Chapter 17

Plants, Fungi, and the Colonization of Land

Part 1
Plants

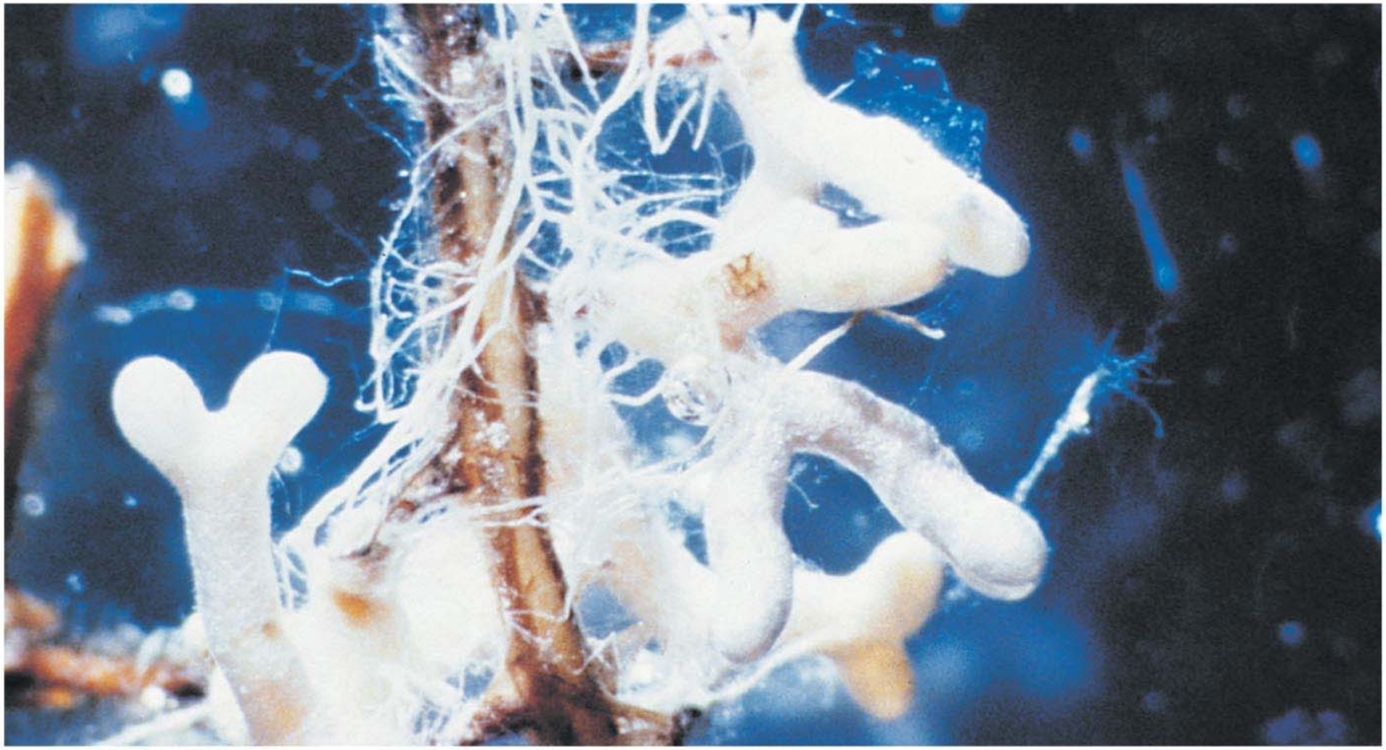
Lecture by Dr. Prince

Plants and Fungi—A Beneficial Partnership

Plants and fungi colonized land together

Mycorrhizae, mutually beneficial associations of plant roots and fungi hyphae, enabled plants to colonize land

Plants and Fungi—A Beneficial Partnership

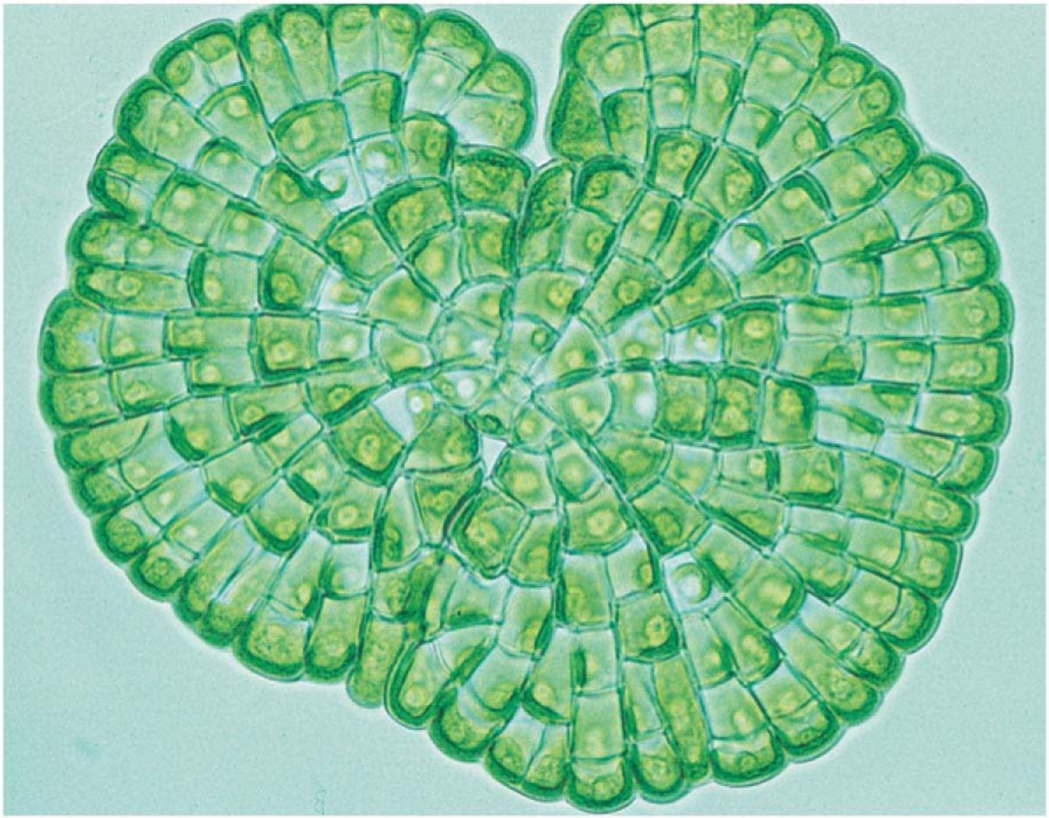


Mycorrhizal fungi absorb water, phosphorus, and other minerals from soil and make them available to the plant

