Week 6; Monday

Announcements: sign up for field trip in lab this week

Lecture: Begin Asteridae s.l.

Synapomorphies of Asteridae s.l.
1) Iridoid compounds – secondary chemical compounds thought to be plant defenses
2) Unitegmic ovules – ovules covered by a single integument (integument is the outer covering of the ovule, becomes seed coat) – result of either loss or fusion of the two integuments found in all other angiosperms
3) Tenuinucellate ovules – thin nucellus in ovule (nucellus is the tissue beneath the integument that surrounds the megagametophyte)

The traditional, or ‘core,’ Asteridae (as first recognized by Takhtajan and Cronquist) included families with the above characters, but only those also with:
- gamopetalous corollas
- 5-parted flowers
- single whorl of stamens that alternate with the petal lobes
- epipetalous stamens
- 2 fused carpels

The traditional view of the evolutionary “trend” in floral evolution went like this:
Many free parts, spirally arranged → radiation to many lineages
 TO distinct no. of free parts in whorls → radiation to many lineages
 TO parts in whorls fused → radiation ...

In this scenario, the Asteridae are considered to be recently evolved.

Families with many of these traits, but with polypetalous corollas, typically were assigned to the Rosidae (e.g., Cronquist).
- Examples include Apiaceae, Cornaceae, Hydrangeaceae, Loasaceae
Families with many of these traits, but with multiple whorls of stamens, or with one whorl opposite the corolla lobes, typically were assigned to the Dilleniidae.
- Examples include Ericaceae, Primulaceae, Fouquieriaceae.

However, what we see from the phylogenetic reconstructions is one of a very early origin of fused floral form, soon after the appearance of the whorled polypetalous forms. Also, fossils belong to Asteridae appear early in the Tertiary.

There are four major groups of Asteridae:
1) The apparently earliest divergent branch of the Asteridae s.l. is composed of polypetalous plants in a group called the Cornales, including the Dogwoods (Cornaceae) and Hydrangeas (Hydrangeaceae).
2) The Ericales sensu lato, including the Ericaceae and Polemoniaceae
3) The Lamiaidae (sometimes simply called Asterids I), including the Boraginaceae, Solanaceae, Apocynaceae, Lamiaceae, Scrophulariaceae, and Oleaceae
4) The Campanulidae (sometimes simply called Asterids II), including the Apiaceae, Caprifoliaceae, Adoxaceae, and Asteraceae.

**Cornales: Cornaceae** – Dogwood family – in lab only.

**Ericaceae** - Heather family - Very abundant in PNW (130 gen/2700 spp)
1) mostly trees and shrubs, some herbs
2) lvs. simple often thick and leathery
3) plants often mycorhizal (symbiotic relationship with fungus) or mycotrophic (nutritionally dependent on fungi underground, which, in turn are dependent on other green plants); some are totally without the ability to photosynthesize. Pine drops, Indian pipe, etc.
4) Flowers
   - actinomorphic (sometimes zygomorphic as in *Rhododendron*)
   - 5- parted perianth, usually connate - flowers usually urn-shaped
   - 10 stamens (sometimes 5 in *Rhododendron*); sometimes epipetalous; anthers poricidal with terminal pores; often with ‘horned’ appendages
   - pollen shed in tetrads
   - 3-5 fused carpels; nectary disk around base of ovary; fruit a **berry** or **capsule**

