Chapter 30

Plant Diversity II: The Evolution of Seed Plants

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Overview: Transforming the World

- Seeds changed the course of plant evolution, enabling their bearers to become the dominant producers in most terrestrial ecosystems.
- A ***seed*** consists of an *embryo* and *nutrients* surrounded by a *protective coat*.
- The gametophytes of seed plants develop within the walls of spores that are retained within tissues of the parent sporophyte.

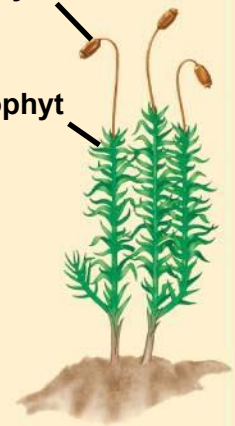
What human reproductive organ is functionally similar to this seed?

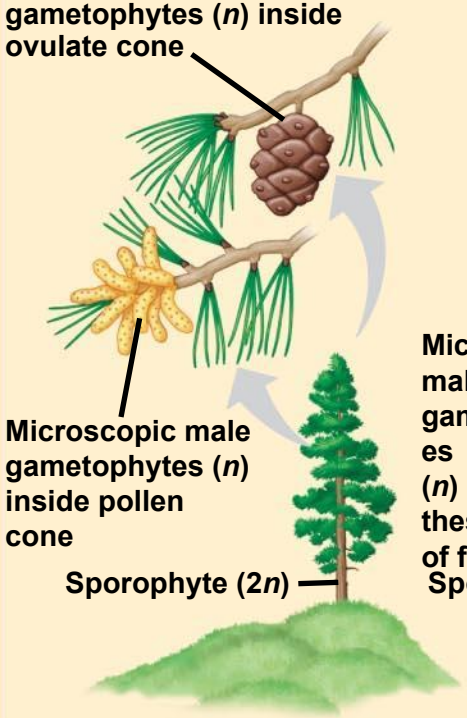
Seeds and pollen grains are key adaptations for life on land

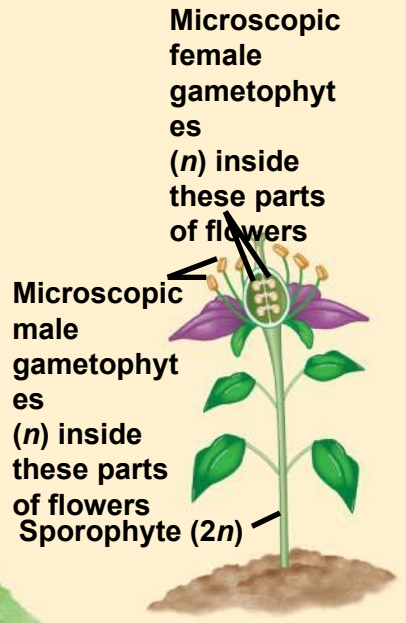
- In addition to seeds, the following are common to all seed plants:
  - Reduced gametophytes
  - Heterospory
  - Ovules
  - Pollen

Gametophyte / sporophyte relationships in different plant groups

	PLANT GROUP		
	Mosses and other nonvascular plants	Ferns and other seedless vascular plants	Seed plants (gymnosperms and angiosperms)
Gametophyte	Dominant	Reduced, independent (photosynthetic and free-living)	Reduced (usually microscopic), dependent on surrounding sporophyte tissue for nutrition
Sporophyte	Reduced, dependent on gametophyte for nutrition	Dominant	Dominant
Example			Gymnosperm / Angiosperm







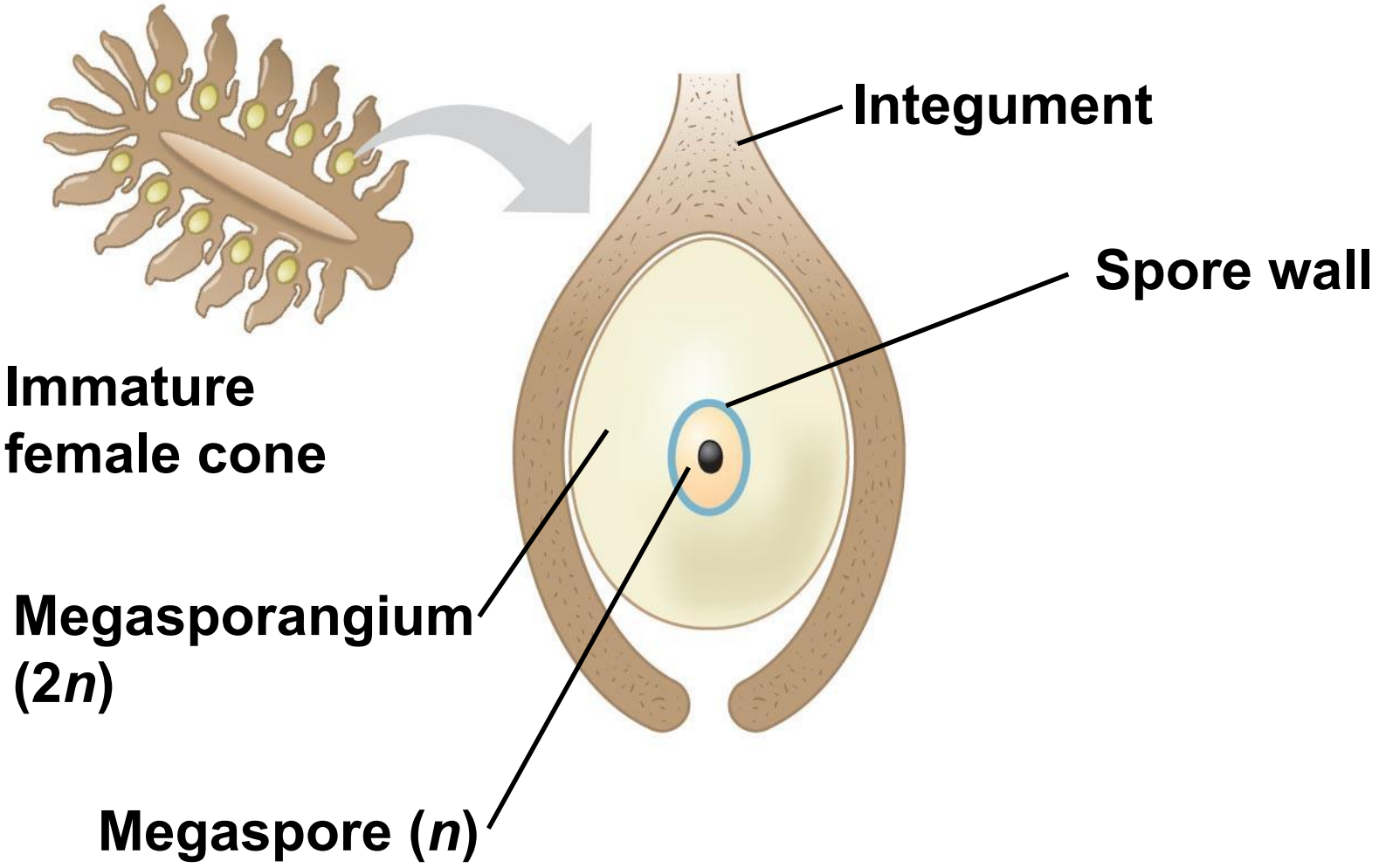
Heterospory: The Rule Among Seed Plants

- The ancestors of seed plants were likely homosporous, while seed plants are heterosporous.
- *Megasporangia* produce *megaspores* that give rise to *female* gametophytes.
- *Microsporangia* produce *microspores* that give rise to *male* gametophytes.

