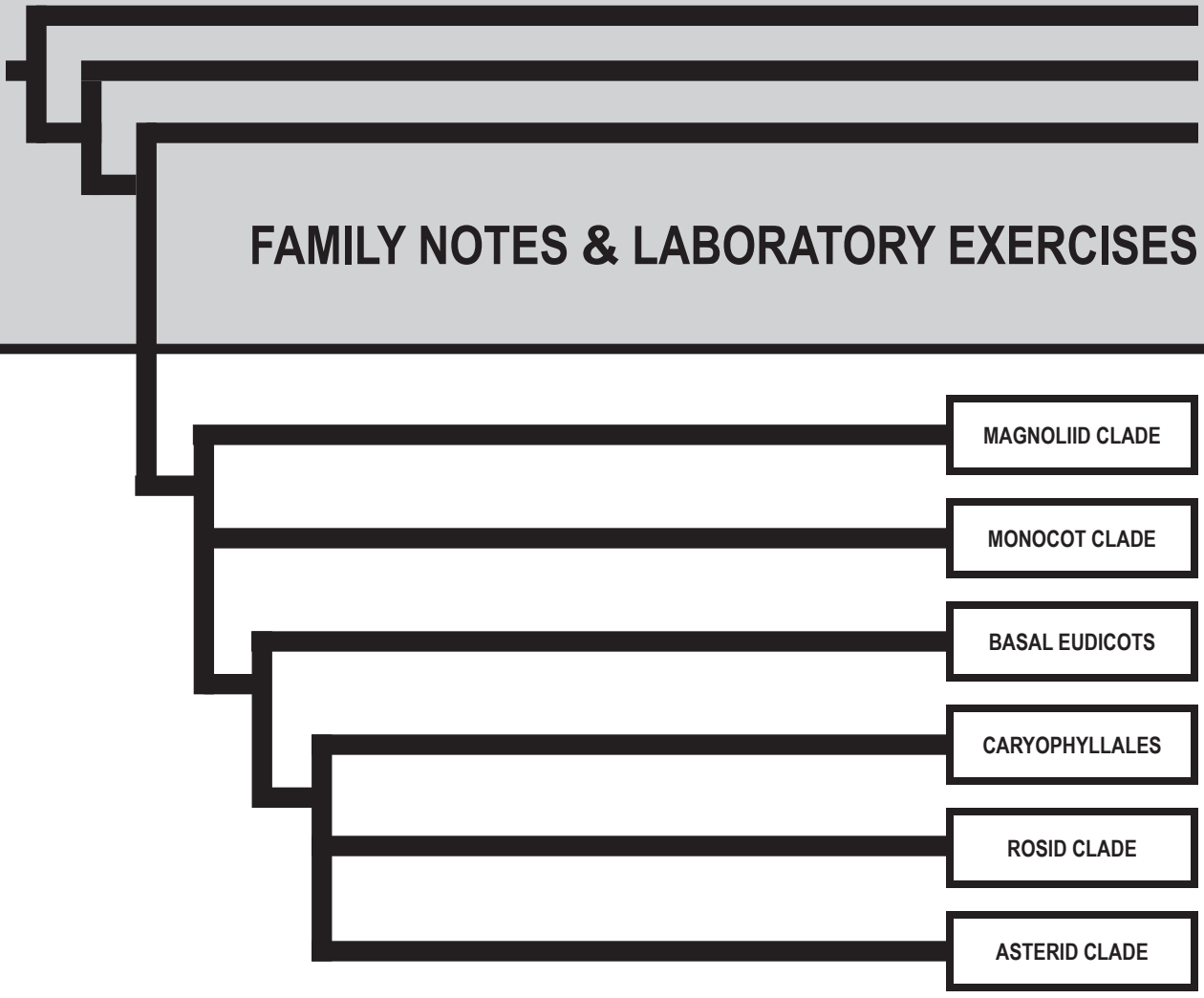
INTEGRATIVE BIOLOGY 335 SPRING 2015

SYSTEMATICS OF PLANTS

FAMILY NOTES & LABORATORY EXERCISES



STEPHEN R. DOWNIE ▪ DANIELLE M. RUFFATTO ▪ KENNETH R. ROBERTSON

Dear Botanist-In-Training,

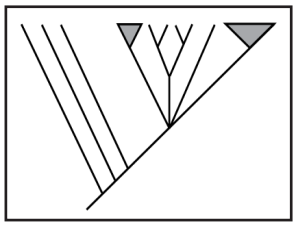
From Charles Darwin to John Audubon and Aldo Leopold, the naturalists of old were extraordinary observers. Further, they could capture all the natural diversity they saw with written descriptions and detailed drawings. Though this class was intended to give you an overview of approximately 40 of the most widespread and/or economically important angiosperm families and subfamilies, it is also meant to teach you how to really observe and describe plants.

Trained as a scientist and artist, I try to view the world around me through the eyes of the early naturalists. So, when I sat down to design this new version of the IB 335 Systematics of Plants Lab Manual, I thought of Georgia O'Keeffe's quote, "When you take a flower in your hand and really look at it, it's your world for the moment. I want to give that world to someone else." Thus, I designed each lab exercise so that you will not only be examining the flowers, leaves, stems and roots of plants, but also describing your observations through answering questions and creating simplistic diagrams.

Hopefully by the end of the semester all of you will recognize the "beauty in the details."

Best wishes,

Danielle M. Ruffatto



INTEGRATIVE BIOLOGY 335

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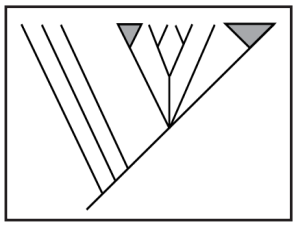


INTEGRATIVE BIOLOGY 335

CLASSIFICATION OF PLANT FAMILIES

The following classification of the plant families covered in Integrative Biology 335 is summarized from Judd et al. (2008, Table 9.1).

MAGNOLIID CLADE (MAGNOLIIDS)

Magnoliaceae

MONOCOT CLADE

Araceae
Arecaceae
Orchidaceae
Iridaceae
Liliaceae
Poaceae

EUDICOT (TRICOLPATE) CLADE

BASAL EUDICOT (BASAL TRICOLPATE) CLADE

Ranunculaceae
Papaveraceae

CORE EUDICOT (CORE TRICOLPATE) CLADE

CARYOPHYLLALES

Cactaceae
Caryophyllaceae
Portulacaceae
Polygonaceae

Hamamelidaceae

EUDICOT (TRICOLPATE) CLADE (CONTD.)

ROSID CLADE (ROSIDS)

EUROSIDS I (FABIDS)

Moraceae
Fagaceae
Betulaceae
Cucurbitaceae
Violaceae
Salicaceae
Fabaceae
Onagraceae
Euphorbiaceae
Rosaceae

EUROSIDS II (MALVIDS)

Brassicaceae
Malvaceae
Aceraceae

ASTERID CLADE (ASTERIDS)

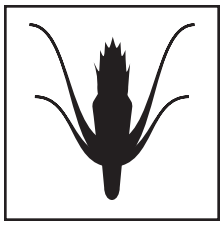
Ericaceae

EUASTERIDS I (LAMIIDS)

Asclepiadaceae
Solanaceae
Oleaceae
Scrophulariaceae
Lamiaceae

EUASTERIDS II (CAMPANULIIDS)

Caprifoliaceae
Asteraceae
Apiaceae



MAGNOLIACEAE

MAGNOLIA FAMILY

Magnoliid Complex (Magnoliid Clade)

♂ $\underline{Ca^{3(x)}\ Co^{6(x)}\ A^{\infty}\ G^{\infty}}$

FLORAL CHARACTERISTICS

- Large perfect flowers
- Actinomorphic symmetry
- Numerous spirally arranged parts
- No adnation or connation
- Anthers **LAMINAR**
- Apocarpous gynoecium
- Superior ovary
- Marginal placentation

INFLORESCENCE TYPE(S)

- Flowers solitary and terminal

FRUIT TYPE(S)

- An aggregate of follicles or samaras
- Seeds often surrounded by a fleshy aril

HABIT

- Trees or less often shrubs
- Aromatic with ethereal oil cells

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Entire margin or lobed at tip in Liriodendron
- Stipules and stipular scars surrounding twigs

NOTE: Several interesting Magnolias are planted in the southeastern corner of Mt. Hope Cemetery [just south and west of the Meat Science Lab and West of Florida Avenue Residence Halls] and also at the corner of Nevada and Busey in Urbana.

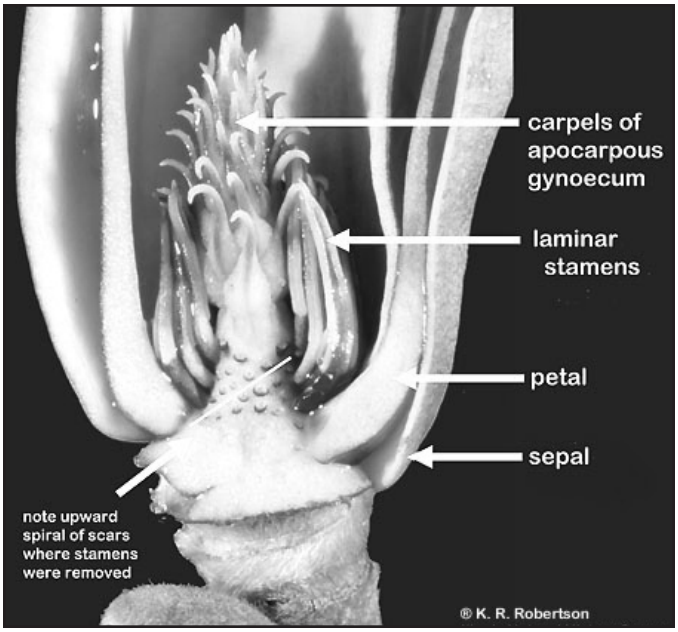
EXAMPLES

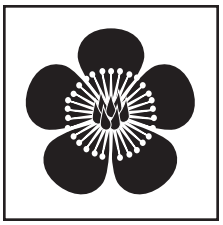
Magnolia spp. [Magnolia]

- M. acuminata (L.) L. [Cucumbertree]
- M. acuminata var. acuminata
- M. acuminata var. subcordata (Spach) Dandy [Yellow Cucumbertree]
- M. fraseri Walter [Fraser Magnolia]
- M. grandiflora L. [Southern Magnolia]
- M. grandiflora × M. virginiana = Magnolia 'Freeman'
- M. macrophylla Michx. [Bigleaf Magnolia]
- M. sieboldii K. Koch [Oyama Magnolia]
- Magnolia × soulangiana Soul.-Bod. [Saucer Magnolia]
- M. stellata (Siebold & Zucc.) Maxim. [Star Magnolia]
- M. tripetala (L.) L. [Umbrella Magnolia]
- M. virginiana L. [Sweet Bay]

Liriodendron spp. [Tuliptree]

- L. tulipifera L. [Tulip poplar]
- L. tulipifera 'Aureo-marginatum'
- L. chinense (Hemsl.) Sarg. [Chinese tuliptree]





RANUNCULACEAE

BUTTERCUP FAMILY

Eudicots: Basal Eudicots

♀ $\underline{Ca^{4-\infty}\ Co^{0-\infty}\ A^{\infty}\ G^{\infty}}$

FLORAL CHARACTERISTICS

- Perfect or rarely imperfect flowers [then dioecious plants]
- Actinomorphic or zygomorphic symmetry
- Parts spirally arranged
- Stamens NOT **LAMINAR**
- Apocarpous gynoecium
- Superior ovary with 1 locule
- Numerous marginal ovules or 1 basal ovule
- Many adaptations for pollination

INFLORESCENCE TYPE(S)

- Various cymes, racemes or panicles
- Terminal

FRUIT TYPE(S)

- Follicles or achenes
- Rarely berries from one carpel
- Frequent adaptations for dispersal

HABIT

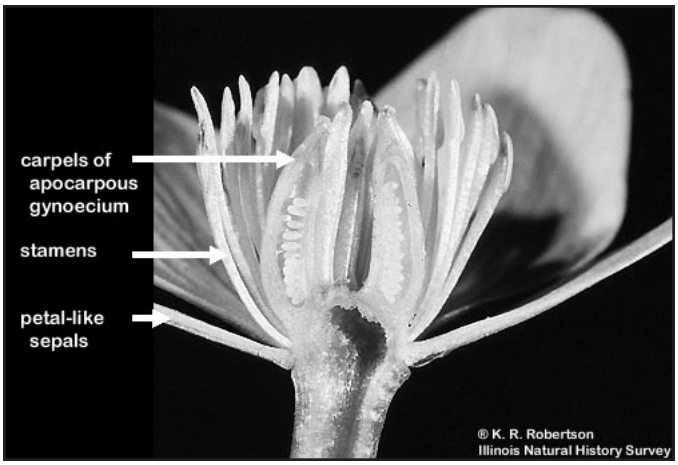
- Perennial and annual herbs
- Rarely woody vines

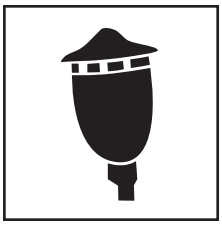
LEAF CHARACTERISTICS

- Simple or compound leaves
- Alternate arrangement
- Without stipules

EXAMPLES

Aconitum columbianum Nutt. [Columbian Monkshood]
Actaea spp. [Baneberry]
  A. pachypoda Elliott [White Baneberry]
  A. rubra (Aiton) Willd. [Red Baneberry]
Anemone spp. [Anemone]
  A. blanda Schott & Kotschy [Greek Thimbleweed]
  A. coronaria L. [Lilies-of-the-Field]
  A. cylindrica A. Gray [Thimbleweed]
  A. patens L. [Pasque Flower]
  Anemone x fulgens (DC.) J. Gay ex Rchb. [Windflower]
Aquilegia canadensis L. [Red Columbine]
Caltha palustris L. [Yellow Marsh Marigold]
Cimicifuga racemosa (L.) Nutt. [Black Cohosh]
Clematis L. spp. [Virgin's Bower]
Delphinium tricorne Michx. [Dwarf Larkspur]
Eranthis hyemalis (L.) Salisb. [Winter Aconite]
Hepatica nobilis Schreb. [Liverleaf]
Ranunculus septentrionalis Poir. [Buttercup]
Thalictrum spp. [Meadow-rue]
  T. revolutum DC. [Waxyleaf Meadow-rue]
  T. thalictroides (L.) Eames & B. Boivin [Rue Anemone]





PAPAVERACEAE

POPPY FAMILY

Eudicots: Basal Eudicots

♀ $Ca^{2(3)}\ Co^{4-8}\ A^{6\text{ or }\infty}\ \underline{G^{(2\text{-}\infty)}}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry [zygomorphic in Fumarioideae]
- Perianth parts distinct
- Sepals **CAUDUCOUS**
- Petals sometimes crumpled in bud
- Numerous stamens [or only 6 in Fumarioideae]
- Syncarpous gynoecium
- Superior ovary
- Usually 1-locular ovary with many parietal ovules

INFLORESCENCE TYPE(S)

- Flowers solitary or in cymes and racemes

FRUIT TYPE(S)

- Capsules [**PORICIDAL** in Papaver]
- Seeds often with fleshy **ELAIOSOMES** for ant dispersal

HABIT

- Annual or perennial herbs, rarely woody
- Sap milky or colored [often bright orange, red or yellow (clear in Fumarioideae)]
- Some with alkaloids

LEAF CHARACTERISTICS

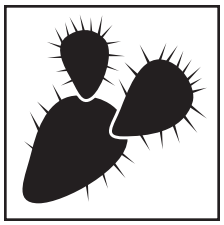
- Alternate to opposite or whorled arrangement
- Entire to lobed or dissected margin

EXAMPLES

Argemone mexicana L. [Mexican Prickly Poppy]
Bocconia frutescens L. [Parrotweed]
Chelidonium majus L. [Celandine]
Eschscholzia californica Cham. [California Poppy]
Hunnemannia fumariifolia Sweet [Mexican Tulip Poppy]
Macleaya cordata (Willd.) R. Br. [Plume Poppy]
Meconopsis grandis Prain [Blue Poppy]
Papaver spp. [Poppy]
  P. orientale L. [Oriental Poppy]
  P. somniferum L. [Opium Poppy]
Sanguinaria canadensis L. [Bloodroot]
Stylophorum diphyllum (Michx.) Nutt. [Celandine Poppy]

FUMARIOIDEAE EXAMPLES

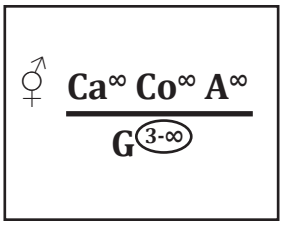
Corydalis spp. [e.g. Corydalis, Fumewort]
Dicentra spp. [Squirrel-corn]
  D. canadensis (Goldie) Walp. [Squirrel corn]
  D. cucullaria (L.) Bernh. [Dutchman's breeches]
  D. spectabilis (L.) Lem. [Bleeding heart]



CACTACEAE

CACTUS FAMILY

Eudicots: Caryophyllid Clade



FLORAL CHARACTERISTICS

- Often large and showy perfect flowers
- Actinomorphic to somewhat zygomorphic symmetry
- Gradual transition from sepals to petals, both numerous
- Syncarpous gynoecium made up of many connate carpels
- Inferior ovary sunken into stem tissue
- 1-locular ovary with many ovules
- Parietal placentation
- Sometimes a hypanthium present

INFLORESCENCE TYPE(S)

- Solitary flowers emerging from **AREOLES**

FRUIT TYPE(S)

- Berries surrounded by stem tissue
- Seeds with embryo coiled around perisperm

HABIT

- Perennial stem succulents, some tree-like or epiphytic
- **BETALAIN** pigments
- **SPINES** produce from an **AREOLE**, which sometimes contains numerous **GLOCHIDS**
- Native to the New World

LEAF CHARACTERISTICS

- Reduced or absent except in Pereskia

EXAMPLES

Carnegia gigantea (Engelm.) Britton & Rose [Saguaro]

Cereus spp. [Night-blooming Cactus]

Echinocereus spp. [Hedgehog Cactus]

Epiphyllum spp. [Orchid Cactus]

Lophophora williamsii (Lem. ex Salm-Dyck) J.M. Coult [Peyote]

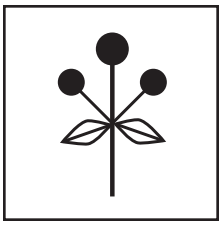
Mammillaria spp. [Pincushion Cactus]

Opuntia spp. [Pricklypears] = 3 found in IL:

- O. fragilis (Nutt.) Haw. [Brittle Pricklypear: Endangered in IL]
- O. humifusa (Raf.) Raf. [Devil's-tongue]
- O. macrorhiza Engelm. [Twistspine Prickly Pear]

Rhipsalis baccifera (Sol. ex J.S. Muell.) Stearn [Mistletoe Cactus]

Schlumbergera truncata (Haw.) Moran [False Christmas Cactus]



CARYOPHYLLACEAE

PINK FAMILY

Eudicots: Caryophyllid Clade

♀ $\underline{Ca^{\overset{5}{\circlearrowleft}}\ Co^{5}\ A^{10}\ G^{(2\text{-}5)}}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Sepals connate and persistent
- Petals distinct and often clawed at base and apically notched
- Syncarpous gynoecium often made up of 3 connate carpels
- Superior ovary
- 1-locular ovary with many free central ovules
- Possess an **ANDROGYNOPHORE** [or **GYNOPHORE**] - a stalk that supports the corolla, androecium and gynoecium

INFLORESCENCE TYPE(S)

- Basically cymes

FRUIT TYPE(S)

- Capsules with apical teeth [denticidal capsules] or achenes in one group
- Seeds with embryo coiled around perisperm

HABIT

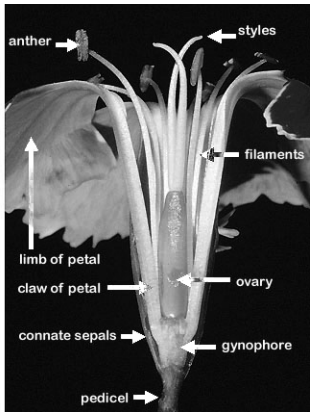
- Annual or perennial herbs
- **ANTHOCYANIN** pigments
- Stems often with swollen nodes

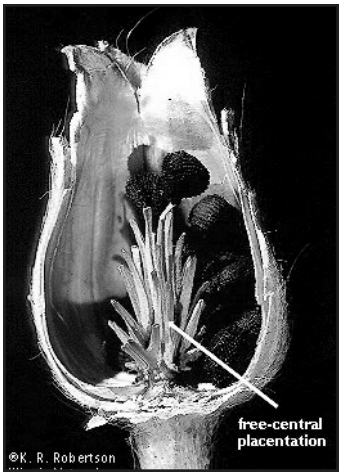
LEAF CHARACTERISTICS

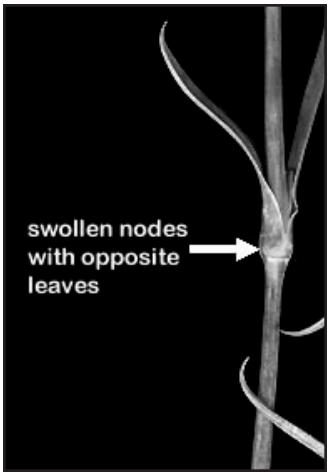
- Simple leaves
- Opposite arrangement
- Entire margin
- Leaf bases often connate and sheathing

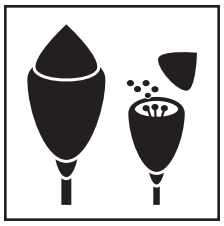
EXAMPLES

Agrostemma spp. [Corncockle]
Dianthus spp. [Pinks, Carnations]
Gypsophila spp. [Baby's Breath]
Lychnis chalcedonica L. [Maltesecross]
Saponaria officinalis L. [Bouncingbet]
Silene spp. [Campion, Catchfly]
S. regia Sims [Royal Catchfly]
Stellaria spp. [Chickweed, Starwort]









PORTULACACEAE

PURSLANE FAMILY

Eudicots: Caryophyllid Clade

♀ $\underline{Ca^{2}\ Co^{5-\infty}\ A^{5-\infty}\ G\textcircled{2-9}}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- 2 persistent sepals [may be bracts]
- 5 to many petals [may be sepals]
- 5 [then opposite petals] to many stamens
- Syncarpous gynoecium made up of 2-9 connate carpels
- Superior or rarely half-inferior ovary
- 1-locular ovary with 2 to many basal or free central ovules

INFLORESCENCE TYPE(S)

- Flowers solitary or cymes, racemes or heads

FRUIT TYPE(S)

- Capsules, sometimes circumscissile capsules [**PYXIS**]
- Rarely a nut
- Seeds with embryo coiled around perisperm

HABIT

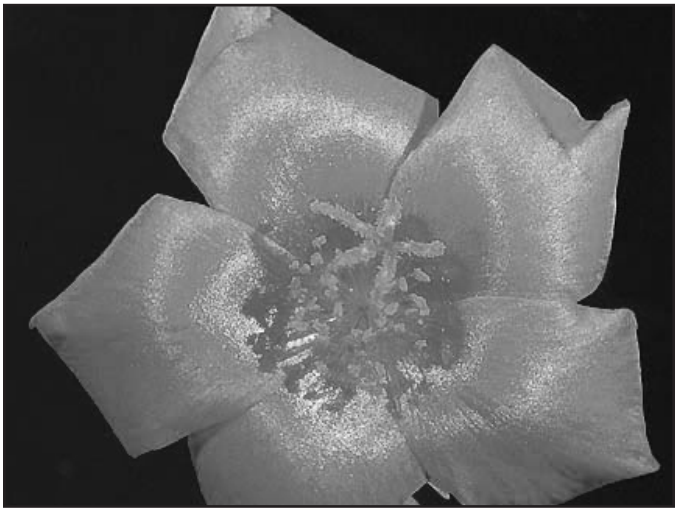
- Annual or perennial herbs, less often shrubs or small trees
- **BETALAIN** pigments

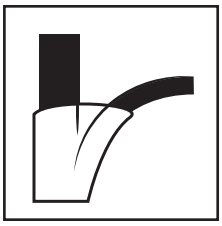
LEAF CHARACTERISTICS

- Simple leaves
- Alternate, opposite or basal arrangement
- Entire margin
- Leaves often succulent

EXAMPLES

Claytonia virginica L. [Virginia Spring Beauty]
Lewisia rediviva Pursh [Bitter Root]
Portulaca grandiflora Hook. [Rose Moss]
P. oleracea L. [Little Hogweed]
Talinum spp. [Fameflower]
T. rugospermum Sims [Prairie Fameflower]
Stellaria spp. [Chickweed, Starwort]





POLYGONACEAE

BUCKWHEAT FAMILY

Eudicots: Caryophyllid Clade

♀ $\underline{Ca^{3+3\,(5)}\ Co^{0}\ A^{3-9}\ G^{(2-3)}}$

FLORAL CHARACTERISTICS

- Perfect or rarely imperfect flowers
- Actinomorphic symmetry
- Sepals often in 2 whorls of 3, distinct or connate at the base, sometimes an inner sepal fused with an outer one
- Petals absent
- Syncarpous gynoecium made up of 2-3 connate carpels
- Superior ovary
- 1-locular ovary with 1 basal ovule

INFLORESCENCE TYPE(S)

- Mostly racemes, spikes or panicles
- Sometimes in small axillary clusters

FRUIT TYPE(S)

- Triangular or lens-shaped achenes
- Embryo straight to curved

HABIT

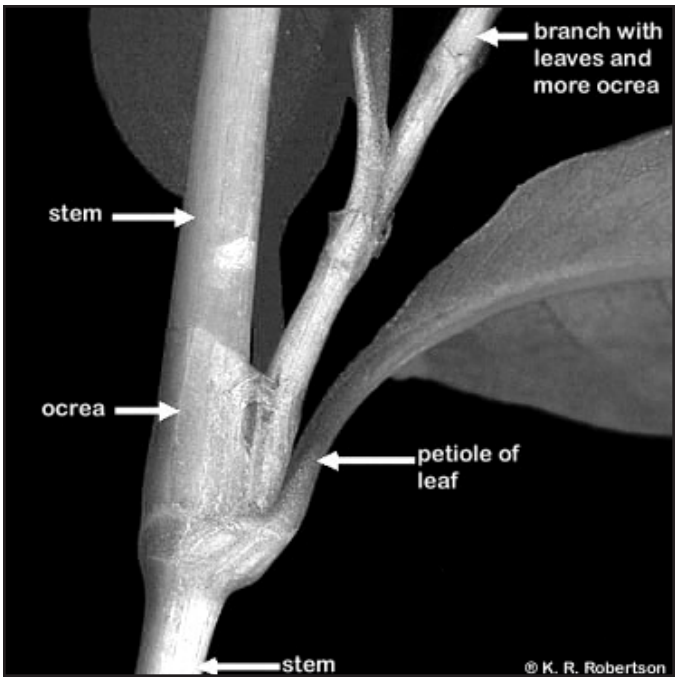
- Annual or perennial herbs, sometimes shrubs or even trees in the tropics
- **ANTHOCYANIN** pigments

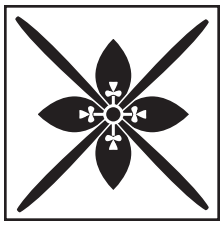
LEAF CHARACTERISTICS

- Alternate, seldom opposite, whorled or basal arrangement
- Entire margin
- Stipules usually present and sheathing around stem [**OCREA**]

EXAMPLES

Coccoloba uvifera (L.) L. [Seagrape]
Fagopyrum esculentum Moench [Buckwheat]
Polygonum spp. [Knotweeds and Smartweeds]
Rheum rhabarbarum L. [Garden Rhubarb]
Rumex spp. [Docks]





HAMAMELIDACEAE

WITCH HAZEL FAMILY

Eudicots: Core Eudicot

♀ $\frac{Ca_{(4\text{-}5)}Co^{4\text{-}5(10)}\ A^{4\text{-}5}}{G^{(2)}}$ OR

♂ $Ca_{(4\text{-}5)}Co^{4\text{-}5(10)}\ A^{4\text{-}5}\ G^{(2)}$

FLORAL CHARACTERISTICS

- Perfect or imperfect flowers [then monoecious plants]
- Actinomorphic symmetry
- Anthers open by flaps in Hamamelis
- Staminodes present in Hamamelis
- Syncarpous gynoecium made up of 2 connate carpels
- Inferior, half-inferior or superior ovary
- 2-locular ovary with axile, pendulous ovules

INFLORESCENCE TYPE(S)

- Axillary clusters, spikes or heads

FRUIT TYPE(S)

- Woody loculicidal capsules
- 1 pendulous seed per locule
- Seed ejected in Hamamelis

HABIT

- Shrubs or trees
- Some wood resinous

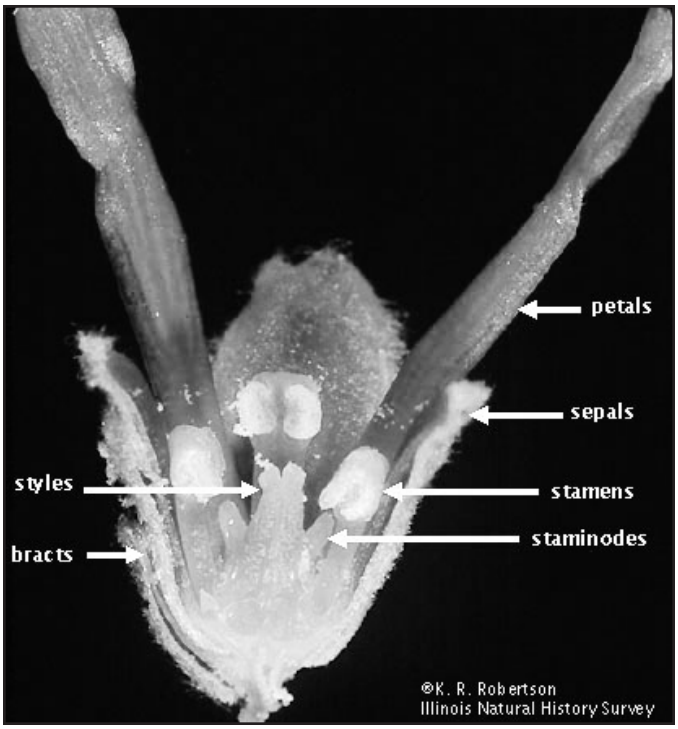
LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Toothed or lobed margin
- Stipules present
- Stellate hairs often present
- Often colored in autumn

EXAMPLES

Corylopsis spp. [Winter Hazel]
Fothergilla gardenii L. [Dwarf Witch Alder]
Hamamelis spp. [Witchhazel]
H. vernalis Sarg. [Spring or Vernal Witchhazel]
H. virginiana L. [American Witchhazel]
Hamamelis × intermedia 'Arnold Promise'
[H. mollis × H. japonica]
Liquidambar styraciflua L. [Sweet Gum]
Parrotia persica (DC.) C.A. Mey. [Persian Ironwood]

NOTE: Most species located in the North Temperate Zone



MORACEAE

MULBERRY OR FIG FAMILY

Eudicots: Rosid Clade

♂ $Ca^4\ Co^0\ A^4\ G^0$

♀ $Ca^4\ Co^0\ A^0\ G^{(2)}$

FLORAL CHARACTERISTICS

- Tiny imperfect flowers
- Plants monoecious or dioecious
- Syncarpous gynoecium of 2 connate carpels
- Superior or inferior ovary
- 1-locular ovary with 1 pendulous ovule

INFLORESCENCE TYPE(S)

- Flowers in heads, catkins or a **SYCONIUM**

FRUIT TYPE(S)

- Achenes or small drupes
- Sometimes multiple fruits with accessory tissue [i.e. **SYCONIUM**]
- Can be very large

HABIT

- Trees and shrubs, sometimes herbs
- Sap milky

LEAF CHARACTERISTICS

- Simple leaves
- Alternate or opposite arrangement
- Entire, toothed or lobed margin

RELATED FAMILY: CANNABACEAE

Cannabis sativa L. [Marijuana]

Humulus lupulus L. [Common Hop]

EXAMPLES

Artocarpus spp. [Breadfruit]

A. altilis (Parkinson) Fosberg [Breadfruit]

A. heterophyllus Lam. [Jackfruit]

Broussonetia papyrifera (L.) L'Hér. ex Vent. [Paper Mulberry]

Dorstenia spp. [Dorstenia]

Ficus spp. [Fig]

F. aurea Nutt. [Florida Strangler Fig]

F. benghalensis L. [Indian Banyan]

F. benjamina L. [Weeping Fig, Shopping Mall Fig]

F. carica L. [Edible Fig]

F. elastica Roxb. ex Hornem. [Indian Rubber Plant]

F. lyrata Warb. [Fiddleleaf Fig]

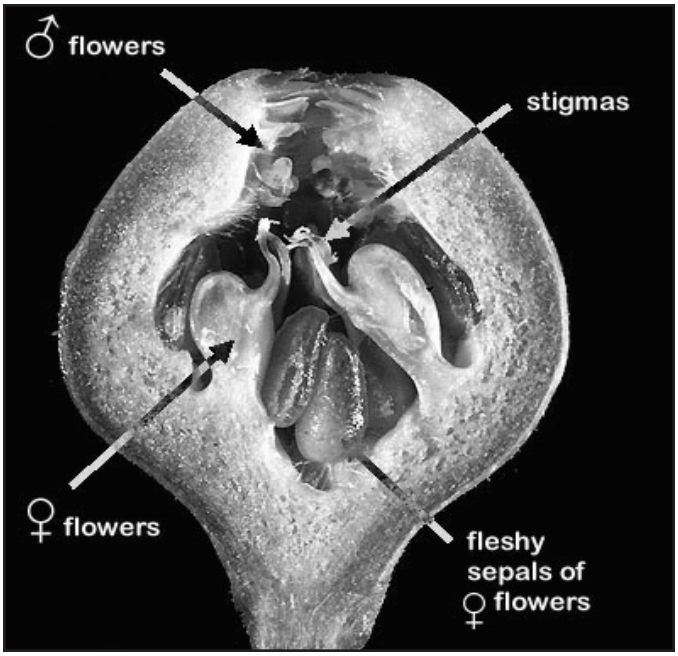
F. religiosa L. [Bo-Tree]

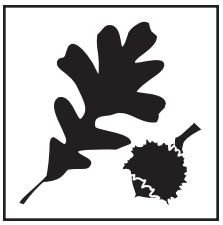
Maclura pomifera (Raf.) C.K. Schneid. [Osage Orange]

Morus spp. [Mulberry]

M. alba L. [White Mulberry, 'Silkworm' Mulberry]

M. rubra L. [Red Mulberry]





FAGACEAE

BEECH OR OAK FAMILY

Eudicots: Rosid Clade

♂ $\underline{Ca^{4\text{-}7}\frown Co^{0}\ A^{4\text{-}\infty}}\ G^{0}$

♀ $\underline{Ca^{4\text{-}7}\frown Co^{0}\ A^{0}}$
$G^{\textcircled{3}}$

FLORAL CHARACTERISTICS

- Tiny imperfect flowers
- Plants usually monoecious
- Actinomorphic symmetry
- Syncarpous gynoecium made up of 3 connate carpels
- Inferior ovary
- 3-locular ovary with 2 pendulous ovules in each locule [only 1 ovule per ovary becoming a seed]

INFLORESCENCE TYPE(S)

- Staminate flowers in catkins
- Carpellate flowers in few-flowered clusters enclosed by an **INVOLUCRE**

FRUIT TYPE(S)

- Nuts: 1-seeded and subtended or surrounded by an **INVOLUCRE** [cupule]

HABIT

- Trees or sometimes shrubs
- Deciduous or evergreen [farther south]

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Toothed or entire margin, or pinnately lobed
- With stipules

EXAMPLES

Castanea spp. [Chestnut]
- C. dentata (Marsh.) Borkh. [American Chestnut]
- C. mollissima Blume [Chinese Chestnut]

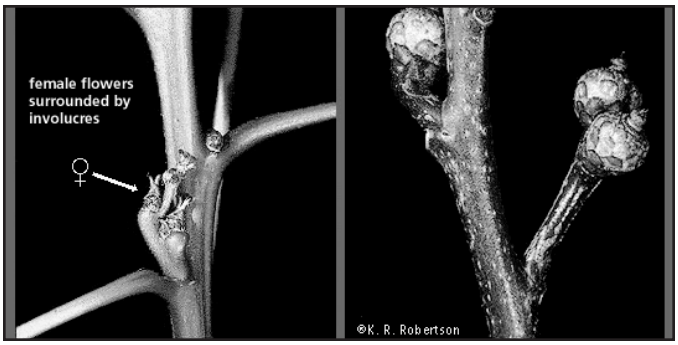
Fagus spp. [Beech]
- F. grandifolia Ehrh. [American Beech]
- F. sylvatica L. [European Beech]
- F. sylvatica 'Atropunicea' [Purple Beech]
- F. sylvatica 'Roseo-marginata' [Tricolor Beech]
- F. sylvatica 'Pendula'

Quercus spp. [Oaks] - 2 subgenera in Illinois

Subgenera Erythrobalanus [Black/Red Oaks]
- Acorns mature in 2 years
- Leaves with bristle-tipped veins
  - Q. palustris Münchh. [Pin Oak]
  - Q. rubra L. [Northern Red Oak]
  - Q. velutina Lam. [Black Oak]

Subgenera Quercus (Leucobalanus) [White Oaks]
- Acorns mature in 1 year
- Leaves without bristle-tipped veins
  - Q. alba L. [White Oak] - State Tree of Illinois
  - Q. macrocarpa Michx. [Bur Oak]

Other Oaks:
- Q. robur L. [English Oak]
- Q. suber L. [Cork Oak]
- Q. virginiana Mill. [Live Oak]



BETULACEAE

BIRCH FAMILY

Eudicots: Rosid Clade

♂ $\underline{Ca^{(0-6)}\ Co^{0}\ A^{2-18}\ G^{0}}$

♀ $\dfrac{\underline{Ca^{0-6}\ Co^{0}\ A^{0}}}{G^{(2)}}$

FLORAL CHARACTERISTICS

- Tiny imperfect flowers
- Plants monoecious
- Actinomorphic symmetry
- Syncarpous gynoecium made up of 2 connate carpels
- Inferior ovary [usually] *hard to see*
- 2-locular ovary below but 1-locular above with 1 pendulous ovule per locule near top of partition

INFLORESCENCE TYPE(S)

- Staminate flowers in 2-3 flowered cymules subtended by bracts and clustered into catkins
- Carpellate flowers in 1-3 flowered cymules subtended by bracts and clustered into catkins [these sometimes cone-like]

FRUIT TYPE(S)

- Nuts and samaras that are 1-seeded

HABIT

- Trees and shrubs
- Mostly of cooler parts of the Northern Hemisphere

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Toothed or doubly serrate margin
- Often with oblique leaf base
- Stipules present

EXAMPLES

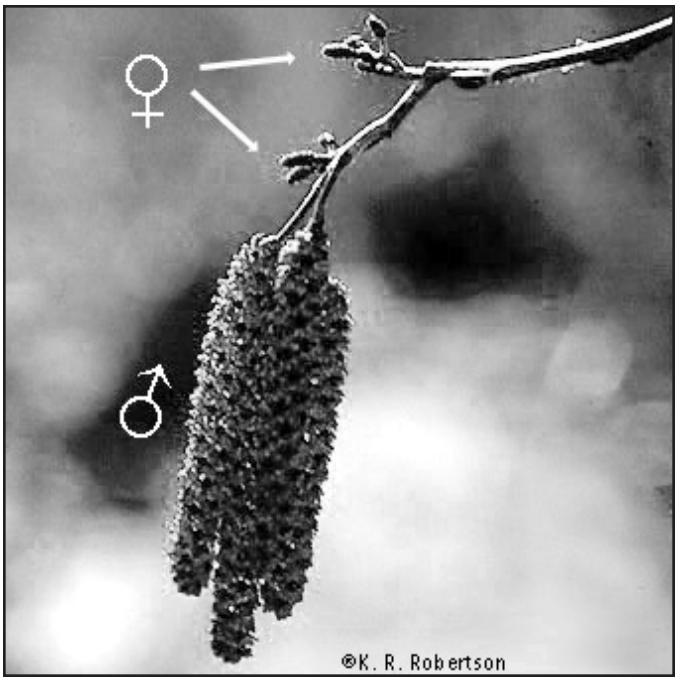
Alnus spp. [Alders]
- A. cordata (Loisel.) Duby [Italian Alder]
- A. glutinosa (L.) Gaertn. [Common or Black Alder]

Betula spp. [Birches]
- B. nigra L. [River Birch]
- B. papyrifera Marsh. [Paper or Canoe Birch]
- B. pendula Roth [European White Birch]

Carpinus spp. [Hornbeams]
- C. betulus L. [European Hornbeam]
- C. caroliniana Walter [American Hornbeam]

Corylus spp. [Hazelnuts, Filberts]
- C. americana Walter [American Hazelnut or Filbert]
- C. avellana L. [European Filbert]
- C. avellana 'Contorta' [Harry Lauder's Walking Stick]

Ostrya spp. [Hophornbeams]
- O. virginiana (Mill.) K. Koch [American Hophornbeam]



CUCURBITACEAE

CUCUMBER FAMILY

Eudicots: Rosid Clade

♂ $\underline{Ca^5\ Co^{\textcircled{5}}\ A^{\textcircled{5}}\ G^0}$

♀ $\underline{Ca^5\ Co^{\textcircled{5}}\ A^0}$
$G^{\textcircled{3}}$

FLORAL CHARACTERISTICS

- Imperfect flowers
- Plants monoecious or dioecious
- Actinomorphic symmetry
- Petals connate and often yellow
- Stamens [both filaments and anthers] often connate
- Anthers straight to folded or bent
- Syncarpous gynoecium made up of 3 connate carpels
- Inferior ovary
- 1-locular ovary with many parietal ovules
- Hypanthium sometimes present

INFLORESCENCE TYPE(S)

- Flowers solitary or in axillary cymes, panicles or racemes

FRUIT TYPE(S)

- **PEPOS**, also berries or capsules

HABIT

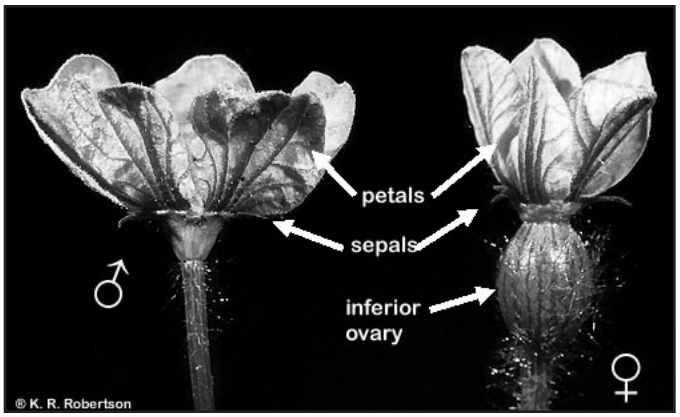
- Herbaceous vines with tendrils
- Produce triterpenoid cucurbitacins

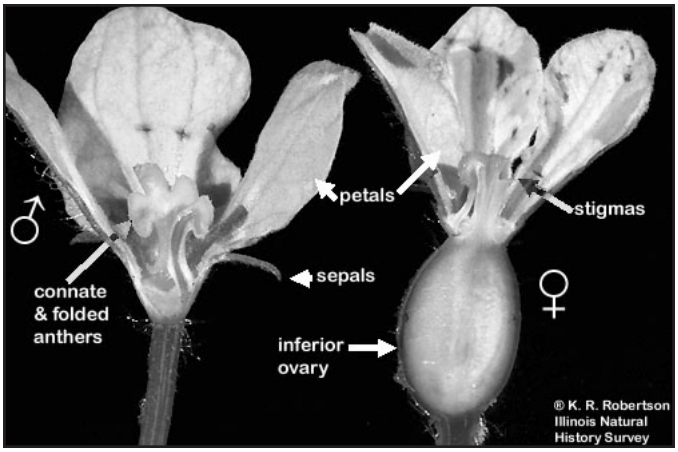
LEAF CHARACTERISTICS

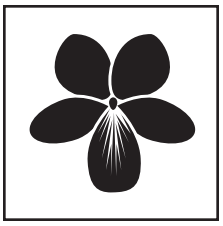
- Alternate arrangement
- Palmately lobed or divided
- No stipules

EXAMPLES

Citrullus lanatus (Thunb.) Matsum. & Nakai [Watermelon]
Cucumis spp. [Melons]
  C. melo L. [Cantelope]
  C. sativus L. [Garden Cucumber]
Cucurbita spp. [e.g. Pumpkin, Squash]
Ecballium elaterium (L.) A. Rich. [Squirting Cucumber]
Echinocystis lobata (Michx.) Torr. & A. Gray [Wild Cucumber]
Lagenaria spp. [White-flowered Gourds]
Luffa aegyptiaca Mill. [Sponge Gourd]
Marah macrocarpus (Greene) Greene [Cucamonga Manroot]







VIOLACEAE

VIOLET FAMILY

Eudicots: Rosid Clade

♀ $\underline{CaZ^5\ CoZ^5\ A^5\ G^{③}}$

FLORAL CHARACTERISTICS

- 2 types of flowers: **CHASMOGAMOUS** and **CLEISTOGAMOUS**
- Perfect flowers
- Zygomorphic symmetry
- 1 petal with **SPUR**
- 2 lower anthers, each with a nectary, protrude into **SPUR**
- Syncarpous gynoecium made up of 3 connate carpels
- Superior ovary
- Ovary has many parietal ovules

INFLORESCENCE TYPE(S)

- Flowers solitary and scapose or in racemes, panicles or cymes

FRUIT TYPE(S)

- Loculicidal capsules [explosively dehiscent in Viola]
- Also berries or nuts

HABIT

- Annual or perennial herbs
- Shrubs and trees in the tropics

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Often toothed margin, sometimes lobed or dissected
- Stipules present

EXAMPLES

Viola spp. [Violets]

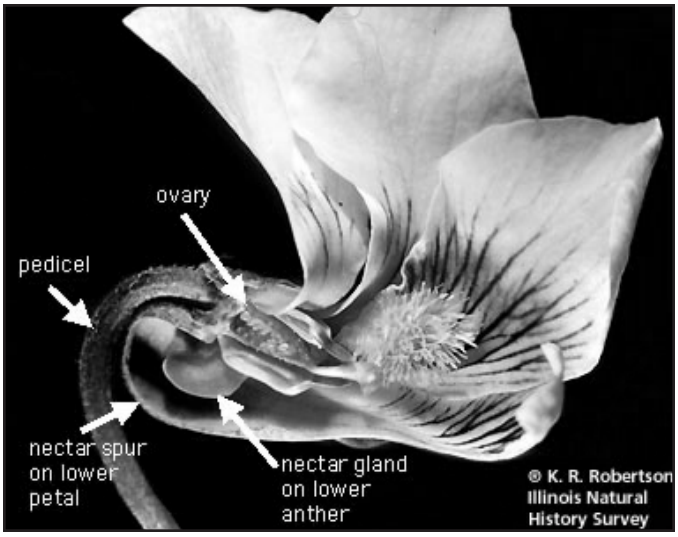
V. pedata L. [Birdfoot Violet]

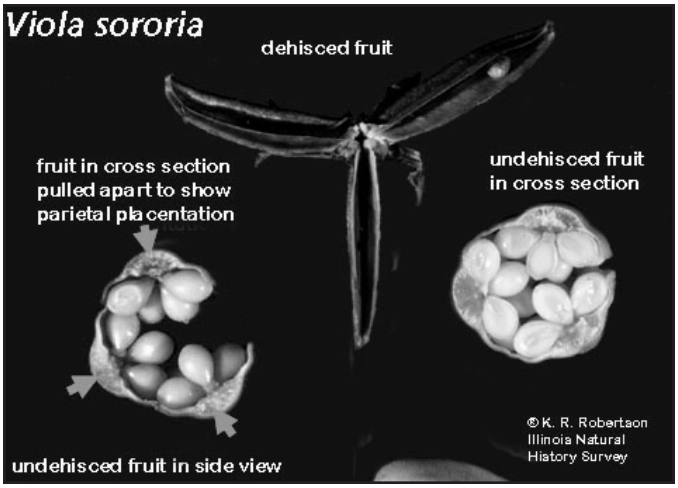
V. sororia Willd. [Common Blue Violet]

V. striata Aiton [Striped Cream Violet]

V. tricolor L. [Pansy]

Hybanthus concolor (T.F. Forst.) Spreng. [Eastern Greenviolet]





SALICACEAE

WILLOW FAMILY

Eudicots: Rosid Clade

♂ $Ca^{0-x}\ Co^{0}\ A^{2-\infty}\ G^{0}$

♀ $Ca^{0-x}\ Co^{0}\ A^{0}\ G^{(2-4)}$

FLORAL CHARACTERISTICS

- Simple imperfect flowers
- Plants dioecious
- Flowers often subtended by a bract
- Calyx reduced to a disk in Populus or nectar glands in Salix
- Syncarpous gynoecium made up of 2-4 connate carpels
- Superior ovary
- 1-locular ovary with many parietal ovules
- Populus wind pollinated and Salix bee pollinated

INFLORESCENCE TYPE(S)

- Catkins

FRUIT TYPE(S)

- Capsules
- Seeds hairy [comose]

HABIT

- Trees and shrubs
- Salicin [aspirin or acetylsalicylic acid] originally from Salix

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Entire or toothed margin
- Stipules present

EXAMPLES

Salix spp. [Willows]

S. amygdaloides Andersson [Peachleaf Willow]

S. babylonica L. [Weeping Willow]

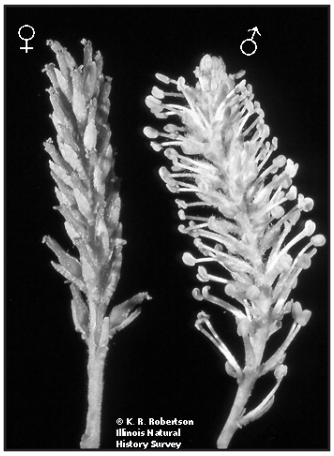
S. humilis Marsh. [Prairie Willow]

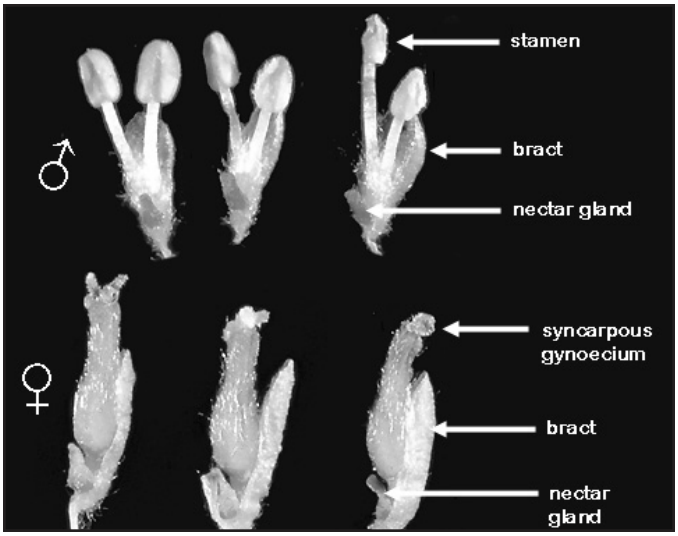
Populus spp. [Poplars]

P. alba L. [White Poplar]

P. deltoides Bartram ex Marsh. [Eastern Cottonwood]

P. tremuloides Michx. [Quaking Aspen]





FABACEAE (LEGUMINOSAE)

LEGUME FAMILY

Eudicots: Rosid Clade

⚥ $\underline{Ca^5\ Co^5\ A^{10\text{-}\infty}\ G^1}$

FLORAL CHARACTERISTICS

- Usually perfect flowers
- Monocarpous gynoecium
- Superior ovary
- Ovary has 2 to many marginal ovules that occur in alternating rows on either side of the carpel opening (suture)

FRUIT TYPE(S)

- **LEGUME:** basically a follicle that opens along two sutures rather than one (Note: The fruit is a “legume” by definition, but there is enormous variation in the morphology of fruits that are produced from the single carpel)
- Seeds lack endosperm

HABIT

- Most legumes have root nodules containing nitrogen-fixing bacteria
- Enormous economic importance, second only to Poaceae (Grass Family) for food

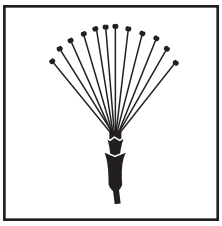
LEAF CHARACTERISTICS

- Leaves alternate, often pinnately compound
- Less often leaves palmately compound or simple

THREE SUBFAMILIES

- **MIMOSOIDEAE** (Mimosa Subfamily)
- **CAESALPINIOIDEAE** (Caesalpinia Subfamily)
- **FABOIDEAE** (Bean or Pea Subfamily)

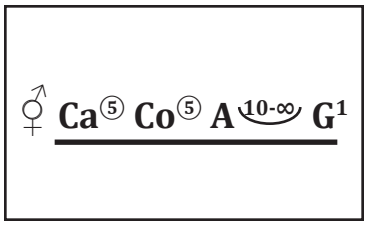
	MIMOSOIDEAE	**CAESALPINIOIDEAE**	**FABOIDEAE**
Floral Symmetry	Actinomorphic	Zygomorphic	Zygomorphic
Corolla Arrangement	Petals connate and often forming a tube	**BANNER** petal internal to lateral petals	1 **BANNER** petal outermost, 2 distinct lateral **WING** petals, and 2 petals fused to form the **KEEL**
Androecium	10 or more stamens Pollen in **POLLINIA** (aggregates of pollen)	10 (or fewer) stamens Anthers often opening by pores	10 stamens either... - **DIADELPHOUS** (usually) - **MONADELPHOUS** - Distinct
Seed PLEUROGRAM	U-shaped **PLEUROGRAM**	O-shaped **PLEUROGRAM**	No **PLEUROGRAM**



MIMOSOIDEAE

MIMOSA SUBFAMILY

Eudicots: Rosid Clade



FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Stamens usually 10 or more and pollen in pollinia
- Calyx, Corolla and filaments of Androecium all connate forming tubes, but Ca, Co and A free from one another
- Thus, flower has a "Tube in a Tube in a Tube" structure

INFLORESCENCE TYPE(S)

- Capitate clusters, spikes or racemes

FRUIT TYPE(S)

- Typically a **LEGUME** [dry and dehiscing along both sutures]
- Seeds without endosperm, often with a U-shaped groove [**PLEUROGRAM**] or pits

HABIT

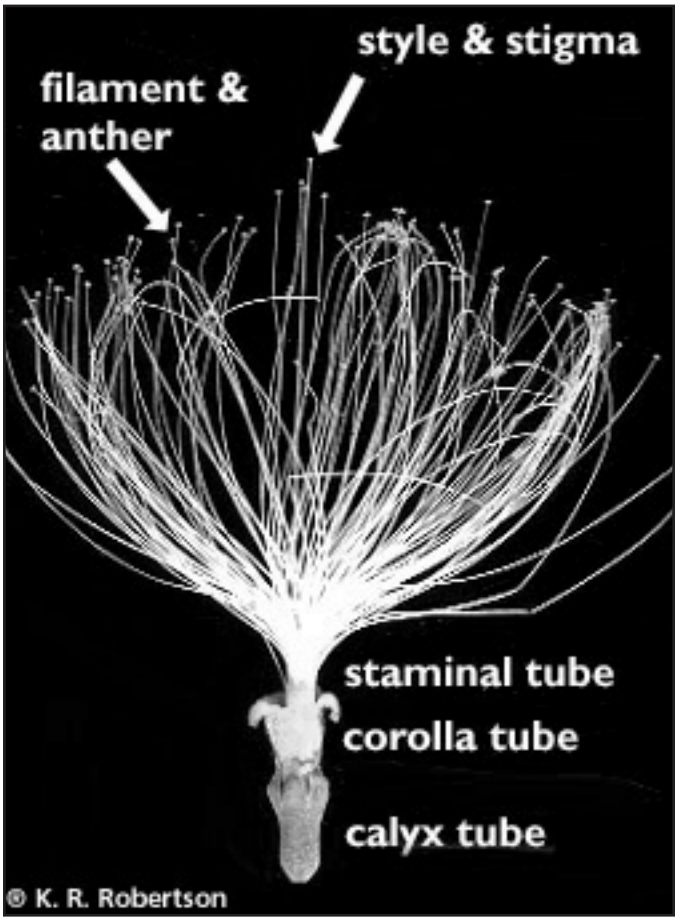
- Mostly tropical and subtropical trees
- A few temperate shrubs and herbs
- Usually with root nodules

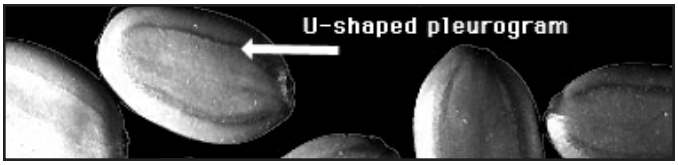
LEAF CHARACTERISTICS

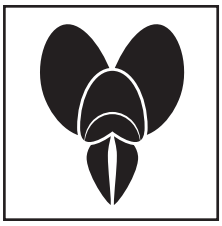
- Bipinnately compound leaves
- Alternate arrangement with a **PULVINUS**
- Some show movement
- Stipules present
- Beltian bodies in some species

EXAMPLES

Acacia spp. [A very BIG genus]
Albizia julibrissin Durazz. [Silktree]
Calliandra spp. [Powderpuff Tree]
Desmanthus illinoensis (Michx.) MacMill. [Illinois Bundleflower]
Mimosa pudica L. [Sensitive Plant]







CAESALPINIOIDEAE

CAESALPINIA SUBFAMILY

Eudicots: Rosid Clade

♂ $Ca^5\ CoZ^5\ A^{10}\ G^1$

FLORAL CHARACTERISTICS

- Perfect flowers
- Zygomorphic symmetry
- **BANNER** (standard) petal internal to 2 distinct lateral (**WING**) petals and 2 distinct petals forming the **KEEL**
- Calyx, Corolla and Androecium usually distinct
- Hypanthium present [too small to see]
- Stamens usually 10 [or fewer] and anthers often opening by pores

INFLORESCENCE TYPE(S)

- Mostly racemes or spikes

FRUIT TYPE(S)

- **LEGUMES** [dry and dehiscing along both sutures or breaking into **LOMENTS**]
- Seeds without endosperm, often with an O-shaped groove [**PLEUROGRAM**]

HABIT

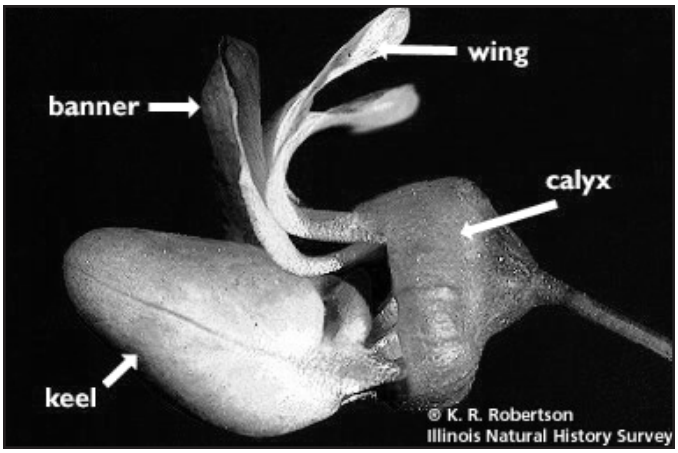
- Tropical and subtropical trees and shrubs
- A few temperate trees and herbs
- Usually without root nodules [only present in 1/3 of species]

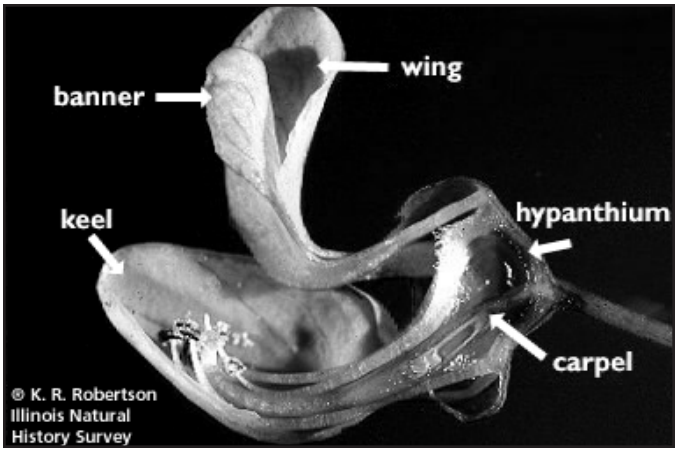
LEAF CHARACTERISTICS

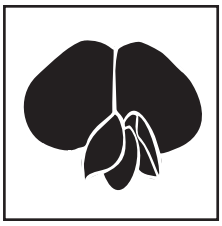
- Pinnately or bipinnately compound leaves, sometimes appearing simple
- Alternate arrangement with a **PULVINUS**
- Stipules present

EXAMPLES

Bauhinia spp. [Orchid Tree]
Caesalpinia pulcherrima (L.) Sw. [Pride of Barbados]
Ceratonia siliqua L. [Carob, St. John's Bread]
Cercis canadensis L. [Redbud]
Chamaecrista fasciculata (Michx.) Greene [Partridge Pea]
Dalbergia spp. [Rosewood]
Delonix regia (Bojer ex Hook.) Raf. [Royal Poinciana]
Gleditsia triacanthos L. [Honey Locust]
Gymnocladus dioicus (L.) K. Koch [Kentucky Coffee tree]
Tamarindus indica L. [Tamarind]







FABOIDEAE

BEAN OR PEA SUBFAMILY

Eudicots: Rosid Clade

♀ $\underline{Ca_{(5)}\ CoZ_{(2)}^{+3}\ A_{(9)}^{+1\text{ or }10}\ G^{1}}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Zygomorphic symmetry
- 1 **BANNER** (standard) petal outermost, 2 distinct lateral **WING** petals and 2 petals fused to form the **KEEL**
- Hypanthium present [too small to see]
- 10 stamens usually **DIADELPHOUS** [9 connate filaments and 1 distinct filament]; sometimes stamens **MONADELPHOUS** or all distinct

INFLORESCENCE TYPE(S)

- Racemes, spikes or heads

FRUIT TYPE(S)

- Diverse **LEGUMES**
- Seeds without endosperm and **PLEUROGRAM**

HABIT

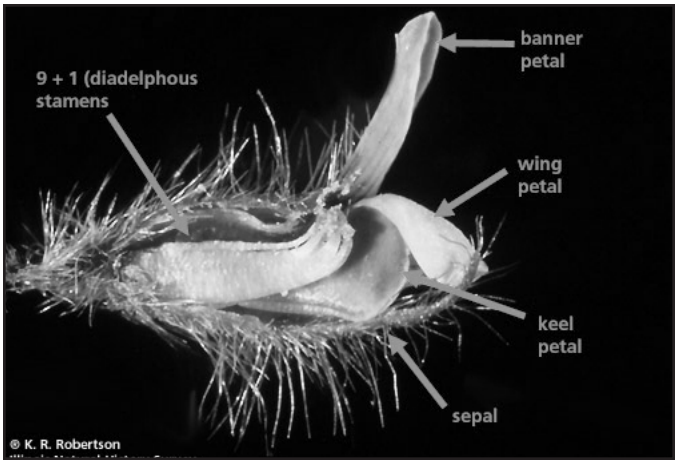
- Mostly herbs, some trees and shrubs
- Temperate, subtropical and tropical
- Usually with root nodules

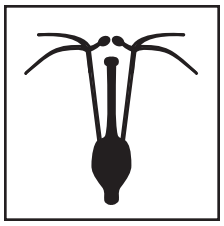
LEAF CHARACTERISTICS

- Usually pinnately compound, sometimes palmately compound; rarely simple
- Alternate arrangement
- Stipules present

EXAMPLES

Amorpha canescens Pursh [Lead Plant]
Arachis hypogaea L. [Peanut]
Baptisia spp. [False Indigo]
Cladrastis kentukea (Dum. Cours.) Rudd [Yellowwood]
Coronilla varia (L.) Lassen [Crownvetch]
Dalea spp. [Prairie Clover]
  D. purpurea Vent. var. purpurea [Purple Prairie Clover]
  D. candida Michx. [White Prairie Clover]
  D. foliosa (A. Gray) Barneby [Leafy Prairie Clover]
Desmodium illinoense A. Gray [Tick Trefoil]
Erythrina herbacea L. [Redcardinal]
Glycine max (L.) Merr. [Soybean]
Glycyrrhiza glabra L. [Cultivated Licorice]
Lathyrus spp. [Sweet Peas]
Lens culinaris Medik. [Lentil]
Lupinus spp. [Lupines]
Medicago spp. [Alfalfa]
Phaseolus vulgaris L. [Common Bean]
Pisum sativum L. [Garden Pea]
Pueraria lobata (Willd.) Ohwi [Kudzu-vine]
Robinia pseudoacacia L. [Black Locust]
Trifolium spp. [Clover]

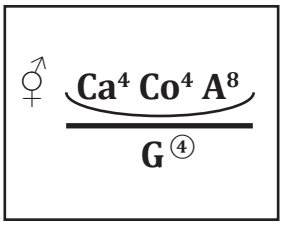




ONAGRACEAE

EVENING PRIMROSE FAMILY

Eudicots: Rosid Clade



FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Flowers 4-merous with hypanthium
- Pollen sometimes with **VISCIN THREADS**
- Syncarpous gynoecium made up of 4 connate carpels
- Inferior ovary
- Often numerous axile or parietal ovules

INFLORESCENCE TYPE(S)

- Flowers solitary and axillary or in racemes or spikes

FRUIT TYPE(S)

- Capsule or berry

HABIT

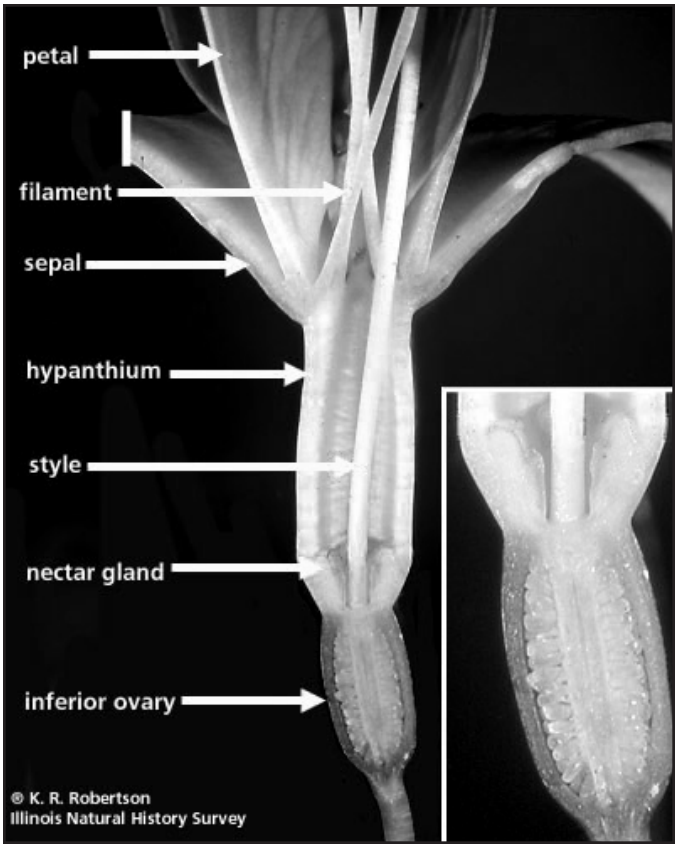
- Herbs or shrubs
- Sometimes aquatic

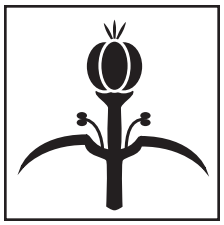
LEAF CHARACTERISTICS

- Simple leaves
- Alternate, opposite or whorled arrangement
- No stipules

EXAMPLES

Clarkia spp. [Clarkia]
Epilobium spp. [Willowherb]
Fuchsia spp. [Fuchsia]
Ludwigia spp. [False Loosestrife]
Oenothera biennis L. [Common Evening Primrose]





EUPHORBIACEAE

SPURGE FAMILY

Eudicots: Rosid Clade

♂ $Ca^0\ Co^0\ A^1\ G^0$

♀ $Ca^0\ Co^0\ A^0\ G^{\textcircled{3}}$

FLORAL CHARACTERISTICS

- Imperfect flowers
- Plants monoecious (usually) or dioecious
- Actinomorphic symmetry
- Syncarpous gynoecium made up of 3 connate carpels
- Superior ovary
- 3-locular ovary with 1 apical ovule per locule

INFLORESCENCE TYPE(S)

- A **CYATHIUM** with staminate flowers (consist of only 1 stamen), carpellate flowers (consist of only a syncarpous gynoecium), nectar glands and petal-like appendages

FRUIT TYPE(S)

- **SCHIZOCARPS** splitting into **MERICARPS**

HABIT

- Extremely variable - annual or perennial herbs, shrubs or, in the tropics, large trees
- Often **SUCCULENT** and resembling cacti, especially in southern Africa
- Often with milky sap
- Often poisonous

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement

EXAMPLES

Acalypha spp. [Chenille plant, Copperleaf]

Chamaesyce spp. [Creeping spurges]

Codiaeum variegatum (L.) A. Juss. [Garden Croton]

Croton spp. [Croton]

Euphorbia spp. [BIG genus, often split into several smaller genera]

- E. corollata L. [Flowering Spurge]
- E. fulgens Karw. ex Klotzsch [Scarlet-Plume]
- E. marginata Pursh [Snow on the Mountain]
- E. milii Des Moul. [Crown of Thorns]
- E. pulcherrima Willd. ex Klotzsch [Poinsettia]
- E. piscatoria Ait. [Figueira do inferno = Fig of Hell]

Hevea brasiliensis (Willd. ex A. Juss.) Müll. Arg. [Rubber Tree]

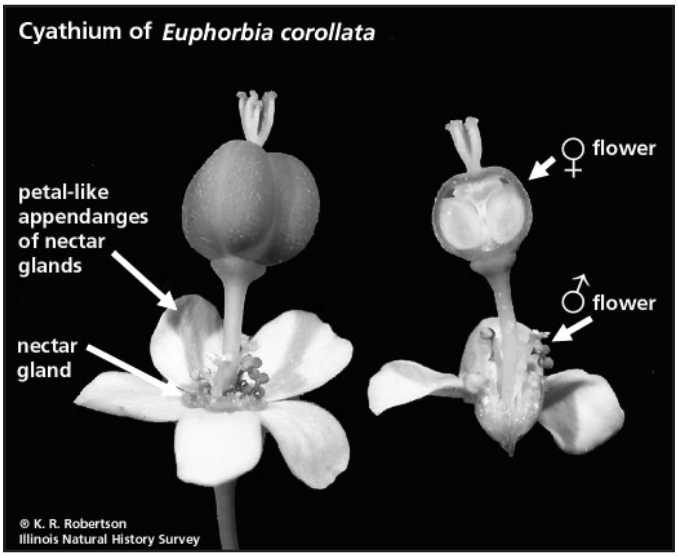
Jatropa podagrica Hook. [Gout plant]

Manihot esculenta Crantz [Cassava, Tapioca]

Ricinus communis L. [Casterbean]

Triadica sebifera (L.) Small [Chinese tallow, Popcorn Tree]

Vernicia fordii (Hemsl.) Airy-Shaw [Tungoil Tree]



ROSACEAE

ROSE FAMILY

Eudicots: Rosid Clade

♀ $\underline{Ca^5\ Co^5\ A^{\infty}}\ G^{\infty}$ or G^1 or $\overline{G^{(2\text{-}5)}}$

FLORAL CHARACTERISTICS

- Perfect, 5-merous flat flowers
- Actinomorphic symmetry
- Hypanthium present, but variable
- Sepals and petals distinct
- Petals round with wavy margins and never really brilliant red or blue in wild
- Stamens whorled
- Superior ovary [except in Subfamily Maloideae]

INFLORESCENCE TYPE(S)

- Various

FRUIT TYPE(S)

- Follicles, achenes, drupes or pomes (not capsules or berries)
- Seeds usually without endosperm

HABIT

- Perennial herbs [rarely annuals], shrubs and trees

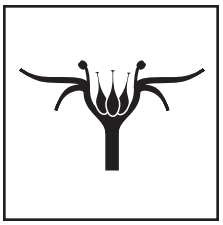
LEAF CHARACTERISTICS

- Simple or compound (pinnate or palmate) leaves
- Alternate arrangement
- Usually stipules present

FOUR SUBFAMILIES

- **SPIRAEOIDEAE** (Spirea Subfamily)
- **ROSOIDEAE** (Rose Subfamily)
- **AMYGDALOIDEAE** (Peach Subfamily)
- **MALOIDEAE** (Apple Subfamily)

	SPIRAEOIDEAE	ROSOIDEAE	AMYGDALOIDEAE	MALOIDEAE
Carpel Number and Fusion	Few (5) distinct carpels	Many distinct carpels	1 carpel	2-5 carpels that are fused to hypanthium
Ovary Position	Superior ovary	Superior ovary	Superior ovary	Inferior ovary
Fruit Type	Follicle	Achenes (in a **HIP**) or drupelets	Drupe	**POME**
Base Chromosome Number	9	7	8	17



SPIRAEOIDEAE

SPIREA SUBFAMILY

Eudicots: Rosid Clade

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Apocarpous gynoecium made up of 2-5 distinct carpels
- Superior ovary
- Marginal ovules
- Base Chromosome Number = 9

EXAMPLES

Aruncus dioicus (Walter) Fernald [Goat's Beard]
Exochorda racemosa (Lindl.) Rehder [Pearlbush]
Physocarpus spp. [Ninebark]
Sorbaria sorbifolia (L.) A. Braun [False Spiraea]
Spiraea spp. [Spirea, Meadowsweet, Hardhack, Steeple-bush]
Neillia sinensis Oliv. [Chinese Neillia]

FRUIT TYPE(S)

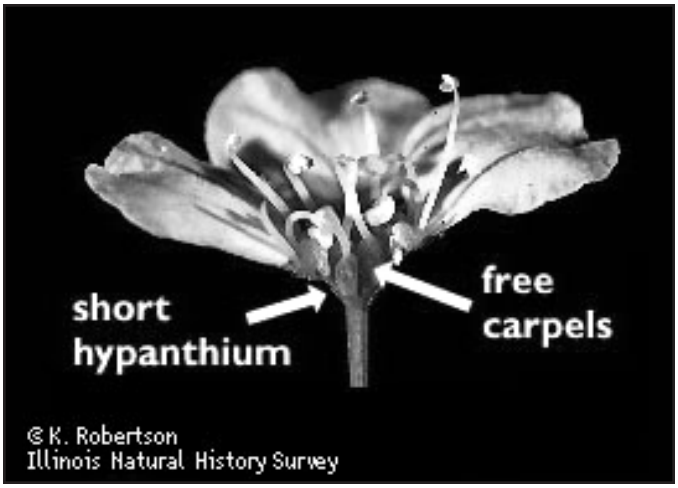
- Follicle [can have up to 5 follicles from one flower]

HABIT

- Mostly shrubs, some herbs

LEAF CHARACTERISTICS

- Most have simple leaves, but Aruncus and Sorbaria have pinnately compound leaves
- Alternate arrangement



ROSOIDEAE

ROSE SUBFAMILY

Eudicots: Rosid Clade

♀ $\underbrace{Ca^5\ Co^5\ A^{10-\infty}}\ G^{\infty}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Apocarpous gynoecium made up of many distinct carpels
- Superior ovary
- Marginal ovules
- Base Chromosome Number = 7

FRUIT TYPE(S)

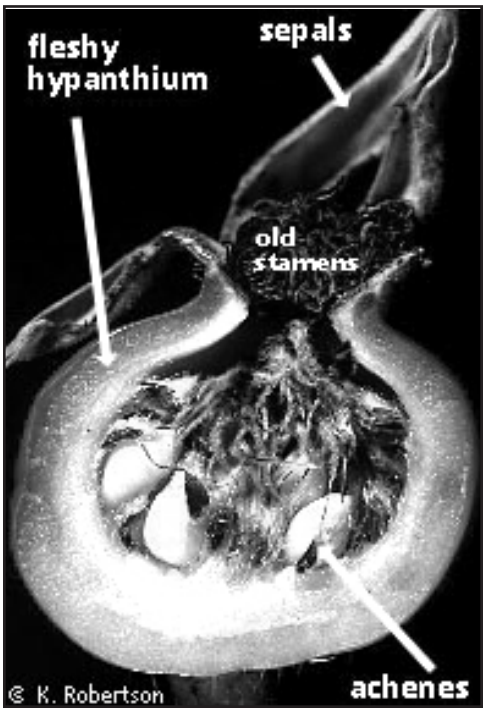
- Achenes [in **HIPS** in Rosa]
- Aggregate fruit of drupelets in Rubus

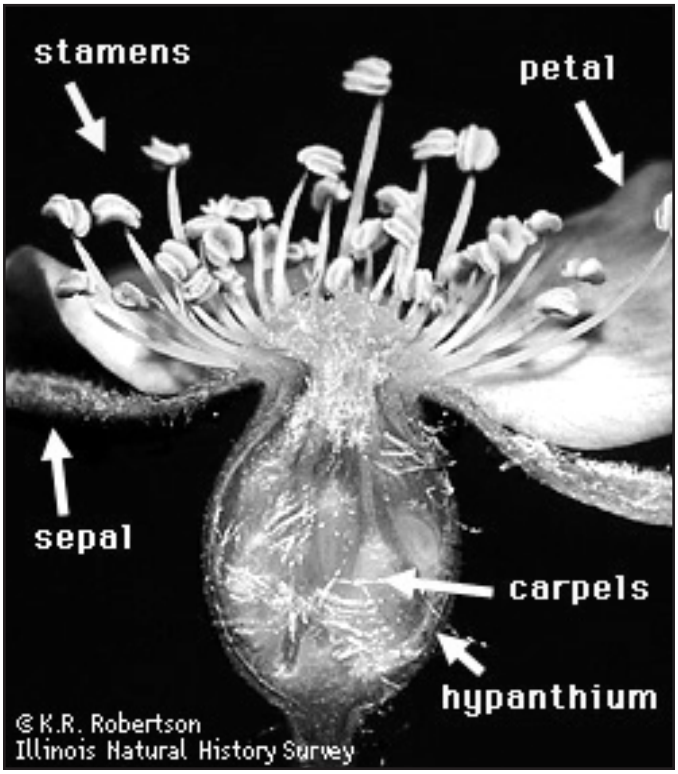
HABIT

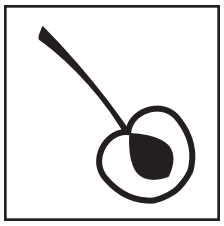
- Shrubs and perennial herbs, rarely annuals

EXAMPLES

Duchesnea indica (Andrews) Focke [Indian Strawberry]
Filipendula rubra (Hill) B.L. Rob. [Queen-of-the-Prairie]
Fragaria spp. [Strawberry]
Geum triflorum Pursh [Prairie Smoke]
Kerria japonica (L.) DC. [Japanese Rose]
Potentilla spp. [Cinquefoil]
Rhodotypos scandens (Thunb.) Makino [Jetbead]
Rosa spp. [Rose]
Rubus spp. [Blackberry, Raspberry]
Sanguisorba spp. [Burnet]
Waldsteinia spp. [Barren Strawberry]







AMYGDALOIDEAE

PEACH SUBFAMILY

Eudicots: Rosid Clade

♀ $\underbrace{Ca^5\ Co^5\ A^{5\text{-}15}}\ G^1$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Monocarpous gynoecium
- Superior ovary
- Marginal ovules
- Base Chromosome Number = 8

EXAMPLES

Prinsepia spp. [Prinsepia]

Prunus spp. [Cherry, Peach, Plum, Apricot, Almond, Nectarine]

P. avium (L.) L. (Sweet Cherry)

P. dulcis (Mill.) D.A. Webb (Sweet Almond)

P. persica (L.) Batsch (Peach)

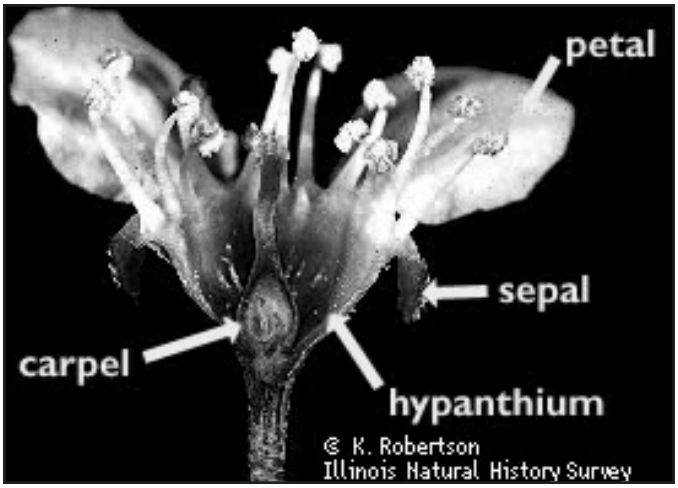
Maddenia spp. [Maddenia]

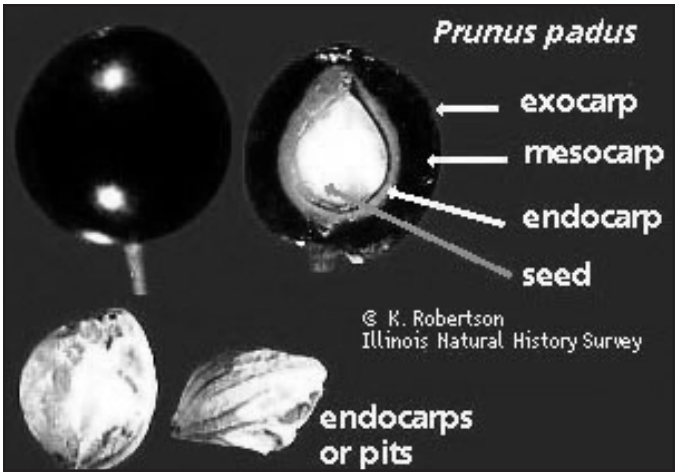
FRUIT TYPE(S)

- Drupe

HABIT

- Trees and shrubs [NO herbs]
- Bark often beautiful with horizontal **LENTICELS**

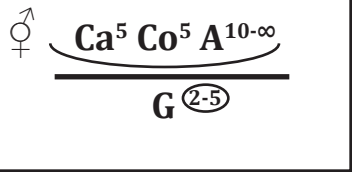




MALOIDEAE

APPLE SUBFAMILY

Eudicots: Rosid Clade



FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Syncarpous gynoecium made up of 2-5 [somewhat] connate carpels
- Half to completely inferior ovary
- Ovary partly to completely adnate to hypanthium
- Base Chromosome Number = 17

