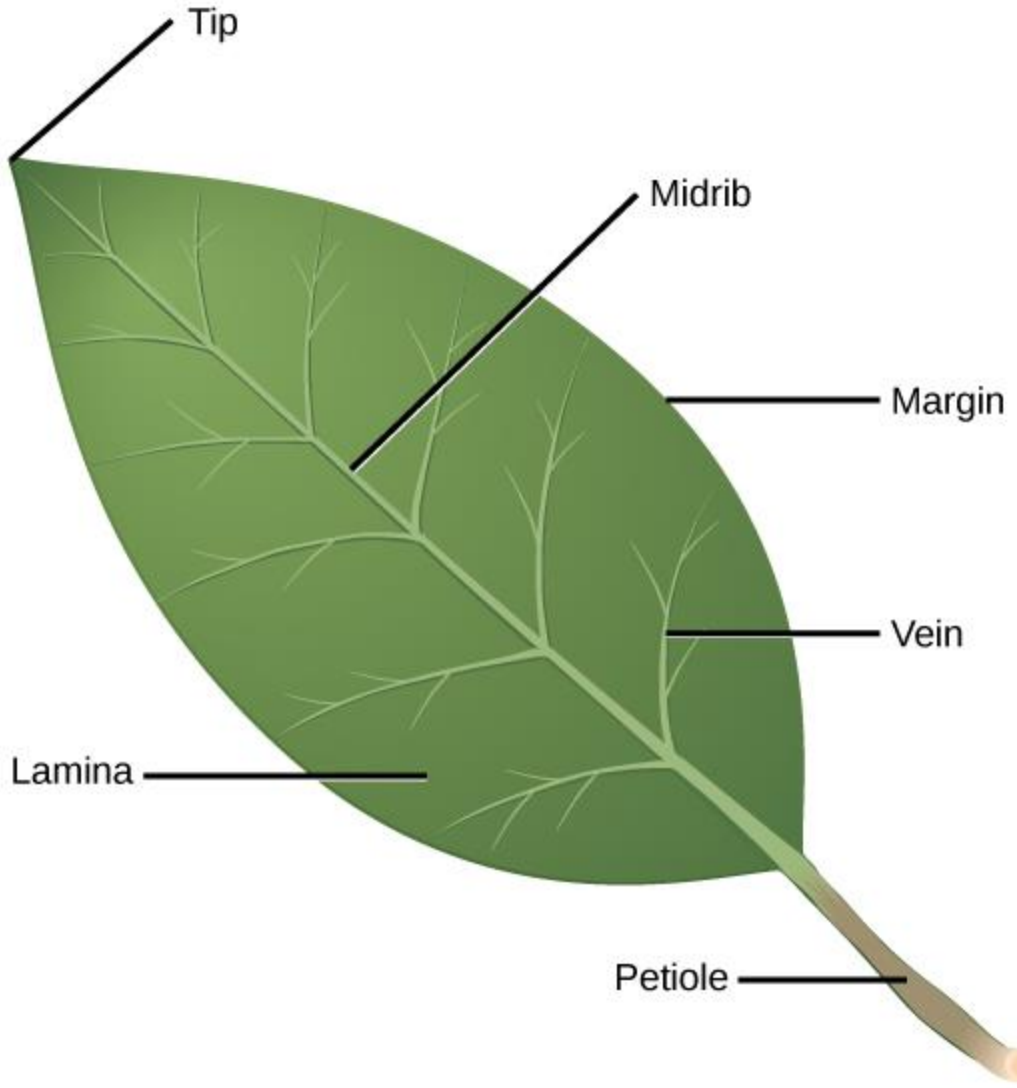
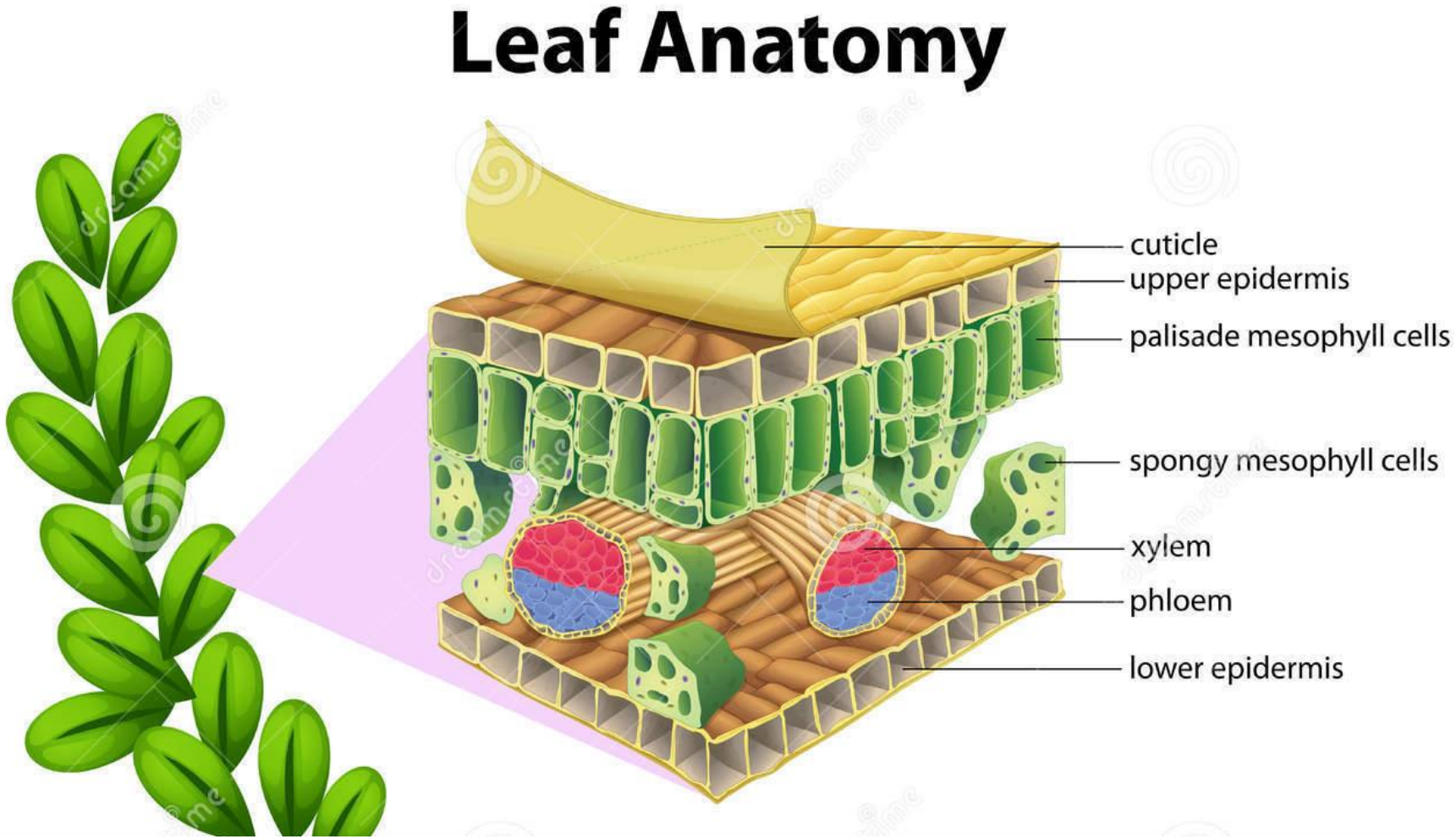
PLANT ORGANS- LEAVES

LEAVES

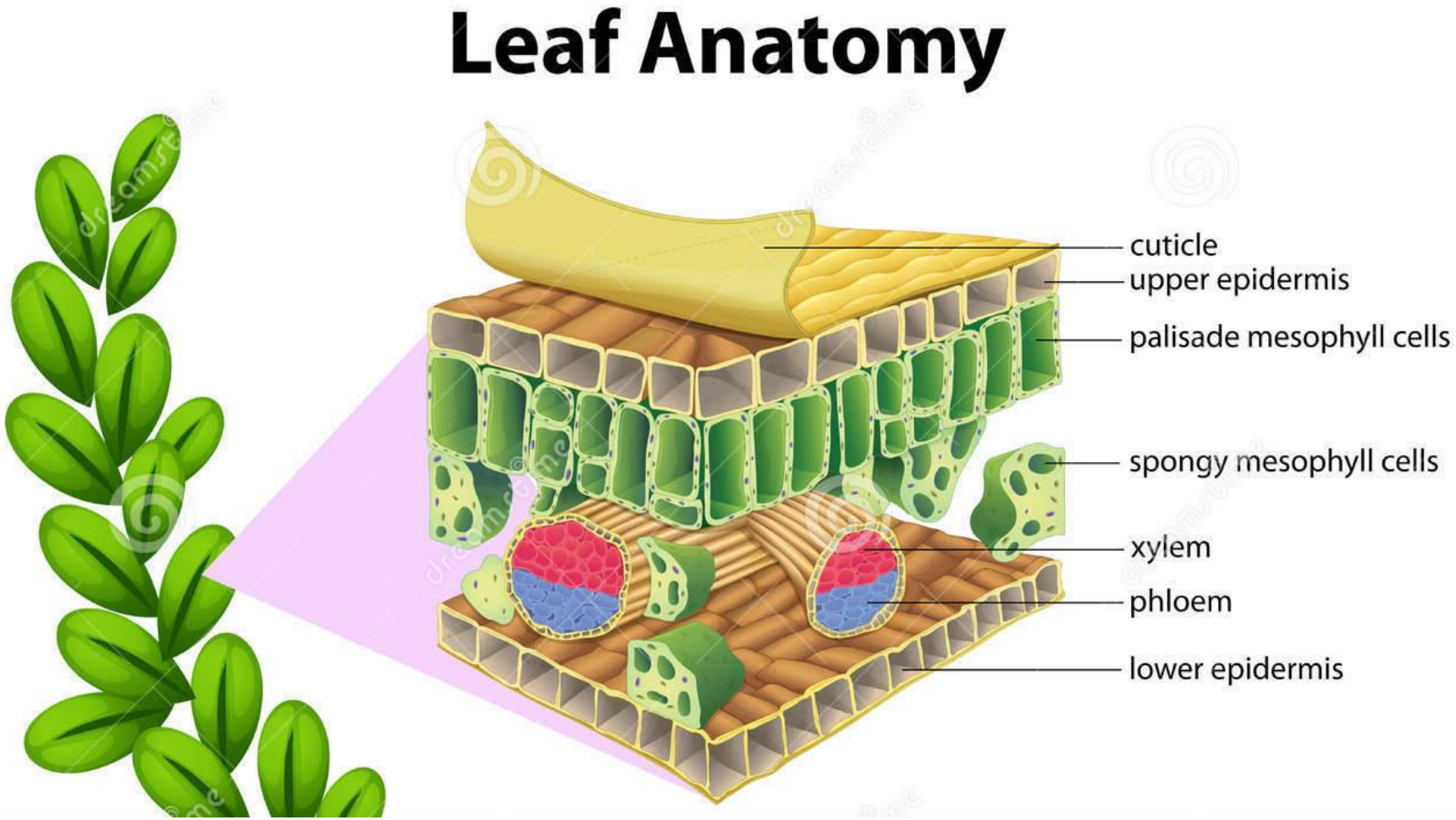
- We have heard that leaves are the "food factories" of plants. What does this really mean and how do they work?



- The anatomy of a leaf is like a sandwich. On either side there are layers called **epidermis** and on top of epidermis **waxy cuticle is present** to protect the leaf against drying out. In the middle are chloroplast containing cells where photosynthesis takes place. This middle layer is called **mesophyll.**

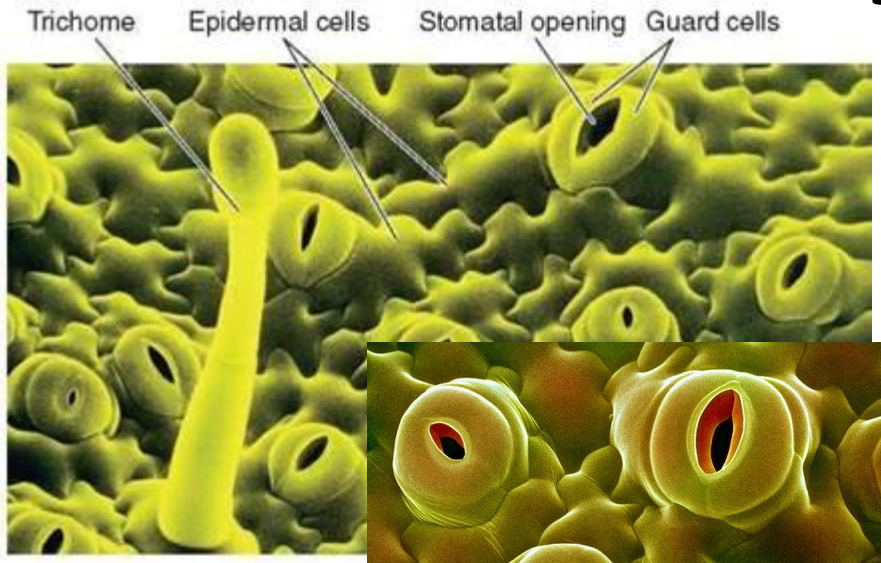


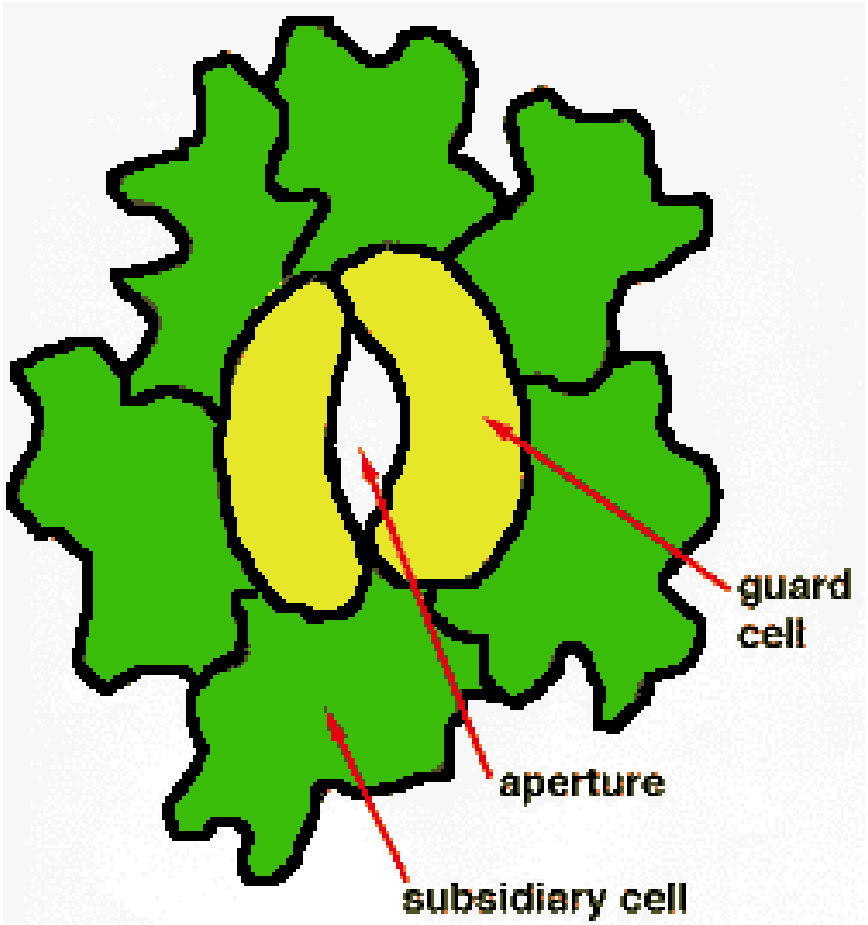
- Each vein contains xylem cells to supply the mesophyll with water and nutrients and phloem cells to remove newly made foods. The upper epidermis is usually smooth and dense to help reduce water loss.

