

Bi8940 Developmental Biology

Lesson 6

Plant Reproduction

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Tato prezentace je spolufinancována
Evropským sociálním fondem
a státním rozpočtem České republiky



Outline of Lesson 6

Plant Reproduction

- Sexual and asexual plant reproduction
- Plant life cycle
- Initiation of flowering
- Determination of floral organ identity
- Microgametogenesis
- Megagametogenesis
 - Female gametophyte patterning
- Pollen tube growth, guidance and fertilization
- Endosperm and seed formation



Outline of Lesson 6

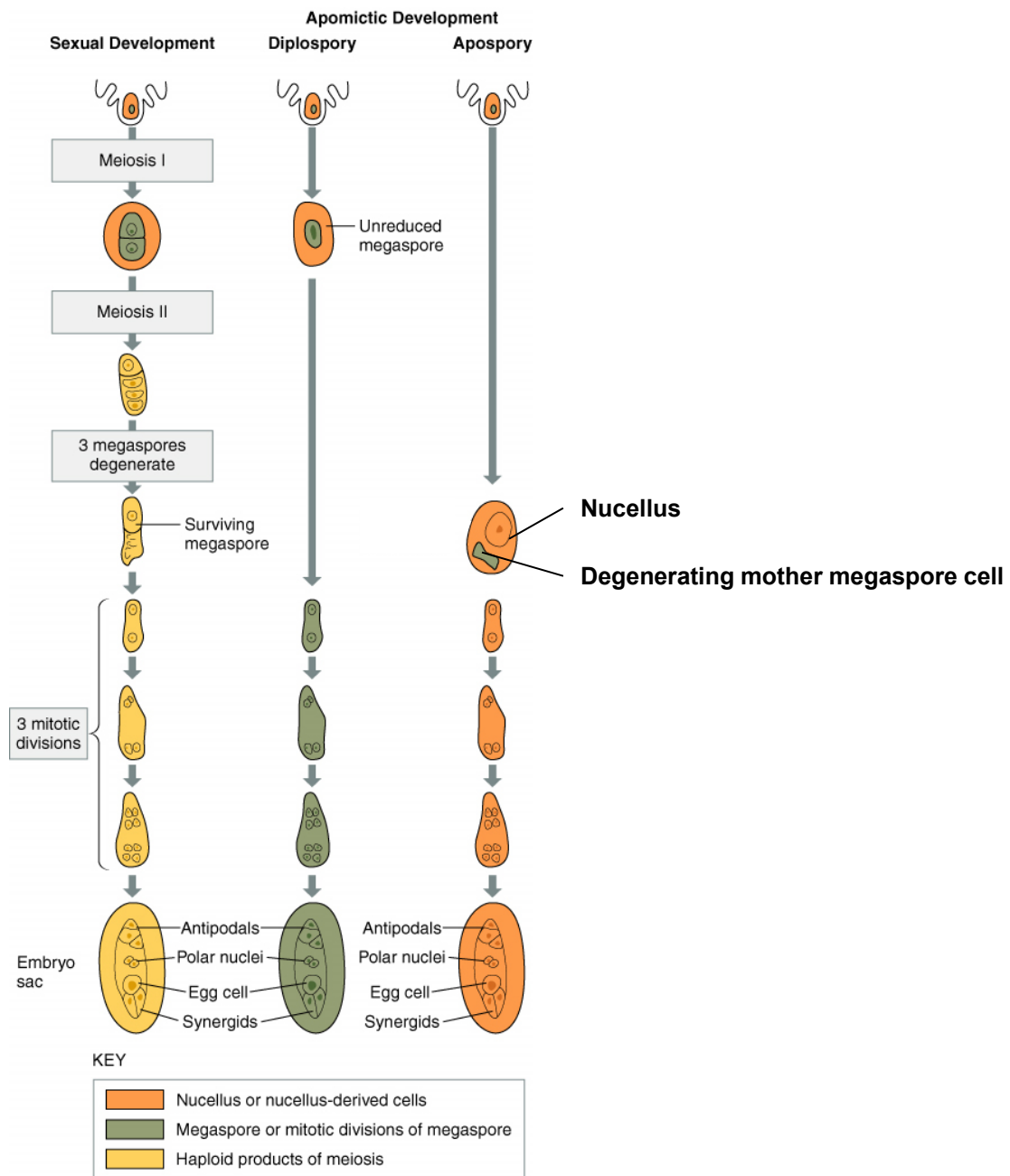
Plant Reproduction

- Sexual and asexual plant reproduction



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

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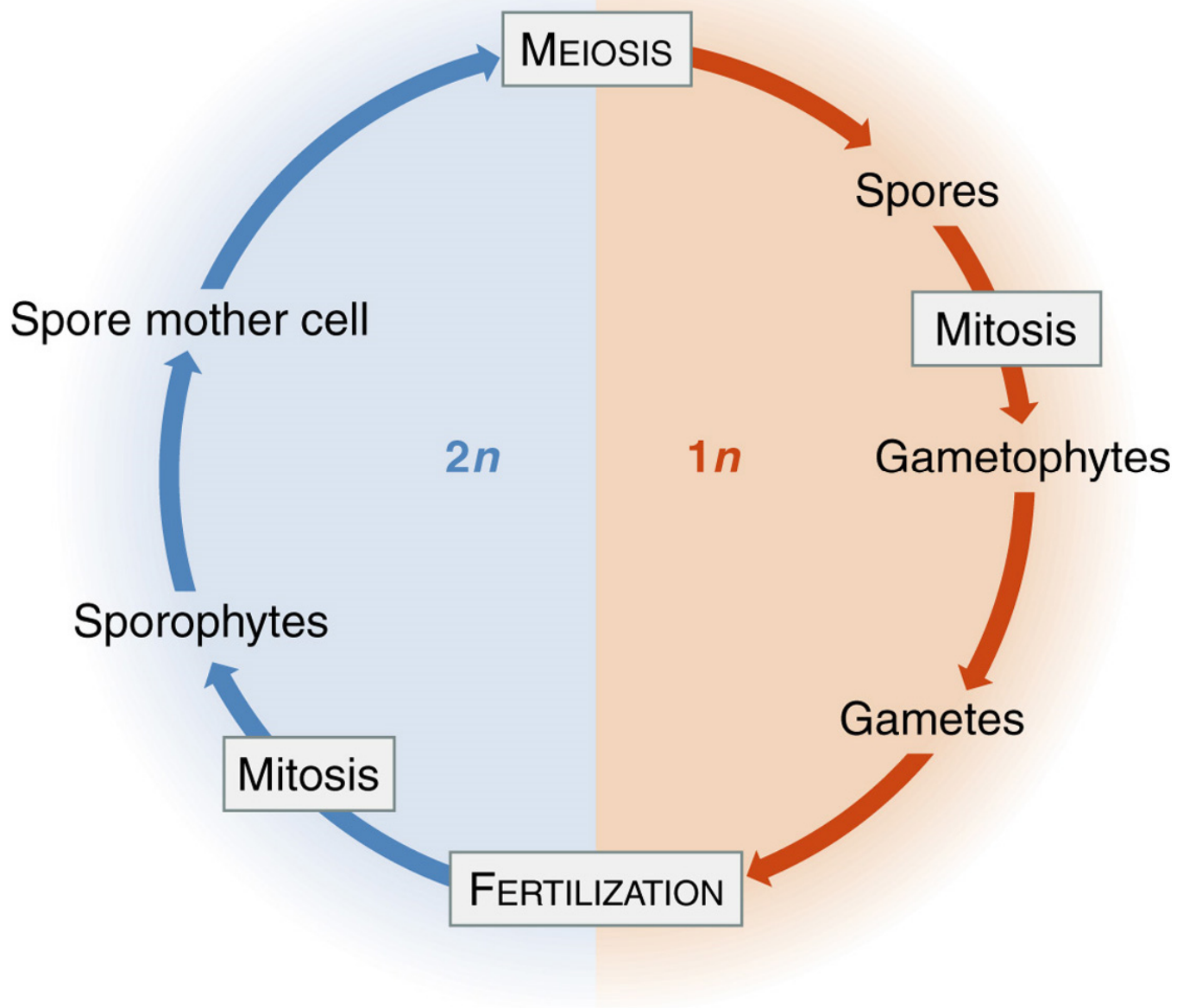


Outline of Lesson 6

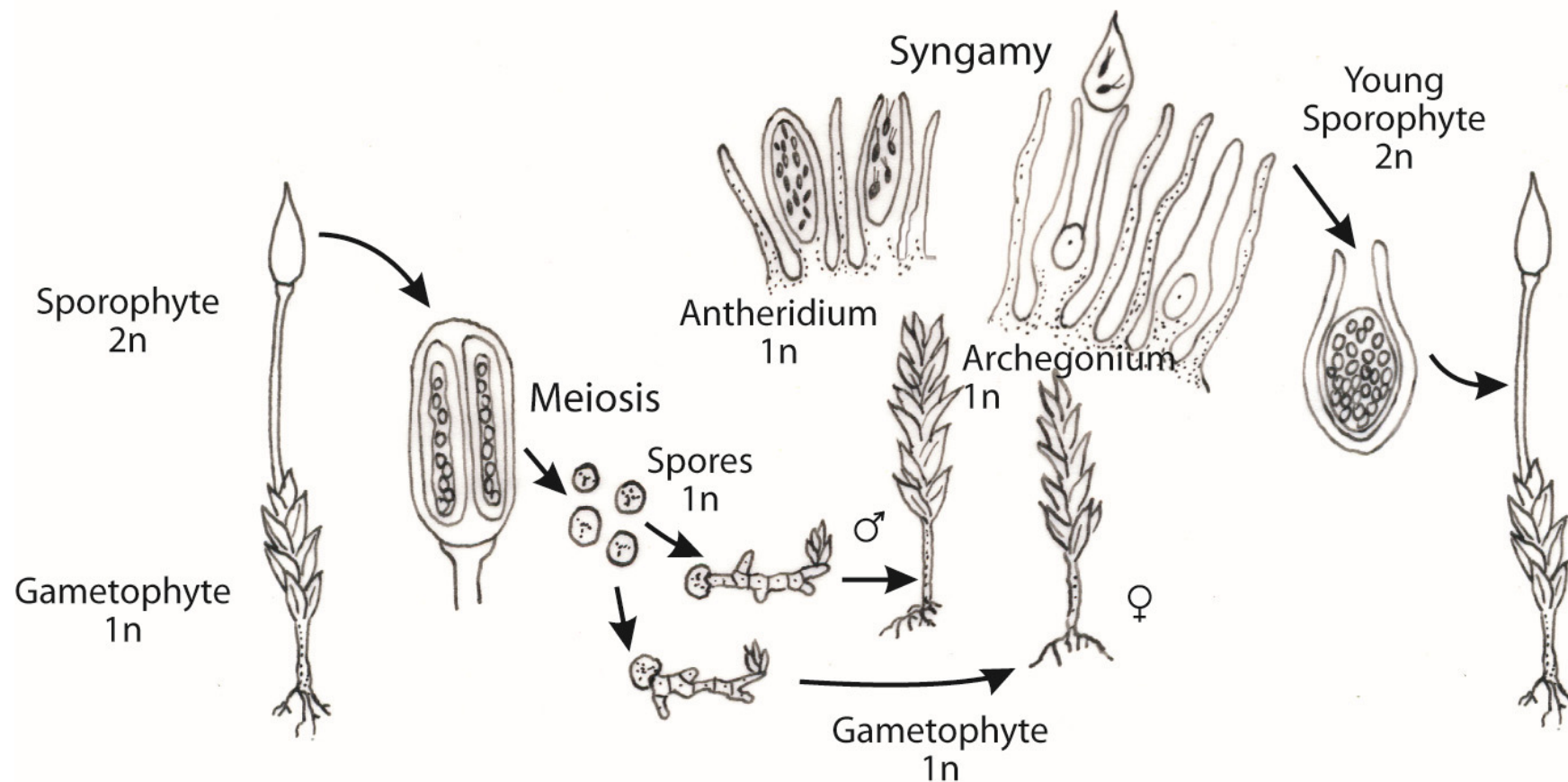
Plant Reproduction

- Sexual and asexual plant reproduction
- Plant life cycle

A.

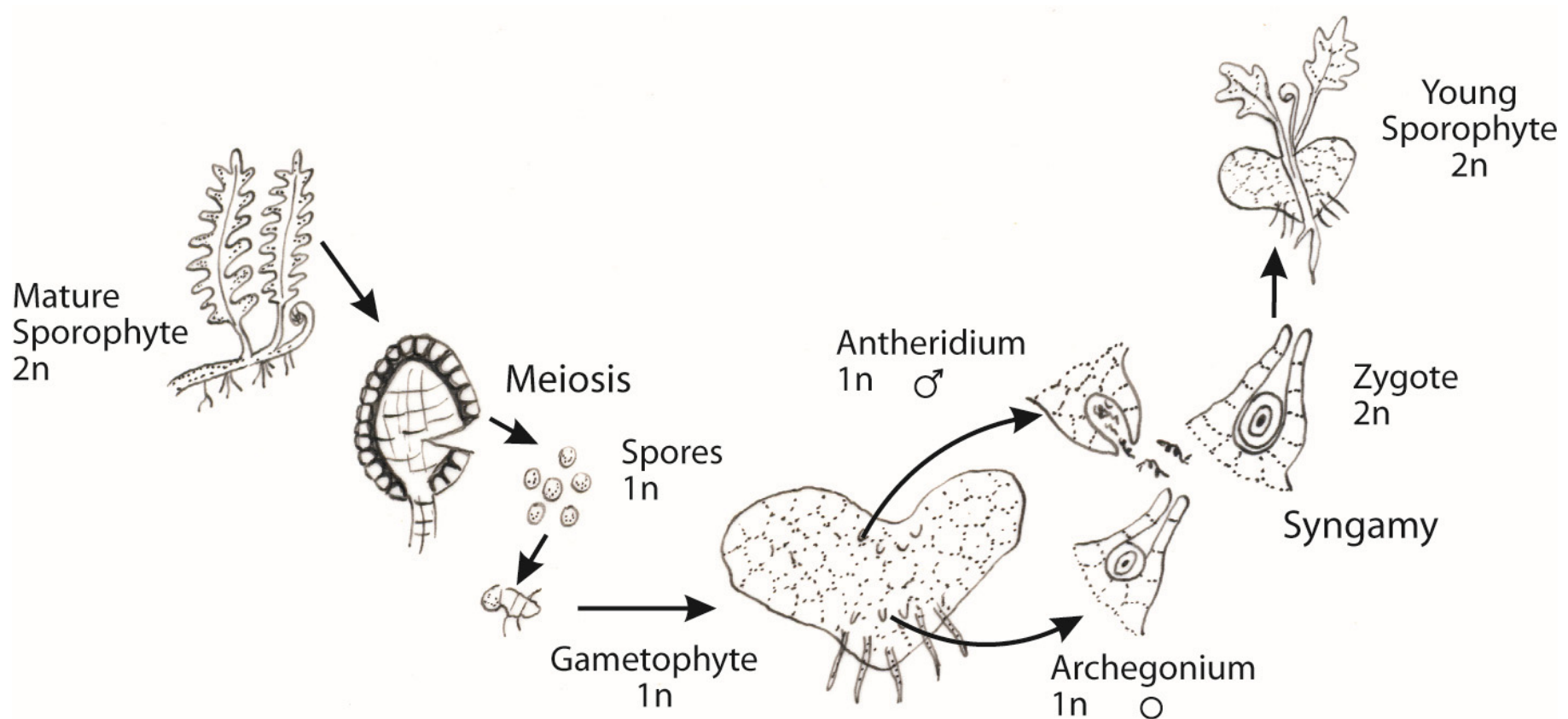


Life Cycle in Mosses



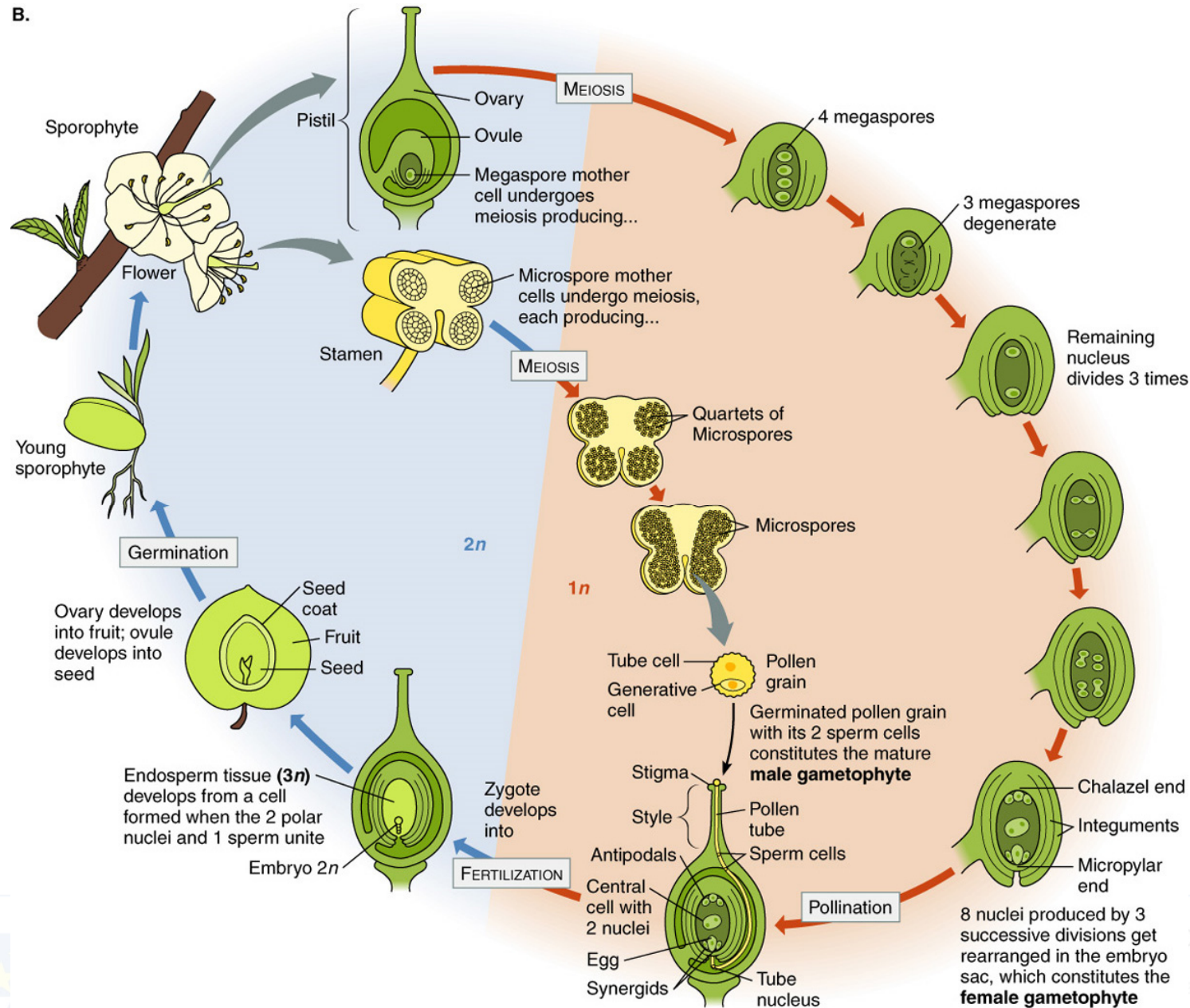
Dubova, Hejatkó, Friml (2005)

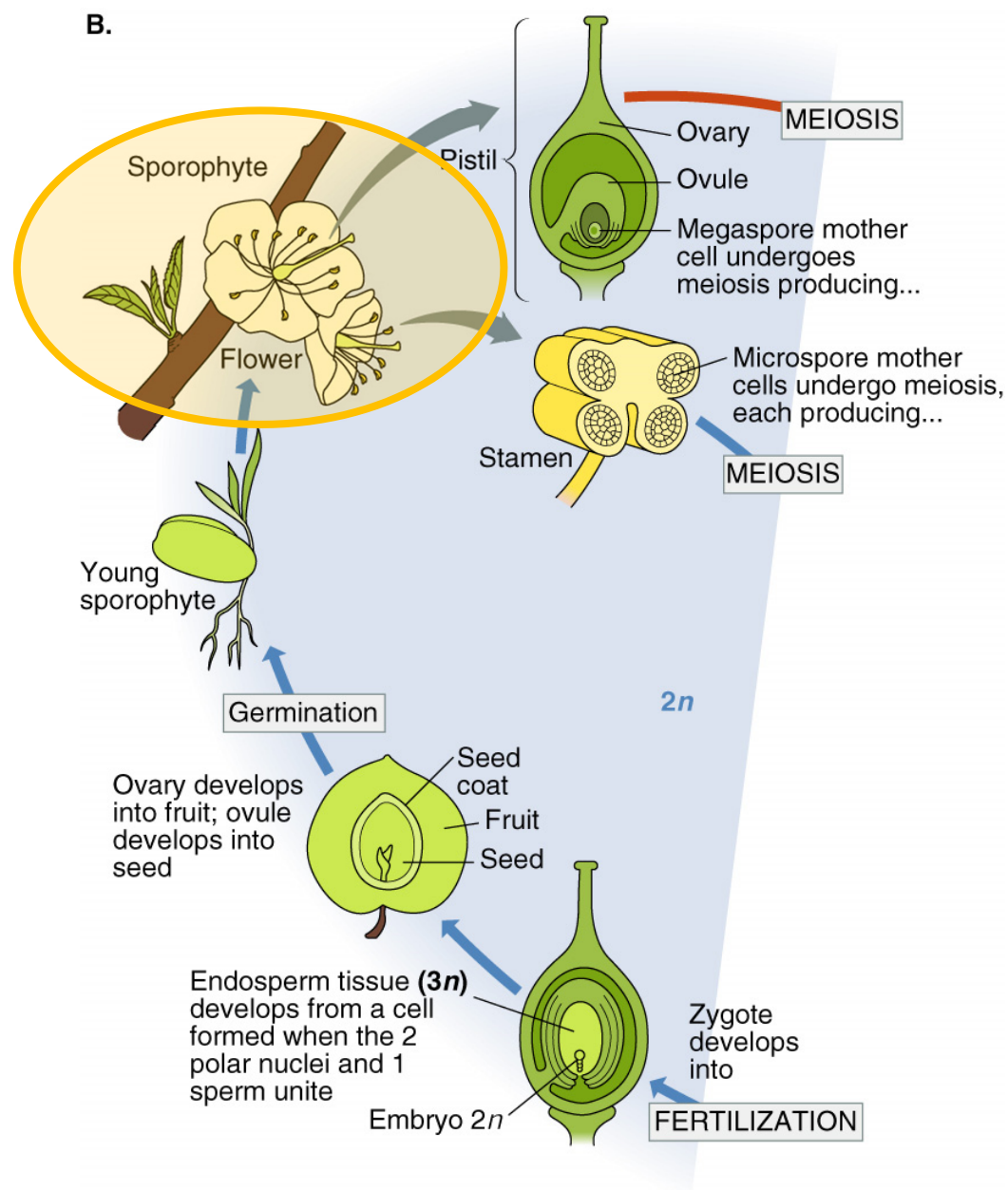
Life Cycle in Ferns



Dubova, Hejatkó, Friml (2005)

Life Cycle in Angiosperms







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Plant Reproduction

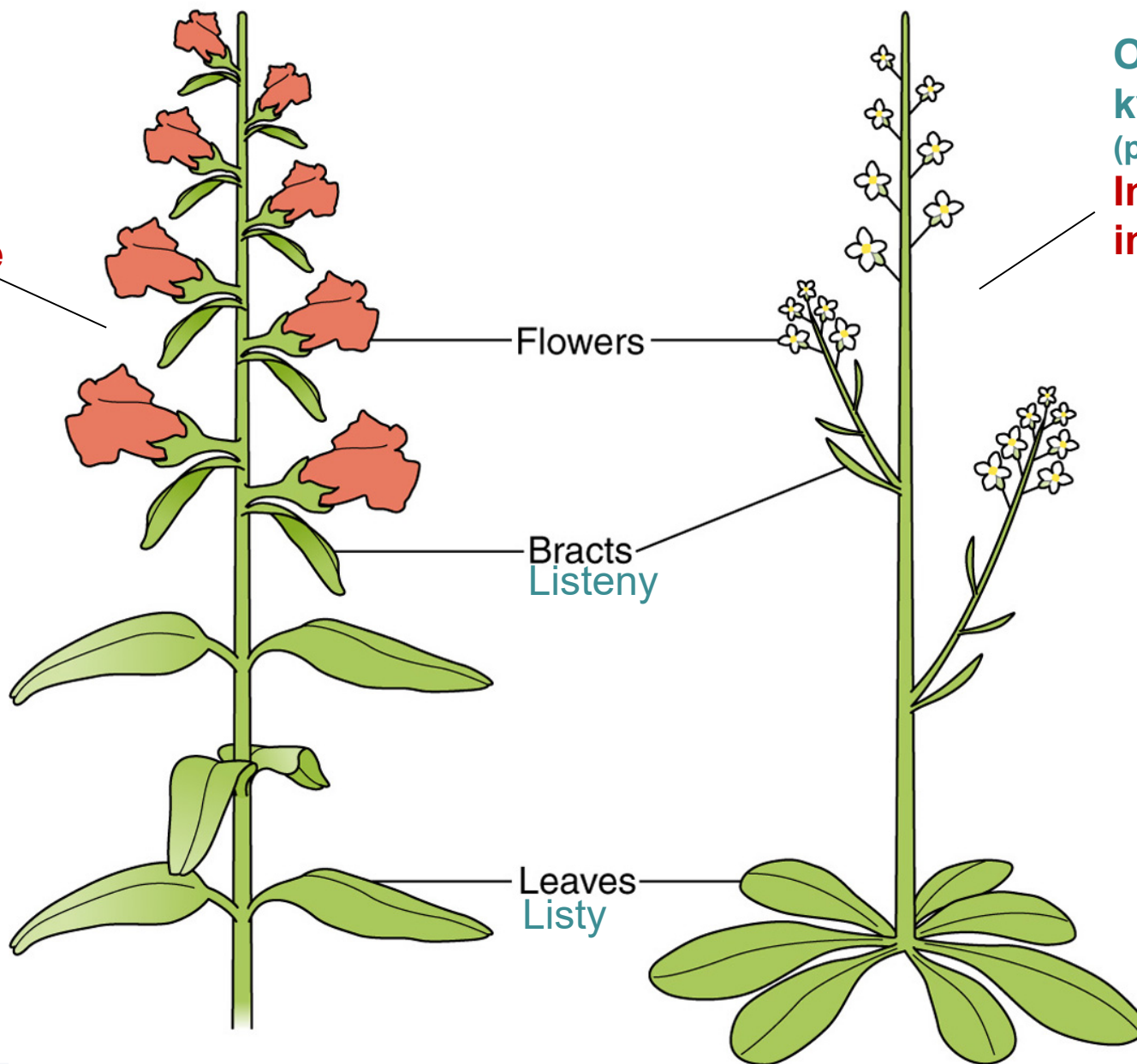
- Sexual and asexual plant reproduction
- Plant life cycle
- Initiation of flowering

A.

