Chapter 35

Plant Structure, Growth, and Development

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

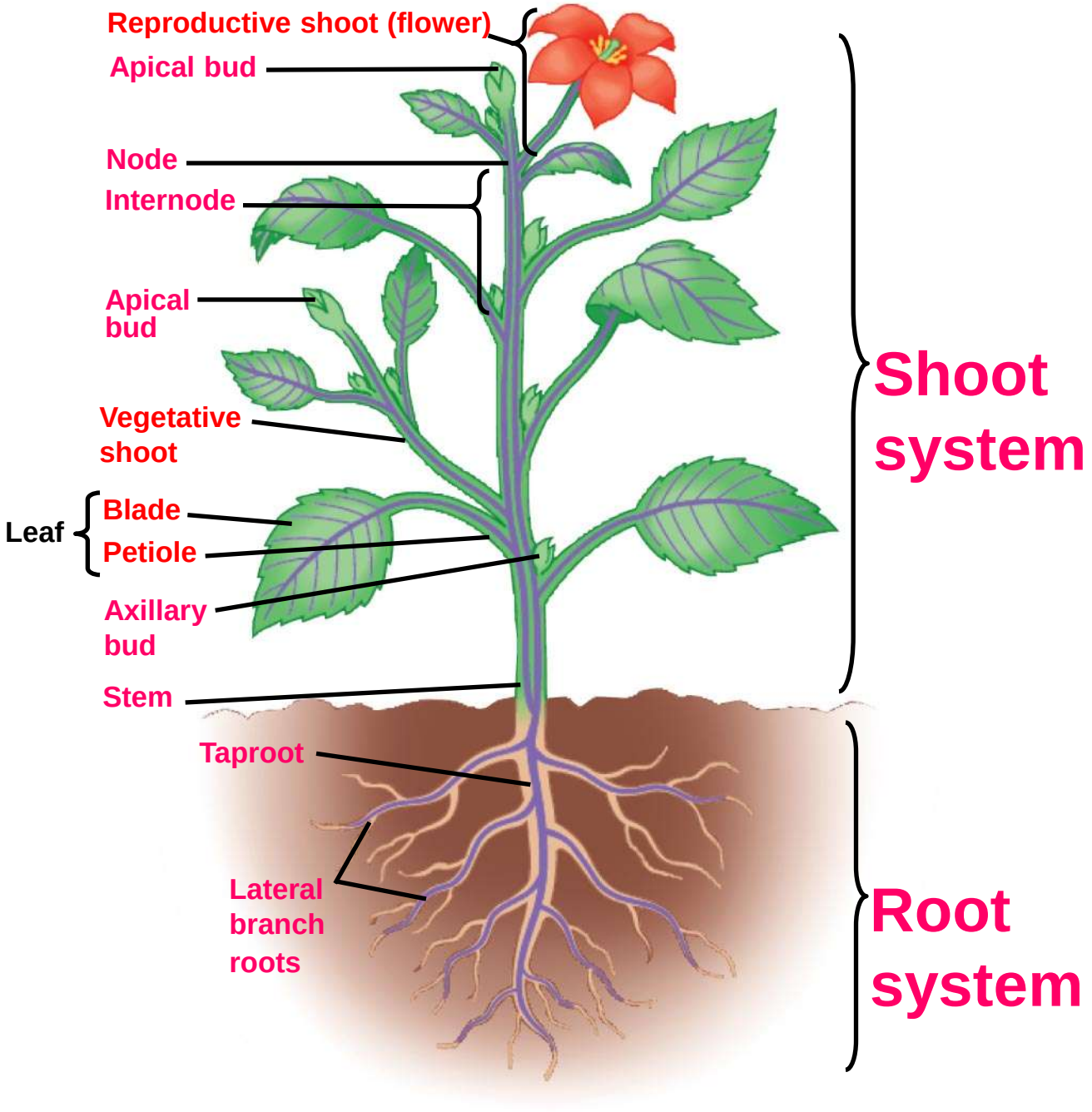
Neil Campbell and Jane Reece

Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Concept 35.1: The plant body has a hierarchy of organs, tissues, and cells

- Plants, like multicellular animals, have **organs** composed of different **tissues**, which in turn are composed of **cells**
- Basic morphology of vascular plants reflects their evolution as organisms that draw nutrients from below ground and above ground
- **Three basic organs** evolved: roots, stems, and leaves
- They are organized into a **root system** and a **shoot system**

Fig. 35-2



- A **taproot** system consists of one main vertical root that gives rise to **lateral roots**, or branch roots
- Gymnosperms and eudicots have a taproot system
- Seedless vascular plants and monocots have a **fibrous root** system characterized by thin lateral roots with no main root

- In most plants, absorption of water and minerals occurs near the **root hairs**, where vast numbers of tiny root hairs **increase the surface area**

Fig. 35-4

Many plants have modified roots

Prop roots

Storage roots

"Strangling" aerial roots

Pneumatophores

Buttress roots

Shoot system

- A **stem** is an organ consisting of
  - An alternating system of **nodes**, the points at which leaves are attached
  - **Internodes**, the stem segments between nodes
- An **apical bud**, or terminal bud, is located near the shoot tip and causes elongation of a young shoot
- An **axillary bud** is a structure between stem and leaf that can produce a lateral shoot, or branch

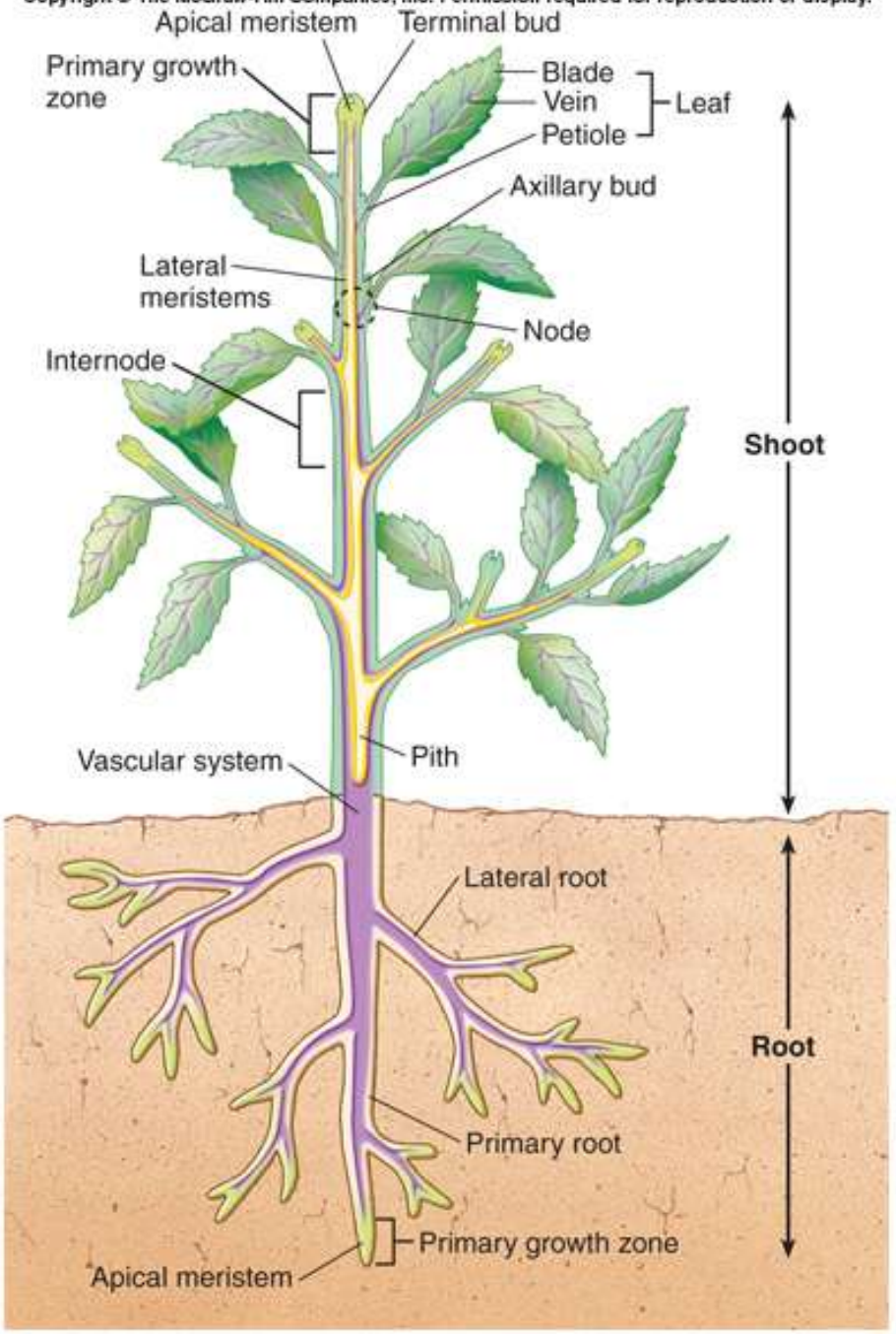
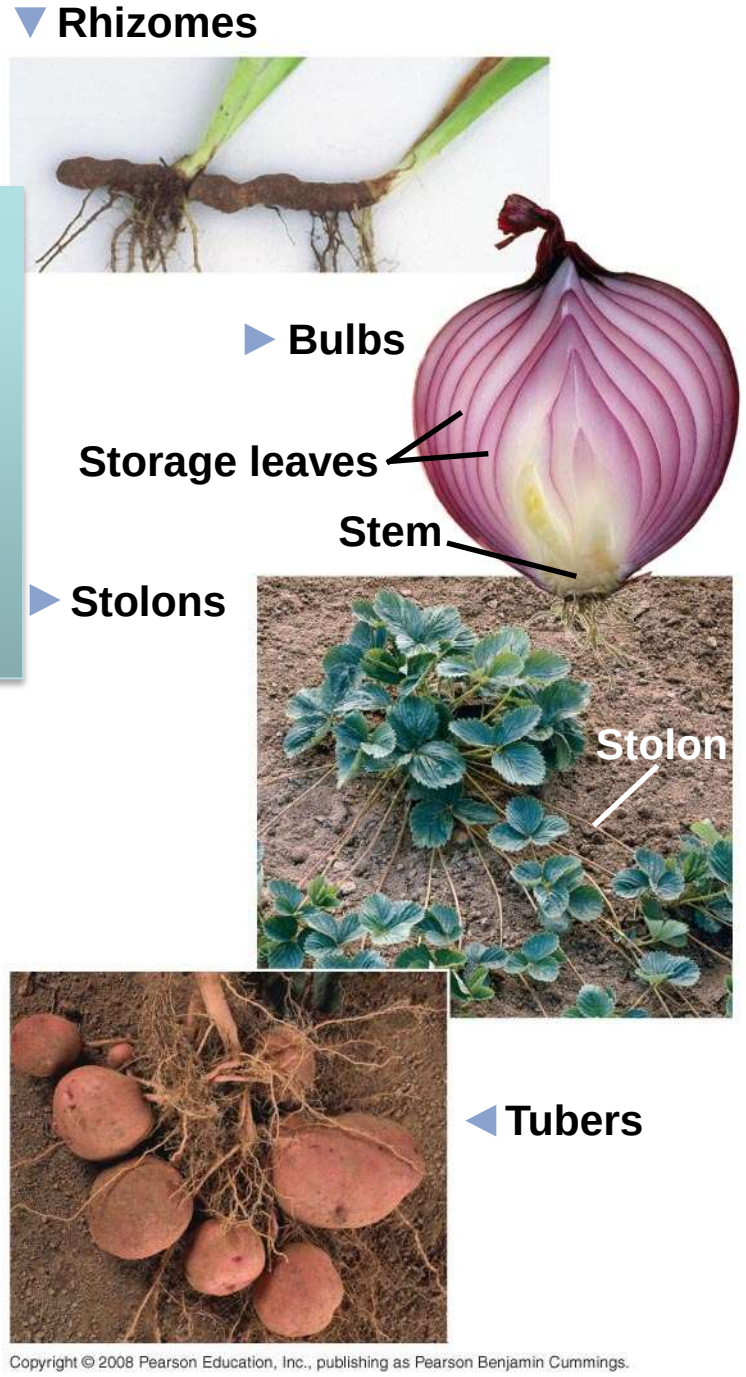


Fig. 35-5

Many plants have modified stems



Leaves

- The **leaf** is the main photosynthetic organ of most vascular plants
- Leaves generally consist of a flattened **blade** and a stalk called the **petiole**, which joins the leaf to a node of the stem

- Monocots and eudicots differ in the arrangement of **veins**, the vascular tissue of leaves
  - Most **monocots** have parallel veins
  - Most **eudicots** have branched veins

Stomata are openings in epidermis of leaf for gas exchange

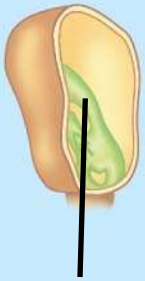
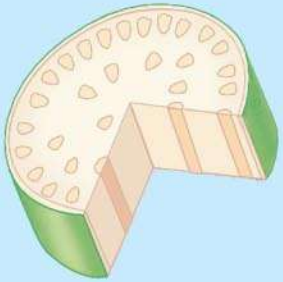
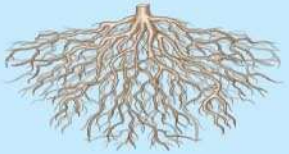
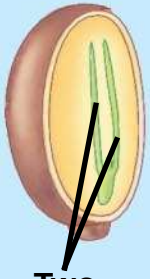
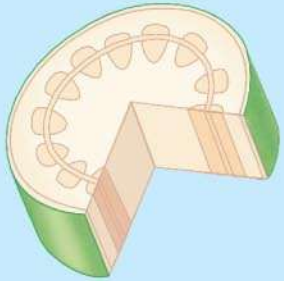
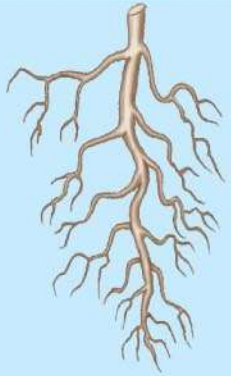
	Seed leaves	Leaf veins	Stems	Flowers	Roots
MONOCOTS	 One cotyledon	 Veins usually parallel	 Vascular bundles in complex arrangement	 Floral parts usually in multiples of three	 Fibrous root system
EUDICOTS	 Two cotyledons	 Veins usually branched	 Vascular bundles arranged in ring	 Floral parts usually in multiples of four or five	 Taproot usually present

Fig. 35-18b

(b) Surface view of a spiderwort (*Tradescantia*) leaf (LM)

Fig. 35-6

Axillary bud presents ONLY at attachment of leaf to stem, and NOT presents at attachment site of leaflets

