



Land Plants



Origin, Evolution, and Diversity

■ Five major periods in the evolution of land plants

- Monophyletic origin from a Charophyte ancestor; sometime in between 460 and 476 million years ago: earliest fossils of spores found
- Silurian/Devonian explosion; between 410 and 360 mya macroscopic fossils from most major lineages are found; all major adaptations for life in dry habitats available now
- Carboniferous formation of coal deposits from lycopods; between 350 and 290 mya; presence of extensive, forested swamps
- Age of gymnosperms (naked seeds); between 250 to 120 mya; dry habitats prevalent at this time
- Age of flowering plants (angiosperms: encased seeds); 125 mya to present

Origin, Evolution, and Diversity

- Ancestor: Green algae lineage called the Charophyta; closest living relative the Charales
- Diversity: major lineages existing today
 - Liverworts, hornworts, mosses: non-vascular; limited number of water conducting cells
 - Lycopods, horsetails, ferns: vascular tissue and leaves, but seedless
 - Gymnosperms: vascular tissue, complex leaves, seed plants
 - Angiosperms: vascular tissue, complex leaves, seed plants with the unique invention of the flower



Liverworts



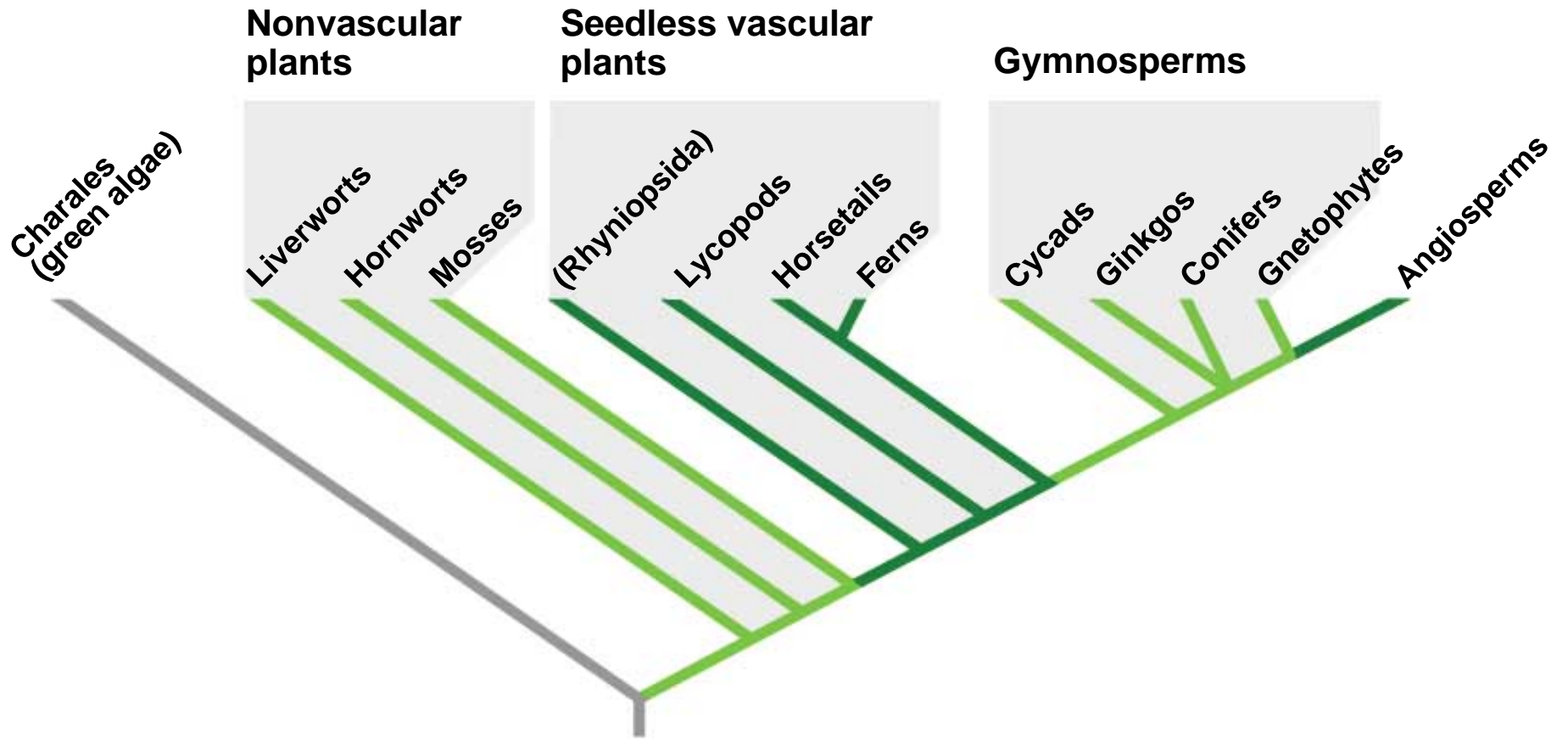
Lycopods



Horsetails



Ferns





Cycads



Ginkgos



Conifers



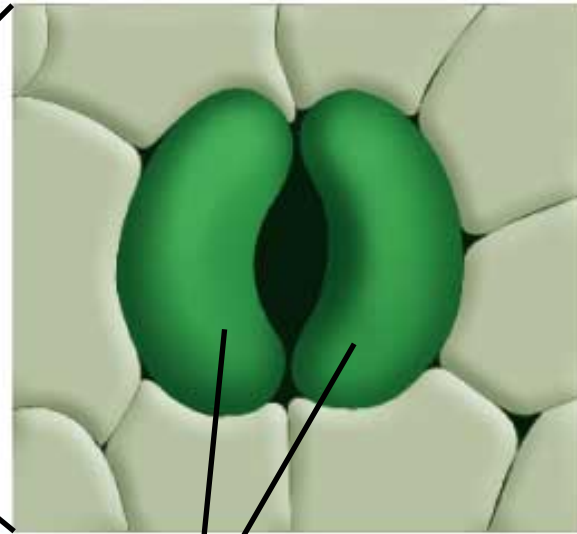
Angiosperms

Transition to Land

- Major evolutionary trend: the colonization of terrestrial environments
- Advantages of living on land
 - Sunlight and CO₂ are more available
- Challenges
 - Threat of desiccation
- Breakthroughs of evolution by natural selection
 - Transporting water through the plant body
 - Establishing an upright body to compete for sunlight
 - Transporting gametes without water

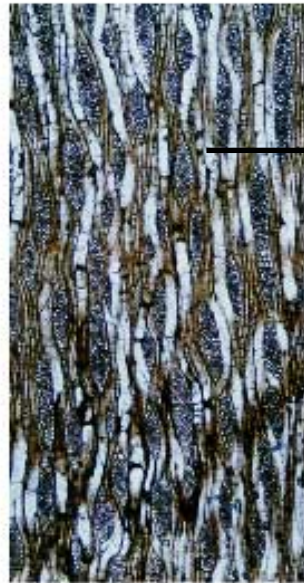
Transition to Land

- **Evolutionary adaptations to terrestrial life**
 - **Homeostasis:**
 - Cuticle and stomata
 - Vascular tissue
 - Lignin in cell walls and an erect growth habit
 - **Reproduction**
 - Reduced gametophytes: male gametophyte travels to female as pollen
 - **Metabolism**
 - Specialized methods of photosynthesis: C₄ and CAM



