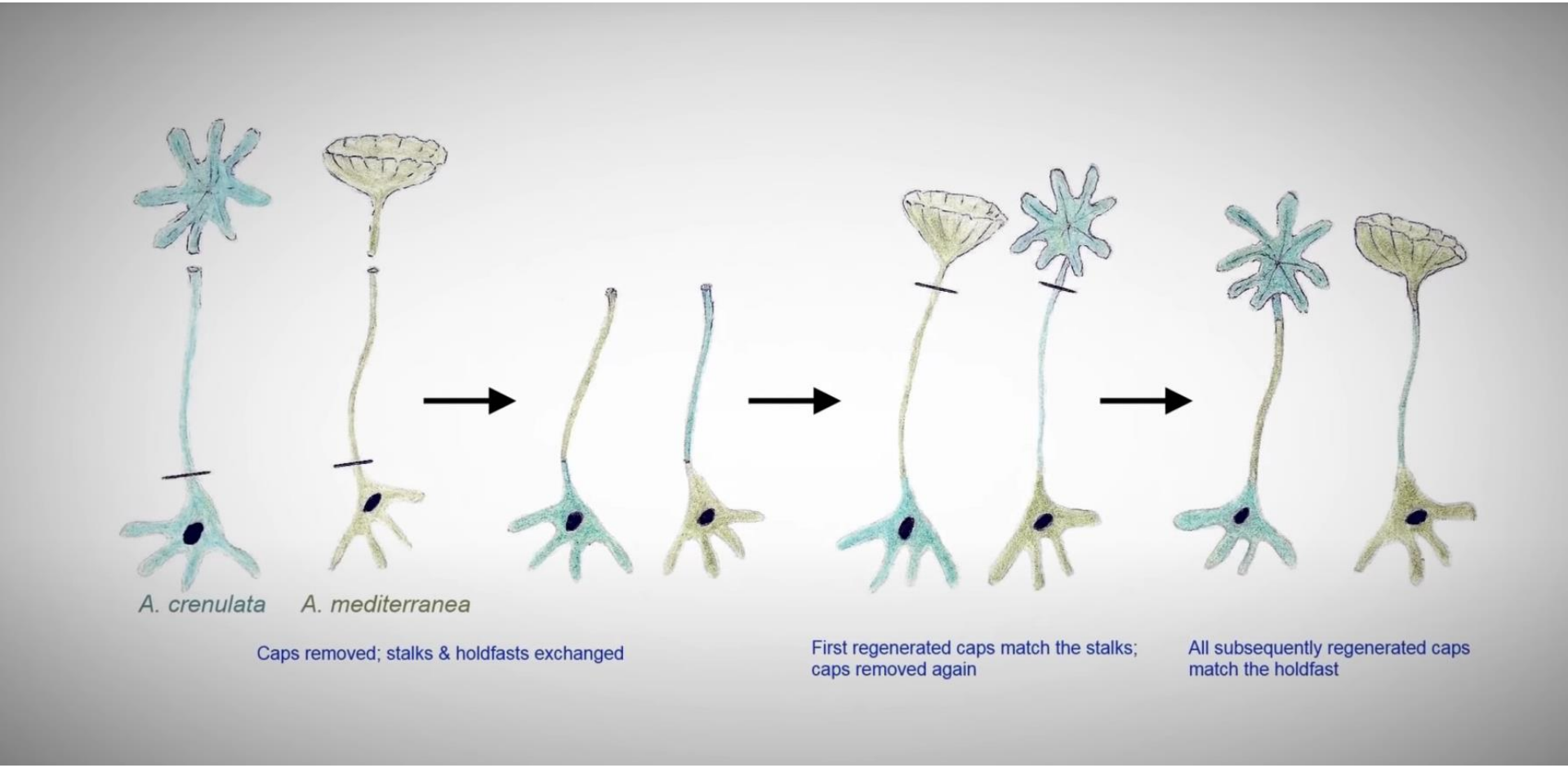
Year Discovered: 2008

Discovery Location: Arabian Sea

Size: 10 cm in height
Habitat: Shallow, subtropical waters
Year Discovered: 1930's

Acetabularia is a genus of green algae

Nucleus as keep for organismal features/information.



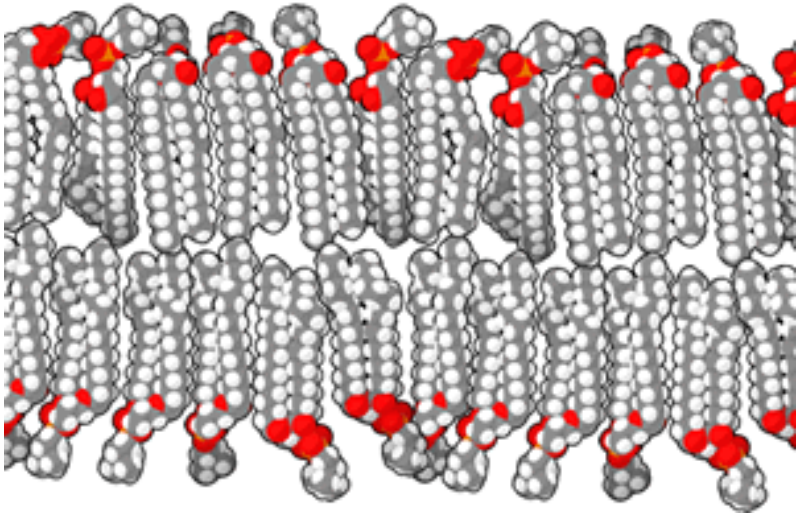
Acetabularia

Caulerpa Taxifolia (Aquarium Strain)

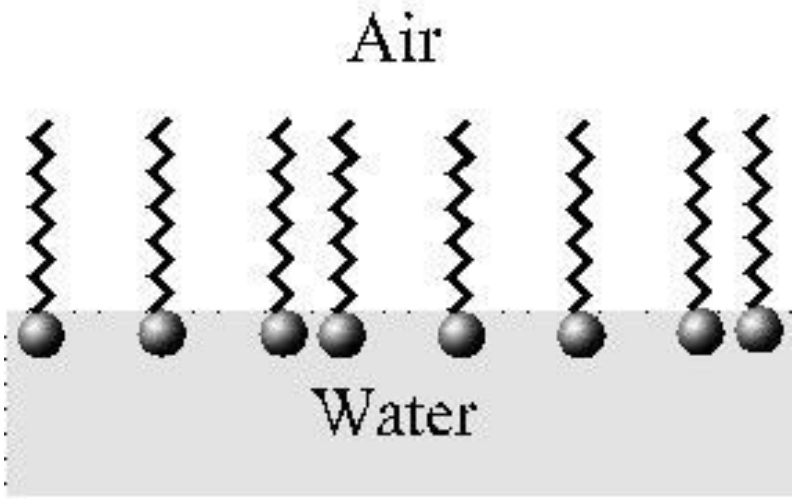
Size: 3 meters in length
Habitat: The Mediterranean Sea
Year Successfully Bred: 1980

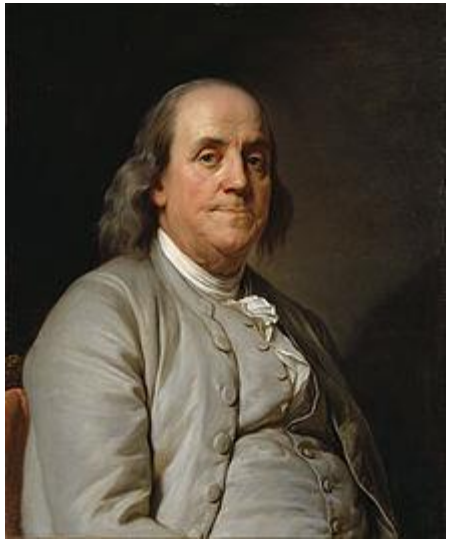
All large single cell organisms are in water environment

What a Cell needs?

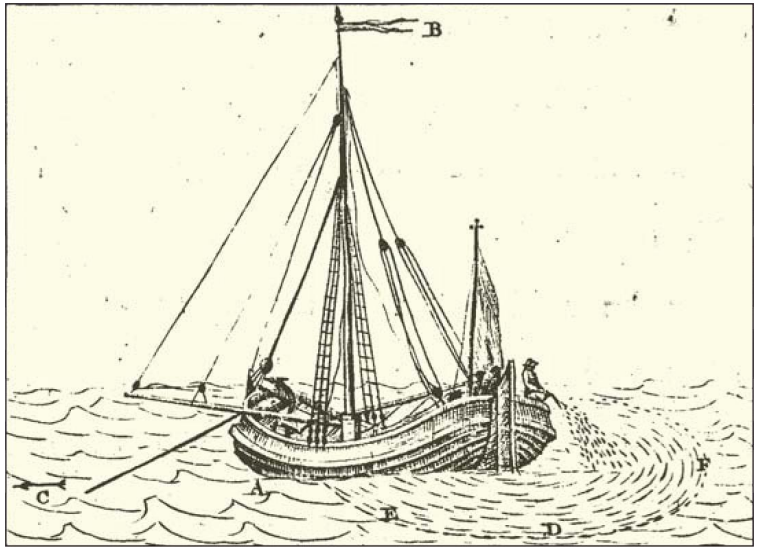


https://en.wikipedia.org/wiki/Lipid_bilayer

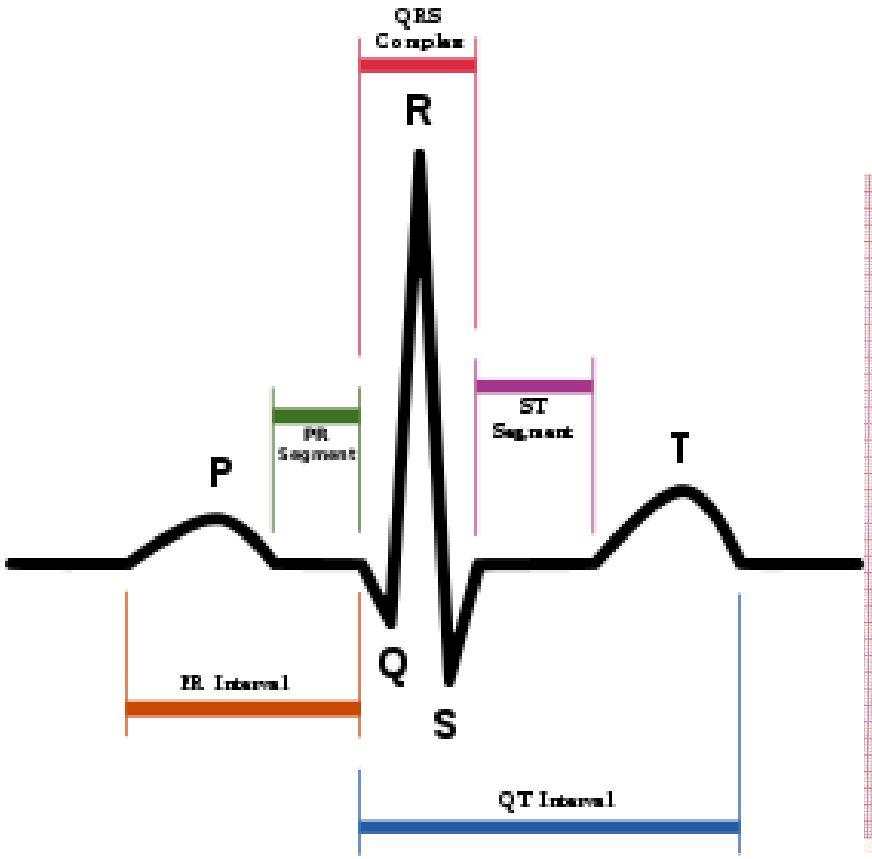


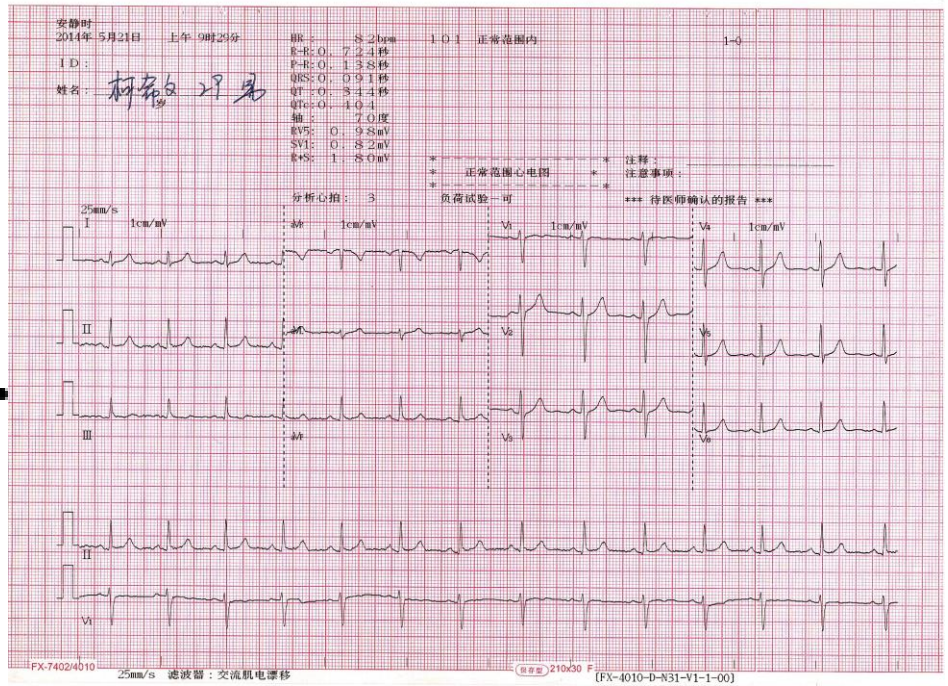


Benjamin Franklin



Electrocardiography

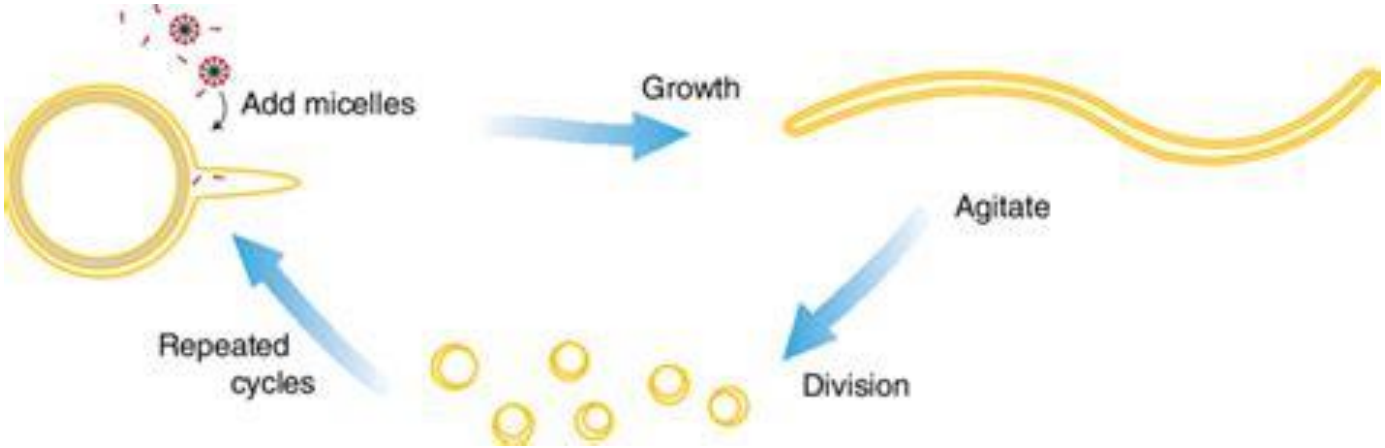


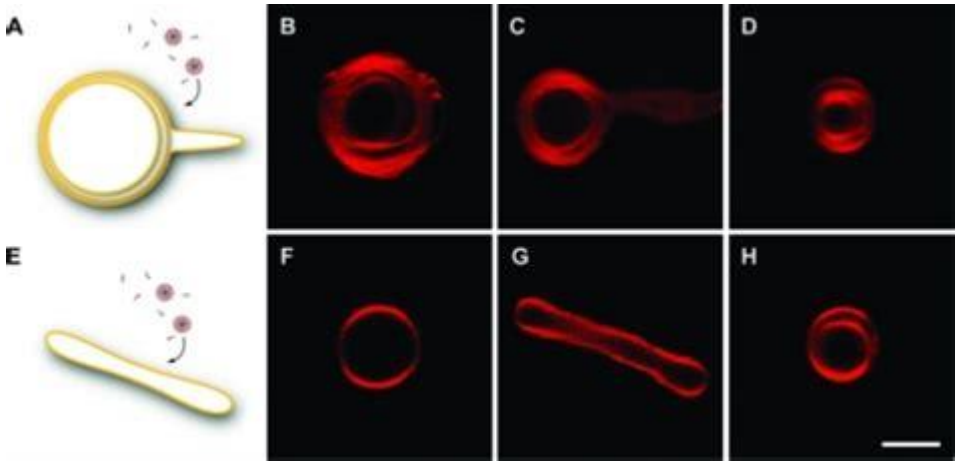


The (Plant) Cell – Vessel for *Life*

life
the ability to grow, ...

Growth of Membrane



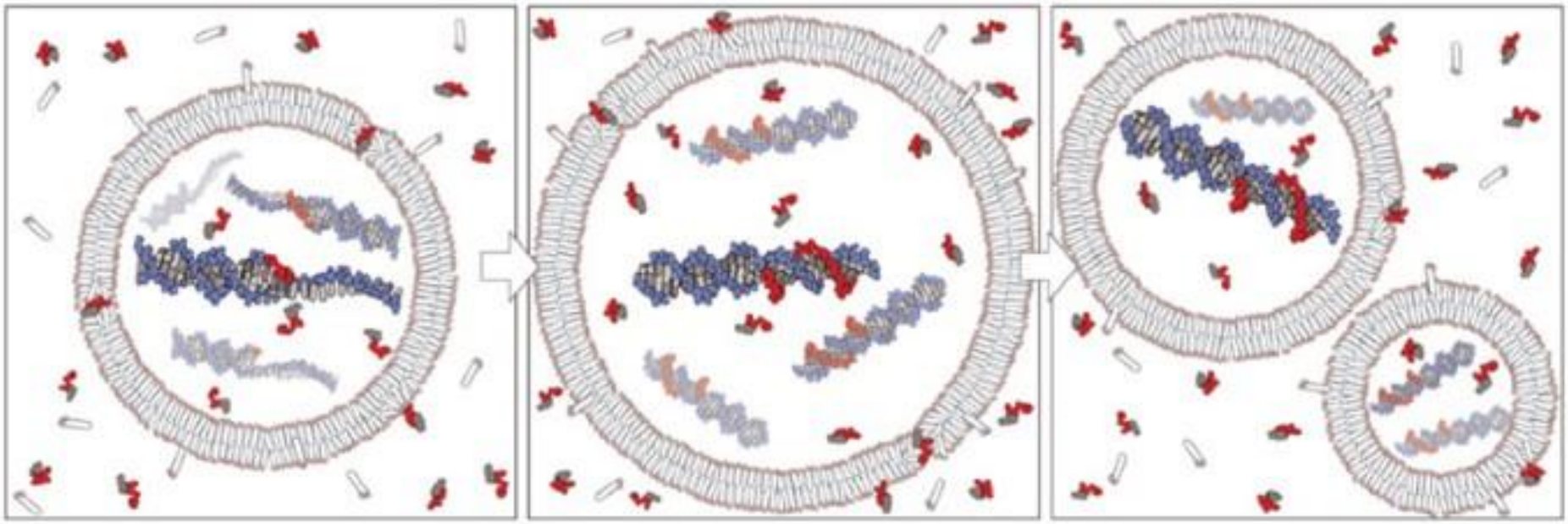


Jack Szostak

IF a proto-cell becomes more complex – what would be good to have…?

What is complexity?

Preservation of information.



Published: 04 June 2008

Template-directed synthesis of a genetic polymer in a model protocell

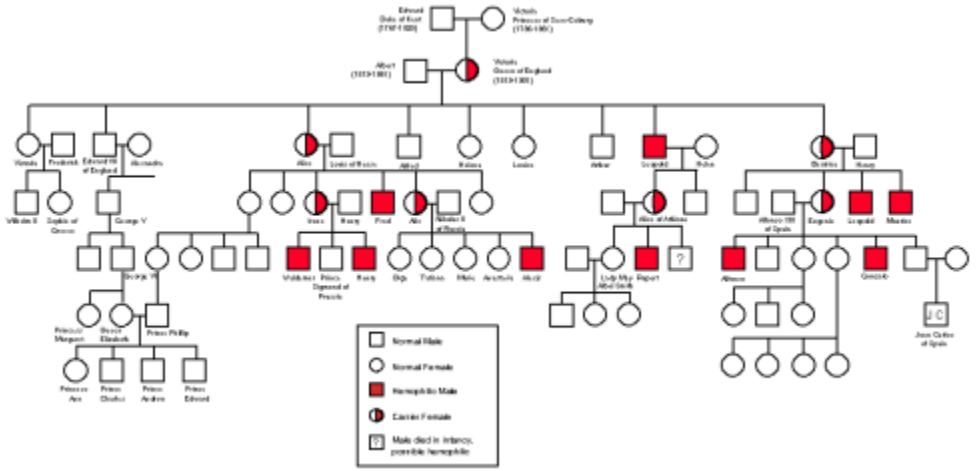
Sheref S. Mansy, Jason P. Schrum, Mathangi Krishnamurthy, Sylvia Tobé, Douglas A. Treco & Jack W. Szostak

Nature **454**, 122–125 (2008) | Cite this article

The (Plant) Cell – Vessel for ***Life***

life
the ability to grow, change, etc., that separates plants and animals from things like water or rocks

Mendel's observation of peas revealed the laws of inheritance



Flag

Coat of arms

Location in the Czech Republic

Coordinates: 49°41′N 16°46′E

Country	Czech Republic
Region	Moravian-Silesian Region
District	Nový Jičín District
Area	
• **Total**	5.87 sq mi (15.21 km^2)
Elevation	899 ft (274 m)
Population (2012)	
• **Total**	845
• **Density**	140/sq mi (56/km^2)
Time zone	CET (UTC+1)
• **Summer (DST)**	CEST (UTC+2)

Hynčice is a little Silesian village, administratively part of Vražné municipality, located.

Gregor Johann Mendel (Řehoř Jan Mendel; 20 July 1822 – 6 January 1884) was a German-speaking Moravian-Silesian scientist and Augustinian friar and abbot of St. Thomas' Abbey in Brno who gained posthumous fame as the founder of the modern science of **genetics**.


