

# Advances and Challenges in Modern Biology

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

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2021.10.04

# The (Plant) Cell – Vessel for Life

Can U see a cell..?

**Seeing is believing**

**There was no concept a “cell”**

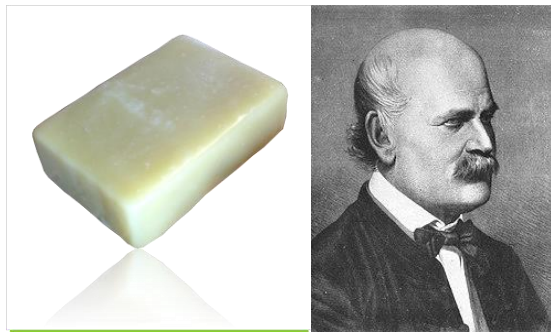
**What was believed before...**





# Spontaneous Generation

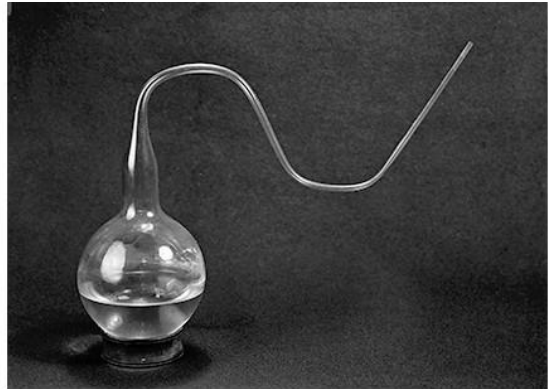
In the early 1600's and before, living organisms **arising from the environment like dust and dirt.**



Disproven in 1864

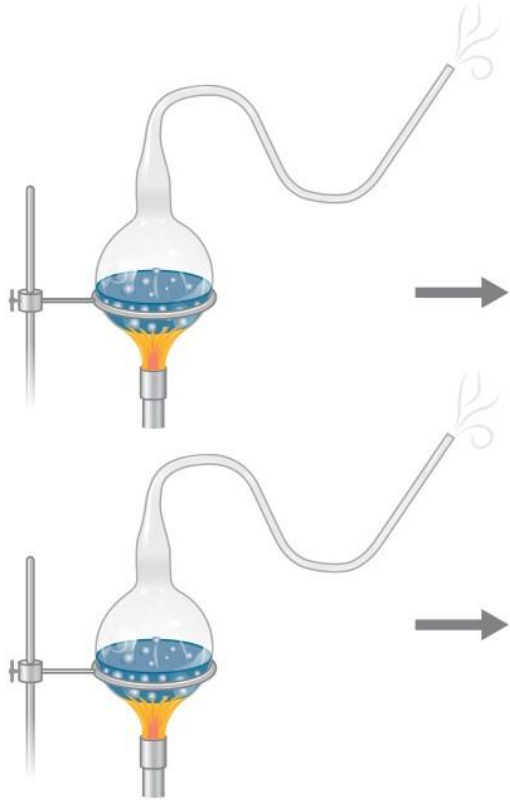
[Streptococcus pyogenes](#)

# Swan-neck bottle used by Pasteur



(a)

(b)



Boiling the broth kills microorganisms.

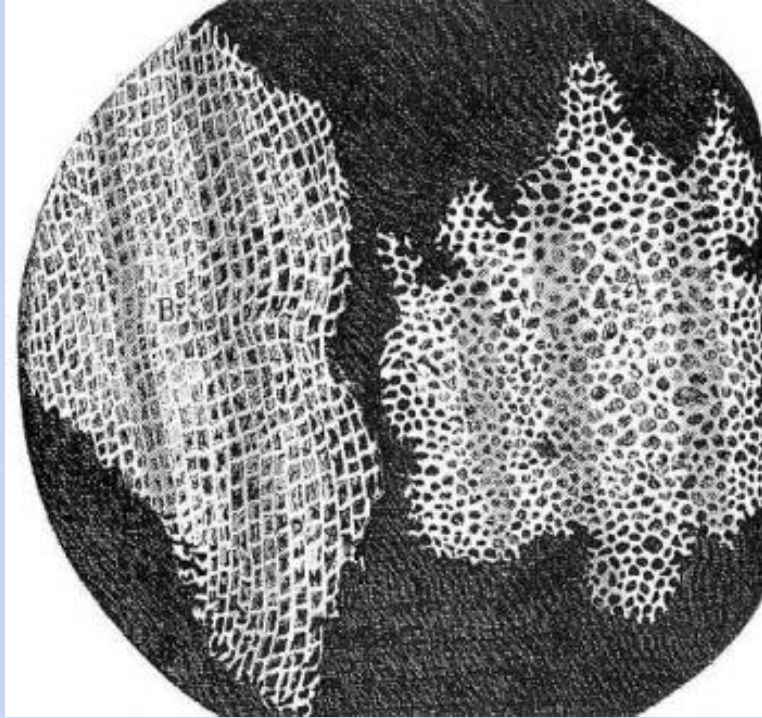


The curve of the flask prevents outside air from entering the flask. No contamination occurs.

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

(c)

Cells were first observed in plants.



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



Photograph of **cork** cells

Little rooms ~ Cells

# MICROGRAPHIA:

OR SOME

*Physiological Descriptions*

OF

## MINUTE BODIES

MADE BY

MAGNIFYING GLASSES.

WITH

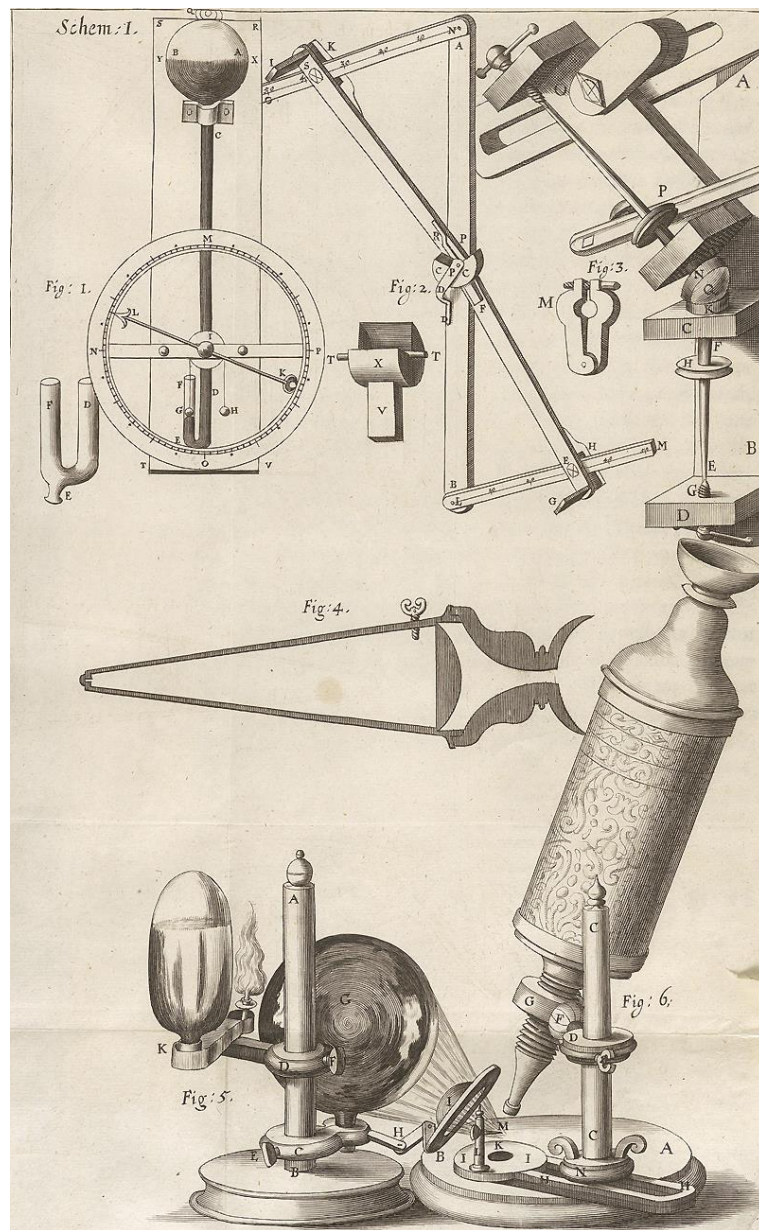
OBSERVATIONS and INQUIRIES thereupon.

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

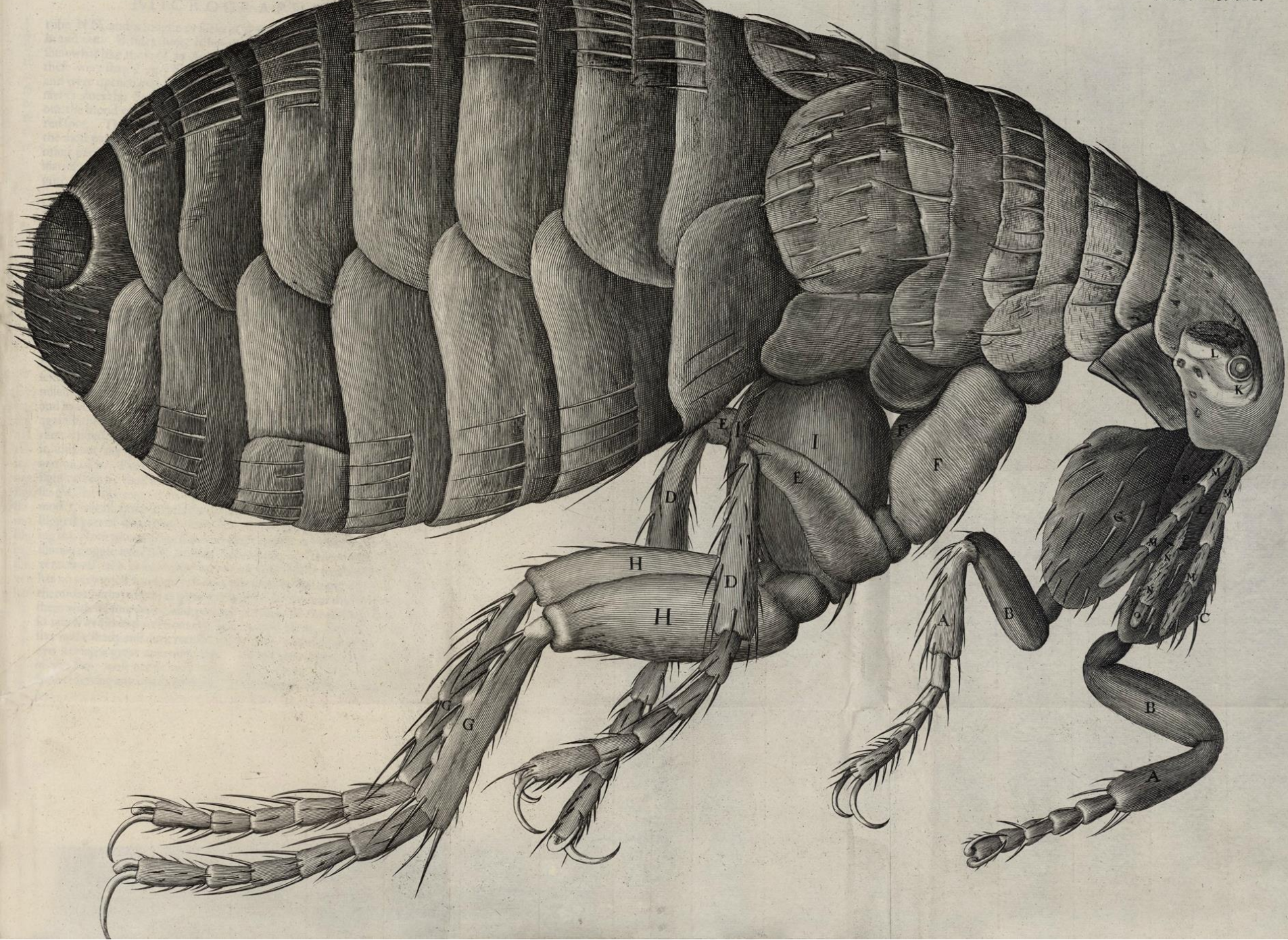
*Non possis oculo quantum contendere Linceus,  
Non tamen idcirco contemnas Lippus iungi. Horat. Ep. lib. 1.*



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. MDC LX V.



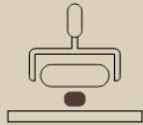






## GROUND

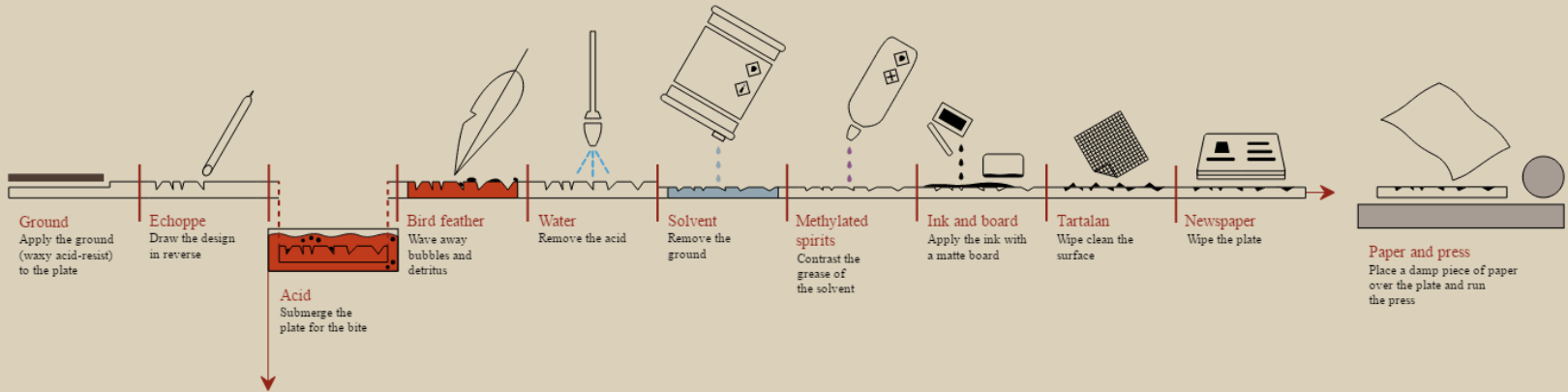
**Solid hard ground**  
Heat the plate and apply the ground by hand and using a roller



"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



# THE TOOLS OF ETCHING



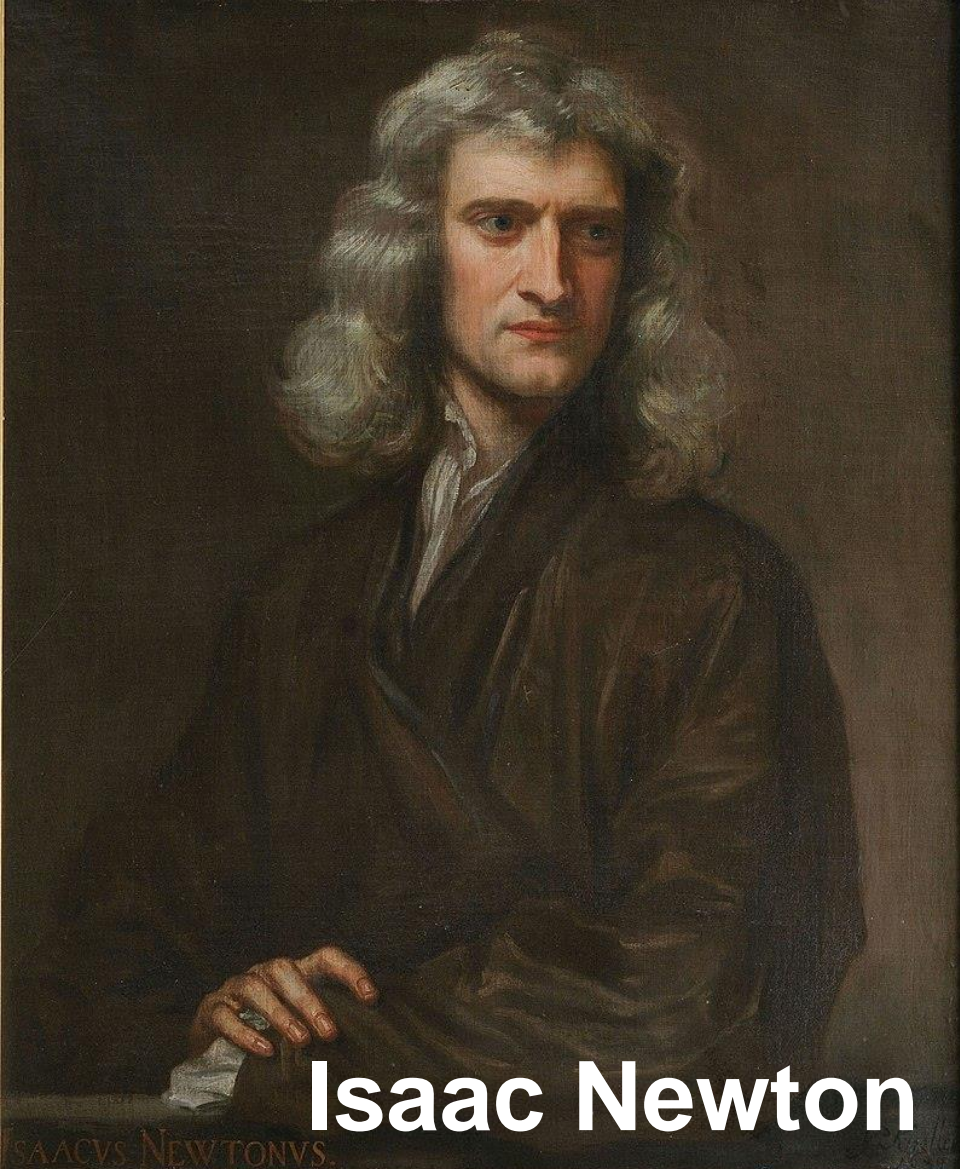
1635 - 1703

1678:  
*ut tensio, sic vis*

"as the extension,  
so the force" or „

the extension is  
proportional to the  
force"



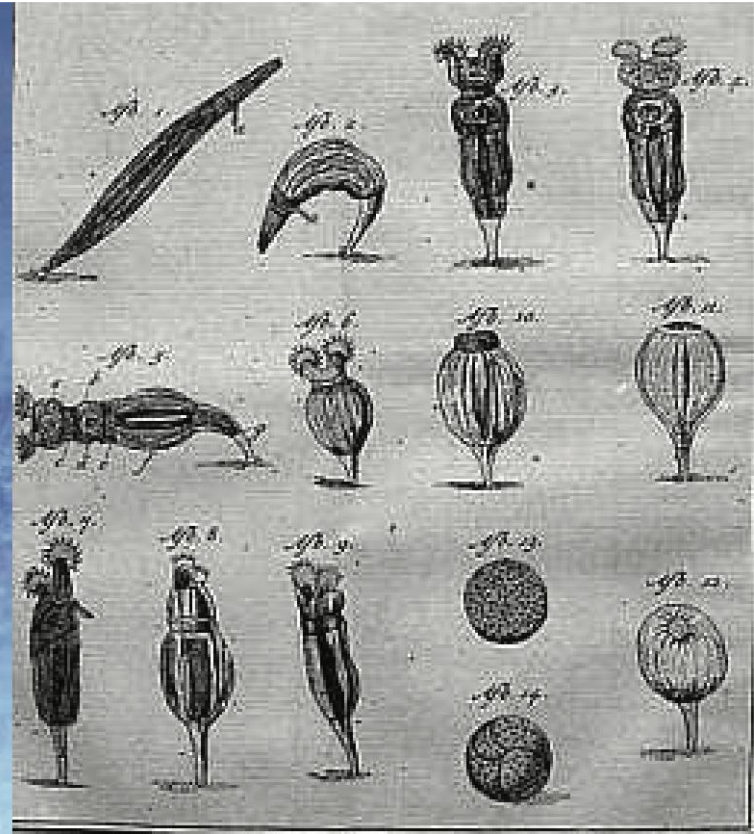


**Isaac Newton**

1643 - 1727



# Antony van Leeuwenhoek



Diaries Diarrhoea

# Animalcules

200x



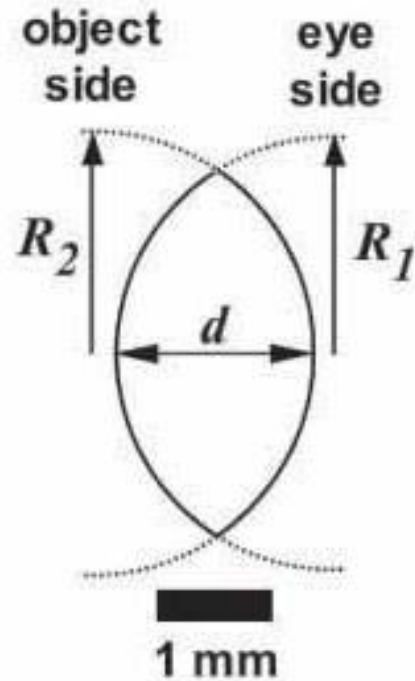
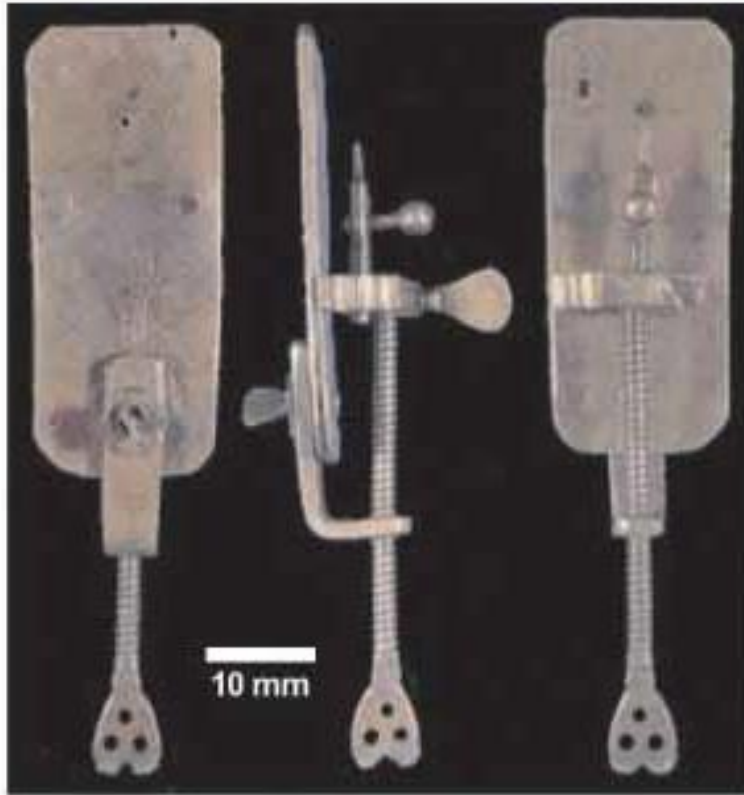
100  $\mu$ m



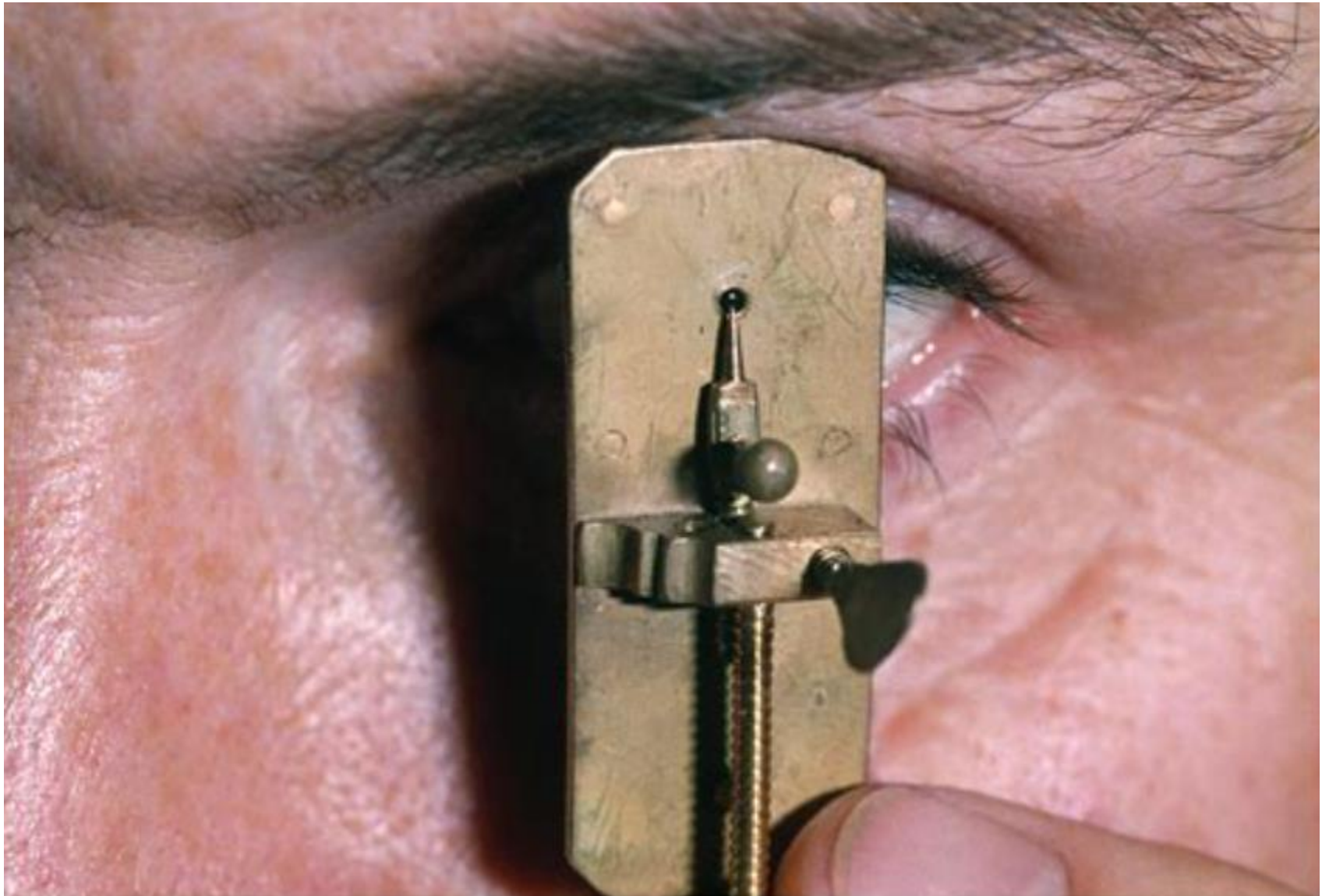
Sperm cells observation helped to abolish the spontaneous generation theory



# Optical Properties of a van Leeuwenhoek Lens



$$M = 117.92$$
$$f = 2.12 \text{ mm}$$
$$R_1 = 1.91 \text{ mm}$$
$$R_2 = 1.96 \text{ mm}$$
$$d = 1.74 \text{ mm}$$
$$n = 1.54$$



