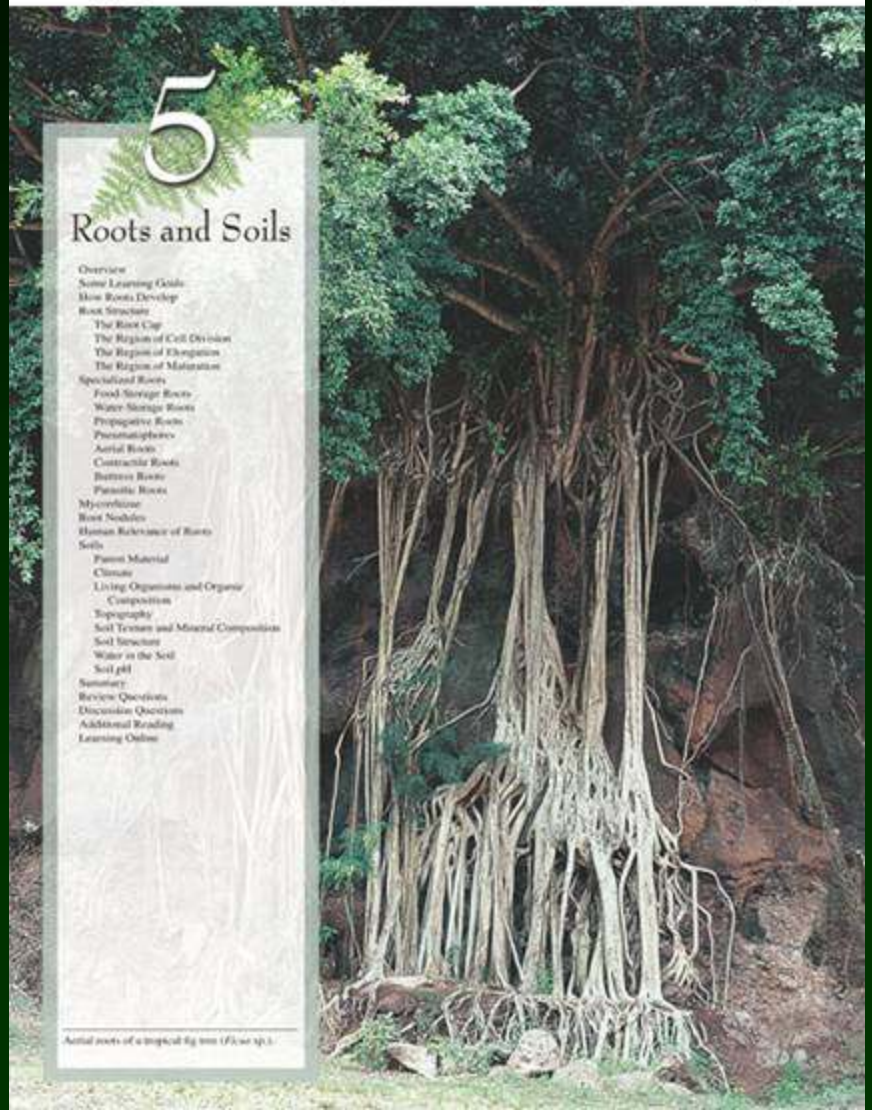
Roots and Soil

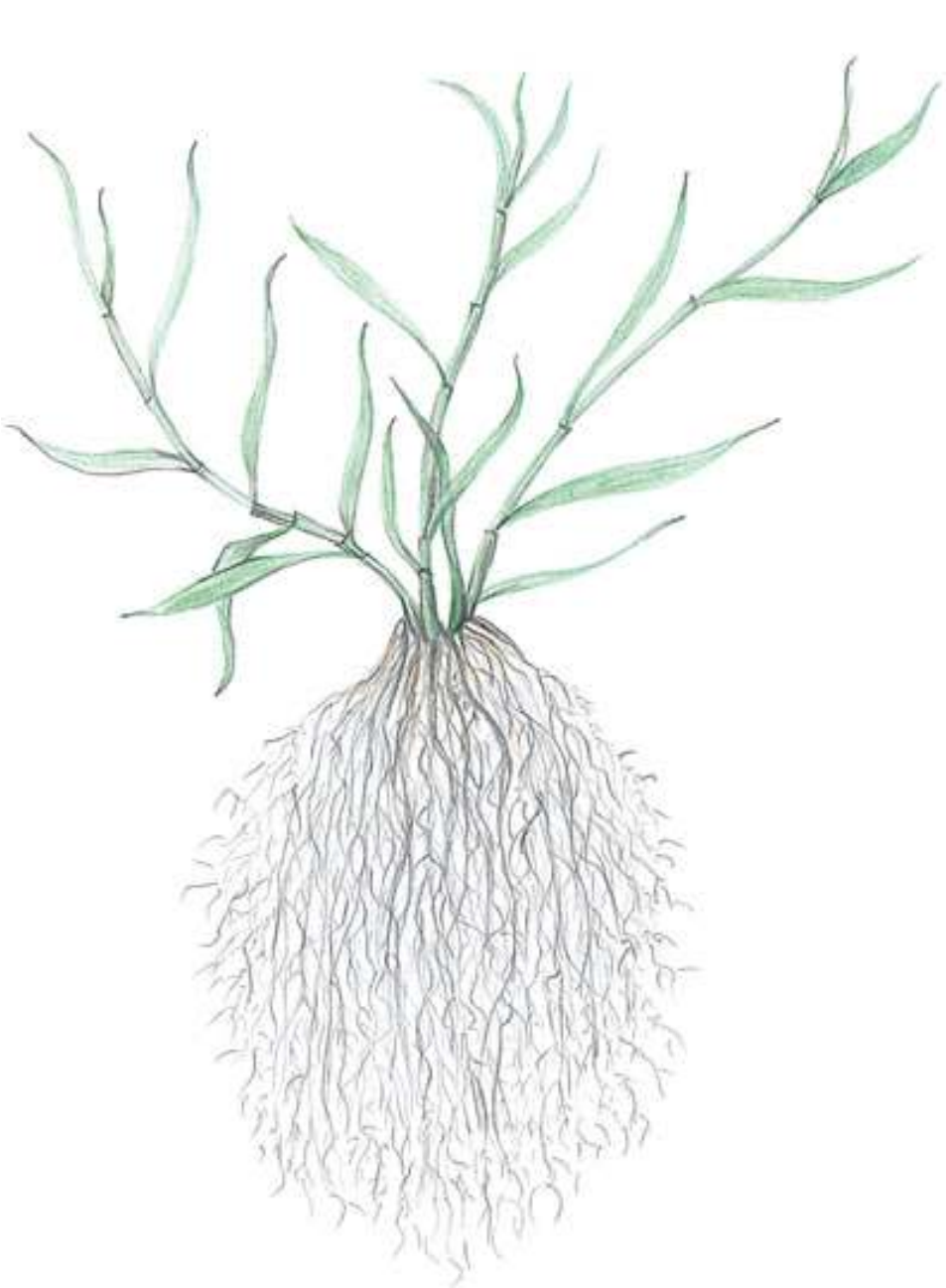


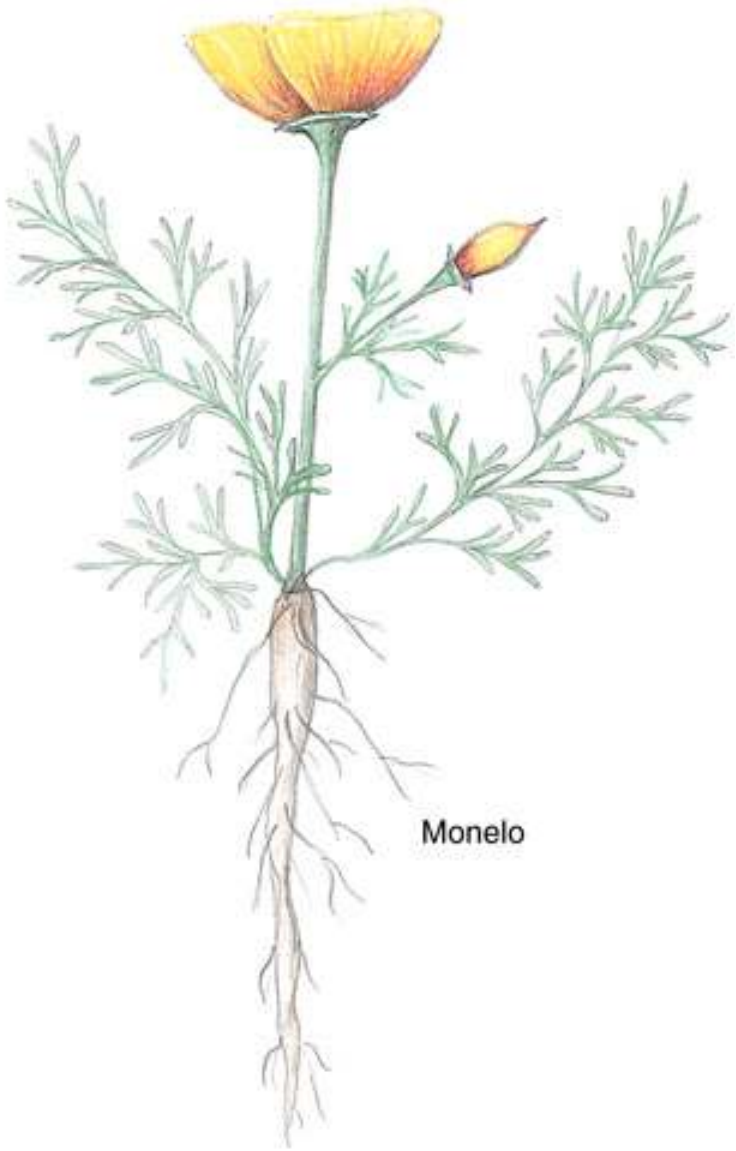
Outline

- Root Development
- Root Structure
- Specialized Roots
- Mycorrhizae
- Root Nodules
- Soils
  - Horizons
  - Soil Formation
    - Factors

How Roots Develop

- When a seed germinates, the embryo's radicle grows out and develops into the first root.
  - May develop into thick taproot with branch roots.
    - Dicotyledonous Plants
  - May develop adventitious roots that develop a fibrous root system.
    - Monocotyledonous Plants

