

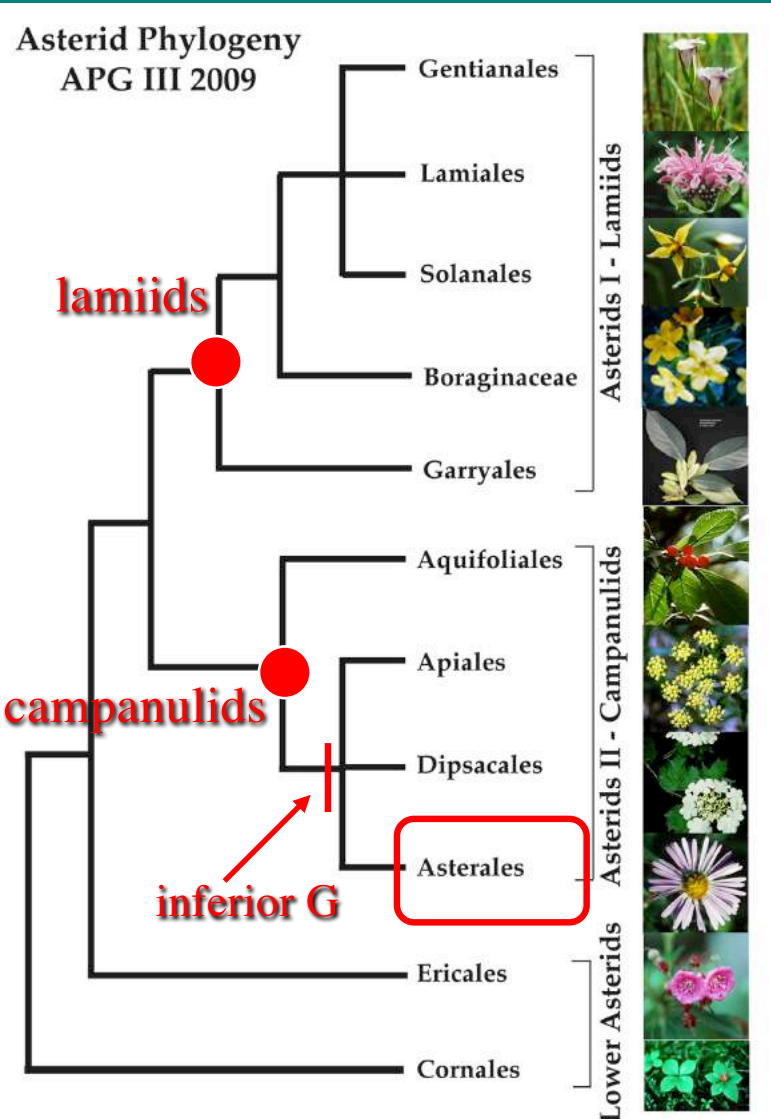


Diversity and Evolution of Asterids

. . . asters, ragweeds, and
goldenrods . . .

Asterales

- 11 families and nearly 26,000 species - **Australasia** appears to be center of diversity
- no iridoids, latex common, inferior gynoecium, pollen presentation



bellflower -
Campanulaceae



chickory -
Asteraceae

* Asteraceae - composites

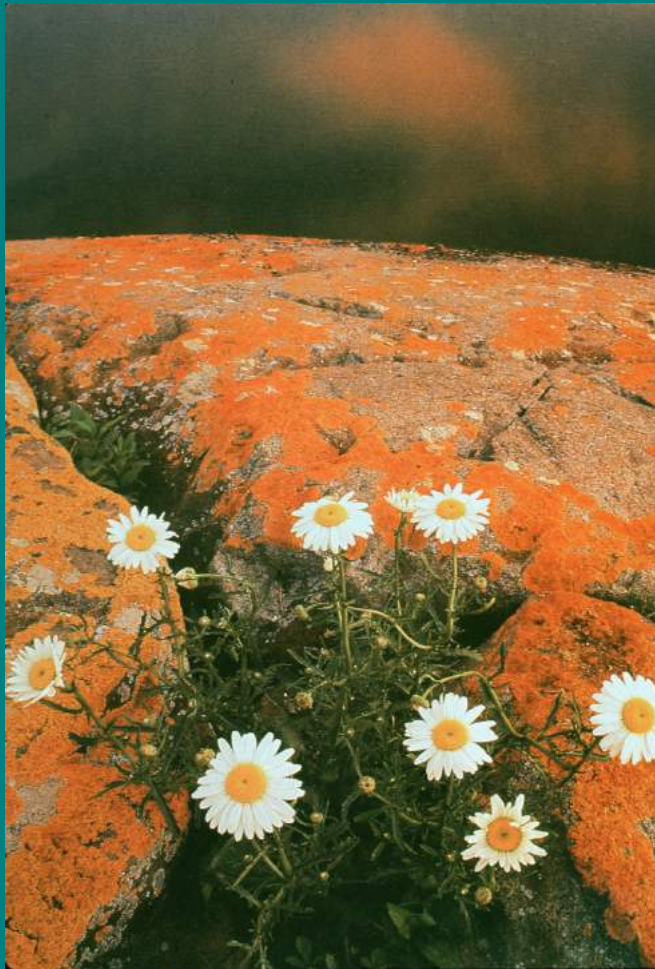
One of the most successful of all flowering plant families with over 1,500 genera and 23,000 species



- composites found throughout the world but most characteristic of the grassland biomes

* Asteraceae - composites

One of the most successful of all flowering plant families with over 1,500 genera and 23,000 species



- but also diverse in arctic to tropical and subtropical regions

* Asteraceae - composites

Family has 4 specialized features important in this radiation:

1. Special inflorescence “head” - **pseudanthia**
2. **Pollen presentation**
3. Diverse **secondary chemistry**
4. **Whole genome duplication**



Pseudanthia in the Asterids



Cornaceae



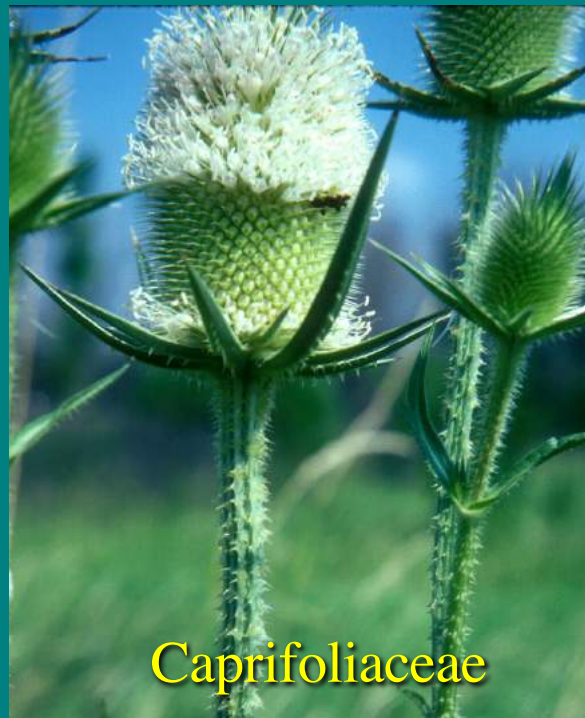
Apiaceae



Rubiaceae



Asteraceae



Caprifoliaceae



Adoxaceae

Pathway to Asteraceae Head?