FRUIT TYPE(S)

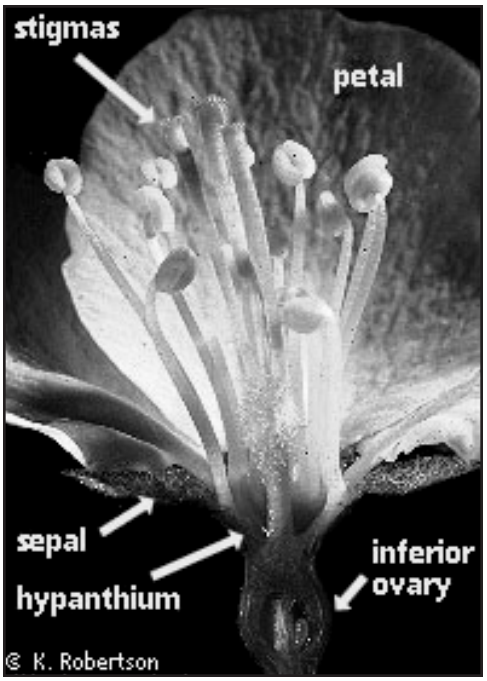
- **POME** with a core or with small stones

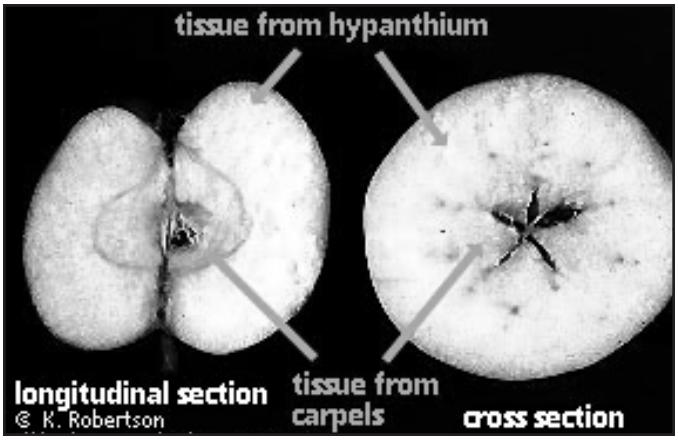
HABIT

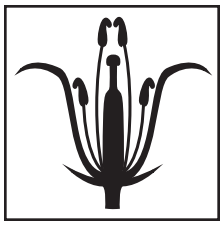
- Trees and shrubs

EXAMPLES

Amelanchier spp. [Shadbush]
Aronia spp. [Chokeberry]
Chaenomeles spp. [Japanese Quince]
Cotoneaster spp. [Cotoneaster]
Crataegus spp. [Hawthorn]
Cydonia spp. [Quince]
Malus spp. [i.e. Apple, Crabapple]
Pyracantha spp. [Firethorn]
Pyrus spp. [Pear]
Sorbus spp. [Mountain Ash]







BRASSICACEAE (CRUCIFERAE)

MUSTARD FAMILY

Eudicots: Rosid Clade

♀ $Ca^4\ Co^4\ A^{4+2}\ \underline{G^{②}}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- 4-merous flowers [traditional family name is Cruciferae meaning “cross”]
- **TETRADYNAMOUS** stamens: 4 long and 2 short stamens
- Syncarpous gynoecium made up of 2 connate carpels
- Superior ovary
- 2-locular ovary with many parietal ovules

INFLORESCENCE TYPE(S)

- Bractless racemes

FRUIT TYPE(S)

- **SILIQUES** or **SILICLES** with a **REPLUM** [siliques or silicles may be flattened perpendicular or parallel to the replum]

HABIT

- Annual, biennial or perennial herbs, very rarely shrubs
- Produce mustard oil glucosides

LEAF CHARACTERISTICS

- Simple or compound leaves
- Alternate arrangement
- May be pinnately lobed
- No stipules

EXAMPLES

Alliaria petiolata (M. Bieb.) Cavara & Grande [Garlic Mustard]

Armoracia rusticana G. Gaertn., B. Mey. & Scherb. [Horseradish]

Barbarea vulgaris W.T. Aiton [Garden Yellowrocket]

Brassica spp. [Mustards]

- B. campestris L. [e.g. Turnips, Chinese cabbage]
- B. juncea (L.) Czern. [India mustard]
- B. nigra (L.) W.D.J. Koch [Black mustard]
- B. napus L. [Rape seed]
- B. oleracea L. [Cabbage]
- B. oleracea var. botrytis L. [Broccoli]
- B. oleracea var. gemmifera DC. [Brussels sprouts]

Capsella bursa-pastoris (L.) Medik. [Shepherd’s purse]

Cardamine concatenata (Michx.) Sw. [Cutleaf Toothwort]

Hesperis matronalis L. [Dames Rocket]

Iberis spp. [Candytuft]

Matthiola spp. [Stocks]

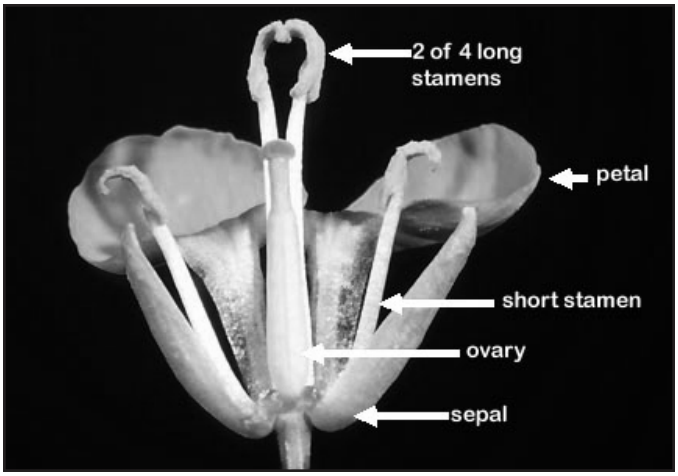
Lepidium spp. [Pepperweeds]

Lesquerella ludoviciana (Nutt.) S. Watson [Bladderpod]

Lunaria annua L. [Money plant, Honesty]

Nasturtium officinale W.T. Aiton [Watercress]

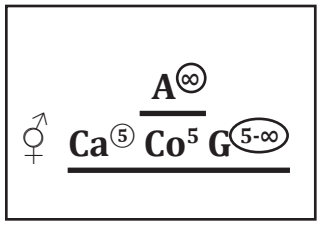
Raphanus sativus L. [Cultivated Radish]



MALVACEAE

MALLOW FAMILY

Eudicots: Rosid Clade



FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Sepals often subtended by bracts **[EPICALYX]**
- Petals distinct but adnate to the staminal tube
- **MONADELPHOUS** stamens - the filaments of the stamens are connate forming a tube around the gynoecium
- Anthers unilocular and crescent-shaped
- Syncarpous gynoecium made up of many connate carpels
- Superior ovary enclosed by staminal tube
- Many locules with many axile ovules

INFLORESCENCE TYPE(S)

- Flowers solitary or in cymes

FRUIT TYPE(S)

- Schizocarps or capsules
- Berries

HABIT

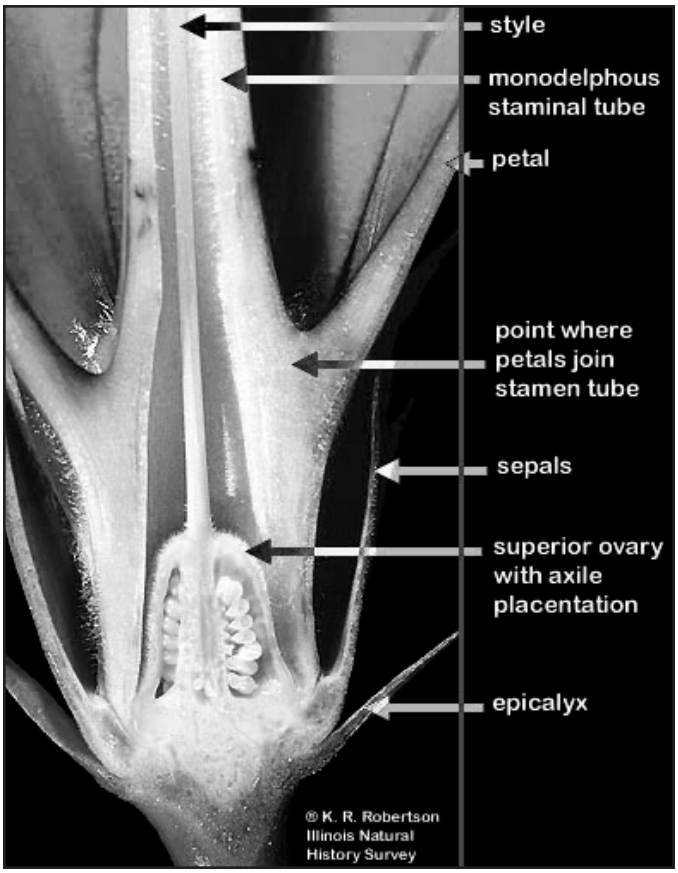
- Herbs and shrubs, rarely trees
- Stellate hairs common
- Often mucilaginous sap

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Often toothed and palmately lobed and veined

EXAMPLES

Abelmoschus esculentus (L.) Moench [Okra]
Abutilon theophrasti Medik. [Velvetleaf]
Alcea rosea L. [Hollyhock]
Althaea officinalis L. [Common Marshmallow]
Callirhoë spp. [Poppy Mallow]
Gossypium spp. [Cotton]
Hibiscus spp. [Rosemallow]
H. syriacus L. [Rose-of-Sharon]
Iliamna remota Greene [Kankakee Mallow]
Napaea dioica L. [Glademallow]



ACERACEAE

MAPLE FAMILY

Eudicots: Rosid Clade

♂ or ♀ ♂ ♀ $Ca^{5(4)}\ Co^{5(4)}\ A^{8,10,5\,*}\ G^{\underline{2}\,\dagger}$

Rudimentary in ♀ flowers (*) and ♂ flowers (†)

FLORAL CHARACTERISTICS

- Imperfect (usually) or perfect flowers
- If imperfect, plants monoecious or dioecious
- Actinomorphic symmetry
- Syncarpous gynoecium made up of 2 connate carpels
- Superior winged ovary
- 2-locular ovary with 2 axile ovules per locule
- Wind or insect pollinated [latter with nectar disk]

INFLORESCENCE TYPE(S)

- Various

FRUIT TYPE(S)

- **SAMAROID SCHIZOCARPS** [Schizocarps break into 2 samaras]

HABIT

- Deciduous trees and some shrubs

LEAF CHARACTERISTICS

- Simple palmately lobed [divided] leaves or compound leaves [pinnately compound in Acer negundo]
- Opposite arrangement
- No stipules

EXAMPLES

Acer spp. [Maples]

A. ginnala Maxim. [Amur maple]

A. griseum (Franch.) Pax [Paperbark maple]

A. negundo L. [Box-elder]

A. nigrum Michx. f. [Black maple]

A. palmatum Thunb. [Japanese maple]

A. pensylvanicum L. [Striped maple, Moosewood]

A. platanoides L. [Norway maple]

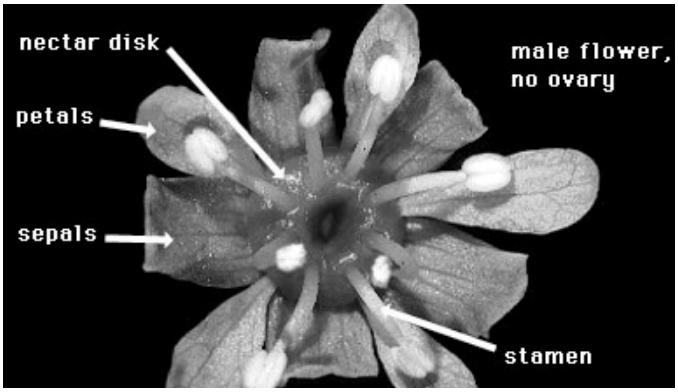
A. pseudoplatanus L. [Sycamore maple]

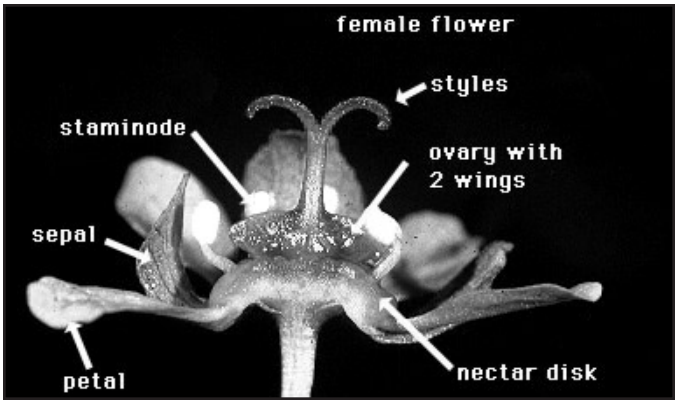
A. rubrum L. [Red maple]

A. saccharinum L. [Silver maple]

A. saccharum Marsh. [Sugar maple]

[40 gallons of sap = 1 gallon of syrup]





ERICACEAE

HEATHER FAMILY

Eudicots: Asterid Clade

$$\text{♀}\ \frac{Ca^{5}\ Co^{(5)}\ A^{10}\ G^{(2\text{-}10)}}{}$$

OR ♂ $\frac{Ca^{5}\ Co^{(5)}\ A^{10}}{G^{(5)}}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry [zygomorphic in Rhododendron]
- Perianth often **URCEOLATE** or **CAMPANULATE**
- Anthers often **APPENDAGED** and opening by pores
- Pollen often in tetrads
- Syncarpous gynoecium; style hollow
- Superior or inferior ovary
- Ovary has as many locules as carpels with many axile ovules

INFLORESCENCE TYPE(S)

- Various

FRUIT TYPE(S)

- Capsules, berries or drupes

HABIT

- Mainly small to large, evergreen or deciduous shrubs
- Prefers acidic soil

LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Mostly entire margin
- Often thick, leathery and evergreen
- No stipules

EXAMPLES

Arbutus spp. [Madrone]

Arctostaphylos spp. [Bearberry, Manzanita]

Calluna and Erica spp. [Heathers]

Calluna vulgaris (L.) Hull [Heather]

Erica tetralix L. [Crossleaf Heath]

Kalmia angustifolia L. [Sheep Laurel]

Oxydendrum arboreum (L.) DC. [Sourwood]

Pieris spp. [Fetterbush]

Rhododendron spp. [e.g. Rhododendron, Azaleas]

Rhododendrons are usually everygreen while Azaleas are mostly deciduous [exceptions to both do occur].

Vaccinium spp. [e.g. Blueberries, Cranberries]

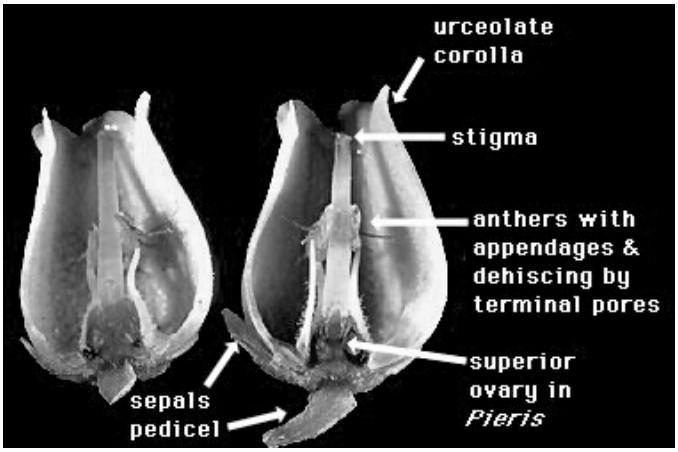
Pyrola spp. [Wintergreen]

Chimaphila spp. [Pipsissewa]

These two genera are often placed in a separate family, Pyrolaceae.

Monotropa spp. [Indian Pipe]

This genus and related genera, which are saprophytic, are often placed in a separate family, Monotropaceae.



ASCLEPIADACEAE

MILKWEED FAMILY

Eudicots: Asterid Clade

$$\text{♀}\ \frac{\text{Ca}^{(5)}\ \text{Co}^{(5)}\ \text{G}^{(2)}}{\text{A}^{(5)}}$$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Petals often with **HORN** and **HOOD** that make up the **CORONA**
- Pollen in pollinia and pollinia of adjacent anther sacs connected by **TRANSLATOR ARMS** with gland or **CORPUSCULUM**
- Androecium [filaments and anthers] and stigma fused into a **GYNOSTEGIUM**
- Syncarpous gynoecium made up of 2 carpels that are distinct below
- Superior ovary
- Ovary with many marginal ovules

INFLORESCENCE TYPE(S)

- Umbels or cymes
- Flowers solitary in succulent species

FRUIT TYPE(S)

- Follicles
- Seeds with a **COMA** of hairs

HABIT

- Perennial herbs, vines, often trees and shrubs in the tropics and succulents in South Africa
- Milky sap

LEAF CHARACTERISTICS

- Simple leaves
- Opposite or whorled arrangement
- Entire margin
- No stipules

EXAMPLES

Asclepias spp. [Milkweeds]

A. curassavica L. [Bloodflower]

A. incarnata L. [Swamp Milkweed]

A. sullivantii Engelm. ex A. Gray [Sullivant's Milkweed]

A. syriaca L. [Common Milkweed]

A. tuberosa L. [Butterfly Milkweed]

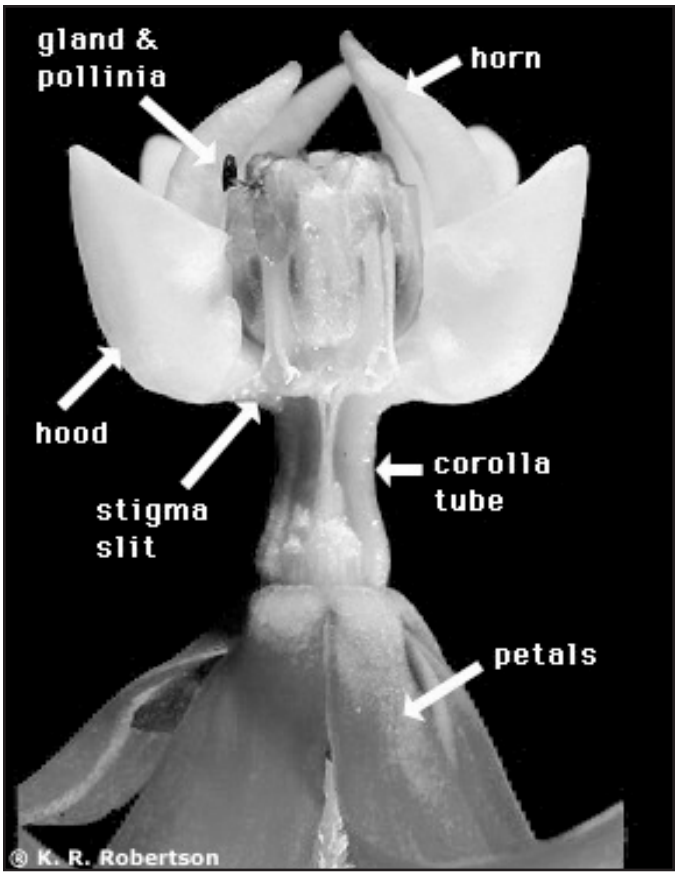
A. verticillata L. [Whorled Milkweed]

Ceropegia sandersonii Decne. ex Hook. [Parachute plant]

Hoya carnosa (L. f.) R. Br. [Porcelainflower]

Stapelia hirsuta L. [Carrion flower]

Stephanotis floribunda Brongn. [Madagascar jasmine]



SOLANACEAE

POTATO FAMILY

Eudicots: Asterid Clade

$$\frac{A^{5}}{\varphi\ \underline{Ca^{(5)}\ Co^{(5)}\ G^{(2)}}}$$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry [or weakly zygomorphic]
- Corolla **PLICATE**
- Epipetalous stamens [stamens adnate to petal tube]
- Anthers often **CONNIVENT**
- Syncarpous gynoecium made up of 2 connate carpels
- Superior ovary
- 2-locular ovary with many axile ovules

INFLORESCENCE TYPE(S)

- Flowers in cymes or solitary

FRUIT TYPE(S)

- Berries or capsules

HABIT

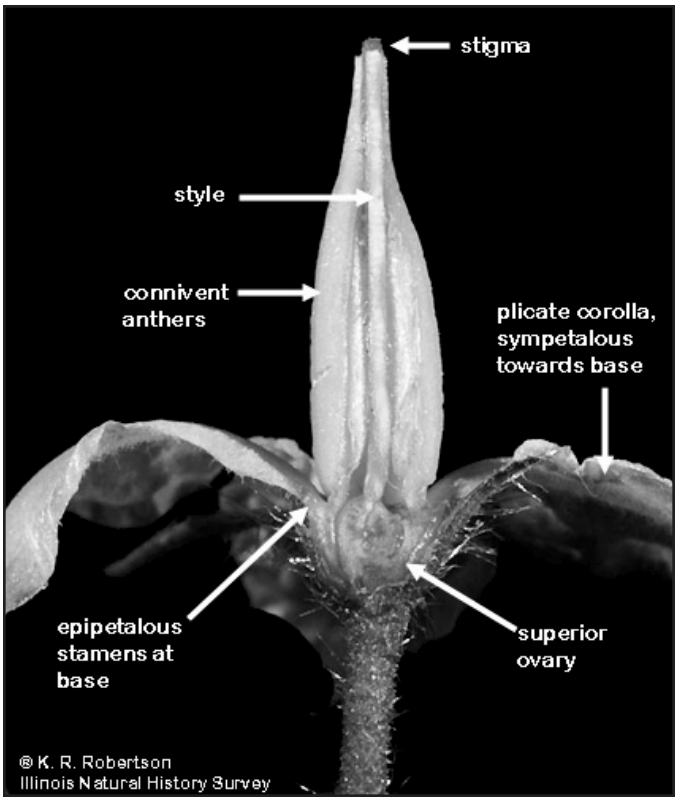
- Mostly herbaceous
- Some shrubs, woody vines and trees in the tropics
- Some species poisonous, medicinal or hallucinogenic

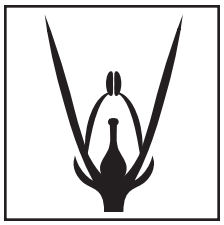
LEAF CHARACTERISTICS

- Simple leaves
- Alternate arrangement
- Entire or variously lobed to pinnate margin
- No stipules

EXAMPLES

Atropa bella-donna L. [Atropine]
Browallia spp. [Browallia]
Capsicum spp. [Peppers]
Datura spp. [Jimsonweed]
Nierembergia spp. [Cupflower]
Nicotiana tabacum L. [Tobacco]
Petunia × hybrida [Petunia]
Physalis spp. [Chinese lanterns]
  P. ixocarpa Brot. [Tomatillo]
Schizanthus spp. [Butterfly flower]
Solanum spp. [e.g. Nightshades, Potatoes, Eggplant]
  S. lycopersicum L. [Garden Tomato]
  S. melongena L. [Eggplant]





OLEACEAE

OLIVE FAMILY

Eudicots: Asterid Clade

$$\frac{A^{2}}{\male\ Ca^{(4)}\ Co^{(4)}\ G^{(2)}}$$

FLORAL CHARACTERISTICS

- Perfect or imperfect flowers
- If imperfect flowers, plants dioecious
- Actinomorphic symmetry
- 4-merous flowers
- 2 epipetalous stamens
- Syncarpous gynoecium made up of 2 connate carpels
- Superior ovary
- 2-locular ovary with 2 axile ovules in each locule [except 4-10 in Forsythia]

INFLORESCENCE TYPE(S)

- Racemes or panicles

FRUIT TYPE(S)

- Berry, capsule, drupe or samara

HABIT

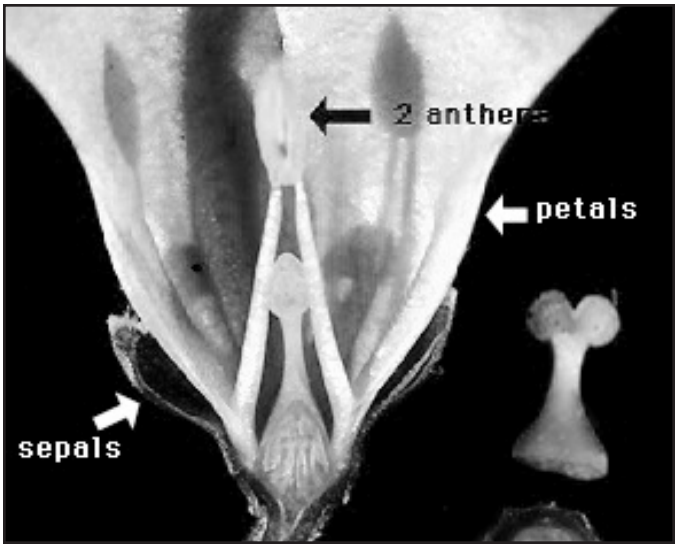
- Trees and shrubs

LEAF CHARACTERISTICS

- Simple or pinnately compound leaves
- Opposite arrangement
- No stipules

EXAMPLES

Chionanthus spp. [Fringe tree]
Forsythia spp. [Forsythia]
Fraxinus spp. [Ash]
Jasminum grandiflorum L. [Jasmine]
Ligustrum spp. [Privet]
Olea europaea L. [Olive]
Syringa spp. [Lilac]



SCROPHULARIACEAE

FIGWORT FAMILY

Eudicots: Asterid Clade

$$\frac{A^{2 \text{ or } 4\,(5)}}{\female\ CaZ^{\textcircled{5}}\ CoZ^{\textcircled{5}}\ G^{\textcircled{2}}}$$

FLORAL CHARACTERISTICS

- Perfect flowers
- Zygomorphic symmetry [2-lipped] to nearly actinomorphic
- Sepals and petals each connate
- Epipetalous stamens
- 2 or 4 **DIDYNAMOUS** stamens
- 5th **STAMINODE** sometimes present
- Syncarpous gynoecium made up of 2 connate carpels
- Superior ovary
- 2-locular ovary with many axile ovules

INFLORESCENCE TYPE(S)

- Various cymes and racemes

FRUIT TYPE(S)

- 2-valved capsules
- Seeds are tiny

HABIT

- Annual or perennial herbs, shrubs, trees or woody vines
- Many photosynthetic root parasites

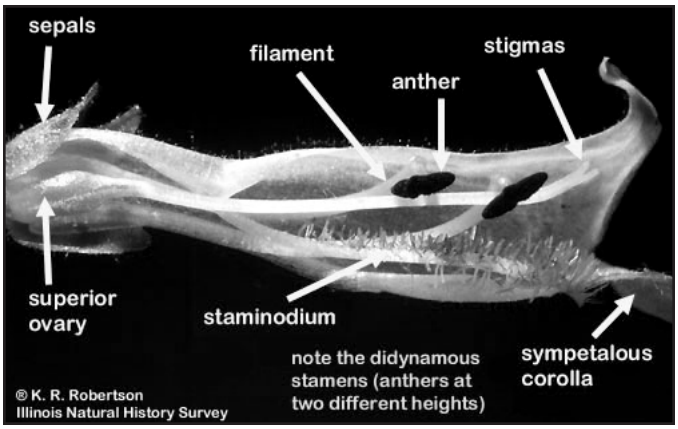
LEAF CHARACTERISTICS

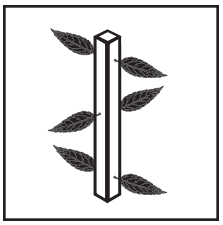
- Simple to divided or compound leaves
- Alternate, opposite or whorled arrangement
- No stipules

EXAMPLES

Antirrhinum spp. [Snapdragon]
Calceolaria spp. [Slipper Flower]
Castilleja spp. [Indian Paintbrush]
Chelone spp. [Turtlehead]
Collinsia verna Nutt. [Blue-eyed Mary]
Digitalis purpurea L. [Purple Foxglove]
Linaria spp. [Butter & Eggs, Toadflax]
Pedicularis spp. [Lousewort]
Penstemon spp. [Beards-tongue]
Striga spp. [Witchweed]
Verbascum spp. [Mullein]
Veronicastrum virginicum (L.) Farw. [Culver's Root]

OROBANCHACEAE: parasitic, no chlorophyll
BIGNONIACEAE: mostly tropical trees and lianas





LAMIACEAE

MINT FAMILY

Eudicots: Asterid Clade

$$\frac{A^4}{\male\female\ CaZ^{(5)}\ CoZ^{(5)}\ G^{(2)}}$$

FLORAL CHARACTERISTICS

- Perfect flowers
- Zygomorphic symmetry
- Calyx and Corolla tubes each present [Corolla bilabiate: 2-lobed upper, 3-lobed lower]
- Epipetalous stamens
- 2 + 2 **DIDYNAMOUS** stamens
- Syncarpous gynoecium made up of 2 connate carpels; deeply 4-lobed with **GYNOBASIC** style
- Superior ovary
- 4-locular ovary with 1 basal/axile ovule per locule

INFLORESCENCE TYPE(S)

- Axillary cymes or **VERTICILS**

FRUIT TYPE(S)

- 4 nutlets
- Pericarp tightly surrounds each seed

HABIT

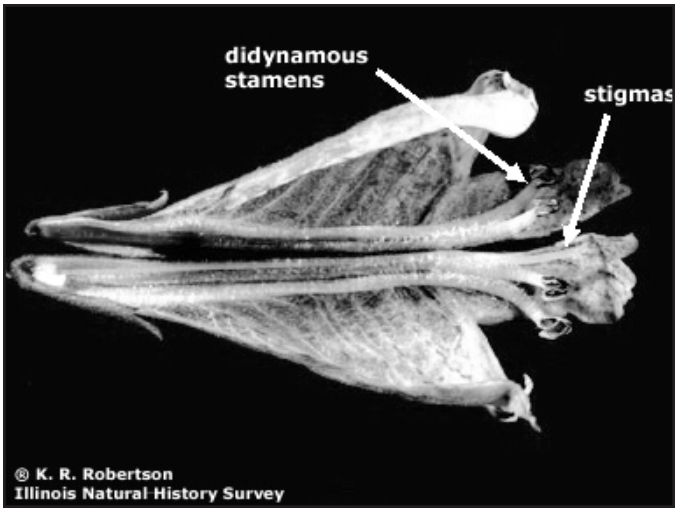
- Aromatic annual or perennial herbs
- Rarely trees, shrubs or woody vines
- Stems square in cross-section

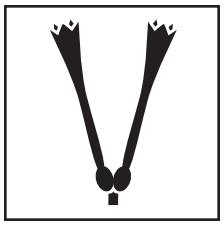
LEAF CHARACTERISTICS

- Simple leaves
- Opposite or whorled arrangement
- No stipules
- Glandular trichomes with essential oils [e.g. menthol]

EXAMPLES

Coleus spp. [Coleus]
Glechoma hederacea L. [Ground Ivy]
Lamium spp. [e.g. Henbit, Dead nettle]
Lavendula spp. [Lavender]
Mentha spp. [Mints]
  M. arvensis L. [Menthol]
  M. piperita L. [Peppermint]
  M. spicata L. [Spearmint]
Monarda fistulosa L. [Beebalm, Horsemint]
Nepeta cataria L. [Catnip]
Ocimum basilicum L. [Basil]
Origanum majorana L. [Marjoram]
Origanum vulgare L. [Oregano]
Physostegia virginiana (L.) Benth. [False Dragonshead]
Rosmarinus officinalis L. [Rosemary]
Salvia officinalis L. [Kitchen Sage]
Satureja hortensis L. [Summer Savory]
Teucrium canadense L. [Canada Germander]
Thymus vulgaris L. [Garden Thyme]

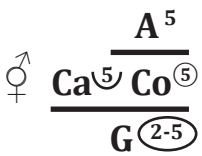




CAPRIFOLIACEAE

HONEYSUCKLE FAMILY

Eudicots: Asterid Clade



FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic or zygomorphic symmetry and sometimes 2-lipped
- Epipetalous stamens
- Syncarpous gynoecium made up of 2-5 connate carpels
- Inferior ovary
- 2 to 5-locular ovary with 1 to few apical ovules per locule
- Ovaries of 2 flowers often paired

INFLORESCENCE TYPE(S)

- Cymes, corymbs, panicles or in axillary clusters

FRUIT TYPE(S)

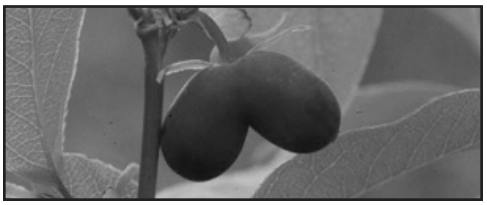
- Berries, capsules or drupes

HABIT

- Shrubs, woody vines and small trees
- Rarely herbs

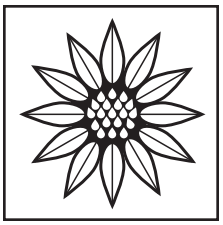
LEAF CHARACTERISTICS

- Simple or pinnately compound leaves
- Opposite arrangement
- No stipules



EXAMPLES

Diervilla spp. [Bush Honeysuckle]
Kolkwitzia amabilis Graebn. [Beautybush]
Linnaea borealis L. [Twinflower]
Lonicera spp. [Honeysuckle]
Sambucus spp. [Elderberry]
Triosteum spp. [Horse Gentian]
Viburnum spp. [e.g. Cranberrybush, Nannyberry]



ASTERACEAE

SUNFLOWER FAMILY

Eudicots: Asterid Clade

$$\varphi \; \frac{\overset{\frown}{A^{5}}}{Ca^{P}\,Co^{\textcircled{5}}} \; \frac{}{G^{\textcircled{2}}}$$

FLORAL CHARACTERISTICS

- Perfect or imperfect flowers
- If imperfect flowers, plants monoecious
- Two kinds of flowers:
  DISK: Actinomorphic, tubular corolla
  RAY: Zygomorphic, ligulate corolla
- Calyx = **PAPPUS**; Bracts = **CHAFF**
- Epipetalous stamens; stamen filaments distinct but anthers connate into a tube around style
- Syncarpous gynoecium made up of 2 connate carpels
- Inferior ovary
- 1-locular ovary with 1 basal ovule

INFLORESCENCE TYPE(S)

- Heads **[CAPITULUM, CAPITULA]** surrounded by **PHYLLARIES**
- Heads arranged in secondary cymes or racemes

FRUIT TYPE(S)

- Achenes

HABIT

- Mostly annual, biennial or perennial herbs
- Shrubs or tree-like at high elevations in the tropics and on some islands

LEAF CHARACTERISTICS

- Mostly simple leaves [often lobed or divided], rarely compound
- Alternate, opposite or whorled arrangement

EXAMPLES: 3 TYPES OF CAPITULA [HEADS]

RADIATE CAPITULUM: Both DISK and RAY flowers

Aster spp. [Aster]
Bidens spp. [Beggar-ticks]
Chrysanthemum spp. [Daisy]
Echinacea, Ratibida, Rudbeckia spp. [Coneflowers]
Helianthus spp. [Sunflowers]
Senecio spp. [Ragworts]
Silphium spp. [Rosinweed]
  S. laciniatum L. [Compass Plant]
  S. perfoliatum L. [Cup Plant]
  S. terebinthinaceum Jacq. [Prairie Dock]
Solidago spp. [Goldenrods]
Tagetes spp. [Marigolds]
Zinnia spp. [Zinnia]

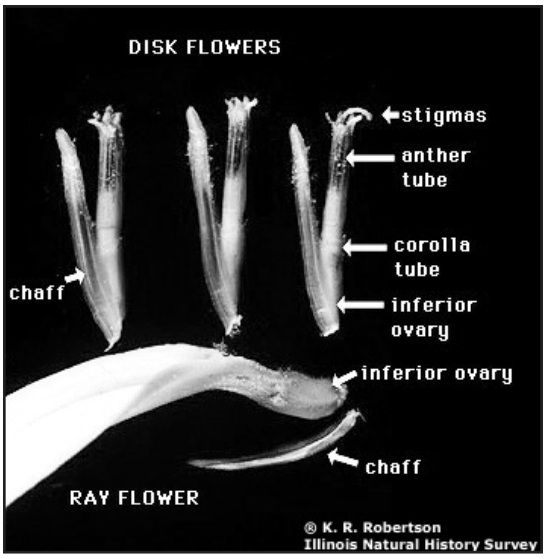
DISCOID CAPITULUM: DISK flowers only

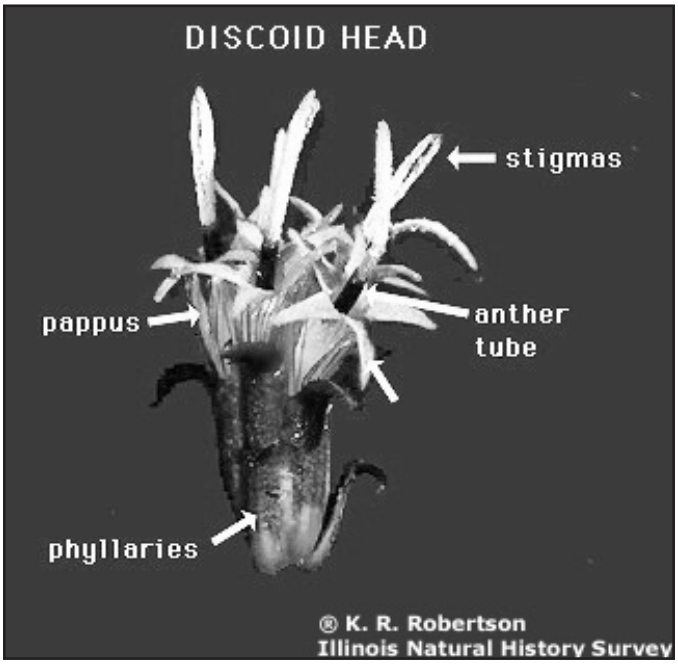
Arctium spp. [Burdock]
Cirsium & Carduus spp. [Thistles]
Cynara scolymus L. [Globe Artichoke]
Eupatorium spp. [Joe-Pyeweed]
Liatris spp. [Blazing Stars]
Vernonia spp. [Ironweeds]

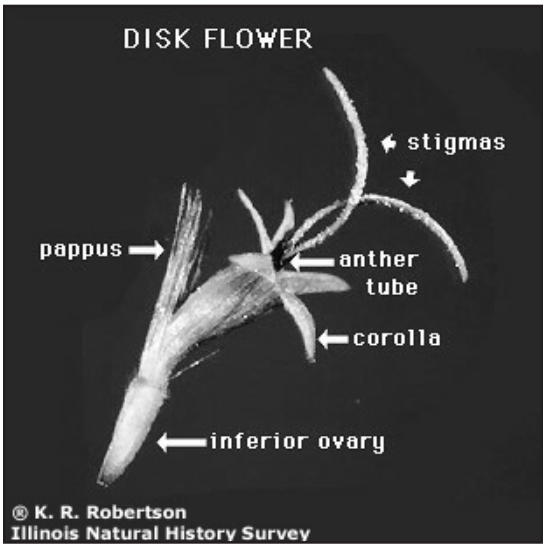
LIGULATE CAPITULUM: RAY flowers only

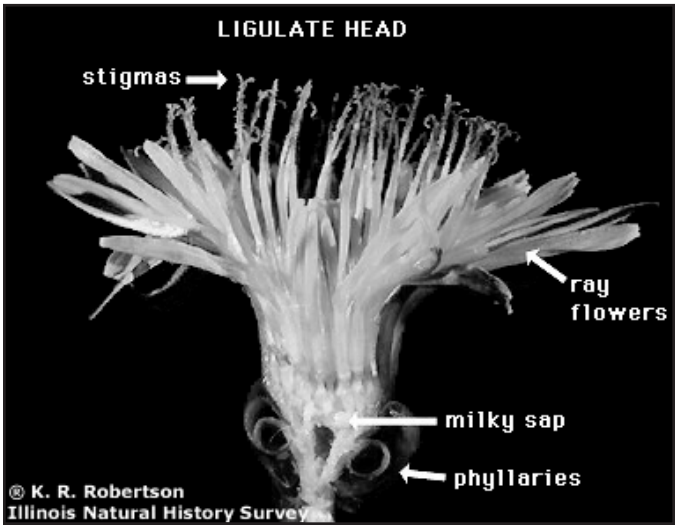
Cichorium spp. [e.g. Chicory, Endive]
Hieracium spp. [Hawkweed]
Krigia spp. [Dwarf Dandelion]
Lactuca spp. [Lettuce]
Taraxacum spp. [Dandelion]
Tragopogon spp. [Goat's Beard]

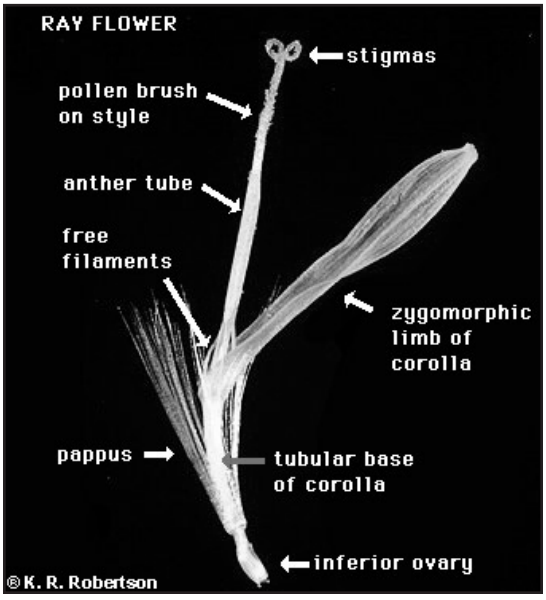

RADIATE HEAD WITH
DISK & RAY FLOWERS
© K. R. Robertson
Illinois Natural History Survey

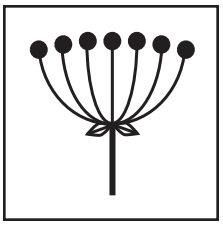

DISK FLOWERS
stigmas
anther tube
corolla tube
chaff
inferior ovary
inferior ovary
chaff
RAY FLOWER
® K. R. Robertson
Illinois Natural History Survey


DISCOID HEAD
stigmas
pappus
anther tube
phyllaries
® K. R. Robertson
Illinois Natural History Survey


DISK FLOWER
stigmas
pappus
anther tube
corolla
inferior ovary
® K. R. Robertson
Illinois Natural History Survey


LIGULATE HEAD
stigmas
ray flowers
milky sap
phyllaries
® K. R. Robertson
Illinois Natural History Survey


RAY FLOWER
stigmas
pollen brush on style
anther tube
free filaments
zygomorphic limb of corolla
pappus
tubular base of corolla
inferior ovary
® K. R. Robertson



APIACEAE (UMBELLIFERAE)

CARROT FAMILY

Eudicots: Asterid Clade

♂ or ♀ $\frac{Ca^5\ Co^5\ A^5}{G\ ②}$

FLORAL CHARACTERISTICS

- Imperfect (usually) or small perfect flowers
- If imperfect, plants monoecious or rarely dioecious
- Actinomorphic symmetry with a trend to zygomorphy
- Syncarpous gynoecium made up of 2 connate carpels; with a **STYLOPODIUM**
- Inferior ovary
- 2-locular ovary with 1 pendulous ovule per locule

INFLORESCENCE TYPE(S)

- Simple or compound umbels

FRUIT TYPE(S)

- Ribbed schizocarps = 2 mericarps that are connected by a **CARPOPHORE**
- Contain oil tubes

HABIT

- Annual, biennial or perennial herbs with hollow stems
- Aromatic and sometimes deadly poisonous

LEAF CHARACTERISTICS

- Most pinnately compound leaves
- Alternate arrangement
- Sheathing leaf base
- Have oil tubes

EXAMPLES

Aegopodium podagraria L. [Bishop's Goutweed]
Anethum graveolens L. [Dill]
Apium graveolens L. [Celery]
Astrantia major L. [Greater Masterwort]
Carum carvi L. [Caraway]
Cicuta bulbifera L. [Bulblet-bearing Water Hemlock]
Conium maculatum L. [Poison Hemlock]
Coriandrum sativum L. [Coriander, Cilantro]
Crithmum maritimum L. [Rock Samphire]
Cuminum cyminum L. [Cumin]
Daucus carota L. [Carrot, Queen Anne's lace]
Eryngium yuccifolium Michx. [Rattlesnake Master]
Foeniculum vulgare Mill. [Sweet Fennel]
Heracleum spp. [Cow Parsnip, Hogweed]
Hydrocotyle bonariensis Comm. ex Lam. [Pennywort]
Monizia edulis Lowe [Tree carrot]
Osmorhiza longistylis (Torr.) DC. [Sweet cicely]
Pastinaca sativa L. [Wild Parsnip]
Petroselinum crispum (Mill.) Nyman ex A.W. Hill [Parsley]
Pimpinella anisum L. [Anise Burnet Saxifrage]
Trachymene spp.
Zizia aurea (L.) W.D.J. Koch [Golden Alexander]

ARACEAE

ARUM FAMILY

Monocot Clade

♂ or ♀ $Ca^{0 \text{ or } 2\text{-}3}\ Co^{0 \text{ or } 2\text{-}3}\ A^{4\text{-}10}\ \underline{G^{(2\text{-}4)}}$

FLORAL CHARACTERISTICS

- Perfect or imperfect flowers
- If imperfect, plants mainly monoecious
- Actinomorphic symmetry
- Flowers very reduced, often sunken into **SPADIX**
- Syncarpous gynoecium made up of 2 to 4 connate carpels
- Superior ovary
- 1 to many-locular ovary with 1 to many ovules

INFLORESCENCE TYPE(S)

- A **SPADIX** subtended by a **SPATHE**
- Can be large [e.g. Amorphophalus]

FRUIT TYPE(S)

- Multiple, often colorful berries

HABIT

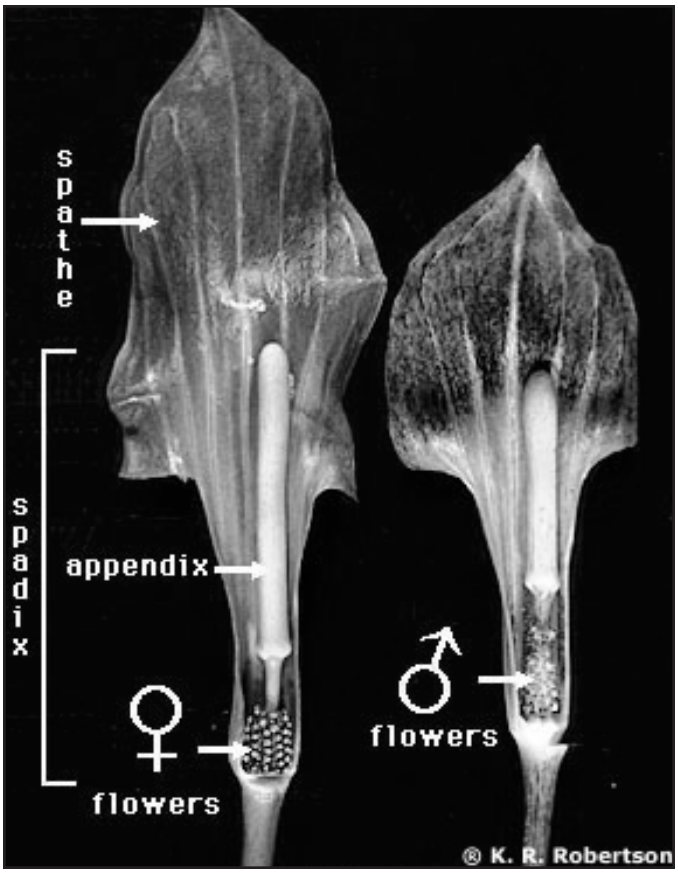
- Perennial herbs or woody vines
- Many species are shade tolerant

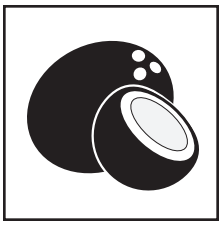
LEAF CHARACTERISTICS

- Simple to pinnately or palmately veined, divided or compound
- Alternate arrangement
- Often with **RAPHIDES** of calcium oxalate, poisonous

EXAMPLES

Amorphophallus titanum (Becc.) Becc. ex Arcang [Titan Arum]
Anthurium spp. [Laceleaf]
Arisaema triphyllum (L.) Schott [Jack-in-the-pulpit]
Caladium spp. [Caladium]
Colocasia esculenta (L.) Schott [Taro root, Poi]
Dieffenbachia spp. [Dumb cane]
Monstera spp. [Monstera]
Philodendron spp. [Philodendron]
Spathiphyllum spp. [Spath or Peace Lilies]
Symplocarpus foetidus (L.) Salisb. ex Nutt. [Skunk cabbage]
Zantedeschia spp. [Calla lily]





ARECACEAE (PALMAE)

PALM FAMILY

Monocot Clade

♀ or ♂ ♀ $Ca^3\ Co^3\ A^6\ G^{3\ or\ \textcircled{3}}$

FLORAL CHARACTERISTICS

- Perfect or imperfect [small] flowers
- If imperfect, plants monoecious or dioecious
- Actinomorphic symmetry
- Apocarpous gynoecium made up of 3 distinct carpels or Syncarpous gynoecium made up of 3 connate carpels
- Superior ovary
- 1 to 3-locular ovary with 1 basal ovule per locule

INFLORESCENCE TYPE(S)

- Various spikes or panicles, sometimes terminal and the plant monocarpic
- Can be gigantic (3,000,000 flowers and 250,000 fruits)

FRUIT TYPE(S)

- Drupe or berry
- 1-seeded
- Can be enormous in size [up to 18" long and 40 lbs in weight]

HABIT

- Unbranched trees, shrubs or woody vines, but without secondary growth

LEAF CHARACTERISTICS

- Often pinnately or palmately compound leaves
- Alternate arrangement
- Sheathing leaf bases
- Sometime huge leaves [up to 65 ft long]

EXAMPLES

Cocos nucifera L. [Coconut Palm]

Corypha umbraculifera L. [Talipot Palm]

Elaeis guineensis Jacq. [African Oil Palm]

Lodoicea maldivica (J.F. Gmel.) Pers. [Double Coconut]

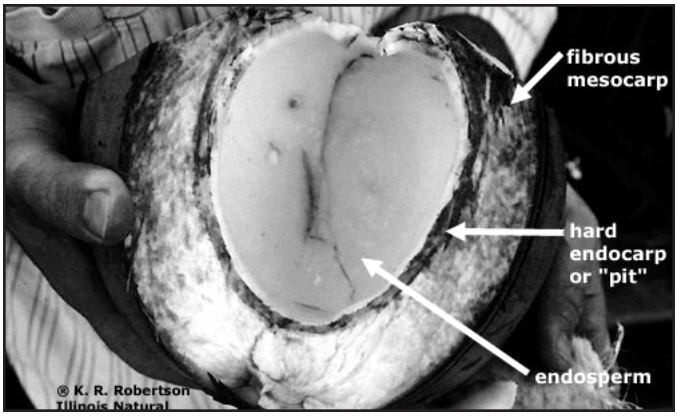
Phoenix dactylifera L. [Date Palm]

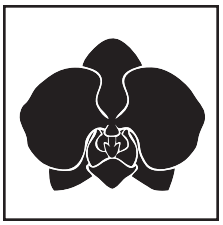
Roystonea elata (Bartram) F. Harper [Royal Palm]

Sabal palmetto (Walter) Lodd. ex Schult. & Schult. f. [Palmetto]

Serenoa repens (Bartram) Small [Saw Palmetto]

Washingtonia filifera (Linden ex André) H. Wendl. [California Fan Palm]





ORCHIDACEAE

ORCHID FAMILY

Monocot Clade

$$\text{♀}\ \frac{\text{Ca}^{3}\ \text{CoZ}^{\,3}\ \text{A}^{1\text{ or }(2)\,(3)}}{\text{G}\,\textcircled{3}}$$

FLORAL CHARACTERISTICS

- Perfect flowers
- Zygomorphic symmetry
- **RESUPINATE** Corolla with 3 petals where one is modified into a **LIP** [**LABELLUM**]
- A and G adnate into a **COLUMN**
- Pollen in **POLLINIA** with a **CAUDICLE** and **VISCIDIUM**
- Part of stigma modified into **ROSTELLUM**
- Syncarpous gynoecium made up of 3 connate carpels
- Inferior [pedicel-like] ovary
- 1-locular ovary with many parietal ovules

INFLORESCENCE TYPE(S)

- Spikes, racemes, panicles or flowers solitary on a scape

FRUIT TYPE(S)

- Loculicidal capsules
- Countless seeds are microscopic and often require a fungal symbiont to germinate

HABIT

- Perennial herbs
- Epiphytic or terrestrial, some saprophytic
- Adventitious roots with **VELAMEN** covering

LEAF CHARACTERISTICS

- Simple, entire [often rather fleshy] leaves
- Alternate or basal arrangement
- In epiphytic species the blade often attached to a **PSEUDOBULB**

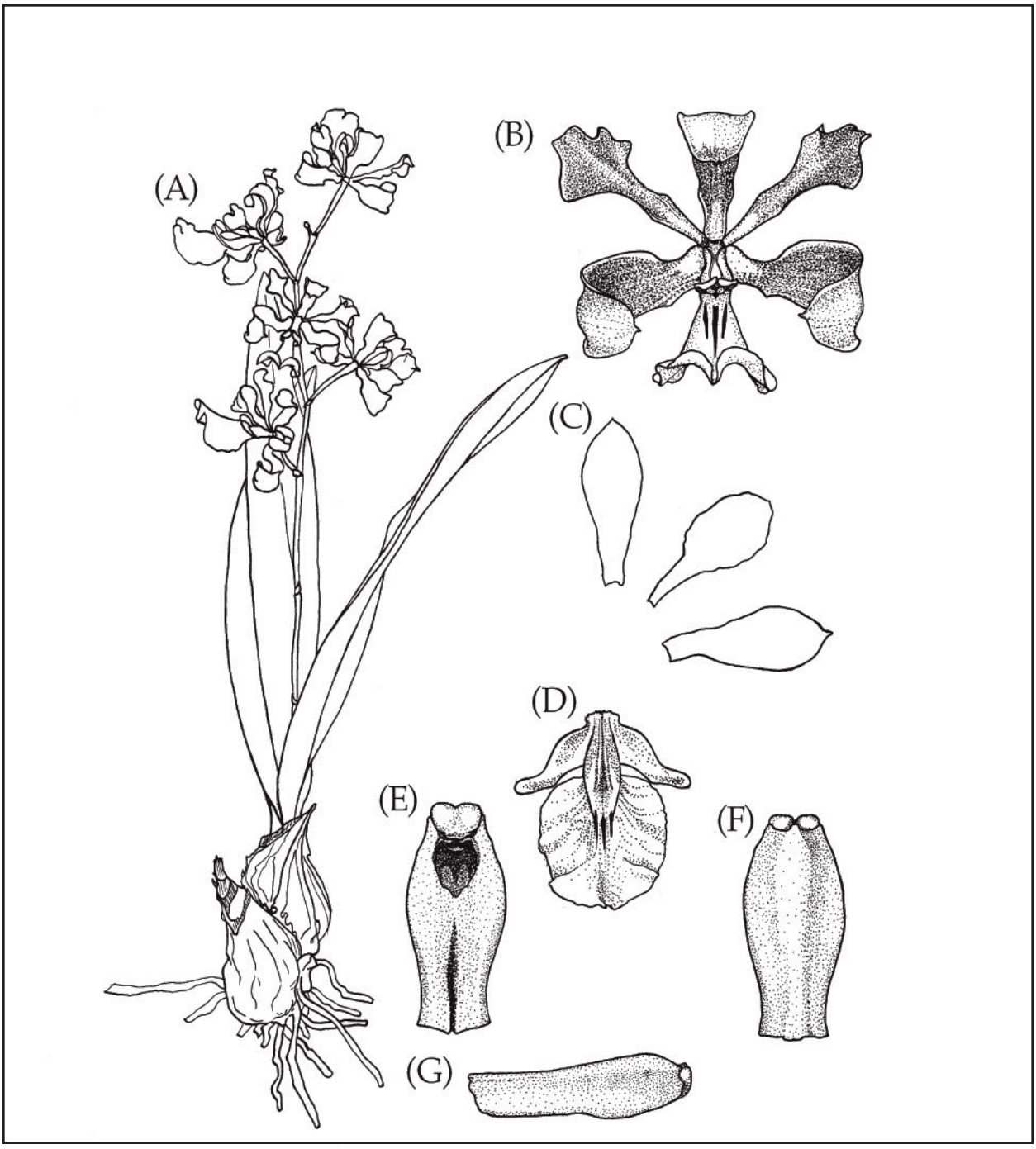
EXAMPLES

TEMPERATE SPECIES

Calopogon spp. [Grass Pink]
Corallorhiza spp. [Coral-root]
Cypripedium spp. [Lady's Slipper]
Goodyera spp. [Rattlesnake Plantain]
Habenaria spp. [Fringed Orchid]
Orchis spp. [Orchids]
Spiranthes spp. [Ladies'-tresses]

TROPICAL SPECIES

Angraecum spp. [Star-of-Bethlehem Orchid]
Cattleya spp. [Cattleya]
Cymbidium spp. [Cymbidium]
Epidendrum spp. [Star Orchid]
Oncidium spp. [Dancing-lady Orchid]
Paphiopedilum spp. [Venus' slipper]
Phalaenopsis spp. [Moth orchid]
Vanda spp. [Vanda]
Vanilla planifolia Jacks. [Vanilla 'beans']



***PLANT SYSTEMATICS, Third Edition*, Figure 9.22**

IRIDACEAE

IRIS FAMILY

Monocot Clade

$$\frac{\text{♂ } Ca^3\ Co^3\ A^3}{G\ \textcircled{3}}$$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic or zygomorphic symmetry
- Hypanthium often present
- Petaloid sepals and showy petals
- Style petaloid in Iris spp.
- 3 stamens in Androecium
- Syncarpous gynoecium made up of 3 connate carpels
- Inferior ovary
- 3-locular ovary with many axile ovules per locule

INFLORESCENCE TYPE(S)

- Cymes, umbels, panicles or flowers solitary on a scape

FRUIT TYPE(S)

- Loculicidal capsules

HABIT

- Perennial herbs with bulbs, rhizomes or corms

LEAF CHARACTERISTICS

- Simple leaves
- Alternate or basal arrangement
- Entire margin
- **EQUITANT** leaves [2 ranked and folded in half lengthwise]
- Sheathing leaf bases

EXAMPLES

Belamcanda chinensis (L.) DC. [Blackberry Lily]

Crocus spp. [Crocus]

C. angustifolius Weston [Cloth of Gold]

C. sativus L. [Saffron = 13,000 stigmas per ounce]

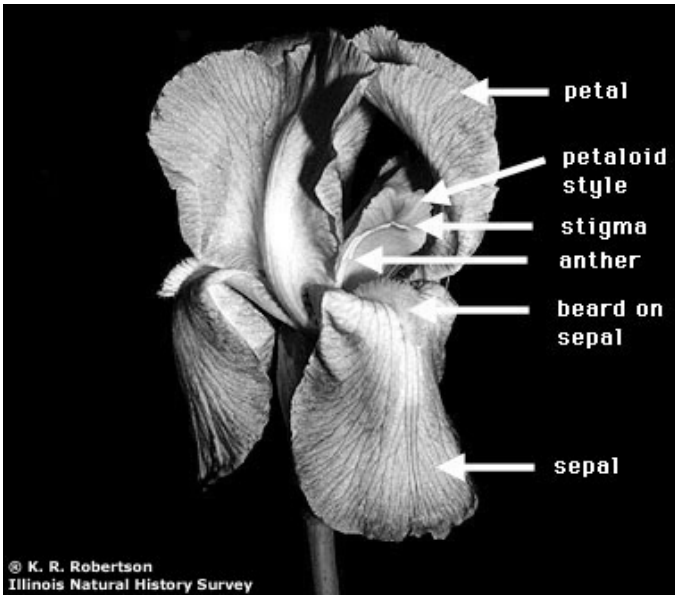
Freesia spp. [Freesia]

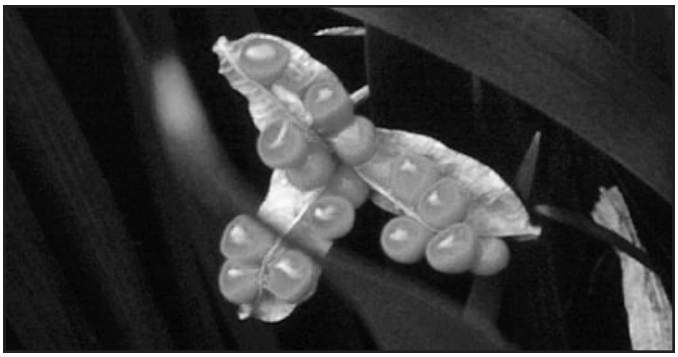
Gladiolus spp. [Gladiolus]

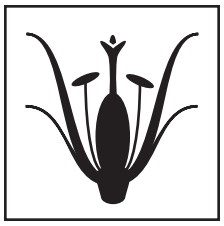
Iris spp. [for Greek Goddess of the Rainbow]

Sisyrinchium spp. [Blue-eyed Grass]

Tigridia spp. [Peacock Flower]







LILIACEAE

LILY FAMILY

Monocot Clade

♀ $Ca^3\ Co^3\ A^6\ G^{③}$

OR ♂ $\frac{Ca^3\ Co^3\ A^6}{G^{③}}$

FLORAL CHARACTERISTICS

- Perfect flowers
- Actinomorphic symmetry
- Sepals and petals similar [thus both called **TEPALS**] except in Trillium spp.
- **TEPALS** distinct or connate
- 6 stamens with often **VERSATILE** anthers
- Syncarpous gynoecium made up of 3 connate carpels
- Superior or inferior ovary
- 3-locular ovary with 1 to many axile ovules per locule

INFLORESCENCE TYPE(S)

- Umbels, panicles, racemes or flowers solitary on a scape

FRUIT TYPE(S)

- Capsules and berries

HABIT

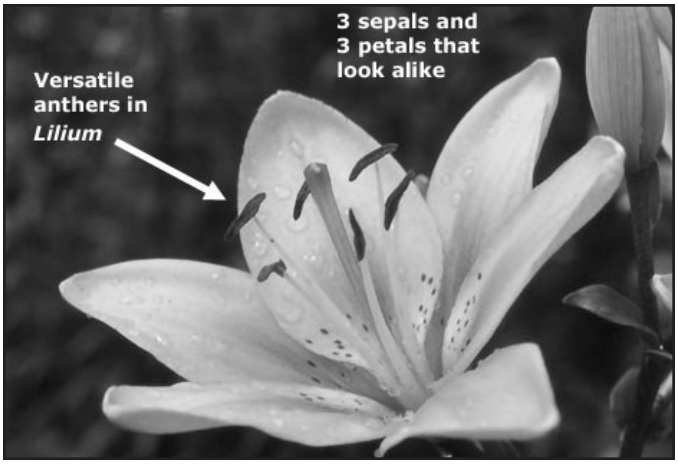
- Perennial herbs often with bulbs, rhizomes or corms

LEAF CHARACTERISTICS

- Simple leaves
- Alternate or basal arrangement, rarely whorled
- Entire margin
- Often sheathing leaf bases
- Leaves reduced to scales in Asparagus

EXAMPLES

Allium spp. [e.g. Onion, Garlic, Leek]
Asparagus officinalis L. [Garden Asparagus]
Clintonia borealis (Aiton) Raf. [Bluebead Lily]
Convallaria majalis L. [European Lily of the Valley]
Erythronium spp. [e.g. Trout or Fawn Lily, Dog-tooth Violet]
Fritillaria imperialis L. [Crown Imperial]
Gloriosa spp. [Gloriosa Lily]
Hawthornia spp. [Star cactus]
Hyacinthus spp. [Hyacinth]
Kniphofia spp. [Redhot poker]
Lilium spp. [Lily]
Liriope spp. [Lilyturf]
Muscari botryoides (L.) Mill. [Common Grape Hyacinth]
Ornithogalum umbellatum L. [Star-of-Bethlehem]
Polygonatum spp. [Solomons seal]
Ruscus aculeatus L. [Butcher's broom]
Smilacina spp. [False Solomon's seal]
Smilax spp. [Greenbrier]
Trillium spp. [Wake-robin]
Tulipa spp. [Tulip]
Uvularia spp. [Bellwort]
Yucca spp. [Yucca]



POACEAE

GRASS FAMILY

Monocot Clade

♂ or ♀ $Ca^{2}\ Co^{0}\ A^{3}\ G^{(2-3)}$

FLORAL CHARACTERISTICS

- Perfect or imperfect [reduced] flowers
- If imperfect, plants monoecious or dioecious
- Basic unit a **FLORET** [a flower subtended by a **PALEA** and **LEMMA**]
- Perianth represented by **LODICULES**
- Anthers **VERSATILE**
- Syncarpous gynoecium made up of 2 or 3 connate carpels
- Superior ovary
- 1-locular ovary with 1 basal ovule

INFLORESCENCE TYPE(S)

- **SPIKELETS** grouped into panicles, racemes or spikes
- Each **SPIKELET** has a **RACHILLA** as the central axis and two **GLUMES** at the base

FRUIT TYPE(S)

- **CARYOPSIS** [an achene with the pericarp fused to the seed coat]

HABIT

- Annual or perennial herbs
- Sometimes quite large [i.e. bamboo]
- Form bunches or with stolons or rhizomes
- Stems [**CULMS**] round in cross section with solid nodes and hollow internodes

LEAF CHARACTERISTICS

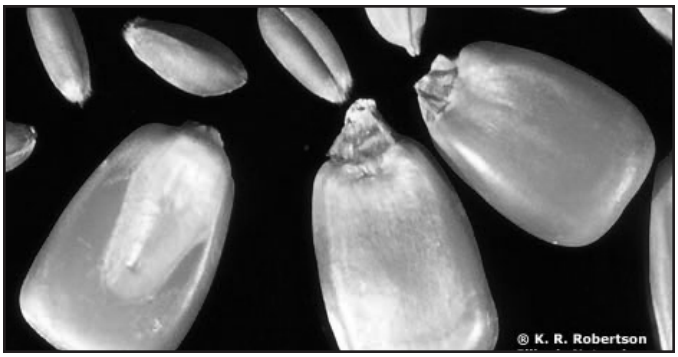
- Simple, 2-ranked, entire or finely toothed, linear leaves
- Alternate or basal arrangement

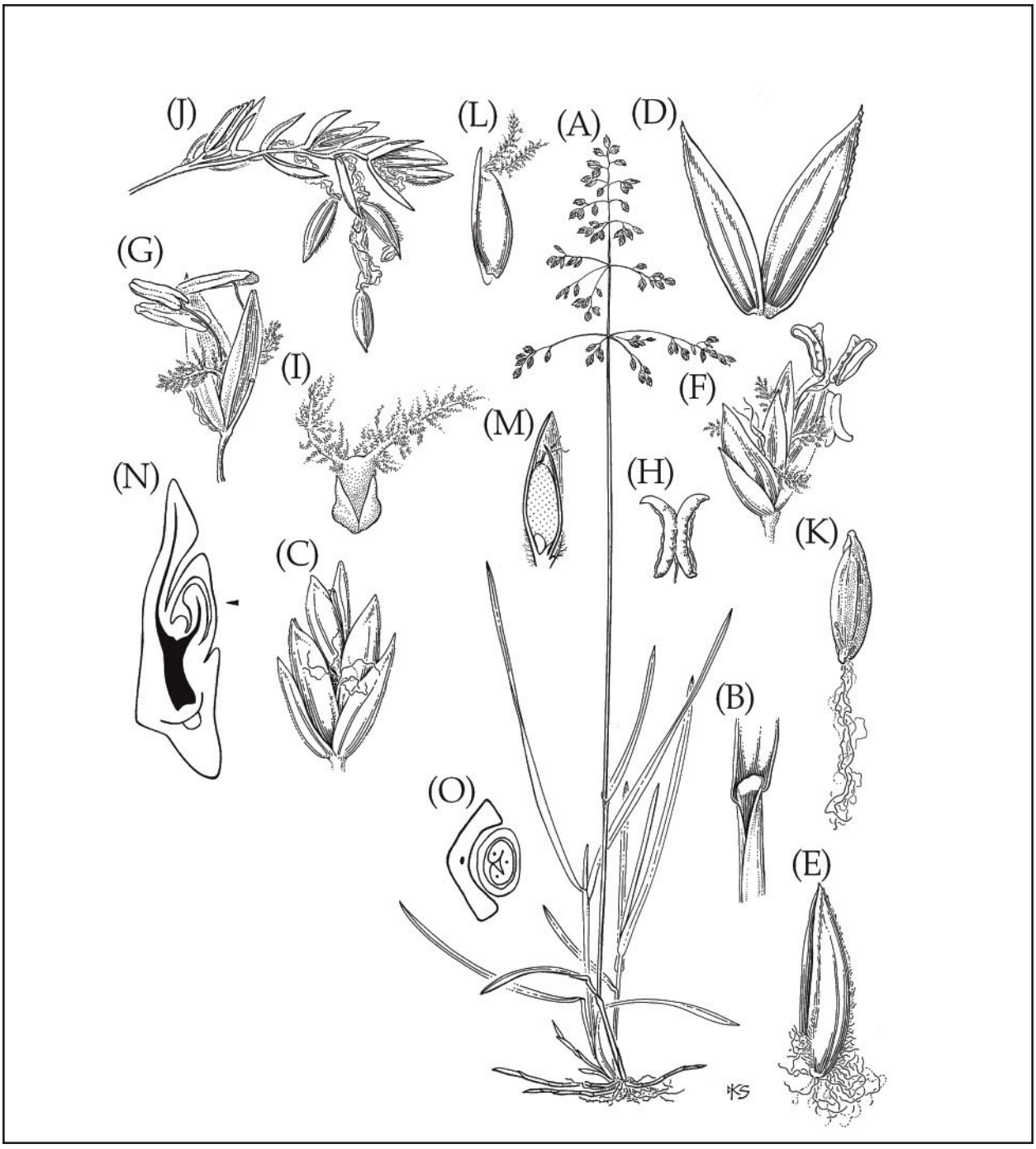
LEAF CHARACTERISTICS [CONTINUED]

- Blades flat and sheathing at base with sheath open
- A **LIGULE** often present at junction of blade and sheath

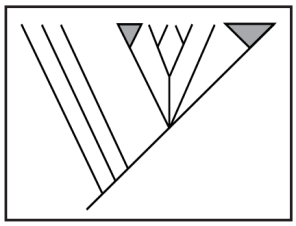
EXAMPLES

Andropogon gerardii Vitman [Big Bluestem]
Avena sativa L. [Common Oat]
Bambusa spp. [Bamboo]
Digitaria spp. [Crab grass]
Elymus spp. [Wild rye]
Festuca spp. [Fescue]
Hordeum vulgare L. [Common Barley]
Miscanthus sinensis 'Zebrinus' [Zebra Grass]
Oryza sativa L. [Rice]
Panicum spp. [Panic grass, Switchgrass]
Poa spp. [Bluegrass]
Saccharum officinarum L. [Sugarcane]
Secale cereale L. [Cereal rye]
Sorghum bicolor (L.) Moench [Sorghum]
Sporobolus heterolepis (A. Gray) A. Gray [Dropseed]
Triticum aestivum L. [Common wheat]
T. durum Desf. [Durum wheat]
Zea mays L. [Maize, corn]
Zizania palustris L. [Northern Wild rice]





***PLANT SYSTEMATICS, Third Edition,* Figure 9.34**



LABORATORY 1

WOODY TWIG TERMINOLOGY

WOODY TWIG TERMINOLOGY LAB EXERCISE

The identification of woody plants in winter is quite different from the techniques used for the determination of the same plants during the other seasons of the year. The features used are, of course, not usually those of the flowers and fruits, or even of leaves, but rather the size and form of the plants and especially characteristics of the twigs. In this Lab, you will gain experience in using a dichotomous key and learning woody twig vegetative terminology while identifying woody plants in non-flowering condition. To complete this Lab Exercise, work through the following steps:

1. Read “Dichotomous Key Guidelines” and then identify all the twig specimens on display using the “Dichotomous (Winter) Key for Woody Plants in Champaign-Urbana”.

Specimen A: _____

Specimen B: _____

Specimen C: _____

Specimen D: _____

Specimen E: _____

Specimen F: _____

Specimen G: _____

Specimen H: _____

Specimen I: _____

Specimen J: _____

Specimen K: _____

Specimen L: _____

Specimen M: _____

Specimen N: _____

Specimen O: _____

Specimen P: _____

Specimen Q: _____

Specimen R: _____

Specimen S: _____

Specimen T: _____

Specimen U: _____

Specimen V: _____

Specimen W: _____

Specimen X: _____

2. In the space below, construct your own dichotomous (winter) key to four woody plant species using only winter condition twig characteristics. Make sure to use some of the terminology that you are learning in Lab today!

3. In the box below, choose one of the twigs you identified, draw it and then label its parts, making sure to include any diagnostic features (especially those mentioned in the “Dichotomous (Winter) Key”).

Note: The subject of woody twigs in winter condition is covered minimally in lecture. Thus, take some time on your own to make sure that you understand all of the woody twig terminology. In future labs, as well as on the lab exams, you may be asked to use a dichotomous key to identify a woody twig.

DICHOTOMOUS KEY GUIDELINES

1. Always make sure you've selected the appropriate key for the materials to be identified. For example, if the material to be identified is cultivated, select a manual treating such plants since most floras do not include cultivated plants unless naturalized.

2. Read the introductory comments on format details, abbreviations, etc. before using the key.

3. Keys are made for average plants. When offered a selection of individual plants avoid the unusual or freakish specimens. Since living things are always somewhat variable, do not base your conclusions on a single observation, but arrive at an average by studying several specimens. It is surprising how often students will find the one unusual or aberrant sample in a large assortment of normal things!

4. Take your time using a key.

5. Always read both choices even if the first seems a logical one to take. The second may be even better. Get both sides of the picture. The second choice, by contrast, may actually help to explain the first one. Note that in some keys the author may have used more than two choices. This is disconcerting if the third choice happens to fall on a different page.

6. Read all the supplemental characters, not just the first ones. However, do not fix on a second or third minor character and ignore the most important first one.

7. Be sure you understand the meanings of the terms involved. Do not guess.

8. When measurements are given, use a calibrated scale. Do not guess.

9. When minute objects are concerned, use a lens of sufficient magnifying power to show clearly the feature you need to see.

10. Check yourself at every possible step with the descriptions. For example, when you arrive at a family in the key (when keying a plant to species) take time to read over the family description before proceeding. This may save you a lot of trouble later on. Use pictures or drawings when available but remember that a good description is far superior to a picture in illustrating the range of variation found within the species.

11. If the choice of division is not clear, or if you have no way of making a choice because you do not have sufficient information, try both divisions, arrive at two possible answers by doing so, and then read descriptions of each in order to make a choice.

12. Once the material has been keyed out with the "Dichotomous (Winter) Key for Woody Plants in Champaign-Urbana", verify your results by reading the description (if available in the literature you are using, or in another reference which describes the plant), or by comparing the specimen with an illustration or an authentically named herbarium specimen.

DICHOTOMOUS (WINTER) KEY FOR WOODY PLANTS IN CHAMPAIGN-URBANA

1. Leaf scars opposite
    2. Bundle scars several and separate, or in several separate groups
        3. Leaf scars about as broad as long — *Aesculus* spp.
        3. Leaf scars somewhat U- or V-shaped
            4. Bud scales overlapping each other, pubescent only on margin — *Acer rubrum*
            4. Bud scales not overlapping each other, pubescent throughout — *Cornus stolonifera*
    2. Bundle scars single, or closely crowded forming a single circle, ellipse or crescent
        5. Terminal buds absent; twig terminated by a pair of axillary buds — *Syringa vulgaris*
        5. Terminal buds present — *Fraxinus pennsylvanica*
1. Leaf scars alternate
    6. Plants armed with thorns or spines
        7. Armature of thorns in axils of leaf scars — *Crataegus crus-galli*
        7. Armature of paired spines at nodes — *Rosa multiflora*
    6. Plants unarmed (Note: Mature twigs of *Maclura pomifera* may be thorny!)
        8. Buds crowded at tips of twigs; pith strongly 3-5 sided in cross section
            9. Twigs corky ridged — *Quercus macrocarpa*
            9. Twigs not corky ridged — *Quercus rubra*
        8. Buds distributed rather evenly along twigs, not crowded at tips; pith circular or not strongly 3-5 sided in cross section
            10. Bundle scars single, or closely crowded forming a single circle, ellipse or crescent
                11. Stipule scars present — *Maclura pomifera*
                11. Stipule scars absent — *Diospyros virginiana*
            10. Bundle scars several and separate, or in several separate groups
                12. Stipule scars present
                    13. Stipule scars encircling twig completely or nearly so
                        14. Stipule scars completely encircling twig
                            15. Buds encircled by leaf scars — *Planatus occidentalis*
                            15. Buds not encircled by leaf scars
                                16. Leaf scars nearly circular-shaped; buds not silky — *Liriodendron tulipifera*
                                16. Leaf scars crescent-shaped; buds densely silky — *Magnolia acuminata*
                        14. Stipule scars nearly encircling twig and slightly offset — *Fagus sylvatica*
                    13. Stipule scars extending less than halfway around twig
                        17. Bud scales one per bud — *Salix* spp.
                        17. Bud scales more than one per bud
                            18. Buds with 2 or 3 visible bud scales — *Tilia americana*
                            18. Buds with more than 3 visible bud scales
                                19. Leaf scars in more than 2 ranks; bark with flavor and odor of almonds when crushed — *Prunus serotina*
                                19. Leaf scars in 2 ranks; bark not as above — *Betula pendula*
                12. Stipule scars absent
                    20. Pith chambered — *Juglans nigra*
                    20. Pith of uniform texture
                        21. Axillary buds nearly or completely surrounded by leaf scars
                            22. Twigs densely velvety-hairy — *Rhus typhina*
                            22. Twigs smooth — *Cladrastis lutea*
                        21. Axillary buds not surrounded by leaf scars
                            23. Bundle scars many; leaf scars large and circular-shaped — *Carya ovata*
                            23. Bundle scars 3; leaf scars small and broadly crescent-shaped — *Liquidambar styraciflua*

BOOK RESOURCES

Several or all of the following books are on display in the lab and have keys to woody plants in winter condition.

1. Barnes, B.V. and W.H. Wagner, Jr. 1981. Michigan Trees. The University of Michigan Press, Ann Arbor, Michigan.
2. Campbell, C.S. and F. Hyland. 1975. Winter Keys to Woody Plants of Maine. University of Main Press, Orono, Maine.
3. Core, E.L. and N.P. Ammons. 1958. Woody Plants in Winter. The Boxwood Press, Pacific Grove, California.
4. Harlow, W.M. 1941. Fruit Key and Twig Key to Trees and Shrubs. Dover Publications Inc., New York.
5. Hosie, R.C. 1969. Native Trees of Canada. Canadian Forestry Service, Department of the Environment, Ottawa, Ontario, Canada.
6. Preston, R.J., Jr. and V.G. Wright. Identification of SE Trees in Winter.
7. Trelease, W. 1931. Winter Botany. Urbana, Illinois.
8. Viereck, L.A. and E.L. Little, Jr. 1972. Alaska Trees and Shrubs. Forest Service, U.S.D.A., Agriculture Handbook No. 410.

ACKNOWLEDGEMENTS

Much of the material presented in this lab exercise was taken from handouts Dr. Downie used while he was an undergraduate student at the University of Guelph, Ontario, Canada. This introductory plant taxonomy course was taught by Dr. Judith Canne-Hilliker. Other than that, the source of the material is unknown.

GLOSSARY OF WOODY TWIG TERMINOLOGY

Listed below is the woody twig terminology that you will need to become skillful at using this semester. You should be able to draw, compare and contrast each of these terms.

WOODY TWIG PARTS

TWIG

The terminal portion of a branch of a woody plant. In most keys this term is used to designate, specifically, the growth of the current year and, to a lesser extent, that of the last preceding year.

NODE

The position on a stem where a leaf or bud is (or was) attached.

INTERNODE

The portion of a stem between two nodes.

AXIL

The upper angle between a leaf (or any other lateral structure) and the stem to which it is attached.

BUDS

The early undeveloped stage of a leafy shoot or flower. These growing points are dormant in winter and are usually covered, for protection, by bud scales.

BUD SCALES

Modified leaves (or, rarely, stipules) that serve to protect the bud.

BUD SCALE SCARS

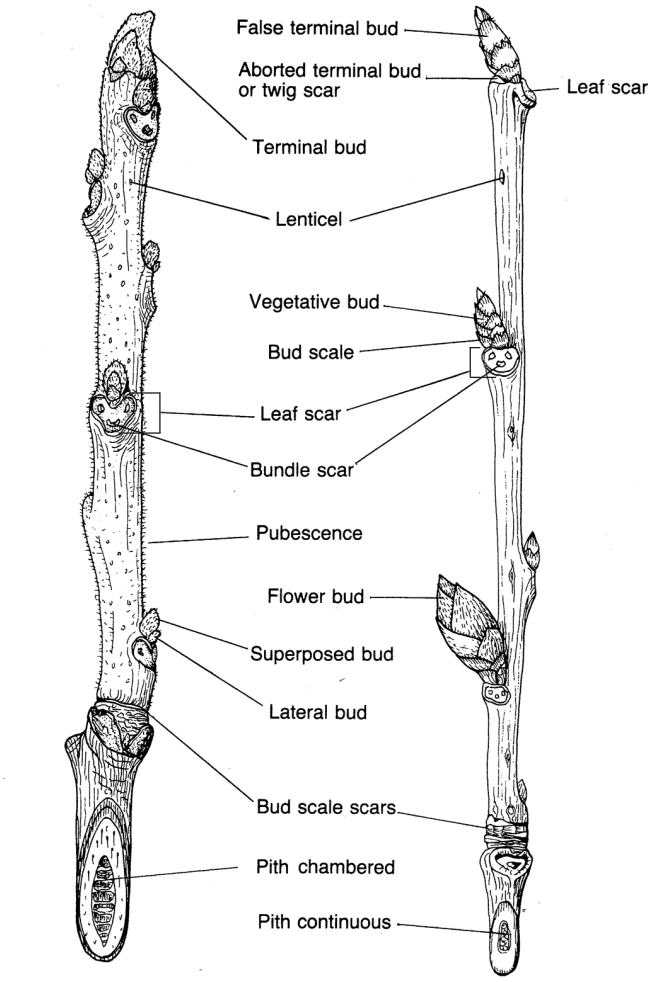
A ring of scars around the twig that marks the place where growth began that year. The distance from the terminal bud to the first ring of bud scale scars represents the amount of growth in length that occurred during the most recent growing season.

