Introduction to Botany

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Lectures 30–31

Outline

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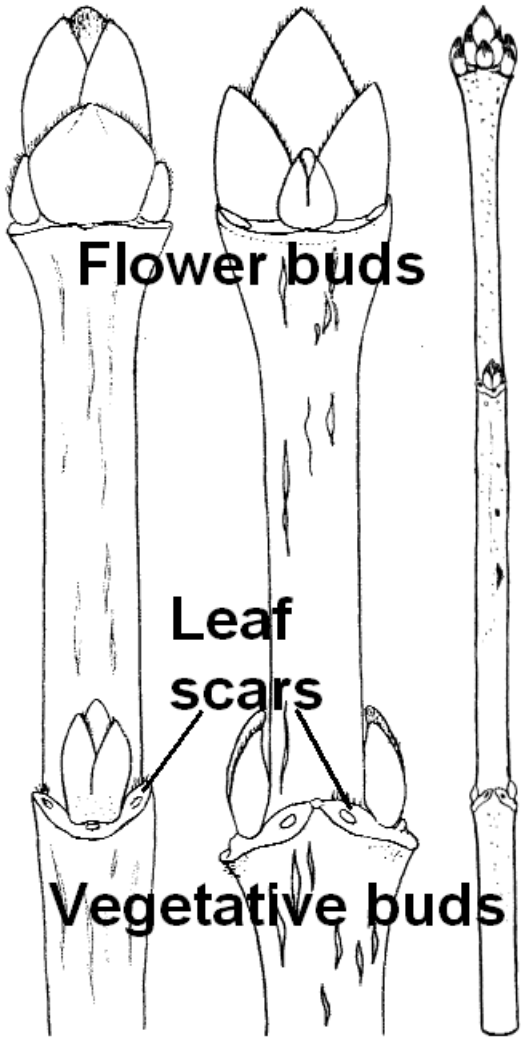
Branching, thickening and the origin of seed

Branching

Where to see branching: winter shoot

A. Vegetative, flower, and mixed buds
B. Leaf and bud scars
C. Leaf traces

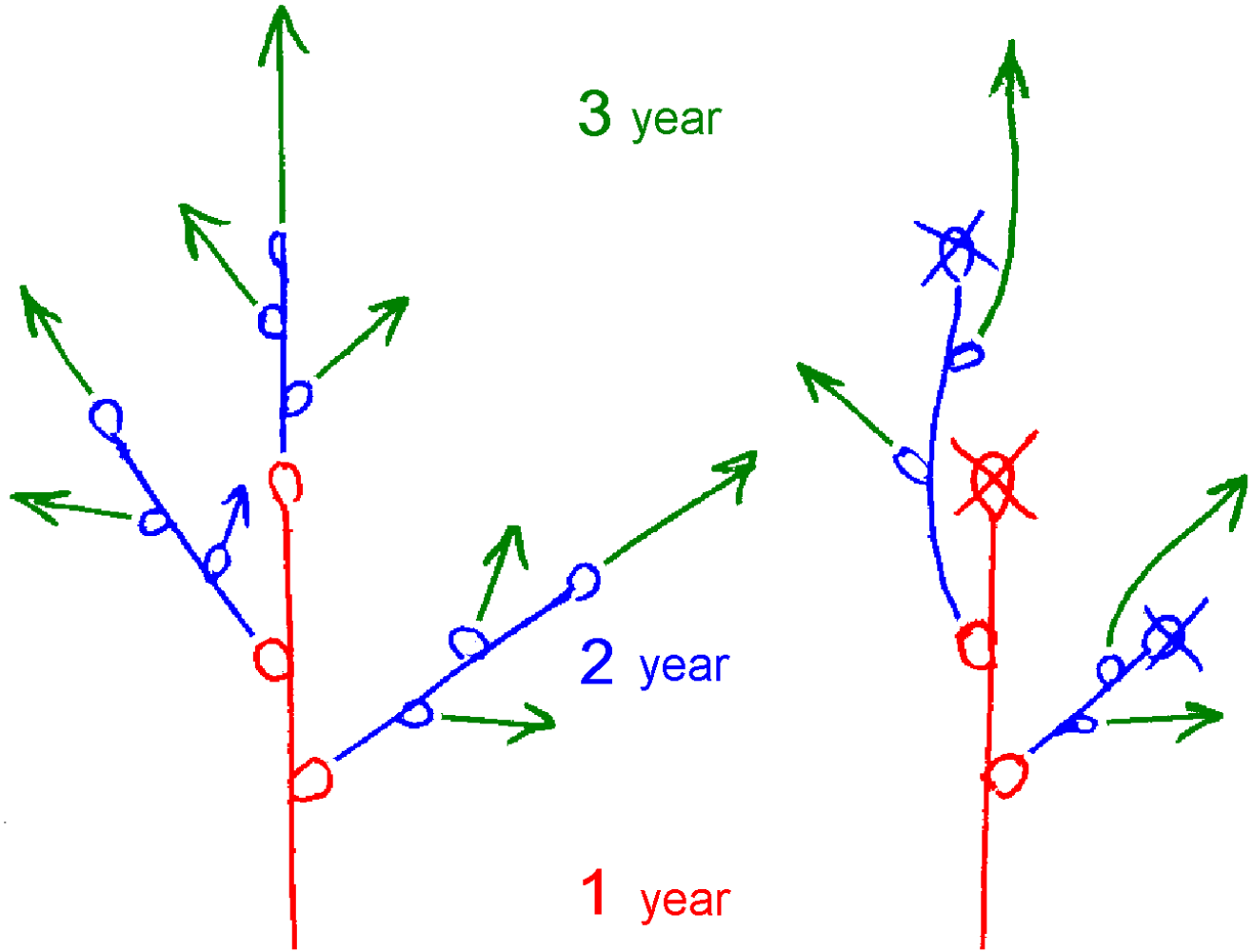
Winter shoot of maple (*Acer platanoides*)



Types of branching

- **Monopodial**: buds do not degrade, all shoots continue to grow
- **Sympodial**: terminal buds degrade, the lateral shoot closest to terminal bud becomes terminal shoot

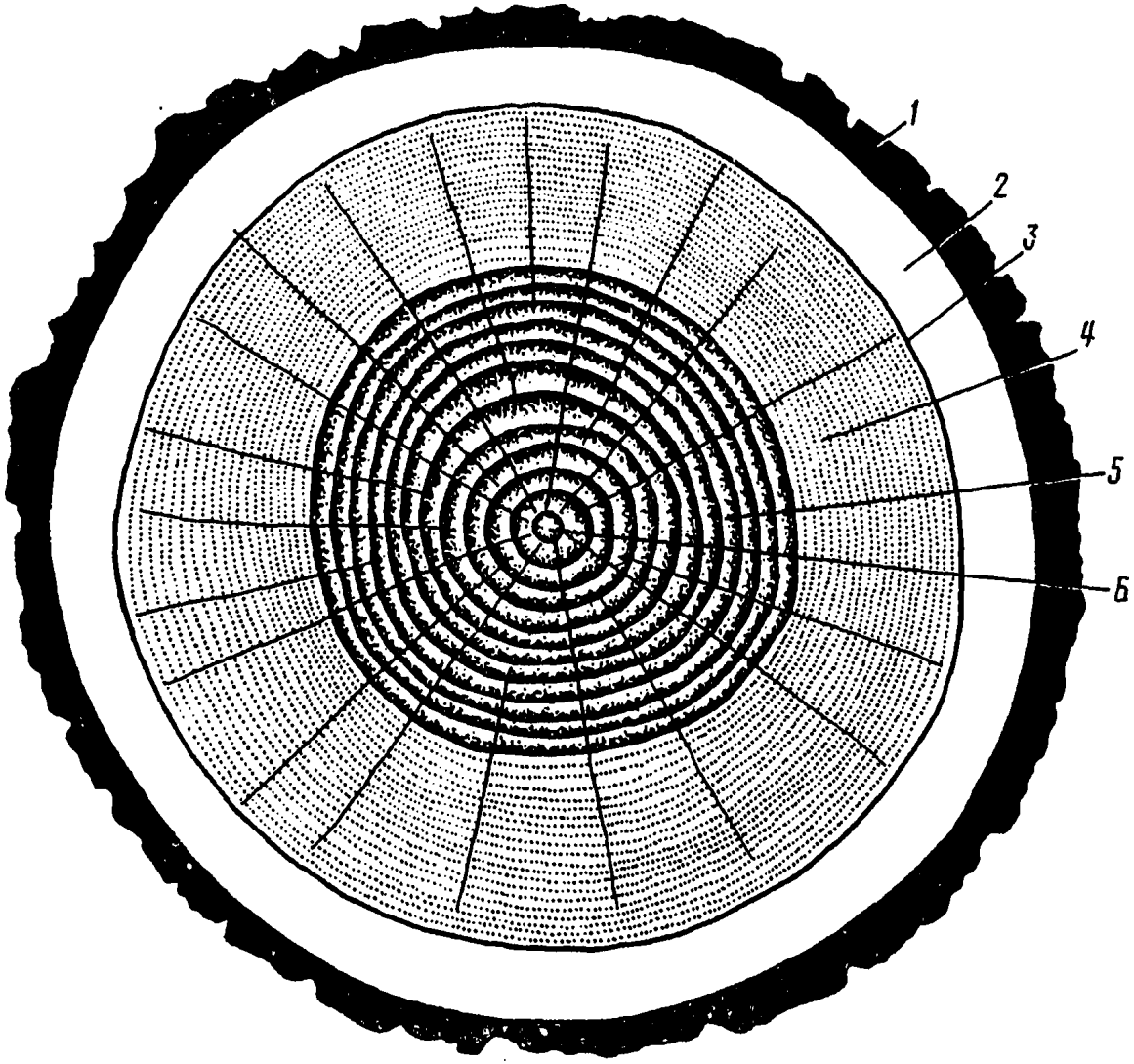
Monopodial (left) and sympodial branching



Branching, thickening and the origin of seed

Secondary stem

Secondary stem = bark + wood



1 cork, 2 bast, $1 + 2 =$ bark, 3 cambium, $4 + 5$ wood, 4 **sapwood**, 5 **heartwood**, 6 pith (if any)

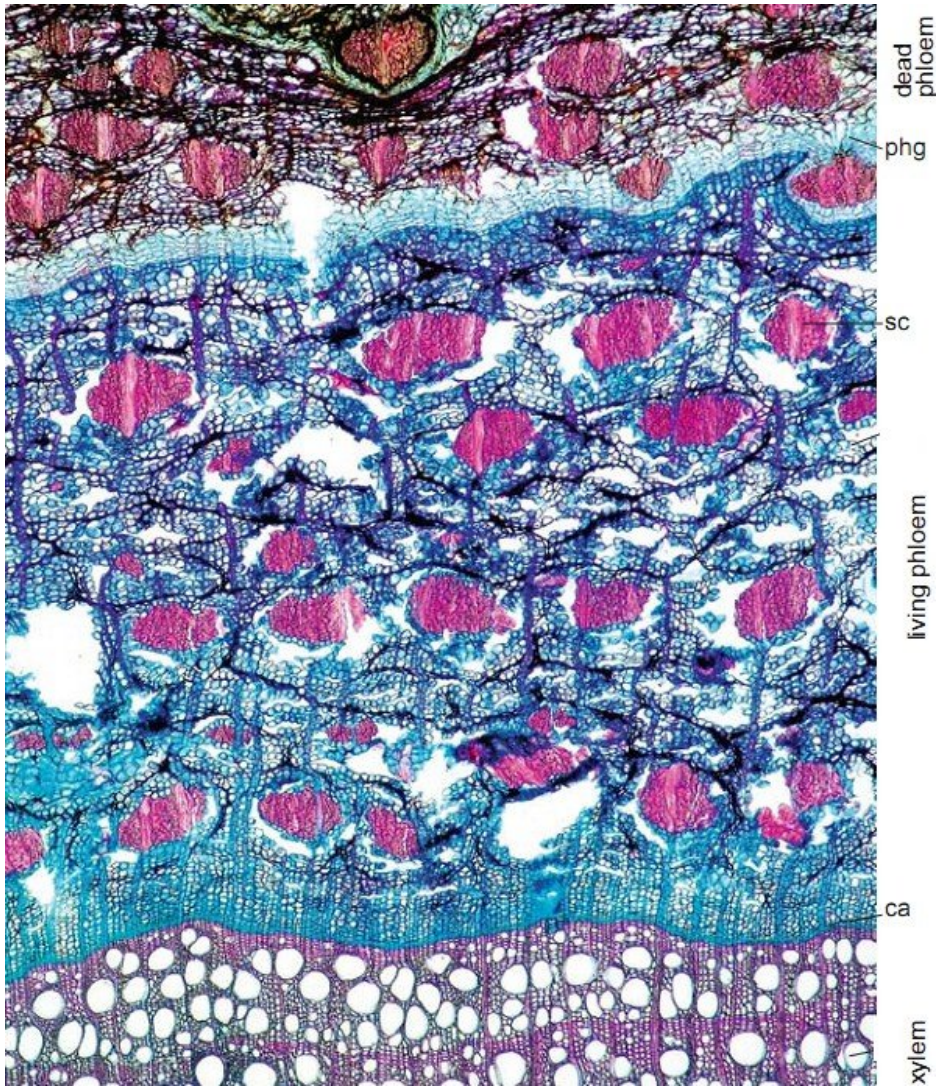
Bark, cork, periderm and wood

- **Bark** is everything outside vascular cambium, i.e. **bark** = secondary phloem + periderm [optionally, also primary phloem, cortex and epidermis]
- **Periderm** = [phelloderm] + cork cambium (phellogen) + phellem (cork)
- **Wood** = trunk − bark, or secondary xylem + [all remnants of central primary tissues]

Cork cambium and origin of bark

- Initially, cork cambium appears in cortex, works some time and then dies out
- Each year new layer of cork cambium appears from parenchyma cells of secondary phloem
- Consequently, bark consists of multiple and mostly uneven layers

Renewal of bark in sea buckthorn (*Hippophaë rhamnoides*)

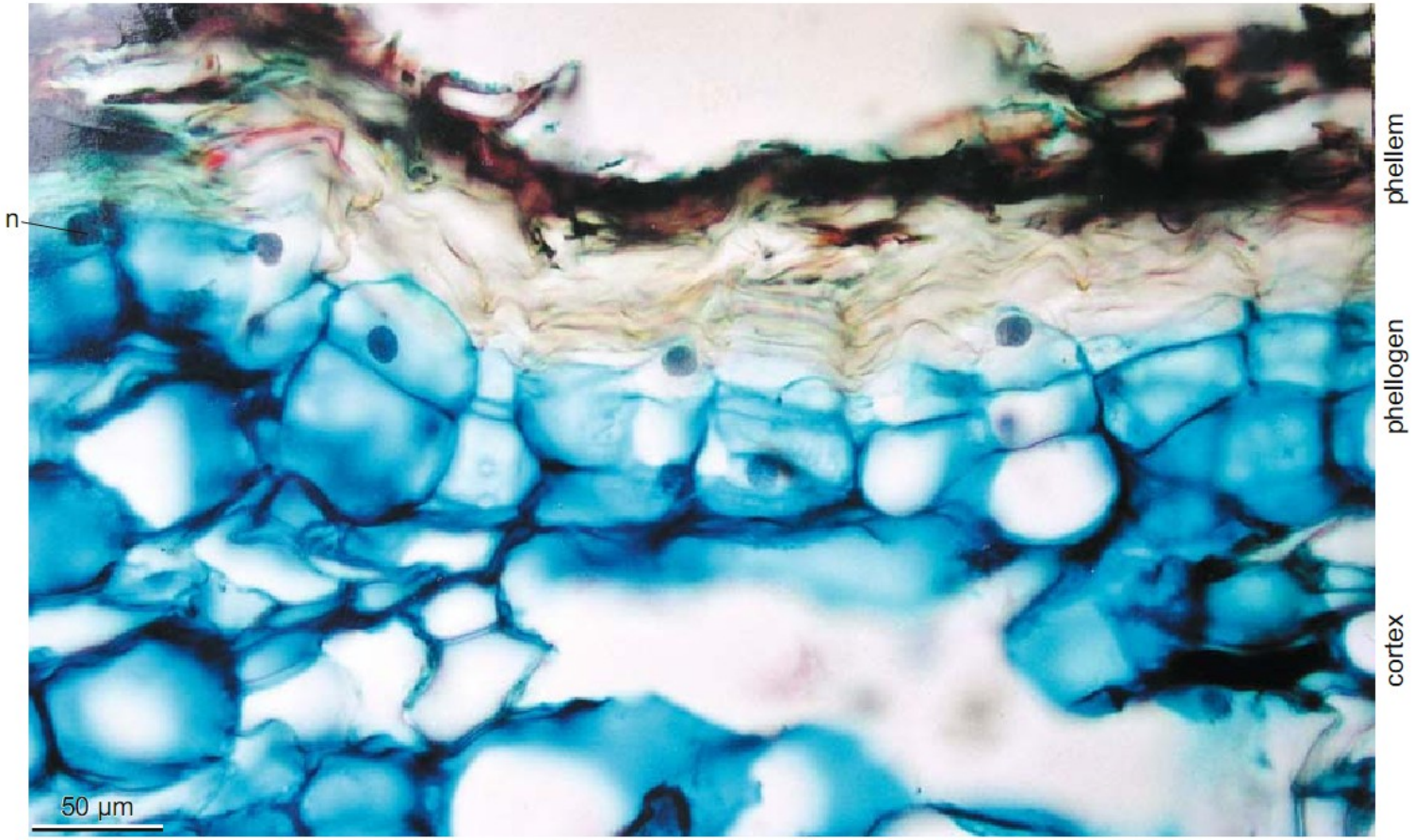


phg phellogen, ca cambium, sc sclerenchyma

Periderm

- Periderm is the product of cork cambium
- 99% of periderm is a **phellem** (cork), thick outside layer
- **Phelloderm** is a tiny layer of living cells inside of cork cambium (phellogen). Phelloderm is sometimes absent.