Ovules and Production of Eggs

- An ***ovule*** consists of a *megasporangium*, *megaspore*, *and one or more protective integuments*.
- A *fertilized ovule* becomes a *seed*.
- Gymnosperm megaspores have one integument.
- Angiosperm megaspores usually have two integuments.

From ovule to seed in a gymnosperm

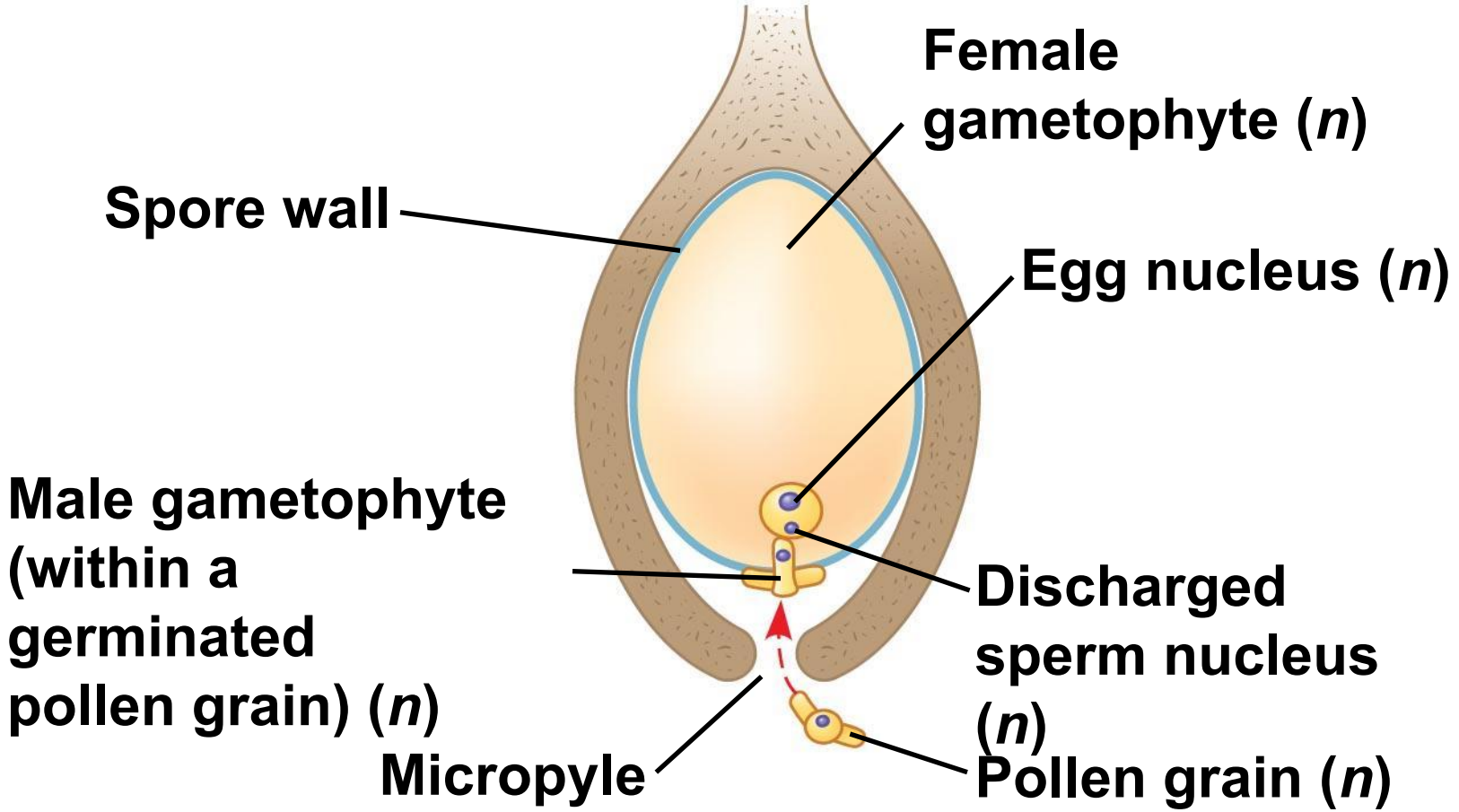


(a) Unfertilized ovule

Pollen and Production of Sperm

- *Microspores* develop into ***pollen grains***, which contain the *male gametophytes*.
- ***Pollination*** is the *transfer of pollen* from the *male to* the *female* part containing the ovules.
- Pollen eliminates the need for a film of water and can be dispersed great distances by air or animals.
- If a pollen grain germinates, it gives rise to a pollen tube that discharges two sperm into the female gametophyte within the ovule.

