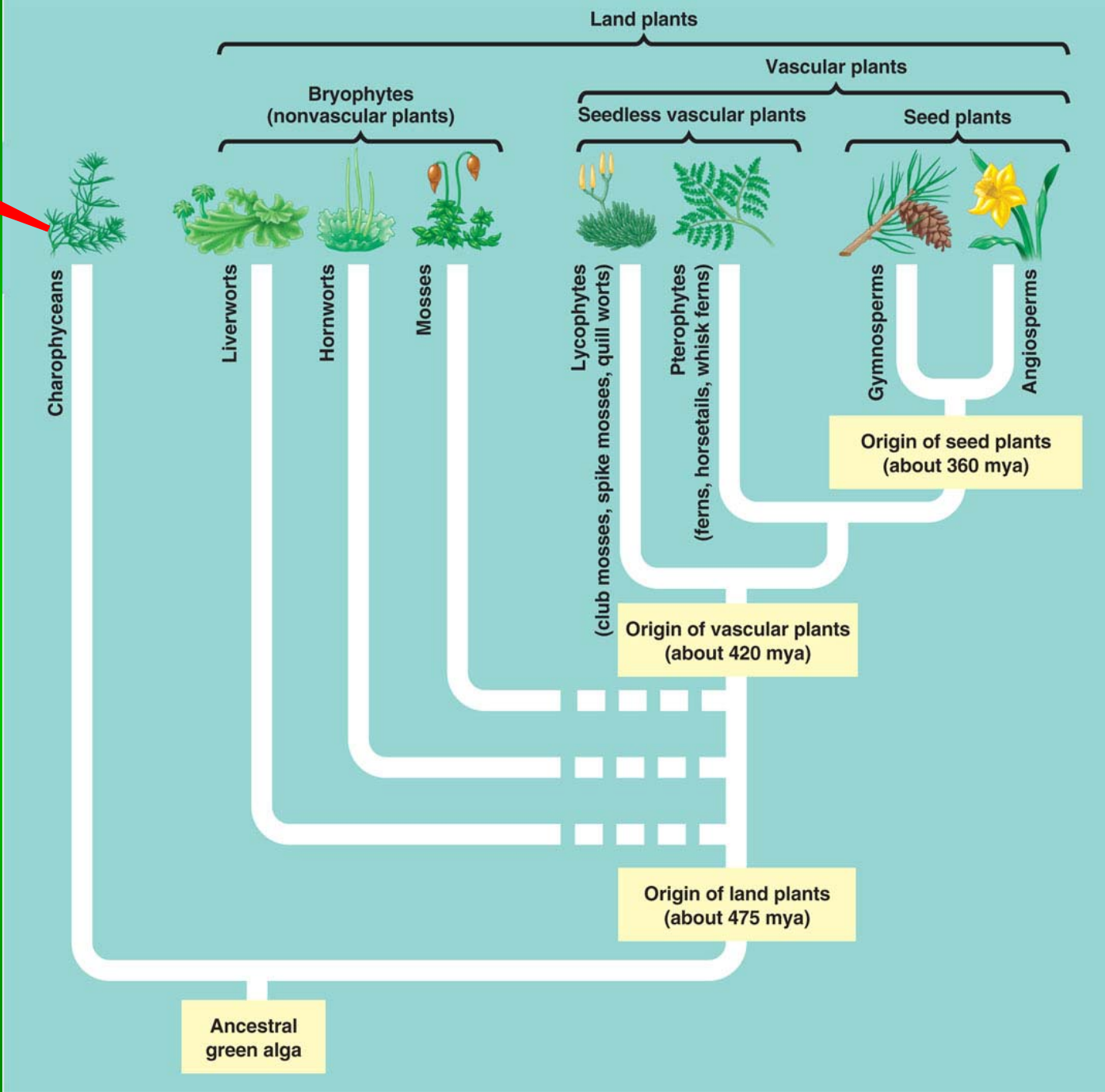


seedless plants

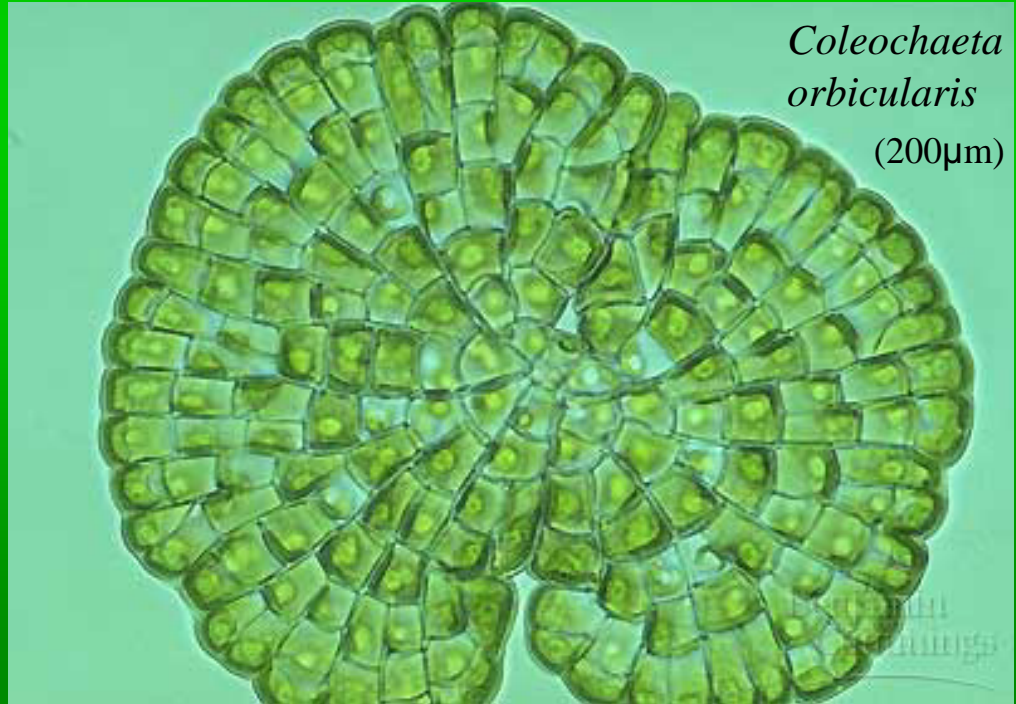
(chapter 29)

a protist!





*Chara
nitella*

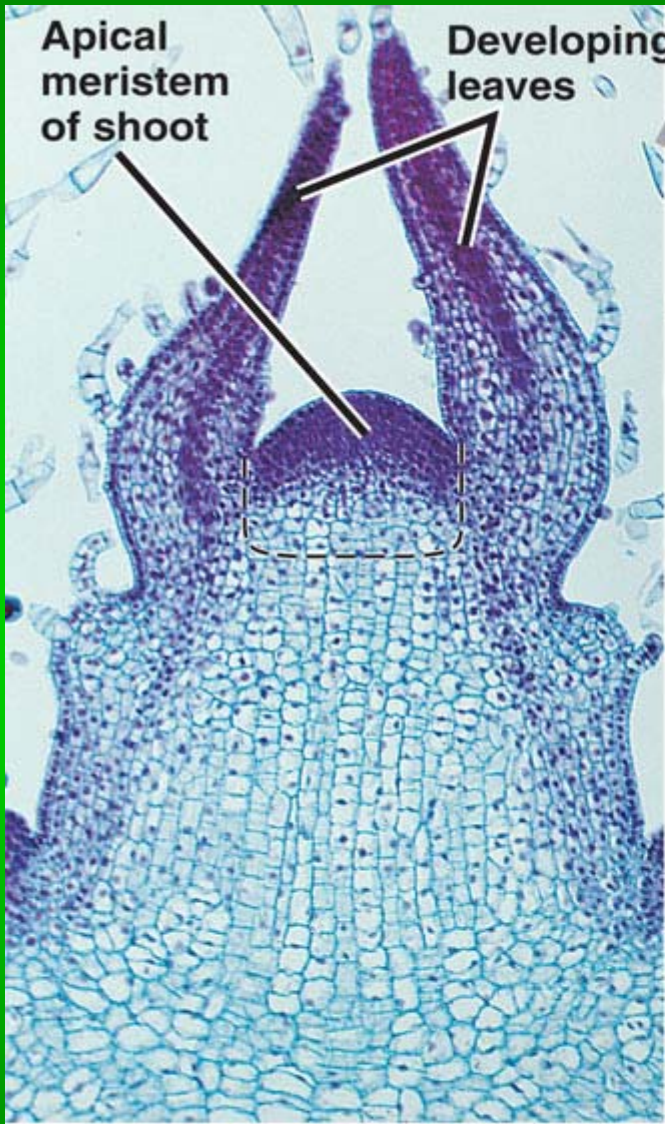


*Coleochaeta
orbicularis*
(200µm)

land plant derived characteristics . . .

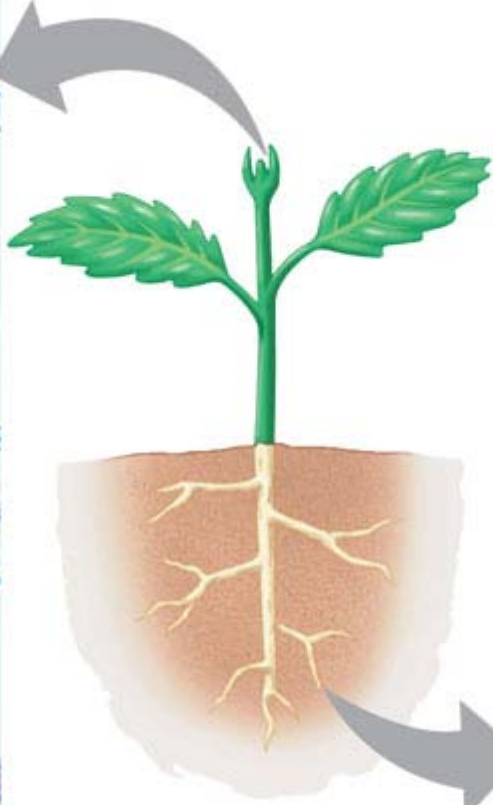
apical meristems

localized regions of cell division & differentiation at tips of shoots and roots



Shoot

100 μm



Apical meristems of plant shoots and roots. The light micrographs are longitudinal sections at the tips of a shoot and root.



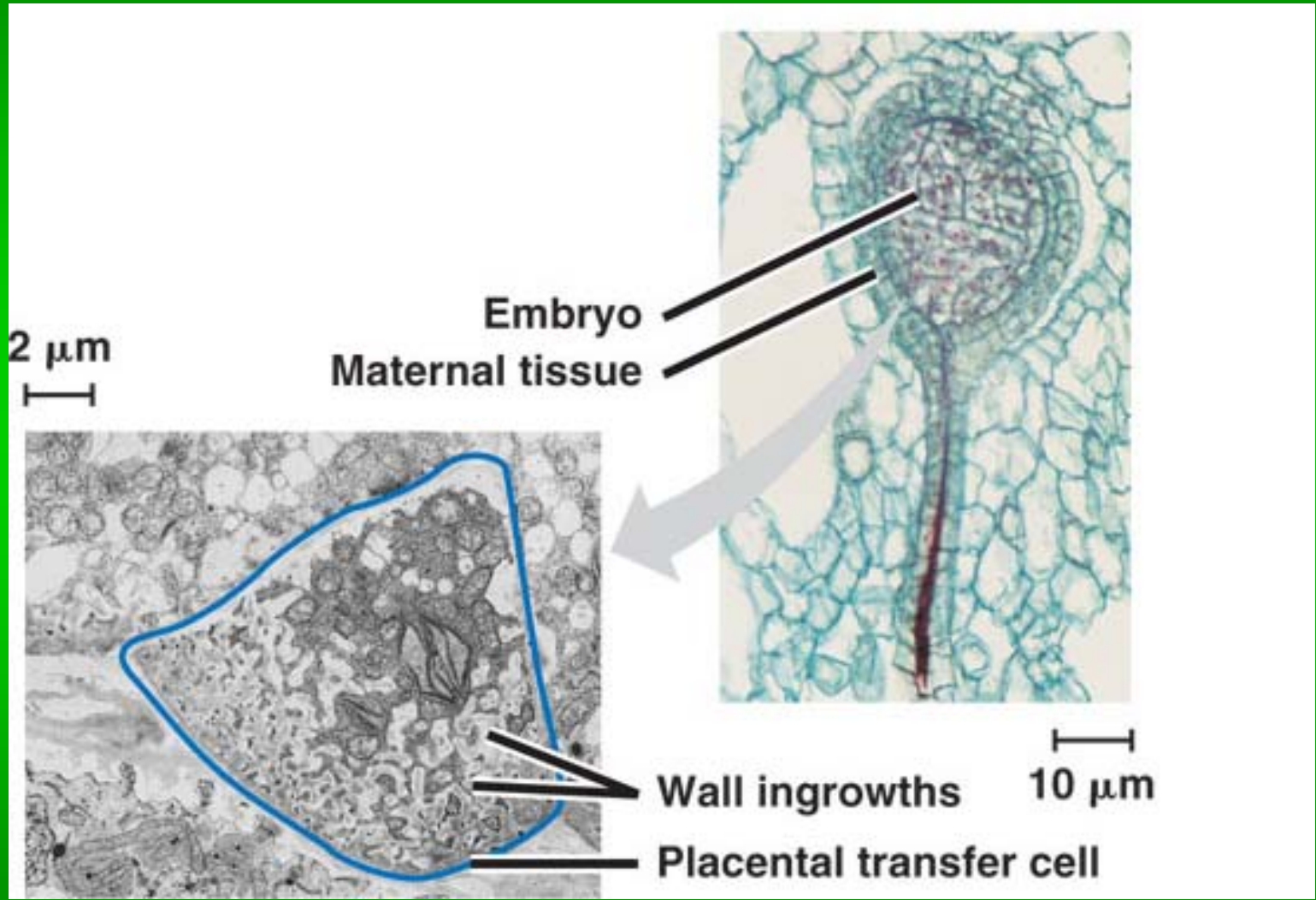
Root

100 μm

land plant derived characteristics . . .