Formation of periderm zone in medlar (*Mespilus germanica*)



No phelloderm

Lenticels

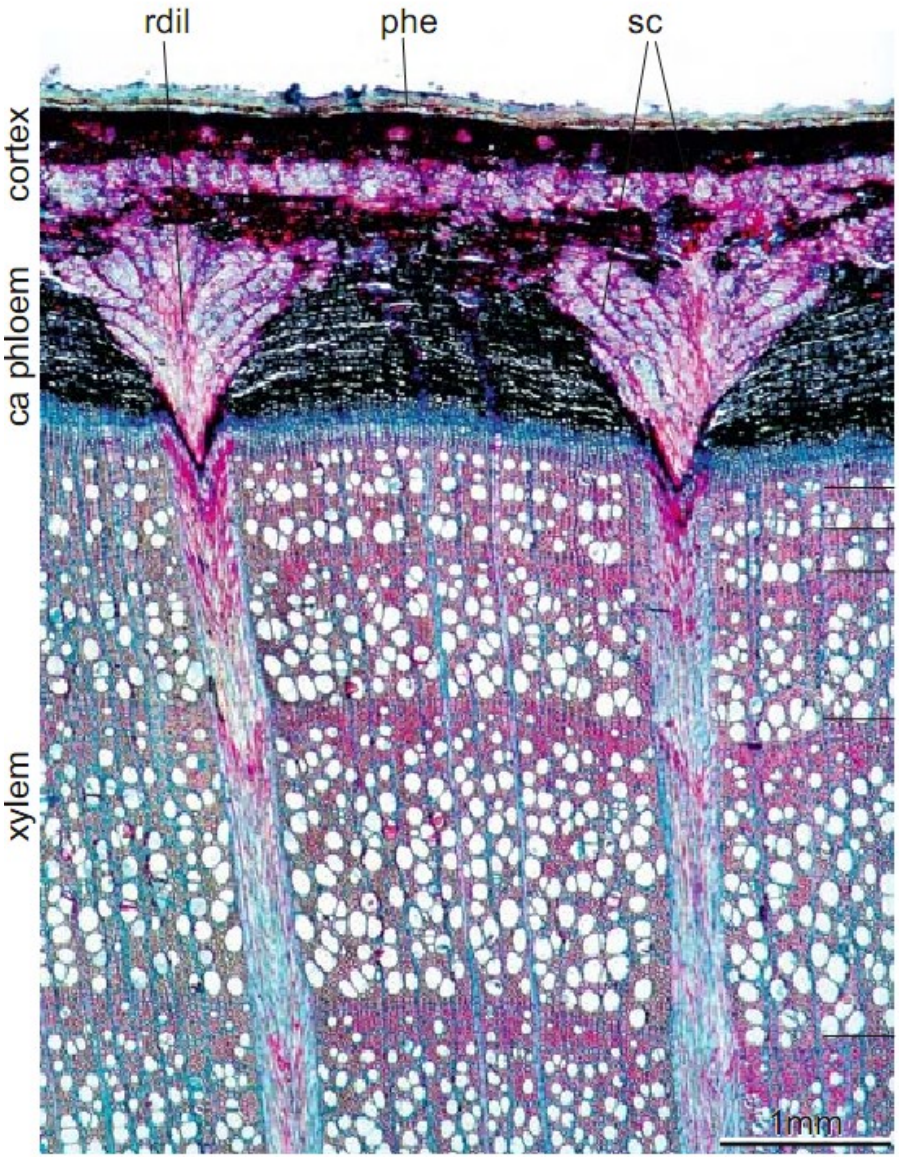
- **Lenticels** are specialized regions of periderm; they supply stem cells with oxygen
- In order to produce lenticel, some cells of cork cambium divide and grow much faster than others

Lenticel of elderberry (*Sambucus* sp.)

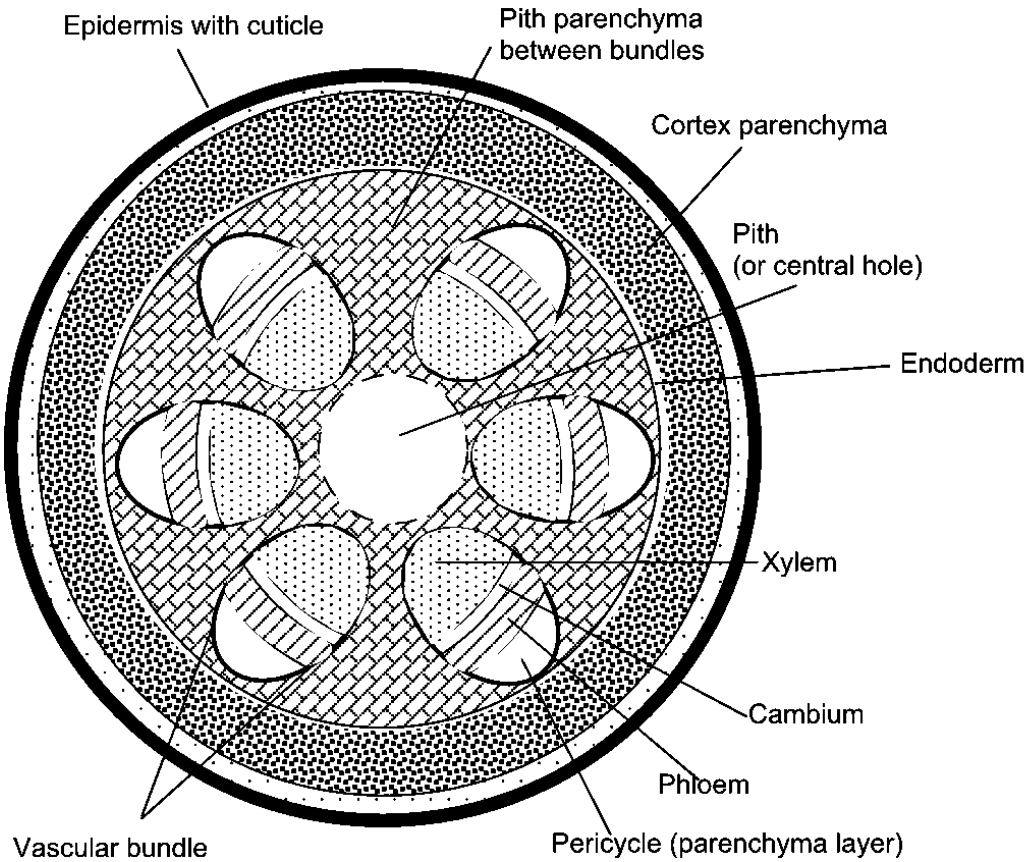
Secondary phloem (bast)

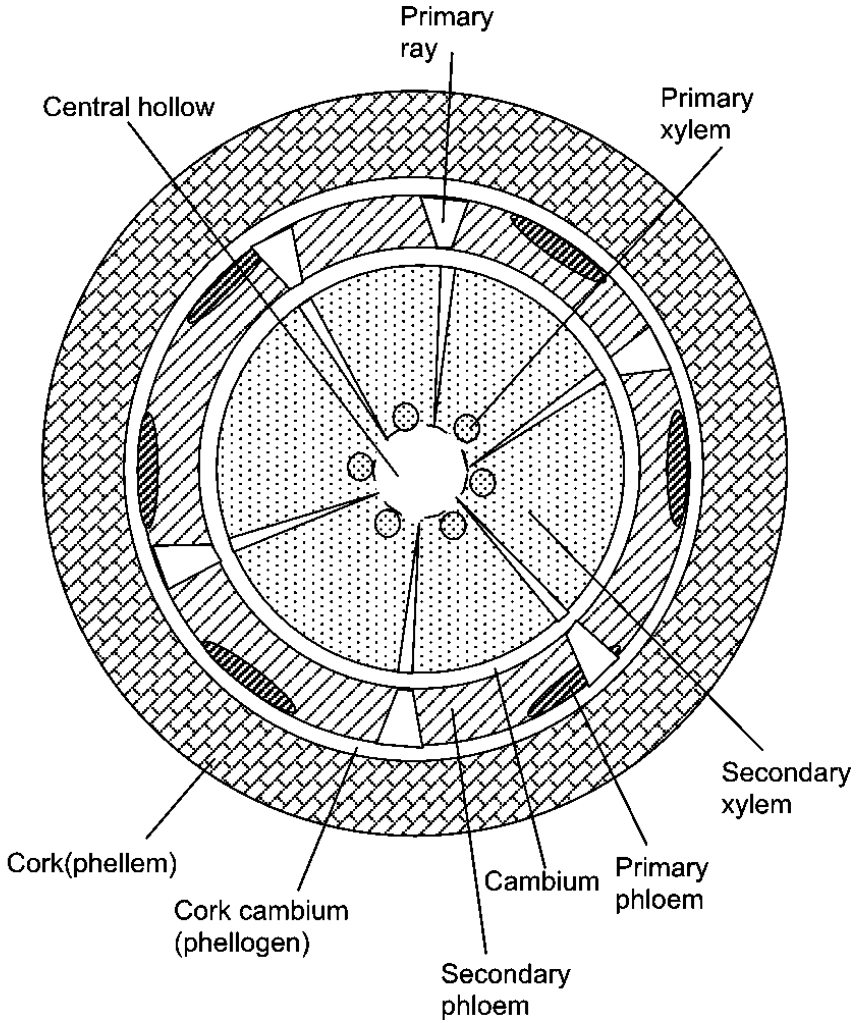
- Forms outside vascular cambium
- Rich of fibers
- Does not form annual rings
- Has rays of parenchyma cells, sometimes wedge-shaped (**dilated**)

Dilated rays in beech (*Fagus* sp.) stem

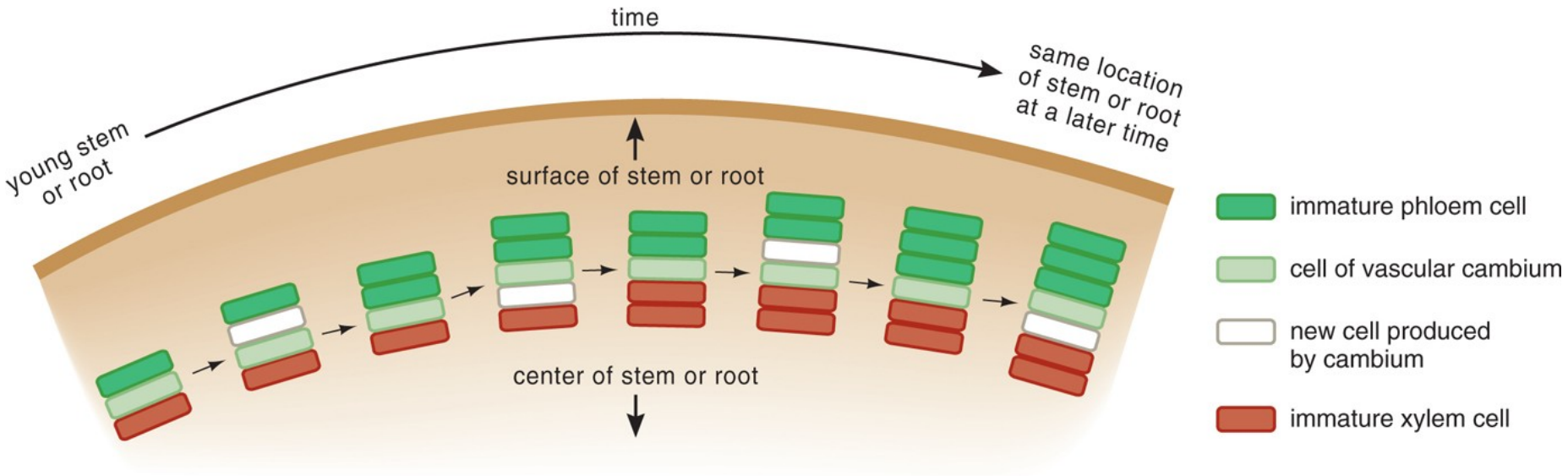


Primary and secondary stems (scheme)

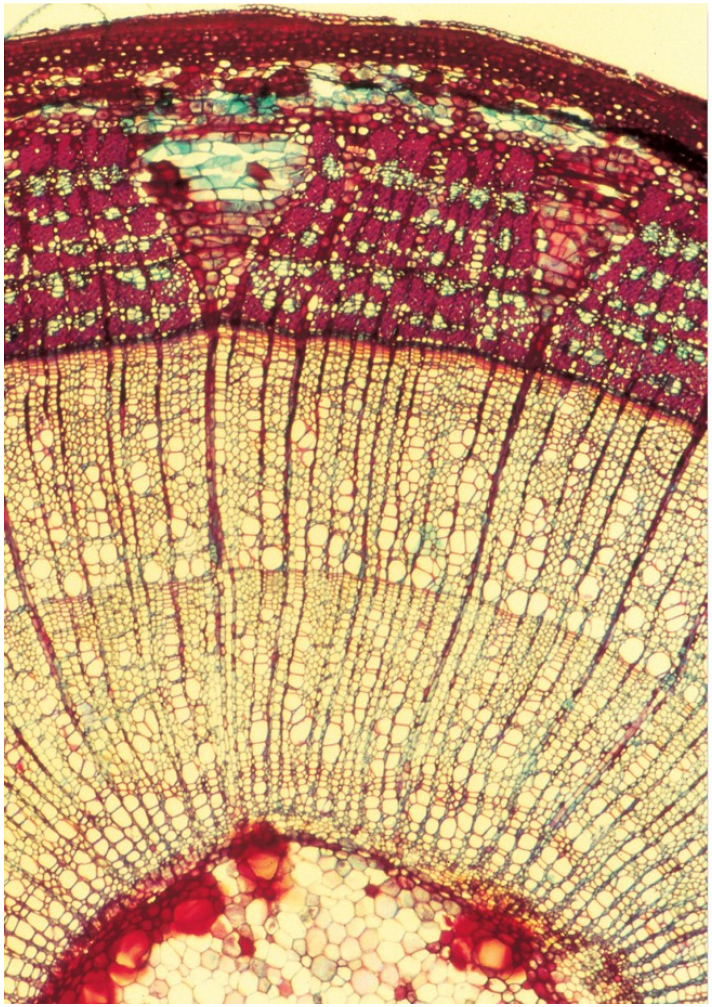


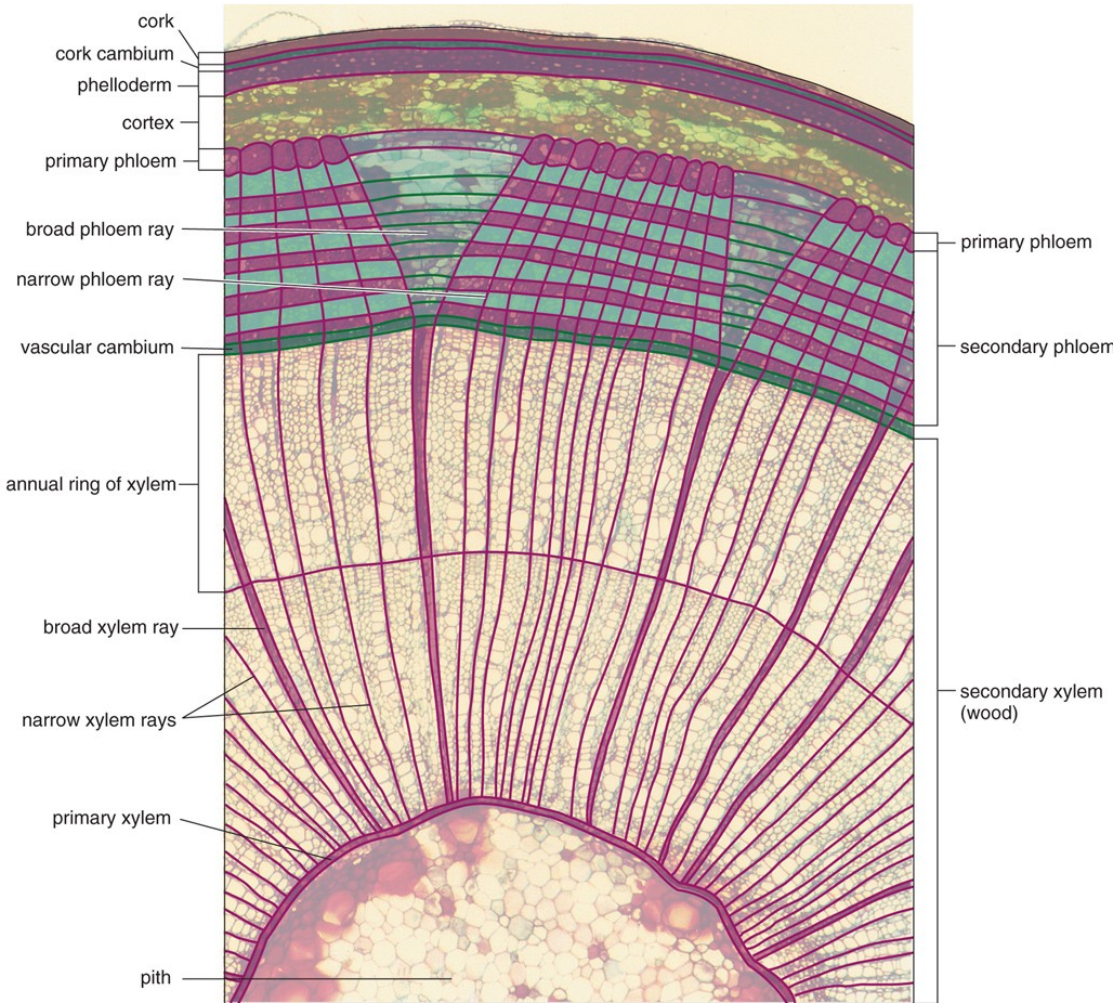


How cambium works



Secondary structure of stem (photo and explanations)

