Chapter 29

Plant Diversity I: How Plants Colonized Land

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Overview: The Greening of Earth

- Since colonizing land at least 475 million years ago, plants have diversified into roughly 290,000 living species.
- Plants supply oxygen and are the ultimate source of most food eaten by land animals.
- *Green algae called charophytes are the closest relatives of land plants*.
- Note that land plants are not descended from modern charophytes, but *share a common ancestor* with modern charophytes.

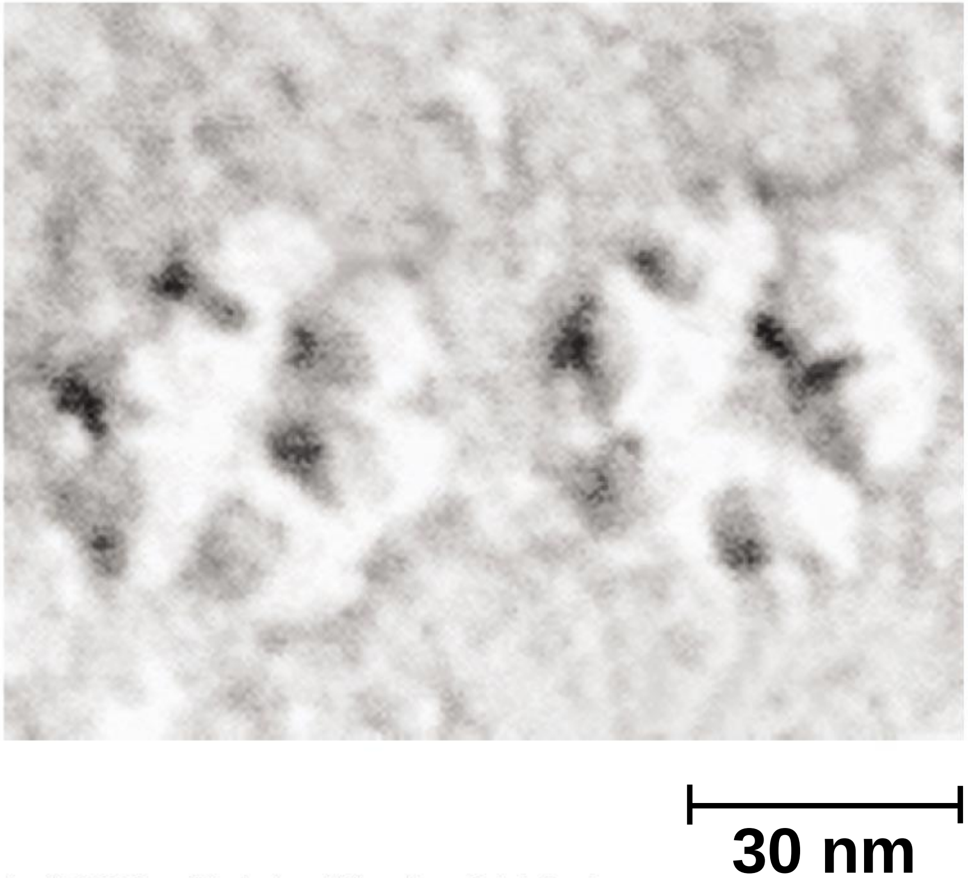
Morphological and Molecular Evidence

Land plants share key traits only with green algae *charophytes*:

- DNA comparisons of both nuclear and chloroplast genes.
- Rose-shaped complexes for cellulose synthesis.
- Peroxisome enzymes - minimize loss from photorespiration.
- Structure of flagellated sperm.
- Formation of a ***phragmoplast*** - *allignment of cytoskeletal elements and Golgi vesicles for cell plate*.

Rosette cellulose-synthesizing complexes

Found only in land plants and charophycean green algae



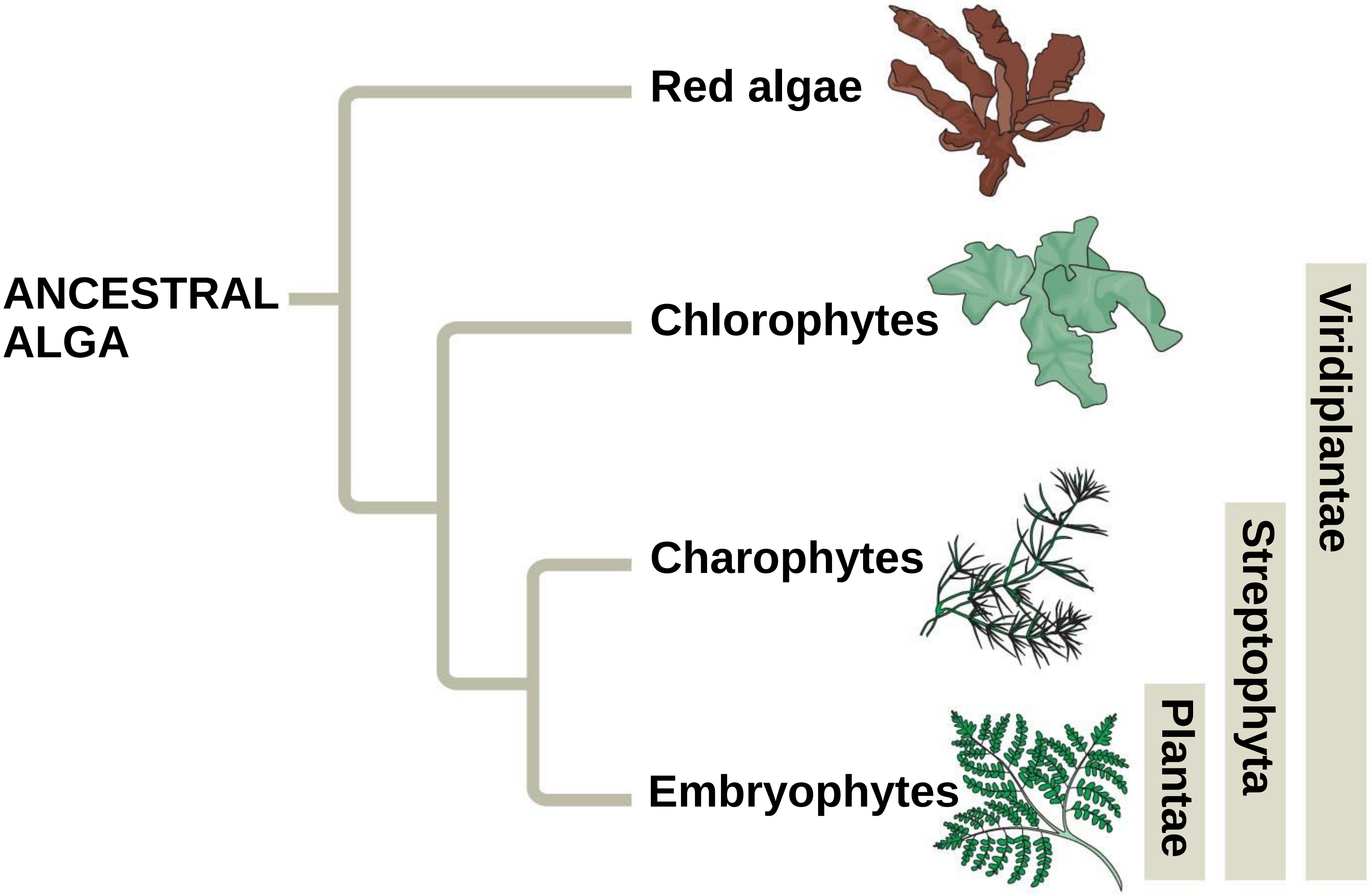
Adaptations Enabling the Move to Land

- In green algae charophytes a layer of a durable polymer called ***sporopollenin*** prevents *dehydration* of exposed zygotes.