TERMINAL BUDS

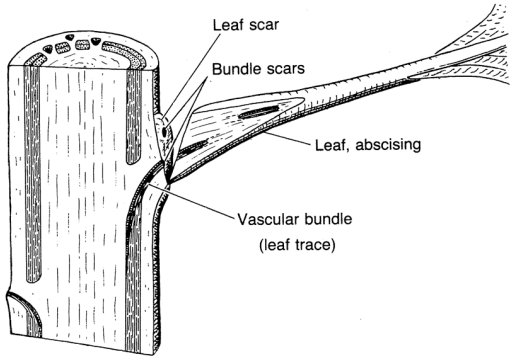
Buds formed at the tips of the stem and its branches.

AXILLARY (LATERAL) BUDS

Buds formed alongside the twigs and arising in the axils of the leaves. Often more than one bud appears at a node, in which case the one directly above the leaf scar is considered the true axillary bud and the others are designated as accessory or collateral buds.



Black Walnut (× 1⅓) **American Elm (× 2)**



WOODY TWIG PARTS (cont.)

PITH
The central portion of a twig.

LEAF SCARS
The place from which the leaf has fallen. This region differs in color and texture from the rest of the twig. Shapes of scars are quite variable.

BUNDLE SCARS
These indicate the broken ends of the vascular bundles passing from the stem into the leaves. They are identified as small dots or lines on the surface of the leaf scar. Also called “Traces”.

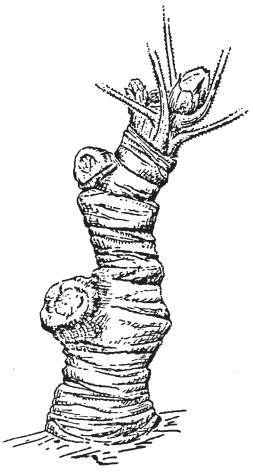
STIPULES
A pair of appendages at the base of a leaf stalk (petiole) and often adnate to it. Stipules are usually leaf-like but can be modified in some plants into prickles or tendrils.

STIPULE SCARS
These are generally slit-like in shape and inconspicuous. In a few species (e.g. *Liriodendron tulipifera*) they encircle the twig from one edge of the leaf scar to the other.

SPECIAL WOODY TWIG PARTS

LENTICILS
Small, often wart-like prominences scattered over the surface of twigs. They serve to admit air to the living tissues beneath.

SPUR SHOOTS
Short, stubby branches with greatly crowded leaf scars and very slow growth (e.g. *Betula* spp.). Often flower buds are produced on short shoots (e.g. *Malus* spp.)

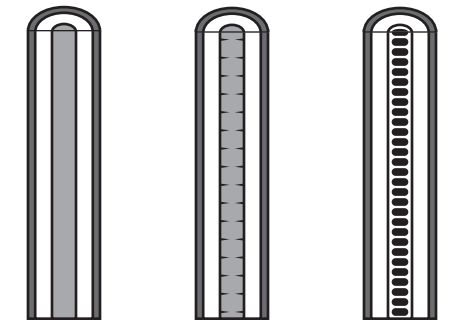


PITH TYPES [TWIG L.S.]

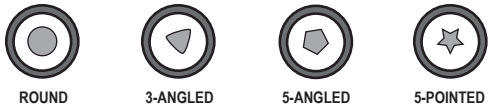
CONTINUOUS PITH
Solid pith (no partitions or chambers)

DIAPHRAGMED PITH
Solid pith with partitions

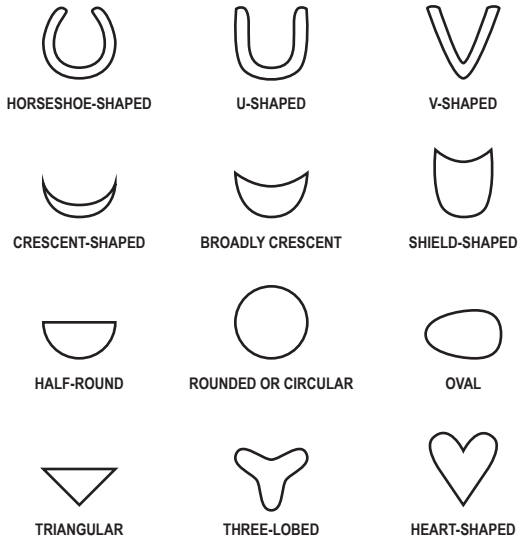
CHAMBERED PITH
Hollow pith with partitions



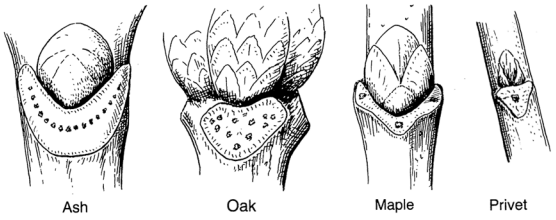
PITH SHAPES [TWIG X.S.]



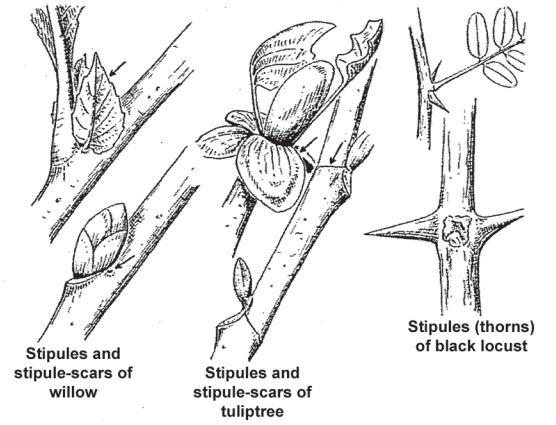
LEAF SCAR SHAPES



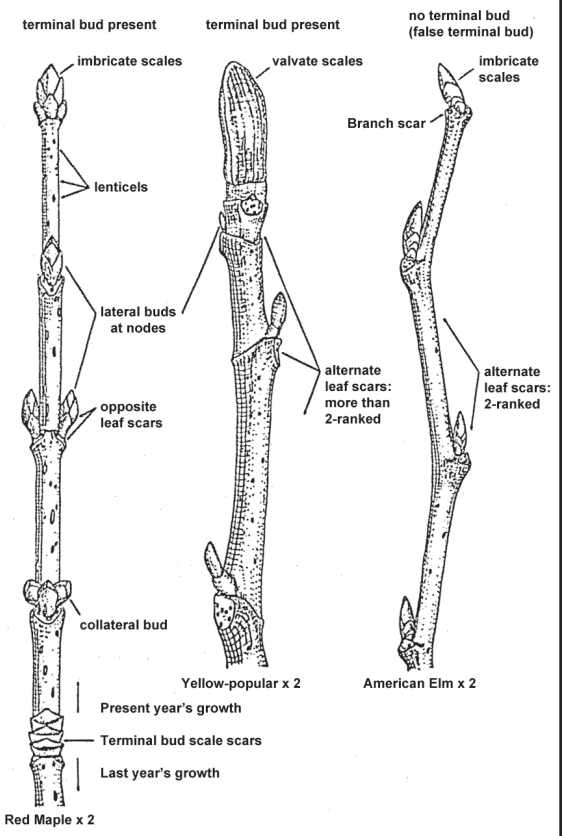
BUNDLE SCAR ARRANGEMENT

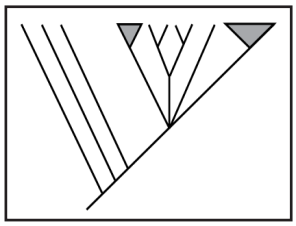


STIPULES AND STIPULE SCARS



LEAF AND SCALE SCARS





LABORATORY 2

VEGETATIVE TERMINOLOGY

Phytography is that part of systematics which deals with descriptions of plants and their various organs, such as roots, stems, and leaves. The variation in size, shape, texture, and structure of these organs provides data that taxonomists use in the naming, identification, and classification of plants. In this class we provide you with a list of terms that describes some of this variation. These terms were selected for you to know because of their widespread use in taxonomy. In this Lab you will become acquainted with some of the terminology used to describe the vegetative body of vascular plants. By working through this exercise and studying the plants carefully, you should be able to obtain a good working knowledge of these basic terms. Enjoy the plants and our wonderful greenhouse facilities!

TAXONOMY TERMS

Taxonomic characters are fundamental to the science of taxonomy. They provide the basic information for classification, they are the features used in identification, they are used to determine relationships, and they give the basis for the naming of taxa. You should know the definition of a **TAXONOMIC CHARACTER** as well as be able to distinguish between **CHARACTER** and **CHARACTER STATES**.

TAXONOMIC CHARACTER

Any attribute of an organism that can be consistently measured, counted, described, or otherwise assessed (e.g. leaf shape, plant height, stamen number, pigment type, DNA nucleotide)

CHARACTER

A group of states considered to be modifications or alternate forms of basically the same thing.

CHARACTER STATE

One of the various conditions (attributes, or values) of a character observed across a group of taxa. It is the fundamental unit of a **CHARACTER**.

CHARACTER	CHARACTER STATE
Flower Color	Red, white or blue
Leaf Shape	Linear, lanceolate or reniform
DNA nucleotide	**A, C, G or T**

LAB EXERCISE

During today's Lab in the Plant Sciences Laboratory, you will practice using vegetative terminology to describe flowering plants. The TA will begin by giving you a brief orientation to the Conservatory and the teaching collection rooms 1401 - 1415. Afterward, you will complete the following Lab exercise by visiting each room, examining the plants listed and answering the questions with the aid of the Glossary of Vegetative Terminology provided at the end of the Lab. To avoid conjestion, you may begin in any room. Just a few reminders: Handle the plants carefully! You may touch them, but please do not destroy them. Also, walk only on the walkways in the Conservatory and make sure to close all doors behind you after entering and exiting a each room (most of the collection rooms are temperature controlled.)

PLANT BIOLOGY CONSERVATORY AND COLLECTION ROOMS

The Conservatory and Plant Collection rooms were created in 1988. By September 1991 the Conservatory landscape installation was finished, including a small pond and waterfall. In total, these facilities occupy 4,000 square feet of the Plant Sciences Laboratory building and house over 1,100 species from 161 familes. While walking through the Conservatory, you will see over 200 plant species from about 70 plant families. Most of these species are representative of tropical rainforests, and some are economically important. From trees and shrubs to ferns and vines, you will also see many plant forms. Each Plant Collection room showcases plants from a unique habitat type.

A NOTE ON NOMENCLATURE

Cultivated varieties of plants, or cultivars, are preceded by the letters “cv.” or their names are included in single quotation marks. The cultivar name is not italicized. For example, both of the following names are written correctly and refer to exactly the same cultivar:

Begonia rex ‘Fireworks’
Begonia rex cv. Fireworks

ROOM 1201 - THE CONSERVATORY

***Cycas circinalis* L. (CYCADACEAE) (Queen Sago)**

Cycads, or tropical evergreens, were the dominant flora in the early Mesozoic (200 million years ago). *C. circinalis*, one of the six species of cycads found in the Conservatory, is **DIOECIOUS**. What does that mean? Make sure to check out its palm-like leaves and the **LEAF SCARS** that cover its trunk. Be aware that *Cycas* is a gymnosperm, not an angiosperm.

***Amorphophallus titanum* (Becc.) Becc. (ARACEAE) (Titan Arum)**

The titan arum (or corpse flower) develops from a **CORM** and then spends years (6 - 7) in the vegetative part of its lifecycle. (Fun Fact: **CORMS** from this species can be over 200lb!) What is a **CORM**?

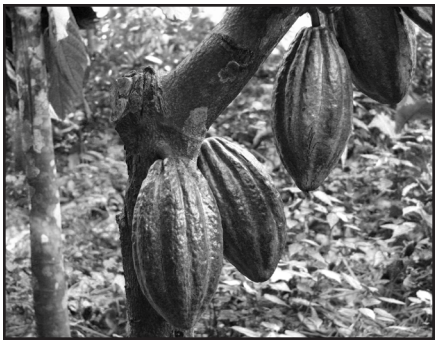
After the vegetative stage is complete, the species will bloom and emit a “rotting-fish-with-burnt-sugar” odor to attract its natural pollinators, carrion beetles and flesh flies. The titan arum is often said to have the “world’s largest flower”. Is this a botanically accurate statement given that this species is in the same family as *Anthurium*? Why or why not?

***Musa* spp. (MUSACEAE) (Banana)**

This economically important plant grows from an underground stem (**RHIZOME**) and its berry fruit is sterile, so no seeds are produced. Why do we consider this plant a **HERB** and not a **TREE** in the true "botanical" sense of the word? What is its **LIFE SPAN**? **LEAF VENATION**?

***Oxalis* spp. (OXALIDACEAE) (Oxalis)**

This genus belongs to the wood-sorrel family and is characterized by having palmately compound leaves typically composed of three to ten leaflets. What is the special **LEAF COMPLEXITY** term applied to this leaf since it has three leaflets? What is the **BLADE SHAPE** of the leaflets?



***Theobroma cacao* L. (STERCULIACEAE) (Chocolate Tree)**

For fellow chocolate lovers like myself, it will come as no surprise that the genus name for this plant, *Theobroma*, is Greek for "food of the gods". *T. cacao* are small **EVERGREEN** trees that produce fly-pollinated flowers directly on their branches. The 20-60 seeds found in each mature fruit is what is used to produce chocolate. Make sure to look at the flowers and pods on this individual!

***Barringtonia racemosa* Roxb. (LECYTHIDACEAE) (Powderpuff Tree)**

B. racemosa is aptly named since its flowers hang in long racemes. Make sure to observe the flowers' prominent stamens in preparation for our floral morphology lab next week. Common along the Indian Ocean's tropical coasts, its fruit have evolved to be very buoyant so that they can be dispersed by water. What would the **PLANT HABIT** and **LEAF APEX** be classified as for this species? Draw the **LEAF APEX** in the box provided.

***Anthurium* spp. hybrid (ARACEAE) (Flamingo flower)**

Characteristic of the Araceae family, this plant's inflorescence is composed of tightly packed flowers arranged on a spadix. Surrounding the spadix is a colorful bract called a spathe. Observe the leaves for *Anthurium*. Sketch and label the **LEAF SHAPE** and **MARGIN** in the box provided.

ROOM 1415 - TROPICAL PLANTS

***Streptocarpella saxorum* Engler (GESNERIACEAE) (Cape Primrose)**

In order to propagate *S. saxorum*, one must divide the root ball or grow leaf cuttings since the flowers are typically sterile. As you can see, the flower petals of this species are fused (connate) and can be described as sympetalous, but more about that next week. What terms describe the **PLANT HABIT** and the **LEAF SURFACE**?

***Callisia fragrans* (Lindl.) Woodson (COMMELINACEAE) (Basket Plant)**

Not only is *C. fragrans* a decorative plant, but it is also a widely used in Russia for medicinal purposes. What is its **LEAF VENATION** and **STEM TYPE**?

***Salvia leucantha* Cav. (LAMIACEAE) (Mexican Bush Salvia)**

Look for the distinctive **STIPULES** on *S. leucantha*. Name the **LEAF ARRANGEMENT** of this species and sketch it in the box provided.

***Mimosa pudica* L. (FABACEAE) (Sensitive Plant, Shameplant)**

The species name, "*pudica*" is very appropriate for this plant in that it means bashful. Touching the leaves of *M. pudica* stimulates it to release chemicals, thereby causing the redistribution of water in the cells. The unequal distribution of water is what allows the leaves to fold up. This mechanism is speculated to be a defense against herbivory.

***Cissus rotundifolia* (Forssk) Vahl (VITACEAE) (Venezuelan Treebine)**

Describe the **LEAF BLADE SHAPE** of *C. rotundifolia*. Its specific epithet should give you a clue! Also, what is the name of the twining structure that this plant uses to climb or support itself?

***Schefflera arboricola* (Hayata) Kanehira (ARALIACEAE) (Dwarf Umbrella Tree)**

This **EVERGREEN** shrub is native to Taiwan and is often used as a houseplant. What is the **LEAF COMPLEXITY** of this plant? Draw one leaf in the box provided and label its parts.

ROOM 1413 - EPIPHYTIC PLANTS, ORCHIDS AND BROMELIADS

Miscellaneous spp. (ORCHIDACEAE)

In many Orchidaceae species, the leaves are attached to a swollen fleshy stem called a **PSEUDOBULB**. What do you think is the purpose of a **PSEUDOBULB**? While in this room make sure to check out all the blossoms! We'll be studying Orchidaceae flower structure later in the semester.

***Phalaenopsis* hybrid (ORCHIDACEAE)**

Epiphytic Orchidaceae, such as this *Phalaenopsis* hybrid, are often characterized by aerial, cord-like roots. These roots are adventitious and are covered by a multi-layered epidermis (called **VELAMEN**) that absorbs moisture from the atmosphere.

***Vanilla planifolia* Jacks. (ORCHIDACEAE) (Flat-leaved Vanilla)**

Consider *V. planifolia*, the source of the flavoring vanilla (from the cured fruits or pods). This species was used by the Aztecs to flavor cocoa. Once more note the large aerial, adventitious roots. What is the **LEAF ARRANGEMENT** and **PLANT HABIT**?

***Dendrobium nobile* 'Montrose' (ORCHIDACEAE)**

Notice the conspicuous parallel leaf venation on *D. nobile*, which is characteristic of Orchidaceae and monocots in general. Classify the **LEAF ATTACHMENT**.

***Vriesea carinata* Wawra (BROMELIACEAE) (Painted Feather)**

Bromeliads, such as *V. carinata*, are acaulous herbs (the prefix "a" = without; "caulous" mean stem). Their leaves are usually leathery or fleshy, covered in a thick cuticle and clustered in a tight rosette. Thus, the **LEAF ARRANGEMENT** could be called what?

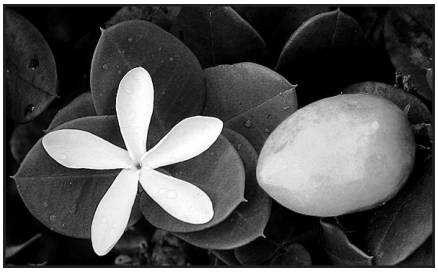
***Ananas comosus* (L.) Merr. (BROMELIACEAE) (Pineapple)**

A. comosus produces a multiple fruit of berries, commonly known as a pineapple. Generally hummingbirds are the main pollinators of this species but are purposefully kept away from pineapple plantings to avoid the development of seeds in the fruit. Most pineapple plants are propagated by vegetative means. Describe the **LEAF SHAPE** and **LEAF APEX**.

ROOM 1411 - SUBTROPICAL PLANTS AND CACTACEAE

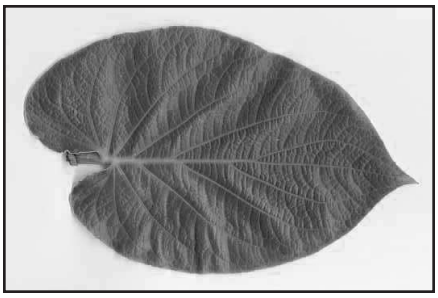
***Rhipsalis cereuscula* Haworth (CACTACEAE) (Coral Cactus)**

The cacti in this room are typical of tropical environments. In particular, *R. cereuscula* is an epiphytic cactus that has jointed stems and spherical translucent and mucilaginous fruits. Can you describe its **HABIT**?



***Carissa macrocarpa* (Eckl.) A. DC. (APOCYNACEAE) (Natal Plum)**

This plant produces plum shaped fruits that are edible when ripe, however don't try to eat any other part of *C. macrocarpa* – it's poisonous! What terms describe its **LEAF APEX** and **LEAF SURFACE**?



***Piper auritum* Kunth (PIPERACEAE) (Root Beer Plant)**

Crush a small bit of the leaf the TA has pulled off and smell it. *P. auritum* is often used as a flavoring due to its spicy aromatic scent and flavor. How would you classify its **LEAF ARRANGEMENT** and **LEAF BASE**?

***Helwingia chinensis* Batalin (HELWINGIACEAE)**

The genus containing these deciduous shrubs, *Helwingia*, was named for the German botanist Georg A. Helwing. What is *H. chinensis*'s **LEAF SHAPE** and **LEAF MARGIN**?

***Fatsia japonica* (Thunb) Decne & Planch (ARALIACEAE) (Paperplant)**

Classified as an evergreen shrub, *F. japonica* is often used for landscaping purposes. What is *F. japonica*'s **LEAF VENATION** and **LEAF MARGIN**? Also, how would you classify the **LEAF ATTACHMENT**? Draw and label a leaf in the box provided.

ROOM 1409 - DESERT PLANT COLLECTIONS

***Opuntia brasiliensis* (Willd.) Haw. (CACTACEAE) (Tree Opuntia)**

Here is a plant trying to pretend it has broad, flat leaves when in actuality it has branching stems. What is the plant's **HABIT**? Though this species of *Opuntia* is native to Brazil, there are three other members of its genus that are native to Illinois (*O. humifusa, O. macrorhiza* and *O. fragilis* (Endangered in IL)).

***Cephalocereus senilis* (Haw.) Pfeiff. (CACTACEAE) (Old-Man Cactus)**

C. senilis is actually rare and endangered in the wild, however its appearance has made it commercially popular and thus widespread in commercial nurseries. Why do you think this plant has evolved to be covered in grayish-white hairs? In any case, doesn't it look like Cousin It from the Addams Family?

***Fouquieria fasciculata* Nash (FOUQUIERIACEAE) (Árbol de Barril)**

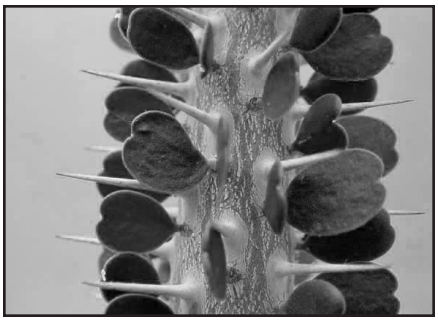
The leaves of *F. fasciculata* are **DECIDUOUS** but a part of the **LEAF PETIOLE** can harden to form the **SPINES** you see covering most of the plant. What is the **LEAF ARRANGEMENT**?

***Welwitschia mirabilis* Hook. (WELWITSCHIACEAE) (Tree Tumbo)**

W. mirabilis is a **DIOECIOUS PERENNIAL** and the only species in the Welwitschiaceae family. Make sure to read the plaque posted – it contains a lot of interesting information about this bizarre species! What **ROOT TYPE** does it have? Be aware that *Welwitschia* is a gymnosperm, not an angiosperm.

***Lithops* spp. (AIZOACEAE) (Stone Plant)**

These unique plants are made up of one pair of **SUCCULENT** leaves, highly modified to retain moisture in times of extreme heat and drought. Their genus name, *Lithops*, comes from the Greek "lithos" (a stone) and "ops" (like). Neat aren't they?



***Alluaudia ascendens* Drake (DIDIEREACEAE) (Fantsiolotse)**

This **DIOECIOUS**, **DECIDUOUS** tree has vertical pairs of leaves arranged under each **SPINE**. What is the difference between a **SPINE**, **THORN** and **PRICKLE**?

***Bulbine alodies* (LILIACEAE)**

The species name for *B. alodies* translates to “aloe-like”. This plant, unlike *Opuntia brasiliensis*, is a **LEAF SUCCULENT**. Be sure you can distinguish between a **LEAF SUCCULENT** (such as those belonging to families Agavaceae, Crassulaceae and Liliaceae) and a **STEM SUCCULENT** (i.e. Cactaceae).

ROOM 1405 - CARNIVOROUS AND AQUATIC PLANTS

***Marsilea mutica* Mett. (MARSILEACEAE) (Floating Water Clover)**

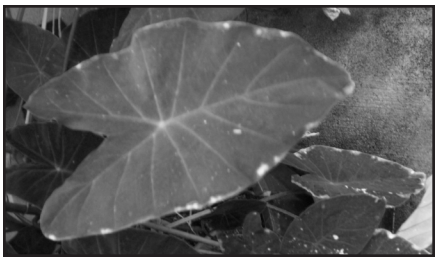
This plant is not an angiosperm (it’s a fern actually) but check out its **COMPOUND LEAF** with four **PINNAE**. Is this the quintessential four-leaf clover? Make a wish!

***Spiranthes odorata* (Nutt) Lindl (ORCHIDACEAE) (Lady’s Tresses)**

Marsh Lady’s tresses is considered an endangered orchid species in three states (Kentucky, Maryland and Tennessee). Make sure to take a look at its beautiful, white flowers! What is its **HABIT**, **LEAF ARRANGEMENT** and **LEAF VENATION**?

***Cyperus papyrus* L. (CYPERACEAE) (Papyrus Plant)**

C. papyrus was the source of papyrus more that 4,000 years ago! The stem pith was sliced into thin strips, then laid side by side. Another layer of strips was added over the top at right angles and the two layers were hammered together until a sheet of “paper” was formed. Note the triangular stems, 3-ranked leaves and closed sheaths (the Cyperaceae family is characterized by these features).



***Colocasia esculenta* (L.) Schott (ARACEAE) (Coco Yam, Taro)**

This large herb arises from an underground **TUBER**. Describe the **LEAF BASE** (Hint: Where does the stem attach?) Also, what type of **LEAF VENATION** does this plant have and is this typical of the Araceae family (a monocot family)?

CARNIVOROUS PLANTS

***Nepenthes* spp. (NEPENTHACEAE) (Pitcher Plants)**

These plants possess hollow, tubular leaves which are urn- or trumpet-shaped and often resemble small pitchers. Note the **TENDRIL** at the tip of each leaf. Insects are attracted by nectar secretions near the rim and when they fall in, the sharp, downward pointing hairs within the pitcher prevent the insects' escape. Digestive enzymes secreted by internal glands then digest the insect.

***Drosera* spp. (DROSERACEAE) (Sundews)**

Drosera's **LEAF SURFACE** can be described as **GLANDULAR** due to the stalked glands found on on their often club-like or linear-shaped leaves. These glands secrete a sticky liquid that catches the prey. Enzymes are also secreted that dissolve the victim, and the resultant nutrients are absorbed by numerous tiny hairs on the leaf.

***Dionaea* spp. (DROSERACEAE) (Venus Flytrap)**

In these plants the leaves are divided into a **LEAF BLADE** and a predominantly winged **PETIOLE**. The blade is made up of two identical semicircular halves united along the middle by a thick midrib. Together they constitute, in effect, a hinged trap. The outer margin of each lobe is characterized by a comb of long, bristle-like teeth. Yes, the archetypal man-eating plant!

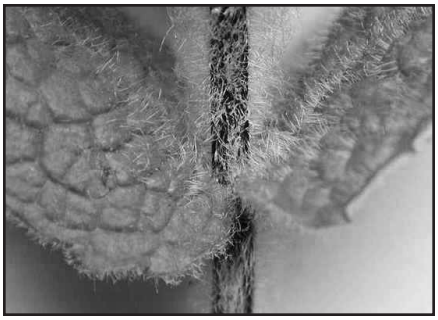
ROOM 1403 - ECONOMIC PLANTS

***Ficus carica* L. (MORACEAE) (Edible Fig)**

Ficus species are characterized by their "fruit-like" structures called syconia, or figs, that contain many small male and female flowers. Many *Ficus* species require a wasp to enter the syconium to pollinate its flowers, however *F. carica* does not. This is fortunate for oftentimes the wasps will die inside the synconium. Make sure to check out the **LEAF SCARS** on *F. carica*'s branches. What is its **LEAF MARGIN**?

***Manihot esculenta* Crantz (EUPHORBIACEAE) (Cassava)**

The **TUBEROUS ROOT** from *M. esculenta* is one of the world's major food crops. The original bitter variety of cassava contained cyanide compounds and thus was poisonous unless they were peeled and boiled multiple times. However, new sweet varieties have been bred so that they can be eaten raw when peeled (the cyanide compounds still remain in the **TUBER**'s skin regardless of the variety). What is *M. esculenta*'s **LEAF ARRANGEMENT** and **LEAF VENATION**?



***Mentha suaveolens* Ehrh. (LAMIACEAE) (Wooly Apply Mint)**
***Origanum vulgare* L. (LAMIACEAE) (Greek Oregano)**

Look, touch, feel and smell these two plant species. What do they have in common? Hint: What is their **HABIT**? **LEAF ARRANGEMENT**? Shape of the stem in cross-section? These features are all characteristic of the Lamiaceae family. The odor comes from small glands on the leaves and stems that contain ethereal oils.

***Cinnamomum zeylanicum* Garcin (LAURACEAE) (Cinnamon)**

C. zeylanicum is one of four *Cinnamomum* species that are utilized for the commercial cultivation of cinnamon. To produce cinnamon, these trees are cut at ground level and the inner bark is removed in rolls and cut into pieces (cinnamon sticks). What terms describe *C. zeylanicum*'s **LEAF SHAPE**, **MARGIN** and **ARRANGEMENT**?

***Swietenia macrophylla* King (MELIACEAE) (Big Leaf Mahogany)**

S. macrophylla has been placed on the endangered species list in its native region and thus is no longer harvested there for its beautiful wood. It has been introduced, however, in other tropical areas for commercial production (in some cases it's actually become invasive!). What is the **LEAF COMPLEXITY** of *S. macrophylla*? Draw and label a leaf in the box provided.

***Coffea arabica* L. (RUBIACEAE) (Arabian Coffee)**

If you're a crazy coffee drinker like your TA, you'll appreciate this amazing plant. (Fun Fact: Americans drink 400 million cups of coffee per day.) Check out the red fruits (drupes) that each contain two seeds, or "beans". In order to produce the best coffee, the fruits need to be hand harvested when they deep red color - not before or later. Determine the **LEAF ARRANGEMENT** and **LEAF SURFACE** of the plant.

***Saccharum officinarum* L. (POACEAE) (Sugar Cane)**

This is sugar cane, the source of half the world's sugar. Look closely at its stem. What is the **LEAF ATTACHMENT** and **LEAF VENATION**?

VEGETATIVE WORKSHEET

Choose one plant in the Conservatory or the teaching collection rooms and complete the following worksheet using the terminology covered in today's Lab. (By describing all of your selected plant's character states, you are essentially creating a species description.) Then in the box below draw the species or at least one of its key features.

FAMILY _____

SPECIES _____

CULTIVAR (IF APPROPRIATE) _____

PLANT HABIT _____

LIFE SPAN _____

STEM TYPE _____

LEAF COMPLEXITY _____

LEAF ARRANGEMENT _____

LEAF ATTACHMENT _____

LEAF (OR LEAFLET) BLADE SHAPE _____

LEAF VENATION _____

LEAF MARGIN _____

LEAF APEX _____

LEAF BASE _____

LEAF SURFACE _____

STIPULES (PRESENT OR ABSENT) _____

OTHER SPECIAL FEATURES _____

_____

NOTES _____

_____

_____

GLOSSARY OF VEGETATIVE TERMINOLOGY

Listed below is the vegetative terminology that you will need to become skillful at using this semester. You should be able to draw, compare and contrast each of these terms. You should also know the relationship between each of the terms listed (i.e. **CHARACTER STATES**) and the major category (i.e. **CHARACTER**) to which they belong.

A Few Words of Caution**:** Terms were coined to represent clearly distinguishable differences. However, plants vary continuously, and the structure that you see on a particular plant may not precisely match the illustrations or definitions provided in this Lab Manual or in the Course Textbook. Often you will encounter a feature that seems to be intermediate between two terms (e.g. a leaf that is between lanceolate and broadly ovate in shape). As you become more familiar with a specific feature, you will gradually develop an understanding of the range of variability that it encompasses.

PLANT HABIT

HERB
No above ground persistent woody tissue but may have underground perennating structures

SUB-SHRUB
Lower stems woody but upper stems herbaceous

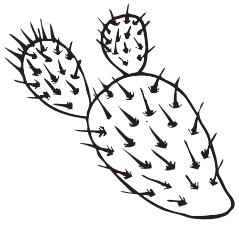
SHRUB
A woody low-stature perennial plant with one to many slender trunks arising from near its base

TREE
A large woody perennial plant with one to several relatively massive trunks and an elevated crown

SUCCULENT
Possessing thick, usually soft, watery leaves and/or stems (there are stem & leaf succulents)

VINE
A woody or herbaceous plant with a long, slender, more or less flexible stem which cannot support itself

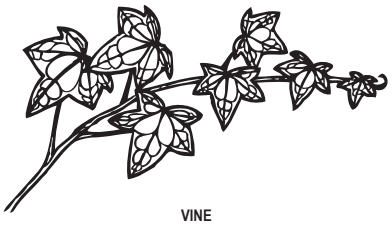
LIANA
A woody, climbing vine (characteristic of the tropics)


SUCCULENT (E.G. STEM)


HERB


LIANA


TREE


VINE


SHRUB

LIFE SPAN (DURATION)

ANNUAL
Completes life cycle in one growing season

BIENNIAL
Completes life cycle in two growing seasons

PERENNIAL
Lives for more than two growing seasons

LEAF PERSISTENCE

DECIDUOUS
Loses leaves during unfavorable conditions (such as at the end of each growing season)

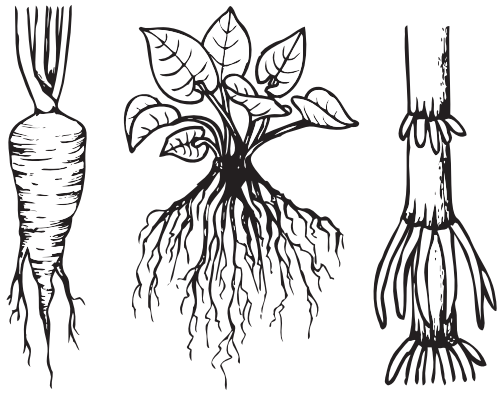
EVERGREEN
Bearing green foliage all year round

ROOT TYPE

TAPROOT
Central main root that descends vertically; larger than any branching root

FIBROUS
Thin, thread-like roots arising from a taproot or from stem tissue

ADVENTITIOUS
Roots that originate from any part of the plant other than the root system



TAPROOT FIBROUS ADVENTITIOUS

STEM TYPE

AERIAL
An erect or prostrate stem (the most common)

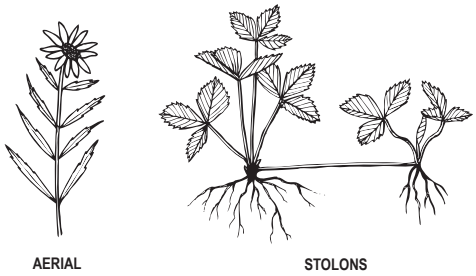
STOLON
A horizontal stem near the ground surface that produces new plants at its nodes or tip (runner)

RHIZOME
An underground horizontal persistent stem; its leaves are often reduced to scales and it usually bears adventitious roots and buds

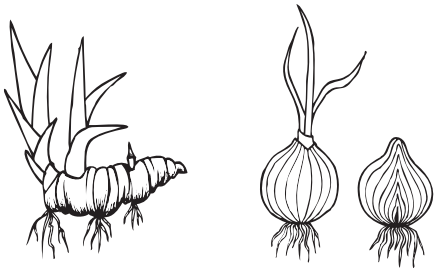
BULB
A thickened, underground, short, vertical stem with large storage leaves; usually below ground

CORM
A solid, erect, underground stem with leaves absent or dry and scale-like

TUBER
A solid, enlarged, underground, horizontal stem that serves as a storage area for food reserves



AERIAL STOLONS



RHIZOME BULB

CORM TUBER

LEAF COMPLEXITY

To determine the complexity of a leaf, always look for the **AXILLARY BUD** located above the **PETIOLE**. Anything above the **AXILLARY BUD** is considered one leaf.

A **SIMPLE LEAF** will have a single blade attached to the petiole, whereas a **COMPOUND LEAF** will have more than one blade attached to the petiole.

SIMPLE LEAF

A leaf with a single blade per petiole (it is not divided into leaflets; there is always a flange of blade tissue connecting adjacent lobes)

TRIFOLIATE

Three separate leaves arising from the same node

COMPOUND LEAF

A leaf with more than one blade per petiole (it is made up of two or more leaflets and these leaflets are wholly separate)

TRIFOLIOLATE

A compound leaf with three leaflets

PINNATELY COMPOUND LEAF

A leaf in which there are more than three leaflets (**PINNA**, pl. **PINNNAE**) arranged in two rows along a 1° rachis.

BIPINNATELY COMPOUND LEAF

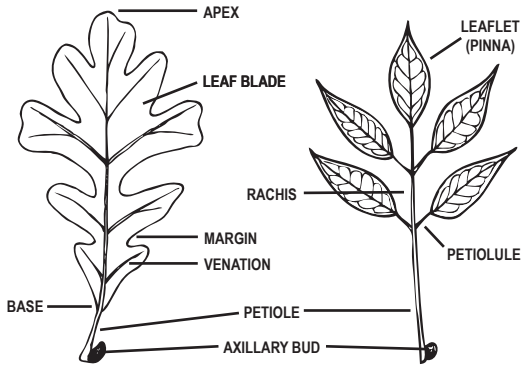
A leaf that is divided twice (has a 1° and 2° rachis)

TRIPINNATELY COMPOUND LEAF

A leaf that is divided three times (have a 1°, 2° and 3° rachis)

PALMATELY COMPOUND LEAF

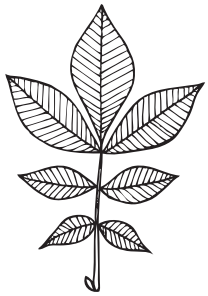
A compound leaf where the leaflets arise from a common point of attachment (no rachis)



SIMPLE LEAF COMPOUND LEAF

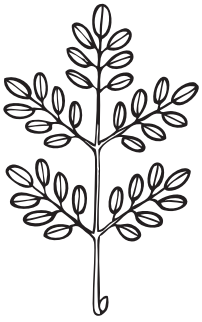
TRIFOLIATE

TRIFOLIOLATE

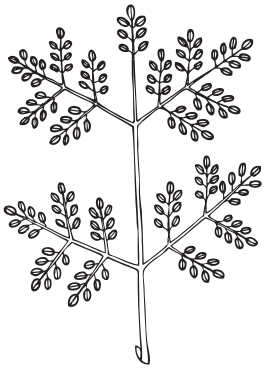


PINNATELY COMPOUND

PALMATELY COMPOUND



BIPINNATELY COMPOUND



TRIPINNATELY COMPOUND

LEAF PARTS

LEAF BLADE
Expanded portion of a leaf

LEAFLET
One of the segments of a compound leaf

PINNA (pl. **PINNNAE)**
The leaflets of a pinnately compound leaf

PINNULE
The leaflets of a bipinnately and tripinnately compound leaf

PETIOLE
Stalk of a leaf

PETIOLULE
The stalk of a leaflet (i.e. **PINNA** or **PINNULE**)

RACHIS
The axis of a pinnately compound leaf.

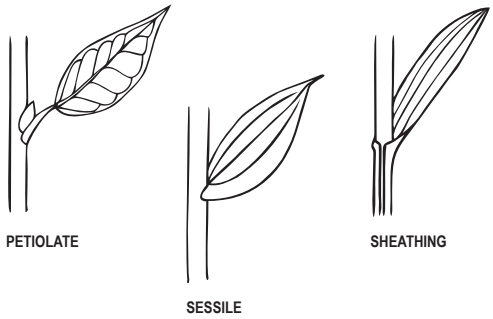
LEAF ATTACHMENT

PETIOLATE
Leaf has a petiole

SESSILE
Leaf lacks a petiole

SUBSESSILE
Leaf posseses a very short petiole

SHEATHING
Leaf base enwraps stem



LEAF ARRANGEMENT

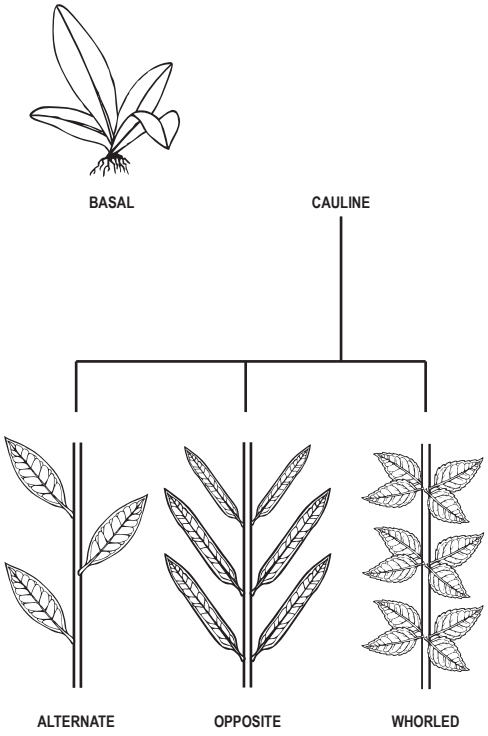
BASAL
Leaves attached to a rhizome or underground stem

CAULINE
Leaves attached to an above-ground stem

ALTERNATE
One leaf per node

OPPOSITE
Two leaves per node

WHORLED
Three or more leaves per node



LEAF BLADE SHAPE

LINEAR
Long and narrow with the side parallel (>4:1)

OBLONG
Nearly rectangular with the sides parallel (2-4:1)

LANCEOLATE
Spear-shaped; widening above base and then long tapering to apex (3-4:1)

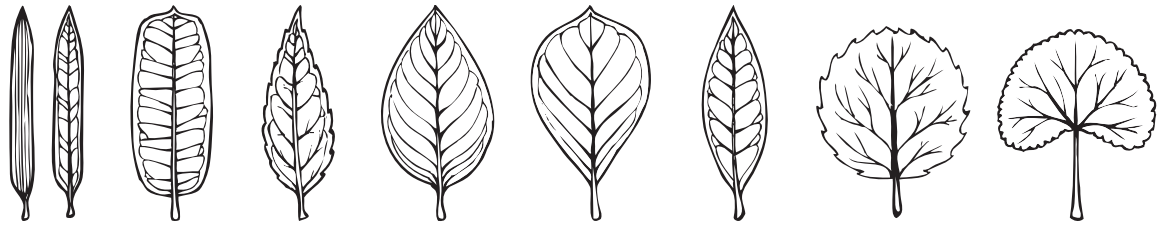
OVATE
Egg-shaped; broadest near base (<3:1)

OBOVATE
Ovate, but with narrower end towards point of attachment (The prefix “ob” means opposite, so “obovate” is the opposite of “ovate”)

ELLIPTIC
Widest near middle and tapering at both ends

ORBICULAR
Circle shaped

RENIFORM
Kidney shaped



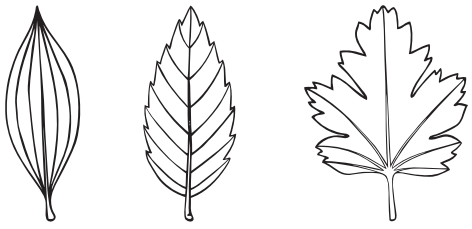
LINEAR OBLONG LANCEOLATE OVATE OBOVATE ELLIPTIC ORBICULAR RENIFORM

LEAF VENATION

PARALLEL
Veins lie roughly parallel to the leaf margins.

PINNATE
Central mid-vein with many 2° veins emerging on both sides.

PALMATE
All 1° veins arise at the same point at the base of the leaf.



PARALLEL PINNATE PALMATE

LEAF APICES

ACUMINATE
Sharp, ending in a long-tapering point with concave sides

ACUTE
Sharp, ending in a point with straight sides to the apex (< 90°)

OBTUSE
Blunt, rounded (> 90°)

MUCRONATE
A small, abrupt point

ACUMINATE ACUTE OBTUSE MUCRONATE

LEAF BASES

ACUMINATE
Sharp, long-tapering point

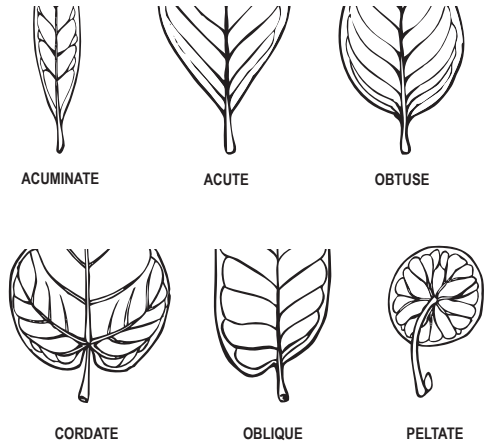
ACUTE
Sharp (< 90°)

OBTUSE
Blunt (> 90°)

CORDATE
Heart-shaped (equal rounded lobes at the base)

OBLIQUE
Unequal sized lobes at base

PELTATE
Umbrella like; the petiole is attached to the blade inside of the margin; leaf often orbicular in shape



LEAF MARGIN

ENTIRE
A margin without any toothing or division

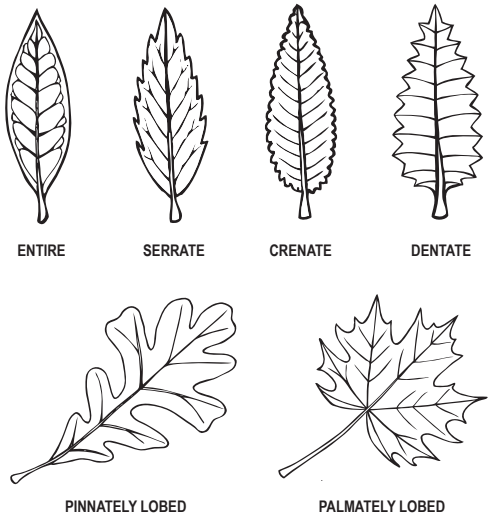
SERRATE
Sharp teeth pointing toward the apex

CRENATE
Scalloped or round-toothed

DENTATE
Sharp teeth projecting at right angles from the margin

PINNATELY LOBED
Lobes towards the midrib but not reaching it

PALMATELY LOBED
Lobes all arising from one point at the leaf base



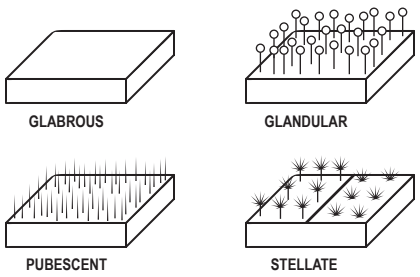
LEAF SURFACE

GLABROUS
Lacking hairs (**TRICHOMES**); a smooth surface

GLANDULAR
Hairs that bear glands that break down into sticky beads of fluid; may be stalked (**STIPITATE**) or sessile

PUBESCENT
Covered with hairs (**TRICHOMES**)

STELLATE
Hairs that branch at or near their base (star-shaped from above)



SPECIAL FEATURES

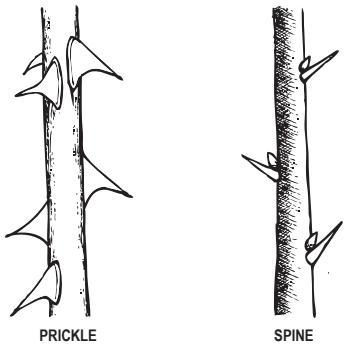
PRICKLE
A sharp-pointed outgrowth from the epidermis

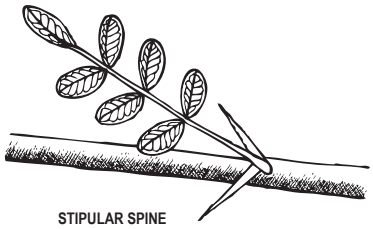
SPINE
A sharp-pointed modified leaf or leaf part

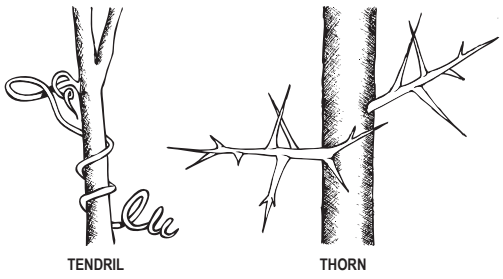
STIPULAR SPINE
Borne in pairs and lateral to leaf (or leaf scar)

TENDRIL
An elongated, twining segment of a leaf, stem or inflorescence by which a plant clings to its support

THORN
A woody, sharp pointed, modified stem (has stem-like vasculature)







LABORATORY 3

FLORAL AND INFLORESCENCE TERMINOLOGY

"*If I could paint the flower exactly as I see it no one would see what I see because I would paint it small like the flower is small. So I said to myself... I'll paint it big.*" - Georgia O'Keefe, 1939

The flowering plants are the most numerous, most diverse and most important plants over much of the earth's land surface. One characteristic feature of the angiosperms is the grouping of reproductive structures with sterile auxiliary ones into a single unit known as the flower. An understanding of their reproductive structures is basic to any introductory taxonomy course. At the end of this Lab exercise you will find an illustrated glossary containing many of the floral terms you must learn.

FLORAL DRAWINGS

As part of all future Lab exercises, you will be required to make floral drawings. For some of you, this will be easy and perhaps even fun. For others, like your professor, who have no natural drawing abilities, this will be laborious at best. However, experience has shown that this is the best way to get you to look at the material closely, to understand the important points, and to record your observations for later reference (such as studying for an exam.) Your drawings will be turned in and graded.

The important point to remember is that the artistic quality of the drawings is not of any consequence. What matters is that the structures are recorded accurately and in their proper relationship. "Stick drawings" or diagrams that do this will be graded just as highly as drawings that look like they were drawn by Leonardo da Vinci. In the same light, detailed drawings that are artistically beautiful but botanically incorrect will be given low grades.

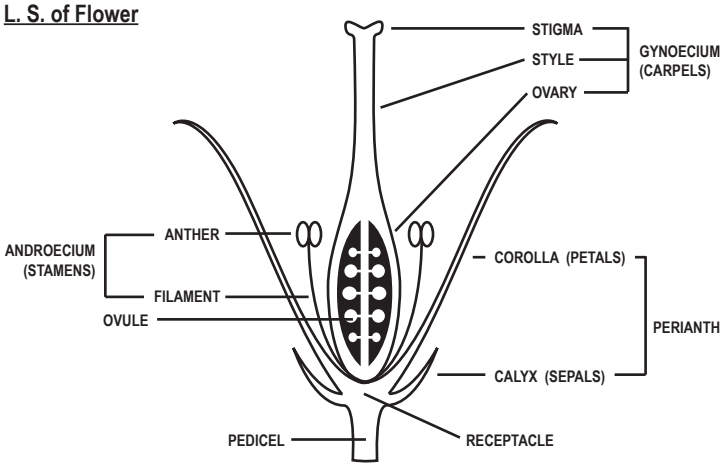
The most common drawings will be of flowers, especially median longitudinal sections and cross sections of ovaries. An example drawing is shown to the right. Please mimic the format presented in this example **EXACTLY**. If you have questions about your drawings, please see your TA or your professor!

Species Name
(Family Name)

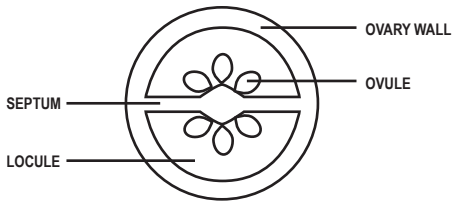
Floral Formula

Your Name
Lab Number
Date

L. S. of Flower

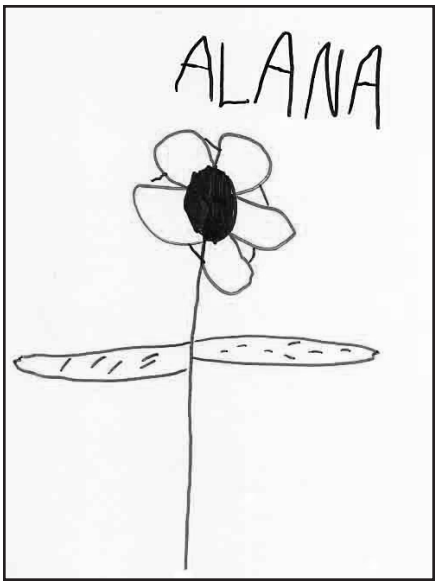


X. S. of Ovary



For full points on your floral drawings, be sure to:

1. Make high quality flower dissections and understand the structure before drawing. Check with the TA if you have questions!
2. Use a quality pencil and have an eraser.
3. Include the scientific name (underlined!) and family.
4. Write out the complete floral formula. This should be of the plant observed, not necessarily the general floral formula for the family.
5. Include your own name, date and lab section.
6. Make your drawings large enough so that the important details can be seen.
7. Label all important parts in the drawings.
8. Use a ruler to add lines for labels. Keep your drawings neat!



FLORAL FORMULAS

Flowers are complex and there is enormous diversity in their structure. Floral formulas provide an easy way to write down the important features of flowers and thereby capture structural diversity. Throughout the semester you will need to interpret the floral formulas provided for each plant family as well as construct your own for the flower specimens we will dissect in Lab. To construct a floral formula, always follow these steps:

1. Write the symbol for the flower's gender. (HINT: Is the flower perfect or imperfect?)

⚥	**HERMAPHRODITE**	Perfect Flowers
♂	**STAMINATE**	Male Flowers
♀	**CARPELLATE**	Female Flowers

2. Identify the floral series present and how they are arranged in relation to one another.

Ca	**CALYX**	Sepals
Co	**COROLLA**	Petals
A	**ANDROECIUM**	Stamen(s)
G	**GYNOECIUM**	Carpel(s)

3. Determine the ovary **INSERTION TYPE** and use the appropriate format to construct your floral formula. (Hint: Is the ovary superior or inferior and is there a hypanthium?)

$\underline{Ca^{?}\ Co^{?}\ A^{?}\ G^{?}}$ **HYPOGYNOUS**

$\underset{\frown}{Ca^{?}\ Co^{?}\ A^{?}\ G^{?}}$ **PERIGYNOUS**

$\dfrac{Ca^{?}\ Co^{?}\ A^{?}}{G^{?}}$ **EPIGYNOUS**

$\dfrac{\overset{\frown}{Ca^{?}\ Co^{?}\ A^{?}}}{G^{?}}$ **EPIGYNOUS WITH HYPANTHIUM**

4. Find the superscript for each **FLORAL SERIES** by counting the number of parts that make it up (Hint: The subscripts can range from 0 (structure not present) to ∞.) For example:

   G^{5} 5 distinct carpels make up an **APOCARPOUS GYNOECIUM**

5. Determine if any of the **FLORAL SERIES** parts are connate to one another. If so, draw a circle around their subscript. For example:

   $G_{\textcircled{5}}$ 5 connate carpels make up a **SYNCARPOUS GYNOECIUM**

6. Determine if the flower's Ca and Co have **ACTINOMORPHIC** or **ZYGOMORPHIC** symmetry. If actinomorphic symmetry, the floral formula remains unchanged and if zygomorphic symmetry add a Z next to Ca, Co or both.

$\underline{Ca^{?}\ Co^{?}\ A^{?}\ G^{?}}$ **ACTINOMORPHIC**

$\underline{CaZ^{?}\ CoZ^{?}\ A^{?}\ G^{?}}$ **ZYGOMORPHIC**

7. If the flower has **EPIPETALOUS STAMENS** make sure to indicate it in the floral formula as pictured below.

$\dfrac{A^{?}}{Ca^{?}\ Co^{?}\ G^{?}}$ **EPIPETALOUS STAMENS**

FLORAL MORPHOLOGY TERMINOLOGY LAB EXERCISE

The major objective of today's Lab exercise is to acquaint you with floral terminology. As in Lab 2: Vegetative Terminology, there is a bewildering number of terms, but we will stress only the more commonly used ones in this course. Make sure to learn these floral terms as soon as possible! The majority of the lab will be spent on plant families and if you do not have the arsenal of floral vocabulary used to describe them, you will quickly become lost.

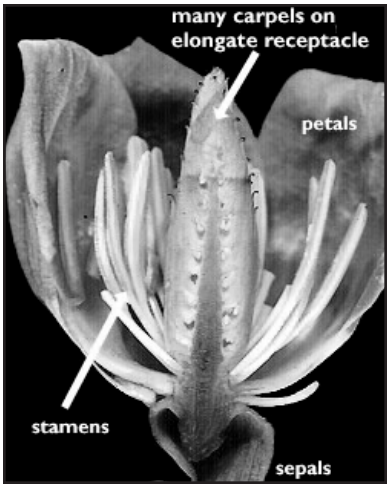
Begin today's Lab by reading over the Floral Formula examples on the next few pages. These will give you an idea of how floral fomulas are constructed and interpreted. Afterward, complete the Floral Morphology Lab exercise by examining, dissecting and answering questions about the flowers of three different plant species. Please use the "Glossary of Floral Terminology" provided at the end of this Lab to help you.

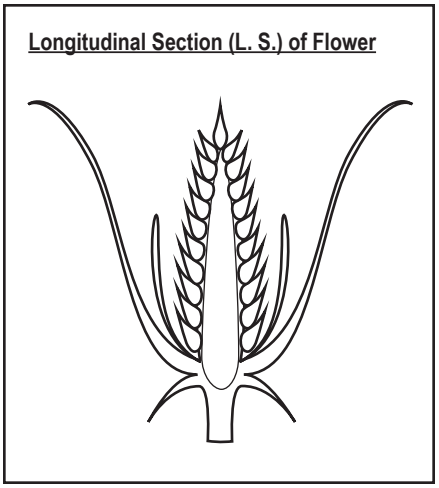
FLORAL FORMULA EXAMPLES

***Liriodendron tulipifera* L. (Magnoliaceae) (Tulip Tree)**

$\text{♀}\ \underline{Ca^{3}\ Co^{6}\ A^{\infty}\ G^{\infty}}$

The flowers of *L. tulipifera* are perfect (thus plants are **SYNOECIOUS**) and complete with **ACTINOMORPHIC** (**RADIAL**) floral symmetry. They have 3 distinct sepals in their calyx, 6 distinct petals in their corolla, numerous stamens in their androecium and numerous carpels in their **APOCARPOUS** gynoecium. All floral series are free from one another. The ovaries are superior and the floral insertion is **HYPOGYNOUS**.





***Geranium maculatum* L. (Geraniaceae) (Spotted Geranium)**

$$\text{♂}\ \underline{\text{Ca}^5\ \text{Co}^5\ \text{A}^{10}\ \text{G}\textcircled{5}}$$

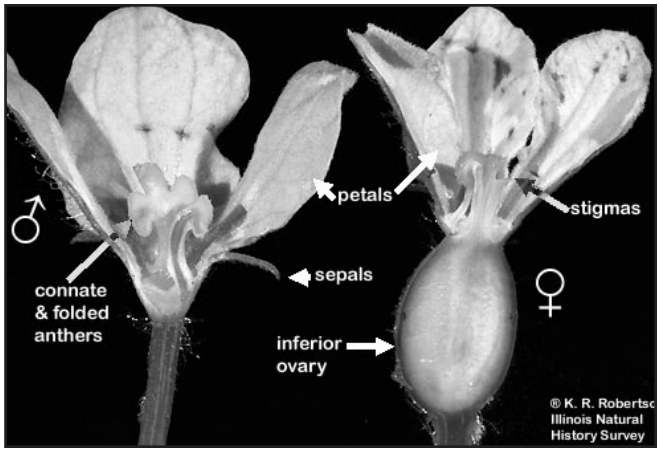
The flowers of *G. maculatum* are perfect (thus plants are **SYNOECIOUS**) and complete with **ACTINOMORPHIC** (**RADIAL**) floral symmetry. They are considered 5-merous because they have 5 distinct green sepals in their calyx, 5 distinct pink petals in their corolla, 10 distinct stamens in their androecium and 5 connate carpels in their **SYNCARPOUS** gynoecium. All floral series are free from one another. The ovary is superior and the floral insertion is **HYPOGYNOUS**.

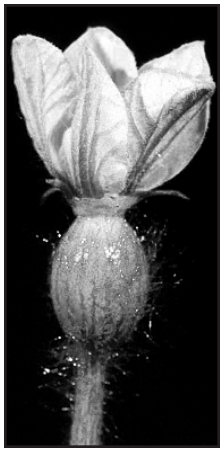
***Citrullus lanatus* (Thunb.) Matsum. & Nakai (Cucurbitaceae) (Watermelon)**

$$\text{♂}\ \underline{\text{Ca}^5\ \text{Co}\textcircled{5}\ \text{A}\textcircled{5}\ \text{G}^0}$$

$$\text{♀}\ \underline{\underline{\text{Ca}^5\ \text{Co}\textcircled{5}\ \text{A}^0}}\ \underline{\text{G}\textcircled{3}}$$

The flowers of *C. lanatus* are imperfect and incomplete, because the **STAMINATE** (male) flowers lack a gynoecium and the **CARPELLATE** (female) flowers lack an androecium. Both genders of flower exhibit **ACTINOMORPHIC** (**RADIAL**) floral symmetry and have 5 distinct sepals in their calyx and 5 connate petals in their corolla. The 5 anthers of the **STAMINATE** flowers are connate (which is an unusual feature) and 3 connate carpels make up the **SYNCARPOUS** gynoecium of **CARPELLATE** flowers. All floral series are free from one another. The ovary of the carpellate flowers is inferior and the floral insertion is **EPIGYNOUS**. Since both male and female flowers are found on the same plant, the plants are **MONOECIOUS**.

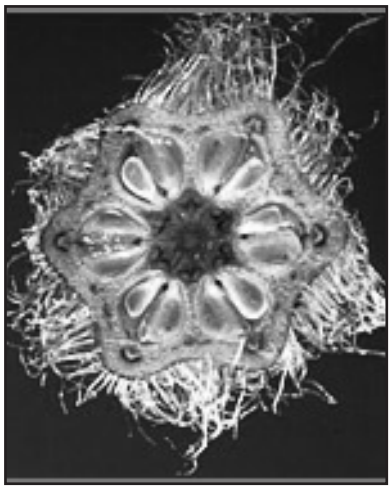


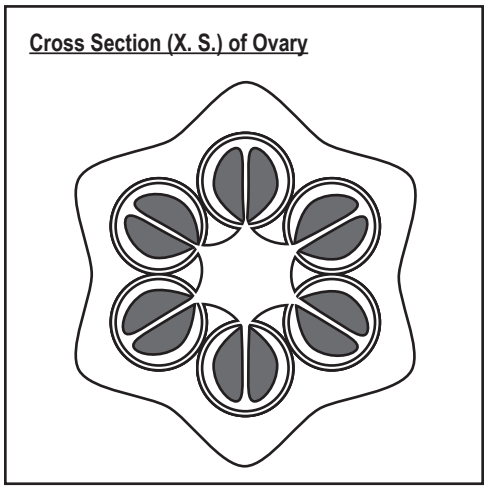


***Asarum canadense* L. (Aristolochiaceae) (Canadian Wild Ginger)**

$$\frac{\text{♂ } Ca^{3}\ Co^{0}\ A^{12}}{G\ ⑥}$$

The flowers of *A. canadense* are perfect (thus plants are **SYNOECIOUS**) with **ACTINOMORPHIC** (**RADIAL**) floral symmetry. However, these flowers are incomplete and **UNISERIATE** because they have 3 distinct sepals in their calyx but have no corolla. There are 12 distinct stamens in their androecium and 6 connate carpels in their **SYNCARPOUS** gynoecium. All floral series are free from one another. The ovary is inferior and the floral insertion is **EPIGYNOUS**.

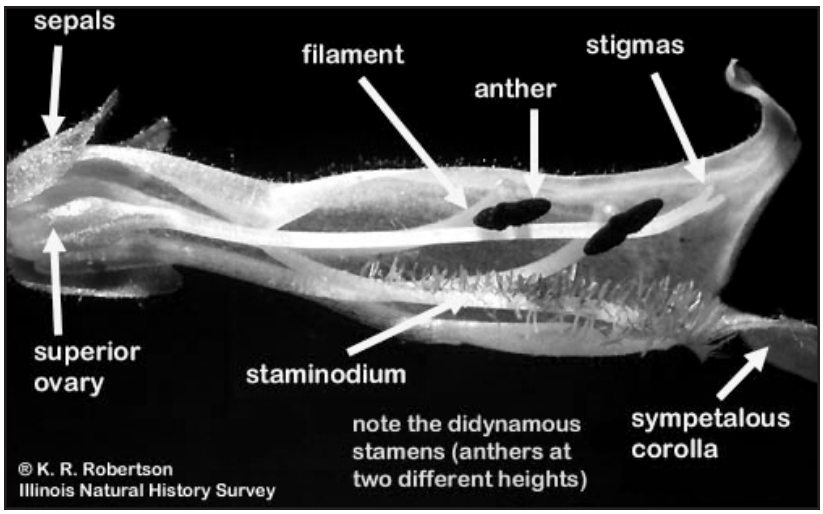




***Penstemon pallidus* Small (Scrophulariaceae) (Pale Beardstongue)**

$$\text{♂ } \frac{CaZ⑤\ CoZ⑤\ G②}{A^{4}}$$

These flowers are perfect (thus plants are **SYNOECIOUS**) and complete with **ZYGOMORPHIC** (**BILATERAL**) floral symmetry. They have 5 connate sepals in their calyx, 5 connate petals in their corolla, 4 stamens in their androecium and 2 connate carpels in their **SYNCARPOUS** gynoecium. The ovary is superior and the floral insertion is **HYPOGYNOUS**. Also, the androecium is adnate to the corolla (**EPIPETALOUS STAMENS**). This flower also has a staminode, which is not indicated in the floral formula.



FLORAL MORPHOLOGY: SPECIMEN 1

Before you being examining any flowers, set up a dissecting microscope and light source. Feel free to work in pairs.

***Crassula argentea* Thunb. (CRASSULACEAE) (Jade plant)**

Crassula is Latin and is the diminutive of "crassus," meaning thick in reference to the thick and fleshy (i.e. succulent) leaves found on this plant. Although the Crassulaceae family is found the world over, it has its greatest diversity in South Africa. Many Crassulaceae species are common in arid regions, usually in stony soil or on rocky outcrops, hence why the family is often called the Stonecrop family.

1. Observe your flower from the top. What is its floral symmetry?

2. **CALYX**: Look at the base of the flower under your dissecting scope and note the 5 small green lobes of the sepals that comprise the calyx. Remember the sepals alternate with the petals, meaning that the sepals are found between the larger, white petals.

3. **COROLLA**: How many petals make up the corolla? Note the small nectariferous appendage that is found externally on each carpel near its base. What is the function of these nectaries?

4. **ANDROECIUM**: Observe how the stamens are alternating with the petals and are opposite the small sepal lobes. How many stamens are there in the androecium?

5. **GYNOECIUM**: The gynoecium of this flower is made up of 5 distinct (un-fused) carpels. How many ovaries are in the flower? Are there few or many ovules per ovary?

GYNOECIUM TYPE _____

OVARY POSITION _____

INSERTION TYPE _____

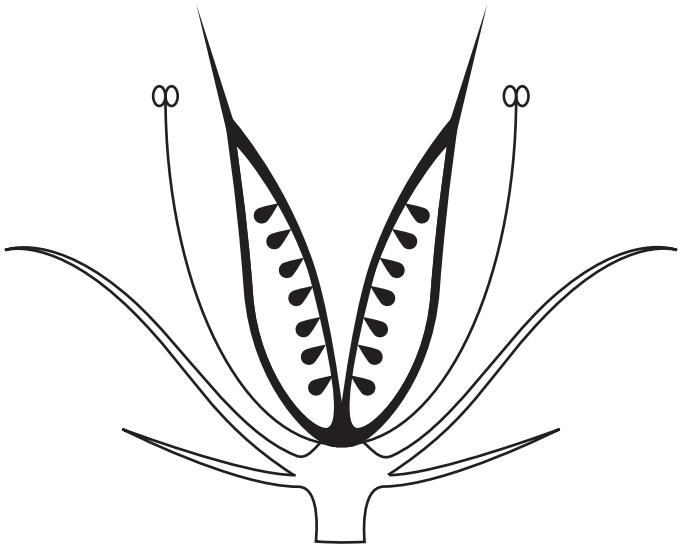
FURTHER QUESTIONS:

1. Dissect a carpel to determine placentation type. You will have to do this under your dissecting scope.

2. Based on your examination of the flower, is it **COMPLETE** or **INCOMPLETE**? **PERFECT** or **IMPERFECT**?

3. Below is a drawing of a longitudinal section (L.S.) of *Crassula*. Label all parts and construct a complete floral formula for this flower. Also, try to verbally describe either in list or paragraph form your rational for your floral formula. Make sure to use the appropriate terminology!

L. S. of Flower



FLORAL FORMULA

RATIONAL

Box 1

FLORAL MORPHOLOGY: SPECIMEN 2

***Nicotiana alata* Link & Otto (SOLANACEAE)**

Nicotiana is named for Jean Nicot (1530 - 1600), French consul to Portugal, who is said to have first presented tobacco to the courts of Portugal and France. Tobacco is native to the Americas. The flower of *Nicotiana* usually open at night and are then most fragrant. What might pollinate this flower?

1. Observe your flower from the top. What is the floral symmetry?

2. **CALYX**: Observe the pubescent calyx. In *Nicotiana*, the calyx is often described as being toothed or cleft (meaning deeply lobed). How many sepals make up the calyx? Are they connate?

3. **COROLLA**: The corolla of this flower is described as salverform because of its long, slender tube and abruptly expanded flat limb. How many connate petals make up the corolla tube? (Hint: Count the number of corolla lobes.)

4. **ANDROECIUM**: How many **EPIPETALOUS STAMENS** make up the androecium of this flower? Also, what does the descriptive term **EPIPETALOUS** mean? Are the stamens in anthesis (that is, is pollen being shed)?

5. **GYNOECIUM**: Note the bilobed stigma of the gynoecium. How many carpels do you think fused to produce this gynoecium? Make a cross section (X.S.) of the ovary, draw it in Box 1 and label its parts. How many locules do you see?

GYNOECIUM TYPE _____

OVARY POSITION _____

INSERTION TYPE _____

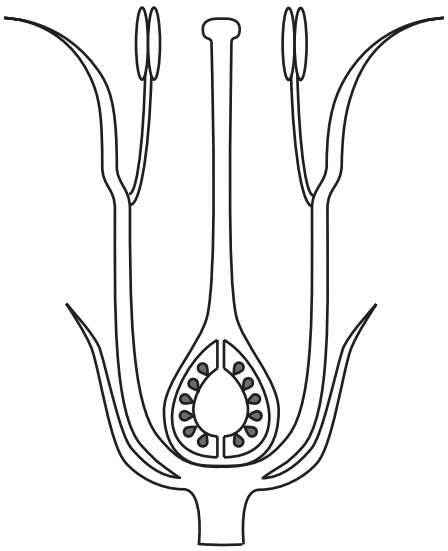
PLACENTATION _____

FURTHER QUESTIONS:

1. Based on your observation of the flower, is it **COMPLETE** or **INCOMPLETE**? **PERFECT** or **IMPERFECT**?

2. Below is a drawing of a longitudinal section (L.S.) of *Nicotiana*. Label all parts and construct a complete floral formula for this flower. Also, try to verbally describe either in list or paragraph form your rational for your floral formula. Again, be sure to use the appropriate terminology!

L. S. of Flower



FLORAL FORMULA

RATIONAL

FLORAL MORPHOLOGY: SPECIMEN 3

***Fuchsia triphylla* L. (Onagraceae)**

The family Onagraceae is cosmopolitan in distribution and especially prominent in western North America. The family includes many showy wildflowers and some ornamentals. *Fuchsia* derives its name from the important physician and botanist, Leonard Fuchs (1501 - 1565). Many physicians of the Renaissance period and before were actually practicing plant taxonomists. Why?

1. Observe the flower. What is the floral symmetry?

2. **CALYX**: In this species the calyx is petaloid (i.e. not green and leafy) and its sepals are larger than the petals. How many sepals make up the calyx?

3. **COROLLA**: Notice how the petals of the corolla alternate with the sepals of the calyx. How many petals make up the corolla? Collectively the calyx and corolla make up the **PERIANTH**. Thus, the **PERIANTH** possesses two whorls.

4. **ANDROECIUM**: Carefully cut the flower from top to bottom using a sharp razor blade and examine the stamens. How many are there? You'll notice that they are not all the same length. The stamens bearing the shorter filaments are opposite the petals, while the stamens bearing the longer filaments are opposite the sepals.

   The "floral tube" of this flower is more accurately called a **HYPANTHIUM**. A **HYPANTHIUM** is a structure derived by the adnation of the bases of the perianth elements (calyx and corolla) and the androecium. However, the sepals, petals and stamens are separate from one another after they arise from the rim of the hypanthium. At the base of the hypanthium you should see four swollen glands or nectaries. What is their purpose? (Hint: If there is a pool of liquid

remaining at the base of the hypanthium, have a taste. It's yummy.)

5. **GYNOECIUM**: The stigma of *Fuchsia* is swollen and prominently 4-lobed. How many carpels make up the gynoecium of the flower and what features did you look at to determine carpel number?

GYNOECIUM TYPE _____

OVARY POSITION _____

INSERTION TYPE _____

PLACENTATION _____

FURTHER QUESTIONS:

1. Based on your observation of the flower, is it **COMPLETE** or **INCOMPLETE**? **PERFECT** or **IMPERFECT**?

2. Draw and label a longitudinal section (L.S.) of a *F. triphylla* flower as well as a cross section (X.S.) of its ovary and construct its floral formula in the space provided.

FLORAL FORMULA

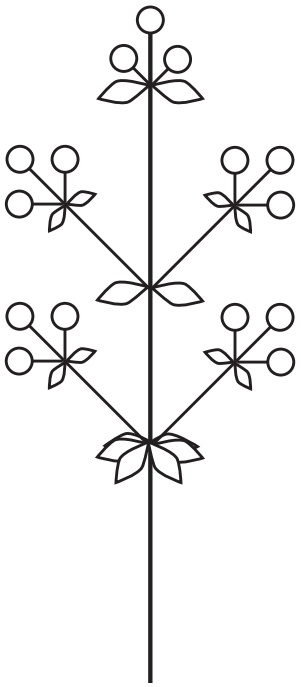
INFLORESCENCE TERMINOLOGY LAB EXERCISE

In this portion of today's Lab exercise, you will become familiar with the parts, positions and types of various **INDETERMINATE** and **DETERMINATE** inflorescences. Remember that an inflorescence is simply the arrangement of flowers on a floral axis. If you're unsure of a term, refer to the Inflorescence Type flow chart on the next page or the "Glossary of Inflorescence Terminology" provided at the end of this Lab.

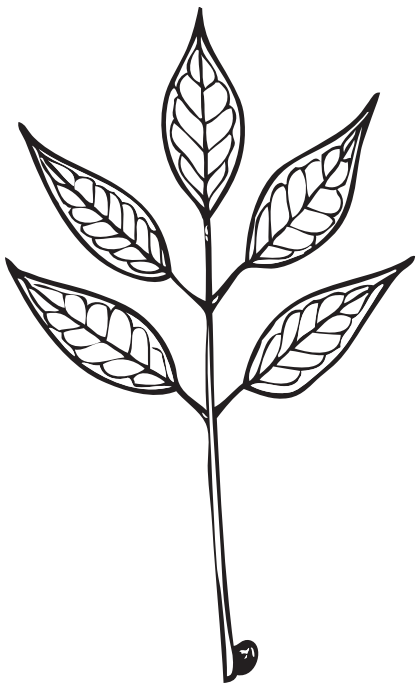
INFLORESCENCE PARTS

Just as leaves have an assortment of terms used to describe their consitituent parts, so too do inflorescences. In the table to the right is a list of the parts of inflorescences and compound leaves that often are mixed up by students (Too many terms that begin with the letter P!). On the diagram below, please label these parts. Also, label the **BRACTS**, **BRACTEOLES** and **INVOLUCRE OF BRACTS** on the inflorescence.

INFLORESCENCE	COMPOUND LEAF
Flower	Leaflet (Pinna)
Pedicel	Petiolule
Rachis	Rachis
Peduncle	Petiole



INFLORESCENCE



COMPOUND LEAF

INFLORESCENCE POSITION

Some plant species have characteristic inflorescence positions. For example, pineapples always display an intercalary inflorescence position. Notice the vegetative material on the top of the fruit. Alternatively, redbud and chocolate trees exhibit a cauliflory inflorescence position due to the placement of the flowers directly on the tree branches. Make sure that you become familiar with all the inflorescence position terms found in the "Glossary of Inflorescence Terminology"!

INFLORESCENCE TYPES

As with inflorescence positions, inflorescence types may be a key feature for a plant family. On display you will find an assortment of live plants and/or herbarium specimens. Examine them and in the space provided below, record the name of the specimen(s) that display(s) each of the major inflorescence types. Keep in mind that some of the inflorescence types will only be represented by one specimen.

RACEME

1. _____
2. _____

CAPITULUM

1. _____
2. _____

PANICLE

1. _____
2. _____

SIMPLE UMBEL

1. _____
2. _____

SPIKE

1. _____
2. _____

COMPOUND UMBEL

1. _____
2. _____

CORYMB

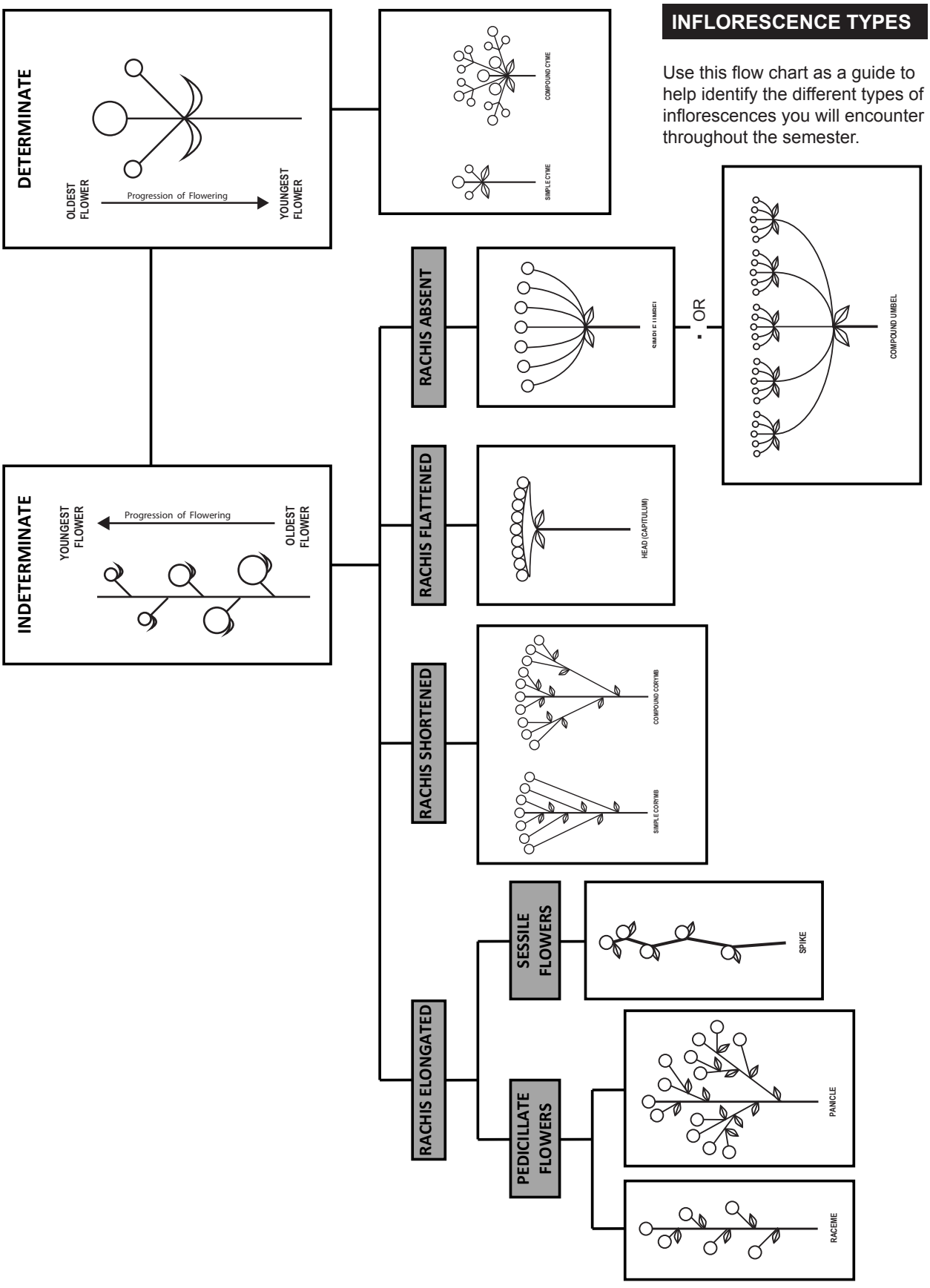
1. _____
2. _____

CYME

1. _____
2. _____

INFLORESCENCE TYPES

Use this flow chart as a guide to help identify the different types of inflorescences you will encounter throughout the semester.



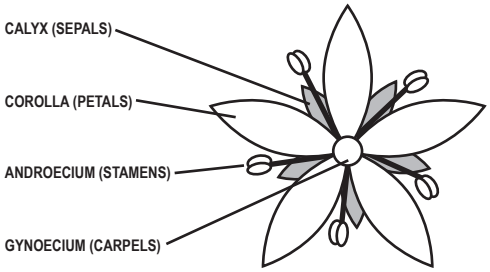
GLOSSARY OF FLORAL TERMINOLOGY

Listed below is the floral terminology that you will need to become skillful at using this semester. You should be able to draw, compare and contrast each of these terms. You should also know the relationship between each of the terms listed (i.e. **CHARACTER STATES**) and the major category (i.e. **CHARACTER**) to which they belong.

FLORAL SERIES

The four floral series terms listed below are the *collective terms* for the major floral parts (i.e. sepals, petals, stamens and carpels). For example, all the sepals cumulatively make up the flower's **CALYX**).