Parkoviště
Mendlovo náměstí
Úvoz
Pekařská
Pekařská
Mendel Museum of
Masaryk University
Science museum...
Gymnázium JG Mendel
rská Starobrno
Mendlovo náměstí
Pekařská
Mendlovo náměstí
Mendlovo náměstí
Mendlovo náměstí
áměstí

KIEPENKERL®

PG F

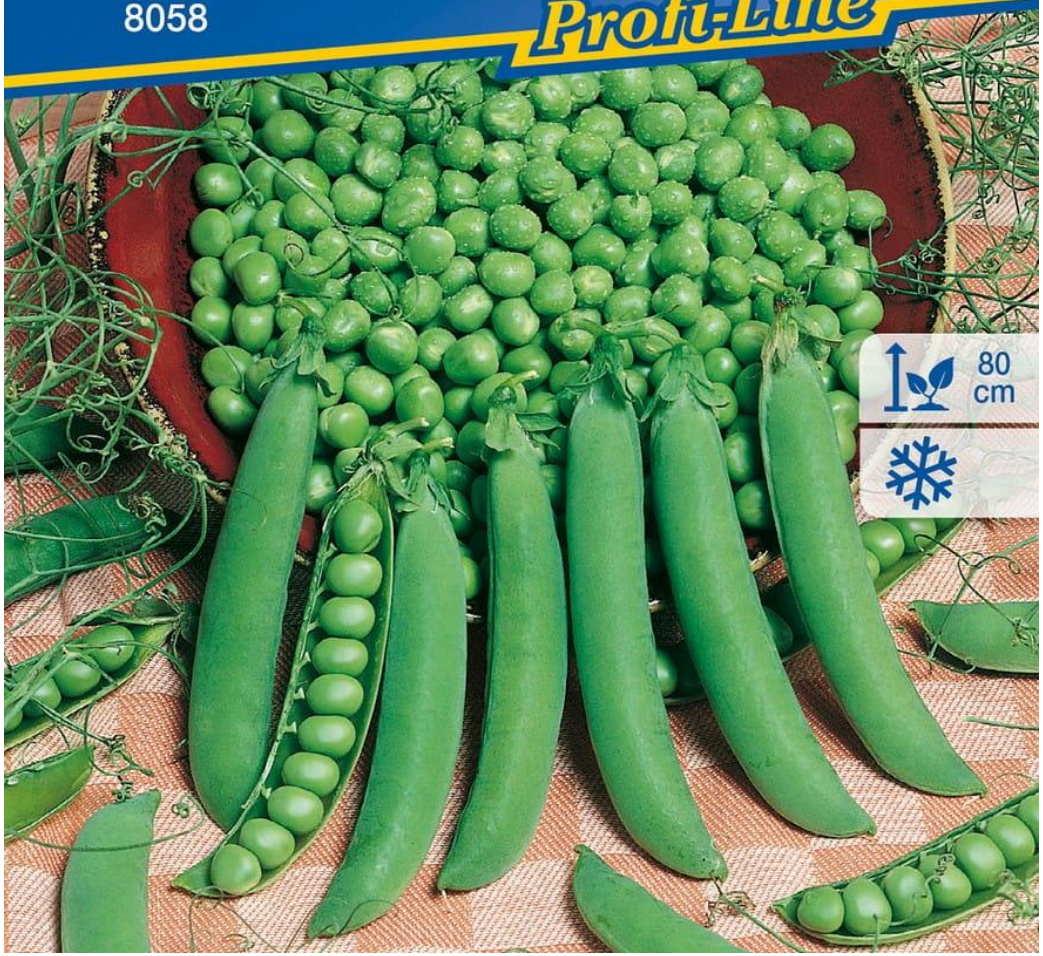
Grandera

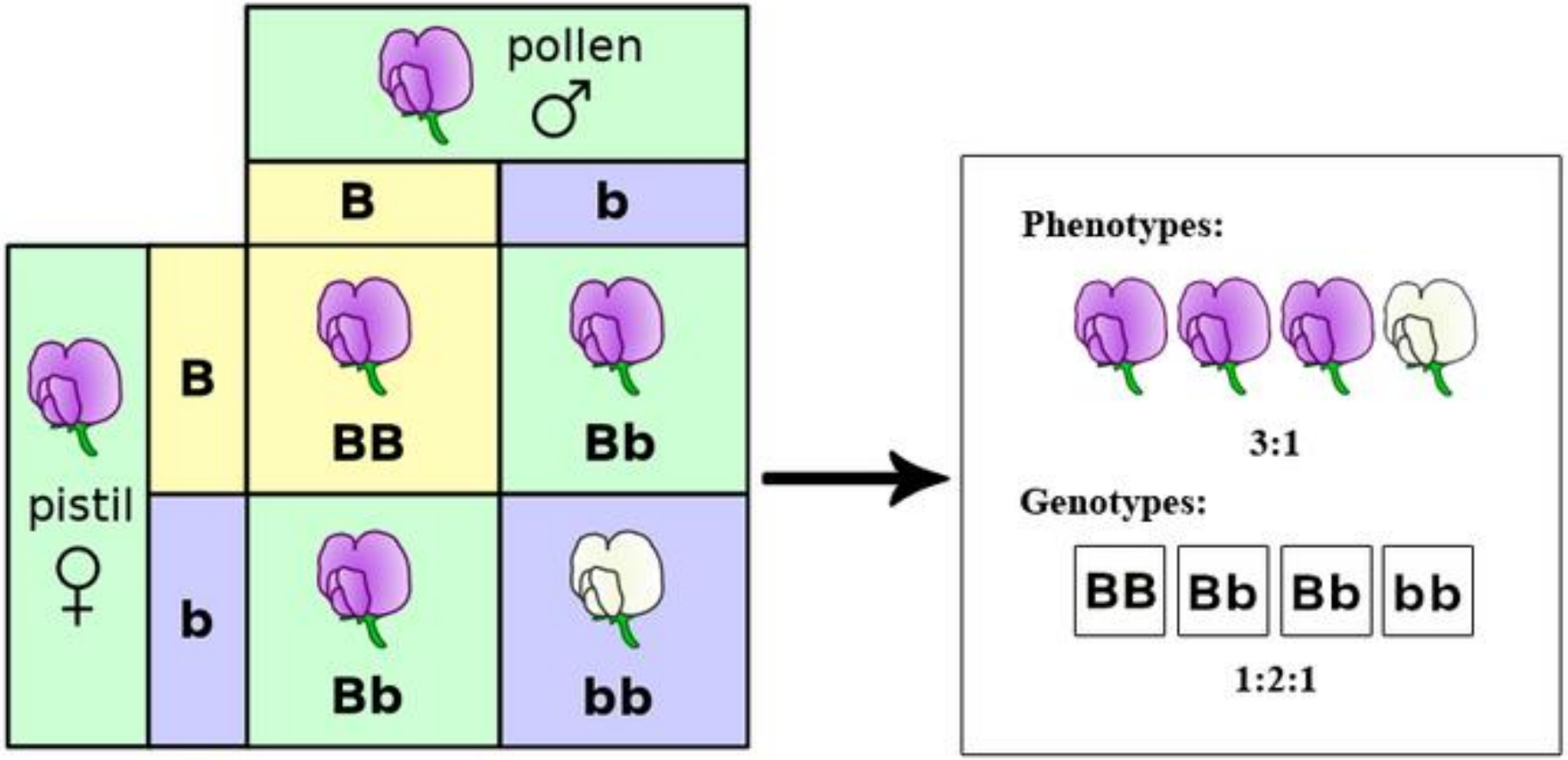
Pisum sativum

CZ Hrách setý
SK Hrach siaty
HU Velőborsó
PL Groch zwyczajny
HR Vrtni grašak
SI Oglatozrnati grah

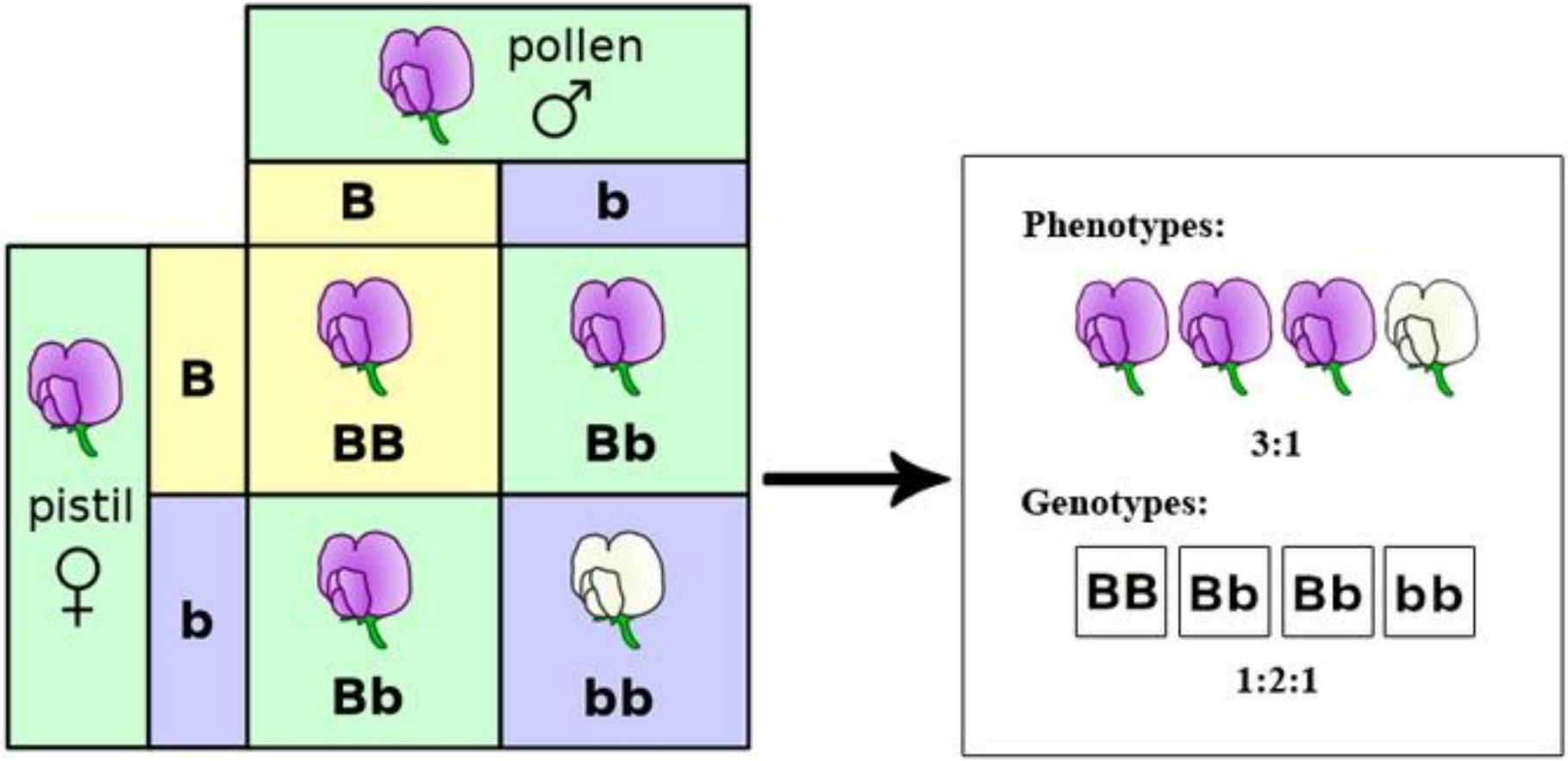
8058

Profi-Line





What was the key approach of Mendel?



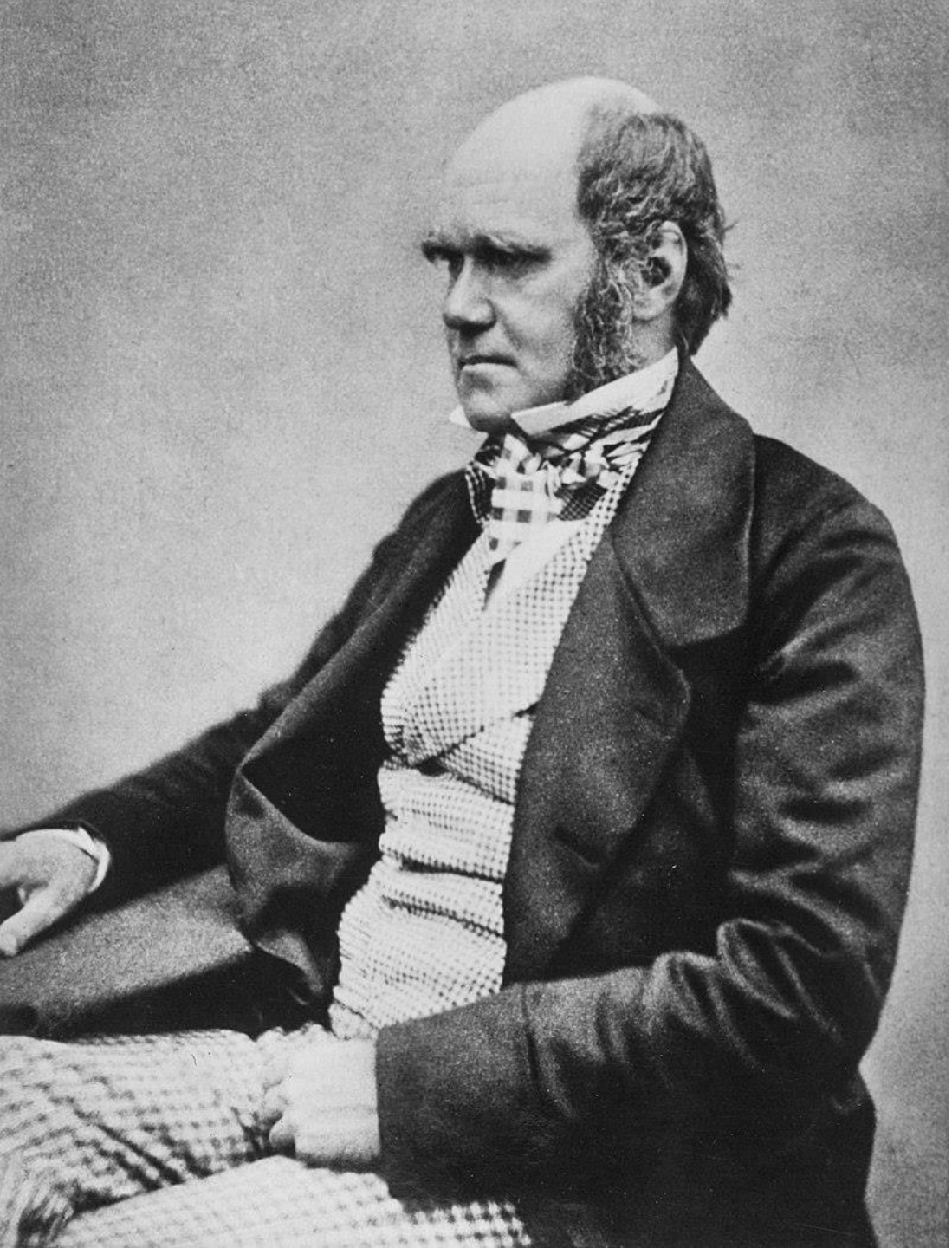
Establishment of homozygous lines

He became a friar because it enabled him to obtain an education **without having to pay for it himself**.

After he was elevated as abbot in 1868, his scientific work largely **ended**, as Mendel became consumed with his increased administrative responsibilities..

The (Plant) Cell – Vessel for ***Life***

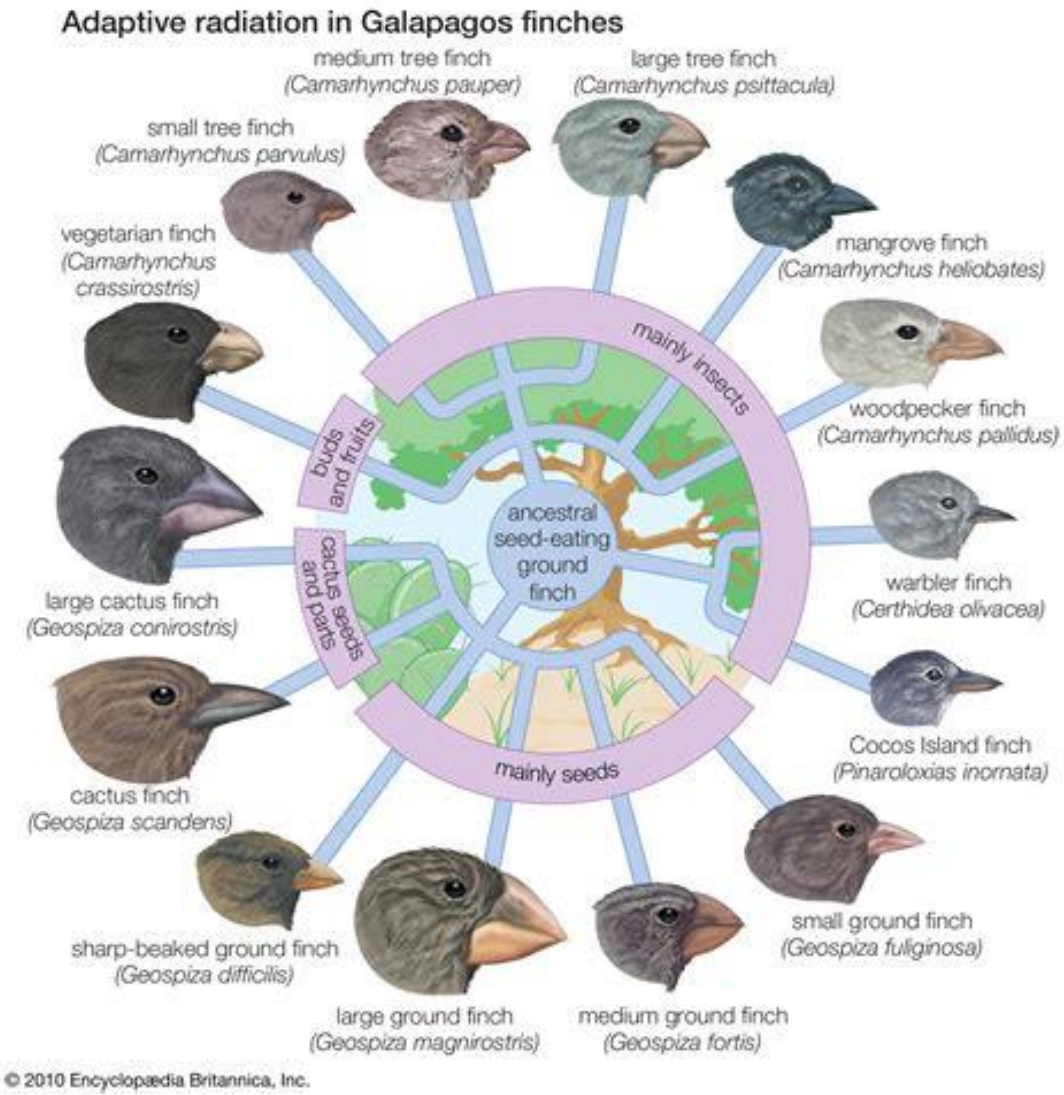
life
the ability to grow, change …~ Evolve



Darwin, c. 1854, when he was preparing On the Origin of Species for publication.

1809 - 1882

Darwin's finches



life

the ability to grow, change ...~ Evolve/adapt to environment

LIST DEFINITION OF LIFE

Living things display the following traits

Growth

Reproduction

Made of cells (one or more)

Responds to stimuli

Ordered and complex

Has metabolism

Maintains homeostasis

Evolves across generations

Life:

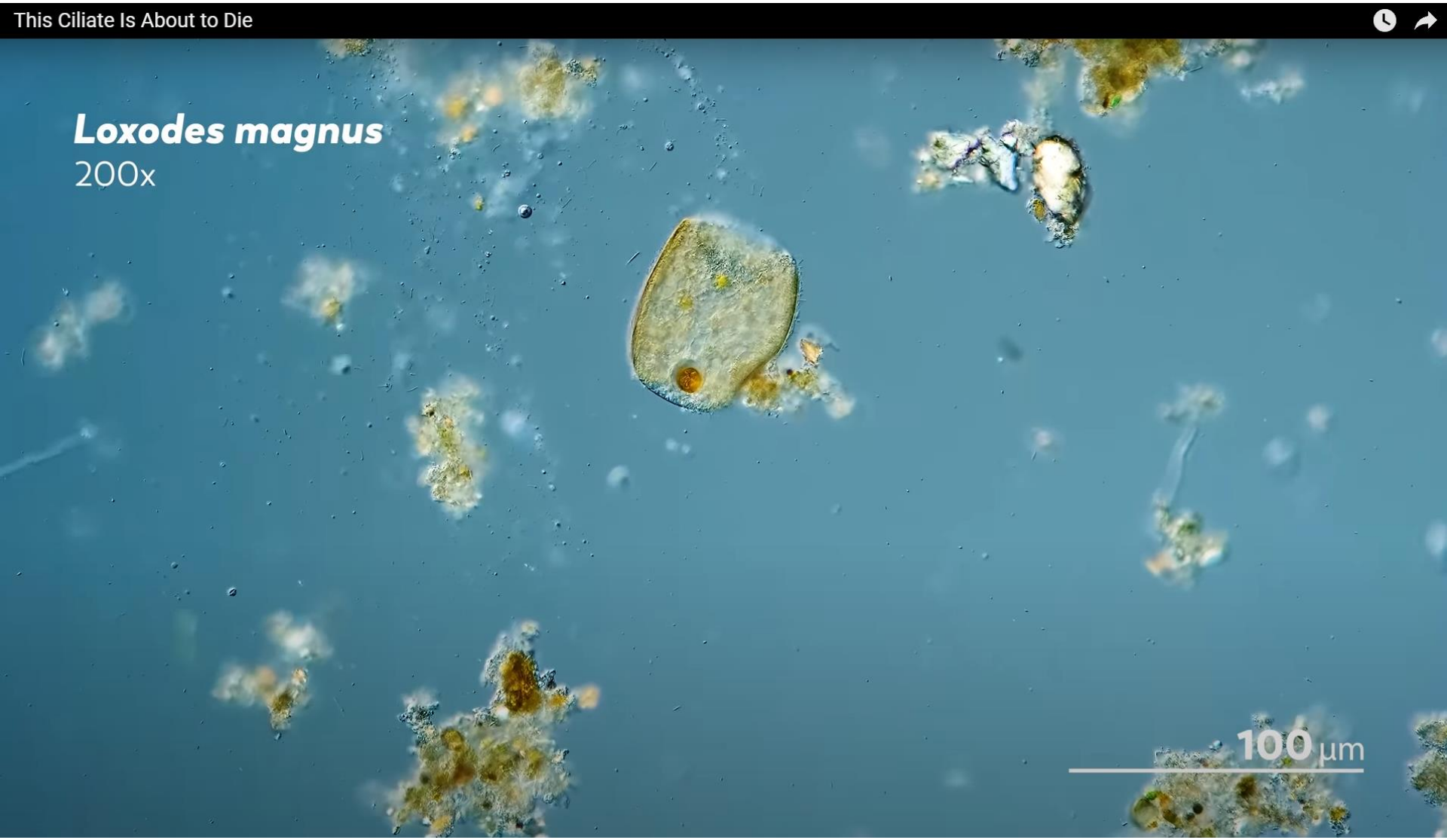
Self-sustaining

chemical system

capable of Darwinian

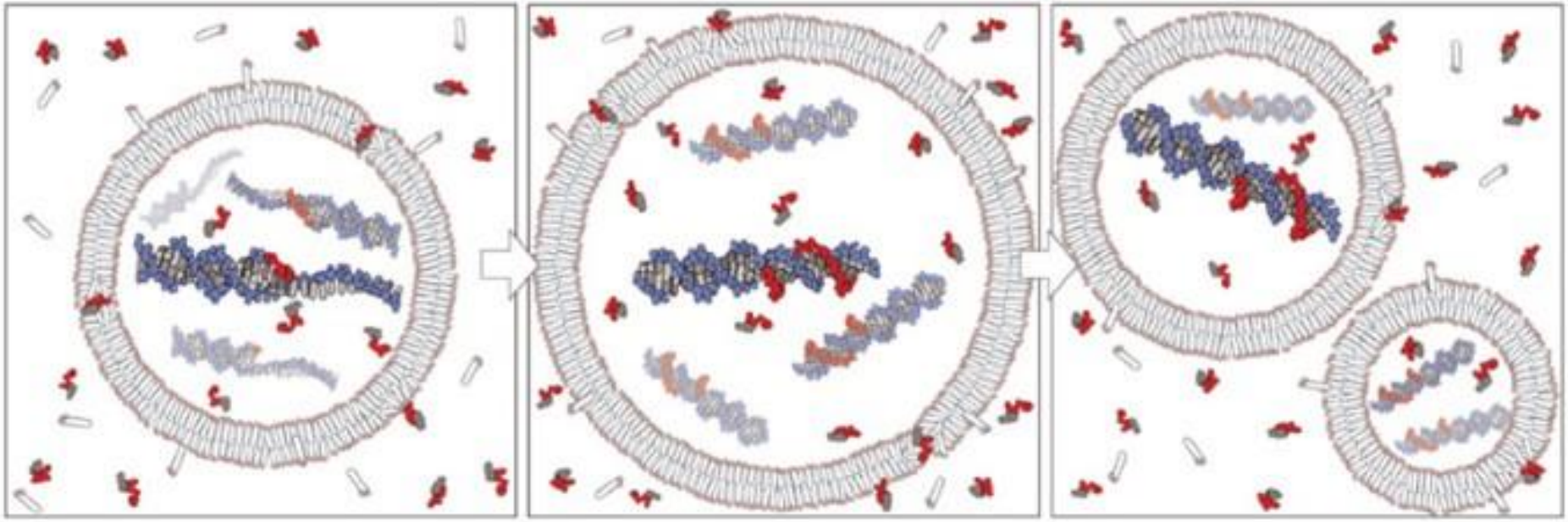
evolution

Life and Death



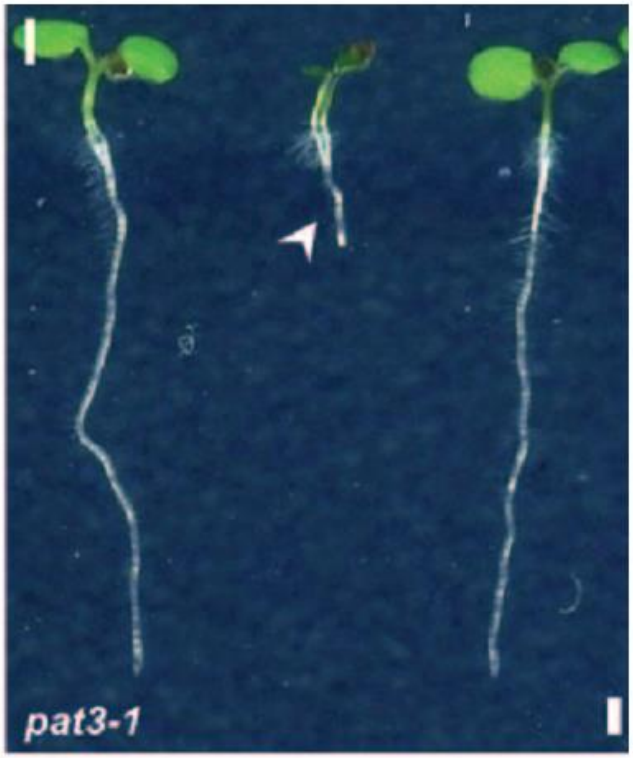
Journey to the Microcosmos - This Ciliate Is About to Die

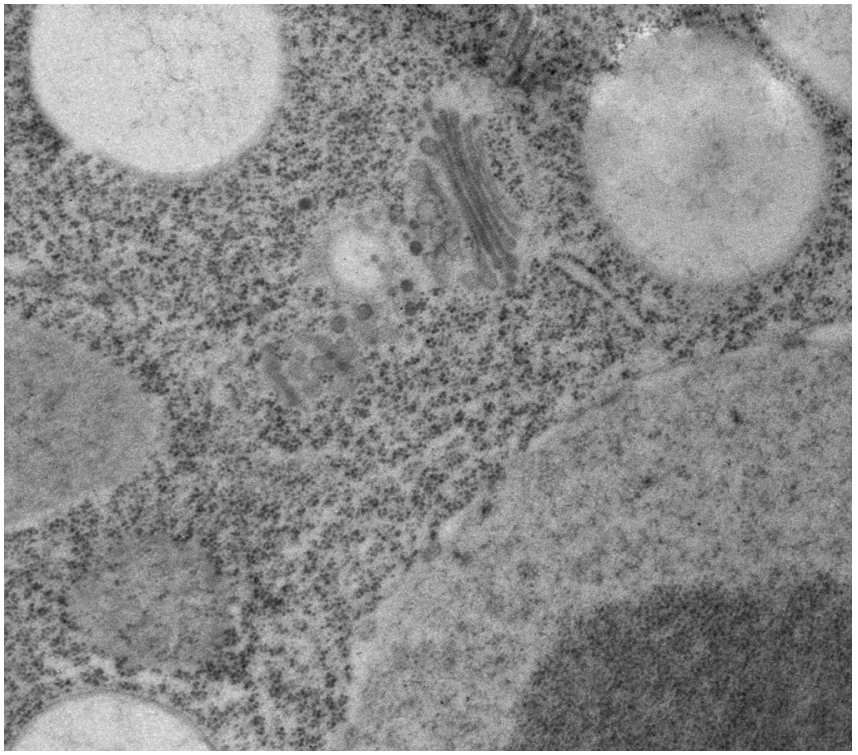
Preservation of information.



