

A close-up photograph of a flower with large, overlapping petals in shades of orange and red. The center of the flower shows several stamens with dark anthers. The background is dark and out of focus.

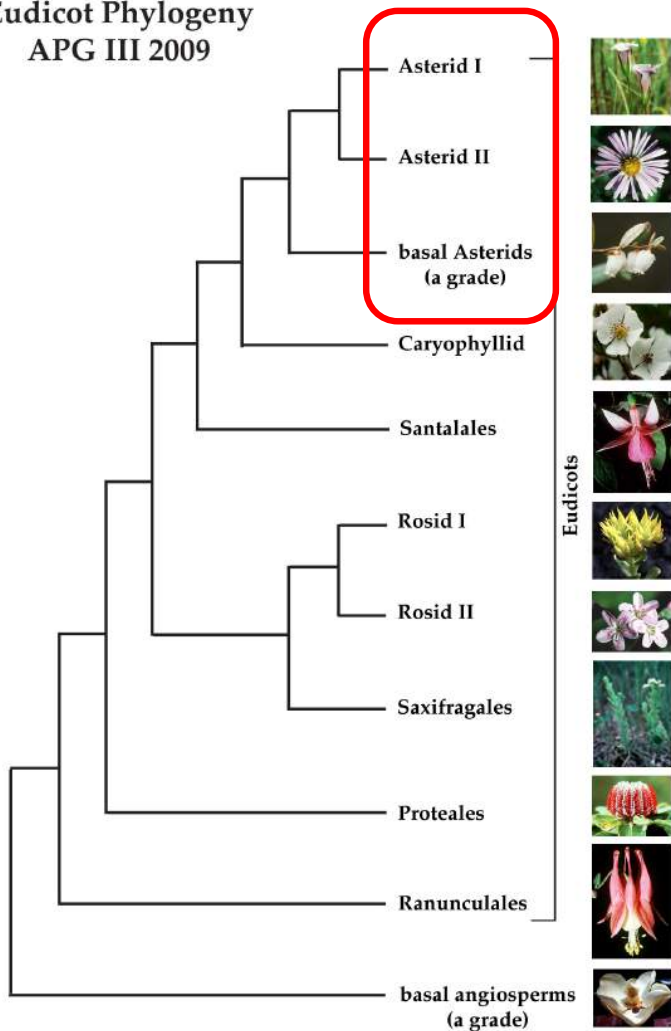
# Diversity and Evolution of Asterids

. . . dogwoods, blueberries, and  
primroses . . .

# Asterids

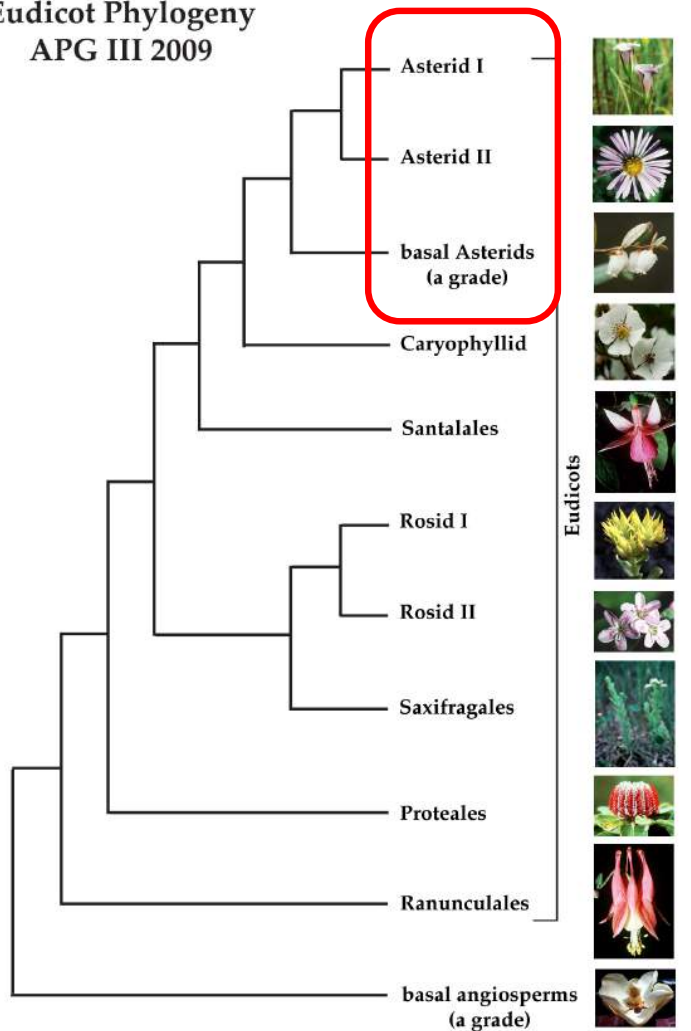
- continue survey through the eudicots or tricolpates after completing Rosids
- the Asterids are the second of the two large groups of dicots and the easier one to define morphologically

Eudicot Phylogeny  
APG III 2009



# Asterid Characteristics

Eudicot Phylogeny  
APG III 2009



- fused petals - **sympetaly**
- stamen number  $\leq$  petal number
- stamens fused to corolla tube





# Asterid Characteristics

- **iridoid** compounds (with losses)
- ‘basal asterids’ have them (previously not placed with asterids)

Rubiaceae  
coffee family



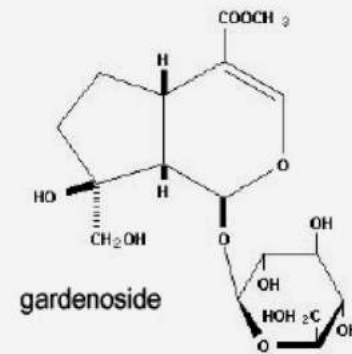
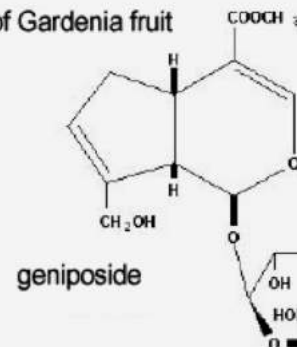
*Gardenia*



*Picrorhiza kurroa*

Plantaginaceae  
snapdragon family

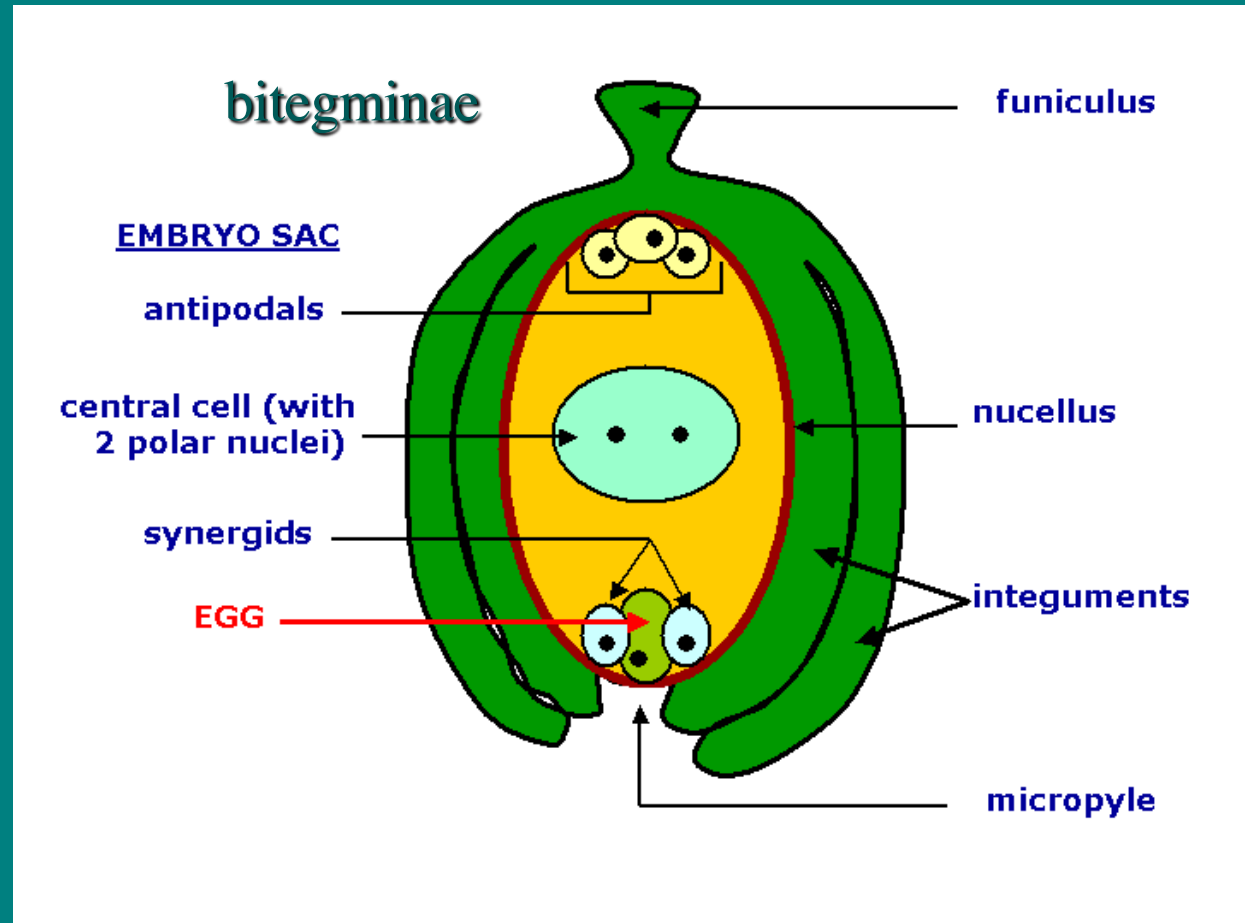
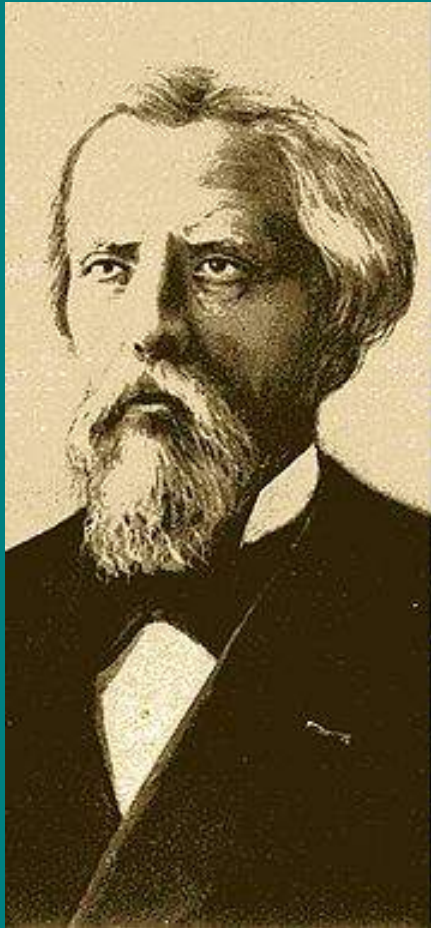
Iridoid glycosides of Gardenia fruit





