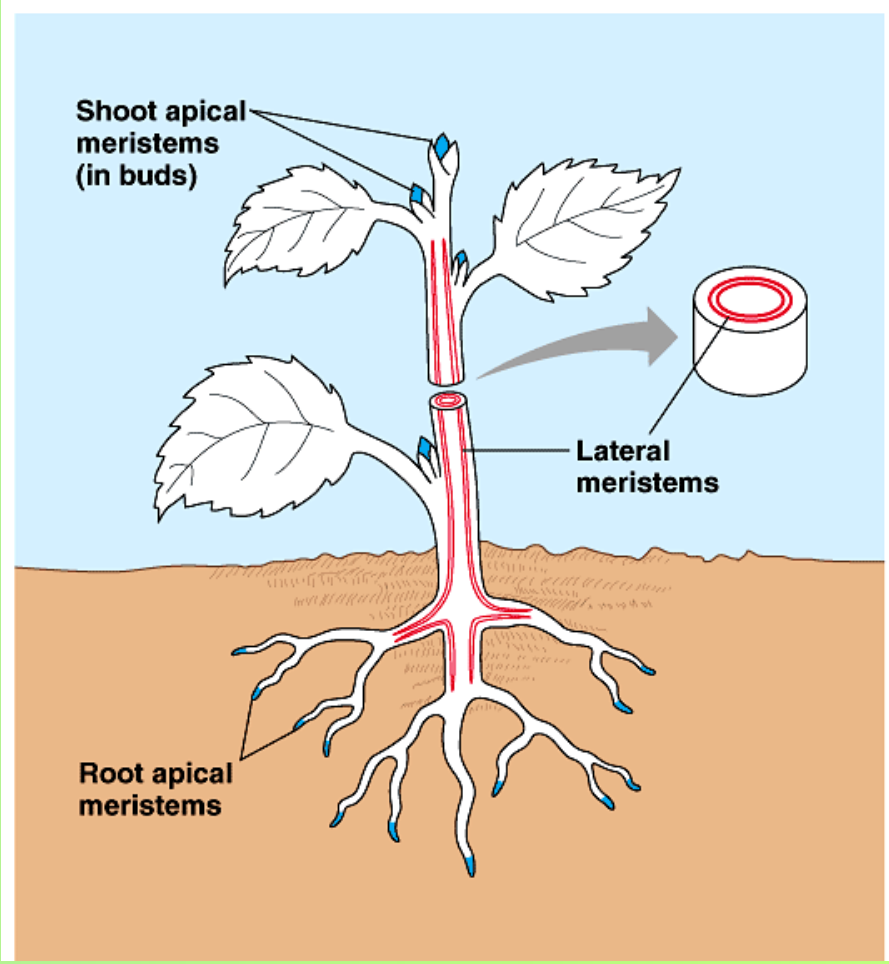
Plant Growth (Ch. 24)

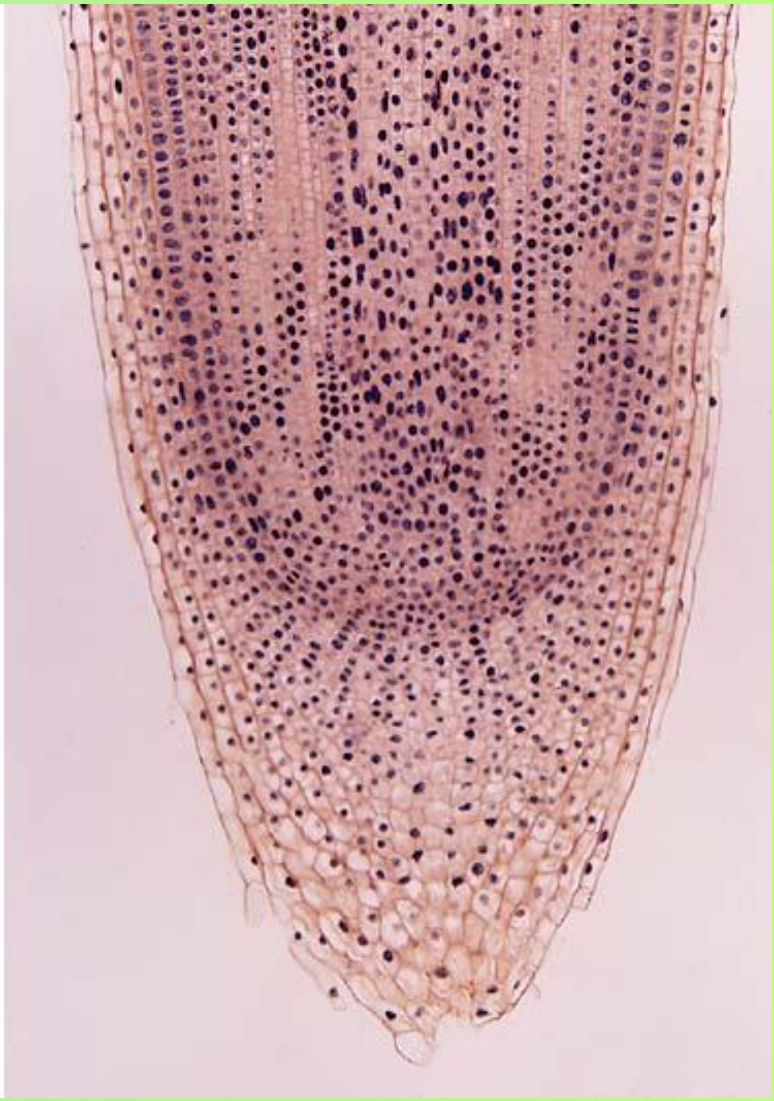
Growth in Plants

- Specific regions of growth: meristems
  - stem cells: perpetually embryonic tissue
  - regenerate new cells
    - apical shoot meristem
      - growth in length
      - primary growth
    - apical root meristem
      - growth in length
      - primary growth
    - lateral meristem
      - growth in girth
      - secondary growth



