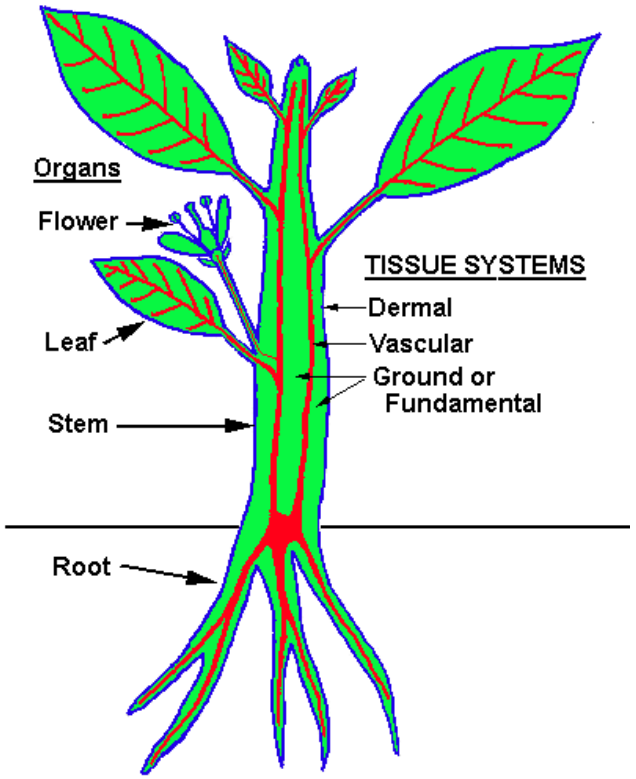
page 3

ORGANS AND TISSUE SYSTEMS IN PLANTS



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PLANT ORGANS, TISSUE SYSTEMS, TISSUES AND CELL TYPES

3 TISSUE SYSTEMS OCCUR IN PLANTS

1) Dermal Tissue System

Function: Protection from the environment and water loss.

Tissues:

a) epidermis - single layer of cells on primary (herbaceous) plant parts.

b) periderm or **bark** - a corky tissue that replaces epidermis on secondary (woody) plant parts.

2) Vascular Tissue System

Function: Conduction of water, nutrients, sugars and hormones throughout the plant.

Tissues:

a) xylem - conducts water and nutrients up roots, stems and leaves.

b) phloem - conducts water, sugar, hormones, etc. down and up roots, stems and leaves; moves from where produced (called **sources**) to where needed (called **sinks**).

3) Ground or Fundamental Tissue System

Function: Storage, support, filler tissue and site of photosynthesis.

Tissues:

a) cortex - outer region of stems and roots.

b) pith - center of stems.

c) mesophyll - middle of leaves and flower petals.

3 BASIC CELL TYPES COMPRISE MOST OF THE TISSUES OF PLANTS

1) parenchyma	• thin, non-lignified primary cell walls • filler, storage, protection, photosynthesis • examples: flesh of potato, lettuce leaf	**parenchyma**  isodiametric
2) collenchyma	• unevenly thickened, non-lignified primary cell walls • support in growing tissues • example: strings in celery stalks	**collenchyma**  longer than wide
3) sclerenchyma **2 Types** **a) fiber** **b) sclereid or stone cell**	• evenly thickened, lignified (tough) secondary cell walls • dead at maturity • support in mature tissue • examples: fiber - bamboo cane sclereid - seed coat stone cell - pear fruit	**fiber** long, slender, pointed on  ends **sclereid or stone cell** multi-shaped, or columnar 

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CELL COMPONENTS

1) cell wall (see next page for structure of primary and secondary cell wall & middle lamella)

- **a) polysaccharide** - a polymer or chain of sugars
  - **1) cellulose** - forms a matrix of microfibrils (chains of **β-1,4-linked glucose**,see below)
  - **2) hemicellulose** - filler between cellulose microfibrils (chains of misc. sugar)
  - **3) pectin** - cementing agent or filler; high in middle lamella and fruit; (chains of galacturonic acid)
- **b) lignin** - tough polymer of phenolic compounds; high in secondary cell wall.
- **c) protein** - mainly structural (most commonly hydroxyproline)

2) plasmalemma or plasma membrane - a double membrane that surrounds the cytoplasm; composed of a bilayer of phospholipids and proteins; it is selectively permeable and regulates absorption into cells and leakage from cells.

3) plasmodesmata - tubular plasma membrane extensions through cell walls that connect adjacent cells.

4) cytoplasm - cytosol plus organelles; most metabolism occurs in the cytosol or its organelles.

- **a) cytosol** - much of the cytoplasm is a water solution of dissolved compounds
- **b) organelles** - specialized structures in cytoplasm, each with specific functions.
  - **1) nucleus** - location of DNA and some of the RNA
    - **a) chromosome** - strands or coils of DNA
    - **b) nucleolus** - spherical, dense body; site of ribosome synthesis.
  - **2) mitochondria** - major site of respiration; called the "power house" of the cell.
  - **3) plastid** - double membrane-bound bodies for storage and photosynthesis
    - **a) leucoplast** - colorless plastids
      - **1) amyloplast** - starch storage (chains of **α-1,4-linked glucose**,seebelow)
      - **2) elaioplast** - fat and oil storage
    - **b) chromoplast** - colored plastids for storage of **carotenoids** (orange and

yellow pigments)

c) **chloroplast** - green plastids that contains **chlorophyll**; site of photosynthesis

4) **endoplasmic reticulum** - tubular membranes for communication across the cytoplasm; site of protein & membrane synthesis

5) **ribosome** - dense spheres of RNA; protein synthesis occurs on their surface

6) **vacuole**- storage of organic acids, salts, **anthocyanins** (blue, red and purple pigments), metabolic wastes, enzymes and metabolites.