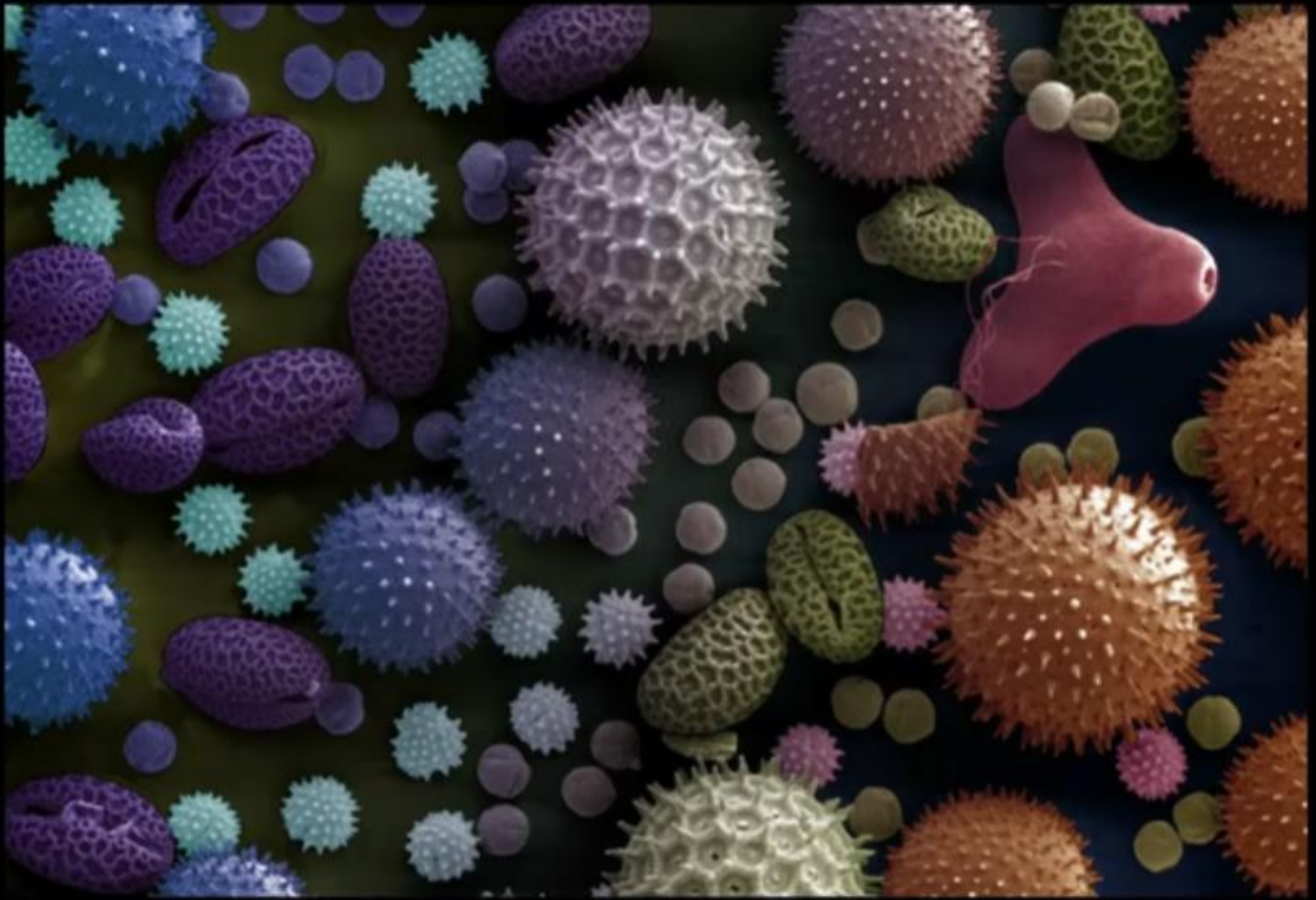


Max Knoll

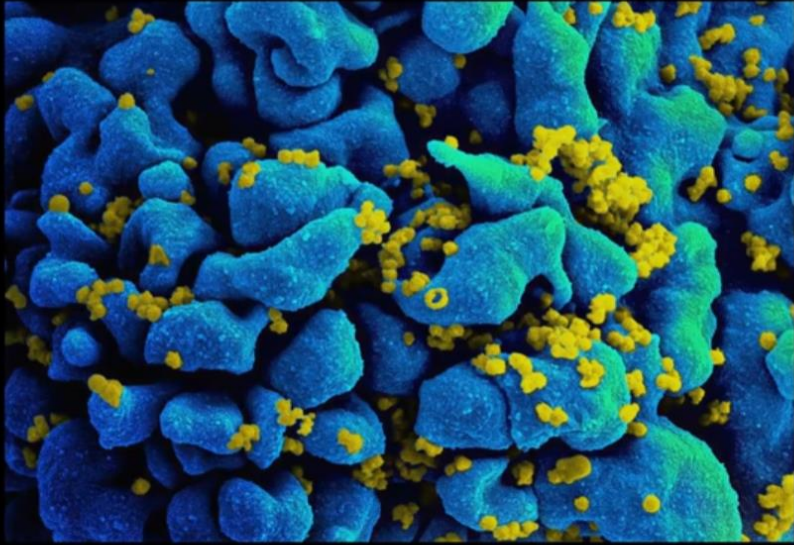


Ernst Ruska

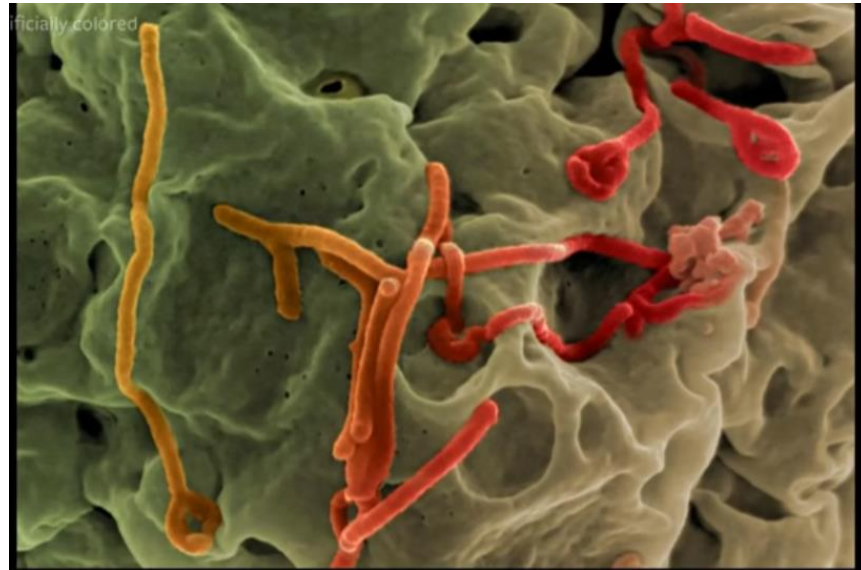




Pollen Grains: Dartmouth Electron Microscope Facility



HIV: National Institute of Allergy and Infectious Diseases

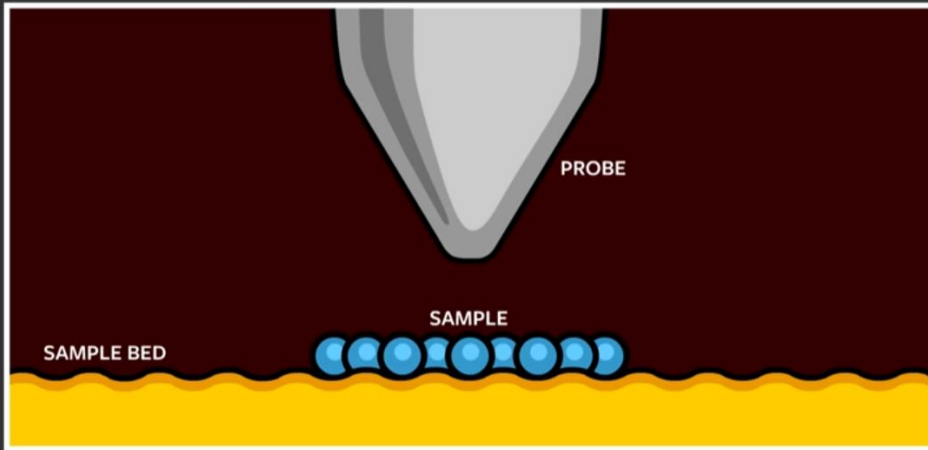


Ebola Virus: National Institute of Allergy and Infectious Diseases



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

# SCANNING PROBE MICROSCOPE



# SILICON ATOMS

(colors assigned artificially)

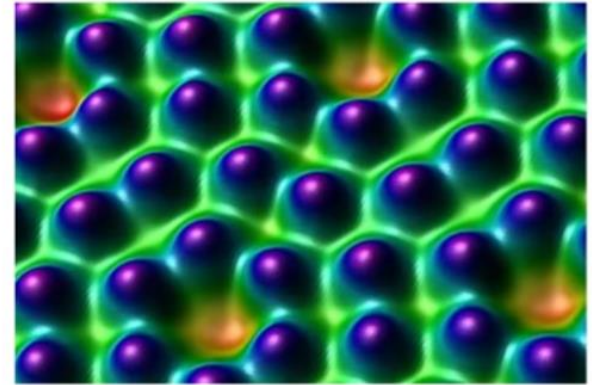
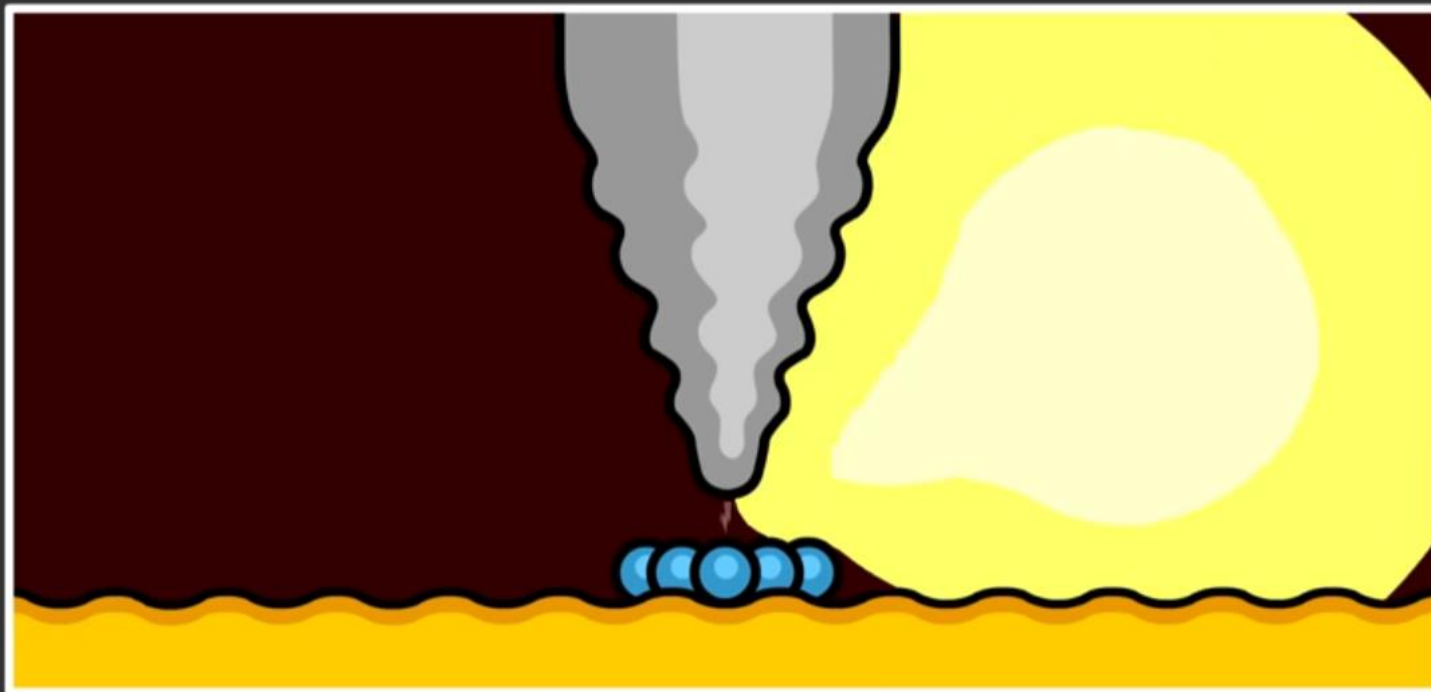


Image produced by lab of Dr. Wilson Ho  
Scanning Tunneling Microscope

Scanning line by line concept.

# Tip-Enhanced Raman Spectromicroscopy



 **CaSTL CENTER**  
Chemistry at the Space-Time Limit



# 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



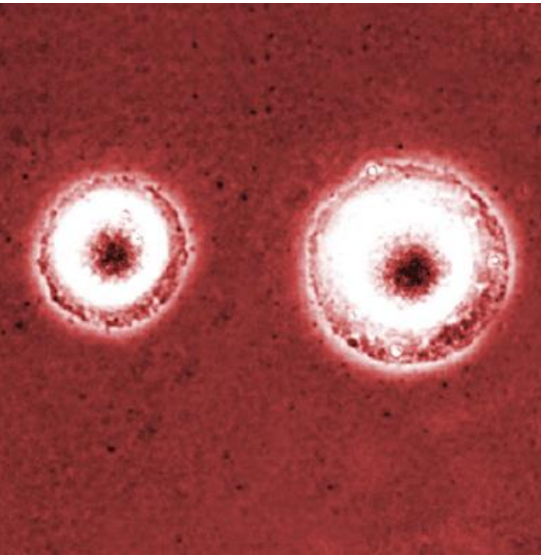
Matthias Jakob Schleiden  
(**botanist**) - German botanist and  
co-founder of the **cell theory**,  
along with Theodor Schwann  
(zoologist/med.) and Rudolf  
Virchow.

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

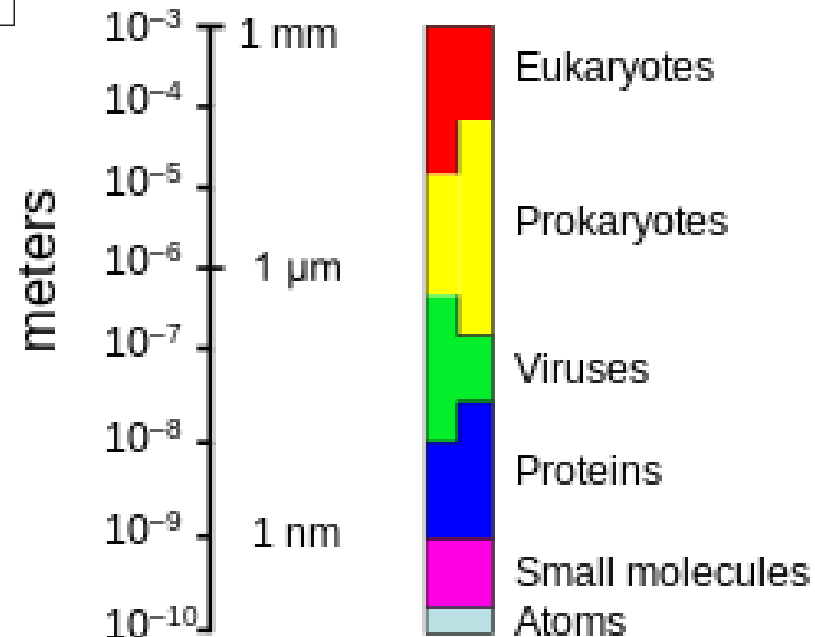


Mycoplasmas (about 0.25 $\mu$ m)

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  $\mu$ m (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

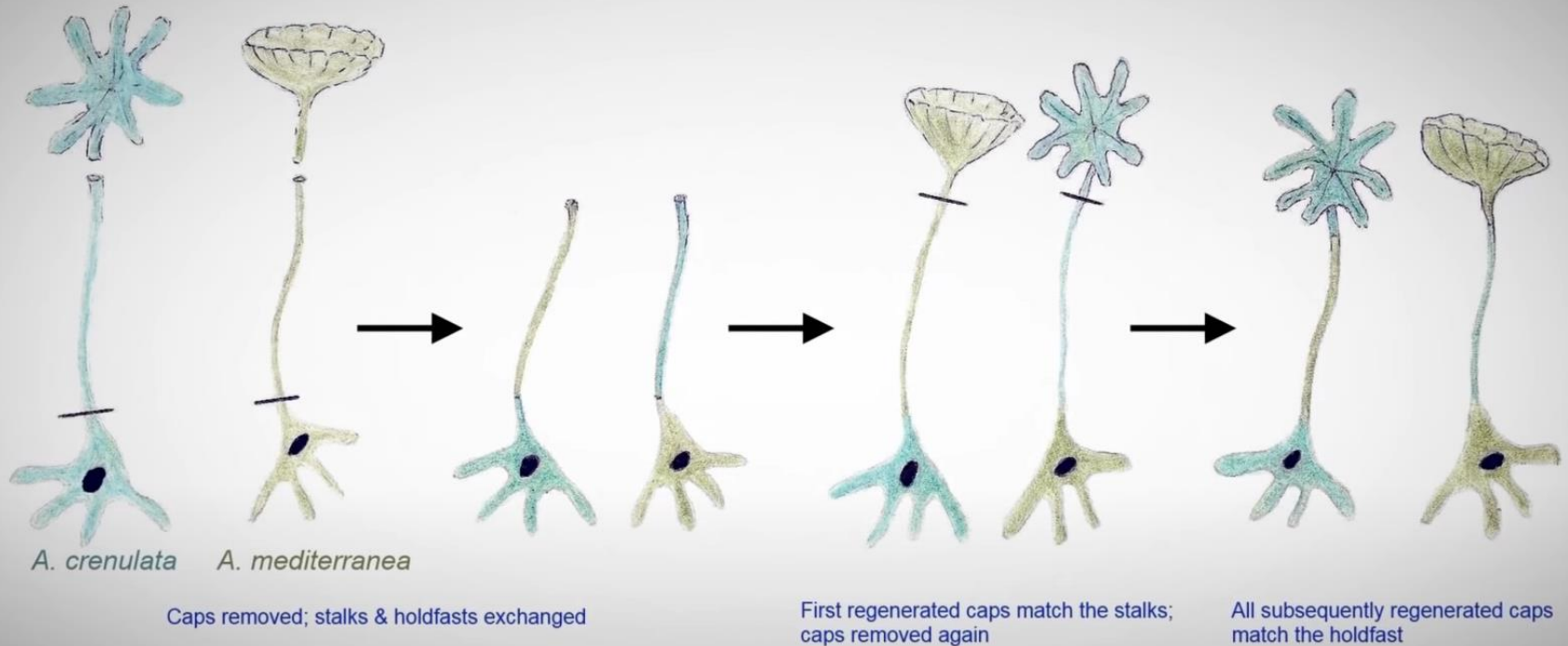
**Habitat:** Shallow, subtropical waters

**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

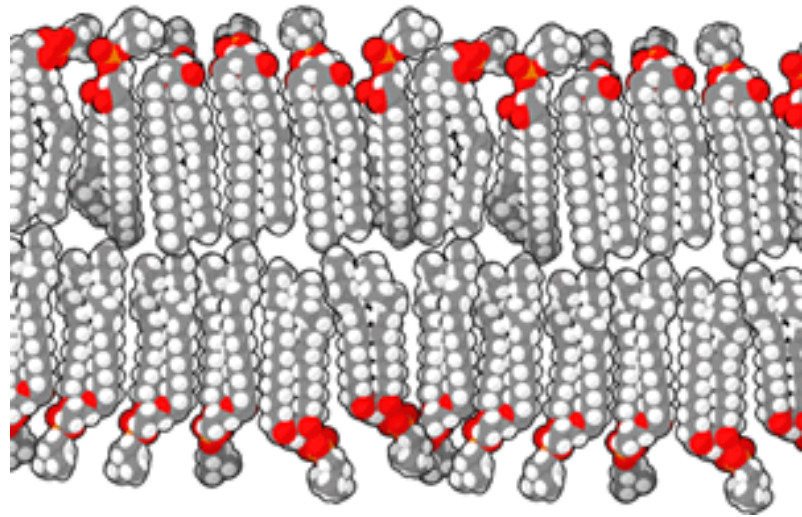
**Habitat:** The Mediterranean Sea

**Year Successfully Bred:** 1980

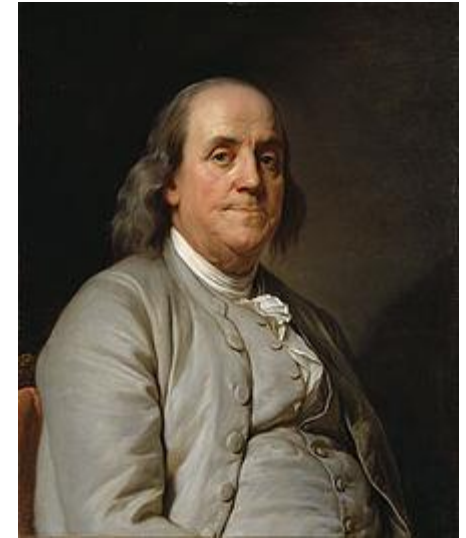
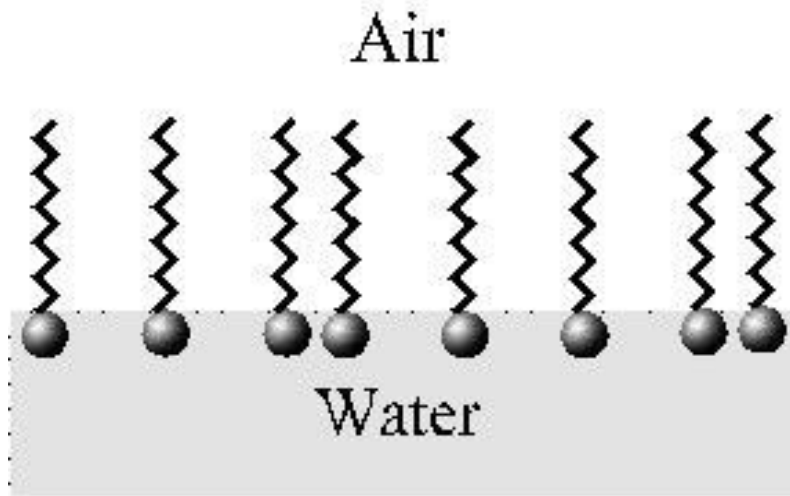


**All large single cell organisms are in water environment**

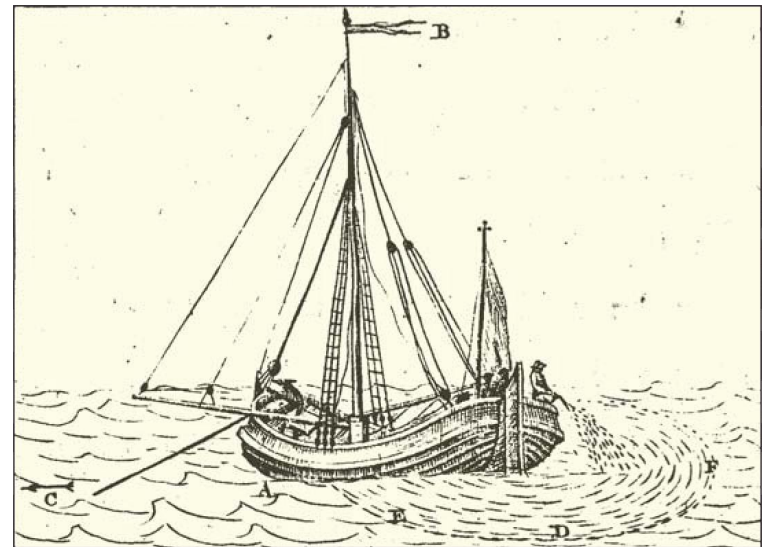
What a Cell needs?



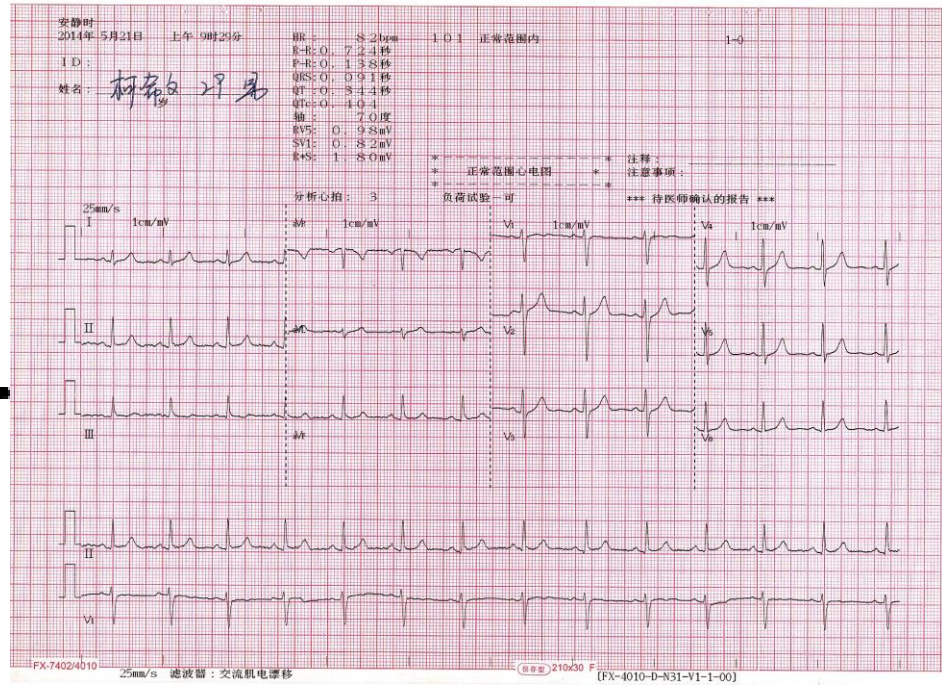
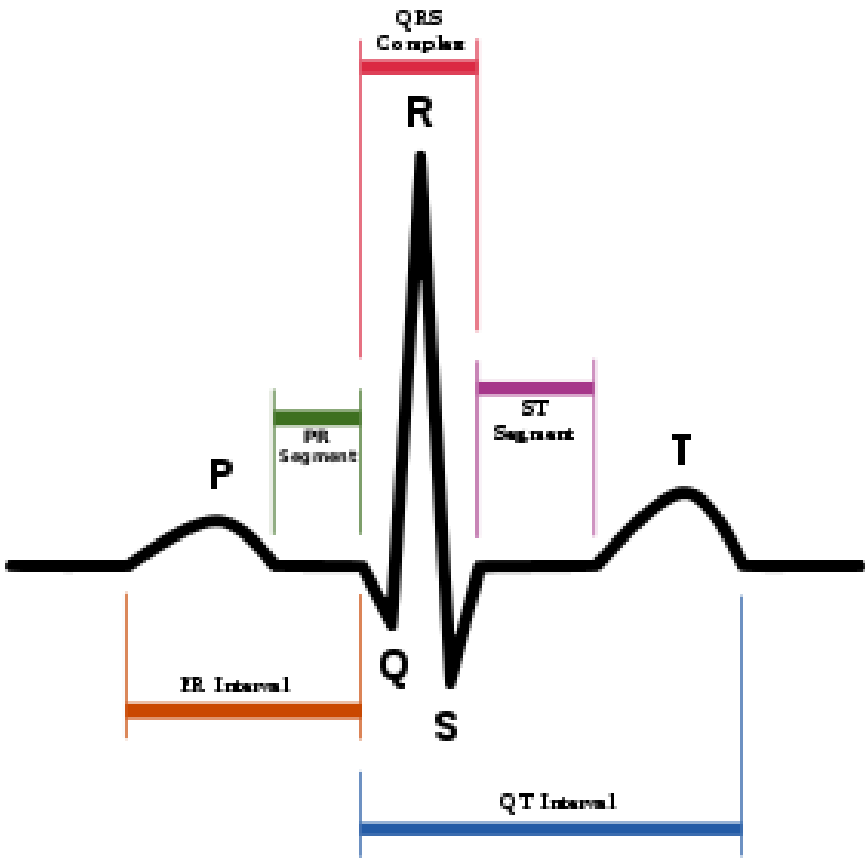
[https://en.wikipedia.org/wiki/Lipid\\_bilayer](https://en.wikipedia.org/wiki/Lipid_bilayer)



Benjamin Franklin



# Electrocardiography

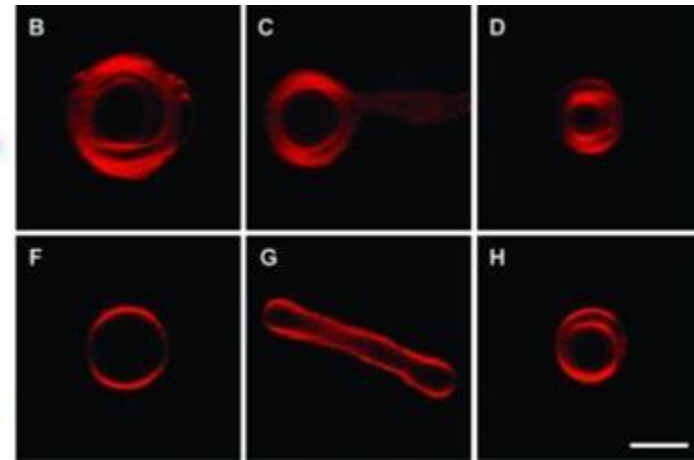
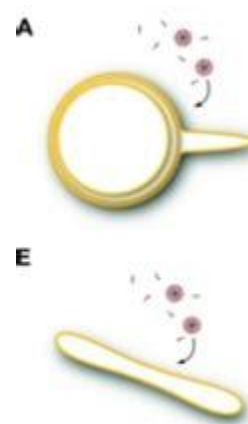
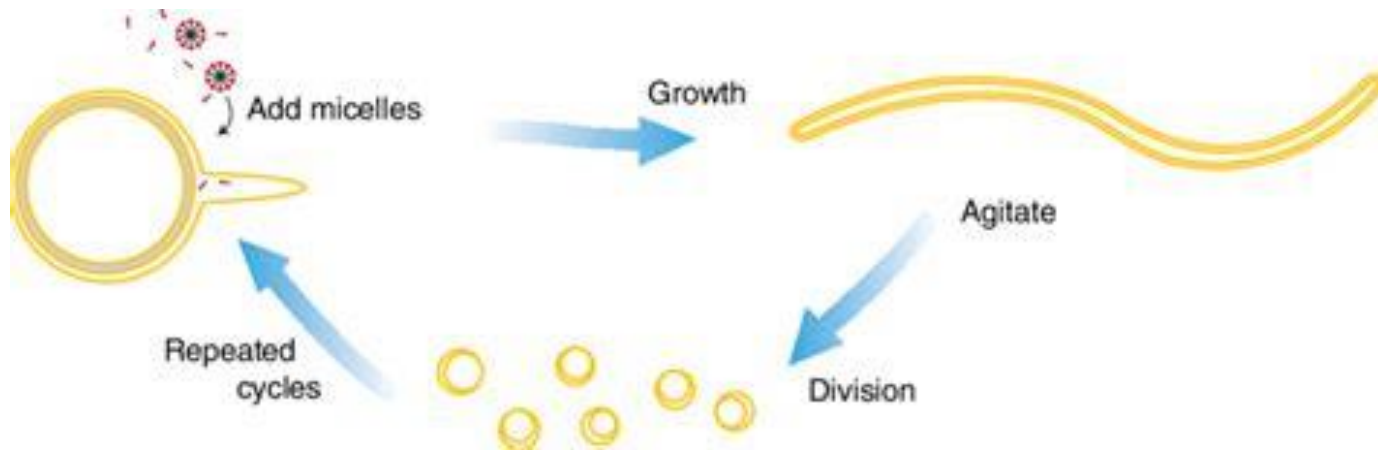


# The (Plant) **Cell** – Vessel for Life

life

the ability to **grow**, ....

