28

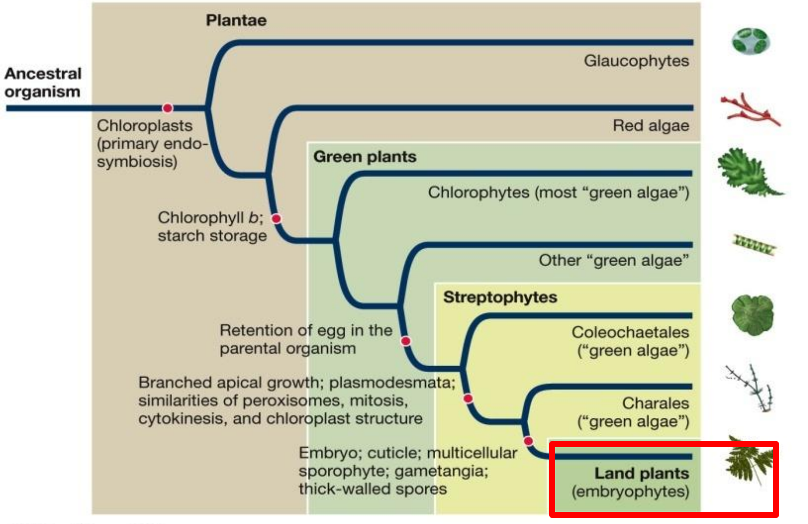
Plants without Seeds: from Water to Land

28 Plants without Seeds: From Water to Land

- 28.1 How Did the Land Plants Arise?
- 28.2 How Did Plants Colonize and Thrive on Land?
- 28.3 What Features Distinguish the Vascular Plants?
- 29.4 What Are the Major Clades of Seedless Plants?

Land plants are monophyletic

- All descended from a single common ancestor
- One shared derived character (i.e. a synapomorphy) – development from an embryo *protected by tissues of the parent plant*
  - Also called **embryophytes**



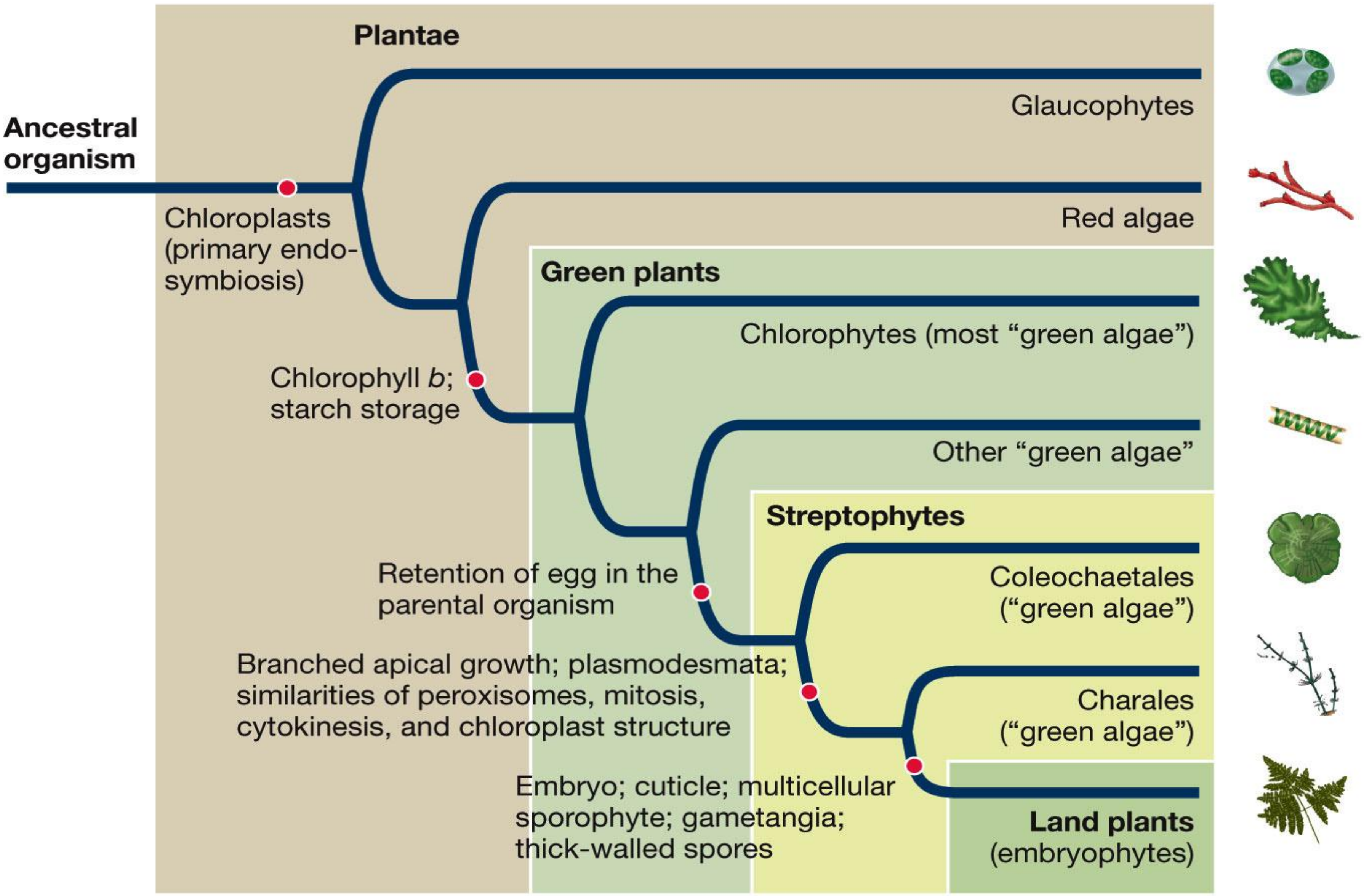
LIFE 9e, Figure 28.1

Land plants retain derived features they share with green algae…

- Chlorophyll *a* and *b*
- Starch as a storage product
- Cellulose in cell walls

Photo 28.2 Green algae of phylum *Chlorophyta* are most likely ancestors of plants.

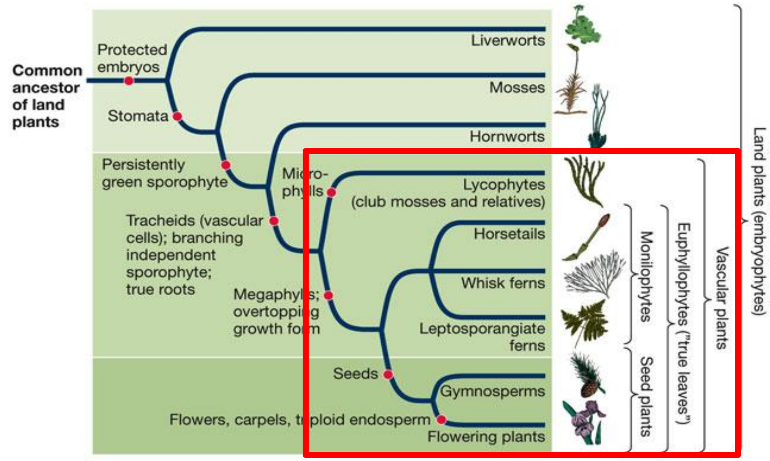
Figure 28.1 What Is a Plant?



LIFE 9e, **Figure 28.1**

Four major clades of land plants

- **"Non-vascular" plants** – not monophyletic
  - ❑ Liverworts
  - ❑ Mosses
  - ❑ Hornworts



LIFE 9e, Figure 28.5

- **Vascular plants** (*tracheophytes)*
  - ❑ Have conducting cells (**tracheids**)
  - ❑ Several major clades within this taxon

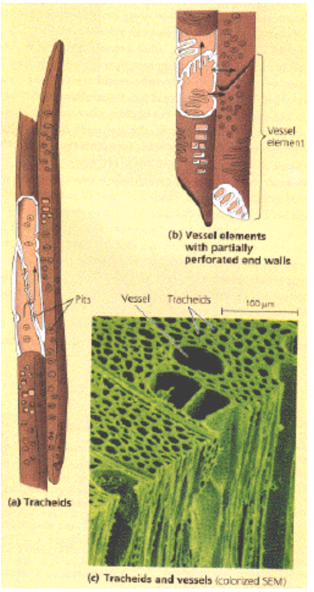
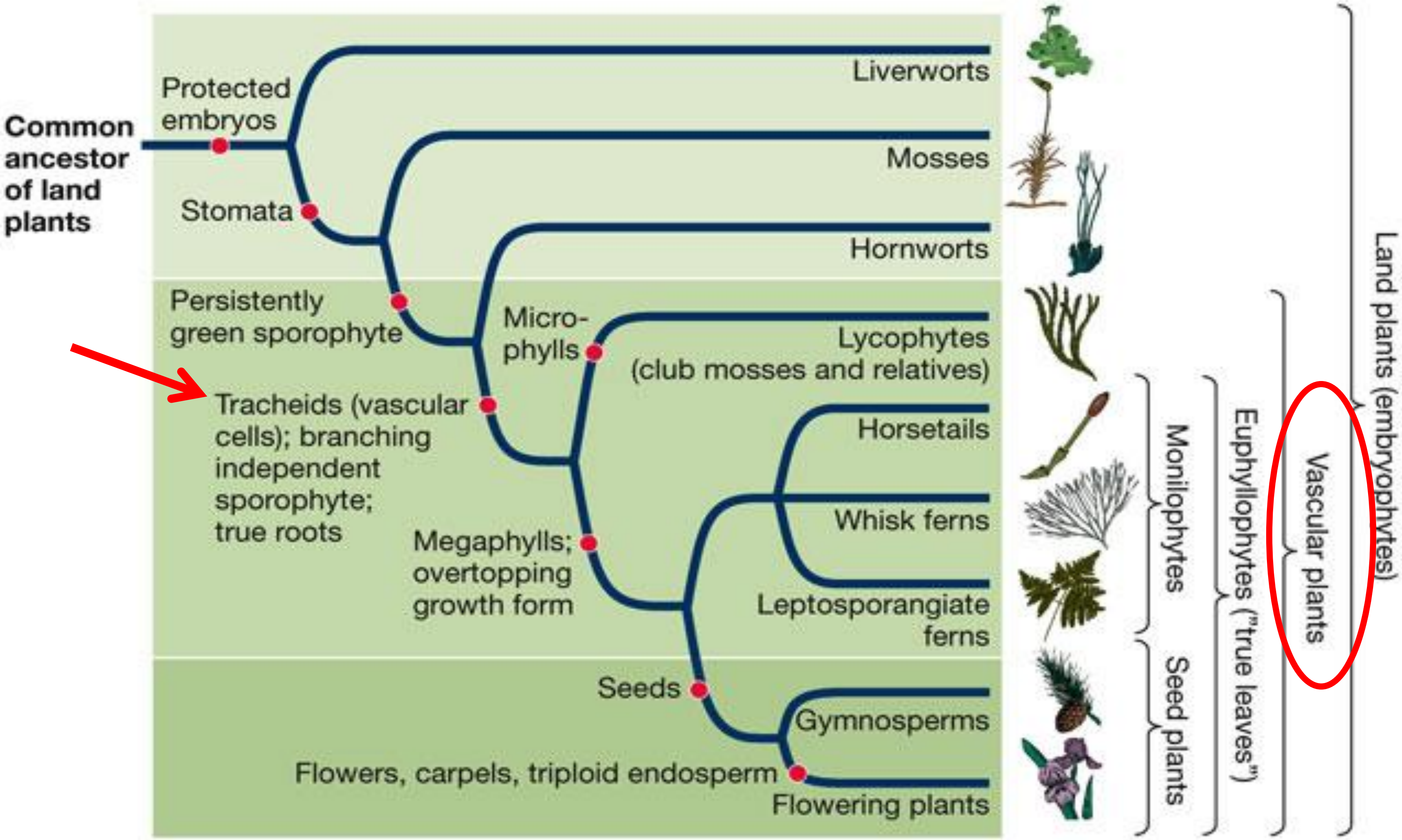


Figure 28.7 The Evolution of Today's Plants



LIFE 9e, **Figure 28.5**

TABLE 28.1

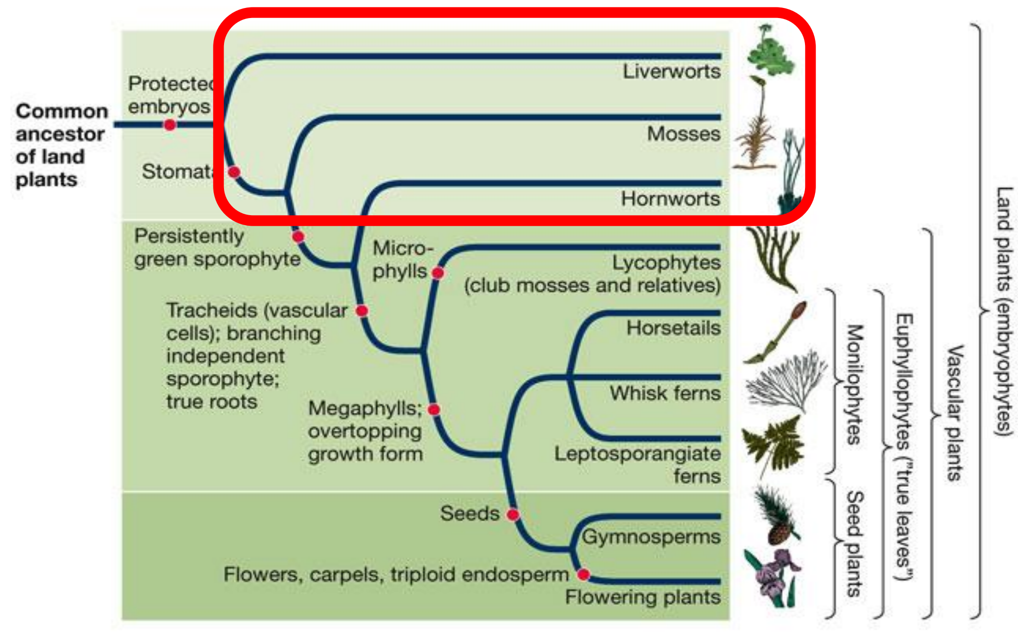
Classification of Land Plants

GROUP	COMMON NAME	CHARACTERISTICS
NONVASCULAR LAND PLANTS		
Hepatophyta	Liverworts	No filamentous stage; gametophyte flat
Anthocerophyta	Hornworts	Embedded archegonia; sporophyte grows basally (from the ground)
Bryophyta	Mosses	Filamentous stage; sporophyte grows apically (from the tip)
VASCULAR PLANTS		
Lycopodiophyta	Lycophytes: Club mosses and allies	Microphylls in spirals; sporangia in leaf axils
Monilophyta	Horsetails, whisk ferns, ferns	Differentiation between main stem and side branches (overtopping growth)
SEED PLANTS		
Gymnosperms		
Cycadophyta	Cycads	Compound leaves; swimming sperm; seeds on modified leaves
Ginkgophyta	Ginkgo	Deciduous; fan-shaped leaves; swimming sperm
Gnetophyta	Gnetophytes	Vessels in vascular tissue; opposite, simple leaves
Coniferophyta	Conifers	Seeds in cones; needlelike or scalelike leaves
Angiosperms	Flowering plants	Endosperm; carpels; gametophytes much reduced; seeds within fruit

***LIFE* 9e, Table 28.1**

"Nonvascular" plants

- Remaining three clades — liverworts, hornworts, and mosses
- These groups do not form a monophyletic clade – why?



LIFE 9e, Figure 28.5

Charales (stoneworts) is thought to be sister group of land plants based on synapomorphies:

- Both exhibit retention of egg in parent
- Plasmodesmata
- Branching, apical growth
- Similar peroxisome contents, mechanics of mitosis and cytokinesis, and chloroplast structure

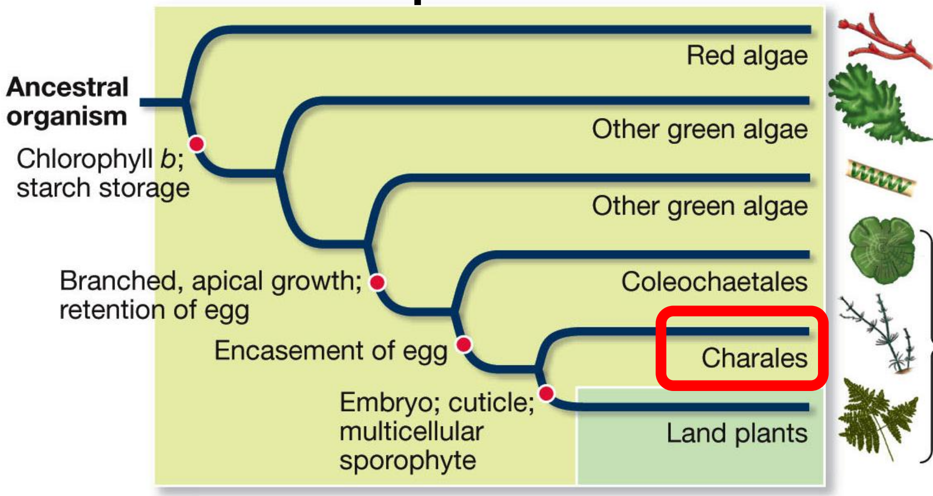
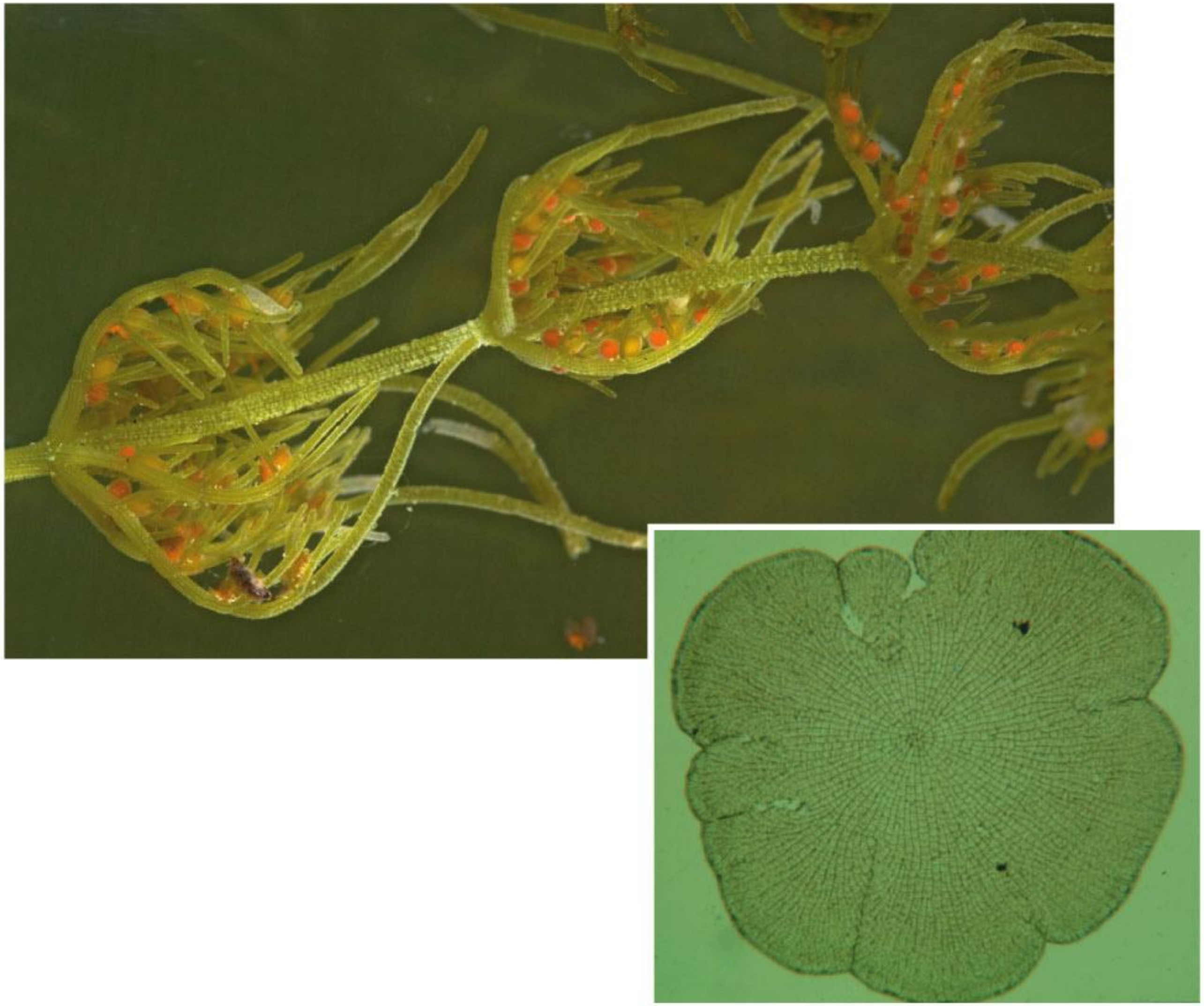


Figure 28.2 The Closest Relatives of Land Plants

(A) *Chara vulgaris* (stonewort)



(B) *Coleochaete* sp.

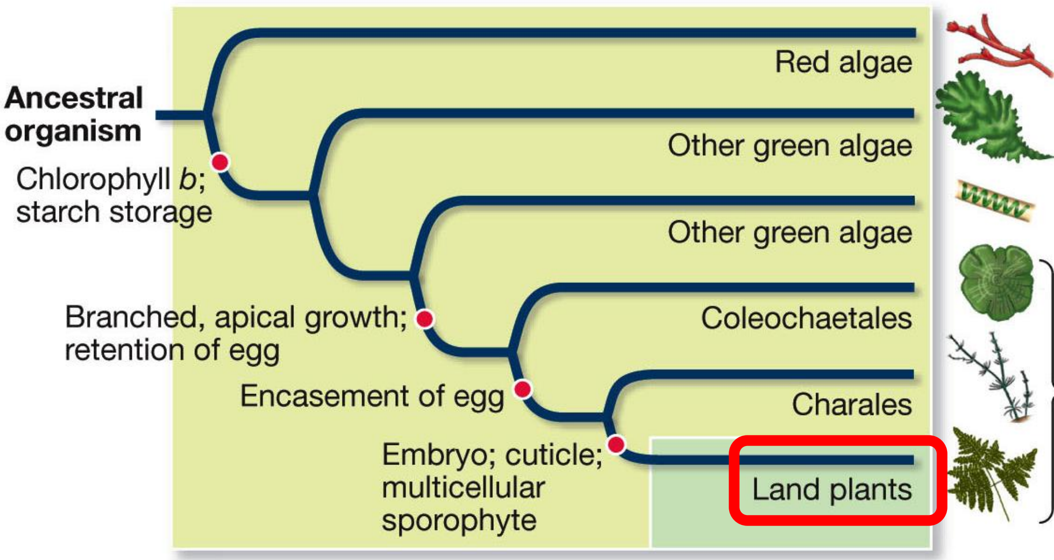
28.2 How Did Plants Colonize and Thrive on Land?

Plants first appeared on land between 400–500 million years ago

- Adaptations needed to survive in dry environments
  - Larger plants must transport water to all parts of plant
  - Needed structural support in air
  - Needed methods to disperse gametes

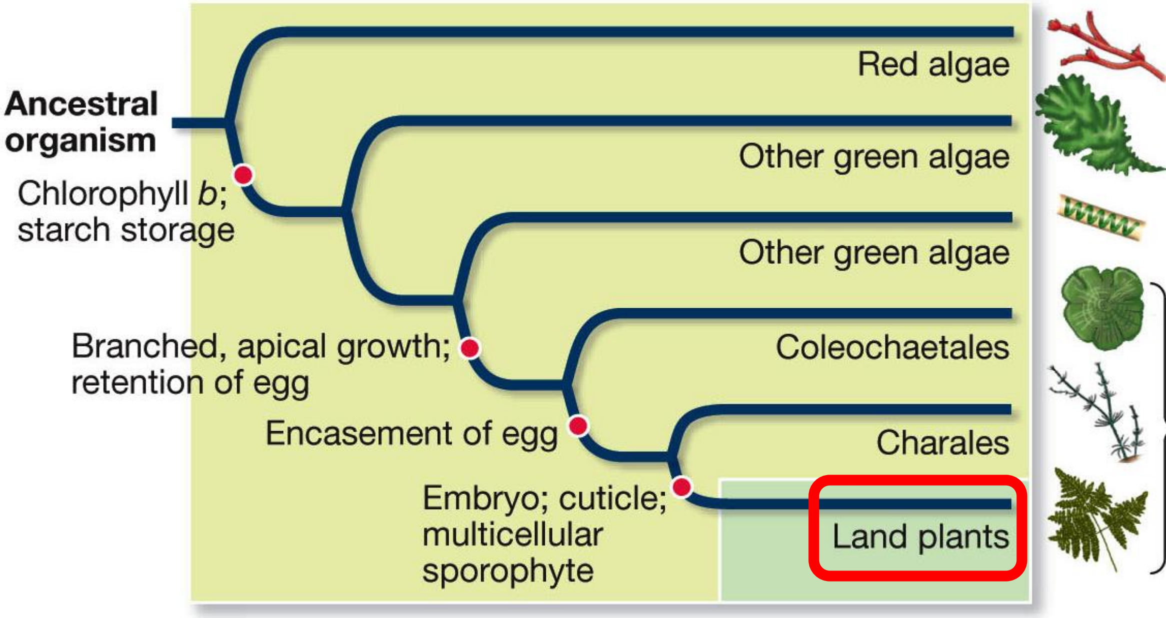
Characteristics of land plants:

- The cuticle
- **Stomata** – openings in stems and leaves; regulate gas exchange (except liverworts)
- **Gametangia** enclose/protect gametes



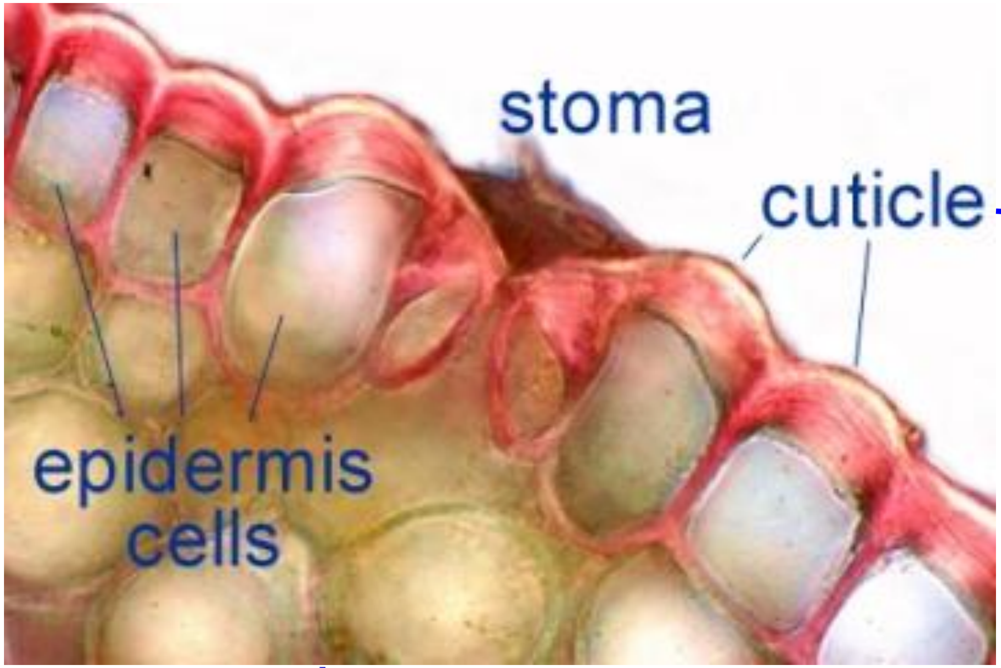
28.2 How Did Plants Colonize and Thrive on Land?