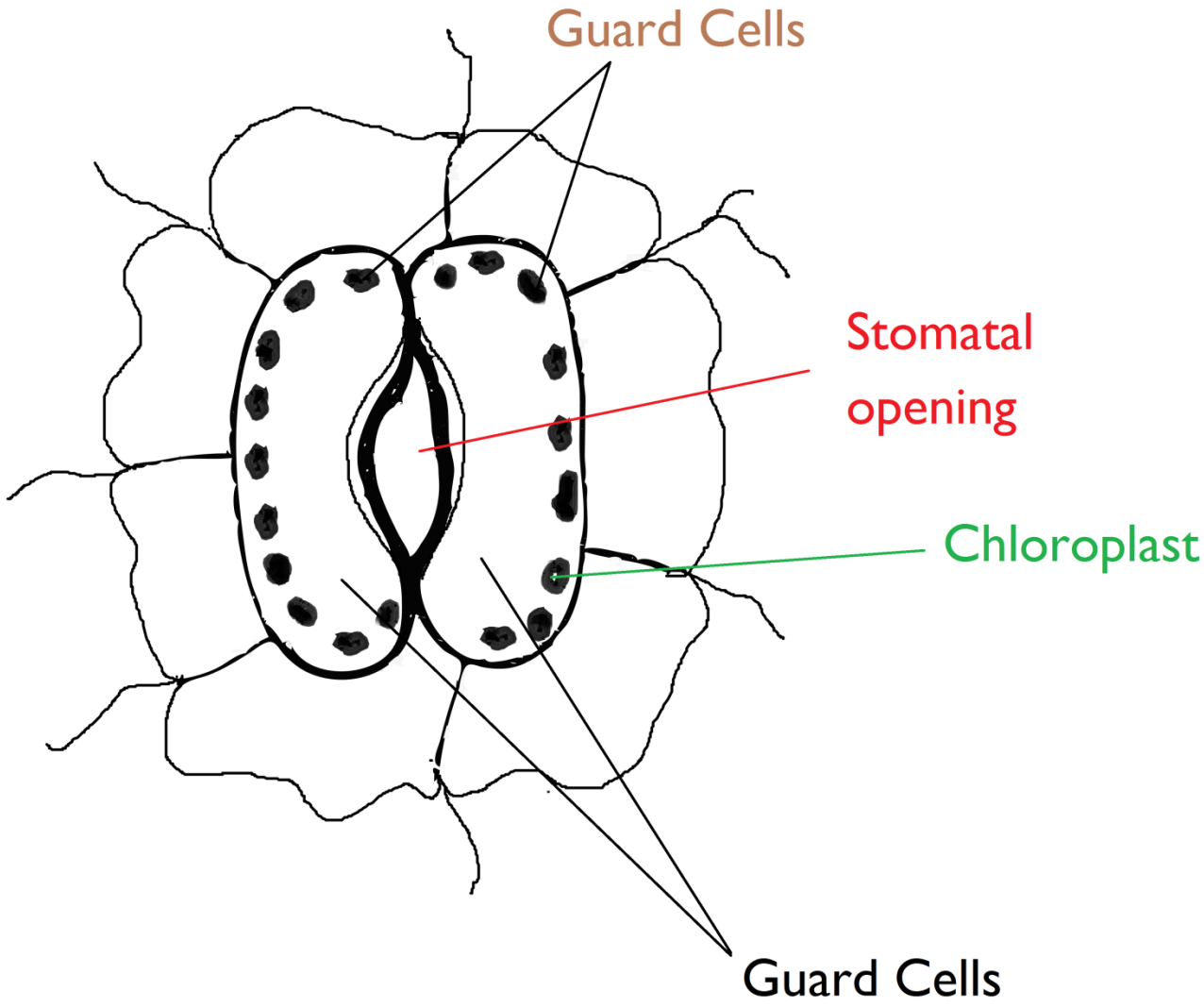


- Some plant leaves are **covered with dense mats of hairs** that help reduce water loss (by reducing evaporation). **And some** protect the plant by secreting toxic substances

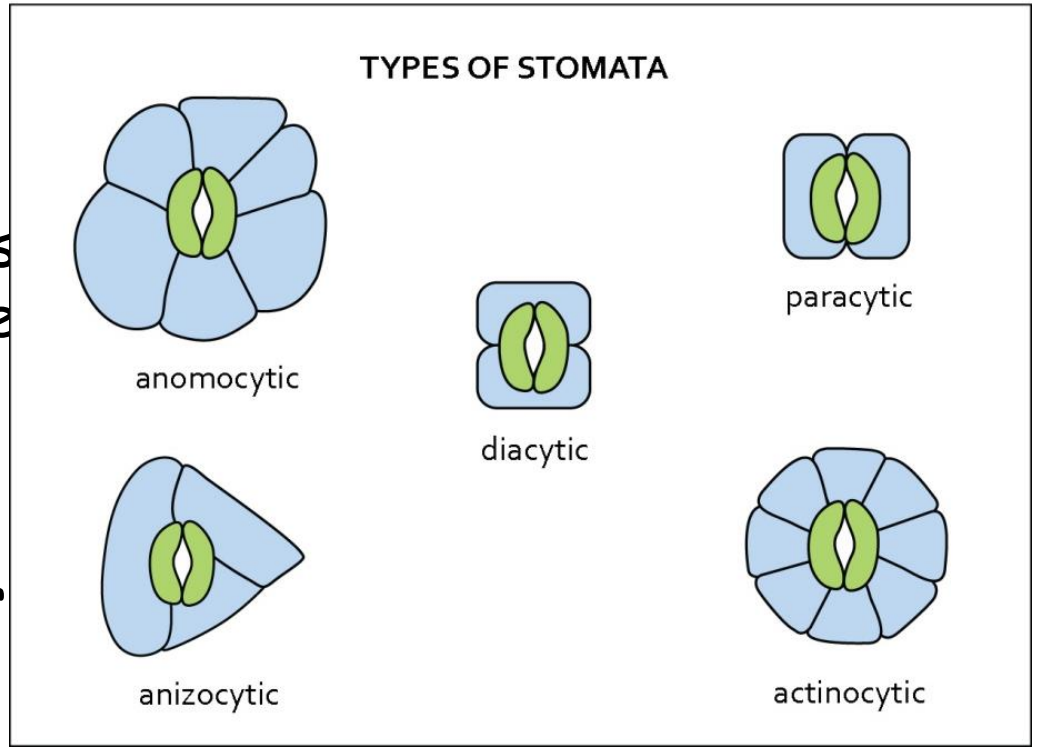
- The lower epidermis contains "**breathing pores**" called **stomata.** The location of the stomata in the lower epidermis keeps them from becoming plugged with dust that normally gathers on the top surface and **prevents entry of harmful air borne fungal spores.** Leaves tending to stand upright, such as Iris, have stomata in both leaf surfaces. And since the lower surfaces of waterlily leaves are submerged, the stomata are on the top surface.




guard
cell
aperture
subsidiary cell

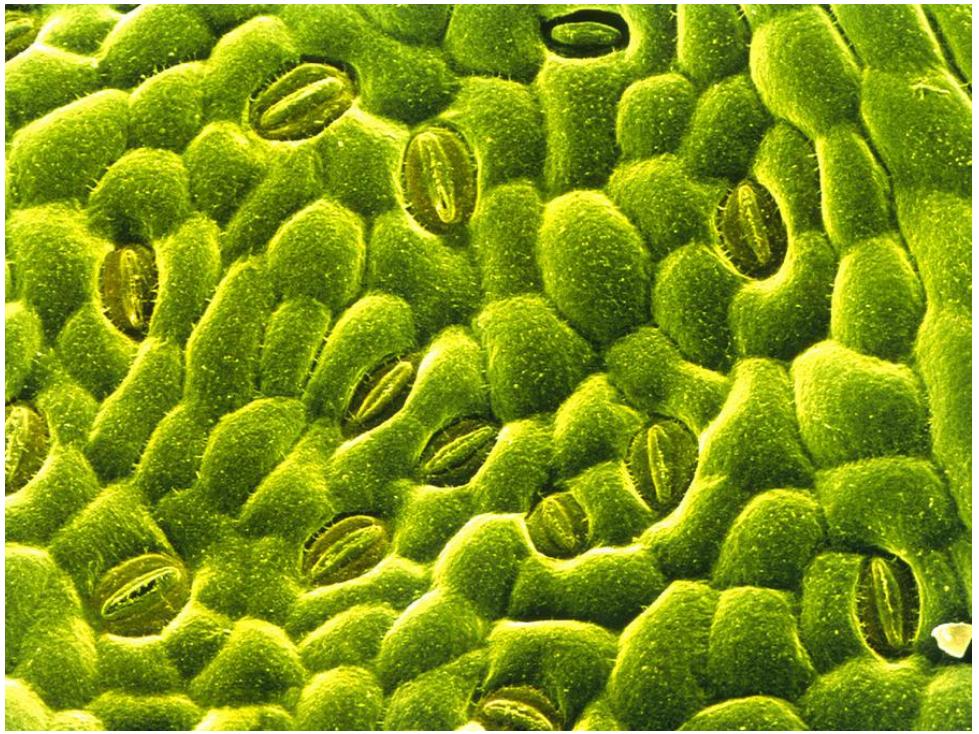

Guard Cells
Stomatal
opening
Chloroplast
Guard Cells

- On the bases of the number and position of subsidiary cells, various types of stomata are distinguished. If the subsidiary cells cannot be distinguished from the ordinary epidermal cells, the stoma is called anomocytic. If two subsidiary cells are born in the complex, the stoma is either paracytic (the longitudinal axis of subsidiary cells is parallel with those of the guard cells) or diacytic (the longitudinal axis and the common wall of subsidiary cells is perpendicular to those of the guard cells). Besides, the stoma may be of tetracytic (four subsidiary cells, two of them in polar, the other ones in lateral position), anisocytic (three subsidiary cells, one being smaller or larger than the other ones), actinocytic (radiate-celled stomata) or any further types.

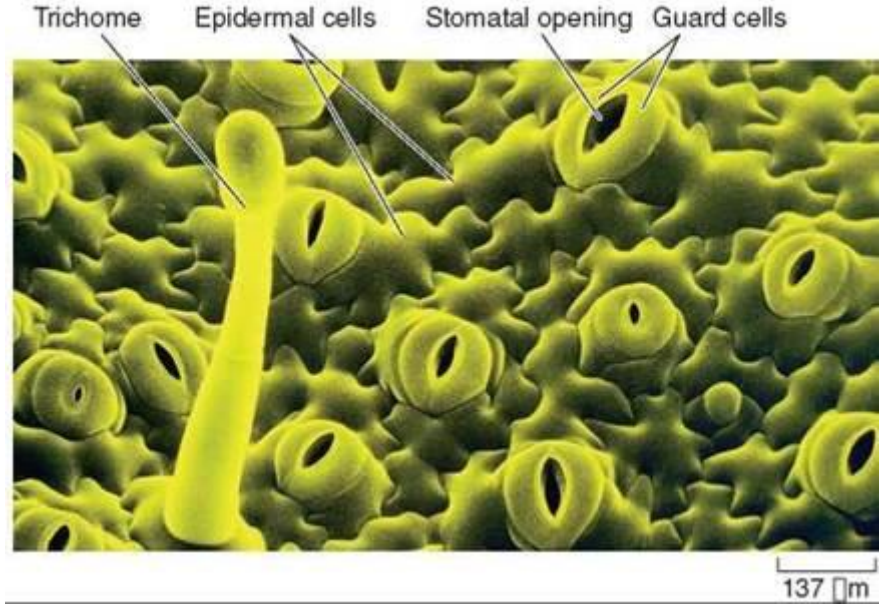


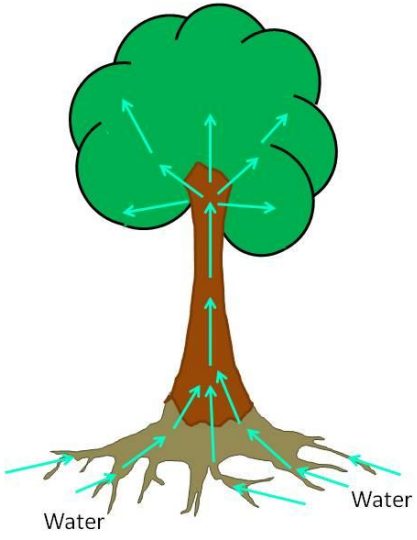
- **Stomatal openings permit gases to enter the leaf and water vapor to escape.** Periodic stomatal closures are used to regulate such water losses. In most plants, **stomata routinely close at night** as the absorption of carbon dioxide is not necessary when photosynthesis is not taking place. They may also close on hot, dry days, in heavy winds or when the soil gets dry or anytime that the uptake of water does not keep up with the rate of water loss.

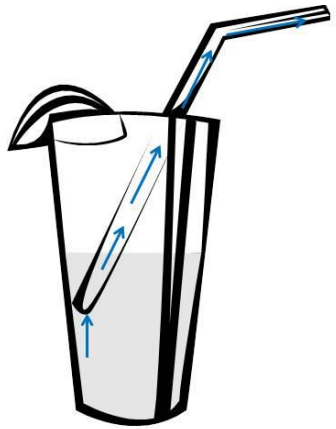
- Each stoma is bordered by two special cells, called **guard cells**, controlling the size of the opening. Inner walls of the guard cells that are adjacent to the openings are **thicker than the outer walls**. In a relaxed state, the guard cells lie parallel to each other with no opening between them.



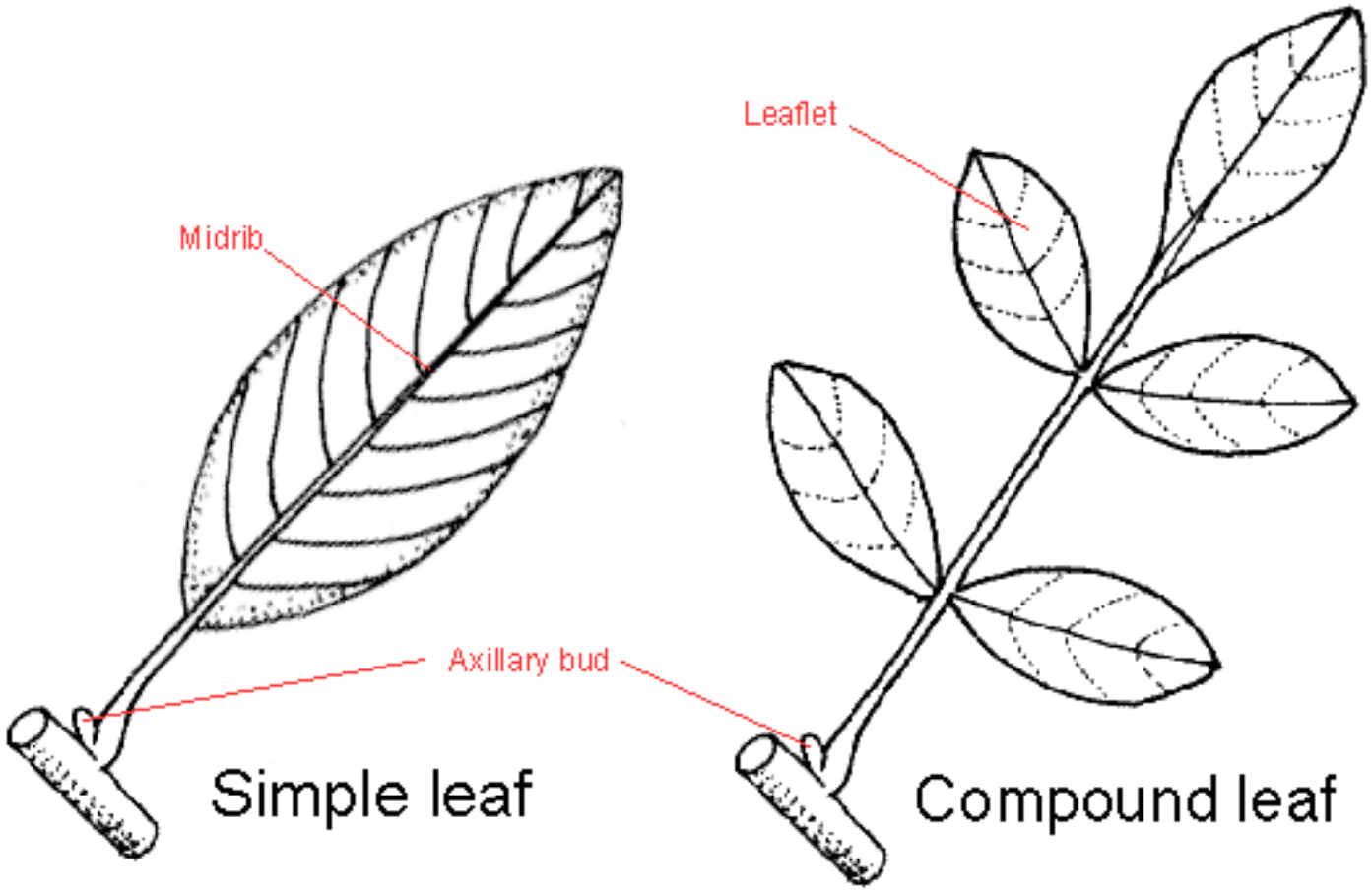
- When the plant pumps water into them, the thin walls stretch, the shape of the cells change, curving away from each other, and the stoma opens. Loss of water to the guard cells reverses the process. The anatomy of leaves is perfectly designed to bring together the ingredients for the chemistry of photosynthesis. **Water and dissolved minerals flow through the plants xylem, connecting roots and stems with leaf petioles, midribs and veins. Carbon dioxide enters the leaf through open stomata, and then defuses into the mesophyll cells, where the gas collects. Finally, in the chloroplasts, light and raw materials converge in the process upon which all life depends.**







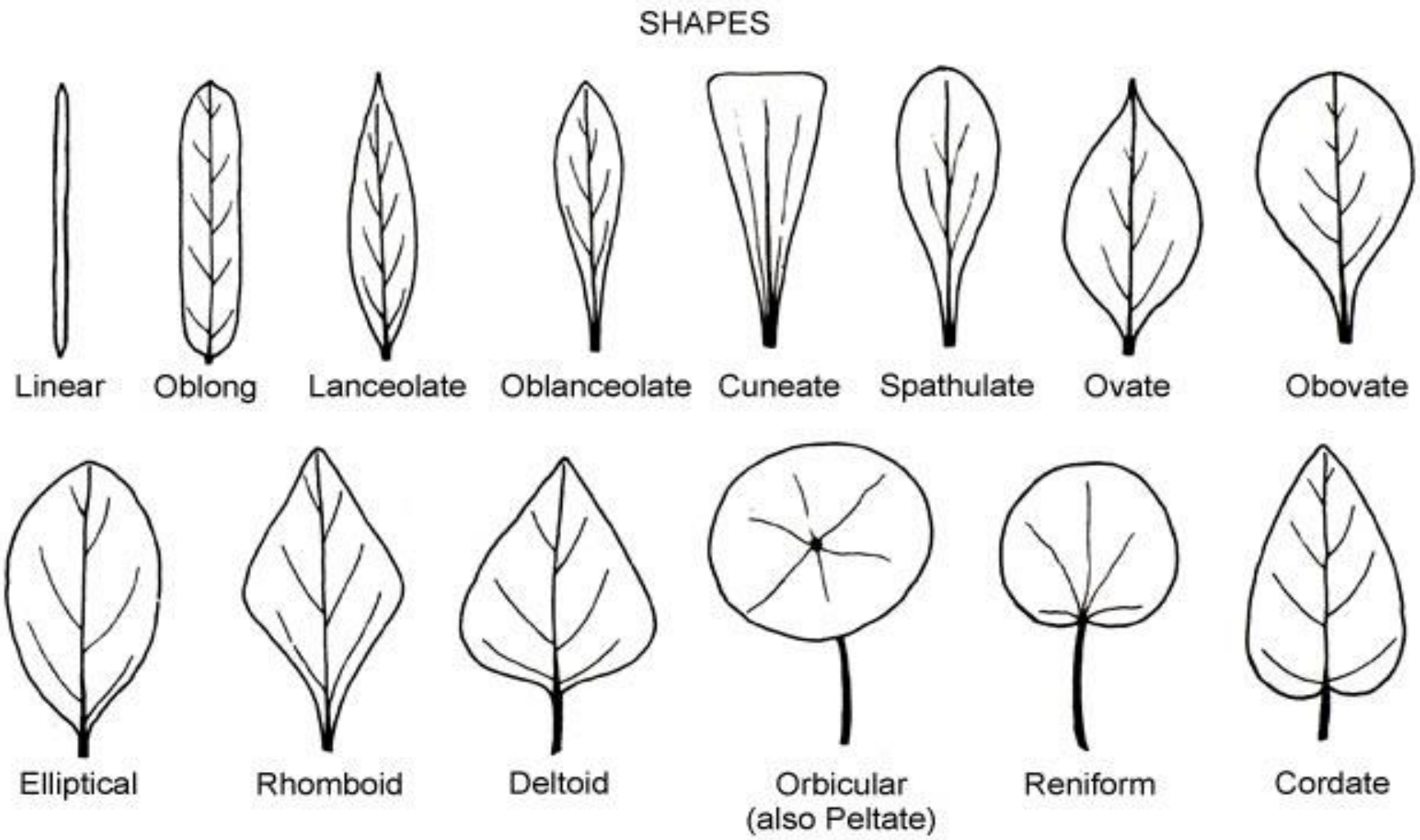
LEAF TYPES



Simple leaves generally show undivided blade.