# Asterid Characteristics

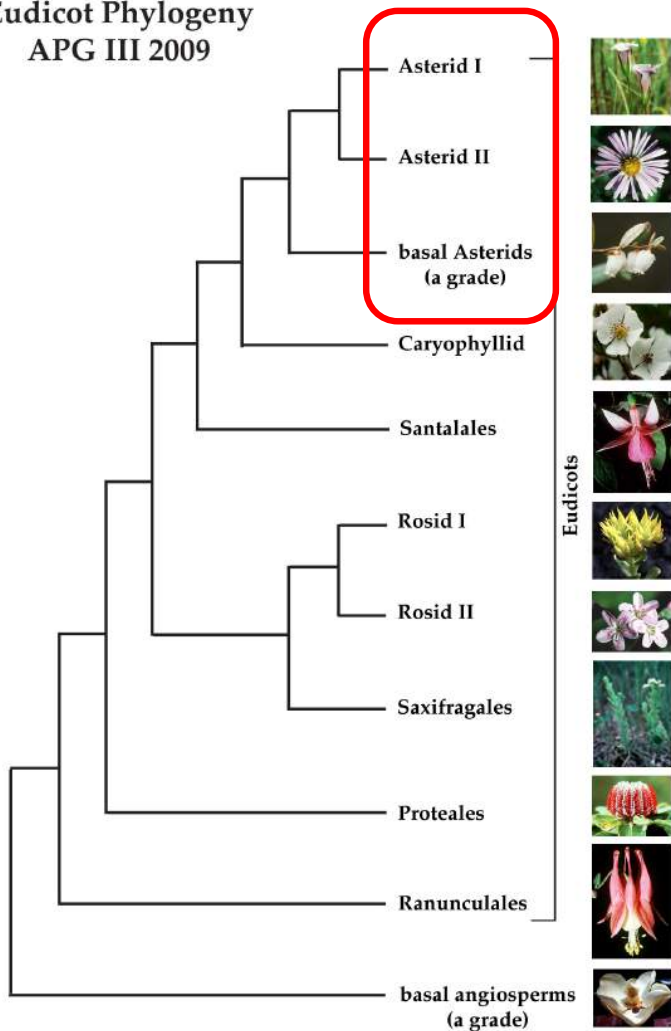
- one layer of integuments in ovule vs. two in other groups
- the “unitegminae” (vs. bitegminae) of van Tieghem in 1901 = new Asterid group!



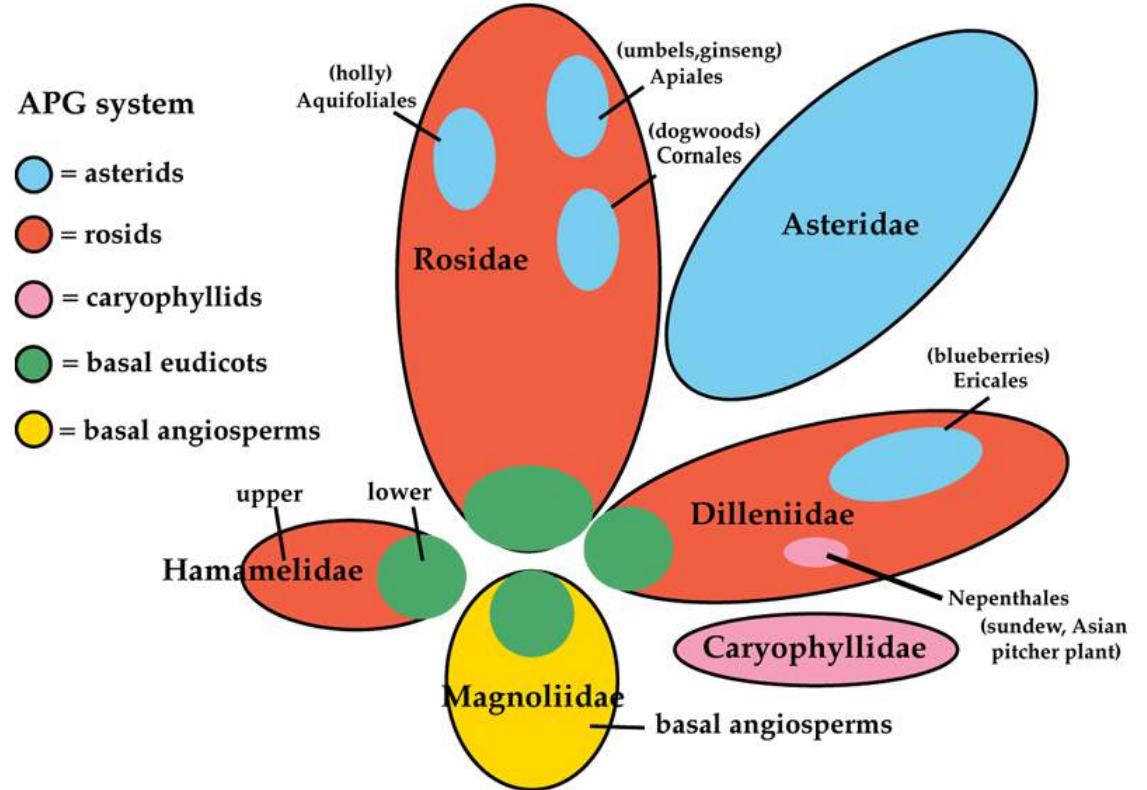
# Asterid Composition

- composition of **Asterids** is largely congruent with previous morphology

Eudicot Phylogeny  
APG III 2009



Cronquist's Dicot Subclasses vs. APG



# Asterid Composition

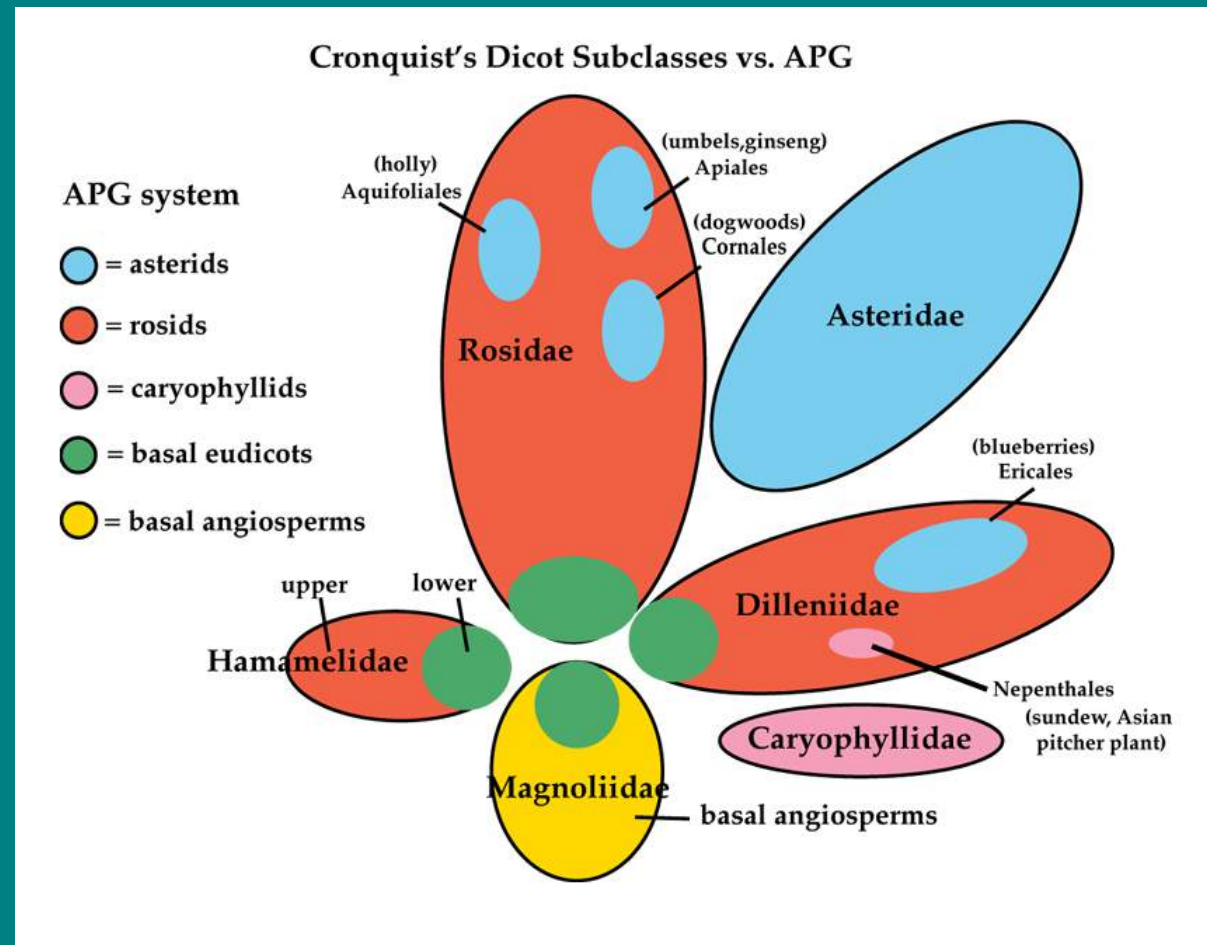


Apiaceae - carrot family



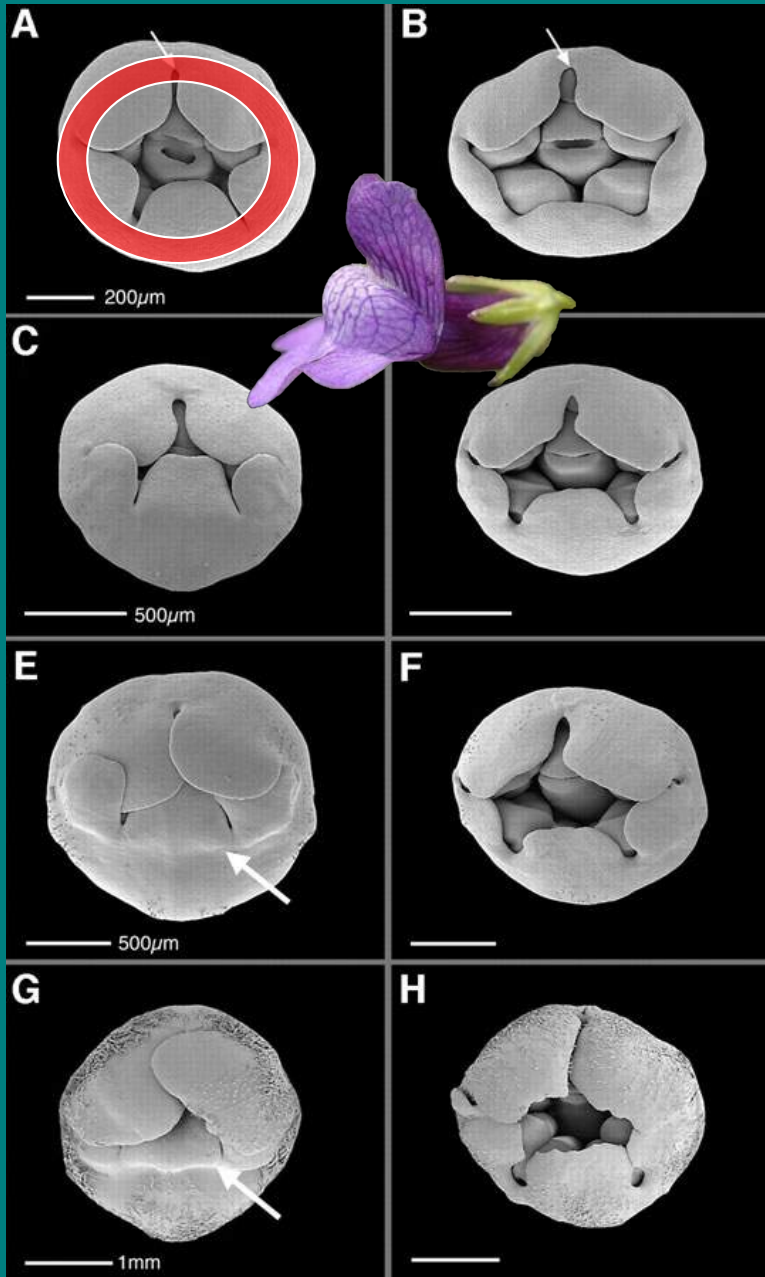
Aquifoliaceae - holly family

- exceptions include the ‘basal asterids’ and separate petal or small flower orders