- The *movement onto land* by charophyte ancestors provided *advantages*: unfiltered sun, more plentiful CO_2, nutrient-rich soil, and few herbivores or pathogens.

- Land presented *challenges*: a scarcity of water and lack of structural support.

Three Clades are candidates for Plant Kingdom



Derived Traits of Plants

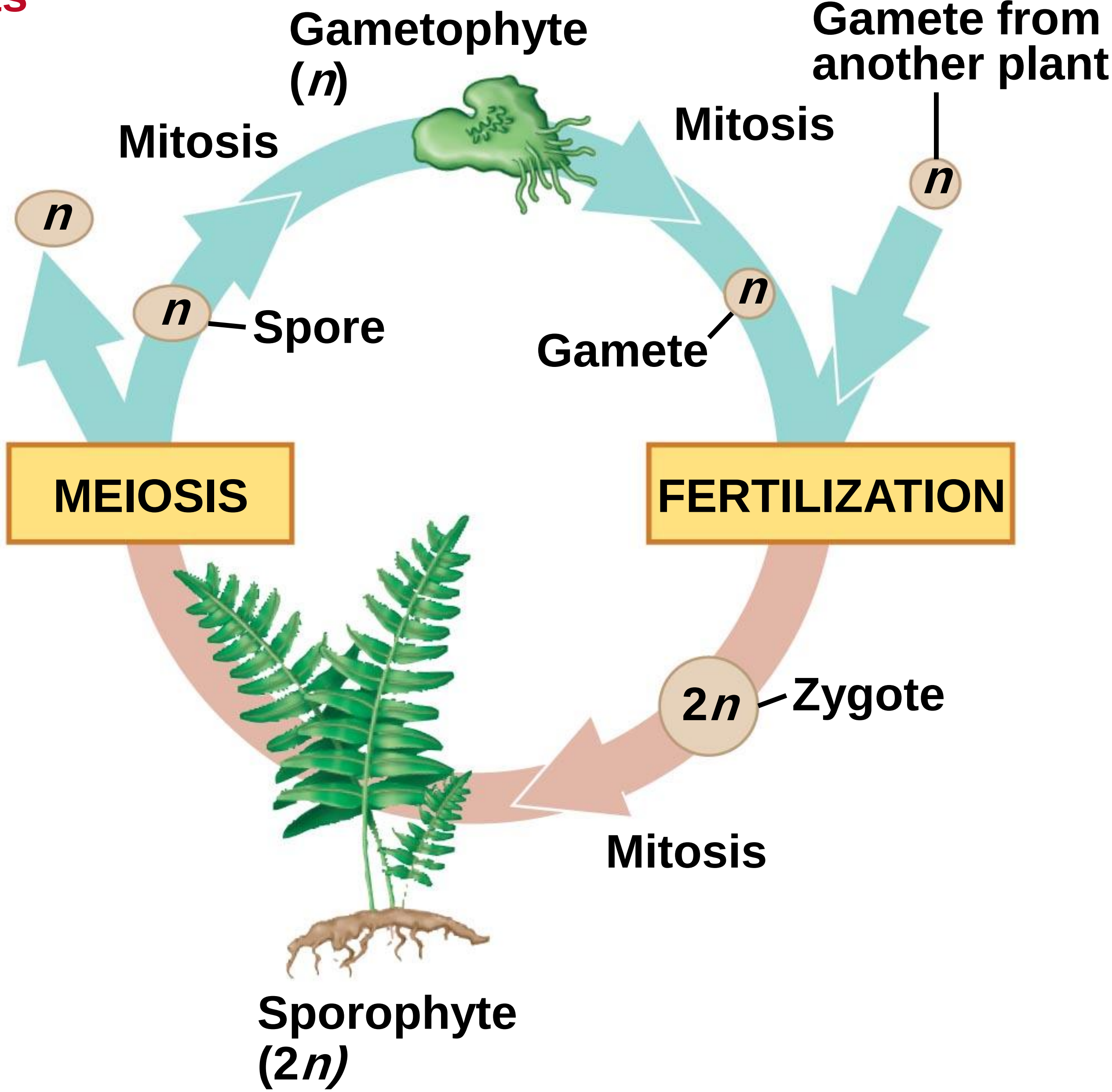
- A ***cuticle*** and *secondary compounds* evolved in many plant species. Symbiotic associations between fungi and the first land plants may have helped plants without true roots to obtain nutrients.

- Four *key derived traits of plants are absent in* the green algae *charophytes*:
  - *Alternation of generations* - with multicellular, dependent embryos.
  - *Walled spores* produced in sporangia
  - *Multicellular gametangia*
  - *Apical meristems*

Alternation of Generations and *Multicellular Dependent Embryos*

- The multicellular ***gametophyte*** is haploid and *produces haploid gametes by mitosis*.
- Fusion of the gametes gives rise to the diploid ***sporophyte***, which *produces haploid spores by meiosis*.
- The diploid embryo is retained within the tissue of the female gametophyte. *Nutrients are transferred from parent to embryo through placental transfer cells.*
- *Land plants* are called ***embryophytes*** because of the *dependency of the embryo on the parent.*

