Disassembling the plant Cell Wall to obtain energy

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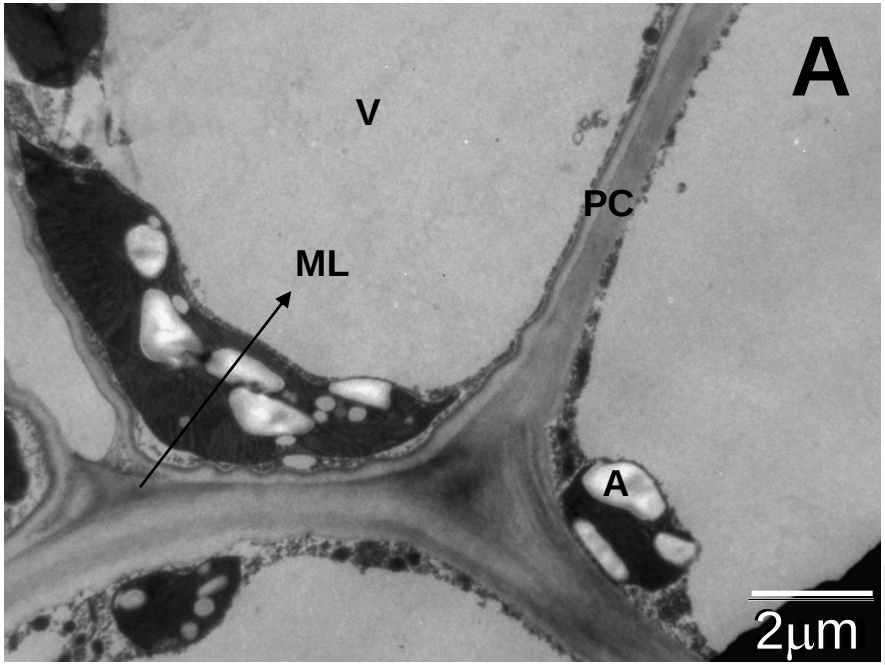
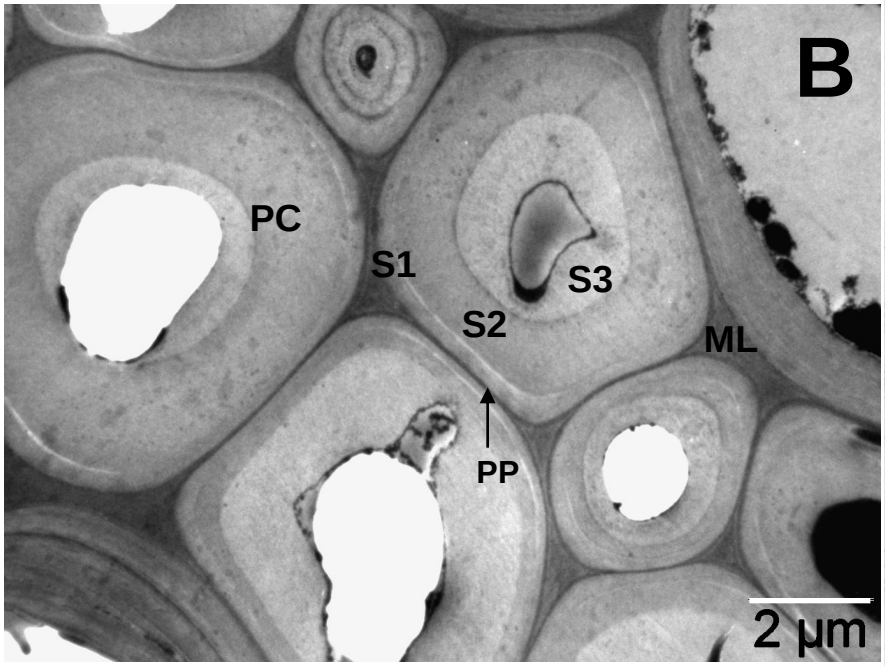
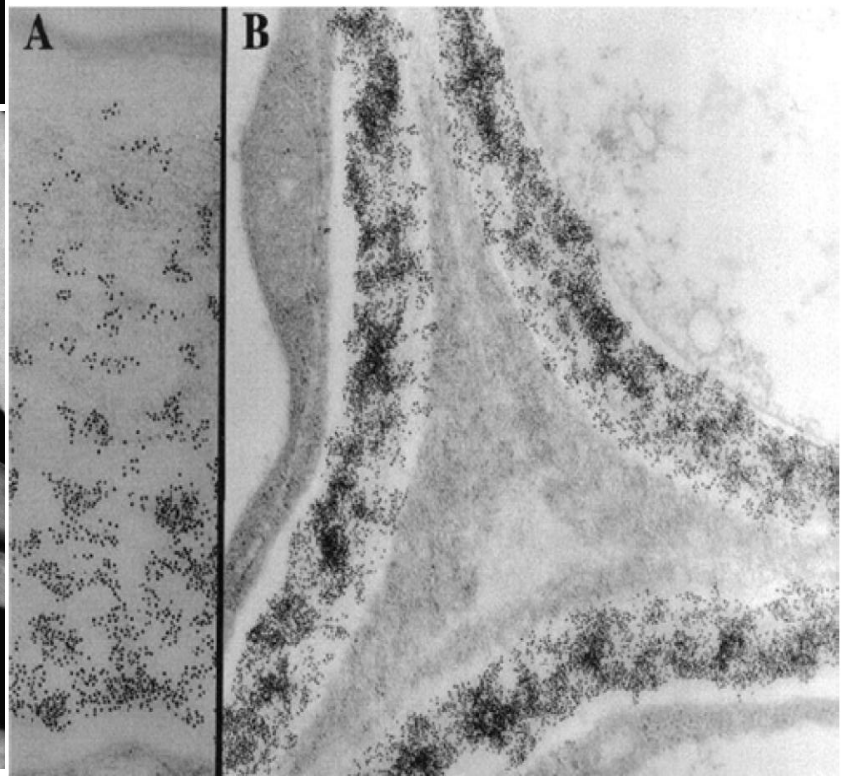
Cell walls from leaves (left), root (below) of legumes and maize







Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan

The wall in the context of plant composition

Obtained from CO_2 and water

96%

- Carbon.....45%
- Oxigen.....45%
- Hidrogen.....6%

Cellulose, hemicelluloses & pectins
96-10%=86%

Macronutrients

3.6%

- Nitrogen.....1.5% X 6.25 = 9.4% (10%)
- Potassium.....1.0% X
- Calcium.....0.5%
- Magnesium.....0.2%
- Phosphorous.....0.2% X
- Sulfur.....0.1% X
- Silicium.....0.1%

Proteins and Nucleic acids

Pectins = 0.7%

Pectins? = 0.7%

Micronutrients

0.4%

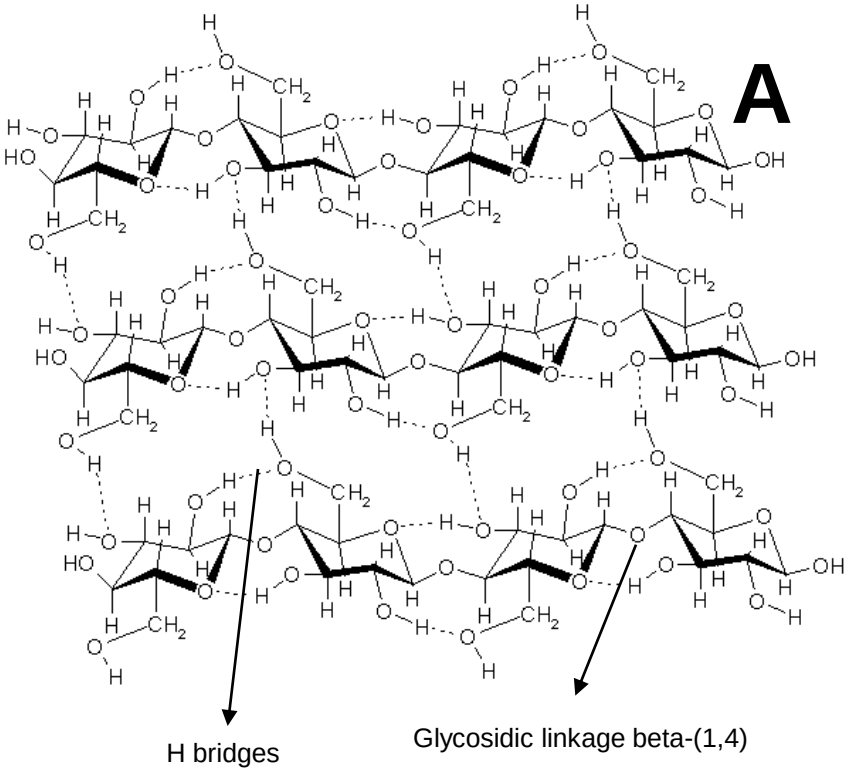
- Boron.....
- Manganese.....
- Chloride..... X
- Iron..... X
- Sodium..... X
- Zinc..... X
- Copper..... X
- Nickel..... X
- Molibdenium..... X

