Botany / Horticulture

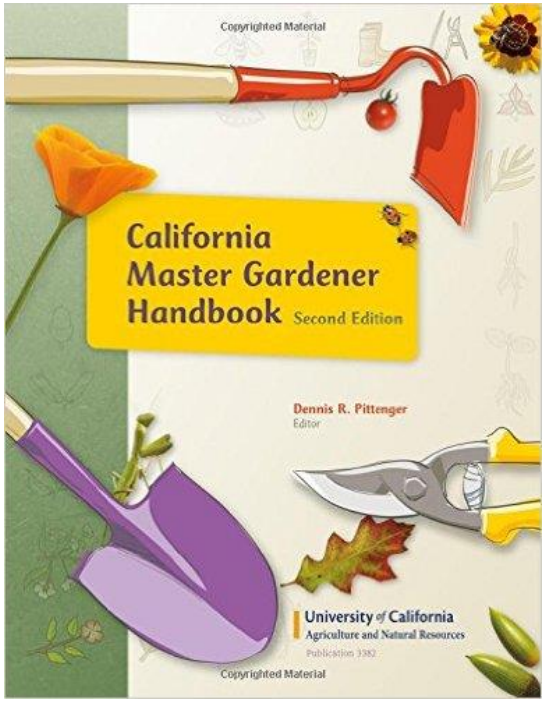
- Botany is the study of plant structure, function and physiology.

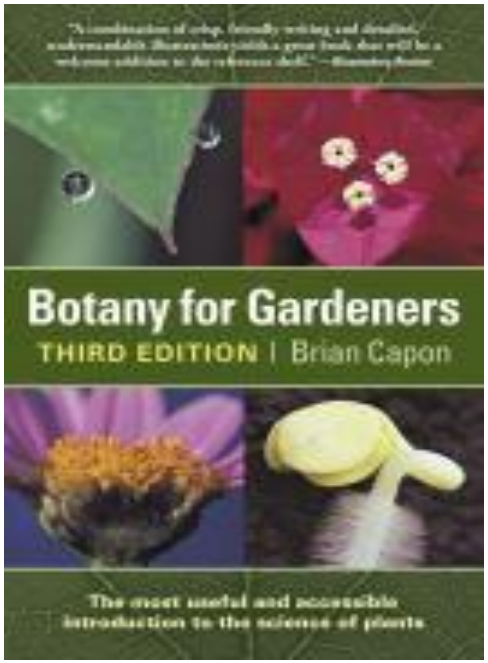
- Horticulture is applied science because it uses basic science principles, largely from Botany, to develop practical technologies.

Botany / Horticulture

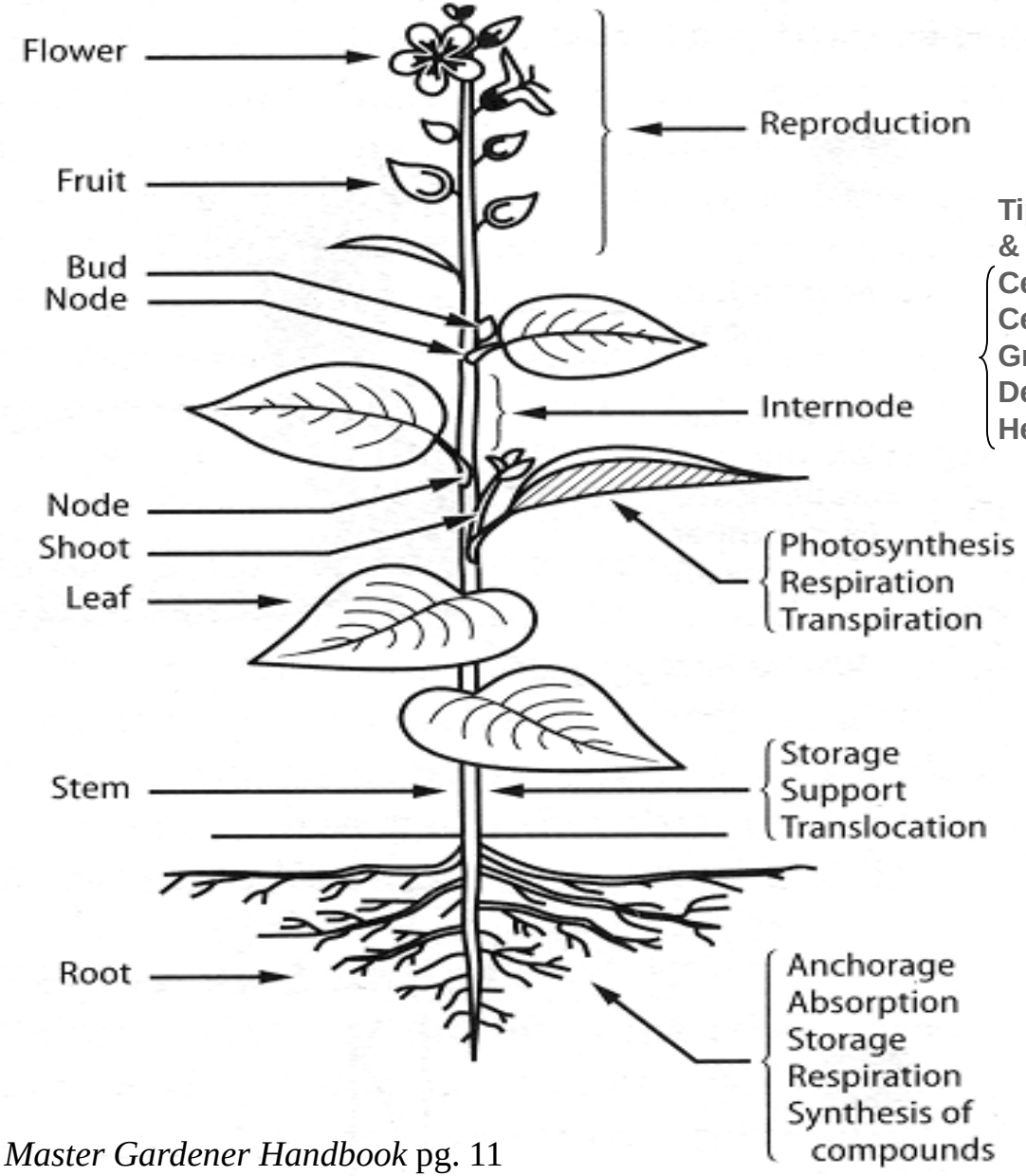
- Plant cells
- Meristems
- Growth & Development
- Roots
- Shoots & Stems
- Leaves
- Flowers, Fruits, Seeds
- Classification

References used





Important structures and functions of a seed plant.



Meristems
Tips of roots & stems
& Cambium in stems
Cell division
Cell reproduction
Growth
Development of new tissue
Healing

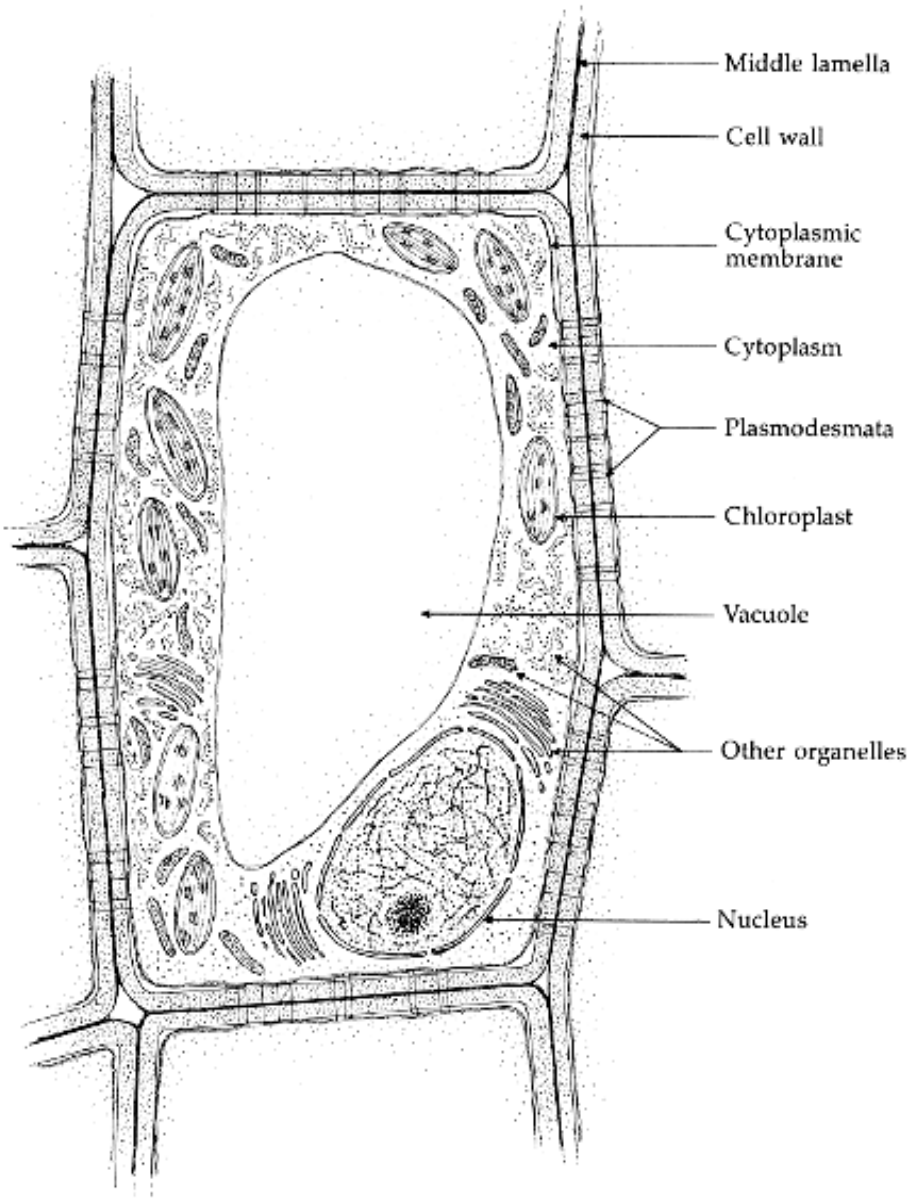
From *California Master Gardener Handbook* pg. 11