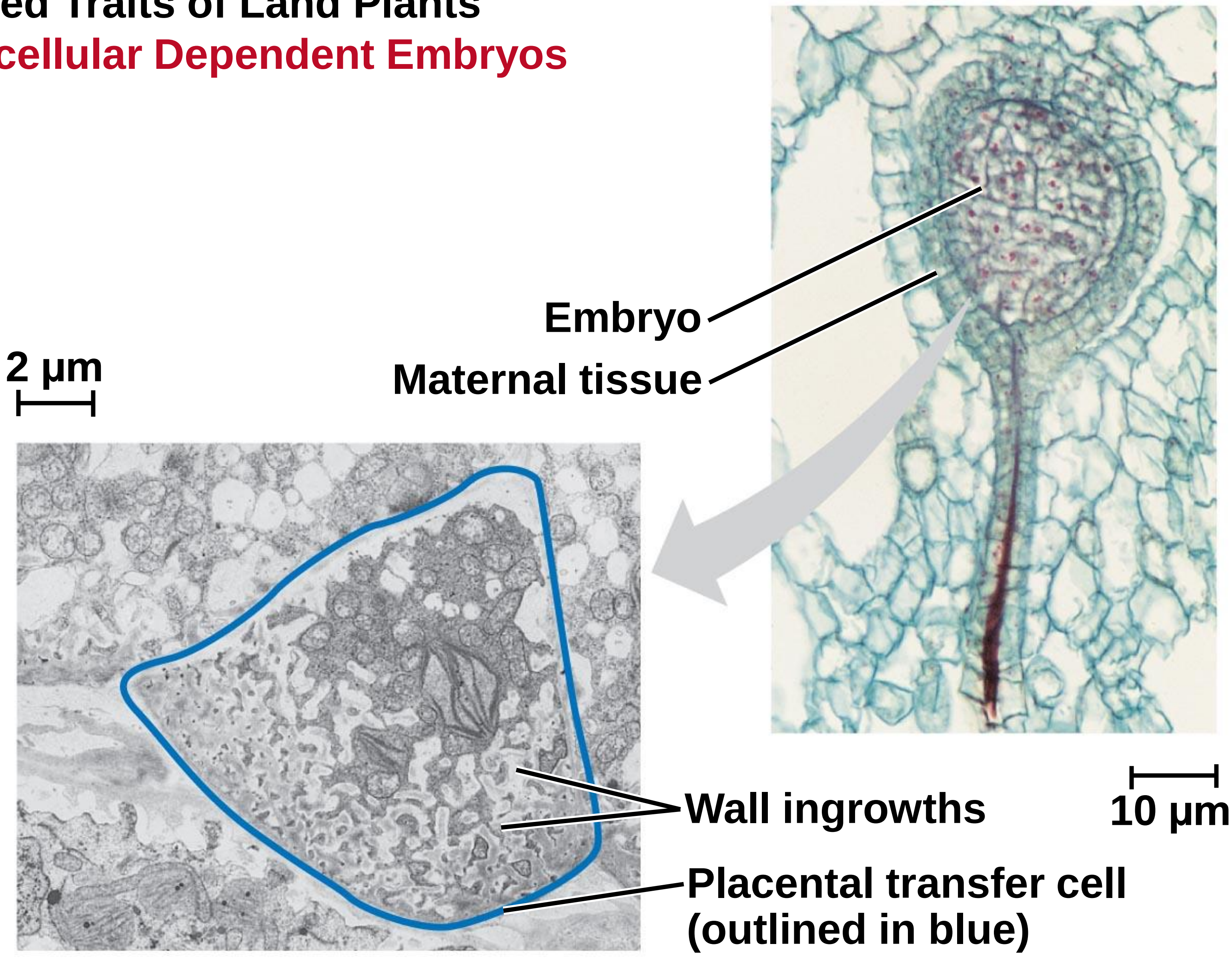
Land Plants
Life Cycle



Alternation of generations = Derived traits of land plants

Derived Traits of Land Plants

Multicellular Dependent Embryos



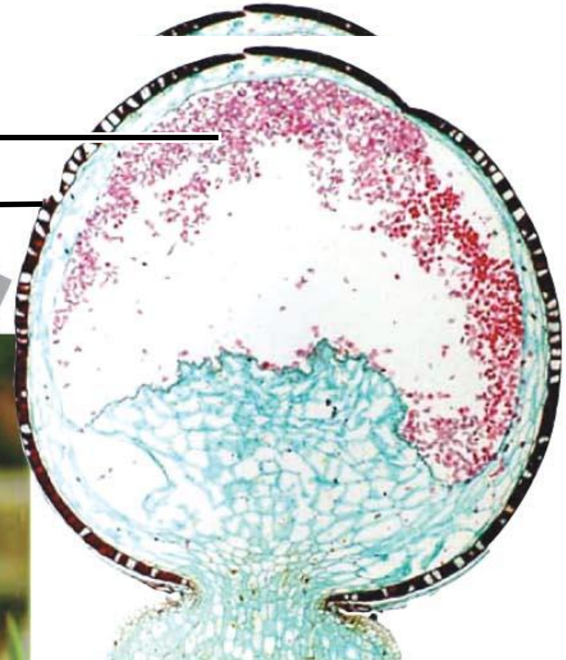
Embryo (LM) and placental transfer cell (TEM) of *Marchantia* (a liverwort)

Walled Spores Produced in Sporangia

- The *sporophyte produces spores* in organs called **sporangia.**
- Diploid cells called **sporocytes** undergo meiosis to generate haploid spores.
- *Spore walls contain sporopollenin*, which *protects against dessication* making them resistant to harsh environments.

Derived Traits of Land Plants:

Walled Spores Produced in Sporangia:

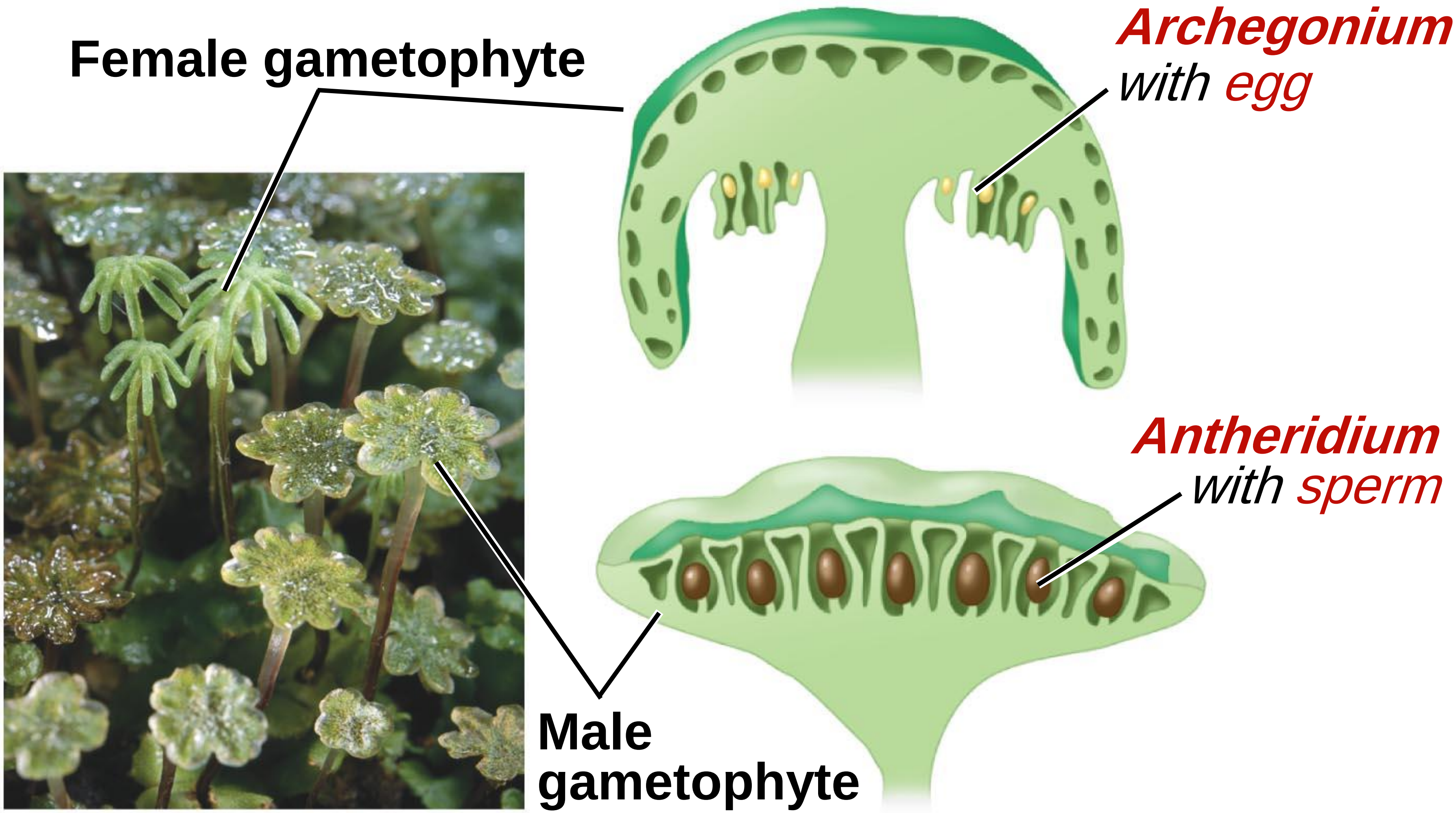



Sporophytes and sporangia of *Sphagnum* (a moss)

Multicellular Gametangia

- Gametes are produced within *'sex organs'* called ***gametangia***.
- *Female* gametangia, called **archegonia**, produce *eggs* and are the site of *fertilization*.
- *Male* gametangia, called ***antheridia***, are the site of *sperm* production and release.

