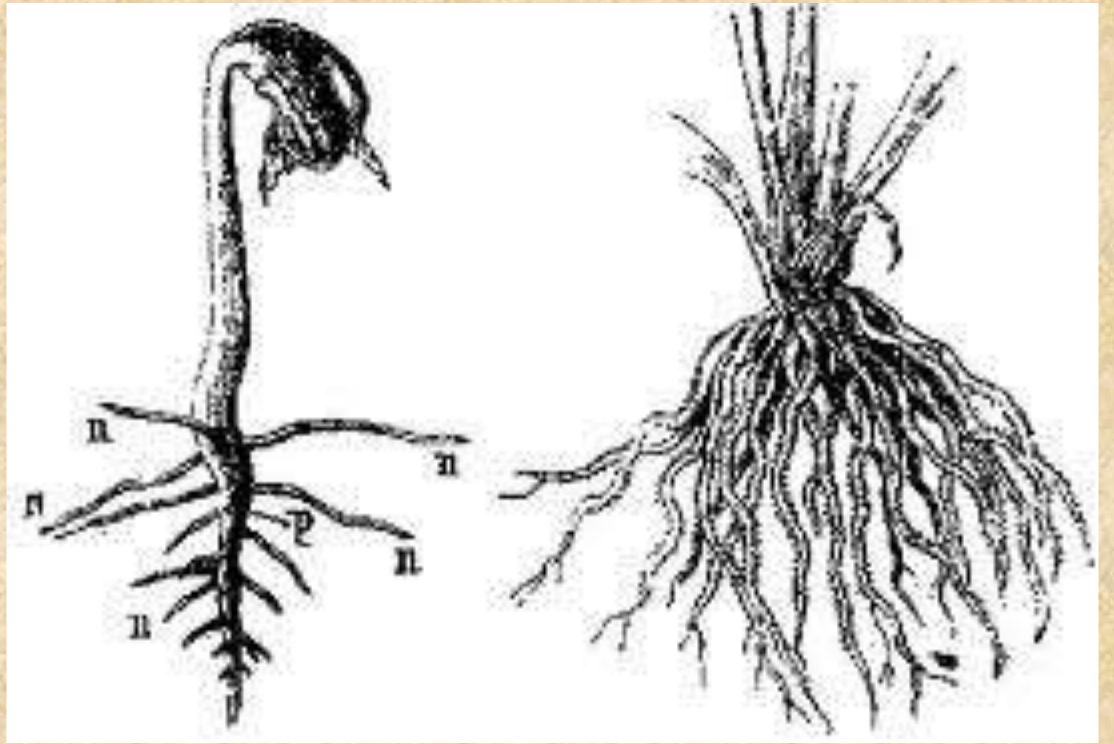
# PLANT ORGANS

The complexity of horticultural plants is illustrated by the diversity of the various organs and their many modifications. Each organ has one or more functions and is composed of numerous tissues. Plants are divided into three primary organ types: **roots**, **stems**, and **leaves**. **Flowers and fruits** are believed to have evolved from stem and leaf tissues.

# Roots



Roots are marvelous organs that are responsible for several characteristics essential to the growth and development of the plant. Uptake of water and nutrients from the soil and provision of anchorage rögzítés and support are major functions of roots. Water and nutrients are slowly absorbed in the region of maximum cell elongation but more rapidly absorbed in the **root hair zone**, where the epidermis is specialized as an absorbing tissue and where often thousands of root hairs occur.

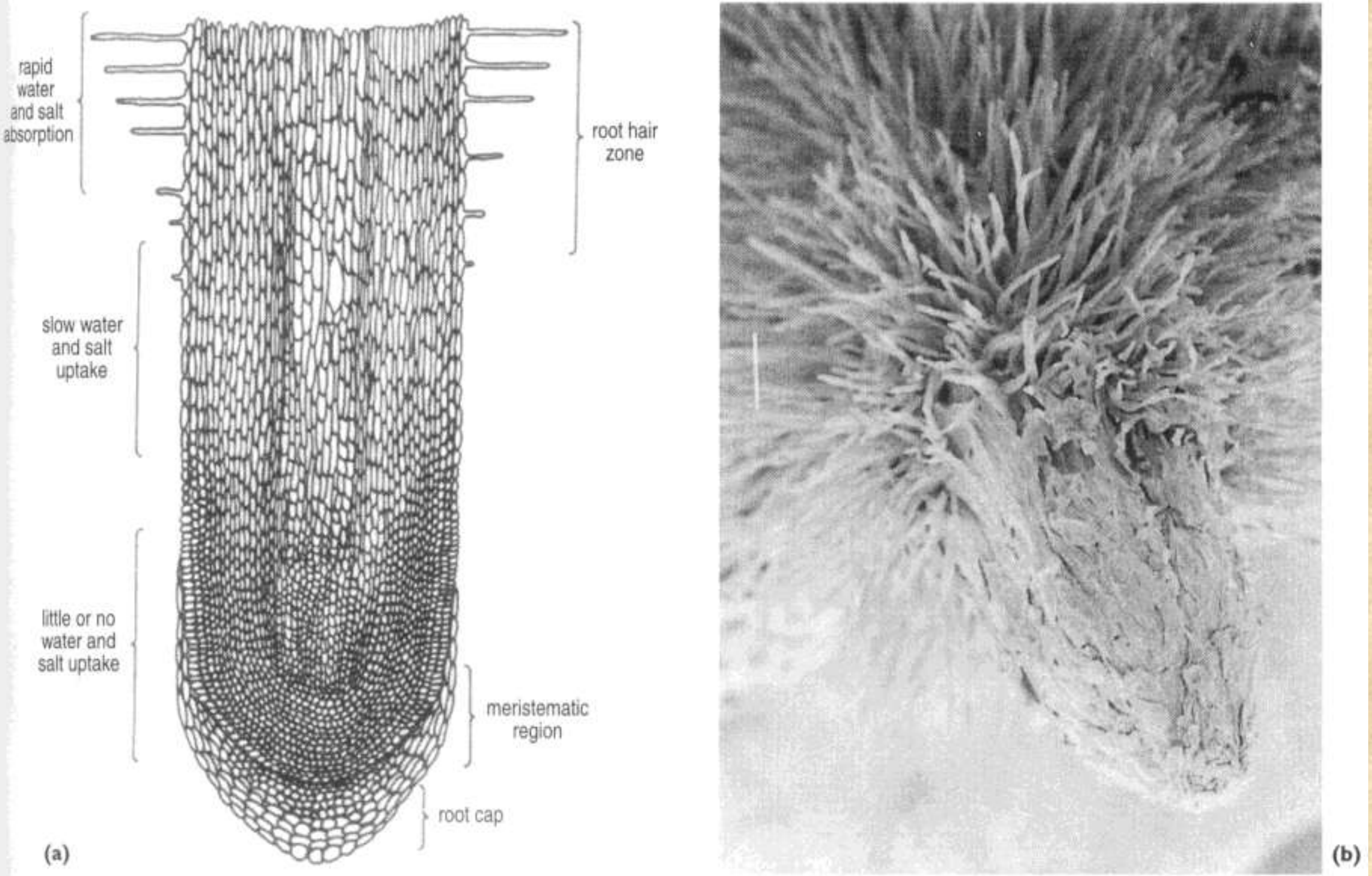
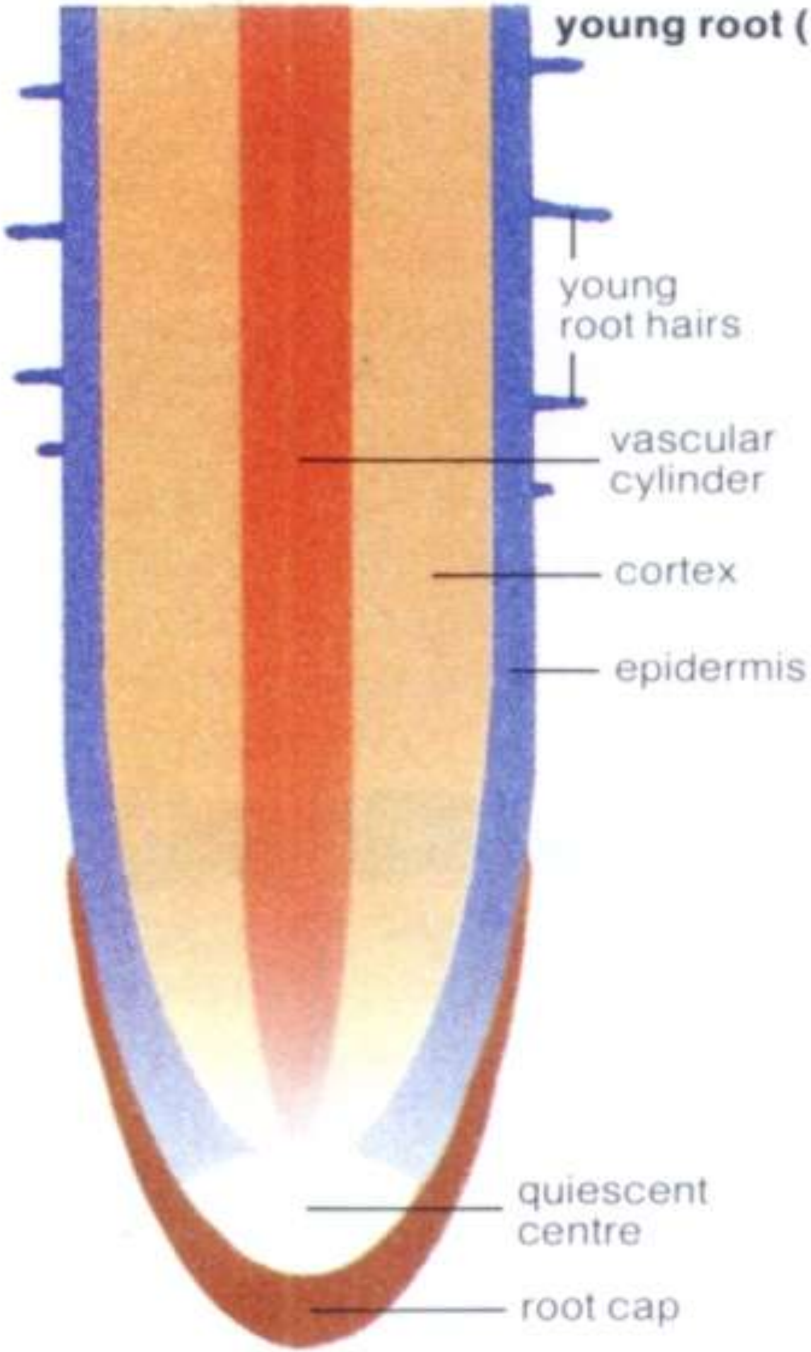


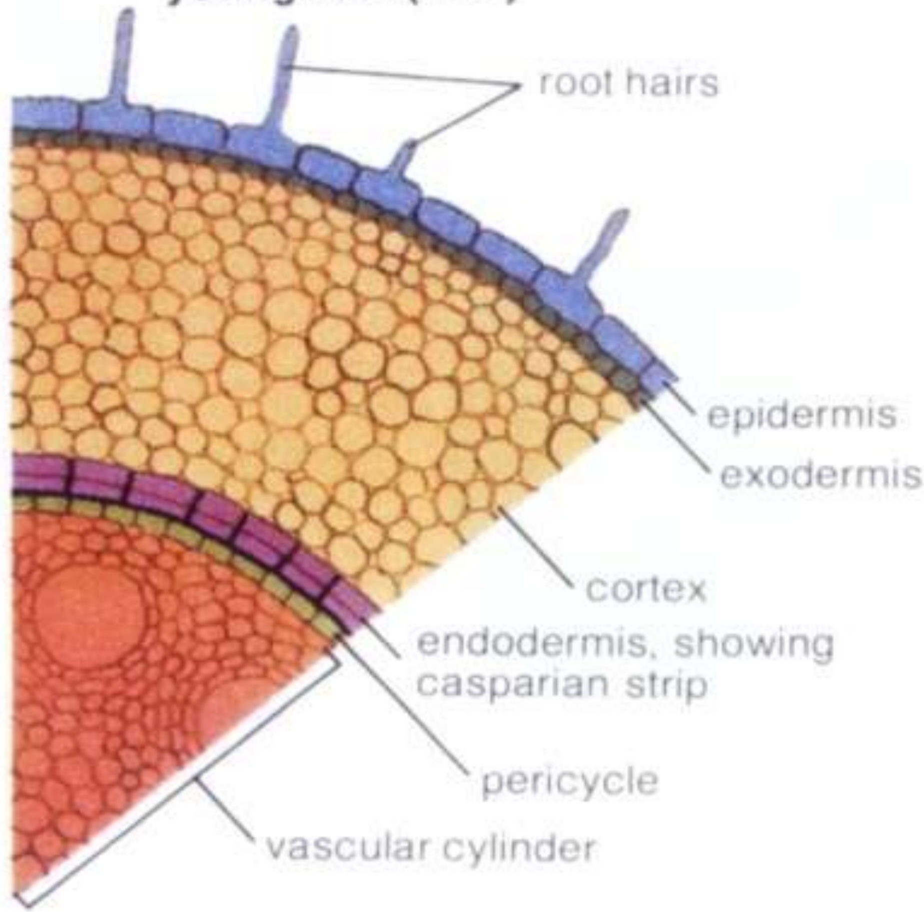

**FIGURE 3-15.** (*a*) Diagram of a longitudinal section through a root tip. (*b*) Scanning electron micrograph of the root tip of *Hibiscus Rosa-sinensis*. Note root cap and numerous root hairs. Bar = 10 microns.

*Photo courtesy of Humberto Puello, Southern Illinois University, Carbondale, IL.*

**young root (L.S.)**




**young root (T.S.)**




**taproots**

Root hairs tremendously increase the root surface area, thus enhancing rapid uptake of water and nutrients. Root hairs are single-celled epidermal modifications that commonly function and survive for **one or two days**. It is important to recognize that very little absorption occurs in mature roots or root tips; maximum absorption takes place within **the first 10 cm** from the tip in rapidly elongating roots and decreases towards the base and root tip.

However, because most plants have large numbers of young roots and millions of root hairs, a great amount of water and nutrients can be absorbed by an actively growing plant. Plants vary significantly in their root system characteristics. Some plants have many fibrous multi-branched roots that may penetrate to only shallow depths, as in some grasses, lettuce, and petunia, while others such as corn, may explore great depths of soil. Indeed, corn roots have been excavated to depths of five meters (15 feet) and more.

In contrast, other types of plants rely upon root systems that contain a dominant **tap root**, the primary root that develops from the original seedling root or radicle. Such roots penetrate to varying depths: shallow, as in carrot and radish or deep, as in alfalfa, oak, and maple.

The depth and extension of a plant's root system depends largely on soil aeration. Oxygen supply to roots is governed by such factors as soil type, compaction, and the depth of the water table.

These diverse root morphologies govern anchorage characteristics of a given plant as well as its ability to absorb water and withstand drought. In addition to their primary functions of anchorage, support, and water and nutrient absorption, plant roots are often modified to perform other functions.

Some roots are enlarged and serve as reservoirs for stored foods. Fleshy tap roots of carrot, parsnip, and beet store significant quantities of sugars and other carbohydrates. The enlarged fleshy or thickened root of the dahlia stores **inulin** (a polymer of fructose). The dahlia does not have a fleshy tap root, but because it is a swollen structure that developed from a fibrous root, it is referred to as a **tuberous root**.

The sweet potato (*Ipomoea batatas*) also has similar fleshy tuberous roots which, depending on cultivar and type, store various amounts of sugars and starches.


*Ipomoea batatas* Sweet potato

It is interesting to note that, although usually referred to as "fleshy tap roots," such structures as the edible part of the *radish*, *beet, and turnip*, are actually composed of both fleshy tap root and significant proportions of fleshy hypocotyl (seedling stem) that has been modified for storage of food. The radish, for example, is often more than 50% hypocotyl.

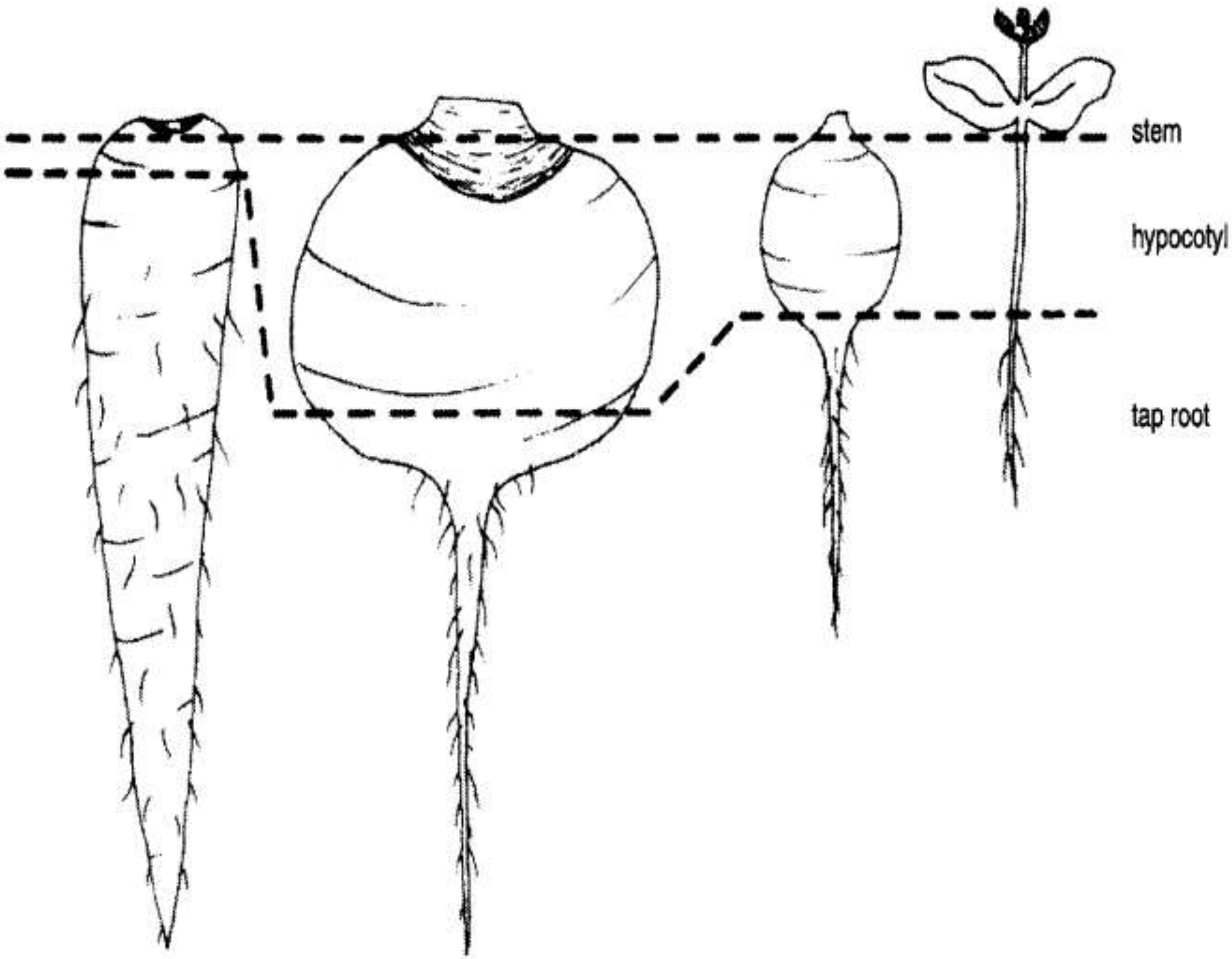
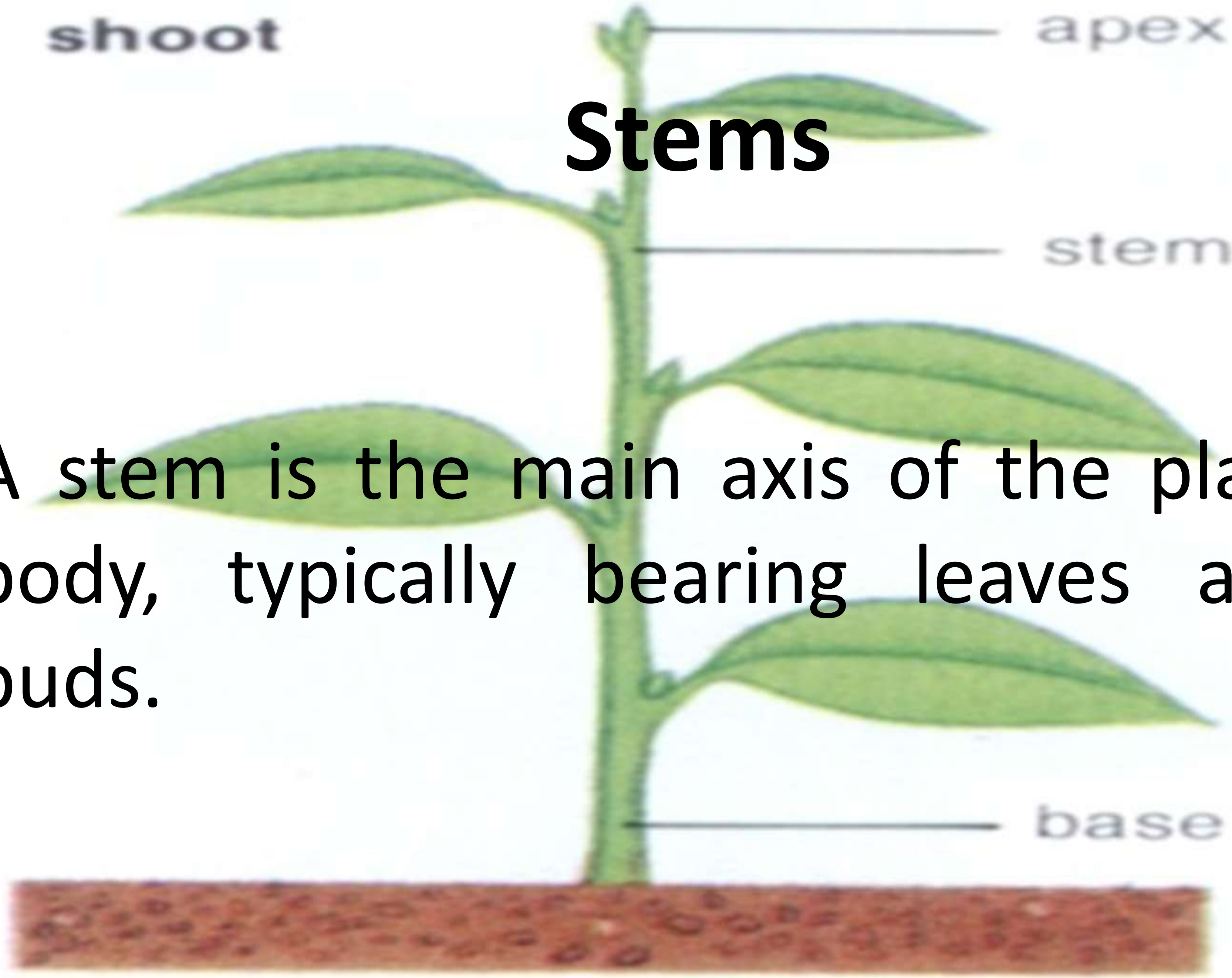