Plant Cell

Water 85-90%, minerals 1-2%, organic compounds 10-15%

Components:

- Cell Wall - selectively permeable membrane
- Plasma membrane - barrier to chemicals
- Vacuole - contains stored water, some minerals
- Nucleus - genetic material, controls cellular operations and reproduction
- Plastids - includes chloroplasts (photosynthesis)
- Mitochondria - site of respiration



Details of a plant cell.

Diagram from *Botany for Gardeners* by Brian Capon

Cells

- Division – occurs only in meristems
- Elongation – cells lengthen
- Walls thicken
- Cell types- Some function alive, some dead
  - Parenchyma – undiffererentiated cells
  - Epidermal – secrete protective layer, cutin, cuticle
  - Sclerenchyma – (dead) fibers and sclereids
  - Collenchyma – (live) thickened, primary walled, flexible support (e.g. leaf petiole)
  - Xylem – (dead) tracheids, vessel elements
  - Phloem – (live) sieve tubes, companion cells

Meristems

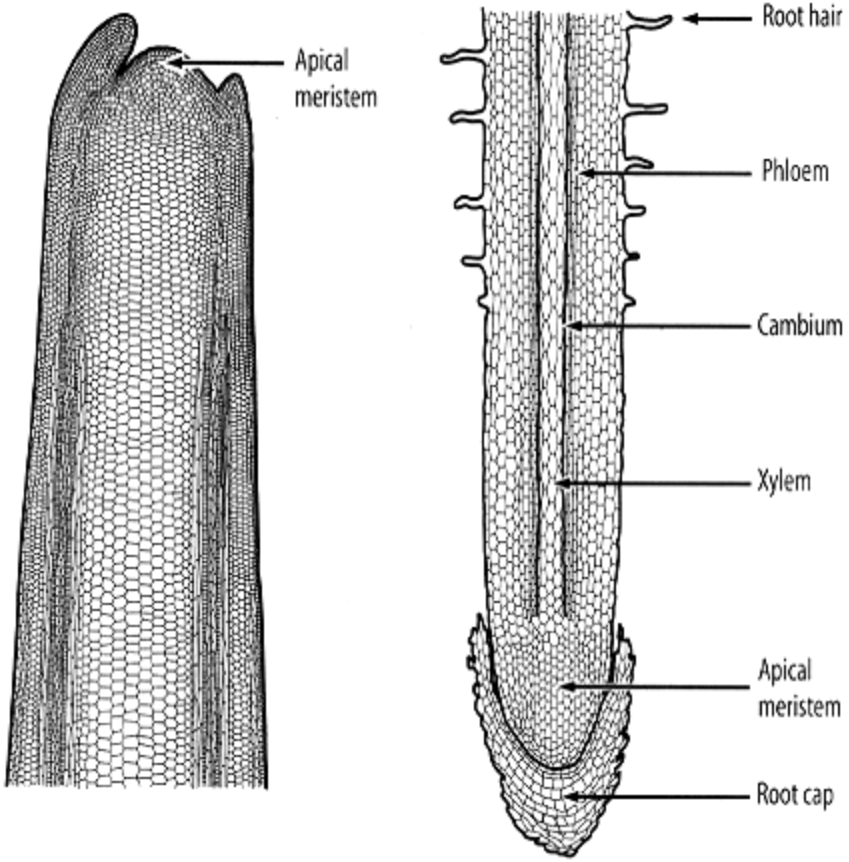
Function: cell division, cell reproduction, growth, new tissue, healing

- Regions of active growth
- Apical - primary growth in root & shoot
- Lateral - secondary growth, thickening
- Intercalary - elongation in monocots
- Basal - monocots
- Marginal - leaf expansion

Apical Meristems:

- *Tips of shoots and roots*
- *Primary Growth - cell division, enlargement, elongation*

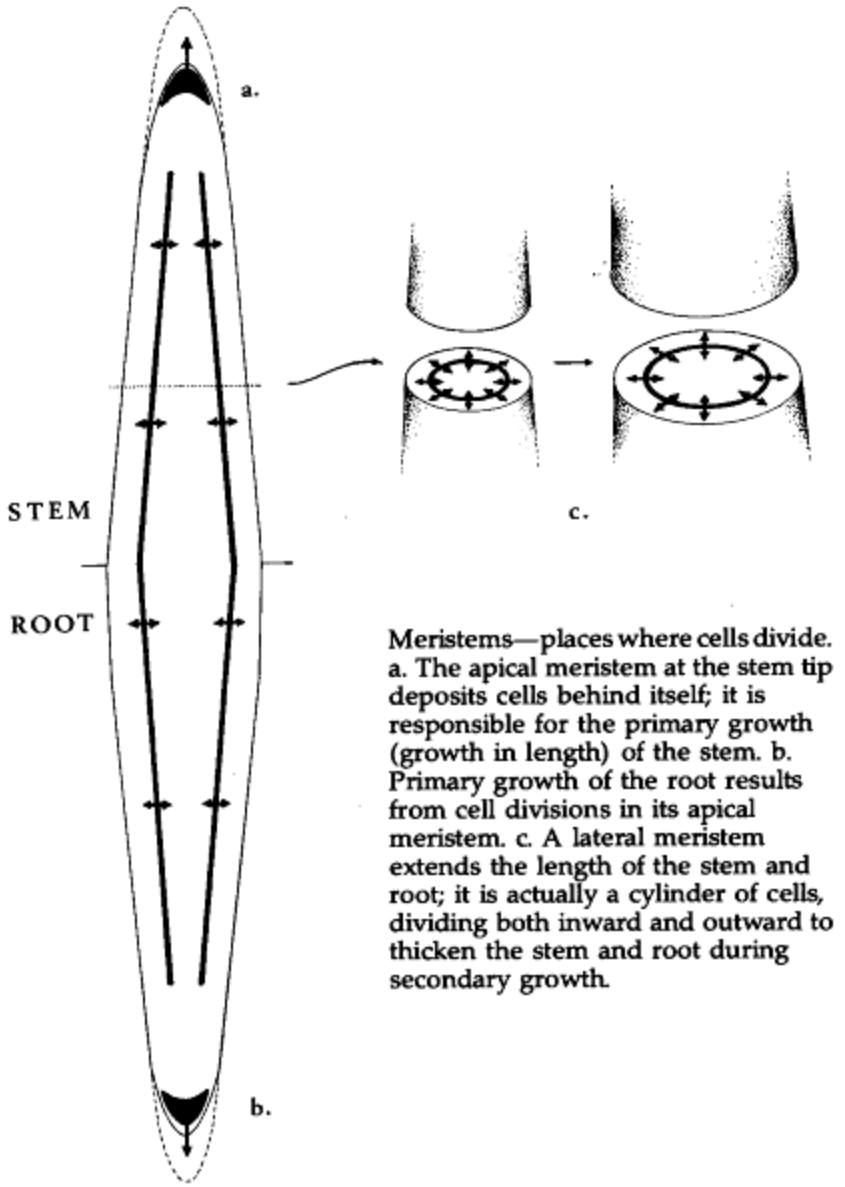
Apical meristems of shoots and roots. The shoot apical meristem (left) and root apical meristem (right) are involved in the formation of new cells via cell division and in plant growth via cell enlargement. Note that the root apical meristem is not at the very tip of the root but instead is protected by the root cap.



From *California Master Gardener Handbook* pg. 13

Lateral Meristems:

- *Vascular Cambium & Cork Cambium*
- *Secondary Growth – thickening of stems & roots*



Meristems—places where cells divide. a. The apical meristem at the stem tip deposits cells behind itself; it is responsible for the primary growth (growth in length) of the stem. b. Primary growth of the root results from cell divisions in its apical meristem. c. A lateral meristem extends the length of the stem and root; it is actually a cylinder of cells, dividing both inward and outward to thicken the stem and root during secondary growth.