Compound leaves have a fragmented blade.

SIMPLE LEAF


SHAPES
Linear
Oblong
Lanceolate
Oblanceolate
Cuneate
Spathulate
Ovate
Obovate
Elliptical
Rhomboid
Deltoid
Orbicular
(also Peltate)
Reniform
Cordate

Some definitions:

- Linear: Leaves long and thin, many times longer than wide, with parallel margins. Grass is an example
- Lanceolate: Leaves shaped like a lance-head, much longer than wide, and, in technical usage, broader towards the base. The reverse situation would be technically termed *oblanceolate*.
- Ovate: Leaves generally egg-shaped, with the broader portion towards the base. Often pointed at the tip. Sometimes includes elliptical leaves that are not clearly broader towards the base. May be modified as in *narrowly ovate* or *broadly ovate*.
- Elliptical or elliptic: Leaves shaped like an ellipse; that is, generally symmetrical, elongated, and more or less evenly rounded at both ends.
- Cordate: Leaves heart-shaped with the lobes at the base of the leaf.

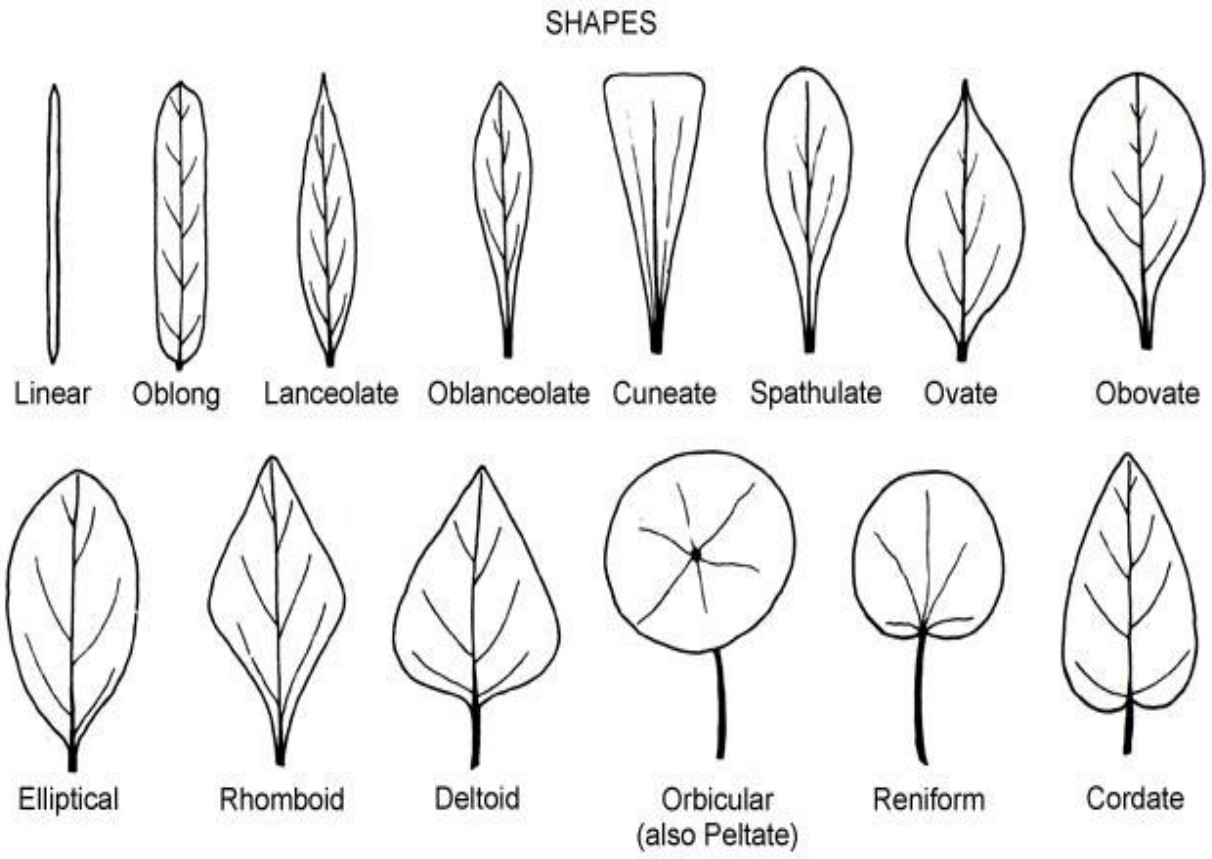


PLATE 4. LEAF MARGINS

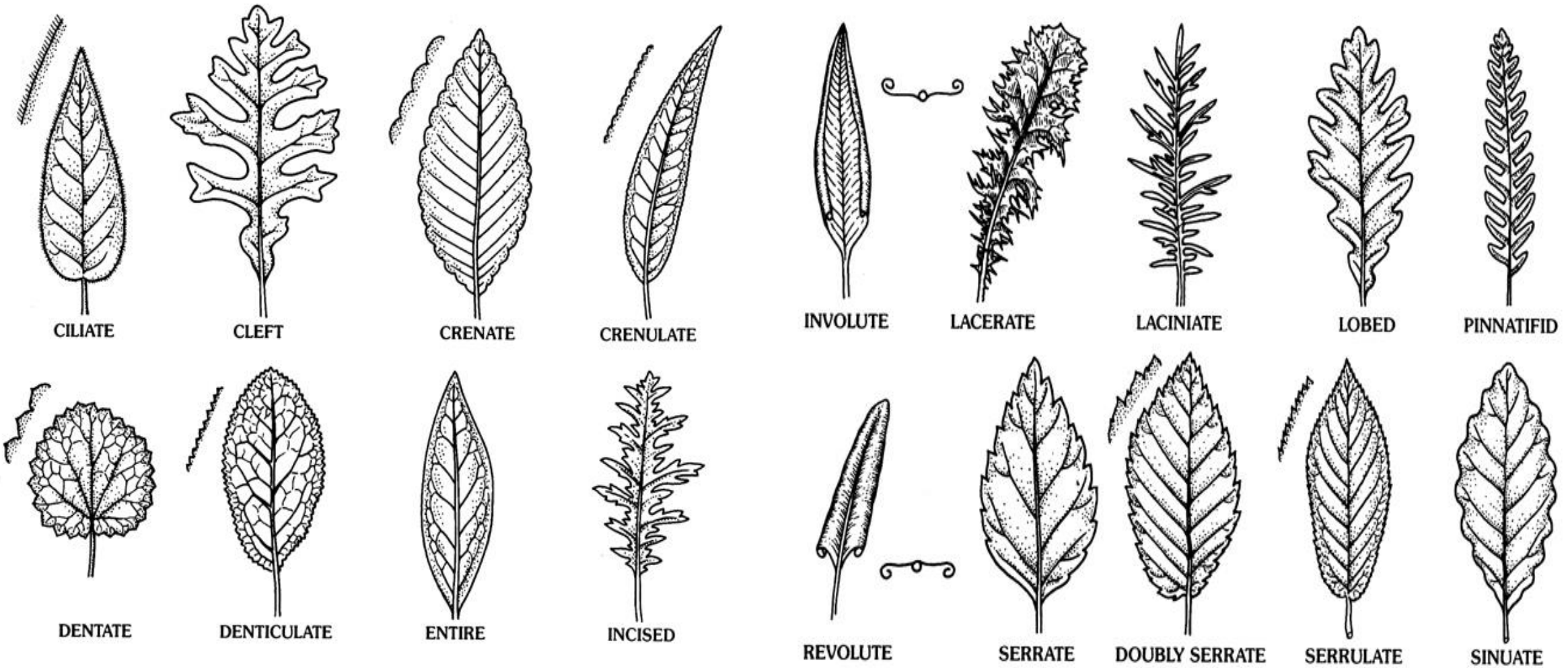
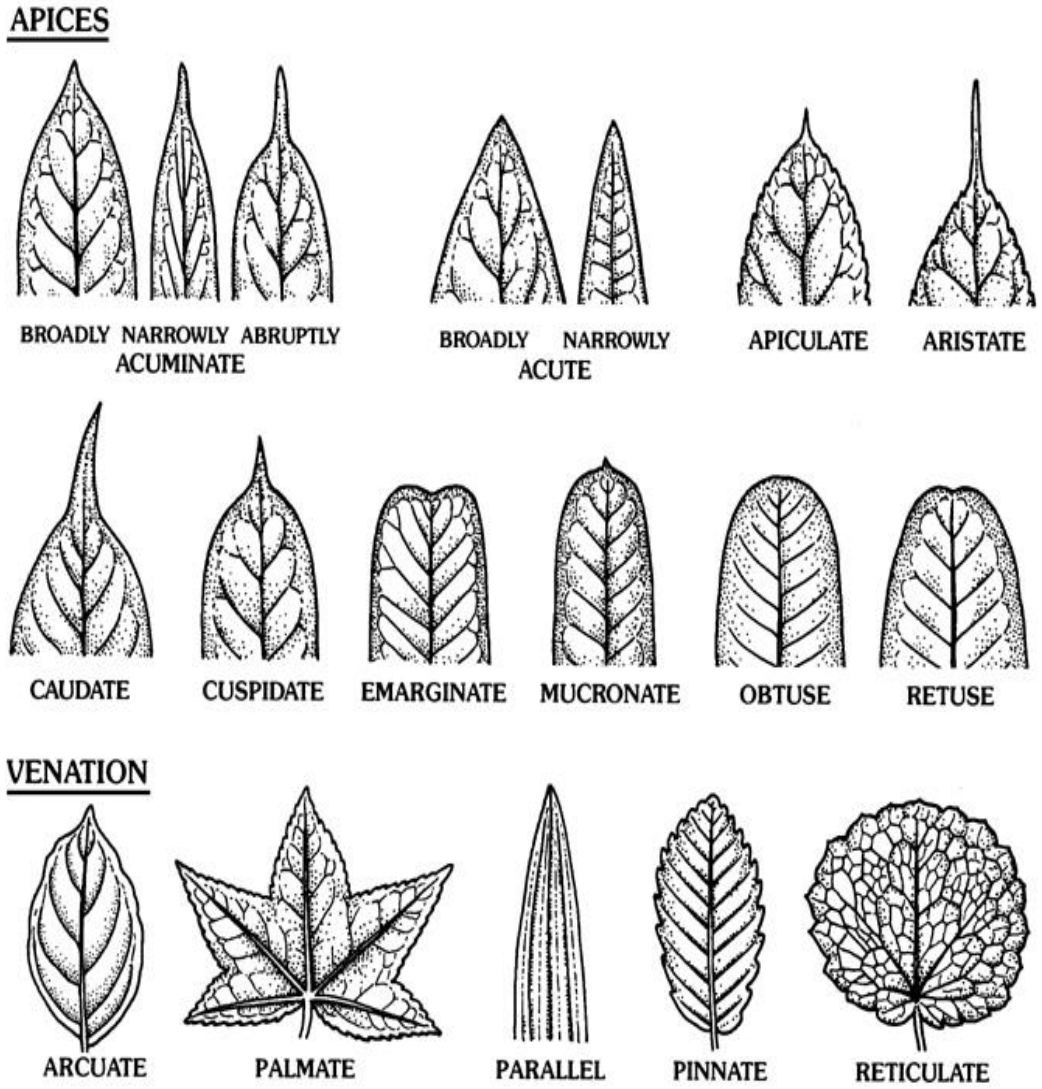


PLATE 5. LEAF APICES, VENATION, AND BASES



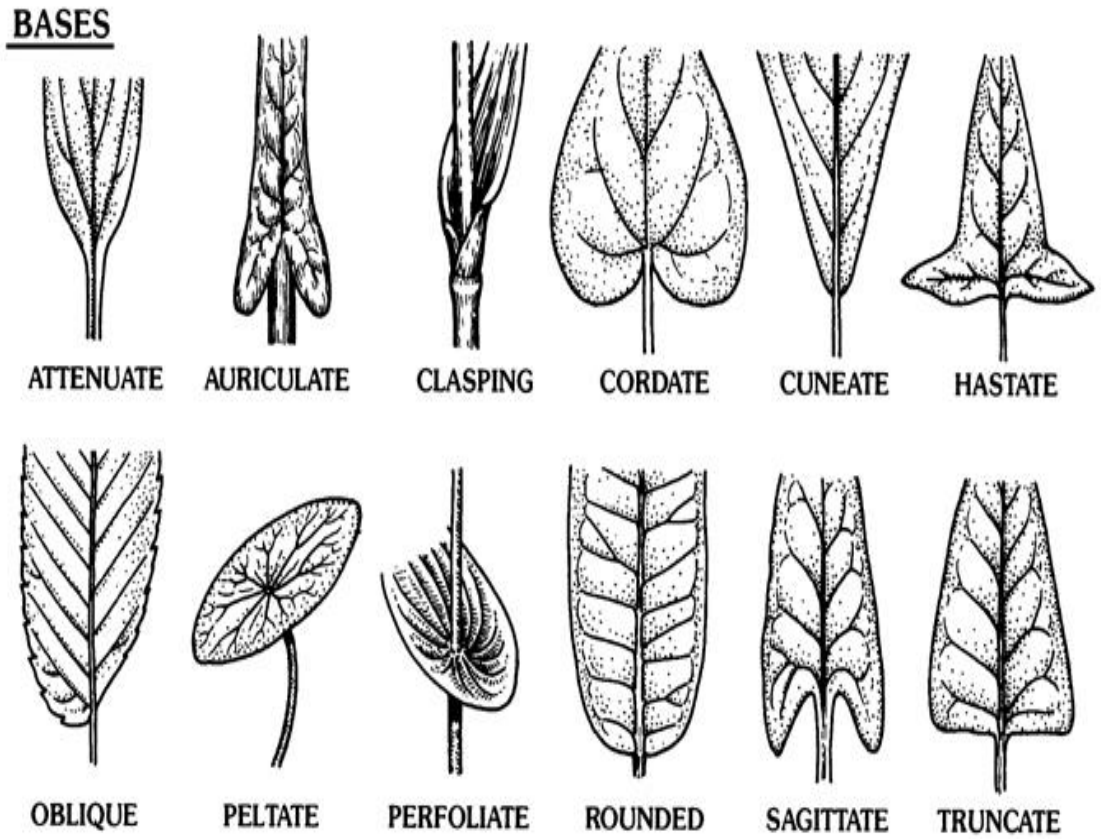
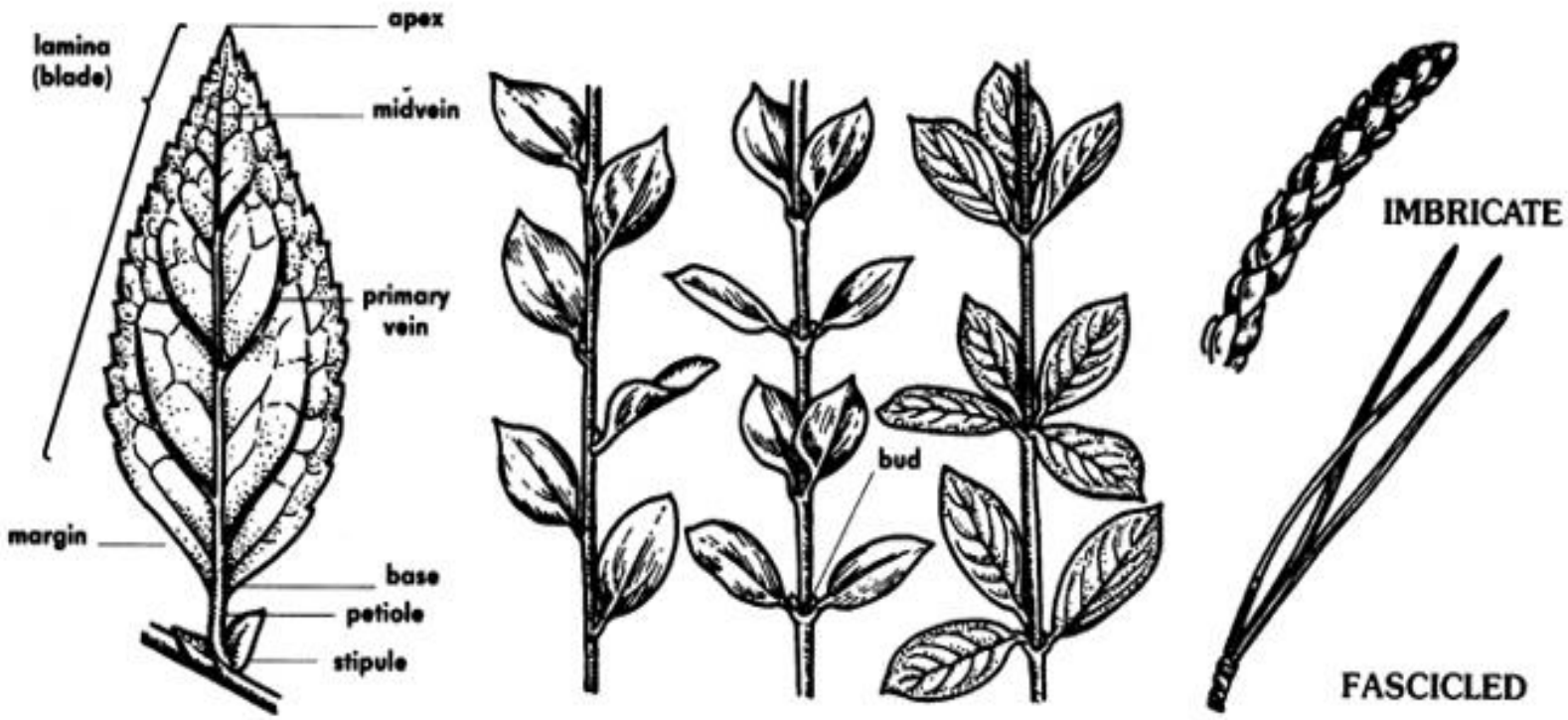
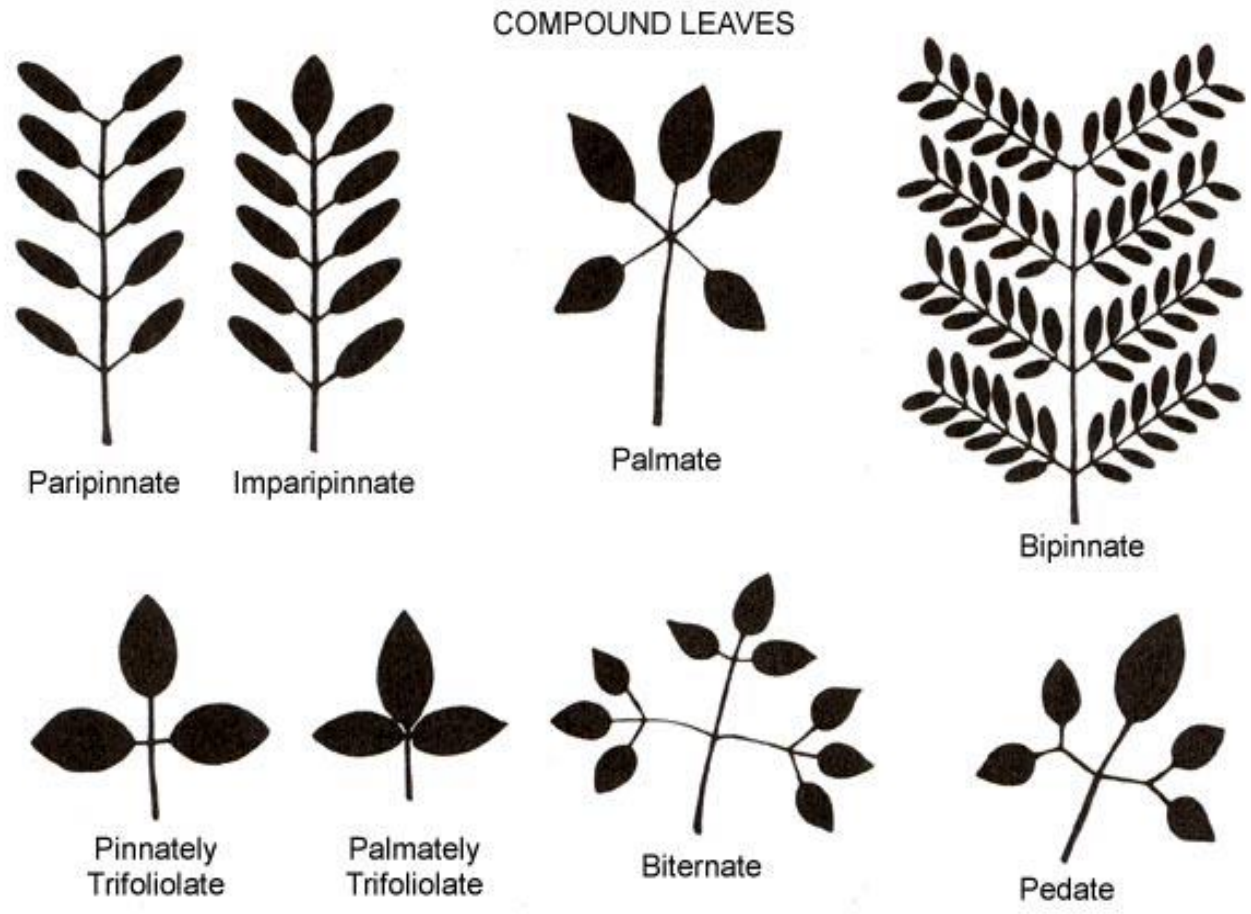