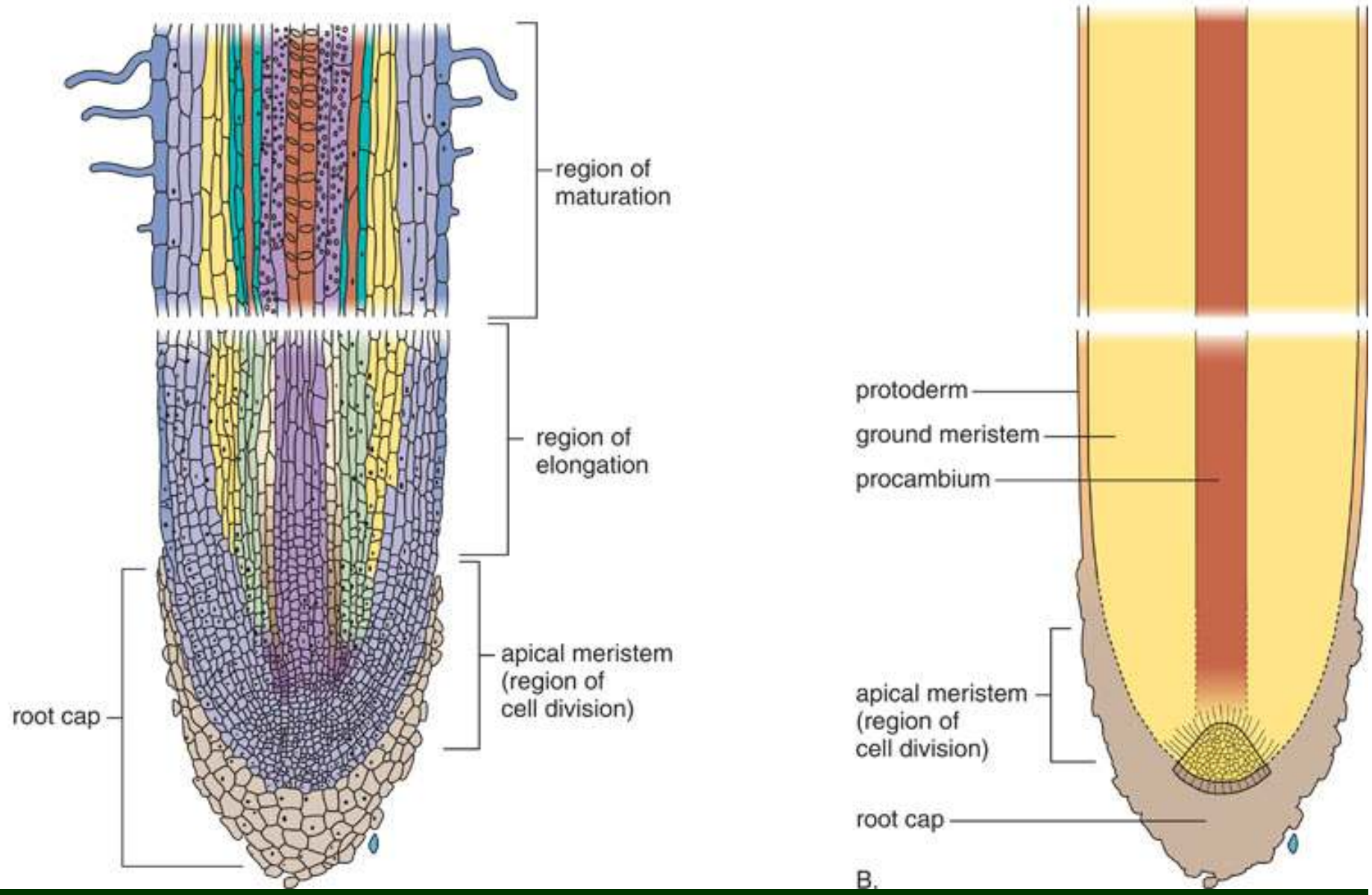




Monelo

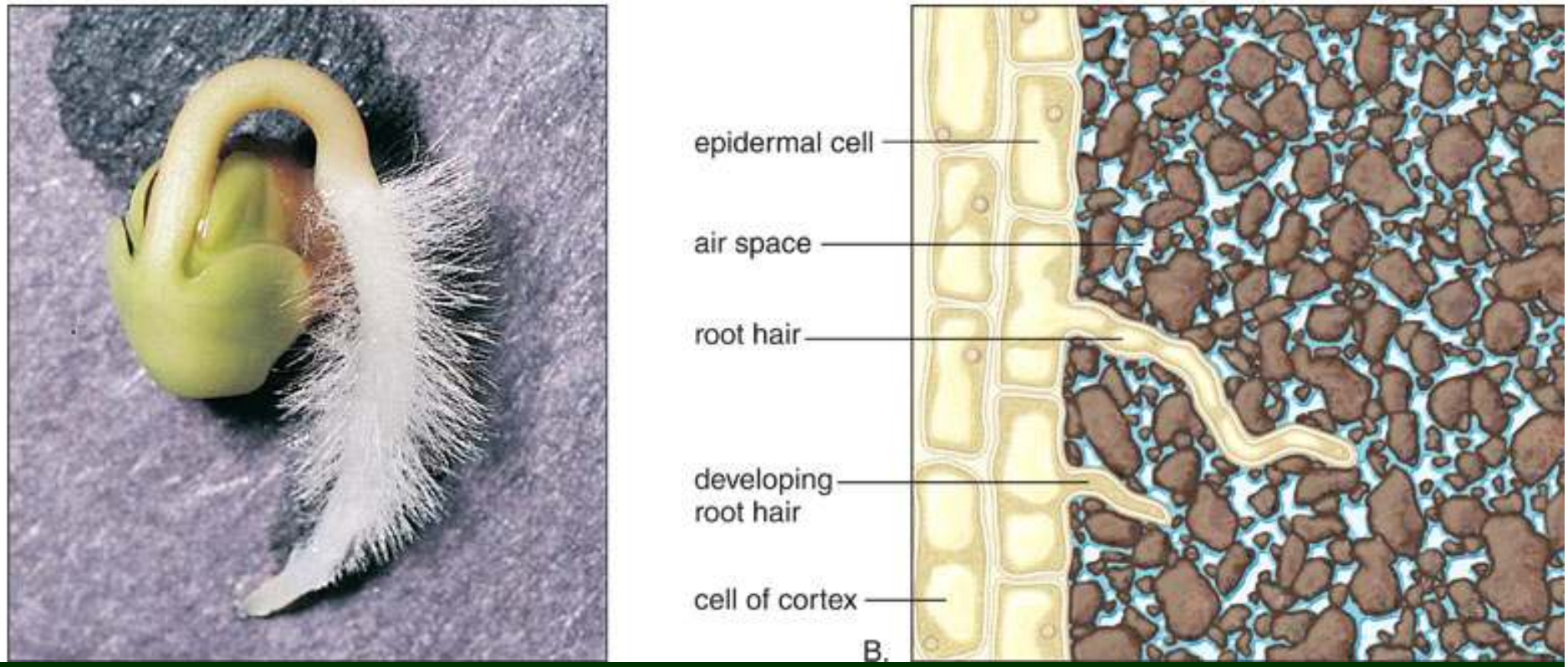
Root Structure

- Root Cap - Thimble-shaped mass of parenchyma cells covering each root tip.
  - Protects tissue from damage.
  - Function in gravity perception.
- Region of Cell Division - Composed of apical meristem in the center of the root tip.
  - Most cell division occurs at the edge of the inverted cup-shaped zone.



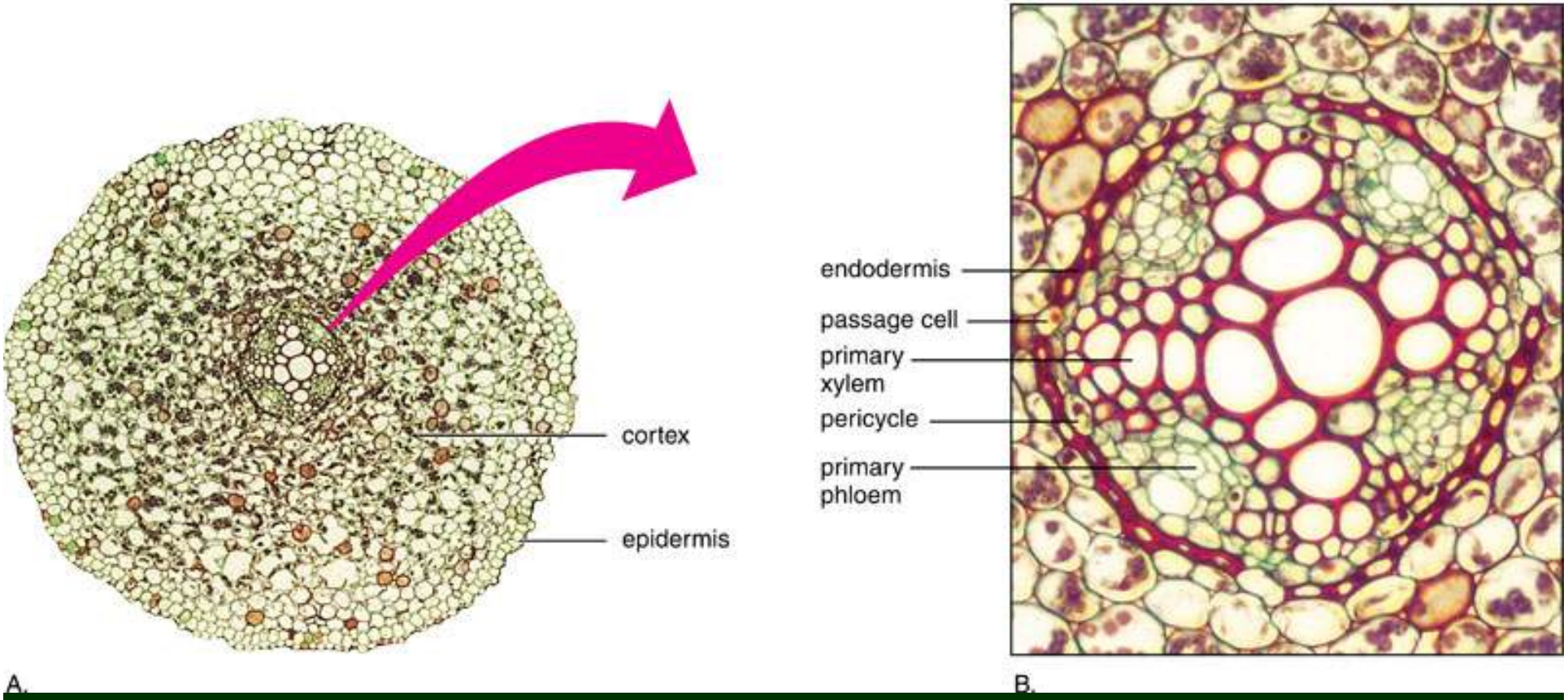
Root Structure

- Region of Elongation - Cells become several times their original length.
  - Vacuoles merge
- Region of Maturation - Most cells differentiate into various distinctive cell types.
  - Root hairs form.
    - Absorb water and minerals and adhere tightly to soil particles.
      - Thin cuticle



Region of Maturation

- Cortex cells mostly store food.
  - Contain endodermis
    - Cell walls impregnated with suberin bands, Casparian Strips.
      - Forces all water and dissolved substances entering and leaving the central core to pass through plasma membranes of the endodermal cells.



Region of Maturation

- Vascular Cylinder lies at the inside of the endodermis.
- Pericycle lies directly against the inner boundary of the endodermis.
  - Lateral Roots
- In both roots and stems, growth may be determinate (stops at a certain size) or indeterminate (new tissues added indefinitely).