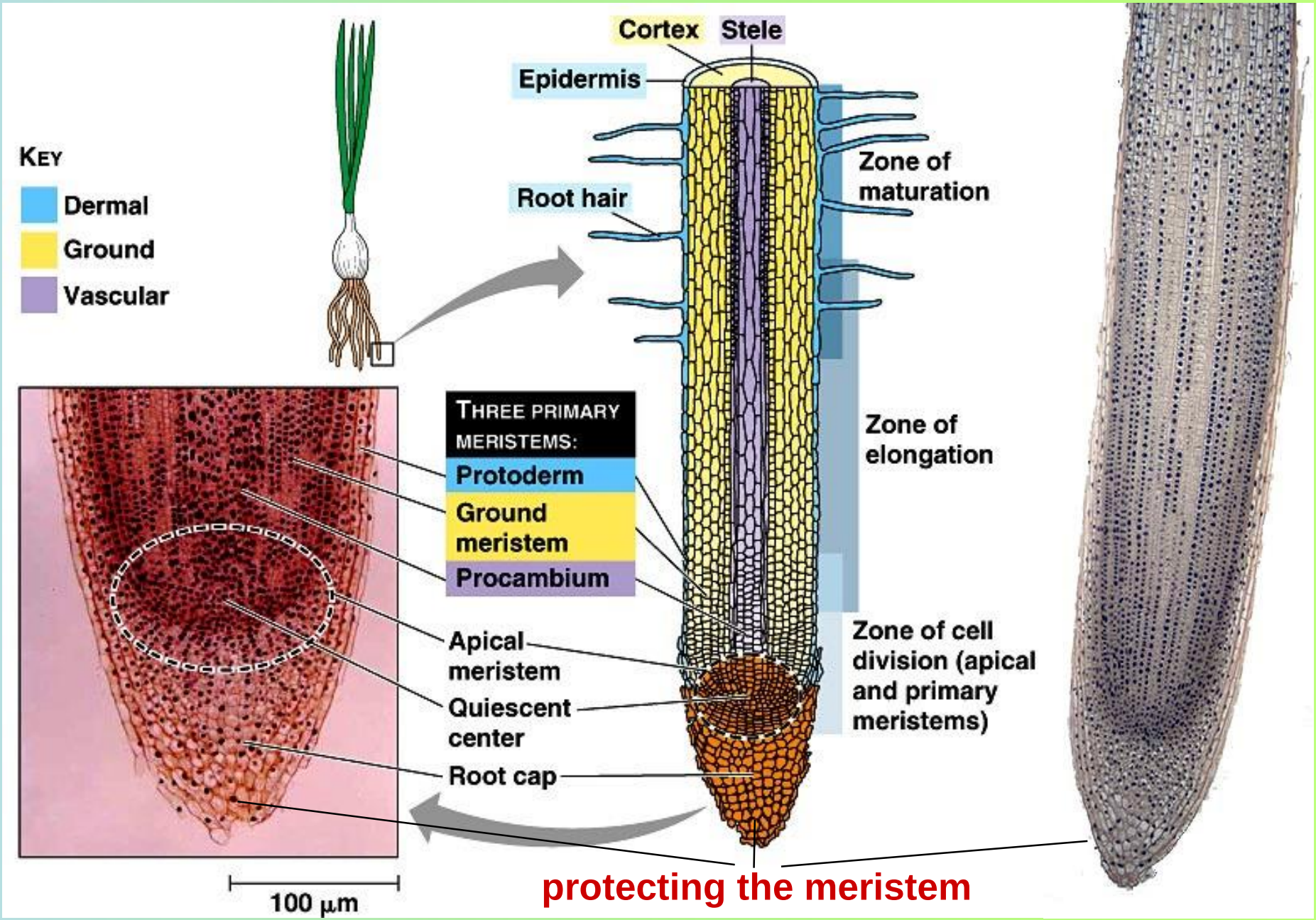
Apical meristems

shoot



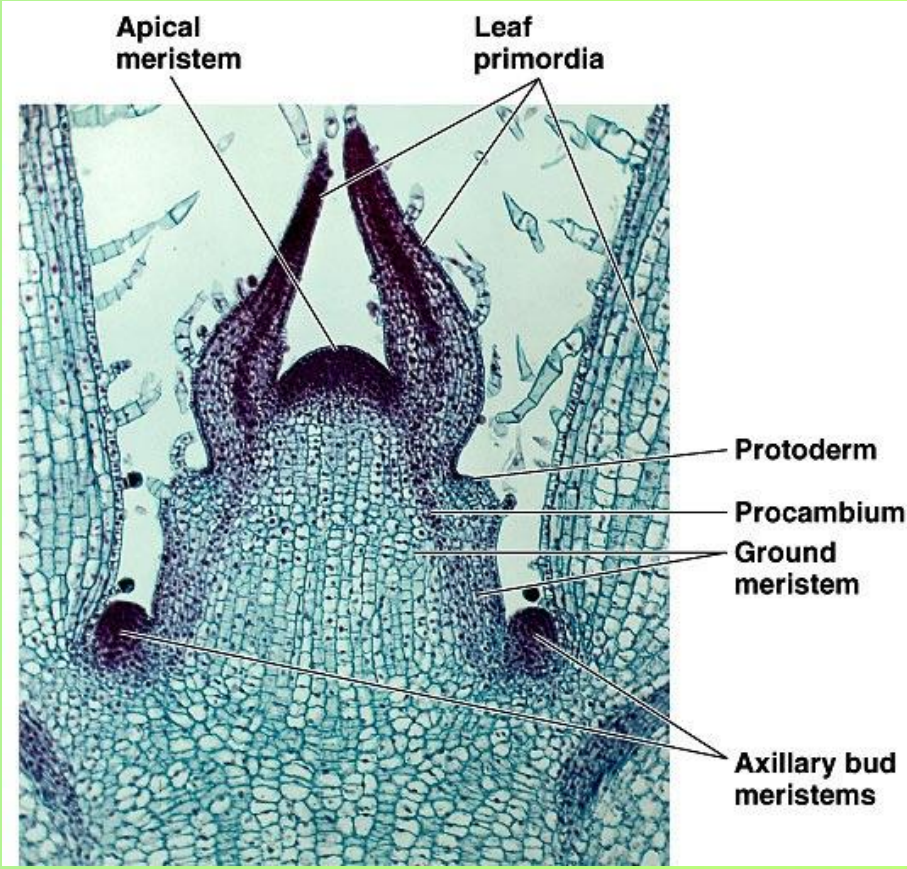
root

Root structure & growth

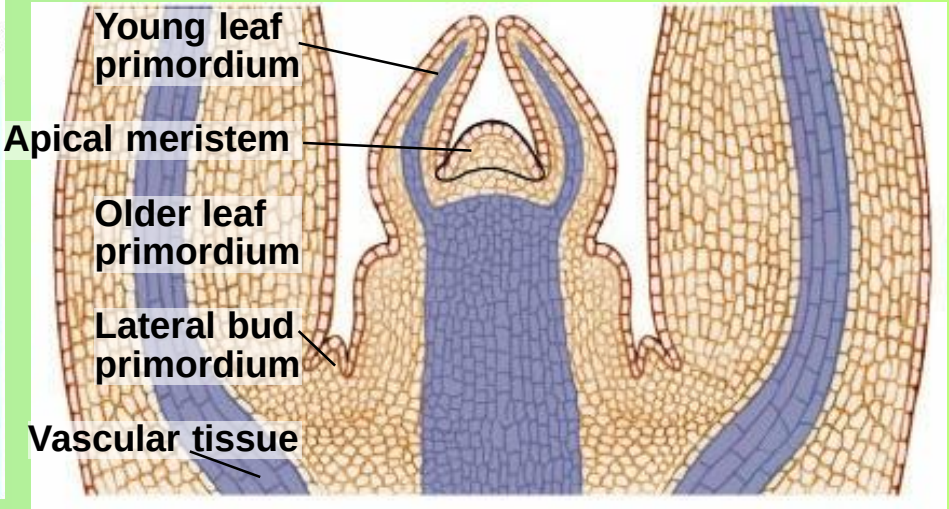


Shoot growth

- Apical bud & primary growth of shoot
  - region of stem growth
  - axillary buds
    - "waiting in the wings"