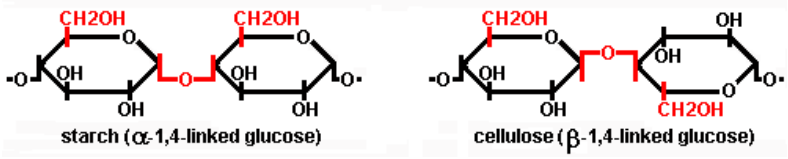
a) **tonoplast** - membrane that surrounds the vacuole

7) **Golgi body or dictyosome** - disk-shaped membranes for membrane and polysaccharide synthesis

8) **microbody** - membrane-bound storage bodies with various functions.

9) **microtubule** - tubular rods used in mitosis and cellulose orientation in cell walls

Structure of starch Vs. cellulose



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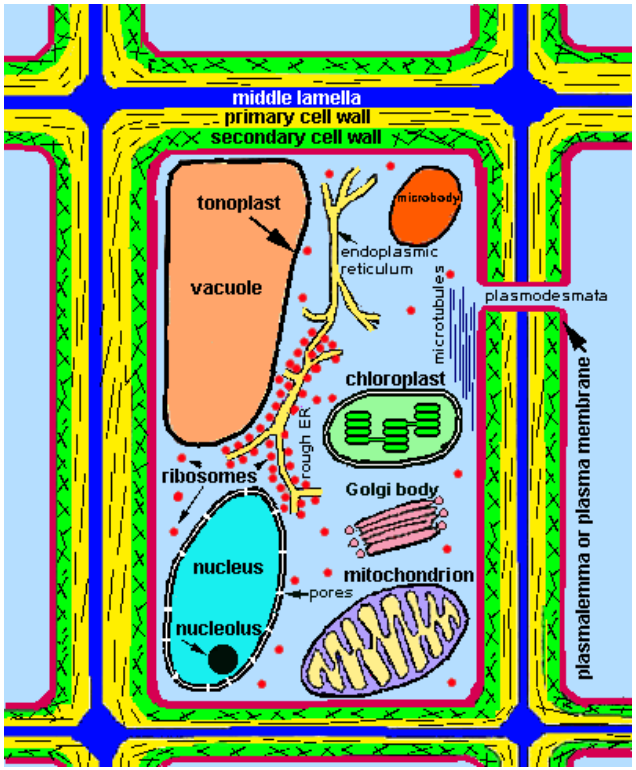
CELL STRUCTURE



Cell Wall

Each cell is surrounded on all sides by the cell wall. The cells of herbaceous tissue (primary tissue) have only the primary cell wall and middle lamella, which are not very rigid. Most of the plant tissue we eat only has primary cell walls. When fruits ripen, the middle lamella breaks down due to pectin digestion, thus the cells slip past each other and the tissue seems softer. The cellulose microfibrils in the primary cell wall are parallel, which allows the cell wall to expand as the cell grows. The cells of woody or wood-like (lignified) tissue possess a secondary cell wall. In the secondary cell wall, the cellulose microfibrils are criss-crossed and are impregnated with lignin, both of which make secondary cell walls very hard and rigid. Generally, only xylem and sclerenchyma (fibers and sclereids) cells have secondary cell walls; all of which are dead at maturity.

Cytoplasm

The cytoplasm is basically a soup of organelles surrounded by the selectively permeable plasmalemma. Plasmodesmata connect the cytoplasm of adjacent cells. The fluid portion is called the cytosol and contains dissolved nutrients, gases (oxygen and carbon dioxide), sugars and other carbohydrates, oil/fat droplets, proteins, enzymes (catalytic proteins), hormones, and all the other components essential for cell metabolism. The metabolic reactions of the cell occur in either the cytosol or the organelles . Each organelle has specific metabolic functions. In addition, many organelles are designed for storage (carbohydrates, proteins, fats, organic acids, pigments, wastes, etc.).