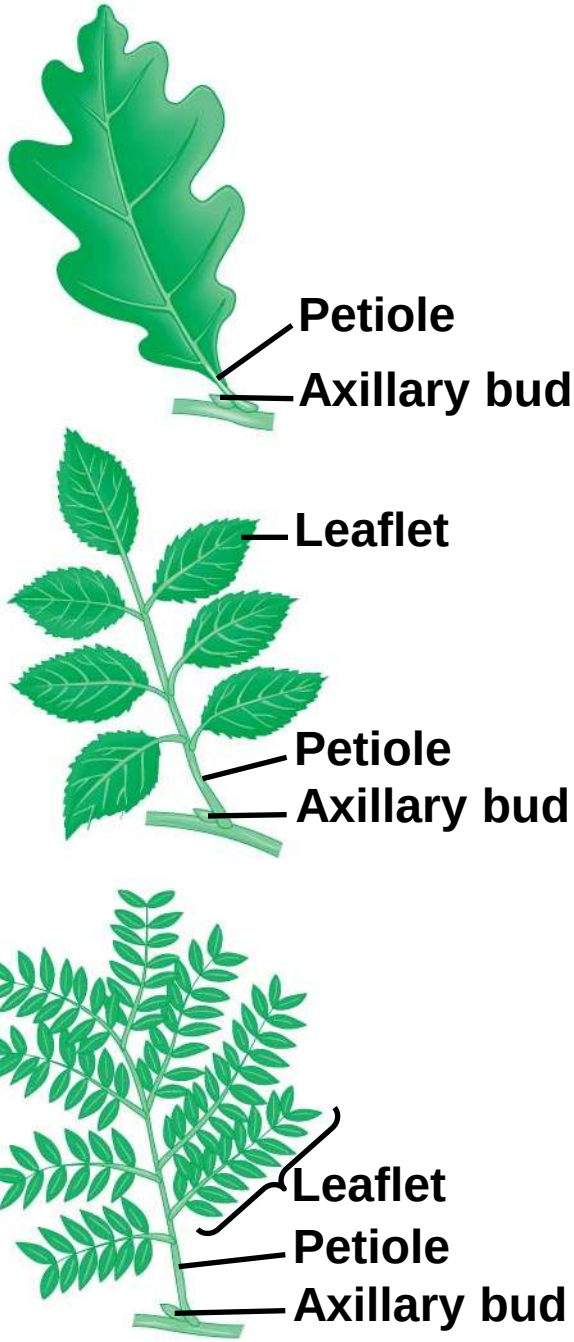


Fig. 35-7

Some plant species have evolved modified leaves that serve various functions

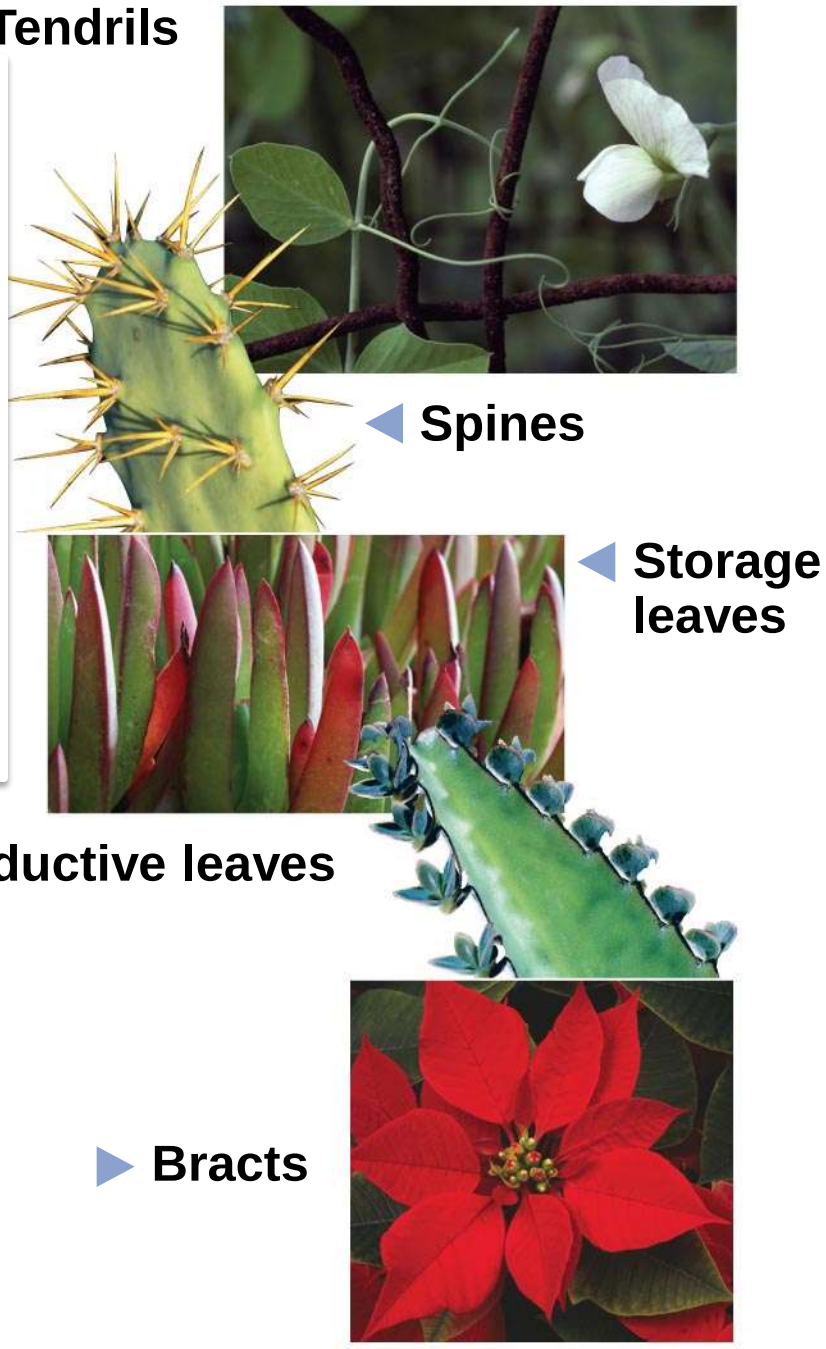
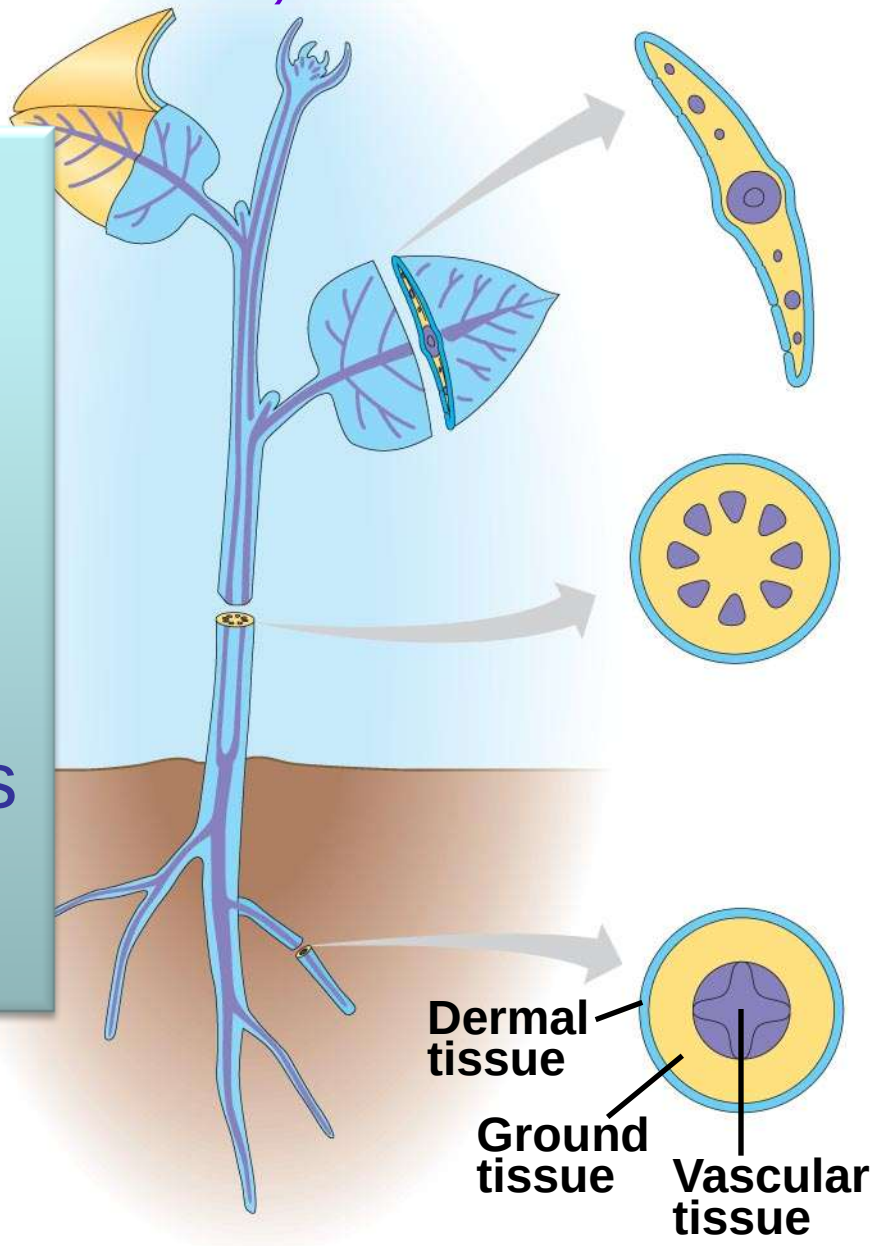


Fig. 35-8

Dermal, Vascular, and Ground Tissues

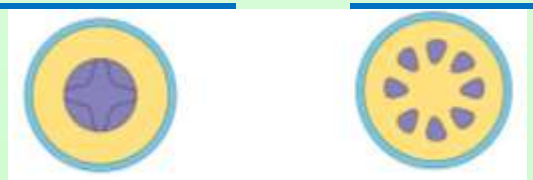
Each plant organ has dermal, vascular, and ground tissues

Each of these three categories forms a **tissue system**

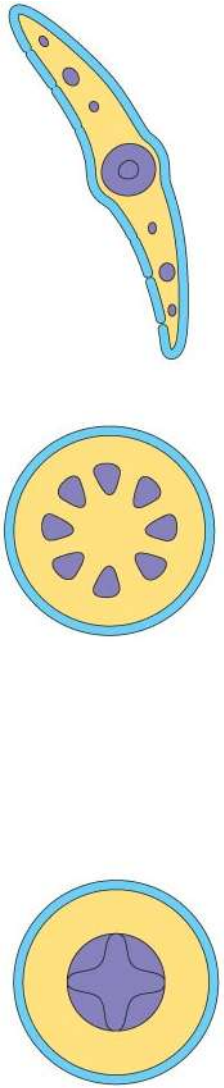


- The **vascular tissue system** carries out long-distance transport of materials between roots and shoots
- The two vascular tissues are xylem and phloem
- **Xylem** conveys water and dissolved minerals **upward** from roots into the shoots
- **Phloem** transports organic nutrients from leaves to other areas of plants

Vascular tissue arranged in cylinders or bundles



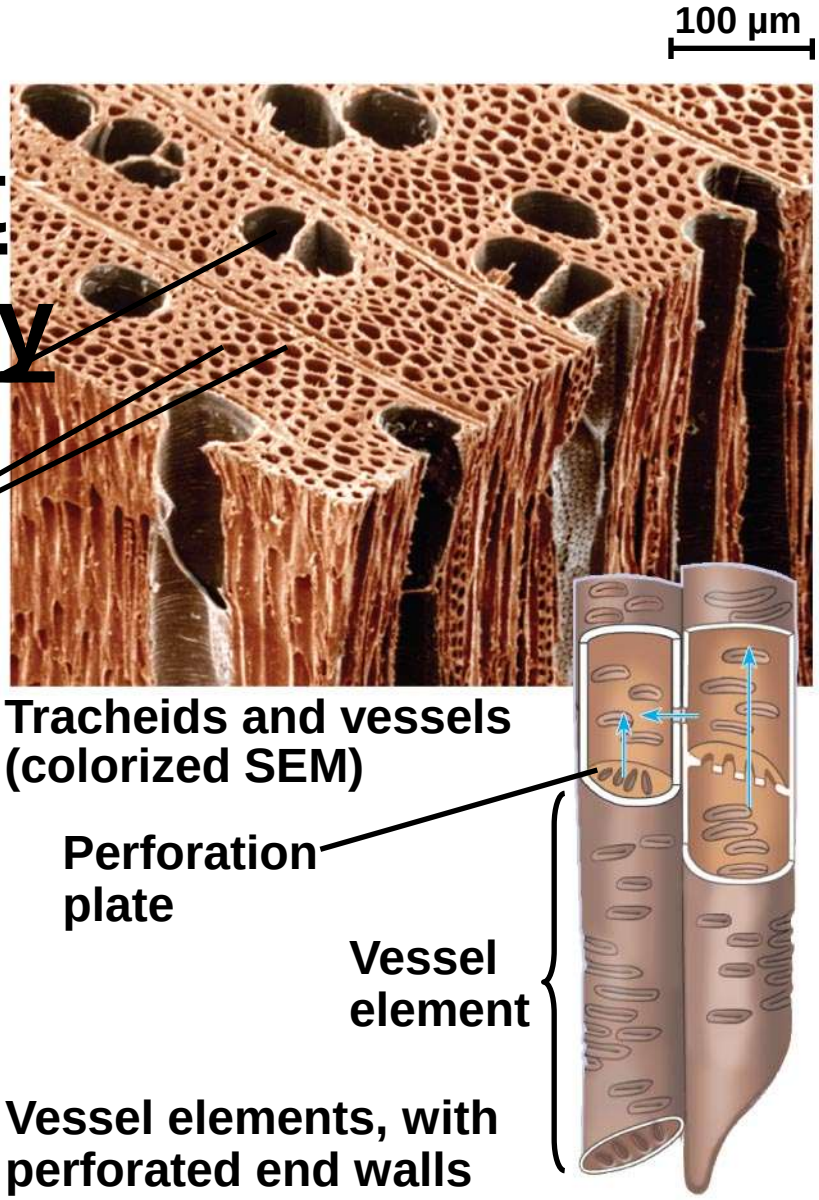
- Tissues that are neither dermal nor vascular are the **ground tissue system**
- Ground tissue includes cells specialized for storage, photosynthesis, and support



Xylem

The two types of water-conducting cells, **tracheids** and **vessel elements**

are dead at maturity



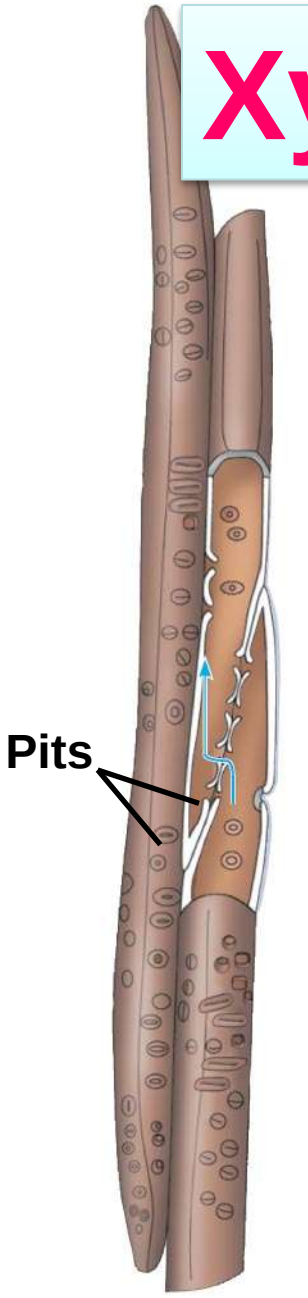
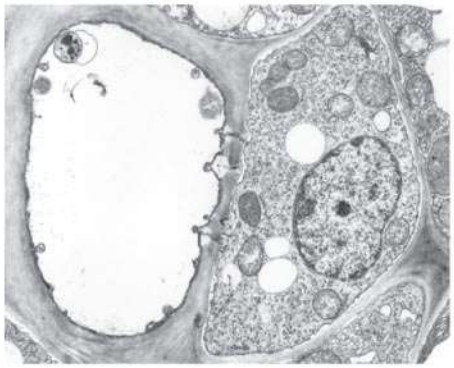


Fig. 35-10e

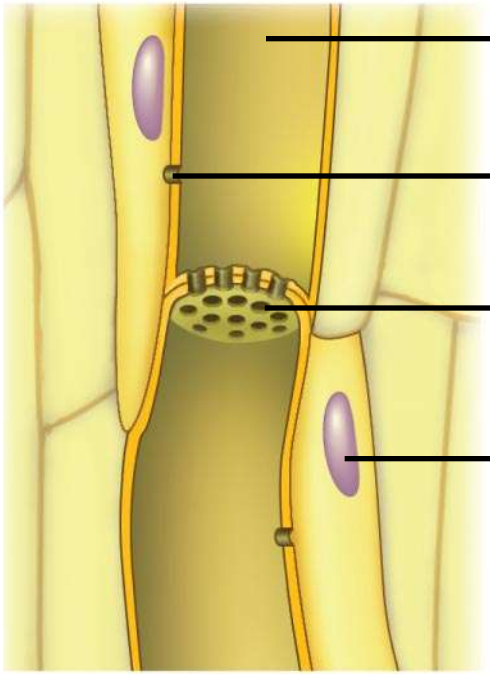


3 µm

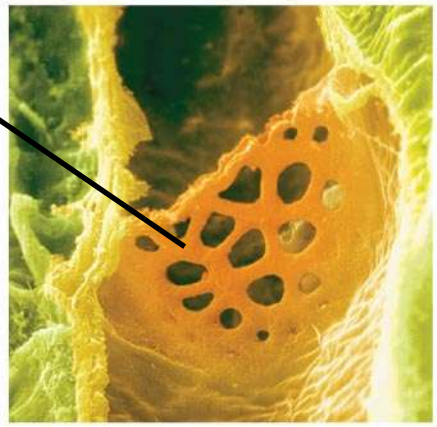
Sieve-tube element (left) and companion cell: cross section (TEM)

Phloem

sugar-conducting cells



Sieve-tube elements: longitudinal view



30 µm

10 µm

Sieve plate with pores (SEM)

Plant Growth: indeterminate

- **Annual**: life span is 1 year or less
- **Biennial**: life span is 2 years
- **Perennial**: life span is for many years

Concept 35.3: Primary growth lengthens roots and shoots

- Primary growth produces the **primary plant body**, the parts of the root and shoot systems produced by apical meristems
- Apical meristems – embryonic tissues

- The root tip is covered by a **root cap**, which protects the apical meristem as the root pushes through soil