1. **CALYX**	Ca	Sepals
2. **COROLLA**	Co	Petals
3. **ANDROECIUM**	A	Stamen(s)
4. **GYNOECIUM**	G	Carpel(s)



COMPLETENESS

COMPLETE
All four floral series present (Ca, Co, A & G)

INCOMPLETE
One or more floral series absent

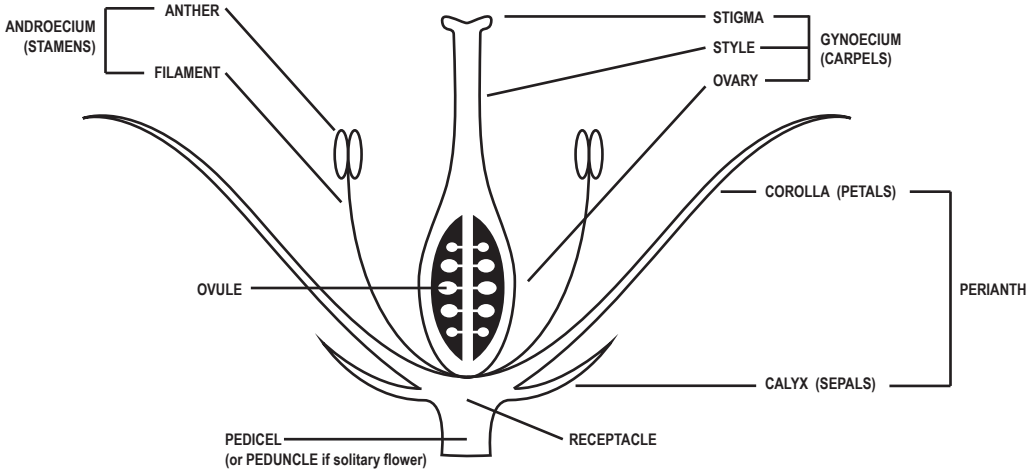
PERFECT
Flower with both A and G functional

IMPERFECT
Flower lacking either a functional A and G

STAMINATE
Male flower; has a functional A but lacks a functional G

CARPELLATE
Female flower; has a functional G but lacks a functional A

FLORAL DIAGRAM

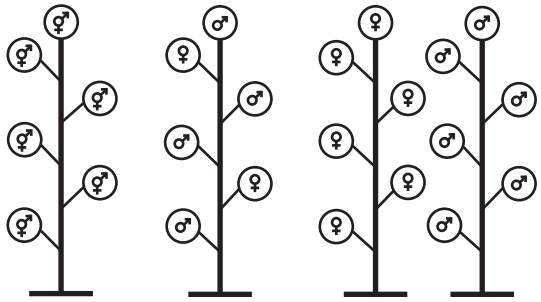


PLANT CONDITION

SYNOECIOUS
All flowers on a plant are perfect

MONOECIOUS
Both staminate and carpellate flowers occur on the same plant

DIOECIOUS
Staminate and carpellate flowers occur on separate plants



SYNOECIOUS MONOECIOUS DIOECIOUS

FLORAL PART FUSION TERMINOLOGY

To determine the correct term to use to describe the fusion of floral parts, use the chart below by answering the following two questions:

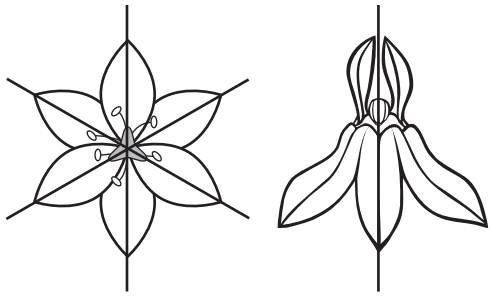
1. Do the floral parts belong to the same or different floral series?
2. Are the floral parts fused to one another or not?

		FLORAL PARTS: Same	FLORAL PARTS: Different
FUSION	Fused	**CONNATE**	**ADNATE**
	Un-fused	**DISTINCT**	**FREE**

FLORAL SYMMETRY

ACTINOMORPHIC (RADIAL)
Divisible into equal halves by two or more planes

ZYGOMORPHIC (BILATERAL)
Divisible into equal halves in one plane only



ACTINOMORPHIC SYMMETRY ZYGOMORPHIC SYMMETRY

PERIANTH (CALYX AND COROLLA)

PERIANTH
Collective term used for the Ca and Co

UNISERIATE
In one whorl or series (i.e. only Ca or only Co)

BISERIATE
In two whorls or series (i.e. both Ca & Co)

CORONA
An extra series of floral parts formed from outgrowths of the perianth parts, stamens or receptacle. Often showy and diverse.

TEPALS
Term used to describe the sepals and petals when the two cannot be differentiated (e.g. Cactaceae and Liliaceae)

3-MEROUS, 4-MEROUS, ETC.
Indicates number of parts in a specific floral series (e.g. a **4-MEROUS** flower might have 4 sepals, 4 petals, 8 stamens, and 4 carpels)

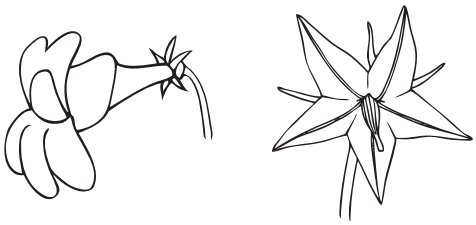
COROLLA TERMS

APETALOUS
Lacking petals

SYMPETALOUS
Petals that are connate at least at the base

BILABIATE COROLLA
Corolla is two-lipped (e.g. Lamiaceae and (sometimes) Scrophulariaceae)

PLICATE COROLLA
Corolla is folded like a fan (e.g. Solanaceae)

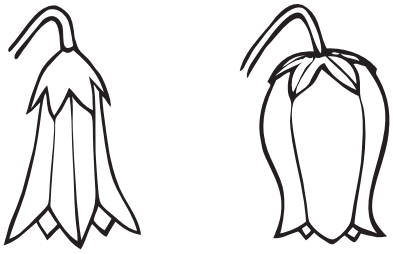


BILABIATE COROLLA PLICATE COROLLA

COROLLA SHAPE

CAMPANULATE
Bell-shaped (e.g. Ericaceae)

URCEOLATE
Urn or pitcher-shaped (e.g. Ericaceae)



CAMPANULATE URCEOLATE

ANDROECIUM

STAMENS
The male reproductive unit (the site of pollen production). One to many separate or fused **STAMENS** comprise an **ANDROECIUM**.

FILAMENT
Stalk of a stamen

ANTHER
Pollen producing portion of a stamen (meiosis occurs within the pollen sacs)

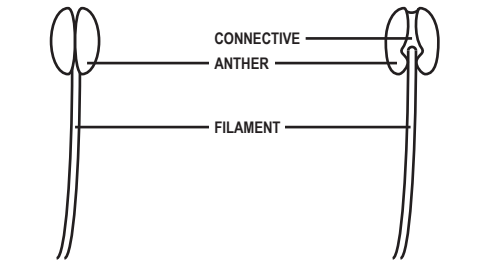
POLLEN
The male gametophytes

CONNECTIVE
The sterile tissue connecting the two locules of an anther

CONNIVENT ANTHERS
Anthers that converge but that are not actually connate to one other (e.g. Solanaceae)

VERSATILE ANTHERS
Anthers attached to filaments in their center rather than at one of their ends (e.g. Liliaceae)

VISCIN THREADS
A clear, sticky substance that holds together large numbers of pollen grains (e.g. Onagraceae)



ANDROECIUM

SPECIAL TYPES OF STAMENS

LAMINAR STAMENS
Ancestral stamens that possess wide and flattened **ANTHERS** and very tiny **FILAMENTS** (e.g. Magnoliaceae)

EPIPETALOUS STAMENS
Stamens that are fused (adnate) to corolla. Key feature of the families in the Asterid clade.

DIDYNAMOUS STAMENS
Having two short and two long stamens (e.g. Lamiaceae and Scrophulariaceae)

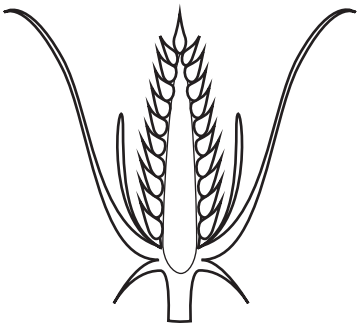
TETRADYNAMOUS STAMENS
Having two short and four long stamens (e.g. Brassicaceae)

MONADELPHOUS STAMENS
Stamen filaments connate to form one staminal tube (e.g. Malvaceae)

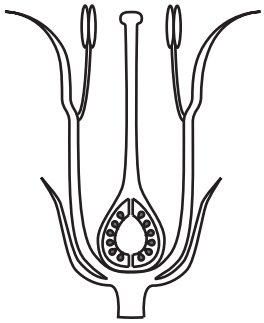
DIADELPHOUS STAMENS
Stamens united into two, often unequal, sets by selective connation among their filaments (e.g. Fabaceae subfamily Faboideae (9 + 1))

STAMINODES
Sterile stamens (they do not produce pollen); variable in form and size

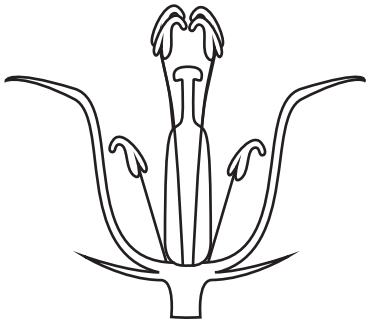
STAMINODIUM
The 5th sterile stamen in Scrophulariaceae



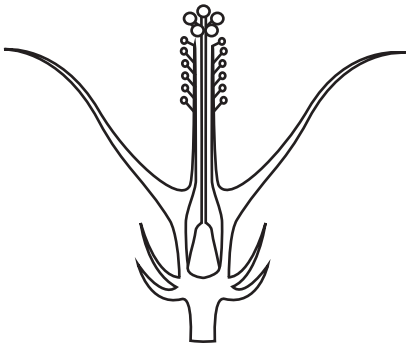
LAMINAR STAMENS



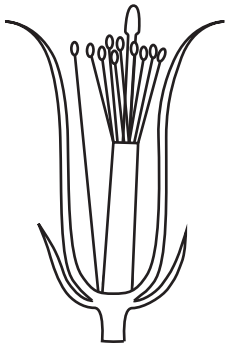
EPIPETALOUS STAMENS



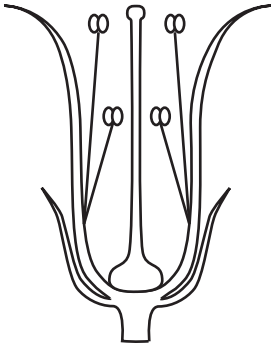
TETRADYNAMOUS STAMENS (4 LONG + 2 SHORT)



MONADELPHOUS STAMENS



DIADELPHOUS STAMENS
(9 CONNATE STAMENS + 1 DISTINCT STAMEN)



DIDYNAMOUS STAMENS
(2 LONG + 2 SHORT)

GYNOECIUM PARTS

CARPELS
The female reproductive unit (the site of ovule production, pollination and fertilization). One to many separate or fused carpels comprise a gynoecium.

STIGMA
The pollen receptive portion of the gynoecium.

STYLE
The elongated portion between stigma and ovary specialized for pollen tube growth.

OVARY
Basal portion that surrounds and protects the ovules.

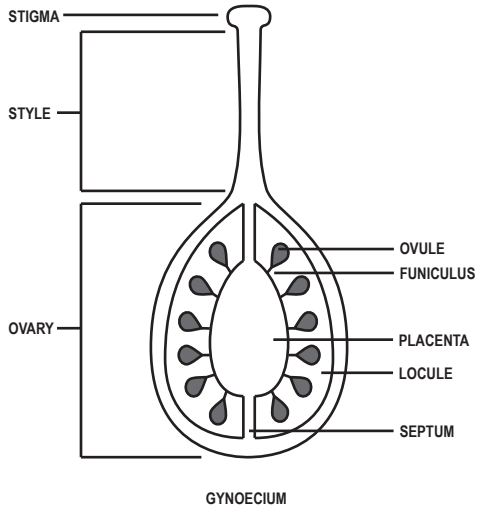
LOCULE
The chamber(s) within an ovary

SEPTUM (**SEPTA**)
Interior wall which separates the locules in instances where 2 or more chambers occur (walls = **SEPTA**)

PLACENTA (pl. **PLACENTAE**)
The region or line along which the ovules are attached

OVULE
Structure containing the female gametophyte (meiosis occurs within the ovule). Matures into a seed

FUNICULUS
The stalk connecting the ovule to the placenta



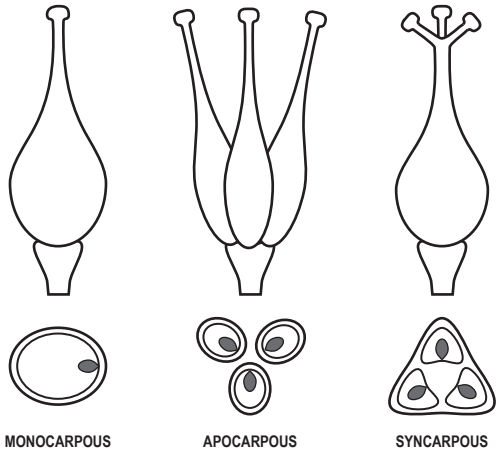
GYNOECIUM

GYNOECIUM TYPES

MONOCARPOUS GYNOECIUM
One carpel makes up the gynoecium

APOCARPOUS GYNOECIUM
Multiple (>1) distinct carpels make up the gynoecium

SYNCARPOUS GYNOECIUM
Multiple (>1) connate carpels make up the gynoecium



OVARY POSITION AND INSERTION TYPE

SUPERIOR OVARY
Ovary situated above the point of attachment of the perianth and androecium and wholly free from them (stamens may be adnate to corolla)

HYPOGYNOUS
A flower with perianth and androecium arising from below the ovary (gynoecium)

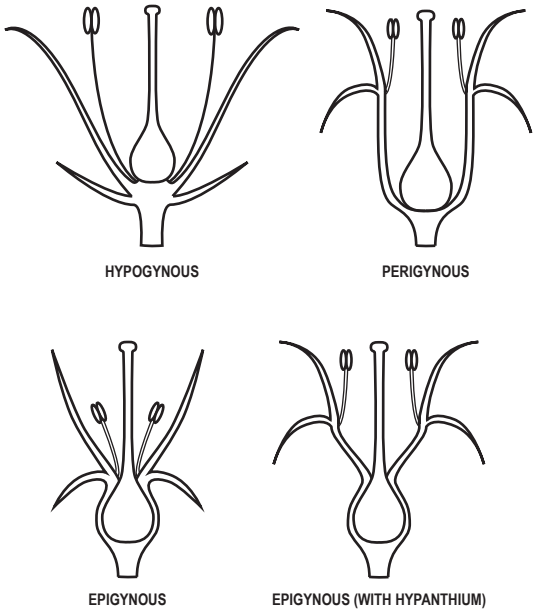
PERIGYNOUS
A flower with perianth and androecium arising from a **HYPANTHIUM** (floral cup) that is not adnate to the ovary. (Remember the ovary is still superior!)

INFERIOR OVARY
Ovary is below the point of attachment of the perianth and androecium. In other words, the outer floral whorls are adnate to the ovary. A **HYPANTHIUM** (floral cup) may or may not be present.

OVARY POSITION & INSERTION TYPE (cont.)

EPIGYNOUS

A flower with perianth and androecium arising upon the ovary rather than the receptacle.



PLACENTATION TYPE

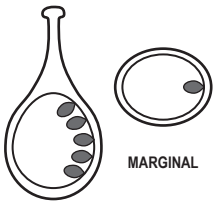
PLACENTATION

The arrangement of ovules within the ovary. To determine the type of placentation, first determine the gynoecium type (certain placentation types are found in certain gynoecium types).

In **MONOCARPOUS** or **APOCARPOUS** gynoecia:

MARGINAL

The ovules are attached to the folded margins of the carpel.



PLACENTATION TYPE (cont.)

In **SYNCARPOUS** gynoecia:

AXILE

The placental area of the ovary is attached to an axis derived from the connate margins of the component carpels - such an ovary is divided into two or more locules by septa. The ovules are borne along the central axis.

PARIETAL

The placental areas are attached to the side walls of the ovary (or extrusions of the wall) - such an ovary usually has one locule (therefore no septa).

APICAL

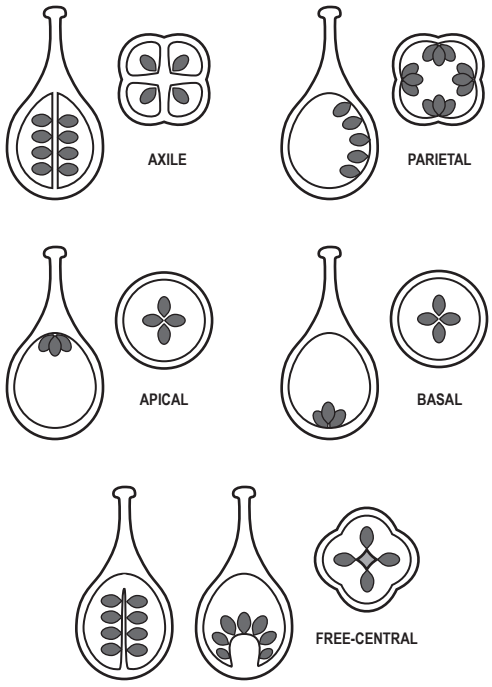
Attachment of ovules to the top of the ovary (one locule - no septa).

BASAL

Attachment of ovules to the bottom of the ovary (one locule - no septa).

FREE-CENTRAL

Attachment of ovules to a free-standing central column in the ovary (one locule - no septa).



MISCELLANEOUS TERMS

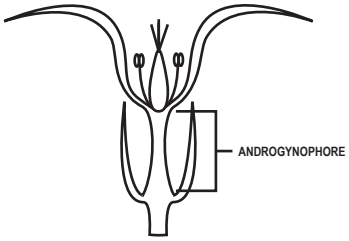
ANDROGYNOPHORE (i.e. **GYNOPHORE**)
Stalk that supports the corolla, androecium and gynoecium (e.g. Caryophyllaceae)

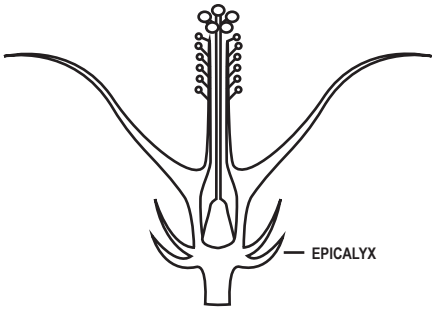
EPICALYX
A whorl of bracts that subtends the sepals (e.g. Malvaceae)

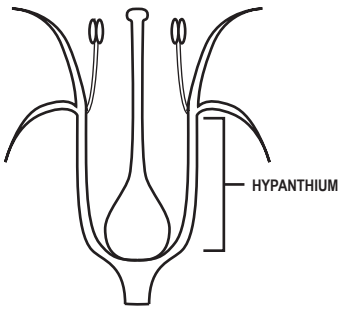
GYNOSTEGIUM
A structure formed from the adnation of the anthers of the androecium and stigmas of the gynoecium (e.g. Asclepiadaceae)

HYPANTHIUM
A floral cup formed from the adnation of the calyx, corolla and androecium

INVOLUCRE
A whorl of bracts subtending a flower or flower cluster (e.g. Fagaceae)







GLOSSARY OF INFLORESCENCE TERMINOLOGY

Listed below is the inflorescence terminology that you will need to become skillful at using this semester. You should be able to draw, compare and contrast each of these terms. You should also know the relationship between each of the terms listed (i.e. **CHARACTER STATES**) and the major category (i.e. **CHARACTER**) to which they belong.

INFLORESCENCE PARTS

BRACTS
A modified or much-reduced leaf associated with an inflorescence or flower. These may differ substantially from foliage leaves.

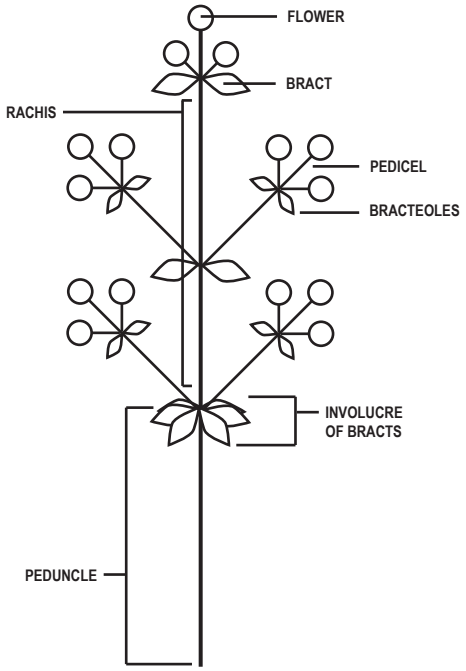
BRACTEOLES or **BRACTLETS**
A smaller **BRACT** (or **BRACTLET**)

INVOLUCRE
A series of **BRACTS** immediately subtending a flower or inflorescence

PEDICEL
The stalk of one flower in an inflorescence of multiple flowers

PEDUNCLE
The stalk of an inflorescence or a solitary flower

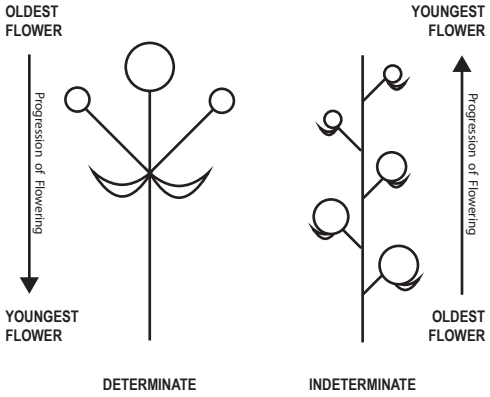
RACHIS
The primary axis of an elongated inflorescence



SEQUENCE OF FLOWERING

DETERMINATE INFLORESCENCE
An inflorescence in which the terminal or central flower opens first, resulting in the cessation of primary axis elongation.

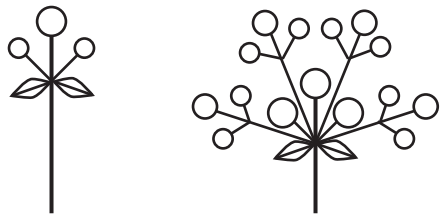
INDETERMINATE INFLORESCENCE
An inflorescence in which the lowermost or outermost flowers open first, with the primary axis often elongating as the flowers develop. Usually no terminal flower is produced.



DETERMINATE INFLORESCENCES

SIMPLE CYME
A three-flowered cluster composed of a peduncle bearing a terminal flower and, below it, two bracts with each bract subtending a lateral flower.

COMPOUND CYME
A branched simple cyme.



SIMPLE CYME COMPOUND CYME

INDETERMINATE INFLORESCENCES

CORYMB
A relatively flat topped inflorescence with the lower pedicels longer than the upper.

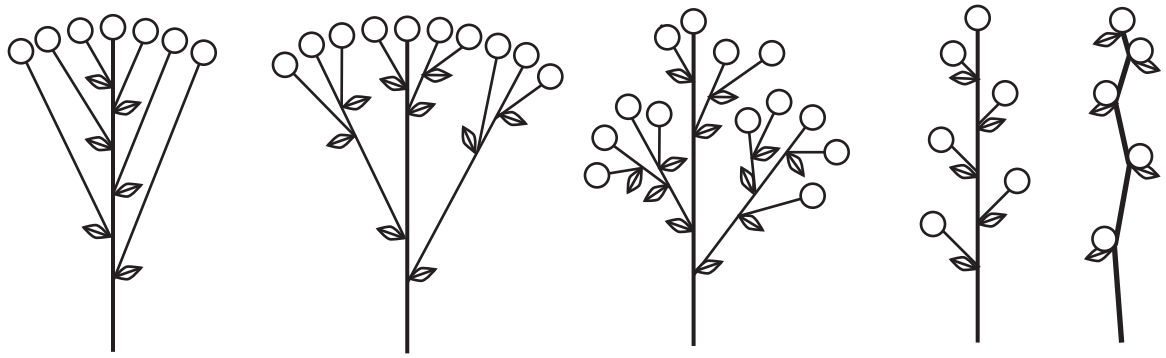
HEAD (CAPITULUM)
A compact inflorescence composed of a very short axis and usually sessile flowers.

PANICLE
Similar to a raceme but greatly branched.

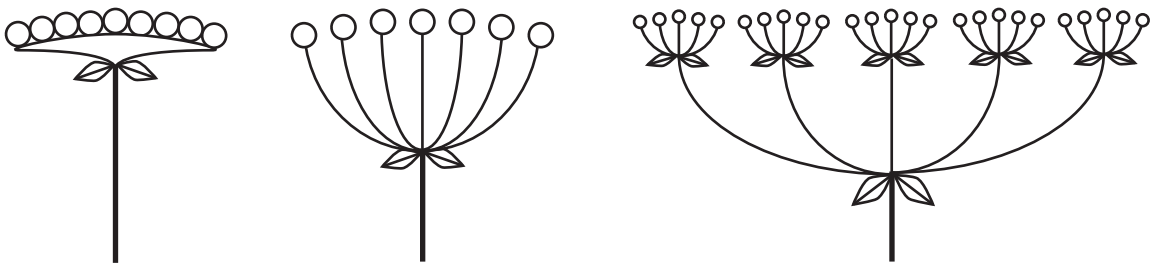
RACEME
Stalked flowers arranged along an elongate central axis (rachis).

SPIKE
Sessile flowers arranged along an elongate central axis (rachis).

UMBEL
Several branches radiating from the same point and are terminated by single flowers (Simple umbels) or 2° umbels (compound umbels).



SIMPLE CORYMB COMPOUND CORYMB PANICLE RACEME SPIKE



HEAD (CAPITULUM) SIMPLE UMBEL COMPOUND UMBEL

INFLORESCENCE POSITION

AXILLARY
Inflorescence arises from the axil of a leaf or bract

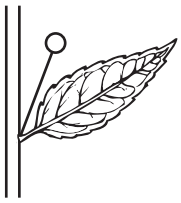
BASAL
Inflorescence where flowers are borne on a leafless peduncle that arises from a cluster of leaves at the base of the plant

CAULIFLORY
Flowers that grow directly upon woody stems or trunks

INTERCALARY
Inflorescence seemingly in the middle of a stem. Essentially, the main stem axis continues to grow vegetatively after having produced an inflorescence

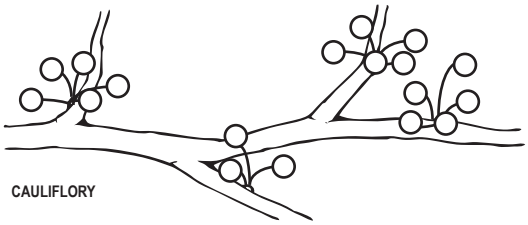
TERMINAL
Inflorescence terminates a stem

WHORLED
Inflorescence where there are multiple flowers arranged in a circle (whorl) around a single node (verticil)



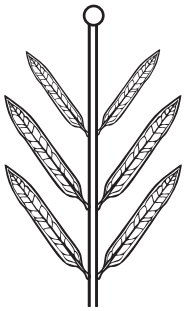
AXILLARY

BASAL



CAULIFLORY

INTERCALARY



TERMINAL

WHORLED (VERTICIL)

SPECIAL INFLORESCENCE TYPES

CATKIN (AMENT)

An inflorescence consisting of a dense spike or raceme of apetalous, unisexual flowers (e.g. Betulaceae, Fagaceae, Salicaceae).

CYATHIUM (pl. **CYATHIA**)

The inflorescence of the genus *Euphorbia* in Euphorbiaceae, consisting of a cup-like involucre containing a single female flower (just gynoecium, no calyx, corolla or androecium) and male flowers with a single stamen.

SPADIX

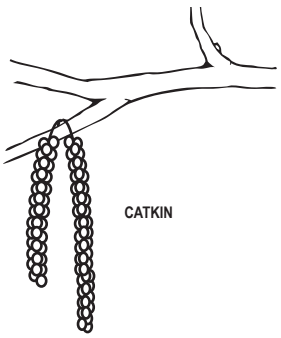
A spike with small flowers crowded on a thickened axis that is subtended by a **SPATHE** (e.g. Araceae)

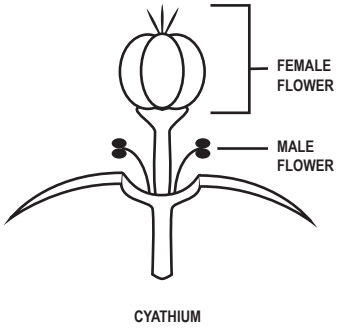
SPIKELET

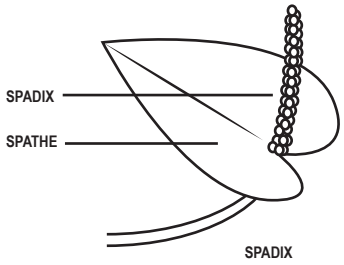
The inflorescence of grasses and sedges consisting of one to many flowers subtended by two bracts (glumes) (e.g. Poaceae).

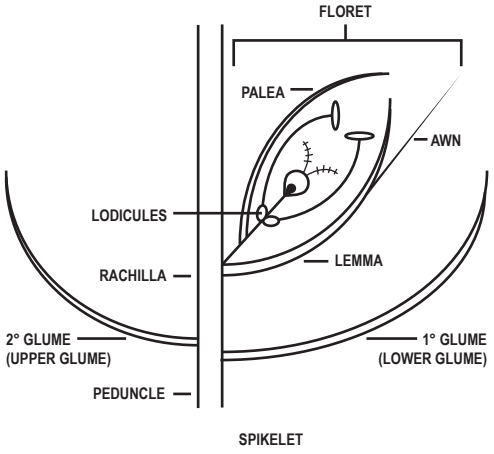
SYCONIUM (pl. **SYCONIA**)

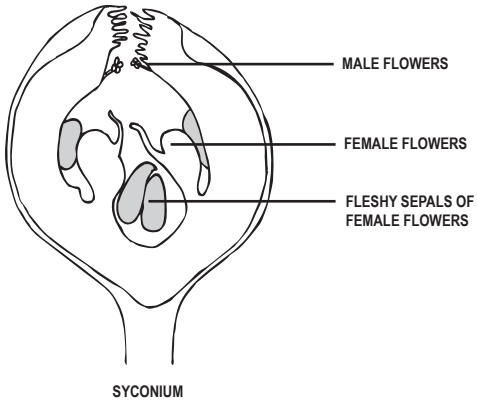
Fig inflorescence consisting of a hollow, inverted receptacle containing simple, unisexual flowers.

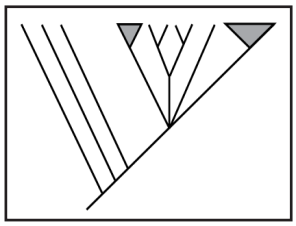












LABORATORY 4

FRUIT TERMINOLOGY

FRUIT AND SEED MORPHOLOGY

- A **FRUIT** is a ripened (mature) ovary of a flower along with any adnate parts.
- A **SEED** is a ripened (or fertilized) ovule containing an embryo within a seed coat and often with additional storage tissue.

The term “fruit” originally meant “any plant used as food”. Since the ancient Greeks, fruits have been eaten at the end of the meal and not with the meal. Consequently, most people commonly view fruits as sweet, soft plant products used in dessert foods. Alternatively, vegetables (the leaves, tubers, roots or even entire inflorescences of plants) are considered savory or main course foods. Though it is true that fruits generally have a much higher sugar content and are often more acidic those those things we call vegetables, botanically speaking not all fruits are soft and sweet and many are not good to eat at all!

A more precise, technical definion for a fruit was established as the science of botany arose in the 18th century. Botanically, a fruit is a mature ovary together with any floral or vegetative structures that are attached to it and that become enlarged and ripen with it. Additionally, the wall of the ovary becomes the **PERICARP** (the wall of the fruit). The **OVULES** become the **SEEDS**. The **ZYGOTE** matures into the **EMBRYO**, the **INTEGUMENTS** mature into the **SEED COAT**, and the **FUNICULUS** develops into the **SEED STALK**.

FLOWER PART	FRUIT PART
▪ Ovary wall	▪ Pericarp
▪ Ovule	▪ Seed
▪ Integuments (outer covering of ovule)	▪ Seed coat
▪ Zygote	▪ Embryo
▪ Fusion Nucleus	▪ Endosperm
▪ Funiculus (stalk of an ovule)	▪ Seed Stalk

Taxonomists have developed a usable classification of fruits based primarily on features such as texture, nature of dehiscence, number of seeds, presence or absence of attached parts, and the morphology of the ovary from which the fruits were derived. Today in Lab you will learn the major fruit types based on morphology and taxonomy as well as begin to examine the characteristics of the flowers they arise from.

MORPHOLOGY-BASED FRUIT TYPES

When classifying fruits based on morphology, there are three main groups:

1. **DRY, DEHISCENT FRUITS**
2. **DRY, INDEHISCENT FRUITS**
3. **FLESHY FRUITS**

MORPHOLOGY-BASED FRUITS

Use this flow chart as a guide to help identify the fruits you will encounter throughout the semester based on their morphology.

DRY

FLESHY

Pericarp splits open [seed is dispersal unit]

Pericarp remains closed [fruit is dispersal unit]

DEHISCENT FRUIT

INDEHISCENT FRUIT

BERRY

Usually syncarpous G

Superior or inferior ovary

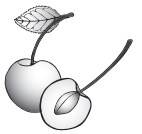
Entire pericarp fleshy

DRUPE

Superior ovary

Usually contains 1 seed

Has distinctive exo-, meso- and endocarp



FOLLICLE

Apocarpous G [from one carpel]

Opens along a single suture

CAPSULE

Syncarpous G

Contains few to many seeds

The most common and variable of all fruit types

SCHIZOCARP

Syncarpous G

Splits into 2 or more 1-seeded segments [mericarps]

ACHENE

Variable G

1-seeded with seed free from pericarp

NUT

Syncarpous G

1-seeded with a thick, bony pericarp

Involucre present

NUTLET

A small nut without the involucre

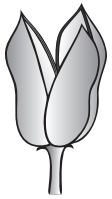
SAMARA

A winged achene

DEHISCENCE TYPE

SEPTICIDAL

Splits along septa

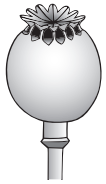


LOCULICIDAL

Splits along locule

PORICIDAL

Seeds released through pores



DENTICIDAL

Seeds released through apical teeth

CIRCUMSCISSLE

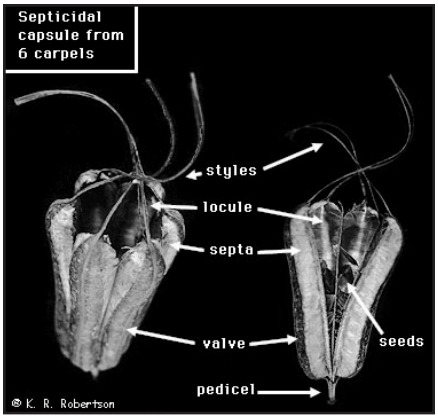
Top comes off [like lid] to release seeds

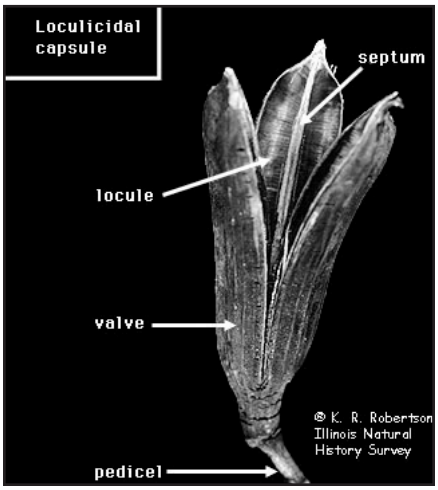
DRY AND DEHISCENT FRUITS

FOLLICLE

- *Asclepias incarnata* L. (Swamp Milkweed)
- *Asclepias syriaca* L. (Common Milkweed)
- *Aquilegia* spp. (Columbines)
- *Spiraea* spp. (Meadowsweet)

There are many plant species that produce **FOLLICLE** fruits including: milkweed, larkspur, columbine and peony. Observe the specimens on display. Notice how **FOLLICLES** split along one side only, exposing the seeds within. **FOLLICLES** are derived from one carpel. Based on this, what type or types of gynoecium could a flower have to produce this fruit type?



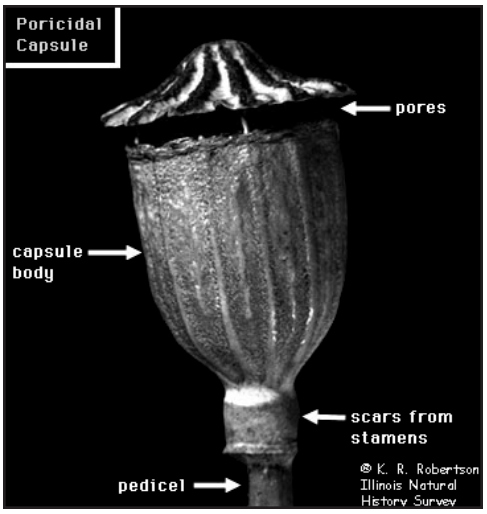


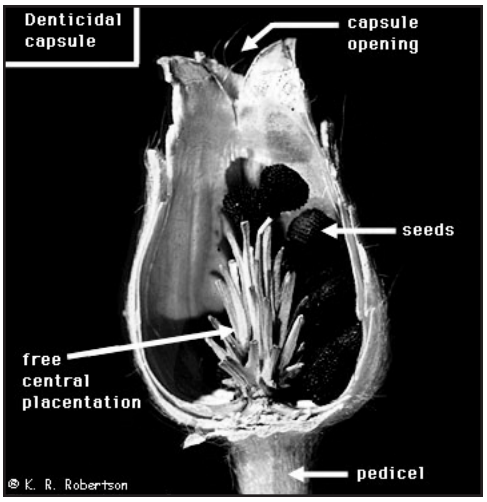
CAPSULE

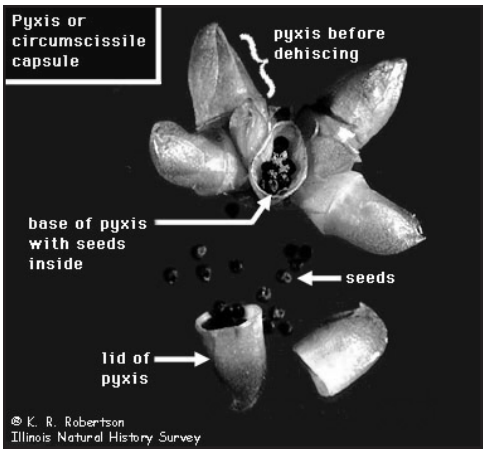
- *Aristolochia* spp. (Dutchman's Pipe)
- *Datura stramonium* L. (Datura)
- *Glaucium* spp. (Horned Poppy)
- *Hamamelis mollis* Oliv. (Witch Hazel)
- *Hemerocallis* spp. (Day Lily)
- *Hibiscus* spp. (Hibiscus)
- *Oenothera speciosa* Nutt. (Pinkladies)
- *Papaver* spp. (Poppies)
- *Portulaca oleracea* L. (Common Purslane)
- *Silene* spp. (Catchfly or Campion)
- *Yucca* spp. (Yucca)

CAPSULES are the most common of the dried fruit types that dehisce. They are derived from a syncarpous gynoecium, are typically several to many-seeded, consist of at least 2 carpels and split in a variety of ways.

Based on their mode of dehiscence (how they release seed), capsules have been classified into five different types. **SEPTICIDAL CAPSULES** split along the partitions or septa between their carpels, while **LOCULICIDAL CAPSULES** split open through the locules to dehisce. **PORICIDAL CAPSULES** have a row of pores through which the seed are shaken out as the fruits rattles in the wind. **DENTICIDAL CAPSULES** release their seeds through apical teeth. **CIRCUMSCISSLE CAPSULES** (or **PYXIS**) form a cap towards one end that pops off during dehiscence.







Box 1

For each capsule type below, list the names of the fruits on display that exhibit that type of dehiscence.

SEPTICIDAL CAPSULE

LOCULICIDAL CAPSULE

PORICIDAL CAPSULE

DENTICIDAL CAPSULE

CIRCUMSCISSLE CAPSULE

Differentiating between loculicidal and septicidal capsules can sometimes be quite tricky. However, if you think about the fruits in terms of their cross sections, it will be much easier. In Box 1, sketch a cross section of a loculicidal capsule and a septicidal capsule. Make sure these drawings clearly show where the fruit splits and where the fruit's septa are located.

DRY AND INDEHISCENT FRUITS

ACHENE

- *Fagopyrum esculentum* Moench (Buckwheat)
- *Helianthus* spp. (Sunflower)
- *Polygonum* spp. (Smartweed)

An **ACHENE** is a dry, indehiscent fruit type that is extremely variable in form and is derived from a monocarpous, apocarpous or syncarpous gynoecium. It is composed of a single seed attached only at its base to the fruit's hard **PERICARP**; therefore the seed is very easily removed from its pericarp. What is a **PERICARP** and what did it arise from in the original flower?

Crack open a sunflower seed or observe one on display. What are you actually cracking open?

NUT

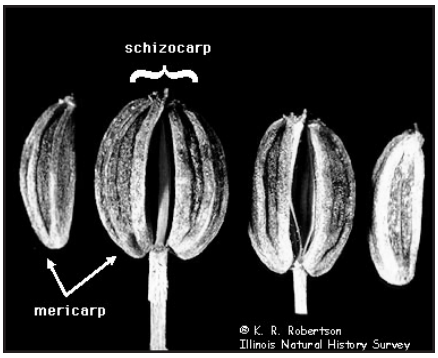
- *Castanea* spp. (Chestnuts)
- *Corylus americana* Marshall (American Hazelnut)
- *Quercus* spp. (Oaks)

NUTS are dry, indehiscent fruits derived from a syncarpous gynoecium, but are one-seeded by the abortion of ovules. They are similar to **ACHENES**, but are generally larger with a much harder and thicker **PERICARP**. Additionally, nuts mature with a cup (**INVOLUCRE**) or cluster of bracts at their base. This semester you'll learn about two plant families that produce **NUTS**, Fagaceae (the Beech family) and Betulaceae (the Birch family).

Many nuts in the popular sense are not nuts, botanically speaking. Which of the following are true nuts?

Peanuts, coconuts, almonds, walnuts, pecans, brazil nuts, cashews, pistachios

Answer: None are true nuts. A peanut is an atypical legume, coconuts and almonds are drupes, and walnuts and pecans are also drupes whose "flesh" withers and dries after the seed matures. Brazil nuts are the seeds of a large capsule, and a cashew is the single seed of a particular drupe. Pistachios are also the seeds of drupes.

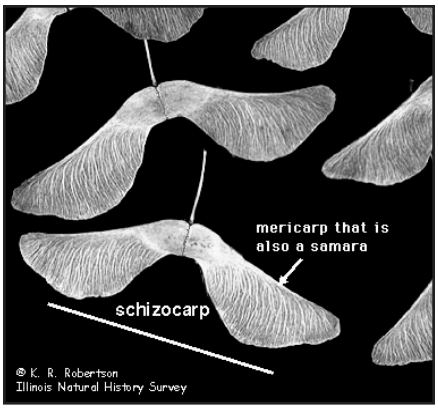


SCHIZOCARPS

- *Anethum graveolens* L. (Dill)
- *Apium graveolens* L. (Celery)
- *Cuminum cyminum* L. (Cumin)
- *Foeniculum vulgare* Mill. (Fennel)

SCHIZOCARPS are dry, indehiscent fruits that break into one-carpellate segments called **MERICARPS**. Each **MERICARP** can contain one to a few seeds, and the seeds remain completely surrounded by the **PERICARP**. What type of gynoecium do **SCHIZOCARPS** develop from?

Members of the carrot family, Apiaceae, are characterized by this type of fruit. However, some species in Malvaceae produce **SCHIZOCARPS** as well, though their morphology is somewhat different. **SCHIZOCARPS** can also be winged as in Aceraceae (the maple family).



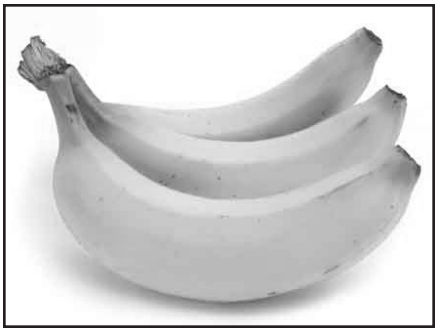
SAMARA

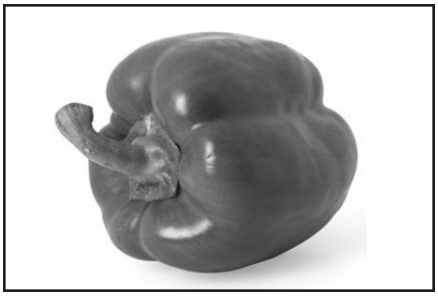
- *Acer* spp. (Maples)
- *Alnus glutinosa* (L.) Gaertner (Black Alder)
- *Fraxinus pennsylvanica* Marshall (Green Ash)

In **SAMARAS**, the **PERICARP** around the seed extends out into a wing or membrane. Essentially, a **SAMARA** is a winged **ACHENE**. What function does the wing serve?

Note: **SAMARAS** can be produced singly as in ashes, elms and birches or in pairs as in maples. For maples, a more precise term for the paired fruit is a **SAMAROID SCHIZOCARP** (and not, as we've seen written a samurai schizocarp) since the two samaras (or one-carpellate segments (**MERICARPS**)) break apart.

FLESHY FRUITS





Box 2

BERRY

- *Persea americana* Mill (Avocado)
- *Musa acuminata* Colla (Banana)
- *Capsicum annuum* L. (Bell Pepper)
- *Vaccinium corymbosum* L. (N. Highbush Blueberry)
- *Solanum melongena* L. (Eggplant)
- *Vitis vinifera* L. (Common Grape)
- *Actinidia deliciosa* C.F. Liang & A.R. Ferguson (Kiwi)
- *Carica papaya* Marsh (Papaya)
- *Physalis philadelphica* Lam. (Tomatillo)
- *Lycopersicon esculentum* Miller. (Tomato)

BERRIES typically develop from syncarpous gynoecia. Their entire pericarp is fleshy and relatively soft at maturity. Although most **BERRIES** contain more than one seed, notable exceptions are dates and avocados, which have only one.

Berries can arise from flowers with superior or inferior ovaries. How can you tell whether a berry has arisen from a superior or inferior ovary?

Which of the fruits on display were derived from flowers with superior ovaries?

Which ones were derived from flowers with inferior ovaries?

Make or observe a cross section (X.S.) through a cherry tomato and draw it in Box 2. What is the placentation type? How many carpels fused to produce the gynoecium of a tomato flower? How do you know?

What is the origin of the green, papery structure that surrounds a tomatillo fruit?

DRUPE

- *Cocos nucifera* L. (Coconut)
- *Olea europaea* L. (Olive)
- *Prunus americana* Marsh (American Plum)
- *Prunus armeniaca* L. (Apricot)
- *Prunus avium* (L.) L. (Sweet Cherry)
- *Prunus dulcis* (Mill.) D.A. Webb (Sweet Almond)
- *Prunus persica* (L.) Batsch (Peach/Nectarine)

DRUPES usually develop from flowers with a superior ovary containing a single ovule. Unlike in **BERRIES**, the **PERICARP** of **DRUPES** is differentiated into an **EXOCARP**, **MESOCARP**, and stony **ENDOCARP** (the pit). Examine the cut fruit on display. Sketch one of them out in Box 3, and then identify and label the following structures: **EXOCARP**, **MESOCARP**, **ENDOCARP** and **SEED**.

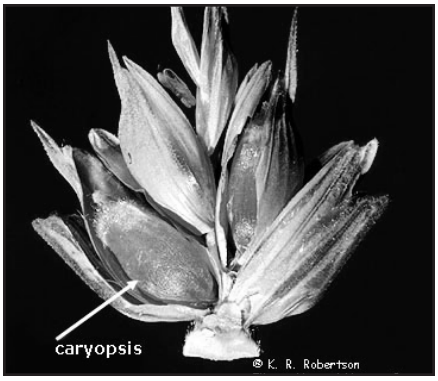
Box 3

The **MESOCARP** of a drupe is not always obviously fleshy. For example, in coconuts the husk (consisting of the **MESOCARP** and **EXOCARP**), is very fibrous and is usually removed before the rest of the fruit is sold in markets. What purpose does this fibrous **MESOCARP** serve? The edible portion of a coconut is the seed and comprises both solid “meat” and liquid “milk” endosperm. The endosperm is surrounded by the thick, hard **ENDOCARP** typical of drupes.

Almonds are typically sold shelled, that is after the shells (or endocarps) are removed. Blanched almonds are shelled almonds that have been treated with hot water to soften and remove the seedcoat.

Olives are a naturally bitter fruit that need to be fermented or cured with lye or brine to make them palatable.

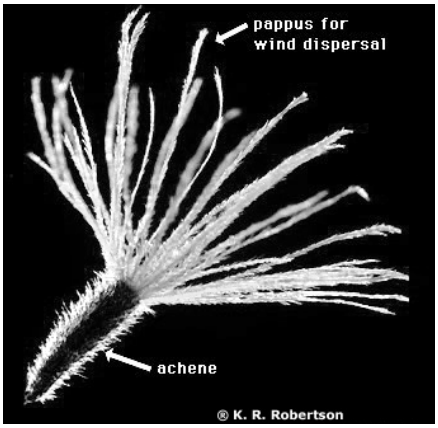
FRUIT TYPES BASED ON TAXONOMY



CARYOPSIS

- *Hordeum vulgare* L. (Common Barley)
- *Secale cereale* L. (Cereal Rye)
- *Triticum aestivum* L. (Common Wheat)
- *Zea mays* L. (Corn)

CARYOPSIS fruits are restricted to Poaceae (the Grass Family). They are dry, indehiscent and very similar to **ACHENES** except that the seed coat is fully adnate to the ovary wall (**PERICARP**). Think of a corn kernel and how difficult it would be to separate the outer part of the kernel from the inner! To review, what does adnate mean?



CYPSELA (CYPSELAE)

- *Helianthus* spp. (Sunflower)
- *Liatris* spp. (Blazing Star)
- *Taraxacum officinale* F.H. Wigg (Common Dandelion)
- *Tragopogon* spp. (Goat's Beard)

CYPSELA fruits are restricted to Asteraceae (the Sunflower Family). They are also dry, indehiscent and very similar to **ACHENES** except that they usually have an adnate calyx. In *Liatris*, the calyx is modified into bristle-like appendages called the **PAPPUS**. Are **CYPSELA** fruits formed from a superior or inferior ovary?

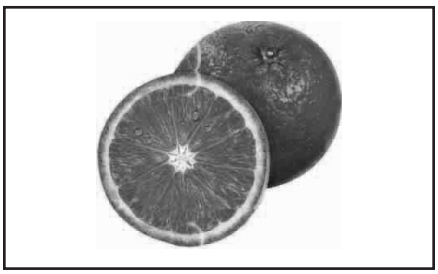
Note: A sunflower fruit (commonly referred to as a sunflower seed) is correctly termed a **CYPSELA** but does not possess an adnate calyx. Consequently, it can be referred to as an **ACHENE**.

HESPERIDIUM

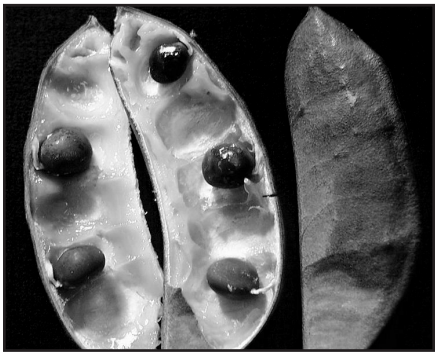
- *Citrus japonica Thunb. (Kumquat)*
- *Citrus* × *limon* (L.) Burm. (Lemon)
- *Citrus* × *paradisi* Macfad. (Grapefruit)
- *Citrus* × *sinensis* (L.) Osbeck (Sweet Orange)
- *Citrus* spp. (Lime)

HESPERIDIUM fruits are produced by most species in Rutaceae (the

Citrus Family). They are fleshy, indehiscent and very similar to **BERRIES** except that they have a leathery rind containing oil glands and numerous septa. Each segment of a **HESPERIDIUM** represents a single carpel from the original flower's gynoecium. Inside these segments are fleshy hairs (outgrowths from the inner lining of the ovary wall) that became swollen with water as the **HESPERIDIUM** developed.



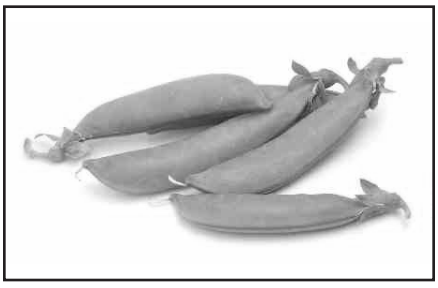
Examine the cut orange on display. Is it derived from a superior or inferior ovary? How many carpels matured to produce it? What is its placentation type?



LEGUME

- *Arachis hypogaea* L. (Peanut)
- *Cercis canadensis* L. (Eastern Redbud)
- *Gleditsia triacanthos* L. (Honey Locust)
- *Gymnocladus dioicus* (L.) K. Koch (Kentucky Coffeetree)
- *Phaseolus vulgaris* L. (Common Bean)
- *Pisum sativum var. saccharatum L. (Snow Pea)*

LEGUME fruits are produced by literally thousands of species in Fabaceae (the Legume Family). They are dry, dehiscent and very similar to **FOLLICLES** except that they usually split along two sutures (seams) rather than one. What type of gynoecium is required to produce a **LEGUME**? What is a **LEGUME**'s placentation type?



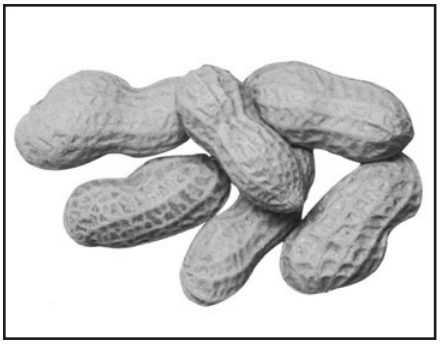
Dissect a bean or snow pea. Sketch it out in Box 4, and then identify and label the following structures: **SEEDS**, **FUNICULUS**, **SUTURES** and **PERICARP**.

Box 4

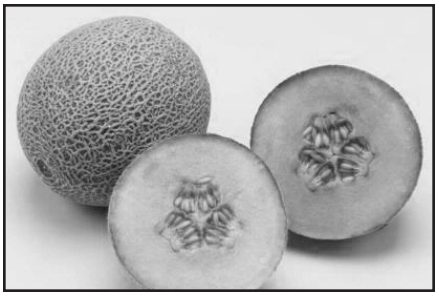
Box 5

Peanuts are also **LEGUMES**, but they are *atypical* in that fruits develop and mature underground; the seeds are usually released in nature by bacterial breakdown of the **PERICARP** instead of through an active splitting action.

Crack open a peanut, sketch it in Box 5 and label the following: **PERICARP**, seed(s), **TESTA** or **SEED COAT, COTYLEDONS**, **PLUMULE** and **EMBRYO**. You'll notice that most of the seed's volume is taken up by the cotyledons, two structures modified to store the energy and protein necessary to get the seedling established. Where is the endosperm? In the peanut (and other legume fruits), the endosperm is absorbed by the embryo, which repackages the nutrients in the cotyledons.



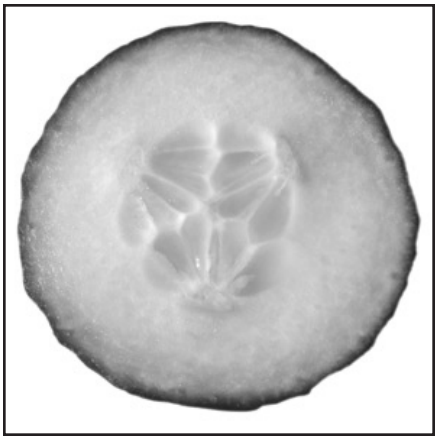
Fun Facts: The high fat content in peanuts renders them especially vulnerable to rancidity and the acquisition of odors from their surroundings. To prevent this, peanuts are roasted. Have you ever eaten a raw peanut? For your general information, the peanut is a native of South America, and has been found in Peruvian settlements dated at 800 B.C.E.



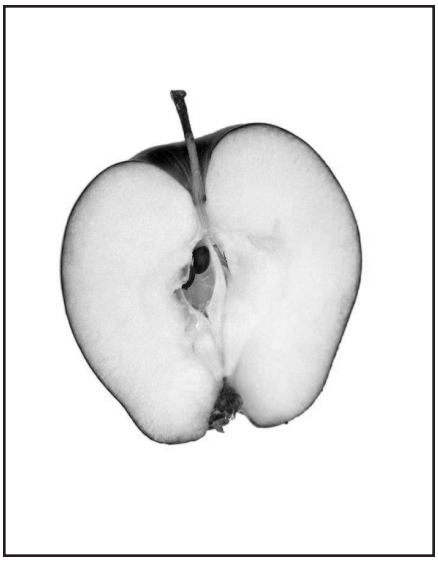
PEPO

- *Citrullus lanatus* (Thunb.) Matsum. & Nakai (Watermelon)
- *Cucurbita moschata* Duchesne. (Butternut Squash)
- *Cucumis sativus* L. (Garden Cucumber)
- *Cucumis melo* subsp. *melo* (Canteloupe)
- *Cucurbita pepo* L. (Field Pumpkin)

PEPO fruits are restricted to Cucurbitaceae (the Cucumber Family). They are fleshy, indehiscent and considered to be a special type of **BERRY** due to their tough outer rind. Examine the fruit on display, identify the following structures and label them on the cucumber cross section below: **SEEDS**, **PLACENTA** and **PERICARP**. Are **PEPOS** derived from inferior or superior ovaries? How can you tell?



Observe the sectioned cucumber on display. This fruit arose from a syncarpous gynoecium of how many connate carpels? What placentation type, characteristic of a **PEPO**, does the cucumber display?

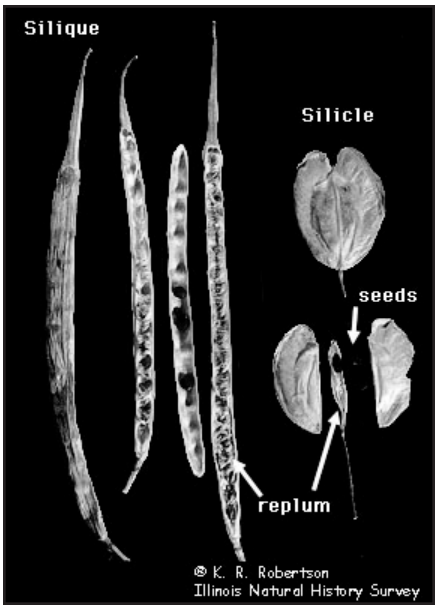


POME

- *Cydonia oblonga* Mill. (Quince)
- *Malus pumila* Mill. (Paradise Apple)
- *Pyrus communis* L. (Common Pear)

POME fruits are restricted to Rosaceae Subfamily Maloideae (the Apple Subfamily). The bulk of the flesh of an apple or pear comes from the enlarged fleshy hypanthium that grows up and around the ovary. In the prepared cross-section of an apple, identify the transition between the regions derived from the ovary (papery tissue) and the hypanthium.

Are **POMES** derived from a superior or inferior ovary? Explain your reasoning. Also, why is a **POME** also considered an **ACCESSORY FRUIT**?



SILIQUE AND SILICLE

- *Arabidopsis thaliana* (L.) Heynh. (Mouse Ear Cress)
- *Hesperis matronalis* L. (Dame's Rocket)
- *Lunaria* spp. (Money Plant)
- *Thlaspi arvense* L. (Field Pennycress)

SILICLE and **SILIQUE** fruits are restricted to Brassicaceae (the Mustard Family). Superficially, these dry, dehiscent fruits may look like **FOLLICLES** or **LEGUMES**, but possess a number of notable characteristics that set them apart. Unlike **FOLLICLES** and **LEGUMES**, **SILICLES** and **SILIQUES** arise from a syncarpous gynoecium. If these fruits possess two locules, how many connate carpels comprise the gynoecium?

Also, though **SILICLES** and **SILIQUES** split along two sutures (sides) like **LEGUMES**, the seeds are borne on a central partition called the **REPLUM**, which is exposed when the two halves of the fruit separate. Observe the *Lunaria* specimen on display - only the **REPLUMS** are left! In this case the valves have already fallen off, thereby releasing the seeds.

Based on your observation of the display fruits, what do you think is the key difference between a **SILIQUE** and a **SILICLE**?

SPECIAL FRUIT TYPES

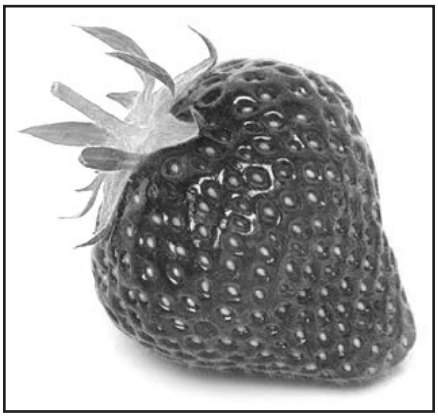
ACCESSORY FRUIT

- *Fragaria* × *ananassa* (Strawberry hybrid)
- *Nelumbo lutea* Willd. (American Lotus)

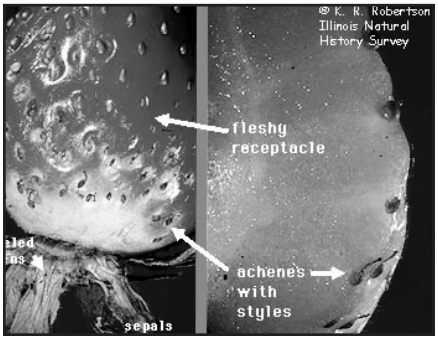
ACCESSORY FRUITS possess tissue in addition to the ovary. In many cases, such as *Nelumbo* and strawberries, the receptacle is the tissue that becomes enlarged.

Examine the **ACCESSORY FRUIT** of *Nelumbo*, an aquatic plant commonly called Lotus. Its flowers are long, pedunculate, perfect and possess 20-30 tepals and numerous stamens (200 - 400). What does pedunculate mean and what is a tepal?

The gynoecium of a *Nelumbo* flower consists of many distinct carpels that are individually sunken in (but free from) the enlarged, spongy receptacle. The **ACHENE**-like fruits within the persistent receptacle have a small respiratory pore at the top. What's the purpose of this enlarged receptacle? How do you think this fruit is dispersed?

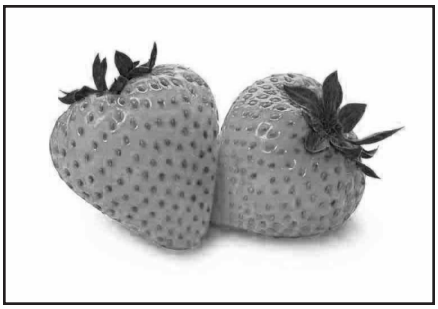


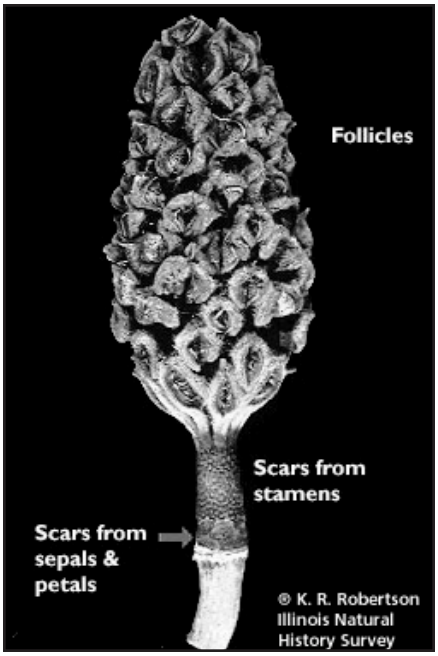
In a strawberry, the cone-shaped receptacle becomes fleshy and red, while the mature ovary of each carpel becomes a little achene on its surface. Have a close look at the strawberry under your dissecting scope. Identify the achenes on the surface of the strawberry. Can you see any styles? Where are they?



Where are (were) the stamens, sepals and petals?

Why have strawberries elaborated such a mechanism for seed dispersal?





AGGREGATE FRUIT

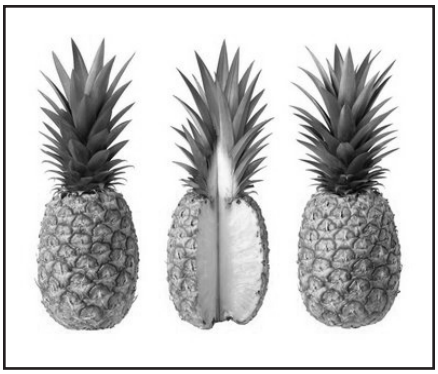
- *Fragaria* × *ananassa* (Strawberry hybrid)
- *Rubus idaeus* L. (American Red Raspberry)
- *Liriodendron tulipifera* L. (Tulip Tree)
- *Magnolia grandiflora* L. (Magnolia)

AGGREGATE FRUITS are derived from a single flower with an apocarpous gynoecium of few to many distinct carpels. The individual carpels each develop into tiny fruits or "fruitlets" (e.g. drupelets), but they mature as a clustered unit on a single receptacle.

Can a strawberry also be an **AGGREGATE FRUIT**? Why?

Examine the **AGGREGATE FRUIT** of *Magnolia*. Can you identify the **FOLLICLES**? What evidence do you have suggesting this fruit matured from only one flower?

Magnolia produces an **AGGREGATE OF FOLLICLES**; a raspberry an **AGGREGATE OF DRUPELETS** (small drupes), *Liriodendron* produces an **AGGREGATE OF SAMARAS**. How are these fruits dispersed?



MULTIPLE FRUIT

- *Ananas comosus* (L.) Merr. (Pineapple)
- *Liquidambar styraciflua* L. (Sweetgum)

MULTIPLE FRUITS arise from the maturation of individual ovaries from many flowers along with accessory tissue (i.e the inflorescence axis, calyx, and receptacle). Identify bracts and persistent sepals on the pineapple. What evidence do you see indicating that the pineapple developed from an intercalary inflorescence position?

Sweetgum is a **MULTIPLE FRUIT OF LOCULICIDAL CAPSULES**. The seeds have most likely already been released from the specimens on display.

GLOSSARY OF FRUIT TERMINOLOGY

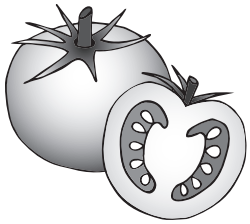
Listed below is the fruit terminology that you will need to become skillful at using this semester. You should be able to draw, compare and contrast each of these terms.

MORPHOLOGY-BASED: FLESHY FRUITS

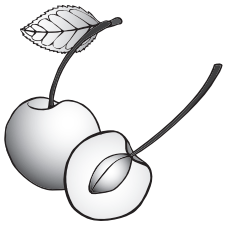
BERRY
An fleshy, indehiscent fruit that contains few to many seeds (rarely one seed) and has a **PERICARP** that is entirely fleshy.

DRUPE
An fleshy, indehiscent fruit whose **PERICARP** is differentiated into exo-, meso-, and endo-carp

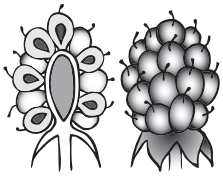
DRUPELET
A small drupe (e.g. segments of a raspberry)



BERRY



DRUPE



DRUPELET

MORPHOLOGY-BASED: DRY AND DEHISCENT FRUITS

CAPSULE
A dry, dehiscent fruit that is derived from a syncarpous gynoecium and contains few to many seeds. Capsules are the most common and variable of all fruit types.

CIRCUMSCISSLE CAPSULE (PYXIS)
Top comes off (like a lid) to release seeds (e.g. Portulaceae)

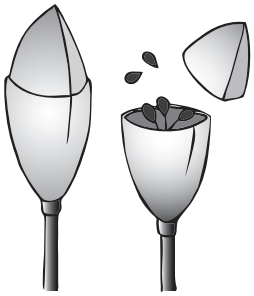
DENTICIAL CAPSULE
Dehisces by apical teeth (e.g. Caryophyllaceae)

LOCULICIDAL CAPSULE
Dehisces directly into the locule

PORICIDAL CAPSULE
Dehisces by apical pores (e.g. Papaveraceae)

SEPTICIDAL CAPSULE
Dehisces along the septa

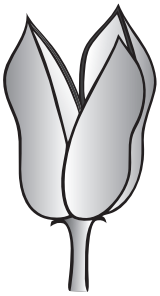
FOLLICLE
A dry, dehiscent fruit that is derived from a monocarpous or apocarpous gynoecium and opens along a single suture



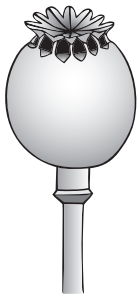
CIRCUMSCISSLE CAPSULE (PYXIS)

DENTICIDAL CAPSULE

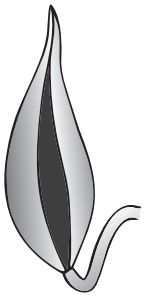
LOCULICIDAL CAPSULE



SEPTICIDAL CAPSULE



PORICIDAL CAPSULE



FOLLICLE

MORPHOLOGY-BASED: DRY AND INDEHISCENT FRUITS

ACHENE
A dry, indehiscent fruit that is derived from variable gynoecium types and is small and single-seeded (seed free from **PERICARP**)

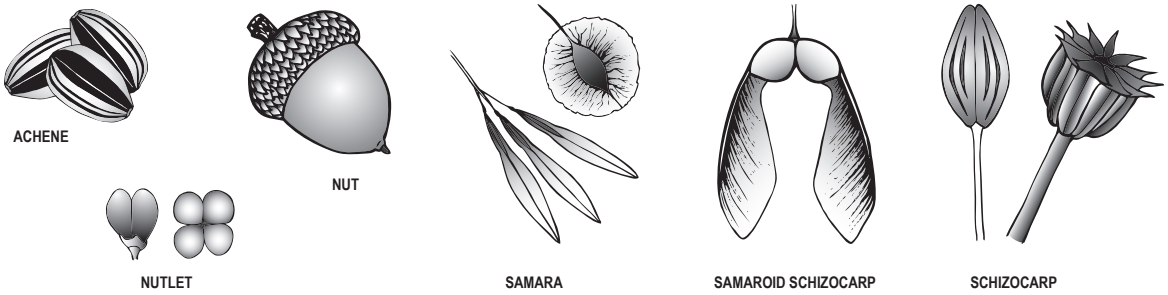
NUT
A dry, indehiscent fruit that is large and single-seeded with a thick, bony **PERICARP** and often with an **INVOLUCRE** (e.g. Fagaceae)

NUTLET
A small **NUT** that does not possess an **INVOLUCRE** (e.g. Lamiaceae)

SAMARA
A winged **ACHENE**

SAMAROID SCHIZOCARP
A winged **SCHIZOCARP** (e.g. maple)

SCHIZOCARP
A dry, indehiscent fruit that is derived from a syncarpous gynoecium that splits into two or more one-seeded segments (**MERICARPS**)



TAXONOMY-BASED FRUIT TYPES

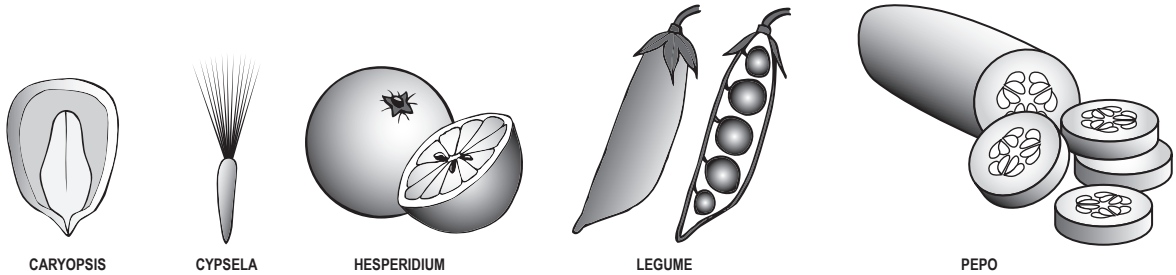
CARYOPSIS
POACEAE (GRASS FAMILY)
A dry, dehiscent fruit with the seed coat fused to the pericarp (e.g. corn, wheat, rye, barley)

CYPSELA (pl. **CYPSELAE)**
ASTERACEAE (ASTER FAMILY)
An achene fruit that usually has an adnate calyx

HESPERDIUM
RUTACEAE (CITRUS FAMILY)
A fleshy, berry-like fruit with a leathery rind that develops from a superior ovary (e.g. orange, lime)

LEGUME
FABACEAE (BEAN FAMILY)
A dry, dehiscent fruit derived from a monocarpous gynoecium that usually opens along two sutures (e.g. beans, peas)

PEPO
CUCURBITACEAE (CUCUMBER FAMILY)
A fleshy, indehiscent, many-seeded fruit with a thick rind that develops from an inferior ovary (e.g. pumpkin, squash, cucumber)



TAXONOMY-BASED FRUIT TYPES (CONT.)

POME

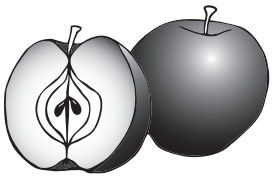
ROSACEAE: MALOIDEAE (APPLE SUBFAMILY)

A fleshy, indehiscent fruit derived from a syncarpous gynoecium with an inferior ovary. Most of a pome's flesh comes from the enlarged, fleshy hypanthium that grows up around the ovary (i.e. apple, pear, quince)

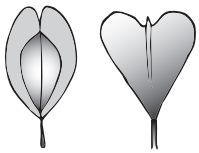
SILIQUE AND SILICLE

BRASSICACEAE (MUSTARD FAMILY)

Dry, dehiscent fruits that have 2 valves which separate from the persistent **REPLUM** (and placentae). **SILIQUES** are typically more than twice as long as wide, while **SILICLES** are typically less than twice as long as wide



POME



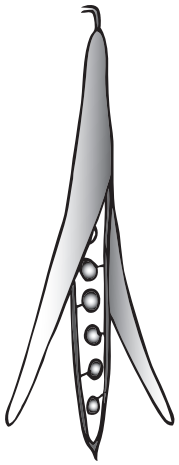
SILICLE

SYCONIUM

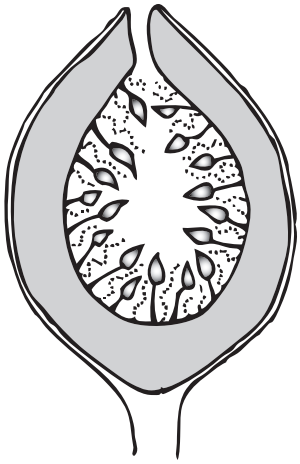
MORACEAE (MULBERRY FAMILY)

(ONLY IN THE FICUS GENUS)

A multiple fruit of many tiny drupes that are borne inside of a hollow, inverted receptacle



SILIQUE



SYCONIUM

SPECIAL FRUIT TYPES

ACCESSORY FRUIT

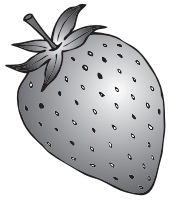
A fruit that has tissue other than, or in addition to, the ovary that enlarges and may become fleshy (e.g. strawberry, fig)

AGGREGATE FRUIT

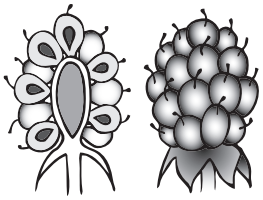
A fruit that is the product of a single flower with an apocarpous gynoecium (has multiple distinct carpels). The ovary of each carpel matures into a fruit (e.g. magnolia, tuliptree, pawpaw, blackberry)

MULTIPLE FRUIT

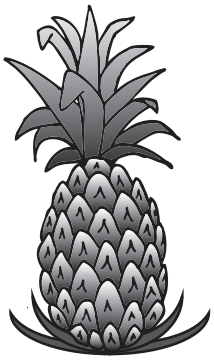
A fruit that is the product of several separate flowers in an inflorescence. (e.g. pineapple, mulberry, sycamore, sweetgum) Other floral structures (i.e., accessory tissue) may become fleshy as well (e.g. strawberry)



ACCESSORY FRUIT



AGGREGATE FRUIT (e.g. OF DRUPELETS)



MULTIPLE FRUIT

MISCELLANEOUS FRUIT TERMINOLOGY

ARIL
A fleshy, often brightly colored seed cover which arises from the funiculus and can either partially or entirely cover a seed (e.g. Magnoliaceae, Papaveraceae)

CARPOPHORE
A slender prolongation of the receptacle forming a central axis between two carpels (e.g. Apiaceae)

COMA
A tuft of hairs, especially on the tip of a seed (e.g. Asclepiadaceae)

ELAIOSOME
Fleshy structures attached to seeds that are rich in lipids and proteins (e.g. Papaveraceae)

ENDOCARP
The inner layer of a fruit's **PERICARP**

EXOCARP
The outer layer of a fruit's **PERICARP**

INVOLUCRE
A whorl of bracts subtending a flower cluster (e.g. Fagaceae)

MESOCARP
The middle layer of a fruit's **PERICARP**

PERICARP
The wall of a fruit

PLEUROGRAM
A groove on the surface of a seed (e.g. Fabaceae)

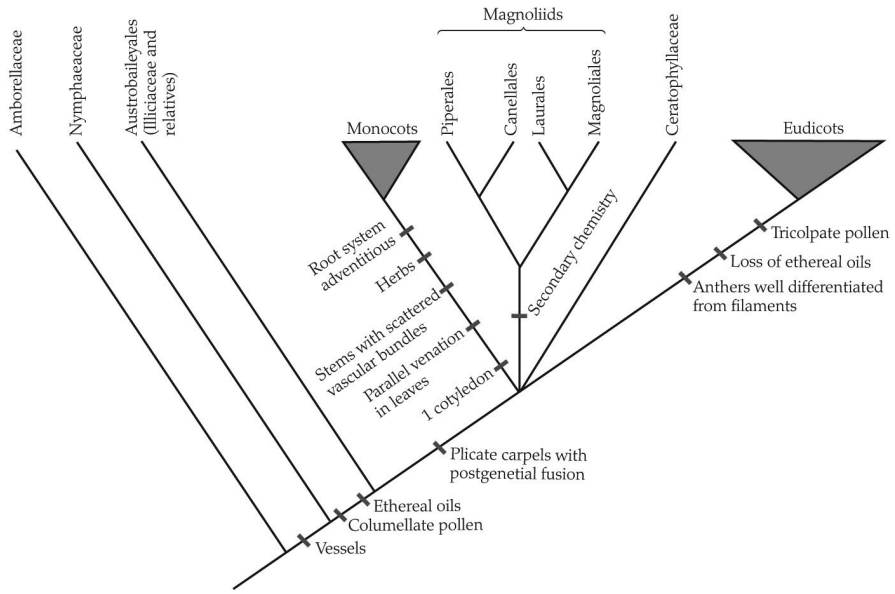
REPLUM
Thin, papery partition between the two valves of **SILIQUES** and **SILICLES** (e.g. Brassicaceae)

LABORATORY 5

MAGNOLIACEAE, RANUNCULACEAE AND PAPAVERACEAE

PHYLOGENETIC RELATIONSHIPS

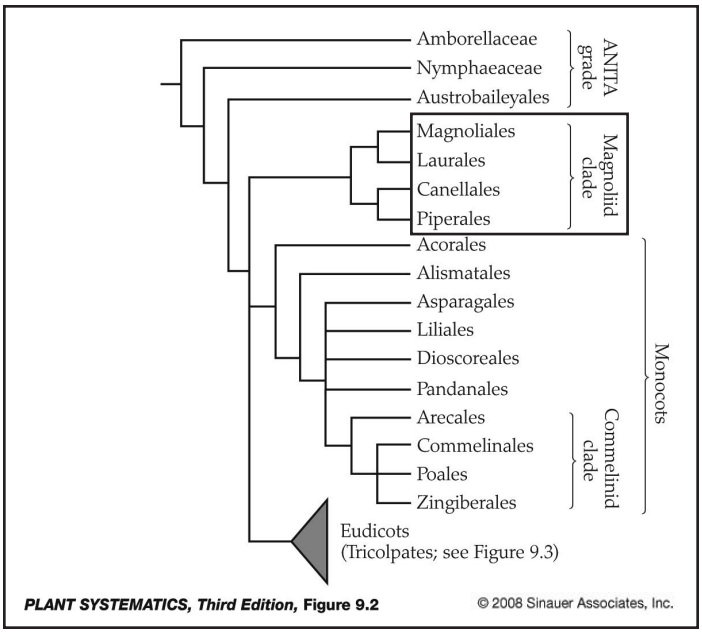
Enormous progress has been made recently in understanding phylogenetic relationships among flowering plants (angiosperms). Such progress has proceeded so rapidly that many taxonomy texts are out of date very soon after they are published! These new findings are having a major impact on our interpretation of angiosperm evoution and the factors that account for the tremendous success of these plants.

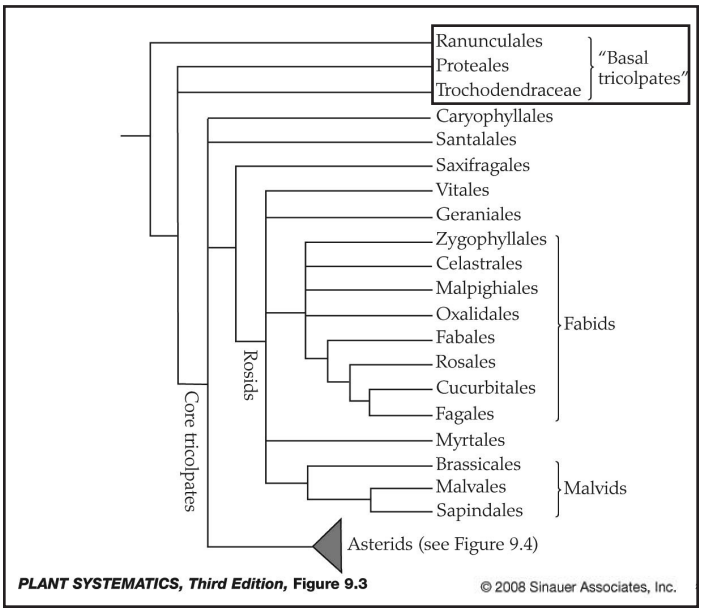


***PLANT SYSTEMATICS, Third Edition,* Figure 9.1**

Until rather recently, most students of angiosperm evolution considered those plants in the subclass “Magnoliidae” as being among the first flowering plants to evolve. The “Magnoliidae” display an impressive range of morphological variation, from large woody plants to small herbaceous ones. Some have large flowers with many spirally arranged parts, while others have tiny flowers with few parts. Recent studies, however, have shown that the subclass “Magnoliidae” is highly paraphyletic.

Recent studies have concluded that the first flowering plants to split from modern angiosperms were *Amborella trichopoda* (a shrubby plant from the island of New Caledonia with small flowers and few spirally arranged parts) and those belonging to the order Nymphaeales (water lilies). The Austrobaileyales form another very early branch of angiosperm evolution. These results were surprising and led to the abandonment of subclass “Magnoliidae” as the most basally branching lineage of flowering plants. Amborellaceae, Nymphaeaceae (the only family in the order Nymphaeales) and Austrobaileyales are considered “basal families”. These three lineages subtend a clade including all the rest of the flowering plants, which are referred to as the core angiosperms. We’ll have more to say about these basal relationships, and the evolutionary implications of these results, in our lecture on the “Origin of Angiosperms”.





