Introduction
One area of botany, the study of plants, is plant anatomy. An understanding of plant parts such as leaves, roots, flowers, etc. and their characteristics is essential when trying to identify a plant. This publication will assist you in learning the terms used to describe these characteristics, with clear, concise definitions and examples, and is an invaluable tool for the beginning botanist.

Chapter 1: The Plant World
The plant world is extremely diverse, ranging from one-celled algae to huge oaks and sequoias. It contains plants such as mushrooms, which have no green coloring, and lichens and mosses, which are green plants but have no true roots and leaves and no flowers. Many gardeners grow ferns of various kinds. They are green plants with true leaves and roots but no flowers or seeds; instead, they reproduce by means of spores. And, finally, there are the seed-bearing plants (Spermatophytes), which make up the vast majority of the plant kingdom and with which this publication is concerned.

Spermatophytes (Seed Plants)
Spermatophytes are plants that produce true seeds, each containing an embryo (a minute, inactive plant) that germinates (begins to grow) under favorable conditions. Seed-bearing plants have true leaves, stems, roots, and vascular tissue. These plants constitute the greater part of the vegetation on earth. They consist of two classes, the gymnosperms and the angiosperms.

GYMNOSPERMS (CONE-BEARING PLANTS AND THEIR ALLIES)
Gymnosperm means “naked seeded.” All gymnosperms are woody, perennial, and, with few exceptions, evergreen plants. The reproductive organs are borne in structures called catkins or in cones with the seeds usually uncovered. Their leaves may be fern-like, scale-like, strap-shaped, or needle-shaped. This group is represented today principally by the cone-bearing plants (conifers) and palm-like plants (cycads). Examples of plant families that are gymnosperms include the following:

- **Cupressaceae**—Cypress family (e.g., juniper and bald cypress)
- **Cycadaceae and Zamiaceae**—Cycad family (e.g., sago and coontie)
- **Pinaceae**—Pine family (e.g., longleaf pine and red cedar)

ANGIOSPERMS (FLOWERING PLANTS)
The angiosperms include those species that have flowers and seeds always protected by a fruit. They form a large, complex group of flowering plants under two main divisions: the monocotyledons (monocots) and the dicotyledons (dicots). These divisions are based upon the number of cotyledons, or “seed leaves,” found in the seed.

---

1. This document is SSENH901, one of a series of the Environmental Horticulture Department, UF/IFAS Extension. Revised May 2016. See Publication History Section for details. Visit the EDIS website at [http://edis.ifas.ufl.edu](http://edis.ifas.ufl.edu).
2. Sydney Park Brown, associate professor emeritus, Environmental Horticulture Department and Kathleen C. Ruppert, Extension scientist emeritus, Department of Agricultural and Biological Engineering; UF/IFAS Extension, Gainesville, FL 32611.
The **monocotyledons** have one cotyledon (seed leaf) in the seed. Generally they have parallel-veined leaves and flower parts in 3s (or in multiples of 3s, but never 4s or 5s). Their stems are made up of vascular bundles without pith or bark. A few of the monocots, such as bamboos and palms, are tree-like. The majority, however, are herbaceous plants such as grasses, lilies, irises, corn, orchids, bananas, and bromeliads.

**Dicotyledons** have two cotyledons in the seed. They can be recognized by their net-veined leaves and by their flower parts (sepals, petals, stamens, and pistils), which are generally in 4s or 5s or multiples of 4s or 5s. Some dicots, such as willows and poplars, have many small flowers without petals or sepals called catkins. Others have flowers with separate petals and sepals, such as roses and southern magnolia. Still others have flowers in which the petals or sepals or both are fused to form a trumpet-shaped flower, such as honeysuckle and allamanda.

---

**Chapter 2: Root Systems**

The functions of roots are to act as support for the stem, to absorb and conduct water and nutrients from the soil, and to store food. Root systems consist of a main or primary root, rootlets or secondary roots, and root hairs.

The **primary root** arises from the seed embryo. Branches of the primary (tap) root are often fibrous and are called **secondary roots**. The primary root system of many plants is short-lived and is eventually replaced by a secondary root system. These secondary root systems become the permanent roots of many monocots such as the grasses. Roots coming from bulbs, corms, rhizomes, or tubers (see Chapter 4) are **adventitious** roots. Stolons, runners, and cuttings from stems or leaves also develop adventitious roots. Banyan, screw pine, and red mangroves all send down adventitious roots that become supports for heavy, horizontal branches.