Fig. 35-13

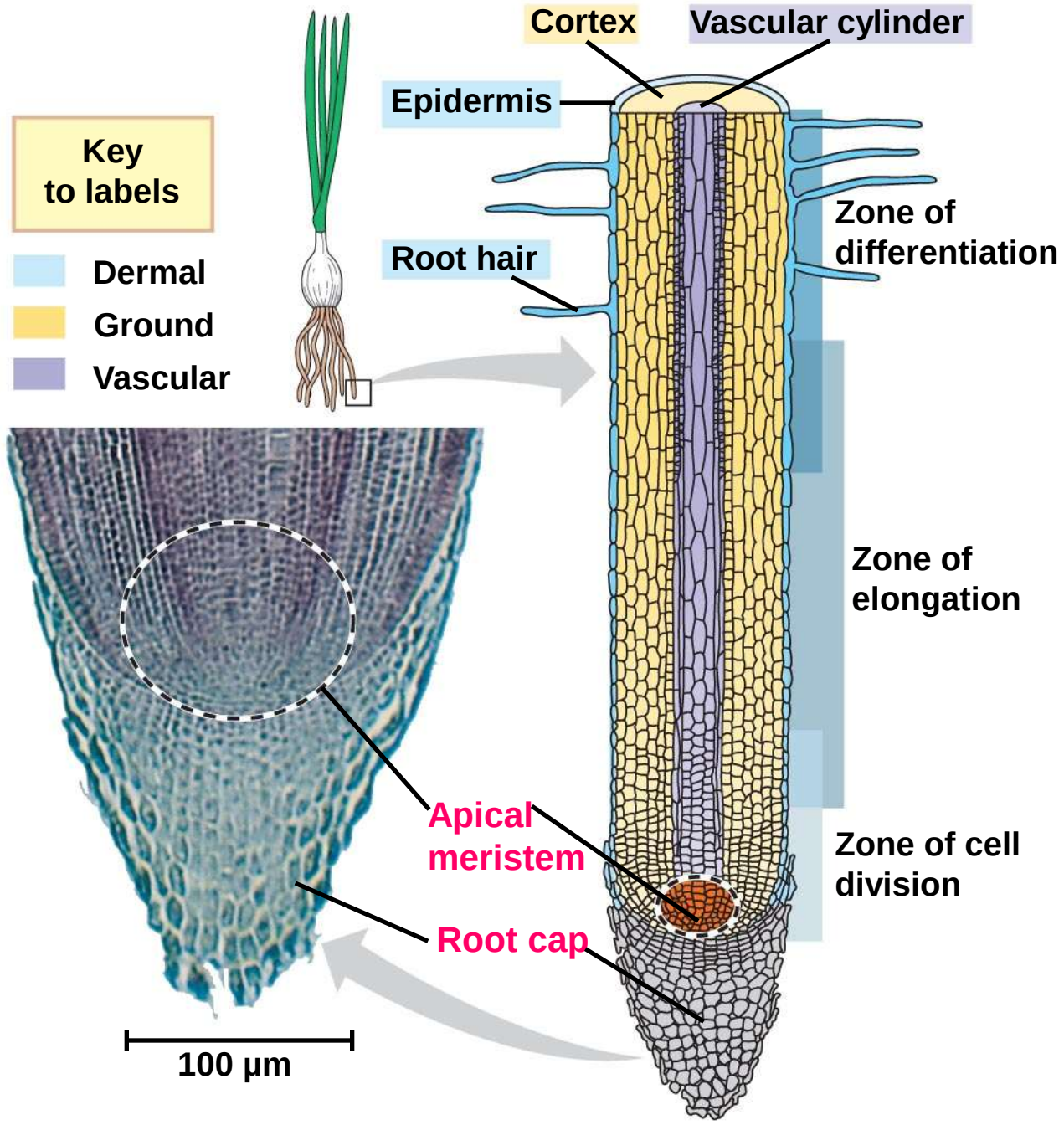


Fig. 35-16

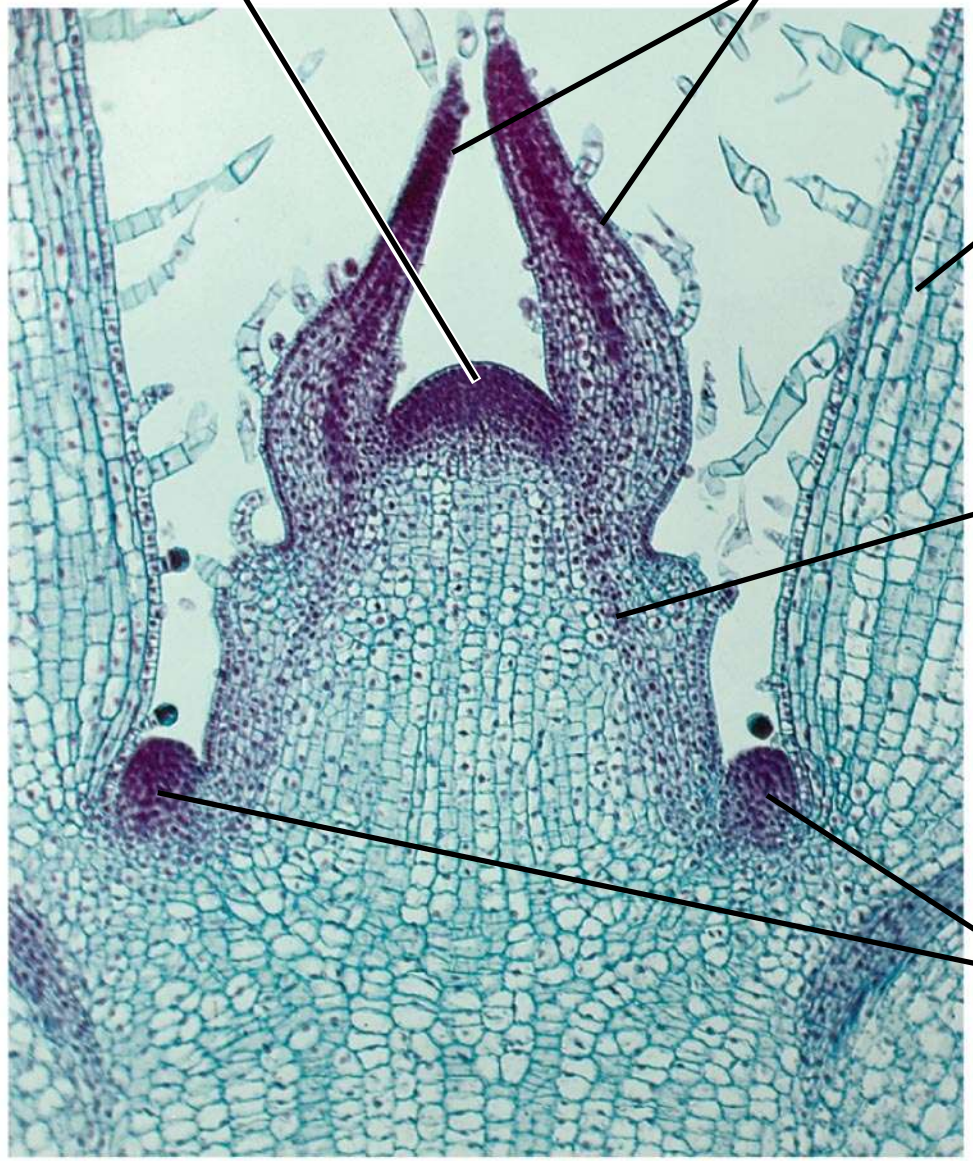
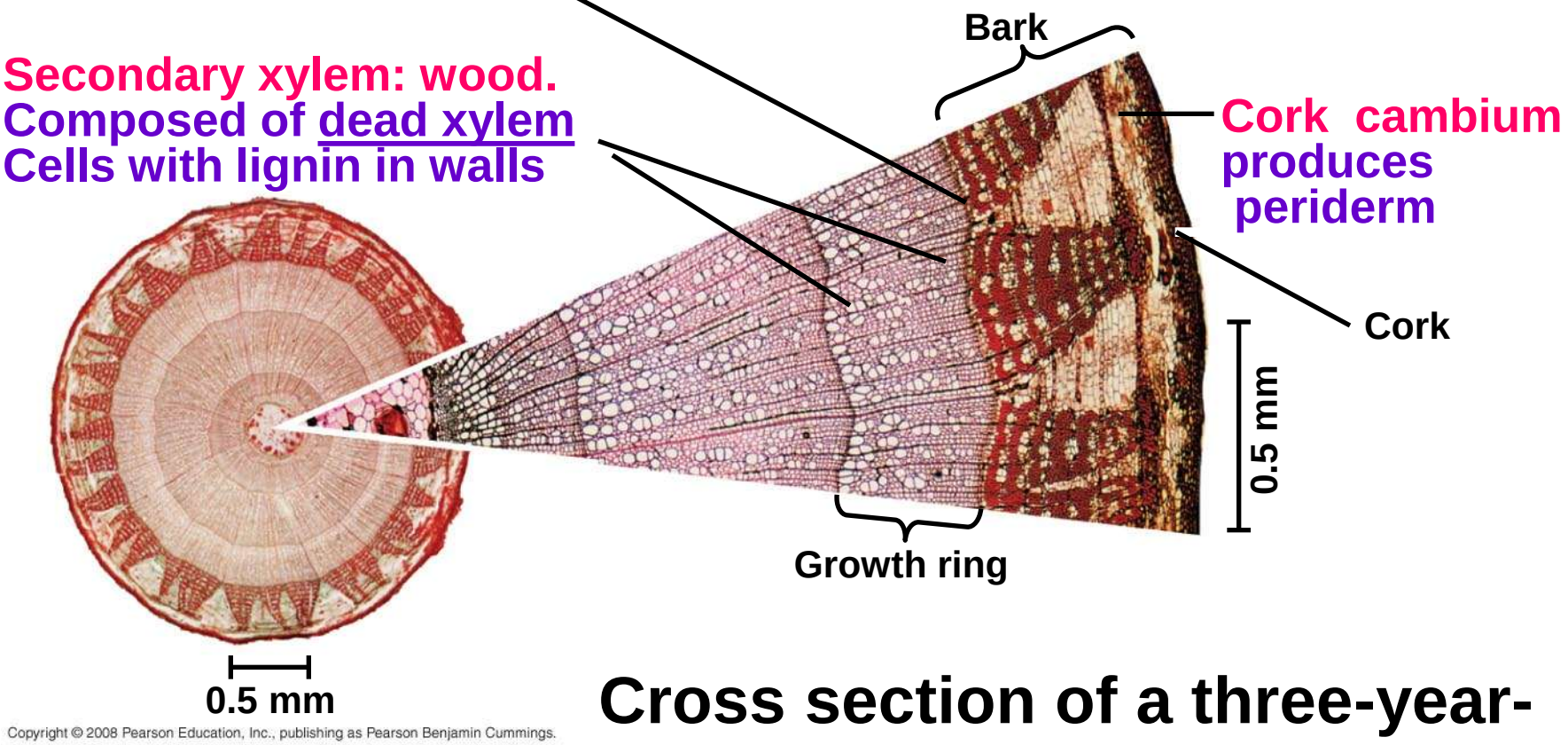


Fig. 35-19b



Cross section of a three-year-old *Tilia* (linden) stem (LM)

- **Tree rings** are visible where **late and early wood meet**, and **can be used to estimate a tree's age**

You should now be able to:

1. Compare the following structures or cells:
   - Fibrous roots, taproots, root hairs
   - Dermal, vascular, and ground tissues
   - Water-conducting cells of the xylem, and sugar-conducting cells of the phloem
2. Understand the composition of wood and bark

Chapter 36

Resource Acquisition and Transport in Vascular Plants

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Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Fig. 36-2-3

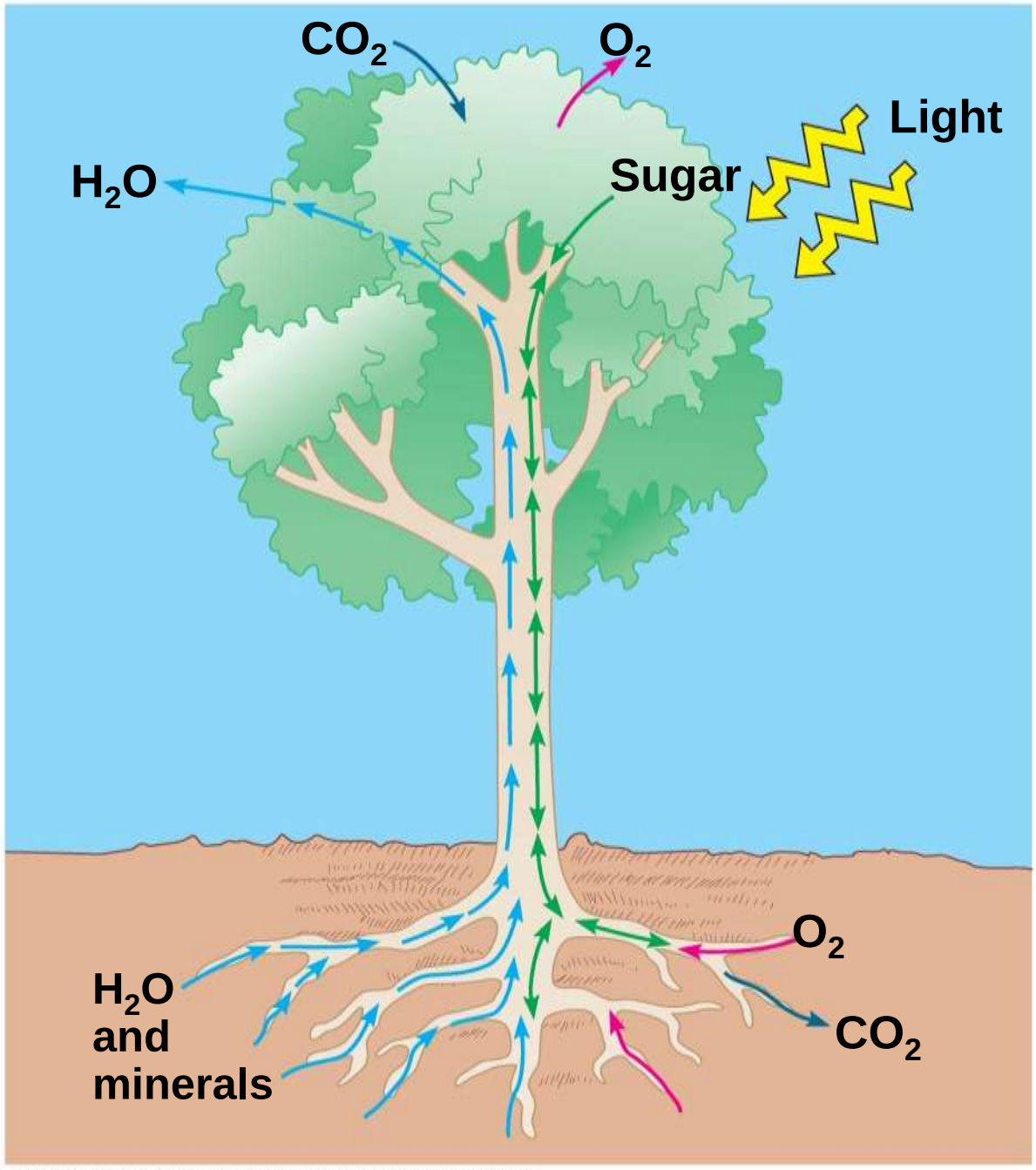
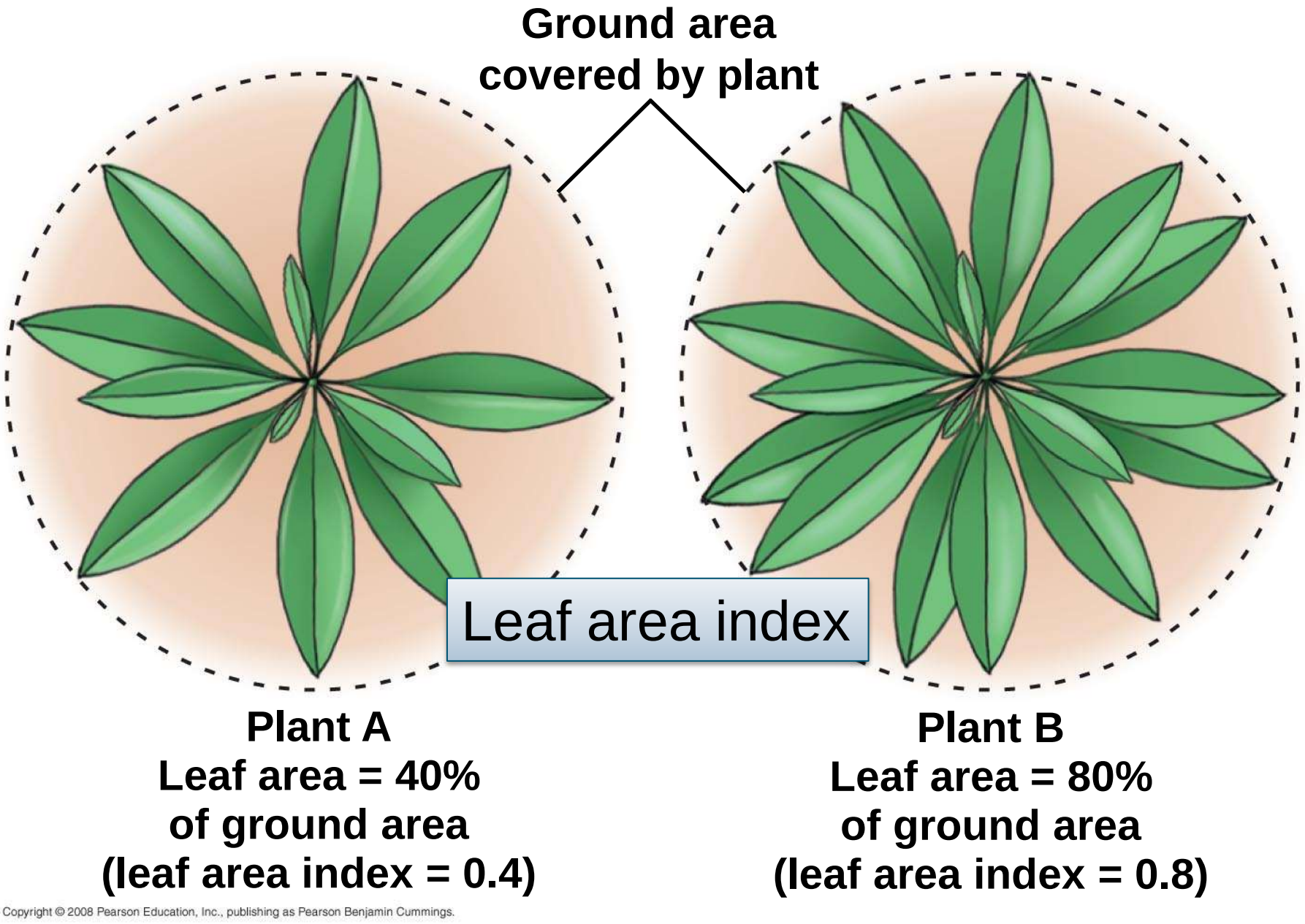


Fig. 36-4



- Roots: absorb water and minerals from soil through epidermis into cortex and on to xylem
- Roots and the **hyphae of soil fungi** form symbiotic associations called **mycorrhizae**

Diffusion of Water (Osmosis)

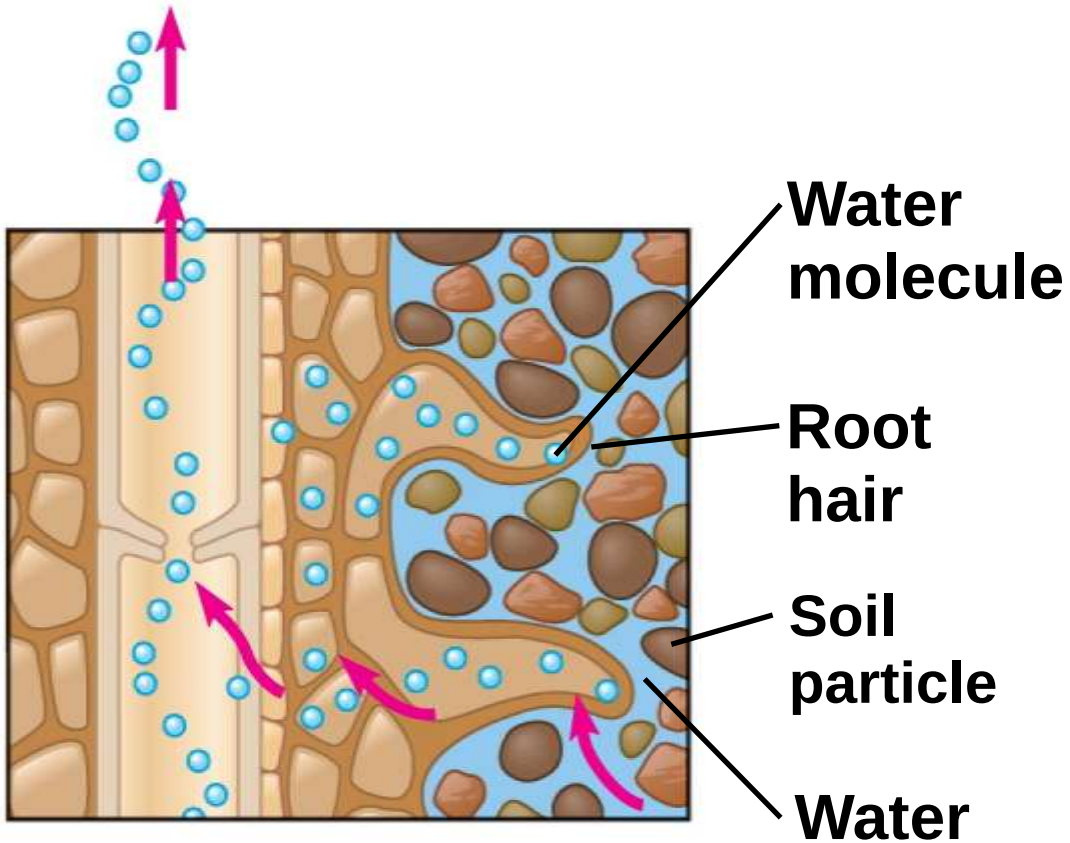
- To survive, plants must **balance water uptake and loss**
- **Osmosis** determines the net uptake or water loss by a cell and is affected by solute concentration and pressure
- Plants can move a large volume of water from their roots to shoots