# Asterid Composition

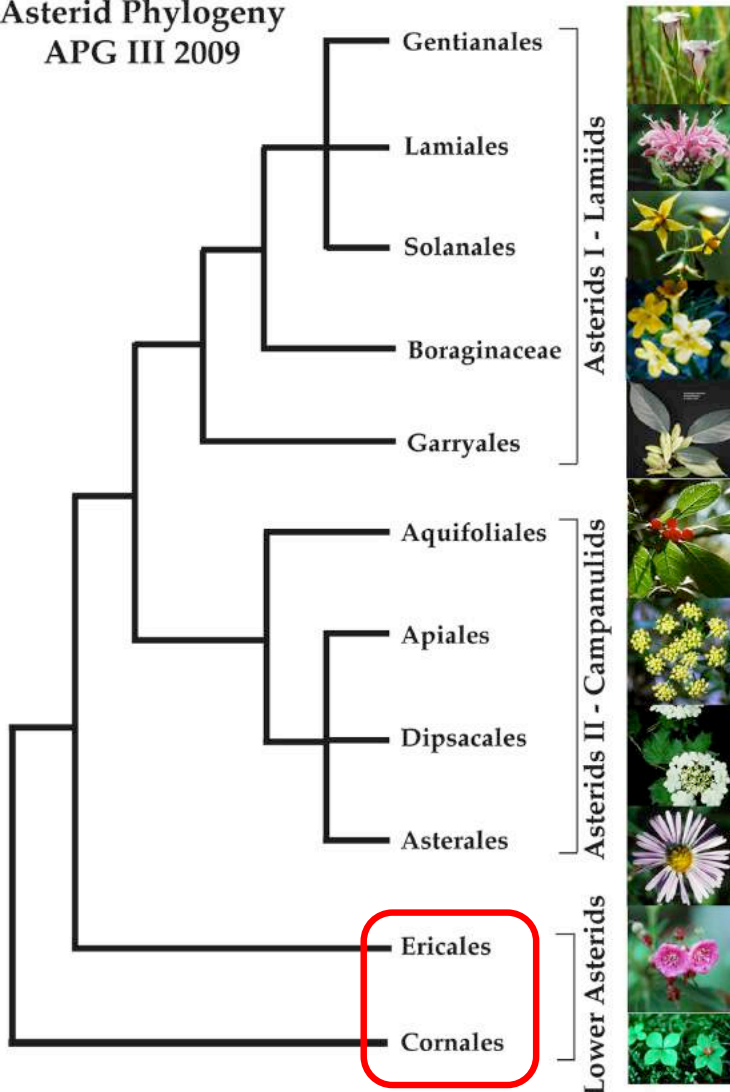


- exceptions include the ‘basal asterids’ and separate petal or small flower orders
- some of these “non” sympetalous Asterids (e.g., order Cornales) have “early” petal ring primordia in development
- subsequent petal development is separate, so appear to be polypetalous!

Early ring primordia of 5 petals in snapdragon (a true asterid) [EMBO Journal (2003) 22: 1058–1066]

# Basal Asterids

Asterid Phylogeny  
APG III 2009



- basal asterids represent a **grade** towards the core asterids
- great **variation in floral form** in the two orders Cornales and Ericales
- the “**standard**” Asterid flower has not been fixed



*Cornus*



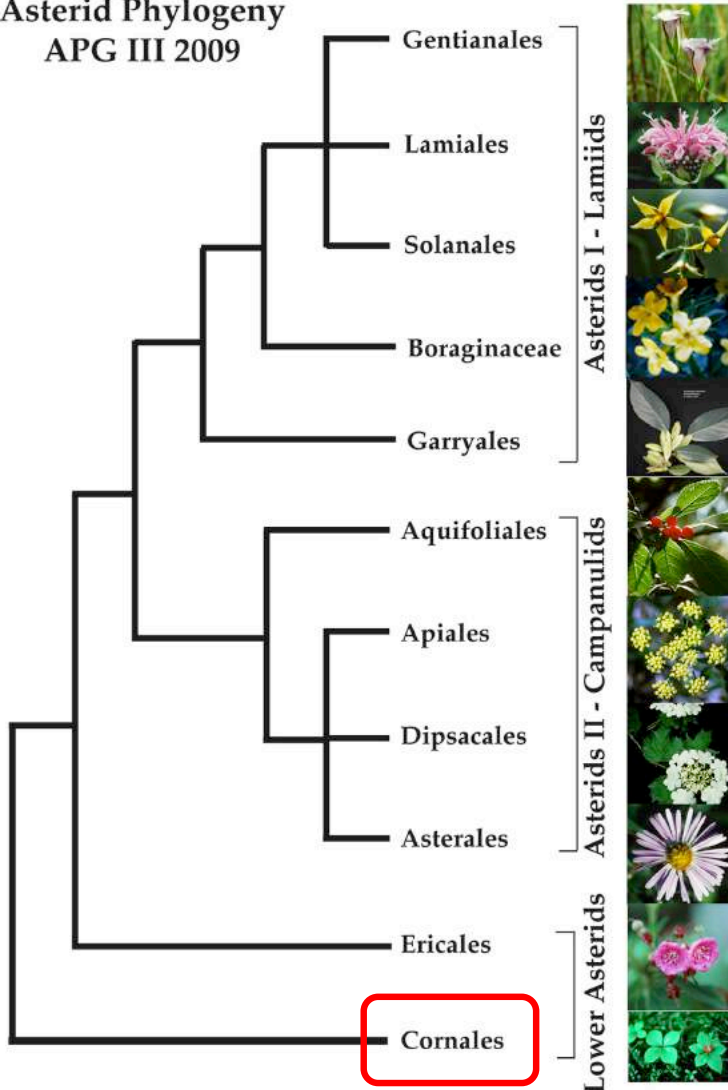
*Chimaphila*



# Cornales

- order sister to remainder of Asterids, comprises 7 small families (diverse)

Asterid Phylogeny  
APG III 2009



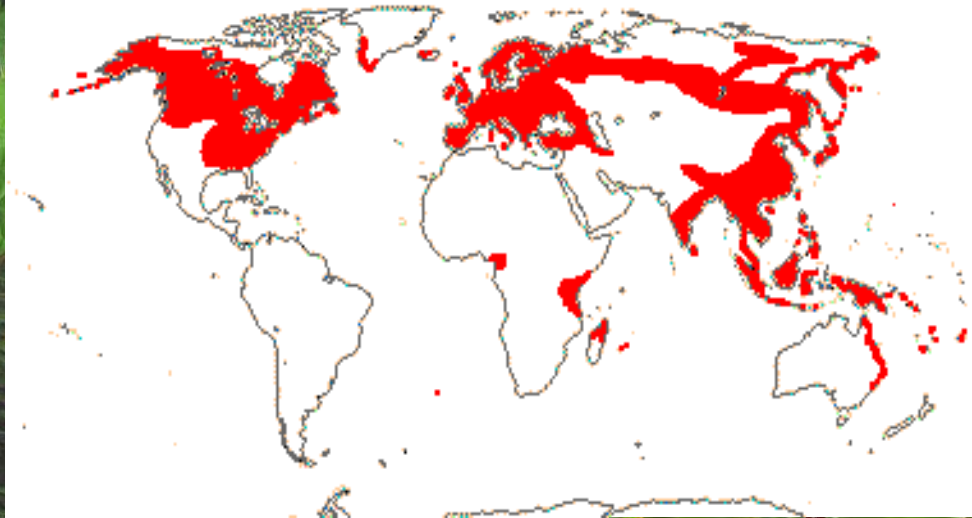


# \*Cornaceae - dogwoods

- mainly north temperate shrub family of 2 genera and 85 species



*Alangium*



*Cornus*



# \*Cornaceae - dogwoods

- opposite, simple leaves
- **arcuate** venation





# \*Cornaceae - dogwoods

*Cornus stolonifera* - red osier

CA 4 CO 4 A 4  $\overline{U}$ (2)



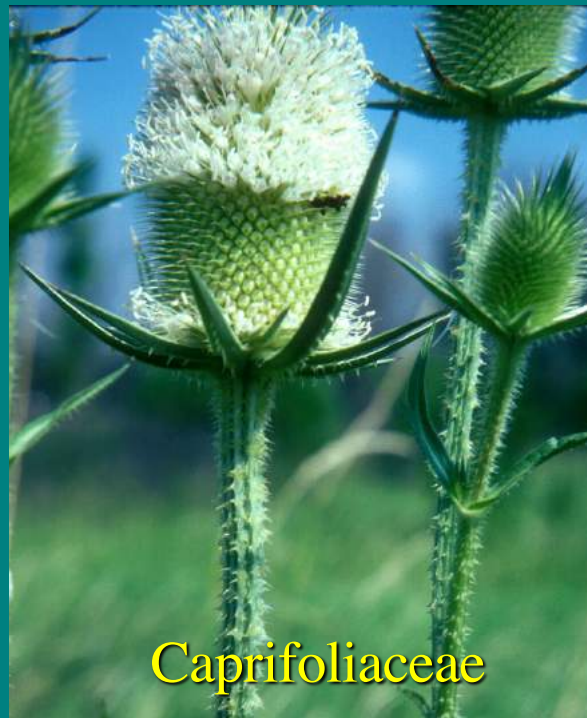
bracts

- 4 merous, small flowers with separate petals
- 2 carpellate inferior ovary
- fruit a 2-seeded 'drupe'
- some inflorescences surrounded by showy bracts
- "head" or "pseudanthium" (false flower)





# 'Pseudanthia' in the Asterids – remember this !





# \*Cornaceae - dogwoods



*Cornus florida* - flowering dogwood

Eastern North American  
small tree with 4  
conspicuous white bracts





# \*Cornaceae - dogwoods

*Cornus canadensis* - bunch berry



Low to ground boreal subshrub, appears to have a whorl of leaves, and has 4 showy bracts below flowers





# \*Cornaceae - dogwoods



*Cornus sericea*  
Red-osier



*Cornus foemina*  
Gray dogwood  
Common component of  
shrub carr



Common in wet places,  
distinctive with red stems

# Hydrangeaceae - hydrangeas

Another small family of trees, shrubs, and vines from North Temperate region - many ornamental woody plants

