SEEDLESS VASCULAR PLANTS: FERNS AND FERN ALLIES

EVOLUTION OF VASCULAR PLANTS

•

(i.e., embryo) and together they form the embryophytes

•The origin is a *Chara*- or *Coleochaete*-like green algae

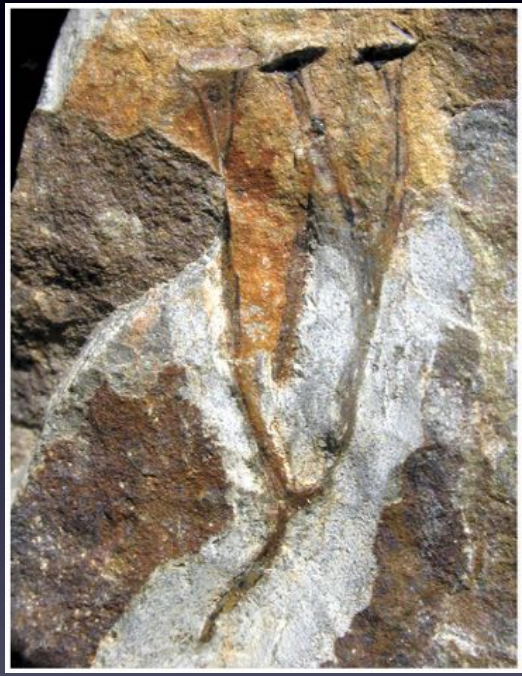
•Similar life cycle: alternation of heteromorphic generations

•Bryophytes have a larger and free gametophyte and a sporophyte permanently attached to the gametophyte

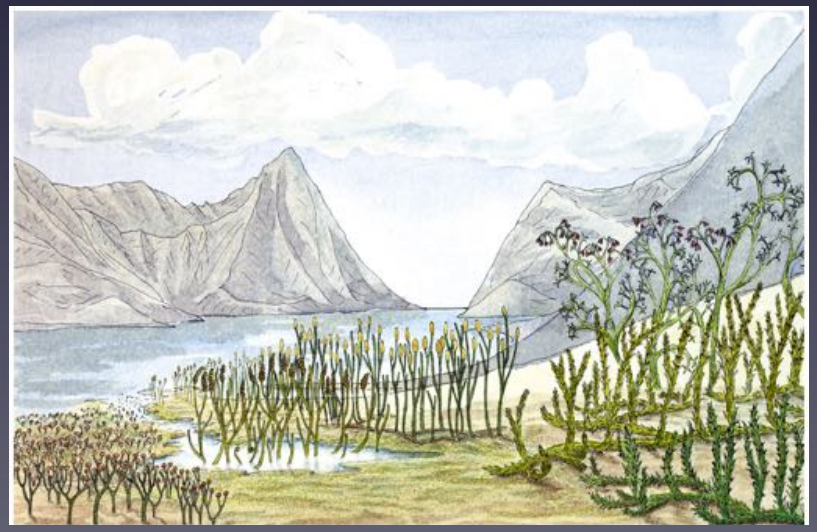
•However, vascular plants have sporophytes larger than gametophytes and free-living

•Xylem and phloem resolved the conduction problem

•Lignin add support to a larger body on a terrestrial habitat



- As plant life progressed on land the plant body developed roots, stems and leaves
- The gametophytic generation underwent a reduction in size
- Seeds evolved providing nutrients and protection to the embryo
- Some vascular plants never developed seeds (seedless vascular plants), their gametophytes are similar to those of the bryophytes
- Vascular plants were numerous and diverse by the Devonian period (408-362 mya)
- There are seven phyla of living vascular plants and several with extinct ones
- Ferns and fern allies belong to two phyla: Lycopodiophyta and Pteridophyta



Organization of the Vascular Plant Body

- morphological and physiological differences arose between various parts of the plant body, and becoming the organs of the plants
- Roots make the Root System, anchoring the plant and absorbing water and minerals from the soil
- Stems and leaves make up the Shoot System, with the stems raising the specialized photosynthetic organs –the leaves- toward the sun
- Cells are organized into tissues
- Tissues are organized into systems
- The Dermal Tissue System is the outer, protective covering of the plant
- The Vascular Tissue System comprises the conductive tissues, xylem and phloem, and it is embedded in…
- The Ground Tissue System

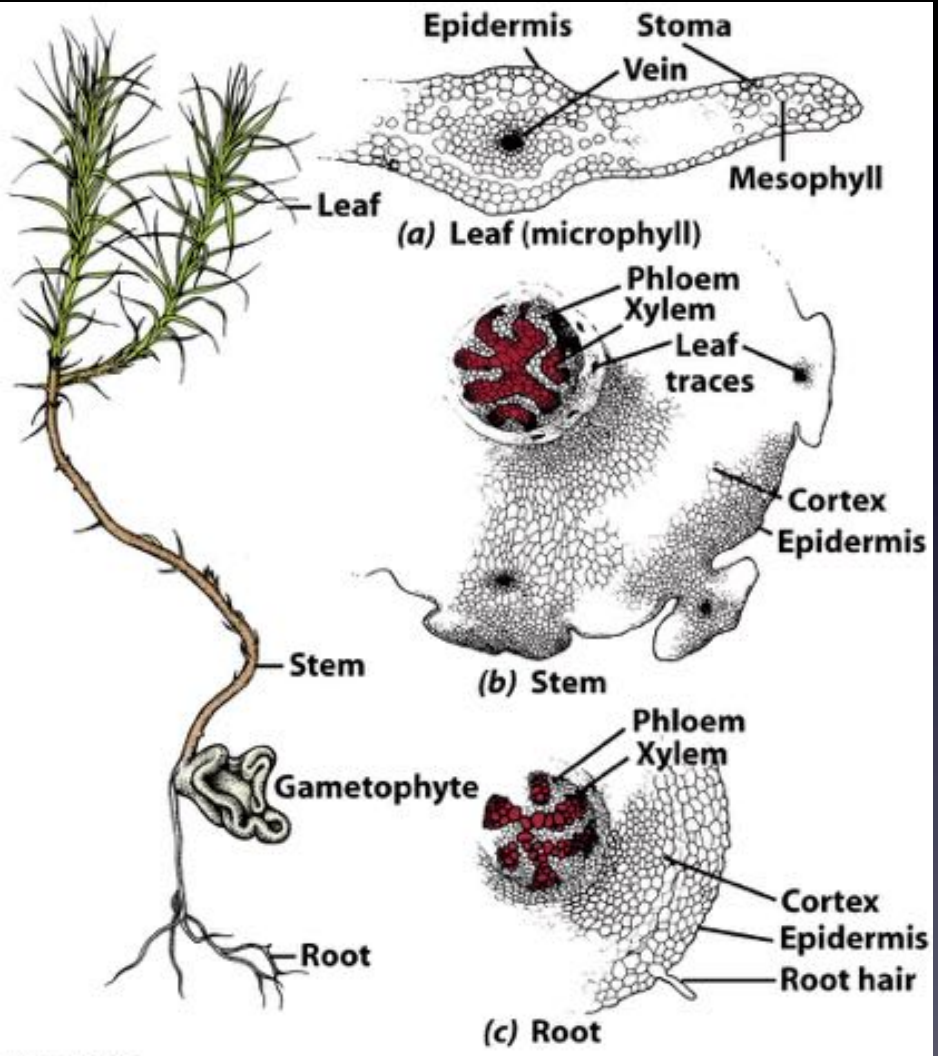


Figure 17-3
Raven Biology of Plants, Eighth Edition

Primary growth involves the extension of roots and stems, and secondary growth increases their thickness

- Primary growth is the growth that occurs relatively close to the tips of roots and stems, initiated by the apical meristems, and involved with the extension of the body
- The primary growth will form the Primary Tissues
- The plant body composed of these primary tissues is called the Primary Plant Body

