

Introduction to Botany. Lecture 31

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1 Questions and answers

- Quiz

2 Branching, thickening and the origin of seed

- Branching
- Secondary stem
- Diversity of wood
- Life forms
- Modifications of stem / shoot



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Questions and answers

Quiz



Final question (3 points)

Why heterospory “is better”?



Final question (3 points)

Why heterospory “is better”?

- It allows for numerous optimizations of life cycle.



Branching, thickening and the origin of seed

Branching

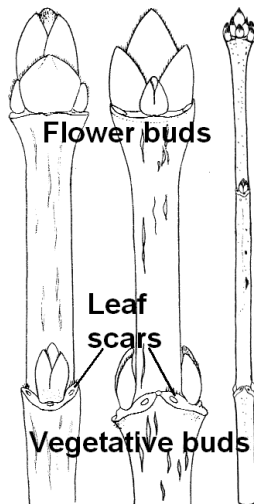


Where to see branching: winter shoot

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



Winter shoot of maple (*Acer platanoides*)

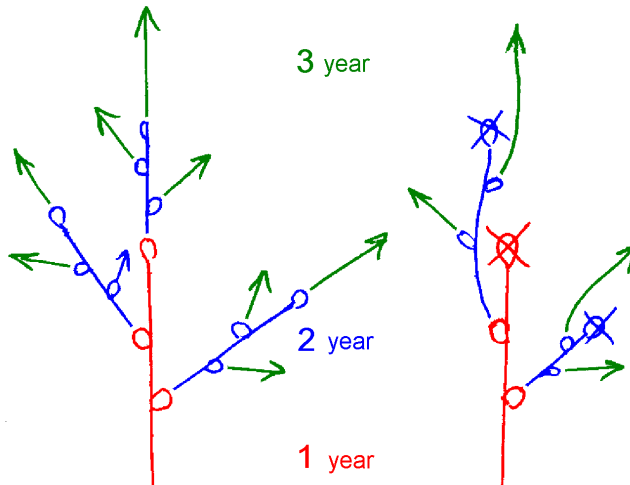


Types of branching

- **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

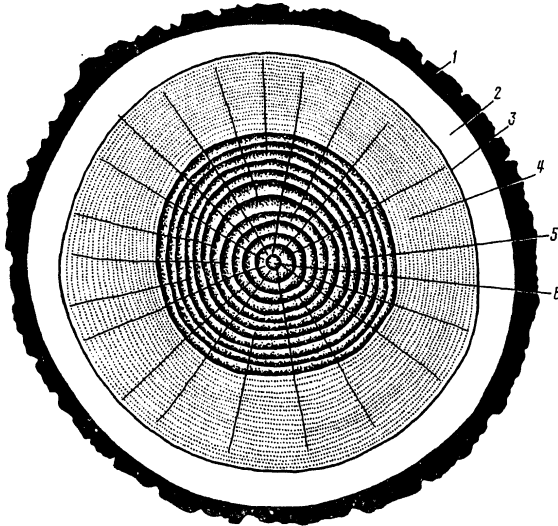


Branching, thickening and the origin of seed

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]

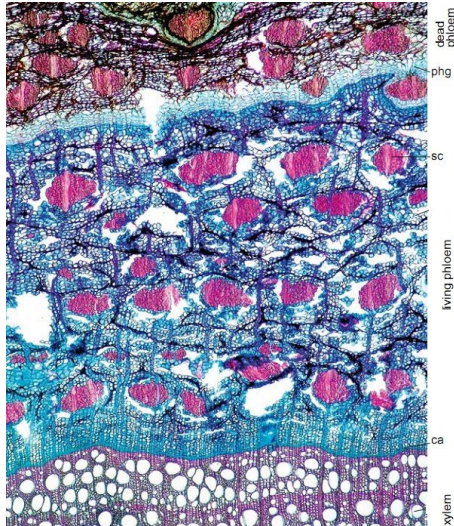


Cork cambium and origin of bark

- 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*)



