

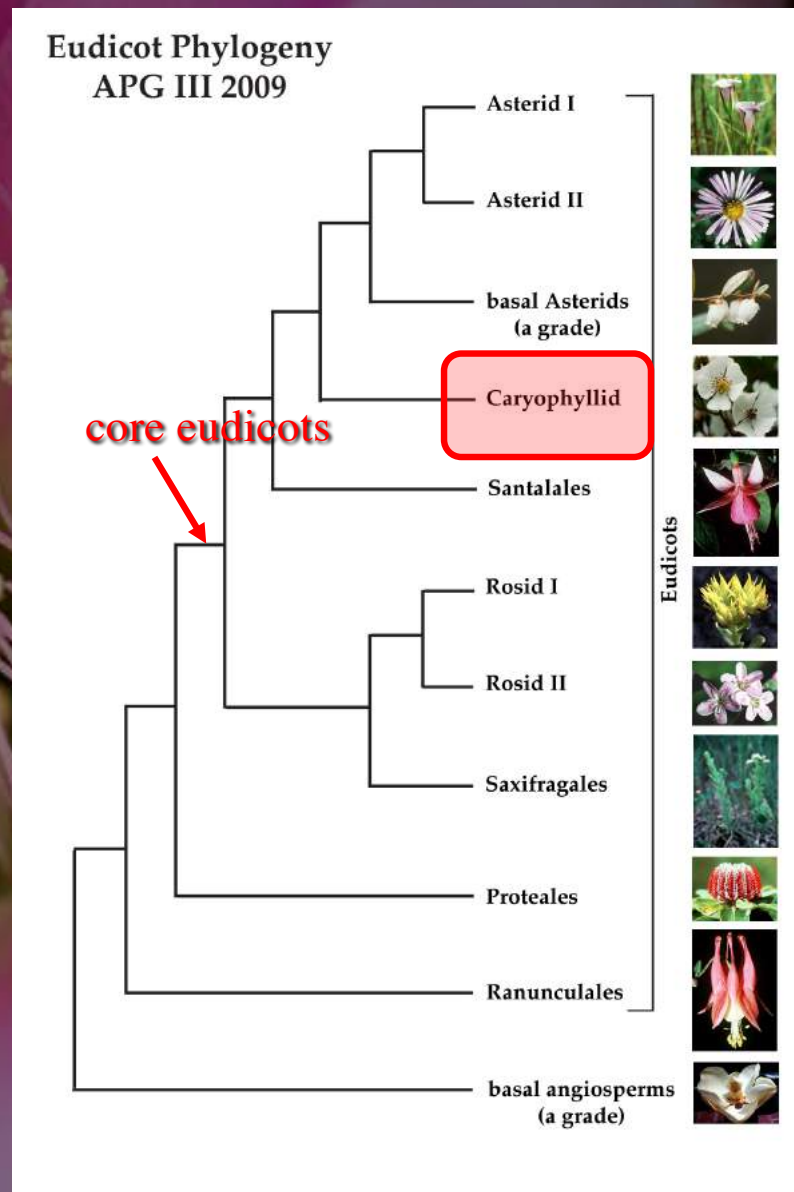
# Diversity and Evolution of Caryophyllids

. . . carnations, cacti, chenopods . . .

# Caryophyllids

## What are caryophyllids?

- First of the **core eudicots** we will examine: Caryophyllids, Rosids, Asterids
- = order **Caryophyllales**
- APG III in 2009 places caryophyllids as sister lineage to the asterids – but probably dates back to 110-100 mya



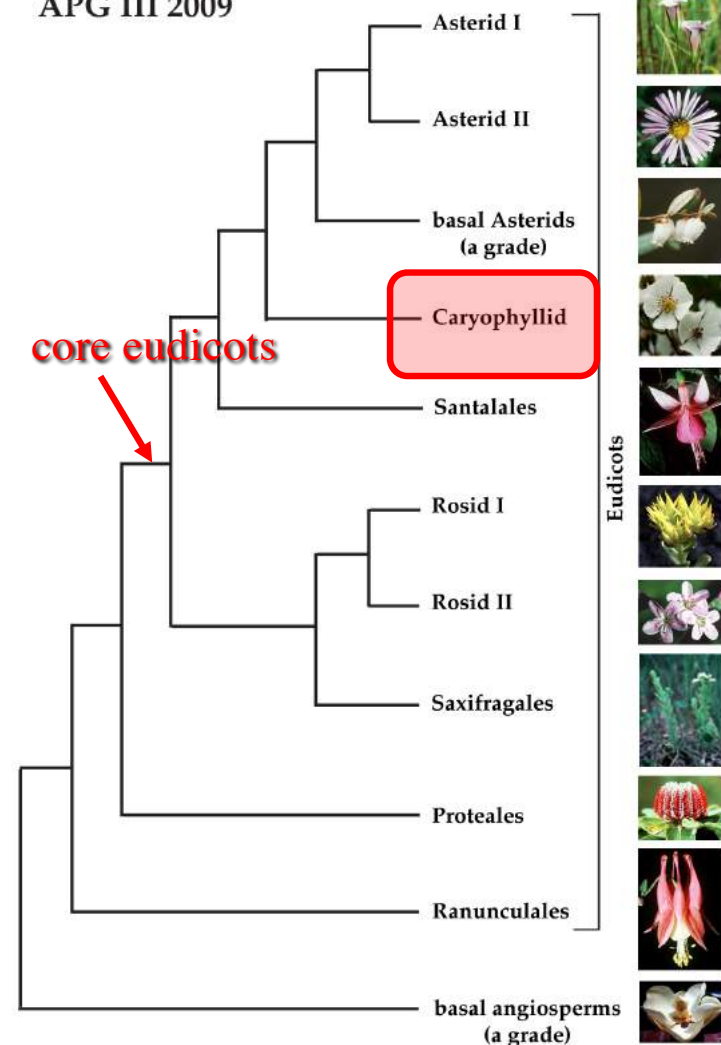


# Caryophyllids

## What are caryophyllids?

- 34 families & 11,155 species = 6% of eudicot diversity
- Unusual (!) group of families not all previously thought to form a natural order
- Share one character?  
sepals only - “petals” if present appear to be of staminal origin