Menyanthaceae

Goodeniaceae

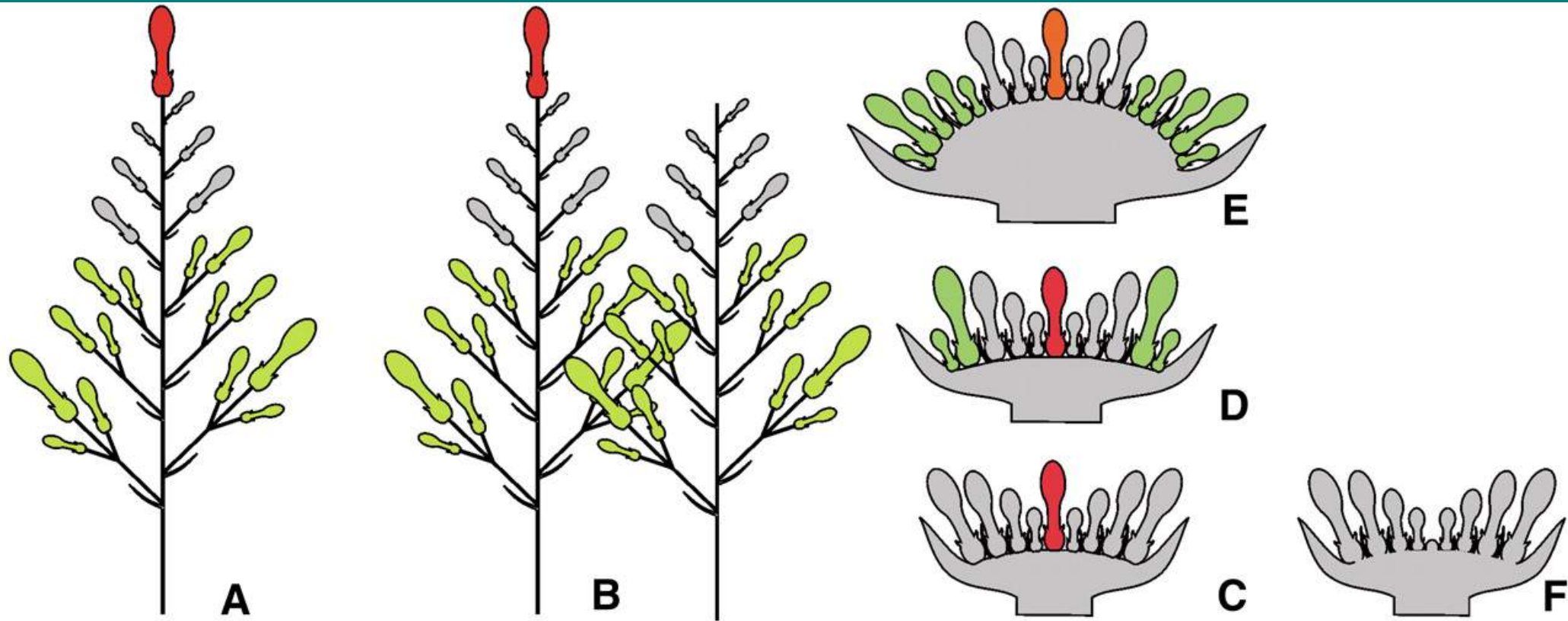
Calyceraceae

Asteraceae



How did this happen morphologically?

Pathway to Asteraceae Head?



Menyanthaceae

Goodeniaceae

Calyceraceae

Asteraceae

- * No internode elongation
- * Presence/absence of cymose branches/units
- * Involucre differentiation