The sugars produced by the plant nourish the fungus

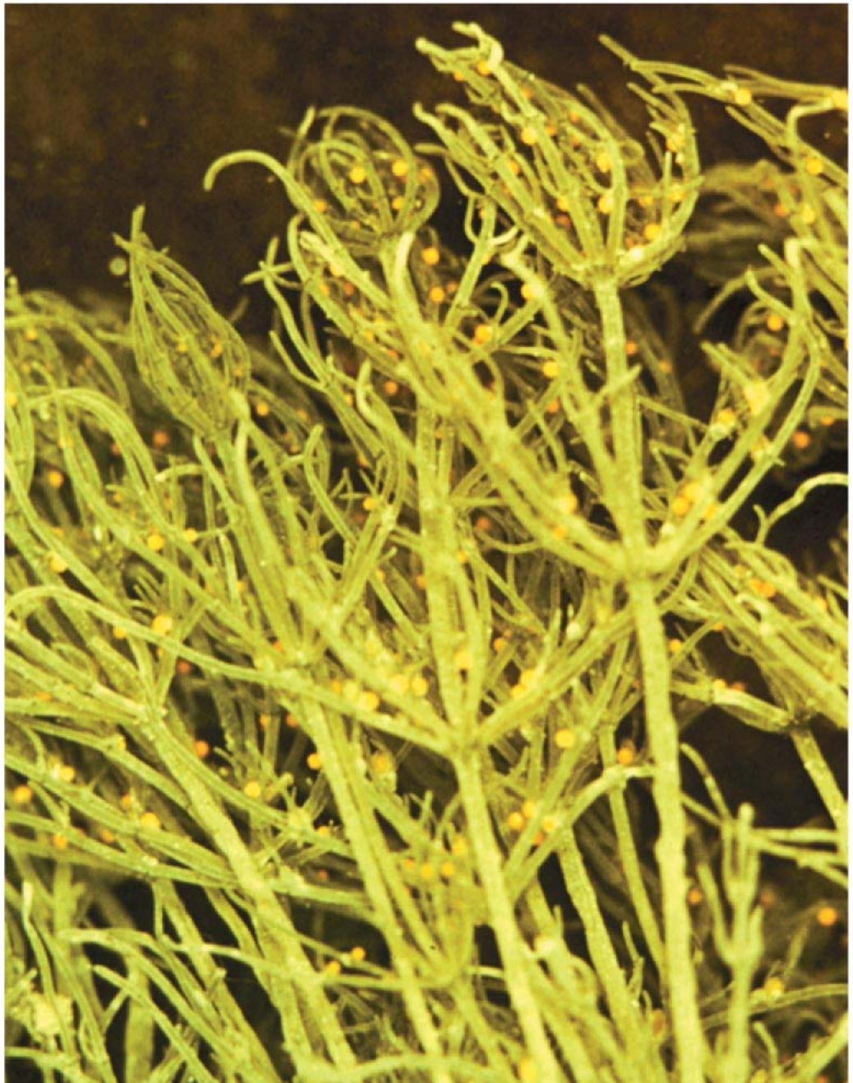
PLANT EVOLUTION AND DIVERSITY

To boldly go where no plant has gone before!



500 million years ago, the algal ancestors of plants formed a green carpet on the edge of lakes and coastal salt marshes

To boldly go where no plant has gone before!



Today green algae called **charophytes** are the closest living relatives of plants

To boldly go where no plant has gone before!

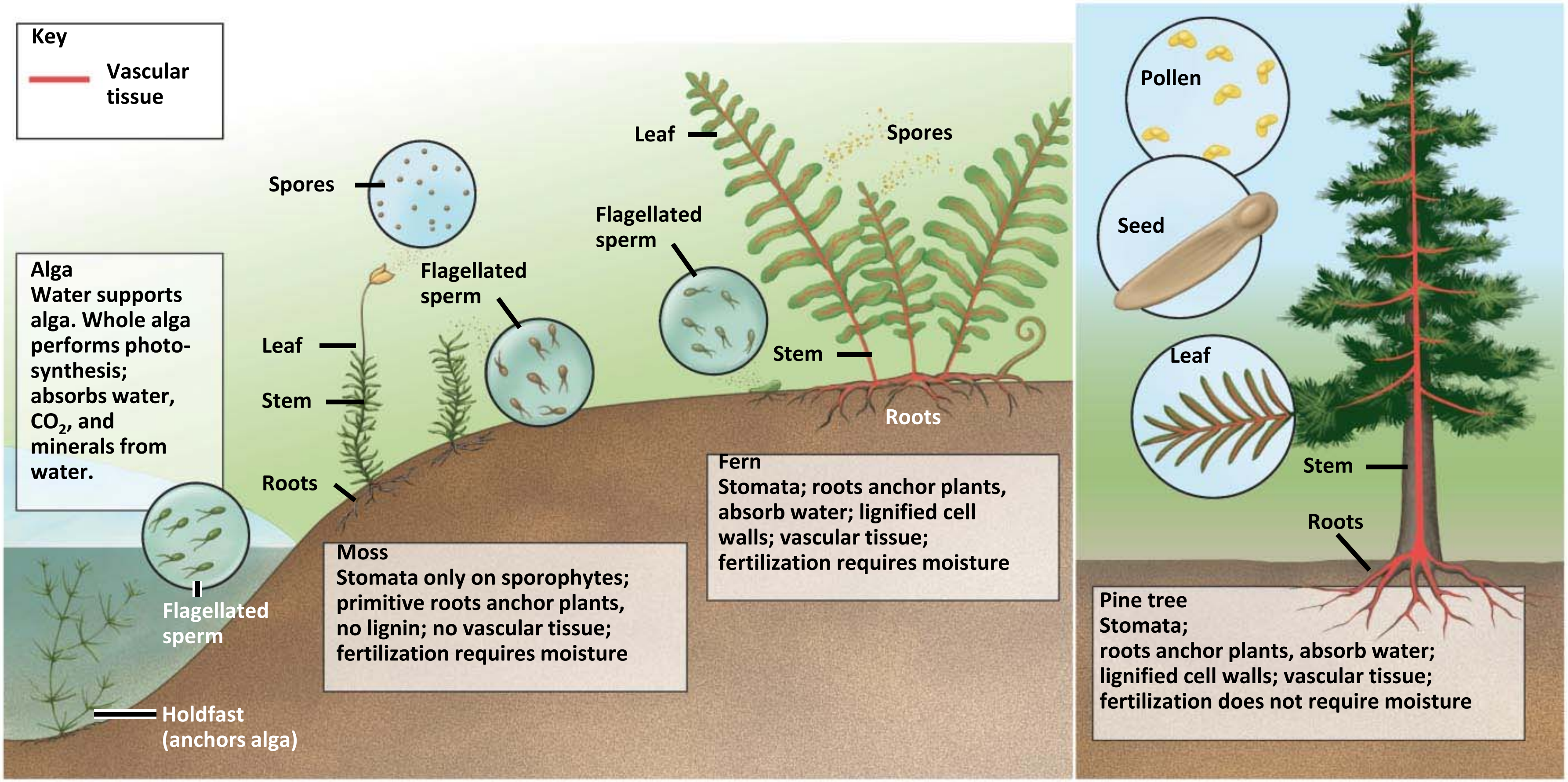
- Land plants are a clade, defined by a set of derived characters
  - Alternation of generations
  - Walled spores produced in sporangia
  - Male and female gametangia
  - Multicellular, dependent embryos

To boldly go where no plant has gone before!

- Life on land offered new opportunities
  - Unlimited sunlight
  - Abundant CO_2
  - Initially, few pathogens or herbivores

To boldly go where no plant has gone before!

