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

Asterid Characteristics
• fused petals - sympetalous
• stamen number ≤ petal number
• stamens fused to corolla tube

Asterid Characteristics
• iridoid compounds (with losses)
• “basal asterids” have them (previously not placed with asterids)

Plants: Rubiaceae (coffee family) and Plantaginaceae (snapdragon family)
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

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!


Exceptions include the 'basal asterids' and separate petal or small flower orders

Apiaceae - carrot family
Aquifoliaceae - holly family
Basal Asterids

- 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

Cornales

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

*Cornaceae - dogwoods

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

*Cornaceae - dogwoods

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

- 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)

**Cornus stolonifera** - red osier
drupe

**Pseudanthia** in the Asterids – remember this!

**Cornaceae - dogwoods**

Eastern North American small tree with 4 conspicuous white bracts

*Cornus florida* - flowering dogwood

**Cornaceae - dogwoods**

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

*Cornus canadensis* - bunch berry
**Cornaceae - dogwoods**

*Cornus foemina*
Gray dogwood
Common component of shrub carr

*Cornus sericea*
Red-osier
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

**Ericales**

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

**Ericales**

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

- Ericales exhibit great diversity in habit and nutrient uptake strategies

  - mycorrhizal associations
  - mycorrhizal parasites (mycotrophs)

- Monotropa - Indian pipe
- Arctostaphylos - bearberry

Ericales

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

  - Rosid
  - core Asterid

Corolla Structure

- sympetalous
- polypetalous

  - Fouquieriaceae
  - Primulaceae
  - Lecythidaceae
  - Roridulaceae

- for instance in...

- Carnivorous plants
Corolla Structure

Re-examined in light of DNA based relationships
- corolla evolution is still complicated
- perhaps one or two separate origins of sympetal and two or three reversals to choripetal

Schoenenberger, Anderson, Sytsma 2005

Integument Number

unitegmic
bitegmic

for instance in ...

Clethraceae
Sympliocaceae
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

Schoenenberger, Anderson, Sytsma 2005

Stamen Number

1 whorl
2+ whorls

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)

- flowers have separate petals and many stamens

Schima
- flowers have separate petals and many stamens

Camellia sinensis - tea

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

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

- Enkianthus
- Epacris
- Monotropa
- Empetrum
**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*

*Leatherleaf in cloud forest epiphyte*

*Leatherleaf in bog*

*Leatherleaf in cloud forest epiphyte*

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

*Leatherleaf in bog*

*Leatherleaf in cloud forest epiphyte*

*Leatherleaf in bog*

*Leatherleaf in cloud forest epiphyte*

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**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**
- 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

*CA (4-5) CO (4-5) A 8,10 G (4-5)*

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*Ericaceae - blueberries*
*Ericaceae - blueberries

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

CA (4-5) CO (4-5) A 8.10 G (4-5)

Superior pistil

Inferior pistil

*Bog species

*Ericaceae - blueberries

Arctostaphylos uva-ursi
Bearberry

Creeping subshrub often seen on beaches
"uva-ursi" translates as bearberry, indicating at least one dispersal agent of the plant

Vaccinium myrtillus
Lowbush blueberry

Vaccinium angustifolium
Lowbush blueberry

Vaccinium myrtillus
Velvet-leaf blueberry

V. macrocarpon
Cranberry

Blueberries and cranberries are inferior ovated and berry fruited:

Kalmia polifolia
Pale laurel

Chamaedaphne calyculata
Leatherleaf

Andromeda glaucophylla
Bog rosemary

Rhododendron groenlandicum
Labrador tea

Rhododendron groenlandicum
Labrador tea

CA (4-5) CO (4-5) A 8.10 G (4-5)

Superior pistil

Inferior pistil
*Ericaceae - blueberries

Chancellor Blank and Dean VandenBosch at Cranberry Creek

V. macrocarpon cranberry

*Ericaceae - blueberries

Major family of the harsh Mediterranean climate regions of the world

Arbutus in Europe

Arbutus menziesii – CA madrone

*Ericaceae - blueberries

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

Wisconsin Dells

*Primulaceae - primroses

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

Primula (Dodecatheon) - shooting star
Primulaceae - primroses

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

Primula - shooting star

Lysimachia - loosestrife

Primula - the classic study organism for dimorphic heterostyly - Darwin

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

Dodecatheon - shooting star

• pistil is unilocular and free-central
• fruits are capsules
*Primulaceae - primroses

- **Primula meadii**
  - Shooting star
  - Basal leaves
  - (formerly in Dodecatheon)

- **P. fassettii**
  - Western shooting star

*Primulaceae - primroses

- **Lysimachia thyrsiflora**
  - Swamp candles

- **Lysimachia ciliata**
  - Fringed loosestrife

- **L. ciliata**

*Primulaceae - primroses

- **Trientalis borealis**
  - Starflower

  - Whorled leaves

  - 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

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

- Sarracenia purpurea - pitcher plant
  - 5 merous flower; unusual peltate stigma; flower structure ensures outcrossing by bees

Polemoniaceae - phlox

- Phlox divaricata - woodland phlox
  - woodland species

- Primarily North Temperate family of 18 genera and 385 species, but with radiations in xeric SW North America and in the Andes
  - 5 merous flowers
  - stamens at different heights
  - 3 fused carpels and 3 styles
**Polemoniaceae - phlox**

- *Polemonium reptans* - Jacob’s ladder
  - Alternate leaved spring flowering plant of woodlands and openings

- *Phlox pilosa* - prairie phlox
  - prairie species

**Foquieriaceae - ocotillo**

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

- *Foquieria splendens* - ocotillo

**Balsaminaceae - jewelweed**

- Small family of juicy-stemmed herbs with spurred sepals

- *Impatiens capensis* - orange jewelweed
- *Impatiens pallida* - yellow jewelweed
Balsaminaceae - jewelweed

- fruit is explosive to the touch, touch-me-nots
- OW tropical Impatiens are diverse (nearly 1000)

Impatiens - touch me not