parent plant-dependent,
multicellular embryos

embryos develop from female retained zygotes (*embryophyte*–land plants producing embryos); parent plant provides nutrients to embryo through embryonic placental cells



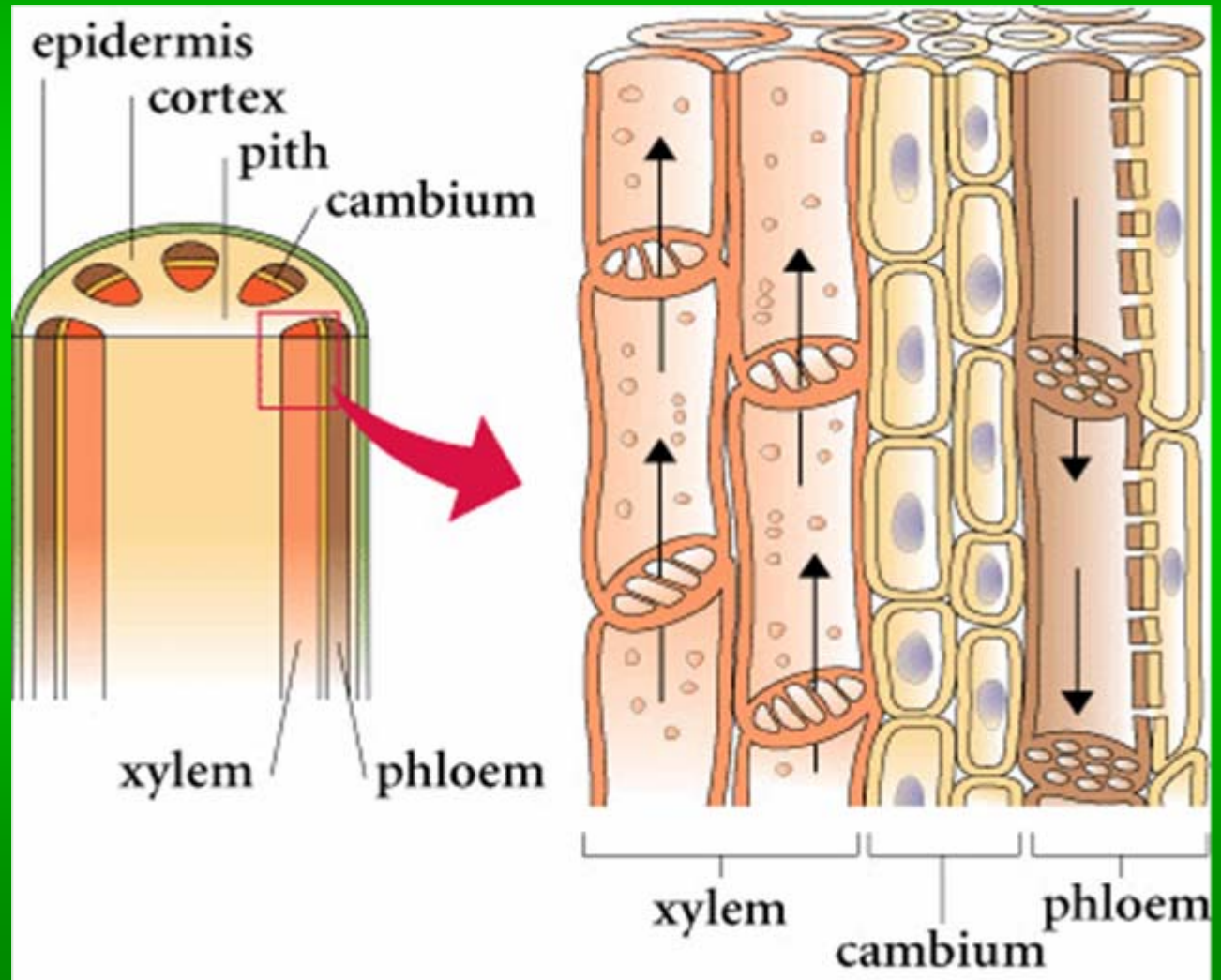
land plant derived characteristics . . .

vascular tissues

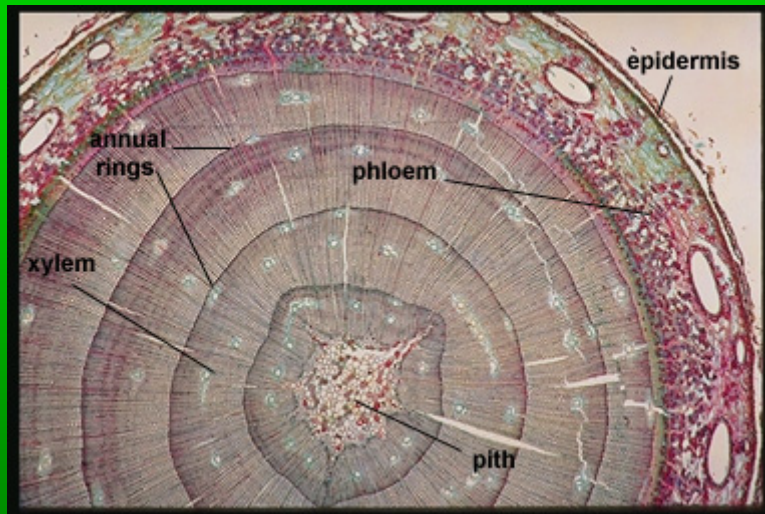
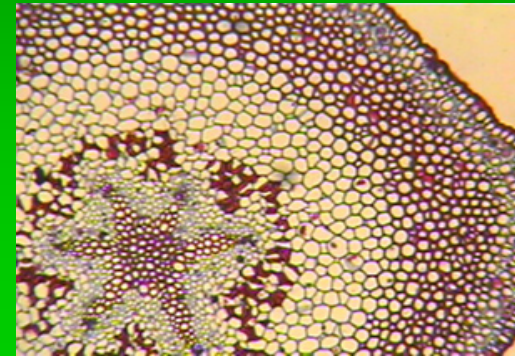
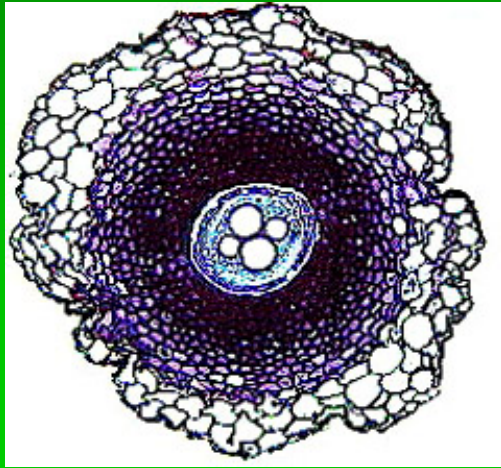
water, nutrient conduction

xylem and phloem . . .

xylem - dead cells whose walls provide tubing; carry **water** and **nutrients up**
phloem - living tissue; tubes for transporting organic products **throughout plant**



vascularization . . .



land plant derived characteristics . . .

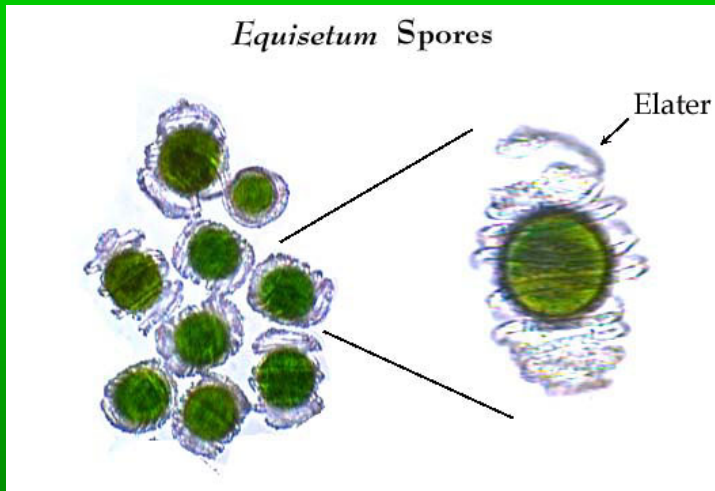
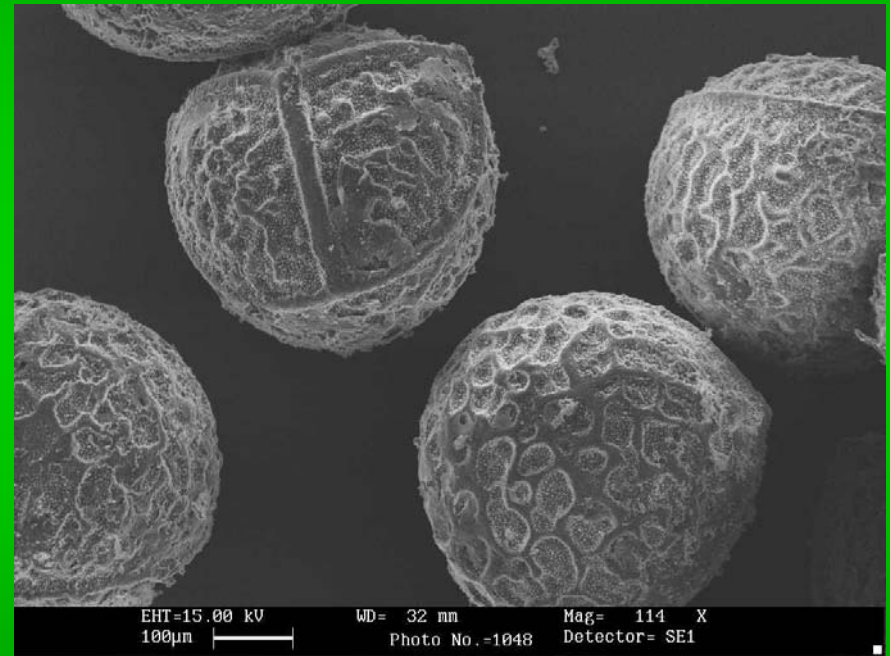
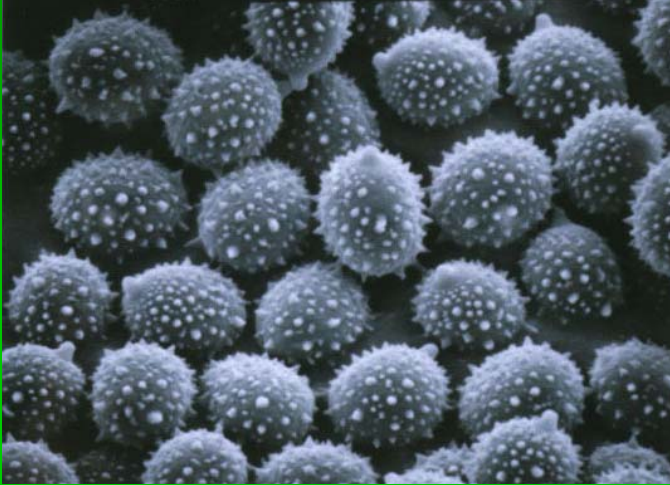
spores

**resistant structures of
sporopollenin**

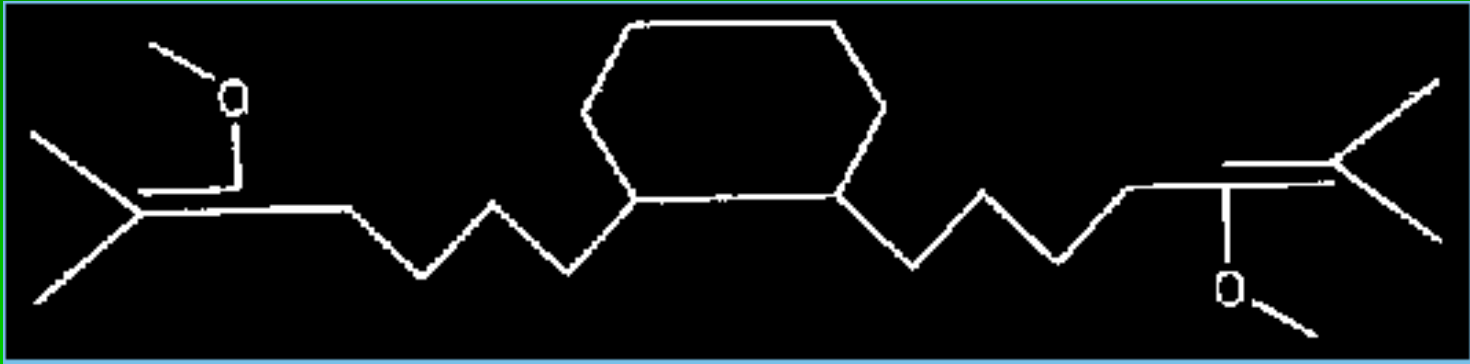
spores ...



e.g. spores ...



sporopollenin...



most durable organic material known!

resistant to

UV

dessication

squashing

to remove in laboratory, must be boiled in acid!!!