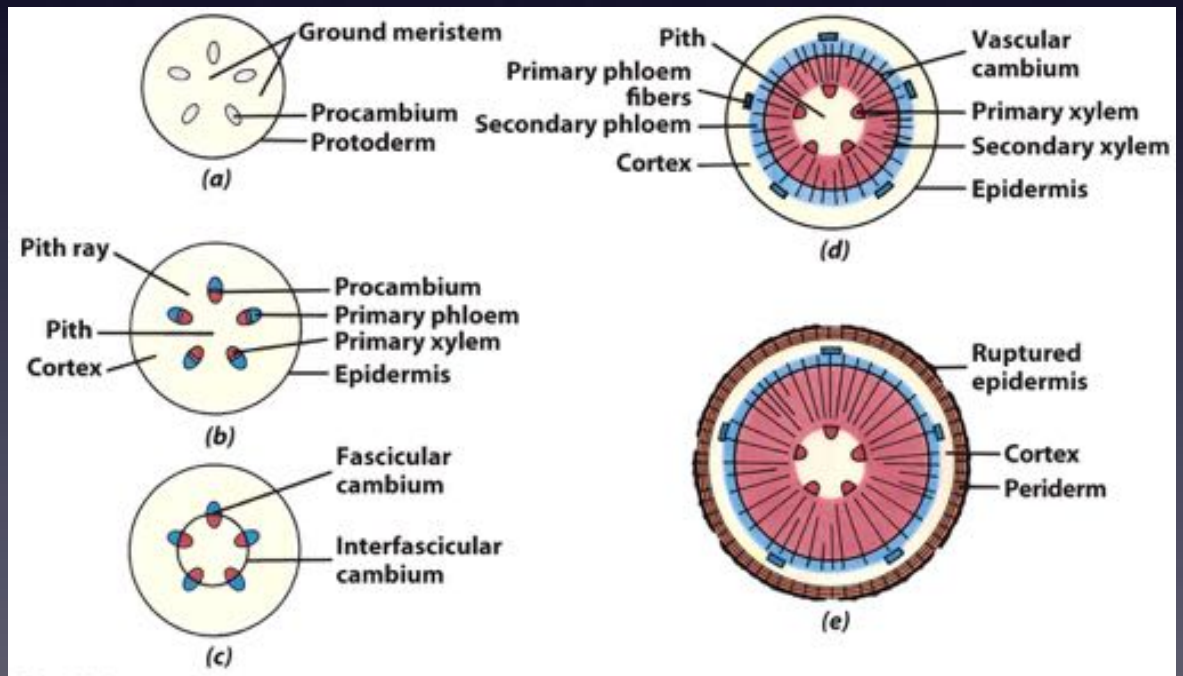


Figure 26-6
Raven Biology of Plants, Eighth Edition

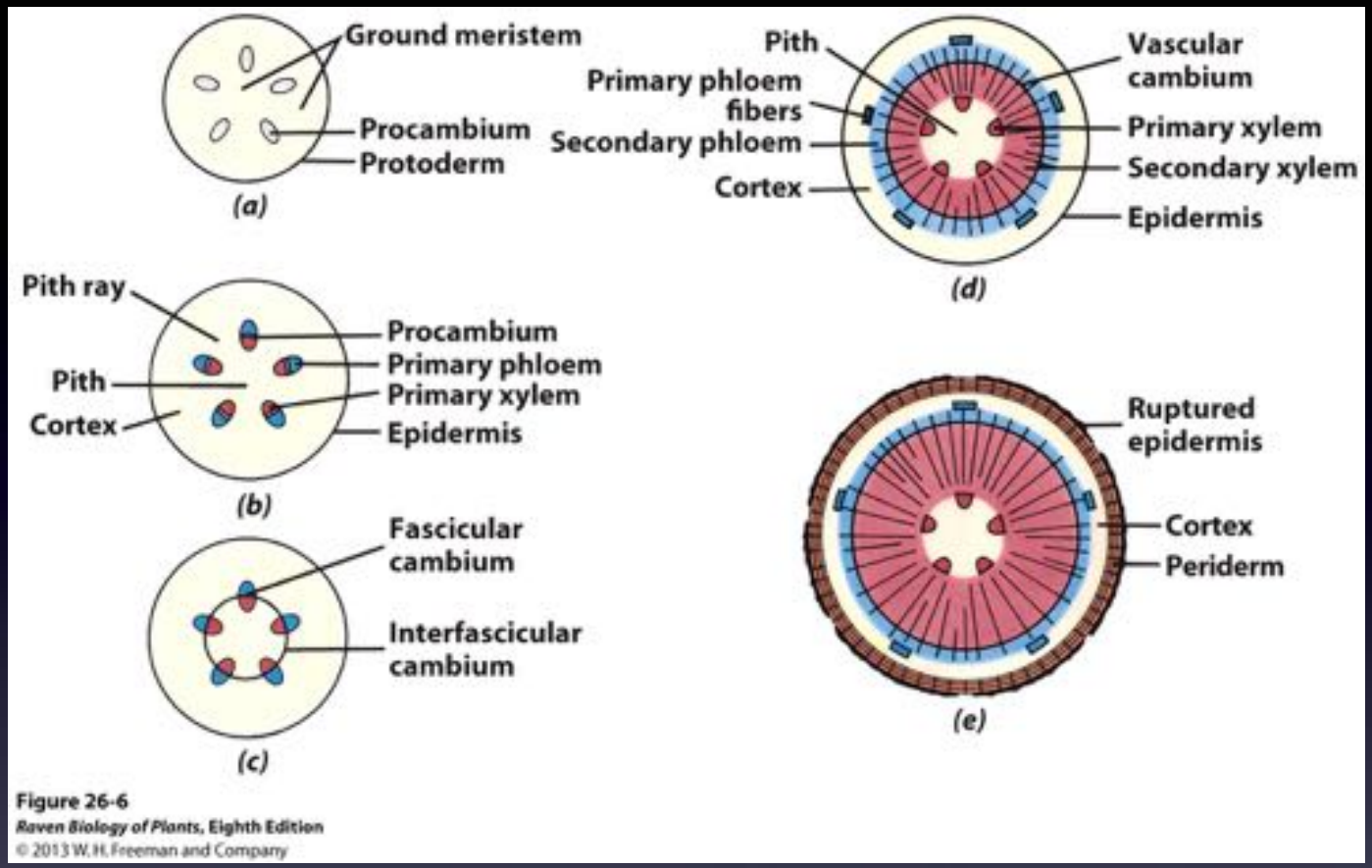


Figure 26-6
Raven Biology of Plants, Eighth Edition

- Many plants engage in additional growth that thickens the stem and root, or Secondary Growth.
- Is the result of lateral meristems, the vascular cambium, that produces secondary vascular tissues or secondary xylem and secondary phloem
- A second lateral meristem, the cork cambium, will form a periderm, mostly cork tissue; this will replace the epidermis.
- Secondary vascular tissues and periderm make up the Secondary Plant Body

Tracheary elements –tracheids and vessel elements- are the conducting cells of the xylem

- Treachery elements are the conductive cells of the xylem with lignified wall thickenings
  - Tracheids are treachery elements with elongated cells with long tapering ends, the only type of water conductive cell in most vascular plants, other than angiosperms
  - Tracheids are more primitive than Vessel elements, which are the principal water-conductive cells in angiosperms
- Sieve elements are the conductive cells of the phloem with soft walls

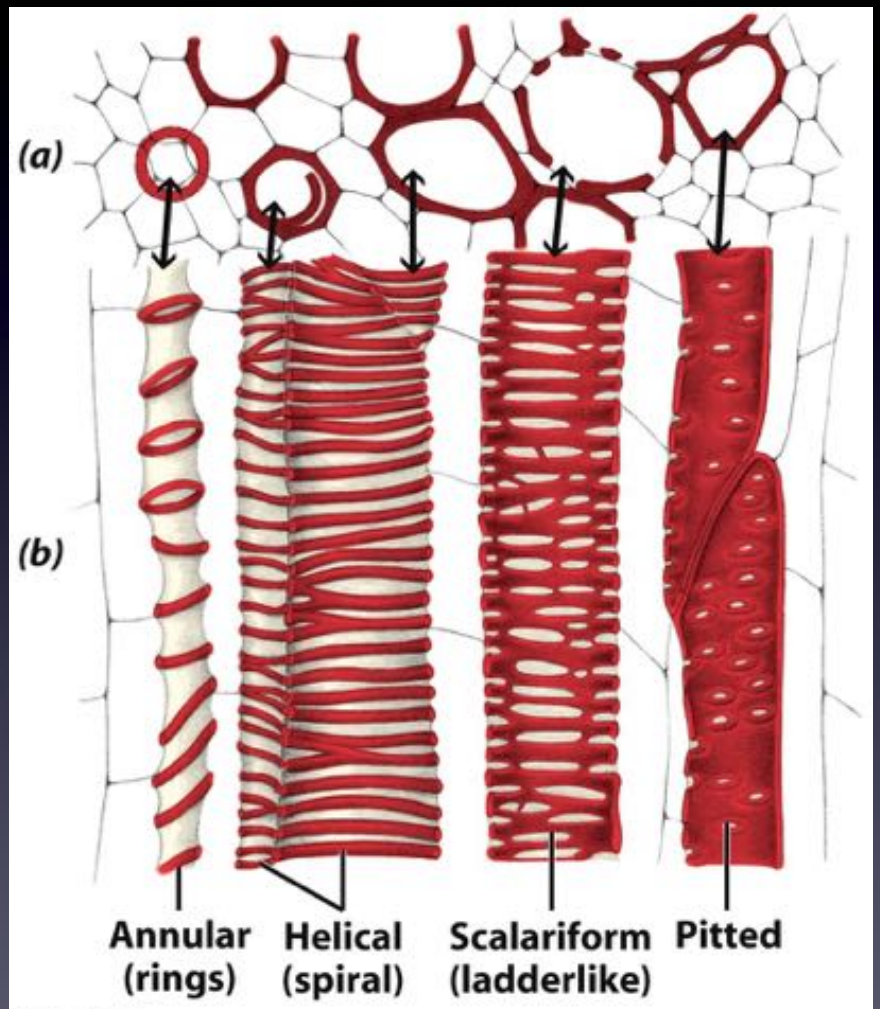
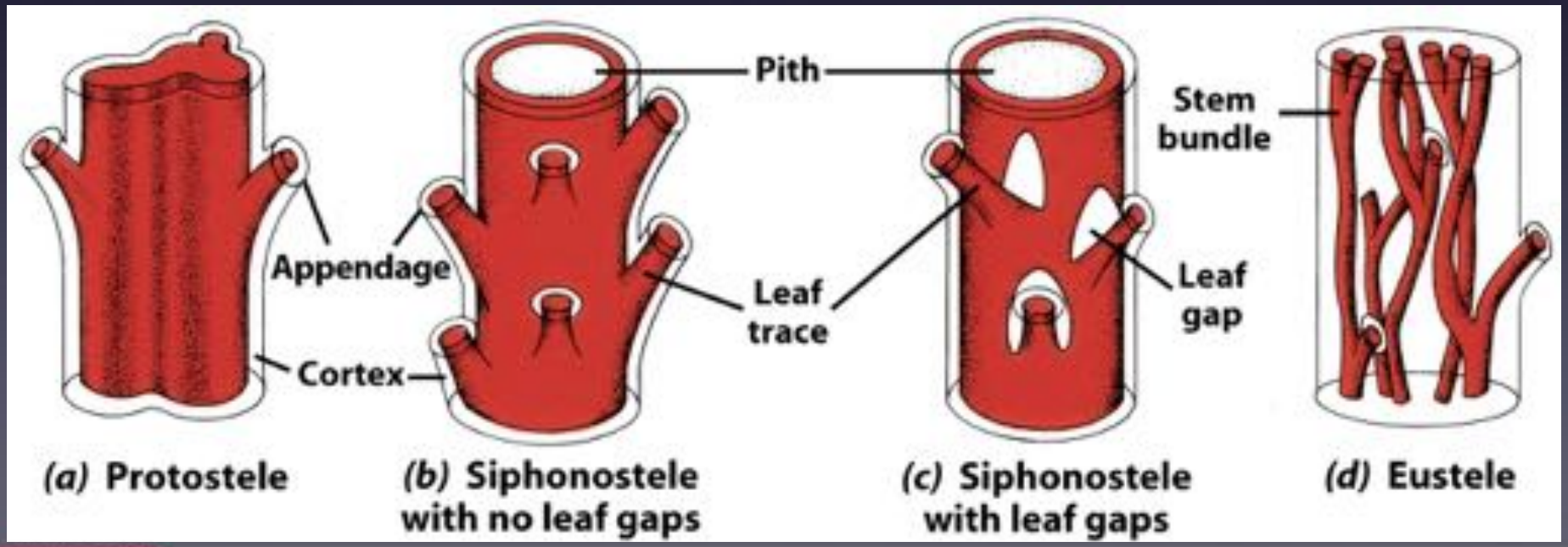