Specialized Roots

- Food Storage Roots
  - Sweet Potatoes
- Water Storage Roots
  - Pumpkin Family
- Propagative Roots
  - Adventitious Buds develop into suckers.
    - Fruit Trees

Specialized Roots

- Pneumatophores
  - Spongy roots that extend above the water's surface and enhance gas exchange between the atmosphere and subsurface roots.
- Aerial Roots
  - Orchids

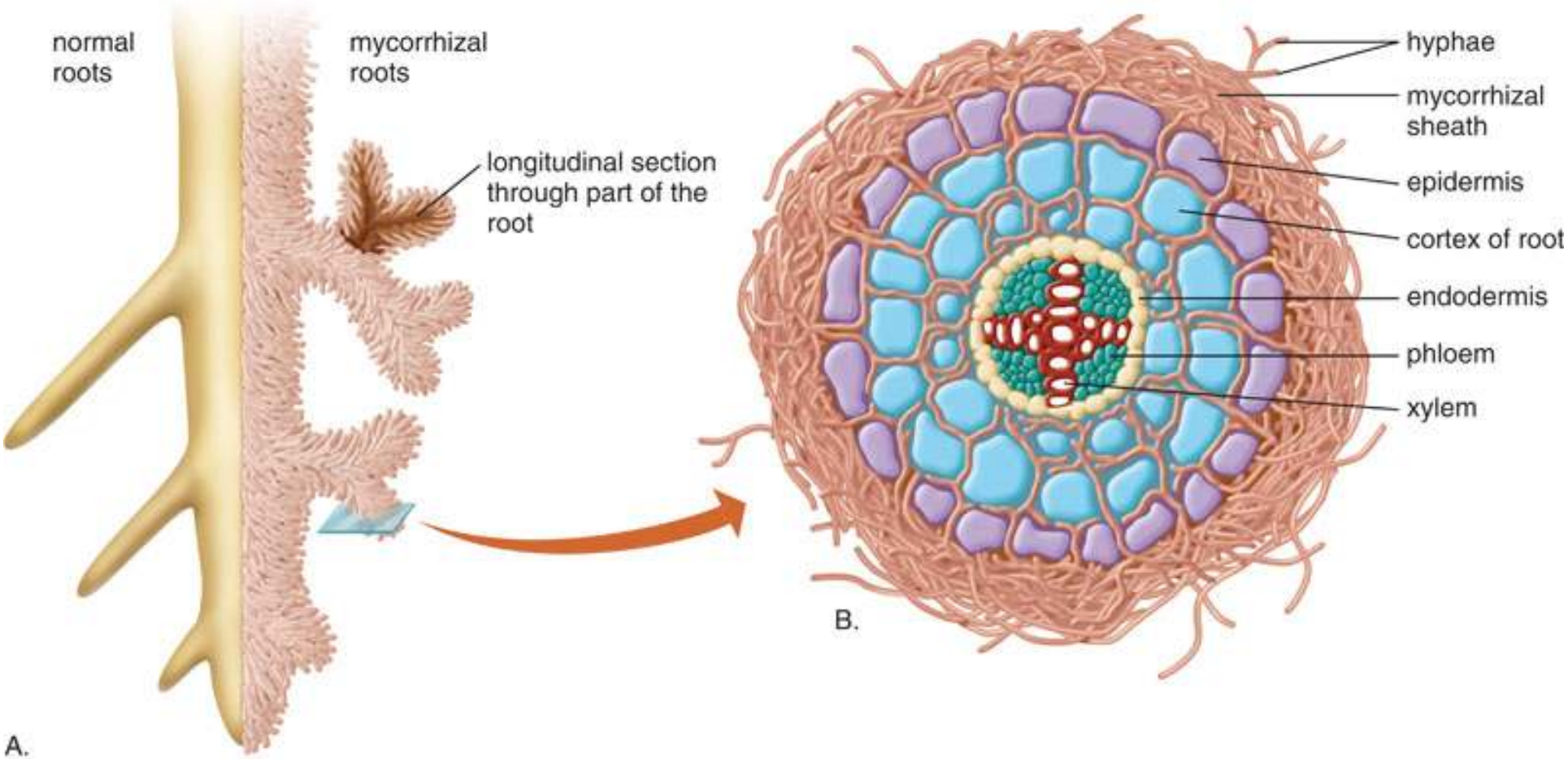
Specialized Roots

- Contractile Roots
  - Pull plant deeper into the soil.
    - Lilly Bulbs.
- Buttress Roots
  - Stability - Tropical Trees.
- Parasitic Roots
  - Have no chlorophyll and are dependent on chlorophyll-bearing plants for nutrition.
    - Dodder

Mycorrhizae

- Mycorrhizae form a mutualistic association with plant roots.
  - Fungus is able to absorb and concentrate phosphorus much better than it can be absorbed by the root hairs.
    - Particularly susceptible to acid rain.

Mycorhizae



Root Nodules

- Few species of bacteria produce enzymes that can convert nitrogen into nitrates and other nitrogenous substances readily absorbed by roots.
  - Legume Family (Fabaceae)
    - Root nodules contain large numbers of nitrogen-fixing bacteria.

Soils

- Soil is formed through the interaction of climate, parent material, topography, vegetation, and living organisms.
  - Solid portion of soil consists of minerals and organic matter.
  - Pore spaces occur between solid particles.
    - Filled with air or water.
  - Divided into soil horizons

Soils

- O Horizon – Organic matter, Humus
- A Horizon - Topsoil
  - Dark, rich soil, high in nutrients
- E Horizon – Leach zone
  - Found only in older soils
- B Horizon - Subsoil
  - More clay, lighter in color
- C Horizon - Parent Material
  - Not broken down into smaller particles.

Orange Apes Eat Baby Children

Soils

- Climate
  - Deserts experience little weathering due to low rainfall.
  - Grasslands have moderate rainfall and well-developed soils.
  - Rainforests have excessive rain and nutrients are quickly leached from the soil.

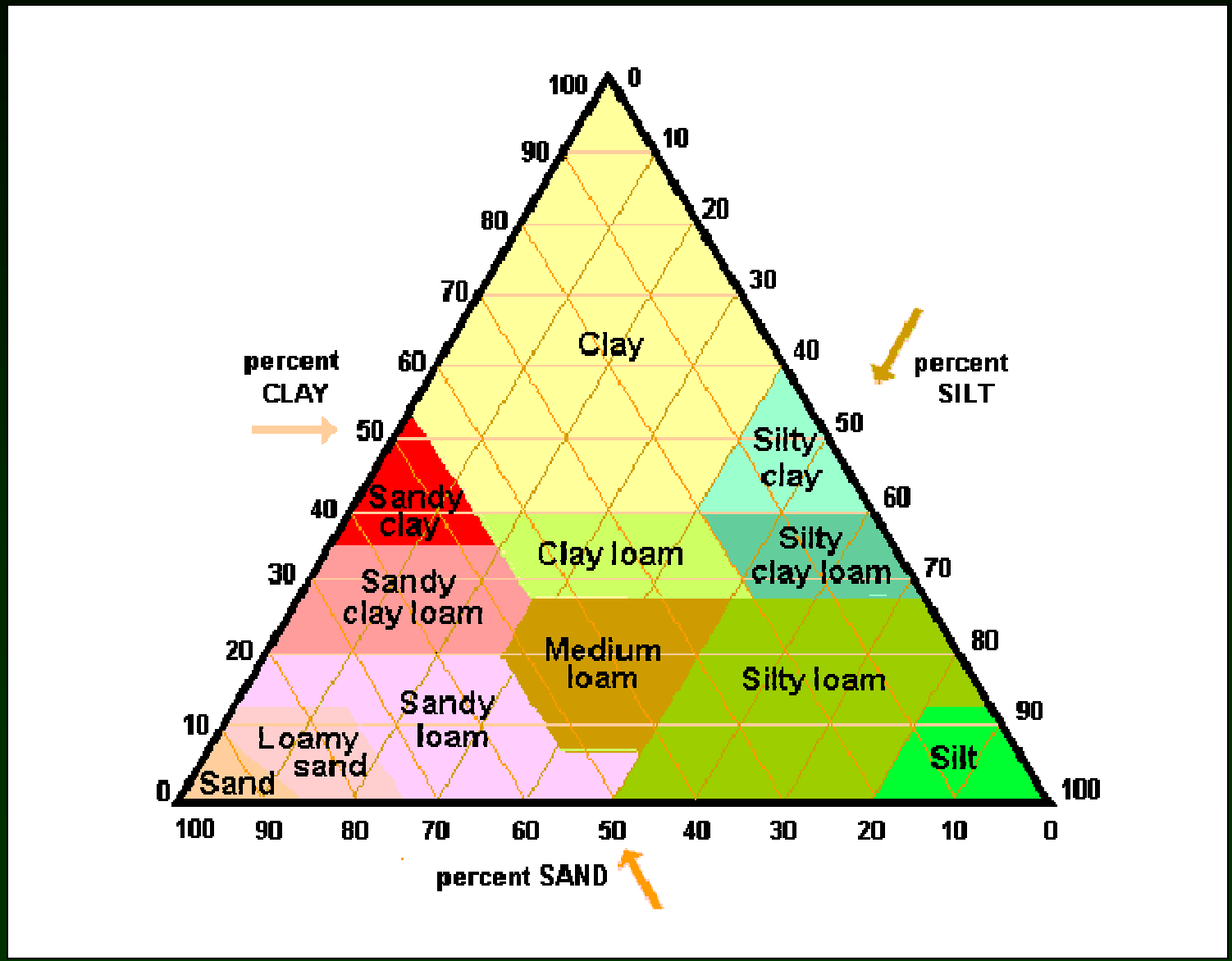
Soils

- Living Organisms and Organic Composition
  - In upper 30 cm of a good agricultural soil, living organisms constitute about one-thousandth of the total soil weight.
  - Bacteria and fungi in the soil decompose organic material.
    - Humus, partially decomposed organic matter, gives soil a dark color.

Soils

- Topography
  - Steep areas may erode via wind or water.
  - Flat areas may be flooded, and thus contain little available oxygen.
- Soil Texture and Composition
  - Best agricultural loams are composed of 40% silt, 40% sand and 20% clay.
    - Coarse soils drain water too quickly
    - Dense soils have poor drainage.

Soil Triangle



Soils

- Soil Structure
  - Arrangement of soil particles into aggregates.
    - Productive agricultural soils are granular with pore spaces occupying between 40-60% of the total soil volume.
      - Particle size is more important than total volume.

Soil Mineral Components

• Stones	> 76 mm
• Gravel	76 mm - 2.0 mm
• Very Coarse Sand	2.0 mm - 1.0 mm
• Coarse Sand	1.0 mm - 0.5 mm
• Medium Sand	0.5 mm - 0.25 mm
• Fine Sand	0.25 mm - 0.10 mm
• Very Fine Sand	0.10 mm - 0.05 mm
• Silt	0.05 mm - 0.002 mm
• Clay	< 0.002 mm

Soils

- Soil Water
  - Hygroscopic Water - Physically bound to soil particles and is unavailable to plants.
  - Gravitational Water - Drains out of pore spaces after a rain.
  - Capillary Water - Water held against the force of gravity in soil pores.

Soils

- Field Capacity - Water remaining in the soil after drainage by gravity.
- Permanent Wilting Point - Rate of water absorption insufficient for plant needs.
- Available Water - Soil water between field capacity and the permanent wilting point.

Soils

- Soil pH
  - Alkalinity causes some minerals to become less available.

    Add nitrogenous fertilizers.
  - Acidity may inhibit growth of nitrogen-fixing bacteria.
    - Add calcium or magnesium compounds.