Guard cells

(a) Tracheids



Pits



(b) Vessels



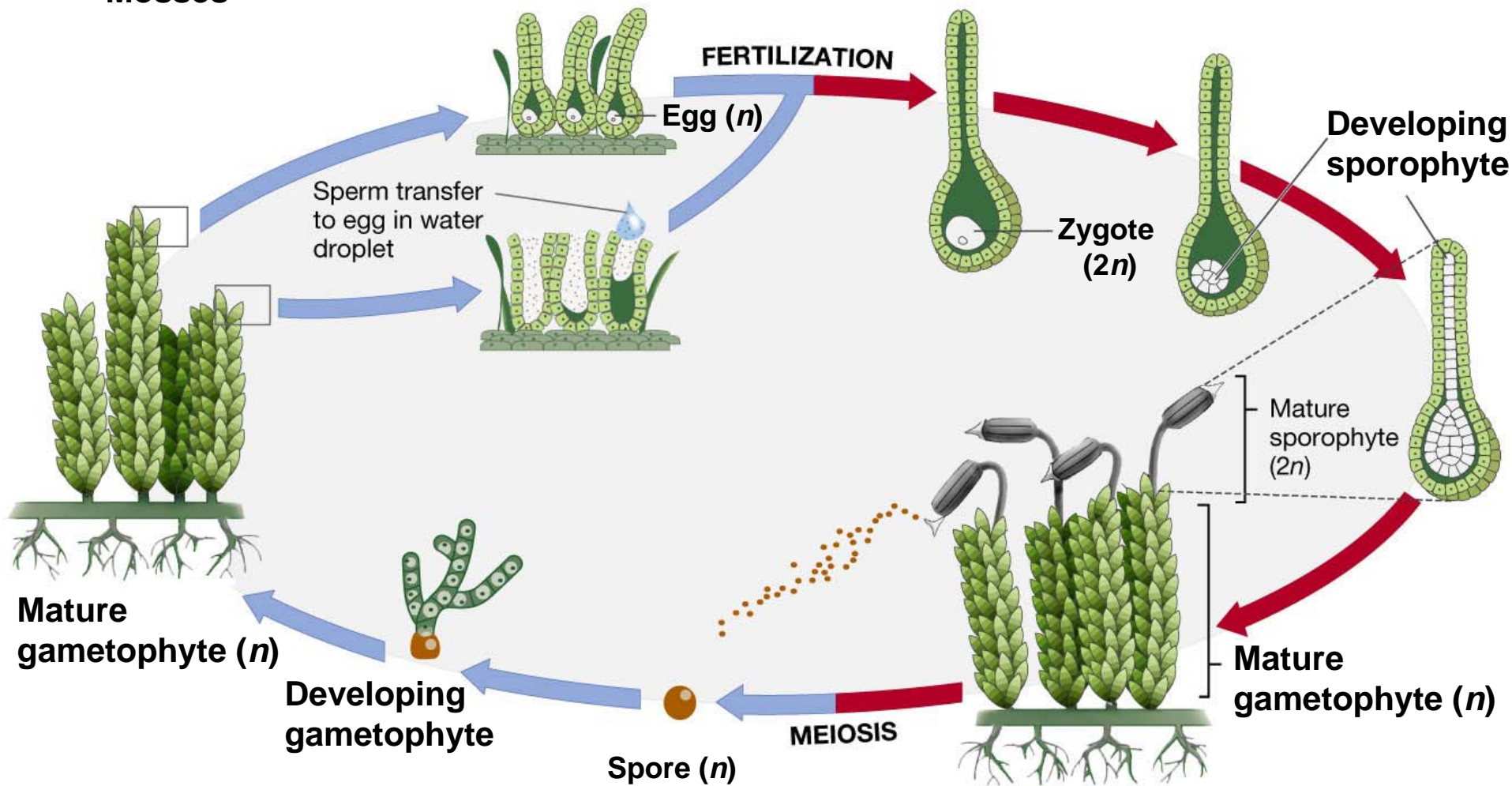
Perforated
end walls



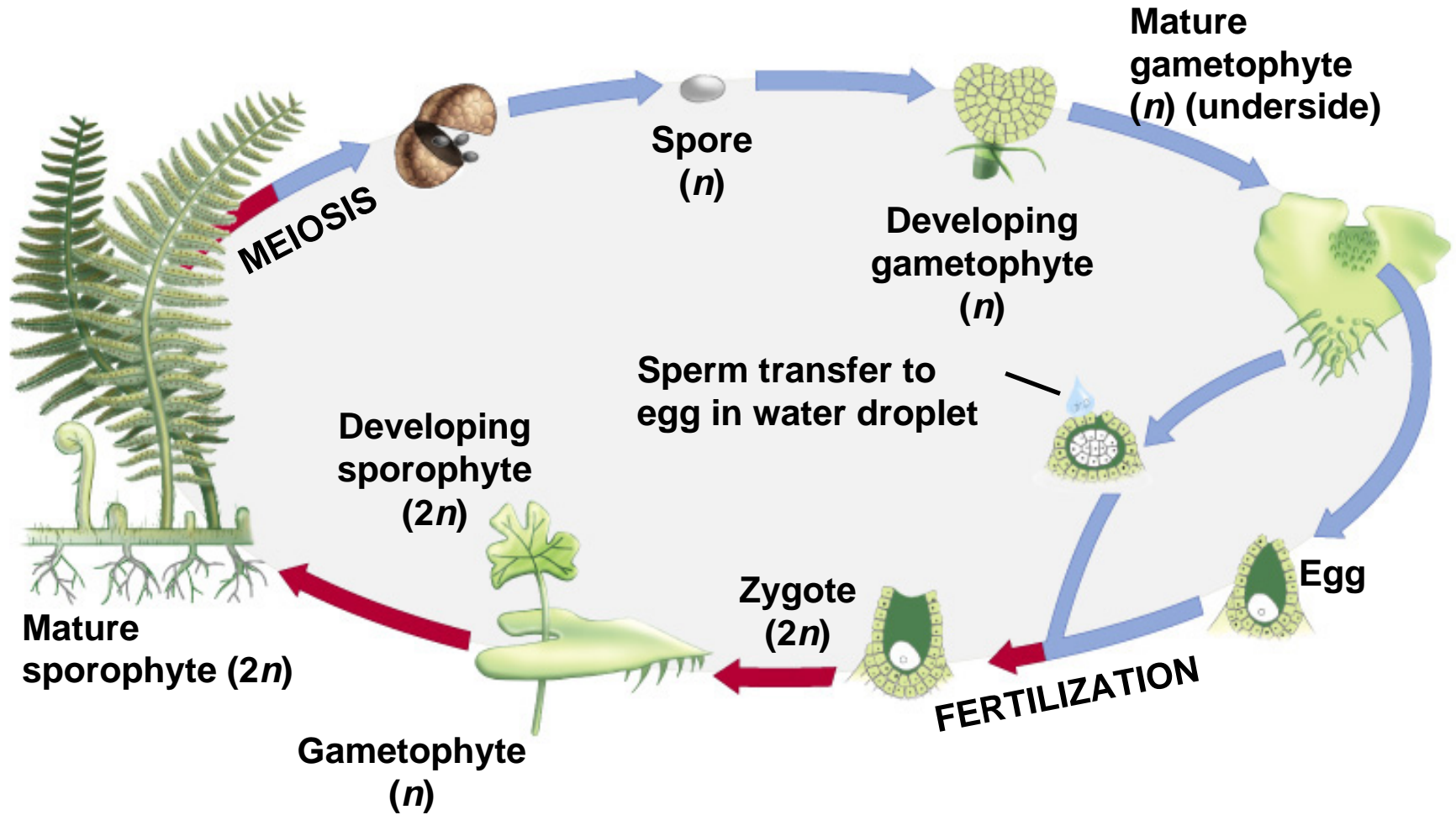
Reproduction

- Pollen as an innovation to reproduce in dry environments
 - Gametophyte is the multicellular haploid stage, they produce haploid gametes by mitosis that unite to form the sporophyte
 - Sporophyte is the multicellular diploid stage, they produce haploid spores by meiosis that develop into the gametophyte
 - Through the evolutionary history of plants there is a tendency for the gametophyte to get reduced in size
 - The dramatic reduction in size of the gametophyte gave rise to the pollen grain
- A second innovation was the evolution of the seed