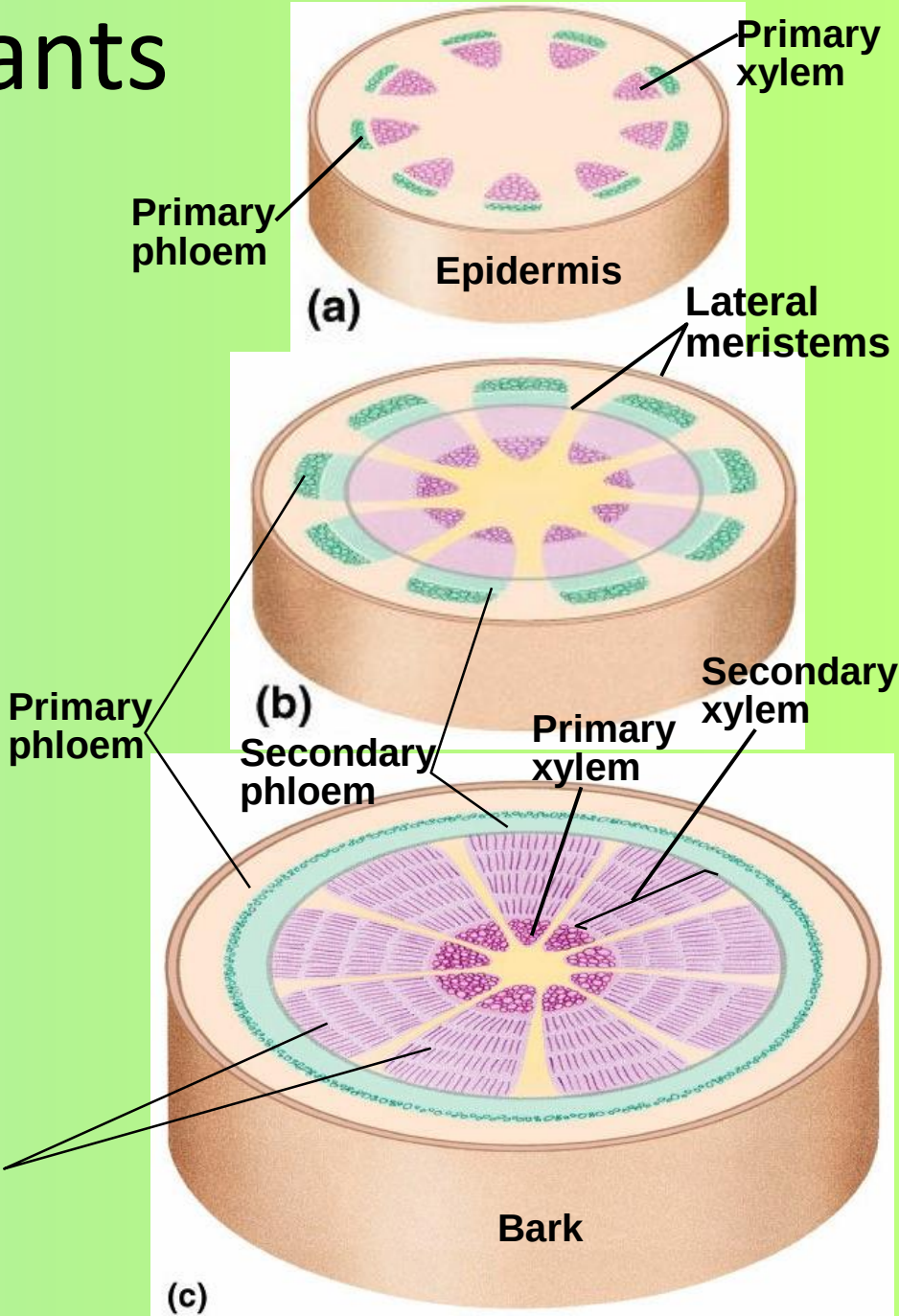


protecting the meristem

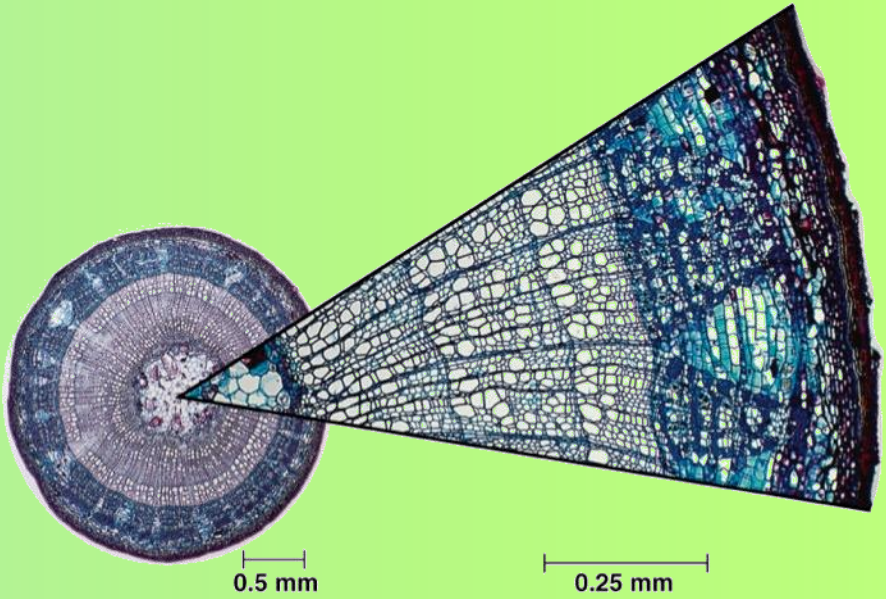


Growth in woody plants

- Woody plants grow in height from tip
  - primary growth
  - apical meristem
- Woody plants grow in diameter from sides
  - secondary growth
  - lateral meristems
    - vascular cambium
      - makes 2° phloem & 2° xylem
    - cork cambium
      - makes bark



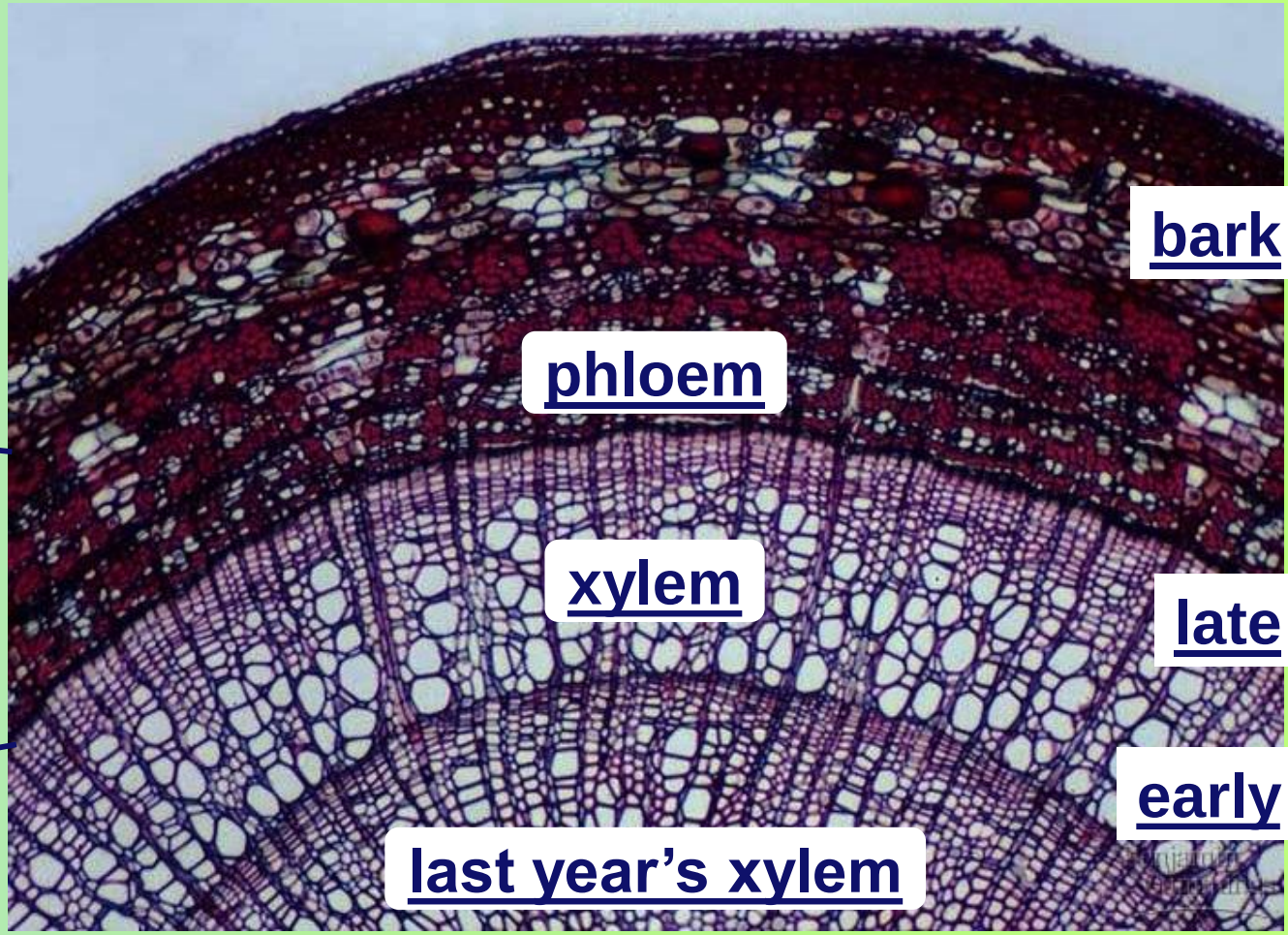
Secondary growth



- Secondary growth
  - growth in diameter
    - thickens & strengthens older part of tree
  - cork cambium makes bark
    - growing ring around tree
  - vascular cambium makes xylem & phloem
    - growing ring around tree

Vascular cambium

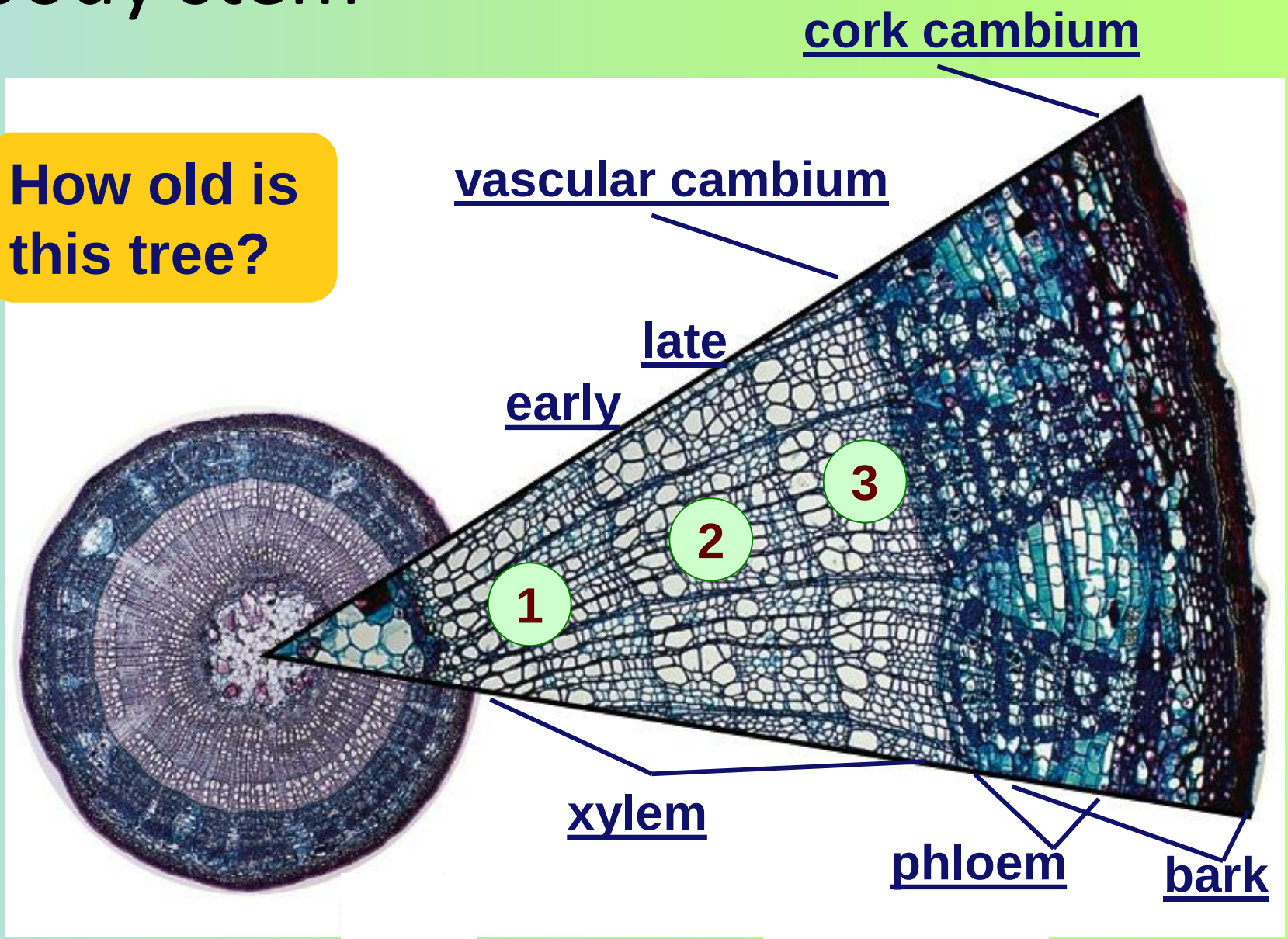
- Phloem produced to the outside
- Xylem produced to the inside