**Root hairs** are thin hair-like outgrowths of a plant root that penetrate into the openings between soil particles and absorb water and minerals from the soil. Water and soluble nutrients enter the root hairs, pass into the rootlets, and travel through the main root into the stems and leaves. Root hairs are formed in great numbers near the tips of roots. In most plants they are short-lived. If a plant is transplanted carelessly, it is the loss of many of these small root hairs with their water-absorbing cells that will cause the plant to wilt.

**Tap roots** are prominent primary roots from which all other lateral rootlets or secondary roots grow. They may divide, become fleshy, and often penetrate deeply into the soil.

**Fibrous roots** are adventitious, have no distinguishable primary root, and are composed of a number of fine, thread-like roots of the same kind and size, originating at the base of the stem. Fibrous roots often spread out near the surface of the soil rather than penetrating deeply.

**Fleshy roots** act as food reservoirs for plants during adverse periods. Carrots, turnips, and beets have primary or tap roots containing food. Sweet potatoes and dahlia have secondary roots modified into tuberous roots packed with food.
Aerial roots form freely on many land and water plants growing in a moist atmosphere. These roots enable climbers such as philodendrons to attach themselves to a host. The aerial roots of air plants or epiphytes such as some orchids not only attach the plant to its host but also absorb water from the air. Many aerial roots are fleshy or semi-fleshy, functioning as reservoirs for water storage.

Knees (pneumatophores) are developed by bald cypress growing on swampy ground. These trees develop woody-knees that protrude above the surface to enable the plant to obtain air.

Chapter 3: Stems

A stem may be defined as a structure that develops from a bud to bear leaves—either full-sized or rudimentary—and buds. Stems have swellings at certain points called nodes. A node is the point on a stem where a leaf is or was attached. The area between nodes is termed the internode. Stems usually grow upward to the light but may grow underground (rhizomes).

The functions of stems are to support and display leaves, fruit, and flowers; to carry water and nutrients from the roots to the leaves; and to carry food produced by the green parts back to the roots. In plants that lack leaves, such as cacti, all food is produced in the green stem. Stems may be annual, biennial, or perennial, although some plants with perennial roots have annual stems.

Stems may be adapted for food storage, such as tubers, corms, bulbs, or rhizomes. They may also be specialized as runners, tendrils, or thorns. The tendrils of grapes and Virginia creeper are modified stems. (Keep in mind that in some species tendrils may be modified leaves.)
• Rhizomes—prostrate, usually thickened, underground stems, with leaves coming from one side and roots from the other, such as canna, and some begonias.

• Stolons—slender, modified stems growing along the surface of the ground and rooting at the nodes, as in strawberry and St. Augustine grass.

Chapter 4: Food Reservoirs

Many plants accumulate food—sugars, starches, and other products—especially in fruits and seeds, and in modified roots and stems.

Fruits of various types (see Chapter 9) serve as food reservoirs. Examples are apples, cherries, mangos, squash, as well as the one-seeded dry fruits of grains such as wheat and corn.

Seeds of such plants as English pea also serve as food reservoirs.

Roots accumulate food, such as the taproot of carrots and the tuberous roots of sweet potatoes and cassava. These root tubers do not have buds or “eyes,” but may produce adventitious buds that become stems.

Stems may be adapted as food reservoirs, as in the following examples:

• Stem Tubers usually grow underground but have buds or “eyes” from which spring new stems, such as in Irish potato or caladium.

• Corms are solid masses of stem tissue. They are actually a condensed stem with a bud on top from which the new stem grows. Gladiolus is an example of a corm.

• Cormels are small corms that form around the base of a larger corm.

• Bulbs are compressed stems containing a growing point (bud) or flower bud enclosed by thick, fleshy scale leaves. Bulbs such as amaryllis and onion are called tunicate bulbs because they are protected from drying and mechanical injury by dry and membranous outer scales called a tunic.
• Other bulbs such as Easter lily are called **non-tunicate** or **scaly** because their outer scales are succulent and separate.

• **Bulblets** are small bulbs growing from the main bulb, such as in amaryllis.