From ovule to seed in a gymnosperm

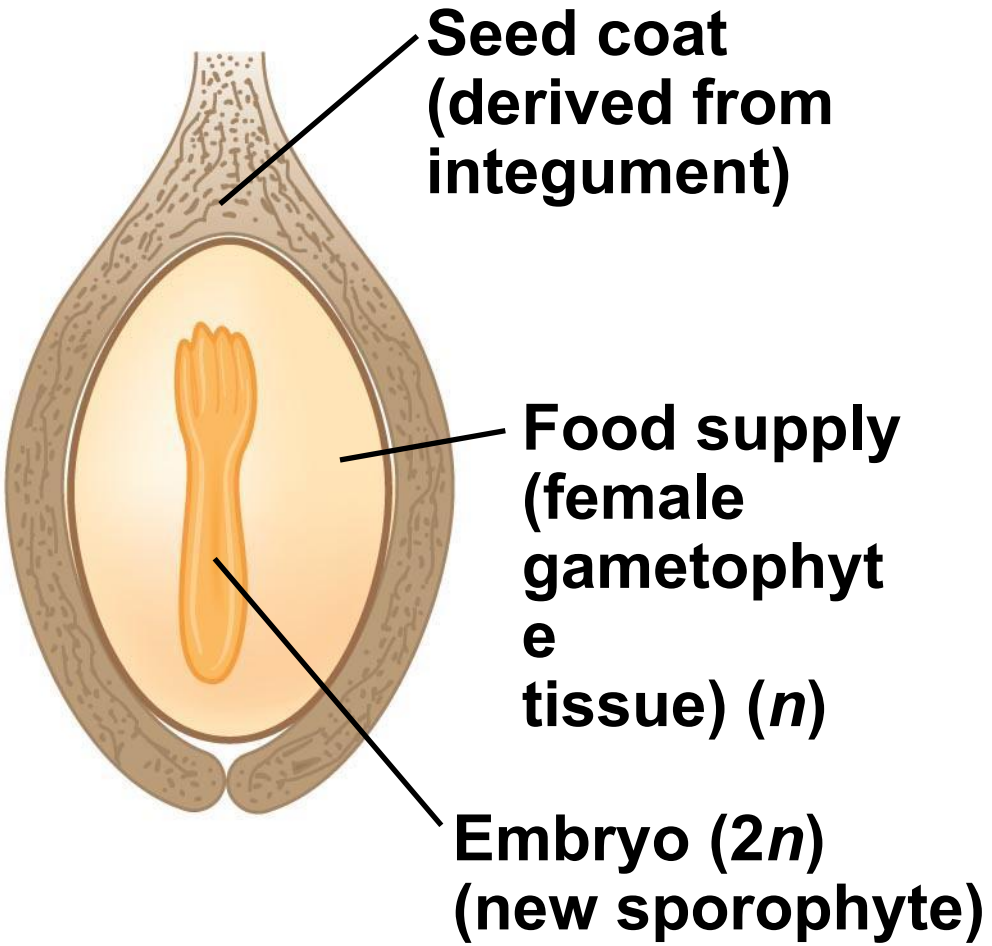


(b) Fertilized ovule

The Evolutionary Advantage of Seeds

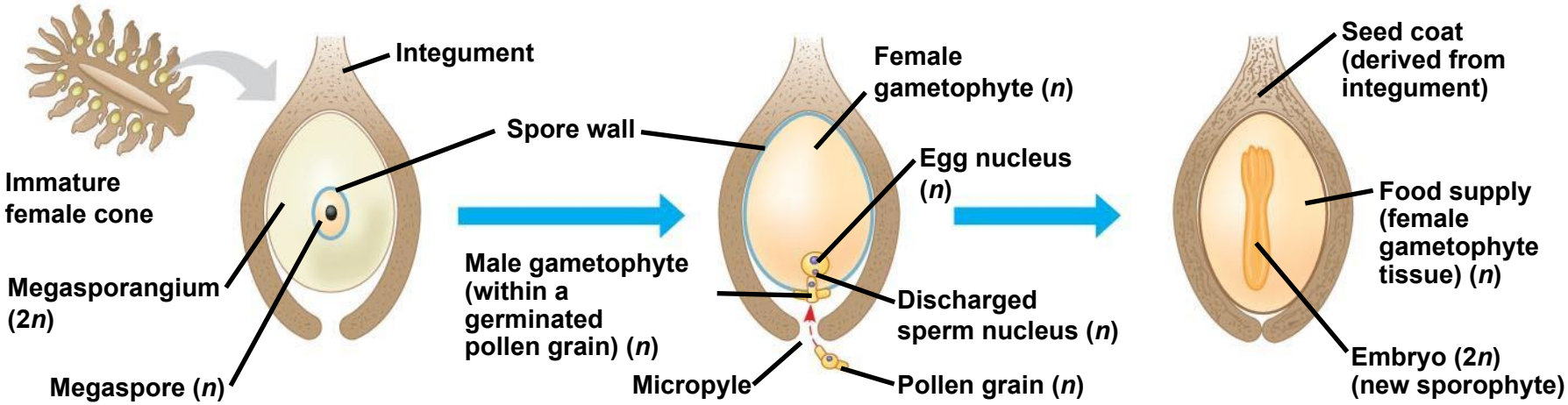
- A seed develops from the whole ovule.
- A seed is a sporophyte embryo, along with its food supply, packaged in a protective coat.
- *Seeds* provide some *evolutionary advantages* over spores:
  - They *may remain dormant* for days to years, until conditions are favorable for germination.
  - They *may be transported long distances by wind or animals*.

From ovule to seed in a gymnosperm



(c) Gymnosperm seed

From ovule to seed in a gymnosperm



(a) Unfertilized ovule

(b) Fertilized ovule

(c) Gymnosperm seed

Gymnosperms bear "naked" seeds, typically on cones

- The *gymnosperms* have *"naked" seeds* not enclosed by ovaries and exposed on modified leaves - *cones*. There are four phyla:
  - Cycadophyta (cycads)
  - Gingkophyta (one living species: *Ginkgo biloba*)
  - Gnetophyta (three genera: *Gnetum, Ephedra, Welwitschia*)
  - Coniferophyta (conifers, such as pine, fir, and redwood).

- Seed plants can be divided into two clades: gymnosperms and angiosperms.
- Gymnosperms appear early in the fossil record and dominated the Mesozoic terrestrial ecosystems.
- Gymnosperms were better suited than nonvascular plants to drier conditions.
- Today, *cone-bearing gymnosperms* called ***conifers*** dominate in the northern latitudes.

Phylum Ginkgophyta

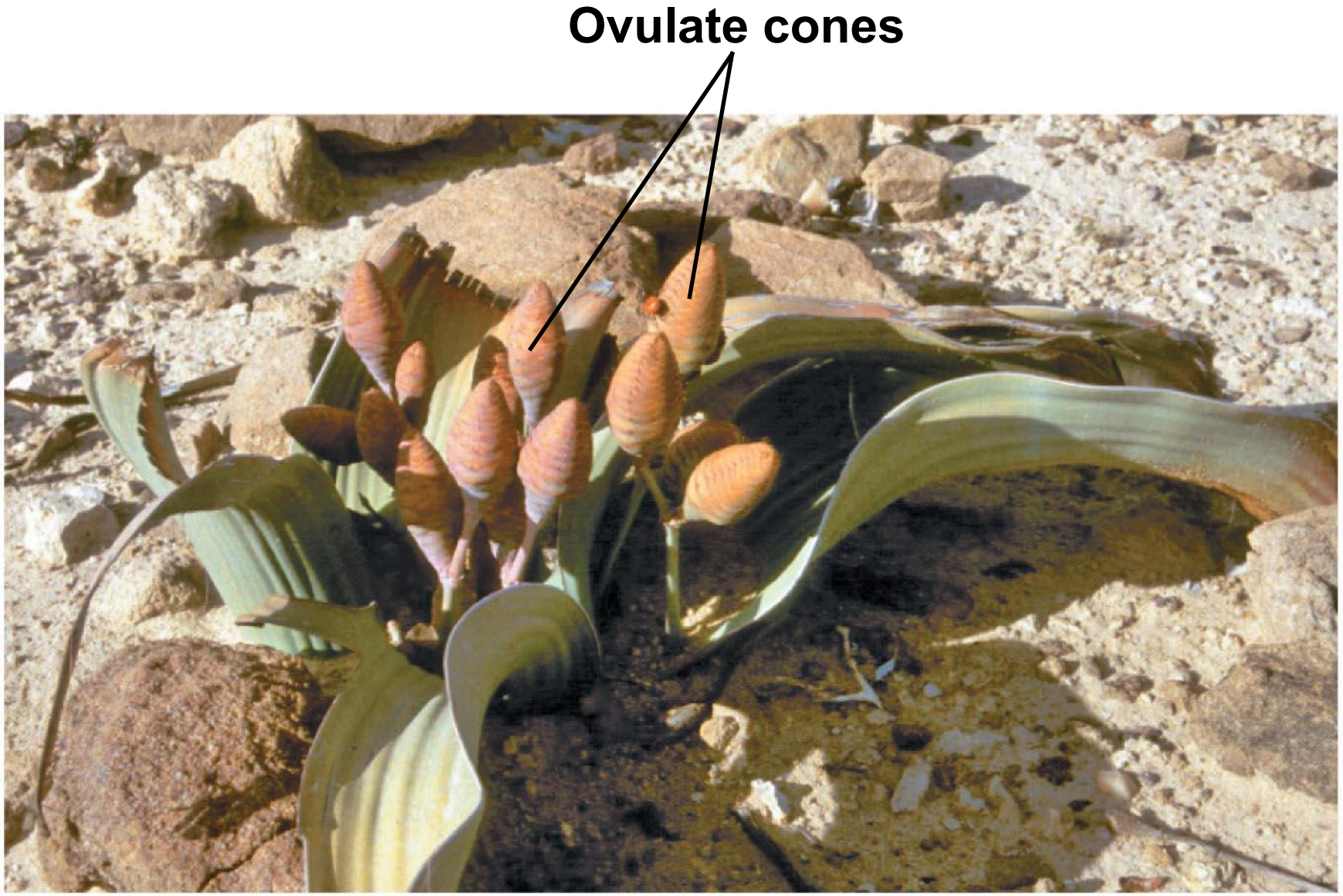
- This phylum consists of a single living species, *Ginkgo biloba.*
- It has a high tolerance to air pollution and is a popular ornamental tree.