cork cambium

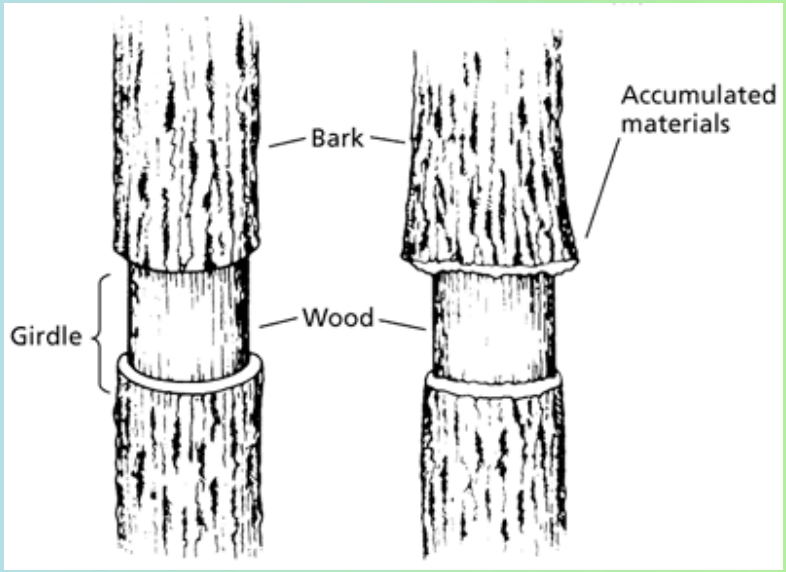
vascular cambium

Woody stem

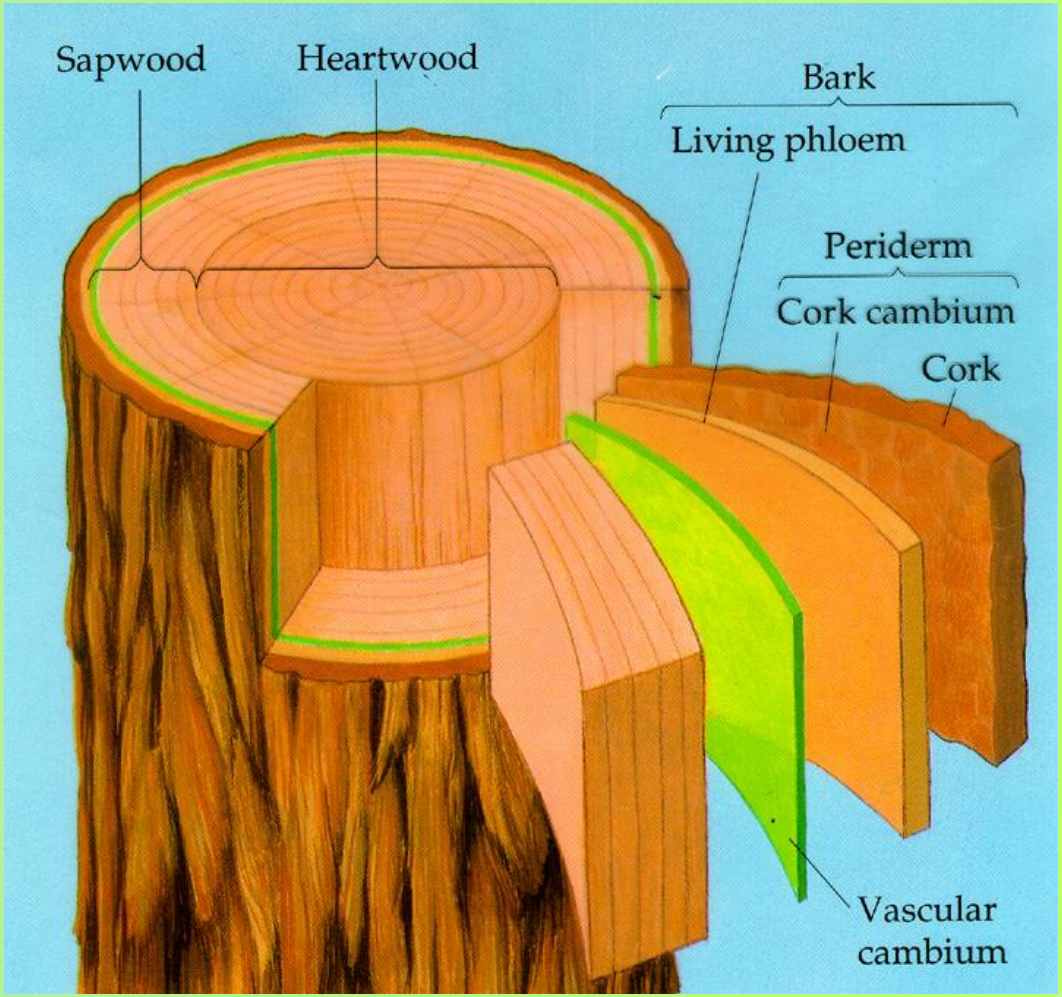


How old is this tree?

Tree trunk anatomy



tree girdling

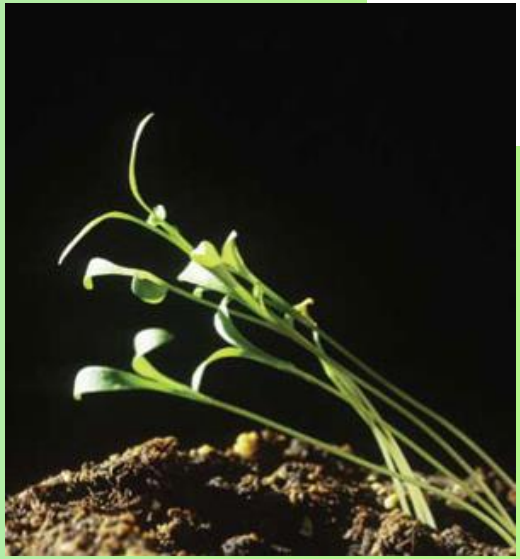


What does girdling do to a tree?

Where will the carving be in 50 years?