PLATE 2. LEAF COMPOSITION, PARTS, AND TYPES



COMPOUND LEAVES



Leaf Glossary:

air space - intercellular gaps within the spongy mesophyll. These gaps are filled with gas that the plant uses (carbon dioxide - CO_2) and gases that the plant is expelling (oxygen - O_2, and water vapor).

axil - the angle between the upper side of the stem and a leaf or petiole.

chlorophyll - a molecule in leaves that can use light energy from sunlight to turn water and carbon dioxide gas into sugar and oxygen (this process is called photosynthesis). Chlorophyll is magnesium-based and is green.

compound leaf - a leaf that is divided into many separate parts (leaflets) along a midrib (the rachis). All the leaflets of a compound leaf are oriented in the same plane.

crenate - having rounded teeth.

cuticle - the waxy, water-repelling layer on the outer surface of a leaf that helps keep it from dying out (and protect it from invading bacteria, insects, and fungi). The cuticle is secreted by the epidermis (including the guard cells) and is often thinner on the underside of leaves. The cuticle is generally thicker on plants that live in dry environments.

entire - having a smooth edge with neither teeth nor lobes.

epidermis - the protective, outler layer of cells on the surface of a leaf. The guard cells (and stoma) are part of the epidermis. The surface of many leaves is coated with a waxy cuticle which is secreted by the epidermis.

guard cell - one of a pair of sausage-shaped cells that surround a stoma (a pore in a leaf). Guard cells change shape (as light and humidity change), causing the stoma to open and close.

lamina - the blade of a leaf.

leaf apex - the outer end of a leaf; the end that is opposite the petiole.

lobed - divided into rounded or pointed sections and the incisions (cuts) go less than halfway to the midrib.

mesophyll - the chlorophyll-containing leaf tissue located between the upper and lower epidermis. These cells convert sunlight into usable chemical energy for the plant.

midrib - the central rib of a leaf - it is usually continuous with the petiole.

palisade mesophyll - a layer of elongated cells located under the upper epidermis. These cells contain most of the leaf's chlorophyll, converting sunlight into usable chemical energy for the plant.

parted (or cleft) - the margins between the irregular teeth go more than halfway to the midrib.

petiole - a leaf stalk; it attaches the leaf to the plant.

photosynthesis - the process in which plants convert sunlight, water, and carbon dioxide into food energy (sugars and starches), oxygen and water. Chlorophyll or closely-related pigments (substances that color the plant) are essential to the photosynthetic process.

pinnate - a compound leaf that is made up of many small leaflets arranged in pairs on either side of a long central midrib (the rachis). There is often a single terminal leaflet at the end of the midrib.

serrate (or toothed) - having small, pointy teeth that point toward the tip of the leaf.

spongy mesophyll - the layer below the palisade mesophyll; it has irregularly-shaped cells with many air spaces between the cells. These cells contain some chlorophyll. The spongy mesophyll cells communicate with the guard cells (stomata), causing them to open or close, depending on the concentration of gases.

stem - (also called the axis) the main support of the plant.

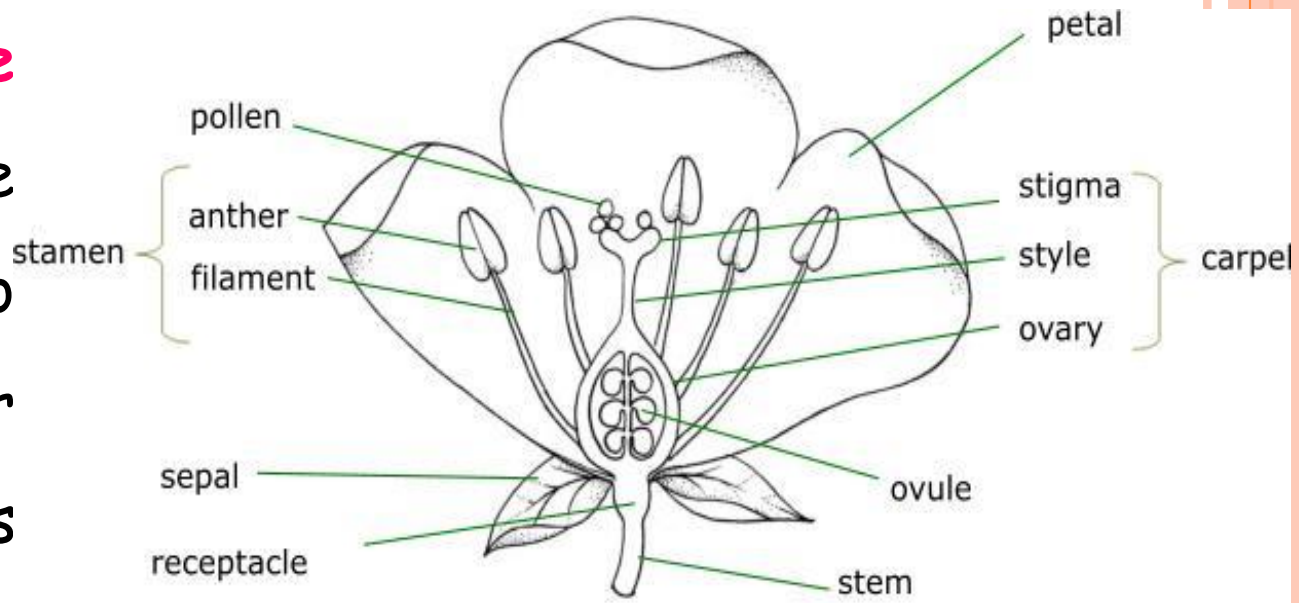
stipule - the small, paired appendages (sometimes leaf-life) that are found at the base of the petiole of leaves of many flowering plants.

stoma - (plural stomata) a pore (or opening) in a plant's leaves where water vapor and other gases leave and enter the plant. Stomata are formed by two guard cells that regulate the opening and closing of the pore. Generally, many more stomata are on the bottom of a leaf than on the top.

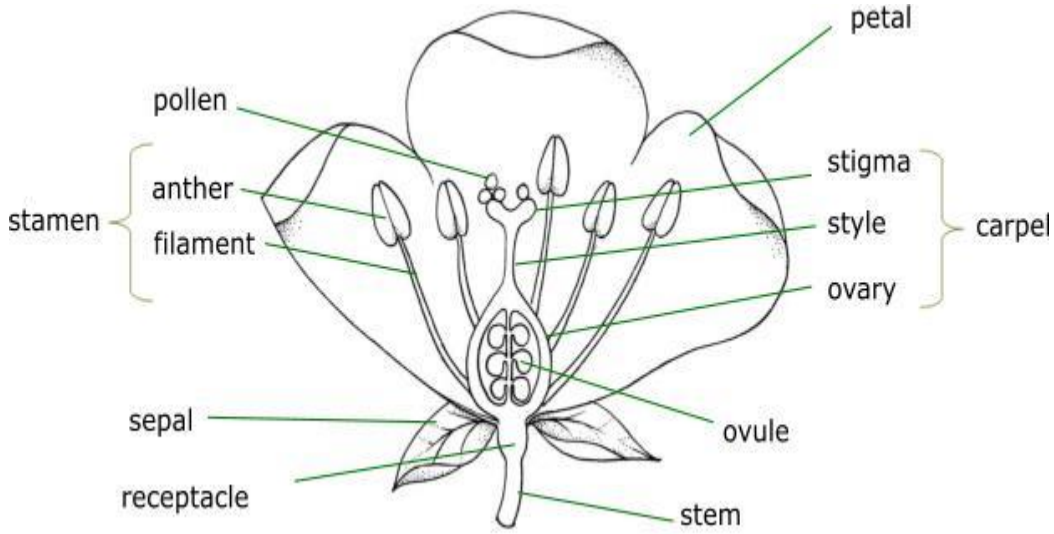
vein (vascular bundle) - Veins provide support for the leaf and transport both water and minerals (via xylem) and food energy (via phloem) through the leaf and on to the rest of the plant.

FLOWER

- A flower is the **reproductive structure** found in flowering plants. The biological function of a flower is to provide **reproduction**, a mechanism for the **union of sperm with eggs.** Flowers give rise to fruit and seeds.

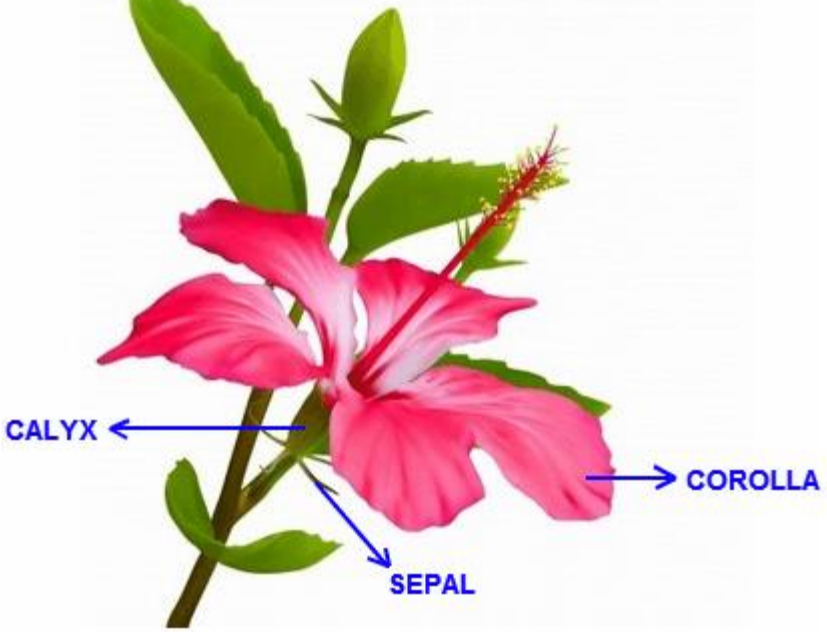


Floral parts



- The essential parts of a flower can be considered in two parts: **the vegetative part,** consisting of **petals** and associated structures in the **perianth,** and the reproductive or sexual parts.
- A stereotypical flower consists of **four kinds of structures attached to the tip of a short stalk.** Each of these kinds of parts is arranged in a whorl on the **receptacle.**

THE FOUR MAIN WHORLS ARE AS FOLLOWS:



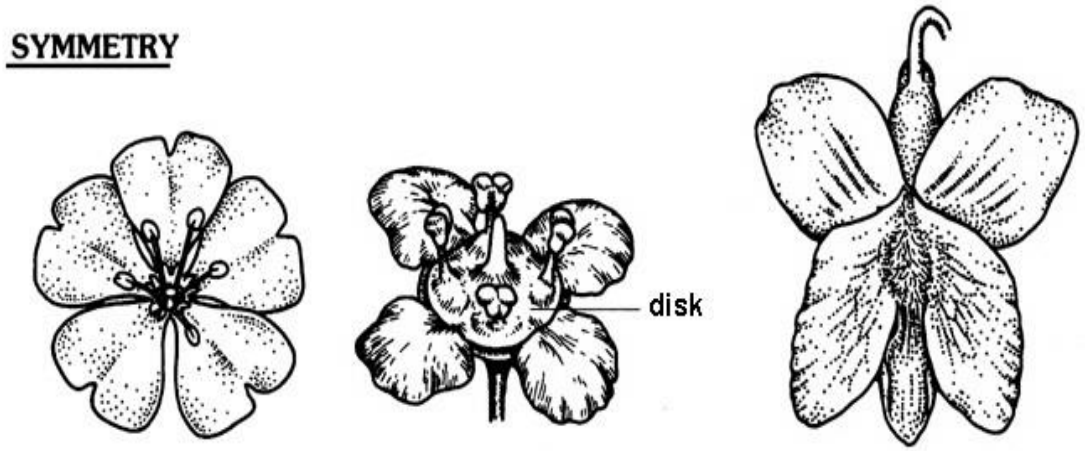
- Vegetative (Perianth)
- 1. Calyx and 2. Corolla form the perianth.

1. Calyx: the outermost whorl consisting of units called sepals; these are typically green and enclose the rest of the flower in the bud stage, however, they can be absent or prominent and petal-like in some species.

2. Corolla: the next whorl toward the apex, composed of units called petals, which are typically thin, soft and colored to attract animals that help the process of pollination.