• **Bulbils** grow on the stem in the axils of leaves or bracts. They may be small bulbs, as in some lilies, or leafy appendages, as in red ginger and daylilies. Bulbils may be used for propagation.

• **Rhizomes** can be a food reservoir and an easy means of propagation by division. Examples are heliconia, switch cane, and Resurrection fern.

---

**Chapter 5: Leaves**

**Evergreen** plants have foliage that remains functional through more than one growing season, whereas **deciduous** plants shed all or nearly all their foliage each year. A typical **leaf** consists of two principal parts: the expanded **leaf blade** or **lamina**, and the slender **petiole** or **leaf stalk**. Frequently there are outgrowths at the base of the petiole known as **stipules**, which may be leaf-like, spines, or glands. In dicots and some gymnosperms, the leaf blade is a thin sheet of green tissue strengthened by the midrib and veins. There are three main types of venation in leaves:

• **Parallel venation**—the veins run parallel to each other. This condition is characteristic of monocots. Parallel veins may run lengthwise on the leaf, as in lilies, or they may be parallel but directed outward from the midrib to the margin (penni-parallel).

• **Pinnate venation**—leaves have a single primary vein or midrib, from which smaller veins branch off, like the divisions of a feather. Examples are loquat and camellia.

• **Palmate venation**—leaves have several principal veins radiating from the base of the leaf blade (like the palm of your hand), as in red maple and papaya.

**Leaf Forms**

**Linear**—narrow, several times longer than wide, and essentially of the same width throughout.

**Lanceolate**—much longer than wide and tapering towards the apex from a broader base.
**Oblanceolate**—much longer than wide, tapering towards the base instead of the apex (the opposite of lanceolate).

**Oblong**—nearly twice as long as broad, with the sides nearly parallel or parallel most of their length.

**Elliptic**—oblong, broadest in the middle with the two ends narrowing.

**Ovate**—egg-shaped, with the broadest part near the base.

**Obovate**—opposite of ovate, with the narrower part near the base.

**Cuneate**—wedge-shaped, broad at the tip and tapering by nearly straight lines to an acute angle at the base.

**Spatulate**—oblong but tapering to a narrow base; spoon-shaped.

**Sagittate**—arrow-shaped; lobes at base acute and pointing downward, while the main body tapers upward to a point.

**Leaf Bases**

**Cordate**—heart-shaped.

**Reniform**—kidney-shaped, like cordate, but rounder and broader than long.

**Auriculate**—a small pair of projections, or ears, usually at the base.

**Hastate**—spear-shaped; lobes at base pointed and narrow and nearly at right angles to petiole.

**Oblique**—slanting, unequal-sided.

**Leaf Tips**

**Acuminate**—prolonged into a narrowed or tapering point.

**Acute**—ending in an acute angle, but not a prolonged point.

**Obtuse**—blunt or rounded apex.

**Truncate**—square end that looks cut off.
**Emarginate**—indented or notched.

**Obcordate**—inversely heart-shaped; an obovate leaf that is much more deeply notched at the tip.

**Cuspidate**—tipped with an elongated sharp or rigid point.

**Mucronate**—abruptly tipped with a small, short point, like a mere projection of the midrib.

---

**Leaf Edges/Margins**

**Entire**—even line, without teeth, notches, or lobes.

**Serrate**—cut into sharp, saw-like teeth pointing forward.

**Dentate**—toothed; teeth point outward instead of forward and are large.

**Crenate**—teeth are short and rounded; also called scalloped.

**Undulate**—margin of the leaf forms a wavy line, bending slightly inward and outward in succession.

**Sinuate**—like undulate, margin is very wavy (sinuous).

**Incised**—cut into sharp, deep, and irregular teeth or incisions.

**Lobed**—incisions do not extend deeper than halfway between the margin and the center of the blade and are rounded.

**Cleft**—incisions extend more than halfway between the margin and the center of the blade, and are sharper.

**Deeply Lobed**—incisions are even deeper, but not quite to the midrib or base of the blade.

---

**Leaf Divisions**

**Simple**—blade is of one piece, as in camellia. It may still be simple and lobed or cleft, as in red maple.

**Compound**—blade is made up of a number of separate leaflets. The two principal types of compound leaves are pinnate and palmate:

**Pinnate**—leaflets or pinnae are arranged on the sides of the main leaf stalk. Examples are Boston sword fern, royal palm, and coontie.

