Plants: Structure and Function of Vascular Plants
Organ Systems

- Recall: Differentiation of cells can result in specialized cells that can form tissues of similar cells. Groups of tissues can work together in an organ. In the same way, multiple organs and tissues can also work together to form an organ system.

- Organ System: a group of tissues and organs that perform specific functions

- Plants generally have two main organ systems: the root system and the shoot system.
Plant Systems

- Root System: an organ system in a plant, which takes in water and minerals from the soil and transports these substances to the shoot system.
Plant Systems

- Shoot System: an organ system in a plant, which supports the plant, performs photosynthesis, and transports sap.
Plant Systems

- The root and shoot systems are a continuous system connected by the tube-like structures formed by the vascular bundles.
Vascular Bundles

- Xylem is composed of dead cells that carry water and minerals from the roots to other parts of the plant.
- Phloem is composed of living tissue that carries sugars produced by photosynthesis to other parts of the plant.
The Leaf

- Primary site of photosynthesis for the plant.
The Leaf: Epidermis

- **Epidermis**: External layer of living tissue which protects interior tissues

  - **Structure**: Thin, flat, transparent cells that fit tightly together.

  - **Function**: Acts as a barrier but allows light through. Secretes a transparent, waxy, non-living, waterproof layer known as the cuticle.
Leaf: Stoma

- **Stoma:** A pore-like opening in the plant’s epidermis (usually in the lower epidermis of a leaf)

- **Structure**
  - Two non-transparent guard cells linked together in pairs surrounds each stoma
  - Each guard cell has thickened inner walls with non-stretchy microscopic rings

- **Function**
  - Control the rate of gas exchange with the surrounding air
  - The larger the opening between the two cells, the faster the rate of gas exchange
Leaf: Stoma

- **Mechanism of action:**
  - To open the stoma, water must flow into the guard cells, increasing water pressure within each guard cell.
    - Guard cells are prevented from increasing in diameter due to the rings, therefore they expand lengthwise.
    - However, because each guard cell is connected in pairs, this causes them to curve outwards, opening the stoma.
  - To close the stoma, water must flow out of the guard cells, decreasing water pressure within each guard cell.
    - Guard cells return to original length and lose their curved shape, which closes the stoma.
Leaf: Stoma

A) Structure of a pair of guard cells

B) Water flows into guard cells

C) Water flows out of guard cells
Leaf: Spongy Layer

Structure
- Loosely packed layer of mesophyll cells inside the dicot leaf
- Large air spaces between cells containing carbon dioxide, oxygen, and nitrogen
- Water vapour is also found in this spongy space

Function
- Facilitates air circulation and allows for gas exchange
- Allows for transpiration of water (movement of water from root to shoot, and then evaporation through the
Leaf: Vascular Tissue

- **Structure**
  - Conducting tissue composed mainly of xylem and phloem tissues
  - Form vascular bundles which appear as the veins in leaves (net-like in dicots, parallel in monocots)
  - Each bundle is surrounded by a bundle sheath

- **Function**
  - Conduct water into the leaf
  - Conduct dissolved minerals into the leaf
  - Conduct dissolved carbohydrates (nutrients) out of the leaf
Leaf: Vascular Tissue
Leaf: Palisade Cells

- **Structure**
  - Tightly packed layer of cylindrical mesophyll cells in the dicot leaf
  - Top of cell is exposed to incoming light; bottom is exposed to the spongy layer
  - Cells contain many chloroplasts

- **Function**
  - Principal light-collecting layer
  - Main site of photosynthesis
sunlight

water travels to the chloroplast by osmosis and the transpiration stream

carbon dioxide diffuses in from air
The Stem

- The stem of a plant has two main roles:
  - Structural support – holding the plant leaves up to light
  - Transport
    - Water and dissolved mineral from roots to the leaves
    - Dissolved sugars from leaves to the roots
    - Stored sugars transported to other parts of the plant
- Depending on the type of plant, stems can be herbaceous (green and flexible) or woody (brown and rigid)
- The cell structures of some of the main tissue types involved are ideal for their role in structural support and transport.
The Stem

