CHAPTER 6

Plantae

PROTISTS

- Protists are eukaryotes and thus have organelles and are more complex than prokaryotes.
- Most protists are unicellular, but there are some colonial and multicellular species

Nutrition

- Protists, the most nutritionally diverse of all eukaryotes, include:
  - Photoautotrophs, which contain chloroplasts
  - Heterotrophs, which absorb organic molecules or ingest larger food particles
  - **Mixotrophs**, which combine photosynthesis and heterotrophic nutrition

Reproduction

- Protists can reproduce asexually or sexually, or by the sexual processes of meiosis and syngamy

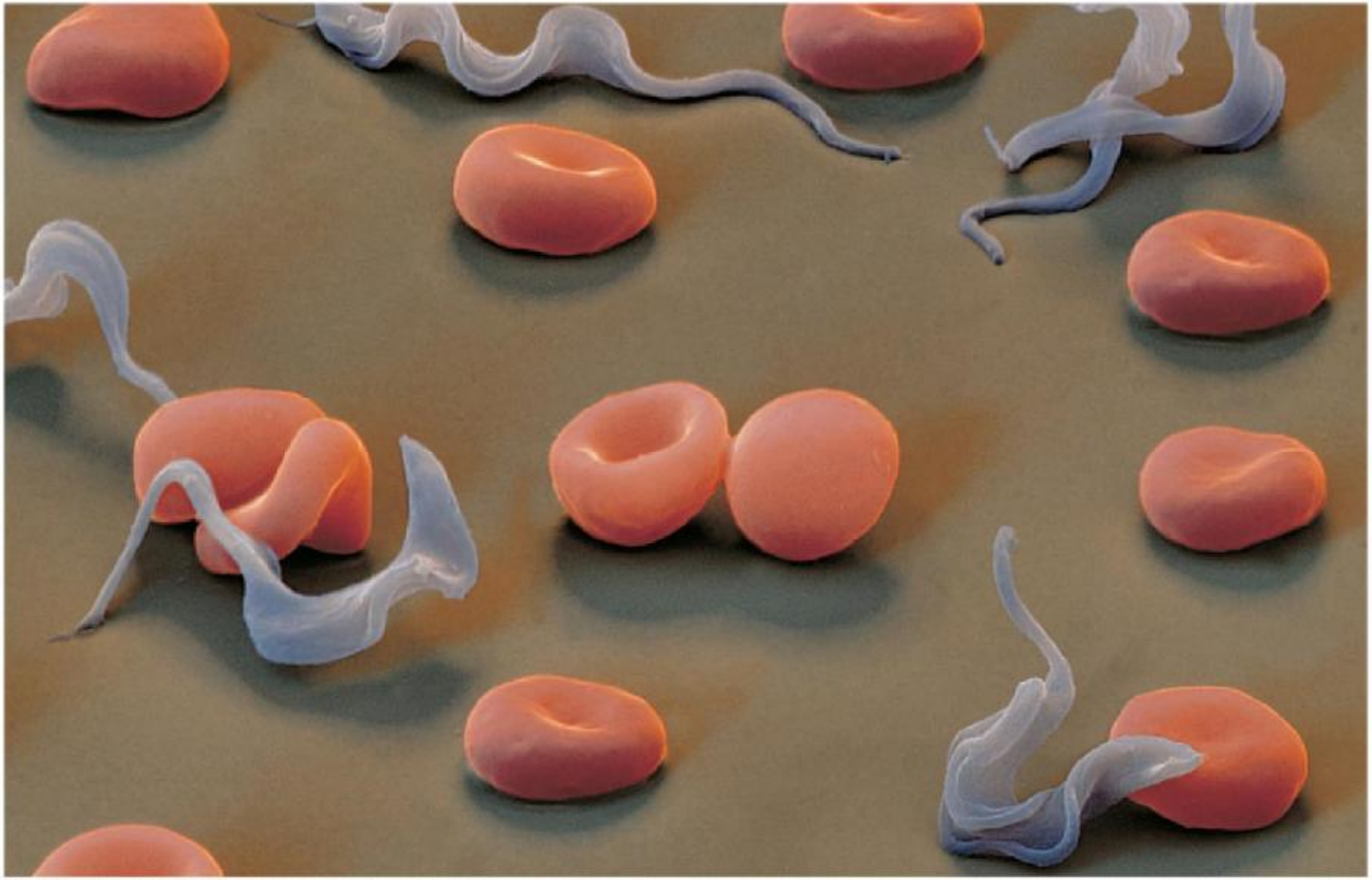
Reproduction

- Protists can reproduce asexually or sexually, or by the sexual processes of meiosis and syngamy

Protozoans

- Protozoans include
  - Flagellates, with flagella
  - Amoebas, with pseudopodia
  - Forams
  - Apicomplexans
  - Ciliates, with cilia

Trypanosomes (flagellates)



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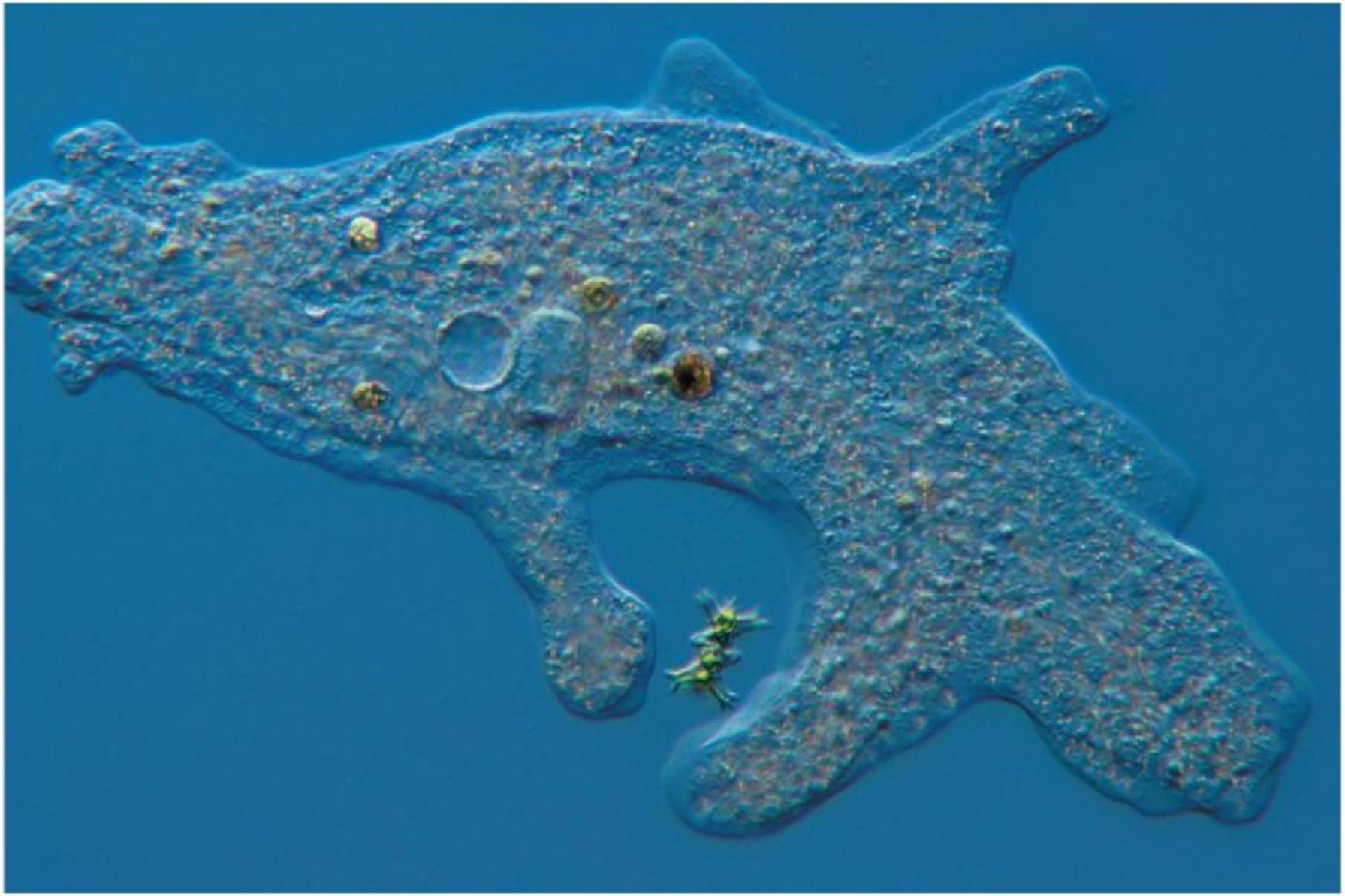
An amoeba ingesting food



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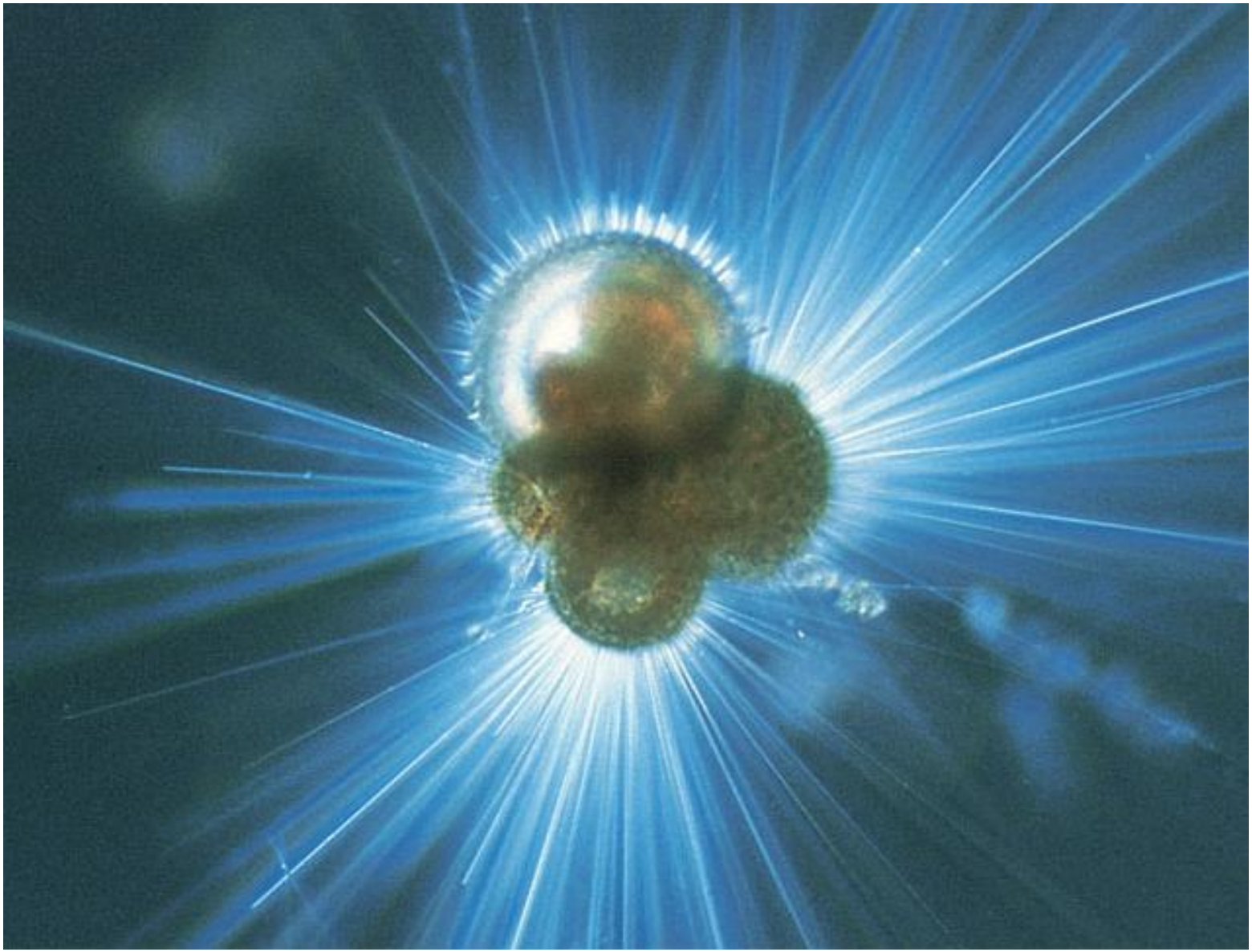
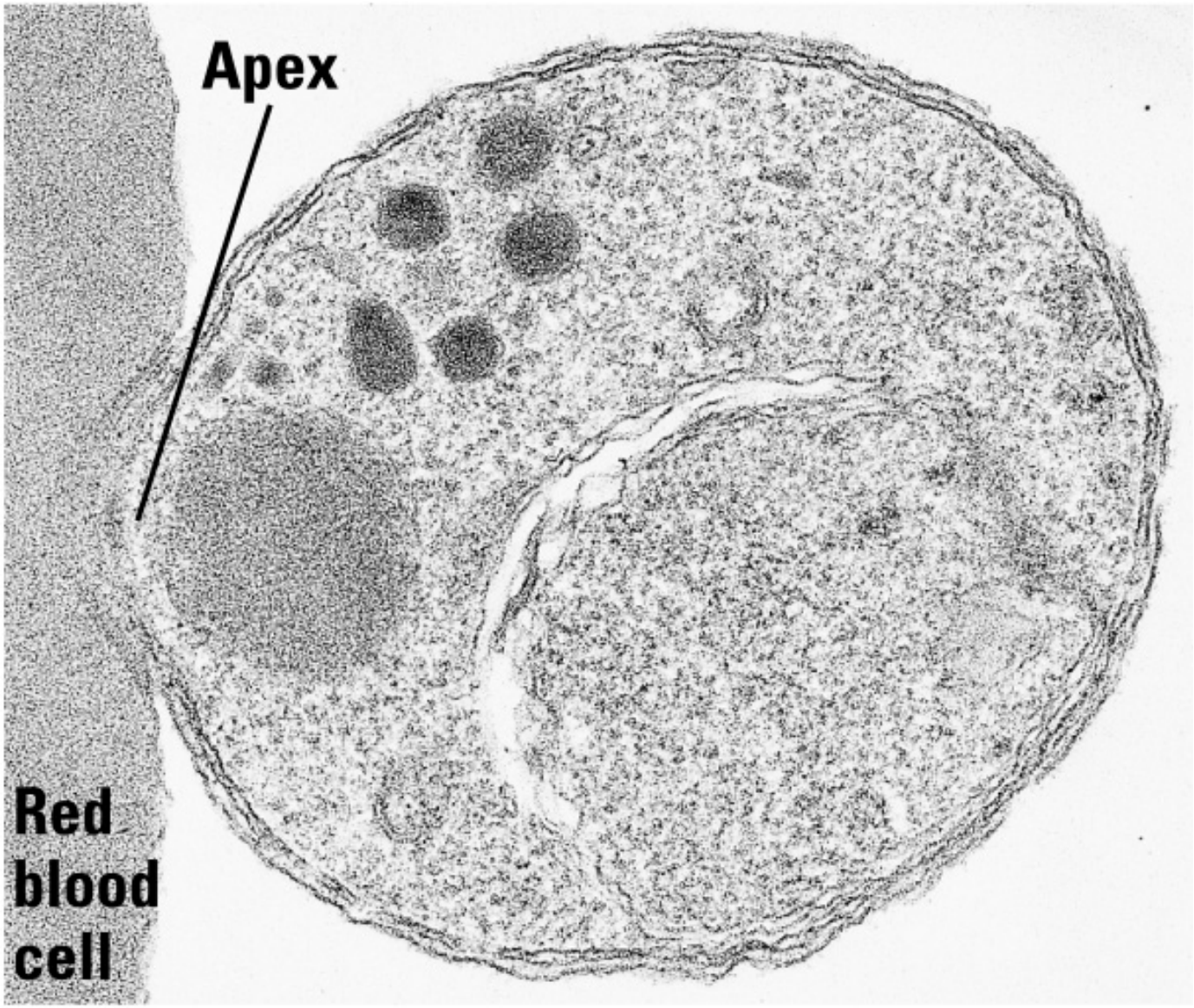
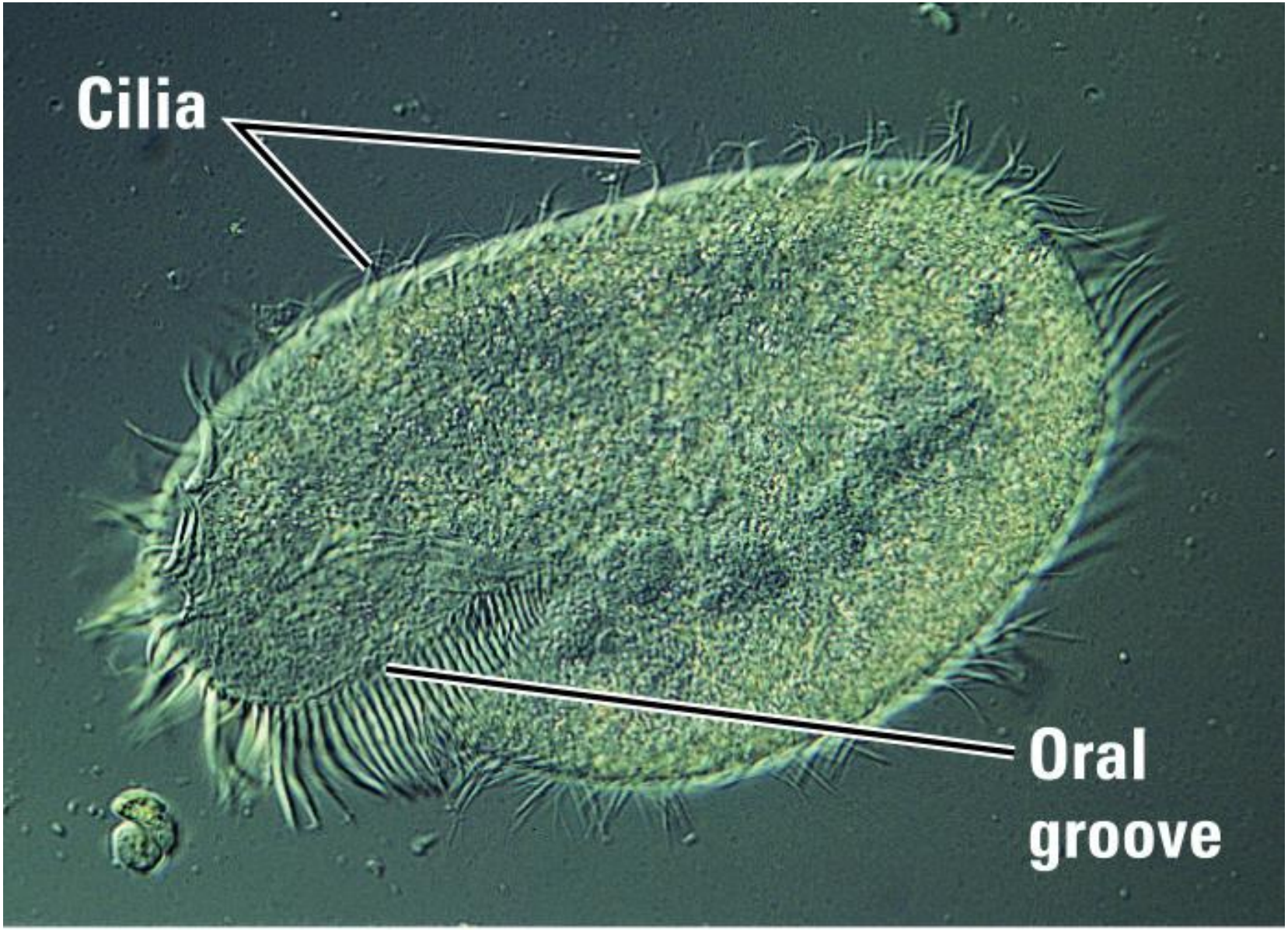
A foram