- Challenges of terrestrial life
  - Maintaining moisture within cells
  - Obtaining resources from soil and air
  - Supporting body in air
  - Reproducing and dispersing offspring without water



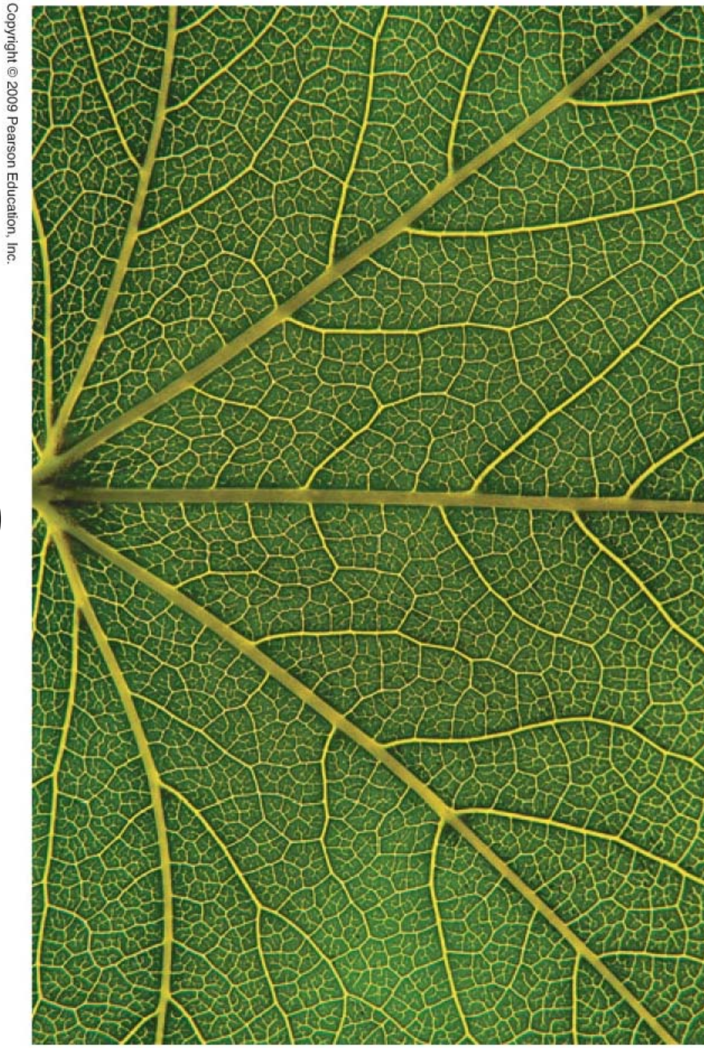
Key
Vascular tissue
Alga
Water supports alga. Whole alga performs photo-synthesis; absorbs water, CO_2, and minerals from water.
Flagellated sperm
Holdfast (anchors alga)
Spores
Flagellated sperm
Leaf
Stem
Roots
Moss
Stomata only on sporophytes; primitive roots anchor plants, no lignin; no vascular tissue; fertilization requires moisture
Leaf
Spores
Flagellated sperm
Stem
Roots
Fern
Stomata; roots anchor plants, absorb water; lignified cell walls; vascular tissue; fertilization requires moisture
Pollen
Seed
Leaf
Stem
Roots
Pine tree
Stomata;
roots anchor plants, absorb water;
lignified cell walls; vascular tissue;
fertilization does not require moisture

To boldly go where no plant has gone before!

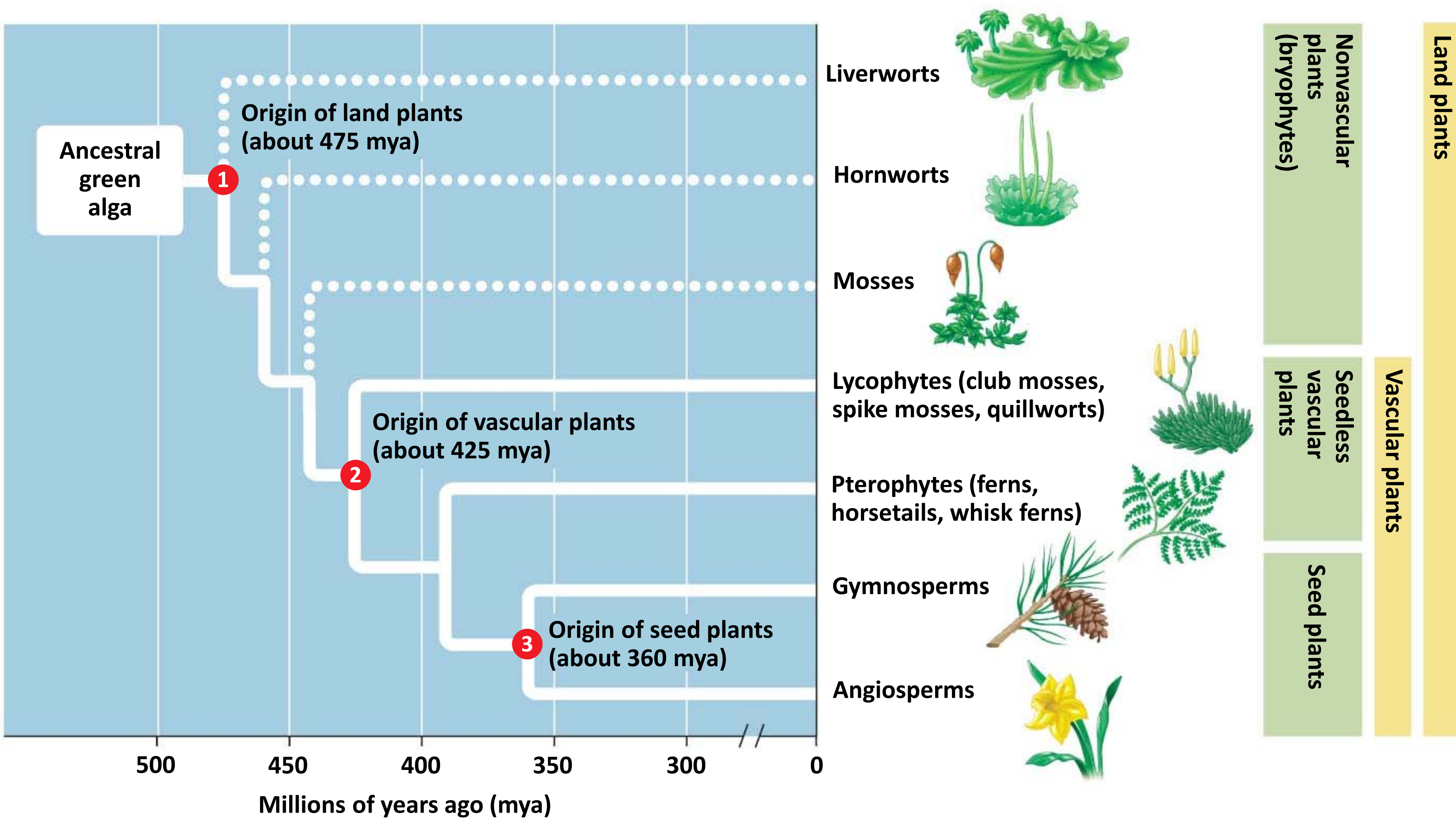
- In all plants, the zygote develops into an embryo while attached and nourished by the parent plant
- Plants are **embryophytes**, with multicellular, dependent embryos