- **Odd Pinnate**—pinnate with an odd number of leaflets; has an end leaflet. Examples are Brazilian pepper and golden rain tree.
• **Even Pinnate**—pinnate with an even number of leaflets; no end leaflet. Examples are candle bush cassia/senna and tamarind.

![Even Pinnate](image1)

• **Bipinnate**—leaflets are twice pinnate (the primary pinnae or leaflets are again divided into secondary leaflets such as mimosa and jacaranda.

![Bipinnate](image2)

• **Palmate**—the leaflets are attached directly to the end of the petiole and extend outward much like fingers in a palm. Examples are schefflera and Virginia creeper.

![Palmate](image3)

---

**Leaf Arrangements on Stem**

• **Alternate**—one leaf at each node, as in hibiscus and citrus.

![Alternate](image4)

• **Opposite**—two leaves at each node, always on opposite sides of the stem. Examples are ixora and sweet viburnum.

![Opposite](image5)

• **Whorled**—more than two leaves at a node spaced around the stem, as in oleander and macadamia.

![Whorled](image6)

---

**Leaf Attachments**

• **Petiolate**—petiole (leaf stalk) is present, examples are hibiscus and oaks.

![Petiolate](image7)

• **Sessile**—petiole (leaf stalk) is absent, leaf is attached directly to the main stem or branch, as in podocarpus and gloriosa lily.

![Sessile](image8)

• **Peltate**—petiole attached to the lower surface of the leaf instead of at the base or margin, as in nasturtium.

![Peltate](image9)
**Clasping**—leaf partially encircles the stem, as in calendula.

**Sheathing**—base of the leaf is wrapped around the stem like a grass leaf, as in corn and ginger.

**Decurrent**—leaf base extends downward to form a wing or ridge along the stem, as in guava.

**Winged petiole**—petiole has a leaf-like or membrane-like extension along its length, as in grapefruit.

**Winged rachis**—compound leaf stem with a membrane-like extension on both sides of the rachis winged sumac.

**Stipule Types**

**Simple**—stipules located on the sides of the petiole, as in hibiscus.

**Adnate**—stipules that adhere to the sides of the petiole, as in rose.

**Leafy**—green, leaf-like stipules that serve as foliage, as in pea and royal poinciana.

**Other Leaf Types**

**Needle-shaped leaves**—such as those in pine.

**Needle-like leaves**—margin of the leaf is so strongly rolled backward that the leaf appears tubular, such as in rosemary.

**Awl-shaped and scale-like leaves**—very reduced leaves, as in arbor vitae, pond cypress, and adult foliage of Eastern red cedar.

**Leaf Textures**

**Succulent**—juicy, fleshy, soft, and thickened in texture.

**Scabrous**—rough to the touch; texture of sandpaper.

**Coriaceous**—leather-like, tough.

**Smooth** (glabrous)—surface is not hairy, rough, pubescent, or scabrous.

**Downy**—covered with very short, weak, and soft hairs.

**Pubescent**—hairy.

**Canescent**—covered with gray or white soft hairs as in Texas sage.
Tomentose—covered with matted, woolly hairs.

Hirsute—pubescent with coarse, stiff hairs.

Hispid—rough with bristles, stiff hairs, or minute spines.

Chapter 6: Flower Branches, Clusters, and Inflorescences

Single Flower—one flower held at the end of an elongated stalk or branch of the main axis of the plant, as in tulip and southern magnolia. The peduncle is the stalk that bears a single flower or a cluster of flowers. The pedicel is the stalk of an individual flower in a cluster.

Cluster—three or more flowers gathered closely together in simple or branched groups to increase their conspicuousness, such as in pentas and pyracantha (firethorn).

Inflorescence—general term for the arrangement of flowers on a plant. There is great diversity in this arrangement among different types of plants, but they generally remain characteristic for a particular type and may be useful in identifying species. There are two main types of inflorescences, racemose and cymose, and each is further subdivided.