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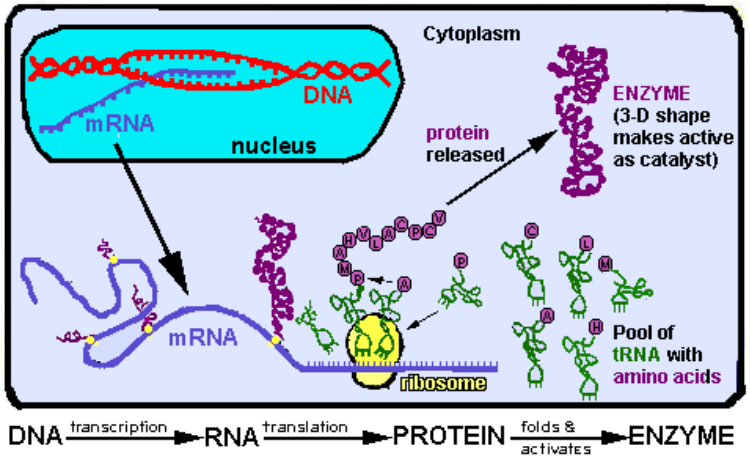
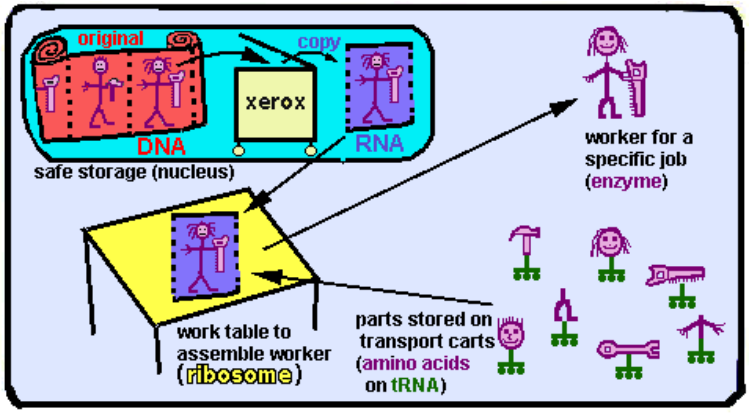
THE GENETIC BASIS OF LIFE



Analogy



DEFINITIONS

DNA (deoxyribonucleic acid) - a double helix chain of sugar-phosphates (deoxyribo sugar-phosphates) connected by nucleic acids (adenine, thymine, guanine, cytosine).

RNA (ribonucleic acid) - a single stranded chain of sugar-phosphates (ribo sugar-phosphates) containing nucleic acids (adenine, uracil, guanine, cytosine).

nucleic Acids - organic acids that form the base pairs of DNA and single-bases of RNA.

Base Pairing of Nucleic Acids between the double strands of DNA

A - T (adenine-thymine)

G - C (guanine-cytosine)

Base Pairing of Nucleic Acids between DNA strands and RNA strands

A - U (adenine-uracil)

G - C (guanine-cytosine)

gene - a length of DNA that codes for the production of a protein or protein subunit,
- also codes for active RNAs (such as tRNA)

protein - a polymer or chain of amino acids.

enzyme - a protein that acts as a metabolic catalyst.

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MERISTEMS AND GROWTH

HOW DO PLANTS GROW?

Plants grow from localized areas called meristems.

meristem - discrete regions or groups of cells that possess continued cell division for the life of the plant or that organ.

PLANTS EXHIBIT TWO TYPES OF GROWTH

1) Primary Growth - growth in length that gives rise to primary (herbaceous) tissues called the primary plant body.

2 Types of meristems give rise to primary growth

a) apical meristem or **apex** - the growing points located at the tips of stems and roots

b) intercalary meristem - the growth region at the base of grass leaves that causes leaves to elongate.

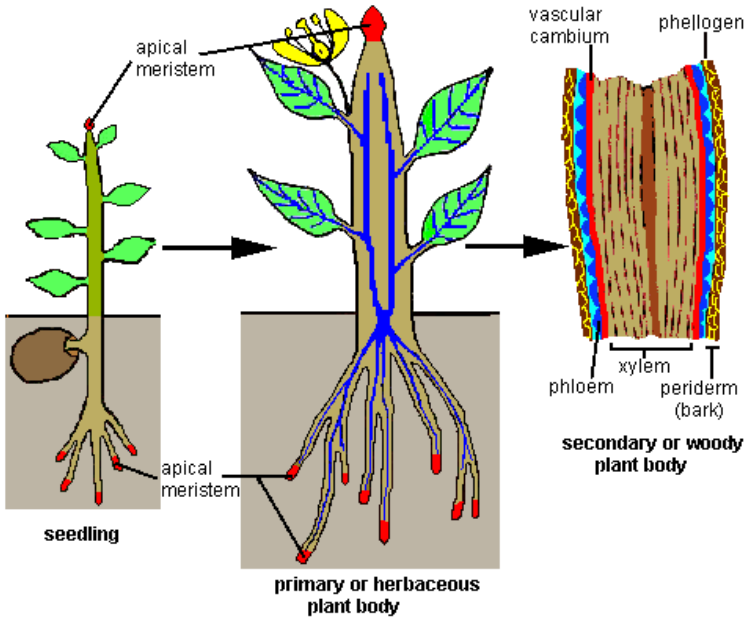
2) Secondary Growth - growth in width or diameter that gives rise to secondary (woody or corky) tissues called the secondary plant body. Secondary growth is due to lateral meristems.

lateral meristem - meristematic regions along the sides of stems and roots.

2 Types of lateral meristems give rise to secondary growth

a) vascular cambium or **cambium** - a sheet-like meristem between the bark and wood along the sides of woody stems and roots; it gives rise to **secondary xylem** (commonly called **wood**) on the inside and secondary phloem on the outside.

b) cork cambium or **phellogen** - gives rise to the **periderm** (commonly called **bark**).



