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 - sympetaly
- stamen number ≤ 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

Plantaginaceae
- snapdragon family

Picrorhiza kurroa

Gardenia
Asterid Characteristics

- one layer of integuments in ovule vs. two in other groups
- the "unitesminae" (vs. bitegmineae) 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
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- 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

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
- 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*

*Pseudanthia* in the Asterids – remember this!

*Cornaceae - dogwoods*

Eastern North American small tree with 4 conspicuous white bracts

*Cornus florida - flowering dogwood*

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 racemosa
  - Gray dogwood
  - Common component of shrub carr

* Cornus sericea
  - Red-osier
  - Common in wet places, distinctive with red stems

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**Hydrangeaceae - hydrangeas**

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

- Most recently placed in Saxifragaceae

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**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

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**Ericales**

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

**Corolla Structure**

- **sympetalous**
- **polypetalous**

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

- Rosid
- core Asterid

**Corolla Structure**

- *Fouquieriaceae*
- *Primulaceae*
- *Lecythidaceae*
- *Fouquieria*
- *Couroupita*
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

Schoenenberger, Anderson, Sytsma 2005

Integument Number

unitegmic

bitegmic

for instance in ...

Clethraceae
Symphocaceae

Polemoniaceae
Roridulaceae

Theaceae
Actinidiaceae

Stamen Number

1 whorl

2+ whorls

for instance in ...

Schisoneuraceae

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
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

*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*
*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*

*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

*Hypopitys monotropa*

*Monotropa uniflora - Indian-pipe*

*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*

*beeberry*

*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
*Ericaceae - blueberries

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

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

**Superior pistil**

**Inferior pistil**

- *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 macrocarpon* - Cranberry
- *Vaccinium vitis-idaea* - Velvet-leaf blueberry
- *Andromeda glaucophylla* - Bog rosemary
- *Chamaedaphne calyculata* - Leatherleaf
- *Rhododendron groenlandicum* - Labrador tea
- *Kalmia polifolia* - Pale laurel

Blueberries and cranberries are inferior ovaried and berry fruited.
**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

Rhododendron - lapland rosebay

**Primulaceae - primroses**

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

Dodecatheon - shooting star

*Primula - primrose*
**Primulaceae - primroses**

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

*Dodecatheon* - shooting star  
*Lysimachia* - loosestrife

- Pistil is unilocular and free-central  
- Fruits are capsules

*Primulaceae - primroses*

- Primula - the classic study organism for 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. (1873)
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)

*Primulaceae - primroses*

Pollen and stigmatic differences in thrum and pin flowers
**Primulaceae - primroses**

* Dodecatheon meadii
  Shooting star
  Basal leaves

* D. amethystinum
  Western shooting star

* Lysimachia thyrsiflora
  Swamp candles

* L. ciliata
  Fringed loosestrife

* L. ciliata
  Opposite leaves

**Primulaceae - primroses**

* Trientalis borealis
  Starflower

**Sarraceniaceae - pitcher plants**

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

* Sarracenia - pitcher plant

* Darlingtonia - cobra lily

* Heliamphora - sun pitcher
**Sarraceniaceae - pitcher plants**

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

**Polemoniaceae - phlox**

- Primarily North Temperate family of 18 genera and 385 species, but with radiations in xeric SW North America and in the Andes
- Phlox divaricata - woodland phlox
- Woodland species
**Polemoniaceae - phlox**

*Phlox pilosa* - prairie phlox

- prairie species

**Foquieriaceae - ocotillo**

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

*Foquiera splendens* - ocotillo

*Ph.D. Work by Jeff Rose*

*Polemoniaceae DNA tree with pollinators mapped onto it*
Balsaminaceae - jewelweed

Small family of juicy-stemmed herbs with spurred sepals

Impatiens capensis
orange jewelweed

Impatiens pallida
yellow jewelweed

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

Impatiens – touch me not