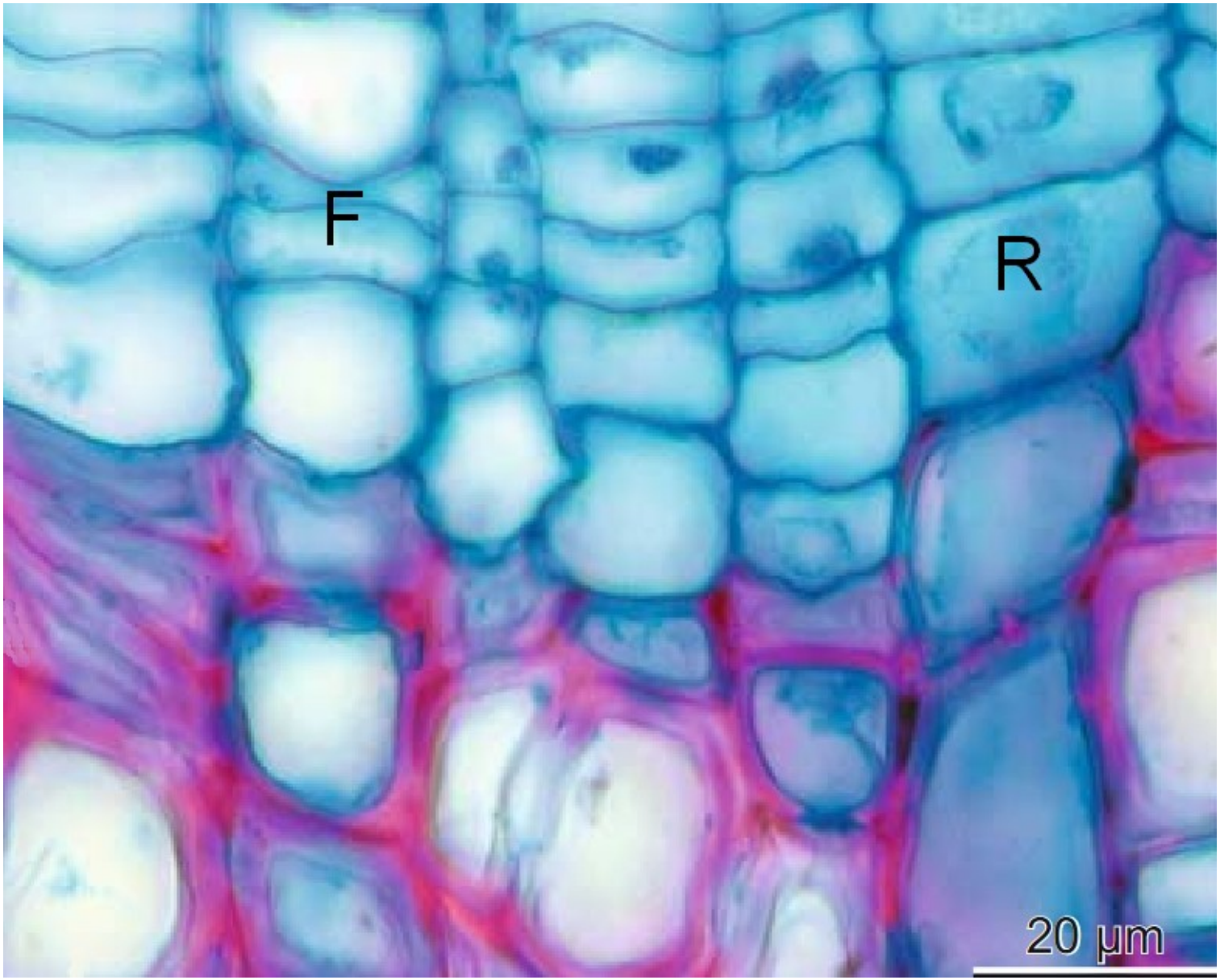




Secondary xylem and rays

- Secondary xylem, or wood, is the product of vascular cambium
- Some cambium cells are **fusiform initials**; they form axial vessel elements
- Other cambium cells are **ray initials**; they form rays (parenchyma + tracheids)
- **Rays** provide horizontal transport of water; **axial system** provide vertical transport

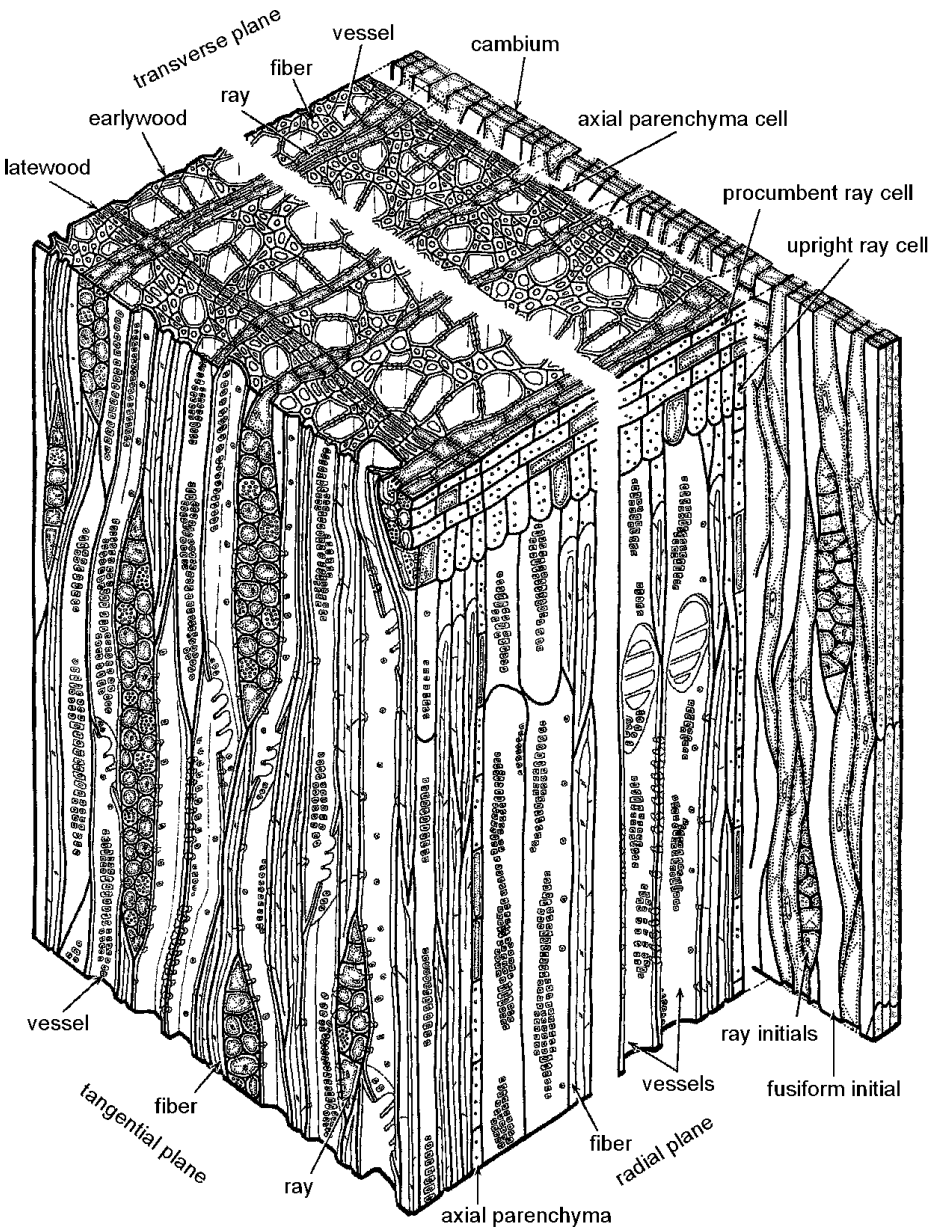
Fusiform and ray initials



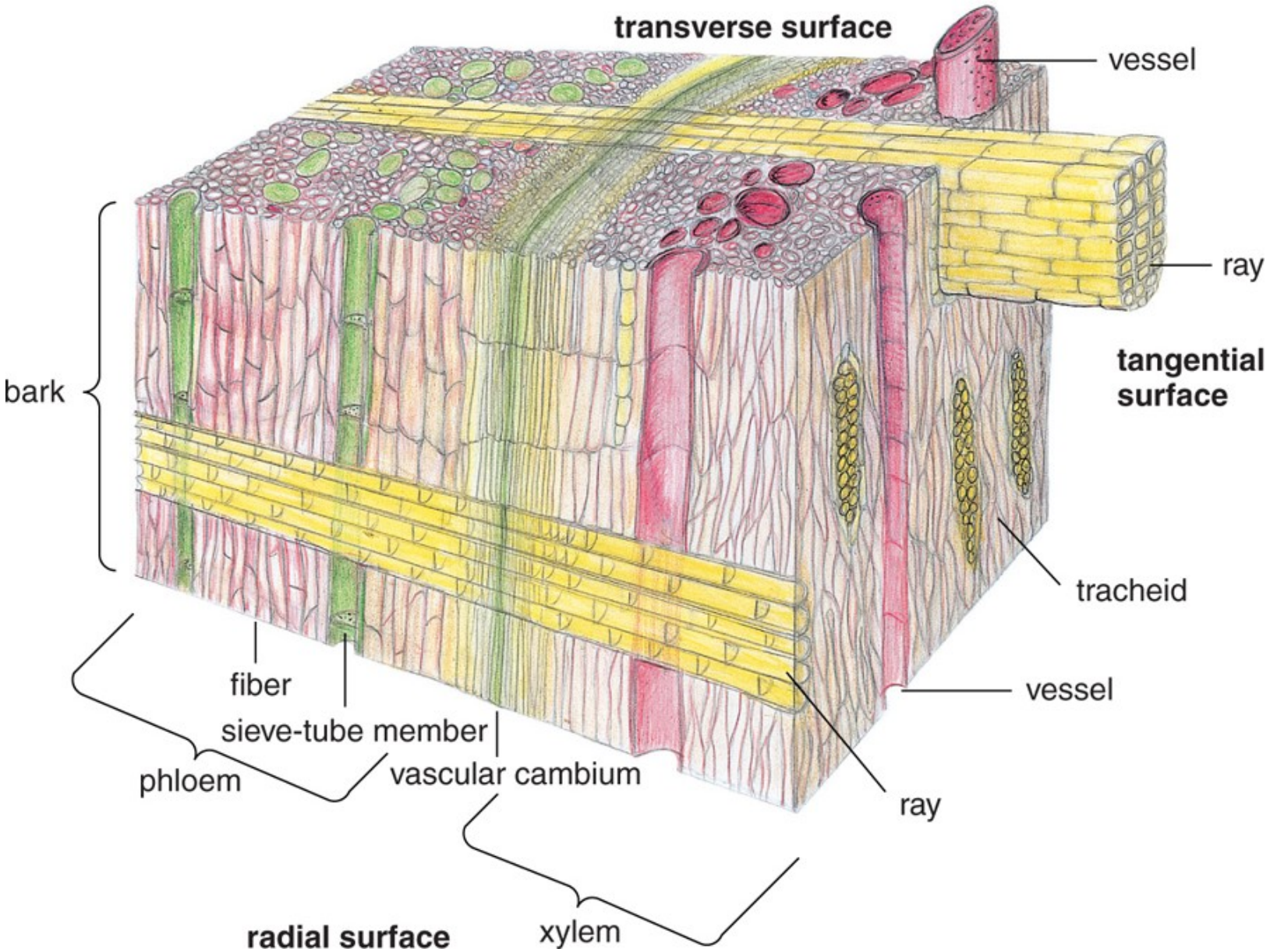
Three planes of view

- **Transverse** (cross-section)
- **Radial** (longitudinal section from center to periphery and perpendicular to stem surface)
- **Tangential** (longitudinal section parallel to stem surface)

Three plains of maple (*Acer* sp.) wood



Three plains again (the scheme)



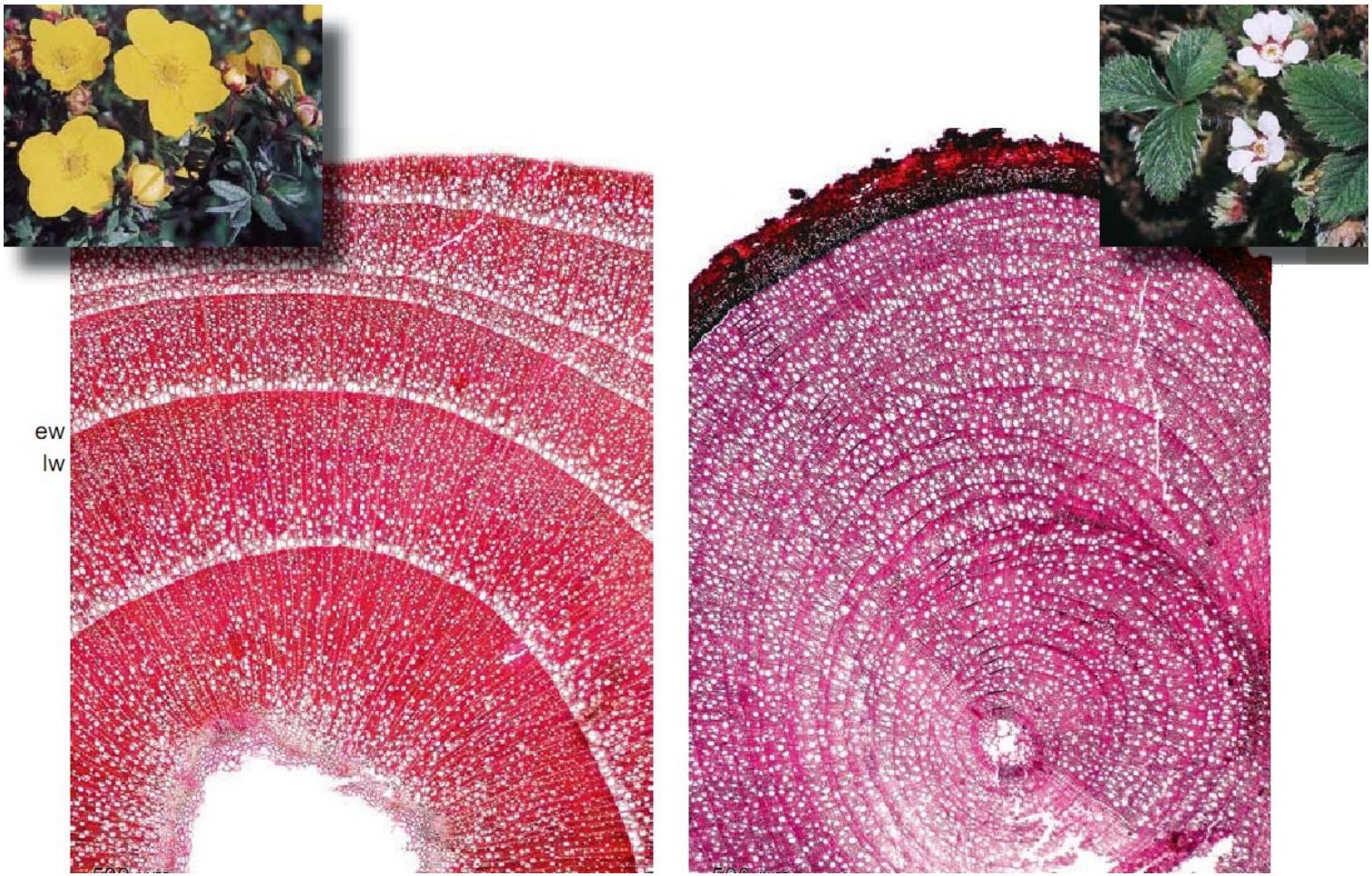
Earlywood and latewood

- **Earlywood** (springwood) contains more parenchyma and often have larger vessel elements
- **Latewood** (summerwood) often have small vessel elements and looks darker

Diffuse and ring porous wood

- In **ring porous** wood (like in red oak) bigger vessel elements concentrate in earlywood
- In **diffuse porous** wood larger vessel elements spread across early- and latewood (American elm)