Floral formula: *(X) 5, 5, (5) 10, 3-5 berry, capsule [carpels fused]

   ovary usually superior, but sometimes inferior

**Polemoniaceae** - Phlox family (16 gen/320 spp) – most diverse in western US
1) herbaceous, sometime slightly woody at base (as in some species of *Phlox*)
2) lvs. variable, but usually simple, alternate, sometimes opposite and sometimes divided or pinnately compound (as in *Polemonium*)
3) flower morphology seems typical of traditional Asteridae s.s., but belongs here with other families traditionally placed in Dilleniidae
   - 1 whorl of stamens alternate with corolla lobes and adnate to corolla
     (this is probably from a loss of one whorl of stamens, but the similarity to core Asterids, such as Solanaceae, led to the classification of Polemoniaceae in Asteridae, whereas its more closely related families with two whorls of stamens were placed in Dilleniidae)
   - 3 fused carpels - note 3-forked style; this is very unusual in traditional, core Asteridae, but this character is fairly common in families in this part of Asteridae s.l. (eg, Primulaceae, the primroses)
   - stamens sometimes unequally inserted on corolla tube

Floral formula: * 5, 5, 5, 3 capsule [carpels fused]
Week 6; Wednesday

Announcements: Field trip on Saturday; last chance to sign up today.
Quiz next Monday in lab;
Exam in lecture one week from Friday; covers material through this Friday;
review session Tuesday at 5:30 pm in HCK 132

Lecture: Asteridae s.l. continued

Most of the rest of the families we will take up all are in the ‘core’ Asteridae and are rather uniformly characterized by their floral morphology. However, each has some distinguishing trait or combination of traits.

Generalized floral formula: */X 5, 5, 5, 2 carpels fused ovary superior or inferior

There are four major lineages in Lamiidae:
Today: Boraginales, Solanales, Gentianales – primarily radial symmetry
Monday: Lamiales – primarily bilateral symmetry

**Boraginaceae**  Borage family (134 gen/2650 spp)
   - Includes former *Hydrophyllaceae*

1) mostly herbs (all of ours); some shrubs and trees, mostly in tropics
2) lvs simple (sometimes deeply divided, eg, in *Hydrophyllum*), alternate, commonly with stiff ‘**hispid**’ hairs – *[Symphytum leaves demo]*
3) Flowers
   - actinomorphic
   - inflorescence a **scorpioid** or **helicoid** cyme (see below and overhead)
   - corolla often with a ‘**corona**’ of infolded appendages at throat of tube
   - stamens either exserted and spreading (former Hydrophyllaceae) or included
   - carpels 2, superior, exhibiting two distinct morphologies:
     1) each with many ovules (formerly Hydrophyllaceae).
     2) each containing 2 ovules and dividing by infolding of the ovary wall forming a false septum between each ovule (Boraginaceae s.s.). In our species this results in four separate **nutlets** when mature (subfamily Boraginoideae, only).
A cyme is a determinant inflorescence, with the terminal bud developing into a flower, then with lateral flowers, lower on the stem, developing in sequence:

Scorpioid cyme

Helicoid cyme

floral formula: \(* 5, 5, 5, 2\) capsule, nutlets [carpels fused, but deeply divided into a 4-parted schizocarp]

Hydrophyllaceae Waterleaf family (18 gen/250 spp) Now included in Boraginaceae. This group is predominantly western North America in distribution and was segregated primarily on the basis of the many ovules per carpel. Gynoecial features were commonly weighted heavily in family circumscriptions in pre-phylogenetic classifications. At present it appears that neither the Boraginaceae or the Hydrophyllaceae are monophyletic (see overhead). However, all of the members of the former Boraginaceae that are found in the Pacific Northwest belong to a monophyletic subfamily of the Boraginaceae (Boraginoideae). Likewise, all members of former Hydrophyllaceae found in the PNW belong to one clade.
Solanaceae    Potato or Nightshade family  (98 gen/~2716 spp)
This is one of the most important food plant families in the world, probably second only to the grass family. Includes potato, tomato, eggplant, peppers, tomatillo, naranjillo, tree tomato, and other crops locally grown in Latin America.

