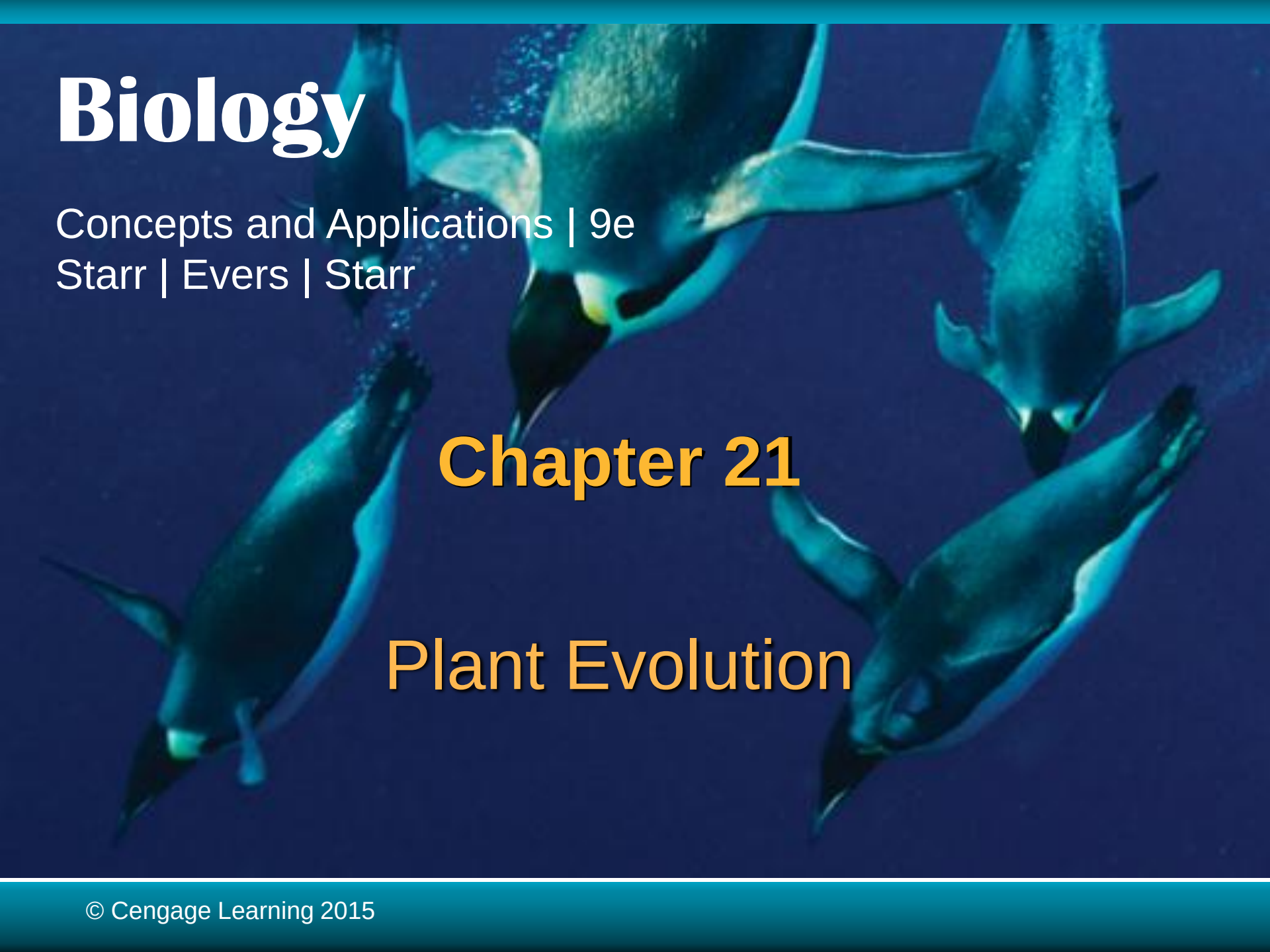

Biology

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Chapter 21

Plant Evolution

21.1 How Did Plants Adapt To Life on Land?

- Plants evolved from green algae, and underwent an adaptive radiation on land
- Plants are embryophytes, which form a multicelled embryo on the parental body