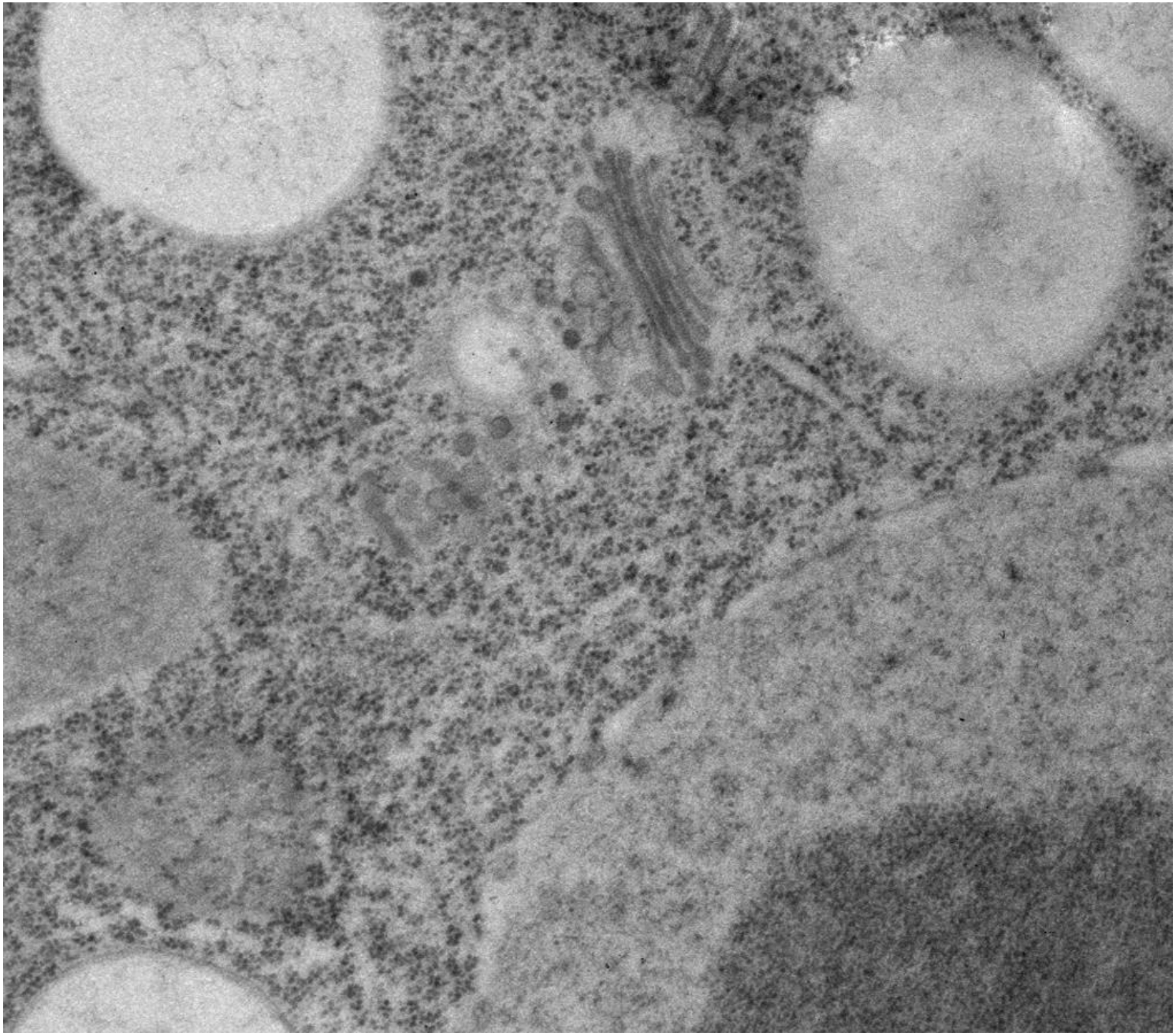
Inside-cell Sub-structures to help

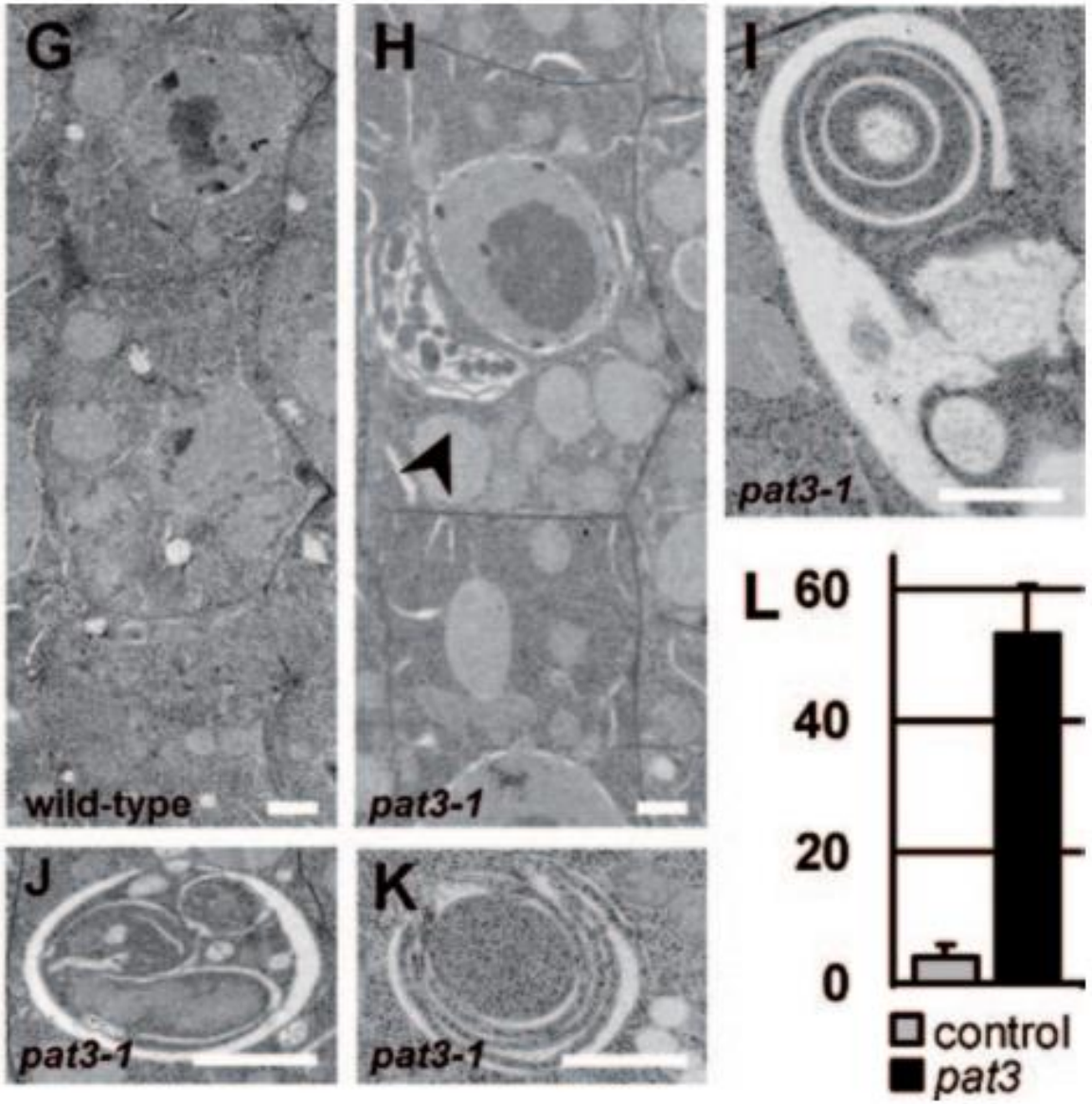
Cell biology (subcellular structures)



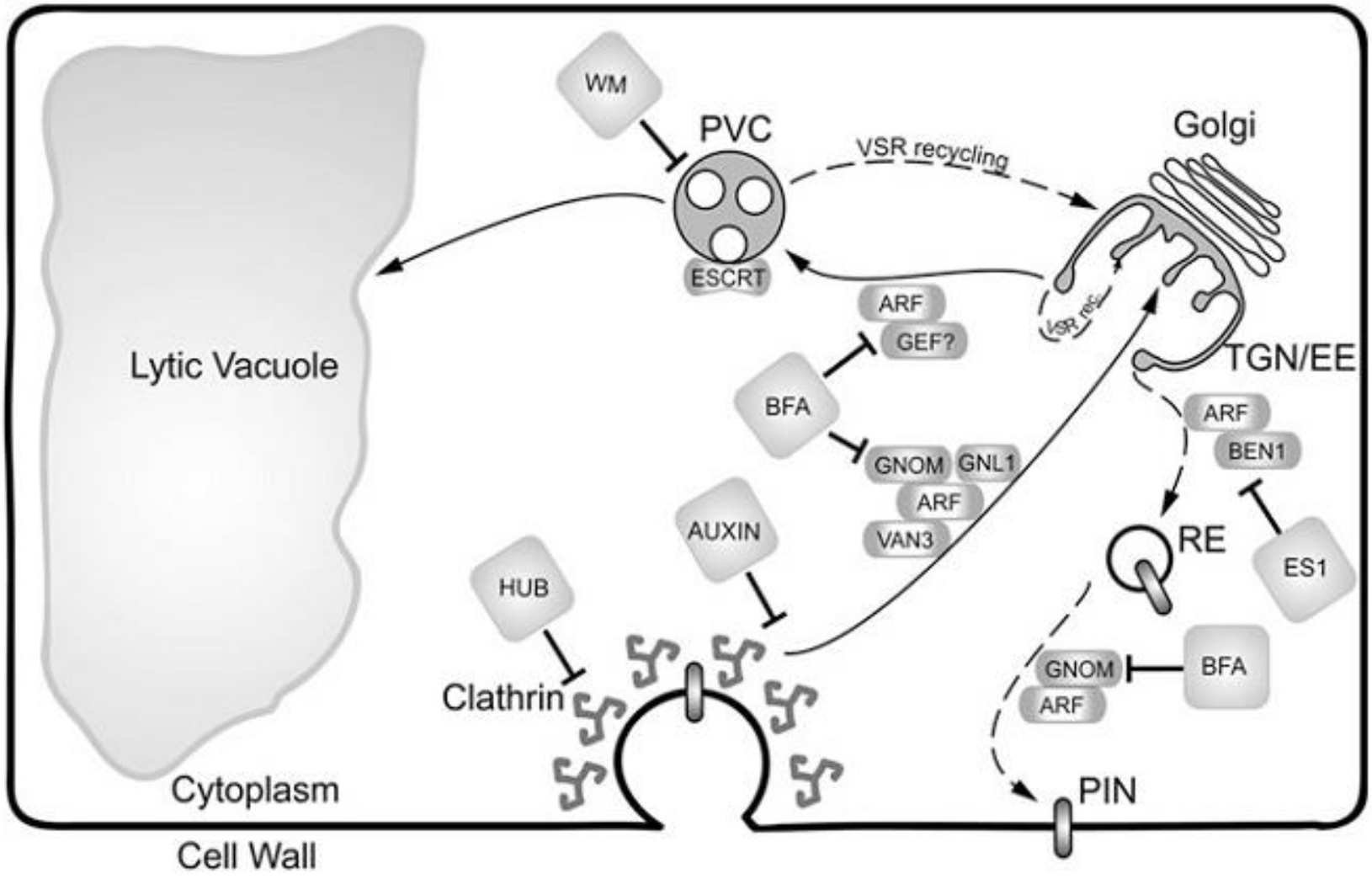


Nodzyński *et al* 2013



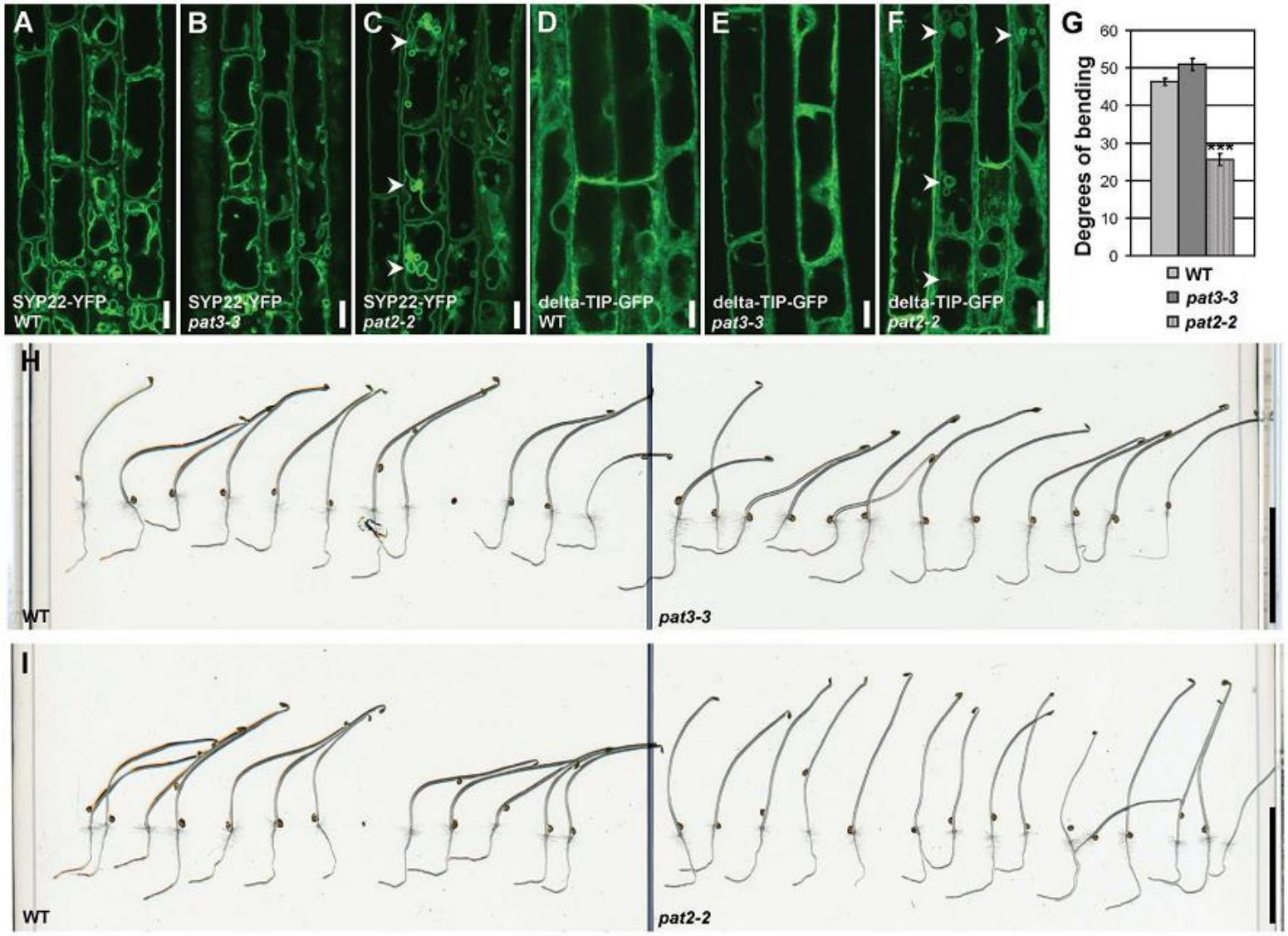

G
wild-type
H
pat3-1
I
pat3-1
J
pat3-1
K
pat3-1
L
60
40
20
0
control
pat3

Intracellular **trafficking**



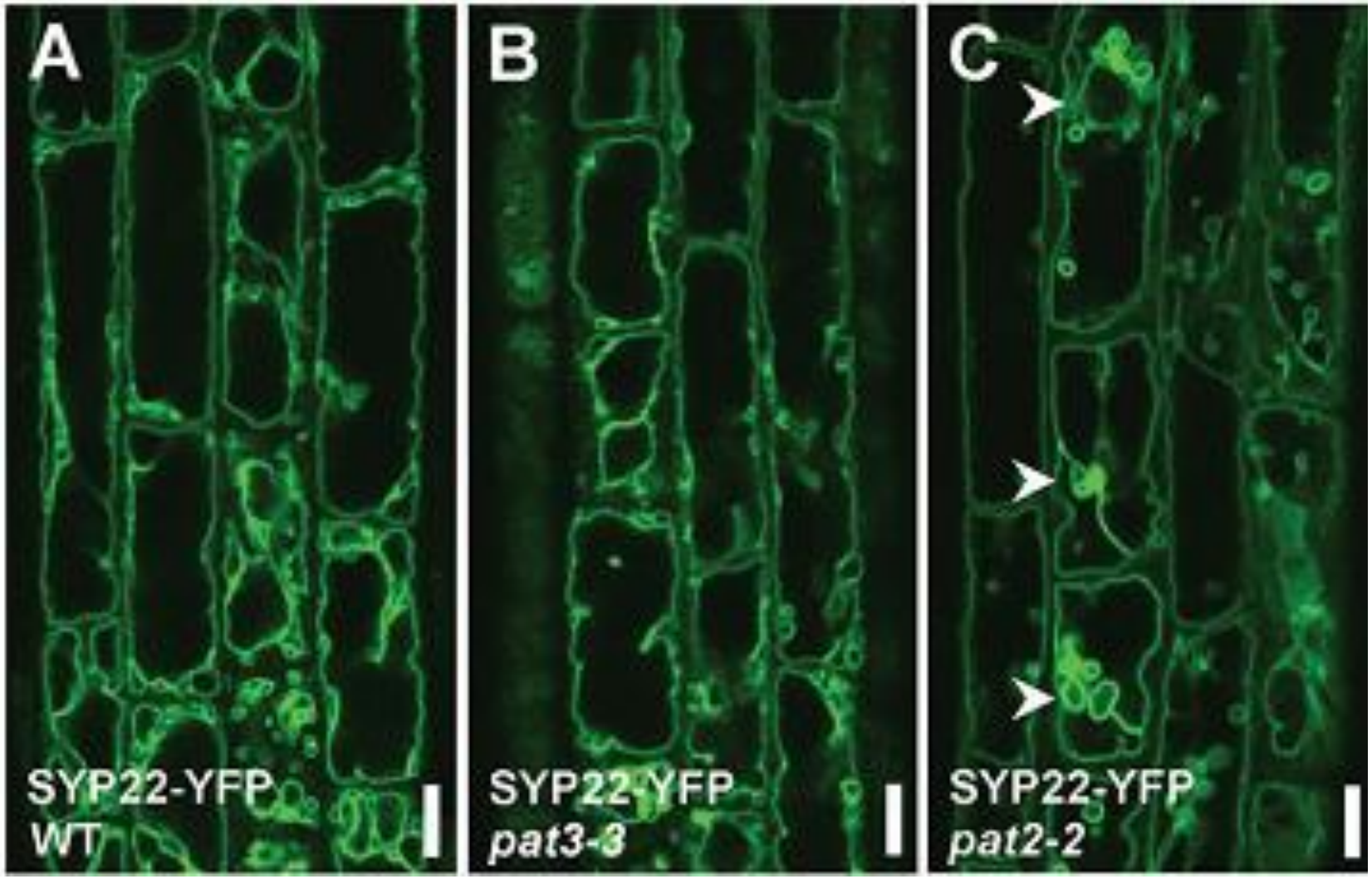
Nodzyński, T. et al. (2012). Endocytic Trafficking of PIN Proteins and Auxin Transport. In Endocytosis in Plants, J. Šamaj, ed (Springer Berlin Heidelberg), pp. 165–183.

Vacuolar mutants have problems with hypocotyl bending



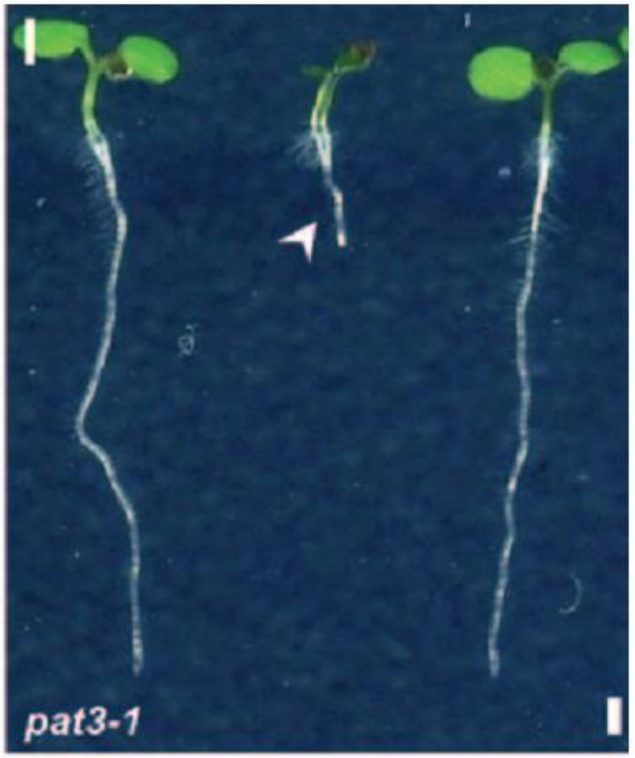
Vacuole role in plant turgor

Complex cell biology phenotypes remain a quantification challenge..

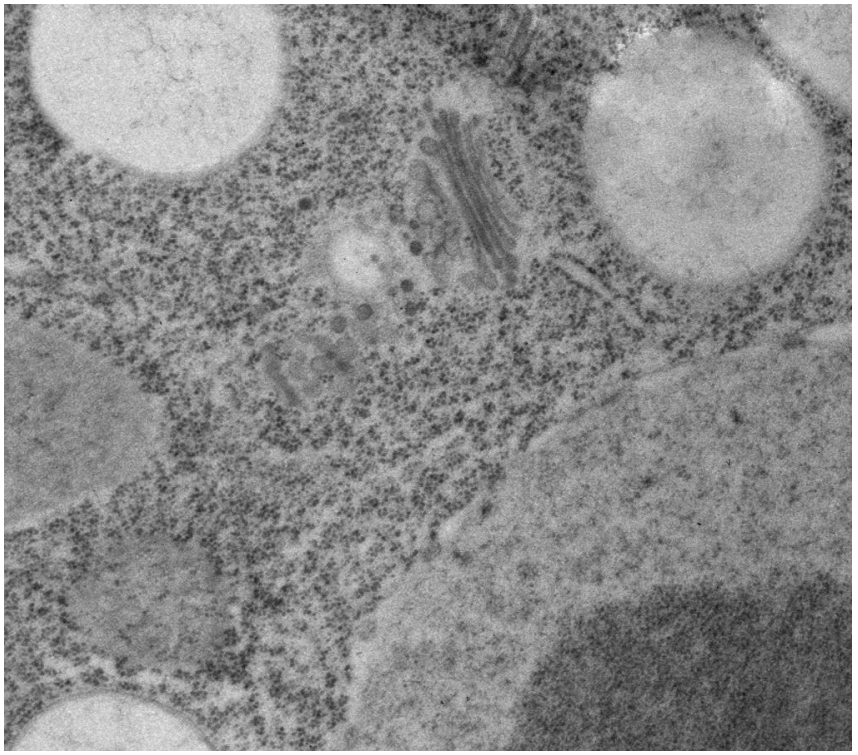


Can Informatics help..?