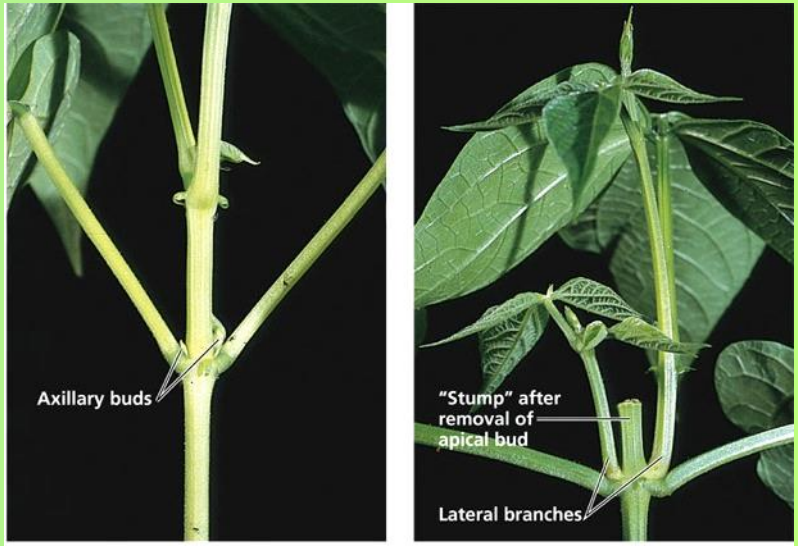
Plant hormones

- auxin
- gibberellins
- abscisic acid
- ethylene
- and more…

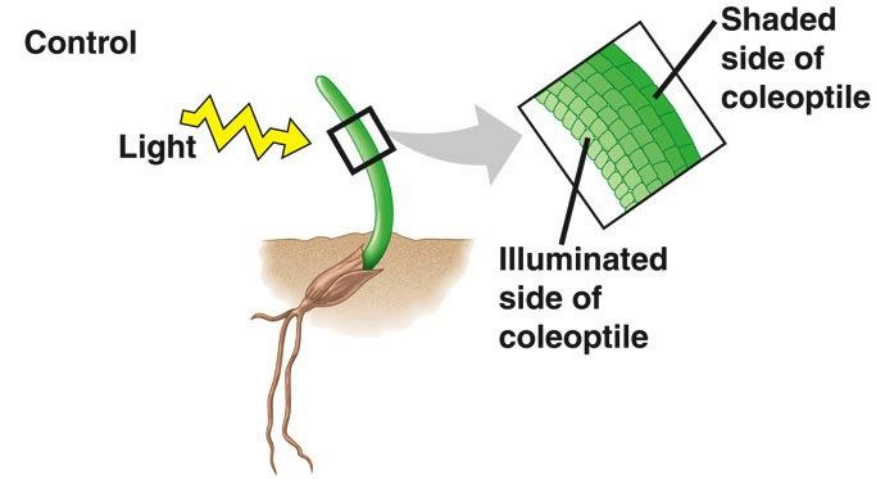


Auxin (IAA)

- Effects
  - controls cell division & differentiation
  - phototropism
    - growth towards light
    - asymmetrical distribution of auxin
    - cells on darker side elongate faster than cells on brighter side
  - apical dominance



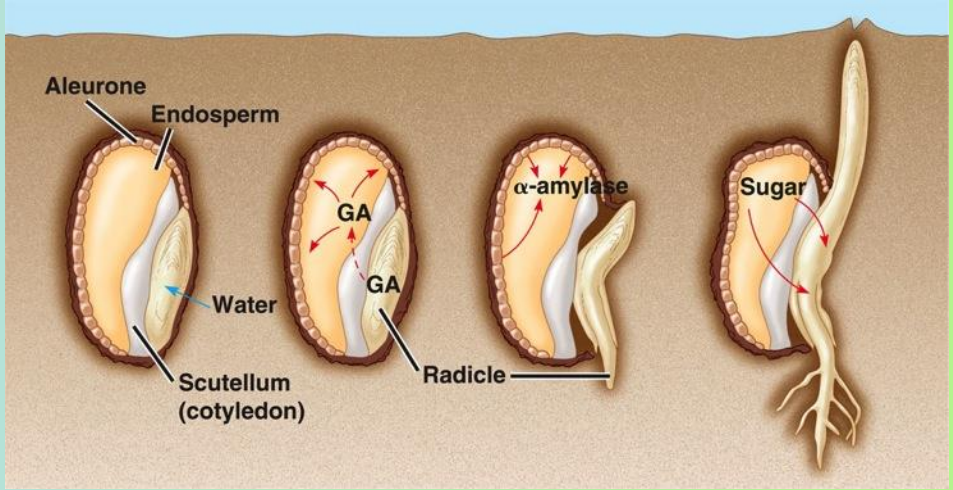
(a) Intact plant (b) Plant with apical bud removed



Gibberellins

- Family of hormones
  - over 100 different gibberellins identified
- Effects
  - stem elongation
  - fruit growth
  - seed germination

plump grapes in grocery stores have been treated with gibberellin hormones while on the vine

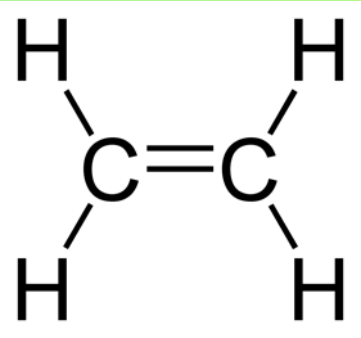


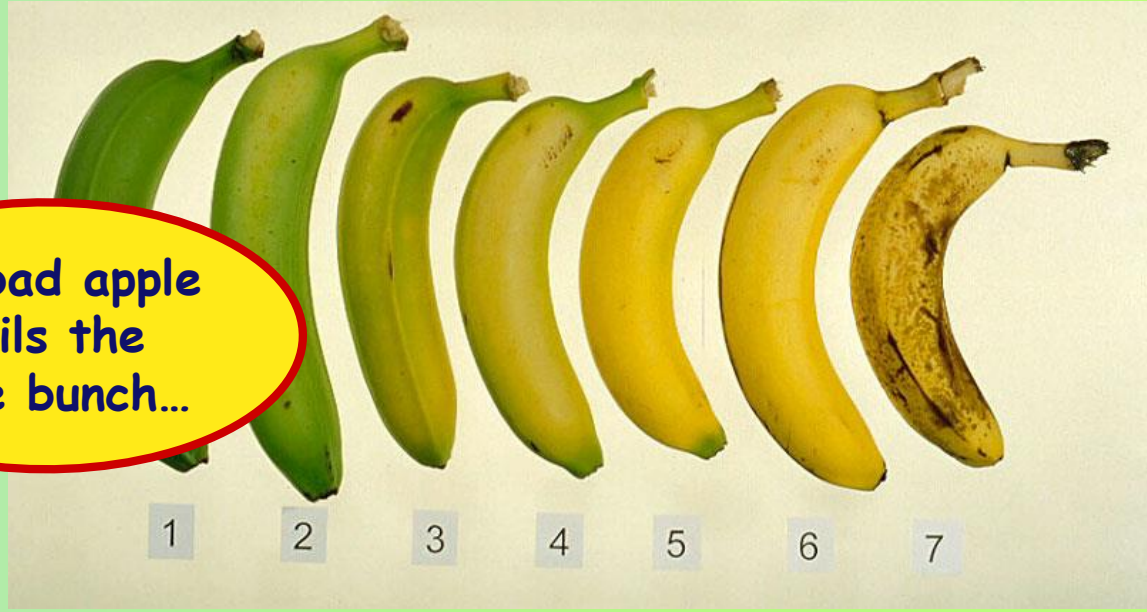
Abscisic acid (ABA)

- Effects
  - slows growth
  - seed dormancy
    - high concentrations of abscisic acid
      - germination only after ABA is inactivated or leeched out
    - survival value:
      seed will germinate only
      under optimal conditions
      - light, temperature, moisture

Ethylene

- Hormone gas released by plant cells
- Effects
  - fruit ripening
  - leaf drop
    - like in Autumn
    - apoptosis





Fruit ripening

- Adaptation
  - hard, tart fruit protects developing seed from herbivores
  - ripe, sweet, soft fruit attracts animals to disperse seed
- Mechanism
  - triggers ripening process
    - breakdown of cell wall
      - softening
    - conversion of starch to sugar
      - sweetening
  - positive feedback system
    - ethylene triggers ripening
    - ripening stimulates more ethylene production

Apoptosis in plants

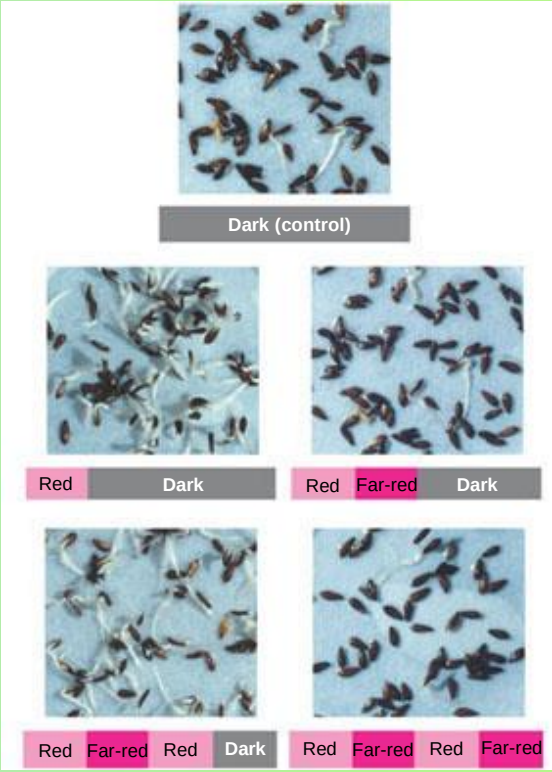
- Many events in plants involve apoptosis
  - response to hormones
    - ethylene
    - auxin
  - death of annual plant after flowering
    - senescence
  - differentiation of xylem vessels
    - loss of cytoplasm
  - shedding of autumn leaves

What is the evolutionary advantage of loss of leaves in autumn?