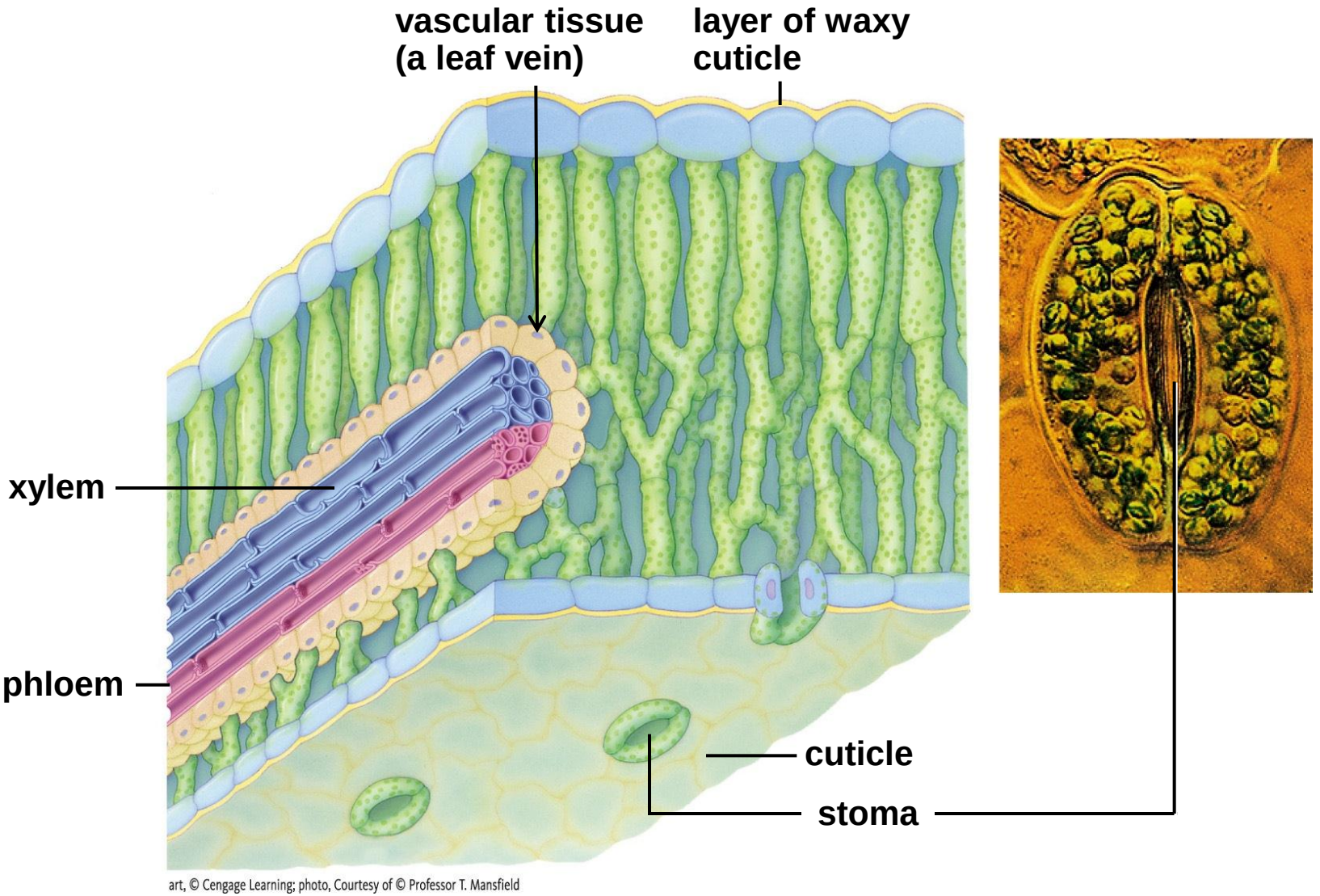
How Did Plants Adapt To Life on Land? (cont'd.)

