BIOL 01112
General Biology II Lecture

CHAPTER 29
Plant Diversity I How Plants Colonized Land

Dr. Adam Hrincevich

CH 29 Learning Objectives

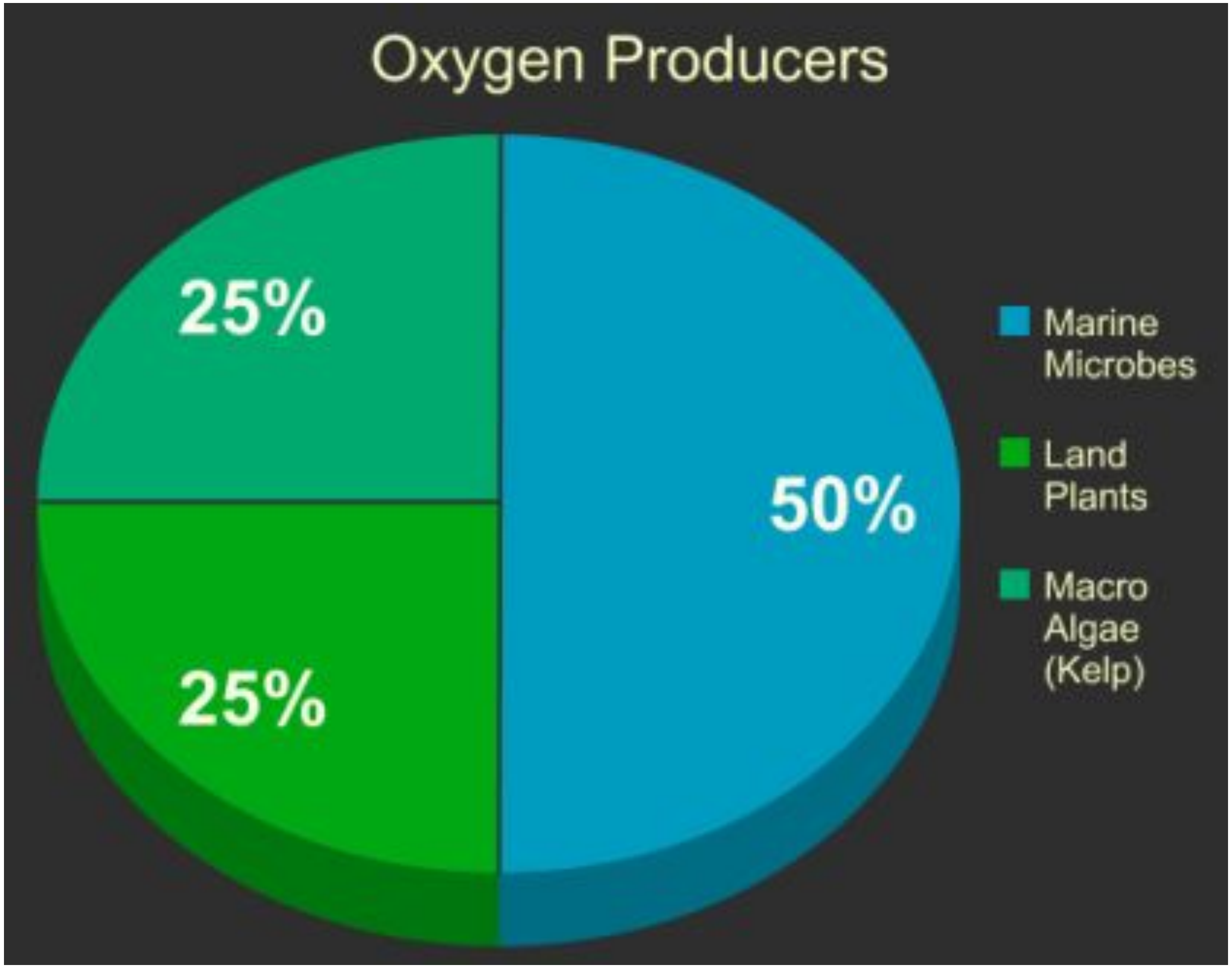
1. Identify key derived characters of plants.
2. Characterize the life cycles of nonvascular plants.
3. Describe characteristics and reproductive processes of seedless vascular plants.

I would suggest completing the crossword puzzle to help you understand the terminology and correlate how the terms relate to topics covered in this chapter.

The Greening of Earth

- For much of Earth's history, the terrestrial surface was lifeless
- Cyanobacteria and protists likely existed on land by 1.2 billion years ago
- Small plants, fungi, and animals emerged on land only within the last 500 million years
- Since colonizing land, plants have diversified into more than 290,000 living species, most live on land
- Algae are **NOT** included in the plant kingdom; they are photosynthetic protists
- Plants supply oxygen (*but how much?*) and are the ultimate source of most food eaten by land animals

Where does earth's oxygen come from?



What species of plant produces the MOST oxygen?
ANSWER: <u>theSnakePlant("Mother-In-Law's Tongue")</u>