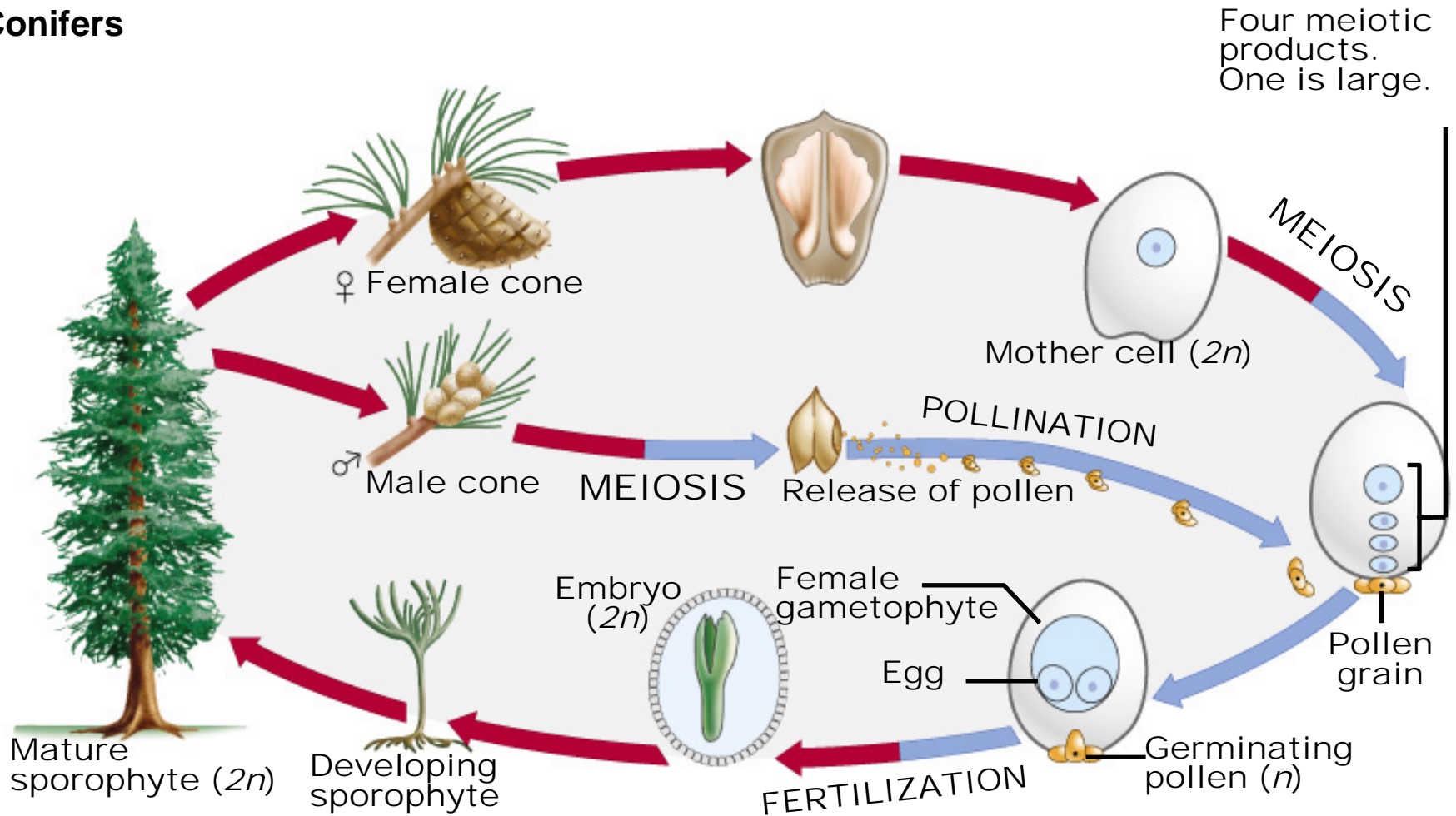
Mosses



Ferns



Conifers



Dispersal by wind



Dispersal by water



Dispersal by animals

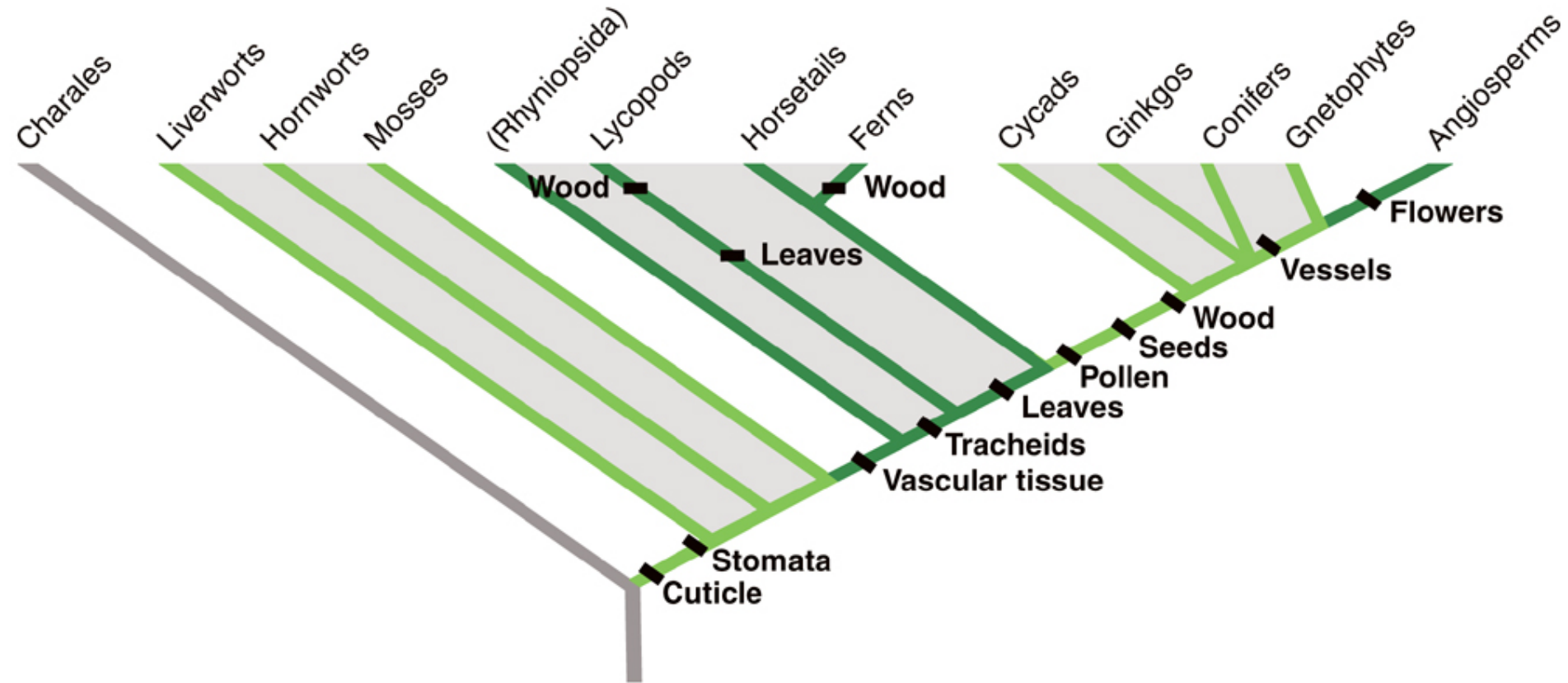


Dispersal by animals



The Flower

- The explosion of angiosperms (the most diverse group of plants) has more to do with the evolution of the flower than with adaptations to wind stand dry environments
 - Flowers are adaptations that increase the probability that pollination occurs in plants. The hypothesis is that flowers provide an award for pollinators to transport pollen from one plant to the other (either sugar rich nectar or protein rich pollen)



C₄ plants use PEP carboxylase rather than rubisco for the initial fixation of carbon.