Storage Vacuole role in Germination

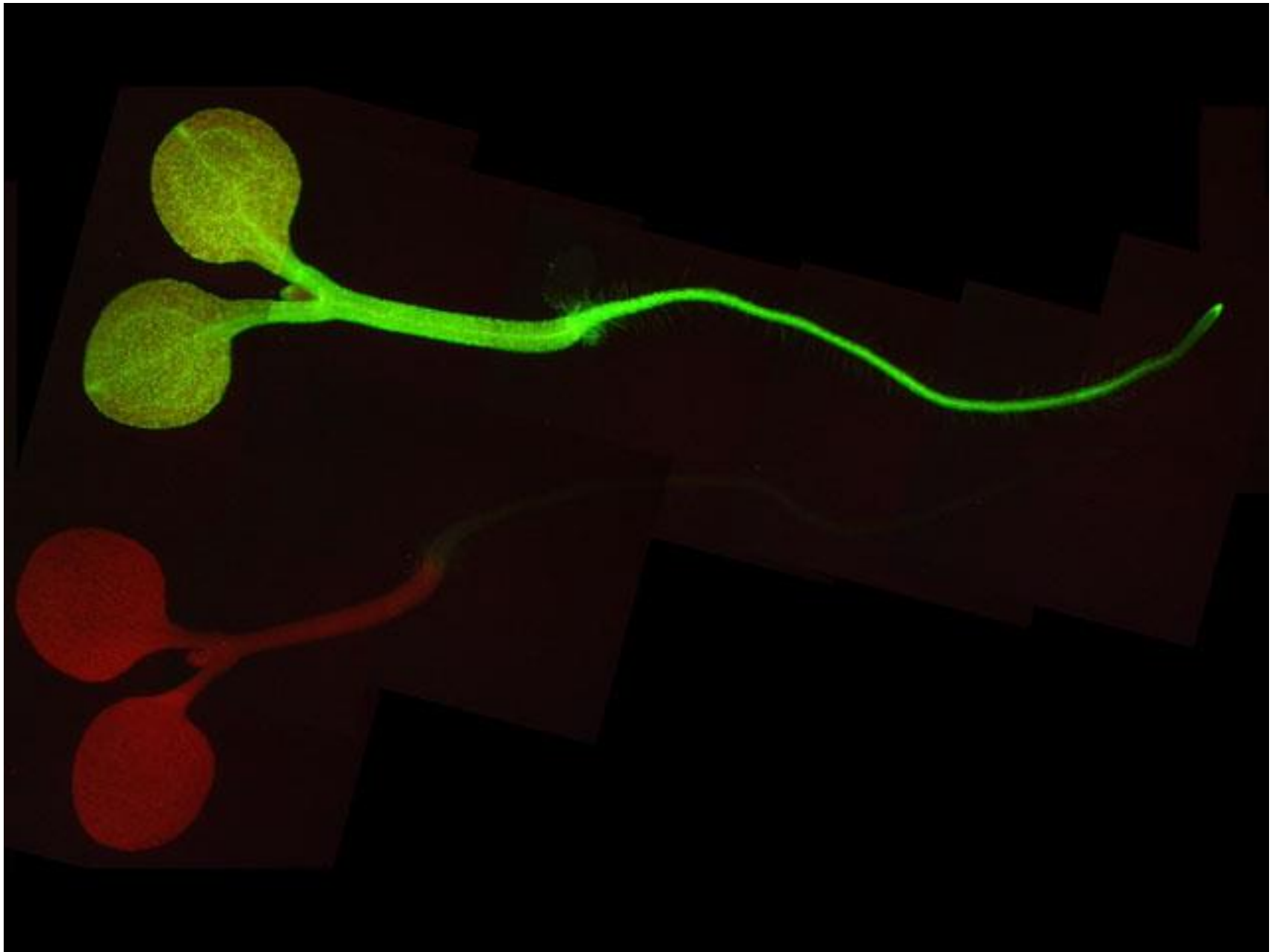


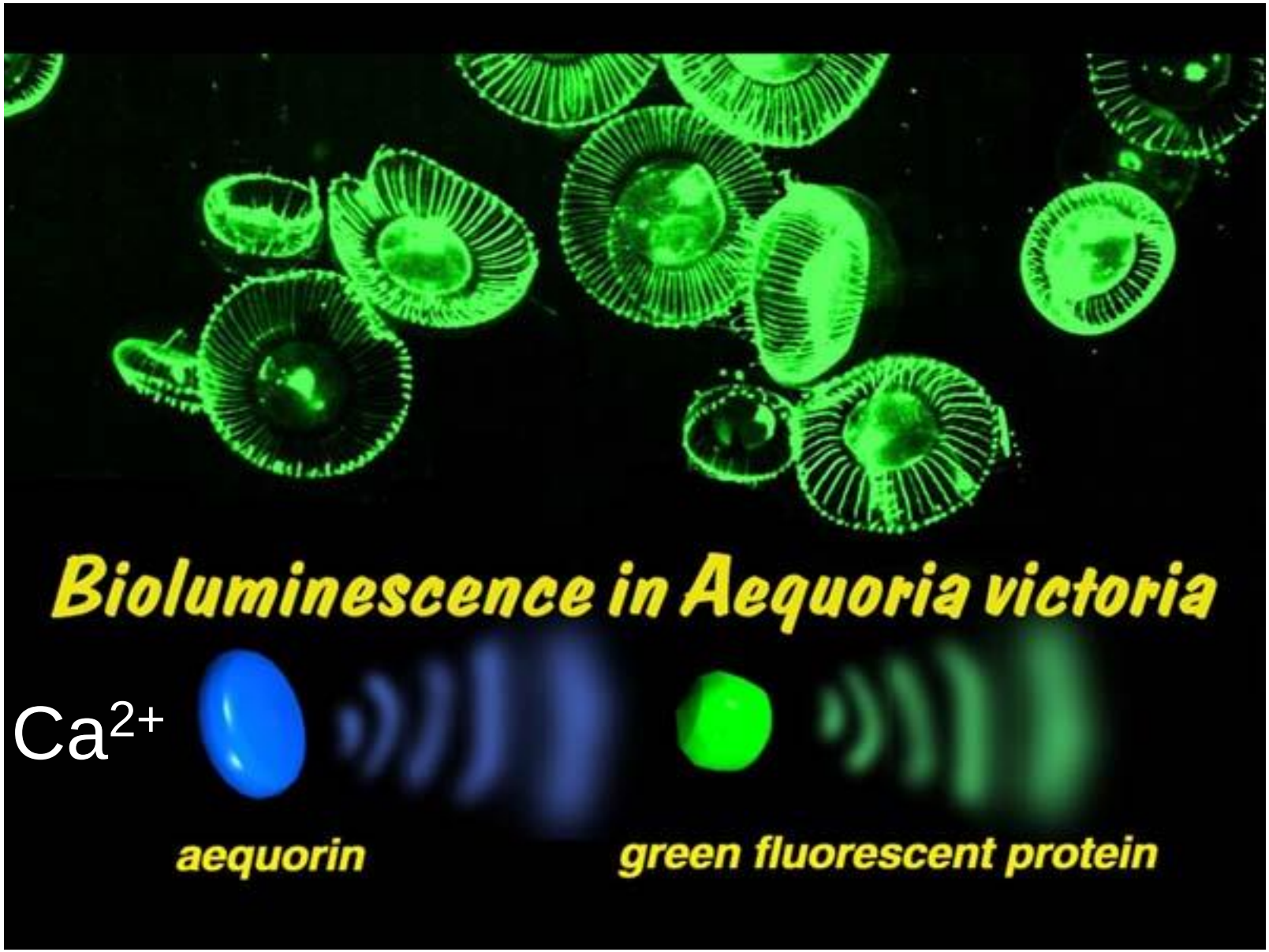
MS-/no sugar

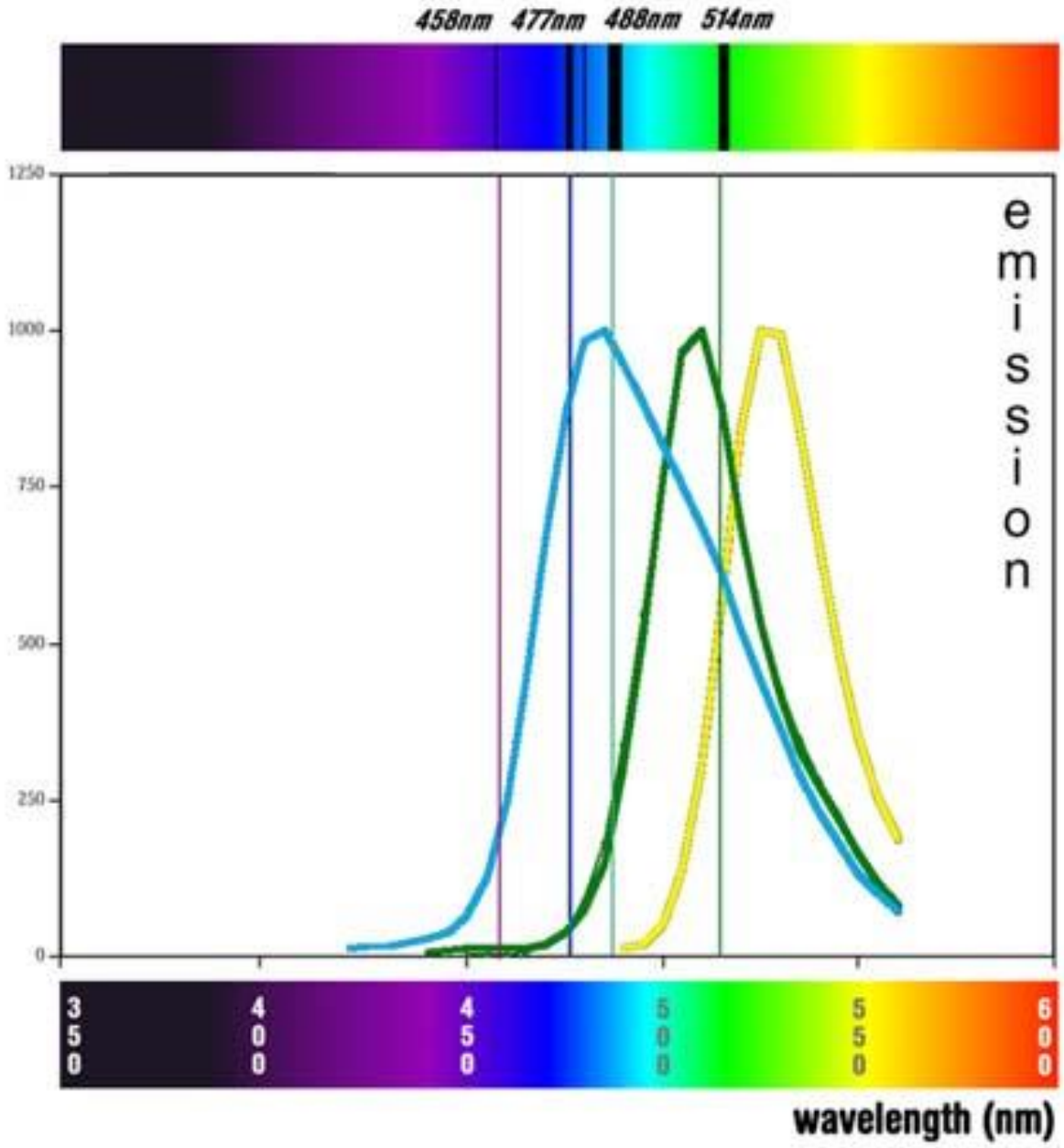


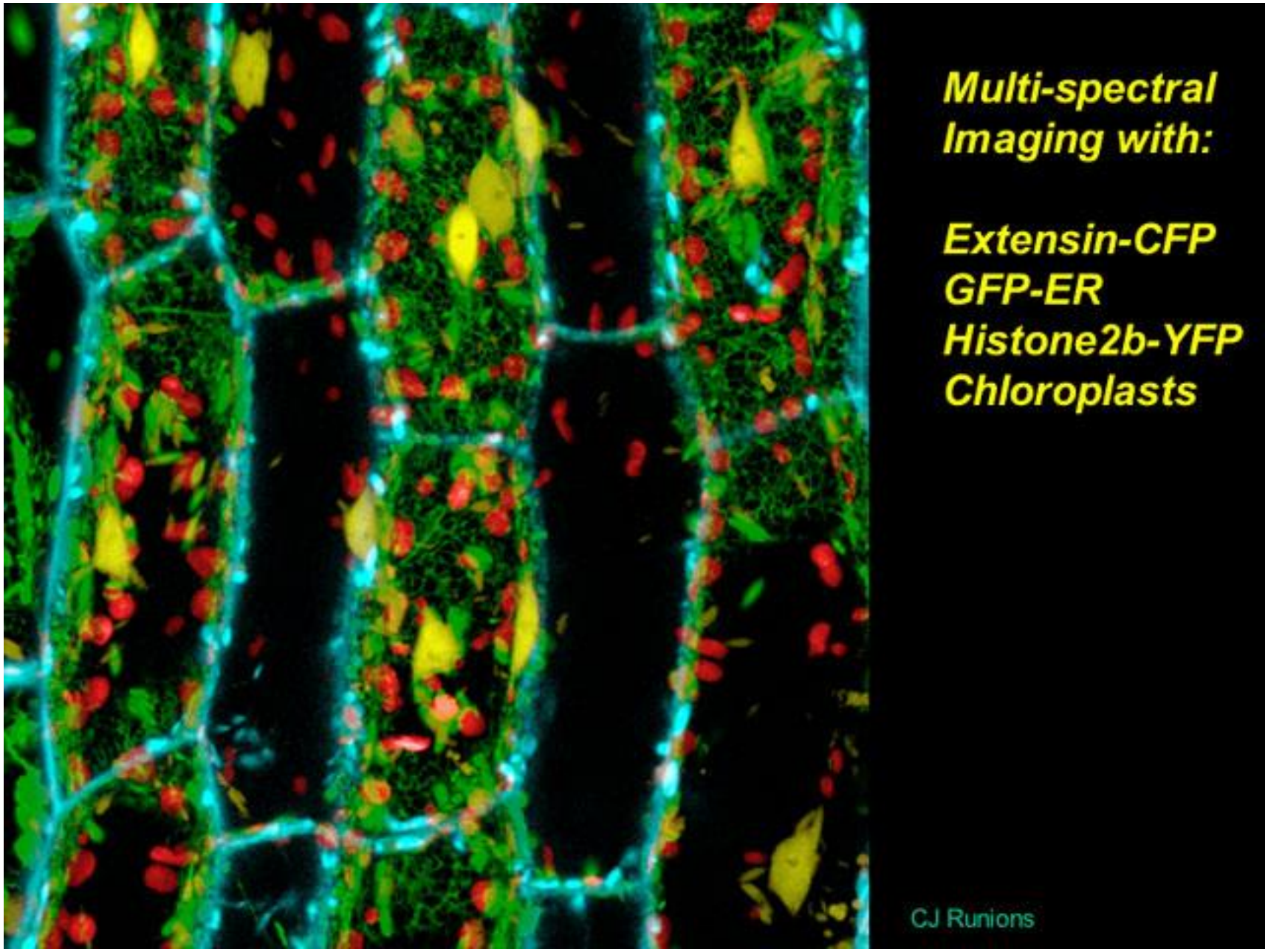
Nodzyński *et al* 2013

Green Fluorescence Protein



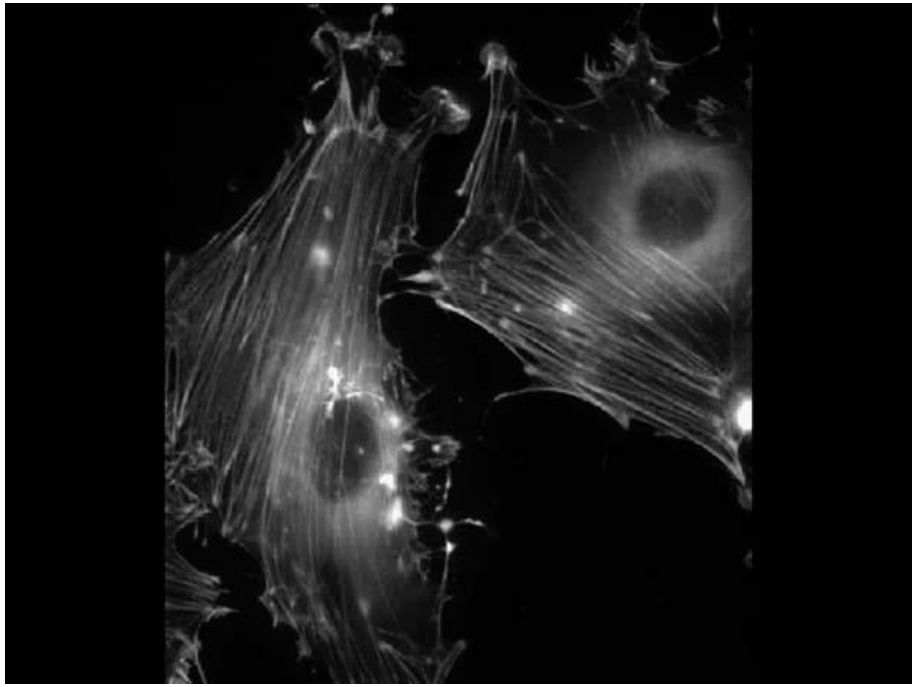

Bioluminescence in Aequoria victoria
Ca^{2+}
aequorin
green fluorescent protein


458nm
477nm
488nm
514nm
1250
1000
750
500
250
0
emission
350
400
450
500
550
600
wavelength (nm)

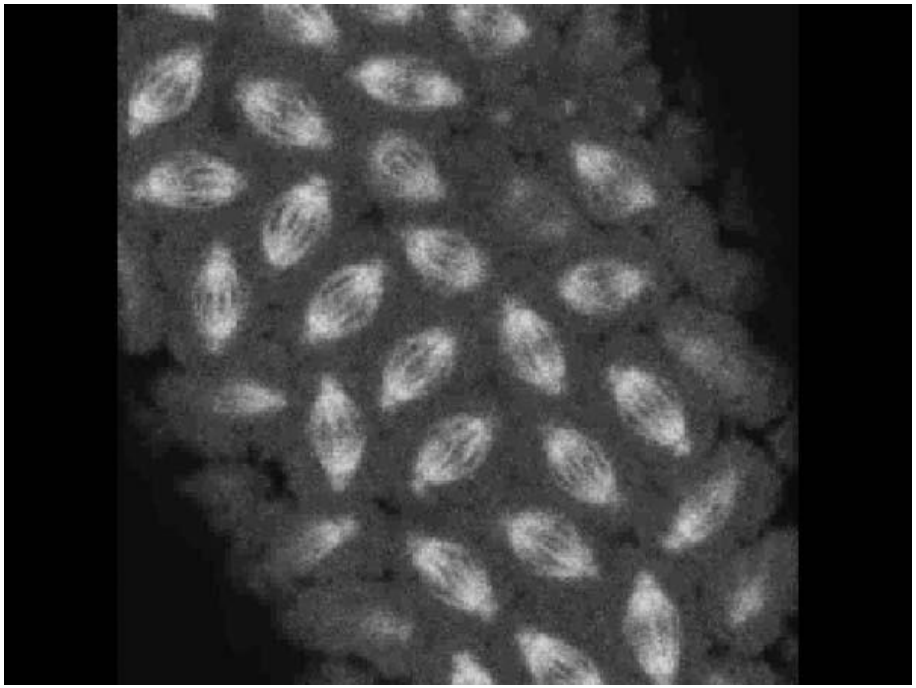

Multi-spectral
Imaging with:
Extensin-CFP
GFP-ER
Histone2b-YFP
Chloroplasts
CJ Runions