Diagram from *Botany for Gardeners* by Brian Capon

Roots

Function: Absorb, Anchor, Store, Respire, Synthesis of Compounds

- Most plants have 80% of roots in top 2’-3’ of soil
- Root growth, like stems is primary & secondary; division, elongation, thickening w/ Root cap
- Absorption of water & minerals
- Anchoring; Fibrous vs. Tap
  - Secondary growth provides strength & support
  - Buttress and prop roots, aerial roots
- Storage; tuberous roots, modified roots

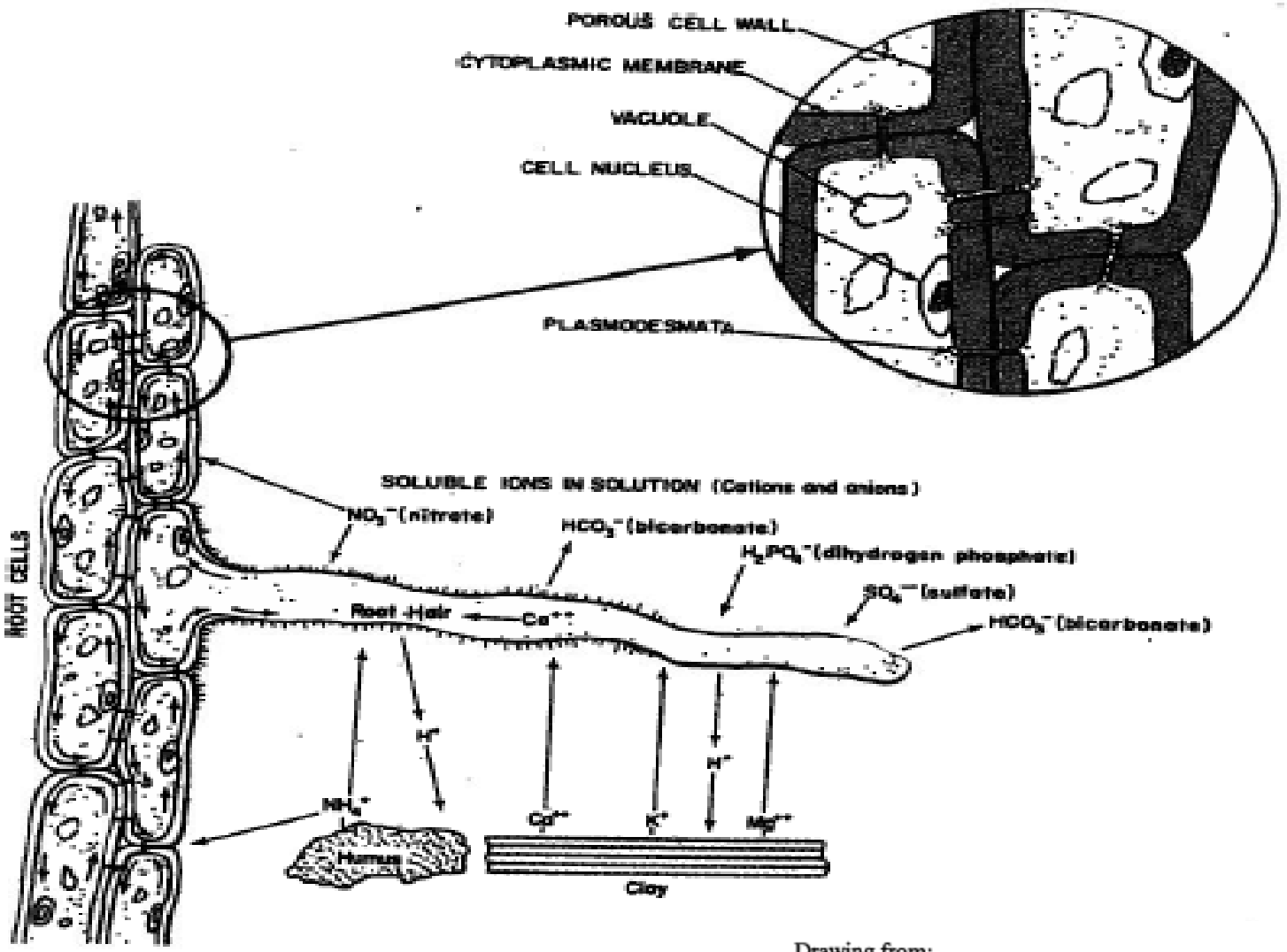
Roots – Absorption & Synthesis

- Root hairs & mycorrhizae absorb H_2O and minerals
- Rhizobium nodules assist nitrogen conversion, N_2 to NH_4 plants can absorb
- Concentration gradient, osmosis
- Root pressure, oozing after pruning and guttation
  - See other handout page 1-3, 12

Well developed root hairs, as on this radish seedling, absorb most of the water that enters the root. New root hairs are formed toward the growing root tip, while older hairs die back at the top of the root hair zone.

Photo from *Botany for Gardeners* by Brian Capon

Root Structure and Nutrient Absorption from Soil

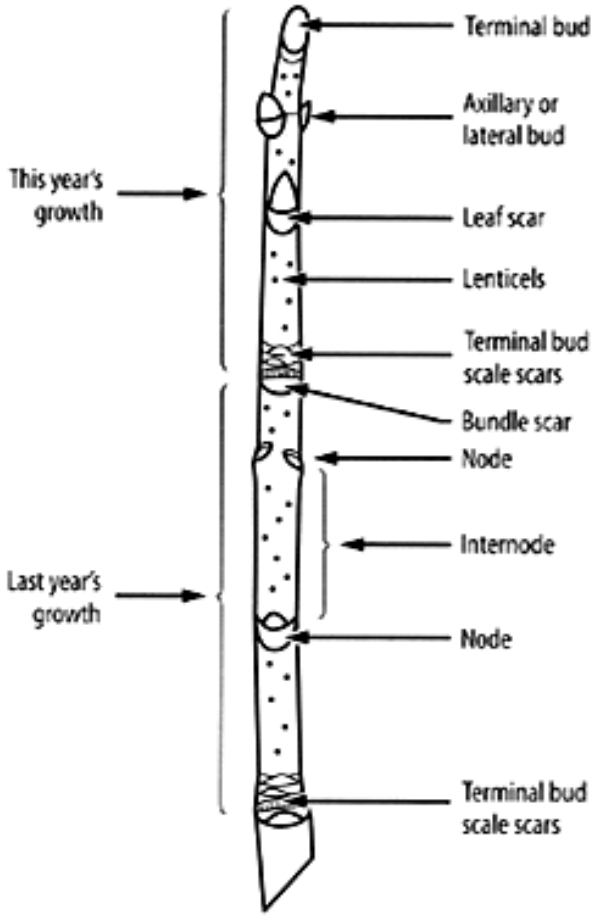


Drawing from:
Soils An Introduction to soils and Plant Growth, Fifth edition
By R.L. Donahue, R.W. Miller, J.C. Shickluna
Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632
Page 212

Stems and Shoots

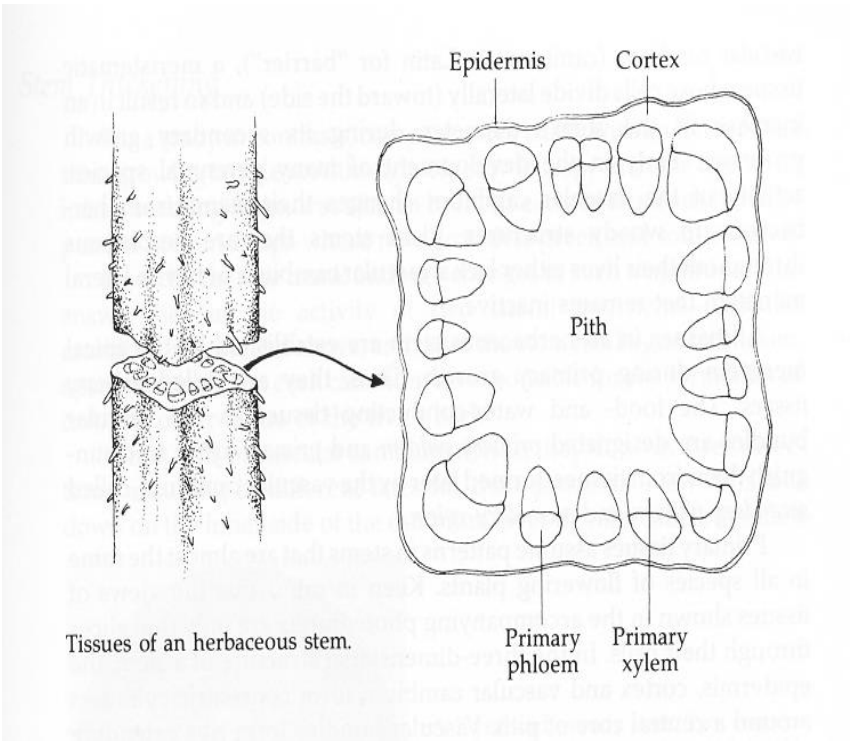
Function: Support, Storage, Translocation or Movement of Water & Food