- Racemose Inflorescences—the axis of the inflorescence is indeterminate (continues to grow). The flowers are borne in the axes of the reduced leaves or bracts, with the oldest flowers at the base and the newest flowers near the growing tip.
- Raceme—flowers on short pedicels of about equal length along the main axis, as in snapdragon.
- Panicle—compound raceme (the branches have branches), with individual flowers replaced by simple racemes, as in crapemyrtle.
- Spike—like a raceme, but flowers lack pedicels and are sessile or almost sessile. Examples are copperleaf and bottlebrush.
- Spadix—type of spike; a fleshy axis bearing the sessile, generally fleshy flowers close together, commonly surrounded and partially enclosed by a spathe. Examples are peace lily and anthurium.
- **Catkin**—spike that normally produces only staminate or pistillate flowers (see next chapter), and at maturity falls away as a unit. Examples are river birch and oaks.

- **Corymb**—pedicels of older flowers longer than those of younger flowers, which bring all of them to nearly the same level. Pedicels come from different points on the main peduncle, giving the inflorescence a rather flat-topped or convex look with the outside flowers opening first. An example is ixora.

- **Umbel**—pedicels appear to arise from a common point (like an umbrella). This gives the inflorescence a knob-like look. The outer flowers open first. Examples are dill and crinum lily.

- **Head**—similar to umbels, but sessile flowers are very close together. Heads may be globular or almost spherical as in clover. What popularly passes for a “flower” in the Composite/Aster family is really an inflorescence with many small, true flowers. For example, in sunflower, ray flowers form a fringe of radiating irregular, asymmetrical flowers that often resemble petals (see chapter 8) on the edge of the head. Disk flowers cover the remainder of the head and are regular, symmetrical, and usually less showy. Heads may also have flowers that are all irregular with no differentiation into rays and disks.

- **Involucre**—not an inflorescence per se; rather it is a (often conspicuous) cluster or whorl of bracts or leaves directly under a flower or a cluster of flowers. They are often found under umbels and heads. Examples are sunflower and the cups of acorns in oak.

**Cymose Inflorescences**—Upward growth of the floral axis is stopped early by the development of a terminal flower. The first flower to open (the oldest) is at the tip; with younger flowers appearing lower down on the axis. The floral axis ceases to elongate after the first flower opens and is, therefore, a determinate inflorescence.

- **Cyme**—one terminal flower and two or more side flowers coming from the end of the axis. An example is frangipani.

- **Scorpioid cyme**—floral axis curves over, carrying the flowers along the top of the curve, as in heliotrope.
• **Fascicle**—flowers are very closely crowded on almost the same plane (in a tight bundle or group), as in dianthus/Sweet William.

![Fascicle Diagram](image)

**Flower Positions**

**Terminal**—flowers or clusters of flowers are carried on the ends of the axis or branches, as in southern magnolia and oleander.

![Terminal Diagram](image)

**Axillary**—a flower or clusters of flowers arise at the junction of the stem and the leaf, as in beautyberry.

![Axillary Diagram](image)

Some plants, such as ixora, have both terminal and axillary flowers.

**Chapter 7: Flower Parts**

A flower is the reproductive structure of some seed-bearing plants (angiosperms). The great variety of forms acts as a guide in separating flowering plants into major groups. Before we look at the different classifications of flowers, we must first learn the terms for the individual structures in the flower.

**Accessory Organs**

The following are known as accessory organs because they are not directly involved in pollination.

**Calyx**—the ring of sepals making up the outermost, leaf-like part of the flower. Sepals are commonly green, but may be almost any color and serve primarily as protection for the other floral parts.

**Corolla**—the inner set of leaf-like parts lying just within the calyx and composed of petals. Petals are generally white or brightly colored to attract pollinating insects to their nectar. They also serve as protection for the innermost organs.

**Perianth**—the outer floral parts, composed of the calyx and the corolla.

![Perianth Diagram](image)

**Tepal**—used when a calyx and corolla are very similar and not easily distinguished, as in pine lily.

**Receptacle or torus**—the apex of the pedicel upon which the organs of a flower are developed.

![Receptacle Diagram](image)

**Floral Bracts**—modified leaves that can simulate petals and add a conspicuous part to otherwise inconspicuous flowers. Examples are the red bracts surrounding the small poinsettia flowers; the purple, red, or white leaves enclosing the small white flowers of bougainvillea; or the white leaves of flowering dogwood. Many plants have floral bracts that are not colorful, such as silver nerve plant.
Reproductive Organs

Reproductive organs are directly involved in pollination and fertilization; hence, their presence usually determines the survival of the species.

