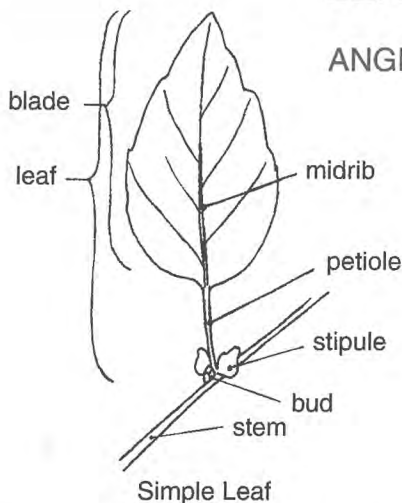


PLANT MORPHOLOGY

In order to successfully identify woody plants it is necessary for an individual to have a keen awareness (working knowledge) of taxonomic terminology and concise mental pictures of leaf, bud, stem, flower and fruit morphology. The glossary in the back of the text capably defines the terminology. This section is devoted to line drawings of woody plant morphological characters which will aid in the identification of various plant types. Definitions and examples are also included.

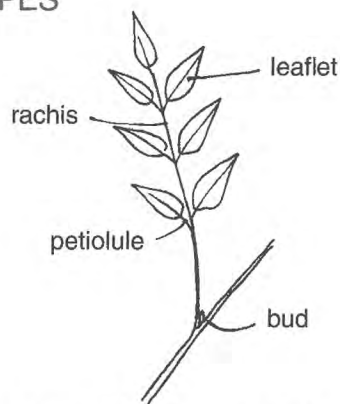
LEAF MORPHOLOGY

ANGIOSPERM LEAF TYPES



Simple Leaf

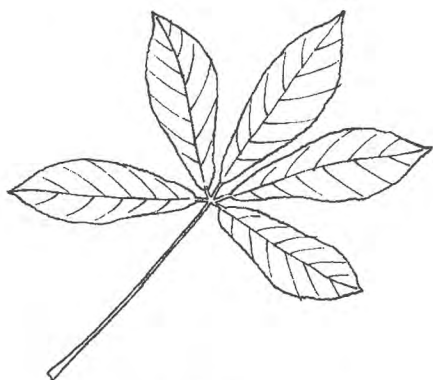
The position of the bud determines whether the leaf is simple or compound. In this case the bud is located in the axil of a single leaf and the stem, therefore, the leaf is classified as simple. Ex: *Acer* (primarily), *Betula*, *Cornus*, *Fagus*, *Quercus*, *Ulmus*.



Pinnately Compound Leaf

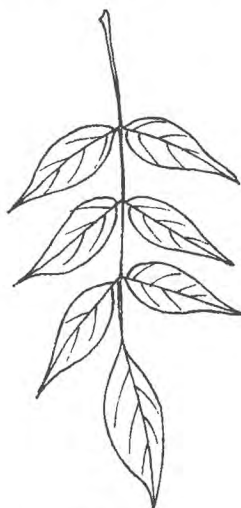
In this case the bud is located in the axil of a structure with more than one leaf (leaflet) attached, therefore, the leaf is termed compound. Compound leaves are composed of anywhere from three (*Acer griseum*) to 400 to 1500 leaf-like structures in the case of *Albizia julibrissin*.

OTHER TYPES OF COMPOUND LEAVES



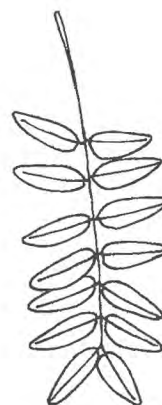
Palmately Compound

In this situation each leaflet is attached to a common point. Ex: *Aesculus*, *Akebia quinata*, *Eleutherococcus*, *Parthenocissus quinquefolia*.



Odd Pinnate

A compound pinnate type of leaf with an odd number of leaflets. Ex: *Acer negundo* has 3 to 5 leaflets; *Cladrastis kentukea* has 7 to 9 leaflets; *Fraxinus americana* has 5 to 9 leaflets; *Rhus glabra* has 11 to 31 leaflets.



Even Pinnate

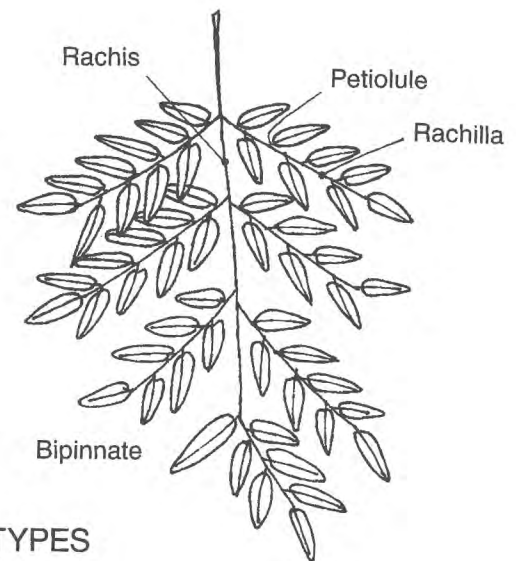
A compound pinnate type of leaf with an even number of leaflets. Ex: *Gleditsia*, *Caragana*, *Pistacia chinensis*, *Sapindus drummondii*.

Bipinnately Compound

Bipinnately compound leaves are twice divided. What was considered the leaflet of the pinnately compound leaf is now another leaf-bearing axis to which additional leaflets are attached. The new leaf bearing axes are referred to as pinnae. Each pinna has a certain number of leaflets. Ex: *Albizia*, *Aralia* (bi- and tripinnately compound), *Gleditsia* (in certain instances), *Gymnocladus*.

