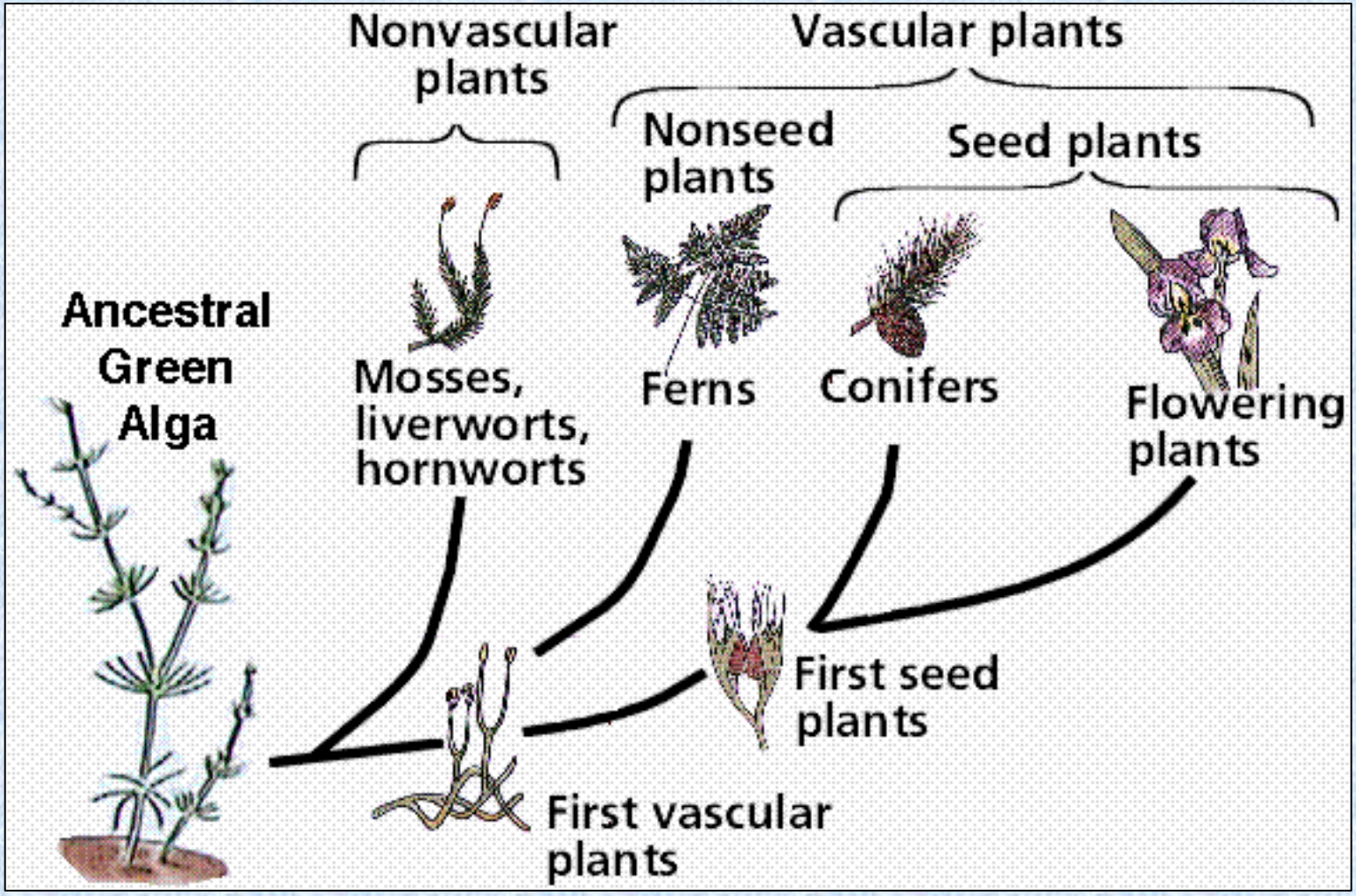
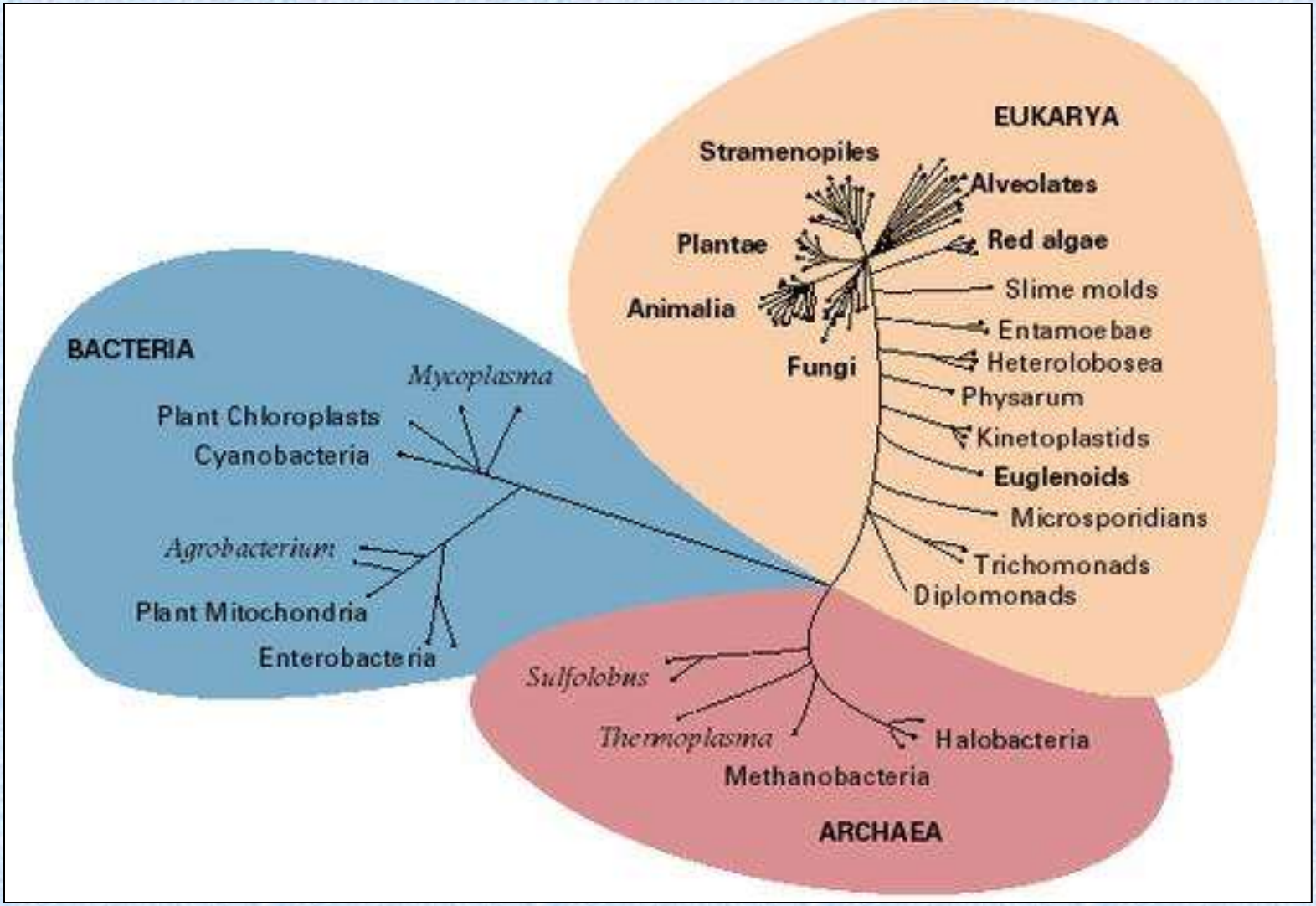
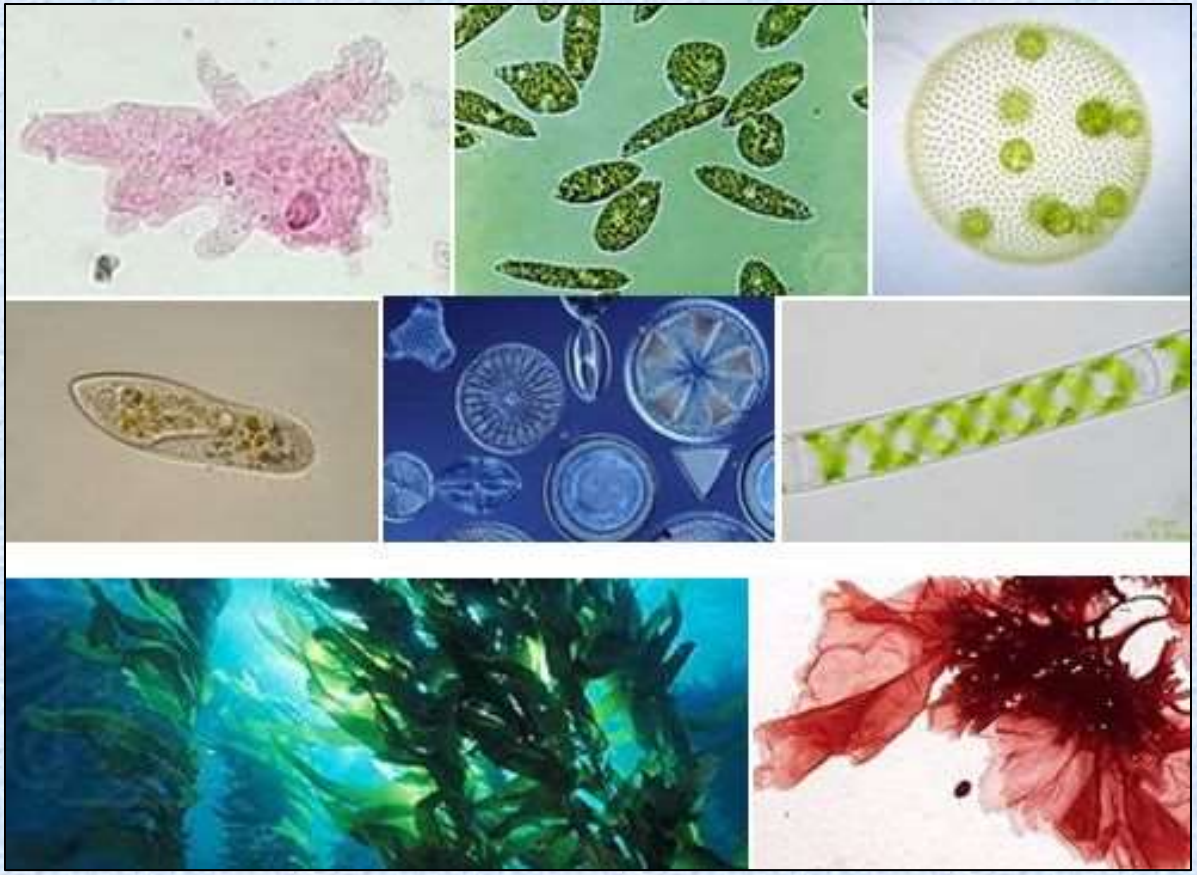
Plant Evolution and Diversity
Part 1: Bryophytes and Ferns



The Three Domains



- Plant-like protists are autotrophs – they contain chloroplasts and make their own food.
- Animal-like and fungus-like protists and are heterotrophs.



Fungi – not plants

Non-photosynthetic eukaryotes, saprophytic,

Reproduce by spores, chitin cell walls (not cellulose)

Includes yeast

What is a plant?

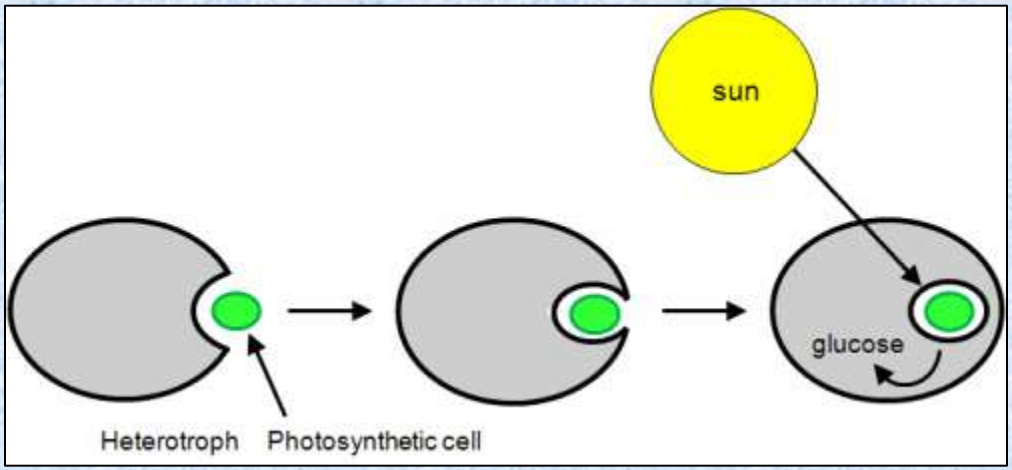
Traditional View of Biology: Animals and Plants

Problem: Microscopic Organisms (Bacteria, Fungi, Algae)

Complication:

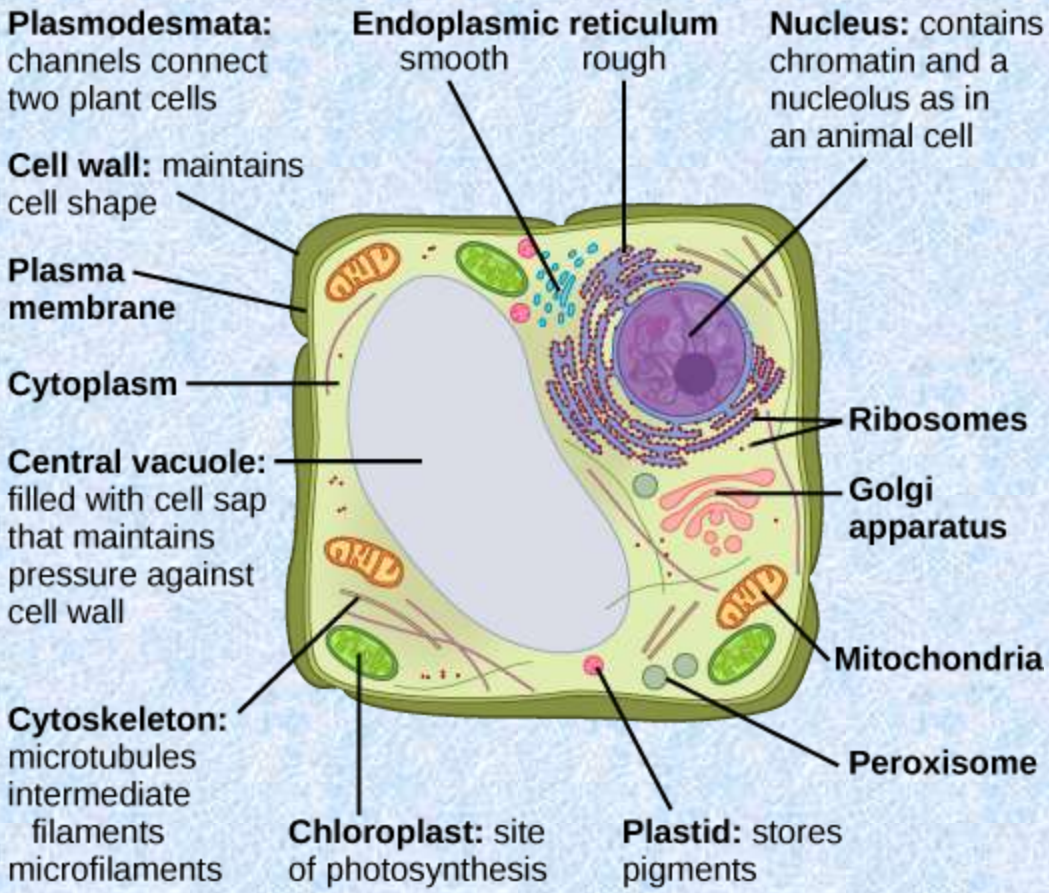
Endosymbiotic origin of organelles (Lynn Margulis)

Membrane-bound structures in eukaryotic cells are derived from formerly free-living organisms that have become intimately symbiotic



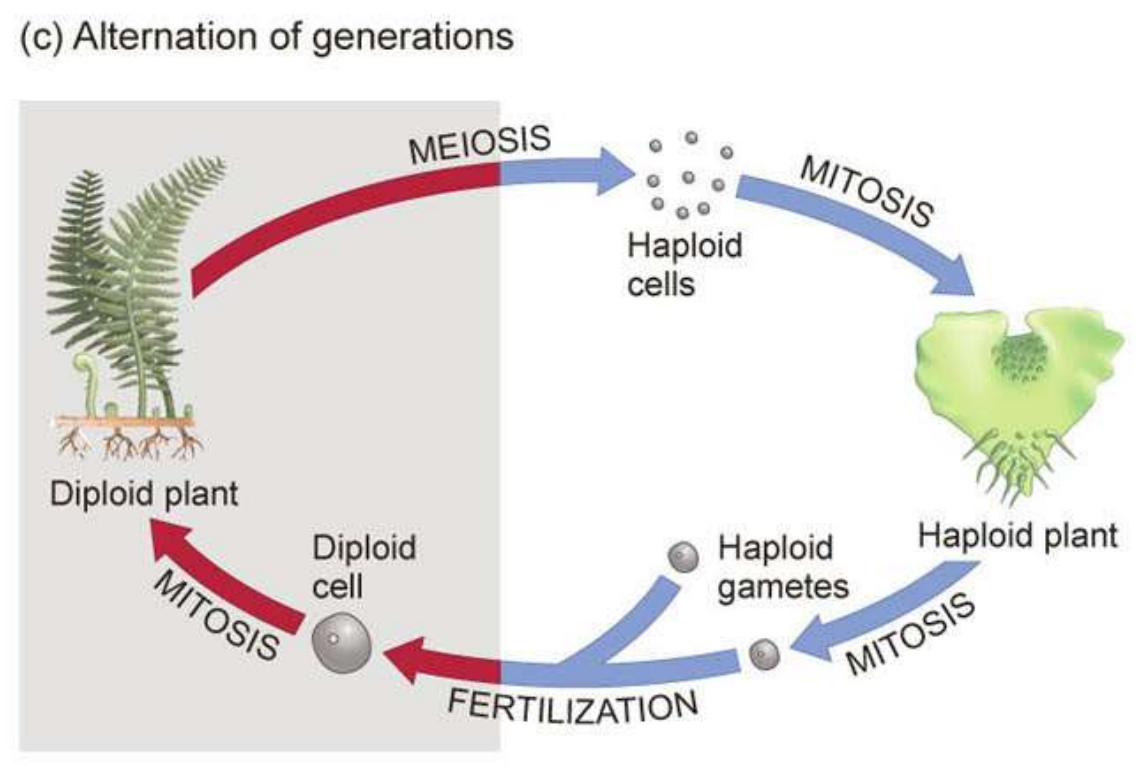
What is a Plant?