Plant diversity reflects their evolutionary history

- Four key adaptations for life on land distinguish the main lineages of the plant kingdom
  - Dependent embryos (characteristic of all plants)
  - Lignified vascular tissues
  - Seeds
  - Flowers



Plant diversity reflects their evolutionary history



Liverworts

Hornworts

Mosses

Lycophytes

Pterophytes

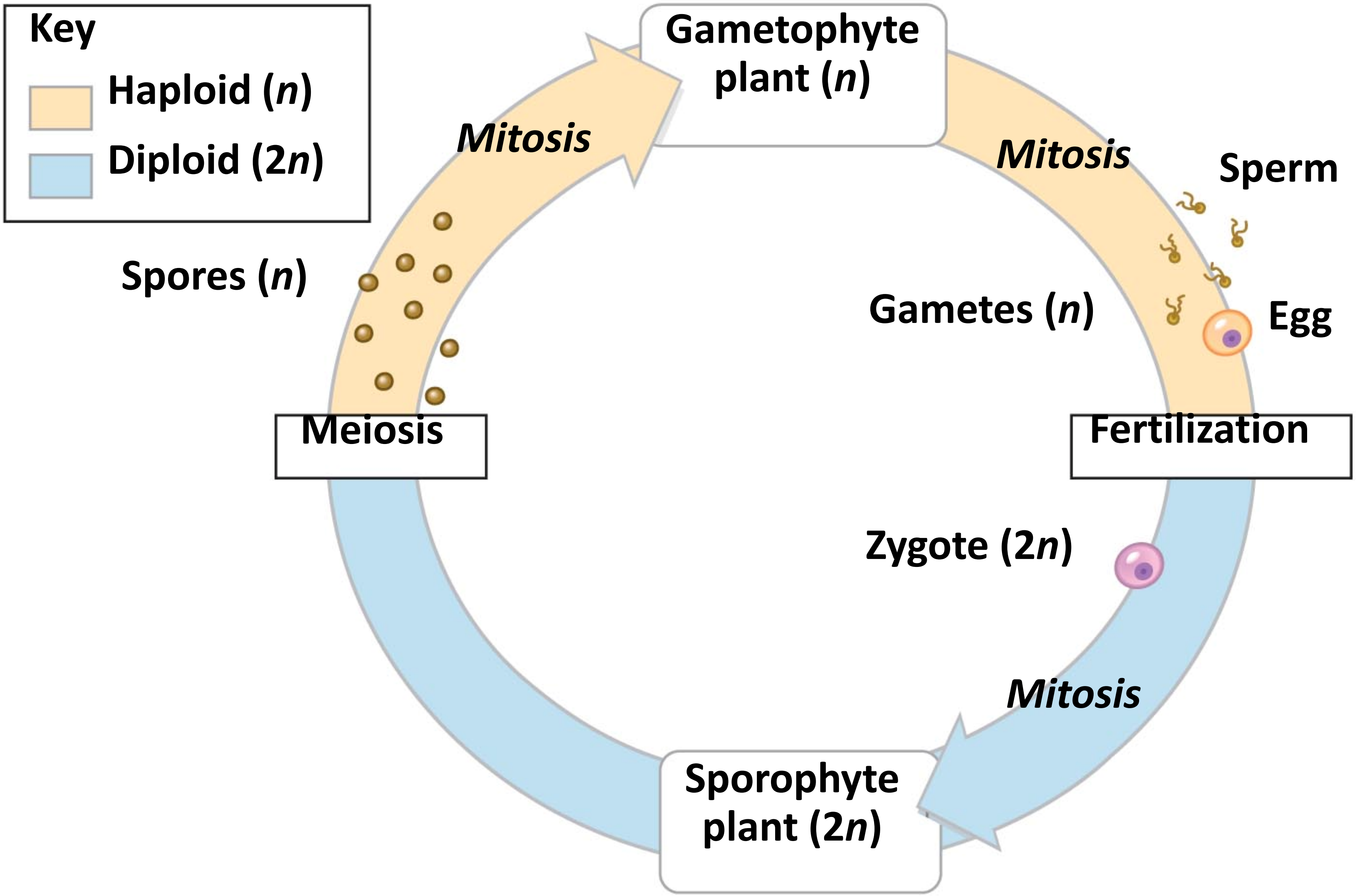
Gymnosperms

Angiosperms

ALTERNATION OF GENERATIONS AND PLANT LIFE CYCLES

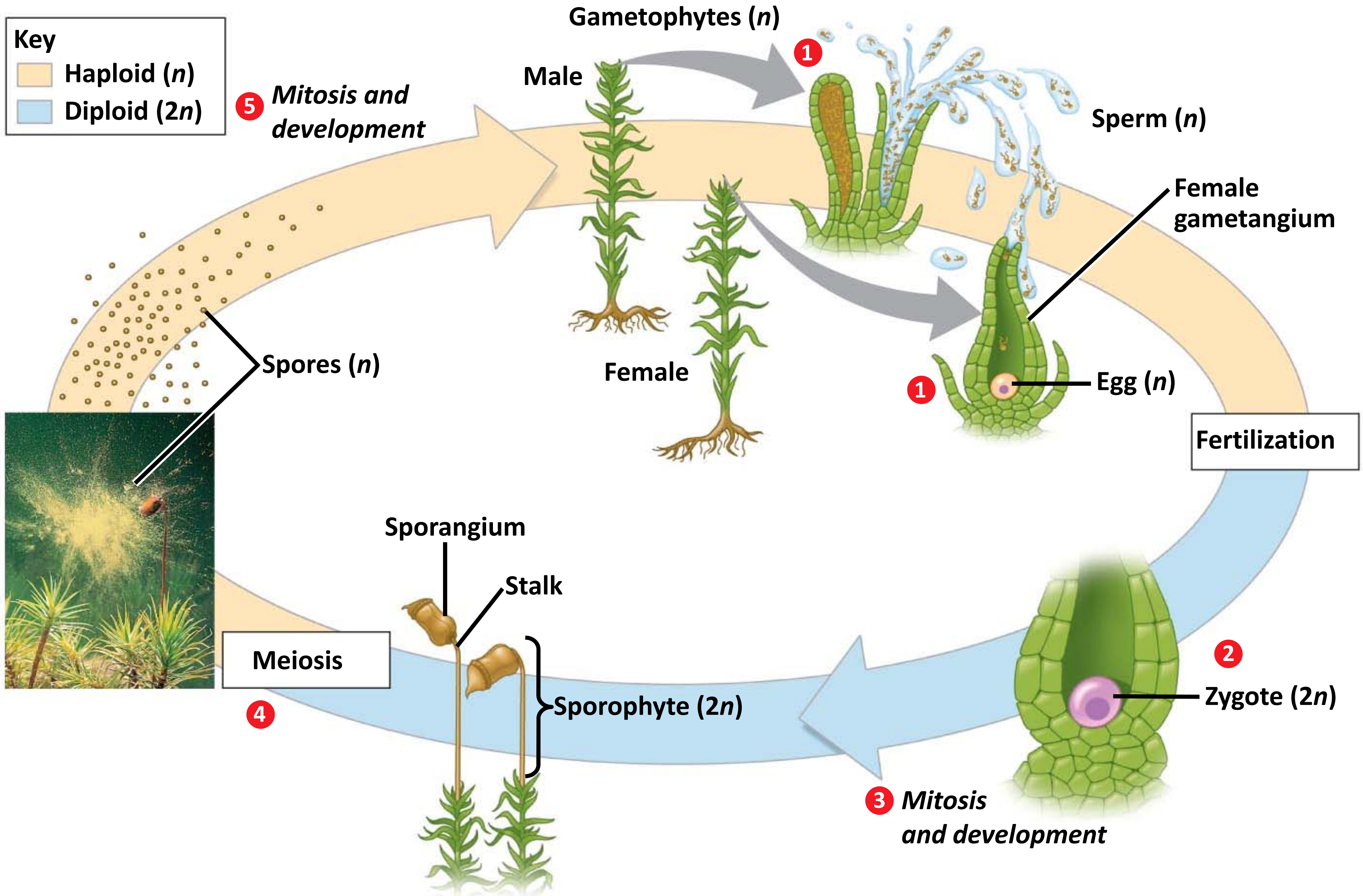
Plants alternate between haploid and diploid generations

