Plant Diversity I

Chapter 29

- Objectives
  - Describe four shared characteristics and four distinct characteristics between charophytes and land plants
  - Distinguish between the phylum Bryophyta and bryophytes
  - Diagram and label the life cycle of a bryophyte
  - Explain why most bryophytes grow close to the ground and are restricted to periodically moist environments
  - Describe three traits that characterize modern vascular plants and explain how these traits have contributed to success on land
  - Explain how vascular plants differ from bryophytes

2

- Distinguish between the following pairs of terms: microphyll and megaphyll; homosporous and heterosporous
- Diagram and label the life cycle of a seedless vascular plant

3

Overview of Plant Evolution

- Looking at a lush landscape it is difficult to imagine the land without any plants or other organisms
- For more than the first 3 billion years of Earth's history the terrestrial surface was lifeless
- Since colonizing land plants have diversified into roughly 290,000 living species

4

Land Plants Evolved From Green Algae

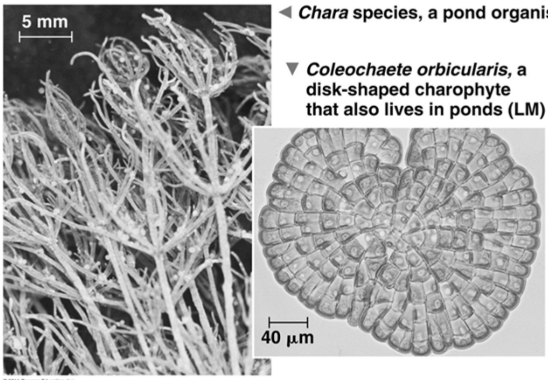
- Researchers have identified green algae called charophyceans as the closest relatives of land plants
- Many characteristics of land plants also appear in a variety of algal clades

6

Morphological and Biochemical Evidence

- There are four key traits that land plants share only with charophyceans
  - Rose-shaped complexes for cellulose synthesis
  - Peroxisome enzymes
  - Structure of flagellated sperm
  - Formation of a phragmoplast
- Comparisons of both nuclear and chloroplast genes point to charophyceans as the closest living relatives of land plants

7



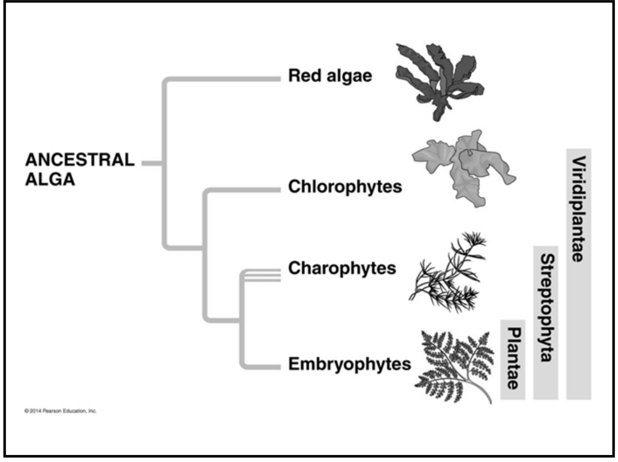
◄ ***Chara* species, a pond organism**

▼ ***Coleochaete orbicularis,* a disk-shaped charophyte that also lives in ponds (LM)**

What is the Plant Kingdom?

- Systematists are currently debating the boundaries of the plant kingdom
- Some biologists think that the plant kingdom should be expanded to include some or all green algae
  - Until this debate is resolved most biologists use the embryophyte definition of kingdom Plantae

9



Adaptations Enabling the Move to Land

- In charophyceans a layer of a durable polymer called sporopollenin prevents exposed zygotes from drying out
- The accumulation of traits that facilitated survival on land may have opened the way to its colonization by plants

11

Derived Terrestrial Adaptations

- Many adaptations emerged after land plants diverged from their charophycean relatives
- Five key traits appear in nearly all land plants but are absent in the charophyceans
  - Alternation of generations
  - Multicellular dependent embryos
  - Walled spores produced in sporangia
  - Multicellular gametangia
  - Apical meristems