How does the order of red and far-red illumination affect seed germination?

EXPERIMENT During the 1930s, USDA scientists briefly exposed batches of lettuce seeds to red light or far-red light to test the effects on germination. After the light exposure, the seeds were placed in the dark, and the results were compared with control seeds that were not exposed to light.

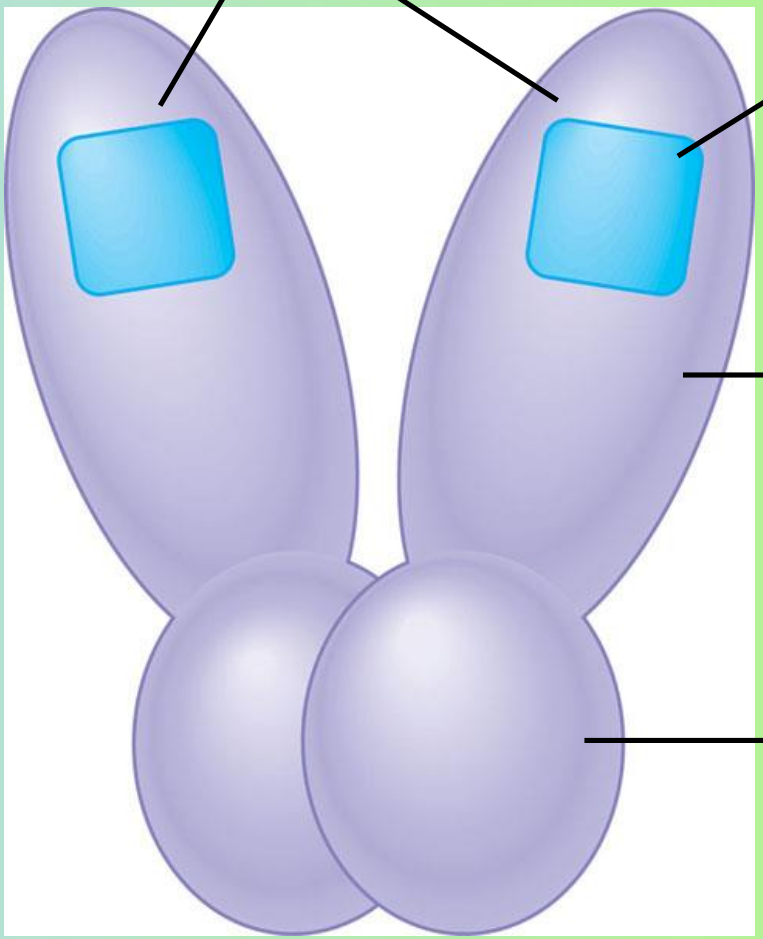
RESULTS The bar below each photo indicates the sequence of red-light exposure, far-red light exposure, and darkness. The germination rate increased greatly in groups of seeds that were last exposed to red light (left). Germination was inhibited in groups of seeds that were last exposed to far-red light (right).



CONCLUSION Red light stimulated germination, and far-red light inhibited germination. The final exposure was the determining factor. The effects of red and far-red light were reversible.

Structure of a phytochrome

A phytochrome consists of two identical proteins joined to form one functional molecule. Each of these proteins has two domains.

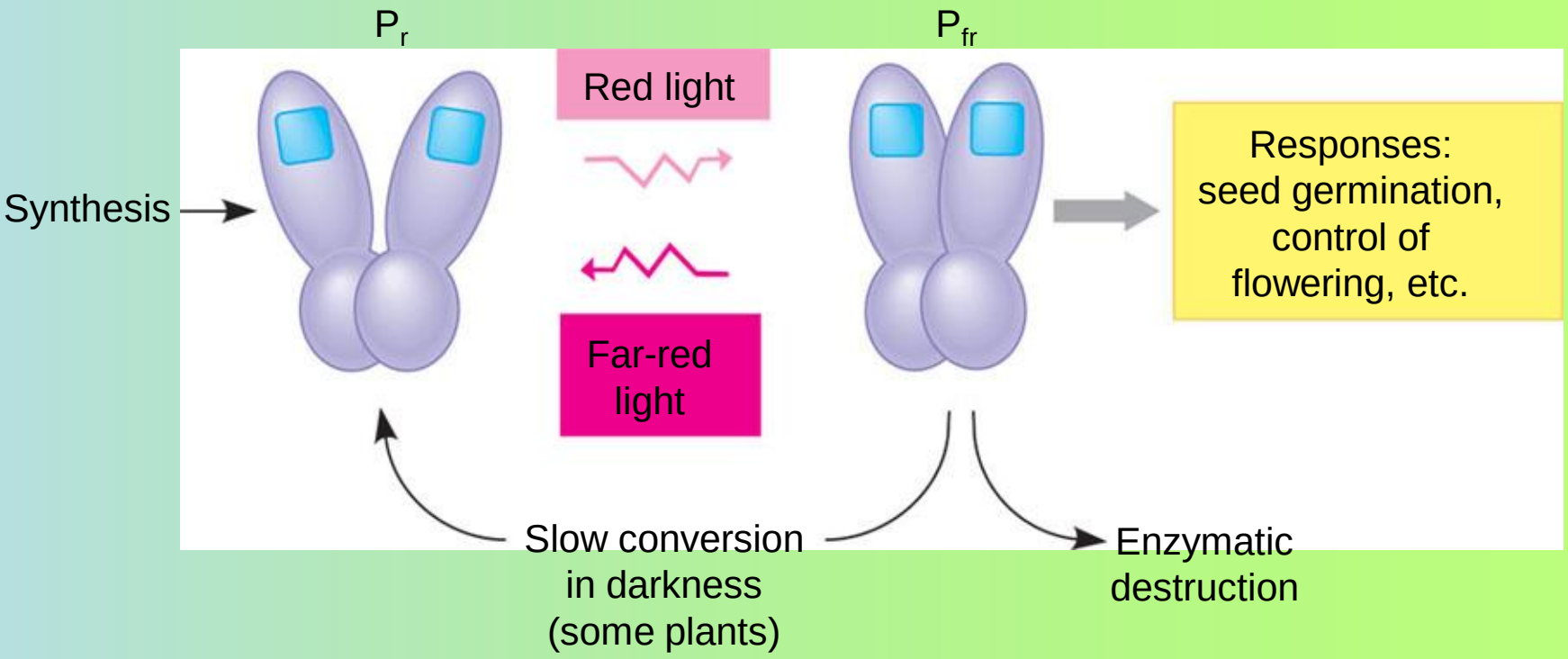


Chromophore

Photoreceptor activity. One domain, which functions as the photoreceptor, is covalently bonded to a nonprotein pigment, or chromophore.

Kinase activity. The other domain has protein kinase activity. The photoreceptor domains interact with the kinase domains to link light reception to cellular responses triggered by the kinase.

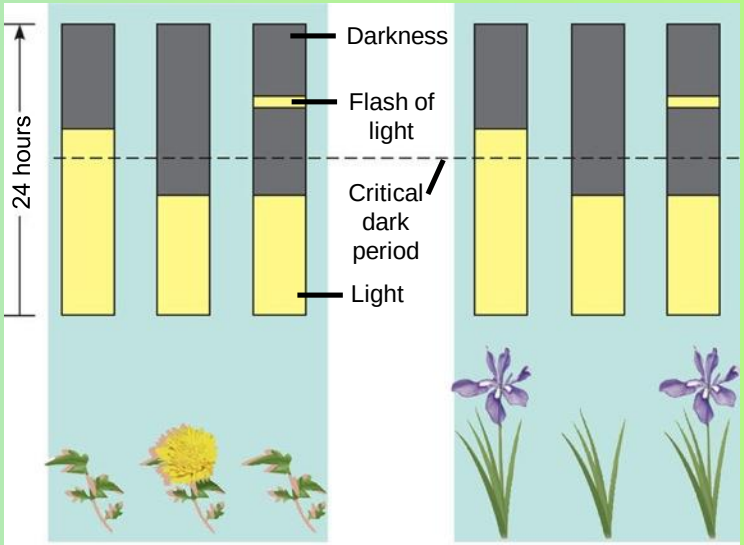
Phytochrome: a molecular switching mechanism



How does interrupting the dark period with a brief exposure to light affect flowering?

EXPERIMENT During the 1940s, researchers conducted experiments in which periods of darkness were interrupted with brief exposure to light to test how the light and dark portions of a photoperiod affected flowering in "short-day" and "long-day" plants.

RESULTS



(a) "Short-day" plants flowered only if a period of continuous darkness was *longer* than a critical dark period for that particular species (13 hours in this example). A period of darkness can be ended by a brief exposure to light.