Derived Traits of Land Plants: Multicellular Gametangia - 'sex organs'

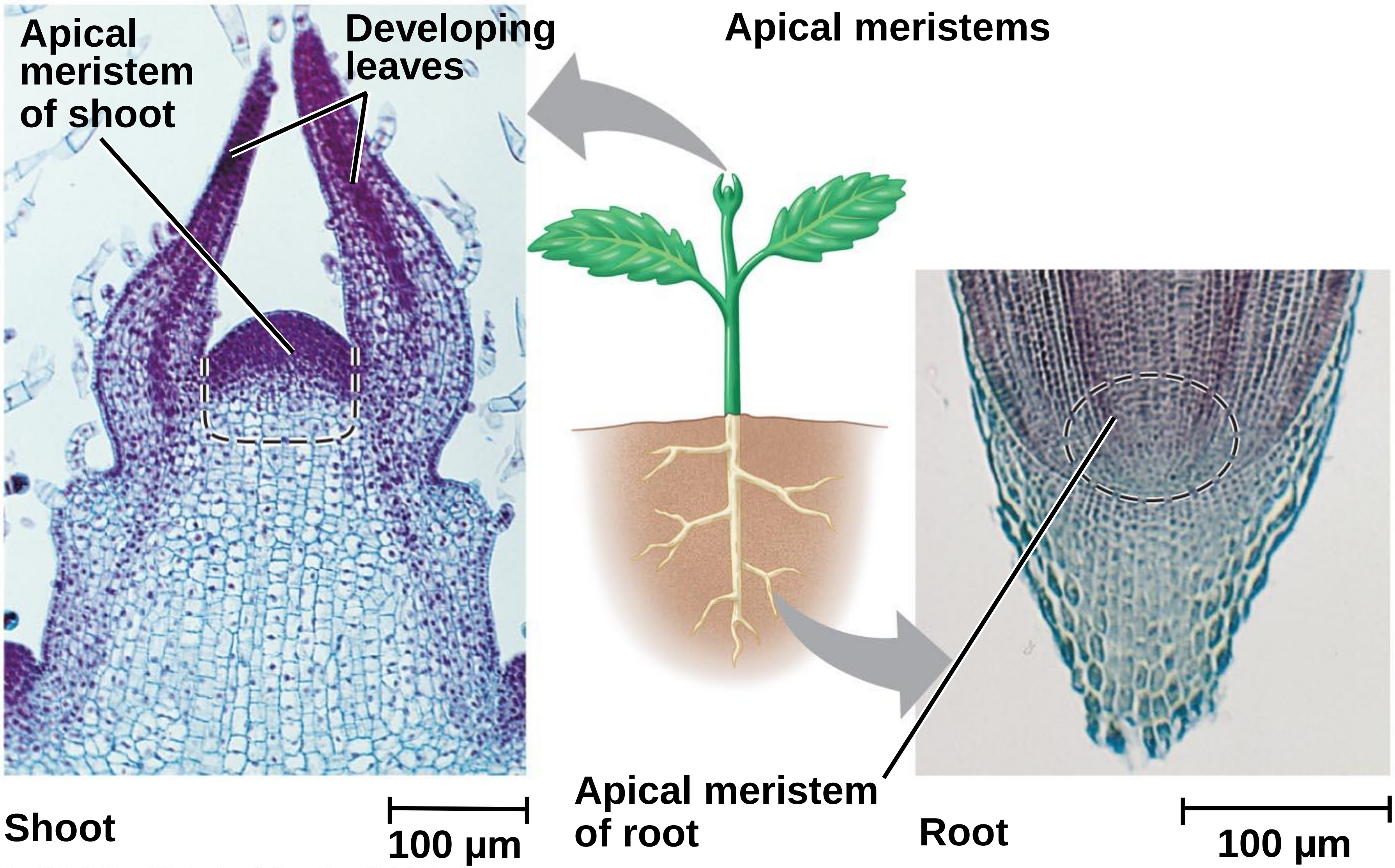


Archegonia and Antheridia of *Marchantia* (a liverwort)

Apical Meristems

- ***Apical meristems*** *are growth regions at plant tips*, allowing plants to sustain *continual growth* in their *length*.
- Cells from the apical meristems differentiate into various tissues.

Apical Meristems - Allow for Growth in Length throughout Plant's Lifetime.



Derived Traits of Land Plants

A Vast Diversity of Modern Plants

- Ancestral species gave rise to land plants which can be informally *grouped based on* the *presence or absence* of ***vascular tissue*.**
- Nonvascular plants are commonly called **bryophytes.**
- Most plants have vascular tissue; these constitute the **vascular plants: seedless vascular** and **seed plants.**

- **Seedless vascular plants** can be divided into clades:
  - **Lycophytes** (club mosses and their relatives)
  - **Pterophytes** (ferns and their relatives).
- Seedless vascular plants are paraphyletic, and are of the same level of biological organization, or **grade.**

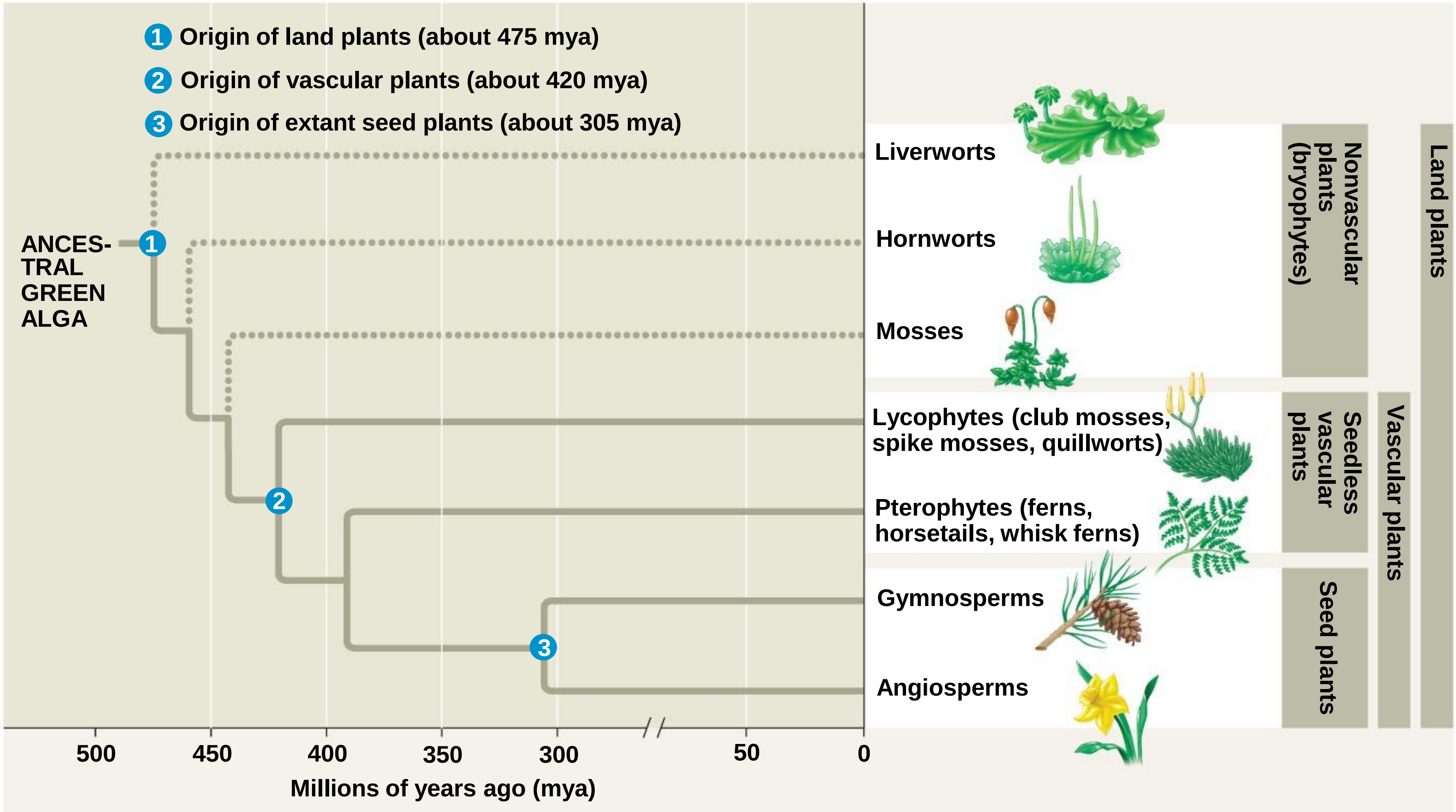
- A ***seed*** is an *embryo* and *nutrients* surrounded by a *protective coat*.
- ***Seed plants*** form a clade and can be divided into further clades:
  - ***Gymnosperms***, the "naked seed" plants including the conifers / *cone = sex organ*
  - ***Angiosperms***, the flowering plants including monocots and dicots / *flower = sex organ*