# Growth of Membrane



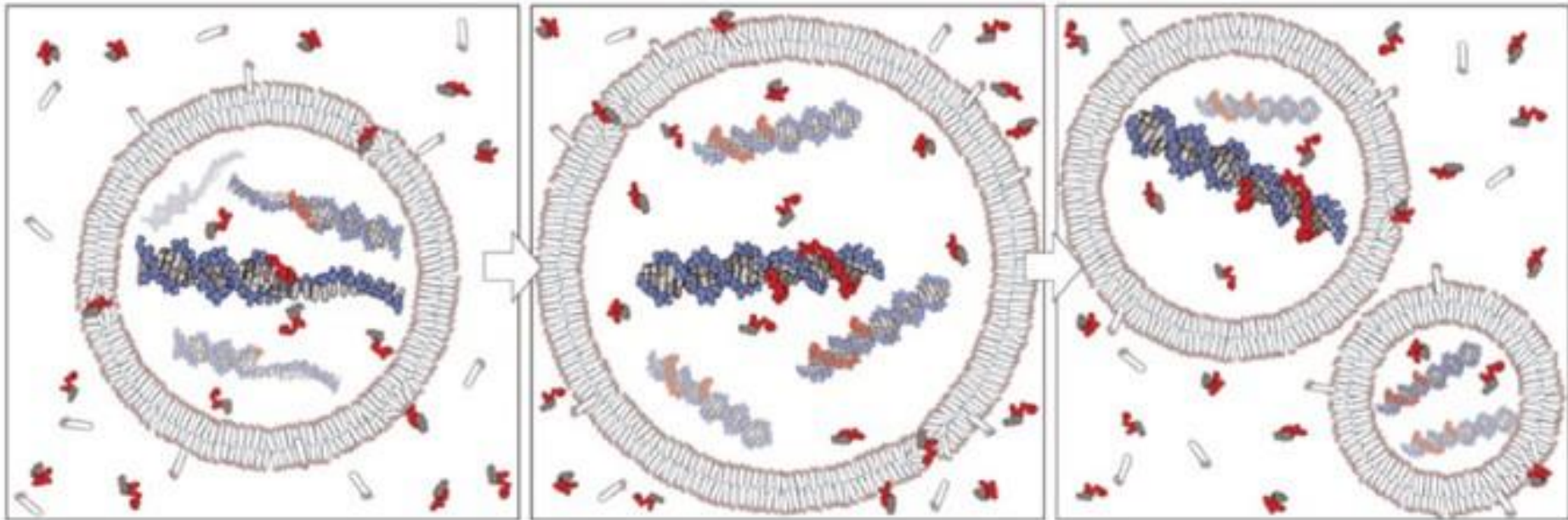
Jack Szostak



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 

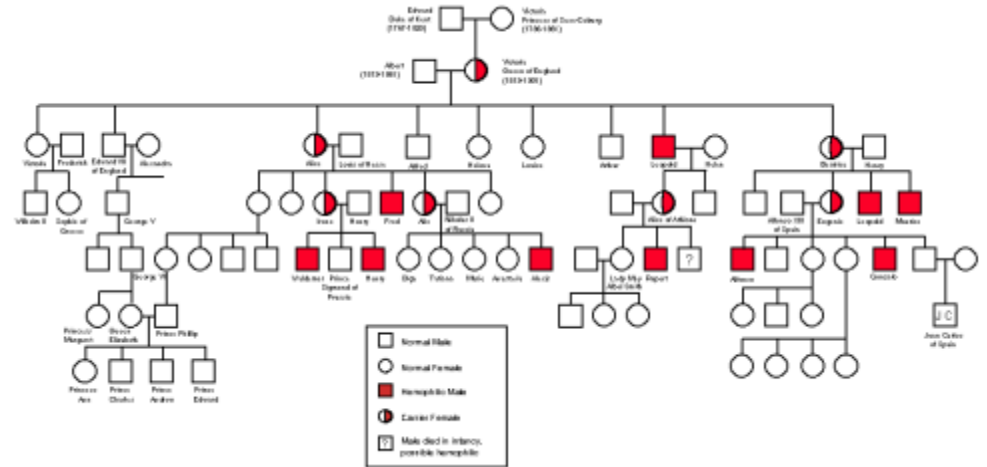
*Nature* **454**, 122–125 (2008) | Cite this article

# 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

**Hynčice** is a little Silesian village, administratively part of [Vražné](#) municipality, located.



Location in the Czech Republic

Coordinates:  49°41'N 16°46'E

<b>Country</b>	 Czech Republic
<b>Region</b>	<a href="#">Moravian-Silesian Region</a>
<b>District</b>	<a href="#">Nový Jičín District</a>
<b>Area</b>	
• Total	5.87 sq mi (15.21 km <sup>2</sup> )
<b>Elevation</b>	899 ft (274 m)
<b>Population (2012)</b>	
• Total	845
• Density	140/sq mi (56/km <sup>2</sup> )
<b>Time zone</b>	CET (UTC+1)
• Summer ( <b>DST</b> )	CEST (UTC+2)

**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**.





## Grandera

*Pisum sativum*

🇨🇵 Hrách setý

🇸🇰 Hrach siaty

🇭🇺 Velőborsó

🇵🇱 Groch zwyczajny

🇭🇷 Vrtni grašak

🇸🇯 Oglatozrnati grah

8058

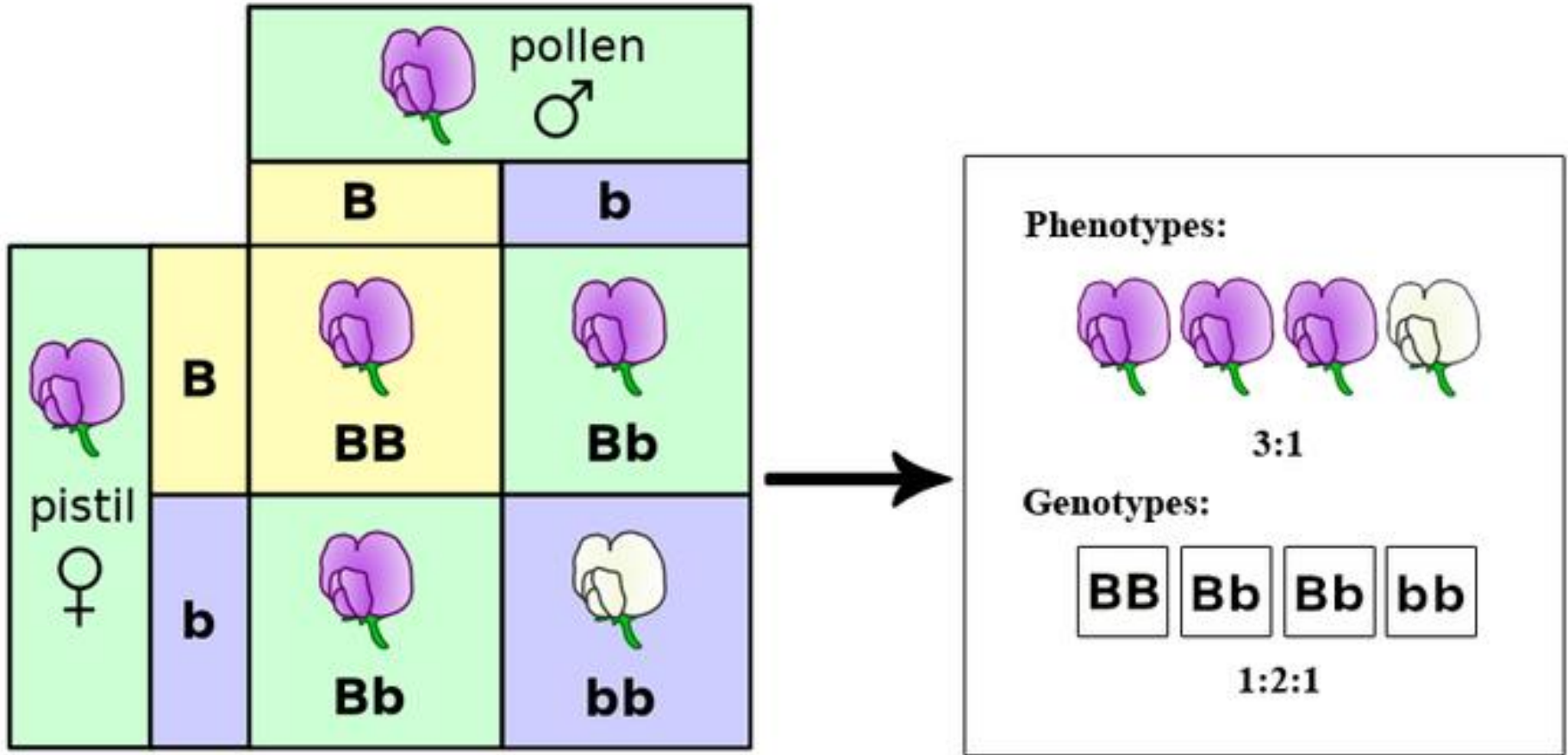
**Profi-Line**



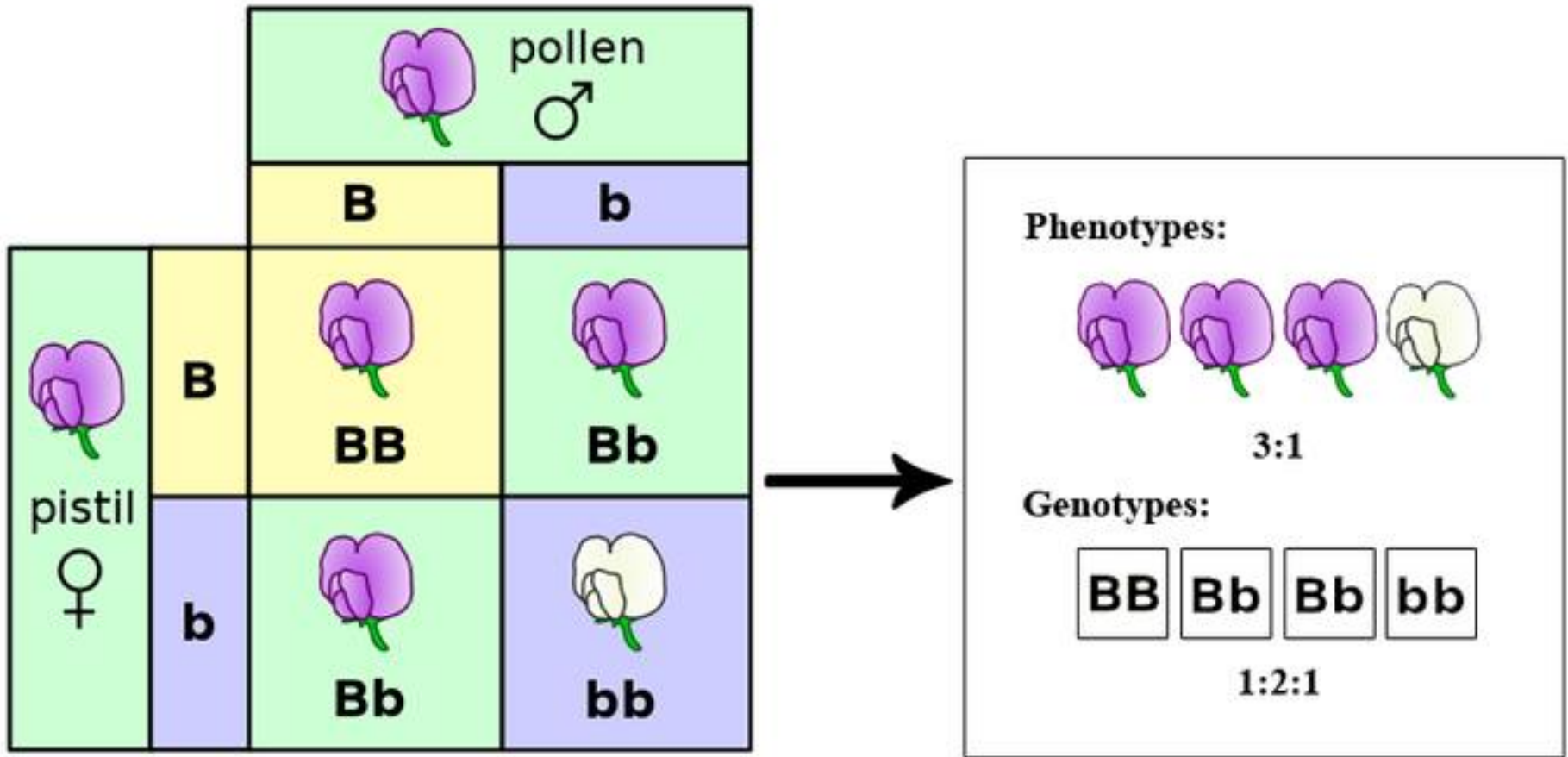
80  
cm







What was the key approach of Mendel?



Establishment of homozygous lines

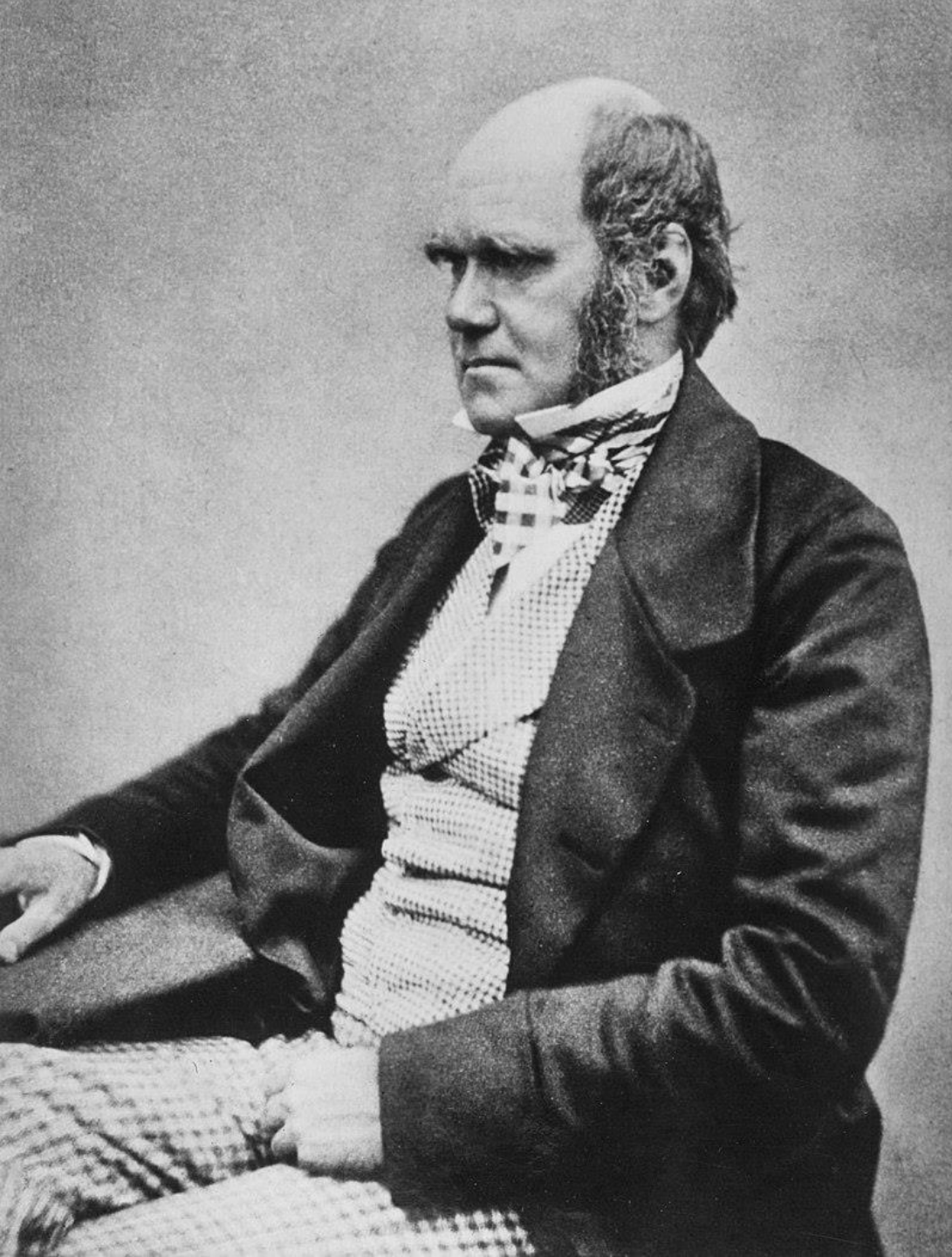
He became a friar because it enabled him to obtain an education **without having to pay for it himself.**

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

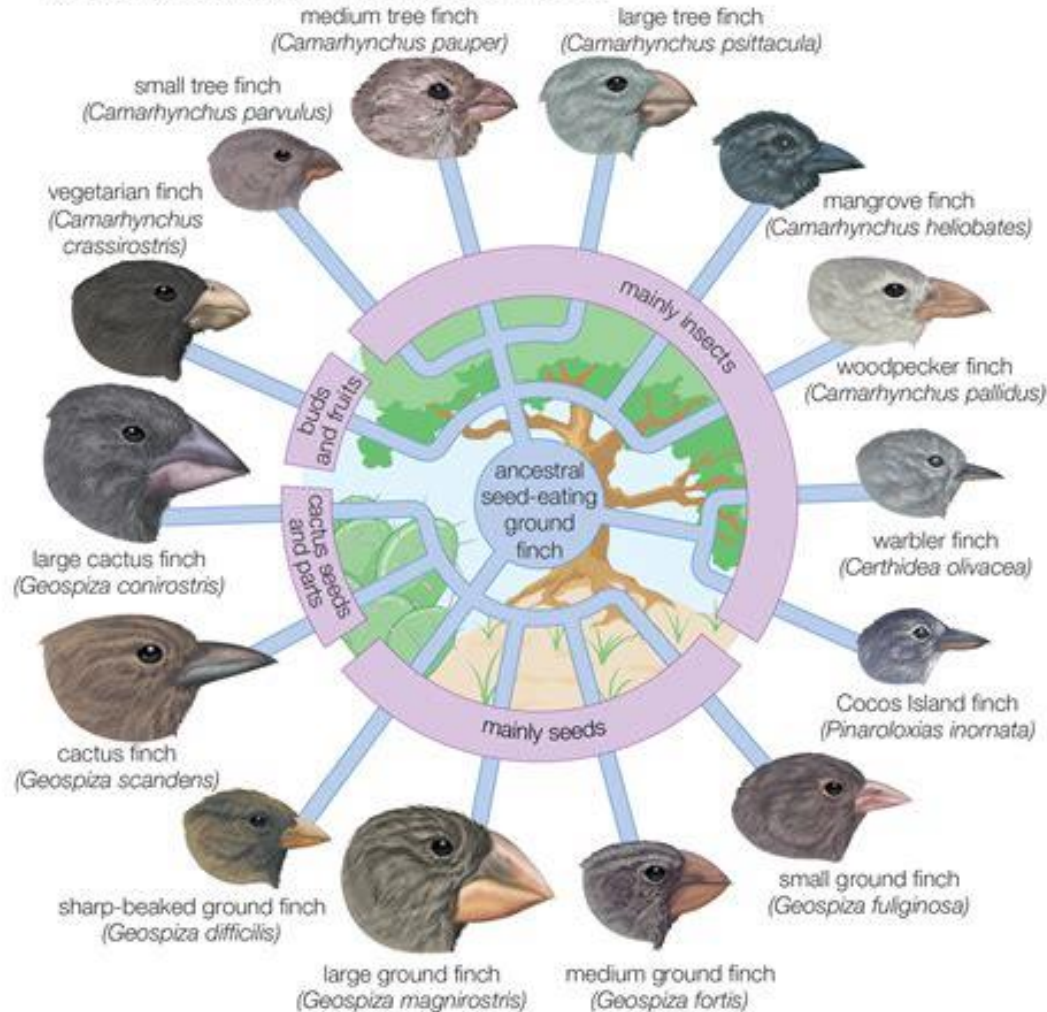


Darwin, c. 1854, when he was preparing *On the Origin of Species* for publication.

1809 - 1882

# Darwin's finches

## Adaptive radiation in Galapagos finches



© 2010 Encyclopædia Britannica, Inc.

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



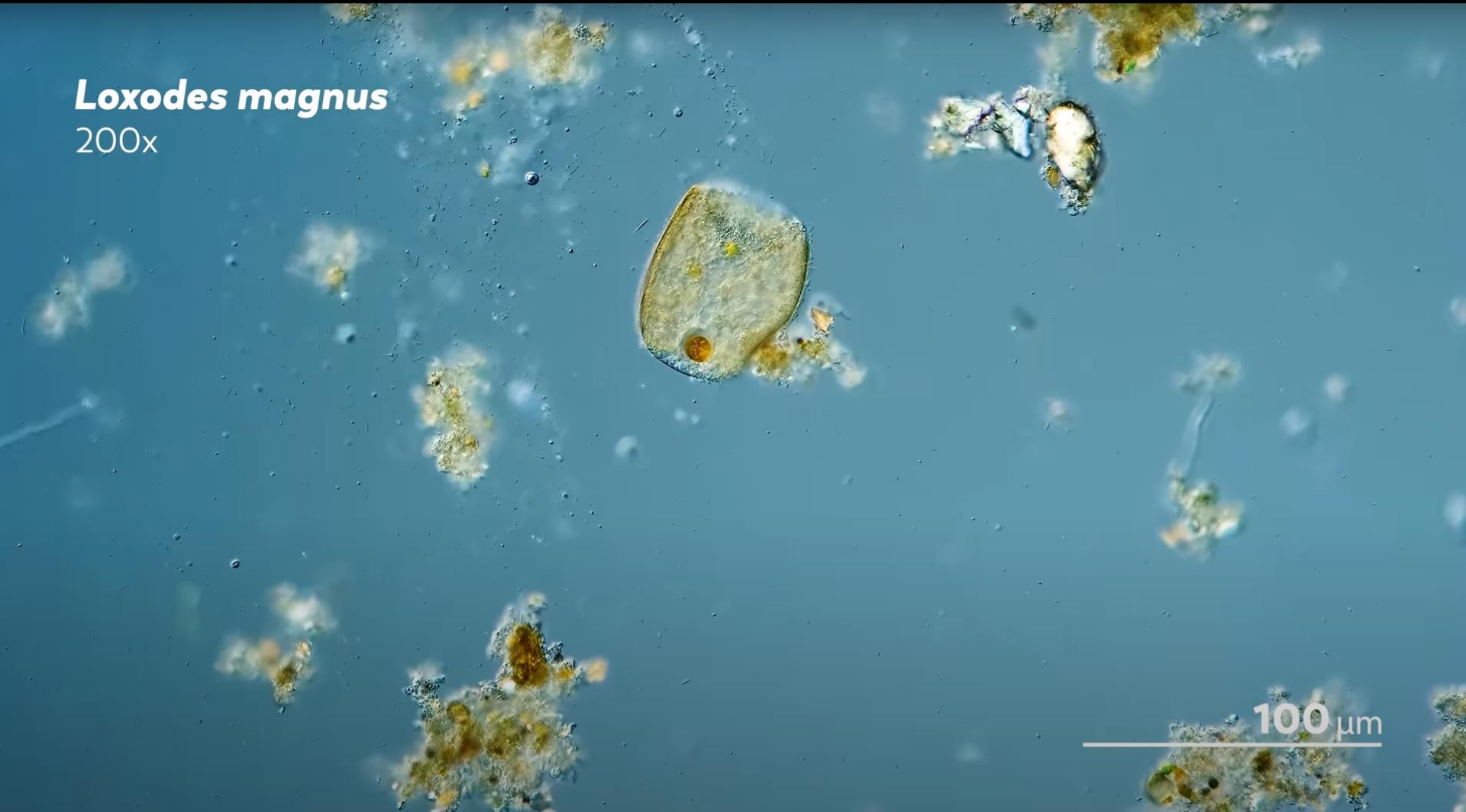
# Life and Death

This Ciliate Is About to Die



***Loxodes magnus***

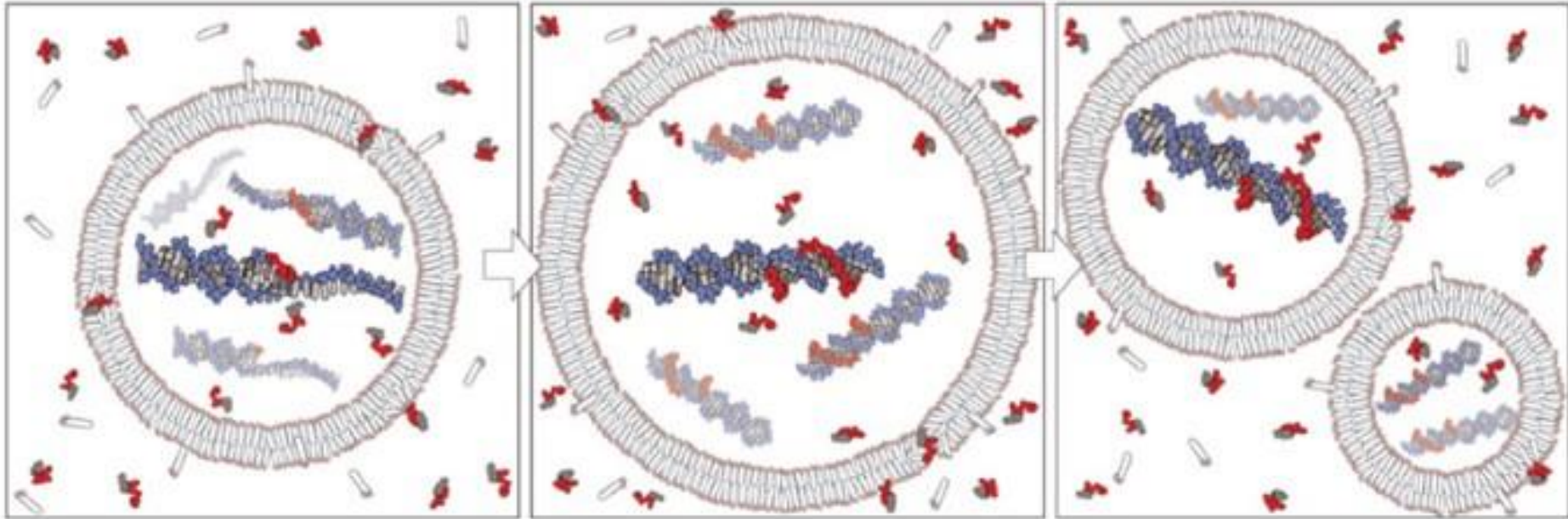
200x



100  $\mu$ m

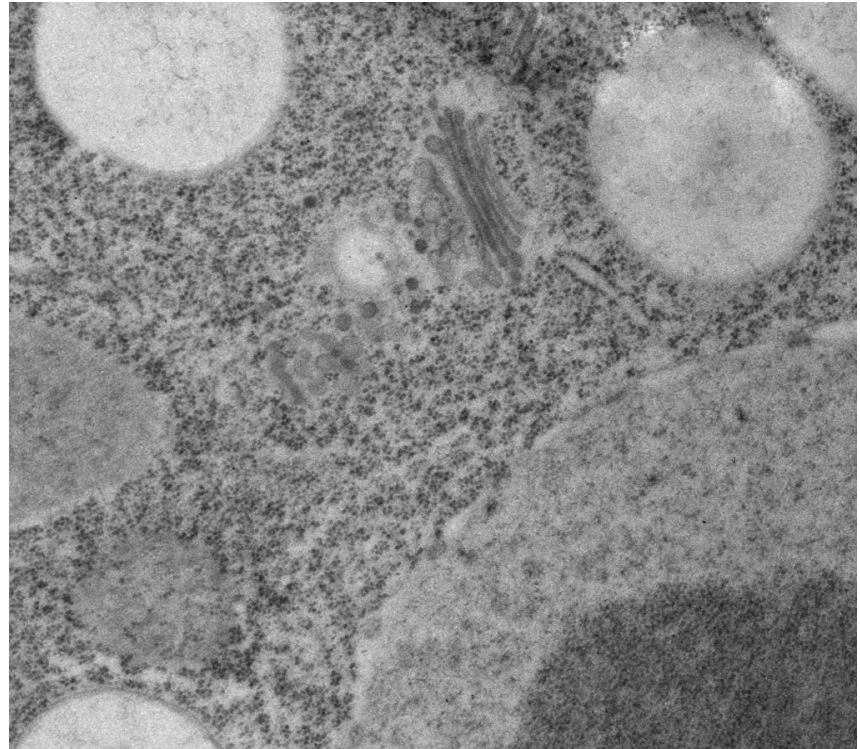
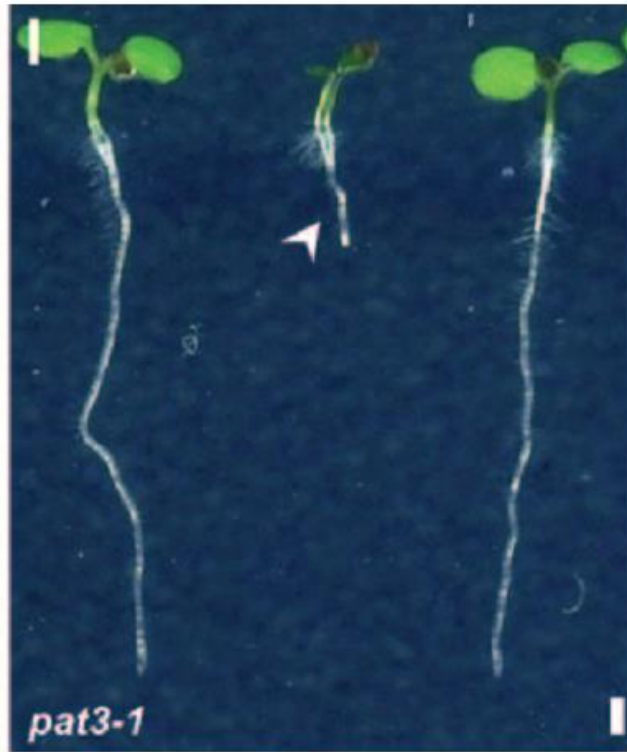
# Journey to the Microcosmos

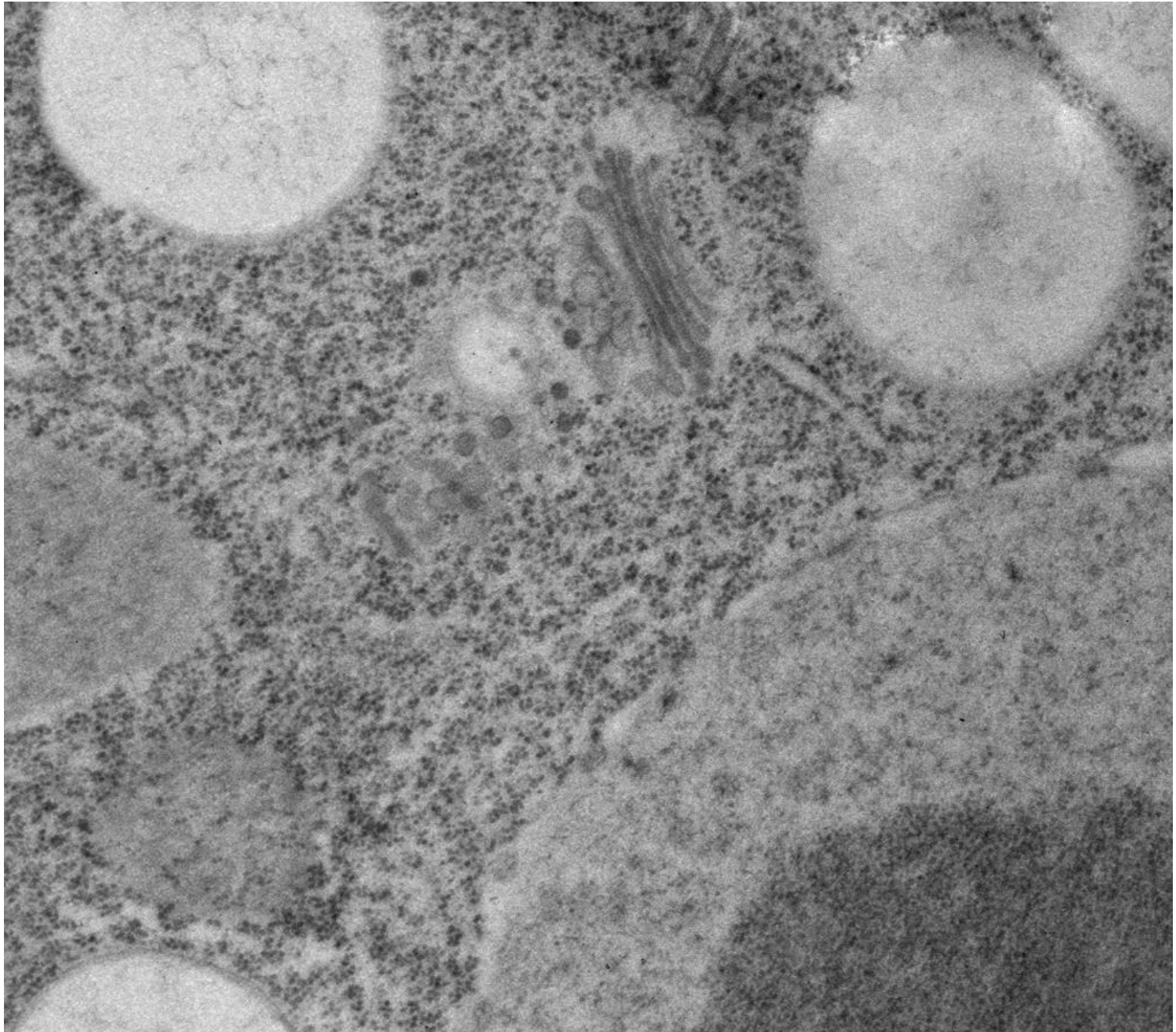
# Preservation of information.