1. Eukaryotic - nucleus
2. Chloroplasts present
3. Cell wall with cellulose
4. Autotrophic – make own food

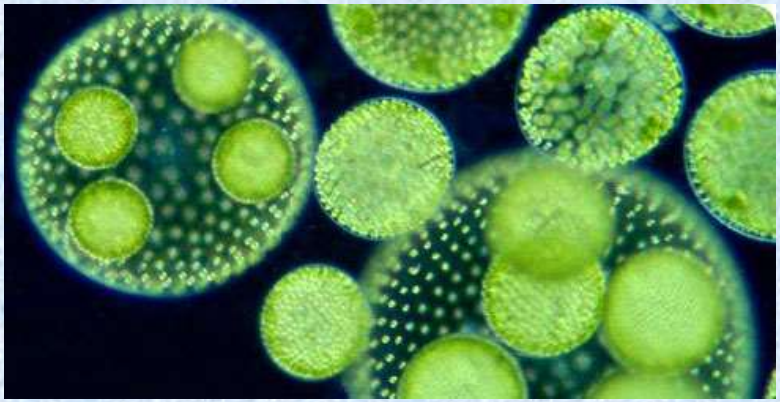


What is a Plant?

1. Eukaryotic
2. Chloroplasts present
3. Cell wall with cellulose
4. Autotrophic
5. Complex Life Cycle (alternation of generations)



Algae - Diverse, single-celled to complex seaweeds
Photosynthetic eukaryotes, green plants

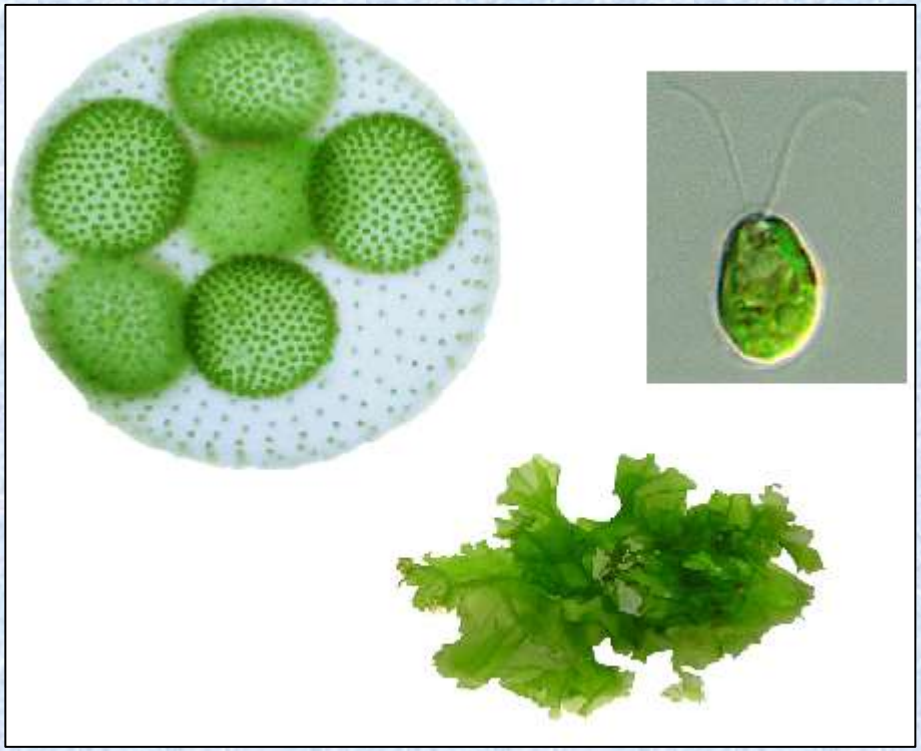


Plant-like protists – “Algae”

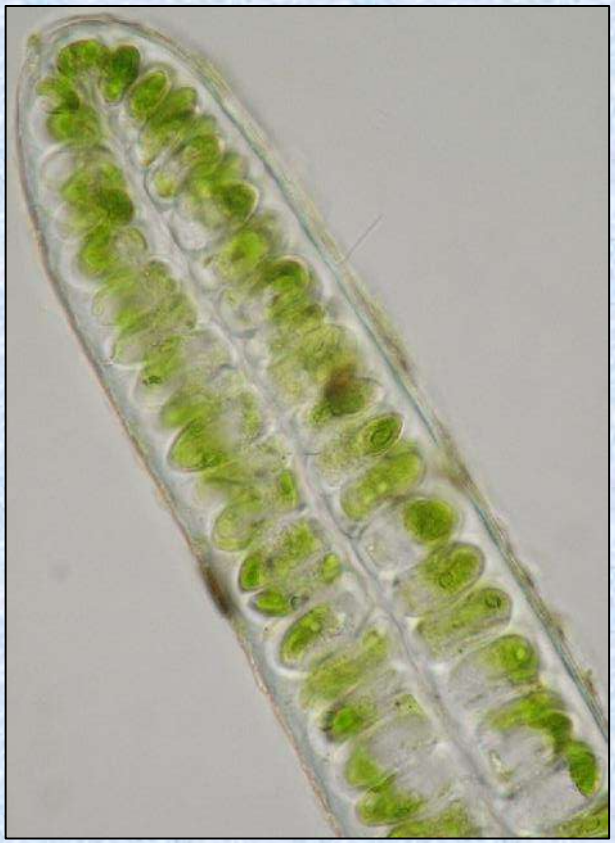
- Diverse group – green, red, and brown algae.
- Single celled or multicellular.
- Autotrophs (plants), form the foundation of Earth’s food chains.
- Produce much of Earth’s oxygen.

Green Algae – Chlorophytes and Charophytes

- Chlorophyll a and b, like land plants
- Many forms – single celled, filamentous, colonial, sheets
- May have other pigments, orange or red
- Related to land plants



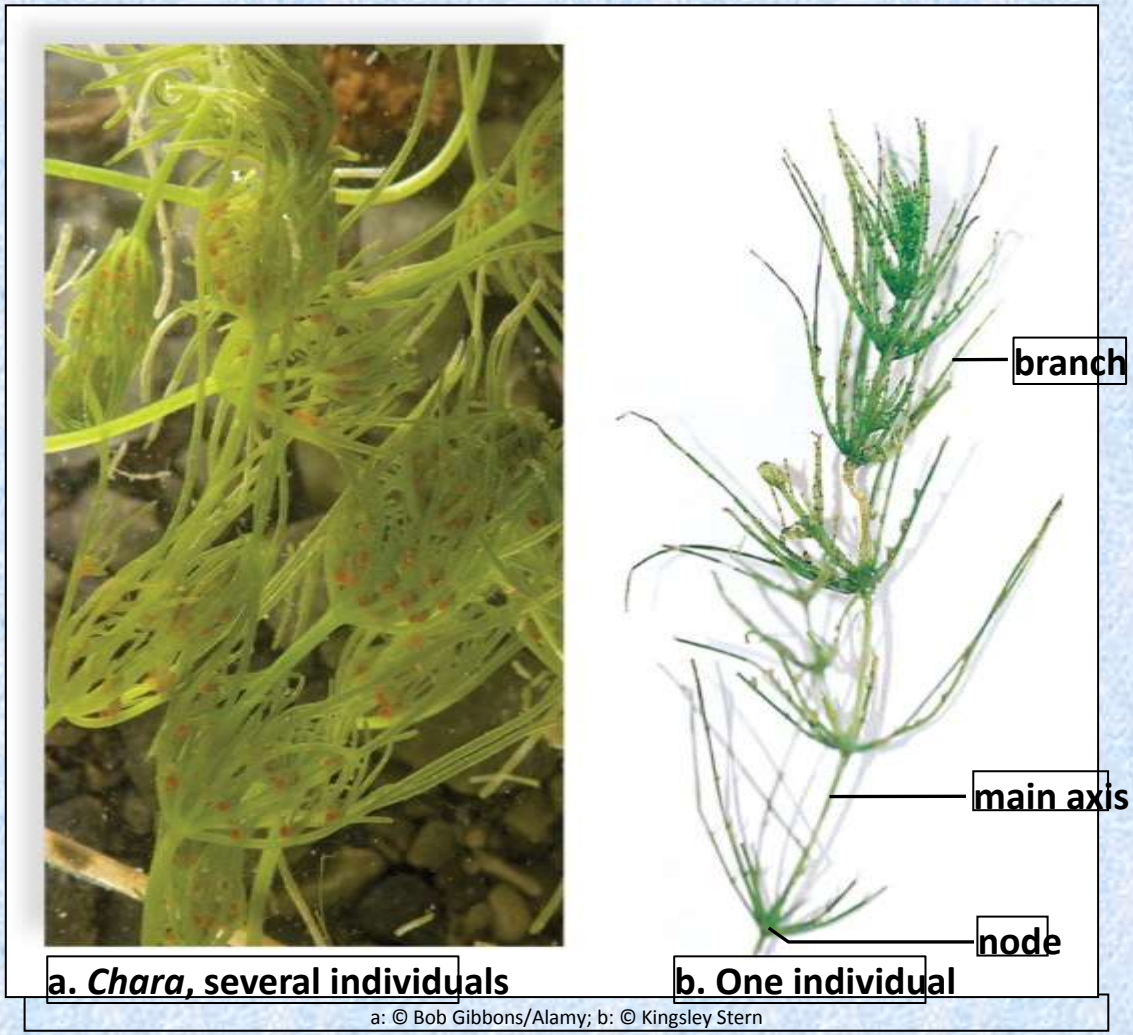
Ulva – Sea Lettuce



- Chlorophyte - Marine
- Sheets 2 cells thick
- Alternation of Generations like land plants

Chara – Stonewort

- Charophyte
- Freshwater
- Calcium carbonate deposits, crusty feel
- Whorls of branches
- Reproductive structures at nodes



The phylogeny of land plants

The likely ancestor are charophycean algae

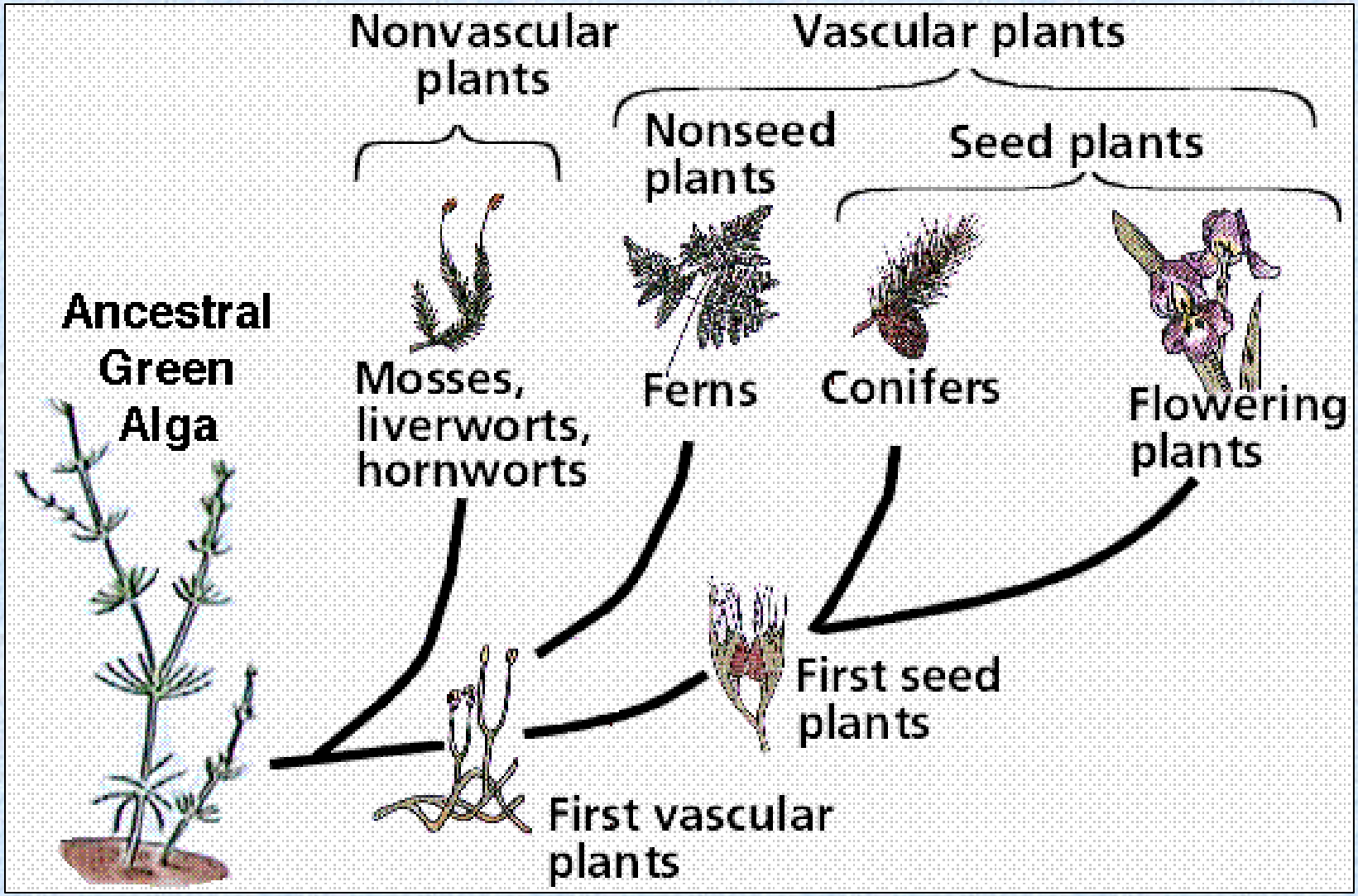
- same chloroplast DNA, ribosomal DNA
- same membrane structure, peroxisomes, sperm cells

Chara

Land plants are most closely related to freshwater green algae known as **charophytes.**

- Charophytes and land plants are in the same clade.
- Their common ancestor no longer exists.
- Characteristics common between charophytes and land plants:
  - Photosynthetic pigments a and b
  - Cellulose cell walls
  - Apical cells
  - Plasmodesmata
  - Cell division
  - Placenta (retain and care for zygote)

Phylogeny of land plants



Colonization of the Land by Plants

Drying out is a big problem to overcome

Colonization of the Land by Plants

Roots or rhizoids to hold on
Cuticle – waxy coat to prevent dessication
Stomata – pores for breathing
Protected gametangia
Vascular system
    Xylem – move water
    Phloem – move food
Leaves – microphylls and megaphylls
Lignin – strengthening material in wood
Pollen grains
Seeds
Flowers