- most recently placed in Saxifragaceae



*Hydrangea*



*Hydrangea arborescens*

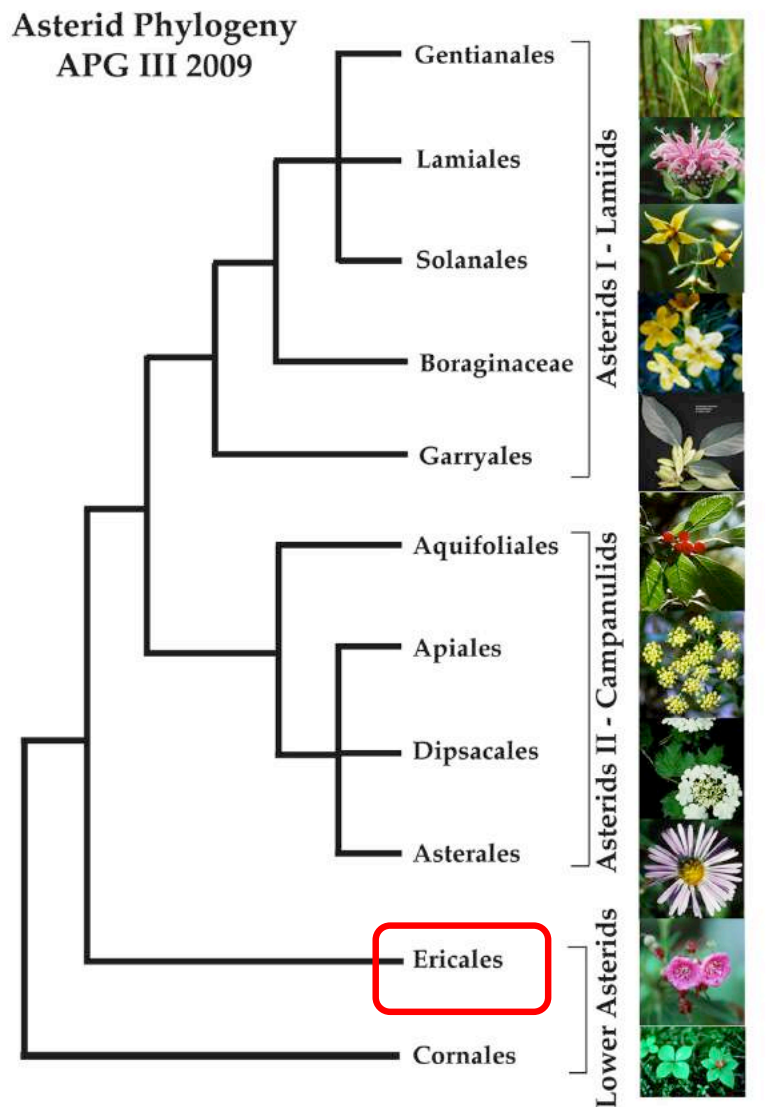


*Philadelphus -  
mock orange*



# Ericales

- large, important order of 23 families, >11,000 species
- will focus on just a few families and learn  
\***Ericaceae** (blueberries) and \***Primulaceae** (primroses)



blueberry

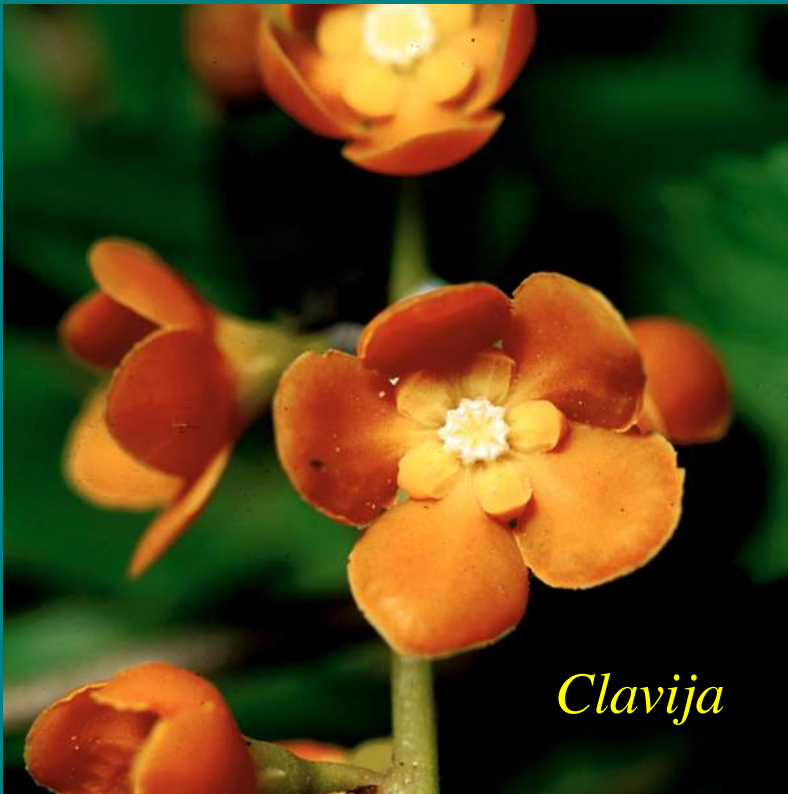


primrose



# Ericales

- Ericales represent less than 6% of eudicot diversity, and 1/3 of these belong to Ericaceae alone . . . but
  - 10% of the understory species in tropical rainforests
  - and about 22% of the total stems in these forests



*Clavija*



# Ericales

- Ericales exhibit great diversity in habit and nutrient uptake strategies



*Monotropa* -  
Indian pipe

- mycorrhizal associations
- mycorrhizal parasites (mycotrophs)



*Arctostaphylos* - bearberry



# Ericales

- Ericales exhibit great diversity in habit and nutrient uptake strategies



*Mitrastema* -  
parasite

- parasitism
- carnivory



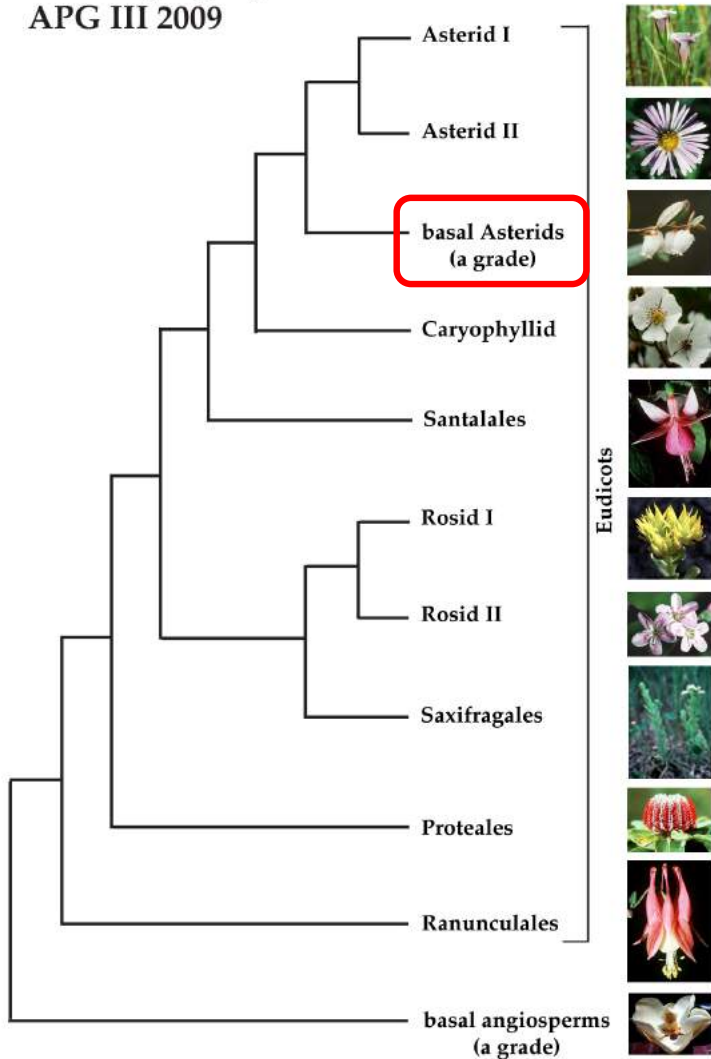
*Sarracenia* - pitcher plant



# Ericales

- as early diverging Asterids, Ericales exhibit a **bewildering mixture of Rosid and Asterid features**

Eudicot Phylogeny  
APG III 2009



Rosid



core Asterid

# Corolla Structure

sympetaly



*Fouquieria*

polypetaly



*Couroupita*

for instance in ...

Fouquieriaceae

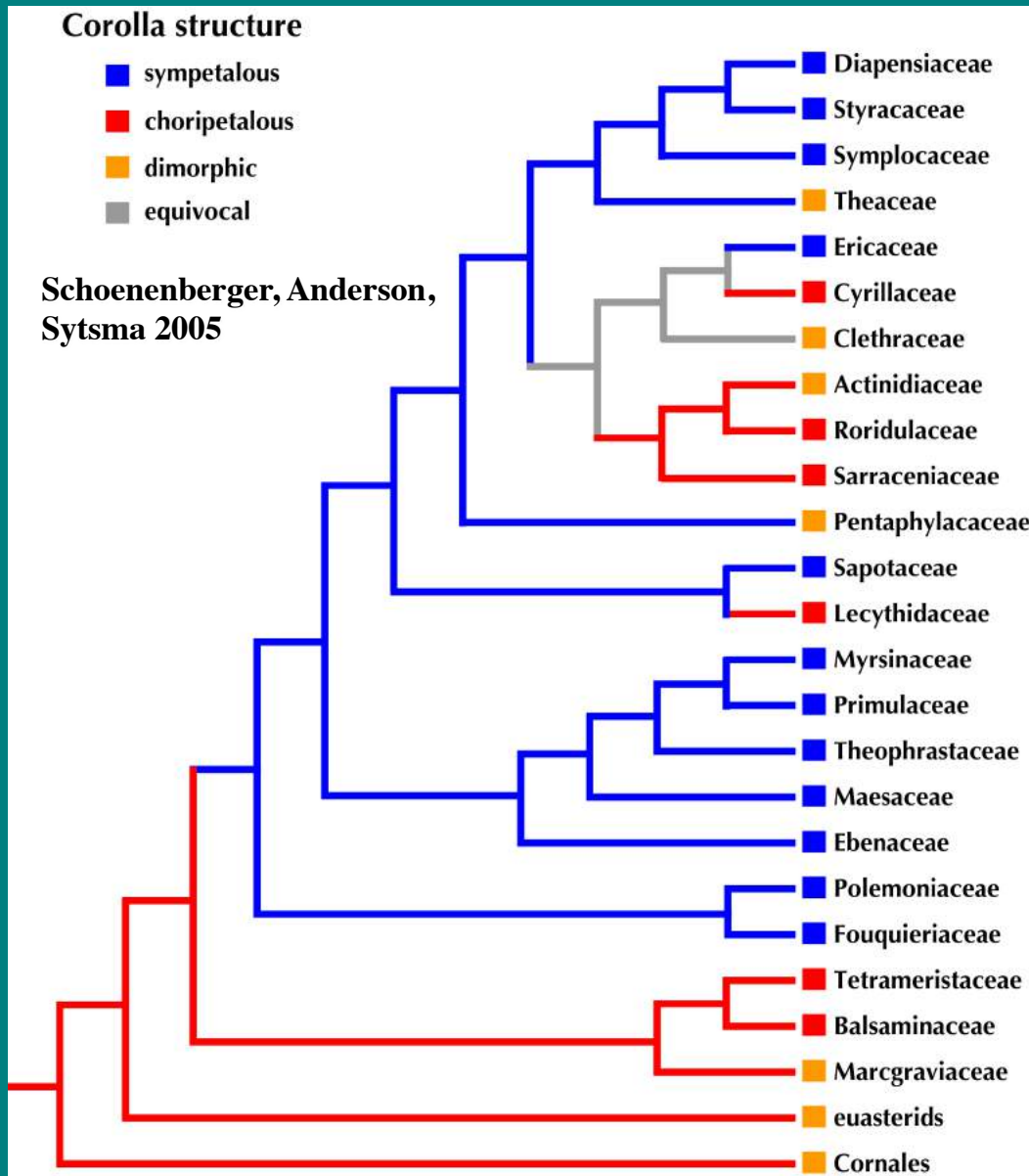
Primulaceae

Lecythidaceae

Roridulaceae



# Corolla Structure



Re-examined in light of DNA based relationships

- corolla evolution is still complicated
- perhaps **one or two** separate origins of sympetaly and **two or three reversals** to choripetaly

# Integument Number

unitegmic



*Clethra*

bitegmic



*Jacquinia*

for instance in ...