- The haploid **gametophyte** produces gametes (eggs and sperm) by mitosis
- Fertilization results in a diploid zygote
- The zygote develops into the diploid **sporophyte**, which produces haploid spores by meiosis
- Spores grow into gametophytes
- And the wheels on the bus go round and round


Key
Haploid (n)
Diploid (2n)
Gametophyte plant (n)
Mitosis
Mitosis
Sperm
Spores (n)
Gametes (n)
Egg
Meiosis
Fertilization
Zygote (2n)
Mitosis
Sporophyte plant (2n)

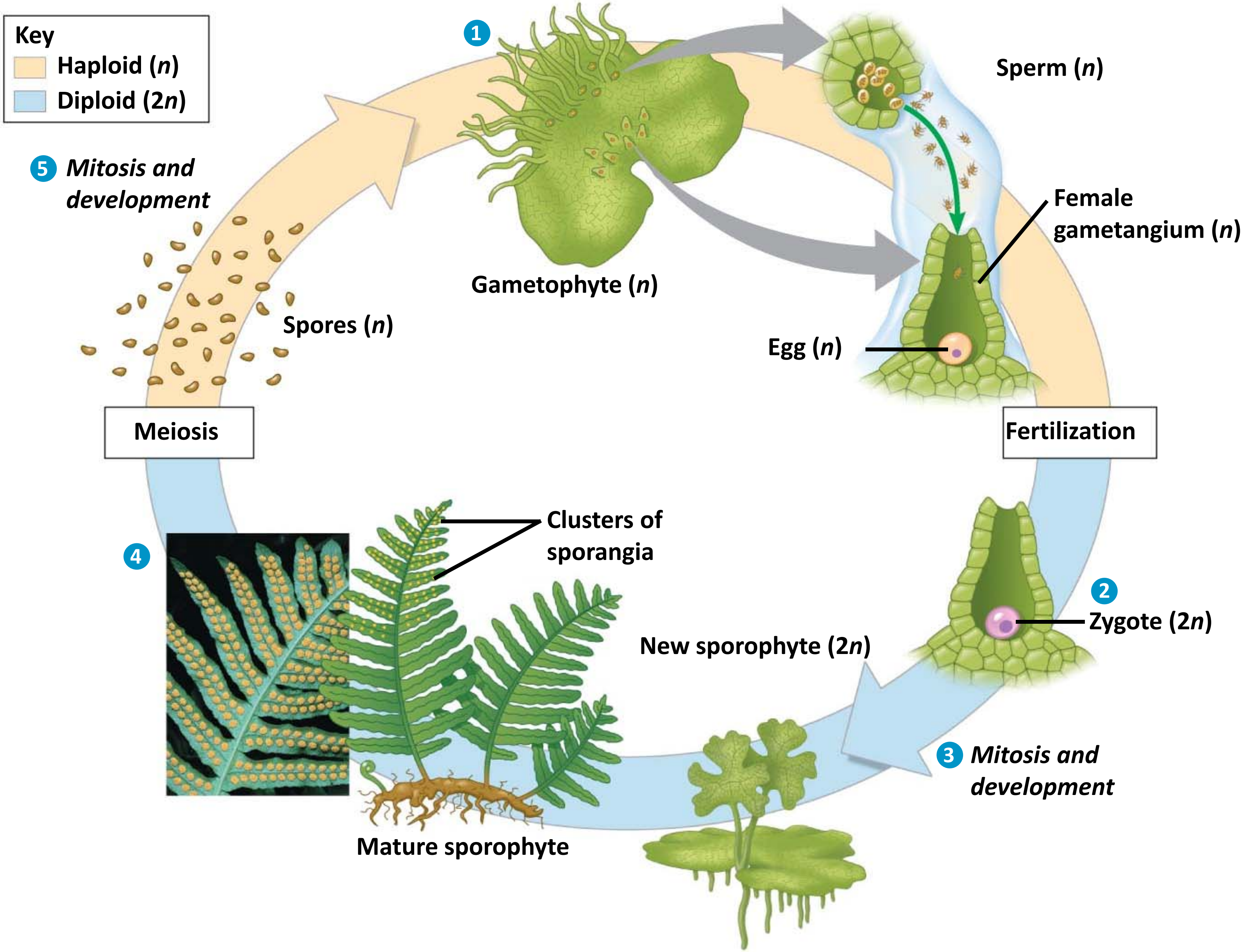
Mosses have a dominant gametophyte

- Gametophytes make up a bed of moss
  - They produce eggs and flagellated sperm in gametangia
  - Sperm swim through water to the egg
- The zygote develops within the gametangium into a mature sporophyte, which remains attached to the gametophyte
  - Meiosis occurs in sporangia at the tips of the sporophyte stalk
  - Haploid spores are released from the sporangium and develop into gametophytes


Key
Haploid (n)
Diploid (2n)
5 Mitosis and development
Gametophytes (n)
Male
1
Sperm (n)
Female gametangium
Female
1
Egg (n)
Spores (n)
Fertilization
Sporangium
Stalk
2
Zygote (2n)
Meiosis
4
Sporophyte (2n)
3 Mitosis and development

Ferns have a dominant sporophyte

- A fern's gametophyte is small
  - They produce flagellated sperm that swim to the egg and fertilize it to produce a zygote
  - The zygote initially develops within the female gametangia but eventually develops into an independent sporophyte
- Sporangia develop on the underside of the leaves of the sporophyte
  - Within the sporangia, cells undergo meiosis to produce haploid spores
  - Spores are released and develop into gametophytes