Spore Tetrads

Found in sediments
> 470 million years old



Individual Spores

Have trilete mark; are found in
younger sediments, from ca.
425 million years ago

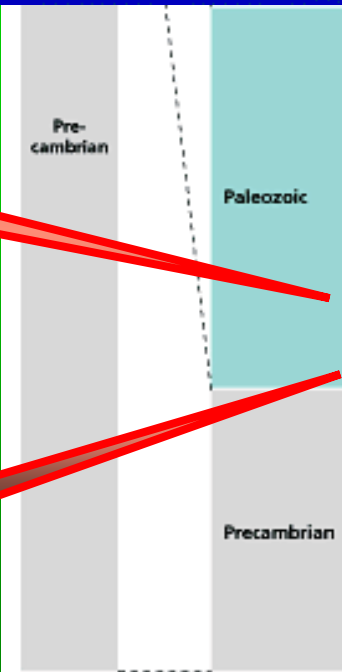


Table 25.1 The Geologic Time Scale

| Period | Epoch | Age (Millions of Years Ago) | Some Important Events in the History of Life |
|---------------|-------------|---|---|
| Quaternary | Recent | | Historical time |
| | Pleistocene | 0.01 | Ice ages; humans appear |
| | Pliocene | 1.8 | Apelike ancestors of humans appear |
| | | 5 | Continued radiation of mammals and angiosperms |
| | Tertiary | 23 | Origins of many primate groups, including apes |
| | | 35 | Angiosperm dominance increases; continued radiation of most modern mammalian orders |
| | | 57 | Major radiation of mammals, birds, and pollinating insects |
| Cretaceous | 65 | Flowering plants (angiosperms) appear; many groups of organisms, including dinosaurs, become extinct at end of period (Cretaceous extinctions) | |
| | 144 | Gymnosperms continue as dominant plants; dinosaurs abundant and diverse | |
| Jurassic | 206 | Cone-bearing plants (gymnosperms) dominate landscape; radiation of dinosaurs | |
| | 245 | Extinction of many marine and terrestrial organisms (Permian mass extinction); radiation of reptiles; origins of mammal-like reptiles and most modern orders of insects | |
| Carboniferous | 290 | Extensive forests of vascular plants; first seed plants; origin of reptiles; amphibians dominant | |
| | 363 | Diversification of bony fishes; first amphibians and insects | |
| Silurian | 409 | Diversity of jawless fishes; first jawed fishes; diversification of early vascular plants | |
| | 439 | Marine algae abundant; colonization of land by plants and arthropods | |
| Ordovician | 510 | Radiation of most modern animal phyla (Cambrian explosion) | |
| | 543 | Diverse soft-bodied invertebrate animals; diverse algae | |
| Precambrian | 2,200 | Oldest fossils of eukaryotic cells | |
| | 2,700 | Atmospheric oxygen begins to increase | |
| | 3,500 | Oldest fossils of cells (prokaryotes) | |
| | 3,800 | Earliest traces of life | |
| | 4,600 | Approximate time of origin of Earth | |

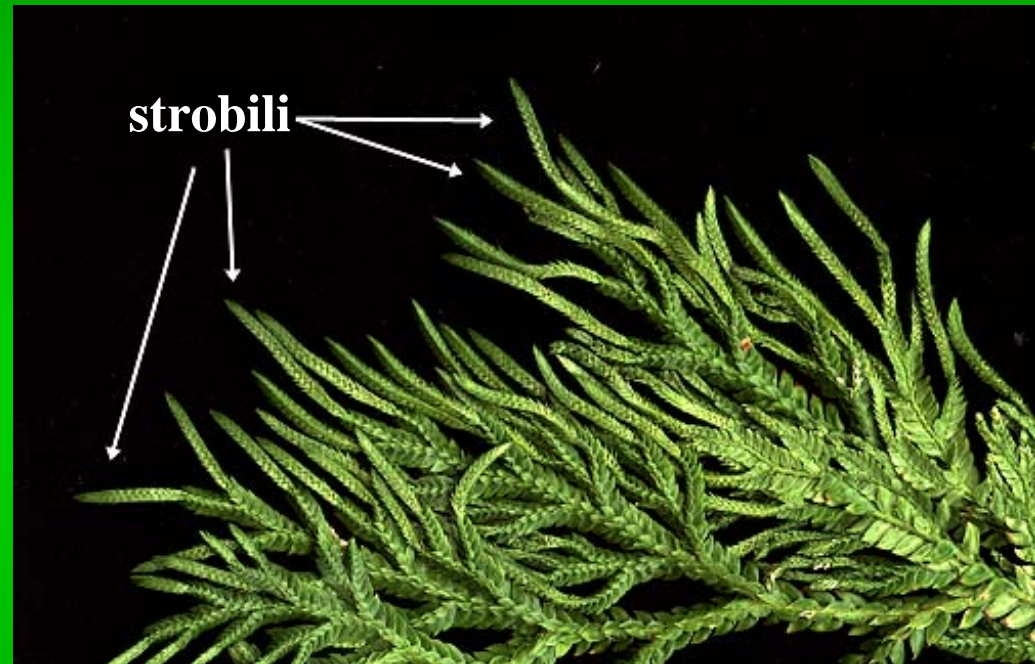
spores!!!

traces



spores...

sporophylls – leaves with sporangia



homosporous – single type of spore; bisexually morphic gametophytes

heterosporous – two types of spores; sexually morphic gametophytes;
from dimorphic sporophylls

megasporangia in **megasporophylls** produce **megaspores** – **female** gamete

microsporangia in **microsporophylls** produce **microspores** – **male** gamete

land plant derived characteristics . . .

multicellular gametophytes

the numbers game!

Female gametophyte

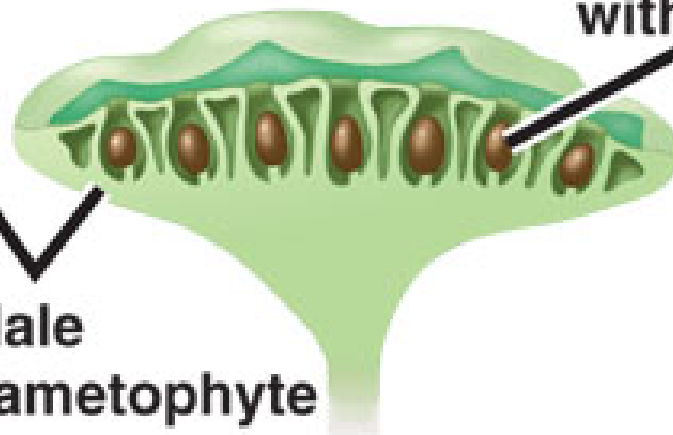


Male gametophyte

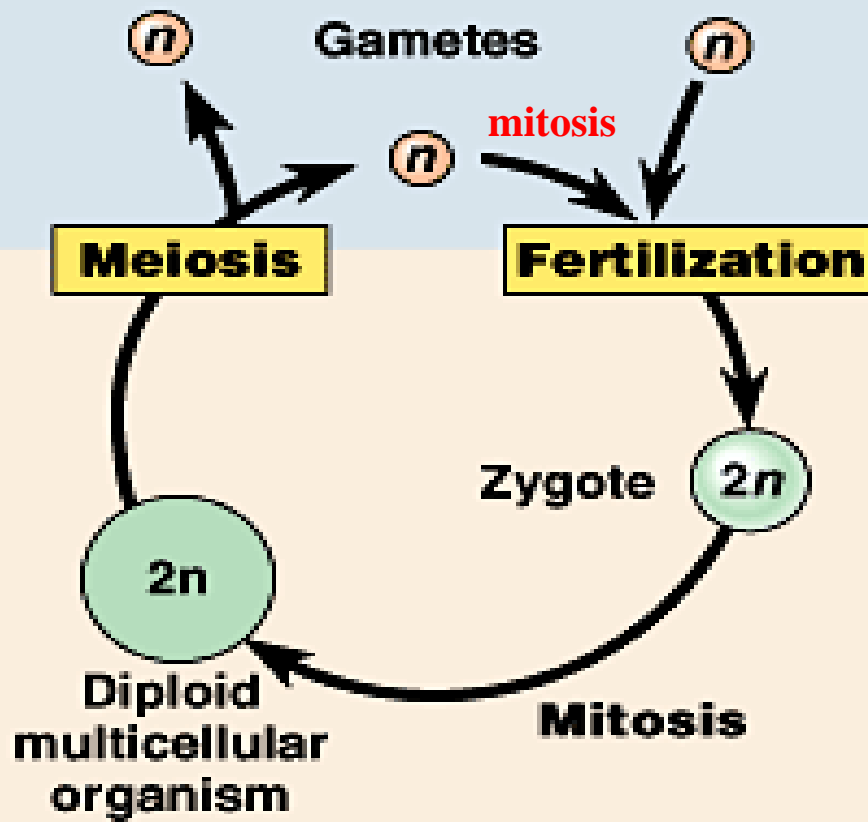


Archegonium with egg

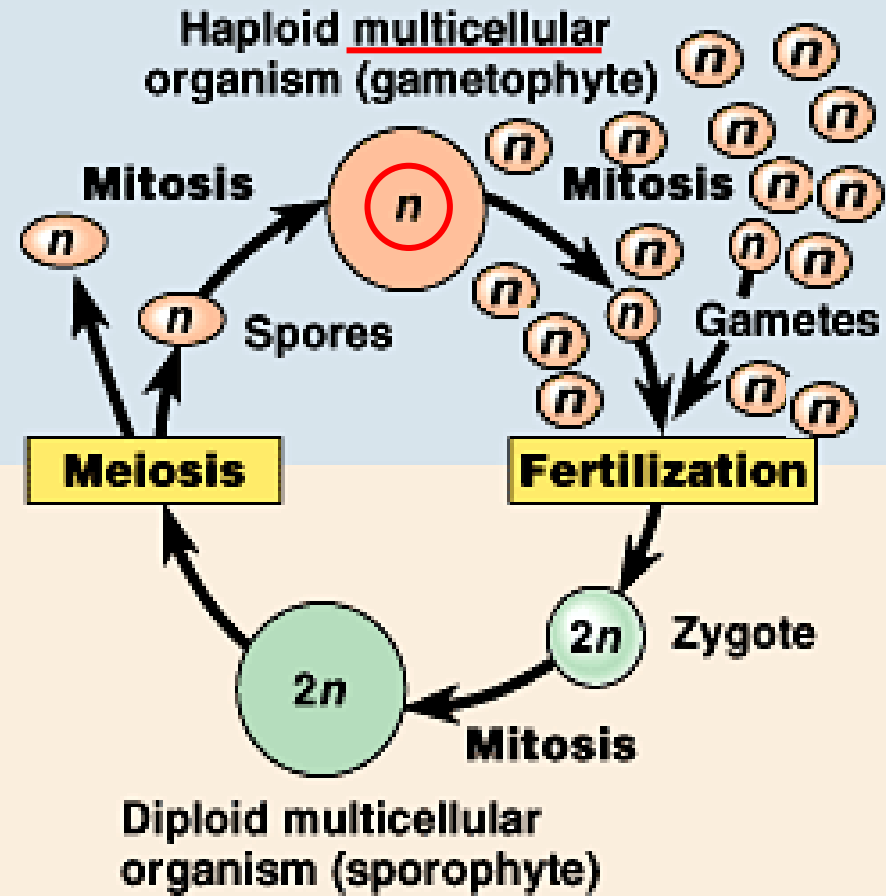
Antheridium with sperm



Archegonia and antheridia of *Marchantia* (a liverwort)