- * Loss of terminal flower
- * Loss of cymose units



G

Pollination Syndromes



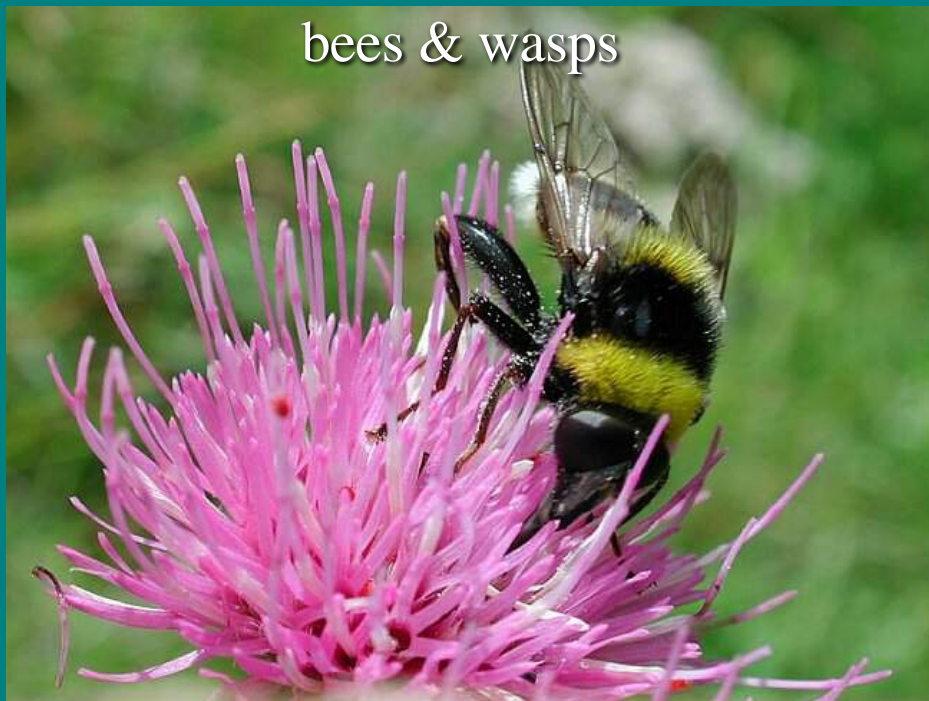
hummingbirds



flies



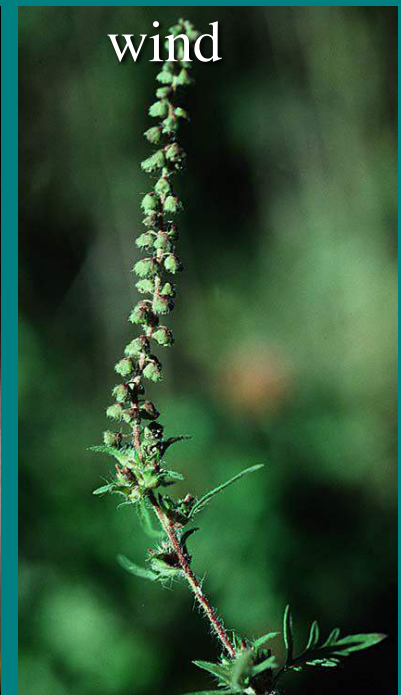
moths



bees & wasps

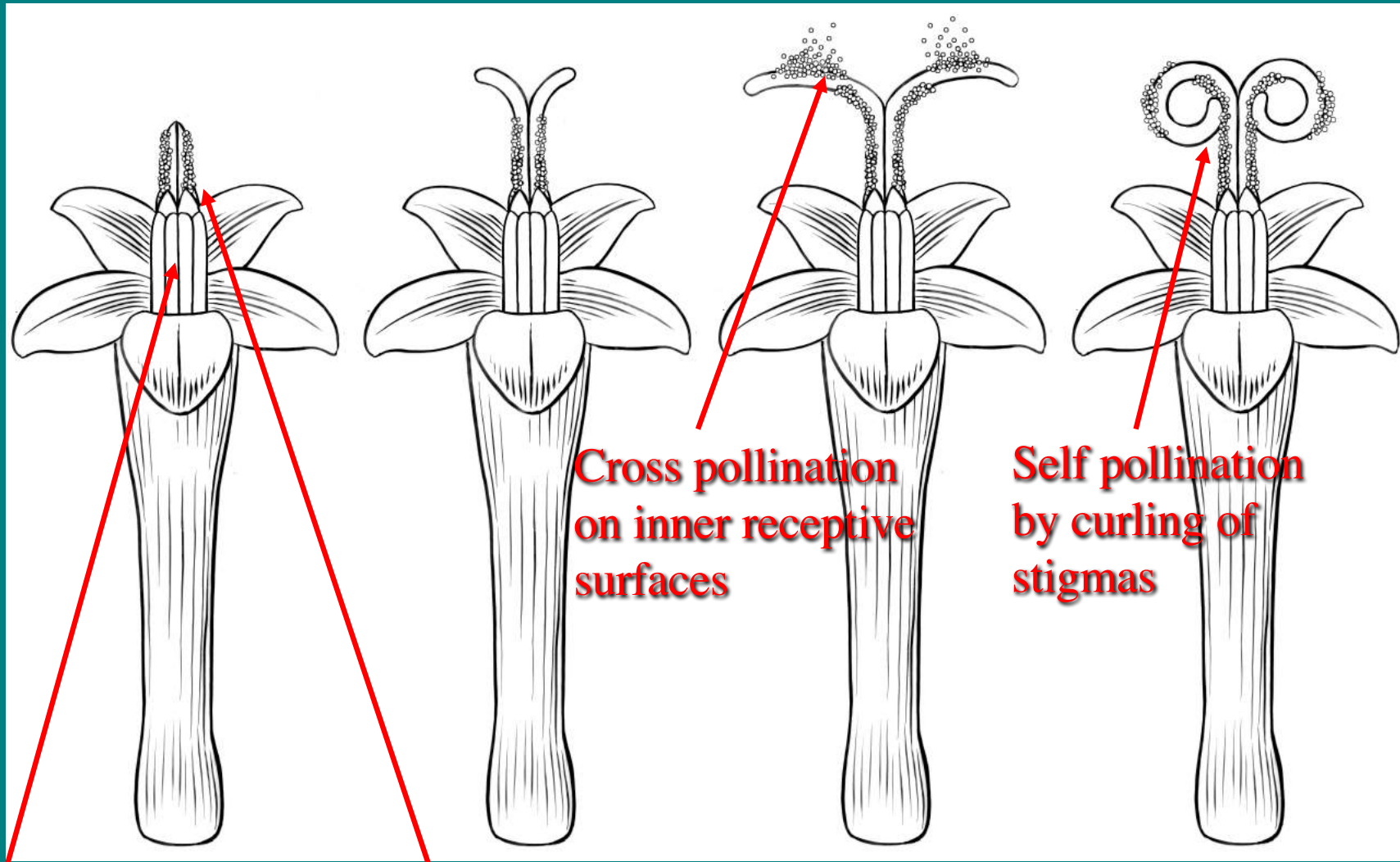


butterflies



wind

Pollen Presentation



Anthers fused forming a tube for pollen release

Pollen pushed out by a style that acts as a plunger

Stigma makes contact with self pollen if necessary

Chemical Diversity



Packera



Agoseris



Tanacetum

- polyacetylenes, sesquiterpene lactones, terpenes, alkaloids, latex

Chemical Diversity



Helenium hoopesii – Sneezeweed,
Owl's-claw

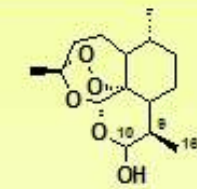
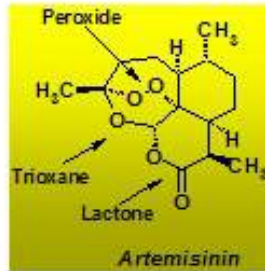
- sesquiterpene lactones poisonous to sheep in the southern Rockies
- “spewing” disease



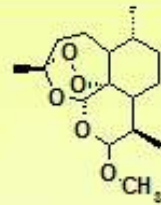
Chemical Diversity



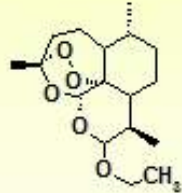
Artemisia annua



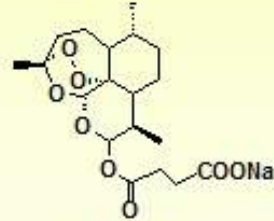
Dihydroartemisinin (DHA) (Artemimol)



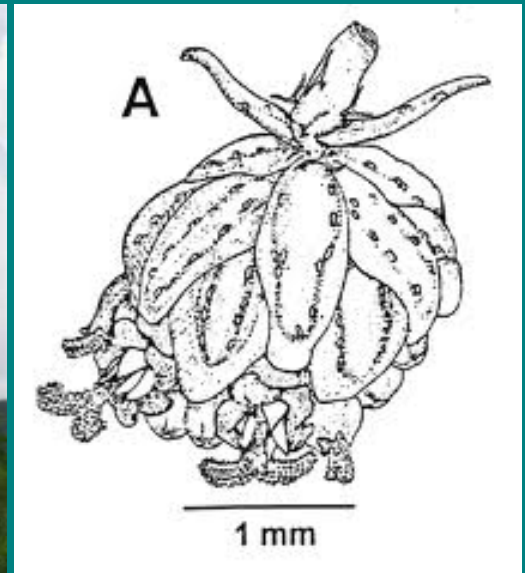
Artemether (Artemos)



Arteether (Artemotil)



Sodium artesunate



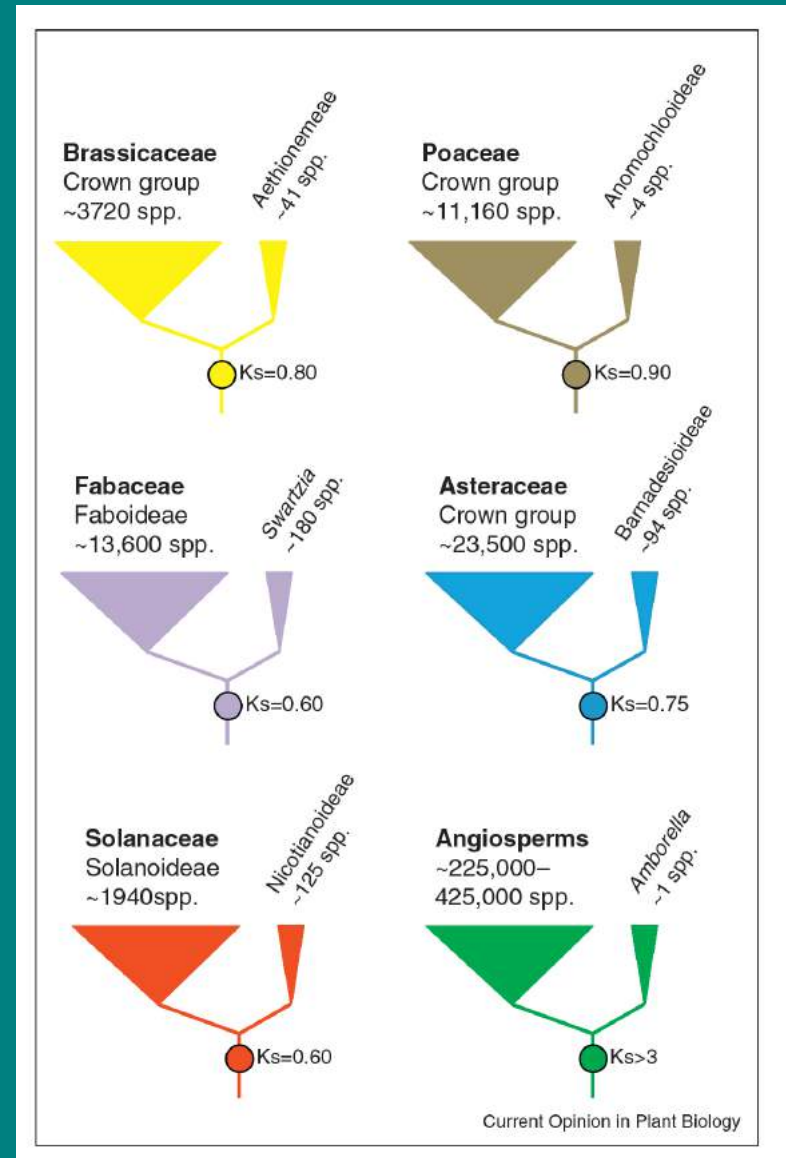
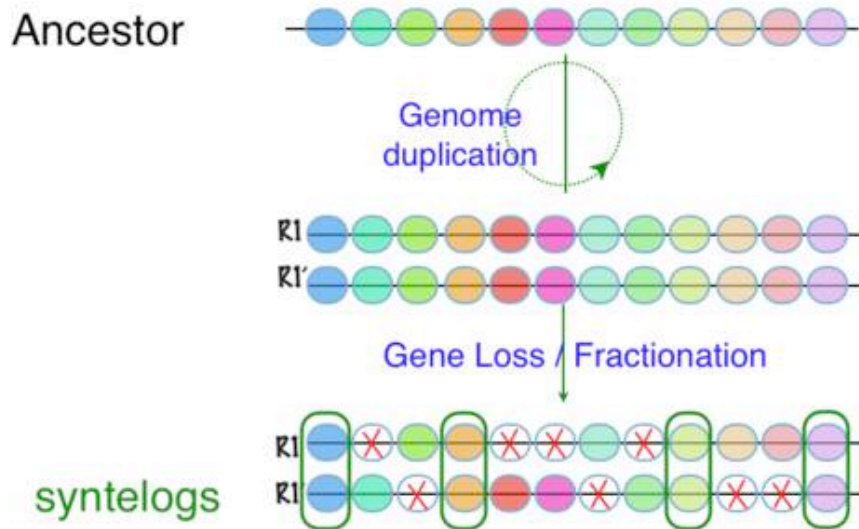
Artemisia annua – Sweet wormwood

- sesquiterpene lactones used in anti-malarial treatment
- Chinese herbal medicine

Whole Genome Duplication

- all Asteraceae have genome doubling – not in other Asterales
- species radiation associated with the WGD shows a “time lag”

Fractionation and diploidization:



Schranz et al. 2012 – Ancient whole genome duplications, novelty and diversification: the WGD Radiation Lag-Time Model.