Stems

Outline

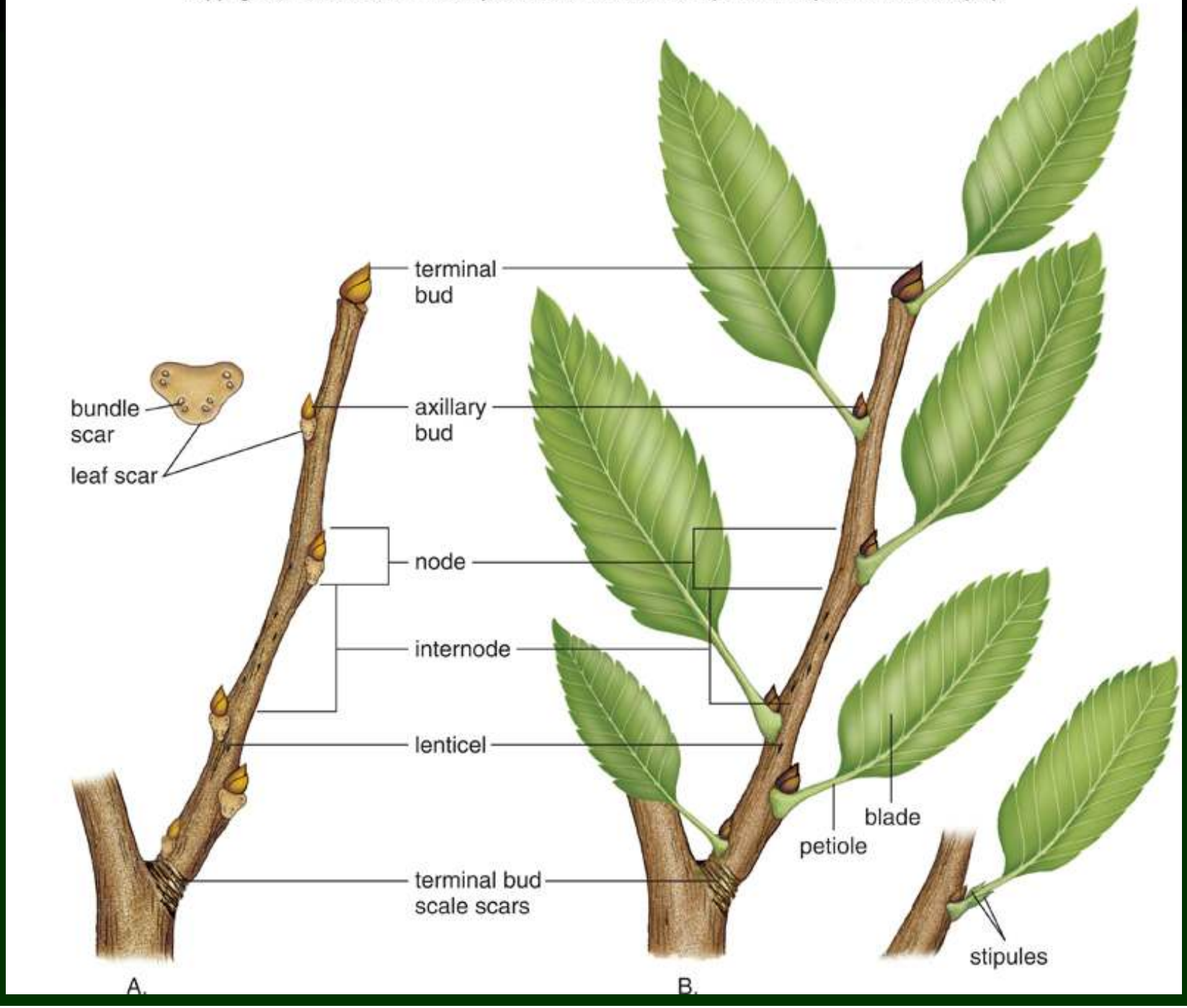
- External Form of a Woody Twig
- Stem Origin and Development
- Stem Tissue Patterns
- Herbaceous Dicotyledonous Stems
- Woody Dicotyledonous Stems
- Monocotyledonous Stems
- Specialized Stems
- Wood and Its Uses

External Form of A Woody Twig

- Woody twig consists of an axis with attached leaves.
  - Alternately or Oppositely arranged.
    - Leaves attached at a node.
      - Stem region between nodes is an internode.
        - Leaf has a flattened blade and is usually attached to the twig by a petiole.

External Form of A Woody Twig

- Axil - Angle between a petiole and the stem.
  - Axillary Bud located in axil.
    - Terminal Bud often found at twig tip.
- Stipules - Paired appendages at the base of a leaf. Often remain throughout leaf life span.
  - Deciduous trees and shrubs have dormant axillary buds with leaf scars left after leaves fall.
    - Bundle scars mark food and water conducting tissue.



Origin and Development of Stems

- Apical meristem is dormant before the beginning of the growing season.
  - Protected by bud scales and by primordia.
- When a bud begins to expand, apical meristem cells undergo mitosis and three primary meristems develop.

Primary Meristems

- Protoderm - Gives rise to epidermis.
- Procambium - Produces primary xylem and primary phloem cells.
- Ground Meristem - Produces tissues composed of parenchyma cells.
  - Pith
  - Cortex

Origin and Development of Stems

- Narrow band of cells between the primary xylem and primary phloem may become vascular cambium.
  - Cells produced by the vascular cambium become components of secondary xylem and secondary phloem.
- In many plants, a second cambium, cork cambium, arises.
  - Produces cork cells and phelloderm cells.

Tissue Patterns in Stems

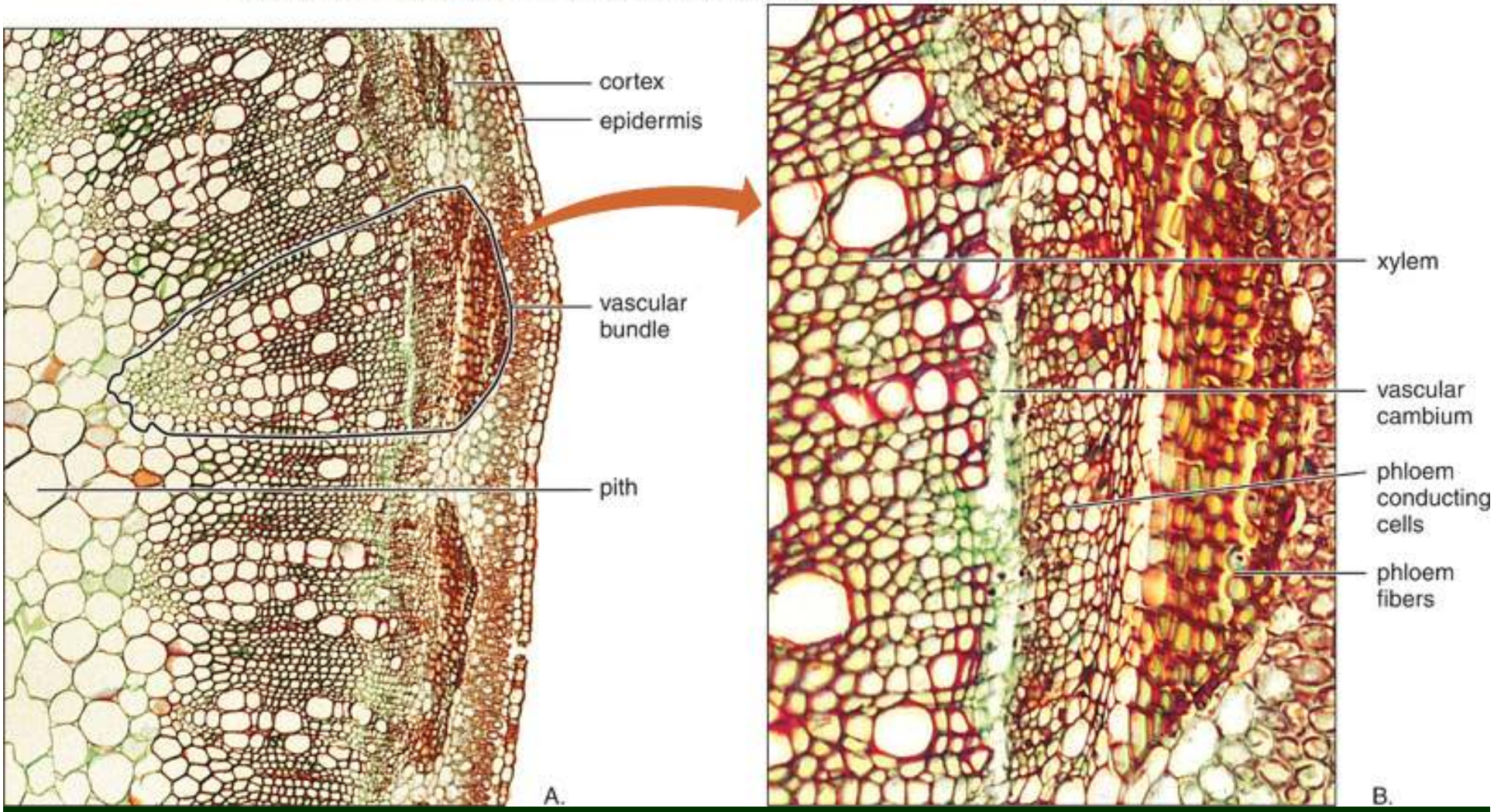
- Steles
  - Stele is made up of primary xylem, primary phloem, and pith (if present).
    - Protostele - Solid core.
    - Sphinosteles - Tubular with pith in center.
    - Eusteles - Vascular bundles.

Tissue Patterns in Stems

- Dicotyledons - Flowering plants that develop from seeds having two seed leaves.
- Monocotyledons - Flowering plants that develop from seeds with a single seed leaf.

Herbaceous Dicotyledonous Stems

- In general, annuals are green, herbaceous plants.
  - Most monocots are annuals, but many dicots are also annuals.
- Herbaceous dicots have discrete vascular bundles composed of patches of xylem and phloem.
  - Procambium produces only primary xylem and phloem, but vascular cambium arises later and adds secondary phloem and xylem to the vascular bundles.