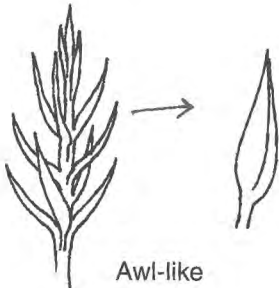
Tripinnately Compound

Tripinnately compound leaves are thrice divided with the leaflet of the bipinnately compound leaf becoming a stalk to which leaflets are attached. Ex: *Nandina domestica*.



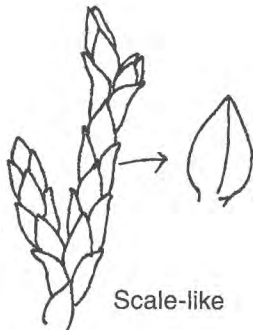
GYMNOSPERM LEAF TYPES

Cone-bearing or naked seeded plants often display different leaf types than those associated with angiosperm plants. Not all conifers (or cone-bearers) have evergreen foliage (several exceptions include *Taxodium*, *Metasequoia*, *Larix*, and *Pseudolarix*.)



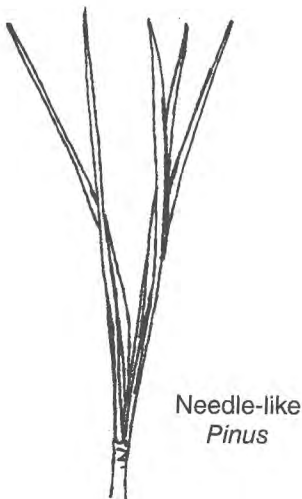
Awl-like

The needles (leaves) are shaped like an awl. They are usually very sharp to the touch. Many *Juniperus* (Junipers) exhibit awl-shaped foliage. This character is manifested in juvenile forms of juniper, however, there are many species and cultivars (*Juniperus communis*, *J. procumbens*, *J. chinensis* 'Pyramidalis' to name a few) which possess the awl-like or needle foliage in youth and old age.



Scale-like

Scale-like foliage overlaps like the shingles on a roof or the scales on a fish. This type of foliage is relatively soft to the touch. *Calocedrus*, *Chamaecyparis*, *Cupressus*, *Thuja*, and many *Juniperus* species exhibit this type of foliage.

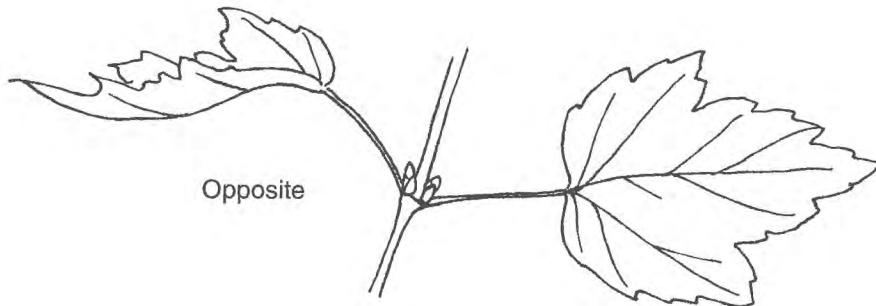


Needle-like
Pinus

Needle-like foliage is typical of several evergreen genera and species. The drawing depicts the foliage of a 5-needled pine. In the genus *Pinus* the leaves (needles) are usually contained in fascicles of 2, 3, 2 and 3, or 5. Other species such as *Abies*, *Cedrus*, *Picea*, *Pseudotsuga*, and *Taxus* have the needles borne singly or in clusters along the stem. The needles may be relatively flat (2-sided) or angular (often quadrangular) in cross-section. See the respective genera for a detailed discussion of their leaf morphology.

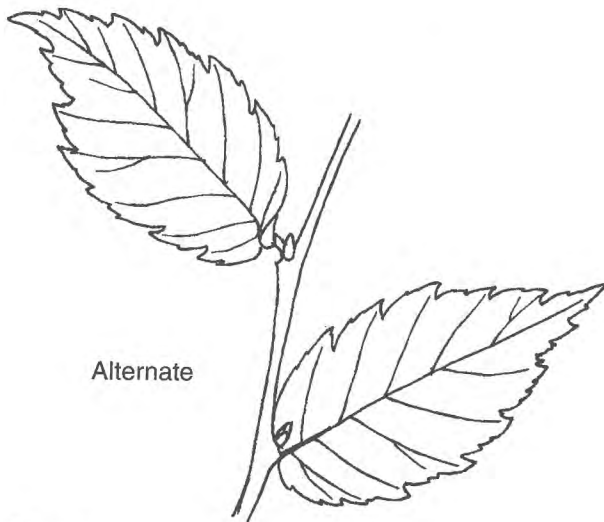
ARRANGEMENT OF LEAVES

Many vegetative keys employ the arrangement of leaves and buds as a basis for separation. Arrangement simply means the position of a leaf or bud in reference to another leaf or bud along the stem. The use of the four categories by the student allows him/her to categorize plants into groups and assists in eliminating many plants from consideration in the process of positive identification.



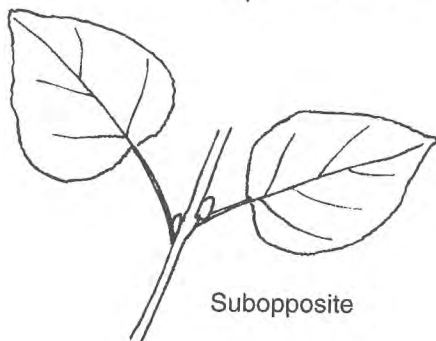
Opposite

Leaves and buds directly across from each other on the stem. Ex: *Acer*, *Aesculus*, *Cornus* (most), *Deutzia*, *Fraxinus*, *Lonicera*, *Phellodendron*, *Tetradium*, *Viburnum*.