Clethraceae

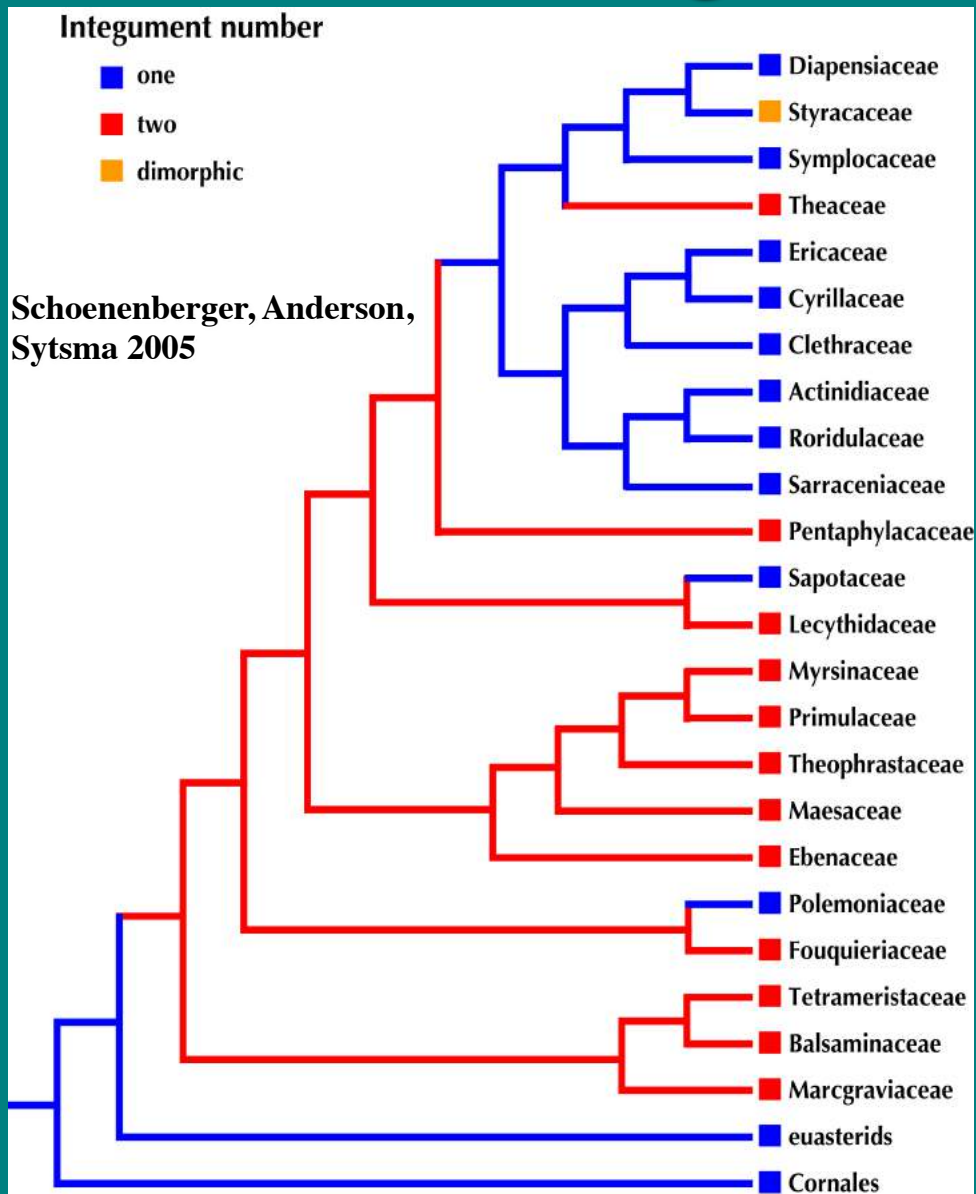
Symplocaceae

Theophrastaceae

Marcgraviaceae



# Integument Number



Re-examined in light of DNA based relationships

- ovule integument evolution is still complicated
- **multiple switches** from the derived asterid condition of unitegmic to bitegmic and back again

# Stamen Number

1 whorl



*Shortia*

2+ whorls



*Schima*

for instance in ...

Polemoniaceae

Roridulaceae

Theaceae

Actinidiaceae



# Theaceae - tea, camellia

North Temperate family of evergreen, serrate leaved shrubs (7 genera and up to 400 species)



*Camellia sinensis*

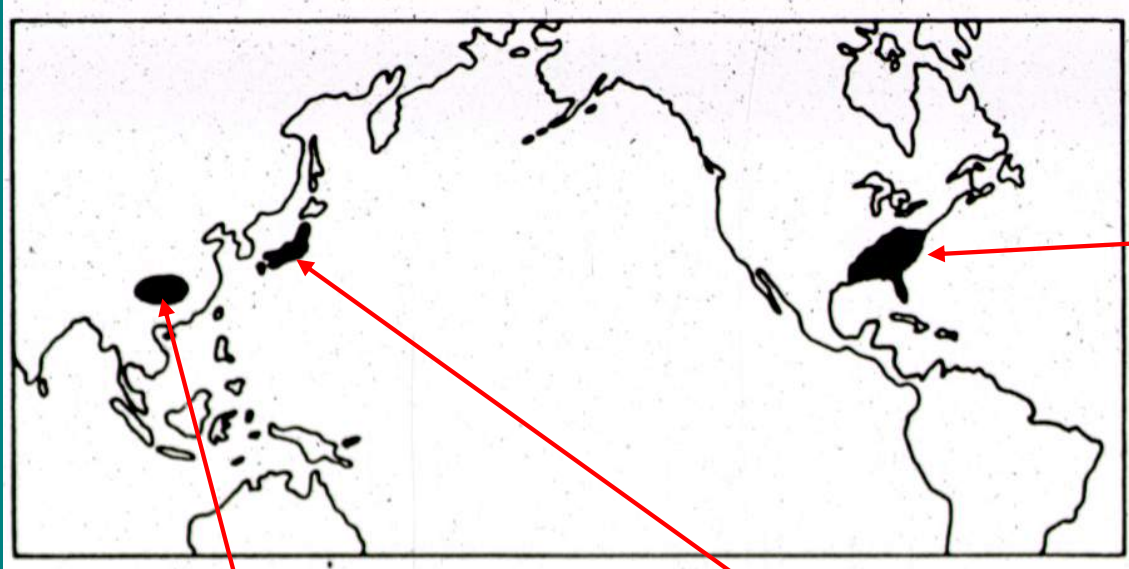
- tea



*Schima*

- flowers have separate petals and many stamens

# Theaceae - tea, camellia



*Stewartia malacodendron*



*Stewartia sinensis*

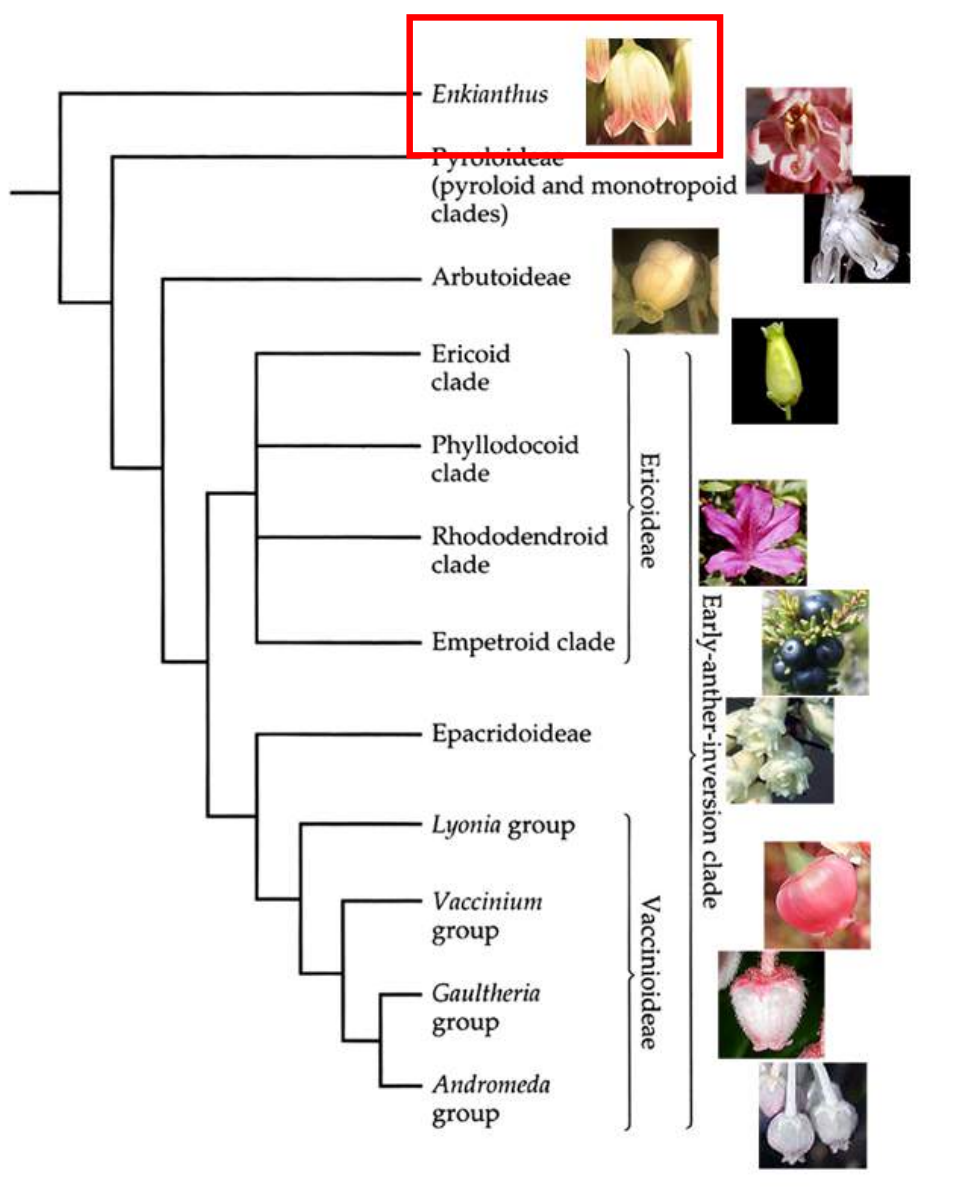


*Stewartia pseudocamellia*

Eastern North America  
and Eastern Asia is the  
“classic” north  
temperate disjunction  
pattern



# \*Ericaceae - blueberries



Worldwide woody family, except lowland tropics, of 126 genera and nearly 4,000 species