B.

**Uzavřené
květenství
(monotelické)
Determinate
inflorescence**

**Otevřené
květenství
(polytelické)
Indeterminate
inflorescence**



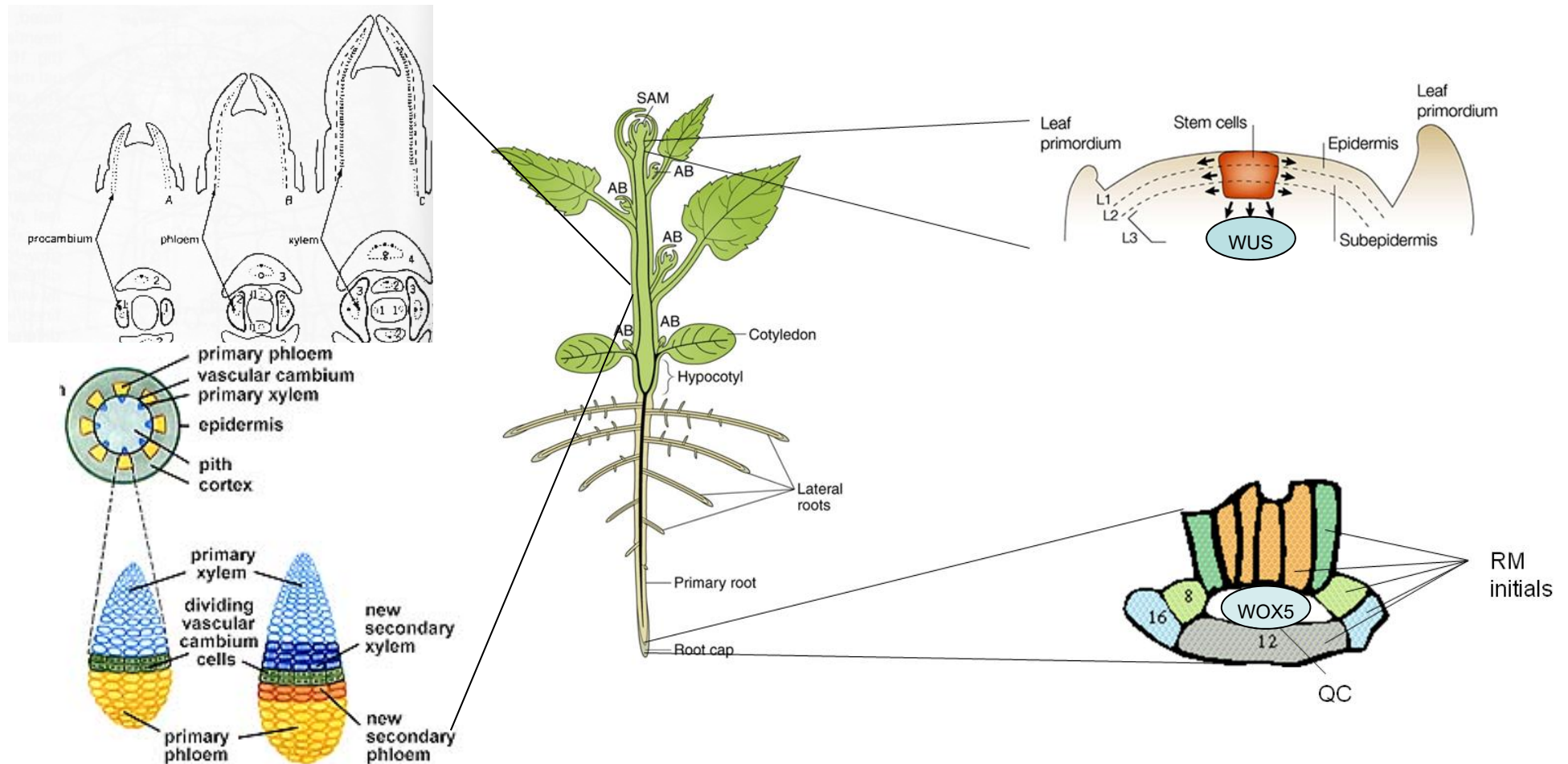
Antirrhinum

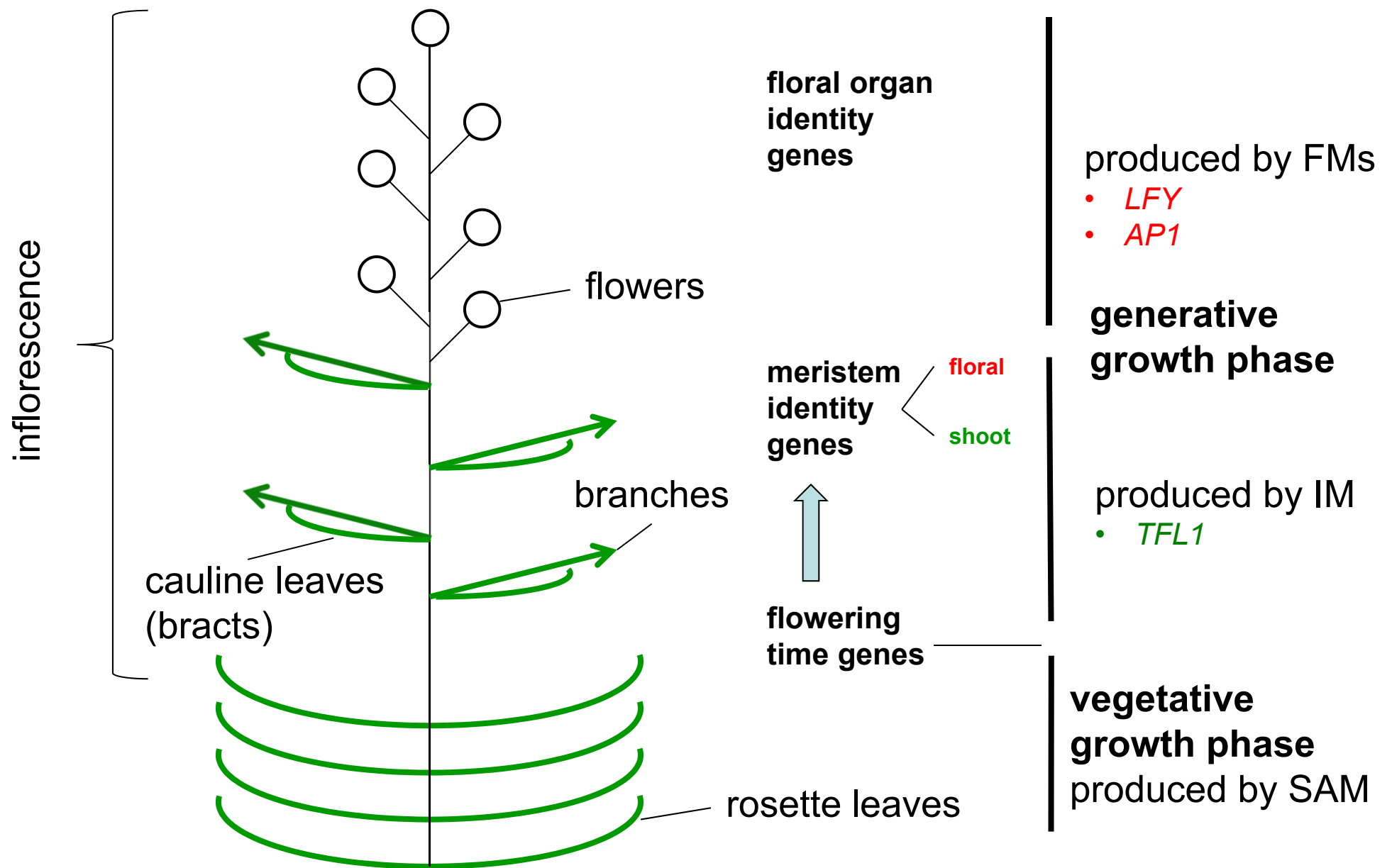
Arabidopsis

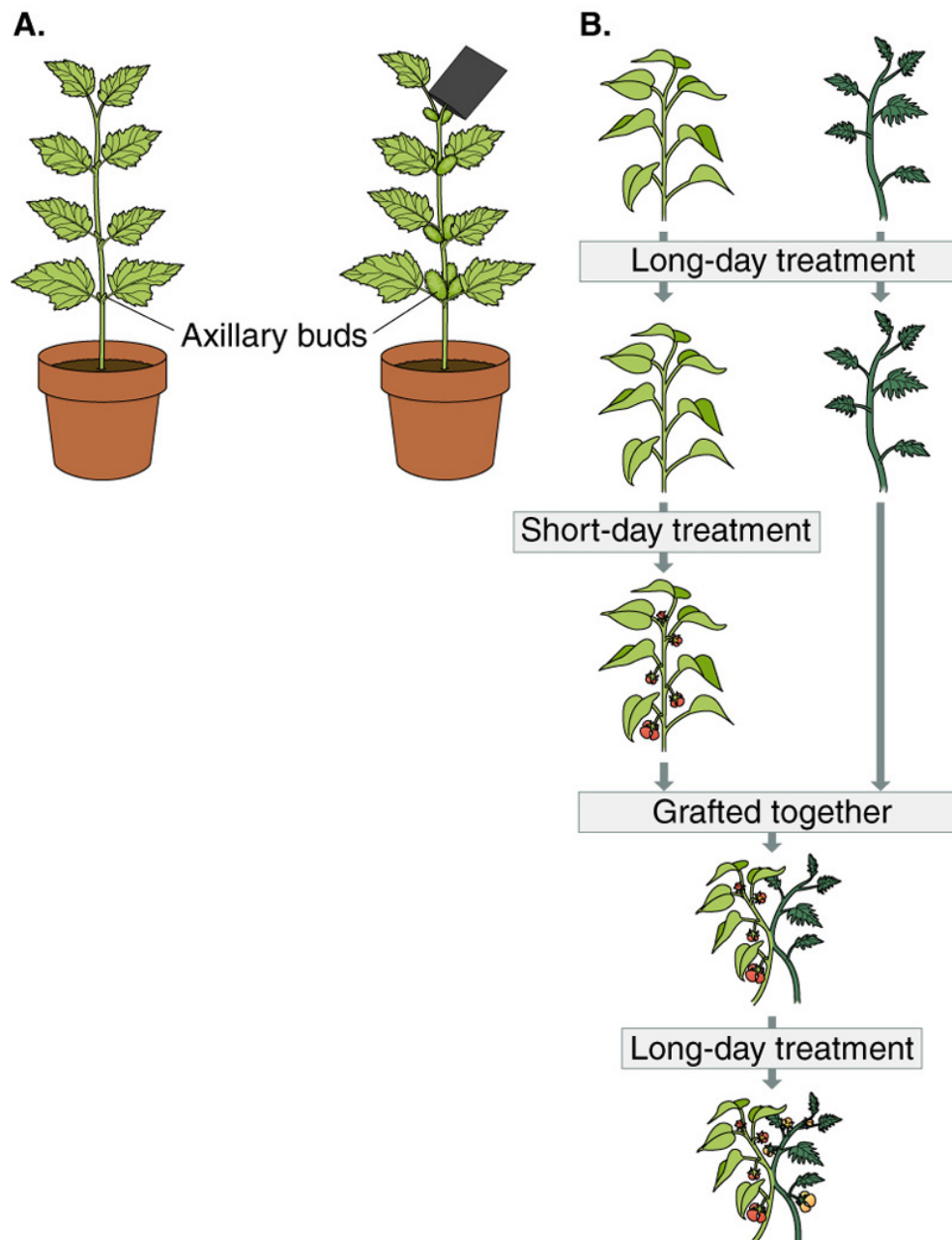
Plant Grow thanks to Meristems

Lateral meristems

Apical meristems







In situ hybridization with *INDETERMINATE (ID1)* mRNA...

....in leaves



Lata (klásků)
Tassel

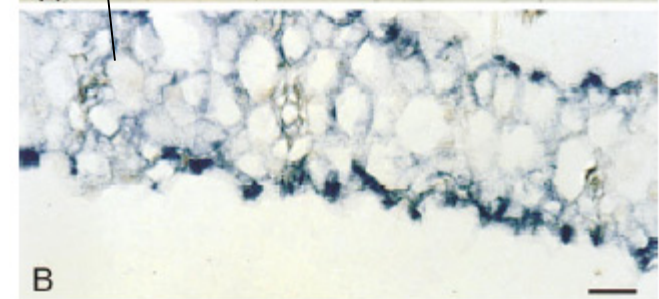
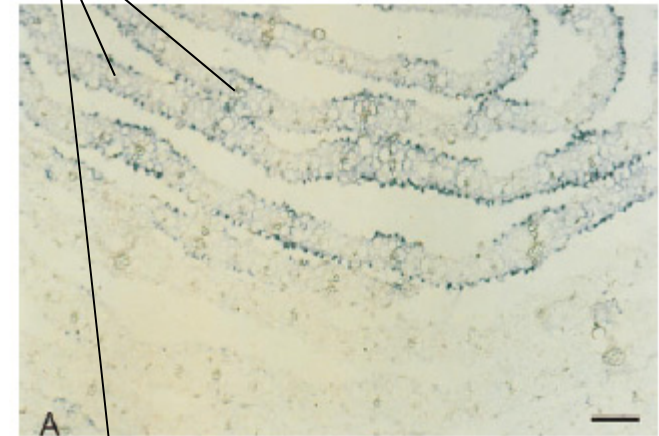
Palice
Ear



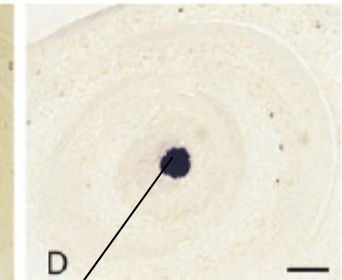
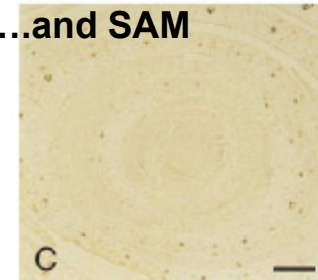
WT



id1



....and SAM



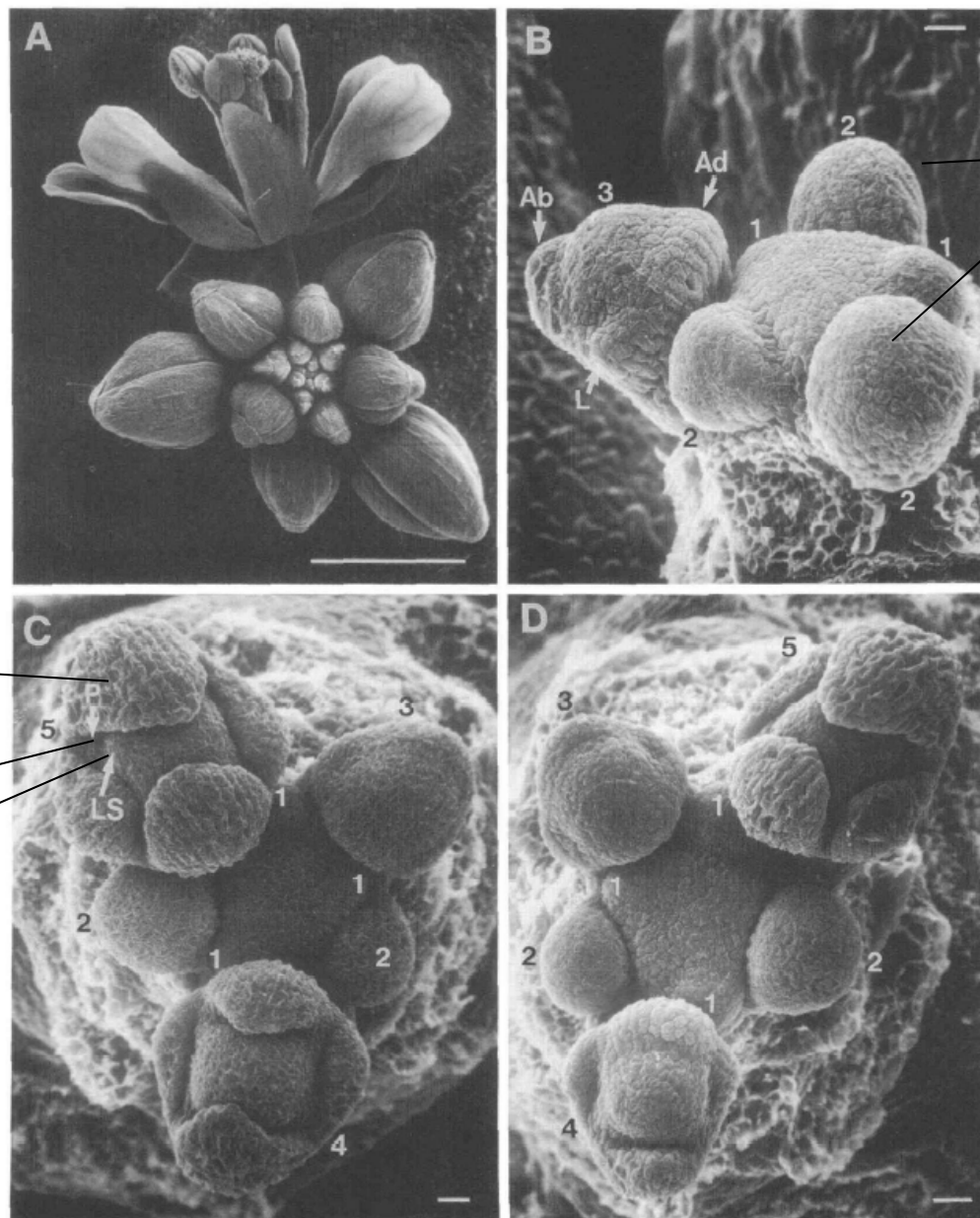
KN1

Okvětní lístky
Sepals

Korunní lístky
Petals

Dlouhé tyčinky
Long stamens

Flower primordia
(buds)

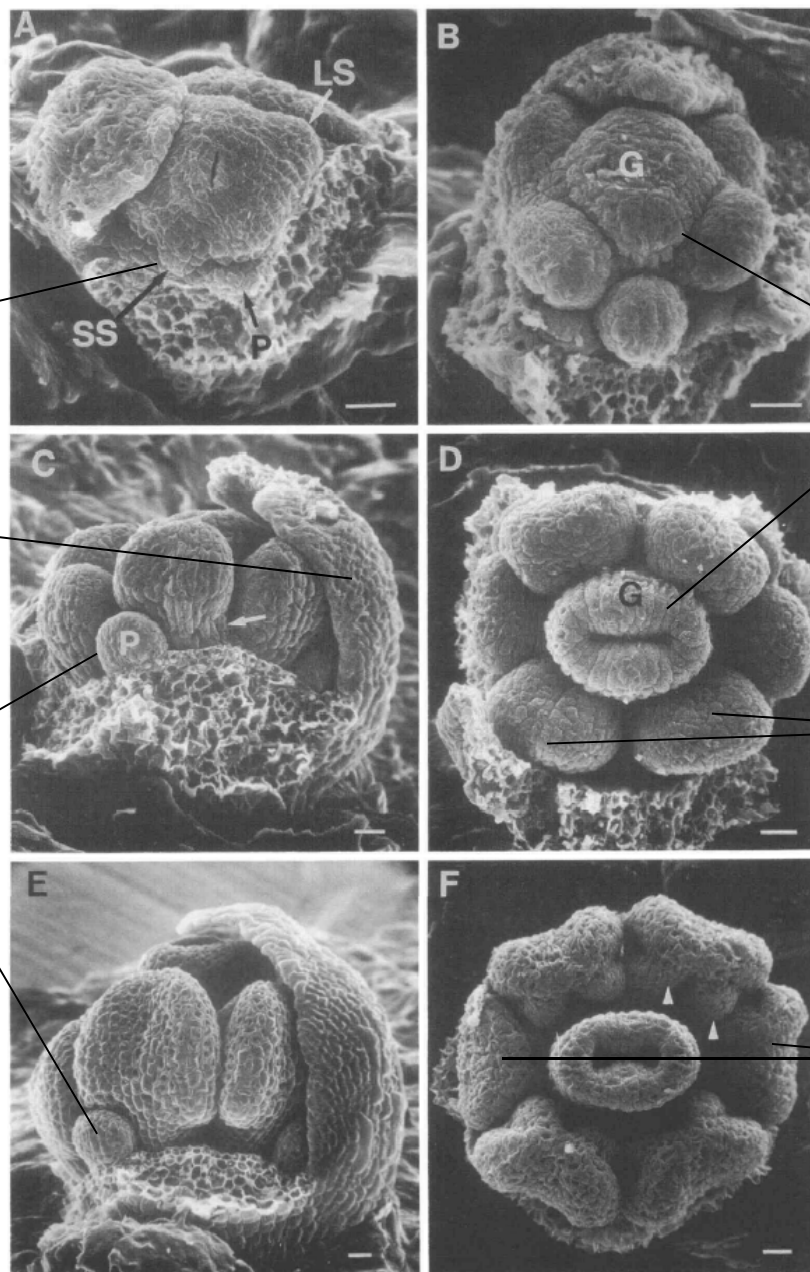


Smyth et al., *Plant Cell* (1990)

Krátké tyčinky
Short stamens

Okvětní lístky
Sepals

Korunní lístky
Petals



Pestík
Gynoecium (pistil)