Gymnosperm

Ginkgo biloba

Pollen-producing tree with fleshy seeds

Gymnosperm



Welwitschia

Phylum Coniferophyta

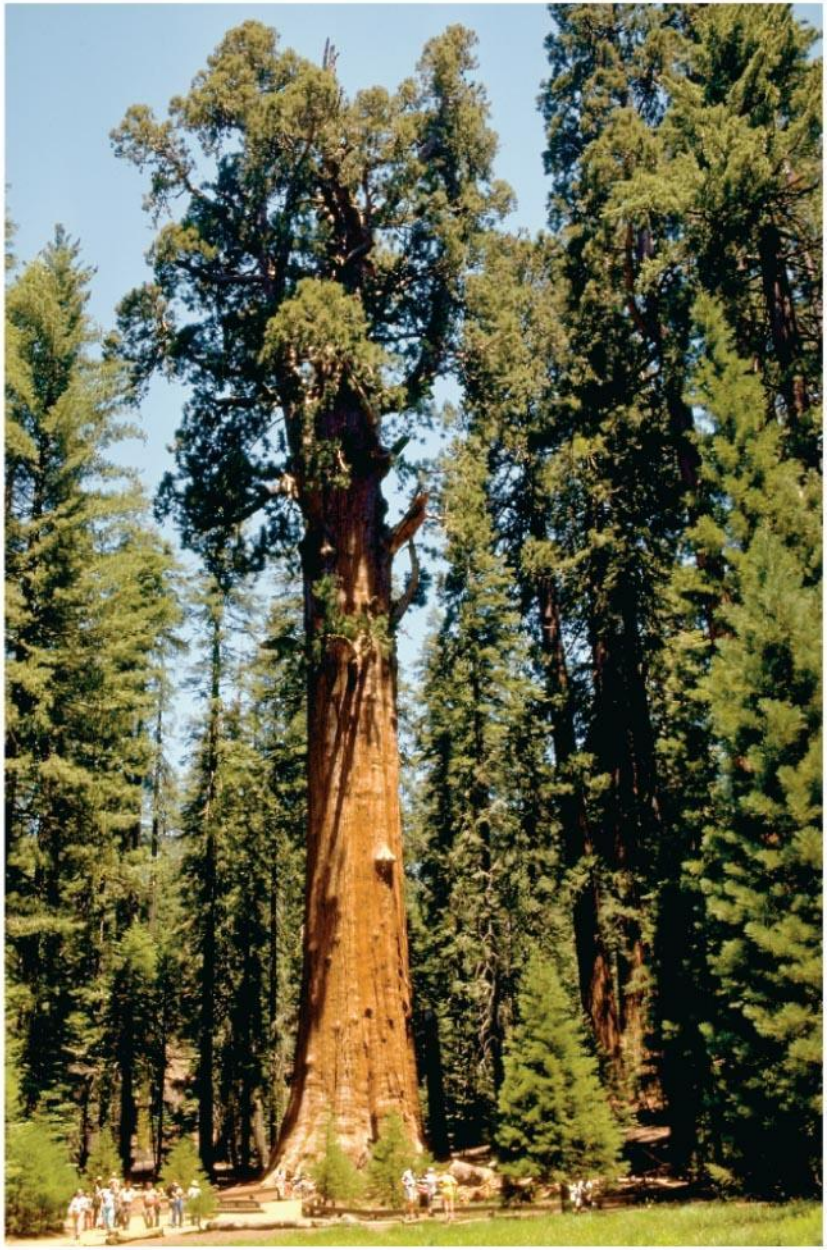
- This phylum is by far the largest of the gymnosperm phyla.
- Most conifers are evergreens and can carry out photosynthesis year round.