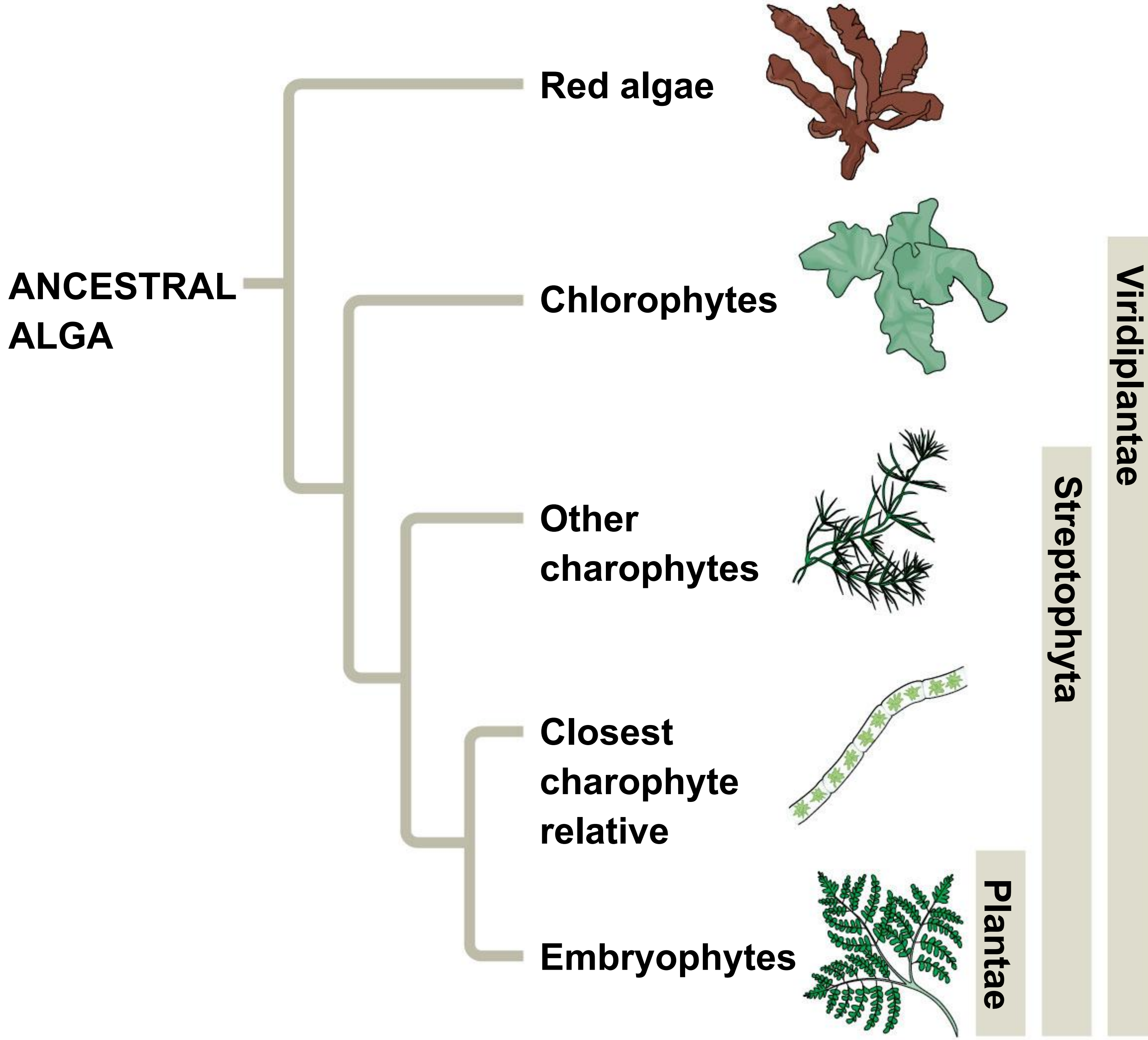
Concept 29.1: Plants evolved from green algae

- Green algae called charophytes are the closest relatives of plants
- Many key traits of plants also appear in some algae
- However, plants share the following traits only with charophytes:
  1. Rings of cellulose-synthesizing proteins
  2. structure of flagellated sperm
  3. formation of a phragmoplast
- Comparisons of nuclear, chloroplast, and mitochondrial DNA indicate that charophytes in the genera *Zygnema* and *Coleochaete* are the closest living relatives of plants

Adaptations Enabling the Move to Land

- In charophytes, a durable polymer layer **sporopollenin** prevents zygotes from drying out
- Sporopollenin is also found in plant spore walls
- The move to land provided **benefits**: unfiltered sunlight, more plentiful CO_2, and nutrient-rich soil
- Land also presented **challenges**: a scarcity of water and lack of structural support against gravity
- Plants diversified as adaptations evolved that enabled them to thrive on land despite challenges
- The placement of the boundary dividing plants from algae is the subject of ongoing debate; we define plants as embryophytes, plants with embryos

Figure 29.2



ANCESTRAL ALGA
Red algae
Chlorophytes
Other charophytes
Closest charophyte relative
Embryophytes
Viridiplantae
Streptophyta
Plantae

Derived Traits of Plants

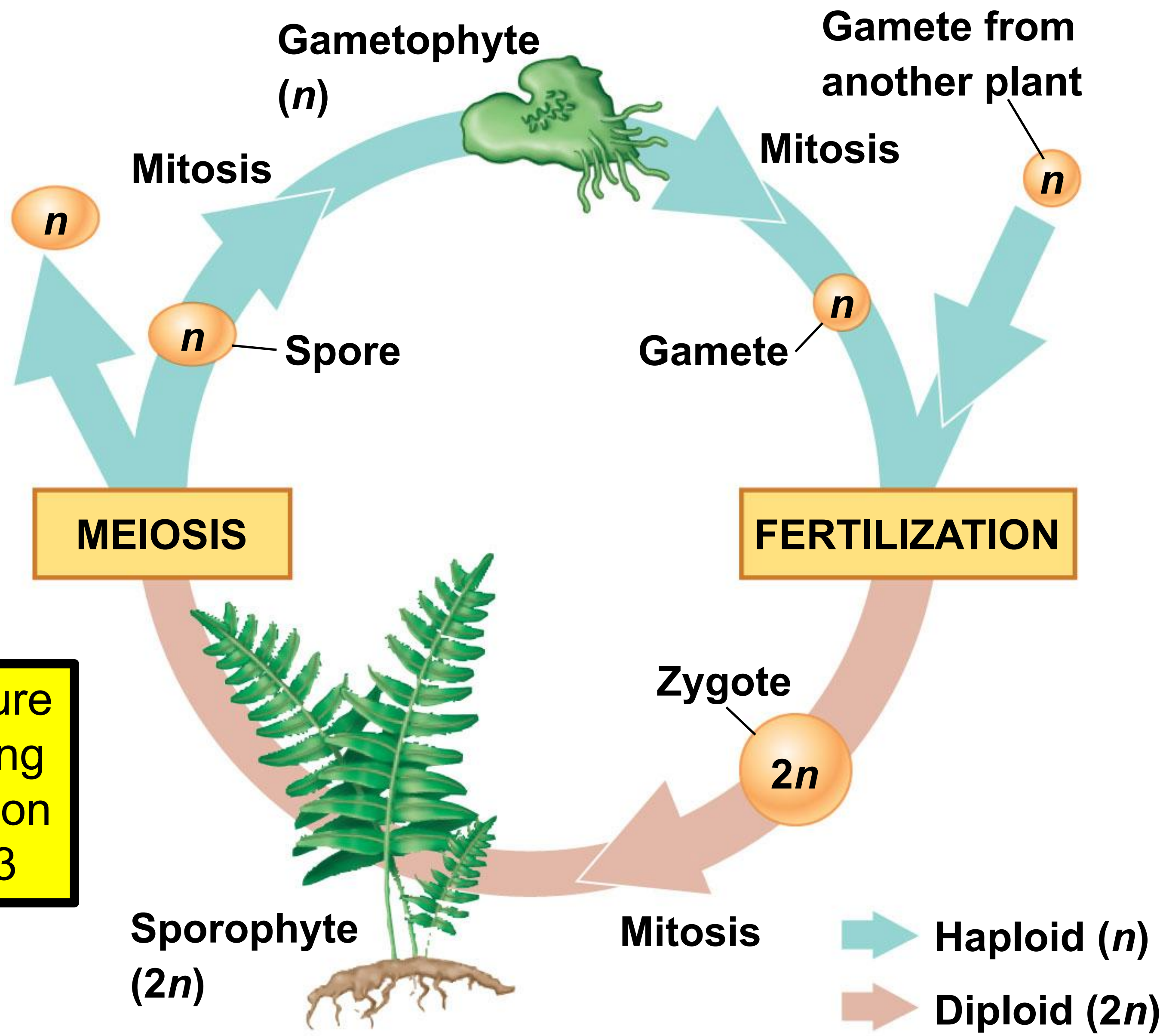
- Five key traits appear in nearly all plants but are absent in the charophytes