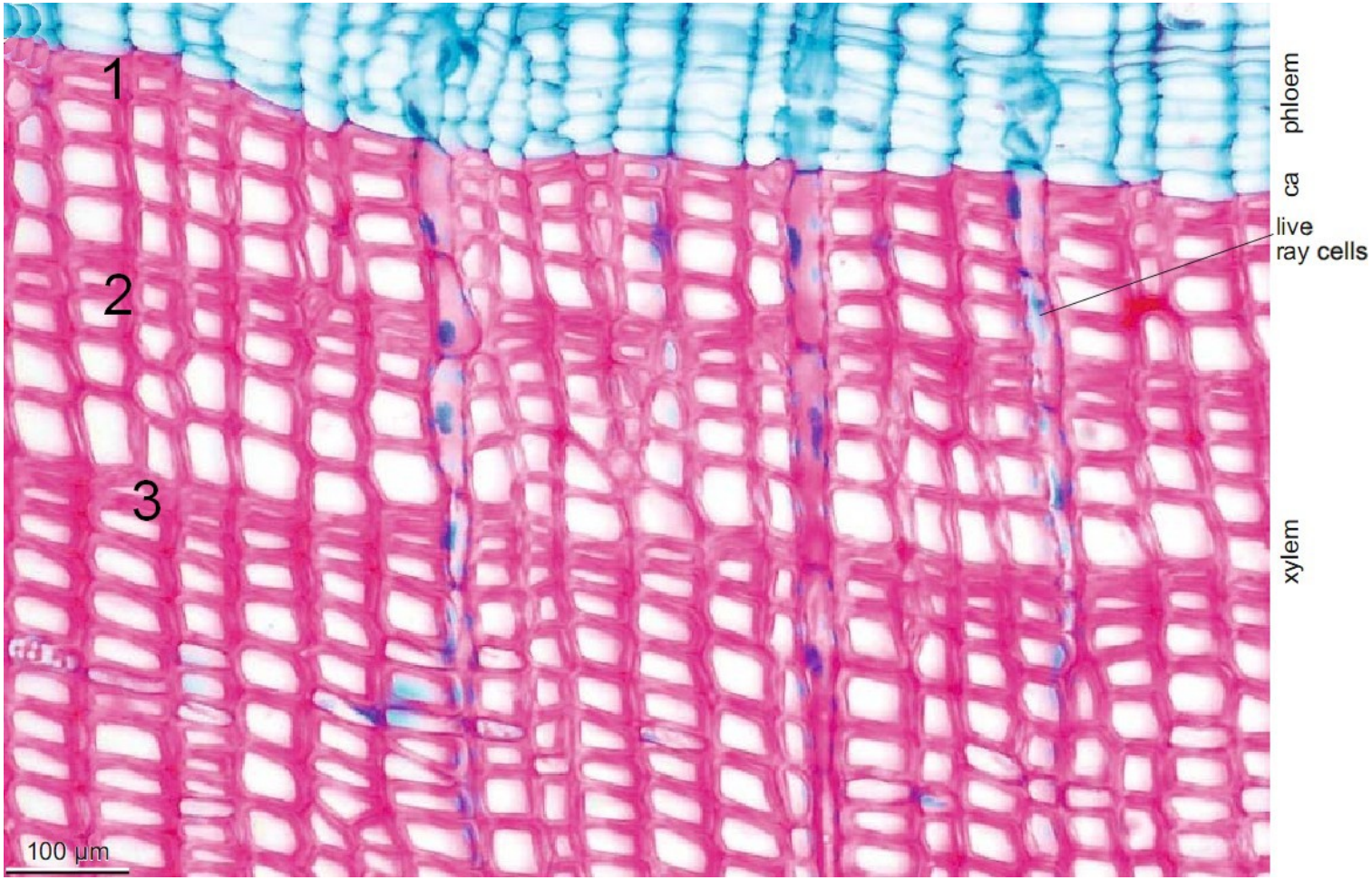
Diffuse and ring porous wood in two species of cinquefoil (*Potentilla* spp.)



Annual rings

- Interleaving early- and latewood from to sequential years form an impression of annual ring
- “Ring” is just a layer of darker (i.e., smaller) cells
- Tropical trees do not form annual rings

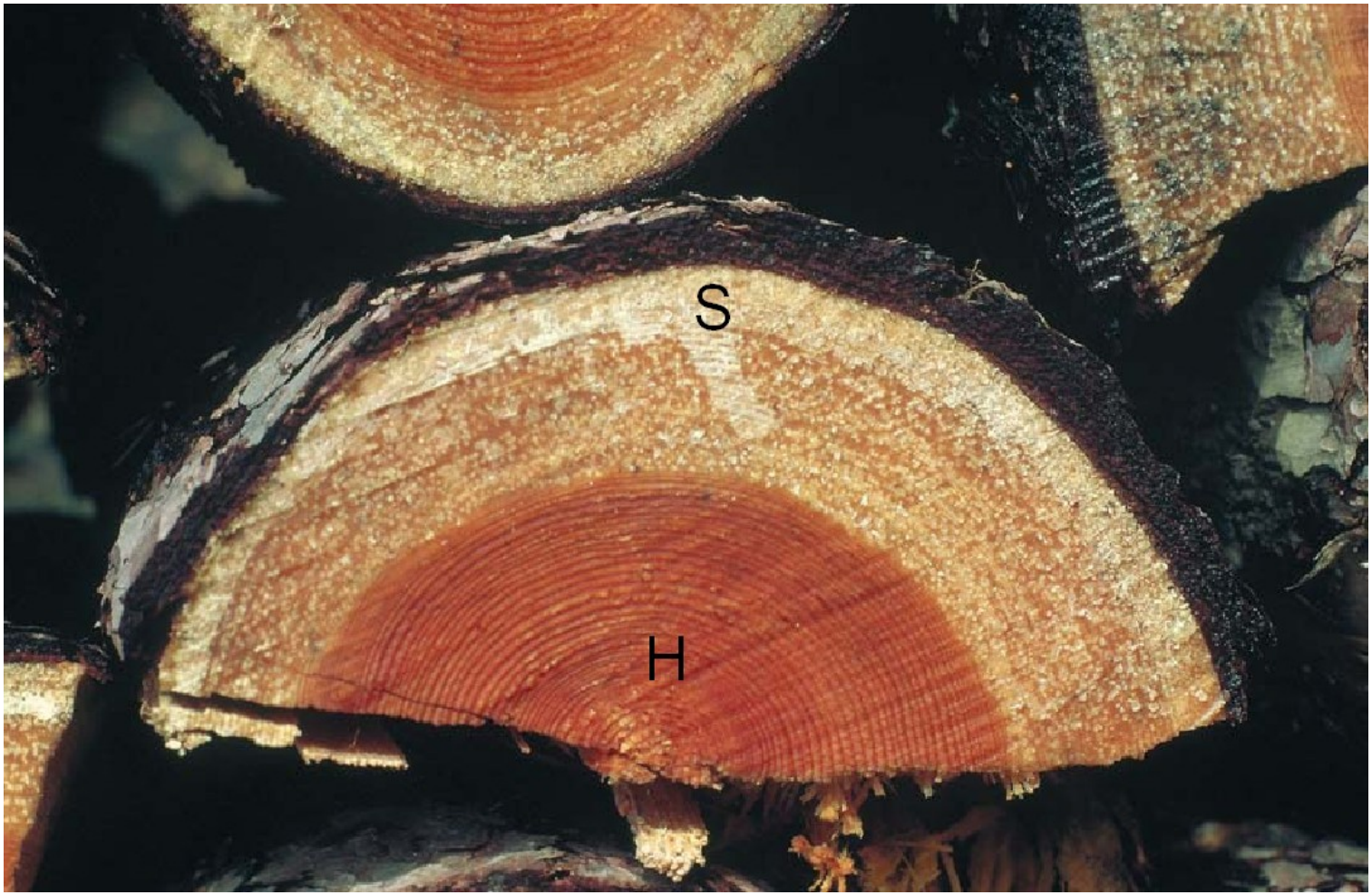
Annual rings in juniper (*Juniperus* sp.)



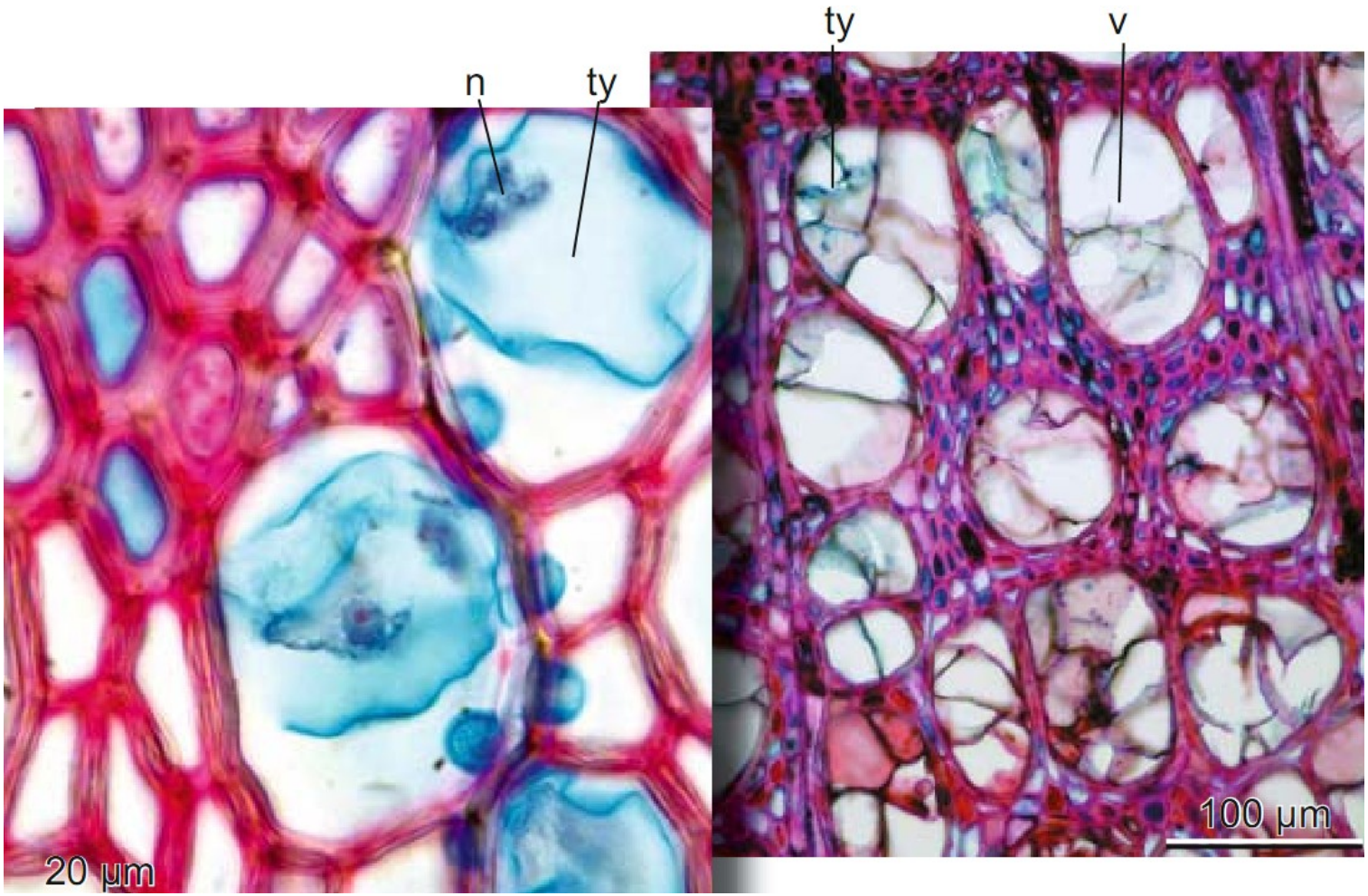
Sapwood and heartwood

- **Sapwood** is a peripheral layer of working xylem, it usually has relatively light color
- **Heartwood** is a central, non-functional, old, dark-colored xylem

Sapwood and heartwood of European pine (*Pinus sylvestris*)



Tyloses



Tyloses control the winter functioning of vessels

Branching, thickening and the origin of seed

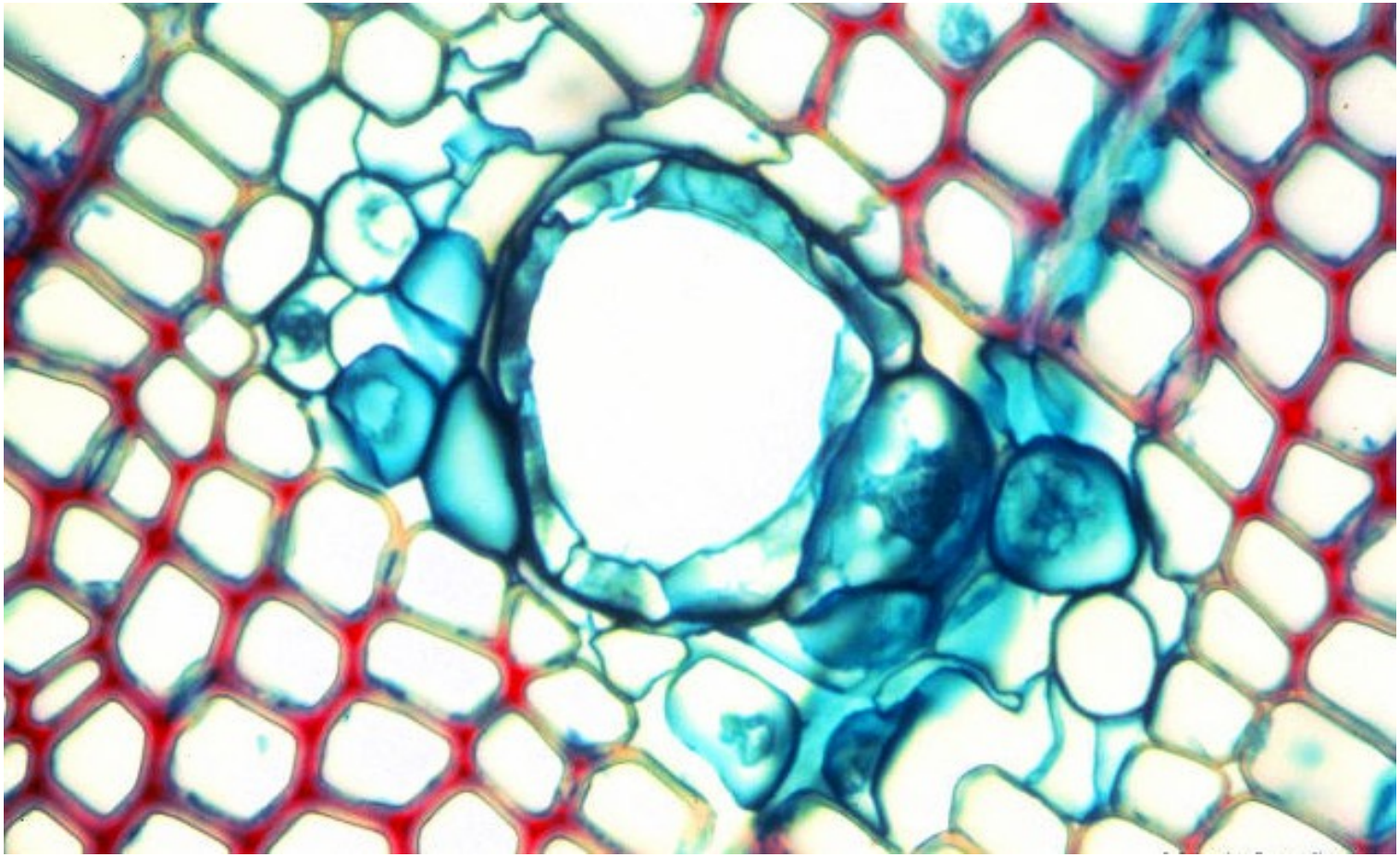
Diversity of wood

Conifer wood

- Simpler structure, few cell types
- Simple rays
- Sometimes have **resin ducts**; resin secreted by epithelial cells

Ginkgo (*Ginkgo biloba*) wood (not a conifer, but gymnosperm)

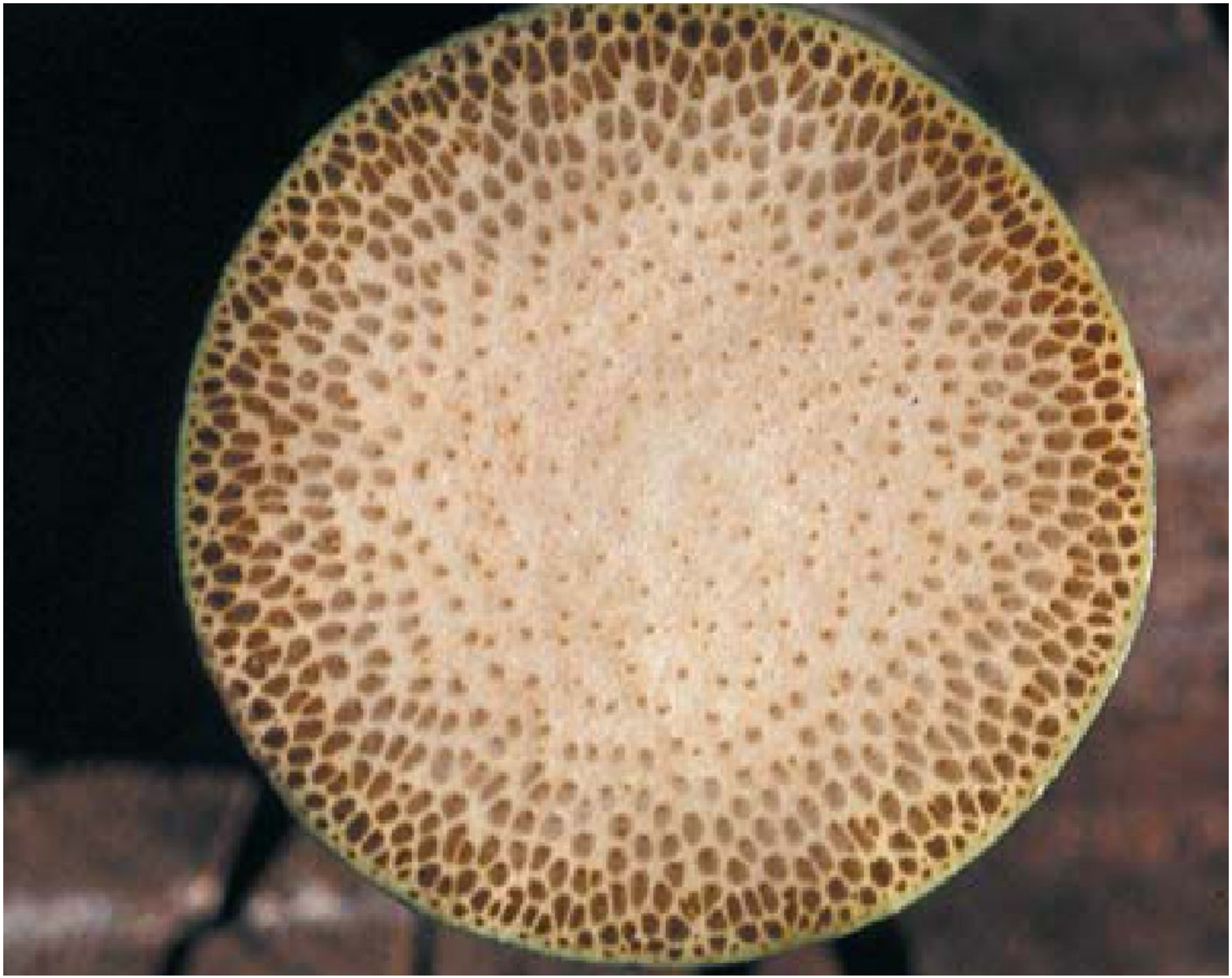
Resin duct in pine wood (©BSA)