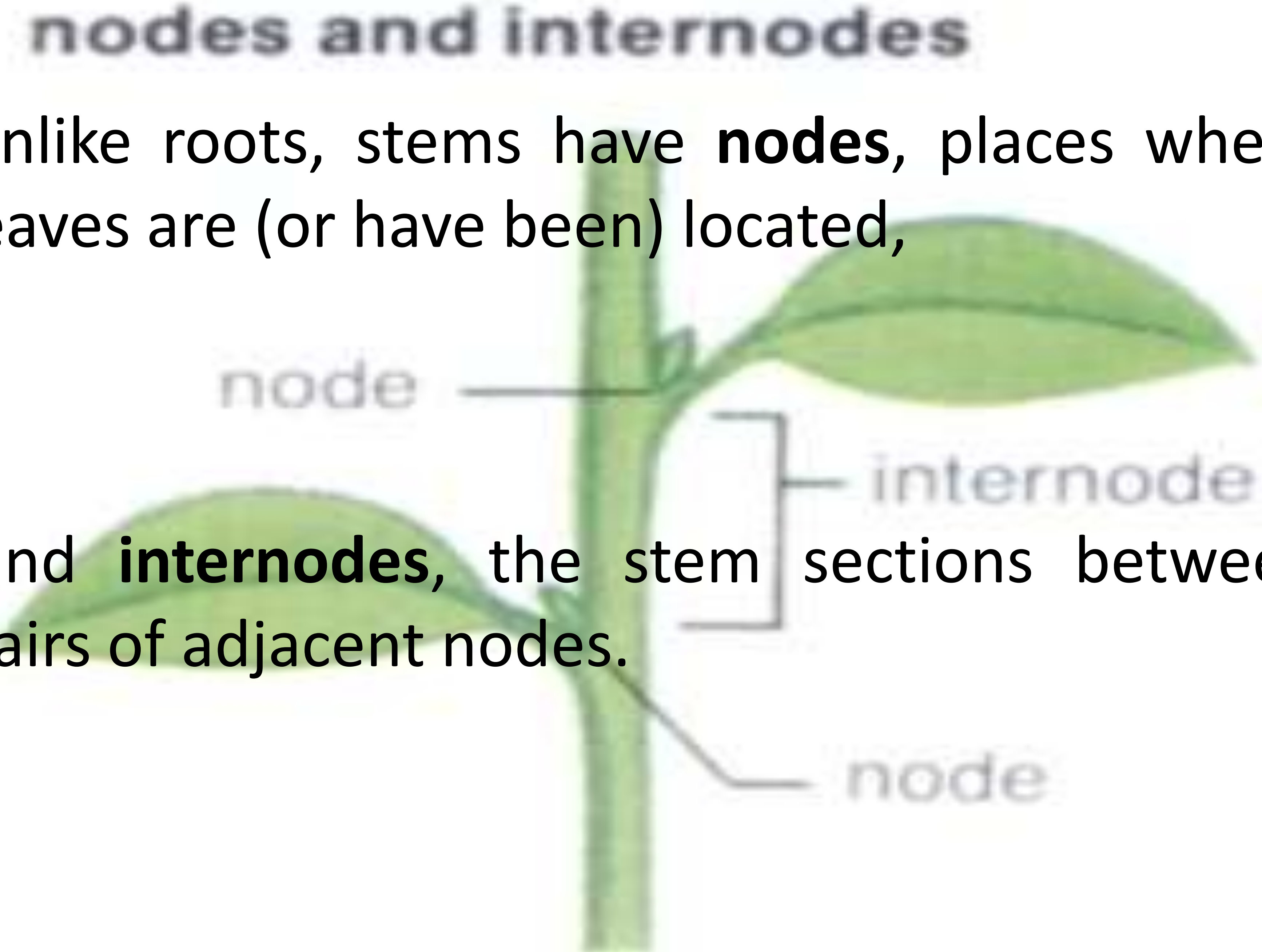

**FIGURE 3-19.** The relative proportions of fleshy tap root, hypocotyl, and stem in some common root vegetables. The figure at the left is mostly fleshy tap root, represented by carrot or parsnip; the next figure has a much greater proportion of fleshy hypocotyl, as in rutabaga and turnip; and the common radish is mostly hypocotyl tissue. A germinated seedling is included for comparison purposes.

Another root type that has evolved in many plant species is termed **adventitious**. Adventitious roots arise from parts other than roots, such as stems and leaves, frequently as a result of injury. In fact, the majority of the root system of *monocot plants* is appropriately called adventitious, because the primary root from the seed is often short-lived and inconsequential. (The roots forming on stem and leaf cuttings used in propagation are all correctly referred to as adventitious roots. Roots formed from callus or plant parts in tissue culture, or in vitro micropropagation, are also adventitious.)

# Stems

A stem is the main axis of the plant body, typically bearing leaves and buds.



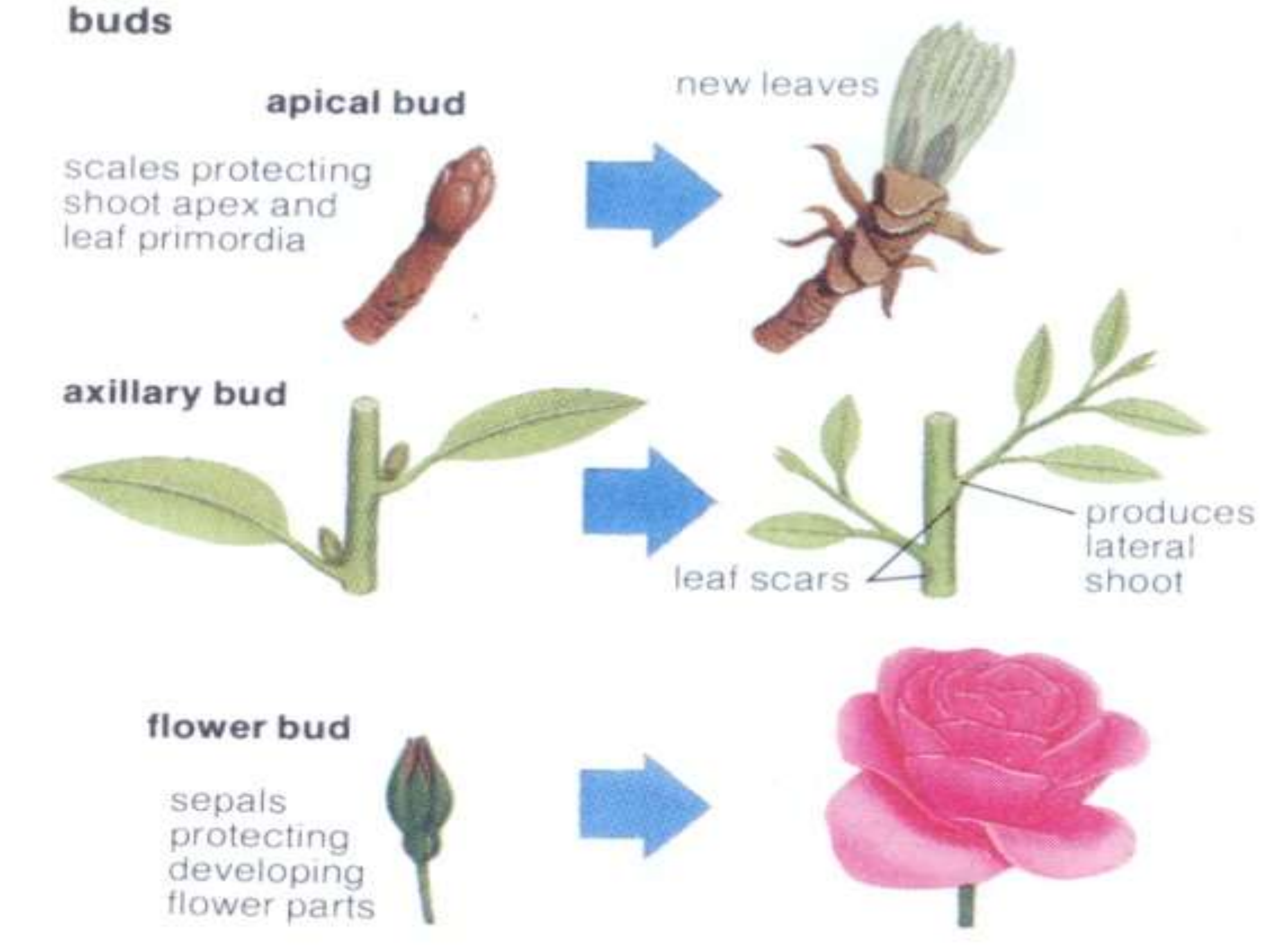



Unlike roots, stems have **nodes**, places where leaves are (or have been) located,

and **internodes**, the stem sections between pairs of adjacent nodes.

**Buds** are undeveloped or compressed stems, flowers, or both, and are known as leaf buds (vegetative), flower buds, or **mixed** buds (containing both leaf and flower primordia). They often have protective coverings known as bud scales (modified leaves).

A bud can be either **terminal**, positioned at the apex, or **lateral (axillary)**, occurring in the **leaf axil**. The leaf axil is the angle formed by the junction of a leaf and stem at a node. Some plants grow tall and relatively unbranched, whereas others have bushy growth habits.


buds
apical bud
new leaves
scales protecting
shoot apex and
leaf primordia
axillary bud
produces
lateral
shoot
leaf scars
flower bud
sepals
protecting
developing
flower parts

The apical bud, to varying degrees, controls the growth of axillary buds by inhibiting their elongation. This is called **apical dominance** and explains why plants become more bushy when pinched back or pruned, because the inhibiting effect of the apical bud is removed by these procedures. (Auxin!)

Buds arising from leaves, roots or internodal stem locations are termed adventitious buds. Such adventitious bud formation may occur naturally and spontaneously or as a result of injury, and its frequency varies with species. During certain seasons, buds may be in an arrested state of development or **dormant**. This mechanism helps plants survive unfavorable growing conditions.

Buds have various shapes, forms, and positions. Indeed, such morphological features may form the basis for identification of deciduous trees and shrubs during their dormant (winter) period. If only one bud is present at a node, the arrangement is said to be **alternate**, while two or more buds present at a node may be termed **opposite** (if two), or **whorled** örvös (if three or more).

Stems of horticultural plants serve a wide array of purposes and functions. They bear the flowers and fruits and place the leaves in a position to intercept sunlight, which is crucial for the process of photosynthesis. Stems also provide a conduit, through the xylem, for necessary water and nutrients to reach the leaves, flowers, and fruits. Food and metabolites manufactured in leaves are translocated to flowers, fruits, and roots through the phloem of the stems.

Stems also store *food reserves*, particularly carbohydrates, and indeed some stems are modified dramatically for such storage functions. An example of such a modified stem is the **tuber** of potato (*Solanum tuberosum*) or the Jerusalem artichoke (*Helianthus tuberosus*).

Jerusalem artichoke

*Helianthus tuberosus*

A tuber is an enlarged or swollen underground stem, and the "eyes" of the potato are actually axillary buds occurring at nodes subtended by vestigial leaf scars (the "eyebrows"). (The true tuber should not be confused with the tuberous root (e.g., *sweet potato*), because a tuber has true stem characteristics including nodes with axillary buds.) The root does not have nodes or lateral buds. The tuber of the potato stores food as *starch* (a glucose polymer), and Jerusalem artichoke stores *inulin* (a polymer of fructose).

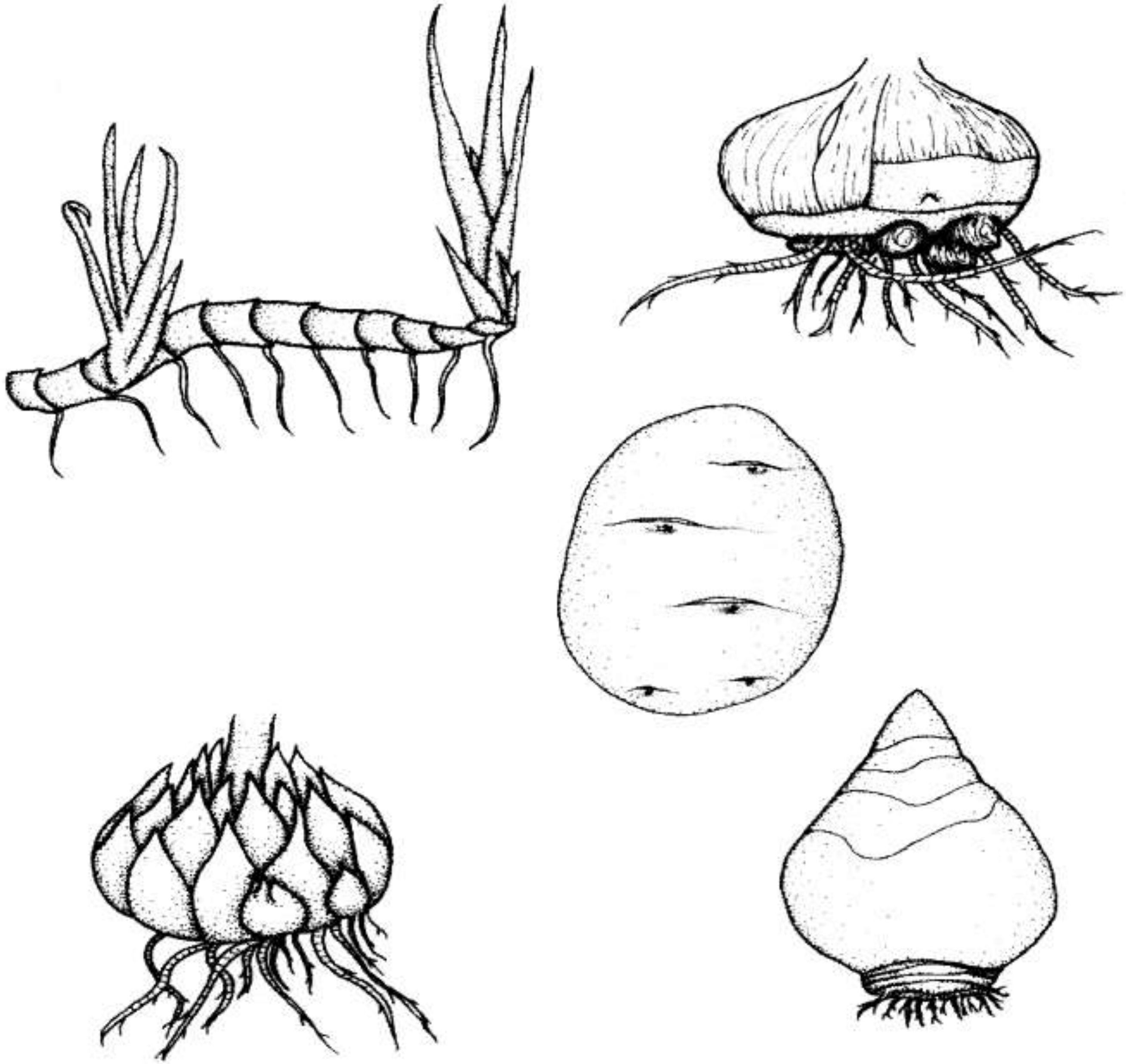
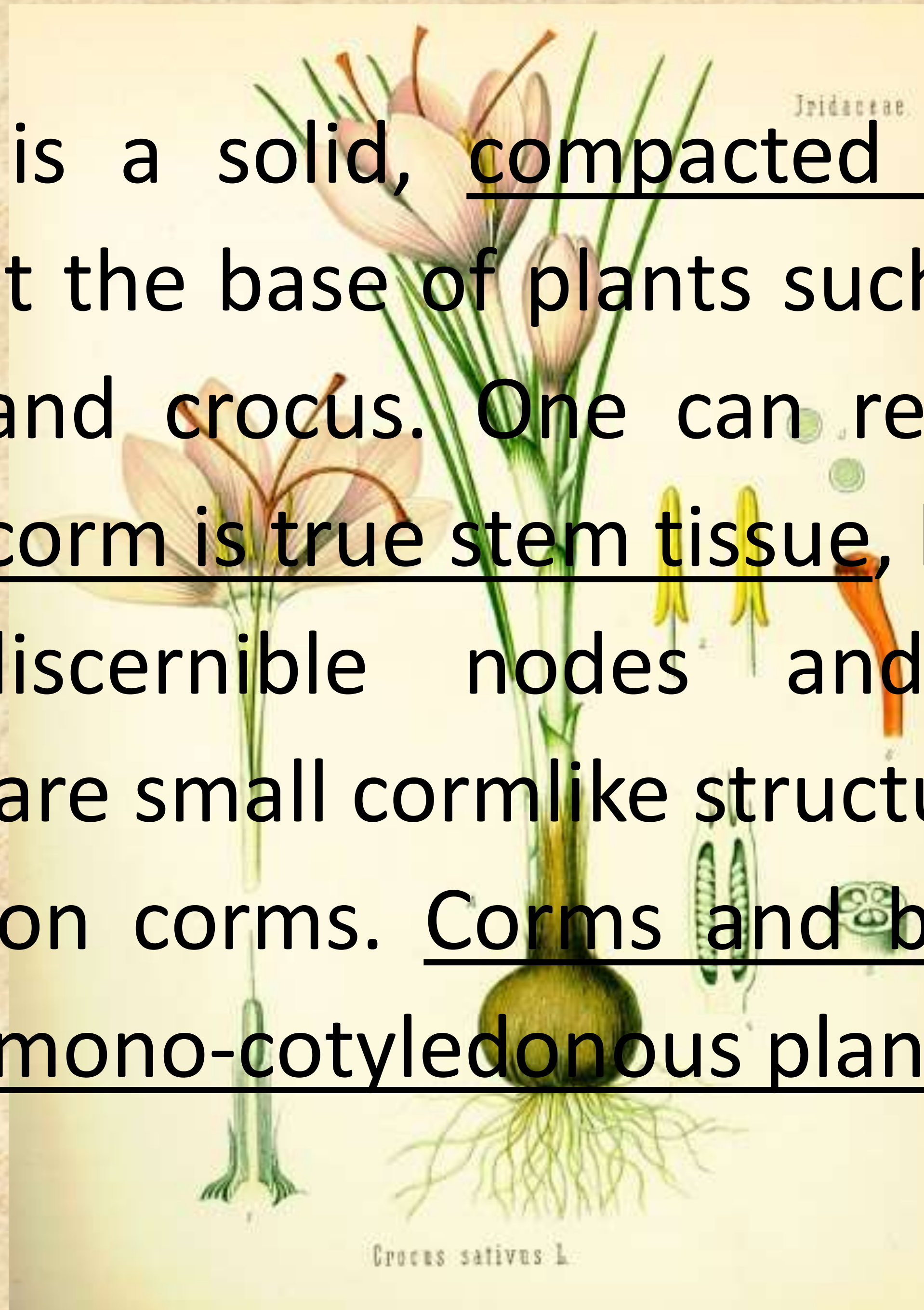


**FIGURE 3-22.** Stem modifications that enable storage of large amounts of food reserves. Clockwise from upper left, fleshy rhizome (e.g., *Iris* spp.); corm (e.g., *Gladiolus*, *freesia*); tuber (e.g., potato, *Solanum tuberosum*). tunicate bulb (e.g., *Narcissus* spp., onion); scaly bulb (e.g., *Lilium* spp.).