- Structural adaptations
  - Waterproof cuticle with stomata
  - Stomata open and close to balance demands for water conservation and gas exchange with air outside the plant
  - Has internal vascular tissue

How Did Plants Adapt To Life on Land? (cont'd.)

- Vascular tissues
  - Transport water/nutrients through a plant body
  - Help plants stand upright and branch
  - Reinforced by lignin (stiffens cell walls)
  - Xylem – distributes water and minerals
  - Phloem – distributes sugars made via photosynthesis
  - 90 percent of modern plant species have vascular tissues

How Did Plants Adapt To Life on Land? (cont'd.)



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How Did Plants Adapt To Life on Land? (cont'd.)

- Life cycle changes
  - Adapted vascular plants to life in drier habitats
  - Plant life cycles include two multicelled bodies
    - The haploid gametophyte
    - The diploid sporophyte
- The gametophyte dominates in early-evolving lineages, but in most plants, the sporophyte is larger and longer lived

Animation: The importance of alternation of generations

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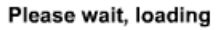
How Did Plants Adapt To Life on Land? (cont'd.)

- Pollen and seeds
  - Can be dispersed without water (pollen grains)
  - Are important adaptations that contribute to the success of seed plants
  - Allow seed plants to reproduce in dry places
  - Many seed features facilitate dispersal from the parent plant

How Did Plants Adapt To Life on Land? (cont'd.)

- Two lineages of seed plants:
  - *Gymnosperms* were the first to evolve
  - *Angiosperms* make flowers and release their seeds inside a fruit

Animation: Evolutionary tree for plants



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21.2 What Are Nonvascular Plants?

- Bryophyte
  - Member of an early plant lineage
  - Has a gametophyte-dominant life cycle
  - Refers to members of three separate lineages
    - Mosses
    - Hornworts
    - Liverworts

What Are Nonvascular Plants? (cont'd.)

- Bryophytes (cont'd.)
  - Nonvascular (no xylem or phloem)
  - Their sperm swim through water droplets to eggs
  - Sporophyte remains attached to the gametophyte
  - Rhizoids attach a gametophyte to the soil or a surface

What Are Nonvascular Plants? (cont'd.)

- Moses
  - Most diverse bryophytes
  - Includes about 15,000 species
  - Threadlike rhizoids hold the gametophyte in place
    - Unlike roots of vascular plants, rhizoids do not distribute water or nutrients; these resources must be absorbed across the gametophyte's leafy surface

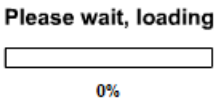
What Are Nonvascular Plants? (cont'd.)

- Moss life cycle
  - The leafy green part of a moss is the gametophyte
    - Supports a sporophyte (stalk and capsule)
  - Spores form by meiosis in the capsule and are released
  - Spores develop into gametophytes that produce eggs or sperm in gametangia at their tips

What Are Nonvascular Plants? (cont'd.)

- Moss life cycle (cont'd.)
  - Sperm released from sperm-producing gametophytes swim through water to eggs of egg-producing gametophytes
  - Fertilization produces a zygote.
  - Zygote develops into a sporophyte while attached to its egg-producing parent

Animation: Moss life cycle



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What Are Nonvascular Plants? (cont'd.)

- Peat mosses (*Sphagnum*)
  - Dominant plants in peat bogs
  - Cover hundreds of millions of acres in high-latitude regions of Europe, Asia, and North America
  - Have persisted for thousands of years
  - Peat is dried and burned as fuel

What Are Nonvascular Plants? (cont'd.)


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What Are Nonvascular Plants? (cont'd.)