Figure 17-4
Raven Biology of Plants, Eighth Edition

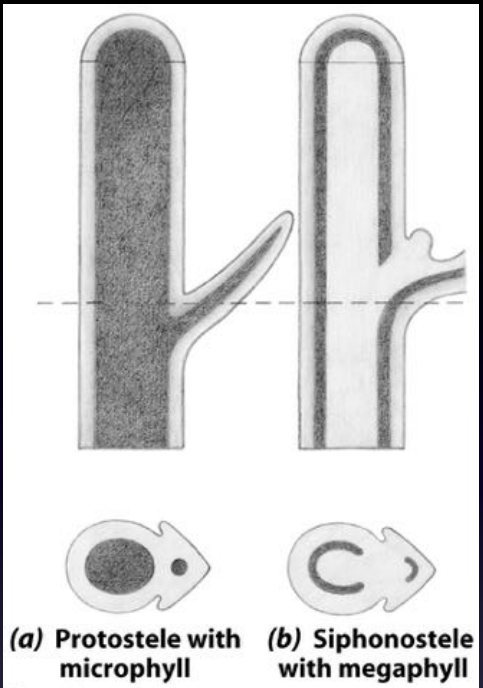
Vascular tissues are located in the Vascular cylinders, or steles, of roots and stems

- Primary vascular tissues (1ary xylem and 1ary phloem) and a central column of ground tissue (pith), form the central cylinder or stele
  - Protostele: primitive, no pith, usually the phloem surrounds the xylem
  - Siphonostele: a central pith surrounded by vascular tissues, the phloem may be outside or on both sides of the xylem; with leaf traces with or w/o leaf gaps
  - Eustele: with a vascular cylinder consisting of a system of discrete strands around a pith

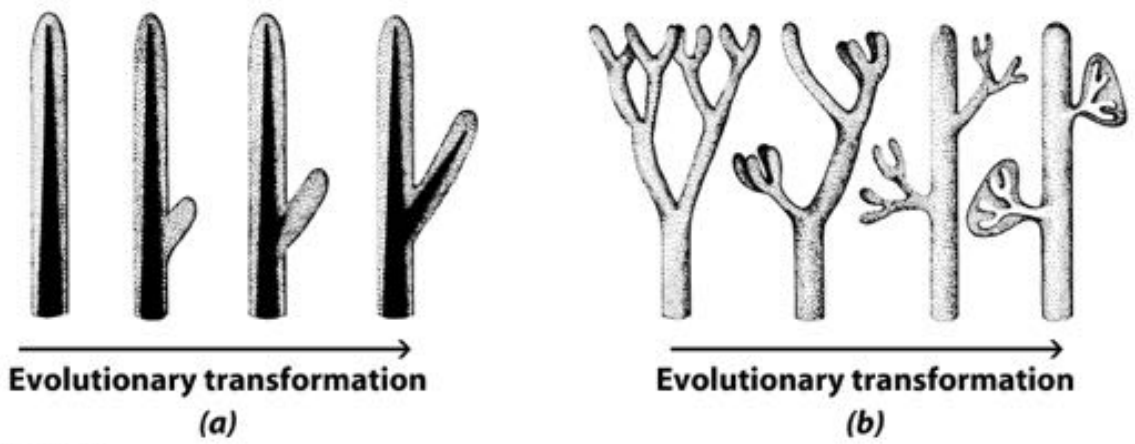


Roots and leaves evolved in different ways:

- Microphylls: small leaves with one single strand of vascular tissue usually associated with protosteles
- Megaphylls: are larger, usually associated with siphonosteles and eusteles, with leaf gaps and a branching vein system

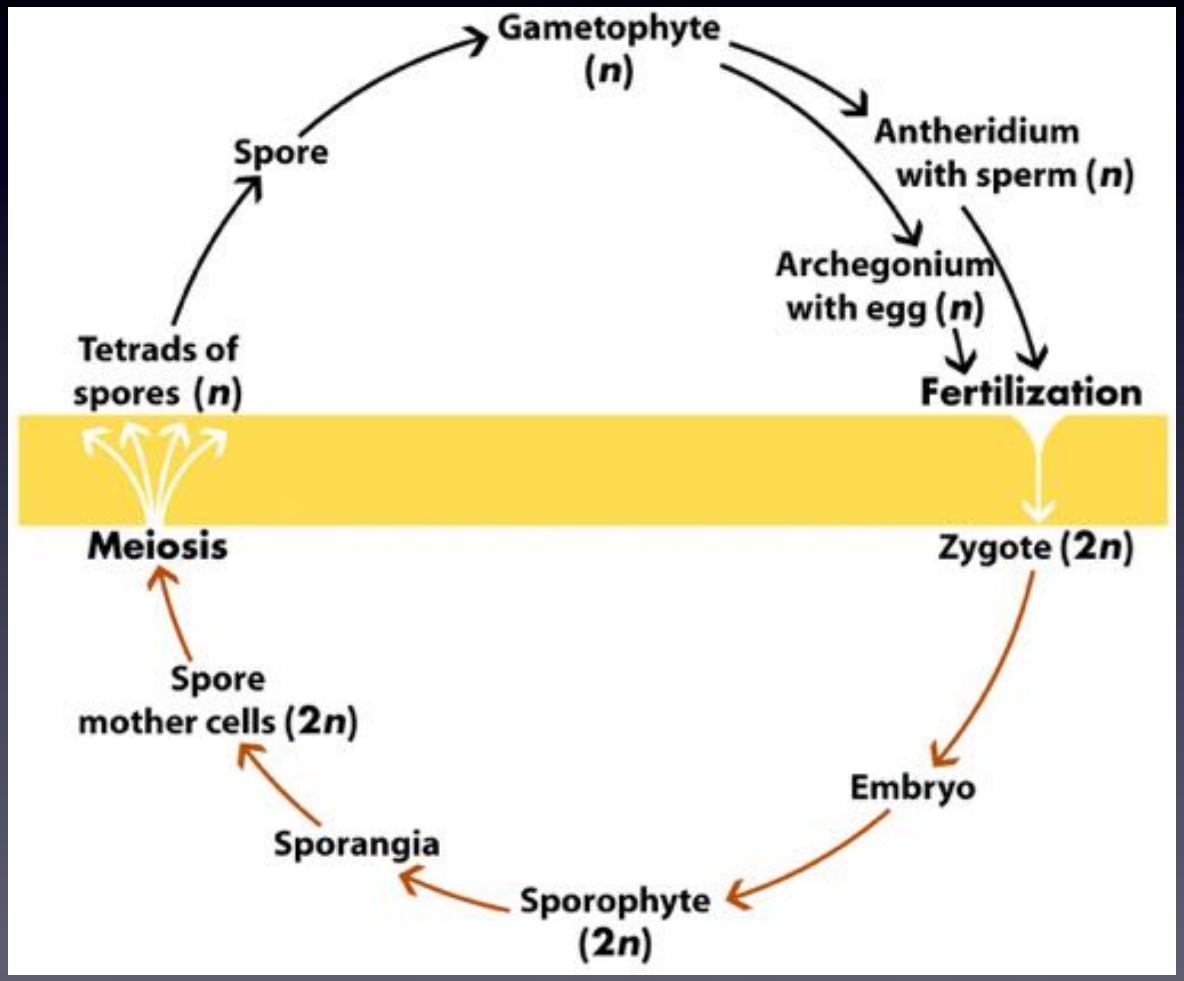


Microphylls evolved as outgrowths or enations, while megaphylls evolved by fusion of branch systems



REPRODUCTIVE SYSTEMS

- Oogamous and have an alternation of heteromorphic generation in which the sporophyte is larger and more complex than the gametophyte



Homosporous plants produce only one kind of spore, whereas heterosporous plants produce two types

•Homosporous plants produce only one kind of spore, which will form a bisexual gametophyte with exosporic development (outside the spore wall). Almost all ferns, horsetails (equisetpophytes) and some lycophytes

- In order to promote cross-fertilization, homosporic ferns mature antheridia and archegonia at different times
- In other cases, sex expression is determined by age, or stimulated by the secretion of antheridiogens
- Self-fertilization maybe advantageous for pioneer species, such as *Dryopteris expansa*

Figure 17-9
Raven Biology of Plants, Eighth Edition

Heterospory is the production of two type of spores in two different kind of sporangia

- Microspores formed in microsporangia
  - Microspores have an endosporic development and form male gametophytes (microgametophytes)
- Megaspores formed in megasporangia
  - Megaspores have an endosporic development and form female gametophytes (megagametophytes)

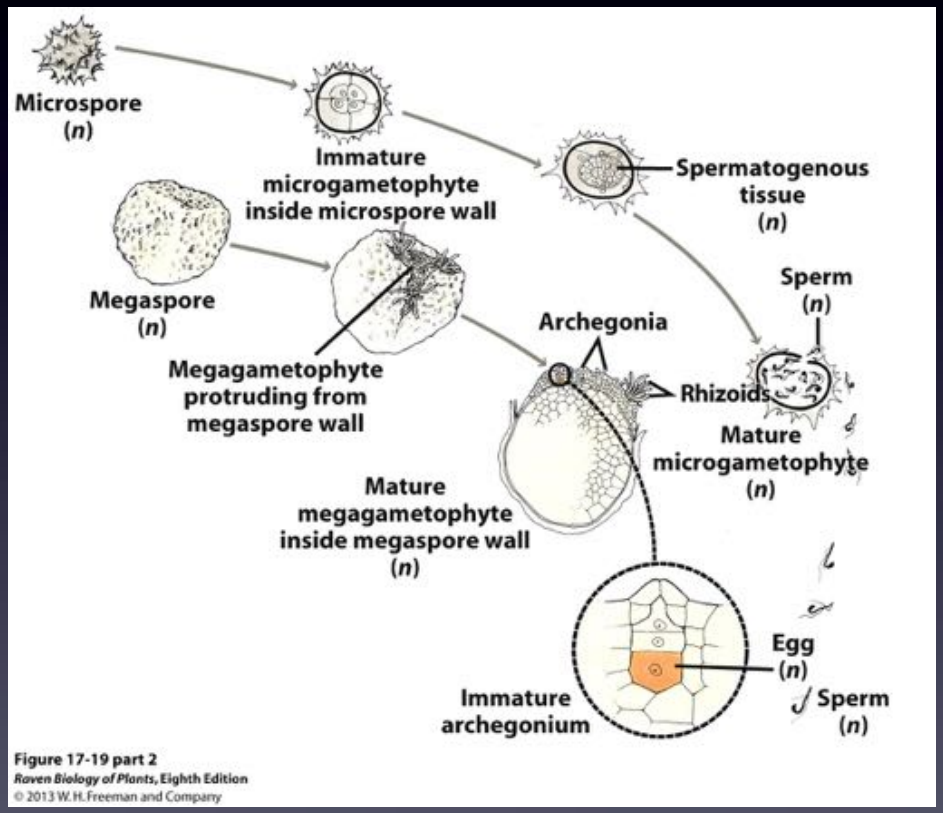


Figure 17-19 part 2
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Over evolutionary time, the gametophytes of vascular plants have become smaller and simpler

