Plant Diversity

Ch 30

- From Sea to Land
- Origins, Relationships, Diversity
- Shared Derived Traits (Synapomorphies)
- Nonvascular to Vascular Plants
- Seedless to Seeds

Videos 28-3, 28-5

03 March 2009
ECOL 182R UofA
K. E. Bonine

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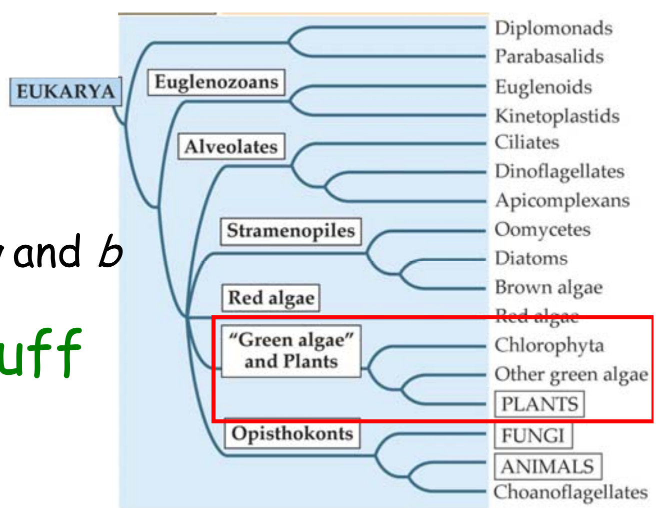
The Evolution of Land Plants

(from the edge of the swamp…)

•chlorophylls *a* and *b*

Green stuff



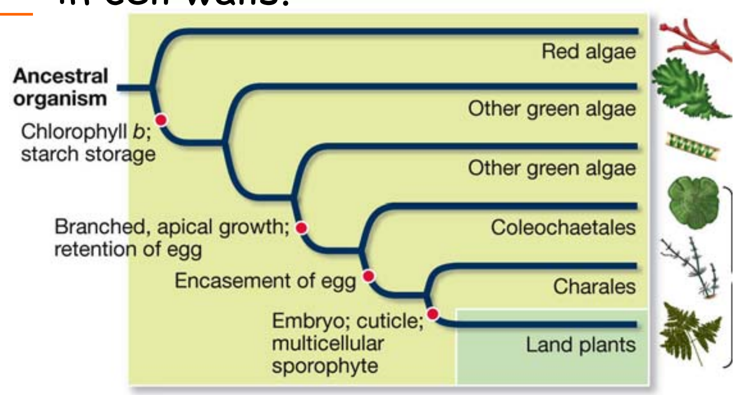
Original Land Plants Related to Algae

Land plants retain derived features they share with green algae (*Charales*):

_____________ and

______ as a storage product.

______ in cell walls.



Land Plants are Monophyletic

Land plants are monophyletic, all descend from a single common ancestor.

One synapomorphy: development from an embryo protected by tissues of the parent plant. Therefore, also called embryophytes.

(*phyton* = plant)

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Land Plants Comprise ~Ten Clades

Nonvascular (3 clades)

- -paraphyletic group
- -liverworts,
- -hornworts
- -mosses

Vascular plants, or *tracheophytes* (7 clades)—all have conducting cells called -**tracheids**.

- -monophyletic group

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Moving to Land

Plants first appeared on land between 400–500 million years ago.

Environmental Challenges:

1.
2. transport to all parts
3. (fight gravity)
4. disperse .

Some challenges met immediately, others took millions of years

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Biological history

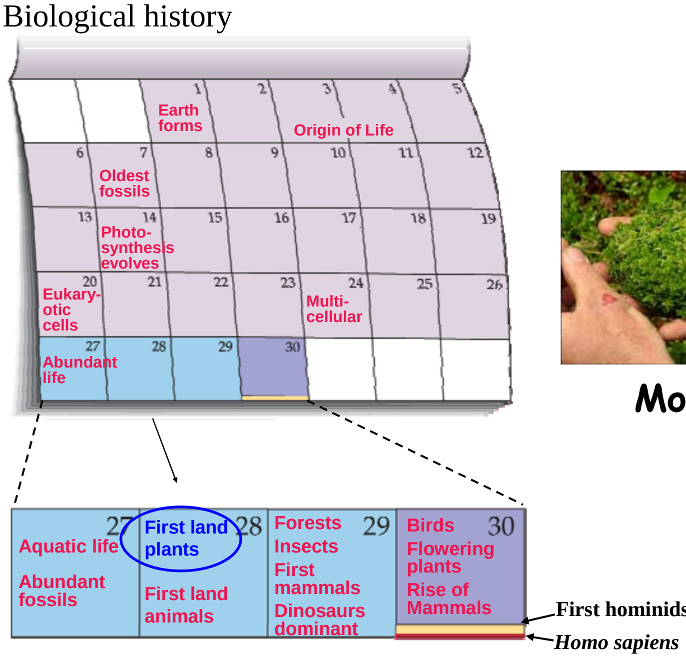
22.1 Earth's Geological History (Part 2)