animals



plants & some algae

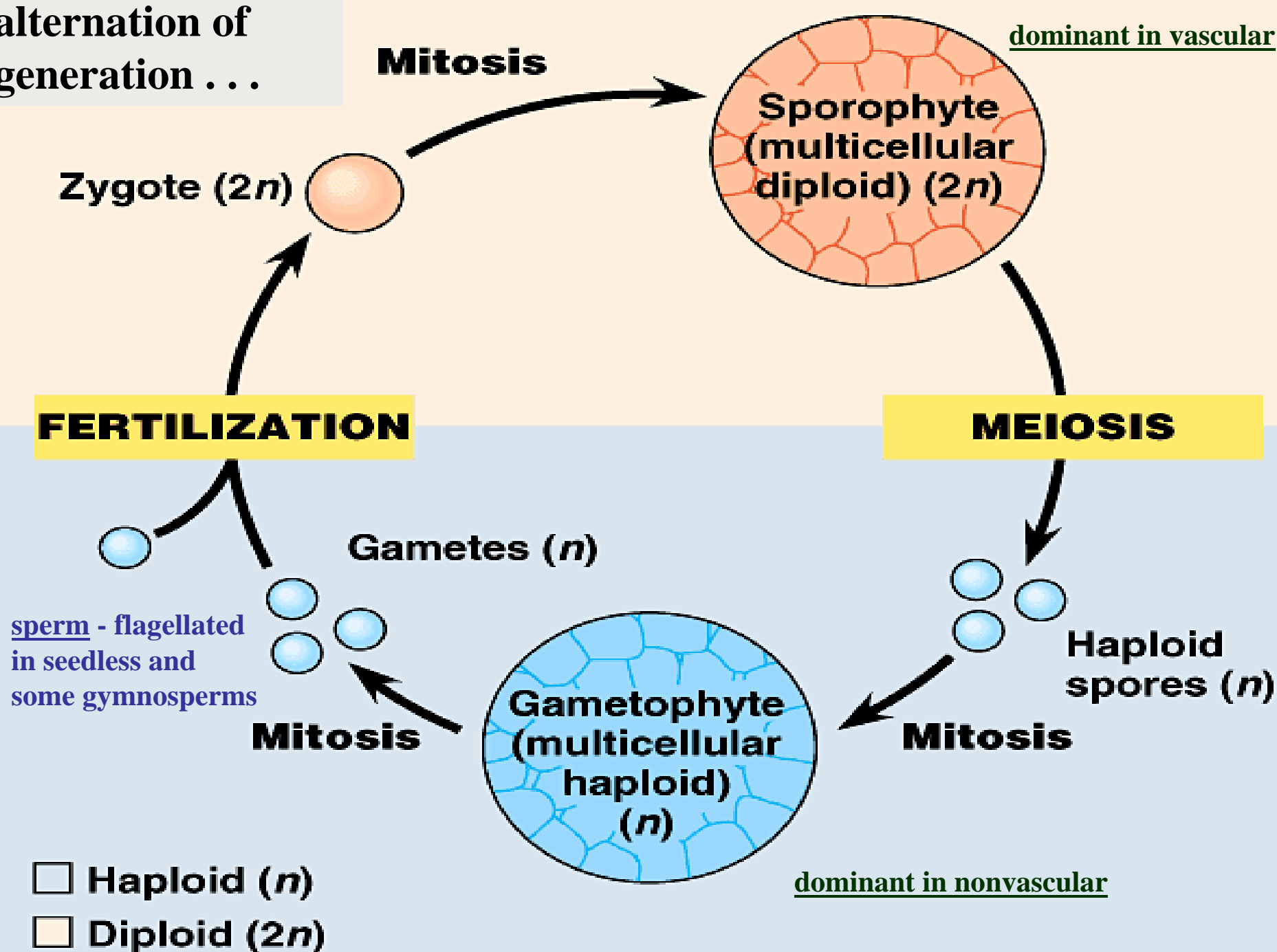
□ Haploid
 □ Diploid

land plant derived characteristics . . .

alternation of generation

the numbers game!

alternation of generation . . .



Charophyceans

Charophyceans

Ancestral green alga

Liverworts

Hornworts

Mosses

Lycophytes
(club mosses, spike mosses, quill worts)

Pterophytes
(ferns, horsetails, whisk ferns)

Gymnosperms

Angiosperms

Bryophytes
(nonvascular plants)

Seedless vascular plants

Seed plants

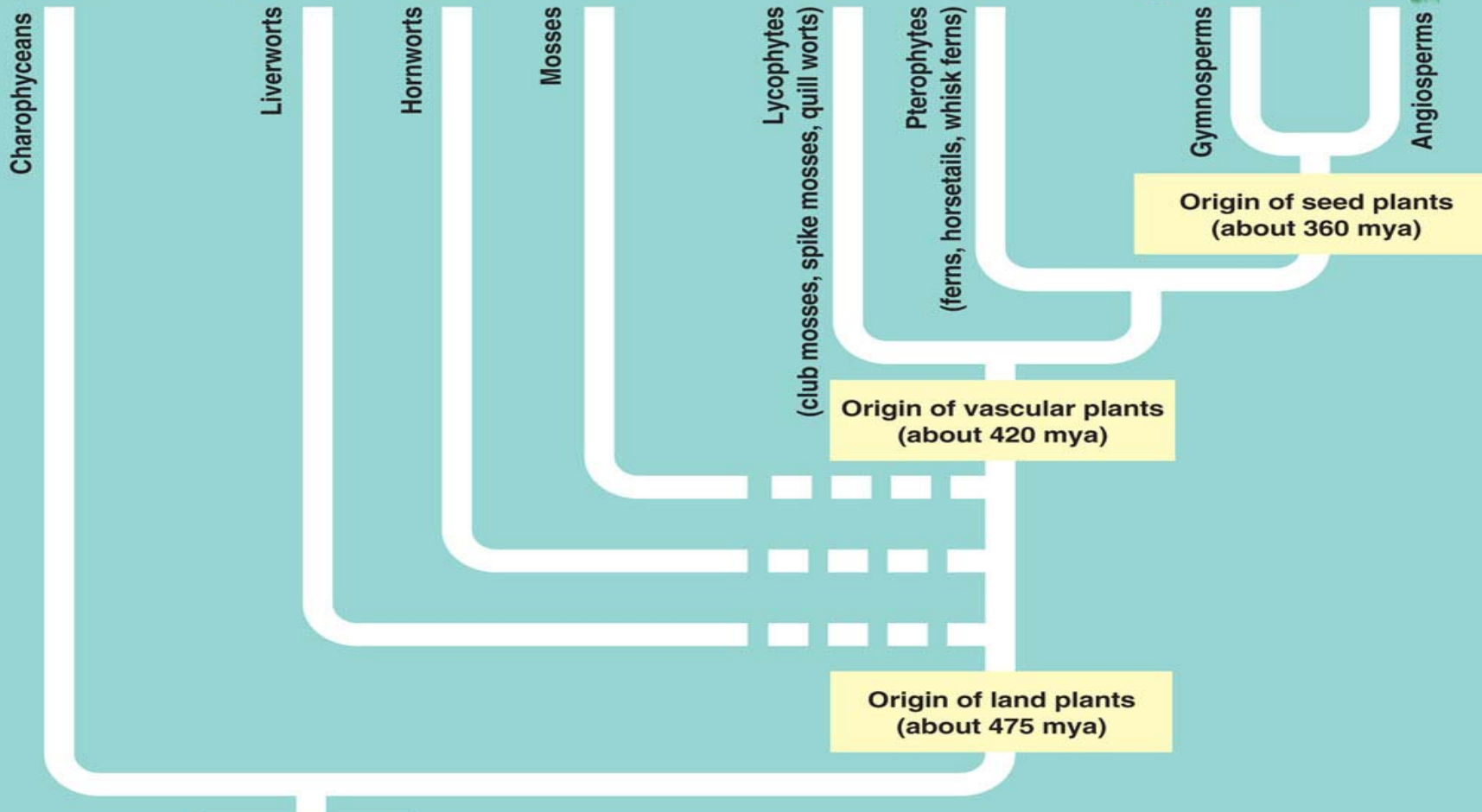
Land plants

Vascular plants

Origin of seed plants
(about 360 mya)

Origin of vascular plants
(about 420 mya)

Origin of land plants
(about 475 mya)



seedless plant systematics . . .

nonvascular

>15,000 spp.

gametophyte dominant

sporophyte dependent

osmosis / diffusion transport

no true roots, stems, or leaves

small

moist environments essential

seedless plant systematics . . .

nonvascular

Hepatophyta (*hepa* = liver)

liverworts (liver-shaped gametophyte)

~6,500 spp.

leafy gametophytes (some thalloid)

reproduction - sexual & asexual

found in moist, tropical habitats

on rocks, shaded trees, fallen logs

thallus . . .

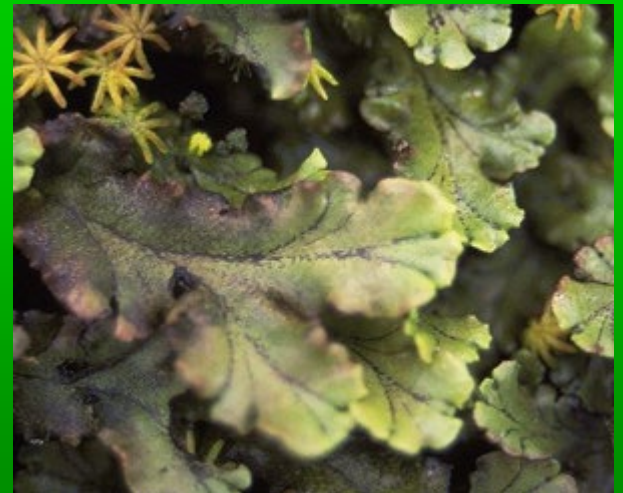
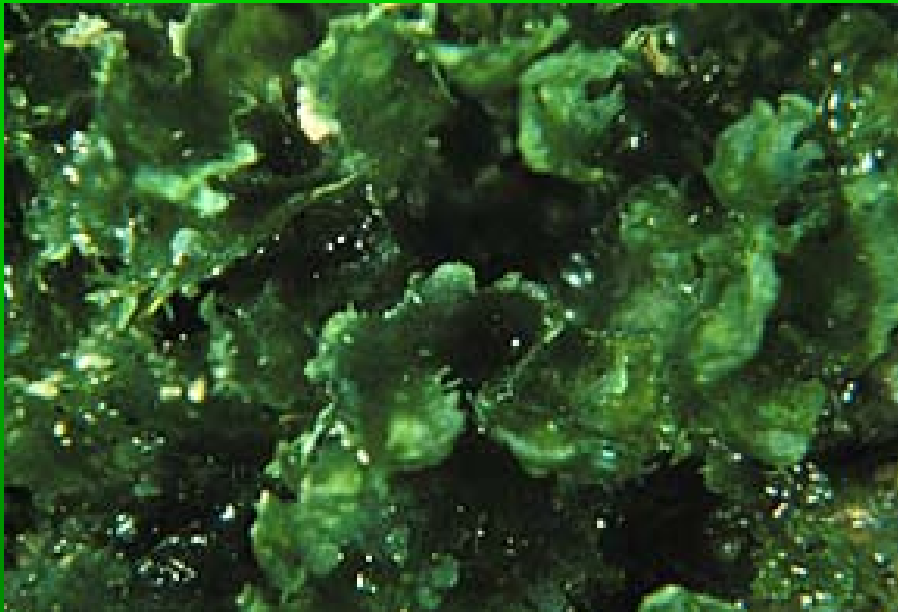
undifferentiated plant body



liverworts . . .