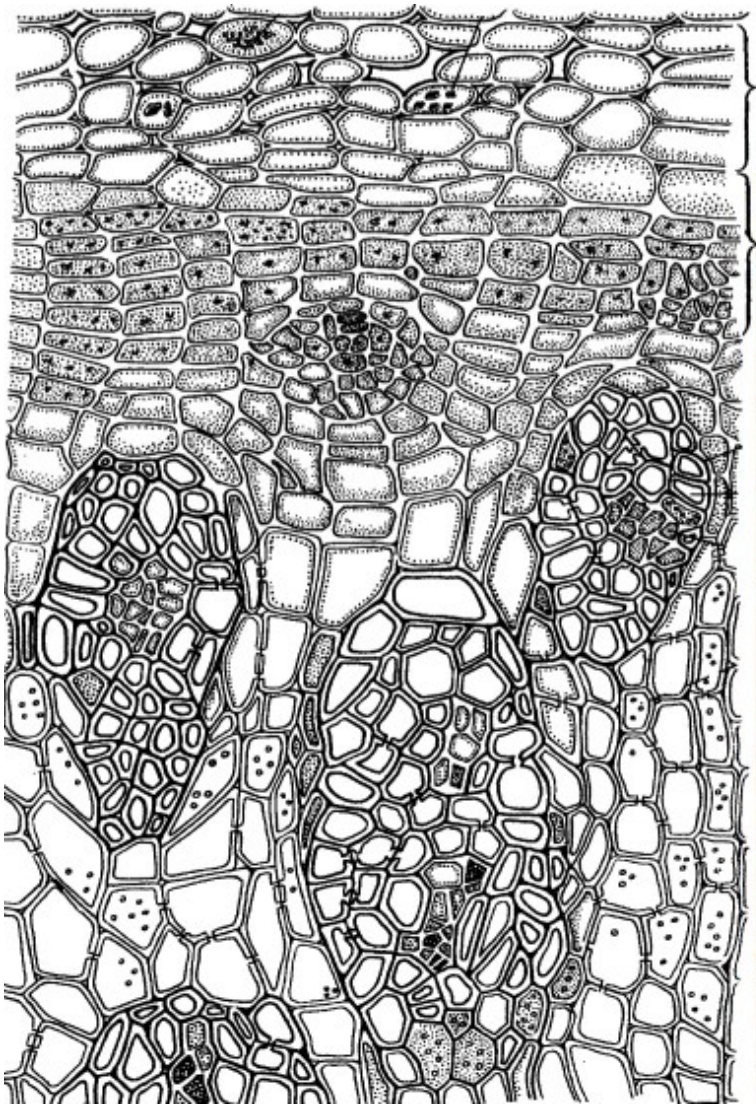
Monocot “wood”

- Most of monocots do not have lateral meristems and therefore have no true wood
- Palms have only primary tissues; their trunk widens from bottom to top
- Some monocots (dragon trees) have **anomalous secondary growth**

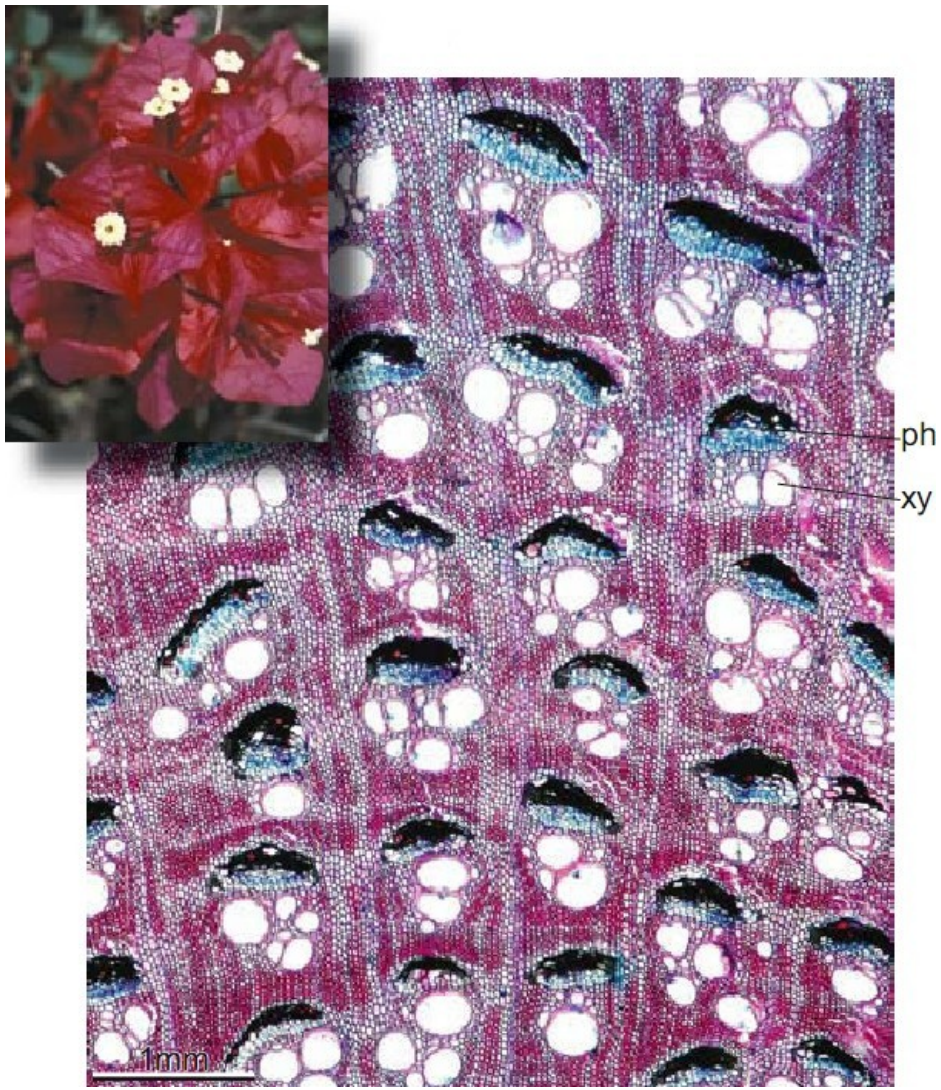
Cross section of palm (*Phoenix canariensis*) trunk



Dragon tree (*Dracaena draco*) and its anomalous cambium



Anomalous secondary growth in Bougainvillea (*Bougainvillea spectabilis*)



Branching, thickening and the origin of seed

Life forms

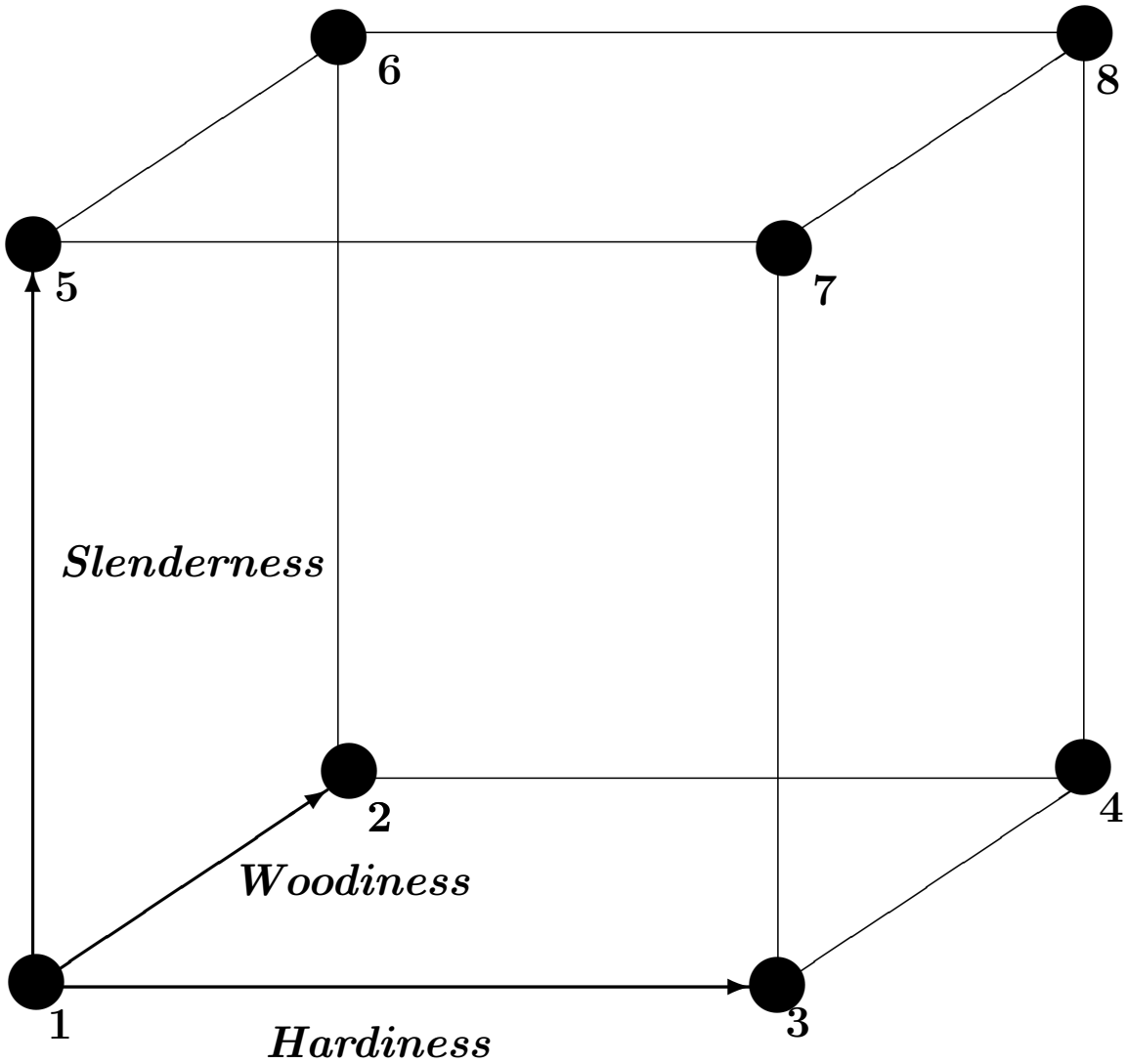
Life forms

- It is a different view on the plant diversity
- Life forms represent different lifestyles
- For example, trees, shrubs, vines, annual and perennial herbs are life forms

Life forms: dynamic approach

- **Hardiness**: sensitivity to all negative influence
- **Woodiness**: % of cells with secondary walls
- **Slenderness**: proportion of linearly ordered stems

Life form cube



#1 could be similar to duckweed, #8—to sequoia

Life forms: Raunkiaer's approach

- **Epiphytes**: aboveground plants
- **Phanerophytes**: winter buds openly exposed
- **Chamaephytes**: winter buds under snow
- **Hemicryptophytes**: winter buds on soil surface
- **Cryptophytes**: winter buds in the soil
- **Therophytes**: no winter buds, only seeds

The Raunkiaer system is very useful to characterize the whole *floras*, especially temperate floras

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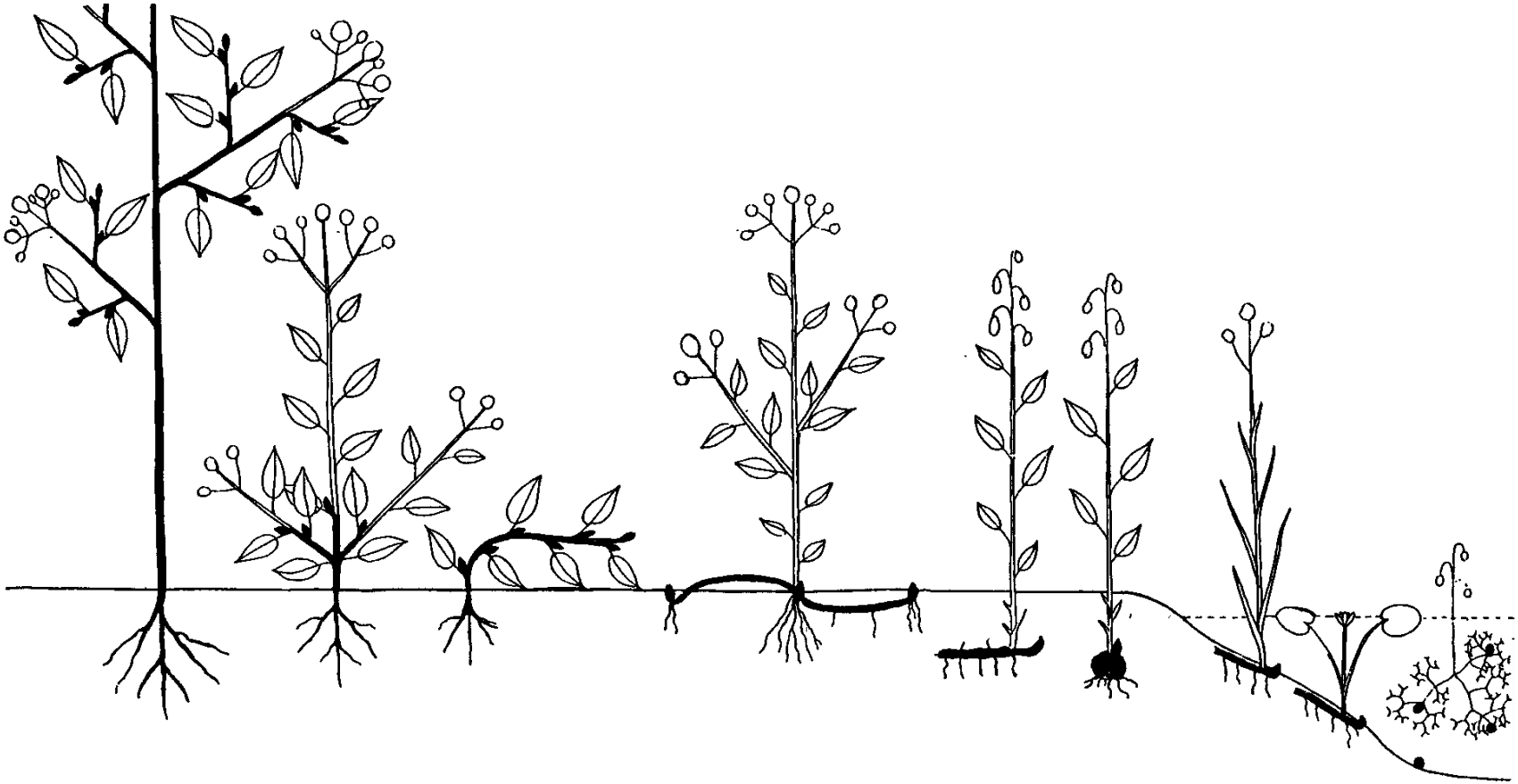
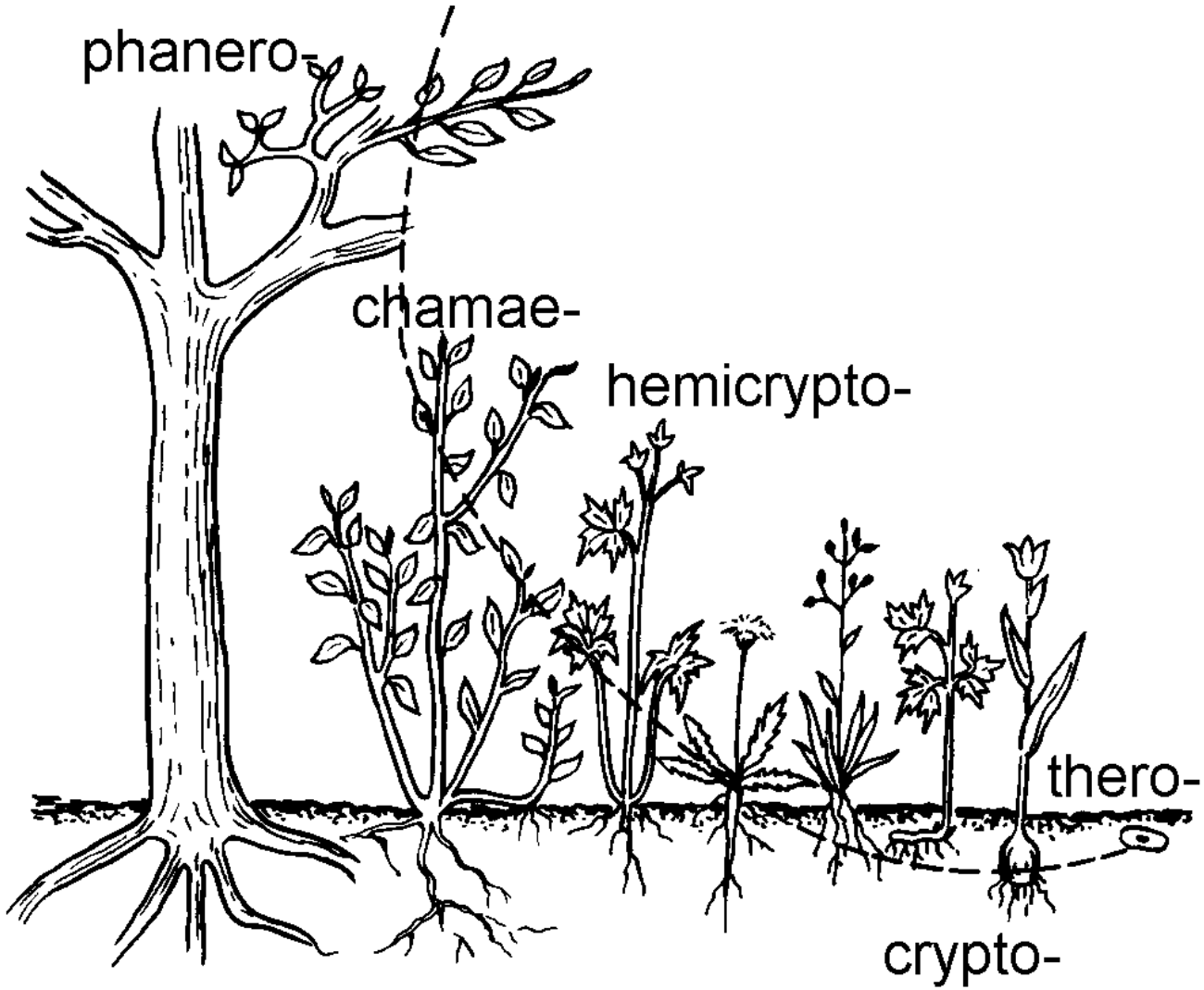
Raunkiaer classification (after Raunkiaer, 1937)