Within the core angiosperm clade, relationships are still poorly resolved. The major clades that are well-supported (by numerous independent studies) include: (1) the Magnoliid complex or clade, which includes the family Magnoliaceae, (2) the Monocots, including such plants as grasses, orchids, palms, lilies and bananas, and (3) the Eudicots (or Tricolpates). The Eudicots contain all other "dicots" not contained within the Magnoliid clade. These plants were originally called the tricolpate clade, in reference to the main morphological character marking this group - namely, the occurrence of pollen grains with three colpi, or germinal furrows. The Eudicots comprise the early diverging "Basal Tricolpate" lineages, containing such families as Ranunculaceae and Papaveraceae, and the Core Tricolpate clade.

This view of angiosperm relationships is quite different from standard classifications in which the flowering plants are divided into two major groups, the monocots and "dicots", and where the subclass "Magnoliidae" is the earliest diverging group of flowering plants. Both "dicots" and "Magnoliidae" are paraphyletic, thus these artificial groups are abandoned in modern classifications. In their places, major new clades have been identified, such as the Eudicots and the Magnoliid complex.

The Magnoliid complex is made up of Orders Magnoliales, Laurales, Canellales and Piperales. The family Magnoliaceae is monophyletic and is one of six families comprising the Order Magnoliales.

To the left is a phylogeny of the Eudicots (or Tricolpate clade of Angiosperms). The family Ranunculaceae (Order Ranunculales) is a member of the Basal Tricolpate group. Also included in the Order Ranunculales are the families Papaveraceae and, in earlier treatments, the Fumariaceae. In modern systems of classification, the Fumariaceae are submerged within the Papaveraceae.

MAGNOLIACEAE

MAGNOLIA FAMILY

Magnoliid Complex (Magnoliid Clade)

$\mathbf{\varnothing\ Ca^{3(x)}\ Co^{6(x)}\ A^{\infty}\ G^{\infty}}$

Figure 5.1 Flower bud of *Magnolia* x *soulangeana*.

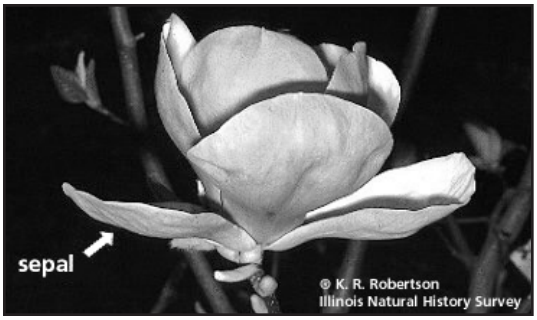


Figure 5.2 Side view of a *Magnolia* x *soulangeana* 'Andre LeRoy' flower. The arrow points to one of the 3 petal-like sepals.

FLORAL CHARACTERISTICS

- Apocarpous gynoecium
- Many floral series are spirally arranged
- No connation or adnation of floral series
- **LAMINAR STAMENS**

***Magnolia* × *soulangeana* Soul. (Saucer Magnolia)**

The species *Magnolia* × *soulangeana* Soul. is named after Chevalier Soulange-Bodin who originally created the hybrid (cross between *Magnolia denudata* and *M. liliflora*) in his garden. Notice the use of the "×" in the scientific name to indicate the tree's hybrid origin. Its inflorescence consists of solitary (terminal) flowers (Figure 5.1) that are purplish or rose-colored outside, white within. While observing the floral parts as instructed below, make sure to check for connation and adnation.

1. Observe a flower. What is its symmetry?

2. **CALYX**: Look for the sepals at the base of the flower (Figure 5.2). (Hint: Sepals are smaller than petals.) How many are there?

3. **COROLLA**: Two series (or whorls) of petals are located above the sepals. The first whorl of petals alternates with the sepals, while the second whorl of petals alternates with the petals below and are arranged opposite the sepals. How many petals make up the corolla?

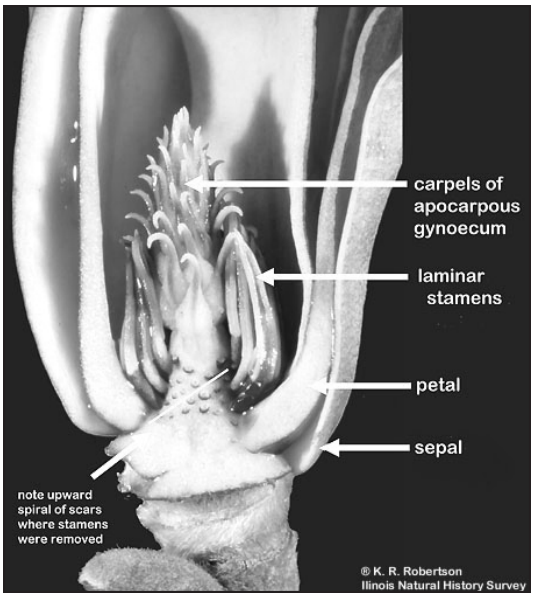


Figure 5.3 *Magnolia* x *soulangeana* flower with several sepals, petals, and stamens removed. Note the spirally arranged stamens with laminar anthers and the numerous distinct carpels on an elongated receptacle.

4. **ANDROECIUM**: Observe the spirally arranged **LAMINAR STAMENS** on the elongated receptacle. How many stamens are there (many or few) and why is their morphology considered to be ancestral?

5. **GYNOECIUM**: Check out the numerous spirally arranged carpels (Figure 5.3). Although the carpels may appear united when young, they are perceptibly separate (distinct) at maturity. (To see this, observe the dried fruit.) What is the term used to describe this type of gynoecium? Is the ovary position superior or inferior and what is the insertion type?

6. **PORTFOLIO DRAWING:** Draw a floral diagram of a longitudinal section (L.S) of *Magnolia* × *soulangeana*, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

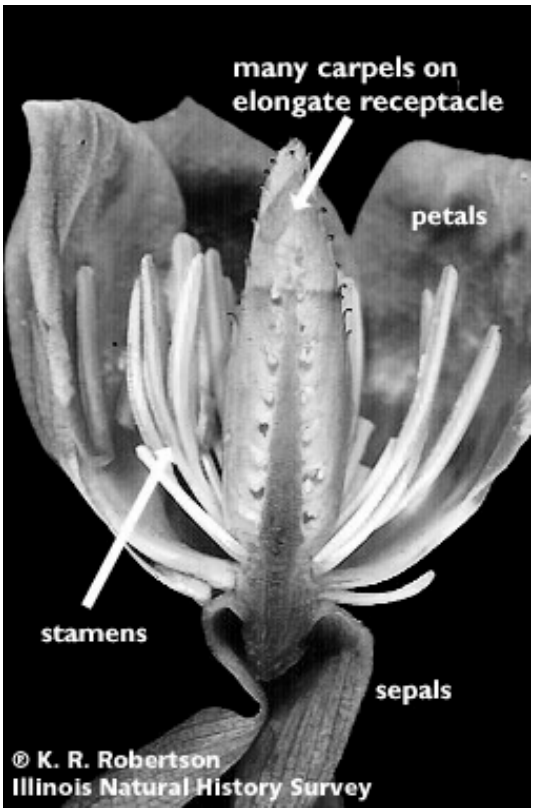


Figure 5.4 Longitudinal section of a *Liriodendron tulipifera*, or tulip tree, flower.

***Liriodendron tulipifera* L. (Tuliptree)**

Examine a *L. tulipifera* flower if they are available. While the color is very different from that of the *Magnolia* flower you just dissected, note that the structure is essentially the same, with many spirally arranged stamens, and a gynoecium composed of many distinct carpels on an elongate receptacle (Figure 5.4). The brown “hairs” on the gynoecium are the styles/stigmas.

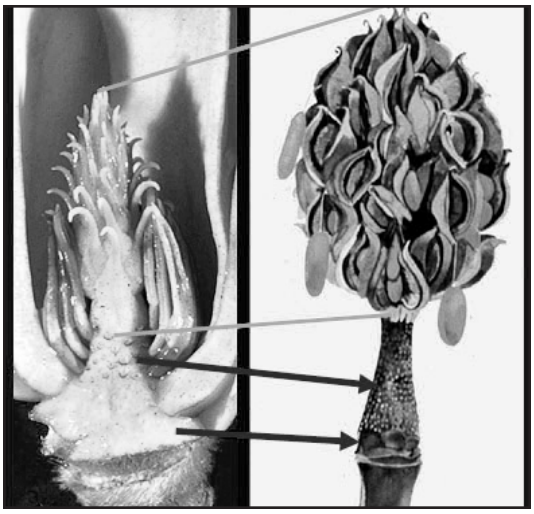


Figure 5.5 *Magnolia grandiflora* flower and fruit.

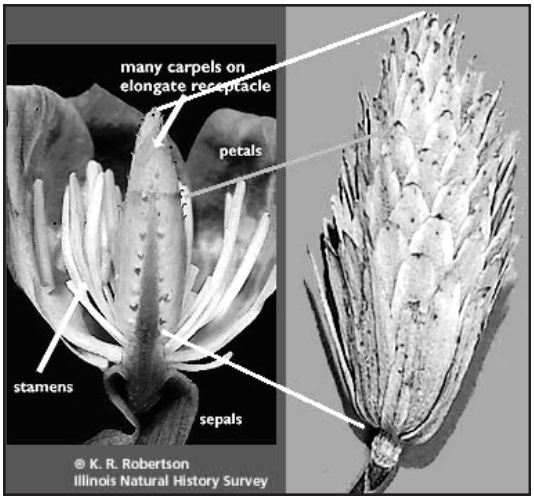


Figure 5.6 *Liriodendron tulipifera* flower and fruit.

Box 1

FRUIT TYPE

- Aggregate fruits of follicles or samaras

***Magnolia grandiflora* L. (Southern Magnolia)**
***Liriodendron tulipifera* L. (Tuliptree)**

Observe the aggregate fruit of follicles produced by *M. grandiflora*. This fruit is formed through elongation of the receptacle and the development of the each of the carpels into a follicle (Figure 5.5). Additionally, its seeds are covered with red **ARILS** and remain attached to the follicle by a thread-like **FUNICULUS** for some time after dehiscence. Alternatively, *L. tulipifera* produces an aggregate fruit of samaras (Figure 5.6). Based on their fruit morphology, what do you suppose is the mechanism utilized by each species for seed dispersal?

How can you tell that the fruits on display were derived from a single flower?

HABIT AND VEGETATIVE CHARACTERISTICS

- Has stipules
- Stipular scars surrounding twigs

***Michelia* spp. (Michelia)**

Michelia is related to our much larger magnolias (*Magnolia* spp.) and tuliptrees (*Liriodendron tulipifera*). To review your vegetative terminology, observe a *Michelia* leaf, sketch it in Box 1 and then add labels describing the leaf shape, apex, base, venation and margin. Don't forget to include the axillary bud!

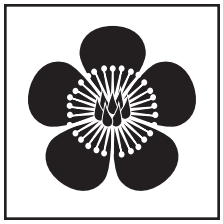
Figure 5.7 Winter twig of a Magnoliaceae species. Notice the distinctive stipules and how the stipular scars completely encircle the twig.

***Magnolia acuminata* (L.) L. (Cucumber-tree)**
***Liriodendron tulipifera* L. (Tuliptree)**

Using the "Dichotomous Key for Woody Plants" in Lab 1: Woody Twig Terminology, determine which twig is from a *Magnolia* and which is from a *Liriodendron* tree. Which characteristics set them apart?

One of the key features used to separate these Magnoliaceae species from other woody species in the dichotomous key is the occurrence of **STIPULES** covering the flower bud. In the spring the stipules dehisce leaving a **STIPULE SCAR** that surrounds the twig. What purpose do you think stipules serve?

Locate the **STIPULES**, **STIPULE SCARS** (on older branches), **LEAF SCARS** and **BUNDLE SCARS** on the branches of the live specimens provided and then label those same structures in Figure 5.7.



RANUNCULACEAE

BUTTERCUP FAMILY

Eudicots: Basal Eudicots

♂ $\underline{Ca^{4-\infty}\ Co^{0-\infty}\ A^{\infty}\ G^{\infty}}$

Figure 5.8 A *Delphinium* flower. Notice its 5 sepals, one of which is a nectar spur.

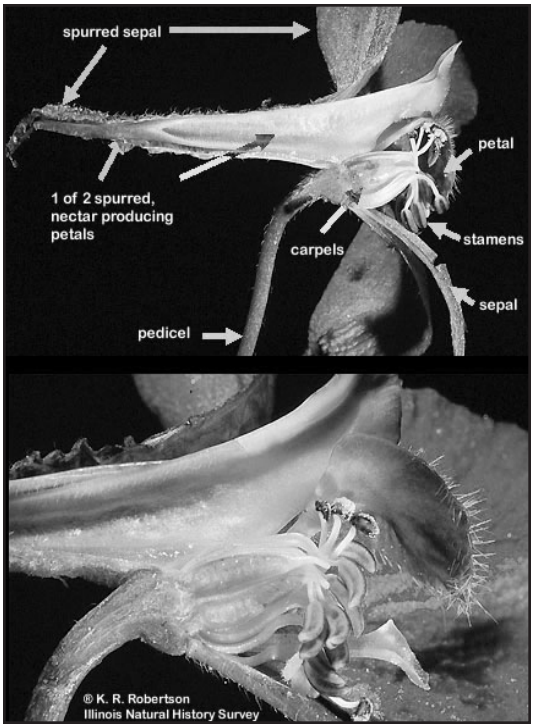


Figure 5.9 A flower of *Delphinium* in longitudinal section.

FLORAL CHARACTERISTICS

- Parts spirally arranged
- Apocarpous gynoecium
- Many marginal ovules or 1 basal ovule
- Stamens NOT laminar

***Delphinium* spp. (Larkspur)**

To observe the floral morphology characteristic of the Ranunculaceae family you will examine and dissect a *Delphinium* flower. There are over 250 species in this genus (commonly called larkspurs), including many that are showy and popular garden plants. These plants contain alkaloids and are usually quite toxic.

1. Determine the *Delphinium* plant's inflorescence type as well as your flower's symmetry.

2. **CALYX**: Note that the posterior sepal is prolonged into a long **NECTAR SPUR** and two other sepals form a landing platform for insects (Figures 5.8 and 5.9). Also, observe the prominent color of these showy sepals. How many sepals are there?

3. **COROLLA**: The upper pair of petals also have spurs that project backward and down into the sepal spur where there is nectar. The remaining two petals, if present, are often crowded in the throat and are small and short-clawed (these are sometimes called the "bee"). How many petals does your flower have?

4. **ANDROECIUM**: Typically the stamens are spirally arranged in Ranunculaceae flowers, but it may be hard to detect in this species. How many stamens are there?

Box 2

5. **GYNOECIUM**: What type of gynoecium does the *Delphinium* flower possess and how many carpels make it up? Sketch out the placentation type of the flower in Box 2.

6. Write out the floral formula for the *Delphinium* flower you dissected in the space below.

Figure 5.10 An *Aconitum* flower.

***Aconitum* spp. (Monkshood)**

Aconitum flowers contain powerful poisons, and drugs are derived from the roots and leaves of certain species (Figure 5.10). Observe its flowers and compare them to the following description: Flowers hypogynous, zygomorphic (most members of Ranunculaceae have actinomorphic symmetry), and all parts are free and distinct. There are 5 sepals; the upper sepal (called the helmet) is the largest and is strongly arched or hooded, its tip prolonged forward and downward into a short beak. The upper two petals are concealed under the helmet, clawed and nectariferous at the tip. The lower three petals are absent or vestigial. Stamens are numerous, while the apocarpous gynoecium is made up of 3 to 5 distinct carpels. *Aconitum* produces an aggregate fruit of follicles.

Figure 5.11 A *Helleborus* flower with its small, tube-like nectaries (modified petals).

***Helleborus* spp. (Hellebore)**

Check out the dissected flower of this species as well as the provided photos (Figure 5.11). Species in this genus have solitary, actinomorphic flowers subtended by leafy bracts, with five green or petaloid sepals and petals modified into small, tube-like nectaries. What do you suppose is the function of the nectaries?

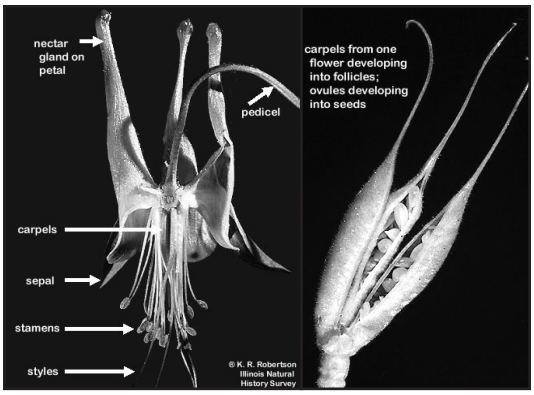


Figure 5.12 Flower longitudinal section (left) and developing follicles (right) of *Aquilegia canadensis*. Two of the carpels (developing follicles) have been split open to show their marginal placentation.

Figure 5.13 Fruit of *Clematis virginiana*, commonly called Virgin's Bower.

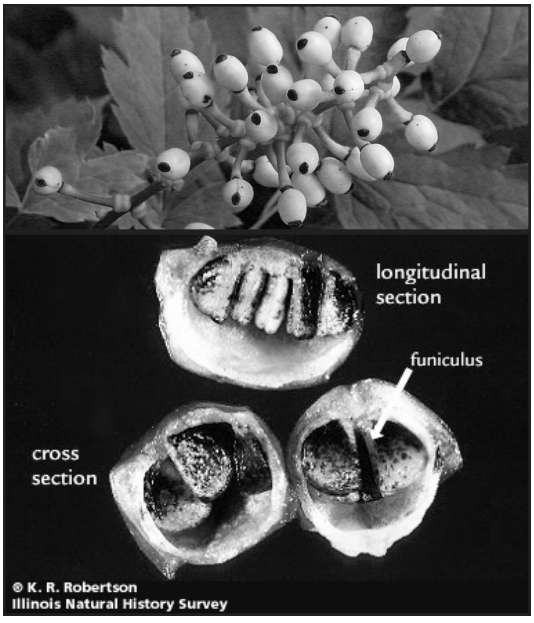


Figure 5.14 Developing infructescence (top) and fruit cross section (bottom) of *Actaea pachypoda*.

FRUIT TYPE

- Fruits are follicles or achenes

Aquilegia spp. (Columbines)

The genus name *Aquilegia* comes from the Latin word for eagle, "aquila," since its characteristic spurred petals resemble an eagle's claw. Additionally, the English common name, columbine, alludes to the Latin word for dove, "columba," because the spurred petals also appear to some like a group of doves drinking (Figure 5.12). What is *Aquilegia*'s fruit type (be specific)?

Clematis spp. (Clematis)

The flowers of this plant have no petals (the showy perianth parts are sepals), numerous stamens and carpels. Based on the provided herbarium specimens and photographs (Figure 5.13), what fruit type do *Clematis* species produce and what gynoecium type do these fruit arise from? Also, what are the vegetative structures that allow this plant to climb?

Actaea pachypoda Elliot (Doll's Eyes)

Observe the photographs and herbarium specimen of this species (Figure 5.14). *Actaea pachypoda* produces a fruit type that is rather rare in the Ranunculaceae family. What is this fruit type called? What seed dispersal mechanism do you think this species uses?

Figure 5.15 Habit of *Anemone patens*, commonly called American Pasqueflower.

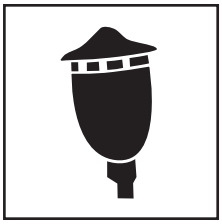
Figure 5.16 Habit of *Hepatica nobilis*, commonly called Liverleaf.

HABIT AND VEGETATIVE CHARACTERISTICS

- Perennial or annual herbs
- Without stipules

***Anemone patens* L. (American Pasqueflower)**
***Hepatica nobilis* Shreb. (Liverleaf)**

Like *A. patens* and *H. nobilis* (a common woodland wildflower in Illinois), the habit of most Ranunculaceae species is an herb (Figures 5.15 and 5.16). (Note: remember that Magnoliaceae are ALL woody). These herbs can be either annual or perennial. What does annual and perennial mean?



PAPAVERACEAE

POPPY FAMILY

Eudicots: Basal Eudicots

♀ $\underline{Ca^{2(4)}\ Co^{4-8}\ A^{6\text{ or }\infty}\ G^{(2-\infty)}}$

Figure 5.17 The prickly poppy, *Argemone mexicana*, is appropriately named as the whole plant is covered with prickles, even the sepals before they fall off (white arrow pointing to prickly sepals.)

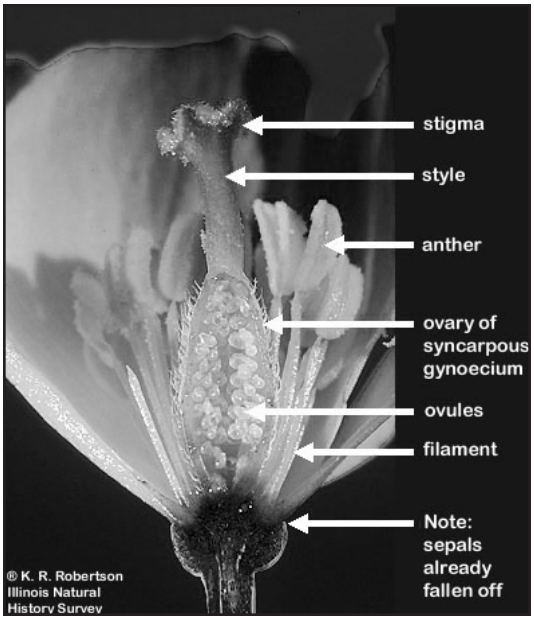


Figure 5.18 A flower of *Stylophorum diphyllum* in longitudinal section.

FLORAL CHARACTERISTICS

- Two sepals are **CAUDUCOUS**
- Petals sometimes crumpled in bud
- Syncarpous gynoecium
- Many parietal ovules

***Argemone mexicana* L. (Mexican Prickly Poppy)**

To observe the floral morphology characteristic of the Papaveraceae family, you will examine and dissect an *A. mexicana* flower (Figure 5.17). The genus name, *Argemone*, comes from the Greek "argema," or cataract, because the plant was originally thought to cure eye cataracts.

1. What is the floral symmetry of the flower?

2. **CALYX**: Can you find the sepals on your specimen? Don't be surprised if you can't. In this family the sepals are **CAUDUCOUS** (that is they fall off as the flower opens). To locate the sepals, you need to look at an unopened flower bud (the sepals will fully enclose the bud.)

3. **COROLLA**: Papaveraceae flowers generally have twice as many petals as sepals. How many petals does your flower have?

4. **ANDROECIUM**: Note the arrangement of the numerous stamens (Figure 5.18). Like Magnoliaceae and Ranunculaceae, the stamens are spirally arranged.

Box 3

5. **GYNOECIUM**: Is the ovary position superior or inferior? Also, what type of gynoecium does the flower possess and how many carpels make it up? (HINT: Count the stigma lobes.) Now draw a cross section (X.S.) of the ovary in Box 3 to show its placentation type.

6. **PORTFOLIO DRAWING:** Draw a floral diagram of a longitudinal section of *Argemone* as well as a cross section (X.S.) of its ovary, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

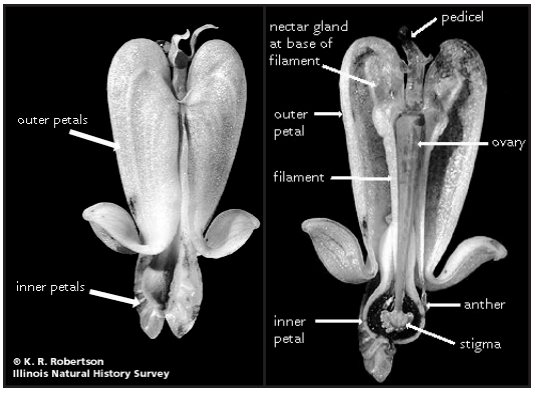


Figure 5.19 Flowers of *Dicentra canadensis*. These flowers are zygomorphic and possess two very different shaped petals - (2) large ones that have nectar spurs at the base and (2) narrow ones that have expanded tips to enclose the anthers and stigma.

***Dicentra* spp. (Bleeding Heart)**

The genus *Dicentra* belongs to Fumerioideae, a subfamily of Papaveraceae. Based on the live *Dicentra* specimen and provided photographs (Figure 5.19), what are two floral characteristics that set this subfamily apart from other Papaveraceae species?

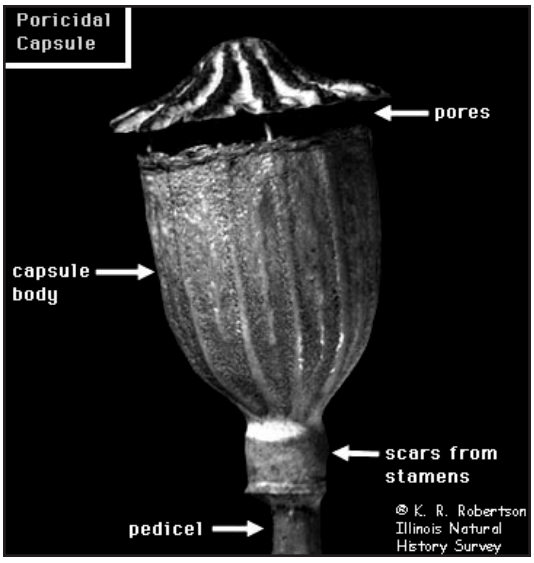


Figure 5.20 Poricidal capsule fruit of *Papaver* species. It dehisces by small pores around the top.

FRUIT TYPE

- Capsules (Poricidal in *Papaver*)
- Seeds have **ELAIOSOMES** for ant dispersal

***Papaver* spp. (Poppies)**
***Glaucium* spp. (Horned Poppy)**

The fruits of *Papaver* and *Glaucium* display a "shaker" method of dispersing seed (Figure 5.20). They are on long stems that wave in the wind, shaking the seeds out through the pores. What specific type of fruit do these species produce? How does it dehisce?

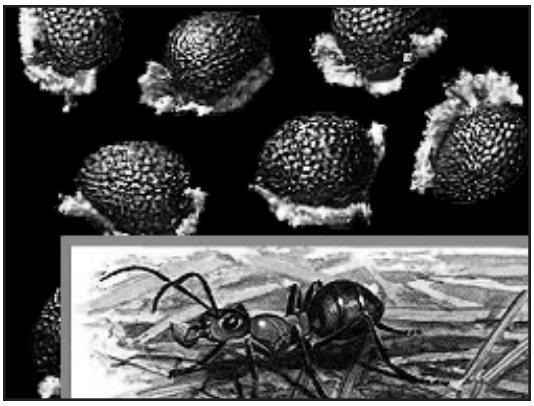


Figure 5.21 Close-up of seeds of *Stylophorum diphyllum*. Note the pale colored elaiosome on each seed that attracts ants to carry the seeds away from the parent plant.

***Stylophorum diphyllum* (Michx.) Nutt. (Celandine poppy)**

Take a close look at the seeds produced by *S. diphyllum* with their distinctive **ELAIOSOMES** (fleshy structures attached to seeds that are rich in lipids and proteins; Figure 5.21). Due to the elaiosomes' nutritional value, ants will come gather the seeds and carry them far from the parent plant to their nest as food for ant larvae. After the larvae have consumed the elaiosome, the undamaged seed is moved to the ants' disposal area. Typically the soil found in disposal areas is rich in nutrients and thus good for seed germination. This is a great example of a mutualistic relationship!

Figure 5.22 Herbaceous habit of *Sanguinaria canadensis*, a woodland wildflower.

Figure 5.23 Cut stems of *Sanguinaria canadensis* oozing orange-red sap.

HABIT AND VEGETATIVE CHARACTERISTICS

- Perennial herbs
- Sap milky or colored

Check out the wide range of milky or colored sap that herbaceous species in the Papaveraceae family exhibit. Some species' sap contains alkaloids.

***Chelodonium majus* L. (Celandine)**

C. majus produces an umbel-like inflorescence of yellow flowers and will exude yellow sap when its stem is cut.

***Bocconia frutescens* L. (Tree Poppy or Parrotweed)**

This member of the Papaveraceae family is an oddity in that it is a tree whereas most other species are herbaceous. *B. frutescens* does, however, produce orange sap that can be seen when some of the bark on a branch is scraped away.

***Sanguinaria canadensis* L. (Bloodroot)**

"Bloodroot", the common name of *S. canadensis*, is very fitting due to the red sap that is stored in the plant's **RHIZOME** (Figures 5.22 and 5.23). The red sap is also present in the stem and thus is a good feature to use for identification in the field.

***Dicentra spectabilis* (L.) Lem. (Bleeding-heart)**

A common garden plant, *D. spectabilis*, or bleeding heart, produces clear sap like most members of the Fumarioideae subfamily.

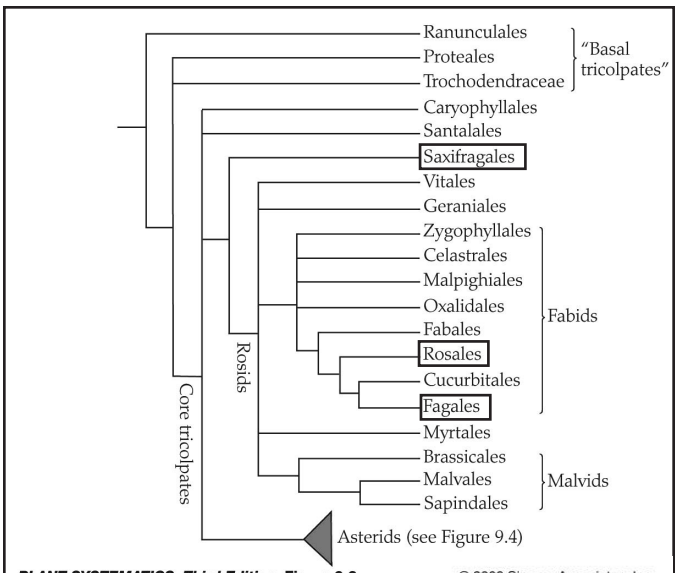
LABORATORY 6

HAMAMELIDACEAE, MORACEAE, FAGACEAE AND BETULACEAE

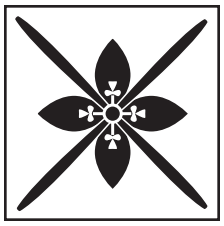
PHYLOGENETIC RELATIONSHIPS

Hamamelidaceae is one of thirteen families belonging to the order Saxifragales. The family Hamamelidaceae is highly variable and its monophyly has been questioned. Some systematists now separate one common tree species, *Liquidambar styraciflua* L. (Sweet Gum), into its own family, Altingiaceae.

Moraceae is treated as its own distinct family by Judd et al., but as a subfamily of Urticaceae by Zomlefer. It is classified in the order Rosales of the Rosid clade. The Rosids are a rather heterogeneous grouping of orders that are supported solely by molecular evidence. The monophyly of Moraceae is supported only by molecular evidence. These plants are characterized by milky sap. Major genera include *Ficus* (figs), *Morus* (mulberries), *Maclura* (osage orange), *Artocarpus* (jackfruit, breadfruit) and *Dorstenia*.



Fagaceae and Betulaceae are members of the order Fagales in the Rosid clade. The order Fagales consists of 8 families and about 1,115 species. Traditionally, the Fagaceae and Betulaceae families were united with the family Hamamelidaceae in the subclass “Hamamelidae”. Recent evidence suggests the Hamamelidaceae and Fagales are not at all closely related. The “Hamamelidae”, as traditionally defined to include the four families covered in today’s lab, are highly polyphyletic.



HAMAMELIDACEAE

WITCH HAZEL FAMILY

Eudicots: Core Eudicot

$$\text{♀}\ \frac{Ca^{(4\text{-}5)}Co^{4\text{-}5(10)}A^{4\text{-}5}}{G^{(2)}}\ \text{OR}$$

$$\text{♂}\ Ca^{(4\text{-}5)}Co^{4\text{-}5(10)}A^{4\text{-}5}\ G^{(2)}$$

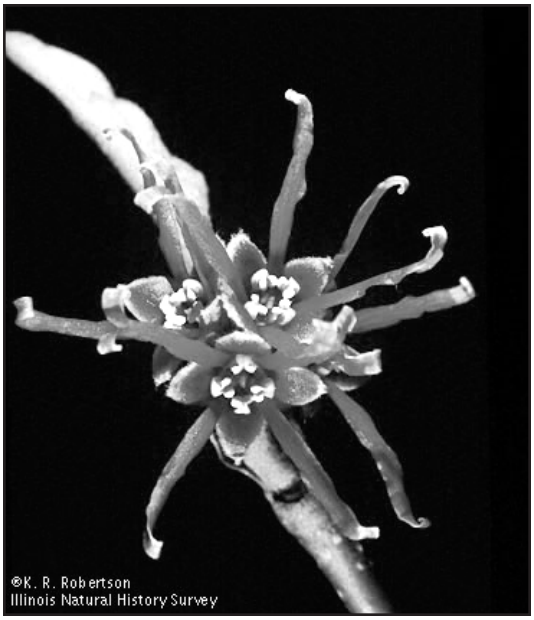


Figure 6.1 Cluster of *Hamamelis* flowers.

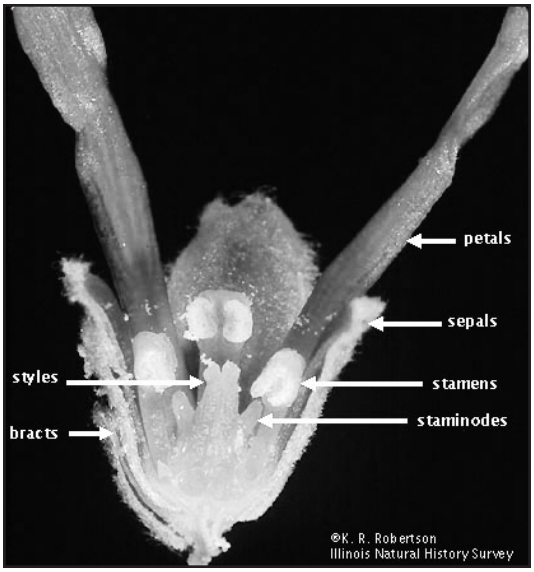


Figure 6.2 Longitudinal section of a *Hamamelis* flower.

FLORAL CHARACTERISTICS

- 4-merous flowers with strap-like petals
- **STAMINODES** present in *Hamamelis*
- Anthers open by flaps in *Hamamelis*

***Hamamelis mollis* Oliv. (Witch Hazel)**

To observe the floral morphology characteristic of Hamamelidaceae, you will examine a *H. mollis* flower.

1. Examine a flower under a dissecting scope. What is its symmetry?

2. **CALYX**: Notice at the base of the flower that there are several bracts. Inside the layer of bracts you should find the sepals. How many sepals are in the calyx?

3. **COROLLA**: The corolla is made up of 4 linear, strap-shaped petals (Figures 6.1 and 6.2).

4. **ANDROECIUM**: Four stamens make up the androecium of this flower. Their anthers open by flaps to release pollen. Also note the **STAMINODES** located at the base of the petals. What are their purpose?

5. **GYNOECIUM**: The ovary is half-inferior and the gynoecium is surrounded by a dense pubescence. Make a longitudinal section of this flower between the two styles (the 2 carpels are basally connate). If done successfully, you should see a solitary, pendulous ovule in each of the 2 locules.

6. **PORTFOLIO DRAWING:** Draw a floral diagram of a longitudinal section of *H. mollis*, making sure to include the floral formula and label all the floral parts. Follow the format as instructed in Lab 3: Floral Terminology.

Figure 6.3 Mature capsule of *Hamamelis vernalis*.

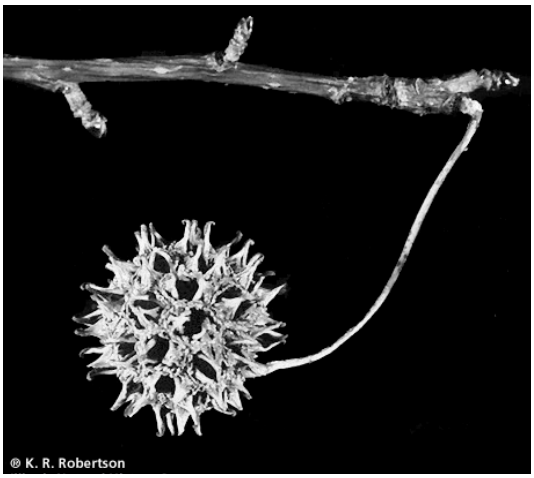


Figure 6.4 Multiple fruit of loculicidal capsules produced by *Liquidambar styraciflua*.

Figure 6.5 Fruits and leaves of *Hamamelis vernalis*.

FRUIT TYPE

- Fruit is a woody loculicidal capsule

***Hamamelis mollis* Oliv. (Witch Hazel)**

The ovary of *H. mollis*, like other Hamamelidaceae species, matures into a loculicidal capsule bearing two black seeds (these seeds are forcibly discharged when the fruit is ripe; Figure 6.3). How can you tell the capsule is loculicidal and not septicidal?

***Liquidambar styraciflua* L. (Sweet Gum)**

Observe the *L. styraciflua* fruits on display (Figure 6.4). Formerly in Hamamelidaceae, this species is now placed in its own family, Altingiaceae. The flowers of Altingiaceae are wind pollinated and the seeds (which are often winged) are wind-dispersed. What type of fruit is this (be specific)?

HABIT AND VEGETATIVE CHARACTERISTICS

- Toothed or lobed leaves
- Stipules present
- Stellate hairs often present
- Often colorful in autumn

***Liquidambar styraciflua* L. (Sweet Gum)**

The leaves of *L. styraciflua* are very distinctive, however in the winter one must rely on twig morphology. Using the "Dichotomous Key for Woody Plants" in Lab 1, key out the winter twig of *L. styraciflua*.

***Hamamelis vernalis* Sarg. (Ozark Witchhazel)**

Like many members of the Hamamelidaceae family, *H. vernalis*, also called spring or vernal witchhazel, has alternate, simple, rather broad leaves with coarsely toothed margins (Figure 6.5). If this photograph were in color, you could see the vibrant yellow color the leaves turn in the autumn.

MORACEAE

MULBERRY FAMILY

Eudicots: Rosid Clade

♂ $Ca^4\ Co^0\ A^4\ G^0$

♀ $Ca^4\ Co^0\ A^0\ G^{\textcircled{2}}$

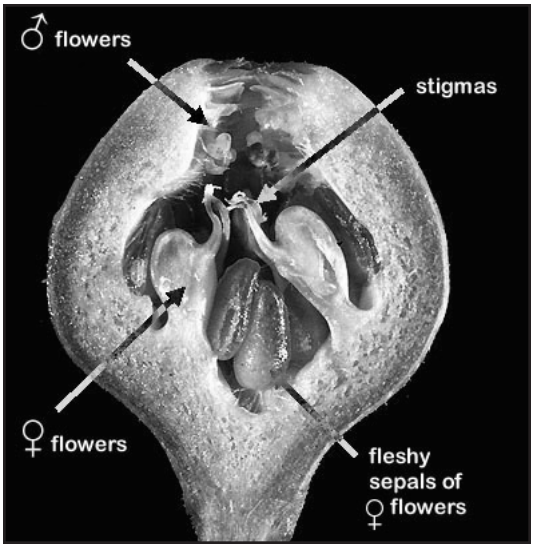


Figure 6.6 Longitudinal section of a *Ficus diversifolia* **SYCONIUM**.

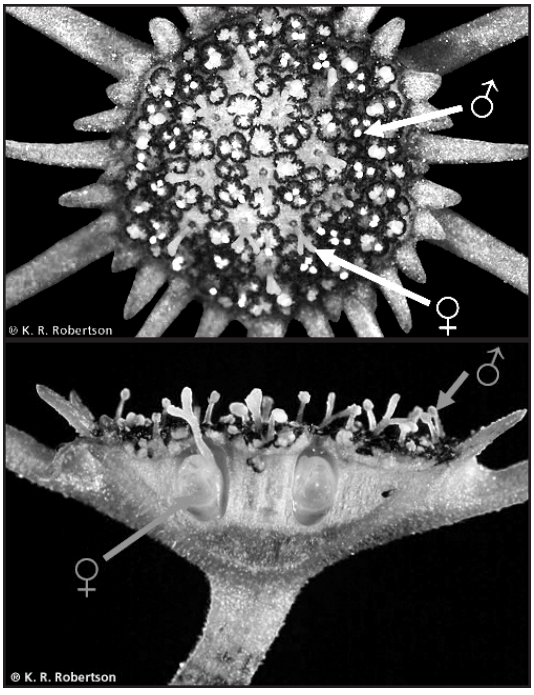


Figure 6.7 *Dorstenia carnulosa* inflorescence.

FLORAL CHARACTERISTICS

- **SYCONIUM** inflorescence
- Imperfect flowers

***Ficus diversifolia* Blume. (Mistletoe Fig)**

The fig is a native of Asia Minor that was imported into the Mediterranean area and used by the Egyptians 6000 years ago. Figs were first introduced into North America around 1600 but commercial cultivation was not begun in this country until 1900. *F. diversifolia* produces a **SYCONIUM** inflorescence (a **SYCONIUM** is also a fruit type). Its small unisexual and apetalous flowers are located inside the **SYCONIUM** (Figure 6.6).

Carpellate Flowers

Note the fertile, white carpellate flowers at the base of the inflorescence with their long styles and stigmas and their orange, fleshy sepals. The ovary is usually unilocular with a single, apical ovule.

Staminate Flowers

Covering the pore at the top of the synconium are numerous scales and below these are the staminate flowers. Typically staminate flowers will have few and often only one stamen per flower. Depending upon your synconium, male flowers may not be obvious.

PORTFOLIO DRAWING: Draw a floral diagram of a longitudinal section of your *F. diversifolia* **SYCONIUM**, making sure to include the floral formula and label all the floral parts. Follow the format as instructed in Lab 3: Floral Terminology.

***Dorstenia carnulosa* Dewild. (Dorstenia)**

Compare the inflorescence of *Dorstenia* (Figure 6.7) to that of *Ficus*. How are they different?

Box 1

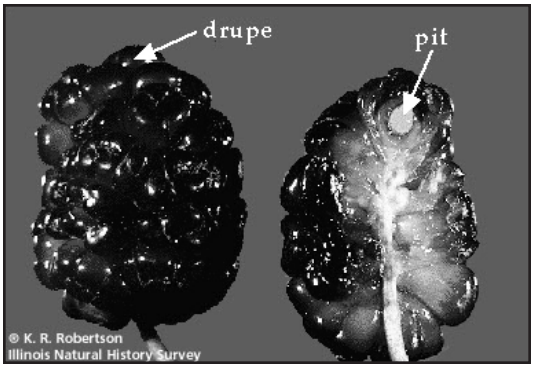


Figure 6.8 *Morus rubra*'s multiple fruit of drupelets.

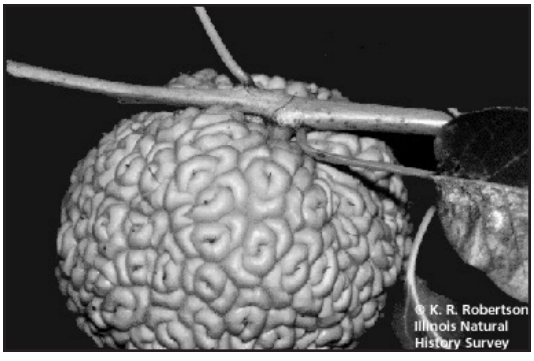


Figure 6.9 *Maclura pomifera* fruit.

FRUIT TYPE

- Achenes or small drupes
- Sometimes multiple fruits with accessory tissue (**SYCONIUM**)

***Ficus carica* L. (Smyrna Fig)**

The fig (**SYCONIUM**) is a peculiar fruit, with its fleshy receptacle surrounding the actual fruits (small drupes). Thus, a **SYCONIUM** could be considered a multiple fruit with accessory tissue. The common fig develops parthenocarpically (without fertilization of the flowers), and the fruits contain no embryos. However, the Smyrna fig must be pollinated by wasps, *Ficus* species' typical pollinator, in order to develop fruit. This particular variety produces only female flowers and depends on the wild caprifig tree for pollination. The grower of Smyrna figs must tie caprifigs containing wasp eggs to the branches of his Smyrna trees. The eggs hatch, the wasps develop, they exit the caprifig and pick up some pollen and then visit Smyrna figs, pollinating them in the process. Dissect a Smyrna fig and try to find a wasp inside. Yummy! Now, create a simple diagram in Box 1 of the wasp-fig life cycle based on your lecture material.

***Morus* spp. (Mulberries)**

Morus species have catkin inflorescences that, when pollinated, develop into multiple fruits of drupelets (Figure 6.8). You might notice that mulberries look very similar to raspberries (*Rubus idaeus* (Rosaceae)) superficially; however raspberries are classified as aggregate fruits of drupes. What is the difference between these two fruit types? (HINT: Think flower number and gynoecium type.)

HABIT AND VEGETATIVE CHARACTERISTICS

- Trees and shrubs
- Milky sap

***Maclura pomifera* (Raf.) C.K. Schneid. (Osage Orange)**

The habit of *M. pomifera* is a tree, and it can be easily recognized by its orangish-brown bark, branches with axillary spines, and multiple fruit of drupes that some

Figure 6.10 Fruit and trunk of a *Maclura pomifera* tree.

people think resemble green brains (Figures 6.9 and 6.10). Key out the *M. pomifera* winter twig using the "Dichotomous Key for Woody Plants" in Lab 1.

M. pomifera has separate male and female inflorescences that are located on different plants. Based on this information, what is the plant condition?

FAGACEAE

BEECH OR OAK FAMILY

Eudicots: Rosid Clade

♂ $\underline{Ca^{(4\text{-}7)}\,Co^{0}\,A^{4\text{-}\infty}}\;G^{0}$

♀ $\underline{Ca^{(4\text{-}7)}\,Co^{0}\,A^{0}}$

$G^{(3)}$

Figure 6.11 *Quercus macrocarpa* inflorescences.

INFLORESCENCE TYPE

- Staminate flowers in catkins and carpellate flowers in few-flowered clusters enclosed by an **INVOLUCRE**

***Quercus* spp. (Oaks)**

Observe the *Quercus* woody twigs and try to identify the **STAMINATE CATKINS** as well as the **OLD** and **YOUNG CARPELLATE FLOWERS** (Figure 6.11). Label these structures in the photograph below.

1. **STAMINATE CATKINS:** long and pendulous
2. **OLD CARPELLATE FLOWERS**: these flowers from the previous year are now developing into **ACORNS**
3. **YOUNG CARPELLATE FLOWERS**: arranged in few flowered clusters enclosed by an **INVOLUCRE**

Figure 6.12 Female flowers of *Quercus rubra*.

Figure 6.13 1-year old female *Quercus rubra* flowers developing into acorns.

Figure 6.14 Catkin of male *Quercus pumila* flowers.

FLORAL CHARACTERISTICS

- Gynoecium of 3 connate carpels with an inferior ovary

Quercus spp. (Oaks)

To observe the floral morphology characteristic of Fagaceae, you will examine staminate and carpellate *Quercus* flowers. *Quercus* and all Fagaceae flowers are imperfect and located on the same plant. Therefore, what is the plant condition?

Carpellate Flowers

Examine the few flowered clusters of the new (this year's) carpellate flowers and the **INVOLUCRE** that surrounds them (Figure 6.12). You'll notice that the carpellate flowers have an inconspicuous, partially connate calyx, but lack a corolla and an androecium. Identify the stigma, style and ovary of the syncarpous gynoecium. Based on the number of stigmas, how many connate carpels form this gynoecium? Is the ovary position superior or inferior? Also, what is the insertion type?

Staminate Flowers

As previously mentioned, the small staminate flowers are arranged into the long, dangling **CATKINS** characteristic of the Fagaceae family. Staminate flowers possess a scale-like calyx of 4 to 7 connate sepals, but lack a corolla and a gynoecium (Figure 6.14). Their androecium is made up of 4 to many un-fused stamens. What is the floral part fusion term that could be used to describe these stamens?

Figure 6.15 *Fagus grandifolia* (left) and *Fagus sylvatica* (right) nuts with surrounding involucres.

Figure 6.16 Acorns of *Quercus palustris*.

Figure 6.17 *Quercus palustris* winter twigs.

FRUIT TYPE

- Fruit is a nut surrounded by an **INVOLUCRE**

***Castanea* spp. (Chestnuts)**
***Fagus sylvatum* L. (European Beech)**
***Fagus grandifolia* Ehrh. (American Beech)**
***Quercus* spp. (Oaks)**

In Fagaceae, the ovary of each flower within an **INVOLUCRE** develops into a nut. Thus, in *Castanea*, *Fagus* and *Quercus* species there are 3, 2 and 1 nut(s), respectively, enclosed in each **INVOLUCRE** (Figures 6.15 and 6.16). Observe the diversity in **INVOLUCRE** morphology among the 3 genera.

HABIT AND VEGETATIVE CHARACTERISTICS

- Trees or sometimes shrubs

***Quercus macrocarpa* Michx. (Bur Oak)**
***Quercus rubra* L. (Northern Red Oak)**
***Fagus sylvatica* L. (European beech)**

Identify the species listed above using the “Dichotomous Key for Woody Plants” in Lab 1. Then label the key twig structures in Figure 6.17.

BETULACEAE

BIRCH FAMILY

Eudicots: Rosid Clade

♂ $\underline{Ca^{0\text{-}6}\,Co^{0}\,A^{2\text{-}18}\,G^{0}}$

♀ $\dfrac{Ca^{0\text{-}6}\,Co^{0}\,A^{0}}{G^{(2)}}$

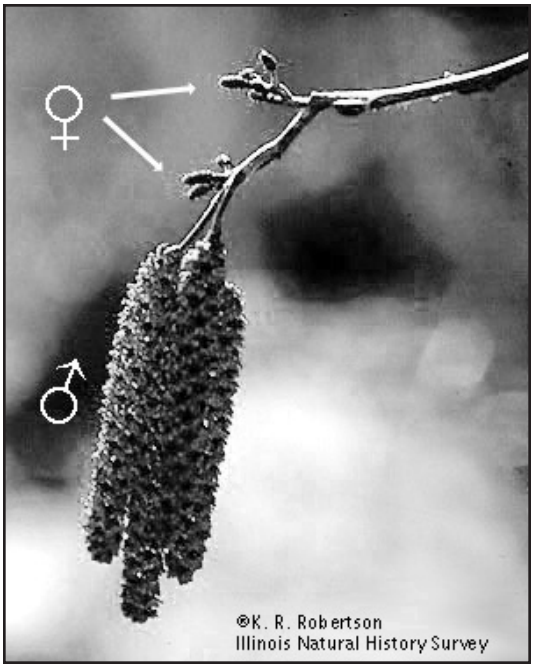


Figure 6.18 Catkins of American Hazelnut, also known as *Corylus americana.*

INFLORESCENCE TYPE

- Staminate and carpellate flowers clustered into separate **CATKINS**

***Alnus glutinosa* (L.) Gaertn. (European Alder)**

Observe the woody twigs that have been collected for *A. glutinosa* and try to identify the three **CATKIN** inflorescences types listed below as well as the twig's **VEGETATIVE BUDS**. Then label those structures on the photograph of *A. glutinosa* below.

1. **STAMINATE CATKINS:** these are long and pendulous and may be releasing yellow pollen
2. **OLD CARPELLATE CATKINS**: these are found at the end of the twig, are woody and resemble small pine cones
3. **YOUNG CARPELLATE CATKINS**: these are very small and are found next to the long pendulous staminate catkins
4. **VEGETATIVE BUDS**

Figure 6.19 *Betula pendula* branch.

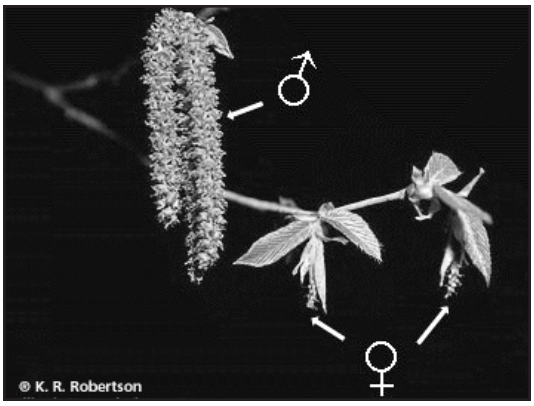


Figure 6.20 *Ostrya virginiana* male and female catkins.

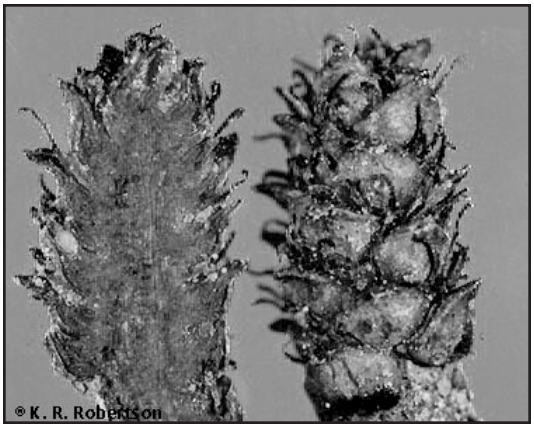


Figure 6.21 Female catkin of *Alnus cordata*.

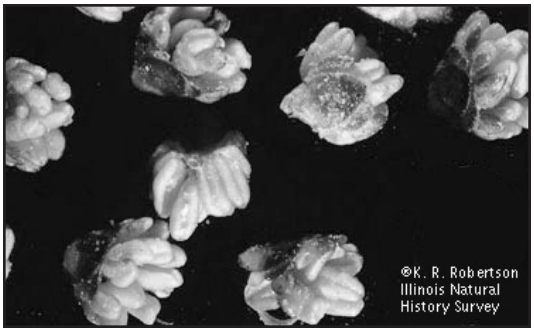


Figure 6.22 Male flowers of *Betula pendula*.

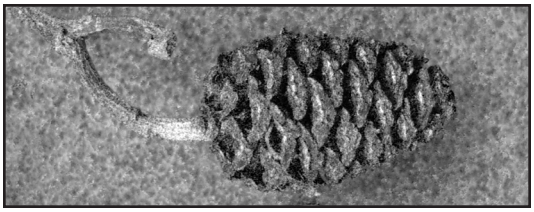


Figure 6.23 Mature female catkin of *Alnus glutinosa*.

FLORAL CHARACTERISTICS

- Gynoecium of 2 connate carpels with an inferior ovary

***Alnus glutinosa* (L.) Gaertn. (Common or Black Alder)**

To observe the floral morphology characteristic of Betulaceae, you will examine staminate and carpellate *A. glutinosa* flowers.

Carpellate Flowers

The carpellate catkins are very short, with each bract subtending two flowers (a **CYMULE**) that lack a calyx and corolla (Figure 6.21). The flowers' ovaries are inferior, bi-carpellate and have two styles. Based on this, what type of gynoecium do you think the flowers have?

Write out the formula for a female *A. glutinosa* flower given the provided information.

Staminate Flowers

The staminate catkins are pendulous. Each bract subtends 3 tiny flowers (a **CYMULE**) and each flower consists of a small 4-parted calyx and 4 stamens with short filaments. There are no petals (corolla). The anthers are deeply divided so that the pollen sacs are distinct. Observe a portion of a staminate catkin under your dissecting scope and identify the bracts and individual flowers with their calyx and stamens. Write out the formula for a male *A. glutinosa* flower given the provided information.

FRUIT TYPE

- Fruits are samaras and one-seeded nuts

***Alnus glutinosa* (L.) Gaertner (Black Alder)**

The carpellate catkins of *Alnus* species are persistent, and

Figure 6.24 Fruits of *Corylus americana*.

Figure 6.25 *Ostrya virginiana* fruits and leaves.

become woody as they mature (Figure 6.23). The small samara fruits contained within are gradually released with movement of the mature, woody catkin.

***Corylus americana* Walter (American Hazelnut)**

C. americana produces the other fruit type characteristic of Betulaceae, a nut (Figure 6.24). Check out the provided fruits, herbarium specimen and illustrations. What is the name of the green structures enclosing these *C. americana* nuts?

HABIT AND VEGETATIVE CHARACTERISTICS

- Habit is a tree or a shrub
- Doubly serrate leaf margins

***Betula pendula* Roth (European White Birch)**

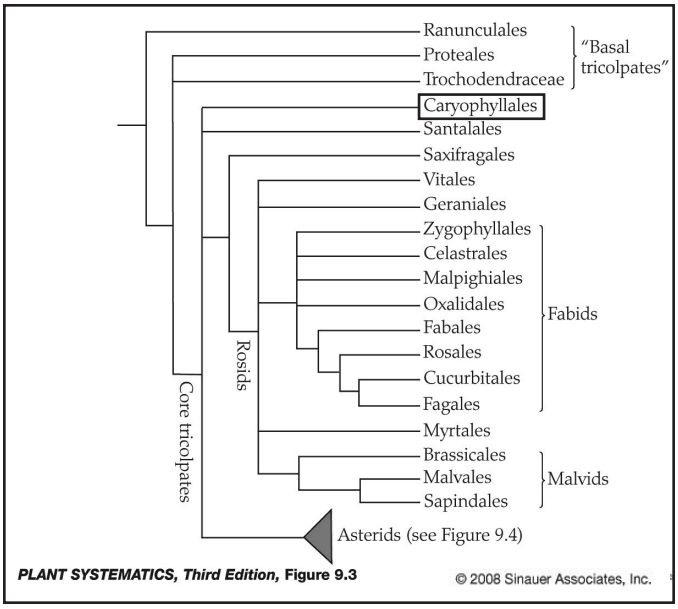
Using the “Dichotomous Key for Woody Plants” in Lab 1, be sure you can identify a winter twig of *B. pendula*.

LABORATORY 7

CACTACEAE, CARYOPHYLLACEAE, PORTULACEAE AND POLYGONACEAE

PHYLOGENETIC RELATIONSHIPS

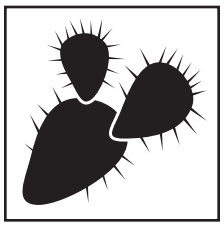
The Caryophyllid clade belongs within the Core Eudicots (Core Tricolpates) clade. The monophyly of the Caryophyllid clade is supported by seed coat anatomy, anther wall development and molecular data. However, their position, whether within the Rosid complex or sister to the Asterid clade is uncertain. The Caryophyllid clade contains two large orders, Caryophyllales and Polygonales.



The order Caryophyllales is clearly monophyletic, as evidenced by their numerous, distinctive synapomorphies, such as an embryo curved around the seed, the presence of perisperm instead of endosperm, free-central or basal placentation, sometimes a single whorl of tepals, a specialized type of plastid with a central protein crystal, loss of the rpl2 intron (a major structural rearrangement of the chloroplast genome), and betalain pigments instead of anthocyanins (except in the family Caryophyllaceae). Recent cladistic analyses suggest that the anthocyanin-possessing Caryophyllaceae evolved from betalain-containing ancestors that lost their betalains and reacquired anthocyanins. These two changes are possibly biochemically interrelated. Of course, the monophyly of the Caryophyllales is strongly supported by comparative DNA sequence data. The Caryophyllales consists of 18 families and 8,600 species, with its major families including Cactaceae, Portulacaceae and Caryophyllaceae.

The Caryophyllales are closely related to the order Polygonales; indeed, in many phylogenetic analysis, they are sister taxa. The Angiosperm Phylogeny Group actually places Polygonales in the order Caryophyllales. Among the 10 families (about 2,050 species) included in Polygonales, are Polygonaceae and Plumbaginaceae as well as the carnivorous plant families Droseraceae and Nepenthaceae. It is of interest to note that the pitcher-like leaves of the Old World family Nepenthaceae are amazingly similar with those of the distantly related, New World carnivorous family Sarraceniaceae. This an amazing case of convergent evolution!

Many of the families of the Caryophyllid clade were treated previously by Arthur Cronquist in the subclass Caryophyllidae. Unlike most other subclasses of flowering plants, the Caryophyllidae are supported as monophyletic through a variety of cladistic analyses of both morphological and molecular data.



CACTACEAE

CACTUS FAMILY

Eudicots: Caryophyllid Clade

$$\text{♀}\ \frac{\text{Ca}^{\infty}\ \text{Co}^{\infty}\ \text{A}^{\infty}}{\text{G}^{(3\text{-}\infty)}}$$

Figure 7.1 Flowers of *Schlumbergera bridgesii*.

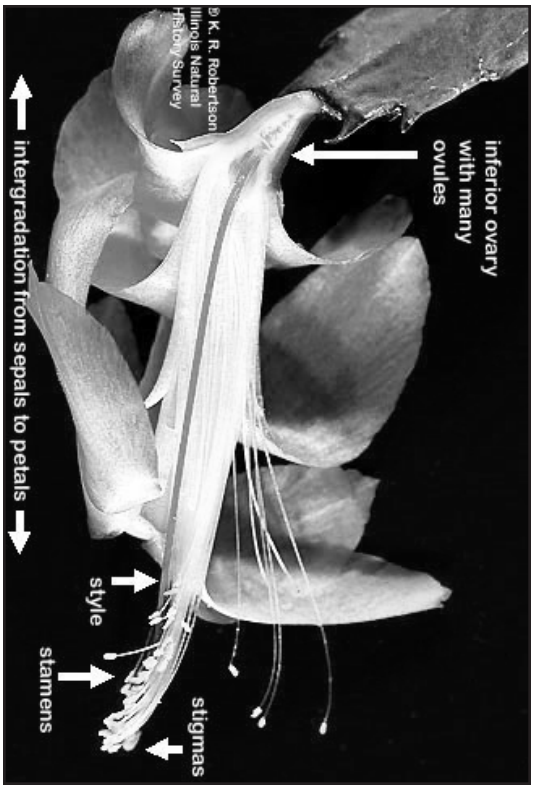


Figure 7.2 Longitudinal section of a *Schlumbergera bridgesii* flower.

THREE SUBFAMILIES

- **CACTOIDEAE**: Stems generally not jointed and glochids absent
- **OPUNTIOIDEAE**: Jointed stems and glochids (each stem-joint represents a season's growth)
- **PERESKIOIDEAE**: Leafy shrubs with scarcely succulent stems

FLORAL CHARACTERISTICS

- Large and showy flowers
- Ovary inferior and sunken into stem tissue

***Schlumbergera* spp. (CACTOIDEAE) (Schlumbergera)**

To observe the floral morphology characteristic of Cactaceae, you will examine and dissect a *Schlumbergera* flower (either *S. bridgesii* (Lemaire) Loefgren., the Christmas Cactus, or *S. truncata* (Haw.) Moran, the Crab Cactus). This genus is native to Brazil and many cultivars have been produced. In their native habitat, these plants grow as epiphytes on trees. What is an epiphyte?

1. Observe a flower. What is its symmetry?

2. **CALYX** and **COROLLA**: The perianth elements increase in size and gradually transition from sepals to petals from the outermost to the innermost whorl (Figures 7.1 and 7.2). Since sepals and petals cannot be distinguished, they are all called **TEPALS**. In this flower a hypanthium is present (not shown in floral formula). Look for it just above the ovary (it's rather small). What adnate parts form the hypanthium?

Figure 7.3 Flower of an *Opuntia macrorhiza* flower.

Figure 7.4 Longitudinal section of an *Opuntia macrorhiza* flower.

Figure 7.5 Berry fruits of *Opuntia*.

3. **ANDROECIUM**: Are there few or numerous stamens in this flower?

4. **GYNOECIUM**: Note the inferior ovary sunken into the stem tissue with its one locule. How many carpels are fused to produce this syncarpous gynoecium? (HINT: Count the number of stigma lobes.)

***Opuntia macrorhiza* Engelm. (OPUNTIOIDEAE)**
(Twistspine Pricklypear)

O. macrorhiza is one of the three *Opuntia* species native to Illinois (Figure 7.3). The other two are *O. humifusa* and *O. fragilis* (an endangered species).

Observe Figure 7.4 depicting a longitudinal section of *O. macrorhiza*. What is its insertion type?

FRUIT TYPE

- Fruit is a berry

***Opuntia* spp. (OPUNTIOIDEAE)**

The fruits of Cactaceae are many-seeded berries (Figure 7.5). Since the ovary is often imbedded in stem tissue, the berry is likewise. Hence, **AREOLES** with **SPINES** and/or **GLOCHIDS** are often found on the outside of the berries. The berries of some species of *Opuntia* are edible and sold in supermarkets. However, be sure to remove the skin and **GLOCHIDS** before trying to eat one!

Figure 7.6 **AREOLES** and **SPINES** of Cactaceae.

Box 1

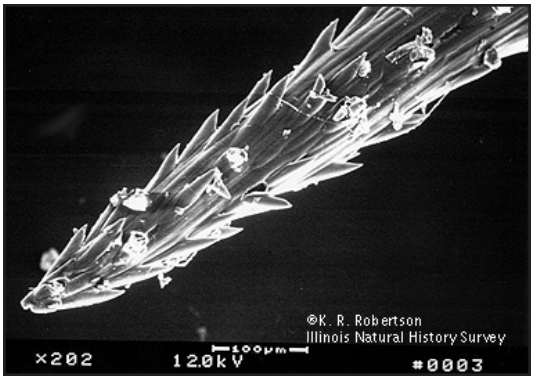


Figure 7.7 A highly magnified photograph of a **GLOCHID** taken with a scanning electron microscope.

HABIT AND VEGETATIVE CHARACTERISTICS

- Stem succulents with **BETALAIN** pigments
- Leaves reduced or absent
- **SPINES** (modified leaves) produced from an **AREOLE** which sometimes contains numerous **GLOCHIDS**

***Echinocactus* spp. (CACTOIDEAE)**
***Cephalocereus senilis* (Haw.) Pfeiff. (CACTOIDEAE)**

As you can see, *Echinocactus* and *C. senilis* (the old man cactus) from Cactoideae are stem succulents and contain numerous **AREOLES** and **SPINES** (Figure 7.6). Areoles are small structures on the photosynthetic stems of cacti that are usually interpreted as rudimentary shoots. Often spines (reduced leaves borne on this shoot) are produced at the areole.

***Opuntia* spp. (OPUNTIOIDEAE)**

Species within the Opuntioideae subfamily also have short yellowish or dark colored bristles called **GLOCHIDS** in addition to their **AREOLES** and **SPINES**. **GLOCHIDS** (or **GLOCHIDIA**) are actually a type of defense mechanism since they are easily detached from the **AREOLE** when brushed against by animals (such as humans) and contain downward pointing barbs that force themselves into the skin, causing great discomfort (definitely an understatement!) (Figure 7.7). They are especially abundant in the genus *Opuntia*. Draw and label **AREOLES**, **SPINES** and **GLOCHIDS** in Box 1 after observing the *Opuntia* specimens on display.

***Pereskia* spp. (PERESKIOIDEAE)**

Observe the vegetative characteristics of *Pereskia*. Why are members of the subfamily Pereskioideae, such as *Pereskia*, considered ancestral within Cactaceae?

CARYOPHYLLACEAE

PINK FAMILY

Eudicots: Caryophyllid Clade

$\male\ Ca^{\overset{\frown}{5}}\ Co^{5}\ A^{10}\ G^{\underline{(2\text{-}5)}}$

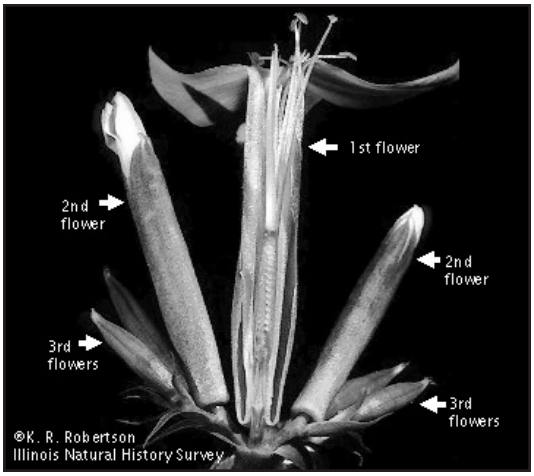


Figure 7.8 Cyme inflorescence of *Saponaria officinalis*.

INFLORESCENCE TYPE

- **CYME** inflorescences

***Saponaria officinalis* L. (Bouncing Bet)**

The basic inflorescence in the Caryophyllaceae is a **CYME**, as seen here in *S. officinalis* (Figure 7.8). Remember that a **CYME** is an example of a **DETERMINATE INFLORESCENCE**. What does that mean?

Box 2

Draw a cyme inflorescence in Box 2. Then label your drawing with the following terms: terminal flower, lateral flower, bracts, pedicel, peduncle.

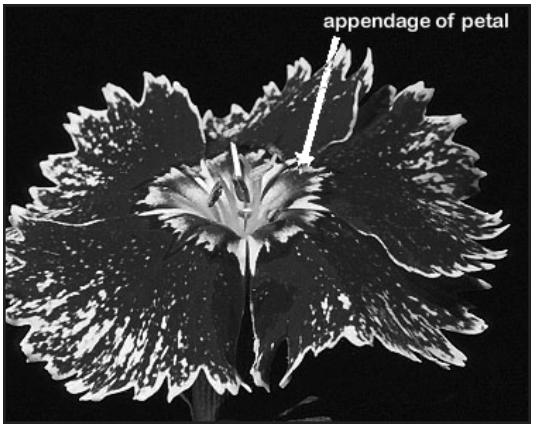


Figure 7.9 Flower of a *Dianthus* cultivar.

FLORAL CHARACTERISTICS

- Petals often clawed at base and apically notched
- Ovary on a **GYNOPHORE** (i.e. **ANDROGYNOPHORE),** a stalk that supports the Corolla, Androecium and Gynoecium

***Dianthus* spp. (Pinks)**

To observe the floral morphology characteristic of Caryophyllaceae, you will examine a *Dianthus* flower.

1. Examine a flower (Figure 7.9). What is its symmetry?

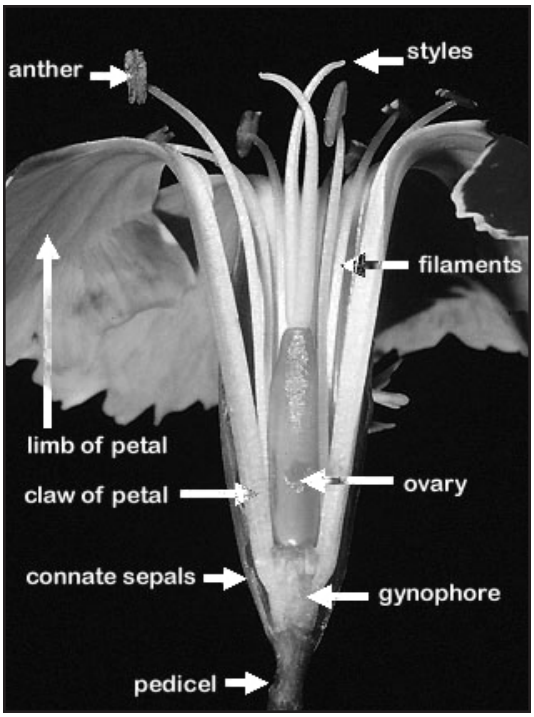


Figure 7.10 Longitudinal section of a *Dianthus* flower.

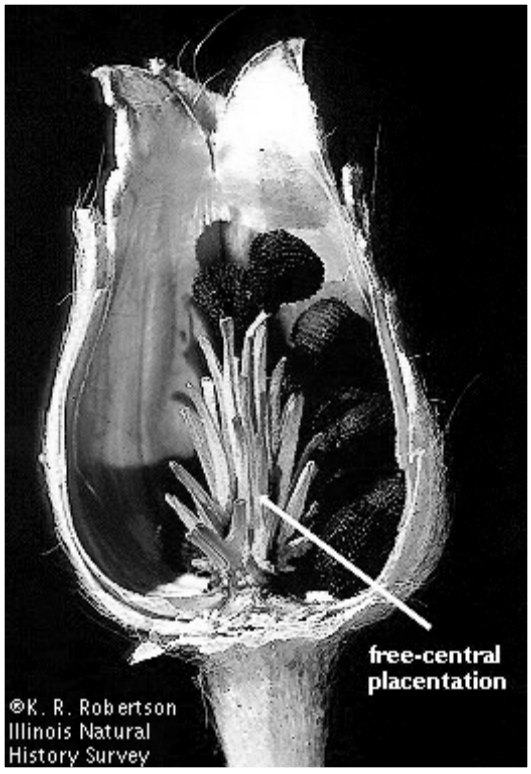


Figure 7.11 Longitudinal section of an *Agrostemma githago* denticidal capsule.

2. **CALYX**: The sepals in the calyx are fused to form a ribbed tube. To determine the number of sepals, count the number of calyx tube lobes.

3. **COROLLA**: The petals are clawed at their base, and at the juncture of the **CLAW** and **LIMB** on the inner surface are two **APPENDAGES** (Figure 7.10). How many petals are there?

4. **ANDROECIUM**: How many stamens make up the androecium? Are they connate or distinct?

5. **GYNOECIUM**: How many carpels make up this syncarpous gynoecium and what is the placentation type? The superior ovary of *Dianthus* sits upon a **ANDROGYNOPHORE** (i.e. **GYNOPHORE**). What is the difference between an **ANDROGYNOPHORE** and a hypanthium?

6. **PORTFOLIO DRAWING:** Draw a floral diagram of a longitudinal section (L.S.) of *Dianthus* as well as a cross section (X.S.) of its ovary, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

FRUIT TYPE

- Fruit is a **DENTICIDAL CAPSULE** (a capsule with apical teeth)

***Silene* spp. (Catchfly or Campion)**
***Agrostemma githago* L. (Corn Cockle)**

Most members of the Caryophyllaceae family, like *Silene* species and *A. githago*, produce **DENTICIDAL CAPSULES** with free central placentation and persistent connate sepals (Figure 7.11). What type of gynoecium is required to produce this fruit type (or any other type of capsule)?

Figure 7.12 Complex cyme from a *Lychnis chalcedonica*.

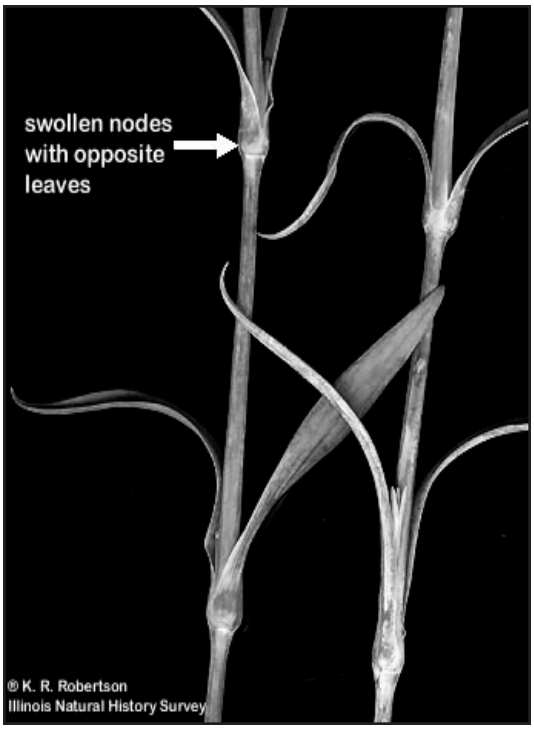


Figure 7.13 Opposite leaves and swollen nodes of a *Dianthus caryophyllus* stem.

HABIT AND VEGETATIVE CHARACTERISTICS

- Herbs with **ANTHOCYANIN** pigments
- Opposite, simple, entire leaves with connate, sheathing leaf bases (creating **SWOLLEN STEM NODES**)

***Lychnis chalcedonica* L. (Maltesecross)**

Review your vegetative terminology while observing some of the major characteristics of Caryophyllaceae like the swollen stem nodes (Figure 7.13).

Complexity _____

Arrangement _____

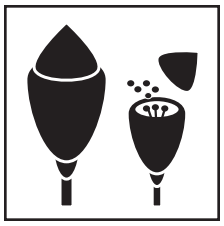
Attachment _____

Leaf venation _____

Leaf apex _____

Leaf base _____

Leaf margin _____



PORTULACACEAE

PURSLANE FAMILY

Eudicots: Caryophyllid Clade

♀ $\underline{Ca^{2}\ Co^{5-\infty}\ A^{5-\infty}\ G^{(2-9)}}$

Figure 7.14 Underside of a *Portulaca grandiflora* flower.

Figure 7.15 Longitudinal section of a *Portulaca grandiflora* flower.

FLORAL CHARACTERISTICS

- Two persistent sepals (may be bracts)
- Two to many ovules with basal or free central placentation

***Portulaca grandiflora* Hook. (Moss-rose Purslane)**

To observe the floral morphology characteristic of the Portulacaceae family you will examine a *P. grandiflora* flower.

1. Looking at the provided photographs, what is the floral symmetry?

2. **CALYX**: Identify the 2 persistent sepals (Figure 7.14).

3. **COROLLA**: How many petals make up the corolla?

4. **ANDROECIUM**: Number of stamens (few or numerous)?

5. **GYNOECIUM**: Note the one-loculed, partially inferior ovary with many ovules (Figure 7.15). What is the placentation type? Also, how many styles or style branches are there? What does this tell you about the type of gynoecium and the carpels that make it up?

6. Write out the floral formula for the *P. grandiflora* flower.

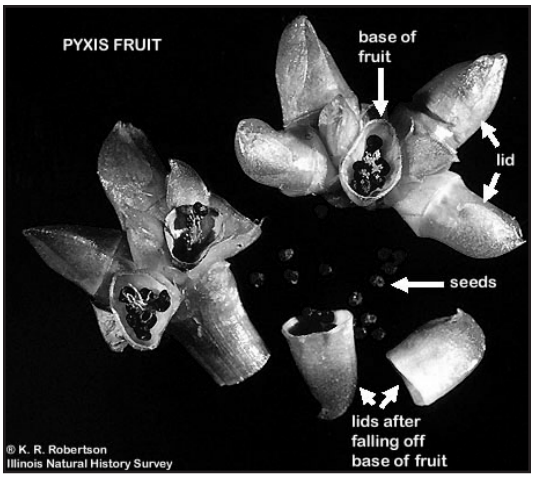


Figure 7.16 Pyxis of *Portulaca oleracea*.

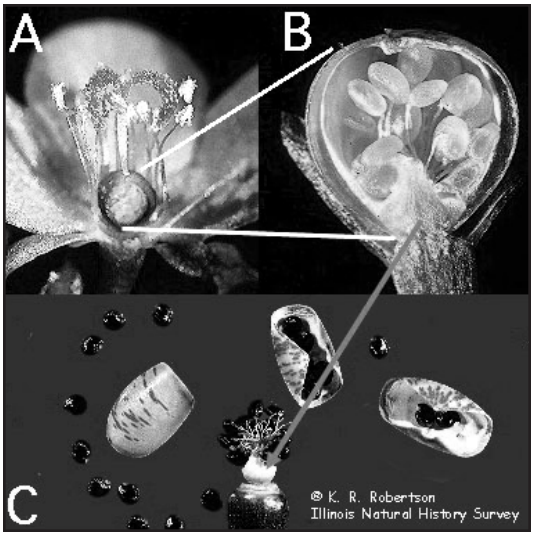


Figure 7.17 Sequence from flower to capsule fruit in *Talinum teretifolium*.

Box 3

FRUIT TYPE

- Fruits are capsules (sometimes **CIRCUMSCISSILE CAPSULES** (**PYXIS**))

***Portulaca oleracea* L. (Common Purslane)**

In *P. oleracea*, the fruit is a circumscissle capsule (**PYXIS**) (Figure 7.16). In order for the seeds to dehisce, or be released from the fruit, the top of the fruit comes off like a lid.

***Claytonia virginica* L. (Spring Beauty)**
***Talinum teretifolium* Pursh. (Quill Fameflower)**

Check out the other capsule types produced by *C. virginica* and *T. teretifolium* (Figure 7.17).

HABIT AND VEGETATIVE CHARACTERISTICS

- Produce **BETALAIN** pigments
- Leaves often succulent

***Portulaca oleracea* L. (Common Purslane)**

The leaves of *P. oleracea* are succulent, a common feature of Portulacaceae. Now take a minute to review your vegetative terminology by drawing and labeling a leaf in Box 3. Also fill in the blanks below.

Complexity _____

Attachment _____

Blade shape _____

Leaf apex _____

Leaf base _____

Leaf margin _____

POLYGONACEAE

BUCKWHEAT FAMILY

Eudicots: Caryophyllid Clade

♀ $\underline{Ca^{3+3\,(5)}\ Co^{0}\ A^{3-9}\ G^{(2-3)}}$

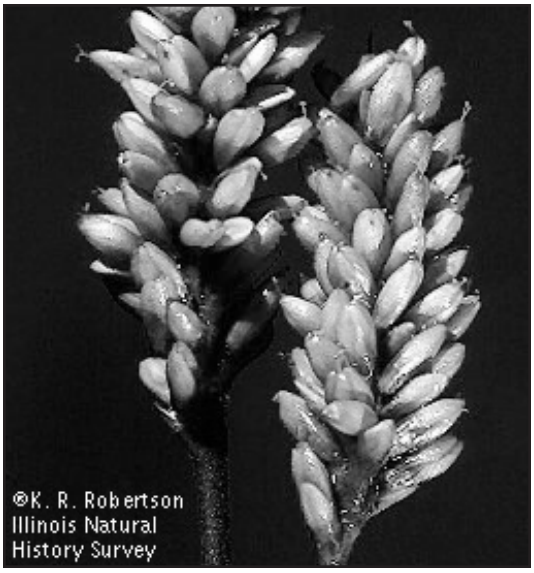


Figure 7.18 Inflorescences of *Polygonum coccineum*.

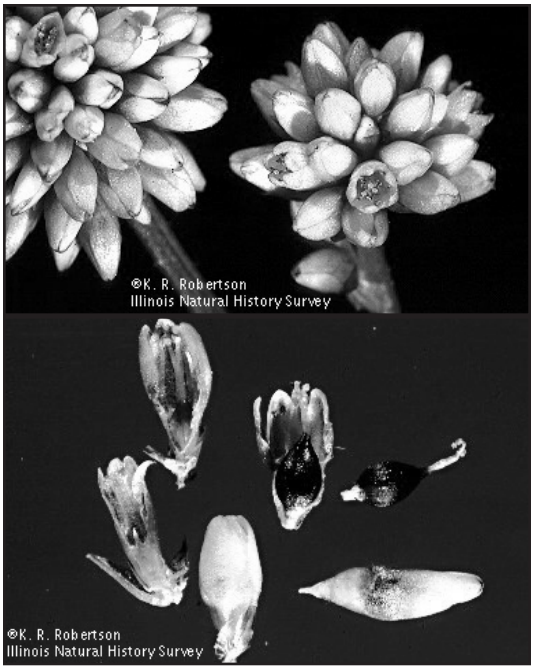


Figure 7.19 Inflorescences (Top) and flowers (Bottom) of *Polygonum capitatum*.