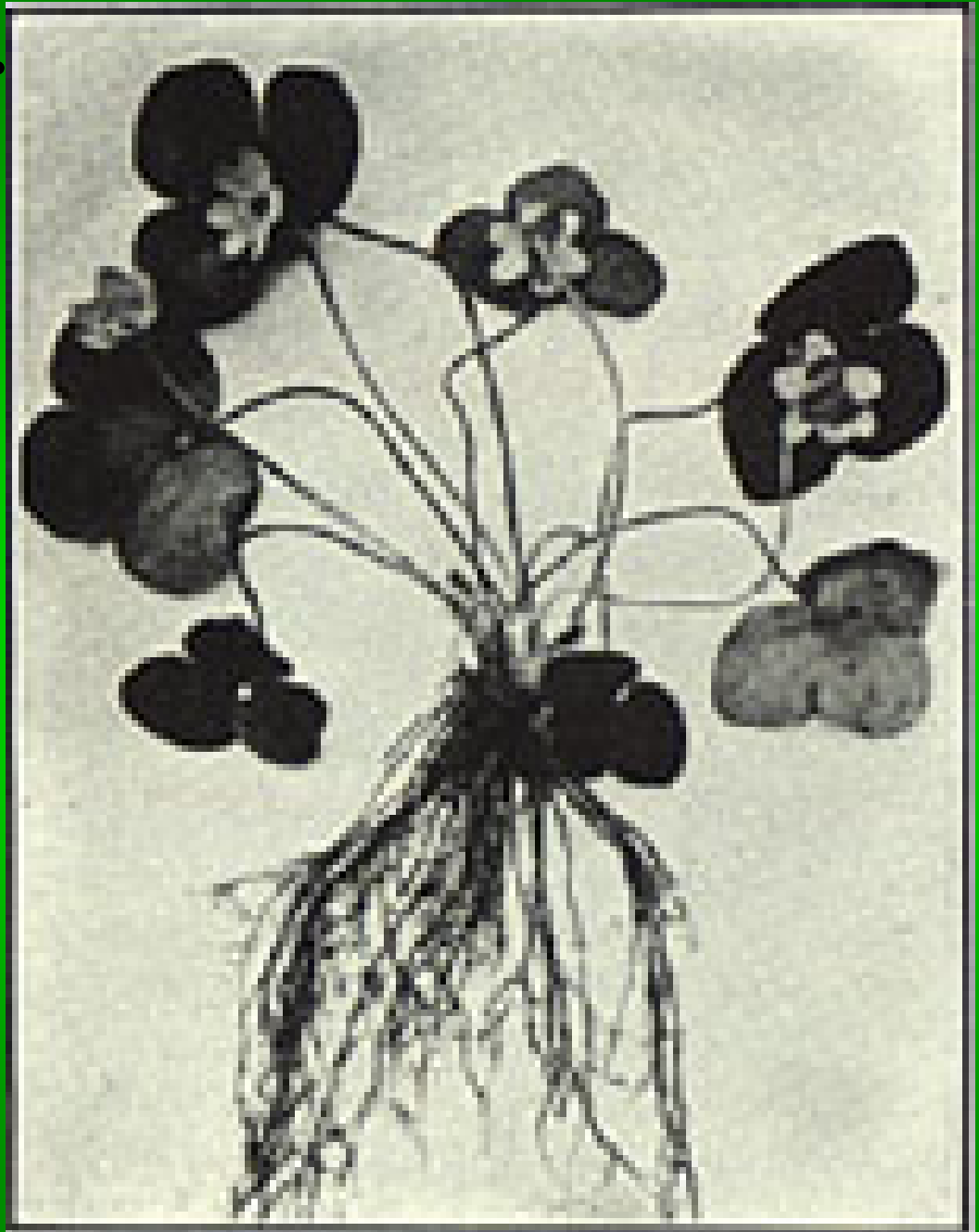


Marchantia



Florida liverworts .

Hepatica americana



Charophyceans

Liverworts

Hornworts

Mosses

Lycophytes
(club mosses, spike mosses, quill worts)

Pterophytes
(ferns, horsetails, whisk ferns)

Gymnosperms

Angiosperms

Ancestral green alga

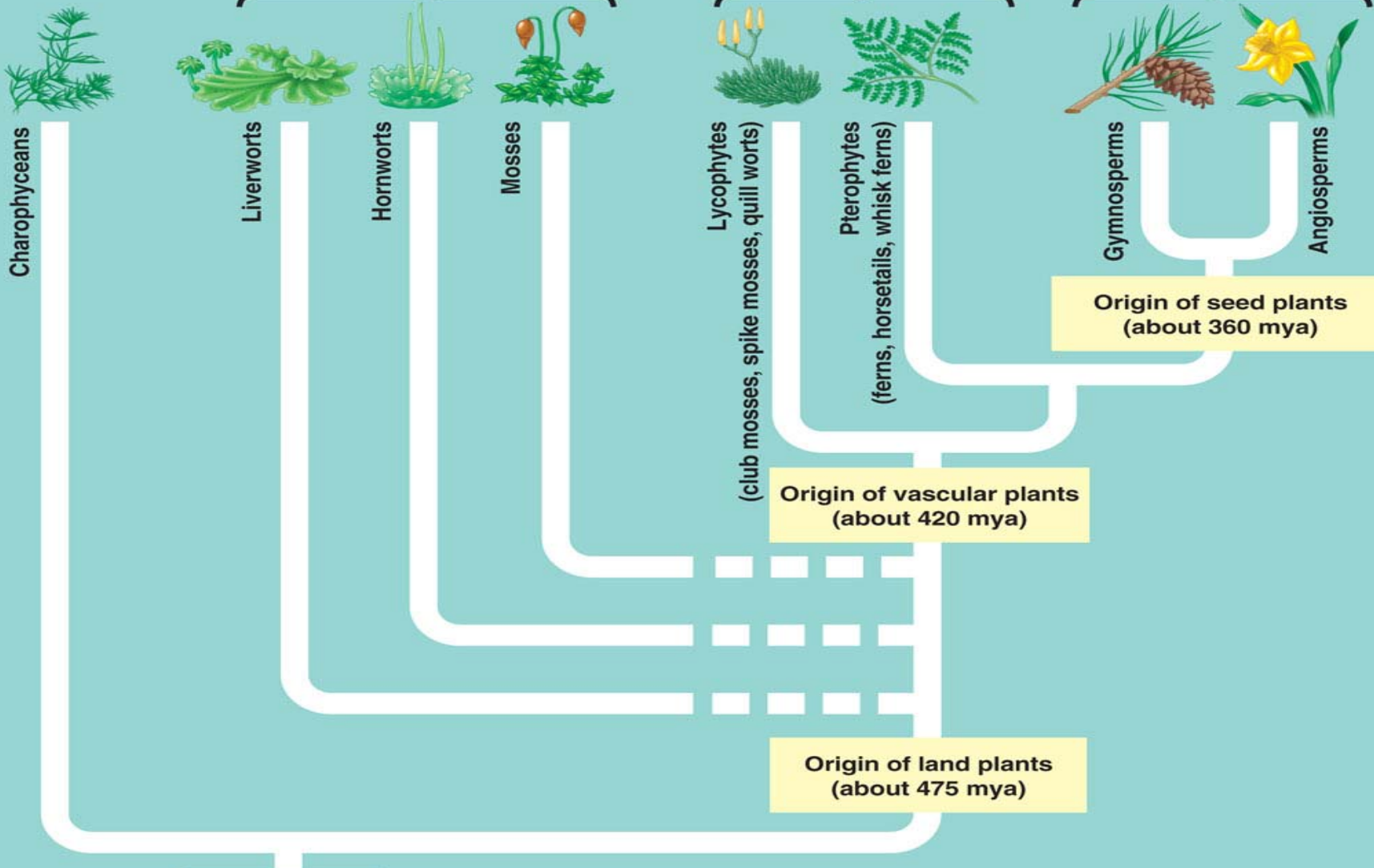
Land plants

Bryophytes
(nonvascular plants)

Seedless vascular plants

Vascular plants

Seed plants



Origin of vascular plants
(about 420 mya)

Origin of land plants
(about 475 mya)

Origin of seed plants
(about 360 mya)

seedless plant systematics . . .

nonvascular

Anthoceroophyta (*anthos* = flower; *keros* = wax)

hornworts

~100 spp.

thalloid gametophyte (filled with cyanobacteria)

green, photosynthetic sporophyte

“pioneer” species

found in temperate and tropical regions

on tree trunks, cliffs, disturbed habitats

hornworts . . .



Florida hornworts . . .



Charophyceans

Charophyceans

Ancestral green alga

Liverworts

Hornworts

Mosses

Lycophytes
(club mosses, spike mosses, quill worts)

Pterophytes
(ferns, horsetails, whisk ferns)

Gymnosperms

Angiosperms

Bryophytes
(nonvascular plants)

Seedless vascular plants

Seed plants

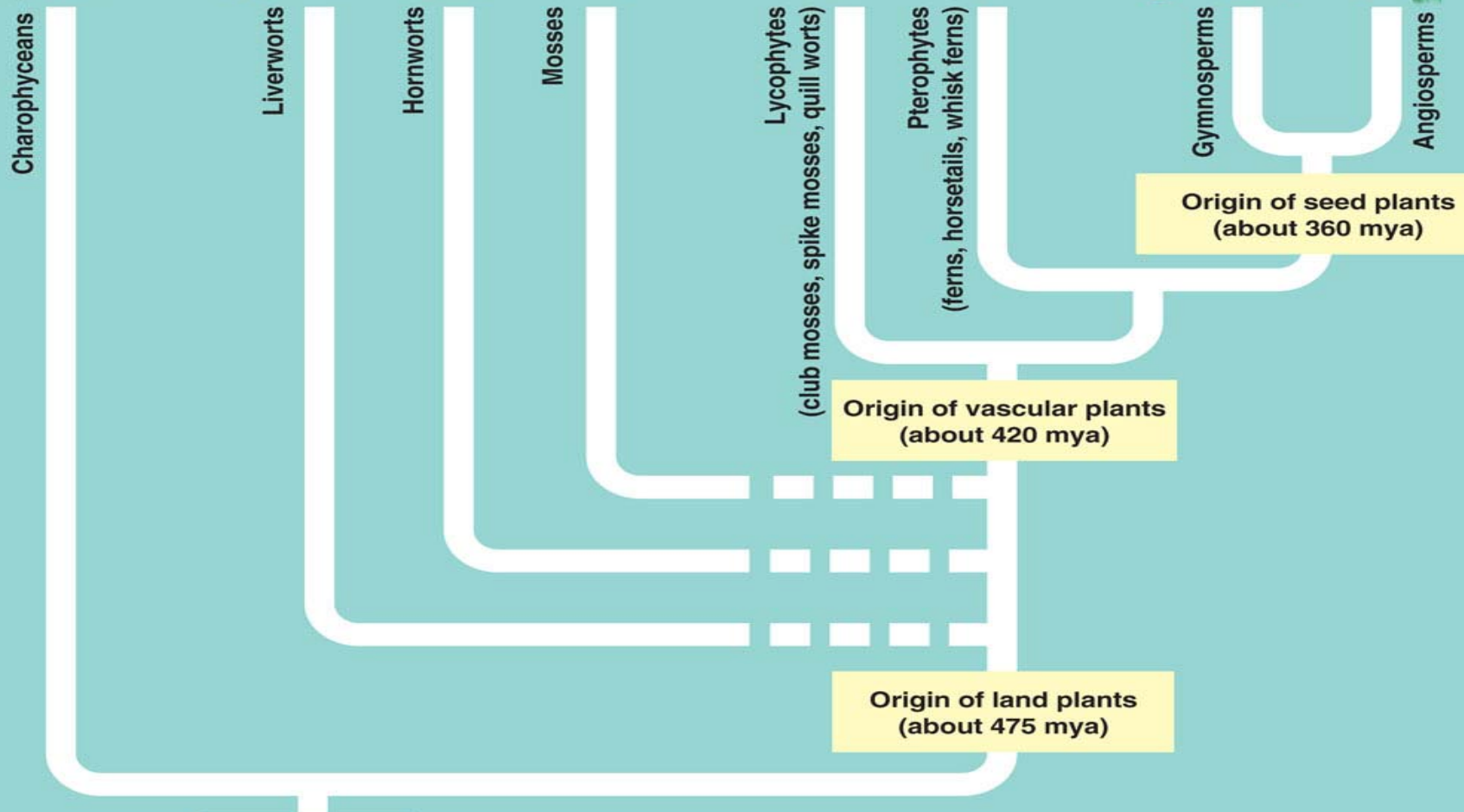
Land plants

Vascular plants

Origin of seed plants
(about 360 mya)

Origin of vascular plants
(about 420 mya)

Origin of land plants
(about 475 mya)



seedless plant systematics . . .
nonvascular

Bryophyta (*bryon* = moss)

mosses

~12,000 spp.