- Liverworts
  - Commonly grow in moist places
  - In most of the 6,000 species, the gametophyte is flattened and attaches to soil by rhizoids
- Hornworts
  - Named for a pointy, hornlike sporophyte
    - Sporophytes grow continually from their base, and can survive even after the death of the gametophyte

What Are Nonvascular Plants? (cont'd.)

Dr. Annkatrin Rose, Appalachian State University

What Are Nonvascular Plants? (cont'd.)

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21.3 What Are Seedless Vascular Plants?

- Seedless vascular plants
  - Plants such as club mosses, horsetails, and ferns that have vascular tissue
  - Have flagellated sperm that swim to eggs; disperse by producing spores, not seeds

What Are Seedless Vascular Plants? (cont'd.)

- Sporophytes
  - The larger, longer-lived phase of the life cycle
  - Typically, sporophyte roots and shoots grow from a horizontal stem, or rhizome
  - Tiny free-living gametophytes make flagellated sperm

What Are Seedless Vascular Plants? (cont'd.)

- Ferns
  - Most diverse group of seedless vascular plants, produce spores in *sori*
    - Cluster of spore-producing capsules on a fern leaf
- Many ferns grow as *epiphytes*
  - Plant that grows on another plant but does not harm it

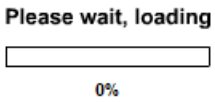
What Are Seedless Vascular Plants? (cont'd.)

- Five steps in the life cycle of a fern
  - The leafy form is the diploid sporophyte
  - Meiosis produces haploid spores on frond undersides
  - Spores are released; germinate/grow into tiny gametophytes that produce eggs and sperm

What Are Seedless Vascular Plants? (cont'd.)

- Five steps in the life cycle of a fern (cont'd.)
  - Sperm swim to eggs and fertilize them, forming a zygote
  - Sporophyte develops attached to the gametophyte, but lives independently after the gametophyte dies

Animation: Fern life cycle



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What Are Seedless Vascular Plants? (cont'd.)