PLATE 9. FLORAL MORPHOLOGY

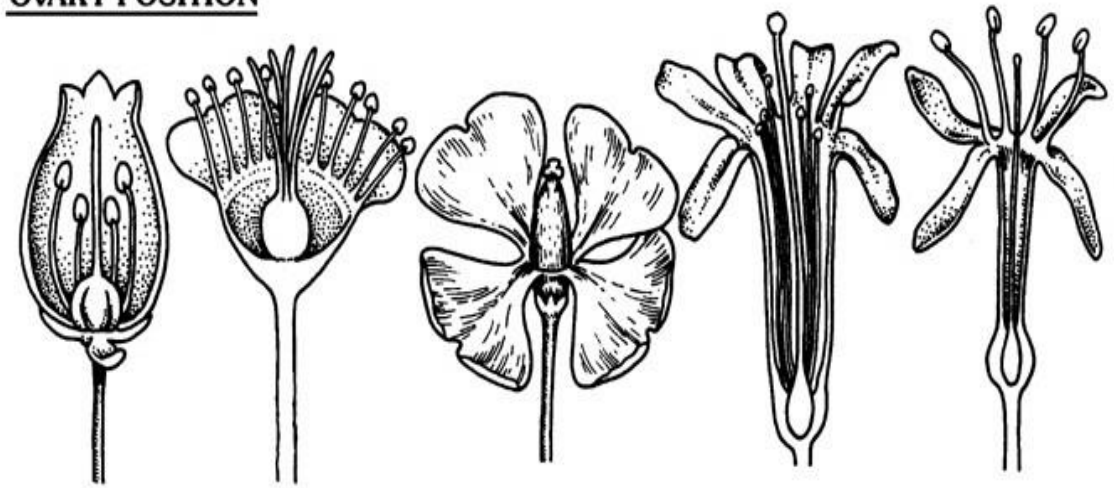
SYMMETRY



ACTINOMORPHIC / RADIAL SYMMETRY

ZYGOMORPHIC / BILATERAL SYMMETRY

OVARY POSITION



SUPERIOR HYPOGYNOUS

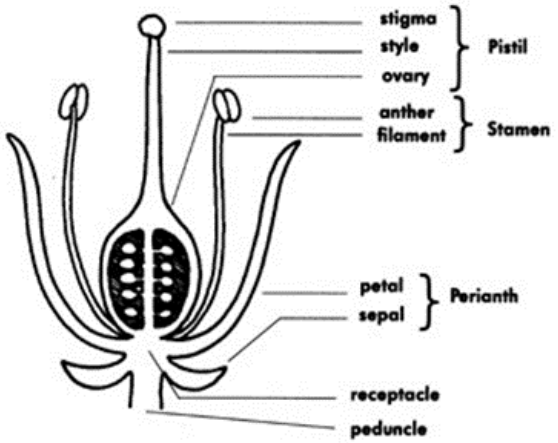
SUPERIOR PERIGYNOUS

1/2 INFERIOR

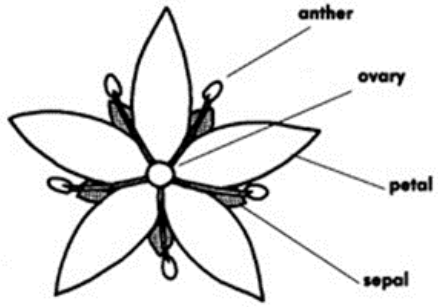
INFERIOR EPIGYNOUS

INFERIOR

COMPONENTS



FLOWER LONGITUDINAL SECTION

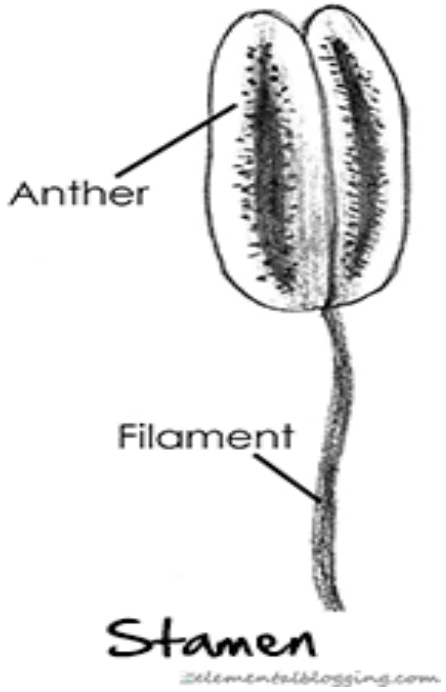


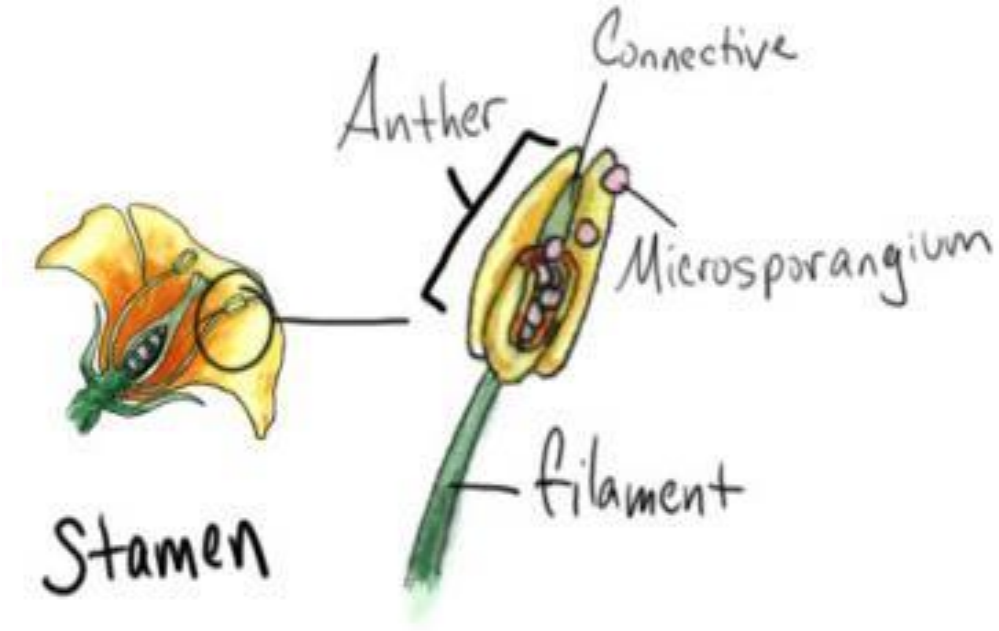
FLOWER TOP VIEW

modified from Swink, F. and G. Willhelm. 1994. *Plants of the Chicago region.* 4th ed. Indianapolis: Indiana Academy of Science.

REPRODUCTIVE

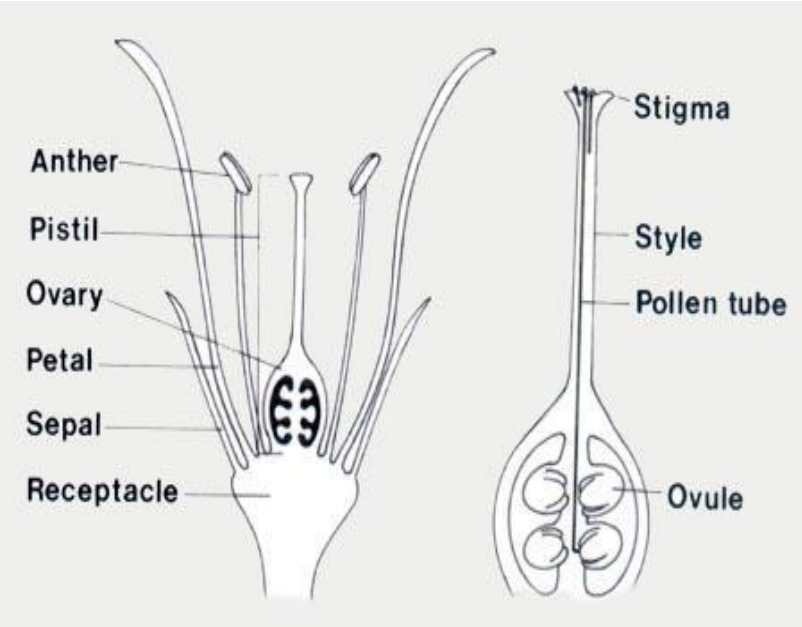
- **3. Androecium:** the next whorl (sometimes multiplied into several whorls), consisting of units called **stamens**. Stamens **consist of two parts**: a stalk called a **filament**, topped by an **anther** where pollen is produced by meiosis and eventually dispersed.



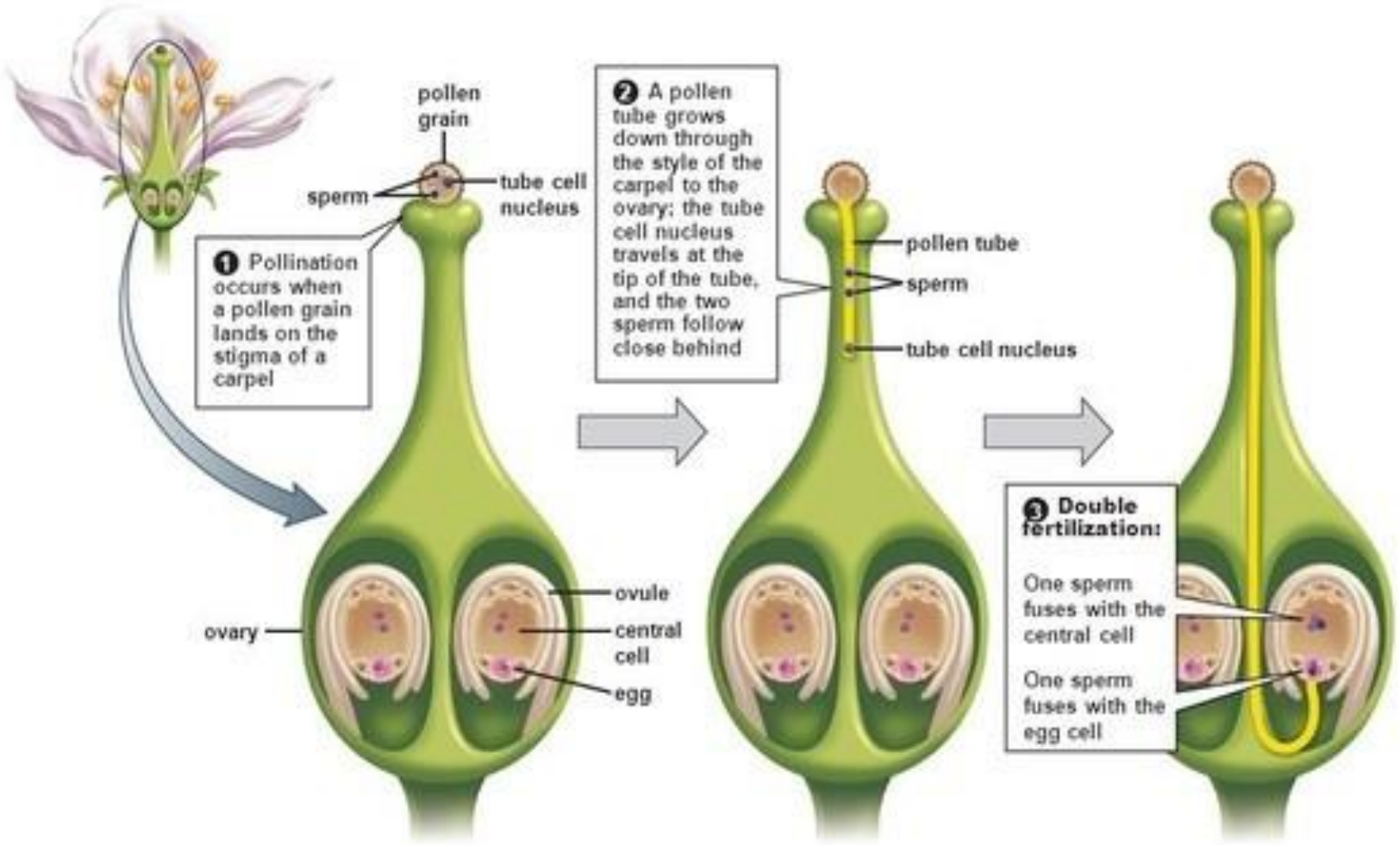


- **4. Gynoecium:** **The gynoecium, innermost whorl (consisting of an ovary, style and stigma) is called a pistil and is composed of one or more units called carpels. The carpel or multiple fused carpels form a hollow structure called an ovary, which produces ovules internally.** Ovules are megasporangia and they in turn produce megaspores by meiosis which develop into female gametophytes. These give rise to egg cells.

The sticky tip of the pistil, the **stigma**, is the receptor of pollen. The supportive stalk, the **style**, becomes the pathway for pollen tubes to grow from pollen grains adhering to the stigma. The relationship to the gynoecium on the receptacle is described as **hypogynous** (beneath a **superior** ovary), **perigynous** (surrounding a superior ovary), or **epigynous** (above inferior ovary).

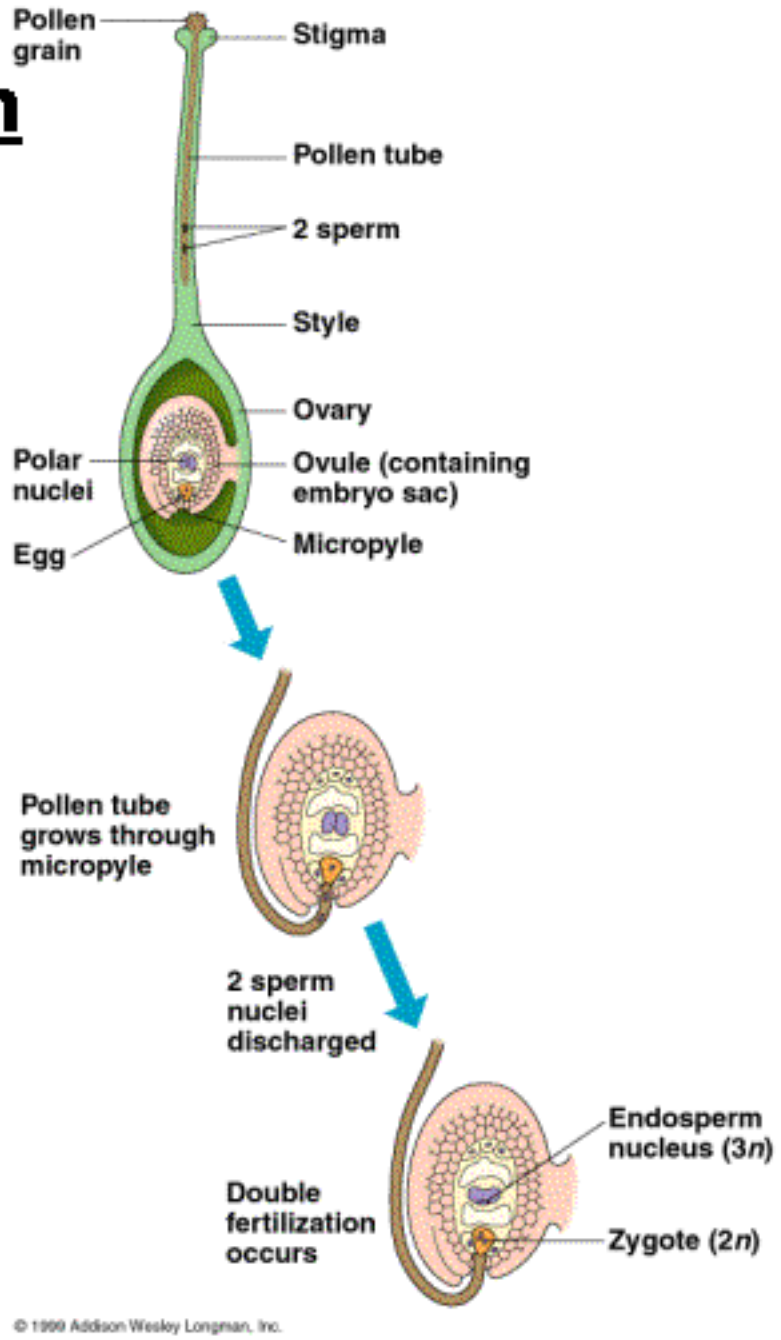


Pollination and Fertilization of a Flower



Summary of Fertilization

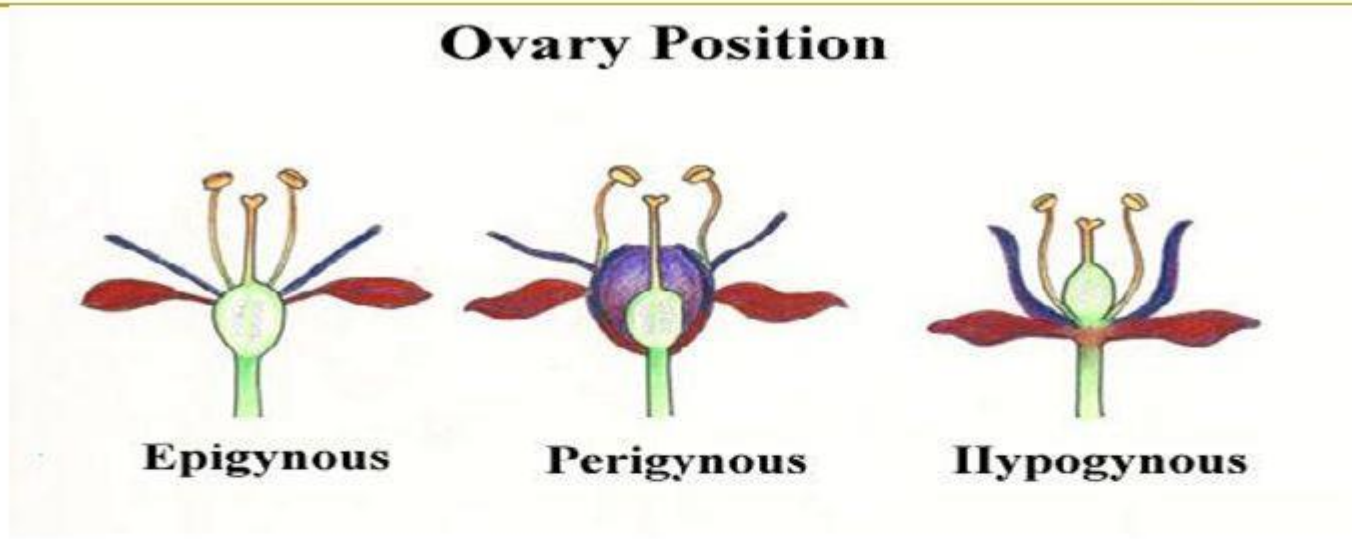
1. A pollen tube grows from pollen grain, down the style, through the micropyle and into the ovule.
2. Two sperm nuclei are discharged into the embryo sac resulting in double fertilization.
3. The fertilized egg (zygote) will develop into the embryo.
4. The ferilized central cell will develop into endosperm.
5. The ovule develops into a seed.
6. The ovary develops into a fruit containing one or more seeds.