RELATIVE TIME SPAN	ERA	PERIOD	ONSET	MAJOR EVENTS IN THE HISTORY OF LIFE
	Cenozoic	Quaternary	1.8 mya[a]	Humans evolve; many large mammals become extinct
		Tertiary	65 mya	Diversification of birds, mammals, flowering plants, and insects
	Mesozoic	Cretaceous	144 mya	Dinosaurs continue to diversify; flowering plants and mammals diversify. **Mass Extinction** at end of period (≈76% of species disappear)
		Jurassic	206 mya	Diverse dinosaurs; radiation of ray-finned fishes
		Triassic	248 mya	Early dinosaurs; first mammals; marine invertebrates diversify; first flowering plants; **Mass Extinction** at end of period (≈65% of species disappear)
	Paleozoic	Permian	290 mya	Reptiles diversify; amphibians decline; **Mass Extinction** at end of period (≈96% of species disappear)
		Carboniferous	354 mya	Extensive "fern" forests; first reptiles; insects diversify
		Devonian	417 mya	Fishes diversify; first insects and amphibians. **Mass Extinction** at end of period (≈75% of species disappear)
		Silurian	443 mya	Jawless fishes diversify; first ray-finned fishes; plants and animals colonize land
		Ordovician	490 mya	**Mass Extinction** at end of period (≈75% of species disappear)
		Cambrian	543 mya	Most animal phyla present; diverse algae
Precambrian	Precambrian		600 mya	Ediacaran fauna
			1.5 bya[a]	Eukaryotes evolve; several animal phyla appear
			3.8 bya	Origin of life; prokaryotes flourish
			4.5 bya	

[a]mya, million years ago; bya, billion years ago.

Plants first appeared on land between 400-500 million years ago.

Biological history



Moss

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Adaptations for Land

1. Cuticle
   - waxy covering that retards water ________
2. Gametangia enclosing gametes
3. Embryos in a protective structure
4. Pigments that protect against UV radiation
5. Spore walls containing sporopollenin
   - resists desiccation and ________
6. Mutualistic relationships with fungus
   - to promote ________ from soil

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Plants Help Create Soil

Ancient plants contributed to soil formation.

Acids secreted by plants help break down rock.

Organic material from dead plants contributes to soil structure.

Create habitat and pave way for succession of other species.

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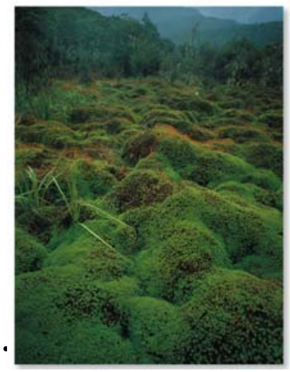
Nonvascular Plants Are Similar to Ancestral Land Plants

Today's nonvascular plants are thought to be similar to the first land plants.

They grow in moist environments in dense mats

They are small, there is no system to conduct water from soil to plant body parts.



mosses

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Traits of Nonvascular Plants

Growth pattern of nonvascular plants allows water to move through mats by capillary action.

Minerals can be distributed through the small plants by diffusion.

Mutualistic relationship with fungi called glomeromycetes which promote absorption of water and minerals.