A **corm** is a solid, compacted vertical stem formed at the base of plants such as gladiolus, freesia, and crocus. One can readily observe that the corm is true stem tissue, because it has easily discernible nodes and internodes. **Cormels** are small cormlike structures that form laterally on corms. Corms and bulbs are only found in mono-cotyledonous plants.

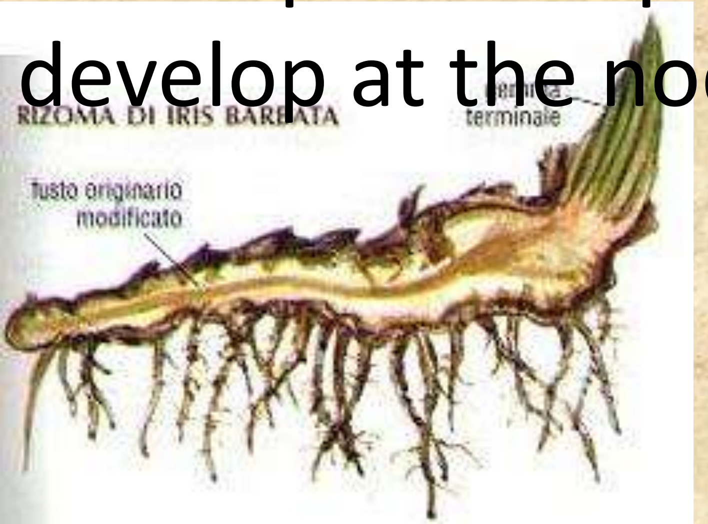


A **bulb** is a structure resembling a large bud comprised of a short, thick stem (the basal plate) with basal roots and fleshy or membranous overlapping **leaf bases** (often called **scales**). The bulk of most bulbs is therefore primarily leaf tissue and the morphology and arrangement of the fleshy leaf bases help determine the bulb type.

In **tunicate** hártyás bulbs such as onion or tulip, each fleshy leaf base completely encloses all parts of the bulb within it. Onion "rings" are therefore cross sections of fleshy leaf bases. Tunicate bulbs also have a papery covering called a tunic.

**FIGURE 3-25.** A comparison of the internal structure of flowering (hyacinth, *left*) and vegetative (onion, *right*) tunicate bulbs. Note that the bulk of the bulb structure is *leaf* tissue.

Another stem adapted for *food storage* is the fleshy **rhizome** of plants such as iris. A rhizome is a more or less subterranean and usually horizontal main stem that produces roots and shoots at the nodes. Some rhizome types are not thickened, as in quackgrass (*Agropyron repens*), but may grow through many feet of soil and reproduce prolifically by the plantlets that develop at the nodes.



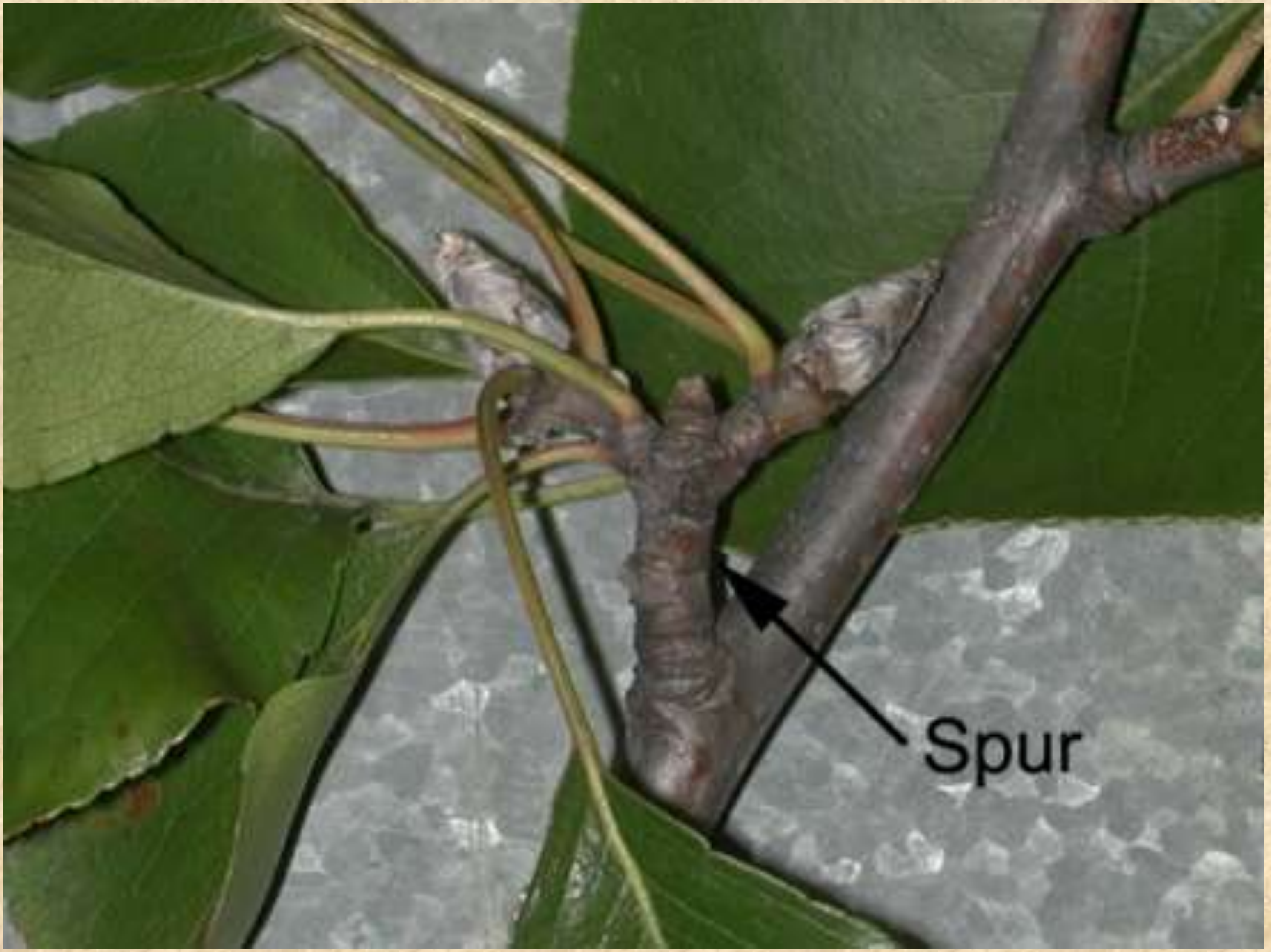

The **stolon** is similar to the rhizome in that it is a horizontal stem that may produce roots and shoots at the nodes, but unlike a rhizome, a stolon arises from leaf axils and is above-ground.

A **runner** is a specialized slender stolen. When a runner contacts the soil, generally at the tip, a new plant is formed that roots and produces its own runners from axillary buds. Strawberries (*Fragaria* spp.) and spider plants (*Chlorophytum* sp.) exhibit this creeping habit of spreading vegetatively by stolons.


The **crown** has two distinct definitions: the horticulturists' definition and the foresters' definition. Horticulturists often use the term to mean the part of the stem near or at the soil surface. It may include the transition zone from root to shoot, or it may be composed of compacted stem tissue.

Foresters use the term *crown* to mean the top of a tree where the branches are located.

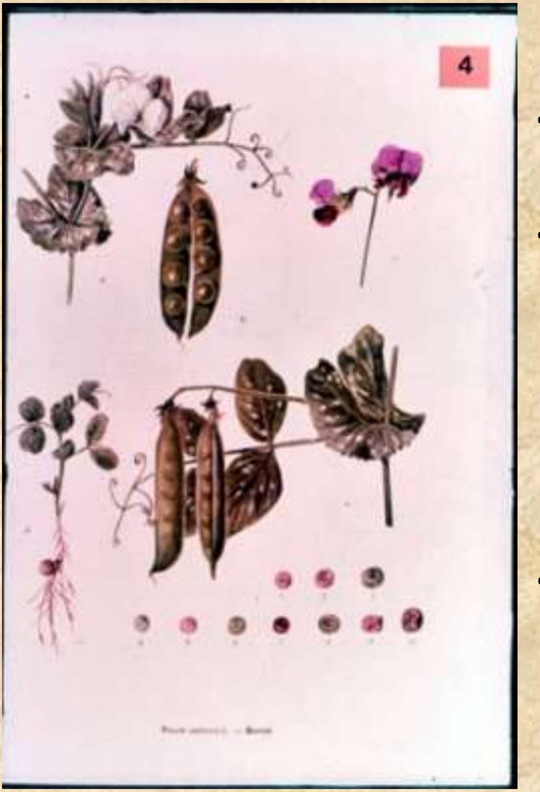
A **spur** is a stem with very short internodes found on a mature woody plant and it is often modified for flower and fruit production, as is seen in apple, pear, and quince. (Care must be taken when harvesting an apple crop because if the spurs are broken off, the next year's crop will be reduced.)


Spur

An interesting stem type useful for propagation purposes (divisions) is the **sucker**, an adventitious shoot arising from root tissue. Suckers are particularly common, and valuable as a propagation device in red raspberry, blackberry, and sumac (*Rhus* spp.).

A **watersprout**, however, is a shoot that arises from stem tissue, often from latent buds located deep within the tissues of branches or the trunk (not at nodes).

Water sprouts generally grow in response to pruning — the greater the amount of stem material removed, the greater the number and growth of these new shoots. Watersprouts are so named because of their very succulent and rapid growth.



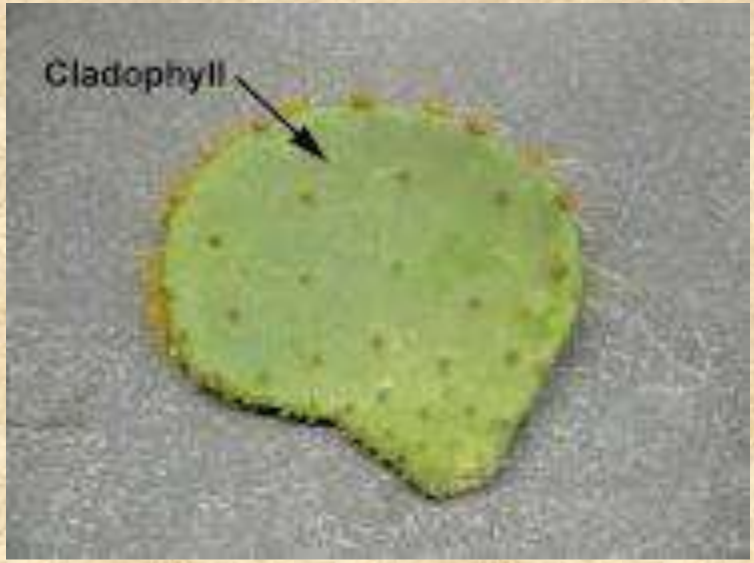
Some stems possess adaptations that facilitate climbing walls, trees, or other supports. These may take the form of stems that merely twist or twine around the adjacent support, as in morning glories (*Ipomoea* spp.), or may take the form of stem or leaf modifications called **tendrils**. Grapes, cucumbers and peas are examples of plants that have tendrils.

Plants of some species are said to be armed; that is, they have stem modifications such as **thorns**, **spines**, or **prickles**.

Prickles are usually small, more or less hardened, pointed outgrowths of the *epidermis* or bark.

Spines are sharp, hard modified leaves. Thorns are modified stems. Spines and thorns may reach several centimeters in length, as they do in the spines of some cacti and thorns of some hawthornes (*Crataegus* sp.).

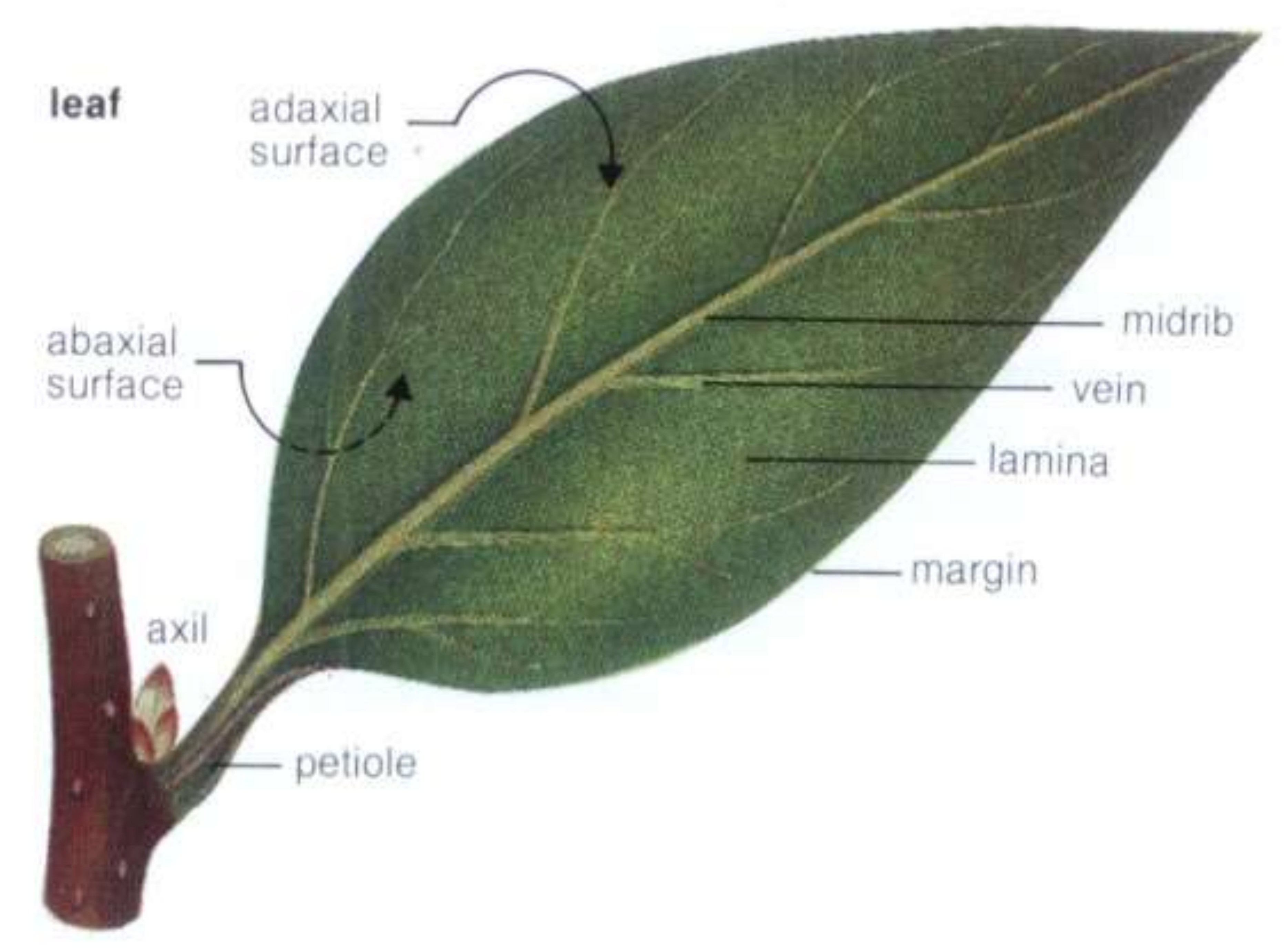
Other stems are highly evolved for photosynthetic activity, having inconsequential or nonexistent leaves.



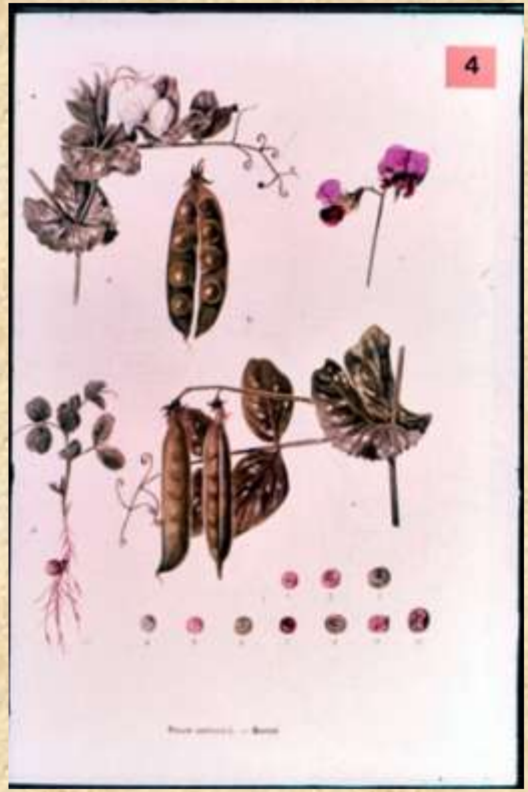

Such stems are referred to as **cladophylls** or **cladodes**, and are typically found on plants such as asparagus and *Ruscus*.