Transpirational pull

- Transpiration: water loss from leaves to air through stomata
- Water vapor in the airspaces of a leaf diffuses down its water potential gradient and exits the leaf via stomata
- Transpiration produces negative pressure (tension) in the leaf, which exerts a pulling force on water in the xylem, pulling water into the leaf

Fig. 36-15a

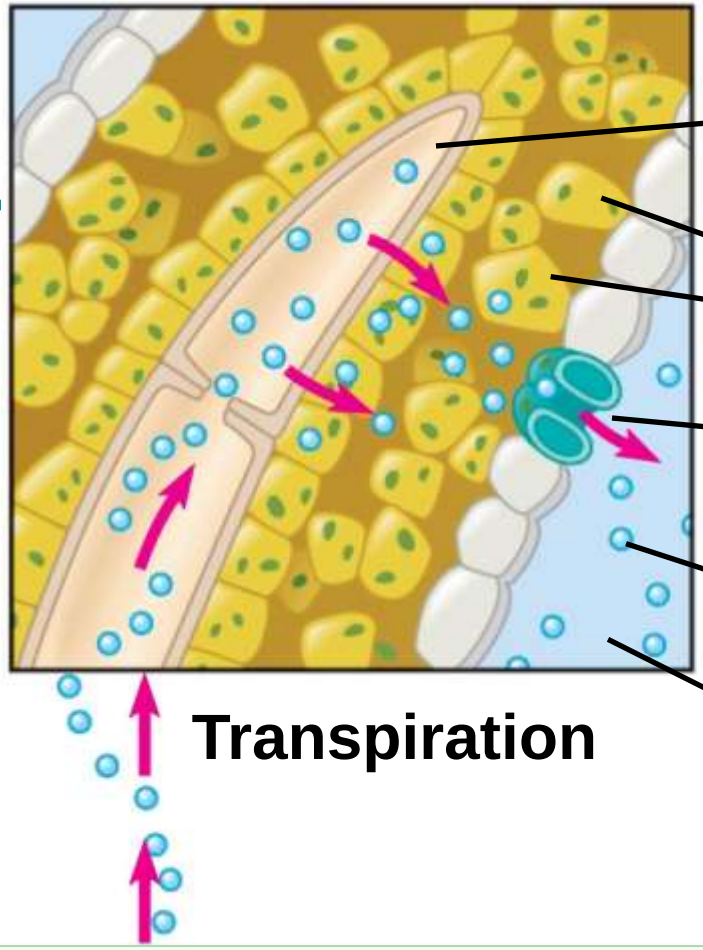
Ascent of xylem sap



Water uptake from soil

Cohesion and Adhesion in the Ascent of Xylem Sap

- The transpirational pull on xylem sap is transmitted all the way from the leaves to the root tips
- Transpirational pull is facilitated by cohesion of water molecules to each other and adhesion of water molecules to cell walls



Transpiration lowers water potential in leaves, and this generates negative pressure (tension) that pulls water up through the xylem

Fig. 36-16

An open stoma (left) and closed stoma (LMs)

Adaptations That Reduce Evaporative Water Loss

- **Xerophytes** are plants **adapted to arid climates**
- They have leaf modifications that reduce the rate of transpiration

Fig. 36-18a

Ocotillo (leafless)

Fig. 36-18b

Ocotillo after heavy rain

Concept 36.5: Sugars are transported from leaves and other sources to sites of use or storage

- The products of photosynthesis are transported through phloem by the process of **translocation** – movement of organic nutrients by positive pressure
- **Phloem sap** is an aqueous solution that is high in sucrose
- It travels from a sugar source to a sugar sink

Movement from Sugar Sources to Sugar Sinks

- A **sugar source** is an organ that is a net producer of sugar, such as mature leaves
- A **sugar sink** is an organ that is a net consumer or storer of sugar, such as a tuber or bulb
- A storage organ can be both a sugar sink in summer and sugar source in winter
- In many plants, phloem loading requires **active transport**
- At the sink, sugar molecules diffuse from the phloem to sink tissues and are followed by water

Chapter 37

Soil and Plant Nutrition

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Neil Campbell and Jane Reece

Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Concept 37.1: Soil is a living, finite resource

- Healthy soils improve plant growth by enhancing plant **nutrition**
- Typically, plants obtain carbon dioxide from the air, and water and minerals from the soil
- Soil is stratified into layers called **soil horizons**
- **Topsoil** consists of mineral particles, living organisms, and **humus**, the **decaying organic material**

Fig. 37-2

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Topsoil Composition

- A soil's composition refers to its inorganic (mineral) and organic chemical components
- Topsoil contains bacteria, fungi, algae, other protists, insects, earthworms, nematodes, and plant roots
- These organisms help to decompose organic material and mix the soil

Soil Conservation and Sustainable Agriculture

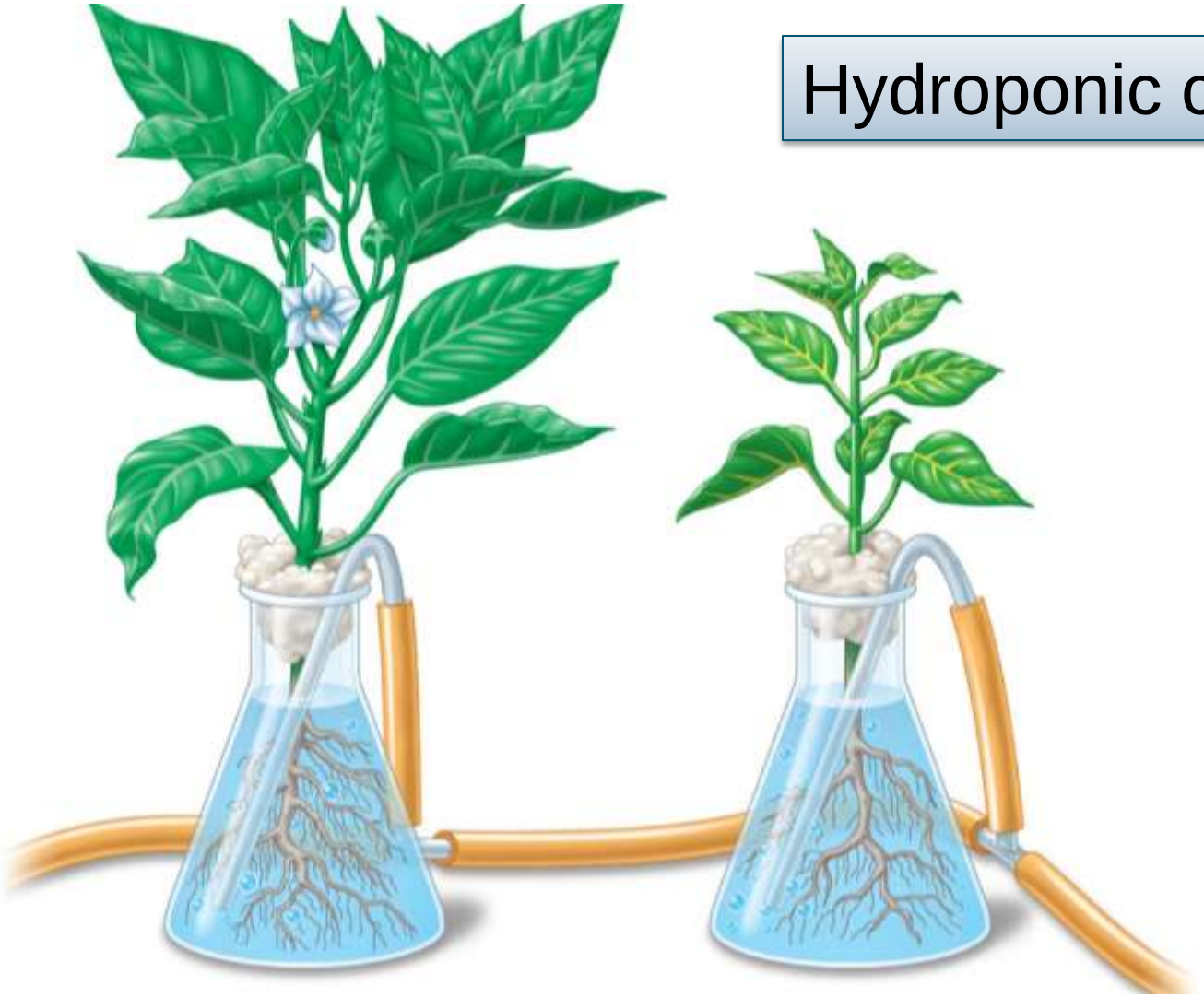
- In contrast with natural ecosystems, agriculture depletes the mineral content of soil, taxes water reserves, and encourages erosion
- The goal of **sustainable agriculture** is to use farming methods that are conservation-minded, environmentally safe, and profitable
- **Fertilization** replaces mineral nutrients that have been lost from the soil

Fig. 37-5

Macronutrients and Micronutrients

- More than 50 chemical elements have been identified among the inorganic substances in plants, but not all of these are essential to plants
- A chemical element is considered an **essential element** if it is **required for a plant to complete its life cycle**
- Researchers use **hydroponic culture** to determine which chemical elements are essential

Hydroponic culture



Control: Solution containing all minerals

Experimental: Solution without potassium

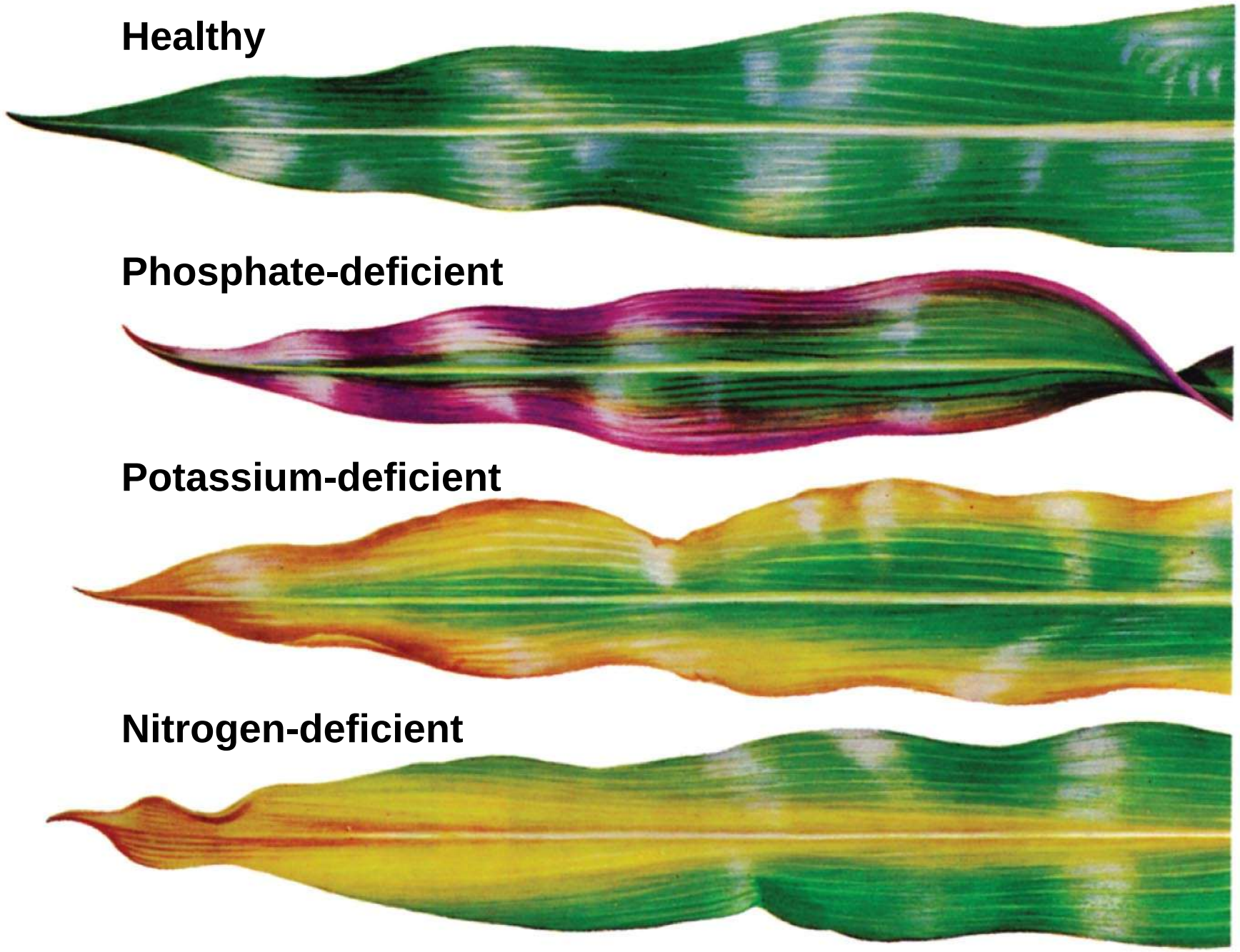
Table 37.1 Essential Elements in Plants

Element	Form Available to Plants	% Mass in Dry Tissue	Major Functions
Macronutrients			
Carbon	CO_2	45%	Major component of plant's organic compounds
Oxygen	CO_2	45%	Major component of plant's organic compounds
Hydrogen	H_2O	6%	Major component of plant's organic compounds
Nitrogen	NO_3^-, NH_4^+	1.5%	Component of nucleic acids, proteins, hormones, chlorophyll, coenzymes
Potassium	K^+	1.0%	Cofactor that functions in protein synthesis; major solute functioning in water balance; operation of stomata
Calcium	Ca^{2+}	0.5%	Important in formation and stability of cell walls and in maintenance of membrane structure and permeability; activates some enzymes; regulates many responses of cells to stimuli
Magnesium	Mg^{2+}	0.2%	Component of chlorophyll; activates many enzymes
Phosphorus	$H_2PO_4^-$, HPO_4^{2-}	0.2%	Component of nucleic acids, phospholipids, ATP, several coenzymes
Sulfur	SO_4^{2-}	0.1%	Component of proteins, coenzymes
Micronutrients			
Chlorine	Cl^-	0.01%	Required for water-splitting step of photosynthesis; functions in water balance
Iron	Fe^{3+}, Fe^{2+}	0.01%	Component of cytochromes; activates some enzymes
Manganese	Mn^{2+}	0.005%	Active in formation of amino acids; activates some enzymes; required for water-splitting step of photosynthesis
Boron	$H_2BO_3^-$	0.002%	Cofactor in chlorophyll synthesis; may be involved in carbohydrate transport and nucleic acid synthesis; role in cell wall function
Zinc	Zn^{2+}	0.002%	Active in formation of chlorophyll; activates some enzymes
Copper	Cu^+, Cu^{2+}	0.001%	Component of many redox and lignin-biosynthetic enzymes
Nickel	Ni^{2+}	0.001%	Cofactor for an enzyme functioning in nitrogen metabolism
Molybdenum	MoO_4^{2-}	0.0001%	Essential for symbiotic relationship with nitrogen-fixing bacteria; cofactor in nitrate reduction

- Nine of the essential elements are called **macronutrients** because plants require them in relatively large amounts
- The macronutrients are **carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, calcium, and magnesium**
- Symptoms of mineral deficiency depend on the nutrient's function and mobility within the plant
- The most common deficiencies are those of **nitrogen**, **potassium**, and **phosphorus**

- The remaining eight are called **micronutrients** because plants need them in very small amounts
- The micronutrients are **chlorine, iron, manganese, boron, zinc, copper, nickel, and molybdenum**

Fig. 37-7



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- **N_2** is abundant in the atmosphere, but **unavailable to plants**
  - Plants absorb nitrogen as either **NO_3^-** or **NH_4^+**
  - **Bacteria** break down organic compounds or use N_2 to produce NH_3, which is converted to NH_4^+
  - *Nitrification* is carried out by bacteria that convert NH_3 into NO_3^-