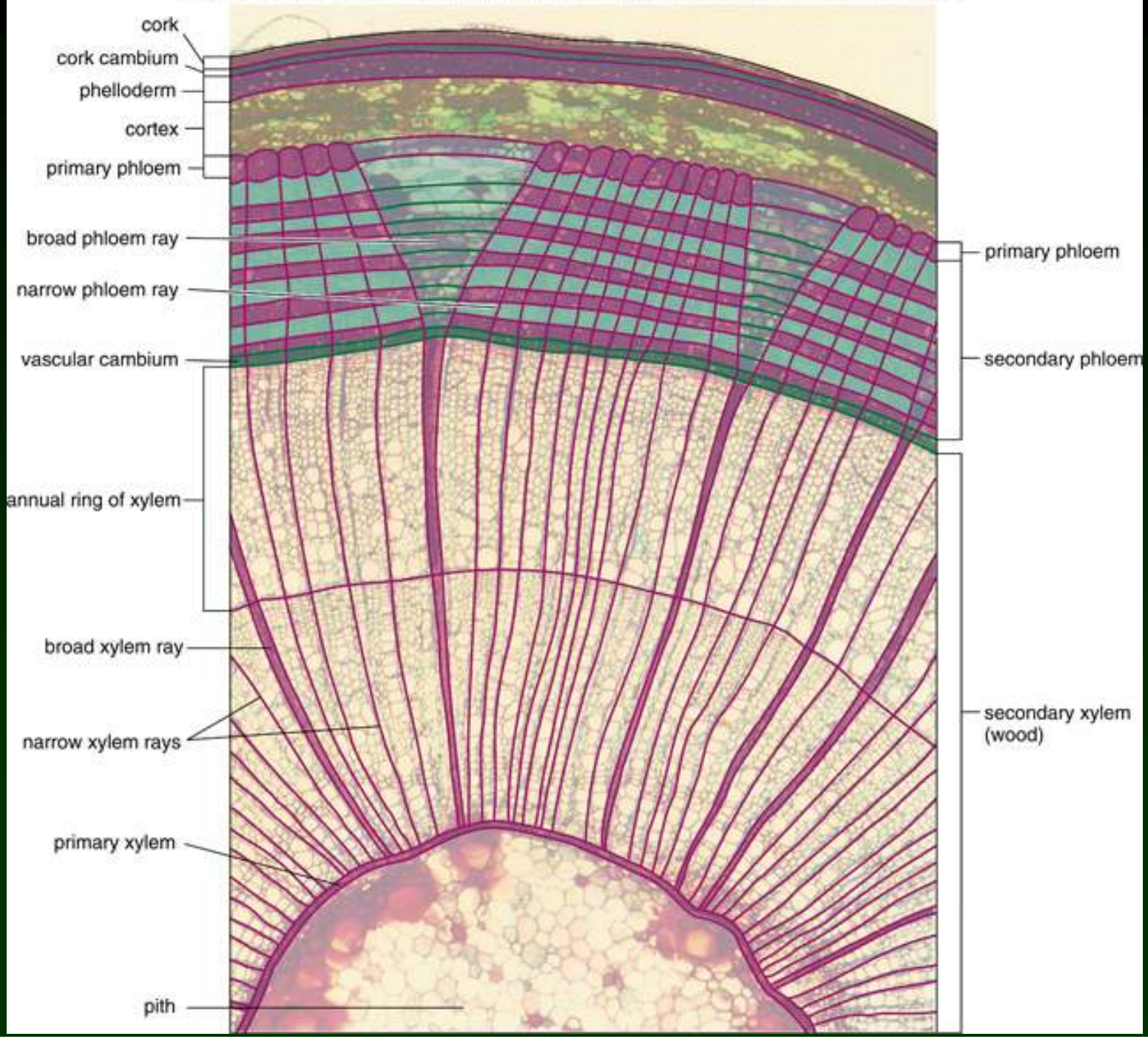


Woody Dicotyledonous Stems

- Vascular cambium of a typical broadleaf tree produces relatively large vessel elements of secondary xylem (spring wood).
  - Xylem produced next has smaller or fewer elements, and is referred to as summer wood.
  - One year's growth of xylem is called an annual ring.

Woody Dicotyledonous Stems

- Vascular cambium produces more secondary xylem than phloem, thus bulk of a tree trunk consists of annual rings of wood.
  - Examining rings can determine the age of a tree, and provide some indications of climatic conditions.
- Vascular Rays consist of parenchyma cells that function in lateral conductions of nutrients and water.
  - Xylem Ray
  - Phloem Ray

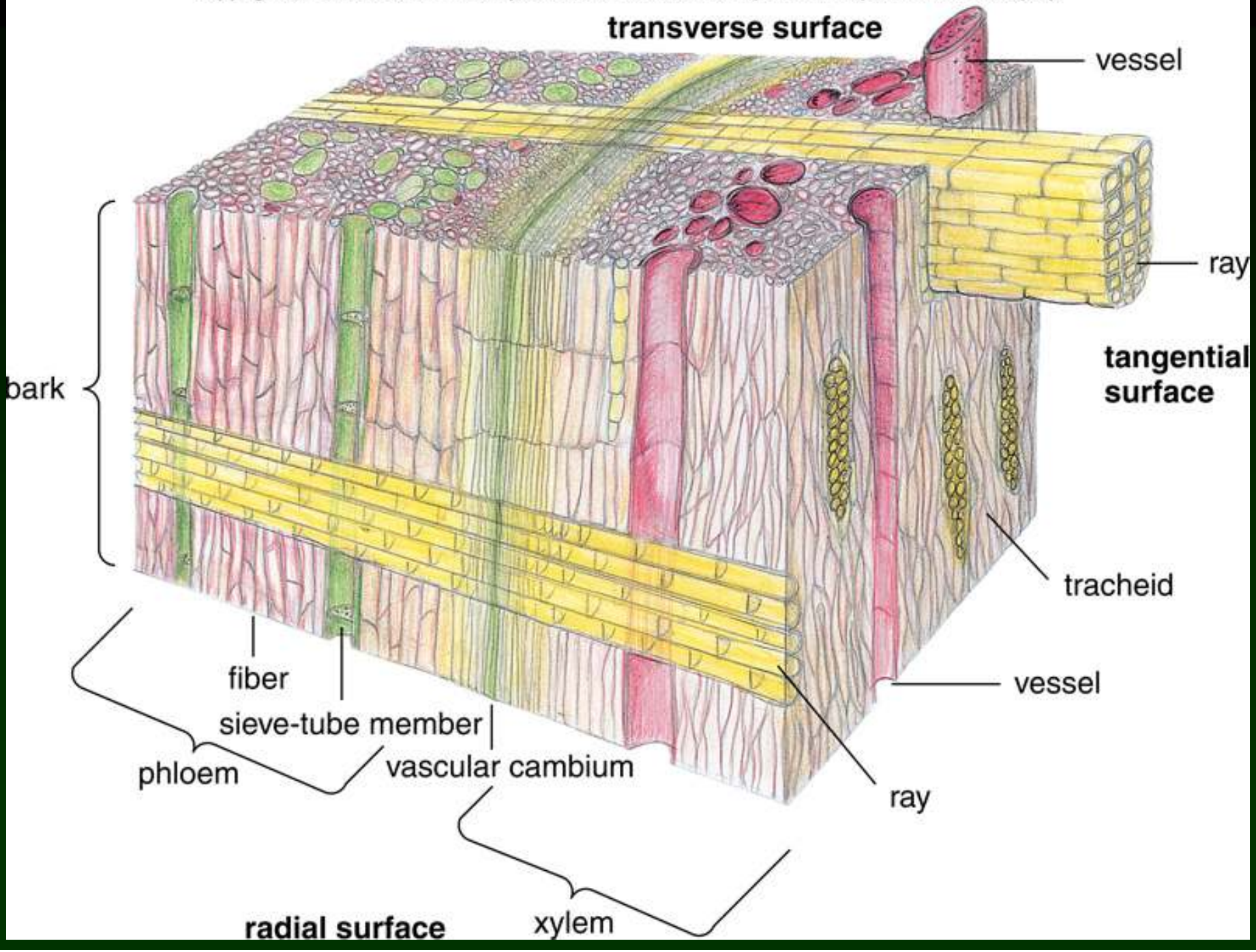


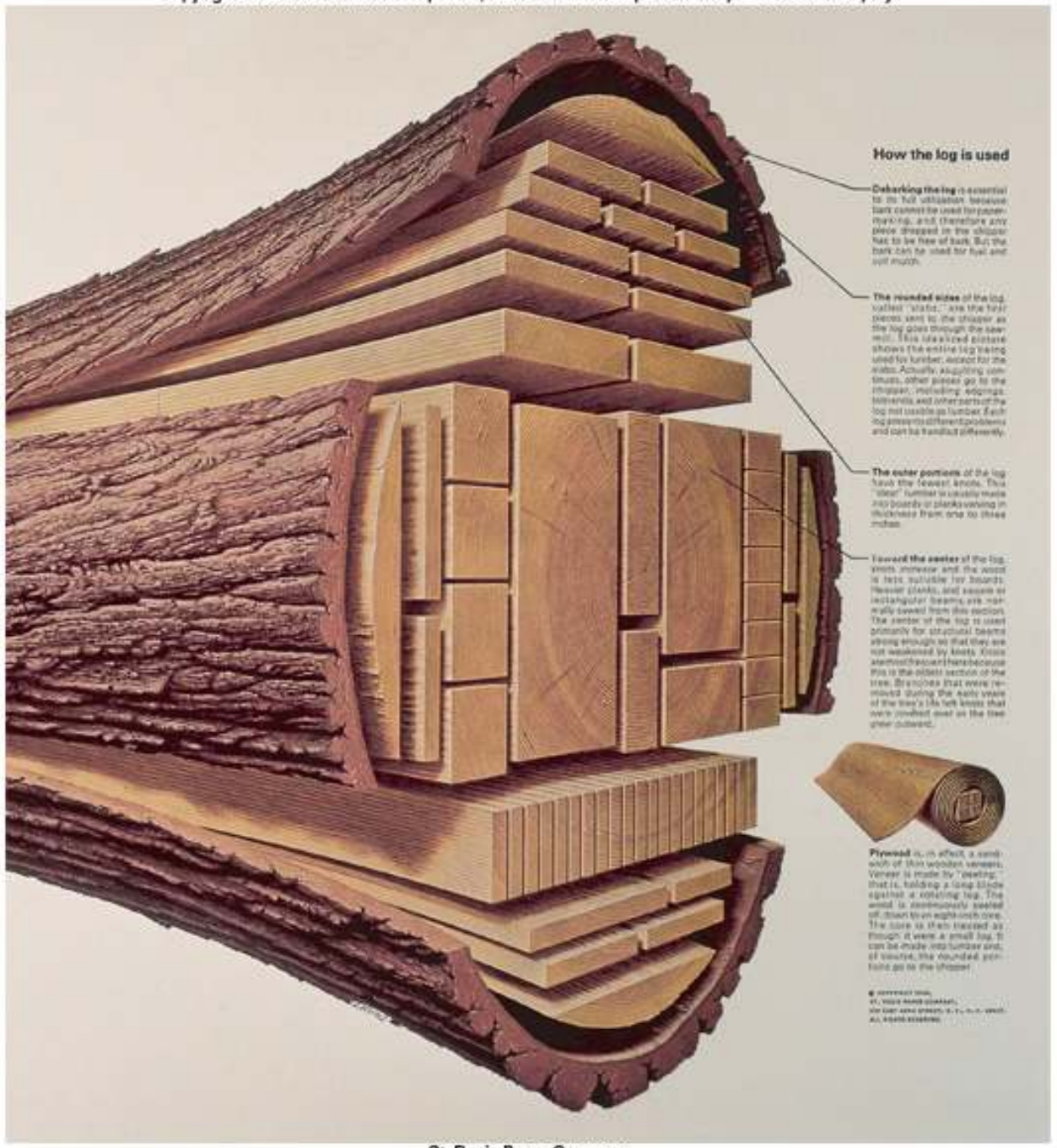
Woody Dicotyledonous Stems

- Older, darker wood at the center is called heartwood, while the lighter, still-functioning xylem closest to the cambium is called sapwood.
  - Formed at roughly the same rate as heartwood.
    - Softwood - Xylem consists primarily of tracheids; no fibers of vessel elements.
      - Cone-bearing trees.

Woody Dicotyledonous Stems

- Bark - Refers to all the tissues outside the cambium, including the phloem.
  - Mature bark may consist of alternating layers of crushed phloem and cork.