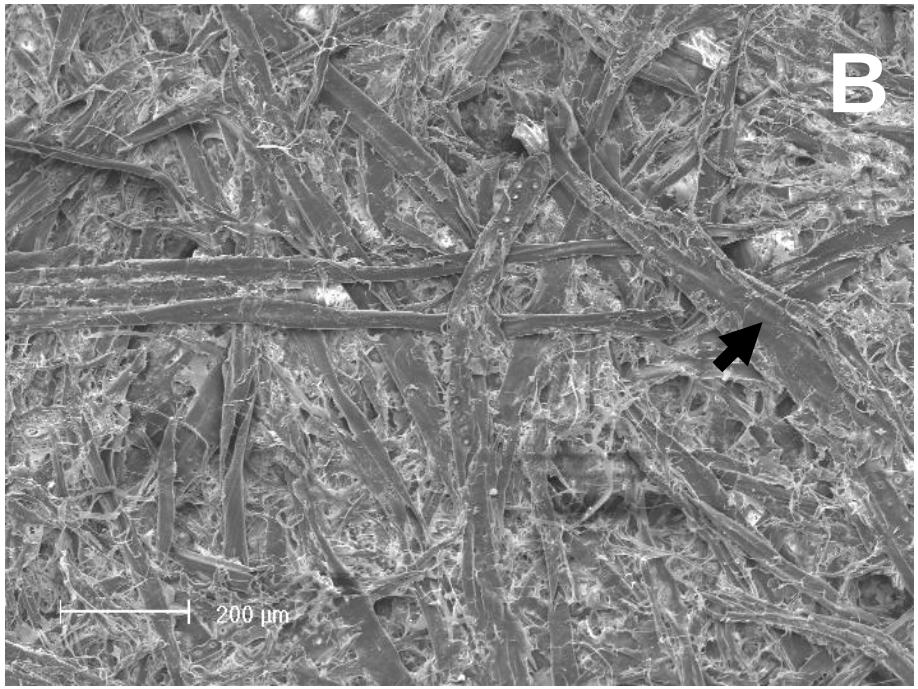
Pectins = traces

Lipids are approximately 15% of plant tissues

Thus, the wall corresponds to ca. 70 % of the plant

In sugarne = leaves contain 68% and stem 50% plus 18% of sucrose

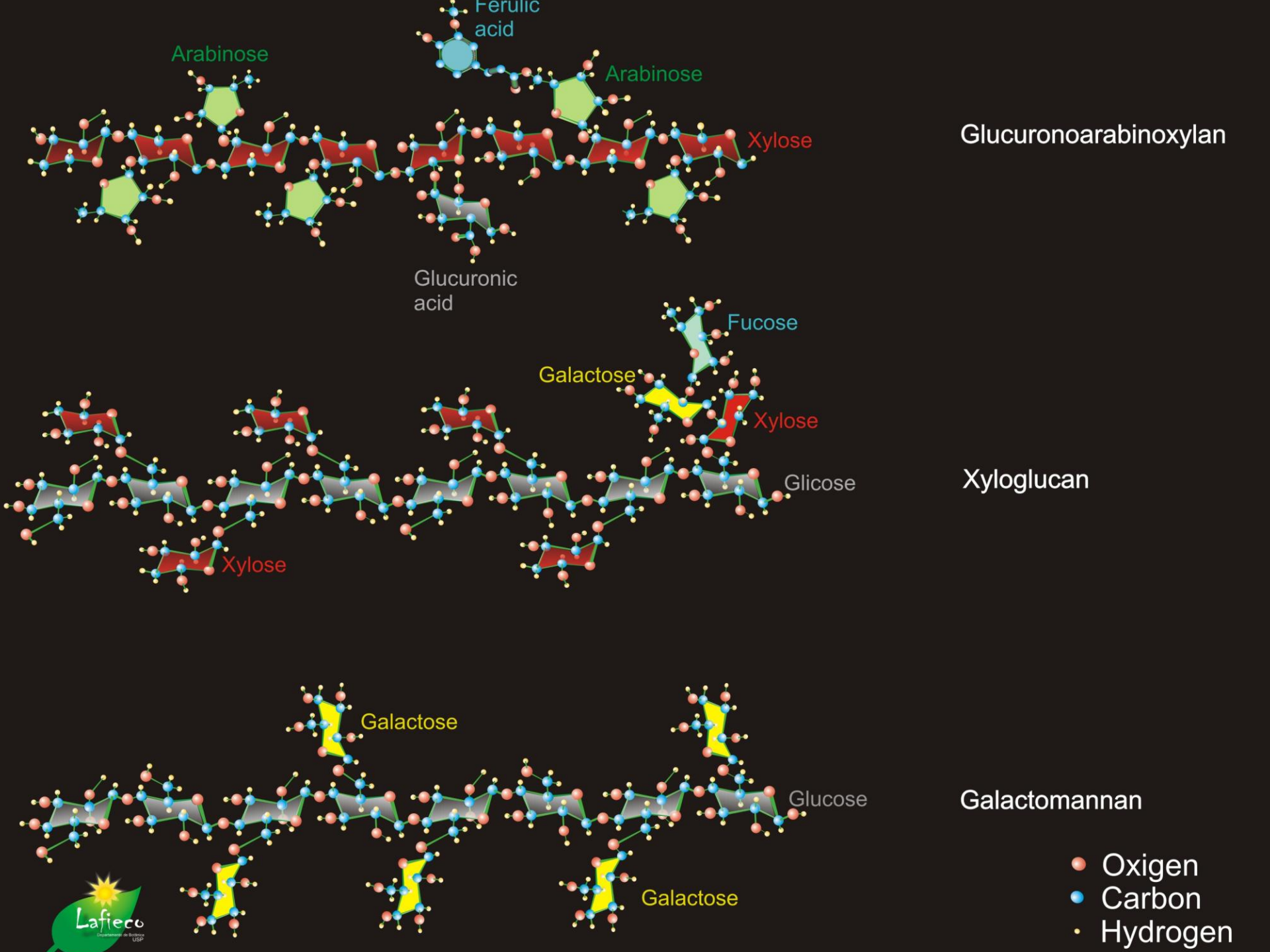


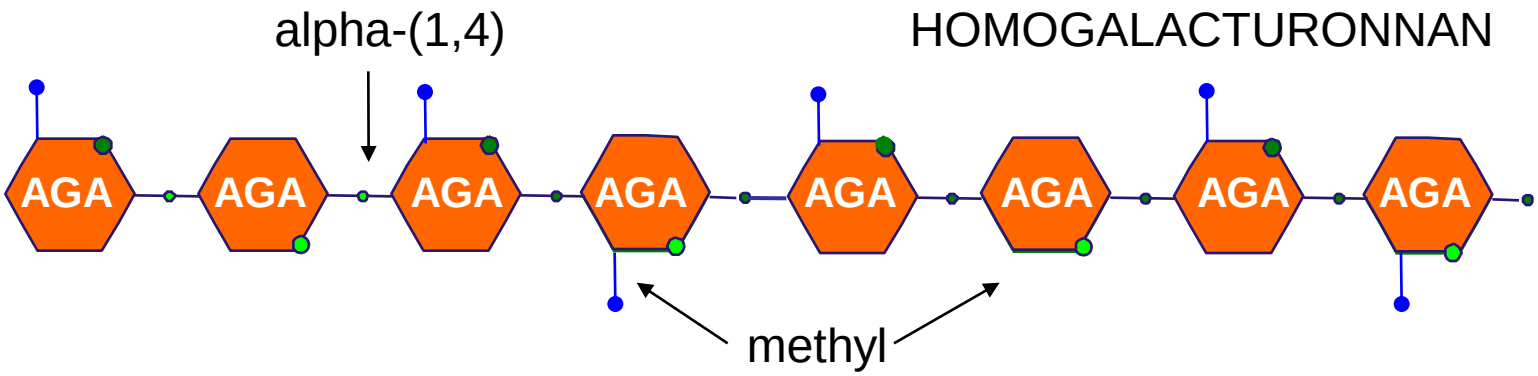


paper

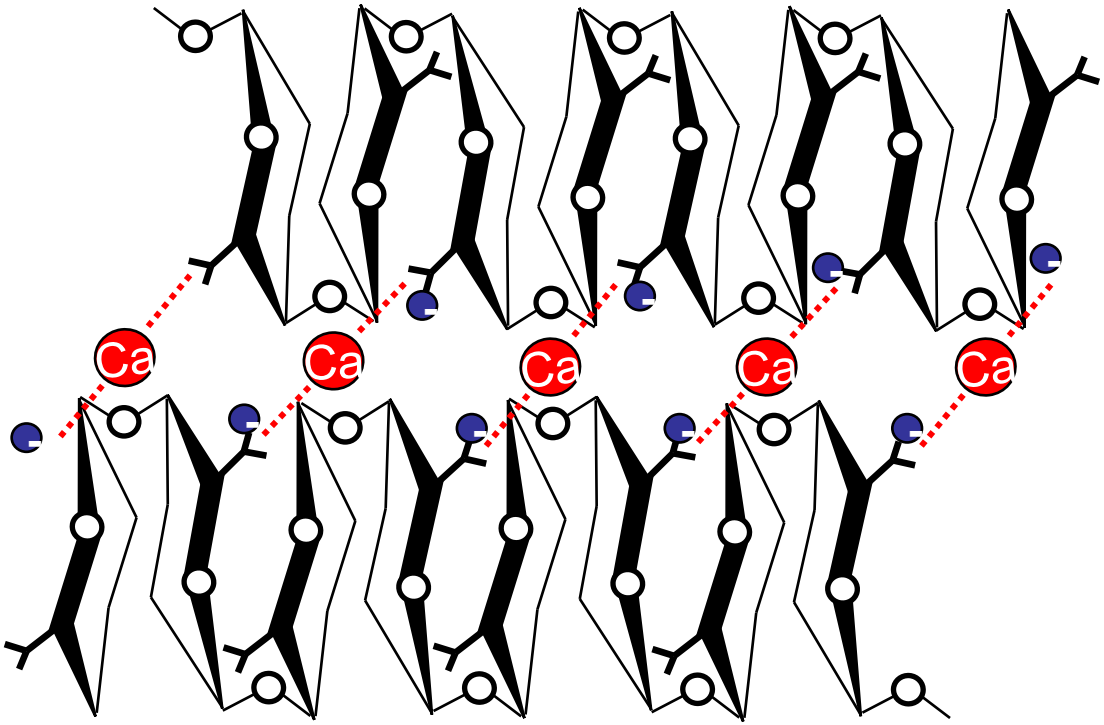
Cellulose: the most abundant polymer on Earth.

Photograph by Cesar Gustavo Lisboa e Marcos Buckeridge, 2005


Ferulic acid
Arabinose
Arabinose
Xylose
Glucuronoarabinoxylan
Glucuronic acid
Fucose
Galactose
Xylose
Glicose
Xylose
Xyloglucan
Galactose
Glucose
Galactose
Galactomannan
Oxigen
Carbon
Hydrogen
Lafieco



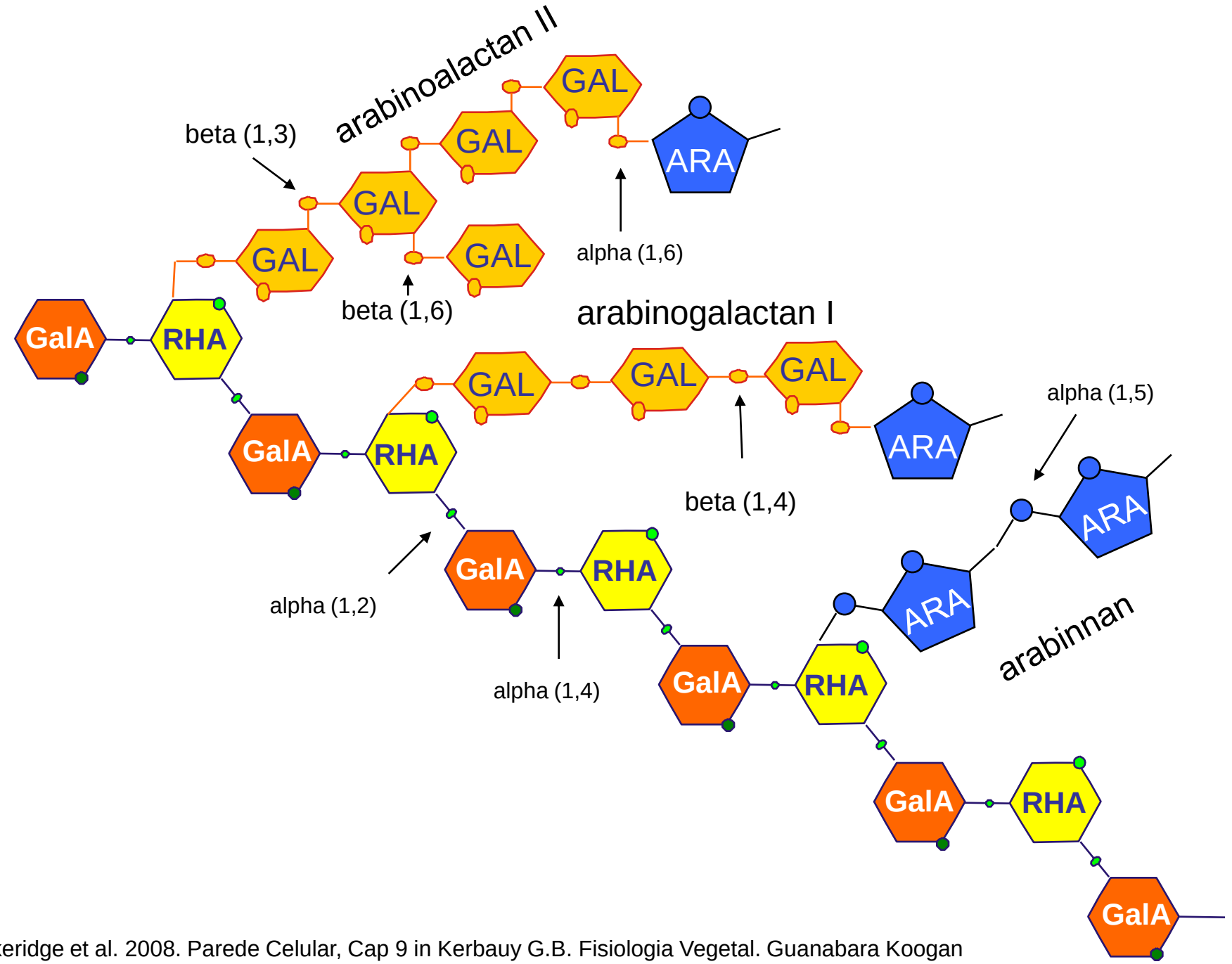
A



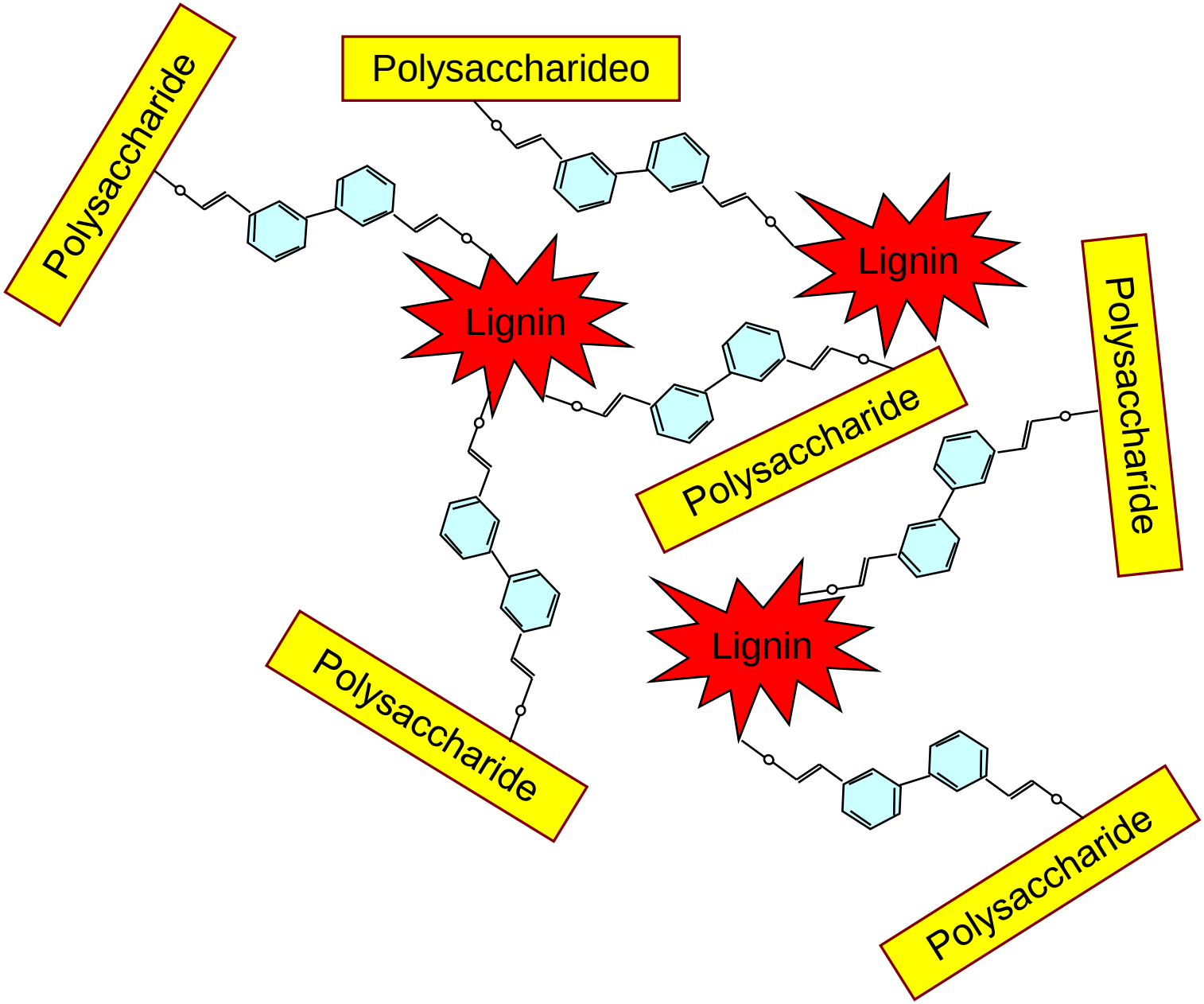
Egg boxes *divalent ion, maily calcium and magnesium induce the formatio of gels in regions that are not methylated of homogalacturonan*

B

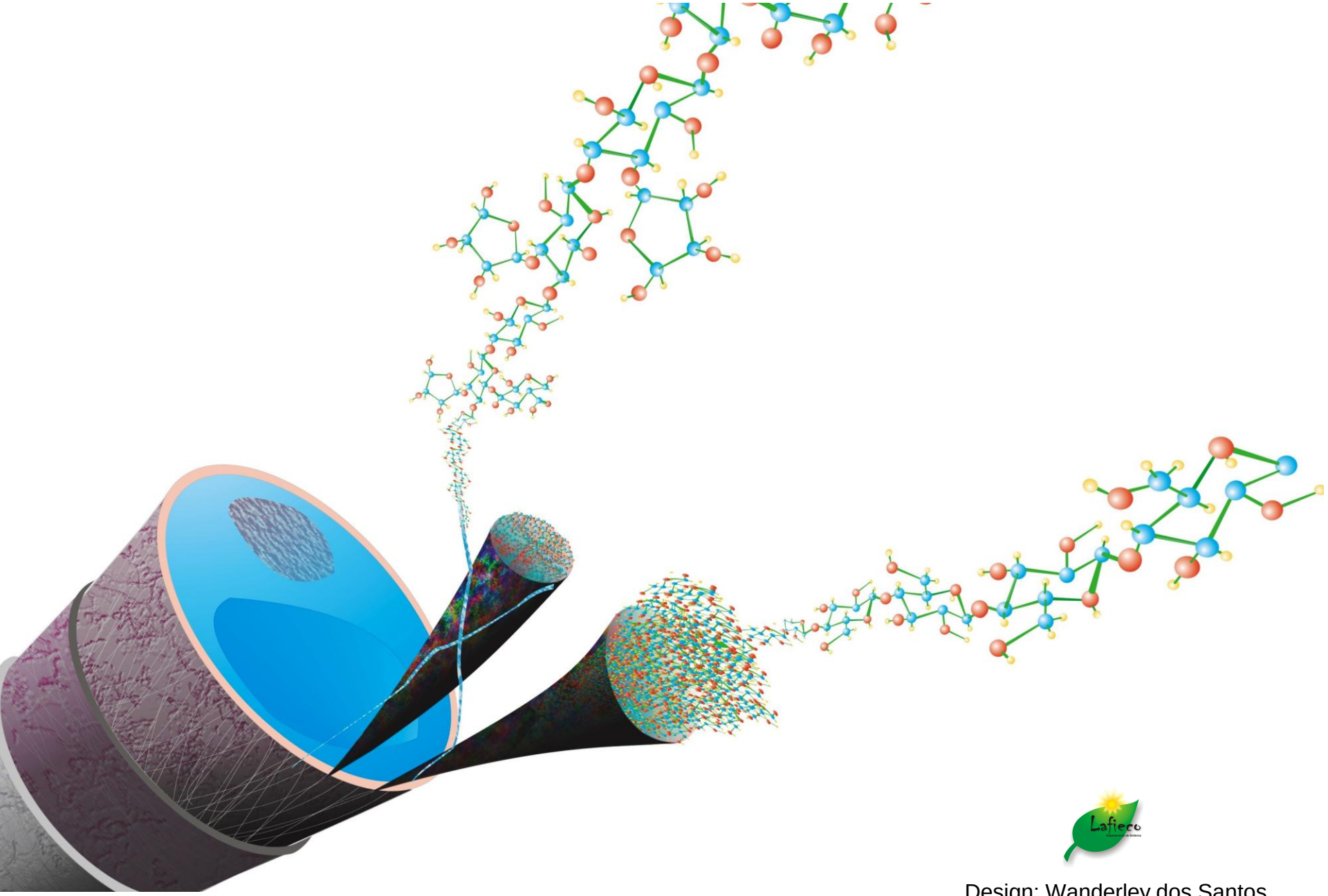
Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan