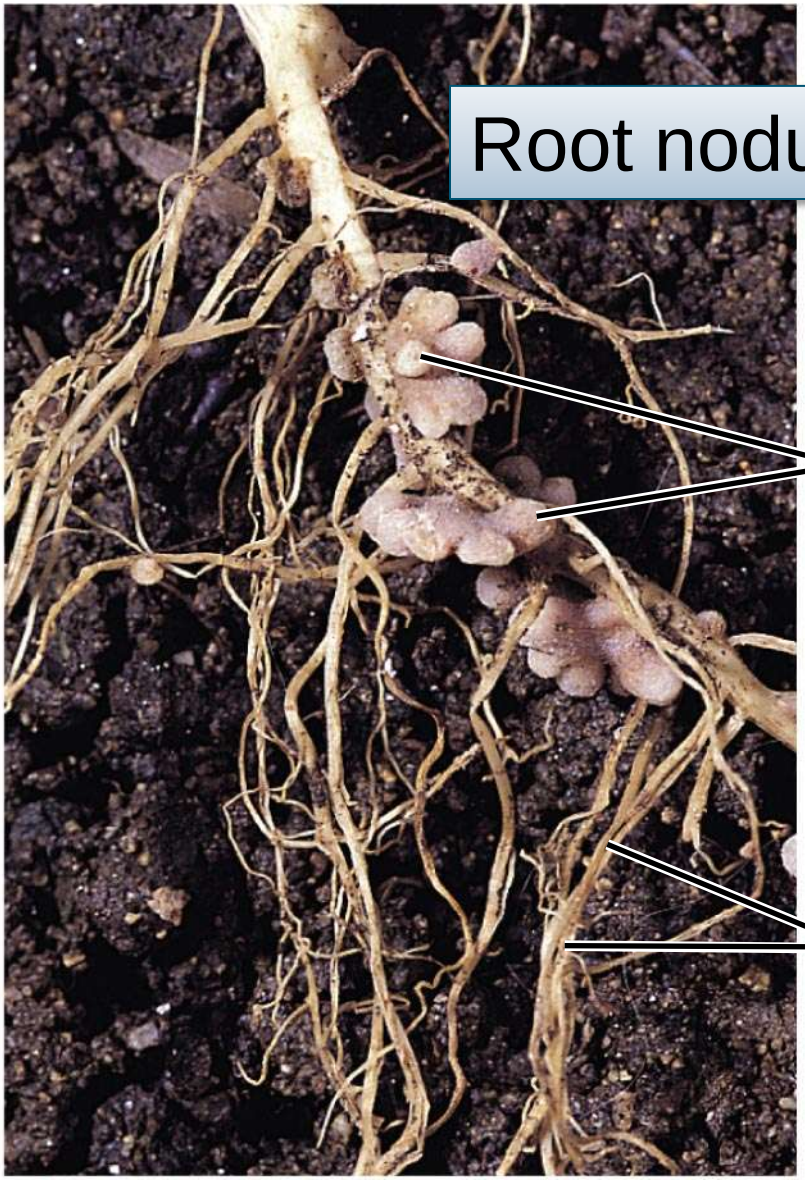
- **Nitrogen fixation** is the conversion of nitrogen from N_2 to NH_3

- Along a legume's roots are swellings called **nodules**, composed of plant cells "infected" by nitrogen-fixing ***Rhizobium*** bacteria

- **The bacteria of a root nodule obtain sugar from the plant and supply the plant with fixed nitrogen**

Fig. 37-10a

Root nodules on legumes

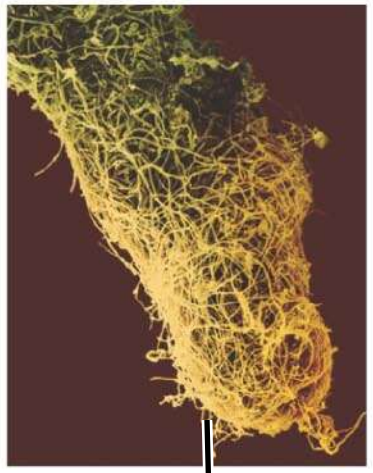


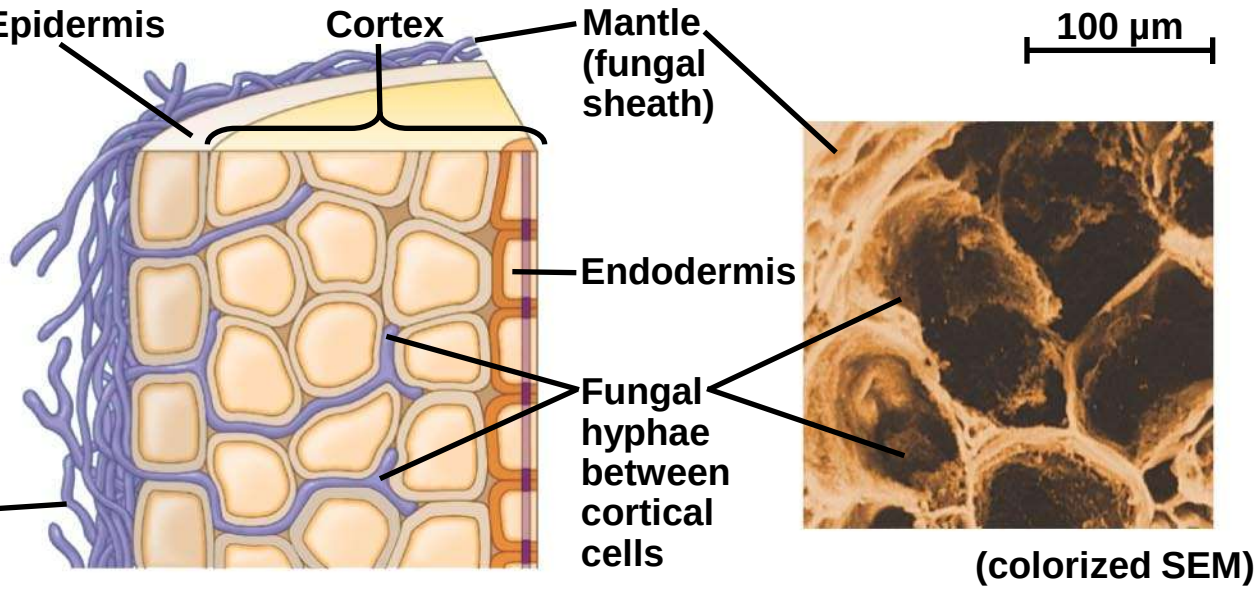
Pea plant root

Fungi and Plant Nutrition

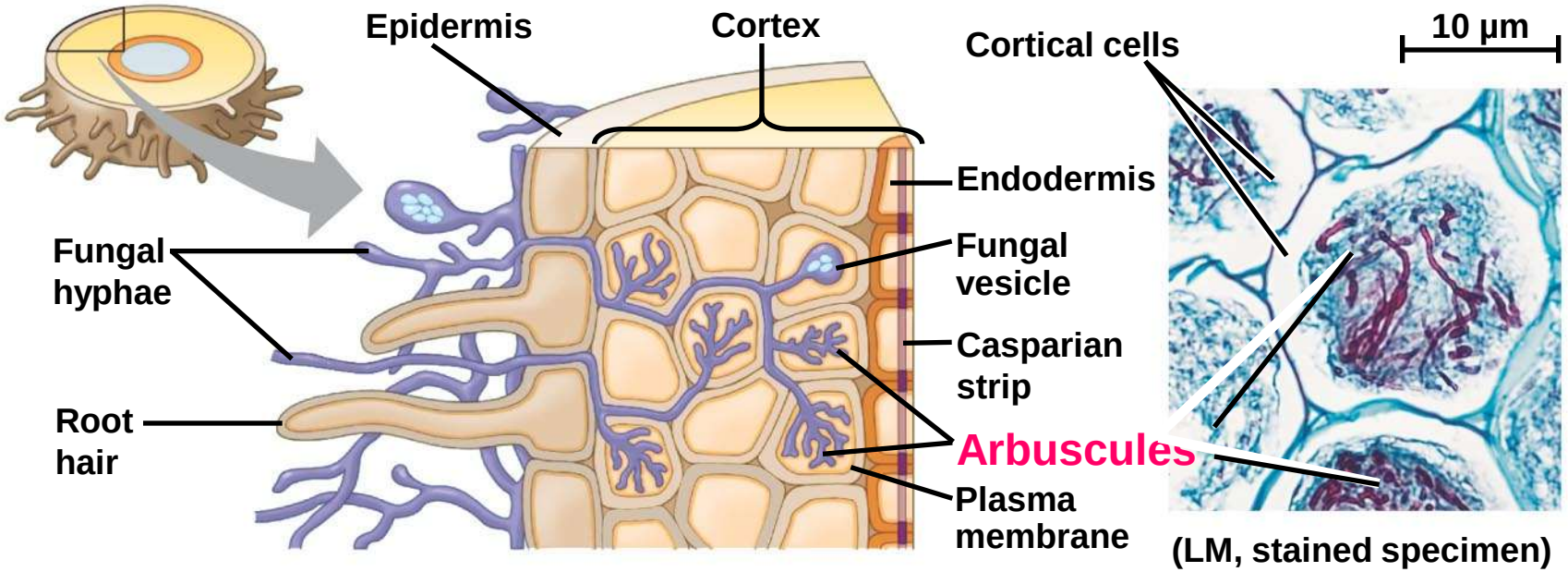
- **Mycorrhizae** are mutualistic associations of fungi and roots
- The fungus benefits from a steady supply of sugar from the host plant
- The host plant benefits because the fungus increases the surface area for water uptake and mineral absorption
- Farmers and foresters often inoculate seeds with fungal spores to promote formation of mycorrhizae

Fig. 37-12





(a) Ectomycorrhizae



(b) Arbuscular mycorrhizae (endomycorrhizae)

Epiphytes, Parasitic Plants, and Carnivorous Plants

- Some plants have nutritional adaptations that use other organisms in nonmutualistic ways
- An **epiphyte** grows on another plant and obtains water and minerals from rain

Fig. 37-14b

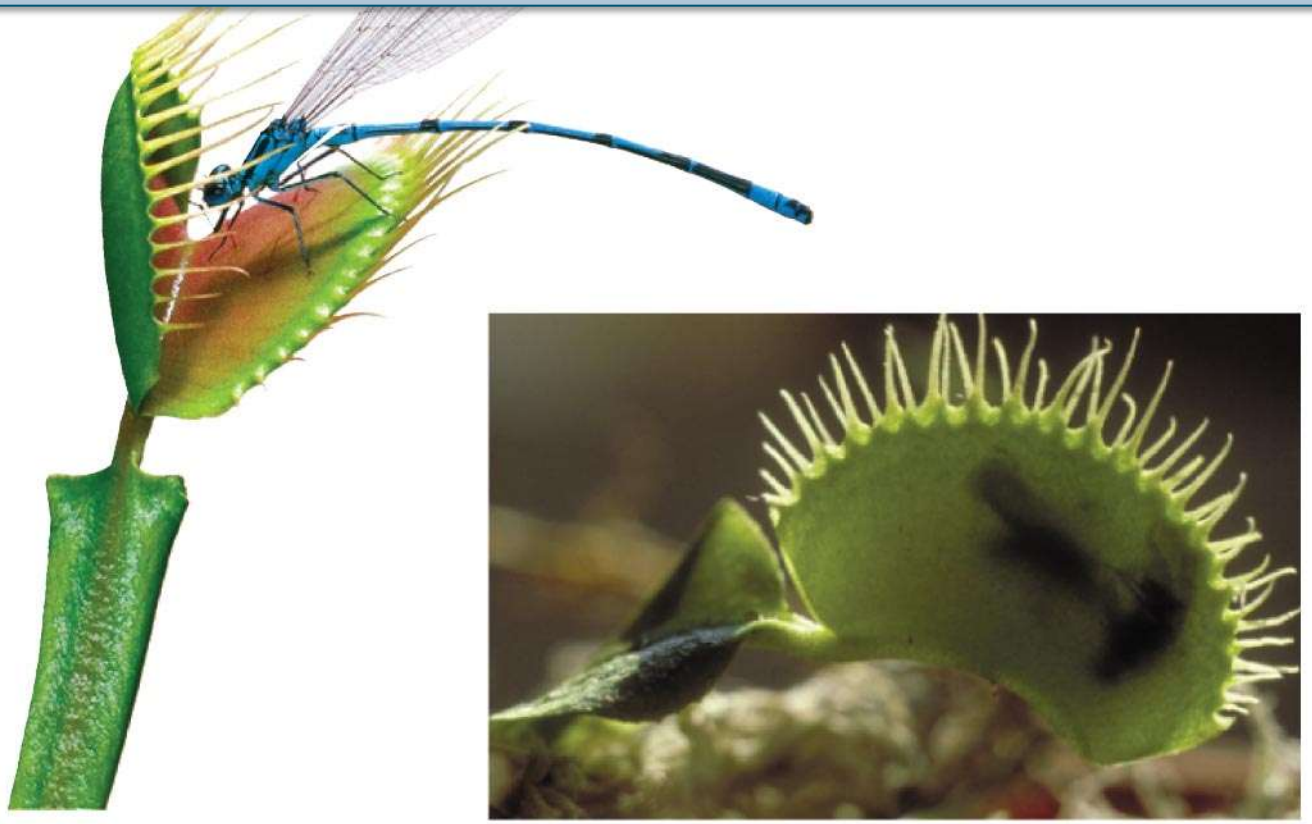
- Parasitic plants absorb sugars and minerals from their living host plant

Mistletoe, a photosynthetic parasite

Fig. 37-14d

Indian pipe, a nonphotosynthetic parasite

- Carnivorous plants are photosynthetic but obtain nitrogen by killing and digesting mostly insects



Venus flytrap

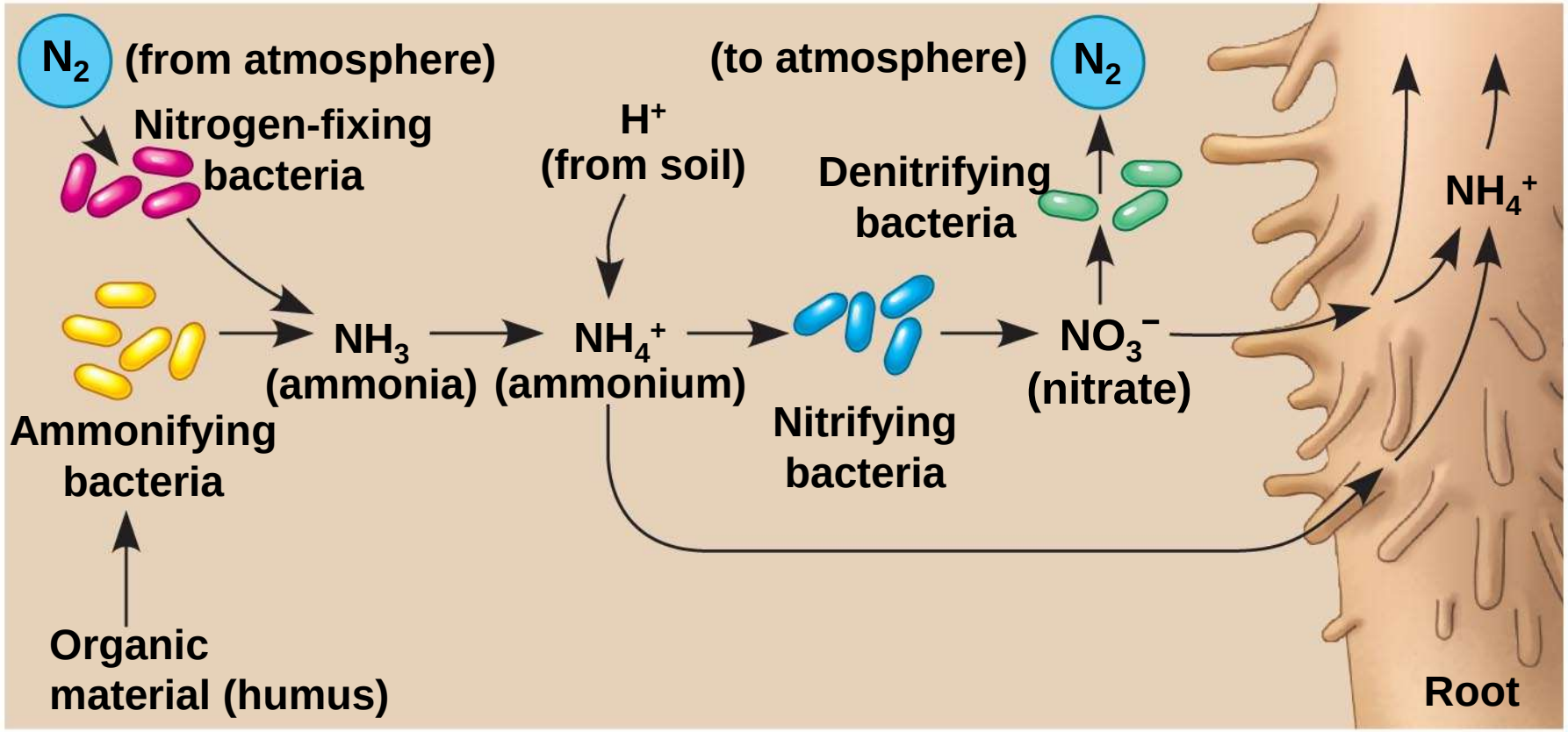
- Carnivorous plants are photosynthetic but obtain nitrogen by killing and digesting mostly insects

Pitcher plants

- Carnivorous plants are photosynthetic but obtain nitrogen by killing and digesting mostly insects

Sundews

Fig. 37-UN1



You should now be able to:

1. Define soil texture and soil composition
2. Distinguish between and list the macronutrients and micronutrients
3. Distinguish between ectomycorrhizae and arbuscular mycorrhizae
4. Describe the adaptations for nutrition of parasitic, epiphytic, and carnivorous plants

Chapter 38

Angiosperm Reproduction and Biotechnology

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Biology

Eighth Edition

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Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Concept 38.1: Flowers, double fertilization, and fruits are unique features of the angiosperm life cycle

- In angiosperms, the sporophyte is the dominant generation, the large plant that we see
- The gametophytes are reduced in size and depend on the sporophyte for nutrients
- The angiosperm life cycle is characterized by "three Fs": *f*lowers, double *f*ertilization, and *f*ruits