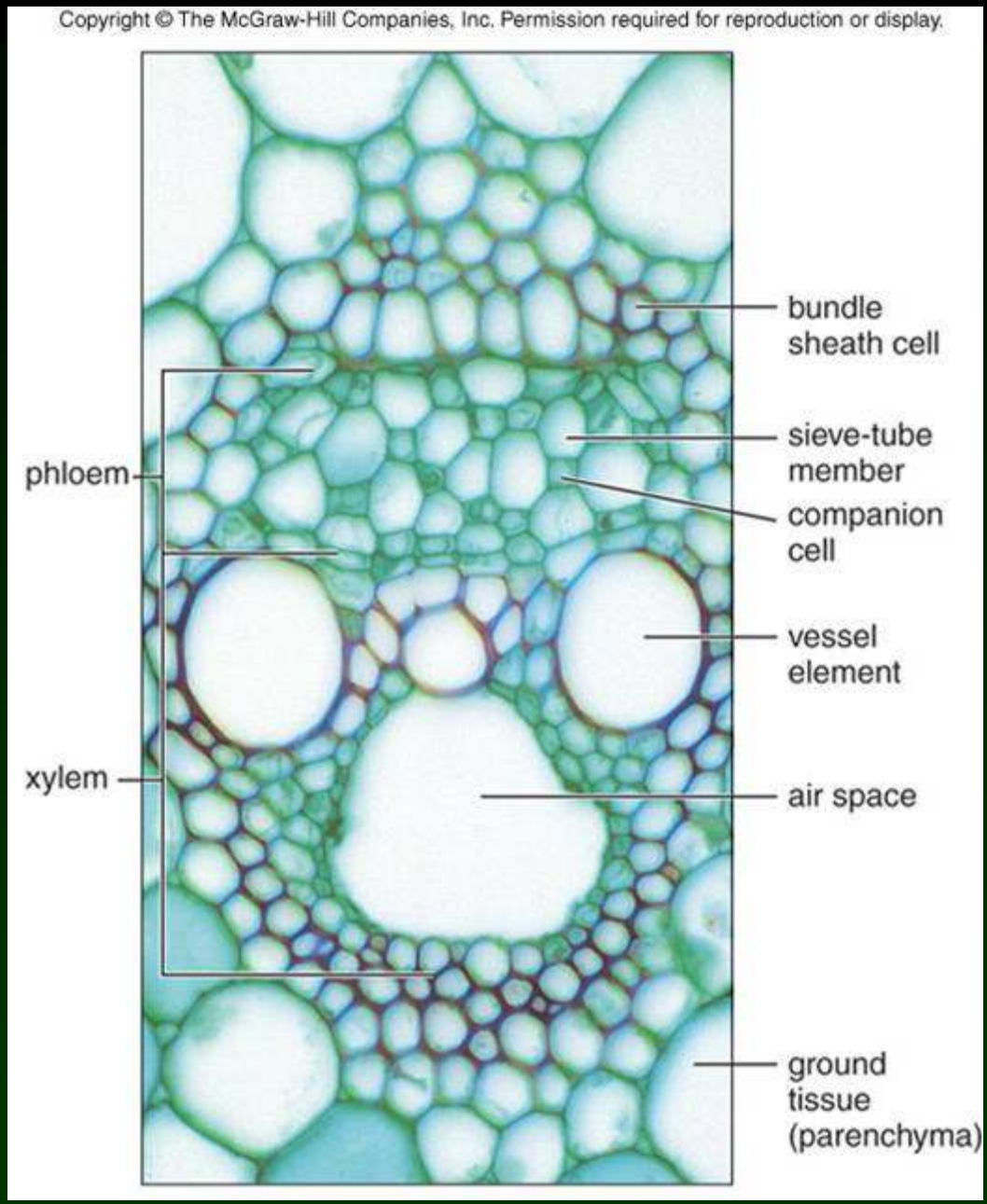




St. Regis Paper Company

Monocotyledonous Stems

- The stems of most monocots have neither a vascular cambium nor a cork cambium and thus produce no secondary vascular tissues or cork.
  - Xylem and phloem exist in discrete vascular bundles.
    - Secondary meristem produces only parenchyma cells to the outside and secondary vascular bundles to the inside.



Specialized Stems

- Rhizomes - Horizontal stems that grow below-ground.
- Runners - Horizontal stems that generally grow along surface.
- Stolons - Produced beneath the surface of the ground and tend to grow in different directions.

Specialized Stems

- Bulbs - Large buds surrounded by numerous fleshy leaves, with a small stem at the lower end.
- Corms - Resemble bulbs, but composed almost entirely of stem tissue.
- Cladophylls - Flattened, leaf-life stems.
- Thorns
- Tendrils

Wood and its Uses

- In a living tree, 50% of the wood weight comes from water content.
  - Dry weight is composed of 60-75% cellulose and 15-25% lignin.
- Density and Durability are two of the most important characteristics in commercial wood.

Wood and its Uses

- Sawing
  - Radially cut (quartersawed) boards show the annual rings in a side view.
  - Tangentially cut (plain-sawed) boards show annual rings as irregular bands of light and dark streaks.

Wood and its Uses

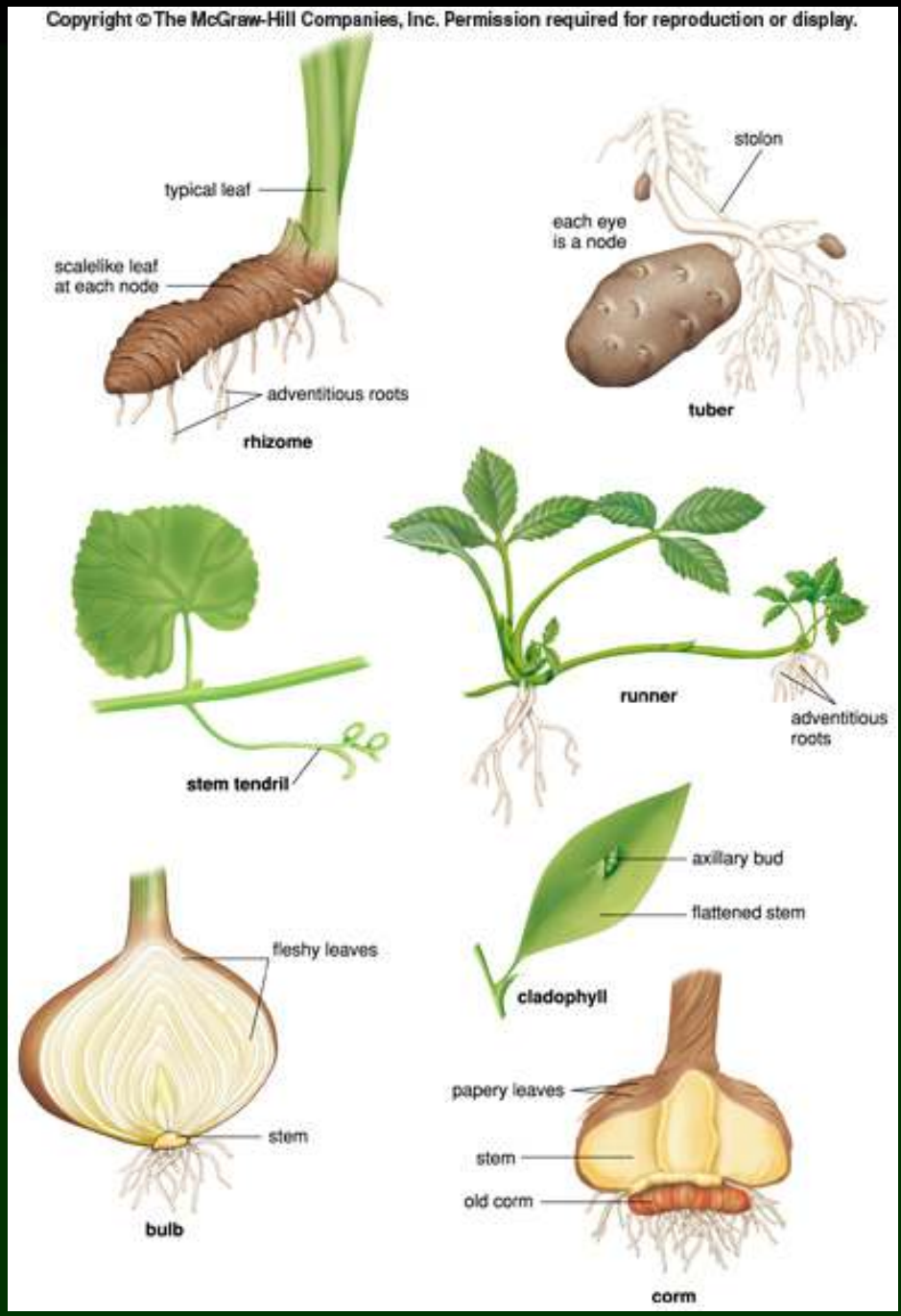
- Knots
  - Bases of lost branches covered by new annual rings produced by the cambium of the trunk.
  - Found in greater concentration in older parts of the log, towards the center.

Wood and its Uses

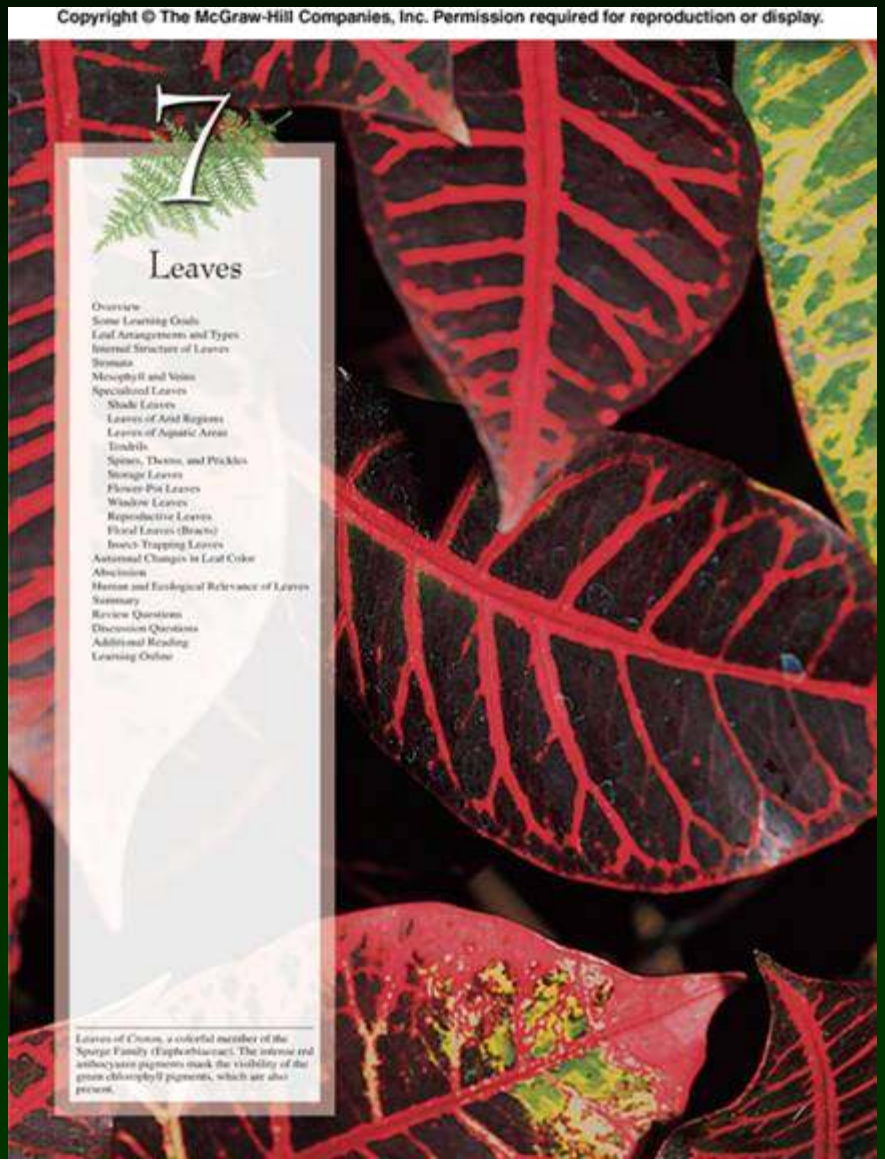
- Wood Products
  - About half of US and Canadian wood production is used as lumber, primarily for construction.
    - Veneer - Thin sheet of desirable wood glued to cheaper lumber.
  - Second most extensive use of wood is pulp.
  - In developing countries, approximately half of cut timber is used for fuel.
    - Less than 10% in US and Canada.