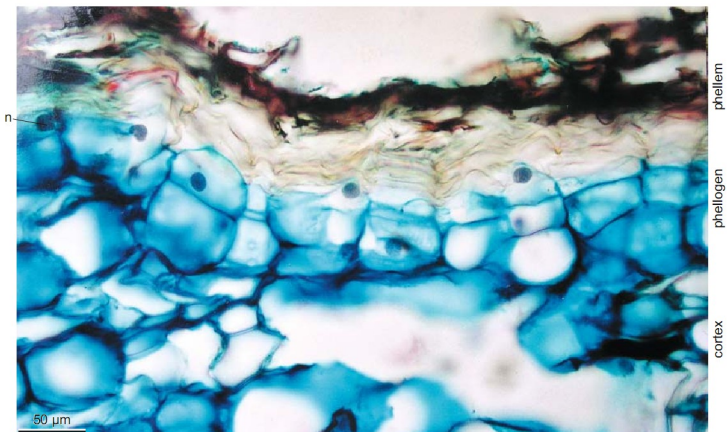
phg phellogen, ca cambium, sc sclerenchyma

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.)

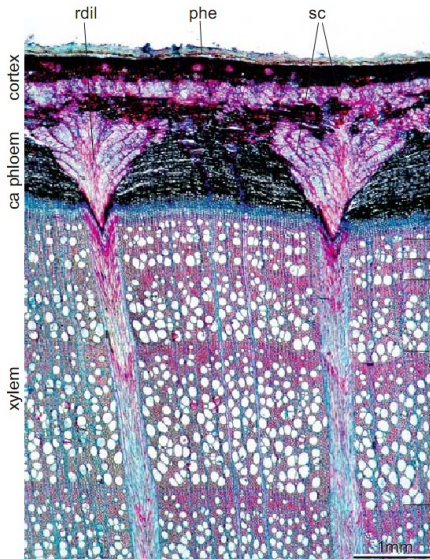


Secondary phloem (bast)

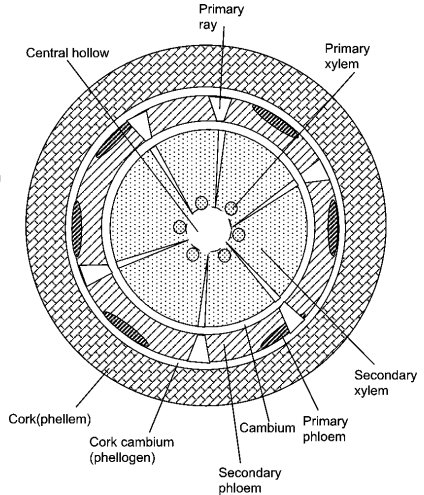
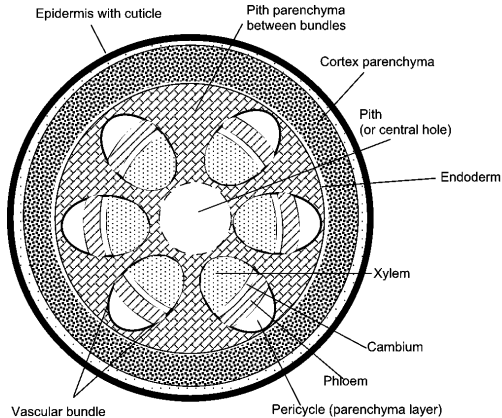
- Forms outside vascular cambium
- Rich of fibers
- Does not form annual rings
- Has rays of parenchyma cells, sometimes wedge-shaped (**dilated**)



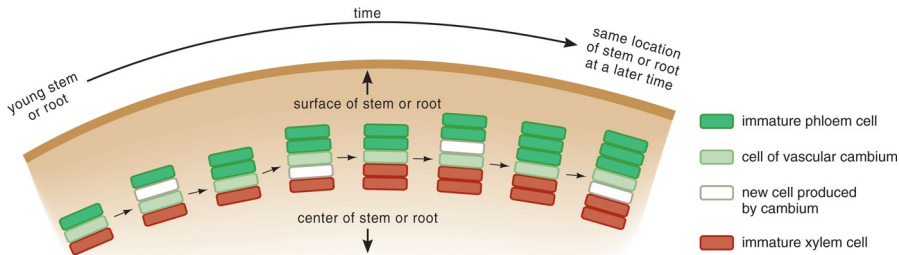
Dilated rays in beech (*Fagus* sp.) stem