Dlouhé tyčinky
Long stamens

Krátké tyčinky
Short stamens

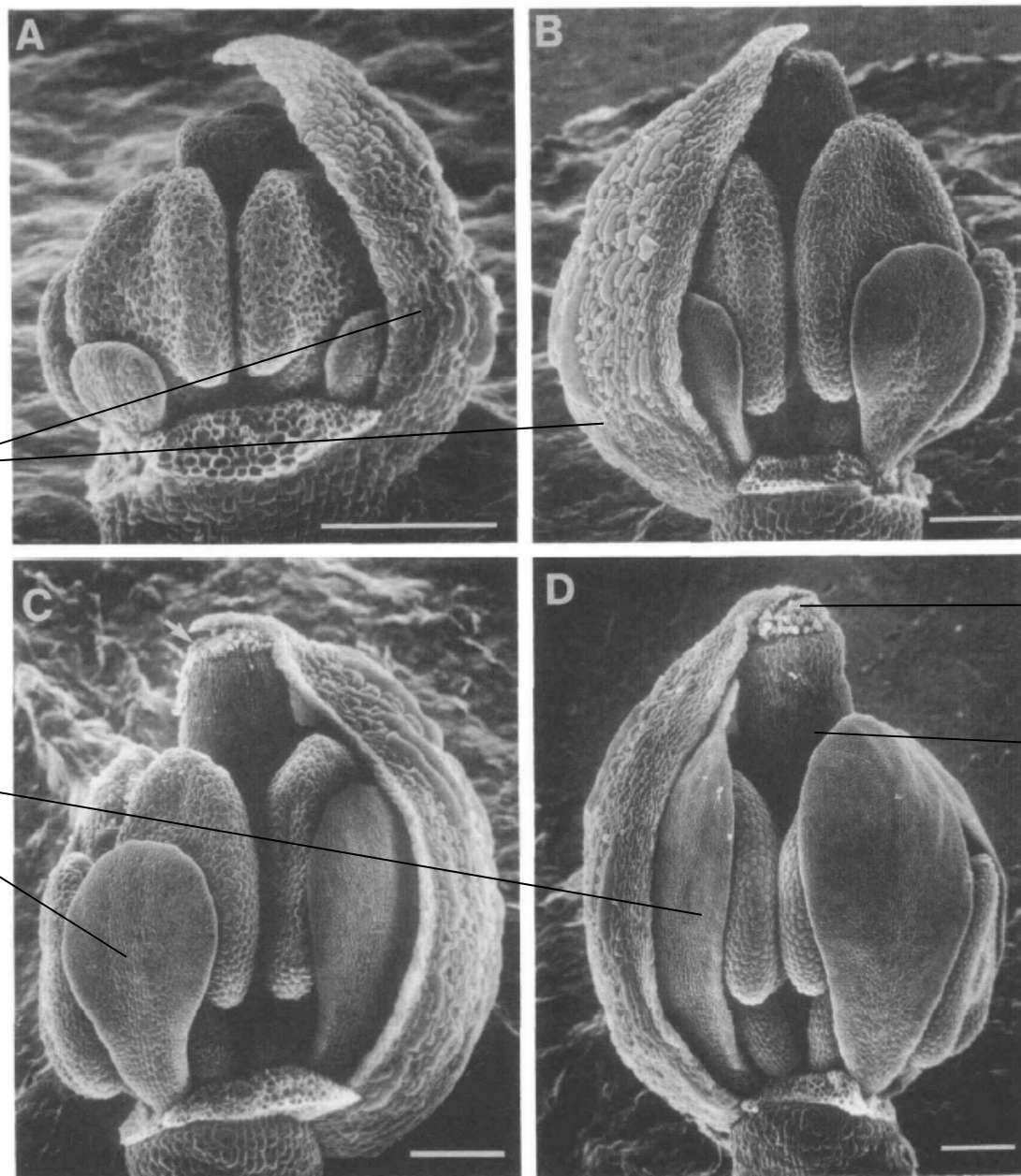
Smyth et al., *Plant Cell* (1990)

Okvětní lístky
Sepals

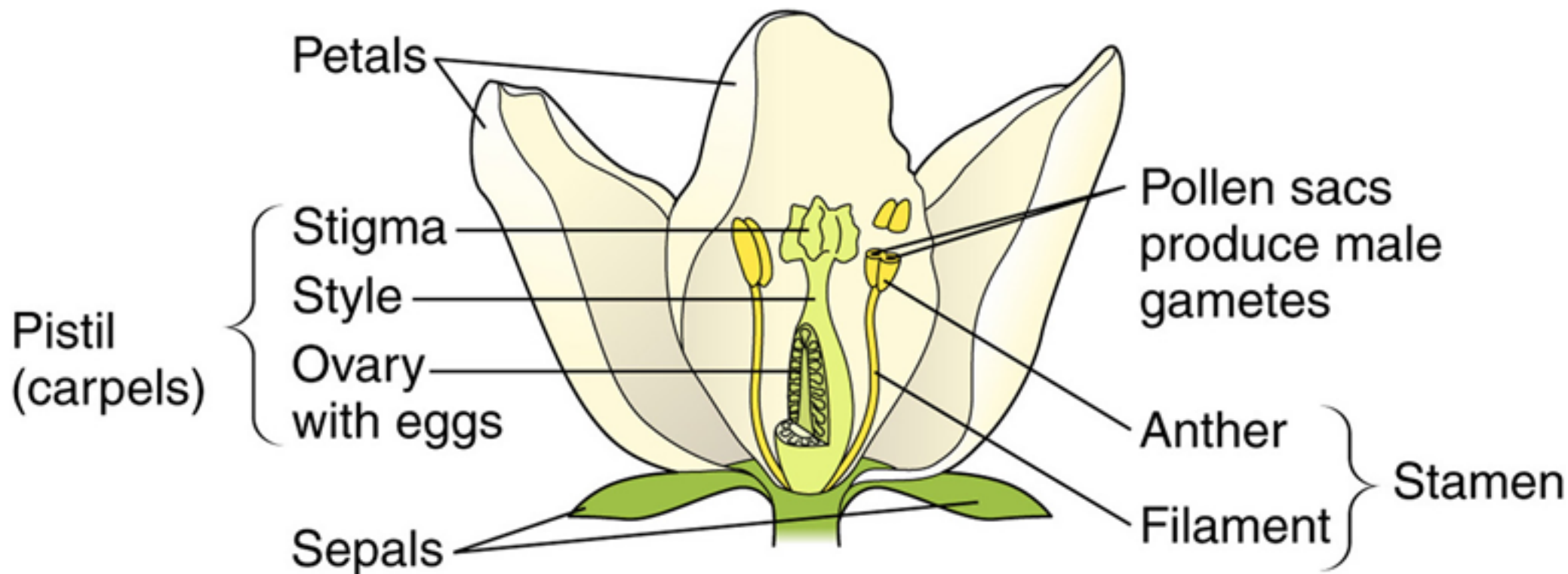
Korunní lístky
Petals

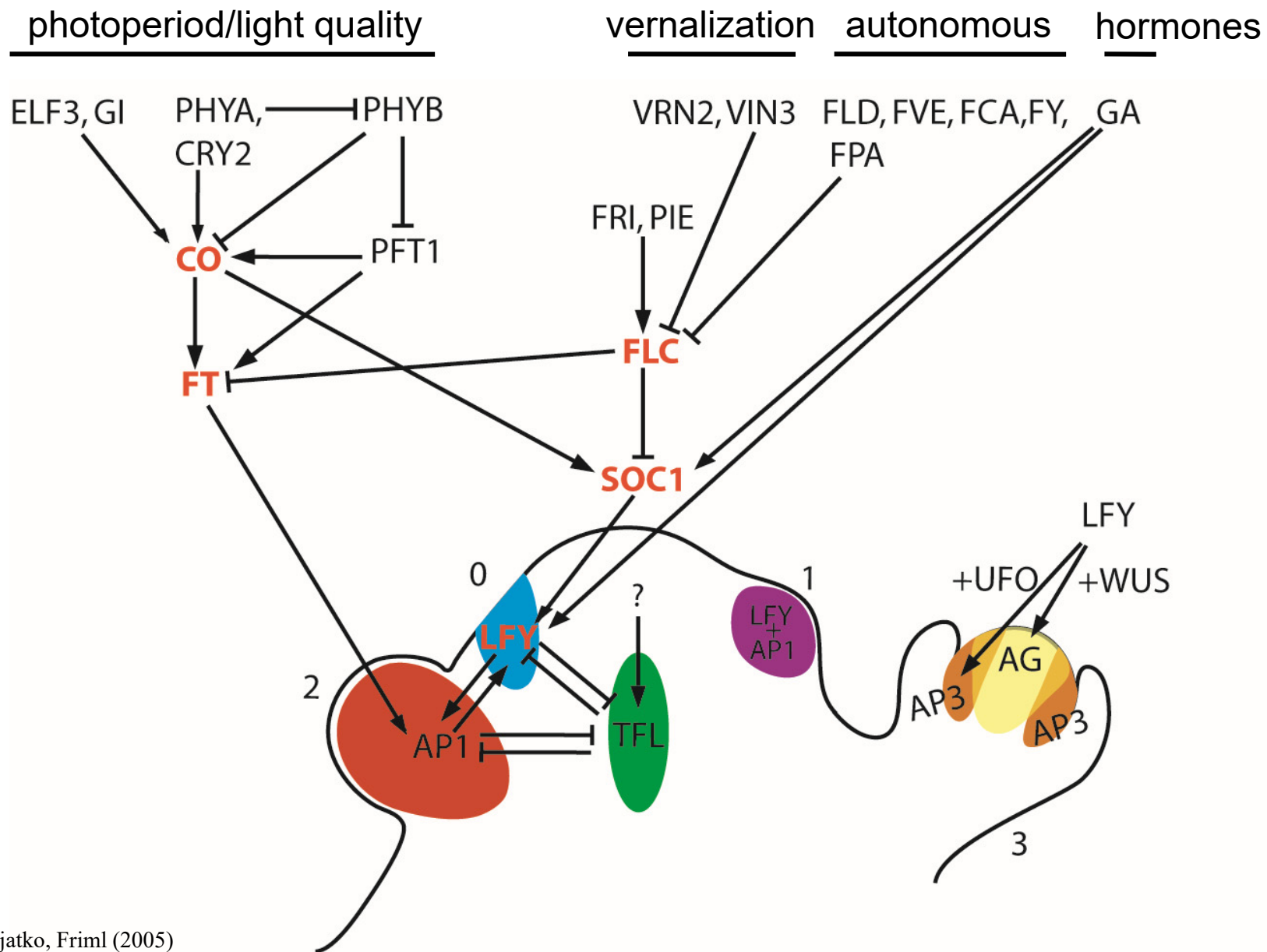
Blizna
Stigma

Pestík
Gynoeceum (pistil)



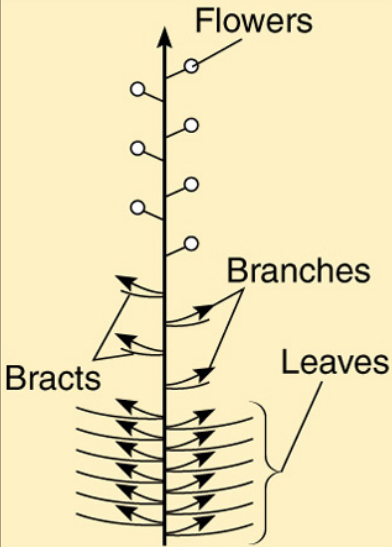
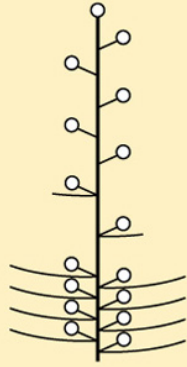
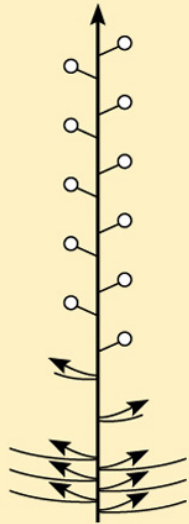
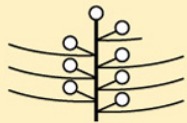
Smyth et al., *Plant Cell* (1990)

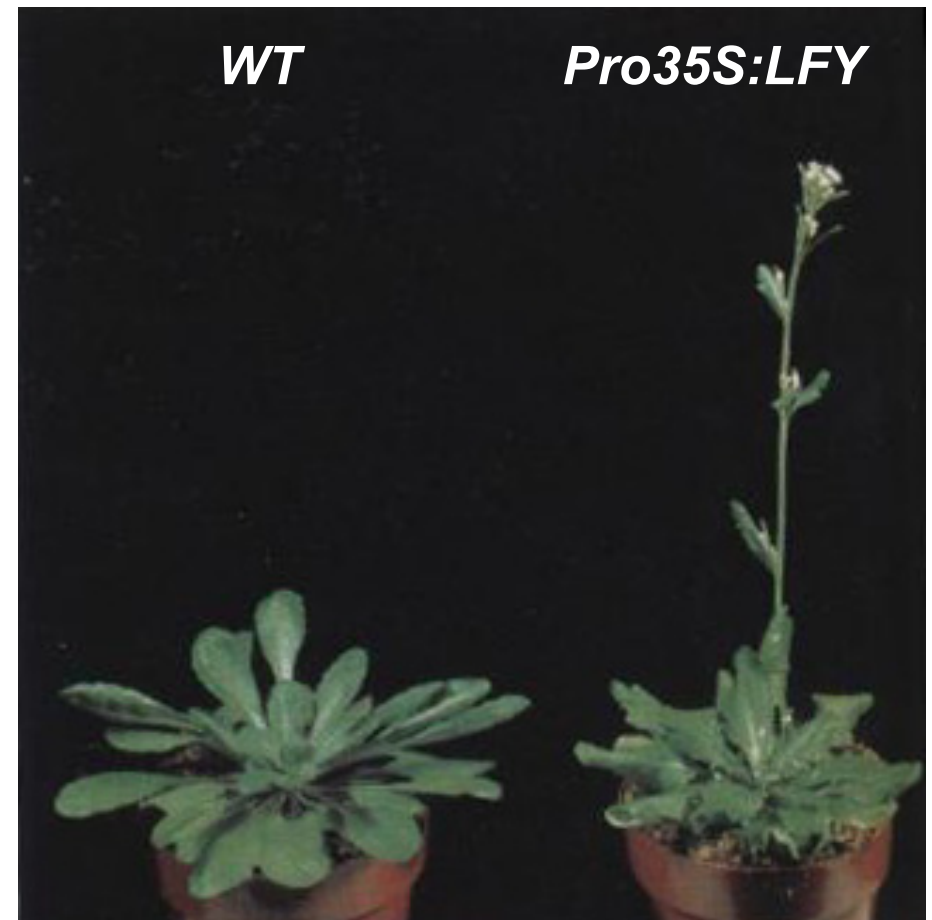




Dubova, Hejatko, Friml (2005)

A.

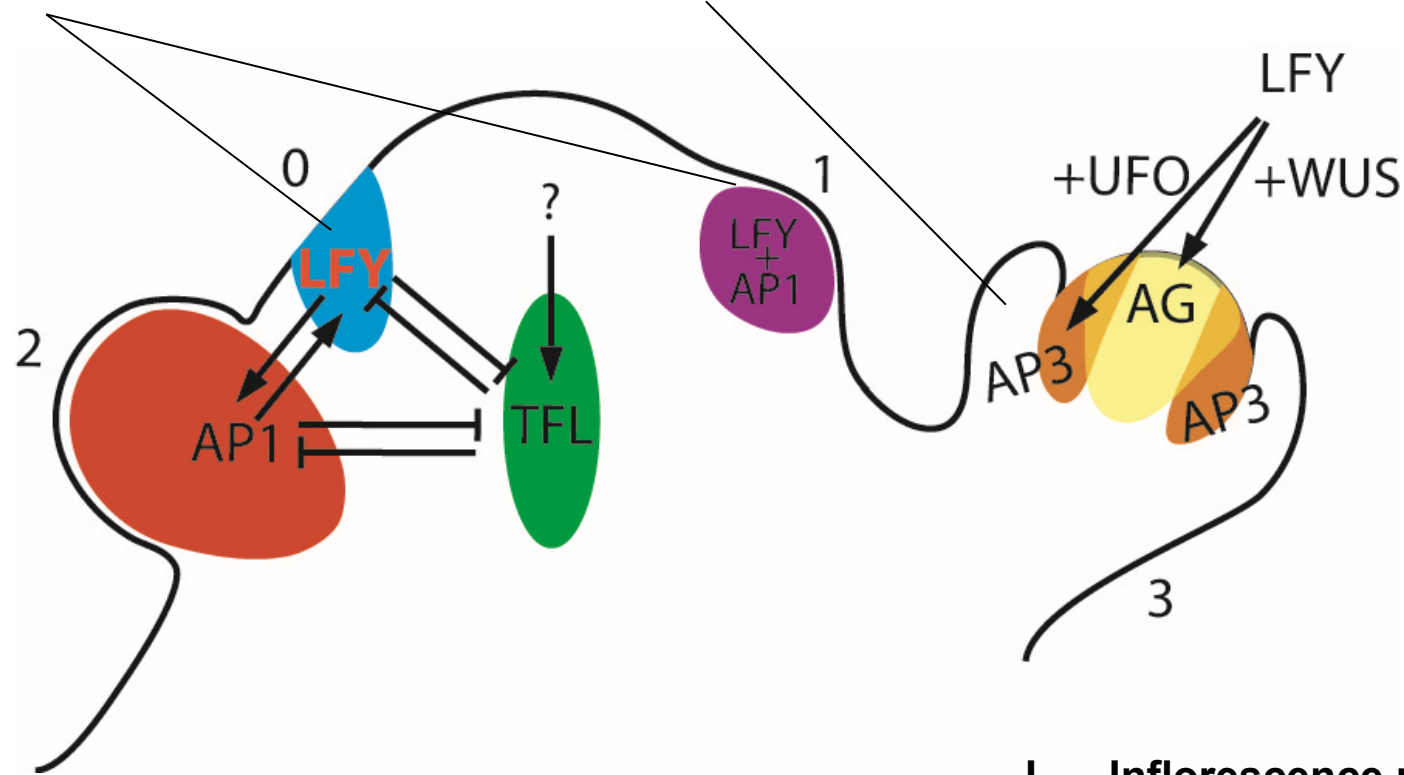
| | Wild type | Overexpression of <i>leafy</i> |
|------------|--|--|
| Short days |  |  |
| Long days |  |  |



II. Floral meristem identity acquisition
(LFY, AP1)

III. Activation of floral organ identity genes
(whorl-specific)

IV. Activation of floral organ building genes



I. Inflorescence meristem formation
(switch from vegetative to reproductive growth)

Dubova, Hejatko, Friml (2005)

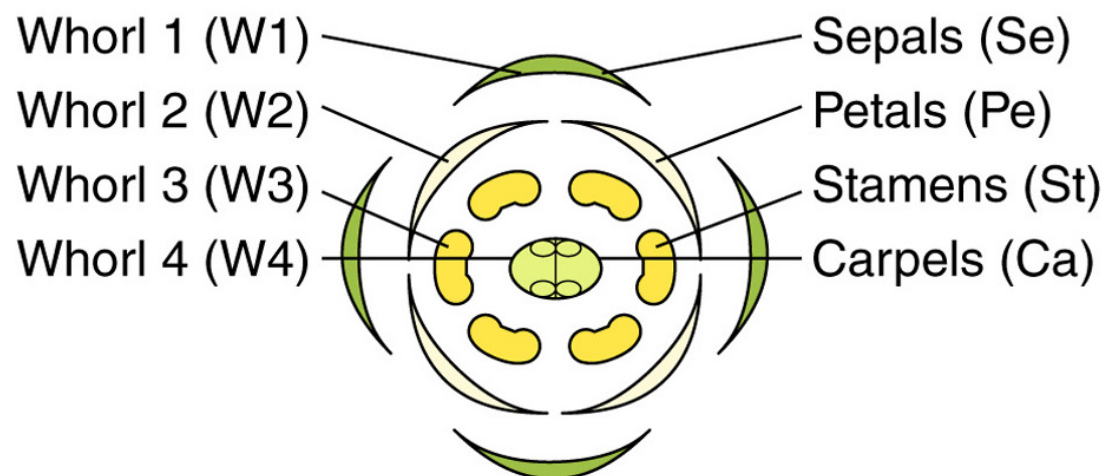
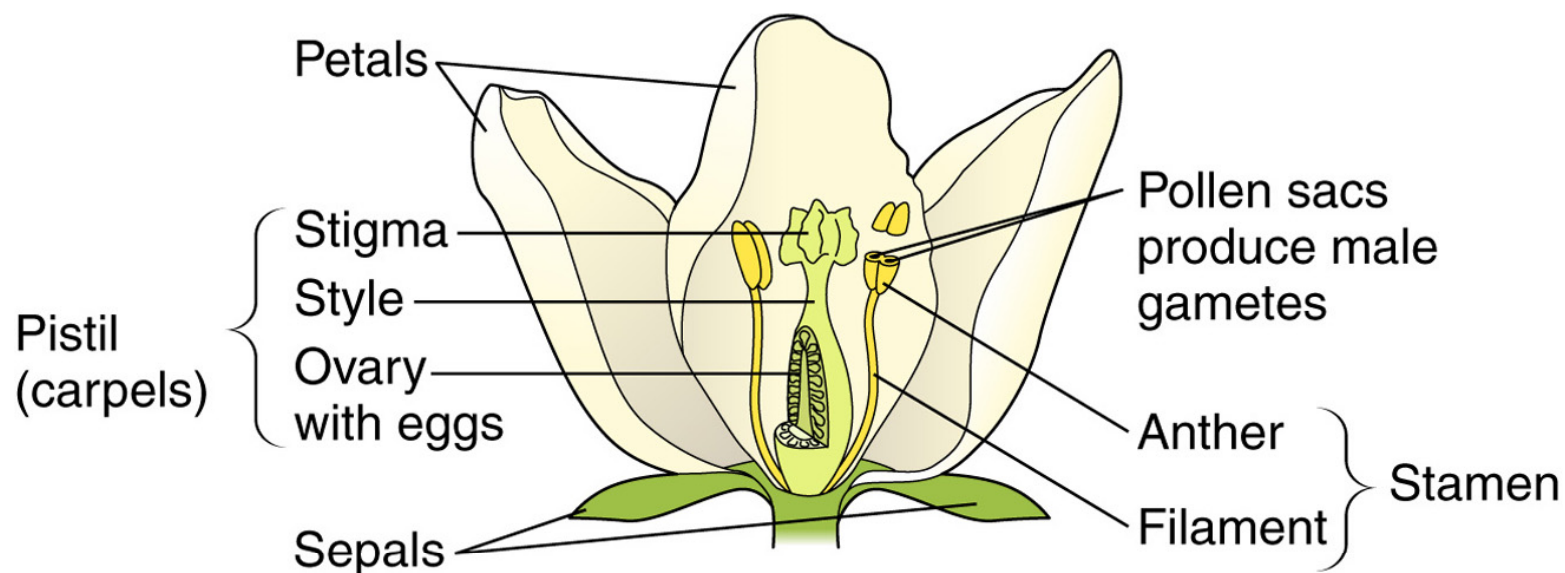


Outline of Lesson 6

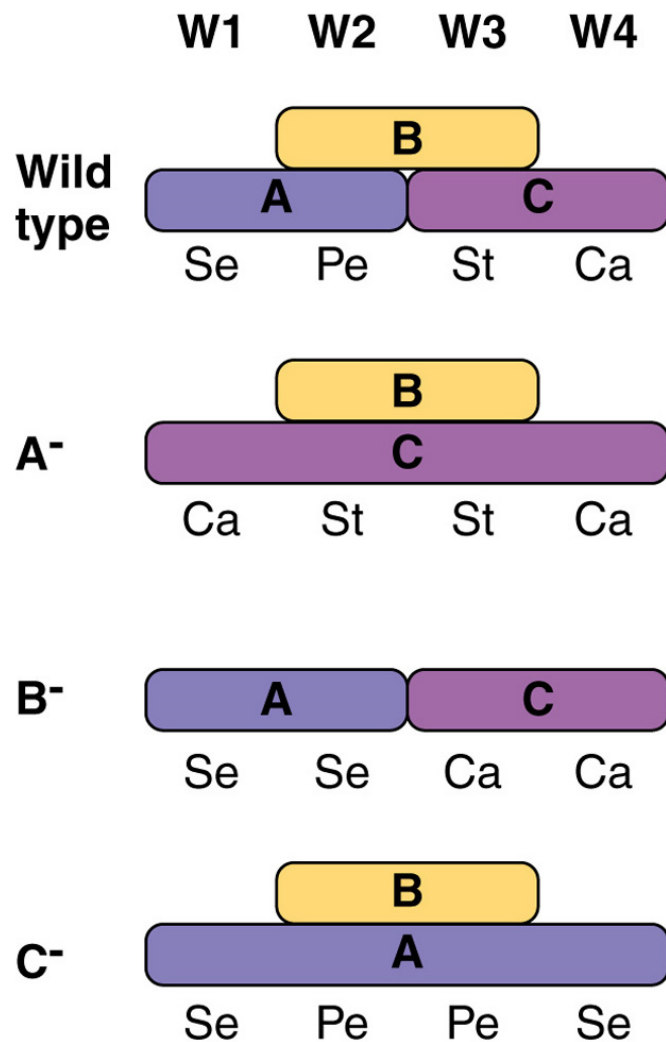
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- Plant life cycle
- Initiation of flowering
- Determination of floral organ identity

A.