Subcellular structure markers

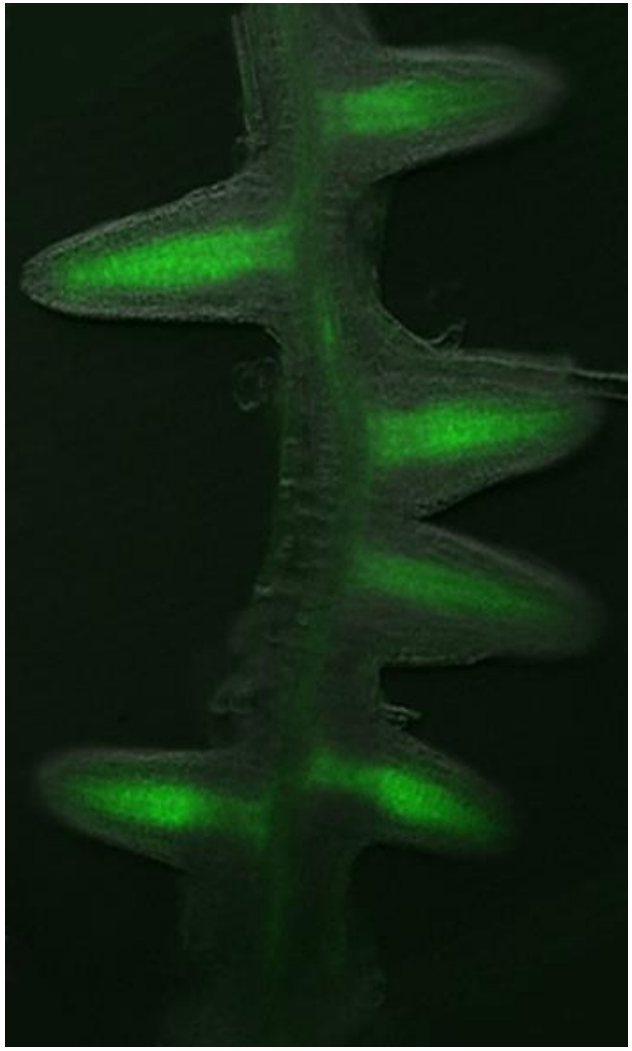
Actin

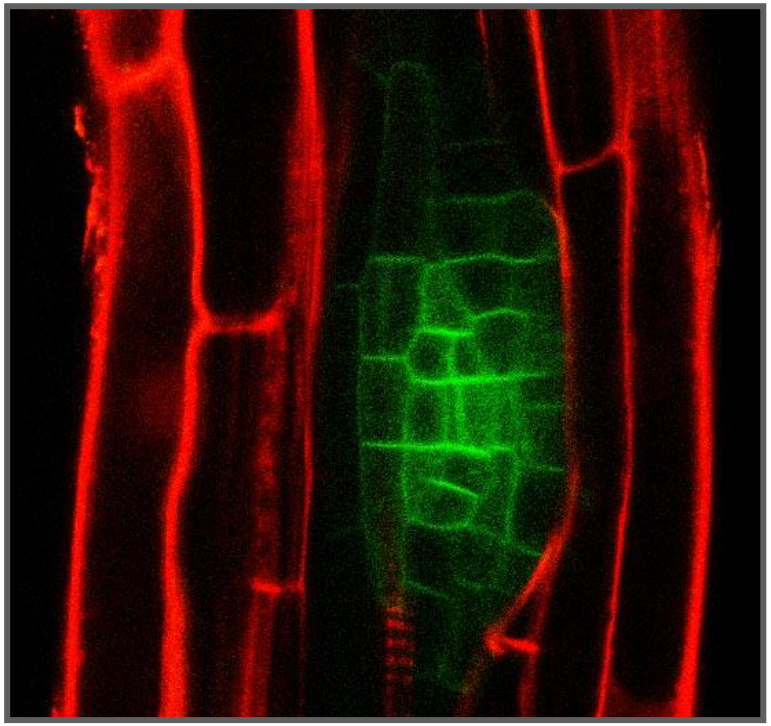


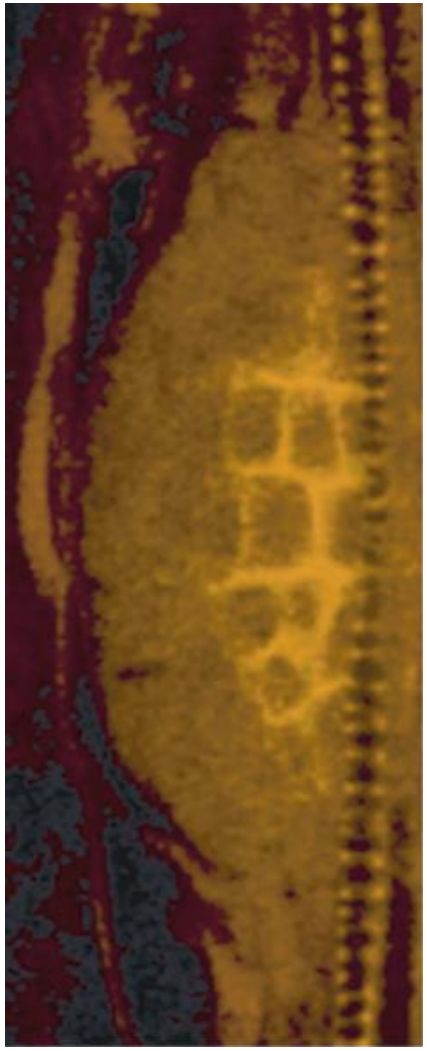
Tubulin



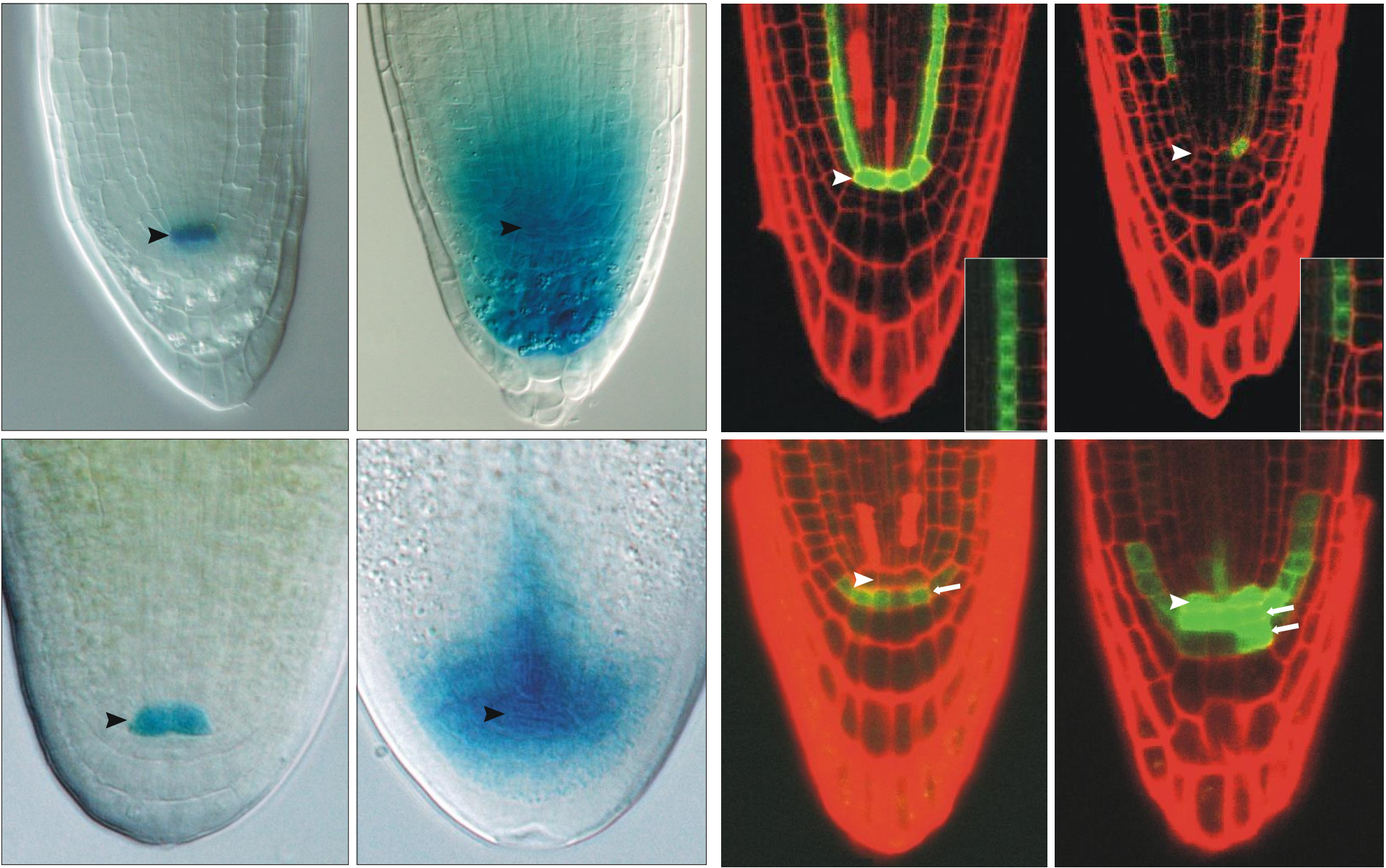
Analysis of protein localisation

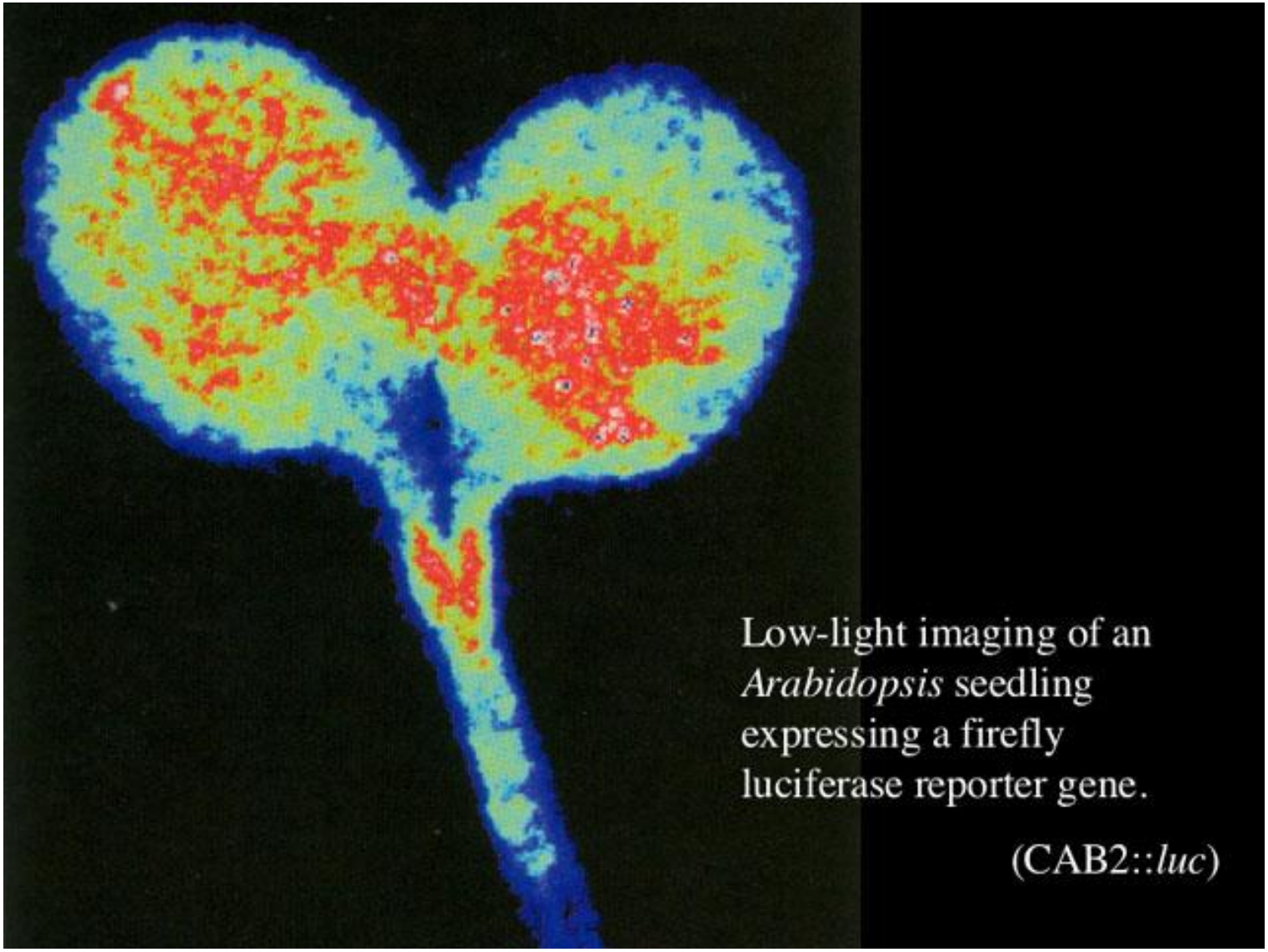






Cell identity markers





luciferin + O_2 → oxyluciferin + light

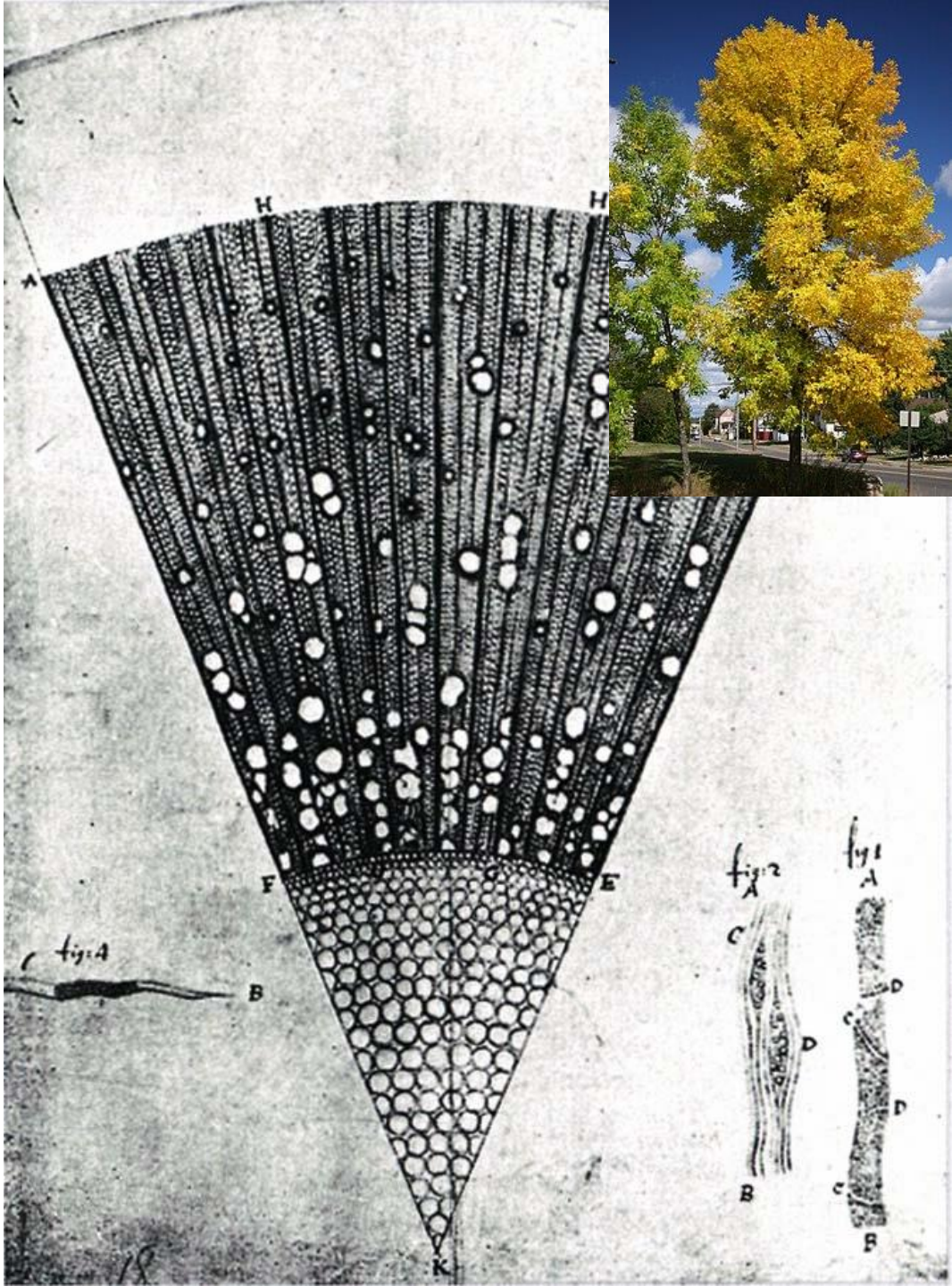
Multiple Cells ~ tissues

Antony van Leeuwenhoek

Cell conglomerates.

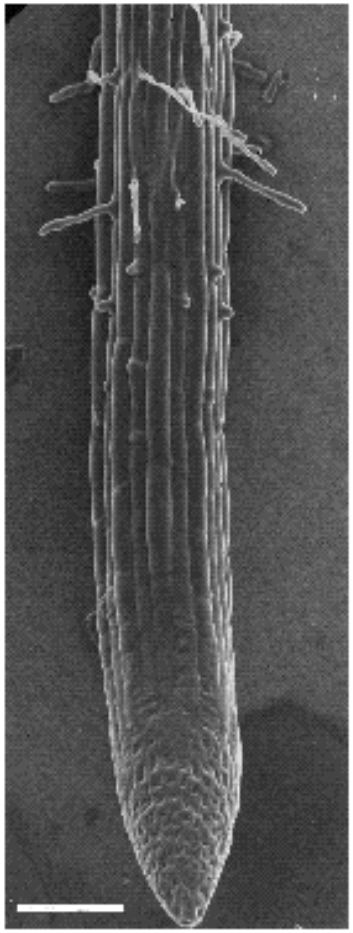
17th century that lens grinding by Antony van Leeuwenhoek provided the resolution needed to make major discoveries.

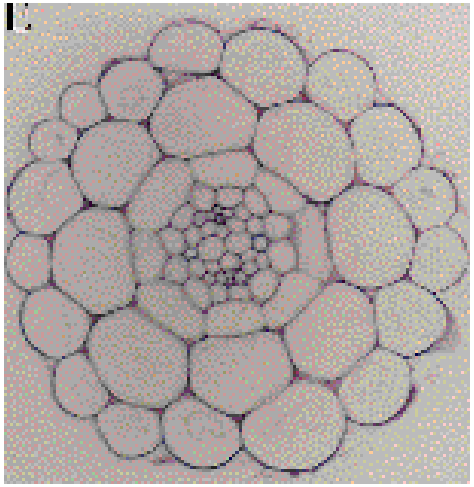
In the first half of the 18th century botany was beginning to move beyond descriptive science into **experimental science**.

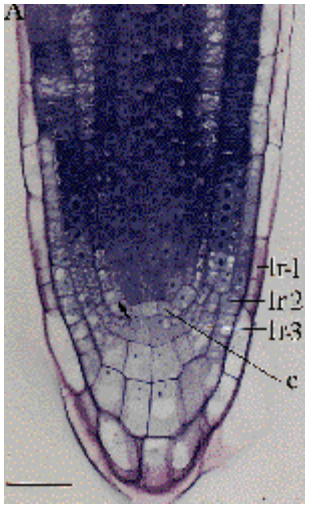


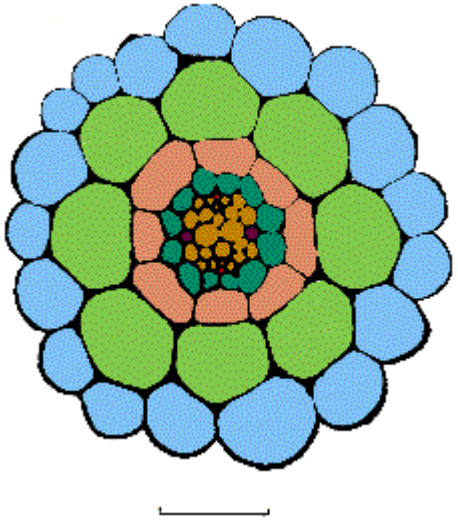
Microscopic section through one-year-old ash tree

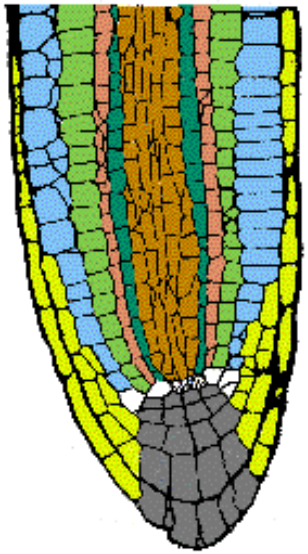
Anatomy – internal structure of plants



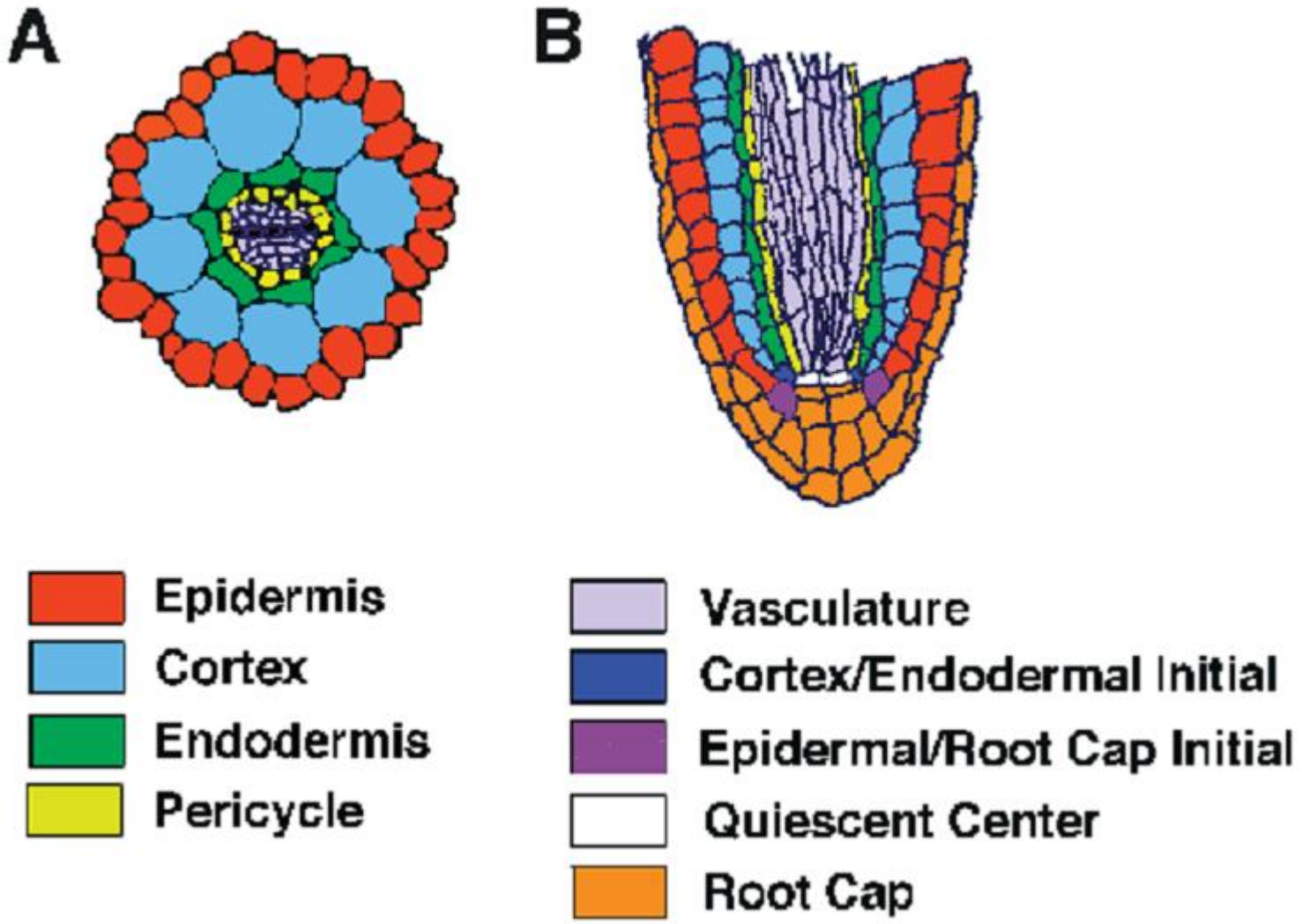






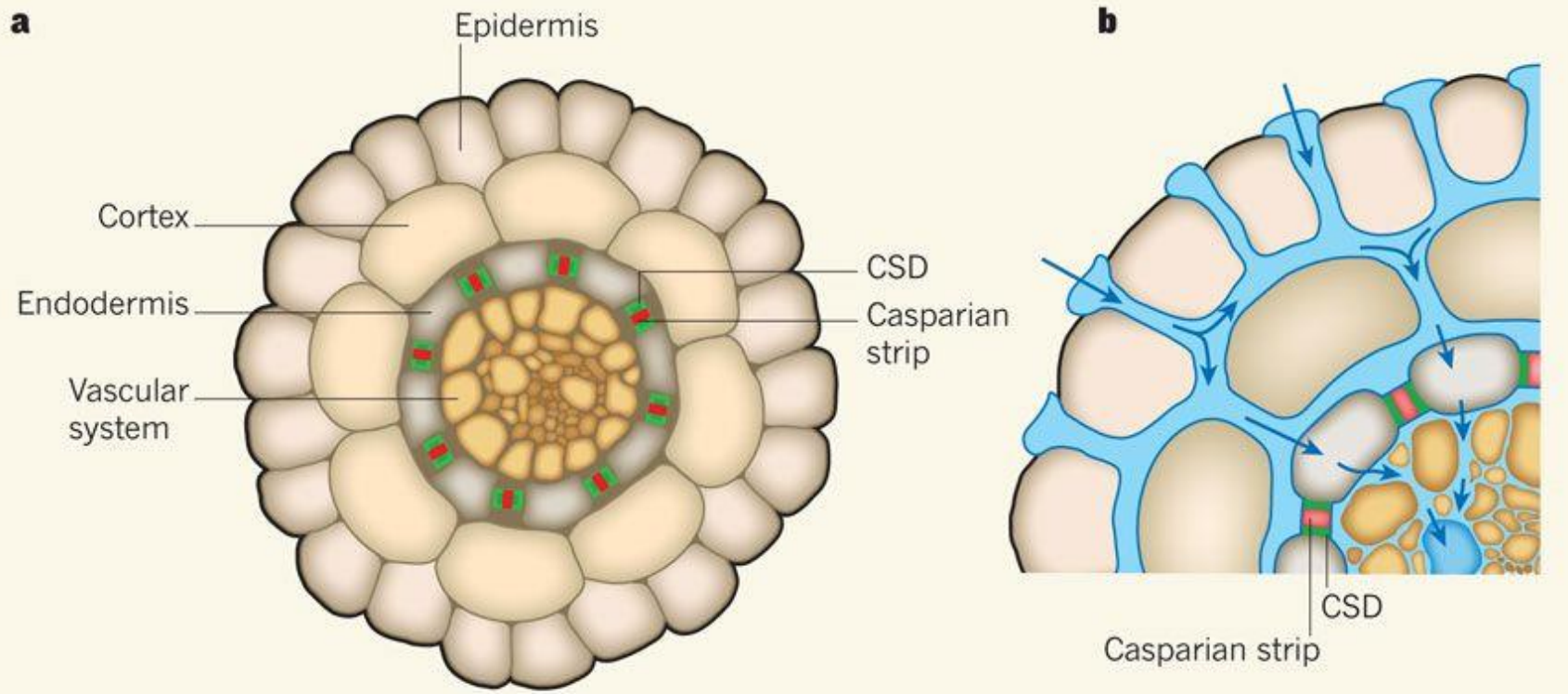


Looking for patterns, tissue organisation..



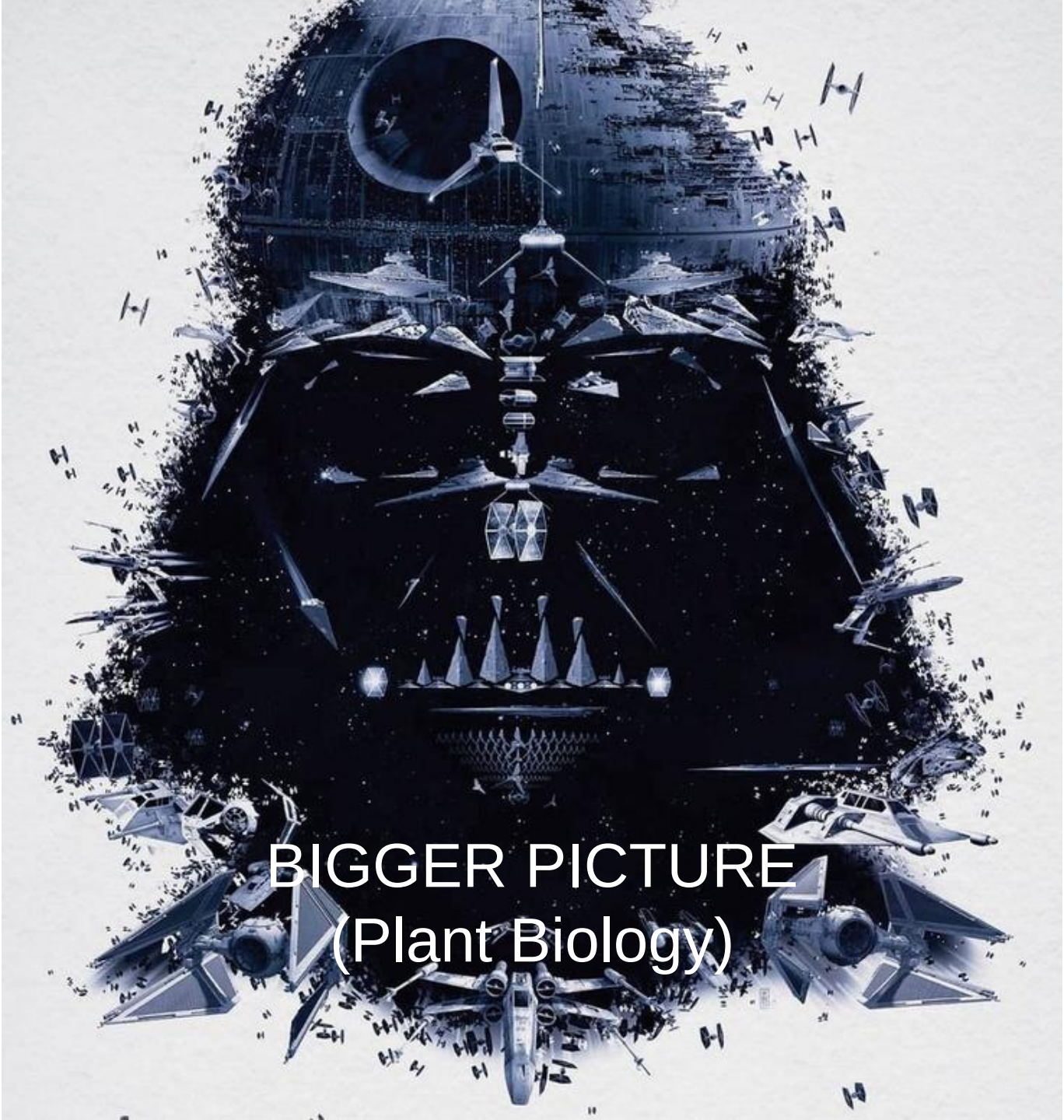
What is the significance of those patterns?
epidermis + cortex vs endodermis

The Casparian strip.



Casparian strip deposition is not fully understood.

BITS


BIGGER PICTURE
(Plant Biology)

How to coordinate the BITS?

How to coordinate the BITS.

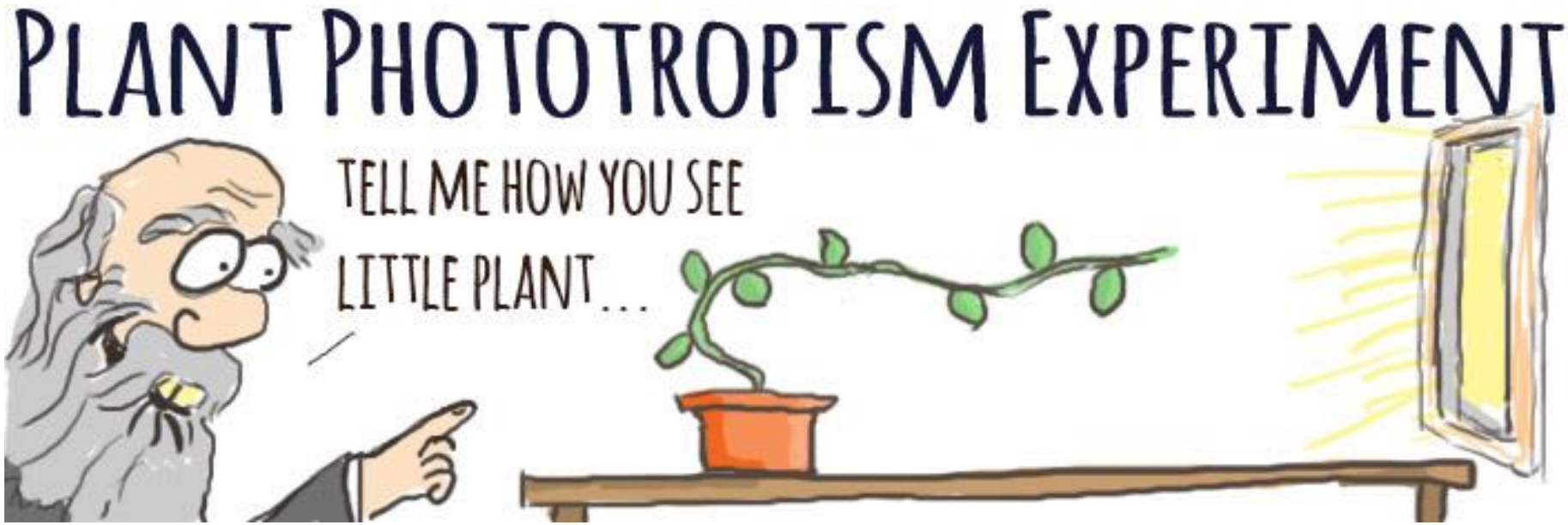
Coordinating signals.

Vibrio harveyi – single cell communication

Signalling discovered in the luminescent marine bacteria *V. fischeri* and *Vibrio harveyi*. In the early 1970s, researchers observed that supernatants from stationary phase cultures could be added to cells at low density and trigger light production, the signalling was species-specific and dependent on cell density rather than the nutritional status of the cells.