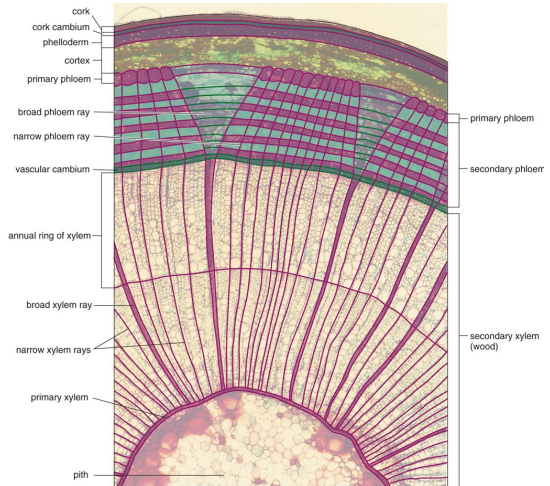
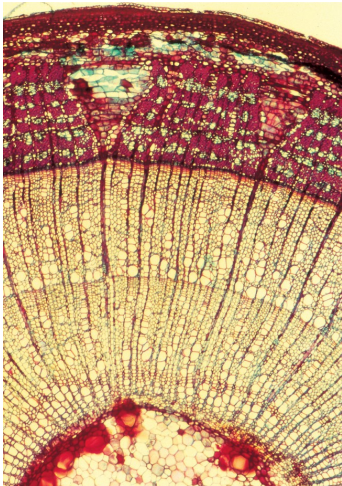
Primary and secondary stems (scheme)



How cambium works



Secondary structure of stem (photo and explanations)