Fungi may have been important

Earliest Land Plants

Bryophytes

Liverwort

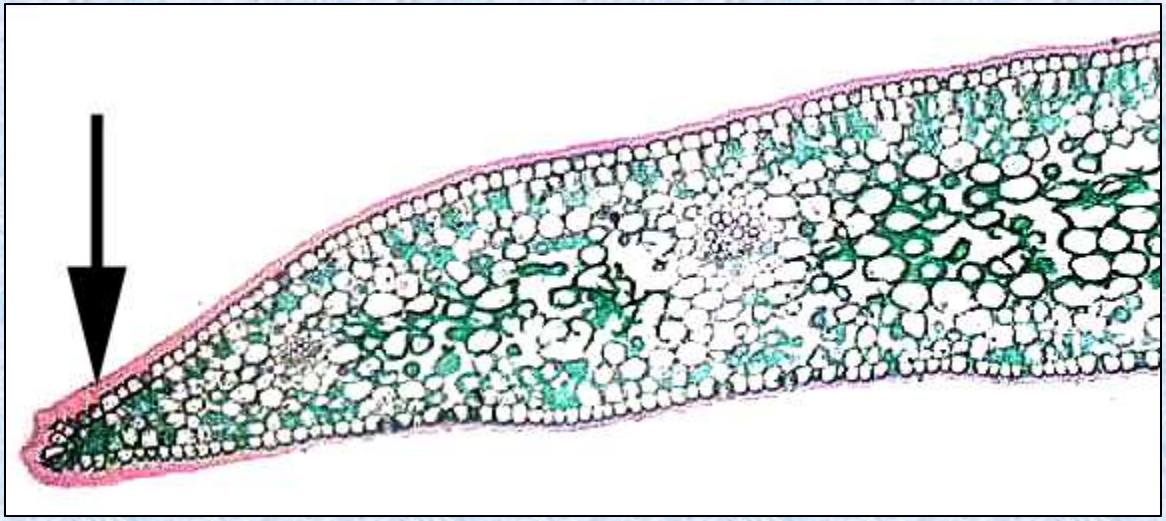
Moss

Hornwort

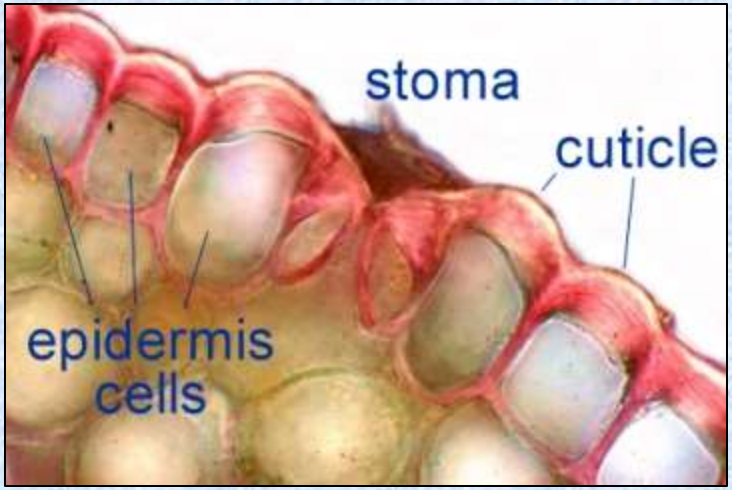
470 Ma, Oman
Mid-Ordovician

Adaptations for Life on Land

Waxy Cuticle

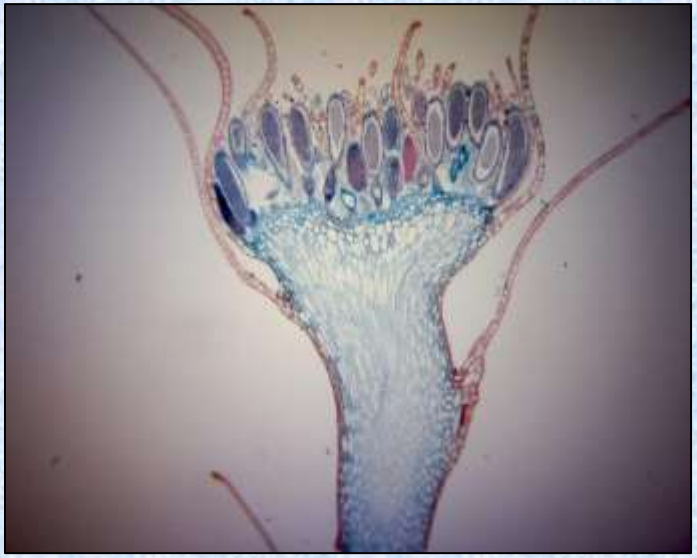


Stomata – openings for gas exchange

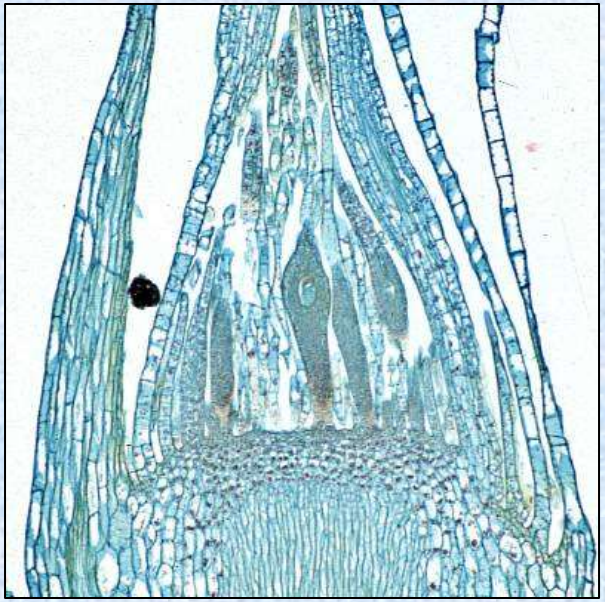


Adaptations for Life on Land

Gametangia – organ that produces gametes, protected by jacket of cells



Antheridia



Archegonia

Major Groups of Plants:

Non-vascular Plants – no xylem and phloem, small

- Bryophytes - mosses, liverworts, hornworts

Vascular Plants - well developed tissues that conduct and distribute water. Roots, stems and leaves

- Ferns, Horsetails, Clubmosses; no seeds
- Gymnosperms - Conifers, Ginkgo, Cycads; seeds naked
- Angiosperms - seeds enclosed in ovary, flowers

Four main groups of Land Plants

- Bryophytes (mosses, etc.) – no vascular tissue, small
- Ferns and relatives – vascular tissue, no seeds, spores, small to very large
- Gymnosperms – vascular tissue, seeds, no flowers
- Angiosperms – vascular tissue, seeds, flowers (fruits), diverse

Bryophytes (Mosses, etc.)

Bryophyte diversity

Hornworts
100 species

Liverworts
6,500 species

Mosses
12,000 species

Mosses

Mosses - 12,000 species

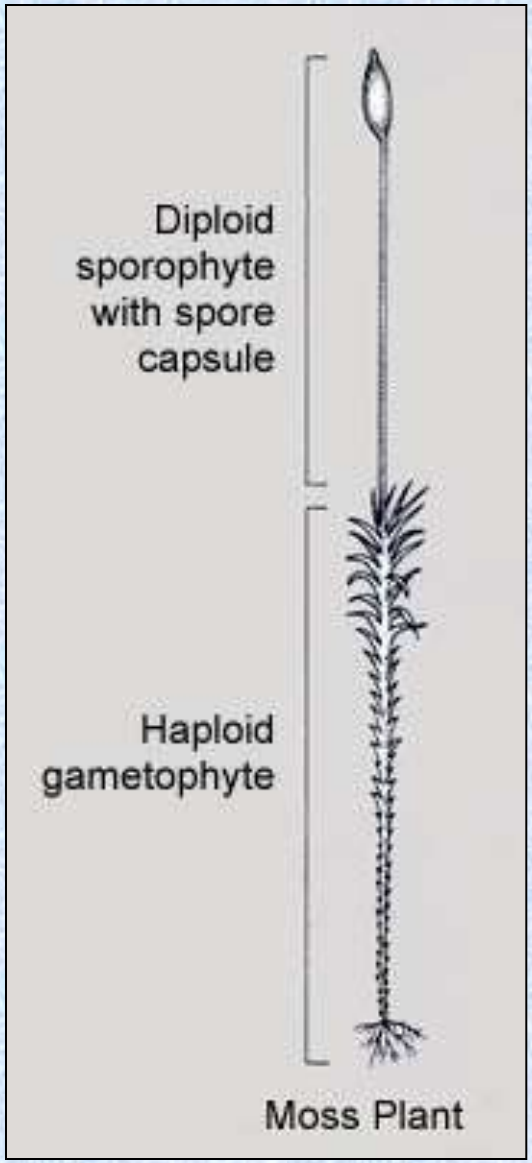
- Widely distributed, especially in alpine, boreal, temperate and tropical forests
- Able to live in very dry or very cold habitats
- Many can dry out entirely, then rehydrate

Famous mosses:
Sphagnum

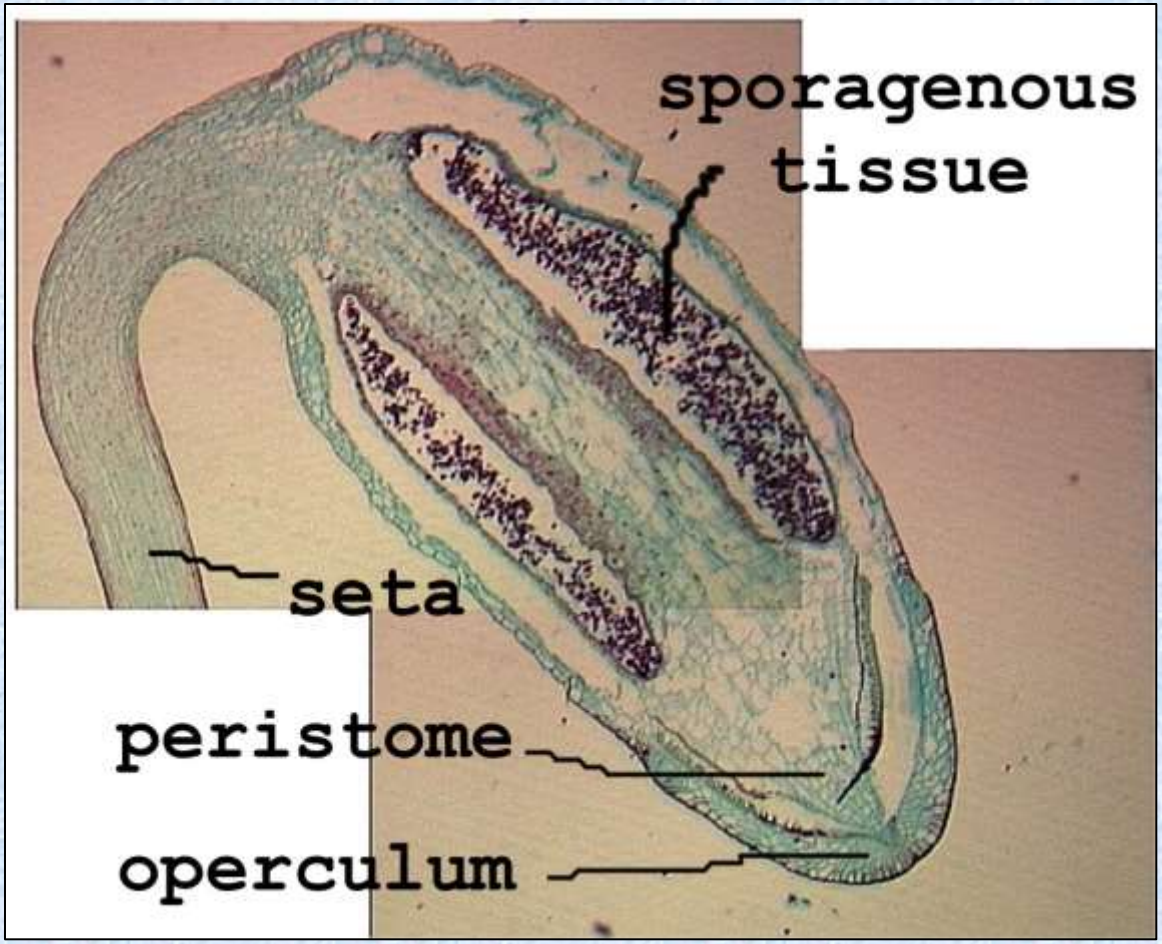
Wetland moss -
"peat moss"

- Boggy regions dominated by it known as peat bogs or peatlands.
- Used in potting soil

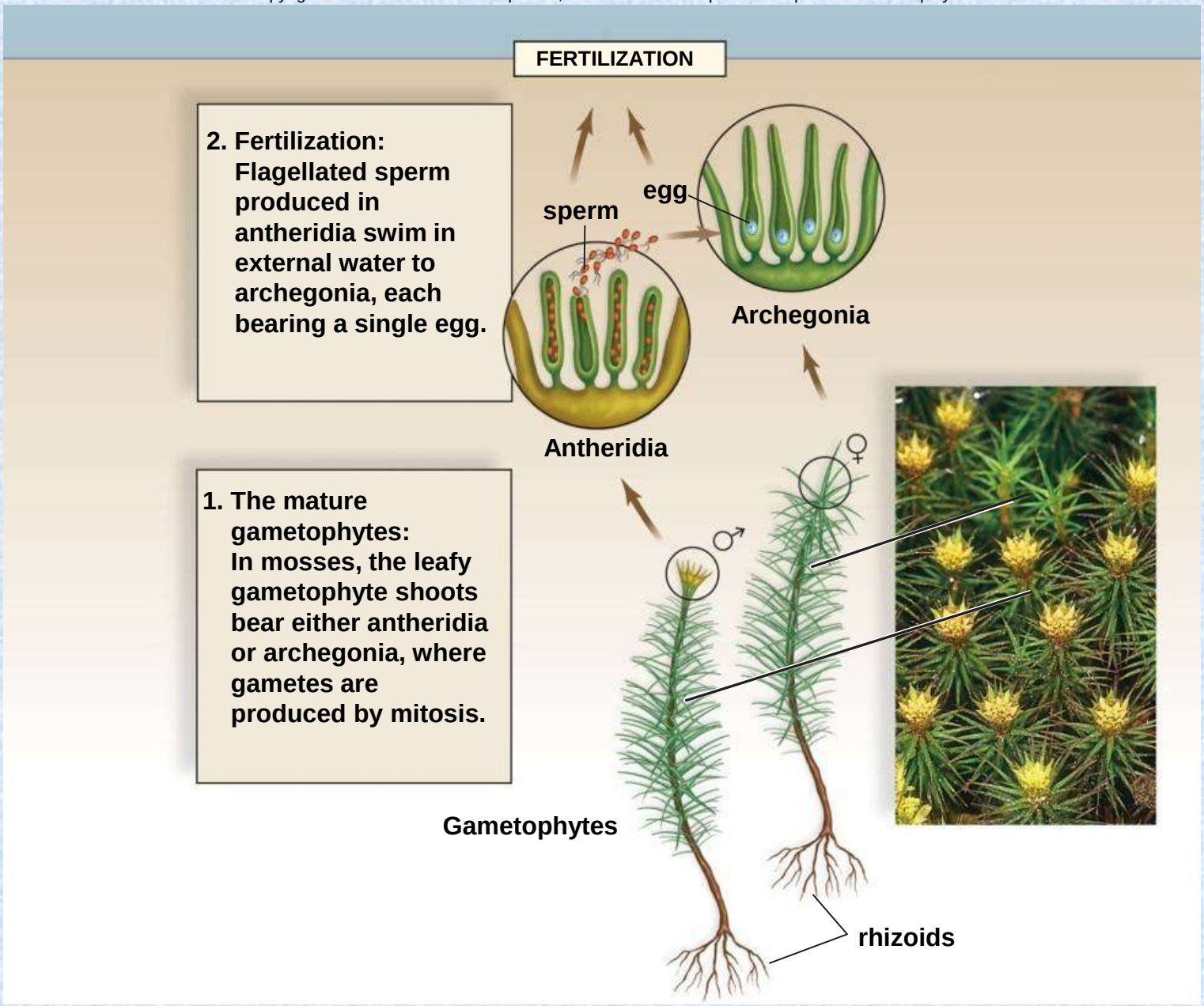
- In bryophytes the gametophyte (haploid n) is the dominant generation and the sporophyte (diploid 2n) is dependent on the gametophyte.



Moss Sporophye - Sporangium

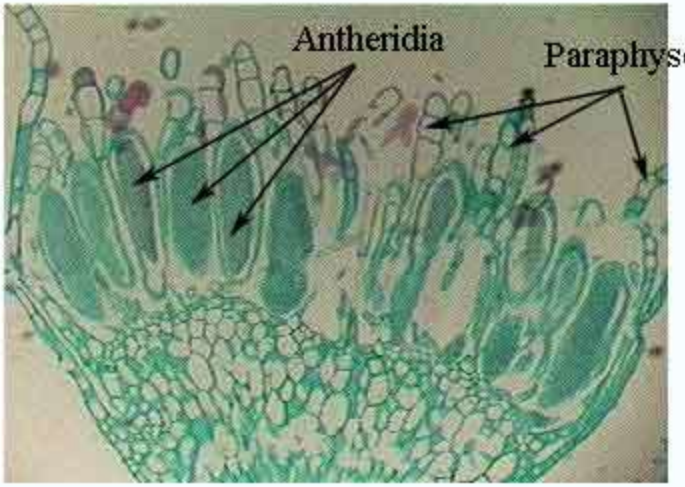


Moss (*Polytrichum*) Life Cycle



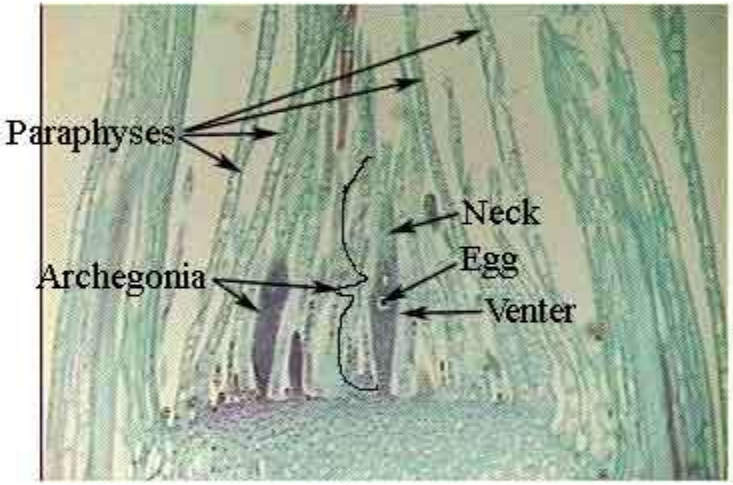
Moss Gametophytes – produce the gametes!