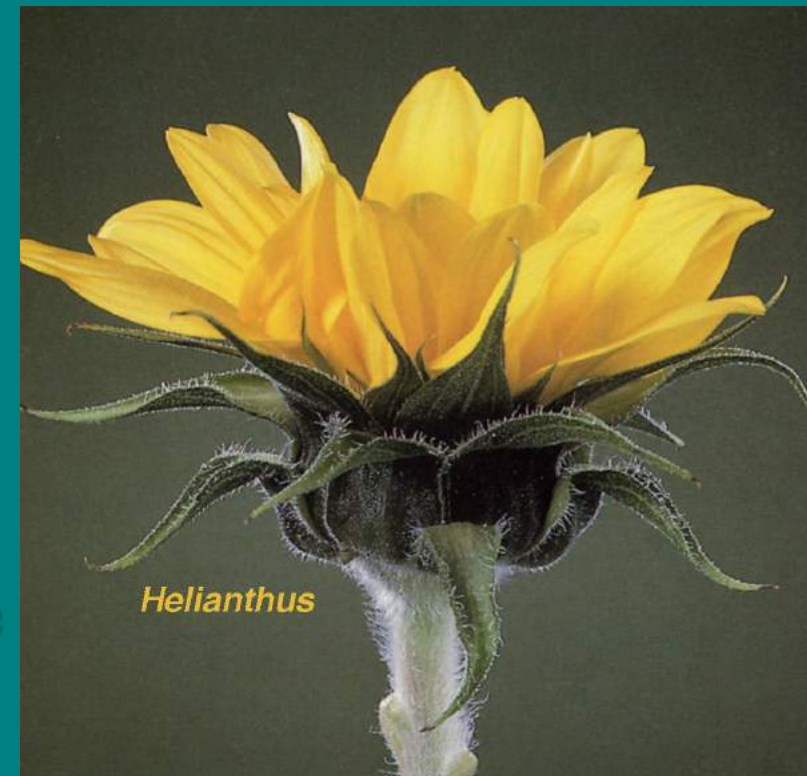
Asteraceae - composites



The **head** or **capitulum** is a cluster of 1 or 2 distinct flower types. The family is also called “**Compositae**” referring to this clustering.

The head is surrounded by special bracts called the **involucre** or **phyllaries**.

The involucre is important in the classification and identification within the family.

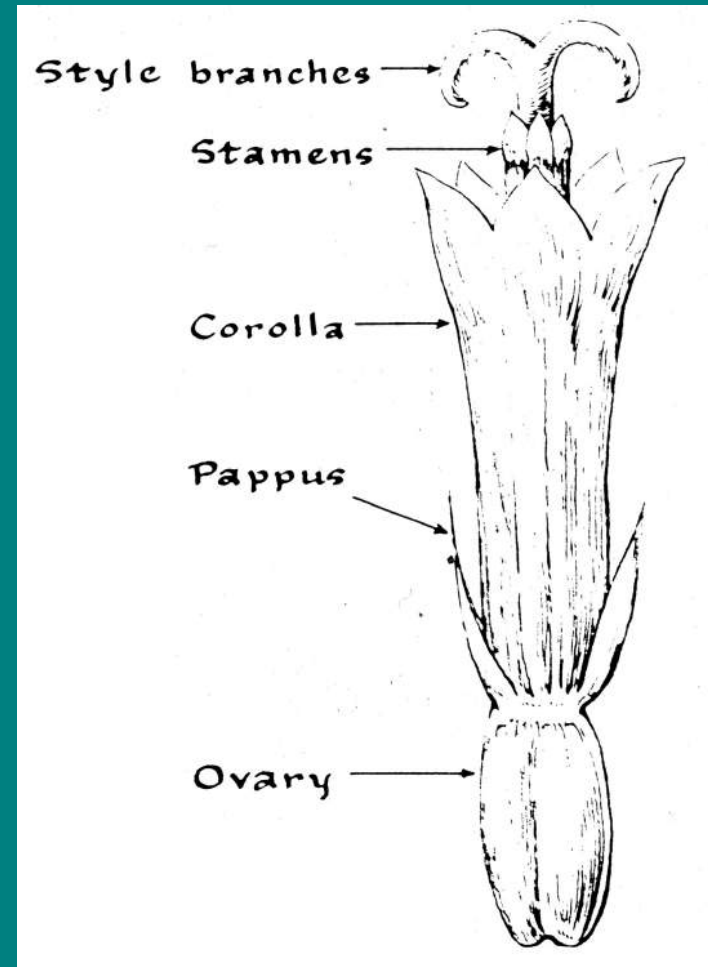


Asteraceae - floral diversity



CA X CO (5) A (5) \overline{G} (2)

- Calyx is reduced to a **pappus** of scales, awns, bristles, or absent
- Corolla has 5 petals but variously fused or zygomorphic
- Anthers (only) fused in a ring

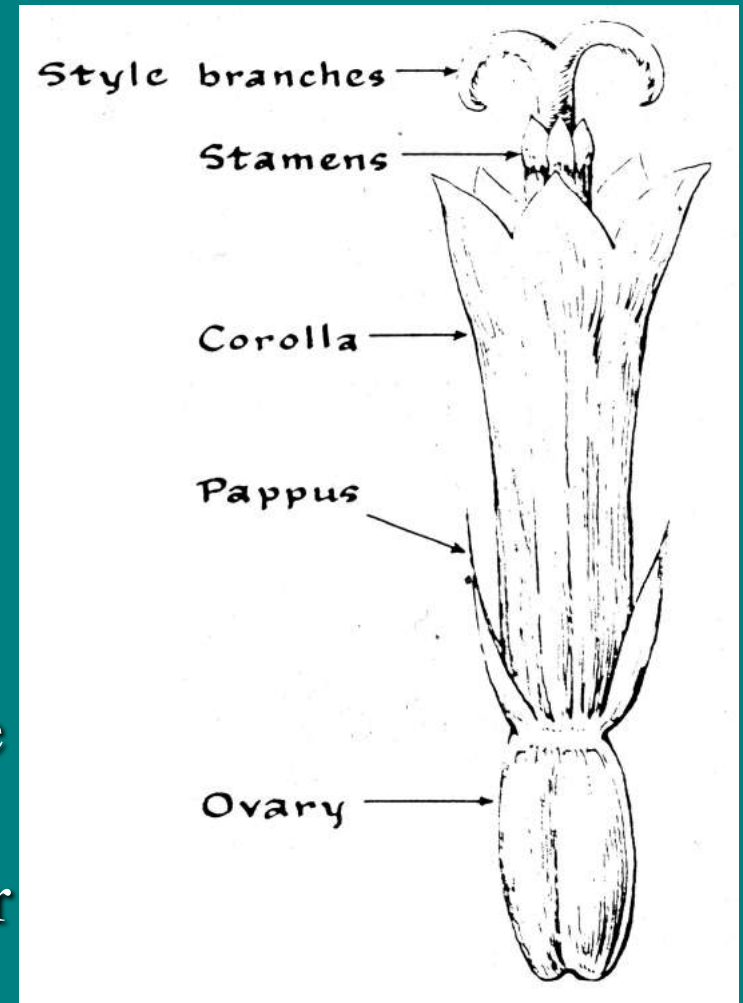


Asteraceae - floral diversity

CA X CO (5) A (5) \overline{G} (2)