12

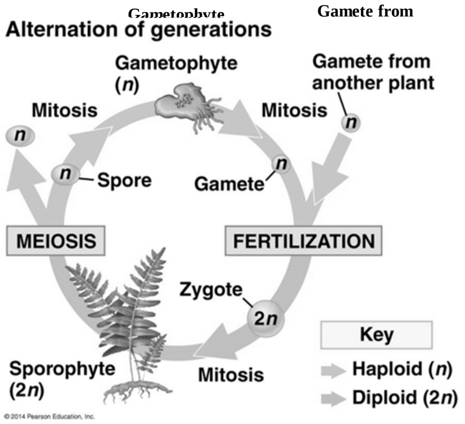
Alternation of Generations

- Plants alternate between two multicellular stages, a reproductive cycle called alternation of generations
- The 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

13

Fig. 29-5a

Gametophyte Gamete from

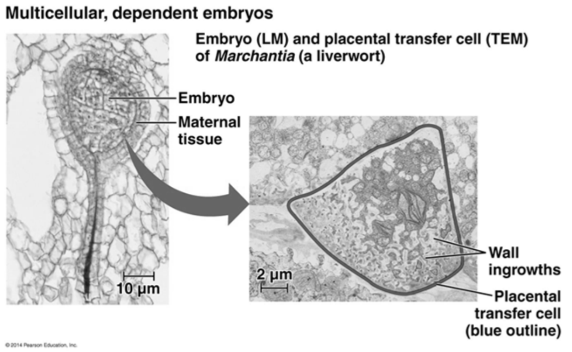


Multicellular, Dependent Embryos

- 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

15

Fig. 29-5b



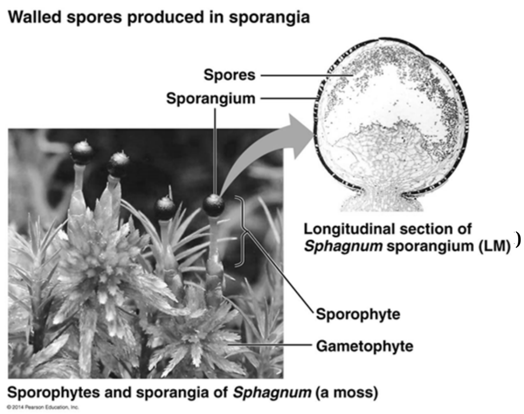
Embryo (LM) and placental transfer cell (TEM) of *Marchantia* (a liverwort)

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 makes them resistant to harsh environments

17

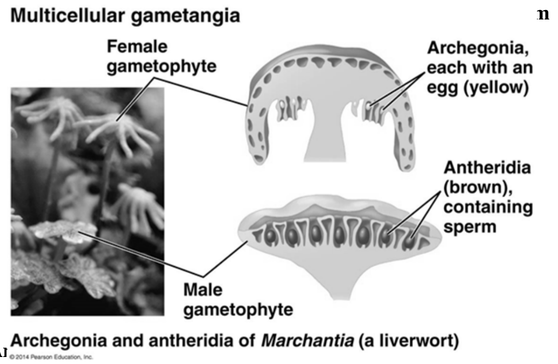
Fig. 29-5c



Multicellular Gametangia

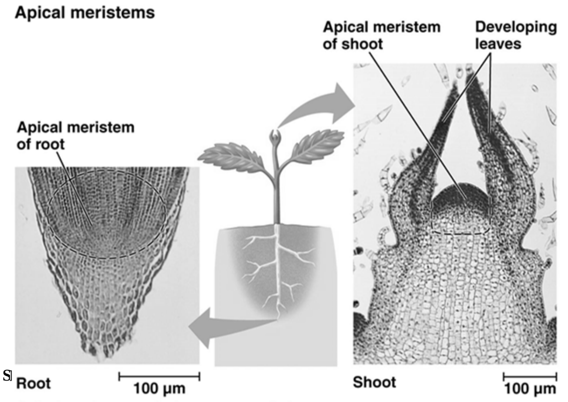
- Gametes are produced within organs called gametangia
- Female gametangia, called archegonia, produce eggs and are the site of fertilization
- Male gametangia, called antheridia, are the site of sperm production and release

Fig. 29-5d



Apical Meristems

- Plants sustain continual growth in their apical meristems
- Cells from the apical meristems differentiate into various tissues