- Embryos in protective structure
- Pigments that protect against UV radiation
- Spore walls containing **sporopollenin**
- Mutualistic relationships with fungi to promote nutrient uptake from soil

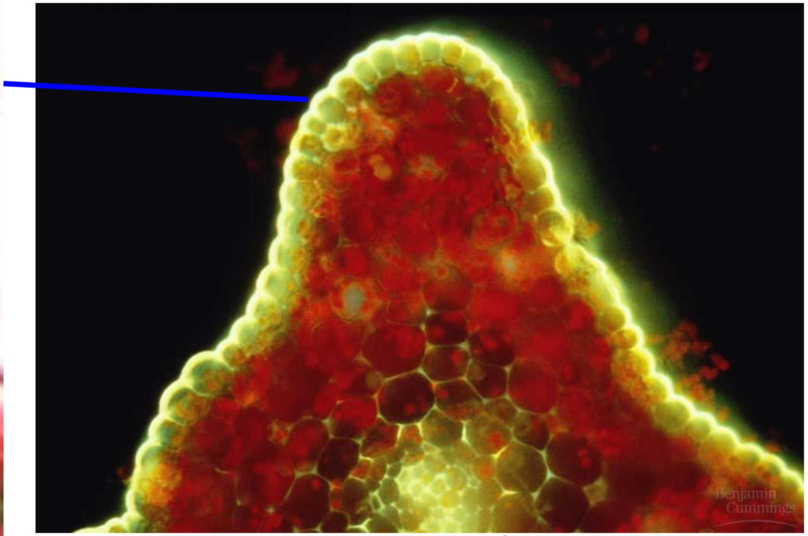


The **cuticle**

- composed of waxy lipids
- prevents water loss by evaporation



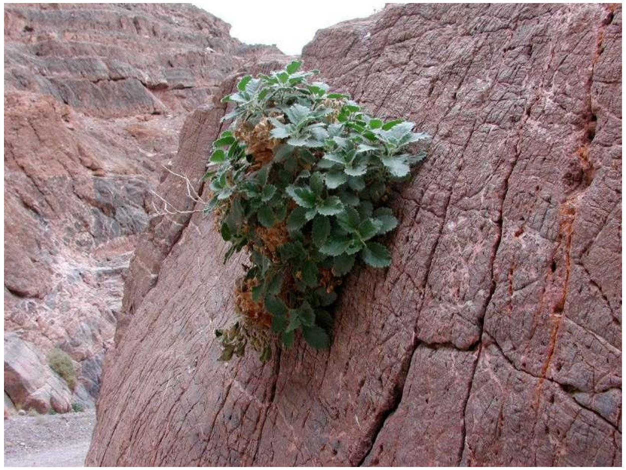
http://www.uni-muenster.de/GeoPalaeontologie/Palaeo/Palbot/cut1a.jpg



http://www.zo.utexas.edu/faculty/sjasper/images/29.10.jpg

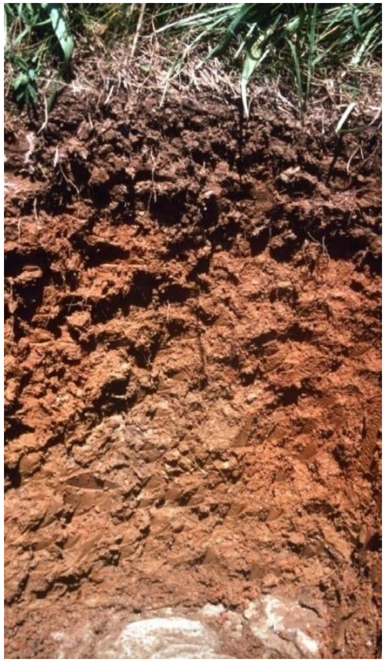
28.2 How Did Plants Colonize and Thrive on Land?

http://www.carto.net/neumann/travelling/death_valley_2003_11/46_plant_on_rock.jpg



Ancient plants contributed to soil formation

- Acids secreted by plants help break down rock
- Organic material from dead plants contributes to soil structure



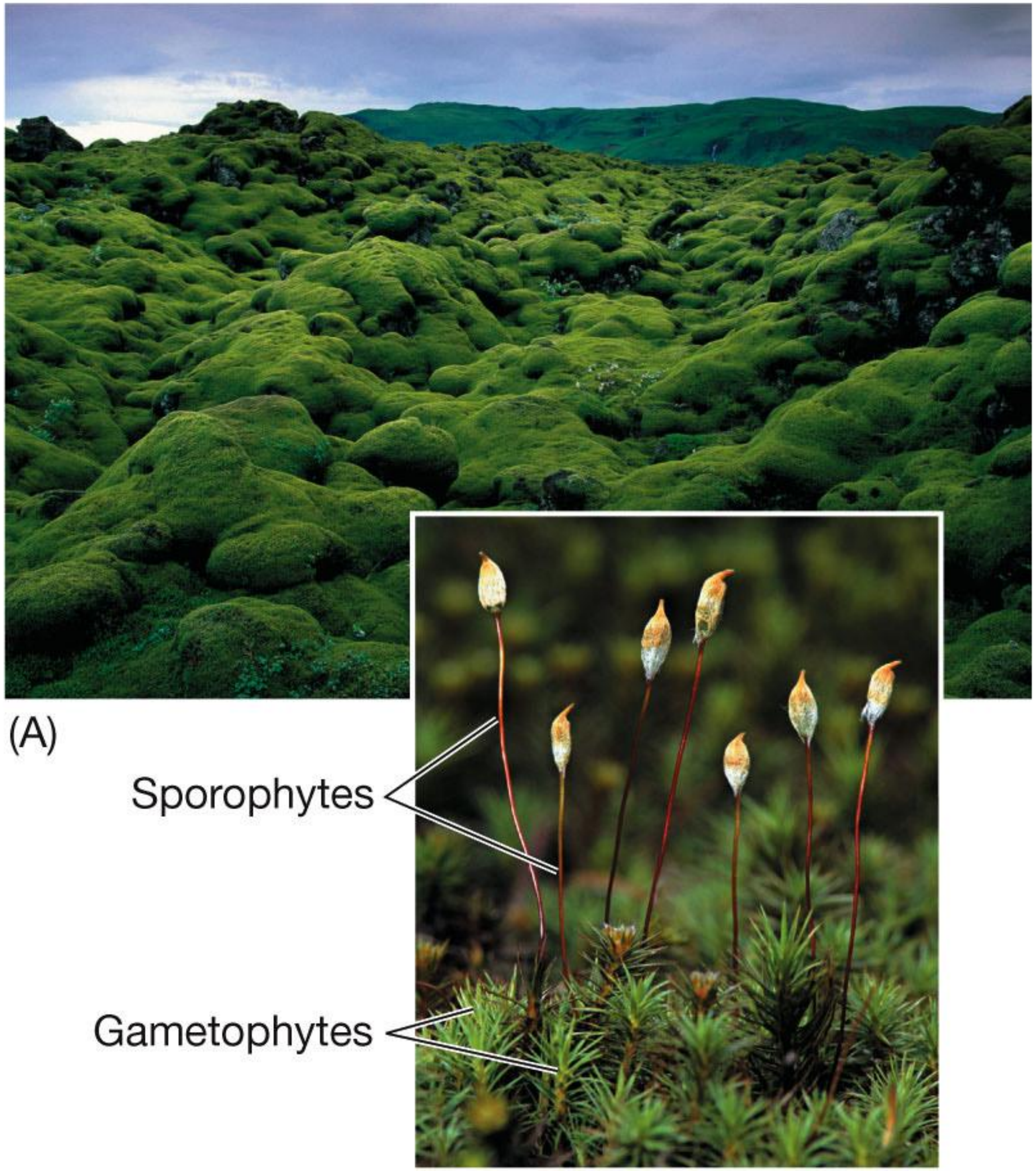
http://www.mysciencebox.org/files/images/Soil%20profile%20Talbott.jpg

Today's nonvascular plants are thought to be similar to the first land plants

- Grow in moist environments in dense mats
- Small
- Lack vacular system to conduct water from soil to plant body parts

www.royalalbertamuseum.ca/natural/botany

Figure 28.12 Mosses Form Dense Mats



(B) *Polytrichum* sp.

28.2 How Did Plants Colonize and Thrive on Land?

- Growth pattern of nonvascular plants allows water to move through mats by capillary action
- Minerals can be distributed through small plants by diffusion

28.2 How Did Plants Colonize and Thrive on Land?

- Many can grow on marginal surfaces, including tree trunks, rocks, even buildings
- Have a mutualistic relationship with fungi (**Glomeromycetes**)
  - Earliest plants were colonized with these fungi — promote absorption of water and minerals

Section of a sporocarp of *Glomus sinuosum*

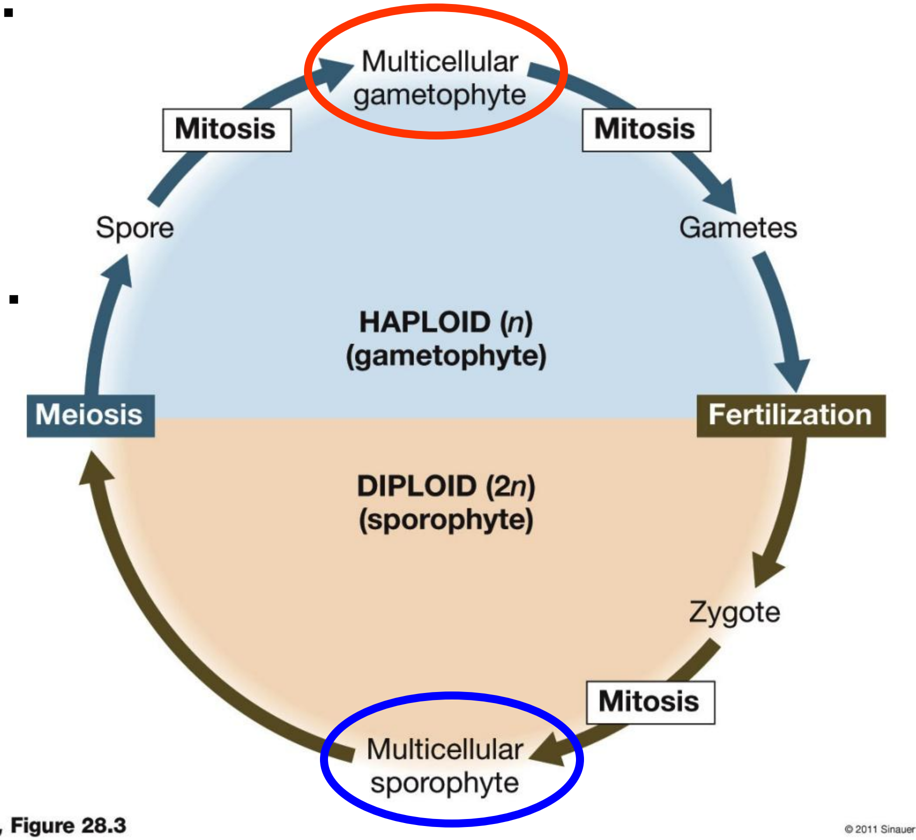
http://www.tolweb.org/tree/ToLimages/sinuosum_adj2.jpg

Alternation of generations

Really important!

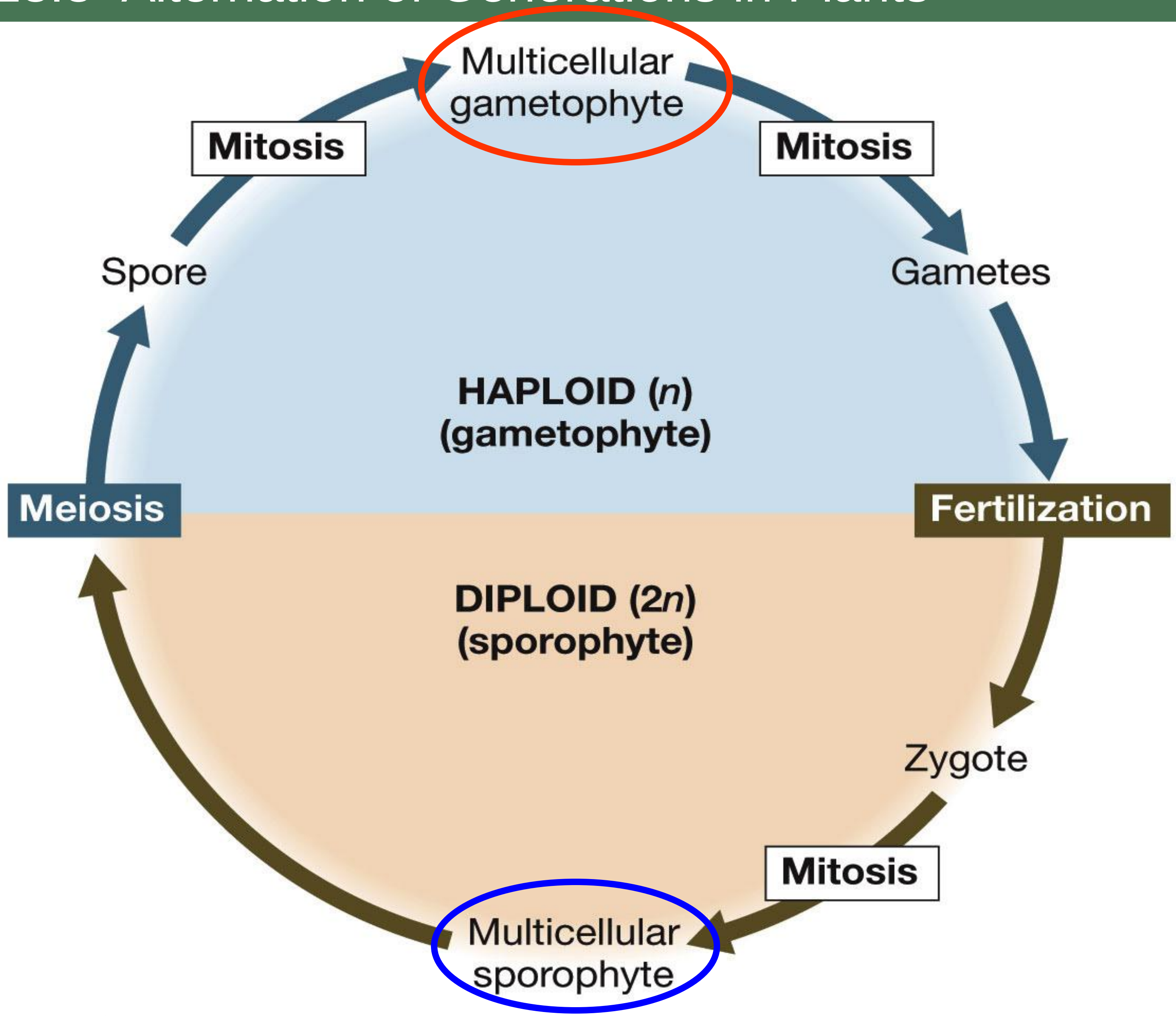
All land plants have a life cycle with **alternation of generations**; includes…

- multicellular haploid (**gametophyte**) and…
- multicellular diploid (**sporophyte**) individuals



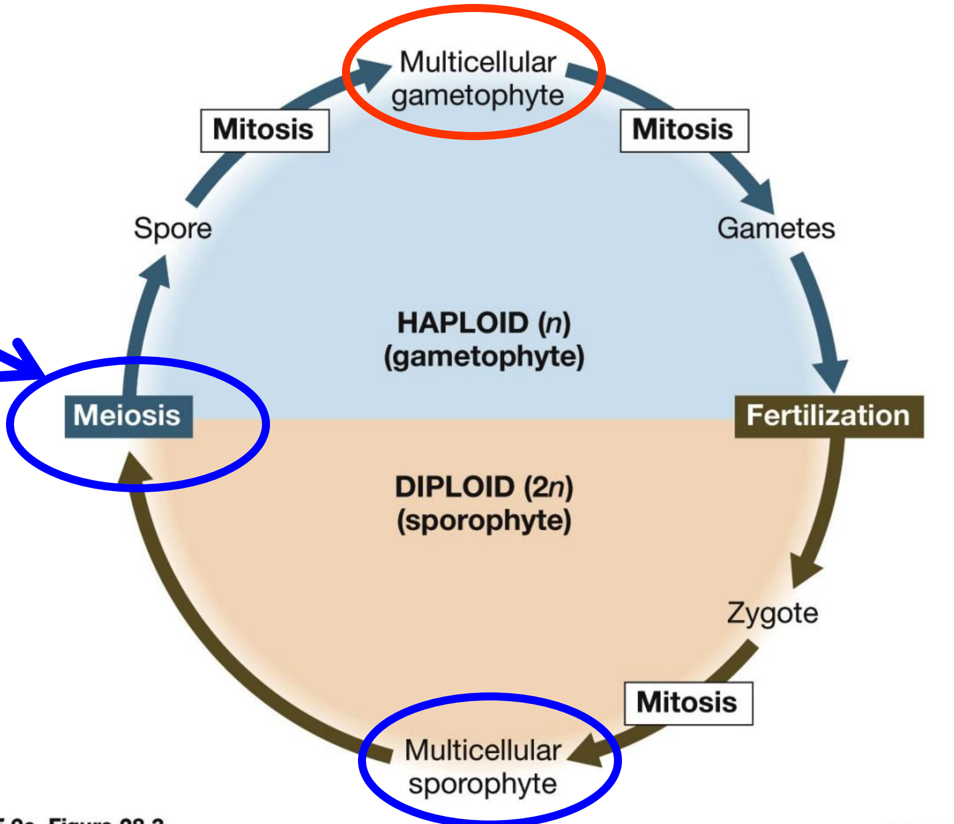
LIFE 9e, Figure 28.3

Figure 28.3 Alternation of Generations in Plants



LIFE 9e, Figure 28.3

- Cells in **sporangia** (in sporophyte) undergo meiosis to produce haploid, unicellular spores
- Spores develop into a multicellular haploid plant — the gametophyte — by mitosis

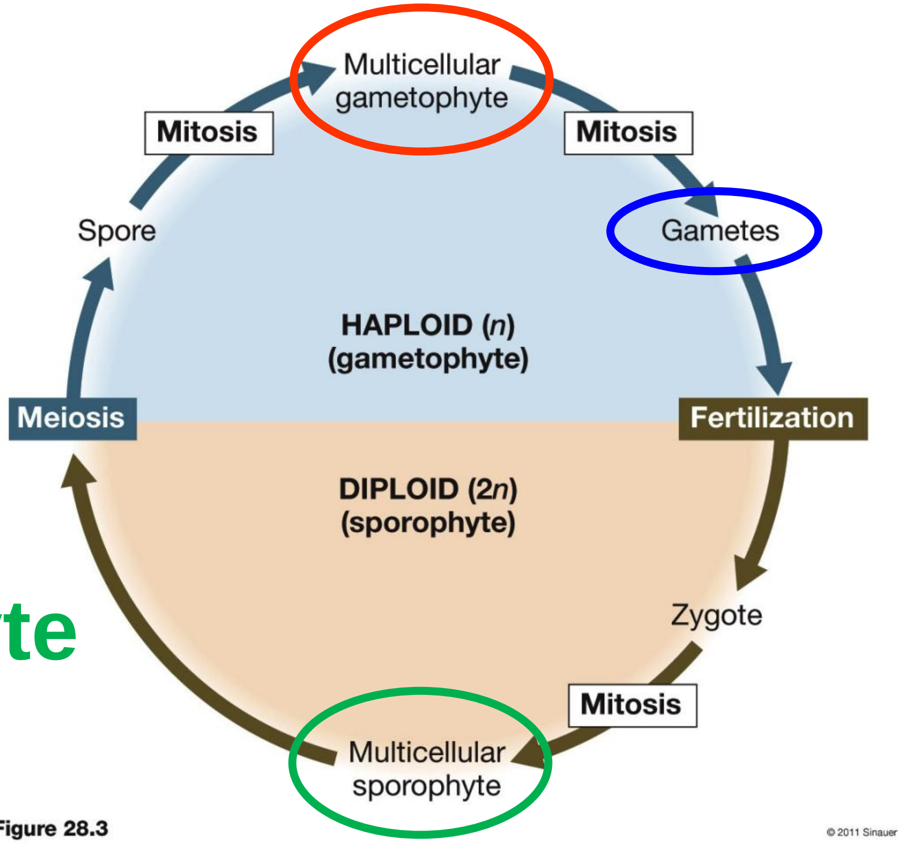


LIFE 9e, Figure 28.3

Sporophytes produce spores

- **Gametophytes** produce haploid gametes by mitosis
- Fusion of gametes (***syngamy*** or *fertilization*) results in diploid zygote
- Zygote develops into multicellular **sporophyte**

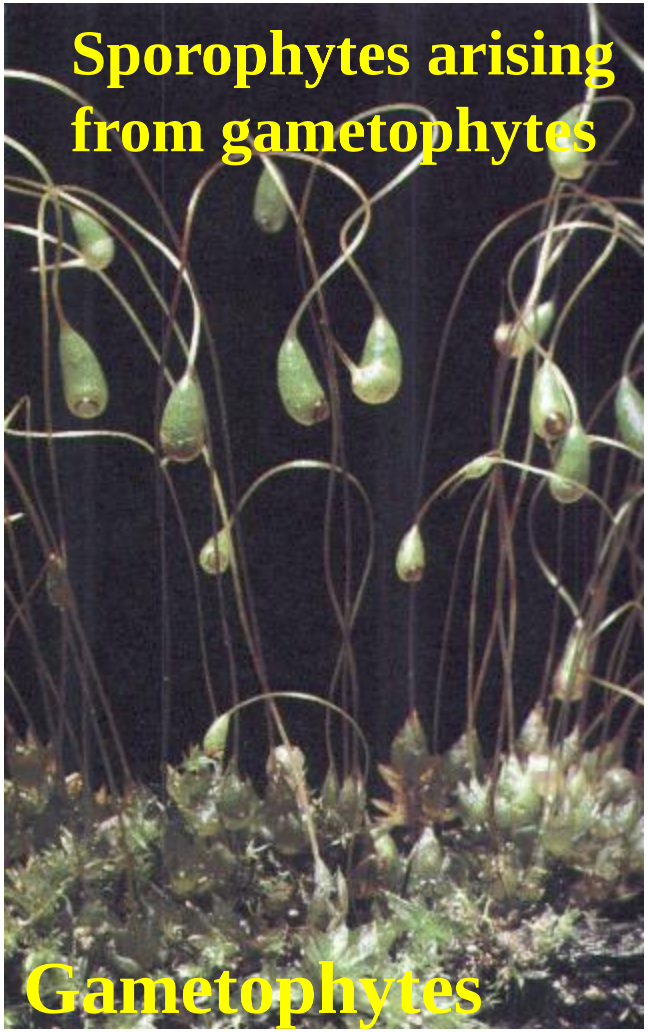
Gametophytes produce gametes



LIFE 9e, Figure 28.3

Reduction of the gametophyte generation is a *major theme in plant evolution*

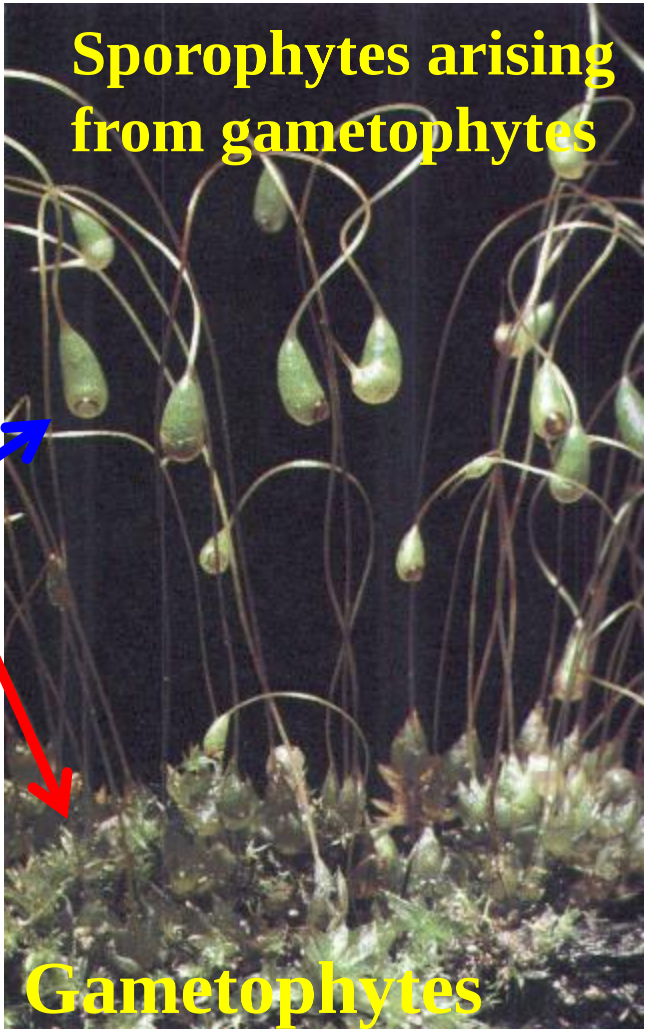
- In nonvascular plants, gametophyte is larger, longer-lived, and more self-sufficient than the sporophyte
- In plants that appeared later, this is reversed



http://taggart.glg.msu.edu/bot335/MOSS.GIF

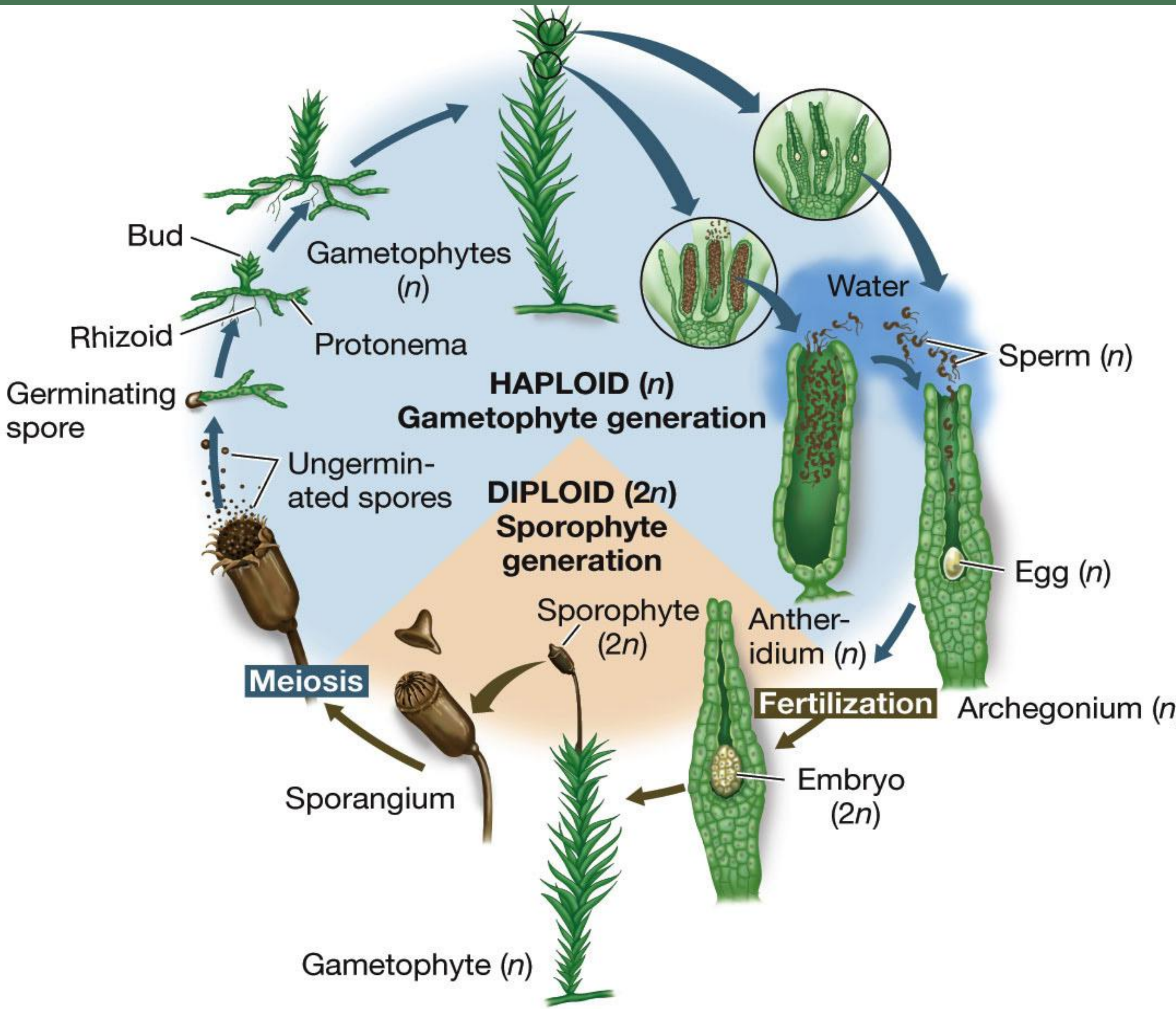
In nonvascular plants, the gametophyte generation is photosynthetic