Chemistry (identification of signals)

Chemistry - the tropic signal is a chemical

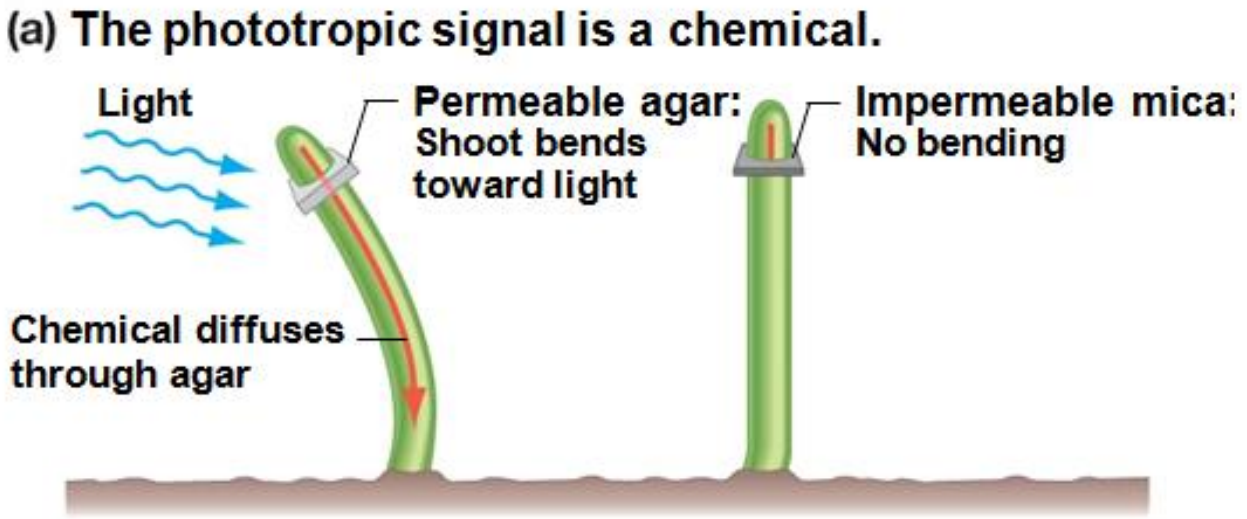


Germinating shoot in of canary grass and oats

Chemistry (identification of signals)

Chemistry - the tropic signal is a chemical

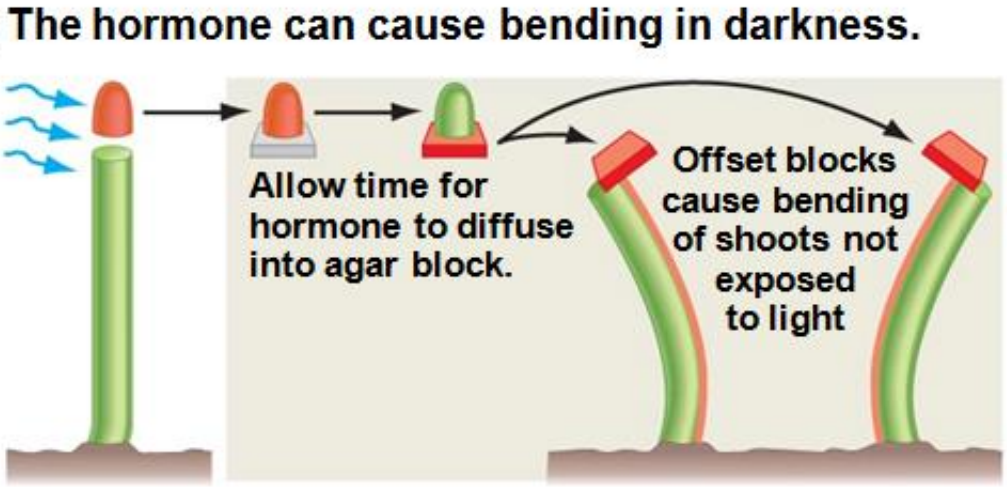
a) 1913, Peter Boysen-Jensen



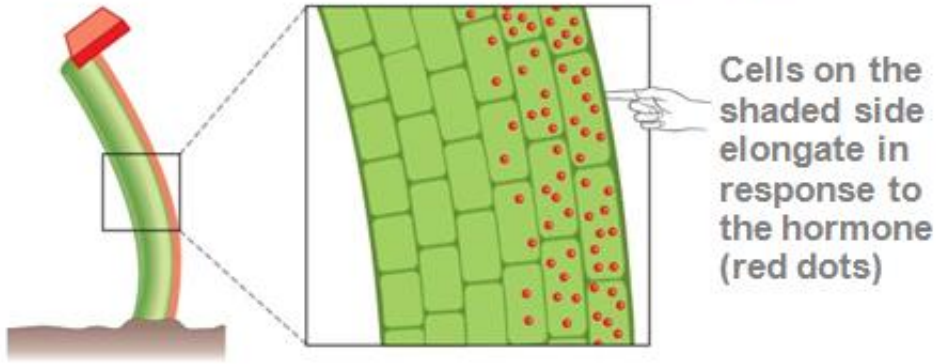
Germinating shoot in of canary grass and oats

Chemistry - the tropic signal is a chemical

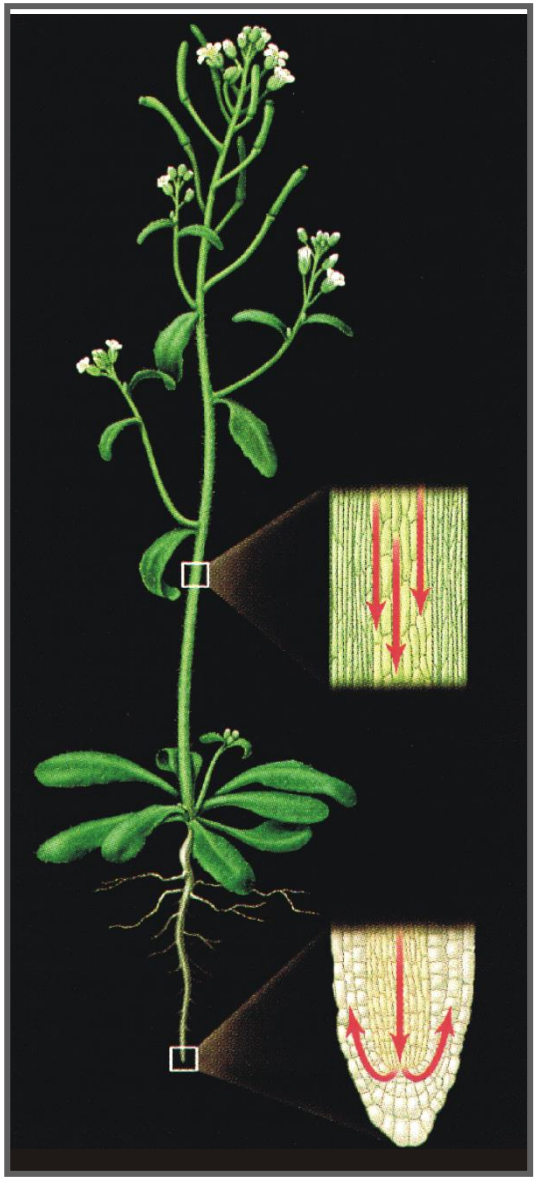
b) 1925, Frits Went

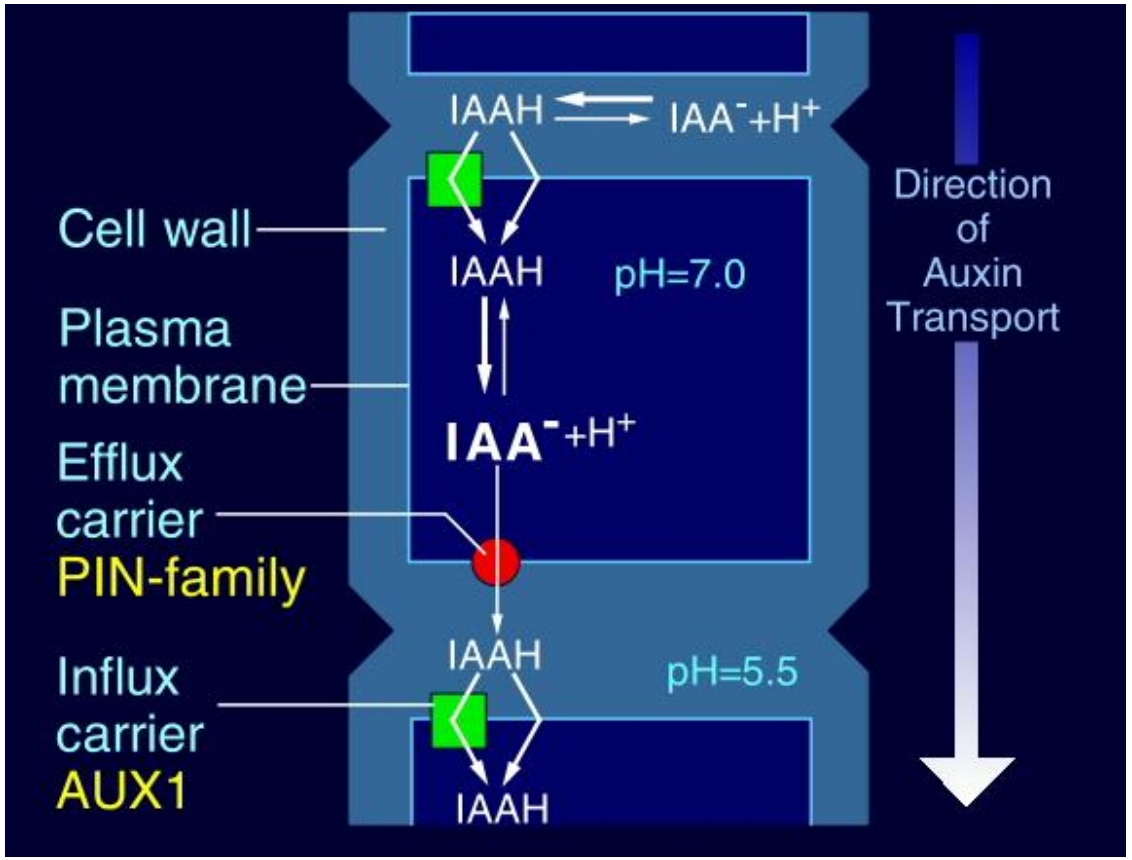


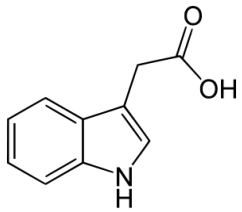
c) Went and Cholodny



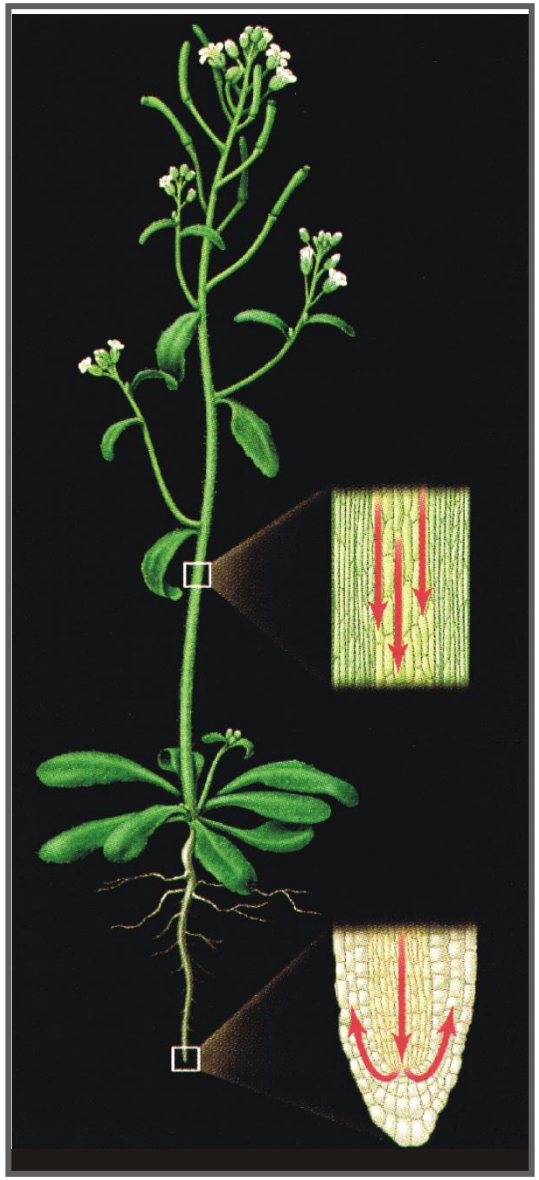
Cell to Cell translocation?







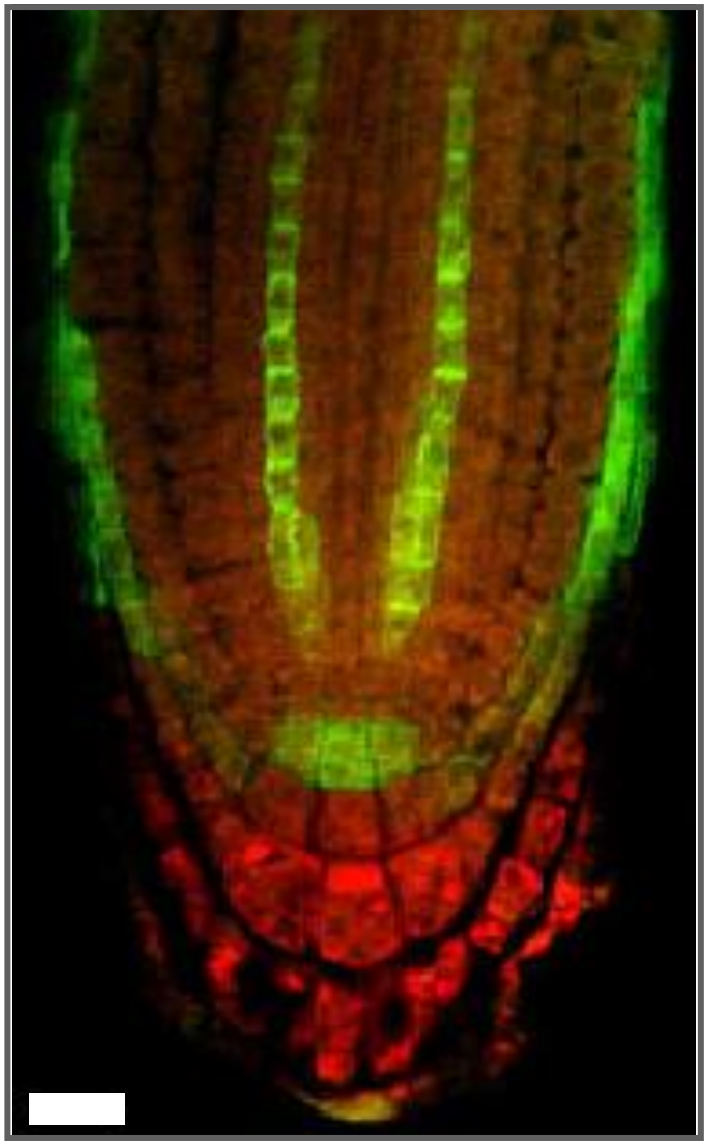
indole-3-acetic acid (IAA)

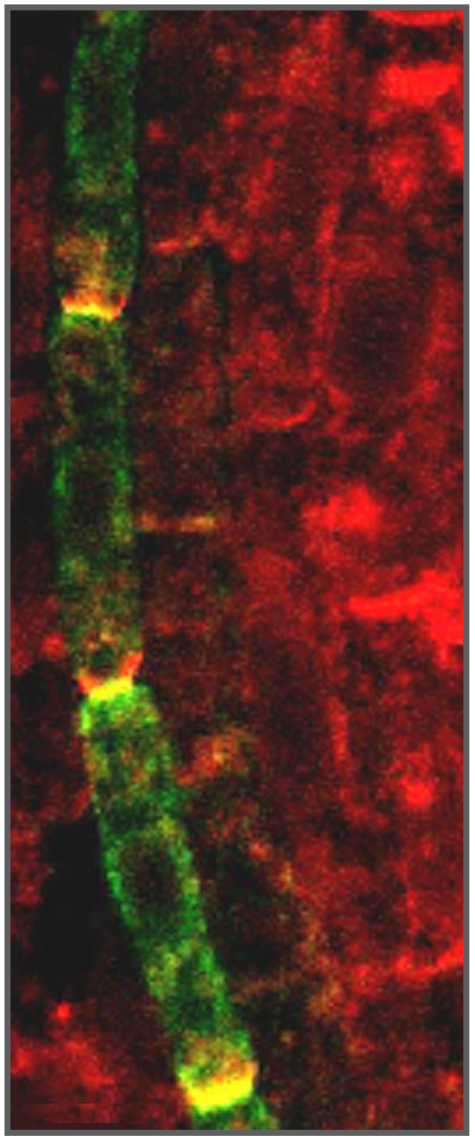


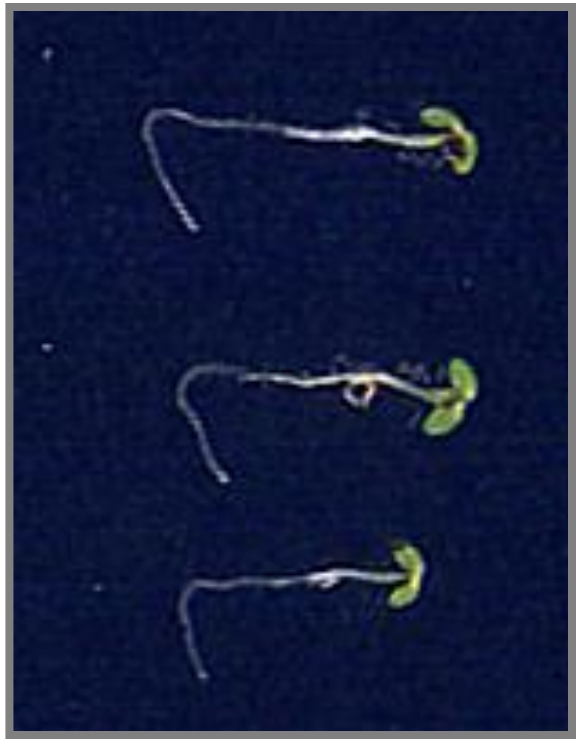

E

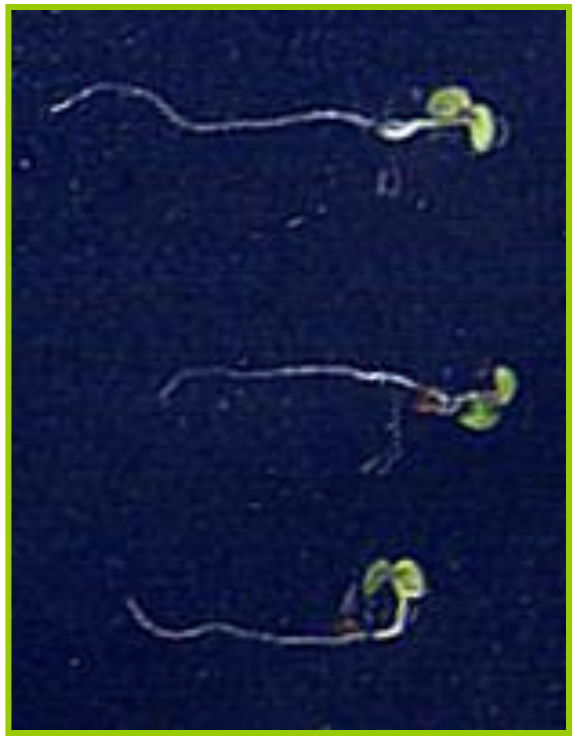

pin1


C



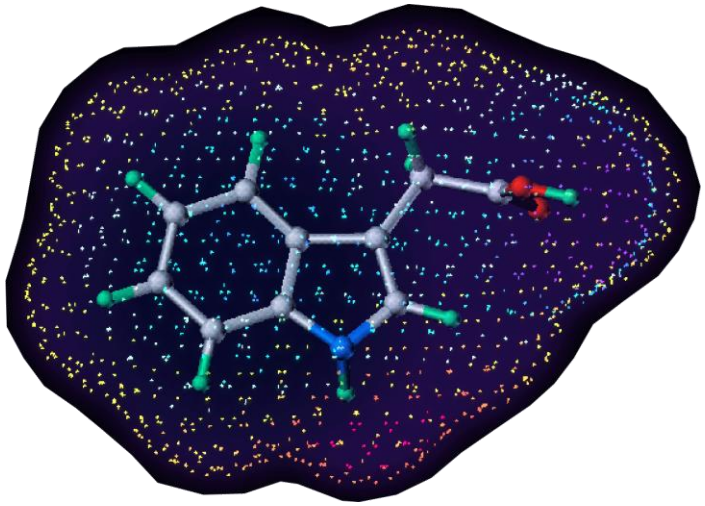






AUXIN

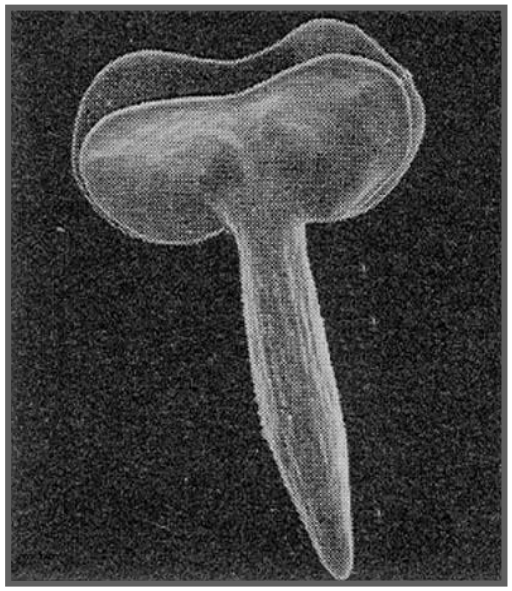
mediates

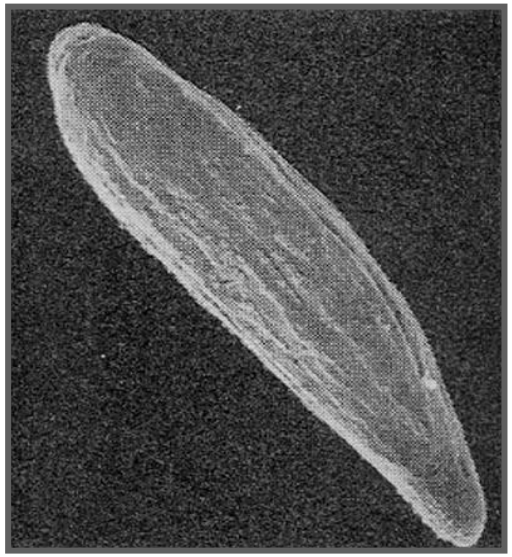


- **Embryo development**
- **Organ initiation and positioning**
- **Vascular tissue differentiation**
- **Shoot and root elongation**
- **Growth responses to light and gravity**
- **Apical hook formation**

Ln*

embryos





Carrier-mediated Auxin Transport*

P. H. Rubery and A. R. Sheldrake**

Department of Biochemistry, Tennis Court Road, Cambridge CB2 1QW, U.K.