Cladophyll – Leaves have been reduced to spines

Specialized Stems



Leaves



Leaves of *Croton*, a colorful member of the Spurge Family (Euphorbiaceae). The intense red anthocyanin pigments mask the visibility of the green chlorophyll pigments, which are also present.

Overview

- All leaves originate as primordia in the buds.
- At maturity, most leaves have a stalk (petiole) and a flattened blade (lamina) with a network of veins (vascular bundles).
- Leaves of flowering plants are associated with leaf gaps and have an axillary bud at the base.
  - May be simple (single blade) or compound (divided into leaflets).

Overview

- Pinnately compound leaves have leaflets in pairs along the rachis, while palmately compound leaves have all the leaflets attached at the same point at the end of the petiole.
  - Pinnately compound leaves may be further subdivided an thus be referred to as bipinnately compound.

Overview

- Green leaves capture sunlight and thus go through photosynthesis.
  - Lower surfaces of leaves are dotted with stomata which allow carbon dioxide to enter and oxygen and water to diffuse out.
    - Guard Cells control stomatal opening.
  - Transpiration occurs when water evaporates from the leaf surface.
  - Guttation - Root pressure forces water out hydathodes.

Leaf Arrangements and Types

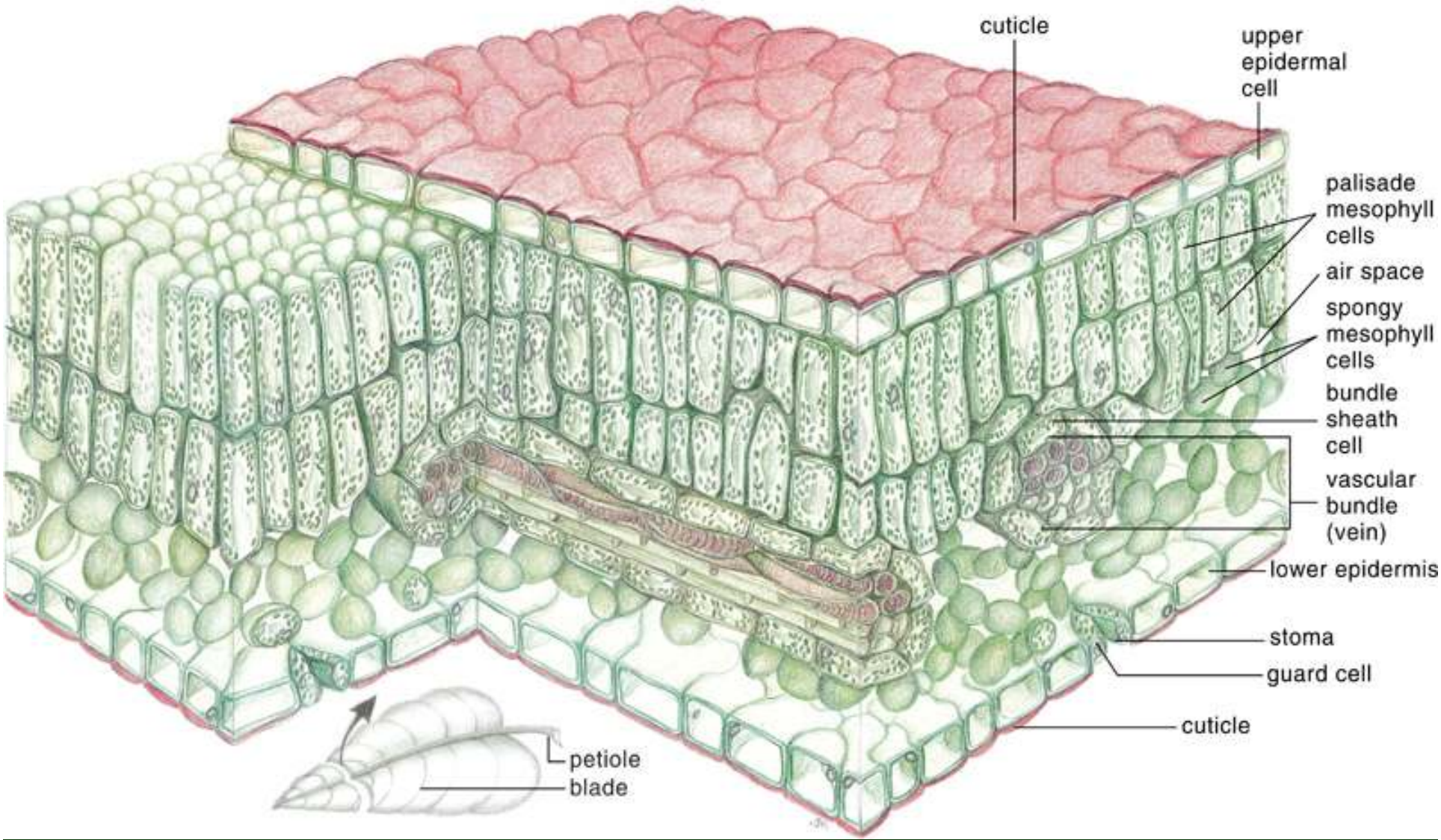
- Leaves are attached to stems at nodes, with stem regions between nodes known as internodes.
  - Phylotaxy (leaf arrangement) generally occurs in one of three ways:
    - Alternate
    - Opposite
    - Whorled

Leaf Arrangements and Types

- Arrangement of veins in a leaf or leaflet blade may also be pinnate or palmate.
  - Pinnately veined leaves have a main midvein within a midrib.
    - Secondary veins branch from midvein.
  - Palmately veined leaves have several primary veins that fan out from the base of the blade.
    - Parallel in monocots
    - Divergent in dicots (reticulate venation)

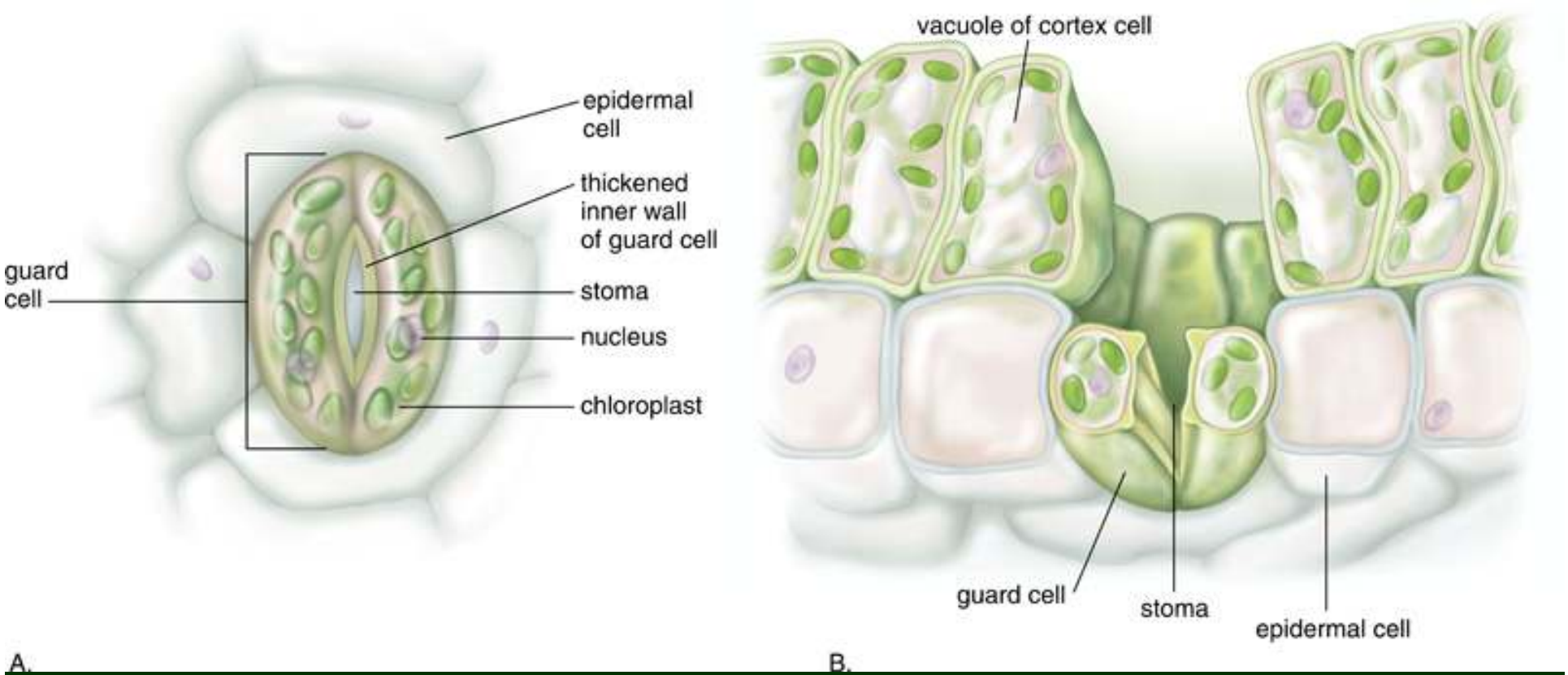
Internal Structure of Leaves

- Epidermis is a single layer of cells covering the entire surface of the leaf.
  - Upper epidermal cells are devoid of chloroplasts.
  - Waxy cuticle often present.
  - Different glands may also be present in the epidermis.