An apicomplexan: *Plasmodium*



Paramecium

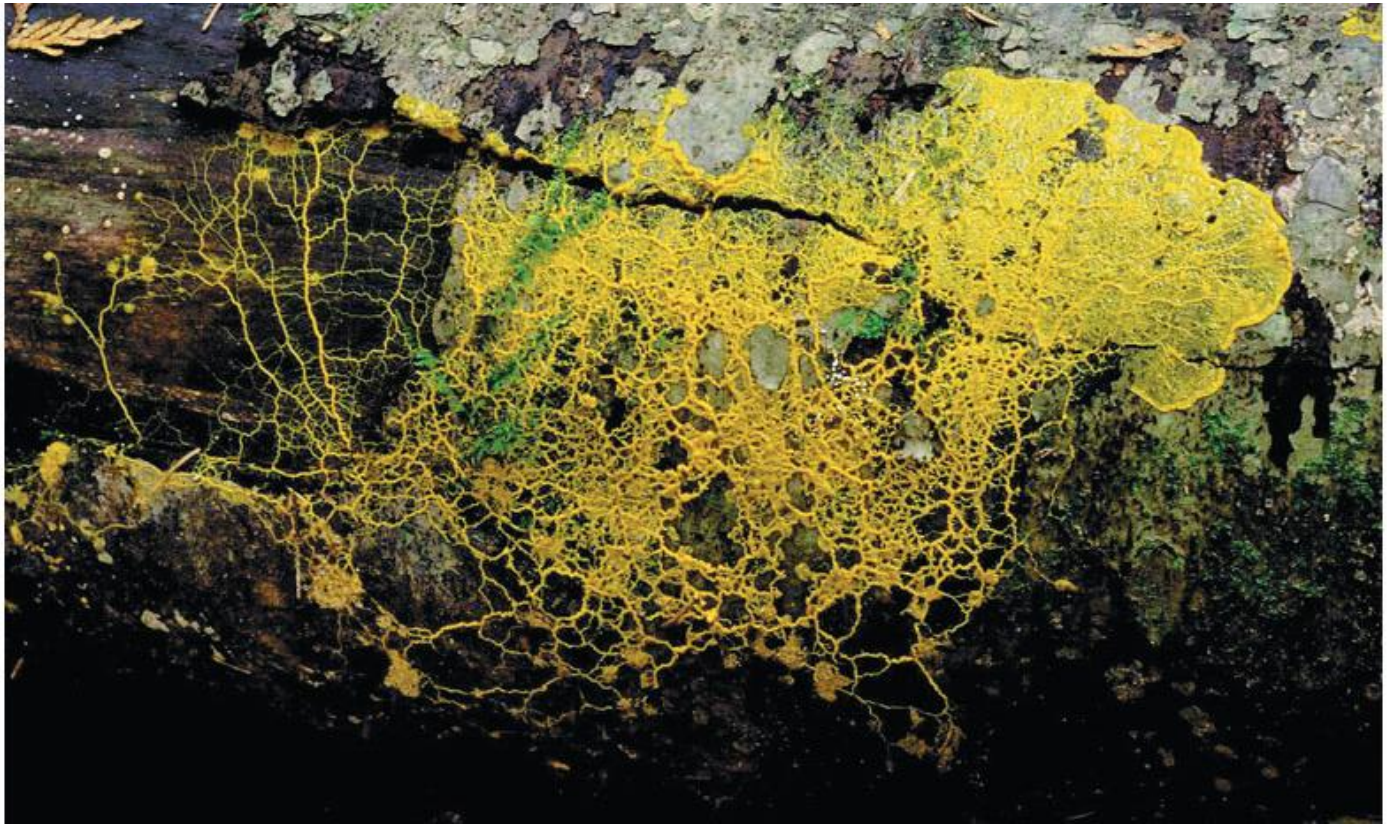


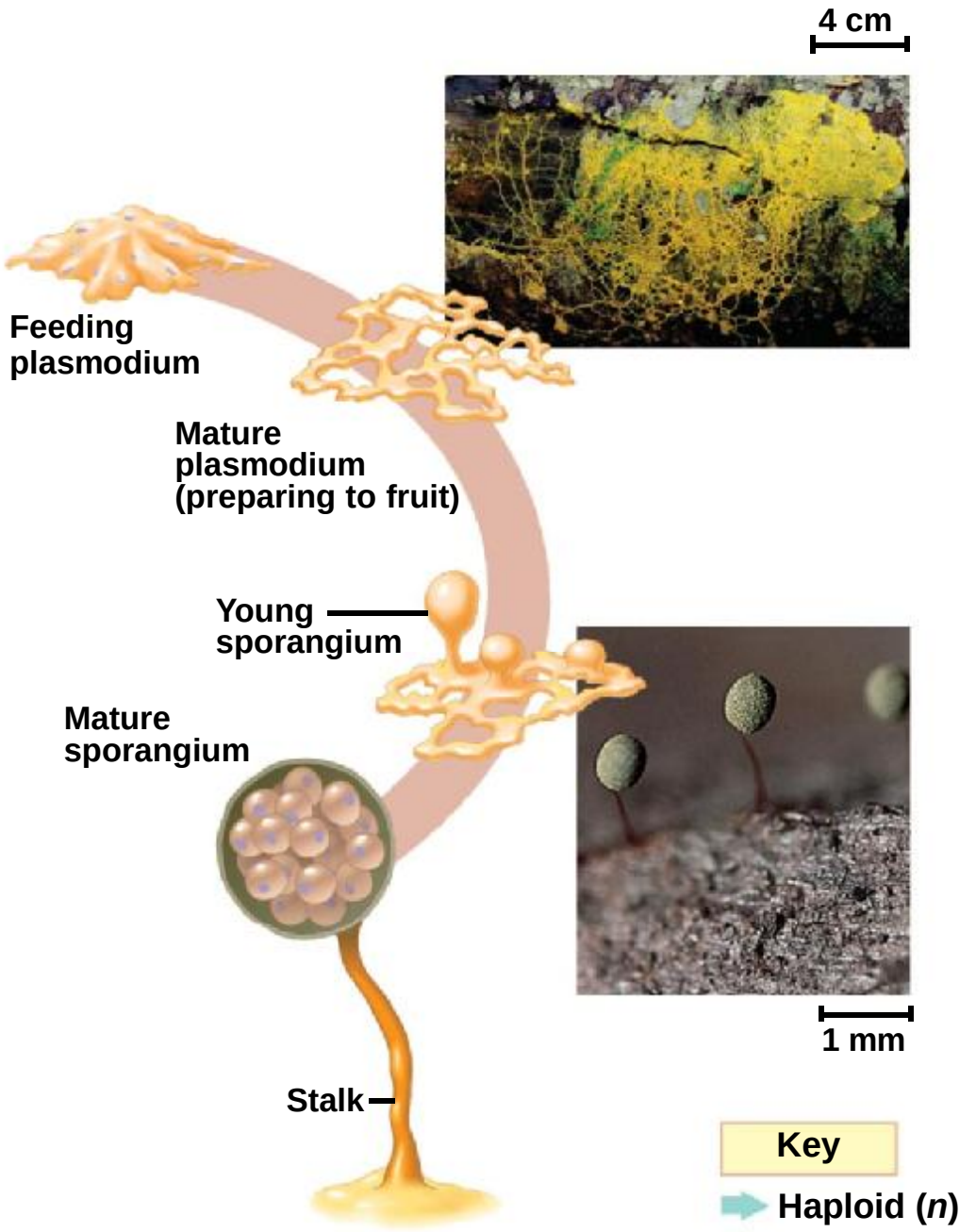
Slime Molds

- Slime molds
  - Resemble fungi in appearance and lifestyle

Plasmodial slime molds

- can be large
- are brightly pigmented, usually yellow or orange





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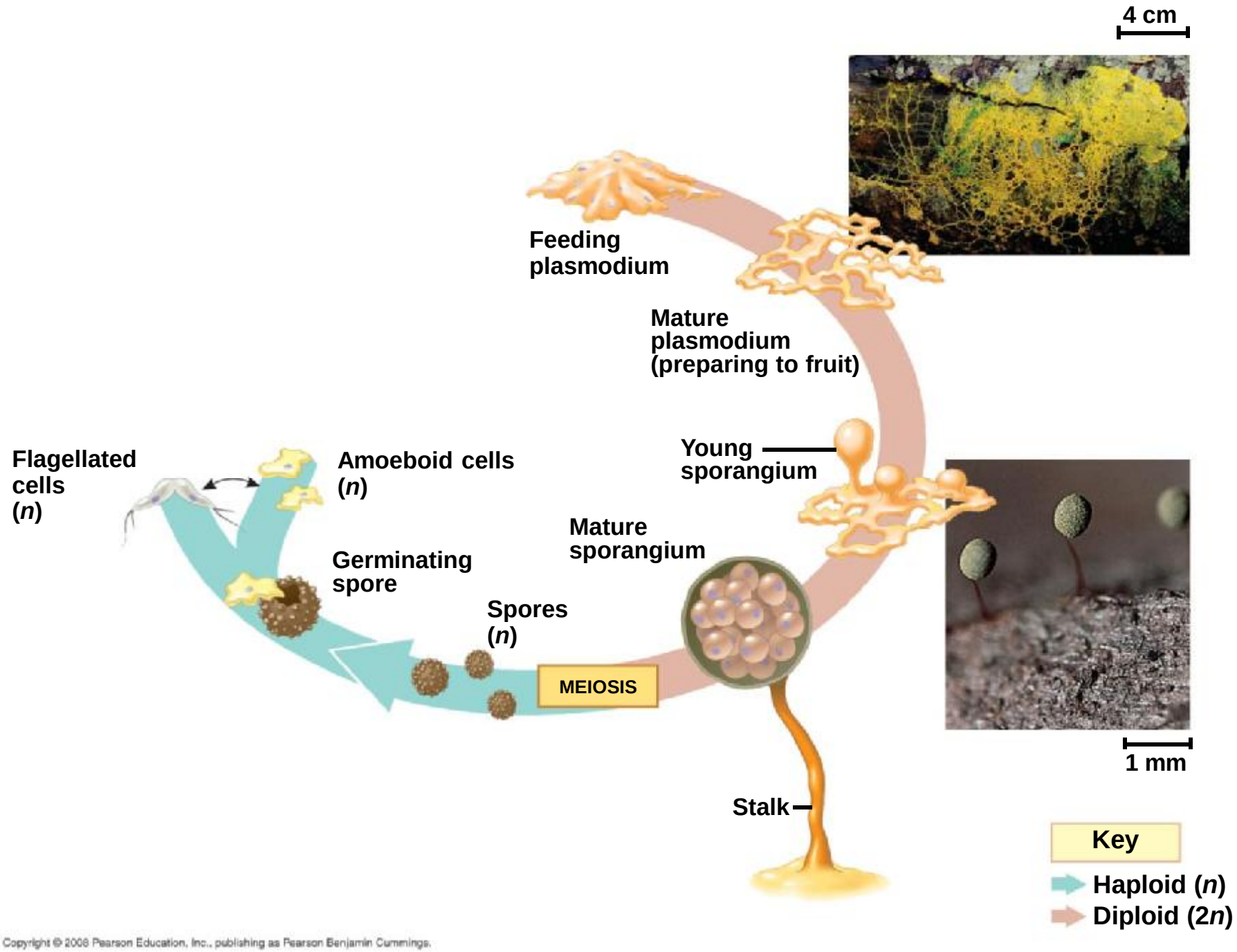

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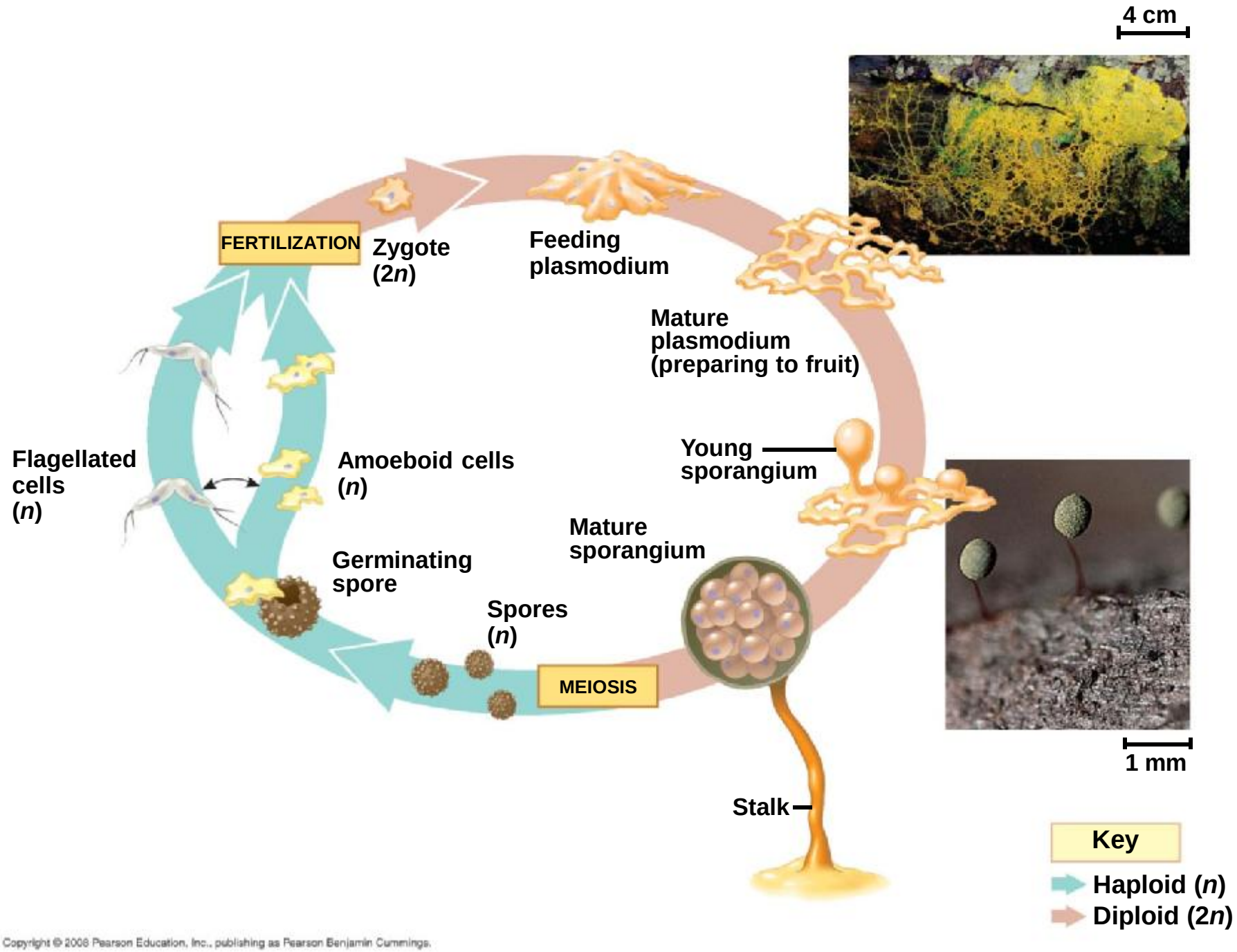

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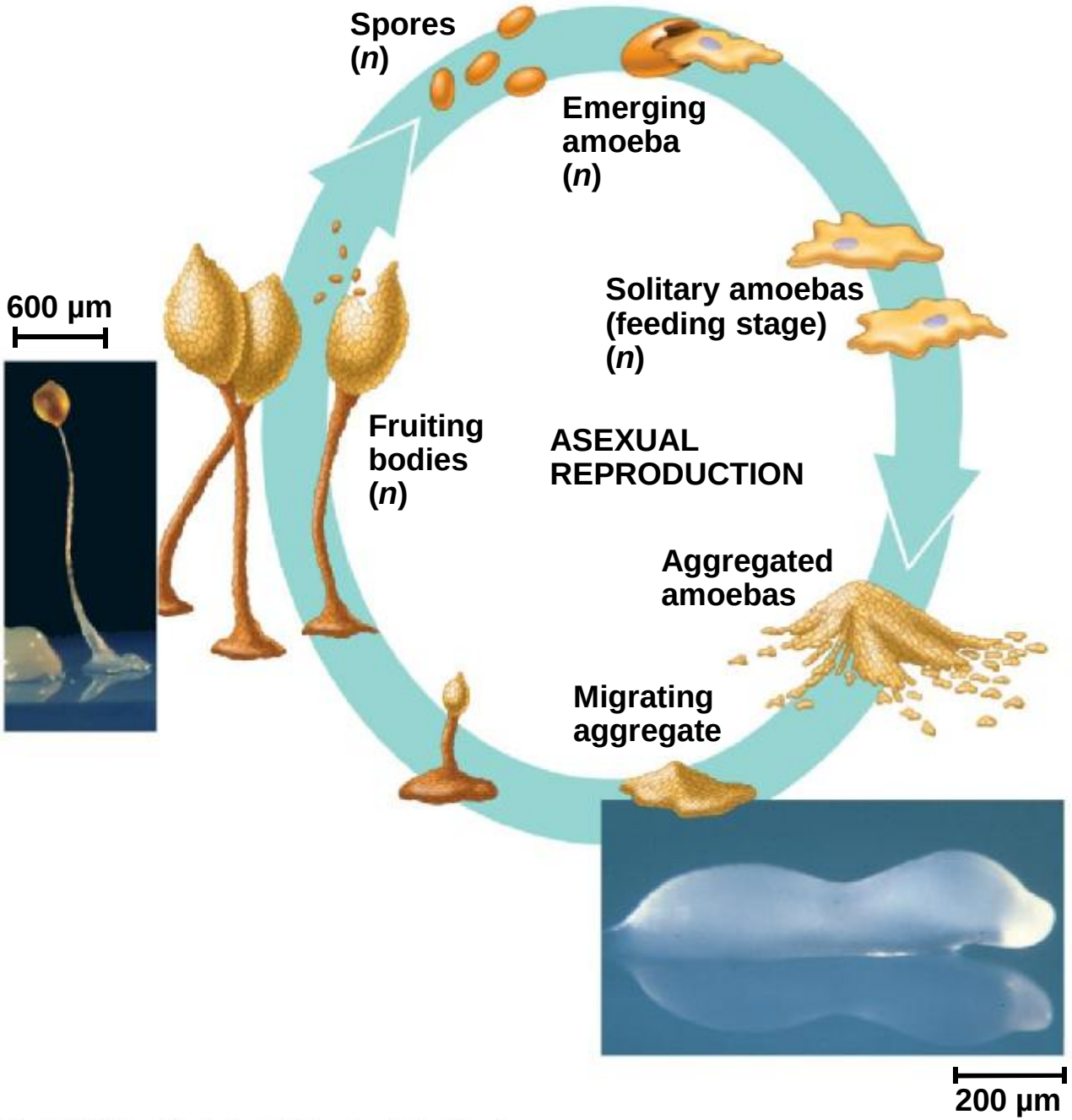
Cellular slime molds

- **Cellular slime molds** form multicellular aggregates in which cells are separated by their membranes
- Cells feed individually, but can aggregate to form a fruiting body
- *Dictyostelium discoideum* is an experimental model for studying the evolution of multicellularity



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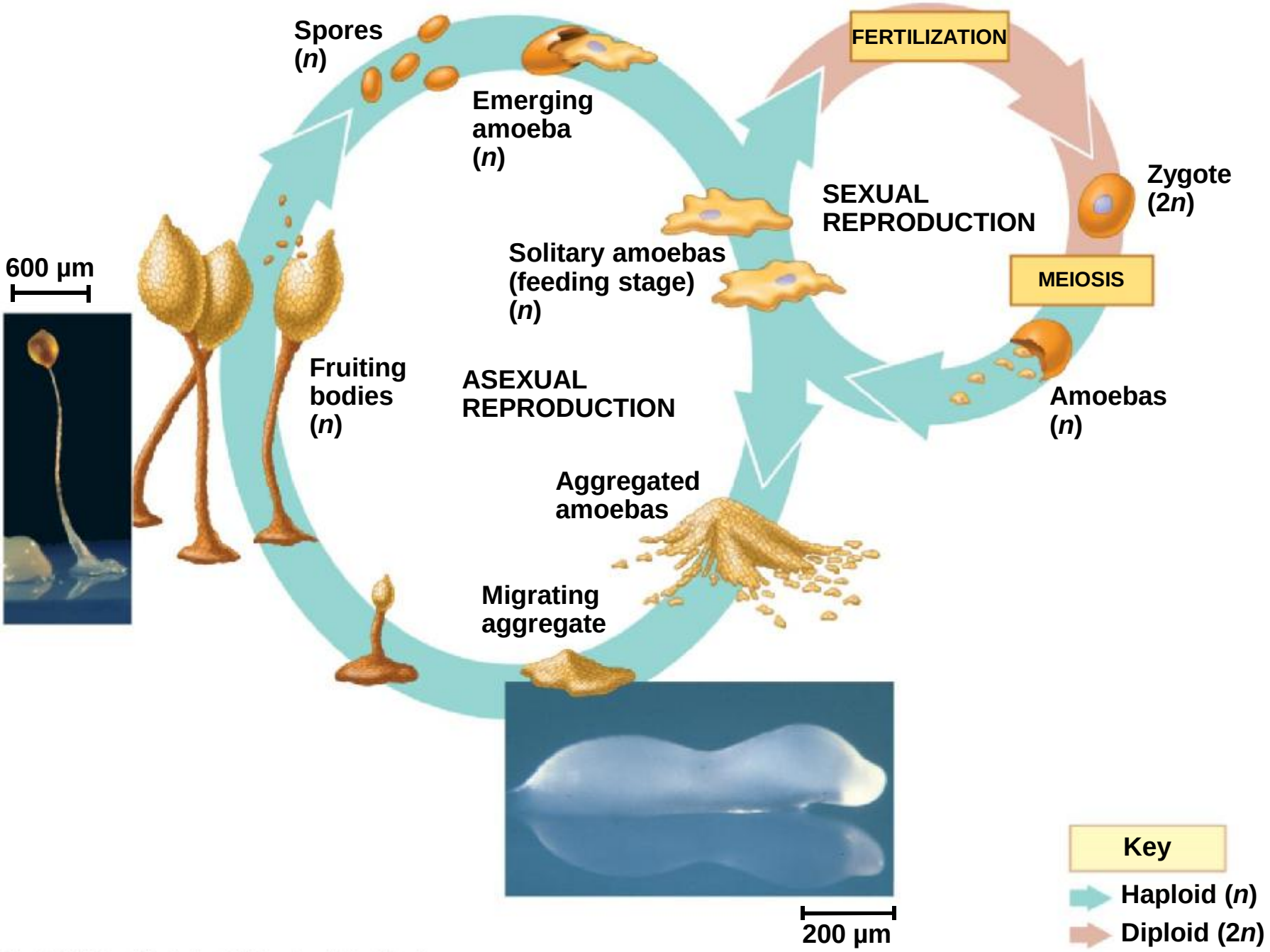

