

Plants

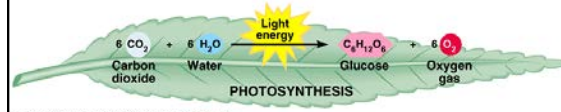
The *Producers*



Ecological classification

- Produce the food (photosynthesis)
- Condition the environment
- Create shelter and habitat

Photosynthesis



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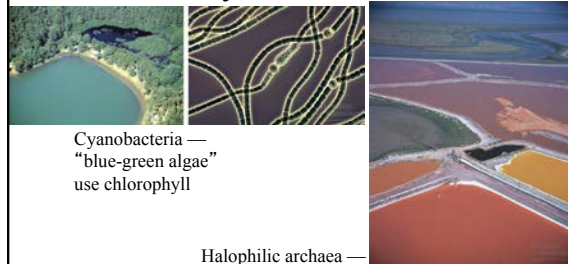
- Glucose for energy fuel, organic chemical monomers, structural polymers.
- Oxygen for aerobic respiration.

Ecological communities are often named for the dominant producers



- Not all producers are plants

Photosynthetic bacteria



Cyanobacteria — “blue-green algae” use chlorophyll

Halophilic archaea — “purple bacteria” use bacteriorhodopsin

Photosynthetic Protists

Phytoplankton [ecological classification] — earth’s dominant producers!

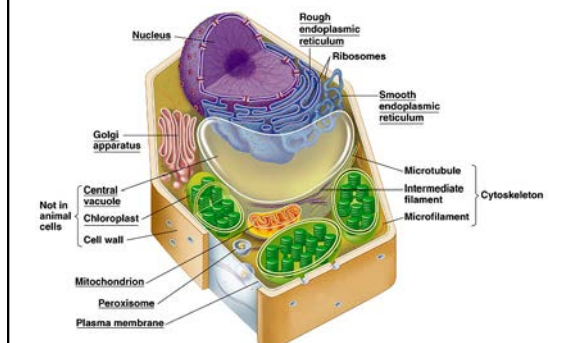
- Diatoms



- Dinoflagellates

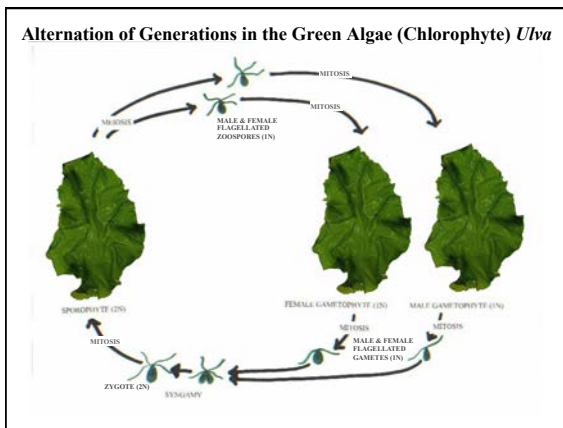
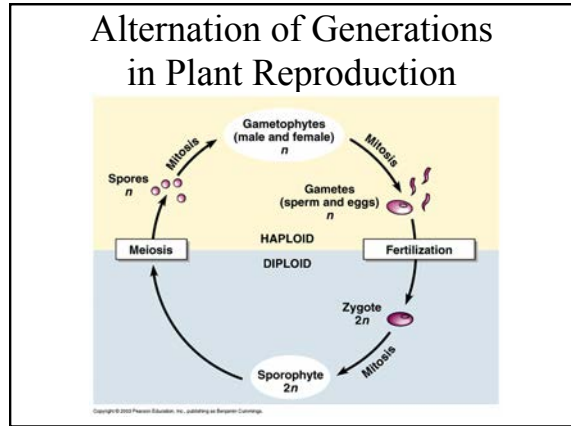
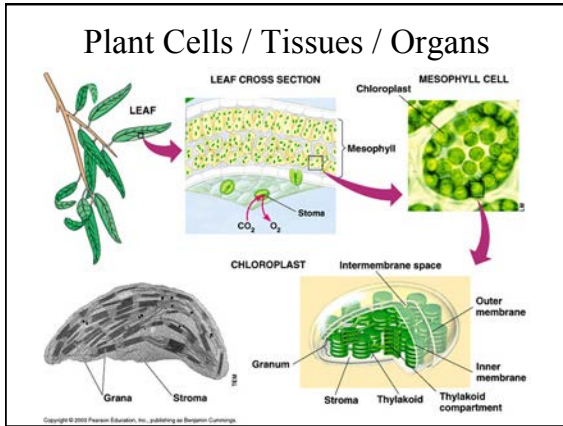


Plants Cells

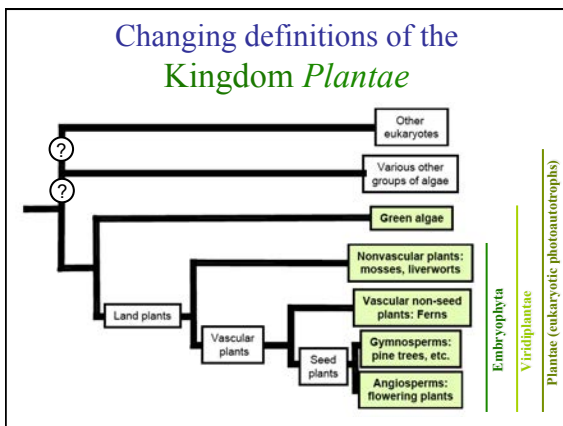


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Plants



- Changing definitions of the Kingdom *Plantae***
1. Classical: everything photosynthetic / not an animal
 2. Whitaker's 5-kingdom model: all eukaryotic multicellular photosynthetic organisms
 3. Phylogenetic: "land plants" — exclude the algae = Embryophyta: dependent embryo, meristem growth & differentiation, cuticle
 4. Cladistic: *Viridiplantae* ("green plants") — embryophyta + chlorophyta ("green algae")




- Plants**
- Algae — green alga, brown alga, red alga
 - Bryophytes — mosses, liverworts, hornworts
 - Pteridophytes — ferns and horsetails
 - Gymnosperms — conifers and cycads
 - Angiosperms — flowering plants


Plants

(Macro-)Algae — Aquatic Plants

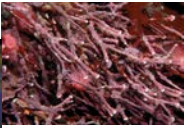
- Three Divisions (Phyla)



Chlorophyta
"Green Algae"



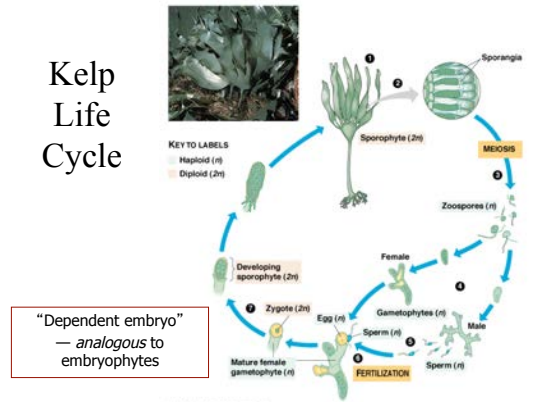
Phaeophyta
"Brown Algae"
{ including the "kelp" family }



Rhodophyta
"Red Algae"

- Not directly related to each other, nor to terrestrial vascular plants.
- Accessory pigments allow greater light sensitivity at depth.