- Parts:
  - Buds
  - Nodes, Internodes
  - Vascular Tissue
    - Phloem – photosynthetically produced food from leaves
    - Xylem – water and minerals from roots
    - Cambium
  - Epidermis & Bark



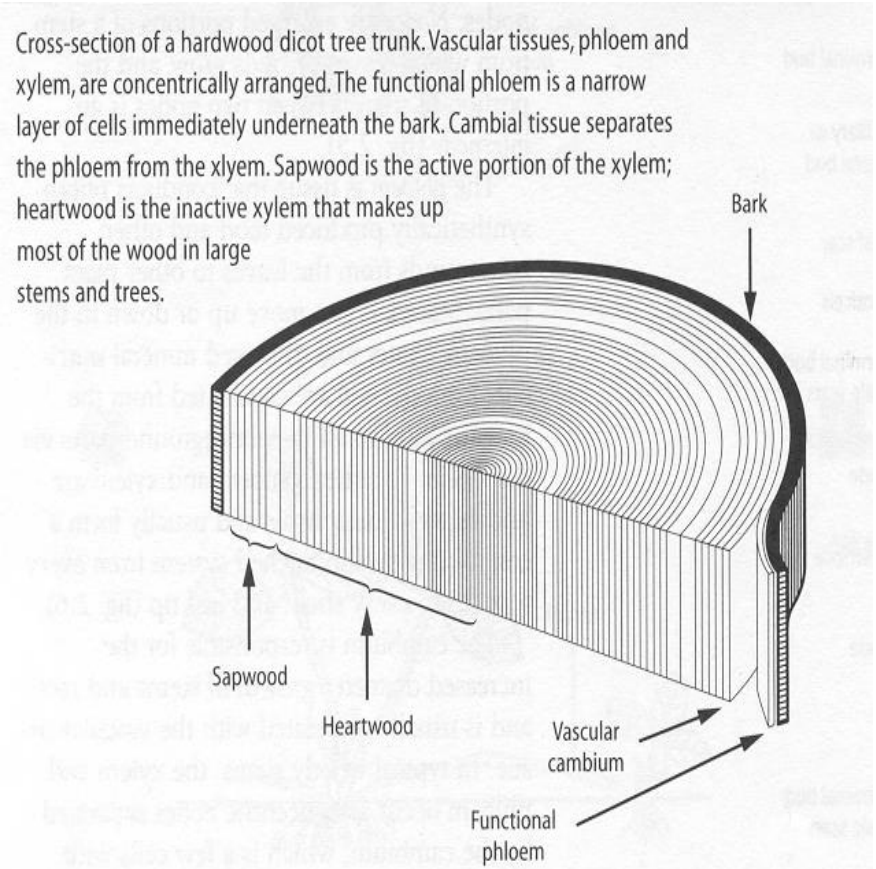
From *California Master Gardener Handbook* pg. 9

Herbaceous vs. Woody Stems



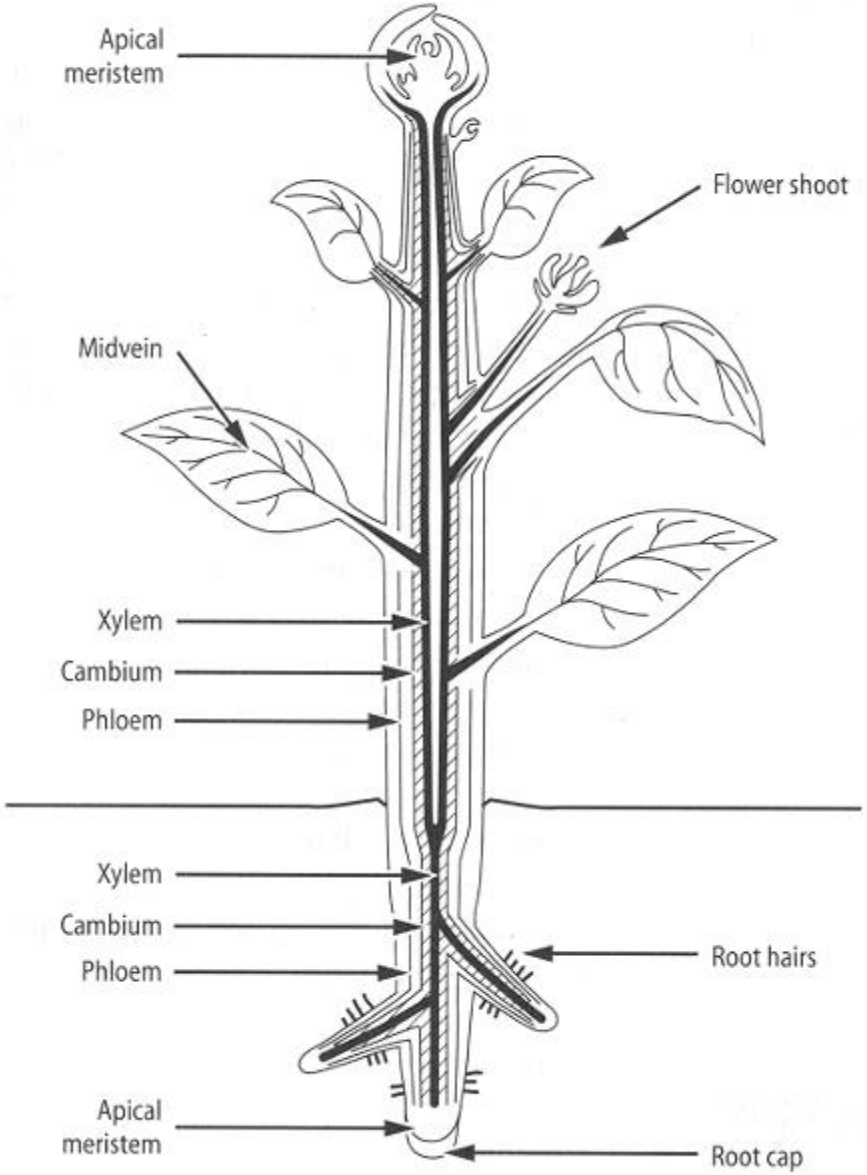
Tissues of an herbaceous stem.

Diagram from *Botany for Gardeners* by Brian Capon

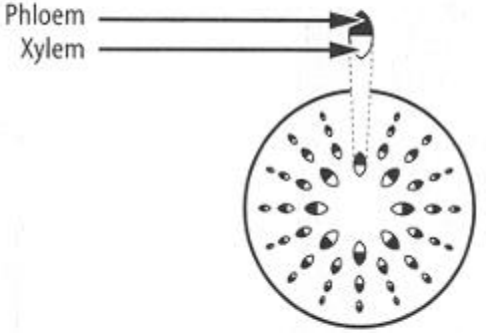


From *California Master Gardener Handbook*

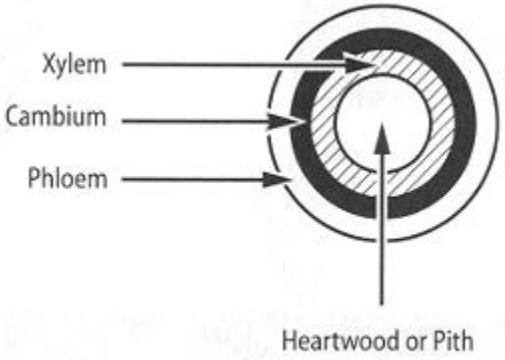
Vascular tissues are continuous from the root tips to the shoot tips. They are organized differently in monocots and dicots.