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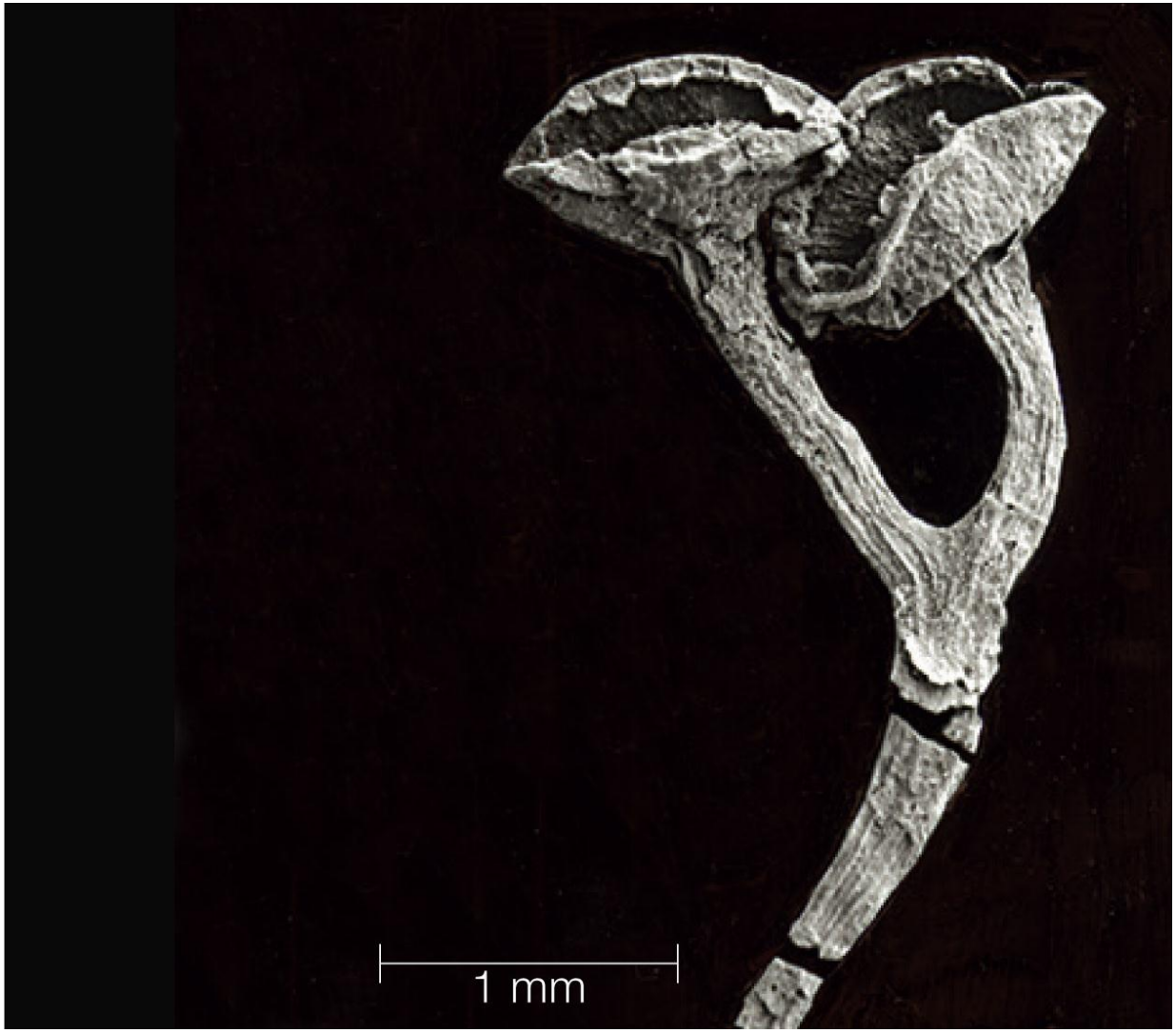
21.4 How Have Vascular Plants Changed Over Time?

- The oldest fossils of vascular plants are spores that date to about 450 million years ago (late Ordovician period)
- Early vascular plants stood only a few centimeters high and had a simple branching pattern, with no leaves or roots
- By the early Devonian, taller species with a more complex branching pattern were common worldwide

How Have Vascular Plants Changed Over Time? (cont'd.)

- Forests of giant seedless vascular plants thrived during the Carboniferous period
  - Heat and pressure transformed the remains of these forests to coal

How Have Vascular Plants Changed Over Time? (cont'd.)



How Have Vascular Plants Changed Over Time? (cont'd.)

How Have Vascular Plants Changed Over Time? (cont'd.)