1. alternation of generations
2. multicellular, dependent embryos
3. walled spores produced in sporangia
4. multicellular gametangia
5. apical meristems

1. Alternation of Generations

- Plants alternate between two multicellular generations, a reproductive cycle called **alternation of generations**
- The **gametophyte** generation is haploid (N) and produces haploid gametes by mitosis
- Fusion of a sperm and egg gives rise to the **diploid sporophyte** (N), which produces haploid **spores** by meiosis
- Spores develop into gametophytes

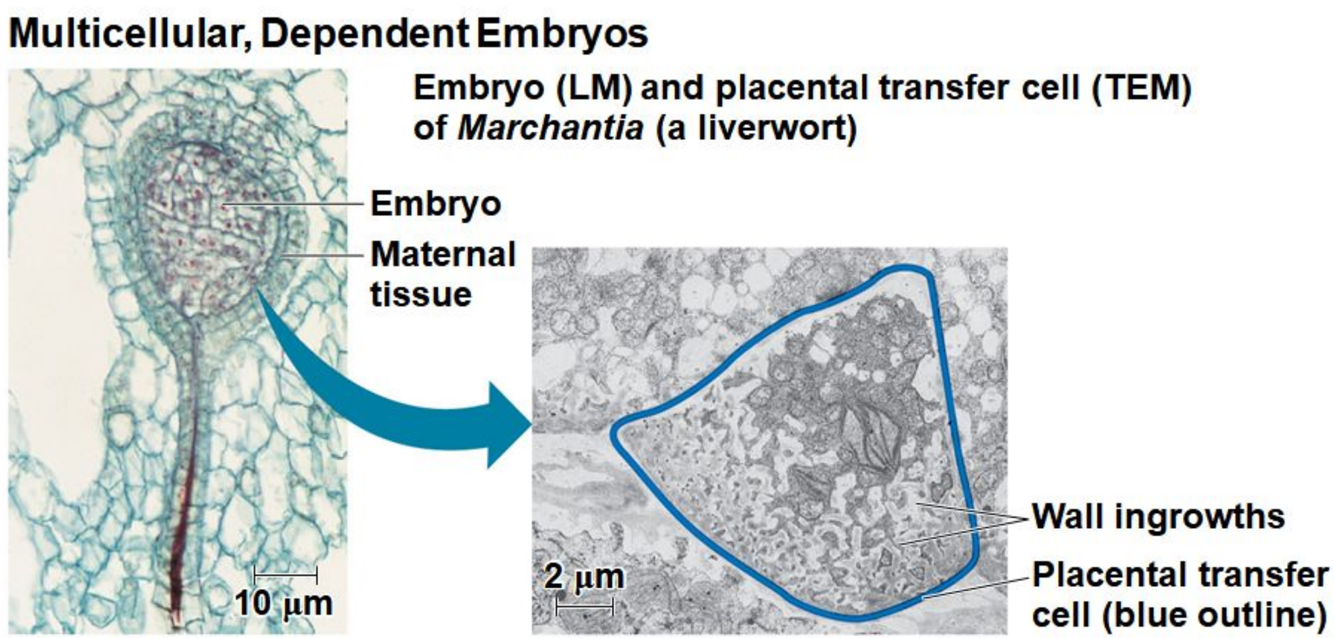
Alternation of generations



Good figure for labeling question on EXAM 3

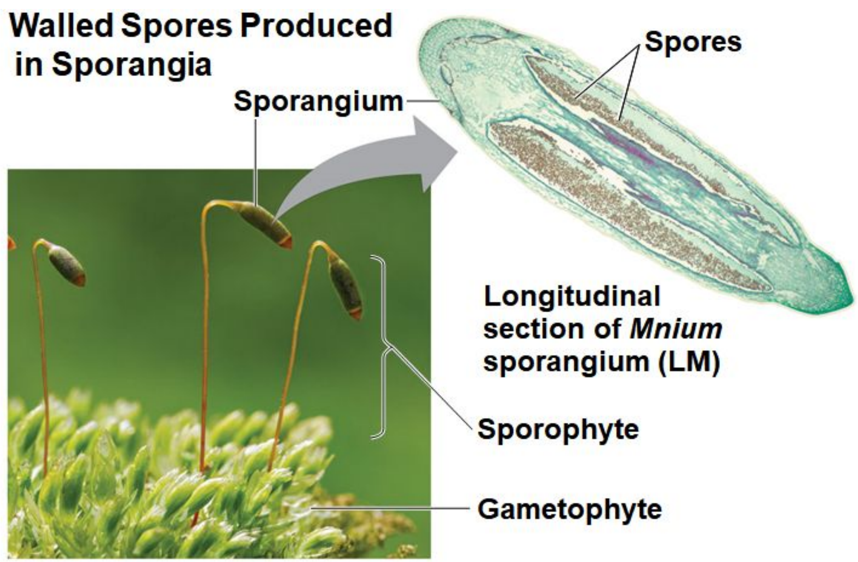
2. Multicellular, Dependent Embryos

- The diploid embryo is retained within <u>the tissue of the female gametophyte</u>
- Nutrients are transferred from parent to embryo through <u>placental transfer cells</u>
- Plants are called **embryophytes** because of the <u>dependency of the embyro on the parent</u>