Moss Antheridial Head
100x



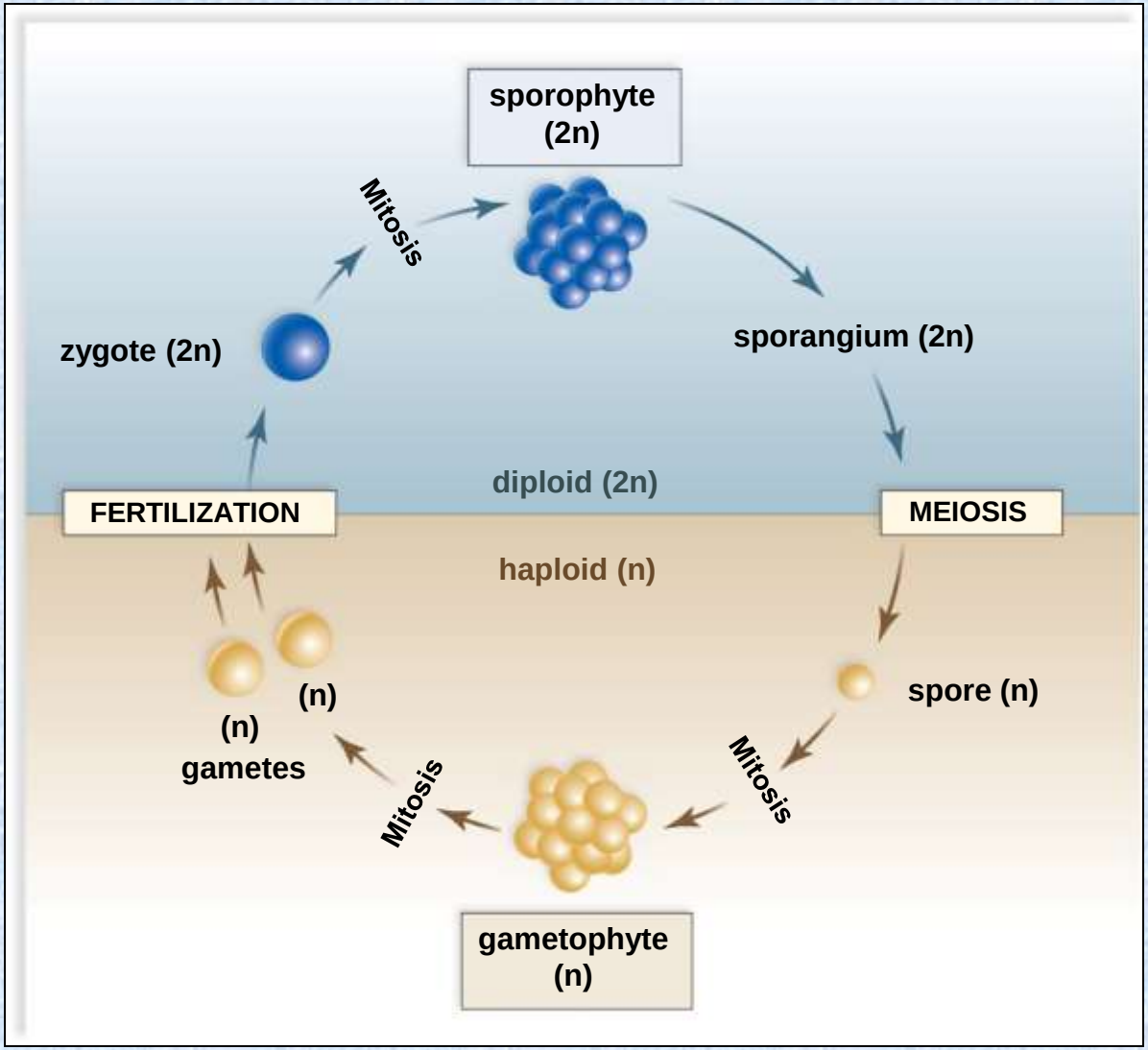
Male Gametophyte

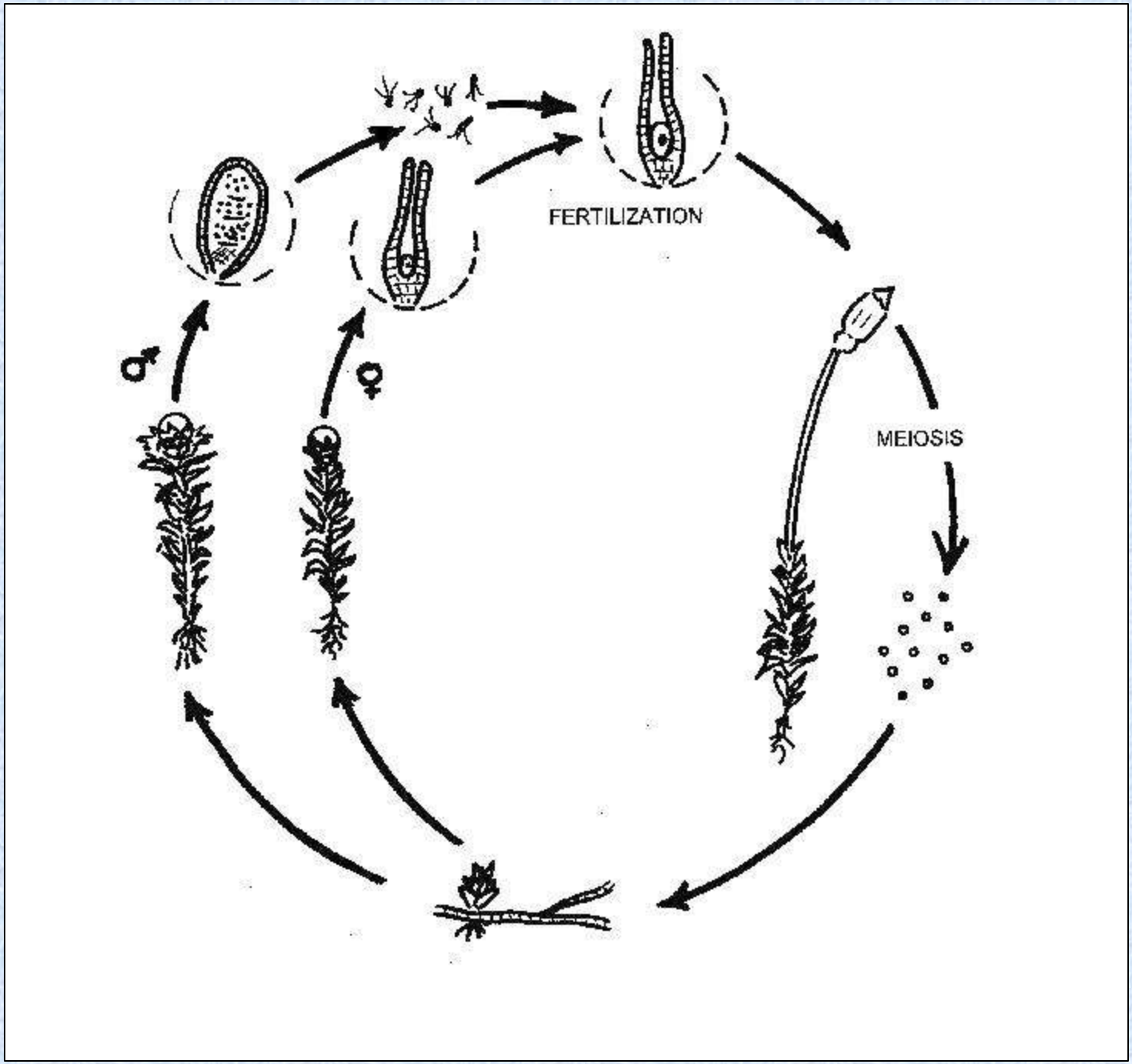
Moss Archegonia 100x



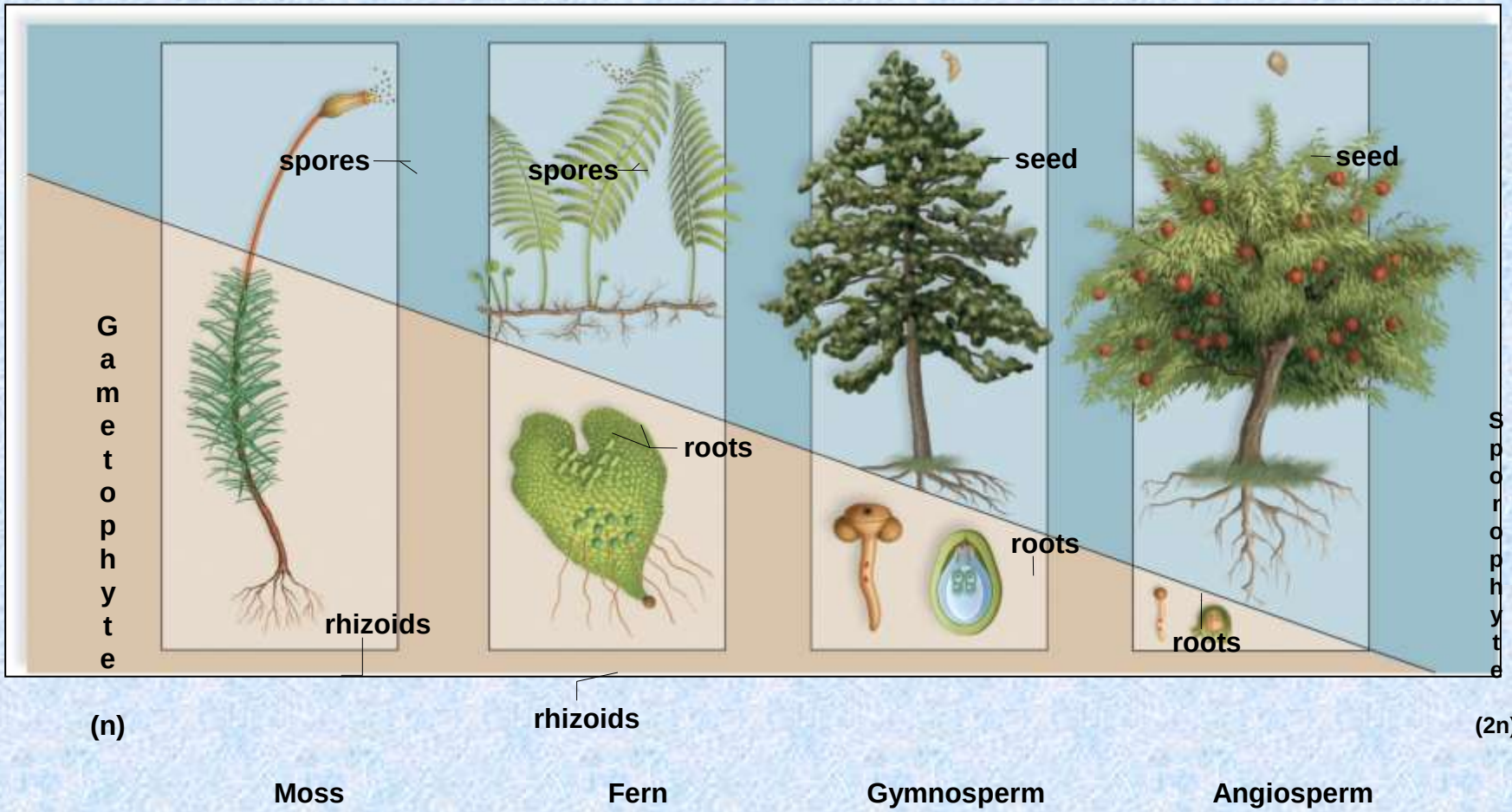
Located at the tip of the moss gametophyte

Alternation of Generations in Land Plants




FERTILIZATION
MEIOSIS
♂
♀

Reduction in the Size of the Gametophyte



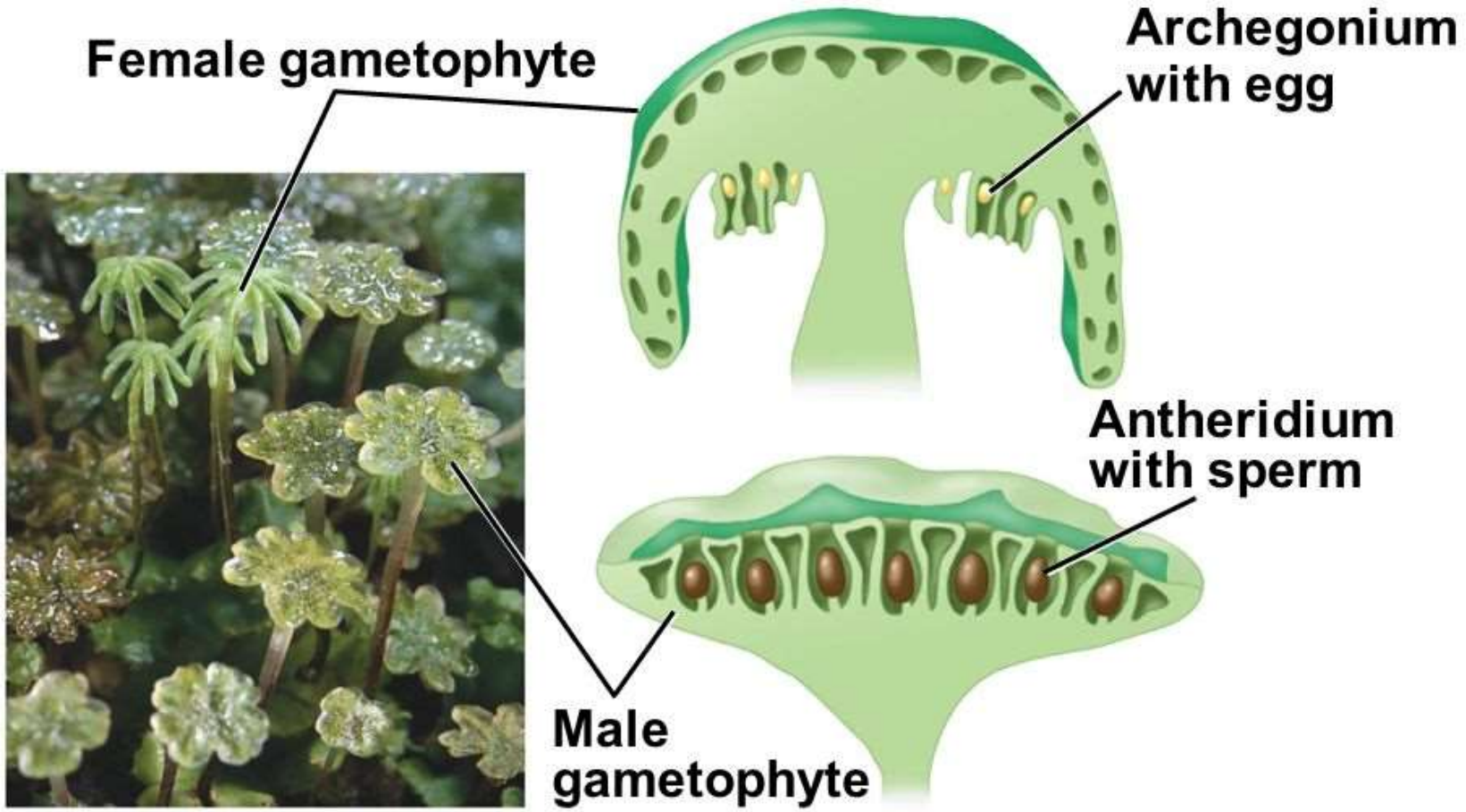
Liverworts

Liverwort, *Marchantia*

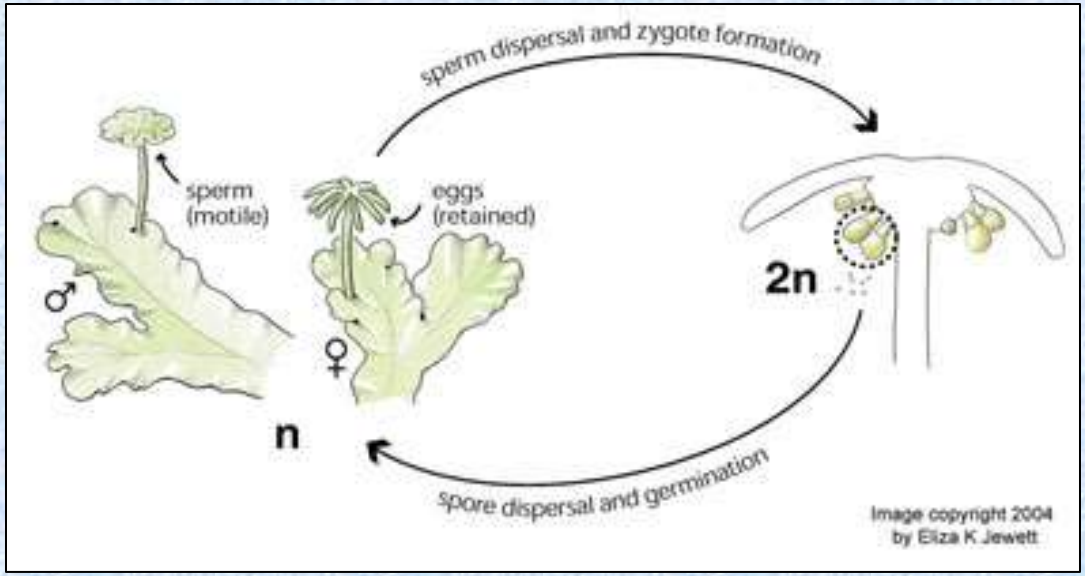
Liverworts

- Flattened thallus body
- Found on rocks in wet areas
- Gemma Cups – asexual reproduction

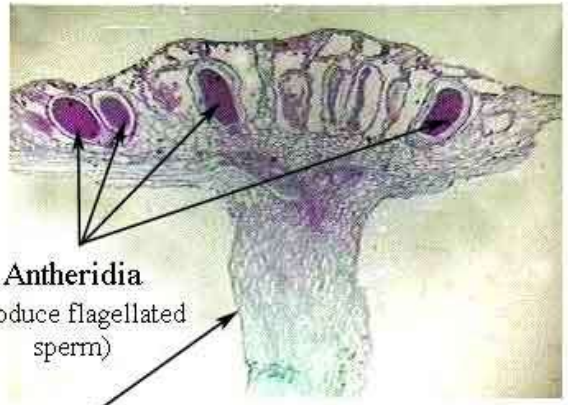
Fig. 29-5d



Archegonia and antheridia of *Marchantia* (a liverwort)