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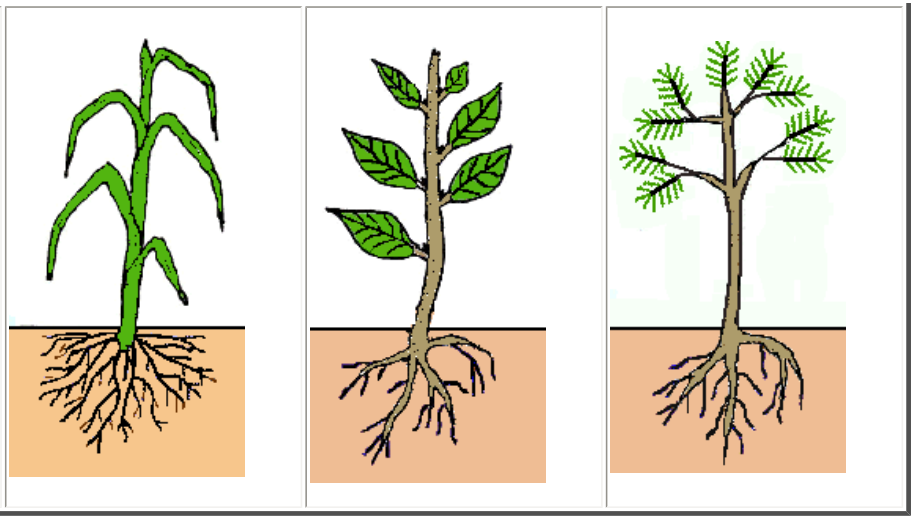
DISTINGUISHING CHARACTERISTICS OF MONOCOTS, DICOTS AND GYMNOSPERMS

Division	**Spermatophyta - seed bearing plants**		
Subdivision	**Angiosperms** (Angiospermae) (flowering plants with seeds enclosed)		**Gymnosperms** (Gymnospermae) (cones with naked seeds)
Class	**Monocots** (Monocotyledoneae) (means 1 cotyledon)	**Dicots** (Dicotyledoneae) (means 2 cotyledons)	
Seeds	1 cotyledon; endosperm often present	2 cotyledons; endosperm often lacking	1 to many cotyledons; no endosperm; female gametophyte tissue present
Flowers	Flower parts in multiples of 3	Flower parts in multiples of 4 or 5	No true flowers
Leaves	Linear; leaf base or petiole (if present) sheathing; parallel venation	Broad; petiole present; net venation	Needle-like or scale-like
Vascular System of Stem	Scattered vascular bundles; no cambium or secondary growth	Ring of vascular bundles in primary growth; cambium present; may have woody secondary growth	Ring of vascular bundles in primary growth; cambium present; may have woody secondary growth
Growth Habit	Herbaceous to wood-like (ex. palm), but no true wood (secondary xylem)	Herbaceous or woody	Herbaceous or woody

General Appearance



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FUNCTIONS OF ORGANS

STEMS

1) **support**; trunk, branches and stems of all plant parts
2) **conduction**; through phloem and xylem
3) **food storage**; ex. Irish potato tubers
4) **protection**; ex. thorns on mesquite
5) **propagation**; ex. bulbs, runners, rhizomes
6) **photosynthesis**; ex. pads (called cladophylls) on cactus

LEAVES

1) **photosynthesis**; site where primarily occurs
2) **regulate water loss**; e.g. by opening and closing stomata
3) **storage**; ex. carbohydrates and water in garlic, aloe vera
4) **support**; ex. tendrils on grape
5) **protection**; ex. spines on cacti; bud scales
6) **attraction**; ex. bracts on poinsettia or dogwood
7) **propagation**; ex. bryophyllum with plantlets on leaves

ROOTS

1) **anchorage**; secures plant to ground or for epiphytes to branches
2) **absorption**; water and nutrients from soil
3) **storage**; ex. sweet potato, carrot, or radish tuberous roots
4) **propagation**; ex. dahlia or sweet potato tuberous roots, blackberry

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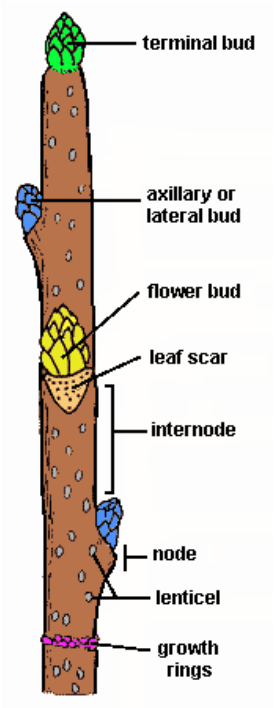
STEM MORPHOLOGY



bud - an underdeveloped and unelongated stem composed of a short axis with compressed internodes, a meristematic apex, and primordial leaves and/or flowers.

terminal bud - a bud at the tip of a stem responsible for terminal growth.

axillary bud or lateral bud - buds along side the axis of a stem; they were produced by the terminal bud during growth; once they grow out and form a lateral stem they become terminal buds of the lateral branch.

flower bud - a bud containing a floral meristem which develops into flowers; usually larger than vegetative buds.

leaf scar - a scar marking the former point of attachment of a leaf or petiole to the stem.

internode - the part of the stem between nodes

node - part of stem marking the point of attachment of leaves, flowers, fruits, buds and other stems.

lenticel - rough areas on stems (and some fruits, ex. apple) composed of loosely packed cells extending from the cortex through the ruptured epidermis; serve as "breathing pores" for gas exchange. Only occur on young stems.

growth rings - bud scale scars from the last terminal bud; they denote flushes of growth (usually per year). Can be used to age stems because usually 1 set of growth rings is produced per year on temperate trees in the Temperate Climatic Zone.