Gymnosperms: Conifers perform year round photosynthesis

Douglas fir

Gymnosperms: Conifers

Sequoia - One of the Largest and Oldest Living Organisms

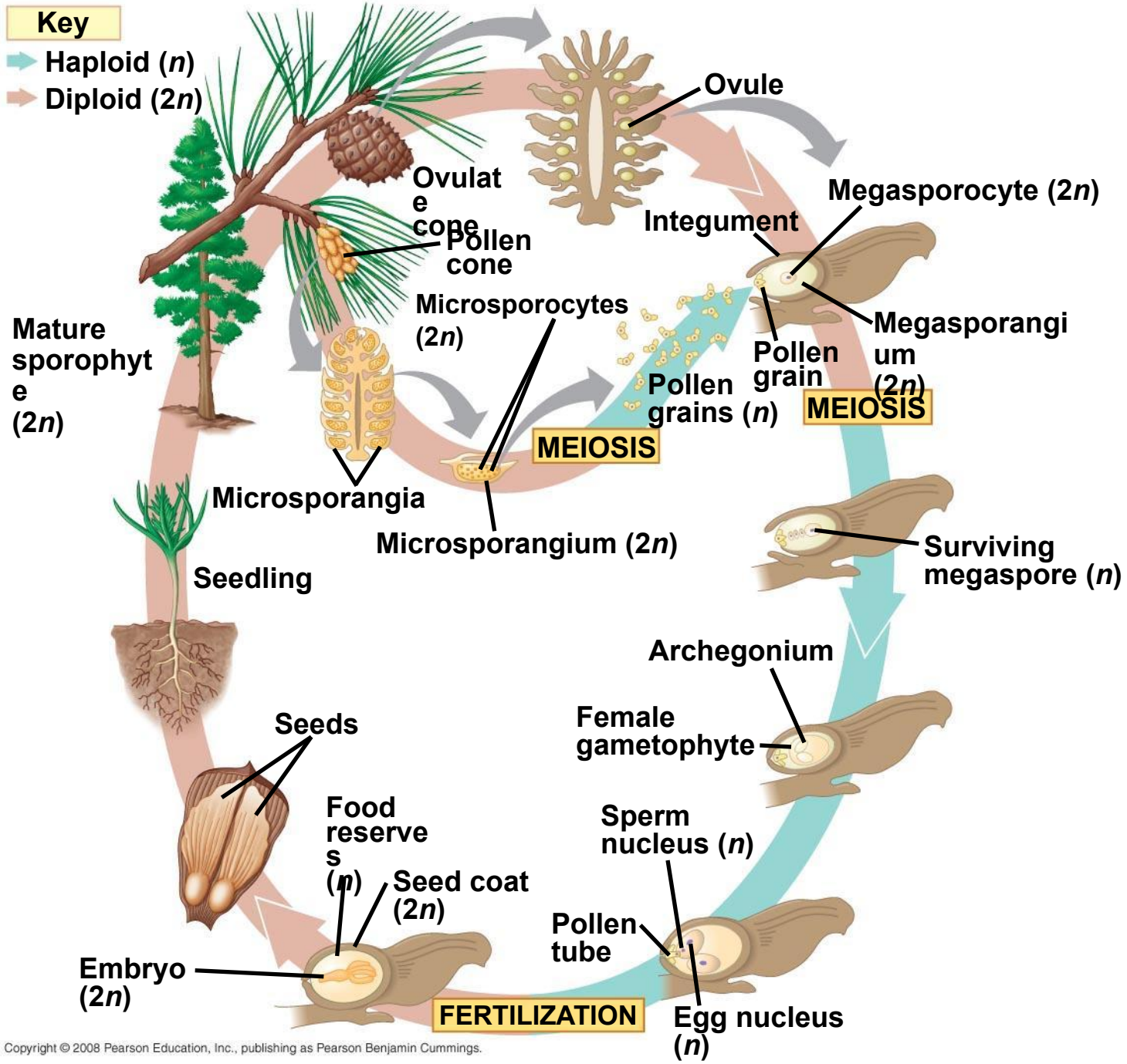


Giant Sequoia: 2,500

The Life Cycle of a Pine: *A Closer Look*

- Three key features of the gymnosperm life cycle are:
  - *Dominance of the sporophyte generation.*
  - *The transfer of sperm to ovules by pollen.*
  - *Development of seeds from fertilized ovules*.
- The life cycle of a pine provides an example.

Life Cycle of a Pine



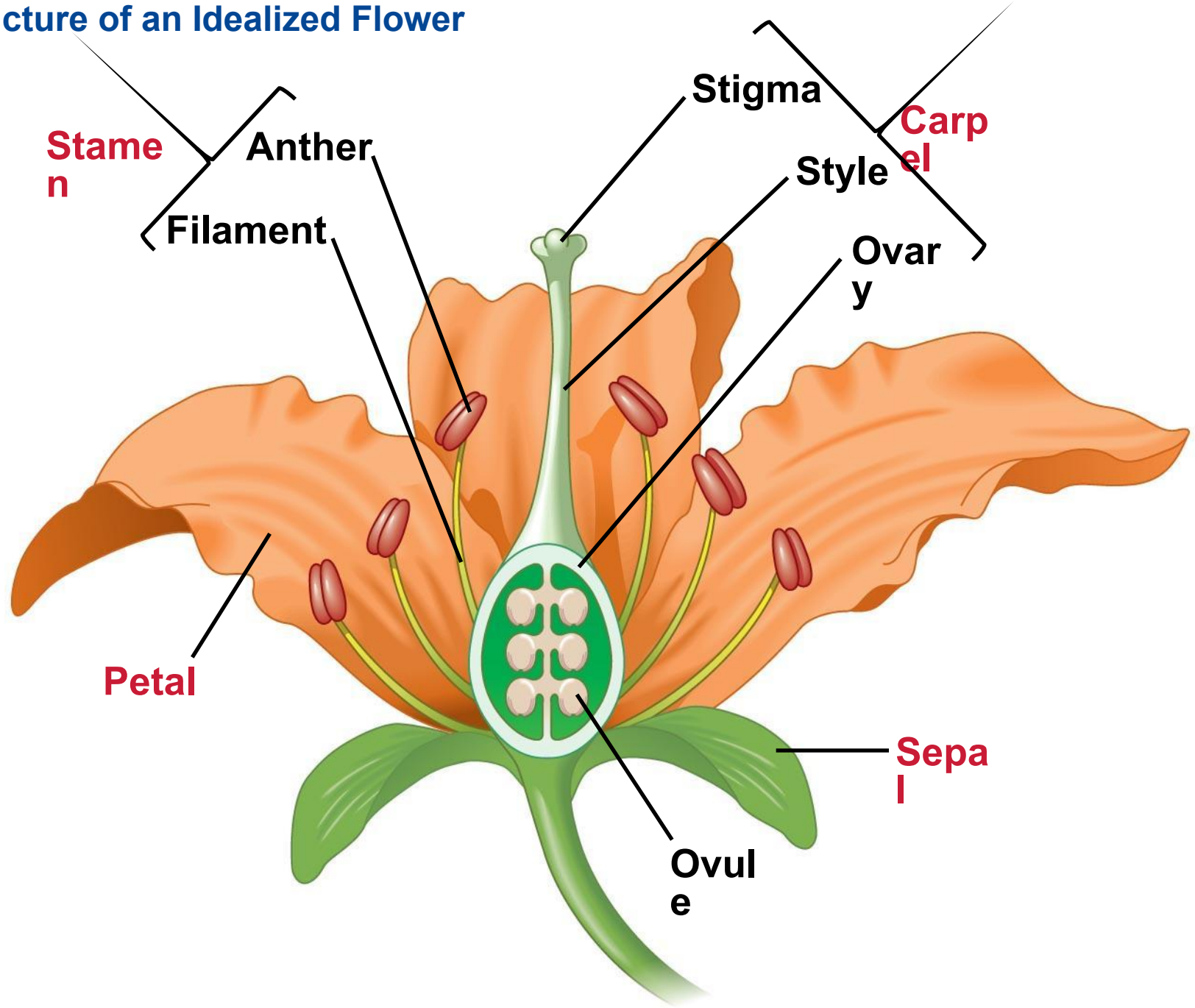
The reproductive adaptations of angiosperms include flowers and fruits

- *Angiosperms* are *seed plants* with *reproductive structures called flowers and fruits*.
- They are the most widespread and diverse of all plants.
- All angiosperms are classified in a single *phylum: Anthophyta*.
- The name comes from the Greek *anthos,* flower.

Flowers - Specialized for Sexual Reproduction

- The ***flower*** is an angiosperm structure specialized for sexual reproduction. It is a specialized shoot with up to four types of *modified leaves*:
  - ***Sepals*** - enclose the flower
  - ***Petals*** - brightly colored and attract pollinators
  - ***Stamens*** - produce pollen on their terminal **anthers**
  - ***Carpels*** - consist of an **ovary** containing **ovules** at the base and a **style** holding up a **stigma**, where pollen is received.

Structure of an Idealized Flower



Fruits

- A ***fruit*** typically consists of *a mature ovary* but can also include other flower parts.
- Fruits *protect seeds* and aid in *seed dispersal*.
- Mature fruits can be either fleshy or dry.
- Various *fruit adaptations help disperse seeds* by wind, water, or animals to new locations.