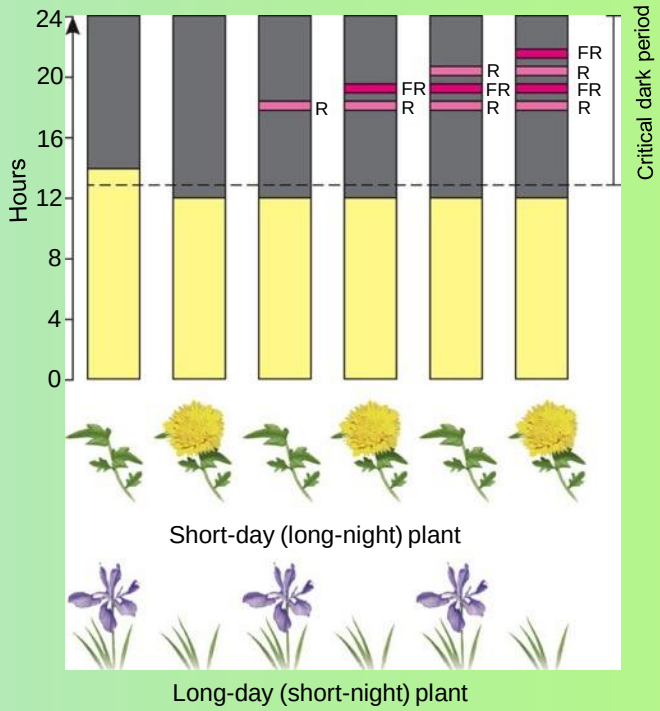
(b) "Long-day" plants flowered only if a period of continuous darkness was *shorter* than a critical dark period for that particular species (13 hours in this example).

CONCLUSION The experiments indicated that flowering of each species was determined by a critical period of *darkness* ("critical night length") for that species, *not* by a specific period of light. Therefore, "short-day" plants are more properly called "long-night" plants, and "long-day" plants are really "short-night" plants.

Is phytochrome the pigment that measures the interruption of dark periods in photoperiodic response?

EXPERIMENT A unique characteristic of phytochrome is reversibility in response to red and far-red light. To test whether phytochrome is the pigment measuring interruption of dark periods, researchers observed how flashes of red light and far-red light affected flowering in “short-day” and “long-day” plants.

RESULTS



CONCLUSION A flash of red light shortened the dark period. A subsequent flash of far-red light canceled the red light’s effect. If a red flash followed a far-red flash, the effect of the far-red light was canceled. This reversibility indicated that it is phytochrome that measures the interruption of dark periods.

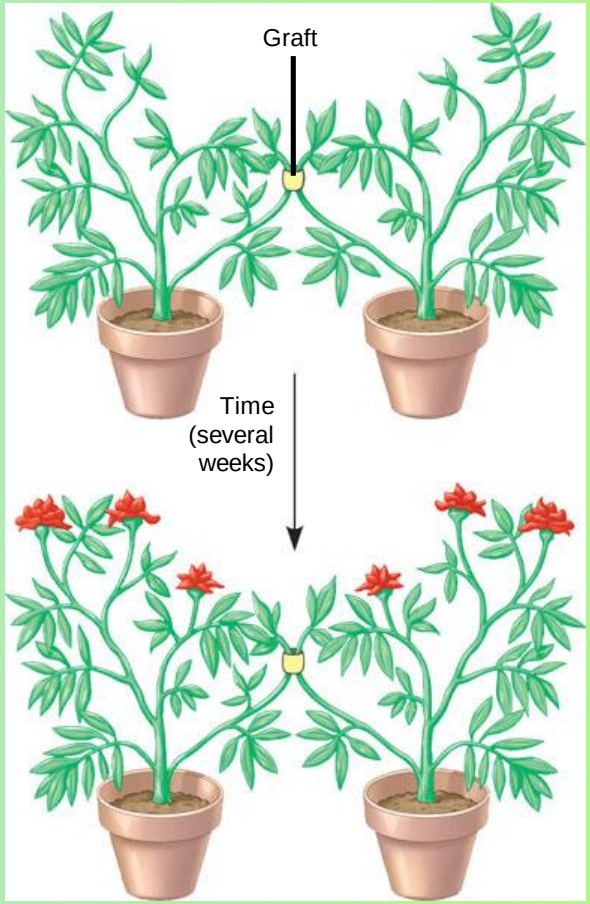
Is there a flowering hormone?

EXPERIMENT To test whether there is a flowering hormone, researchers conducted an experiment in which a plant that had been induced to flower by photoperiod was grafted to a plant that had not been induced.

RESULTS

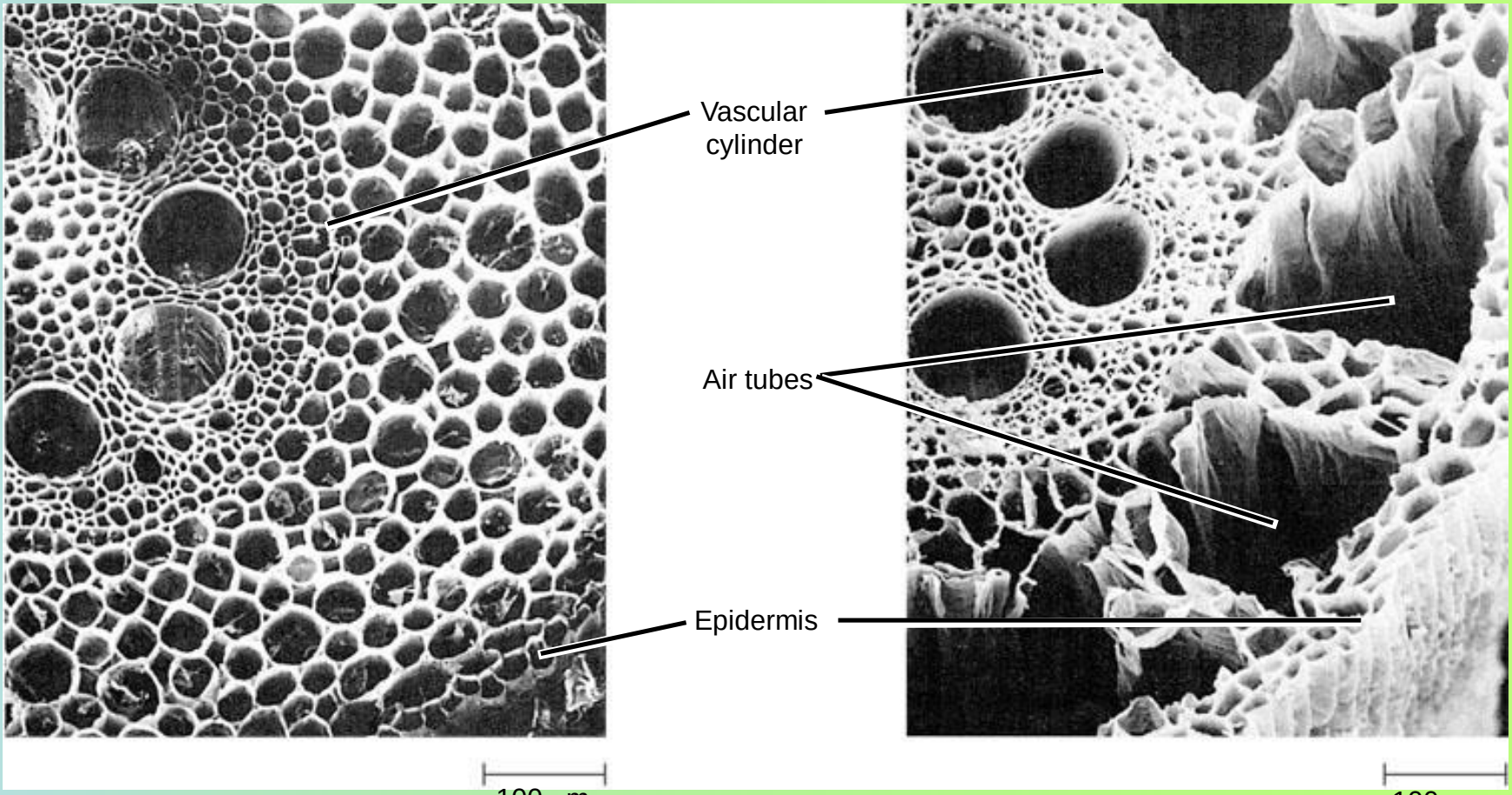
Plant subjected to photoperiod that induces flowering

Plant subjected to photoperiod that does not induce flowering



CONCLUSION Both plants flowered, indicating the transmission of a flower-inducing substance. In some cases, the transmission worked even if one was a short-day plant and the other was a long-day plant.