NonVascular
and
Vascular Plants

Table 29.1 Ten Phyla of Extant Plants

	Common Name	Estimated Number of Species
Nonvascular Plants (Bryophytes)		
Phylum Hepatophyta	Liverworts	9,000
Phylum Anthocerophyta	Hornworts	100
Phylum Bryophyta	Mosses	15,000
Vascular Plants		
Seedless Vascular Plants		
Phylum Lycophyta	Lycophytes	1,200
Phylum Pterophyta	Pterophytes	12,000
Seed Plants		
Gymnosperms		
Phylum Ginkgophyta	Ginkgo	1
Phylum Cycadophyta	Cycads	130
Phylum Gnetophyta	Gnetophytes	75
Phylum Coniferophyta	Conifers	600
Angiosperms		
Phylum Anthophyta	Flowering plants	250,000

Highlights of Plant Evolution

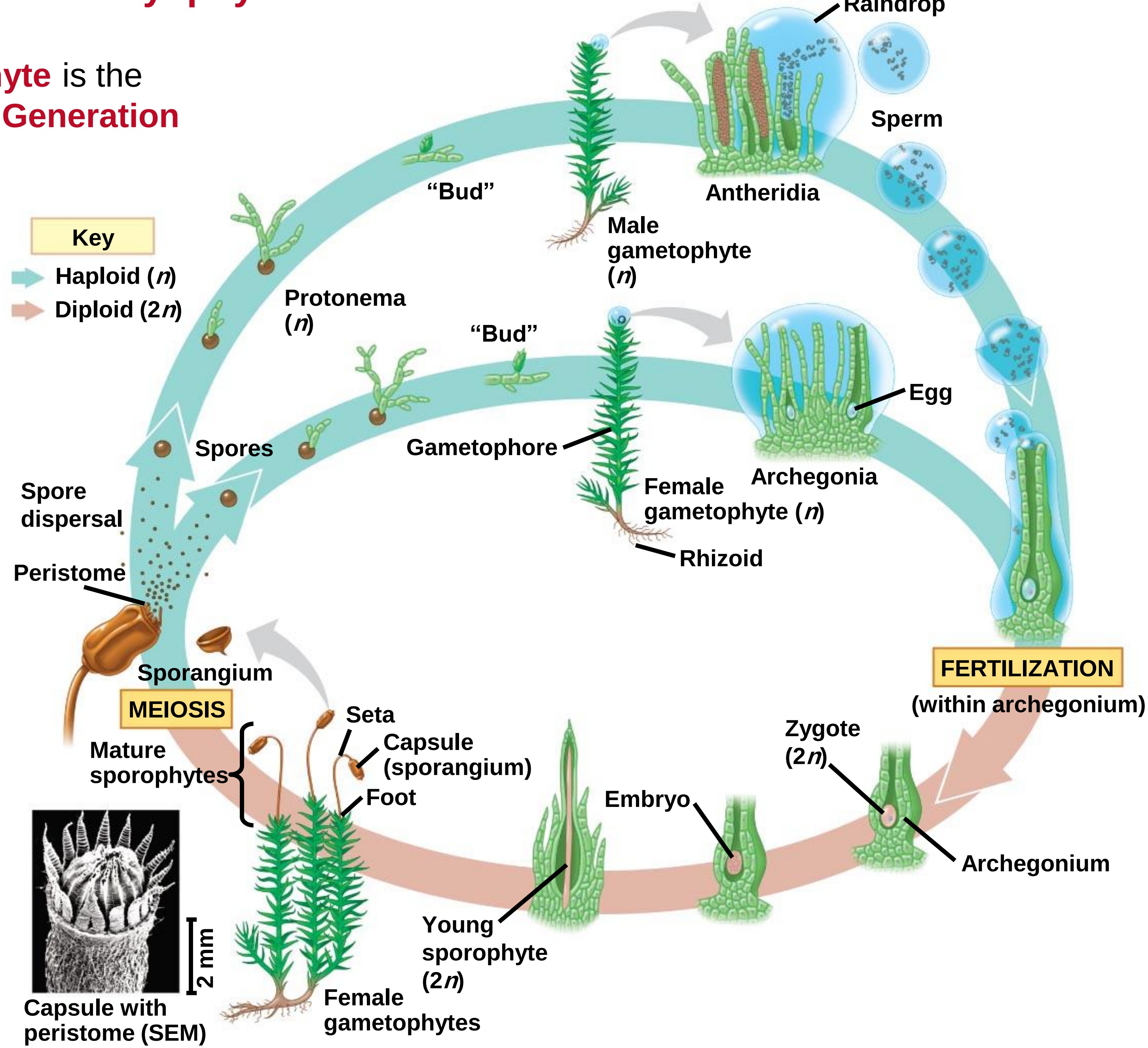


NonVascular plants have life cycles dominated by gametophytes

- ***Bryophytes*** are *nonvascular* and represented today by three phyla of *small herbaceous (nonwoody) plants*:
  - ***Liverworts***, phylum Hepatophyta
  - ***Hornworts***, phylum Anthocerophyta
  - ***Mosses***, phylum Bryophyta
- Mosses are most closely related to vascular plants.
- *Gametophytes* are *dominant:* larger and longer-living than sporophytes. Sporophytes are present only part of the time and dependent on the gametophytes.