Insertion of Floral Parts

- Hypogynous: the sepals, petals, and stamens are inserted under the carpel
  - Ovary is said to be ***superior***

Hypogynous



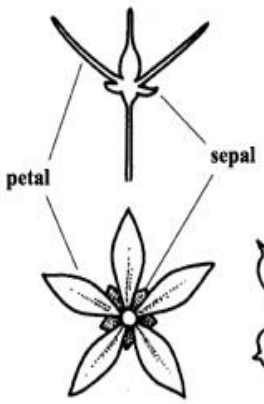
Depending upon its position the ovary may be

i) Inferior: When all the floral parts arise from above the ovary as in epigynous flowers.

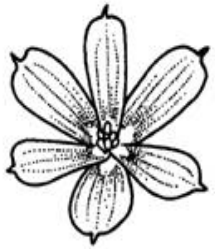
ii) Semi-inferior: Where the floral parts are seen developing from about the middle of ovary as in perigynous flowers.

iii) Superior: When all the floral parts arise from the base of the ovary as in hypogynous flowers.

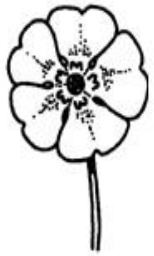
PLATE 10. COROLLA TYPES



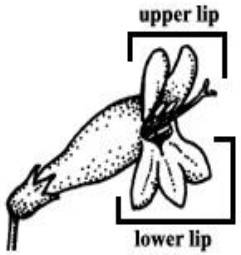
SEPALS & PETALS



TEPALS



ROTATE



BILABIATE

CRUCIFORM

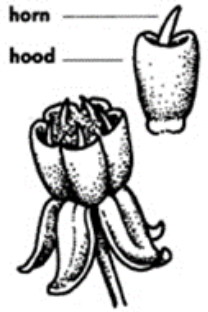
CORONATE

CAMPANULATE

FUNNELFORM

GALEATE

GIBBOUS



HOOD & HORN

LIGULATE

PALATE

PAPILIONACEOUS

CARINATE

SACCATE

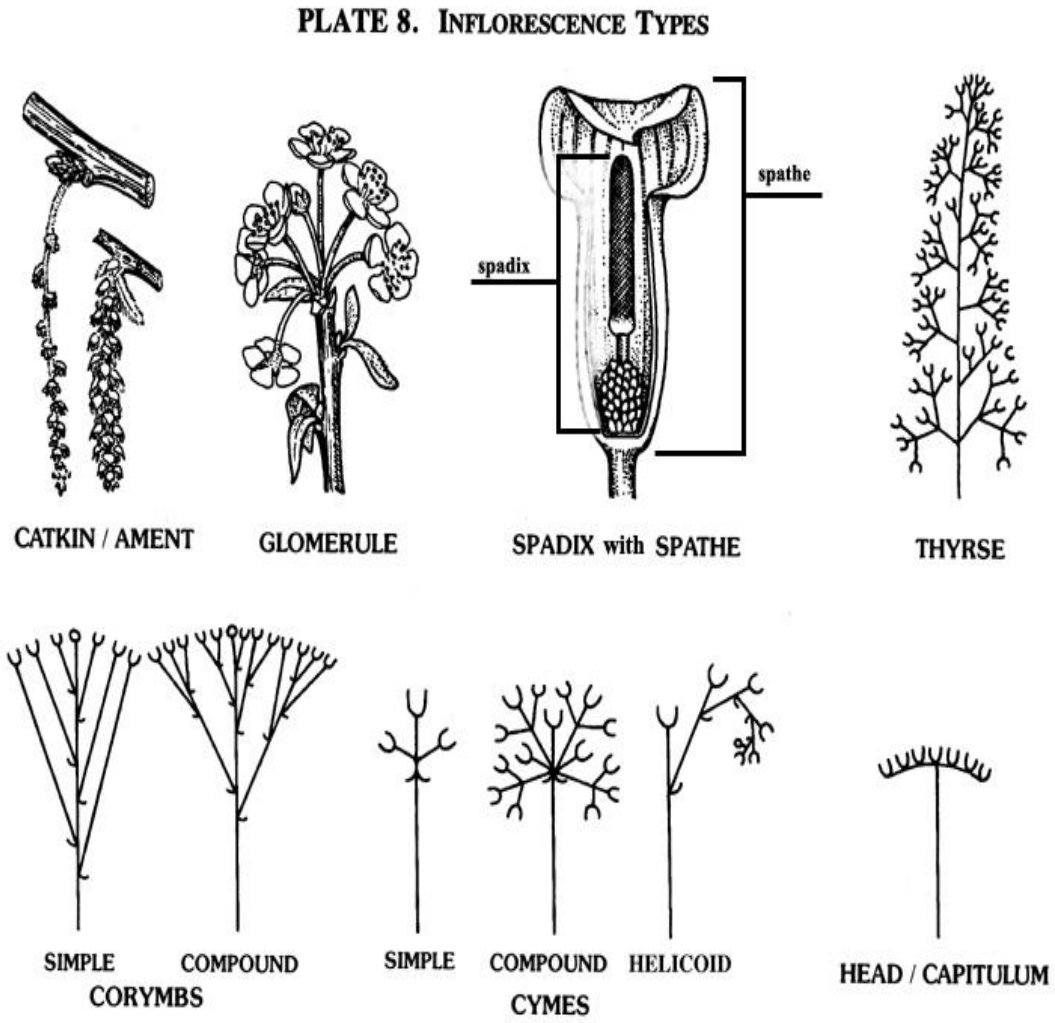
SALVERFORM

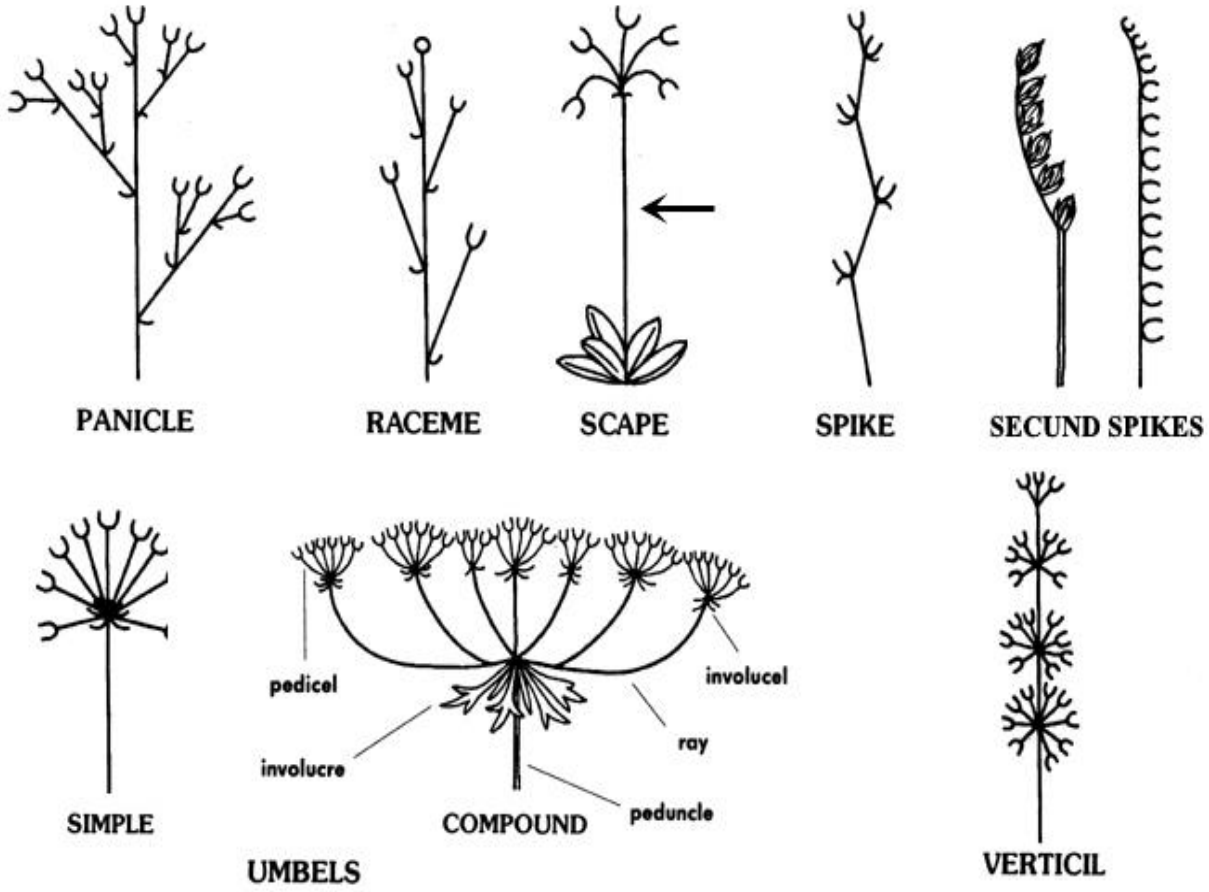
SPURRED

TUBULAR

URCEOLATE

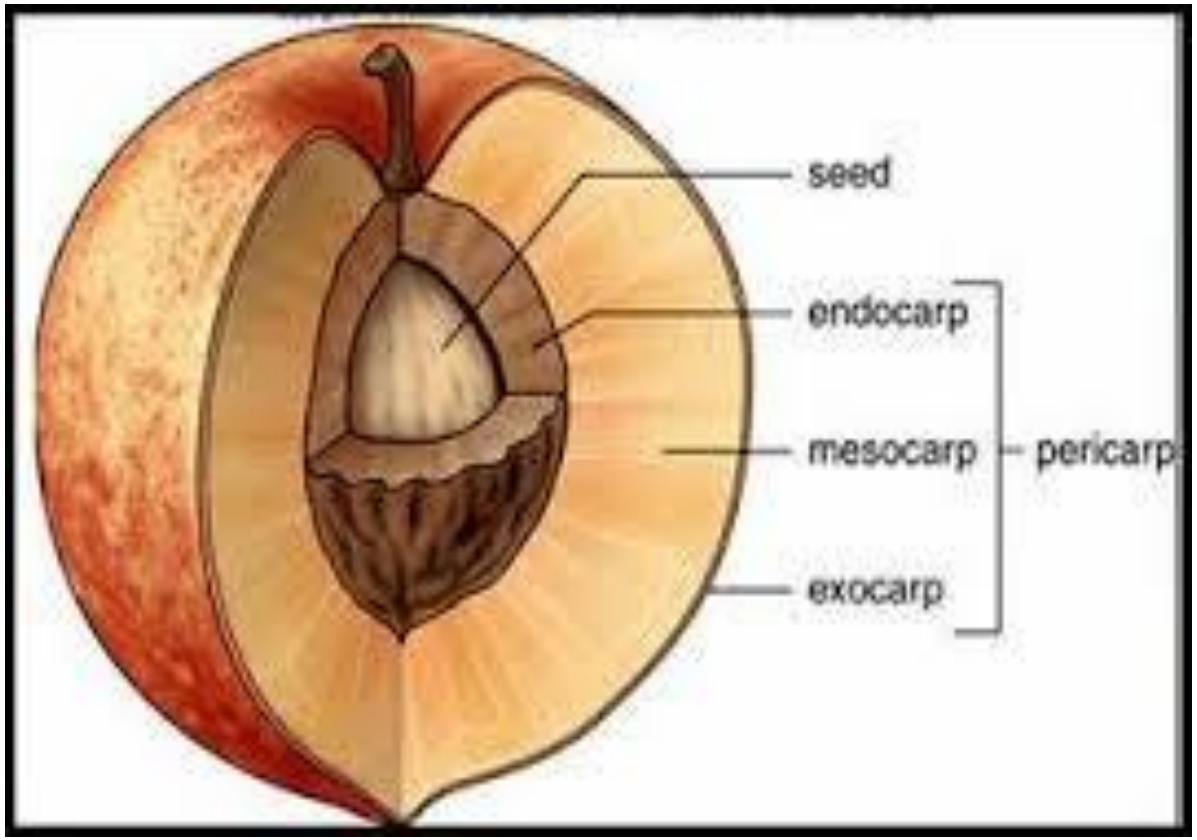
INFLORESCENCE: IT IS ACTUALLY AN INFLORESCENCE OF TINY FLOWERS PRESSED TOGETHER ON A CENTRAL STALK THAT IS SURROUNDED BY A LARGE PETAL-LIKE BRACT.





FRUIT

- A fruit results from **maturation of one or more flowers,** and the **gynoecium of the flower(s) forms all or part of the fruit.**
- Inside the ovary/ovaries are **one or more ovules** where the **megagametophyte contains the egg cell.** After double fertilization, these **ovules will become seeds**. The **ovules are fertilized in a process that starts with pollination,** which involves the movement of **pollen from the stamens to the stigma of flowers.**



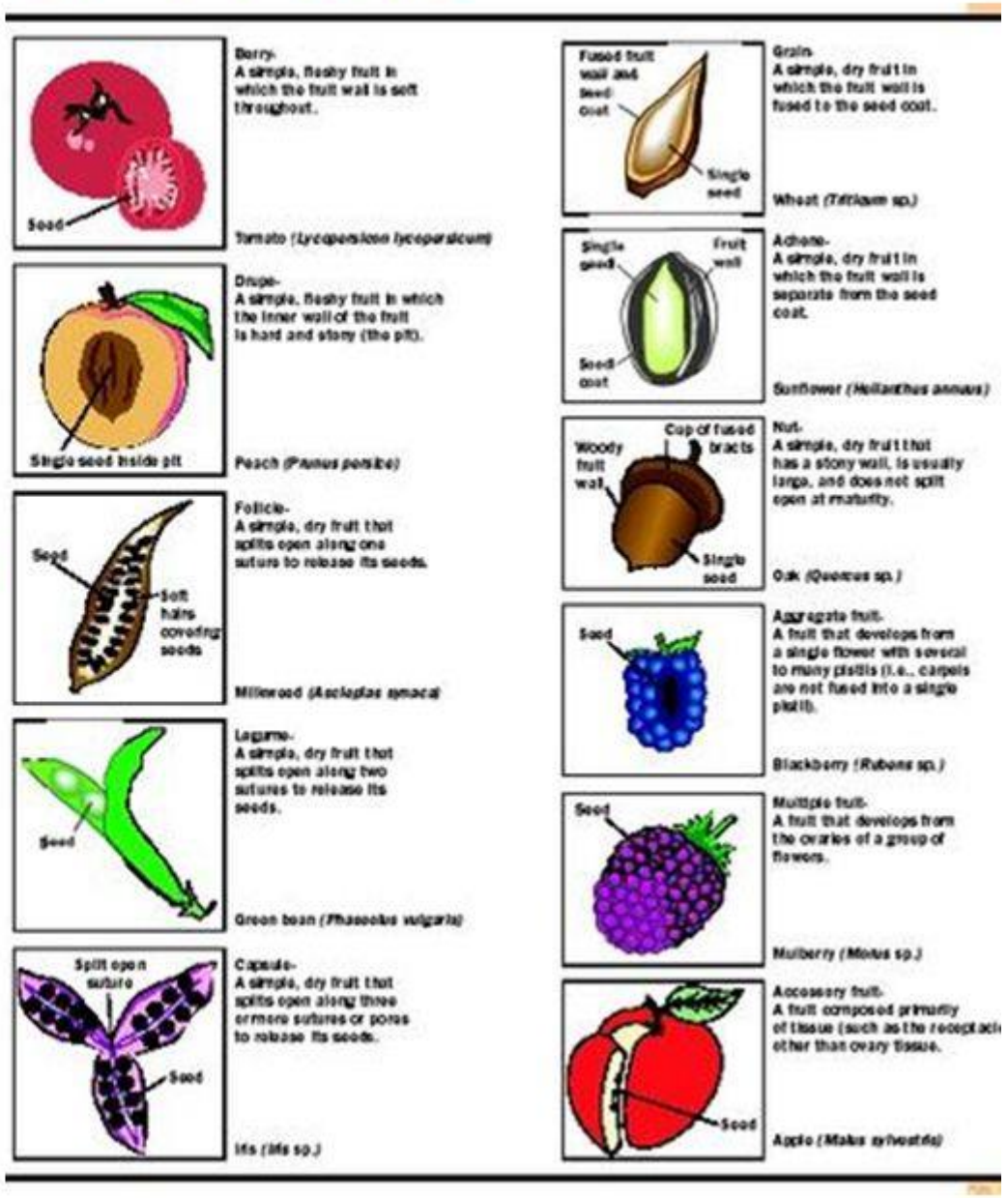
- After pollination, a tube grows from the pollen through the stigma into the ovary to the ovule and two **sperms are transferred from the pollen to the megagametophyte.** Within the megagametophyte one of the two sperm unites with the egg, forming a zygote, and the second sperm enters the central cell forming the endosperm mother cell, which completes the double fertilization process. Later the **zygote will give rise to the embryo of the seed,** and the **endosperm** mother cell will give rise to endosperm, **a nutritive tissue used by the embryo.**

There are three general modes of fruit development:

- **Apocarpous fruits** develop from a single flower having one or more separate carpels, and they are the simplest fruits.
- **Syncarpous fruits** develop from a single gynoecium having two or more carpels fused together.
- **Multiple fruits** form from many different flowers.

Types of Fruits

- *Simple Fruits*: These fruit types are produced by flowers containing one pistil, the main female reproductive organ of a flower.
- *Aggregate Fruits*: These fruits types are developed from flowers which have more than one pistils. They consist of mass of small drupes that develops from a separate ovary of a single flower.
- *Multiple Fruits*: These fruit types are developed not from one single flower but by a cluster of flowers.
- *Accessory Fruits*: These fruit types are developed from plant parts other than the ovary.