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Unicellular Algae

- Algae
  - Are photosynthetic protists
  - Are found in plankton

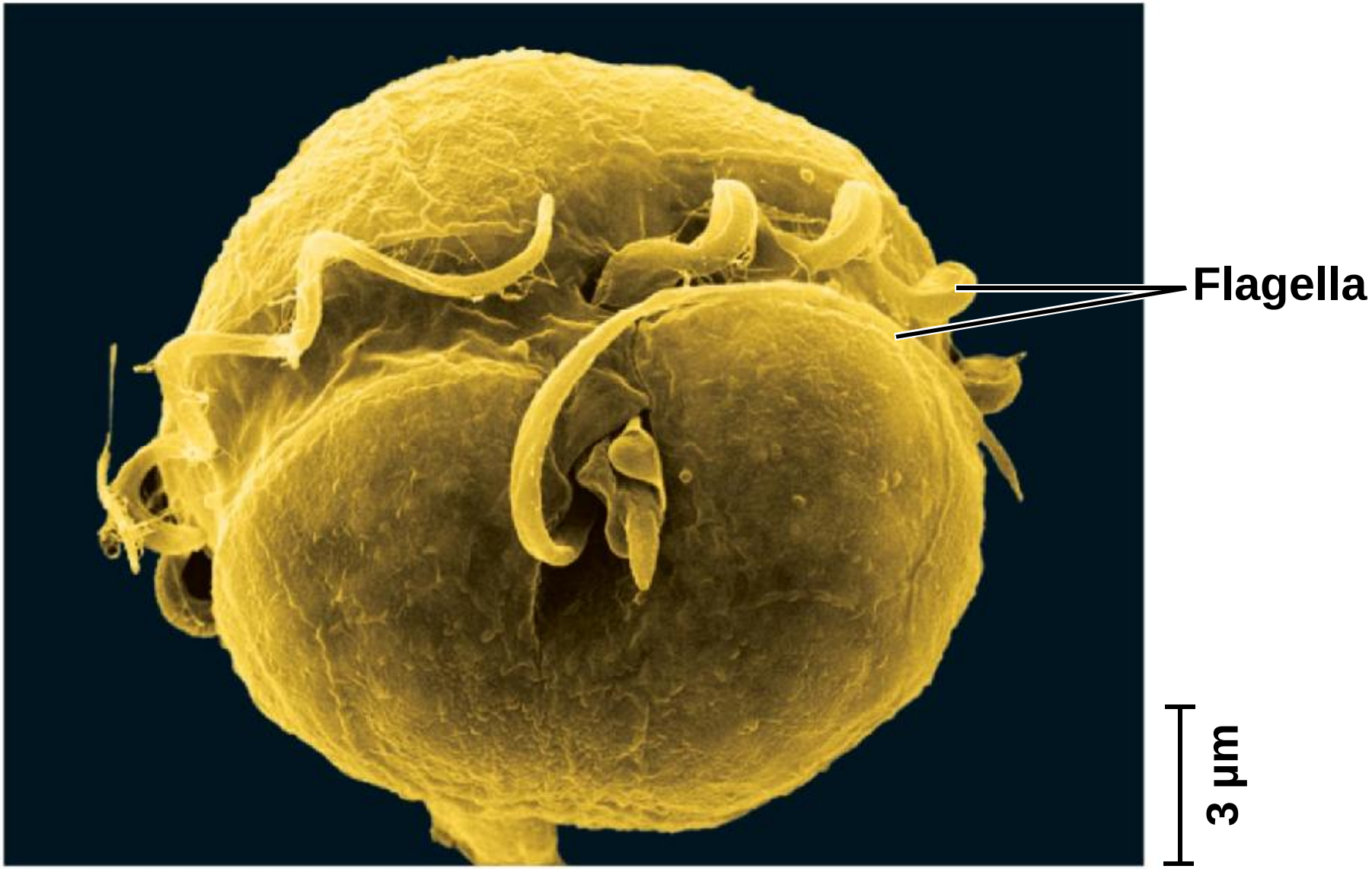
Unicellular algae

- include
  - Dinoflagellates, components of phytoplankton
  - Diatoms, which have glassy walls
  - Green algae, unicellular and colonial

Dinoflagellates

- **Dinoflagellates** are a diverse group of aquatic mixotrophs and heterotrophs
- They are abundant components of both marine and freshwater phytoplankton.
- Dinoflagellate blooms are the cause of toxic “red tides”

Pfiesteria shumwayae, a dinoflagellate



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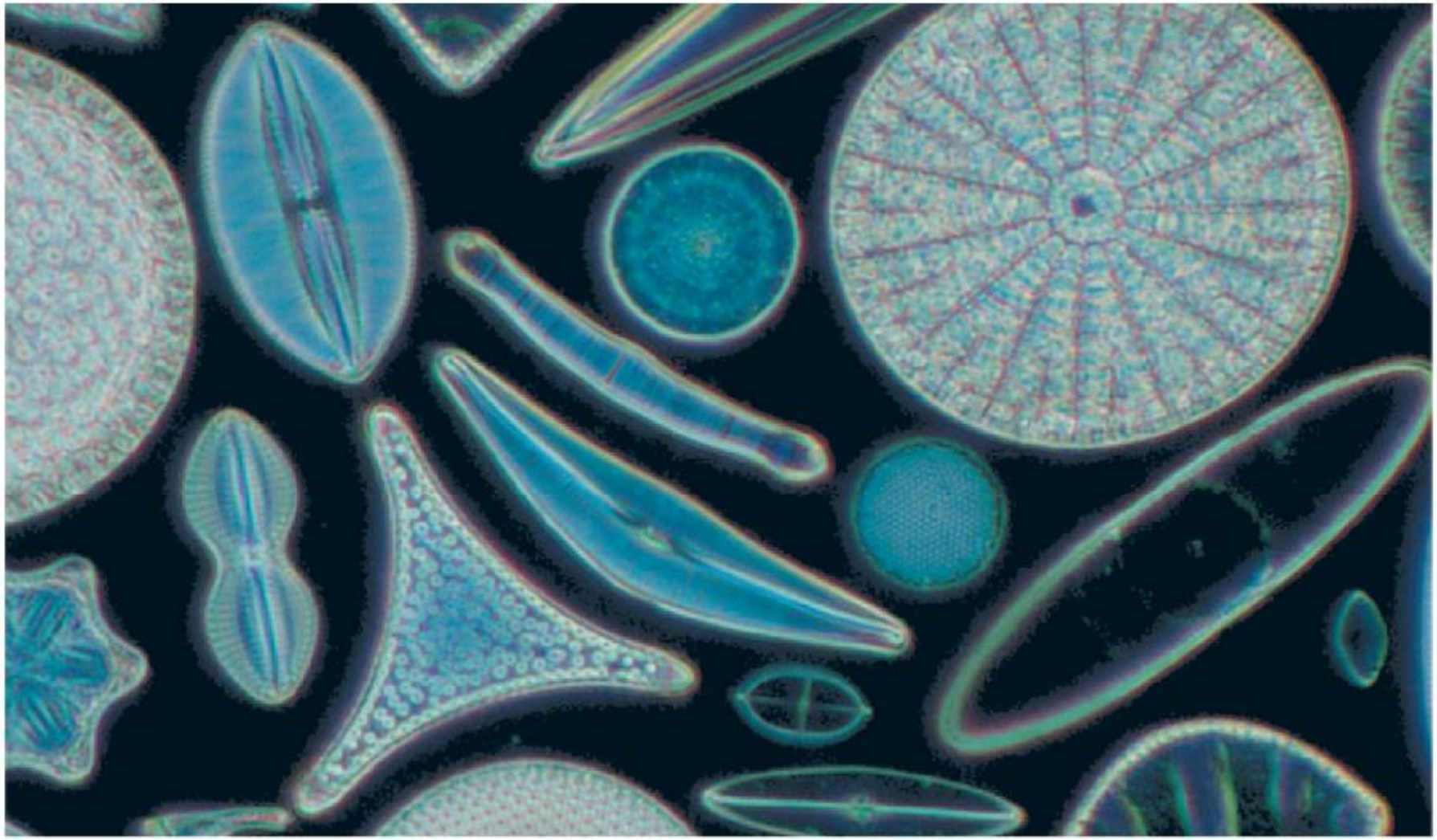
Red tides

Diatoms

- **Diatoms** are unicellular algae with a unique two-part, glass-like wall of hydrated silica
- Diatoms usually reproduce asexually, and occasionally sexually



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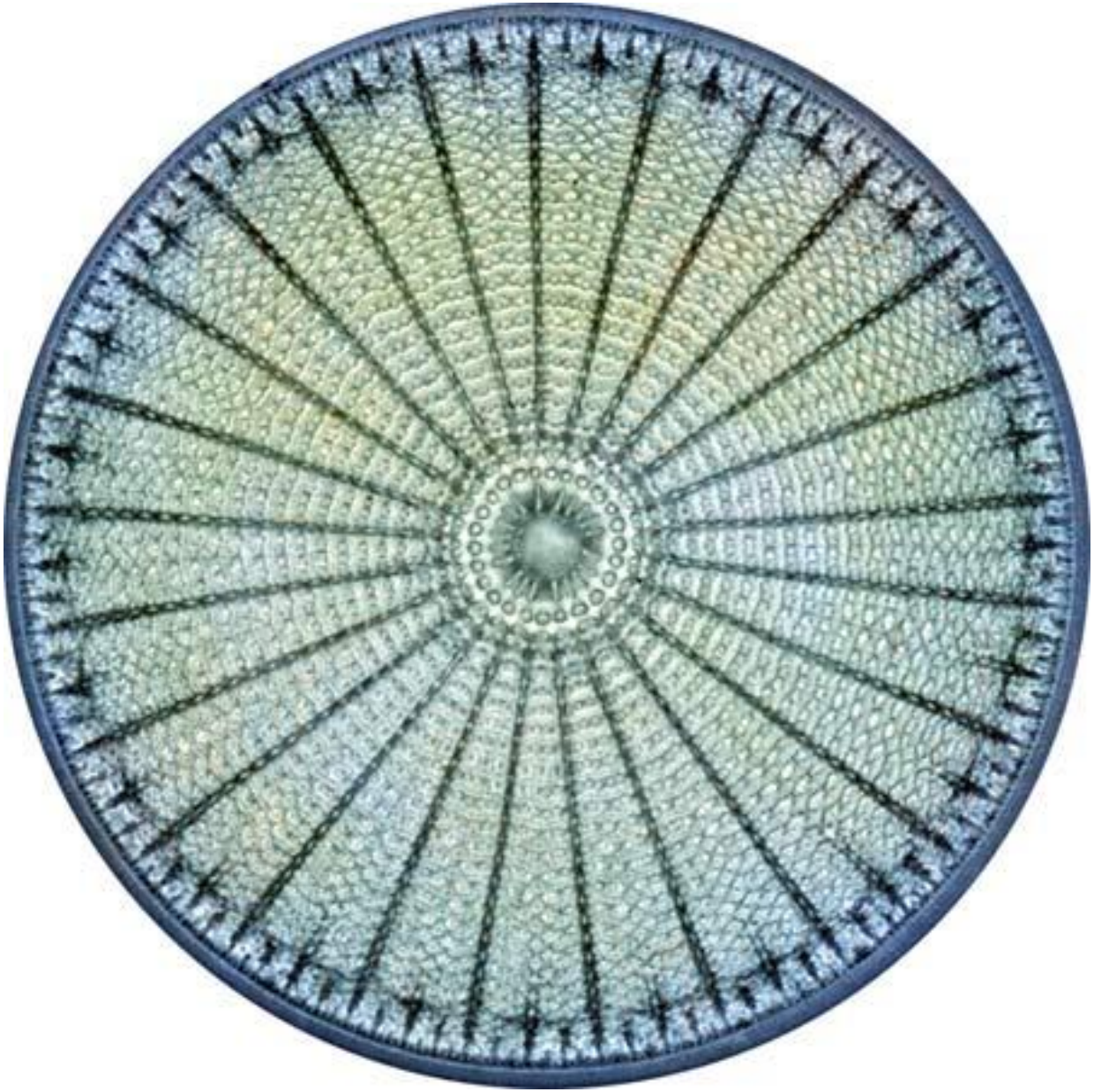
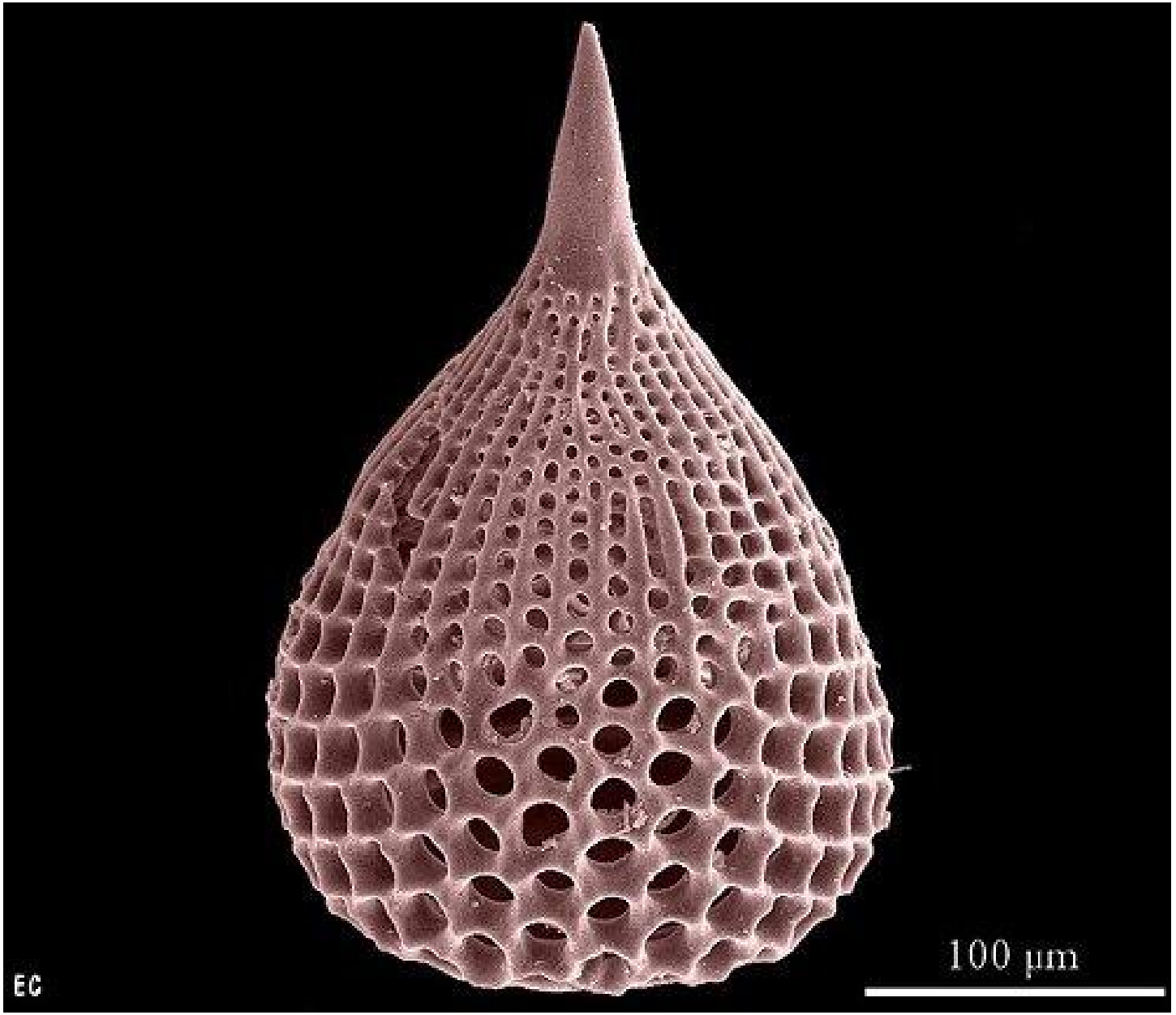
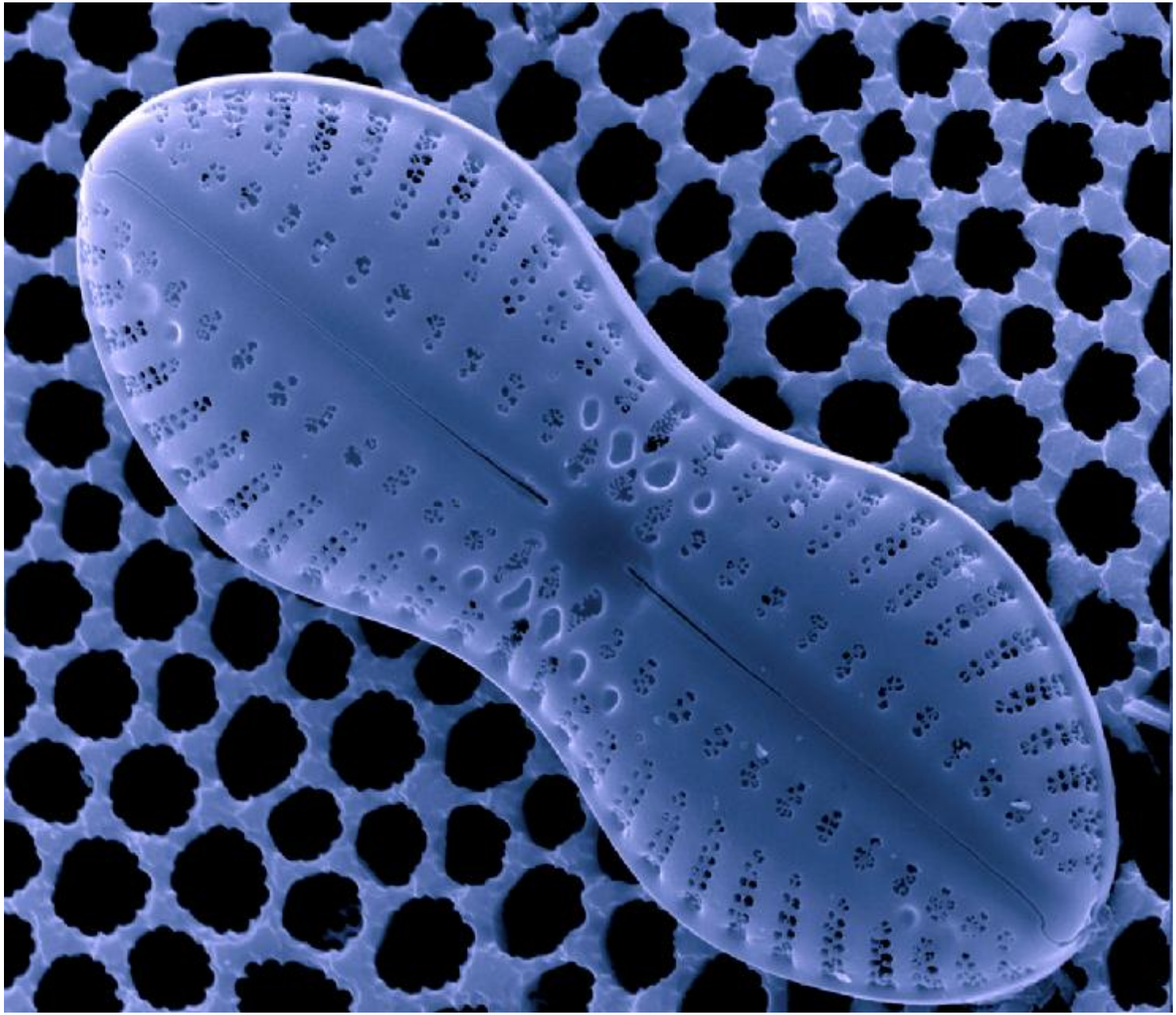
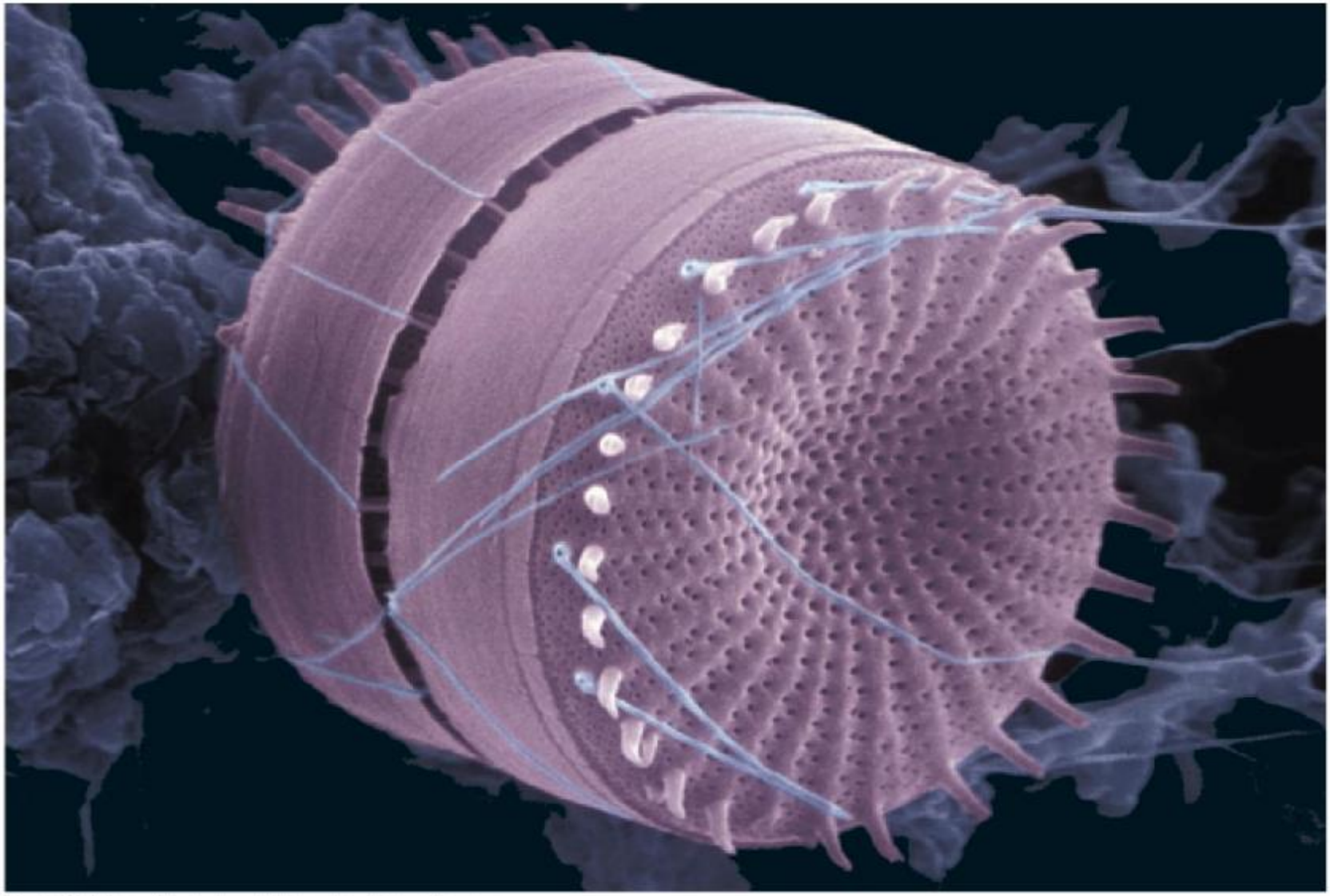