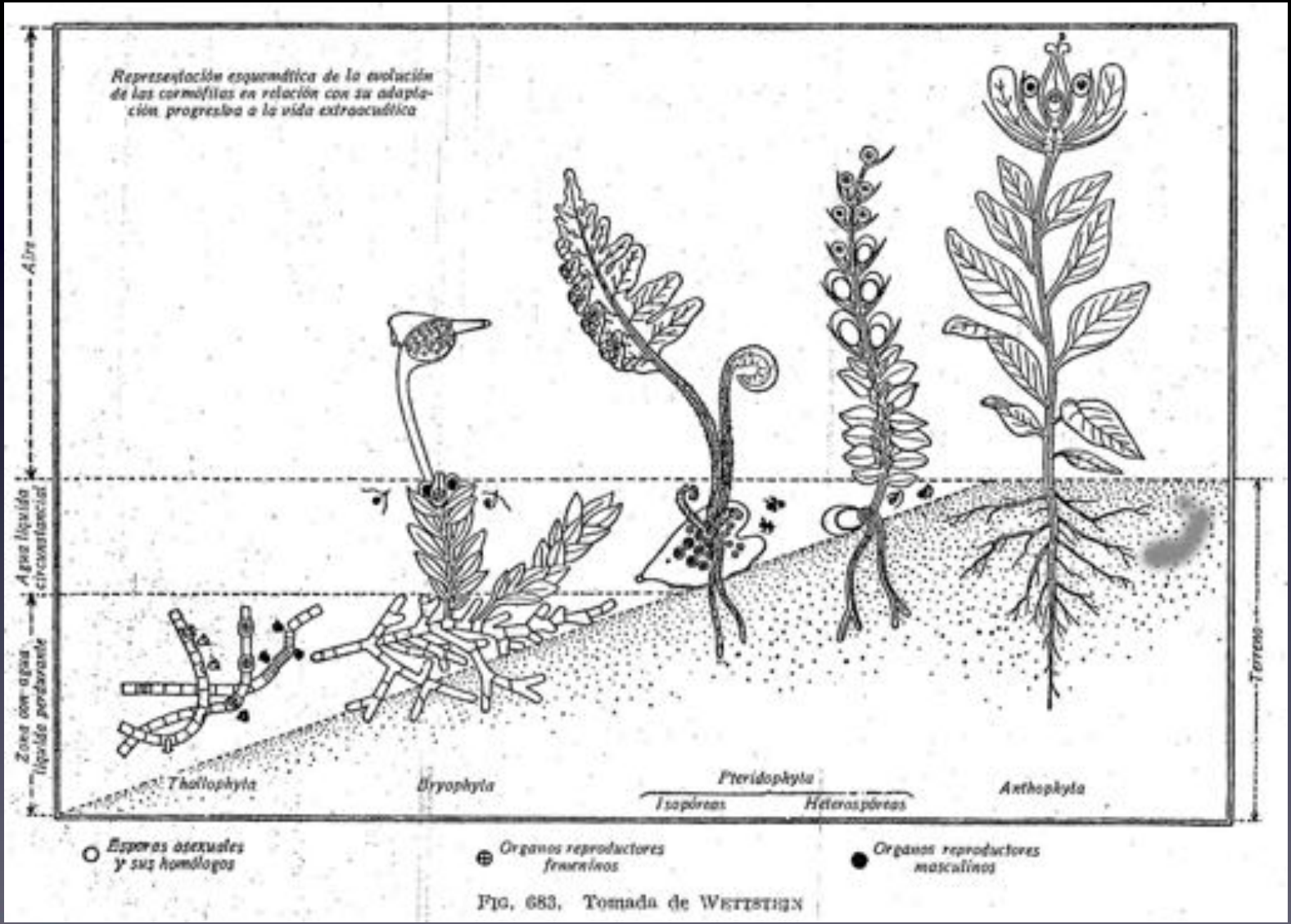


Fig. 683. Tomada de Wettstein

In land, the life cycles of plants have been modified:

GAMETOPHYTE (1N)	SPOROPHYTE (2N)
Sexual	Asexual
Requires water for fertilization	No water is required for sporogenesis
Smaller and smaller and smaller	Larger and larger and larger

Still, plants need sex…..!

THE PHYLA OF SEEDLESS VASCULAR PLANTS

1. Early vascular plants: small size and simple morphologies, dominants during the Silurian to Devonian (425 to 370 mya). Three phyla: rhyniophytes, zosterophyllophytes, and trimerophytes

Figure 17-11
Raven Biology of Plants, Eighth Edition

2. Monilophytes, lycophytes, progymnosperms: complex groups dominant from Devonian to Carboniferous (375-290 mya)
3. Seed plants arose at the end of Devonian (380 mya). Gymnosperms dominated from the Mesozoic to about 100 mya
4. Flowering plants, appeared 125 mya and dominant ever since

THE EARLY VASCULAR PLANTS (EXTINCT)

•Rhyniophyta: Dichotomously branched, stems only, with terminal sporangia, homosporous, protostele. Ancestors of trimerophytes

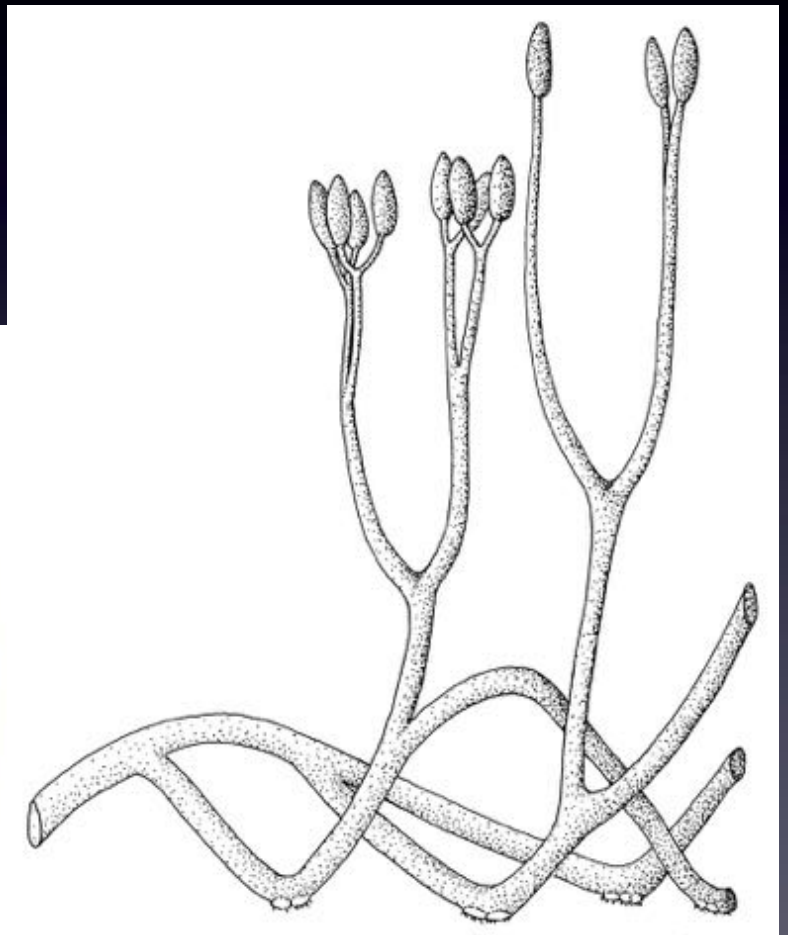


Figure 17-13
***Raven Biology of Plants*, Eighth Edition**

•Zosterophyllophyta: Dichotomously branched, stem only, homosporous and heterosporous, protostele, lateral sporangia. Related to lycophytes

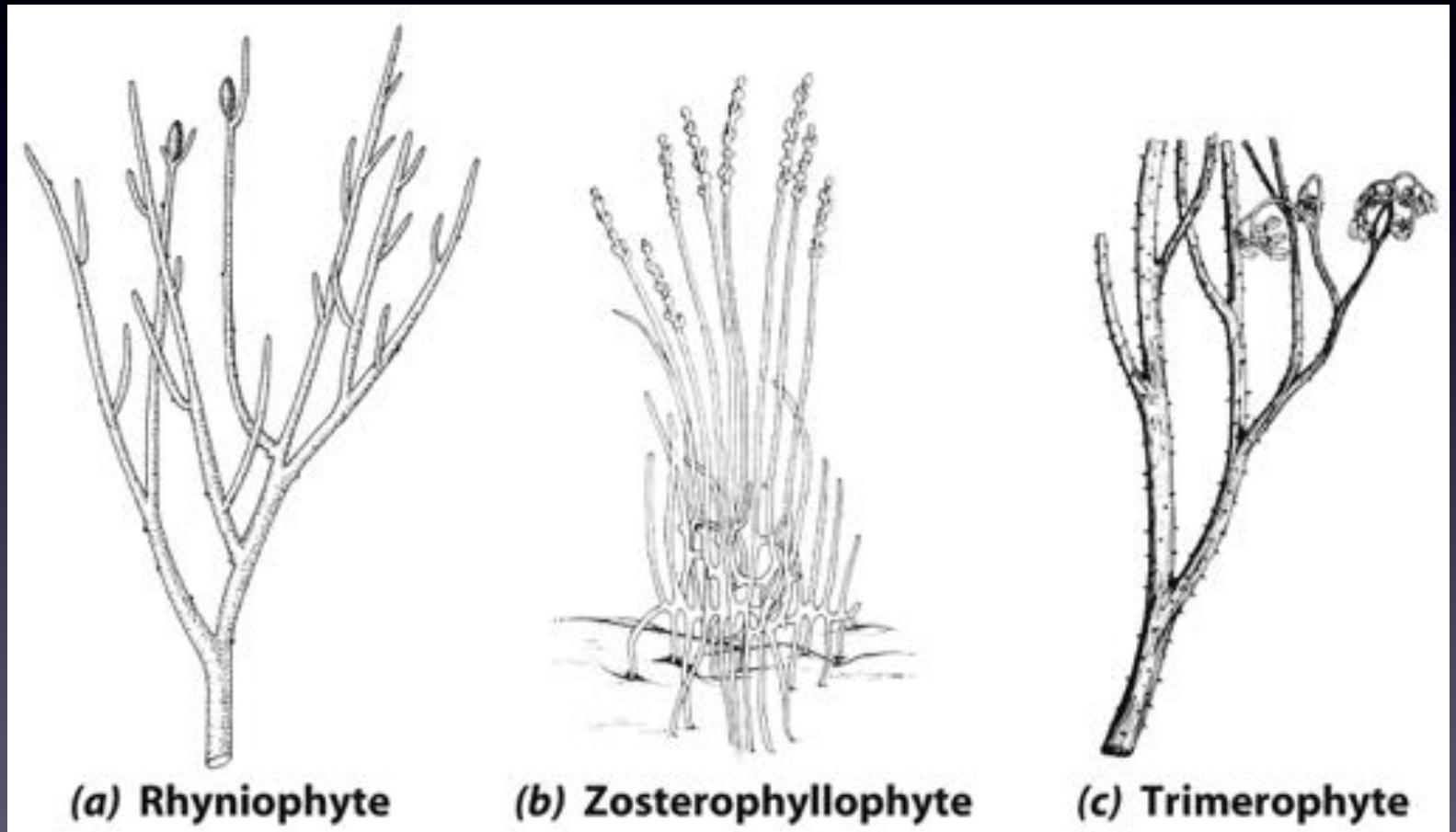


Figure 17-10
Raven Biology of Plants, Eighth Edition

•Trimerophytophyta: Larger, complex branching, only stems, homosporous, protostele, terminal sporangia. Ancestors of ferns and progymnosperms