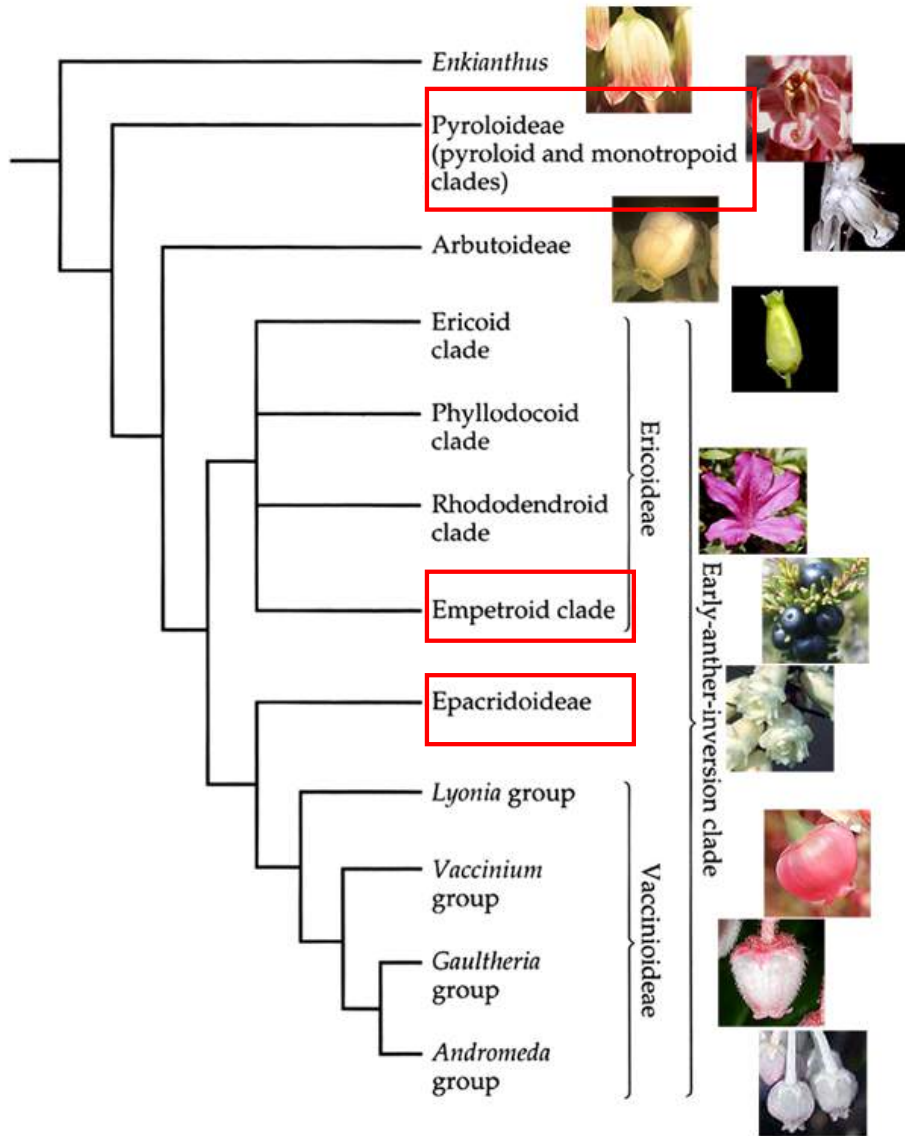
- the E. Asian genus *Enkianthus* is sister to the rest of the family



*Enkianthus*

# \*Ericaceae - blueberries

- comprises the former families Pyrolaceae, Monotropaceae, Empetraceae, Epacridaceae





# \*Ericaceae - blueberries

- characteristic of **nutrient poor soils** - bogs, acidic pine dominated forests, tropical epiphytes, or sandy soils
- **mycorrhizal** relationship, forming **haustoria** - root to fungus connection, permits nutrient uptake by plants, carbon uptake by fungus

Leatherleaf in bog



*Cavendisia* - cloud forest epiphyte



# \*Ericaceae - blueberries

- **mycotrophs** - lacking chlorophyll and totally parasitizing the fungus for food, nutrients, and water
- former family Monotropaceae, derived from within mycorrhizal Ericaceae



*Monotropa uniflora*  
Indian-pipe



*Hypopitys monotropa*  
Pinesap



*Pterospora andromedea*  
Giant pinedrops



# \*Ericaceae - blueberries

- evergreen, tough, leathery leaves
- often **revolute** or inrolled
- sunken stomata, and bottom of leaves often covered with protective hairs



*Rhododendron (Ledum)*  
Labrador tea  
Note revolute leaves



*Arctostaphylos*  
bearberry

*Chimaphila*  
shinleaf

# \*Ericaceae - blueberries

CA (4-5) CO (4-5) A 8,10  $\bar{G}$  (4-5)



- calyx and **corolla are fused**, the corolla tube bell or vase shaped
- stamens are 2X the number of petals;
- often exhibit **terminal pores** for pollen release for **buzz pollination** by bees





# \*Ericaceae - blueberries

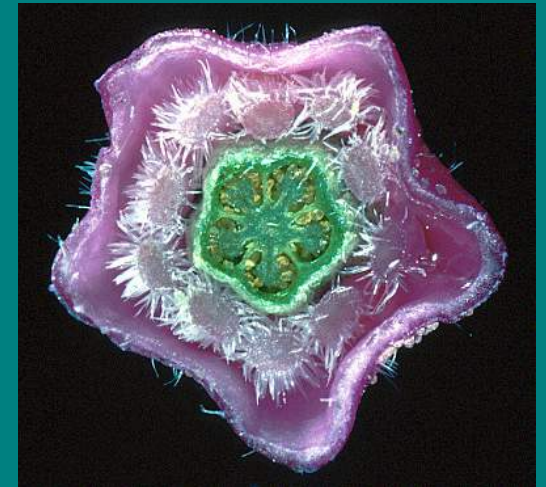
CA (4-5) CO (4-5) A 8,10  $\overline{G}$  (4-5)



Superior pistil

Inferior pistil

- pistil is **superior**, but **inferior** in blueberries and relatives
- fruit a berry or capsule with 4-5 partitions and many seeds





# \*Ericaceae - blueberries

*Andromeda glaucophylla* -  
bog rosemary

*Rhododendron groenlandicum*  
Labrador tea

*Kalmia polifolia* -  
pale laurel

*Chamaedaphne calyculata*  
leatherleaf

Bog species





# \*Ericaceae - blueberries



*Arctostaphylos uva-ursi*  
Bearberry

Creeping subshrub often  
seen on beaches

“*Arcto-staphylos*” and “*uva-ursi*” both translate as “*bear-berry*” indicating at least one dispersal agent of the plant



# \*Ericaceae - blueberries



*Vaccinium myrtilloides*  
Velvet-leaf blueberry

*V. macrocarpon*  
cranberry

Blueberries and cranberries are  
inferior ovaried and berry fruited

*Vaccinium angustifolium*  
Lowbush blueberry



# \*Ericaceae - blueberries

Chancellor Blank and  
Dean VandenBosch at  
Cranberry Creek



*Vaccinium macrocarpon*

*V. macrocarpon*  
cranberry





# \*Ericaceae - blueberries



*Arbutus* in Europe



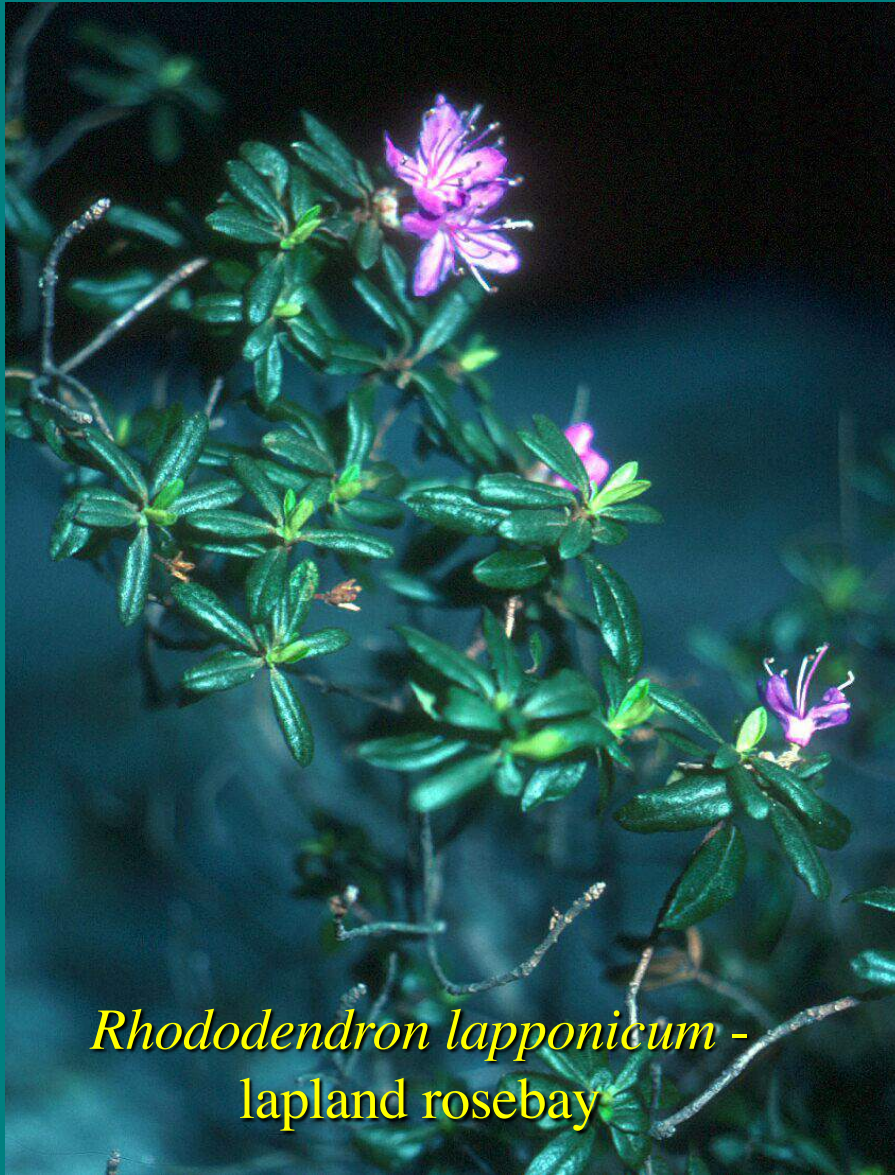
Major family of the harsh  
**Mediterranean climate** regions of  
the world

*Arbutus menziesii* – CA madrone





# \*Ericaceae - blueberries



*Rhododendron lapponicum* -  
lapland rosebay



Wisconsin Dells

rhododendrons and  
azaleas are prized  
ornamentals - greatest  
species diversity in  
Himalayas





# \*Primulaceae - primroses

Chiefly north temperate family of **scapose herbs** (or opposite leaved) - 9 genera and about 900 species



*Primula* -  
primrose



*Primula*  
(*Dodecatheon*) -  
shooting star



# \*Primulaceae - primroses

CA (5) CO (5) A 5 G (5)

- 5 merous, stamens attached unto petals, and **opposite the petals** rather than the sepals



*Primula* - shooting star

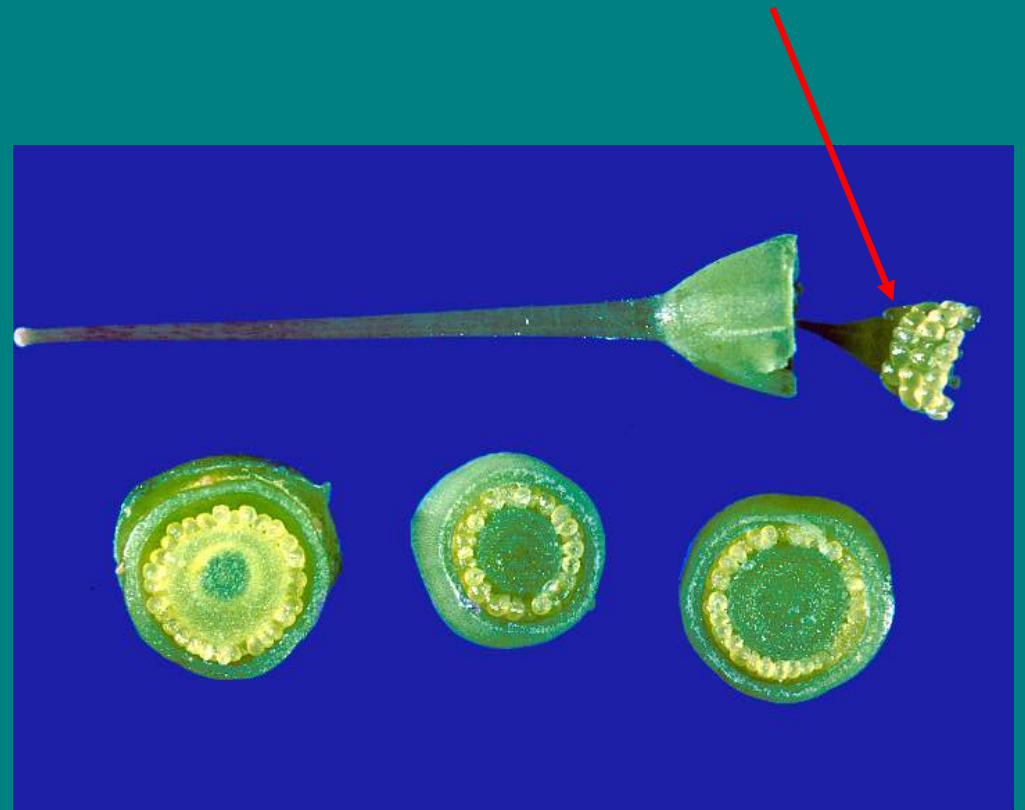


*Lysimachia* - loosestrife

# \*Primulaceae - primroses

CA (5) CO (5) A 5 G (5)