commonly in dense colonies or bed

leafy gametophytes

leafless sporophyte

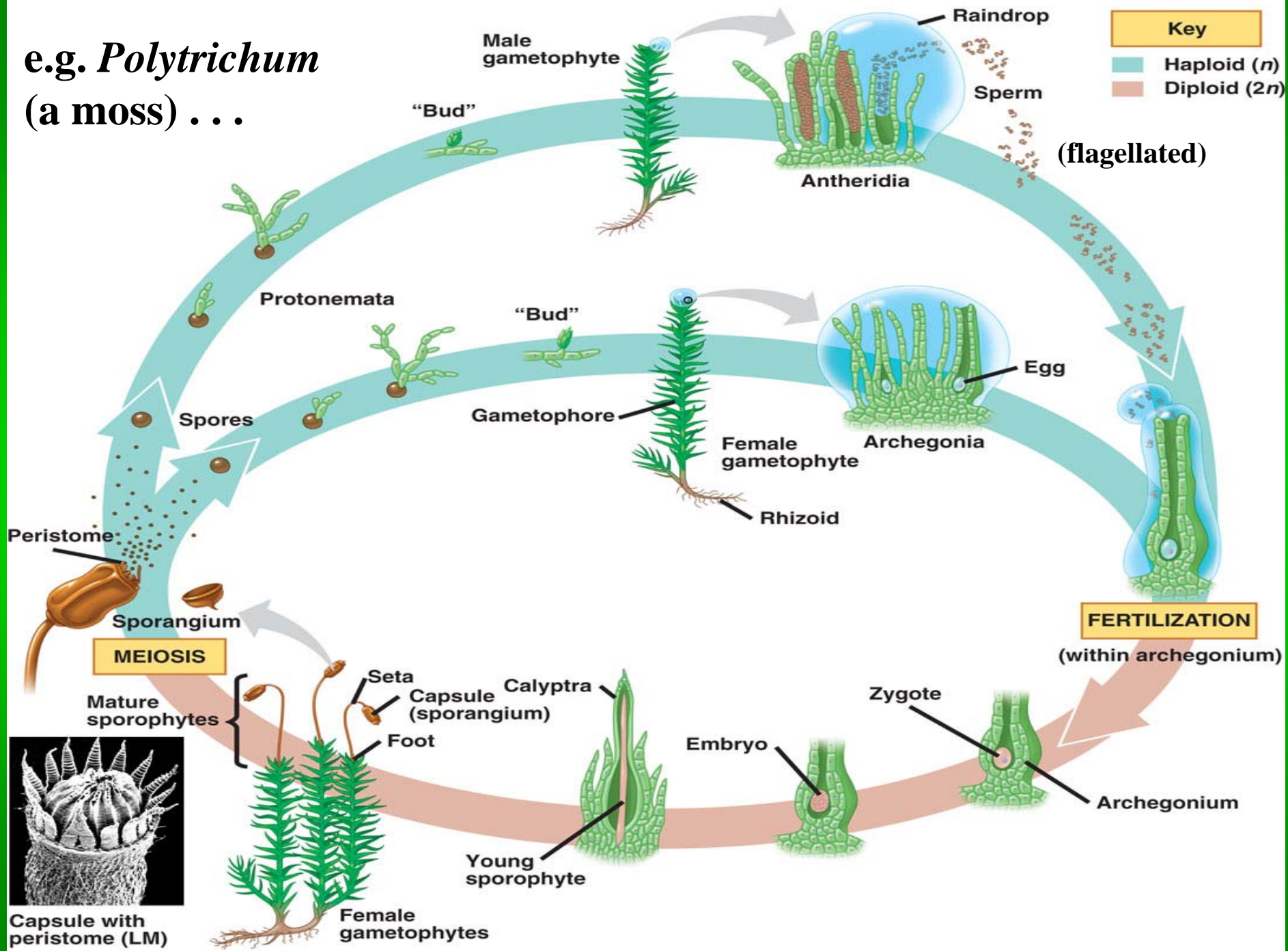
important in soil formation (slow erosion, hold water)

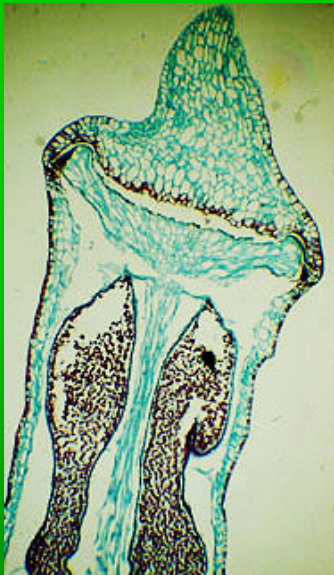
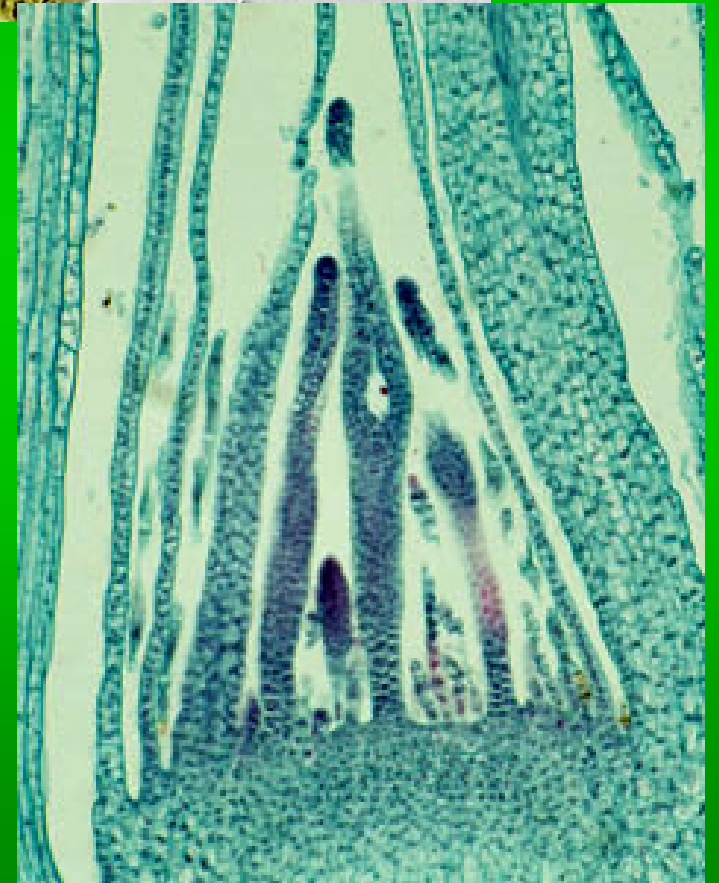
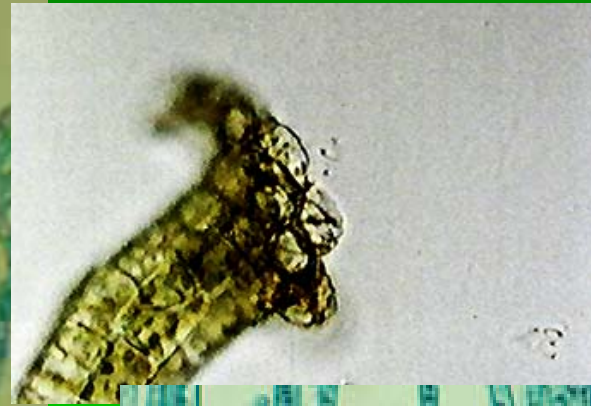
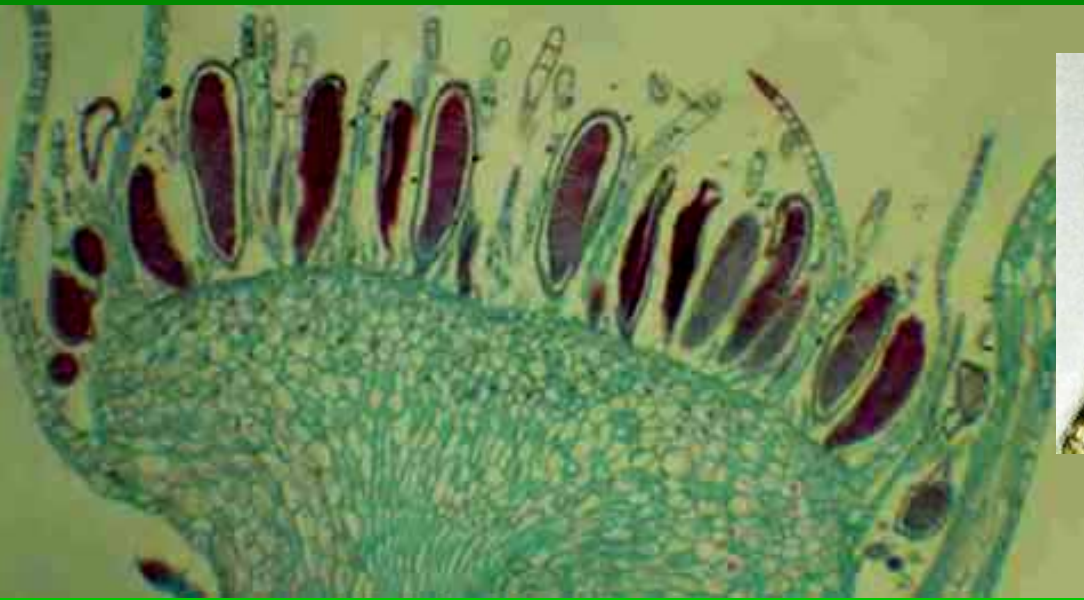
reproduction

sexual; asexual (gemma - budding)

found in moist tropical and temperate habitats

e.g. *Polytrichum*
(a moss) . . .





gemma . . .



gemma cups



bryophytes . . .



bryophytes . . .



Florida bryophytes . . .



Charophyceans

Charophyceans

Ancestral green alga

Liverworts

Hornworts

Mosses

Lycophytes
(club mosses, spike mosses, quill worts)

Pterophytes
(ferns, horsetails, whisk ferns)

Gymnosperms

Angiosperms

Bryophytes
(nonvascular plants)

Seedless vascular plants

Seed plants

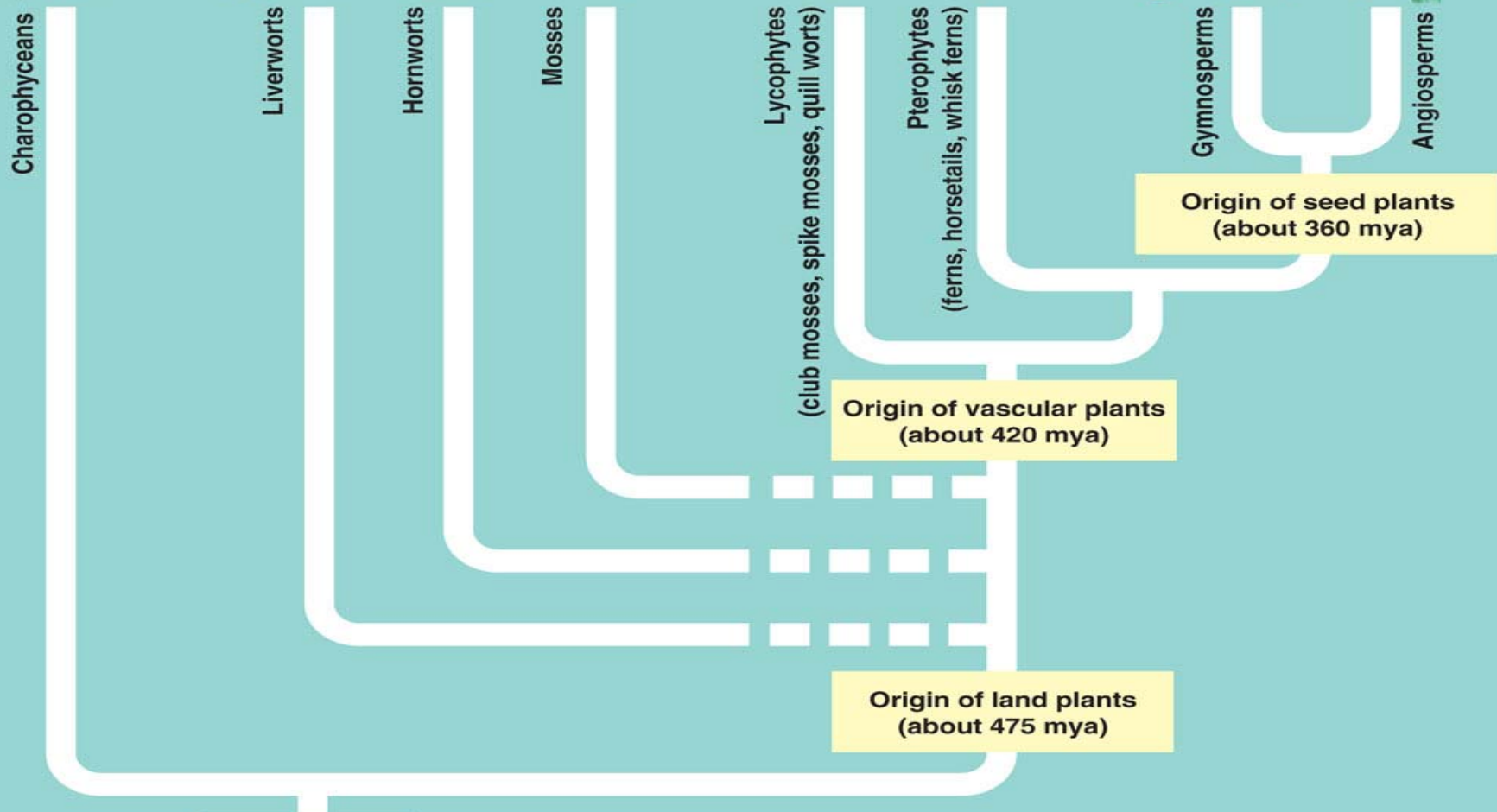
Land plants

Vascular plants

Origin of seed plants
(about 360 mya)

Origin of vascular plants
(about 420 mya)

Origin of land plants
(about 475 mya)



seedless plant systematics . . .

vascular

>11,000 spp.

sporophyte dominant and independent

xylem and phloem

temperate woodlands and tropical rain forests

evolved >400 mya

Cooksonia (extinct; earliest known vascular plant)

form coal deposits



sporangia



Cooksonia

Charophyceans

Liverworts

Hornworts

Mosses

Lycophytes
(club mosses, spike mosses, quill worts)

Pterophytes
(ferns, horsetails, whisk ferns)