- Sporophytes may or may not be photosynthetic,…
- Sporophytes are always nutritionally dependent on gametophyte, and is permanently attached



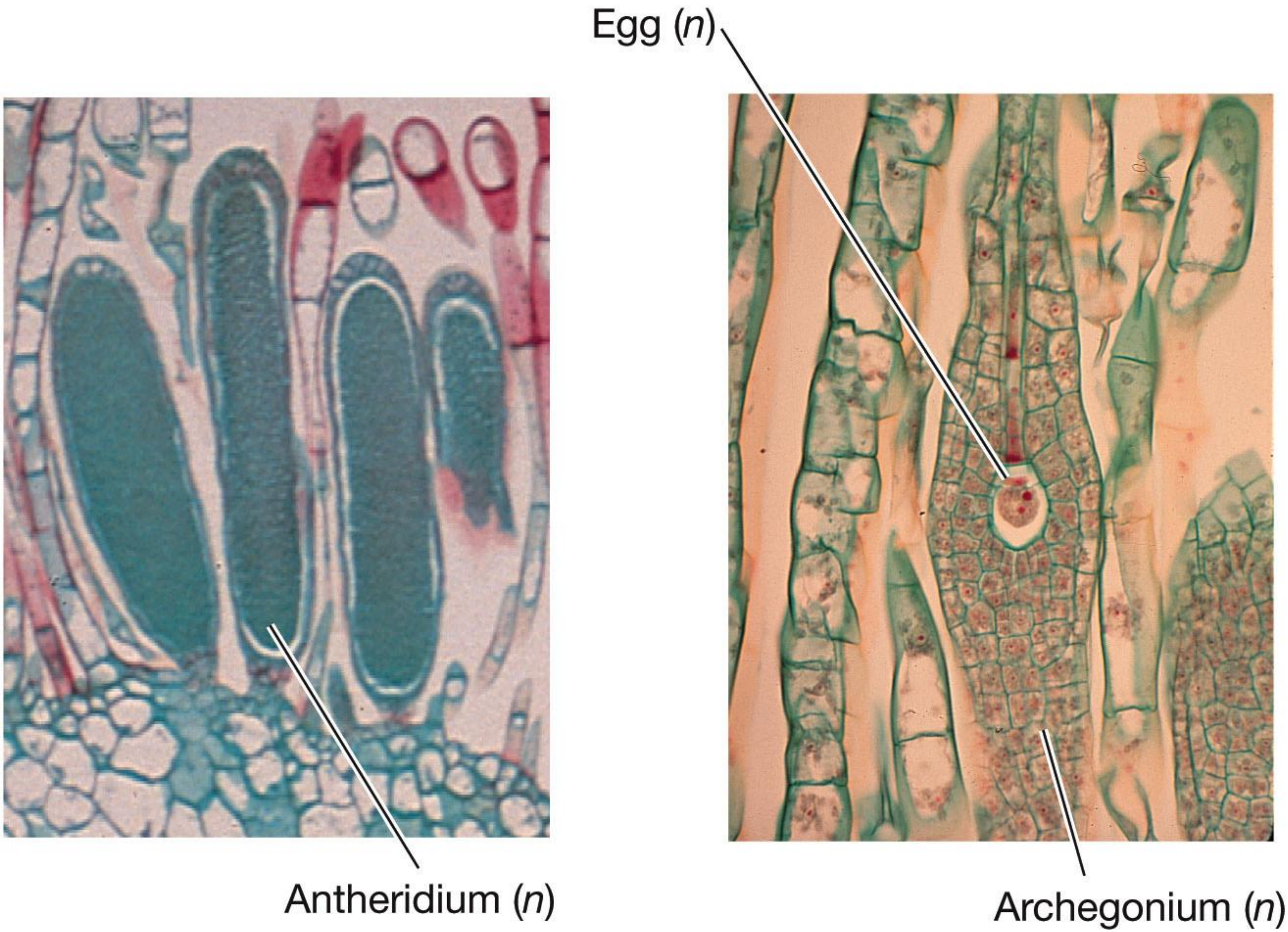
http://taggart.glg.msu.edu/bot335/MOSS.GIF

Figure 28.4 A Moss Life Cycle (Part 1)



LIFE 9e, Figure 28.4 (Part 1)

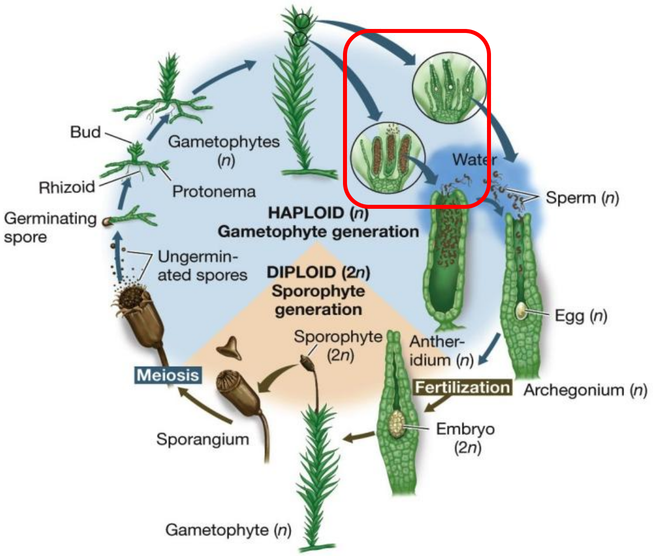
Figure 28.4 A Moss Life Cycle (Part 2)



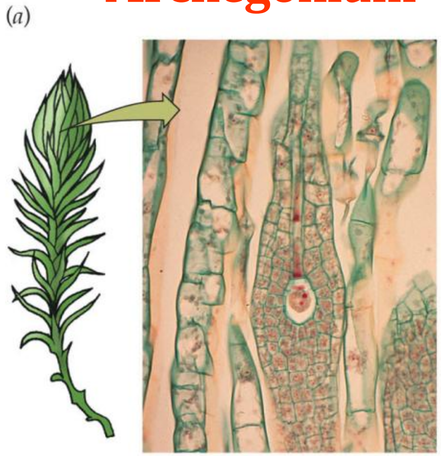
Life Cycle of a Moss

Haploid gametophyte produces gametes in specialized sex organs (**gametangia**)

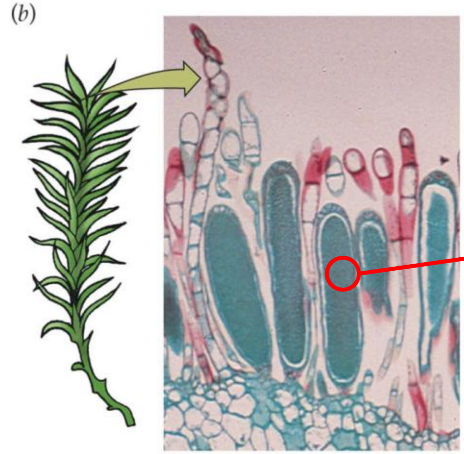
- Female: **archegonium →** produces one egg
- Male: **antheridium →** produces many sperm with two flagella each



Archegonium



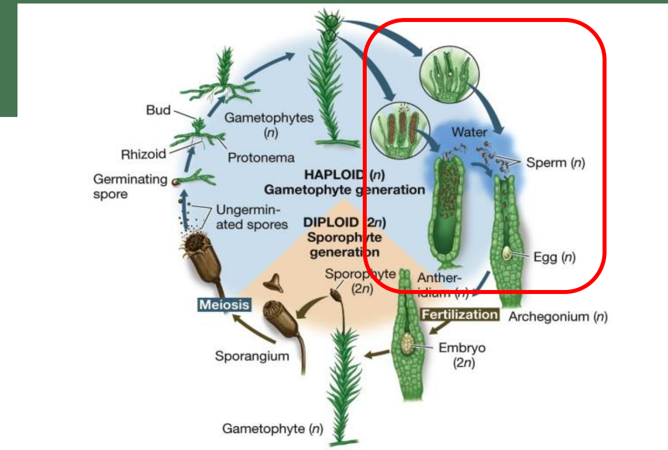
Antheridium



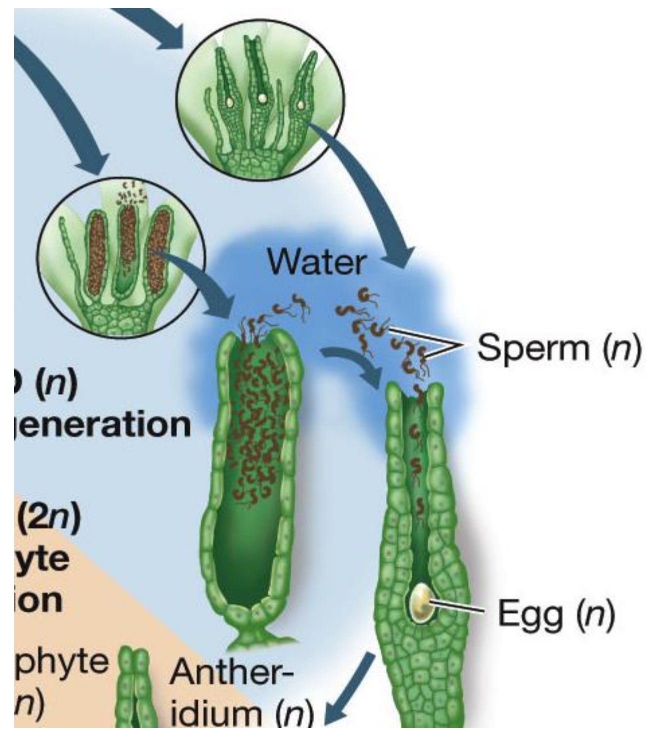
Flagellated moss sperm

http://www.dkimages.com/discover/previews/832/20113674.JPG

- Flagellated sperm must swim to archegonium, or be splashed by raindrops
  - Egg or archegonium releases chemical attractants for sperm
  - Cells in archegonium break down to form a water-filled canal for sperm to travel through
  - *Water is required for all these events*



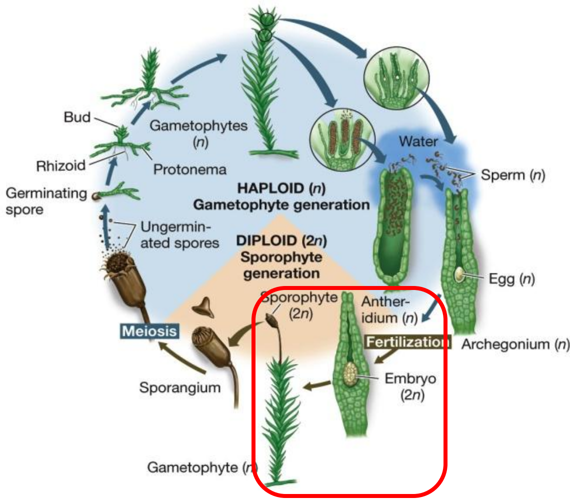
LIFE 9e, Figure 28.4 (Part 1)

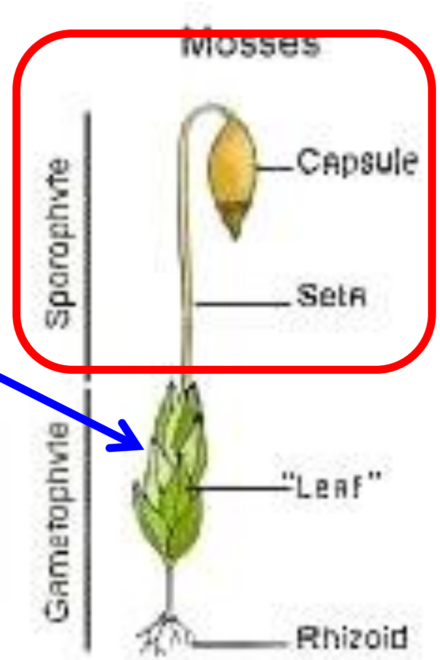


Life Cycle of a Moss

Egg and sperm form a diploid zygote →

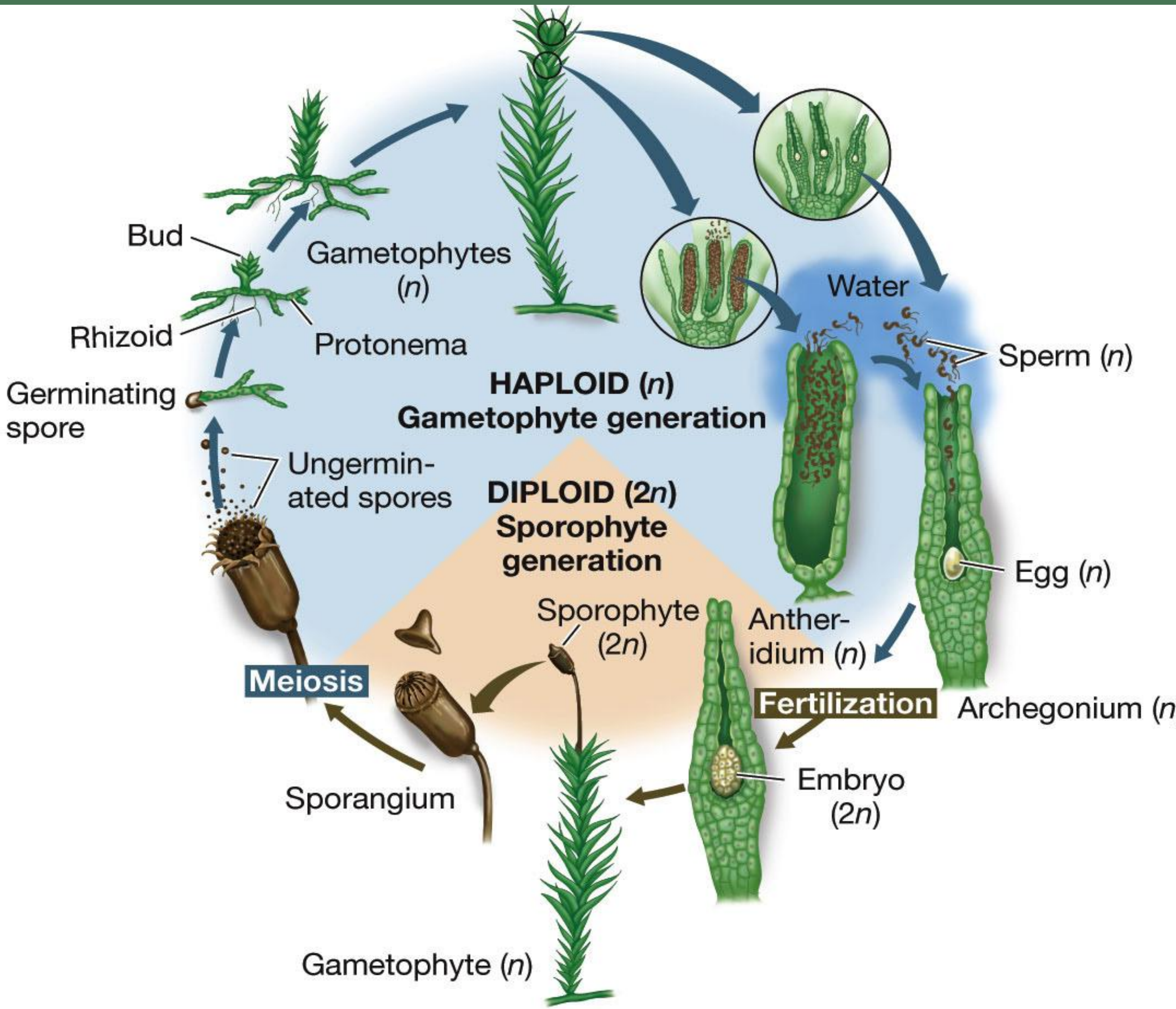
- Zygote develops into a multicellular, diploid sporophyte embryo
- Base of archegonium grows to protect embryo during early development
- Sporophyte remains attached to gametophyte by seta and “foot”





www.davidlnelson.md/Cazadero/CazImages

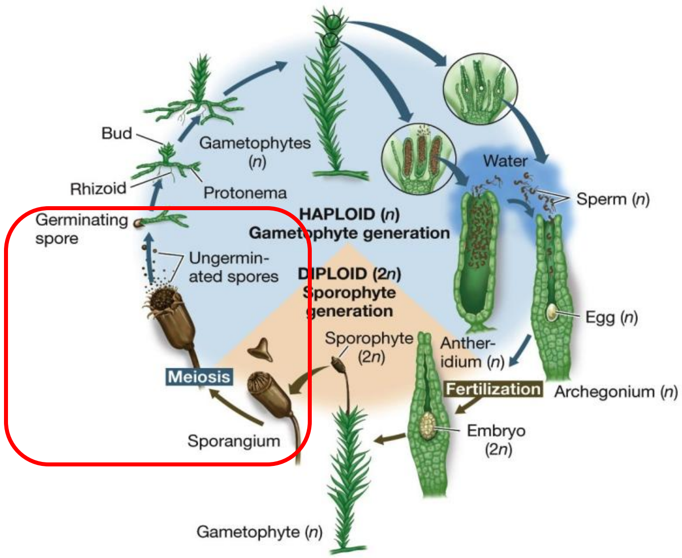
Figure 28.4 A Moss Life Cycle (Part 1)

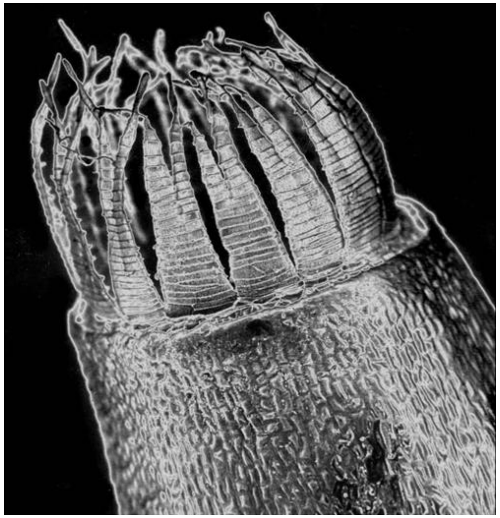


LIFE 9e, Figure 28.4 (Part 1)

Life Cycle of a Moss

- Sporophyte produces unicellular, haploid spores by meiosis within a **sporangium** or **capsule**
- Spores germinate and gives rise to a multicellular, haploid gametophyte whose cells contain chloroplasts





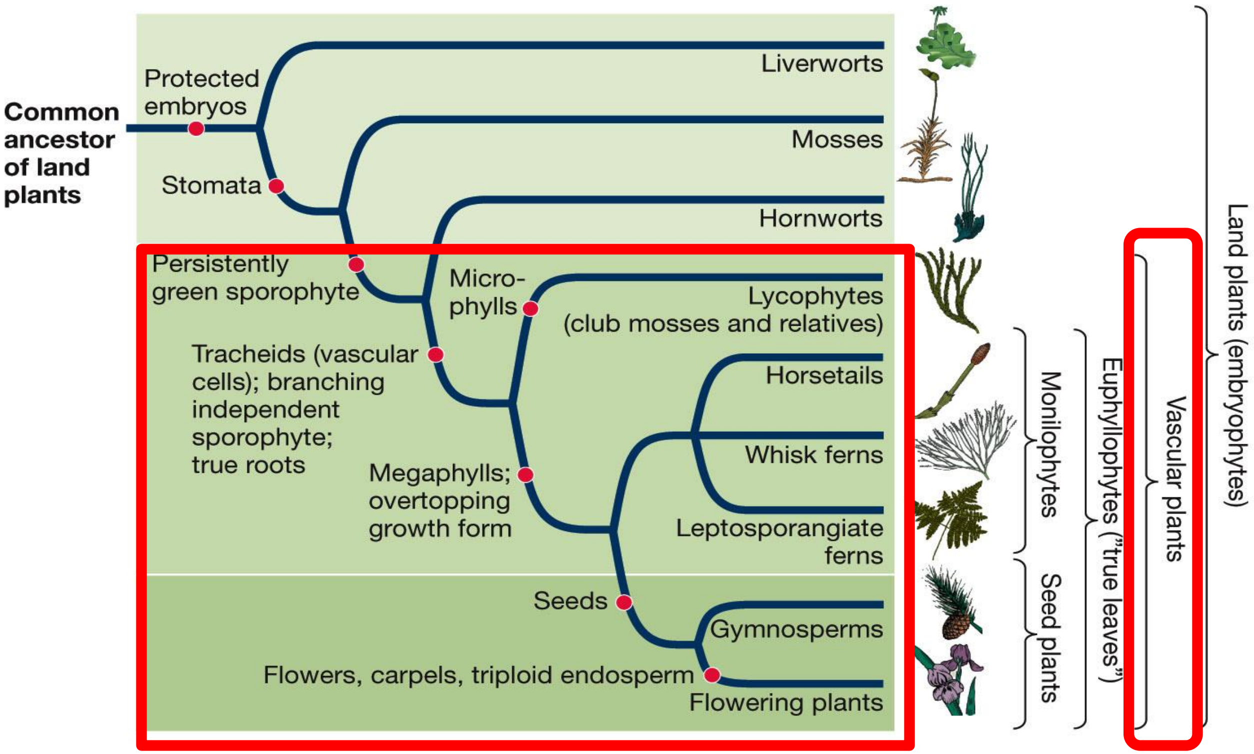
Calyx of a mature moss sporangium capsule through which spores are released

www.zyvex.com/EIPBNuG

www.botany.hawaii.edu/faculty/webb/BOT311/BOT311-00/AntherArch

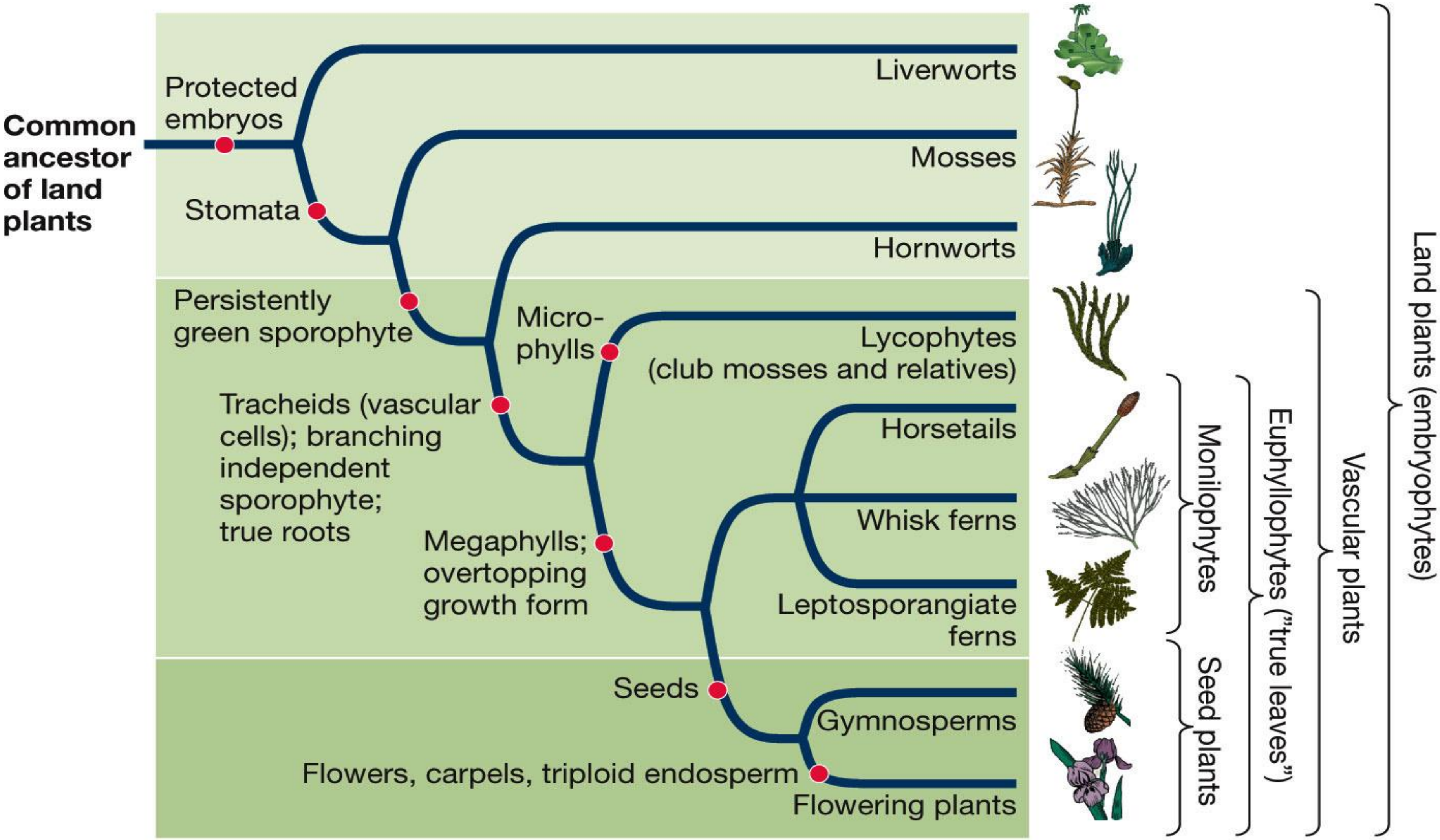
Animation 28.1 Life Cycle of a Moss

Vascular plants include the club mosses, ferns, gymnosperms, and angiosperms (flowering plants).