FLORAL CHARACTERISTICS

- Sepals often in 2 whorls of 3 (sometimes an inner sepal fused with an outer one)
- Petals are absent

***Polygonum capitatum* Buch.-Ham. (Pinkhead Smartweed)**

Polygonum is Greek for "many-kneed" in reference to the jointed stems characteristic of the genus. To observe the floral morphology characteristic of the Polygonaceae family you will examine a *P. capitatum* flower. Flowers produced by Polygonaceae species are considered perfect but incomplete. How is this possible?

1. Observe one of these tiny flowers. What is its symmetry?

2. **CALYX**: Using a microscope, verify that there are 5 sepals making up the calyx. Typically the sepals for Polygonaceae species will occur in 2 whorls of 3 (noted in the floral formula as 3 + 3). However, in *P. capitatum* one of the inner sepals is fused with a sepal in the outer whorl creating a total of 5 sepals. Also notice that these sepals are white to pink in color - not all sepals are green!

3. **COROLLA**: Petals, and thus the corolla, are absent in members of the Polygonaceae Family.

4. **ANDROECIUM**: Note the arrangement of the 8 stamens that make up the androecium.

5. **GYNOECIUM**: The ovary is trigonous (3-sided) and has 3 capitate stigmas (Figure 7.19). Based on this, how many carpels do you think fused to produce the flower's syncarpous gynoecium? What is the ovary position?

Figure 7.20 Achenes of *Fagopyrum esculentum*.

Figure 7.21 Achenes of *Rumex crispus*.

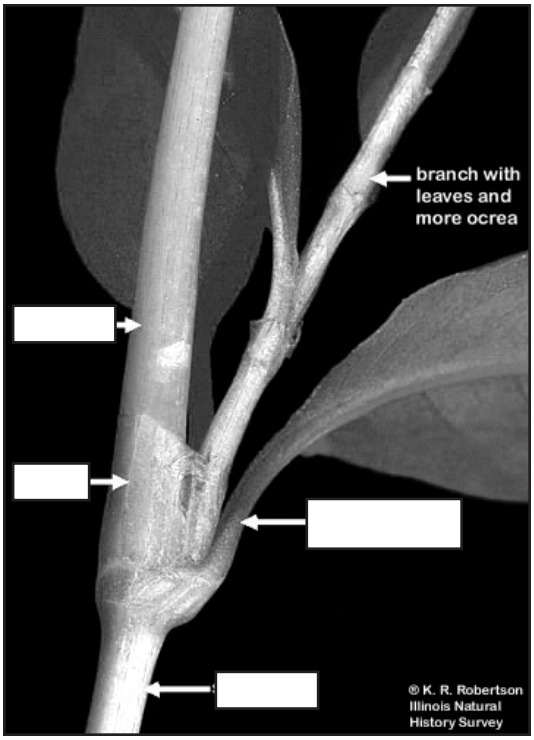


Figure 7.22 Stem of *Polygonum pennsylvanicum* displaying its characteristic **OCREA**.

FRUIT TYPE

- Fruits are triangular or lens-shaped achenes

***Fagopyrum esculentum* Moench (Buckwheat)**
***Rumex* spp. (Docks)**

Check out the triangular achenes produced by *F. esculentum* and *Rumex* (Figures 7.20 and 7.21). What are some of the key features of an achene fruit? Also, how many ovules were in the original flower to produce these achenes?

HABIT AND VEGETATIVE CHARACTERISTICS

- Produce **ANTHOCYANIN** pigments
- Stipules are usually present and sheathing around stem, called **OCREA**

***Coccoloba uvifera* L. (Seaside grape)**
***Polygonum pennsylvanicum* L. (Pennsylvania smartweed)**

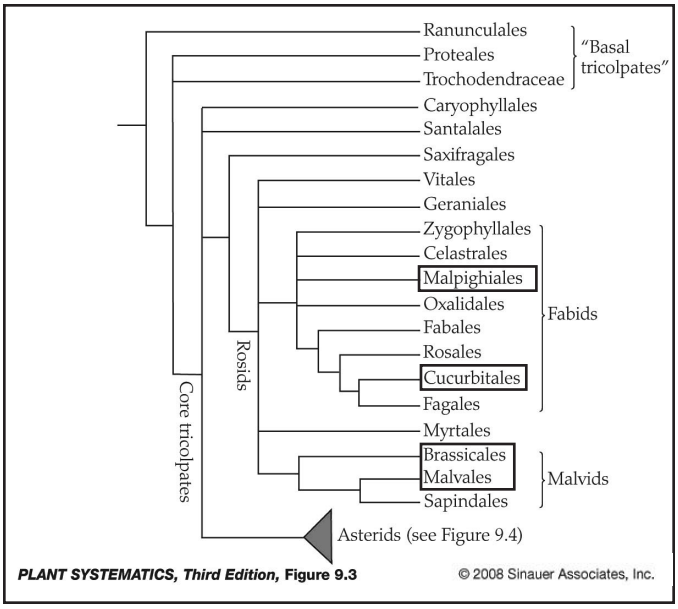
Find the sheathing stipules (**OCREA**) at the base of the petioles surrounding the stem. This character is diagnostic for Polygonaceae, and its shape and pubescence is often used to identify species in the *Polygonum* genus. Please label the **OCREA**, node, stem and petiole in Figure 7.22.

LABORATORY 8

CUCURBITACEAE, SALICACEAE, VIOLACEAE, MALVACEAE, BRASSICACEAE AND ERICACEAE

PHYLOGENETIC RELATIONSHIPS

All of the families examined in today's lab, with the exception of Ericaceae, belong to the Rosid clade.



PLANT SYSTEMATICS, Third Edition, Figure 9.3

Cucurbitaceae, along with begonias, comprise the order Cucurbitales in the Fabids subclade. Synapomorphies include inferior ovaries, strongly intruded parietal placentae, unisexual flowers, and the presence of cucurbitacins. The highly modified androecium of Cucurbitaceae is similar in appearance to the style and stigma, and insects are fooled into visiting both staminate and carpellate flowers. The family is very important economically for its edible fruits (**PEPOS**).

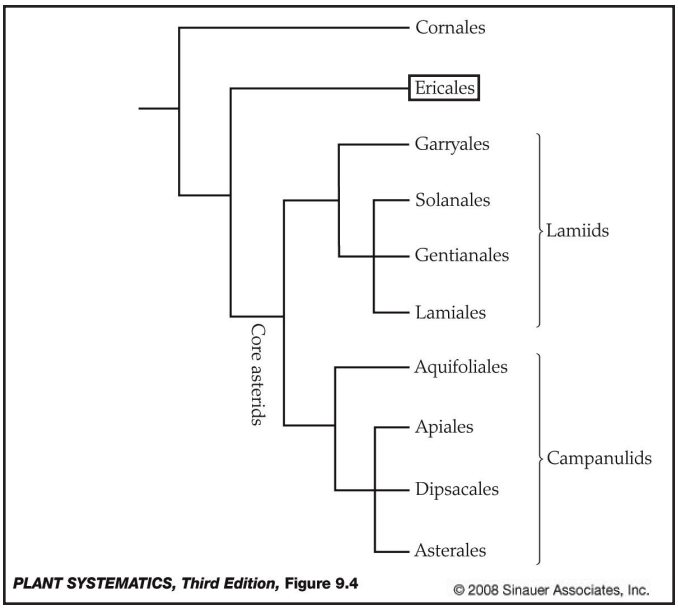
Violaceae is included within the order Malpighiales, an order in the Fabids subclade, that is circumscribed on the basis of molecular data only.

Salicaceae is also found in the order Malpighiales. The monophyly of the family is supported primarily by molecular evidence, but also by the distinctive salicoid teeth and associated gladular hairs, imperfect apetalous flowers and salicin. Though the flowers of the two major genera in Salicaceae, *Salix* (willows) and *Populus* (i.e. poplar, cottonwood, aspen), may seem simple, they are not primitive; they are actually highly reduced. *Salix* and *Populus* both provide lumber, wood pulp and ornamentals. Additionally, the bark of *Salix* was used medicinally as a source of salicylic acid (the original Aspirin) to reduce swelling and fever. Also included in Salicaceae are those genera previously treated in the "Flacourtiaceae", such as the ornamentals *Oncoba*, *Casearia* and *Idesia*.

Brassicaceae is found in the order Brassicales (15 families), and thus is part of the Malvids subclade. Synapomorphies for Brassicaceae include sulfur-bearing glucosinolate compounds, the cruciform arrangement of the petals and the unique structure of the endoplasmic reticulum. It includes many important food plants, such as capers, radish, cabbage, kale, broccoli, cauliflower, brussels sprouts, turnips, Chinese cabbage, mustard and horseradish. Canola oil is extracted from the seeds of *Brassica napus*. *Arabidopsis* is also incuded here, and is the most widely used vascular plant in molecular biology!

Malvaceae, the Mallow family, is placed in the order Malvales along with eight other families. Phylogenetic analysis of DNA sequences clearly place the order within the Malvid subclade; previously, many systematics had considered Malvales to be related to the Urticales. Synapomorphies include mucilage (slime) canals and cavities, stellate hairs, and connate sepals. Stamens are frequently numerous and develop centrifugally. Judd et al. place *Theobroma cacao* (chocolate) within the Malvaceae family. Other economically important plants within the Malvaceae include *Cola nitida* (cola seeds), *Durio zibethinus* (durian fruit), and *Hibiscus esculentus* (okra). You can have a wicked party serving just these food items!

Lastly, Ericaceae, found in the order Ericales, is distantly related to the other five families. It is a member of the Asterid clade, a large and specialized subgroup within the Eudicots. The Ericales are a sister group to the Core Asterids. Ericaceae is broadly circumscribed to include five other families that are sometimes recognized separately. The family is circumscribed as monophyletic on the basis of phylogenetic analysis of molecular data and includes many showy ornamentals and plants with edible fruits (e.g. blueberries, cranberries).



***PLANT SYSTEMATICS, Third Edition,* Figure 9.4**

CUCURBITACEAE

CUCUMBER FAMILY

Eudicots: Rosid Clade

♂ $\underline{Ca^5\ Co^{⑤}\ A^{⑤}\ G^0}$

♀ $\underline{Ca^5\ Co^{⑤}\ A^0}$
$G^{③}$

Figure 8.1 A *Citrullus vulgaris* plant.

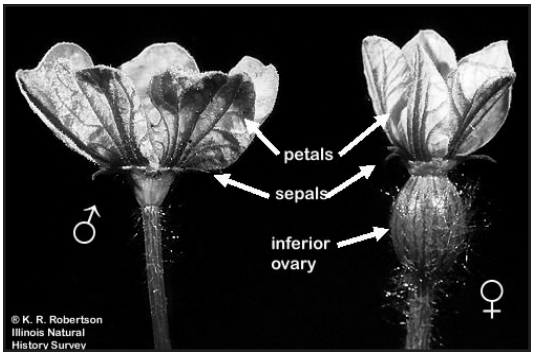


Figure 8.2 Male and female flowers of *Citrullus vulgaris*, commonly known as watermelon.

Box 1

FLORAL CHARACTERISTICS

- Imperfect flowers that are often yellow
- Staminate flowers: filaments and anthers connate and anthers folded or bent

***Cucumis* spp. (Cucumbers and Melons)**

To observe the floral morphology characteristic of the Cucurbitaceae family you will examine and dissect carpellate and staminate flowers of a *Cucumis* species.

CARPELLATE FLOWER

1. Examine a carpellate flower. What is its symmetry?

2. **CALYX** and **COROLLA**: Determine the number of sepals and petals. Is each perianth whorl connate or distinct?

3. **ANDROECIUM**: Notice that the androecium is not present in the carpellate flower. However, what structure is present in place of the stamens?

4. **GYNOECIUM**: How many stigmas and styles do you see and what does this tell you about the number of carpels fused to produce the flower's syncarpous gynoecium? Is the ovary position inferior or superior? Make a cross-section (X.S.) of the ovary, observe the single locule and then sketch the X.S. in Box 1. What type of placentation does the ovary have?

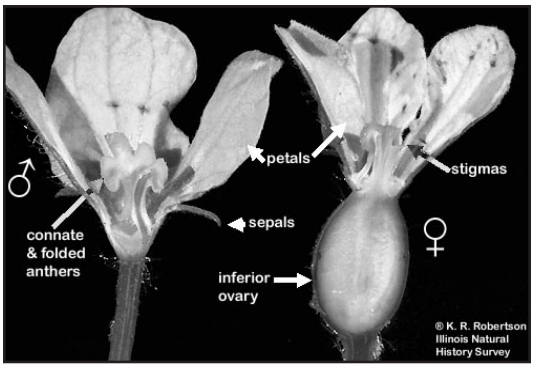


Figure 8.3 Longitudinal sections of male and female *Citrullus vulgaris* flowers.

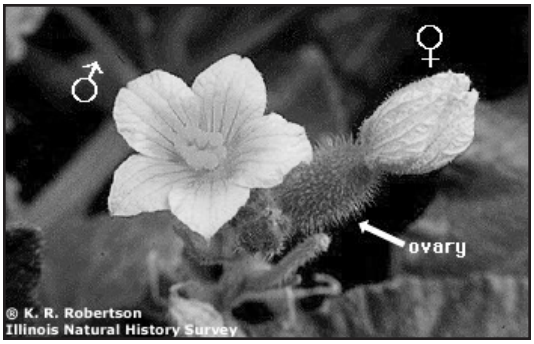


Figure 8.4 Male and female flowers of *Ecballium elaterium*, or squirting cucumber.

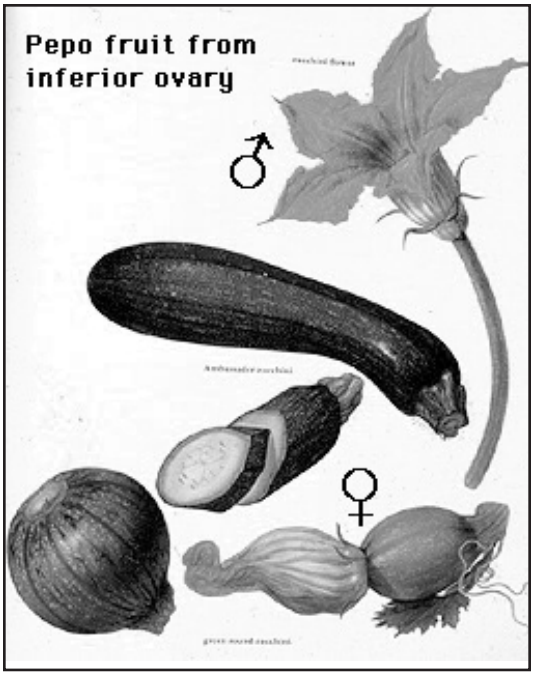


Figure 8.5 Assortment of Cucurbitaceae flowers and fruits.

STAMINATE FLOWER

1. Examine a staminate flower and notice its long peduncle. What is its symmetry?

2. **CALYX** and **COROLLA**: Determine the number of sepals and petals. Is each perianth whorl connate or distinct?

3. **ANDROECIUM**: Count the number of connate stamens that make up the androecium. Also note the folded anthers. Why do you think the androecium of the male flowers has evolved to look this way?

4. **GYNOECIUM**: Notice that the gynoecium is not present in the male flower.

FRUIT TYPE

- Fruit is a **PEPO**

***Cucurbita moschata* Duchesne. (Butternut Squash)**
***Cucumis sativus* L. (Garden Cucumber)**
***Cucumis melo* subsp. *melo* (Canteloupe)**

Characteristic of this family, the ovaries of these species mature into large, water-filled, thick-walled fruits called **PEPOS**. In what ways does a **PEPO** differ from a hesperidium and a berry?

Figure 8.6 Herbaceous vine of *Citrullus vulgaris*. Notice the male and female flowers.

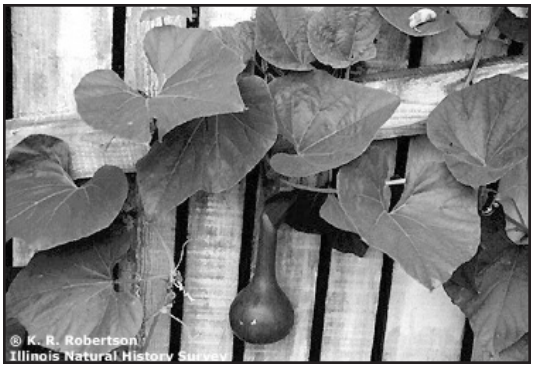


Figure 8.7 *Cucurbita* vine with pepo fruit.

HABIT AND VEGETATIVE CHARACTERISTICS

- Herbaceous vines with **TENDRILS**
- Leaves palmately lobed or divided

***Cucurbita* spp. (Squashes and Pumpkins)**

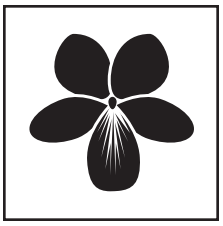
Review your vegetative terminology while observing the two main features of Cucurbitaceae listed above on the live plant specimen provided. The **TENDRILS** on the vine allow it to climb (Figures 8.6 and 8.7)!

Complexity _____

Arrangement _____

Attachment _____

Venation _____



VIOLACEAE

VIOLET FAMILY

Eudicots: Rosid Clade

♀ $\underline{\mathrm{CaZ^5\ CoZ^5\ A^5\ G^{③}}}$

Figure 8.8 *Viola tricolor* flower exhibiting prominent nectar guides.

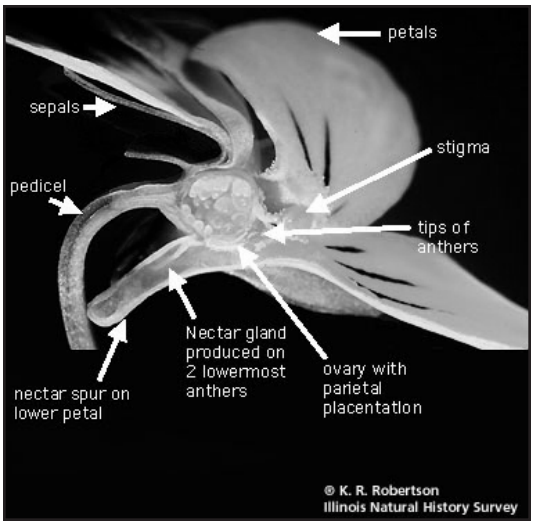


Figure 8.9 Longitudinal section of *Viola* with characteristic **NECTAR SPUR**.

FLORAL CHARACTERISTICS

- Zygomorphic symmetry
- One petal has a **NECTAR SPUR**
- Two lower anthers have a nectary that protrudes into the **NECTAR SPUR**
- Produce two types of flowers (**CHASMOGAMOUS** and **CLEISTOGAMOUS**)

***Viola* spp. (Violets)**

In the spring, most species produce normal petaliferous flowers (**CHASMOGAMOUS** flowers) like you will see in lab today, but in the summer they may also produce fertile **CLEISTOGAMOUS** flowers.

1. Observe a flower (Figure 8.8). What is its symmetry?

2. **CALYX**: How many sepals make up the calyx? Are they connate or distinct?

3. **COROLLA**: How many petals make up the corolla and are they connate or distinct? What is unusual about the lowermost petal (Figure 8.9)?

4. **ANDROECIUM**: How many stamens are in the androecium? Observe the small filaments, and the anthers with their membranous appendages. The lower two anthers each have a gland-like nectary on them that extends into the spur of the lowermost petal.

Figure 8.10 *Viola sororia* flowers.

5. **GYNOECIUM**: What is the ovary position and what type of insertion does the flower display? How many carpels form the syncarpous gynoecium?

6. What are the small, unopened flowers located near the base of a violet called (Figure 8.10)?

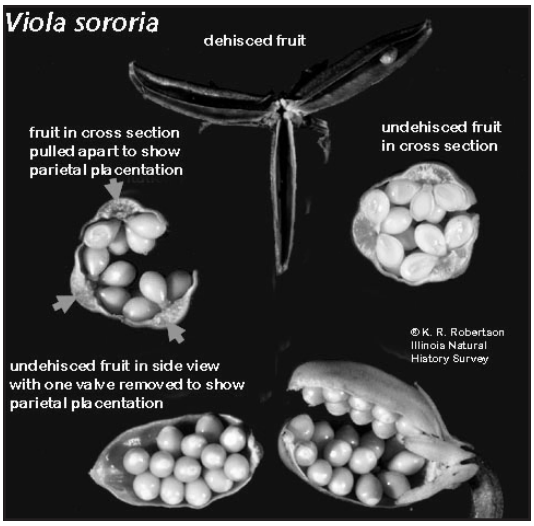


Figure 8.11 Loculicidal capsules of *Viola sororia*.

FRUIT TYPE

- Fruits are loculicidal capsules that are explosively dehiscent

***Viola sororia* Willd. (Common Blue Violet)**
***Viola pedata* L. (Birdfoot Violet)**

Check out the pictures of the loculicidal capsules produced by *V. sororia* and *V. pedata*. Based on what you see, what type of placentation did the original flower have?

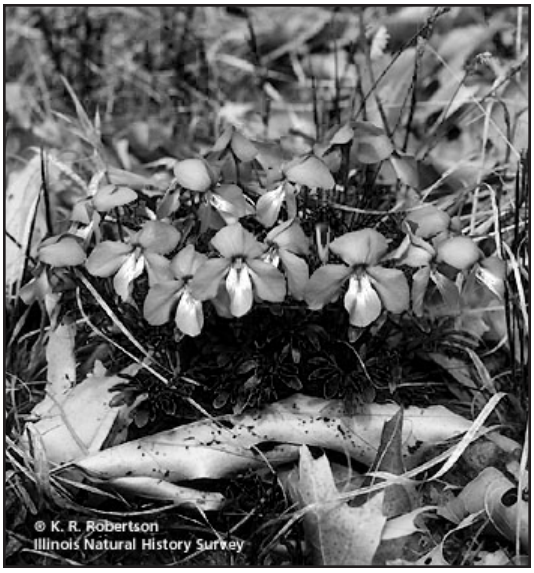


Figure 8.12 Habit of *Viola pedata*.

HABIT AND VEGETATIVE CHARACTERISTICS

- Habit is an herb

***Viola sororia* Willd. (Common Blue Violet)**
***Viola pedata* L. (Birdfoot Violet)**
***Viola striata* Aiton (Pansy)**

Observe the herbarium specimens on display to see the characteristic habit and some species diversity of the Violaceae family (Figure 8.12). The State Flower of Illinois is the “Blue Violet”. The only problem is that there are several different species of blue violets native to Illinois, and state law does not specify which one is the official state flower.

SALICACEAE

WILLOW FAMILY

Eudicots: Rosid Clade

♂ $Ca^{0-x}\ Co^{0}\ A^{2-\infty}\ G^{0}$

♀ $Ca^{0-x}\ Co^{0}\ A^{0}\ G^{(2-4)}$

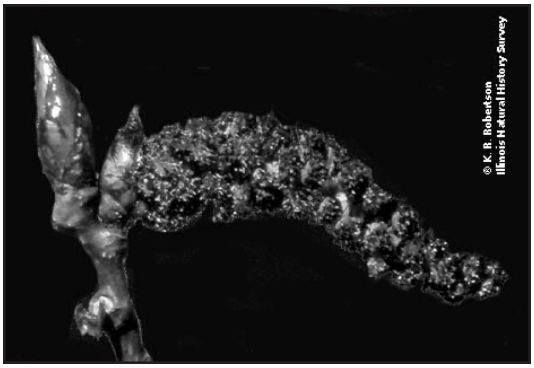


Figure 8.13 Male catkin of *Populus deltoides*.

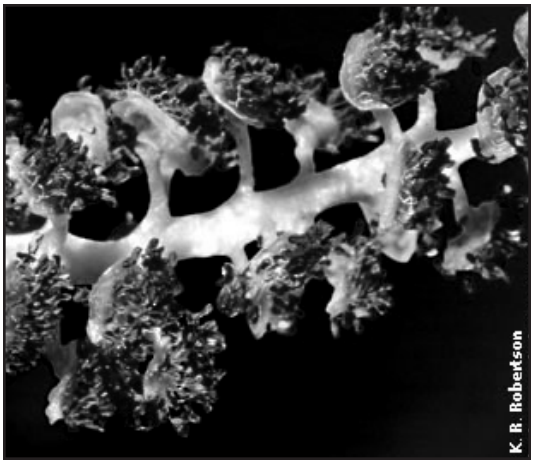


Figure 8.14 Close-up of *Populus deltoides* male catkin.

Figure 8.15 Close-up of *Populus deltoides* female catkin.

TWO MAJOR GENERA

- ***Populus*** spp. (Aspen, Poplar and Cottonwood)
- ***Salix*** spp. (Willows)

FLORAL CHARACTERISTICS

- Flowers imperfect and plant dioecious
- Calyx reduced to a disk in *Populus* or nectar glands in *Salix* and often subtended by a bract
- *Populus* wind pollinated and *Salix* bee pollinated

***Populus deltoides* Marsh. (Eastern Cottonwood)**

The staminate flowers of *Populus* species exhibit a disk- or cup-like calyx that the five to many dangling stamens are attached to (Figures 8.13 and 8.14). The carpellate flowers possess a similar calyx but instead have a syncarpous gynoecium attached to it that is made up of 2 to 4 connate carpels (Figure 8.15). Both staminate and carpellate flowers are subtended by a fringed bract.

What type of inflorescence are both the staminate and carpellate flowers clustered into?

What is the mechanism for pollination in *Populus* species? Why do you think this is the case based on the morphology of the staminate and carpellate flowers?

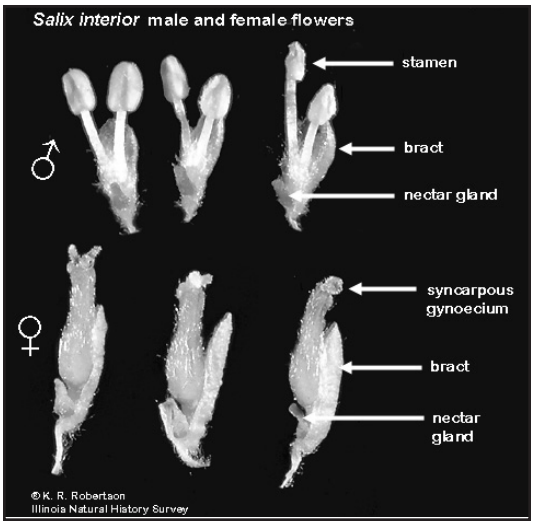


Figure 8.16 Individual male and female flowers of *Salix exigua*, sandbar willow. Note that both sexes of flowers have bracts and nectar glands.

***Salix* spp. (Willows)**

In *Salix* species, the calyx of both staminate and carpellate flowers are reduced to one or two basal nectary glands. Evidence from vascular anatomy indicates that these glands might represent reduced sepals (or even petals). Typically, each staminate flower has only two stamens while each carpellate flower has a syncarpous gynoecium of 2 connate carpels and a superior ovary (Figure 8.16). Both flowers are subtended by bracts which may be quite pubescent as in *S. discolor* (pussy willow.)

Based on your class notes, the plant condition for members of the Salicaceae family is **DIOECY** (**DIOECIOUS**). What does this mean? Also, what is the mechanism of pollination in *Salix* species? Why do you think this?

Figure 8.17 Loculicidal capsules and comose seeds of *Populus deltoides*.

FRUIT TYPE

- Fruits are capsules and contain hairy (**COMOSE**) seeds

***Populus deltoides* Marsh. (Eastern Cottonwood)**
***Salix interior* Rowlee (Sandbar Willow)**
***Salix nigra* Marsh. (Black Willow)**

Check out the capsule fruits of *P. deltoides*, *S. interior* and *S. nigra* and the **COMOSE** seeds emerging from them (Figures 8.17 and 8.18). What do you suppose disperses the seeds of these species?

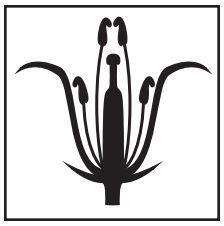
Figure 8.18 Loculicidal capsules of *Salix exigua*.

HABIT AND VEGETATIVE CHARACTERISTICS

- Habit is a tree or shrub

***Populus alba* L. (White Poplar)**
***Salix* spp. (Willow)**

Examine the live material and herbarium specimens on display to see sample vegetative material of the Salicaceae family.



BRASSICACEAE (CRUCIFERAE)

MUSTARD FAMILY

Eudicots: Rosid Clade

♀ $\underline{Ca^4\ Co^4\ A^{4+2}\ G^{(2)}}$

Figure 8.19 *Brassica* flower with **TETRADYNAMOUS STAMENS**.

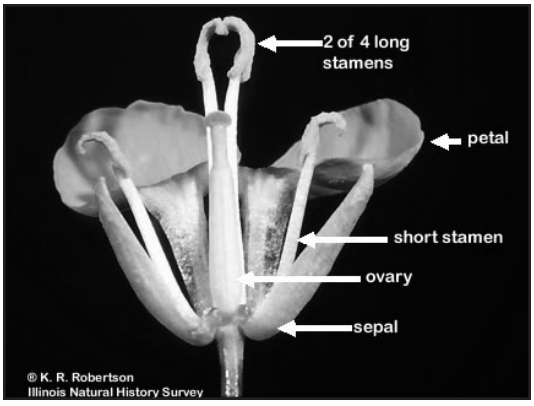


Figure 8.20 Longitudinal section of *Brassica* flower.

Box 2

FLORAL CHARACTERISTICS

- 4-merous flowers
- **TETRADYNAMOUS** stamens
- Ovaries are 2-locular with numerous parietal ovules

***Brassica* spp. (Canola or Rape)**

To observe the floral morphology characteristic of the Brassicaceae family you will dissect a *Brassica* flower.

1. Observe a flower (Figure 8.19). What is its symmetry?

2. **CALYX** and **COROLLA**: How many sepals and petals are present? Do you detect any adnation or connation? Note that the petals have an elongate claw and an abruptly spreading blade.

3. **ANDROECIUM**: The androecium in this family is described as **TETRADYNAMOUS** (Figure 8.20). What does this term mean and how is this feature accounted for in Brassicaceae's floral formula?

4. **GYNOECIUM**: Observe the short, solitary style. The ovary is bicarpellate and is divided into two locules by a thin septum. The ovules are borne in 2 rows and are separated by this partition. As the ovary matures, the septum forms a persistent **REPLUM**. Make a cross section of the ovary and then draw and label it in Box 2.

5. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of *Brassica* as well as a cross section (X.S.) of its ovary, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

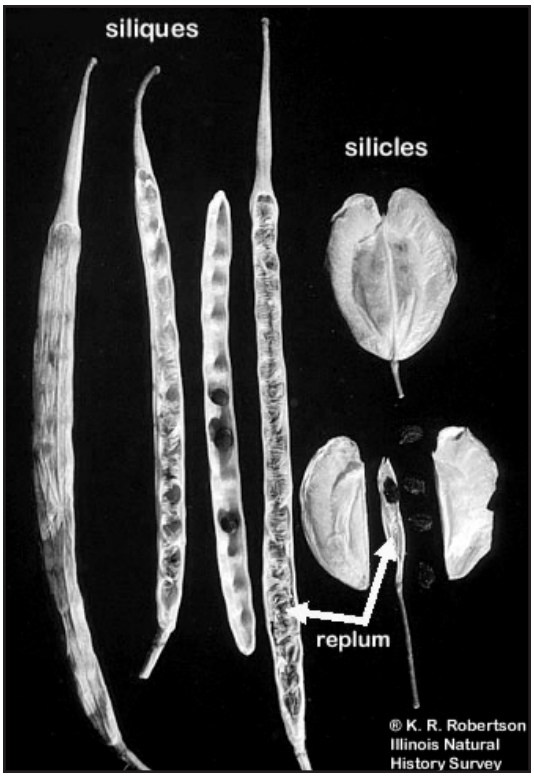


Figure 8.21 Silique fruits of *Hesperis matronalis* and silicle fruits of *Thlaspi* species.

Figure 8.22 Raceme of *Brassica rapa*, or canola.

FRUIT TYPE

- Fruits are **SILIQUES** or **SILICLES** with a **REPLUM**
- Seeds contain a bent embryo

***Hesperis matronalis* L. (Dame's Rocket)**
***Lunaria* spp. (Money Plant)**
***Thlaspi arvense* L. (Field Pennycress)**

Although Brassicaceae flowers are diagnostic for the family, their uniformity can cause many taxonomic problems; taxonomic distinction among taxa largely rests on characters of the mature fruit. If fruits are not available, one can make an educated guess about what kind of fruit will be formed (**SILIQUE** or **SILICLE**) by examining the ovary of the flower. A **SILIQUE** forms from a gynoecium with a long and thin ovary, whereas a **SILICLE** forms from a short and broad ovary (Figure 8.21). Thus, what do you think is the major difference between a **SILIQUE** and a **SILICLE**?

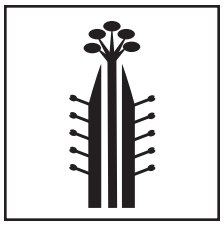
When a fruit is ready to disperse its seeds, the two valves fall away leaving the persistent **REPLUM**. Observe the *Lunaria* specimen on display - only the **REPLUMS** are left! In this case the valves have already fallen off, thereby releasing the seeds.

HABIT AND VEGETATIVE CHARACTERISTICS

- Usually annual, biennial or perennial herbs

***Arabidopsis thaliana* (L.) Heynh. (Mouseear Cress)**

Since the 1900s this herb, *A. thaliana*, has been used as a model organism by plant biologists. Aside from being easy to propagate, its small size and rapid life cycle (six weeks from germination to fruiting) make *A. thaliana* an ideal candidate for manipulative experiments. Additionally, in 2000 this species became the first plant to have its entire genome sequenced.



MALVACEAE

MALLOW FAMILY

Eudicots: Rosid Clade

$$\mathrm{A}^{\infty}$$
$$\mathrm{\female\ Ca^{(5)}\ Co^{5}\ G^{(5\text{-}\infty)}}$$

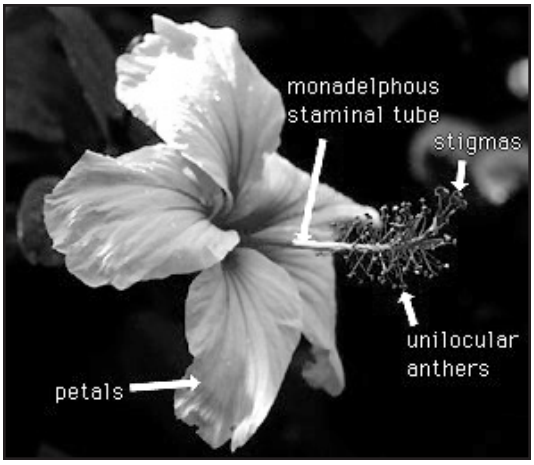


Figure 8.23 A *Hibiscus* flower with its characteristic **MONADELPHOUS** staminal tube.

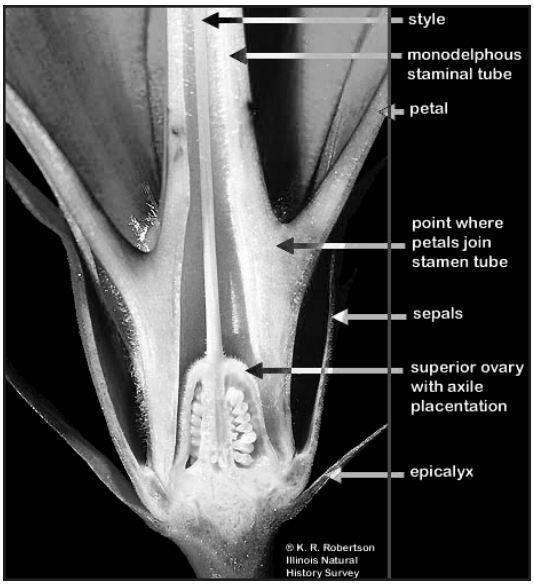


Figure 8.24 Longitudinal section of a *Hibiscus* flower. Notice the **EPICALYX** subtending the sepals.

FLORAL CHARACTERISTICS

- Sepals often subtended by bracts (**EPICALYX**)
- Petals adnate to staminal tube
- **MONADELPHOUS** stamens with unilocular and crescent-shaped anthers

***Hibiscus rosa-sinensis* L. (Rose-of-China)**

To observe the floral morphology characteristic of the Malvaceae family you will examine and dissect a *H. rosa-sinensis* flower.

1. Observe a flower (Figure 8.23). What is its symmetry?

2. **CALYX**: Distinguish between the **EPICALYX** (an involucre or whorl of bracts immediately subtending the calyx) and the connate calyx (Figure 8.24). How many sepals make up the calyx?

3. **COROLLA**: The petals are distinct and are adnate to the base of the androecium's staminal tube. Notice how the floral formula is written to account for the adnation of these two parts. How many petals are there?

4. **ANDROECIUM**: Observe the **MONADELPHOUS** (in Greek: "mon" = one and "adelphous" = brother) stamens characteristic of this family. This term refers to the connation of the filaments at their base forming a single staminal tube. At the top of the staminal tube the filaments branch off, each bearing a crescent-shaped anther.

Figure 8.25 Capsule fruit of *Iliamna remota*, commonly called Kankakee mallow.

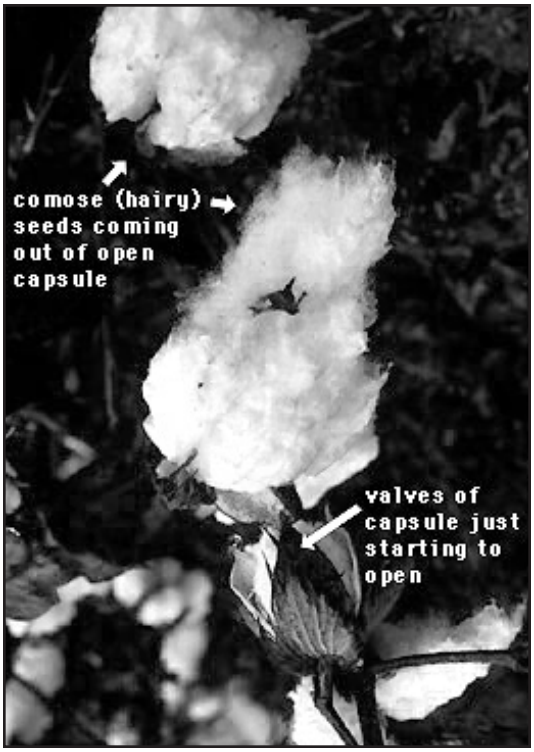


Figure 8.26 Capsule fruit of *Gossypium*, or cotton. Notice the long hairs attached to the seeds.

5. **GYNOECIUM**: How many carpels have fused to produce this syncarpous gynoecium? (Hint: Count the stigmas or upper style branches.) What is the ovary position and the placentation type?

6. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of *H. rosa-sinensis* as well as a cross section (X.S.) of its ovary, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

***Abutilon* spp. (Abutilon or Flowering Maple)**

If available, dissect one of the flowers of *Abutilon*. You will notice that unlike *H. rosa-sinensis*, there is no **EPICALYX** present and the connate carpels each contain two or more ovules.

FRUIT TYPE

- Fruits are schizocarps or capsules

***Iliamna remota* Greene (Kankakee Mallow)**
***Abutilon theophrastii* Medik. (Velvetleaf)**

The fruit type produced by both these species is a capsule, a dry dehiscent fruit type that will open to release multiple seeds (Figure 8.25).

***Gossypium* spp. (Cotton)**

Observe the dehiscing capsule fruit of *Gossypium*. The long hair on the seeds is the cotton fiber that we all know and love (Figure 8.26). What is the term used to describe the “hairiness” of the seeds?

Box 3

Figure 8.27 Marshmallows, yum!

HABIT AND VEGETATIVE CHARACTERISTICS

- Leaf and stem surfaces commonly have **STELLATE HAIRS**
- Palmately lobed or veined leaves
- Plants often contain mucilaginous sap

***Abutilon* spp. (Abutilon or Flowering Maple)**

Observe a piece of this plant's leaves under a microscope to see the **STELLATE HAIRS** on its surface. How would you describe the leaf margin and leaf venation of *Abutilon*? Sketch out a typical Malvaceae leaf, including its stellate hairs, in Box 3.

***Althaea officinalis* L. (Marsh Mallow)**

The first marshmallows were originally made during the early 19th century in France by whipping the mucilaginous sap of this plant's roots and sweetening it (Figure 8.27). By the late 19th century the mucilaginous sap in marshmallows was replaced with gelatin mixed with a modified corn starch. Yum!

ERICACEAE

HEATHER FAMILY

Eudicots: Asterid Clade

$$\text{♀}\ \frac{Ca^{5}\ Co^{\textcircled{5}}\ A^{10}\ G^{\textcircled{2-10}}}{}$$

OR

$$\text{♀}\ \frac{Ca^{5}\ Co^{\textcircled{5}}\ A^{10}}{G^{\textcircled{5}}}$$

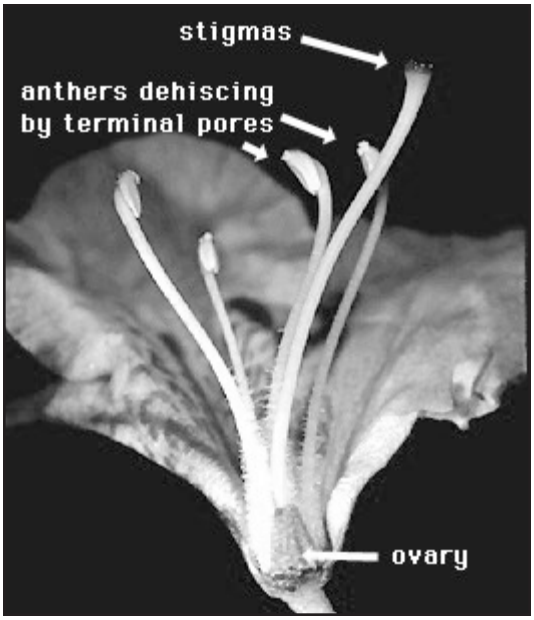


Figure 8.28 Longitudinal section of *a Rhododendron* 'PJM' flower.

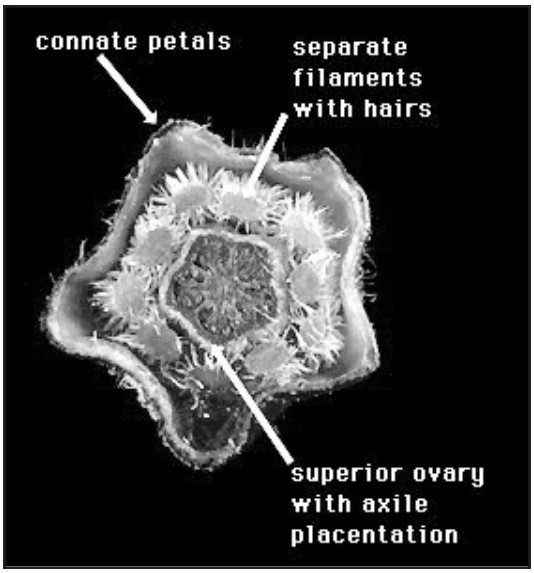


Figure 8.29 Cross section of *a Rhododendron* 'PJM' flower's base.

FLORAL CHARACTERISTICS

- Corolla often **URCEOLATE** or **CAMPANULATE**
- Anthers often **APPENDAGED** and opening by pores with pollen in tetrads
- Gynoecium exhibits axile placentation and a hollow style

***Rhododendron* spp. (Rhododendron or Azaleas)**

To observe the floral morphology characteristic of the Ericaceae family you will examine and dissect a *Rhododendron* flower.

1. Observe a flower (Figure 8.28). What is its symmetry? Is this typical in the Ericaceae family?

2. **CALYX**: How many sepals make up the calyx? Are they connate or distinct?

3. **COROLLA**: The **CAMPANULATE** shaped corolla of this flower is formed through the connation of its five petals.

4. **ANDROECIUM**: How many stamens make up the androecium? Locate and examine the pubescent, elongate filaments and the short anthers with terminal pores which are characteristic of Ericaceae species.

5. **GYNOECIUM**: *Rhododendron*'s syncarpous gynoecium is composed of 5 carpels, and, like most genera of Ericaceae, the ovary is superior. Make a cross-section (X.S.) of the ovary (Figure 8.29). What is the placentation type?

Figure 8.30 Urceolate flowers of *Pieris japonica*.

***Pieris japonica* (Thunb.) D. Don ex G. Don. (Japanese Andromeda)**

This 5-merous flower has 5 distinct sepals, an ovoid-**URCEOLATE** corolla of 5 connate petals, 10 stamens with anthers having a pair of awns near the base and a 5-locular ovary containing numerous ovules (Figure 8.30).

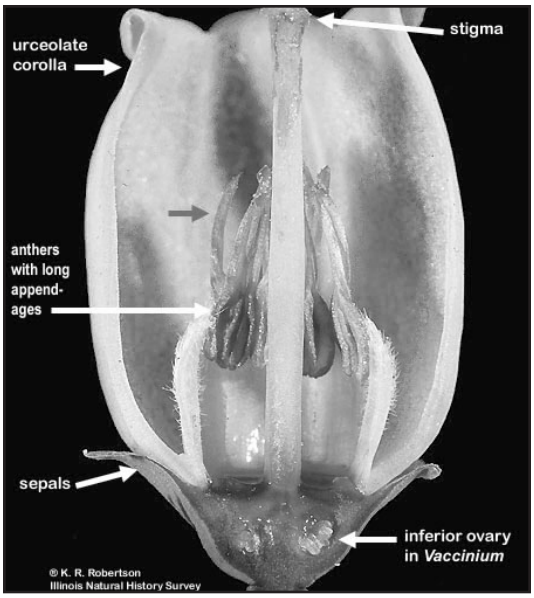


Figure 8.31 Longitudinal section of *Vaccinium corymbosum* flower.

FRUIT TYPE

- Fruit can be capsules, berries or drupes

***Vaccinium corymbosum* L. (N. Highbush Blueberry)**

The fruit produced by *V. corymbosum*, a blueberry, is also botanically considered a berry (Figures 8.31 and 8.32). Is it produced from a superior or an inferior ovary? How can you tell?

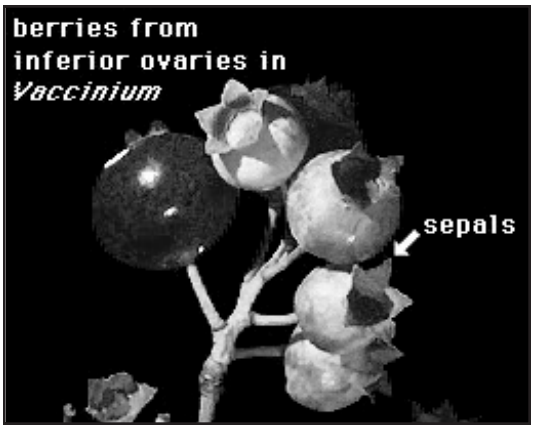


Figure 8.32 Berry fruit of *Vaccinium corymbosum*.

HABIT AND VEGETATIVE CHARACTERISTICS

- Mainly shrubs that prefer acidic soil
- Leaves simple, mostly entire and often thick, leathery and evergreen

***Kalmia angustifolia* L. (Sheep Laurel)**
***Rhododendron groenlandicum* (Oeder) Kron & Judd (Bog Labrador Tea)**

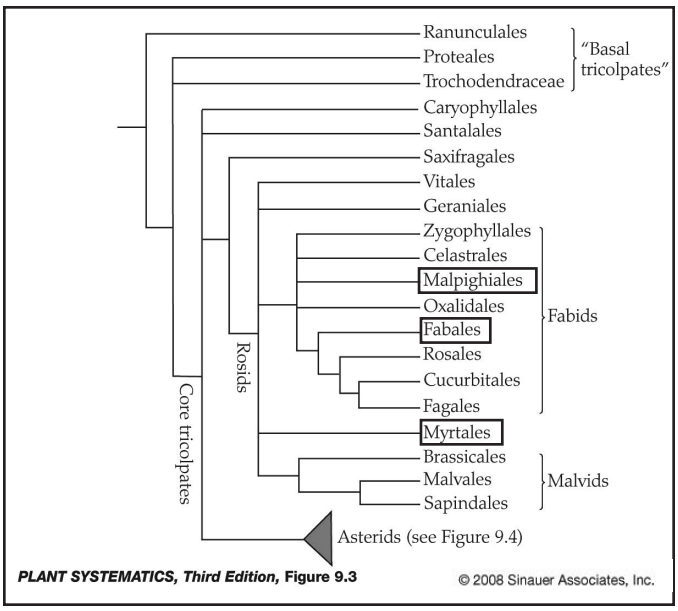
Observe the herbarium specimens on display to see the few vegetative characteristics representative of the Ericaceae family.

LABORATORY 9

FABACEAE, ONAGRACEAE AND EUPHORBIACEAE

PHYLOGENETIC RELATIONSHIPS

All of the families we will examine today belong to the Rosid clade.



***PLANT SYSTEMATICS, Third Edition,* Figure 9.3**

Fabaceae (or Leguminosae) is a member of the order Fabales in the Fabids subclade. This family is allied closely with the Rosales (e.g. Rosaceae, Moraceae), Cucurbitales (e.g. Cucurbitaceae) and Fagales (e.g. Betulaceae, Fagaceae). The monophyly of Fabales is supported by molecular data, vessel elements with single perforations, a large green embryo, and the presence of ellagic acid. Fabaceae is the third largest family in the world, with some 18,000 species. It is also of incredible economic importance, second only to the grass family (Poaceae). The Fabaceae contain beans, soybeans, lentils, peanuts, chickpeas and a host of other agricultural and ornamental species, such as alfalfa, clover, vetch, orchid tree, redbud, lupine, sensitive plant and acacia. The family is typically divided into three subfamilies (Mimosoideae, Caesalpinioideae and Faboideae), although some taxonomists, such as Cronquist, have considered these taxa as three separate families. Recent analyses have shown that the Caesalpinioideae are paraphyletic, with some members more closely related to Mimosoideae and others more closely related to Faboideae than they are to each other. The redbuds (*Cercis* spp.) may be sister to the rest of the family.

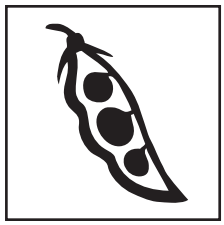
Onagraceae belongs within the order Myrtales of the Rosid clade. However, the taxonomic placement of this order is uncertain; in the phylogeny it falls outside of the Fabids and Malvids subclades. The monophyly of Onagraceae is supported by having pollen grains associated with **VISCIN THREADS**, flowers with a well-developed hypanthium, 4-merous flowers, 4 fused carpels and an inferior ovary. *Fuchsia*, *Oenothera* and *Clarkia* are ornamentals with showy flowers.

Euphorbiaceae belongs in the order Malpighiales alongside the Salicaceae and Violaceae in the Fabid clade. It is a large and extremely diverse family, with some 300 genera and over 6,000 species. Many genera produce chemicals that are medicinally as well as industrially important, such as *Hevea brasiliensis* (rubber plant) and *Ricinus communis* (caster oil). Some other members are eaten (e.g. *Manihot esculenta* (cassava)). The family also occupies a wide range of habitats, from wet tropical rain forests to desert environments where species have evolved a remarkable resemblance to the Cactaceae. Within the Euphorbiaceae is the large tribe Euphorbieae (containing the genus *Euphorbia*, or poinsettia), which is monophyletic on the basis of their inflorescence type (**CYATHIUM**, pl. **CYATHIA**).

FABACEAE (LEGUMINOSAE)

LEGUME FAMILY

Eudicots: Rosid Clade



♂ ♀ $\underline{Ca^5\ Co^5\ A^{5-\infty}\ G^1}$

Figure 9.1 Legumes of *Phaseolus vulgaris*.

THREE SUBFAMILIES

- **MIMOSOIDEAE**
- **CAESALPINIOIDEAE**
- **FABOIDEAE**

Fabaceae is divided into three distinct subfamilies. The subfamilies can be differentiated based on floral and vegetative characteristics.

FLORAL CHARACTERISTICS

- Perfect flowers
- Single, superior carpel with marginal placentation

Though all members of Fabaceae have perfect flowers containing a single, superior carpel with marginal placentation, the 3 subfamilies differ in their floral symmetry, corolla arrangement and androecia.

Subfamily	Floral Formula	Floral Symmetry	Corolla Arrangement	Androecium
MIMOSOIDEAE (Mimosa Subfamily)	♂ ♀ $\underline{Ca^{⑤}\ Co^{⑤}\ A^{\overset{\frown}{10\text{-}\infty}}\ G^1}$	Actinomorphic	Petals connate and forming a tube	- 10 or more stamens, and forming a tube - Pollen in **POLLINIA**
CAESALPINIOIDEAE (Caesalpinia Subfamily)	♂ ♀ $\underline{Ca^5\ CoZ^5\ A^{10}\ G^1}$	Zygomorphic	**BANNER** petal *internal* to lateral petals	- 10 (or fewer) stamens - Anthers often opening by pores
FABOIDEAE (Bean / Pea Subfamily)	♂ ♀ $\underline{Ca^{\overset{\frown}{5}}CoZ^5\ A^{\overset{\frown}{9}+1\text{ or }10}\ G^1}$	Zygomorphic	**BANNER** petal *outermost*, 2 distinct lateral **WING** petals, and 2 petals fused to form the **KEEL**	10 stamens either... - **DIADELPHOUS** - **MONADELPHOUS** - Distinct

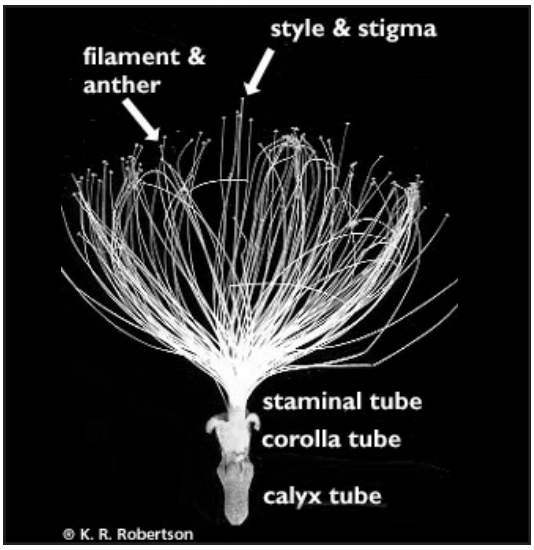


Figure 9.2 An *Inga* flower.

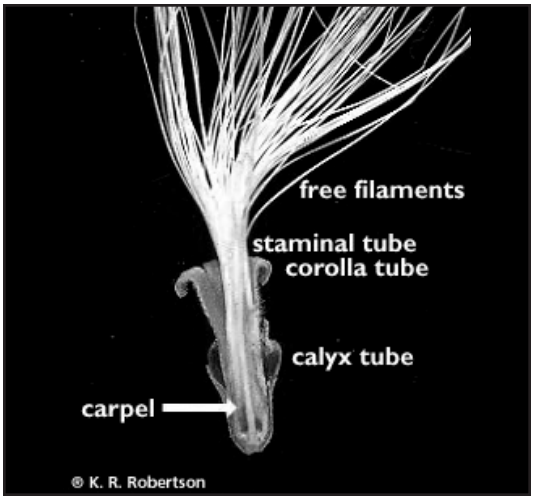


Figure 9.3 A longitudinal section of an *Inga* flower.

Box 1

MIMOSOIDEAE

***Calliandra* spp. (Powderpuff Tree)**

The name of this genus is from the Greek, “kalos” (beautiful) and “andros” (stamens), referring to its conspicuous thin, red stamens. The key to remembering this subfamily is the phrase, “**TUBE IN A TUBE IN A TUBE**”, referring to the connation of the sepals, the petals and (at least the base of) the stamens (Figure 9.2).

1. Observe a flower. What is its symmetry?

2. **CALYX**: Notice that the sepals are fused into a tube, or connate. How many are present?

3. **COROLLA**: The petals are also connate forming a tube. How many are there?

4. **ANDROECIUM**: These flowers contain 10 to many stamens that are fused at the base, but have distinct filaments (Figure 9.3). As mentioned above, the genus and common name of these flowers refer to the long, thin stamens that project far above the corolla tube.

5. **GYNOECIUM**: Examine the monocarpous gynoecium. Now sketch out a longitudinal section of the flower in Box 1.

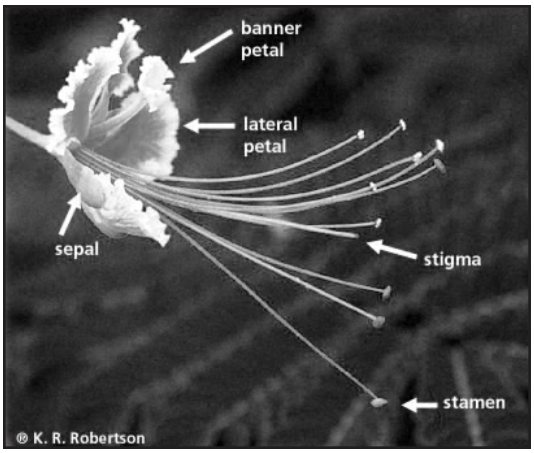


Figure 9.4 A *Caesalpinia pulcherrima* flower.

Box 2

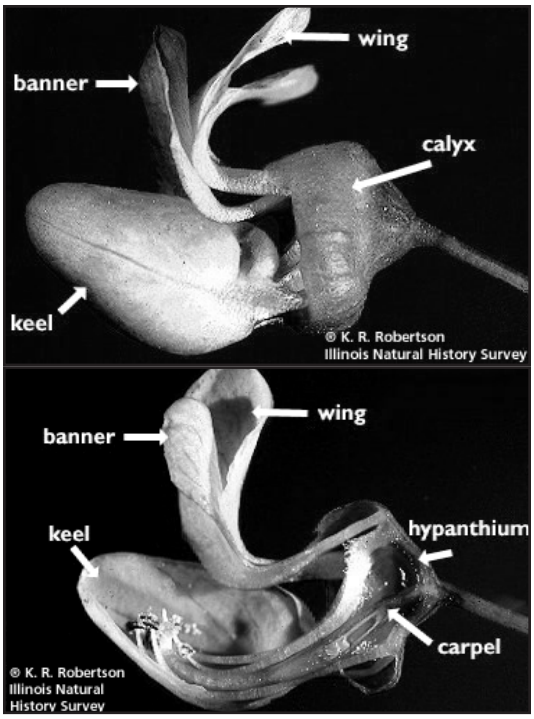


Figure 9.5 *Cercis canadensis*: a flower (top) and a longitudinal section of a flower (bottom).

CAESALPINIOIDEAE

***Caesalpinia pulcherrima* (L.) Sw. (Pride-of-Barbados)**

To observe the floral morphology characteristic of the Fabaceae subfamily Caesalpinioideae, you will examine and dissect a *C. pulcherrima* flower. The genus *Caesalpinia* was named for Andreas Caesalpini (1519 - 1603), an Italian botanist and physician.

1. Observe a flower (Figure 9.4). What is its symmetry?

2. **CALYX**: How many sepals are present? Do you detect any adnation or connation?

3. **COROLLA**: Observe the five petals in this flower. There are 2 lateral petals (the wings), a **BANNER** petal that is internal to the lateral petals, and two lower petals that are distinct from one another. The position of the **BANNER** petal is critical!

4. **ANDROECIUM**: How many stamens make up the androecium in this flower? The anthers in Fabaceae subfamily Caesalpiniodeae often open by pores to release pollen.

5. **GYNOECIUM**: Examine the single carpel with its superior ovary. What is the gynoecium type and insertion type found in this flower? Sketch out a longitudinal section of the flower in Box 2.

***Cercis canadensis* L. (Eastern Redbud)**

These trees bloom very early in the spring prior to their leaves flushing out. What is the position of the inflorescences based on the photo/material provided?

Though the species belongs to Caesalpinioideae, *C. canadensis* flowers have connate sepals (not shown in the floral formula for the subfamily) and “pea-like” or Faboideae subfamily-like petals (i.e. 2 **WING** petals, 2 **KEEL** petals and 1 **BANNER** petal which is inside the other petals) (Figure 9.5).

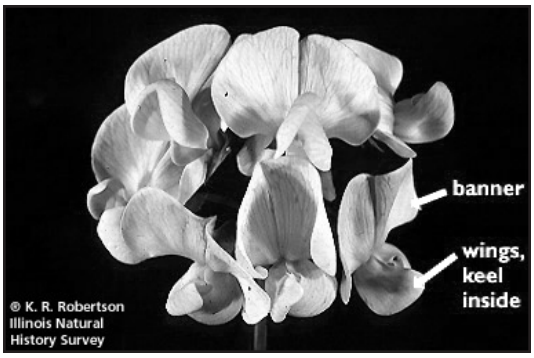


Figure 9.6 Flowers of *Lathyrus latifolius.*

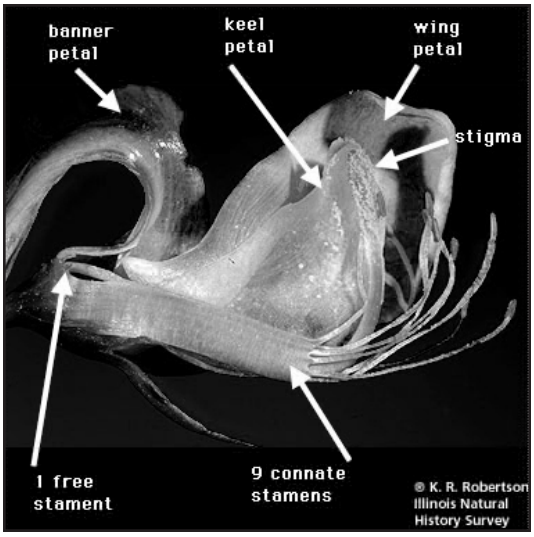


Figure 9.7 Longitudinal section of a *Lathyrus latifolius* flower. Notice the 9 connate stamens and 1 distinct stamen.

Box 3

FABOIDEAE

***Lathyrus odoratus* L. (Sweetpea)**

To observe the floral morphology characteristic of the Fabaceae subfamily Faboideae you will examine and dissect a *L. odoratus* flower. The genus name *Lathyrus* is from the Greek meaning “pea”.

1. Observe a flower (Figure 9.6). What is its symmetry?

2. **CALYX**: How many sepals are present? Do you detect any adnation or connation?

3. **COROLLA**: Observe the five petals in this flower. There are 2 lateral petals (the **WINGS**), a **BANNER** petal that is outermost to the lateral petals, and 2 lower petals that are fused to form the **KEEL**.

4. **ANDROECIUM**: There are 10 stamens in this flower, 9 of which are connate and 1 is distinct (Figure 9.7). What term can be used to describe them?

5. **GYNOECIUM**: Examine the carpel of this monocarpous gynoecium. What is the ovary position? Sketch out a longitudinal section of the flower in Box 3.

Figure 9.8 Legumes of *Gymnocladus dioicus*.

Figure 9.9 Legumes of *Glycine max*.

Box 4

FRUIT TYPE

- Fruit is a **LEGUME**

There is enormous variation in the morphology of the Fabaceae's **LEGUME** fruits. Observe the **LEGUMES** produced by species in the 3 subfamilies: Mimosoideae, Caesalpinioideae and Faboideae.

Examples
MIMOSOIDEAE
Albizia julibrissin Durazz. (Mimosa Tree)
CAESALPINIOIDEAE
Cercis canadensis L. (Eastern Redbud) *Gleditsia triacanthos* L. (Honey Locust) *Gymnocladus dioicus* (L.) K. Koch (Kentucky Coffeetree)
FABOIDEAE
Baptisia alba (L.) Vent. var. *macrophylla* (Larisey) Isely (Largeleaf Wild Indigo) *Desmodium illinoense* A. Gray (Illinois Ticktrefoil) *Glycine max* (L.) Merr. (Soybean) *Phaseolus vulgaris* L. (Common Bean) *Pisum sativum* var. *saccharatum* L. (Snow Pea)

***Phaseolus vulgaris* L. (Common Bean)**
***Pisum sativum* var. *saccharatum* L. (Snow Pea)**

Based on what you see in these examples, what was the gynoecium type and the placentation type of the original flower? How many sutures does a mature **LEGUME** dehisce along?

Dissect a bean or snow pea and sketch it in Box 4. Label all of the fruit or remnant flower structures listed in the table below.

Flower Part	Fruit Part
Pedicel	---
Sepals	---
Ovary wall	Pericarp
Ovule	Seed

Figure 9.10 The seeds of many legumes are beans!

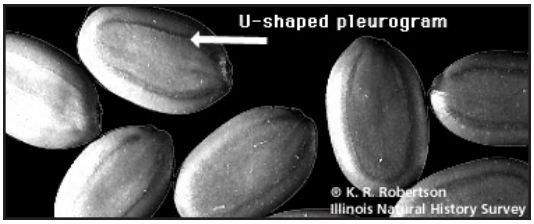


Figure 9.11 U-shaped pleurogram of *Albizia julibrissin*.

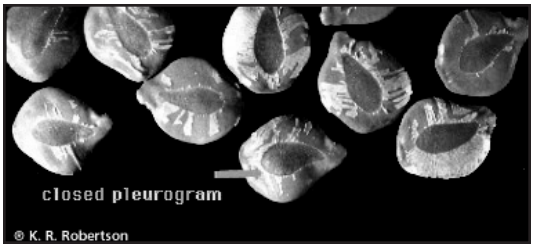


Figure 9.12 O-shaped, or closed, pleurogram of a caesalpinoid legume.

Figure 9.13 Pinnately compound leaves of *Mimosa pudica*.

LEGUME: *Cercis canadensis* L. (Fabaceae)
FOLLICLE: *Aquilegia canadensis* L. (Ranunculaceae)
SILIQUE: *Hesperis matronalis* L. (Brassicaceae)

What are the major differences among **LEGUMES**, **FOLLICLES** and **SILIQUES**? (HINT: Think about the original gynoecium type and the number of sutures the fruit has.)

SEED MORPHOLOGY

- Seeds lack an endosperm

Check out the seeds from the three Fabaceae subfamilies. Make sure that you can tell if there is a **PLEUROGRAM** and, if there is, describe its shape (Figures 9.11 and 9.12).

Examples
MIMOSOIDEAE: U-shaped groove *Albizia julibrissin* Durazz. (Mimosa Tree)
CAESALPINIOIDEAE: O-shaped groove *Gleditsia triacanthos* L. (Honey Locust)
FABOIDEAE: No **PLEUROGRAM** *Phaseolus vulgaris* L. (Common Bean)

HABIT AND VEGETATIVE CHARACTERISTICS

- Most species have root nodules containing nitrogen-fixing bacteria

Examine the vegetative characters displayed by members of the three Fabaceae subfamilies (Figure 9.13). Make sure that you can identify a **PULVINUS** (a cushion-like swelling at the base of a leaf or leaflet stalk) and determine leaf complexity (i.e. pinnately compound, bipinnately compound or palmately compound).

Subfamily	Habit	Leaf Complexity	PULVINUS	Examples
MIMOSOIDEAE	Mostly tropical and subtropical trees	Bipinnately compound	Present	*Albizia julibrissin* Durazz. (Mimosa Tree) *Mimosa pudica* L. (Sensitive Plant)
CAESALPINIOIDEAE	Mostly tropical and subtropical trees	Pinnately or bipinnately compound	Absent	*Chamaecrista fasciculata* (Michx.) Greene *Gleditsia triacanthos* L. (Honey Locust)
FABOIDEAE	Mostly herbs, some trees and shrubs	Usually pinnately compound, sometimes palmately compound	Absent	*Amorpha canescens* Pursh (Leadplant) *Lupinus* spp. (Lupine) *Phaseolus* spp. (Beans) *Trifolium pretense* L. (Red Clover)

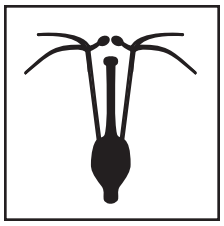
Figure 9.14 Pinnately compound leaves of *Mimosa pudica* displaying a **PULVINUS**.

***Mimosa pudica* L. (Sensitive Plant)**

Touch a leaflet of the sensitive plant! The species name, "pudica" is very appropriate for this plant in that it means bashful. Touching the leaves of *M. pudica* stimulates it to release chemicals, thereby causing the redistribution of water in the cells. The unequal distribution of water is what allows the leaves to fold up (Figure 9.14). This mechanism is speculated to be a defense against herbivory. Also, take a minute to examine the **PULVINUS** of *M. pudica* leaves.

Complexity _____

Attachment _____



ONAGRACEAE

EVENING PRIMROSE FAMILY

Eudicots Rosid Clade

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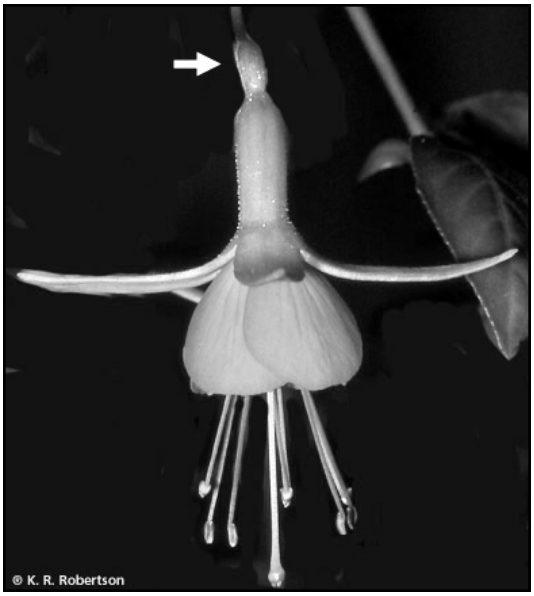


Figure 9.15 Flower of a cultivated *Fuchsia*.

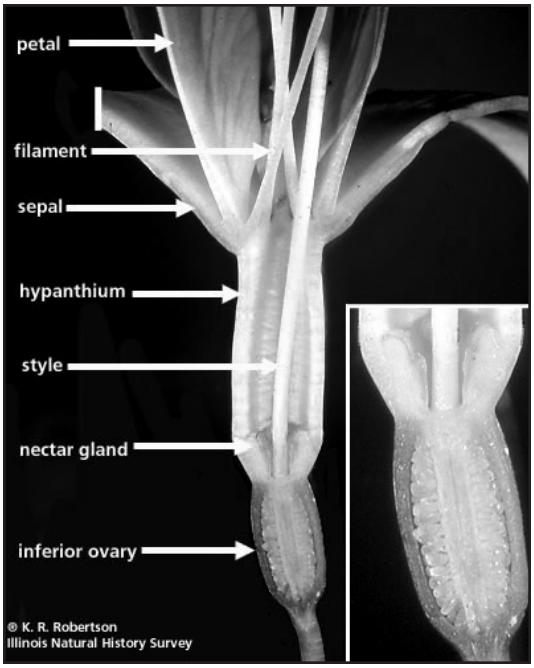


Figure 9.16 Longitudinal section of a *Fuchsia* flower.

INFLORESCENCE TYPE

***Gaura mollis* James (Velvetweed)**
***Oenothera biennis* L. (Common Evening Primrose)**

Examine the herbarium specimens provided. What is the inflorescence type of each?

FLORAL CHARACTERISTICS

- 4-merous flowers with a **HYPANTHIUM** and an inferior ovary
- Pollen sometimes with **VISCIN THREADS**

***Fuchsia triphylla* L. (Fuchsia)**

To observe the floral morphology characteristic of the Onagraceae family, you will examine and dissect a *F. triphylla* flower.

1. Observe the flowers (Figure 9.15). What symmetry type do they display?

2. **CALYX**, **COROLLA** and **ANDROECIUM**: How many sepals, petals and stamens are present in this flower? The adnation of these three floral series forms what structure (Figure 9.16)?

3. **GYNOECIUM**: How many carpels make up the gynoecium in this flower? Are they connate or distinct? Is the ovary position superior or inferior? What is the insertion type?

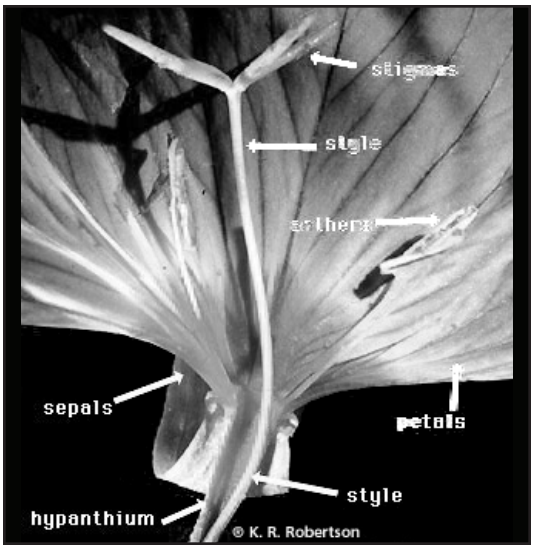


Figure 9.17 Longitudinal section of an *Oenothera speciosa* flower.

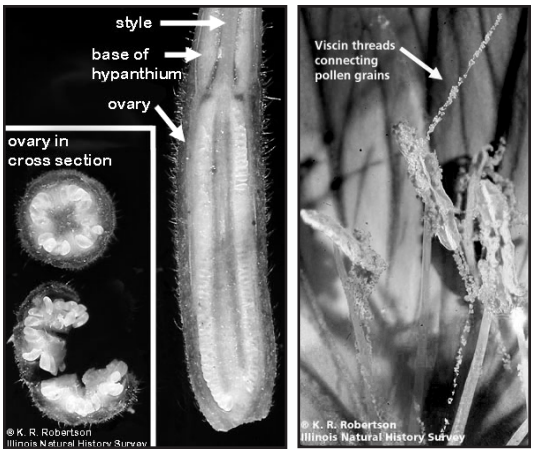


Figure 9.18 *Oenothera* flower characteristics.

Figure 9.19 Fruit produced by *Oenothera biennis*.

4. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of *F. triphylla*, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

FRUIT TYPE

- Fruit is a capsule or berry

***Oenothera speciosa* Nutt. (Pinkladies)**

Like *Fuchsia triphylla*, *Oenothera speciosa* has a **HYPANTHIUM** (floral cup) (Figure 9.17). Characteristic of Onagraceae, this species also has **VISCIN THREADS** connecting its pollen grains (Figure 9.18).

Examine the *Oenothera* fruit on display (Figure 9.19). What is the fruit type (be specific)? What type of gynoecium is required to produce this fruit type?

HABIT AND VEGETATIVE CHARACTERISTICS

- Herbs or shrubs
- No stipules

***Clarkia* spp. (Clarkia)**

The genus *Clarkia* has more than 30 species ranging from western North America to northern South America. The genus is named for William Clark (1770-1838), the co-leader of the Lewis and Clark expedition. Notice the herbaceous habit of the plant.

EUPHORBIACEAE

SPURGE FAMILY

Eudicots: Rosid Clade

♂ $Ca^0\ Co^0\ A^1\ G^0$

♀ $Ca^0\ Co^0\ A^0\ G^{\textcircled{3}}$

Figure 9.20 Three *Euphorbia cotonifolia* cyathia at different stages of female flower maturity.

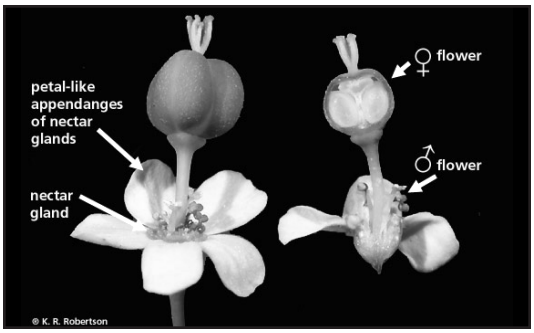


Figure 9.21 *Euphorbia corollata* **CYATHIA**.

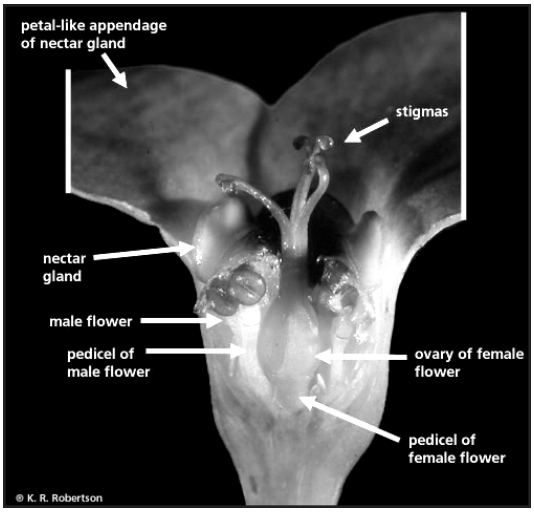


Figure 9.22 Longitudinal section of an *Euphorbia milii* **CYATHIUM**.

FLORAL CHARACTERISTICS

- Imperfect flowers
- Typically has a **CYATHIUM** inflorescence with nectar glands and petal-like appendages
- 3 connate carpels make up the syncarpous gynoecium
- Superior ovary is 3-locular with 1 apical ovule per locule

There are two types of flowers in the Euphorbiaceae family: the "Euphorbia" type (restricted to the genus *Euphorbia*) and the "Normal" type (like *Jatropha* species). In this class we will focus on the "Euphorbia" type flowers. Within the entire family though, flowers are imperfect and the plants are monoecious or dioecious. What is the difference between the monoecious and dioecious plant condition?

***Euphorbia cotinifolia* L. (Mexican Shrubby Spurge)**
***Euphorbia corollata* L. (Flowering Spurge)**
***Euphorbia millii* Desmoul. (Crown-of-Thorns)**
***Euphorbia fulgens* Karw. (Scarlet-Plume)**

In the *Euphorbia* genus the flowers are highly reduced and what you see is not a "flower", but actually a specialized inflorescence called a **CYATHIUM** (pl. **CYATHIA**; Figures 9.20 and 9.21). The petal-like structures (appendages) are actually glands that secrete nectar. Embedded within the cup-like **CYATHIUM** are the staminate flowers which are each reduced to a single stamen (Figure 9.22). The single carpellate flower arises from the center of the cyathium on a stalk and is comprised of three carpels, each with one ovule. The perianth parts are absent. Think of a **CYATHIUM** as a highly reduced cymose inflorescence with associated bracts.

DRAWING PORTFOLIO: Draw a floral diagram of an *E. fulgens* **CYATHIUM**, making sure to include the floral formula for the carpellate and staminate flowers. Follow the format as instructed in Lab 3: Floral Terminology.

Figure 9.23 Schizocarp fruits of *Euphorbia corollata*.

FRUIT TYPE

- Fruit is a **SCHIZOCARP** splitting into **MERICARPS**

***Euphorbia corollata* L. (Flowering Spurge)**

With what you know about the gynoecium of *Euphorbia* female flowers, how many **MERICARPS** do you think the **SCHIZOCARP** of this species will split into (Figure 9.23)?

Figure 9.24 Vegetative features and **CYATHIA** of *Euphorbia millii.*

HABIT AND VEGETATIVE CHARACTERISTICS

- Succulent plants often with milky sap

***Euphorbia millii* Desmoul. (Crown-of-Thorns)**

According to legend, *E. millii* was the species that was used to make the crown of thorns worn by Jesus during the Crucifixion, hence its common name (Figure 9.24). Examine the plant's succulent leaves and the slender **SPINES** that cover its stem. Now take a minute to review your vegetative terminology by filling in the blanks below.

Complexity _____

Attachment _____

Blade shape _____

Leaf apex _____

Leaf margin _____

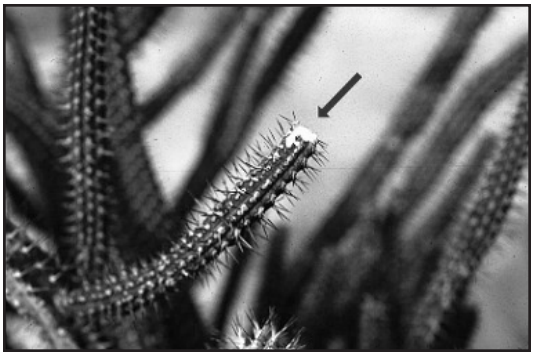


Figure 9.25 Milky sap is common in Euphorbiaceae succulents.

***Euphorbia* spp.**

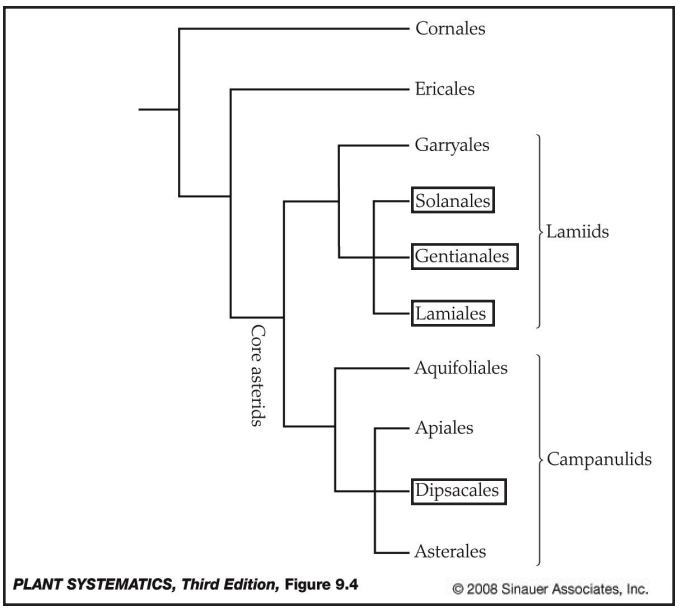
Notice how these *Euphorbia* species resemble members of the Cactaceae family with their succulent stems (Figure 9.25). What feature do they have though that Cactaceae species do not?

LABORATORY 10

ASCLEPIADACEAE, SOLANACEAE, OLEACEAE AND CAPRIFOLIACEAE

PHYLOGENETIC RELATIONSHIPS

All of the families we will examine today belong to the Asterid clade.



***PLANT SYSTEMATICS, Third Edition,* Figure 9.4**

The Asterid clade is a large and specialized subgroup of the angiosperm eudicot (tricolpate) clade. It is hypothesized to be monophyletic on the basis of molecular evidence, as well as on the shared presence of ovules having only a single integument and a thin-walled megasporangium. The "Core Asterid" clade is supported as monophyletic on the basis of the number of stamens equaling the number of petals, epipetalous stamens, an obviously sympetalous corolla, and molecular data. This group approximates the subclass Asteridae of Cronquist.