Alternate

Leaves and buds are spaced in alternating fashion along the axis of the stem and seldom, if ever, are seated directly across from each other. Ex: *Betula*, *Carya*, *Celtis*, *Cercis*, *Fagus*, *Gleditsia*, *Gymnocladus*, *Juglans*, *Quercus*, *Robinia*, *Ulmus*.



Subopposite

Subopposite refers to a condition where the leaves and buds are not spaced sufficiently far apart to be considered alternate nor are they perfectly opposite, hence, the term subopposite. Ex: *Cercidiphyllum japonicum*, *Chionanthus retusus*, *Chionanthus virginicus*, *Rhamnus cathartica*.



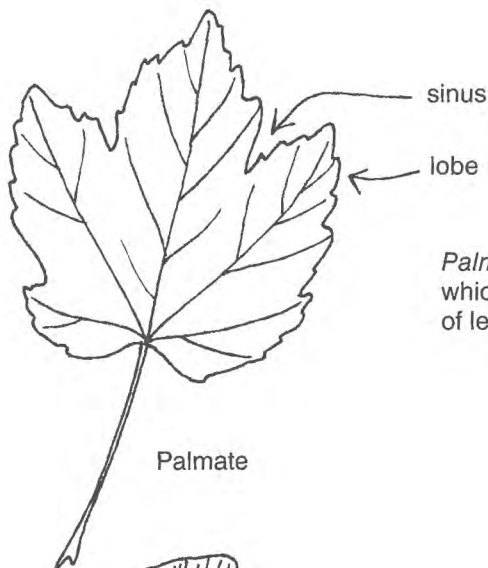
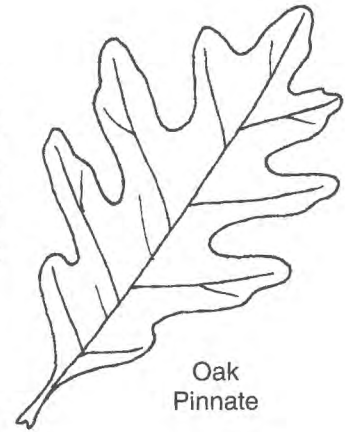
Whorled

Whorled refers to a condition when three buds and leaves (or more) are present at a node. Often, the more rapid the growth the more pronounced the whorled condition. Ex: *Catalpa*, *Cephalanthus occidentalis*, *Hydrangea paniculata* 'Grandiflora', *Nerium oleander*.

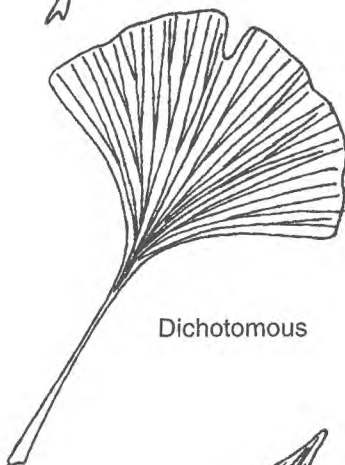
TYPES OF VENATION



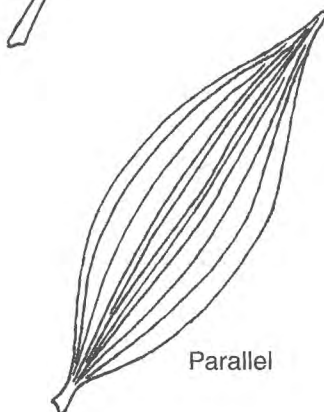
Pinnate. The leaf has a prominent central vein (often termed the midrib) which extends from the base, where the petiole attaches to the blade, to the apex of the leaf. If the interveinal areas were removed the overall effect would be that of a fishbone. Pinnate venation occurs in the leaves of many plant types. The Elm (*Ulmus*) and Oak (*Quercus*) are classic examples.



Palmate. There are several main veins all of approximately equal size which extend from the base of the leaf to the apex of the lobe or margin of leaf. Ex: *Acer*, *Cercis*, *Platanus*.



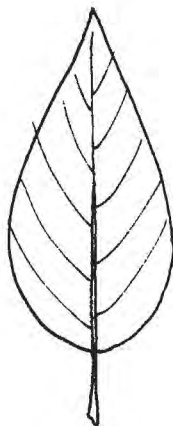
Dichotomous. A very limited type of venation, the most familiar representative of which is *Ginkgo biloba*. The basal veins extend for a distance and then branch forming a "Y" type pattern.



Parallel. Typical of many monocotyledonous plants. The veins run essentially parallel to each other along the long axis of the leaf. Ex: *Danae*, *Ruscus*.

LEAF SHAPES

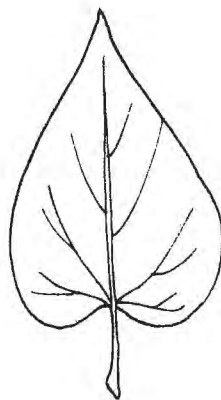
The tremendous quantity of terminology related to leaf shapes can be confusing. Association of the following pictures with the terms will help to alleviate the burden of strict terminology. This also applies to leaf bases, margins, and apices.