Fruits

Tomato

Ruby grapefruit

Nectarine

Milkweed

Hazelnut

Fruit Adaptations for Seed Dispersal

- Wings

- Seeds within berries

- Barbs

The Angiosperm Life Cycle

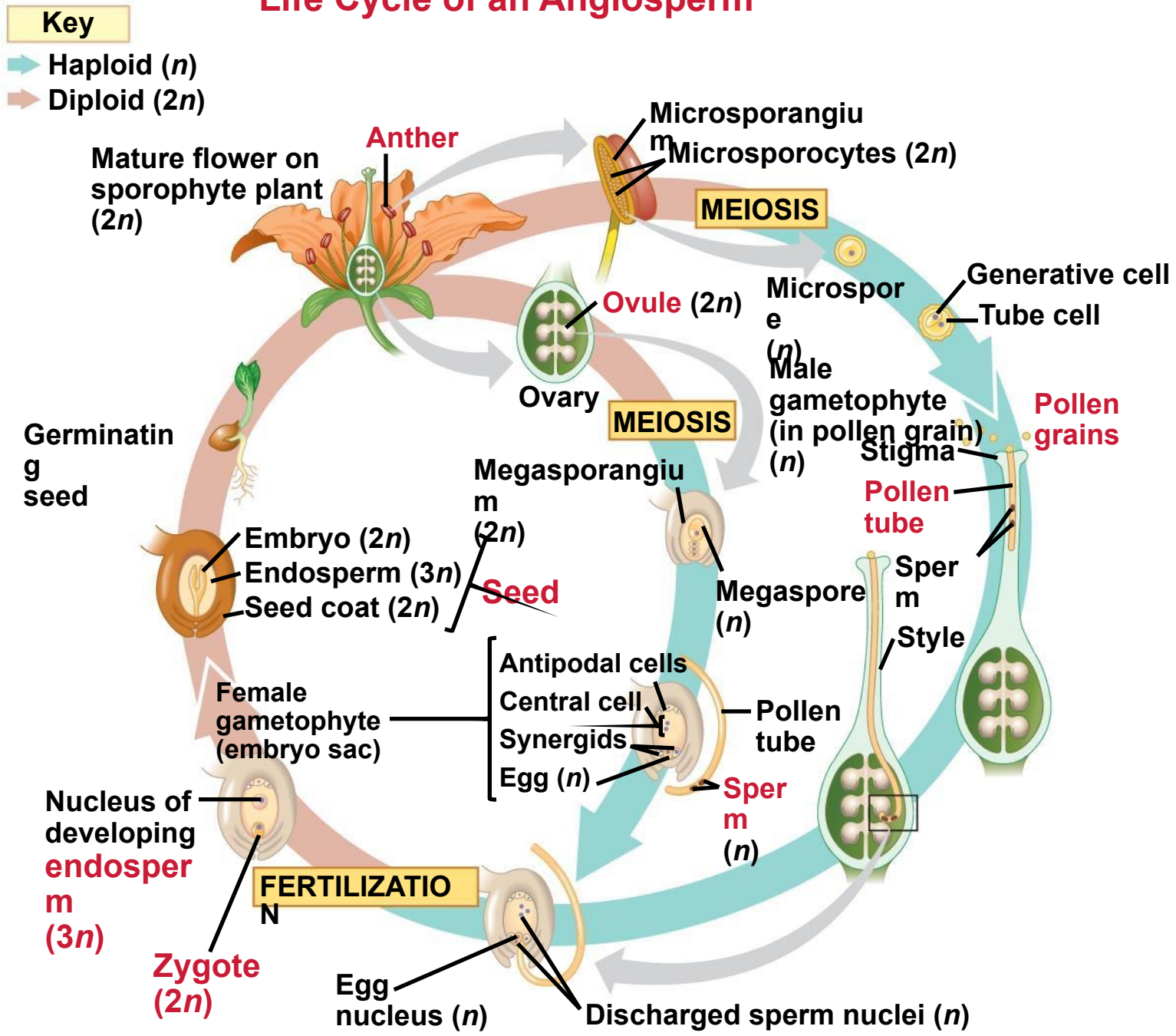
- The flower of the sporophyte is composed of both male and female structures.
- *Male gametophytes* are contained *within pollen* grains produced by the microsporangia of *anthers*.
- The *female gametophyte* = *embryo sac*, develops within an *ovule* contained within an ovary at the base of a stigma.
- Most flowers have mechanisms to ensure **cross-pollination** between flowers from different plants of the same species.

- A *pollen grain* that has landed on a stigma *germinates* and the *pollen tube* of the male gametophyte grows down to the ovary.
- *Sperm enter* the *ovule* through a pore *opening* called the ***micropyle***.
- ***Double fertilization*** occurs when the pollen tube discharges *two sperm* into the female gametophyte within an ovule.

Double Fertilization: Produces Zygote 2n and *endosperm (food) 3n*

- *One sperm fertilizes the egg forming a zygote.*
- The *other sperm combines with two nuclei* and initiates development of food-storing ***endosperm*.**
- The *endosperm nourishes the developing embryo*.
- Within a seed, the embryo consists of a root and two seed leaves called **cotyledons.**