mosses

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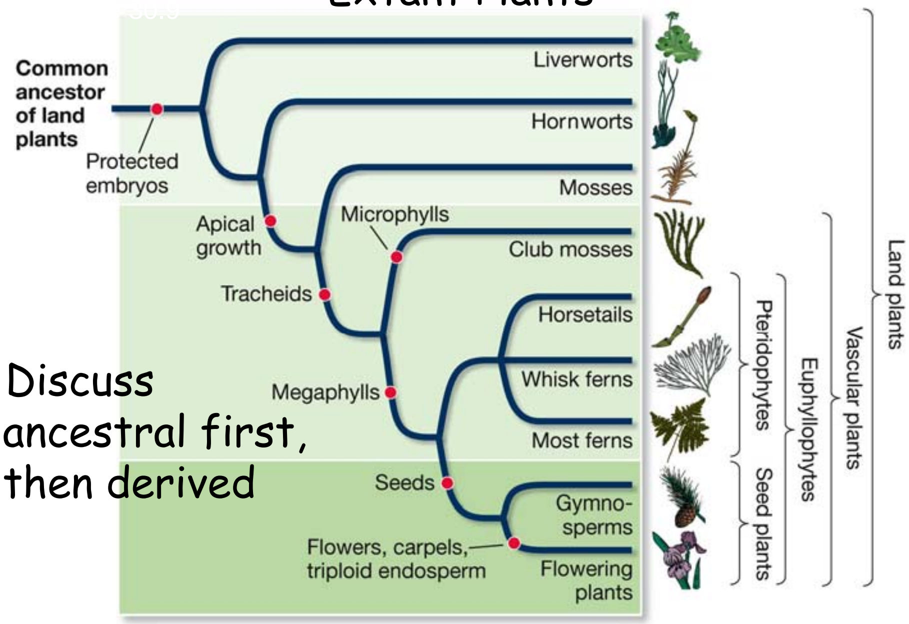
Extant Plants



Discuss ancestral first, then derived

LIFE 8e, Figure 28.7

Three Nonvascular Clades

(paraphyletic group)

Liverworts

(C) *Marchantia* sp.

Hornworts

Anthoceros sp.

Mosses

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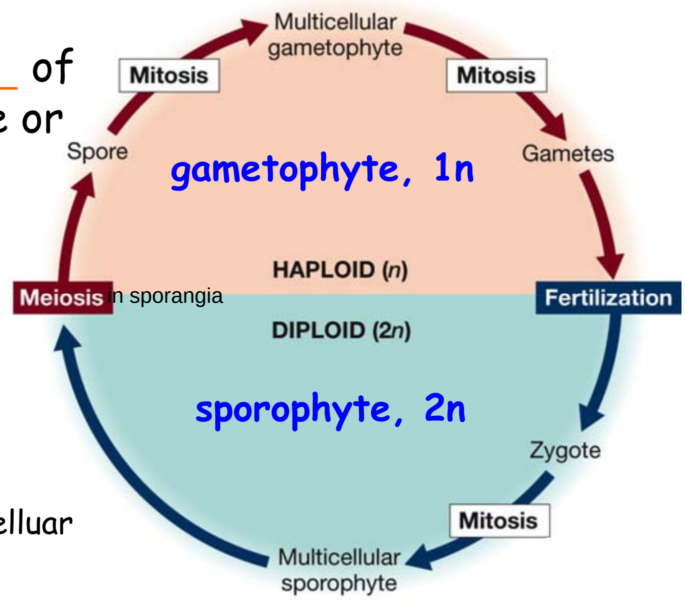
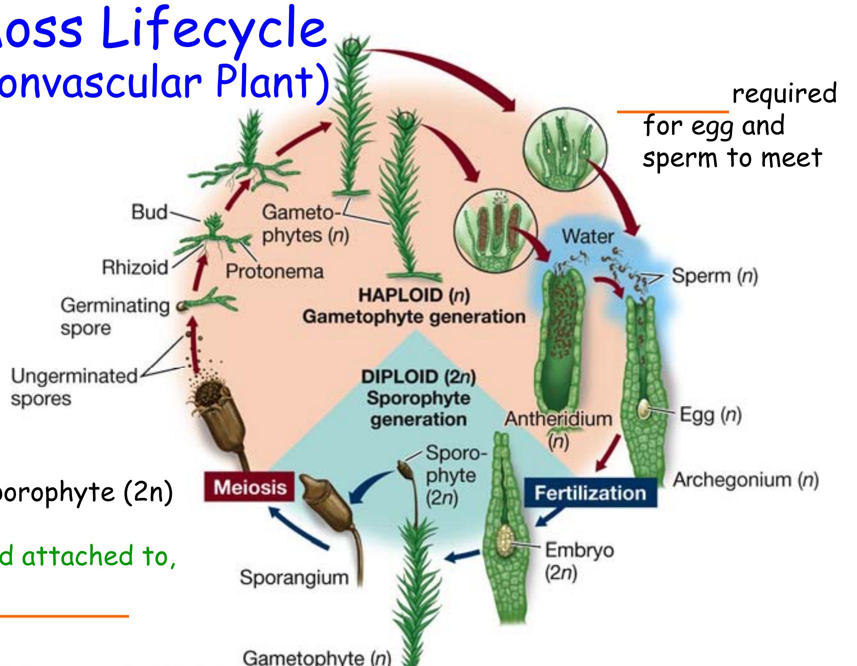
Alternation of Generations

and
______________ of
gametophyte or
sporophyte
changes



All plants have
alternation of
generations
(= multicellular
haploid & multicelluar
diploid)