Apical meristems of plant roots and shoots

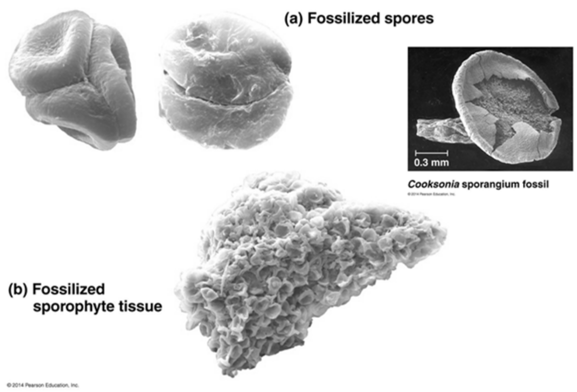
- Additional derived units such as a cuticle and secondary compounds, evolved in many plant species
- Symbiotic associations between fungi and the first land plants may have helped plants without true roots to obtain nutrients

23

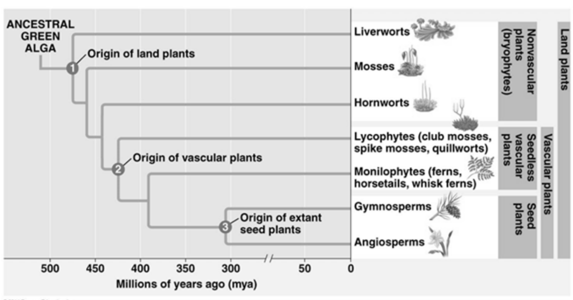
The Origin and Diversification of Plants

- Fossil evidence indicates that plants were on land at least 450 million years ago
  - Fossilized spores and tissues have been extracted from 450-million-year-old rocks
  - Earliest evidence of plant spore fossils dates from 470 million years ago
  - Large spore-bearing structures found in rocks dating from 425 million years ago

24



- Whatever the age of the first land plants those ancestral species gave rise to a vast diversity of modern plants



- Land plants can be informally grouped based on the presence or absence of vascular tissue
  - Bryophytes (non-vascular plants)
    - Hepatophyta (also known as Marchantiophyta)
    - Anthocerophyta
    - Bryophyta
  - Seedless vascular plants
    - Lycophyta (also known as Lycopodiophyta)
    - Monilophyta

28

- Vascular plants
  - Gymnosperms
    - Ginkgophyta
    - Cycadophyta
    - Gnetophyta
    - Coniferophyta
  - Angiosperms
    - Anthophyta

29

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

Bryophytes

- Bryophytes are represented today by three phyla of small herbaceous (nonwoody) plants
  - Liverworts, phylum Hepatophyta
  - Hornworts, phylum Anthocerophyta
  - Mosses, phylum Bryophyta
- Debate continues over the sequence of bryophyte evolution
  - Earliest fossil spores have features only found in living liverworts
  - Hornworts are most closely related to vascular plants

31

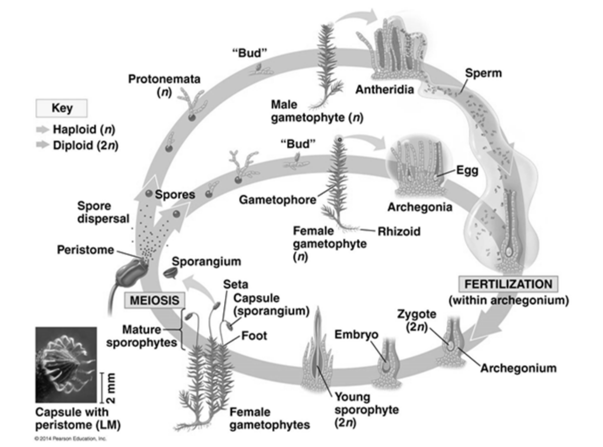
Bryophyte Gametophytes

- In all three bryophyte phyla gametophytes are larger and longer-living than sporophytes
  - A spore germinates into a gametophyte composed of a protonema and gamete-producing gametophore
  - Bryophyte gametophytes
    - Produce flagellated sperm in antheridia and produce an egg in each archegonium
      - sperm swim through a film of water to reach and fertilize the egg
    - Generally form ground-hugging carpets and are at most only a few cells thick