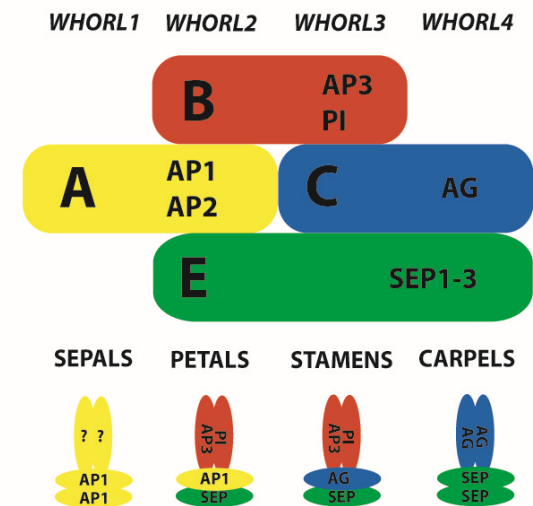


B.



MADS-box genes

- *MCM1* (yeast)
- *AGAMOUS* (*Arabidopsis*),
- *DEFICIENS* (*Antirrhinum*),
- *SERUM RESPONSIBLE FACTOR* (human).





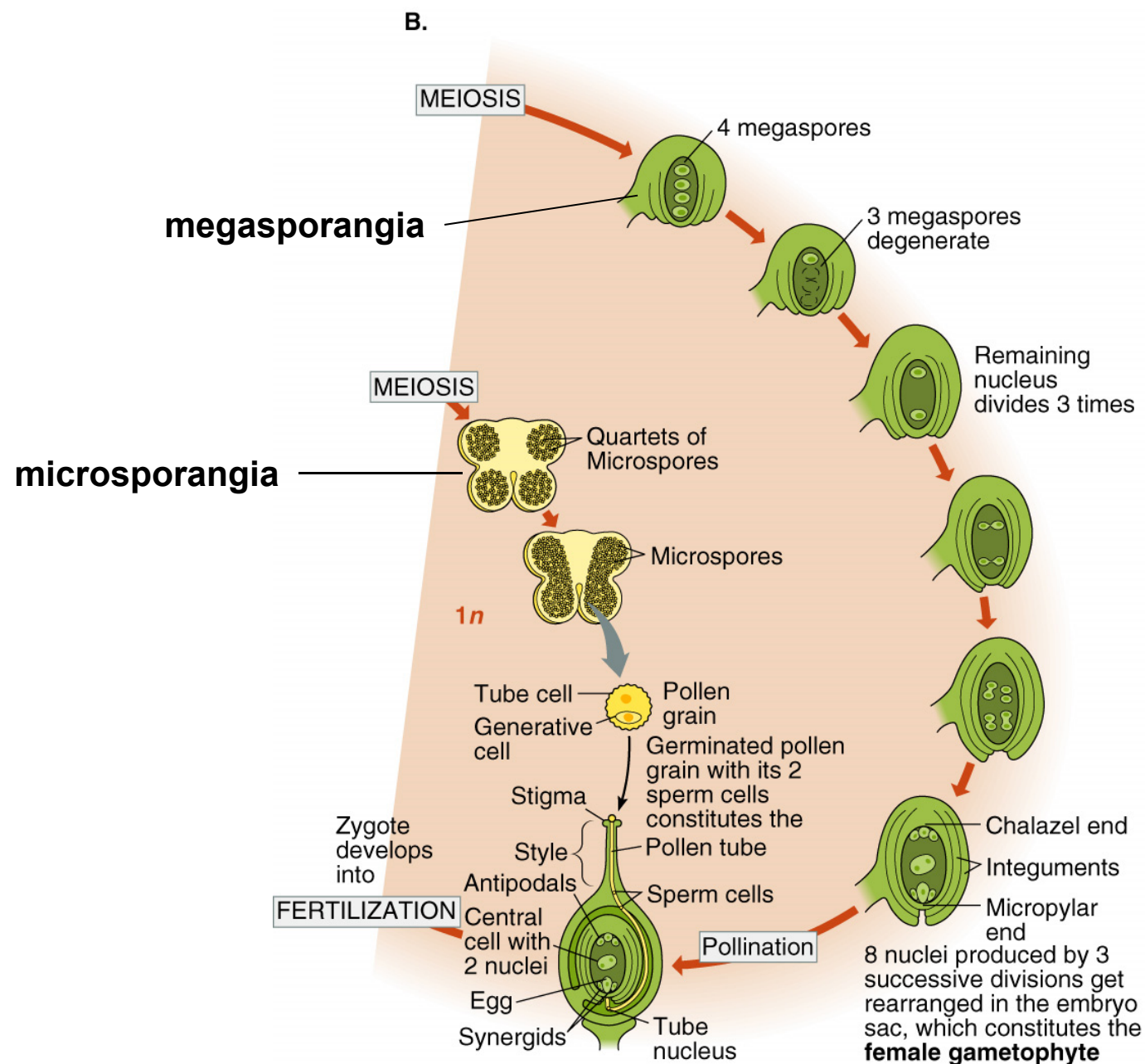
Author of ABC model, professor Elliot Meyerowitz (middle) during his visit of MU campus

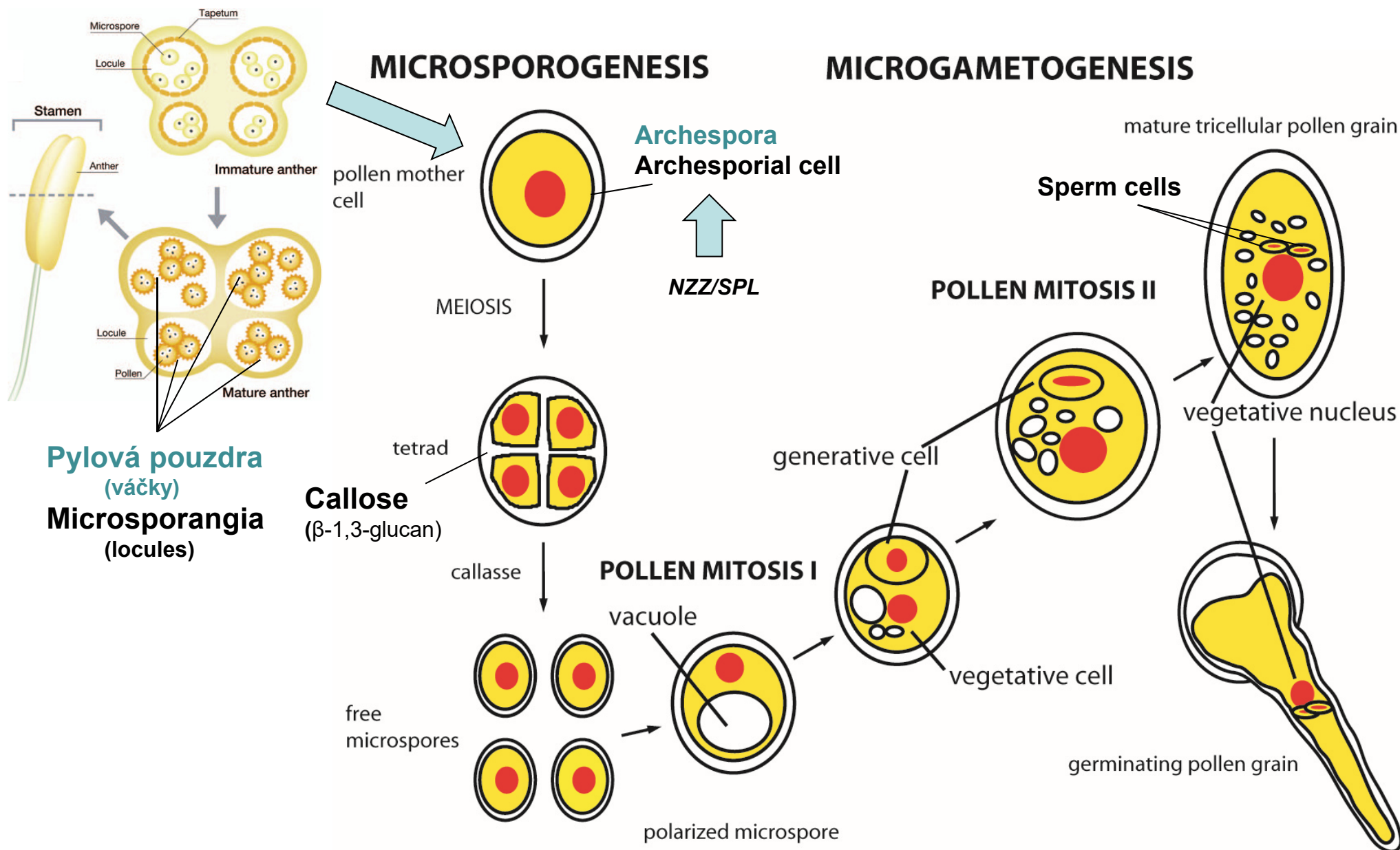


Outline of Lesson 6

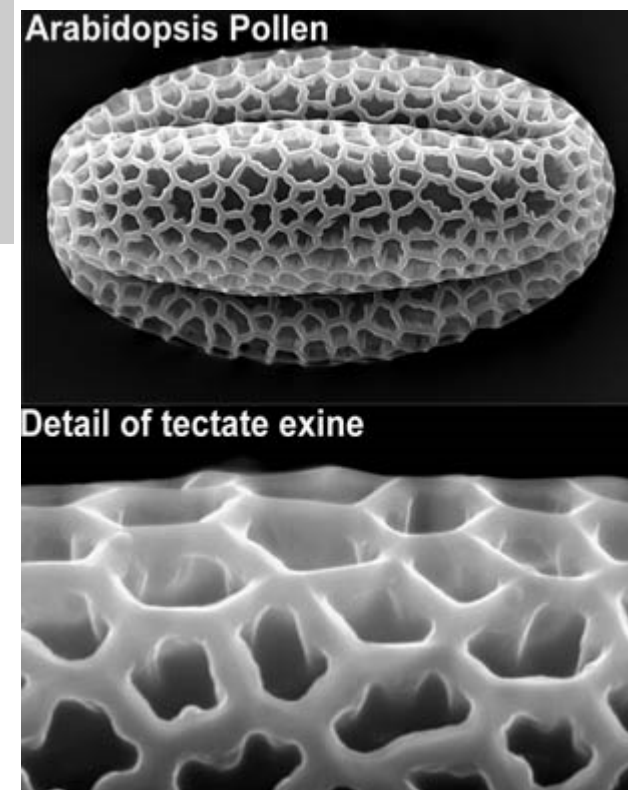
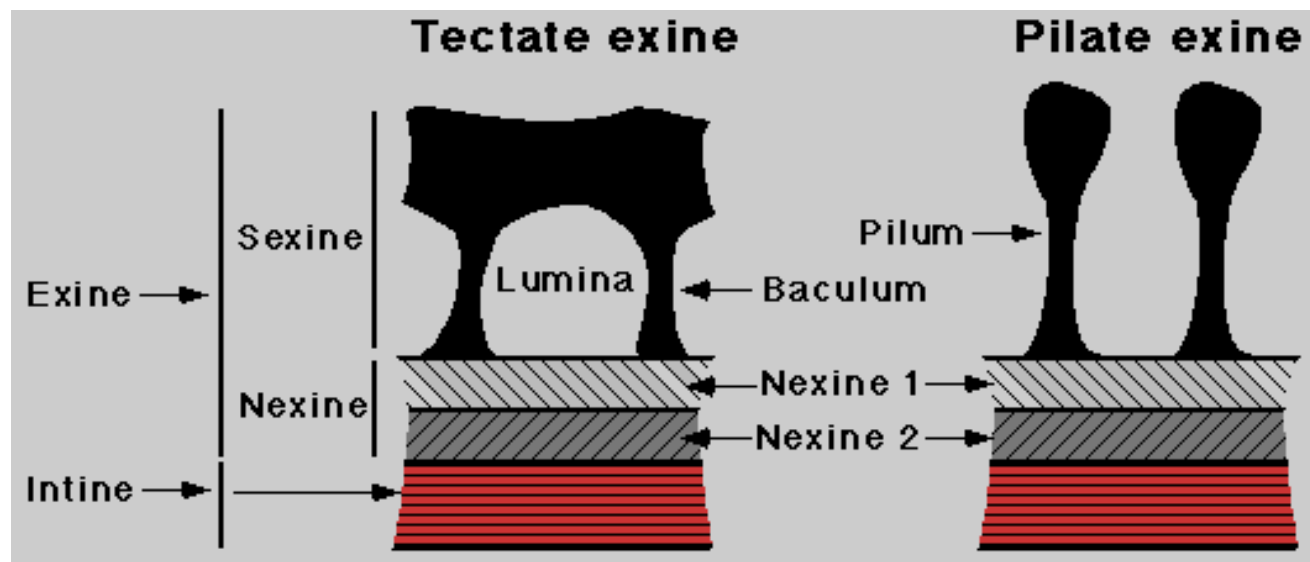
Plant Reproduction

- Sexual and asexual plant reproduction
- Plant life cycle
- Initiation of flowering
- Determination of floral organ identity
- Microgametogenesis





Dubova, Hejatko, Friml (2005)

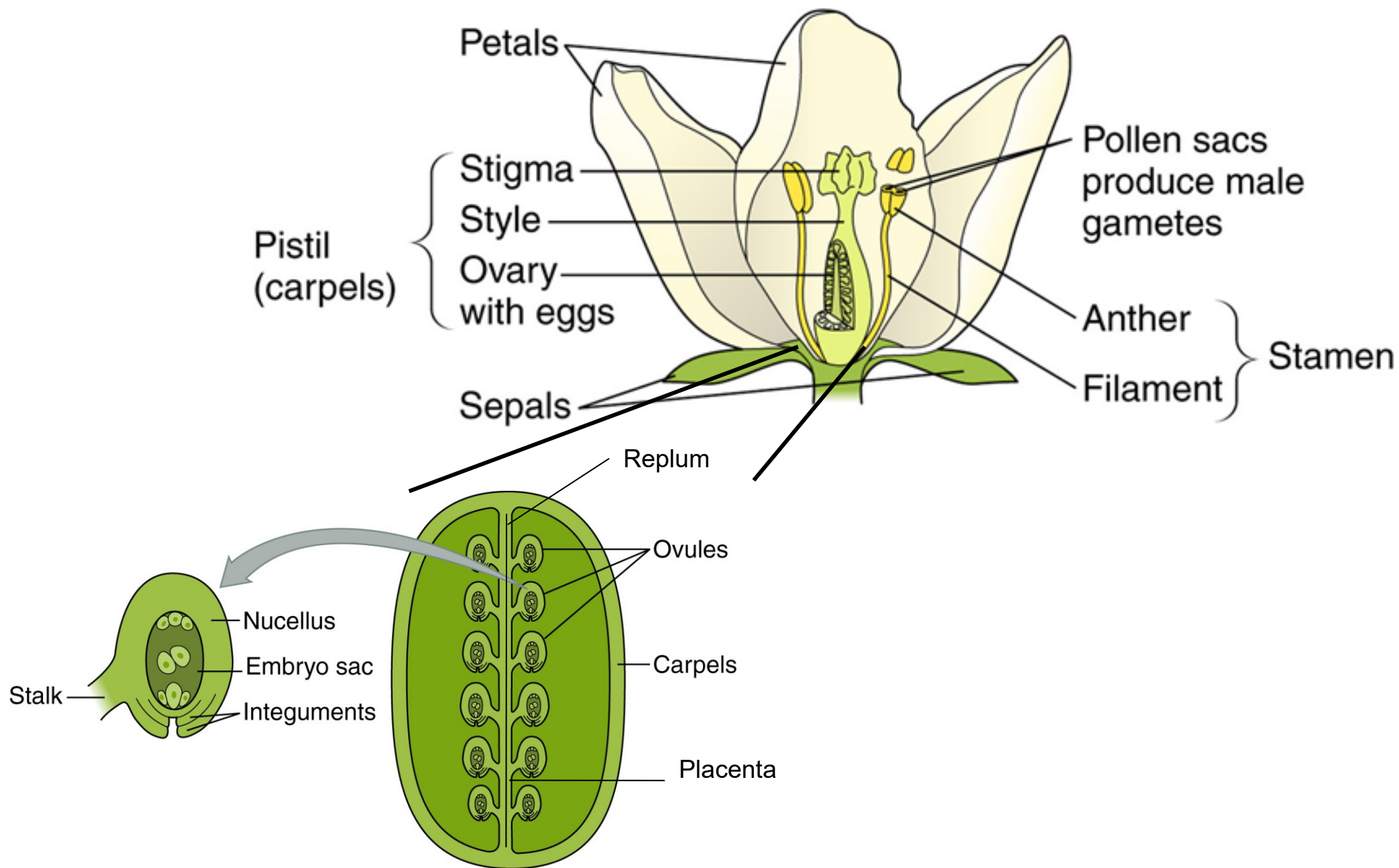


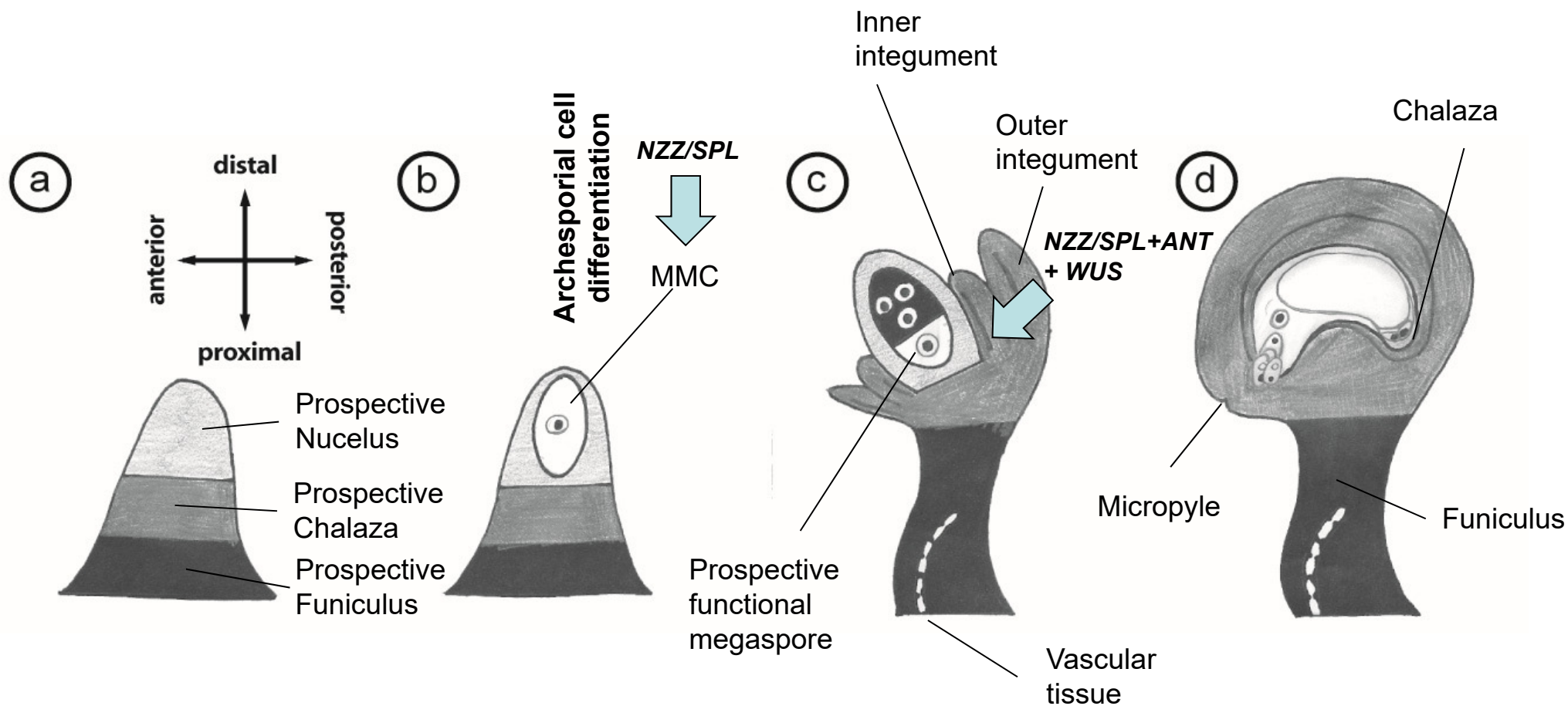


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- Megagametogenesis





Dubova, Hejatko, Friml (2005)