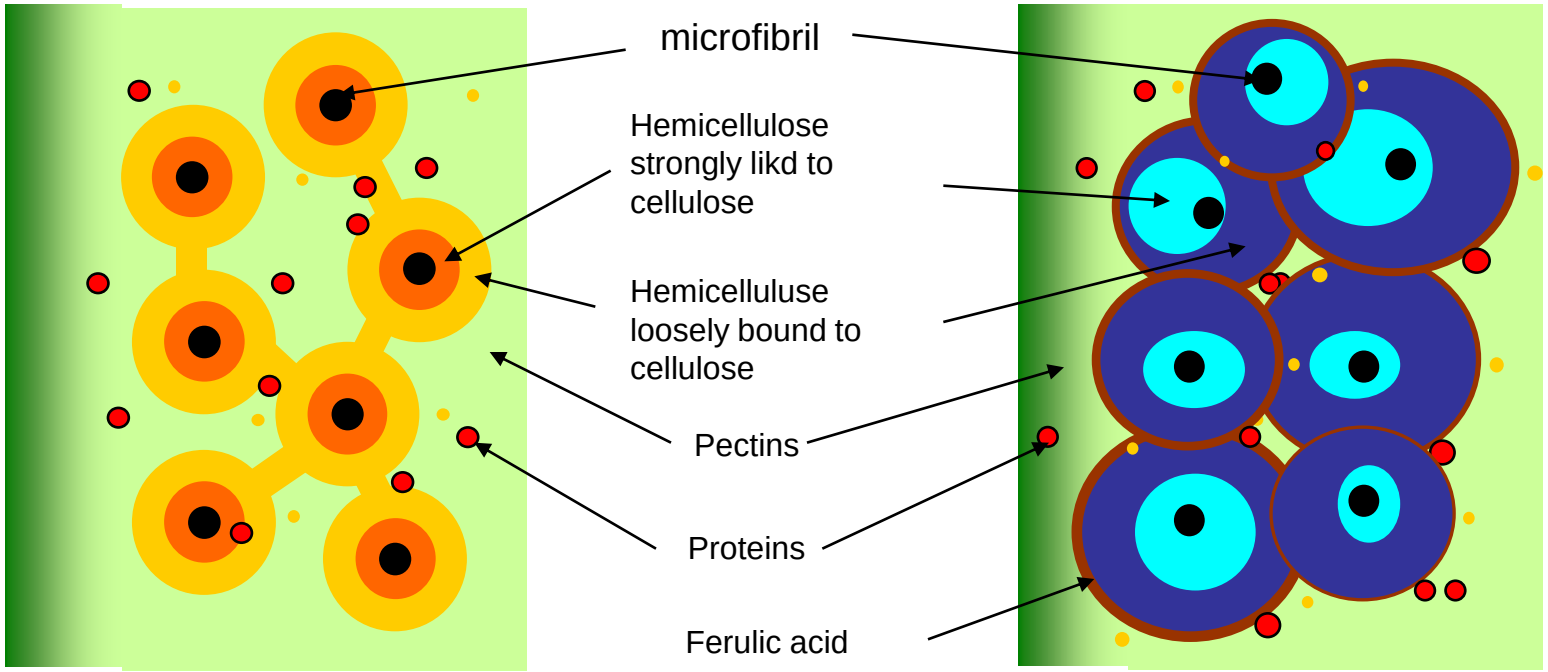
Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan


Polysaccharide
Polysaccharideo
Lignin
Lignin
Polysaccharide
Polysaccharide
Lignin
Polysaccharide
Polysaccharide

THE ARCHITECTURE OF THE CELL WALL



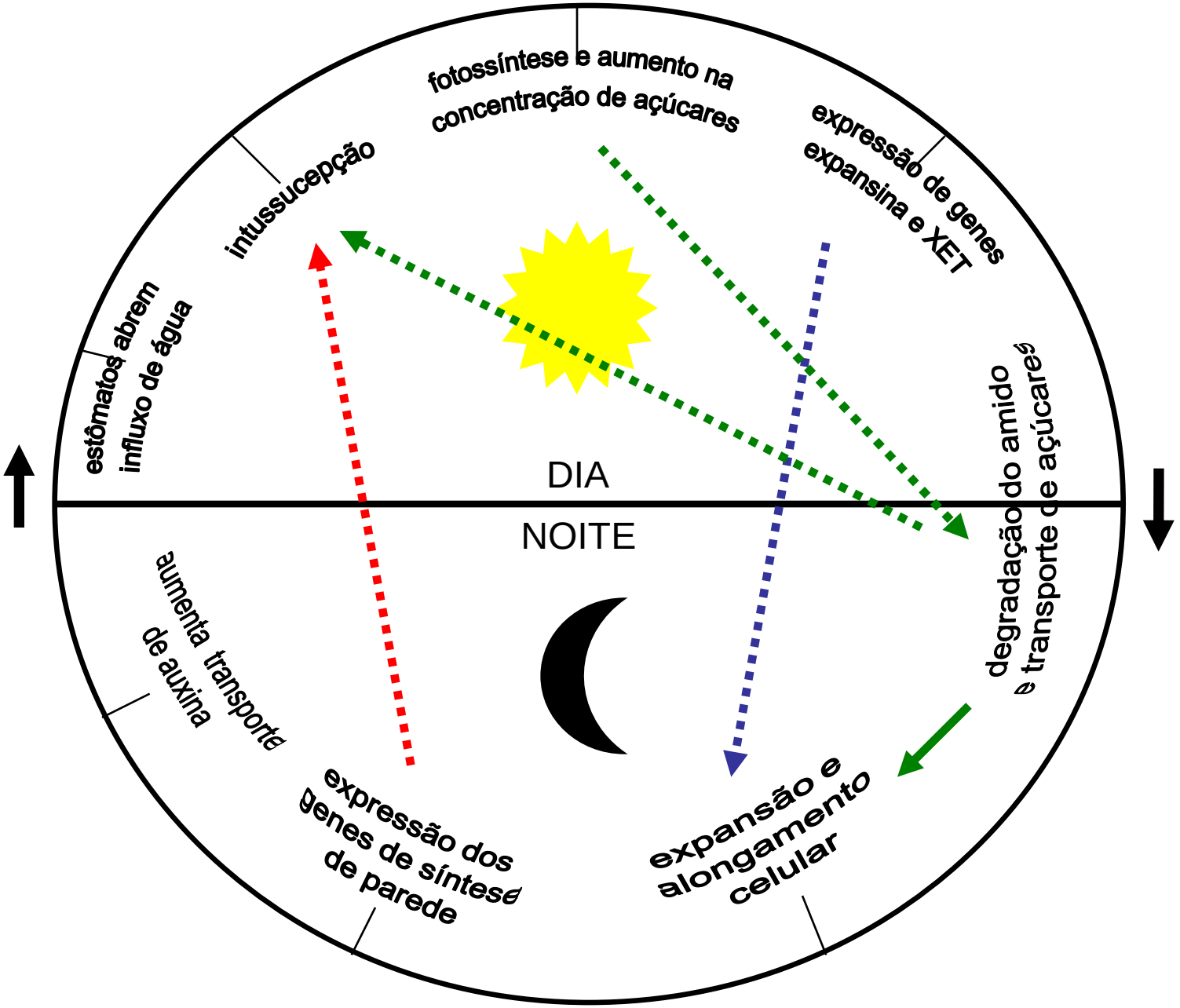
Design: Wanderley dos Santos



Type I

Type II

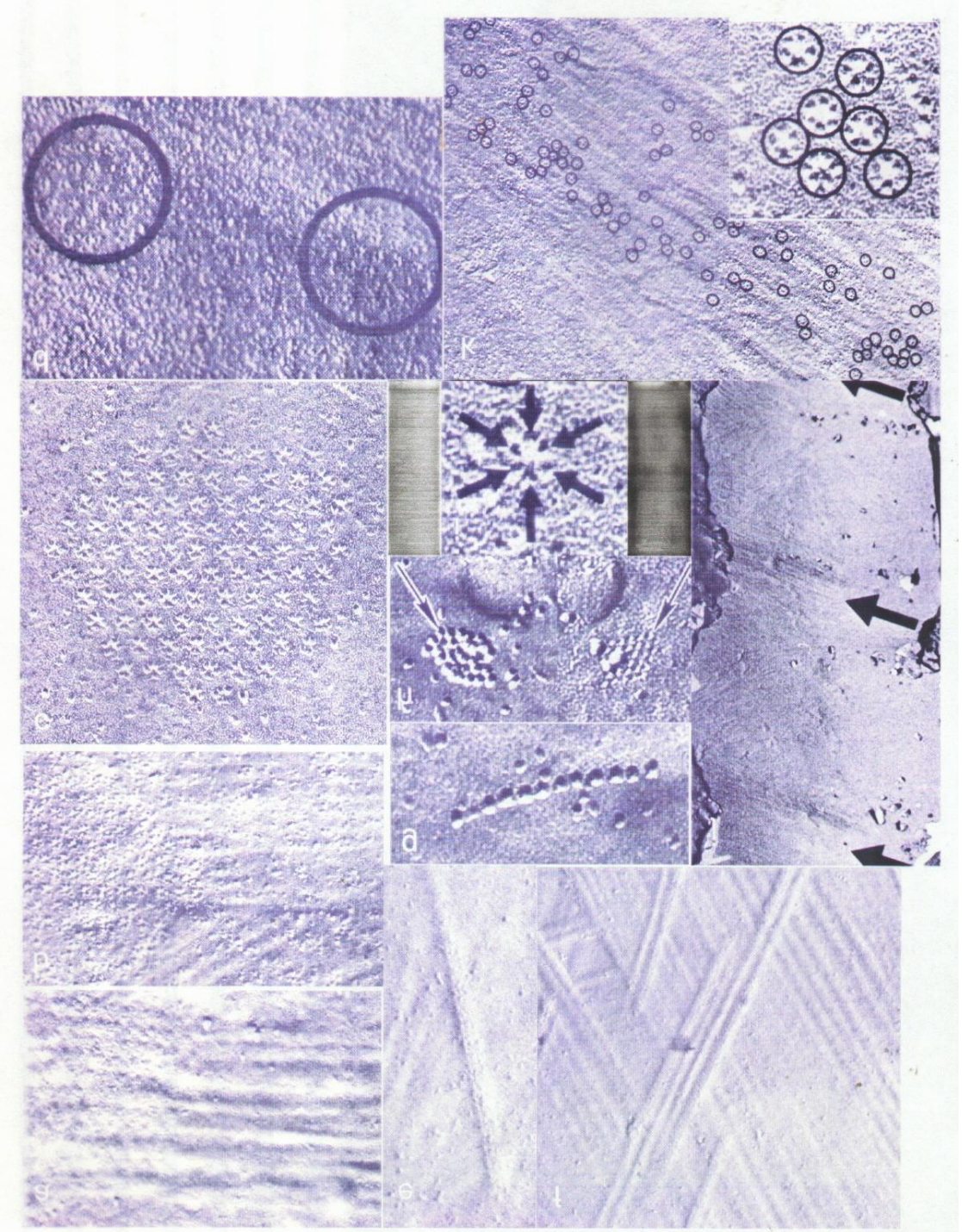
Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan

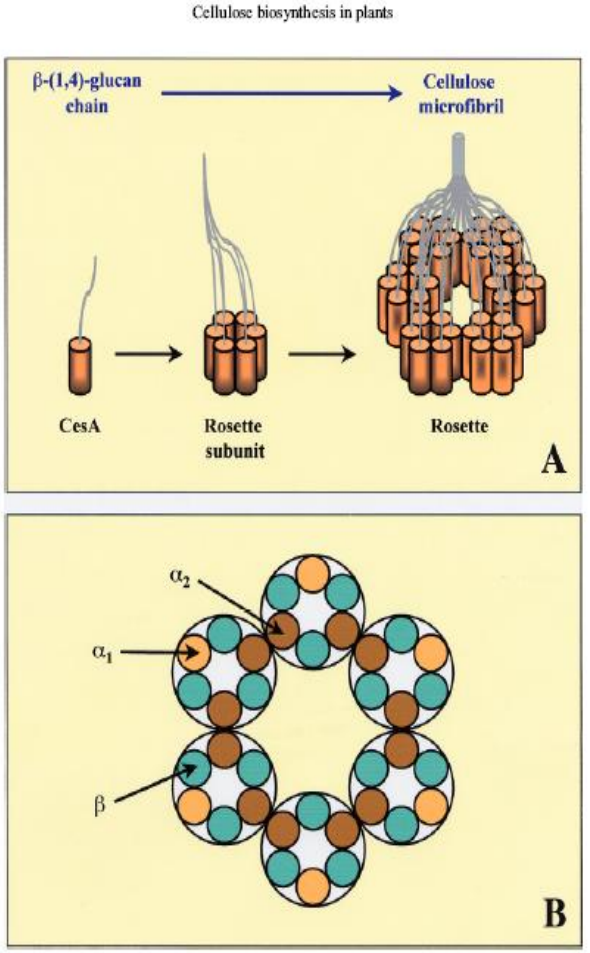


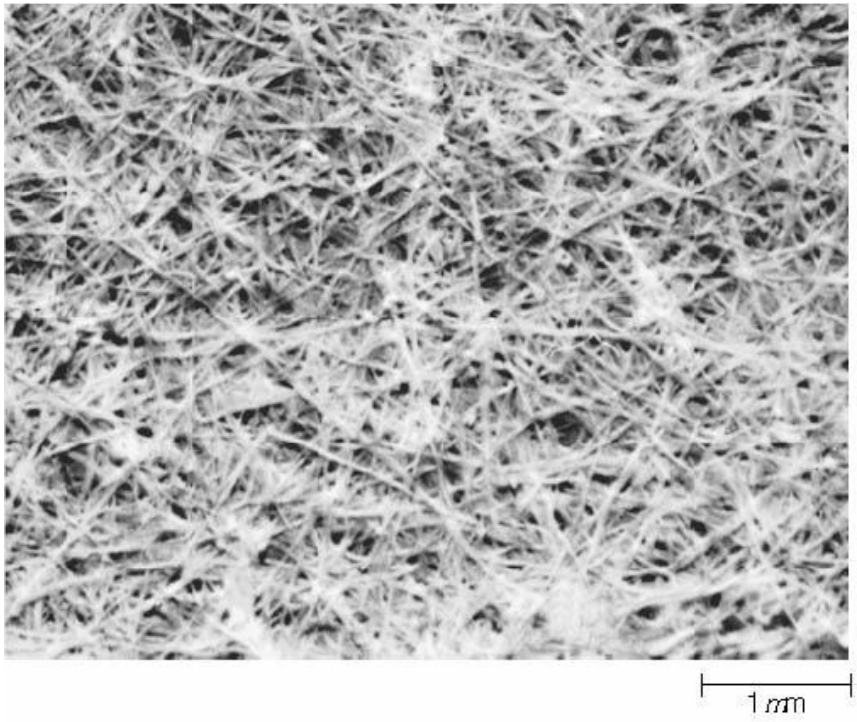
Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan

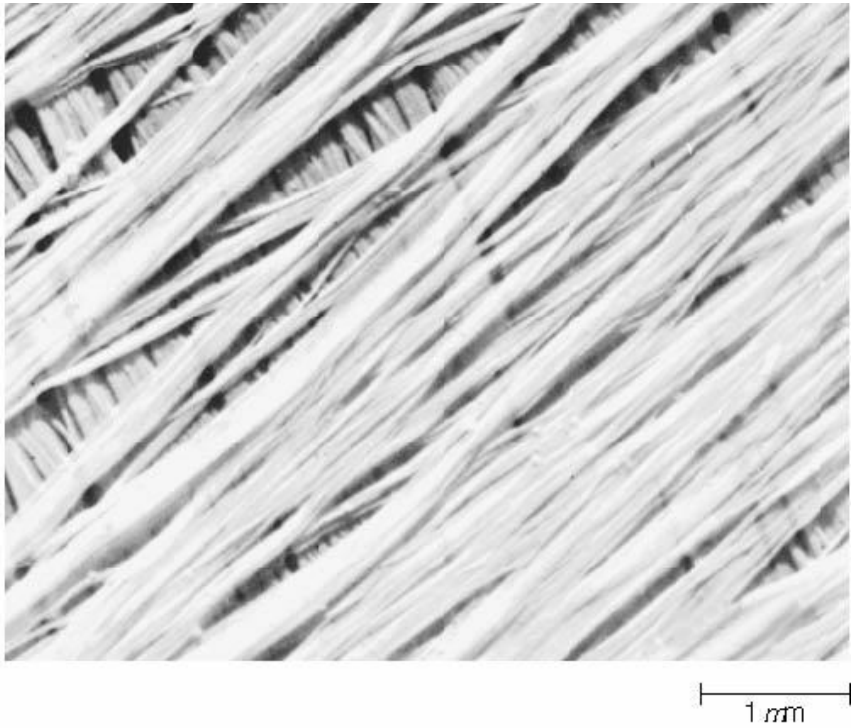
WALL BIOSYNTHESIS

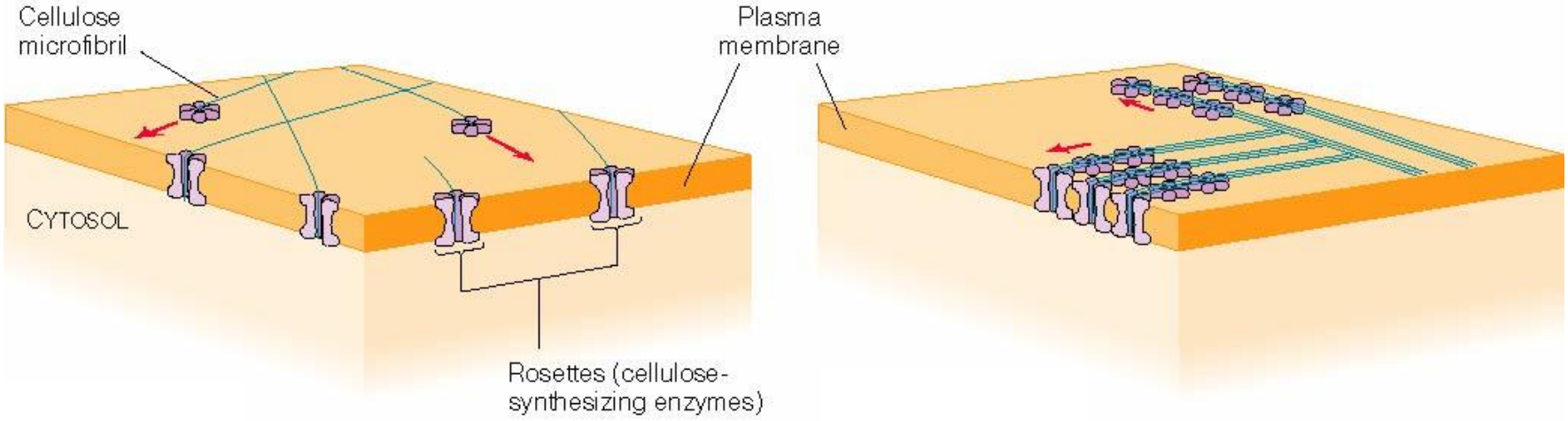
Biosynthesis of cellulose: the only wall polymer made in the plasma membrane





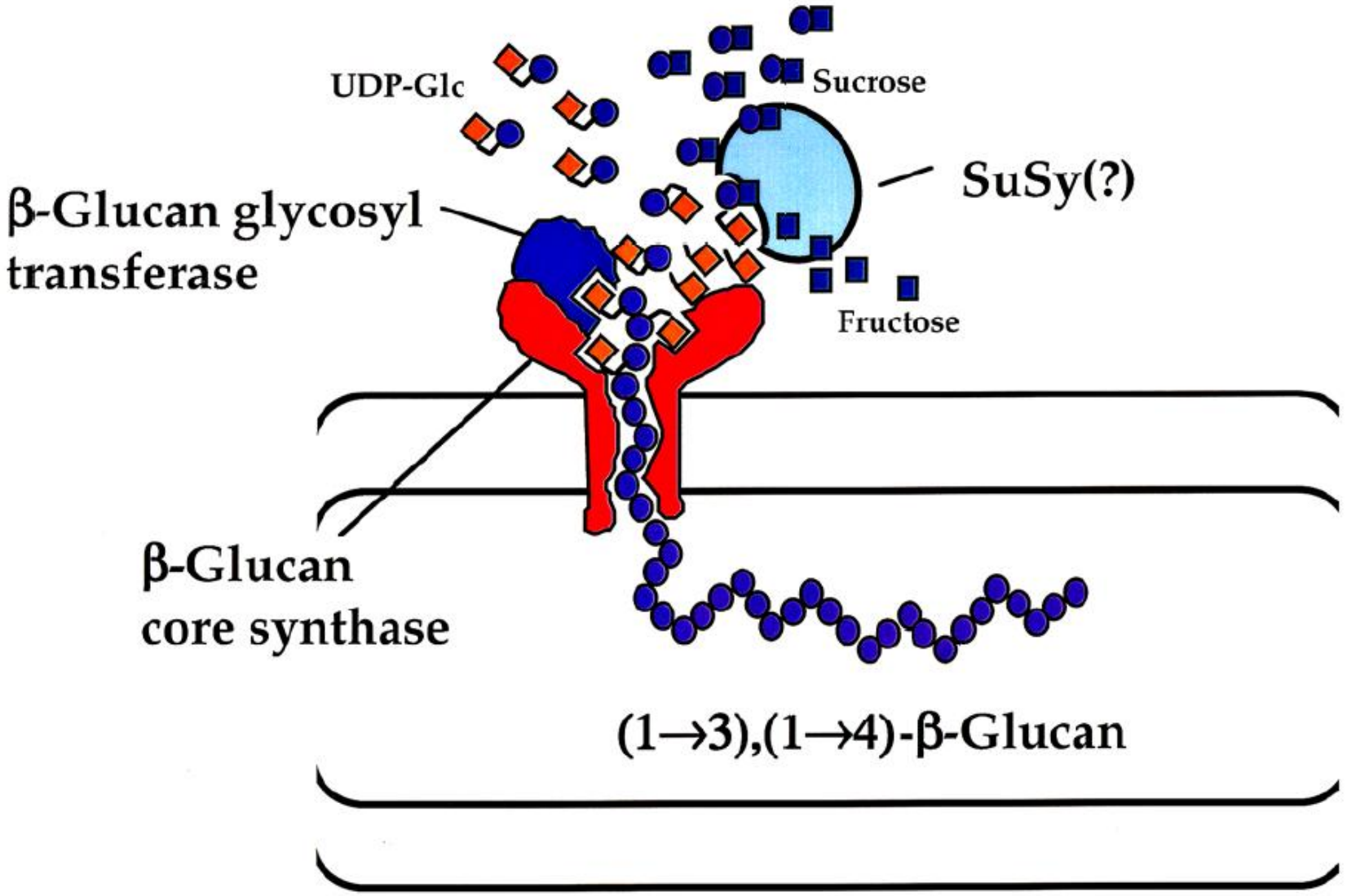

1 μm


1 μm


Cellulose microfibril
Plasma membrane
CYTOSOL
Rosettes (cellulose-synthesizing enzymes)

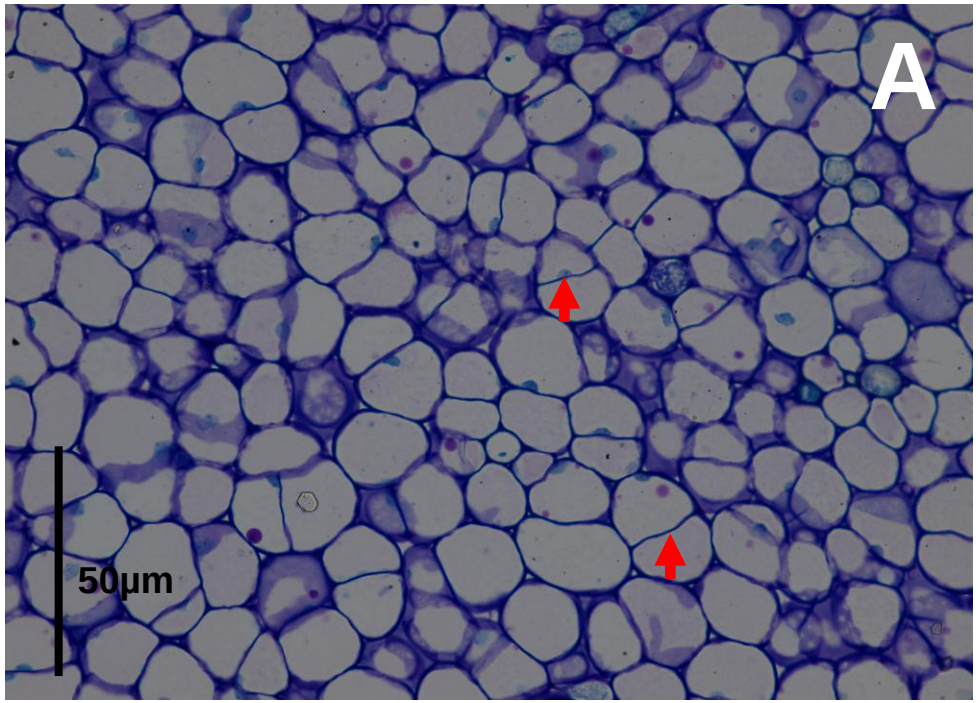
The remaining wall polymers are made in the Golgi Complex

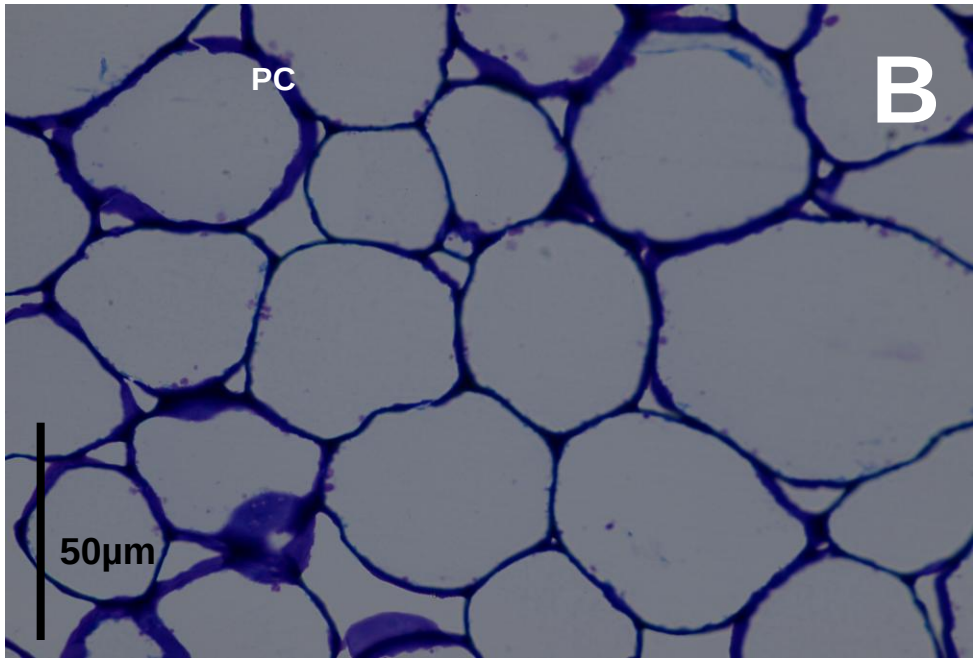
Hemicellulose biosynthesis



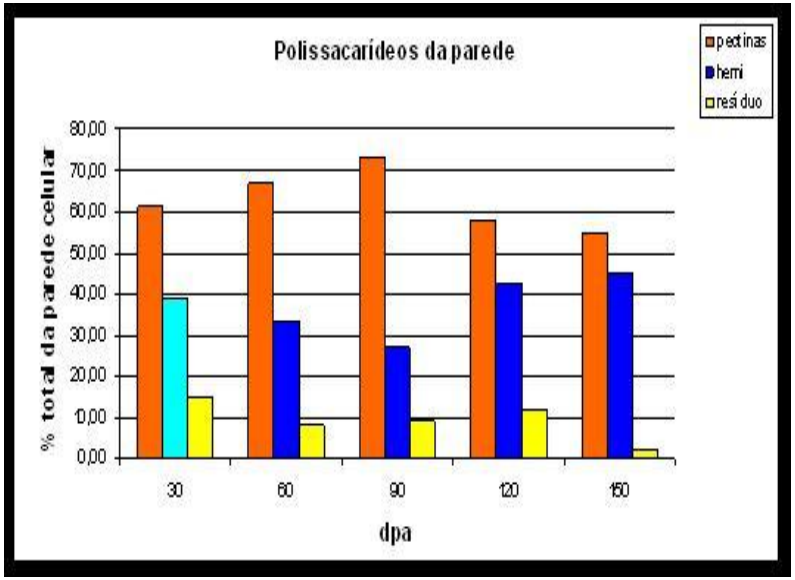
Buckeridge et al. 2004, Cereal Chemistry, Vol. 81 pg. 115

PLANT DEVELOPMENT AND WALL DEGRADATION

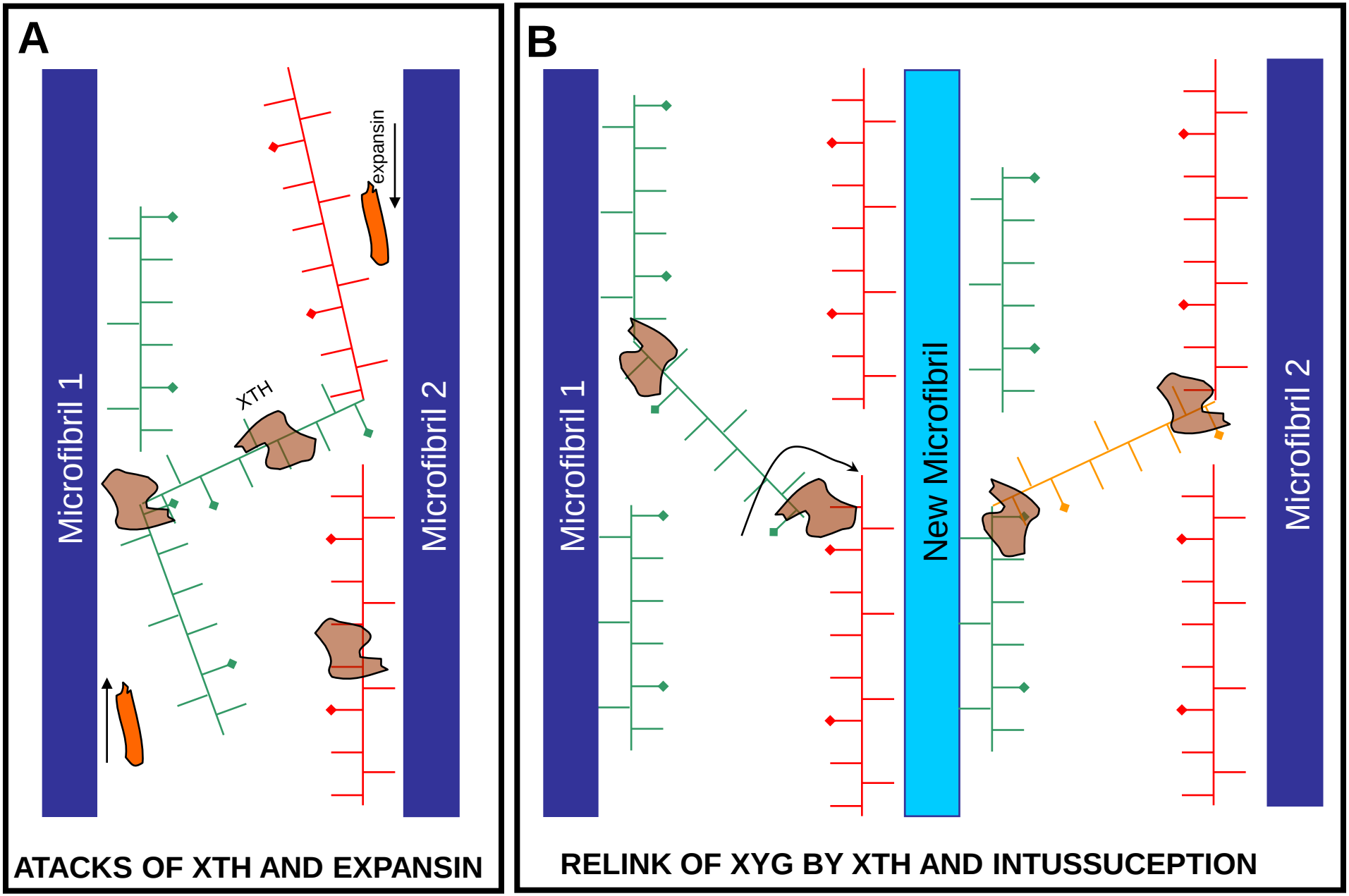




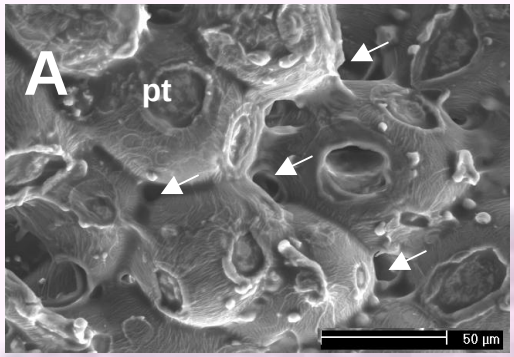
Cell expansion in papaya during development