EC
100 µm





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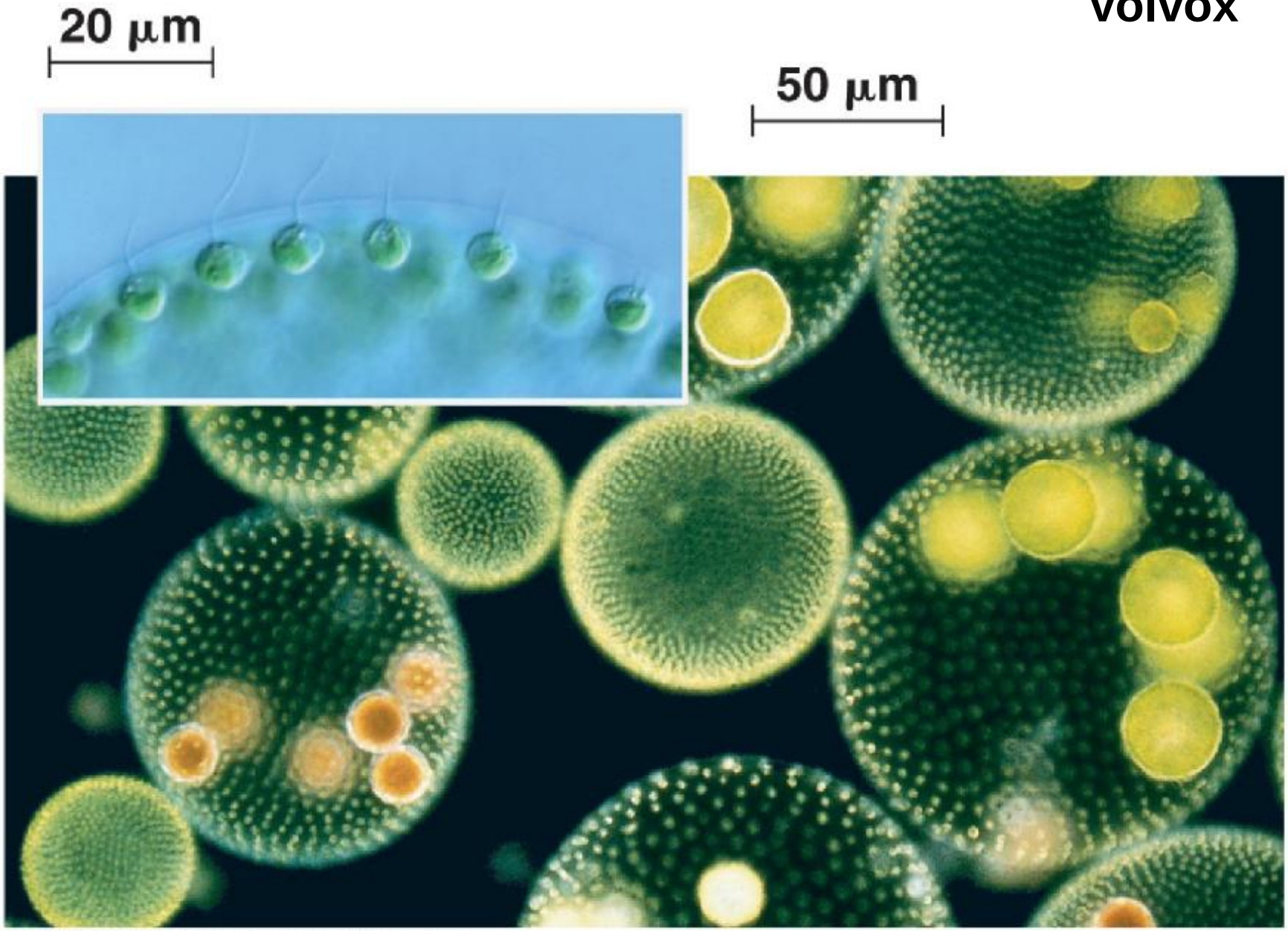
Green Algae

- **Green algae** are named for their grass-green chloroplasts
- Plants are descended from the green algae
- Green algae include unicellular, colonial, and multicellular forms

Chlamidomonas

Volvox



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Seaweeds

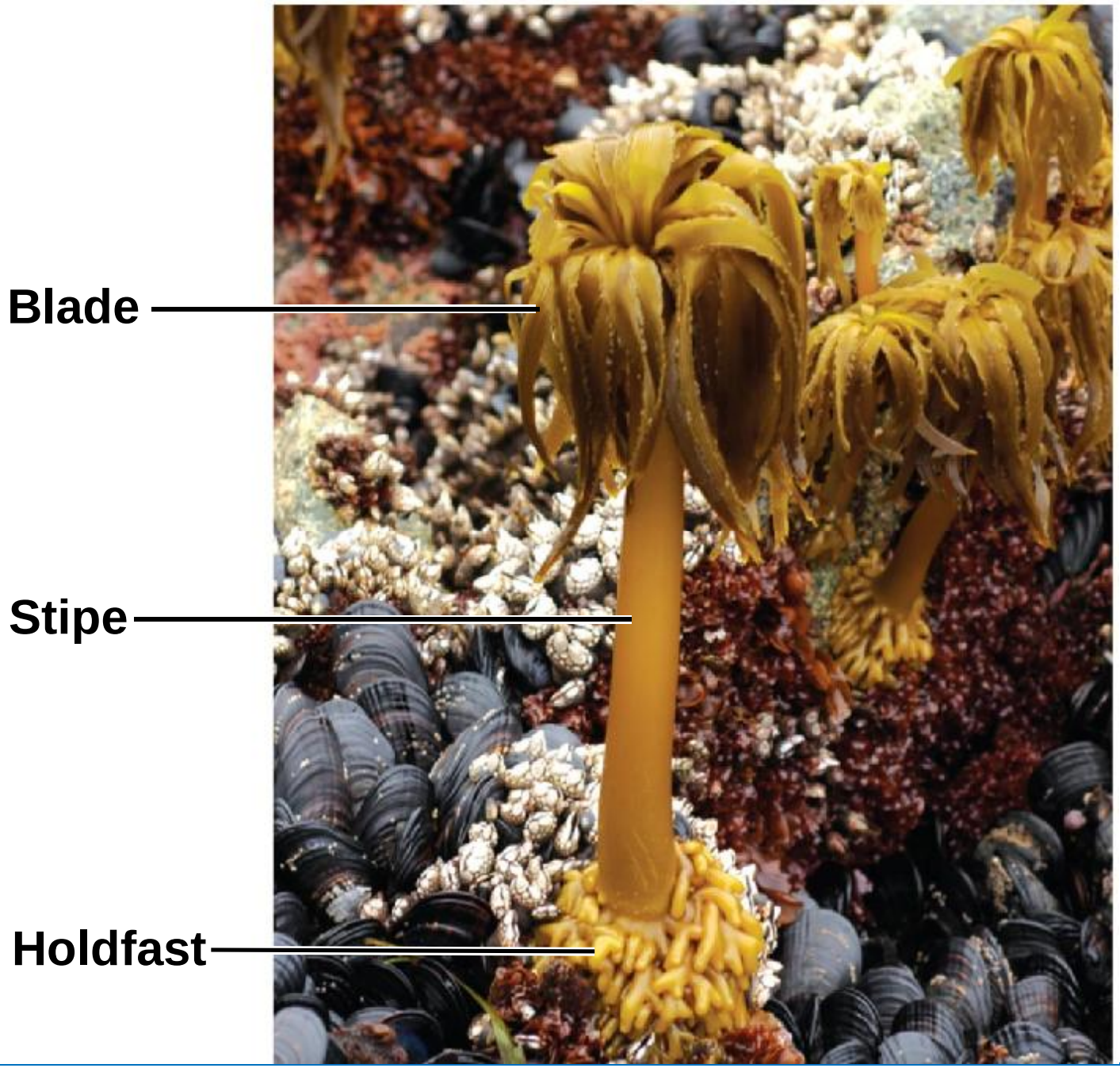
- Seaweeds
  - Are large, multicellular marine algae
  - Grow on rocky shores and just offshore
  - Are often edible

Seaweeds

- The three major groups of seaweeds
  - Brown algae
  - Red algae
  - Green algae

Brown Algae

- **Brown algae** are the largest and most complex algae
- All are multicellular, and most are marine
- Brown algae have the most complex multicellular anatomy of all algae


Blade
Stipe
Holdfast


Sargassum fluitans

Laminaria digitata


Fucus sp

Red Algae

- **Red algae** are reddish in color due to an accessory pigment call phycoerythrin, which masks the green of chlorophyll
- The color varies from greenish-red in shallow water to dark red or almost black in deep water
- Red algae are usually multicellular; the largest are seaweeds
- Red algae are the most abundant large algae in coastal waters of the tropics

- ***Bonnemaisonia hamifera***

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20 cm

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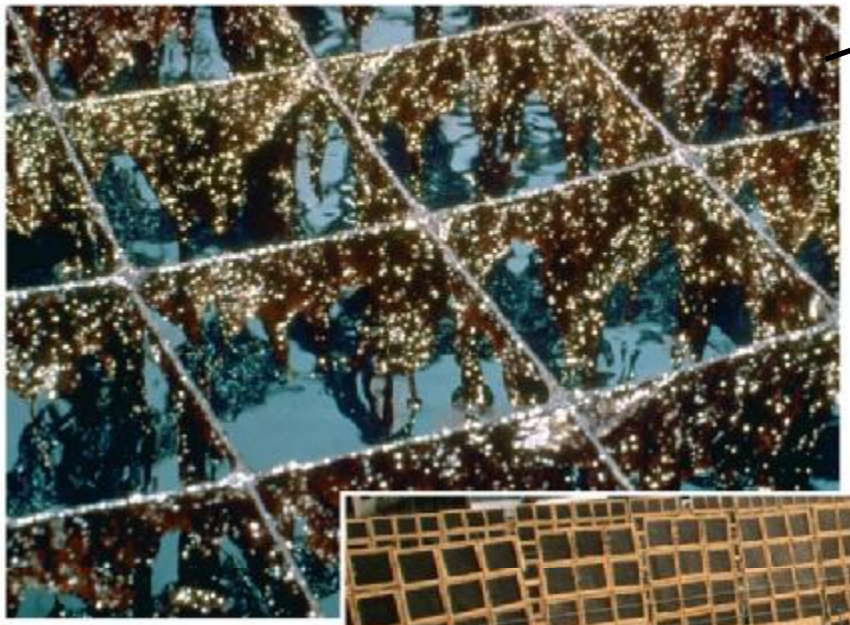
◀ ***Palmaria palmata***

Antithamnion plumula

Gracilaria coronopifolia

▼ **Nori. The red alga *Porphyra* is the source of a traditional Japanese food.**



The seaweed is grown on nets in shallow coastal waters.

The harvested seaweed is spread on bamboo screens to dry.

Paper-thin, glossy sheets of nori make a mineral-rich wrap for rice, seafood, and vegetables in sushi.

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Green algae

2 cm

Ulva
(sea lettuce)

***Caulerpa,* an intertidal chlorophyte**

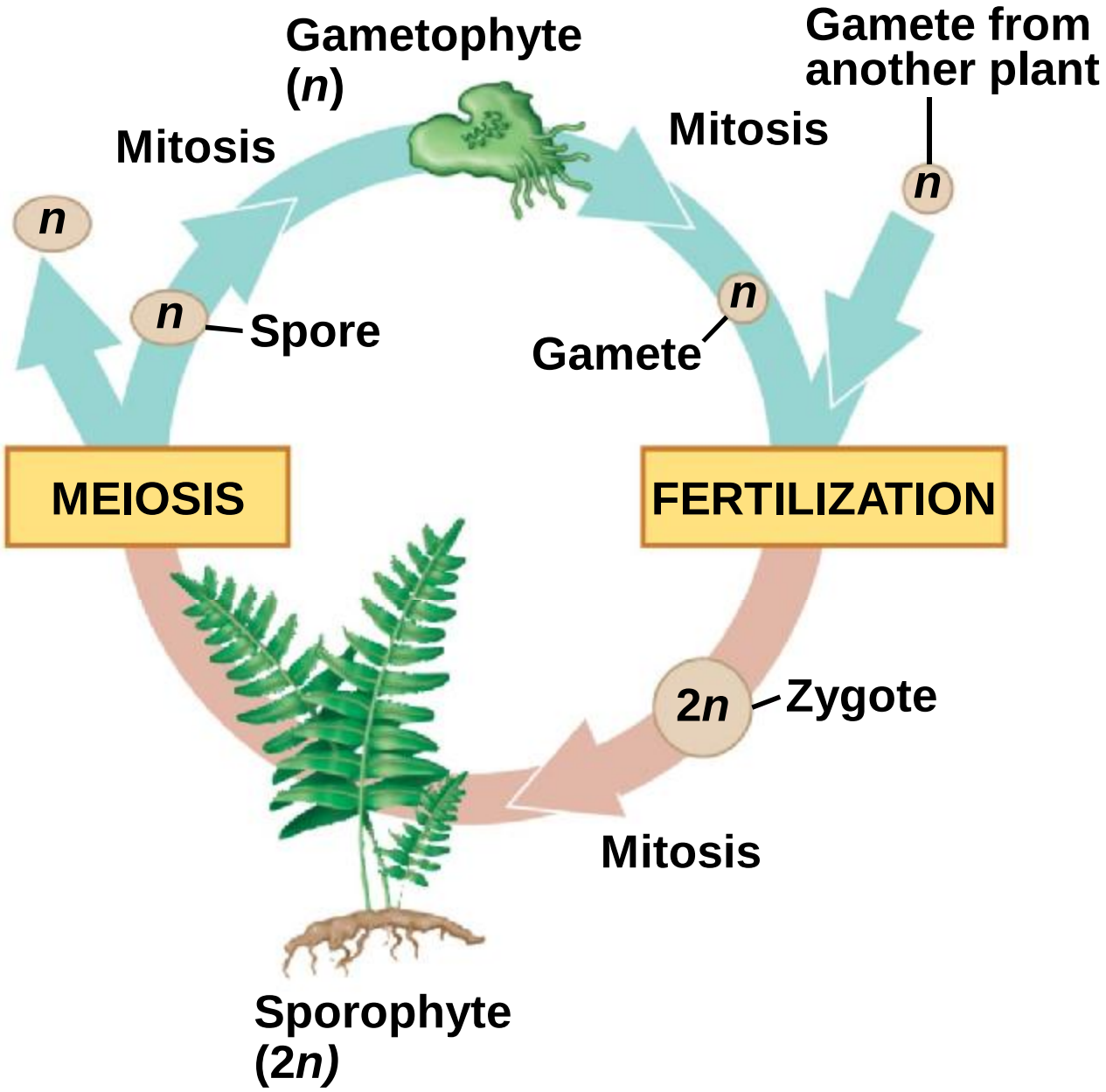
Derived Traits of Plants

- Four key traits appear in nearly all land plants:
  - Alternation of generations (with multicellular, dependent embryos)
  - Walled spores produced in sporangia
  - Multicellular gametangia
  - Apical meristems

- Additional derived traits 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