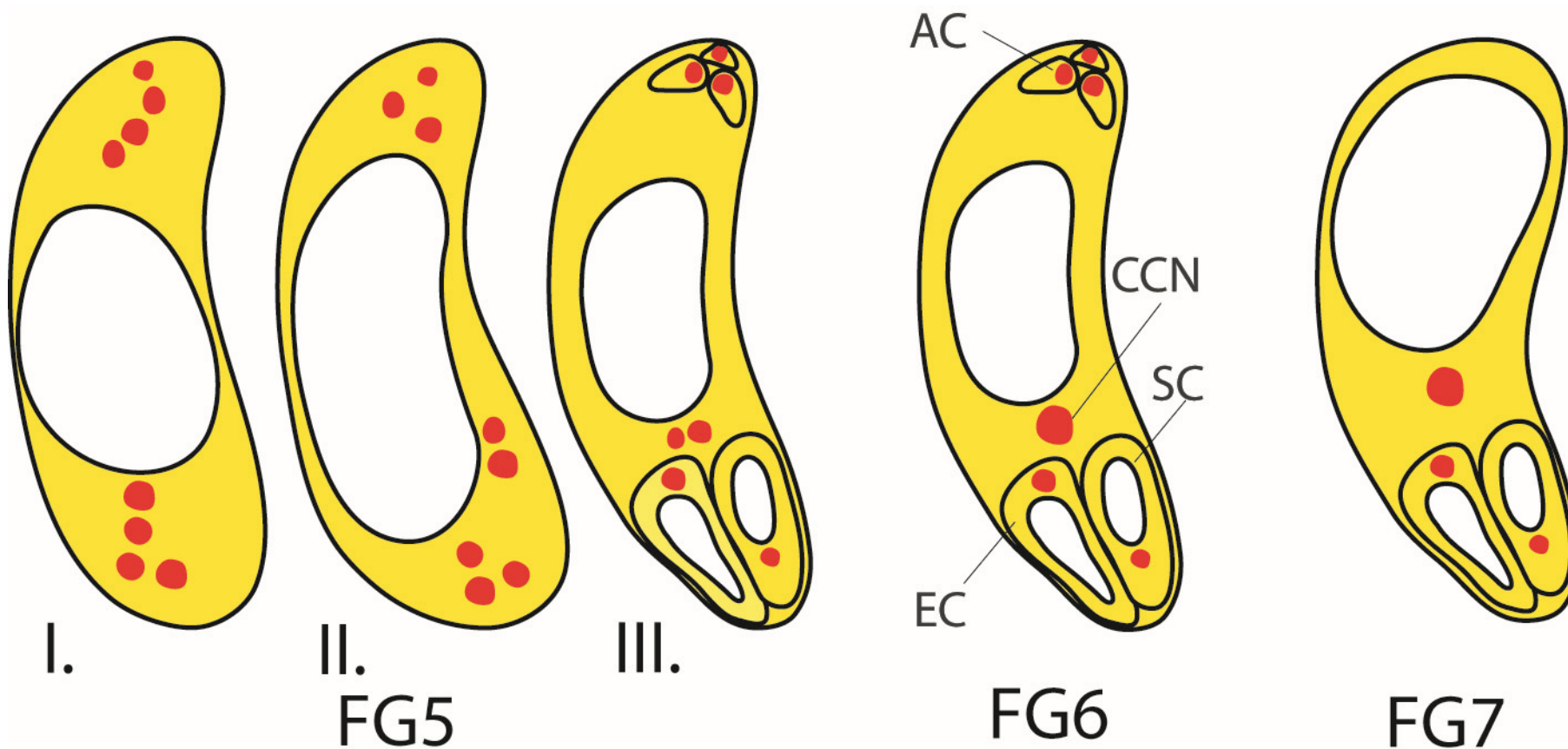
FG1

FG2

FG3

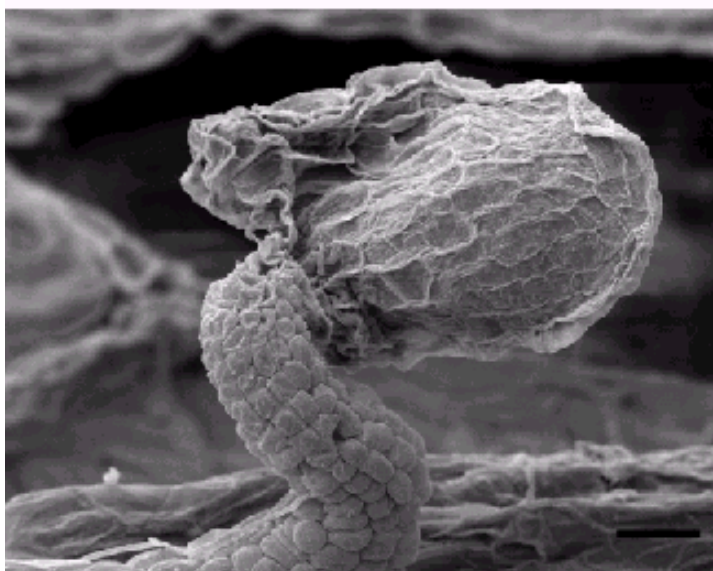
FG4

Dubova, Hejatk, Friml (2005)

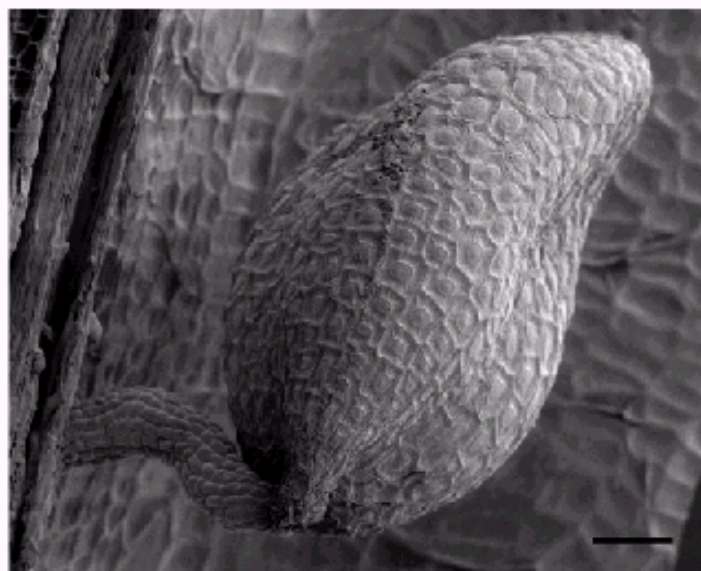


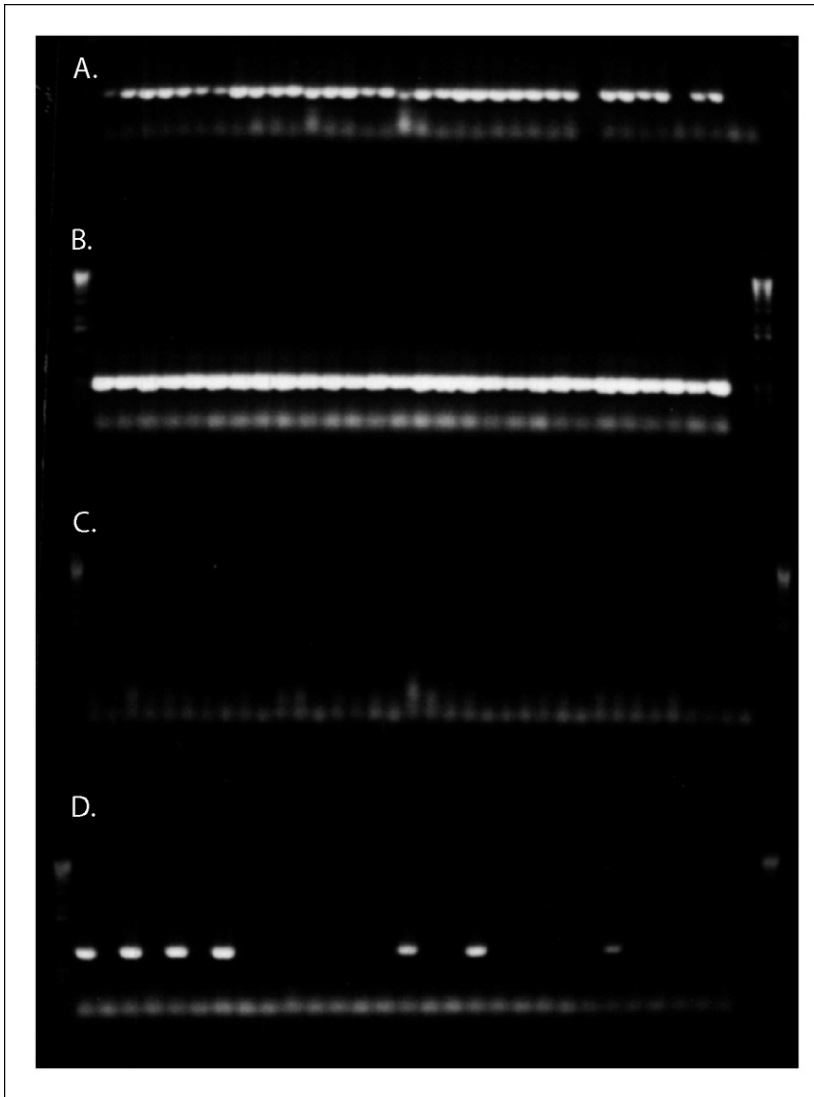
Dubova, Hejatkó, Friml (2005)

CKI1/cki1-i



CKI1/CKI1





A. ♂ wt x ♀ *CKI1/cki1-i*

↕ *CKI1* specific primers (PCR positive control)

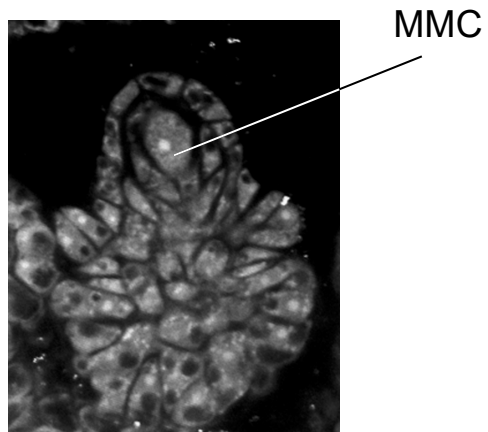
B. ♂ *CKI1/cki1-i* x ♀ wt

C. ♂ wt x ♀ *CKI1/cki1-i*

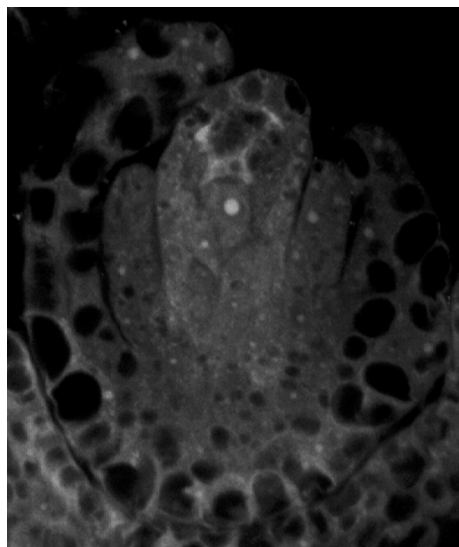
↕ *cki1-i* specific primers

D. ♀ wt x ♂ *CKI1/cki1-i*

FG 0



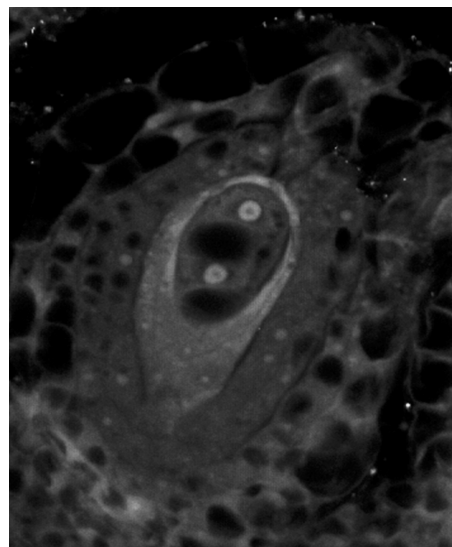
FG 1



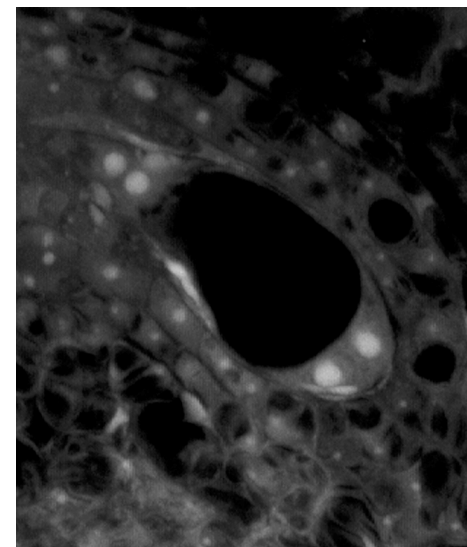
FG 2



FG 3



FG 4



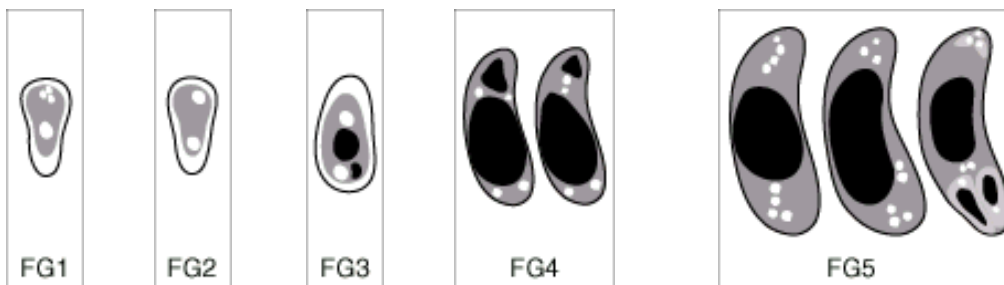
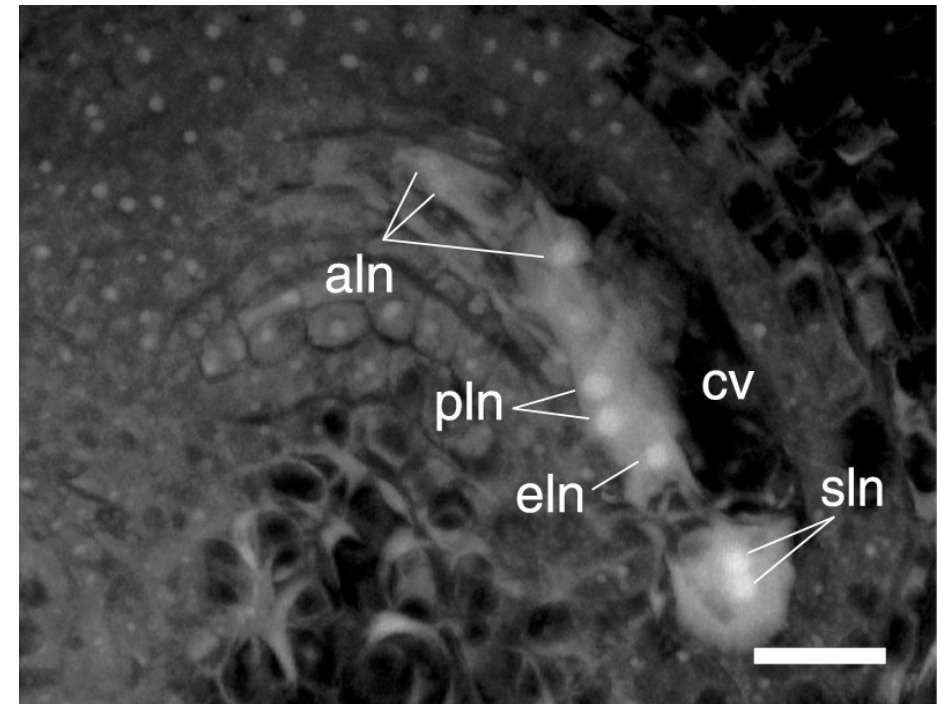
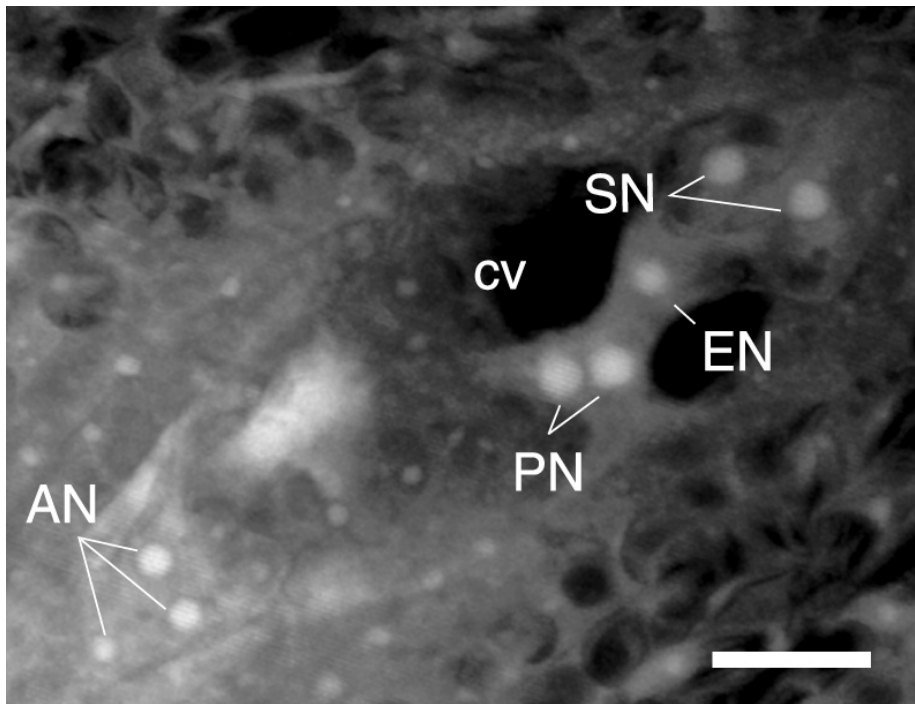
Hejátka et al., *Mol Genet Genomics* (2003)

CKI1

late FG5

cki1-i

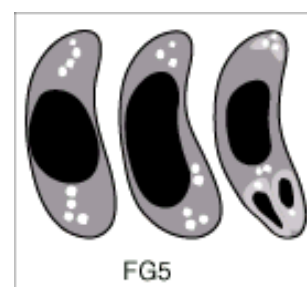
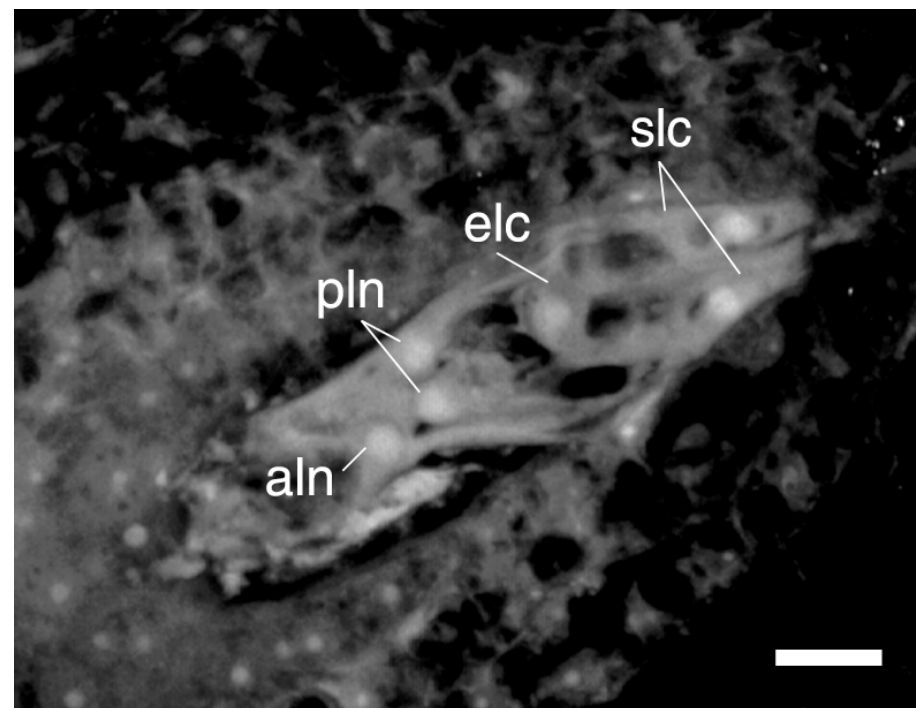
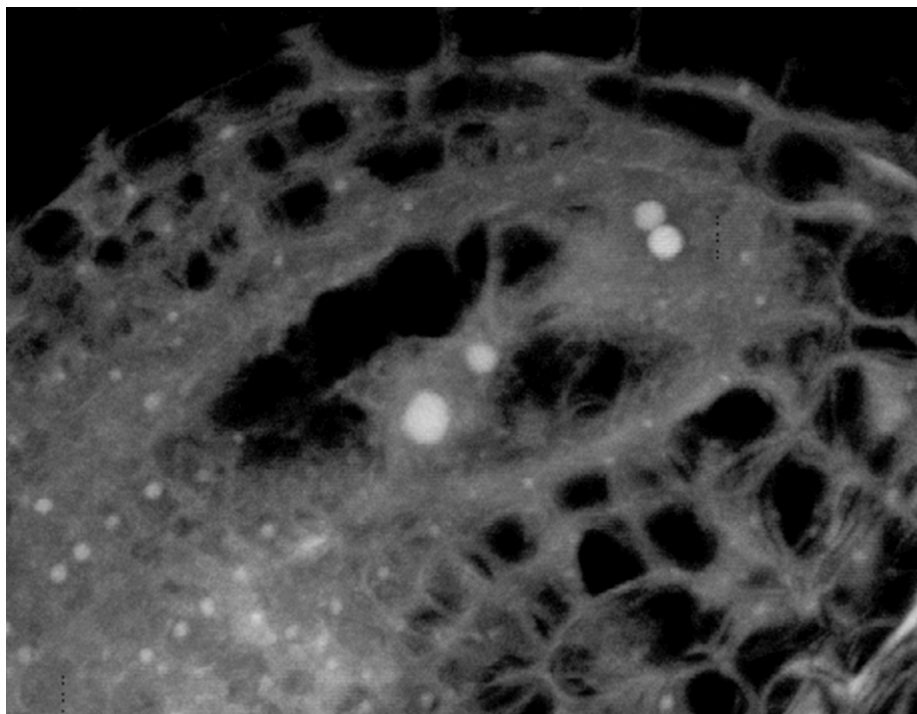
24 HAE



Hejátko et al., *Mol Genet Genomics* (2003)

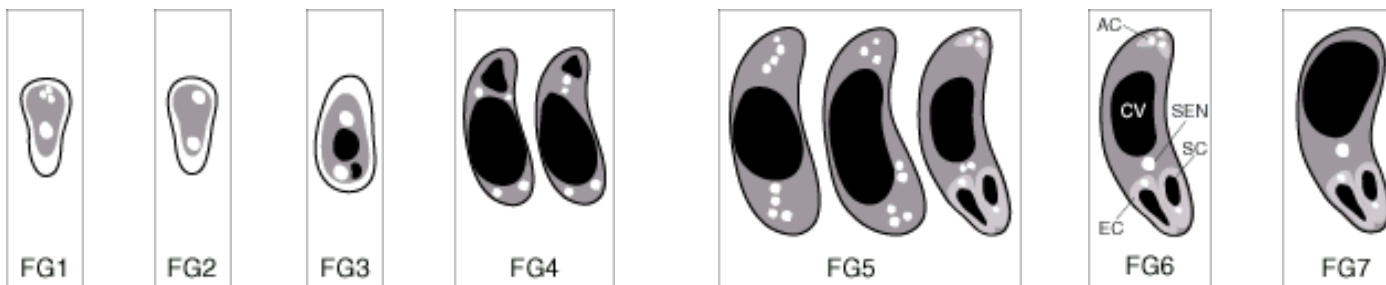
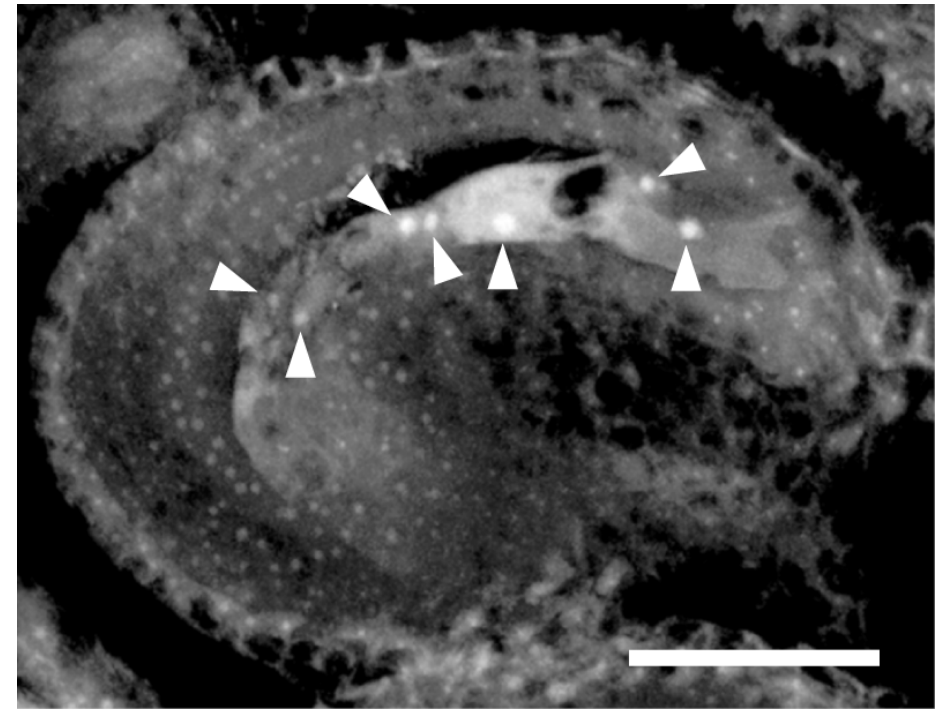
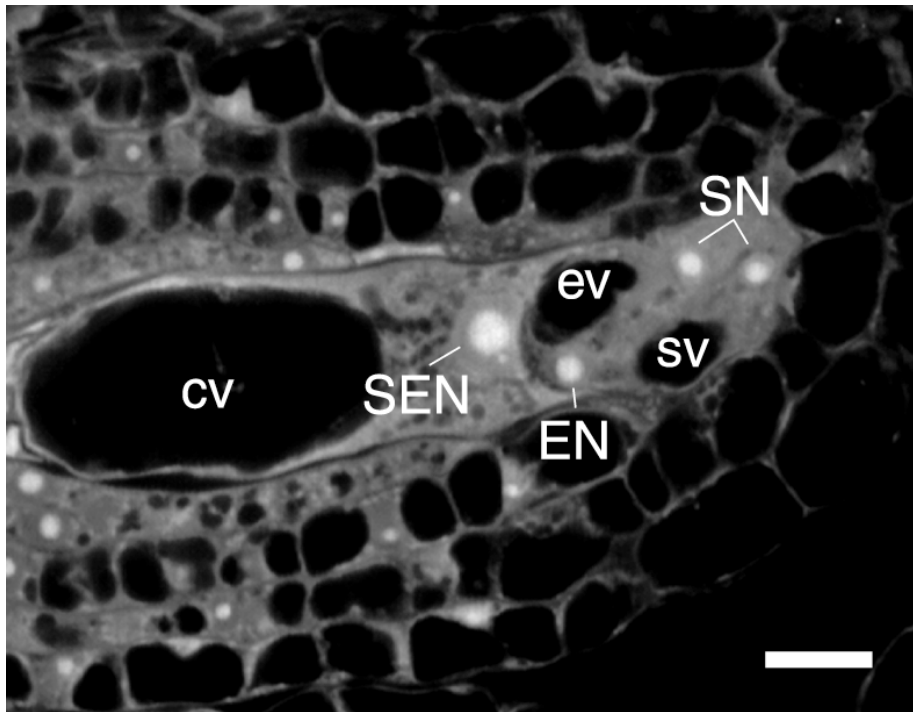
FG6

