Plant Structure and Growth

Plant body divided into root and shoot
Shoot consists of leaves, buds, flowers, and stem
Root consists of primary and secondary (lateral) roots

Growth occurs at **meristems**
Apical meristems of root and shoot allow for increase in length - primary growth
**lateral meristems** allow for increase in girth (diameter) - **secondary growth**
Plant growth
Primary growth occurs at root and shoot apical meristems

Apical Shoot Meristem
- Young leaf primordium
- Apical meristem
- Older leaf primordium
- Lateral bud primordium

Young leaf primordium
- Apical meristem
- Older leaf primordium
- Lateral bud primordium
- Vascular tissue
Root apical meristem is covered by protective root cap
Apical meristems give rise to primary tissues:
- **protoderm** - gives rise to epidermis
- **procambium** - gives rise to primary vascular tissue (primary xylem and phloem)
- **ground meristem** - gives rise to parenchyma

Lateral meristems produce secondary growth:
- **cork cambium** - produces cork cells of outer bark
- **vascular cambium** - produces secondary vascular tissue (secondary xylem and phloem)
Plant tissue types

**ground tissue** - thin walled parenchyma cells in interior of root and shoot - which function in storage, photosynthesis, and secretion often capable of giving rise to other tissue types

![Image of ground tissue](image)

**dermal tissue** - covers entire plant body (more detail later)

**vascular tissue** -
- **xylem** - for conducting water and dissolved minerals
- **phloem** - for conducting carbohydrates and other substances necessary for plant growth
**Secondary growth** - only possible in woody plants produced by lateral meristems. Vascular cambium produces secondary xylem to the interior of the stem and secondary phloem to the outside of the stem. Cork cambium produces cork cells of bark as diameter increases.
Dermal tissue

epidermal cells originate from protoderm - covered by waxy cuticle in green shoots, young roots, and leaves

specialized cells in the epidermis include guard cells and trichomes

root hairs are extensions of individual epidermal cells
**Ground tissue**

**Parenchyma** - irregularly shaped thin walled living cells that fill much of the interior of a root, shoot, or fruit

**Collenchyma** - elongate living cells with thickened walls provide support for plant organs like leaves and stems without secondary growth - e.g. strings in celery

**Sclerenchyma** - usually nonliving cells - cell walls reinforced with lignin fibers - long slender cells grouped together into strands that provide support - e.g. linen fibers from flax

**Sclerids** - irregular shaped cells found in groups and serve to strengthen and protect - e.g. grit of pears
Vascular tissue

Xylem: tracheids and vessel elements - both dead cells, lacking cytoplasm, attached end to end, for water and mineral transport

Tracheids are found in all vascular plants, vessels are only common in angiosperms

Vessels are more efficient conductors
**Vascular tissue**

Phloem: consists of sieve tubes and companion cells, for transport of carbohydrates from areas of photosynthesis.

Sieve tubes have cytoplasm, and cell membrane, but lack a nucleus, and are maintained by companion cells (modified parenchyma cells).

Sieve tube elements connected through sieve plate.
**Root structure:**

Developing roots have four regions:

- **Root cap** - parenchyma cells that cover and protect tip of young root - secretes mucilaginous substance, also functions to perceive gravity

- **Zone of cell division** - root apical meristem - dome of cells at center of root tip can divide every 12 to 36 hours, gives rise to protoderm, procambium and ground meristem

- **Zone of elongation** - Cells become longer than wide by expansion of vacuoles, no further increase in cell size afterwards

- **Zone of maturation** - cells differentiate into specific cell types
**Root structure:**

- Epidermal cells can develop root hairs as outgrowths.
- Cortex - Parenchyma cells that can function in food storage.
- Endodermis - Single layer of cells with cell walls impregnated with suberin - Prevents water and mineral passage between cells. Suberin band around cells is the “Casparian strip.”
- Stele - All cells interior to the endodermis.
- Pericycle - Parenchyma just interior to the endodermis - Can produce lateral roots and the root vascular cambium.
Dicot roots have central core of primary xylem, arms radiate toward pericycle and phloem between arms. Monocot xylem forms ring of vascular bundles surrounding central cylinder of pith.
Differentiation of Plant Tissues