3. Walled Spores Produced in Sporangia

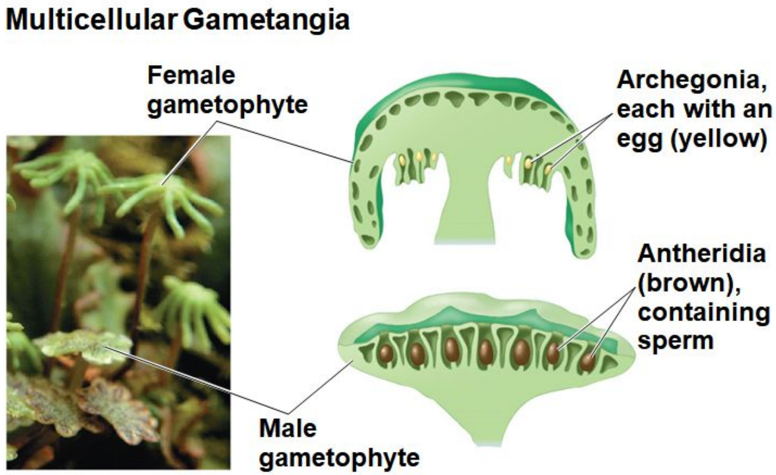
- The sporophyte produces <u>spores in organs called **sporangia**</u>
- Diploid cells called **sporocytes** undergo meiosis to <u>generate haploid spores</u>
- Spore walls contain sporopollenin, which makes <u>them resistant to harsh environments</u>



Sporophytes and sporangia of *Mnium* (a moss)

4. Multicellular Gametangia

- Gametes are <u>produced within **gametangia**</u>
- Female gametangia, called **archegonia**, produce <u>a single non-motile egg</u>
- Male gametangia, called **antheridia**, produce <u>and release sperm</u>
- Each egg is <u>fertilized within an archegonium</u>

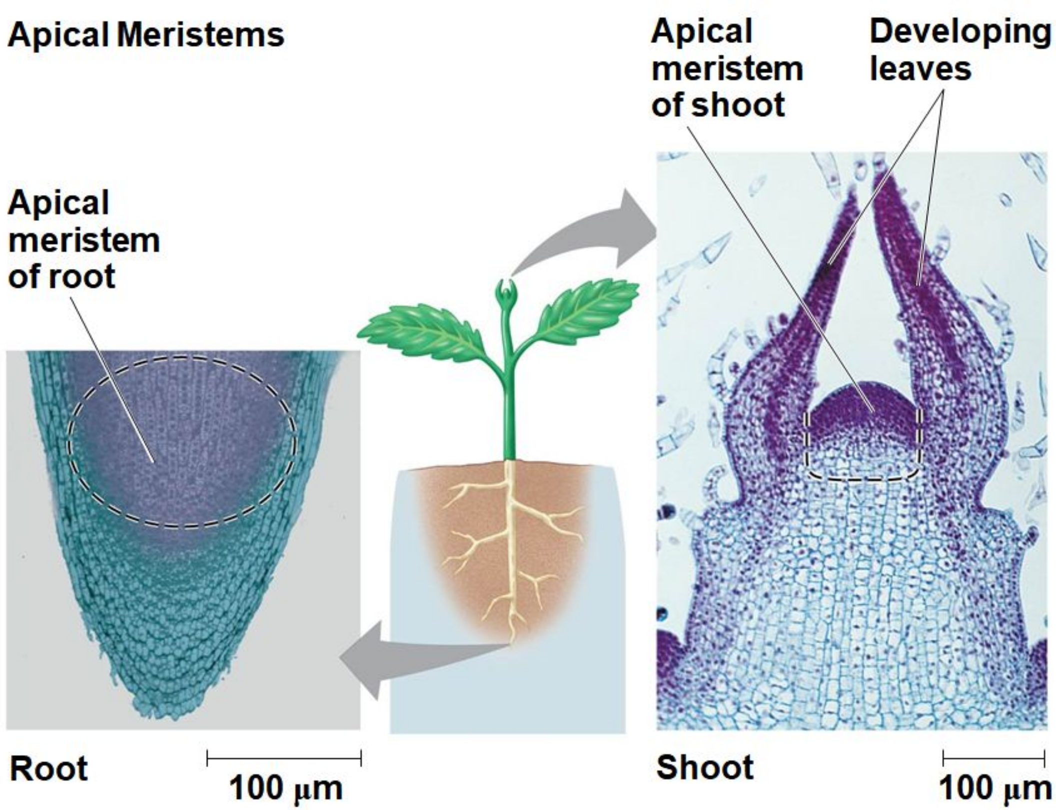


Archegonia and antheridia of *Marchantia* (a liverwort)

5. Apical Meristems

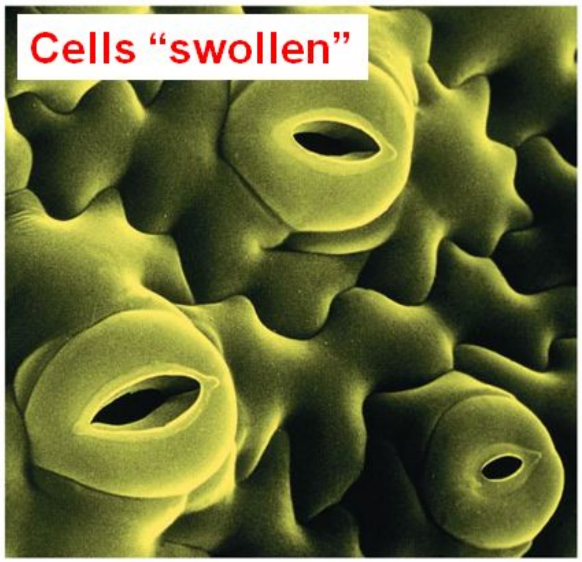
- Plants sustain continual growth in length by repeated cell division within the **apical meristems**
- Cells from the apical meristems differentiate into various tissues

Apical Meristems

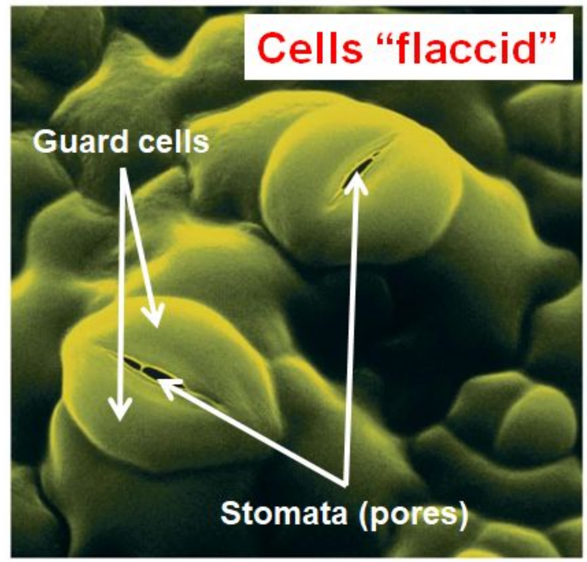


Apical meristems of plant roots and shoots

- Additional derived traits include
  - **Cuticle**, a waxy covering of the epidermis
  - **Stomata & Guard cells**, specialized cells that allow for gas exchange between the outside air and the plant