VASCULAR SYSTEM OF A MONOCOTYLEDONOUS STEM



VASCULAR SYSTEM OF A DICOTYLEDONOUS STEM



From *California Master Gardener Handbook* pg. 10

Leaf

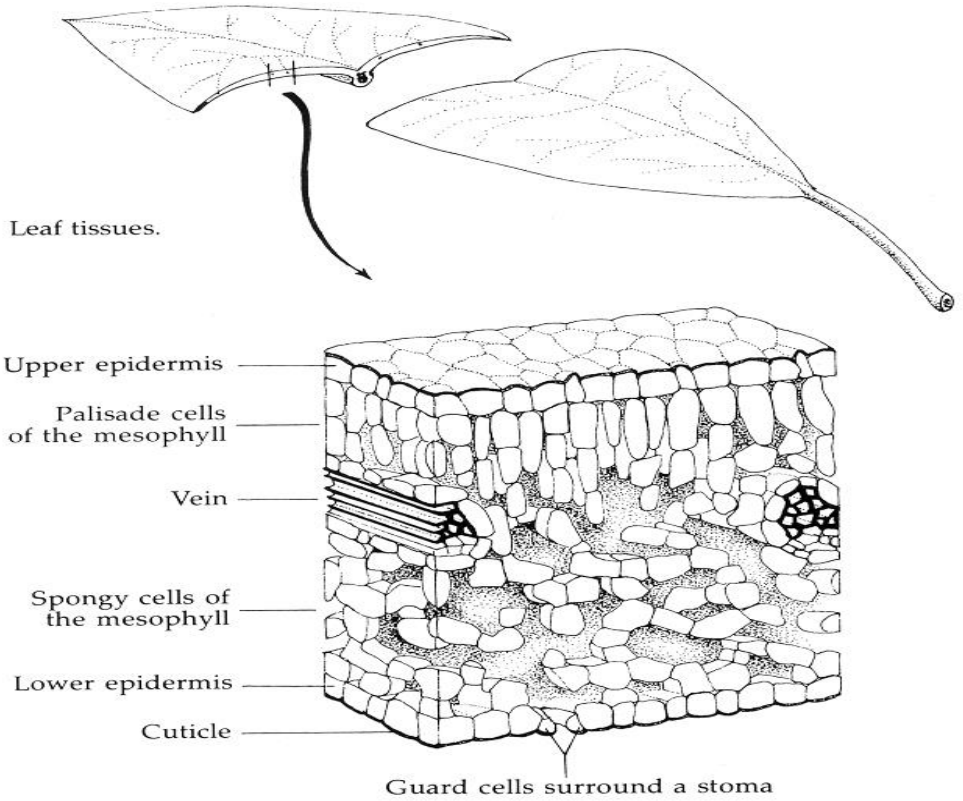
Function: Collect light, Gas Exchange- CO_2 , O_2 , H_2O, Photosynthesis, Respiration, Translocation of water & food

- Parts: cuticle, upper epidermis, palisade parenchyma, vascular tissue, xylem & phloem, spongy mesophyll, lower epidermis, stomates, including guard cells and stoma
- Bud placement
- Venation
- Simple or compound

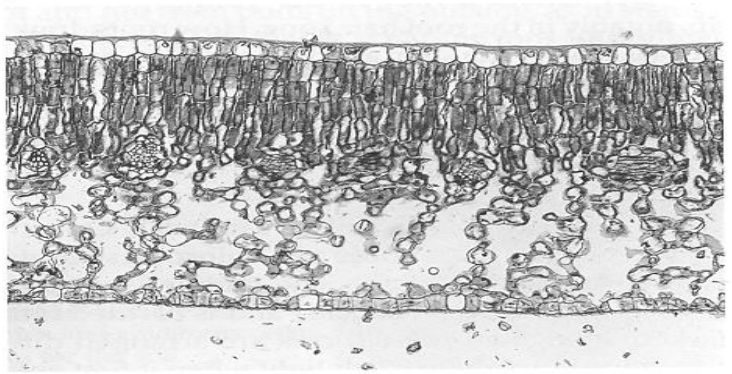
Leaf

Parts

- Cuticle
- Upper Epidermis
- Palisade parenchyma
- Vascular tissue, xylem and phloem
- Spongy mesophyll
- Lower Epidermis
- Stomata, including guard cells and stoma



The anatomy of a leaf. Tissues may be identified by comparing the photograph with the above diagram.



Taken from *Botany for Gardeners* by Brian Capon

Photosynthesis & Respiration

- The Process by which green plants produce their own carbohydrates, or nutrients,
  and obtain a source of chemical energy.

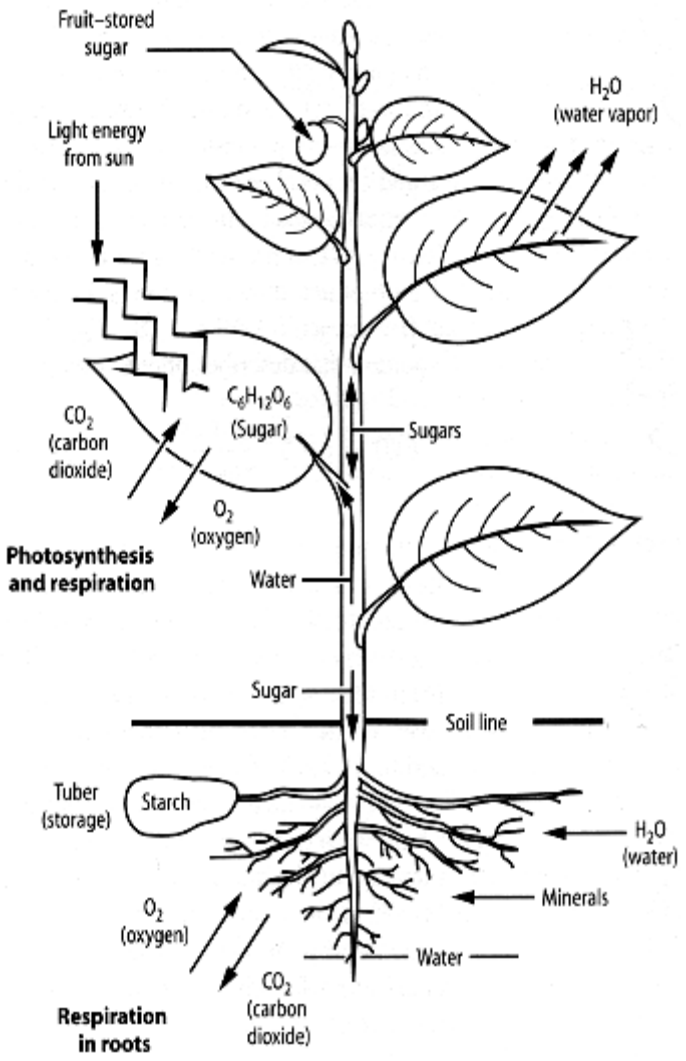
Photosynthesis: ⟶

- $6CO_2 + 6H_2O \xrightarrow{\text{Light \& Chlorophyll}} C_6H_{12}O_6 + 6O_2$
  Carbon dioxide Water Carbohydrate Oxygen
  (energy taken in and stored)

Respiration: ⟵

- $6CO_2 + 6H_2O \xrightarrow{\text{enzymes}} C_6H_{12}O_6 + 6O_2$
  Carbon dioxide Water Carbohydrate Oxygen

  (energy is released from reaction)



Leaf

- Bud position:
  - Apical
  - Lateral
  - Axillary
- Bud arrangement:
  - Alternate – 1 per node
  - Opposite – 2 per node
  - Whorled – many per node
- Leaf venation:
  - Parallel
  - Pinnate
  - Palmate
- Entire (simple) or Divided (compound)
  - Pinnate
  - Palmate
  - Compound

Modified Plant Parts

- roots
- stems
- leaves

Modified Roots

- Tuberous roots – storage, survival, propagation
- Arial roots – water absorption from air
- Prop roots - support
- Root nodules – nutrient collection
- Lignified roots – resistance to drought
- Adventitious roots – climbing

Modified Stems and Leaves

- Underground rhizomes, Tuberous stems
- Stolons, runners
- Bulbs, Corms
- Pineapple
- Spines, Tendrils, Hostoria
- Stems for water storage and photosynthesis

Root-like Modified stems:
Underground Stem – Rhizome

Lab break – Roots

Function: Absorb, Anchor, Store, Respire, Synthesis of Compounds

- Tap roots vs. fibrous roots, healthy or not
  - Economic uses: food, erosion control
- Root nodules, observe clover, nitrogen fixing bacteria
- Storage, modified roots/stem
- Why would the type of root matter for weed control?

Lab break – stems and wood

Function: Support, Storage,
Translocation or Movement of Water & Food

- Wood cuts- Look for :
  - ✓Heartwood vs. sapwood, branching
  - ✓Xylem, phloem, cambium
  - ✓Yearly growth rings
  - ✓Healing of wounds

- Compare monocotyledon vs. dicotyledon

Lab break – stems and wood

Function: Support, Storage,
Translocation or Movement of Water & Food

- Demo of transpiration & translocation of H_2O
  - ✓ Observe Celery under microscope
  - ✓ What is the colored tissue?
- Apple (pome) twigs & Peach (stone fruit) twigs
  - ✓ Look for : apical bud, leaf bud, fruit bud, nodes, internodes, leaf scar, bud scar, yearly growth
  - ✓ Look for: patterns of growth over several years
  - ✓ How many years old is the piece you have?

Ref: See MG handbook pages 468-472

Lab break – leaves

Function: Collect light, Gas Exchange - CO_2 , O_2 , H_2O, Photosynthesis, Respiration, Translocation of water & food

Observe leaf types:

- Bud position:
  - Apical
  - Lateral
  - Axillary
- Bud arrangement:
  - Alternate – 1 per node
  - Opposite – 2 per node
  - Whorled – many per node
- Leaf venation:
  - Parallel
  - Pinnate
  - Palmate

Type of leaf division

- Entire (simple) or Divided (compound)
  - Pinnate compound
  - Palmate compound
  - Multiple Compound

Lab break – leaves

Function: Collect light, Gas Exchange - CO_2 , O_2 , H_2O, Photosynthesis, Respiration, Translocation of water & food

- Leaf adaptations (aralia, rosemary, pine, succulent)

  What are the advantages of each type of leaf for…

  - ✓ Light collection
  - ✓ Water loss or retention
  - ✓ Resistance to freezing

- Some plants have different shaped leaves at different life stages, what advantage might this provide plant?