A developmental response of maize roots to flooding and oxygen deprivation



(a) Control root (aerated)

(b) Experimental root (nonaerated)

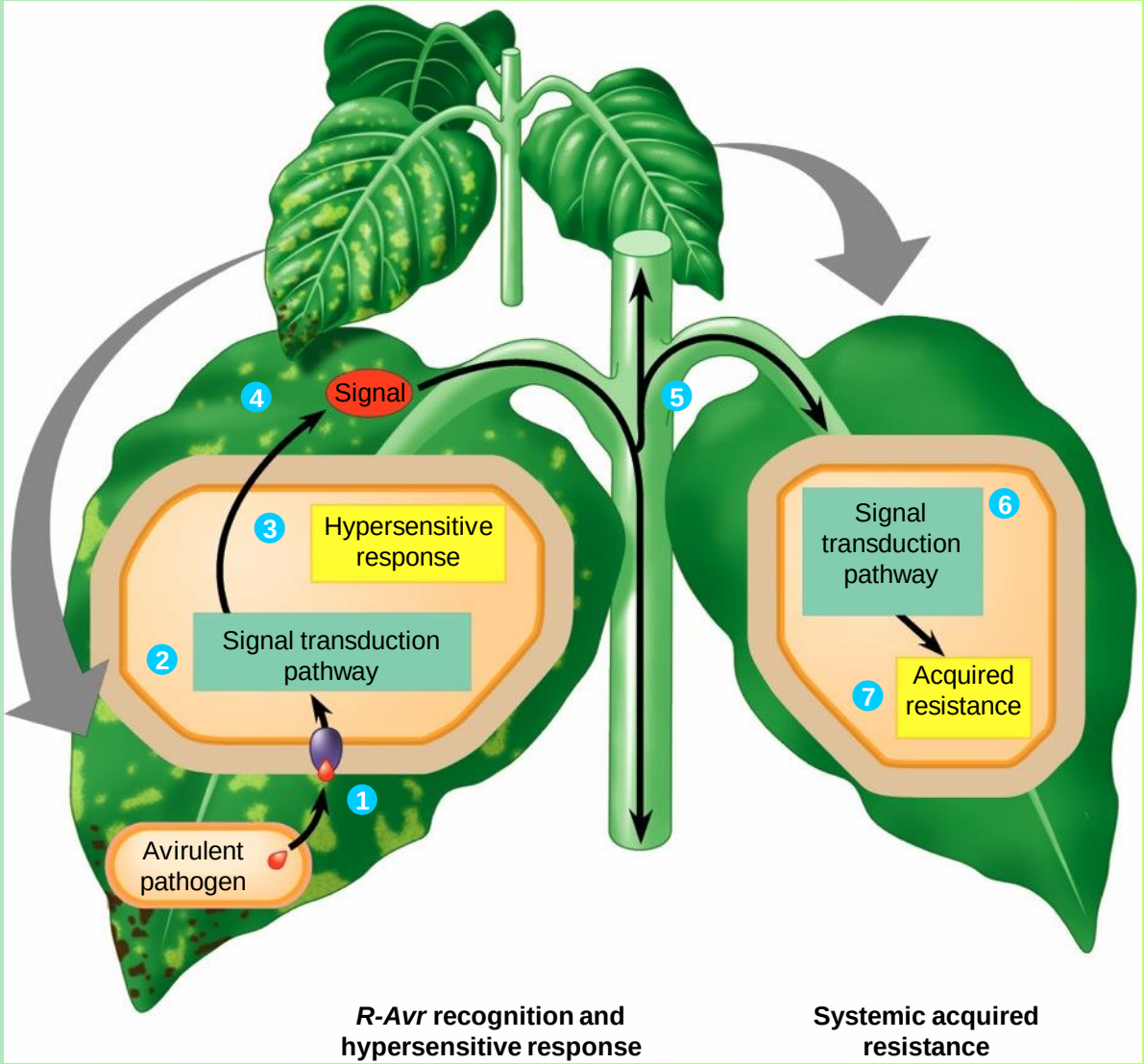
Defense responses against an avirulent pathogen

4 Before they die, infected cells release a chemical signal, probably salicylic acid.

3 In a hypersensitive response (HR), plant cells produce anti-microbial molecules, seal off infected areas by modifying their walls, and then destroy themselves. This localized response produces lesions and protects other parts of an infected leaf.

2 This identification step triggers a signal transduction pathway.

1 Specific resistance is based on the binding of ligands from the pathogen to receptors in plant cells.

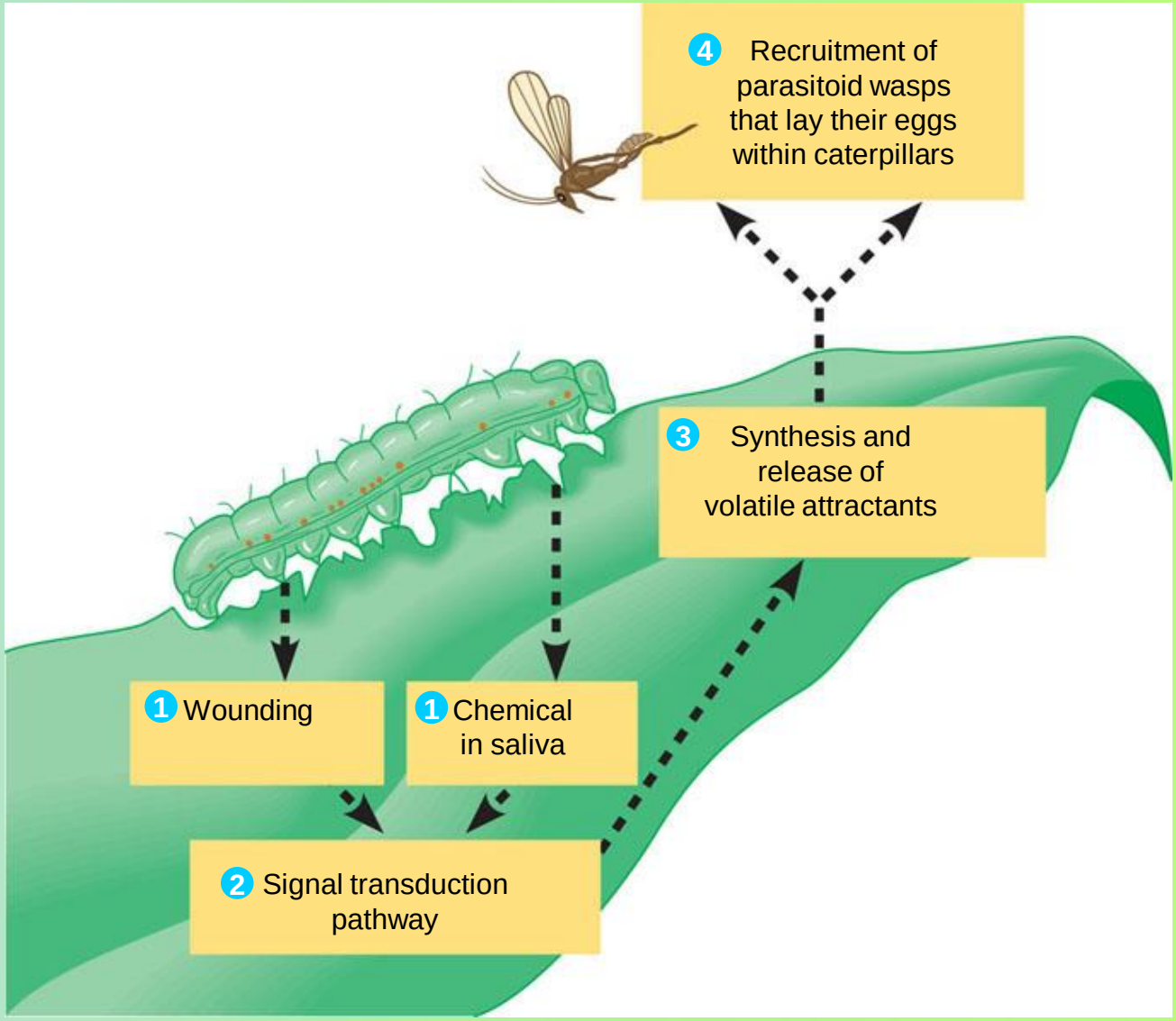


5 The signal is distributed to the rest of the plant.

6 In cells remote from the infection site, the chemical initiates a signal transduction pathway.

7 Systemic acquired resistance is activated: the production of molecules that help protect the cell against a diversity of pathogens for several days.

A maize leaf “recruits” a parasitoid wasp as a defensive response to an herbivore, an army-worm caterpillar



Don’t take this lying down…

Ask Questions*!!*

Review Questions

1. What is one result of an organism having meristems?
   A. a rapid change from juvenile to adult state
   B. a seasonal change in leaf morphology
   C. a rapid change from a vegetative state to a reproductive state
   D. indeterminate, life-long growth
   E. production of a fixed number of segments during growth

Pick one of the following choices for each of the following questions:

A. Auxin
B. Gibberellin
C. Ethylene
D. Abscisic Acid
E. Phytochrome

2. Controls the phototropic response in plants
3. Contributes to fruit development
4. Contributes to fruit ripening
5. Contributes to seed dormancy
6. Contributes to flowering