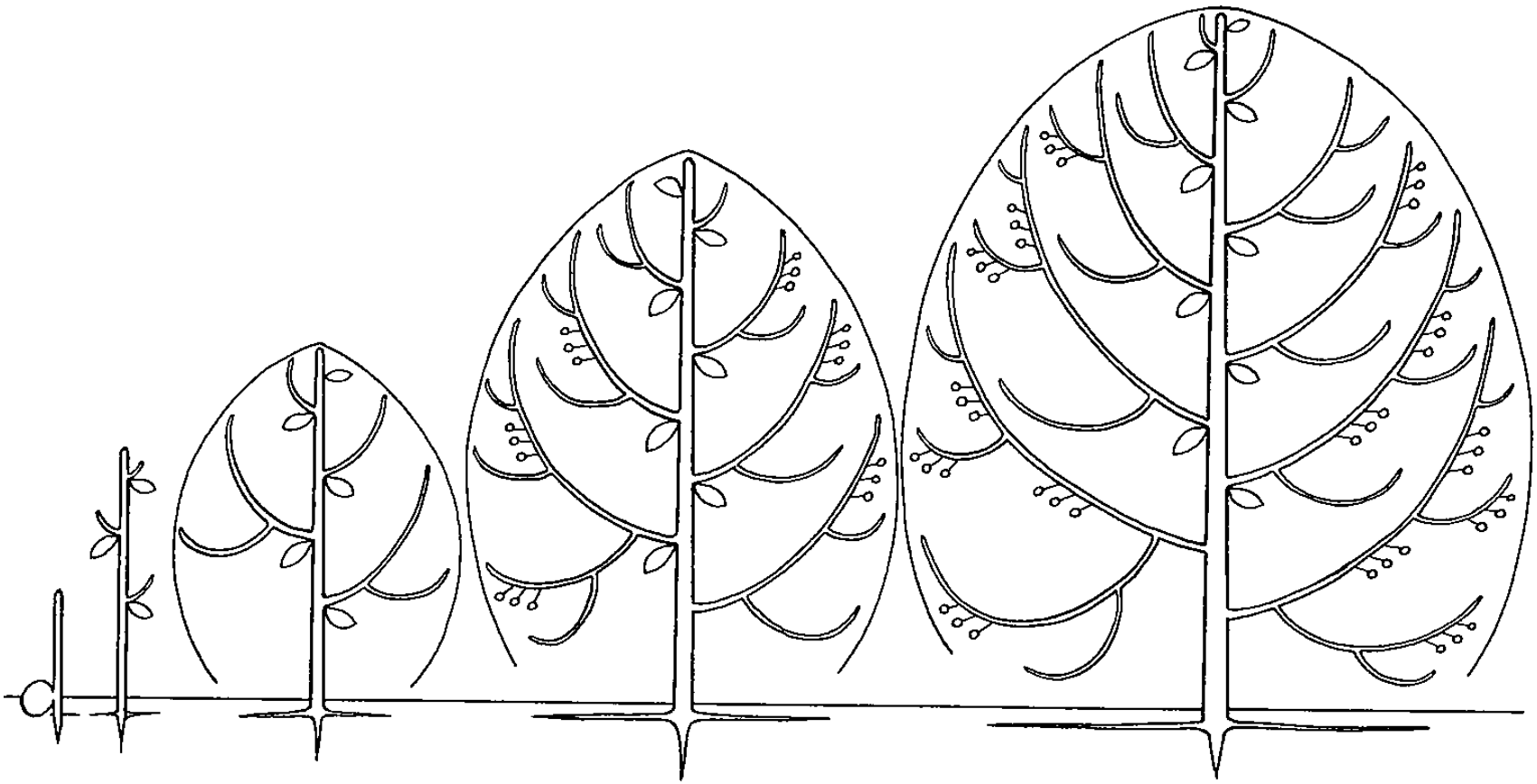
Raunkiaer classification again



Life forms: architectural models

- Developed for tropical trees, but also cover temperate forms which are less diverse
- Each model has a name of famous botanist, e.g. Thomlinson, Cook, Attims
- Based on the character of branching, development of generative shoots, directions of growing

Example of architectural model: Attims



Many temperate trees are growing according to this model

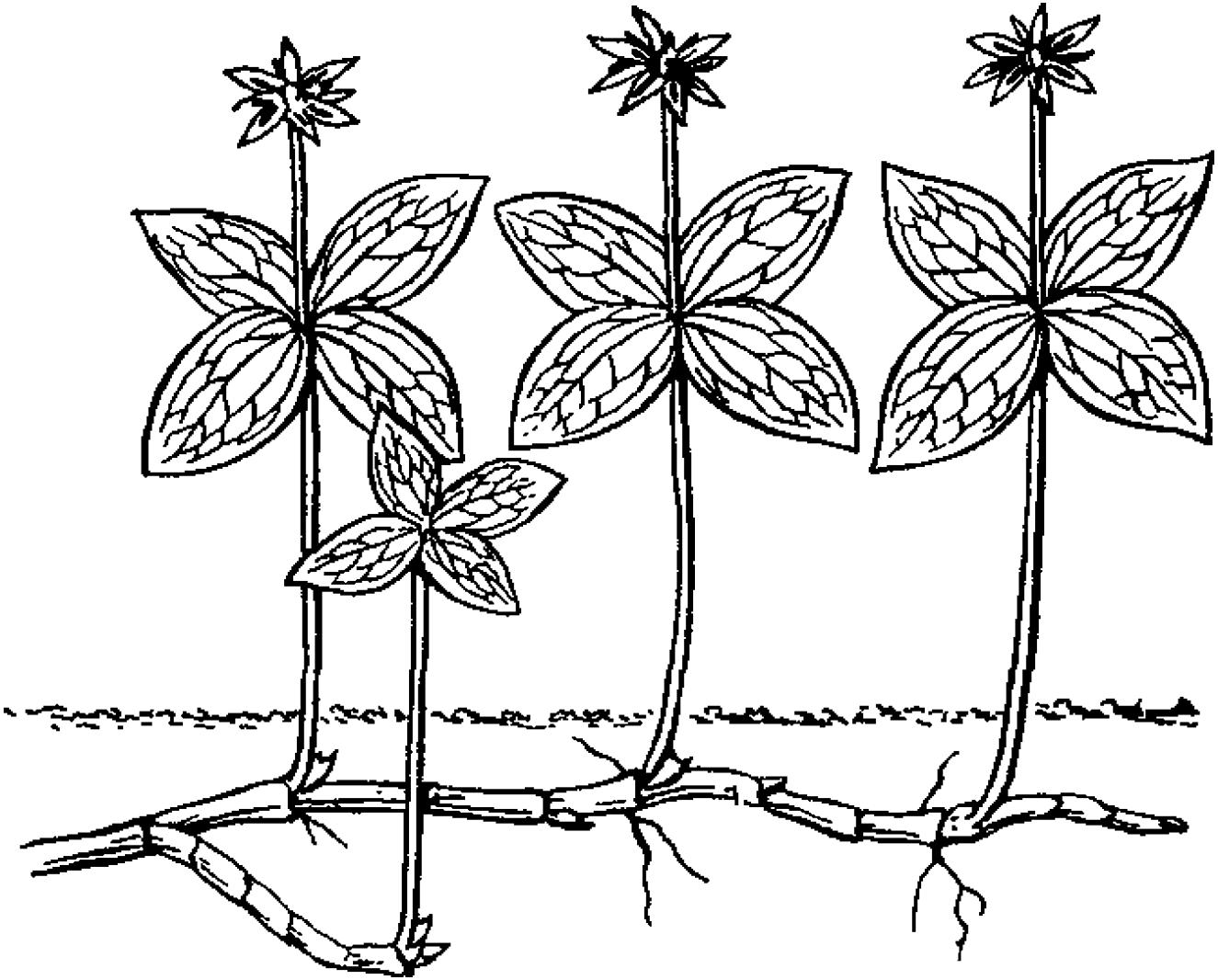
Branching, thickening and the origin of seed

Modifications of stem / shoot

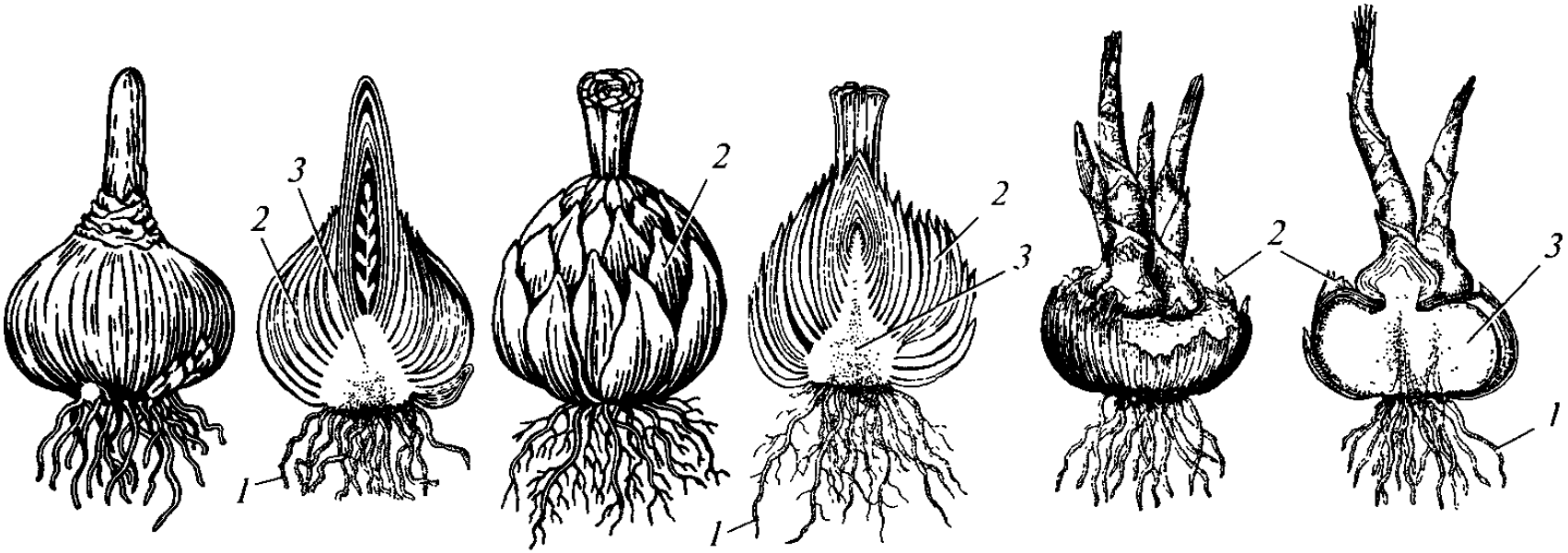
Modifications of shoots and stems

- **Rhizomes**: underground stems
- **Stolons** (runners): aboveground horizontal shoots
- **Tubers**: enlarged portions of rhizomes
- **Bulbs**: storage shoots, leaves $>$ 50% of volume
- **Corms**: storage shoots, leaves $<$ 50% of volume
- **Thorns**: defense shoots
- **Spines**: defensive emergencies of stem surface
- **Cladophylls**: leaf-like shoots
- **Stem traps**: catch animals for some carnivorous plants