Gymnosperms

Angiosperms

Ancestral green alga

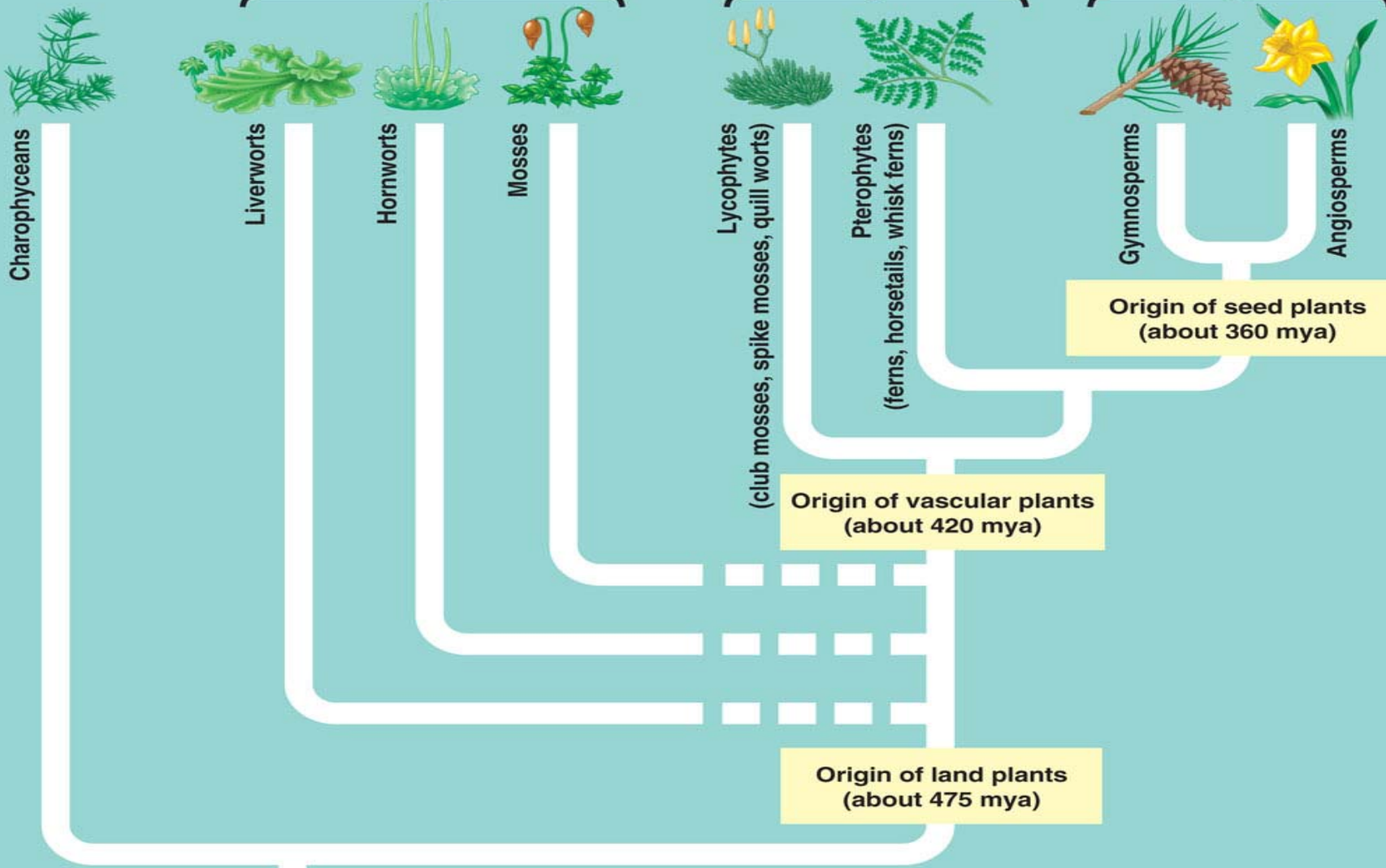
Land plants

Bryophytes
(nonvascular plants)

Seedless vascular plants

Vascular plants

Seed plants



Origin of vascular plants
(about 420 mya)

Origin of land plants
(about 475 mya)

Origin of seed plants
(about 360 mya)

seedless plant systematics . . .

vascular

Lycophyta (*lycos* = wolf)

club “mosses”, spike “mosses”, quillworts

~1000 spp.

relict species (Carboniferous - ~350 mya)

existed as small plants or giant woody trees

extant spp. are much smaller

extinction when Earth cooled

herbaceous

microphylls

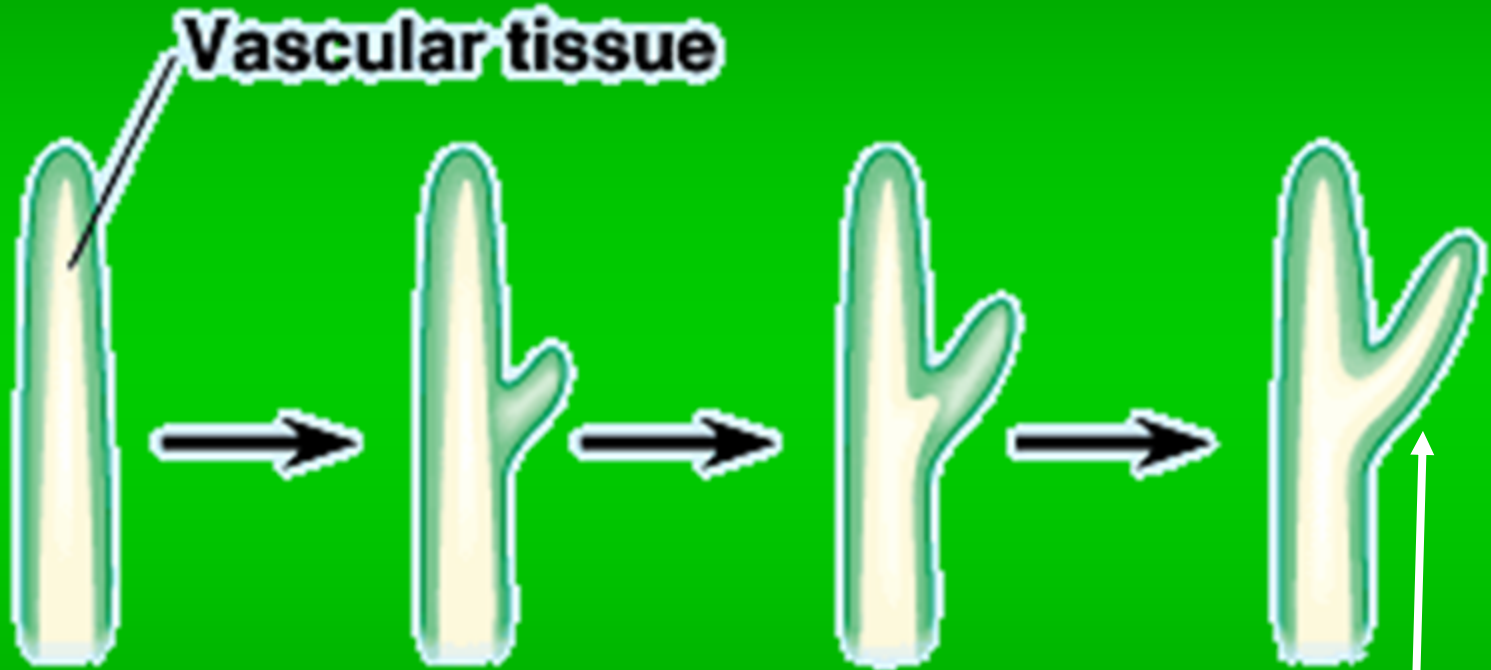
spores formed in strobili

some heterosporous

found in temperate and tropical habitats

some tropical spp. grow as epiphytes

leaf evolution



microphylls – single vein

spike moss . . .



club moss . . .

quillworts . . .



a Florida club moss. . .



Lycopodium



epiphytes . . .



Hanging club moss (*Lycopodium varium*) – New Zealand



**Spanish moss (*Tillandsia usneoides*)
NOT A MOSS – bromeliad (flowering plant)**

seedless plant systematics . . .

vascular

Pterophyta

ferns, whisk ferns, horsetails

~12,000 spp.

first appear in Devonian (~400 mya) extensive radiation
from tropics to Arctic Circle

mostly terrestrial, few aquatic habitats

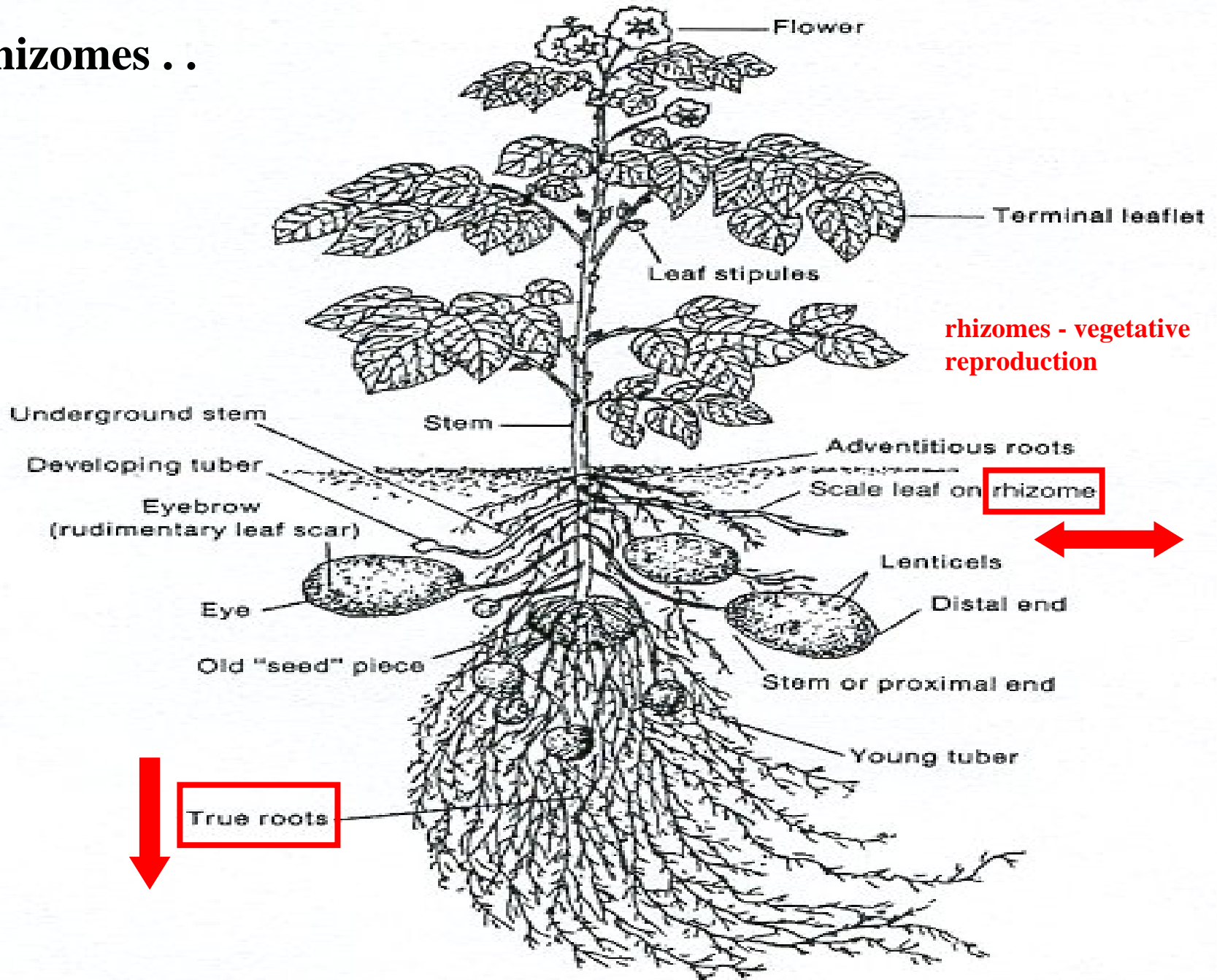
swamps, marshes, moist woodlands,
stream banks, rocky crevices of cliffs
or mountains, and deserts

possess true roots & rhizomes

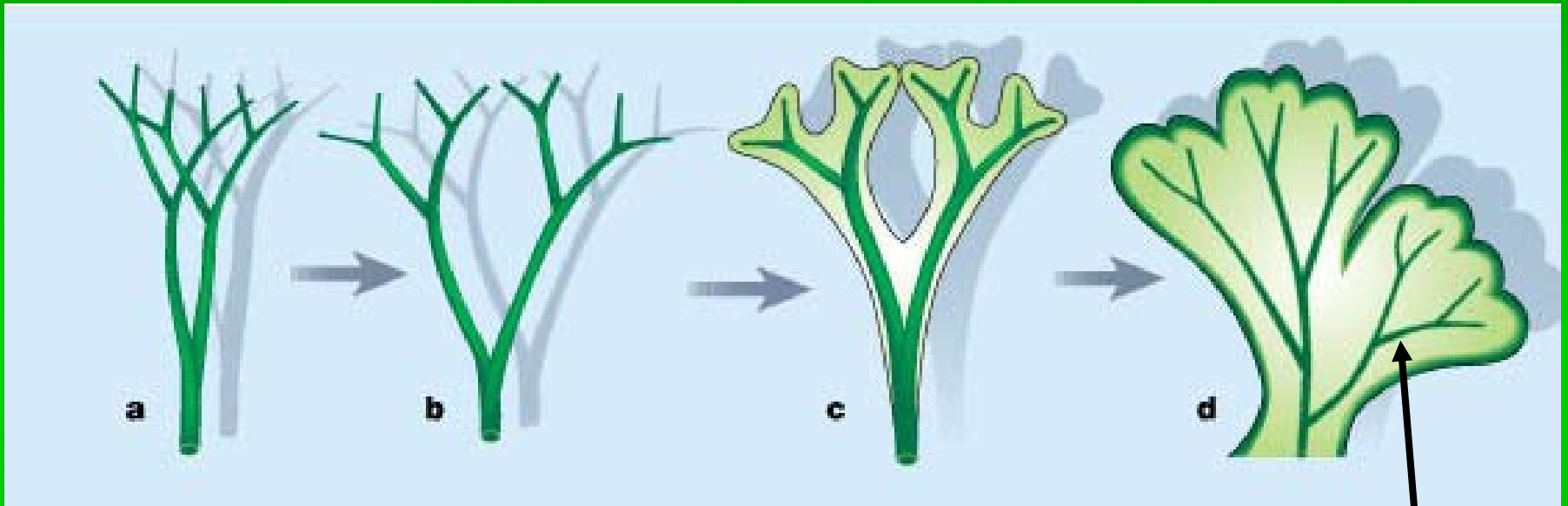
megaphyll

spore production in sori under fronds (leaves)

rhizomes . .



leaf (megaphyll) evolution . . .



megaphylls – highly branched vascularization



ferns . . .