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



Alternation of generations

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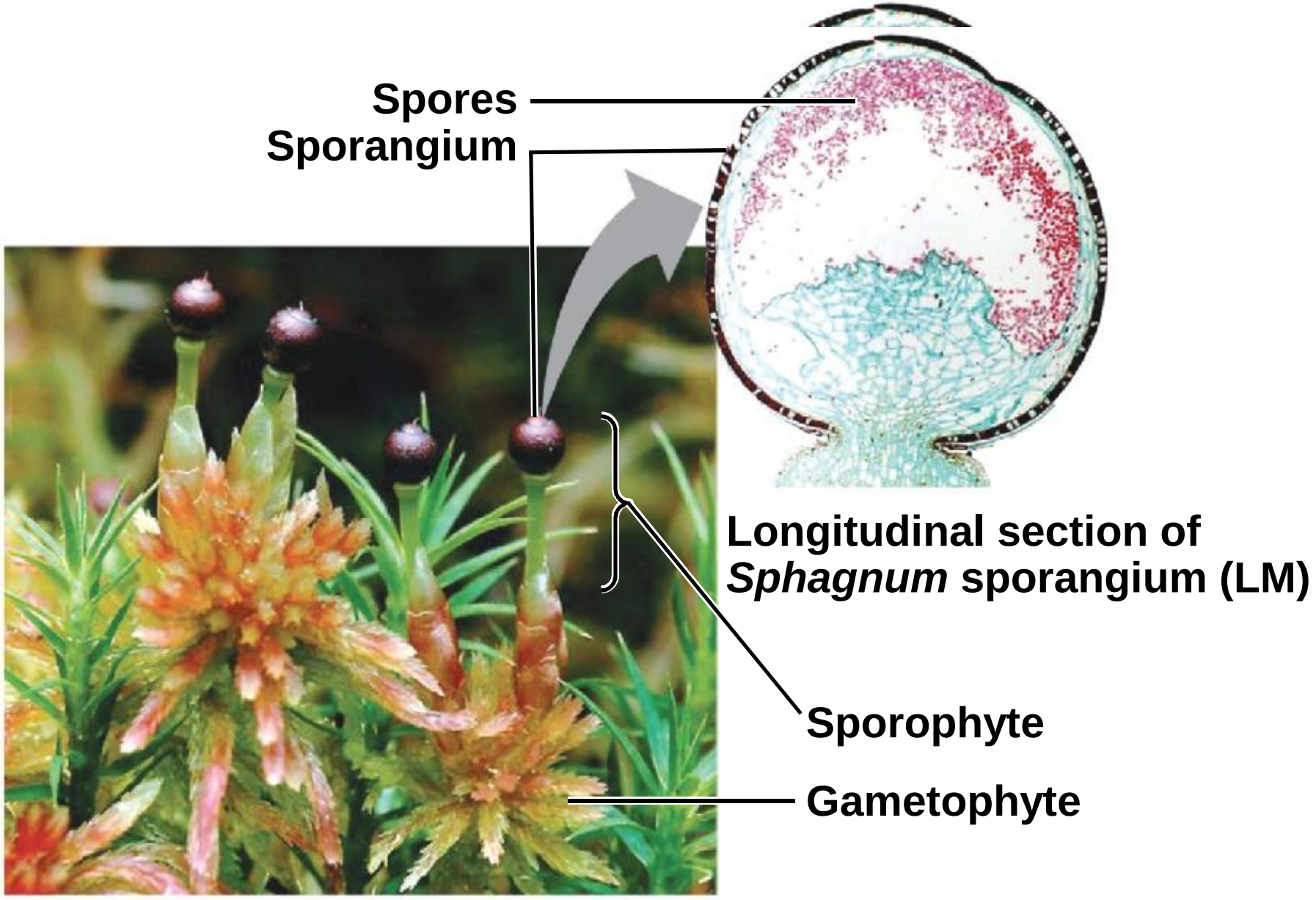
Walled Spores Produced in Sporangia

- 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



Sporophytes and sporangia of *Sphagnum* (a moss)

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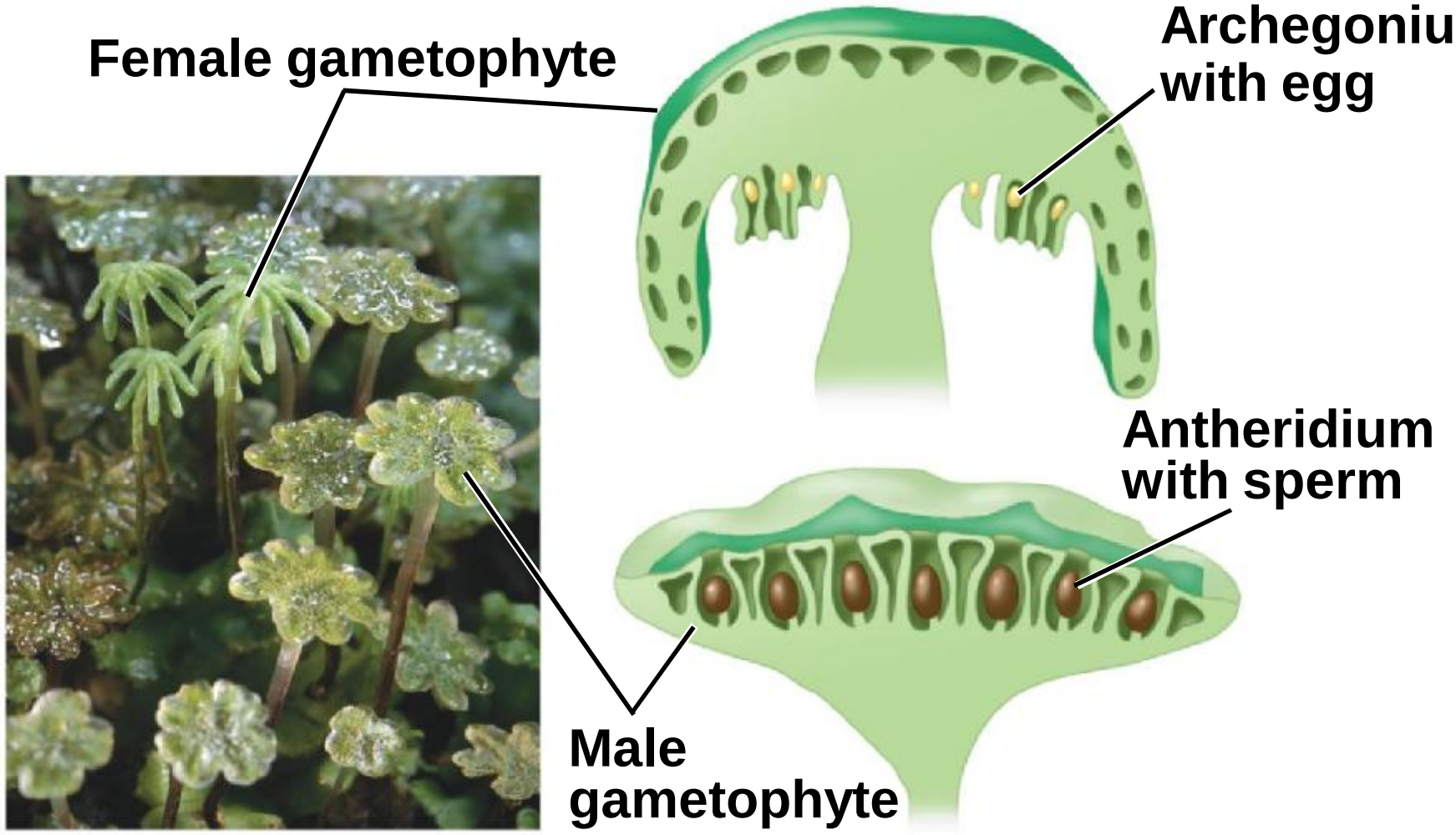
Multicellular Gametangia

- 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



Archegonia and antheridia of *Marchantia* (a liverwort)

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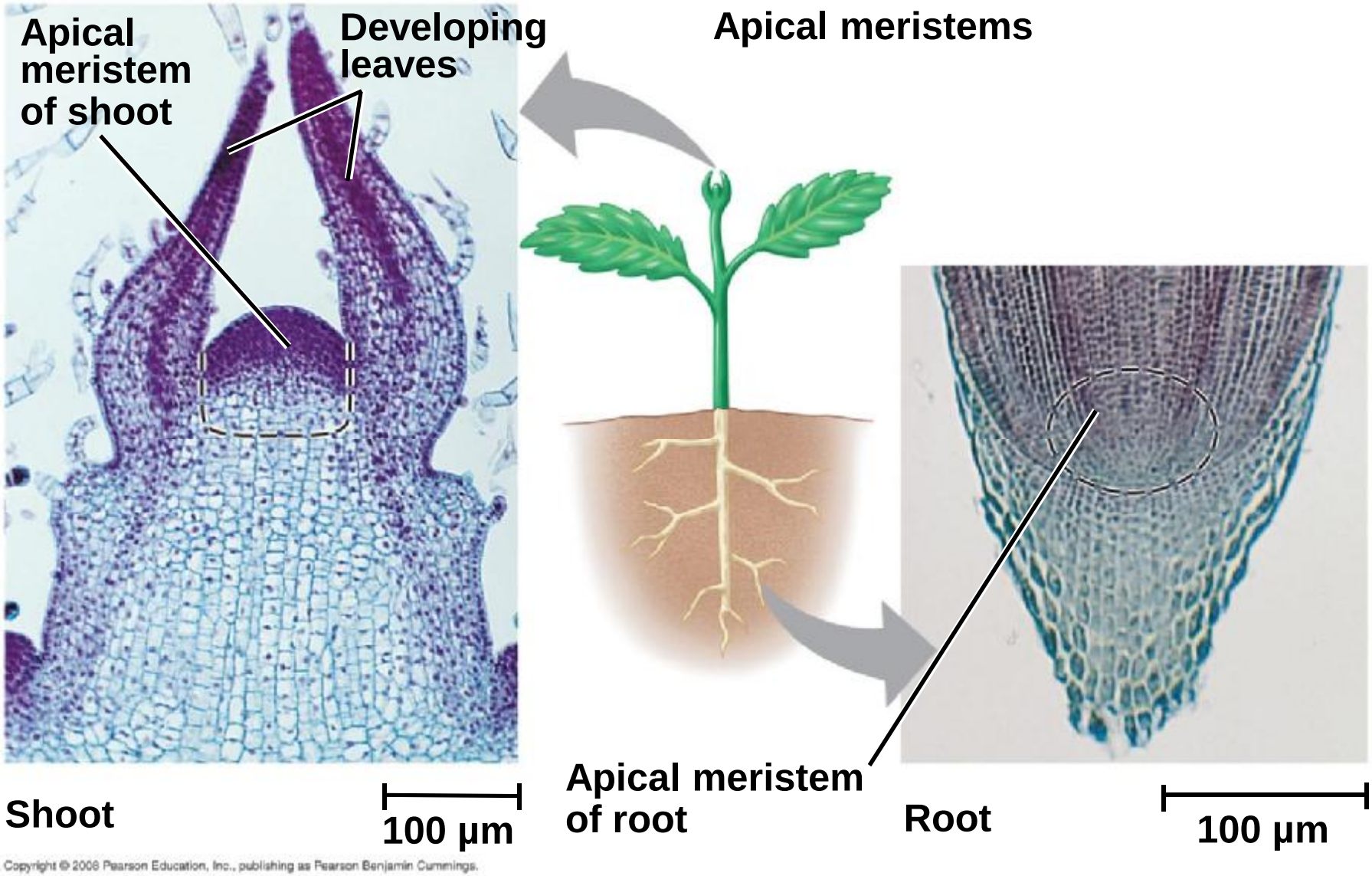
Apical Meristems

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



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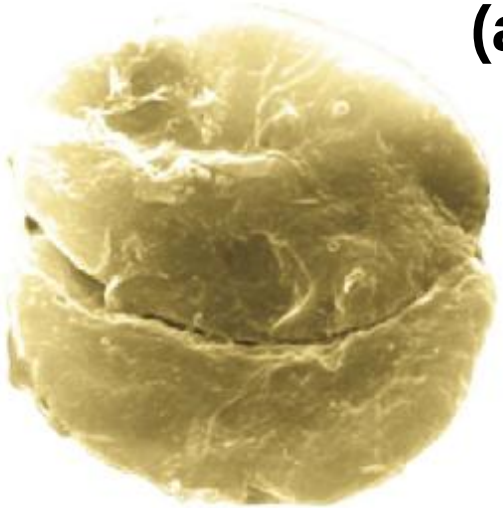
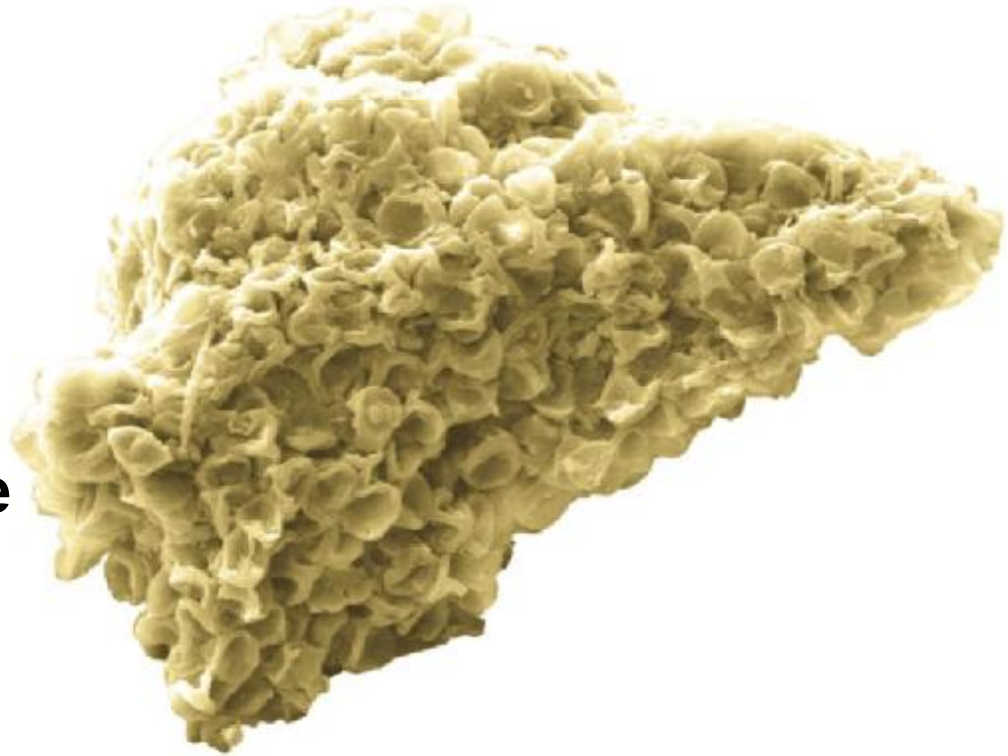
The Origin and Diversification of Plants

- Fossil evidence indicates that plants were on land at least 475 million years ago
- Fossilized spores and tissues have been extracted from 475-million-year-old rocks



(a) Fossilized spores



(b) Fossilized sporophyte tissue

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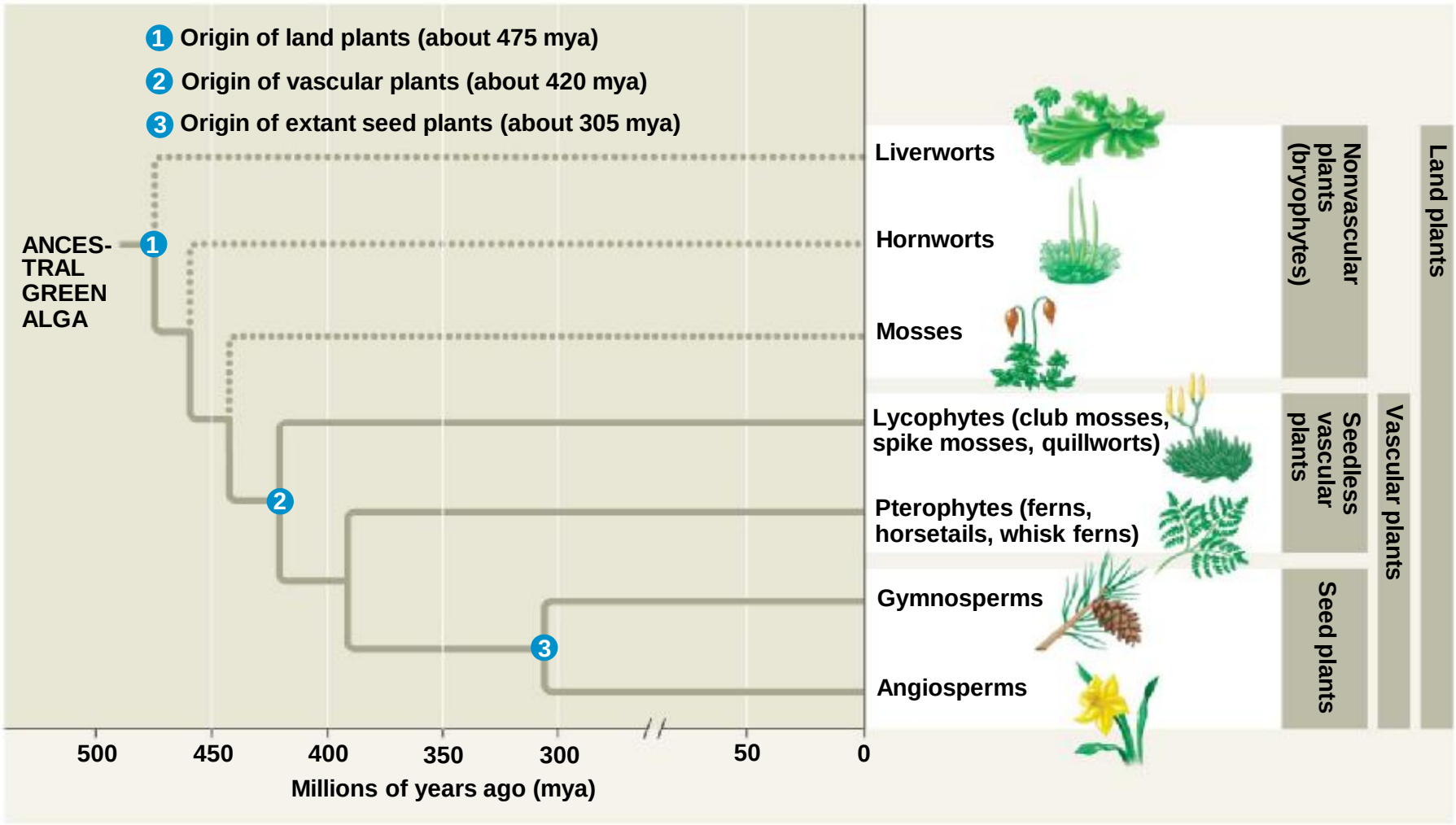
- Those ancestral species gave rise to a vast diversity of modern plants
- Land plants can be informally grouped based on the presence or absence of **vascular tissue**
- Most plants have vascular tissue; these constitute the **vascular plants**
- Nonvascular plants are commonly called **bryophytes**

- **Seedless vascular plants** can be divided into clades
  - **Lycophytes** (club mosses and their relatives)
  - **Pterophytes** (ferns and their relatives)

- 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
  - **Angiosperms**, the flowering 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



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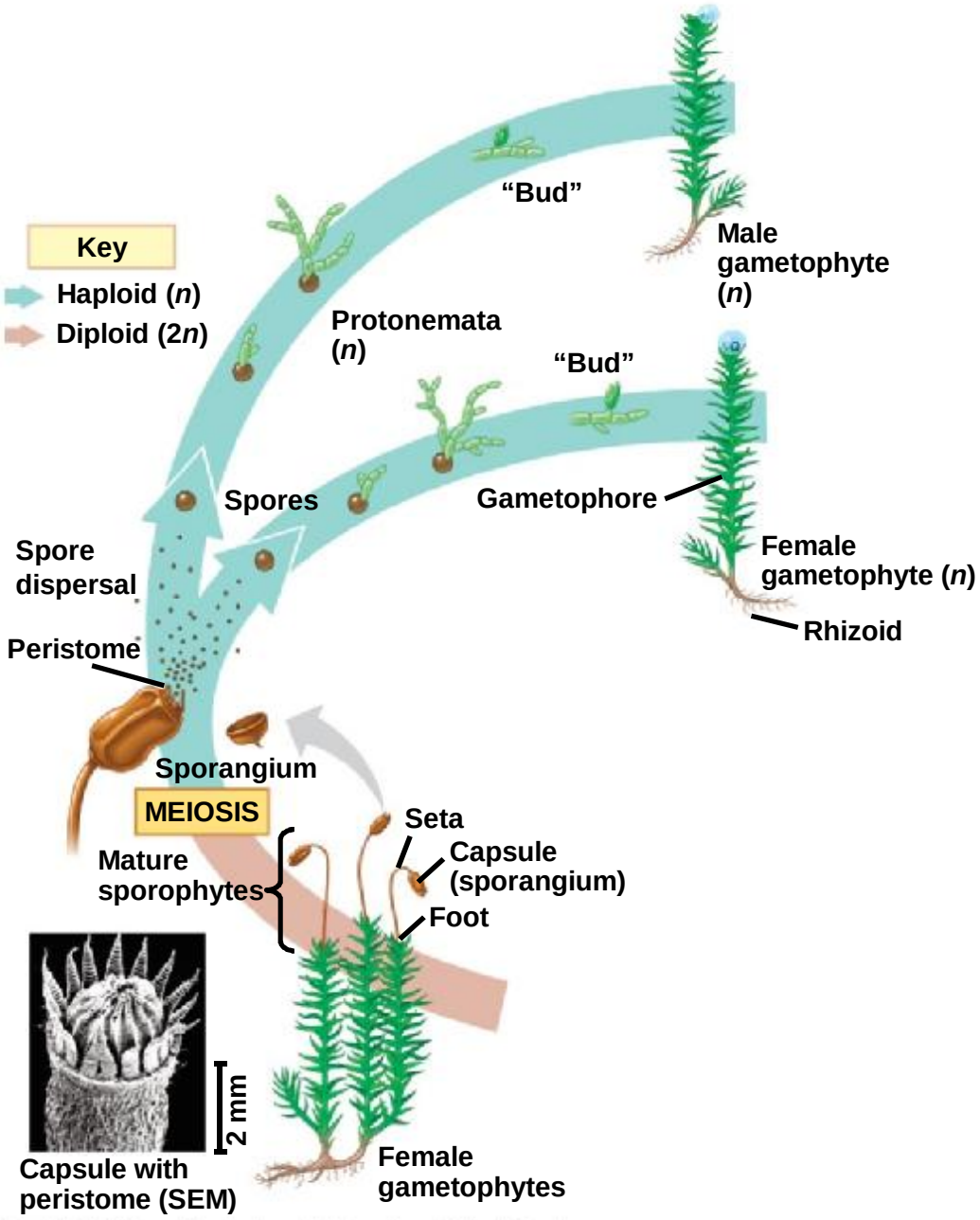
Bryophytes