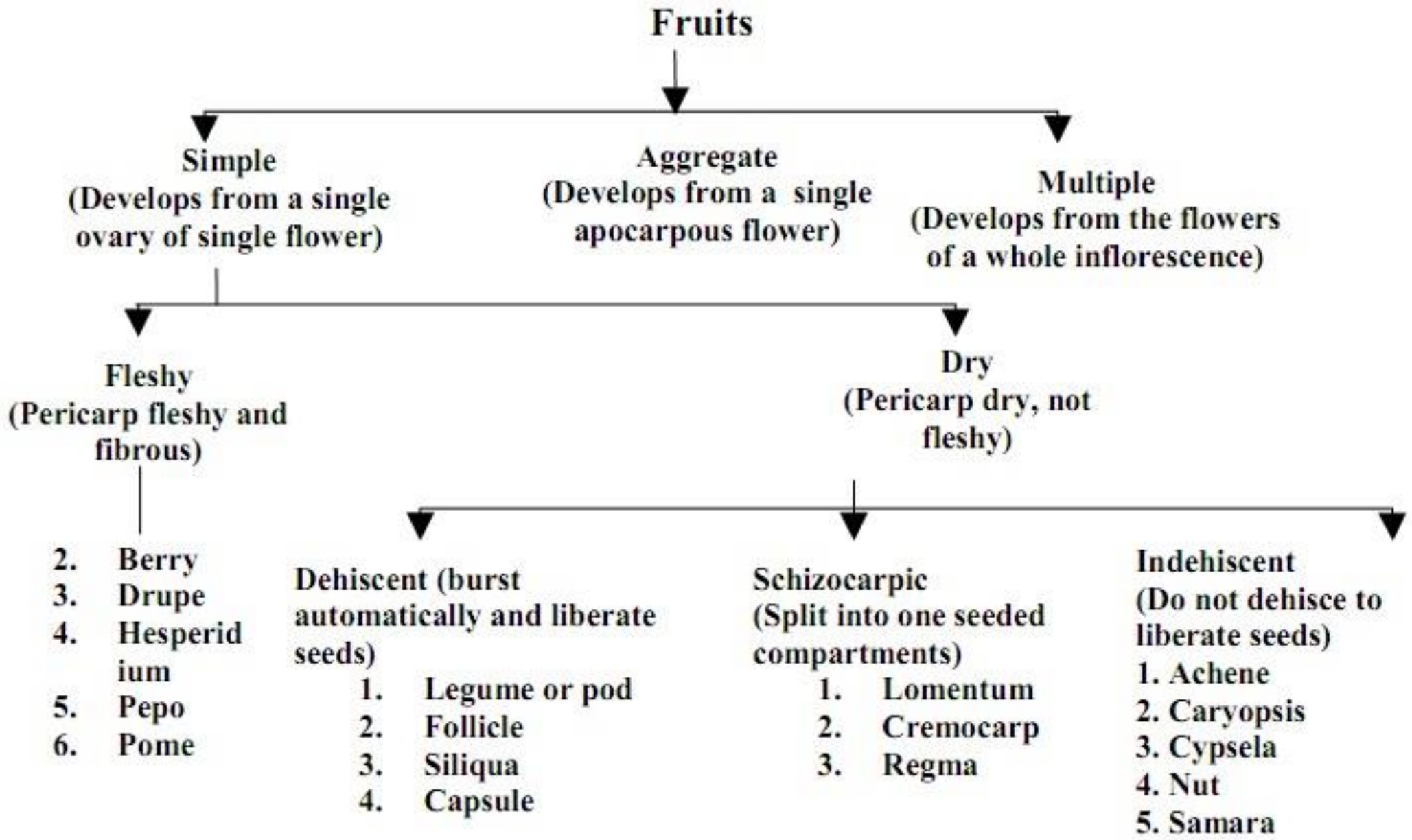
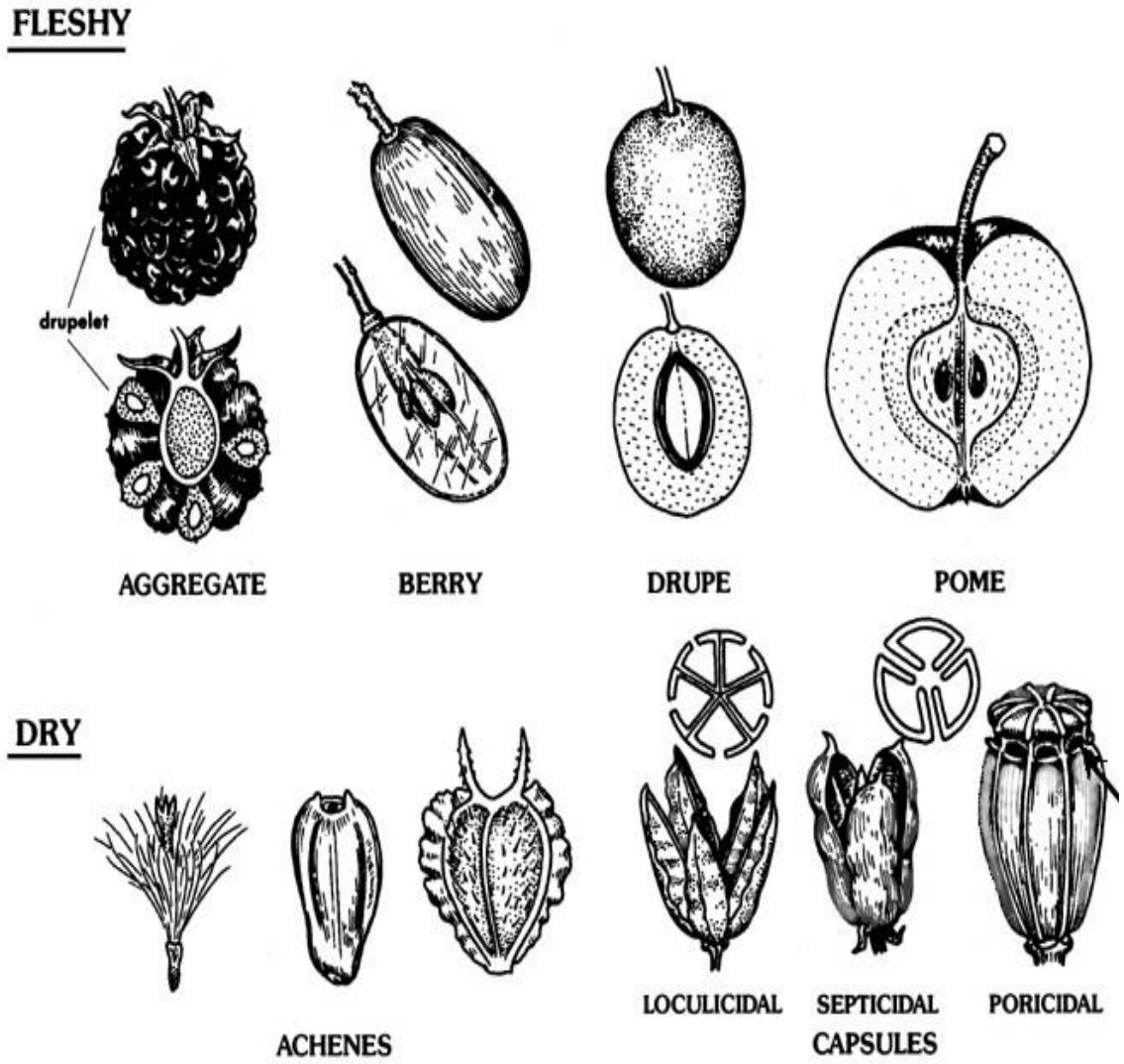
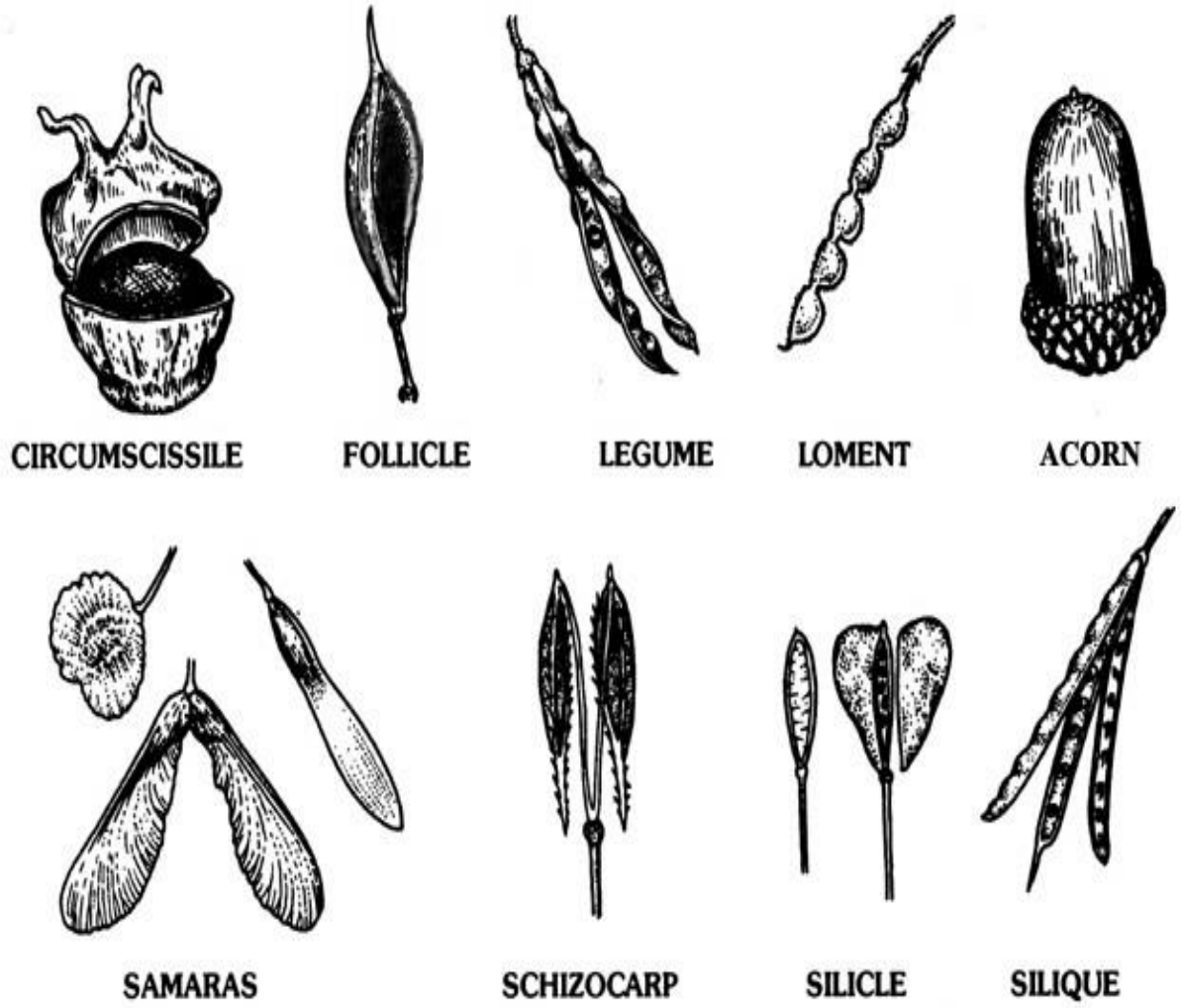

Fruits
Simple
(Develops from a single ovary of single flower)
Aggregate
(Develops from a single apocarpous flower)
Multiple
(Develops from the flowers of a whole inflorescence)
Fleshy
(Pericarp fleshy and fibrous)
Dry
(Pericarp dry, not fleshy)
2. Berry
3. Drupe
4. Hesperid ium
5. Pepo
6. Pome
Dehiscent (burst automatically and liberate seeds)
1. Legume or pod
2. Follicle
3. Siliqua
4. Capsule
Schizocarpic
(Split into one seeded compartments)
1. Lomentum
2. Cremocarp
3. Regma
Indehiscent
(Do not dehisce to liberate seeds)
1. Achene
2. Caryopsis
3. Cypsela
4. Nut
5. Samara

PLATE 11. FRUIT TYPES





SIMPLE FRUIT

- Simple fruits can be either dry or fleshy, and result from the ripening of a simple or compound ovary in a flower with only one pistil. Dry fruits may be either dehiscent (opening to discharge seeds), or indehiscent (not opening to discharge seeds).

Types of DRY, simple fruits, with examples of each, are:

- **achene** – Most commonly seen in aggregate fruits (e.g. strawberry)
- **capsule** – (Brazil nut)
- **caryopsis** – (wheat)
- **Cypsela** – An achene-like fruit derived from the individual florets in a capitulum (e.g. dandelion).
- **fibrous drupe** – (coconut, walnut)
- **follicle** – is formed from a single carpel, and opens by one suture (e.g. milkweed). More commonly seen in aggregate fruits (e.g. magnolia)
- **legume** – (pea, bean, peanut)
- **loment** – a type of indehiscent legume
- **nut** – (hazelnut, beech, oak acorn)
- **samara** – (elm, ash, maple key)
- **schizocarp** – (carrot seed)
- **silique** – (radish seed)
- **silicle** – (shepherd's purse)

TYPES OF FLESHY, SIMPLE FRUITS WITH EXAMPLES OF EACH, ARE:

- Fruits in which part or all of the **pericarp (fruit wall)** is fleshy at maturity are **simple fleshy fruits**.

- **berry** – (redcurrant, gooseberry, tomato, cranberry)

- **stone fruit or drupe** (plum, cherry, peach, apricot, olive)

- An aggregate fruit develops from a single flower with numerous simple pistils.

- Schizocarp fruits form from a **syncarpous ovary** and **do not really dehisce**, but **split into segments** with one or more seeds; they include a number of different forms from a wide range of families. Carrot seed (Apiaceae) is an example.

AGGREGATE FRUIT

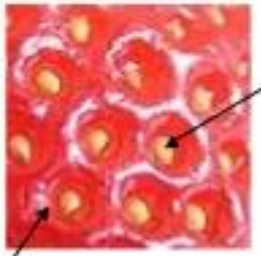
- Aggregate fruits form from **single flowers that have multiple carpels which are not joined** together, i.e. each pistil contains one carpel.

- Four types of aggregate fruits include **achenes, follicles, drupelets**, and **berries.**

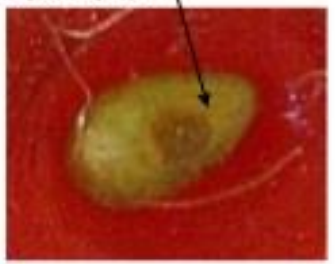
- The raspberry, whose pistils are termed drupelets because each is like a small drupe attached to the receptacle. In some bramble fruits (such as blackberry) the receptacle is elongated and part of the ripe fruit, making the blackberry an aggregate-accessory fruit. The strawberry is also an aggregate-accessory fruit, only one in which the seeds are contained in achenes. **In all these examples, the fruit develops from a single flower with numerous pistils.**

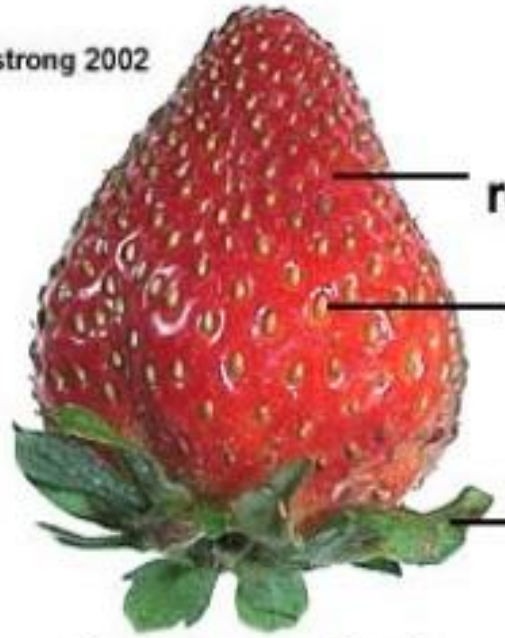
Strawberry = Aggregate-accessory fruit

This accessory “fruit" is actually an enlarged receptacle.