# Leaves

Leaves are flattened or expanded appendages of the stem of vascular plants where photosynthesis typically takes place.


leaf
adaxial surface
abaxial surface
midrib
vein
lamina
margin
axil
petiole

Leaves of many Angiosperms are composed of a **petiole** (leaf-stalk), which bears the flattened expanded portion or leaf **blade**, sometimes called the **lamina**. The petiole may have flared, flattened, or scalelike outgrowths known as **stipules**, which may appear more or less leaflike. In the leafless pea cultivars, much of the photosynthesis takes place in the stipules.



If the leaf blade lacks a petiole, but is attached directly to the stem, it is said to be **sessile**. Leaves normally occur singly (**alternate** leaf arrangement), in pairs (**opposite** leaf arrangement), or in groups of three or more (**whorled** leaf arrangement), and they subtend buds.

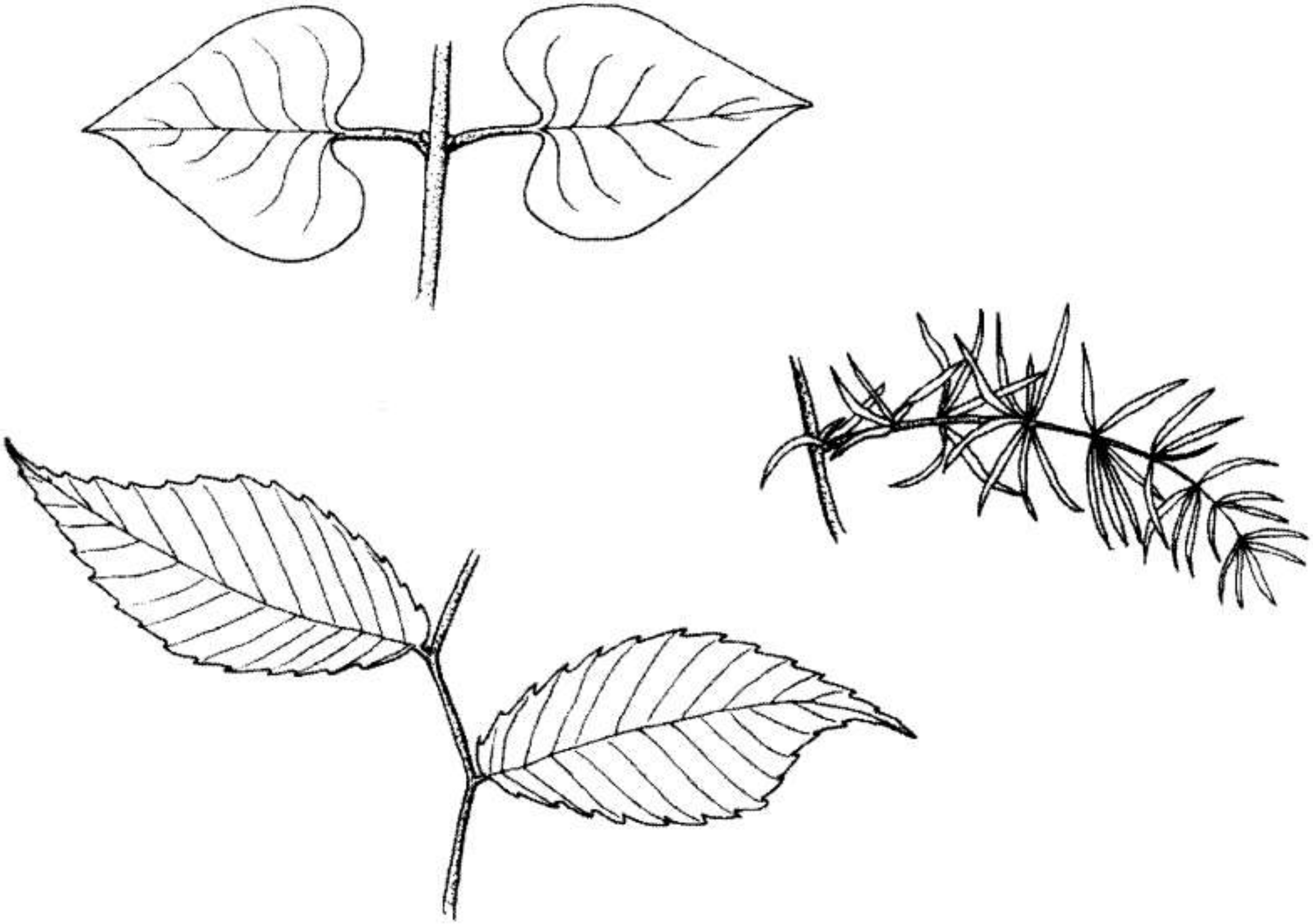
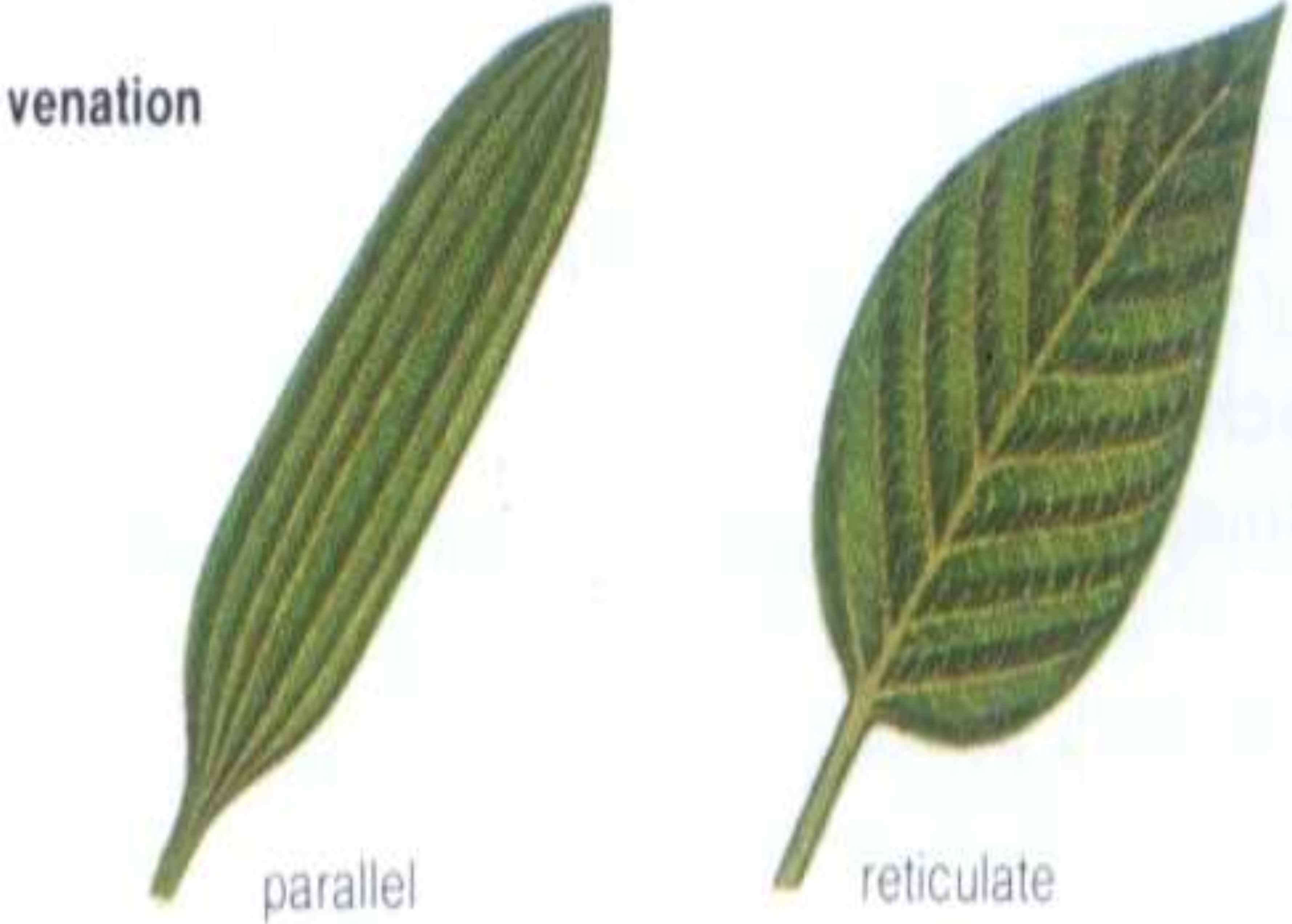


**FIGURE 3-32.** Leaf arrangement patterns: opposite, *top left*; alternate, *bottom left*; whorled, *right*.

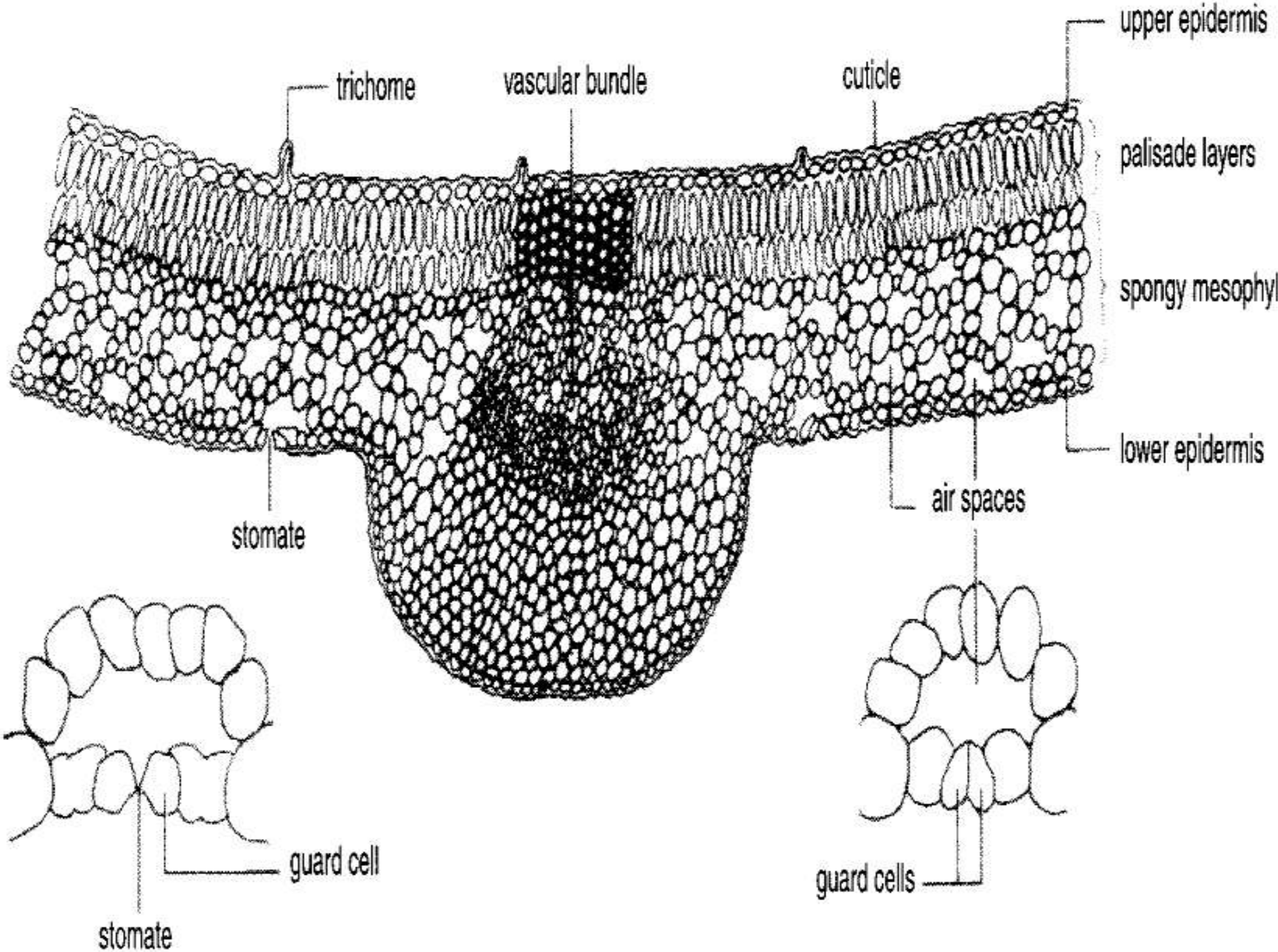

The position of this bud helps distinguish between a **simple** leaf and a **compound** leaf. Simple leaves have **entire** leaf margins — that is, the blade is not divided into leaflets — whereas compound leaves are composed of two or more leaflets, or blade portions, which often appear leaflike but do not have a bud at their bases.

Simple leaves (and leaflets) have one of three kinds of **venation**, or pattern of the veins, in the blade; **parallel** venation, as in monocot leaves; **palmate** venation, where the main veins arise from a common point of origin (as in the palm of a human hand); and **pinnate** venation (literally, "feather-form"), with the veins placed laterally on either side of a main vein, which usually appears to be simply a continuation of the petiole.

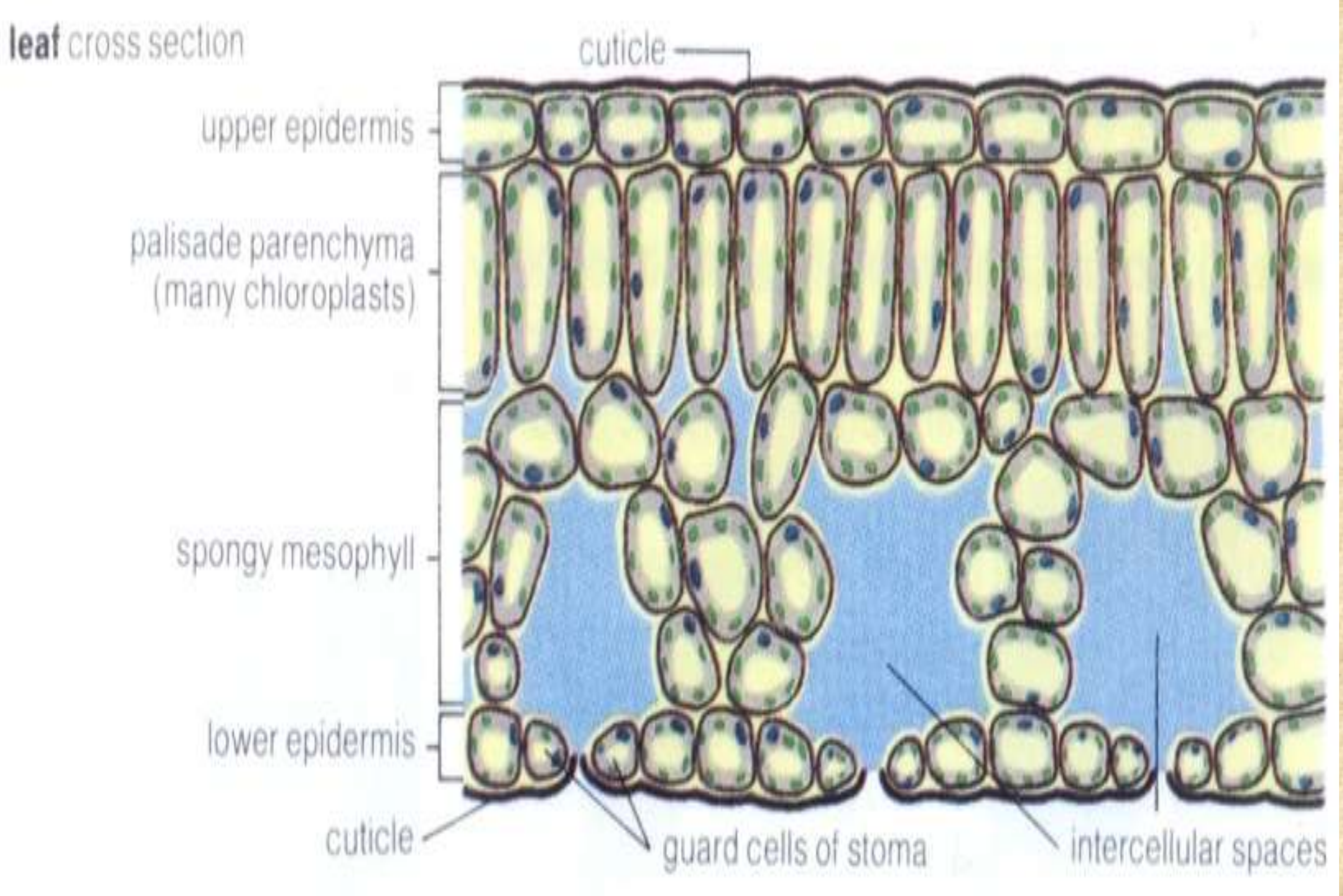

venation
parallel
reticulate

The anatomy of a leaf.

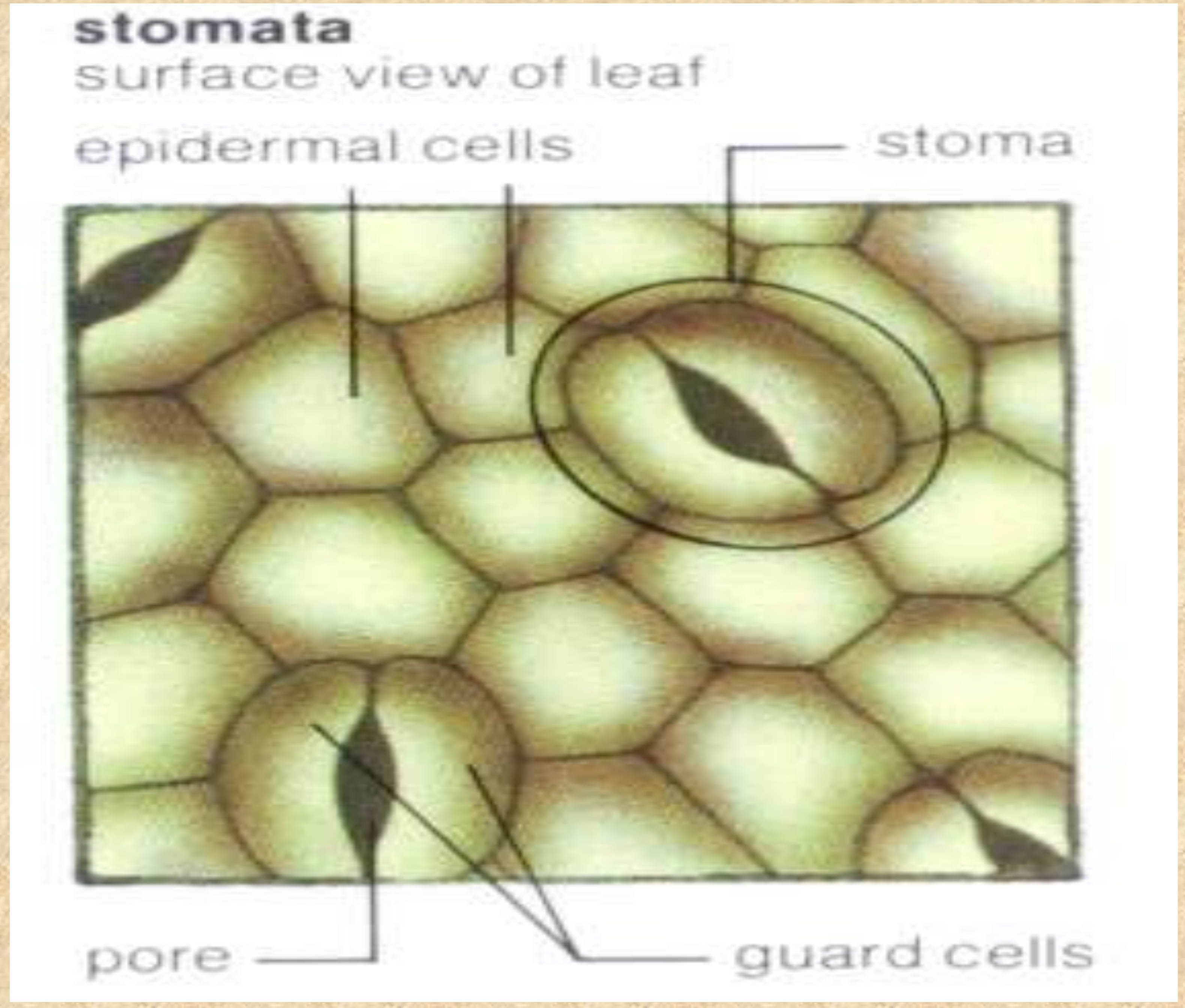
The **upper epidermis** and **lower epidermis** enclose the **palisade** cells and the **spongy mesophyll**, together with the veins (vascular system) that supply them with water, mineral nutrients, and metabolites. A protective noncellular layer of a waxy substance called **cutin** covers the epidermis of most leaves and this layer is termed **cuticle**.


upper epidermis
trichome
vascular bundle
cuticle
palisade layers
spongy mesophyll
lower epidermis
air spaces
stomate
guard cell
stomate
guard cells

The palisade cells appear to be tightly packed, whereas the spongy mesophyll is loosely arranged, but both layers contain intercellular spaces, which are connected to the external atmosphere by pores in the epidermis called the **stomata** (the singular form is **stomate**).


leaf cross section
cuticle
upper epidermis
palisade parenchyma
(many chloroplasts)
spongy mesophyll
lower epidermis
cuticle
guard cells of stoma
intercellular spaces

Each stomate is enclosed by two highly modified epidermal cells called **guard cells**. These guard cells pull apart when they are turgid and collapse toward one another when flaccid, thus opening and closing the stomate.