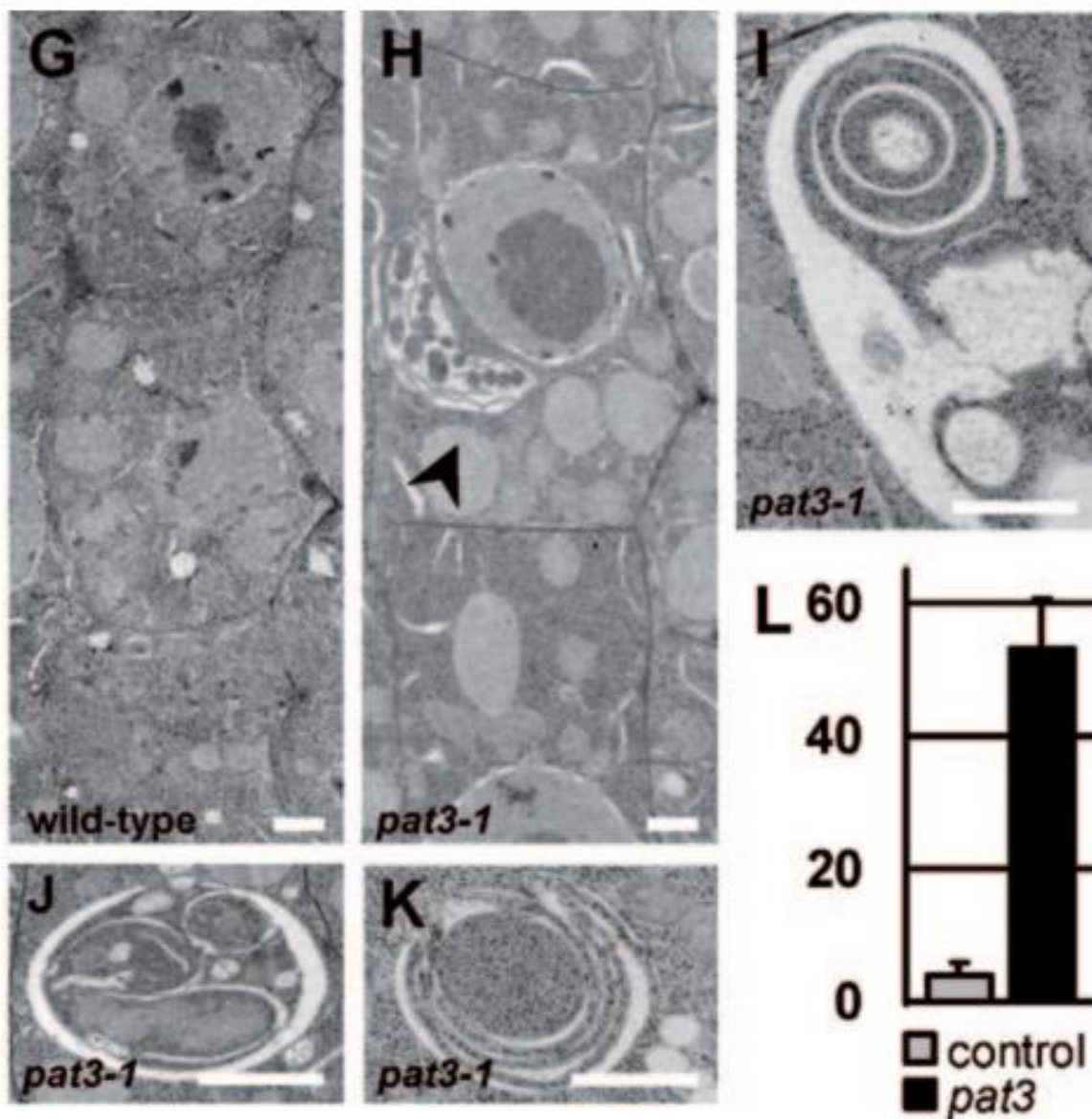


**Inside-cell Sub-structures to help**

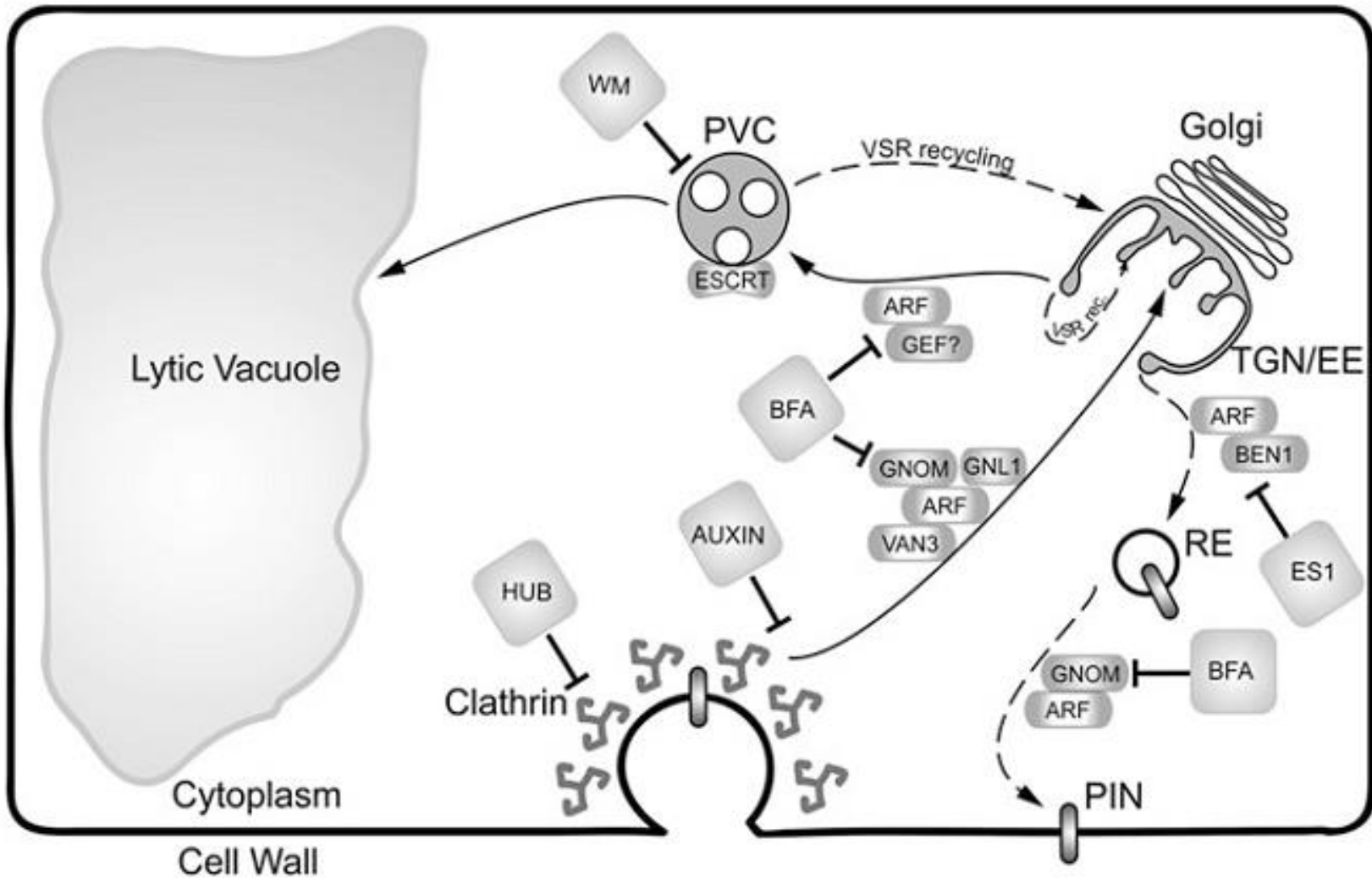
# Cell biology (subcellular structures)



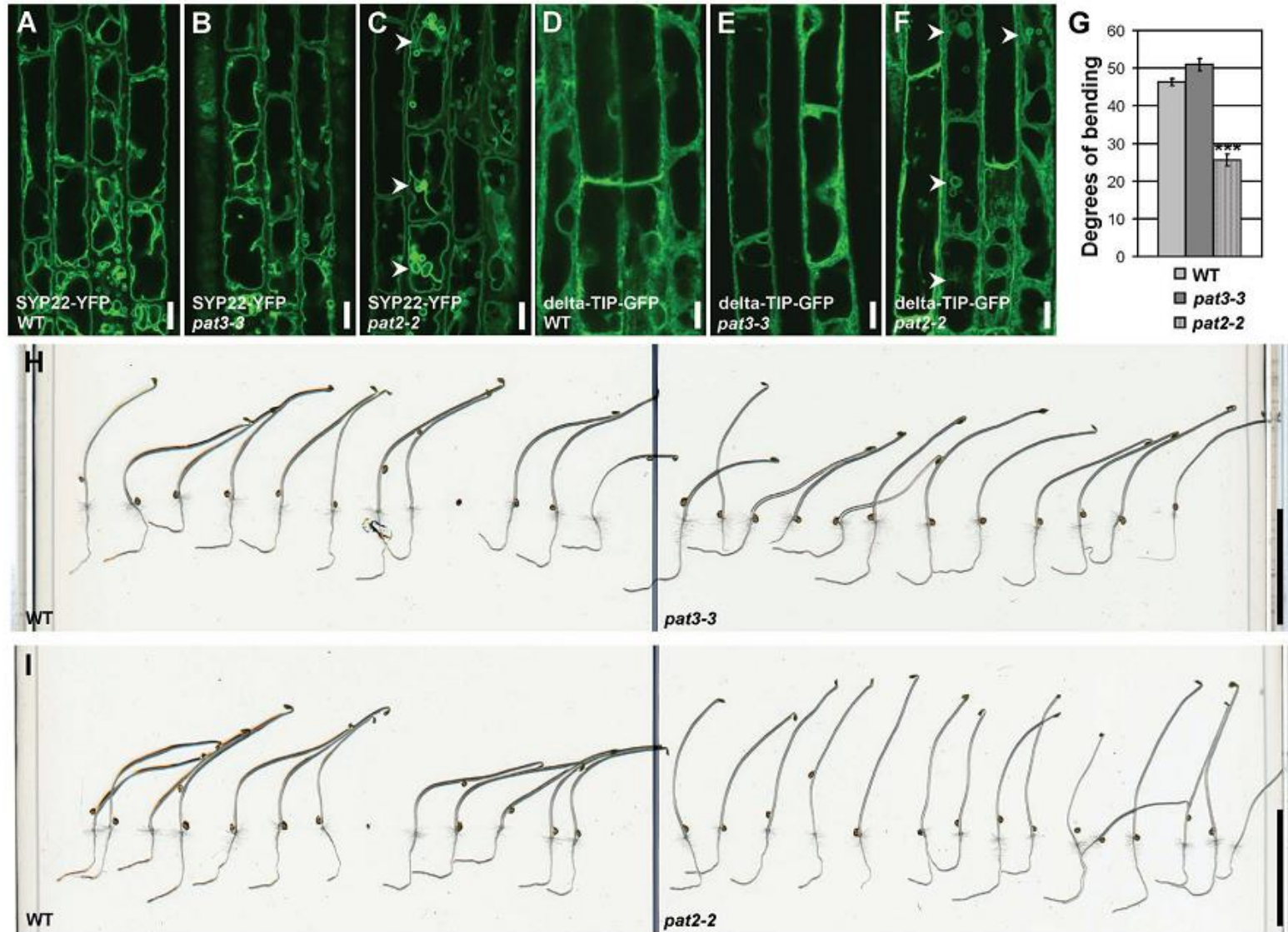




# Intracellular trafficking

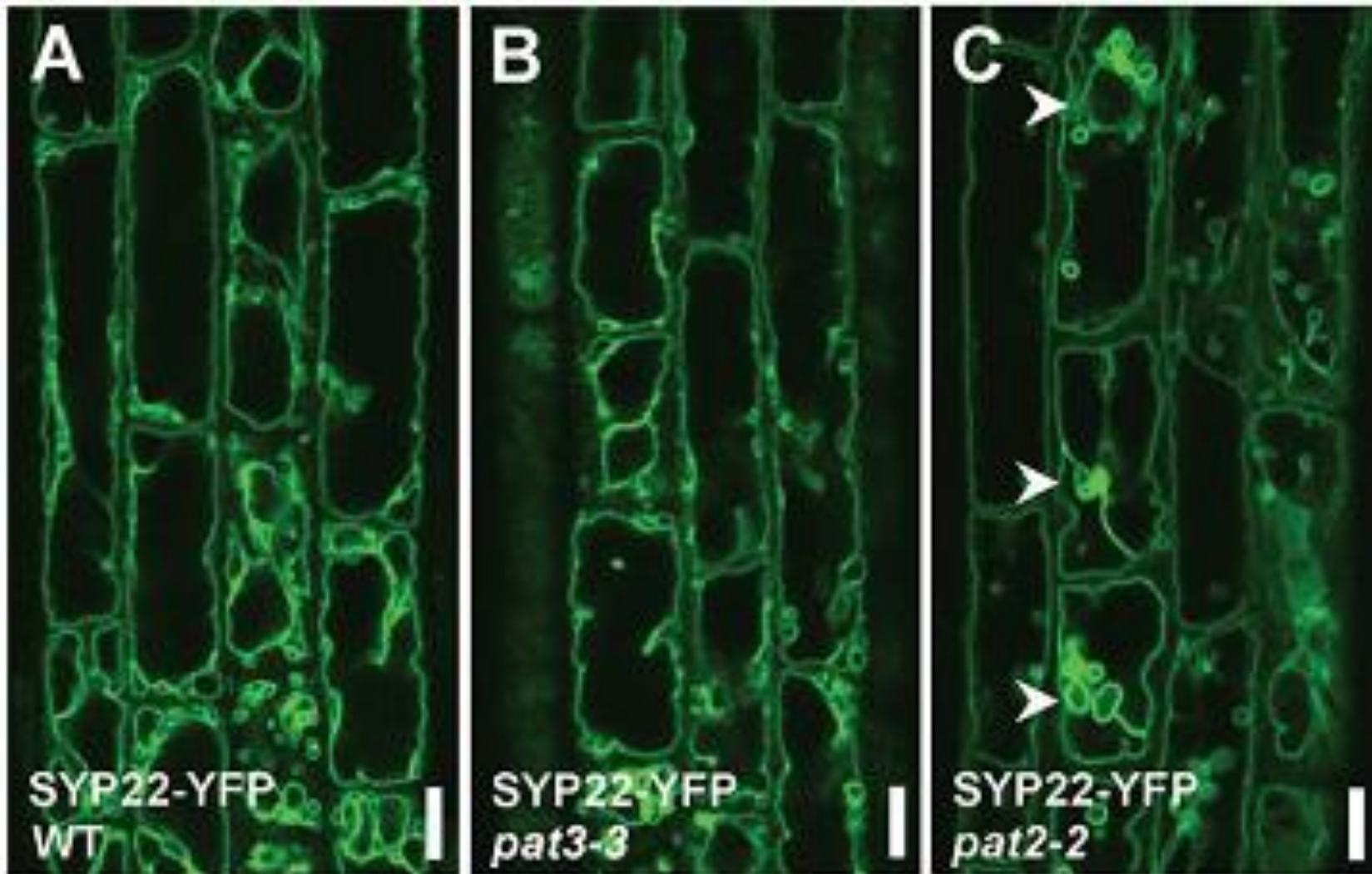


# Vacuolar mutants have problems with hypocotyl bending



Vacuole role in plant turgor

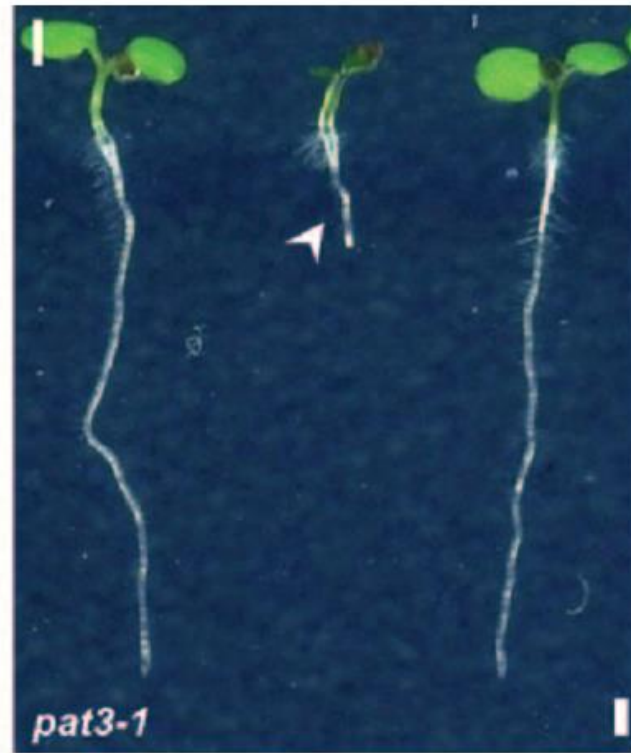
Complex cell biology phenotypes remain a quantification **challenge**..



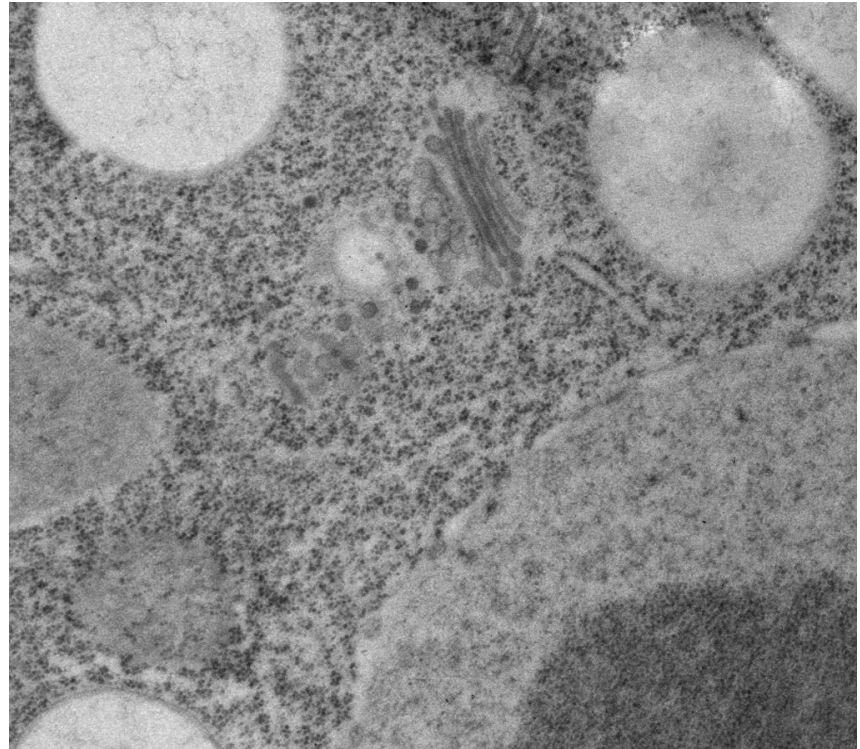
Can Informatics help..?