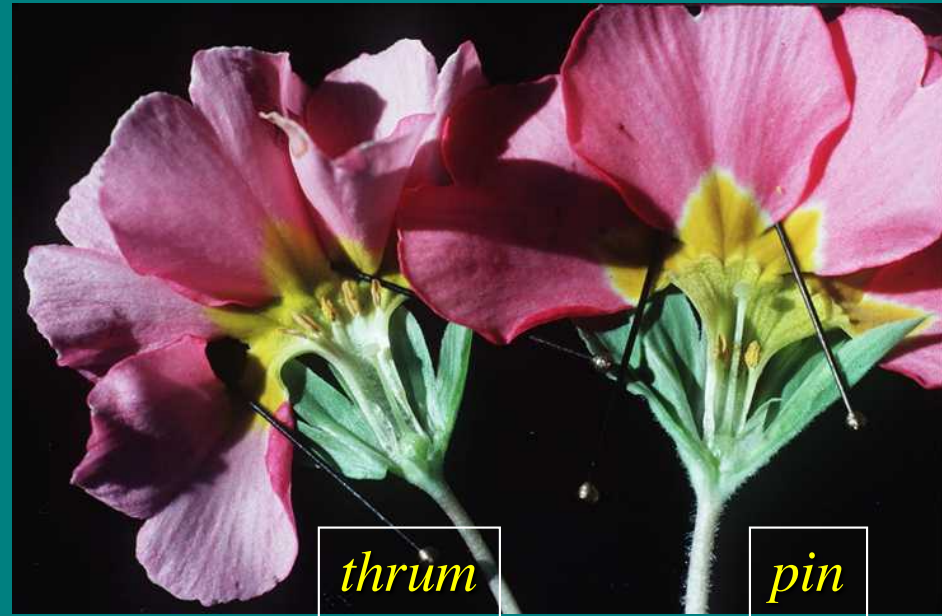
- pistil is unilocular and **free-central**
- fruits are capsules



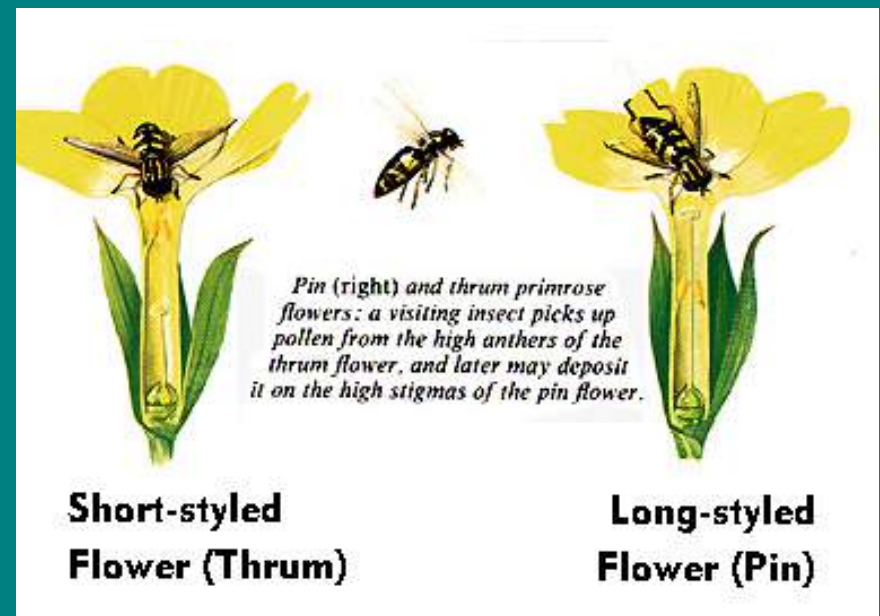
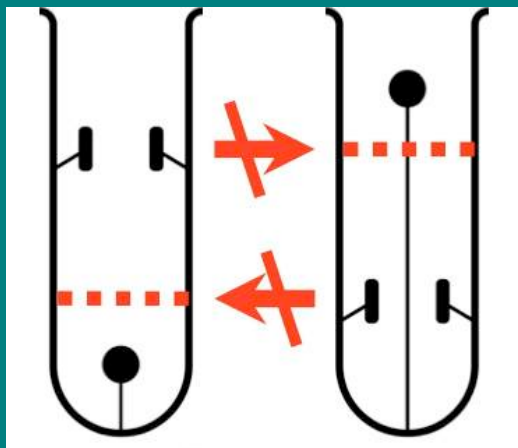
*Dodecatheon* - shooting star



# \*Primulaceae - primroses



*Primula* - the classic study organism for dimorphic heterostyly - Darwin



# \*Primulaceae - primroses

1. *On the various contrivances by which British and foreign orchids are fertilised by insects, and on the good effects of intercrossing.* (1862)

2. *Variation of plants and animals under domestication.* (1868)

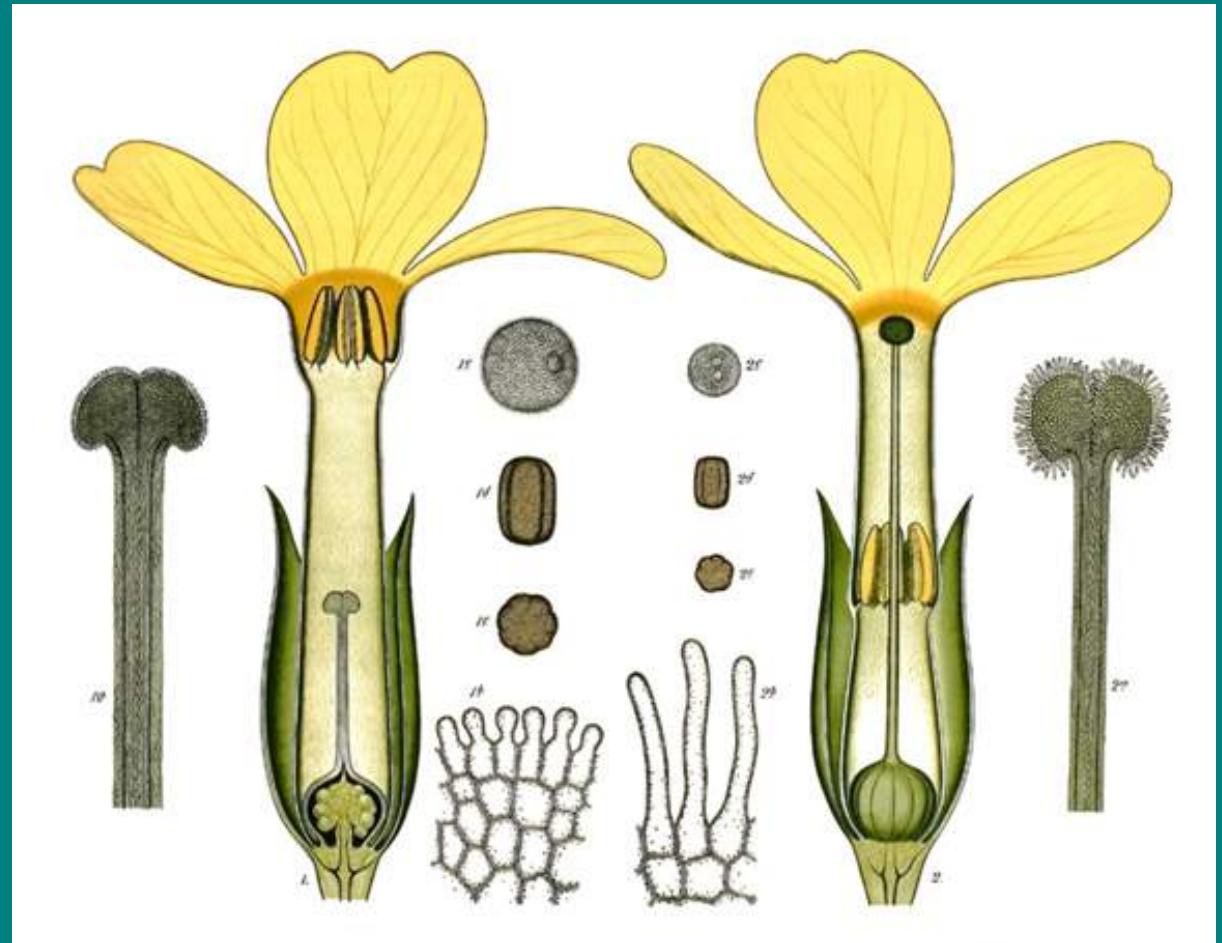
3. *Movement and habits of climbing plants.* (1875)

4. *Insectivorous plants.* (1875)

5. *The effects of cross and self fertilization in the vegetable kingdom.* (1876)

6. *The different forms of flowers on plants of the same species.* (1877)

7. *The power of movement in plants.* (1880)



Pollen and stigmatic differences in  
**thrum** and **pin** flowers



# \*Primulaceae - primroses

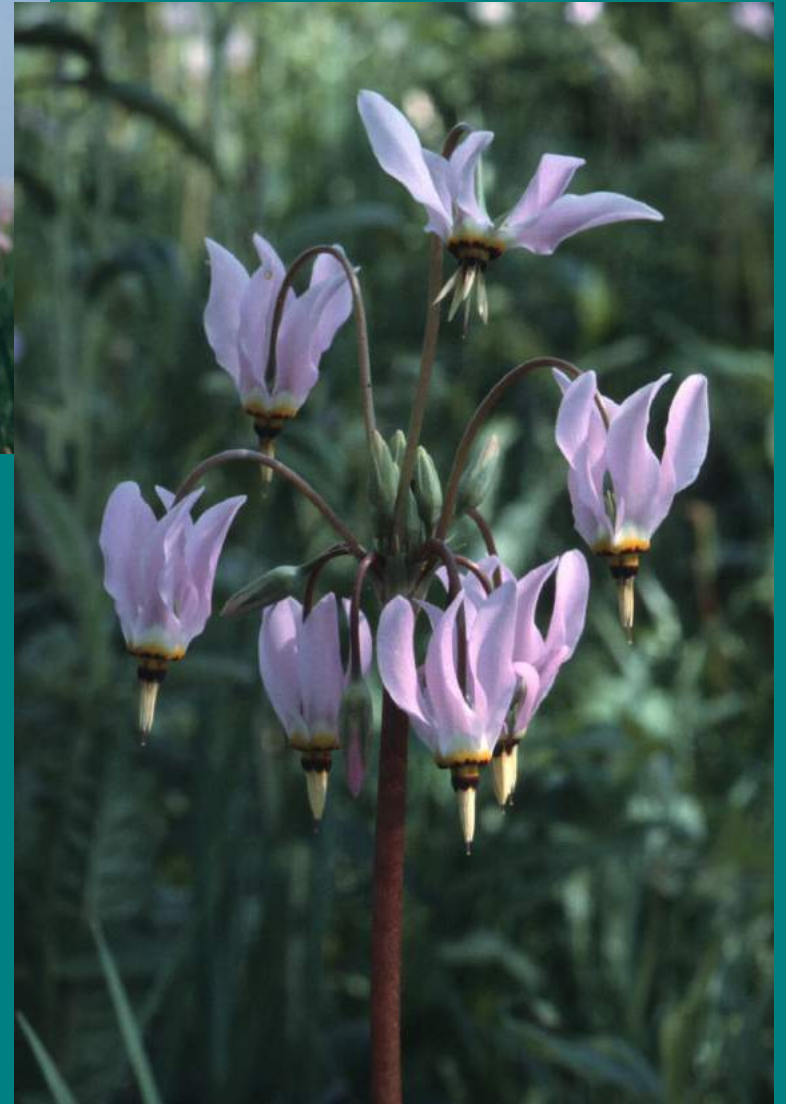


*Primula meadii*  
shooting star

Basal leaves

(formerly in *Dodecatheon*)