Moss Lifecycle
(Nonvascular Plant)



_______ required
for egg and
sperm to meet

Sporophyte (2n)

and attached to,

____

LIFE 8e, Figure 28.5 (Part 1)

Nonvascular: Gametophyte Dominates

In nonvascular plants:

gametophyte is larger, longer-lived, and more self-sufficient than the sporophyte.

gametophyte generation is ________ .

sporophyte may or may not be photosynthetic, but is always nutritionally dependent on the gametophyte, and is permanently attached.

________ of the ________ generation is a major theme in plant evolution.

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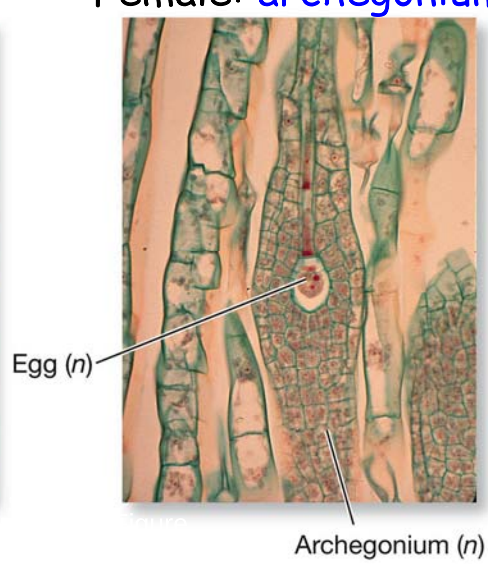
Nonvascular Plant Reproduction

Male: antheridium

Female: archegonium



Nonvascular Plant Reproduction

Base of archegonium grows to protect embryo during early development.

(land plants aka **embryophytes**)

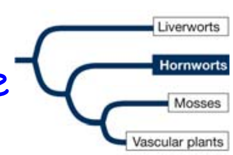
Nonvascular Diversity

Hornworts: **Anthocerophyta**—100 species.

Gametophytes are flat plates of cells.

Have stomata, which do not close.

Hornwort cells have a single, large chloroplast.



The sporophyte has no stalk; but has a basal region capable of infinite cell division. Sporophytes can grow up to 20 cm.

Hornworts have internal cavities filled with nitrogen-fixing cyanobacteria.

Life cycle of a moss

Video
28-3

Mosses are ________________ group to ________________ plants

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Moss…

Sphagnum grows in swampy places.

The upper layers of moss compress lower layers that are beginning to decompose, forming *peat*.

Long ago, continued compression led to the formation of ________.

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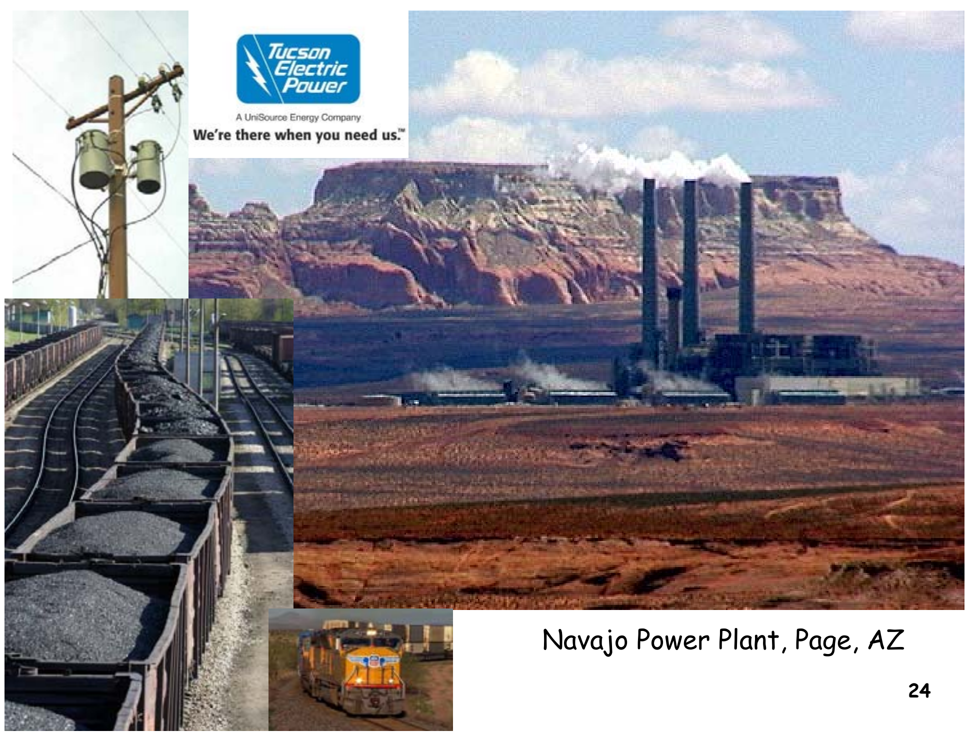
LIFE 8e, Figure 28.15