The fruit is a one-seeded **achene** with the pappus serving as the fruit disperser (e.g., barbs for animal dispersal, hairs for wind dispersal)

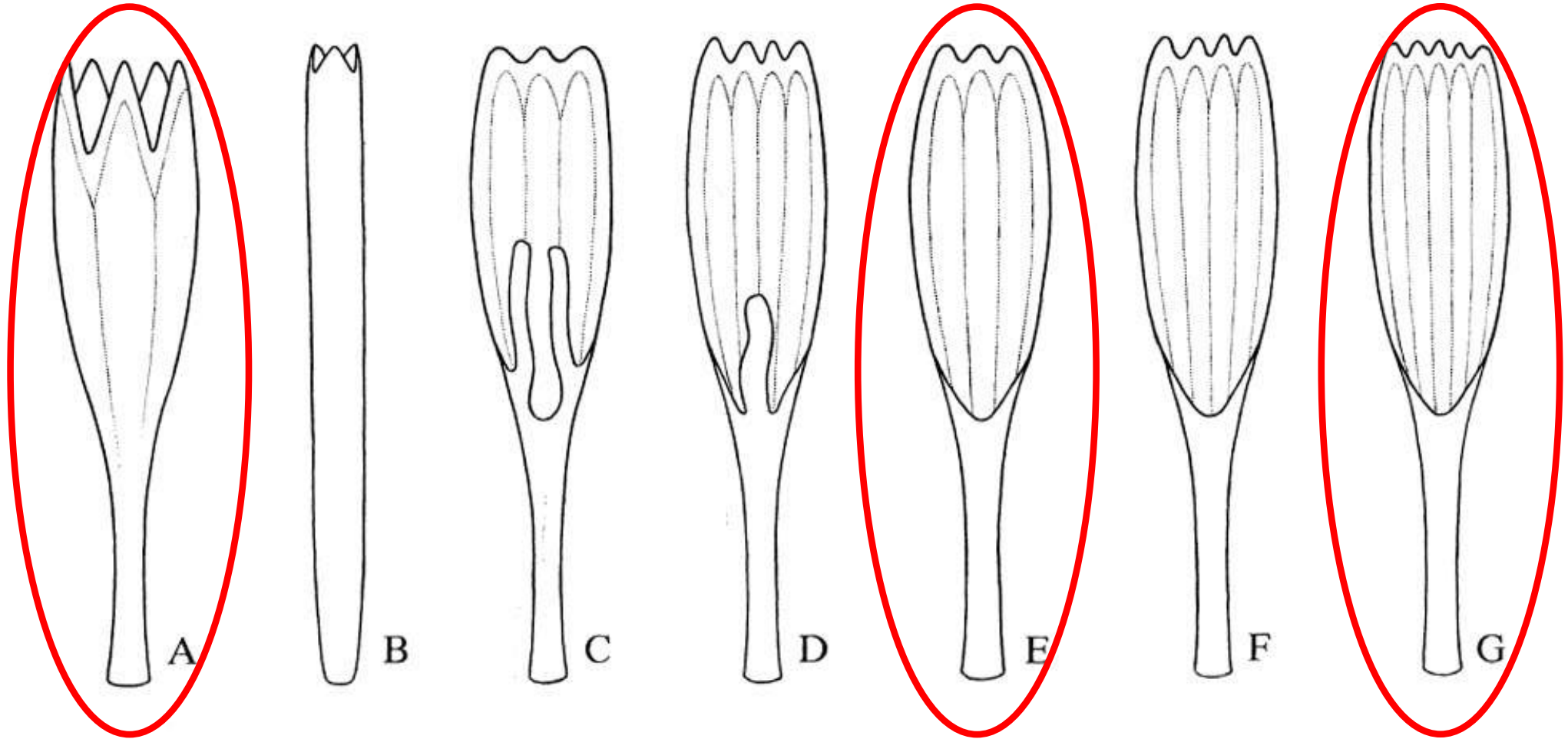


Asteraceae - floral diversity

Disc floret

True Ray

Ligulate floret



- the family exhibits a diverse array of floral types
- these three corolla types are seen in Wisconsin

Asteraceae - floral diversity



Main floret types

1. **Disk** or **tubular** florets are actinomorphic

Asteraceae - floral diversity



Main floret types

1. **Disk** or **tubular** florets are actinomorphic
2. **Ray** florets are usually 3 long fused petals + 2 obsolete petals

Asteraceae - floral diversity



Main floret types

1. **Disk** or **tubular** florets are actinomorphic
2. **Ray** florets are usually 3 long fused petals + 2 obsolete petals
3. **Ligulate** florets are 5 fused petals but split open

Asteraceae - head diversity

These various types of florets combine to form a number of different looking heads

Radiate head: disk florets in the center, ray florets along the edge (these usually pistillate)



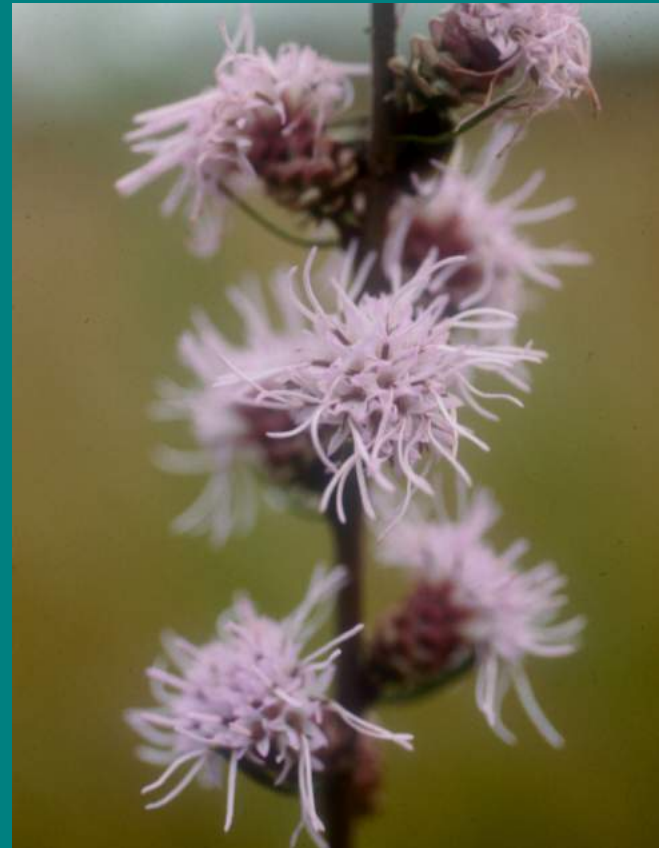
Symphotrichum - aster

Asteraceae - head diversity

These various types of florets combine to form a number of different looking heads

Radiate head: disk florets in the center, ray florets along the edge (these usually pistillate)

Discoid head: only disk or tubular florets comprise the entire head



Liatris - blazing star

Asteraceae - head diversity

These various types of florets combine to form a number of different looking heads

Radiate head: disk florets in the center, ray florets along the edge (these usually pistillate)