LIFE 9e, Figure 28.5

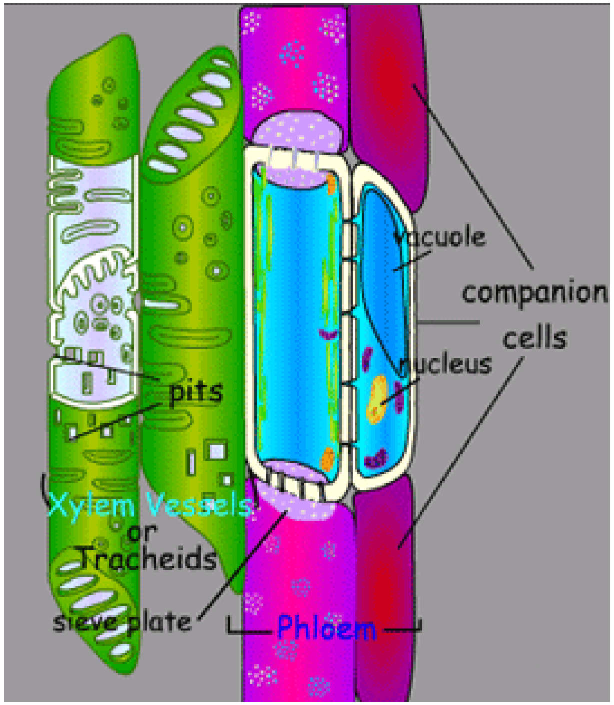
Figure 28.5 The Evolution of Plants



LIFE 9e, **Figure 28.5**

The **vascular system** consists of tissue specialized for transport of materials

- **Xylem**
  - conducts water and minerals from soil up to aerial parts of plant.
  - Some cells have **lignin** — provides support
- **Phloem**
  - conducts products of photosynthesis through plant.

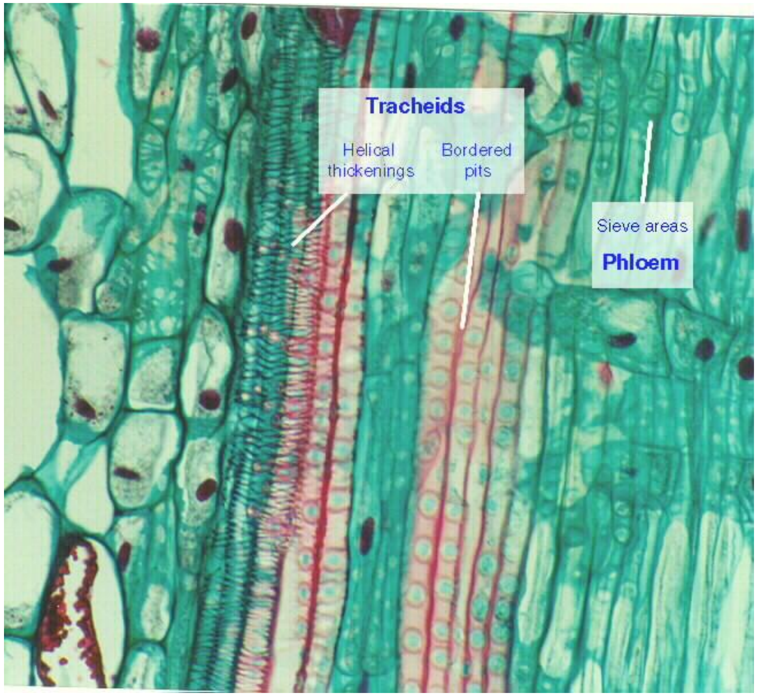


http://plantandsoil.unl.edu/croptechnology2005/UserFiles/Image/siteImages/Fig-3-large.gif

28.3 What Features Distinguish the Vascular Plants?

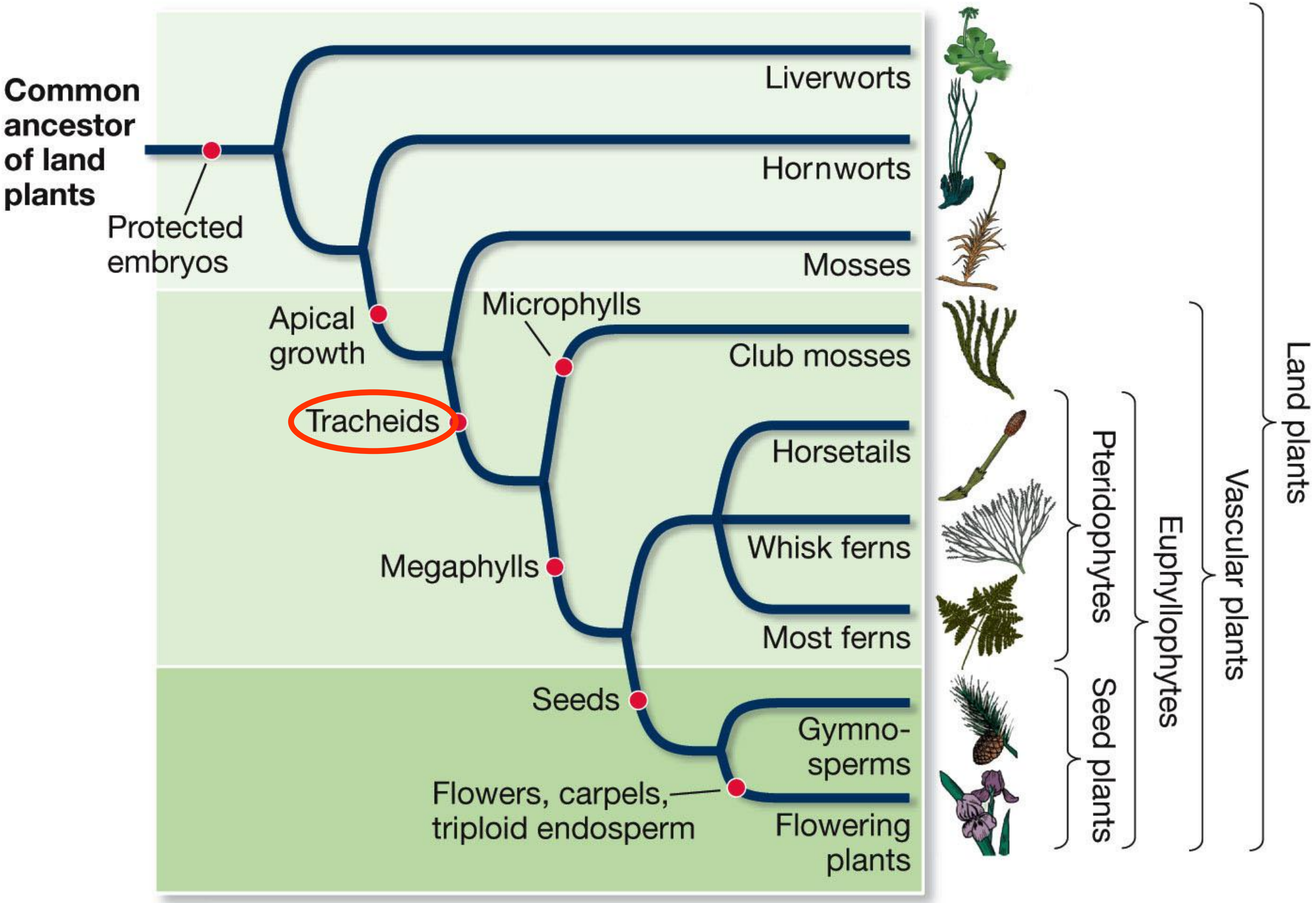
A single event probably launched the vascular plants:

- In the mid-Silurian (430 mya), the sporophyte generation of a now extinct plant produced a new cell type, the **tracheid**
- Tracheids are main water-conducting element in xylem



www.unlv.edu/Colleges/Sciences/Biology/Schulte/Anatomy/CellsTissues

Figure 28.7 The Evolution of Today's Plants



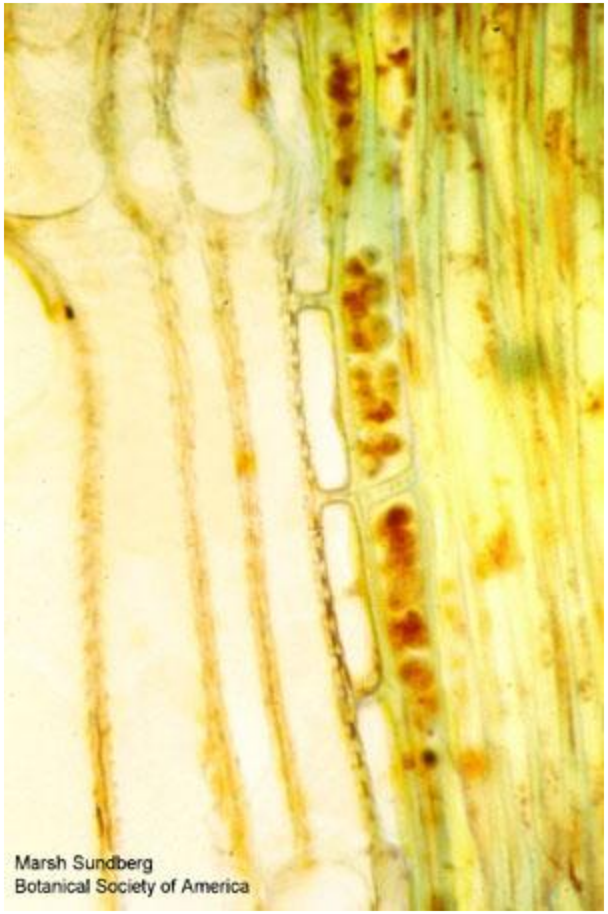
LIFE 8e, Figure 28.7

28.3 What Features Distinguish the Vascular Plants?

Evolution of tracheids had two important consequences:

- *Transport* of water and minerals
- *Rigid structural support* (not needed in aquatic green algae)
- Tracheids set stage for full invasion of land

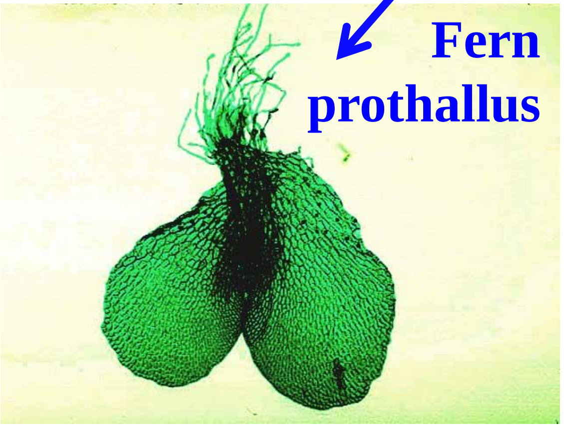
Robinia **xylem, l.s. bordered pit hairs**



http://pix.botany.org/set13/13-051h_300.jpg

Vascular plants also have a branching, independent sporophyte

- Mature sporophyte is nutritionally independent from gametophyte



Small independent gametophyte (left) and branched sporopythe (right) of ferns

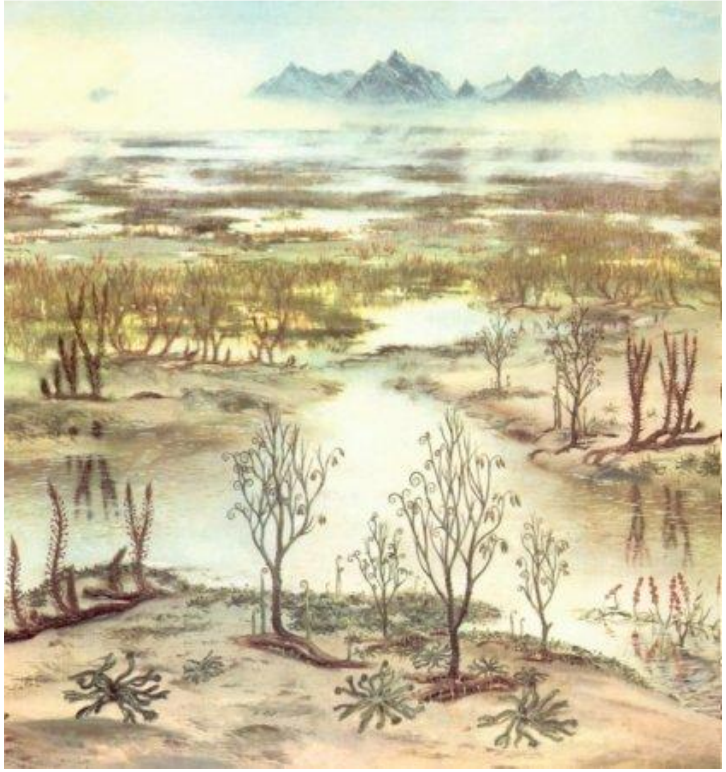
http://virtual.yosemite.cc.ca.us/randerson/Lynn's%20Bioslides/20.jpg

http://web.cortland.edu/broyles/hayg

28.3 What Features Distinguish the Vascular Plants?

First vascular plants were successful on land because of…

- cuticle
- protective layers for gametangia, and
- absence of herbivores



http://universe-review.ca/I10-68-Silurian.jpg

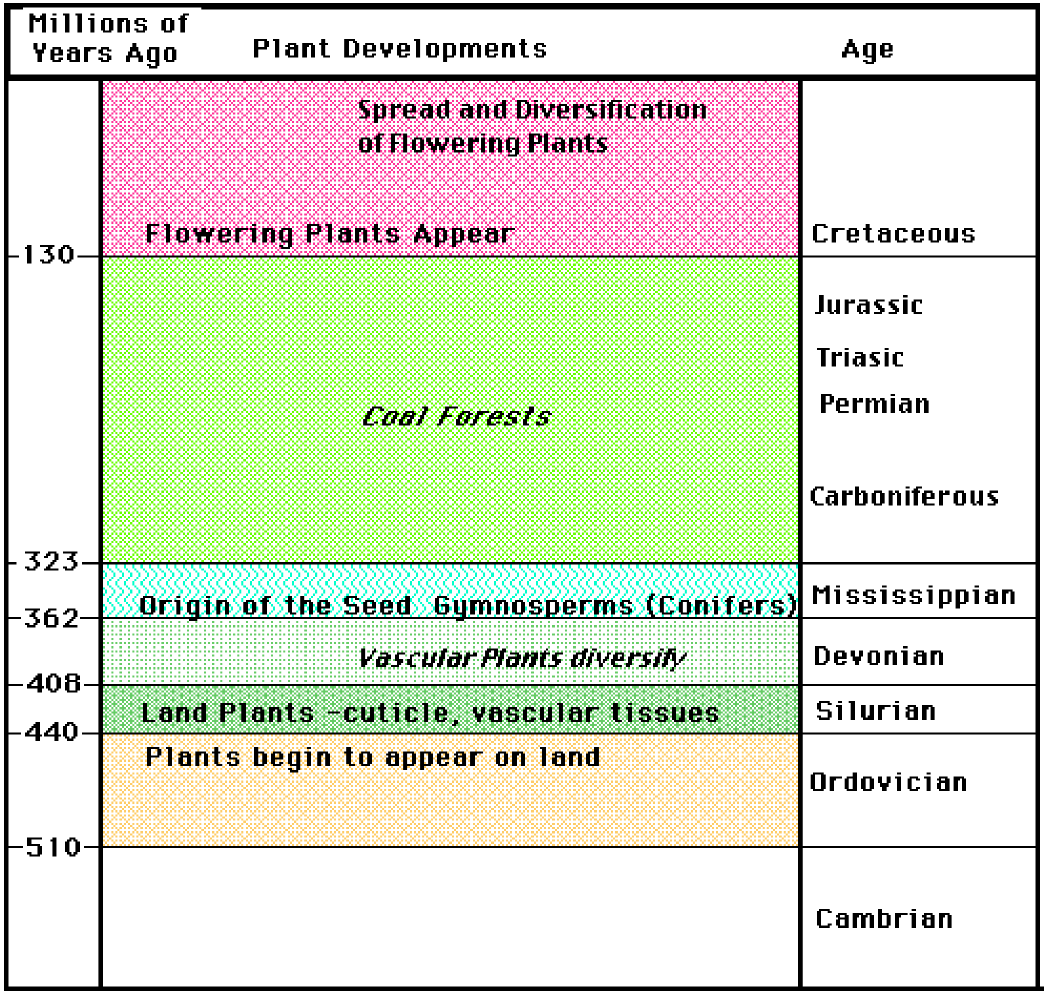
28.3 What Features Distinguish the Vascular Plants?

First plant fossils are from Silurian (408-440 mya)

- Made land more hospitable for animals
- Amphibians and insects arrived soon after plants

LIFE 9e, Ch. 28 Opener 1

28.3 What Features Distinguish the Vascular Plants?



During Devonian, the lycophytes (club mosses) and pteridophytes (horsetails and ferns) appeared

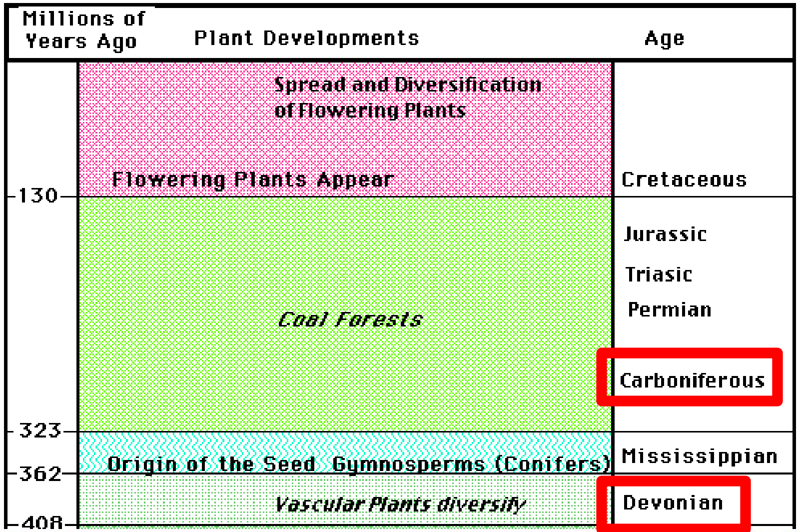
- Amphibians and insects were also arriving on land

http://curriculum.calstatela.edu/courses/builders/lessons/less/les8/les8gifs/plantchart.gif

28.3 What Features Distinguish the Vascular Plants?

Trees appeared in Devonian and dominated in Carboniferous

- Forests of lycophytes, horsetails, and tree ferns flourished in swamps
- Plant parts that were buried in swamps →subjected to heat and pressure became coal deposits



LIFE 9e, Figure 28.6

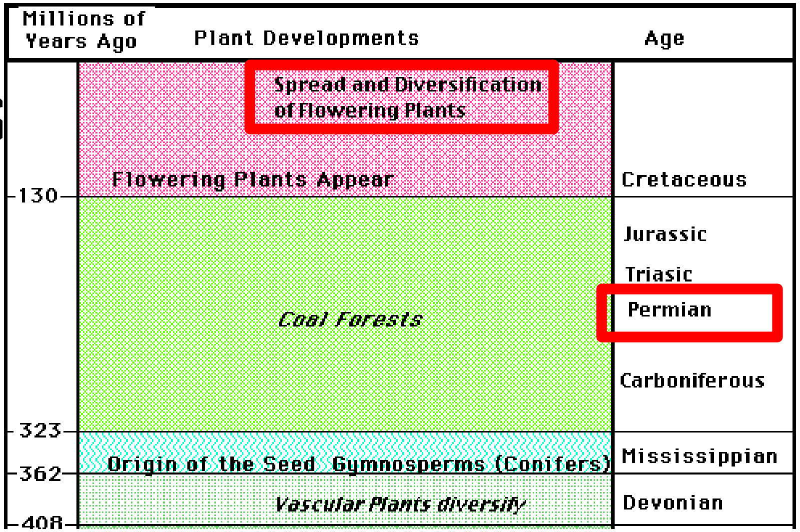
Figure 28.6 Reconstruction of an Ancient Forest

LIFE 9e, Figure 28.6

28.3 What Features Distinguish the Vascular Plants?

During Permian, continents came together to form Pangaea

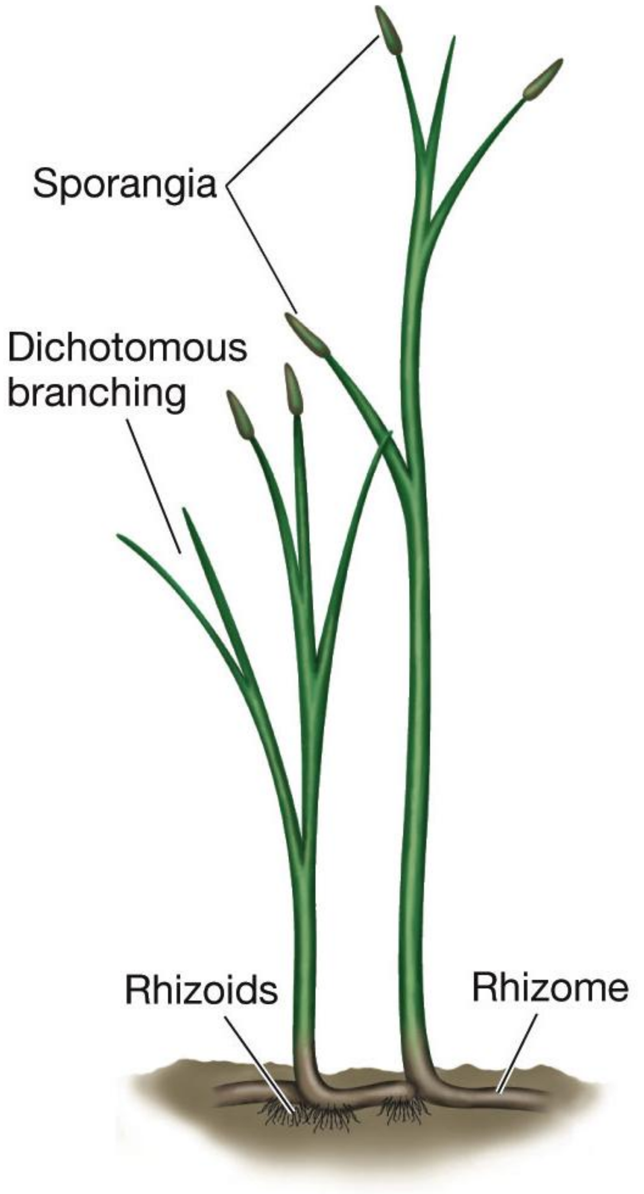
- Extensive glaciation occurred in late Permian → cooler, drier
- Lycophyte–fern forests replaced by gymnosperms
- Angiosperms overtook landscape ~65 mya



http://universe-review.ca/I10-32-Permian.jpg

Earliest vascular plants (now extinct) were **Rhyniophytes** (Silurian)

- **dichotomous branching**, but lacked leaves and roots
- anchored by **rhizomes** (horizontal portions of stem) and **rhizoids** (water-absorbing filaments)



28.3 What Features Distinguish the Vascular Plants?

Lycophytes (club mosses) also appeared in Silurian

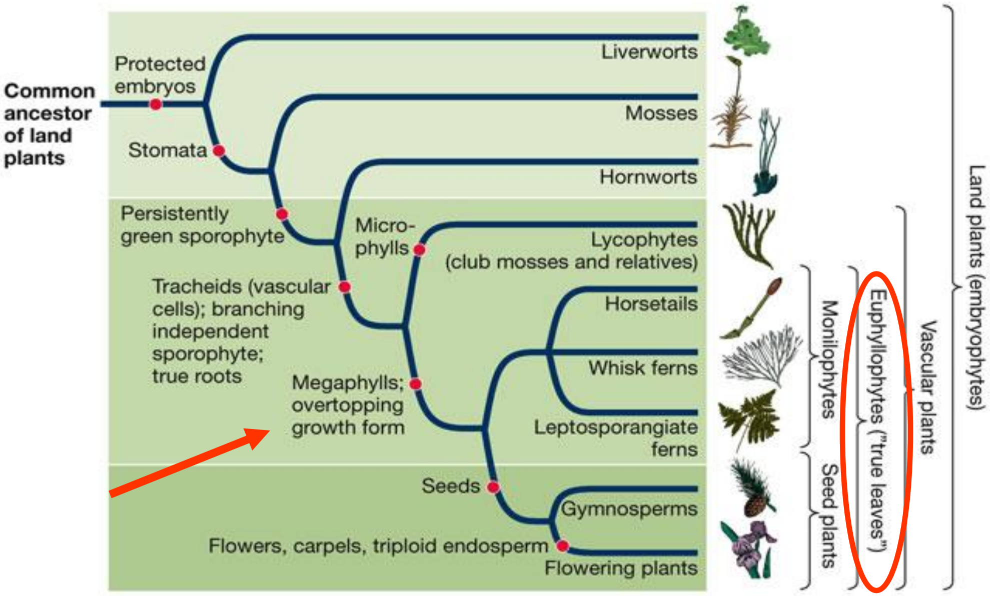
Monilophytes (a.k.a. **pteridophytes**; ferns & allies) appeared in Devonian

- These groups had true roots and leaves, and two types of spores

www.anselm.edu/homepage/jpitocch/genbios

Monilophytes and seed plants form a clade called **euphyllophytes** (“true leaf plants”)

- Synapomorphies include **overtopping** growth — new branches grow beyond the others — an advantage in the competition for light



LIFE 9e, Figure 28.5

Roots probably originated from rhizome or stem

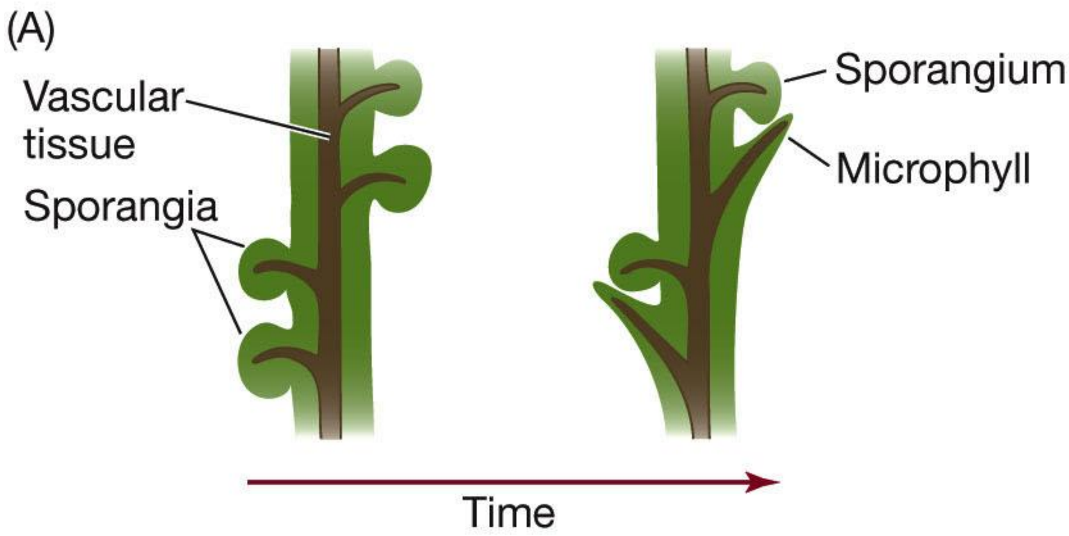
- Underground and aboveground stems would be subjected to very different selection pressures →
  - evolved distinctive structures