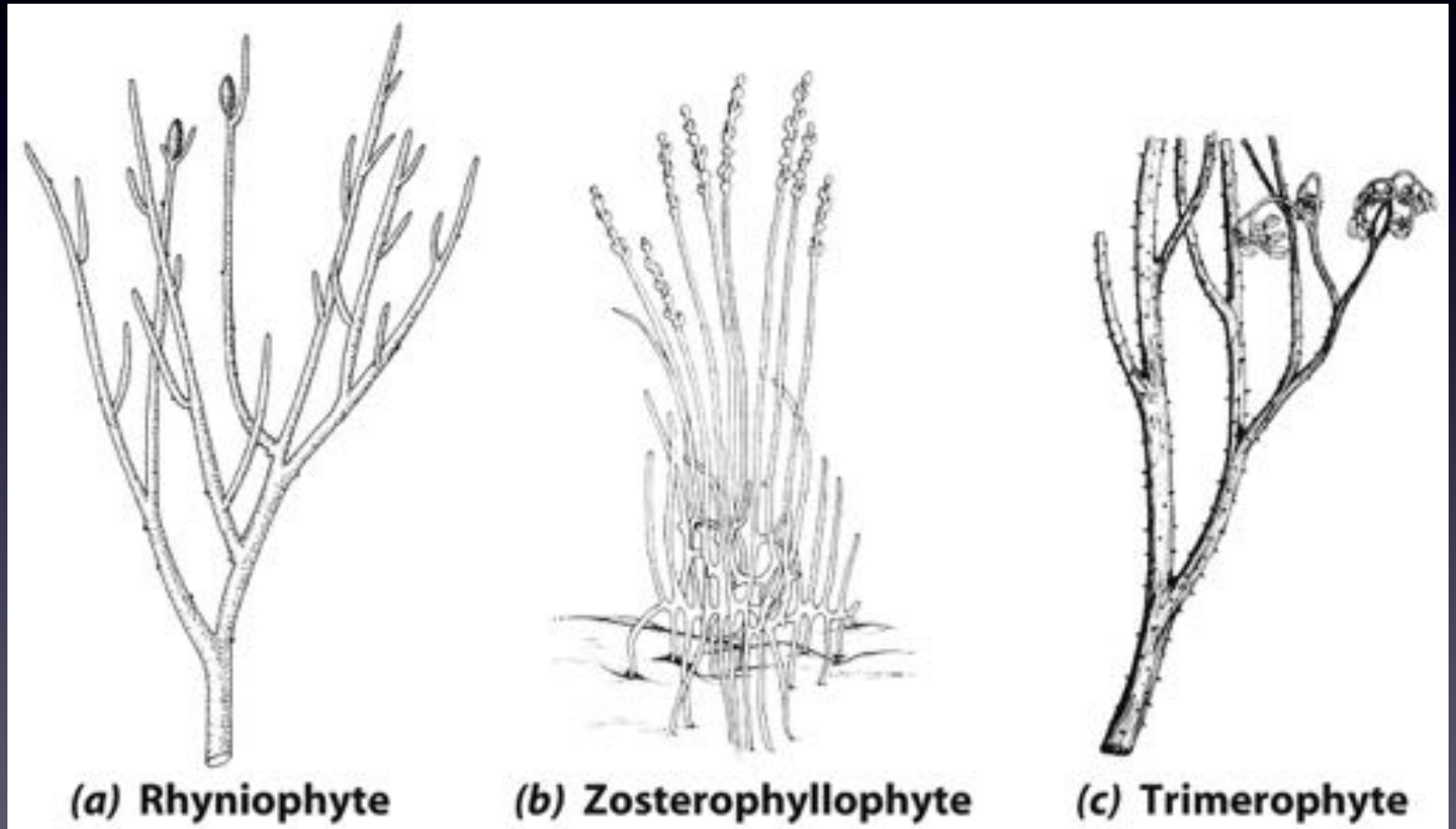


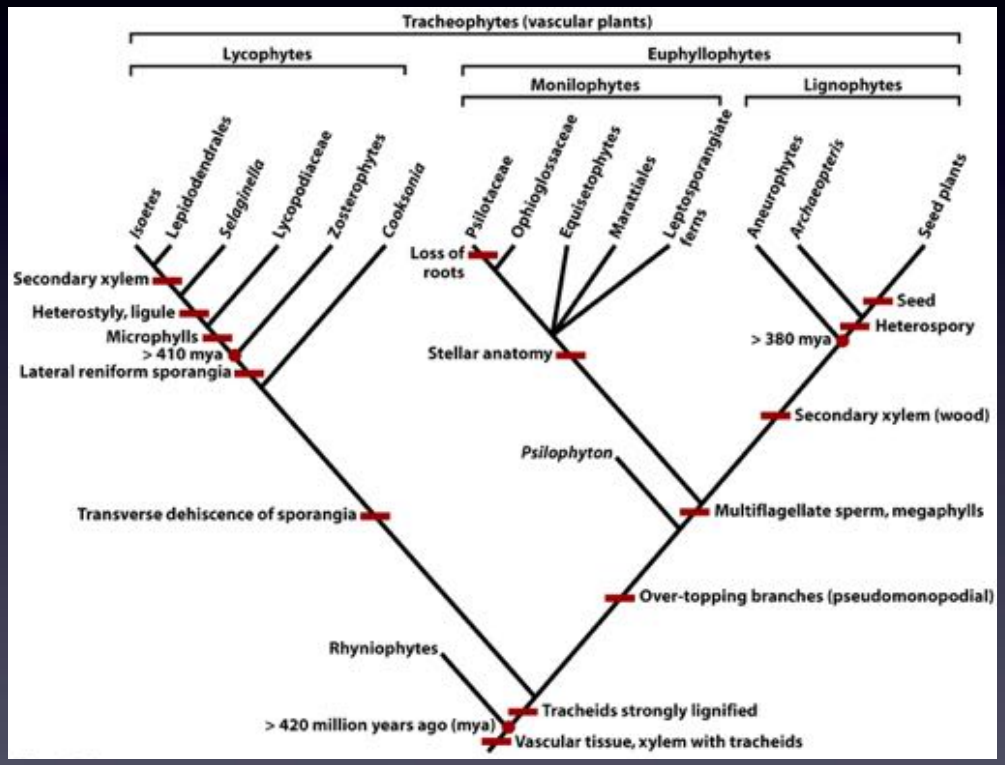
Figure 17-10
Raven Biology of Plants, Eighth Edition

PHYLUM LYCOPODIOPHYTA: THE LYCOPHYTES

- 10-15 genera and ca. 1200 living species
- Representatives appeared at the Devonian period (408 mya)
- Molecular and fossil evidence indicate that by the mid-Devonian (400 mya) the Vascular Plants or Tracheophytes had a basal split forming two lineages:

  - Lycophyte clade includes the modern lycophyte lineage

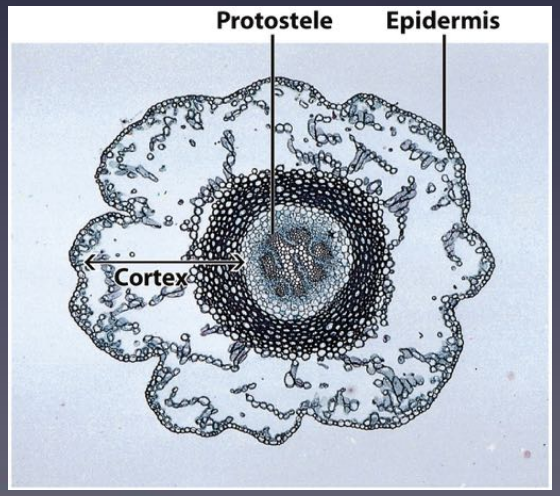
  - Euphyllophyta clade includes all other living vascular plant lineages (ferns and fern allies or monilophytes, and the seed plants

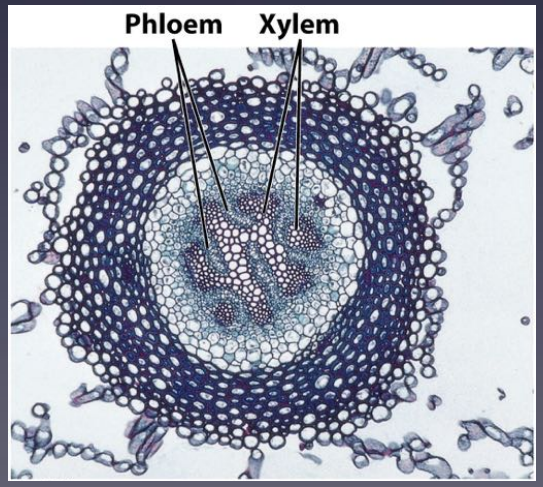


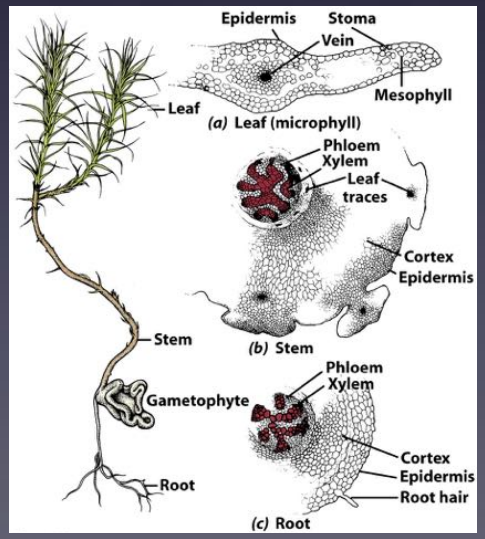
- All lycophytes are herbaceous and with microphylls
- Tree lycophytes were dominant plants during the Carboniferous period
- Three orders with one family each