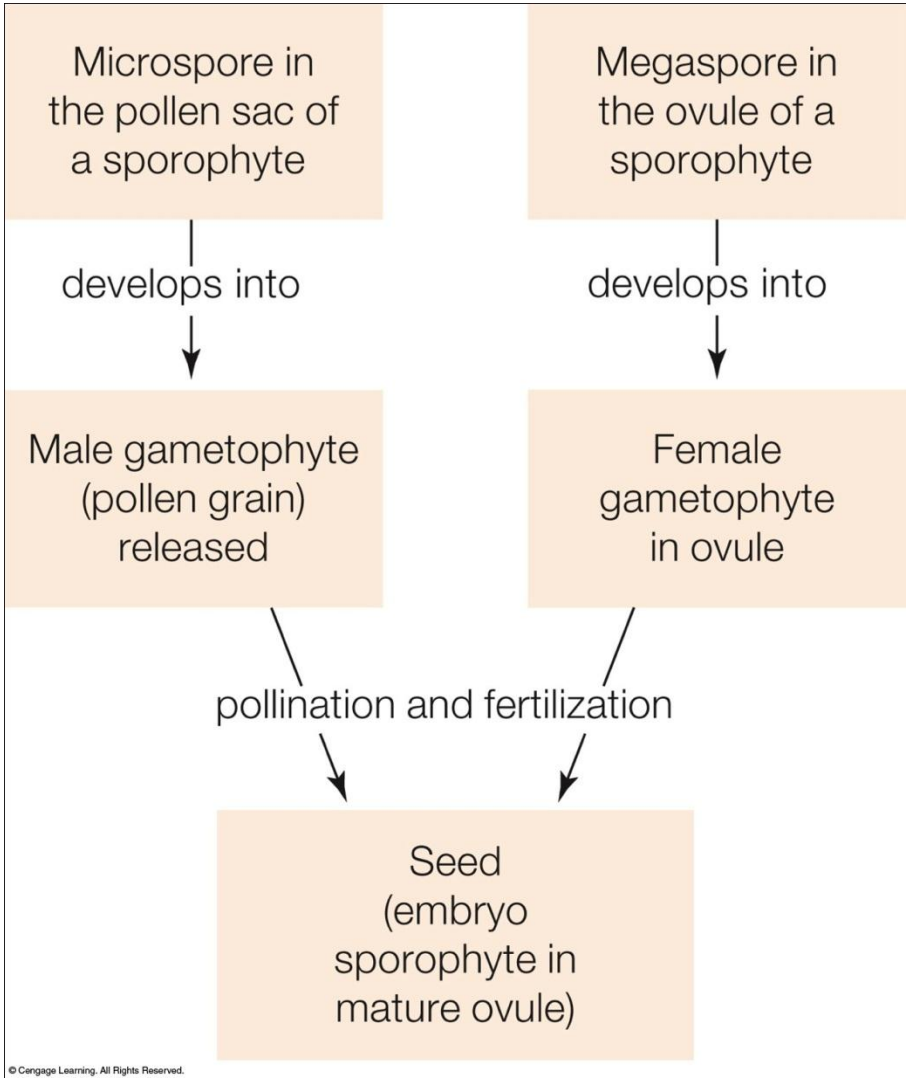
- Rise of the seed plants
- Evolved in the late Devonian (365 mya)
- Cycads and ginkgos were among the earliest gymnosperm lineages
- Early angiosperms such as magnolias evolved while dinosaurs walked on Earth

How Have Vascular Plants Changed Over Time? (cont'd.)

How Have Vascular Plants Changed Over Time? (cont'd.)

- Seed plant sporophytes have pollen sacs, where microspores form and develop into male gametophytes (pollen grains)
- Sporophytes also have ovules, where megaspores form and develop into female gametophytes

How Have Vascular Plants Changed Over Time? (cont'd.)



21.5 What Are Gymnosperms?

- Gymnosperms
  - Vascular seed plants
  - Produce seeds on the surface of ovules
  - Seeds are “naked” (not inside a fruit)
  - Does not make flowers
  - Includes:
    - Conifers, cycads, ginkgos, and gnetophytes

What Are Gymnosperms? (cont'd.)

- Conifers
  - Gymnosperm with nonmotile sperm
  - Ovules form on the surfaces of woody cones
  - Typically have needlelike or scalelike leaves
  - Tend to be resistant to drought and cold
  - Examples: pines, redwoods

What Are Gymnosperms? (cont'd.)

- Ponderosa pine life cycle
  - Inside the ovule, a megaspore forms by meiosis and develops into a female gametophyte
  - Male cones hold pollen sacs where microspores develop into pollen grains

What Are Gymnosperms? (cont'd.)

- Ponderosa pine life cycle (cont'd.)
  - Pollen grains are released; pollination occurs when one lands on an ovule, and the pollen grain germinates
  - It takes about a year for a pollen tube to grow through ovule tissue and deliver sperm to the egg

What Are Gymnosperms? (cont'd.)