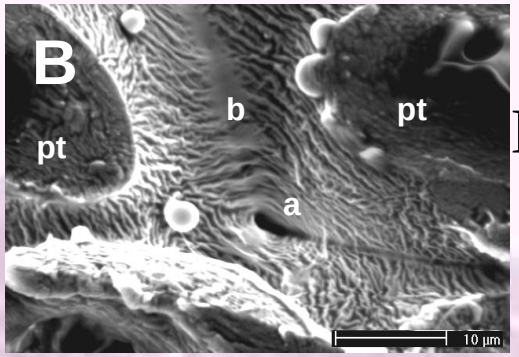


Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan



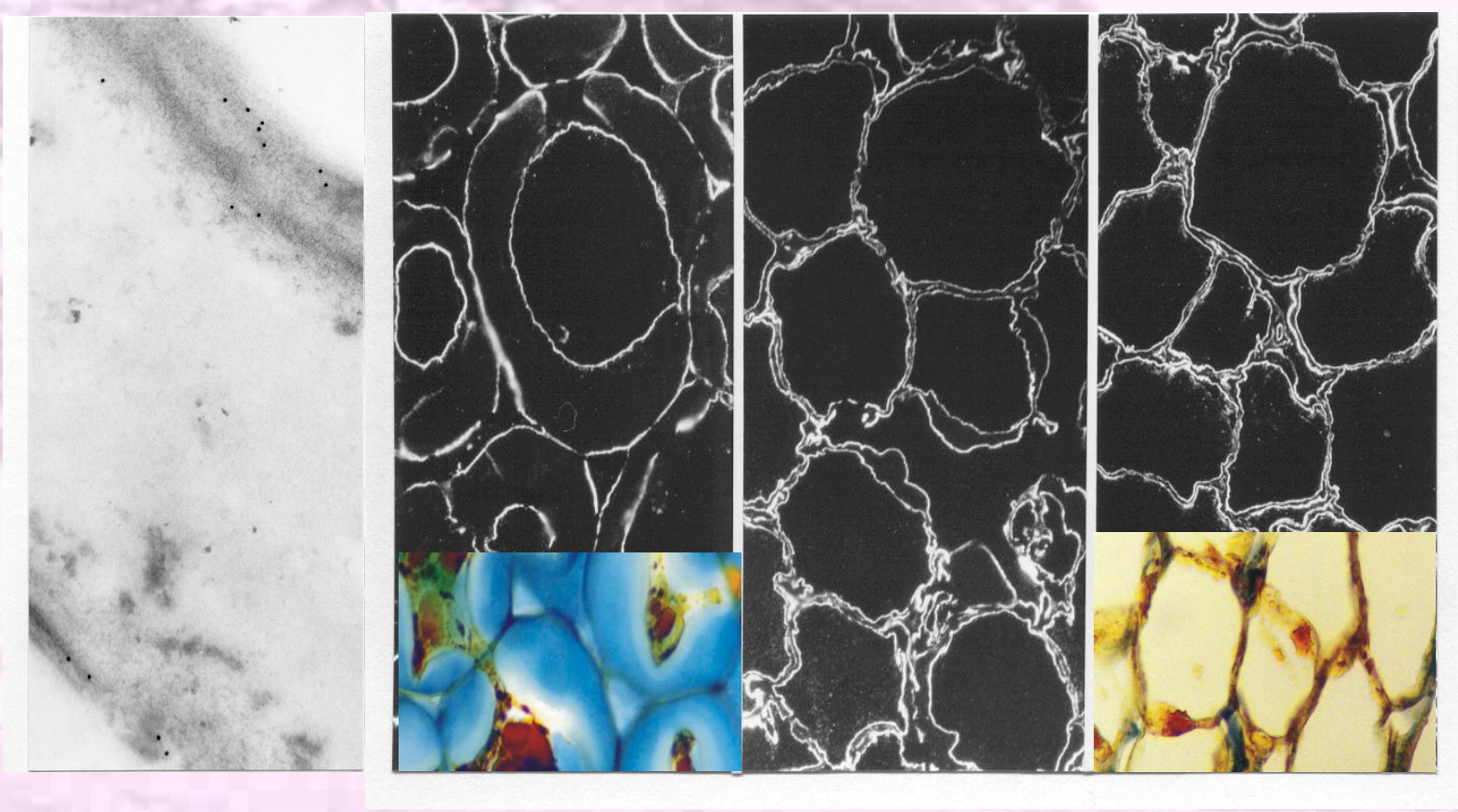
Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan



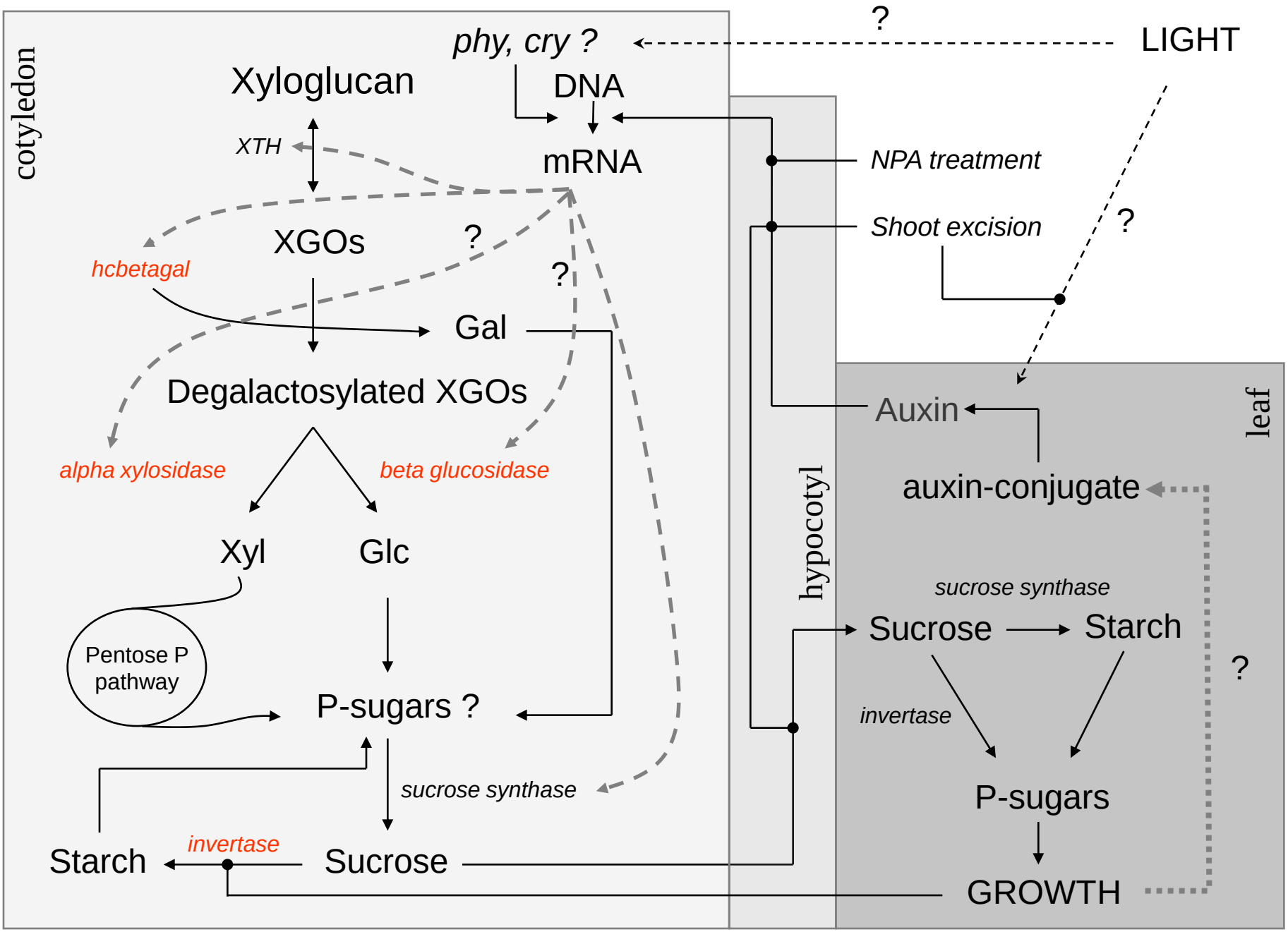


Cotyledons of Hymenaea courbaril (jatobá) Storage walls can be very complex

M1 antibody binds specifically to fucosylated XGs, which are present only in primary cell walls

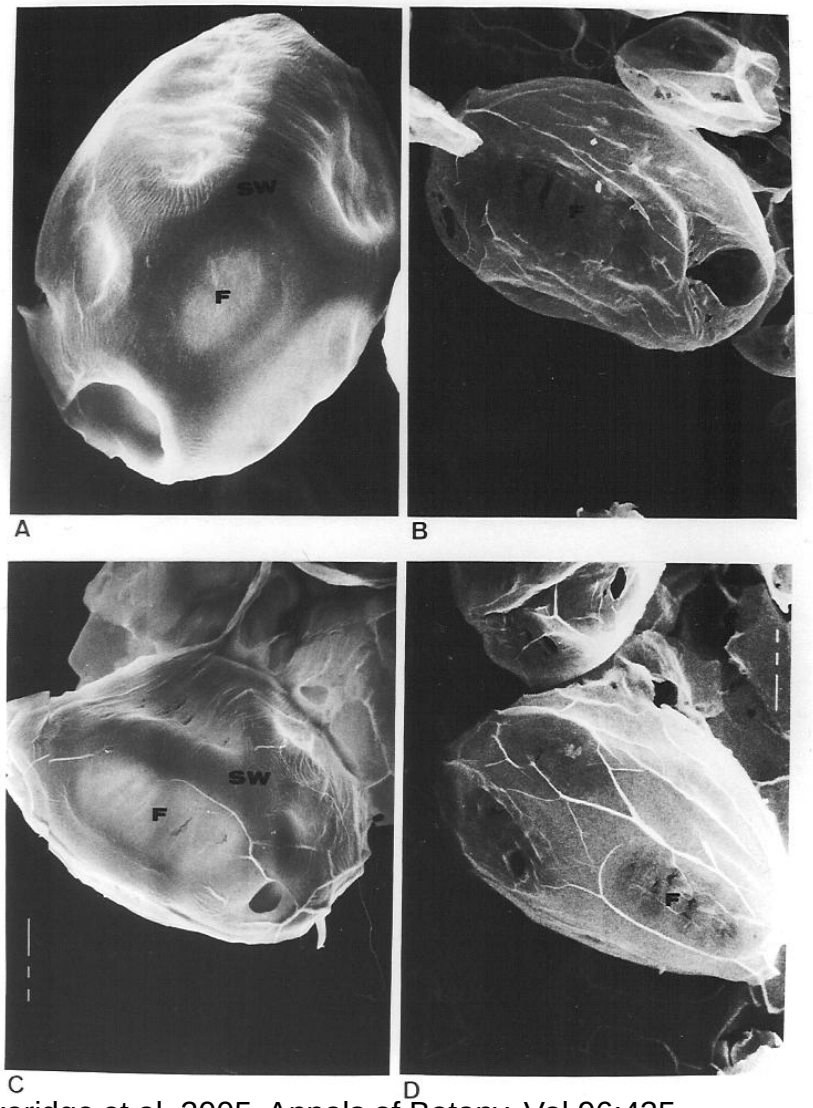


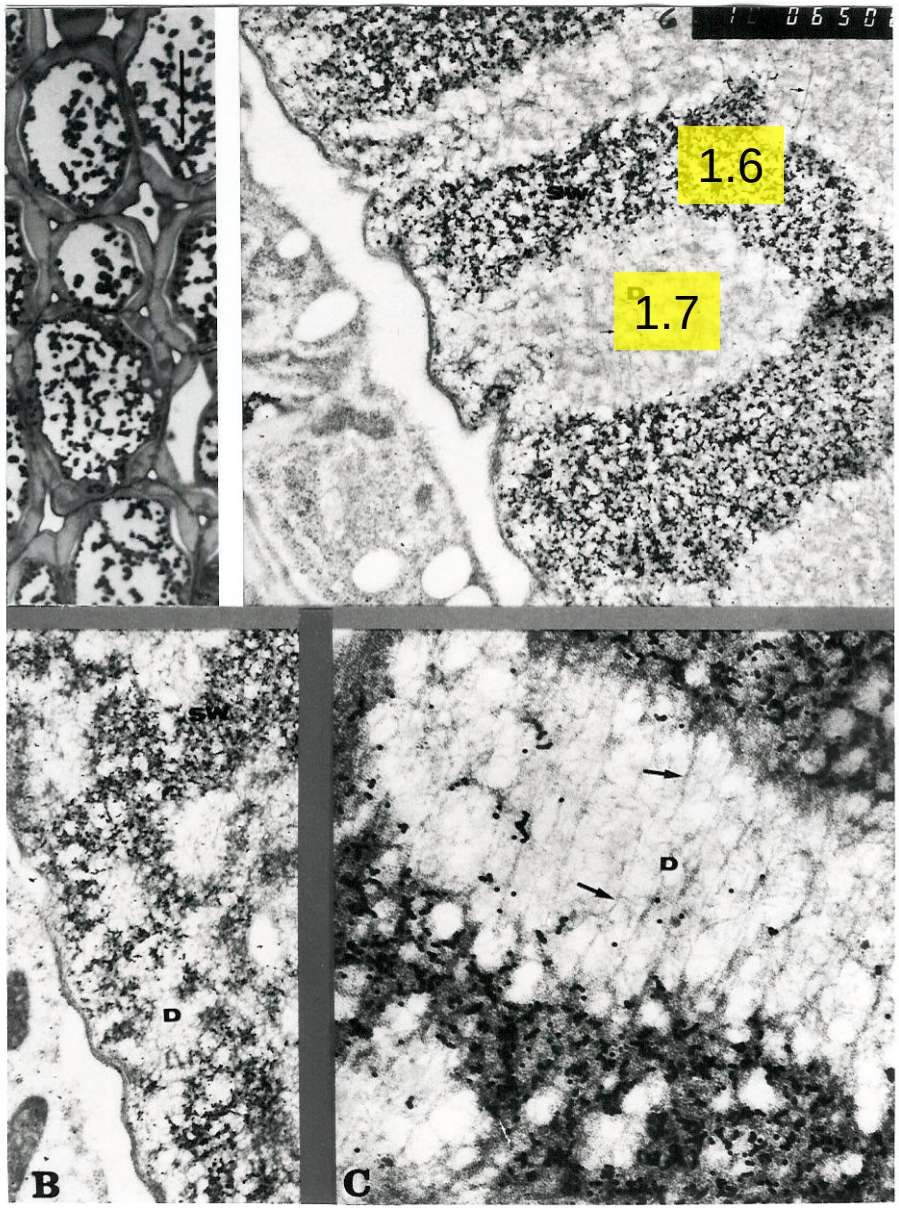
Tiné, Braga, Hahn, Freshhour & Buckeridge, unpublished results