ORDER LYCOPODIALES, FAMILY LYCOPODIACEAE

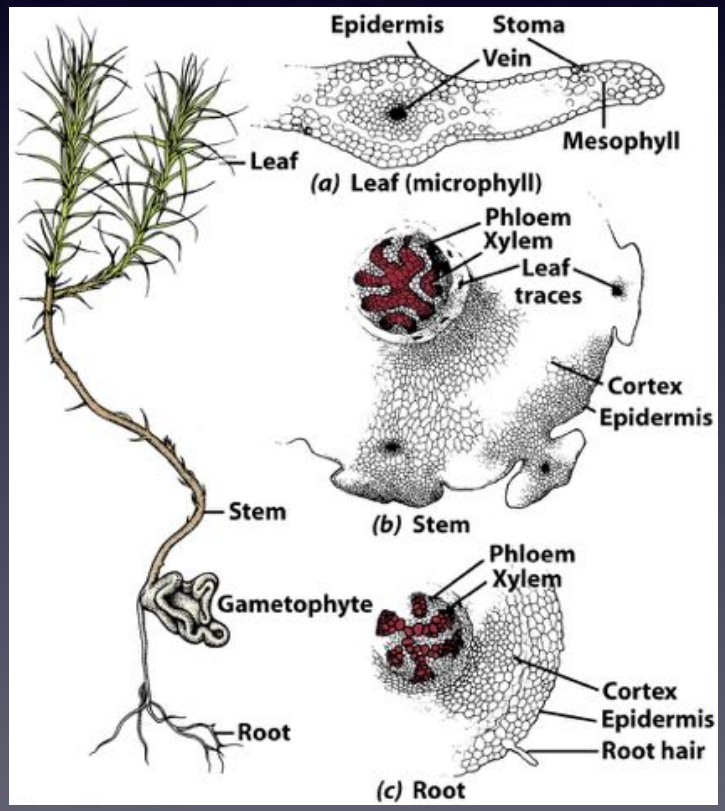
- Known as club mosses, genus *Lycopodium* with 400 spp
- Sporophyte is a branching rhizome with aerial branches and roots
- Roots and stems are protostelic
- Microphylls spirally arranged, although appearing sometimes as opposite or whorled
- Homosporic
- Sporangia singly on fertile microphylls called sporophylls
- Sporophylls are interspersed with vegetative microphylls or grouped into terminal strobili or cones

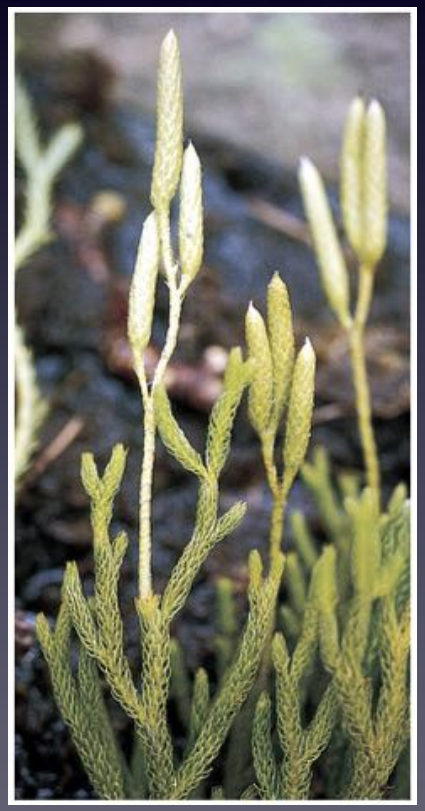




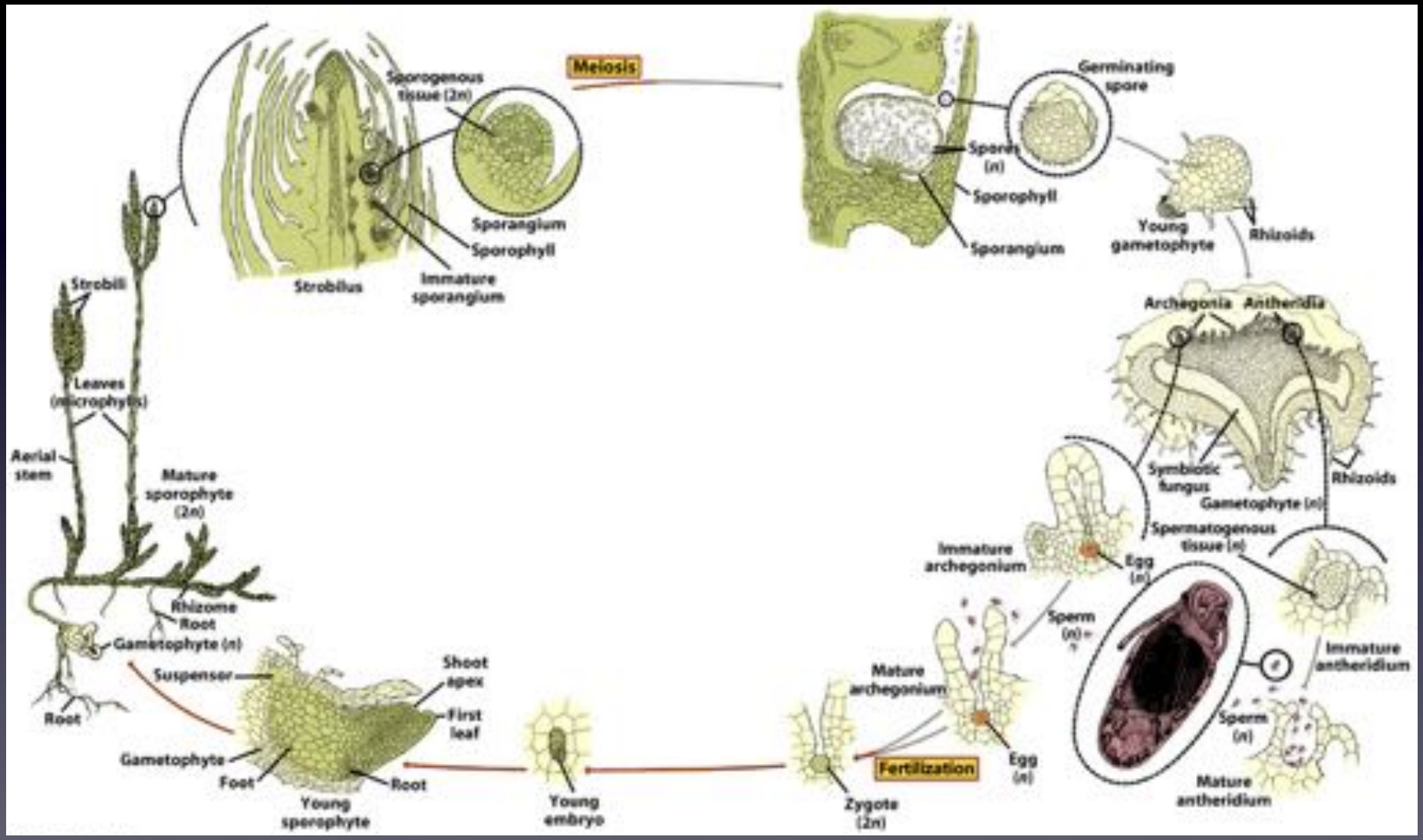


- Gametophytes are bisexual: green or irregular masses or subterranean colorless and mycorrhizal
- Archegonia and antheridia may take 6-15 years to form
- Biflagellated sperm requires water for fertilization
- Zygote develops into an embryo
- Embryo grows within the venter of the archegonium
- Young sporophyte remain attached to the gametophyte for a long time





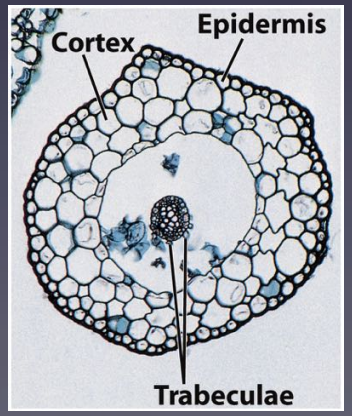
Life cycle of *Lycopodium*

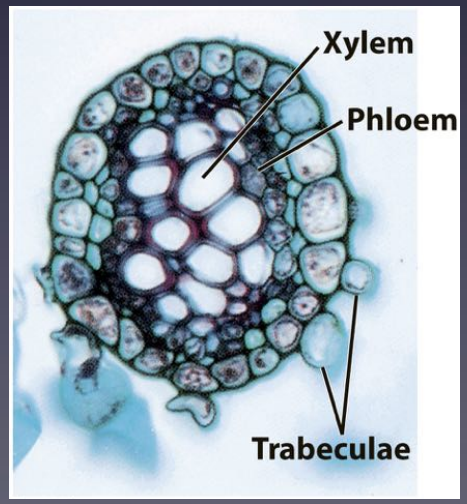


ORDER SELAGINELLALES, FAMILY SELAGINELLACEAE

- *Selaginella* with 750 spp
- Mostly tropical in moist places, "spike mosses"
- Sporophyte is herbaceous with microphylls
- Sporophylls in strobili
- Ligule, scalelike outgrowth near the base of the upper surface of the microphyll and sporophyll
- Stem and root are protostelic
- Trabeculae filaments holding the stele in the hollow center of the stem

The resurrection fern





Heterosporous, with unisexual gametophytes

- Megasporangia are borne on megasporophylls
- Microsporangia are borne on microsporophylls