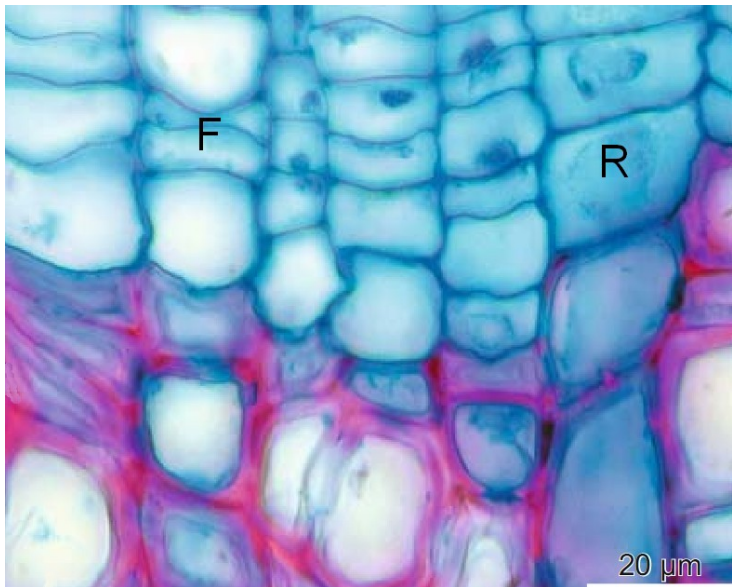


Secondary xylem and rays

- 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

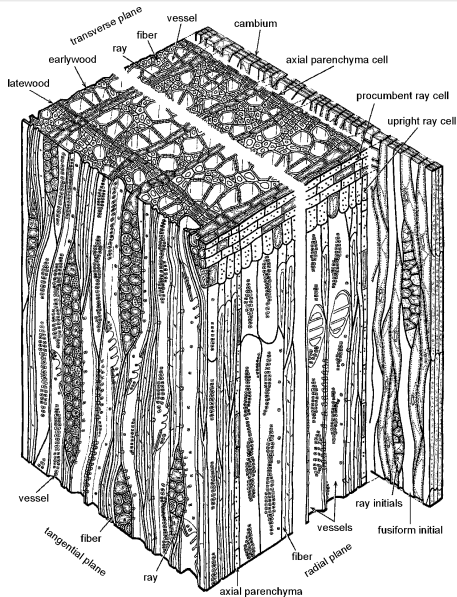


Three planes of view

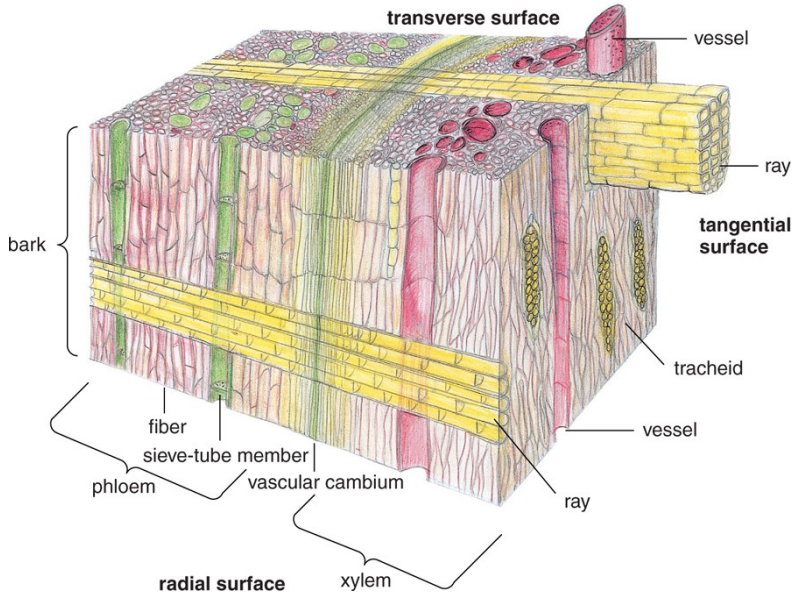
- **Transverse** (cross-section)
- **Radial** (longitudinal section from center to periphery and perpendicular to stem surface)
- **Tangential** (longitudinal section parallel to stem surface)



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.)



ew
lw

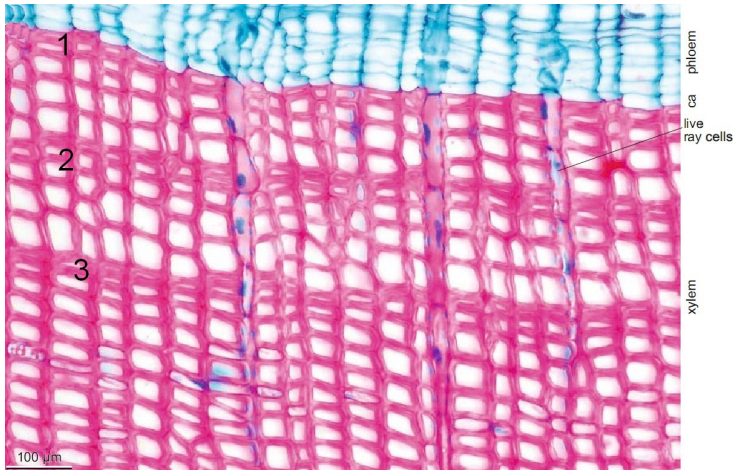


Annual rings

- 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.)