Zygote → Embryo

- Shoot apical meristem
  - Cork cambium
  - Vascular cambium
  - Leaf primordia
  - Bud primordia
  - Lateral shoots
  - Shoot elongation

- Root apical meristem
  - Cork cambium
  - Vascular cambium
  - Perticycle
  - Lateral roots
  - Root elongation

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<th>Undifferentiated</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
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Root modifications

**Adventitious roots** - arise along stem or locations other than base of plant

**Aerial roots** - roots that extend out into the air, unconnected to the ground

**Prop roots** - located on lower part of stem of some monocots like corn, grow down into ground, anchor against wind

**Pneumatophores** - spongy outgrowths from underwater roots
   - May extend above water, increase oxygen supply to roots

**Parasitic roots** - penetrate host plants to parasitize them

**Food storage roots** - branch roots of plants like sweet potatoes
   - produce extra parenchyma cells for carbohydrate storage

**Buttress roots** - produced by certain varieties of fig and tropical trees for support
Types of Modified Roots
**Stem structure:**

- **Node** - the region of leaf attachment
- **Internode** - stem area between nodes

Leaves project from stem

- **Blade**: Flattened portion
- **Petiole**: Slender stalk supporting blade

**Axil** - angle formed by leaf attachment to the stem

**Axillary bud** is produced in each axil

Axillary buds may develop into branches

**Terminal bud** - produced at tip of stem

Terminal buds extend length of stem
Dicot stems have vascular bundles arranged in ring around a core of pith - with primary xylem to the inside and primary phloem to the outside - vascular cambium is found between xylem and phloem.

Monocot stems have vascular bundles scattered throughout ground tissue - have no vascular cambium - so secondary growth is not possible.
Secondary growth

Vascular cambium produces secondary xylem to inside and secondary phloem to outside.

Secondary xylem is wood and is added in sequential layers. Phloem is thin-walled and is older layers are crushed as new layers are produced and stem increases in girth.

Cork cambium arises in cortex and produces new cork to outside.
Lenticels

Transverse Section
Modified stems

- Runners (strawberry)
- Tubers (potato)
- Bulbs (onion)
- Rhizomes (iris)
- Fleshy leaves
- Knob-like stem
- Scale-like leaf at each node
- Rhizome
- Adventitious roots
- Photosynthetic leaf
- Tendrils (grape)
- Cladophylls (prickly pear)
Leaf structure

Dicot and Monocot Leaves
Simple Versus Compound Leaves
Leaf Arrangements

Alternate (spiral): Ivy
Opposite: Periwinkle
Whorled:
Leaf cellular structure

Upper and lower epidermis covered by waxy cuticle

Epidermal cells are nonphotosynthetic except for guard cells that surround stomata

Interior cells are called mesophyll cells and are photosynthetic palisade mesophyll tightly packed under upper epidermis spongy mesophyll composed of loose cells above lower epidermis
Stomate and Guard Cells:
Two guard cells surround the stomate
  cell wall thickened along stomate border - allows opening
  and closing of stomate with change in cell volume
**Modified leaves**

**Floral leaves** (bracts) - brightly colored leaves that surround flowers and add to ability to attract pollinators - e.g. Poinsettias, flowering dogwood

**Spines** - reduce water loss and protect against predators - e.g. cactus

**Reproductive leaves** - leaves that form new plantlets and allow for asexual reproduction - e.g. *Kalanchoe* (AKA “leaf of life”)

**Insectivorous leaves** - leaves that trap insects in order to digest and extract minerals that are in short supply otherwise - e.g. pitcher plants, Venus flytrap, and sundew