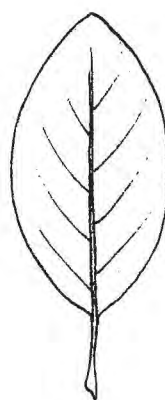
Lanceolate



Cordate



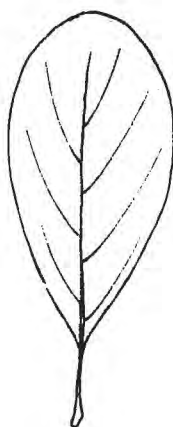
Elliptical



Spatulate



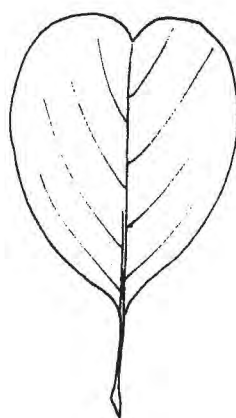
Ovate



Obovate



Oblanceolate



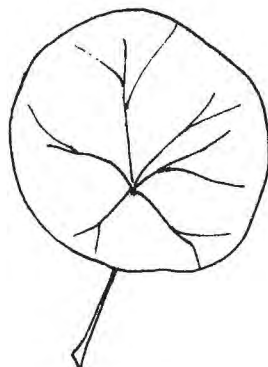
Obcordate



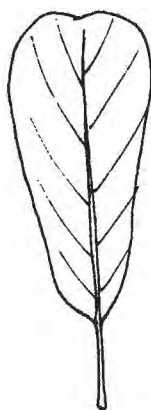
Oblong



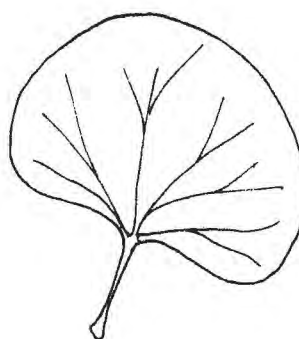
Linear



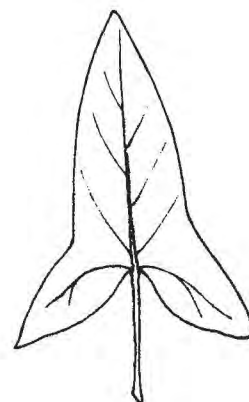
Peltate



Cuneate



Reniform



Hastate

LEAF BASES, MARGINS, APICES

BASES



Cuneate



Acute



Rounded



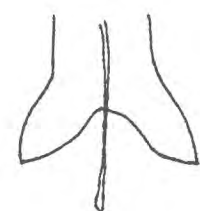
Cordate



Oblique



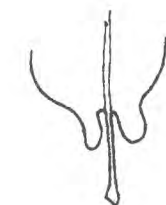
Sagittate



Hastate



Truncate

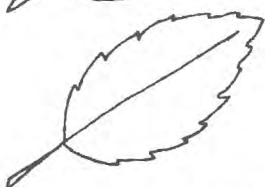


Auriculate

MARGINS



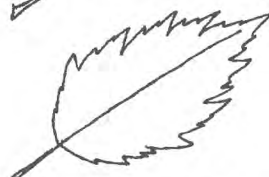
Entire



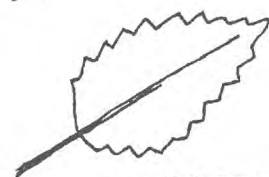
Serrate



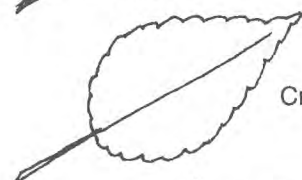
Serrulate



Doubly-Serrate



Dentate



Crenate



Incised



Sinuate



Undulate



Lobed

APICES



Acuminate



Acute



Obtuse



Truncate



Emarginate



Obcordate



Mucronate



Cuspidate

STEM AND BUD MORPHOLOGY

Deciduous woody plant identification in winter must be based on stem, bud and bark characters. Buds and stems offer the principal means of identification.

The shape, size, color, and texture of *buds* offer interesting identification characters. The large, sticky, mahogany brown bud of *Aesculus hippocastanum*, Common Horsechestnut, contrasts with the pubescent, soft-textured bud of *Magnolia x soulangeana*, Saucer Magnolia.

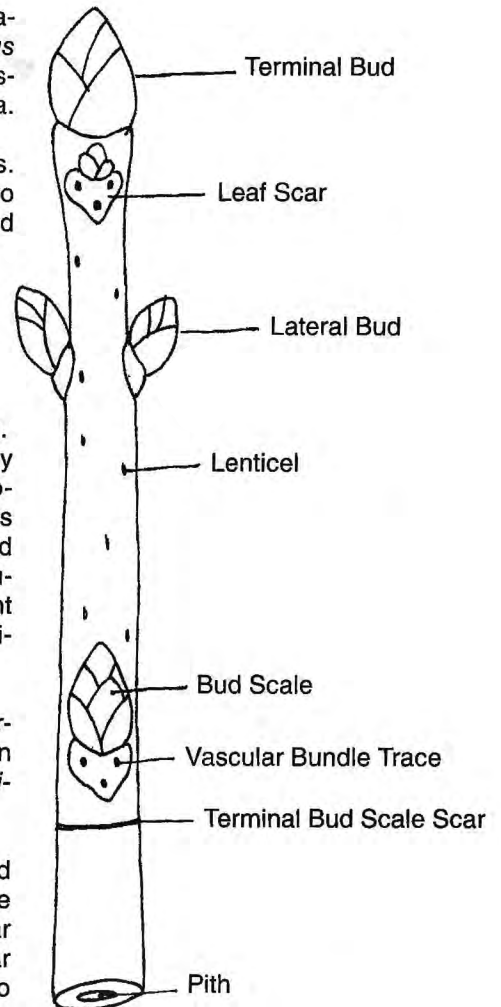
Leaf Scars often provide distinguishing identification characters. Both the shape and vascular bundle arrangement are often used to separate plants. *Fraxinus americana*, White Ash, can be separated from *F. pennsylvanica*, Green Ash, on the basis of leaf scar shape. The leaf scar of White Ash usually possesses a notch while the leaf scar of Green Ash is straight across. The leaf scar of *Aesculus pavia*, Red Buckeye, is flat across the top while that of *A. parviflora*, Bottlebrush Buckeye, is indented.