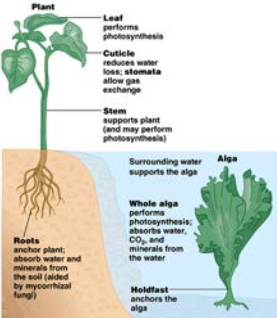
Kelp Life Cycle



KEY TO LABELS
● Haploid (n)
● Diploid (2n)

"Dependent embryo" — analogous to embryophytes

Contrast between terrestrial vascular plant form and aquatic algal form.



Plant

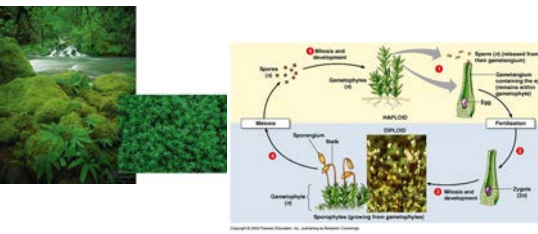
- Leaf performs photosynthesis
- Cuticle reduces water loss; stomata allow gas exchange
- Stem supports plant (and may perform photosynthesis)
- Roots anchor plant; absorb water and minerals from the soil (aided by mycorrhizal fungi)

Alga

- Surrounding water supports the alga
- Whole alga performs photosynthesis; absorbs water, CO₂, and minerals from the water
- Holdfast anchors the alga

- Land plants**
 - Photosynthesis and gas exchange in leaves.
 - Nutrient and water uptake from soil by roots.
 - Vascular system transports between leaves & roots.
 - Woody tissues provide erect support.
 - Waxy cuticle resists drying.
- Algae**
 - Bathed in medium providing water, nutrients, and dissolved gases — roots, stomata, cuticle, and vascular systems not needed
 - Photosynthesis occurs all over plant body — no leaf specialization
 - Water environment provides buoyancy / woody tissue not needed

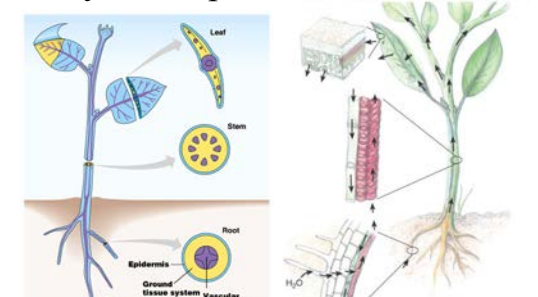
Bryophytes: Mosses



- Haploid gametophytes are the dominant, conspicuous phase
- Sperm "swim" to female gametophyte; require moist habitat
- Spores may be dispersed by wind


Vascular Plants (Tracheophytes)

Xylem - up! Phloem - down!



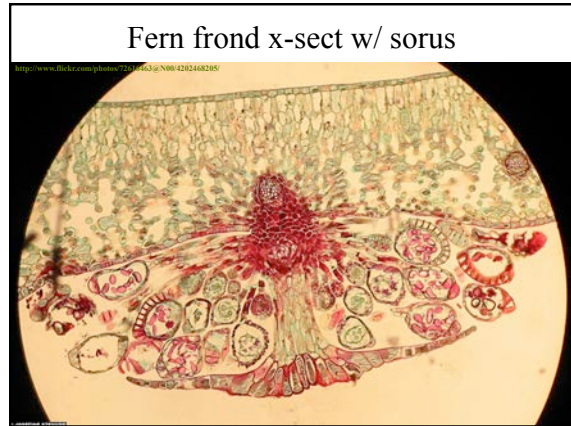
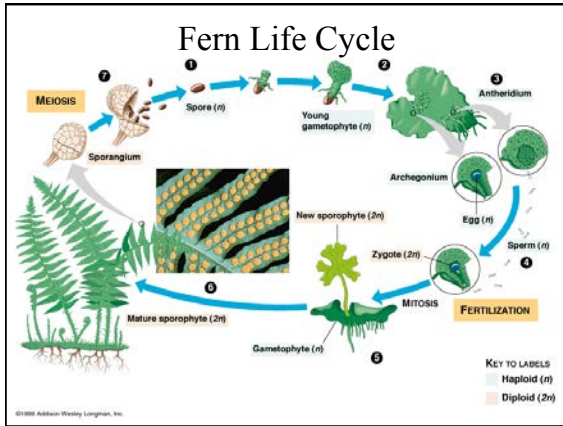
Leaf
Stem
Root
Epidermis
Ground tissue system
Vascular tissue system

Pterophytes: Ferns



- Diploid sporophyte is the dominant, conspicuous phase
- Sperm "swim" to female gametophyte; require moist habitat
- Spores are dispersed by wind

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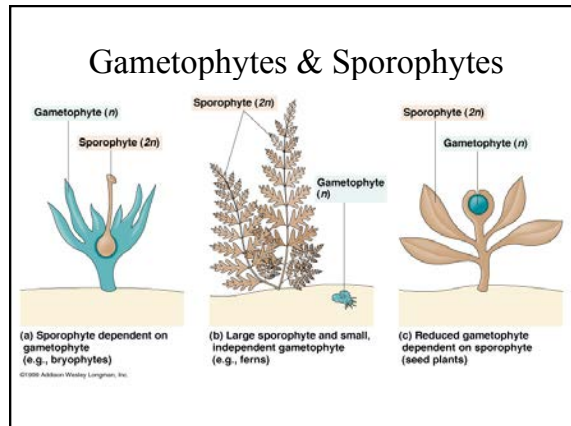


Seed-bearing plants (Spermatophytes)

Two Clades:

- Gymnosperms “*naked seeds*”
 - Division: Conifers “*cone bearers*”
- Angiosperms “*vessel seeds*”
 - Division: Anthophytes “*flowering plants*”

- The visible plant body is the diploid sporophyte
- The gametophytes are transient microscopic structures
 - Female gametophyte within the ovule
 - Male gametophyte within the pollen grain
- Pollen grains resist desiccation — allow transport of sperm independent of water
- After fertilization, ovule develops into seed bearing the embryo



Gymnosperms “*naked seeds*”

Conifers “*cone bearers*”

World’s largest biome: boreal coniferous forest [taiga]
World’s largest organisms: sequoia & coast redwood

Angiosperms — the flowering plants

>250,000 known living species
= 90% of all plant species

The diagram shows a flowering plant with its shoot system (terminal bud, leaf, blade, petiole, axillary bud, stem, flower) and root system (taproot, root hairs). It also includes images of a sequoia tree and a palm tree.