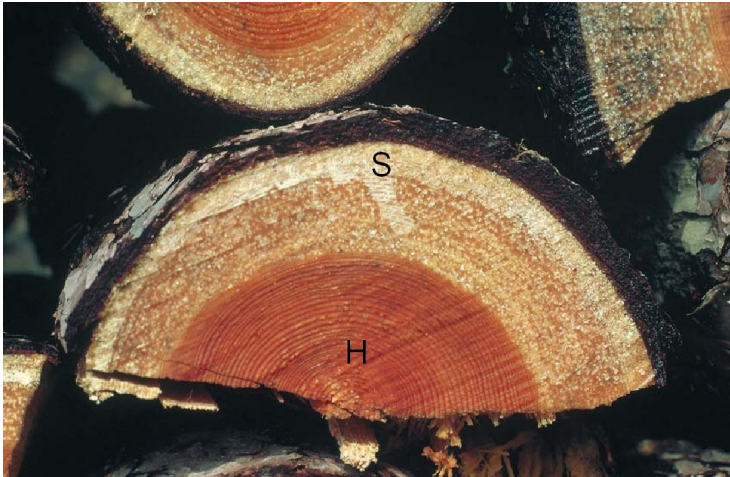


Sapwood and heartwood

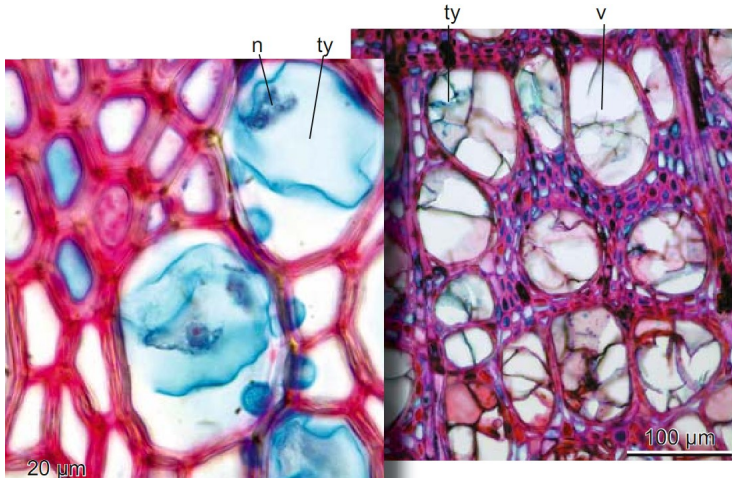
- **Sapwood** is a peripheral layer of working xylem, it usually has relatively light color
- **Heartwood** is a central, non-functional, old, dark-colored xylem



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

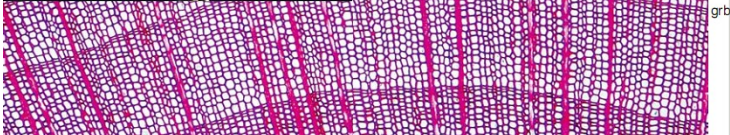
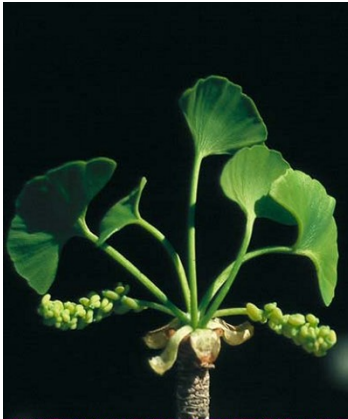


Conifer wood

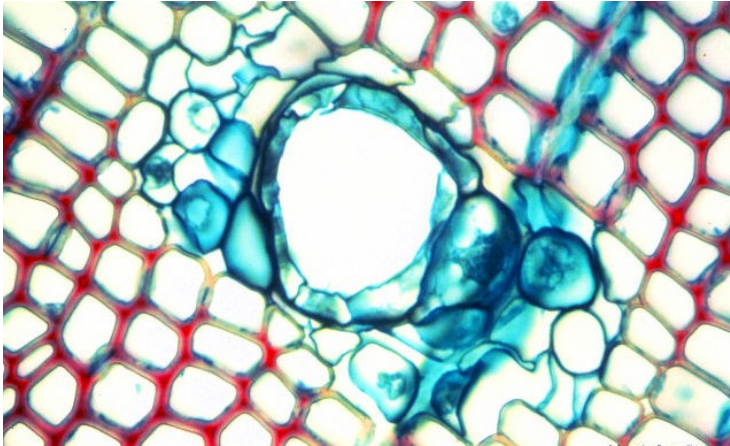
- Simpler structure, few cell types
- Simple rays
- Sometimes have **resin ducts**; resin secreted by epithelial cells