32

- Rhizoids anchor gametophytes to substrate
- The height of gametophytes is constrained by lack of vascular tissues
  - some mosses have conducting tissues in the center of their “stems” and may grow vertically

33



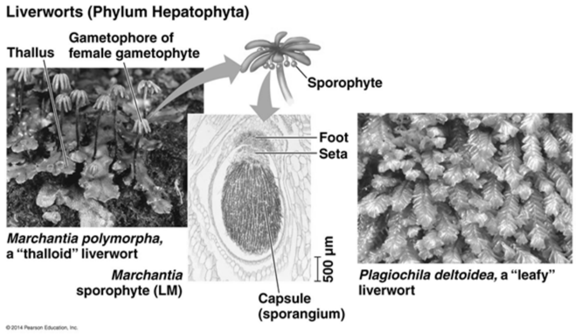
Bryophyte Sporophytes

- Bryophyte sporophytes
  - Grow out of archegonia
  - Are the smallest and simplest of all extant plant groups
  - Consist of a foot, a seta, and a sporangium
  - Hornwort and moss sporophytes have stomata for gas exchange

35

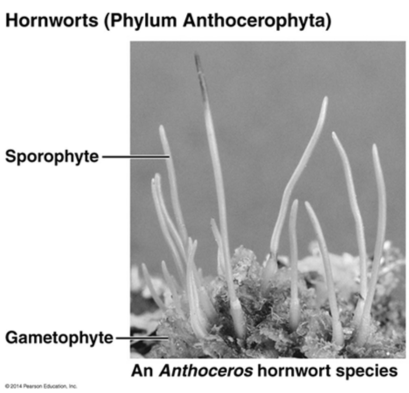
- Liverworts (Hepatophyta)
  - less conspicuous than mosses
  - plant body sometimes divided into lobes
  - life cycle similar to mosses
    - sporangia have coil-shaped cells (elaters) that spring out of capsule and disperse spores
  - can reproduce asexually from gemmae (plantlets)
    - released from cups on surface of gametophyte when hit by rainwater
  - greatest diversity in tropical forests

36



– Hornworts (Anthocerophyta)
  - resemble liverworts
    – sporophytes are horn-shaped and grow from mat-like gametophyte
  - photosynthetic cells have one large chloroplast

38



– Mosses (Bryophyta)
- tight pack of many mosses forms spongy layer that can absorb and retain water
- grips substratum with rhizoids
  - elongated cells or cellular filaments
- photosynthesis occurs mostly in stems and leaf-like structures in upper parts of plant
  - not homologous with similar structures in vascular plants
- cover about 3% of land surface
  - contain large amounts of organic carbon

40

Mosses (Phylum Bryophyta)

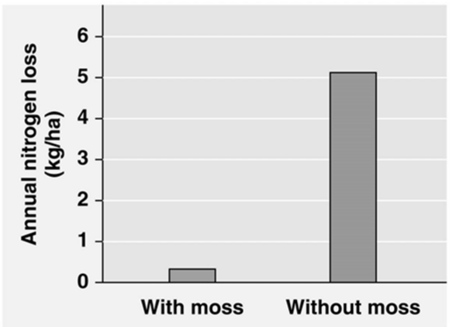
***Polytrichum commune*, hairy-cap moss**

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

42

Results



- Sphagnum, or “peat moss” forms extensive deposits of partially decayed organic material known as peat
  - Plays an important role in the Earth’s carbon cycle

44

(a) Peat being harvested from a peatland

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

Seedless Vascular Plants

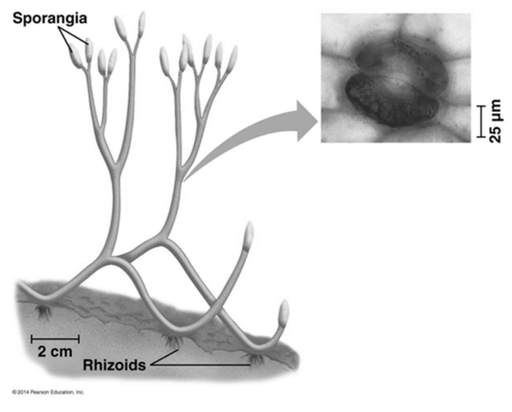
- Bryophytes and bryophyte-like plants were the prevalent vegetation during the first 100 million years of plant evolution
- Vascular plants began to evolve during the Devonian and Carboniferous periods
  - Vascular tissue allowed these plants to grow tall
  - Seedless vascular plants have flagellated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