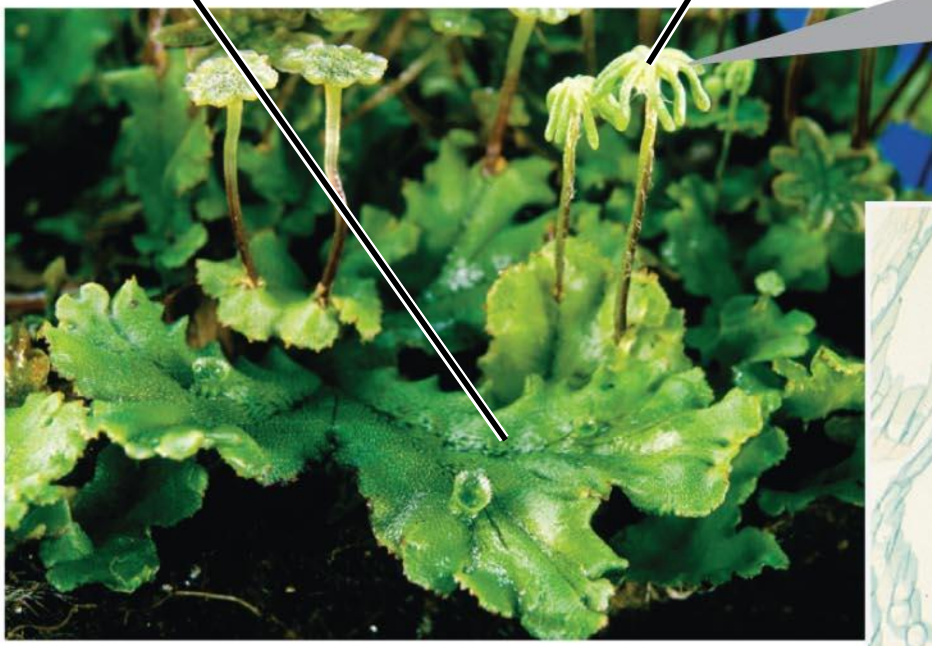
Life Cycle of a Bryophyte > Moss

Gametophyte is the **Dominant Generation**

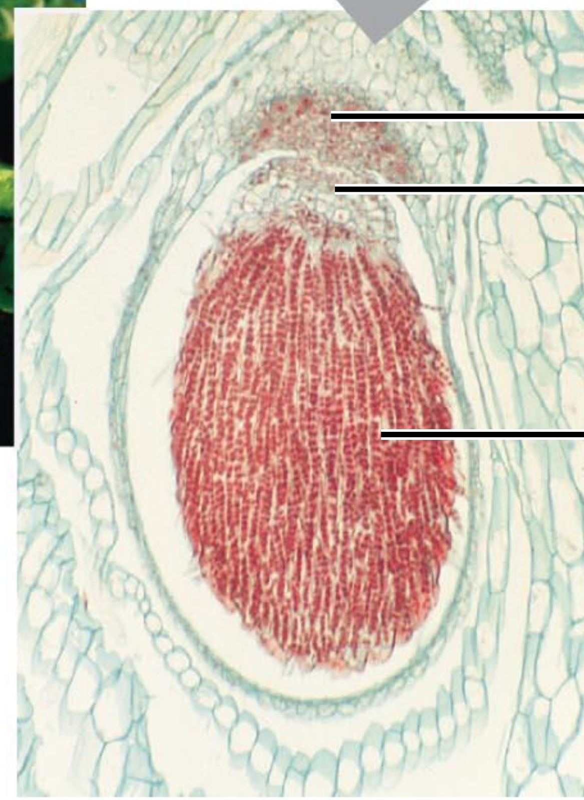


- A spore germinates into a *gametophyte* composed of a **protonema** and gamete-producing **gametophore.**
- **Rhizoids** anchor gametophytes to substrate.
- The height of gametophytes is constrained by lack of vascular tissues.
- *Mature gametophytes produce flagellated sperm in antheridia and an egg in each archegonium.*
- *Sperm swim through a film of water to reach and fertilize the egg.*

Bryophyte Structures



Marchantia polymorpha,
a "thalloid" liverwort



Marchantia sporophyte (LM)

The Ecological and Economic Importance of Mosses

- Moses are capable of inhabiting diverse and sometimes extreme environments, but are especially common in moist forests and wetlands.
- Some mosses might help retain nitrogen in the soil.
- *Sphagnum*, or "*peat moss*," forms extensive deposits of *partially decayed organic material* known as **peat**.
- *Sphagnum is an important global reservoir of organic carbon*.

Bryophytes / Moss may help retain Nitrogen in the soil, an Ecological Advantage

RESULTS

Sphagnum, or peat moss:

economic and archaeological significance

(a) Peat being harvested from a peat bog.

(b) “Tollund Man,” a bog mummy: The acidic, oxygen poor conditions can preserve bodies.

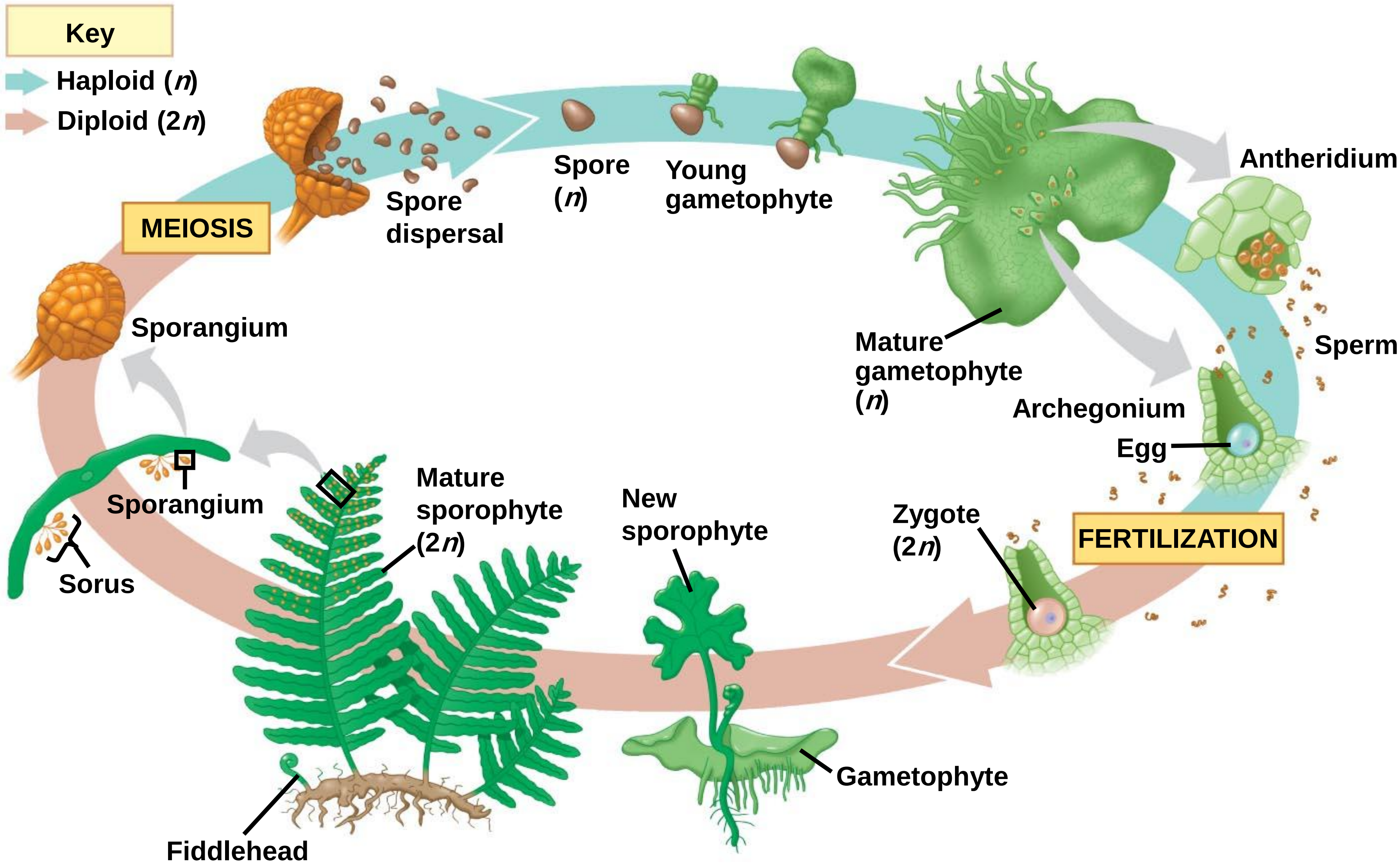
Concept 29.3: Ferns and other seedless vascular plants were the first plants to grow tall