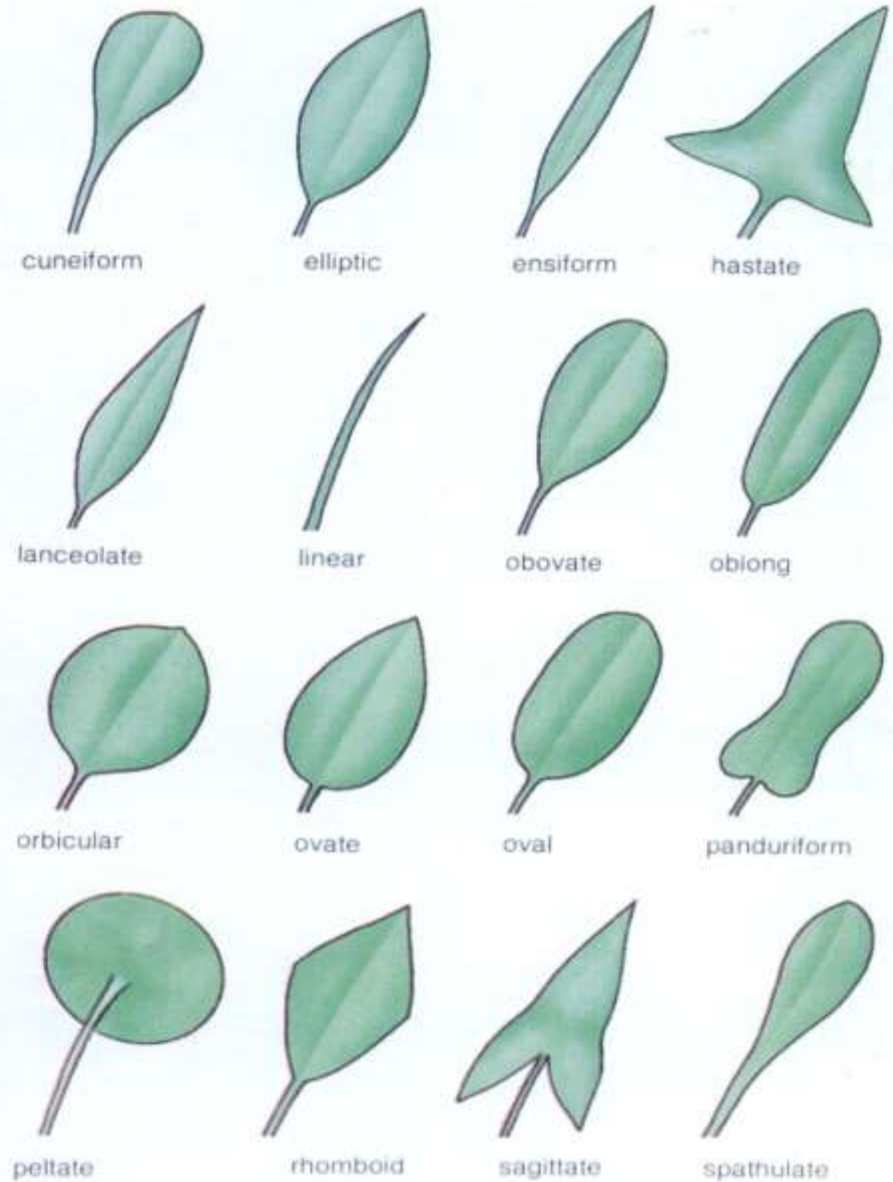

stomata
surface view of leaf
epidermal cells
stoma
pore
guard cells

Gaseous exchange takes place through such open stomata, thus providing carbon dioxide for photosynthesis and facilitating **transpiration**. Transpiration is the evaporation of water from internal leaf cell surfaces and the subsequent loss of water, primarily through the stomata.

Water is to a lesser extent also lost directly through the leaf's surface ("cuticular transpiration") or through specialized structures composed of one or more permanently open pores called **hydathodes**.

This latter process, called **guttation**, is thought to be a result of root pressure and usually occurs at night during periods of high humidity, when the stomata are closed.

**Shapes of simple leaves**



Leaves of coniferous tűlevelű species are frequently awl-shaped or needle-shaped and are referred to as needles. A thick cuticle on such persistent (evergreen) leaves may prevent water loss in winter. Other leaves may be cylindrical, as in the green leaves of onion,


a—c: Brassica oleracea *L.* var. sabauda *L.* — **Kelkáposzta**

d: Brassica oleracea *L.* var. gemmifera *DC.*— **Bimbós kel**

or modified for food storage, as in cabbage and brussels sprouts, and the fleshy leaf bases already described for tunicate bulbs.

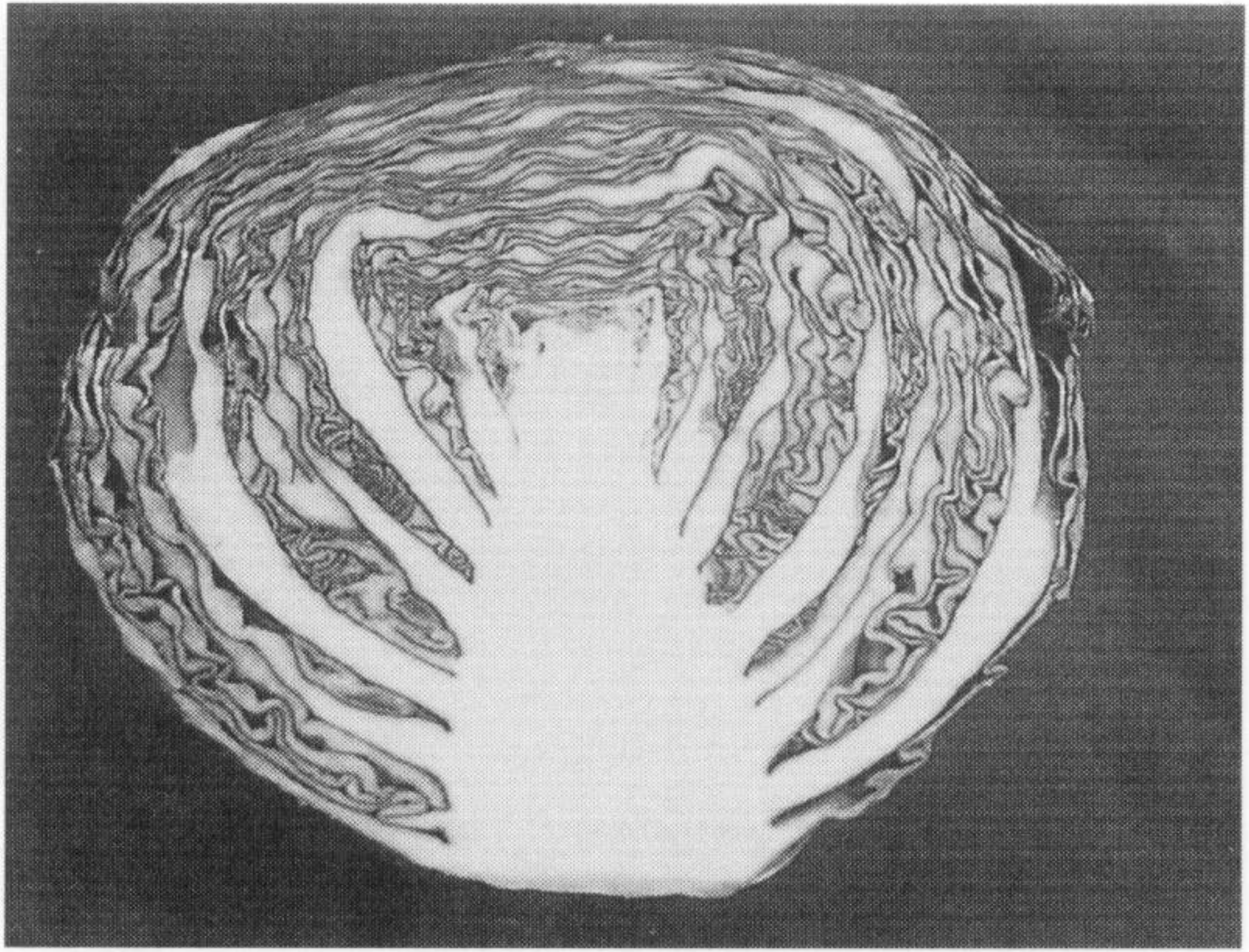


**FIGURE 3-40.** Longitudinal section of the head of cabbage. Note that the core is a greatly compressed stem.

The fleshy petioles of celery and rhubarb are popularly eaten and the bracts that enclose the immature inflorescence (bud) of the globe artichoke (*Cynara scolymus*) are considered a delicacy by many vegetable connoisseurs. ínyenc


fleshy petioles
*Apium graveolens*
Celery

'Green Globe'

Globe artichoke

*Cynara scolymus*

# FLOWERS

Although varying vastly from species to species, a "typical" flower normally is composed of **sepals, petals, stamens**, and **pistils**. These four floral organ types are arranged in whorls and are attached to a stem tip referred to as the **receptacle**. The numbers of sepals, petals, stamens, and **carpels** termőlevél (leaflike structures that comprise the body of the ovaries) are relatively constant for a species.

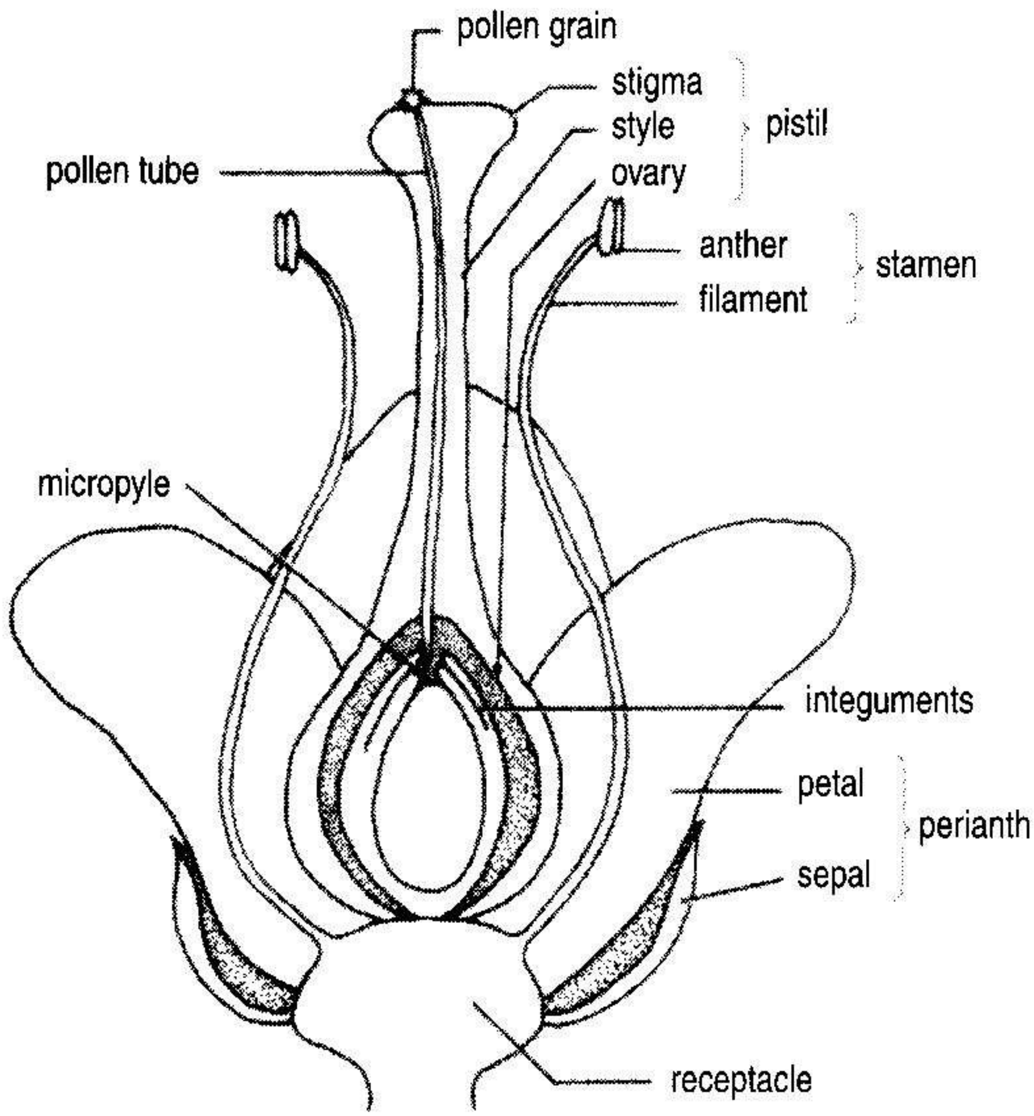


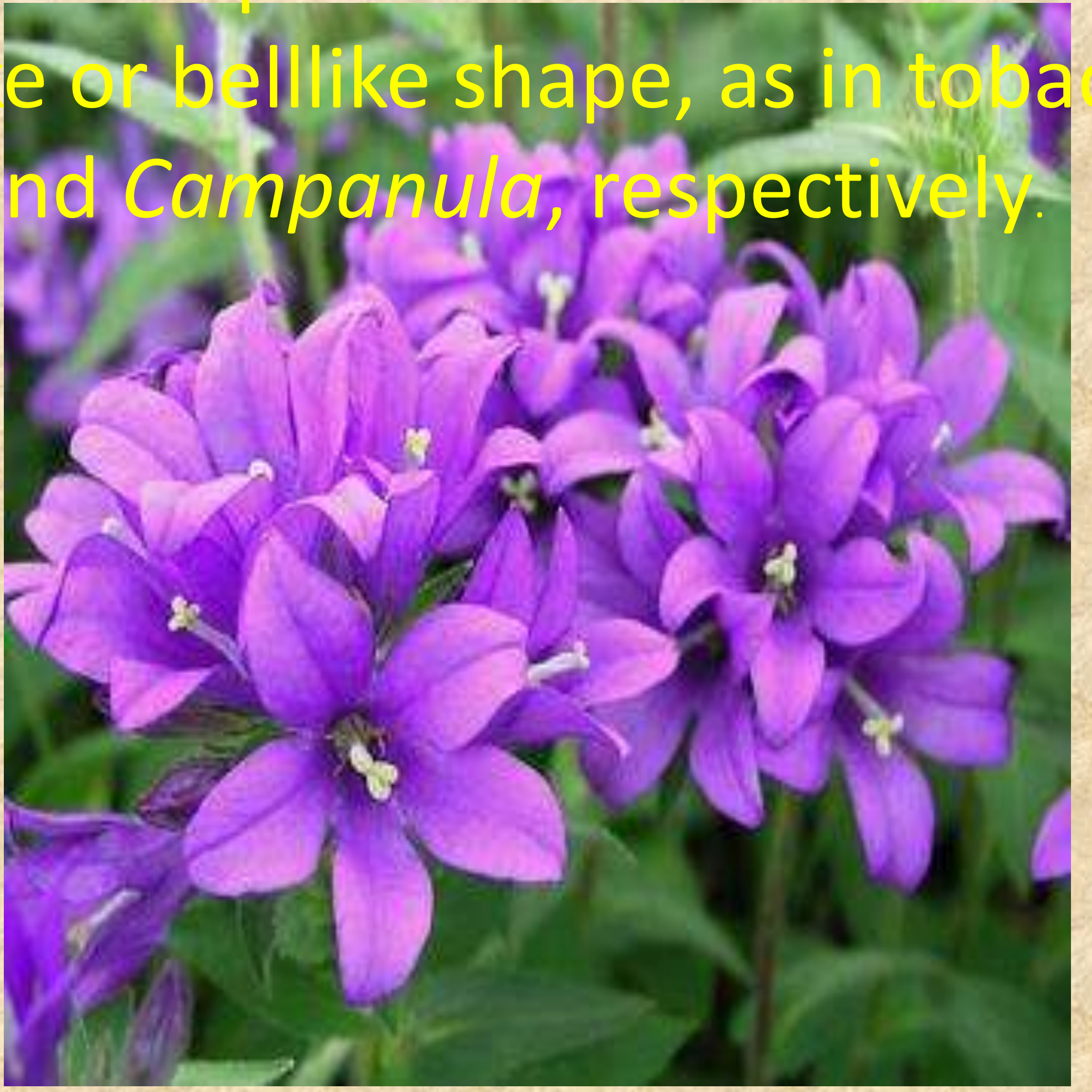

**FIGURE 3-43.** A diagram of a "typical" flower.

The number is typically five (or multiples of five) for dicots and three (or multiples of three) in monocots, although other numbers may occur (e.g., four sepals and four petals in the *Cruciferae/Brassicaceae*). Sepals tend to appear leaflike and enclose the bud, and they may be fused at their bases.

Collectively, the sepals are called the **calyx**. The petals, collectively the **corolla**, are usually showy, white, or colored, and are attractive to insects and other animals that could be potential pollinating agents.

The calyx and corolla are collectively termed the **perianth** and when fused together (often with the stamen and ovary bases also), they are called the **hypanthium**.

Sometimes the petals are fused into a tubular, funnel-like or belllike shape, as in tobacco, petunia and *Campanula*, respectively.