PhD thesis Aline Brandão

Cotyledons of Lupin: one enzyme does the job



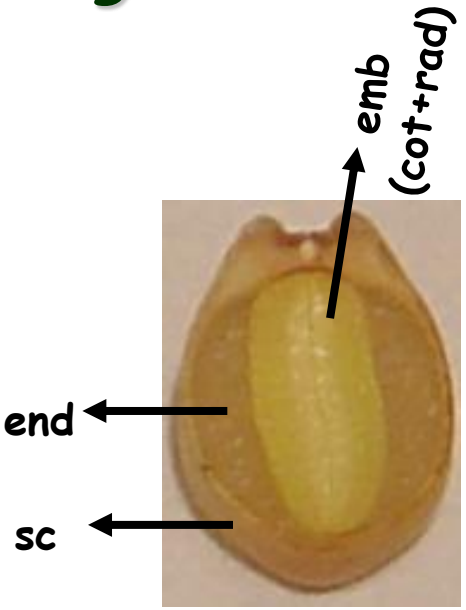


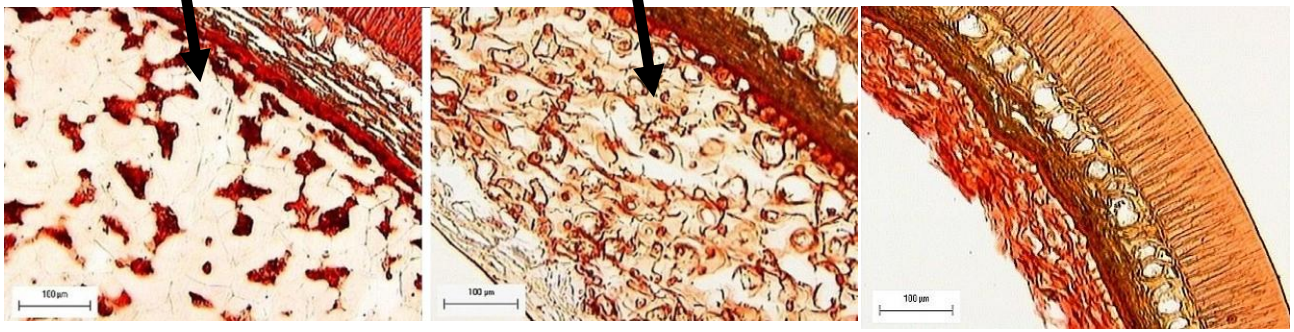
Buckeridge et al. 2005. Annals of Botany, Vol.96:435.

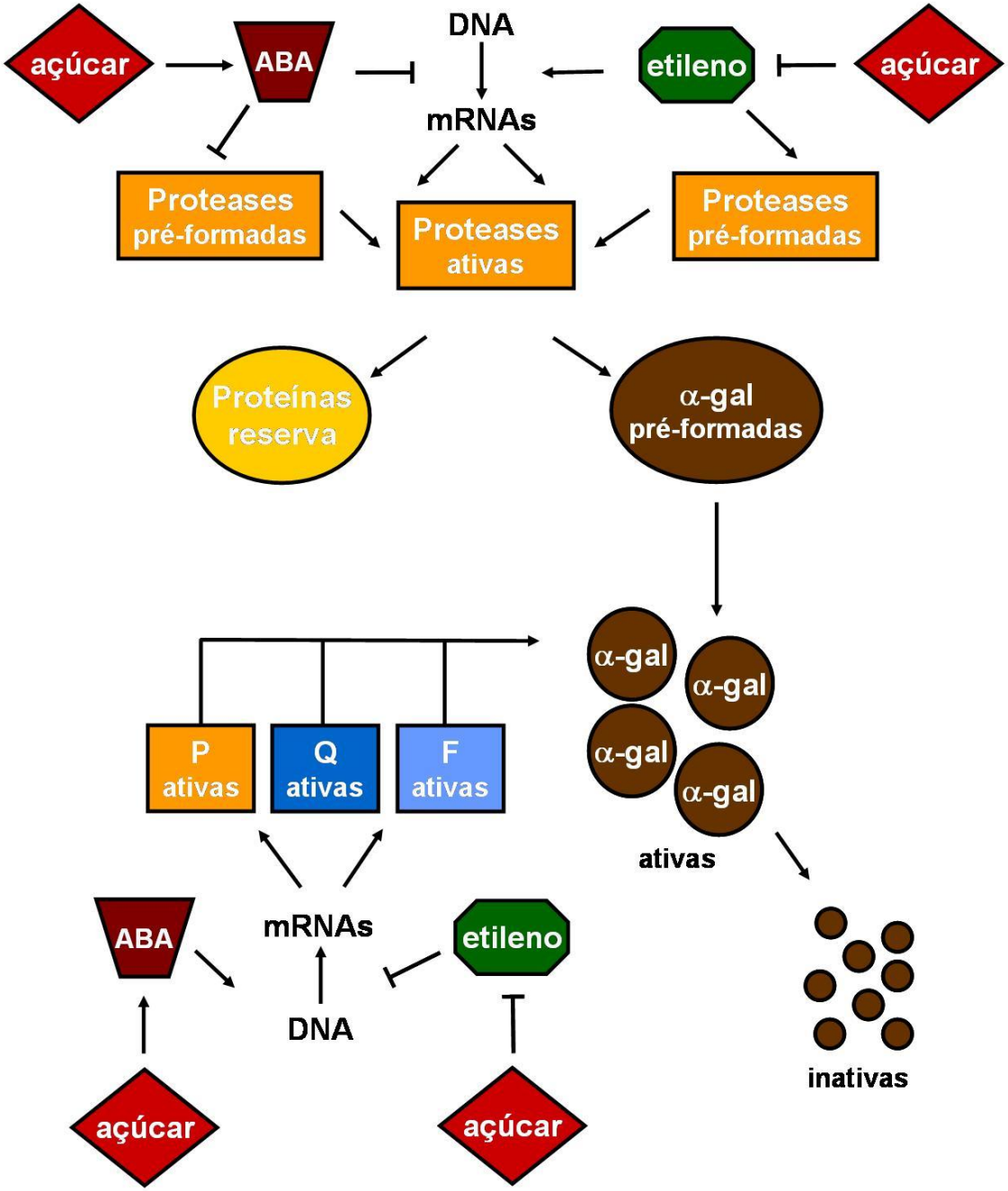
⇨ Galactomannan degradation in *S. virgata*

0 1 2 3 4

Time (days)

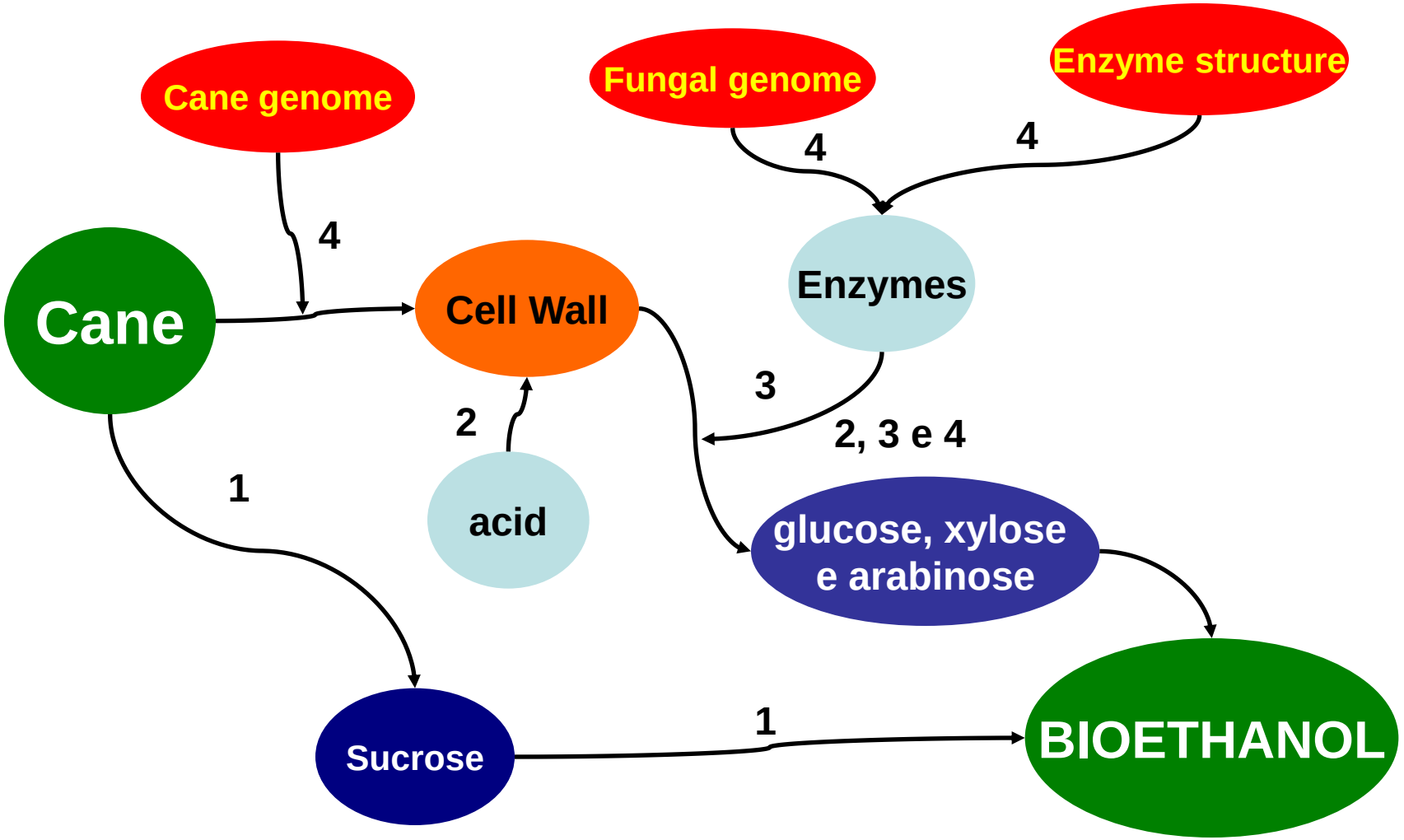






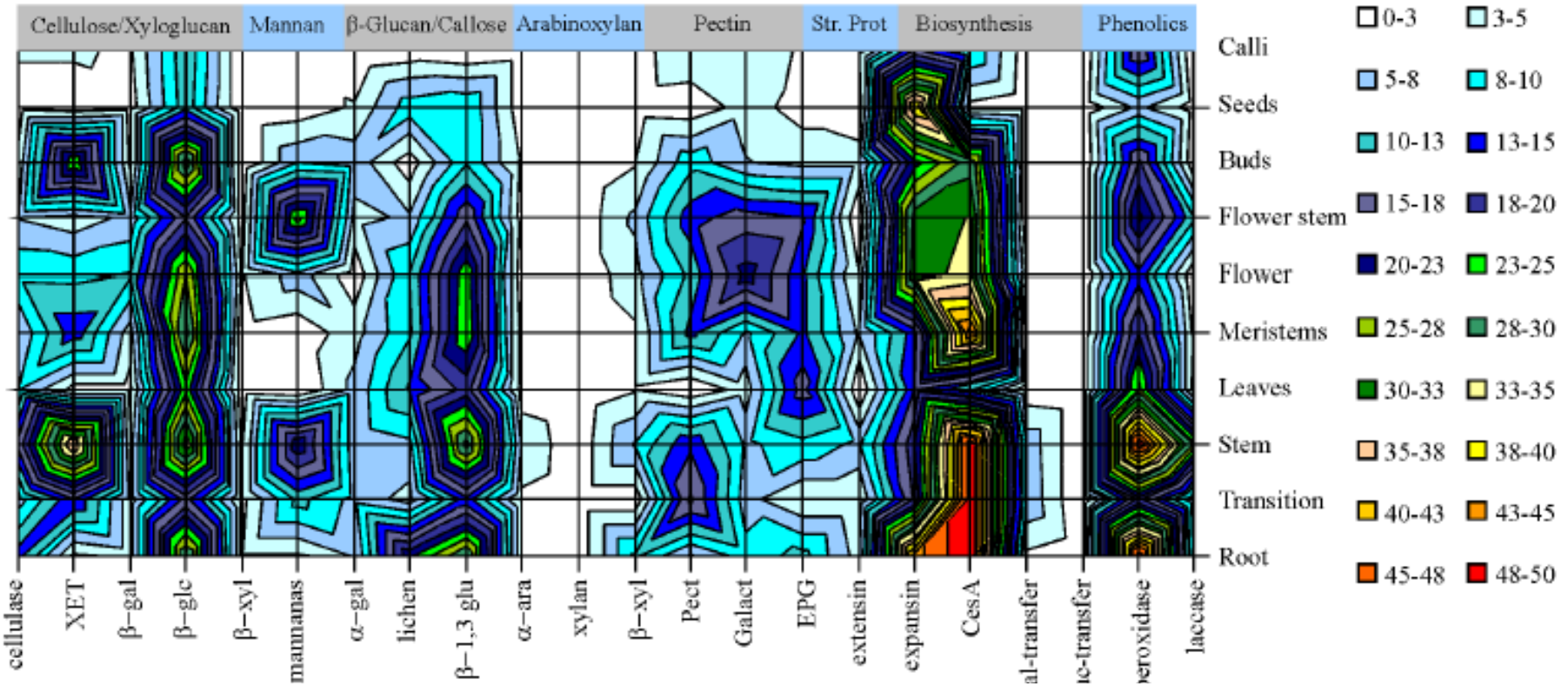
germinação e pós-germinação

THE FOUR GENERATIONS OF BIOTHANOL



Rotas para o etanol celulósico – Marcos Buckeridge, msbuck@usp.br

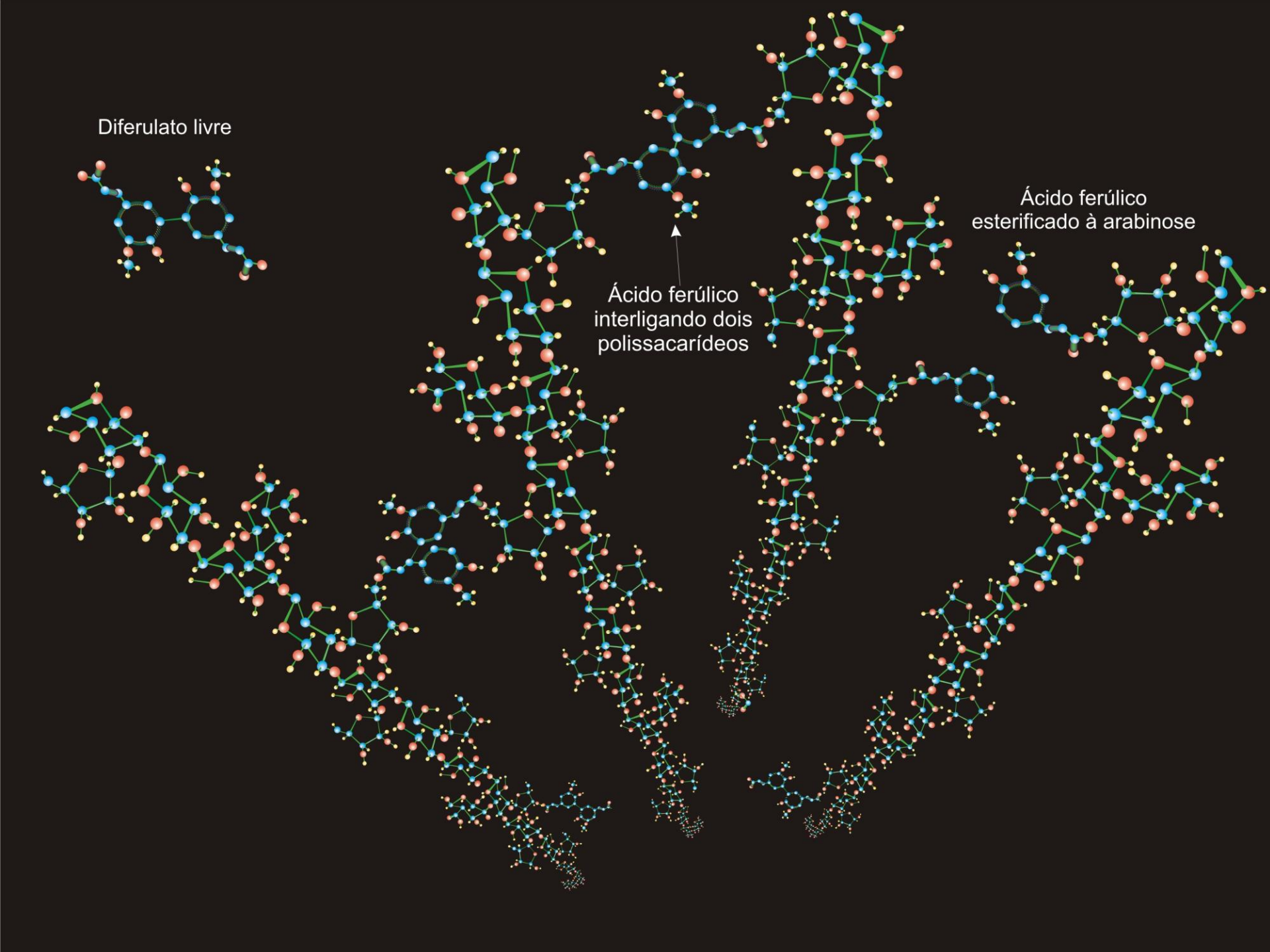
From 1999 to 2001, the SUCEST genome program produced 238,000 ESTs from various tissues of the sugar cane plant.