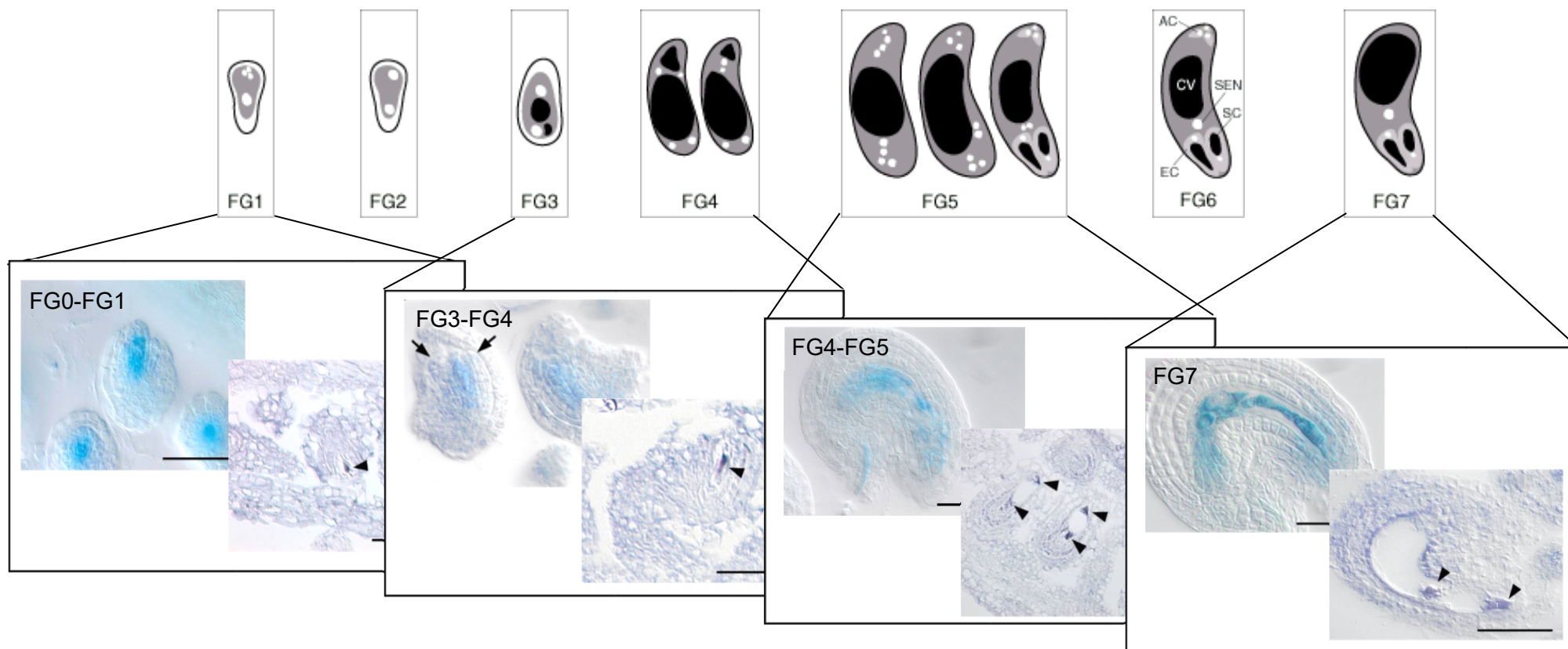
24 HAE



FG7

48 HAE





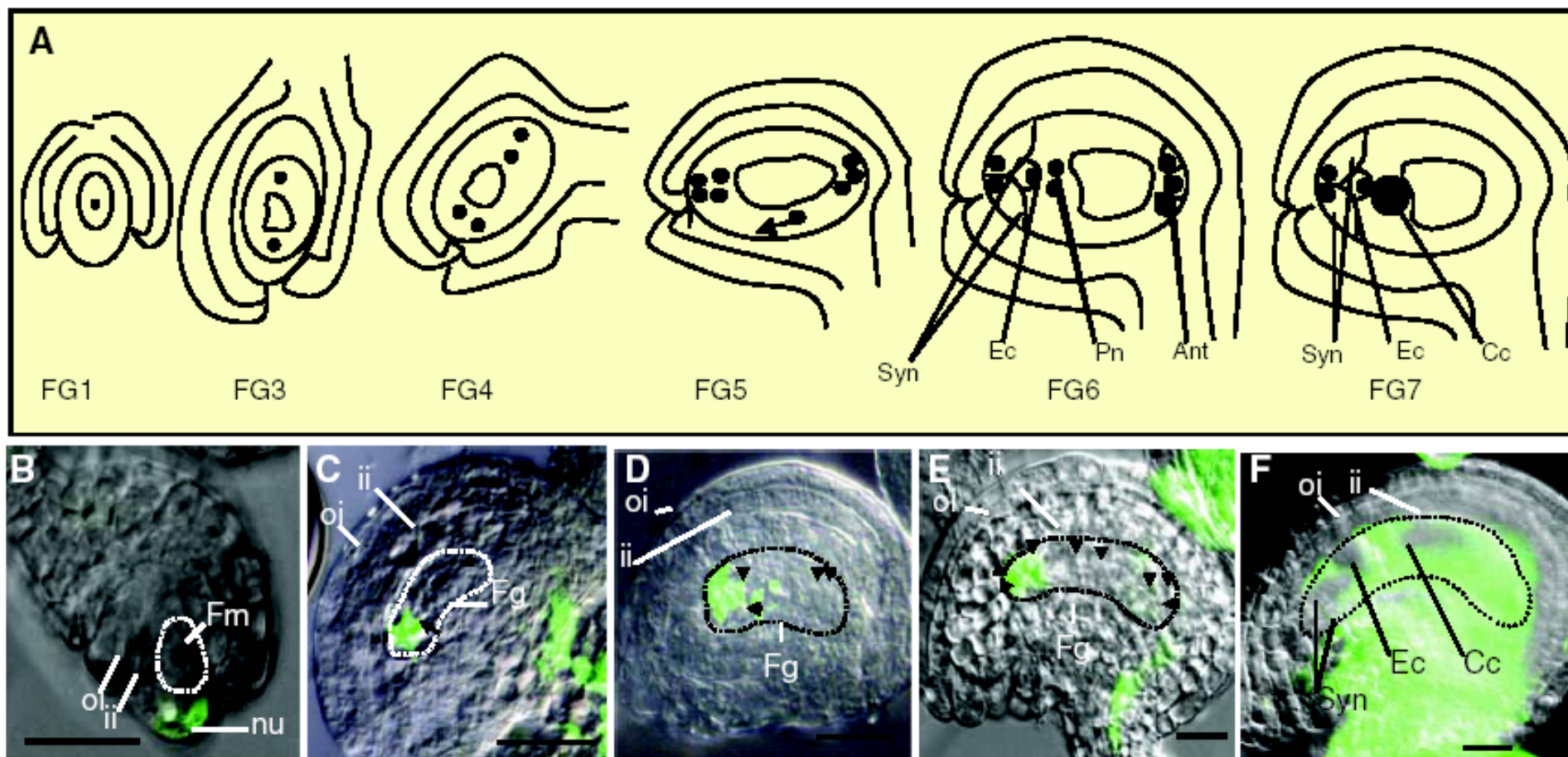
Hejátko et al., *Mol Genet Genomics* (2003)



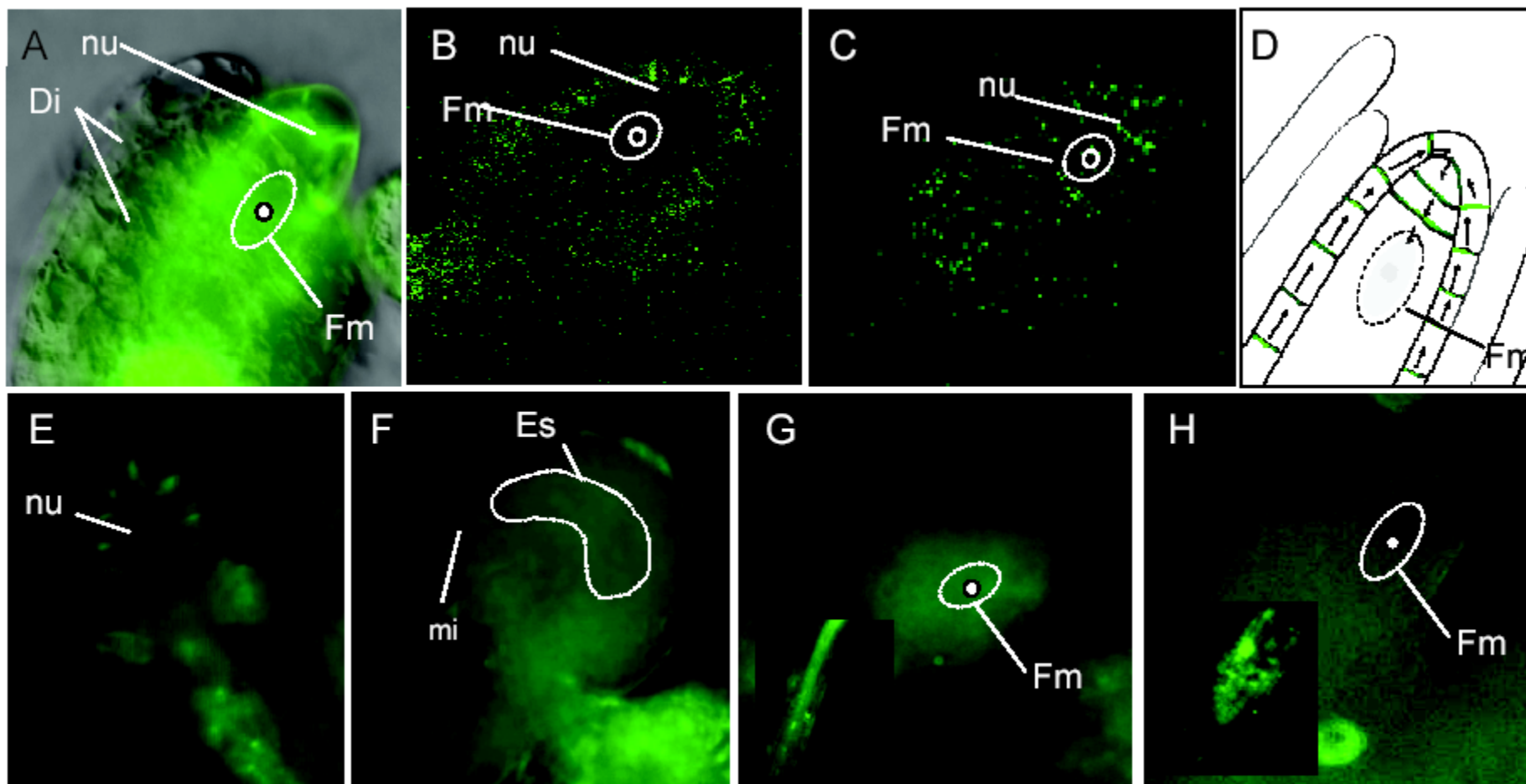
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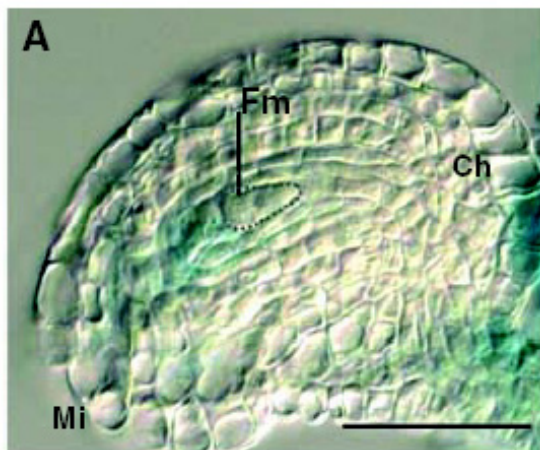
Pagnussat et al., *Science* (2009)



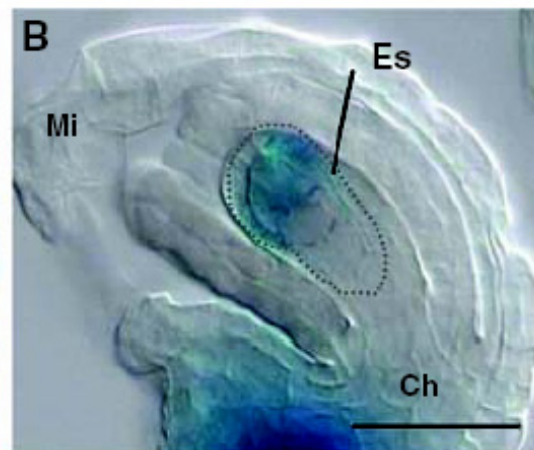
Pagnussat et al., *Science* (2009)

YUC1::GUS

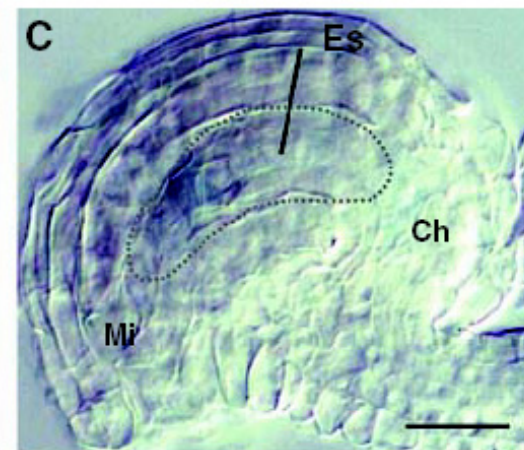
FG1



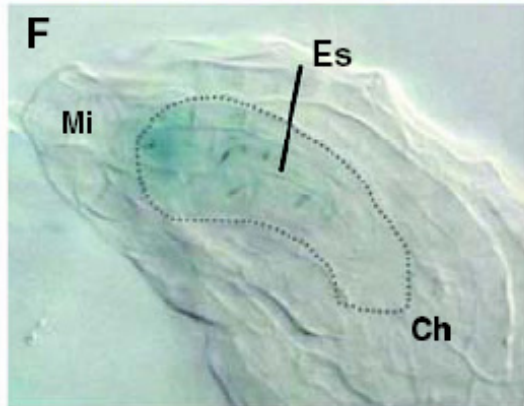
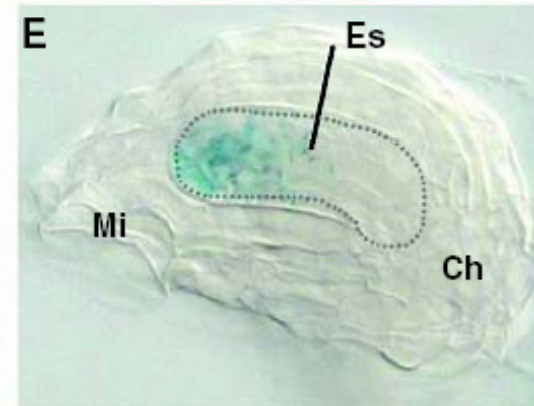
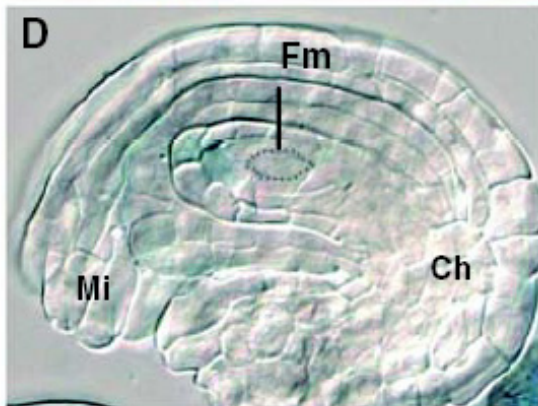
FG3