46

Origins and Traits of Vascular Plants

- Fossils of the forerunners of vascular plants date back about 420 million years
- These early tiny plants had independent, branching sporophytes
  - Lacked other derived traits of vascular plants
- Living vascular plants are characterized by:
  - Life cycles with dominant sporophytes
  - Vascular tissues called xylem and phloem
  - Well-developed roots and leaves

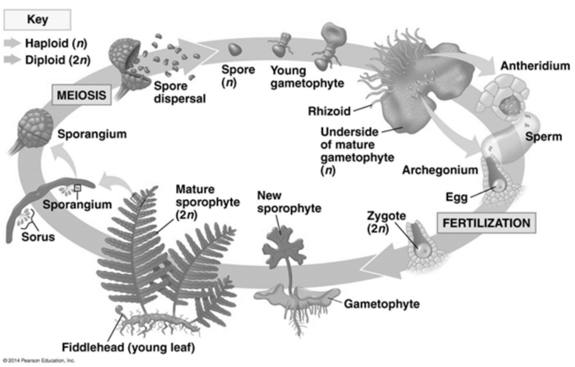
47



Life Cycles with Dominant Sporophytes

- In contrast with bryophytes sporophytes of seedless vascular plants are the larger generation, as in the familiar leafy fern
  - The gametophytes are tiny plants that grow on or below the soil surface

49



Transport in Xylem and Phloem

- Vascular plants have two types of vascular tissue
  - Xylem
    - Conducts most of the water and minerals
    - Includes dead cells called tracheids
  - Phloem
    - Distributes sugars, amino acids, and other organic products
    - Consists of living cells

51

Evolution of Roots

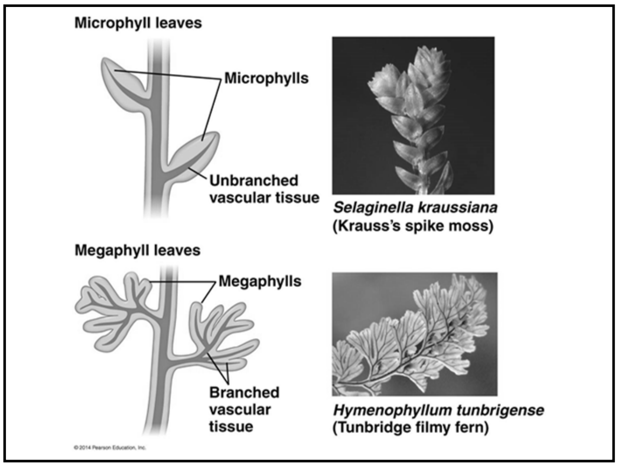
- Roots are organs that anchor vascular plants
  - Enable vascular plants to absorb water and nutrients from the soil
  - May have evolved from subterranean stems

52

Evolution of Leaves

- Leaves are organs that increase the surface area of vascular plants, thereby capturing more solar energy for photosynthesis
- Leaves are categorized by two types
  - Microphylls, leaves with a single vein
  - Megaphylls, leaves with a highly branched vascular system
- According to one model of evolution microphylls evolved first, as outgrowths of stems

53



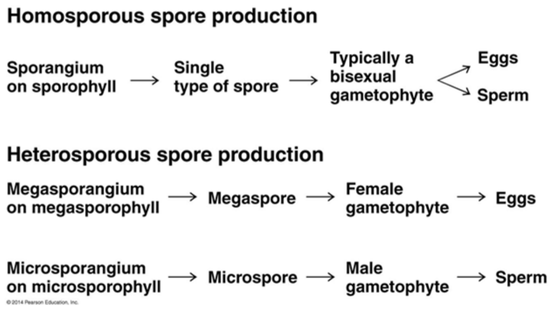
Sporophylls and Spore Variations

- Sporophylls are modified leaves with sporangia
  - Sori are clusters of sporangia on the undersides of sporophylls
  - Strobili are cone-like structures formed from groups of sporophylls

55

- 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
  - Megaspores give rise to female gametophytes and microspores give rise to male gametophytes