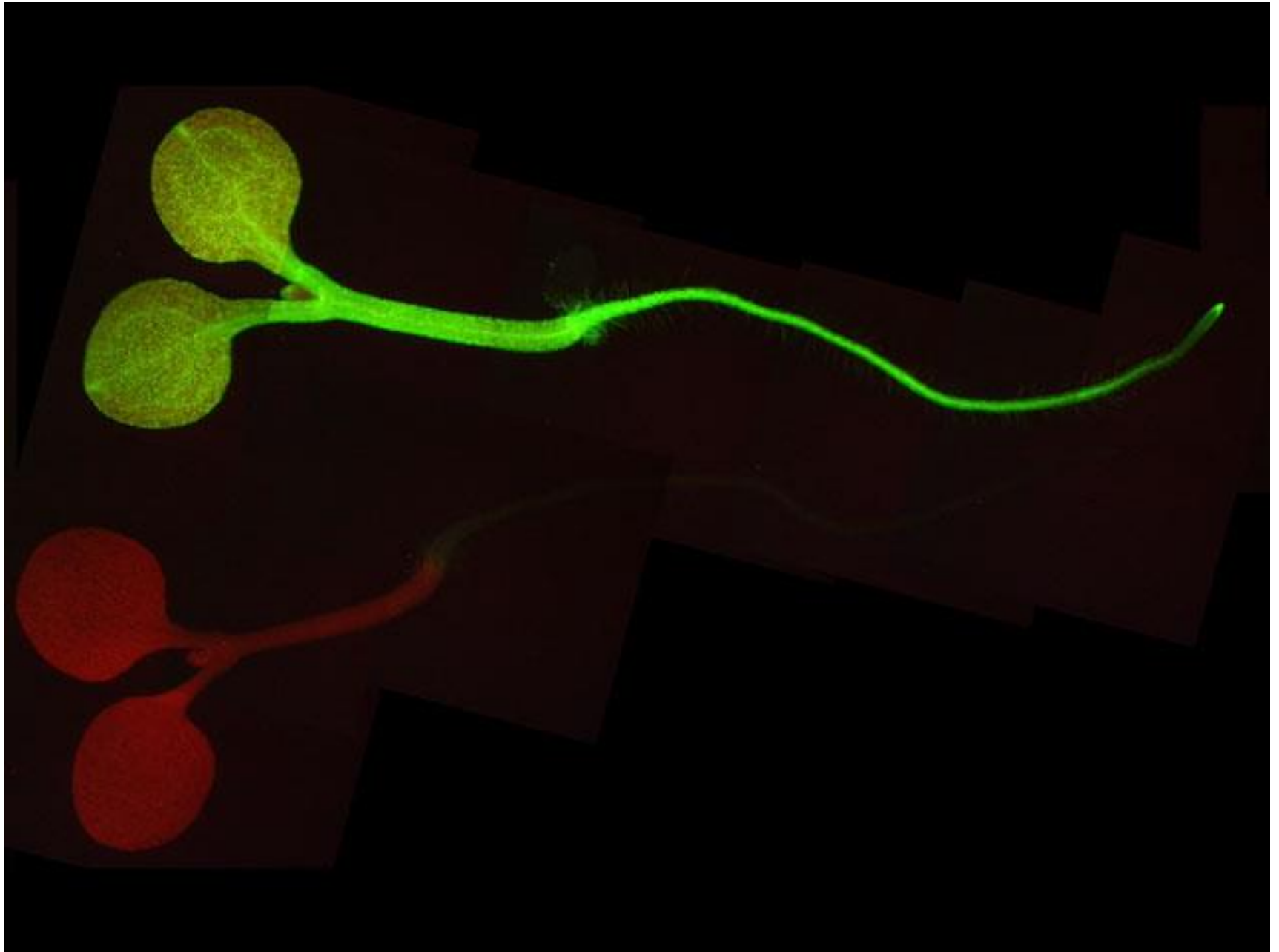
# Storage Vacuole role in Germination



MS-/no sugar



# Green Fluorescence Protein





## *Bioluminescence in Aequoria victoria*

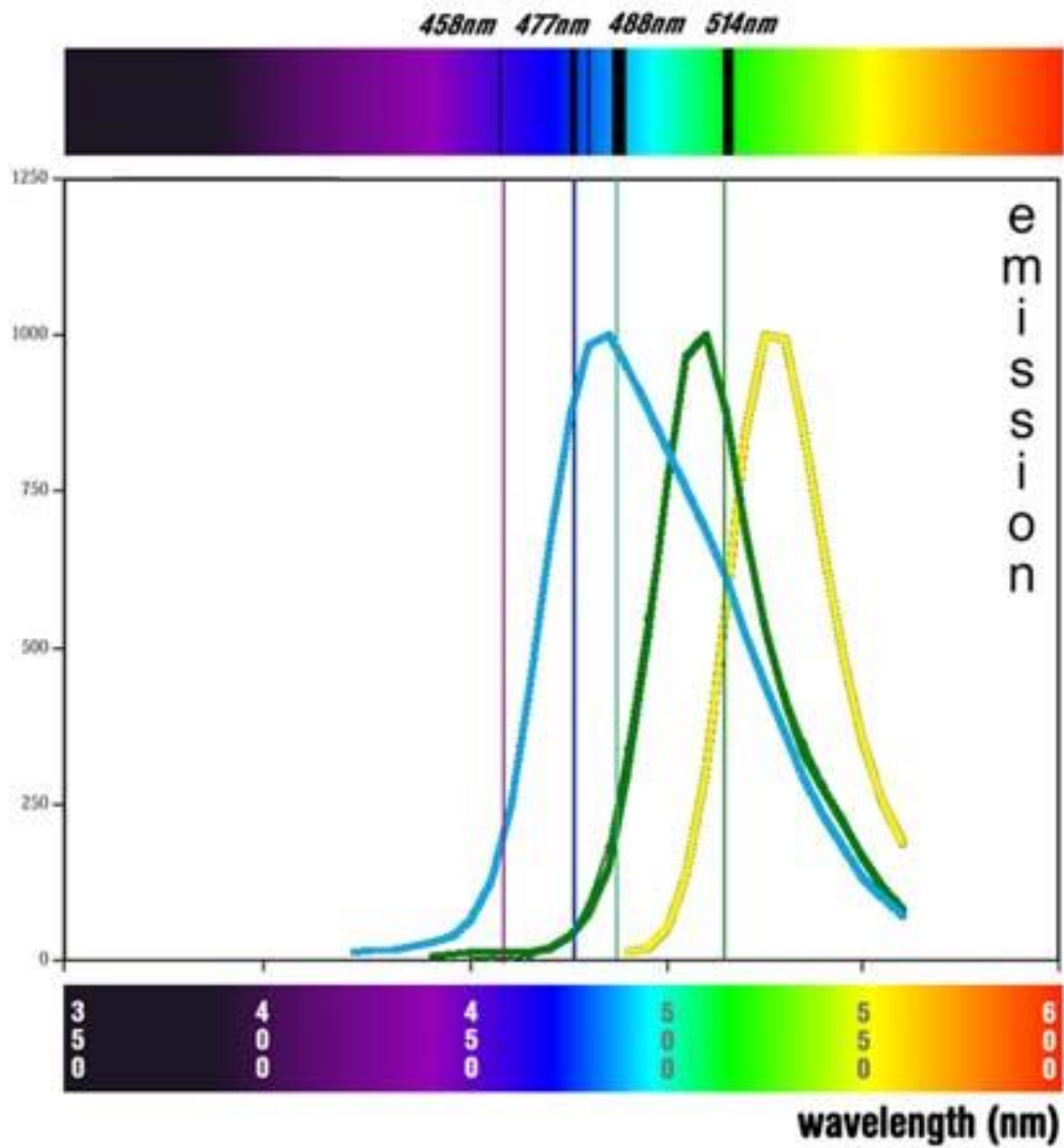
Ca<sup>2+</sup>

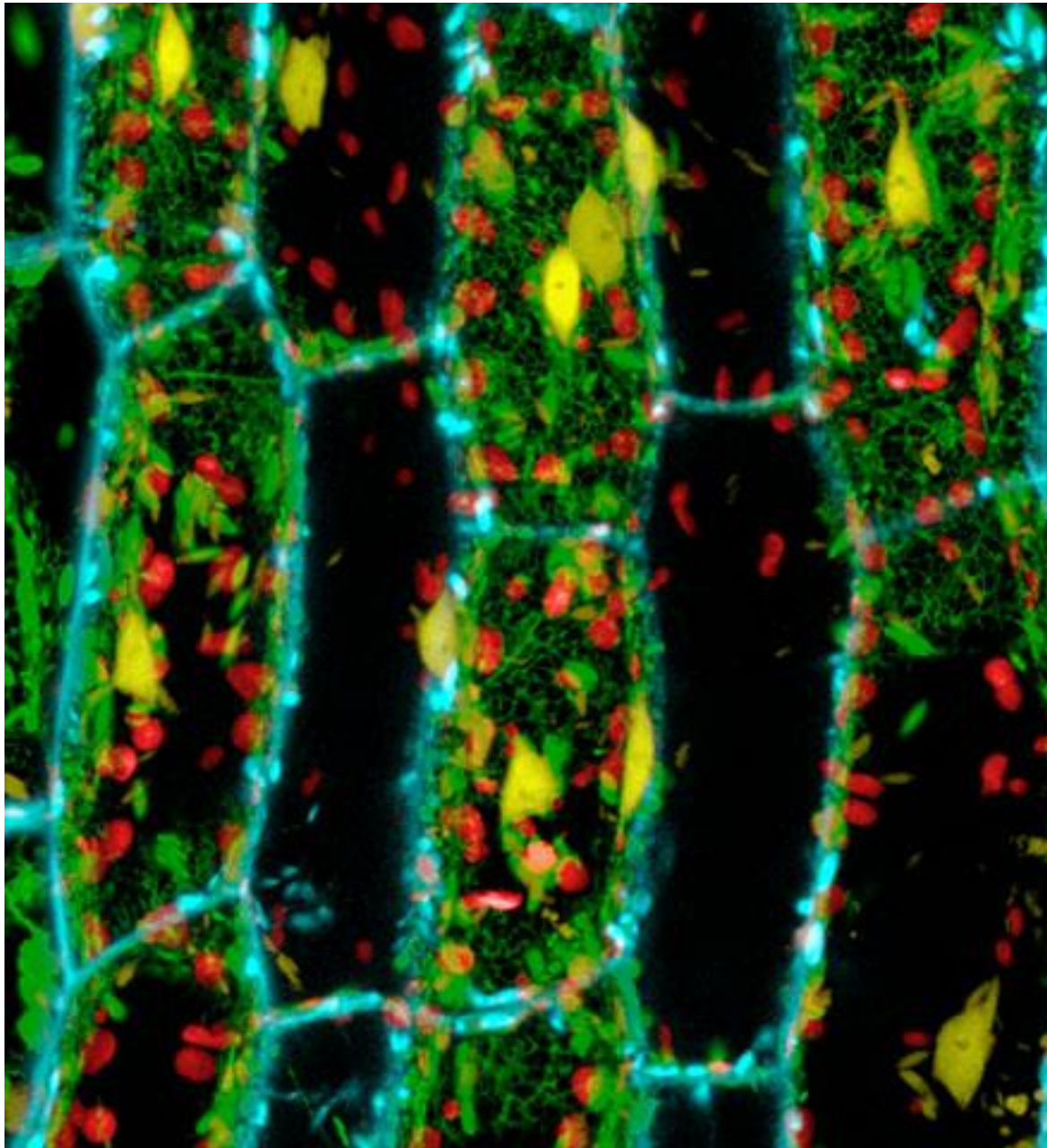


*aequorin*



*green fluorescent protein*





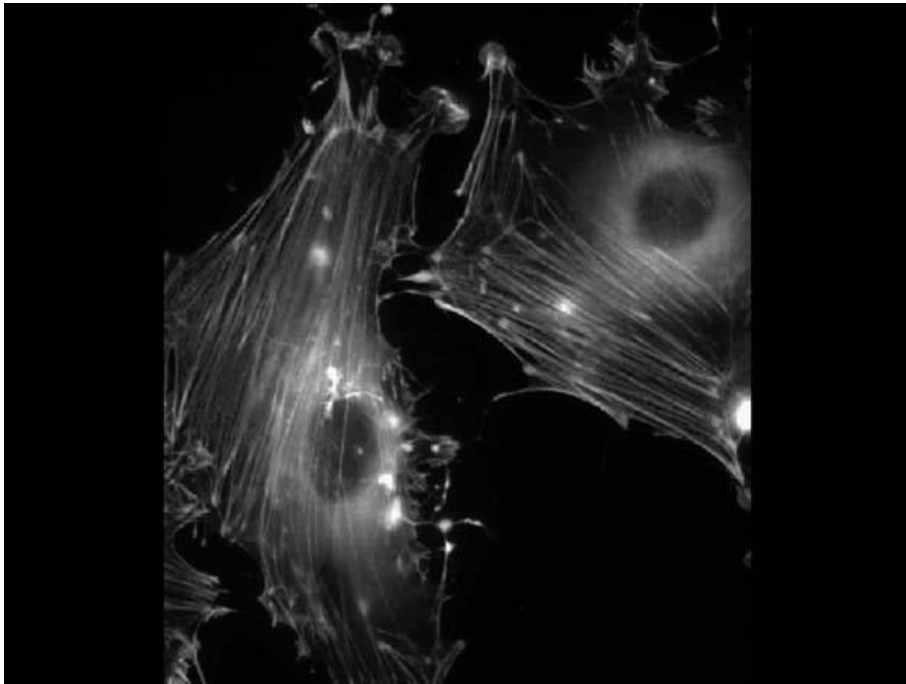
**Multi-spectral  
Imaging with:**

**Extensin-CFP  
GFP-ER**

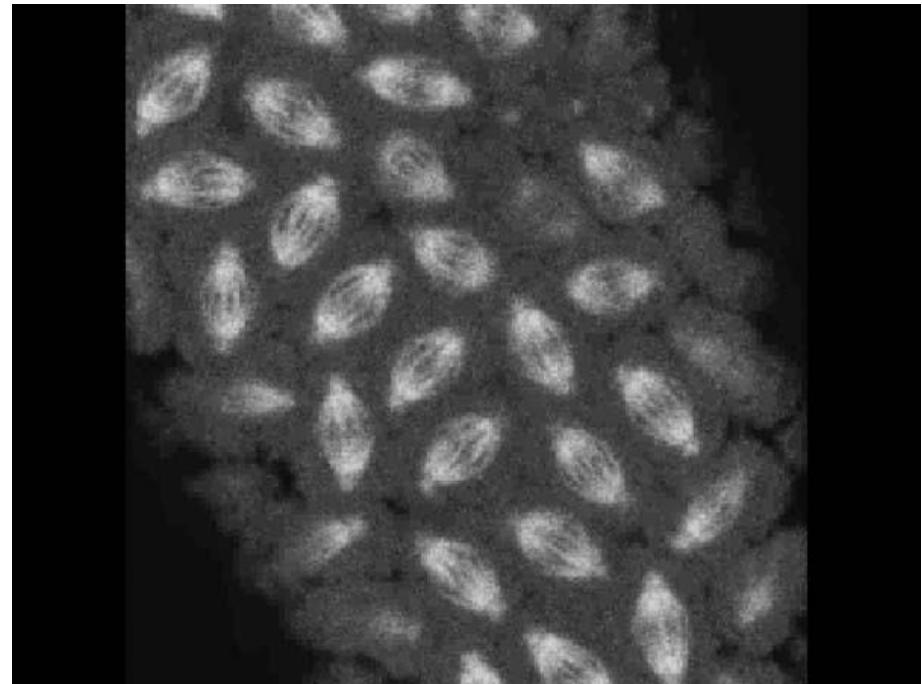
**Histone2b-YFP  
Chloroplasts**

# Subcellular structure markers

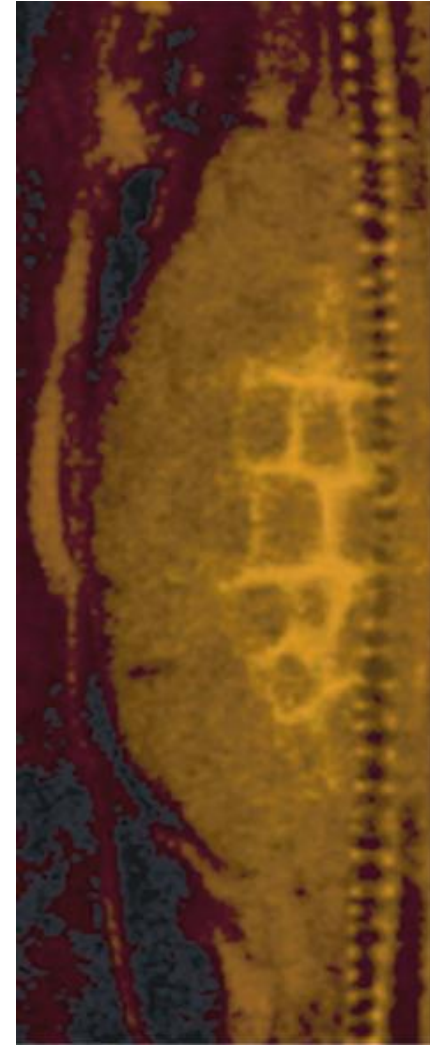
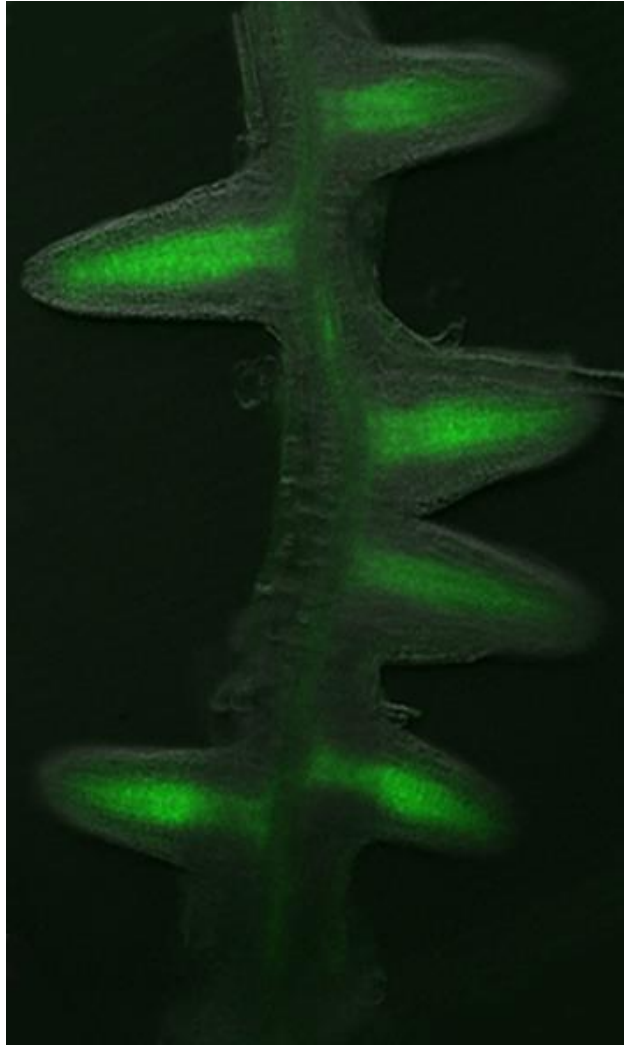
Actin



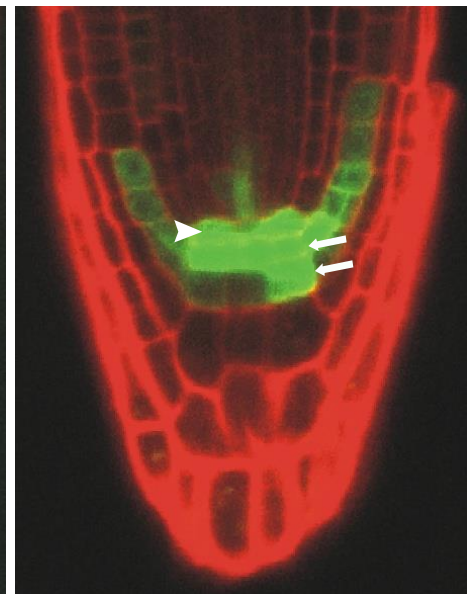
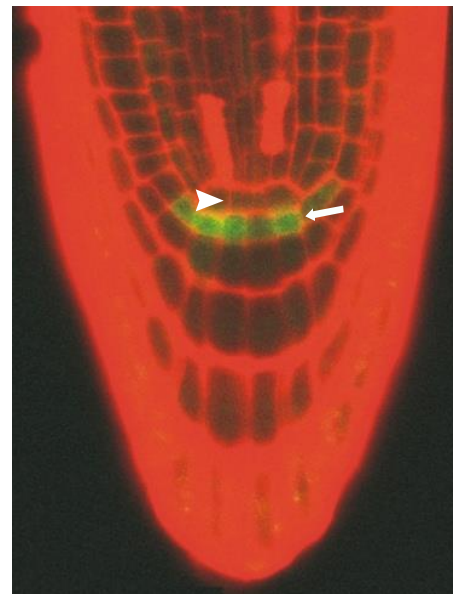
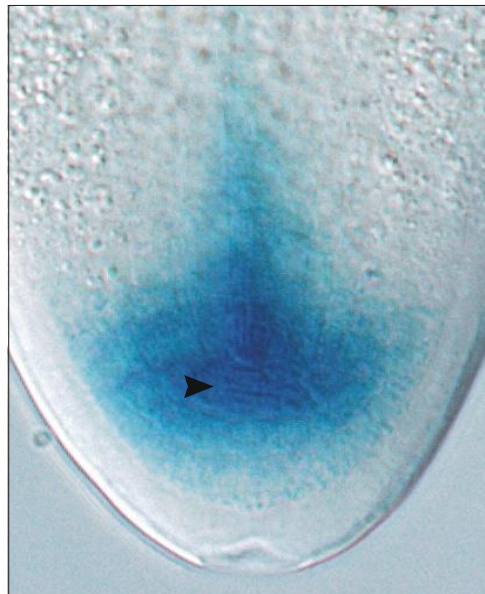
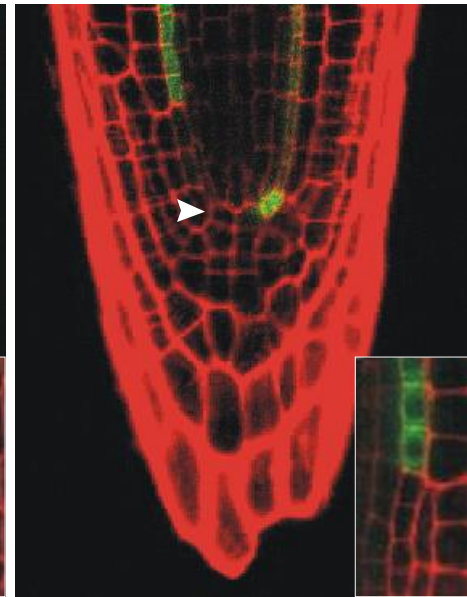
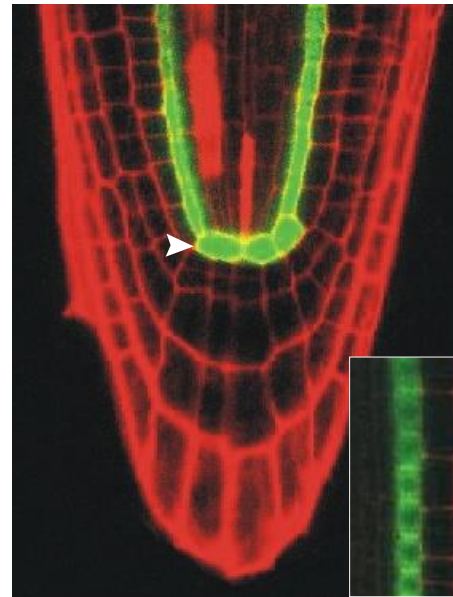
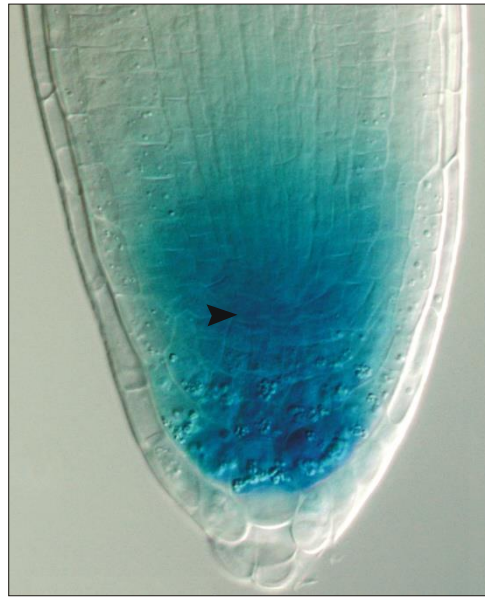
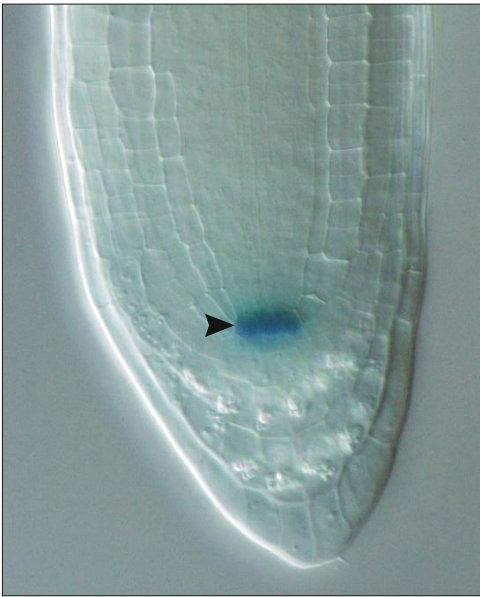
Tubulin



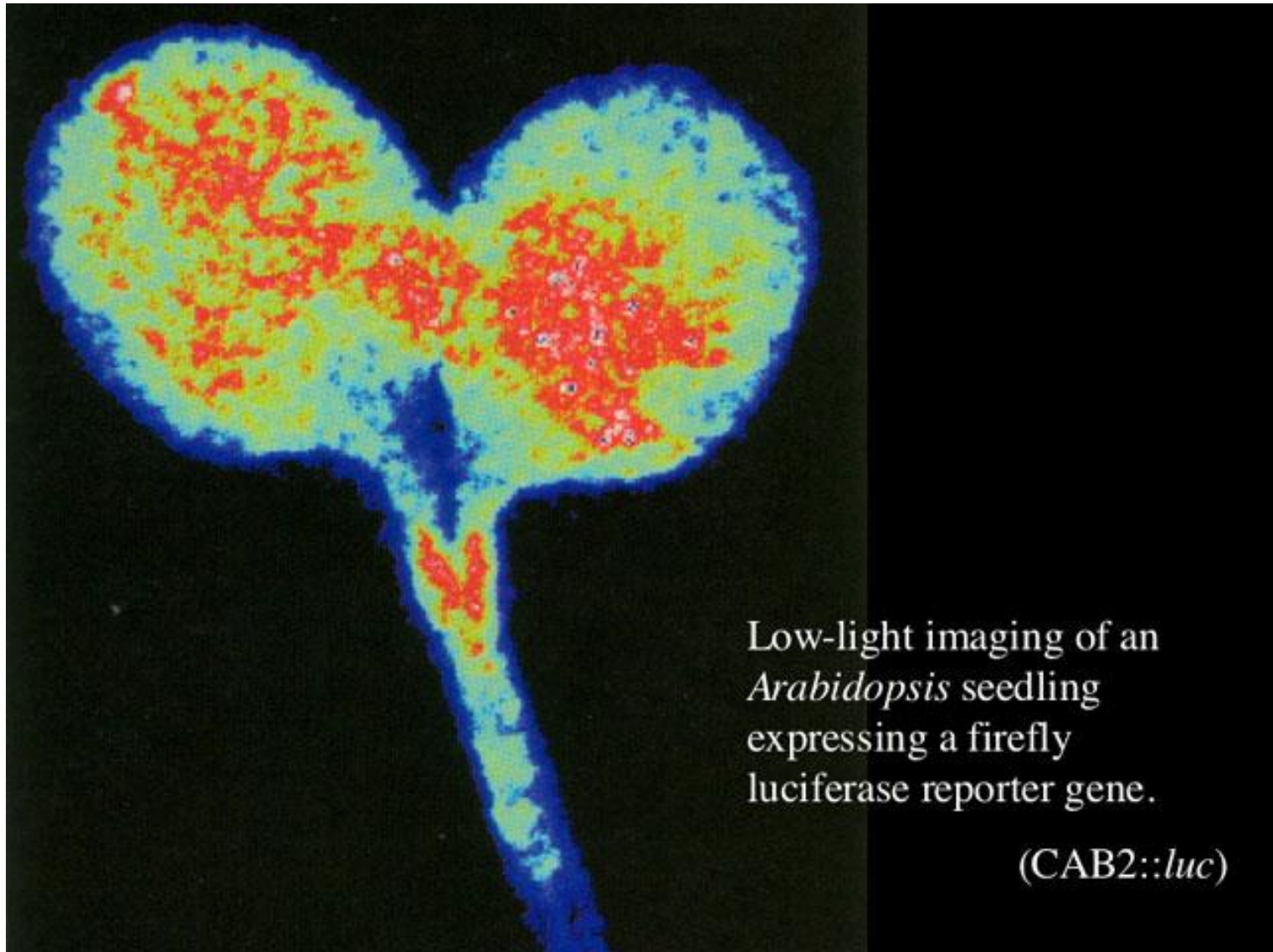
# Analysis of protein localisation



# Cell identity markers



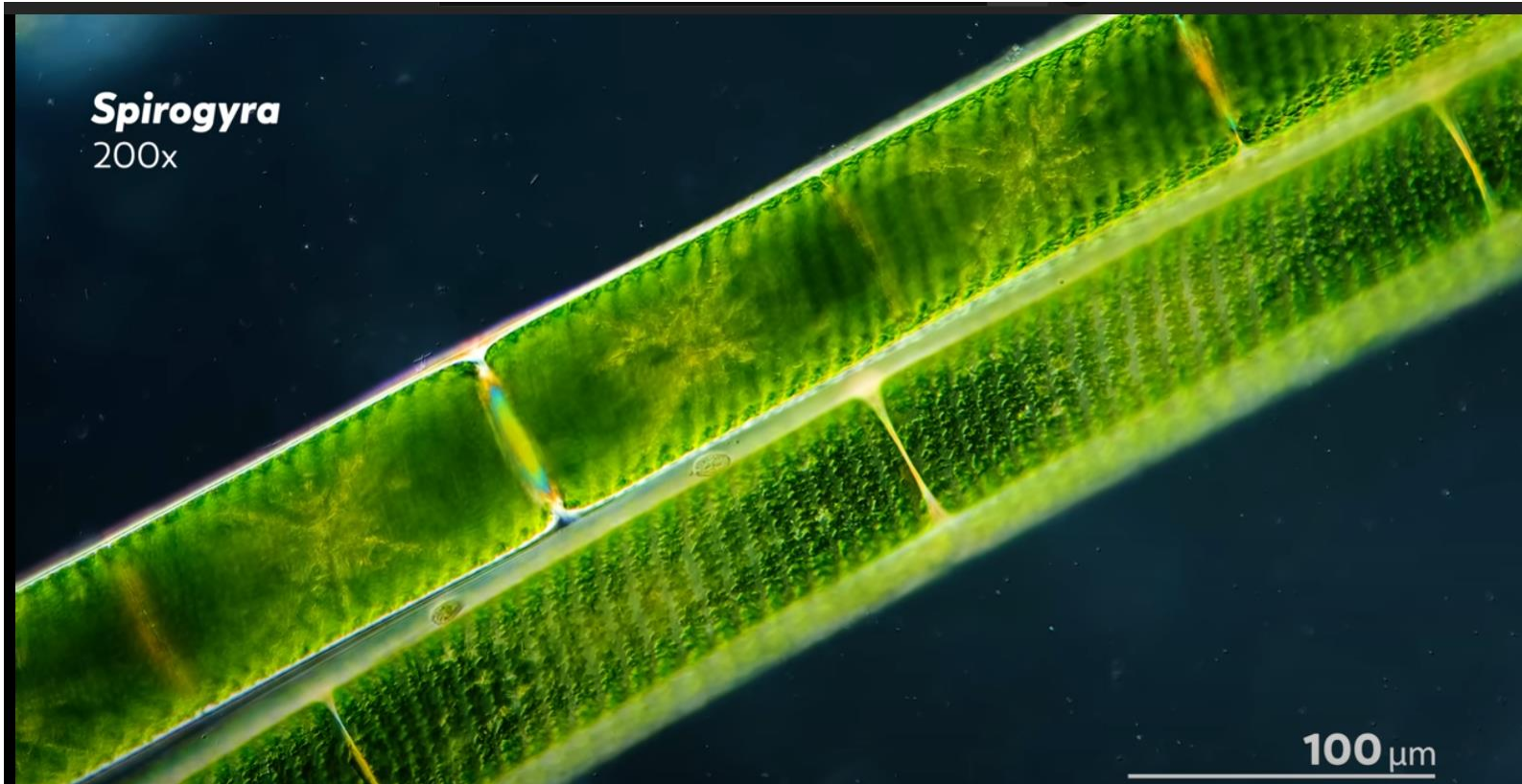




**Multiple Cells ~ tissues**

# Antony van Leeuwenhoek

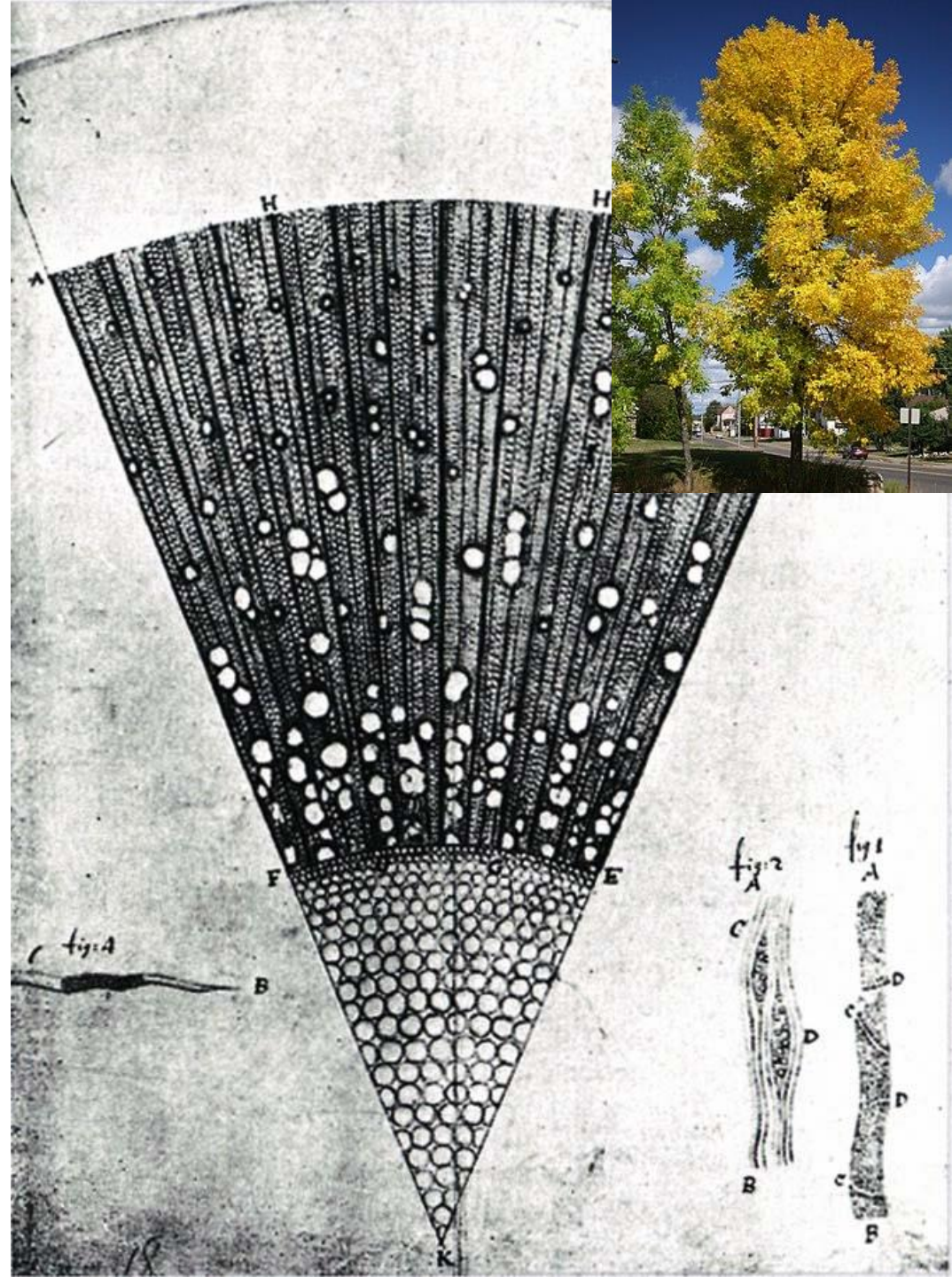
## Cell conglomerates.