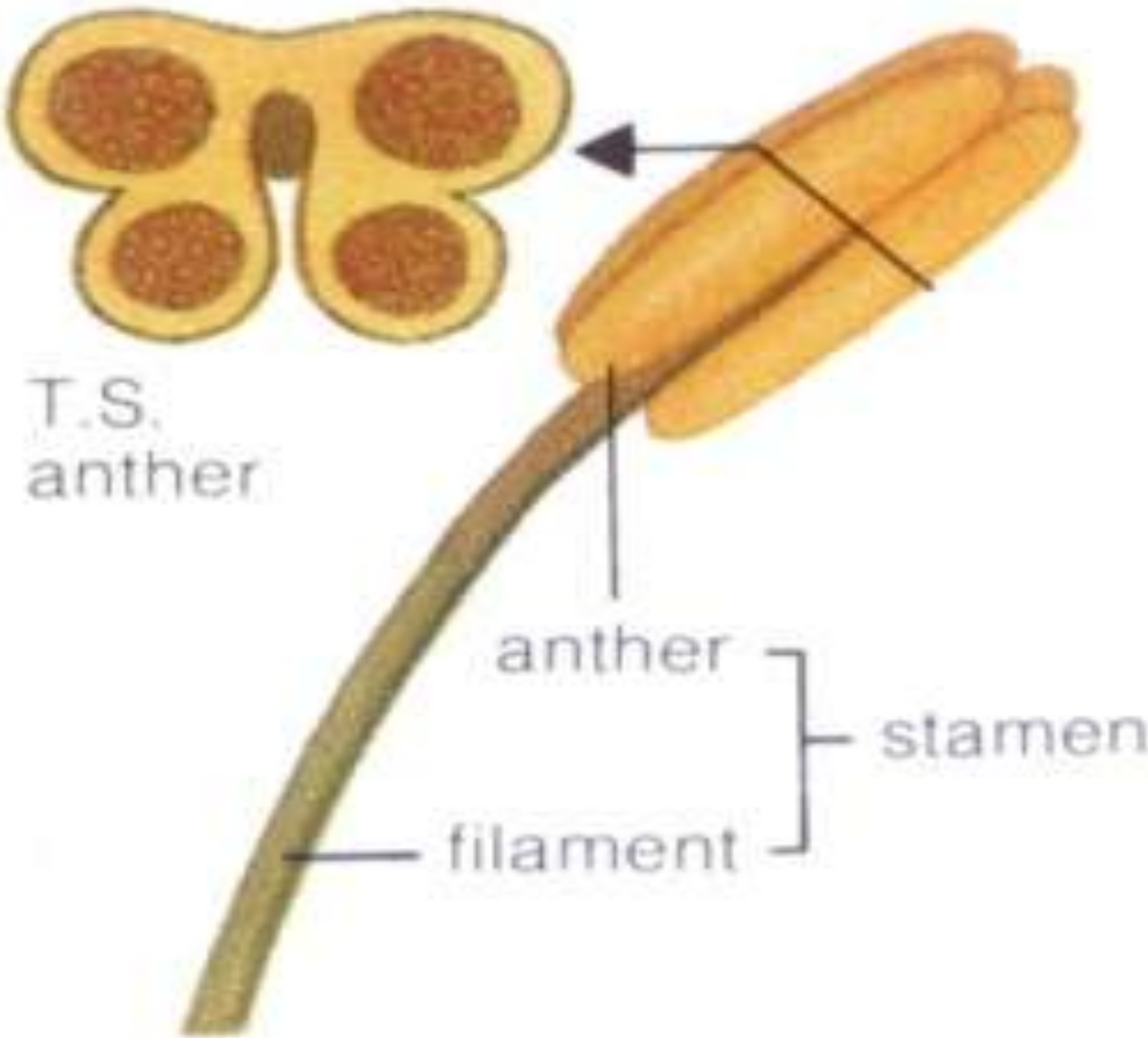


*Campanula glomerata* 'Joan Elliot'

The stamens are the male organs of the flower and consist of two parts, the **pollen**-bearing part called the **anther** and the usually slender stalk upon which the anther is born, called the **filament**. The pollen is shed by the splitting, or **dehiscence**, of the anther (**anthesis**). Stamens of many plants may appear as highly modified structures that are petal-like sziromszerű in appearance called **staminodes**.


Flowers with numerous staminodes are the "double" flowers of many important horticultural species such as cultivated roses. Indeed, some botanists consider the normal petals of many flowers to have evolved from stamens and therefore to be staminodes.

# male floral parts

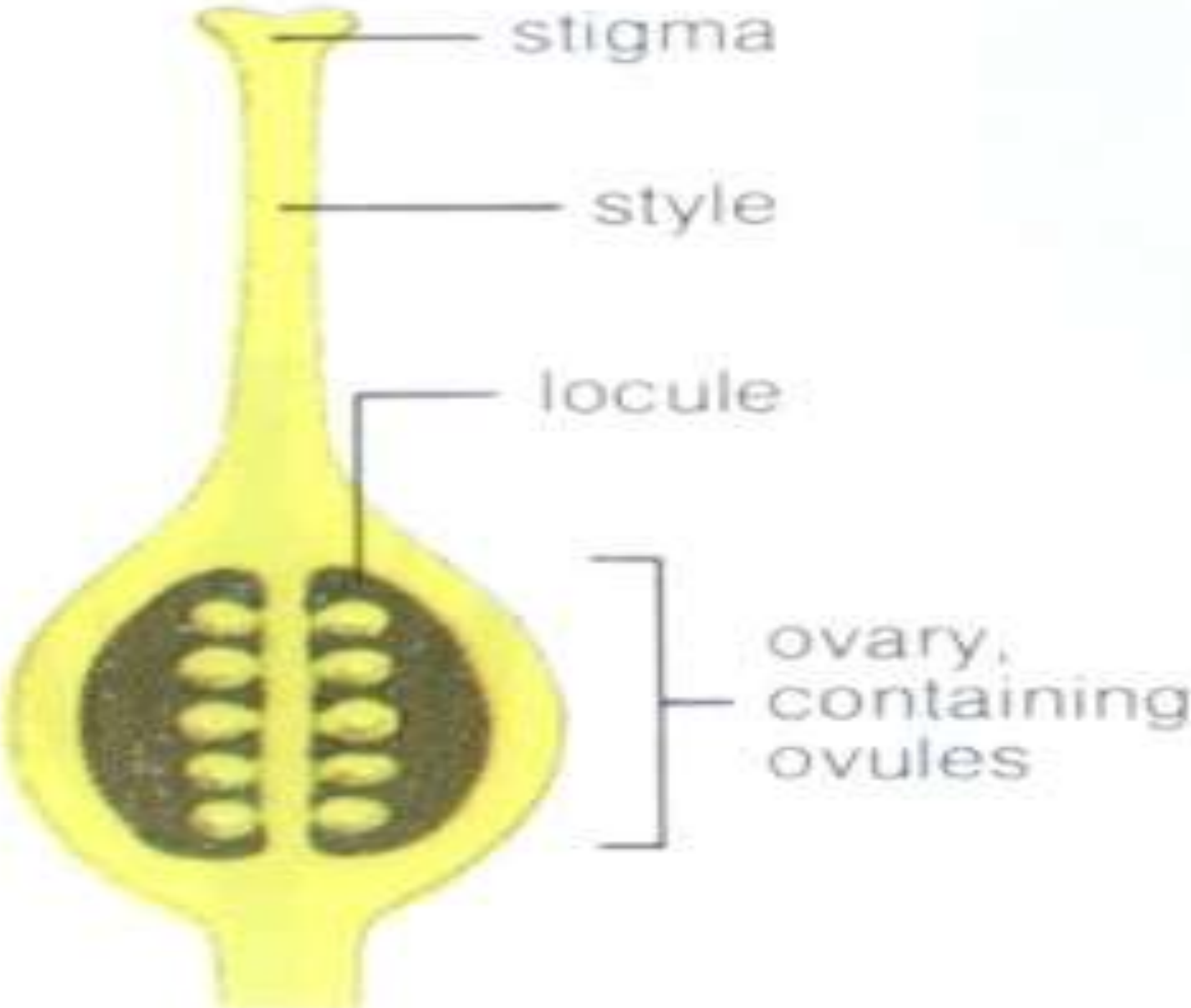


The pistil is the female part of the flower and is comprised of one or more carpels, which are modified leaves bearing **ovules** along each edge. If the pistil has a single carpel, it is called a **simple pistil** and the carpel is folded lengthwise so that the ovules are protected and enclosed. In ovaries with more than one carpel (a **compound pistil**), the carpels are fused along adjacent edges, thus forming a tubular structure, somewhat analogous to tubular forms of a corolla or calyx.

Whether simple or compound, a pistil is normally differentiated into three parts: the basal portion, or **ovary**, contains the ovules; the **stigma** is the upper portion and receives the pollen; and the **style** is the usually slender part of the pistil that connects the stigma to the ovary. In compound pistils, the stigma may be split or lobed into as many parts as there are carpels — three for lily, for example.

The ovary chambers are referred to as **locules**. The placement of the ovules in the locules, or on the interior of the carpels, is termed **placentation** and is a useful tool in plant identification.

pistil



If all four kinds of floral organs are present, the flower is said to be **complete**; if one or more floral organ types is missing, the flower is **incomplete**. The stamens and pistil are considered the **essential parts** and if both are present, the flower is considered to be a **perfect** flower; if either is absent, the flower is termed **imperfect**. Perfect flowers are also called **hermaphroditic**. They are typical of flowers found in many angiosperm families.

Position of the ovary is another useful parameter in classification and identification of plants. The types of ovary position are illustrated (*in next figure*), and include **hypogynous** (hypo = below) wherein the origin of the bases of the sepals, petals and stamens is below, and distinct from, the ovary base (**superior** ovary).

the **perigynous** (peri = around or encircling) flower is still an example of a superior ovary, but the fused bases of sepals, petals, and stamens (hypanthium) surround the ovary, without fusing with the ovary as they do in the **epigynous** flower (epi = above).

In an epigynous flower, the hypanthium is fused to the ovary walls so that the sepals, petals, and stamens appear to arise from the top of the ovary, hence the term **inferior** ovary. Lily and raspberry flowers are hypogynous; cherry flowers are perigynous; and flowers of the members of the *Cucurbitaceae* are epigynous.

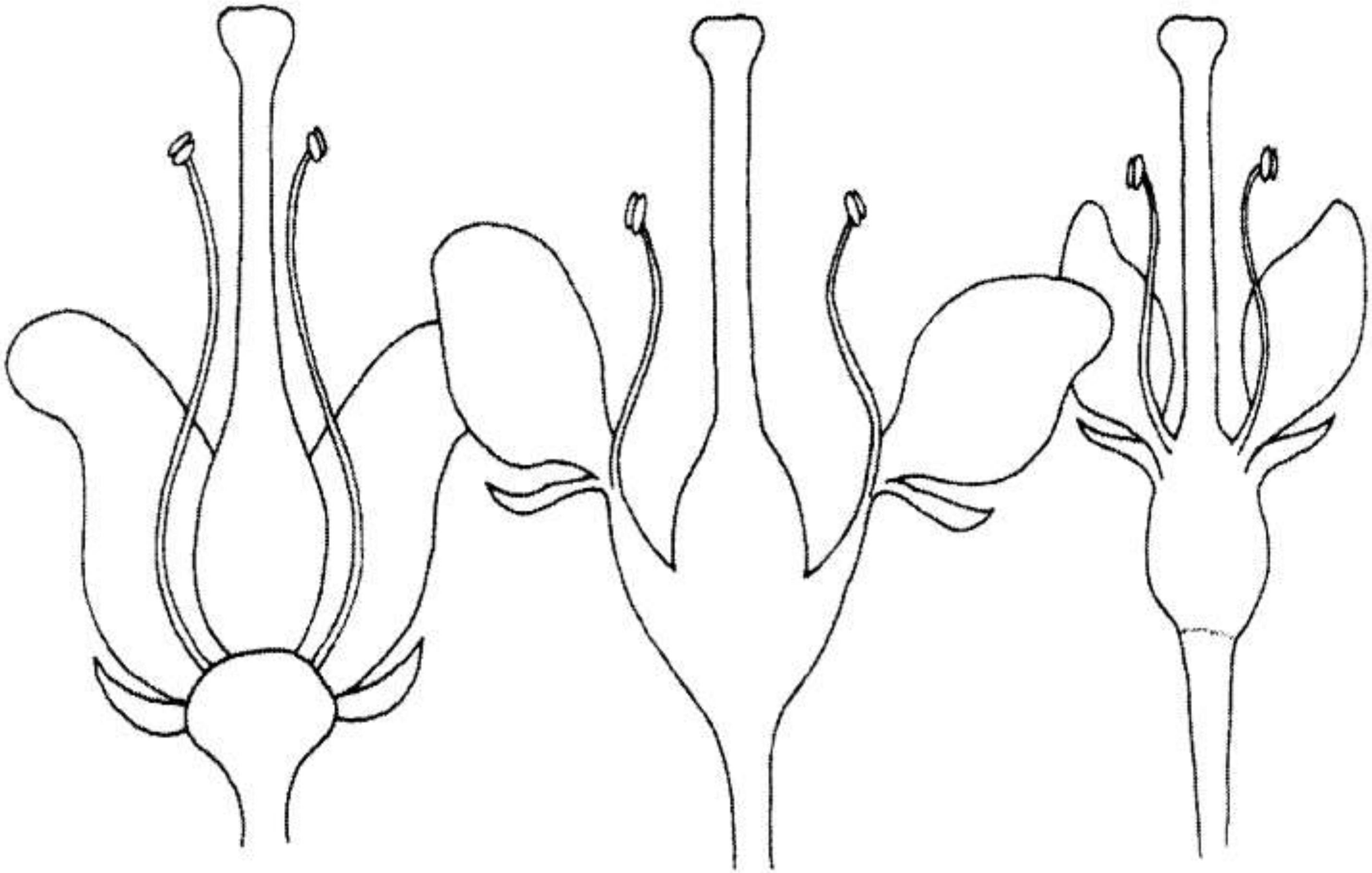
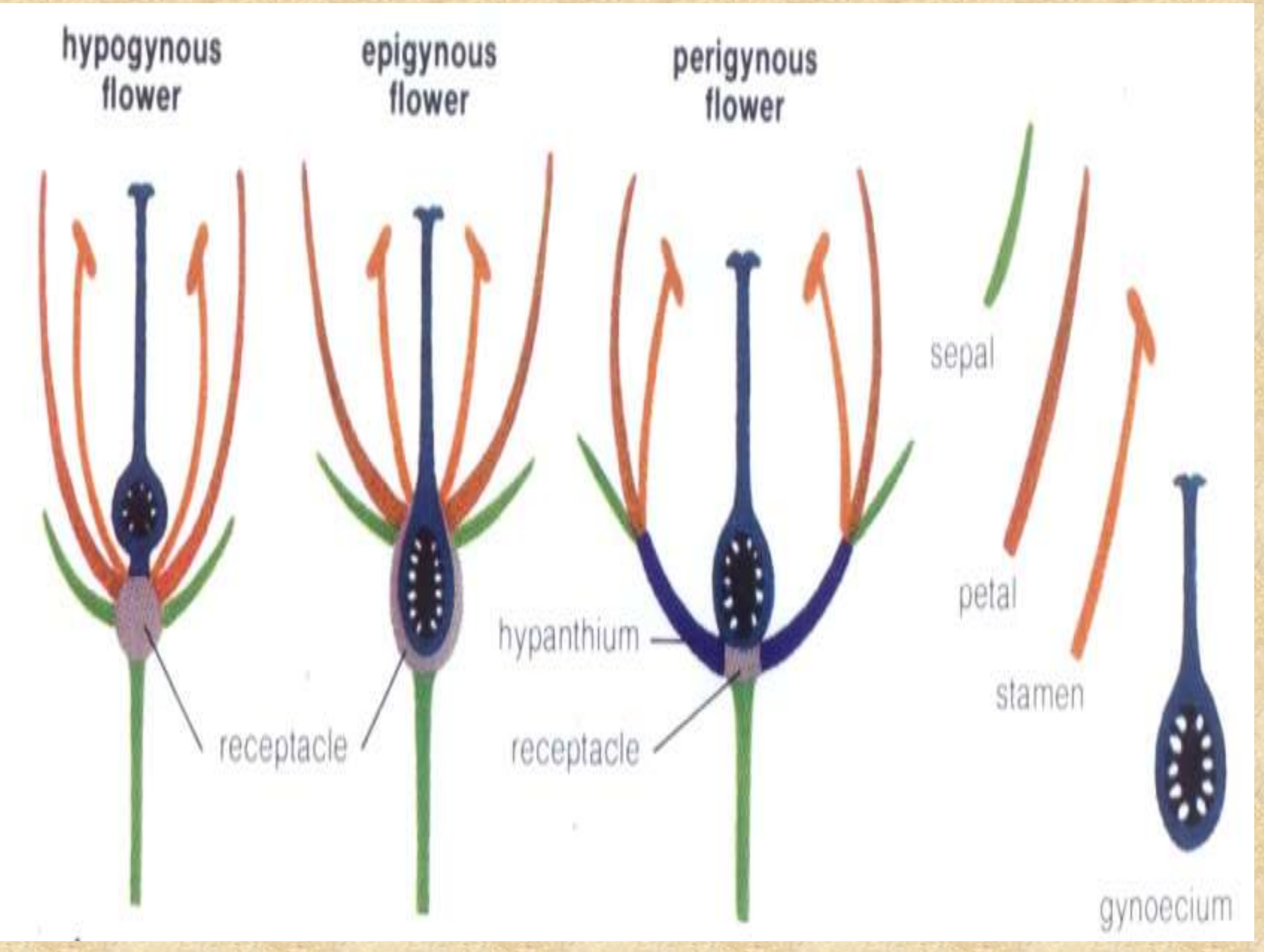


**FIGURE 3-48.** Types of ovary positions: hypogynous flower of lily, *left*; perigynous flower of cherry, *center*; and epigynous flower of muskmelon, *right*. Hypogynous and perigynous flowers are superior ovary types and the ovaries of epigynous flowers are called inferior.


hypogynous flower
epigynous flower
perigynous flower
sepal
petal
stamen
hypanthium
receptacle
receptacle
gynoecium

The placement or arrangement of flowers on a stem can also vary greatly from species to species. Flowers may be borne singly (**solitary** flowers) or may be grouped in various clusters called **inflorescences**. Solitary flowers and inflorescences are borne on stems called **peduncles**, the tip of which is the receptacle. The smaller stemlike structures bearing the individual flowers in an inflorescence are called **pedicels**.

Each flower in an inflorescence is usually subtended by a bract. Some specialized inflorescences are typical of certain taxa or groups, such as the umbel for the *Umbelliferae (Apiaceae)* and the spikelet found on the spikes, racemes, and panicles of the *Graminae (Poaceae)*. The highly membranous tough modified leaves known as **glumes**, **lemma**, and **palea** serve as the outer floral organs in such grass flowers. Like many other species of wind pollinated plants, these flowers tend to be inconspicuous and less showy.

There are two general types of inflorescences based on their pattern of floral opening: the **determinate**, in which the apical bud opens first, followed sequentially by those below and working downward (e.g., **cymes** of strawberry) or **indeterminate**, typical of many other common inflorescence types including **panicles** and **racemes**.

Because botanists tend to think of fusion of floral organs and/or reduction in numbers as evolutionary advancements, species in the *Compositae (Asteraceae)* that have a **head (capitulum)** are considered more advanced than those species in which panicles are the norm. **Regular** flowers, radially symmetrical, are thought to be less advanced than **irregular** flowers, which are bilaterally symmetrical.