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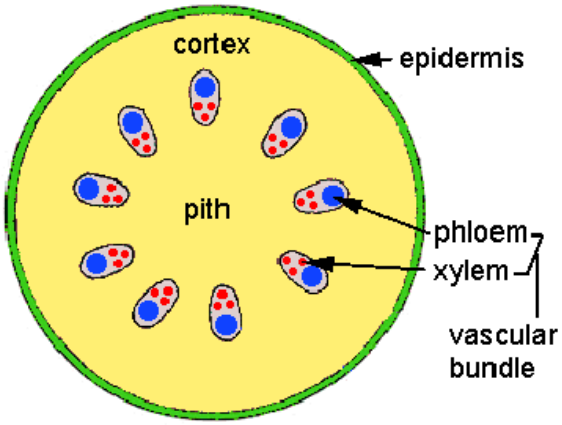
STEM ANATOMY

Herbaceous or Young Woody Dicot or Gymnosperm Stem

Primary Growth

Vascular bundles are arranged as a ring between the cortex and pith. The pith and cortex are usually comprised of parenchyma cells. Inside each vascular bundle, the phloem is orientated towards the outside and xylem towards the inside of the stem. The outer surface is covered by the epidermis.

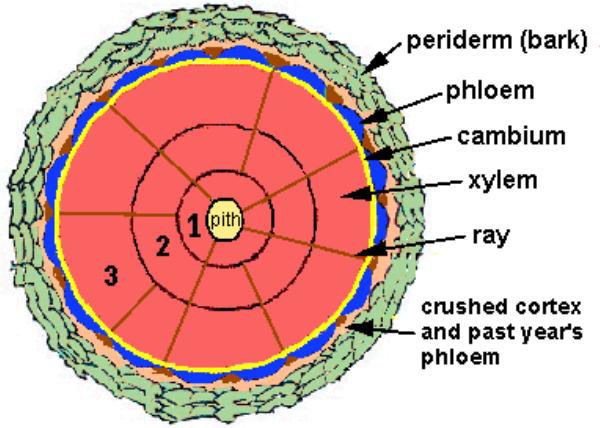


Click for animated version

Woody Dicot or Gymnosperm Stem

Secondary Growth

Remnants of the pith occur in the center, surrounded by rings of xylem (one ring for every year), then the cambium. The phloem is ridged (dilated). Rays transverse the xylem and extend into the phloem (where they dilate). The outer surface is covered by the periderm or bark, which occurs as irregular layers.



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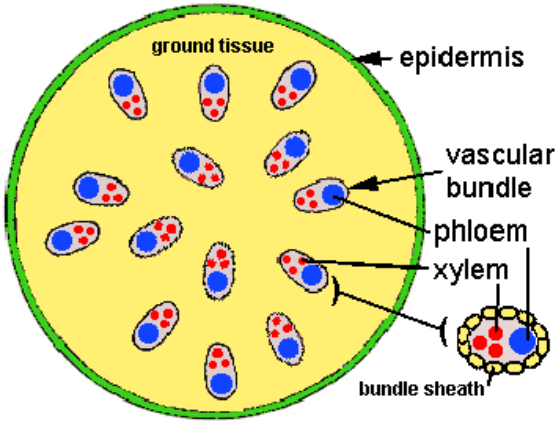
STEM ANATOMY

Monocot Stem

Primary Growth

The vascular bundles are randomly scattered in the ground tissue (usually comprised of parenchyma cells). Each vascular bundle is surrounded by a bundle sheath and contains xylem orientated towards the inside and phloem towards the outside of the stem. The outer layer is epidermis.