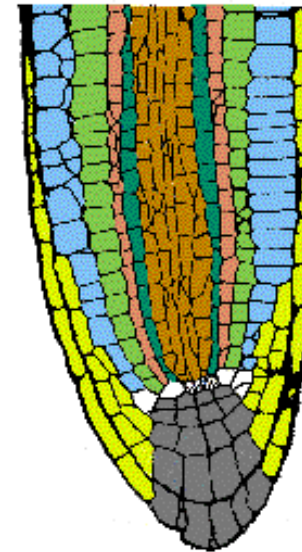
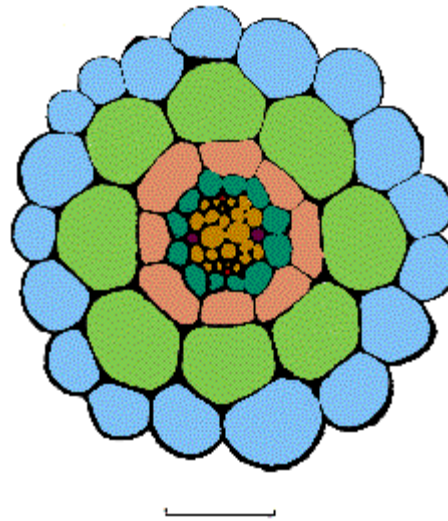
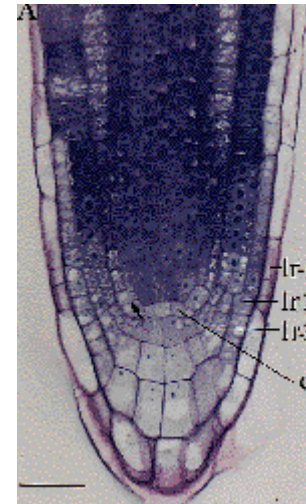
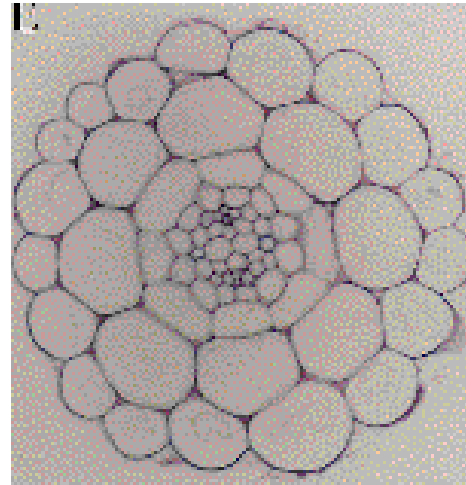
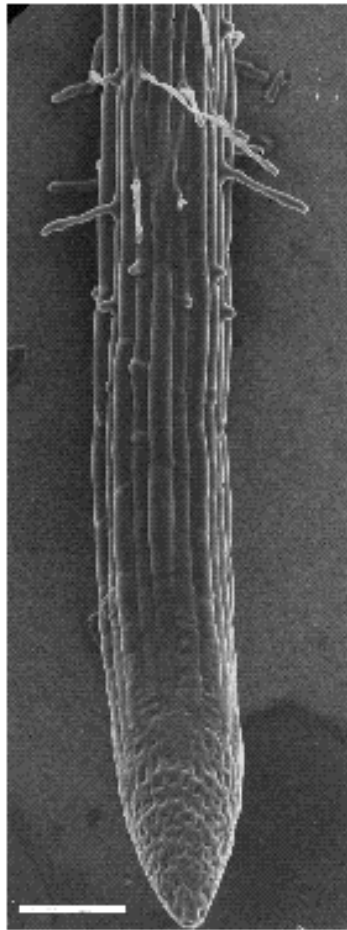
17th century that lens grinding by [Antony van Leeuwenhoek](#) provided the resolution needed to make major discoveries.

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

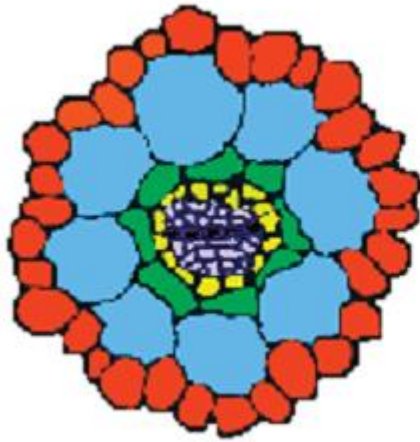
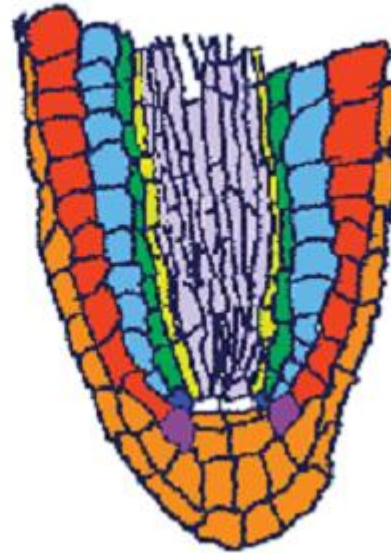
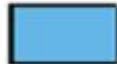
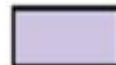
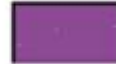
Microscopic section through one-year-old [ash tree](#)



# Anatomy – internal structure of plants

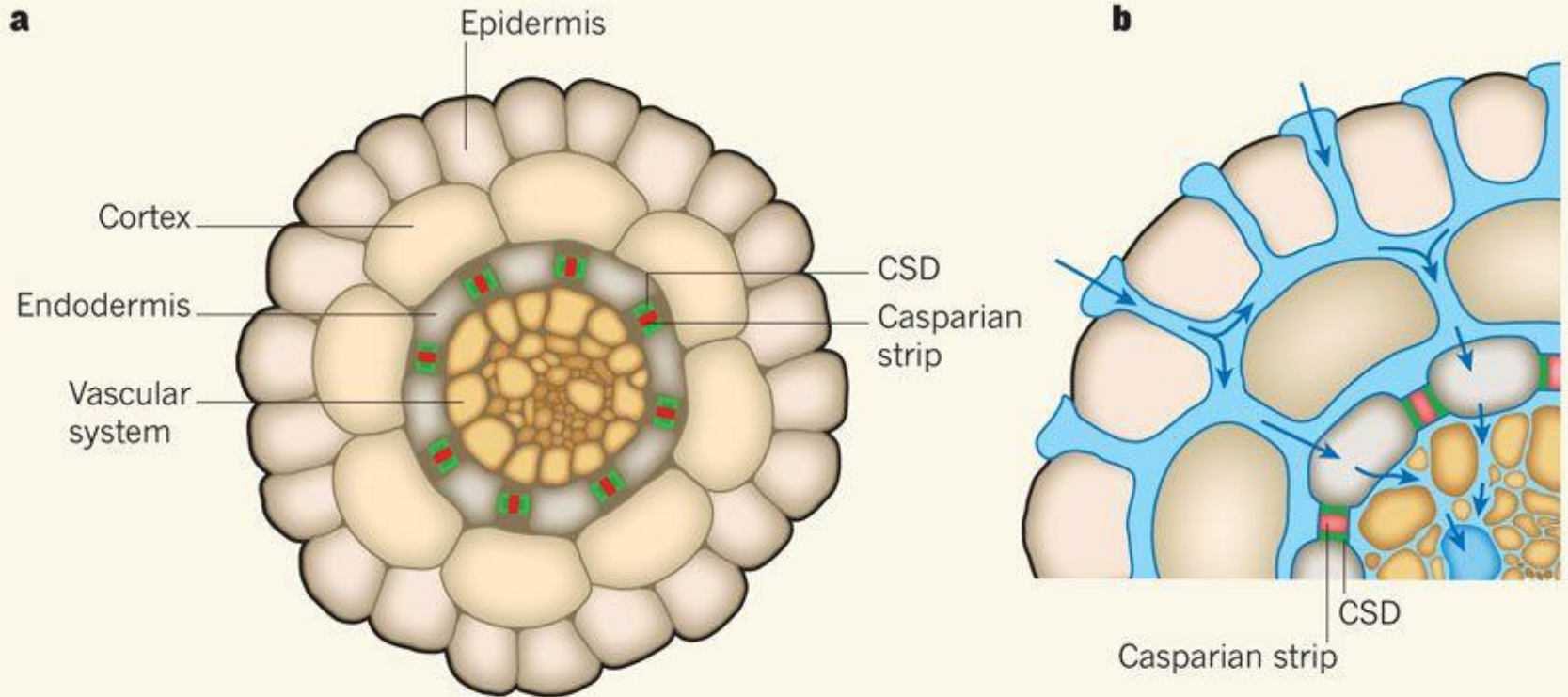


Looking for patterns, tissue organisation..

**A****B****Epidermis****Cortex****Endodermis****Pericycle****Vasculature****Cortex/Endodermal Initial****Epidermal/Root Cap Initial****Quiescent Center****Root Cap**

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

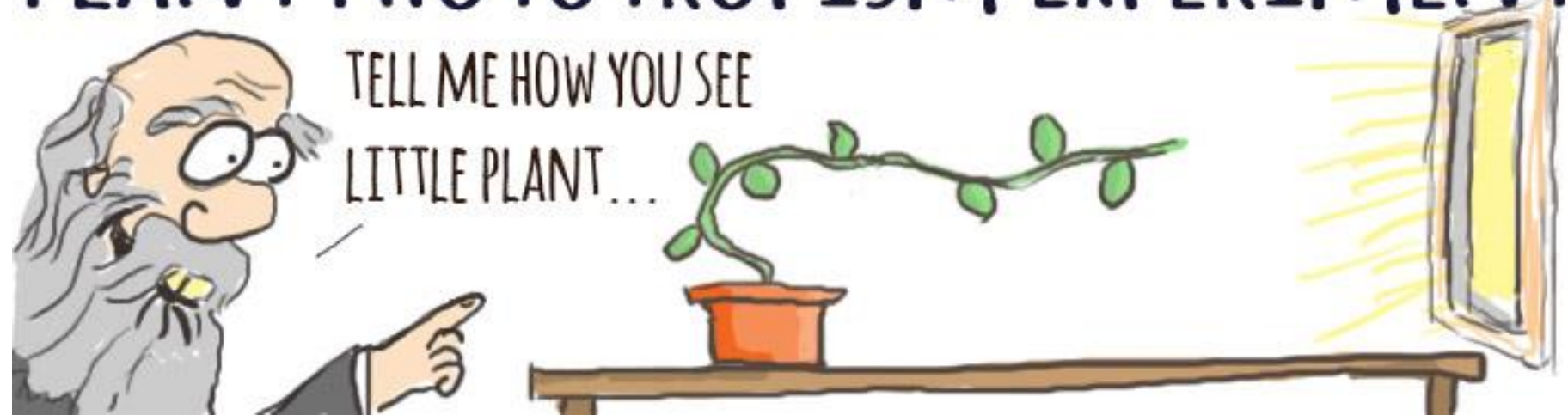


**Signalling** discovered in the luminescent marine bacteria *V. fischeri* and [\*Vibrio harveyi\*](#). In the early 1970s, researchers observed that **supernatants from stationary phase cultures** could be added to cells at low density and trigger light production, the **signalling was species-specific**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

# Chemistry (identification of signals)

Chemistry - the tropic signal is a chemical

## PLANT PHOTOTROPISM EXPERIMENT



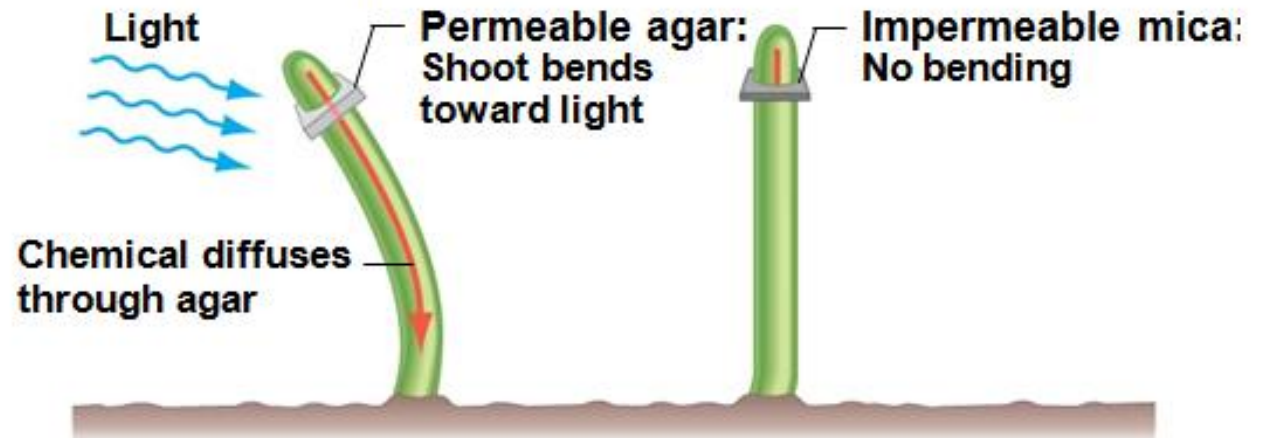
Germinating shoot in of canary grass and oats

# Chemistry (identification of signals)

Chemistry - the tropic signal is a chemical

a) 1913,  
Peter  
Boysen-  
Jensen

(a) The phototropic signal is a chemical.

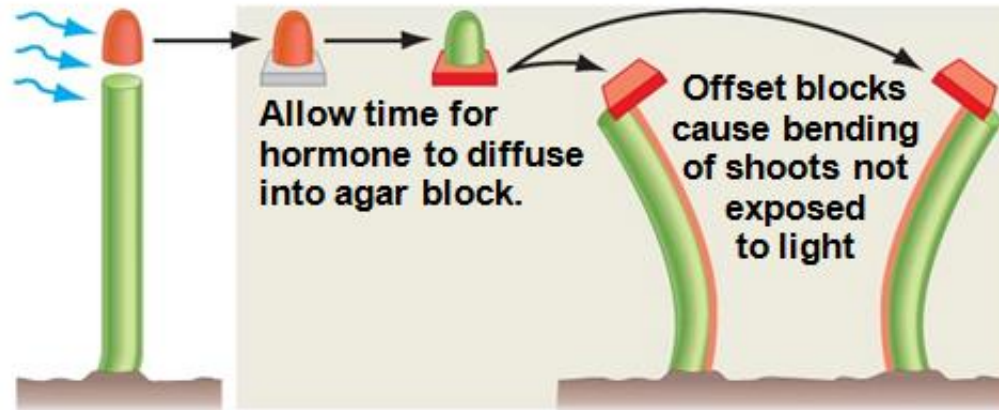


Germinating shoot in of canary grass and oats

# Chemistry - the tropic signal is a chemical

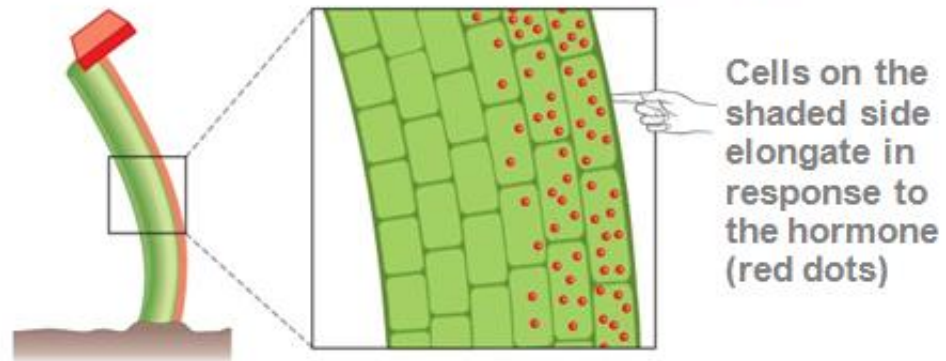
b) 1925,  
Frits Went

(b) The hormone can cause bending in darkness.

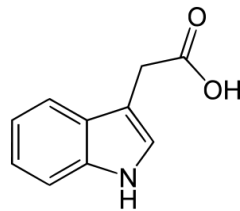
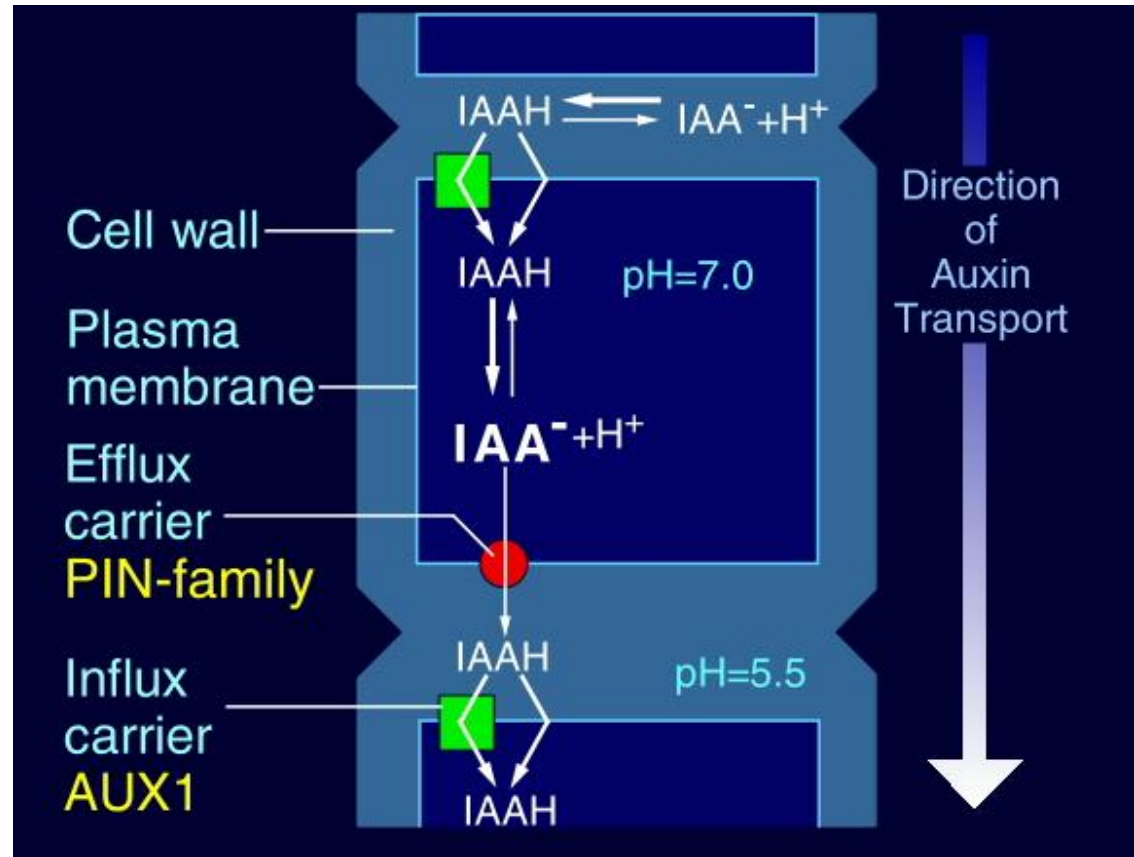
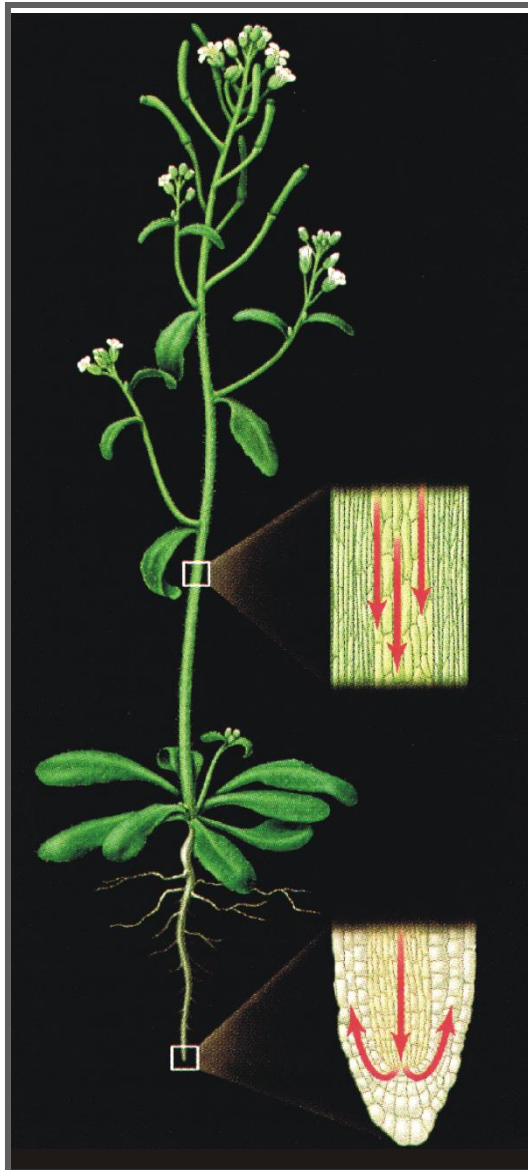


c) Went and  
Cholodny

(c) The hormone causes bending by elongating cells.

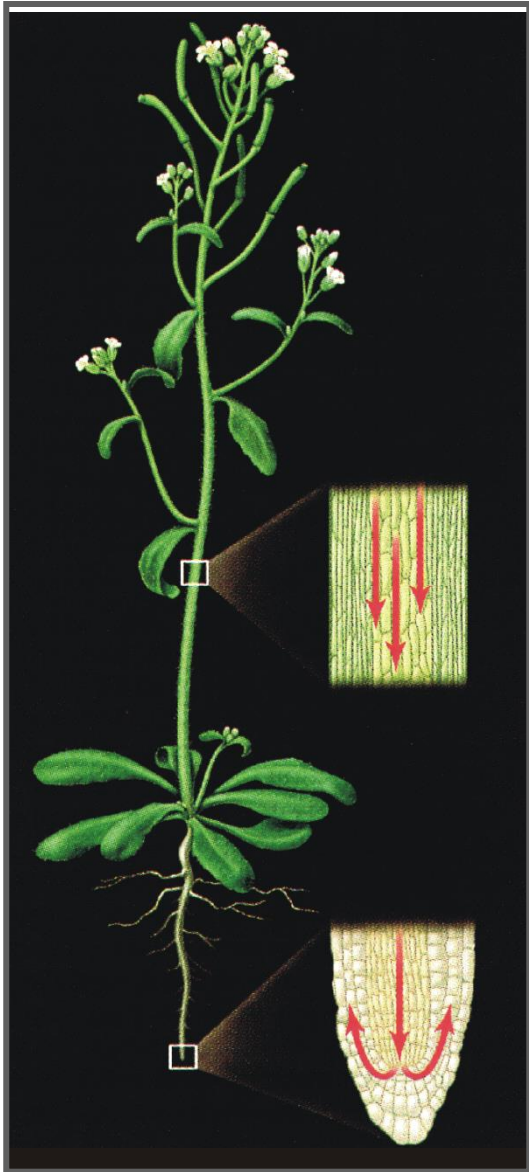


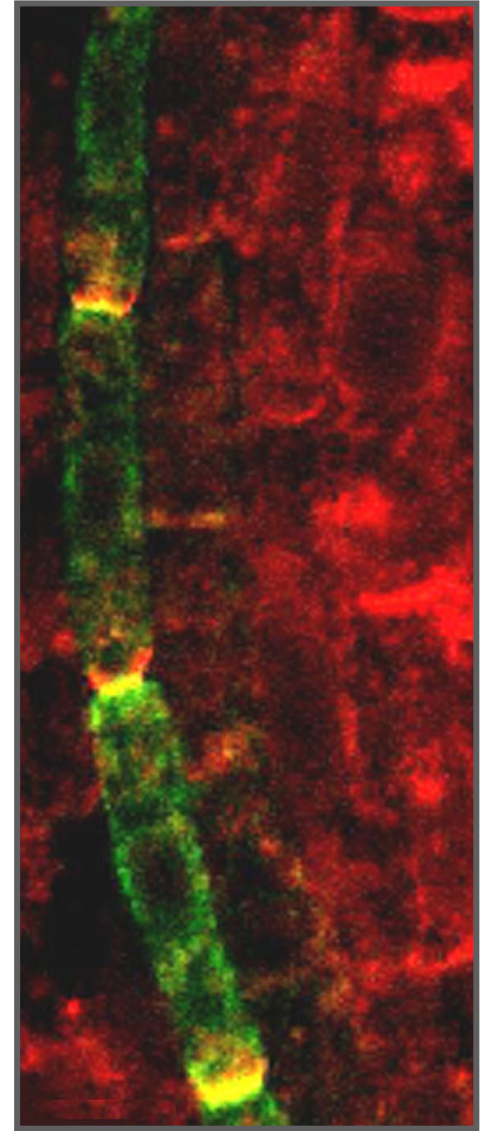
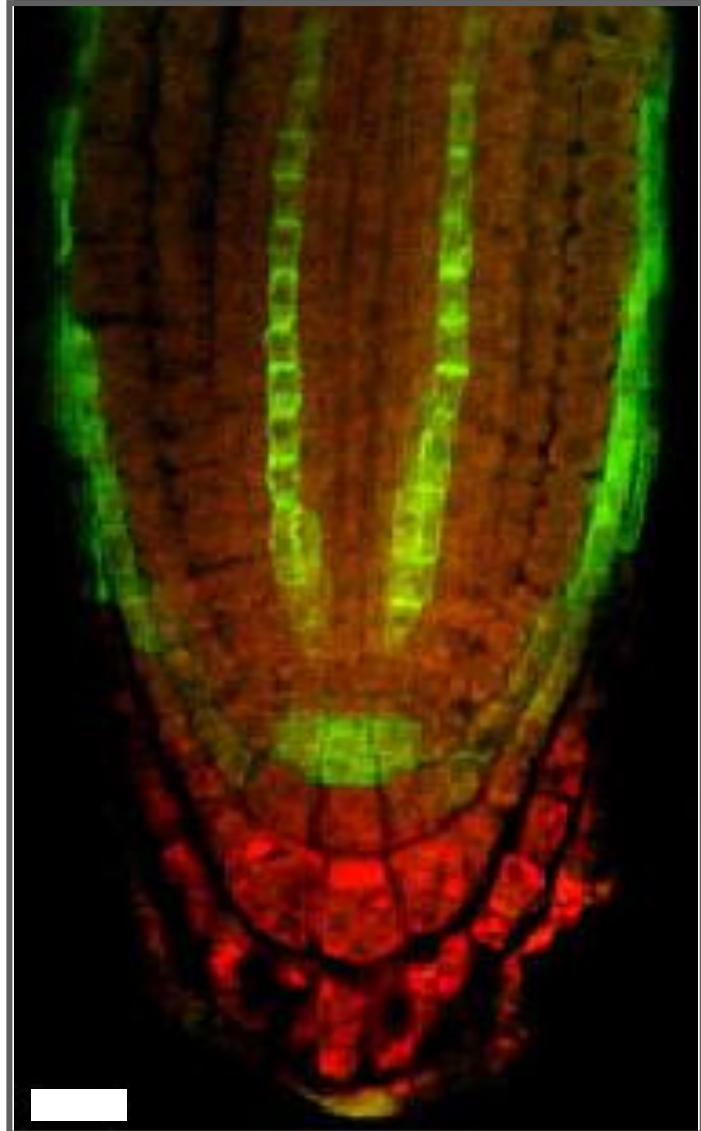
# Cell to Cell translocation?