Received March 8, 1974 / April 10, 1974

CellPress
PARTNER JOURNAL

Molecular Plant
Research Article

Enquiry into the Topology of Plasma Membrane-Localized PIN Auxin Transport Components

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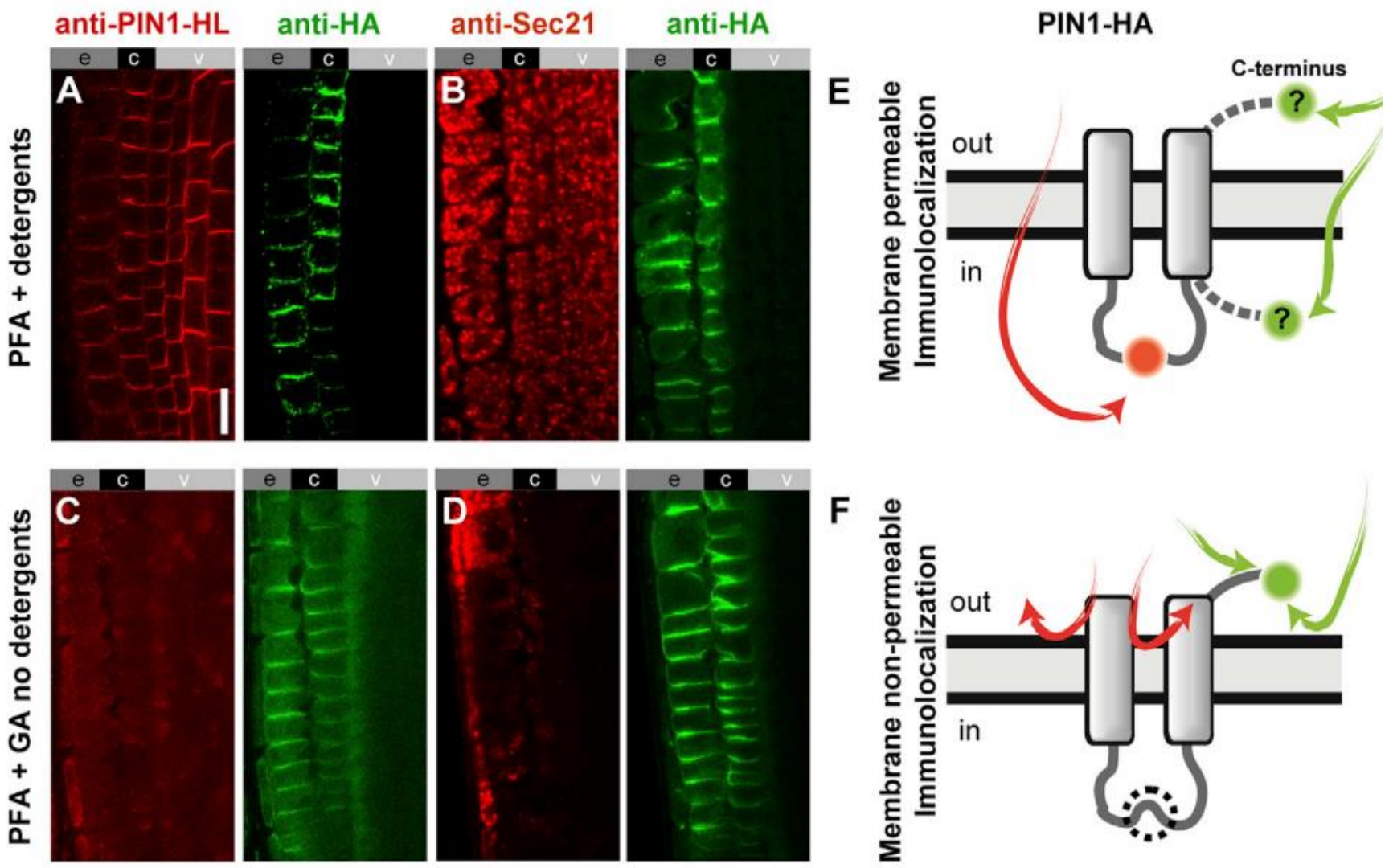
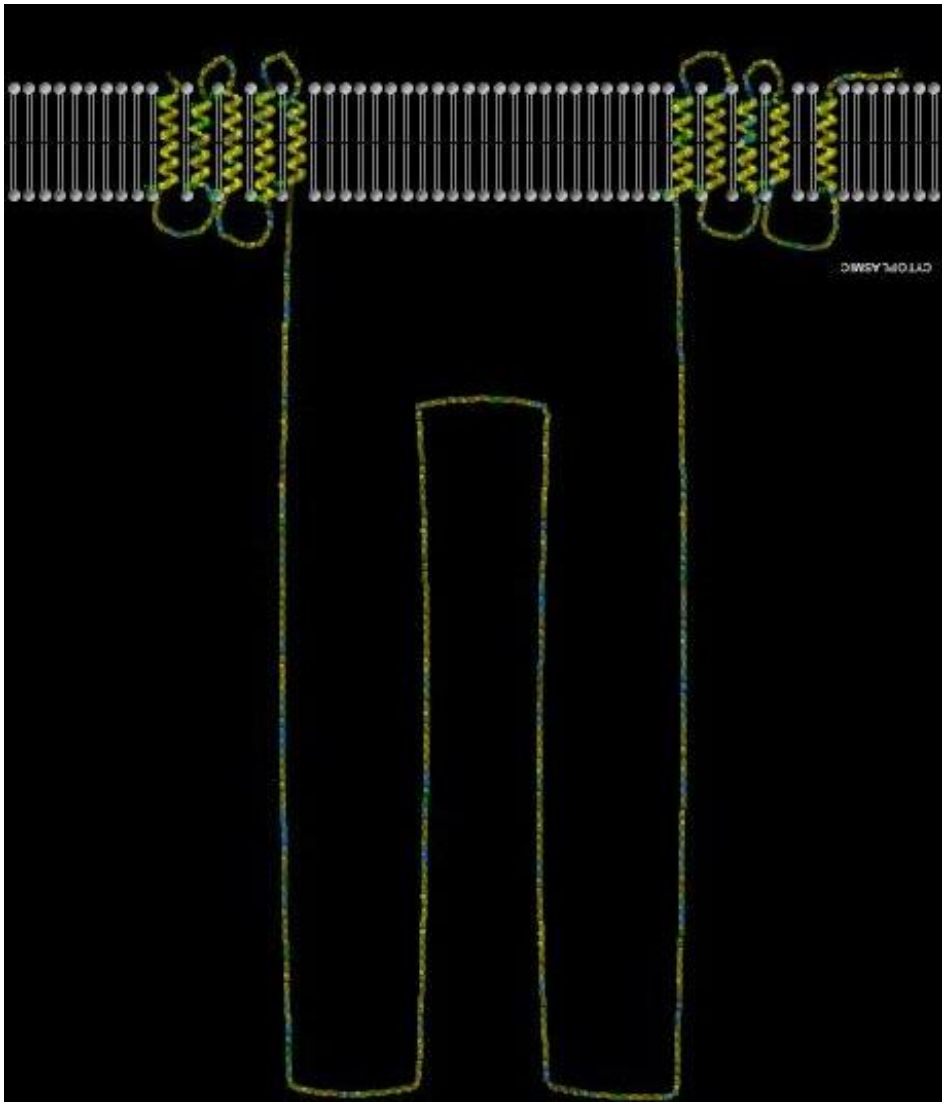
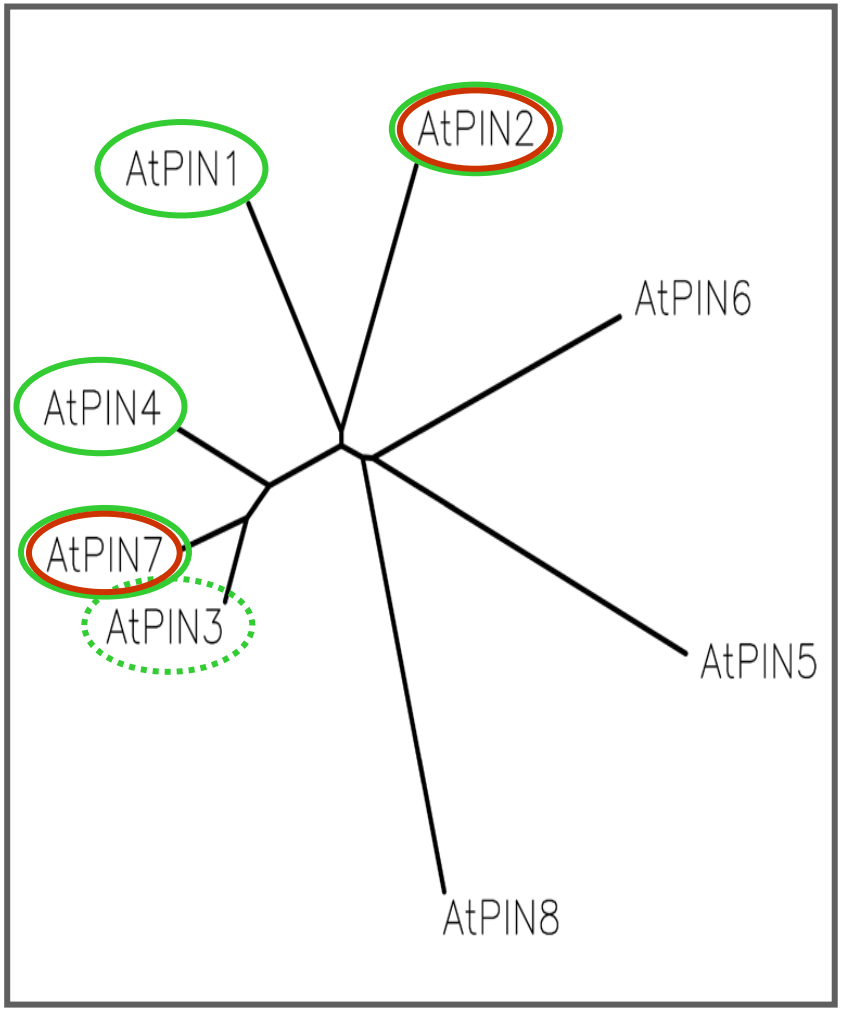
http://dx.doi.org/10.1016/j.molp.2016.08.010


anti-PIN1-HL
anti-HA
anti-Sec21
anti-HA
PFA + detergents
PFA + GA no detergents
e
c
v
A
B
C
D
PIN1-HA
C-terminus
E
Membrane permeable
Immunolocalization
out
in
?
F
Membrane non-permeable
Immunolocalization
out
in

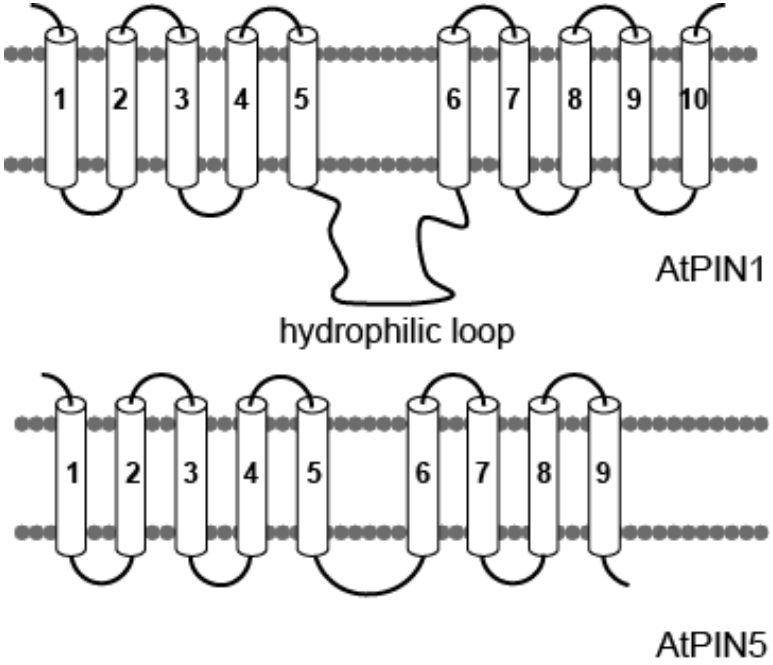
Solving crystal structures of PM proteins remains a challenge, and even more observing that structure (significance) in action.



PINs in *Arabidopsis*

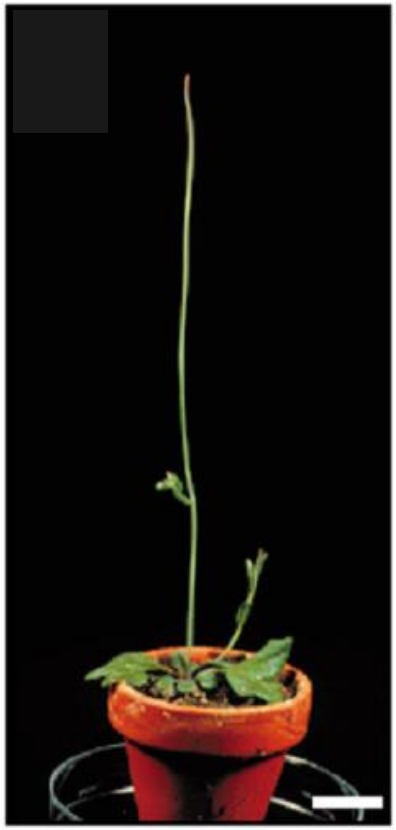


PIN Protein Topology

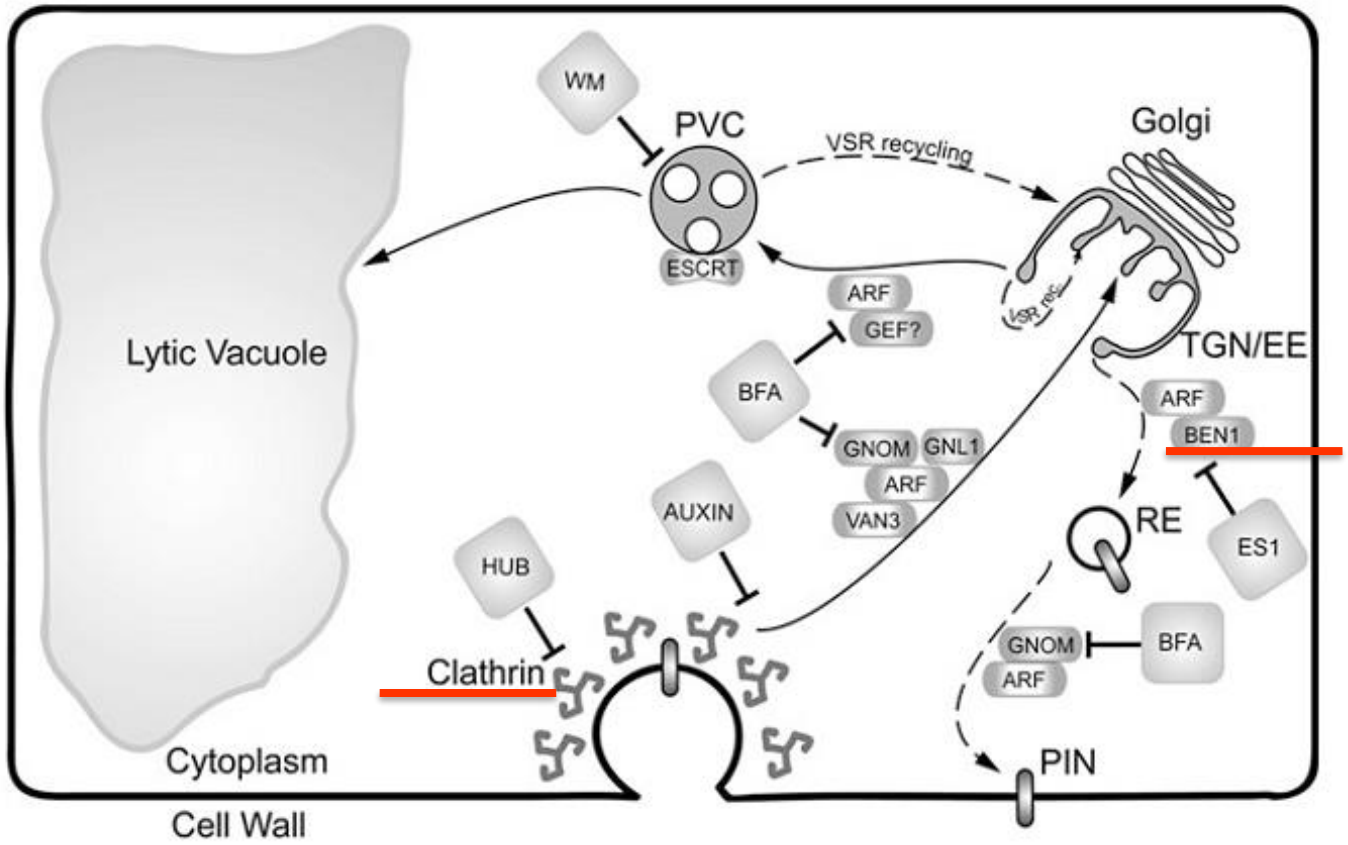


Intracellular/Vesicular **trafficking** contributes to PIN **polarity** the PM.

Vesicular **trafficking** delivers also membrane.

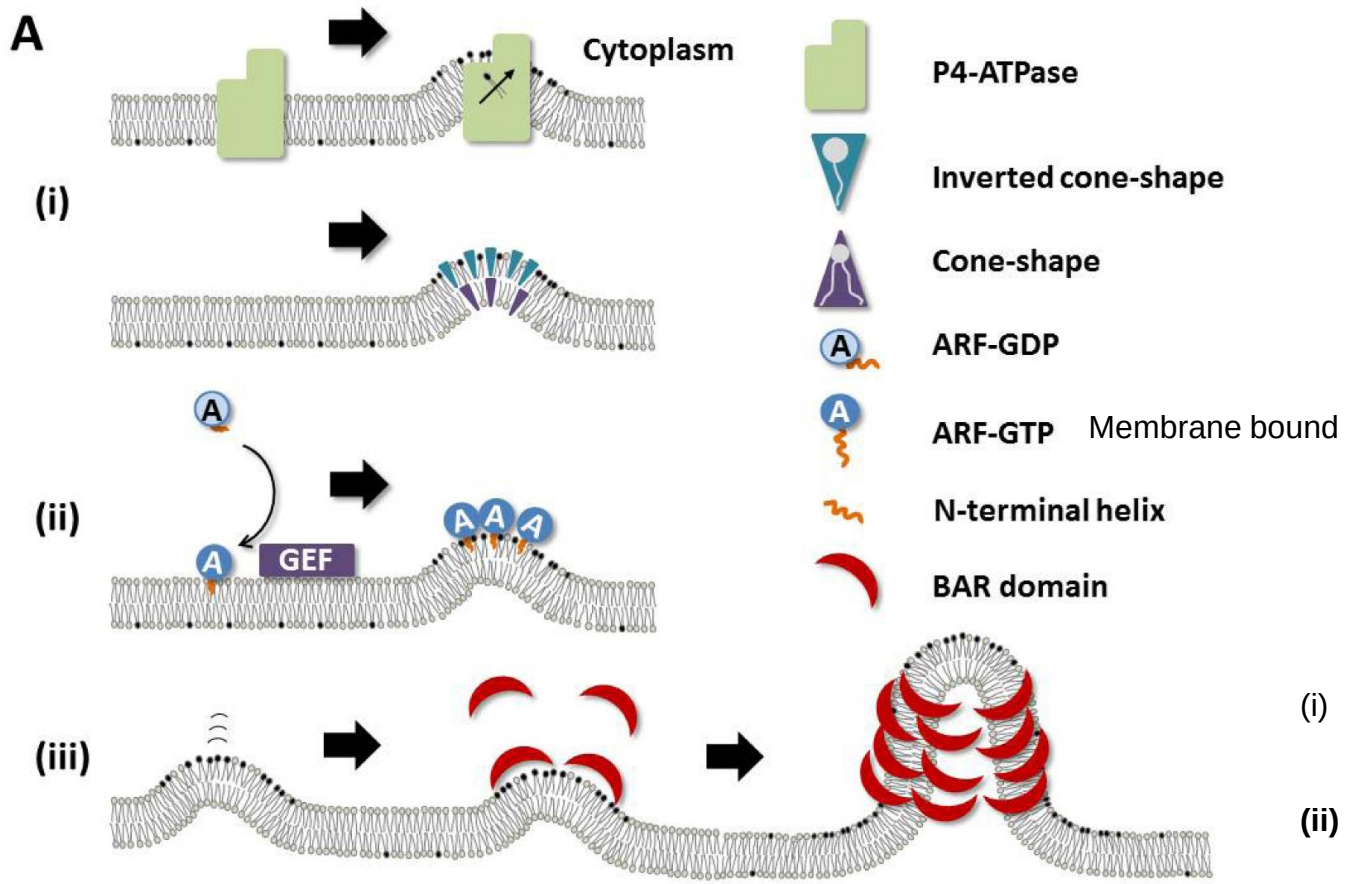


Adopted from Gälweileret al., 1998



Nodzyński, T. et al. (2012). Endocytic Trafficking of PIN Proteins and Auxin Transport. In Endocytosis in Plants, J. Šamaj, ed (Springer Berlin Heidelberg), pp. 165–183.

Mechanistic model for the generation of membrane curvature.

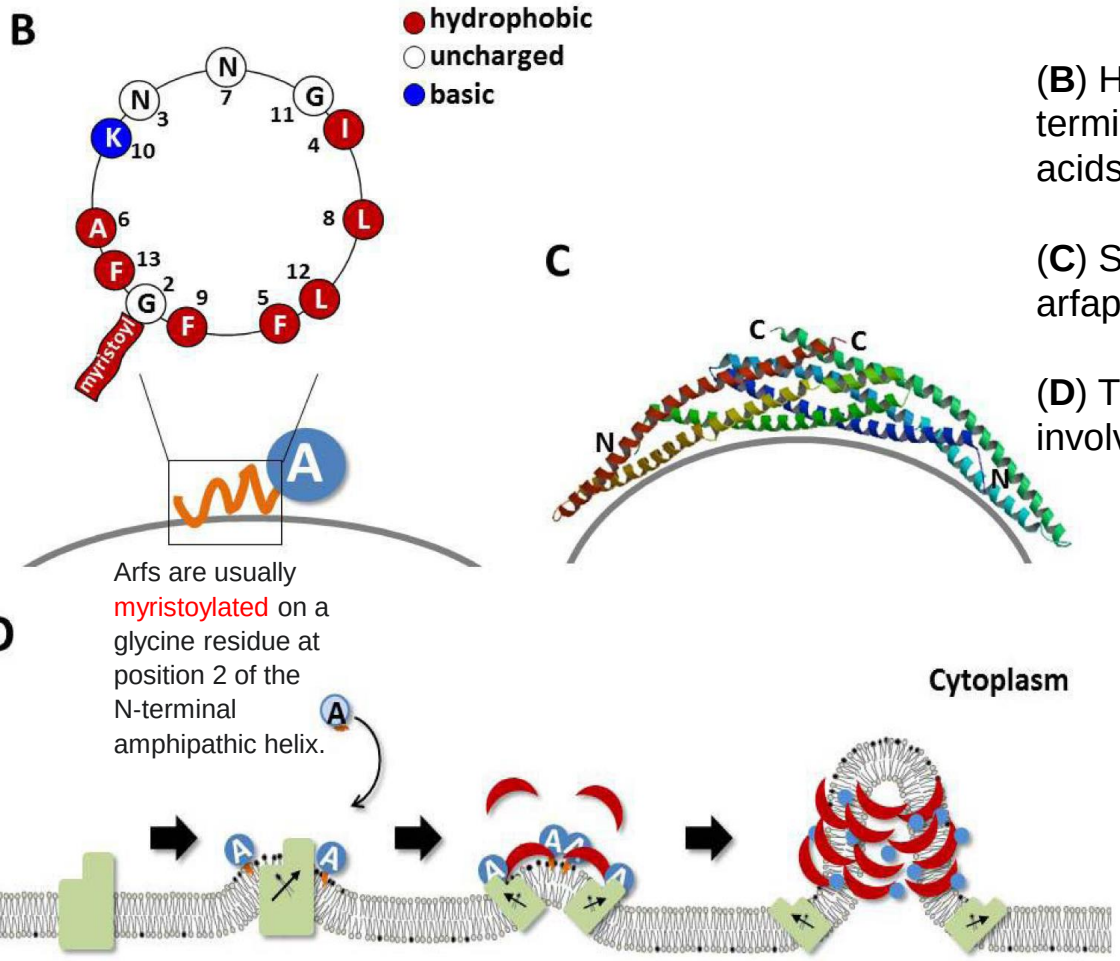


(i) Lipid composition is changed by P4-ATPases, LPAT and PLA2;

(ii) **amphipathic** helices of Arf family small GTPases are inserted into the cytoplasmic leaflet of the membrane;

(iii) the resultant curvature is sensed and stabilized by **BAR** domain protein

Mechanistic model for the generation of membrane curvature.

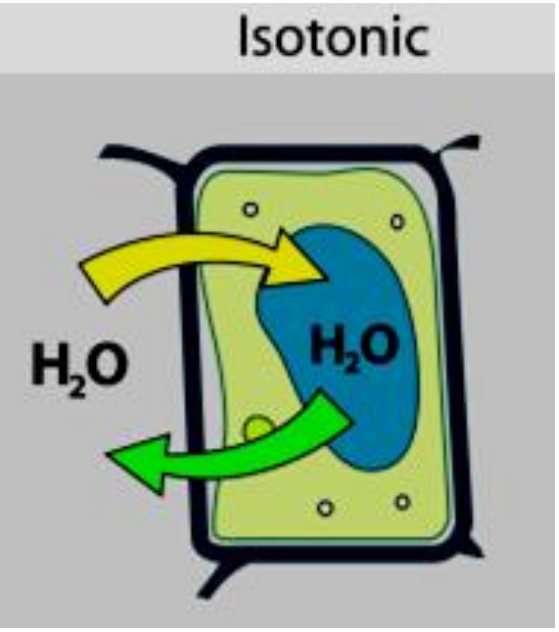


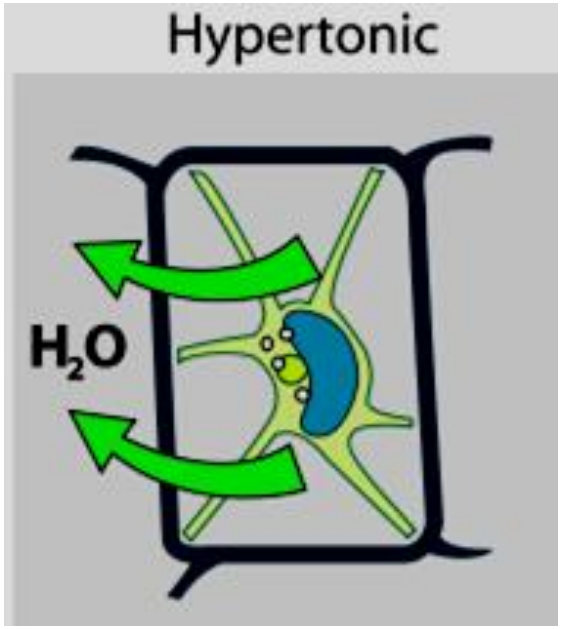
(**B**) Helical-wheel representation of the N-terminal amphipathic helix of Arf1 (amino acids 2-13);

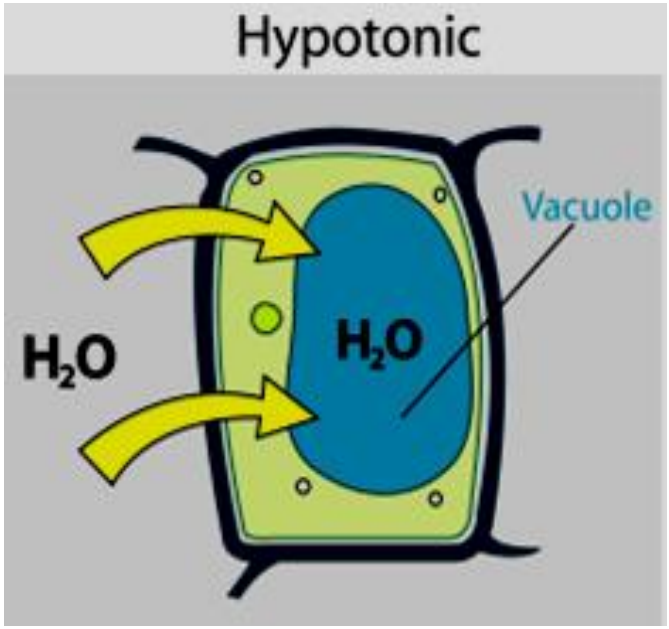
(**C**) Structure of the BAR domain dimer of arfaptin;

(**D**) The complex regulation of proteins involved in generating membrane curvature.