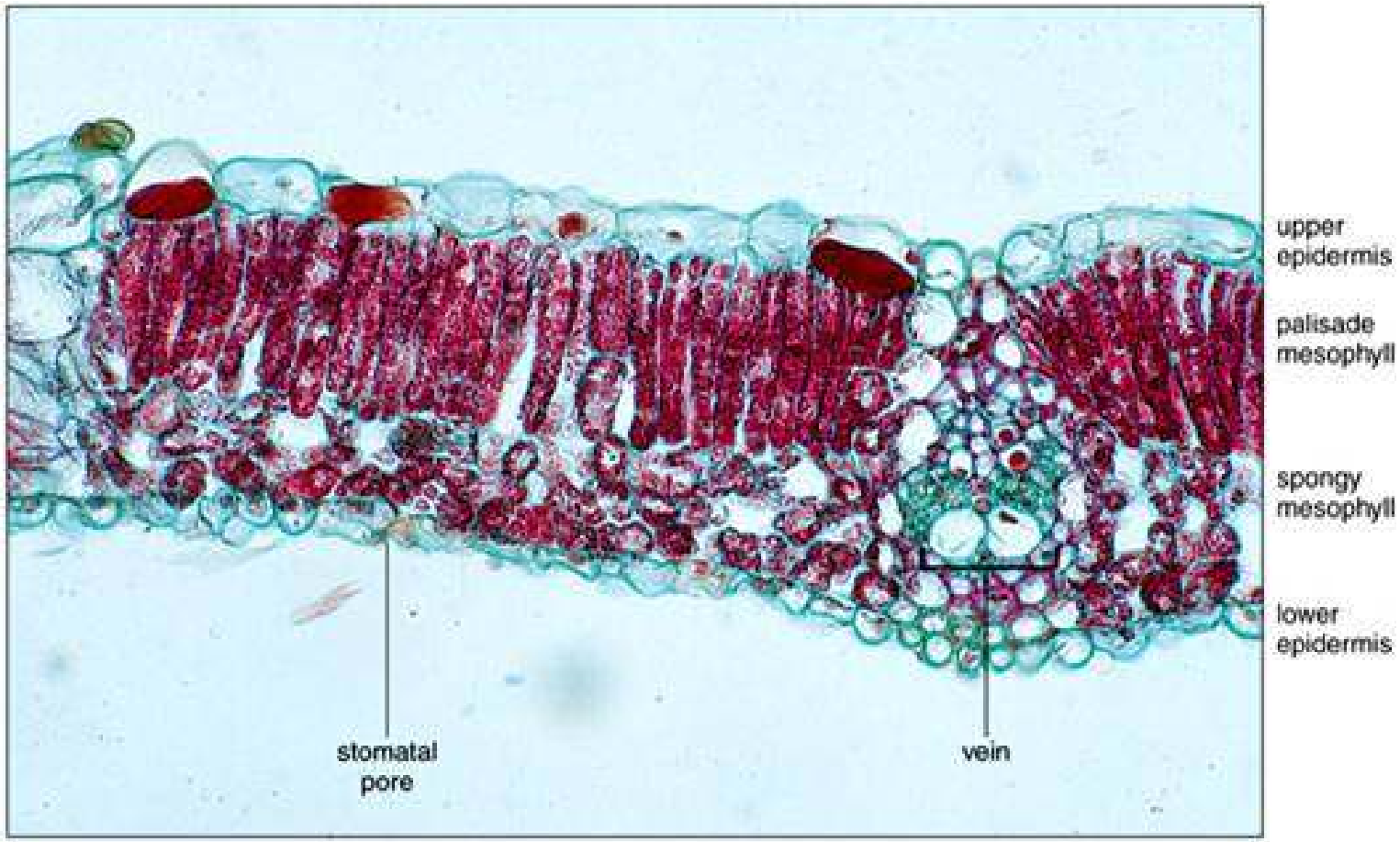
Stomata

- Lower epidermis of most plans is perforated by numerous stomata.
  - Guard cells originate from the same parent cell, and contain chloroplasts.
    - Primary function includes regulating gas exchange between leaf interior and the atmosphere, and the evaporation of water.
      - Cell water pressure regulates guard cells which in turn regulate stomata.



Mesophyll and Veins

- Most photosynthesis takes place in the mesophyll between the two epidermal layers.
  - Palisade Mesophyll - Uppermost layer Contain most of leaf's chloroplasts.
  - Spongy Mesophyll - Lower layer
- Veins (Vascular bundles) are scattered throughout the mesophyll.
  - Consist of xylem and phloem tissues surrounded by the bundle sheath.



Specialized Leaves

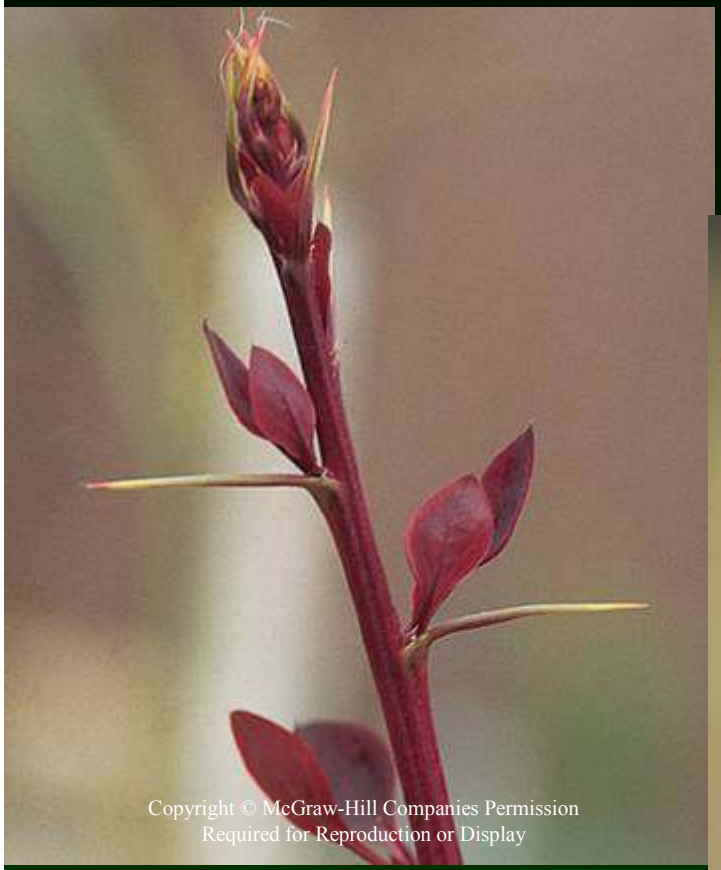
- Shade Leaves
  - Leaves in the shade receive less total light, thus tend to be thinner and have fewer hairs than leaves on the same tree exposed to direct light.
- Leaves of Arid Regions
  - Many have thick, leathery leaves and few stomata.
  - Some have succulent, water-retaining leaves, or dense, hairy coverings.

Specialized Leaves

- Tendrils
  - Modified leaves that curl around more rigid objects helping the plant to climb or support weak stems.
    - Become coiled like a spring as they develop.
      - When contact is made, the tip curls around the object, and the direction of the coil reverses.

Specialized Leaves

- Spines, Thorns, and Prickles
  - Spines - Modified leaves designed to reduce water loss and protect from herbivory.
  - Thorns - Modified stems arising in the axils of leaves of woody plants.
  - Prickles - Outgrowths from the epidermis or cortex.



Specialized Leaves

- Storage Leaves - Succulents
- Flower-Pot Leaves - Urn-Like Pouches
- Window Leaves - Leaves buried in ground.
- Reproductive Leaves - New plants at tips.
- Floral Leaves - Bracts

Specialized Leaves

- Insect-Trapping Leaves
  - Pitcher Plants
  - Sundews

Specialized Leaves

- Insect-Trapping Leaves
  - Venus's Flytraps
  - Bladderworts

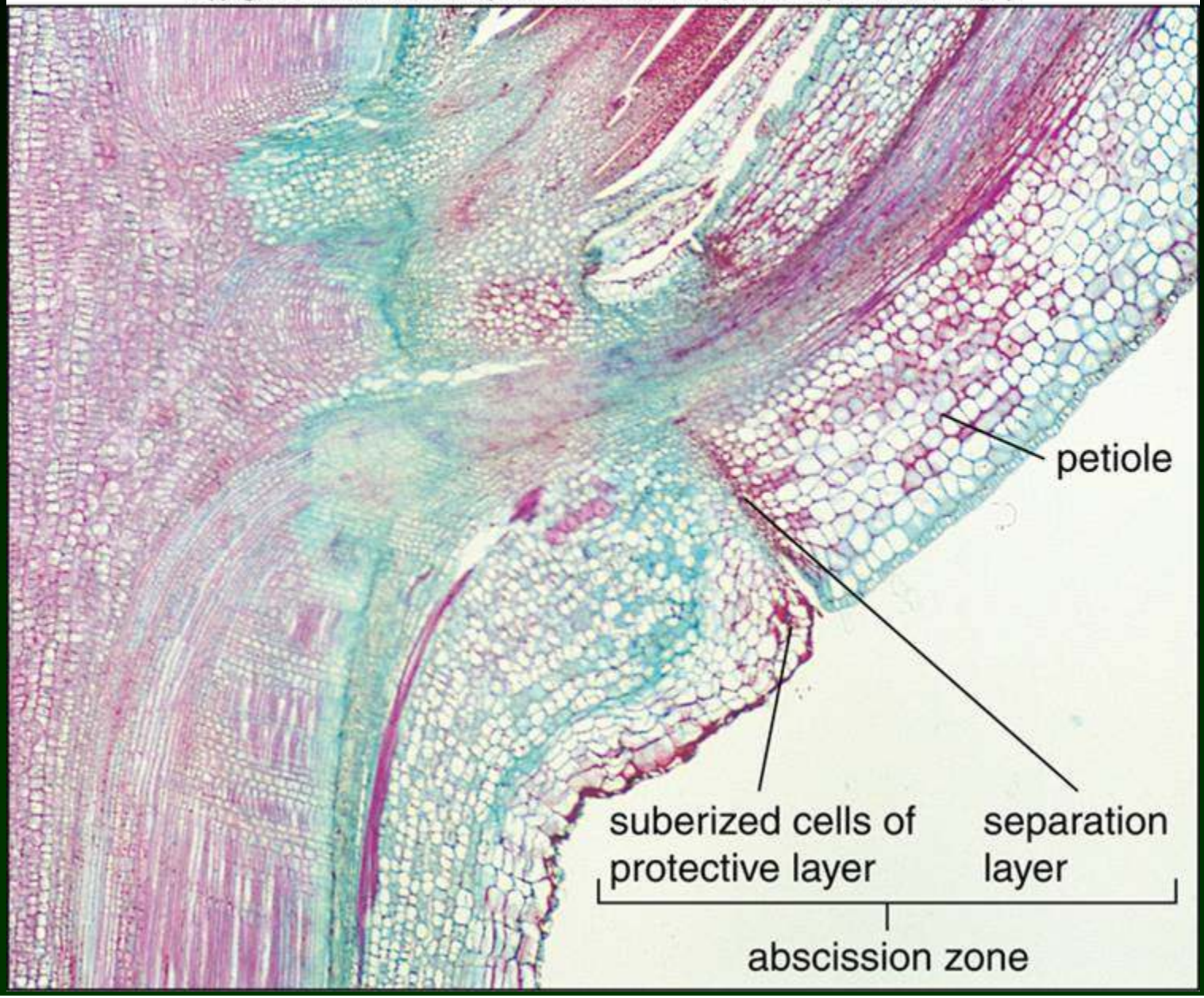
Autumnal Changes in Leaf Color

- Cholorplasts of mature leaves contain several groups of pigments.
  - Chlorophylls - Green
  - Carotenoids - Yellows
    - In fall, chlorophylls break down and other colors are revealed.
- Water soluble anthocyanins (red or blue) and betacyanins (red) may also be present in the vacuole.

Abscission

- Deciduous plants drop their leaves seasonally.
  - Occurs as a result of changes in an abscission zone near the base of the petiole of each leaf.
    - Cells of the protective layer become coated and impregnated with suberin.

Leaf Abscission Zone



Human and Ecological Relevance of Leaves

- Landscaping
- Food
- Dyes
- Ropes and Twine
- Drugs
  - Tobacco
  - Marijuana
- Insecticides
- Waxes