1) mostly herbs (some vines or woody plants)
2) lvs alternate, simple, often lobed
3) presence of **alkaloids** in various forms gives these plants various uses, including:
   - culinary (capsaicin in chilis)
   - medicinal (atropine in belladona)
   - narcotic (nicotine in tobacco)
   - hallucinogenic (various alkaloids in Datura - jimson weed)
4) Flowers - these flowers are often the most ‘generic’ Asteridae flowers
   - actinomorphic (some zygomorphic)
   - anthers not exserted, or if so, then **connivent** (held together, but not fused) as in Solanum
   - **style capitate** (not divided)
   - carpels 2, fused, usually with many ovules.; fruit a **berry** or **capsule**

Floral formula: *(X) 5, 5, (2, 4)5, 2    berry, capsule    [carpels fused]

examples of berry fruits: tomato, eggplant, chili pepper, and bell pepper

**POWERPOINT: SOLANACEAE PHYLOGENY & BIOGEOGRAPHY**

If time: reading on Capsicum from Heiser’s “The fascinating world of nightshades”

BIOL 317 family: **Apocynaceae**
Week 6; Friday

**Announcements:** Field trip departs at 7:45 sharp! Bring lunch, rain gear, and sturdy footwear.

**Lecture:** Washington plant geography: Factors contributing to present-day plant distributions in Washington and the PNW

Distinguish “flora” and “vegetation”
The word flora refers to all plant species that occur in an area (Flora with a capital “F” is a published list, usually with keys and descriptions, e.g., Hitchcock & Cronquist).

Vegetation is the pattern of plant distributions on the landscape

“Vegetation zone” is a broad area where a similar type of vegetation exists (e.g., sagebrush-steppe or lowland forest).

Physiographic provinces (geomorphic landforms) and Geologic provinces (common geologic features) of PNW (overhead of PNW regions)

Geology and landforms are among the most important elements in determining the vegetation of a region

**Climatic factors:**
1) **Rainfall** (overhead of state iso-precipitation lines)
2) **Temperature**

Interaction of climatic factors with landforms (Overhead of Snoqualmie pass transect; Overhead of temp vs, precip graph of communities)

The interaction of rainfall, temperature, and mountains is what controls most of our vegetation patterns in Washington. The physics of this process goes something like this:

• Prevailing westerly winds bring cool moist air from over the Pacific on land in Washington.
• As this cool air comes over land, it is forced to rise, first to cross the Olympic mountains and then to cross the Cascades.
• Air pressure decreases as it rises, and thus cools (this is called adiabatic cooling); cool air can hold less moisture than warm air, so moisture condenses and falls as rain on the west sides of our mountains.
• As the air passes the mountain crest, it drops and warms (adiabatic warming); this air now has less moisture than it did at the same elevation on the west side, and is warmer, so it can hold more moisture and has a low relative humidity.
• The air moving east across eastern Washington stays at about the same elevation, so the dry air does not release much moisture as rain. However, it does pick up moisture along the way from bodies of water, the soil, and plants, so by the time it reaches the eastern edge of the state (e.g., Spokane) it has more moisture and the precipitation begins to increase again.
Historical and physical factors:

1) Volcanism and Mountain building
   - continental drift and plate tectonics – Pacific and North American plates built the Cascades and cause the chain of volcanoes from Ca to Alaska
   - lava flows – 600-1500 meters thick east of the Cascades; formed in early Miocene, 20 million years ago (source near west edge of Rocky Mts)
   - volcanoes – local impact today, e.g., Mt. St. Helens eruption in 1980

2) Glaciation
   - creating landforms – continental glaciers carved Puget Sound and deposited the hills in Seattle.
   - relatively recent phenomenon in PNW; vegetation may not be in equilibrium

3) Edaphic factors
   - soil types:
     Limestone is rich in Ca -> soil with high pH
     granite is mineral poor -> soil usually low pH, thus different vegetation
     Serpentine soils are low in N, P, and K; while being rich in magnesium and iron and other elements often toxic to plants (e.g., nickel, iron, cobalt)