Key
Haploid (n)
Diploid (2n)
1
Gametophyte (n)
Sperm (n)
Female
gametangium (n)
Egg (n)
Fertilization
2
Zygote (2n)
3 Mitosis and
development
New sporophyte (2n)
Mature sporophyte
4
Clusters of
sporangia
Meiosis
Spores (n)
5 Mitosis and
development

Seedless plants dominated vast “coal forests”

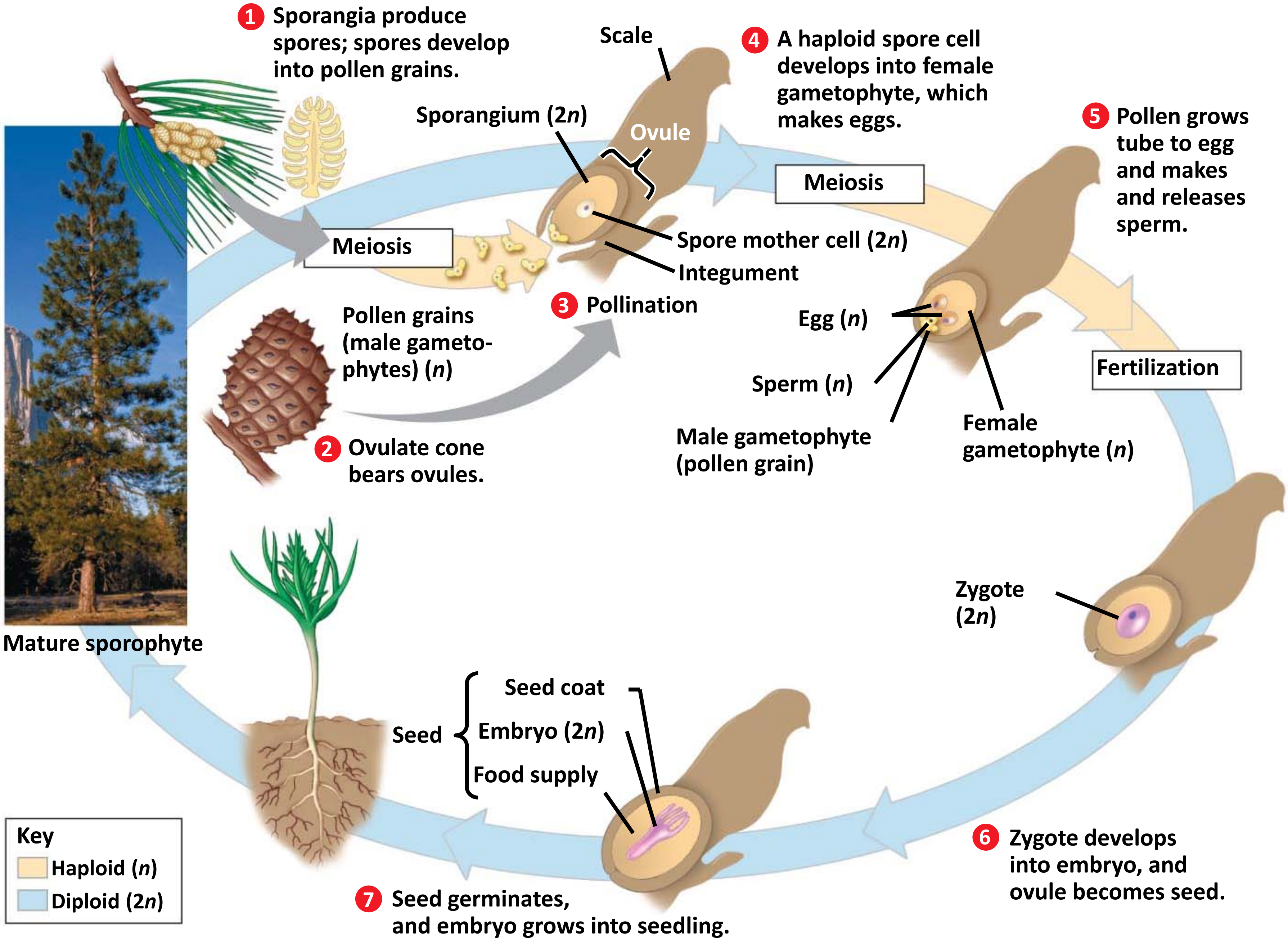
- Seedless plants formed vast ancient forests in low-lying wetlands during the Carboniferous period (360–299 million years ago)
  - When they died, the plants formed peat deposits that eventually formed coal
- Coal, oil, and natural gas are **fossil fuels**
  - Oil and natural gas formed from marine organisms; coal formed from seedless plants
  - Burning fossil fuels releases CO_2, causing climate warming

A pine tree is a sporophyte with gametophytes in its cones

- A pine cone holds all of the tree's reproductive stages: spores, eggs, sperm, zygotes, and embryos
  - Each scale of the cone contains sporangia that produce spores by meiosis
  - The spores produce gametophytes within the cone
- The male gametophyte is a pollen grain, released from pollen cones and carried by wind to female cones
- Female ovulate cones carry two ovules on each stiff scale