Stomata open



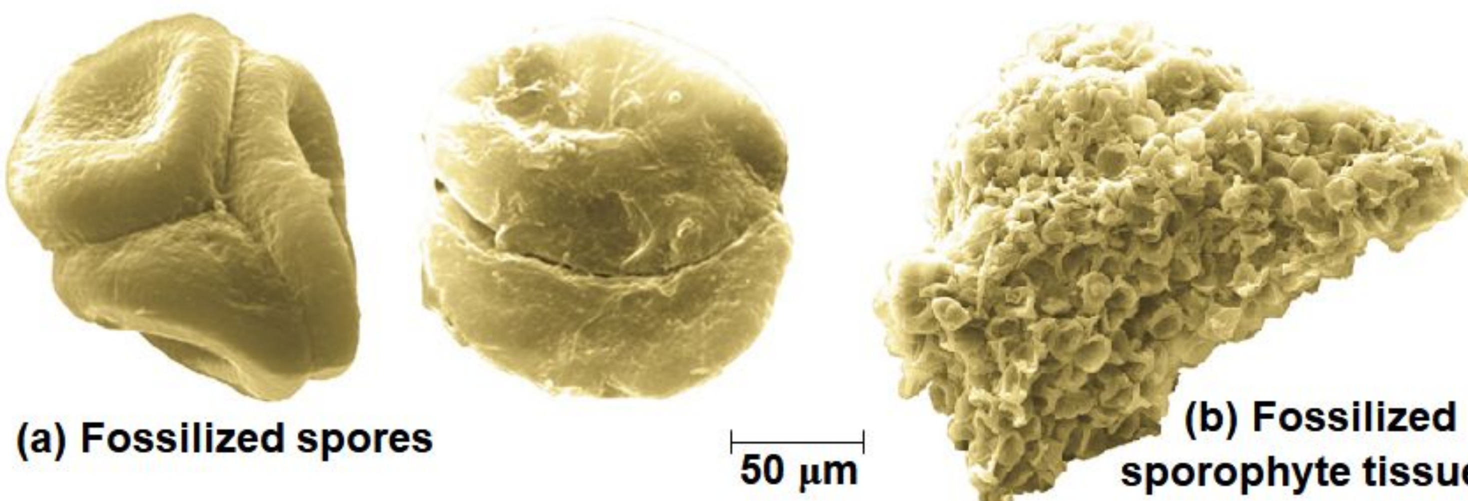
Stomata closed

Guard cells opening and closing (click me)

- Mycorrhizae, symbiotic associations between fungi and plants, may have helped plants without true roots obtain nutrients

The Origin and Diversification of Plants

- The appearance of plant spores in the fossil record indicates that plants colonized land at least 470 million years ago
- Fossilized spores and plant tissues have been extracted from 450-million-year-old rocks
- Fossils of larger structures, such as a sporangium, date to 425 million years ago



(a) Fossilized spores

(b) Fossilized sporophyte tissue

- Ancestral species gave rise to <u>a vast diversity of modern plants</u>
- Most plants have **vascular tissue**, cells joined into tubes for the transport of water and nutrients; these constitute <u>the **vascular plants**</u>
- Nonvascular plants are <u>commonly called **bryophytes**</u>
- Bryophytes do not form a <u>monophyletic group (a clade)</u>

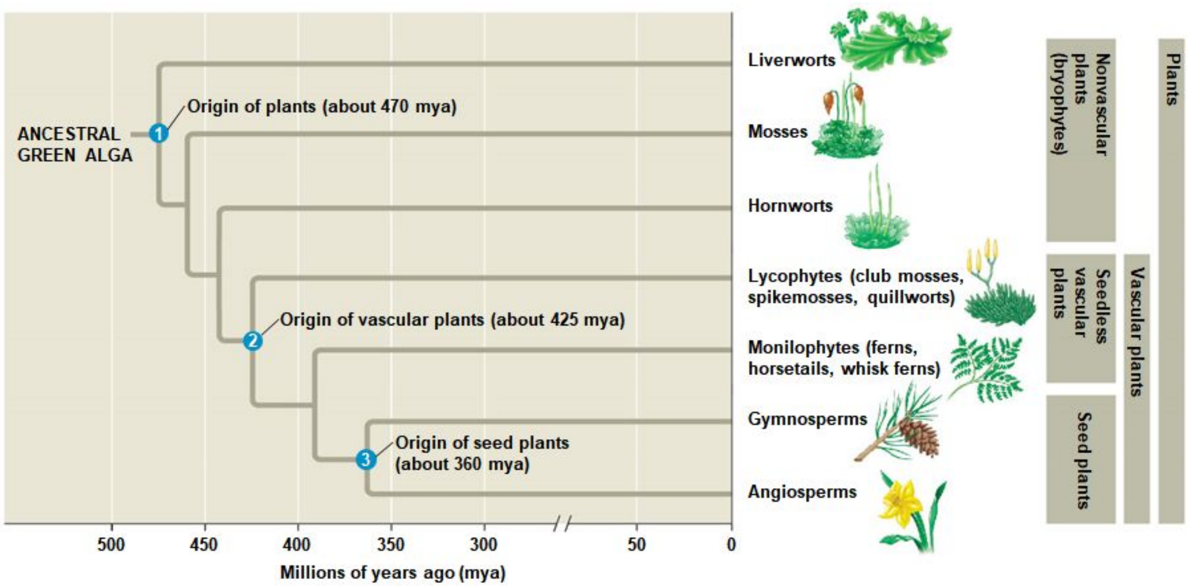


Table 29.1

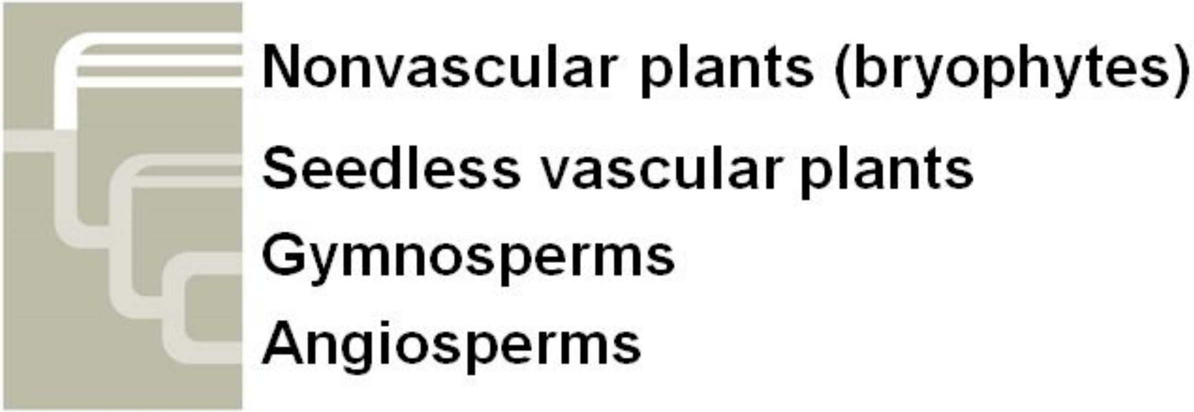
Table 29.1 Ten Phyla of Extant Plants

	Common Name	Number of Known Species
Nonvascular Plants (Bryophytes)		
Phylum Hepatophyta	Liverworts	9,000
Phylum Bryophyta	Mosses	15,000
Phylum Anthocerophyta	Hornworts	100
Vascular Plants		
Seedless Vascular Plants		
Phylum Lycophyta	Lycophytes	1,200
Phylum Monilophyta	Monilophytes	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