Vascular-plant structure

Tracheophytes

Vascular Plants

Xylem - up! Phloem - down!

Yet more surprising **analogy** between **land plants** and **kelps**

- Dependent embryos
- Meristematic growth
- Differentiated tissues
- **Vascular tissue**
 - **Phloem-like sieve vessels**
 - Trumpet-filaments joined by sieve plates in medulla

T.S. Stipe / midrib of brown seaweed

cross section of a giant kelp stipe

Rhizoids

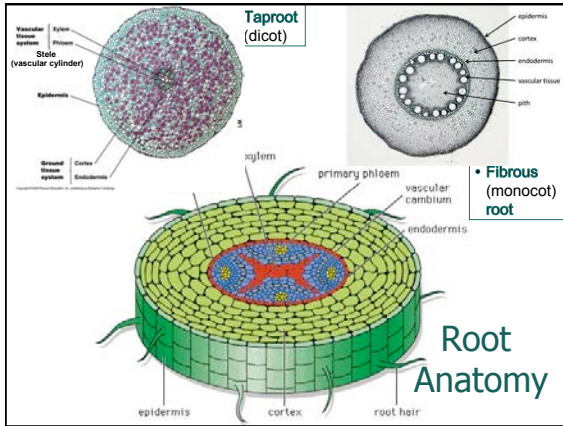
- Non-vascular plants increase surface area for absorption & attachment with **rhizoids**

Non-vascular Rhizoids → Vascular Root

Roots

- **Taproot**: from enlargement and branching of the seminal (seed) root.
 - Extends deeply
 - Starch storage
- **Fibrous root**: thin roots originating from base of stem around seminal root.
 - Dense network near soil surface
- **Adventitious root**: fibrous-like roots originating from additional stem nodes.
 - Extend fibrous root area
 - Asexual propagation
 - Prop roots
 - Climbing anchors

Plants

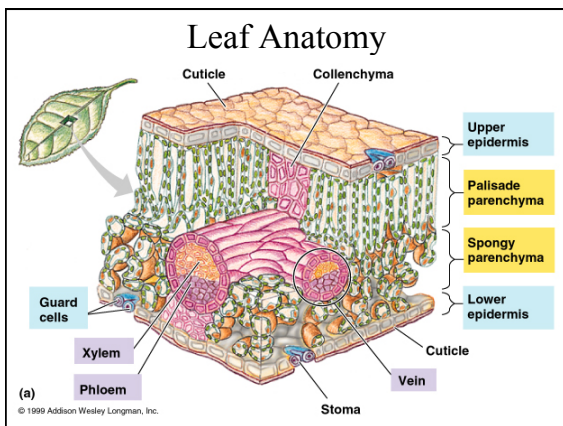
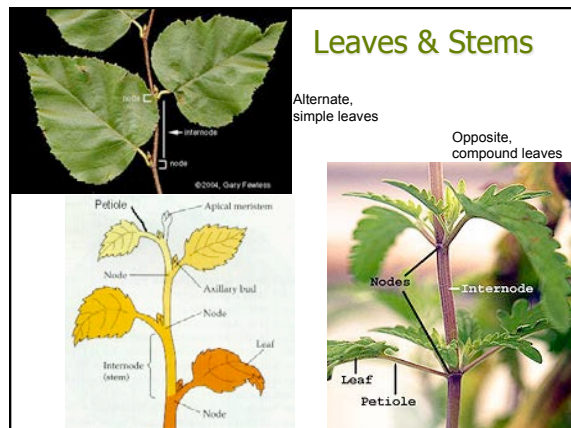
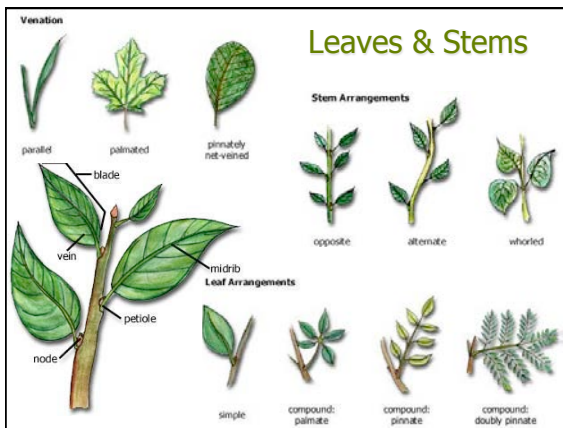


Gas exchange in vascular plants

- CO_2 taken *in* and O_2 given *out* by leaves for/from **photosynthesis**.
- Dissolved O_2 taken *in* with H_2O from soil by roots for tissue **respiration**.
- During daylight: $\text{O}_2 \text{ out} > \text{O}_2 \text{ in}$
- In dark of night: $\text{O}_2 \text{ out} < \text{O}_2 \text{ in}$

Labels: CO_2 , O_2 , Minerals (inorganic ions), H_2O .