56



Classification of Seedless Vascular Plants

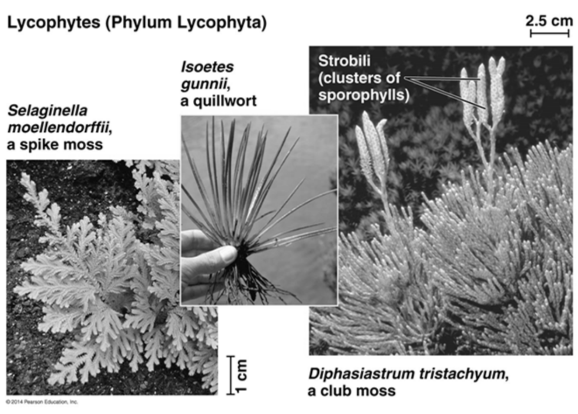
- Seedless vascular plants form two phyla
  - Lycophyta, including club mosses, spike mosses, and quillworts
  - Pterophyta, including ferns, horsetails, and whisk ferns and their relatives

58

Phylum Lycophyta: Club Mosses, Spike Mosses, and Quillworts

- Modern species of lycophytes are relics from a far more eminent past
  - Survived through Devonian and dominated land during Carboniferous
  - Some temperate, low-growing plants with rhizomes and true leaves
  - Modern lycophytes are small herbaceous plants
    - some species of lycophytes are epiphytes
  - Club mosses and spike mosses have vascular tissues and are not true mosses

59

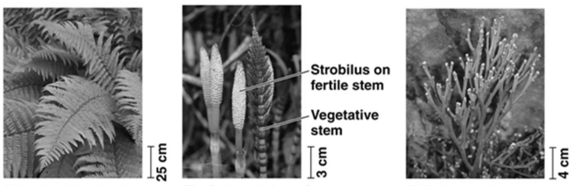


Phylum Monilophyta: Ferns and Their Relatives

- Ferns are the most diverse seedless vascular plants
  - Psilophytes, the whisk ferns, used to be considered a “living fossil”
    - dichotomous branching and lack of true leaves and roots seemed similar to early vascular plants
      - comparisons of DNA sequences and ultrastructural details, indicate that the lack of true roots and leaves evolved secondarily
  - Sphenophytes
    - commonly called horsetails because of their often brushy appearance

61

Monilophytes (Phylum Monilophyta)



***Athyrium filix-femina*, lady fern** ***Equisetum telmateia*, giant horsetail** ***Psilotum nudum*, a whisk fern**

- During the Carboniferous, sphenophytes grew to 15m
  - survive as about 15 species in a single wide-spread genus, *Equisetum*
  - often found in marshy habitats and along streams and sandy roadways
- Roots develop from horizontal rhizomes that extend along the ground
- Upright green stems, the major site of photosynthesis, also produce tiny leaves or branches at joints

63

- Horsetail stems have a large air canal to allow movement of oxygen into the rhizomes and roots, which are often in low-oxygen soils
- Reproductive stems produce cones at their tips
  - these cones consist of clusters of sporophylls
  - sporophylls produce sporangia with haploid spores

64

- Ferns
  - First appeared in Devonian
    - coexisted with tree lycopods and horsetails in Carboniferous forests
  - Most represented of modern seedless plants
    - more than 12,000 existing species; most diverse in tropics
  - Generally larger than lycopods and have a different evolutionary origin
    - lycopods have microphylls-small leaves, evolved from stem emergences, with single vascular strand
    - ferns have megaphylls-leaves with branched vein system

65

- Have compound leaves
  - coiled frond unfurls as it grows
  - leaves may sprout directly from stem
- The leafy fern is homosporous sporophyte
  - specialized sporophylls have sporangia on undersides
    - can be arranged in clusters called sori
    - equipped with spring-like devices to catapult spores into the air; increases spore dispersal
- The free-living gametophyte requires moist environment
  - water is necessary for fertilization

66

- flagellated sperm cells must swim from antheridium to archegonium
- sporophyte embryo develops in archegonium

67

The Significance of Seedless Vascular Plants

- The ancestors of modern lycophytes, horsetails, and ferns grew to great heights during the Carboniferous, forming the first forests
- The growth of these early forests may have helped produce the major global cooling that characterized the end of the Carboniferous period
  - This material decayed and eventually became coal

68