Figure 17-18b
Raven Biology of Plants, Eighth Edition

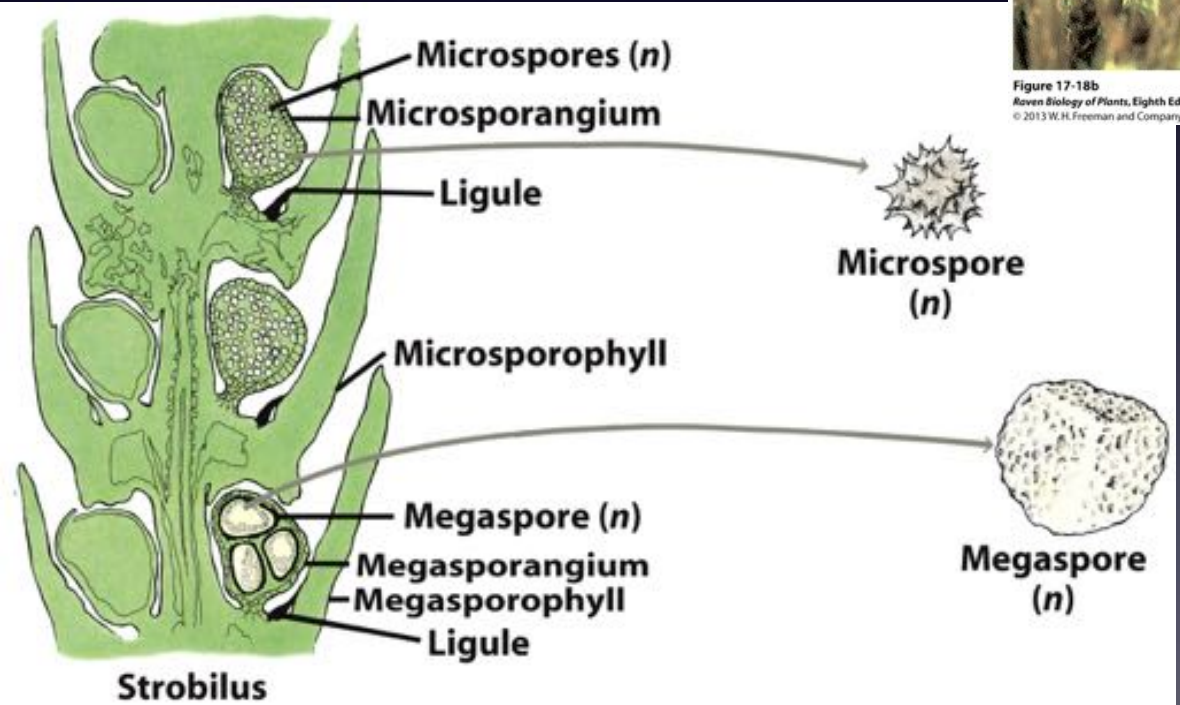


Figure 17-19 part 1
Raven Biology of Plants, Eighth Edition

- Microgametophytes, the males, develop within the microspore and are colorless, consisting of one prothallial cell (vegetative) and the antheridium
- The sperm are biflagellated
- Megagametophytes, the females, are also endosporic
- The megaspore wall ruptures and the multicellular female gametophyte protrudes to the outside exposing the archegonia

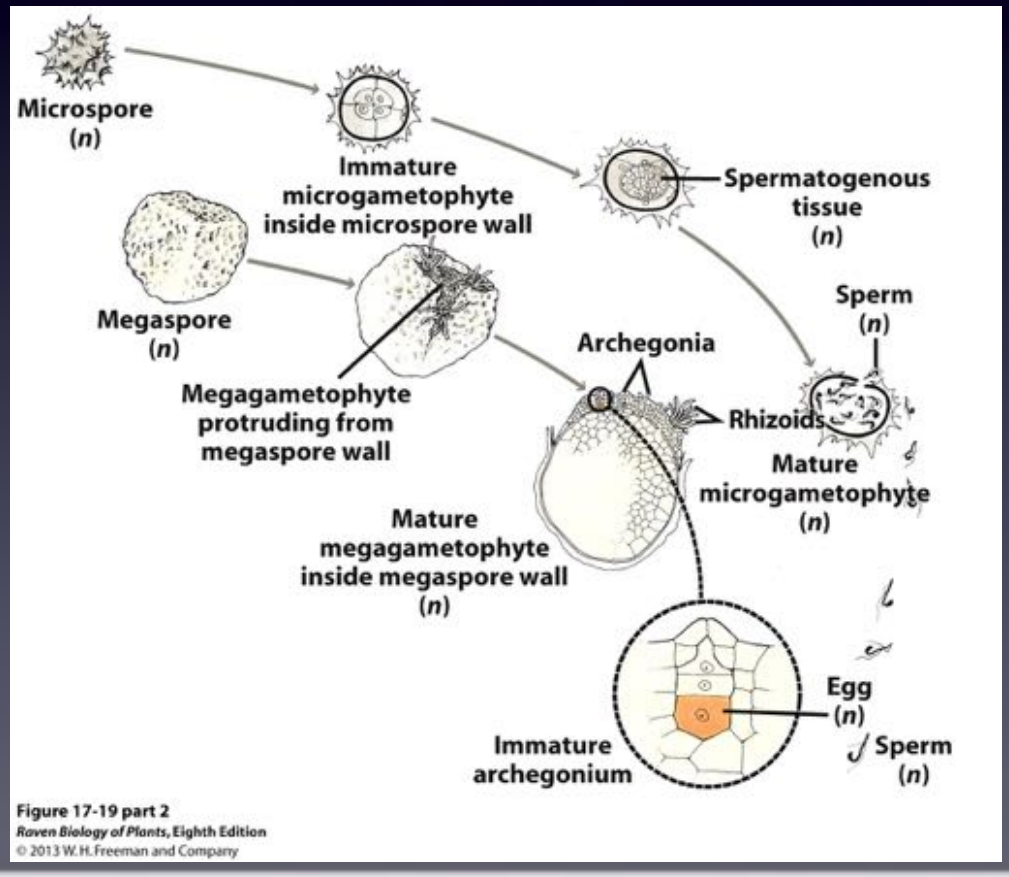


Figure 17-19 part 2
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- Water is required for fertilization
- Embryos of *Selaginella* and *Lycopodium* develop a suspensor
- Suspensor serves to thrust the developing embryo deep within the nutrient-rich tissue of the female gametophyte

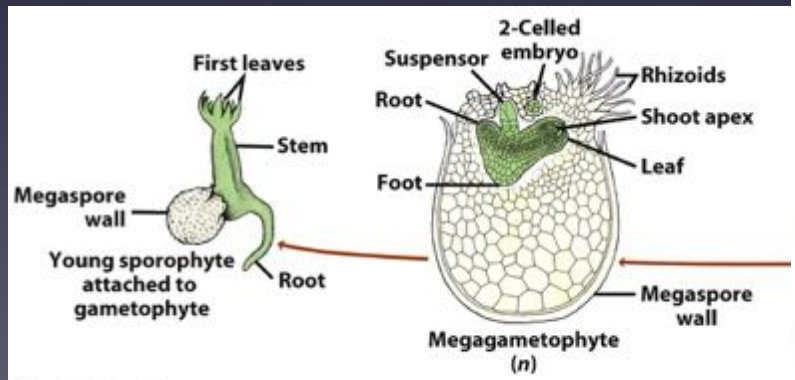

Figure 17-19 part 4
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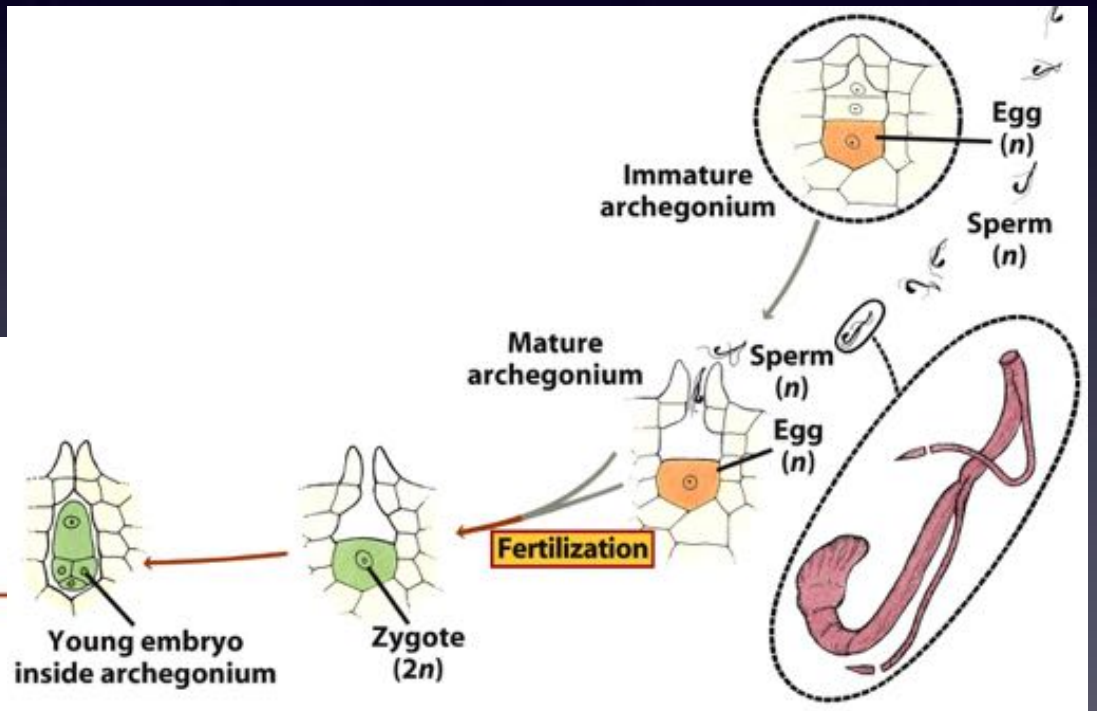

Figure 17-19 part 3
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Life cycle of *Selaginella*