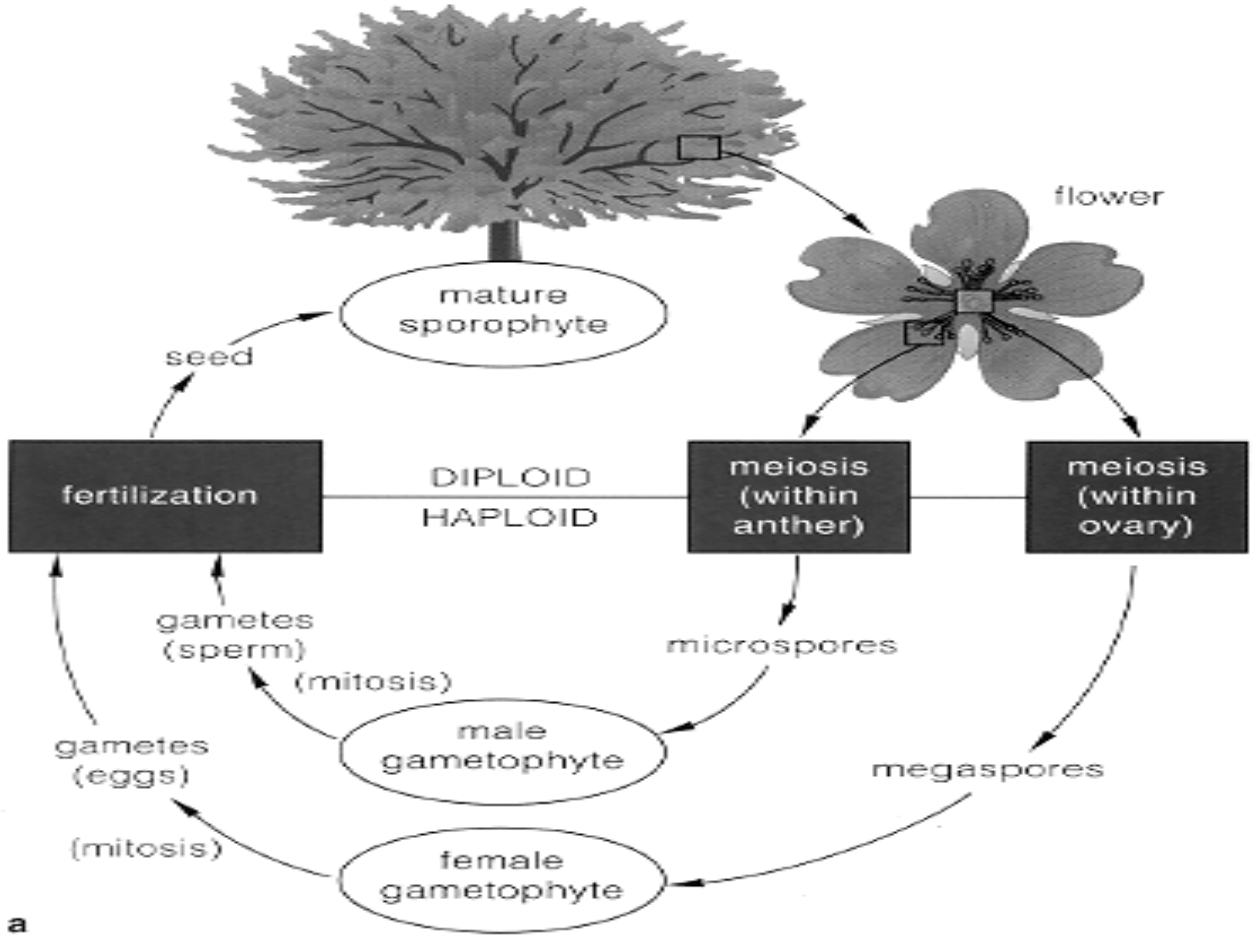
Flowers, Seeds, Fruits

Function: genetic mixing, dispersal, survival

- Flowers - pollination, genetic mixing, seed
- Seeds - genetic dispersal, survival, growth
- Fruits - embryo protection, dispersal