Lenticels are produced through the action of the cork cambium. Essentially they are lip-shaped structures composed of rather corky cells. Possibly they function in gas exchange between the atmosphere and the intercellular areas of the plant tissues. Lenticels are beneficial for identification as they possess different colors and sizes. *Rhamnus frangula*, Glossy Buckthorn, has whitish, rectangular, vertically arranged lenticels which offer a valid and consistent identification character. *Prunus*, cherry, species have elongated horizontal lenticels.

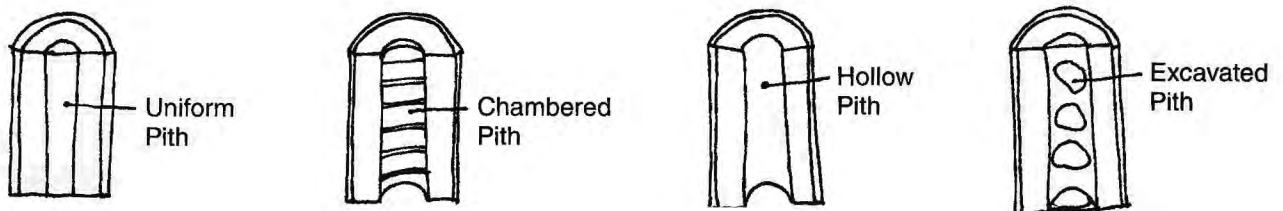
Bud Scales by their size, color, shape or markings offer good characters for identification. The scales of *Ostrya virginiana*, American Hophornbeam, are striately marked while those of *Carpinus caroliniana*, American Hornbeam, are smooth.

Terminal Bud Scale Scar is the place where the previous year's bud scales were attached. As the buds open and expand in Spring the scales abscise and leave a distinct scar around the stem. This scar can be useful for gauging the amount of linear growth in a particular season or over a number of seasons. The distance from the scar to the new terminal bud which is set in late summer and early fall represents the growth for that season.

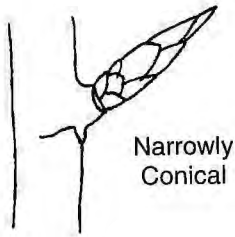
Pith is a very valuable plant tissue for separating closely related plants. Pith is derived from a primary meristem and is usually vestigial. The color and texture of pith can often be used for separating similar plant types. *Forsythia* types can be separated by the texture and arrangement of the pith. Several closely related *Cornus* species can be identified by pith color [*C. amomum* (brown) from *C. sanguinea* (white)].



SEVERAL TYPES OF PITH COMMON TO WOODY PLANTS



BUD TYPES FREQUENTLY FOUND IN WOODY PLANTS



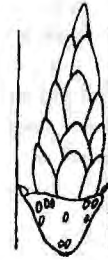
Narrowly
Conical

Beech



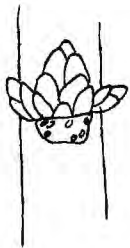
Ovoid

Chestnut



Conical

Chestnut Oak



Accessory

Scrub Oak



Superposed

Walnut



One-scaled

Willow



Stalked

Striped Maple



Outermost
scale centered
directly over
leaf scar

Aspen



Scales in
two ranks

Elm



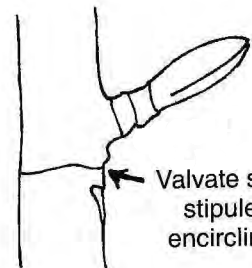
Striate
scales

Hophornbeam



Rounded

White Ash



Valvate showing
stipule scar
encircling twig

Tuliptree

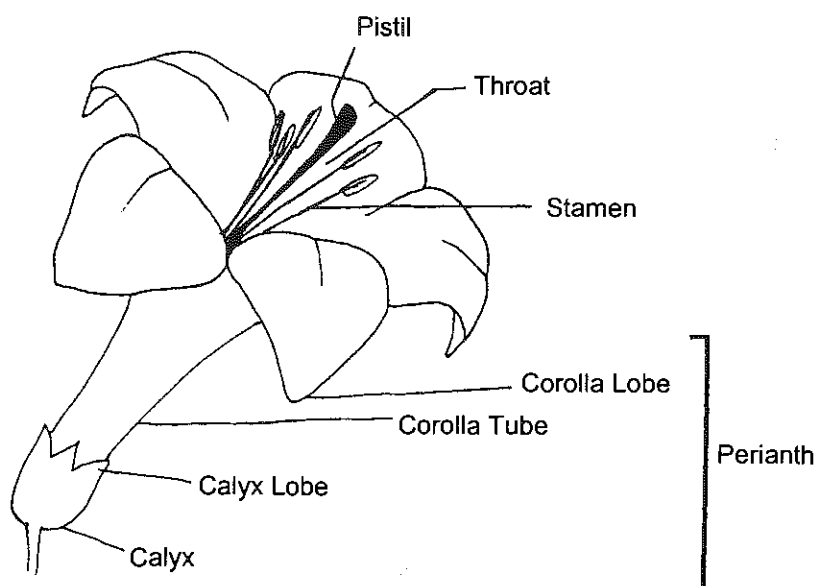
FLORAL MORPHOLOGY

Flowers are important components of most botanical keys and the positive identification of various plants is based on some aspect of floral morphology. This approach is acceptable but only allows for positive identification a short period of the year (the flowering periods of most woody plants would average seven to fourteen days). The homeowner, nurseryman, student, and interested plantsman often wish or are required to identify plants the year-round and the use of features other than flowers is a must. If there is significant doubt about a certain plant the most logical approach is to wait for flowers and then consult a reputable text such as Rehder's, Bailey's, Bean's, or Krüssmann's great taxonomic works.