- Bryophytes are 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

Bryophyte Gametophytes

- In all three bryophyte phyla, gametophytes are larger and longer-living than sporophytes
- Sporophytes are typically present only part of the time



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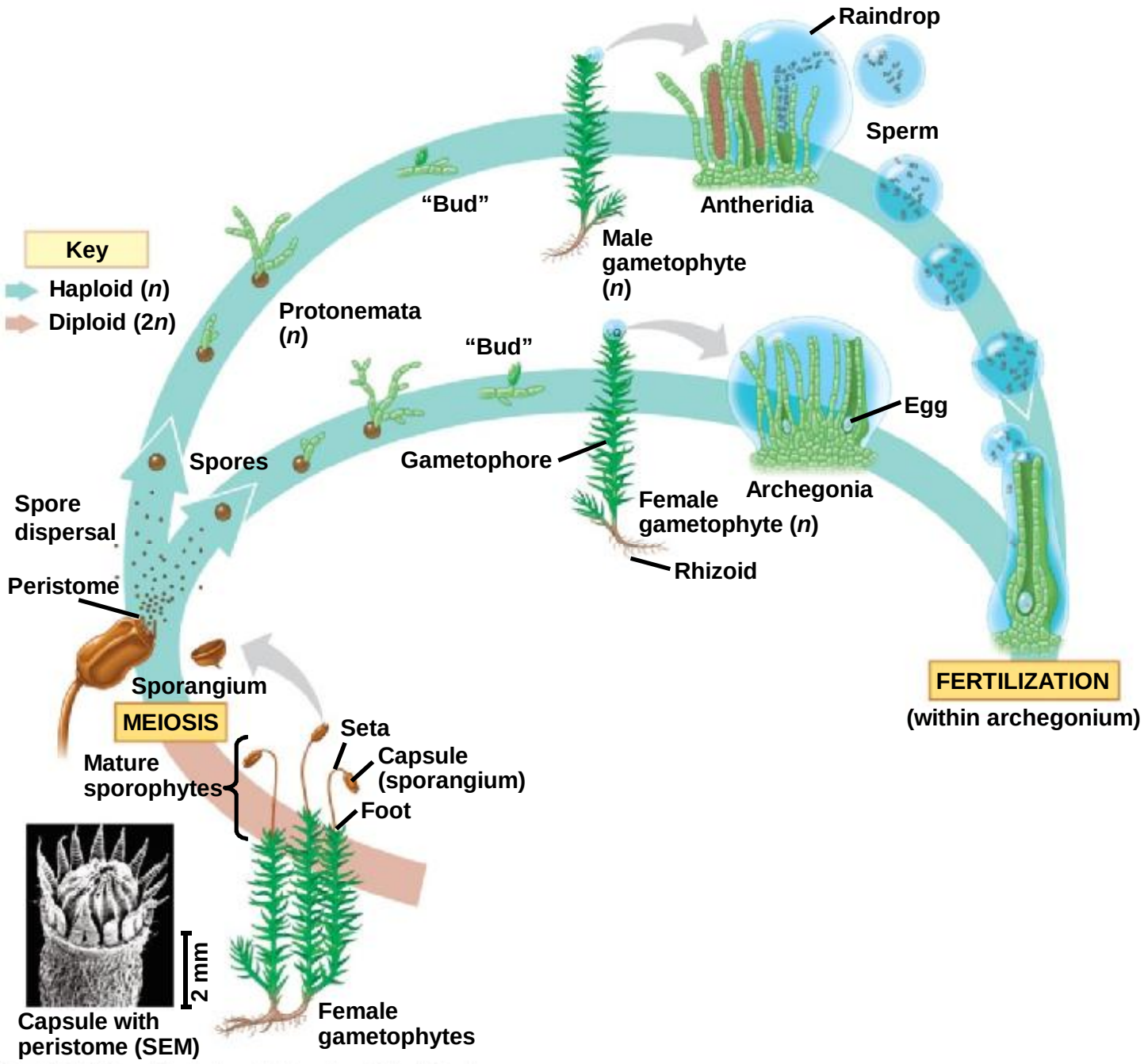

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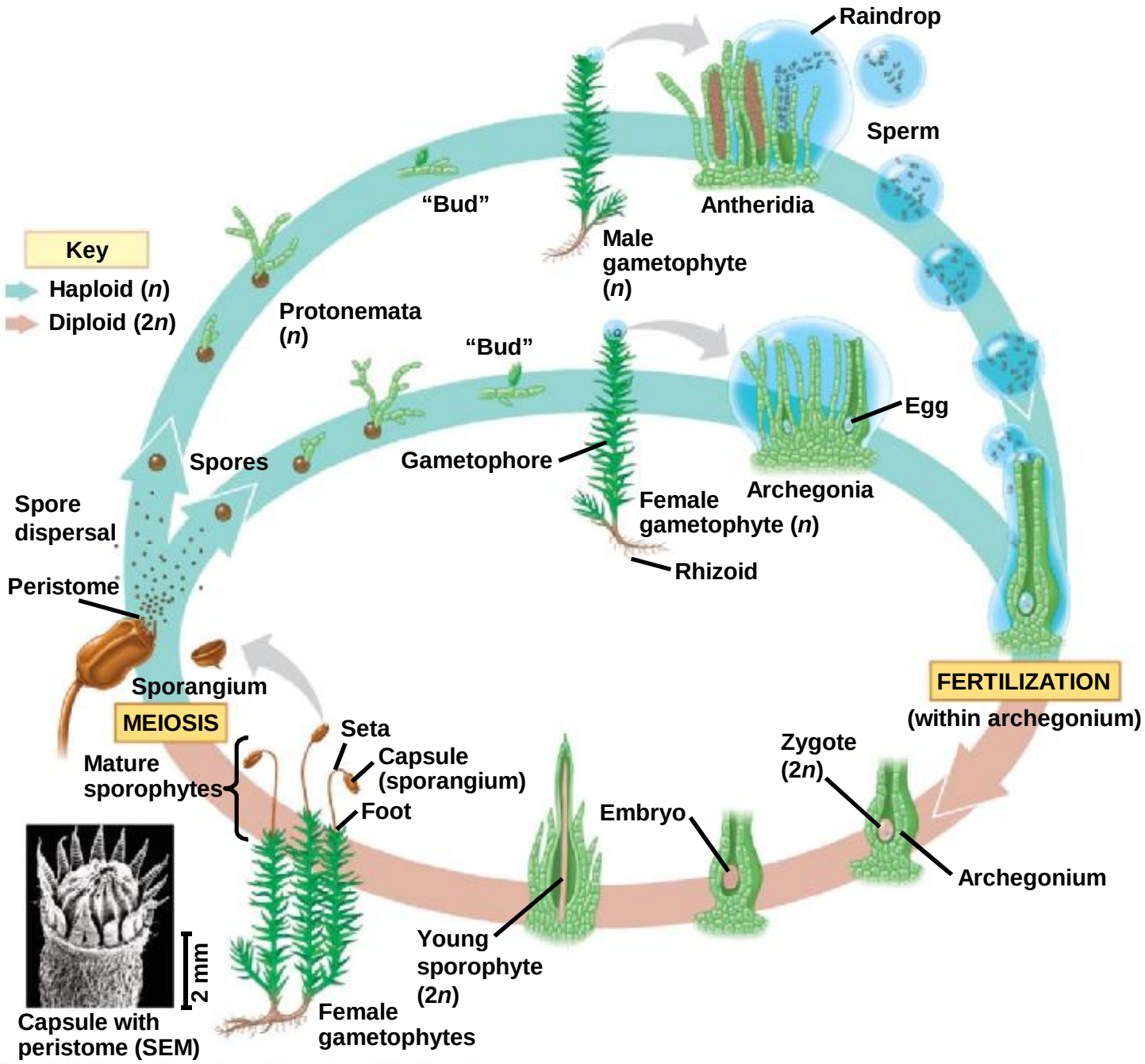

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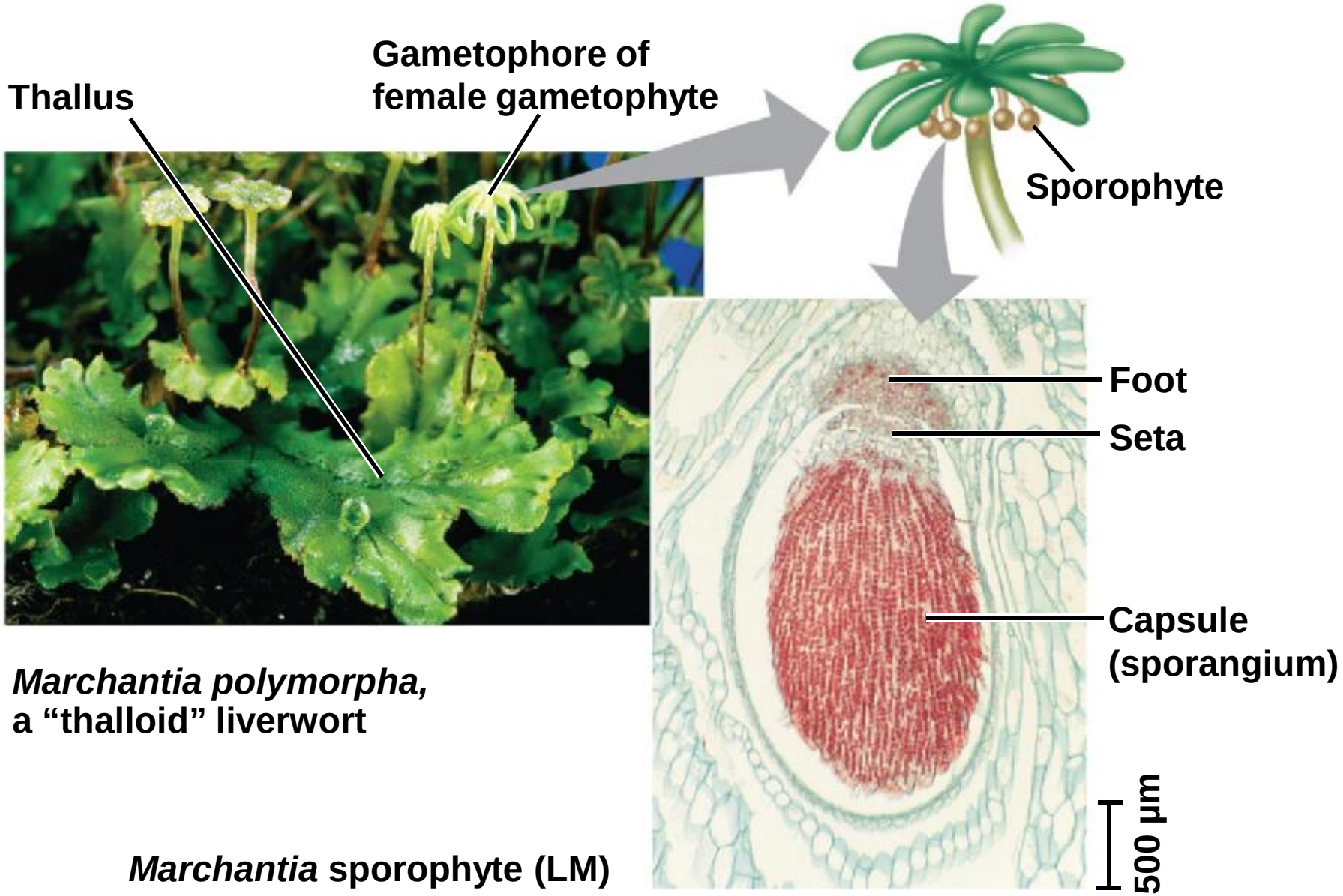
- A spore germinates into a gametophyte composed of a **protonema** and gamete-producing **gametophore**
- **Rhizoids** anchor gametophytes to substrate
- The height of gametophytes is constrained by lack of vascular tissues
- Mature gametophytes produce flagellated sperm in antheridia and an egg in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

Bryophyte Sporophytes

- Bryophyte sporophytes grow out of archegonia, and are the smallest and simplest sporophytes of all extant plant groups
- A sporophyte consists of a **foot**, a **seta** (stalk), and a sporangium, also called a **capsule**, which discharges spores through a **peristome**
- Hornwort and moss sporophytes have **stomata** for gas exchange



***Marchantia polymorpha*, a "thalloid" liverwort**

***Marchantia* sporophyte (LM)**

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Plagiochila eltoidea, "leafy" liverwort

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An *Anthoceros* hornwort species

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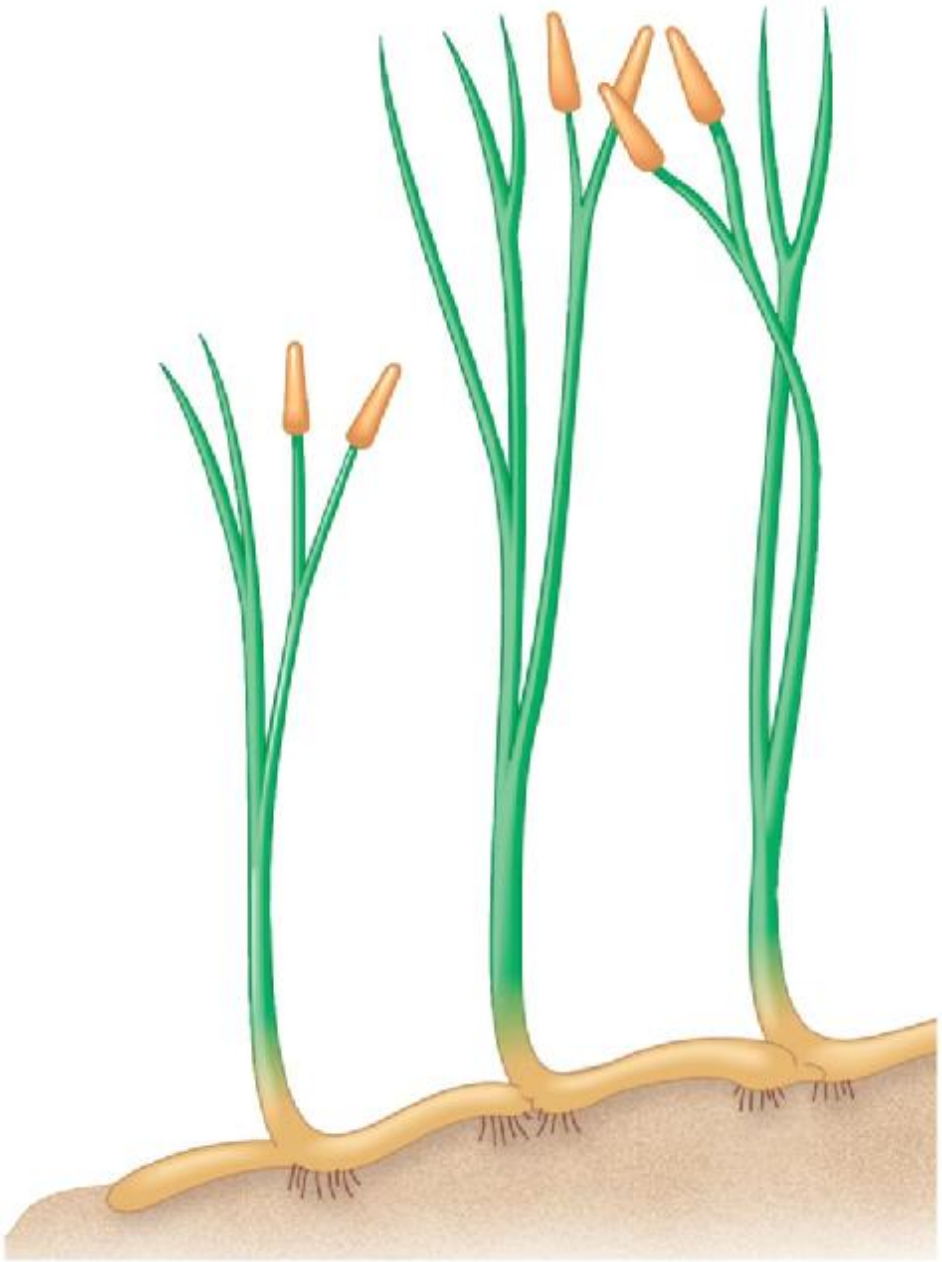
Seedless vascular plants

- Bryophytes and bryophyte-like plants were the prevalent vegetation during the first 100 million years of plant evolution
- Vascular plants began to diversify 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

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
- Living vascular plants are characterized by:
  - Life cycles with dominant sporophytes
  - Vascular tissues called xylem and phloem
  - Well-developed roots and leaves



Sporophytes of *Aglaophyton major*

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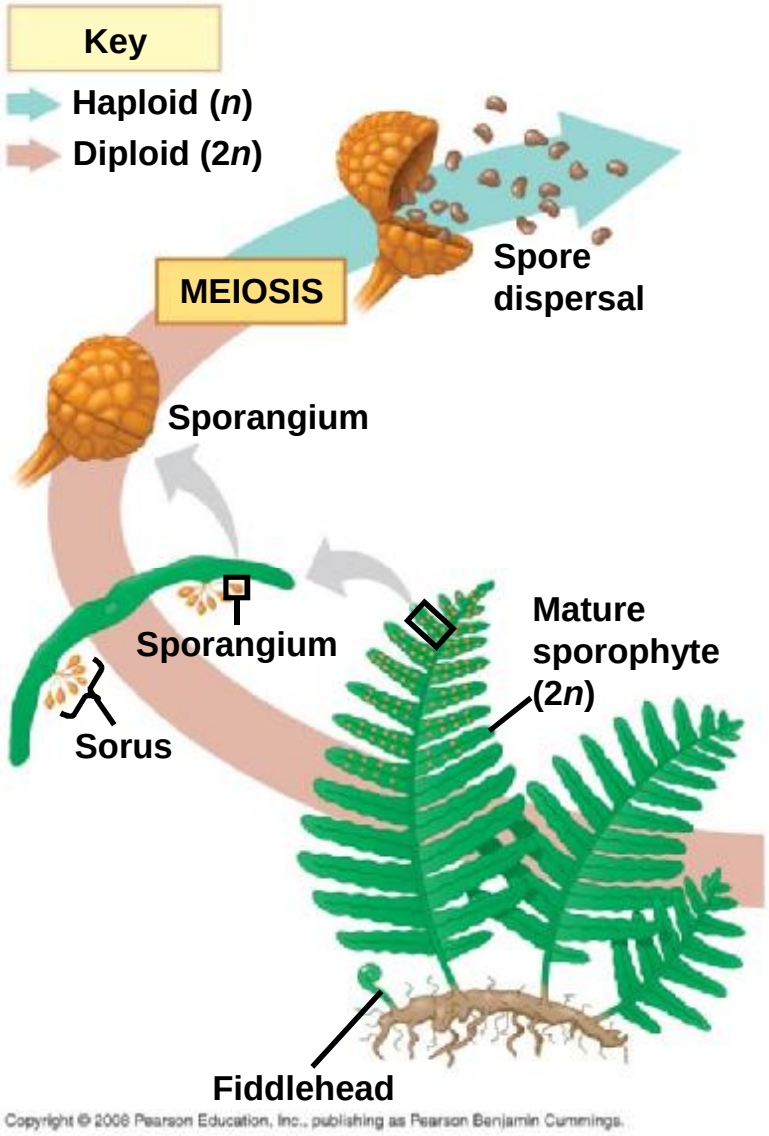
Life Cycles with Dominant Sporophytes