Navajo Power Plant, Page, AZ

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Paleozoic: Carboniferous

- Large glaciers and swamp forests of treeferns and horsetails.

- Fossilized forests formed the we now mine for
  ________.

Vascular Plants Arose from Nonvascular

Recently, fossilized fragments of ancient liverworts have been discovered.

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Vascular Plants Comprise Seven Clades

10 clades of land plants:

Nonvascular (3 clades)
- -liverworts, hornworts, and mosses
- -paraphyletic group

Vascular plants, or *tracheophytes* (7 clades)
- -conducting cells called **tracheids**.
- -monophyletic group

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Seedless Vascular Plants

TABLE 28.1

Classification of Land Plants

	GROUP	COMMON NAME	CHARACTERISTICS
	NONVASCULAR PLANTS		
1	Hepatophyta	Liverworts	No filamentous stage; gametophyte flat
2	Anthocerophyta	Hornworts	Embedded archegonia; sporophyte grows basally (from the ground)
3	Bryophyta	Mosses	Filamentous stage; sporophyte grows apically (from the tip)
	VASCULAR PLANTS		
4	Lycophyta	Club mosses and allies	Microphylls in spirals; sporangia in leaf axils
5	Pteridophyta	Horsetails, whisk ferns, ferns	Differentiation between main stem and side branches (overtopping growth)
	SEED PLANTS		
	Gymnosperms		
6	Cycadophyta	Cycads	Compound leaves; swimming sperm; seeds on modified leaves
7	Ginkgophyta	Ginkgo	Deciduous; fan-shaped leaves; swimming sperm
8	Gnetophyta	Gnetophytes	Vessels in vascular tissue; opposite, simple leaves
9	Coniferophyta	Conifers	Seeds in cones; needle-like or scale-like leaves
10	Angiosperms	Flowering plants	Endosperm; carpels; gametophytes much reduced; seeds within fruit

Note: No extinct groups are included in this classification.

Traits of Vascular Plants

The **vascular system** consists of tissue specialized for the transport of materials.

________ conducts water and minerals from soil up to aerial parts of plant. Some cells have *lignin*—provides support.

Tracheids are the main water-conducting element in xylem. Angiosperms have tracheids plus a more efficient system of vessels and fibers.

________ conducts products of photosynthesis through plant.

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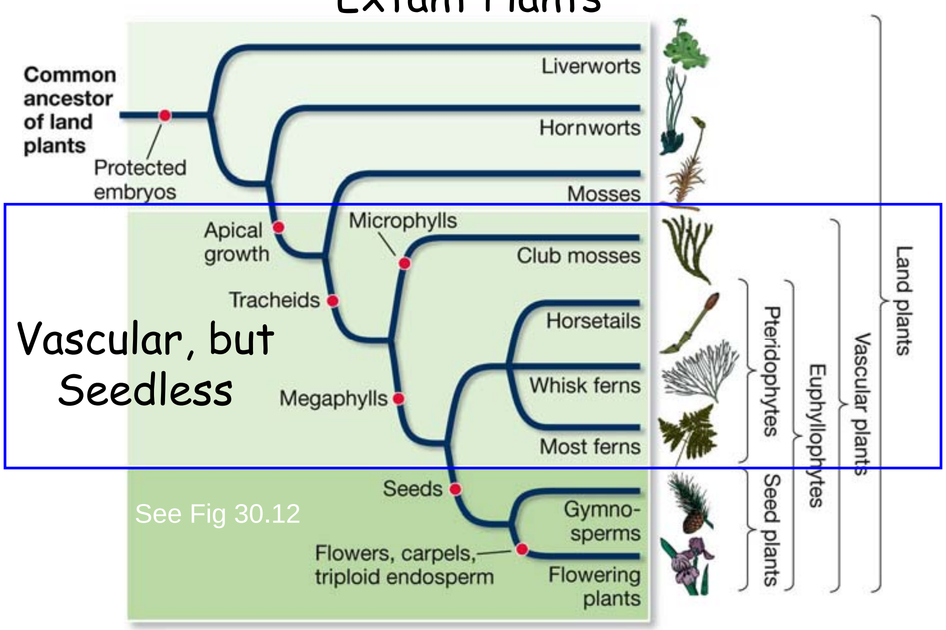
Extant Plants