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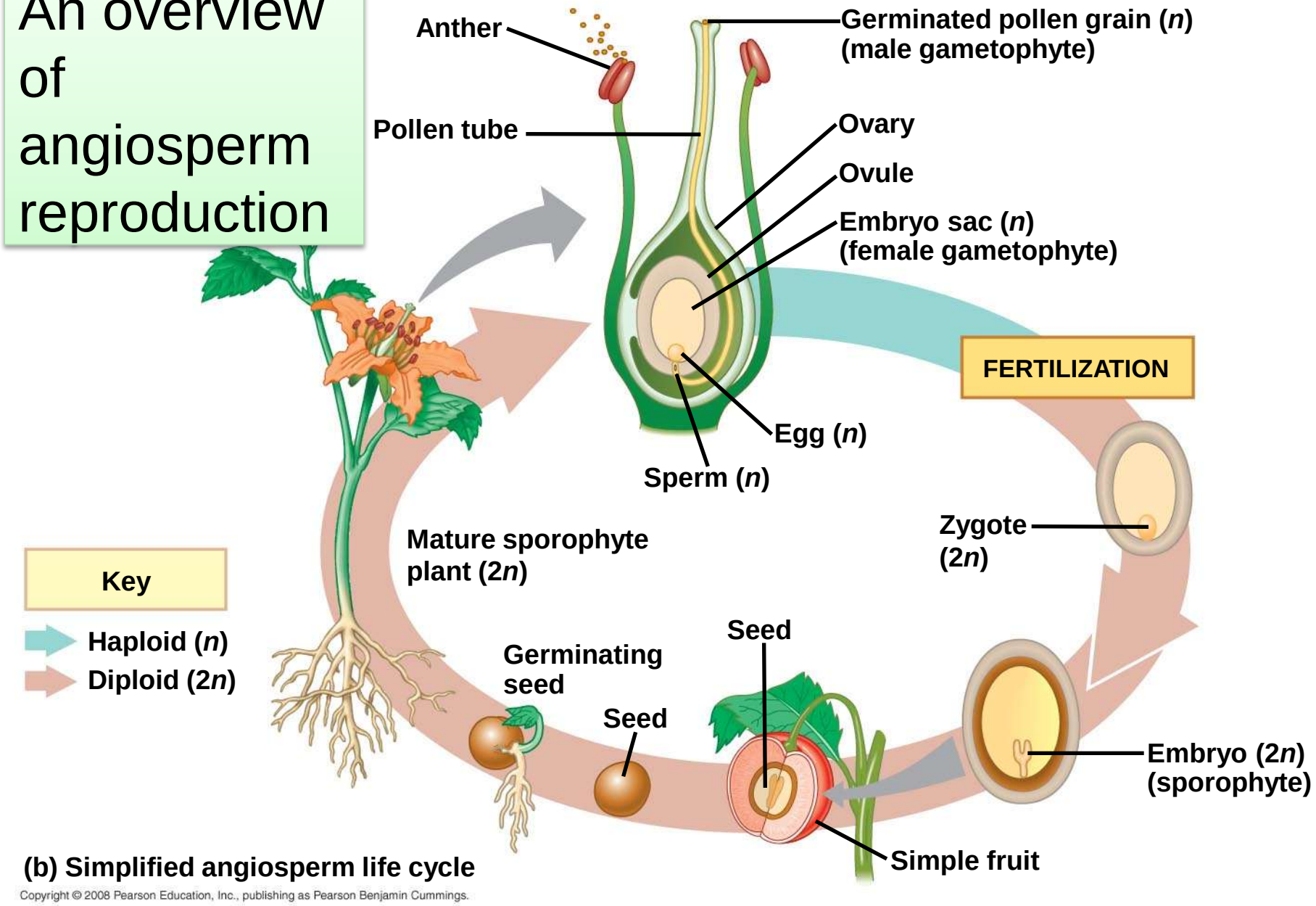
Fig. 38-2b

An overview of angiosperm reproduction



(b) Simplified angiosperm life cycle

Flower Structure and Function

- Flowers are the reproductive shoots of the angiosperm sporophyte; they attach to a part of the stem called the **receptacle**
- Flowers consist of four floral organs: **sepals**, **petals**, **stamens**, and **carpels**

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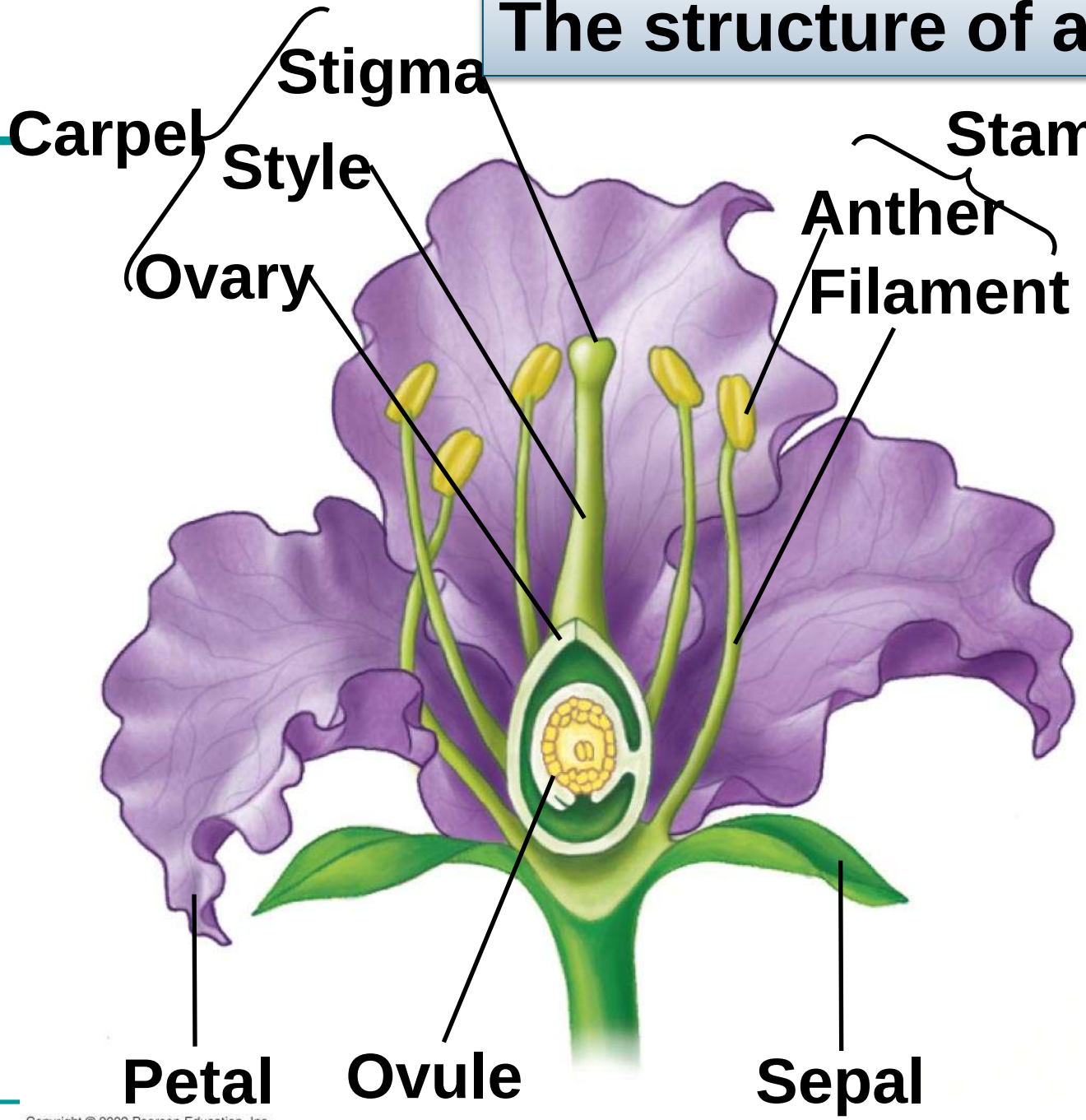
The structure of a flower



- A stamen consists of a filament topped by an **anther** with pollen sacs that produce pollen
- A carpel has a long **style** with a **stigma** on which pollen may land
- At the base of the style is an **ovary** containing one or more **ovules**
- A single carpel or group of fused carpels is called a **pistil**
- **Complete flowers** contain all four floral organs
- **Incomplete flowers** lack one or more floral organs, for example stamens or carpels
- Clusters of flowers are called **inflorescences**

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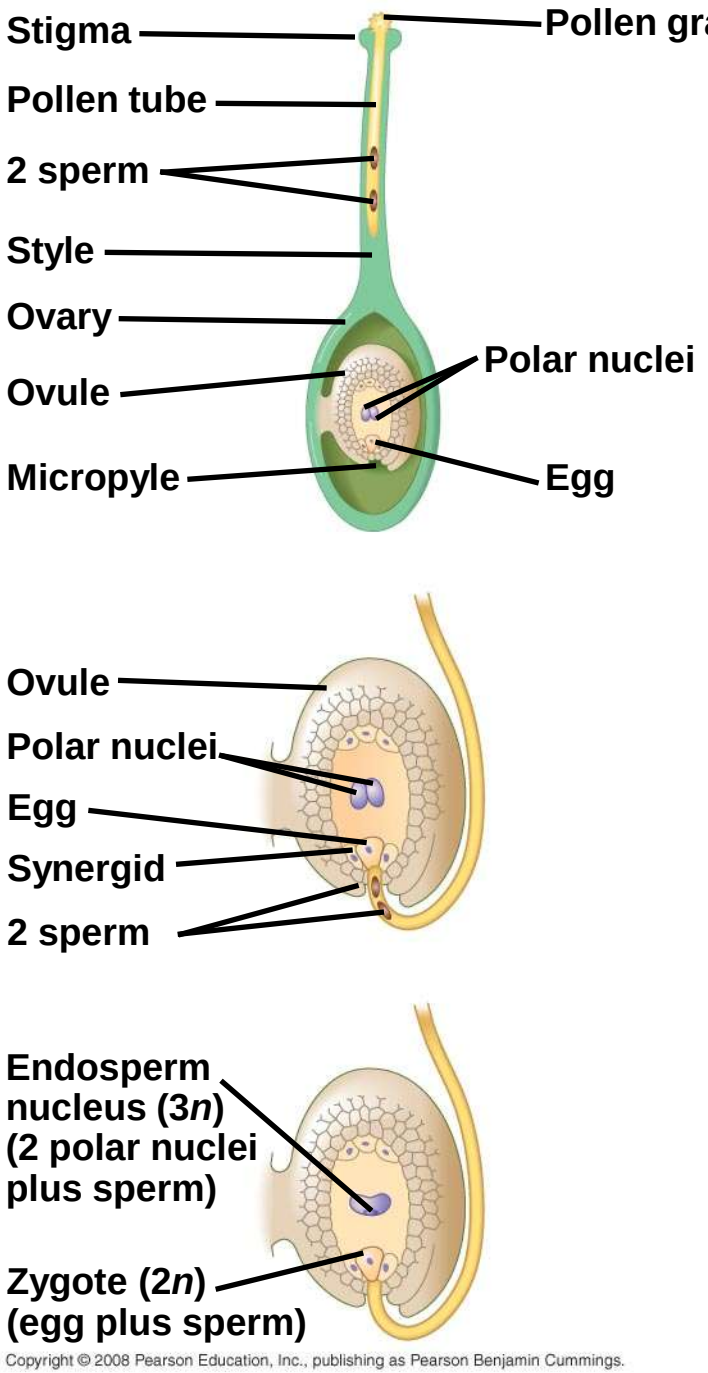
Pollination

- In angiosperms, **pollination** is the transfer of pollen from an anther to a stigma
- Pollination can be by wind, water, bee, moth and butterfly, fly, bird, bat, or water

Double Fertilization

- After landing on a receptive stigma, a pollen grain produces a pollen tube that extends between the cells of the style toward the ovary
- **Double fertilization** results from the discharge of two sperm from the pollen tube into the embryo sac
- **One sperm fertilizes the egg**, and **the other combines with the polar nuclei, giving rise to the triploid (3*n*) food-storing endosperm**

Fig. 38-5



Growth of the pollen tube and double fertilization

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- After double fertilization, each ovule develops into a seed
- The ovary develops into a fruit enclosing the seed(s)
- Endosperm development usually precedes embryo development
- In most monocots and some eudicots, endosperm stores nutrients that can be used by the seedling
- In other eudicots, the food reserves of the endosperm are exported to the cotyledons

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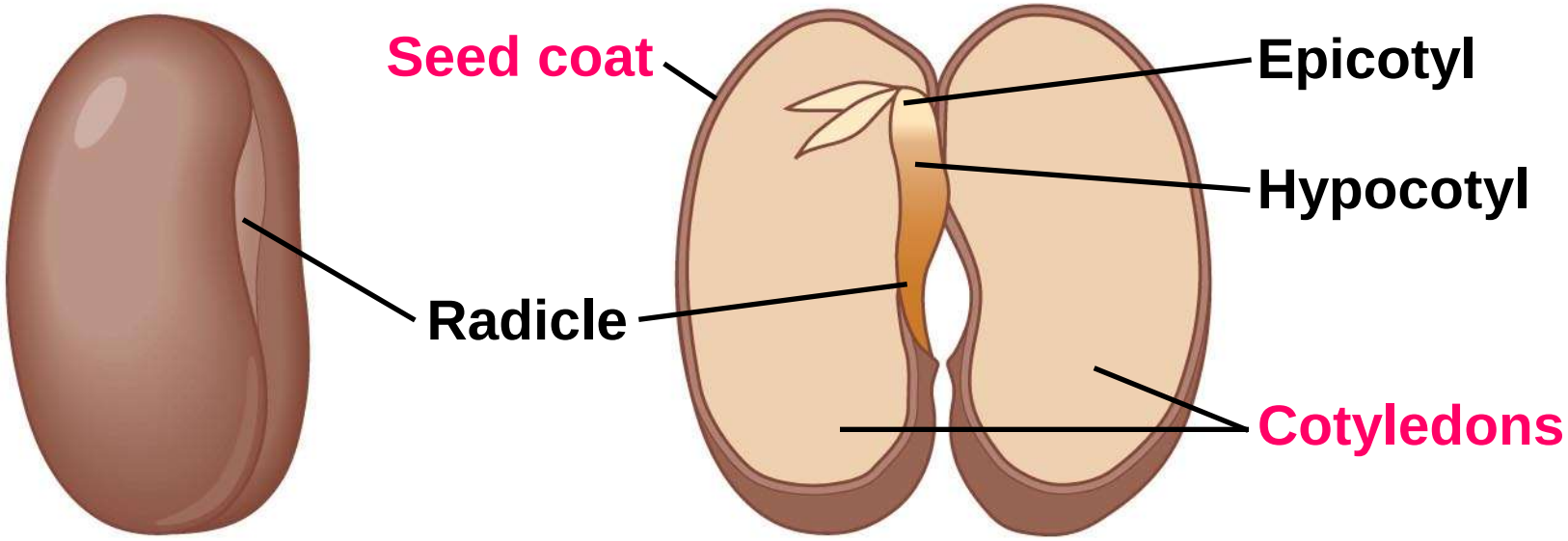
- The embryo and its food supply are enclosed by a hard, protective **seed coat**
- The seed enters a state of **dormancy**
- In some eudicots, such as the common garden bean, the embryo consists of the embryonic axis attached to two thick cotyledons (seed leaves)
- Below the cotyledons the embryonic axis is called the **hypocotyl** and terminates in the **radicle** (embryonic root); above the cotyledons it is called the **epicotyl**

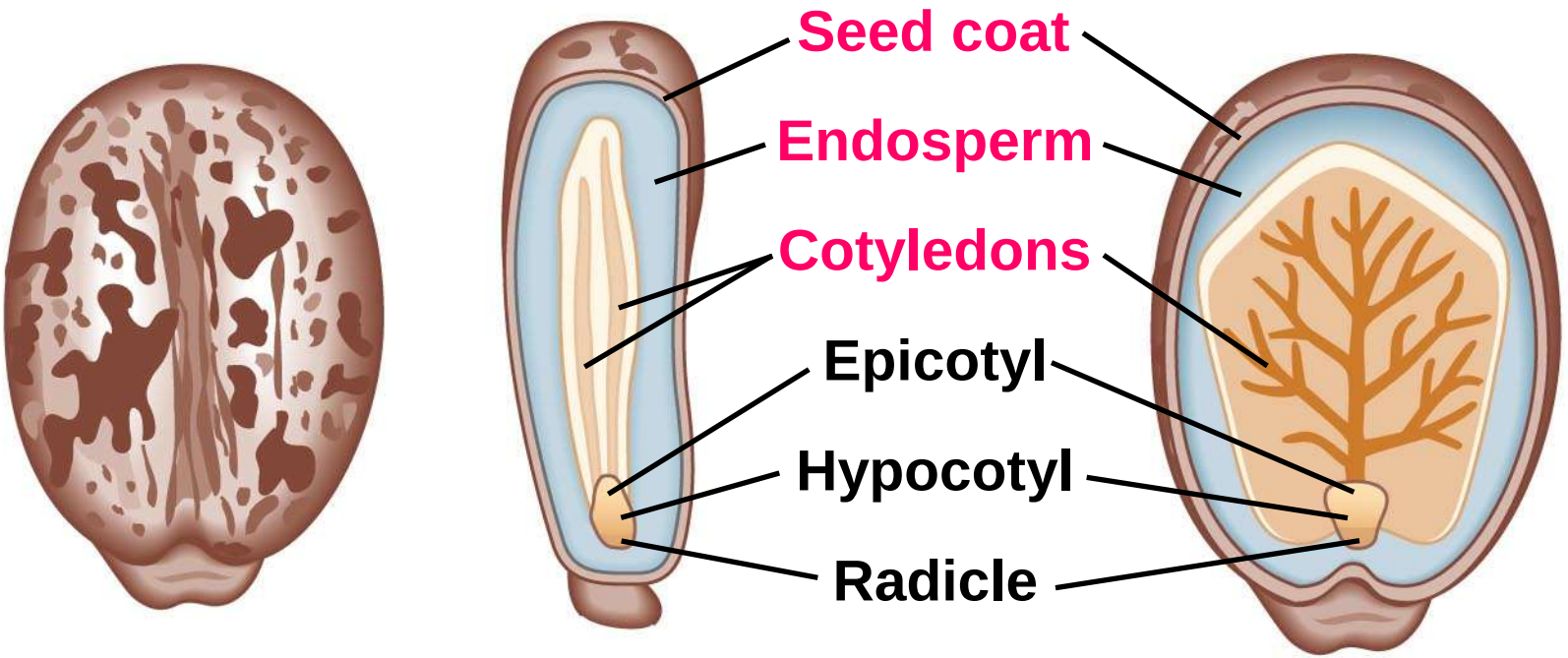
Fig. 38-8a



(a) Common garden bean, a eudicot with thick cotyledons

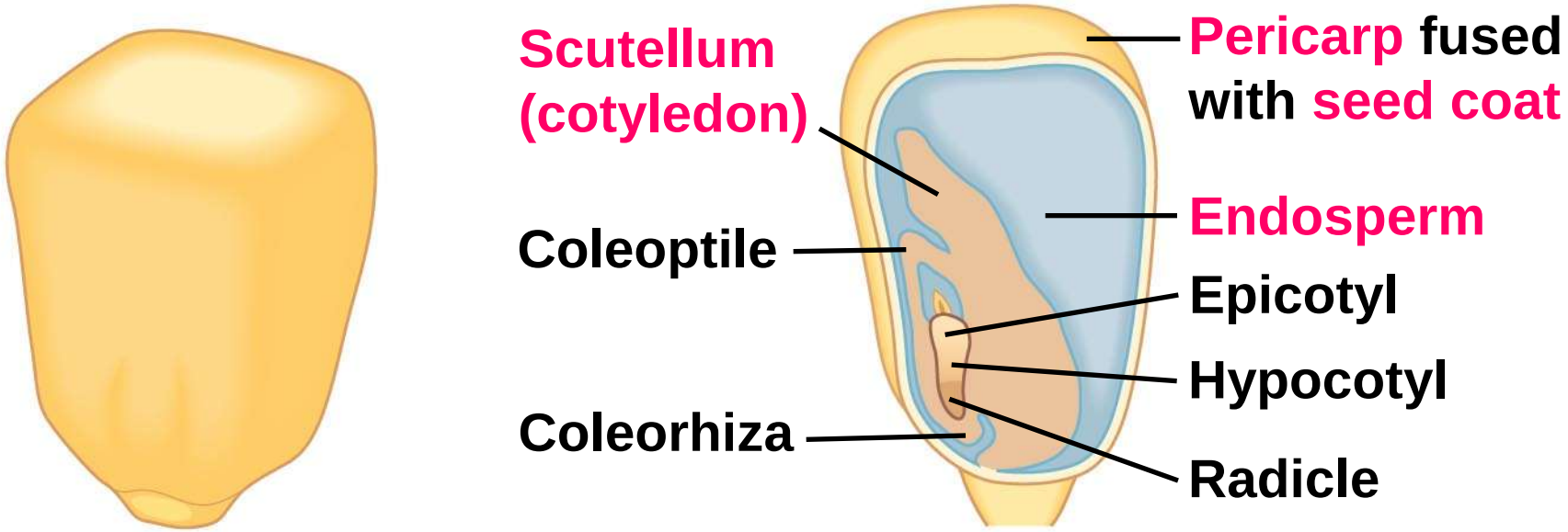
Fig. 38-8b

- **The seeds of some eudicots, such as castor beans, have thin cotyledons**



(b) Castor bean, a eudicot with thin cotyledons

Fig. 38-8c



(c) Maize, a monocot

Seed Dormancy: An Adaptation for Tough Times

- **Seed dormancy** increases the chances that germination will occur at a time and place most advantageous to the seedling
- The breaking of seed dormancy often requires environmental cues, such as temperature or lighting changes