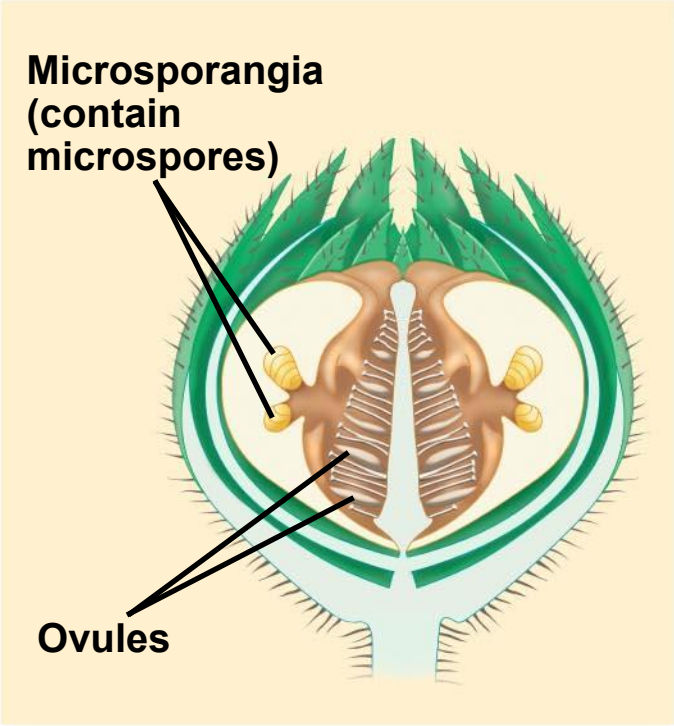
Life Cycle of an Angiosperm



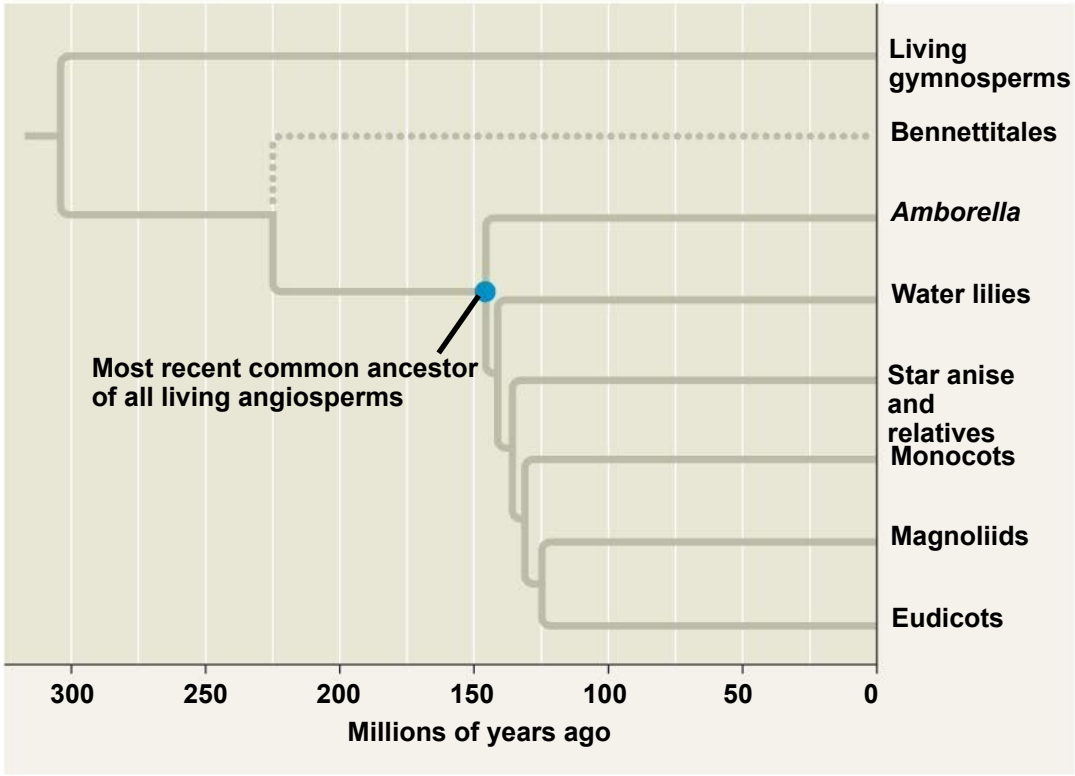
Angiosperm Phylogeny

- The ancestors of angiosperms and gymnosperms diverged about 305 million years ago.
- Angiosperms may be closely related to Bennettitales, extinct seed plants with flowerlike structures.
- *Amborella* and water lilies are likely descended from two of the most ancient angiosperm lineages.

Angiosperm evolutionary history



(a) A possible ancestor of the angiosperms?



(b) Angiosperm phylogeny

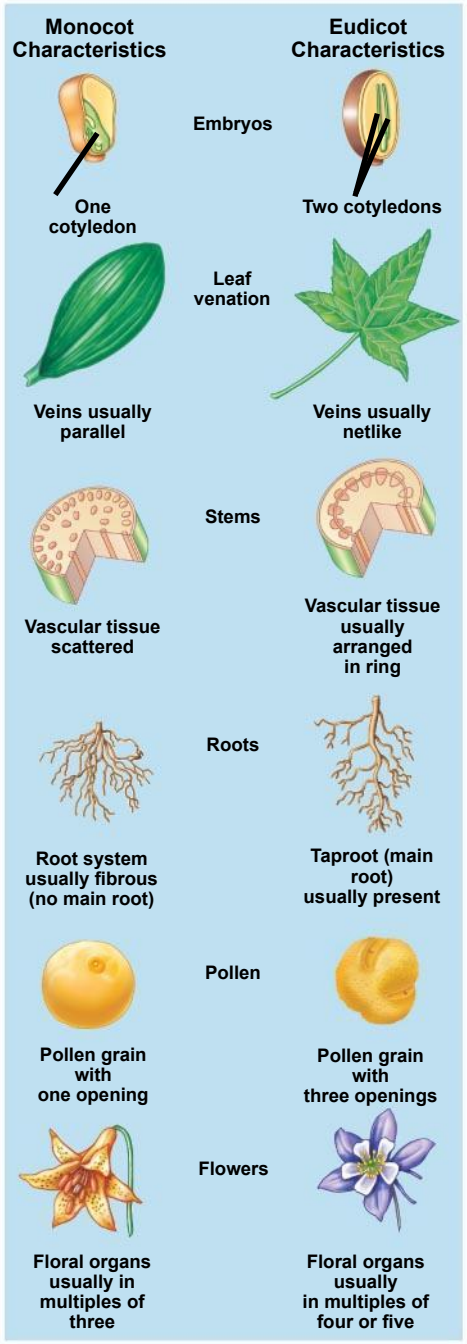
Angiosperm Diversity

- The two main groups of *angiosperms* are:
  monocots - one cotyledon
  eudicots ("true" dicots) - two cotyledons.

- More than one-quarter of angiosperm species are monocots.
- More than two-thirds of angiosperm species are eudicots.

Angiosperms:

Monocots and Eudicots

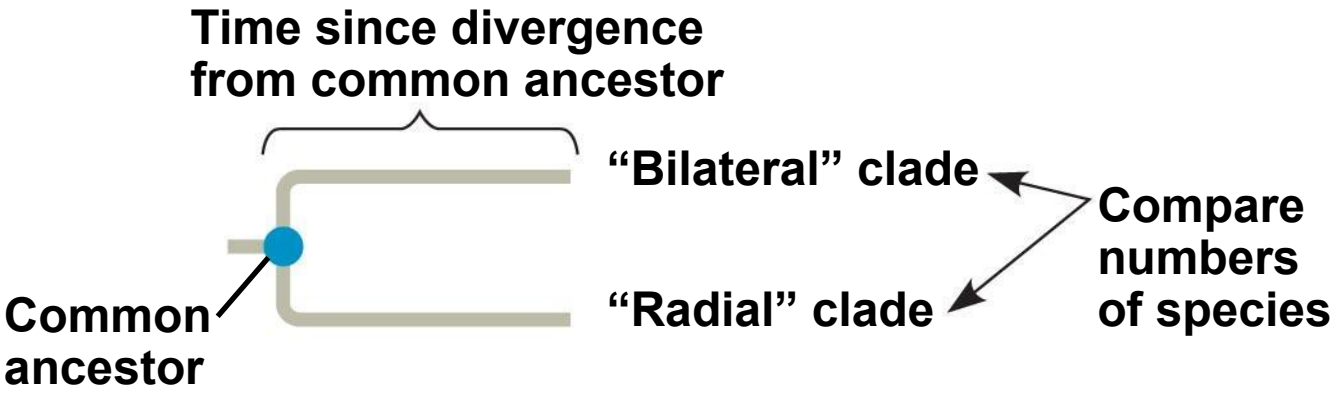


Evolutionary Links Between Angiosperms and Animals

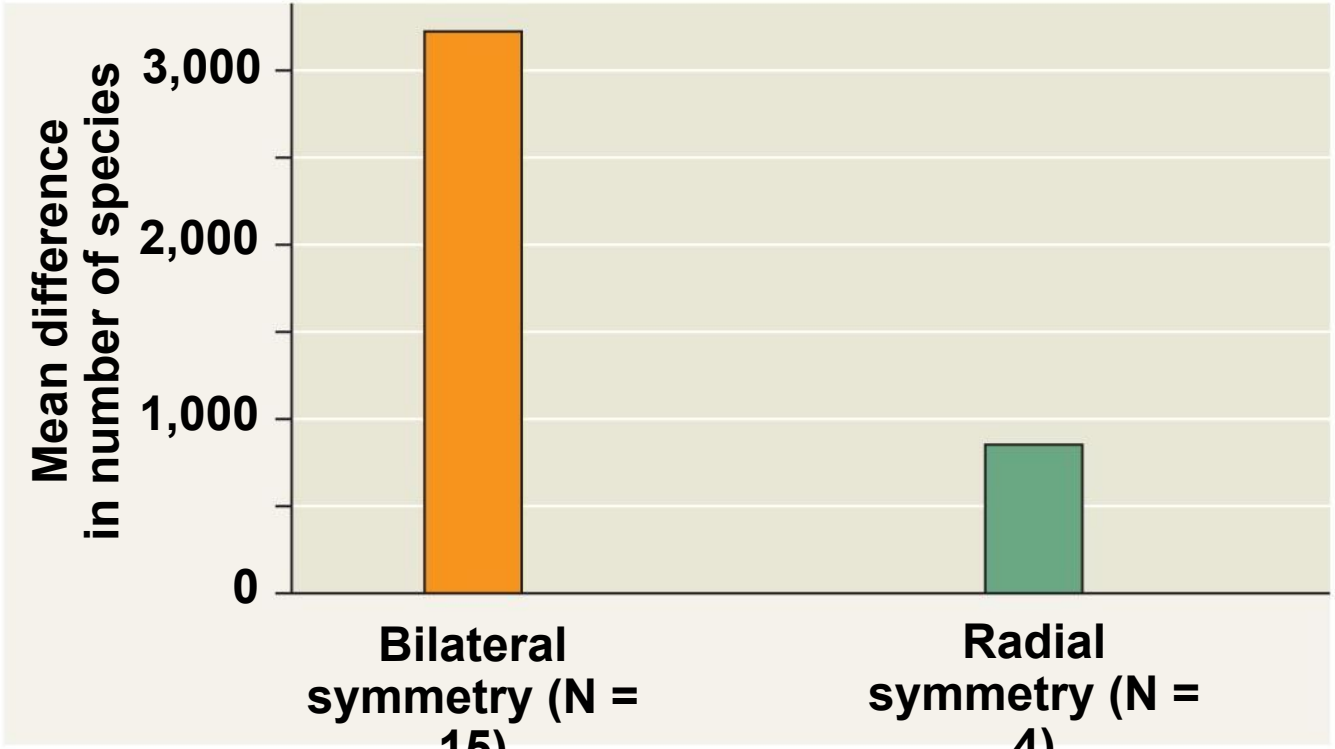
- *Pollination of flowers and transport of seeds by animals are two important relationships in terrestrial ecosystems*.
- Clades with bilaterally symmetrical flowers have more species than those with radially symmetrical flowers.
- This is likely because bilateral symmetry affects the movement of pollinators and reduces gene flow in diverging populations.