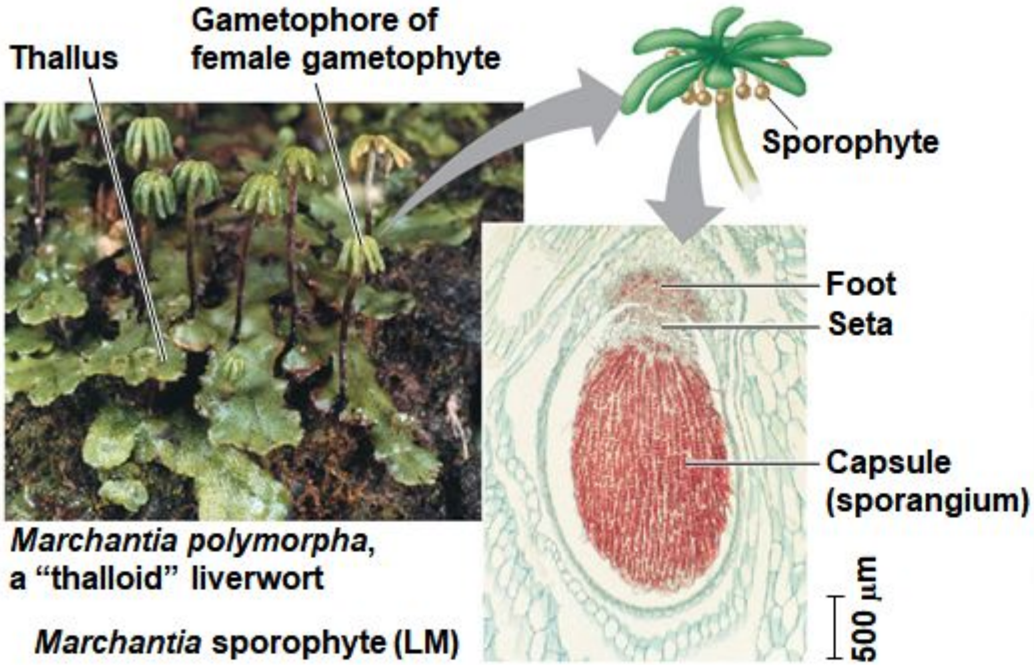
- **Seedless vascular plants** can be divided into two clades:
  1. **Lycophytes:** club mosses and their relatives
  2. **Monilophytes:** ferns and their relatives
- A **seed** is an embryo and nutrients surrounded by a protective coat
- **Seeded vascular plants** form a clade and can be divided into further clades
  1. **Gymnosperms** produce seeds that are not enclosed in chambers
  2. **Angiosperms** produce seeds that develop inside chambers that originate within flowers

Concept 29.2: Mosses and nonvascular plants have life cycles dominated by gametophytes

- Bryophytes are represented today by three phyla of small, herbaceous (non-woody) plants
  1. **Liverworts**, phylum Hepatophyta
  2. **Mosses**, phylum Bryophyta
  3. **Hornworts**, phylum Anthocerophyta
- These groups represent the earliest lineages to diverge from the common ancestor of land plants



Liverworts (Phylum Hepatophyta)



Marchantia polymorpha, a “thalloid” liverwort

Marchantia sporophyte (LM)

Plagiochila deltoidea, a “leafy” liverwort

Mosses (Phylum Bryophyta)

Polytrichum commune, hairy-cap moss

Hornworts (Phylum Anthocerophyta)

An *Anthoceros* hornwort species

Bryophyte Gametophytes

- In all three bryophyte phyla, gametophytes are larger (dominant-form) and longer-living than sporophytes
- Sporophytes are typically present only part of the time
- The height of gametophytes is constrained by ***lack*** of vascular tissues
- **Rhizoids** anchor gametophytes to substrate
- Mature gametophytes produce flagellated sperm in antheridia and an egg in each archegonium
- Sperm swim through water to reach & fertilize the egg
- Many bryophytes also reproduce asexually
  - EX: some mosses produce brood bodies, that detach from the parent and grow into genetic clones

Bryophyte Sporophytes

- Bryophyte sporophytes never live <u>independently of the gametophyte</u>
- They are the smallest and simplest sporophytes of all <u>extant plant groups</u>
- A sporophyte consists of a **foot**, a **seta** (stalk), and a sporangium, also called a **capsule**, which discharges <u>spores through a **peristome**</u>
- Hornwort and moss sporophytes have <u>stomata; liverworts do not</u>

Ecological & Economic Importance of Mosses

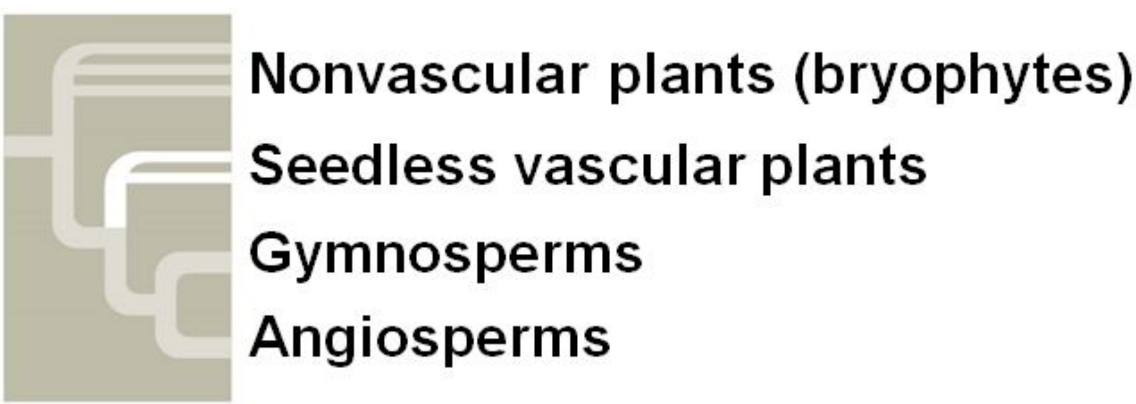
- *Sphagnum*, or "peat moss," forms extensive deposits of partially decayed organic material known as **peat**
- Peat can be used as a source of fuel
- The low temperature, pH, and oxygen level of peatlands inhibit decay of moss and other organisms
- Peatlands cover 3% of Earth's land surface and contain roughly 30% of the world's soil carbon
- Overharvesting of *Sphagnum* could release stored CO_2 to the atmosphere

(a) Peat being harvested from a peatland

(b) "Tollund Man," a bog mummy dating from 405–100 B.C.E.