*P. fassettii*  
Western shooting star





# \*Primulaceae - primroses



*Lysimachia ciliata*  
Fringed loosestrife

Opposite leaves



*Lysimachia thyrsiflora*  
Swamp candles



# \*Primulaceae - primroses



- flower is unusual with 7 merous perianth
- note how stamens are lined up with petals rather than sepals
- one of the most ubiquitous plants in northern Great Lakes

Whorled leaves

*Trientalis (Lysimachia) borealis*  
Starflower

# Sarraceniaceae - pitcher plants

Insectivorous family of 3 genera - New World; related to South African carnivore Roridulaceae

*Darlingtonia* -  
cobra lily



*Sarracenia* - pitcher plant



*Heliamphora* - sun pitcher



# Sarraceniaceae - pitcher plants

CA 5 CO 5 A ∞ G (5)

5 merous flower; unusual **peltate stigma**; flower structure ensures outcrossing by bees



*Sarracenia purpurea* - pitcher plant

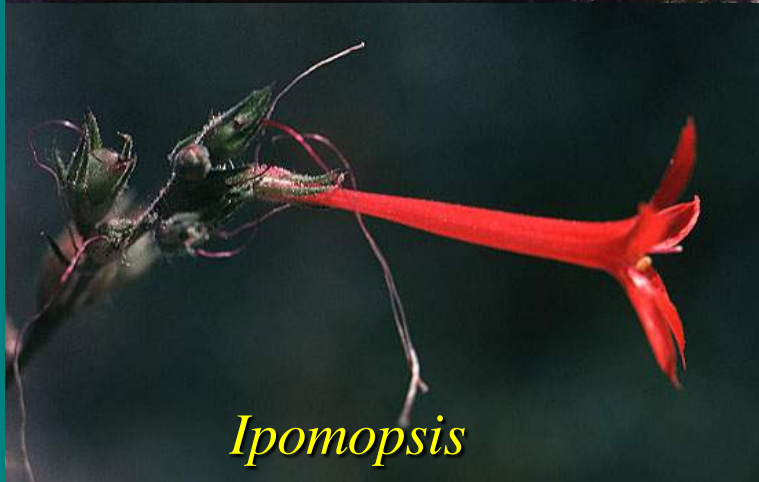


# Polemoniaceae - phlox

Primarily North Temperate family of 18 genera and 385 species, but with radiations in xeric SW North America and in the Andes



*Cobaea*



*Ipomopsis*





# Polemoniaceae - phlox

CA (5) CO (5) A 5 G (3)

- 5 merous flowers
- stamens at different heights
- 3 fused carpels and 3 styles



# Polemoniaceae - phlox



*Phlox divaricata* - woodland phlox

- woodland species



# Polemoniaceae - phlox



*Phlox pilosa* - prairie phlox

- prairie species



# Polemoniaceae - phlox



- Alternate leaved spring flowering plant of woodlands and openings



*Polemonium reptans* -  
Jacob's ladder



# Foquieriaceae - ocotillo



11 species of weird **xeromorphic trees and shrubs** from N American deserts - related to Polemoniaceae



*Foquieria splendens* - ocotillo



*Foquieria columnaris*  
- boojum tree



# Balsaminaceae - jewelweed

Small family of juicy-stemmed herbs  
with spurred sepals



*Impatiens capensis*  
orange jewelweed



*Impatiens pallida*  
yellow jewelweed





# Balsaminaceae - jewelweed

Small family of juicy-stemmed herbs  
with spurred sepals



*Impatiens capensis*  
orange jewelweed



- fruit is explosive to the touch, **touch-me-nots**



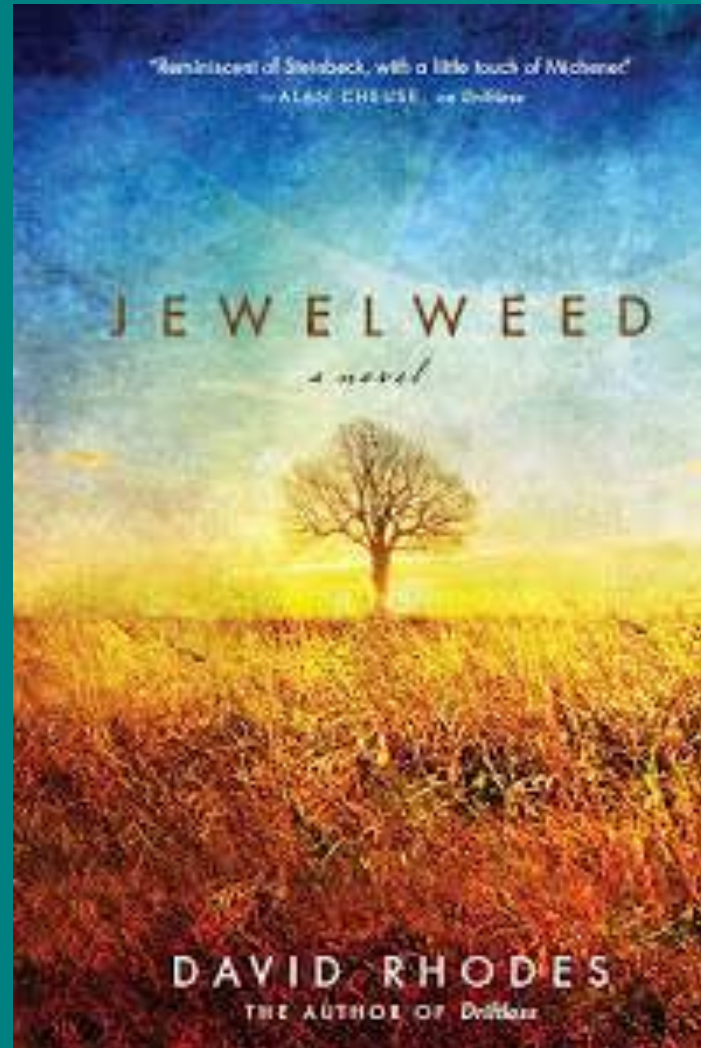
# Balsaminaceae - jewelweed

Great books!

*Driftless* and *Jewelweed*

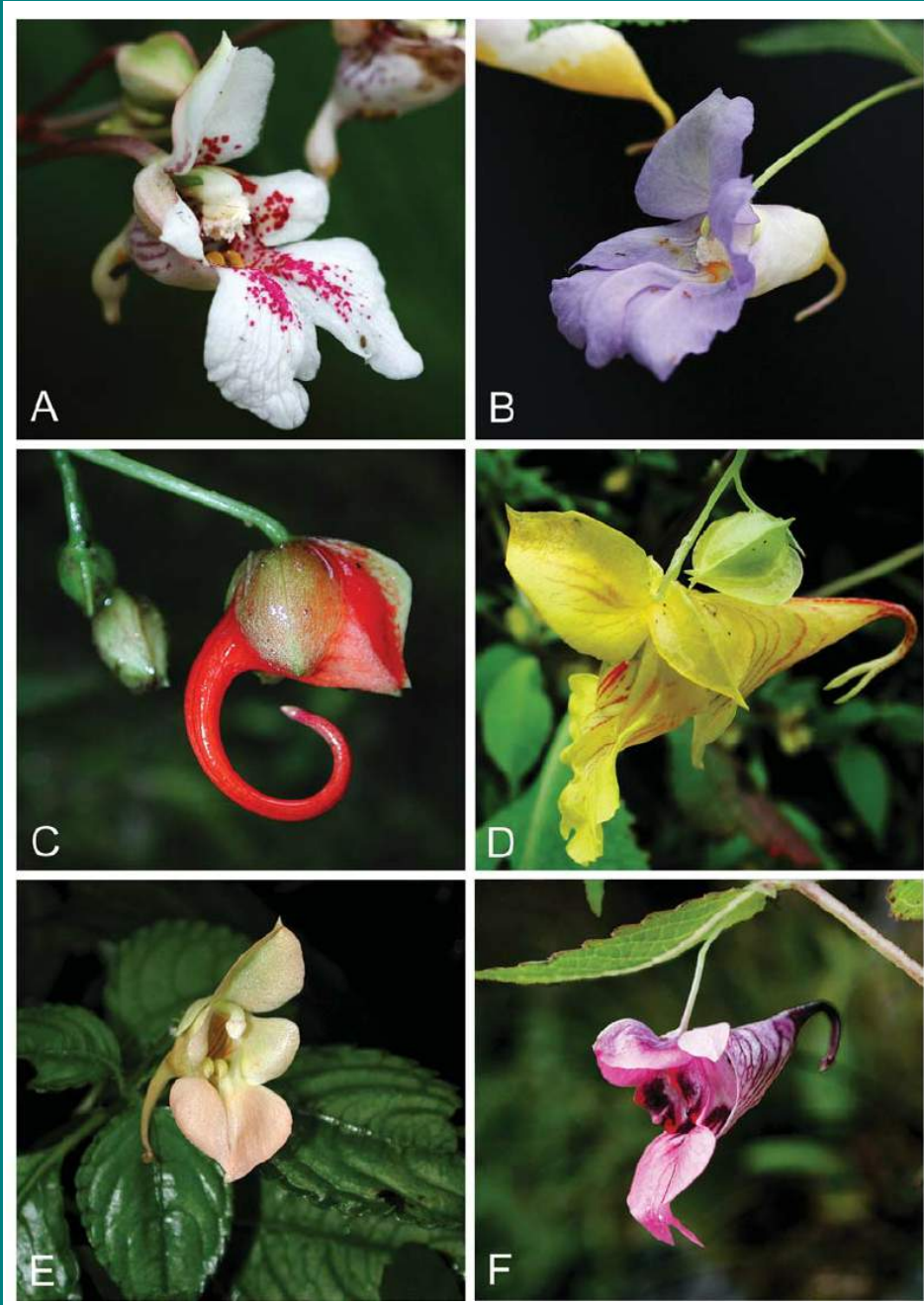


*Impatiens capensis*  
orange jewelweed





# Balsaminaceae - jewelweed



Molecular Phylogenetics and Evolution

Volume 52, Issue 3, September 2009, Pages 806-824



Rapid radiation of *Impatiens* (Balsaminaceae) during Pliocene and Pleistocene: Result of a global climate change

OW tropical *Impatiens* are diverse (nearly 1000) and recent in origin