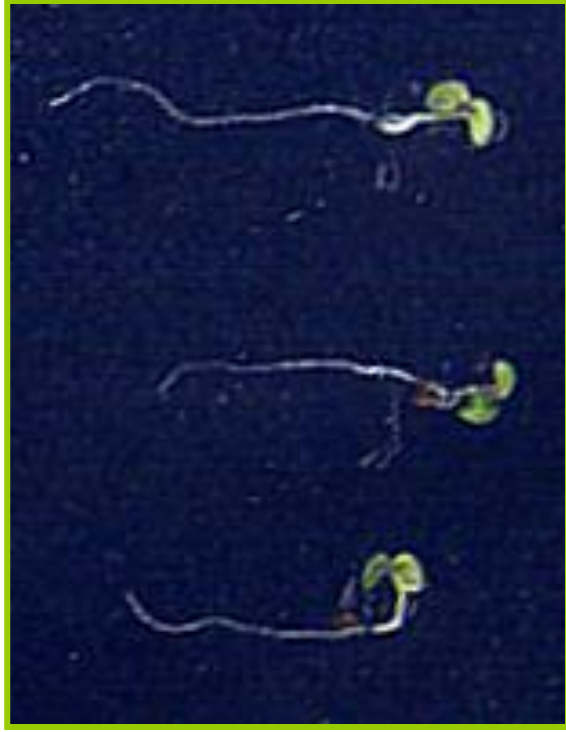
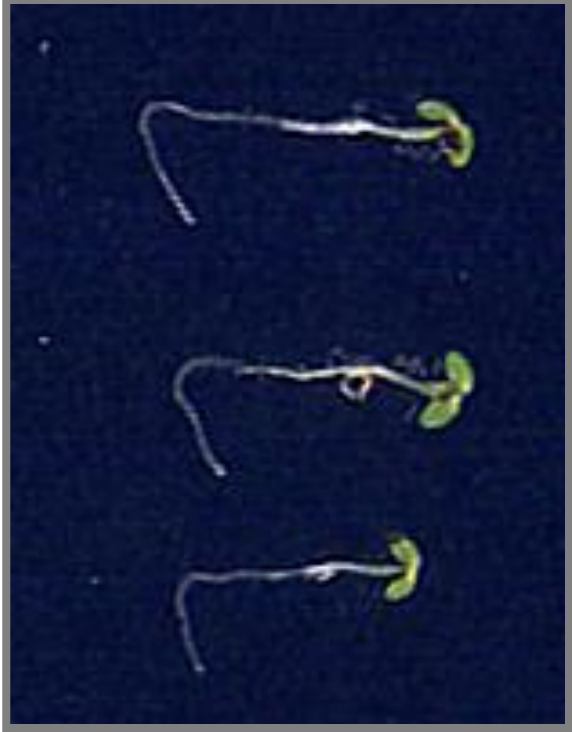


**indole-3-acetic acid (IAA)**



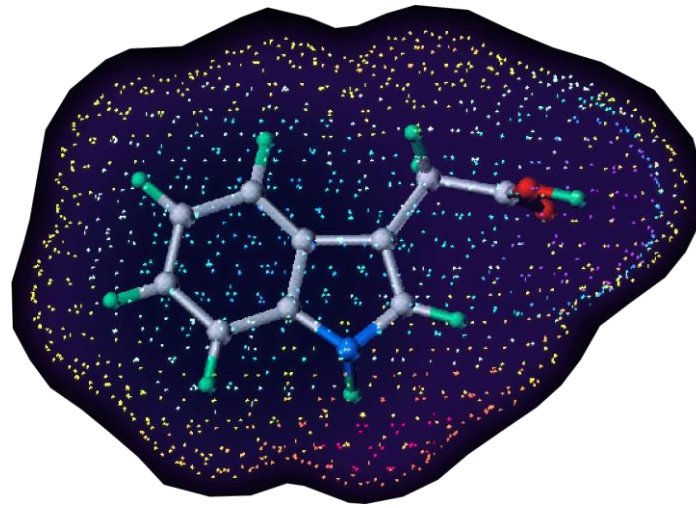






# AUXIN

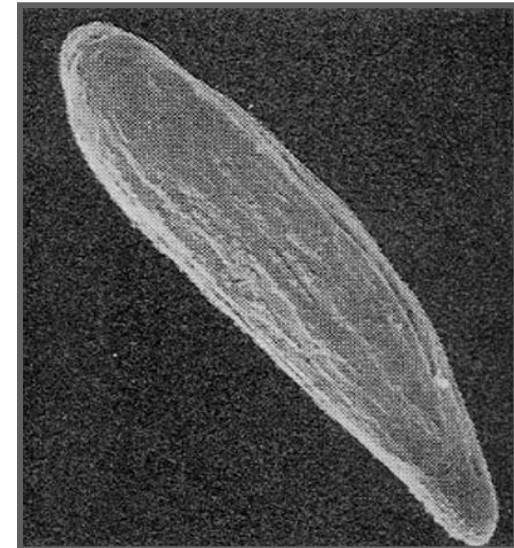
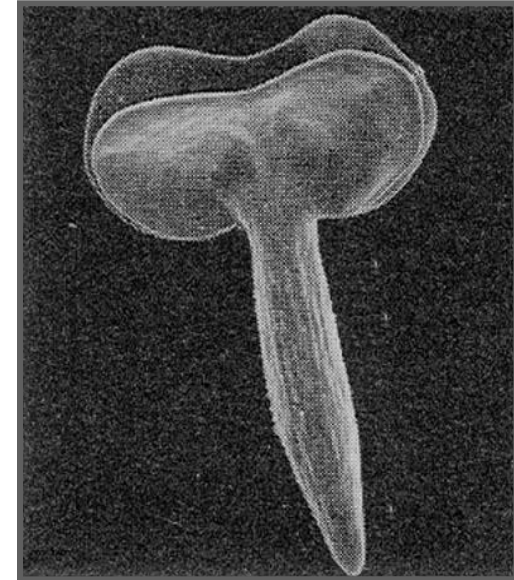
mediates



- 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

Tomasz Nodzyński<sup>1,\*</sup>, Steffen Vanneste<sup>2,3</sup>, Marta Zwiewka<sup>1</sup>, Markéta Pernisová<sup>1,4</sup>, Jan Hejátko<sup>1,4</sup> and Jiří Friml<sup>5,\*</sup>

<sup>1</sup>CEITEC – Central European Institute of Technology, Masaryk University, Kamenice 5, 62500 Brno, Czech Republic

<sup>2</sup>Department of Plant Systems Biology, VIB, 9052 Gent, Belgium

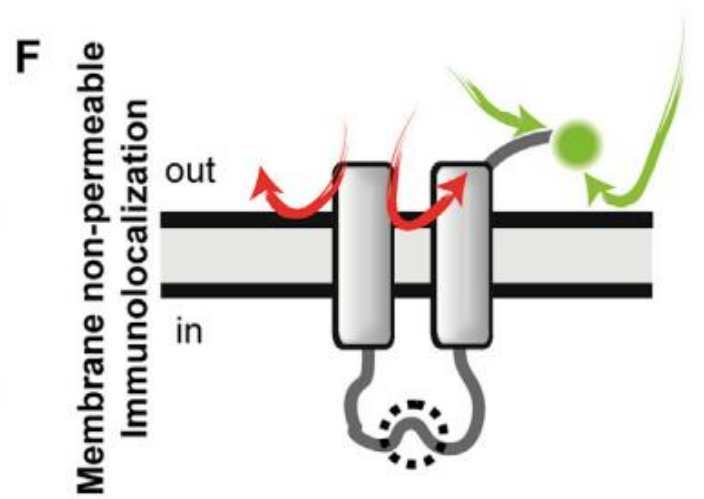
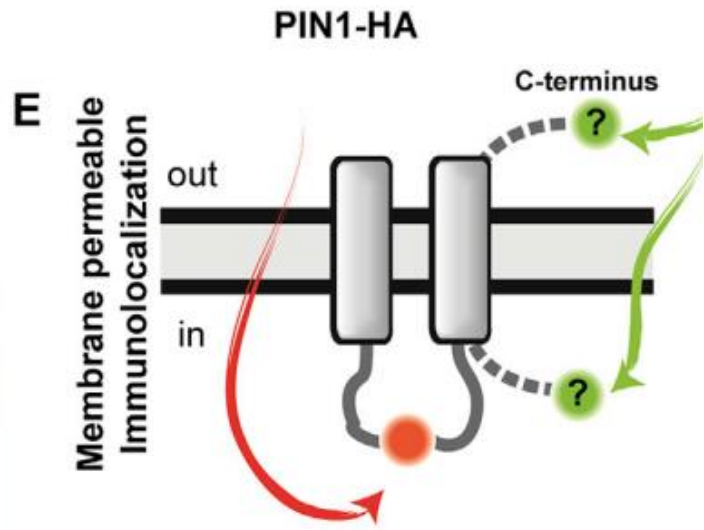
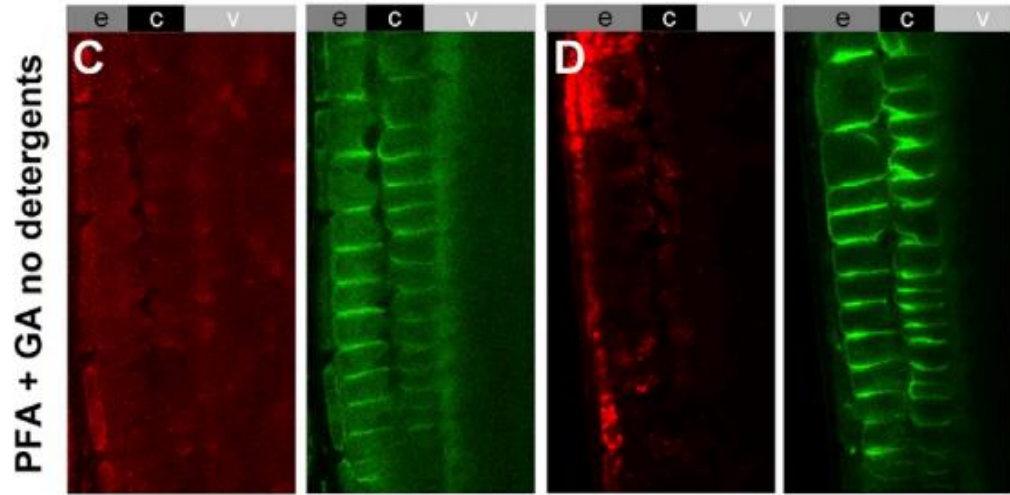
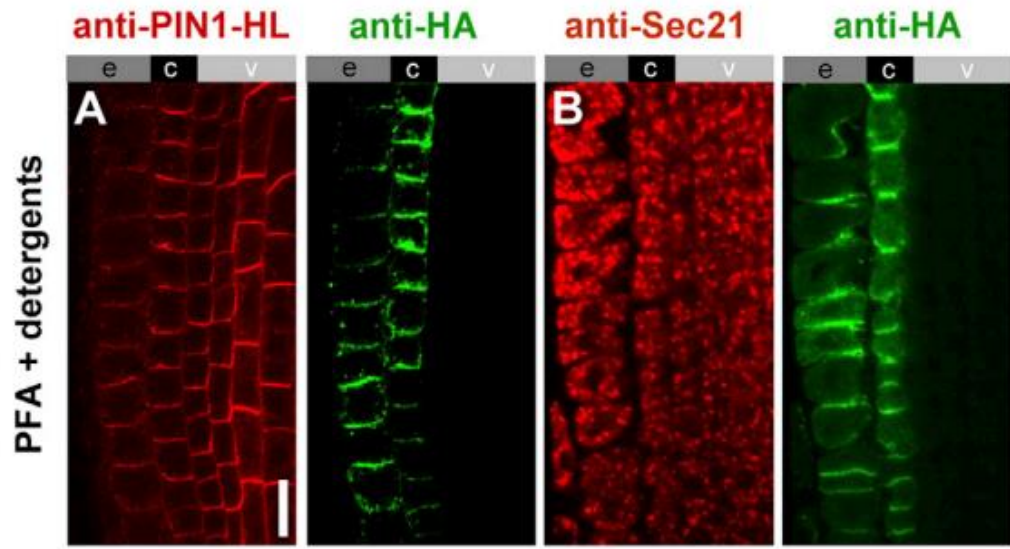
<sup>3</sup>Department of Plant Biotechnology and Bioinformatics, Ghent University, 9052 Gent, Belgium

<sup>4</sup>National Centre for Biomolecular Research, Masaryk University, Kamenice 5, 62500 Brno, Czech Republic

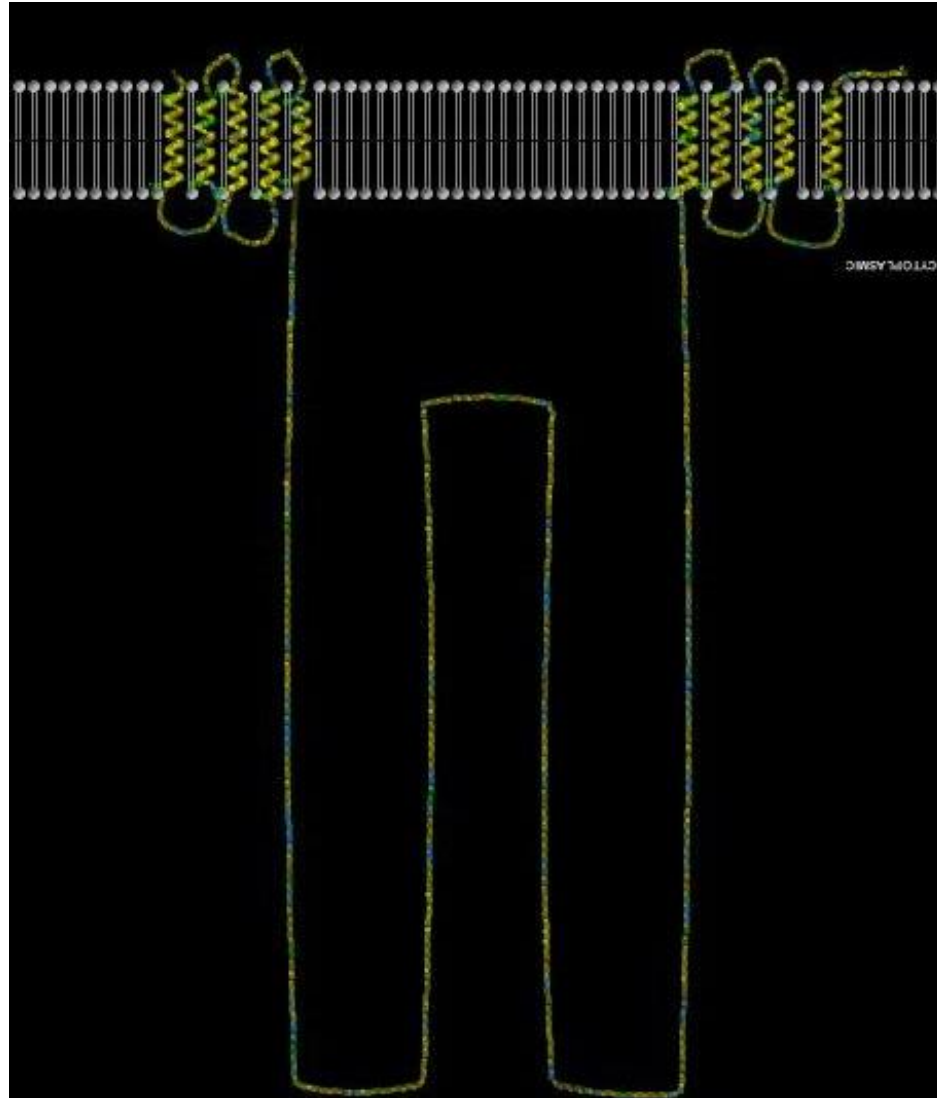
<sup>5</sup>Institute of Science and Technology Austria (IST Austria), Am Campus 1, 3400 Klosterneuburg, Austria

\*Correspondence: Tomasz Nodzyński ([tomasz.nodzynski@ceitec.muni.cz](mailto:tomasz.nodzynski@ceitec.muni.cz)), Jiří Friml ([jiri.friml@ist.ac.at](mailto:jiri.friml@ist.ac.at))

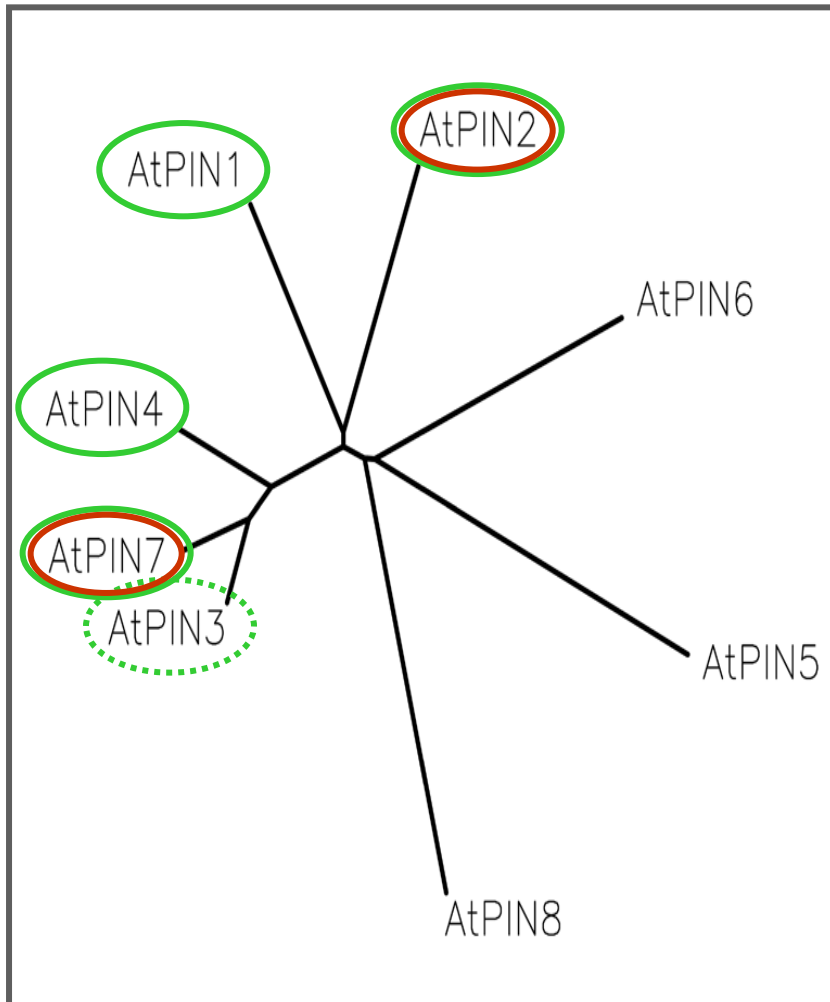
<http://dx.doi.org/10.1016/j.molp.2016.08.010>



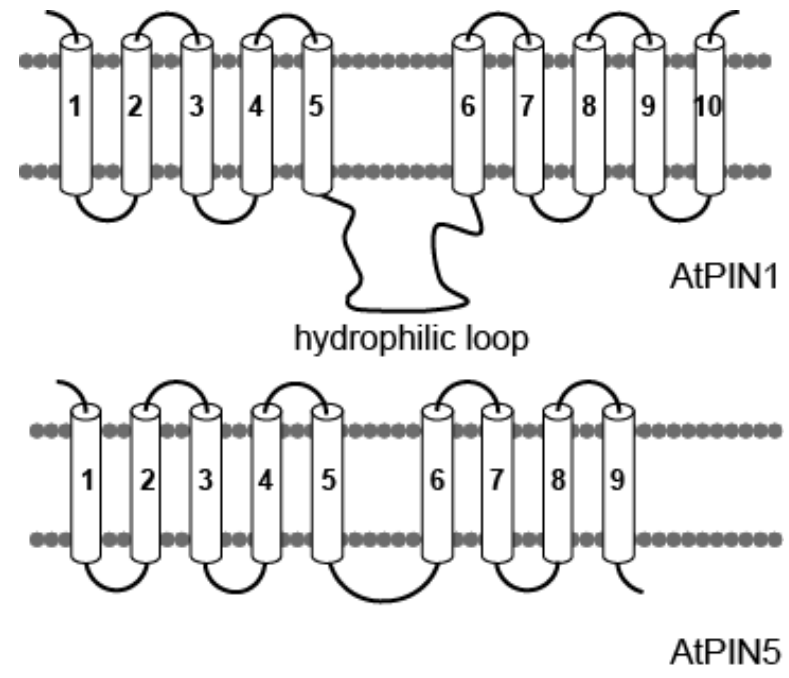
Solving crystal structures of PM proteins remains a challenge, and even more observing that **structure (significance) in action.**



## PINs in *Arabidopsis*



## PIN Protein Topology



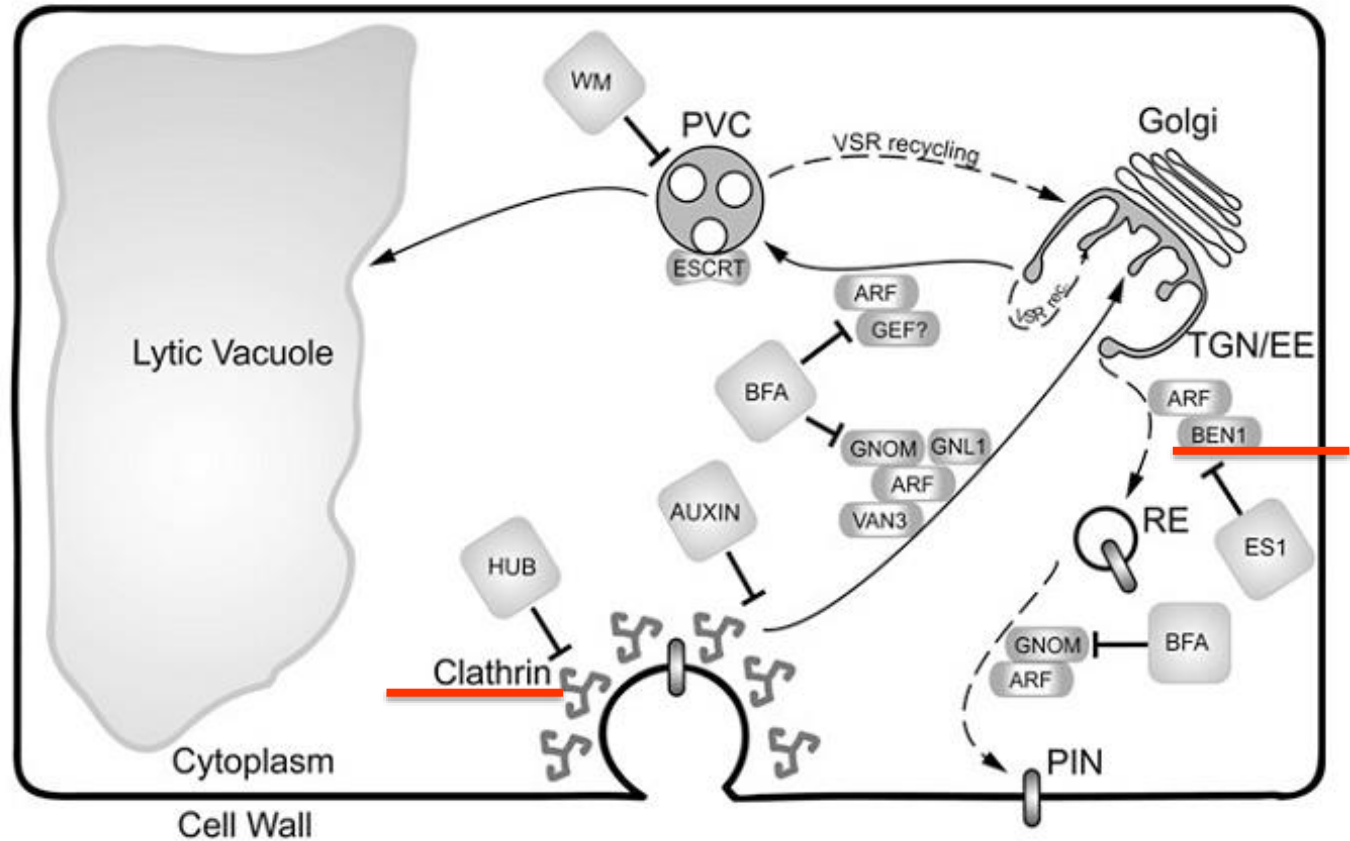


Intracellular/**Vesicular** trafficking contributes to PIN polarity the PM.

**Vesicular** trafficking delivers also membrane.

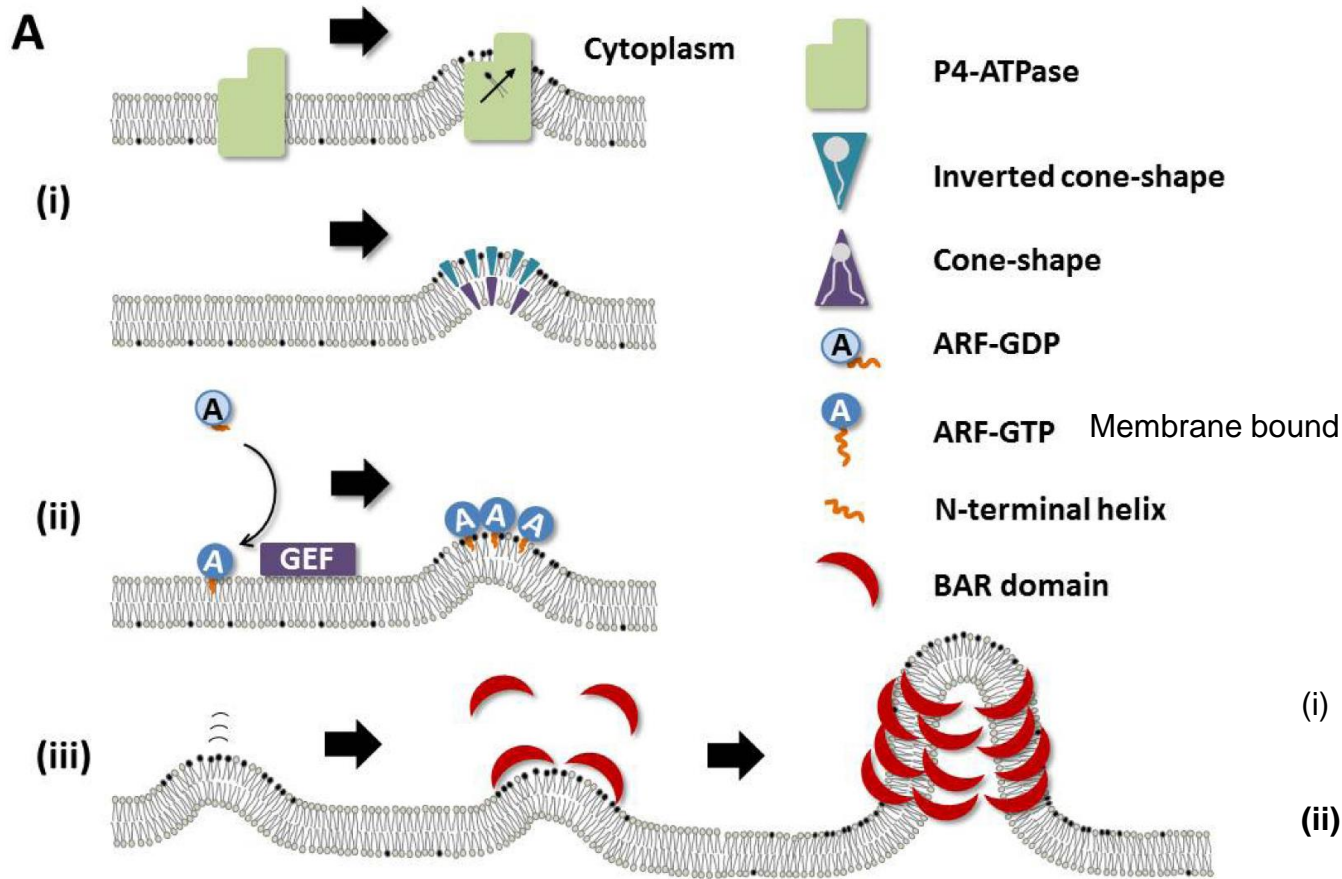


Adopted from Gälweiler et al.,  
1998



**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.



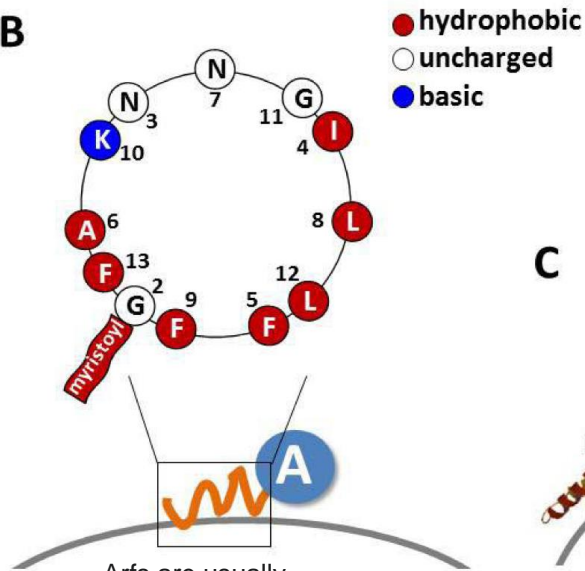
(i) Lipid composition is changed by P4-ATPases, LPAT and PLA2;

(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

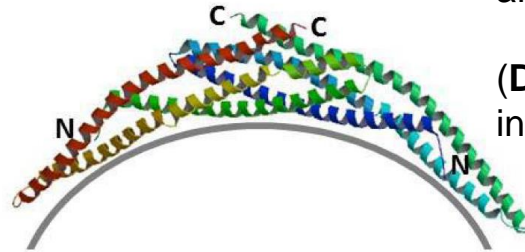
# Mechanistic model for the generation of membrane curvature.