LIFE 8e, Figure 28.7

Evolution of Vascular Plants

Vascular plants have a branching, __________________

Mature sporophyte is nutritionally independent from the gametophyte.

Still must have water for part of the life cycle—for the flagellated, swimming sperm.

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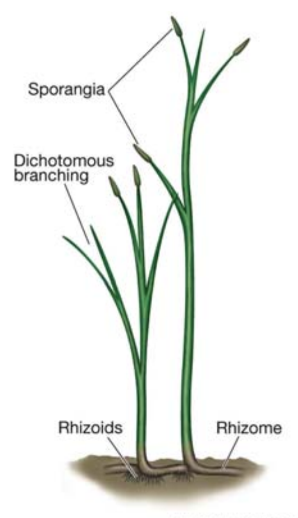
Evolution of Vascular Plants

Earliest vascular plants (now extinct):

Rhyniophytes (Silurian) had dichotomous branching, but lacked leaves and roots.

They were anchored by **rhizomes** (horizontal portions of stem) and **rhizoids** (water-absorbing filaments).

Earliest vascular plants _________ _____



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Evolution of Vascular Plants

Lycophytes appeared in the Silurian.

Pteridophytes appeared in the Devonian.

These groups had true roots and leaves, and two types of spores.

Overtopping evolved --new branches grow beyond the others—an advantage in the competition for light

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Evolution of Vascular Plants

Leaf: a flattened photosynthetic structure arising from a stem or branch; has true vascular tissue.

Two types: microphylls and megaphylls.

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Evolution of Leaves

Small megaphylls first appeared in the Devonian. Large megaphylls did not appear until the Carboniferous.

One theory: high CO_2 concentrations in the Devonian prevented development of *stomata*.

Stomata allow heat to be lost by the evaporation of water. Large leaves with no stomata would have resulted in

___________.

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Evolution of Vascular Plants

Horsetails: Fifteen species in one genus—*Equisetum*.

Silica in cell walls—"scouring rushes."

Have true roots

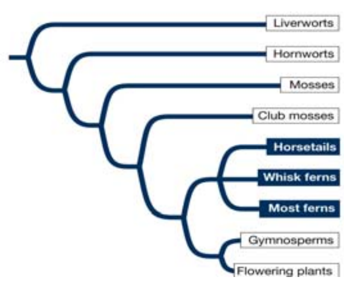

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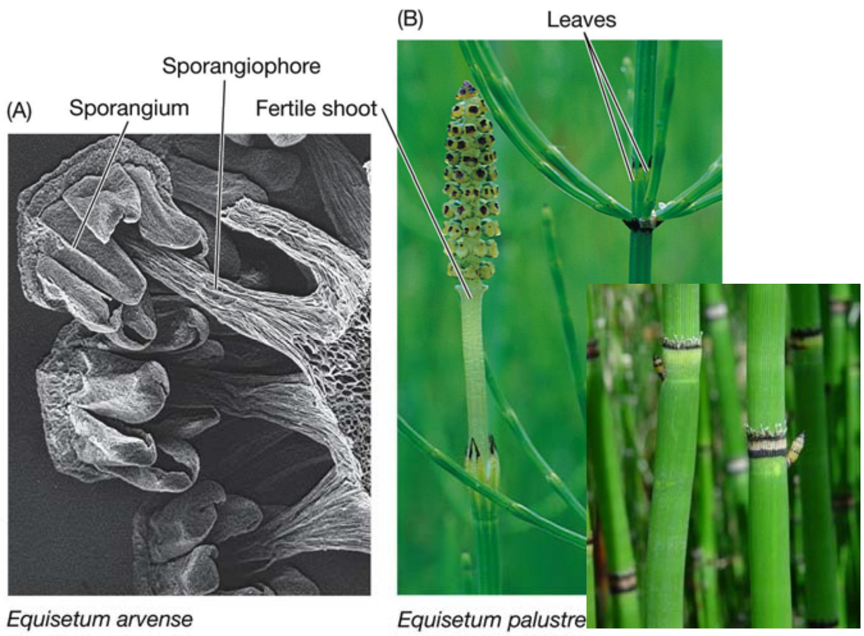
Figure 28.17 Horsetails



LIFE 8e, Figure 28.17

Evolution of Vascular Plants

Ferns: 12,000 species. About 97 percent are in a clade—leptosporangiate ferns—sporangia walls only one cell thick, borne on a stalk.