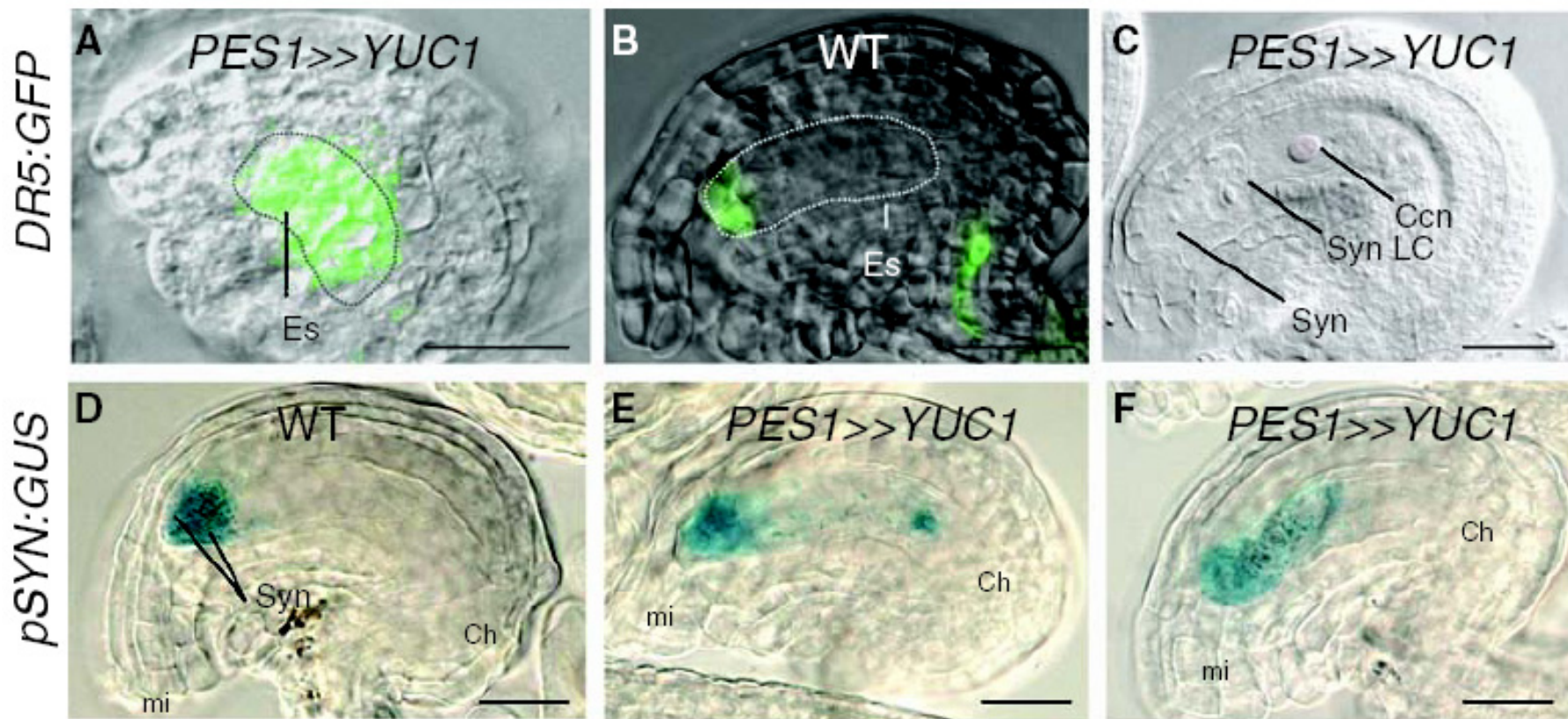
FG4



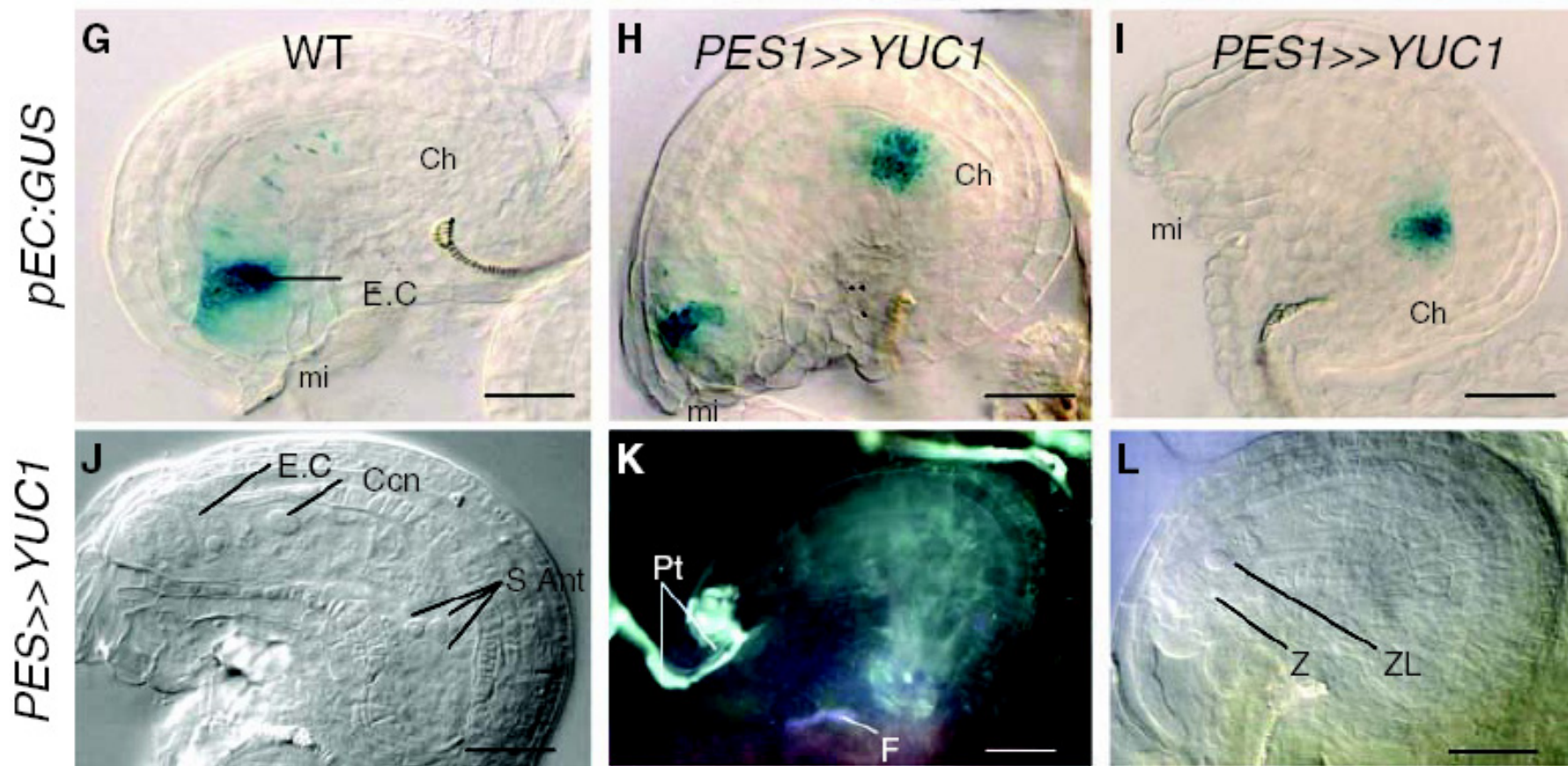
YUC2::GUS



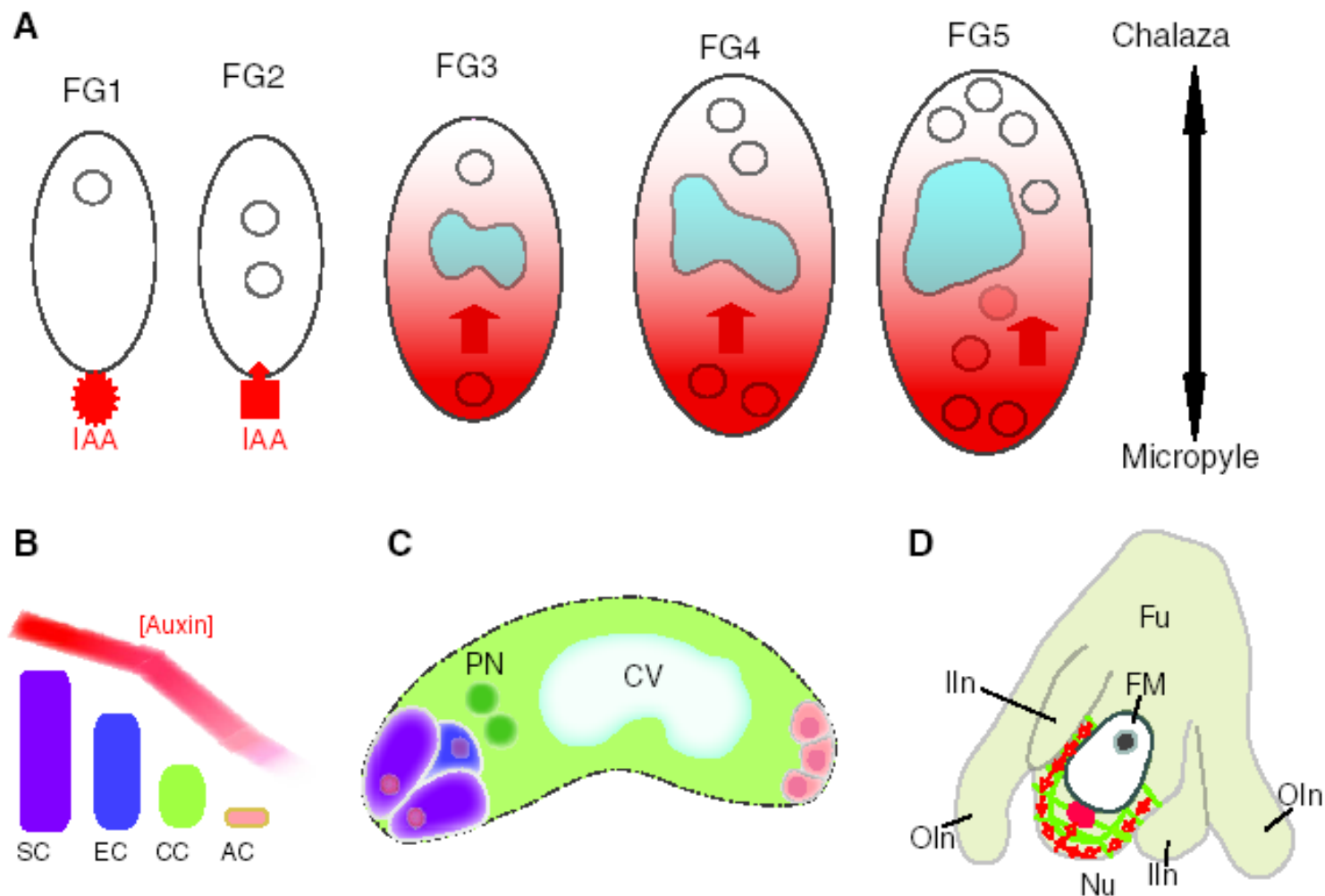
Pagnussat et al., *Science* (2009)



Pagnussat et al., *Science* (2009)



Pagnussat et al., *Science* (2009)



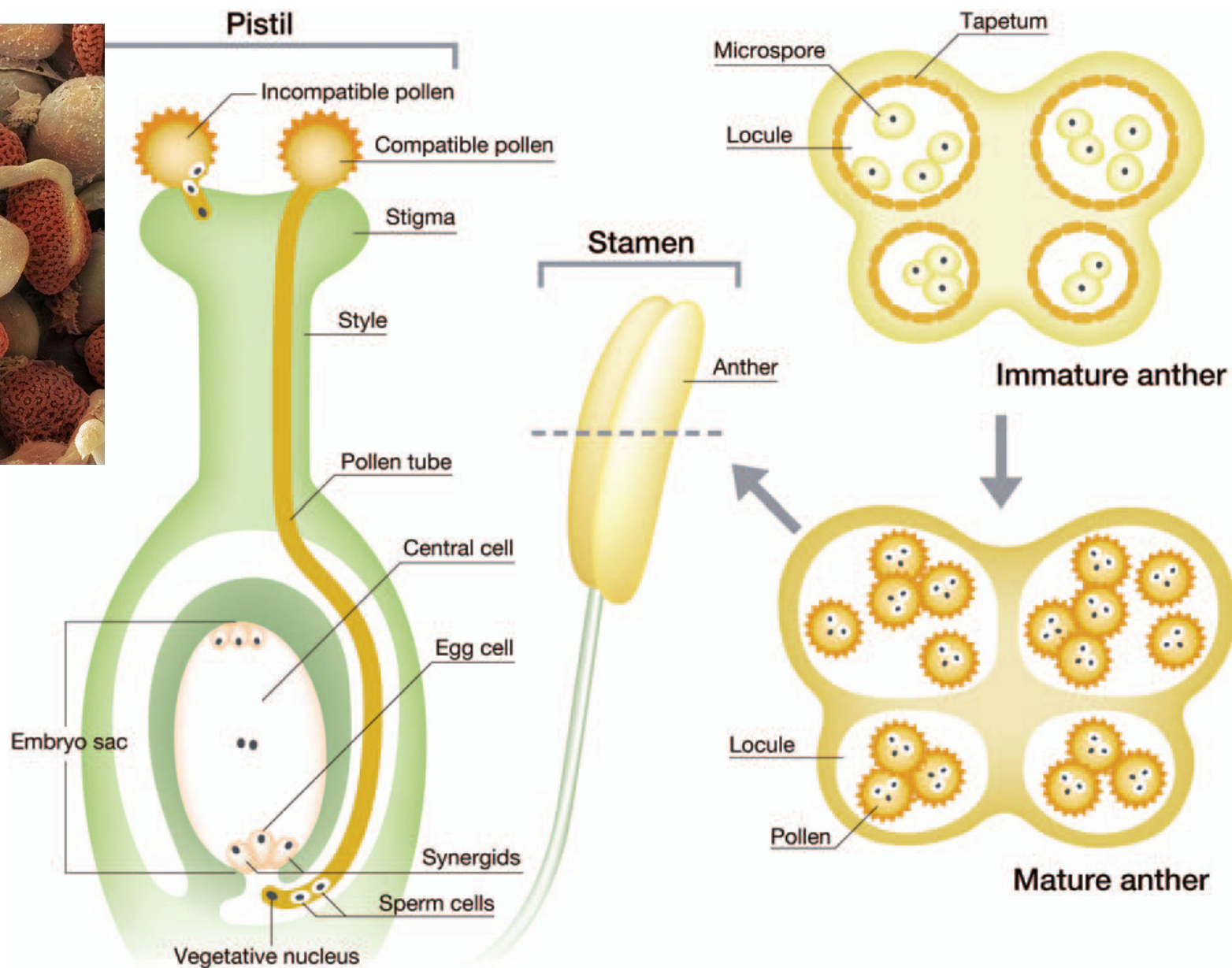
Sundaressan and Alandete-Saez, *Development* (2010)



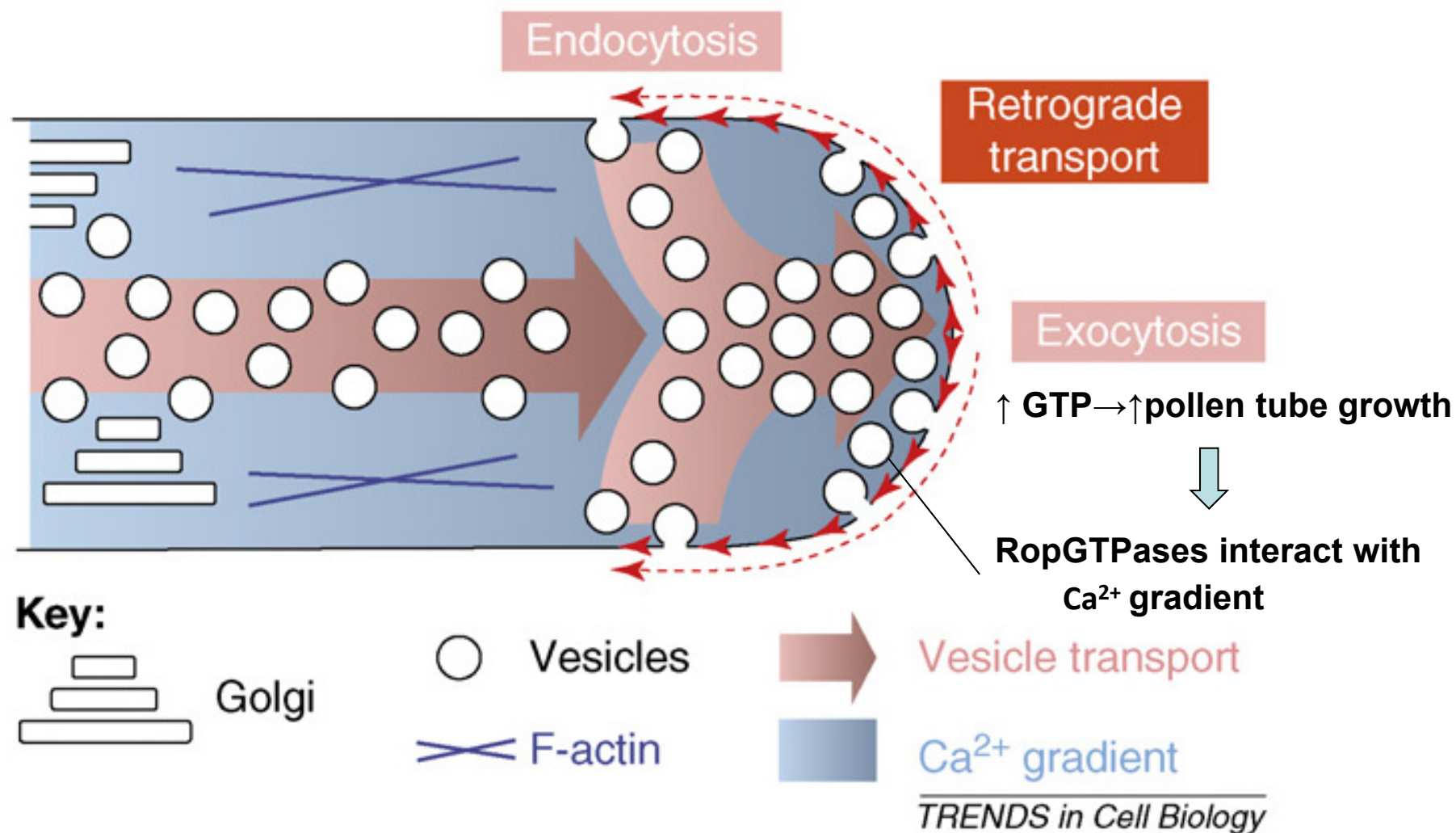
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- Pollen tube growth, guidance and fertilization



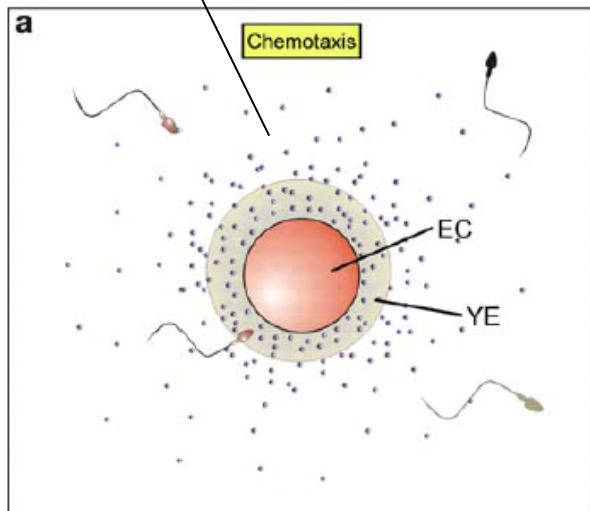
Suzuki, *Plant and Cell Physiol* (2009)



Kost., *Trends in Plant Science* (2008)

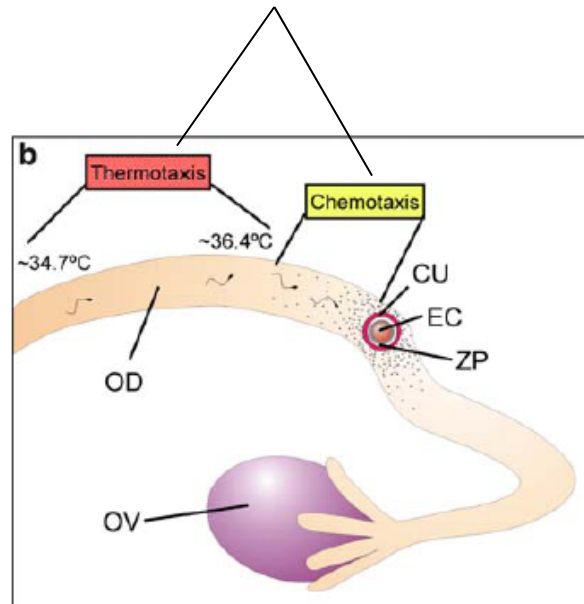
Chemotaxis and fertilization

Chemotaxis



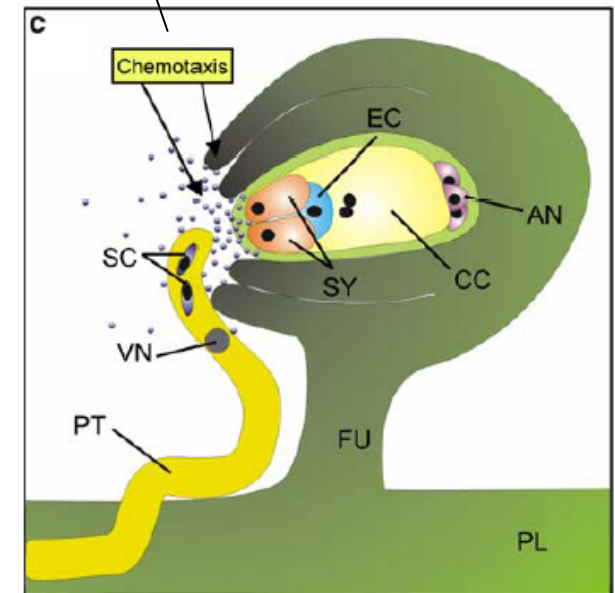
sea urchin

Chemo- and Thermotaxis



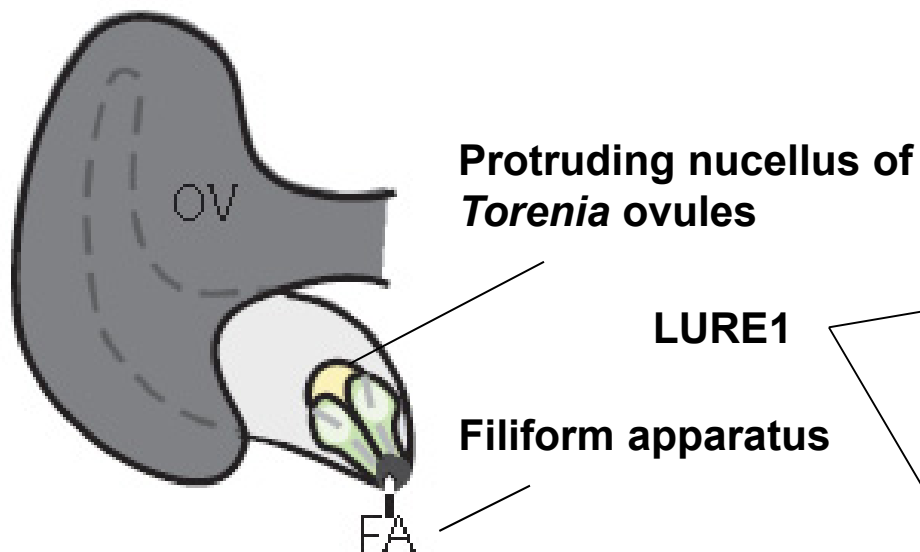
mammals

Chemotaxis



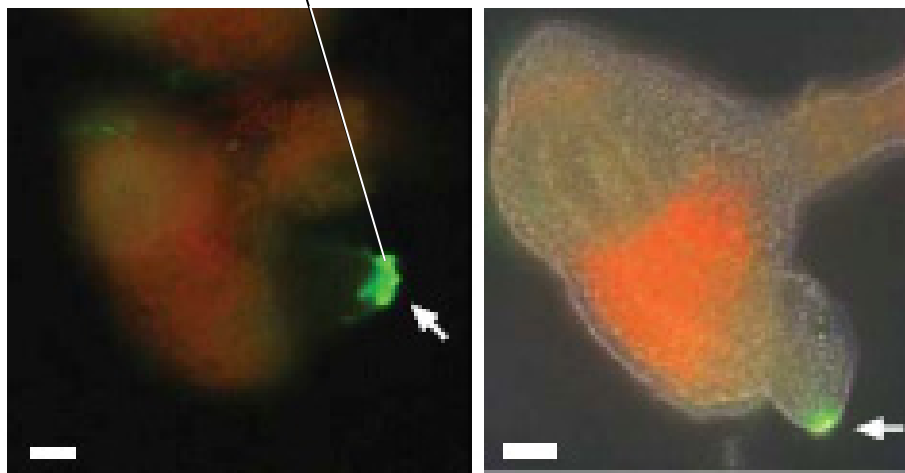
plants

Marton and Dresselhaus., *Plant Sex Reprod* (2007)

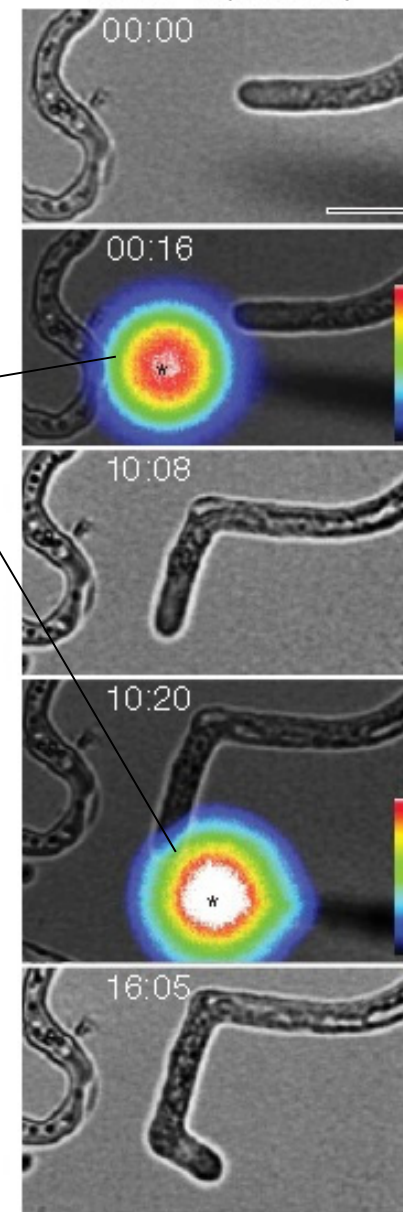


LURE1 and LURE2 (CRPs) → RLKs → pollen tube and synergid behavior

Anti-TfCRP3



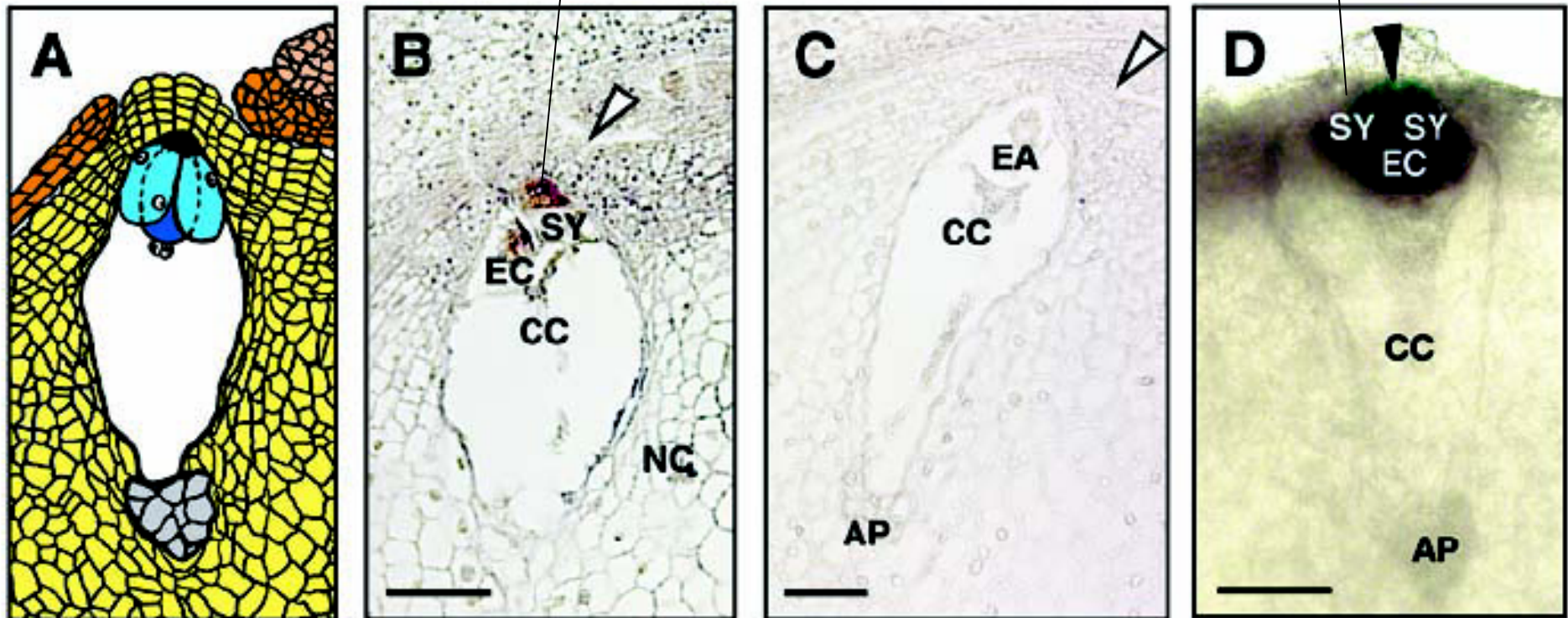
a TfCRP3 (LURE2)