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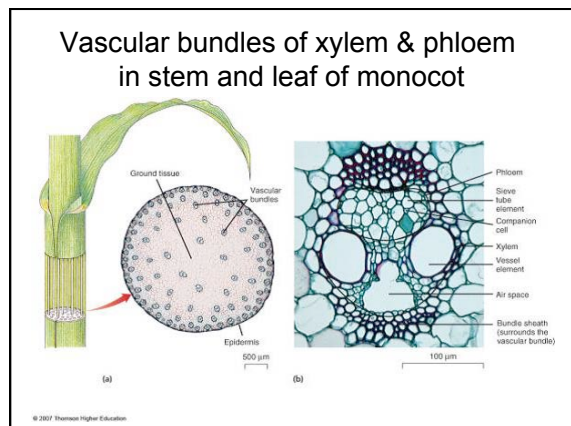
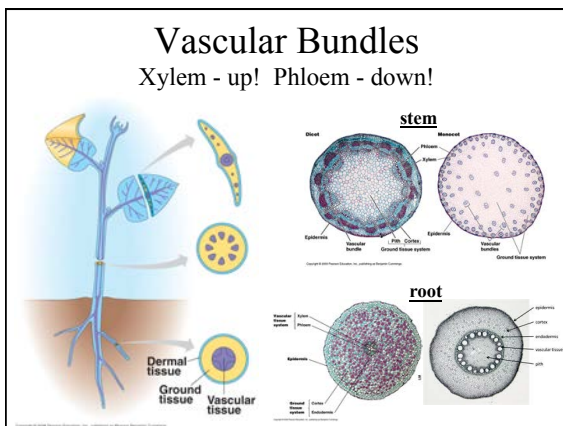
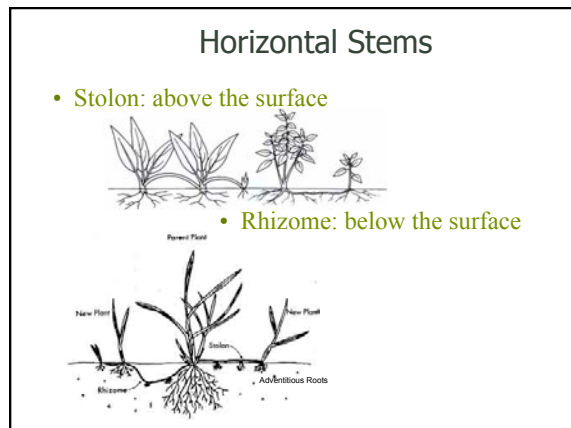
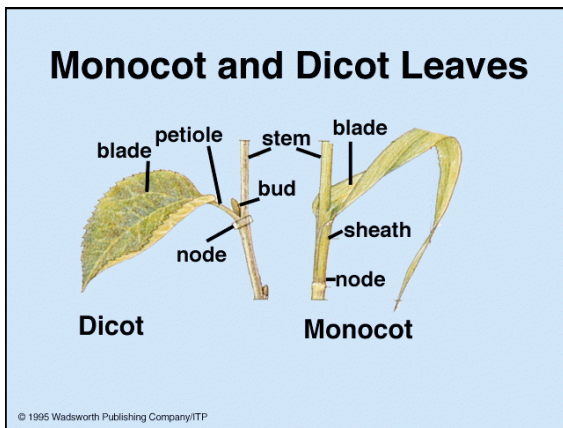
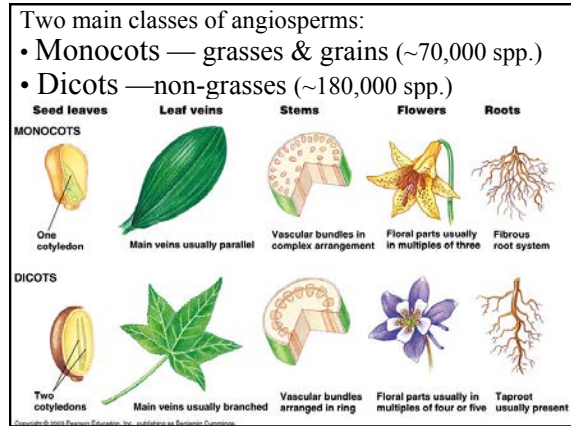
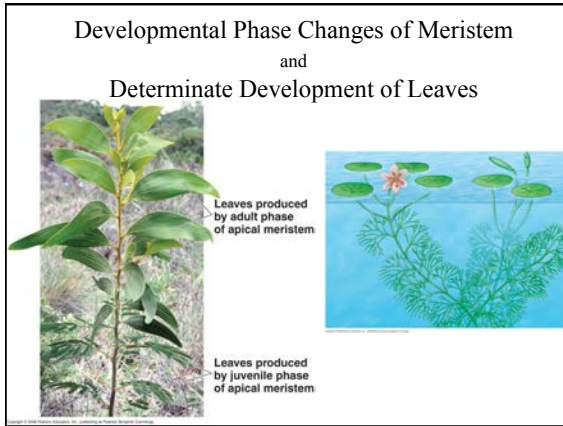


Stomata — “little mouths”

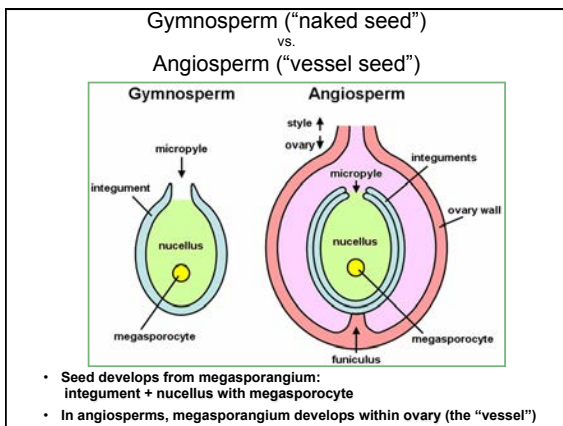
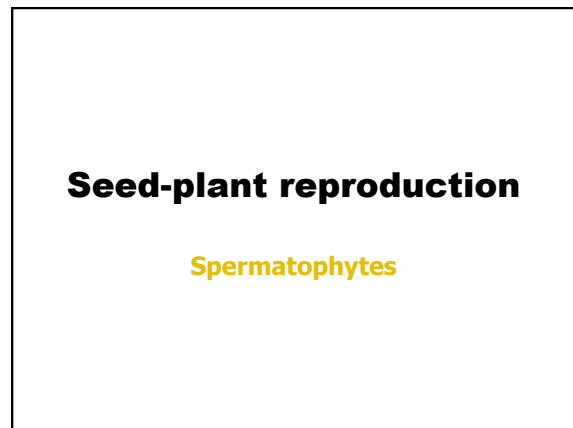
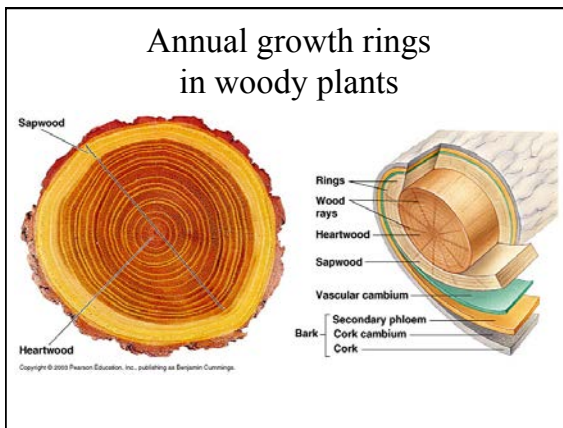
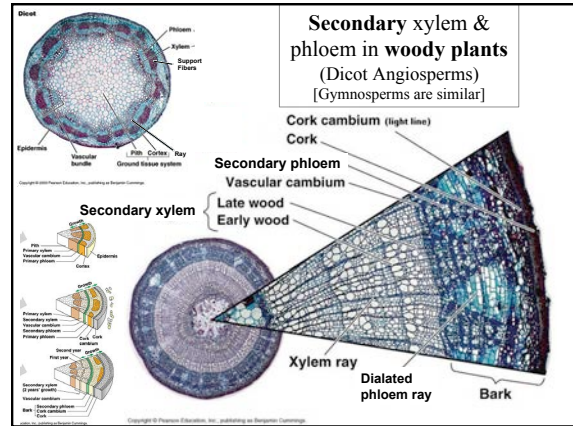
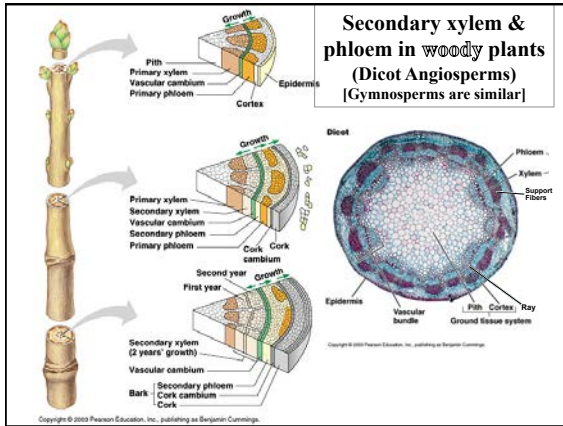
— adjustable openings for gas exchange on the undersides of leaves