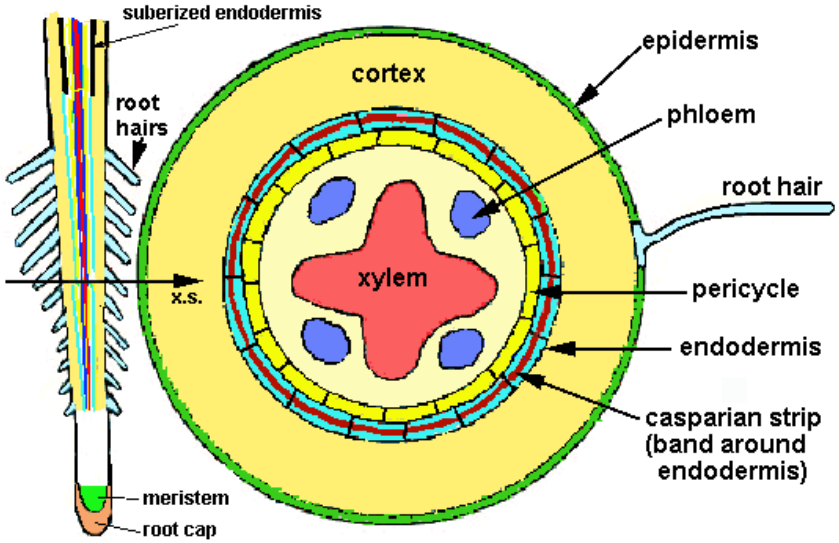


ROOT ANATOMY

Monocot, Dicot or Gymnosperm Root

Primary Growth

Root anatomy is virtually the same for monocots, dicots and gymnosperms. The vascular tissue occurs in the center, which is surrounded by two rings of cells, the pericycle and endodermis, then the cortex and epidermis. The cell walls of the endodermis that are perpendicular to the root surface (i.e. the radial and anticlinal walls) are sealed by a suberized band called the Casparian strip. Root hairs are extensions of the epidermal cells..



Woody Dicot or Gymnosperm Root - Secondary Growth

A woody dicot or gymnosperm root in secondary growth looks almost identical to a stem in secondary growth. Therefore, see Woody Dicot or Gymnosperm - Secondary Growth. The only difference is that the woody root has remnants of the xylem in the center as opposed to pith.

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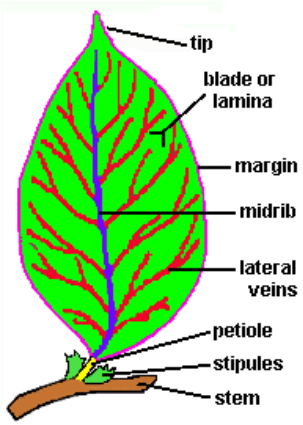
LEAF MORPHOLOGY

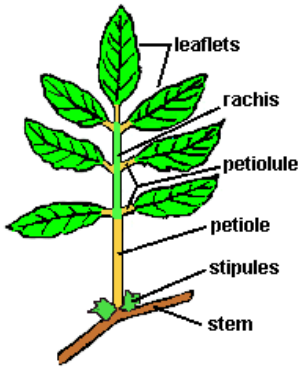


SIMPLE LEAF

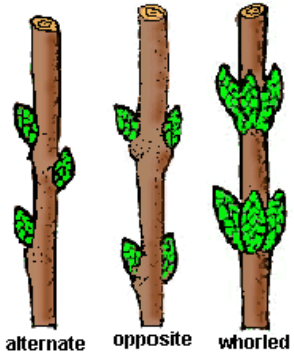
tip - the terminal point of the leaf
blade or lamina - the flattened, green, expanded portion of a leaf.
margin - edge of a leaf.
midrib - the most prominent central vein in a leaf.
lateral veins - secondary veins in a leaf.
petiole - the leaf stalk (connects blade to stem). **stipules** - leaf-like appendages (at the base of petiole of some leaves).

COMPOUND LEAF

leaflet - secondary leaf of a compound leaf.
rachis - an extension of the petiole bearing



leaflets.
petiolule - the leaflet stalk.
petiole - the leaf stalk.
stipules - leaf-like appendages (at the base of the petiole of some leaves).



LEAF ARRANGEMENTS

alternate - one leaf attached per node, usually staggered (spiral) along stem.
opposite - two leaves (a pair) attached per node, usually opposite each other.
whorled - three or more leaves attached per node, usually equally spaced around the node.

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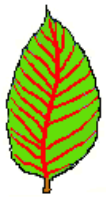
LEAF TYPES

SIMPLE LEAF - blade of the leaf occurs as one unit (i.e. is not divided into leaflets; however, the blade may be highly lobed or indented).

Types of simple leaves based on venation (arrangement of veins)

pinnate venation
feather-like, net venation with lateral veins extending from a central midrib
(dicots - ex. elm, oak)


pinnate venation

palmate venation
finger-like, net venation with several major veins diverging from the union of the petiole and the leaf blade
(dicots - ex. maple)


palmate venation

parallel venation
principal veins parallel to the axis of the leaf
(monocots - ex. grasses).

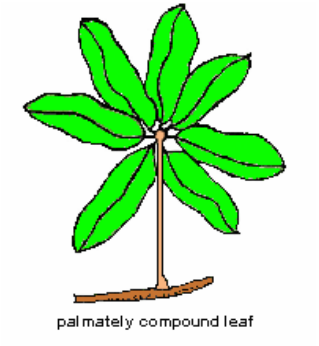

parallel venation

COMPOUND LEAF - the blade of the leaf is divided into individual leaflets.