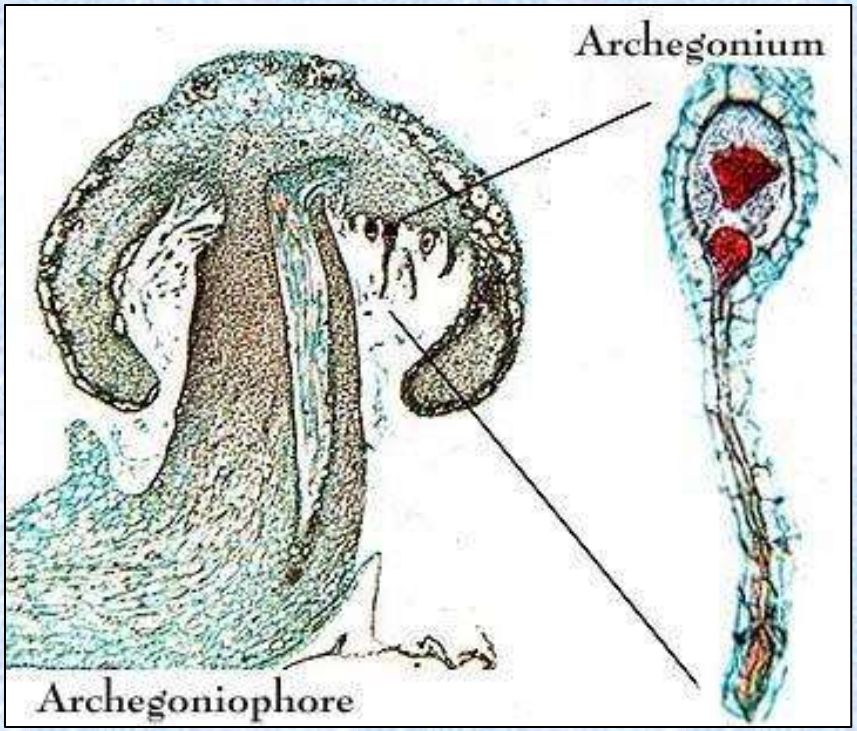


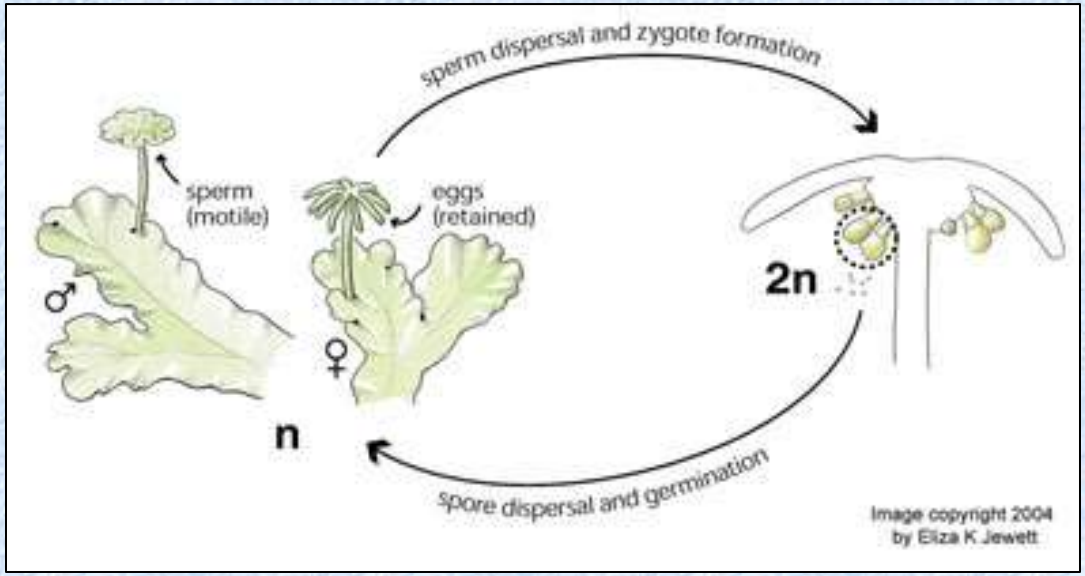
***Marchantia sp.* antheridiophore**
40x



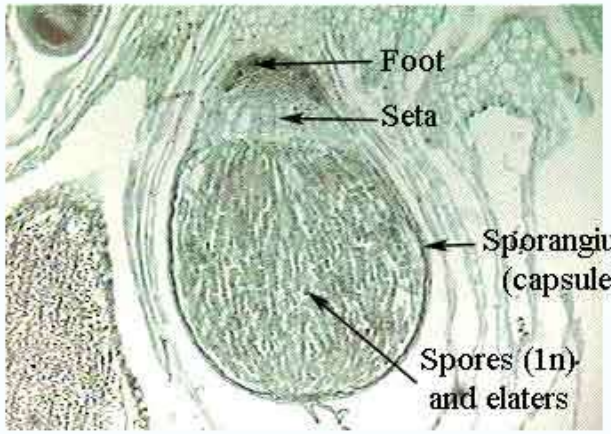
Antheridia
(produce flagellated sperm)

Antheridiophore
(lifts antheridia above the thallus)

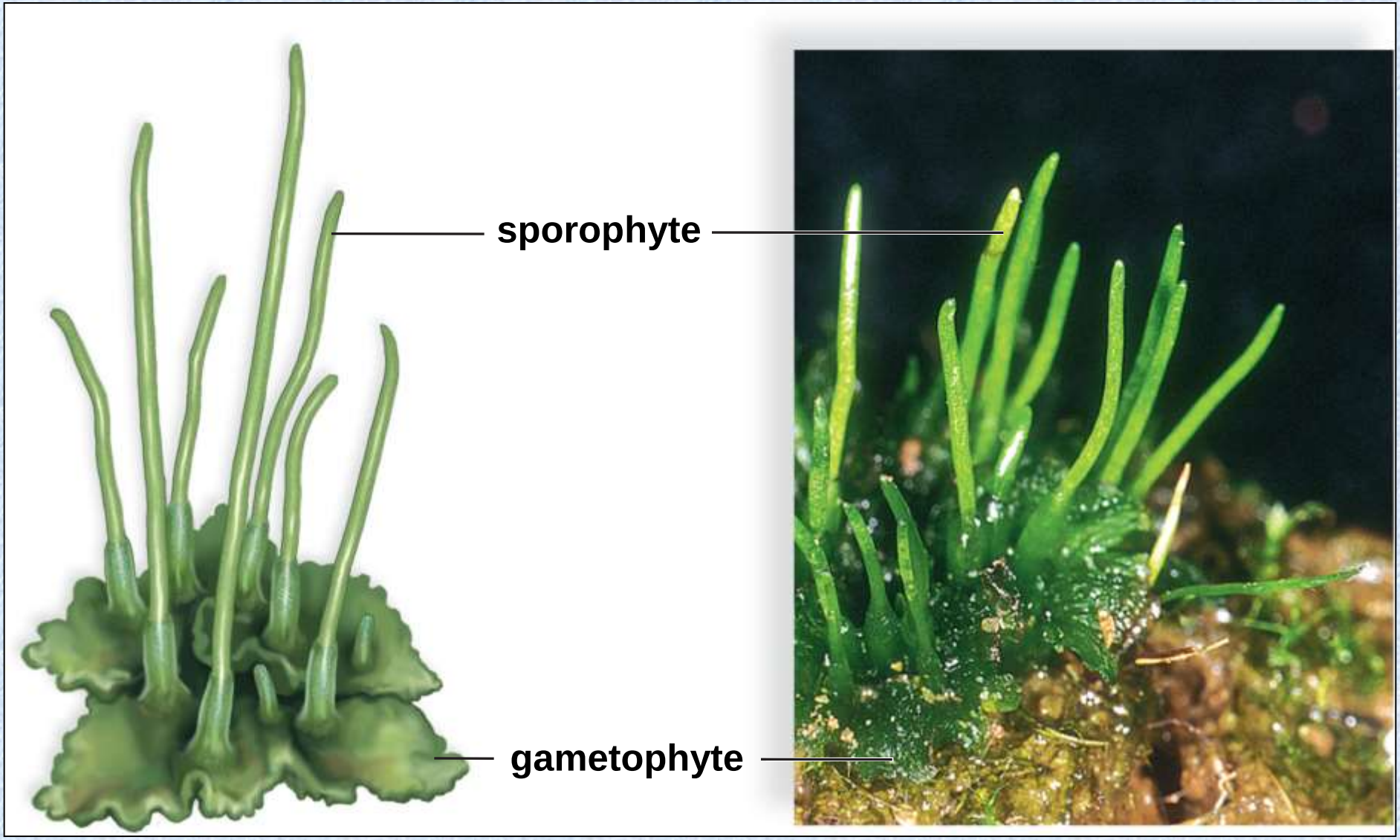




Marchantia sp. **Sporophyte**
100x



Hornwort, *Anthoceros* sp.

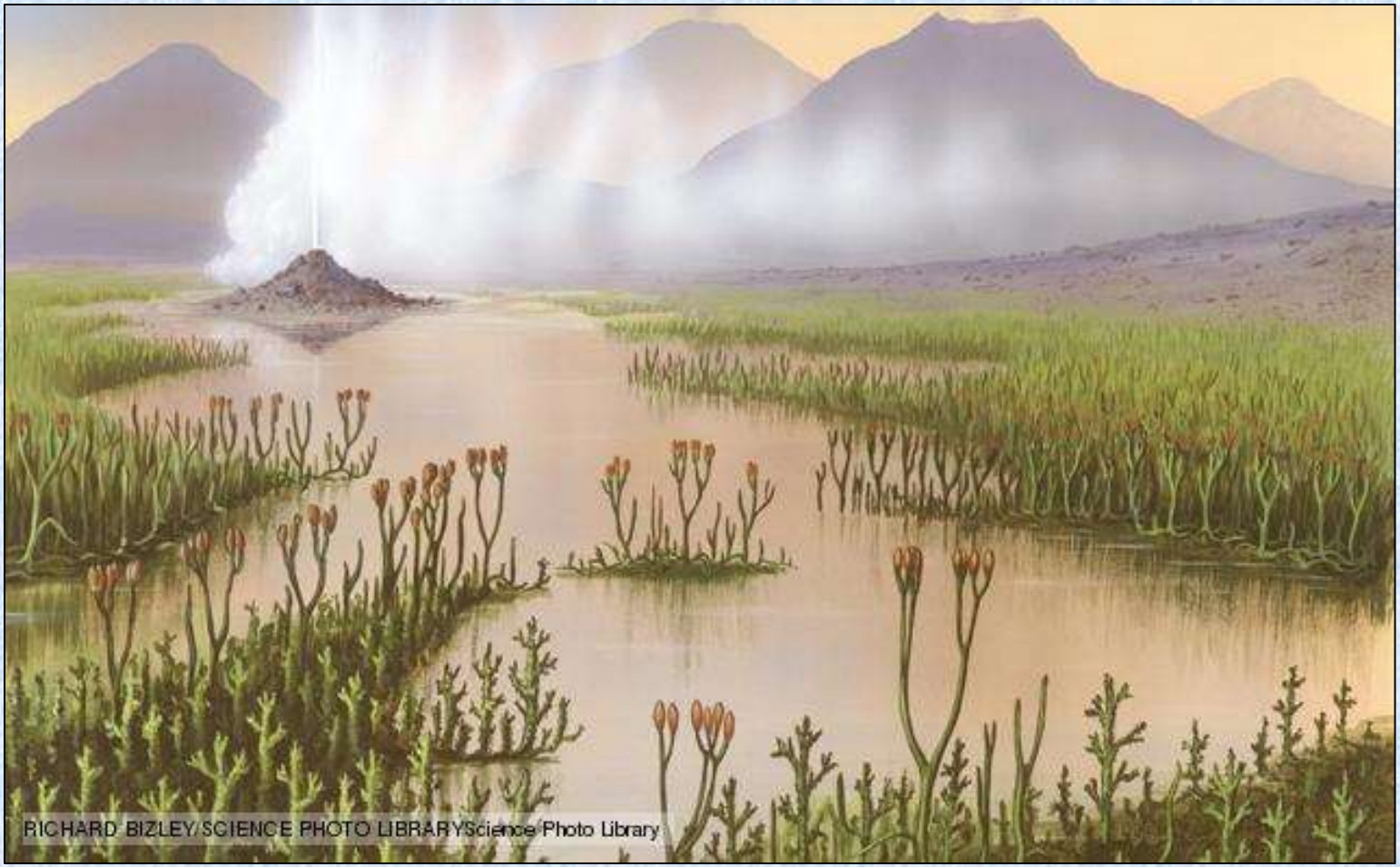


Ferns and fern allies

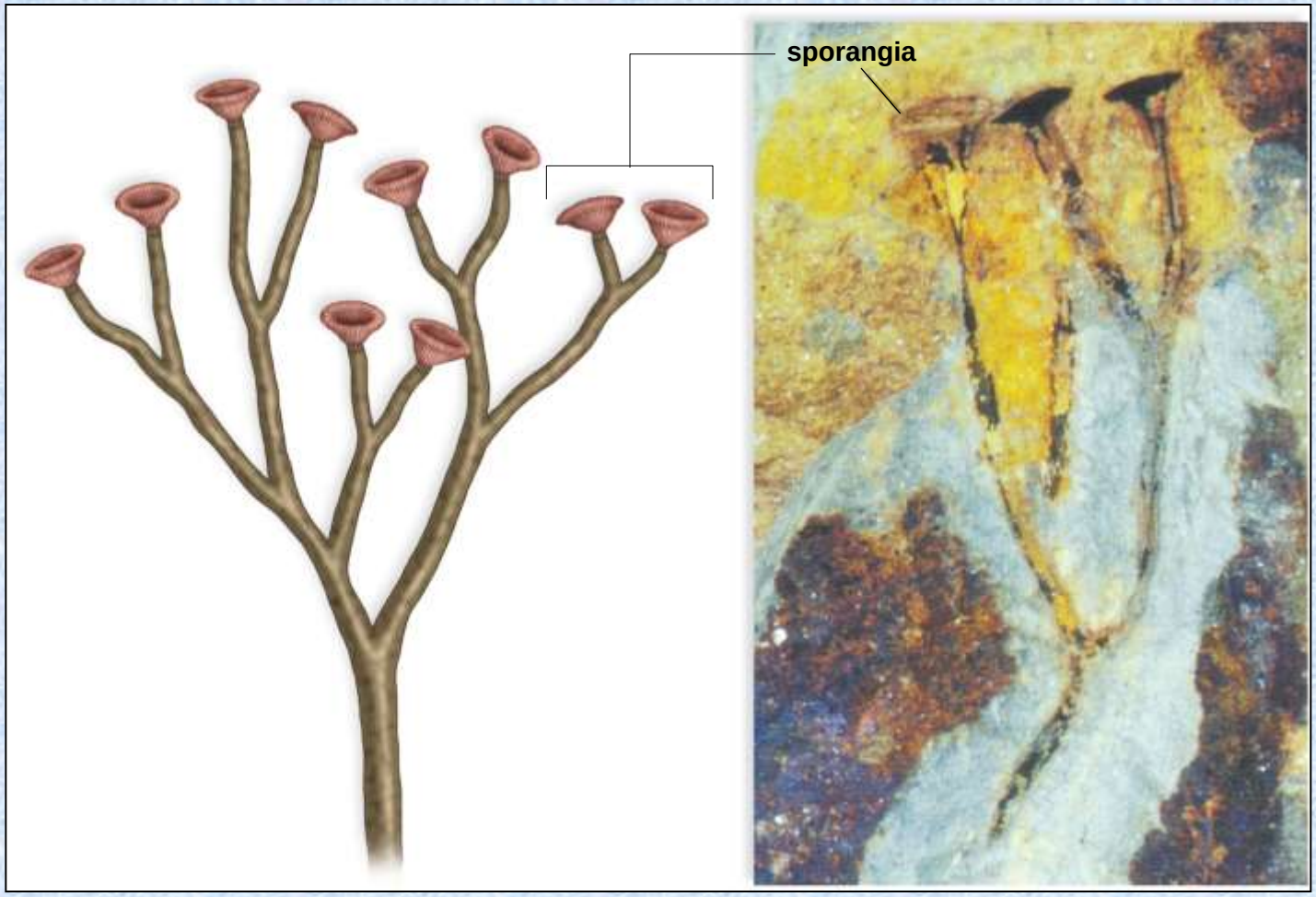
- Lycophytes
- Pteridophytes

Evolution of Lycophytes: Vascular Tissue

- **Vascular plants**
  - Dominate the natural landscape
  - Can achieve great heights because of roots and vascular tissue and nutrient-conducting tissue
  - **Xylem** conducts water and dissolved minerals up from roots.
  - **Phloem** conducts sucrose and other organic compounds throughout the plant.
  - **Lignin** strengthens cell walls of conducting cells in xylem.
  - Most **seedless vascular plants** are homosporous.
    - Windblown spores are dispersal agents.
  - *Cooksonia*, early vascular plant