- Bryophytes and bryophyte-like plants were the vegetation during the first 100 million years of plant evolution.
- Vascular plants began to diversify during the Devonian and Carboniferous periods.
- *Vascular tissue allowed vascular plants to grow tall*.
- *Seedless vascular plants* have *flagellated sperm* and are usually restricted to *moist environments*.

Origins and Traits of Vascular Plants

- Fossils of the forerunners of vascular plants date back about 420 million years.
- In contrast with bryophytes, sporophytes of seedless vascular plants are the larger generation. The gametophytes are tiny plants that grow on or below the soil surface.
- *Vascular plants* are characterized by:
  - Life cycles with *dominant sporophytes*
  - *Vascular tissues* called xylem and phloem.
  - Well-developed / *true roots and leaves*.

Life Cycle of a Seedless Vascular Plant - Fern
Dominant Sporophyte



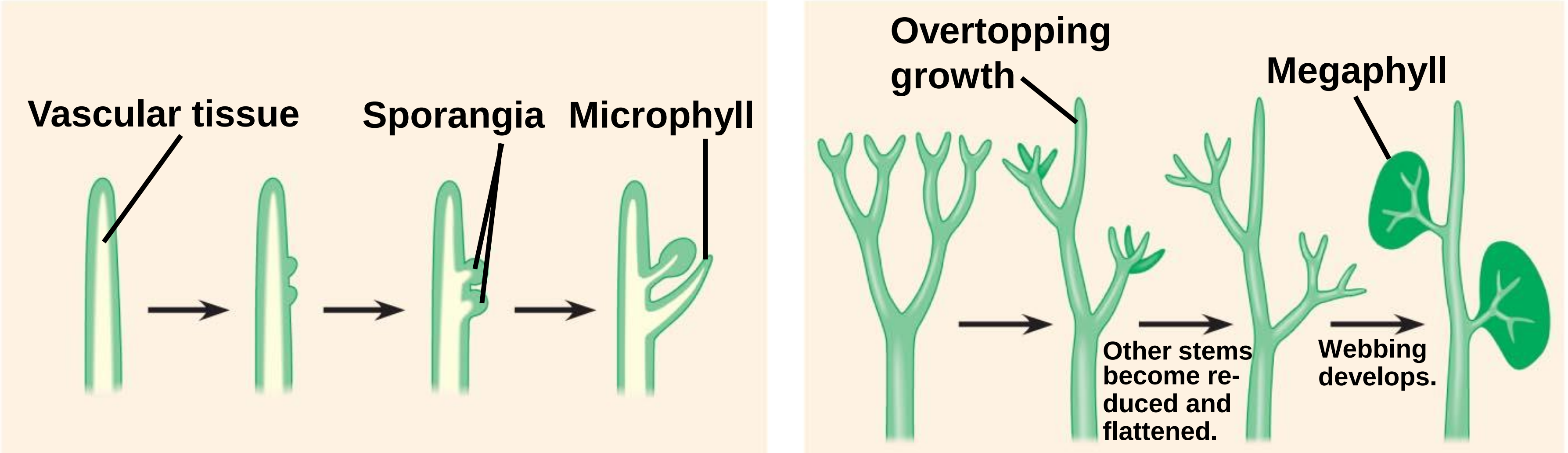
Transport in Vascular Tissue: Xylem and Phloem

- Vascular plants have two types of vascular tissue: xylem and phloem.
- *Xylem* conducts most of the *water and minerals* and includes *dead cells* called ***tracheids***.
- ***Phloem*** consists of *living cells* and distributes *nutrients*: sugars, amino acids.
- Water-conducting cells are strengthened by ***lignin*** and *provide structural support*.
- Increased height was an evolutionary advantage.

Evolution of Roots and Leaves

- ***Roots*** are organs that *anchor* vascular plants and enable plants to *absorb water and nutrients from the soil.*
- Roots may have evolved from subterranean stems.
- ***Leaves*** are organs that *increase the surface area* of vascular plants for capturing more *solar energy* used for photosynthesis.

Hypotheses for Evolution of Leaves



(a) Microphylls - single veined leaves

(b) Megaphylls - branching leaf veins

- Most *seedless vascular plants* are ***homosporous***, producing *one type of spore* that develops into a *bisexual gametophyte*.
- *All seed plants* and some seedless vascular plants are ***heterosporous***, producing *megaspores* that give rise to *female gametophytes*, and *microspores* that give rise to *male gametophytes*.

Homosporous spore production

Sporangium on sporophyll → Single type of spore → Typically a bisexual gametophyte → Eggs / Sperm

Heterosporous spore production

Megasporangium on megasporophyll → Megaspore → Female gametophyte → Eggs

Microsporangium on microsporophyll → Microspore → Male gametophyte → Sperm

Seedless Vascular Plants

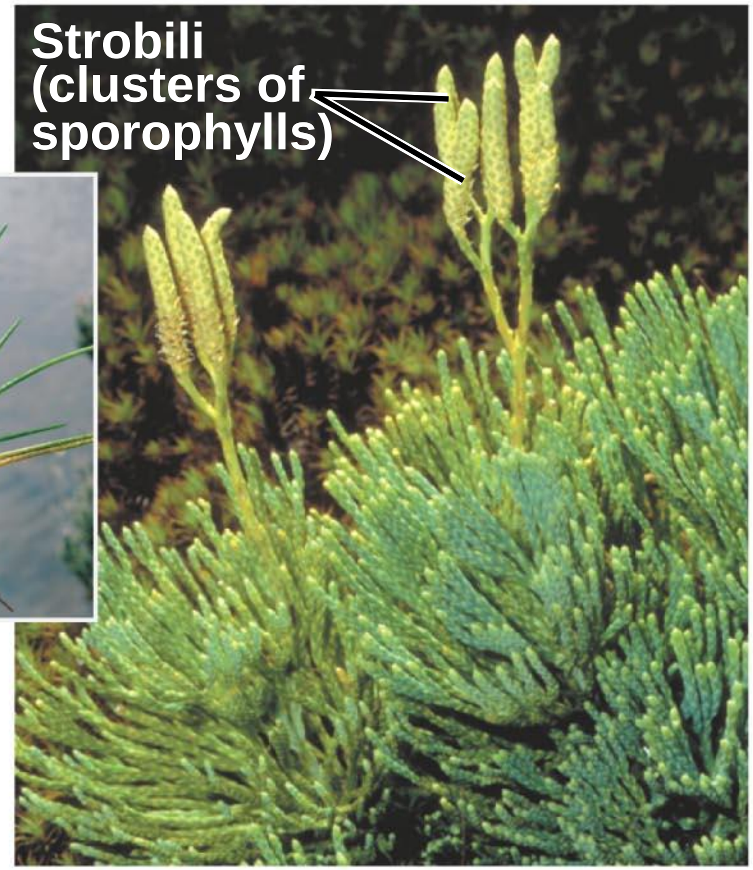
Lycophytes (Phylum Lycophyta)