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



Resin duct in pine wood (©BSA)

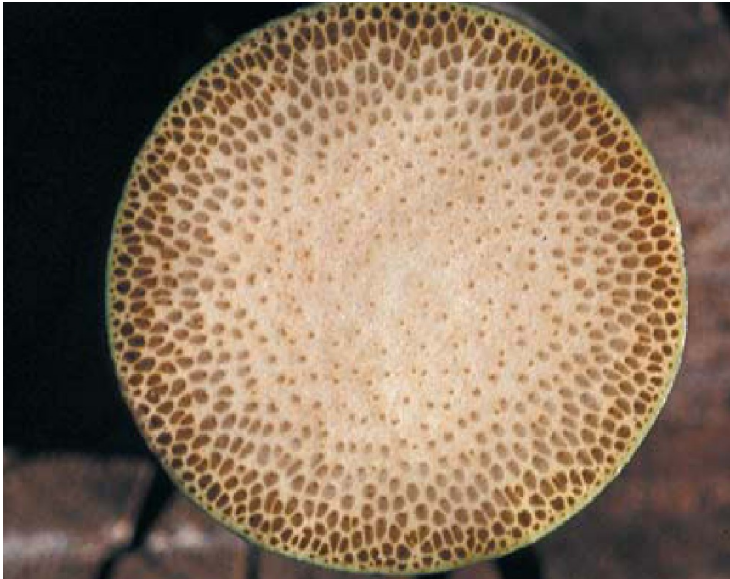


Monocot “wood”

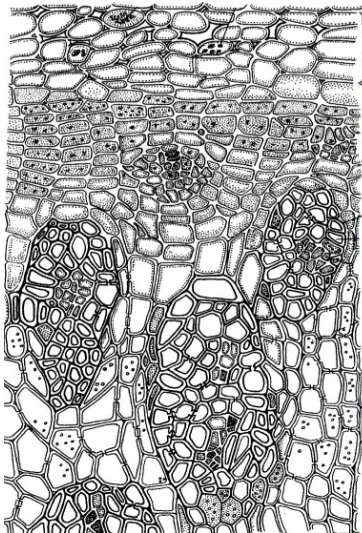
- Most of monocots do not have lateral meristems and therefore have no true wood
- Palms have only primary tissues; their trunk widens from bottom to top
- Some monocots (dragon trees) have **anomalous secondary growth**



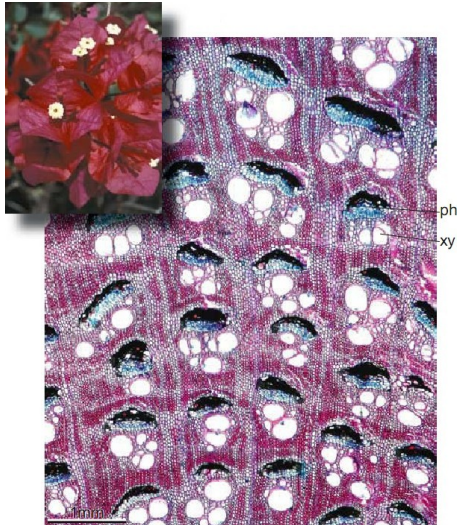
Cross section of palm (*Phoenix canariensis*) trunk