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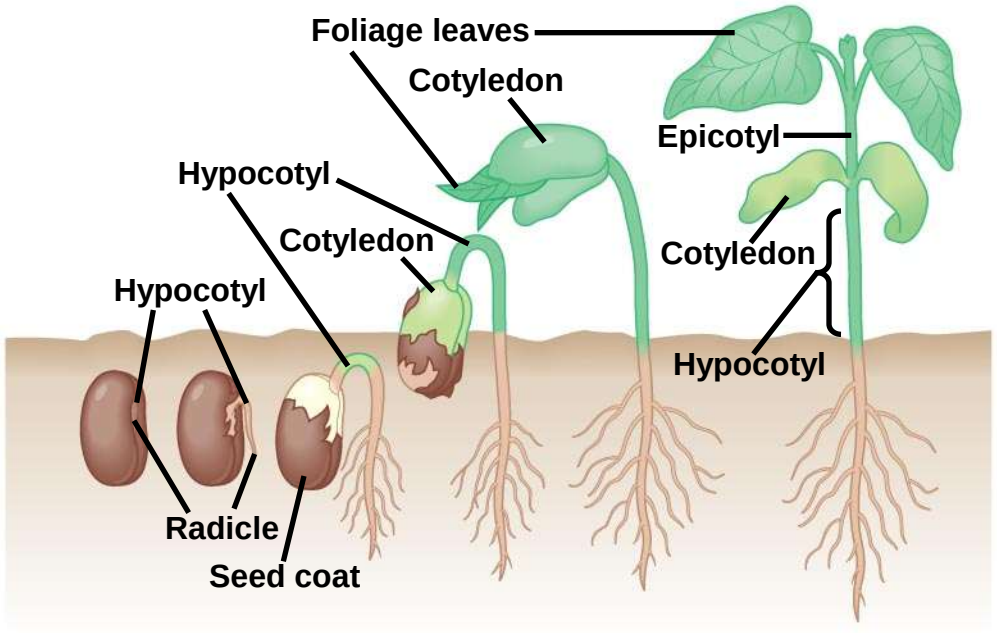
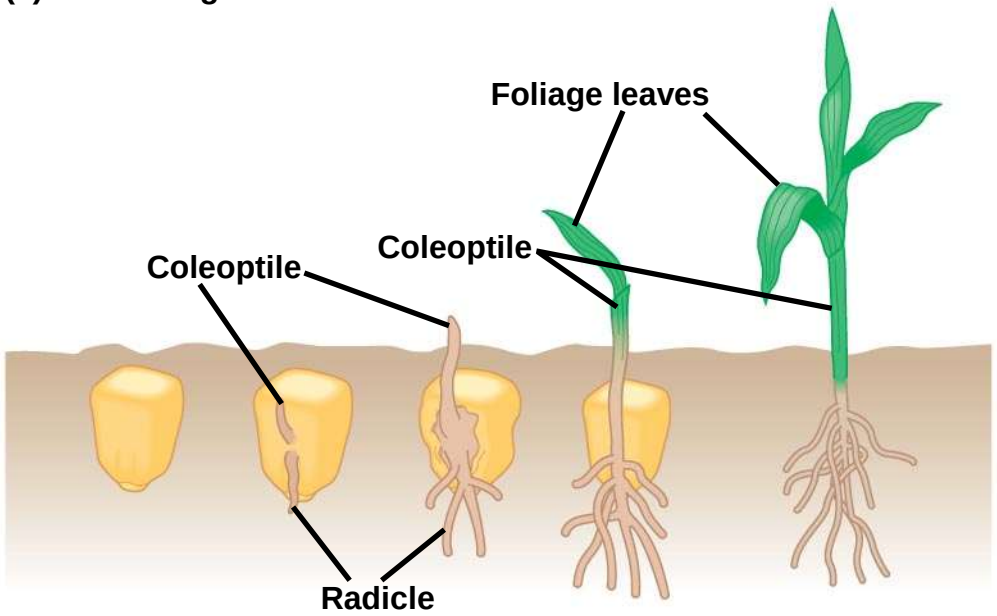
Fig. 38-9

Two common types of seed germination



(a) Common garden bean



(b) Maize

Fruit Form and Function

- A **fruit** develops from the ovary
- It protects the enclosed seeds and aids in seed dispersal by wind or animals
- A fruit may be classified as dry, if the ovary dries out at maturity, or fleshy, if the ovary becomes thick, soft, and sweet at maturity

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- Fruits are also classified by their development:
  - **Simple**, a single or several fused carpels
  - **Aggregate**, a single flower with multiple separate carpels
  - **Multiple**, a group of flowers called an inflorescence
  - An **accessory fruit** contains other floral parts in addition to ovaries

Fig. 38-10

Developmental origin of fruits

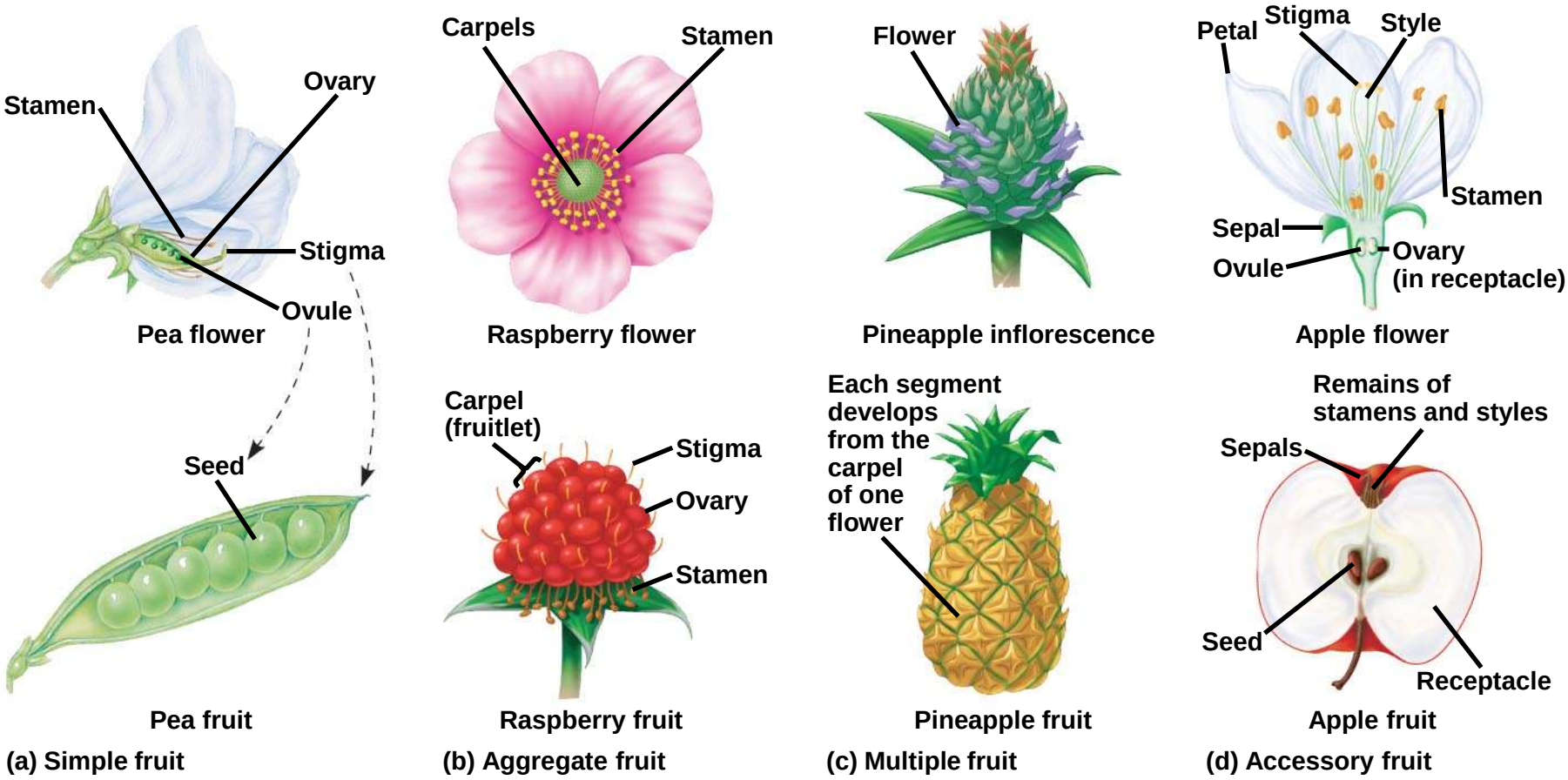
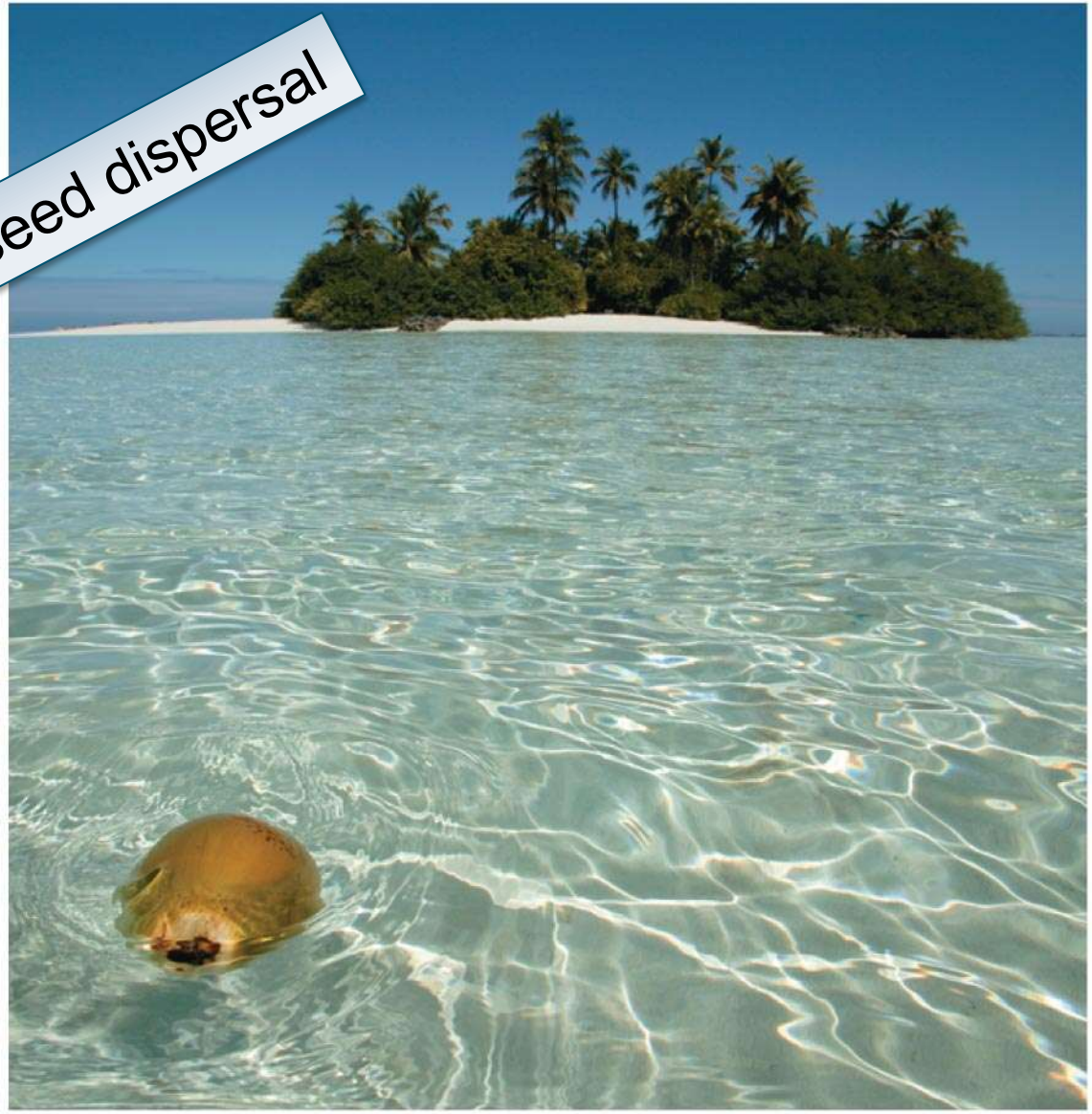


Fig. 38-11a

Dispersal by Water



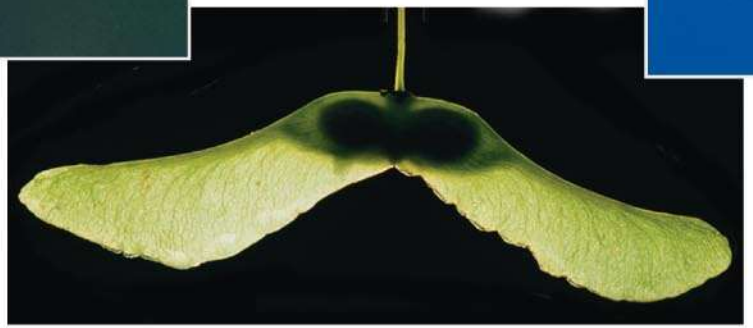
Coconut

Fig. 38-11b

Dispersal by Wind

Winged seed of Asian climbing gourd

Dandelion "parachute"



Winged fruit of maple

Tumbleweed

Fruit and seed dispersal

Fig. 38-11c

Fruit and seed dispersal

Dispersal by Animals

Barbed fruit

Seeds in feces

Seeds carried to ant nest

Seeds buried in caches

Concept 38.2: Plants reproduce sexually, asexually, or both

- Many angiosperm species reproduce both asexually and sexually
- Sexual reproduction results in offspring that are genetically different from their parents
- **Asexual reproduction** results in a clone of genetically identical organisms

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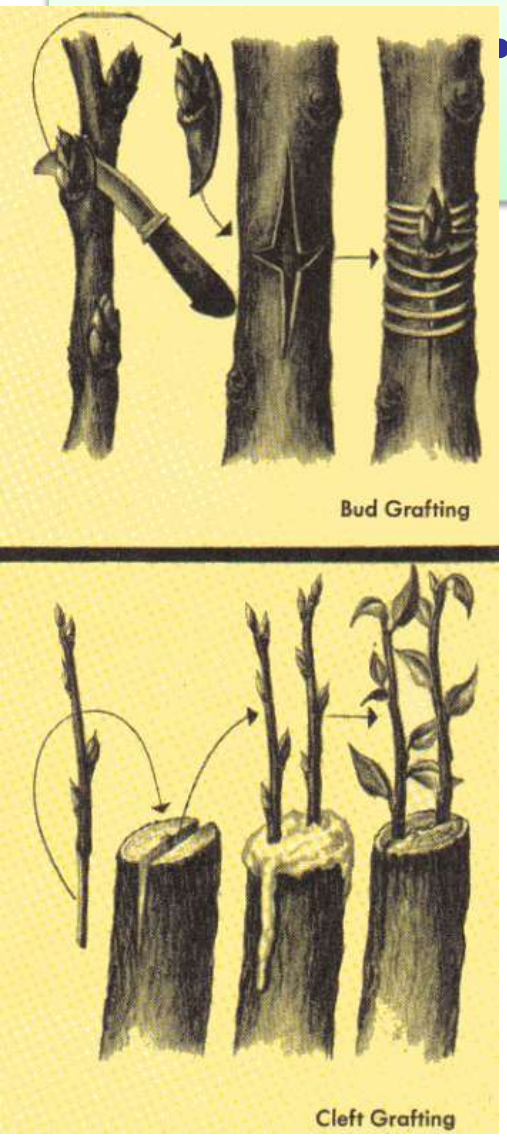
Mechanisms of Asexual Reproduction

- **Fragmentation**, separation of a parent plant into parts that develop into whole plants, is a very common type of asexual reproduction
- In some species, a parent plant's root system gives rise to adventitious shoots that become separate shoot systems
- **Apomixis** is the asexual production of seeds from a diploid cell
- **Grafting:** a twig or bud can be grafted onto a plant of a closely related species or variety

Grafting



- The **stock** provides the root system
- The **scion** is grafted onto the stock

Advantages and Disadvantages of Asexual Versus Sexual Reproduction

- Asexual reproduction is also called **vegetative reproduction**
- Asexual reproduction can be beneficial to a successful plant in a stable environment
- However, a clone of plants is vulnerable to local extinction if there is an environmental change