C₃ plants:

RuBP + CO₂



Rubisco

2 3PG

(3 carbon sugar)

C₄ plants:

**3-carbon
compound + CO₂**

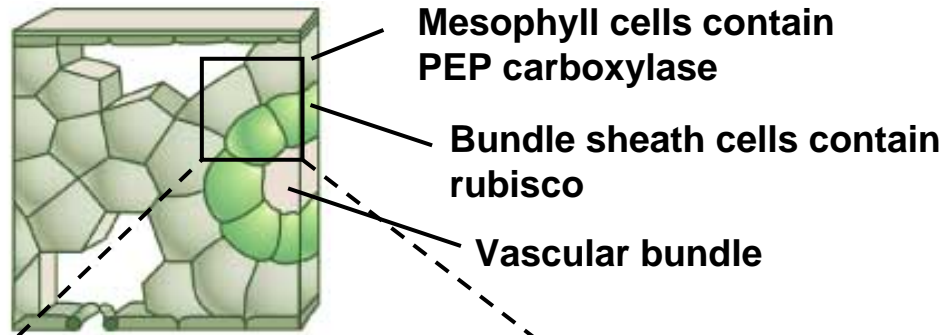


PEP carboxylase

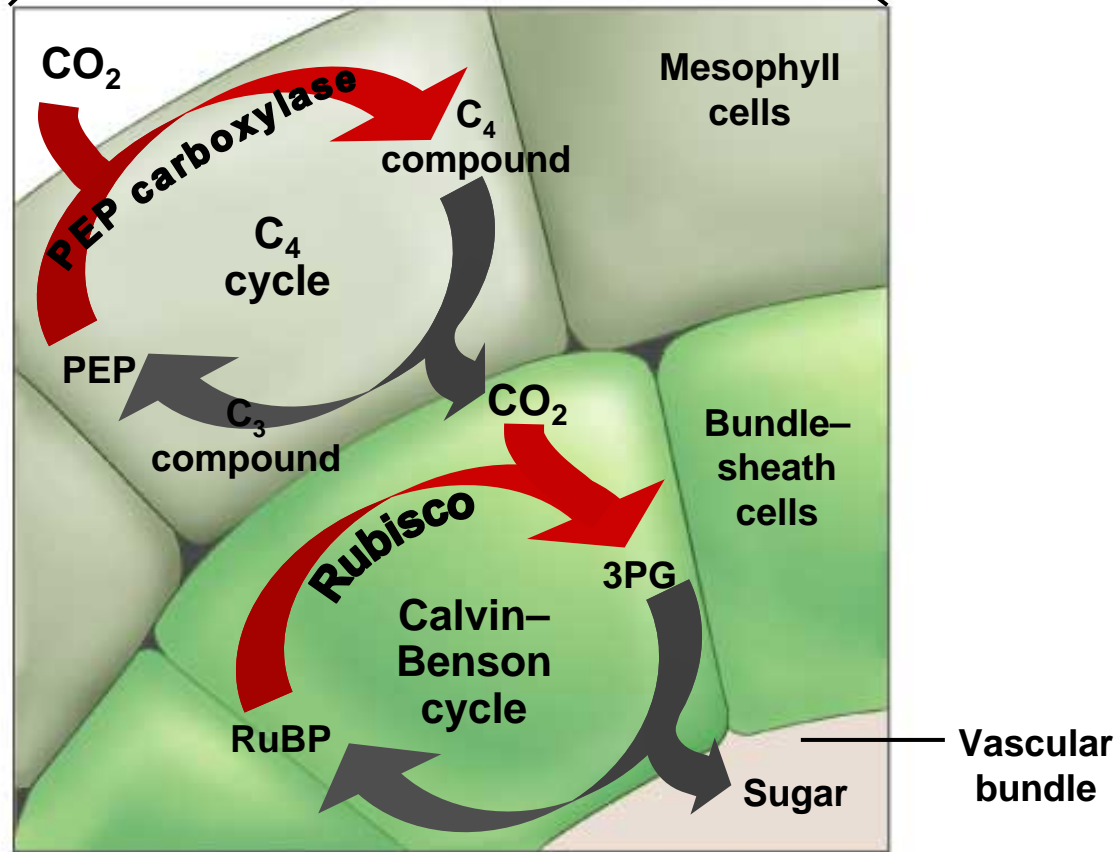
4-carbon

organic acids

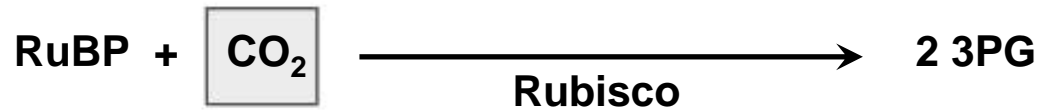
(b) C₄ plant



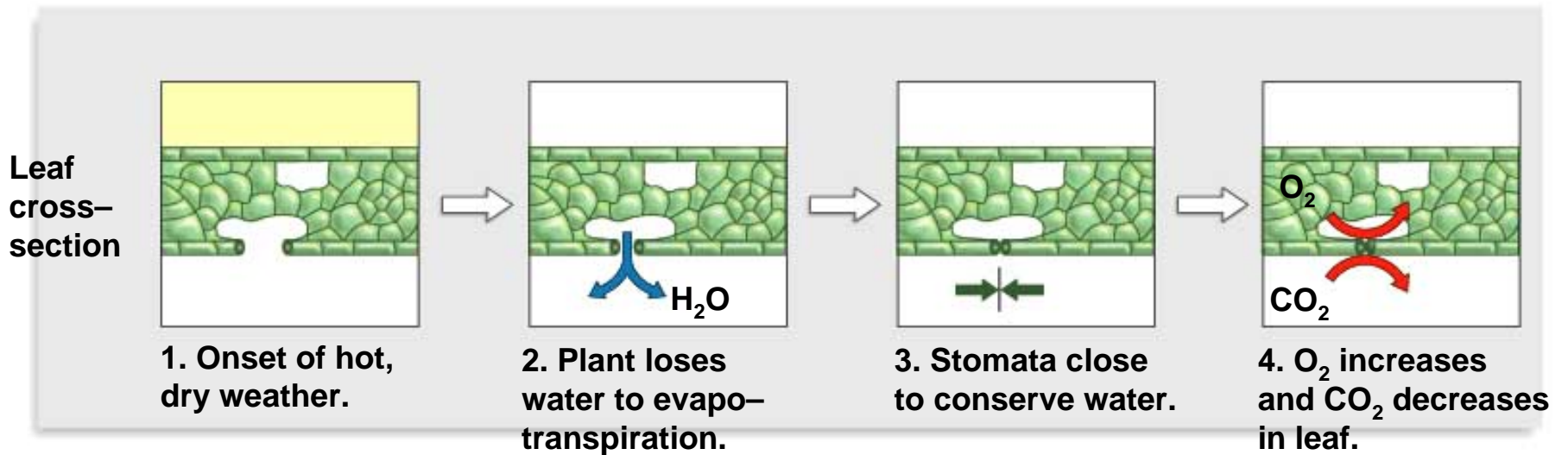
(c)



Rubisco can catalyze two reactions, which have very different outcomes



CIRCUMSTANCES LEADING TO PHOTORESPIRATION



CAM Metabolism

- Crassulacean acid metabolism is another method of limiting the effects of photorespiration; it is also an additional preparatory step to the sugar making machinery of photosynthesis. It increases the concentration of CO₂ inside photosynthesizing cells, but instead of occurring in different areas of the cells it occurs at different times

Importance of Land Plants

- Food
 - Crop domestication and selective breeding
 - Genetic engineering introduces new traits
- Fuel: wood and coal
- Fibers for clothing, building, papermaking, etc. : high tensile strength
- Seed banks salvage genetic diversity for possible future uses.