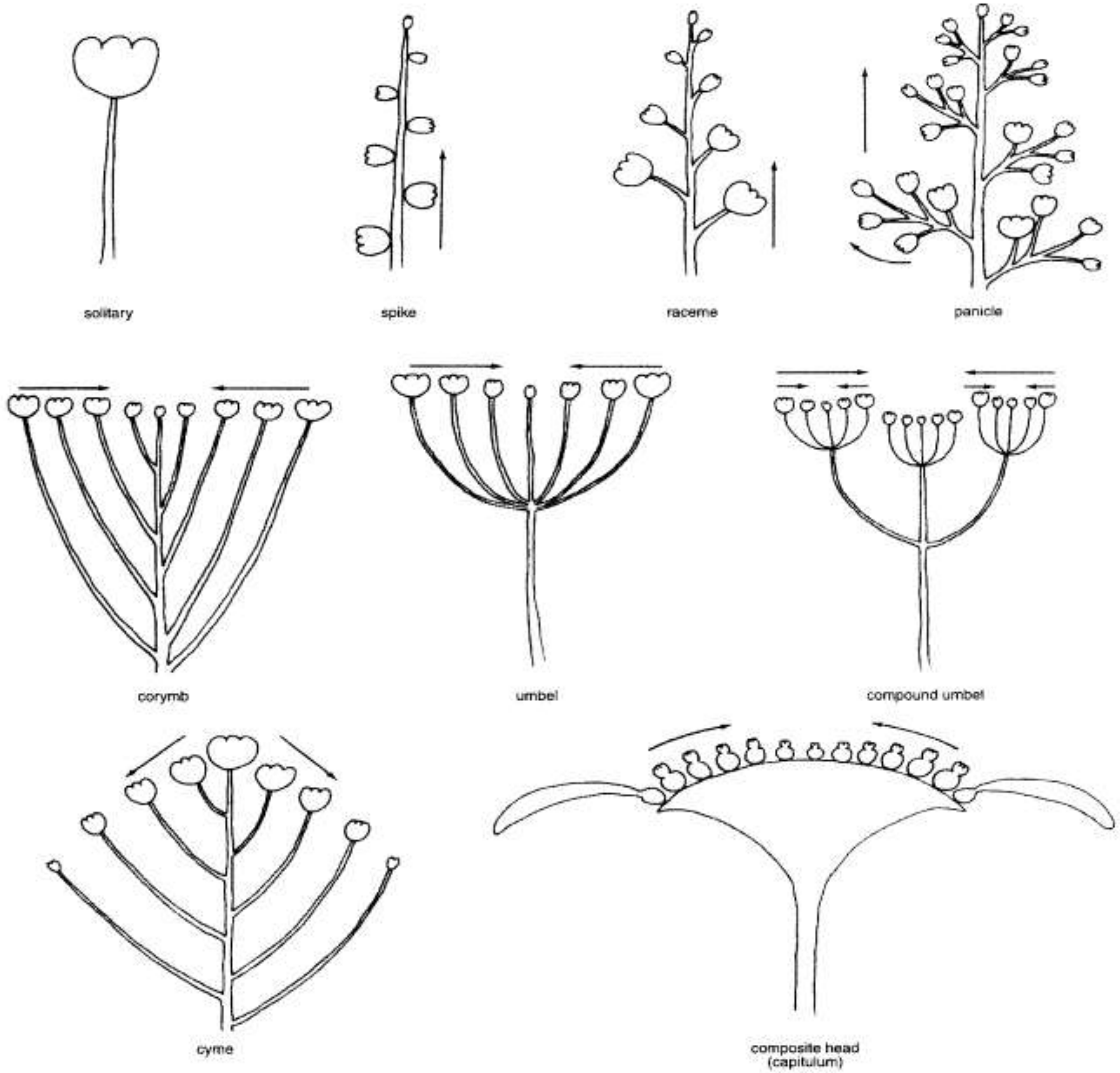
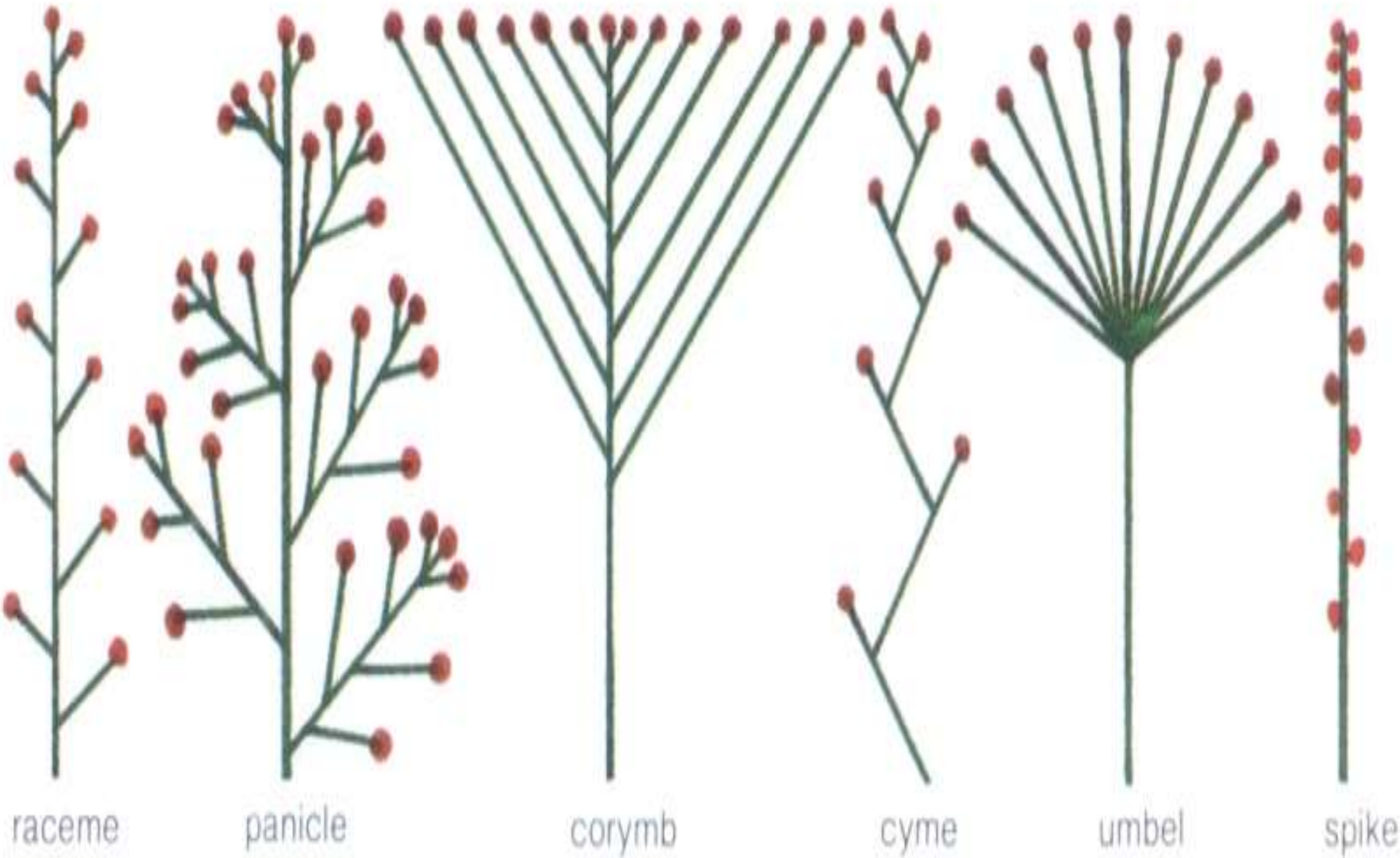



**FIGURE 3-49.** Some common inflorescence types. Flowers are represented schematically, with larger "flowers" indicating open flowers, and smaller structures unopened buds. Note that the first flower to open in the cyme is the apical, as in the "king flower" of strawberries, whereas the most proximal flowers open first and the apical last in the corymb. Arrows represent order of opening.

inflorescence types



# FRUITS

The general public, horticulturists, and botanists often have different definitions of a fruit. A simple botanical definition asserts that a fruit is a ripened ovary and any associated parts.

A horticultural, or usage, definition of a fruit *does not include* most vegetables that are correctly termed fruits botanically, but only those fruits that usually are consumed fresh or processed as a dessert food, (e.g., apples, strawberries, citrus). In angiosperms, a fruit normally is formed following fertilization of the ovules and contains seeds resulting from such fertilization.

Fruits that form without fertilization are called **parthenocarpic** (**parthenos** = virgin and **karpos** = fruit). Examples are banana and navel orange. In some normally fertilized fruits such as apple and pear, it is known that hormones are produced by the developing seeds and that such hormones aid in fruit development.

When the fruit ripens, the ovary wall is referred to as the **pericarp**. The pericarp usually consists of three parts, the outer layer, or **exocarp**; the middle layer, **mesocarp**; and the inner layer, the **endocarp**. The relative development of these layers is often different and distinctive for various fruits.

**<u>TERMINOLOGY:</u>**
**MULTIPLE FRUITS**. A **multiple** fruit is a fruit formed by the development of <u>several flowers</u>, which fuse during ripening.


Usually such fruits have a common receptacle (e.g., the "core" of mulberry). Examples: pineapple (*Ananas comosus*), fig (*Ficus* spp.), mulberry (*Moms* spp.), and the "seed" of beet (*Beta vulgaris*).

**AGGREGATE FRUITS**. An **aggregate** fruit is one formed by the development of several ovaries produced by one flower. Examples: raspberry and blackberry (*Rubus* spp.).

(Note that in blackberry the receptacular tissue is part of the edible fruit at maturity, whereas in raspberry the receptacle remains on the stem when the fruit is picked.)

**SIMPLE FRUITS**. A **simple** fruit is one that is formed by the development of a single pistil or ovary. Simple fruits are further subdivided:

**Fleshy Fruits.** In fleshy fruits, the pericarp is usually soft, succulent, or fleshy when the fruit matures.

***Berry***. If the pericarp is fleshy throughout, the fruit is called a **berry**. Examples of berries are tomato, blueberry, eggplant, and cranberry. Two specialized types of berries also exist:

The **pepo** has a thick, hard exocarp or rind at maturity. Examples of pepo fruits are most members of the *Cucurbitaceae*, such as squash, muskmelon, and watermelon.

A **hesperidium** is a type of berry that has a leathery exocarp and mesocarp with a very juicy endocarp that has distinct segments. Examples include grapefruit, orange, and lime.

***Drupe***. A **drupe** is a fleshy, usually one-seeded fruit in which the seed is enclosed in a stony endocarp composed of masses of sclereids (the "pit"). The exocarp is thin and the mesocarp is usually fleshy, constituting the edible portion of various species of *Prunus* (cherry, plum, and peach) and olive (*Olea europea*).

In the case of almond (*Prunus dulcis*), the edible portion is the seed that is enclosed in the stony endocarp and the exocarp and mesocarp are not considered edible.

***Pome***. A **pome** is a fruit produced by a compound inferior ovary containing many seeds and which is composed primarily of fleshy perianth bases, exocarp, and mesocarp. The endocarp is often cartilaginous, encloses the seeds, and is called the "core." Apple, pear, and quince (*Cydonia oblonga*) are examples. In some classifications, pomes are referred to as accessory fruits.

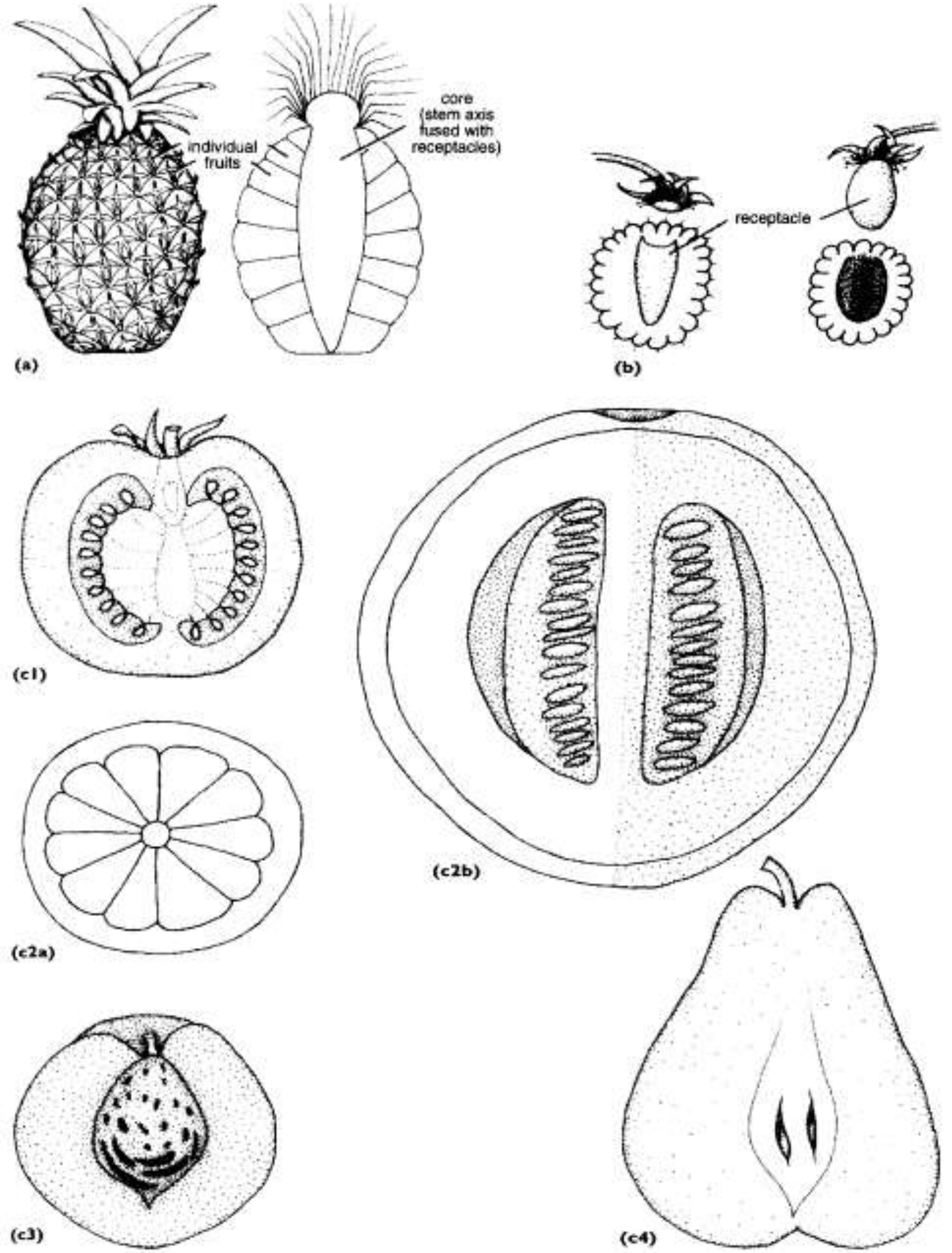



**FIGURE 3-57.** Fruit types. (*a*) Multiple: pineapple *left* and *right*. (*b*) Aggregate: blackberry (retains fleshy receptacle when harvested, *left*), and raspberry (does not include receptacle when harvested, *right*). (c) Simple fleshy fruits. (*c1*) Berry: tomato. (*c2*) Specialized types of berries: (*c2a*) Hesperidium: lime. (*c2b*) Pepo: muskmelon. (*c3*) Drupe: peach. (*c4*) Pome: pear.

**Dry Fruits.**

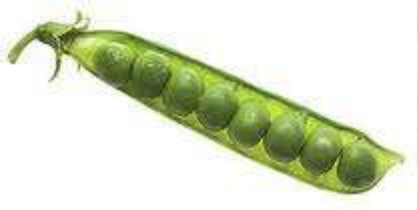
The pericarp tissue of dry fruits is not moist and often is hard or brittle törékeny when the fruit is ripe.

***Dehiscent*.** felpattanó

The pericarp splits or **dehisces** along definite lines or sutures at maturity.

*Follicle*. A follicle is composed of a single carpel and dehisces along one suture at maturity. Examples: milkweed (*Asclepias* spp.), and *Delphinium*.

*Legume*. A legume is found only in the legume family (*Fabaceae/Leguminosae*) and is composed of a single carpel that dehisces along two sutures at maturity. Examples: bean (*Phaseolus* spp.), pea (*Pisum sativum*), and honeylocust (*Gleditsia triacanthos*).



*Silique*. A **silique** is composed of two carpels, which dehisce along two sutures and the fruit is divided lengthwise by a wall-like structure called a **replum**. A silique is usually longer than it is broad. Examples: radish (*Rhaphanus sativus*), and mustard (*Brassica* spp.). A **silicle** is a modified silique that is usually as broad as it is long. Examples: sweet alyssum (*Lobularia maritima*) and honesty (*Lunaria annua*). Siliques and silkies are found only in the mustard family (*Brassicaceae/Cruciferae*).

*Capsule*. Capsule is a multi-carpelled fruit that dehisces along more than two sutures varrat at maturity. Examples: poppy (*Papaver* spp.), okra (*Abelmoschus esculentus*), and azalea (*Rhododendron* spp.).

***Indehiscent.***

The pericarp does not split or open at maturity; fruits usually have one or two seeds.

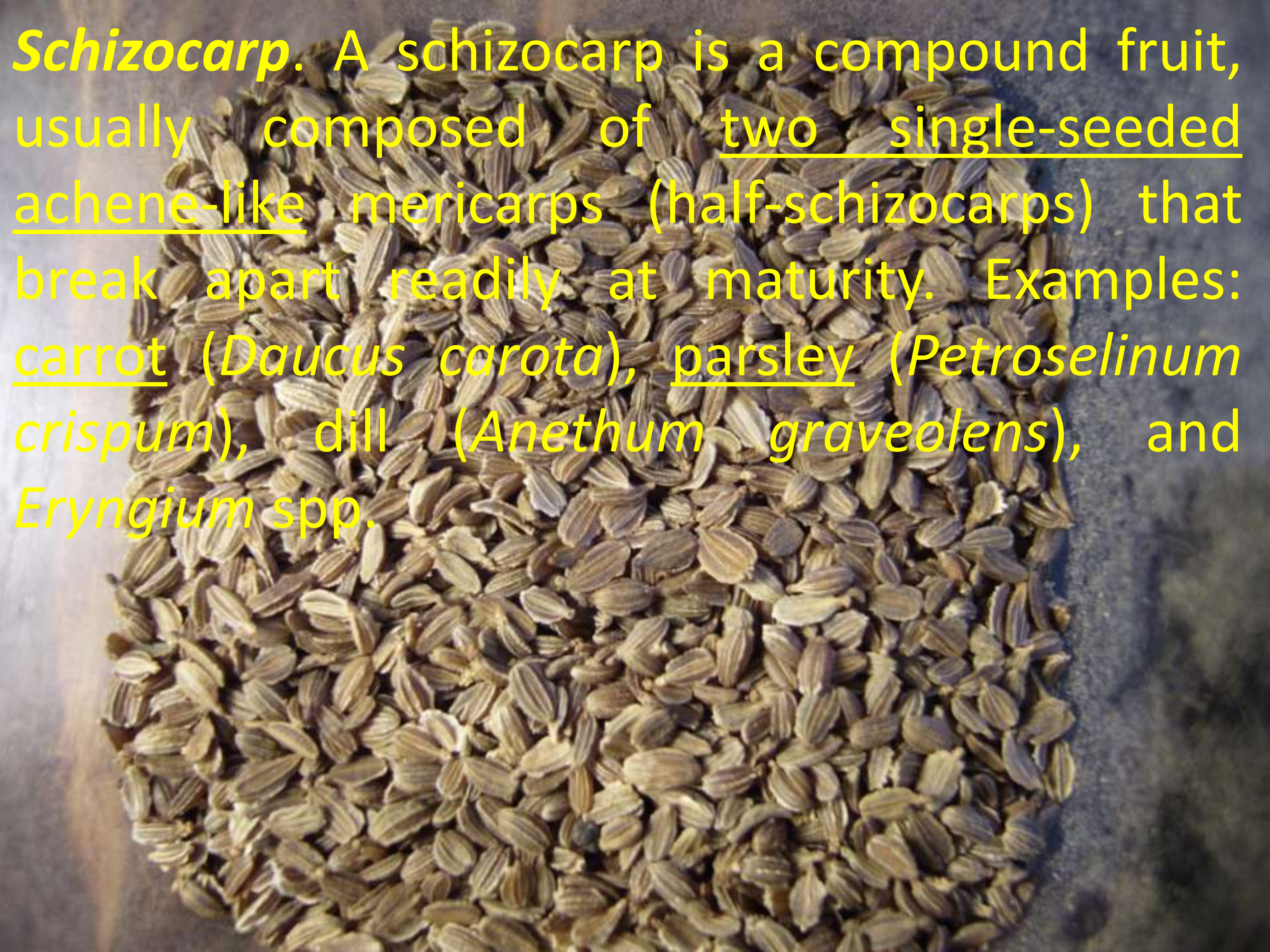
*Caryopsis*. A one-seeded fruit in which the pericarp and seed coat are fused. Examples: Kentucky bluegrass (*Poa pratensis*) and corn (*Zea mays*).

*Achene*. (ejkin) One-seeded fruit in which the pericarp may be fairly easily separated from the seed coat; pericarp not fused to the seed coat. Examples: sunflower (*Helianthus annuus*), *Zinnia elegans*, *Dahlia* sp., and the "seed" found in strawberry fruits.