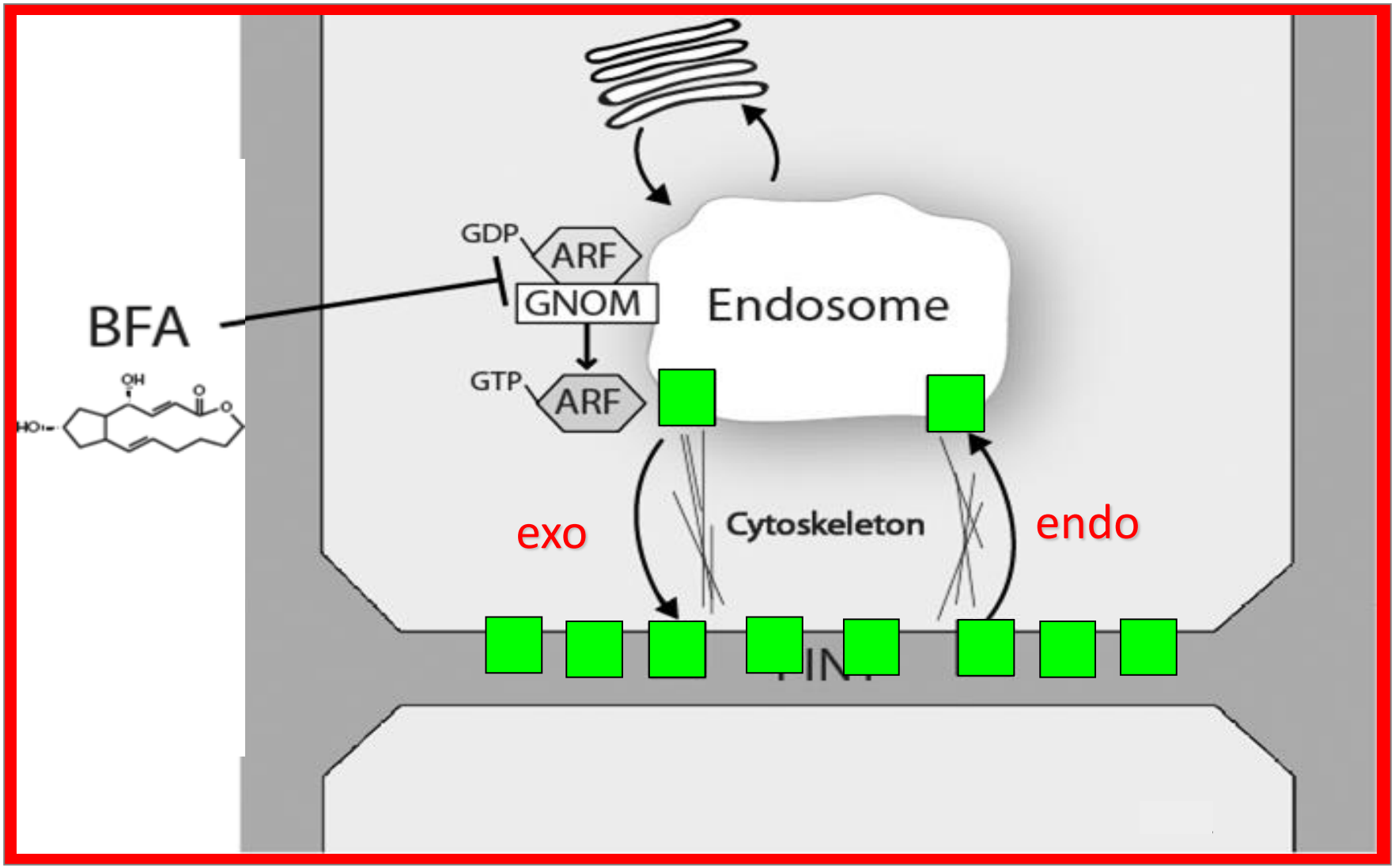
Osmotic conditions influence turgor





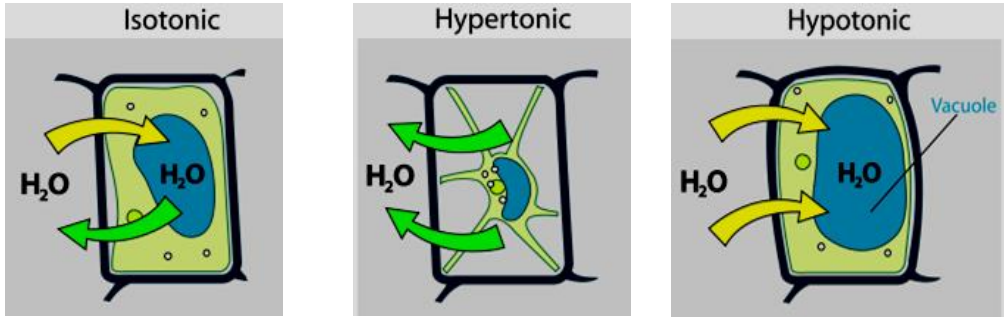


How the preserve membrane integrity during osmotic changes



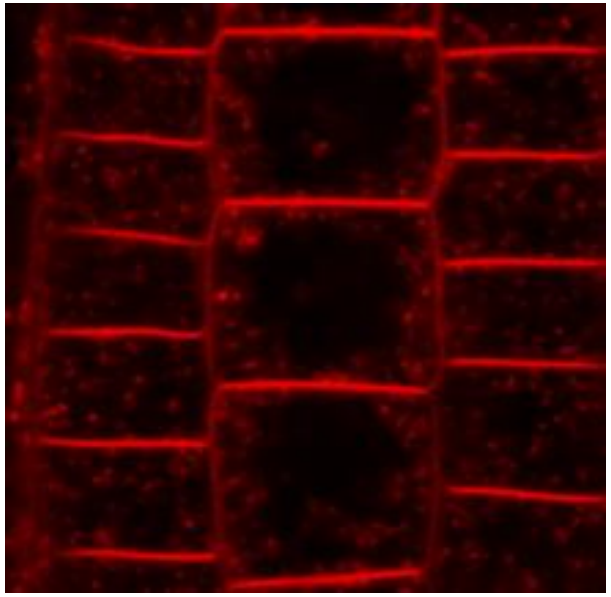
Regulate membrane delivery

Do Osmotic conditions influence early steps of endocytic trafficking?

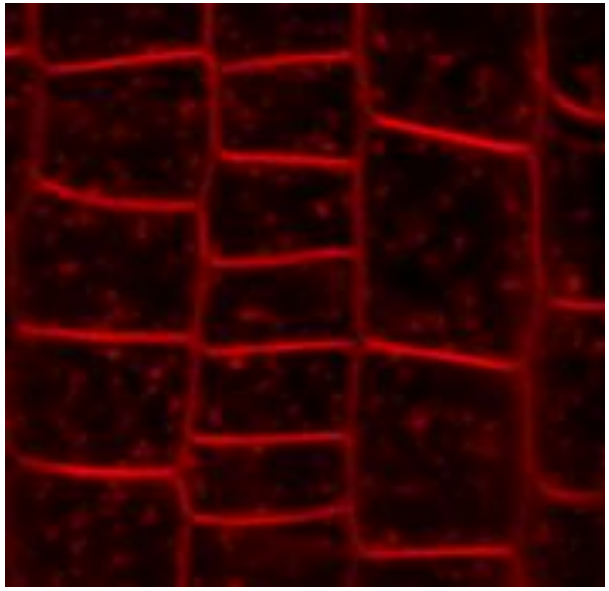


FM4-64[2] 10’

MS+

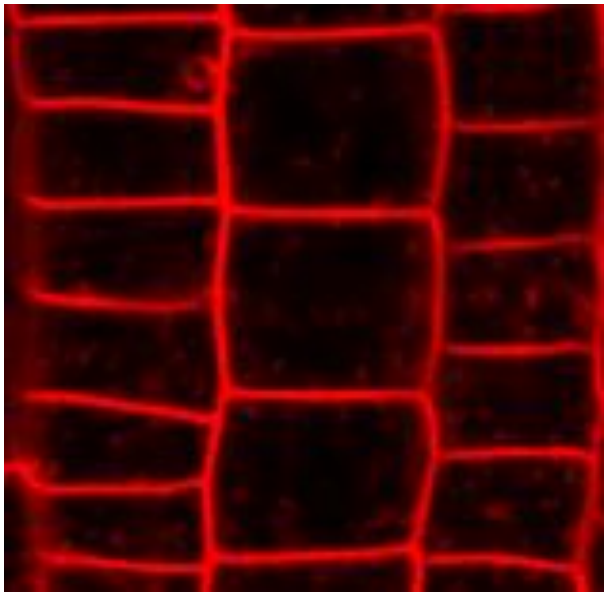


NaCl[100]



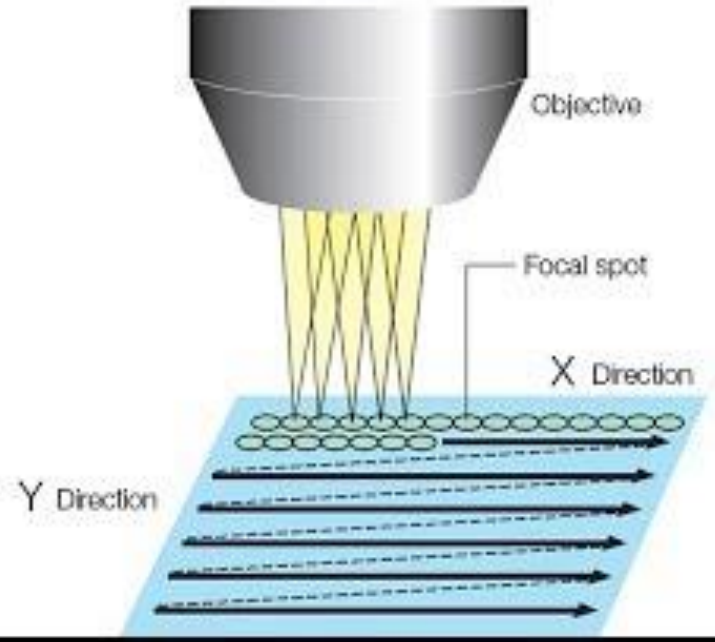
remove

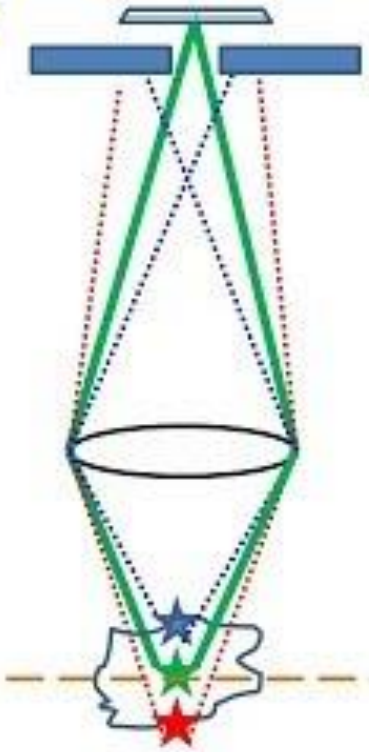
MQ



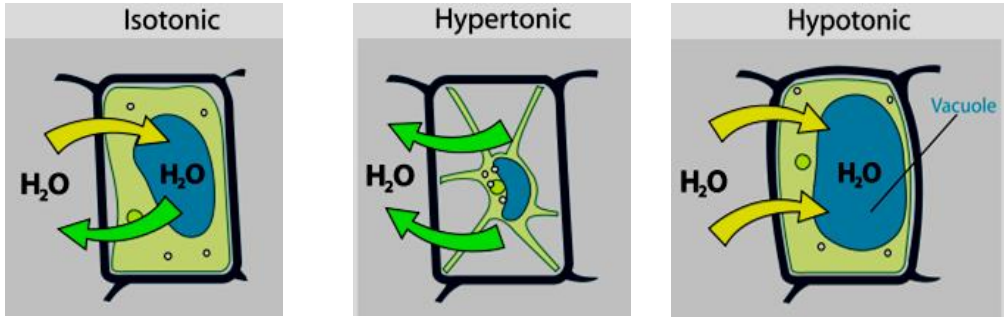
deliver

Confocal Microscopy



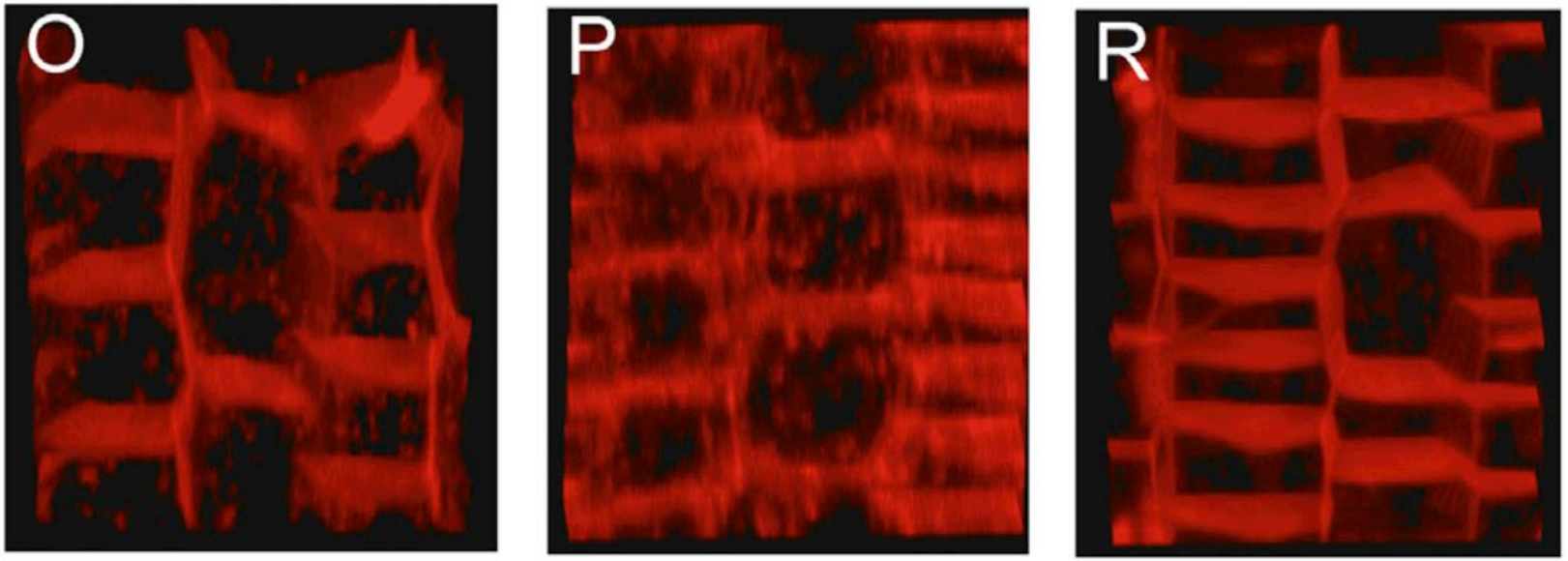


Osmotic conditions influence early steps of endocytic trafficking



FM4-64[2] 10' (Z-stack)

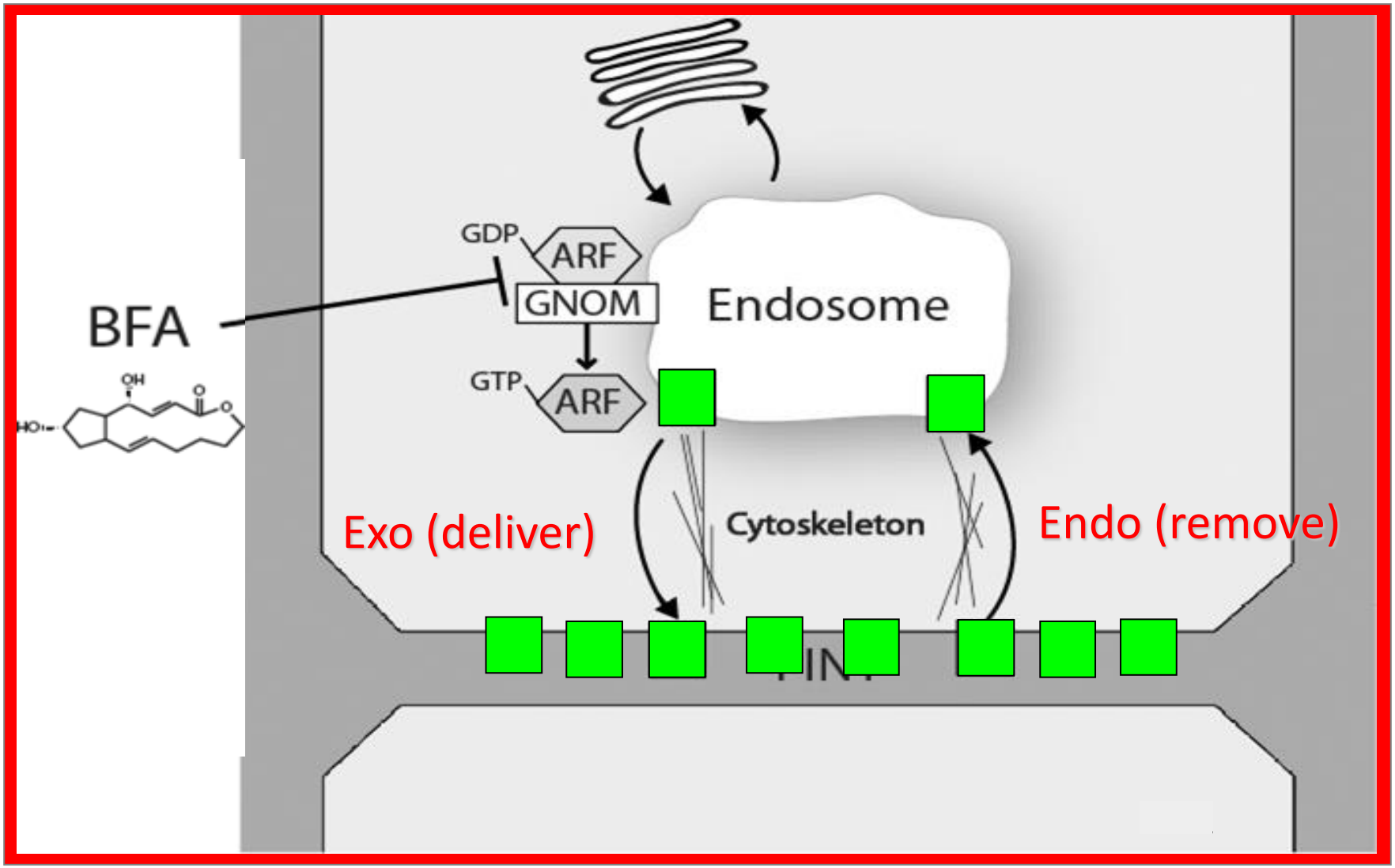
MS+ | NaCl[100] | MQ



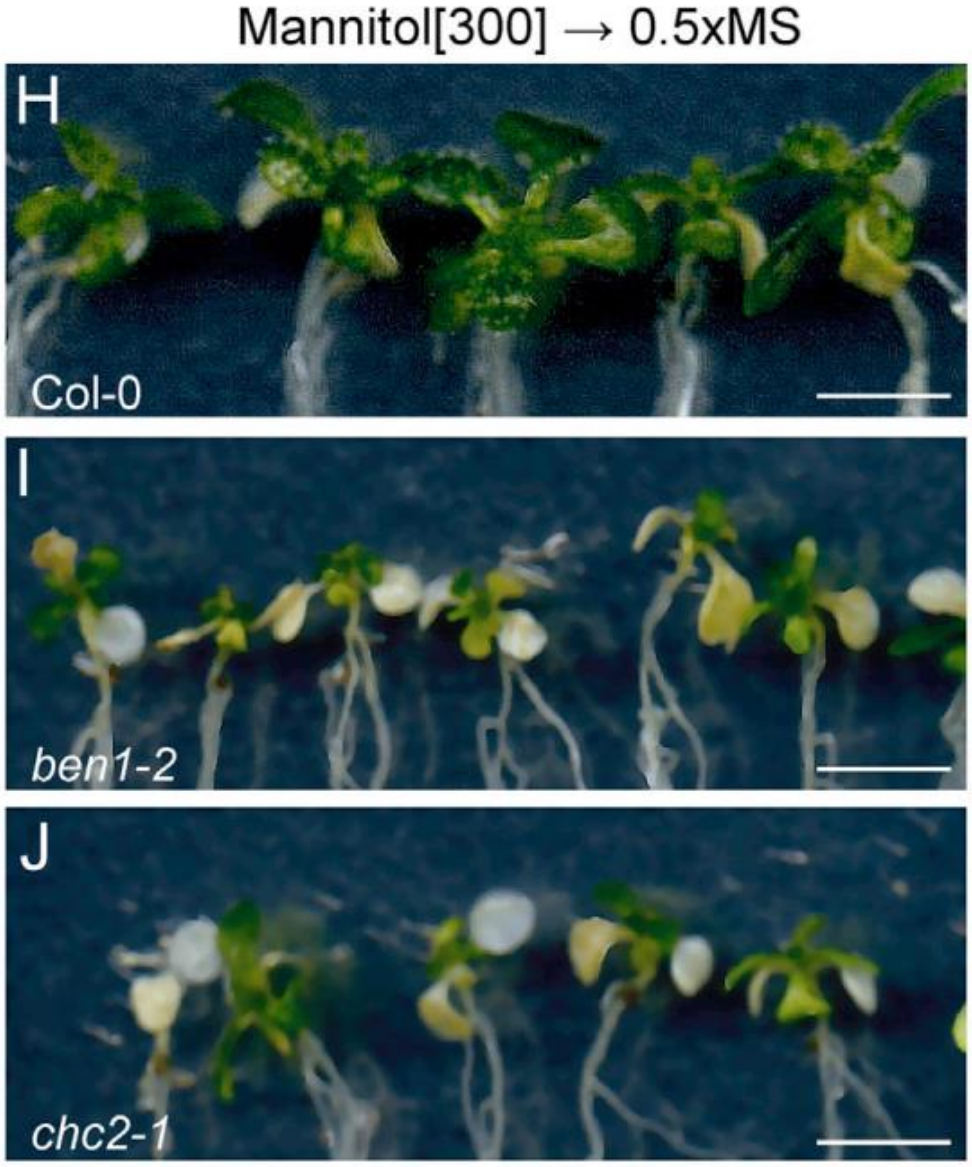
remove

deliver

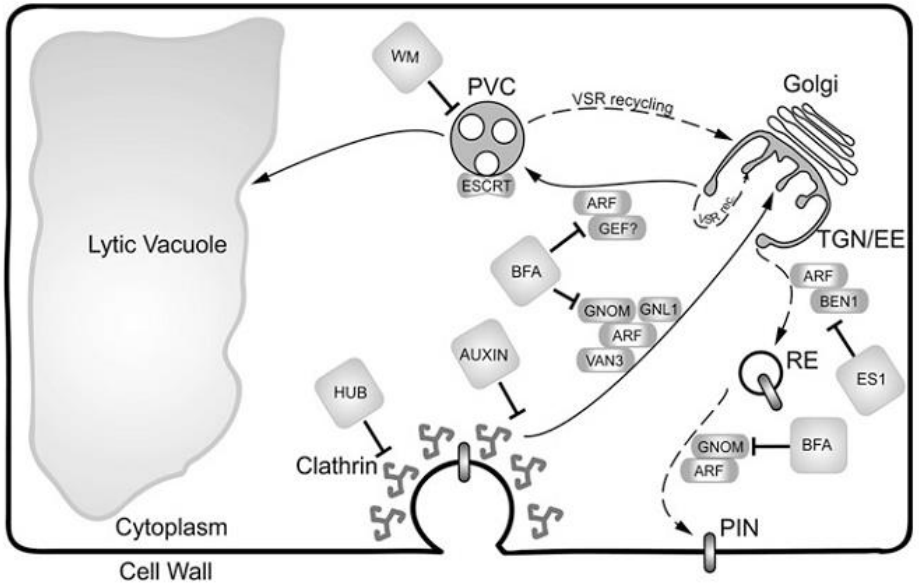
Preserve membrane integrity during osmotic changes



Regulate membrane delivery



Zwiewka *et al.*, 2015



More flexible trafficking better plant survival.

Role of intracellular trafficking in the context of stress/plant adaptation is not fully understood.

Thank you for your attention!

In case of questions write

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Building A26

Where to find us

E26 building (indicated by red square)

Other courses to consider

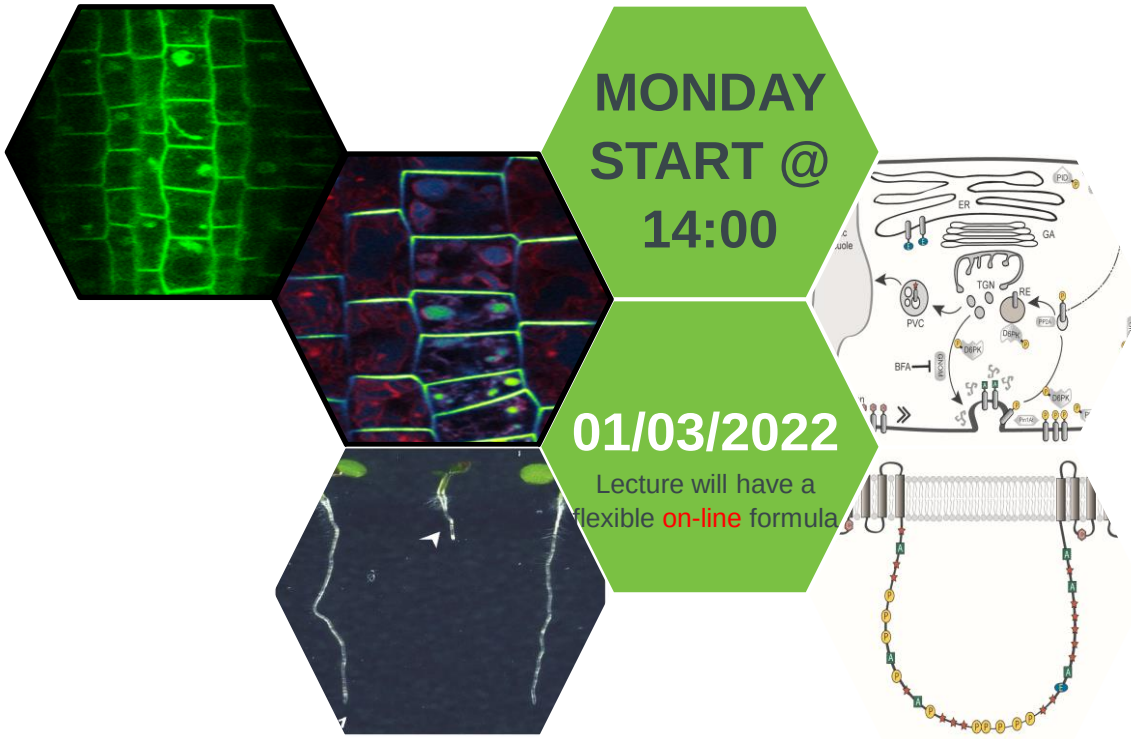
Developmental and Cell Biology of Plants (S2008)

Course is in Spring semester

Given by

Tomasz Nodzyński

Marta Zwiewka



Exact starting dates might be subject to change, check IS system for updates.

S2011 Hormones in plant development

Given by Helene Boisivon Course is in Spring semester

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ResearcherID
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Exact starting dates might be subject to change, check IS system for updates.