Since then we found:

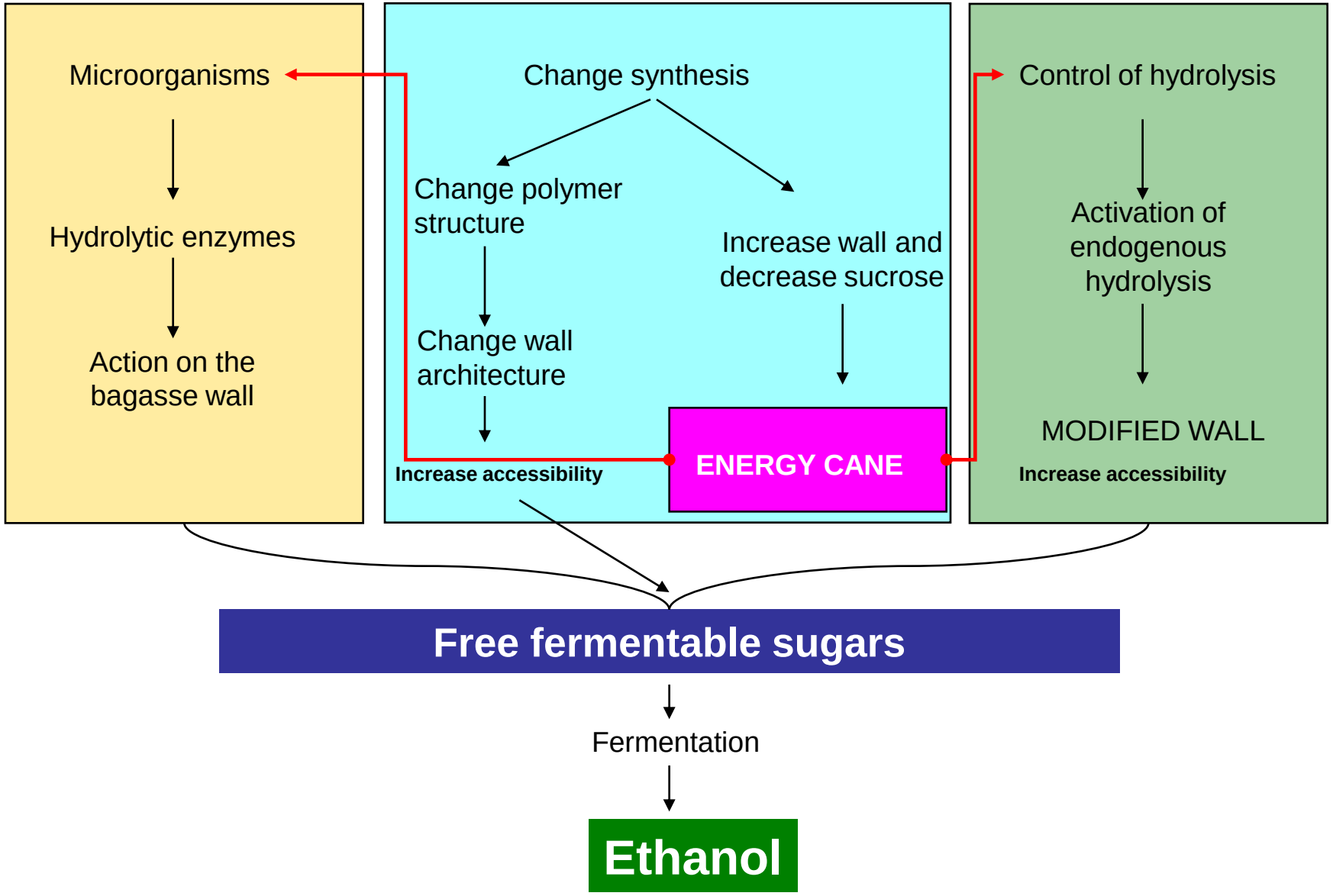
1) 469 cell wall related genes in different cane tissues (*Lima et al. 2001, GMB*)

1) Determined the chemical composition and structure of the cell wall polymers of different sugarcane tissues

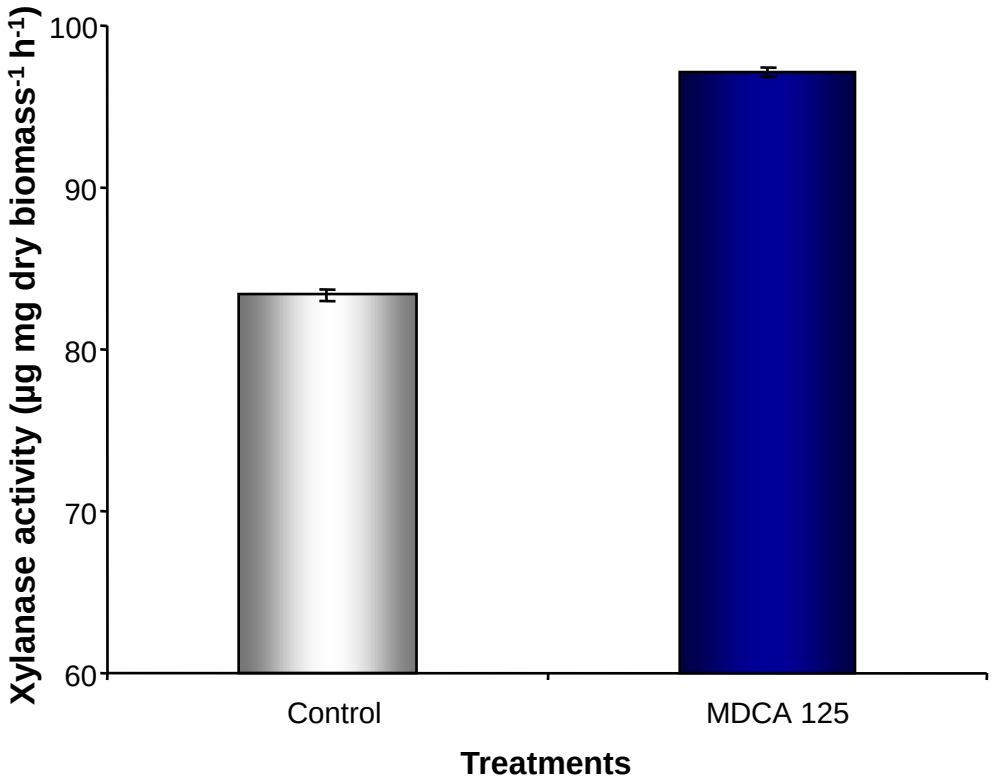

Diferulato livre
Ácido ferúlico interligando dois polissacarídeos
Ácido ferúlico esterificado à arabinose

OPPORTUNITIES TO STUDY BIOSYNTHESIS AND DEGRADATION OF THE CELL WALL IN SUGARCANE

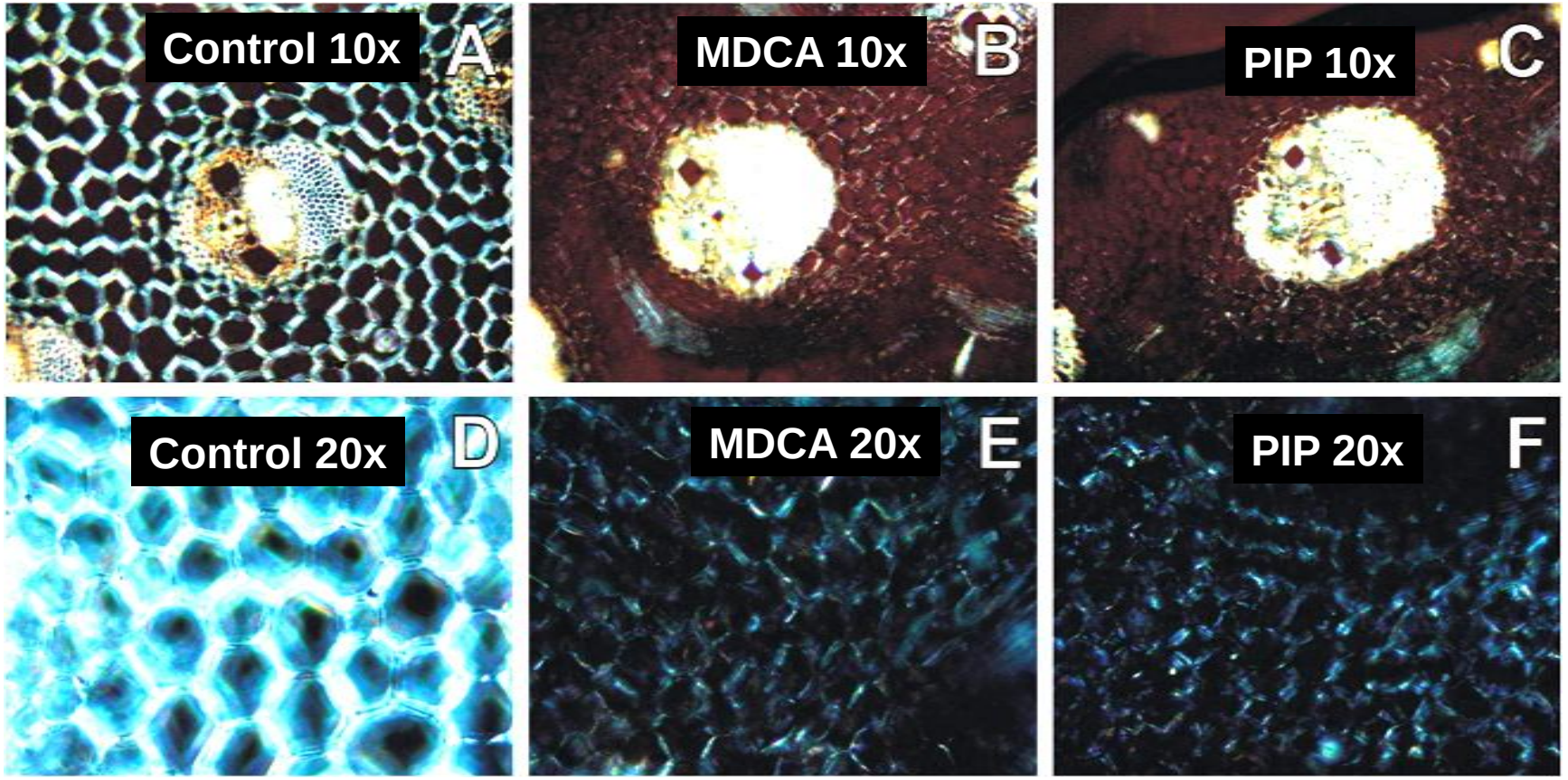
How to modify the wall to obtain energy?



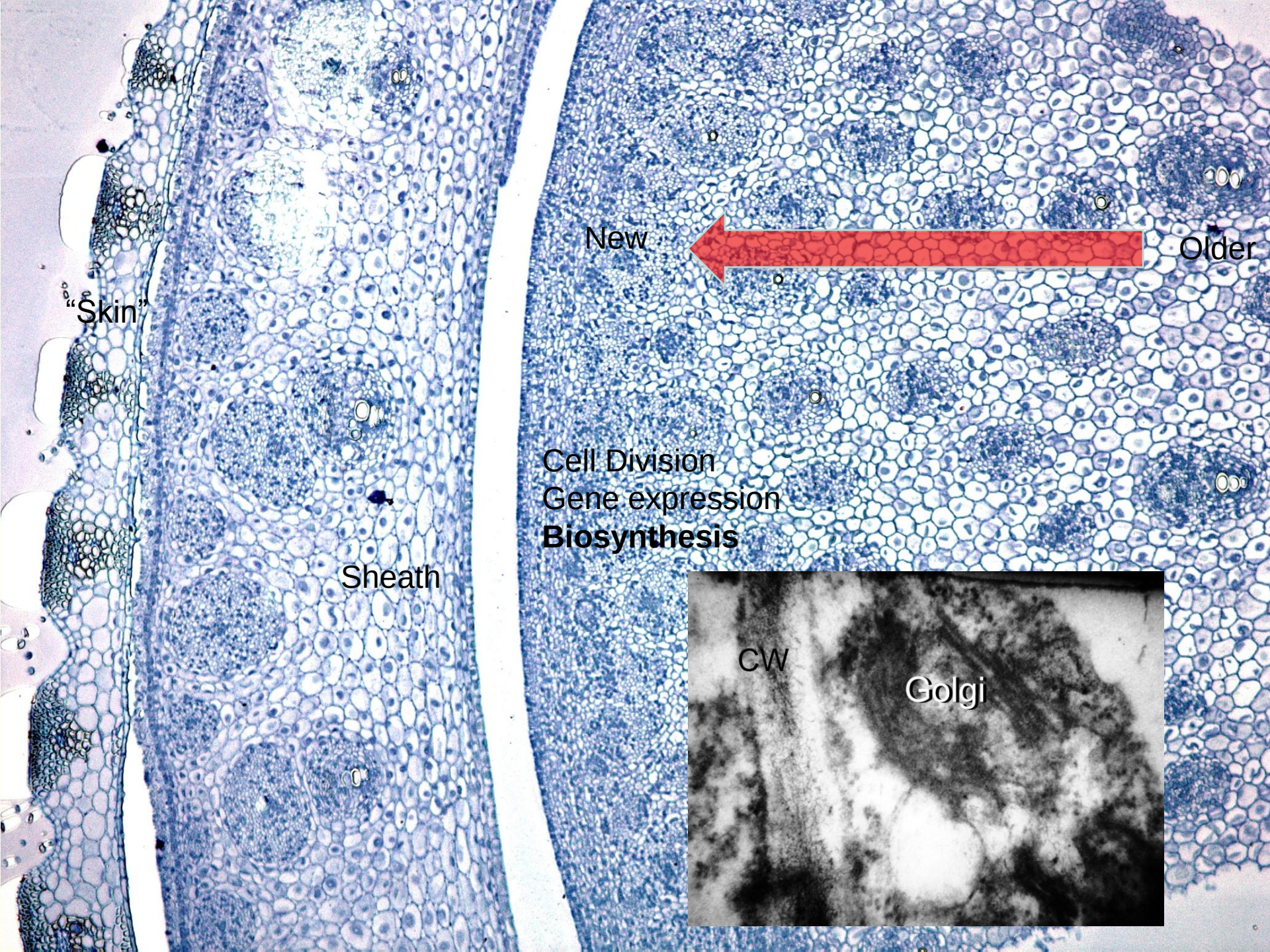
Activity of xylanase (detail)