The family Apocynaceae, as circumscribed on the basis of cladistic analyses of both morphological and molecular data, is paraphyletic. The family Asclepiadaceae (treated as subfamily Asclepiadoideae) arises from within Apocynaceae. In this class, for the sake of convenience only, we will continue to treat the milkweeds in their own family, Asclepiadaceae. This family is placed in the order Gentianales of the Lamiids subclade.

Solanaceae and Oleaceae belong to the orders Solanales and Lamiales, respectively, also in the Lamiids subclade.

Caprifoliaceae (and Adoxaceae) are members of the order Dipsacales, of the Campanulids subclade. Traditionally these families were combined as one (Caprifoliaceae), but recent analyses treat them as sister families. Caprifoliaceae is characterized by opposite leaves, a zygomorphic corolla (with epipetalous stamens), and an inferior ovary. The showy flowers of Caprifoliaceae are pollinated by various nectar-gathering insects (primarily bees and wasps) and birds.

ASCLEPIADACEAE

MILKWEED FAMILY

Eudicots: Asterid Clade

$$\varphi \; \frac{\mathbf{A}^{(5)}}{\mathbf{Ca}^{(5)}\,\mathbf{Co}^{(5)}\,\underset{\frown}{\mathbf{G}^{(2)}}}$$

Figure 10.1 An umbel inflorescence of *Asclepias curassavica*.

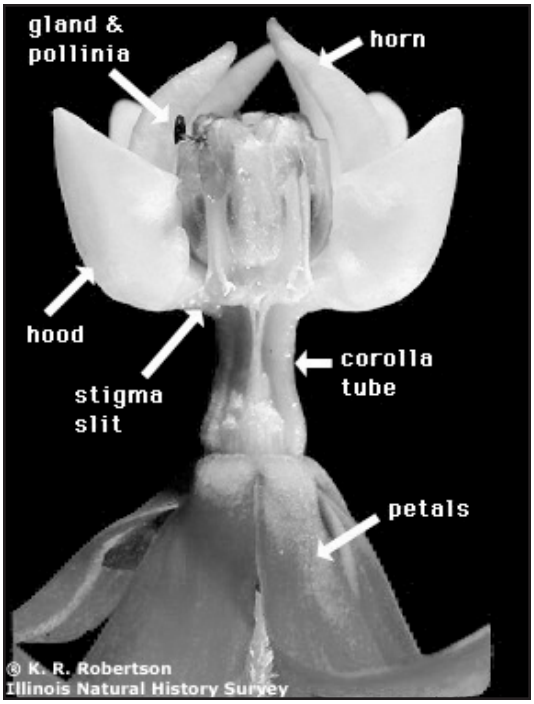


Figure 10.2 Close-up of an *Asclepias curassavica* flower.

FLORAL CHARACTERISTICS

- Petals often a **CORONA** (consisting of a **HORN** & **HOOD**)
- Filaments, anthers and stigma fused into a **GYNOSTEGIUM**
- Pollen in pollinia and pollinia of adjacent anther sacs connected by **TRANSLATOR ARMS** with gland or **CORPUSCULUM**
- Carpels connate above and distinct below

***Asclepias curassavica* L. (Bloodflower)**

To observe the floral morphology characteristic of Asclepiadaceae, you will examine and dissect an *Asclepias curassavica* flower. Make sure to look at the provided diagrams and read through the verbal description of the floral parts that follow to understand the morphology of this complicated flower.

1. Observe a flower. What is its symmetry?

1. **CALYX**: The green calyx is hidden under the reflexed corolla (it's easier to see the calyx on an unopened flower). Are the sepals fused? (Typically they are in the family, but in this species they are not.)

2. **COROLLA**: Arising from the red corolla is a yellow **CORONA** (Figure 10.2). This **CORONA** consists of a petaloid **HOOD** and a **HORN** (also called the **BEAK**). The beak is exserted from the **HOOD** (meaning it sticks out) and at its base (that is, within the **HOOD**) are nectaries. The lower, inner part of the **CORONA** is attached to the **GYNOSTEGIUM**.

3. **ANDROECIUM** and **GYNOECIUM**: Between each **CORONA** element (**HORN** + **HOOD**) is a longitudinal slit called the stigmatic slit. At the top of the slit is a dark brown structure called a gland or **CORPUSCULUM**. At the base of the slit is the receptive portion of the stigma (you can't see this). If you take a sharp probe or needle and have a steady hand, you can run your probe up the slit to the base of the gland. This gland

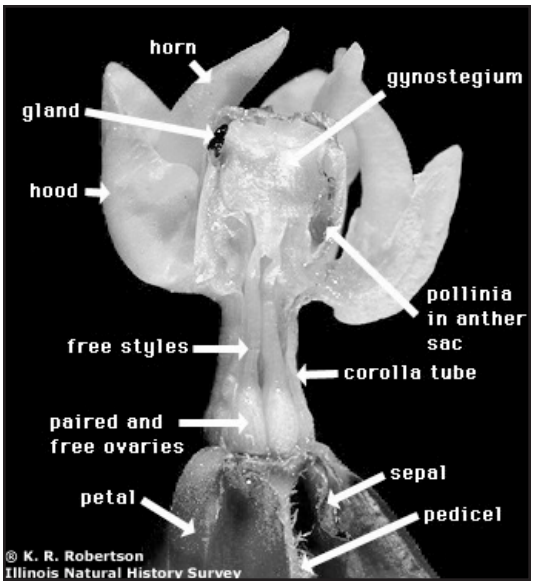


Figure 10.3 Longitudinal section of an *Asclepias curassavica* flower.

is connected to two **TRANSLATOR ARMS** which in turn each connect to a pollen sac called a **POLLINIUM** (pl. **POLLINIA**). If you lift the gland up and away from the flower, you can pull out the two pollinia. Each of these pollinia actually belong to adjacent anthers as the anthers are positioned opposite the **CORONA** elements and are alternate with the petals. The pollen within each **POLLINIUM** is united into a large, waxy mass. The two carpels have fused to produce the gynoecium in this flower and they are united at their summit into a large stigmatic head. The anthers are united, and thus adnate to the stigmatic head. The large region in the center of the flower (formed from the fusion of the stigma to the anthers) is called the **GYNOSTEGIUM**. Make a longitudinal cut through the flower and locate the two ovaries (Figure 10.3). Within each ovary are marginal ovules.

4. Label all the parts of the *Asclepias* flower on the line drawing in Figure 10.4, using the live specimen and the photographs provided.

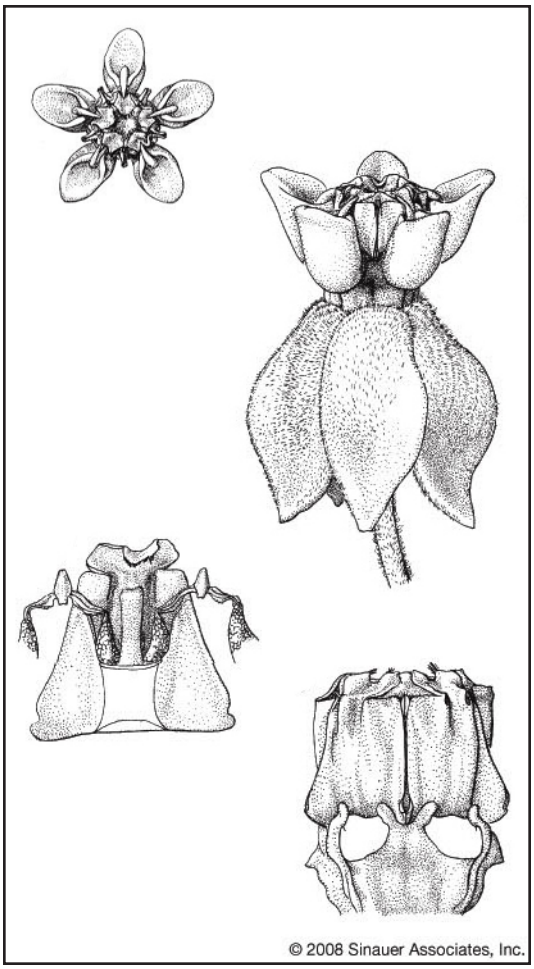


Figure 10.4 Diagram of an *Asclepias* flower.

***Stapelia* spp. (Carrion Flowers)**

Check out the photos of these unique plants. As their common name suggests, the flower blossoms smell like rotting meat to attract their major pollinators, flies.

POLLINATION MECHANISM

Asclepiadaceae species have evolved a unique mechanism for pollination. Because the apex of the **GYNOSTEGIUM** is polished and slippery, an insect's leg will tend to slide off it and into the **STIGMATIC SLIT** between two adjacent anthers. When the leg is pulled back up it may be caught by the wishbone-shaped translators and **CORPUSCULUM**. If the insect is strong, such as a bumblebee, the pollinia are pulled free from the anthers but remain attached to the insect's leg as it flies to another flower. (Weaker insects may be unable to loosen the pollinia and are held so firmly that they die on the flower.) At one of the subsequent flowers that is visited, the leg will again slip off the top of the **GYNOSTEGIUM** and down into the **STIGMATIC SLIT**. But this time, as the leg is pulled back there is the possibility that part or all of one pollinium may become lodged in the slit and break loose from the insect's foot. With the pollinium now lodged in the groove of a different flower, it is adjacent to the receptive area of the stigma and cross-pollination is achieved. Fertilization will follow after the pollen grains in the waxy mass germinate and their pollen tubes grow through the stigma, down the styles, into the ovaries, into the ovules and enter into the embryo sac. And voila, more milkweeds!

Figure 10.5 An *Asclepias syriaca* flower with follicles.

Figure 10.6 Dehiscing follicles of *Asclepias syriaca*.

Figure 10.7 *Asclepias sullivantii* plant with milky sap.

FRUIT TYPE

- Fruit is a follicle containing seeds with **COMA** of hairs

***Asclepias incarnata* L. (Swamp Milkweed)**
***Asclepias syriaca* L. (Common Milkweed)**

Observe the milkweed fruits (follicles) provided (Figure 10.5). What are the key characteristics of the follicle fruit type? Based on the tufts of hair (**COMA**) on the seeds, what is the seed dispersal mechanism (Figure 10.6)?

HABIT AND VEGETATIVE CHARACTERISTICS

- Plants contain milky sap
- Leaves are simple with entire margin and opposite arrangement

***Asclepias sullivantii* Engelm. ex A. Gray (Prairie Milkweed)**
***Asclepias tuberosa* L. (Butterfly Milkweed)**

Check out the provided herbarium specimens for these two *Asclepias* species. Both species contain milky sap and can be found in higher quality prairie remnants around Illinois (Figure 10.7). What type of leaf arrangement do they have? Also, how would you describe the leaf attachment for each specimen?

***Asclepias verticillata* L. (Whorled Milkweed)**

Unlike many other species of milkweed, the leaves of *A. verticillata* are very slender and display a whorled arrangement; hence the species name ‘verticillata’ or ‘having whorls’.

SOLANACEAE

POTATO FAMILY

Eudicots: Asterid Clade

$$\mathbf{A^5}$$
$$\mathbf{\varnothing\ Ca^{(5)}\ Co^{(5)}\ G^{(2)}}$$

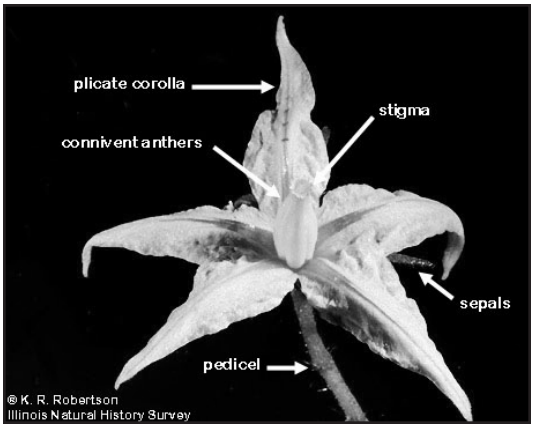


Figure 10.8 Close up of a *Solanum lycopersicum*, or tomato, flower.

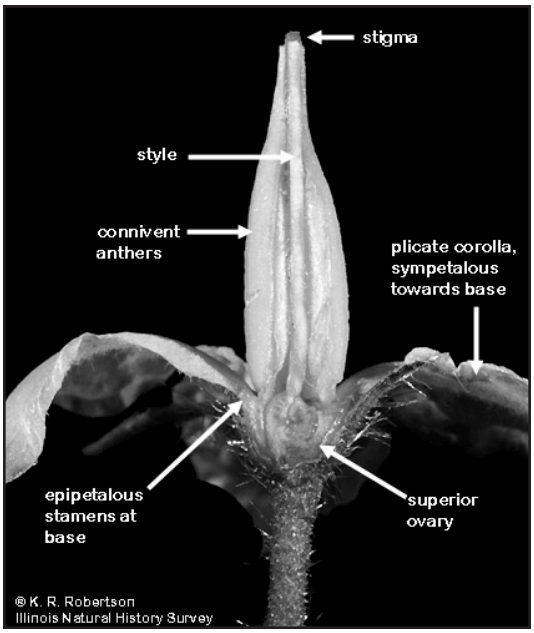


Figure 10.9 Longitudinal section of a *Solanum lycopersicum* flower. Notice the **PLICATE** corolla and the stamen's **CONNIVENT** anthers.

FLORAL CHARACTERISTICS

- Have **PLICATE** (folded) corolla
- Anthers often **CONNIVENT**

***Solanum lycopersicum* L. (Garden Tomato)**

To observe the floral morphology characteristic of Solanaceae, examine and dissect a *S. lycopersicum* flower.

1. Examine a flower (Figure 10.8). What is its symmetry?

2. **CALYX**: How many sepals make up the calyx? Are they distinct or connate?

3. **COROLLA**: How many petals make up the flower's **PLICATE COROLLA** (folded, connate petals)?

4. **ANDROECIUM**: Examine the epipetalous stamens with their short filaments and elongate, tapering anthers that terminate in a sterile tip. These **CONNIVENT** anthers are just stuck together, not truly connate (Figure 10.9). Although the anthers dehisce by longitudinal slits, the pollen is released towards the inside of the "tube". How does it escape the flower?

5. **GYNOECIUM**: The ovaries of Solanaceae flowers are bicarpellate and often bilocular, although in many cultivated varieties of tomato often more than 2 locules exist. Numerous ovules should be apparent on axile placentae within the ovary.

6. **DRAWING PORTFOLIO:** Draw a floral diagram of a

Box 1

Figure 10.10 The poisonous fruits of *Solanum dulcamara*, or bittersweet nightshade.

Figure 10.11 A capsule fruit of *Datura stramonium*.

longitudinal section (L.S.) of *S. lycopersicum*, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

FRUIT TYPE

- Fruit is a berry or capsule

***Capsicum annuum* L. (Bell Pepper)**
***Solanum lycopersicum* L. (Garden Tomato)**
***Physalis philadelphica* Lam. (Tomatillo)**
***Solanum melongena* L. (Eggplant)**

Examine each of the edible berry fruits provided and locate their persistent sepals. Do these berries develop from a superior or an inferior ovary and how can you tell? Sketch out a cross section of a tomato in Box 1 and label the placentation type.

***Solanum dulcamara* L. (Climbing or Bittersweet Nightshade)**

This species of *Solanum* produces poisonous berry fruits, though generally toxicity is highest in unripe berries (Figure 10.10). Incidences of poisoning in livestock, however, are low due to the unpleasant odor that the plant gives off.

***Datura stramonium* L. (Datura)**

Datura plants are also extremely poisonous (Figure 10.11). Their fruit is a 2-carpellate, 4-locular, spiny capsule that opens by 4 apical valves. Based on this information, what type of gynoecium does this fruit arise from?

HABIT AND VEGETATIVE CHARACTERISTICS

- Habit of plants is mostly herbaceous
- Leaves have alternate arrangement

***Solanum tuberosum* L. (Potato)**

Potatoes are actually a type of stem. What stem type are they?

OLEACEAE

OLIVE FAMILY

Eudicots: Asterid Clade

$$\frac{A^2}{\female\ Ca^{(4)}\ Co^{(4)}\ G^{(2)}}$$

Figure 10.12 A branch of *Forsythia* flowers.

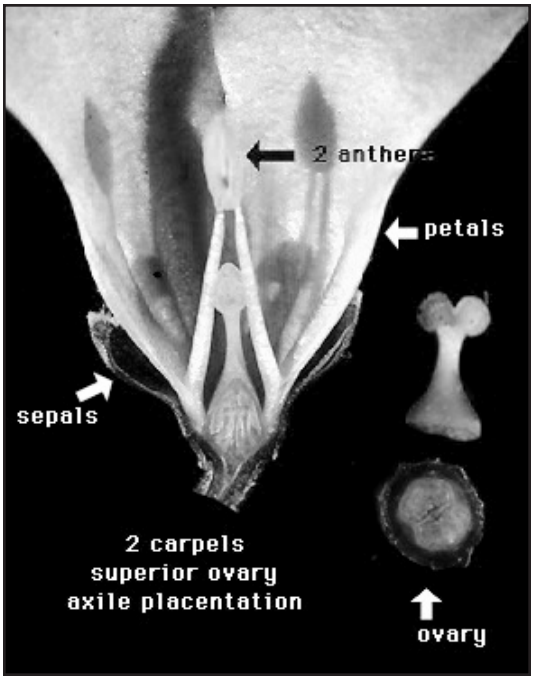


Figure 10.13 Longitudinal section of a *Forsythia* flower.

FLORAL CHARACTERISTICS

- 4-merous flowers
- 2 stamens in Androecium
- 2-locular with two axile ovules in each locule (except 4-10 in *Forsythia*)

***Forsythia* spp. (Showy Forsythia)**

To observe the floral morphology characteristic of Oleaceae, you will examine a *Forsythia* flower.

1. Examine a flower (Figure 10.12). How would you describe its floral symmetry?

2. **CALYX**: The calyx is deeply 4-lobed, made up of 4 connate sepals.

3. **COROLLA**: The corolla is made up of 4 connate petals. What other term can be used to describe connate petals?

4. **ANDROECIUM**: Observe the 2 **EPIPETALOUS** stamens in the androecium (Figure 10.13). Few plant families only have 2 stamens!

5. **GYNOECIUM**: The ovary is superior with a terminal style and a 2-lobed stigma. Thus, two connate carpels make up the flower's syncarpous gynoecium. In *Forsythia*, there are 4-10 ovules per locule.

6. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of *Forsythia*, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

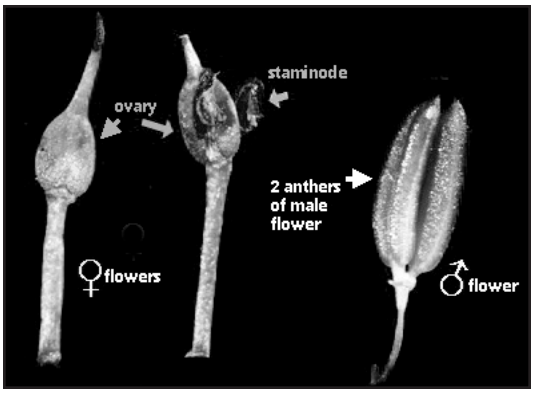


Figure 10.14 *Fraxinus pennsylvanica* flowers.

***Fraxinus pennsylvanica* Marshall (Green Ash)**

In the Oleaceae family there is a trend towards wind pollinated flowers. For those plants with imperfect flowers, like *Fraxinus*, the plants are dioecious (Figure 10.14). The flowers of ash are very reduced. Being wind pollinated, there is no need for a perianth to attract pollinators, so the calyx and corolla are absent. Be sure to examine the herbarium specimens of the staminate and carpellate trees on display.

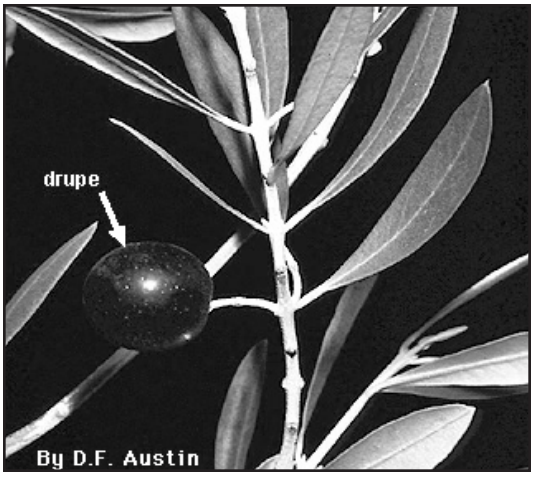


Figure 10.15 Drupe fruit of *Olea europea*.

FRUIT TYPE

- Fruits variable - can be a berry, capsule, drupe or samara

***Ligustrum vulgare* L. (Wild Privet or Common Privet)**

Examine the tiny berries produced by *L. vulgare*. Seed dispersal occurs via thrushes, who eat the berries and release the seeds in new locations through their droppings. Don't be fooled into eating the berries yourself though, they are toxic to humans!

***Syringa vulgaris* L. (Common Lilac)**

This species produces capsule fruits, which dehisce to release two winged seeds. What type of capsule is it classified as? Also, what is the inflorescence type assuming that each capsule fruit was originally a flower?

Figure 10.16 Samaras produced by a *Fraxinus* tree.

***Olea europaea* L. (Olive)**

Olives are botanically considered drupes (Figure 10.15). After looking at the dissected olives on display, explain why they are classified as drupes and not berries.

***Fraxinus pennsylvanica* Marshall (Green Ash)**

Ash trees produce an overwhelming amount of samaras (Figure 10.16). How are these fruits dispersed?

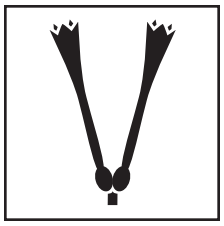
Figure 10.17 Leaves of a *Fraxinus quadrangulata*, or blue ash tree.

HABIT AND VEGETATIVE CHARACTERISTICS

- Habit is either a tree or shrub
- Leaves have opposite arrangement

***Fraxinus pennsylvanica* Marshall (Green Ash)**
***Syringa vulgaris* L. (Common Lilac)**

Using the "Dichotomous Key for Woody Plants" in Lab 1: Woody Twig Terminology, determine which twig is from *F. pennsylvanica* and which is from *S. vulgaris*. Notice how the leaf scars on the twigs appear opposite one another due to the opposite leaf arrangement characteristic of the Oleaceae family.



CAPRIFOLIACEAE

HONEYSUCKLE FAMILY

Eudicots: Asterid Clade

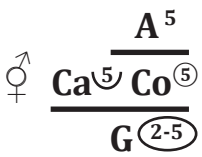


Figure 10.18 Flowers of *Lonicera japonica*.

Figure 10.19 Flowers of *Viburnum opulus*.

FLORAL CHARACTERISTICS

- Ovaries of two flowers often paired
- Ovary inferior with 2-5 locules

***Kolkwitzia amabilis* Graebn. (Beautybush)**
***Lonicera japonica* Thunb. (Japanese Honeysuckle)**
***Lonicera sempervirens* L. (Trumpet Honeysuckle)**
***Lonicera tatarica* L. (Tatarian Honeysuckle)**
***Viburnum carlesii* Hemsl. (ADOXACEAE) (Korean Spice)**
***Viburnum opulus* L. (ADOXACEAE) (European Cranberrybush)**

Flowers in the Caprifoliaceae family have inferior ovaries, and often the ovaries of two separate flowers will be paired together. To see these features, examine the herbarium specimens and the dissected flower diagrams provided. What term is used to describe the stamens in the family (as well as most of the Asterid clade)?

These showy flowers are pollinated by various nectar-gathering insects (primarily bees and wasps) and birds. What is the floral symmetry of the flowers in Figure 10.18? What about Figure 10.19?

Figure 10.20 Fruit of *Lonicera purpusii*.

Figure 10.21 Fruit of *Viburnum opulus*.

Figure 10.22 Close up of *Lonicera maackii* flowers.

FRUIT TYPE

- Fruits can be berries, capsules or drupes

***Lonicera maackii* Maxim. (Amur Honeysuckle)**
***Viburnum* spp. (ADOXACEAE)**

All of the members of the genus *Lonicera* produce berries, which will often be paired like the ovaries they arose from (Figure 10.20). The color of these berries can be red, blue or black and each fruit will contain a number of seeds.

Alternatively, the members of the genus *Viburnum* produce single-seeded drupe fruits (Figure 10.21,) although the color varies (i.e. red, purple, blue or black). Check out the herbarium specimens to see the drupes produced by a few different *Viburnum* species. What is the major difference between a berry and a drupe?

HABIT AND VEGETATIVE CHARACTERISTICS

- Plants possess a variety of woody habit types
- Leaves have opposite arrangement and do not have stipules

***Lonicera maackii* Maxim. (Amur Honeysuckle)**

Review your vegetative terminology while observing this herbarium specimen.

Complexity _____

Arrangement _____

Attachment _____

Venation _____

Blade shape _____

Leaf apex _____

Leaf base _____

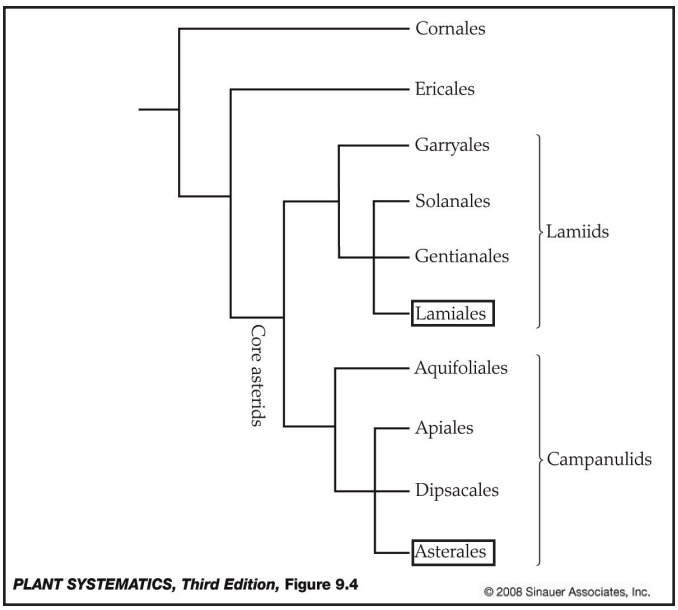
Leaf margin _____

LABORATORY 11

SCROPHULARIACEAE, LAMIACEAE AND ASTERACEAE

PHYLOGENETIC RELATIONSHIPS

The order Lamiales consists of about 24 families and 17,800 species and is classified within the Core Asterid clade (Lamiids subclade). Included here are Scrophulariaceae and Lamiaceae, which we will study in today's lab. The order is undoubtedly monophyletic, being held together by the shared possession of a large suite of morphological, anatomical, chemical and molecular characters.



***PLANT SYSTEMATICS, Third Edition,* Figure 9.4**

Scrophulariaceae, as traditionally delimited, is highly polyphyletic, with some members of this group more closely related to members of various other families of Lamiales than they are to other scrophs. Recent systems of classification place the following genera formerly found in the Scrophulariaceae family in the Plantaginaceae family: *Antirrhinum*, *Digitalis*, *Mimulus*, *Penstemon*, *Plantago* and *Veronica*. The family Scrophulariaceae is treated in a very strict sense and only includes a few genera (i.e. *Verbascum* and *Scrophularia*, which occur in North America). In this class, we will treat the family in its traditional (i.e., broad) sense to include those genera recently placed in the Plantaginaceae. Scrophulariaceae is well known for its many ornamental plants.

The Asteraceae family is contained within the order Asterales, which includes 12 families and about 25,000 species. Asterales is found in the Campanulids subclade.

-

SCROPHULARIACEAE

FIGWORT FAMILY

Eudicots: Asterid Clade

$$\frac{A^{2 \text{ or } 4\,(5)}}{\female\!\!\male\ CaZ^{(5)}\ CoZ^{(5)}\ G^{(2)}}$$

Figure 11.1 *Antirrhinum majus* inflorescence.

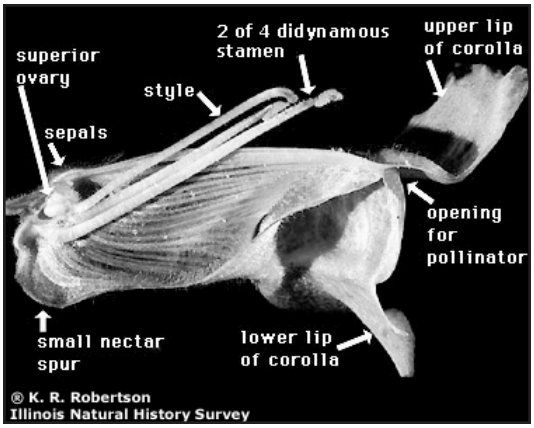


Figure 11.2 Longitudinal section of an *Antirrhinum majus* flower.

FLORAL CHARACTERISTICS

- Zygomorphic symmetry due to 2-lipped to nearly regular corolla
- **DIDYNAMOUS** stamens (2 or 2+2) sometimes with fifth staminode (**STAMINODIUM**) present

***Antirrhinum majus* L. (Snapdragons)**

To observe the floral morphology characteristic of Scrophulariaceae, you will examine and dissect a *A. majus* flower. If you hold a fresh blossom by the corolla tube immediately below the lobes and squeeze gently between thumb and forefinger, the two lips will open like the jaws of an animal's mouth (a dragon perhaps?) and will snap closed again when the pressure is released. Hence the common name for the species, 'snapdragon'.

1. Observe a flower (Figure 11.1). What is its symmetry?

2. **CALYX**: The calyx of these flowers is deeply 5-parted and zygomorphic.

3. **COROLLA**: The corolla is sympetalous and **BILABIATE** (upper lip is formed from 2 petals, while the lower lip is formed from 3 petals). Observe that the lower lip has a prominent palate that closes the throat of the corolla.

4. **ANDROECIUM**: How many stamens are there? In Scrophulariaceae, the stamens are arranged in a **DIDYNAMOUS** fashion (Figure 11.2). What other plant family covered this semester had **TETRADYNAMOUS** stamens? What is the difference between these two terms?

5. **GYNOECIUM**: Examine the syncarpous gynoecium of this flower consisting of 2 connate carpels. Its superior ovary is bilocular and contains numerous axile ovules. The style is terminal, as it is in all the other families we have studied so far.

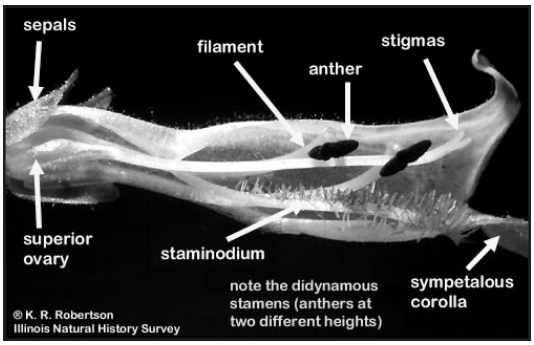


Figure 11.3 Longitudinal section of a *Penstemon pallidus* flower.

Figure 11.4 Capsules produced by a *Penstemon* plant.

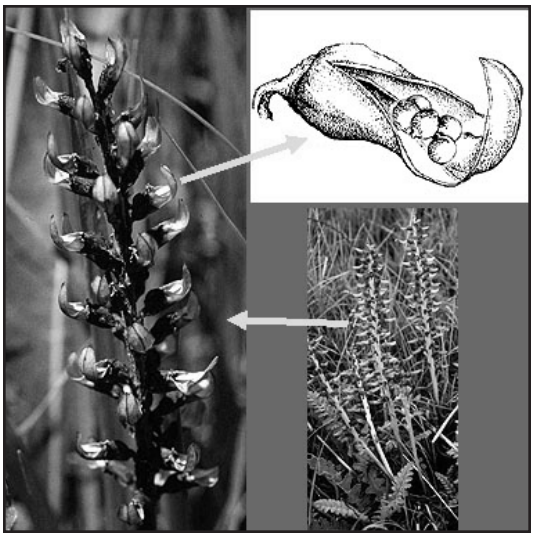


Figure 11.5 Capsules produced by *Pedicularis canadensis*.

6. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of *A. majus*, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

***Penstemon* spp. (Beardstongue)**

Flowers from this genus possess a **BILABIATE** corolla, **DIDYNAMOUS** stamens (2 + 2), a gynoecium with a 2-lobed stigma and a superior ovary (Figure 11.3). They also have a 5th hairy, sterile stamen (hence the common name 'beardstongue'). What is the name of this structure?

FRUIT TYPE

- Fruit is a 2-valved capsule

***Penstemon* spp. (Beardstongue)**
***Verbascum blattaria* L. (Moth Mullein)**
***Verbascum thapsus* L. (Common Mullein)**

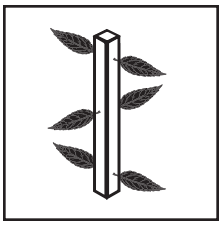
Observe the Scrophulariaceae fruits provided. These capsule fruits have two valves which arise from the two connate carpels that make up the syncarpous gynoecium of the original flower (Figure 11.4).

HABIT AND VEGETATIVE CHARACTERISTICS

- Many photosynthetic root parasites

***Pedicularis canadensis* L. (Canadian Lousewort)**

This species is a hemiparasite, meaning that it establishes connections with other plants' roots to obtain resources but it is also capable of photosynthesis itself. Its habit is either an herb or a subshrub. The fruits of *P. canadensis* are capsules that only open on the upper side; they are an example of "splash-cup" dispersal (Figure 11.5).



LAMIACEAE

MINT FAMILY

Eudicots: Asterid Clade

$$\overline{A^4}$$
$$\underline{\text{♀ } CaZ^{⑤}\ CoZ^{⑤}\ G^{②}}$$

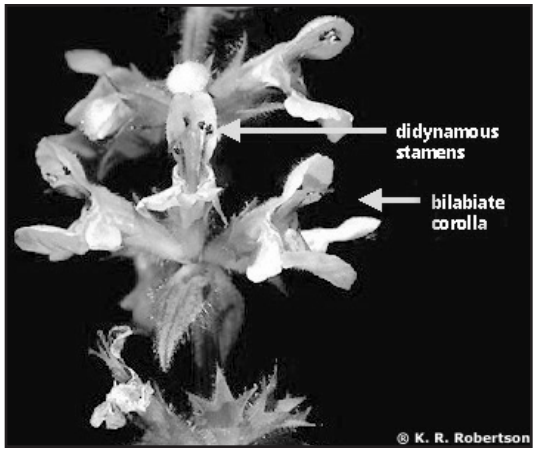


Figure 11.6 *Teucrium canadense* flowers arranged in **VERTICILS**.

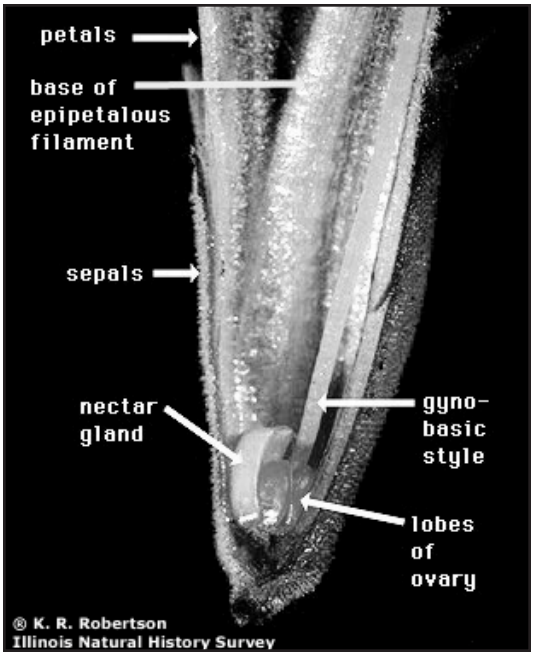


Figure 11.7 Base of a *Physostegia virginiana* flower.

INFLORESCENCE TYPE

- Axillary cymes or **VERTICILS**

***Mentha spicata* L. (Spearmint)**
***Nepeta cataria* L. (Catnip)**
***Stachys arenicola* Britt. (Hairy Hedgenettle)**

Observe how the flowers are arranged in **VERTICILS** or whorls in these plant species (Figure 11.6). This is a diagnostic inflorescence feature of many members of Lamiaceae.

FLORAL CHARACTERISTICS

- Zygomorphic symmetry due to **BILABIATE** corolla (upper portion of corolla has 2-lobes and lower part has 3-lobes)
- **DIDYNAMOUS** stamens (2+2 arrangement)
- Gynoecium deeply 4-lobed with **GYNOBASIC** style and 1 basal/axile ovule per locule

***Lavendula* spp. (Lavendar)**

To observe the floral morphology characteristic of Lamiaceae, you will examine a *Lavendula* flower.

1. Examine a flower. What is its symmetry?

2. **CALYX**: How many sepals make up the calyx and are they distinct or connate?

3. **COROLLA**: The corolla is made up of five connate petals and is described as **BILABIATE** since it has two lips, a 2-lobed upper lip and a 3-lobed lower lip.

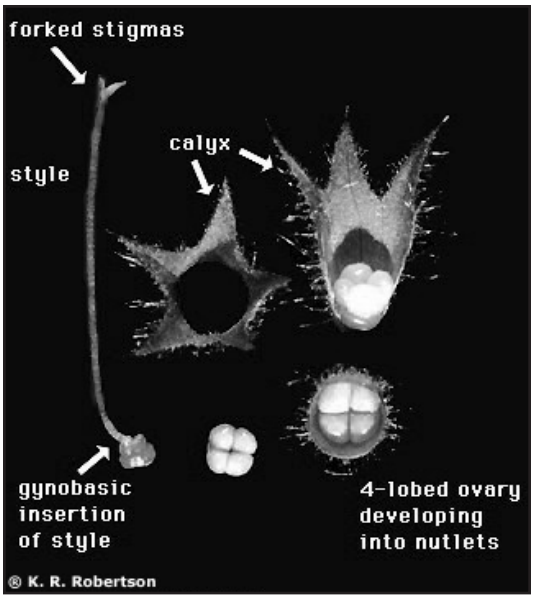


Figure 11.8 Dissected parts of a *Teucrium canadense* flower including its 4-lobed ovary.

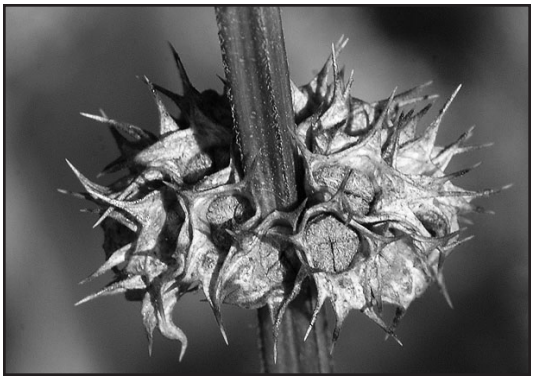


Figure 11.9 Nutlets of *Leonurus cardiaca*.

Figure 11.10 Bee visiting a *Monarda fistulosa* flower.

4. **ANDROECIUM**: Observe the **EPIPETALOUS** stamens with their **DIDYNAMOUS** arrangement. How many stamens make up the androecium?

5. **GYNOECIUM**: How many carpels make up the syncarpous gynoecium of this flower? Examine the ovary of the flower. It is deeply four lobed and possesses a **GYNOBASIC** style (Figure 11.7 and 11.8). What does **GYNOBASIC** mean?

***Molucella laevis* L. (Bells-of-Ireland)**
***Salvia* spp. (Sage)**
***Teucrium* spp. (Germander)**

Dissect one of the *Molucella* flowers and check out the photos and herbarium specimens provided for *Salvia* and *Teucrium*. As you do so, try to pick out the important Lamiaceae floral characteristics.

FRUIT TYPE

- Produces 4 nutlets

***Leonurus cardiaca* L. (Common Motherwort)**

Take one of the fruits and dissect it so that you can see the 4 nutlets that each flower produces (Figure 11.9). What is the difference between a nutlet and a nut?

HABIT AND VEGETATIVE CHARACTERISTICS

- Stems are square in cross section
- Leaves are simple and oppositely arranged
- Produce essential oils and are aromatic

***Majorana* spp. (Majoram)**
***Mentha* spp. (Mint)**
***Ocimum* spp. (Basil)**

Box 1

***Thymus* spp. (Thyme)**

Take some time to observe the vegetative characteristics of these plants. What is their habit?

Cut a small piece of stem off of one of the plants and draw its cross section in Box 1. The cross section shape is a very important feature for the Lamiaceae family! Also notice the plants' lovely aromatic scents.

ASTERACEAE

SUNFLOWER FAMILY

Eudicots: Asterid Clade

$$\varphi \; \frac{A^{(5)}}{Ca^{P}\ Co^{(5)}\ G^{(2)}}$$

Figure 11.11 Field of *Helianthus annuus* flowers.

Figure 11.12 Radiate capitulum of *Helianthus annuus*.

INFLORESCENCE TYPE

- Head (**CAPITULUM, CAPITULA**) inflorescences surrounded by **PHYLLARIES**
- Three **CAPITULUM** types: **RADIATE CAPITULUM, DISCOID CAPITULUM** and **LIGULATE CAPITULUM**

When looking at a sunflower, blazing star or dandelion, you might assume you are looking at a solitary flower (Figures 11.11 and 11.12). However, that is not the case. If you were to split one of the "flowers" lengthwise, you will see many small flowers (called **FLORETS**) arranged side by side on a large common receptacle. (Note: The use of the word "receptacle" is technically not correct, as a true receptacle is part of a flower, while in this instance it is used for the base of an inflorescence.) This compact arrangement of sessile flowers is a called a **CAPITULUM** (**HEAD**) or composite head, hence the alternative name for Asteraceae, Compositae. Asteraceae **CAPITULA** are divided into three types based on the type of **FLORETS** that make them up. The **CAPITULA** are surrounded by several to many green bracts called **PHYLLARIES** or involucral bracts. The stalk of the inflorescence (i.e. **CAPITULUM**) is called a **PEDUNCLE**. Is a capitulum a determinate or an indeterminate inflorescence?

FLORAL CHARACTERISTICS

- Two kinds of flowers (**FLORETS**): **DISK** and **RAY**
- Bracts called **CHAFF** and calyx called a **PAPPUS**
- Stamens with distinct filaments attached to base of corolla, but anthers connate into a tube around style
- Syncarpous gynoecium is made up of 2 connate carpels and has a 1-locular, inferior ovary with 1 basal ovule

There are two kinds of flowers (**FLORETS**):

1. **DISK:** actinomorphic symmetry with a tubular corolla
2. **RAY:** zygomorphic symmetry with a ligulate corolla

Figure 11.13 Radiate capitulum of *Helianthus angustifolius* with disk and ray florets.

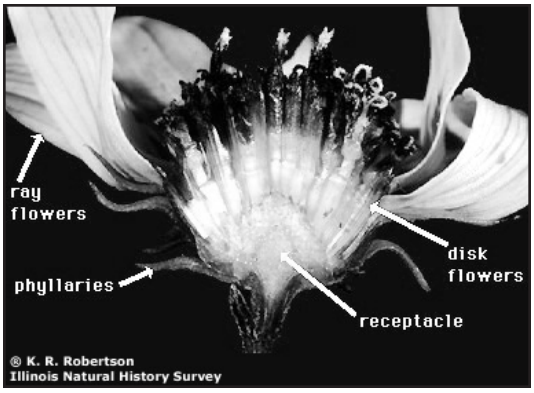


Figure 11.14 Longitudinal section of a *Helianthus angustifolius* radiate capitulum.

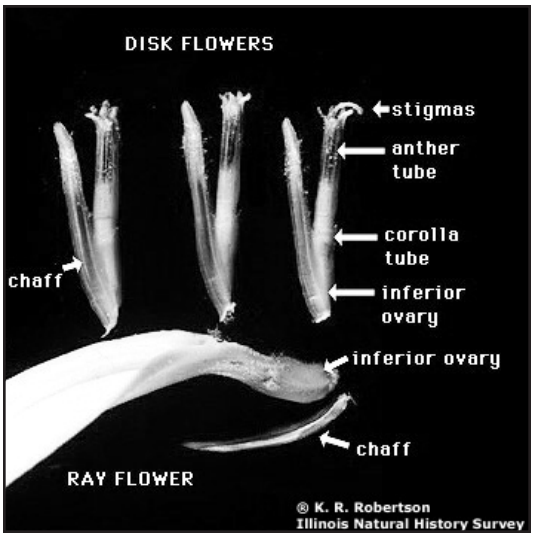


Figure 11.15 Close up of disk and ray florets from *Heliopsis helianthoides*.

As previously mentioned, the three **CAPITULUM** types are differentiated based on which **FLORET(S)** they possess.

1. **RADIATE CAPITULUM:** both **DISK** and **RAY FLORETS**
2. **DISCOID CAPITULUM:** only **DISK FLORETS**
3. **LIGULATE CAPITULUM**: only **RAY FLORETS**

RADIATE CAPITULUM

Helianthus spp. (Sunflower)

The genus name *Helianthus* comes from the Greek words "helios" (sun) and "anthos" (flower). Pretty isn't it? Now examine the **RADIATE CAPITULUM** of *Helianthus*, with its inner **DISK FLORETS** (actinomorphic and brown) and outer **RAY FLORETS** (zygomorphic, strap-like and yellow; Figures 11.13 and 11.14).

DISK FLORETS

1. Identify the **CHAFF**, if present. These are the bracts that subtend the florets and arise off the receptacle.

2. **CALYX**: Find the **PAPPUS** (the modified calyx). The pappus may be modified into long white bristles, retrorsely barbed awns, scales, or be missing altogether.

3. **COROLLA**: Observe that the corolla is actinomorphic, tubular and 5-lobed at the summit.

4. **ANDROECIUM**: The androecium is made up of 5 stamens. The stamens' anthers are united by their margins to form a cylinder around the style, while the filaments are distinct but adnate to the corolla tube (Figure 11.15). Based on this, what term can be used to describe the stamens?

5. **GYNOECIUM**: Observe the 2 stigmas, elongate style and inferior ovary of the syncarpous gynoecium. Each ovary contains only one locule and one basal ovule. What is the insertion type?

RAY FLORETS

1. Identify the **CHAFF** if present.

2. **CALYX**: Find the **PAPPUS** (the modified calyx).

3. **COROLLA**: Observe that the zygomorphic corolla arises as a very short tube at the summit of the ovary but immediately splits into a long, narrow, flat, strap-

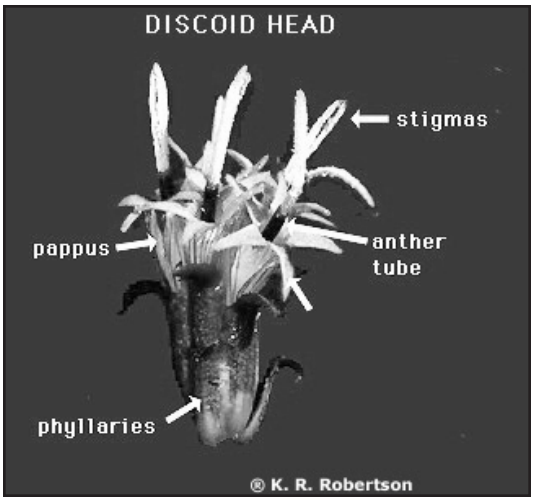


Figure 11.16 *Liatris pycnostachya* discoid capitulum.

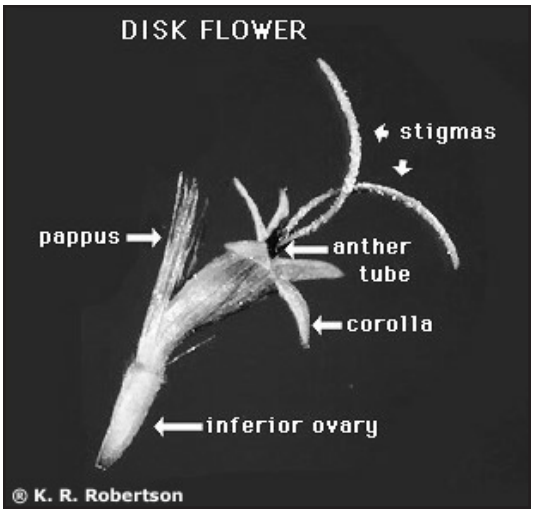


Figure 11.17 *Liatris pycnostachya* disk floret.

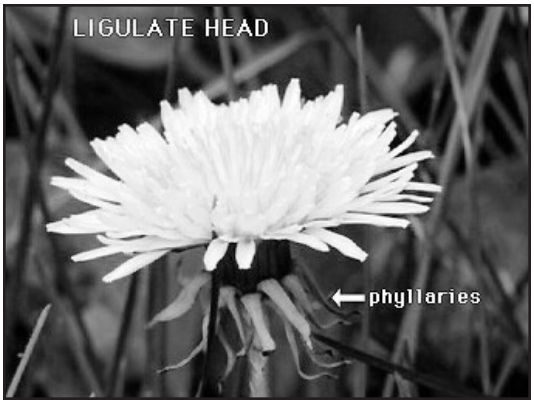


Figure 11.18 Ligulate head of *Taraxacum officinale*.

shaped structure with commonly three terminal lobes.

4. **ANDROECIUM**: In this floret there is no androecium (therefore, the florets are imperfect) or, in some species, the florets may be sterile. If sterile, what is their function?

5. **GYNOECIUM**: Observe the inferior ovary of the gynoecium.

6. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of a *Helianthus* **CAPITULUM**, making sure to include its floral formula. On the same page, include floral diagrams of individual **DISK** and **RAY FLORETS**. Follow the format as instructed in Lab 3: Floral Terminology.

***Chrysanthemum* spp. (Daisy)**

Take time to dissect a *Chrysanthemum* **CAPITULUM** and try to pick out the same features that you saw in the *Helianthus* **CAPITULUM** including the two types of **FLORETS** and their constituent parts.

DISCOID CAPITULUM

***Liatris* spp. (Blazing Star)**

DISCOID CAPITULA are inflorescences that contain only **DISK FLORETS** (Figure 11.16). Examine one to verify that their structure is the same as **DISK FLORETS** found in a **RADIATE CAPITULUM** (Figure 11.17).

LIGULATE CAPITULUM

***Taraxacum officinale* F.H. Wigg (Common Dandelion)**

LIGULATE CAPITULA are inflorescences that contain only **RAY FLORETS** (Figure 11.18). These **RAY FLORETS** are somewhat different than those found on the margin of a **RADIATE CAPITULUM**. Most notably they are perfect, unlike **RAY FLORETS** in a **RADIATE CAPITULUM** which are either carpellate only or sterile. Dissect a *T. officinale* flower to see the **RAY FLORET** features.

1. Observe a **RAY FLORET**. What is its floral symmetry?

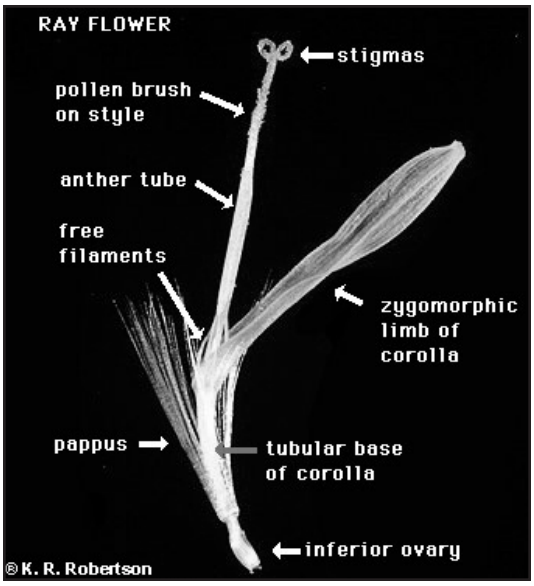


Figure 11.19 *Taraxacum officinale* ray floret from a ligulate head.

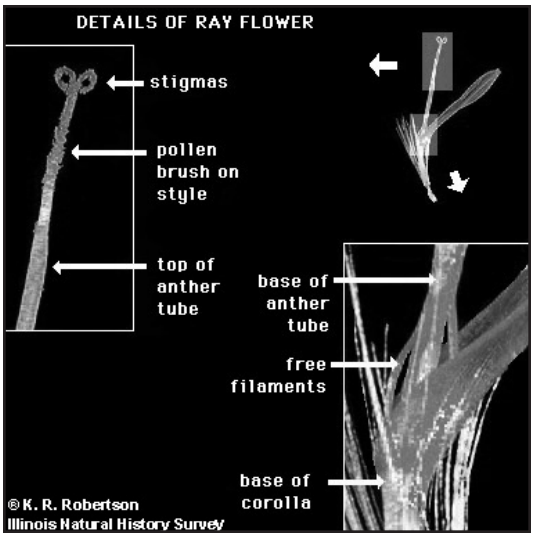


Figure 11.20 Details of *Taraxacum officinale* ray florets.

Figure 11.21 Achenes from *Helianthus* disk florets.

2. **COROLLA**: The corollas of the outer florets are obviously flat. Those of the center appear regular and might be considered tubular. However they are the same as the outer ones, only they are younger and have not opened or expanded. There are 5 terminal lobes to the floret corolla (Figure 11.19).

3. **ANDROECIUM**: In this floret the filaments are distinct above the point where they attach to the corolla tube, but the anthers are connate into a tube.

4. **GYNOECIUM**: Observe the inferior ovary, solitary style and 2 stigma lobes of the gynoecium (Figure 11.20).

POLLINATION MECHANISM

In the Asteraceae family, pollen is shed inside the staminal tube. As the style of the gynoecium elongates, the pollen is pushed out the tip of the staminal tube. Sometimes there is a special “brush” towards the tip of the style to assist in pushing the pollen out. The 2 stigmas are folded shut as the style elongates, but they spread open after they emerge beyond the anther tube. Now pollination is free to occur.

FRUIT TYPE

- Fruit is an achene

RADIATE CAPITULUM: *Helianthus* spp. (Sunflower)

The fruit type typically produced by Asteraceae is an achene (Figure 11.21). What are some key features of an achene fruit based on the examples provided (i.e. characteristics of parent flower, fruit features, etc.)?

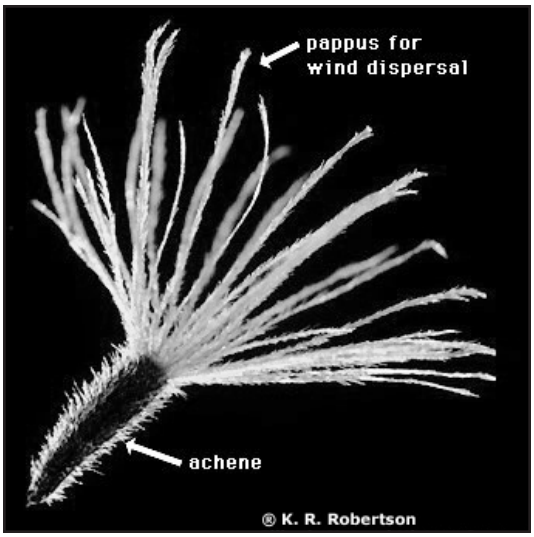


Figure 11.22 Achene from *Liatris aspera*.

DISCOID CAPITULUM: *Liatris* spp. (Blazing Star)
LIGULATE CAPITULUM: *Tragopogon* spp. (Goat's Beard)

CYPSELA fruits are restricted to some species in Asteraceae. They are dry, indehiscent and very similar to **ACHENES** except that they usually have an adnate calyx. In *Liatris*, the calyx is modified into bristle-like appendages called the **PAPPUS** (Figure 11.22).

Note: A sunflower fruit (commonly referred to as a sunflower seed) is correctly termed a **CYPSELA** but does not possess an adnate calyx. Consequently, it can also be referred to as an **ACHENE**.

Figure 11.23 *Taraxacum officinale* plant.

HABIT AND VEGETATIVE CHARACTERISTICS

- Habit is usually an herb

RADIATE CAPITULUM: *Tagetes* spp. (Marigold)

Like this *Tagetes* species, the majority of the Asteraceae family members are herbaceous. If they are available, dissect the **RADIATE CAPITULA** of the *Tagetes* species.

LIGULATE CAPITULUM: *Taraxacum officinale* F.H. Wigg (Common Dandelion)

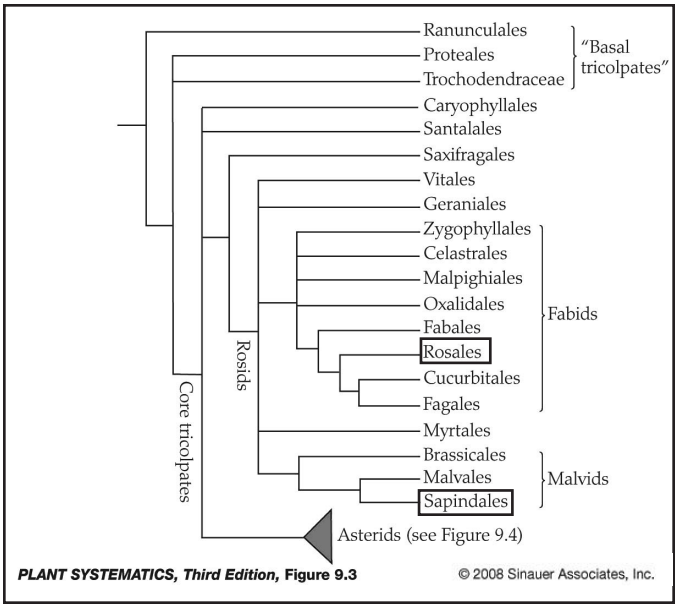
Many members of the Asteraceae with a ligulate capitulum have milky sap, like the *T. officianale* on display (Figure 11.23). What root type does this plant exhibit?

LABORATORY 12

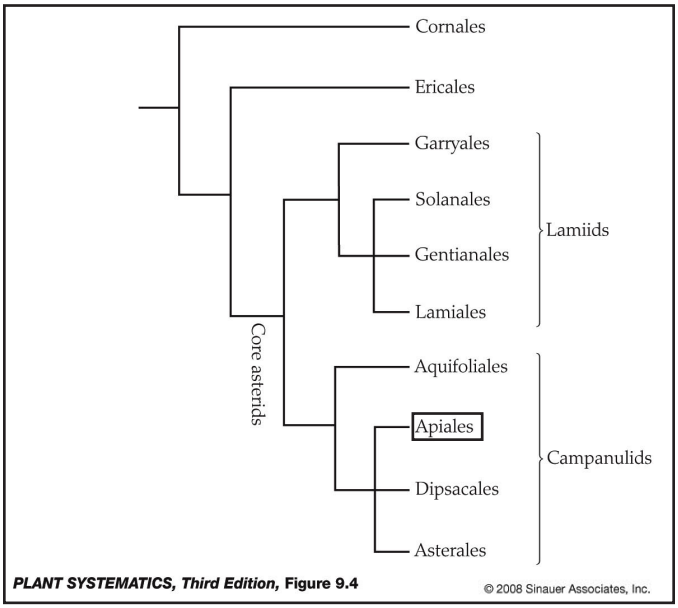
ROSACEAE, ACERACEAE AND APIACEAE

PHYLOGENETIC RELATIONSHIPS

In today's Lab we will examine Rosaceae and Aceraceae from the Rosid clade, and Apiaceae from the Asterid clade.



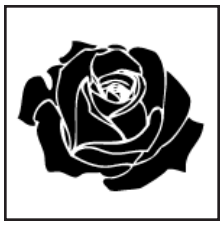
Rosaceae is treated in the Rosales clade of the Rosids. Many characters support its monophyly, such as the presence of numerous stamens, the absence of alkaloids and DNA sequences. Alternate leaves with stipules plus showy flowers with radial symmetry and a hypanthium also aid in their recognition. Traditionally, the family is divided into four subfamilies, and we will highlight these subfamilies in Lab. Fruit type, carpel number, ovary position and base chromosome number are the primary criteria in subfamily recognition. Recent results of phylogenetic analyses of molecular data, however, suggest that not all of these subfamilies are monophyletic.



Aceraceae is now treated within the family Sapindaceae (the soapberry family). Along with the maples and relatives are members of the Hippocastanaceae (horse chestnuts and relatives) and several important tropical fruits, such as longan, lychee and rambutan (in which the fleshy part of the fruit you eat is derived from a large aril surrounding the seed). While your textbook defines the Sapindaceae broadly, we will treat the Aceraceae as a separate, distinct family (as a matter of convenience only). Therefore, the Aceracee sensu stricto (Aceraceae s.s.) is circumscribed by plants bearing opposite leaves, non-appendaged petals, stamens borne on a nectar disk, and two ovules per carpel. Aceraceae s.s. is classified within the order Sapindales of the Malvids subclade. So, actually this family is more closely related to the Malvaceae and Brassicaceae than it is to the Apiaceae.

The family Apiaceae (or Umbelliferae, the carrot family), as circumscribed in the Judd et al. text, is treated in the broad sense to include not only those herbaceous species traditionally considered in

Apiaceae, but also those woody species which are usually segregated as a separate family, the Araliaceae. However, in this class, we consider only Apiaceae sensu stricto (Apiaceae s.s.) as constituting the family. Synapomorphies for Apiaceae s.s. include hollow internodes, secretary canals containing ethereal oils and resins, umbel inflorescences, a stylopodium atop the inferior ovary, and a schizocarpic fruit. The family Apiaceae s.s is treated within the order Apiales of the Campanulids subclade (of the core Asterid clade), as indicated by their ovules with a single integument and usually a thin megasporangium wall, sympetalous corollas, 5 stamens and molecular data. This order is closely related to the Asterales (e.g. Asteraceae) and Dipsacales (e.g. Caprifoliaceae). Apiaceae s.s. is the subject of Dr. Downie's research.



ROSACEAE

ROSE FAMILY

Eudicots: Rosid Clade

♀ $\underbrace{Ca^5\ Co^5\ A^{\infty}}\ G^{\infty}$ or G^1 or $\overline{G^{(2\text{-}5)}}$

Figure 12.1 Bowl of Rosaceae fruit. As Dr. Ken Robertson says, "The Rose Family (Rosaceae) makes life worth living!"

FOUR SUBFAMILIES

- **SPIRAEOIDEAE**
- **ROSOIDEAE**
- **AMYGDALOIDEAE**
- **MALOIDEAE**

Rosaceae is divided into four distinct subfamilies. The subfamilies can be differentiated based on carpel number and fusion, ovary position, fruit type and base chromosome number.

FLORAL CHARACTERISTICS

- Actinomorphic symmetry
- Flowers with **HYPANTHIUM**

Though all members of the Rosaceae family have perfect, actinomorphic flowers with a hypanthium, the subfamilies differ in their carpel number and fusion as well as their ovary position.

Subfamily	Floral Formula	Carpel Number and Fusion	Ovary Position
SPIRAEOIDEAE (Spirea Subfamily)	♀ $\underbrace{Ca^5\ Co^5\ A^{10\text{-}\infty}}\ G^{2\text{-}5}$	Few (5) distinct carpels	Superior ovary
ROSOIDEAE (Rose Subfamily)	♀ $\underbrace{Ca^5\ Co^5\ A^{10\text{-}\infty}}\ G^{\infty}$	Many distinct carpels	Superior ovary
AMYGDALOIDEAE (Peach Subfamily)	♀ $\underbrace{Ca^5\ Co^5\ A^{5\text{-}15}}\ G^1$	1 carpel	Superior ovary
MALOIDEAE (Apple Subfamily)	♀ $\underbrace{Ca^5\ Co^5\ A^{10\text{-}\infty}}_{\overline{G^{(2\text{-}5)}}}$	2-5 carpels that are fused to hypanthium	Inferior ovary

Figure 12.2 Cluster of *Spirea* flowers.

Figure 12.3 Flower of *Exochorda racemosa*.

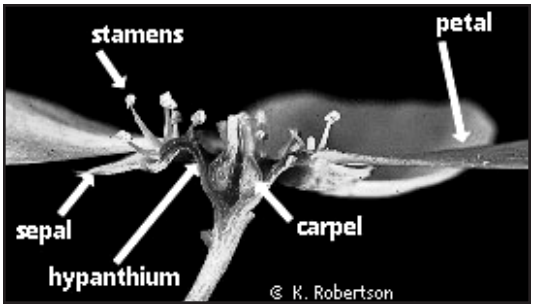


Figure 12.4 Longitudinal section of an *Exochorda racemosa* flower.

Box 1

SPIRAEOIDEAE

***Spiraea* spp. (Spirea)**
***Exochorda racemosa* (Lindl.) Rehder (Pearlbush)**

To examine the floral characteristics of Spiraeoideae, dissect either a *Spiraea* (Figure 12.2) or an *Exochorda racemosa* flower (Figure 12.3).

1. Observe a flower. What is its symmetry?

2. **CALYX**, **COROLLA** and **ANDROECIUM**: These three floral series are adnate to form what?

3. **GYNOECIUM**: Five weakly united carpels make up the gynoecium of this flower, making it atypical of subfamily Spiraeoideae (Figure 12.4). Most Spiraeoideae species have apocarpous gynoecia made up of 2-5 distinct carpels. What is the ovary position?

4. In Box 1, sketch a longitudinal section (L.S.) of a *Spiraea* or an *Exochorda racemosa* flower.

5. Construct the floral formula for the flower you are dissecting in the space below.

Figure 12.5 Flower of *Rosa carolina*.

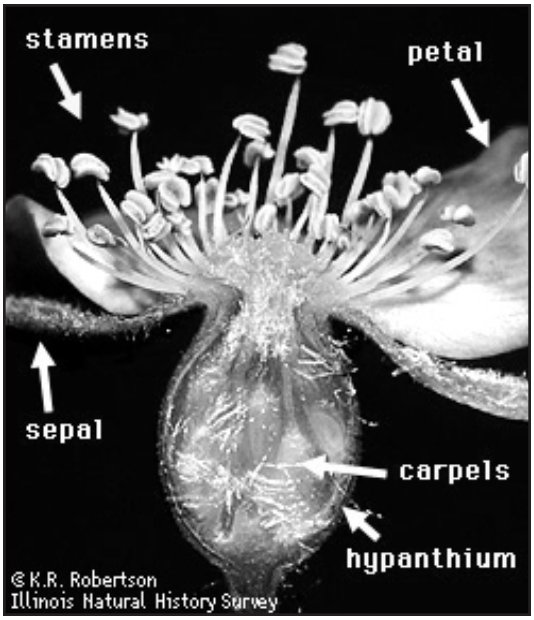


Figure 12.6 Longitudinal section of a *Rosa rubrifolia* flower.

Box 2

ROSOIDEAE

***Duchesnea* spp. (Duchesnea)**
***Fragaria* spp. (Strawberry)**
***Rosa* spp. (Rose)**

Subfamily Rosoideae species are distinguished from members of the other three subfamilies by their numerous and distinct carpels and superior ovaries (Figure 12.5). Dissect one of the species on display.

1. What is the floral symmetry of the flower?

2. **CALYX**, **COROLLA** and **ANDROECIUM**: How many sepals, petals and stamens does your flower possess? In *Rosa*, a deep hypanthium is present, and though it may appear to be, the hypanthium is *NOT* adnate to the gynoecium (Figure 12.6).

3. **GYNOECIUM**: Observe how the carpel styles protrude through the opening in the top of the hypanthium. What is the gynoecium type if it is made up of many distinct carpels? Also, what is the ovary position and insertion type in the flower?

4. In Box 2, sketch a longitudinal section (L.S.) of a *Duchesnea*, *Fragaria* or *Rosa* flower.

5. Construct the floral formula for the flower you are dissecting in the space below.

Figure 12.7 Inflorescence of *Prunus padus*.

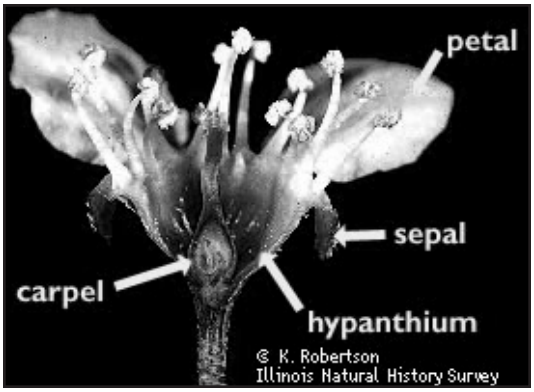


Figure 12.8 Longitudinal section of a *Prunus padus flower*.

Box 3

AMYGDALOIDEAE

***Prunus* spp. (Plum)**

To learn the floral morphology characteristic of Rosaceae subfamily Amygdaloideae, you will examine and dissect *Prunus* flowers.

1. Observe a flower (Figure 12.7). What is its floral symmetry?

2. **CALYX**, **COROLLA** and **ANDROECIUM**: *Prunus* flowers have large hypanthiums lined with nectar secreting tissue that are formed from the adnation of these three floral series (Figure 12.8). How may sepals, petals and stamens does your flower possess?

3. **GYNOECIUM**: At the base of the hypanthium is a monocarpous gynoecium with a superior ovary. What is the insertion type?

4. In Box 3, sketch a longitudinal section (L.S.) of a *Prunus* flower.

5. Construct the floral formula for the *Prunus* flower you are dissecting in the space below.

Figure 12.9 Cluster of *Malus* flowers.

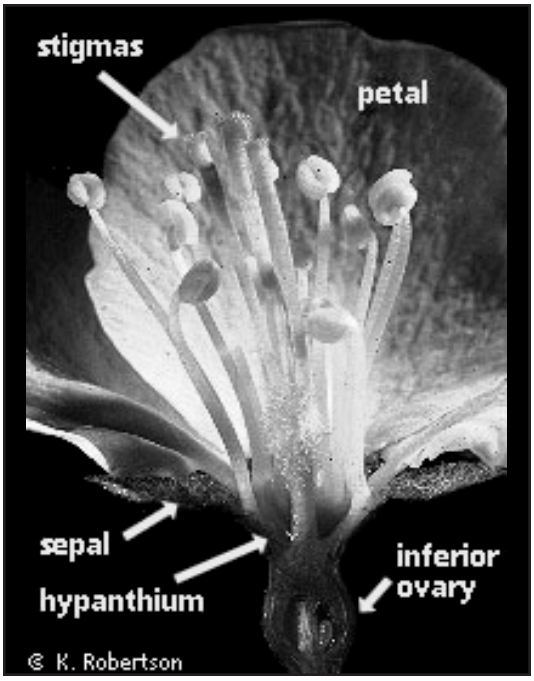


Figure 12.10 Longitudinal section of a *Malus* flower.

Box 4

MALOIDEAE

***Pyrus calleryana* 'Bradford' (Pear)**
***Malus* spp. (Apple)**

To learn the floral morphology characteristic of Subfamily Maloideae, you will examine and dissect *Pyrus* and *Malus* flowers. The genus names *Pyrus* and *Malus* come from the Latin for "pear" and "apple," respectively.

1. Observe a flower (Figure 12.9). What is its floral symmetry?

2. **CALYX**, **COROLLA** and **ANDROECIUM**: Like the other Rosaceae subfamilies, Maloideae flowers have a hypanthium (Figure 12.10). How many sepals, petals and stamens do they possess?

3. **GYNOECIUM**: What is the gynoecium type, ovary position and insertion type of these flowers?

4. In Box 4, sketch a longitudinal section (L.S.) of a *Pyrus calleryana* or *Malus* flower.

5. Construct the floral formula for the flower you are dissecting in the space below.

Figure 12.11 *Spirea* × *vanhouttei* flowers produce an aggregate fruit of follicles.

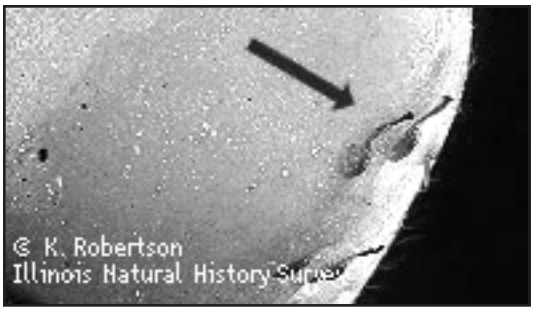


Figure 12.12 Arrow is pointing to an achene fruit of *Fragaria* × *ananassa*.

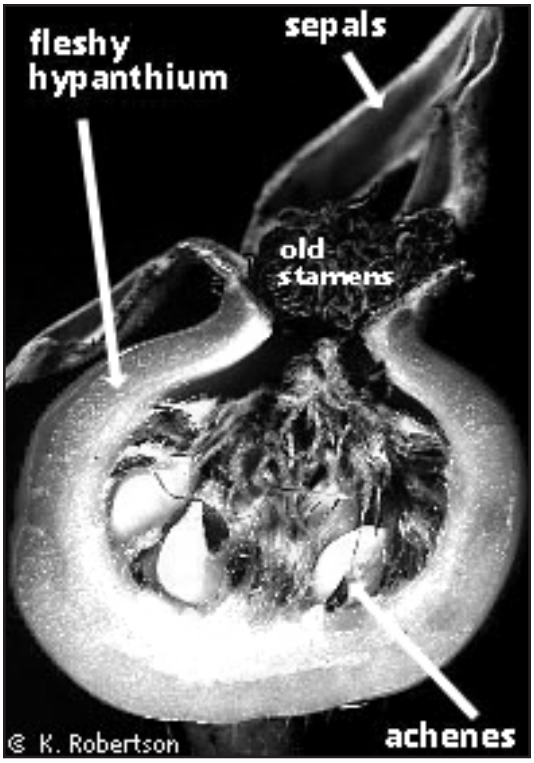


Figure 12.13 Hip of *Rosa setigera*.

FRUIT TYPE

- Do *NOT* produce capsules or berries

The fruit types produced in the Rosaceae family vary among the four subfamilies. In fact, fruit type is one of the major features that distinguish the subfamilies from one another.

Subfamily	Fruit Type
SPIRAEOIDEAE	Follicle
ROSOIDEAE	Achenes (in a **HIP**) or drupelets
AMYGDALOIDEAE	Drupe
MALOIDEAE	**POME**

SPIRAEOIDEAE

***Exochorda giraldii* Hesse (Redbud Pearlbush)**
***Physocarpus opulifolius* (L.) Maxim. (Ninebark)**
***Spiraea* spp. (Meadowsweet)**

Follicles, a dry dehiscent fruit type, are characteristic of the Spiraeoideae subfamily (Figure 12.11). Examine the array of follicle fruits on display. What gynoecium type must Spiraeoideae species have in order to produce them?

ROSOIDEAE

***Fragaria* × *ananassa* (Strawberry Hybrid)**

The Rosoideae subfamily typically produces achene fruits. In *Fragaria* × *ananassa*, the fruit is composed of many achenes on the outside of an enlarged receptacle (Figure 12.12). Thus, what *three* fruit types can a strawberry be classified as?

***Rosa canina* L. (Dog Rose)**
***Rosa multiflora* Thunb. (Multiflora Rose)**

Rosa species produce **HIPS** containing many achene fruits (Figure 12.13). The **HIP** itself is formed when the original flower's deep hypanthium becomes fleshy and its ovaries (located inside the hypanthium) mature into achenes. Cut

Figure 12.14 *Rubus* aggregate fruit of drupelets.

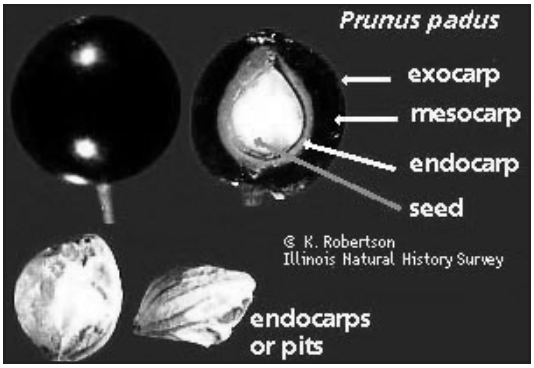


Figure 12.15 Drupe fruit of *Prunus padus*.

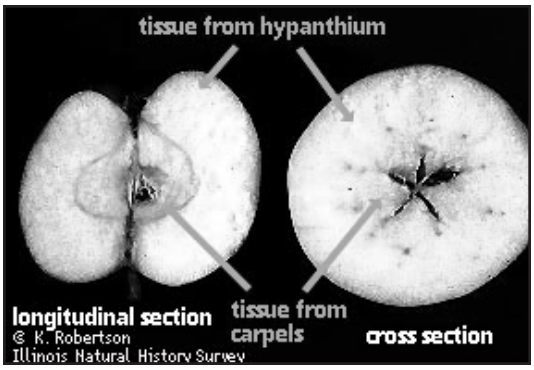


Figure 12.16 **POME** fruit of *Malus pumila.*

Figure 12.17 **POME** fruit of *Malus* 'Red Jade'.

open one of the **HIPS** provided and examine the achenes.

***Rubus idaeus* L. (American Red Raspberry)**
***Rubus allegheniensis* Porter. (Allegheny Raspberry)**

Although less common, the Rosoideae subfamily does also produce drupelet fruits. For example, the genus *Rubus* produces "**AGGREGATE FRUITS OF DRUPELETS**" (Figure 12.14). What type of gynoecium is required to produce this fruit type?

AMYGDALOIDEAE

***Prunus americana* Marsh (American Plum)**
***Prunus armeniaca* L. (Apricot)**
***Prunus avium* (L.) L. (Sweet Cherry)**
***Prunus dulcis* (Mill.) D.A. Webb (Sweet Almond)**
***Prunus persica* (L.) Batsch (Peach/Nectarine)**

After pollination, the petals of Amygdaloideae flowers fall off quickly, while the sepals and stamens persist for a short while. The carpel then enlarges and begins to develop into a fruit (Figure 12.15). What are some of the characteristics that define the drupe fruit type?

MALOIDEAE

***Amelanchier* spp. (Serviceberry)**
***Crataegus mollis* Scheele (Downy Hawthorn)**
***Malus pumila* Mill. (Paradise Apple)**
***Pyrus communis* L. (Common Pear)**

A **POME** is the fleshy **ACCESSORY FRUIT** of subfamily Maloideae and is derived from the adnation of the hypanthium to the ovary wall. Thus, the flesh of apples and pears is mostly hypanthium tissue (Figure 12.16). Did the **POMES** on display arise from a superior or an inferior ovary? How can you tell based on the fruits?

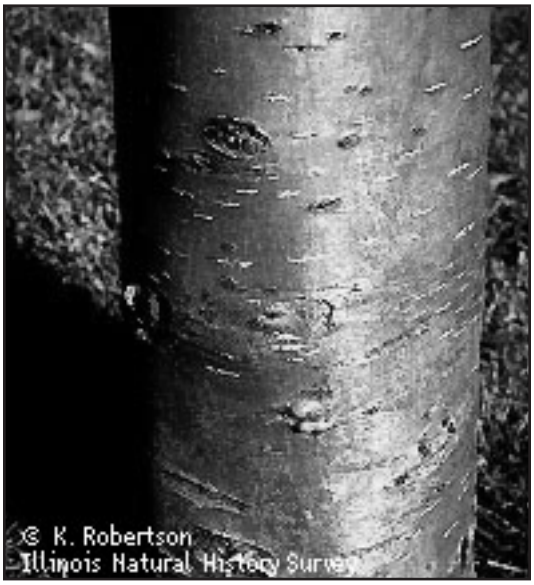


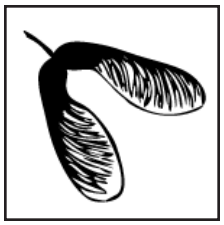
Figure 12.18 Trunk (with horizontal lenticels) of a *Prunus maackii* tree.

HABIT AND VEGETATIVE CHARACTERISTICS

- Habit varies with Rosaceae subfamily

Look back at the material provided under the flower and fruit portion of this lab to see the habits characteristic of the four Rosaceae subfamilies.

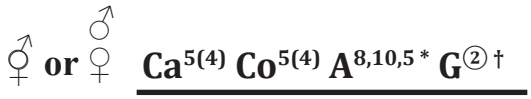
Subfamily	Plant Habit	Base Chromosome #
SPIRAEOIDEAE	Mostly shrubs, some herbs	9
ROSOIDEAE	Shrubs and perennial herbs	7
AMYGDALOIDEAE	Trees and shrubs	8
MALOIDEAE	Trees and shrubs	17



ACERACEAE

MAPLE FAMILY

Eudicots: Rosid Clade



Rudimentary in ♀ flowers (*) and ♂ flowers (†)

Figure 12.19 Cluster of *Acer platanoides* flowers.

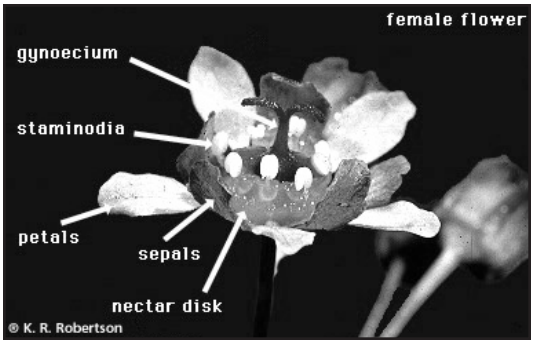


Figure 12.20 *Acer platanoides* female flower.

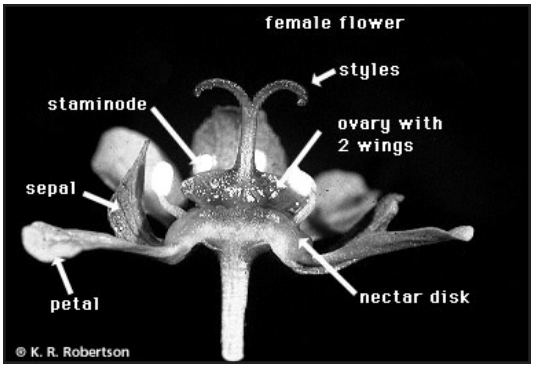


Figure 12.21 Longitudinal section of an *Acer platanoides* female flower.

FLORAL CHARACTERISTICS

- Perfect or imperfect flowers that are wind or insect pollinated
- Syncarpous gynoecium composed of two connate carpels
- Superior ovary is winged and 2-locular with 2 axile ovules per locule

***Acer platanoides* L. (Norway Maple)**

To observe the floral morphology characteristic of Aceraceae, you will examine carpellate and staminate *A. platanoides* flowers. This species is insect pollinated, so you will notice that all flowers, regardless of gender, possess a large, green nectar disk. Also, carpellate and staminate flowers are typically located on the same tree in *A. platanoides* (Figure 12.19). What then is the plant condition?

CARPELLATE FLOWER

1. Examine a carpellate flower. What is its symmetry?

2. **CALYX** and **COROLLA**: How many sepals and petals make up the calyx and corolla, respectively?

3. **ANDROECIUM**: Examine the staminodes present in the female flower (Figure 12.20). How many are there and what is their function?

4. **GYNOECIUM**: The syncarpous gynoecium of this flower is made up of how many connate carpels? Note that the ovary already shows signs of wing development; at this stage of floral maturity, there is a small wing on each side of the ovary (Figure 12.21).

Figure 12.22 *Acer platanoides* male flower.