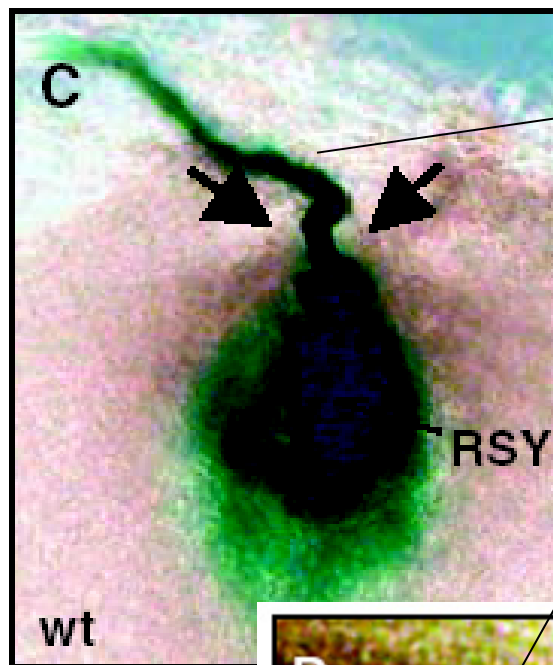
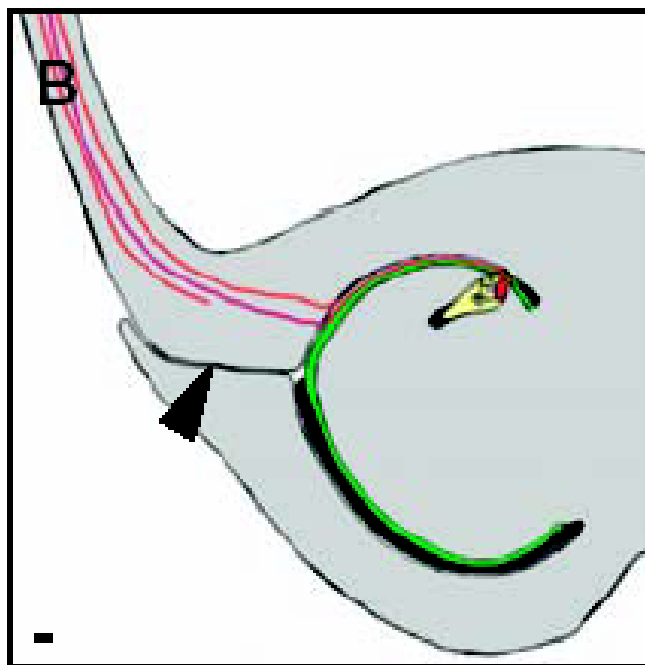
Okuda et al., *Nature* (2009)

Zm EGG APARATUS1 mRNA

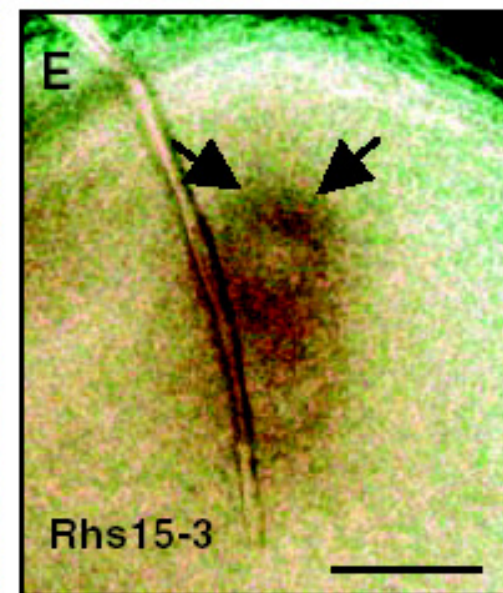
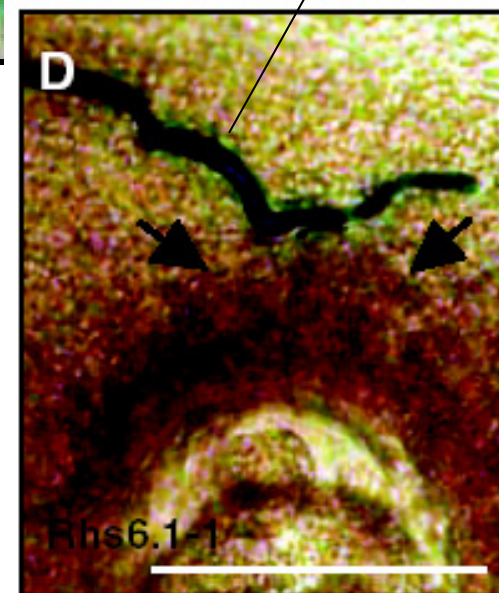
ProZmEA1:GUS



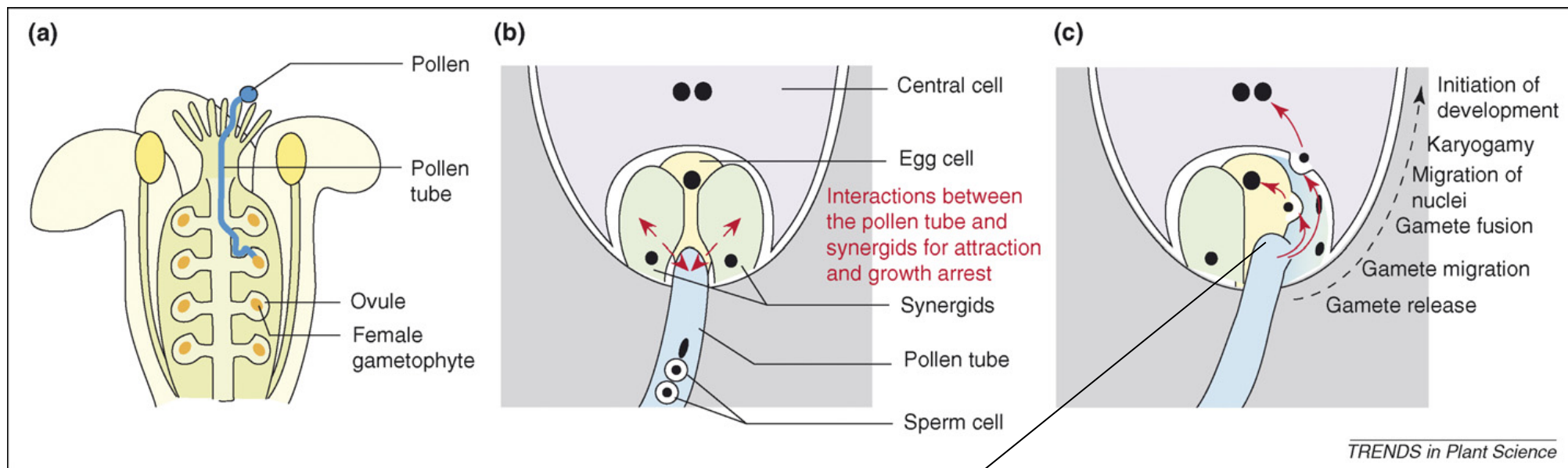
Marton et al., *Science* (2005)



Pollen tube



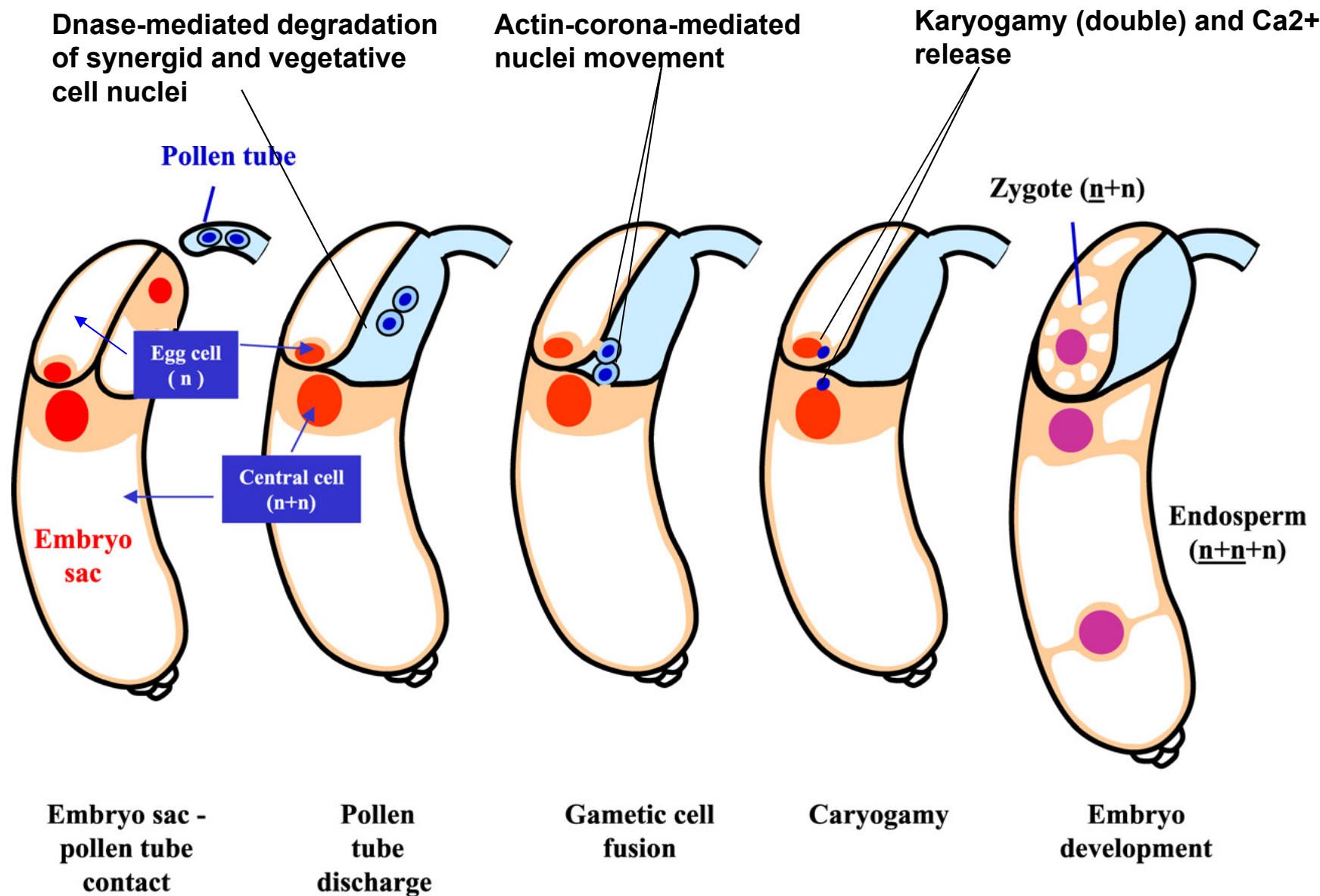
Marton et al., *Science* (2005)



Receptive synergid

- cytoskeleton reorganization
- Ca²⁺ accumulation
- Organelles and plasmamembrane degeneration

Berger et al., *Trends in Plant Science* (2008)



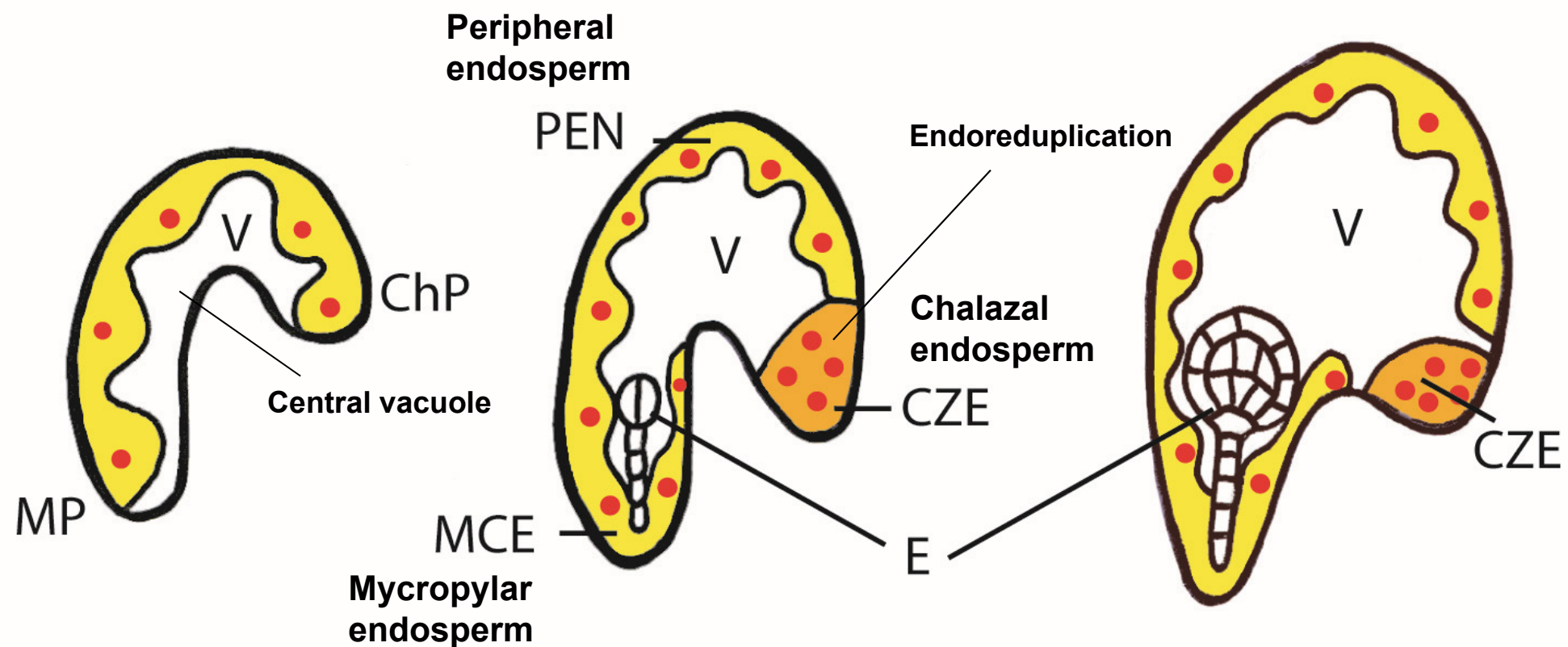
Dumas and Rogowsky., *C. R. Biologies* (2008)



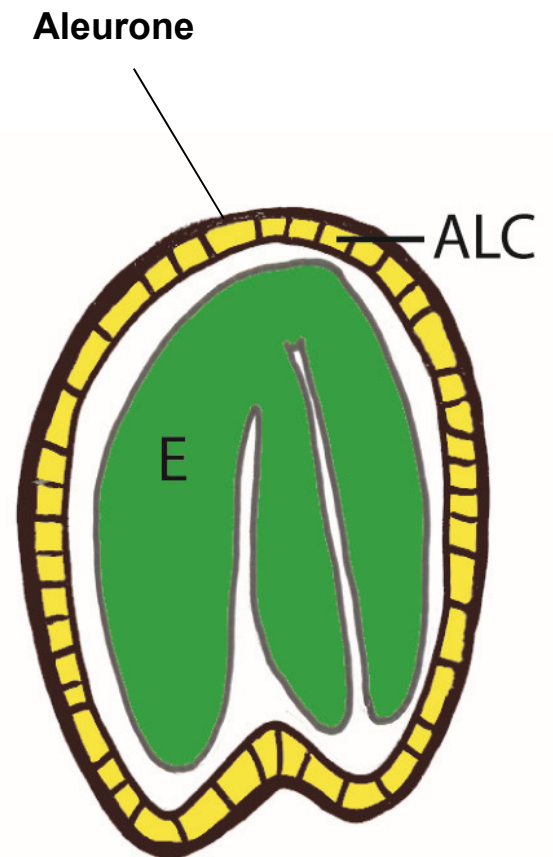
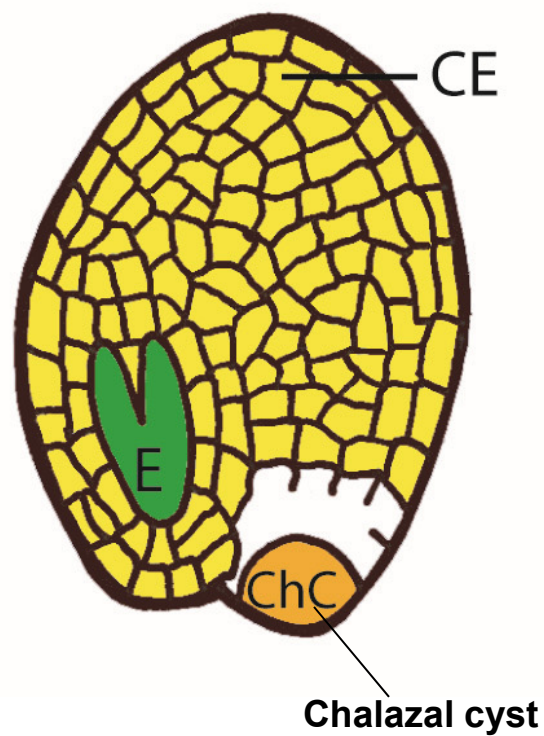
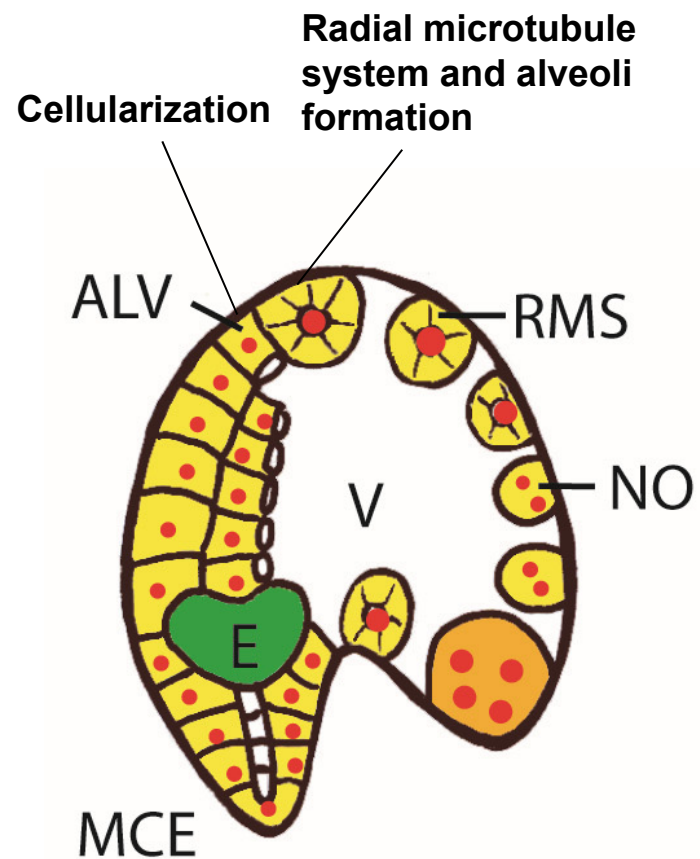
Outline of Lesson 6

Plant Reproduction

- Sexual and asexual plant reproduction
- Plant life cycle
- Initiation of flowering
- Determination of floral organ identity
- Microgametogenesis
- Megagametogenesis
 - Female gametophyte patterning
- Pollen tube growth, guidance and fertilization
- Endosperm and seed formation

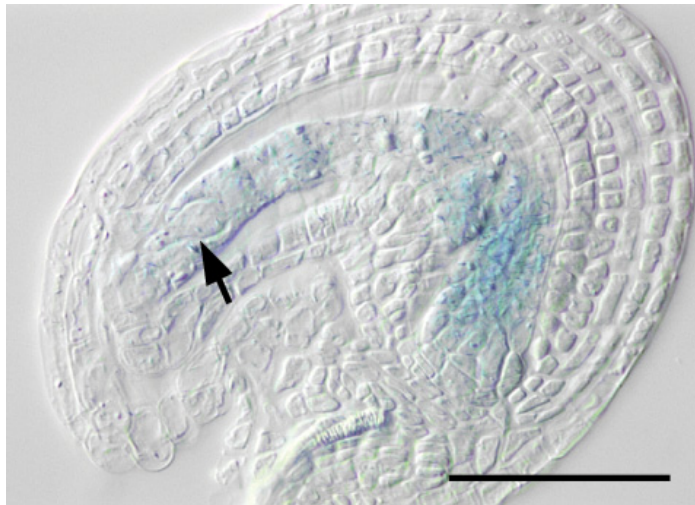


Dubova, Hejatko, Friml (2005)

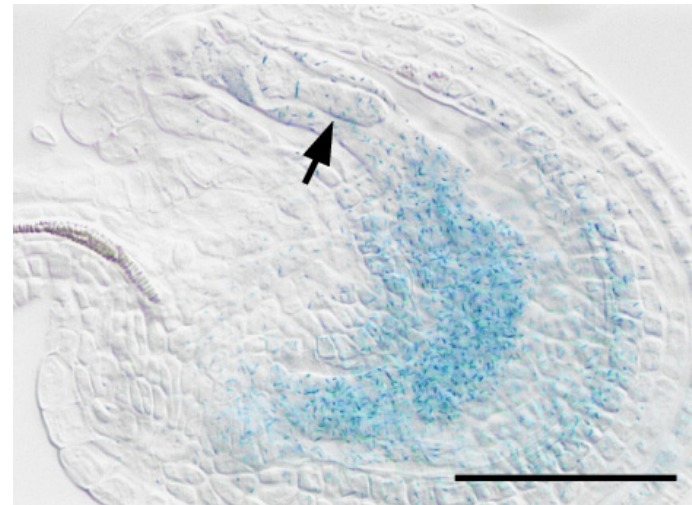


Dubova, Hejatko, Friml (2005)

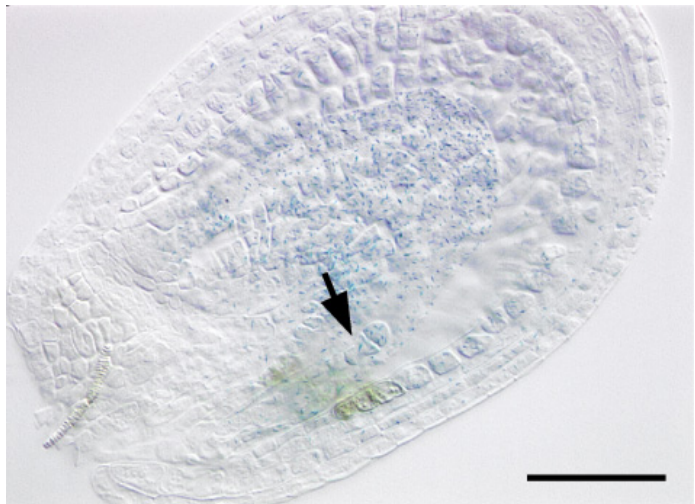
♀ wt x ♂ *CKI1prom::uidA*



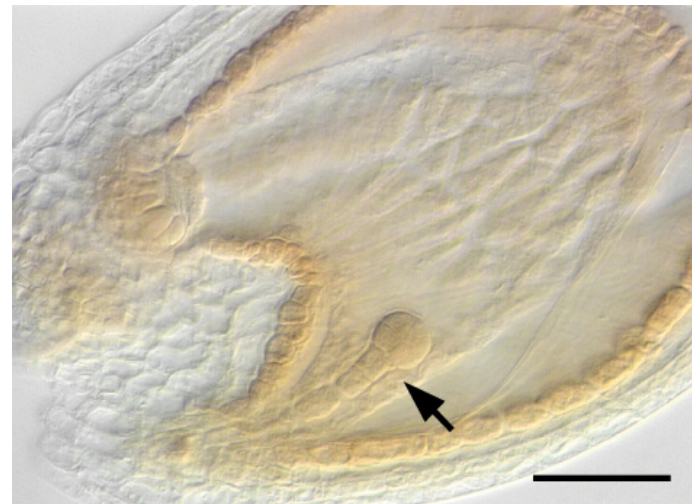
12 HAP



24 HAP



48 HAP



72 HAP

Hejátko et al., *Mol Genet Genomics* (2003)



Key Concepts

Plant Reproduction

- In plants, **gametophytic** and **sporophytic portion** (“generation”) of the life cycle could be distinguished
- **Initiation of flowering** integrates **multiple inputs** (light quality/photoperiod, vernalization, autonomous and hormonal signals)
- **Several developmental switches** resulting into **acquisition of floral meristem** and **floral organ identity** take place during onset of flowering. These **switches** are under control of **specific genes** that mutually interact
- In angiosperms, the gametophyte is reduced to **three-celled pollen tube** (male gametophyte) and mostly **seven-celled female gametophyte** (embryo sac). **Auxin gradient** determines **acquisition of cell identity** during embryo sac development
- Pollen tube growth is complex process associated with large amount of cell material deposition. **Pollen tube guidance is mediated by specific molecules** allowing **synergid-cell mediated chemotaxis**.
- **Expression of maternal** and **paternal genes** is **tightly regulated** during seed development.