Chinese club moss, *Huperzinea serrata*

http://www.brainlightning.com/graphics/Huperzia.jpg

True **leaves** evolved

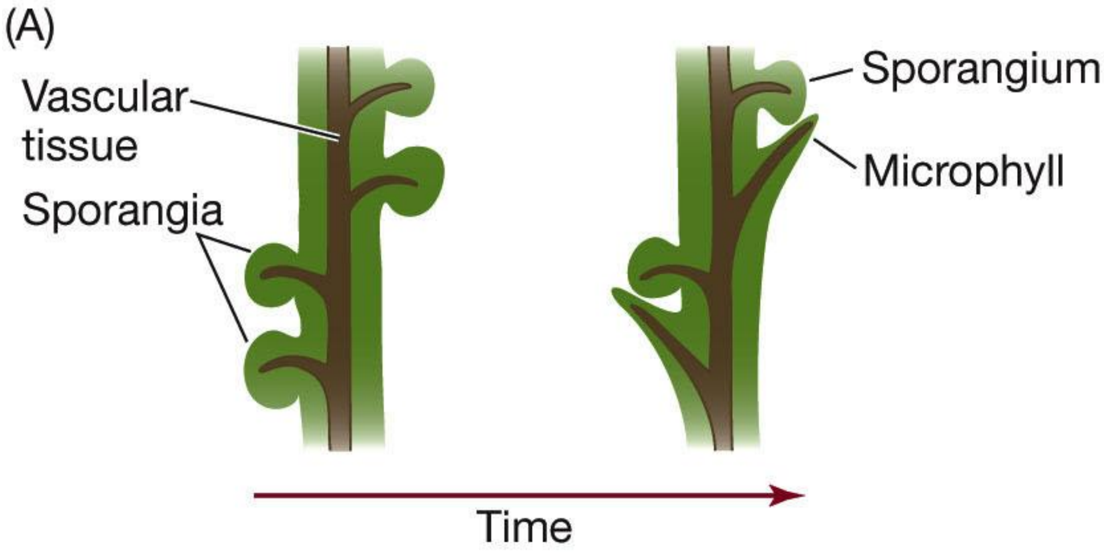
- flattened photosynthetic structures arising from a stem or branch
- has true vascular tissue
- two types: microphylls and megaphylls



Lycopodium

Club mosses (lycophytes)

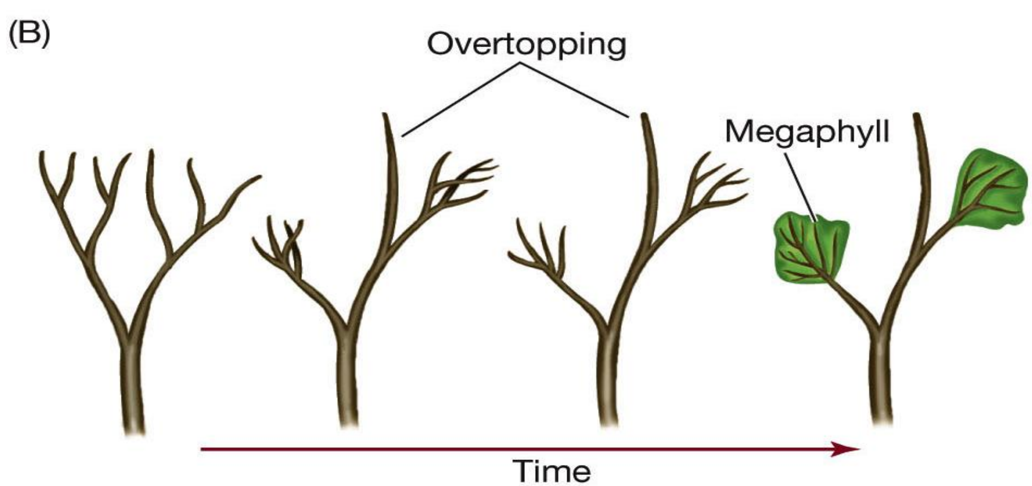
- have **microphylls**: small, simple leaves, usually one central vascular strand
- May have originated as sterile sporangia



Lycopodium

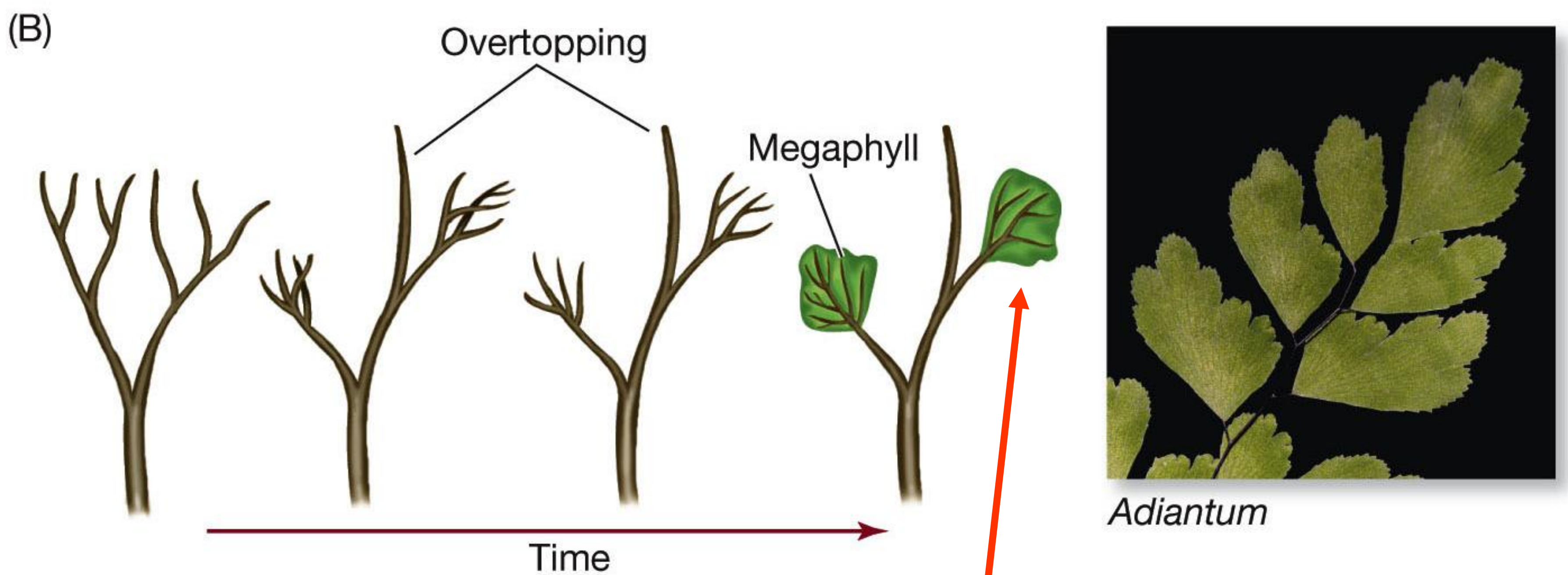
Monilophytes and seed plants have **megaphylls**

- larger, more complex leaves
- may have arisen from reduced and flattened branching stems → increase photosynthetic surface area
- → branching stem with overtopping growth



Adiantum

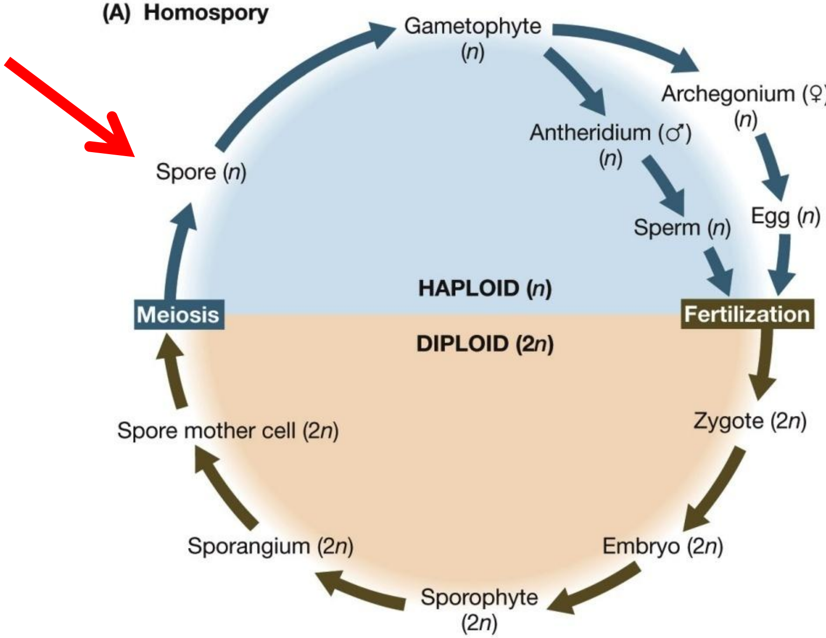
Figure 28.10 The Evolution of Leaves (B)



- Flat plates of photosynthetic tissue developed between branches.
- End branches evolved into leaf veins

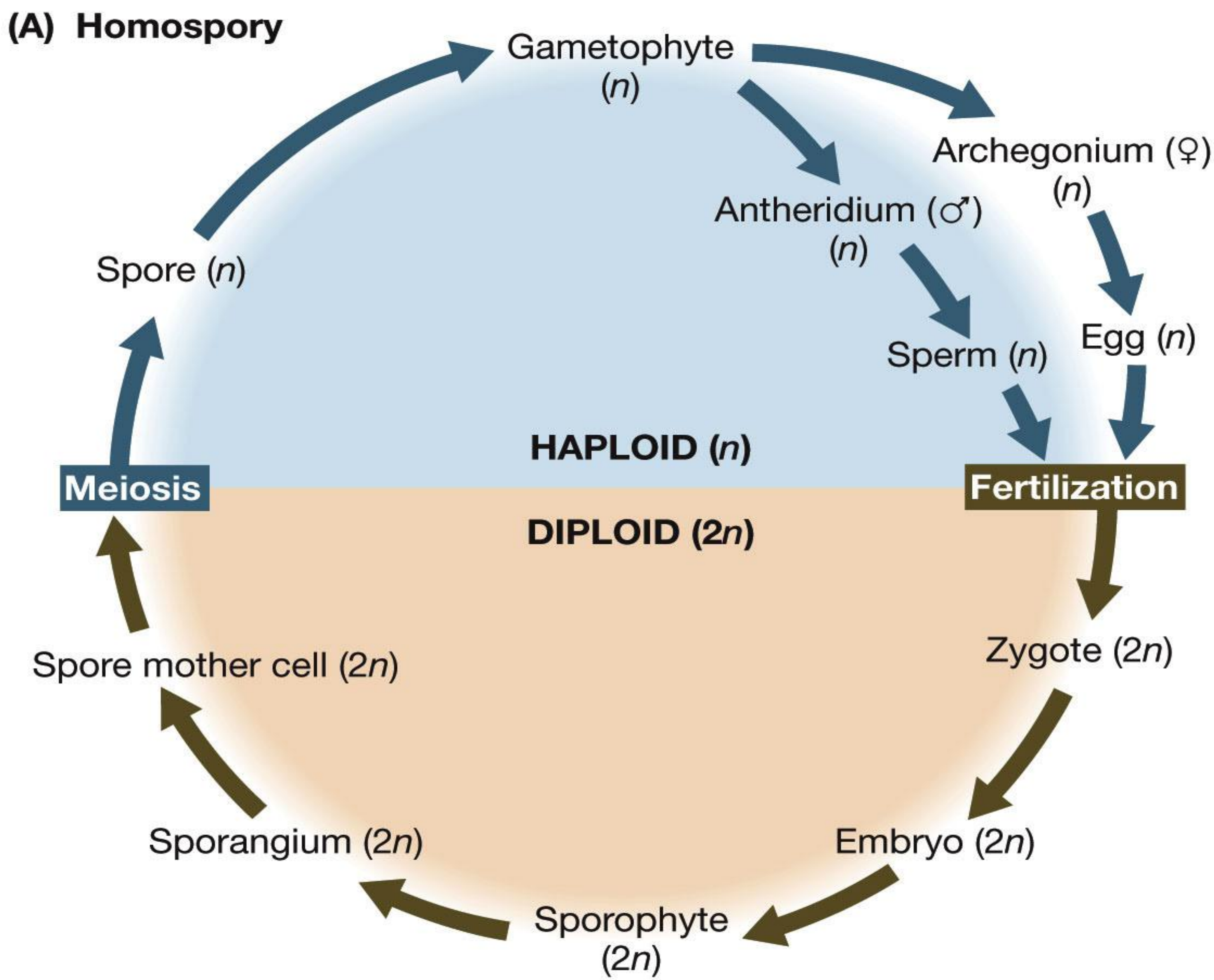
The most ancient vascular plants were **homosporous** — single type of spore

- Spores produce one type of gametophyte that has both archegonium and antheridium



LIFE 9e, Figure 28.10 (Part 1)

Figure 28.10 Homospory and Heterospory (Part 1)



LIFE 9e, Figure 28.10 (Part 1)

Heterosporous plants produce two types of spores:

- **Megaspores**
  - Megaspores are produced in small numbers in **megasporangia**
  - Develop into female gametophytes — **megagametophyte**

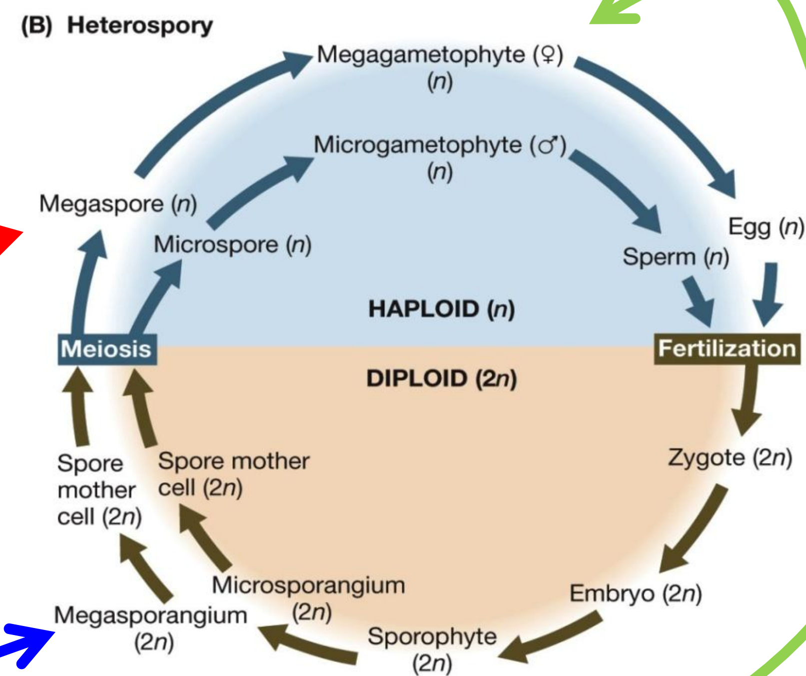
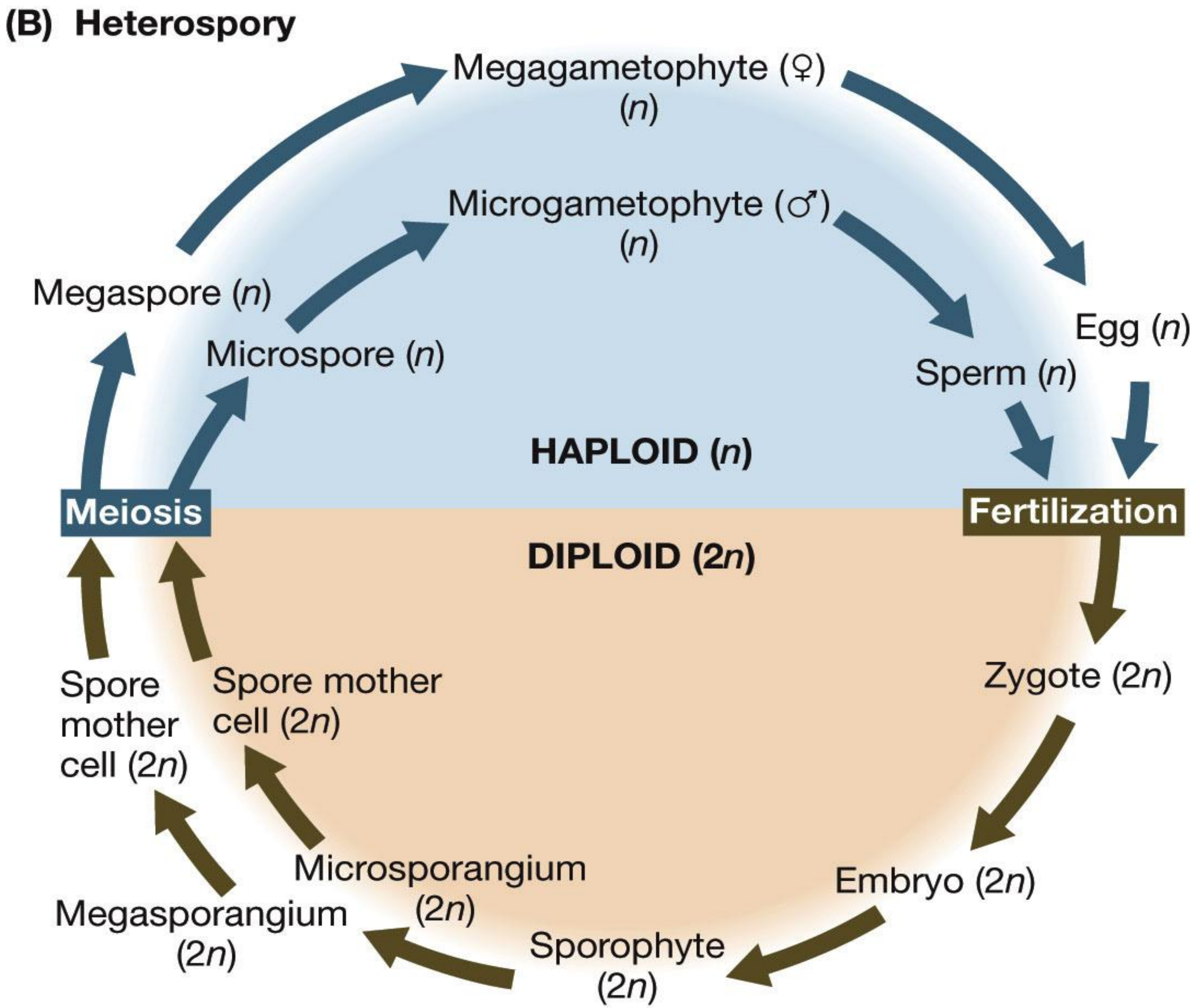


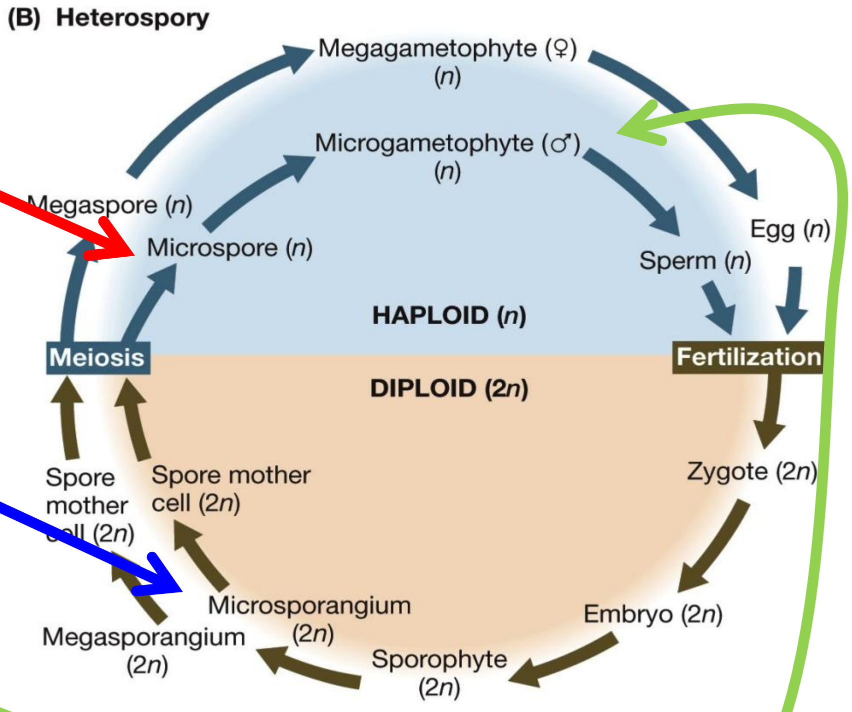
Figure 28.10 Homospory and Heterospory (Part 2)



LIFE 9e, Figure 28.10 (Part 2)

28.3 What Features Distinguish the Vascular Plants?

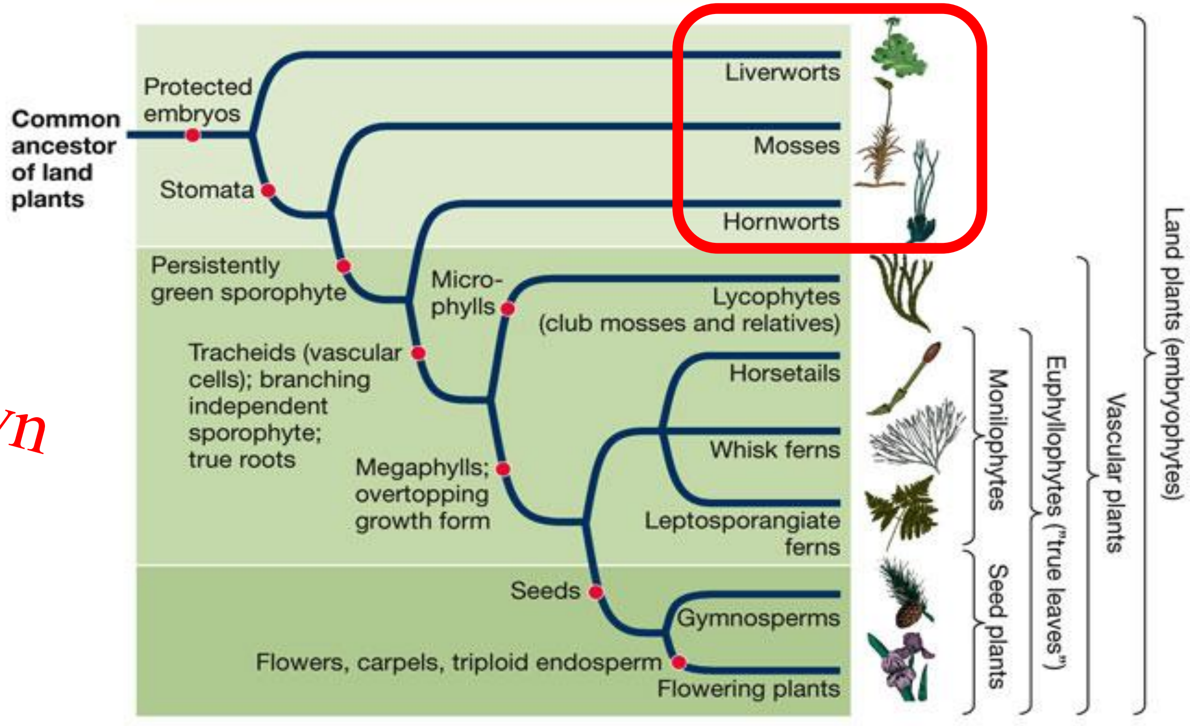
- **Microspores**
  - Microspores are produced in large numbers in **microsporangia**
  - Develop into male gametophytes — **microgametophyte**
- *Heterospory evolved several times suggesting that it affords a selective advantage*



Nonvascular land plants: three non-monophyletic clades:

- liverworts
- mosses
- hornworts

On your own



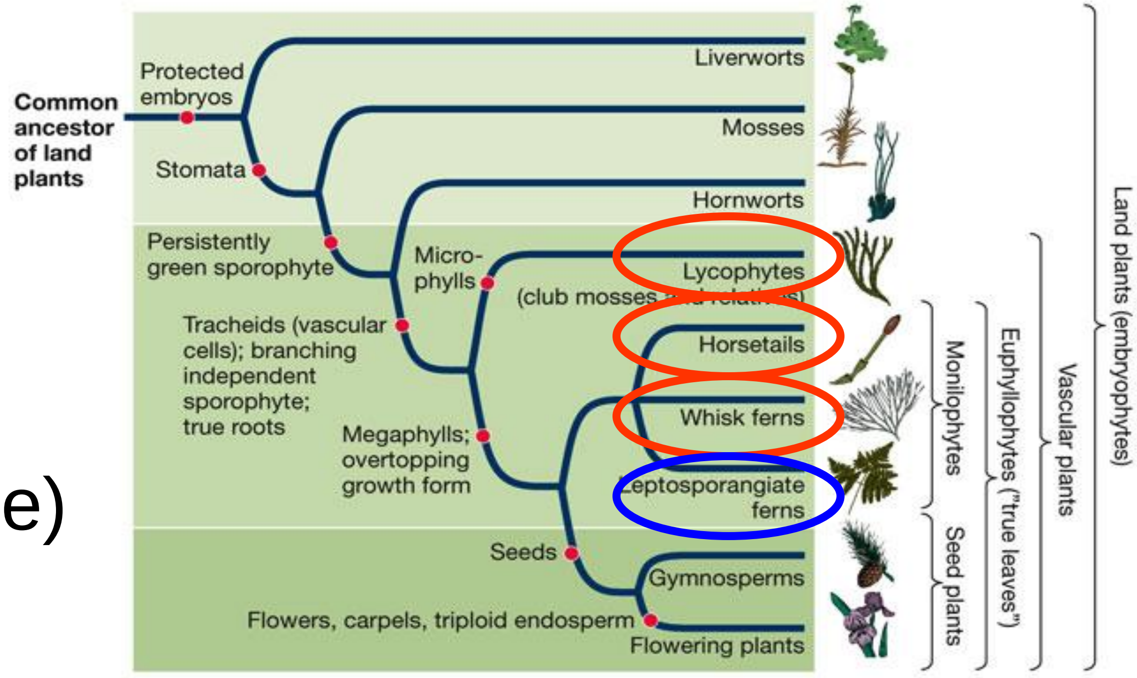
LIFE 9e, Figure 28.5

28.4 What Are the Major Clades of Seedless Plants?

Seedless vascular plants – three monophyletic clades:

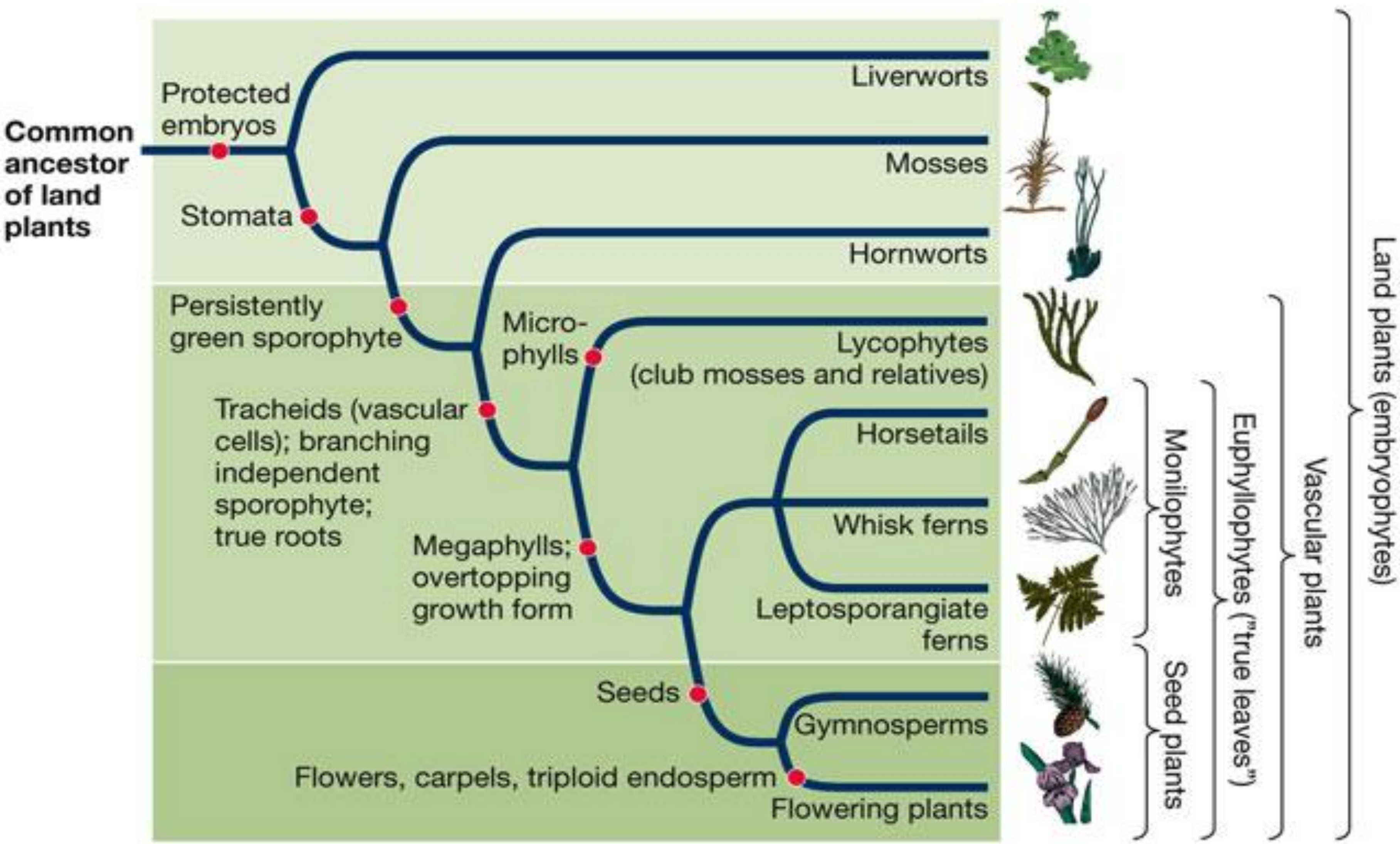
- club mosses
- horsetails
- whisk ferns
- plus ferns and allies (not monophyletic, though 97% are)

On your own



LIFE 9e, Figure 28.5

Figure 28.7 The Evolution of Today's Plants

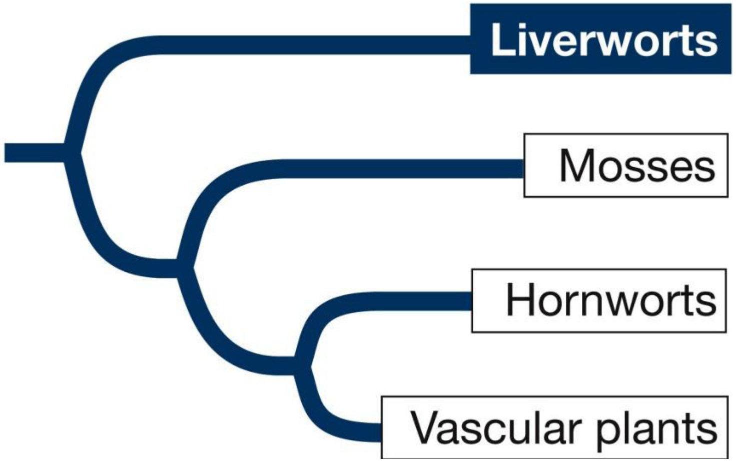


LIFE 9e, **Figure 28.5**

Liverworts: **Hepatophyta**

- 9,000 species
- Most have leafy gametophytes
- Somehave “leaf-like” *(thalloid)* gametophytes

www.bcbiodiversity.homestead.com/files



Liverworts: Hepatophyta

- Sporophytes very short — few millimeters
- Stalk raises simple sporangium above ground level to disperse spores

Leafy liverwort w/sporophyte

http://pix.botany.org/set02

Liverworts: Hepatophyta

Liverworts also reproduce asexually:

- By simple fragmentation of gametophyte
- And by ***gemmae*** — “lens-shaped” clumps of cells located inside of ***gemmae cups***
- Gemmae are dispersed by raindrops

http://homepage.eircom.net/~hedgerow2

Marchantia with gemmae cups

Astella with gemmae inside cup

http://waynesword.palomar.edu/bryoph1.htm

Figure 28.13 Liverwort Structures

(A) *Bazzania trilobata*

(B) *Marchantia* sp.

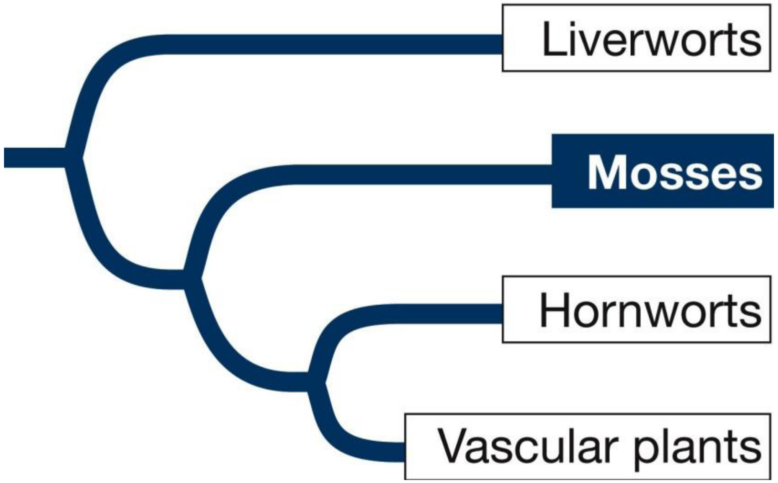
Marchantia with gemmae inside gemmae cups

(C) *Marchantia* sp.

LIFE 8e, Figure 28.13

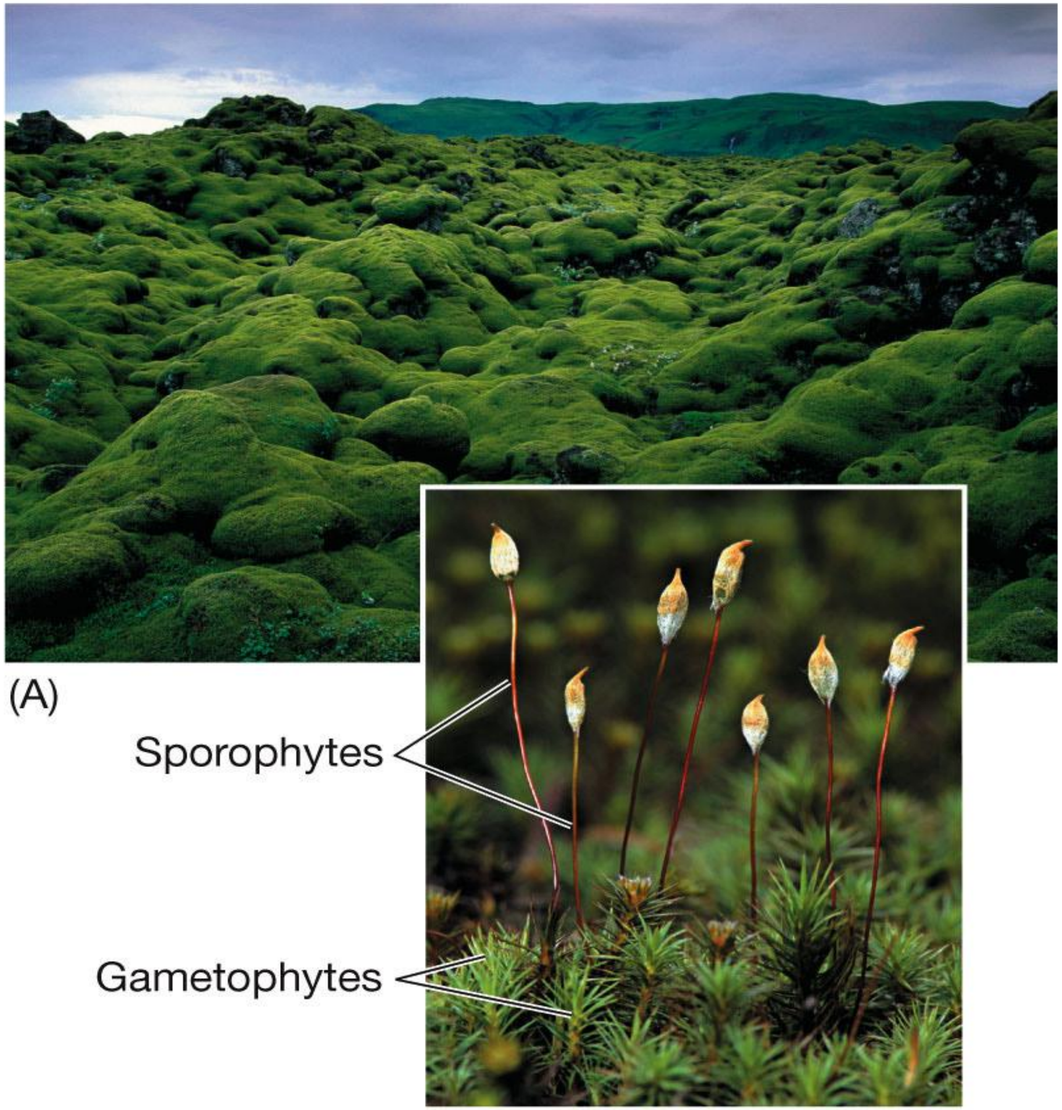
The **mosses**: **Bryophyta**

- 15,000 species
- Mosses (plus hornworts and vascular plants) have stomata→ important in water & gas exchange



LIFE 8e, Figure 28.15

Figure 28.12 Mosses Grow in Dense Mats



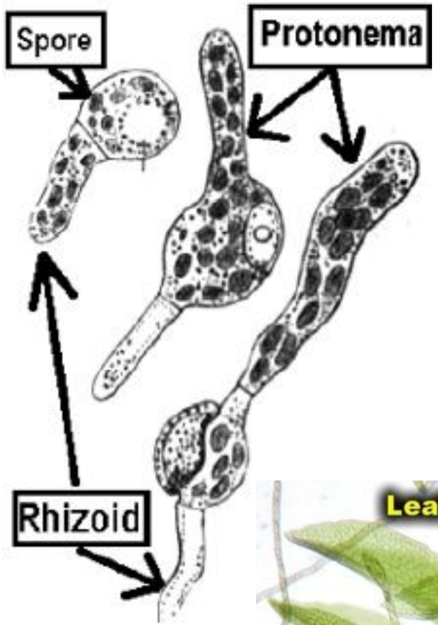
(B) *Polytrichum* sp.

The **mosses: Bryophyta**

www.botany.hawaii.edu/faculty/webb/Bot201/Mosse

Gametophyte begins as a branched, filamentous structure — the **protonema**

- Some filaments are photosynthetic, others are **rhizoids** that anchor the protonema
- Tips of photosynthetic filaments form *buds* which produce the leafy moss shoots



www.botany.hawaii.edu/faculty/webb/Bot201/Mosse

The **mosses**: **Bryophyta**

Moss sporophytes and vascular plants grow by **apical cell division**

- Division at growing tip of plant
- Provides organized pattern of division, elongation, and differentiation

Haircap Moss (*Polytrichum* sp.)

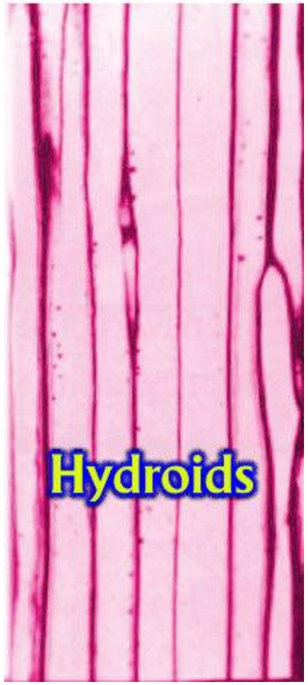
www.perspective.com/nature/plantae

The **mosses: Bryophyta**

http://www.botany.hawaii.edu/faculty/webb/bot201/transition/transition_to_land-Xylem.htm

Some moss gametophytes are too large to depend on diffusion for water transport

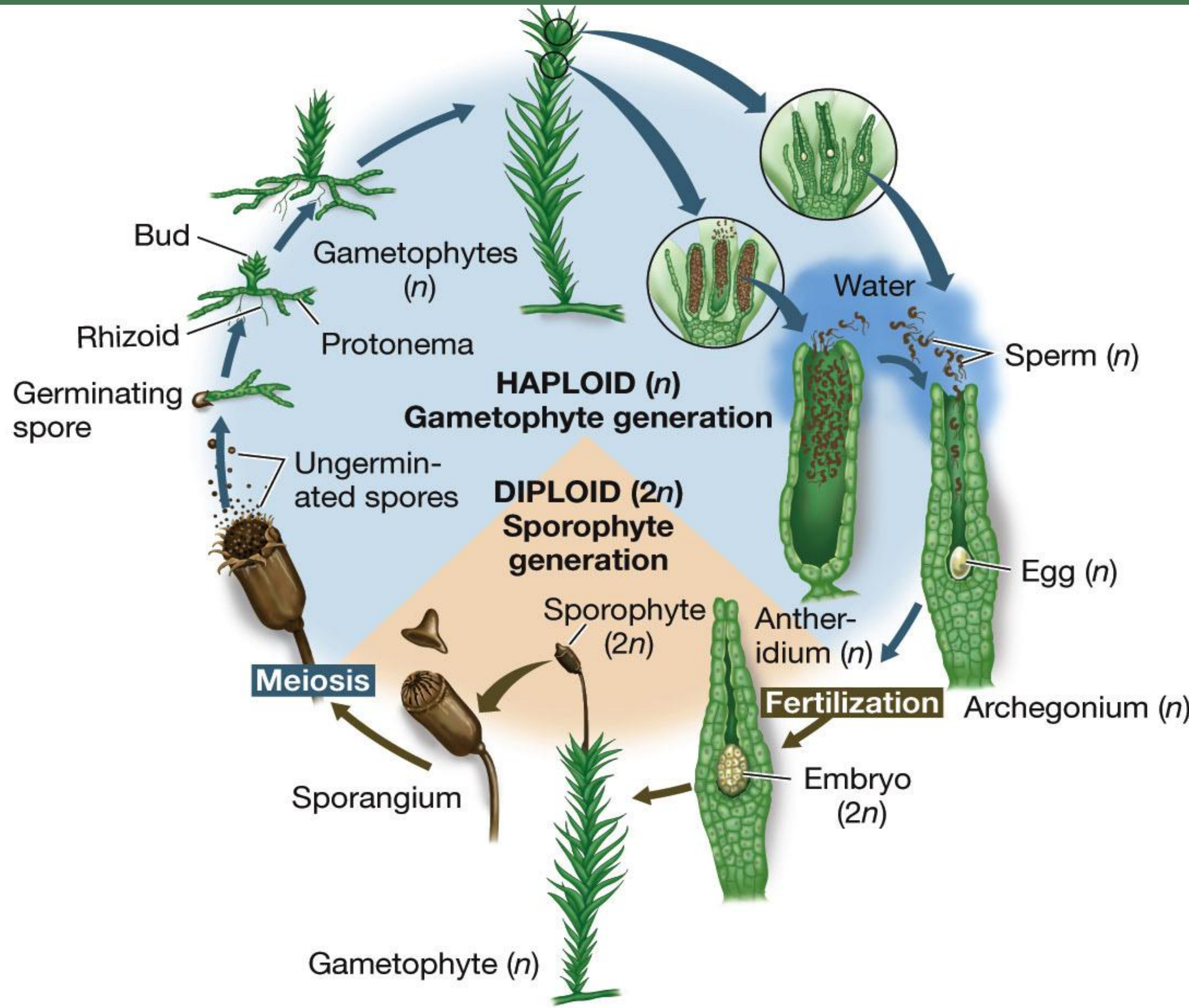
- Cells called **hydroids** die, and provide channels in which water can travel – but walls are thin and lack lignin
- Hydroids are functionally similar (analogous) to tracheids but may or may not be progenitor (??)



White spots in x-section of *Sphagnum* moss are pores in "leaf" cells, through which water passes.

www.genomenewsnetwork.org/gnn_images/news_content/2004/03/04/moss

Figure 28.4 A Moss Life Cycle (Part 1)



LIFE 9e, Figure 28.4 (Part 1)

The **mosses: Bryophyta**

Sphagnum grows in swampy places

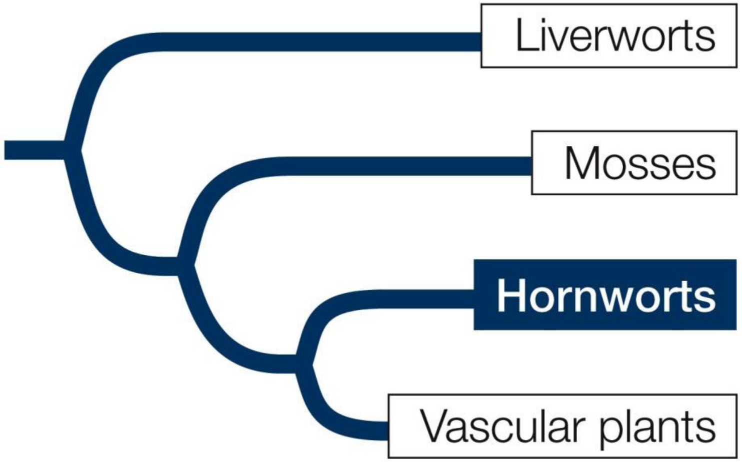
- Upper layers of moss compress lower layers that are beginning to decompose, forming *peat*
- Long ago, continued compression led to the formation of coal

http://www.ubcbotanicalgarden.org/potd/sphagnum_squarrosum.jpg

Figure 28.13 Sphagnum Moss

Hornworts: Anthocerophyta

- 100 species
- Gametophytes are flat plates of cells
- Have stomata, which do not close

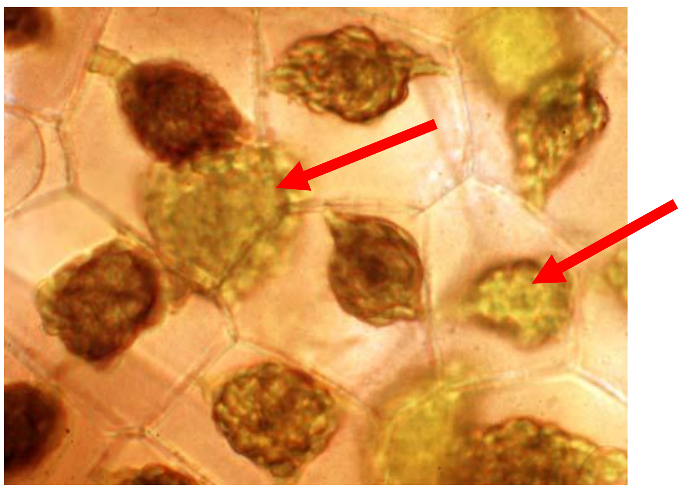


http://www.botany.org/PlantImages/Conant/CA06-014_300.jpg

Hornworts: Anthocerophyta

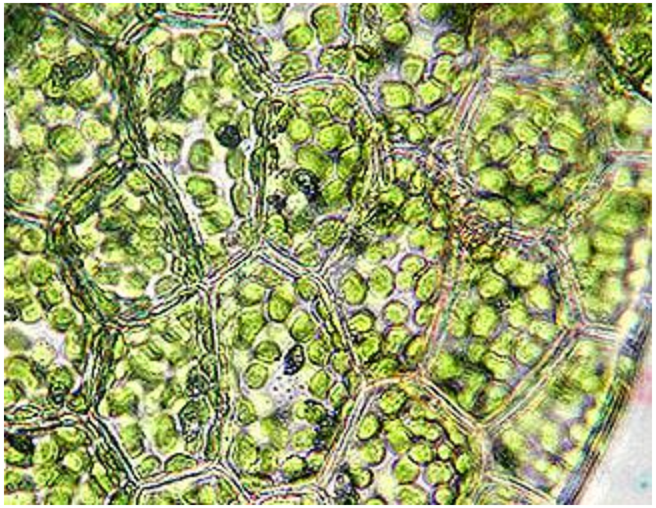
- Hornwort cells have a single, large chloroplast, rather than multiple chloroplasts

Cells of *Phaeoceros* sp., a hornwort, gametophyte with large, solitary, starch-laden chloroplasts. Photo by K. S. Renzaglia



www.science.siu.edu/landplants/Anthocerophyta/images

Liverwort cells with multiple chloroplast and oil bodies for comparison



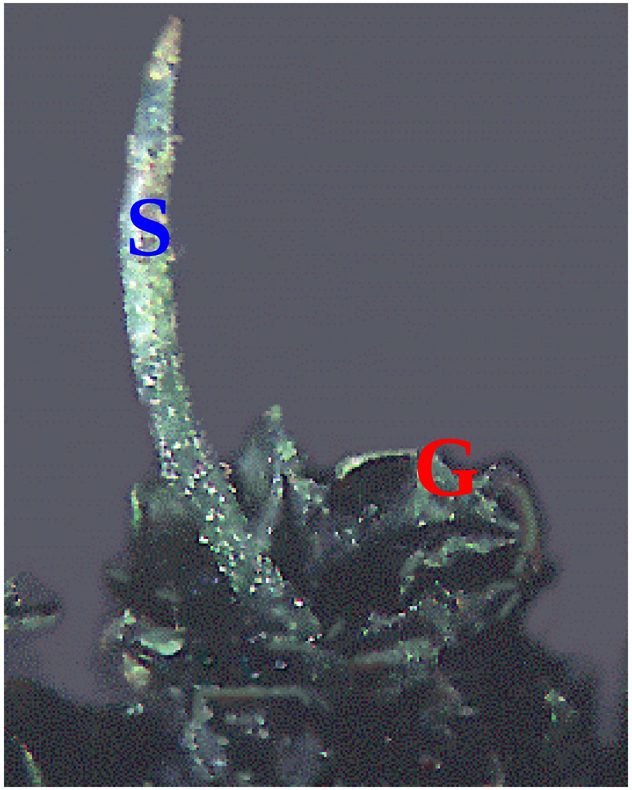
www.botany.ubc.ca/bryophyte

Hornworts: Anthocerophyta

- Sporophyte lacks stalk
  - has basal region capable of infinite cell division
  - can grow up to 20 cm

Dendroceros: Leaf-like gametophyte with horn-like sporophyte

Anthoceros sp.



LIFE 8e, Figure 28.14

www.biologie.uni-hamburg.de/b-online/library/bryophytes

Hornworts: Anthocerophyta

- Hornworts have internal cavities filled with nitrogen-fixing cyanobacteria

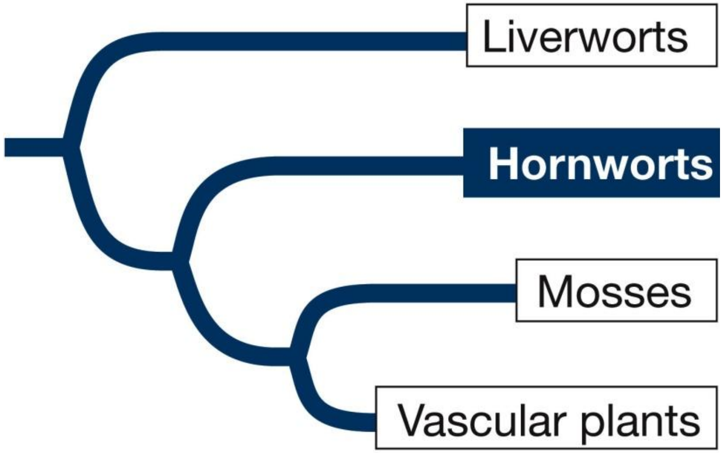
www.botany.hawaii.edu/faculty/webb/BOT311/Cyanobacteria

Figure 28.14 A Hornwort

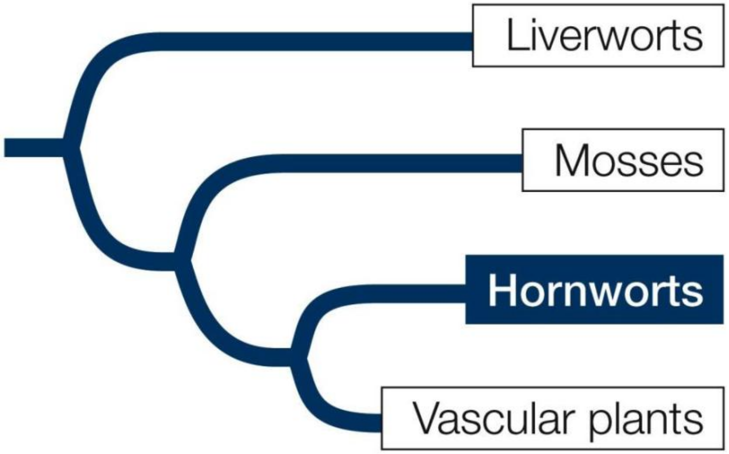
Anthoceros sp.

The exact evolutionary position of the hornworts is still unclear

- In some morphological analyses they are placed as the sister group to the mosses plus the vascular plants (both groups express apical cell division)

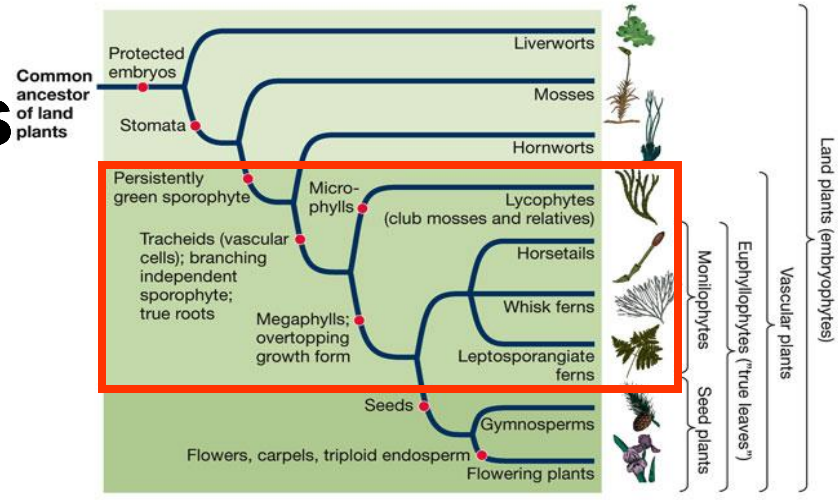


?