- **Stamen**—male reproductive organ consisting of an anther and a filament attached to the receptacle inside the corolla or to the corolla itself.

- **Filament**—thin stalk that attaches the anther to the rest of the flower. Its attachment is called **basal** if it is at the lower end of the anther (as in tulip) and **versatile** if it is lateral, near the center of the anther (as in crinum lily).

- **Anther**—lobed, oblong, bag-like appendage at the top of the filament that produces the pollen grains that develop the male germ cells. Anthers are usually yellow and when young have from one to four cavities (cells) in which pollen grains arise. When mature, the anther usually contains two cavities from which the pollen grains are released by the formation of apical pores or longitudinal slits in the cavity wall.

- **Pollen Grains**—usually appear as tiny specks barely visible to the unaided eye, but are produced in such quantity that they often form a layer of powder. Each grain is usually two-celled, spherical, ovoid, or disk-like in appearance, its surface marked with ridges, spines, and germ spores. Pollen grains, collectively known as pollen, are so characteristic of the different species that they are used for identification purposes.

Stamens are called **opposite** when they are opposite to the petals, as in muscadine grape, and **alternate** when they alternate with the petals, as in garden violet. The stamens are usually free or separate from each other, but in a few families they are united either by their filaments (hibiscus and tomato) or by their anthers, as in sunflower.

- **Pistil**—female reproductive organs composed of a stigma, style, and ovary. Flowers may have just one simple pistil—sweet pea—or two, three, four, five, or more separate pistils—as in larkspur. It (they) usually occurs in the very center of the flower and are often surrounded by the stamens, petals, and sepals. A **carpel** refers to either a simple pistil or one of the segments of a compound pistil. United carpels are found in African iris and snapdragon. Pistils are usually flask- or bottle-shaped.

- **Stigma**—the tip of the pistil especially adapted to receive the pollen grains. The stigma may be expanded into a bulb or disk or divided into two or more slender parts. The stigma is often located atop a style.

- **Style**—the elongated stalk or neck connecting the stigma with the ovary.

Ovary—enlarged, bulbous, basal part of the pistil that bears the **ovules** (the egg-containing units that, after fertilization, become the seeds) attached either to its central axis or to its inner wall. The tissue to which the ovules are attached is called the placenta. Each ovule usually contains one **egg**, the female gamete or sex cell. The ovule normally develops into a seed when fertilized. Generally there are two or more ovules per carpel. In some plants, only one may mature into a seed. The ovary normally develops into a fruit containing seeds. An example is the pod of lima bean. A pistil is said...
to be compound when several or many carpels become united. Carpels are united so that a compound ovary often contains as many cavities as there are carpels. In some flowers a compound ovary becomes “one-celled” by the disappearance of the partitions between the different carpels as in primrose. Union of carpels may be so complete that it includes the styles and stigmas as well as the ovaries.

Below are the different classifications of flowers according to the presence or absence of their parts:

- **Complete** flowers are made up of calyx, corolla, stamens, and a pistil or pistils (the four “regular parts”).
- **Incomplete** flowers lack one or more of the four regular parts of a complete flower, as in the oak, birch, and walnut families.
- **Perfect** flowers have both stamens and pistils, but not necessarily sepals or petals.
- **Imperfect** flowers lack either stamens or pistils, and may or may not have sepals or petals.
- **Naked** flowers are without petals (apetalous) or sepals (asepalous), as in calla lily.

Three terms are applied to plants based on their flowering characteristics:

- **Monoecious** plants bear both staminate and pistillate flowers on the same plant, as in oak) and corn.
- **Dioecious** plants bear staminate flowers on one plant and pistillate flowers on a different plant, hence the terms male and female plants. Hollies and all cycads and many conifers are examples.
- **Polygamous** plants bear staminate, pistillate, and hermaphroditic (bisexual—both sexes present and functional in the same flower) flowers on the same plant. An example is red maple.