Selaginella apoda,
a spike moss

1 cm

Isoetes gunnii,
a quillwort

2.5 cm



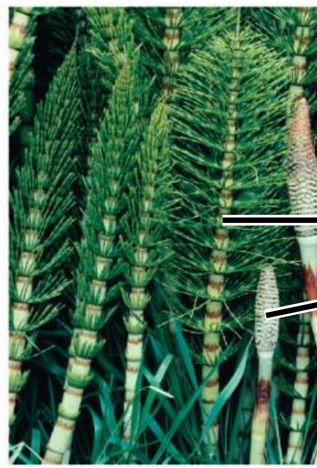
Diphasiastrum tristachyum, a club moss

Seedless Vascular Plants

Pterophytes (Phylum Pterophyta)

Athyrium filix-femina, lady **fern**

25 cm



Equisetum arvense, field horsetail

Vegetative stem

Strobilus on fertile stem

1.5 cm

Psilotum nudum, a whisk fern

2.5 cm

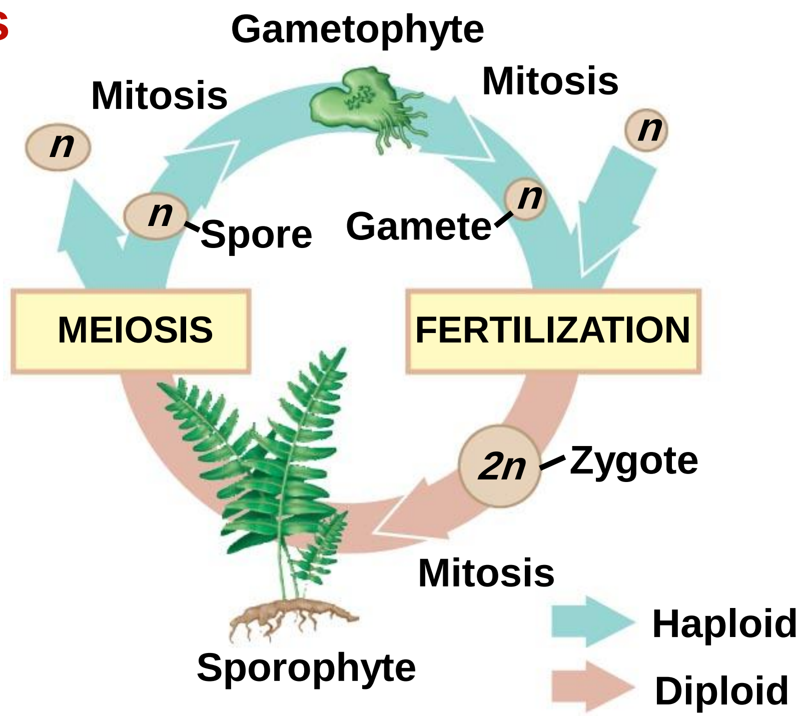
The Significance of Seedless Vascular Plants

- Increased photosynthesis may have helped produce the global cooling at the end of the Carboniferous period.

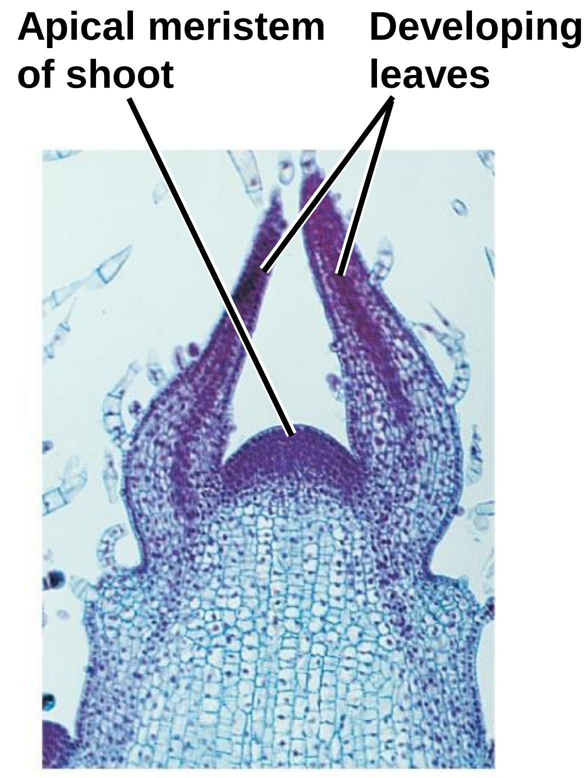
- *The decaying plants of these Carboniferous forests eventually became coal = fossil fuel.*

Artist's depiction of a Carboniferous forest based on fossil evidence

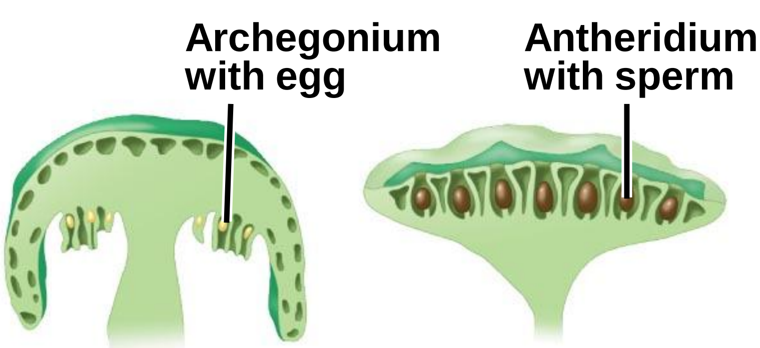
Derived Traits of Plants



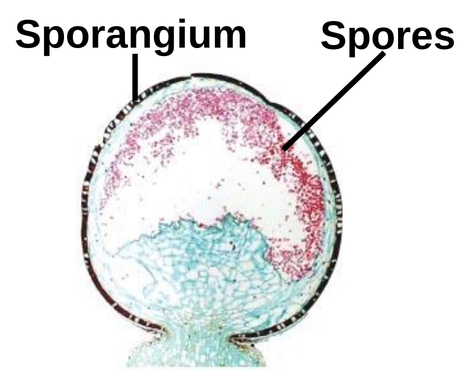
1 Alternation of generations



2 Apical meristems



3 Multicellular gametangia



4 Walled spores in sporangia

You should now be able to:

1. Describe four shared characteristics and four distinct characteristics between charophytes and land plants.
2. Diagram and label the life cycle of a bryophyte
3. Explain why most bryophytes grow close to the ground and are restricted to periodically moist environments.
4. Describe three traits that characterize modern vascular plants and explain how these traits have contributed to success on land.

5. Explain how vascular plants differ from bryophytes.
6. Distinguish between the following pairs of terms: homosporous and heterosporous.
7. Diagram and label the life cycle of a seedless vascular plant.