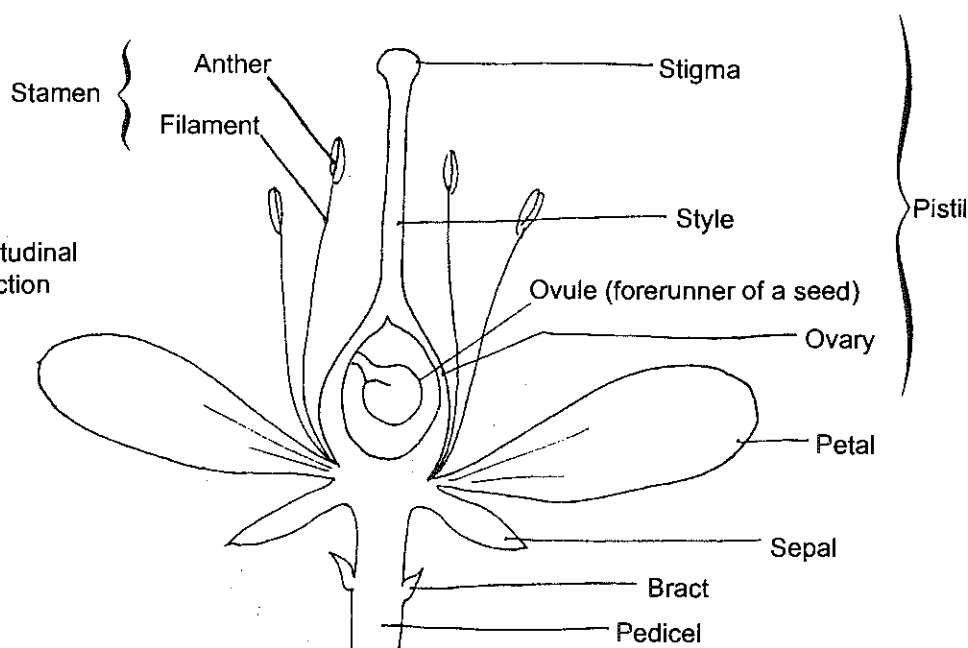
The following diagrams are representative of a "typical" angiosperm flower. There are numerous variations in flower shape but the reproductive parts, i.e., stamens (male, staminate) and pistils (female, pistillate) are essentially similar.

SIMPLE FLOWER STRUCTURE

Overview



Longitudinal Section



Flowers which have all the parts (sepals, petals, stamens, and a pistil or pistils) are termed *complete*. *Incomplete* flowers lack one or more whorls of floral parts such as the petals. *Imperfect* flowers lack either stamens or pistils. *Perfect* flowers have both stamens and pistils. *Monoecious* means that staminate and pistillate flowers are present on the same plant but in different structures (*Betula*, *Carpinus*, *Carya*, *Fagus*, *Ostrya*, *Quercus*,). *Dioecious* means the staminate and pistillate flowers are borne on different plants (*Cercidiphyllum*, *Gymnocladus dioica*, *Ilex*, and *Lindera*). *Polygamo-monoecious* refers to a condition where perfect, pistillate, and staminate flowers occur on the same tree. *Polygamo-dioecious* implies perfect and pistillate flowers on the same plant or perfect and staminate flowers. Several woody plants which show polygamous characters include *Chionanthus*, *Fraxinus*, *Gleditsia*, *Morus*, *Osmanthus*.

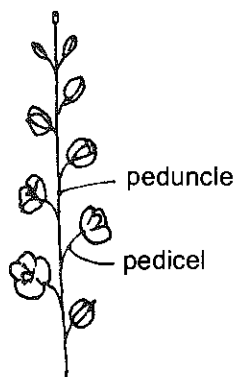
INFLORESCENCES

Flowers are borne on structures which are referred to as inflorescences. An inflorescence is a collection of individual flowers arranged in some specific fashion. The following are some of the representative types found in both woody and herbaceous plants.

Spike. Individual flowers are sessile on the elongated axis (peduncle). The male flower of *Alnus*, *Betula*, *Carpinus*, *Carya*, *Populus*, *Quercus*, and *Salix* are spikes with a special name termed catkin or ament (Indeterminate). Indeterminate inflorescences continue to elongate as the flowers open with the uppermost opening last.

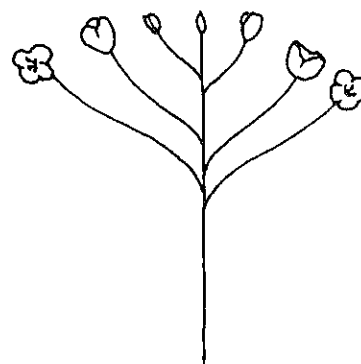


Spike



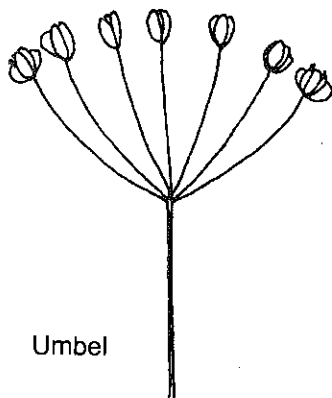
Raceme

Raceme. In the simplest terms it is a modification of a spike with the individual flowers stalked (on a pedicel). *Clethra*, *Itea*, *Laburnum*, and *Wisteria* possess racemose flowers (Indeterminate).



Corymb

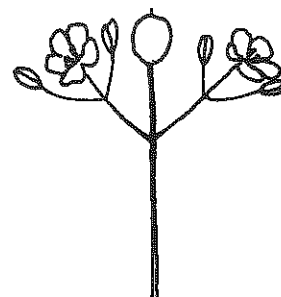
Corymb. An indeterminate (can continue to elongate) inflorescence in which the individual flowers are attached at different points along the peduncle. The outer flowers open first. *Iberis*, *Malus*, and *Prunus* show corymb inflorescences.