O_2 bubbles forming from stomata

Plants



Plants



Plants

Gymnosperm

Conifers:
cones as sex organs

- **Sporophylls**
 - "spore leaves" with
 - sporangia
- **Pollen cones [male]**
 - Microsporophylls
 - Microsporangia
 - Microspores (n)
- **Ovulate cones [female]**
 - Megasporophylls
 - Megasporangia
 - Megaspores (n)

Pinus sylvestris (pine)

One year old ovulate cone

Pollen-bearing cone (male cone) with microsporophylls

Two year old ovulate cone

Young ovulate cone (female cone) with megasporophylls

Ovulate scale (megasporophyll, ovuliferous scale) with two ovules bottom view (left), top view (right)

Mature ovulate scale with two winged seeds (left), dispersed seeds (right)

Wing

Seed

From: Schmedt [1992] *Leitfaden der Pflanzen- und Tierwelt*.
© 2007 Bernhard Leubner - The Seed Biology Project - <http://www.seedbiology.de>

Gymnosperm Life Cycle

Conifers:
cones as sex organs

Single scale (sporophyll)

Scale sectioned through ovule

Nucellus (megasporangium) (2n)

Megasporangium mother cell (2n)

Megaspore (n)

Integuments (2n)

Micropyle

POLLINATION

Pollen cone

Sporophyll

Pollen grain (n)

MEIOSIS

Microsporangium

Mature sporophyte

Seed coat (2n) (derived from parent sporophyte)

Pine seed

Integuments (2n)

Egg nucleus (n)

Archegonium (n)

Tap (n)

Germinating pollen (n)

Discharged sperm nucleus (n)

Pollen tube (n)

FERTILIZATION

Embryo (2n) (new sporophyte)

Food reserves (n) (gametophyte tissue)

KEY TO LABELS

Haploid (n)

Diploid (2n)

Gymnosperm Seed Development

Integuments (2n)

Nucellus (megasporangium) (2n)

Megaspore (n)

Spore case (n)

Female gametophyte (n)

Seed coat (2n) (derived from integuments)

Food supply (derived from female gametophyte tissue)

Embryo (2n) (new sporophyte)

MEIOSIS

Pollen tube (n)

Micropyle

Egg nucleus (n)

Discharged sperm nucleus (n)

(a) Ovule

(b) Fertilized ovule

(c) Seed

KEY TO LABELS

Haploid (n)

Diploid (2n)

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Angiosperms — the flowering plants

Anthophytes: flowers as the sex organs

- **Non-reproductive perianth**
 - Sepals form calyx
 - Petals form corolla
- **Male organ: Stamen**
 - Filament & Anther
 - Anther produces pollen
- **Female organ: Carpel**
 - Stigma, Style & Ovary
 - Stigma collects pollen
 - Ovary produces ovules

Pollen grains

Anther

Stigma

Style

Ovary

Petal

Receptacle

Sepal

Stamen

Carpel

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Reproductive Phase Changes of Meristem and Floristic Development

(A) An schematic diagram of the ABC hypothesis

- **Meristem identity genes:** leaf primordia → floral primordia
- **Organ identity genes:** which floral primordia becomes which floral component
 - The ABC hypothesis

Active genes: A A C C C C A A

Whereas: C C C C C C C C

A A C C C C A A

A A A A A A A A

Wild type

Mutant lacking A

Mutant lacking B

Mutant lacking C

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Angiosperm Gametophyte Development

(a) Development of a male gametophyte (in pollen grain)

Microsporangium (pollen sac)

Microsporocyte (2n)

MEIOSIS

4 microspores (n)

Each of 4 microspores (n)

MITOSIS

Generative cell (n)

Male gametophyte

Nucleus of tube cell (n)