- Ponderosa pine life cycle (cont'd.)
  - When fertilization finally occurs, it produces a zygote
  - The zygote develops into an embryo sporophyte that, along with tissues of the ovule, becomes a seed
  - The seed is released, germinates, and grows and develops into a new sporophyte

Animation: Pine life cycle

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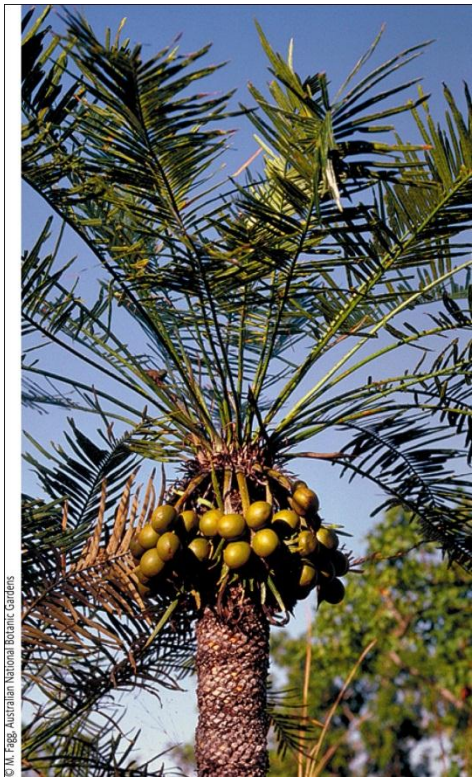
What Are Gymnosperms? (cont'd.)

- There is great Gymnosperm diversity
  - Cycads resemble palm trees and live mainly in the dry tropics and subtropics
  - Gingko is a tree native to China
  - Gnetophytes like *Ephedra* include woody vines, tropical trees and shrubs

What Are Gymnosperms? (cont'd.)



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21.6 What Are Angiosperms?

- Angiosperms
  - Seed plants make flowers
    - Specialized reproductive shoot of a flowering plant
    - Flower structure can vary
  - Seed plants make fruits
    - Mature flowering plant ovary; encloses a seed or seeds
  - Largest seed plant lineage

What Are Angiosperms? (cont'd.)

- Flowers
  - Consists of modified leaves arranged in concentric whorls of sepals and petals
  - Stamens of a flower produce pollen
  - Eggs form in the female part of the flower (carpel)
  - Ovary at the base of the carpel holds one or more ovules

What Are Angiosperms? (cont'd.)

- Angiosperms
  - Flowering plants
  - Dominant plants in most land habitats
  - Ecologically important
  - Essential to human existence
  - Feed and shelter animals
  - Provide us with food, fabric, oils, medicines, drugs

What Are Angiosperms? (cont'd.)