Sporophytes have true roots, stems, and leaves.

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Figure 28.19 Fern Leaves Take Many Forms

(A)

Adiantum pedatum

(B)

LIFE 8e, Figure 28.19 (Part 1)

Ferns…

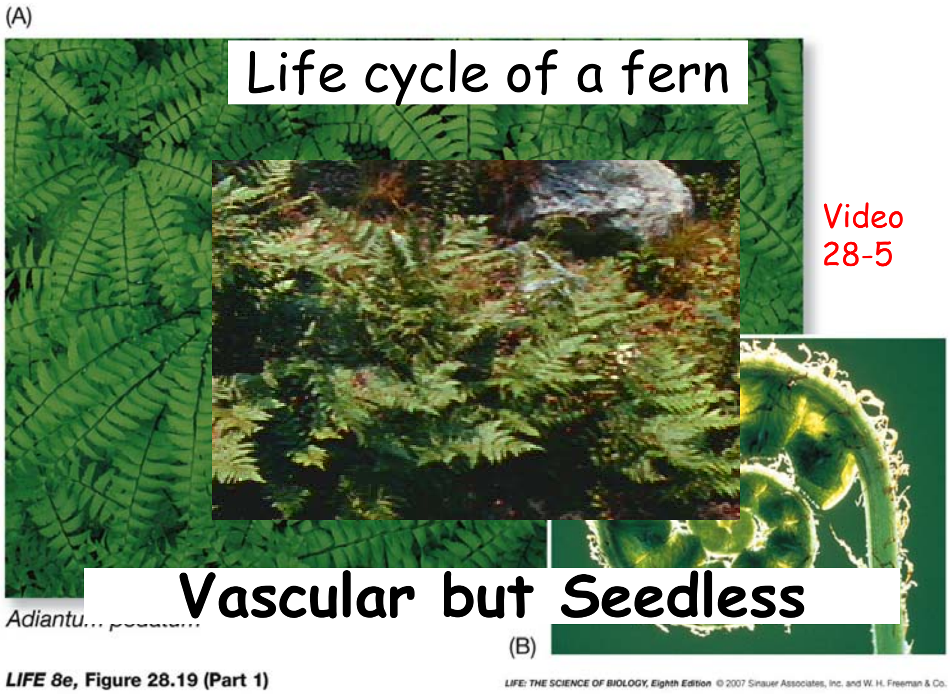
Most ferns are in shaded, moist environments.

Tree ferns can reach heights of 20 m.

Sporangia occur on undersides of leaves in clusters called *sori*.

Some genera have a tuberous gametophyte that depends on a mutualistic fungus for nutrition.

40



(A)
Life cycle of a fern
Video 28-5
Vascular but Seedless
Adiantu...
(B)
LIFE 8e, Figure 28.19 (Part 1)
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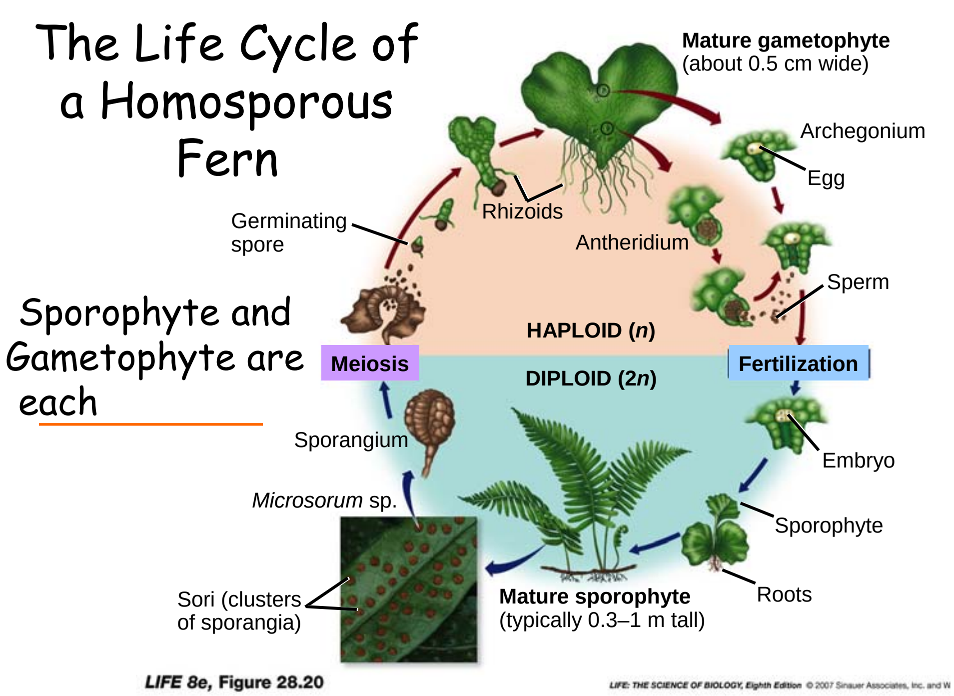