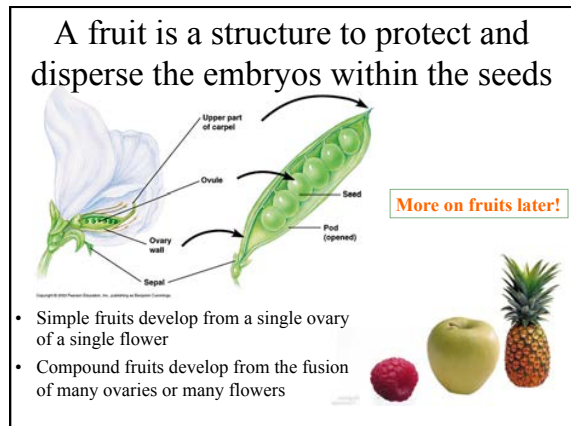
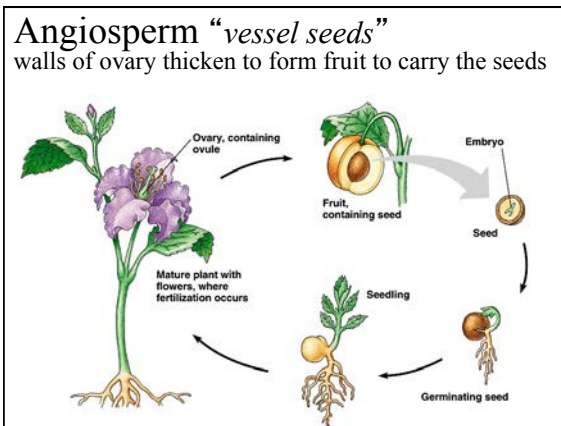
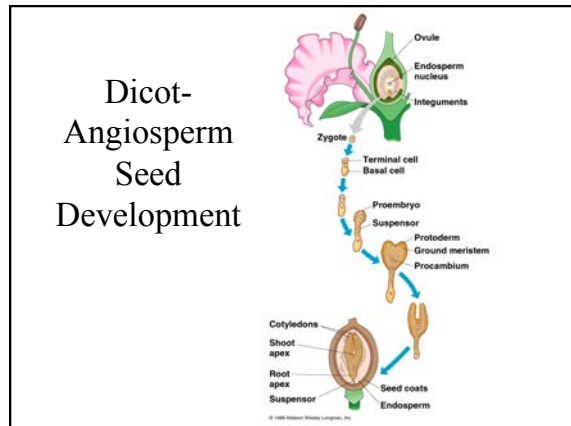
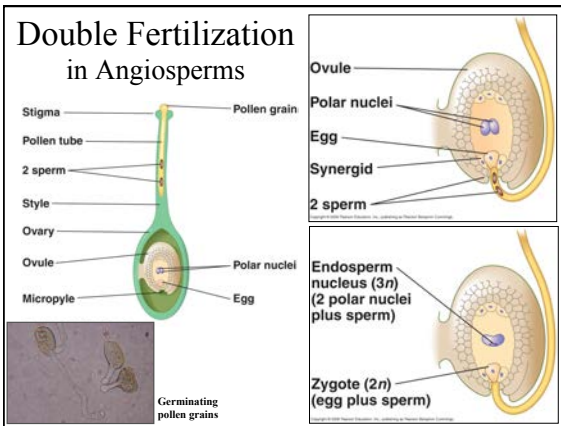
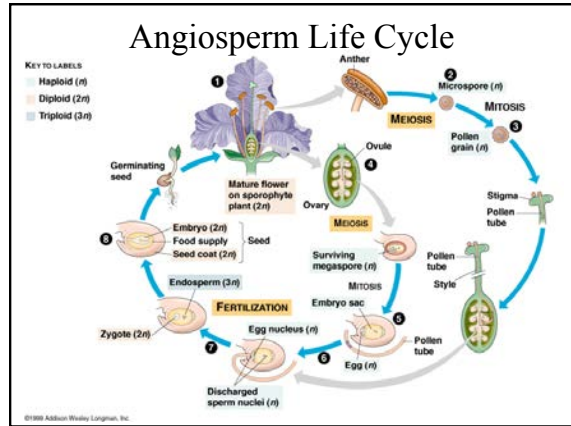
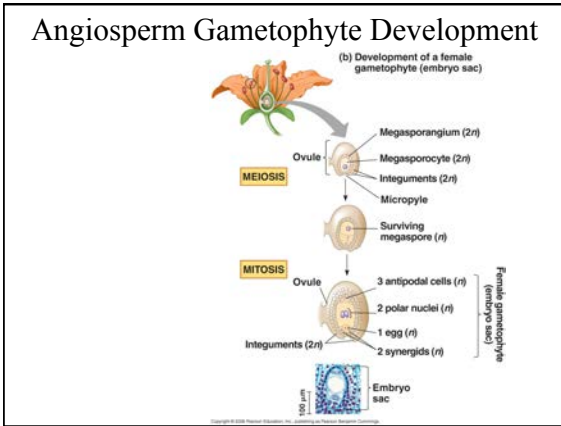
20 µm

Ragwee pollen grain

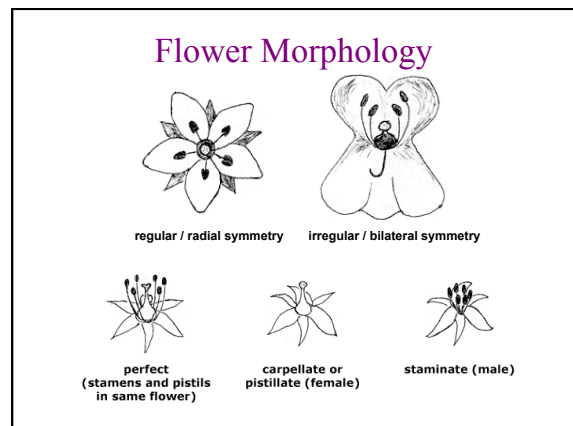
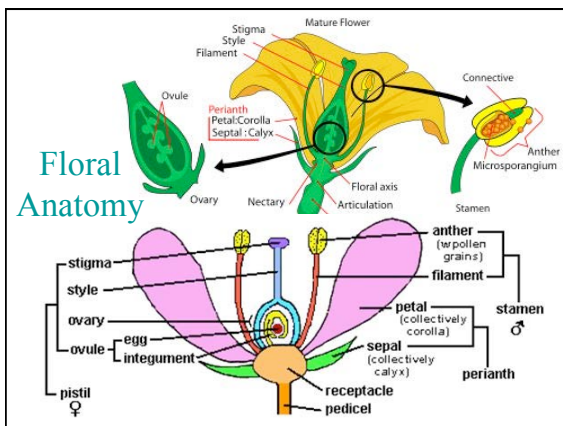
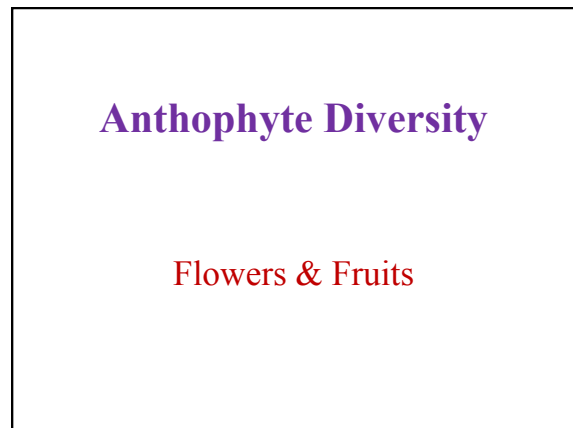
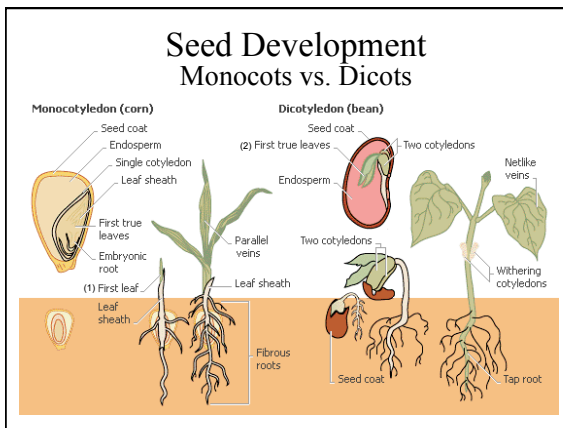
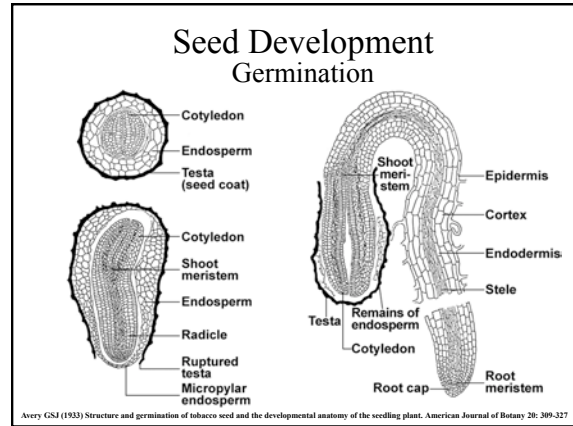
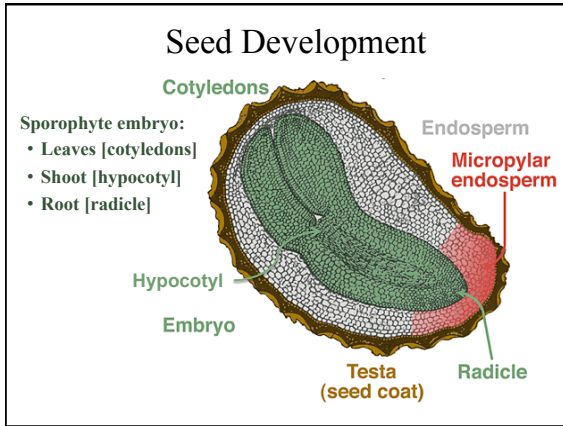
75 µm