Rhizome

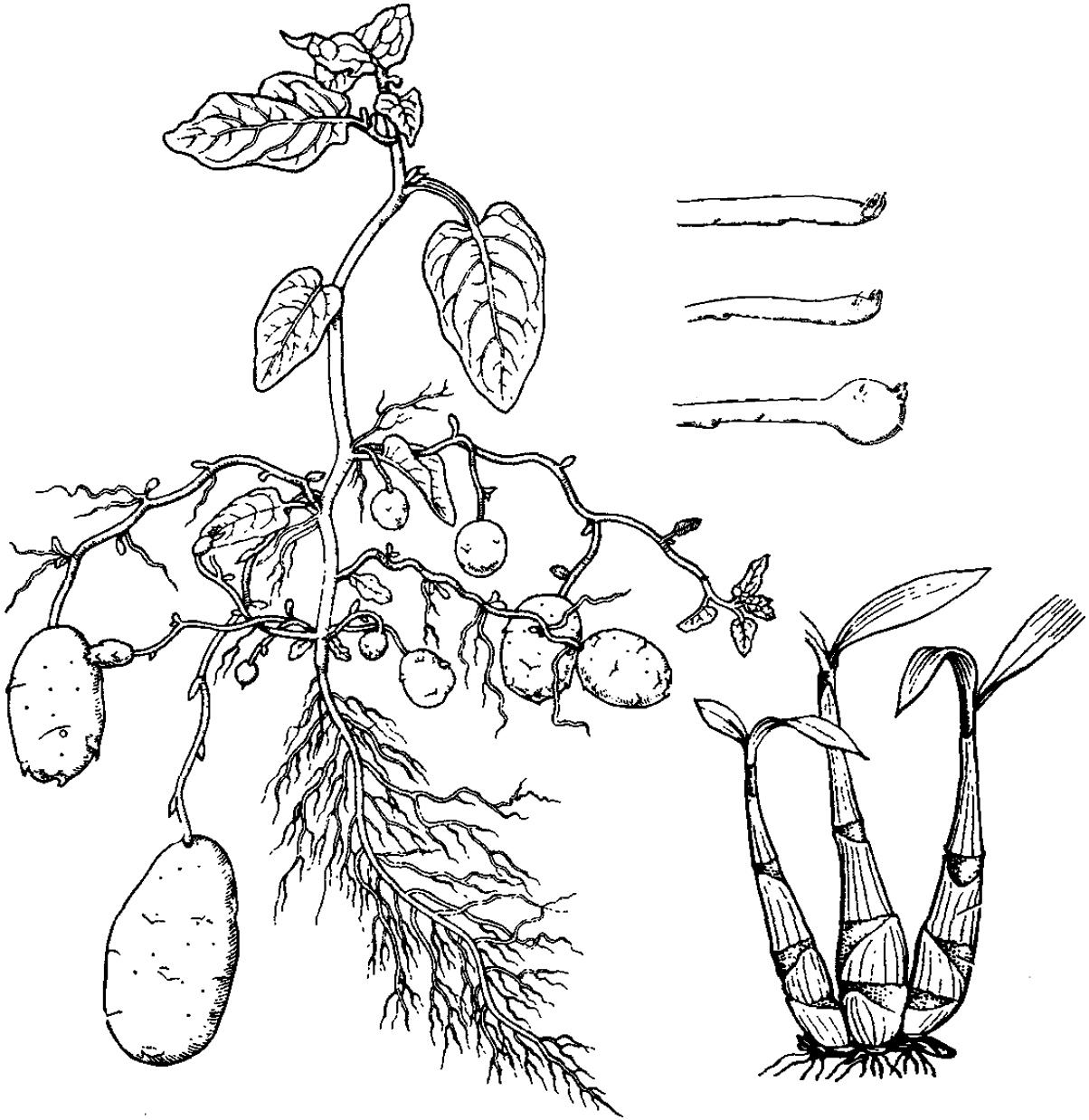


Bulbs and corms

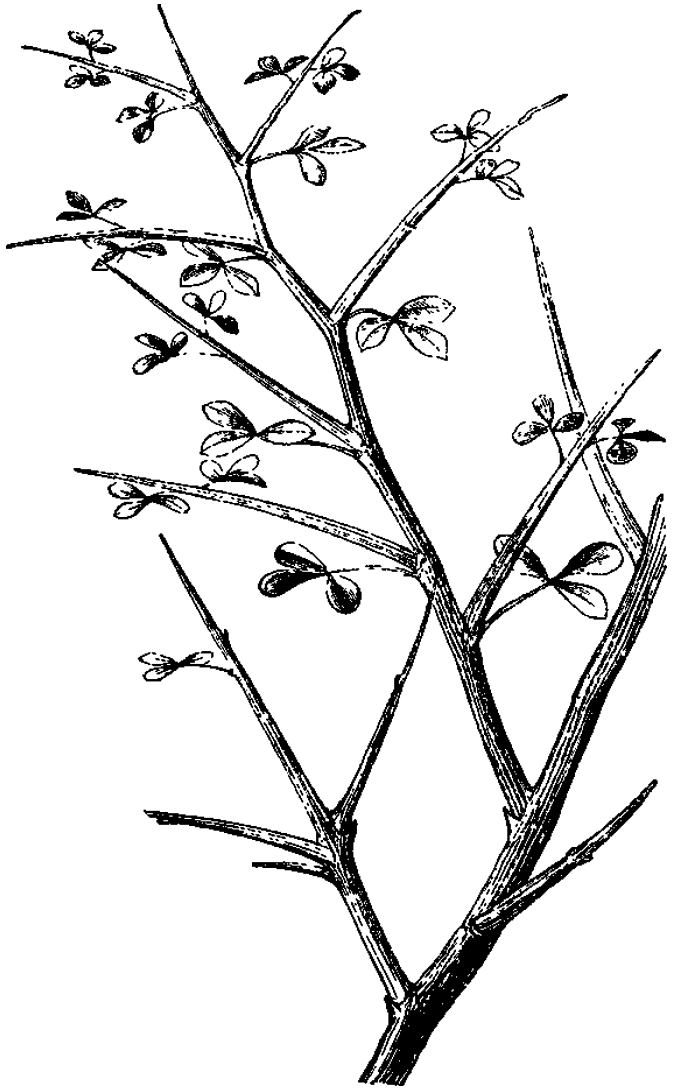


(1) roots, (2) leaves, (3) stems

Tubers: potato and orchids

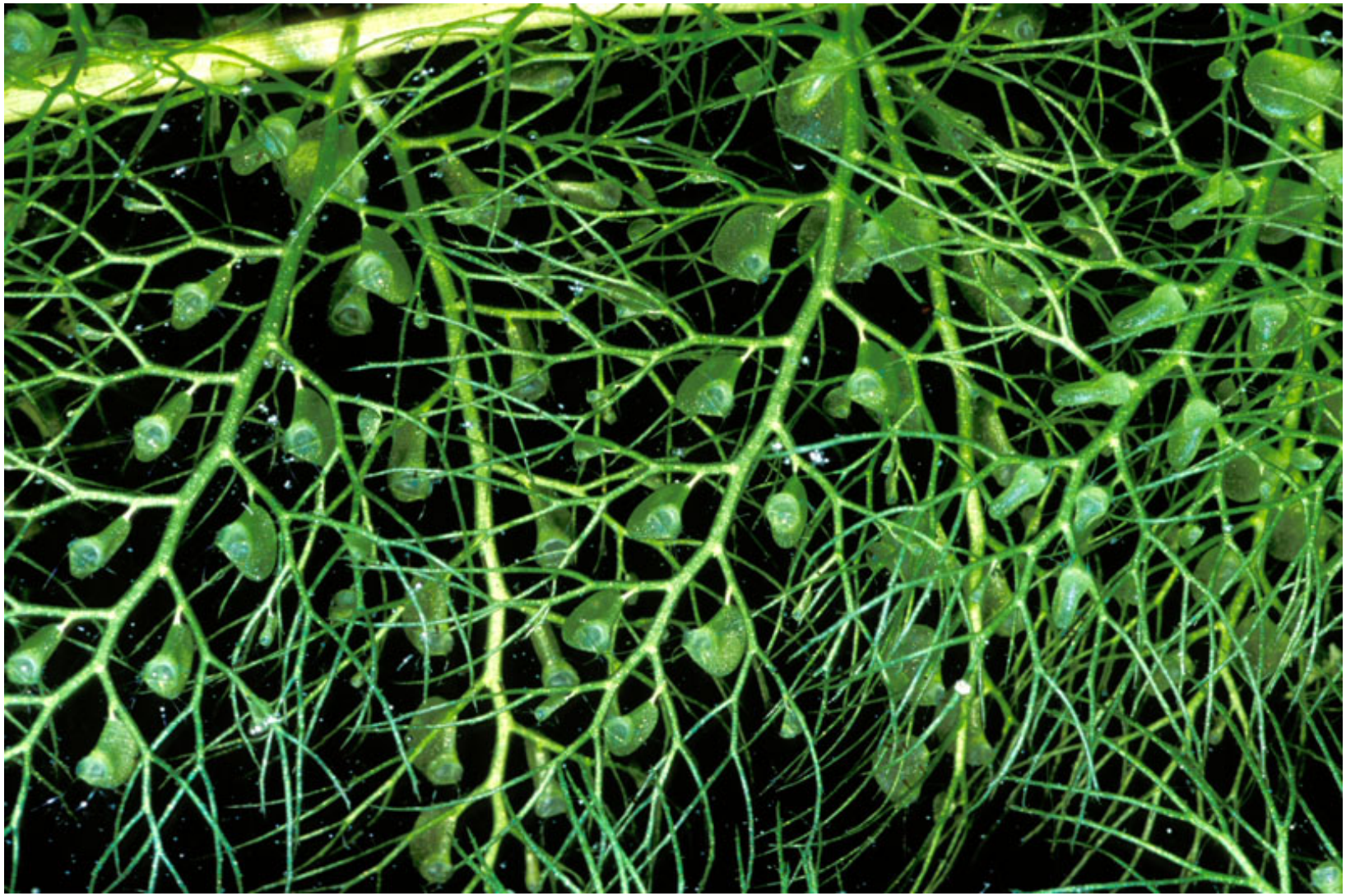


Thorns



Cladophylls: leafy stems

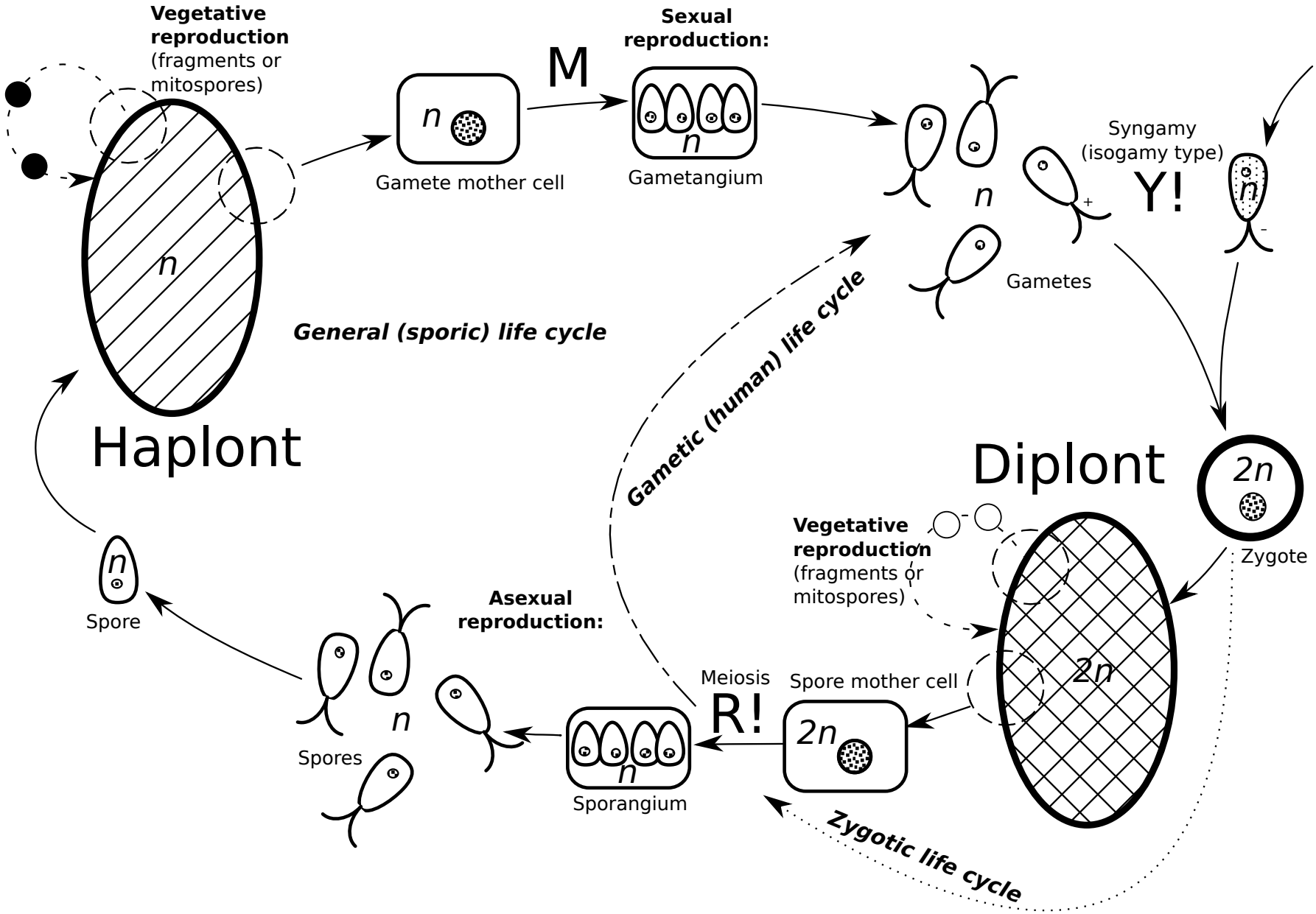
Traps of bladderwort (*Utricularia*)



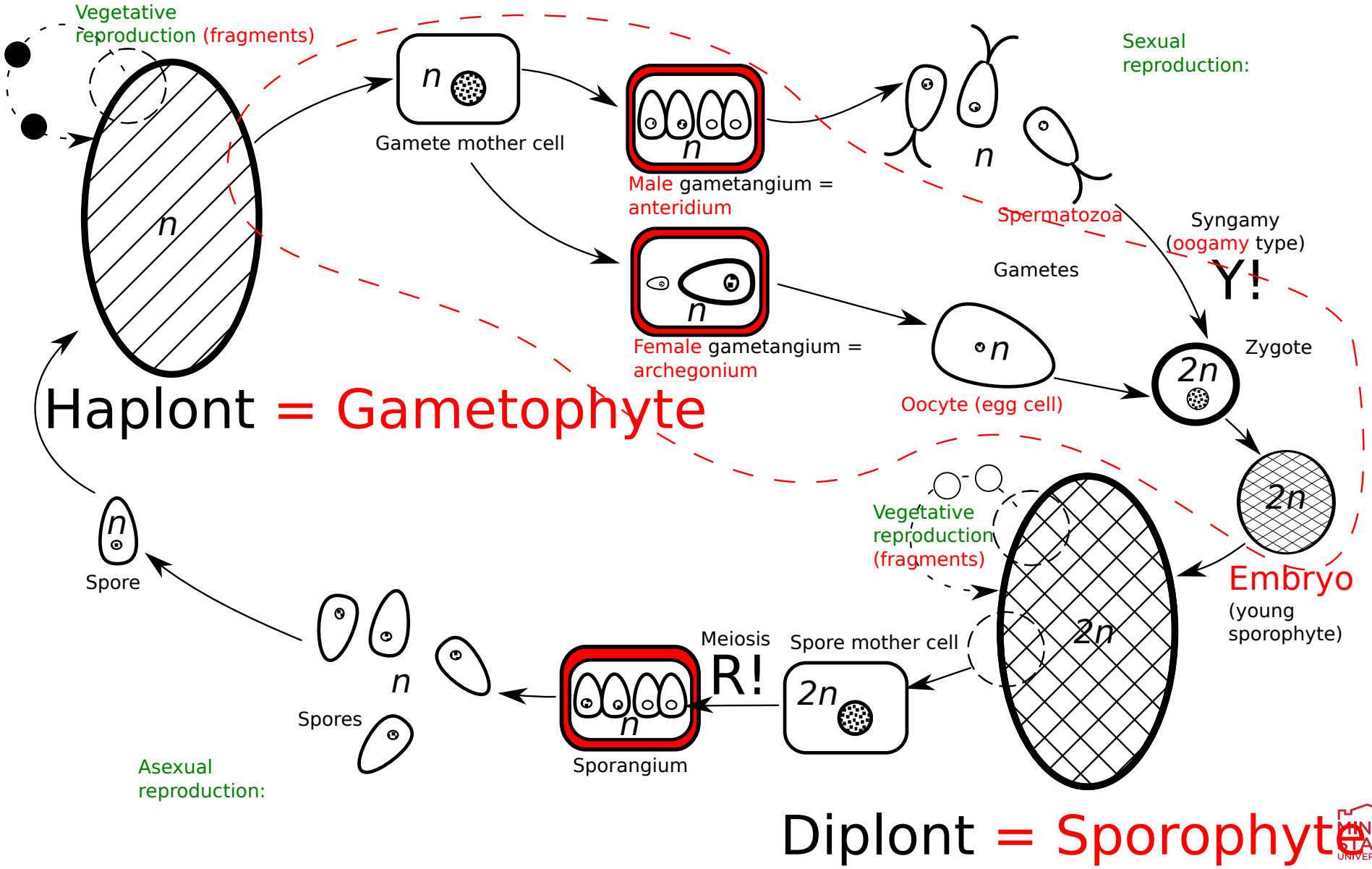
Branching, thickening and the origin of seed