Can Flower Shape Influence Speciation Rate?

EXPERIMENT



RESULTS



Human welfare depends greatly on seed plants

- No group of plants is more important to human survival than seed plants.
- *Plants are key sources of food, fuel, wood products, and medicine*.
- Our reliance on seed plants makes preservation of plant diversity critical.

Products from Seed Plants

- *Most of our food* comes from angiosperms. Six crops (wheat, rice, maize, potatoes, cassava, and sweet potatoes) yield 80% of the calories consumed by humans.
- *Modern crops* are products of relatively recent genetic change resulting from *artificial selection*.
- Many seed plants *provide wood*.
- *Secondary compounds* of seed plants are used in *medicines*.

Table 30.1 A Sampling of Medicines Derived from Seed Plants

Compound	Source	Example of Use
Atropine	Belladonna plant	Pupil dilator in eye exams
Digitalin	Foxglove	Heart medication
Menthol	Eucalyptus tree	Ingredient in cough medicines
Morphine	Opium poppy	Pain reliever
Quinine	Cinchona tree (see below)	Malaria preventive
Taxol	Pacific yew	Ovarian cancer drug
Tubocurarine	Curare tree	Muscle relaxant during surgery
Vinblastine	Periwinkle	Leukemia drug

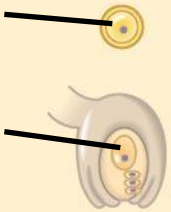
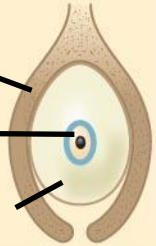
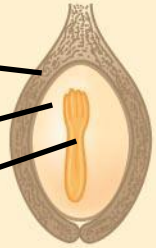
Cinchona bark, source of quinine

Threats to Plant Diversity

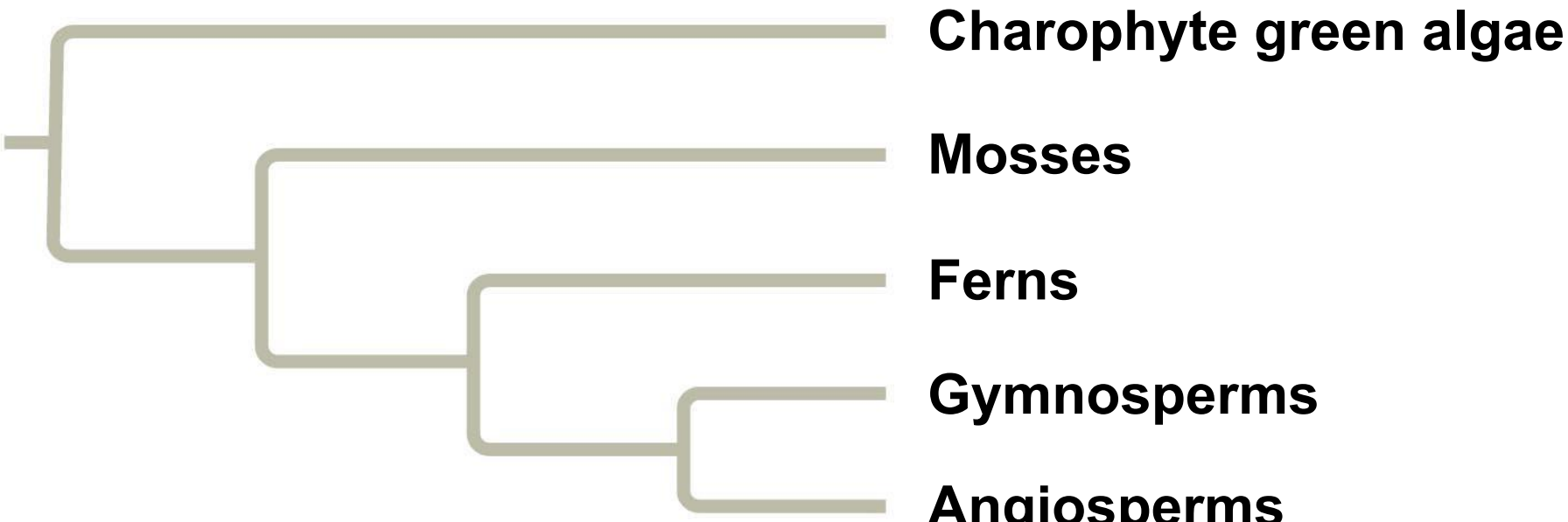
- *Destruction of habitat is causing extinction of many plant species*.
- Loss of plant habitat is often accompanied by loss of the animal species that plants support.
- At the current rate of habitat loss, 50% of Earth's species will become extinct within the next 100–200 years.

Summary

Five Derived Traits of Seed Plants

Reduced gametophytes	**Microscopic male and female gametophytes (*n*) are nourished and protected by the sporophyte (2*n*)** 
Heterospory	**Microspore (gives rise to a male gametophyte)** **Megaspore (gives rise to a female gametophyte)** 
Ovules	**Ovule (gymnosperm)** 
Pollen	**Pollen grains make water unnecessary for fertilization** 
Seeds	**Seeds: survive better than unprotected spores, can be transported long distances** 

Plant Evolutionary Relationships: Clades



You should now be able to:

1. Explain why pollen grains were an important adaptation for successful reproduction on land.
2. List the four phyla of gymnosperms.
3. Describe the life history of a pine; indicate which structures are part of the gametophyte generation and which are part of the sporophyte generation.

You should now be able to:

4. Identify and describe the function of the following floral structures: sepals, petals, stamens, carpels, filament, anther, stigma, style, ovary, and ovule.
5. Explain how fruits may be adapted to disperse seeds.
6. Diagram the generalized life cycle of an angiosperm; indicate which structures are part of the gametophyte generation and which are part of the sporophyte generation.
7. Describe the current threat to plant diversity caused by human population growth.