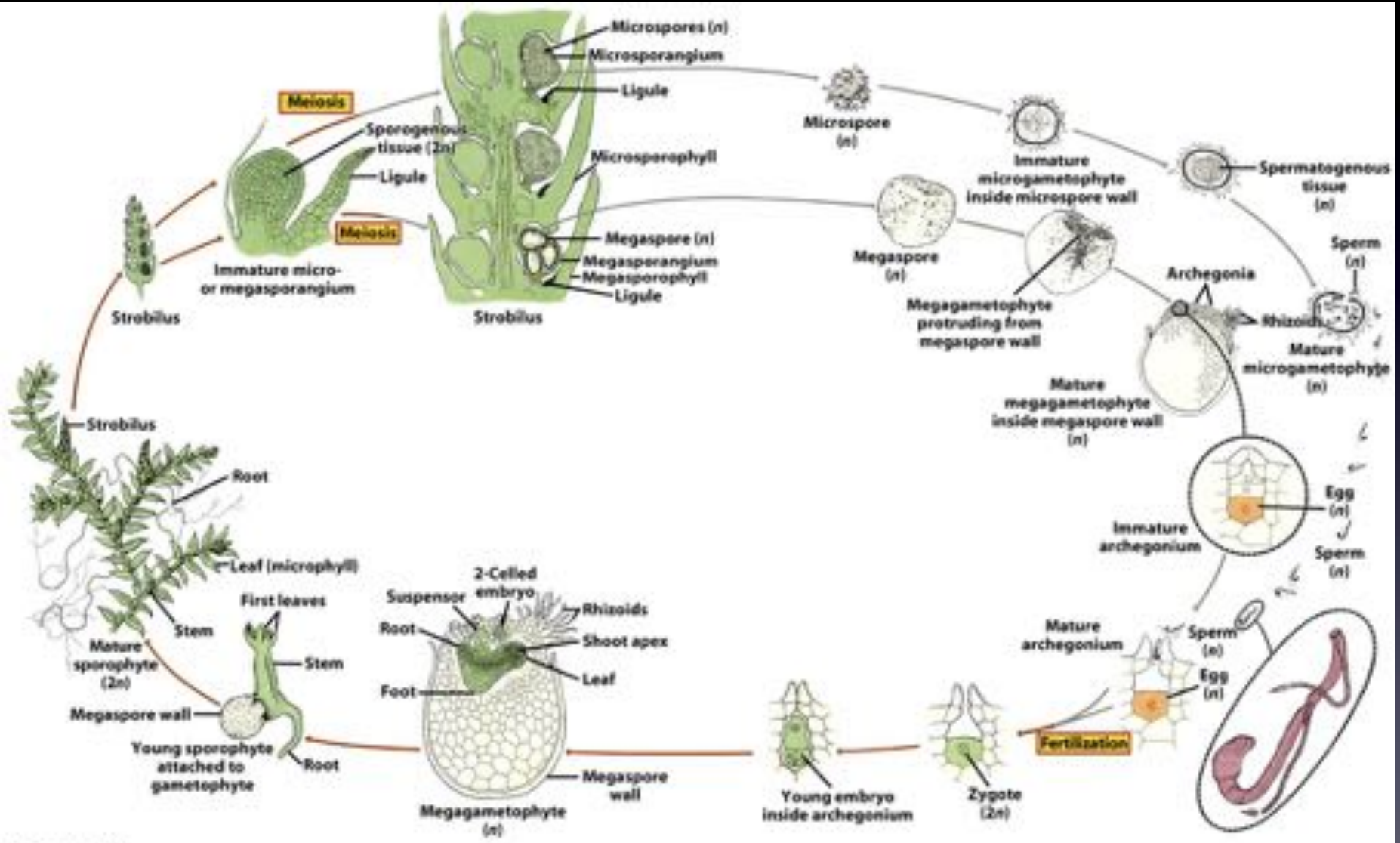
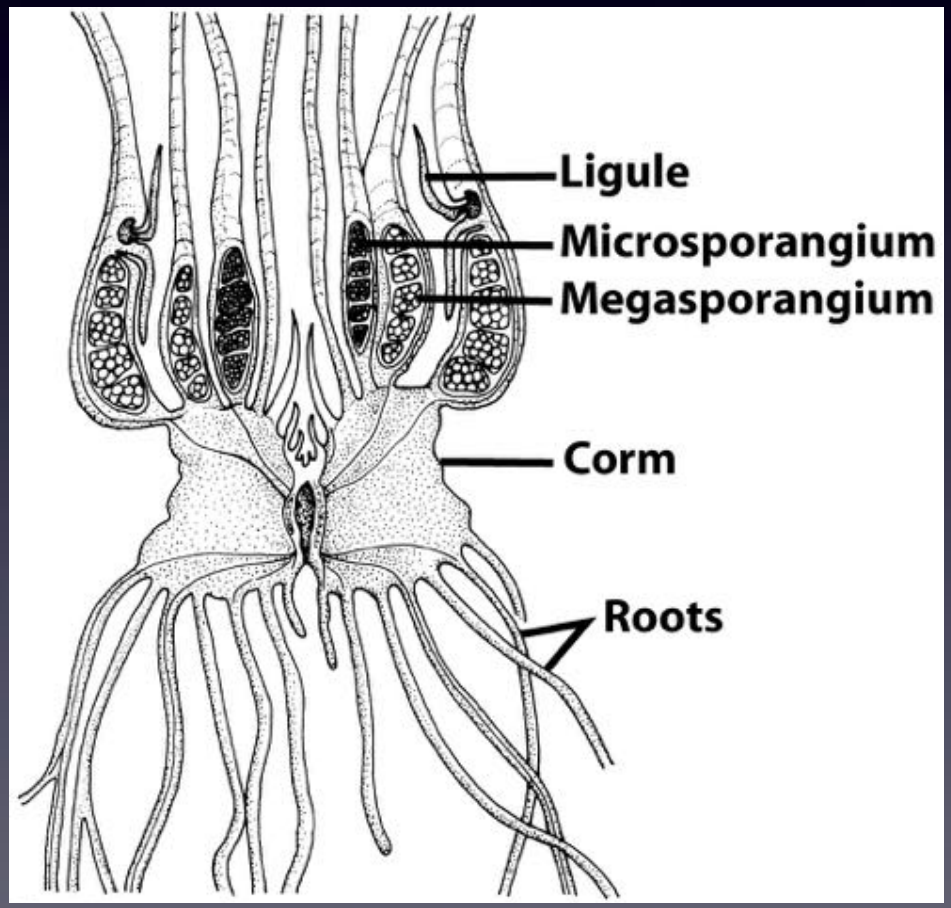


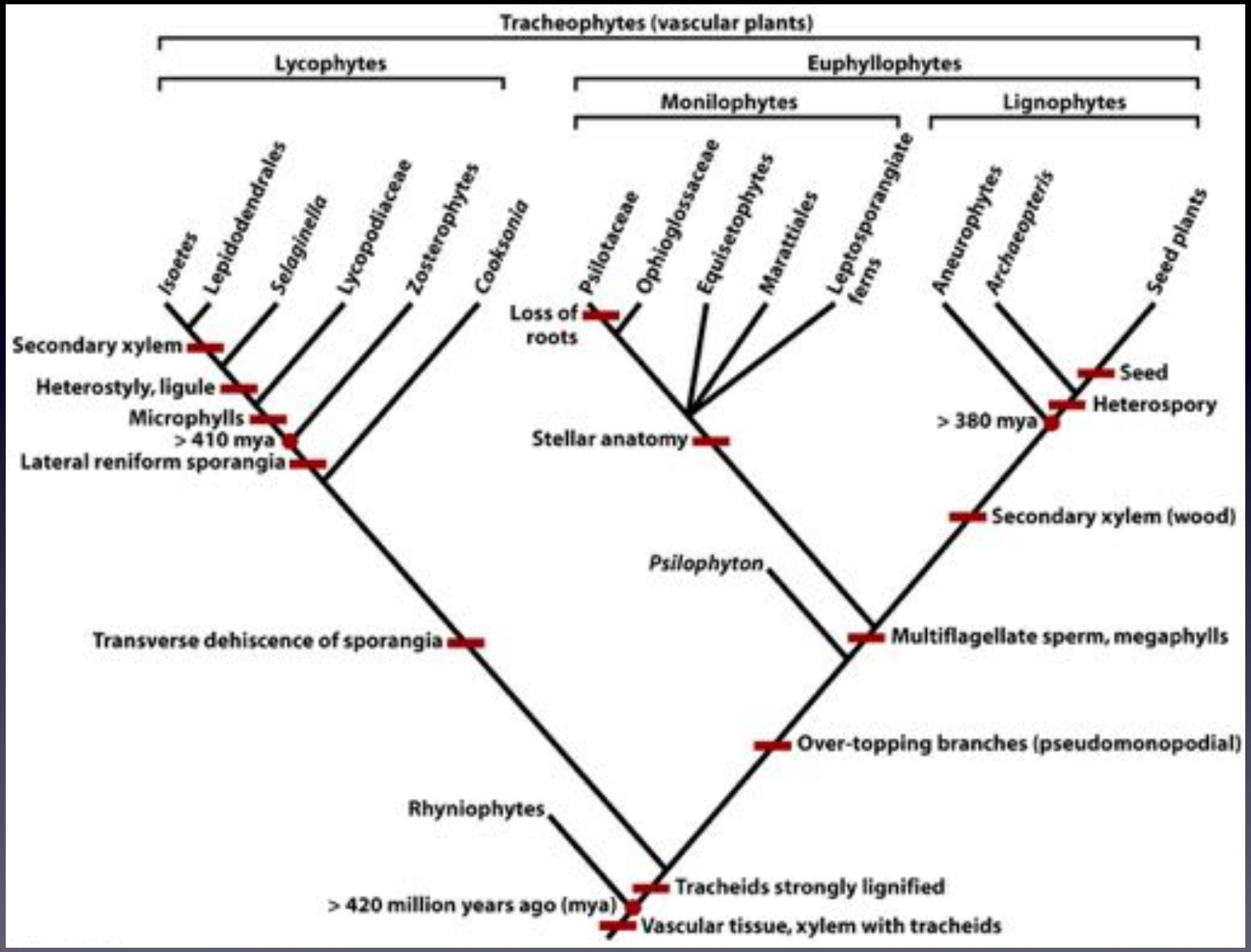
Figure 17-18
Biology of Plants, Seventh Edition

ORDER ISOETALES, FAMILY ISOETACEAE

- *Isoetes* with ca. 150 spp
- The "quillworts" are aquatics
- Sporophytes consists of a short, fleshy underground stem (corm) surrounded with quill-like microphylls on its upper surface
- Lower surface of the corm bearing the roots
- Each leaf is a potential sporophyll

- Heterosporous
- Megasporangia on outer megasporophylls
- Microsporangia on inner microsporophylls
- Ligule is present
- Cambium (!) adds secondary tissues to the corm: parenchyma to the outside and vascular tissue toward the inside




Tracheophytes (vascular plants)
Lycophytes
Euphyllophytes
Monilophytes
Lignophytes
Isoetes
Lepidodendrales
Selaginella
Lycopodiaceae
Zosterophytes
Cooksonia
Psilotaceae
Ophioglossaceae
Equisetophytes
Marattiales
Leptosporangiate ferns
Aneurophytes
Archaeopteris
Seed plants
Loss of roots
Secondary xylem
Heterostyly, ligule
Microphylls
> 410 mya
Lateral reniform sporangia
Stellar anatomy
Seed
Heterospory
> 380 mya
Secondary xylem (wood)
Psilophyton
Transverse dehiscence of sporangia
Multiflagellate sperm, megaphylls
Over-topping branches (pseudomonopodial)
Rhyniophytes
Tracheids strongly lignified
> 420 million years ago (mya)
Vascular tissue, xylem with tracheids