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

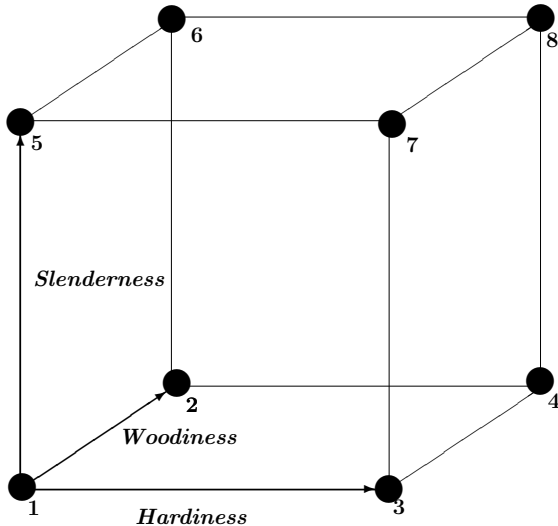


Life forms: dynamic approach

- **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



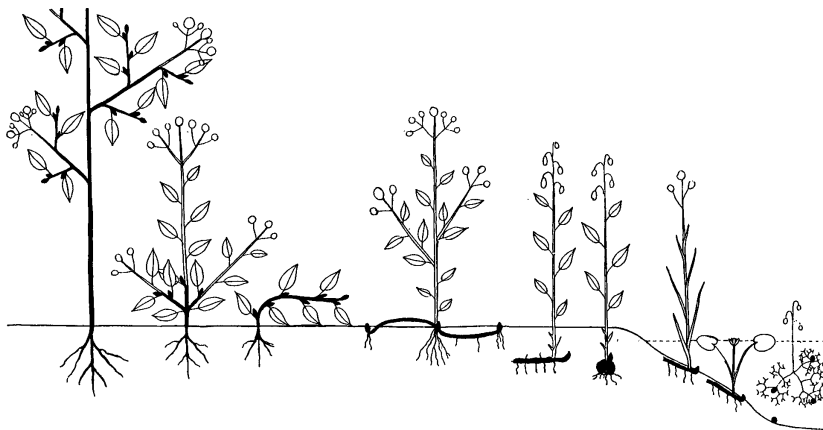
Life forms: Raunkiaer's approach

- **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

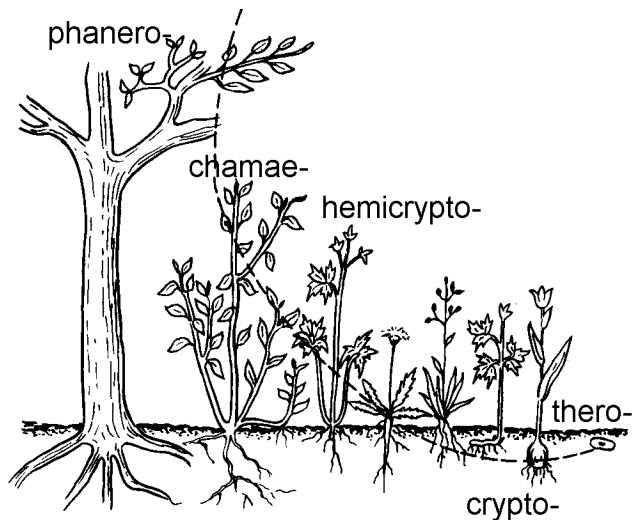
The Raunkiaer system is very useful to characterize the whole *floras*, especially temperate floras



Raunkiaer classification (after Raunkiaer, 1937)