Flowers

Reproduction – facilitate pollination, genetic mixing



Diagrams from *Plant Structure and Function* by Cecie Starr and Ralph Taggart

Flower Parts

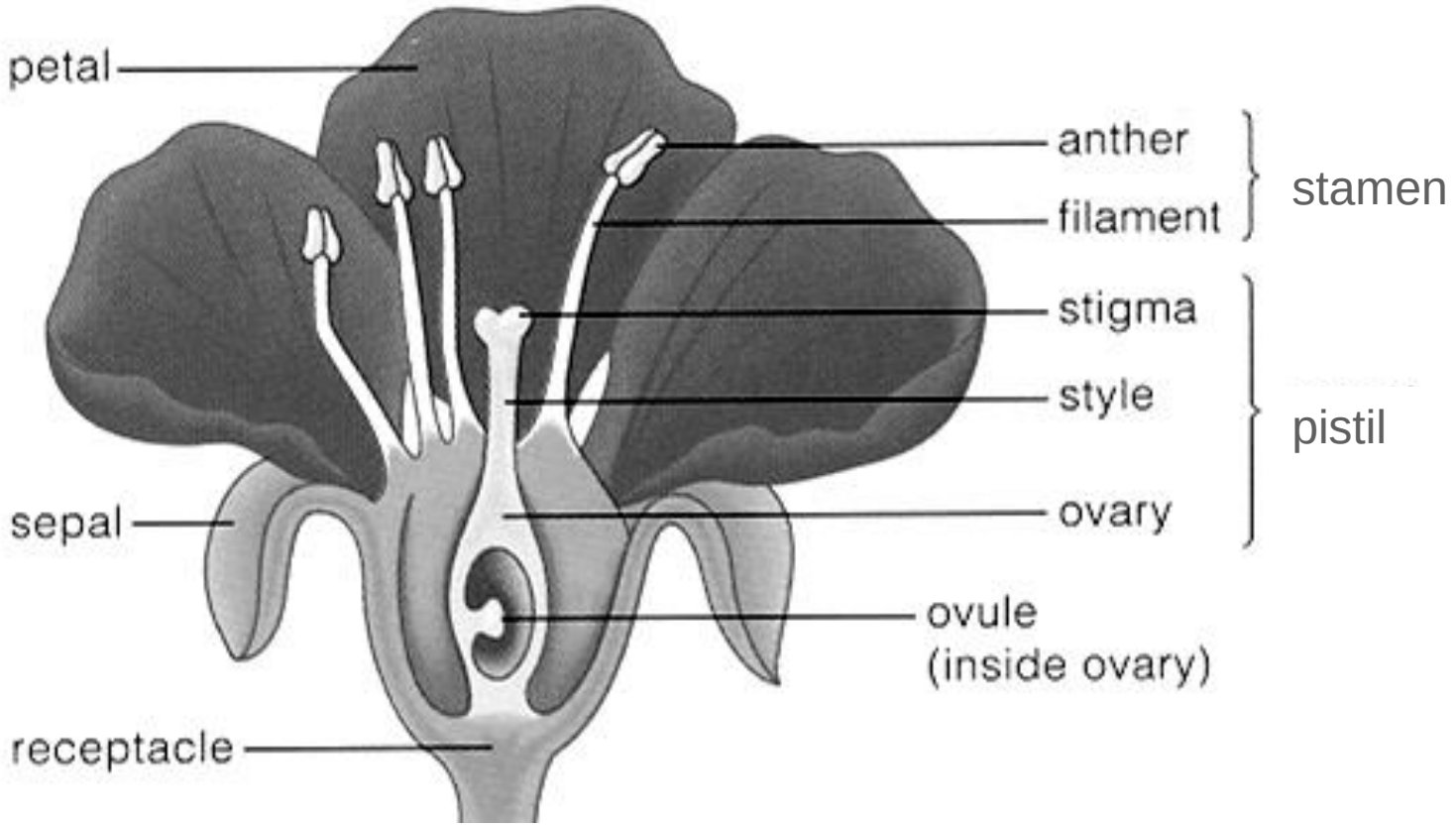


Diagram from *Plant Structure and Function* by Cecie Starr and Ralph Taggart

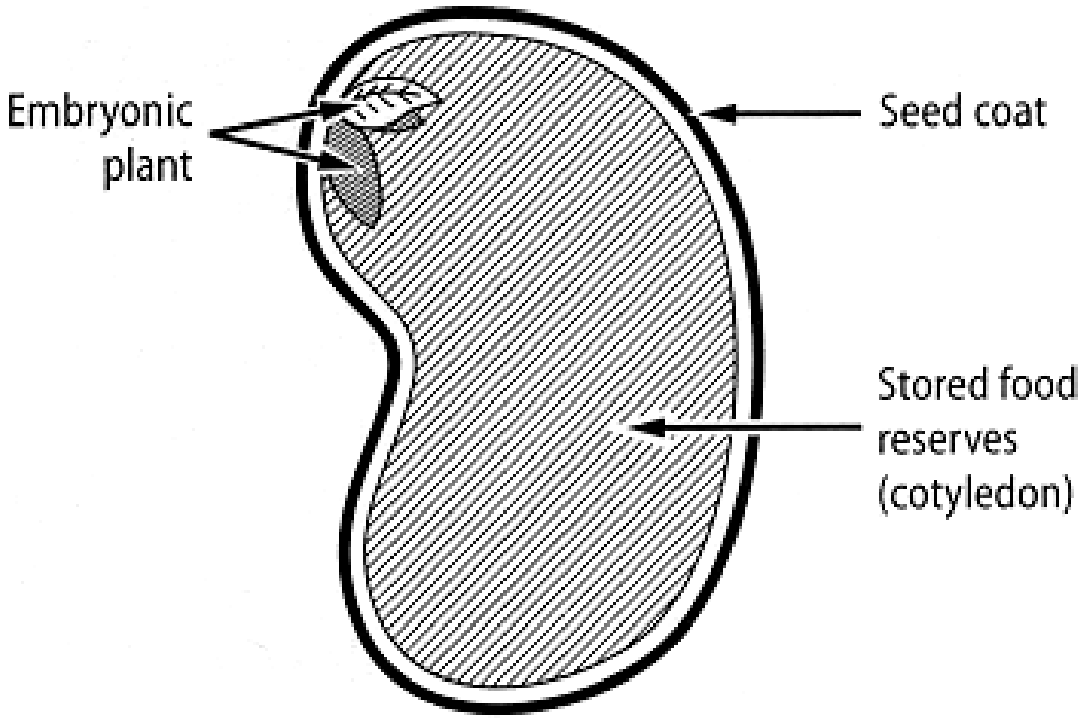
Flowers

- Perfect/ complete- male & female parts
- Imperfect/ incomplete- only male or female parts
  - Staminate – stamen only, male
  - Pistillate – pistil only, female
- Monoecious (*one house*) male & female flowers on same plant. Flowers perfect or imperfect
- Dioecious (*two houses*) male & female flowers on separate individual plants

Seeds & Fruits

Function: Dispersal and Survival

Typical seed structures illustrated in a garden bean seed.



From *California Master Gardener Handbook* pg. 13

Fruit Types

Simple- single carpel, two or more united carpels in a single flower	1. Fruit wall dry split at maturity 2. Fruit wall dry intact at maturity 3. Fruit wall fleshy sometimes with leathery skin	1. Pea, magnolia, tulip, mustard 2. Sunflower, wheat, rice, maple 3. Grape, banana, lemon, cherry, orange
Aggregate – many separate carpels of a single flower	Aggregate of mature ovaries all attached to receptacle	Blackberry, raspberry
Multiple – carpels of several associated flowers	Multiple matured ovaries, massed together; may include accessory structures such as receptacle, sepal, and petal bases	Pineapple, fig, mulberry
Accessory – one or more ovaries plus receptacle tissue that becomes fleshy	1. Simple: single ovary enclosed in receptacle tissue 2. Aggregate: swollen fleshy receptacle with dry fruits on surface	1. Apple, pear 2. Strawberry

Fruit

Function: Dispersal and Survival

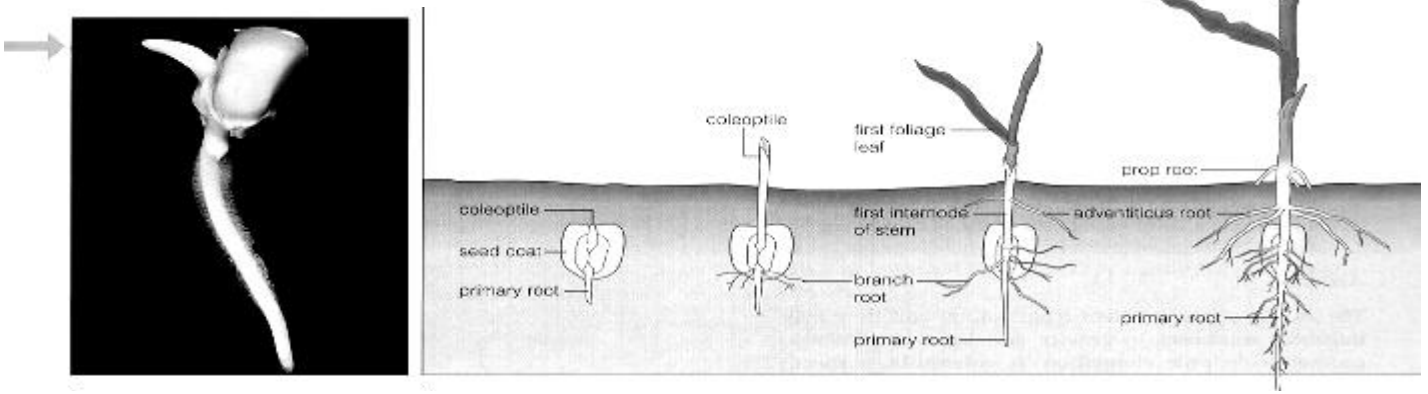
Types of fruit:

- Simple
- Aggregate
- Multiple
- Accessory

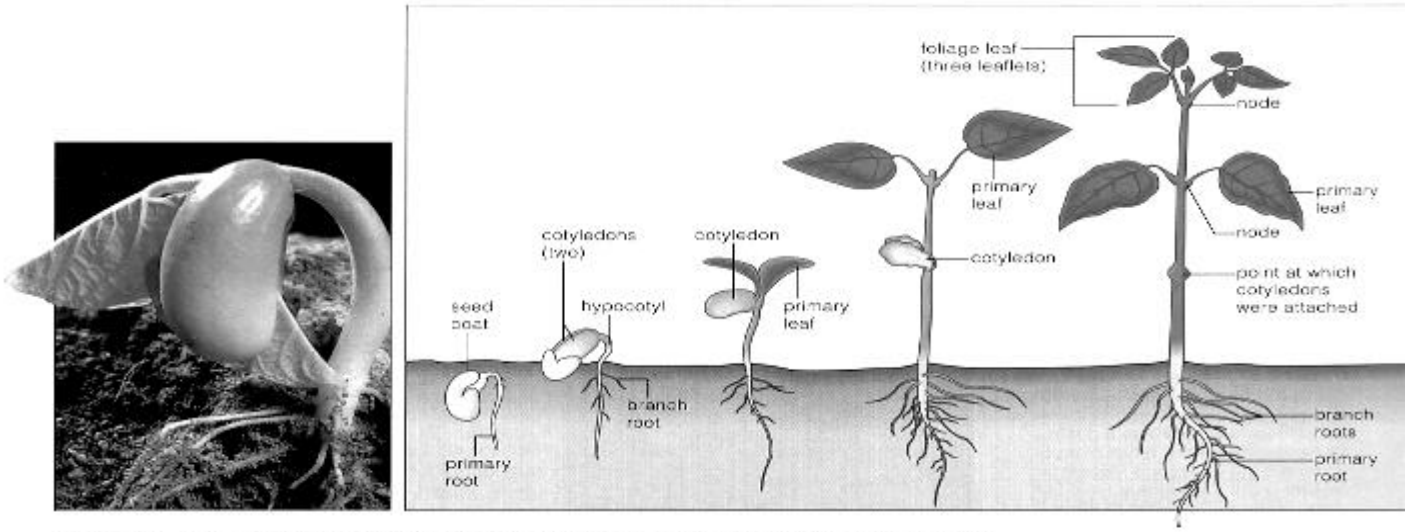
Dispersal mechanisms:

- Self propelled
- Wind
- Water
- Animal

Seed Germination



Monocotyledon (monocot)



Dicotyledon (dicot)

Diagrams from *Plant Structure and Function* by Cecie Starr and Ralph Taggart

Monocotyledon vs Dicotyledon

see MG handbook page 23 figure 2.18

Growth and Development

- Photosynthesis & Respiration
- Chemicals (Hormones)
- Growth patterns
- Dormancy

Plant Growth

- Hormones
- Apical dominance

See page 27 in California Master Gardener Handbook

- Auxin –
  - cell elongation - apical dominance, phototropism, gravitropism
  - promotes adventitious roots
  - low concentration promotes roots, high concentration can kill broadleaf weeds
  - fruit set or abortion depending on species - thinning tree crops
- Gibberellins –
  - cell division, stem elongation, promote flowering
  - seed germination - starch breakdown
- Cytokinins
  - Cell division
  - Assist with two above
- Ethylene
  - Fruit ripening
  - Hastens senescence and abscission
  - Works with auxin for injury response
- Abscisic acid
  - Regulates and promotes dormancy
  - Abscission and stomata closure