- Growth pattern of stems can also vary to make modified stems
  - Stolons: above-ground horizontal stems
  - Rhizomes: underground, horizontal stems
  - Tubers: enlarged storage structure
  - Corms: bulbous underground structure, dormant during winter months
Stem Cross Section

cuticle
epidermis
cortex
pith
vascular tissue

cortex
bark
wood
pith
The Stem: Epidermis

- Like in the leaf, the epidermis is a layer of close-fitting cells that act as a protective barrier.
- In a young green stem, the epidermis is covered by a cuticle and can have stomata for gas exchange.
- When the stems are young and green, the cells contain chloroplasts for photosynthesis.
The Stem: Vascular Tissue

- Part of the continuous conducting network of xylem and phloem
- Depending on if the plant is monocot or dicot, there will be a difference in the distribution of vascular bundles in the stem.
  - If they are scattered, it is a monocot
  - If they are in a ring, it is a dicot
The Stem: Cortex and Pith

- The interior of a plant stem contain ground tissue.
- **Structure**
  - High water pressure inside the cells which maintains turgor pressure.
- **Function**
  - This helps to keep the stem upright.
- **Ground tissue in a dicot stem is split into two parts:**
  - the cortex and the pith. The pith is spongier due to thinner cell walls and more air spaces between cells.
  - The cortex stores food in the form of starch.
  - The pith stores water and small amounts of food.
Phloem
Xylem
Vascular bundle
Pith
Cortex
Ground tissue
Epidermis
Phloem
Xylem
Vascular bundle
Ground tissue
Epidermis
Monocot and dicot stem

(a) Cross section of a eudicot stem

(b) Cross section of a monocot stem
The Root

- The roots' main roles are:
  - **Absorption**
    - Roots absorb water and minerals from the soil
  - **Transport**
    - Roots transport water, minerals, and nutrients to the shoot system
  - **Anchorage**
    - Roots anchor the plant to the soil and preventing erosion
  - **Storage**
    - Roots store food produced from photosynthesis
- Two common types of roots are tap roots and fibrous roots
Root Cross Section
The Root: Nutrient Transport Function

- Nutrient transport:
  - Roots will absorb water for photosynthesis and replace water that has been lost during transpiration.
  - Roots will absorb dissolved minerals and regulate the quantity of these minerals entering the plant.
  - Roots will store food in the form of starch which can then be broken down and transported to other parts of the plant.
  - Root cells can’t photosynthesize and therefore need to obtain glucose from the breakdown of stored starch.
- This can then be used for cellular respiration.
The Root: General Structure

- **Root hairs**: Increase surface area for absorption
- **Zone of maturation**: Cells differentiate for specific functions
- **Zone of elongation**: Cells elongate to extend root tip
- **Meristematic region**: Undifferentiated meristematic cells undergo mitosis
- **Root cap**: Touch layer of cells which protect the meristematic region
The Root: Epidermis

- As with the leaf and stem, the epidermis of roots is a protective layer of close fitting cells.
- However, the epidermis of roots does not secrete a cuticle because a key role of the root is to absorb water and dissolved minerals.
- The epidermis of the root also has specialized cells that produce extensions known as root hairs.
- Root hairs increase the surface area of the root which increases absorption.
The Root: Cortex

- **Structure**
  - Irregularly shaped cells with large vacuoles.
  - Cells are arranged with numerous air pockets between them.
  - Makes up the majority of a dicot root.

- **Function**
  - Storage of starch, which is formed from the carbohydrate molecules manufactured by the leaves.
The Root: Endodermis

Structure
- Close fitting cells that form a thin, flat, continuous layer just inside the cortex of the root.
- Cells are selectively permeable.

Function
- Filters out harmful substances while allowing passage of water and nutrients.
- Controls which minerals get through to the vascular tissue of the plant.
The Root: Vascular Tissue

- The root vascular tissue in a young plant usually starts as a single vascular cylinder containing both xylem and phloem.
- Water and minerals must enter through the root hairs, pass through the cortex, selectively pass through the endodermal cells, before entering into the xylem tissue for transport.
- Phloem
- Xylem
- Epidermis
- Cortex
- Endodermis
- Root hair
- Pith
- Endodermis
- Xylem
- Phloem