Raunkiaer classification again

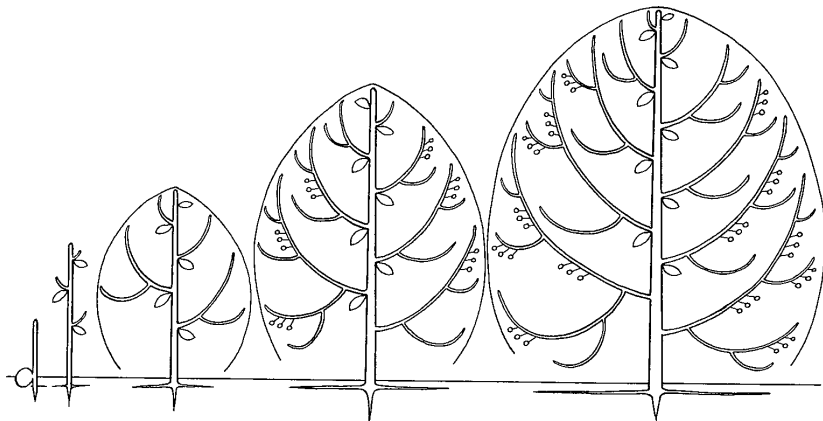


Life forms: architectural models

- 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: Attimis



Many temperate trees are growing according to this model

Branching, thickening and the origin of seed

Modifications of stem / shoot

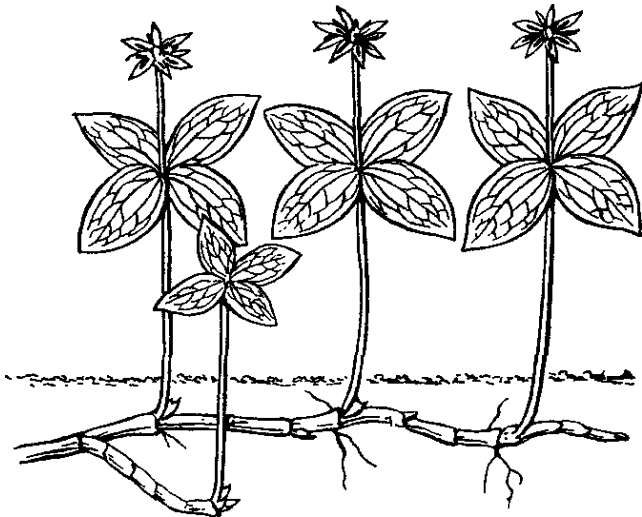


Modifications of shoots and stems

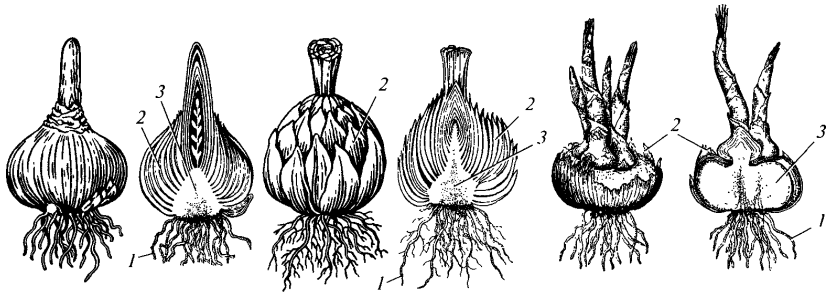
- **Rhizomes**: underground stems
- **Stolons** (runners): aboveground horizontal shoots
- **Tubers**: enlarged portions of rhizomes
- **Bulbs**: storage shoots, leaves $> 50\%$ of volume
- **Corms**: storage shoots, leaves $< 50\%$ of volume
- **Thorns**: defense shoots
- **Spines**: defensive emergencies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



Rhizome

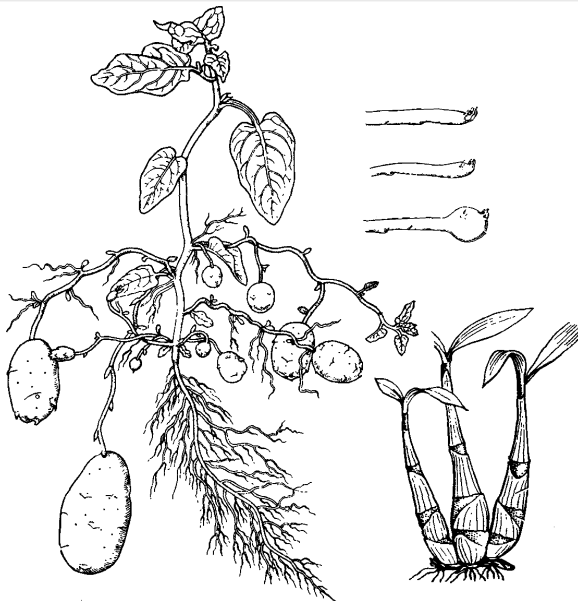


Bulbs and corms



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

Tubers: potato and orchids



Thorns



Cladophylls: leafy stems



Traps of bladderwort (*Utricularia*)



Final question (2 points)



Final question (2 points)

What is a heartwood?



For Further Reading



A. Shipunov.

Introduction to Botany [Electronic resource].

Mode of access:

http://ashipunov.info/shipunov/school/biol_154