Types of compound leaves based on arrangement of leaflets

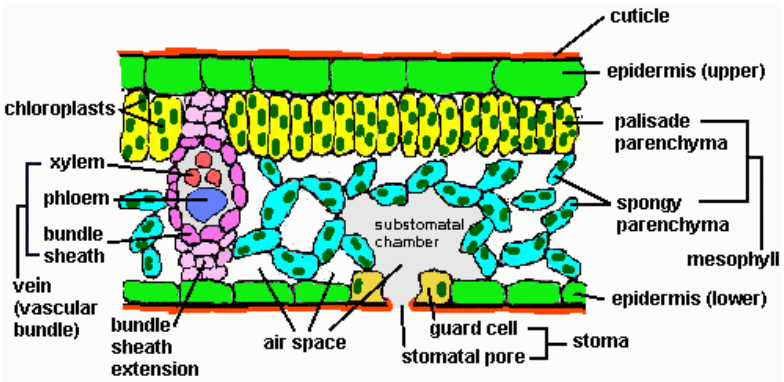
pinnately compound
leaflets arising from along both sides of the rachis (ex. rose, pecan).

palmately compound
leaflets all arising from the same location at the top of the petiole (ex. buckeye, schefflera, poison ivy, bean).



LEAF ANATOMY

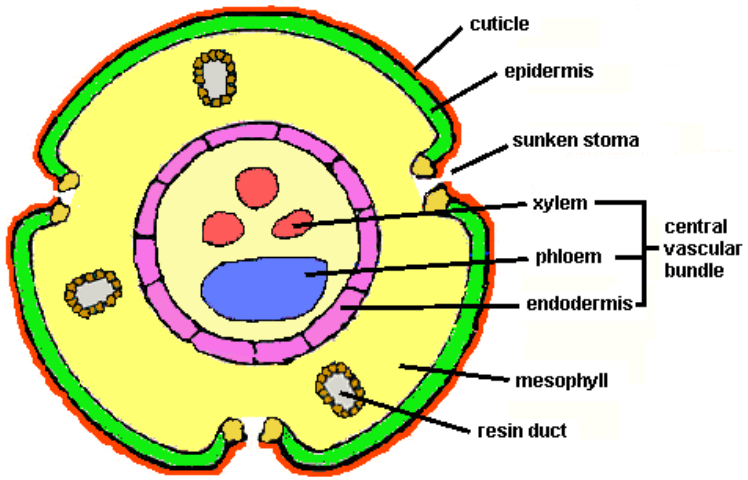
Dicot Leaf



Monocot Leaf

A monocot leaf is similar to a dicot leaf, except monocot leaves have no palisade and the mesophyll is all spongy parenchyma.

Gymnosperm Leaf (pine needle)



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FUNCTION OF LEAF PARTS

STOMATA

stoma - an open aperture (the **stomatal pore**) in the epidermis surrounded by two **guard cells**.
stomata - plural
a) Usually more frequent on epidermis of lower leaf surface.
b) Found on some herbaceous stems, fruits and petals..

Mechanism of Opening

a) open when guard cells are turgid (due to water uptake in response to potassium influx)
b) closed when guard cells are flaccid (due to water loss in response to potassium efflux)

Daily Cycle

C-3 and C-4 Plants
a) open during day
b) closed during night
CAM Plants
a) open during night
b) closed during day

Designed for gas exchange

a) CO_2 in and 0_2 out for photosynthesis
b) CO_2 out and 0_2 in for respiration
c) H_20 out during transpiration

MESOPHYLL

Palisade parenchyma
a) Contains 70-80% of the chloroplasts in the leaf.
b) Specialized for photosynthesis - because it contains a large number of chloroplasts and it occurs towards the top side of leaf
Spongy mesophyll
a) Contains large air spaces
b) Specialized for gas exchange - because of the large air space and more stomata occur in the epidermis of lower leaf surface

Sun Grown Leaf

a) thicker, due to thicker palisade parenchyma layer

Shade Grown Leaf

a) thinner, due to thinner palisade parenchyma, therefore, higher proportion of spongy mesophyll
b) larger size
c) softer and more pliable

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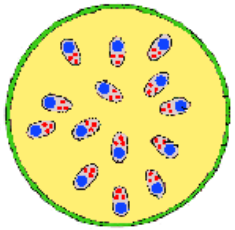
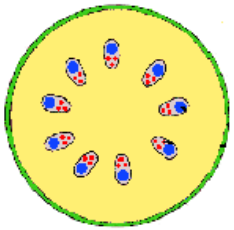
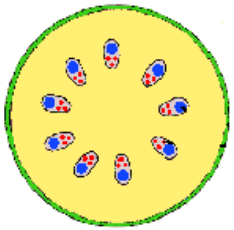
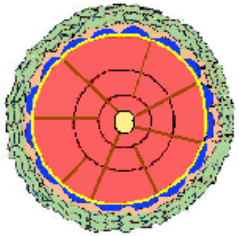
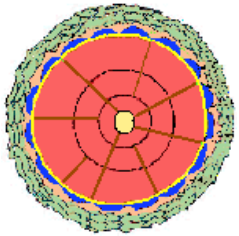
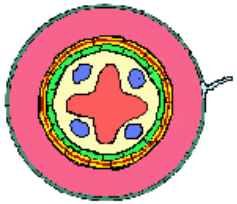
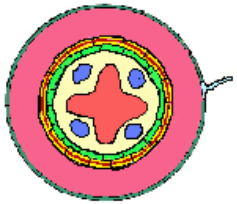
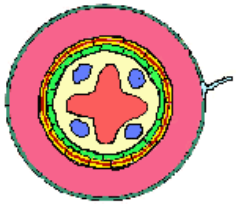
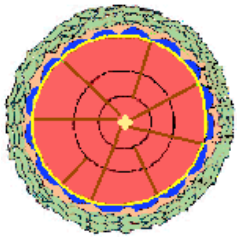
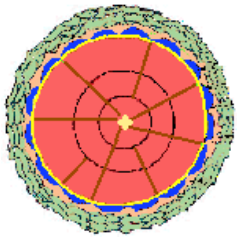
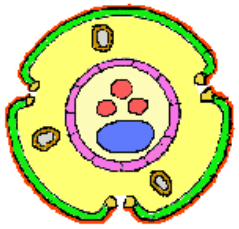
SUMMARY OF ANATOMY