Origin of seed

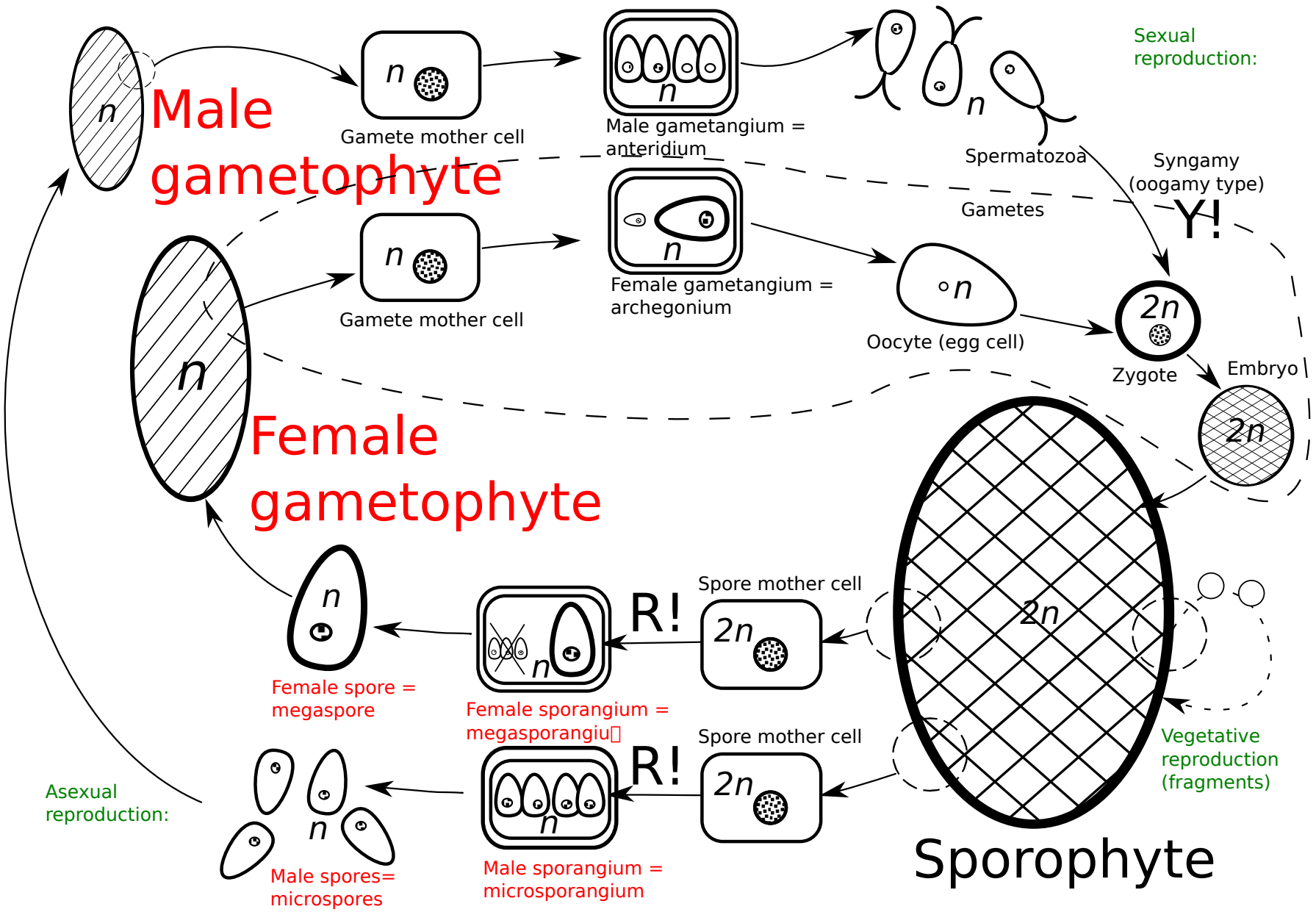
General life cycle



Life cycle of land plants: differences



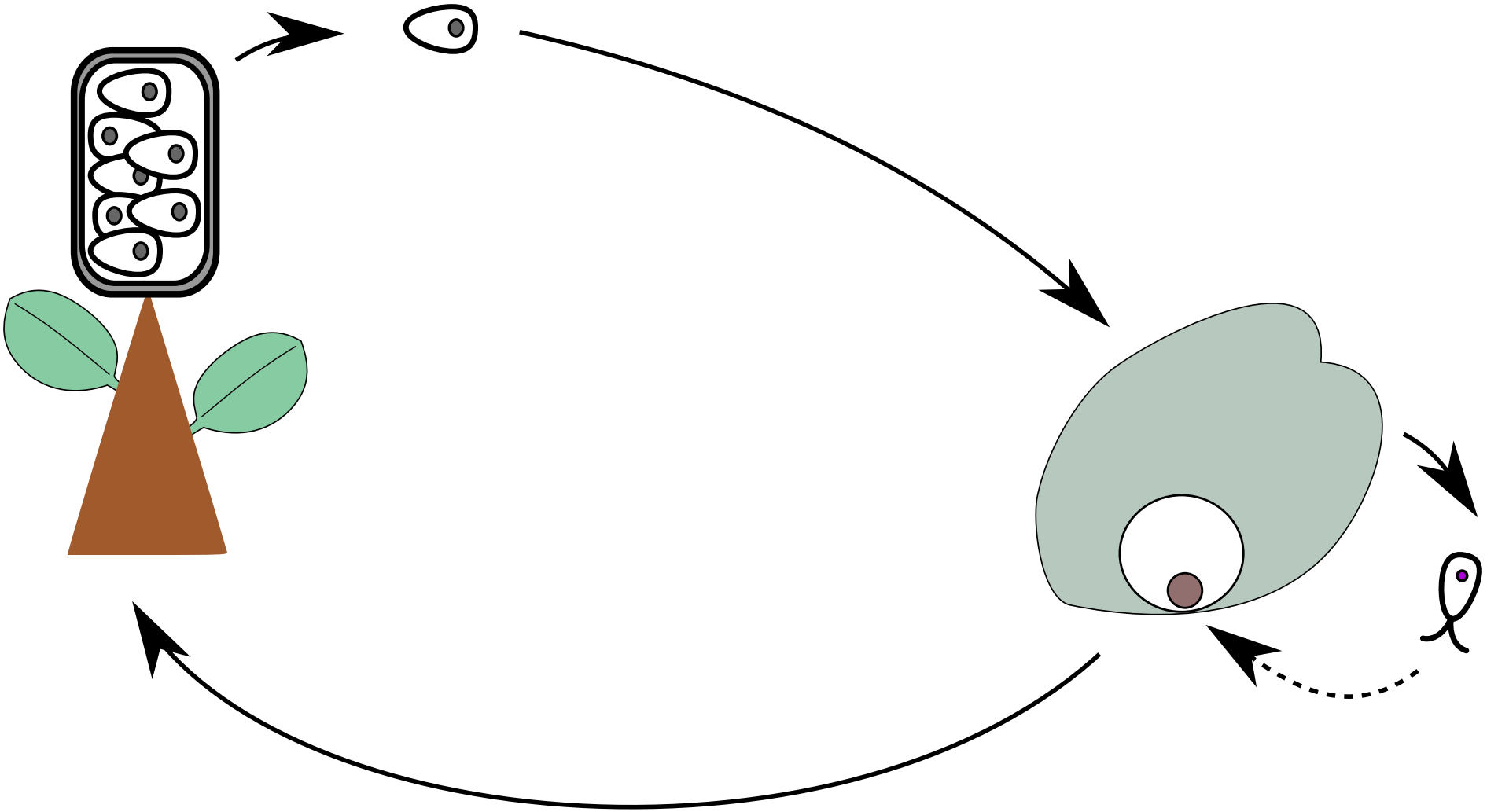
Heterosporic cycle: differences



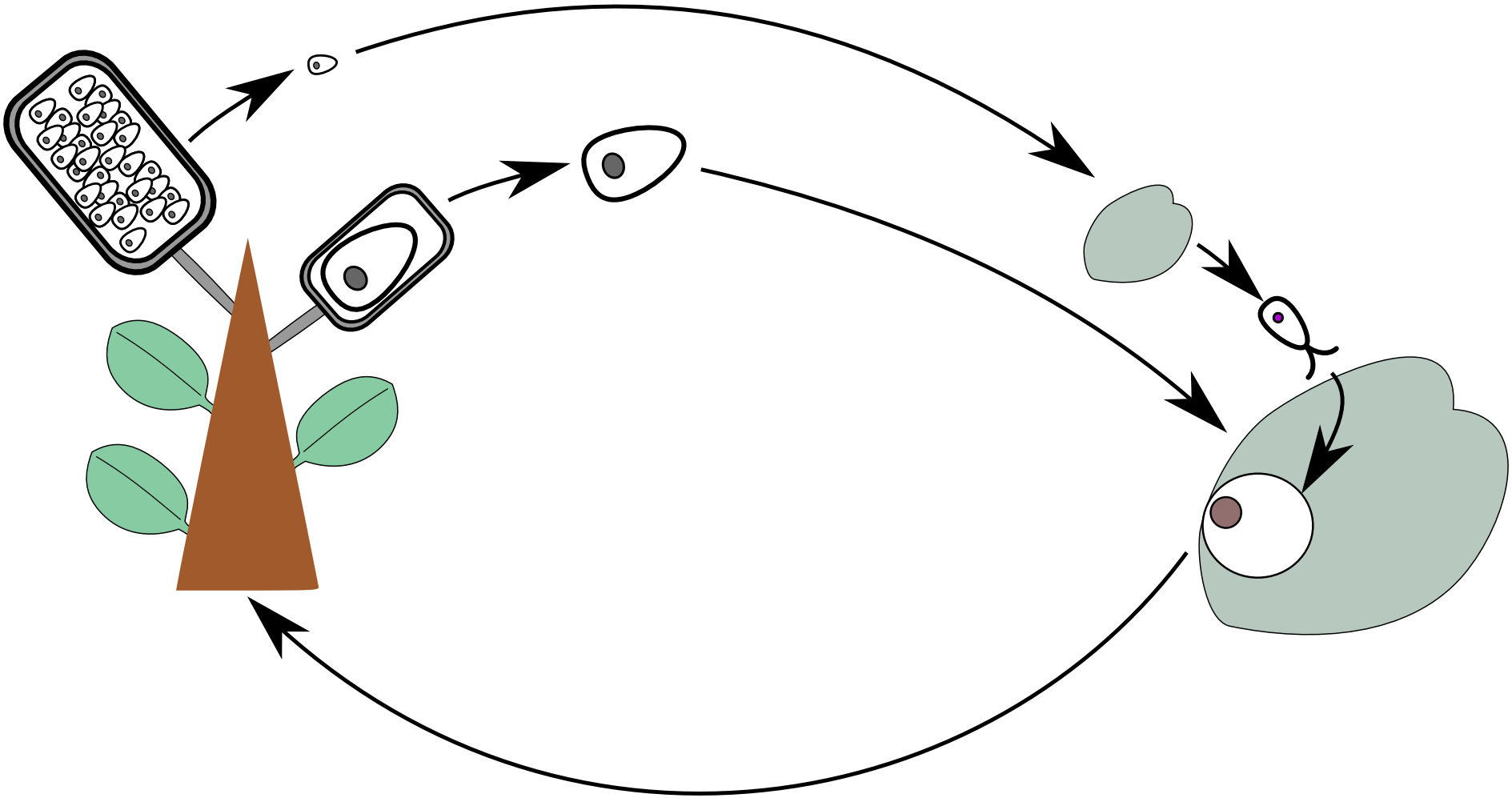
Origin of seed

- **“Dinosaur problem”:** without control on the *r*-strategic gametophyte, *K*-strategic tree sporophyte cannot guarantee its reproduction
- **Seed is the result of enforced control of sporophyte over gametophyte**
- Growing of gametophytes, syngamy (fertilization) and growing of daughter sporophyte—everything happens **directly on mother sporophyte**

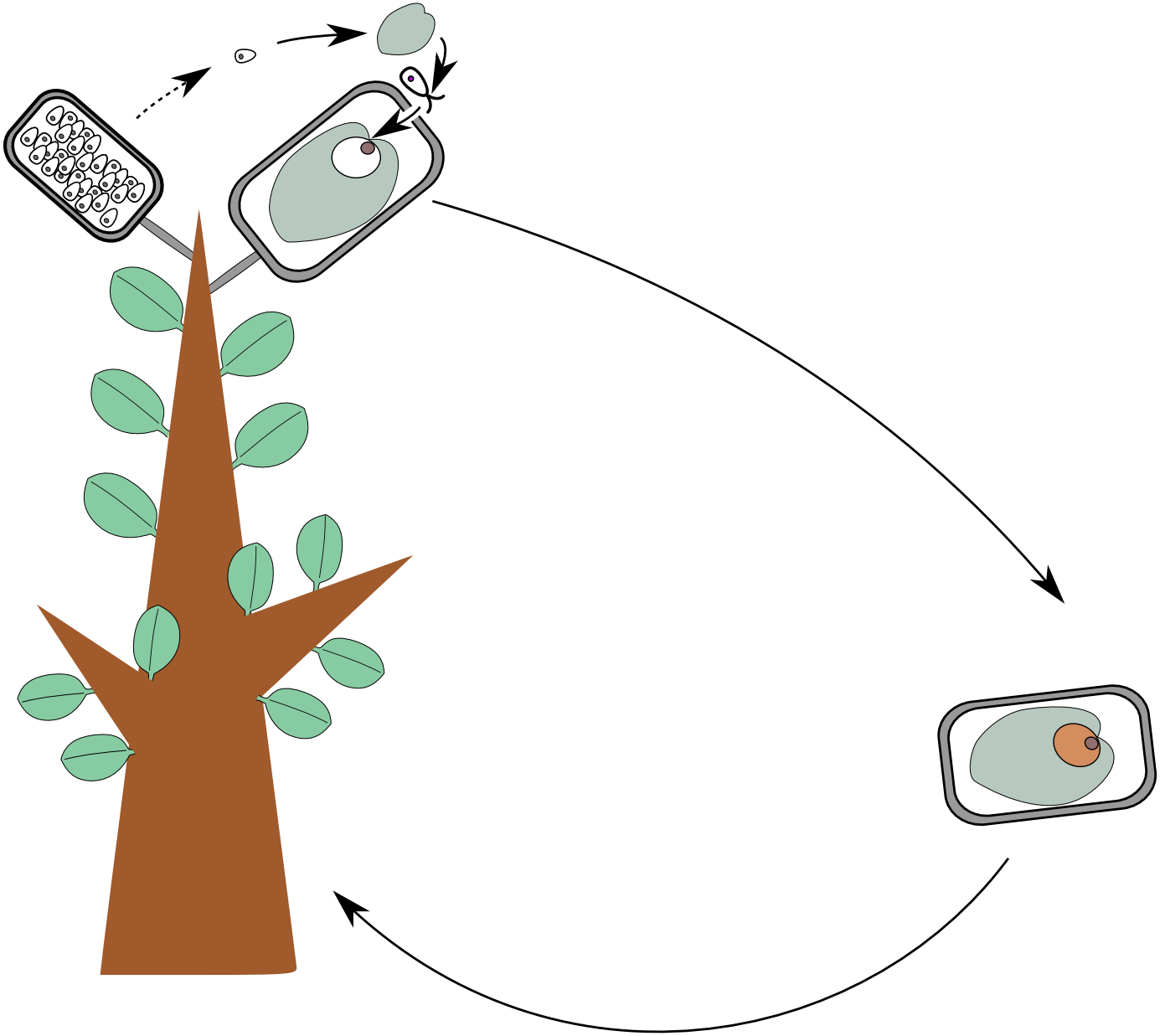
Seed origin: step I, homospory



Seed origin: step II, heterospory



Seed origin: step III, seed

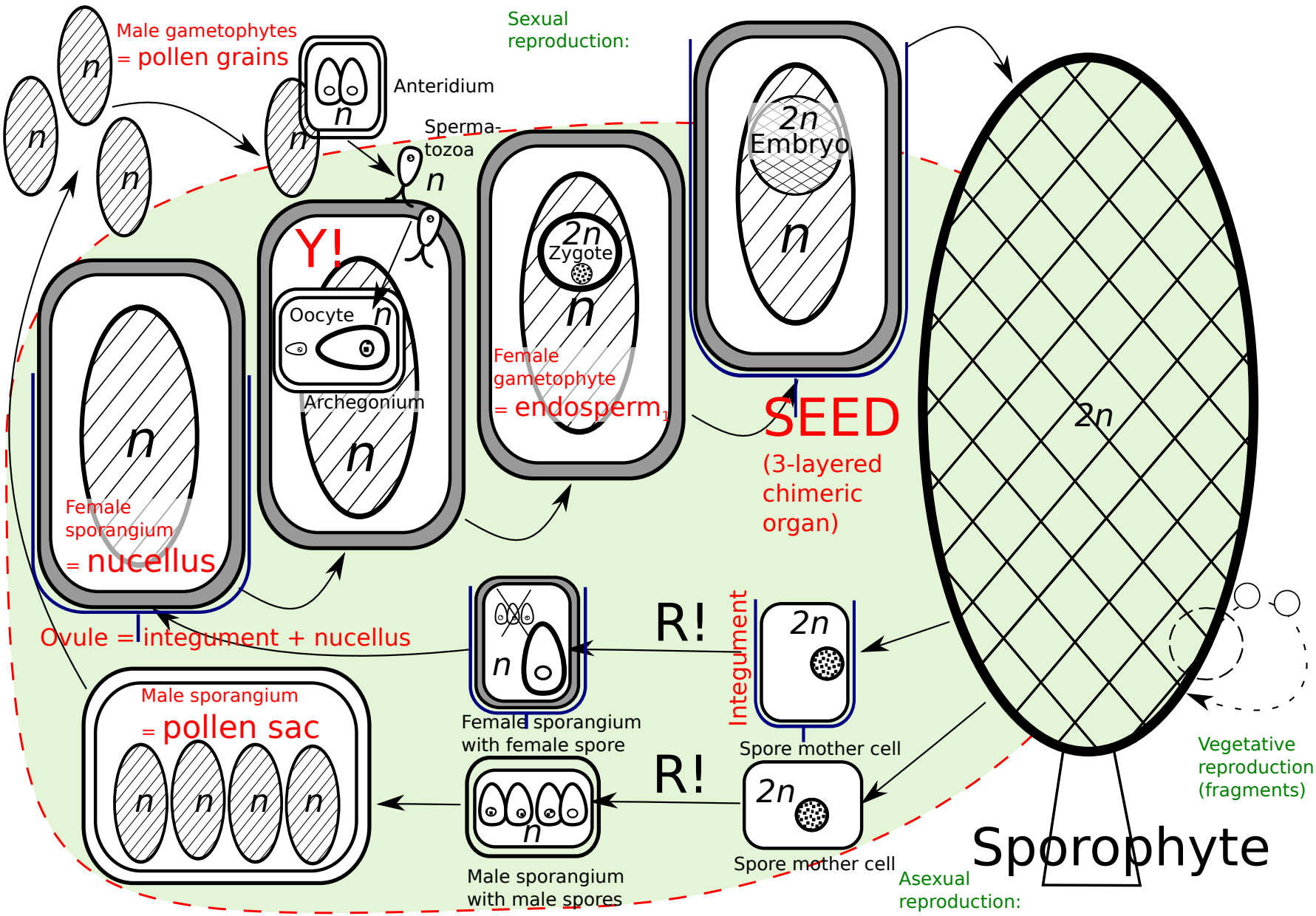


Seed plants have life cycle where almost all stages happen on mother sporophyte

Terms covered:

- Ovule and integument
- Nucellus and pollen sac
- Pollen grains and endosperm
- Seed

Seed plant cycle: differences



Summary: the seed

- Seed is a **chimeric organ** with three layers: (1) mother sporophyte tissue (integument + nucellus), (2) female gametophyte tissue (endosperm) and (3) daughter sporophyte (embryo)
- Biggest disadvantages of having seed are: (a) low probability of fertilization (pollination needed) and (b) overall slowness of cycle
- “Hot spots” of seed life cycle: (1) pollination with wind, insects or anything, (2) fertilization with **pollen tube** and (3) reduction of gametophytes

For Further Reading

A. Shipunov.
Introduction to Botany [Electronic resource].
Mode of access:
http://ashipunov.info/shipunov/school/biol_154