Discoïd head: only disk or tubular florets comprise the entire head

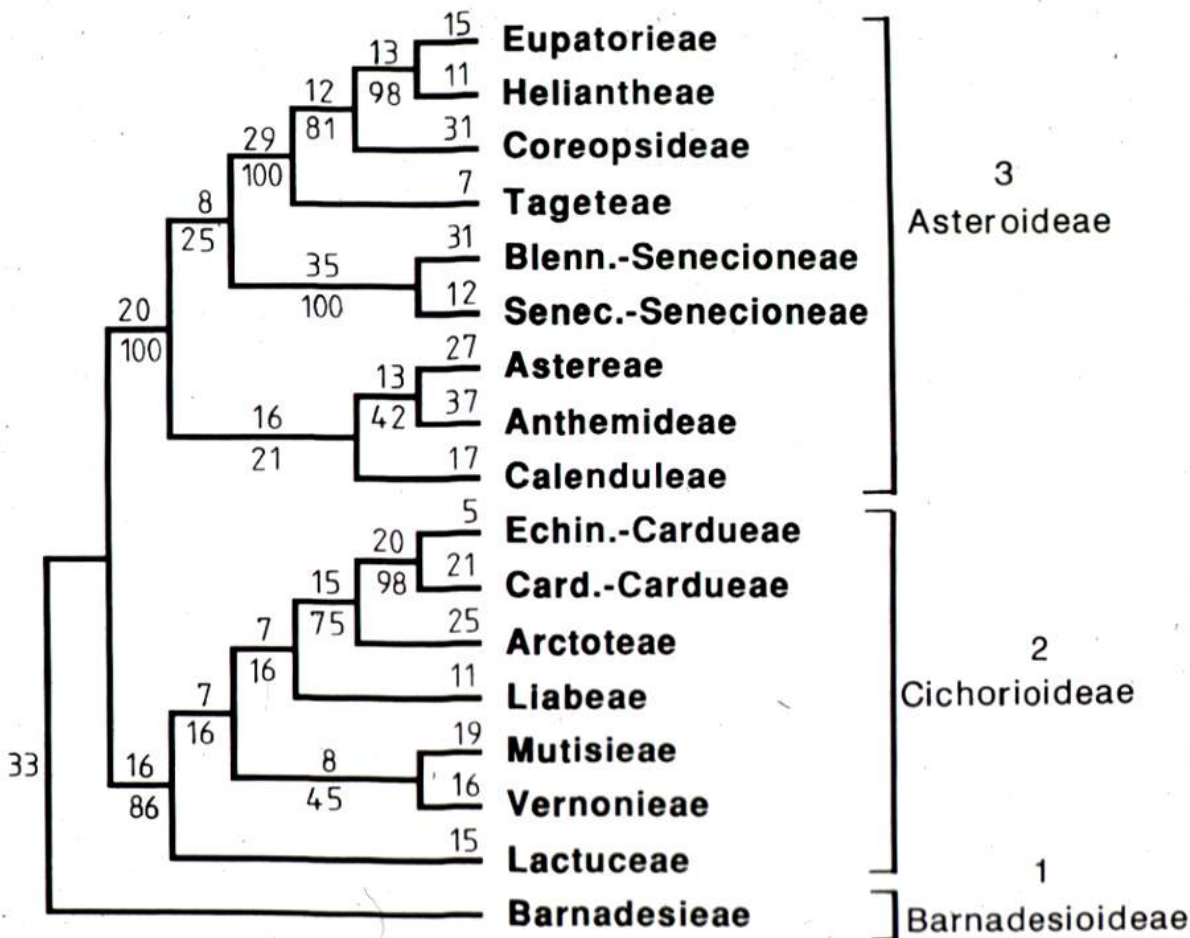
Ligulate head: only ligulate florets comprise the entire head



Cichorium - chickory

Asteraceae - phylogeny

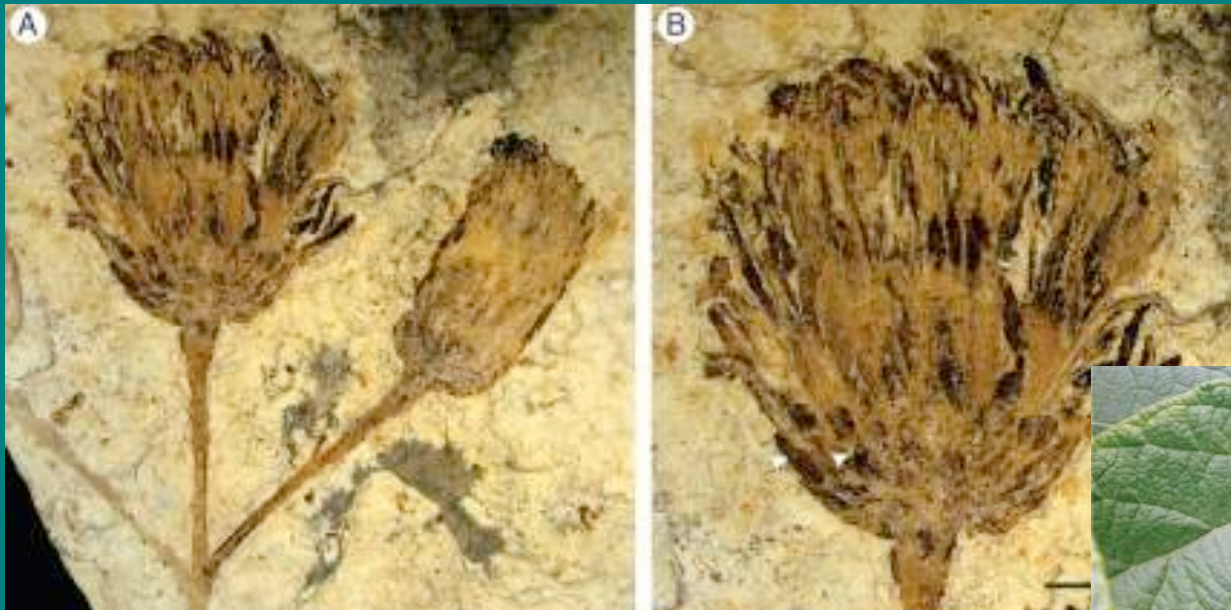
- early DNA based work surprisingly placed a small group of **South America genera** as sister to the rest of the family and recognition of **3 subfamilies** and many tribes



Barnadesia lanceolata

Asteraceae - phylogeny

- early DNA based work surprisingly placed a small group of **South America genera** as sister to the rest of the family and recognition of **3 subfamilies** and many tribes