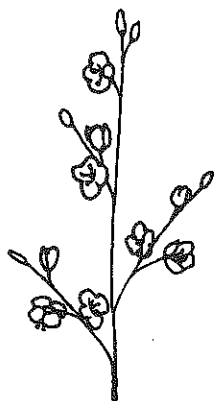
Umbel

Umbel. An indeterminate inflorescence in which the pedicels of the individual flowers radiate from about the same place at the top of the peduncle. Flowers open from outside in. *Aralia*, *X Fatshedera*, *Fatsia*, and *Hedera helix*, are examples.

Cyme. A determinate, flat or convex inflorescence, the central or inner flowers opening first. *Cornus*, *Viburnum* (many) are examples.



Cyme



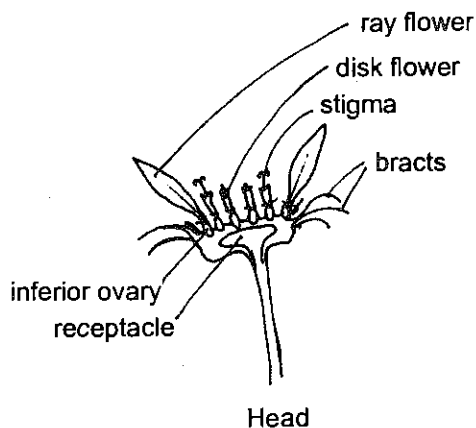
Panicle (of Racemes)

Panicle. An indeterminate inflorescence with repeated branching. Panicles can be made up of many racemes, spikes, corymbs, or umbels. Racemose-panicles are found in *Koeleria*, *Pennis*; spikose-panicles in corn; corymbose-panicles in *Pyracantha*; umbellose-panicles in *Aralia*.

Solitary. Indicates a single flower with a pedicel attached to the stem. *Calycanthus*, *Kerria*, *Magnolia* and many other woody plant flowers fall into this category.



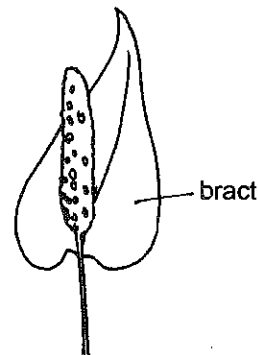
Solitary



Head

Head. The typical inflorescence of the family Asteraceae (Compositae). Made up of ray (sterile) and disk (fertile) flowers which are arranged on a flattened receptacle. *Baccharis* is an example.

A **spadix** is a specialized type of inflorescence typical of many tropical plants. The showy part is the bract or spathe while the spike-like structure which is partially surrounded by the spathe bears the fertile flowers. Examples include: *Anthurium*, *Caladium*, *Calla*, *Philodendron*, *Spathiphyllum*.



Spadix

FRUIT MORPHOLOGY

The longitudinal section of the "typical" flower offers a representative view of the ovary. The ovary is the forerunner of the fruit and is defined as an unripened fruit. The ovary is composed of carpel(s) which are highly modified leaf-like structures which inclose ovules (forerunner of seeds). An ovary may be composed of one carpel (simple fruit) or two or more carpels (compound fruit). Fruits are very important considerations in woody landscape plants for they offer good ornamental assets (color, texture) and positive identification features through late summer, into fall, and often persist until spring of the year following maturation. Fruits of many woody plants are essentially foodstuffs for birds, bears, squirrels and the forest community. The fruits of *Ilex* (Holly) are often colorful for a long period of time while fruits of *Prunus* (Cherry), some *Malus* (Flowering Crabapples), and several *Crataegus* (Hawthorns) persist briefly after ripening (2 to 4 weeks).

The following classification scheme for fruits along with their definitions and line drawings should afford an idea of the diversity of fruit types which are manifested by woody or herbaceous plants.

I. SIMPLE FRUITS

A. Dry Fruits

1. *Indehiscent fruits* (not splitting open at maturity)

- a. *Achene* — one-seeded fruit with seed attached at only one place to the pericarp. Pericarp is very close-fitting and does not split open, at least along regular established lines. Examples: *Calycanthus*, *Chimonanthus*, *Rosa*.
- b. *Caryopsis* — similar to an achene but the pericarp is adherent to the seed, the two often being indistinguishable (seed coat is inseparable from the pericarp). Examples: Corn, Wheat.
- c. *Samara* — usually one-seeded (not always) with a membranous wing which develops from the pericarp. Examples: *Acer*, *Fraxinus*, *Ulmus*.
- d. *Nut* — a bony, hard, one-seeded fruit. The pericarp is bony throughout. Examples: *Castanea*, *Corylus*, *Quercus*.
- e. *Utricle* — similar to an achene but the ovary wall is relatively thin and inflated so it fits only loosely around the seed. Examples: Goosefoot, Pigweed.
- f. *Nutlet* — diminutive of nut. Examples: *Betula*, *Carpinus*, *Ostrya*.

2. *Dehiscent fruits* (splitting open when mature)

- a. *Legume (Pod)* — composed of one carpel and opens along two sutures; characteristic of most members of the Fabaceae (Leguminosae); contains several to many seeds. Examples: *Albizia*, *Cercis*, *Gleditsia*, *Gymnocladus*, *Laburnum*, *Robinia*.
- b. *Follicle* — composed of one carpel but splits open at maturity along one suture exposing several to many seeds. Examples: *Spiraea*, individual fruits of *Magnolia*.
- c. *Capsule* — many-seeded fruits formed from more than one carpel. The carpels are united. Loculicidal Capsule opens along midrib; Septicidal Capsule divides through the partitions. Examples: *Deutzia*, *Forsythia*, *Philadelphus*, *Rhododendron*, *Syringa*.
- d. *Silique* — composed of two carpels which separate at maturity, leaving a thin partition between. Example: Mustard family.
- e. *Silicle* — a short, broad silique. Examples: Shepherd's Purse, Peppergrass.
- f. *Pyxis* — type of capsule which opens around a horizontal ring, the top of fruit falling away like a lid. Example: Purslane.