You should now be able to:

1. Describe how the plant life cycle is modified in angiosperms
2. Identify and describe the function of a sepal, petal, stamen (filament and anther), carpel (style, ovary, ovule, and stigma), seed coat, hypocotyl, radicle, epicotyl, endosperm, cotyledon

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You should now be able to:

3. Distinguish between simple, aggregate, multiple, and accessory fruit
4. Describe the process of double fertilization
5. Describe the fate and function of the ovule, ovary, and endosperm after fertilization

6. Explain the advantages and disadvantages of reproducing sexually and asexually

7. Name and describe several natural and artificial mechanisms of asexual reproduction

Chapter 39

Plant Responses to Internal and External Signals

PowerPoint® Lecture Presentations for

Biology

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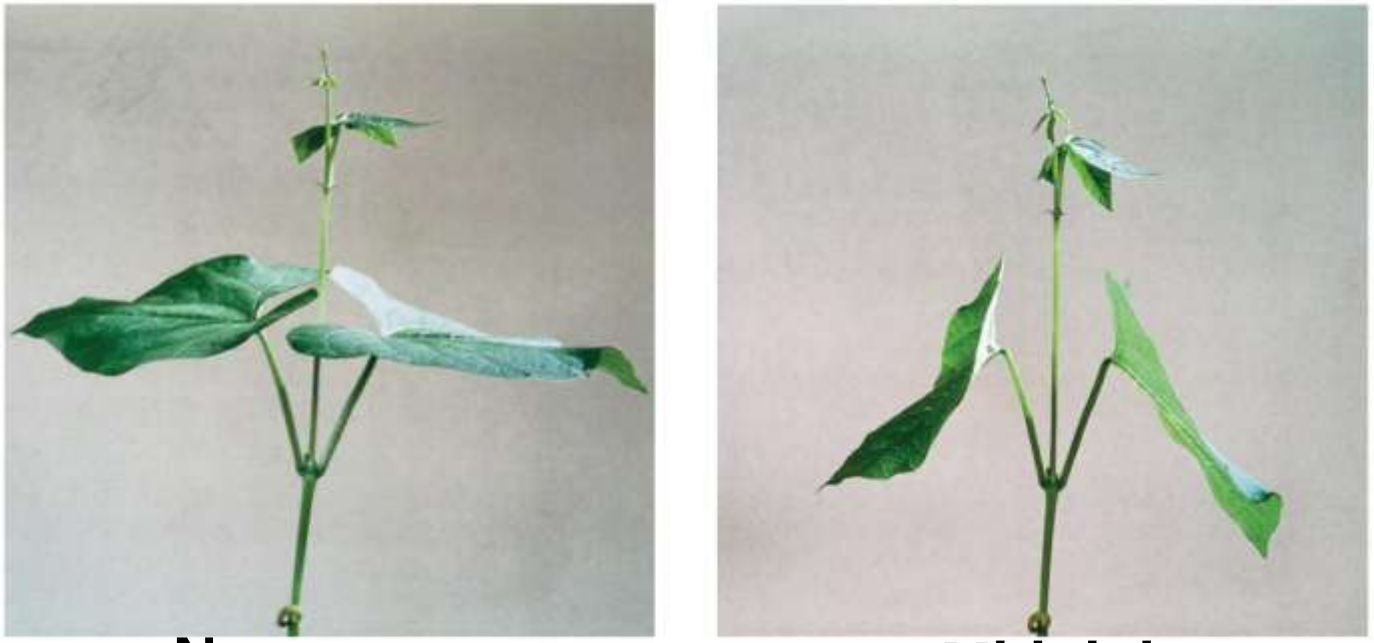
Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Overview: Stimuli and a Stationary Life

- Plants, being rooted to the ground, must respond to environmental changes that come their way
- For example, the bending of a seedling toward light begins with sensing the direction, quantity, and color of the light

Fig. 39-20

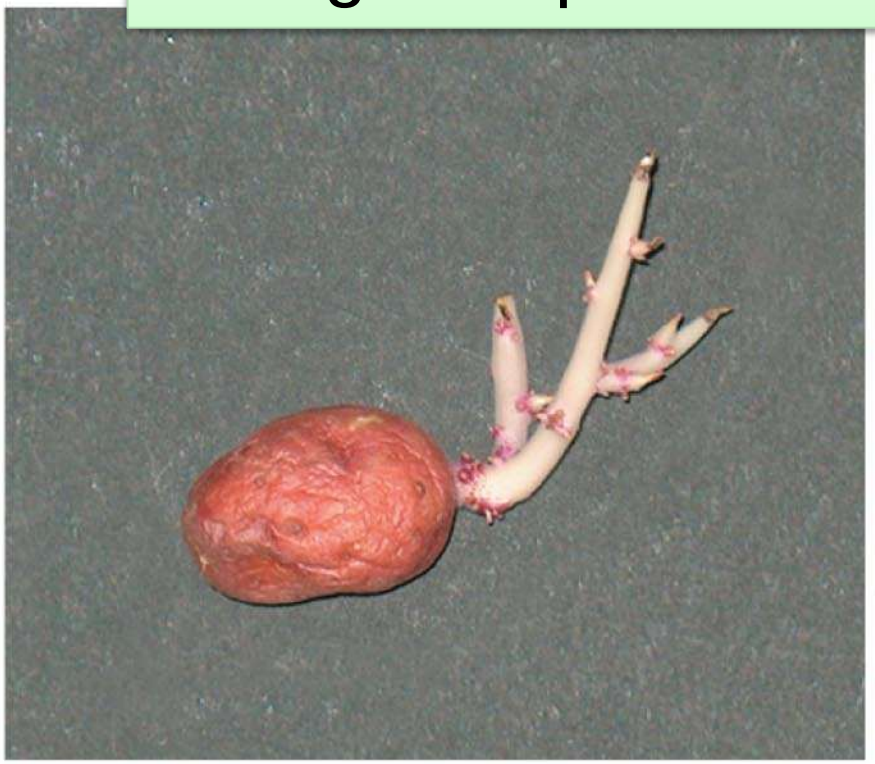


Concept 39.1: Signal transduction pathways link signal reception to response

- Plants have cellular receptors that detect changes in their environment
- For a stimulus to elicit a response, certain cells must have an appropriate receptor
- Stimulation of the receptor initiates a specific signal transduction pathway

Fig. 39-2

Light-induced de-etiolation (greening) of dark-grown potatoes



(a) Before exposure to light

(b) After a week's exposure to natural daylight

Concept 39.2: Plant hormones help coordinate growth, development, and responses to stimuli

- **Hormones** are chemical signals that coordinate different parts of an organism
- In general, hormones control plant growth and development by affecting the division, elongation, and differentiation of cells
- Plant hormones are produced in very low concentration, but a minute amount can greatly affect growth and development of a plant organ

Table 39-1

Table 39.1 Overview of Plant Hormones

Hormone	Where Produced or Found in Plant	Major Functions
Auxin (IAA)	Shoot apical meristems and young leaves are the primary sites of auxin synthesis. Root apical meristems also produce auxin, although the root depends on the shoot for much of its auxin. Developing seeds and fruits contain high levels of auxin, but it is unclear whether it is newly synthesized or transported from maternal tissues.	Stimulates stem elongation (low concentration only); promotes the formation of lateral and adventitious roots; regulates development of fruit; enhances apical dominance; functions in phototropism and gravitropism; promotes vascular differentiation; retards leaf abscission.
Cytokinins	These are synthesized primarily in roots and transported to other organs, although there are many minor sites of production as well.	Regulate cell division in shoots and roots; modify apical dominance and promote lateral bud growth; promote movement of nutrients into sink tissues; stimulate seed germination; delay leaf senescence.
Gibberellins	Meristems of apical buds and roots, young leaves, and developing seeds are the primary sites of production.	Stimulate stem elongation, pollen development, pollen tube growth, fruit growth, and seed development and germination; regulate sex determination and the transition from juvenile to adult phases.
Brassinosteroids	These compounds are present in all plant tissues, although different intermediates predominate in different organs. Internally produced brassinosteroids act near the site of synthesis.	Promote cell expansion and cell division in shoots; promote root growth at low concentrations; inhibit root growth at high concentrations; promote xylem differentiation and inhibit phloem differentiation; promote seed germination and pollen tube elongation.
Abscisic acid (ABA)	Almost all plant cells have the ability to synthesize abscisic acid, and its presence has been detected in every major organ and living tissue; may be transported in the phloem or xylem.	Inhibits growth; promotes stomatal closure during drought stress; promotes seed dormancy and inhibits early germination; promotes leaf senescence; promotes desiccation tolerance.
Ethylene	This gaseous hormone can be produced by almost all parts of the plant. It is produced in high concentrations during senescence, leaf abscission, and the ripening of some types of fruits. Synthesis is also stimulated by wounding and stress.	Promotes ripening of many types of fruit, leaf abscission, and the triple response in seedlings (inhibition of stem elongation, promotion of lateral expansion, and horizontal growth); enhances the rate of senescence; promotes root and root hair formation; promotes flowering in the pineapple family.

Fi

(a) Gibberellin-induced stem growth

(b) Gibberellin-induced fruit growth

Auxin, cytokinins, gibberelins, brassinosteroids:
stimulate cell division, elongation, fruit growth, and cell differentiation

Abscisic acid: stimulates seeds to be dormant

Plants produce **ethylene** in response to stresses such as mechanical stress, leaf abscission, infection, and fruit ripening

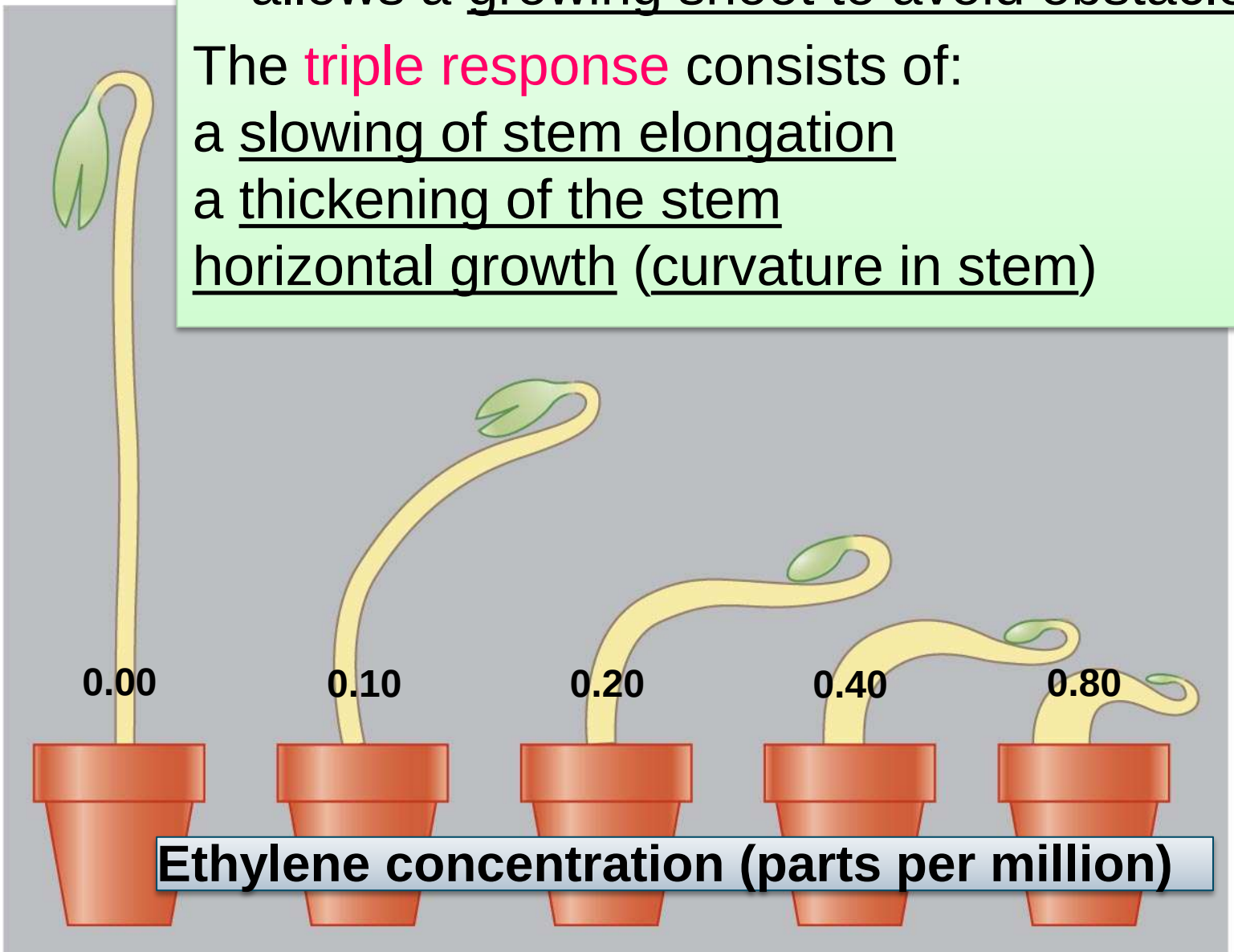
Ethylene: stimulates triple response to above mentioned factors

Fig. 39-13

Triple Response

Ethylene induces the **triple response**, which allows a growing shoot to avoid obstacles

The triple response consists of:
a slowing of stem elongation
a thickening of the stem
horizontal growth (curvature in stem)



Responses to light

- **Phototropism** – movement of plant's parts depending on light direction and intensity
- **Photoperiodism** – physiological response of organism on relative lengths of night and day (daily light/dark ratio)
-

Gravity

- Response to gravity is known as **gravitropism**
- Roots show positive gravitropism; shoots show negative gravitropism
- Experiments on gravitropism in the space are very interesting

Other responses

- **Thigmotropism** is growth in response to touch
- It occurs in vines and other climbing plants

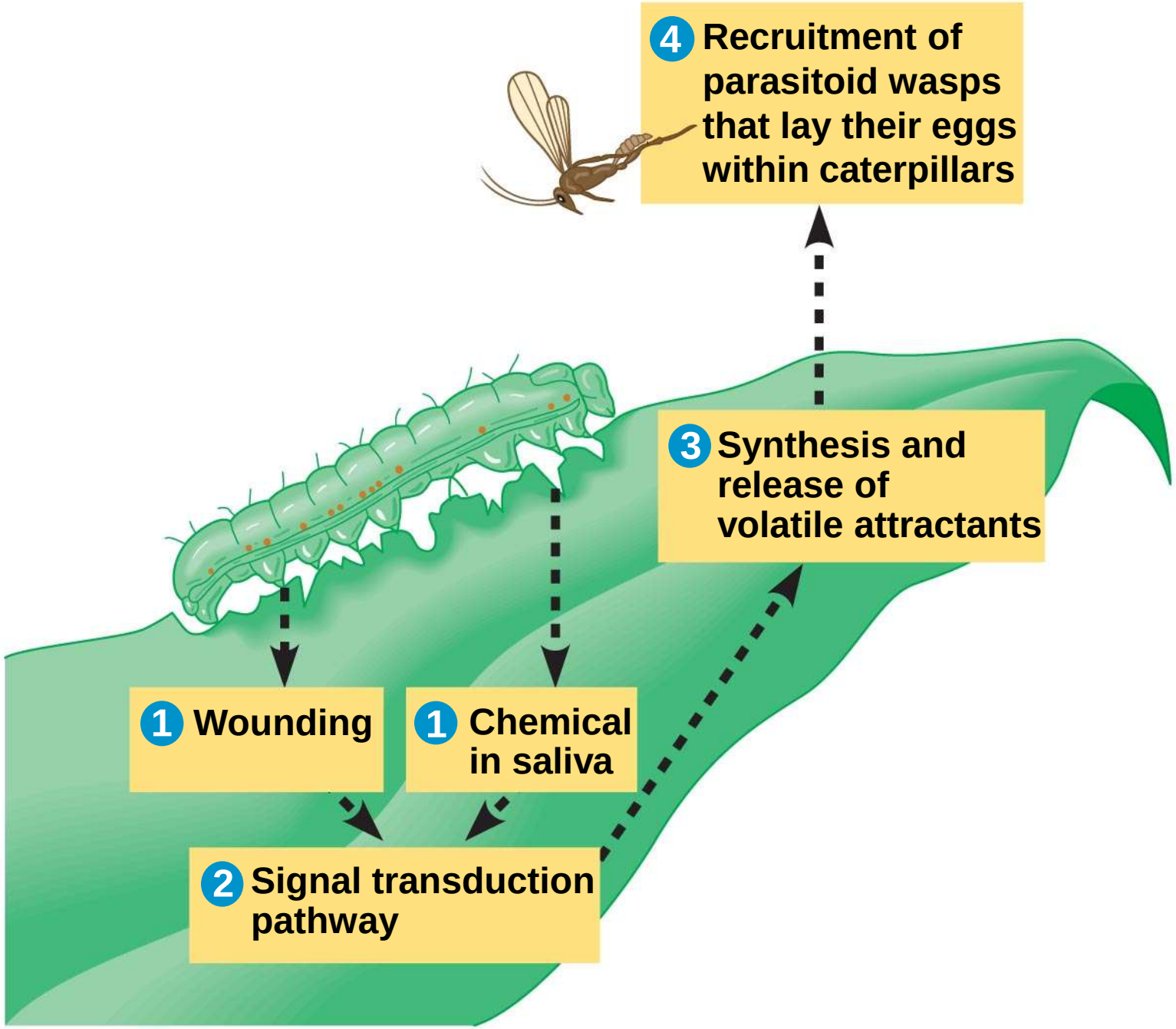
Environmental Stresses

- Environmental stresses have a potentially adverse effect on survival, growth, and reproduction
- Stresses can be **abiotic** (nonliving) or **biotic** (living)
- Abiotic stresses include drought, flooding, salt stress, heat stress, and cold stress

Concept 39.5: Plants respond to attacks by herbivores and pathogens

- Plants use defense systems to deter herbivory, prevent infection, and combat pathogens
  - Herbivory, animals eating plants, is a stress that plants face in any ecosystem
  - Plants counter excessive herbivory with physical defenses such as thorns and chemical defenses such as distasteful or toxic compounds
  - Some plants even "recruit" predatory animals that help defend against specific herbivores

Fig. 39-28



You should now be able to:

1. List six classes of plant hormones and describe their major functions
2. Describe how plants tell up from down