*Samara*. lependék The samara is similar to an achene, but it has a winglike, somewhat membranous outgrowth of the pericarp. Examples: maple (*Acer* spp.), ash (*Fraxinus* spp.), and elm (*Ulmus* spp.).

*Nut*. This one-seeded fruit is somewhat like an achene, but possesses an extremely hardened pericarp. Examples: pecan (*Carya illinoensis*), walnut (*Juglans* spp.), and oak (*Quercus* spp.).

***Schizocarp***. A schizocarp is a compound fruit, usually composed of two single-seeded achene-like mericarps (half-schizocarps) that break apart readily at maturity. Examples: carrot (*Daucus carota*), parsley (*Petroselinum crispum*), dill (*Anethum graveolens*), and *Eryngium* spp.



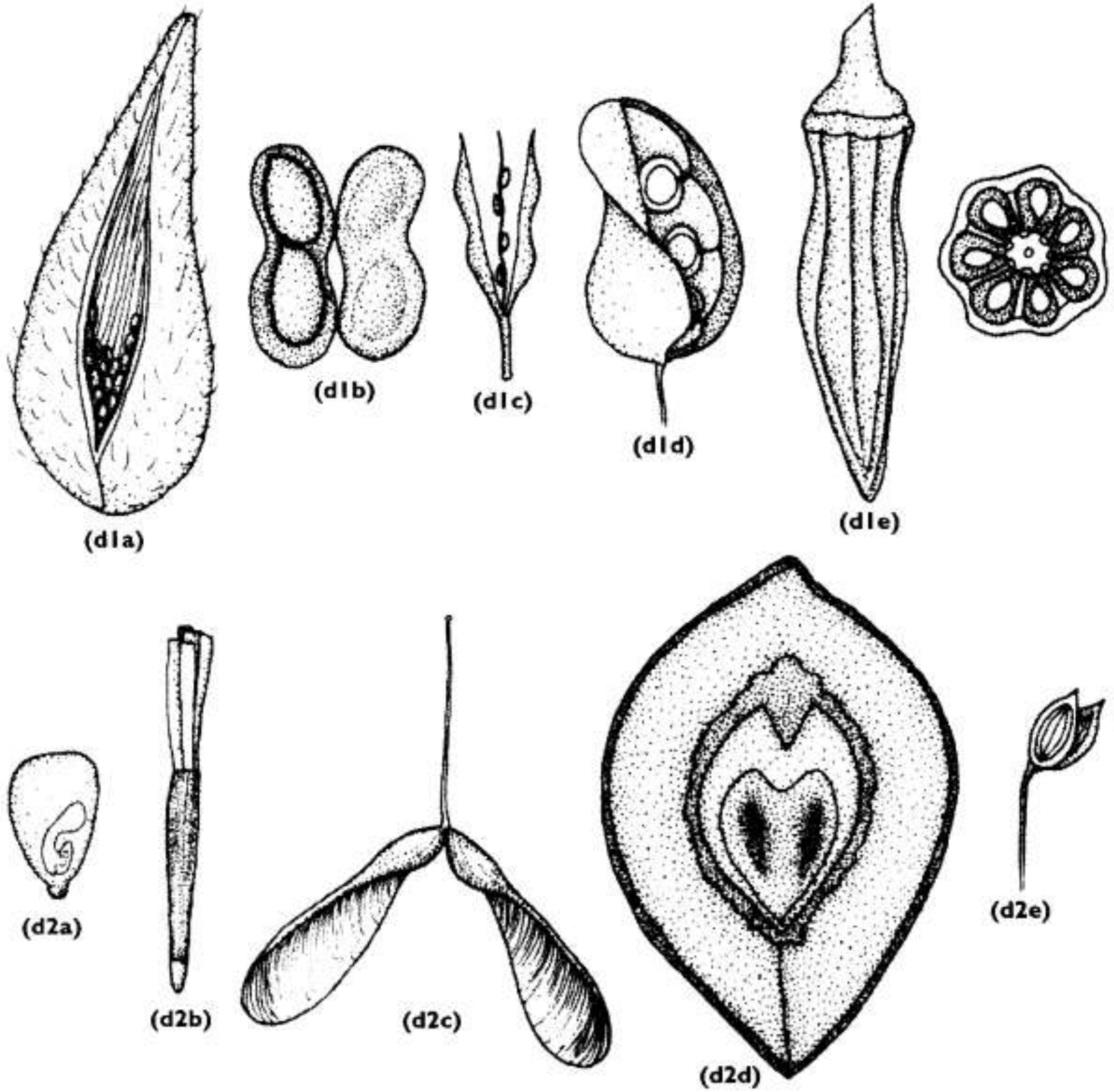
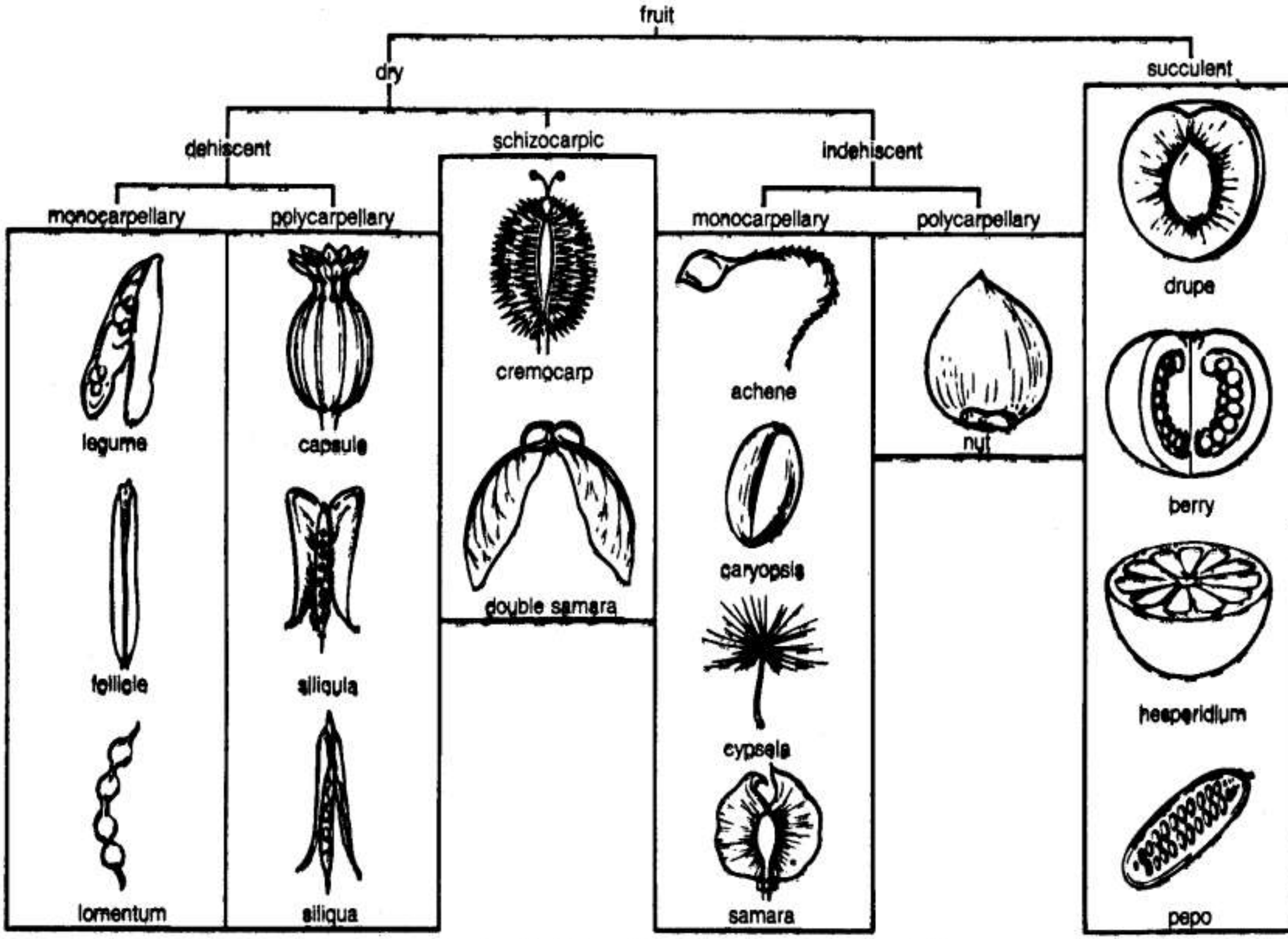



**FIGURE 3-57. *(continued)*** (*d*) Simple dry fruits: (*d1*) Dehiscent. (*d1a*) Follicle: *Asclepias*. (*d1b*) Legume: peanut. (*d1c*) Silique: radish. (*d1d*) Silicle: *Lunaria*. (*d1e*) Capsule: okra. (*d2*) Indehiscent. (*d2a*) Caryopsis: corn. (*d2b*) Achene: marigold. (*d2c*) Samara: maple. (*d2d*) Nut: pecan. (*d2e*) Schizocarp: carrot.

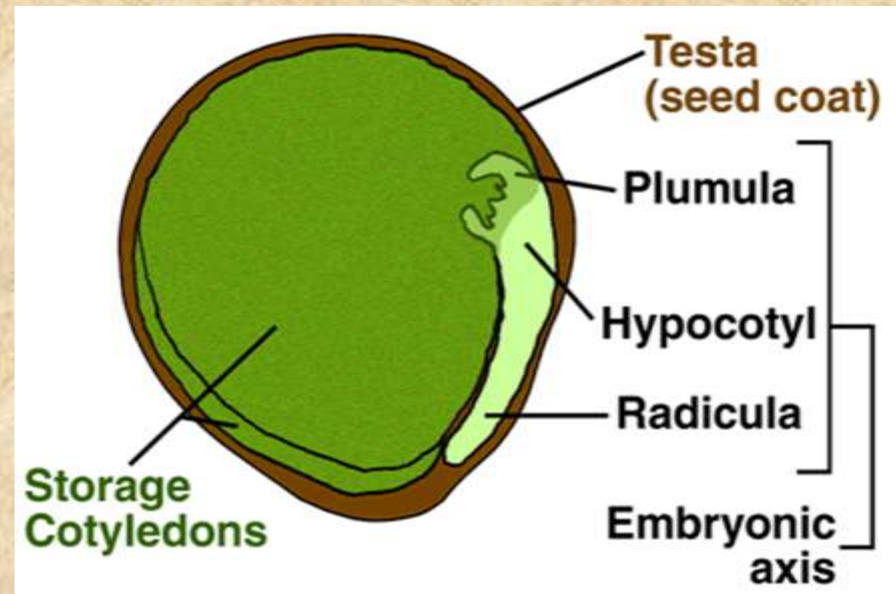



A simple classification of the different types of true fruit.

## Seeds

The **seed** is composed of a developed embryo (the structure that will become the plant), enveloped by a protective **seed coat** or *testa*, which was formed by development (and usually hardening) of the outer ovule layers, or **integuments**.

It generally contains stored food reserves, either in the endosperm or the cotyledons. If the stored food is primarily in the endosperm, the seed is an **albuminous** seed. If the food has been digested from the endosperm during the development of the seed and subsequently stored in the cotyledons, it is referred to as an **exalbuminous** seed.




*Pisum sativum*

In angiosperms, seeds develop inside the developing ovary, or fruit. However, in gymnosperms, the seeds are termed "naked seeds"; seed development takes place on the surface of a fertile leaf (the "scale" of cones of coniferous species) rather than in a developing ovary (fruit). A distinct taxonomic separation into subclasses of the angiosperms is based in part on cotyledon number; that is, plants having seeds with one cotyledon are monocots and those with two cotyledons are dicots.

Two basic patterns of <u>seed germination</u> occur with respect to cotyledon position following germination. In **epigeous** germination, the hypocotyl elongates to bring the cotyledons *above* the soil line, but in **hypogeous** germination the hypocotyl does not elongate to any extent, so the cotyledons remain *below* the soil surface.

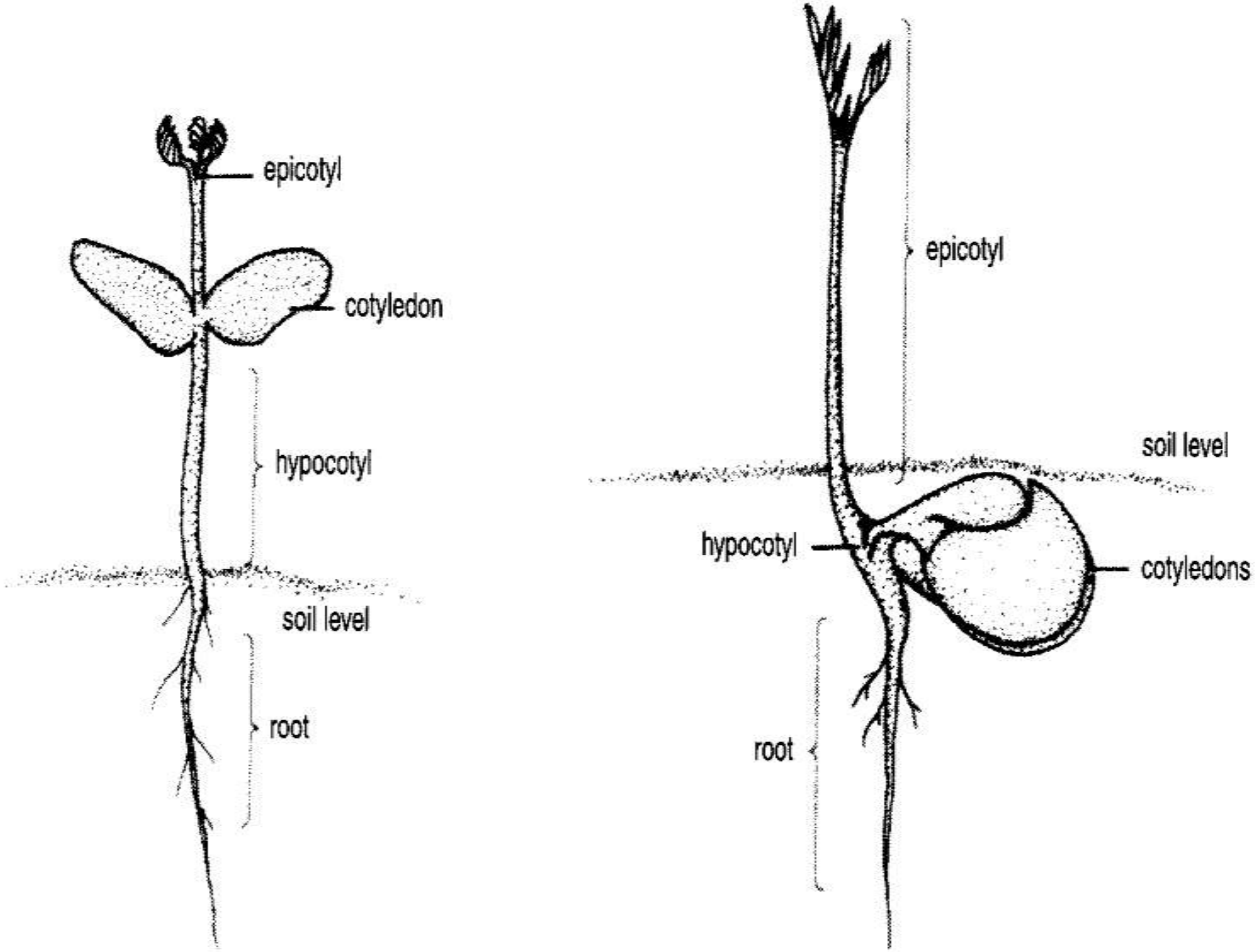
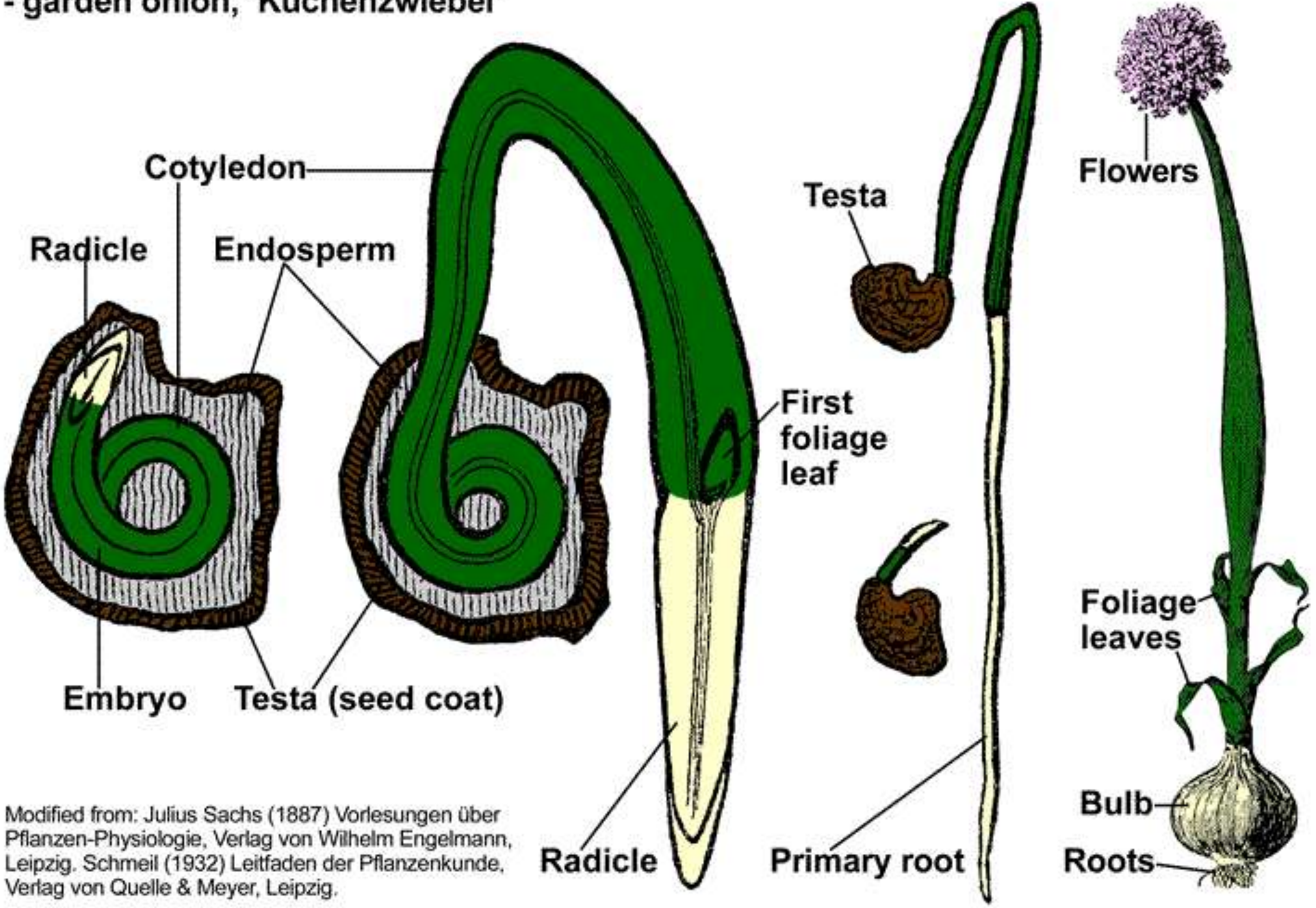



**FIGURE 3-60.** Germination patterns. Epigeous, *left*; hypogeous, *right*.

Seed germination and seedling growth of *Allium cepa* (Alliaceae, Liliales, monocots) - garden onion, 'Küchenzwiebel'




Modified from: Julius Sachs (1887) Vorlesungen über Pflanzen-Physiologie, Verlag von Wilhelm Engelmann, Leipzig. Schmeil (1932) Leitfaden der Pflanzenkunde, Verlag von Quelle & Meyer, Leipzig.