Florida ferns . . .

*Osmunda
regalis*

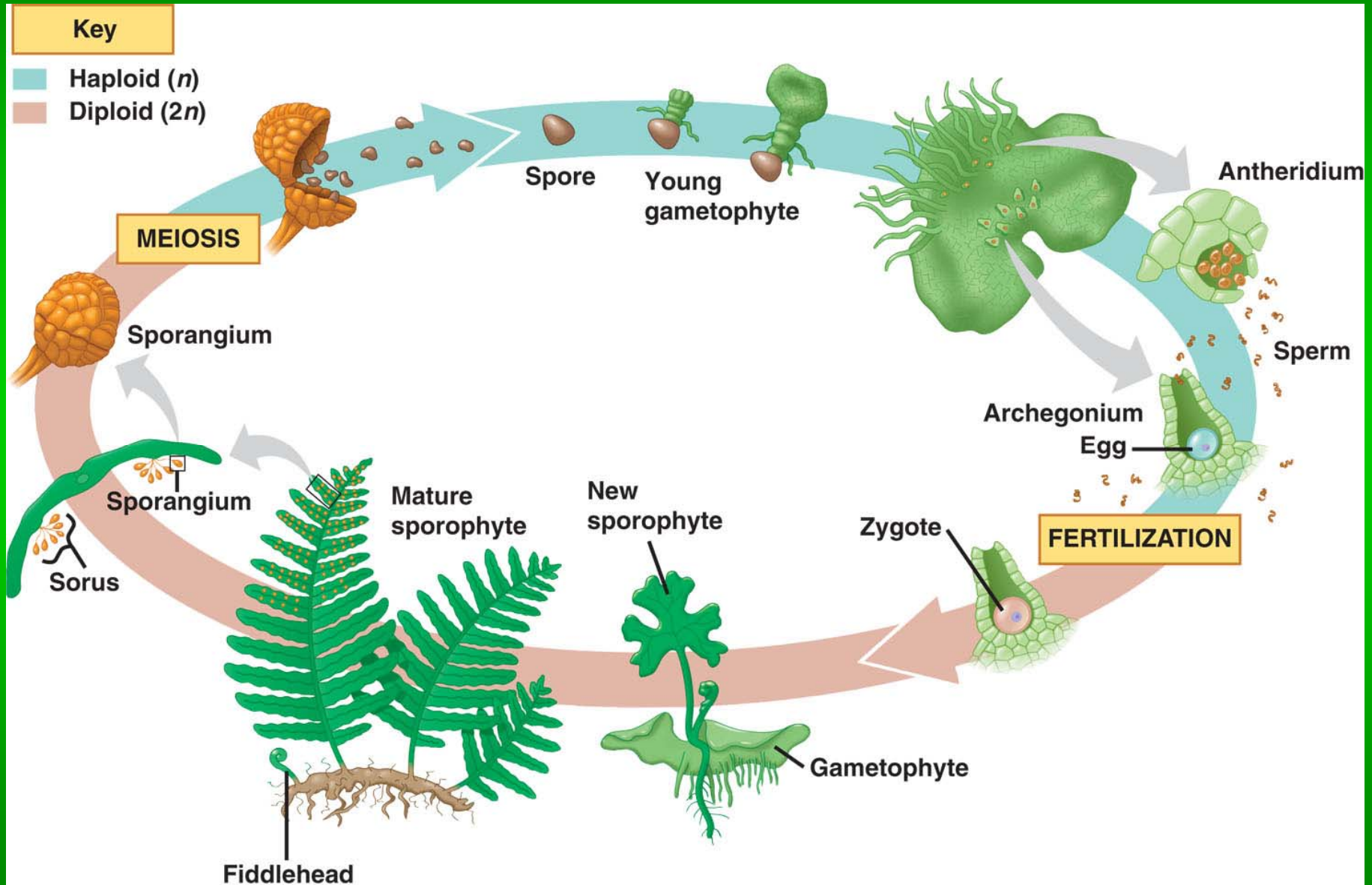


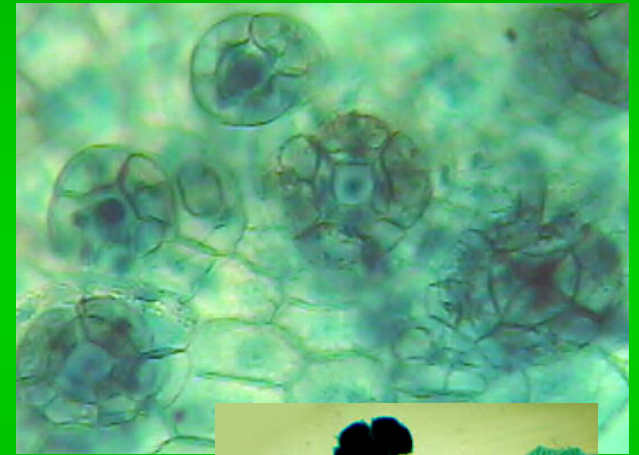
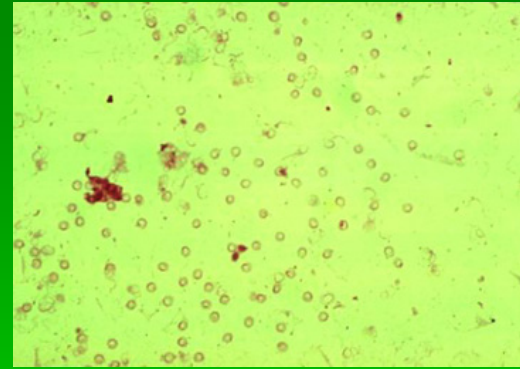
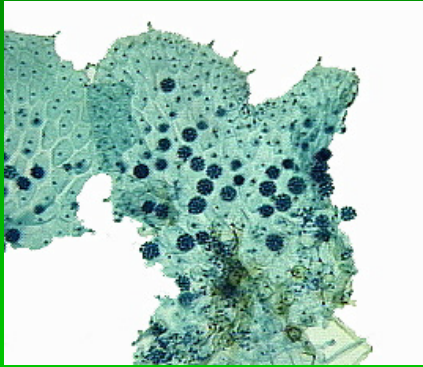
*Osmunda
cinnamomea*



*Acrostichum
danaeifolium*

fern reproduction...





whisk ferns . . .



Florida whisk ferns . . .



Psilotum nudum

horsetails ...



Florida horsetails . . .



Equisetum hyemale
Scouring-rush horsetail

Photo by Vic Ramey
Copyright 1999 University of Florida

Charophyceans

Charophyceans

Ancestral green alga

Liverworts

Hornworts

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Lycophytes

(club mosses, spike mosses, quill worts)

Pterophytes

(ferns, horsetails, whisk ferns)

Gymnosperms

Angiosperms

Bryophytes
(nonvascular plants)

Seedless vascular plants

Seed plants

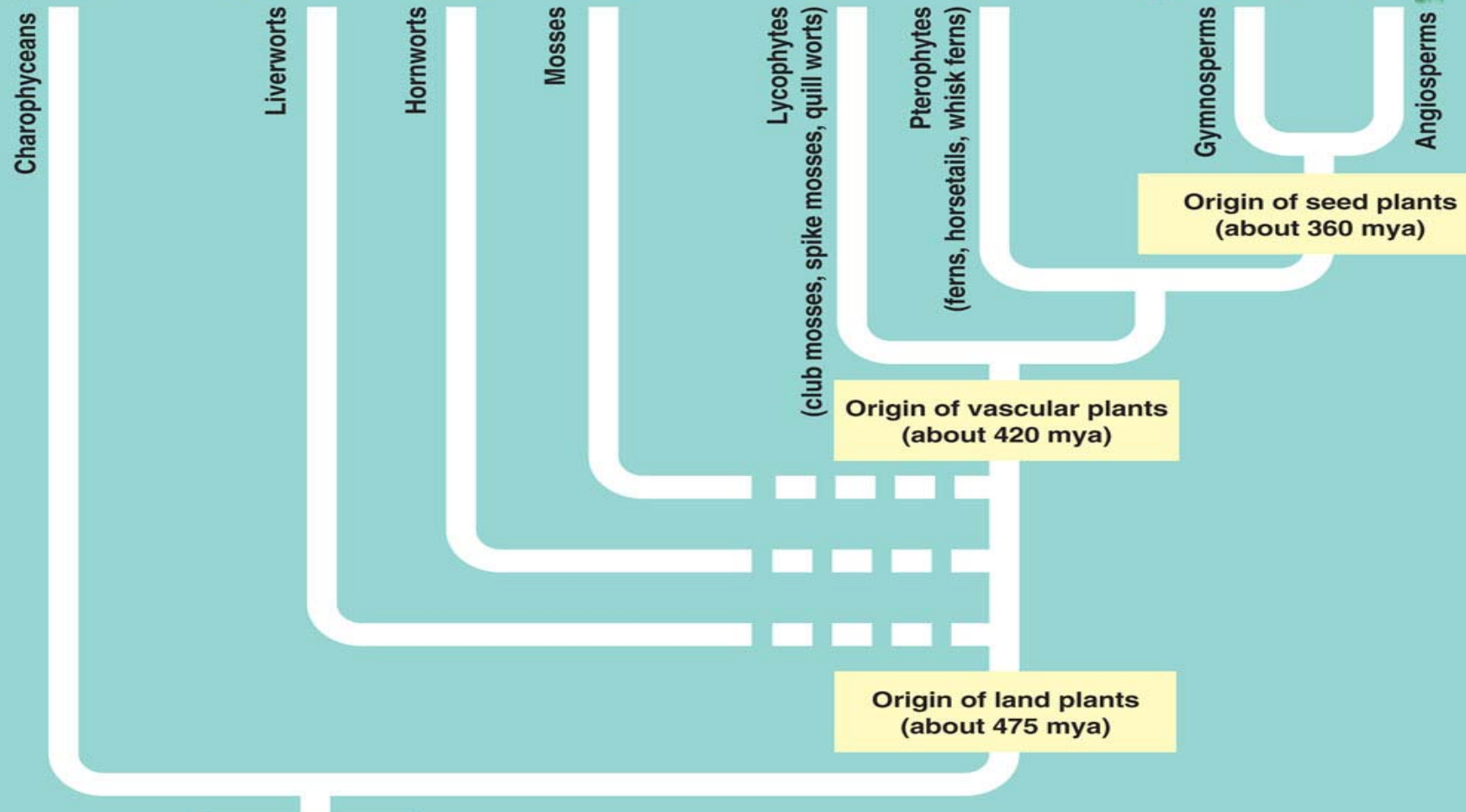
Land plants

Vascular plants

Origin of seed plants
(about 360 mya)

Origin of vascular plants
(about 420 mya)

Origin of land plants
(about 475 mya)





**Charo-
phyceans**

Land!

Dry?



Spores!



Bryophytes

More land!

Moist habitats

Gametophyte dominant

Drier habitats?



Concentrate on spore production

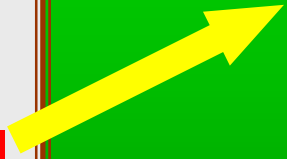
Vascularization



Pteridophytes

Sporophyte dominant

RADIATION!!!



**Gymno-
sperms**



**Angio-
sperms**