RICHARD BIZLEY/SCIENCE PHOTO LIBRARYScience Photo Library

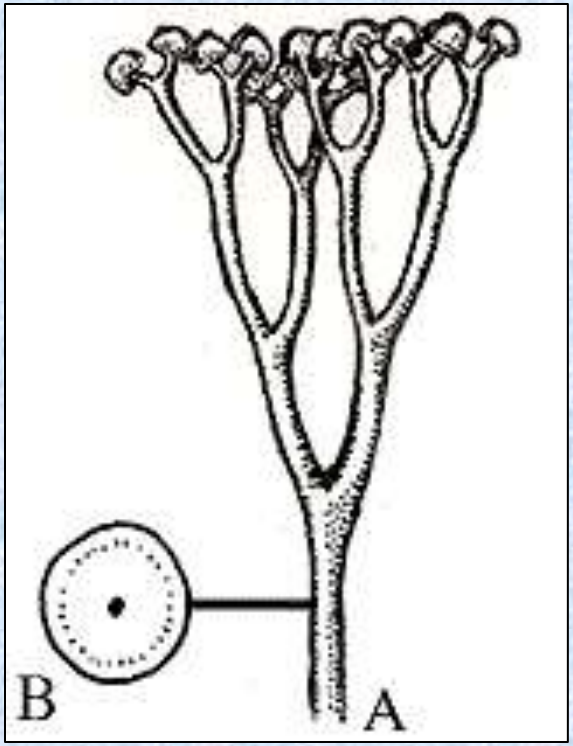
A Cooksonia Fossil

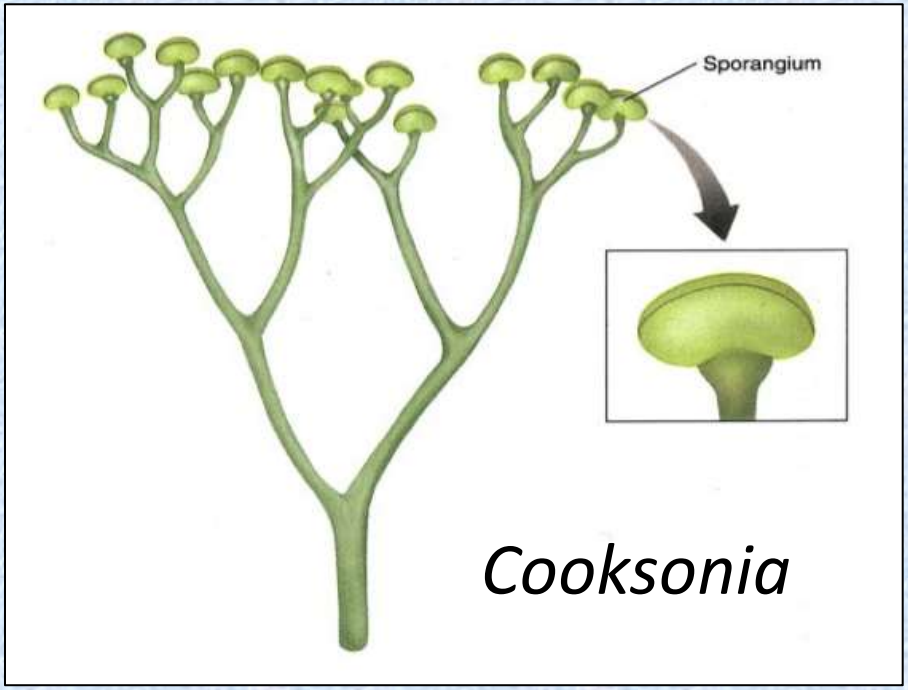


Silurian Plants – 450 MY

Lived near shorelines and in shallow waters

Slowly ‘invaded’ the land area by spreading in from rivers and lakes



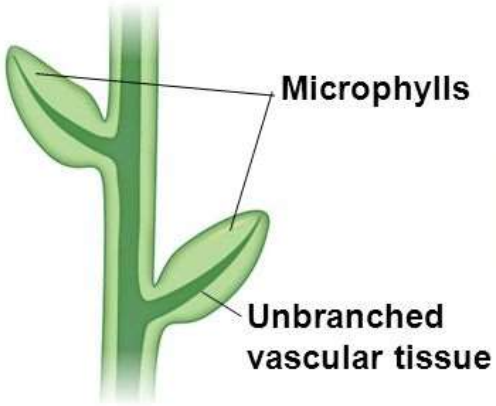


Cooksonia

Leaves – microphylls and megaphylls

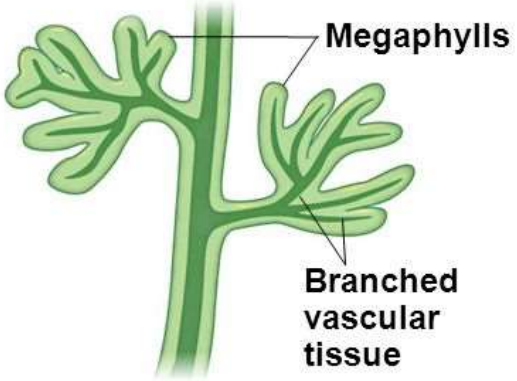
Figure 29.12

Microphyll leaves



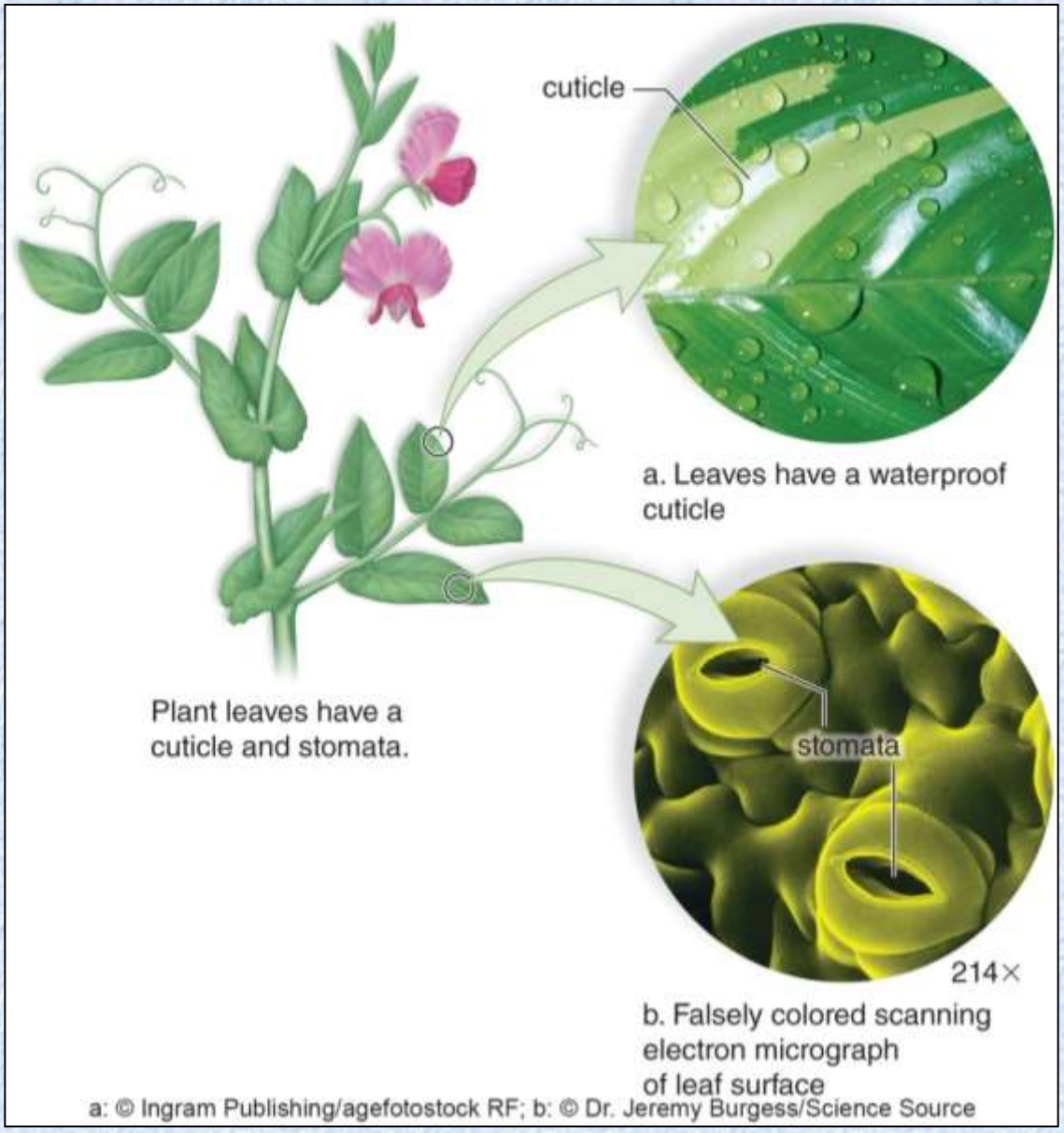
Selaginella kraussiana
(Krauss's spike moss)

Megaphyll leaves

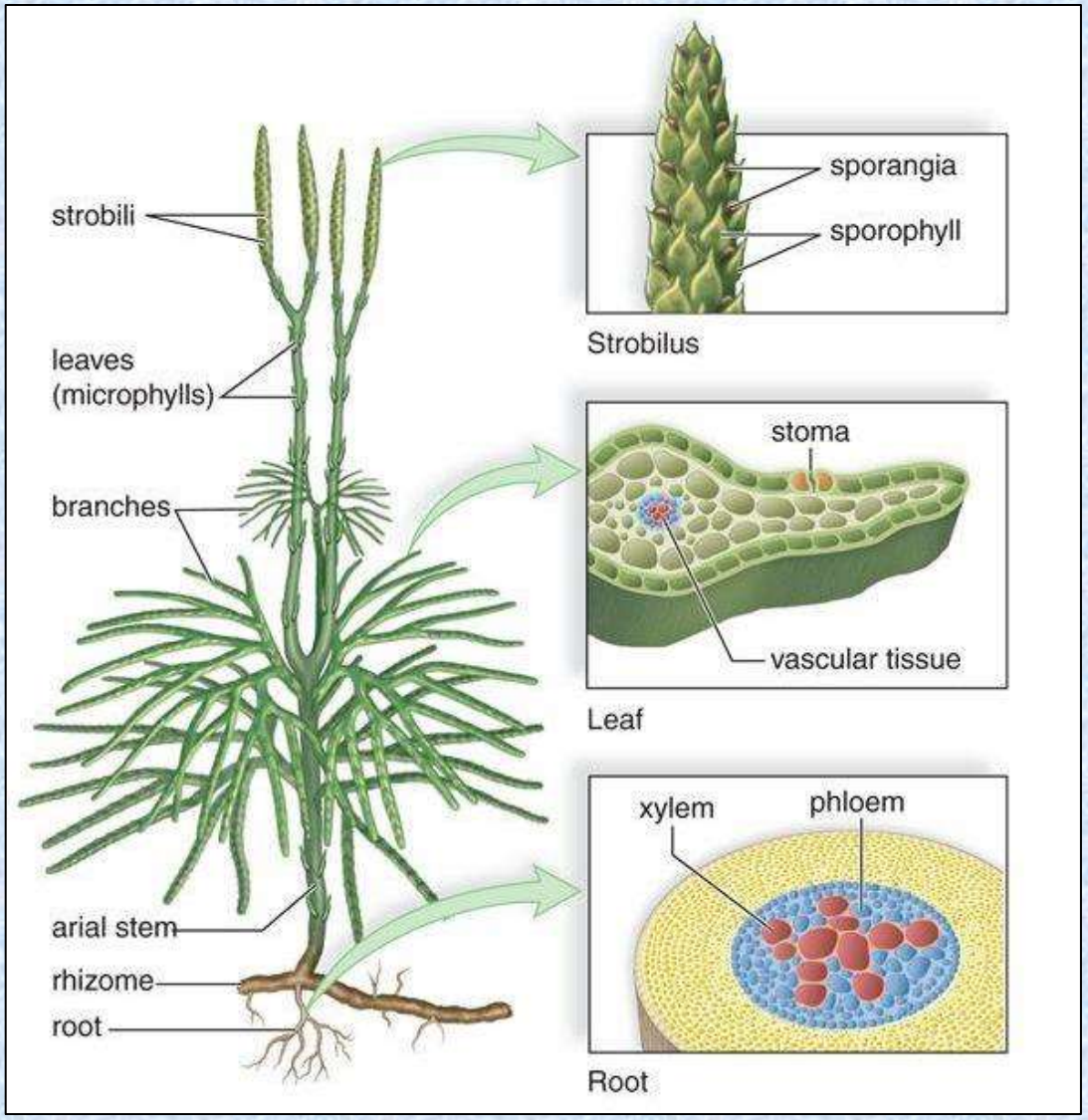


Hymenophyllum tunbrigense
(Tunbridge filmy fern)

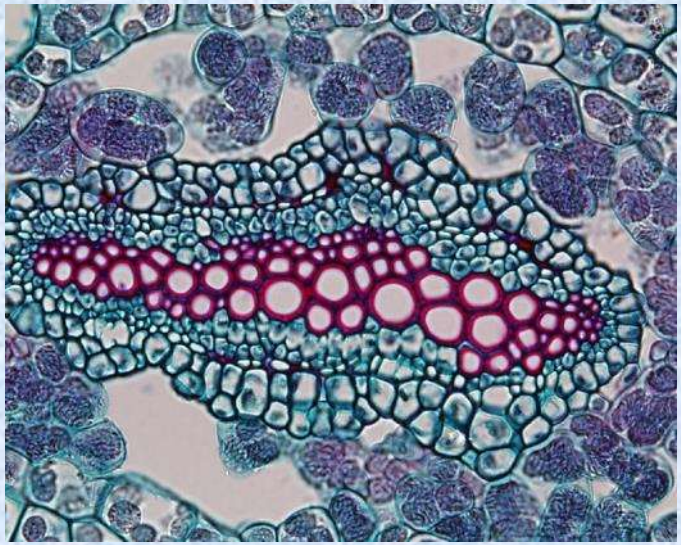
Leaf Adaptation to Prevent Desiccation



Adaptations for Life on Land

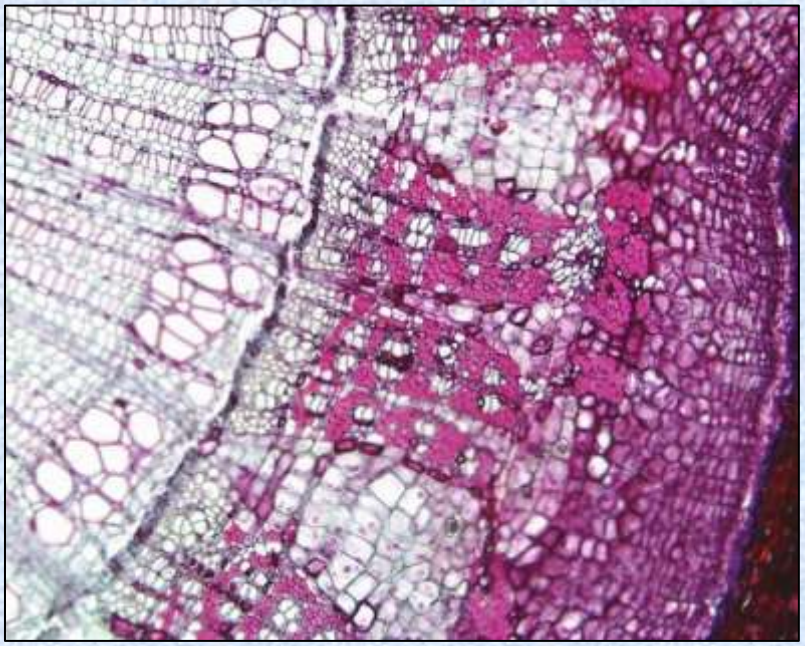


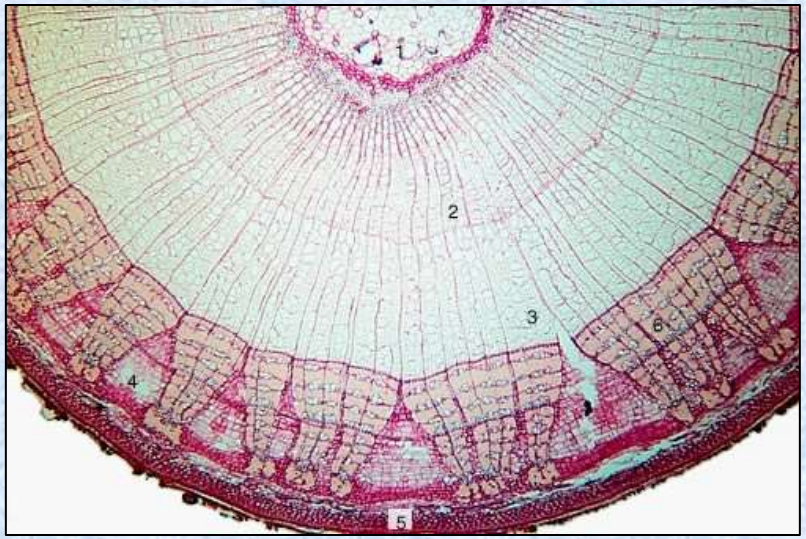
Vascular tissue (xylem and phloem)



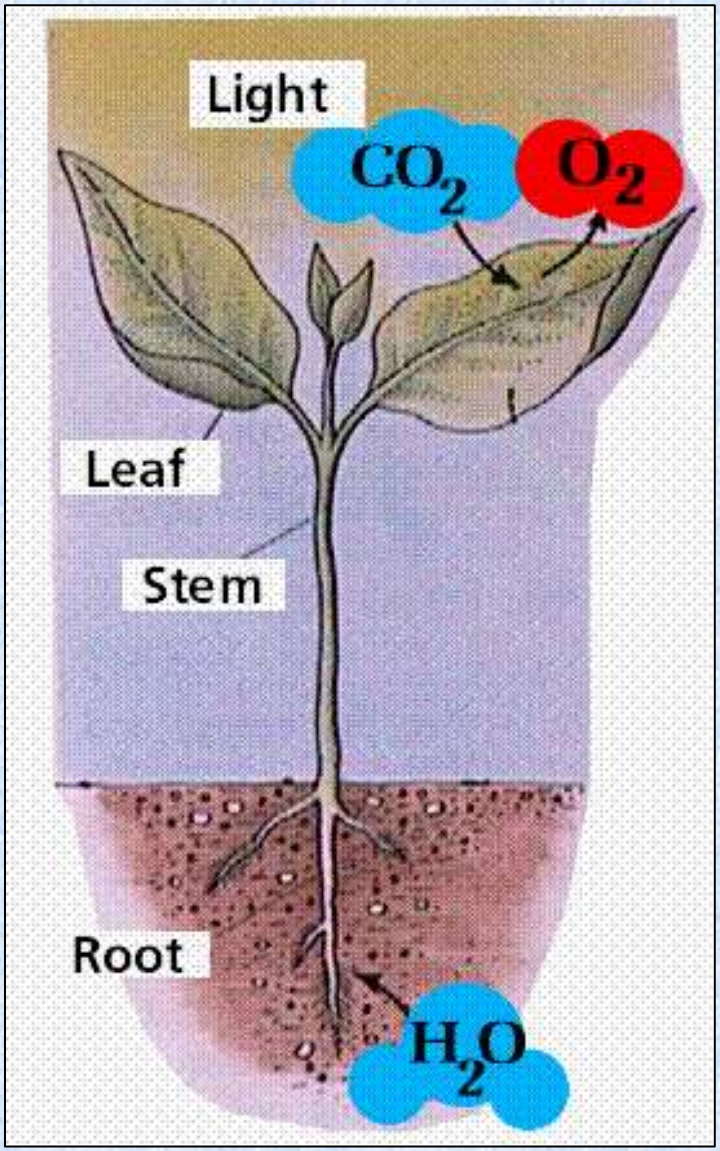
Adaptations for Life on Land

Lignin - strengthening chemical **compound in wood**, allowed growth of stems and branches. Allowed trees and forests to appear