PLAY Animation: Pine Life Cycle

– Each ovule contains a sporangium surrounded by



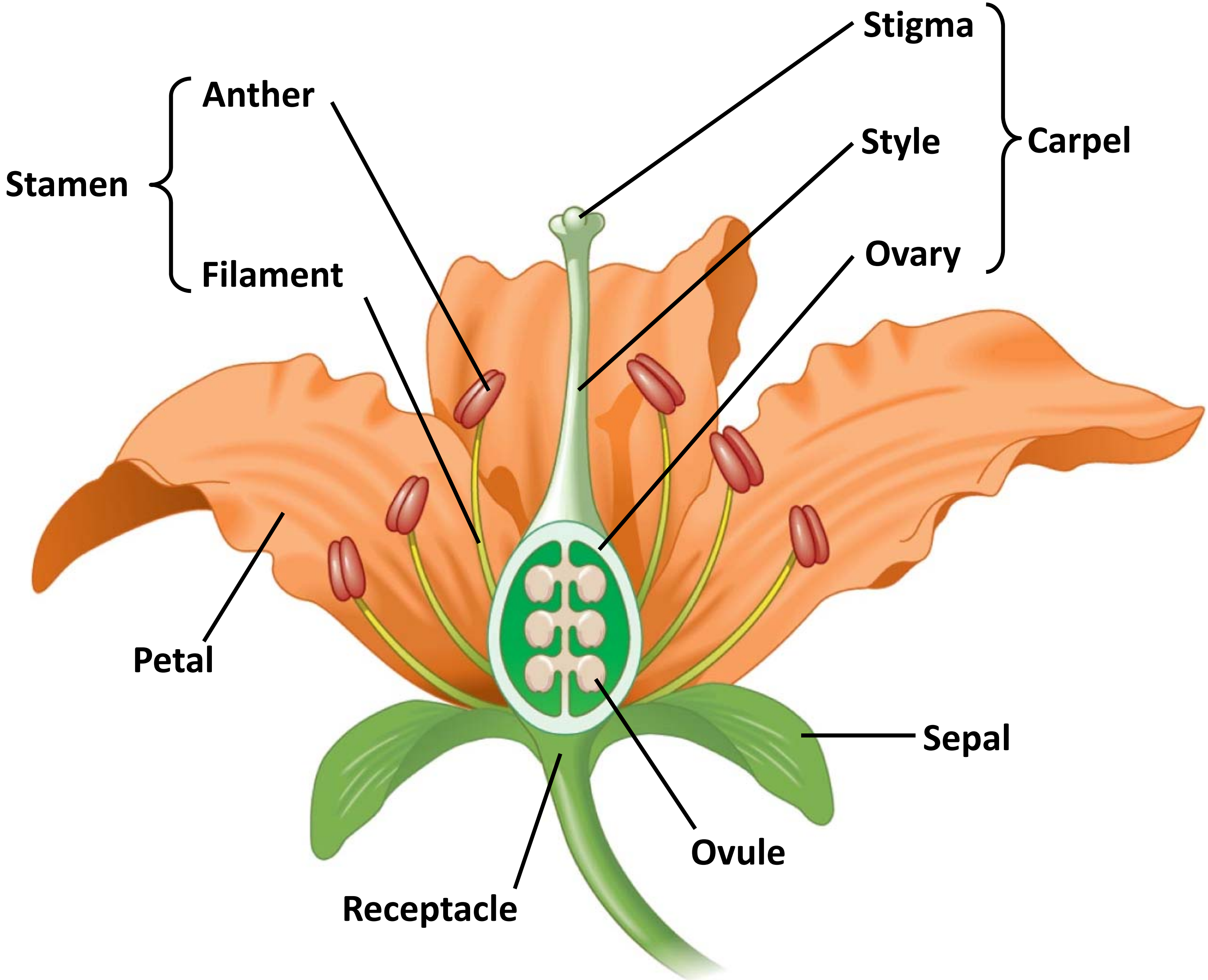
1 Sporangia produce spores; spores develop into pollen grains.
Scale
4 A haploid spore cell develops into female gametophyte, which makes eggs.
Sporangium (2n)
Ovule
Meiosis
5 Pollen grows tube to egg and makes and releases sperm.
Meiosis
Spore mother cell (2n)
Integument
3 Pollination
Pollen grains (male gameto-phytes) (n)
Egg (n)
Fertilization
Sperm (n)
Female gametophyte (n)
Male gametophyte (pollen grain)
2 Ovulate cone bears ovules.
Mature sporophyte
Zygote (2n)
Seed
Seed coat
Embryo (2n)
Food supply
Key
Haploid (n)
Diploid (2n)
6 Zygote develops into embryo, and ovule becomes seed.
7 Seed germinates, and embryo grows into seedling.

A pine tree is a sporophyte with gametophytes in its cones

- In **pollination**, a pollen grain lands on a scale in an ovulate cone and enters an ovule
  - The scales then grow together, sealing up the cone
  - Within the sealed cone, the gametophytes produce gametes
- **Fertilization** occurs a year after pollination, when a sperm moves down a pollen tube to the egg to form a zygote
  - The zygote develops into a sporophyte embryo, and the ovule becomes a **seed**, with stored food and a protective **seed coat**

The flower is the centerpiece of angiosperm reproduction

- Flowers contain separate male and female sporangia and gametophytes
- Flowers usually consist of sepals, petals, stamens (which produce pollen), and carpels (which produce eggs)
  - **Sepals** enclose the flower before it opens
  - **Petals** attract animal pollinators
- **Stamens** include a filament and **anther**, a sac at the top of each filament that contains male sporangia and releases pollen

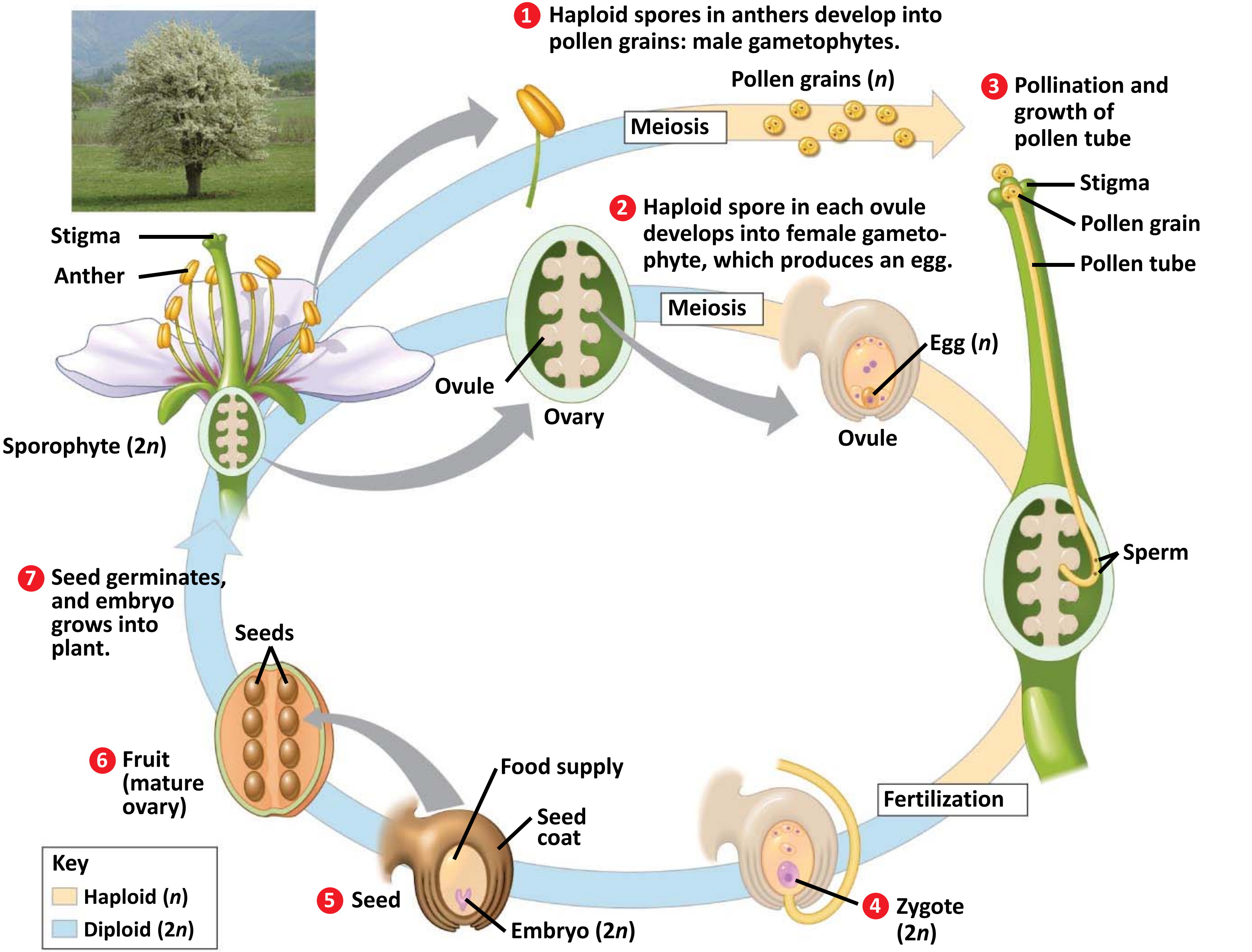

Stigma
Anther
Style
Carpel
Stamen
Ovary
Filament
Petal
Sepal
Ovule
Receptacle

The flower is the centerpiece of angiosperm reproduction

- The **carpel** is the female reproductive structure, including the ovary
  - The **ovary** encloses the ovules, which contain sporangia that will produce a female gametophyte
- Ovules develop into seeds; ovaries mature into **fruit**