**Chapter 8: Flower Forms**

Even a casual glance at the flowers in your garden will convince you of their diversity of form. This characteristic diversity in flower forms is a very important factor in plant identification. We have seen in Chapter 7 that flowers vary in the number of their floral parts, but they also vary in other ways relative to their parts:

1. Variations in the degree to which floral parts are united

- **Gamopetalous**—petals united to form a tubular or rotate corolla with the united part known as the tube and the spreading or flat part known as the limb. These flowers take different forms as:
  - **Funnel-form**—the tube gradually widens upward and flares into the limb without any particular point of demarcation. Examples include oleander and bush morning-glory
• **Rotate**—the tube is short and the limb is flat and circular, as in tomato and elderberry.

• **Urn-shape (urceolate)**—broad tube and slightly recurved, short limb, as in blueberry.

• **Salver-form**—slender tube and an abruptly widened, flat limb. Annual phlox and vinca/periwinkle are examples.

• **Gamosepalous**—flower with united sepals. Vinca/periwinkle and hibiscus are examples.

• **Polypetalous**—petals of corolla composed of separate parts. Southern magnolia, camellia, and rose are examples.

2. Variations in placement of floral parts on the receptacle

• **Hypogynous (hi-po’ji-nus)**—sepals, petals, and stamens are attached to a convex or conical receptacle at the base of the ovary. Sepals are arranged in the outermost or lowest layer, followed by petals and stamens, with carpels or ovary innermost. The ovary is called **superior** and the perianth is **inferior** or hypogynous. Tomato is an example.

• **Perigynous (pe-rij’i-nus)**—sepals, petals, and sometimes stamens borne on the edge or margin of the receptacle so that they appear to form a cup around the pistil. Peach is an example.

• **Epigynous (e-pij’i-nus)**—sepals, petals, and stamens appear to arise from the top of the ovary. The concave receptacle not only surrounds the ovary, but is fused with it. In this case, the ovary is called **inferior** and the perianth is called **superior** or epigynous. Apple is an example.

3. Variations in the number of subdivisions of each of the four regular parts

The number of sepals and petals is three (or multiples of three), as in monocots, four or five of each in the dicots, and reduced to none in some plants.

There is a large and indefinite number of stamens in many flower types, but in some there is a definite number, often the same as or twice the number of petals, or even further reduced to one or two.

Some flowers have a large number of separate pistils, but in others they are more or less united to form a compound pistil, and in many there is just one simple pistil.

4. Variations in the symmetry of flower forms

• **Regular or Actinomorphic (ak’ti-no-mor’fik)**—floral parts, especially the corolla, are arranged symmetrically so that when quartered all sections are equal. Rose and camellia are examples.
• **Irregular or Zygomorphic** (zi'go-mor'fik)—floral parts are not arranged symmetrically, and when divided horizontally the two parts are unequal and dissimilar. There are three types of irregular flowers:

• **Papilionaceous** (Peas or beans)—Flowers consist of five petals of three distinct types. Types are 1) **Standard or Banner**—large petal in the uppermost part or back of the flower. 2) **Keel**—two usually narrow and elongated petals in front of and usually below the standard. 3) **Wings**—two petals placed to the right and left of the keel and more or less clasping the keel.

• **Labiate** (Mints)—tube of corolla usually deeply split into two irregular lobes, the upper lobe erect and made up of two petals, and the lower lobe spreading or open and composed of three petals. **Bilabiate** means two-lipped or double-lipped corolla. Salvia and snapdragon are examples.

• **Orchidaceous** (Orchids)—three sepals and three petals, with one petal, usually the lower one, modified to form a distinctive lip. Stamens are reduced and united with the pistil to form the **column**.

**Dry fruits** are generally dull in color and have a very thin and dry ovary wall, so that the food is largely confined to the seeds. These may be further subdivided based on the number of seeds and whether the fruit remains closed at maturity **(indehiscent)** or opens naturally **(dehiscent)**.

• **Achene**—small, hard, indehiscent, one-cavitied, one-seeded fruit with a thin, almost inseparable wall, as in sunflower.

- **Samara**—indehiscent, one or two-seeded winged fruit, as in red maple.

- **Nuts**—hard-shelled, usually one-seeded, indehiscent fruits, such as black walnut or pecan.

- **Grain or Caryopsis**—one-seeded, indehiscent fruit of most grasses, including the cereals. The enclosed seed is almost inseparable from the enveloping ovary wall. This fruit is little more than a seed for all practical purposes.