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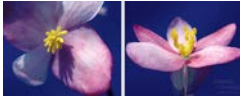
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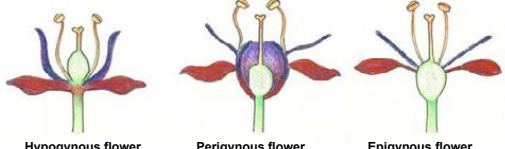
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Flowers

- **Complete flower**
– calyx+corolla+stamens+carpels
- **Hermaphroditic:**
– Both male + female organs in same flower
- **Monoecious:**
– Separate male flowers & female flowers on the same plant
- **Dioecious:**
– Separate male flowers & female flowers on separate plants

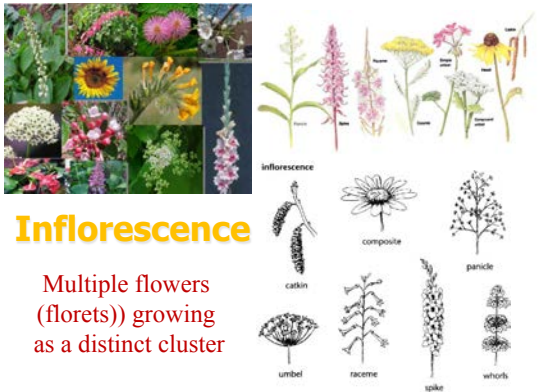
Flower Morphology and Ovary Position



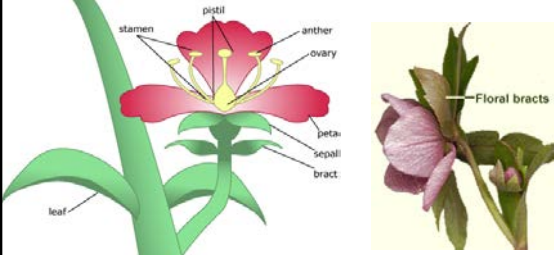
- **Hypogynous** (flower "below ovary"): ovary positioned on the peak of the receptacle (torus). Other flower parts arise below the base of the carpels. E.g., Pea.
- **Perigynous** (flower "around ovary"): ovary positioned in cup-like torus. Other flower parts arise from edge of the cup. E.g., Rose.
- **Epigynous** (flower "above ovary"): ovary completely embedded and fused within the receptacle. Other flower parts arise from the top of the ovary. E.g., Apple.

Inflorescence

Multiple flowers (florets) growing as a distinct cluster




Bracts



- Specialized leaves associated with flowers or cones
- Most commonly with an inflorescence

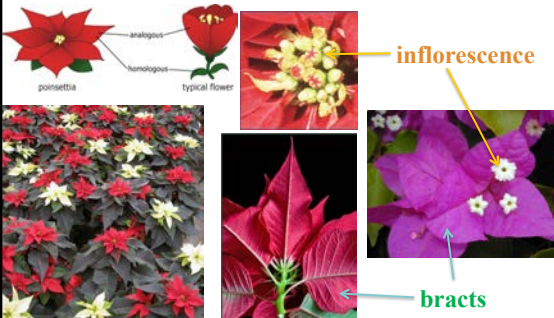
Protective bracts

Enclosing inflorescence of banana flowers (florets)



Bract convergence with flower parts

- Petal-like bracts of poinsettias & bouganvillas

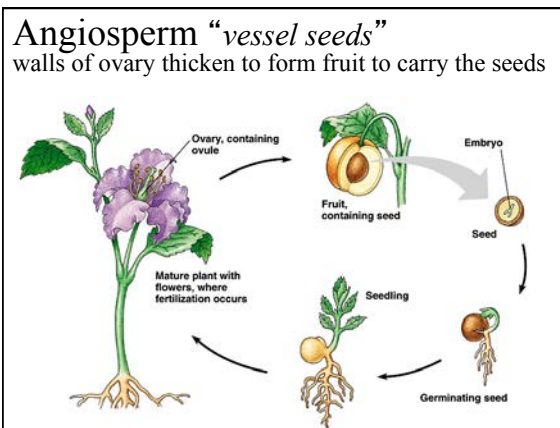


Plants

Myriads of floral designs reflect methods to achieve pollination

Floral characters relevant to pollination

FLOWER	Bats	Bees	Beetles	Birds	Butterflies	Flies	Wind
color	dull white, green, purple	bright white, yellow, blue	dull white, green	red, orange, white	red, orange, purple	dull brown, purple	dull green, brown
odor	strong, fruity	fresh, mild, pleasant	fruity, spicy	none	spicy, none	putrid	none
shape	regular, bowl-shaped. Closed during day	tubular with shallow landing platform	large, bowl-shaped	large, funnel-shaped; perch support, but no landing platform	narrow tube with wide landing pad	shallow funnel or trap-like	regular or petals reduced or absent; stigmata protruding
bloom time	night	day	day	day	day	any time	any time
nectar	abundant; hidden	usually present; not hidden	sometimes present; not hidden	abundant; deeply hidden	abundant; deeply hidden	usually none	none