**B**



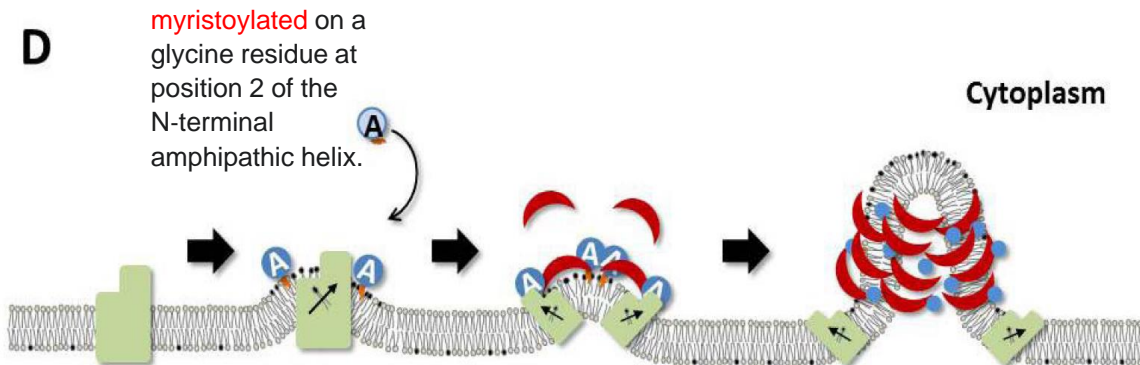
(B) Helical-wheel representation of the N-terminal **amphipathic helix** of Arf1 (amino acids 2-13);

**C**



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

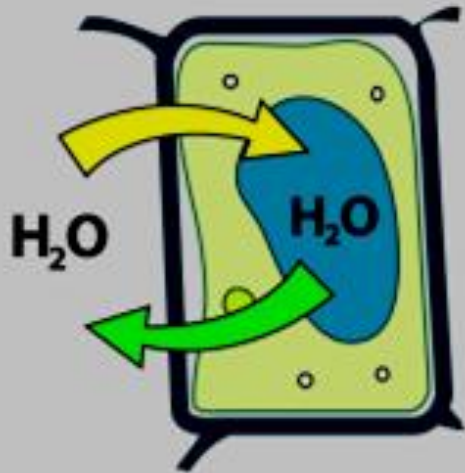
**D**



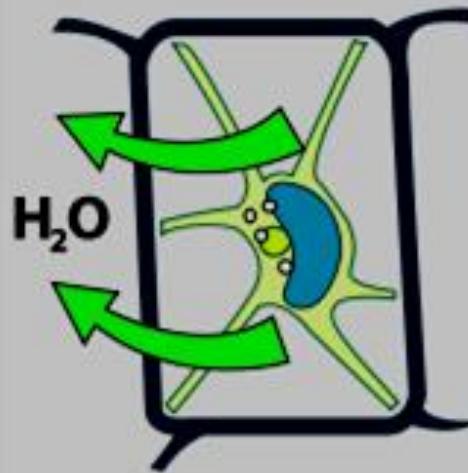
(D) The complex regulation of proteins involved in generating membrane **curvature**.

# Osmotic conditions influence turgor

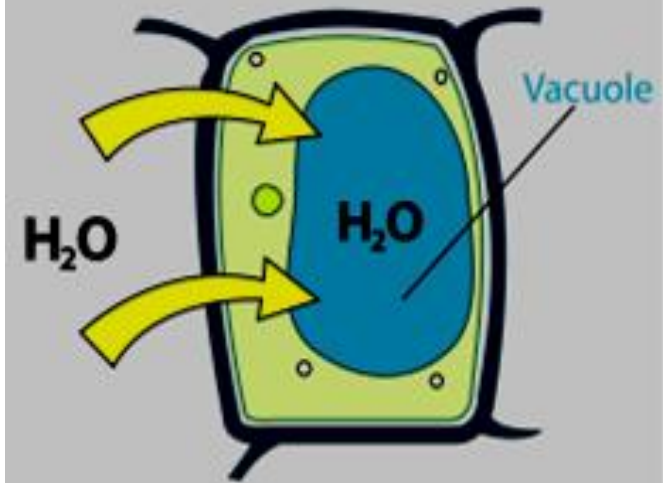
Isotonic



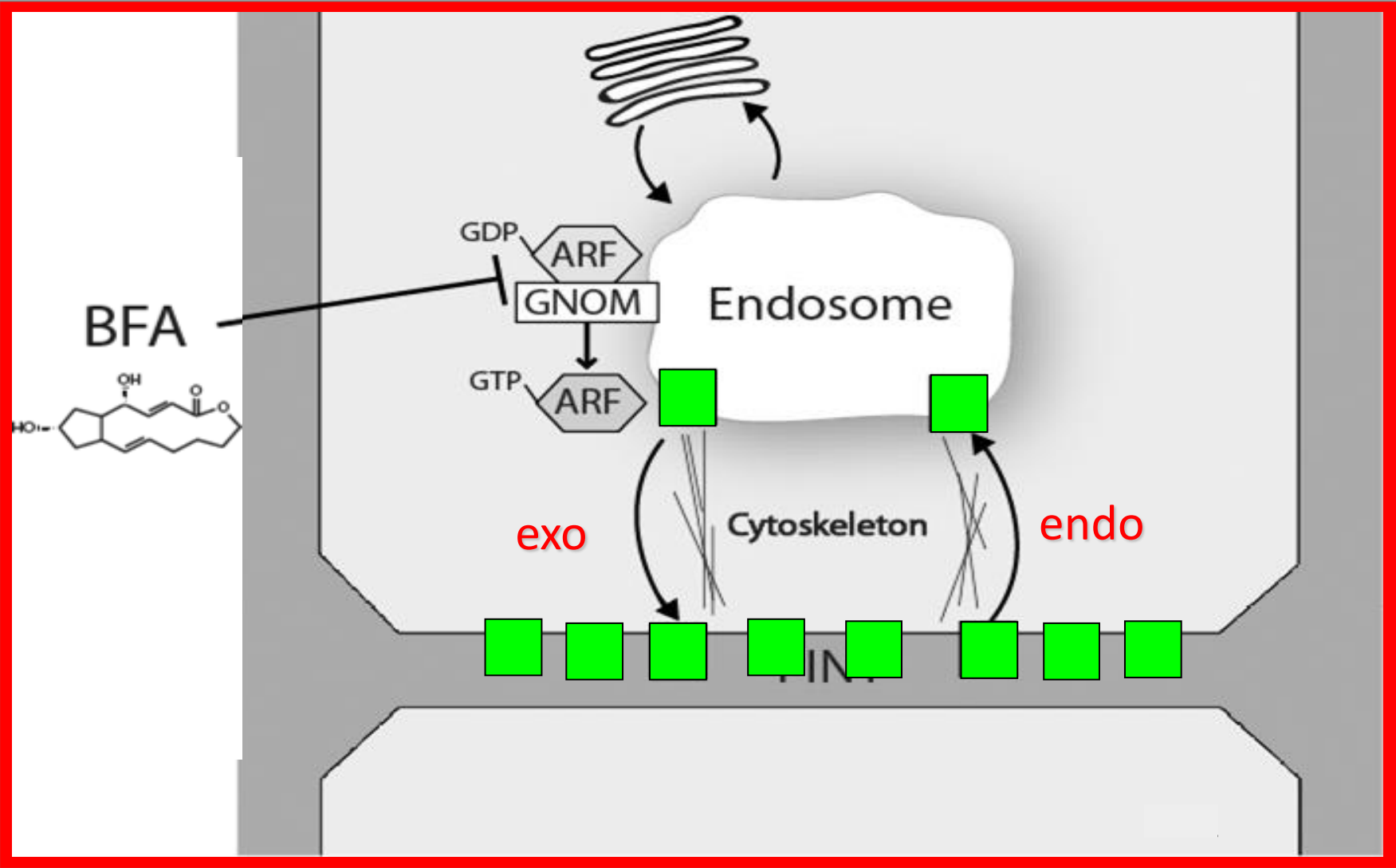
Hypertonic



Hypotonic

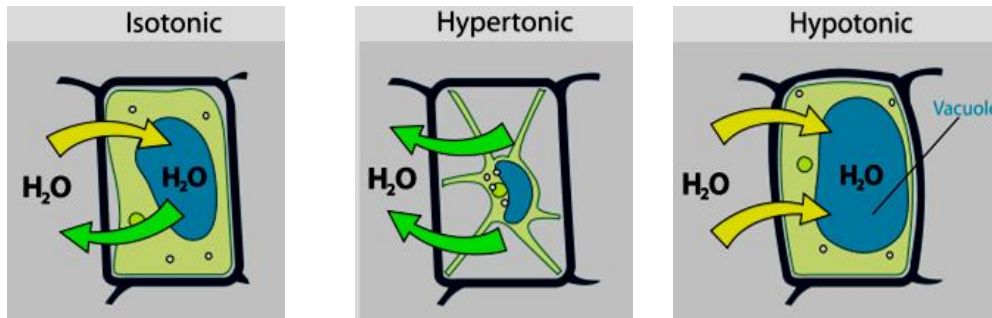


# How the preserve membrane integrity during osmotic changes



Regulate membrane delivery

# Do Osmotic conditions influence early steps of endocytic trafficking?

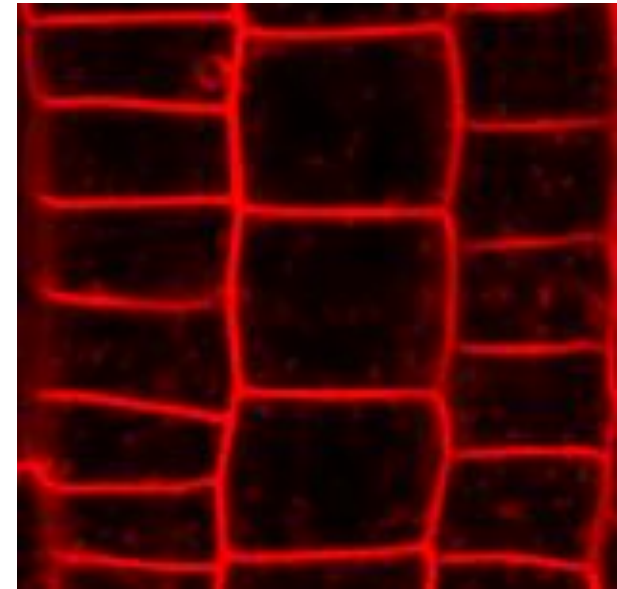
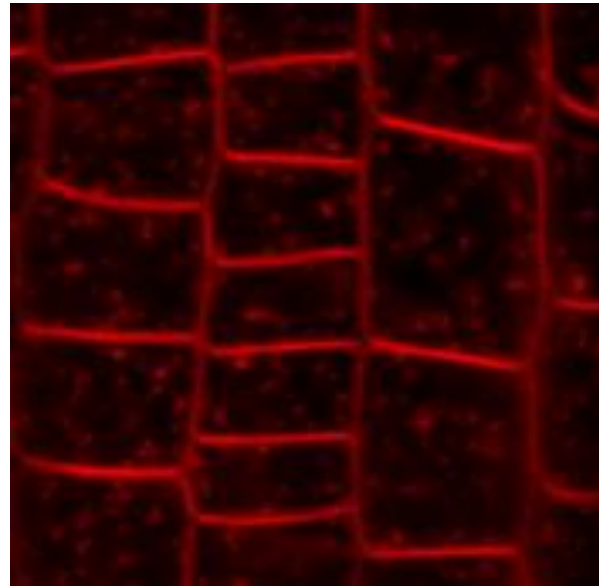
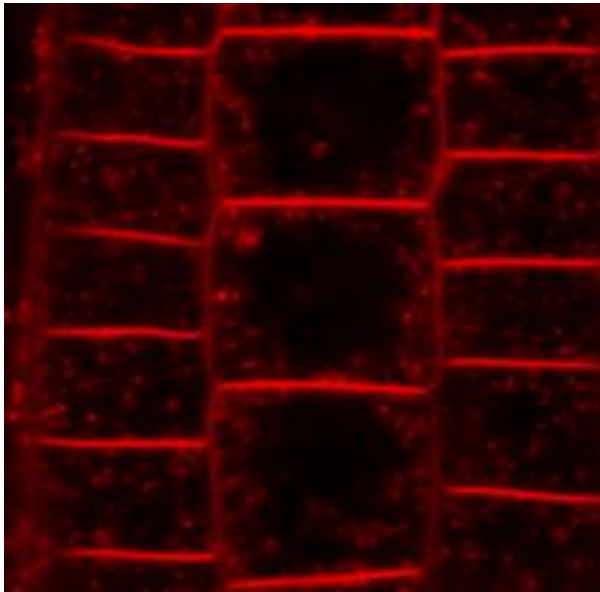


FM4-64[2] 10'

MS+

NaCl[100]

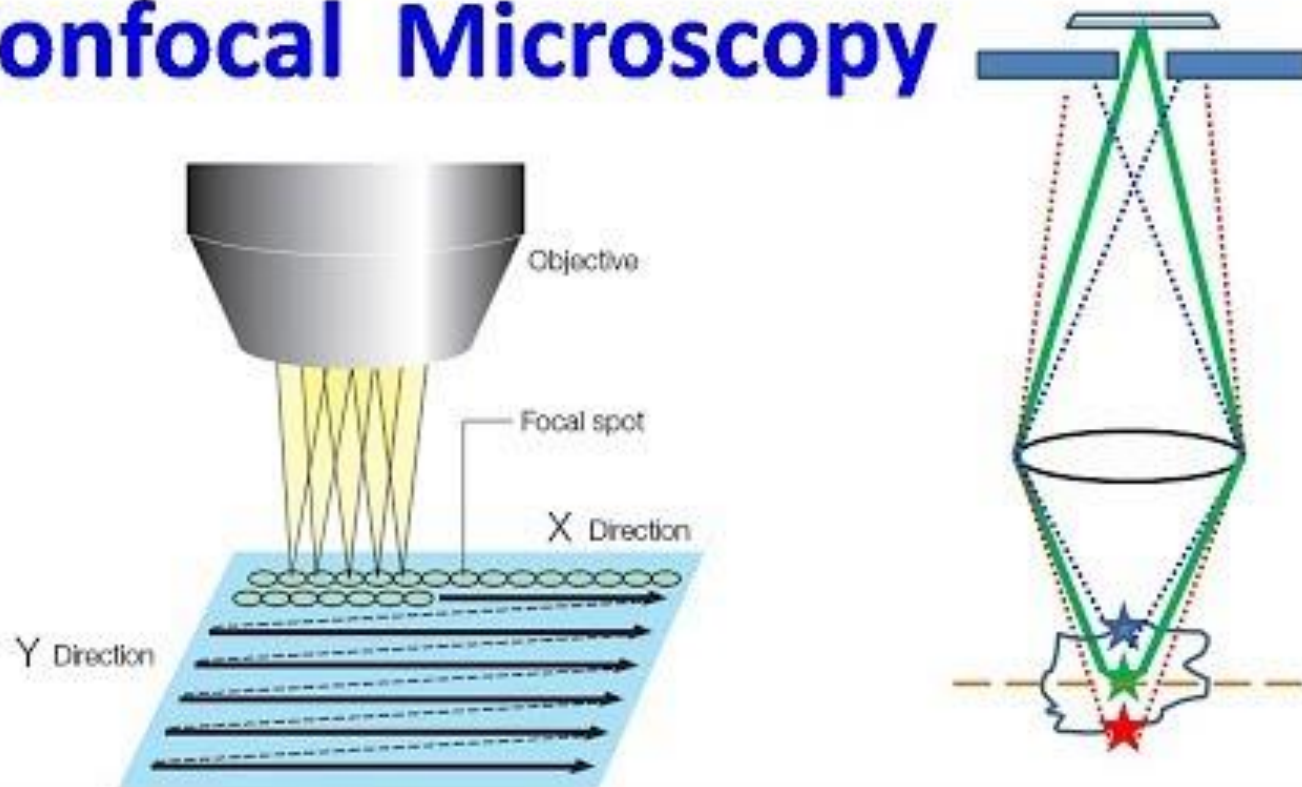
MQ



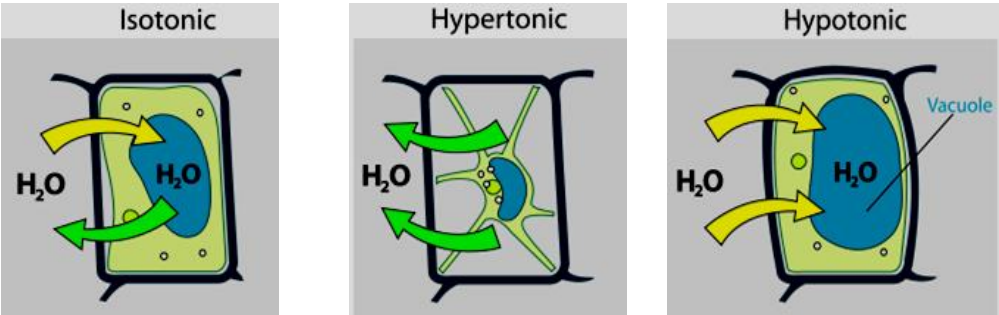
remove

deliver

# Confocal Microscopy



# Osmotic conditions influence early steps of endocytic trafficking

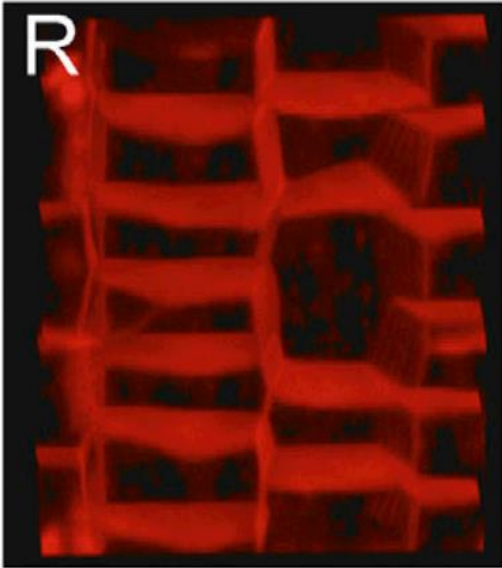
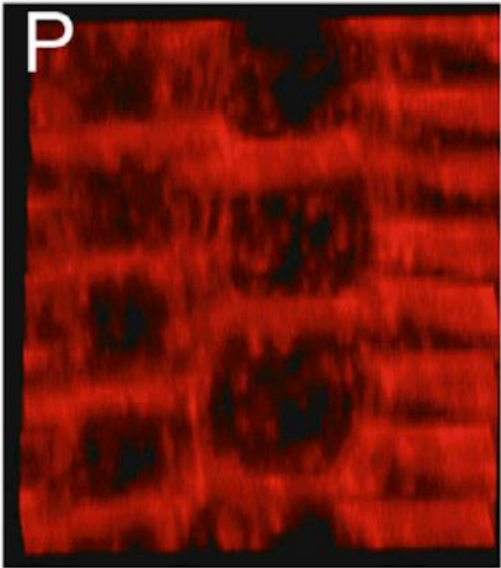
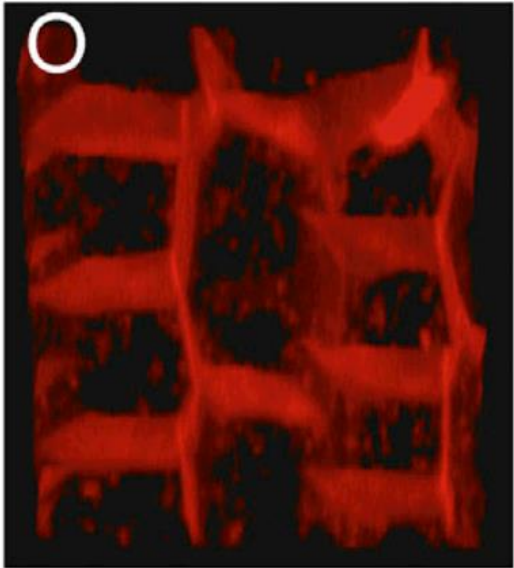


FM4-64[2] 10' (Z-stack)

MS+

NaCl[100]

MQ

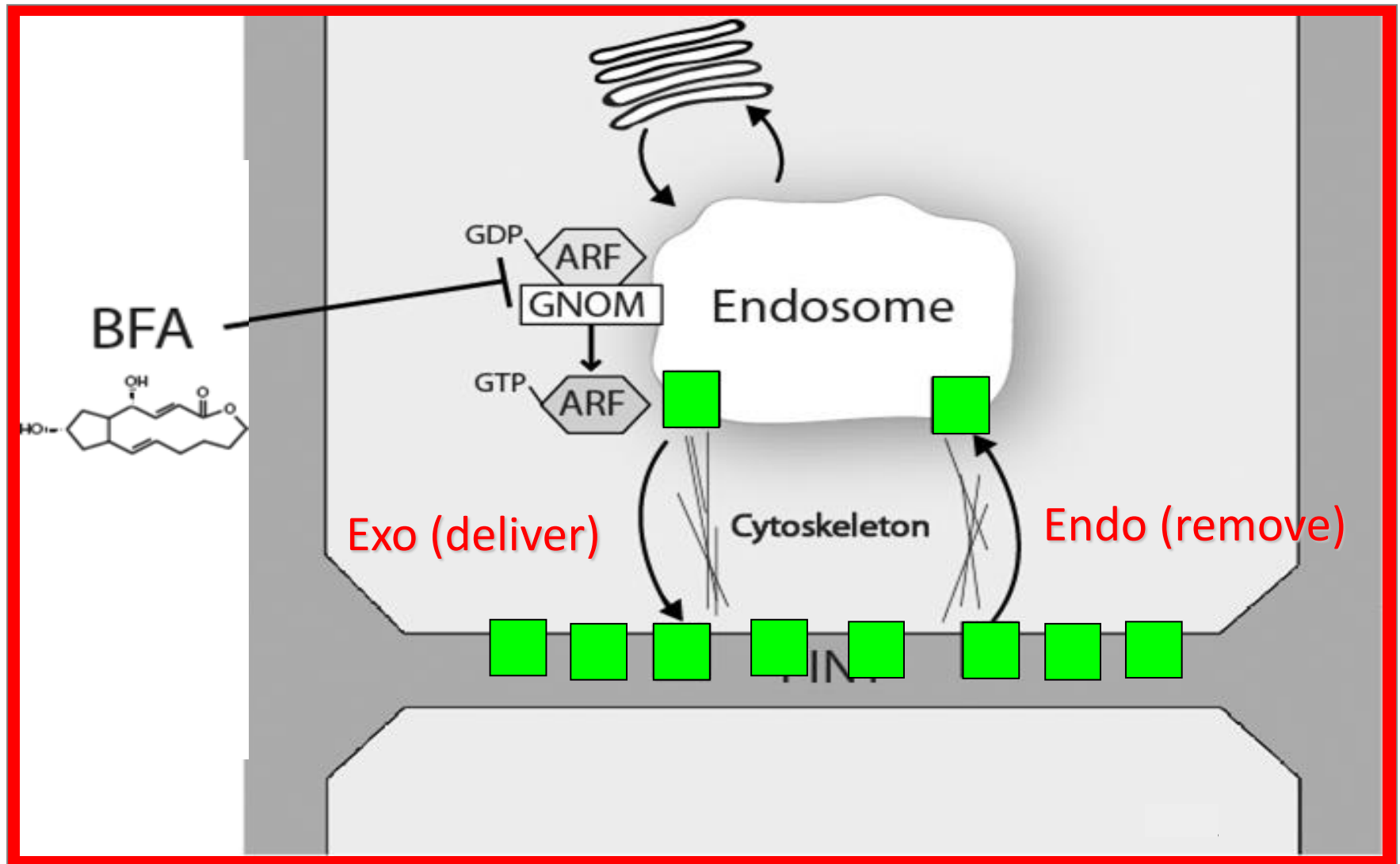


remove

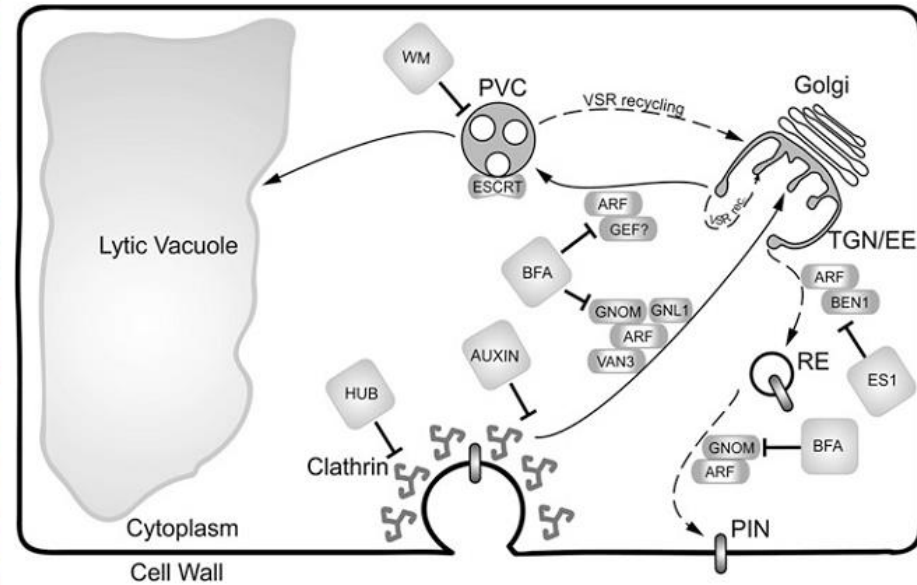
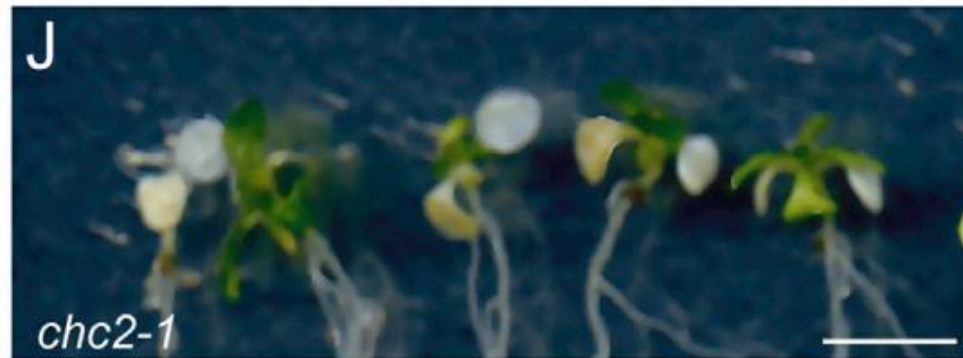
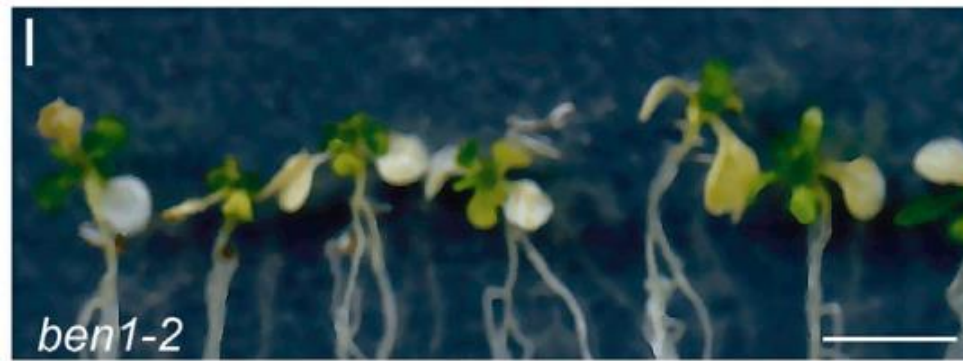
deliver



# Preserve membrane integrity during osmotic changes



Mannitol[300] → 0.5xMS



More flexible trafficking better plant survival.

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

Zwiewka *et al.*, 2015

**Thank you for your attention!**



**Tomasz Nodzyński**  
**nodzynski@ceitec.muni.cz**

**Building E26**



**Where to find us**

**E26 building (indicated by red square)**



## **Other courses to consider**

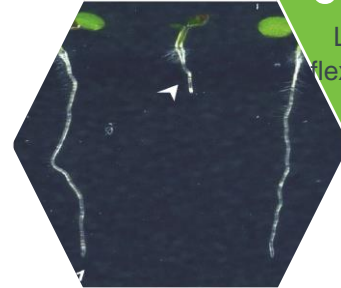
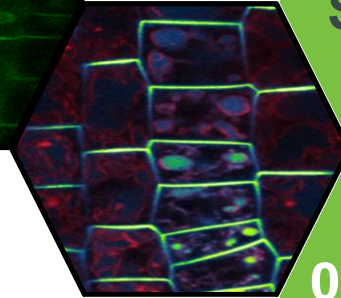
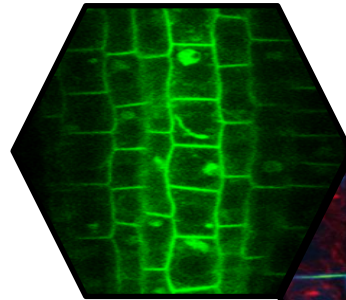
# Developmental and Cell Biology of Plants (S2008)

Course is in Spring semester

Given by

Tomasz Nodzyński

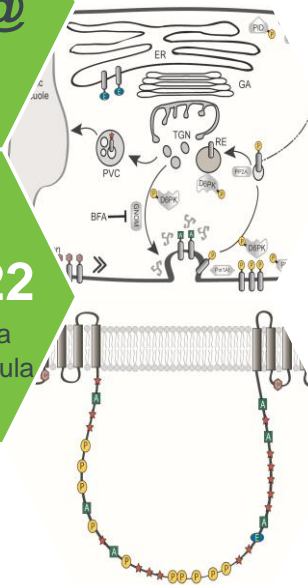
Marta Zwiewka



MONDAY  
START @  
14:00

01/03/2022

Lecture will have a  
flexible **on-line** formula



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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[PEOPLE](#)

[PUBLICATIONS](#)

[GRANTS](#)

[EQUIPMENT](#)

[PHD TOPICS](#)



## Research Group Leader



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**E-mail:** [helene.robert.boisivon@ceitec.muni.cz](mailto:helene.robert.boisivon@ceitec.muni.cz)

**Office:** Kamenice 753/5, Brno, 625 00

ResearcherID

Click here to see  
my profile

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