- **Capsule**—dehiscent fruit composed of two or more carpels, generally with several or many seeds in each carpel, as in cotton.

- **Silique**—several-seeded fruit with two carpels that pull away from the central partition at maturity, as in mustard.

**Chapter 9: Fruits and Seeds**

Fruits are the ripened and seed-bearing ovaries of flowers. Fruits are nearly as varied in color, form, size, texture, and number as are flowers, making them valuable tools in plant identification.

**Fruits**

Botanists use the term “fruit” in a much broader way than does the layperson. Fruits are divided into two large categories: **dry fruits** and **fleshy fruits**.
• **Silicle**—a silique that is wider than long, such as in peppergrass.

![Silique](image)

• **Legume**—pod formed from a simple pistil, dehiscent along both sides, as seen in pea.

• **Follicle**—several-seeded fruit formed from a single carpel and splitting open along one side only. There may be two or more follicles produced by each flower, as in milkweed.

• **Pepo**—berry-like fruit of large size, with a tough or very firm and hard outer wall (rind) that is developed from the receptacle, such as watermelon, cucumber, and squash.

• **Hesperidium**—berry-like fruit of citrus with a thick rind with numerous oil glands, and an interior fleshy part composed of wedge-shaped compartments, with or without seeds.

• **Pome**—fruit developed largely from the receptacle that surrounds the carpels or inedible core parts, as in apple.

• **Aggregate**—fleshy fruit developed from the ovaries of a single flower, which becomes enlarged and bears many simple, true fruits as in strawberry.

• **Multiple**—fruits derived from many closely clustered flowers, such as in mulberry and pineapple.

### Fleshy Fruits

Fleshy Fruits are usually juicy and brightly colored to make them more noticeable to the animals that eat and disperse them. All fleshy fruits are indehiscent, and considerable fleshy tissue is developed as the ovary changes into the fruit.

• **Drupe**—“stone fruit”, a simple fruit produced from a single carpel, usually one-seeded, with an outer fleshy layer of tissue called the **pericarp** and an inner, heavy stony layer called the **endocarp**. Examples are peach, coconut, mango, and olive.

• **Berry**—one or more carpels developed within a thin covering, very fleshy within, with the seeds embedded in the common flesh of a single ovary, such as tomato and blueberry.

Seeds

Seeds consist of an outer coat or wall, which is usually very tough, hard, or woody, within which are cotyledons and the embryo. Seeds normally have just one embryo, but sometimes have more than one, like citrus, which results in two or more new plants growing from one seed. Seeds are developed as a result of the fertilization of the egg in the ovule of the ovary of a flower. Typically, seeds are oval or globular and range in size from dust-like orchid seeds to the large seed of the avocado, with some plants bearing seeds of even greater size, such as coconut. Seeds vary greatly in color, texture, longevity, and methods of dispersal. Some of the modifications of seeds that aid in dispersal are coverings of spines, hooks, bristles, cotton, or plumes, or having wings and arils. They also vary in the types and abundance of food they contain. Gymnosperms produce seeds but not true fruits since they have no ovary; such seeds are said to be naked and are borne on the inside of the scales or cones, but in plants such as junipers and podocarpus they are embedded in a fleshy fruit-like organ, known as an aril.

### Publication History and Acknowledgements

**Previous Versions**


This handbook was originally published in 1965 by the Florida Department of Agriculture and Consumer Services and the Florida Federation of Garden Clubs, Inc. The original text was by Nancy A. Knox and Ethel McSwiney. Drawings by Edith L. Alexander, Elizabeth Calerdine, Irma
Gall, Sylvia Milks and Gertrude Wilson from her “Outline of Analytical Botany.”


Includes new introduction, extensive revisions to text, and new illustrations by Suzanne McCullough, an illustrator in the Department of Ornamental Horticulture at the University of Florida, Gainesville, Florida.

The editor gratefully acknowledges the following University of Florida faculty for their assistance in reviewing the original IFAS publication: Dr. Robert J. Black, emeritus associate professor, and urban horticulturist; Dr. David Hall, former associate in natural sciences and botanist; and Dr. Bijan Dehgan, emeritus professor, woody ornamentals. Appreciation is also extended to Dr. Nancy Coile, botanist, Florida Department of Agriculture and Consumer Services, Gainesville, FL.