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

- Bryophytes were prominent types of vegetation during the first 100 million years of plant evolution
- The earliest fossils of vascular plants date to 425 million years ago; Carboniferous forests formed coal
- Vascular tissue allowed these plants to grow tall
- Like bryophytes, seedless vascular plants have flagellated sperm and are usually live in most areas

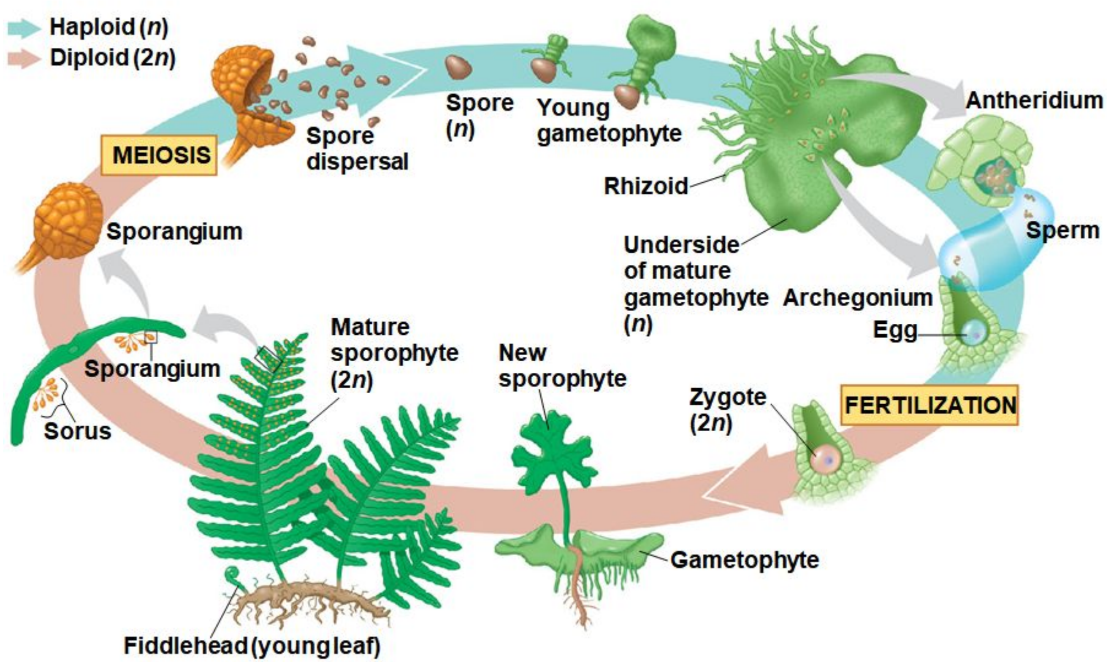


Origins and Traits of Vascular Plants

- Early vascular plants had independent, braching sporophytes
- Living vascular plants are characterized by
  - life cycles with dominant sporophytes
  - vascular tissues called xylem and phloem
  - well-developed roots and leaves
  - spore-bearing leaves called sporophylls

Life Cycles with Dominant Sporophytes

- In contrast with bryophytes, sporophytes of seedless vascular plants are the <u>larger, more complex generations</u>
  - EX: In ferns, the familiar leafy plants are the sporophytes; the gametophytes are tiny plants that <u>grow on or below the soil surface</u>



Transport in Xylem and Phloem

- Vascular plants have
  1. Xylem
  2. Phloem
- **Xylem** conducts most of the water and minerals and includes tube-shaped cells called **tracheids**
- Water-conducting cells are strengthened by **lignin** and provide structural support
- **Phloem** has cells arranged into tubes that distribute sugars, amino acids, and other organic products
- Vascular tissue allowed for increased height, which provided an evolutionary advantage

Evolution of Roots

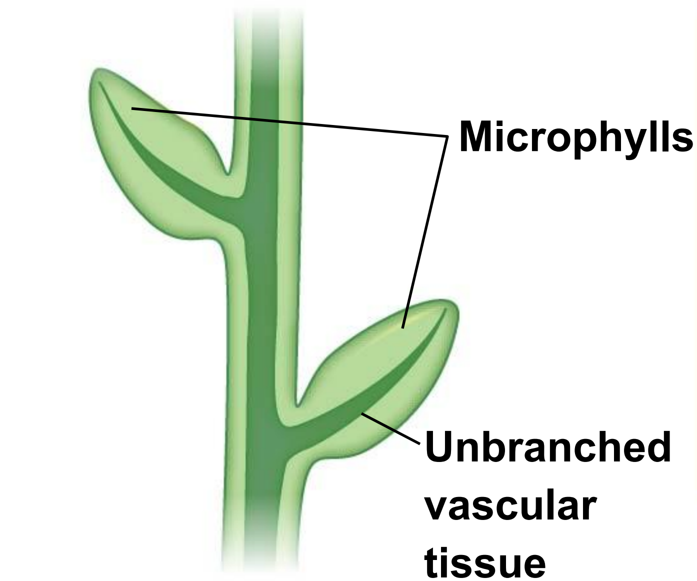
- **Roots** are organs that anchor vascular plants
- They enable vascular plants to absorb water and nutrients from the soil
- Roots may have evolved from subterranean stems

Evolution of Leaves

- **Leaves** are organs that increase the surface area of vascular plants, maximizing photosynthesis
- Leaves are categorized by two types:
  - **Microphylls**, small leaves with a *single* vein
  - **Megaphylls**, larger leaves with a *highly branched* vascular system