As ovules within the ovary develop into seeds, the walls of the ovary (carpels) grow & develop into the walls of the fruit (**pericarp**)

- **Simple fruits** develop from a single ovary of a single flower
- **Compound fruits** develop from the fusion of many ovaries or many flowers

Myriads of fruit designs reflect methods to disperse seeds

Fruit: agents of seed dispersal

- **Autochory**: self dispersed (explosive or recoil)
- **Anemochory** (wind-) & **Hydrochory** (water-dispersed)

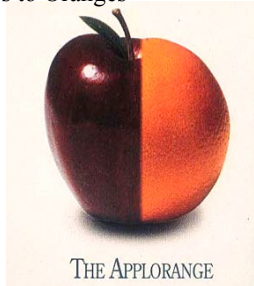
Fruit: agents of seed dispersal

- **Zoochory** (animal-dispersed)
 - Synzoochory – stockpiling & sloppy feeding
 - Epizoochory – attach/adhere to fur/feathers
 - Endozoochory – digestion-resistant seeds pass through gut



Fruit Types

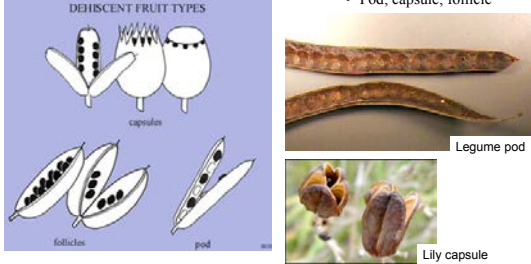
- Comparing Apples to Oranges



- An orange *is* a fruit.
- An apple *contains* a fruit!

Fruit Types

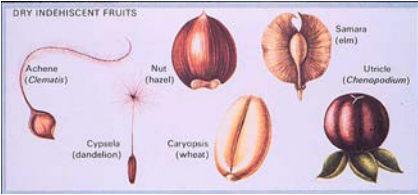
- **Simple Fruit**: derived from a single ovary
 - **Dehiscent Fruit**: dry fruit remains attached to plant. Splits open to release mature seeds



- Pod; capsule; follicle

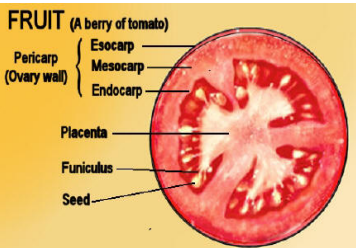
Fruit Types

- **Simple Fruit**: derived from a single ovary
 - **Indehiscent Fruit**: fruit dispersed with seeds.
- **Dry Fruit**: pericarp hardens
 - **Grain (Caryopsis)**: pericarp thin, fused to seed coat
 - **Achene**: pericarp thin, not fused to seed
 - **Nut**: pericarp forms thick shell, not fused to seed



Fleshy Fruits

- **Pericarp** (from carpels of ovarian wall) thickens
- Derives into three layers




- **Endocarp** – innermost layer
- **Mesocarp** – middle layer
- **Exocarp** – outermost layer

- Mesocarp becomes thick, fleshy, & juicy.

Fruit Types

- **Simple Fruit**: derived from a single ovary
 - **Indehiscent Fruit**: fruit dispersed with seeds.
- **Fleshy Fruit**: mesocarp thick/pulpy/juicy (= sarcocarp)
 - **Berry**: endocarp thin
 - » **Bacca (true berry)**: exocarp → thin skin
 - » Tomato, grape, coffee bean, cucumber
 - » **Hesperidium**: exocarp → thick rind
 - » Citrus

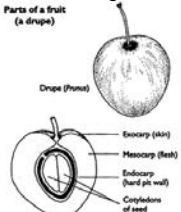



Plants

Fruit Types

- **Simple Fruit:** derived from a single ovary
 - **Indehiscent Fruit:** fruit dispersed with seeds.
 - **Fleshy Fruit:** mesocarp thick/pulpy/juicy (= sarcocarp)
 - **Drupe:** endocarp thickens/hardens → pit around single seed

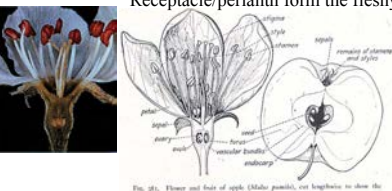

» Peach, cherry, plum, mango, olive, coconut

Fruit Types

- **Simple Fruit:** derived from a single ovary
 - **Indehiscent Fruit:** fruit dispersed with seeds.
 - **Accessory Fruit (Anthocarp):** pericarp thin; other flower parts contribute to much of fruit structure
 - **Pome:** papery pericarp from inferior ovary forms core around seeds; Receptacle/perianth form the fleshy layer & skin

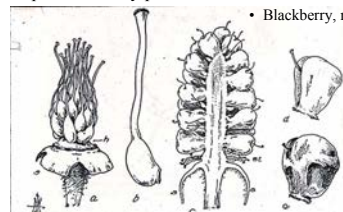
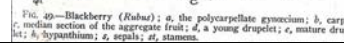
» Apple, pear

Fruit Types

- **Compound Fruit:** derived from multiple ovaries or multiple flowers
 - **Aggregate drupes:** from flowers with multiple ovaries; each drupelet with tiny pit

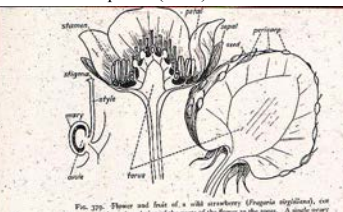
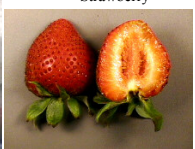
• Blackberry, raspberry

Fruit Types

- **Compound Fruit:** derived from multiple ovaries or multiple flowers
 - **Aggregate achenes with accessory fruit:** from flowers with multiple ovaries; multiple achenes on fleshy receptacle (torus)



• Strawberry

Fruit Types

- **Compound Fruit:** derived from multiple ovaries or multiple flowers (inflorescence)
 - **Multiple fruit:** fusion of fruits from multiple flowers



• Pineapple, fig, mulberry

Plant Behavior

- Photoperiod responses
- Defense responses
- Tropisms (analogous to taxis in animals)

1. Phototropism
2. Geotropism
3. Thigmotropism

Plants