The Plant Body



Shoot System

Vascular System for transporting water and food up and down

Root System

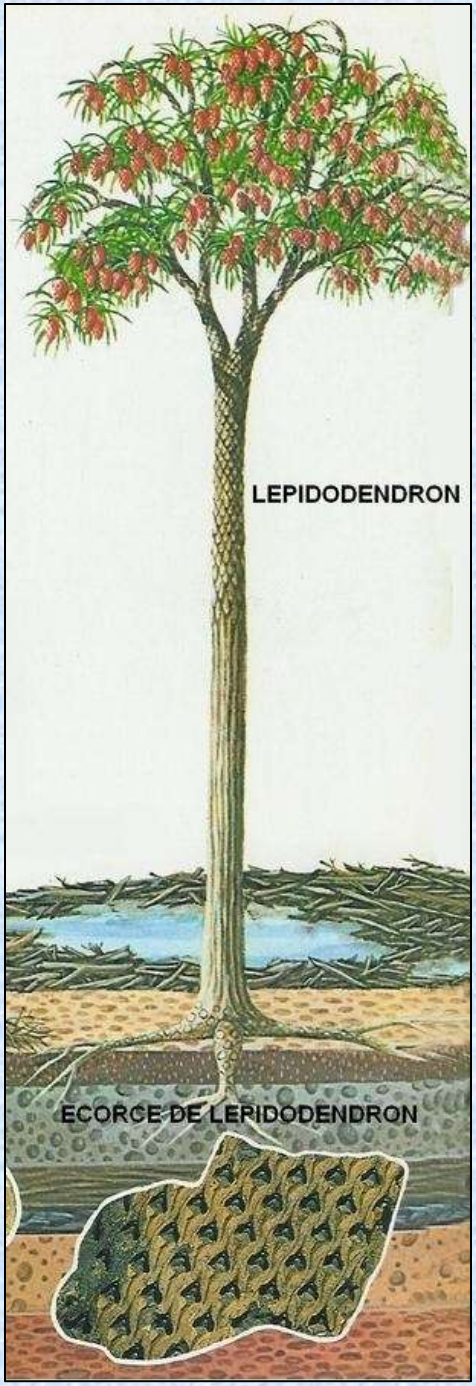
Carboniferous Forests - Lycophytes

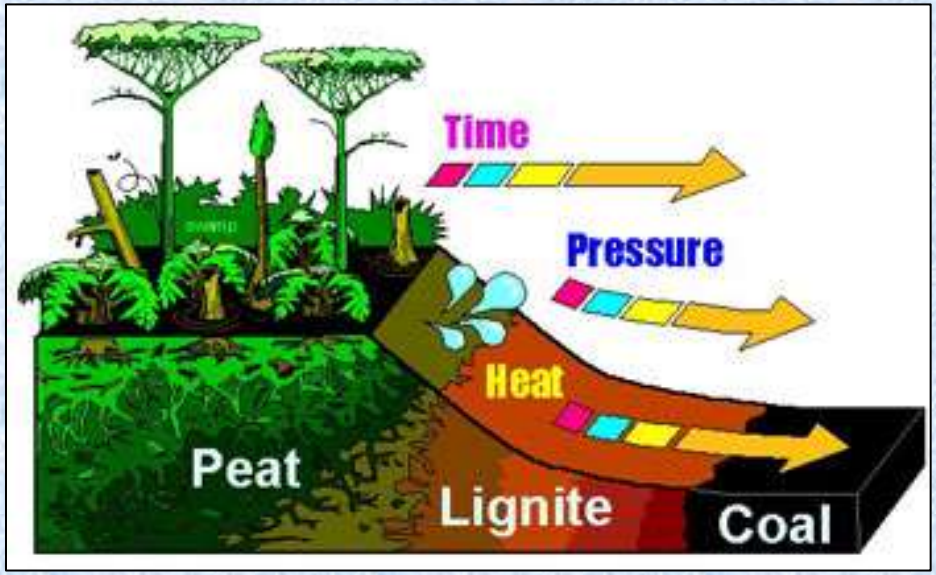
Seedless vascular plants: Ferns and fern allies

- Giant tree ferns, horsetails and lycopods were the dominant vegetation of the Carboniferous period.
- Their fossilized remains formed extensive coal beds.
- They were ultimately superseded by the seed plants and far fewer survive today.

Carboniferous Forest – 300 mya

Coal Fromation





Ferns and Fern Allies

Vascular plants (Xylem, Phloem)

No flowers, no seeds, reproduce by spores

Present day fern allies

- Lycopods: About 1,000 species. Includes tropical epiphytes and northern hemisphere low growing club mosses.
- Horsetails: today about 15 species of *Equisetum* occur in northern hemisphere in damp conditions.
- Quillworts - *Isoetes*
- Whisk Ferns - *Psilotum*

Equisetum

Lycopod

Ferns

- A very diverse group about 12,000 species most abundant in the tropics, but distributed worldwide.

- Most are small to moderately large plants, but tree ferns are many meters tall.

Common ferns

Boston fern

Staghorn fern

Maidenhair fern

Pteris

Diversity of Ferns

(leatherleaf fern): © Gregory Preest/Alamy; (tree fern): © Danita Delimont/Getty Images; (hart's tongue fern): © Organics image library/Alamy RF

Fern morphology

Underground rhizome (stem)

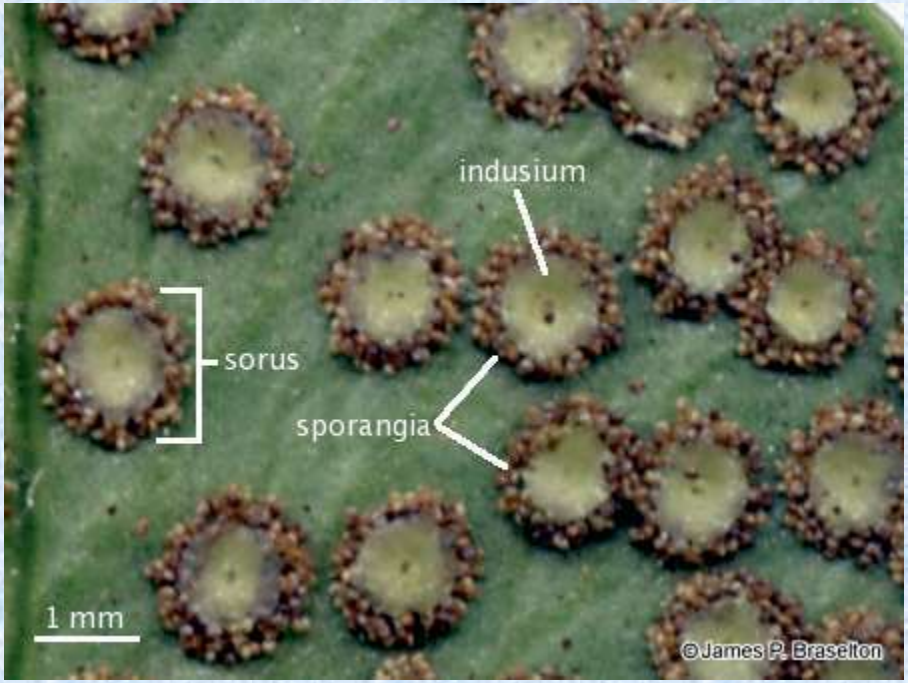
Fronds = leaves

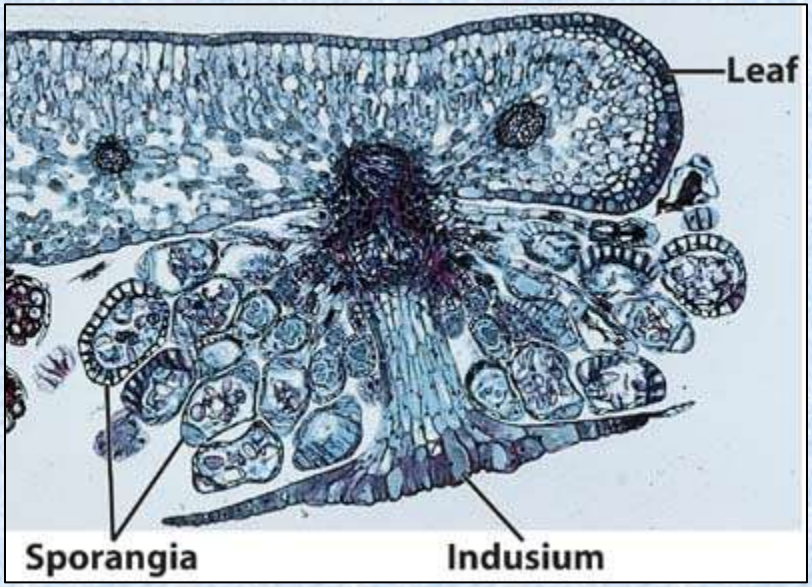
Sori - sporangia

Fern life cycle - spores

- Produced by sporangia
- Sporangia clustered in **sori** (singular = sorus)
- Usually small button-like dots on backs of fronds
- Sometimes covered by indusium

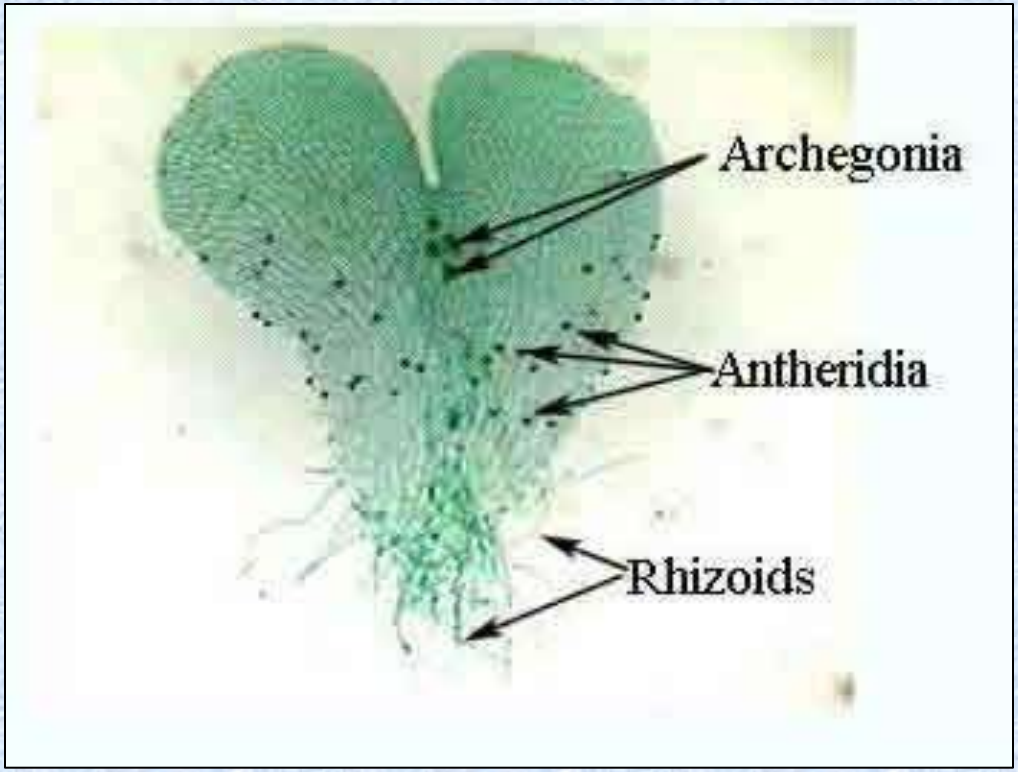
Fern Sori, Sporangia



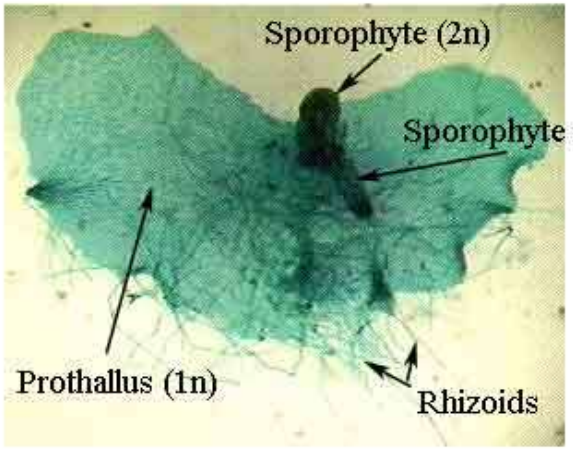


Fern Life Cycle

Fern Sporophyte



Fern prothallus with developing sporophyte



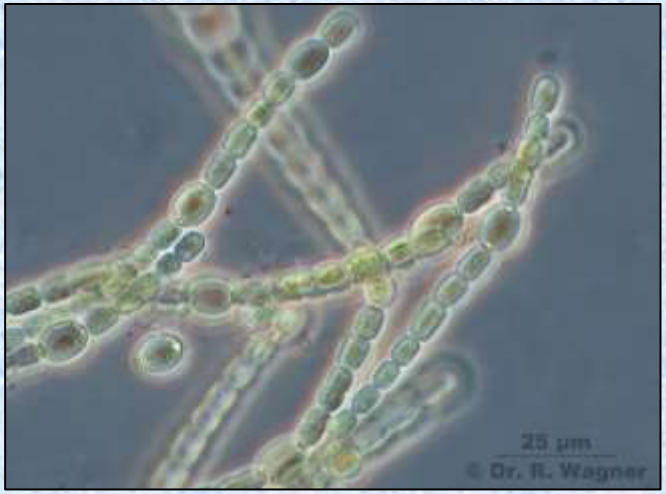
40x

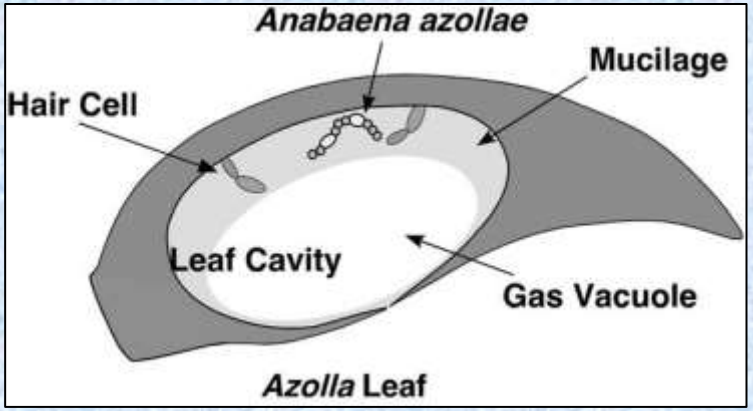
The Uses of Ferns

- Economic and medicinal value.
- Edible ferns are used as a food source.
- *Azolla* harbors nitrogen-fixing cyanobacteria and is grown in rice paddies, where it fertilizes rice plants.
- Ferns and their allies are used as medicines in China.
- Extracts from ferns have also been used to kill insects.
- Ferns are used as decoration.