- 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


Key
Haploid (n)
Diploid (2n)
MEIOSIS
Spore dispersal
Sporangium
Sporangium
Sorus
Mature sporophyte (2n)
Fiddlehead
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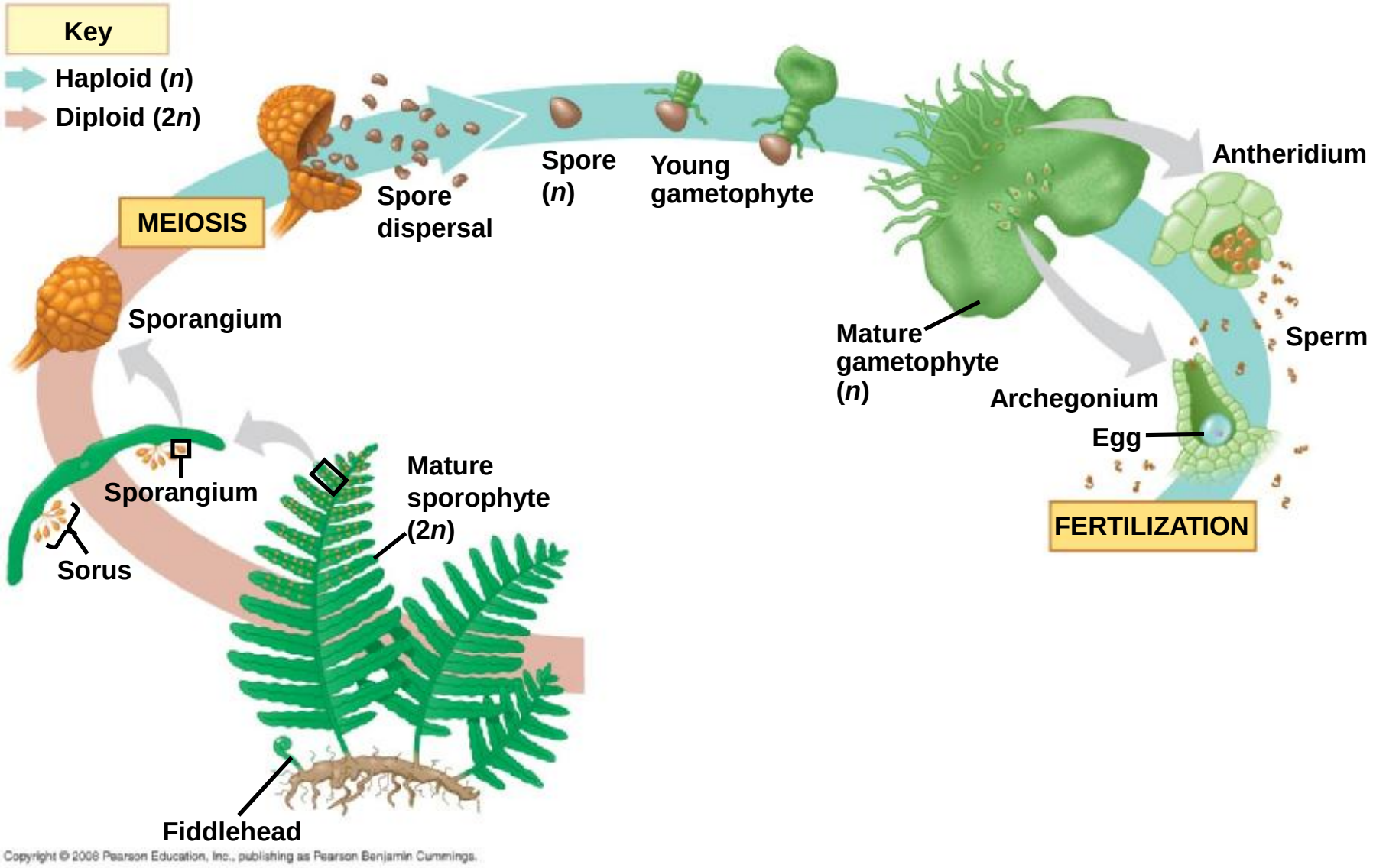
Key
Haploid (n)
Diploid (2n)
MEIOSIS
Spore dispersal
Spore (n)
Young gametophyte
Antheridium
Sporangium
Mature gametophyte (n)
Sperm
Archegonium
Egg
FERTILIZATION
Sporangium
Mature sporophyte (2n)
Sorus
Fiddlehead
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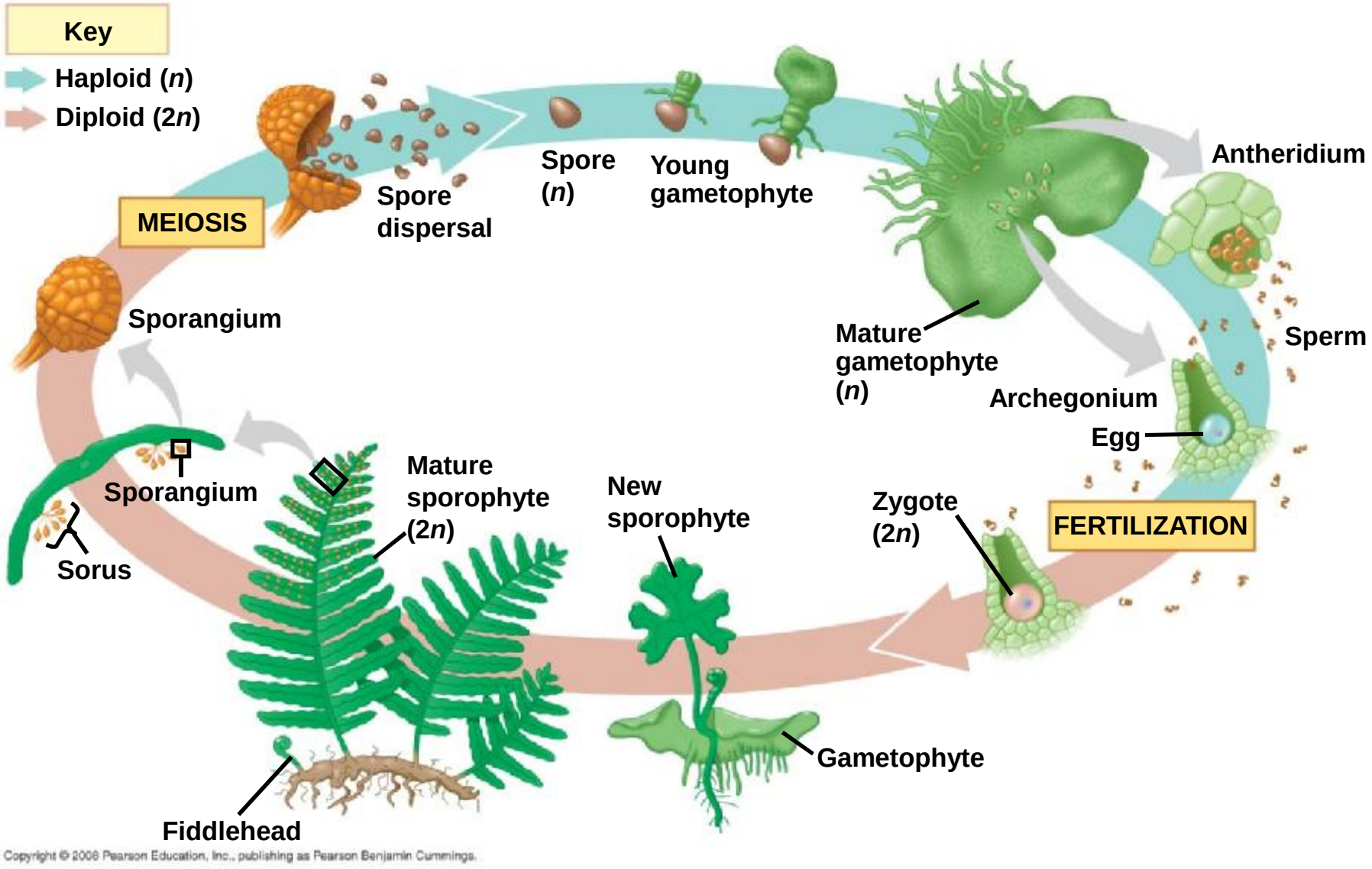

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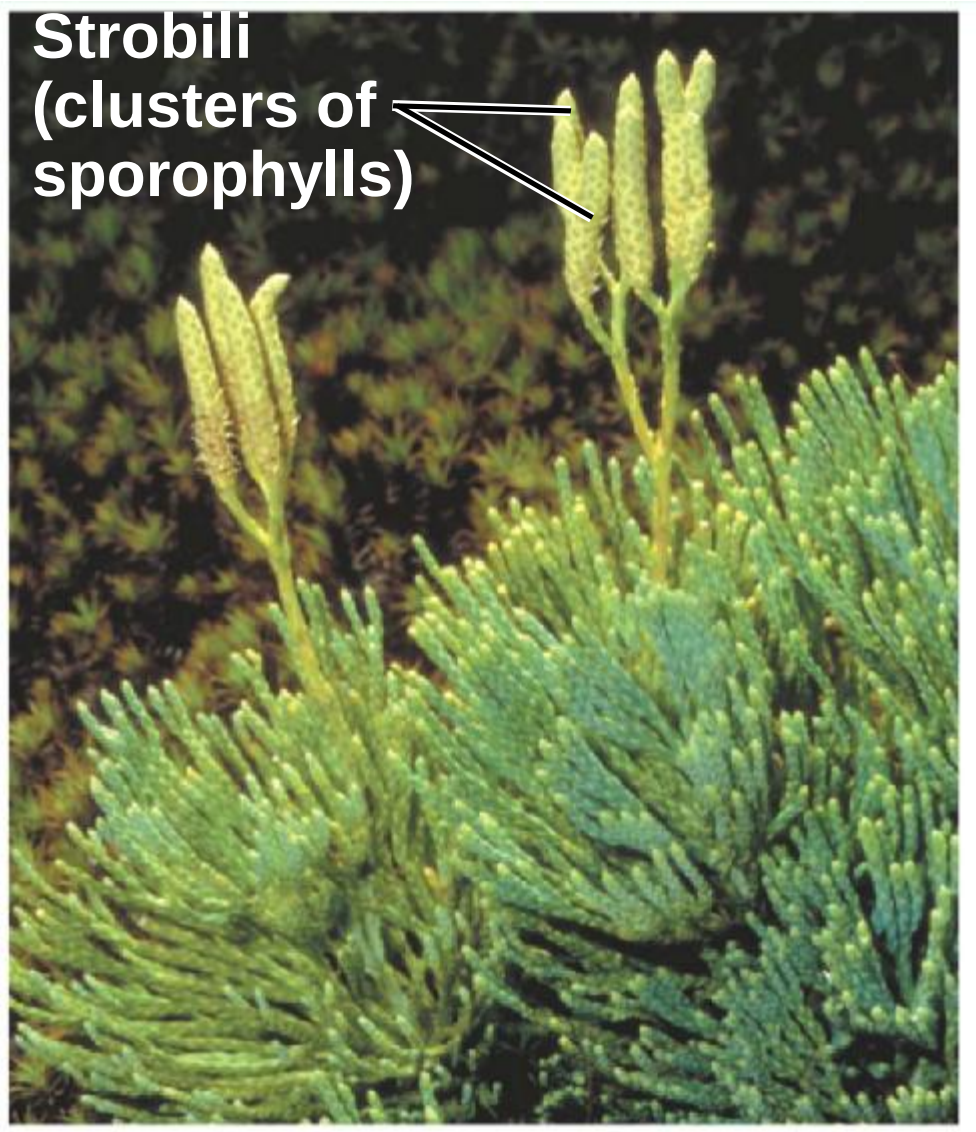
Classification of Seedless Vascular Plants

- There are two phyla of seedless vascular plants:
  - Phylum Lycophyta includes club mosses, spike mosses, and quillworts
  - Phylum Pterophyta includes ferns, horsetails, and whisk ferns and their relatives

Diphasiastrum tristachyum, a club moss



Selaginella apoda, a spike moss

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Isoetes gunnii, a quillwort

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Athyrium filix-femina, lady fern

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Equisetum arvense, field horsetail

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Psilotum nudum, a whisk fern

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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

Gymnosperms

- The gymnosperms have “naked” seeds not enclosed by ovaries and consist of four phyla:
  - Cycadophyta (cycads)
  - Gingkophyta (one living species: *Ginkgo biloba*)
  - Gnetophyta (three genera: *Gnetum*, *Ephedra*, *Welwitschia*)
  - Coniferophyta (conifers, such as pine, fir, and redwood)

Gymnosperm Evolution

- Fossil evidence reveals that by the late Devonian period some plants, called **progymnosperms**, had begun to acquire some adaptations that characterize seed plants

***Archaeopteris*, a progymnosperm**

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- Living 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 Cycadophyta

- Individuals have large cones and palmlike leaves
- These thrived during the Mesozoic, but relatively few species exist today

Cycas revoluta

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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

Ginkgo biloba (Bạch quả)

Ginkgo biloba leaves and fleshy seeds

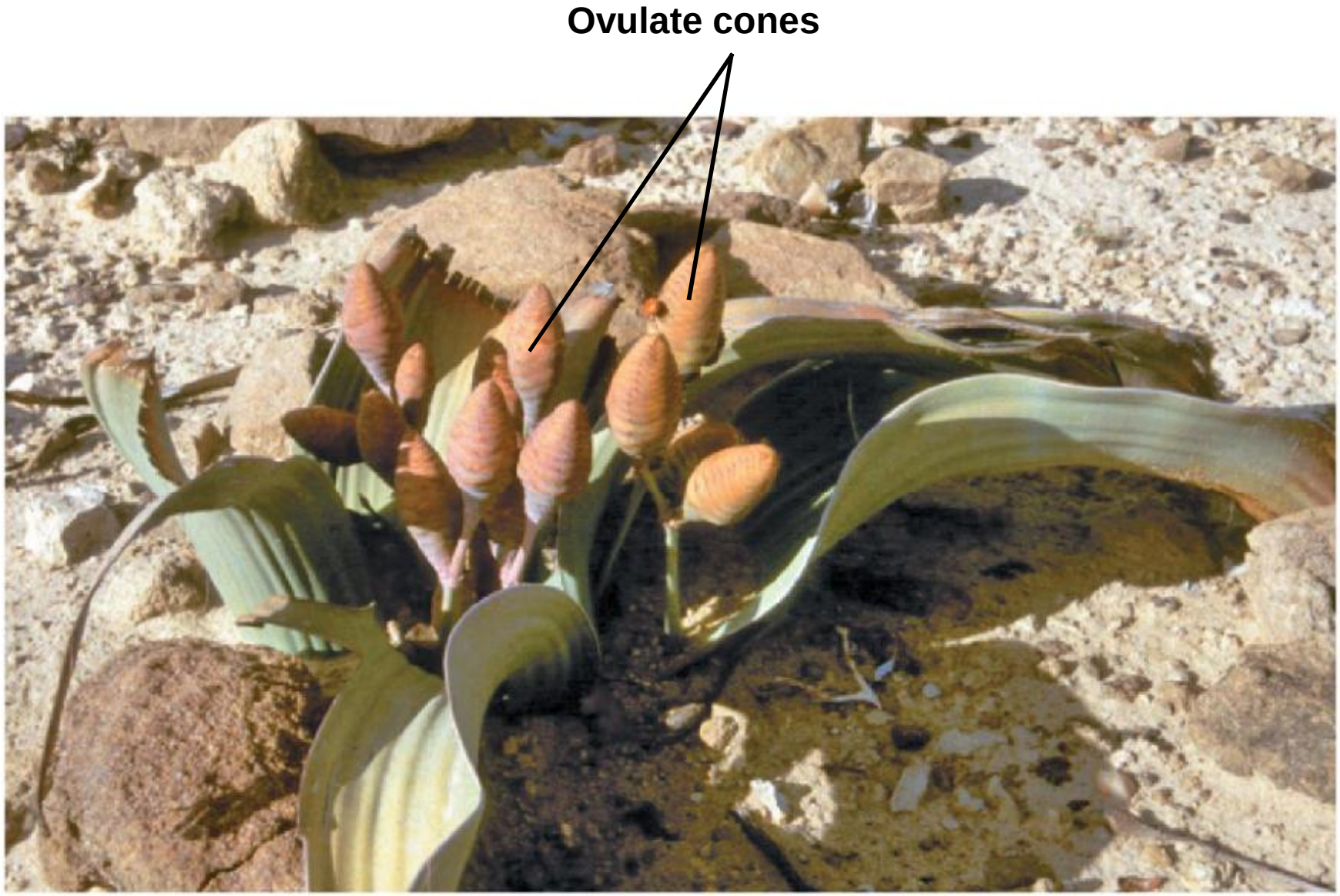
Phylum Gnetophyta

- This phylum comprises three genera
- Species vary in appearance, and some are tropical whereas others live in deserts

Gnetum (Dây gấm)

Ephedra (Ma hoàng)

Welwitschia (hai lá)



Welwitschia

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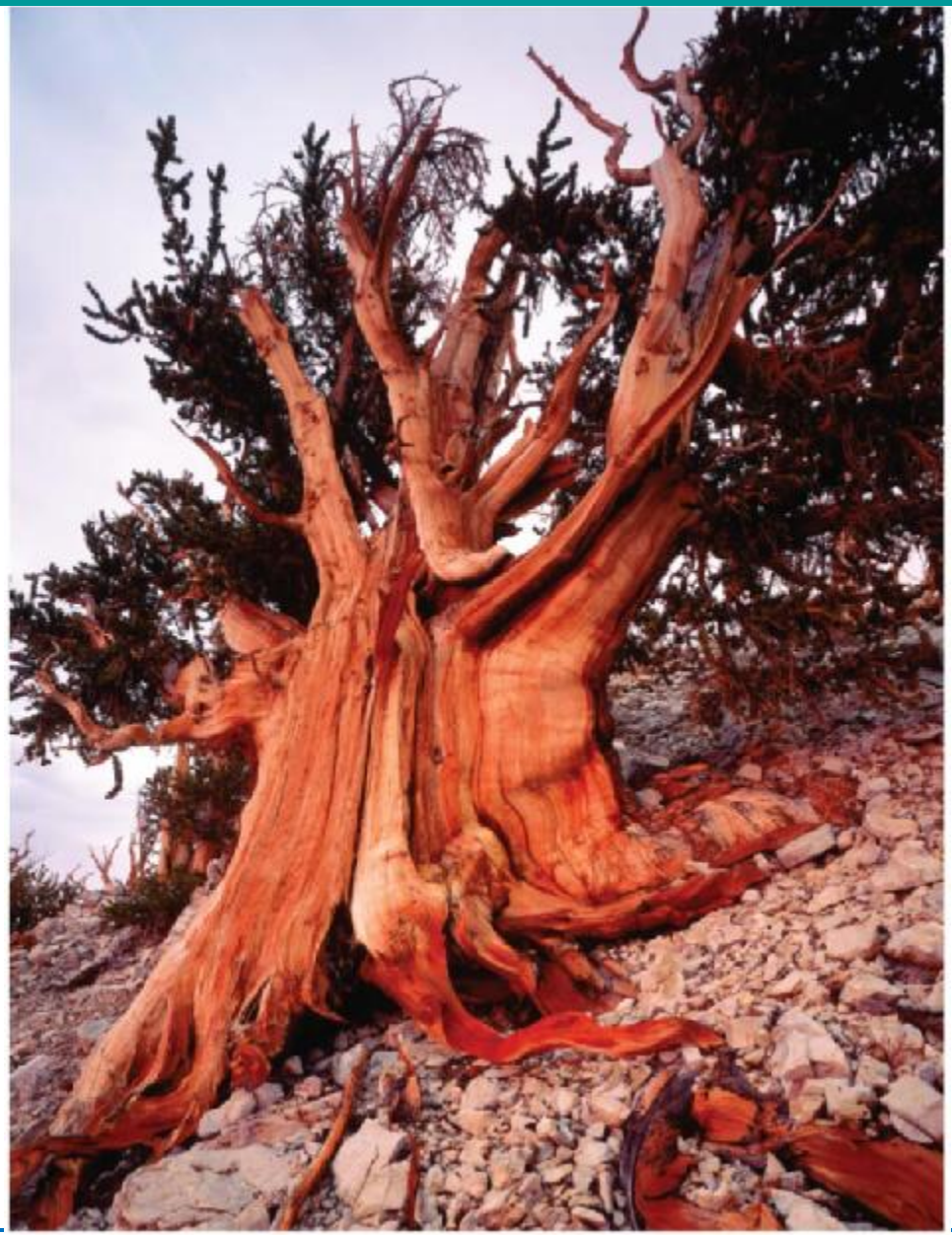
Phylum Coniferophyta