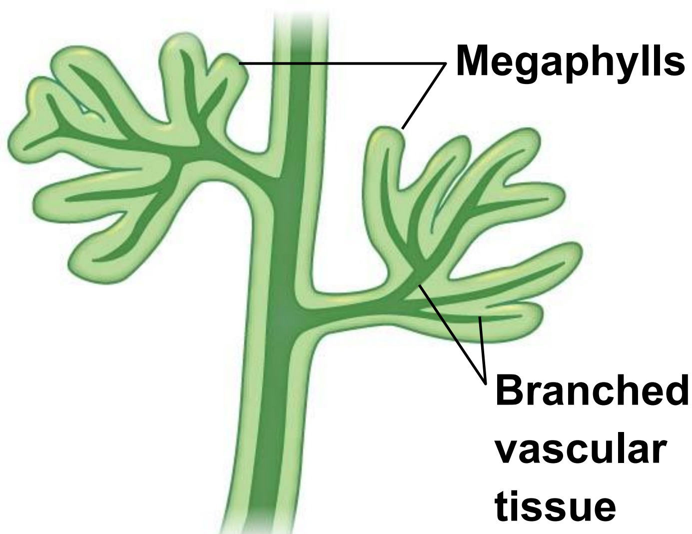
Figure 29.13

Microphyll leaves



Selaginella kraussiana
(Krauss's spikemoss)

Megaphyll leaves



Hymenophyllum tunbrigense
(Tunbridge filmy fern)

Sporophylls and Spore Variations

- **Sporophylls** are modified leaves with sporangia
- **Sori** are sporangia clusters on sporophyll undersides
- **Strobili** are cone-like structures formed from groups of sporophylls
- 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**
- Heterosporous species produce **megaspores**, which give rise to **female** gametophytes, and **microspores**, which give rise to **male** gametophytes

Classification of Seedless Vascular Plants

- There are two clades of seedless vascular plants
  1. Phylum **Lycophyta**: club mosses, spike mosses, and quillworts
  2. Phylum **Monilophyta**: ferns, horsetails, and whisk ferns and their relatives

1. Phylum Lycophyta: Club Mosses, Spike Mosses, and Quillworts

- Giant lycophyte trees thrived for millions of years in moist swamps, but diversity declined when the climate became drier during the <u>Permian period</u>
- Living lycophytes are <u>small herbaceous plants</u>
- Club mosses and spike mosses have <u>vascular tissues and are not true mosses</u>

Figure 29.14a

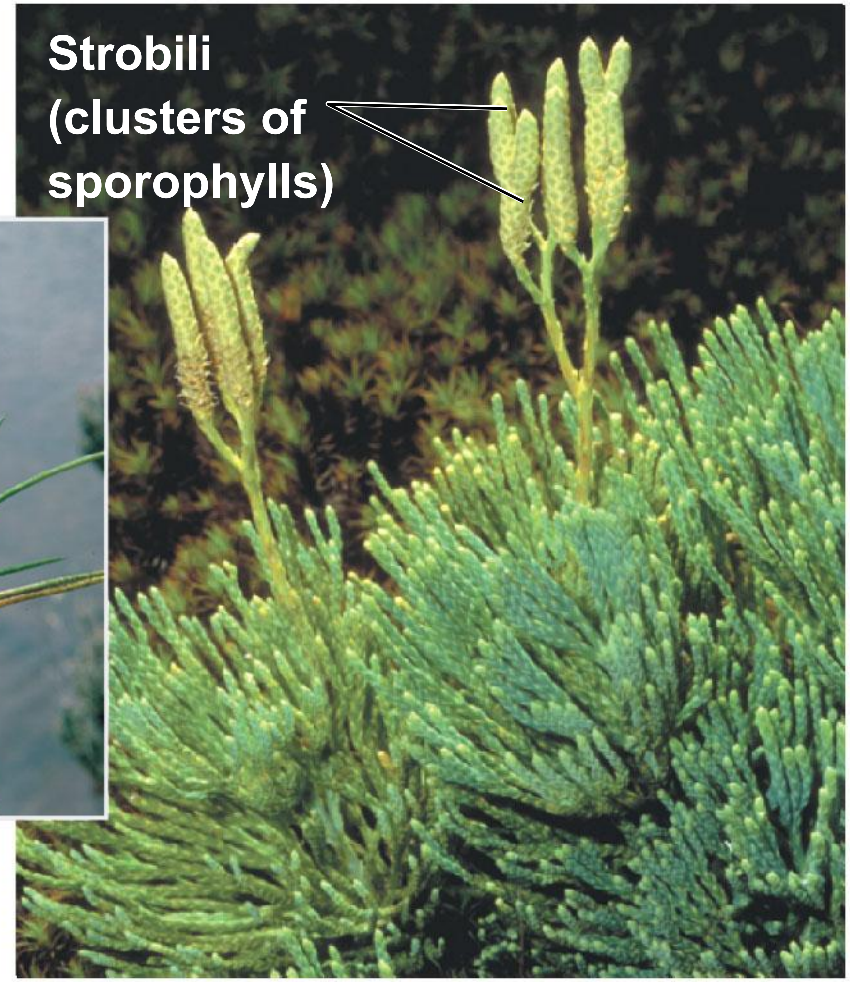
Lycophytes (Phylum Lycophyta)

2.5 cm

Selaginella moellendorffii, a spike moss

Isoetes gunnii, a quillwort

1 cm



Diphasiastrum tristachyum, a club moss

2. Phylum Monilophyta: Ferns, Horsetails, and Whisk Ferns and Relatives

- Ferns are the most widespread seedless vascular plants, with more <u>than 12,000 species</u>
- They are most diverse in the tropics but also <u>thrive in temperate forests</u>
- Horsetails were diverse during the Carboniferous period, but are now restricted <u>to the genus *Equisetum*</u>
- Whisk ferns resemble ancestral vascular plants but are <u>closely related to modern ferns</u>

Horsetails

Figure 29.14b

Monilophytes (Phylum Monilophyta)

Matteuccia struthiopteris **(ostrich fern)**

2.5 cm

Ferns

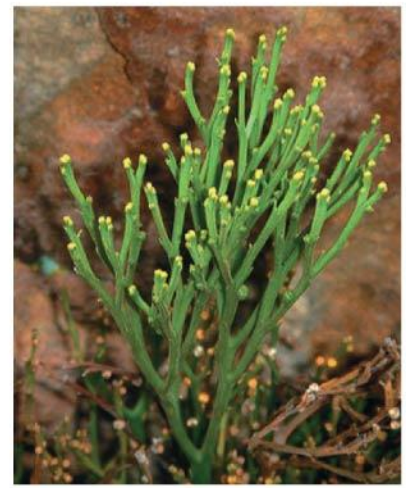
Equisetum telmateia**, giant horsetail**

Strobilus on fertile stem

Vegetative stem

3 cm

Horsetails



Psilotum nudum**, a whisk fern**

4 cm

Whisk Ferns and Relatives