Growth & Development

- Tropisms
  - Phototropism,
  - Gravitropism,
  - Thigmotropism
- Light (MG handbook pg 25)
  - Photoperiodism
  - Short-day - spring
  - Long-day - fall
  - Day-neutral - maturity
- Temperature
  - Vernalization - low temperature stimulation
  - Breaking dormancy cold for set amount of time
- Dormancy
  - Multiple clues: temp., light, moisture, low nitrogen
- Senescence
  - abscission

Classification of Plants

- Growth habit - annual, biannual, perennial
- Structure or form – vine, shrub, tree
- Leaf retention – deciduous, evergreen
- Climatic adaptation – tropical, subtropical, temperate, Mediterranean
- Use - ornamental, fruit, nut, vegetable, herb
- Botanical or scientific

Scientific Classification

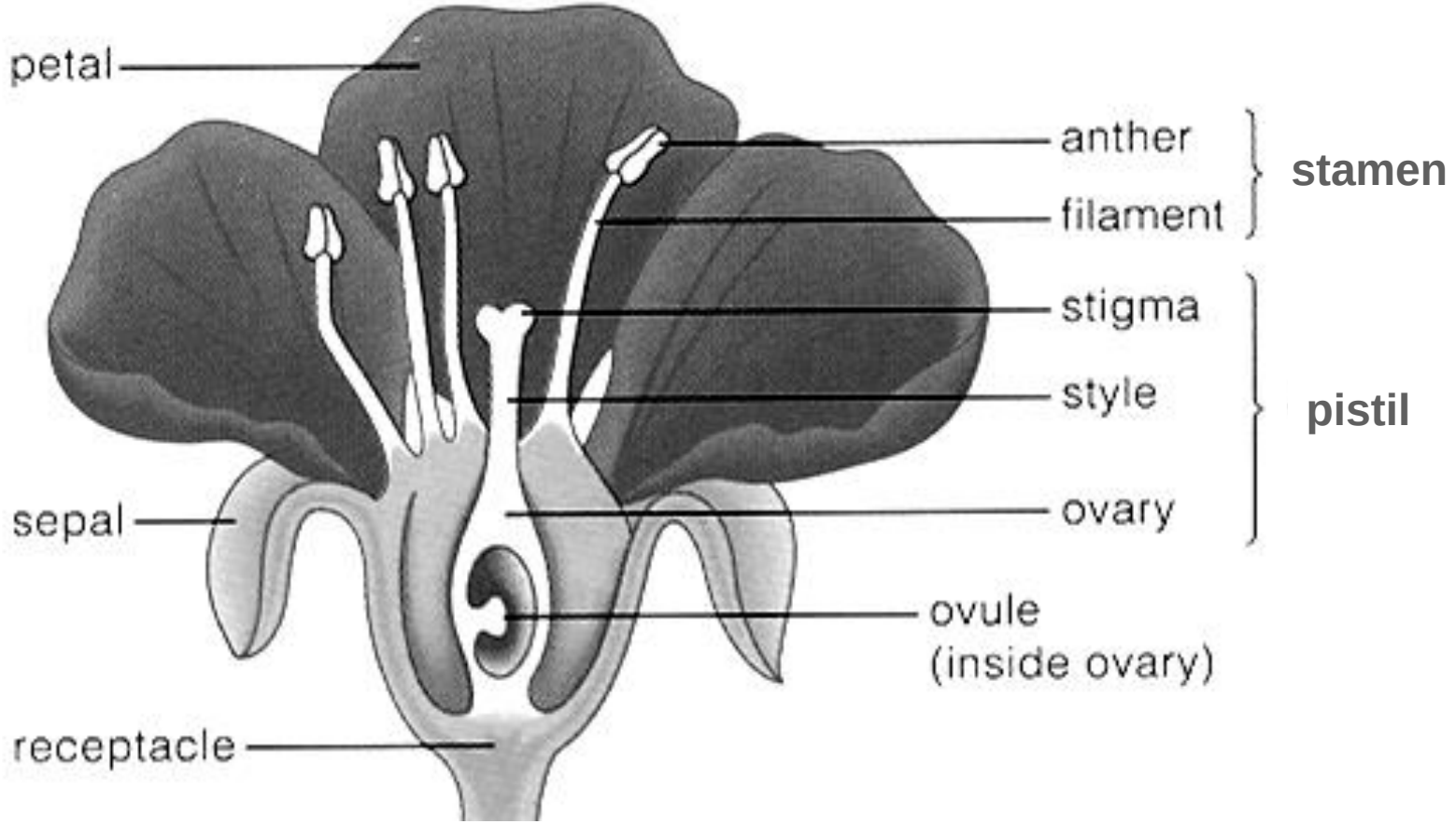
- Genus + specific epithet = Species
- Based on morphology usually flowers and fruit
- Grafting & sexual compatibility
- Variety vs. cultivated variety
- Gymnosperms: conifers, cycads, ginkgos,
- Angiosperms: flowering plants
  - Monocots
  - Dicots

Classification
Why is it helpful?

- Clear communication
- For diagnosis, e.g.
  - Pome group – fireblight; peach &nectarine leaf curl
- Planting choices and management
- Propagation and grafting compatible
- Timing of fertilizers, watering, pruning, etc.

Lab break - flowers

- Look at flowers, dissect and identify the parts



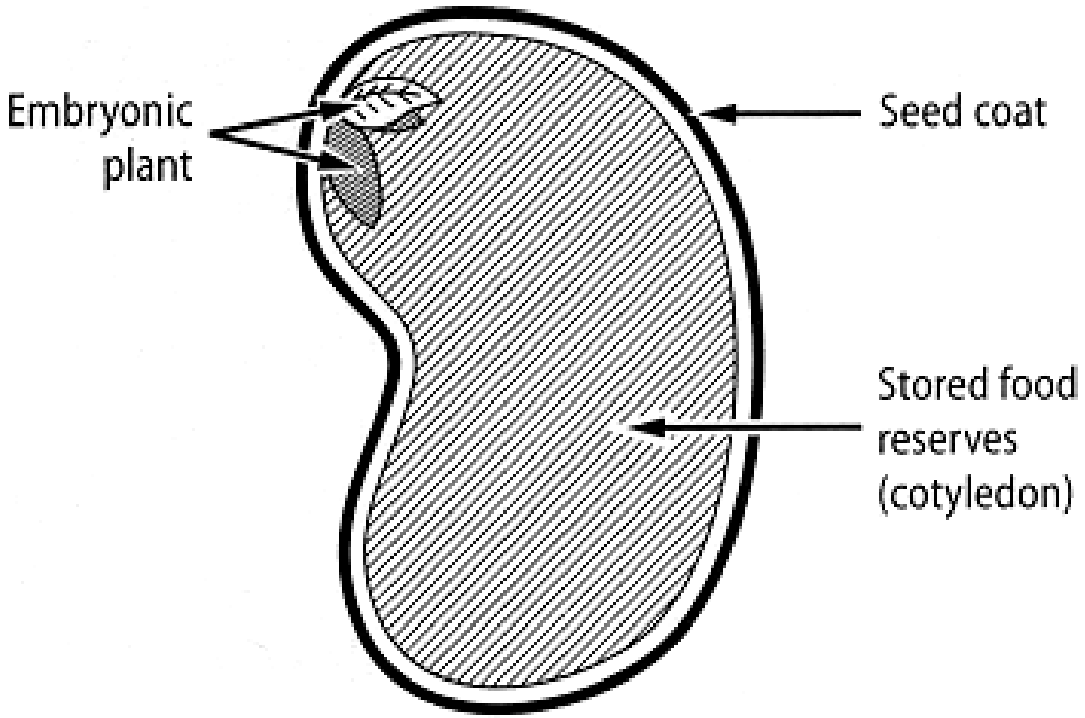
Lab break - flowers

- Name two example plants for each of following:
  - Perfect flowers _____ _____
  - Imperfect flowers (staminate & pistillate)
    _____ _____
  - Dioecious _____ _____
  - Monoecious _____ _____

Seeds & Fruits

Function: Dispersal and Survival

Typical seed structures illustrated in a garden bean seed.



From *California Master Gardener Handbook* pg. 18

Fruit Types

Simple- single carpel, two or more united carpels in a single flower	1. Fruit wall dry split at maturity 2. Fruit wall dry intact at maturity 3. Fruit wall fleshy sometimes with leathery skin	1. Pea, magnolia, tulip, mustard 2. Sunflower, wheat, rice, maple 3. Grape, banana, lemon, cherry, orange
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Accessory – one or more ovaries plus receptacle tissue that becomes fleshy	1. Simple: single ovary enclosed in receptacle tissue 2. Aggregate: swollen fleshy receptacle with dry fruits on surface	1. Apple, pear 2. Strawberry

Lab break - plant growth

- What growing adaptations would give a plant an advantage in these various scenarios?
  Can you think of an example for each?

  - Seasonal wet / dry cycles
  - Seasonal frost
  - low light
  - high light
  - hot temperatures with low water
  - leaves shaded by an object