B. Fleshy Fruits

1. *Berry* — the entire pericarp (exocarp, endocarp, mesocarp) is fleshy. Examples: Tomato, Date, Banana, *Lonicera*, *Vaccinium* (Blueberry, Cranberry).
 - a. *Hesperidium* — a berry with a leathery rind. Examples: *Poncirus*, Lemon, Grapefruit.
 - b. *Pepo* — a berry with a hard rind and fleshy inner matrix. Examples: Watermelon, Squash, Pumpkin.
2. *Drupe* — the pericarp is clearly differentiated into three layers; exocarp is the epidermis; middle layer, the mesocarp, is fleshy; and the inner layer, the endocarp, is stony. Examples: *Ilex*, *Prunus* (Cherry, Peach, Plum), *Sassafras*, *Viburnum*, and numerous other woody ornamental plants.
3. *Pome* — the pericarp is surrounded by the floral tube (hypanthium) which becomes fleshy and tasty. Examples: *Malus* (Apple), *Pyrus* (Pear), *Cydonia* and *Chaenomeles* (Quince).

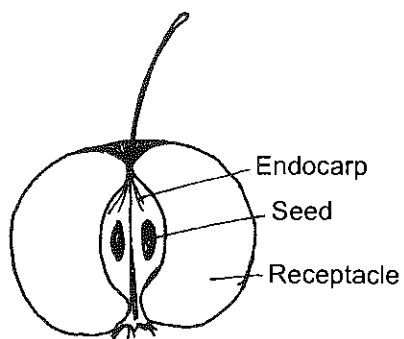
II. AGGREGATE FRUITS

Develop from a single flower which contains many pistils. Several to many fruitlets are massed on one receptacle. Examples: *Fragaria* (strawberry)—aggregate of achenes; *Liriodendron*—aggregate of samaras; *Maclura*—aggregate of drupes; *Magnolia*—aggregate of follicles; *Rubus* (raspberry)—aggregate of drupes.

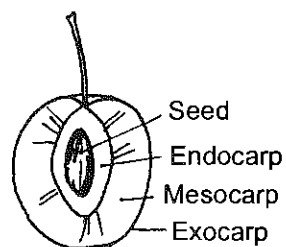
III. MULTIPLE FRUITS

Consists of several flowers which are more or less united into one mass. Example: *Morus* (mulberry).

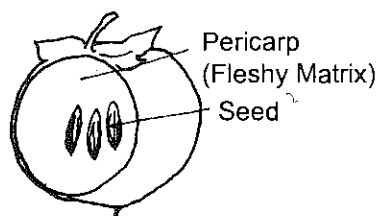
FRUIT TYPES



POME
(*Malus*, *Pyrus*,
Chaenomeles)



DRUPE
(*Prunus*, *Viburnum*,
Celtis, *Sassafras*)



BERRY
(*Asimina*, *Diospyros*,
Lonicera)



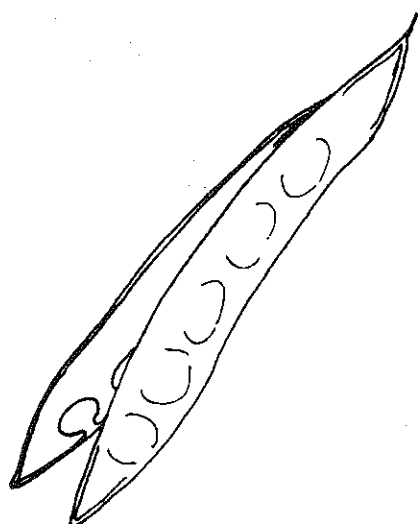
SAMARA
(*Ulmus*)



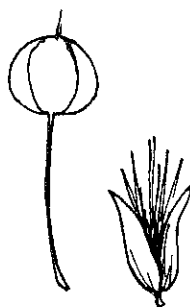
SCHIZOCARP
(*Acer*)



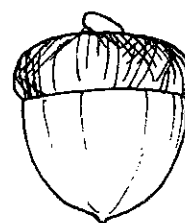
SAMARA
(*Fraxinus*)



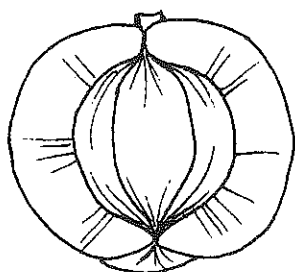
LEGUME (POD)
(*Robinia*, *Cercis*,
Gleditsia)



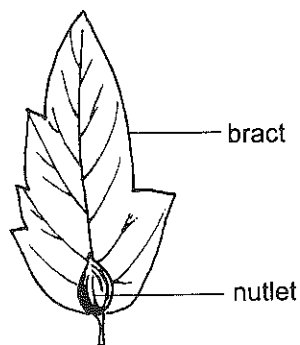
CAPSULES
(*Kalmia*, *Forsythia*,
Rhododendron)



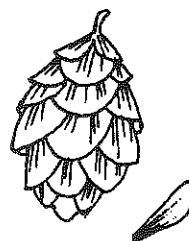
ACORN
(*Quercus*)



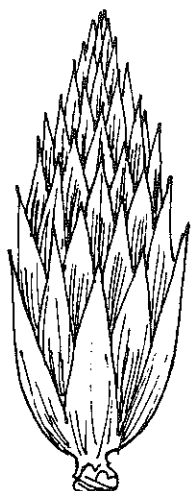
NUT WITH DEHISCENT HUSK
(*Carya*)



NUTLET
(*Carpinus*)



CONE
(*Tsuga*, *Pinus*, *Abies*)



AGGREGATE OF SAMARAS
(*Liriodendron*)



MULTIPLE FRUIT
OF SMALL DRUPES
(*Morus*)



STROBILE:
WINGED NUTLET
(*Betula*)



AGGREGATE OF FOLLICLES
(*Magnolia*)