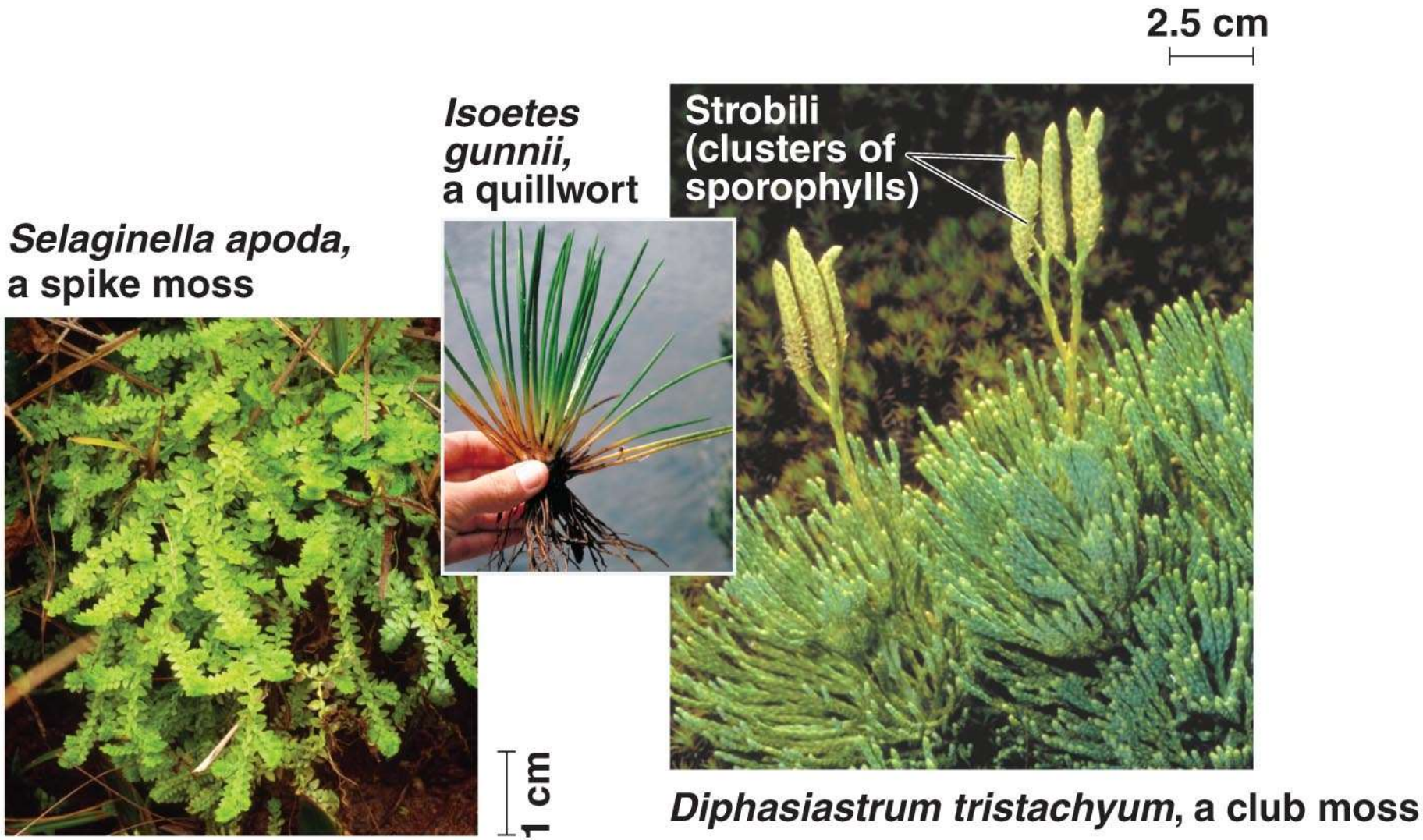
Azolla Fern

- Pockets with cycanobacteria
- Used to fertilize rice paddies

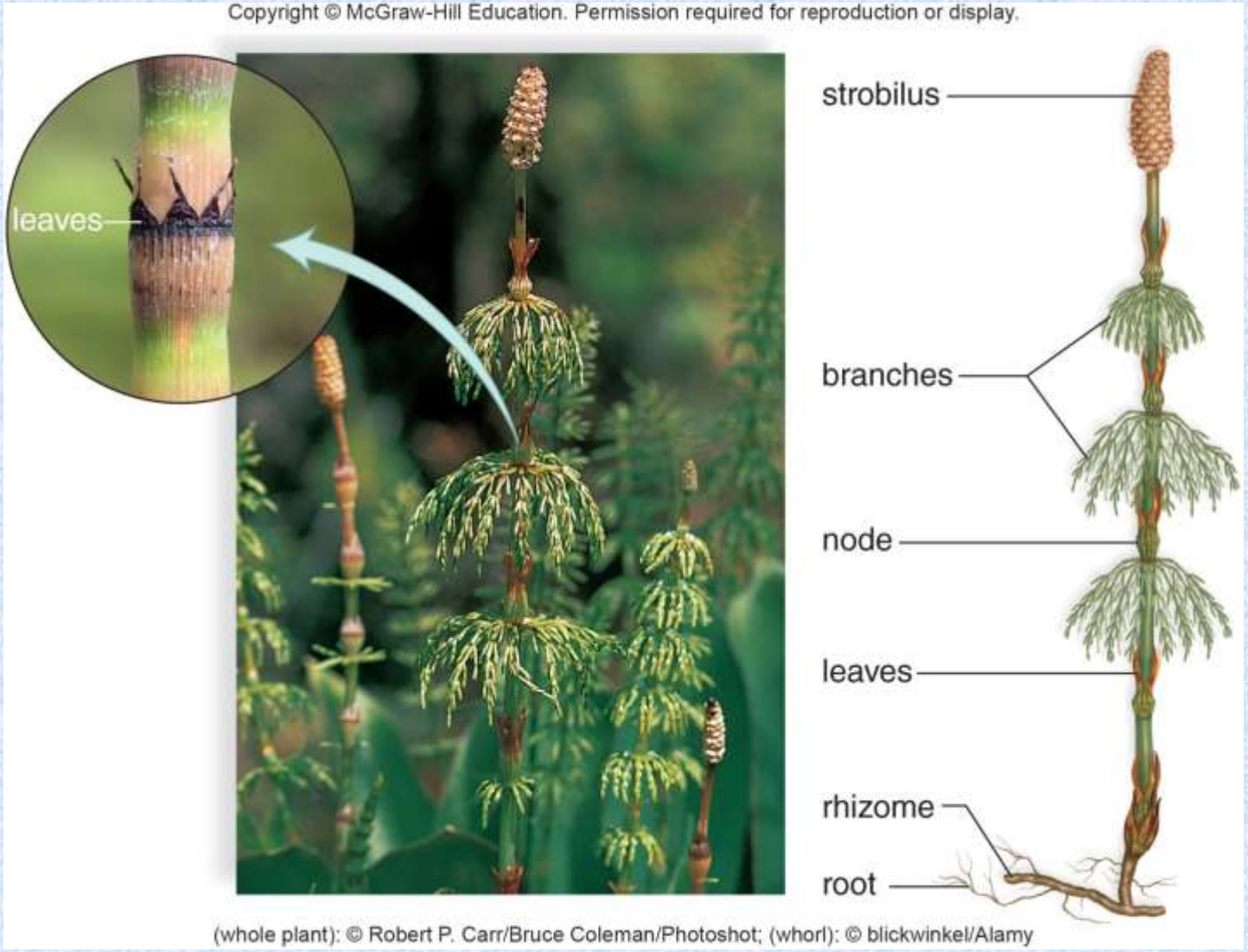




Lycophytes (Phylum Lycophyta)

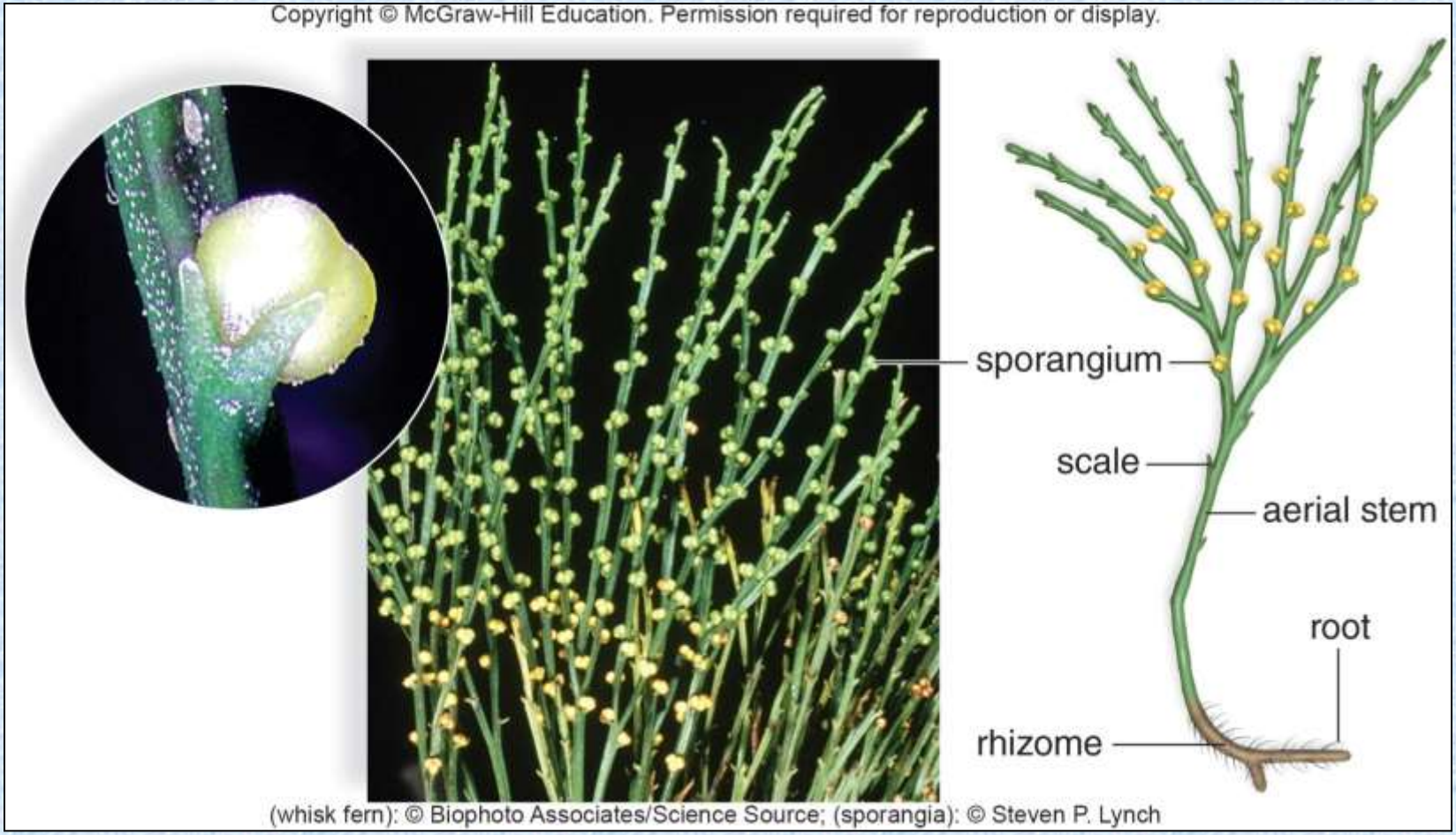


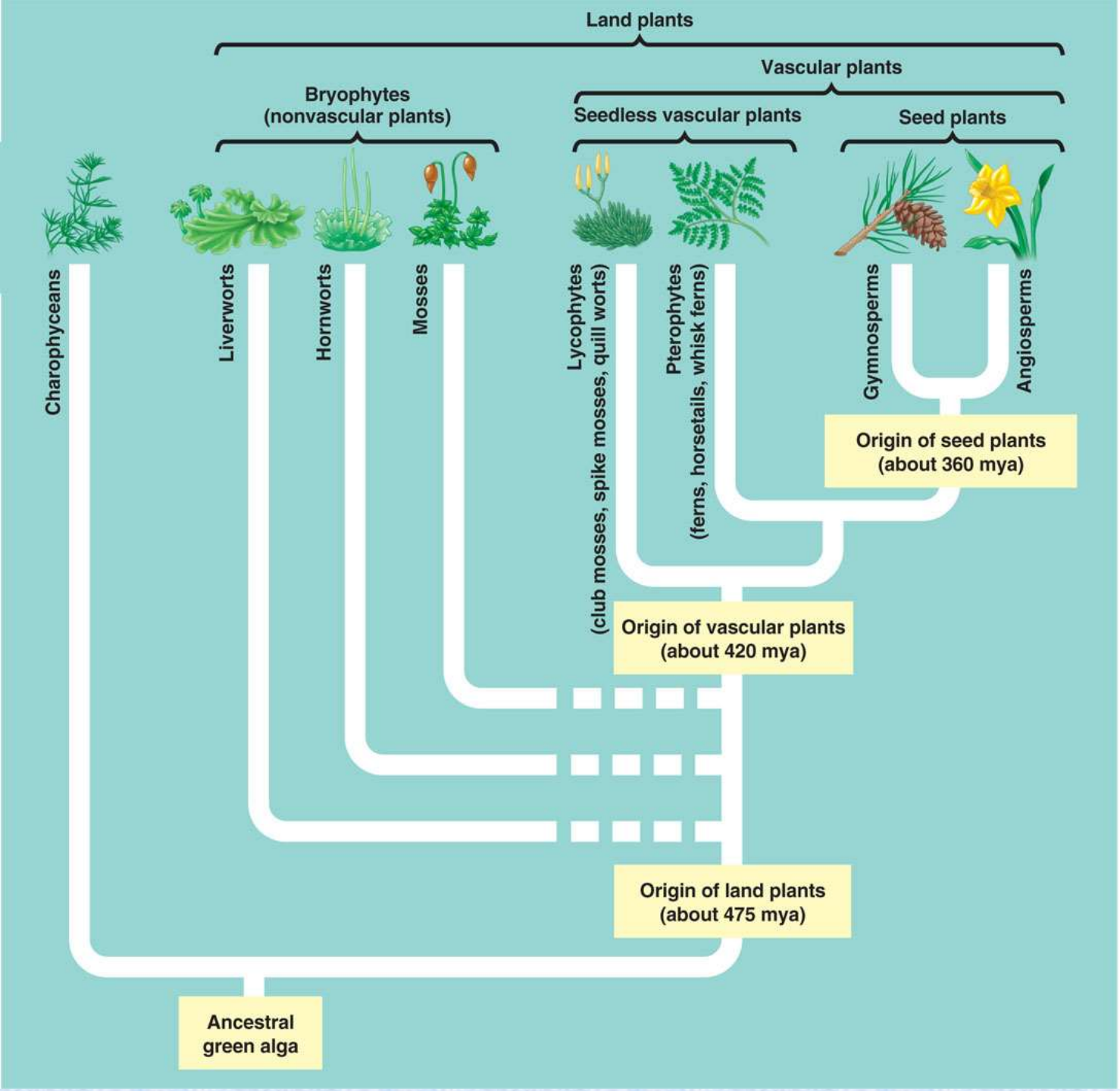
Horsetail, *Equisetum*



(whole plant): © Robert P. Carr/Bruce Coleman/Photoshot; (whorl): © blickwinkel/Alamy

Whisk Fern, *Psilotum*




Land plants
Vascular plants
Bryophytes (nonvascular plants)
Seedless vascular plants
Seed plants
Charophyceans
Liverworts
Hornworts
Mosses
Lycophytes (club mosses, spike mosses, quill worts)
Pterophytes (ferns, horsetails, whisk ferns)
Gymnosperms
Angiosperms
Origin of seed plants (about 360 mya)
Origin of vascular plants (about 420 mya)
Origin of land plants (about 475 mya)
Ancestral green alga

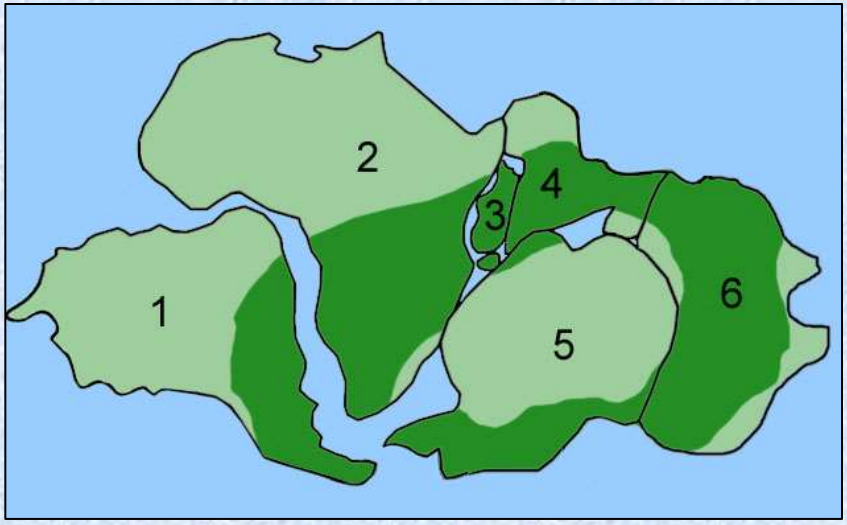
Spores and seeds

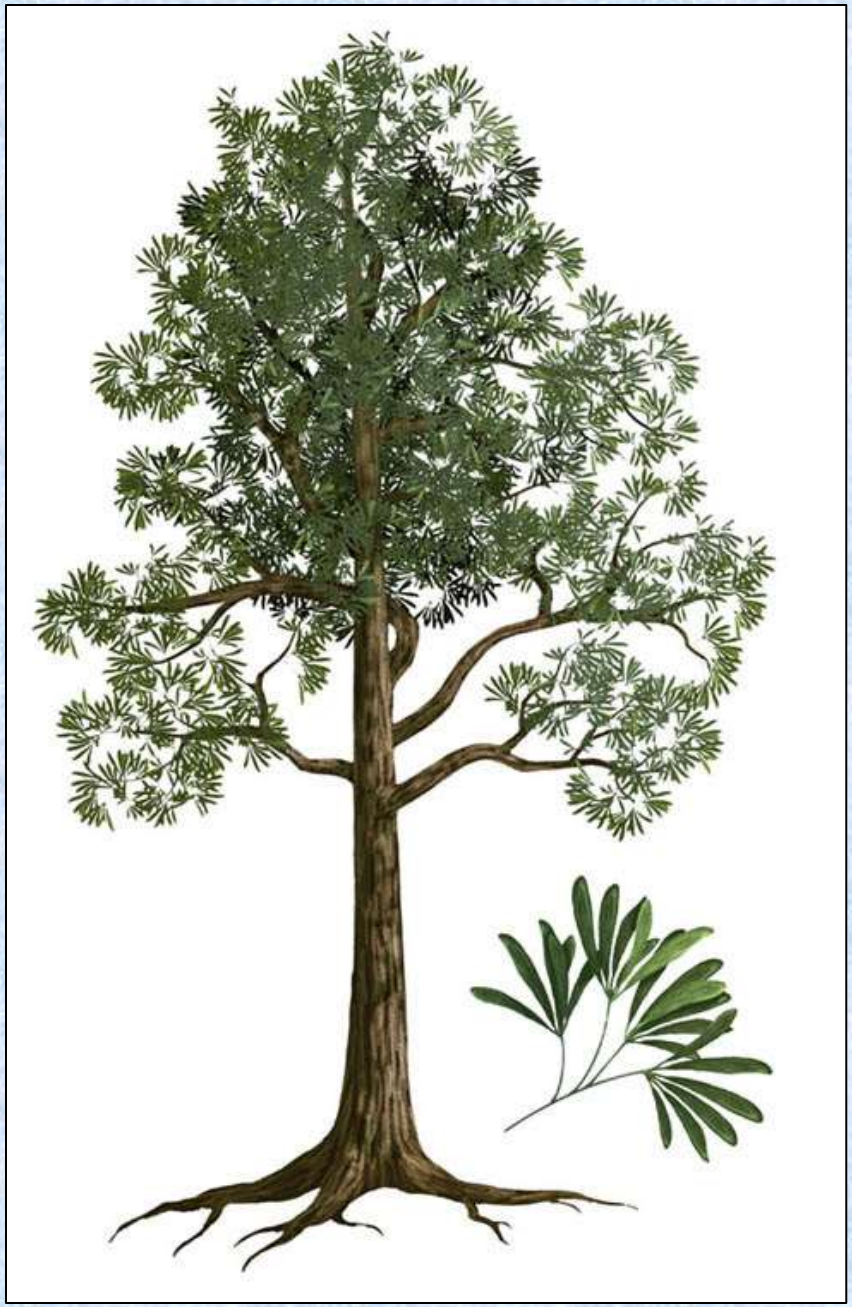
- The spores of ferns are tiny and vast numbers are produced. However, their prospects of survival are low.

- A new evolutionary innovation, the seed, arose in the Carboniferous Period. Seeds and later fruit proved to be enormously successful and seed plants especially angiosperms came to dominate the planet.

Glossopteris – Seed Ferns

Permian





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