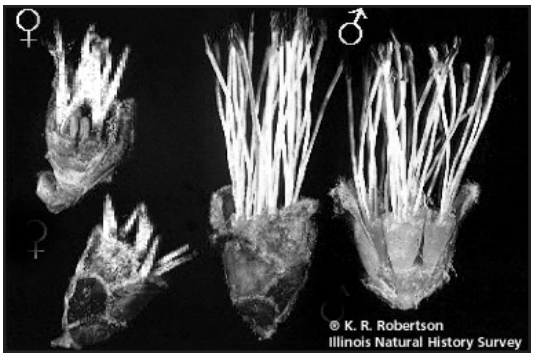


Figure 12.23 Male and female *Acer saccharinum* inflorescences.

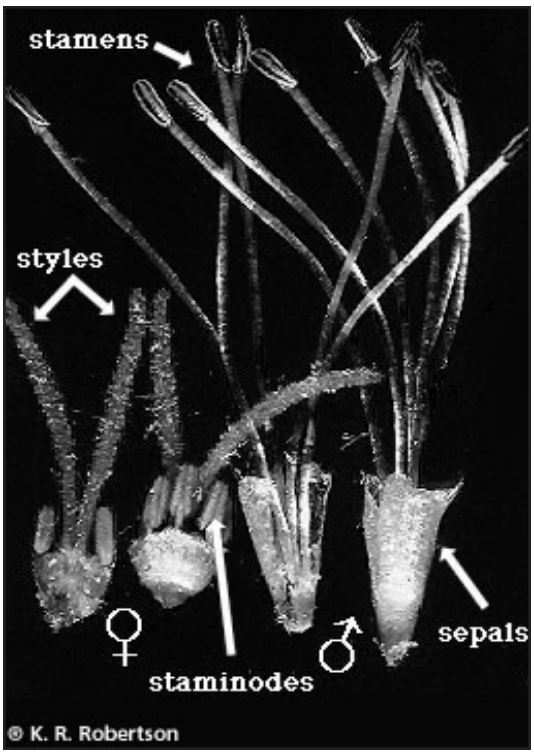


Figure 12.24 *Acer saccharinum* female and male flowers

STAMINATE FLOWER

1. Examine a staminate flower. What is its symmetry?

2. **CALYX** and **COROLLA**: How many sepals and petals make up the calyx and corolla, respectively?

3. **ANDROECIUM**: Note that there are 8 stamens in the androecium of this flower. Amongst plant families in general this is an unusual number of stamens to have, but it is common in the Aceraceae.

4. **GYNOECIUM**: There is no rudimentary gynoecium in staminate flowers (Figure 12.22).

5. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of the carpellate and staminate *A. platanoides* flowers, making sure to include their floral formulas. Follow the format as instructed in Lab 3: Floral Terminology.

Acer rubrum L. (Red Maple)

The flowers of maples range from comparatively showy and insect-pollinated like *A. platanoides* to small, inconspicuous and wind-pollinated. Many are intermediate between the two. Examine the *Acer rubrum* flowers provided, comparing their structure to what you observed for *A. platanoides*. In the male flower there are 8 stamens arising off a nectariferous disk. How can you tell that these stamens are functional? - Check if they contain pollen! These stamens surround a small, non-functional gynoecium. In the female flower there is a large, glabrous, bilocular ovary with 2 distinct styles. The ovary is visibly compressed and has 2 projecting wing-like protuberances. You can also see staminodes arising off a nectariferous disk. Based on this description and your own observations, what is their pollination mechanism?

Acer saccharinum L. (Silver Maple)

The flowers of *A. saccharinum* are adapted to wind pollination rather than insect pollination. This species blooms very early in the spring before the leaves appear. The female flowers have 2 long styles that project outward to catch windblown pollen. Note the staminodes in the female flowers. The male flowers have very long filaments to place the anthers out where they can pick up the pollen grains from the wind. In both flowers, petals and nectar disks are absent (Figures 12.23 and 12.24).

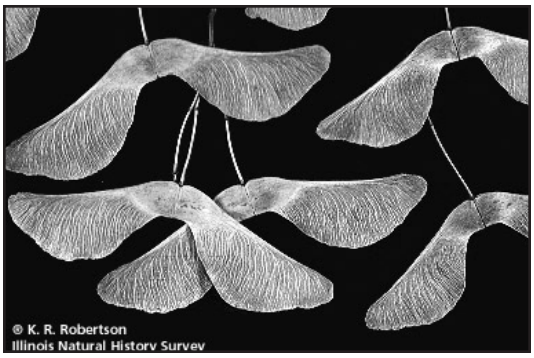


Figure 12.25 *Acer platanoides* **SAMAROID SCHIZOCARPS**.

Figure 12.26 *Acer rubrum* leaves.

Box 5

FRUIT TYPE

- Fruit a schizocarp that breaks into samaras (thus **SAMAROID SCHIZOCARP** fruits)

***Acer* spp. (Maples)**

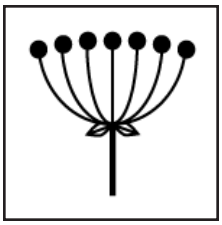
As with the Apiaceae family, Aceraceae produces **SCHIZOCARPS**. However, these schizocarps are special in that their **MERICARPS** are **SAMARAS**, or winged achenes. Thus, the proper name for the fruits are **SAMAROID SCHIZOCARPS**.

HABIT AND VEGETATIVE CHARACTERISTICS

- Deciduous trees
- Opposite leaf arrangement and palmately lobed leaf margin

***Acer* spp. (Maples)**

Learn the vegetative characteristics of these plants by examining the fresh material and herbarium specimens provided (Figure 12.26). Then sketch out a typical Aceraceae species leaf in Box 5, making sure to label its parts.



APIACEAE (UMBELLIFERAE)

CARROT FAMILY

Eudicots: Asterid Clade

♂ or ♀ $\frac{Ca^5\ Co^5\ A^5}{G\ ②}$

Figure 12.27 Umbel inflorescence of *Daucus carota*.

Figure 12.28 *Anethum graveolens* umbel inflorescence.

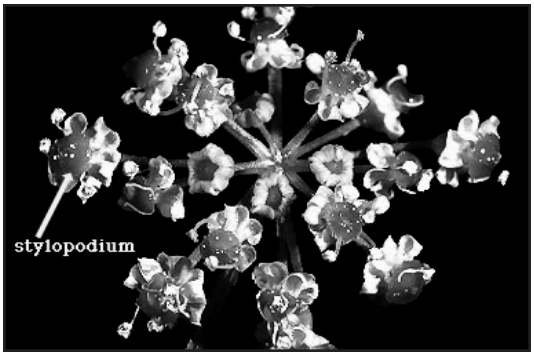


Figure 12.29 Umbel inflorescence of *Pastinaca sativa* flowers. Flowers possess a **STYLOPODIUM**.

INFLORESCENCE TYPE

- Simple or compound umbels

***Angelica atropurpurea* L. (Purplestem Angelica)**
***Daucus carota* L. (Queen Anne's Lace)**

Examine the compound umbels provided (Figure 12.27). Is an umbel inflorescence considered determinant or indeterminant? Also, what part usually present in most inflorescence types is missing in umbel inflorescences?

FLORAL CHARACTERISTICS

- Small flowers with a syncarpous gynoecium composed of 2 connate carpels and an inferior ovary
- Has a **STYLOPODIUM** (an enlargement at the style's base

***Anethum graveolens* L. (Dill)**

To observe the floral morphology typical of Apiaceae, you will examine and dissect a *A. graveolens* flower.

1. Observe a flower. What is its symmetry?

2. **CALYX**: Try to find the sepals. If they are not obvious, examine under magnification the shoulder of the ovary between and slightly outside of the petals. The small bumps or protuberances that you see there are actually the very reduced sepals. In some flowers the sepals are completely absent and in others, such as *Coriandrum*, the sepals are obvious.

3. **COROLLA**: The petals making up the corolla have an unusual shape, being pocketed or deeply contoured

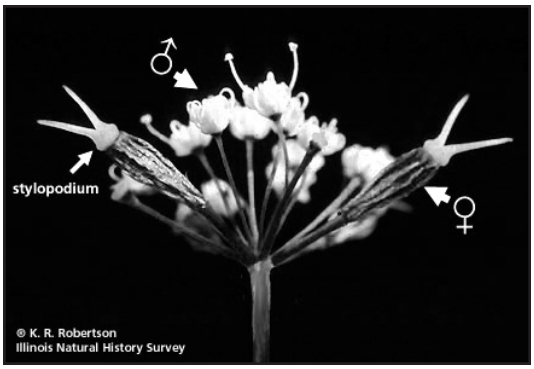


Figure 12.30 *Osmorhiza longistylis* umbel inflorescence containing male and female flowers.

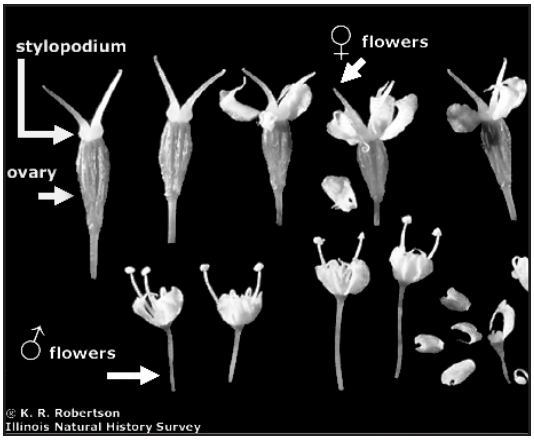


Figure 12.31 Close-up of *Osmorhiza longistylis* male and female flowers.

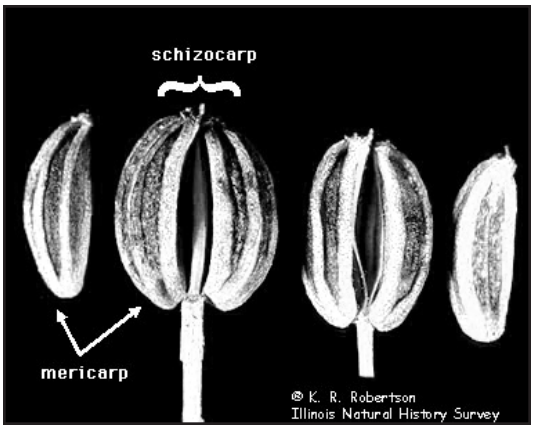


Figure 12.32 Schizocarps of *Zizia aurea*, or Golden Alexanders.

and partially enclosing the anthers in these pockets.

4. **ANDROECIUM**: How many stamens do you see? Because each of the five stamens in these flowers matures at different times, not all stamens may be seen. In younger flowers, the stamens may still be enclosed by the petals. Also, note how the filament attaches near the summit of the ovary but under the swollen bases of the style (called **STYLOPODIUM**).

5. **GYNOECIUM**: How many carpels fused to create the syncarpous gynoecium of this flower and how can you tell? Is the ovary superior or inferior and what is the insertion type for the flower?

***Osmorhiza longistylis* (Torr.) DC. (Longstyle Sweetroot)**

In this species, there are separate staminate and carpellate flowers (Figure 12.30). If both flower genders are located on the same plant, what is the plant condition?

Note the inferior ovary of the carpellate flowers and the prominant **STYLOPODIUM** at the top of the ovary (Figure 12.31).

FRUIT TYPE

- Fruit is a **SCHIZOCARP** made up of 2 **MERICARPS** joined together by a **CARPOPHORE**
- Mericarps contain oil tubes

***Anethum graveolens* L. (Dill)**
***Apium graveolens* L. (Celery)**
***Cuminum cyminum* L. (Cumin)**
***Foeniculum vulgare* Mill. (Fennel)**
***Aethusa cynapium* L. (Fool's Parsley)**
***Osmorhiza claytonia* (Michx.) C.B. Clark. (Sweetroot)**

Observe the Apiaceae **SCHIZOCARP** fruits provided. In mature fruits, each carpel of the ovary separates from a slender axis called a **CARPOPHORE** (Figure 12.32). When the fruit splits apart, each carpel section is called a **MERICARP**. What other families have we studied this semester produce **SCHIZOCARP** fruits?

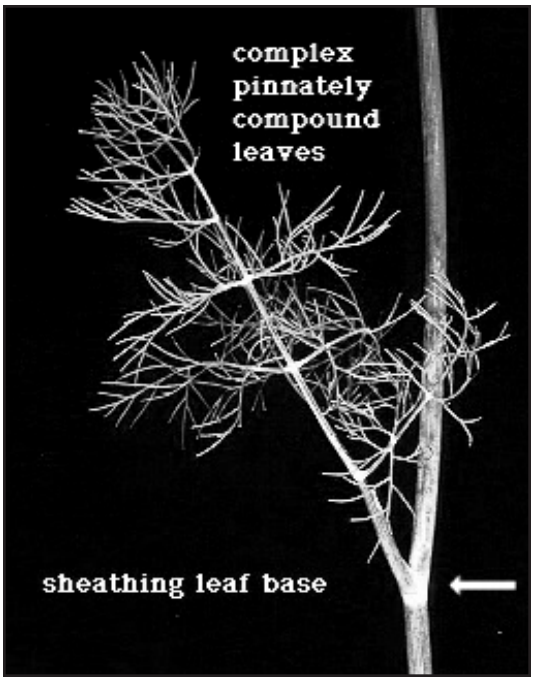


Figure 12.33 Pinnately compound leaves of *Anethum graveolens*, or dill.

Box 6

HABIT AND VEGETATIVE CHARACTERISTICS

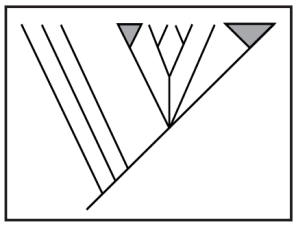
- Herbs that possess hollow stems, are aromatic and sometimes are deadly poisonous
- Leaves are mostly pinnately compound with a sheathing leaf base and display alternate arrangement

***Coriandrum sativum* L. (Coriander)**

Try to pick out some of the vegetative characteristics of this family, especially those listed above, on the coriander plant on display. Also, if there are flowers on the plant, check out their distinctive sepals.

***Anethum graveolens* L. (Dill)**
***Daucus carota* subsp. *sativus* (Carrot)**

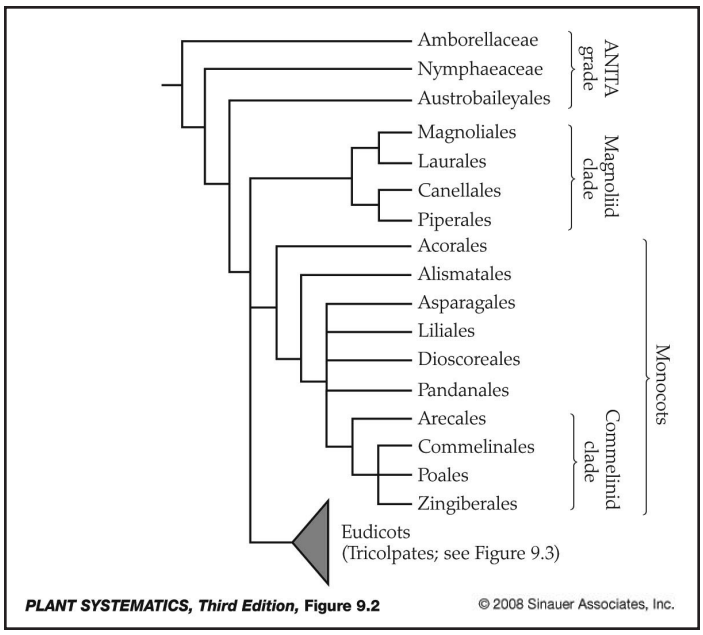
Cut a cross-section of the fresh dill (Figure 12.33) and carrot stems available. What do you notice about them? Now sketch the cross section in Box 6.



LABORATORY 13

ARACEAE, ORCHIDACEAE, IRIDACEAE, LILIACEAE, ARECACEAE AND POACEAE

PHYLOGENETIC RELATIONSHIPS



In a cladogram from Zomlefer (1994) showing the relationships of traditional "dicotyledons" and monocotyledons, the traditional "dicots" are paraphyletic, while the monocots are monophyletic. Therefore, the traditional dicot versus monocot split of angiosperms is invalid. Synapomorphies for the monocots include parallel-veined leaves, embryos with one cotyledon, sieve cell plastids with cuneate protein bodies and DNA sequences. Stems with scattered vascular bundles and adventitious roots also characterize the monocots, but these characters also occur in the "dicot" family Nymphaeaceae. There may be exceptions (such as some monocots having pinnate to palmate leaves with obviously reticulate ventation patterns, like the Araceae), but these are reversals of character states. Three-merous flowers and the herbaceous habit, characters often used to circumscribe the monocots, also occur in Nymphaeaceae and relatives and in some magnoliids. The monocot clade plus the "dicot" families Aristolochiaceae, Piperaceae and Nymphaeaceae are known as the paleoherbs. In the Zomlefer cladogram, these families are closely allied with the monocots. In the Judd et al. text, these families arise in the Magnoliid clade and more basally within the tree (e.g., in the "basal families" group). The monocots are divided into 11 orders. In today's Lab you will see a diversity of monocot families, but we will emphasize only six: Araceae (Alismatales), Orchidaceae and Iridaceae (Asparagales), Liliaceae (Order Lilales, or the petaloid monocots), Arecaceae (Arecales), and Poaceae (Poales). The families of the orders Arecales, Poales, Commelinales and Zingiberales comprise the Commelinid clade of the Monocots.

Your textbook treats Liliaceae in the strict sense (recognizing only 22 genera), whereas in this class we take a broad view of the family (and recognize Liliaceae sensu lato). Those species with inferior ovaries, a connate perianth with adnate stamens, or a corona, or those with a "tree-like" or succulent habit are treated in at least nine other families (see Table 19 in Zomlefer).

Poaceae is a large and complex family has been divided into 2-12 subfamilies and as many as 60 tribes. This lab is meant to give you a broad overview of Poaceae morphology without going into depth on the subfamily characteristics.

ARACEAE

ARUM FAMILY

Monocot Clade

♂ or ♀ $Ca^{0 \text{ or } 2\text{-}3}\ Co^{0 \text{ or } 2\text{-}3}\ A^{4\text{-}10}\ \underline{G^{(2\text{-}4)}}$

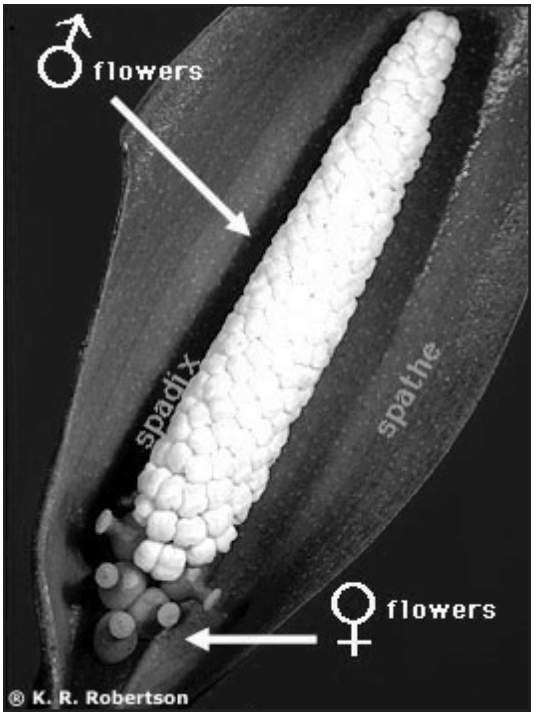


Figure 13.1 Close-up of an *Aglaconema modestum* **SPADIX** and **SPATHE**.

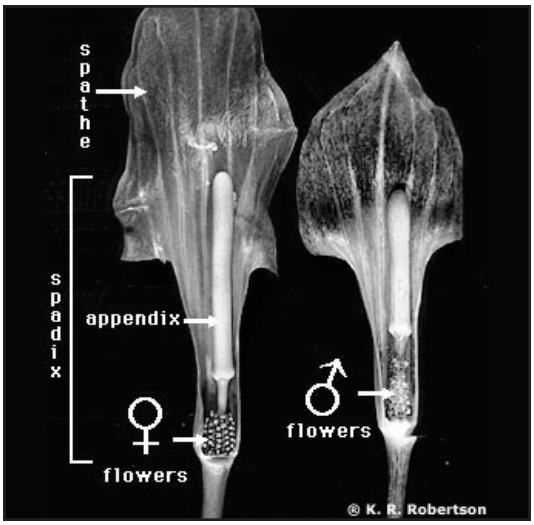


Figure 13.2 *Arisaema triphyllum* inflorescences.

FLORAL CHARACTERISTICS

- Inflorescence is a **SPADIX** subtended by a **SPATHE**
- Flowers very reduced, often sunken into **SPADIX**

***Zantedeschia* spp. (Calla Lily)**

Examine the **SPADIX** inflorescence, where many reduced flowers are crowded onto a fleshy axis. Subtending the **SPADIX** is a (often) colorful bract called a **SPATHE**. The tiny, highly reduced flowers lack or have an inconspicuous perianth, are often sunken into the **SPADIX** and can be perfect or imperfect. When imperfect, female flowers are generally located on the bottom of the **SPADIX** while male flowers are located at the top.

***Aglaconema modestum* Schott (Chinese Evergreen)**
***Arisaema triphyllum* (L.) Schott (Jack-in-the-Pulpit)**

A. modestum contains both male and female flowers on its spadix inflorescence (Figure 13.1). Thus, what is the plant condition?

In the *Arisaema* genus, the **SPADIX** has a large sterile appendix and the flowers are confined to the lowermost part (Figure 13.2). Further, male and female flowers are found on separate spadix inflorescences. What is the plant condition of *A. triphyllum*?

Figure 13.3 *Arisaema triphyllum* multiple fruit.

FRUIT TYPE

- Produce multiple fruits of berries

***Arisaema dracontium* (L.) Schott (Green Dragon)**
***Arisaema triphyllum* (L.) Schott (Jack-in-the-Pulpit)**

Check out the herbarium specimens of Araceae. Each of the flowers clustered on the **SPADIX** of these plants has produced a berry fruit (Figure 13.3). What is the name of a fruit formed from several separate flowers crowded together on a compact inflorescence?

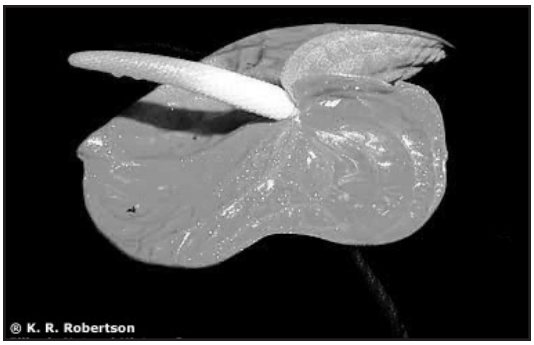


Figure 13.4 An *Anthurium* **SPADIX** and **SPATHE**.

HABIT AND VEGETATIVE CHARACTERISTICS

- Perennial herbs or woody vines
- Basal leaves with sheathing bases
- Parallel, pinnate or palmate leaf venation
- Leaves often with **RAPHIDES** (needle-like crystals) of calcium oxalate

***Anthurium* spp. (Flamingo Flower)**

Check out the **SPADIX** inflorescence of *Anthurium* surrounded by its bright red **SPATHE** (Figure 13.4). Like many other Araceae species, *Anthurium* has an herbaceous habit. Additionally, its tissue contains bundles of needle-like crystals (**RAPHIDES**) of calcium oxalate that can cause painful injury to the mouth and throat. No matter what your TA says, do not chew on these plants! What type of leaf arrangement and venation does *Anthurium* possess?

Figure 13.5 An *Amorphophallus titanum* inflorescence.

***Amorphophallus titanum* (Becc.) Becc. ex Arcang**

Remember this plant from Lab 2: Vegetative Terminology? The titan arum develops from a **CORM** and then spends years in the vegetative part of its lifecycle (Figure 13.5). What is a **CORM**?

After the vegetative stage is complete, the species will bloom and emit a “rotting-fish-with-burnt-sugar” odor to attract its natural pollinators, carrion beetles and flesh flies. The titan arum is often said to have the “world’s largest flower”. Based on what you now know about Araceae species, is this a botanically accurate statement? Why or why not?

ORCHIDACEAE

ORCHID FAMILY

Monocot Clade

$$\text{♀}\ \frac{\text{Ca}^{3}\ \text{CoZ}^{\,3}\ \text{A}^{1\text{ or }(2)\,(3)}}{\text{G}^{\textcircled{3}}}$$

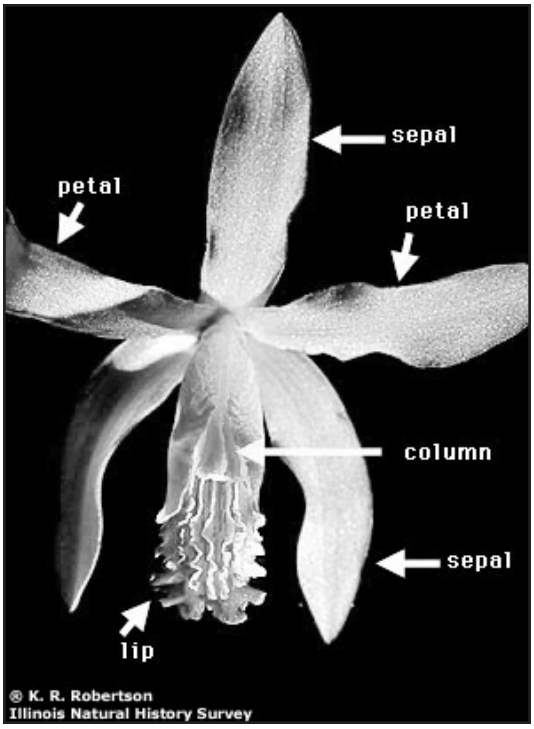


Figure 13.6 A *Bletilla striata* flower.

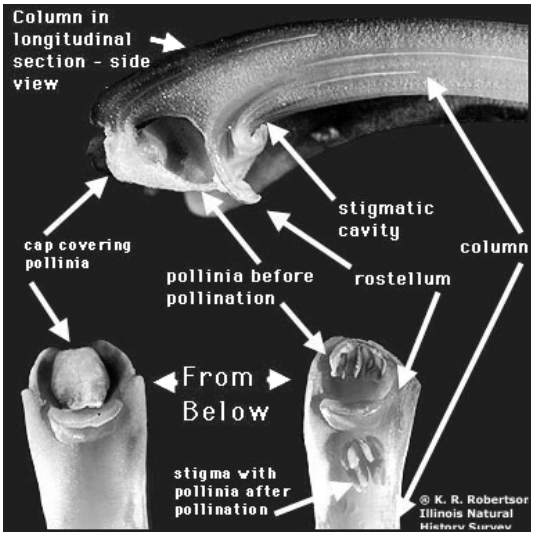


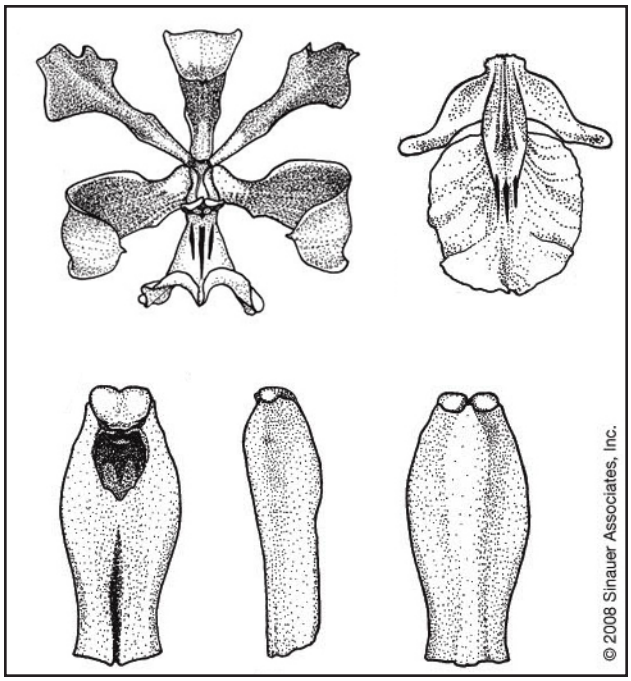
Figure 13.7 Close-up of a *Bletilla striata* column.

FLORAL CHARACTERISTICS

- Zygomorphic, resupinate flowers
- Stigma, style and androecium adnate forming a **COLUMN**

***Dendrobium* spp. (Dendrobium)**
***Phalaenopsis* spp. (Moth Orchids)**

The Orchidaceae family is characterized as having strikingly zygomorphic, 3-merous flowers with a highly-specialized middle petal (called a **LIP** or **LABELLUM**, which may be highly modified in shape and color). The stigma, style and androecium are adnate, forming a **COLUMN** (Figures 13.6 and 13.7). This **COLUMN** of Orchidaceae is unique among monocots and is analogous to the **GYNOSTEGIUM** found in Asclepiadaceae. One stamen makes up the androecium, with its cap-like anther separated from the receptive part of the stigma by the **ROSTELLUM** (the central, sterile lobe of the stigma.) Pollen is agglutinated into **POLLINEA**. Label these structures on the illustration provided below. Then, take some time to appreciate the complexity of orchid flowers especially when you visit the Orchid room of the Plant Biology Collections.



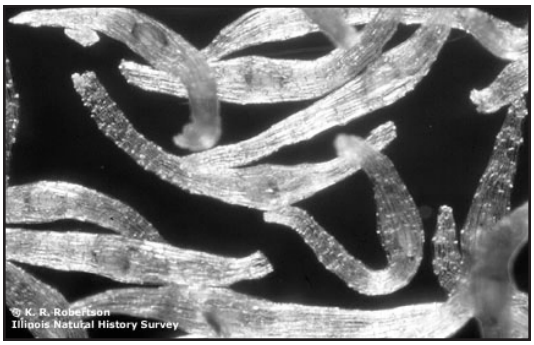


Figure 13.8 *Close-up of Cypripedium parviflorum* seeds.

FRUIT TYPE

- Fruit is a loculicidal capsule

Miscellaneous Orchidaceae spp.

The seeds found in the loculicidal capsules of orchid species are microscopic and often require a fungal symbiont to germinate (Figure 13.8).

Figure 13.9 A *Phalaenopsis* orchid.

HABIT AND VEGETATIVE CHARACTERISTICS

- Possess a **PSEUDOBULB** and **VELAMEN** covering the adventitious roots

Miscellaneous Orchidaceae spp.

In epiphytic species of Orchidaceae, which are largely limited to the tropics, the leaf blade often arises from a **PSEUDOBULB**, and the whitish, cord-like, adventitious roots have a **VELAMEN** covering (Figure 13.9). What is the purpose of the **VELAMEN** covering?

IRIDACEAE

IRIS FAMILY

Monocot Clade

$$\frac{\text{♀}\ \text{Ca}^3\ \text{Co}^3\ \text{A}^3}{\text{G}\ \textcircled{3}}$$

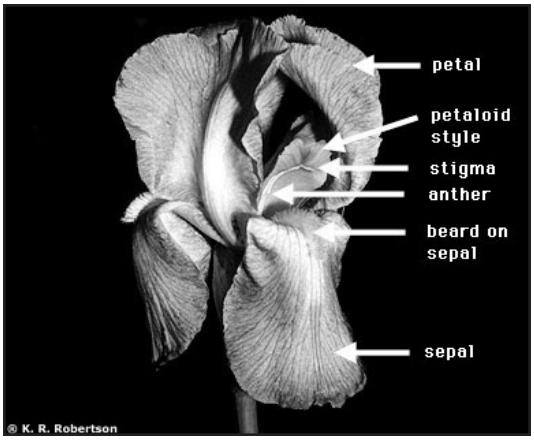


Figure 13.10 An *Iris* flower.

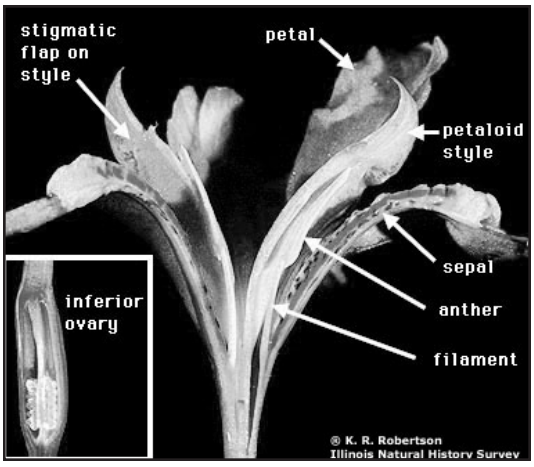


Figure 13.11 Longitudinal section of an *Iris cristata* flower.

Box 1

FLORAL CHARACTERISTICS

- Petaloid sepals (thus, petals and sepals may both be referred to as tepals)
- Style is petaloid

***Iris* spp. (Iris)**

To learn the floral characteristics of Iridaceae, you will examine and dissect an *Iris* flower.

1. Examine a flower (Figure 13.10). What is its floral symmetry?

2. **CALYX** and **COROLLA**: Observe the 3-merous petaloid perianth of this flower. The large **TEPALS** of the outer perianth (called “falls”) are spreading and deflexed, while those of the inner whorl (called “standards”) are smaller and erect (Figure 13.11).

3. **ANDROECIUM**: How many stamens make up the androecium? Do you detect any adnation or connation?

4. **GYNOECIUM**: In *Iris*, the styles of the gynoecium are flat, petaloid and colorful. Observe how the three style branches curve along the tepals, forming a protective covering over the stamens. A flap-like stigma is situated on the underside of each style branch near the top. What is the gynoecium and ovary type? In Box 1, sketch and label a cross section of the ovary.

Figure 13.12 Close-up of an *Iris foetidissima* capsule.

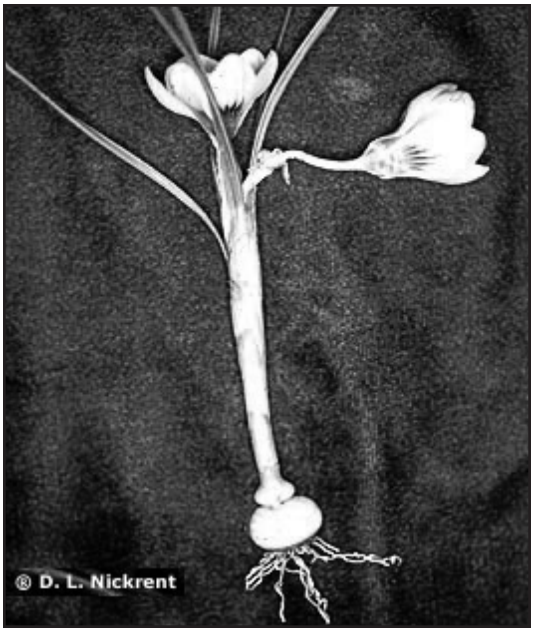


Figure 13.13 A *Crocus* corm.

Figure 13.14 **EQUITANT** leaves of an *Iris* plant.

FRUIT TYPE

- Fruit is a loculicidal capsule

***Iris pseudacorus* L. (Pale Yellow Iris)**
***Sisyrinchium albidum* Raf. (White Blue-Eyed Grass)**

Examine the loculicidal capsules on display (Figure 13.12). Make sure that you can differentiate between a loculicidal and a septicidal capsule! Remember that a loculicidal capsule will split open between the septa into the locule to release its seeds whereas a septicidal capsule will split open along its septa.

HABIT AND VEGETATIVE CHARACTERISTICS

- Perennial herbs with bulbs, rhizomes or corms
- Leaves are 2-ranked (**EQUITANT**) and sheathing at base

***Crocus* spp. (Crocus)**
***Iris* spp. (Iris)**

Iridaceae is composed of many perennial species that possess bulbs, rhizomes or corms (Figure 13.13).

***Neomarica* spp. (Walking Iris or Apostle Plant)**

Look at the leaves of this plant (Figure 13.14). Characteristic of Iridaceae, the leaves are described as 2-ranked or **EQUITANT**. What does this mean?

LILIACEAE

LILY FAMILY

Monocot Clade

$$\text{♀}\ \frac{Ca^3\ Co^3\ A^6\ G\textcircled{3}}{}$$

OR

$$\text{♂}\ \frac{Ca^3\ Co^3\ A^6}{G\textcircled{3}}$$

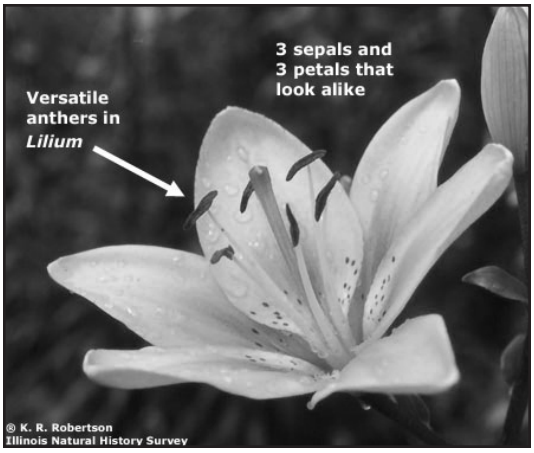


Figure 13.15 *Lilium* 3-merous flower with versatile anthers

Figure 13.16 Close-up of a *Lilium* flower.

Box 2

FLORAL CHARACTERISTICS

- Petals and sepals look similar (**TEPALS**)
- 3-merous flowers
- Anthers **VERSATILE**

***Lilium* spp. (Lily)**

To learn the floral characteristics of Liliaceae, you will examine and dissect a *Lilium* flower (Figure 13.15).

1. Examine a flower. What is its floral symmetry?

2. **CALYX** and **COROLLA**: How many sepals and petals are there? In this family the sepals and petals are often hard to distinguish from one another. What is the name assigned to them in this case?

3. **ANDROECIUM**: How many stamens make up the androecium? Do you detect any adnation or connation? In this family the anthers are **VERSATILE**. What does this mean?

4. **GYNOECIUM**: The syncarpous gynoecium of this flower is made up of how many connate carpels? Is the ovary superior or inferior? Make a cross section through the center of the ovary, examine it with your dissecting scope, and then sketch it in Box 2. What is the insertion type and placentation type?

5. **DRAWING PORTFOLIO:** Draw a floral diagram of a longitudinal section (L.S.) of *Lilium* spp. as well as a cross section (X.S.) of its ovary, making sure to include its floral formula. Follow the format as instructed in Lab 3: Floral Terminology.

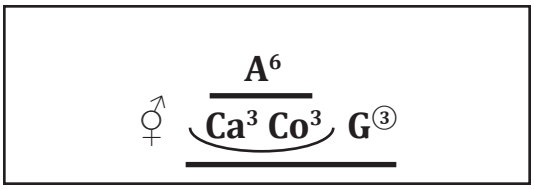


Figure 13.17 Close-up of a *Polygonatum* flower.

We will only focus on the floral morphology characteristic of the majority of Liliaceae species, but there are some species that require a unique floral formula. As you can see, these species have 3 sepals in the calyx, 3 petals in the corolla and 6 epipetalous stamens in the androecium. The perianth is connate with adnate stamens ("epi-tepalous"). The flower's syncarpous gynoecium is composed of three connate carpels with a superior ovary.

Figure 13.18 A *Hemerocallis* capsule.

FRUIT TYPE

- Fruit is a capsule

***Hemerocallis* spp. (Day Lily)**

One of the fruit types commonly produced by Liliaceae species is a capsule (Figure 13.18). What type of gynoecium do capsules always arise from? Specifically, what capsule type is on display?

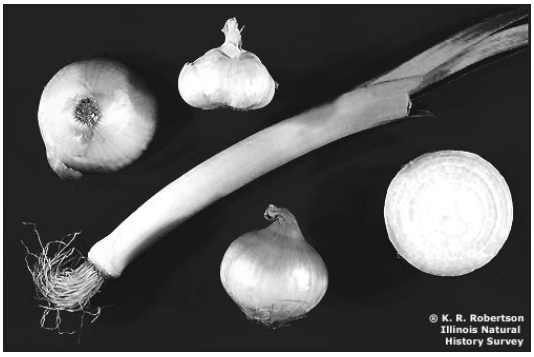


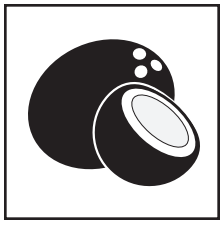
Figure 13.19 Bulbs, corms and rhizomes from Liliaceae species.

HABIT AND VEGETATIVE CHARACTERISTICS

- Perennial herbs with bulbs, rhizomes or corms

***Allium* spp. (Onion)**
***Allium sativum* L. (Garlic)**
***Lilium* spp. (Lily)**
***Tulipa* spp. (Tulip)**

Like Iridaceae, many members of Liliaceae have underground structures that enable the plants to be perennial (Figure 13.19). Onions, garlic, lilies and tulips all produce bulbs. Corms and rhizomes are also found in the Liliaceae. What characteristics can you use to differentiate between these stem types?



ARECACEAE (PALMAE)

PALM FAMILY

Monocot Clade

♀ or ♂ ♀ $Ca^3\ Co^3\ A^6\ G^{3\ or\ \textcircled{3}}$

Figure 13.20 *Cocos nucifera* inflorescences.

Figure 13.21 *Roystonea borinquena* flowers.

FLORAL CHARACTERISTICS

- Small perfect or imperfect flowers
- Flowers usually 3-merous

***Chamaedorea* spp. (Palm)**

The perfect or imperfect flowers characteristic of this family are found in highly branched inflorescences subtended by large, basal sheaths (bracts). When perfect, the flowers themselves consist of 3 distinct sepals, 3 distinct petals, 6 stamens and an apocarpous or syncarpous gynoecium of 3 carpels. Fusion of the floral series varies considerably among the genera in this family.

***Cocos nucifera* L. (Coconut)**

Coconuts produce inflorescences of imperfect flowers (Figure 13.20). Note that the staminate flowers are above the few carpellate flowers. What is the plant condition when both staminate and carpellate flowers are located on the same plant?

***Roystonea borinquena* O.F. Cook (Puerto Rico royal palm)**

Observe the closeup photograph of Puerto Rico royal palm flowers in bloom (Figure 13.21).

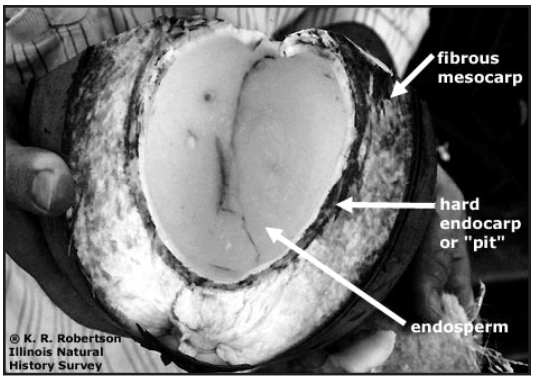


Figure 13.22 *Cocos nucifera* drupe.

Figure 13.23 *Lodoicea maldivica* drupe.

Figure 13.24 Unbranched trunk of *Areca catechu*.

FRUIT TYPE

- Fruit is either a drupe or berry

***Cocos nucifera* L. (Coconut)**

Most species within the Arecaceae produce drupe fruits (or 1-seeded berries) exhibiting fleshy, fibrous or leathery mesocarps (Figure 13.22). In the case of the coconut, the husk (consisting of the mesocarp and exocarp), which is usually removed before the rest of the fruit is sold in markets, is very fibrous. What purpose do you think this fibrous mesocarp serves?

The part of the coconut you buy in grocery stores is the "pit" or endocarp. The edible portion of a coconut is the seed within the endocarp, and it comprises both solid "meat" and liquid "milk" endosperm.

***Lodoicea maldivica* (J.F. Gmel.) Pers.**

Lodoicea maldivica, commonly called Coco-de-mer or Double Coconut, is a dioecious species that produces the world's largest seed, weighing up to 38.7 pounds (Figure 13.23). To produce its "double coconut" fruit, the flowers mature over a six to seven year span. *L. maldivica* is currently listed as endangered and is restricted to the Seychelles island in the Indian Ocean. Neat isn't it?

HABIT AND VEGETATIVE CHARACTERISTICS

- Trees or shrubs with unbranched trunks but without secondary growth
- Leaves pinnately or palmately divided or compound with large basal sheaths

***Areca catechu* L. (Betal Palm)**

The "woody" trunk of species in this family is composed of many interconnected vascular bundles and fibers; true wood, from a permanent vascular cambium, is not produced. Also, the trunks are often covered with the remains of overlapping leaf bases, which add structural rigidity. The persistent petioles can sometimes act as spines. Make sure to check out the additional Arecaceae family members found in the Conservatory.

POACEAE

GRASS FAMILY

Monocot Clade

♀ or ♂ ♀ $Ca^2\ Co^0\ A^3\ G^{(2-3)}$

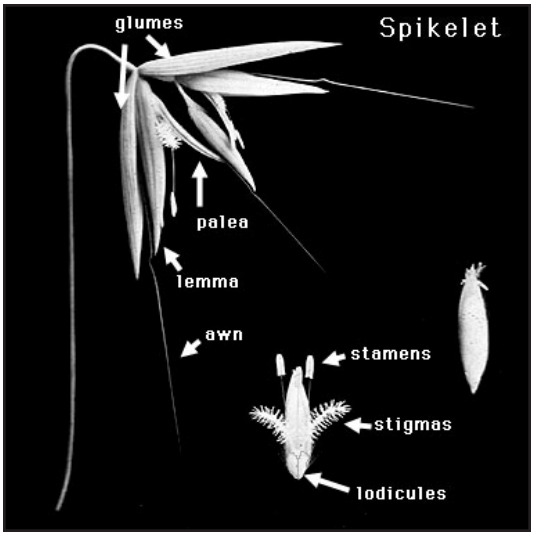


Figure 13.25 Spikelet of *Avena fatua*.

Box 3

FLORAL CHARACTERISTICS

- Inflorescence is a **SPIKELET**
- **SPIKELET** and **FLORET** terminology important

***Avena* spp. (Oats)**
***Triticum* spp. (Wheat)**

The **SPIKELET** inflorescences found in Poaceae are subtended by 2 bracts (**GLUMES**) and arranged in various secondary inflorescences (i.e. spikes, racemes or panicles). The flowers themselves are reduced, subtended by 2 bracts (**PALEA** and **LEMMA**), and are collectively called the **FLORET** (Figure 13.25). The perianth is reduced to scales (**LODICULES**), and there are usually 3 stamens in the androecium. Two to three connate carpels (typically 3 carpels with 2 styles) make up the syncarpous gynoecium in these flowers.

Be sure you understand the relationship among primary (first or lower) and secondary (second or upper) **GLUMES**, **PALEA**, **LEMMA**, **FLORET**, flower, **RACHILLA** and **SPIKELET**. Create your own drawing of a Poaceae spikelet in Box 3, making sure to label all the terms listed above. Use the live material on display as well as the provided photographs to help you.

Figure 13.26 Tassels and ears of *Zea mays*.

***Zea mays* L. (Corn)**

Perhaps the most familiar grass in Illinois today is *Zea mays*, or corn. The flowers are imperfect and the plants are monoecious. The staminate flowers are produced in tassels at the top of the plant, while the female flowers are born in "ears". In light of this, what actually is the stuff protruding out of an ear of corn that we commonly call "corn silk"?

Figure 13.27 **CARYOPSIS** fruits of rice, wheat and corn.

FRUIT TYPE

- Fruit is a **CARYOPSIS**

***Hordeum vulgare* L. (Common Barley)**
***Secale cereale* L. (Cereal Rye)**
***Triticum aestivum* L. (Common Wheat)**
***Zea mays* L. (Corn)**

All members of the Poaceae family produce **CARYOPSIS** fruits (Figure 13.27). This fruit type is basically an achene where the pericarp is fused to the seed coat. How does this differ from an achene?

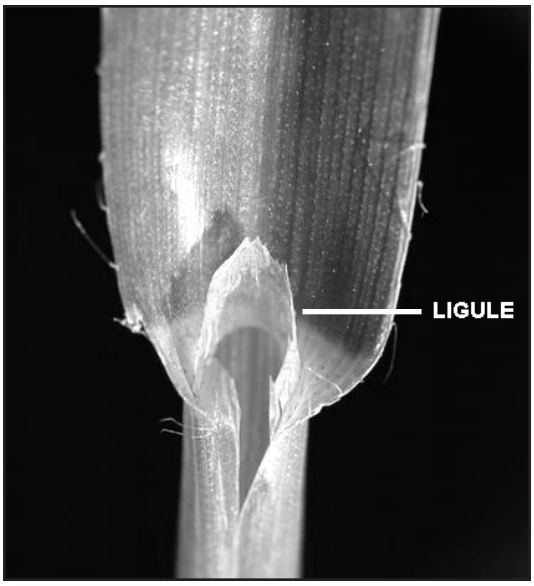


Figure 13.28 **LIGULE** of a Poaceae species.

HABIT AND VEGETATIVE CHARACTERISTICS

- Annual or perennial herbs

***Avena* spp. (Oats)**
***Triticum* spp. (Wheat)**

What is the habit of Poaceae species? The plants in Poaceae have rhizomes or stolons and possess **TERETE** (round in cross section) stems (**CULMS**) with hollow internodes. Observe the 2-ranked leaves. What type of leaf attachment is being demonstrated? Notice that a **LIGULE** is present at the junction of blade and sheath (Figure 13.28).

Practice Lecture Exam 1

For each of the multiple choice questions below, circle the one correct response.

1. What is taxonomy?

   a) At the same time, the most basic and the most derived or synthetic field of biology.
   b) The science of classification, especially the classification of biological organisms.
   c) The study and description of the variation of organisms, the investigation of the causes and consequences of this variation, and the manipulation of the data to produce a system of classification.
   d) All of the above.

2. Which of the following groups of taxa is written in the correct DESCENDING order of the taxonomic hierarchy?

   a) Magnoliopsida, Magnoliophyta, Magnoliales, Magnoliaceae, *Magnolia virginiana*
   b) Magnoliophyta, Liliopsida, Poaceae, Cyperaceae, *Zea mays*
   c) Magnoliophyta, Magnoliopsida, Asteraceae, Asterales, *Aster tenuifolius*
   d) Magnoliopsida, Malvales, Sterculiaceae, *Theobroma*, *Theobroma cacao*

3. What is wrong with this sentence, paraphrased from a popular nature magazine? "*There is only one specie of plant, of which I am aware, that can be used in the religious exercises of the Buibui tribe.*"

   a) The name of the plant family is not provided, and it should be.
   b) The word "specie" must be underlined.
   c) The word "specie" is written incorrectly. "Species" is both singular and plural.
   d) There are actually two species of plants that are used by the Buibuies.

4. Approximately how many extant species of flowering plants are there?

   a) 520,000
   b) 280,000
   c) 130,000
   d) 36,000

5. You discover a new species of *Theobroma* (*T. cacao* is the source of cacao, or chocolate) and want to honor one of your first plant taxonomy instructors, Danielle Ruffatto, by naming the species after her. Unfortunately, while you were collecting these plants you were hit on the head with a liana and had to be told that your surname is Smith. What is the best correct scientific name of your new species, student Smith?

   a) *Theobroma smithii* Ruffatto
   b) *Theobroma cacao* (Ruffatto) Smith
   c) *Theobroma cacao* 'Ruffatto'
   d) *Theobroma ruffattiana* Smith

6. A herbaceous plant:

    a) always completes its life cycle in one growing season.
    b) may have underground perennial structures like corms or tubers.
    c) develops persistent above ground woody tissue.
    d) All of the above.

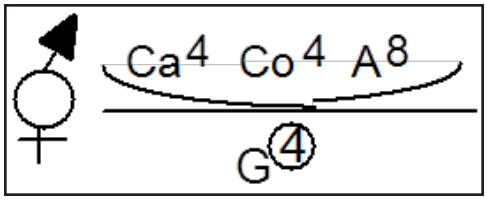
7. *Fragaria virginiana* is the wild strawberry of eastern North America. *Fragaria chiloensis* is the wild strawberry of western North America and South America. The cultivated strawberry is a hybrid of these two species. The scientific name of this hybrid may be written correctly in what way?

    a) *Fragaria chiloensis* + *F. virginiana*
    b) *Fragaria virginiana* cv. 'Sweet Bite'
    c) *Fragaria virginiana* subsp. *chiloensis*
    d) *Fragaria* × *ananassa*

8. The three plant genomes differ dramatically in size and this severely affects their utility in molecular systematic study. Which genome(s) is(are) the smallest?

    a) Chloroplast
    b) Mitochondrion
    c) Nucleus
    d) Both plant mitochondrial and nuclear genomes are equally small in size.

Use this floral formula to answer the next THREE questions on this page. This formula is representative of all flowers on a single herbaceous plant.



9. The insertion of floral parts in this flower is:

    a) hypogynous
    b) epigynous
    c) perigynous
    d) synoecious

10. What type of gynoecium is exhibited by this flower?

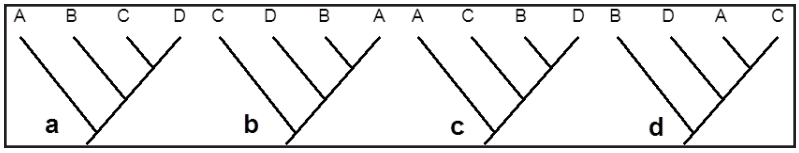
    a) monocarpous
    b) apocarpous
    c) syncarpous
    d) perigynous

11. What type of placentation would you expect NOT to occur in this flower?

    a) parietal
    b) free-central
    c) marginal
    d) axile

12. Using the data matrix below and the method of maximum parsimony, which tree is produced from the analysis of these data? For all characters, consider state "1" as the derived condition.

Species A 0 0 0 1 0 1 0 1 0
Species B 0 1 0 0 0 0 0 0 0
Species C 0 0 0 1 0 0 0 1 1
Species D 0 0 0 0 1 0 0 1 0



a) tree "a"
b) tree "b"
c) tree "c"
d) tree "d"

13. Consider tree "b" above only. If species C, D and B have been traditionally classified in the family Urticaceae and species A in the family Moraceae, the family Urticaceae is:

a) monophyletic
b) paraphyletic
c) polyphyletic
d) synapomorphic

14. Again, consider tree "b" above and the family designations of question 13. What changes to the traditional classification would have to be made in order to produce a classification that is truly phylogenetic?

a) Transfer species A into the Urticaceae.
b) Transfer species B into the Moraceae.
c) Transfer species C into a new, yet to be described family.
d) No change to the traditional classification system would be required.

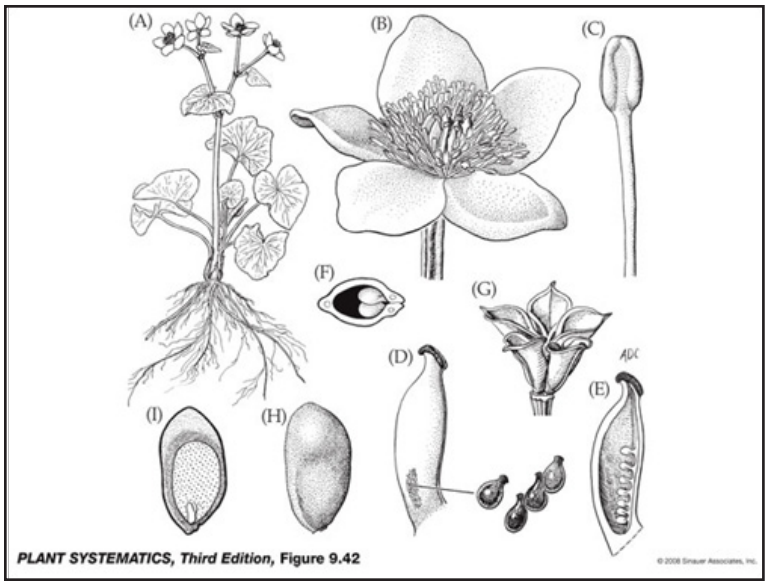
15. What family am I? I have flowers with 2 cauducous sepals, crumpled petals in bud, many stamens arranged in whorls, milky or colored latex, and a syncarpous gynoecium.

a) Magnoliaceae
b) Ranunculaceae
c) Papaveraceae
d) Moraceae

16. What is unusual about the androecium of *Hamamelis* (Hamamelidaceae)?

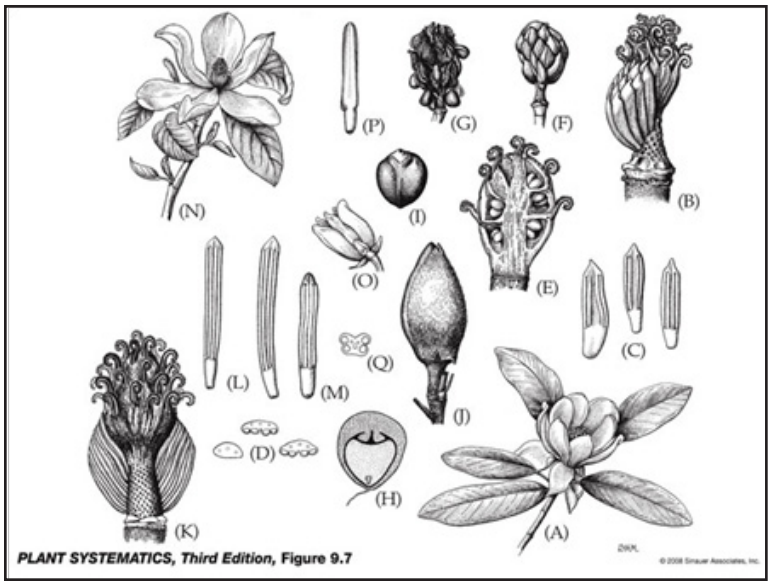
a) The pollen is ejected forcibly through a ballistic propulsion mechanism.
b) The anthers are colorful in autumn.
c) The stamens are pendulous and serve to attract pollinators.
d) Staminodes are present and the anthers open by flaps.

17. What family is illustrated below?



a) Magnoliaceae
b) Ranunculaceae
c) Papaveraceae
d) Hamamelidaceae

18. What family is illustrated below?



a) Hamamelidaceae
b) Magnoliaceae
c) Fagaceae
d) Betulaceae

19. What is a follicle?

    a) Any dry, dehiscent fruit derived from a syncarpous gynoecium.
    b) A dry fruit derived from a single carpel that opens along a single suture.
    c) A small anatomical cavity or depression in which the ovule lies.
    d) The product of the fusion of the egg and sperm nuclei.

20. Major structural rearrangements of which genome are known to be rare enough in evolution that they can be used to demarcate major groups of plants and infer evolutionary relationships? Such rearrangements include inversions and the gains and losses of genes or their introns.

    a) Chloroplast
    b) Mitochondrion
    c) Nucleus
    d) Both chloroplast and mitochondrial genomes are equally rarely rearranged.

21. What molecular technique involves the automatic replication of DNA using an enzyme and repeated cooling and heating so that millions of copies of DNA are produced from one copy of DNA in a very short period of time?

    a) polymerase chain reaction (PCR)
    b) restriction site mapping
    c) DNA polymerase
    d) amino acid translation

22. Which of the following shows an incorrect pairings between a character and its character states?

    a) life span: annual, biennial, perennial
    b) habit: herb, shrub, tree
    c) root type: rhizome, stolon, corm
    d) condition: synoecious, monoecious, dioecious

23. What is the best definition of a raceme?

    a) A determinate compound (multi-branched) inflorescence
    b) An indeterminate inflorescence in which all flowers have pedicels of equal length that arise from a single region at the apex of the inflorescence axis
    c) A compact inflorescence composed of a very short axis and usually sessile flowers
    d) A simple, indeterminate inflorescence with an elongate single axis bearing pedicellate flowers

24. Using a strict botanical definition, what are the following: green beans, tomatoes, eggplants, corn, and cucumbers?

    a) vegetables
    b) fruits
    c) accessory fruits
    d) seeds

25. What type of fruit could possibly develop from a flower having a syncarpous gynoecium?

    a) follicle
    b) aggregate
    c) capsule
    d) all of the above

26. Compare and contrast the families Fagaceae and Betulaceae. For full points, you need to indicate two shared characters and two characters where they differ. Use only those diagnostic floral/fruit and inflorescence characters emphasized in lecture. [4 points]

    2 shared chars.: _____ and _____

    Fagaceae unique char.: _____ Betulaceae unique char.: _____

27. In general terms, outline the fig wasp–fig life cycle. [4 points]

28. What is a carpel? For full points, you must provide two different components to your answer. [2 points]

29. What is the difference between an aggregate fruit and a multiple fruit? For full points, you must explain the difference clearly and provide one example of each. [4 points]

30. Use simple and neat drawings to illustrate each of the following terms. To obtain the point for each drawing, you must show all necessary critical features and label as necessary to avoid any ambiguity. [6 points; no partial credit (any error will receive a score of 0)]

A palmately compound leaf

A lanceolate leaf with serrate margin

A X.S. of a syncarpous gynoecium with axile placentation

Any leaf with a cordate base, an acuminate apex, & palmate venation

A L.S. of any perfect, incomplete flower

A drupe X.S.

31. The generic name for redbuds in *Cercis*. Linnaeus gave the specific epithet of *canadensis* to the native redbud that occurs in Illinois. Most redbuds have dark pink/mauve flowers. In Missouri, a few trees occur in the wild that have white flowers. Rehder described these white-flowered plants as a botanical form, using the epithet of *alba*. What is the complete scientific name of the white-flowered redbud? [2 points]

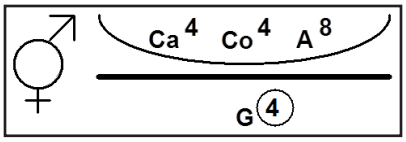
32. Draw a simple cladogram showing the relationships among the four major angiosperm groups: eudicots, monocots, magnoliids, and the ANITA grade. [3 points]

BONUS: Why is systematics important in biological investigations and to society? [3 points]

TOTAL SCORE (out of 50): _____ (maximum score with BONUS is 53 points)

PRACTICE LECTURE EXAM 2

Use this floral formula to answer the first four questions on this page. This formula is representative of all flowers on a single herbaceous plant.



1. The insertion of floral parts in this flower is:

   a) hypogynous
   b) epigynous
   c) perigynous
   d) synoecious

2. What family is best characterized by this floral formula?

   a) Brassicaceae
   b) Oleaceae
   c) Ericaceae
   d) Onagraceae

3. Which of the following statements is CORRECT given the floral formula above?

   a) The stamens are epipetalous.
   b) The flower is imperfect.
   c) The flower is wind pollinated.
   d) The flower is actinomorphic.

4. What type of fruit(s) could possibly develop from this flower?

   a) follicle
   b) capsule or berry
   c) aggregate
   d) silique or silicle

5. While dissecting a flower, you observe that it has a syncarpous gynoecium with parietal placentation, 2 locules, 1 style, 1 stigma, tetradynamous stamens, and 4 sepals and 4 petals arranged in a cross-like formation. How many carpels have likely fused to produce the gynoecium of this flower?

   a) one
   b) two
   c) four
   d) The data are insufficient to determine this.

6. Sporophytic self-incompatibility:

    a) is controlled by multiple alleles of a single gene
    b) ensures that a plant cannot produce a zygote with its own pollen
    c) is determined by the interaction between the pollen exine and stigma tissues
    d) all of the above

7. In the Indian balsam (Impatiens sp.), the nectar is held deep in the flower so that the bee has to enter the flower to get it. When all the pollen is removed, the stamens fall off to expose the sticky, receptive stigma. What type of breeding system is exhibited by this species?

    a) protogyny
    b) protandry
    c) polygamodioecy
    d) heterostyly

8. A legume fruit is derived from what type of gynoecium?

    a) monadelphous
    b) apocarpous
    c) syncarpous
    d) monocarpous

9. Fill in the blanks. In a species exhibiting a heterostylous breeding system, pollen from a _____ flower must reach the stigma of a _____ flower in order for fertilization to be successful.

    a) pin, thrum
    b) pin, pin
    c) staminate, carpellate
    d) thrum, thrum

10. Members of Fabaceae subfamilies Faboideae and Caesalpinioideae are alike in that they share:

    a) diadelphous stamens
    b) zygomorphic corollas
    c) a keel formed from the fusion of two petals
    d) all of the above

11. Plants have evolved a variety of adaptations that can either increase, reduce or maintain the amount of genetic heterozygosity in a population. Which of the following kinds of breeding systems actually increases the fitness or evolutionary potential of a species?

    a) self-pollination
    b) apomixis or agamospermy
    c) gametophytic self-incompatibility
    d) cleistogamy

12. Which of the following androecium modifications is an INCORRECT match?

    a) monadelphous stamens — Malvaceae
    b) tetradynamous stamens — Brassicaceae
    c) diadelphous stamens — Fabaceae subfamily Caesalpinioideae
    d) stamens arranged in catkins — Salicaceae

13. As seen in the video “Branching Out,” the acacias (Fabaceae subfamily Mimosoideae) of Africa have relied on elephants to:

    a) trample and bury their seeds during the long, hot, dry seasons so that they don’t dry out before they are ready to germinate
    b) disinfect the grub-infested fruits by ingesting and defecating the seeds
    c) facilitate pollination of its flowers by knocking against or rubbing the trees
    d) disperse its fruits due to their claw-like appendages which attach harmlessly to the thick elephant skin

14. The tropical durian fruit, with its foul-smelling rind that wafts over great distances and its sweet caramel custard-like pulp (... yeah, really it’s disgusting!), is favored by what type(s) of animal?

    a) rhinos
    b) orangutans and tigers
    c) cassowaries
    d) gnat flies

15. What family am I? In temperate regions, I am a perennial herb. My flowers are zygomorphic with prominent nectar guides. One of my anterior petals has a large spur, and two of my lowermost anthers bear gland-like appendages (nectaries) which extend into this spur. When an insect (usually a bee) probes for nectar, it gets showered by pollen.

    a) Brassicaceae
    b) Violaceae
    c) Ericaceae
    d) Asclepiadaceae

16. What is a diaspore?

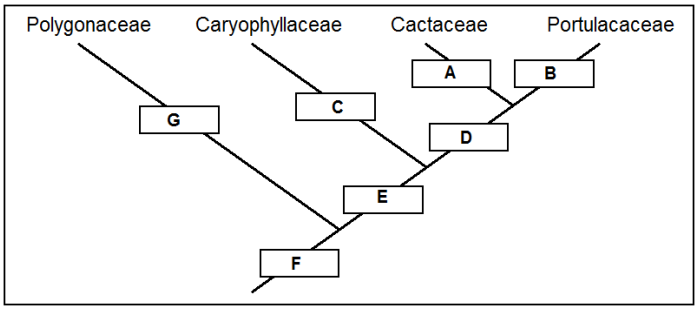
    a) Any unit of dispersal, no matter what it is morphologically
    b) The smallest of all spores, produced by fungi and dispersed most widely
    c) The breaking up and scattering of plant vegetative tissue into new areas
    d) Spores produced by a puffball and knocked from it like puffs of smoke

17. What family am I? I have yellow, sympetalous, imperfect flowers, my anthers are often connate, and my ovary is inferior. I am a herbaceous vine with tendrils. My fruit has a hard, leathery rind, its inside is fleshy with numerous seeds, are there are no septa. And, I am absolutely terrible baked into a pie.

    a) Brassicaceae
    b) Malvaceae
    c) Oleaceae
    d) Cucurbitaceae

18. *Hamamelis* (witch hazel), dwarf mistletoes, Himalayan balsam (*Impatiens* sp.) and squirting cucumber (*Echbalium*) share what kind of seed dispersal mechanism?

    a) shaker
    b) hydroscopic
    c) adhesion by viscin threads
    d) ballistic



Use this phylogeny of four families with mapped character states (A-G) to answer the following three questions.

19. The character state at position E is most likely what?

    a) The presence of betalain pigments
    b) The loss of the intron in chloroplast gene rpl2
    c) The presence of a gynophore
    d) All of the above

20. Which character states are mapped at the INCORRECT position?

	Position	Character State(s)
a)	A	Monadelphous stamens, palmately lobed and veined leaves
b)	B	Two persistent sepals, pyxis fruit
c)	D	Succulent leaves or succulent stems
d)	G	Apetalous flowers, ochrea, sepals often in two whorls of three

21. At what position on the tree would you expect to find the following synapomorphies: opposite, simple leaves; swollen nodes; distinct clawed petals; capsular fruit with apical teeth; cymose inflorescence?

    a) A
    b) C
    c) E
    d) G

22. Which of the following statements is TRUE?

    a) Champaign-Urbana receives, on average, less rain per year than London, England
    b) About ten percent (by area) of the original prairie remains in Illinois today
    c) Illinois is part of the “mixed-grass” prairie region
    d) The word prairie comes from the French for “a meadow grazed by cattle”

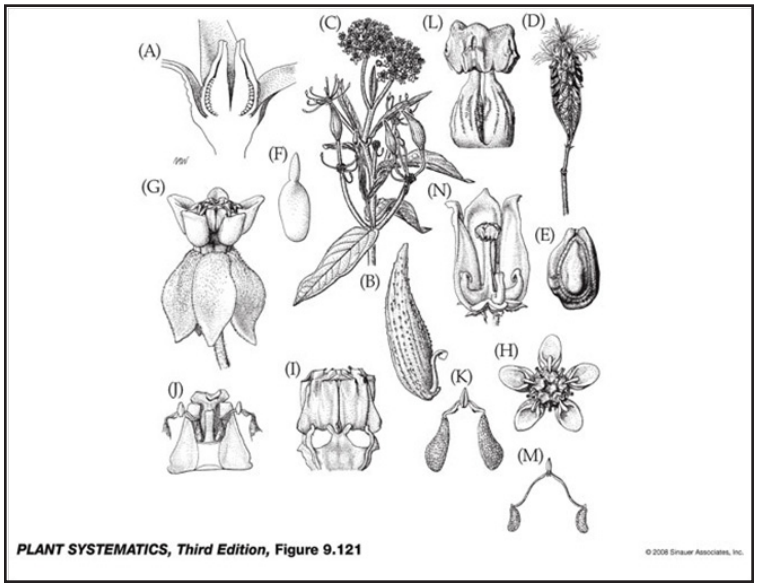
23. Prairies formed in Illinois when its climate became substantially warmer and drier (and within the relatively short time of 500 to 800 years, most of the forests in Illinois died out). This significant warming – called the hypsithermal interval – occurred how many years ago?

    a) 100,000
    b) 12,000
    c) 8,300
    d) 1,000

24. Because North American prairie ecosystems are recently developed, there are actually very few plant species that are unique (endemic) to them. Where, then, did the species we find on Illinois prairies come from?

    a) They migrated from cooler regions in the north
    b) They migrated from regions in the southeast
    c) They migrated from the eastern deciduous forests
    d) All of the above

25. What family is illustrated below?



    a) Euphorbiaceae
    b) Caryophyllaceae
    c) Asclepiadaceae
    d) Brassicaceae

26. Plants of the Cactaceae, Euphorbiaceae and Asclepiadaceae families, with their succulent stems bearing spines, may look superficially similar when growing in arid regions. Provide two diagnostic floral or vegetative features for each family that could be used to differentiate them from the other two families. Each feature you choose should be unique to that family. [6 points]

Cactaceae: 1) _____

2) _____

Euphorbiaceae: 1) _____

2) _____

Asclepiadaceae: 1) _____

2) _____

27. Congratulations! You have just been appointed assistant curator of the Alfred Rehder Garden of beans and peas at the Chicago Botanic Garden. Unfortunately, to create this garden, they had to destroy a small plot of tomatoes. Your first job is to construct a proper dichotomous key for the identification of the three subfamilies of Fabaceae: Mimosoideae, Caesalpinioideae, and Faboideae. Your first couplet, however, should distinguish between tomatoes (Solanaceae) and all legumes (Fabaceae). [4 points]

28. Select the most appropriate mode of pollination for each of the floral features described. Fill in the blank with the letter of the best match. There is only one correct answer per question, and each type of pollinator is only to be used once. (4 points)

a) hummingbirds
b) bats
c) beetles
d) bees
e) carrion beetles and flies
f) bush mice and other small mammals
g) butterflies
h) hawkmoths

_____ Purple or brown-colored actinomorphic flowers sometimes smelling strongly of rotten meat, and no nectar or other award offered (examples, *Rafflesia*, titan arum, skunk cabbage, pawpaw)

_____ Large, sturdy, bowl-shaped flowers opening at night, white or cream in color, strong odor smelling musty or like fermenting yeast, abundant nectar and pollen, and no nectar guides (examples, saguaro cactus, durian tree)

_____ Sturdy flowers accessible near the ground, usually brown in color or sometimes white or creamy, opening at night with a yeasty odor, and with abundant nectar and/or pollen (example, *Protea*)

_____ Actinomorphic, stiff, wide tubular, and easily accessible flowers with hanging stamens opening during the day, Ferrari-red in color in the New World, no obvious odor, no nectar guides, but loaded with abundant nectar (examples, *Fuchsia*, *Aquilegia* and *Lychnis*)

_____ Actinomorphic flowers open during the day with narrow tubular corollas, erect anthers, and a wide landing platform, yellow, blue, or pink in color, often with nectar guides and abundant nectar hidden deep in spurs (examples, soapwort, *Phlox*, many Asteraceae)

_____ Bright yellow, blue or white zygomorphic flowers opening during the day with sweet odor, abundant nectar, nectar guides, and sometimes reflecting UV light in a "bulls-eye" pattern (examples, many Fabaceae, Lamiaceae, and Scrophulariaceae, *Salix*)

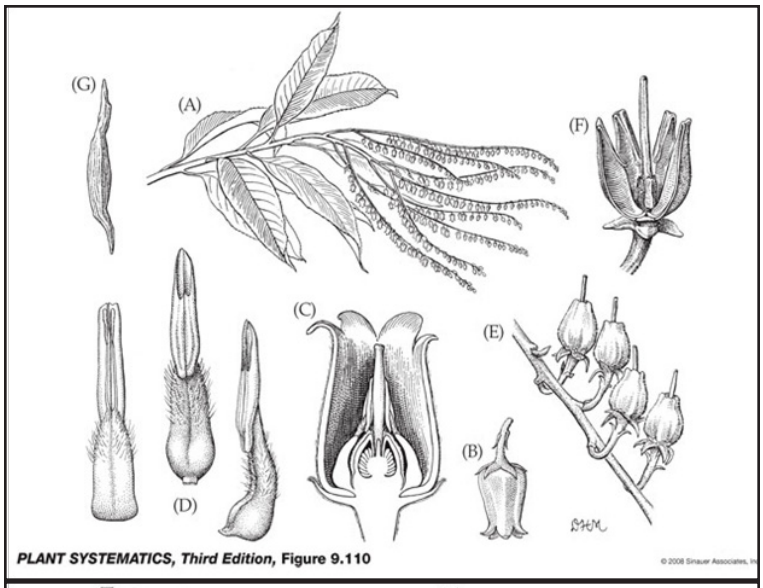
_____ Actinomorphic white to sometimes pale green flowers with narrow tubular corollas, opening at night or dusk, with a heavy sweet odor at night, abundant hidden nectar, and no nectar guides (examples, *Angraecum* orchid, honey suckle)

_____ Large, bowl-shaped, unspecialized actinomorphic flowers with numerous floral parts and ovules protected on an elongate receptacle or in a hypanthium, dull, creamy-white or green in color, strong fruity or aminoid odor, no nectar guides, and abundant pollen and sometimes nectar (examples, strawberry, *Magnolia*, water lily)

29. Draw the following. There is no need to label your drawings. [2 points]

A L.S. through a flower from any typical member of the asterid clade	A single male flower of *Euphorbia* (Euphorbiaceae)

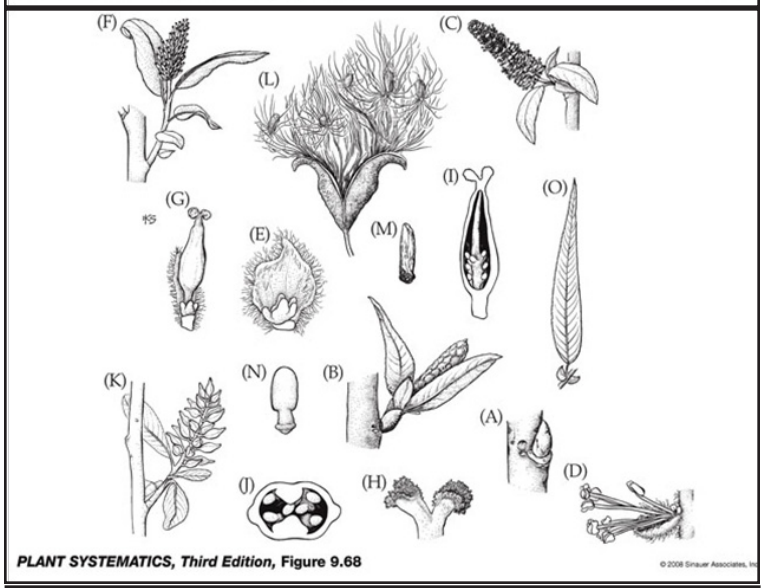
30. For each of the following figures from your text, answer the following in the spaces to the right of each figure: (a) Family or subfamily? (b) List two diagnostic floral/fruiting features for that taxon that can be seen in the illustration. (c) Indicate the major clade to which the taxon belongs (i.e., asterid, Caryophyllales, rosid). [3 points for each figure; 9 points total]


(G)
(A)
(F)
(C)
(E)
(B)
(D)
PLANT SYSTEMATICS, Third Edition, Figure 9.110

a) _____

b) _____

c) _____


(F)
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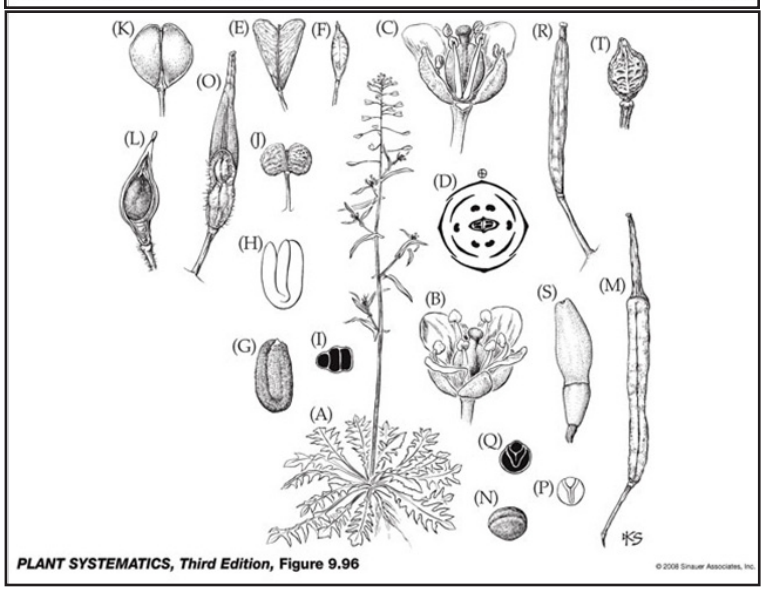
PLANT SYSTEMATICS, Third Edition, Figure 9.68

a) _____

b) _____

c) _____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(P)
PLANT SYSTEMATICS, Third Edition, Figure 9.96

a) _____

b) _____

c) _____

BONUS (5 points)

List four reasons why seed/fruit dispersal is important to a plant species. [4 points]

1)

2)

3)

4)

Name one plant whose seed/fruit is dispersed by water. [1 point]

Total Score: _____ (maximum score, with bonus, is 55 out of 50)

THE STORY OF BLACKEYED SUE

I rose early, at four o'clock, the morning glory still iris away. I was worried. Anemone of mine, Johnny Jump Up, was looking for me, and I'd heard he was carrying a pistil, a 357 magnolia. I ironed a periwinkled blouse, got dressed, and took a sprig of a dusty Miller's beer. Johnny Jump Up. He was one of several rhizomes who'd gone to seed in Forsythia, Montana. He was convicted of graft in 1984, arrested again in '85 for digging in coreopsis. Then he drifted on the wind up to my neighborhood, the corner of Hollyhock and Vine. He was a petal pusher in a phloxhous nearby.

I knew he was trouble when he rode-a-dendron to my house and said, "Hey, little Black-eyed Susan, wanna come over to my place and take a look at my vetches?" I didn't want to tell him that in all the cosmos, there was no one for me but Sweet William, so I said no, I was taking care of a pet dogwood that'd had a litter of poppies, which was weird 'cause she'd just been spaded. But Johnny had no sense of humus. He stamped his foot with impatiens. "You'll rue the day you turned me down," he snapped. Then he spit a wad of salvia into the petunia on my portulaca and stalked away. "Forget me not, Sue, 'cause I'll be zinnia."

Ever since then, he'd cultivated a relationship with Lily of the Valley, a self-sowing biennial. One day, I aster what she seed in him. "Mum's the word on this," she said. "He's got a trillium dollars in the bank."

"A trillium?" I snorted. "He's lime to you. Besides, what about love?"

"Alyssum," she said. "You bleeding hearts are all alike. Kid, you can go for a guy who'll azalea with affection. Orchid, you can be like me and try to marigold. Now begonia."

Now I was in my kitchen mullein over these past events. But it was thyme to quit dilly-dahliaing. The calendula read August 3rd, and Johnny had sworn to propagate vengeance before the snowdrop.

I hopped into my autolobelia and drove over to Daisy's for help. Daisy was a pretty little transplant from Florida, who'd wilted in the humidity there, but was rooted in the well-drained soil of Bloom County. She mostly took care of her babies breath, but lately she'd branched out and was columbining work with home life. "We're all sick today, I think it's gaillardia," she said. "Even the cat's got harebells. If we could take a knapweed be OK." Her face was a blight yellow. She'd be no help.

I beetled feet over to Sweet William's. "Will, am I gladiolus to see you!"

"And Blackeyed Sue. I been prayingmantis see you. Let's lilac in the snow on the mountain before it all melts down the geranium. Let's ride a sage to Tansynia. It's only a chamomile away."

"Don't be fritillary, honeysuckle," I said, clinging to him. "Look. Here comes the clematis of the story."

Uh oh. Johnny had hired Pete Moss, a bearded iris-man to do me in. He was wearing a blue nectar and larkspurs. He had larva men with him. The pests. They began to charge. In all the confuscia, I said to Will, "Stem still and give me some ground cover." I ran down the primrose path in my ladyslippers right towards Pete.

“Don’t gimme any flax, bud, or I’ll slug ya,” I said.

“You’ll look dandelion in the alley.” “Don’t gimme any flax bud,” Pete quoted me verbena. It nettled me. I clovered him with a 2 x 4.

“Sound the timpansy,” we sang. “We won!”

“Curses,” moaned Pete, “foliaged again.”

I noticed Johnny Jump Up planted on the border. “I’ve sunk pretty loam, Sue, but now I’m turning over a new leaf” he said.

“Bouquet,” I said. And he did. And Will and I lived pearly everlasting.