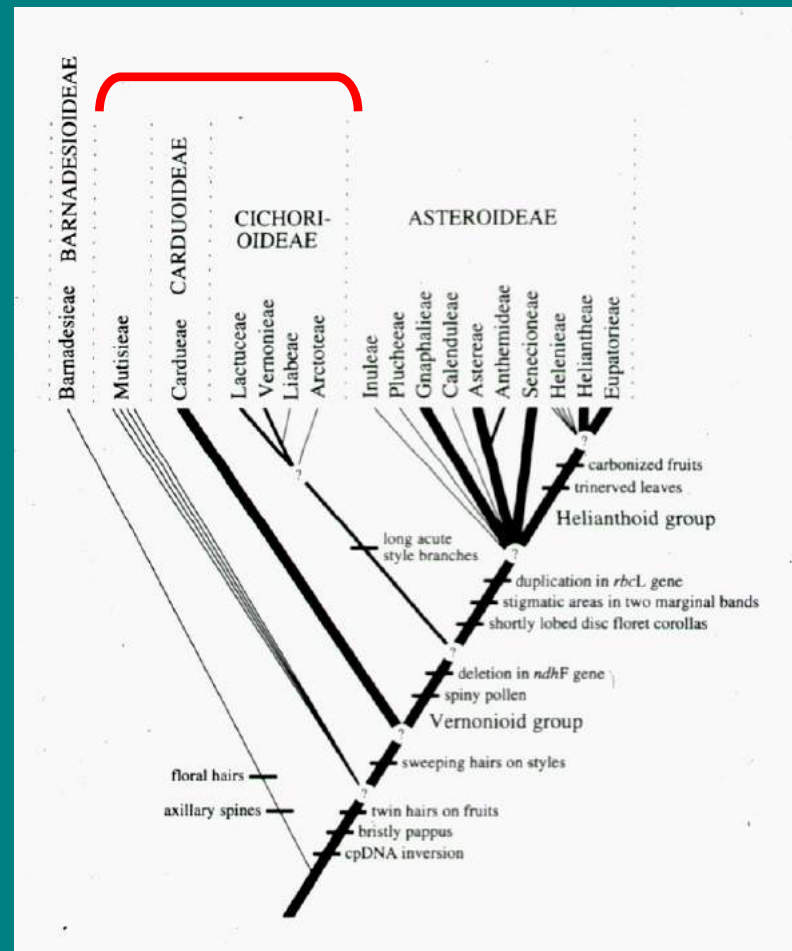
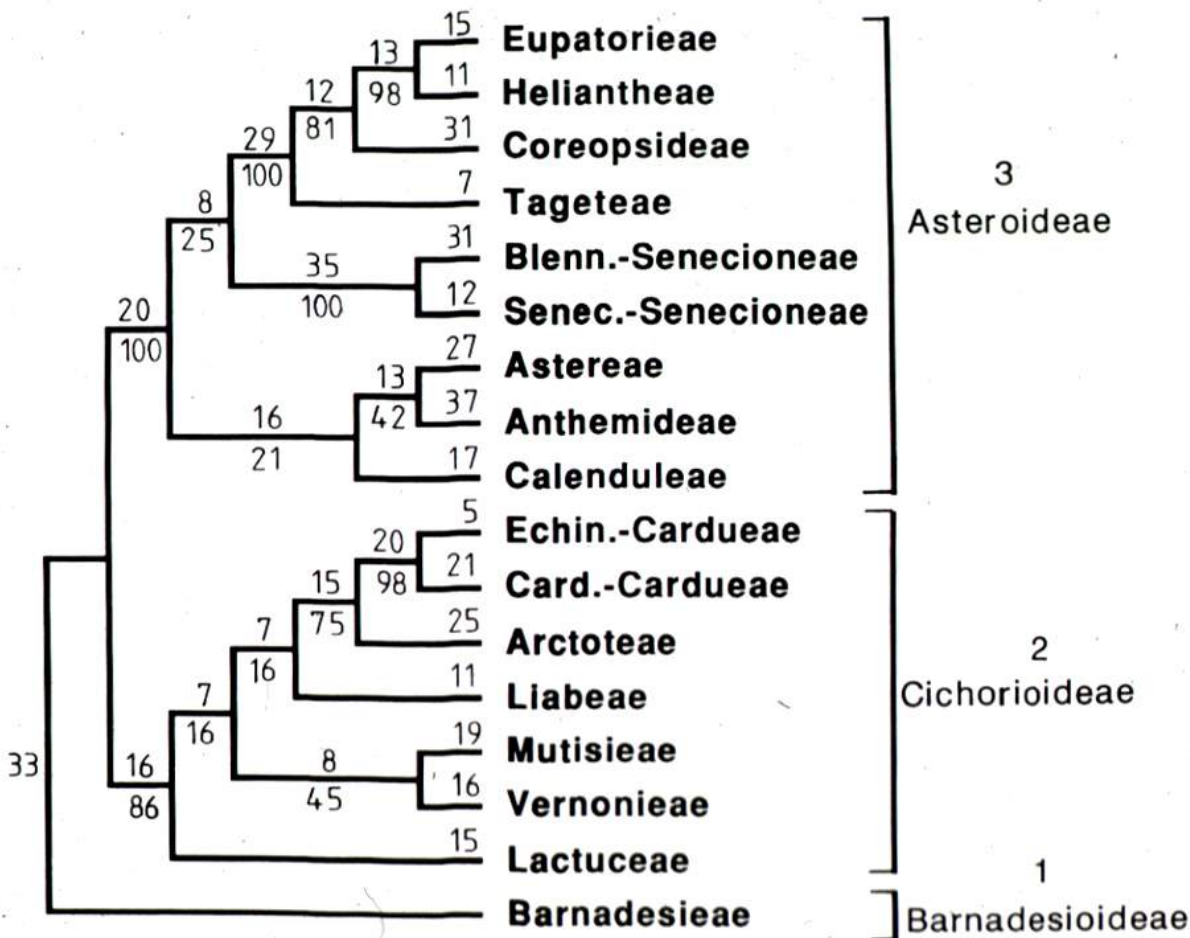
47.5 million-year-old from Patagonia

Extant member of an early branching lineage of Asteraceae (Mutisioideae), *Cnicothamnus lorentzii*



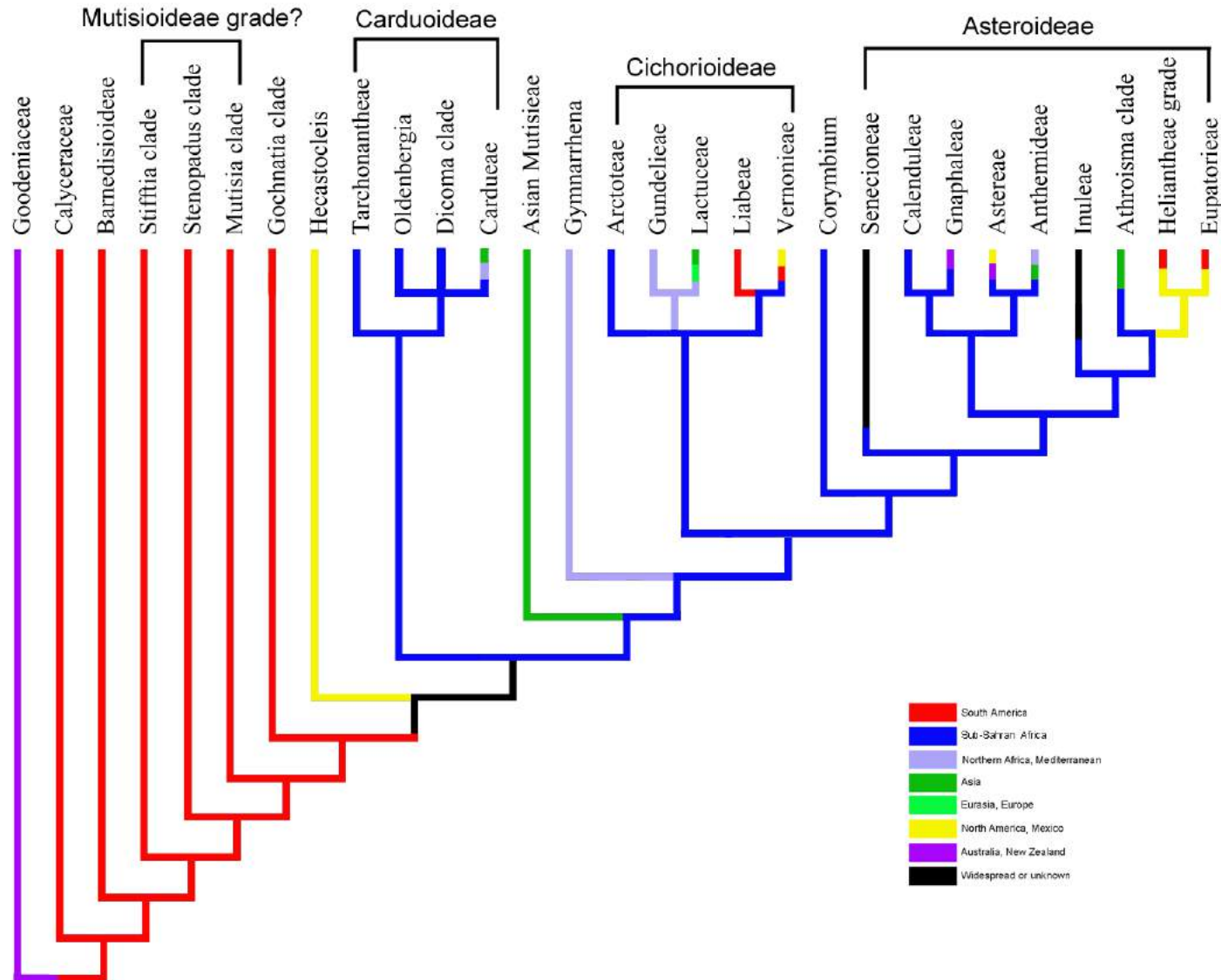
Asteraceae - phylogeny

- later DNA based work questioned the monophyly of subfamily **Cichorioideae** - classification still in progress