The angiosperm plant is a sporophyte with gametophytes in its flowers

- The angiosperm life cycle
  1. Meiosis in the anthers produces haploid spores that form the male gametophyte (pollen grains)
  2. Meiosis in the ovule produces a haploid spore that forms a tiny female gametophyte, including the egg
  3. A pollen tube from the pollen grain to the ovule carries a sperm that fertilizes the egg to form a zygote
  4. Each ovule develops into a seed, consisting of an embryo (a new sporophyte) with a food supply and a seed coat


1 Haploid spores in anthers develop into pollen grains: male gametophytes.
Pollen grains (n)
Meiosis
3 Pollination and growth of pollen tube
Stigma
Pollen grain
Pollen tube
2 Haploid spore in each ovule develops into female gameto-phyte, which produces an egg.
Stigma
Anther
Meiosis
Egg (n)
Ovule
Ovary
Ovule
Sporophyte (2n)
Sperm
7 Seed germinates, and embryo grows into plant.
Seeds
6 Fruit (mature ovary)
Food supply
Seed coat
Fertilization
Key
Haploid (n)
Diploid (2n)
5 Seed
Embryo (2n)
4 Zygote (2n)

The structure of a fruit reflects its function in seed dispersal

- Fruits, ripened ovaries of flowers, are adaptations that disperse seeds
  - Some rely on wind for seed dispersal
  - Some hitch a ride on animals
  - Fleshy, edible fruits attract animals

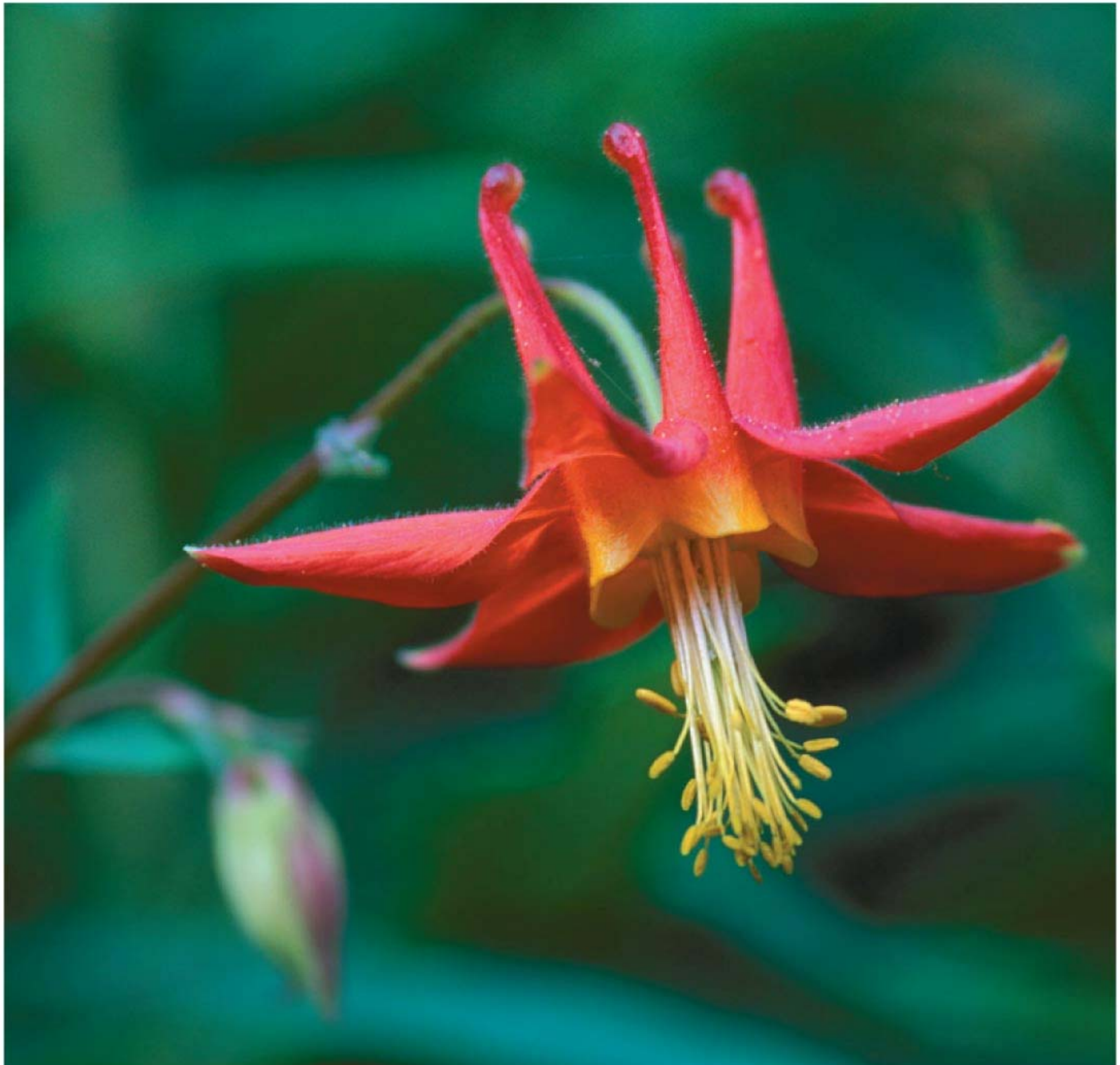
PLAY **Animation: Fruit Development**

Angiosperms sustain us—and add spice to our diets

- Most human food is provided by the fruits and seeds of angiosperms
  - Corn, rice, wheat, and other grains are dry fruits
  - Apples, cherries, tomatoes, and squash are fleshy fruits
  - Spices such as nutmeg, cinnamon, cumin, cloves, ginger, and licorice are also angiosperm fruits

Pollination by animals has influenced angiosperm evolution

- 90% of angiosperms use animals to transfer pollen
  - Birds are attracted by colorful flowers, but not scent
  - Beetles are attracted by fruity odors, but not color
  - Bats are attracted by large, highly scented flowers
  - Wind-pollinated flowers produce large amounts of pollen



Plant diversity is an irreplaceable resource

- More than 50,000 square miles of forest are cleared every year
  - Replanted areas have greatly reduced biological diversity
- Loss of forests has greatly reduced diversity of life on Earth
  - The loss of plant diversity removes potentially beneficial medicines
  - More than 25% of prescription drugs are extracted from plants

TABLE 17.13 A SAMPLING OF MEDICINES DERIVED FROM PLANTS

Compound	Example of 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	Malaria preventive
Taxol	Pacific yew	Ovarian cancer drug
Tubocurarine	Curare tree	Muscle relaxant during surgery
Vinblastine	Periwinkle	Leukemia drug