The Life Cycle of a Homosporous Fern
Sporophyte and Gametophyte are each
Mature gametophyte (about 0.5 cm wide)
Archegonium
Egg
Rhizoids
Antheridium
Germinating spore
Sperm
HAPLOID (n)
DIPLOID (2n)
Meiosis
Fertilization
Sporangium
Embryo
Microsorum sp.
Sporophyte
Sori (clusters of sporangia)
Mature sporophyte (typically 0.3–1 m tall)
Roots
LIFE 8e, Figure 28.20
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Ferns…

DNA research suggests that diversification of modern ferns is fairly recent.

Ferns may have taken advantage of shady environments created by angiosperm trees.

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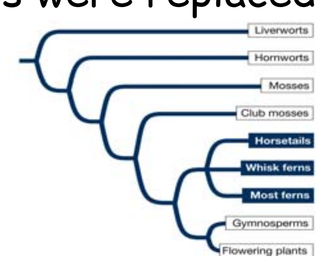
Early Vascular Plants

During the Permian, the continents came together to form Pangaea.

Extensive glaciation occurred late in the Permian.

Lycophyte-fern forests were replaced by gymnosperms.



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Bristlecone Pine

If you could imagine a living tree as old as the pyramids of Egypt, what do you think it would look like? It would look like a bristlecone pine, *Pinus longaeva*, the_______ known tree species in the world.

The bristlecone pine only lives in scattered, arid mountain regions of six western states of America, but the oldest are found in the Ancient Bristlecone Pine Forest in the White Mountains of California. There the pines exist in an exposed, windswept, harsh environment, free of competition from other plants and the ravages of insects and disease. The oldest bristlecones usually grow at elevations of 10,000 to 11,000 feet.

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Bristlecone Pine

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sec ... ing
son ... as
he ... ld,
his
Se
Pro ... s a
30 ... ilt
in Egypt.

Laboratory of Tree-Ring Research
http://www.ltrr.arizona.edu/

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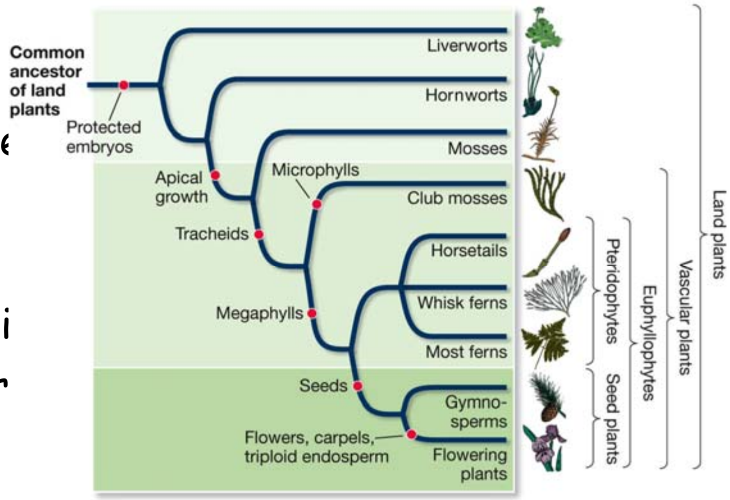
Which of the following are vascular plants?

a Juniper
b Sunflowe
c Fern
d Moss
e Horsetai
f Liverwor
g Lily



LIFE 8e, Figure 28.7