Asteraceae - phylogeny

- family originated in **South America**



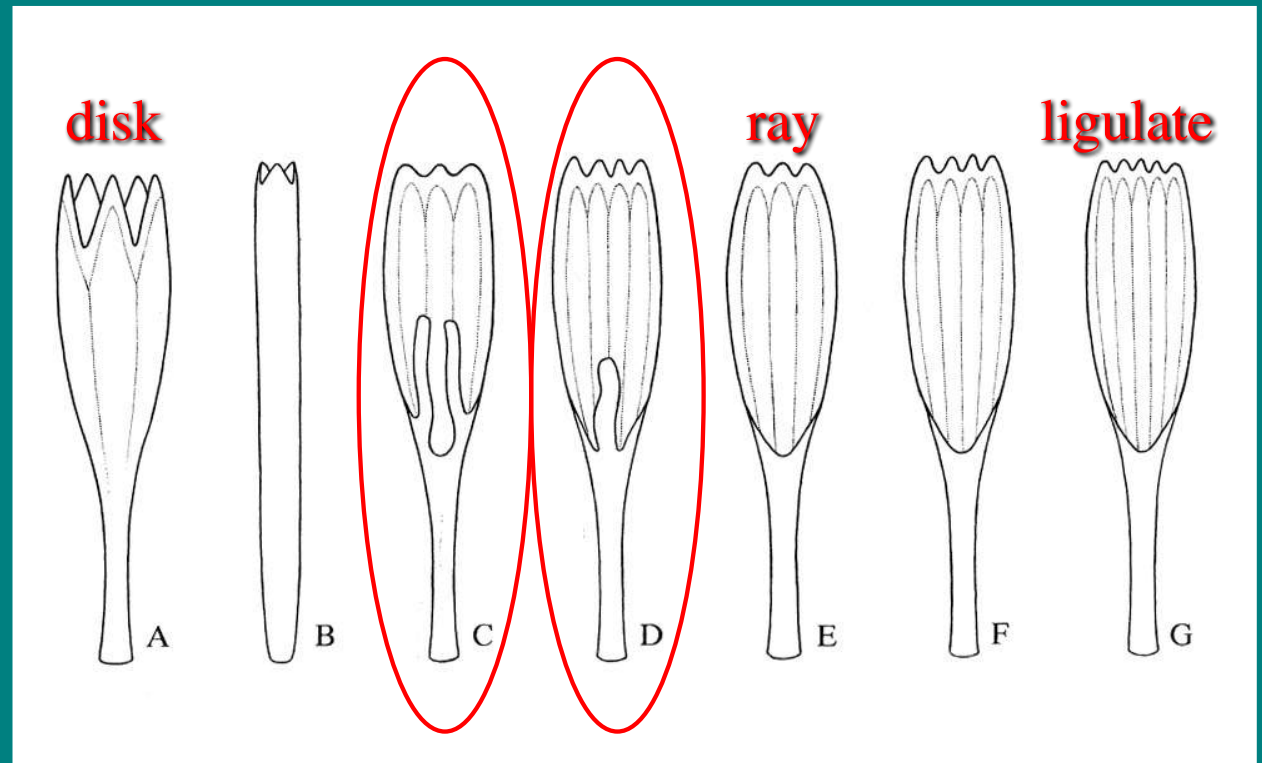
Asteraceae - tribes

Tribe Barnadesiinae

Small South American tribe with **bilabiate** (C) or **pseudolabiate** (D) corolla - similar to some other families of Asterales



Barnadesia lanceolata



Asteraceae - tribes

Tribe Mutisieae

South American tribe usually with bilabiate flowers; characteristic of tepuis in northern South America



Stomochaeta



Duidaea



Cerro Autana

Asteraceae - tribes

Tribe Lactuceae (Cichorieae)



Only have **ligulate heads**, milky **latex** in vegetative parts, pappus of filaments

Dandelion, goat' s-beard, chickory, hawkweed



Taraxacum - dandelion

Asteraceae - tribes

Tribe Lactuceae (Cichorieae)



Cichorium intybus - chickory

Eurasian weed - totally naturalized
and distributed widely even to **Botany**
400 plant collections

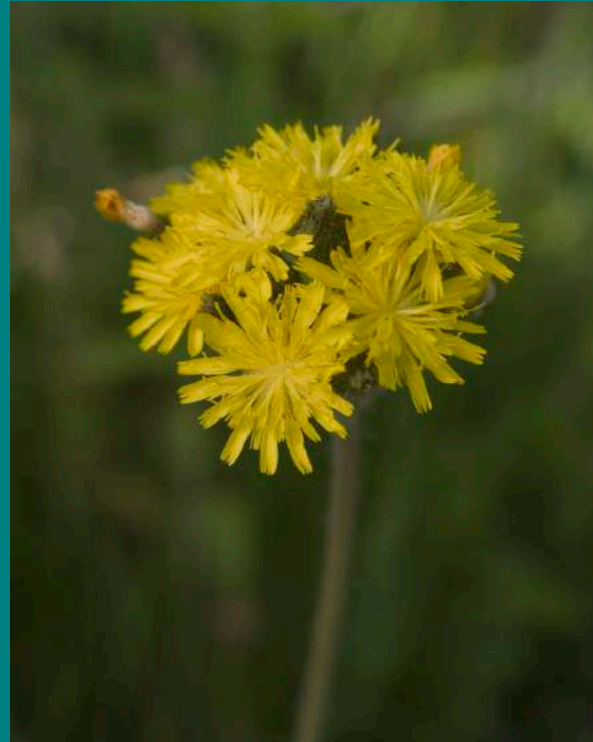


Asteraceae - tribes

Tribe Lactuceae (Cichorieae)



Sonchus asper – sow thistle



Hieracium -
hawkweeds



Asteraceae - tribes

Tribe Cardueae (Cynareae)

Cirsium - thistles



- spiny phyllaries and often leaves and stems
- heads never radiate
- petals white or cyanic colors (blues, purples)
- thistle, knapweed, burdock

Asteraceae - tribes

Tribe Cardueae (Cynareae)



Centaurea maculosa - Spotted knapweed



Arctium - burdock

Asteraceae - tribes

Tribe Vernonieae

Alternate leaves
Purple flowers generally

Hesperomannii
Hawaii



Vernonia fasciculata - ironweed



Asteraceae - tribes

Tribe Inuleae (Gnaphalieae)

Plants usually covered with white hairs, pappus of bristles or hairs

Pussy toes, cudweed, pearly everlasting



Antennaria plantaginifolia - pussy toes

Asteraceae - tribes

Tribe Inuleae (Gnaphalieae)



Anaphalis margaritacea
Asteraceae
© G. D. Carr

Anaphalis margaritacea - pearly everlasting

Asteraceae - tribes

Tribe Astereae

Conspicuous rays in radiate head, pappus of plumose bristles; asters, goldenrods, fleabanes



Symphyotrichum pilosus – frost aster
(Botany 400 plant collections)



Symphyotrichum novae-angliae
- New England aster

Asteraceae - tribes

Tribe Astereae



Solidago rigida -
stiff goldenrod



Erigeron annuus –
daisy fleabane

Asteraceae - tribes

Tribe Anthemideae

Aromatic plants, with dissected, alternate leaves; pappus of awns or scales or missing

Ox-eye daisy, yarrow, wormwood, tansy, dog fennel



Leucanthemum vulgare

Ox-eye daisy, chrysanthemum



Tanacetum bipinnatum –
Lake Huron tansy

Asteraceae - tribes

Tribe Anthemideae



Achillea millefolium – yarrow
(Botany 400 plant collections)



Matricaria discoidea - pineapple weed

Asteraceae - tribes

Tribe Senecioneae



Alternate or basal leaved, phyllaries in 1 row, capillary pappus; ragwort, Indian plantain



Packera aurea - golden ragwort

Asteraceae - tribes

Tribe Helenieae

Alternate leaved, radiate heads, 3-lobed ray flowers always widest at tip



Helenium autumnale –
common sneezeweed



Gaillardia aristata–
common blanket-flower

Asteraceae - tribes

Tribe Heliantheae



Ratibida pinnata - coneflower

Large tribe with radiate, multi-layered phyllaries, rays mostly yellow, tendency for opposite leaves

Coneflower, sunflower, rosinweed, ox-eye, black-eyed Susan, prairie dock, coreopsis, Peruvian daisy



Helianthus annuus - sunflower

Asteraceae - tribes

Tribe Heliantheae



Biden cernuus - bur marigold



Echinacea pallida - purple coneflower

Asteraceae - tribes

Ambrosia artemisiifolia
ragweed



Tribe Ambrosieae

(or Heliantheae)

Unisexual and wind
pollinated, rays absent,
stamens not fused

Ragweed, cocklebur

Male florets

Female florets

Asteraceae - tribes



Eutrochium maculatum
Joe-pye weed



Eupatorium perfoliatum
Boneset

Tribe Eupatorieae

(or Heliantheae)

Opposite or
whorled leaves

Discoid heads

Corolla never
yellow

Joe-pye weed,
boneset,
snakeroot,
blazing star