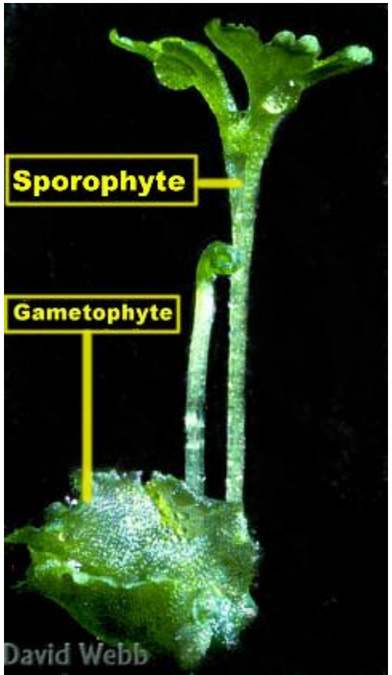


Seedless vascular plants

- Small, short-lived gametophyte is *independent* of the large sporophyte
- Single-celled spore is resting stage
- Must have water for part of life cycle — for the flagellated, swimming sperm



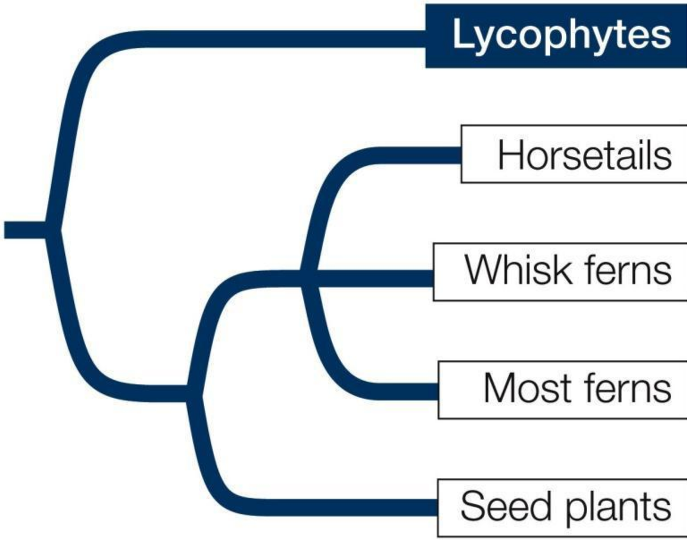
LIFE 9e, Figure 28.5

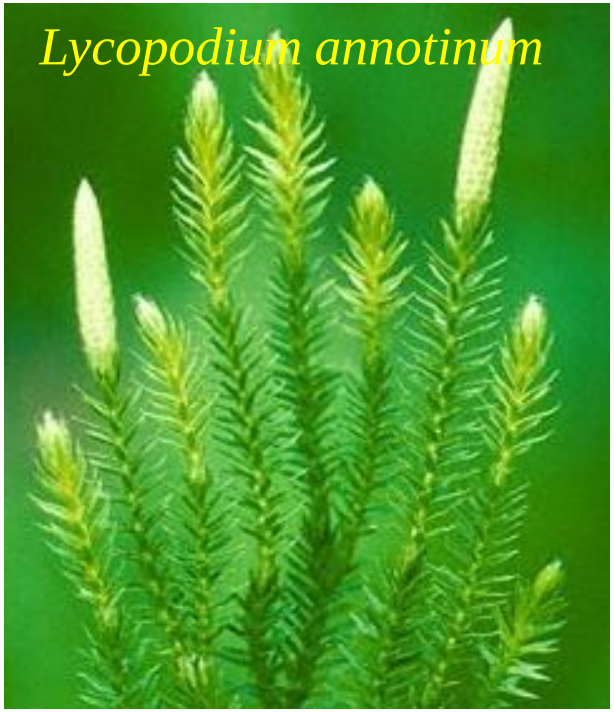


www.biologie.uni-hamburg.de/b-online/library/webb/BOT311/FERNS

Lycophytes: **club mosses**, spike mosses, and quillworts

- 1,200 species
- Roots and stems have dichotomous branching
- Leaves are microphylls

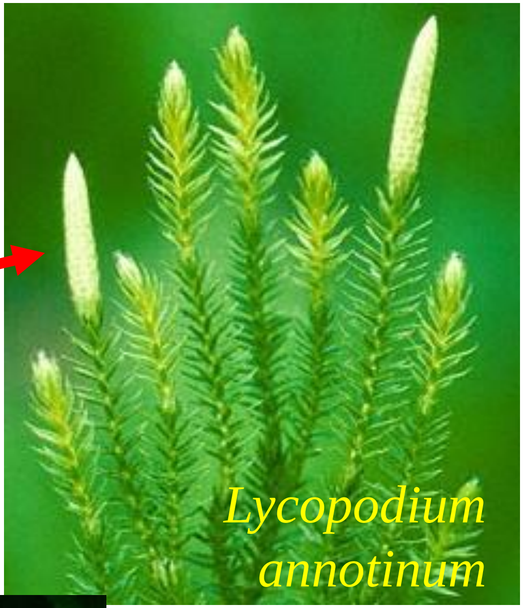




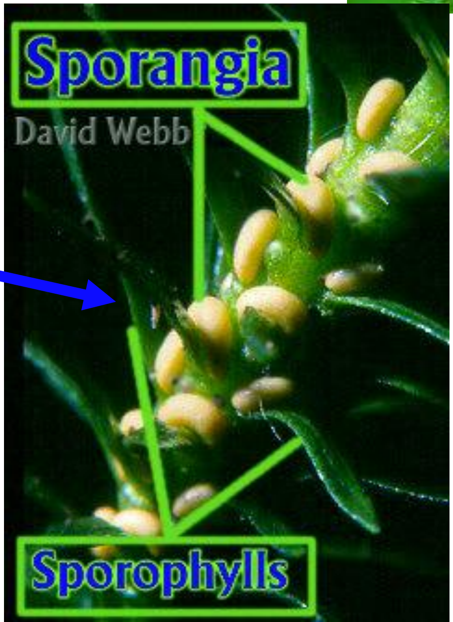
http://ip30.eti.uva.nl/bis/flora/pictures

28.4 What Are the Major Clades of Seedless Plants?

http://ip30.eti.uva.nl/bis/flora/pictures

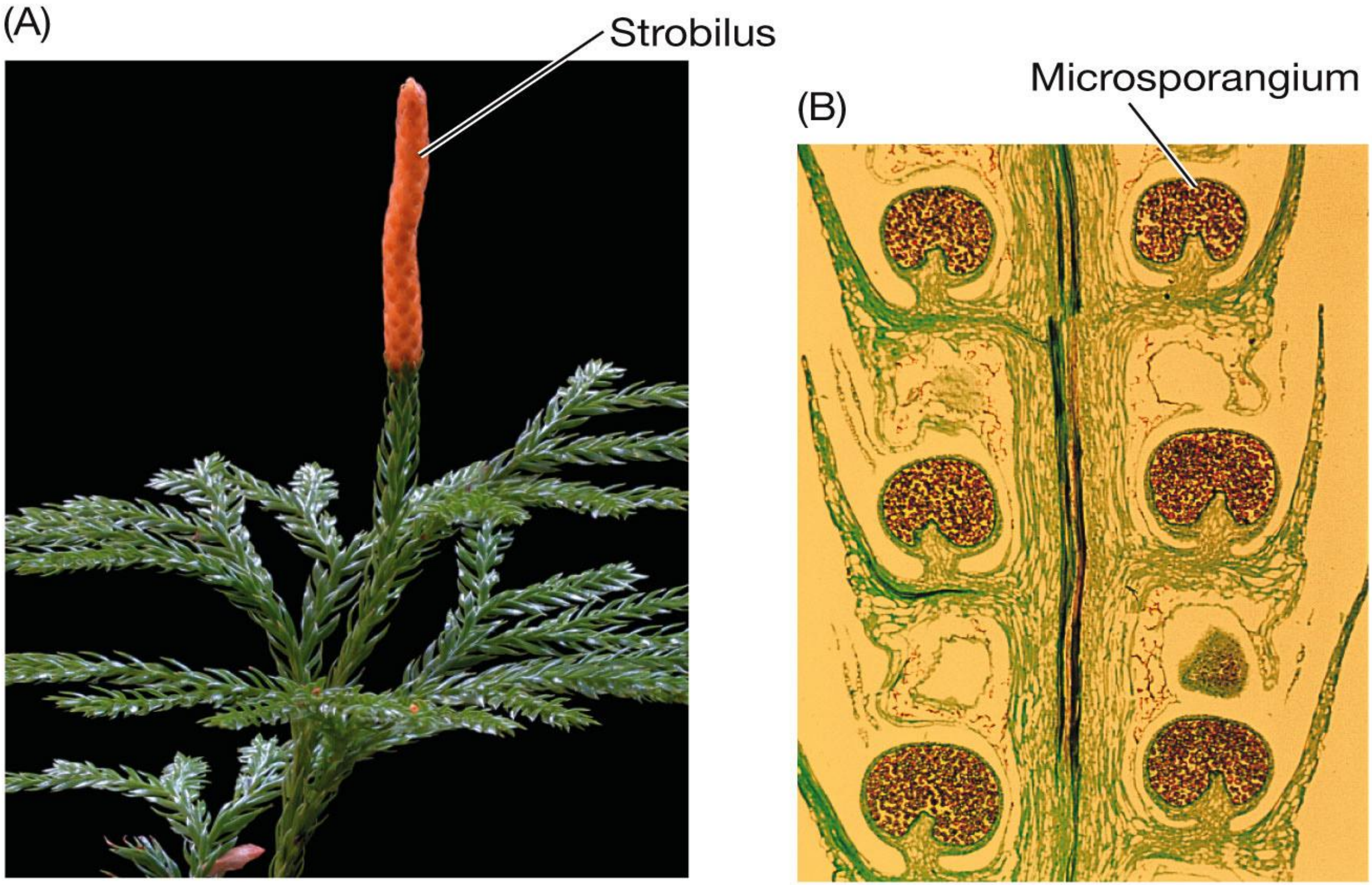


- Some club mosses have sporangia arranged in clusters called **strobili**
- Others have sporangia on upper leaf surfaces — **sporophylls**



http://www.botany.hawaii.edu/faculty/webb/BOT311/BOT311-00/AntherArch/SporophyllHighMagLab.jpg

Figure 28.15 Club Mosses



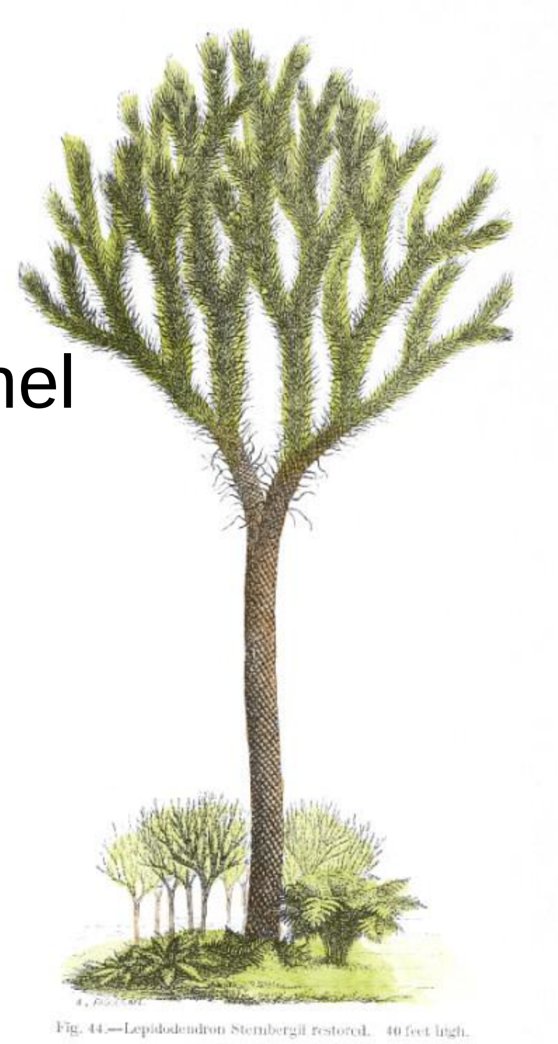
Lycopodium obscurum

***LIFE 9e*, Figure 28.15**

28.4 What Are the Major Clades of Seedless Plants?

Lycophytes were dominant during Carboniferous

- One type of coal (cannel coal or oil shale) is formed from spores of tree lycophyte, *Lepidodendron*
- Fact that its from the *spores* indicates enormous abundance

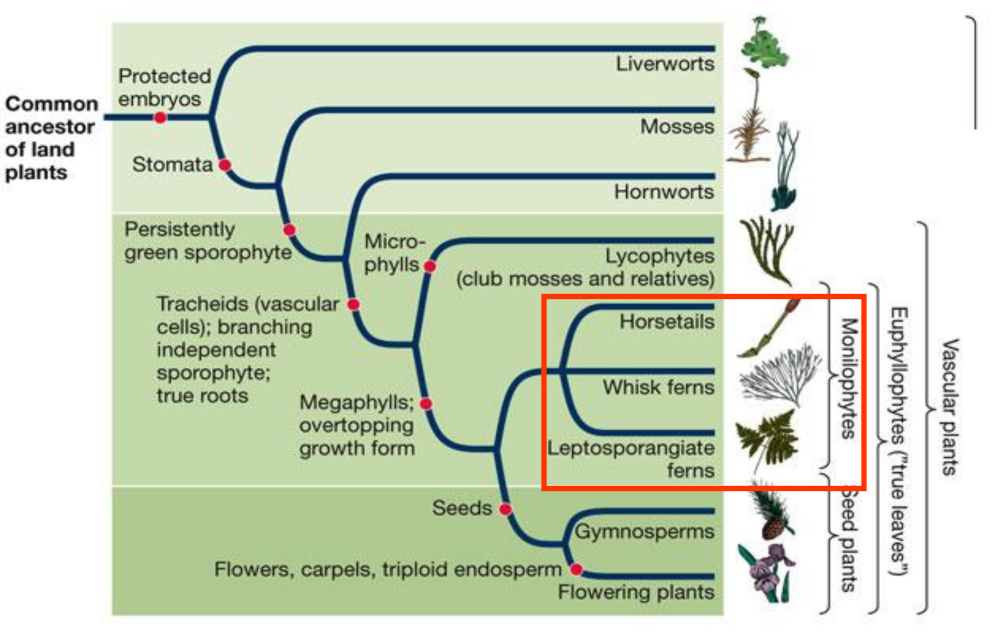


http://www.clearlight.com/~mhieb/WVFossils/PageMill_Images/image211.gif

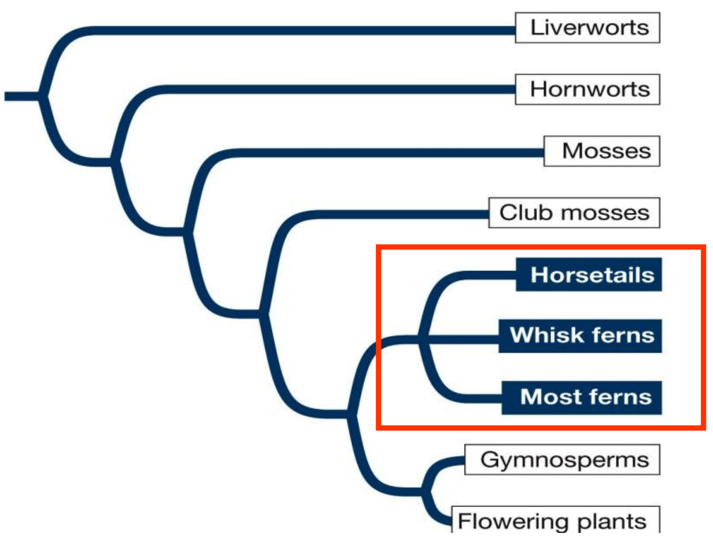
http://www.dkimages.com/discover/previews/893/20156718.JPG

Monilophytes (a.k.a. **Pteridophytes**) — horsetails, whisk ferns, and ferns & allies, form a clade

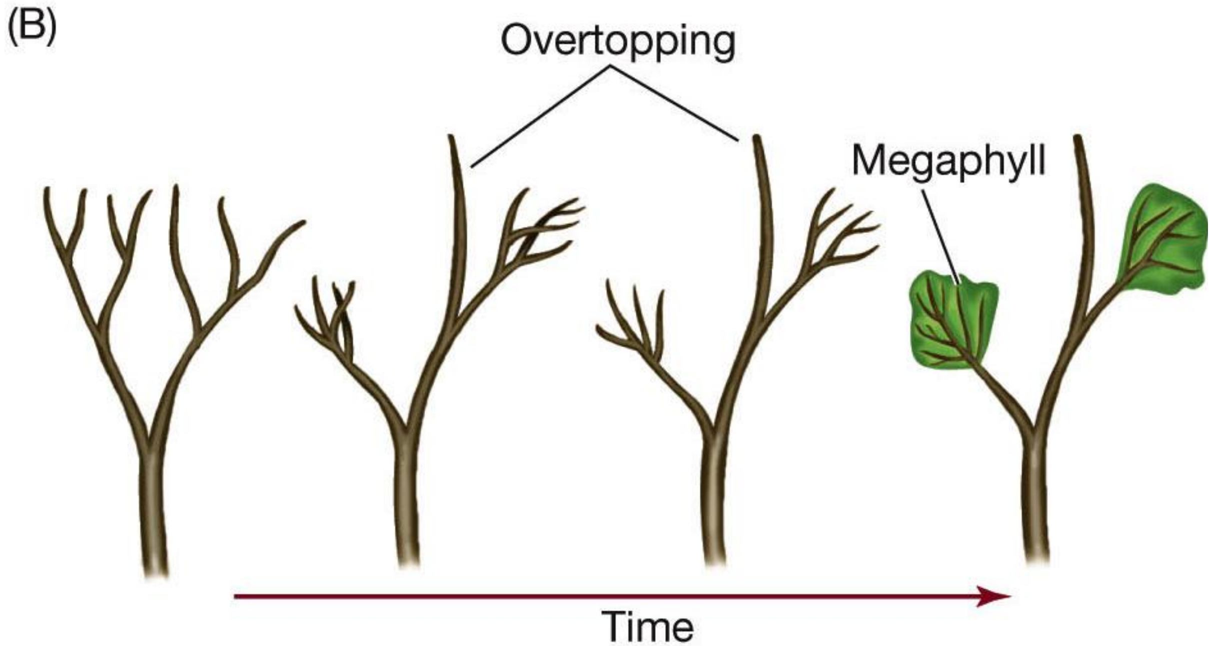
- Horsetails and whisk ferns are both monophyletic, but ferns are not
  - But 97% of ferns form a single clade — the leptosporangiate ferns



LIFE 9e, Figure 28.5



In Monilophytes and all seed plants, growth is overtopping

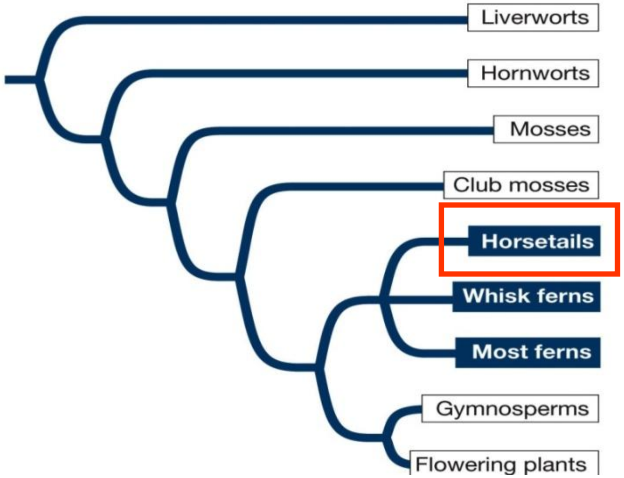


Psilotum flaccidum

Pteridophytes – Horsetails

Horsetails

- 15 species in one genus — ***Equisetum***
- Silica in cell walls — "scouring rushes"… used for cleaning



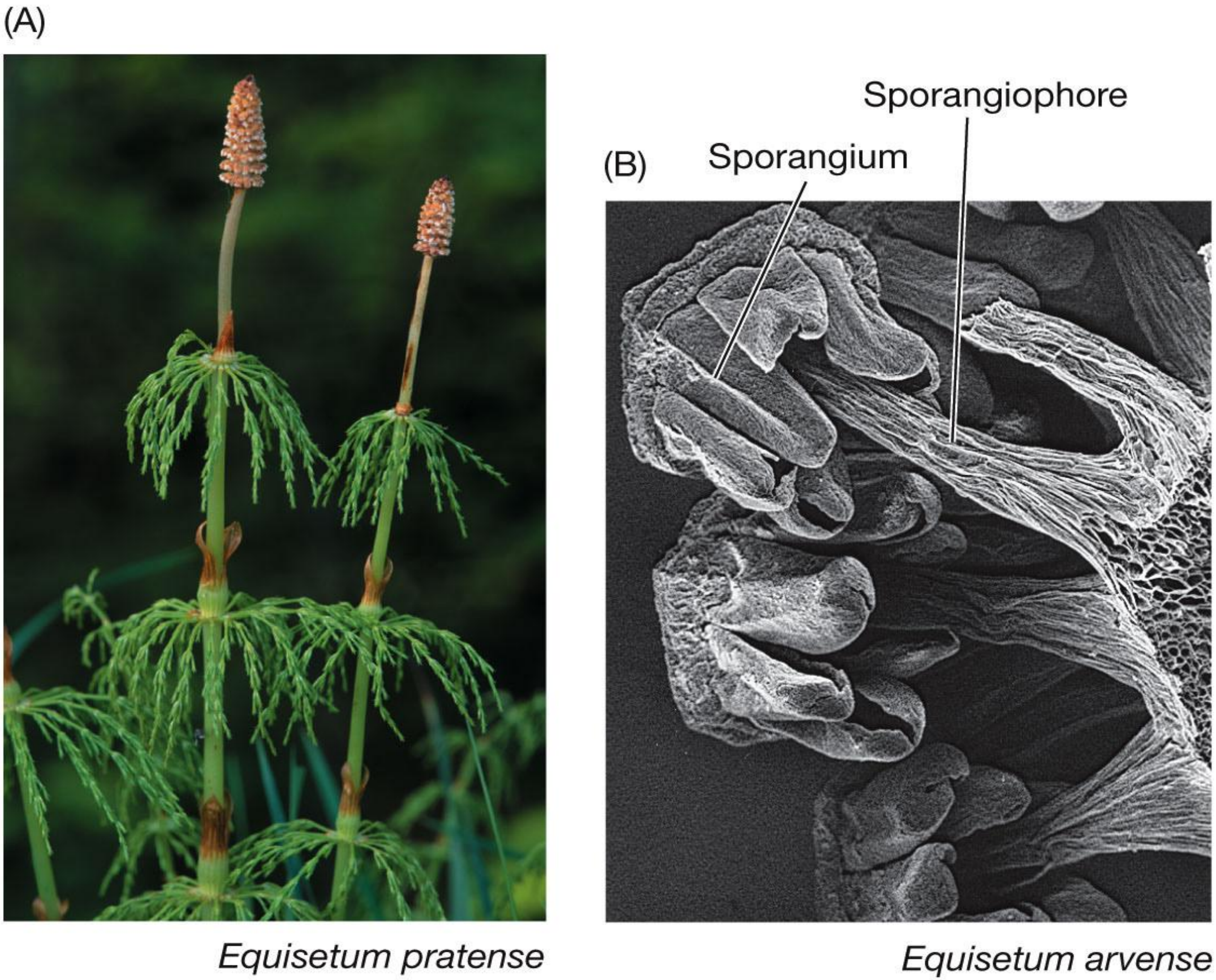
www.plantoftheweek.org/image

Monilophytes – Horsetails

- Have true roots
- Sporangia are on short stalks called **sporangiophores**
- Leaves are reduced megaphylls in whorls
- Each stem segment grows from base

www.plantoftheweek.org/image

Figure 28.16 Horsetails

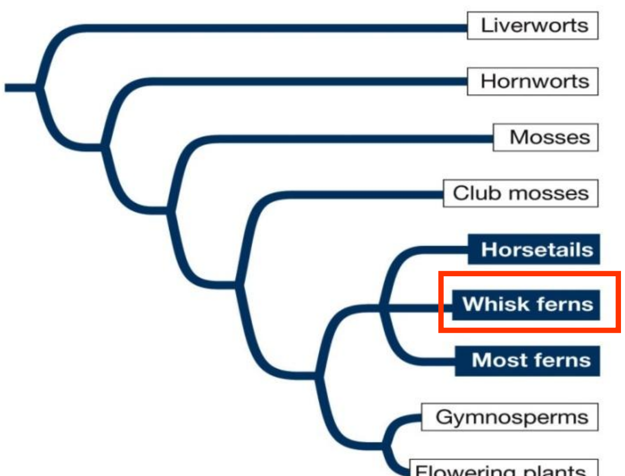


LIFE 9e, Figure 28.16

Monilophytes – Whisk ferns

Whisk ferns

- 15 species in two genera
- No roots but well-developed vascular system



http://www.botanik.uni-karlsruhe.de/garten/fotos-knoch/Psilotum%20nudum%20Gabelblatt%201.jpg

Monilophytes – Whisk ferns

- *Psilotum flaccidum* has scales instead of leaves
- *Tmesipteris* has flattened, reduced megaphylls

Tmesipteris norfolkensis

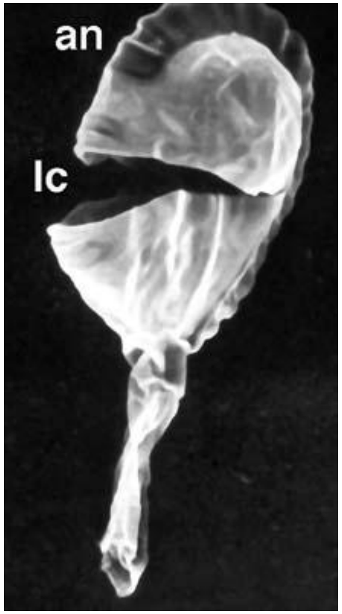
Psilotum flaccidum

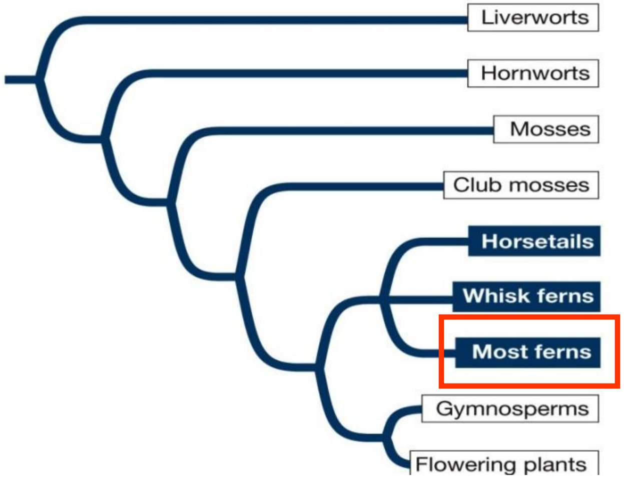
http://www.anbg.gov.au/images/photo_cd/9J18G146043/075_2.jpg www.science.siu.edu/landplants/Pterophyta/images/spore.8cell.JPEG