- Flowers
  - Consists of modified leaves arranged in concentric whorls of sepals and petals
  - Stamens of a flower produce pollen
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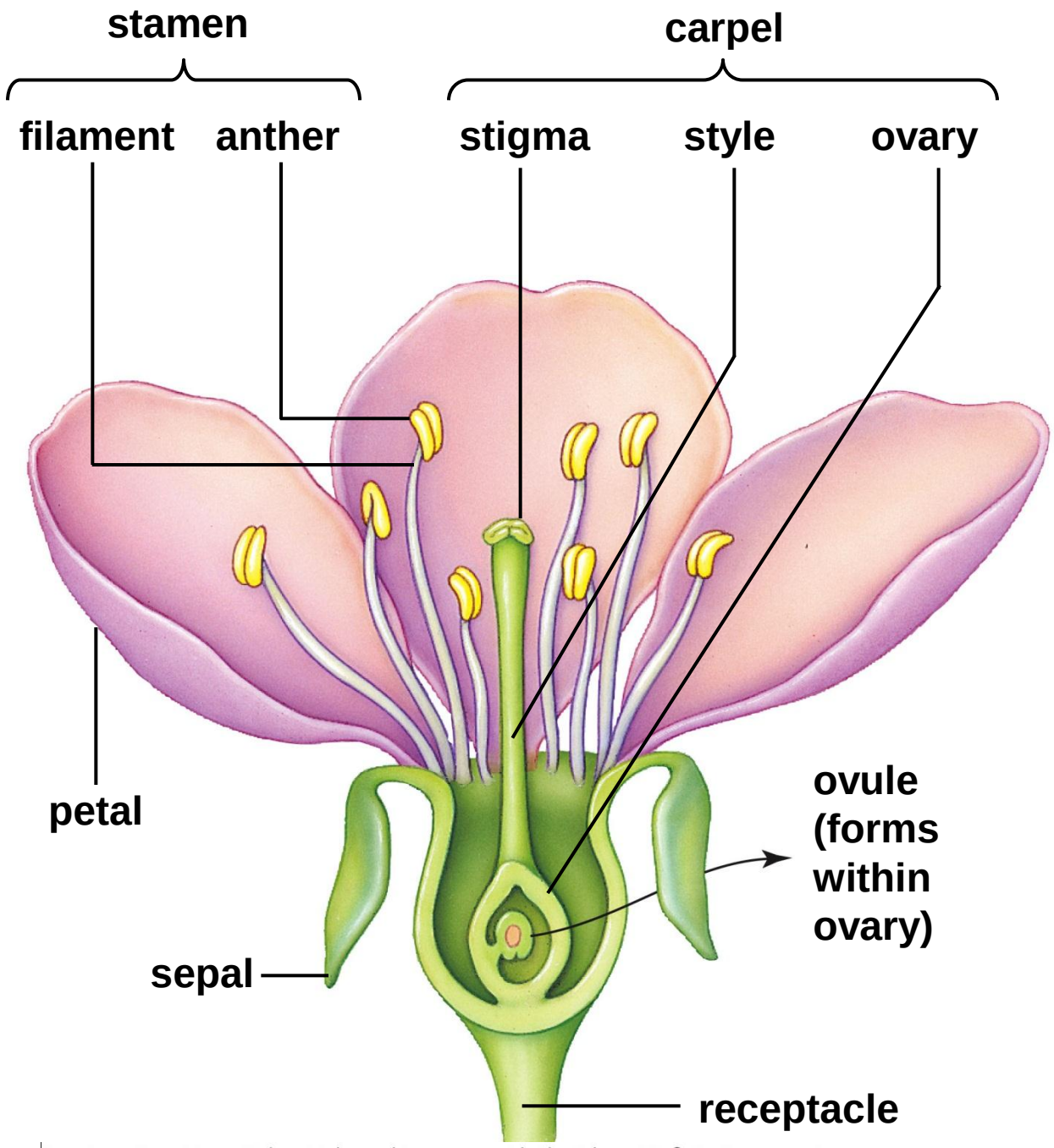
What Are Angiosperms? (cont'd.)



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Animation: Monocot life cycle

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What Are Angiosperms? (cont'd.)

- Two major lineages differ in seed structure and other traits:
  - Monocots include orchids, palms, lilies, and grasses
  - Eudicots include most herbaceous (nonwoody) plants such as tomatoes, cabbages, roses, poppies, most flowering shrubs and trees, and cacti

What Are Angiosperms? (cont'd.)

A

B

C

D

21.7 Why Are Angiosperms So Diverse and Widespread?

- Several factors contributed to angiosperm diversity
  - Accelerated life cycle compared to gymnosperms
  - Have a partnership with pollinators, animals that moves pollen
    - Birds, bats, butterflies and other insects
  - Animal-dispersed fruits
    - Hooks or spines stick to animal fur, bright colored fruits

Why Are Angiosperms So Diverse and Widespread? (cont'd.)

A

B

21.8 Saving Seeds

- Plant diversity is declining
  - Many valuable sources of food, medicine and other products could disappear
  - Need to sustain wild plants
  - Seeds can be stored in a seed vault

Saving Seeds (cont'd.)

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