4) Human intervention
   - deforestation – particularly clear-cutting, but also tree removal for development
   - wetland filling – especially in the Puget Sound
   - urbanization – ca. 70% of lowland Puget Sound forest lost in past 30 years
   - agriculture – mostly eastern Washington, where only very small remnants of native grassland remain
   - introduction of foreign (alien) species of plants and animals (e.g., mountain goats in Olympics, cheat grass in E WA, and English ivy in Seattle)
   - GLOBAL WARMING – decreased summer water availability and other impacts

Biological Factors

1) Plant Migration
   - restricts many plants that might be able to live here, enables others to arrive either naturally or by human intervention
   - slow establishment of equilibrium following disturbance or climatic change

2) Evolution
   - Origin of new species in isolation and in unusual sites (e.g., Olympics; serpentine); evolution and migration are why species in the PNW and the Amazonian rainforest might be related.

3) Symbioses
   - fungal associates (e.g., Mycorrhizae; mycotrophism)
   - pollinators
   - parasitic plants

4) Competition
   - stable, non-stressful environments typically have fewer species, because the evolution of strong competitors keeps others out
- heterogenous (spatially and temporally) stressful environments (e.g., dry) typically have more species

**Endemic species** - species restricted to a narrow geographic region (e.g., species “A” is endemic to the Olympic Mountains, or species “B” is endemic to Washington)

**Plant Communities**
Are these a coincidental assemblage of species that have similar physical requirements, or a group of species that have an obligate relationship to coexist? A debate in the early 20th century considered whether environmental conditions affecting individual species resulted in ‘communities’ of plants over broad distributions or whether obligate interactions between species resulted in ‘communities.’ The conclusion of many experiments and studies is the former. Species interactions are still sometimes important for individual species, but for the most part, plant communities are the result of environmental requirements that are shared among many individual species. We’re not going to answer this here, but this is an important historical question in plant ecology.

**Traditional view** is one of *“Seral stages”* leading to a stable *“climax”*

This process is called **succession**.

**Disturbance** (e.g., fire, windstorm, avalanches, lava flow, glaciation) knocks the vegetation back to an early seral stage, followed by development back to a stable climax.

Disturbance is viewed to be common in some communities, which never achieve a true climax, but rather achieve a ‘disturbance climax’ (e.g., fire climax in the prairies of the upper midwest as in the essay about Bur oak by Aldo Leopold that I read earlier this quarter).

**Seral**, or **successional** plants are ones that are replaced by other plants after one or a few generations, because they cannot reproduce in competition with mature plants of their own species.

**Climax** plants are ones that can reproduce generation after generation in the same environment, until a disturbance alters the habitat.

**Current view** is one of regular disturbance maintaining a dynamic patchwork of vegetation in different stages.

An interesting example of where these two views differ in their interpretation of climax communities here in Washington is the lowland Puget Sound forest community. Mature forests are a mix of Western Hemlock, Western Red Cedar
and Douglas Fir. The first two species can reproduce in the shade of the deep forest, whereas Douglas Fir cannot.

Traditional view: Douglas fir is not a climax species, but because it is long lived, we often see it in mature, but not climax communities

Washington Plant Communities:

**Alpine tundra** - low vegetation; short, cool growing season

**Subalpine** - mixed forest and open meadows; short growing season, but not as short or cool as tundra

**Montane forest** - continuous tree canopy; species composition varies with environmental conditions (precip, temp, etc.)

**Temperate rainforest** – forest with sufficient rainfall to sustain a heavy epiphytic plant community (eg, Pacific coast side of Olympic Peninsula and places on west slope of Cascades. Needs at least 2 meters of rainfall per year.

**Lowland forest** - long growing season; lots of precip (30”-100”+ per year)

**Shrub-steppe** - sagebrush and bunch grasses; low precipitation (5-20” per year)
Washington Vegetation Zones
Figure 26. - Climatic cross section of the Cascade Range in the vicinity of Snoqualmie Pass, Washington (47° 25' N, lat.), distance from Seattle to Ellensburg approximately 153 km. (data from U.S. Weather Bureau 1946).