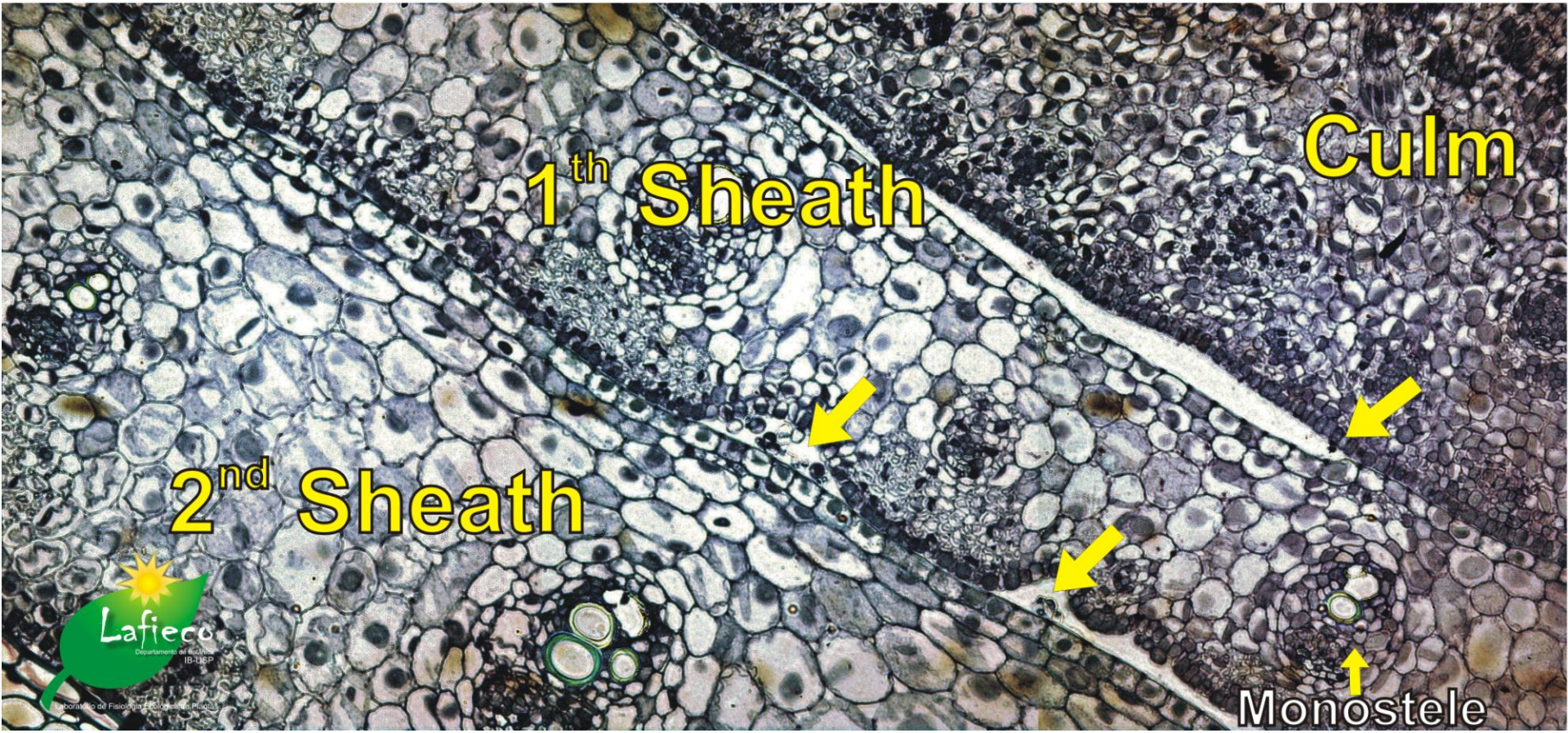


Polarized light microscopy from sugarcane stems

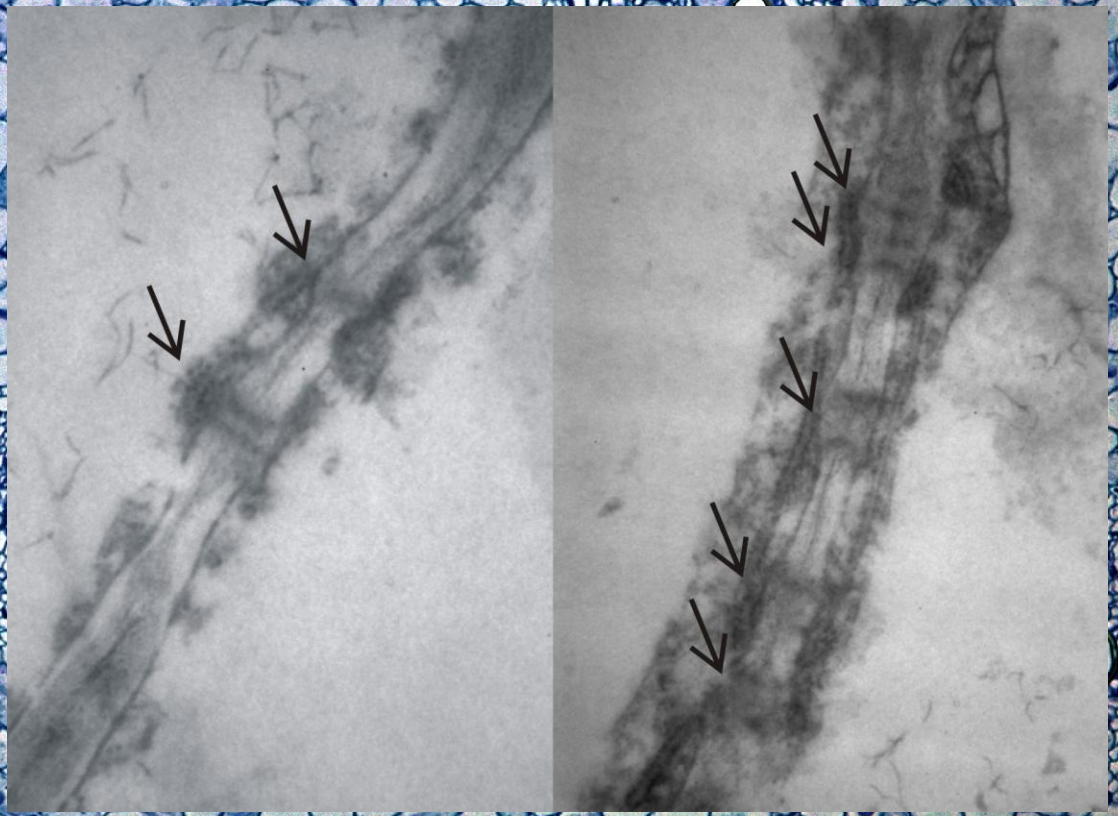


A, B, C = 10×; D, E, F = 20×; A, D = control, B, E = MDCA 500 mM; C, F = PIP 100 mM.


New
Older
"Skin"
Cell Division
Gene expression
Biosynthesis
Sheath
CW
Golgi


1th Sheath
Culm
2nd Sheath
Monostele
Lafieco
Departamento de Ecologia
IB-USP
Laboratório de Fisiologia Ecológica de Plantas

Sugarcane stem (culm)



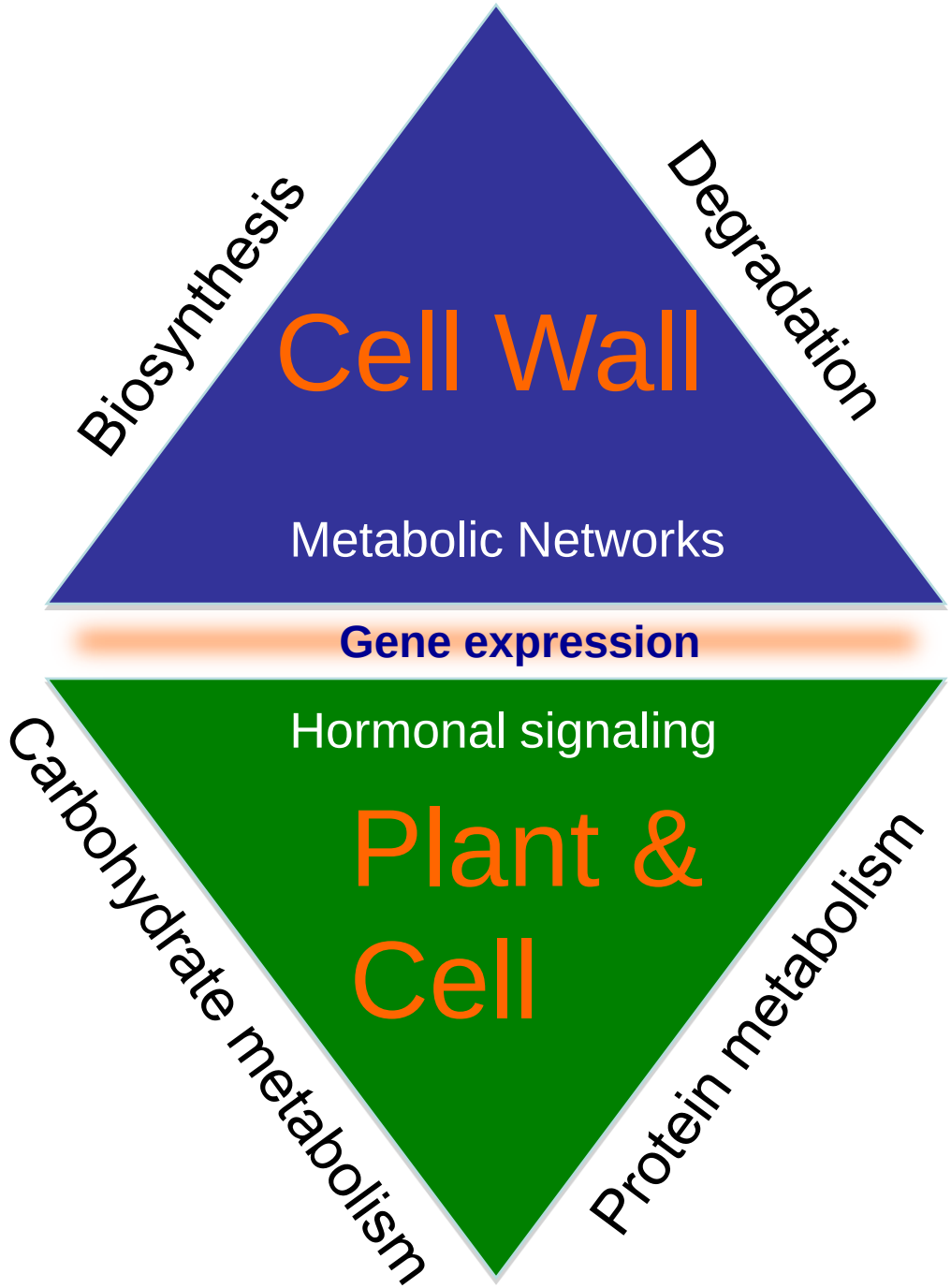
FOCAL POINTS FOR FURTHER STUDIES

Understanding and controlling biosynthesis

- Regarding stem development:
  - Isolate Golgi
  - Characterize enzymes
  - Find genes
  - Integrate and transform

Understanding and controlling wall degradation

- Regarding plasmodesmata:
  - Characterize the phenomenon
  - Detect enzymes
  - Topology of enzymes (immunolocalization)
  - Topology of genes (in situ hibridization)
  - Integrate and transform


Biosynthesis
Degradation
Cell Wall
Metabolic Networks
Gene expression
Hormonal signaling
Plant & Cell
Carbohydrate metabolism
Protein metabolism

THANK YOU

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Instituto de Biociências – USP

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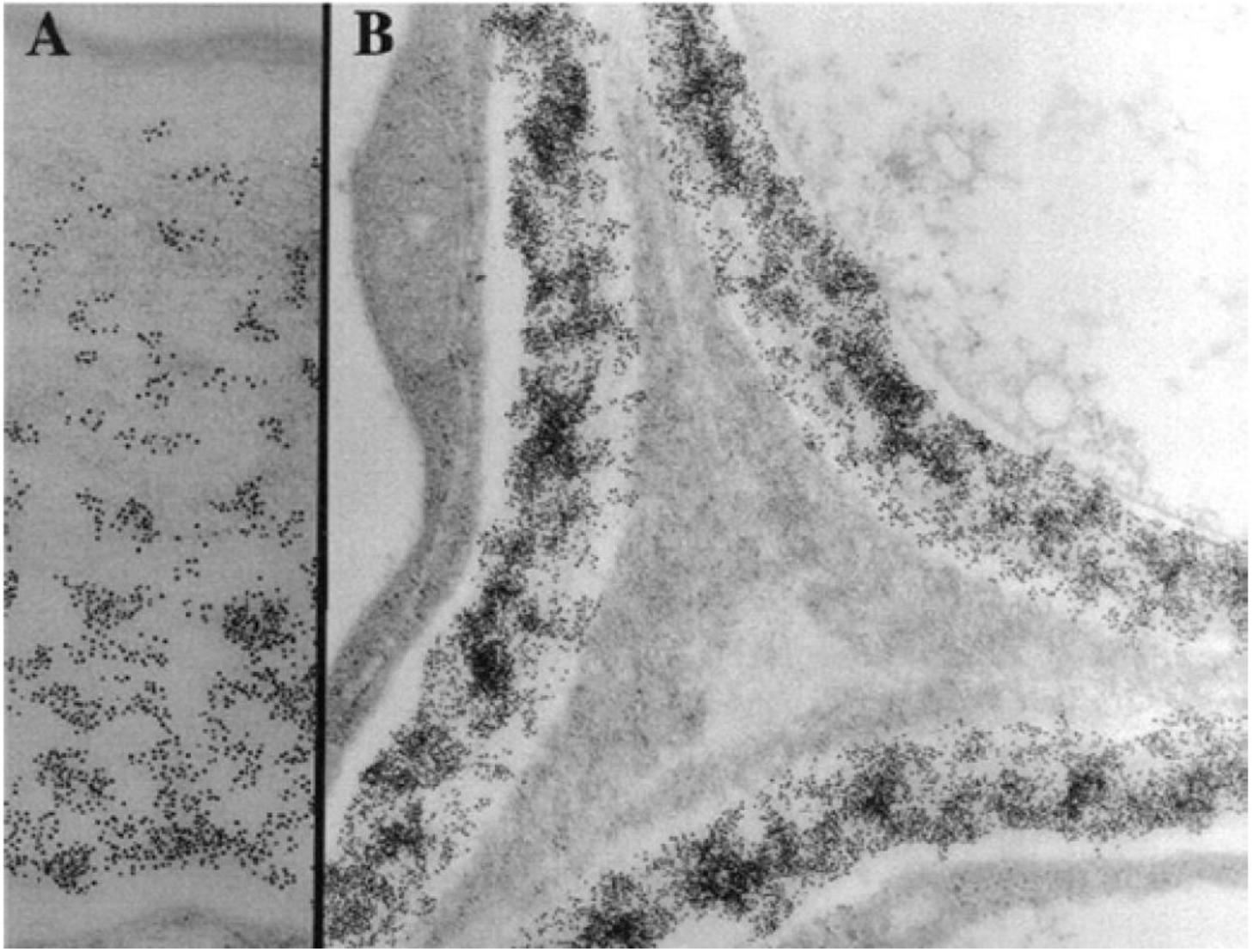
Cell wall deposition is not uniform



Buckeridge et al. 2004, Cereal Chemistry, Vol. 81 pg. 115