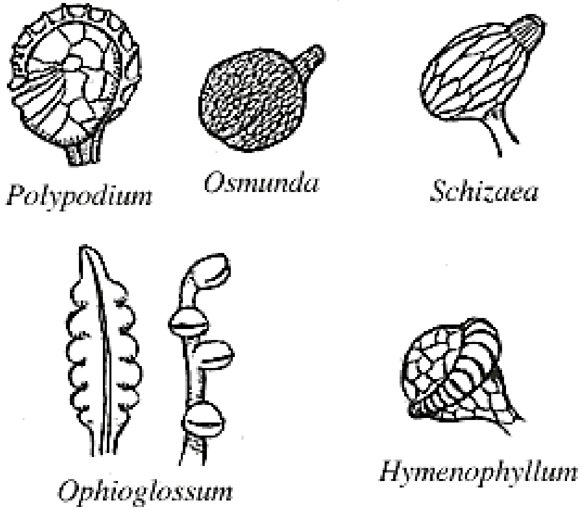
Monilophytes (Pteridophytes) – Ferns

Leptosporangiate ferns

- 12,000 species
- Includes about 97 percent of fern in monophyletic clade
- Sporangia walls only one cell thick, borne on stalk







http://www.ucmp.berkeley.edu/IB181/VPL/SpheFe/SpheFeD/SpheFeD9.gif

Monilophytes (Pteridophytes) – Ferns

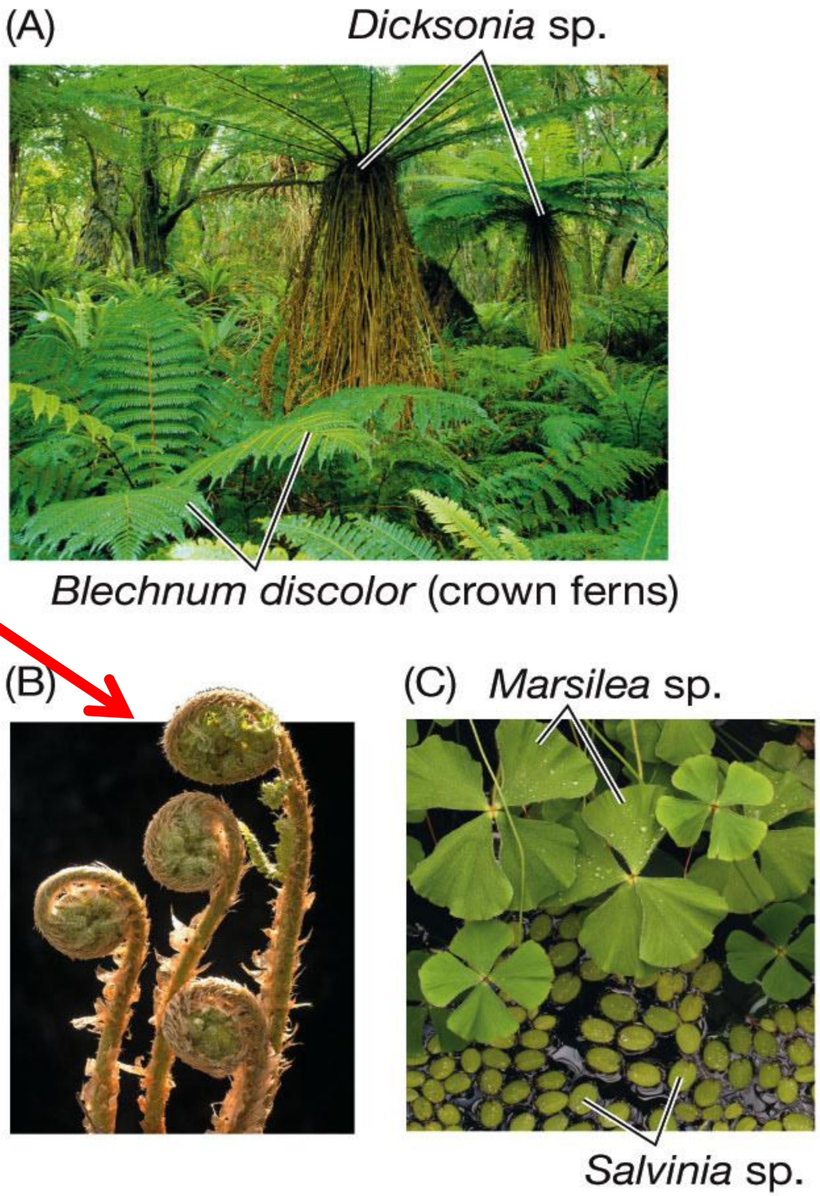
- Sporophytes have true roots, stems, and leaves
- Fern leaf starts development as a coiled "**fiddlehead**"

Costa Rican tree fern

http://jrscience.wcp.muohio.edu/photos/TreeFernMonteverde00.jpg

Figure 28.18 Fern Leaves Take Many Forms

- Fern leaf starts development as a coiled "**fiddlehead**"

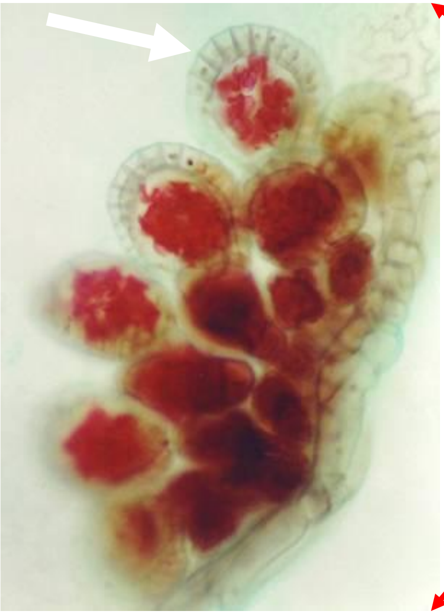


***LIFE* 9e, Figure 28.18**

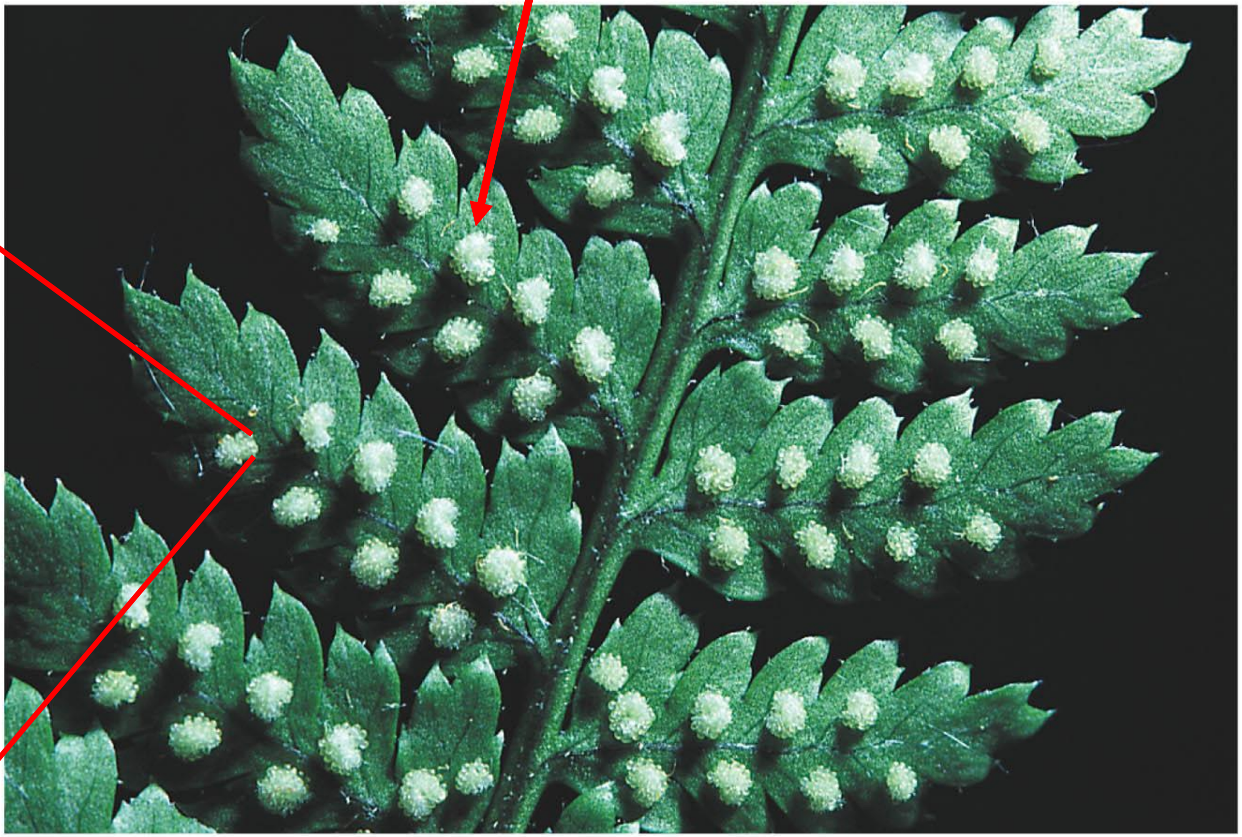
Monilophytes (Pteridophytes) – Ferns

- Sporangia occur on undersides of leaves in clusters called ***sori***

Note one-cell thick sporangium wall for leptosporangiate ferns



http://departments.bloomu.edu/biology/pics/botany/fern_sori2w.jpg



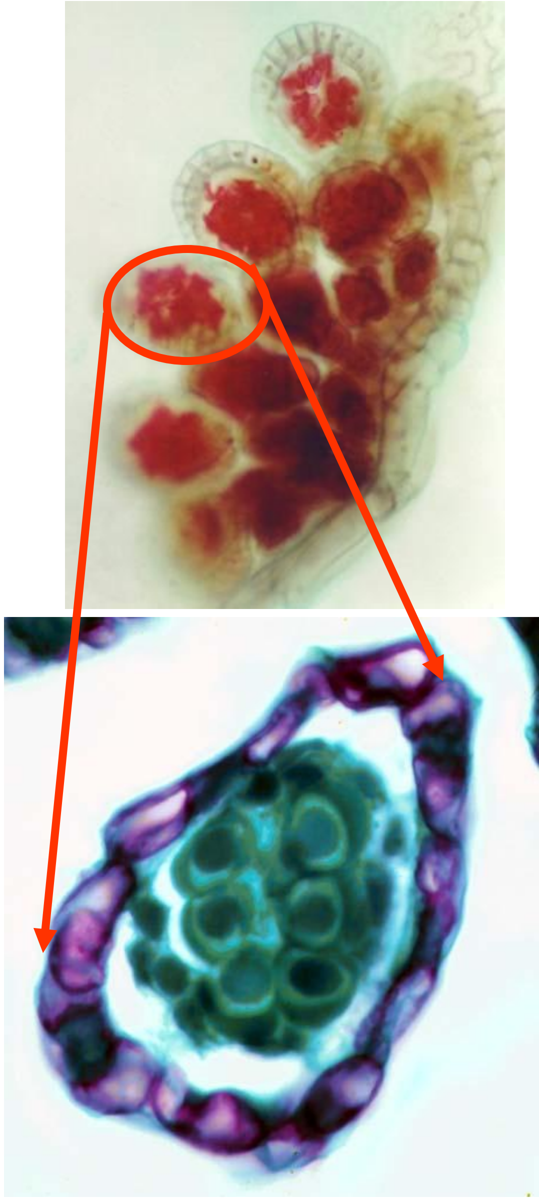
Dryopteris intermedia

LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 29.19 Fern Sori Are Clusters of Sporangia

Monilophytes (Pteridophytes) – Ferns

Fern life cycle:

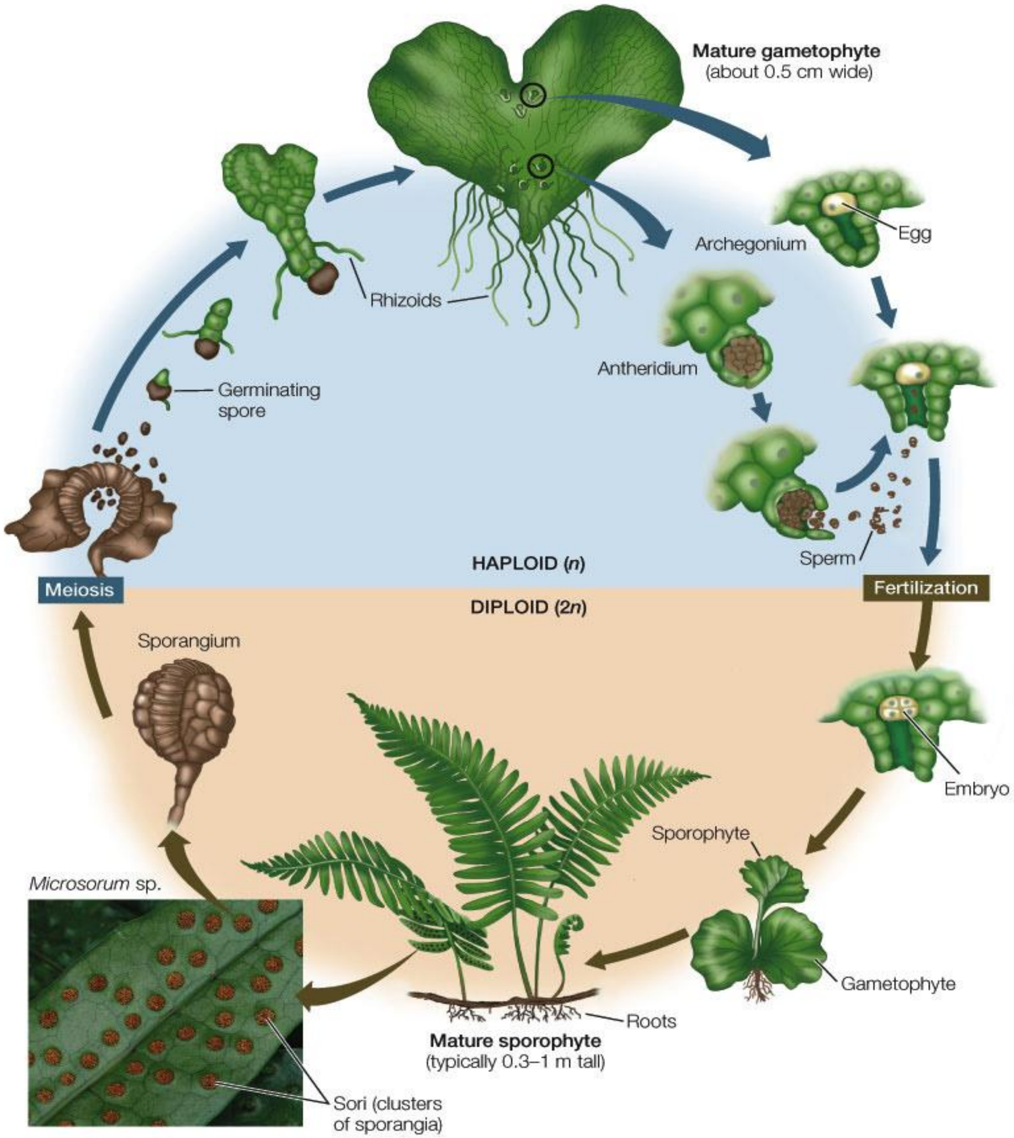
- *Spore mother cells* in sporangia form haploid spores by meiosis
- Spores can be blown by wind and develop into gametophyte far from parent plant



http://departments.bloomu.edu/biology/pics/botany/fern_sori2w.jpg

http://www.science.siu.edu/landplants/Pterophyta/images/spore.64cell.jpeg

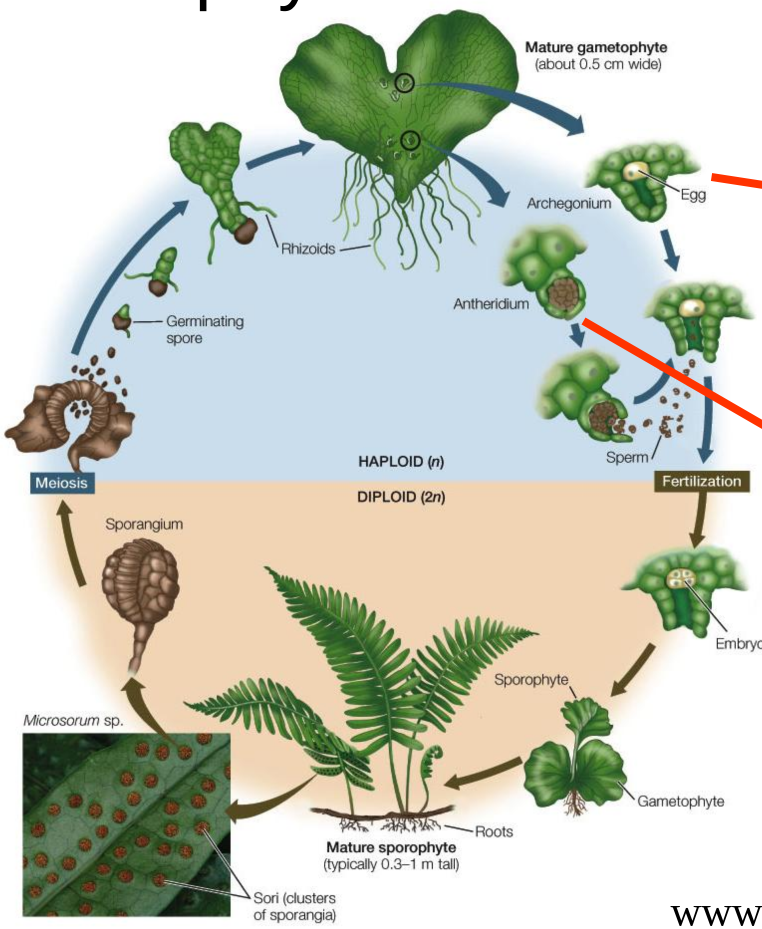
Figure 28.19 The Life Cycle of a Homosporous Fern

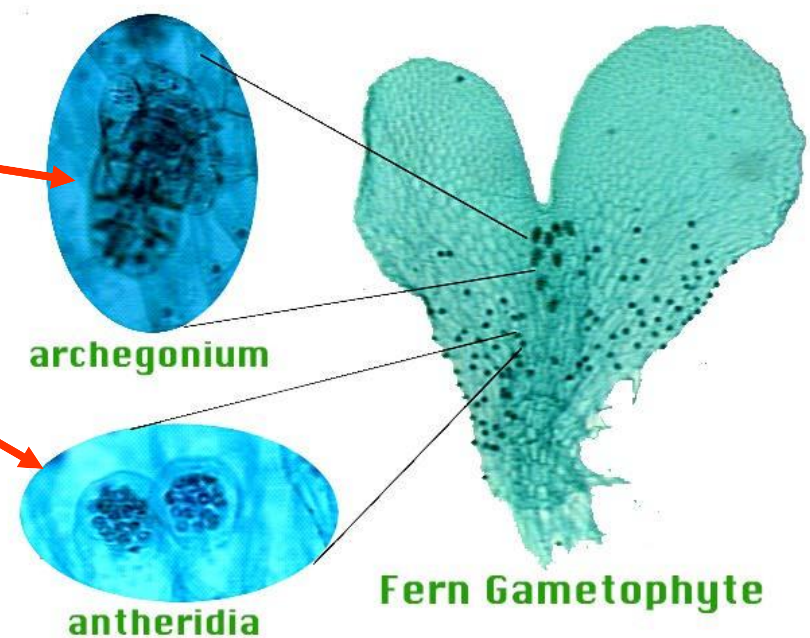


***LIFE* 9e, Figure 28.19**

Monilophytes (Pteridophytes) – Ferns

- Fern gametophytes produce antheridia and archegonia, not always at same time or on same gametophyte

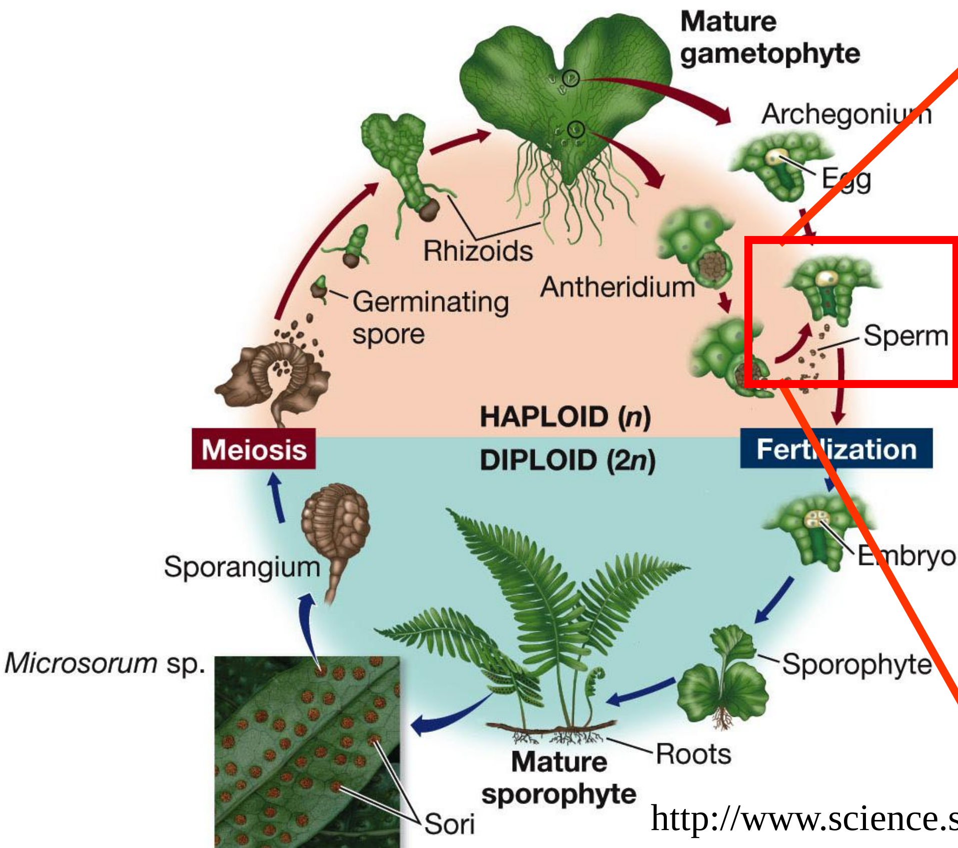


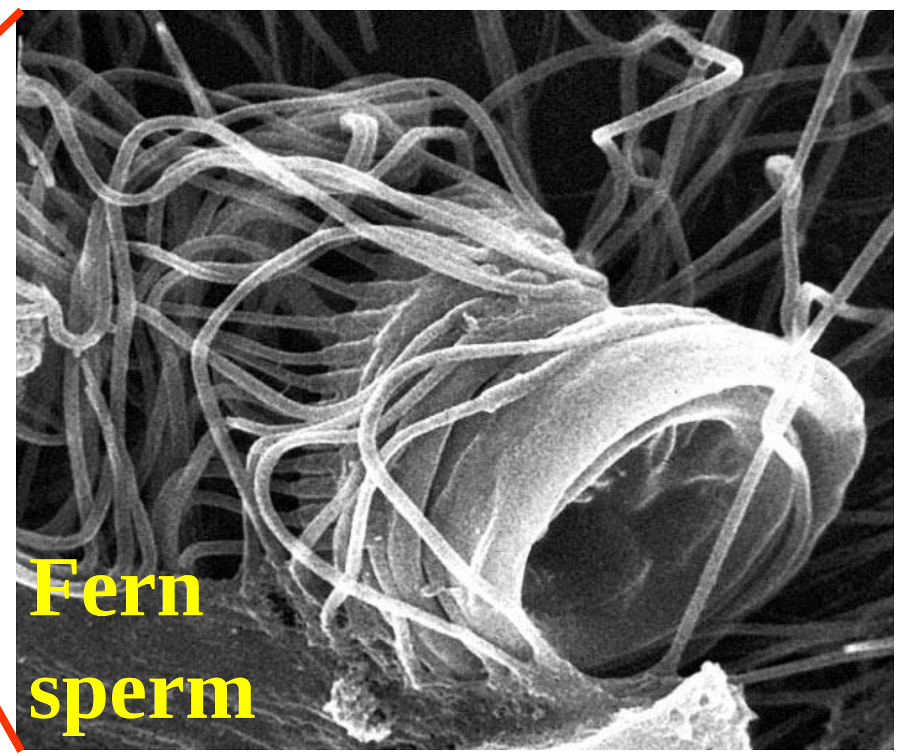


www.esu.edu/~milewski/intro_biol_two/lab_2_moss_ferns

Monilophytes (Pteridophytes) – Ferns

- Sperm swim through water to archegonium to fertilize egg
- Zygote develops into *independent sporophyte*



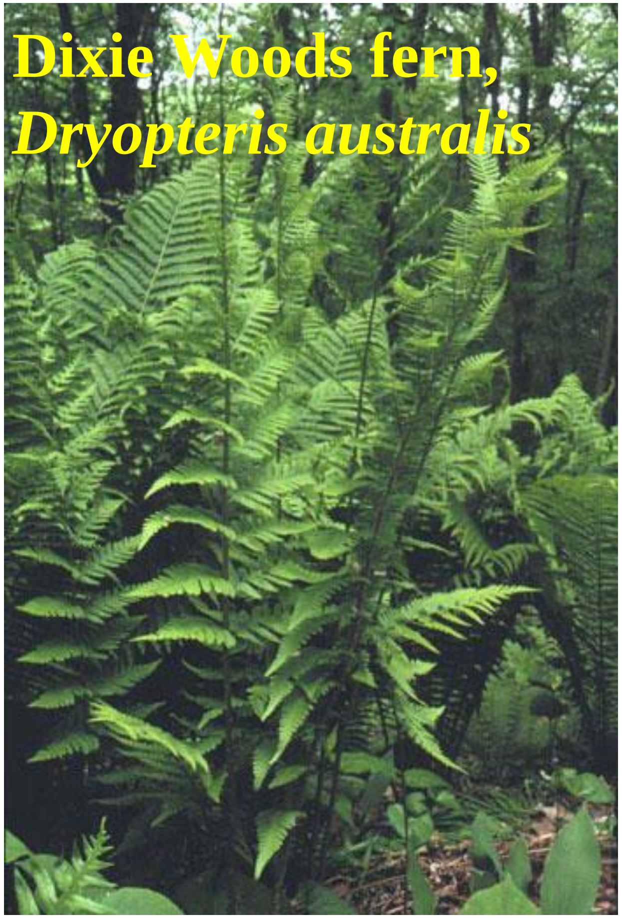


http://www.science.siu.edu/landplants/Pterophyta/images/Ceratopteris.sperm.JPEG

Monilophytes (Pteridophytes) – Ferns

Most ferns found in shaded, moist environments

- Tree ferns can reach heights of 20 m



http://www.we-du.com/images/plants/350/frndrydwf.jpg

http://www.wettropics.gov.au/st/rainforest_explorer/Resources/Images/plants/TreeFerns.jpg

Monilophytes (Pteridophytes) – Ferns

Most ferns are homosporous, but two groups of aquatic ferns are heterosporous

http://www.plantacquari.it/images/piante/Salvinia_natans.jpg

Monilophytes (Pteridophytes) – Ferns

Some genera have a subterranean, nonphotosynthetic tuberous gametophyte

- Depends on mutualistic fungus for nutrition

http://www.discoverlife.org/nh/tx/Plantae/Pteridophyta/Botrychium/biternatum/index.html