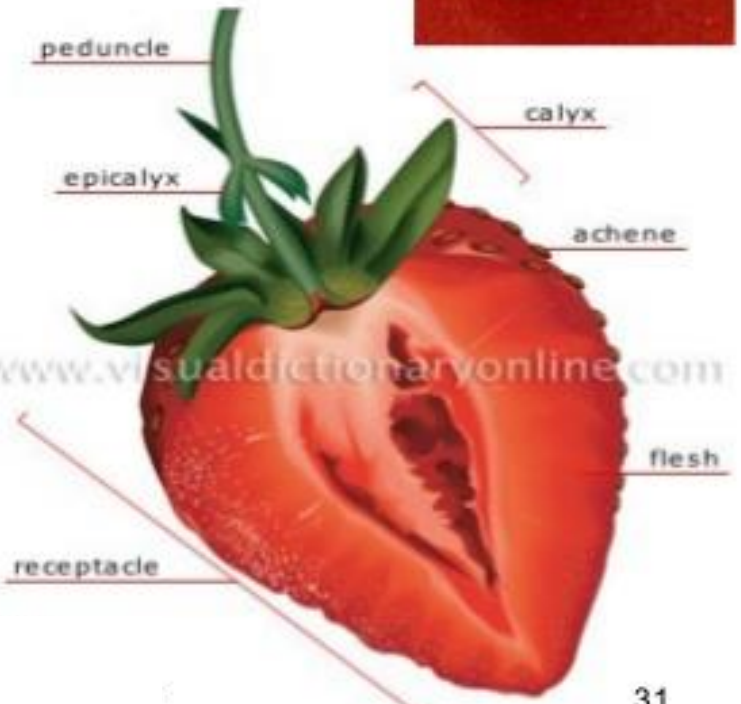


“seed” is really a simple fruit





http://waynesword.palomar.edu/termfr4.htm



• section of a strawberry

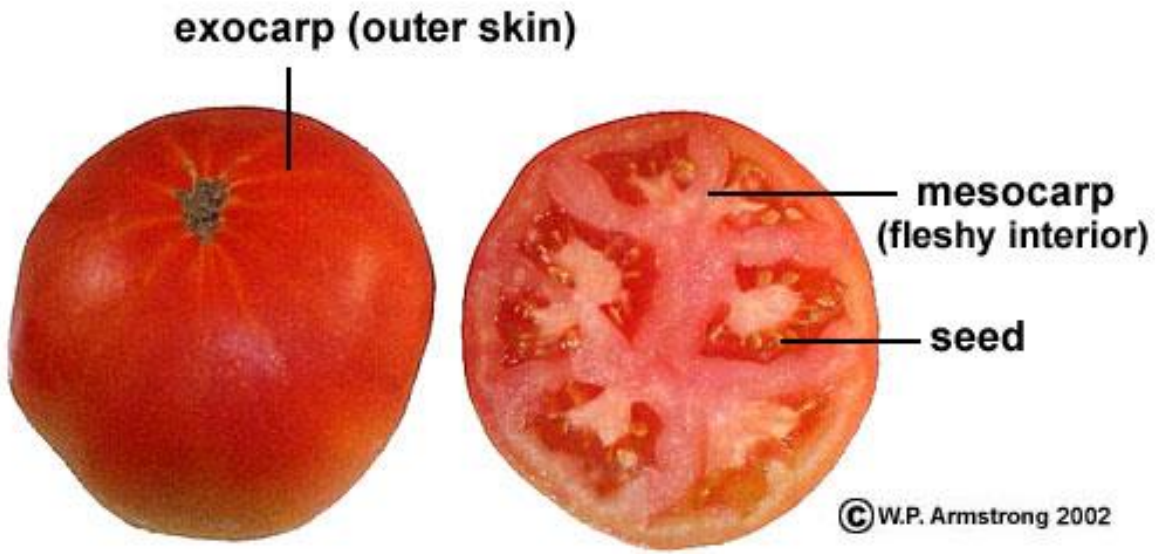
MULTIPLE FRUITS

A multiple fruit is one formed from a cluster of flowers (called an inflorescence). Each flower produces a fruit, but these mature into a single mass. Examples are the pineapple, **fig, mulberry**.

After fertilization, each flower develops into a drupe, and as the drupes expand, they become connate (merge) into a multiple fleshy fruit called a syncarp.

Berries

- Berries are **another type of fleshy fruit; they are simple fruit created from a single ovary.** The **ovary may be compound, with several carpels.**

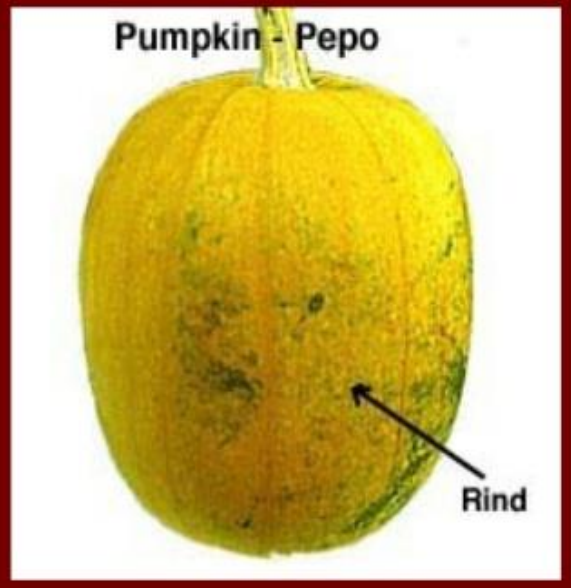


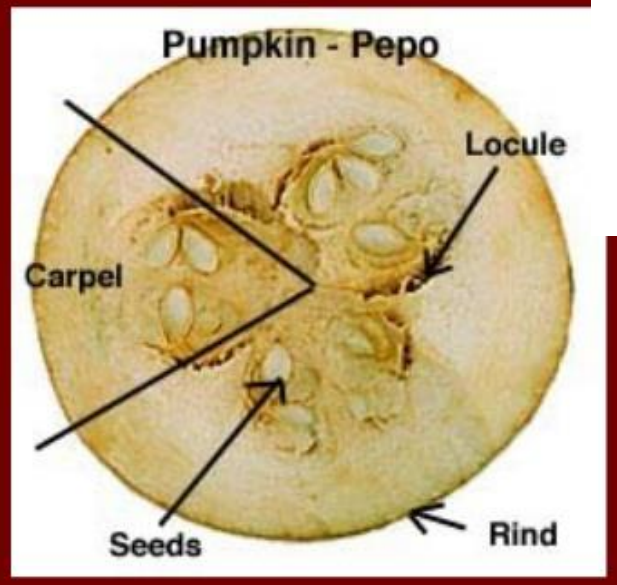
Berry (All of most of pericarp is fleshy)
e.g. tomato (*Lycopersicon esculentum*)

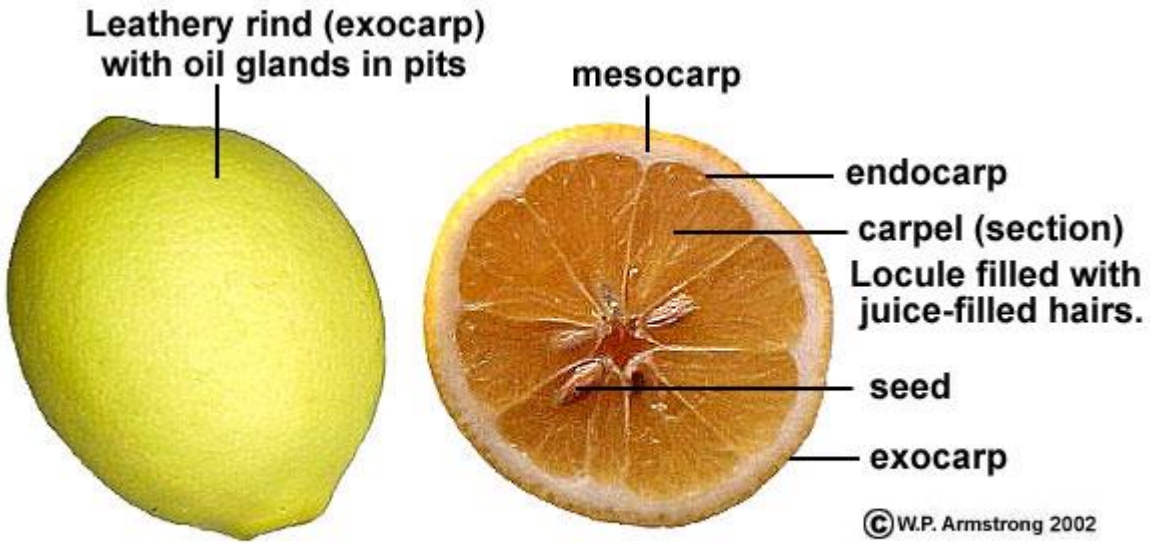
- **Pepo** – Berries where the skin is hardened, cucurbits
- **Hesperidium** – Berries with a rind and a juicy interior, like most citrus fruit

Pepo

- Berry with a relatively hard rind (watermelon, gourds, squash).







Hesperidium (berry with a leathery rind)
e.g. lemon (*Citrus lemon*)

Accessory fruit

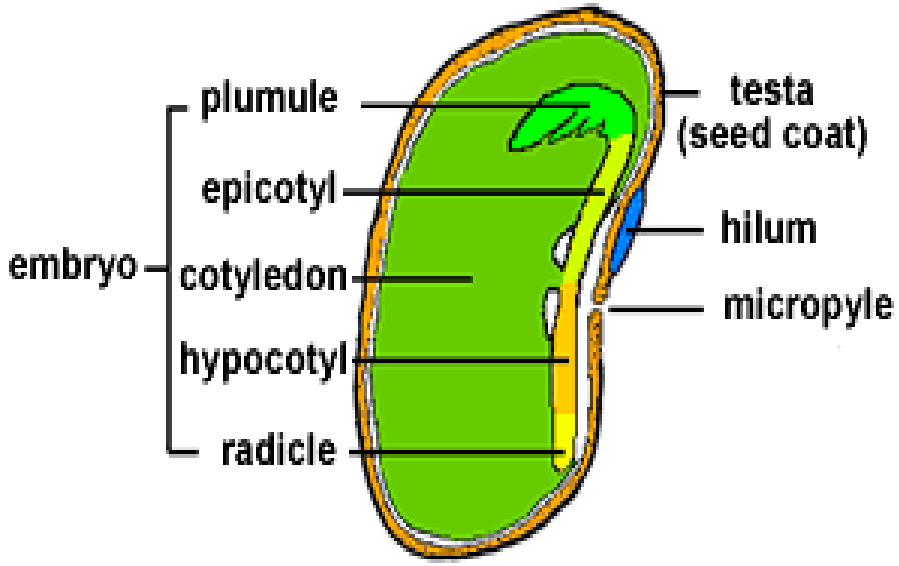
- The fruit of a **pineapple** includes tissue from the sepals as well as the pistils of many flowers. It is an **accessory fruit** and a **multiple fruit.**
- **Accessory fruit can be simple, aggregate, or multiple,** i.e., they can include **one or more pistils** and **other parts from the same flower, or the pistils and other parts of many flowers.**

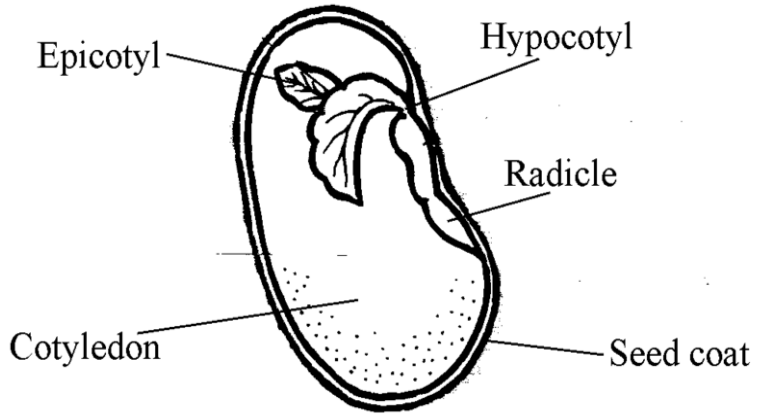
Examples for each group:

- **True berry:** Blackcurrant, Redcurrant, Gooseberry, Tomato, Eggplant, Guava, Lucuma, Chili pepper, Pomegranate, Kiwifruit, Grape, Cranberry, Blueberry.
- **Pepo:** Pumpkin, Gourd, Cucumber, Melon.
- **Hesperidium:** Orange, Lemon, Lime, Grapefruit.
- **Aggregate fruit:** Blackberry, Raspberry, Boysenberry.
- **Multiple fruit:** Pineapple, Fig, Mulberry, Hedge apple.
- **Accessory fruit:** Pineapple, Apple, Strawberry, Stone fruit.

SEED

- A seed is an embryonic plant enclosed in a protective outer covering known as the **seed coat (=testa).**
- It is a characteristic of spermatophytes (gymnosperm and angiosperm plants) and the product of the ripened ovule which occurs after fertilization and some growth within the mother plant. The formation of the seed completes the process of reproduction in seed plants (started with the development of flowers and pollination), with the embryo developed from the zygote and the seed coat from the integuments of the ovule.



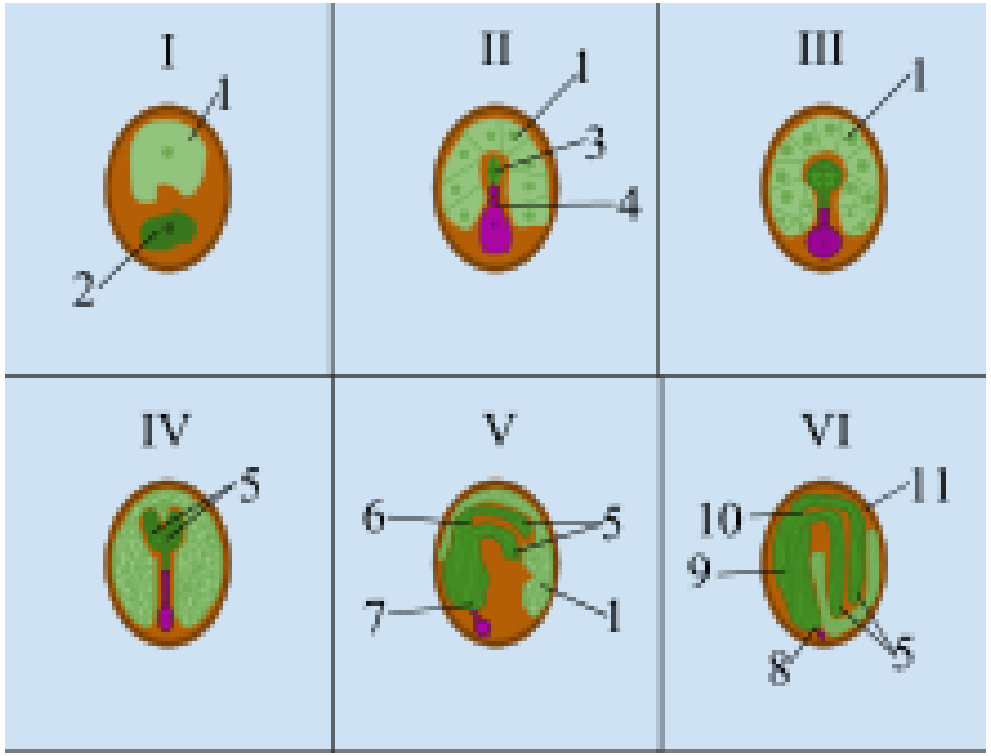


Bean seed (dicot)

- Seeds have been an important development in the reproduction and spread of gymnosperm and angiosperm plants, relative to more primitive plants such as **ferns** and **mosses**, which do not have seeds and use other means to propagate themselves. This can be seen by the success of seed plants (both gymnosperms and angiosperms) in dominating biological niches on land, from forests to grasslands both in hot and cold climates.

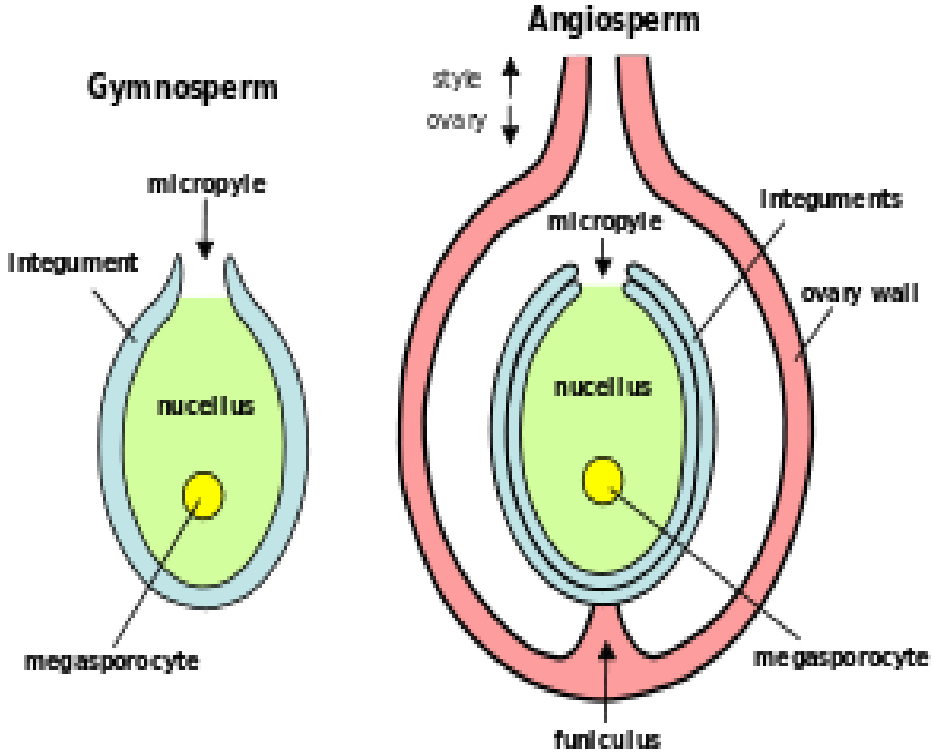
- Many structures commonly referred to as "seeds" are actually dry fruits.

OVULE



Stages of seed development:

Key: *1. Endosperm 2. Zygote 3. Embryo 4. Suspensor 5. Cotyledons 6. Shoot Apical Meristem 7. Root Apical Meristem 8. Radicle 9. Hypocotyl 10. Epicotyl 11. Seed Coat*



Plant ovules: Left: Gymnosperm ovule; Right: angiosperm ovule (inside ovary)

After fertilization the ovules develop into the seeds. The ovule consists of a number of components:

The **funicle (funiculus, funiculi)** or **seed stalk** which attaches the ovule to the placenta and hence ovary or fruit wall, at the pericarp.

The nucellus, the remnant of the megasporangium and main region of the ovule where the megagametophyte develops.

The micropyle, a small pore or opening in the apex of the integument of the ovule where the pollen tube usually enters during the process of fertilization.

The chalaza, the base of the ovule opposite the micropyle, where integument and nucellus are joined together).

Embryo

- **The main components of the embryo are:**
- **The cotyledons,** the seed leaves, attached to the embryonic axis. There may be one (Monocotyledons), or two (Dicotyledons). The cotyledons are also the source of nutrients in the non-endospermic dicotyledons, in which case they replace the endosperm, and are thick and leathery. In endospermic seeds the cotyledons are thin and papery. Dicotyledons have the point of attachment opposite one another on the axis.
- **The epicotyl,** the embryonic axis above the point of attachment of the cotyledon(s).
- **The plumule,** the tip of the epicotyl, and has a feathery appearance due to the presence of young leaf primordia at the apex, and will become the shoot upon germination.
- **The hypocotyl,** the embryonic axis below the point of attachment of the cotyledon(s), connecting the epicotyle and the radicle, being the stem-root transition zone.
- **The radicle**, the basal tip of the hypocotyl, grows into the primary root.