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

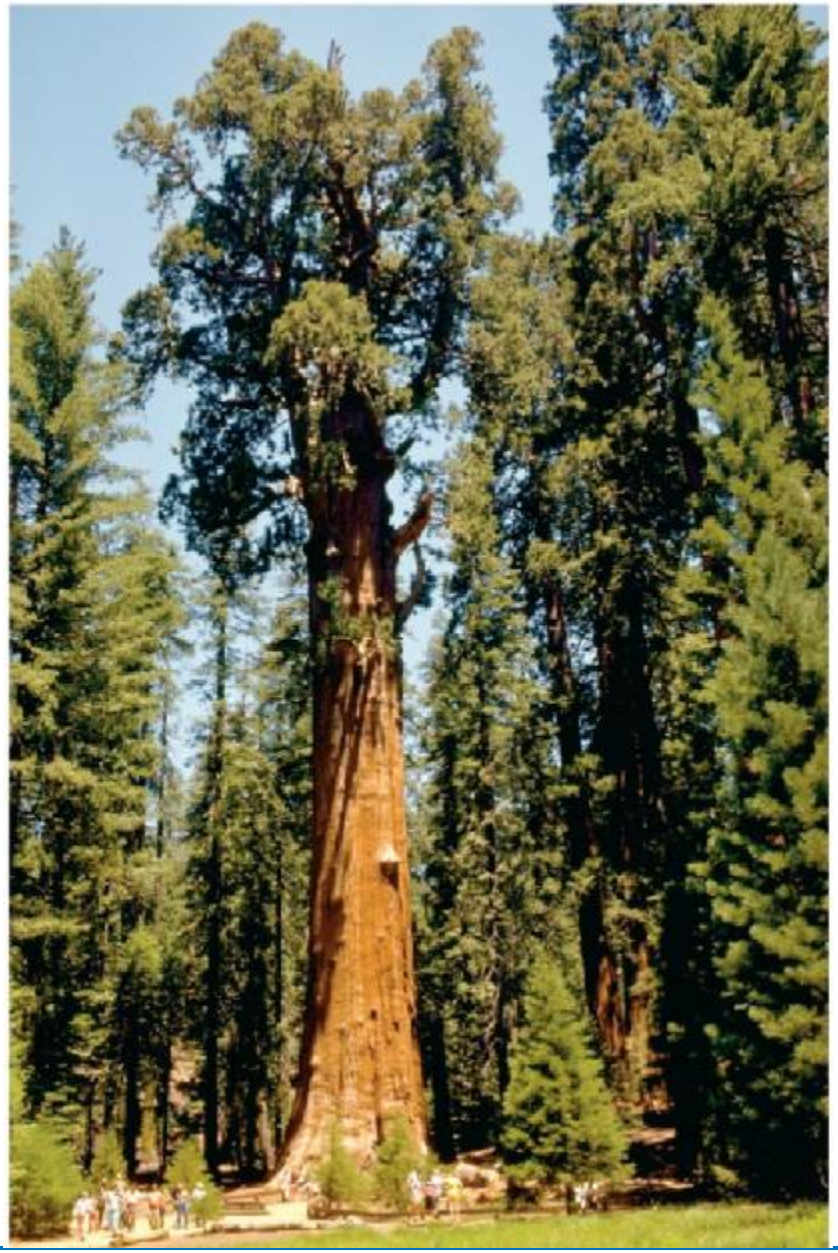
Douglas fir (Linh sam)

European larch (Thông rụng lá)

Bristlecone pine



Sequoia

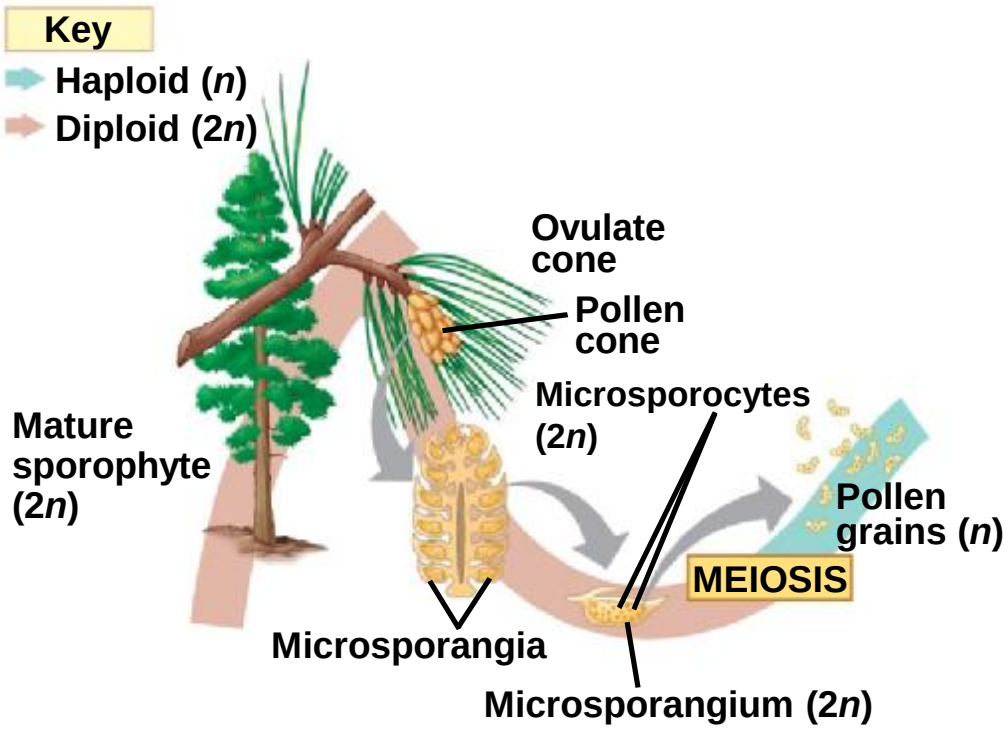


Common juniper (Bách xù)

The Life Cycle of a Pine

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

- The pine tree is the sporophyte and produces sporangia in male and female cones
- Small cones produce microspores called pollen grains, each of which contains a male gametophyte
- The familiar larger cones contain ovules, which produce megaspores that develop into female gametophytes
- It takes nearly three years from cone production to mature seed



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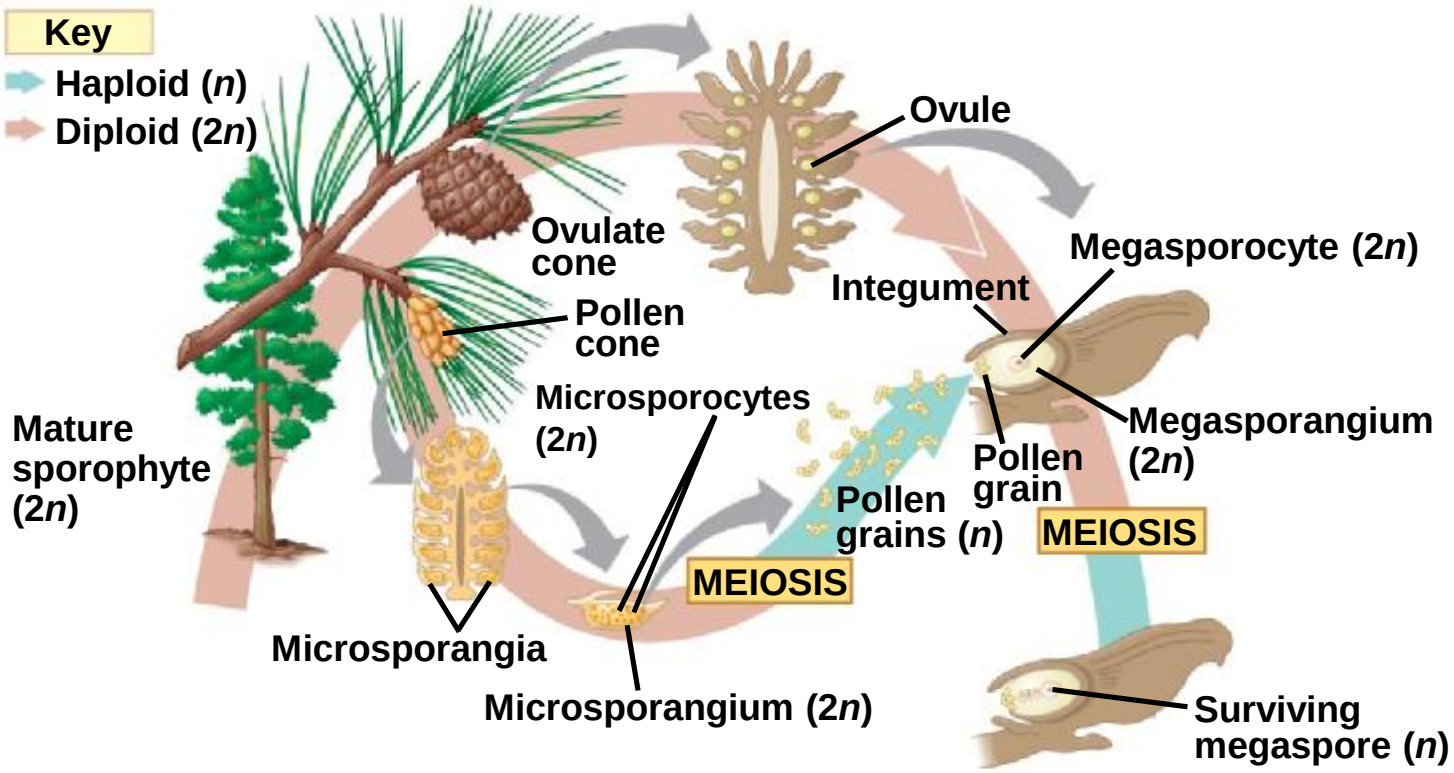

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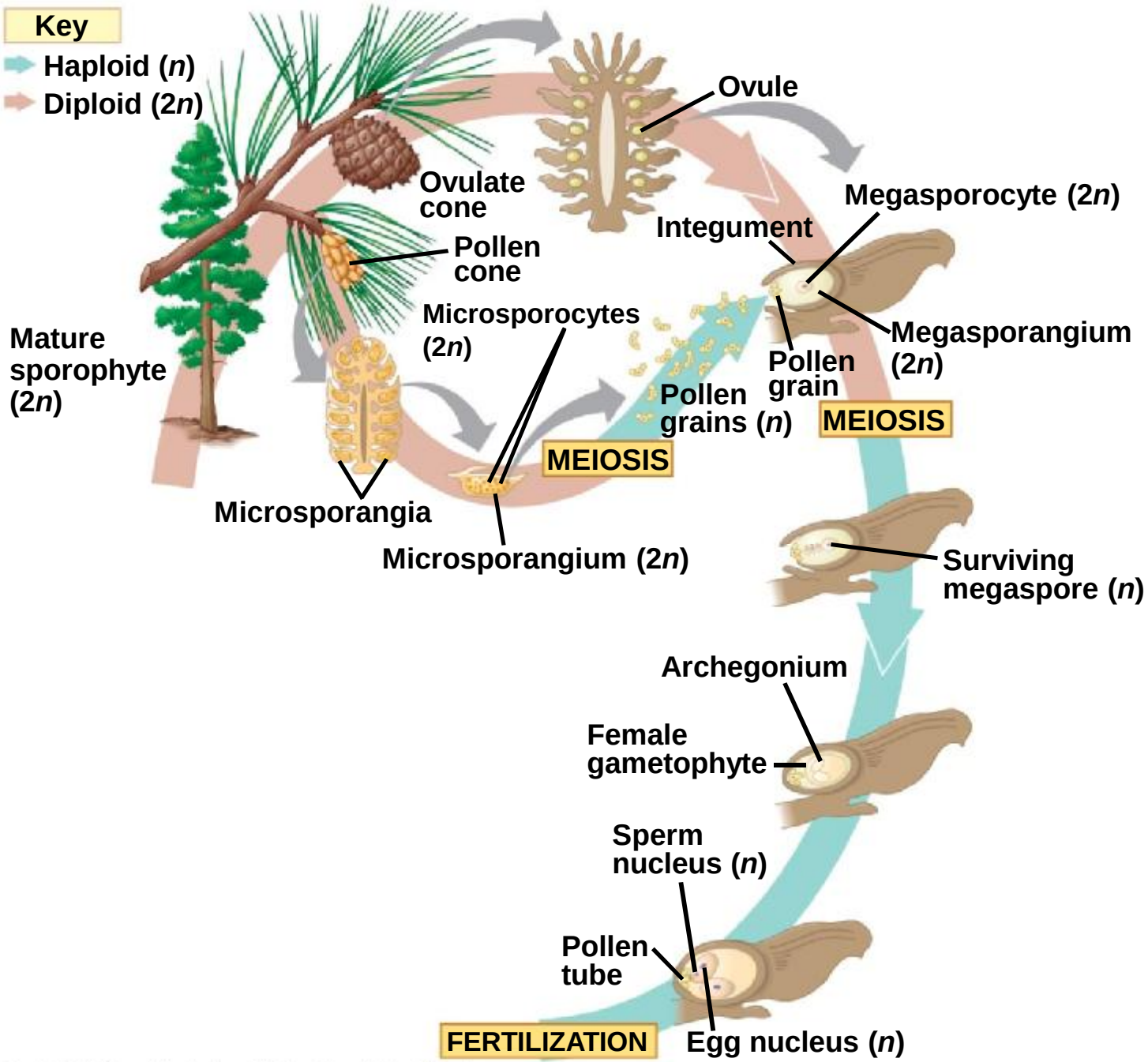

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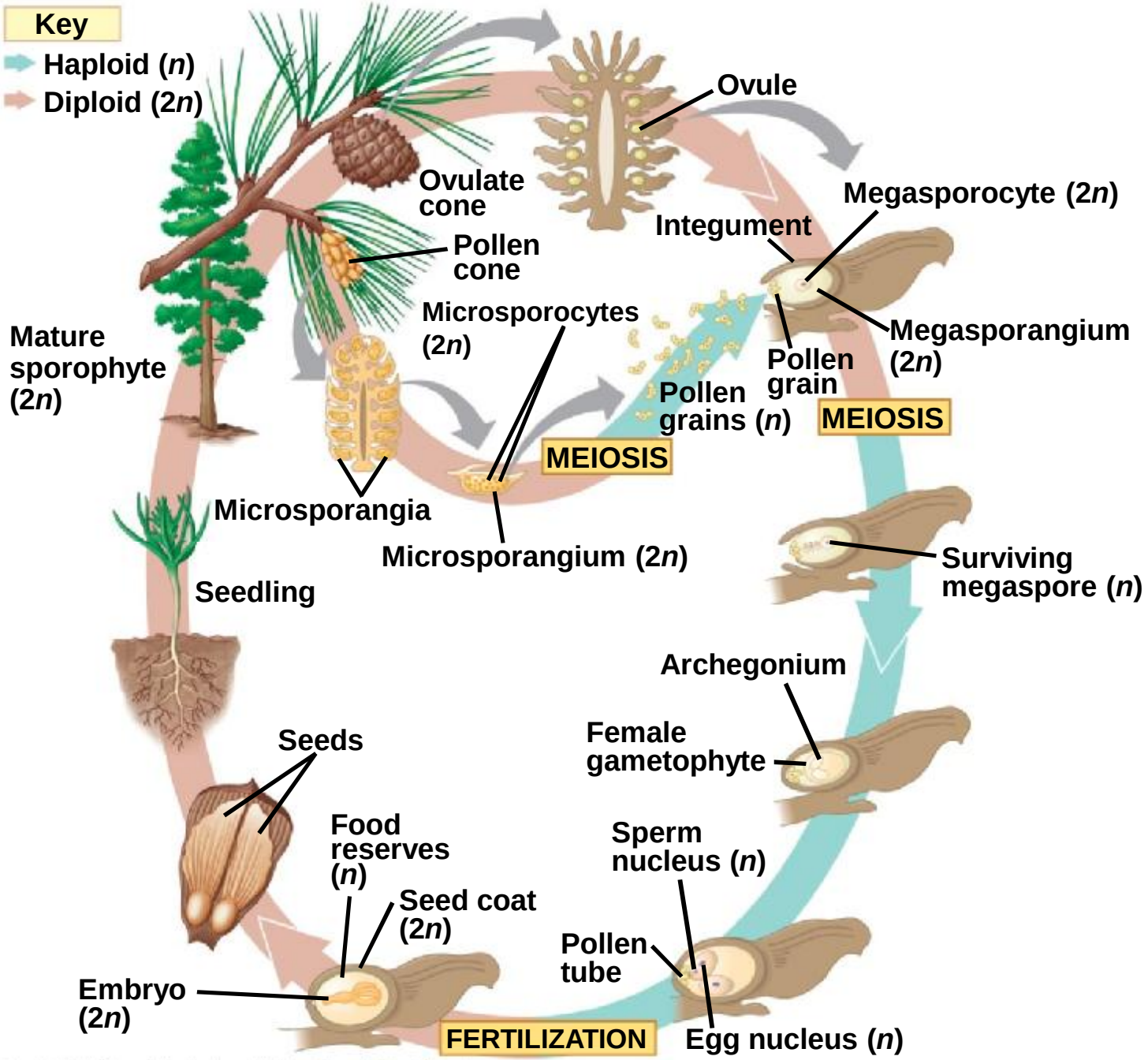

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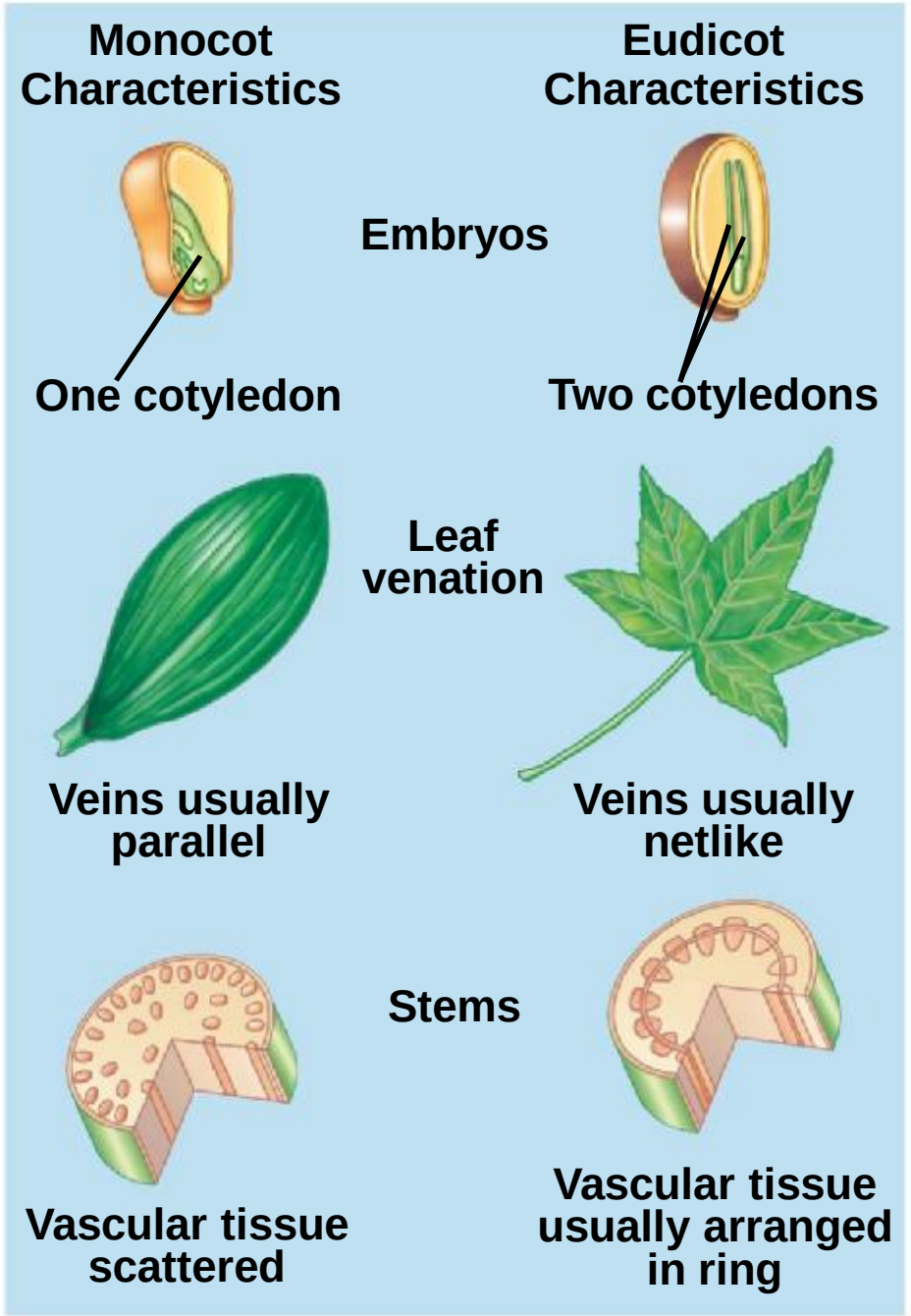
Angiosperms

- Angiosperms are seed plants with reproductive structures called flowers and fruits
- They are the most widespread and diverse of all plants

Angiosperm Diversity

- The two main groups of angiosperms are **monocots** (one cotyledon) and **eudicots** (“true” dicots)
- The clade eudicot includes some groups formerly assigned to the paraphyletic **dicot** (two cotyledons) group



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Monocot Characteristics		Eudicot Characteristics
	Roots	
Root system usually fibrous (no main root)		Taproot (main root) usually present
	Pollen	
Pollen grain with one opening		Pollen grain with three openings
	Flowers	
Floral organs usually in multiples of three		Floral organs usually in multiples of four or five

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