	MONOCOT	DICOT	GYMNOSPERM
STEM primary growth			
STEM secondary growth	**does not exist**		
ROOT primary growth			
ROOT secondary growth	**does not exist**		
LEAF primary growth			
LEAF secondary growth	**does not exist**	**does not exist**	**does not exist**

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FLOWERS, FLOWER TYPES, FRUITS AND SEEDS

FLOWER MORPHOLOGY

flower - the reproductive organ of higher plants (e.g. angiosperms or flowering plants), which contains at least 1 female reproductive part, the pistil, and/or 1 male reproductive part, the stamen.

Flower Types

complete - contains all floral parts, i.e. sepal, petal, stamen and pistil
incomplete - lacks one or more of the floral parts
perfect - contains both pistil and stamen (may or may not have sepal or petal)
imperfect - lacks either pistil or stamen (may or may not have sepal or petal)
- **pistillate** (female) - contains only pistil (may or may not have sepal or petal)
- **staminate** (male) - contains only stamen (may or may not have sepal or petal)

sterile - both stamen and pistil are absent, or are non-functional

Plant Types Based on Flower Type Present

monoecious - both staminate (male) and pistillate (female) flowers occur on the same plant; ex. corn, cucumber
dioecious - staminate (male) and pistillate (female) flowers occur on separate plants; ex. holly, persimmon, ginkgo

FRUIT MORPHOLOGY

fruit - a ripened or matured ovary and its contents plus any accessory tissues.

pericarp - the fruit wall, which developed from the ovary wall
Composed of 3 layers:
1) exocarp - outer layer of the pericarp
2) mesocarp - middle layer of the pericarp
3) endocarp - inner layer of the pericarp.

SEED MORPHOLOGY

seed - a ripened or matured ovule consisting of an embryo with associated stored food and covered by a **testa.**
testa - protective, outer most layer of seeds; commonly called **seed coat**.

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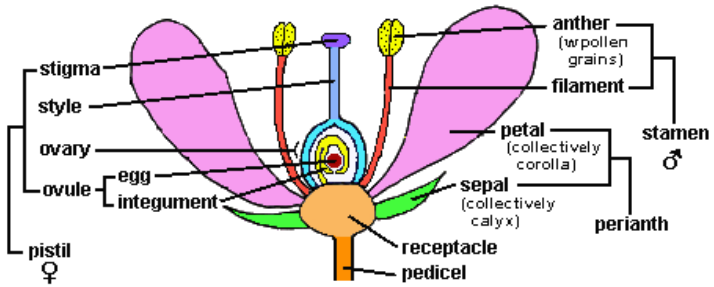
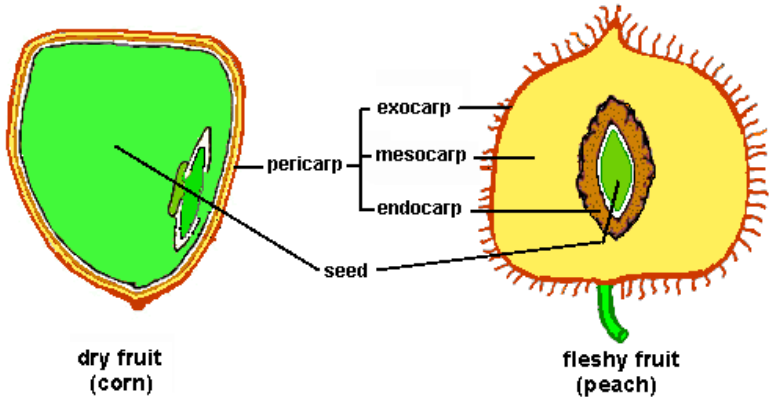
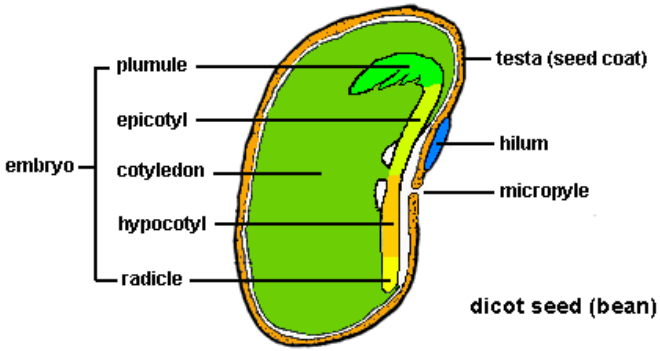
FLOWER STRUCTURE



FRUIT STRUCTURE



SEED STRUCTURE



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