Eudicot Phylogeny  
APG III 2009



# Caryophyllids

## What are caryophyllids?

- Exhibit unusual adaptations to “stressful” environments — desert or arid regions: high salt, low water, xerophytes



saltbush- *Amaranthaceae*



cacti- *Cactaceae*



# Caryophyllids

## What are caryophyllids?

- Exhibit unusual adaptations to “stressful” environments — salt marshes, halophytes



glasswort- Amaranthaceae

# Caryophyllids

## What are caryophyllids?

- Exhibit unusual adaptations to “stressful” environments — alpine, tundra, cushion plants



chickweed- Caryophyllaceae



spring-beauty- Montiaceae



# Caryophyllids

## What are caryophyllids?

- “new” (unplaced) members to the group include desert families



*Frankenia laevis*  
Frankeniaceae  
Canary Islands

# Caryophyllids

## What are caryophyllids?

- “new” (unplaced) members to the group include desert families



*Simmondsia chinensis*  
jojoba  
Simmondsiaceae  
Sonoran Desert endemic



# Caryophyllids

## What are caryophyllids?

- “new” (unplaced) members to the group include desert families

*Tamarix* - tamarisk  
Tamaricaceae





# Caryophyllids

## What are caryophyllids?

- “new” (unplaced) members to the group include desert families

*Halophytum*  
Halophytaceae

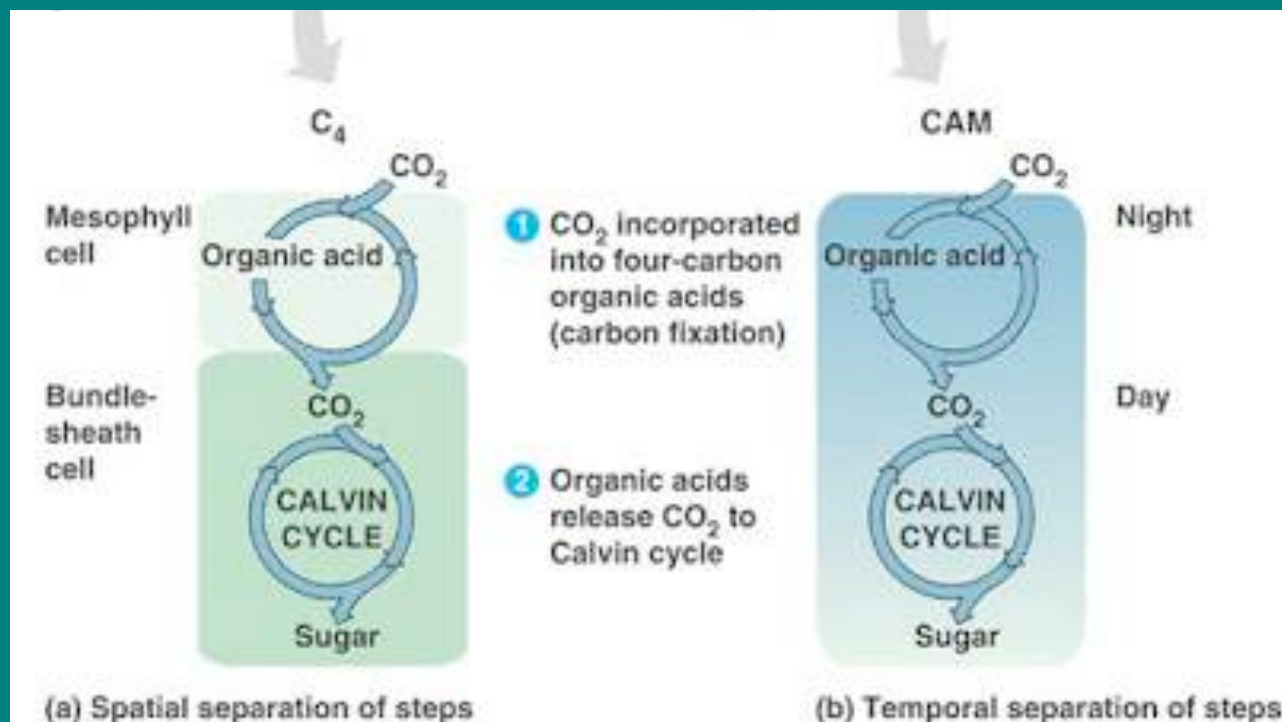




# Caryophyllids

Suite of morphological and/or physiological adaptations for life in the arid world - succulence, no leaves,  $C_4$  and CAM photosynthesis, salt excretion

## $C_4$ and Crassulacean Acid Metabolism



# Caryophyllids

What are caryophyllids?

- troublesome “weeds”



*Tamarix* - tamarisk



*Gypsophila* - baby' s-breath



# Caryophyllids

## What are caryophyllids?

- some, but not all, of the **carnivorous** plants - **low N**

Sundews - Droseraceae



*Nepenthes* – Asian pitcher plant

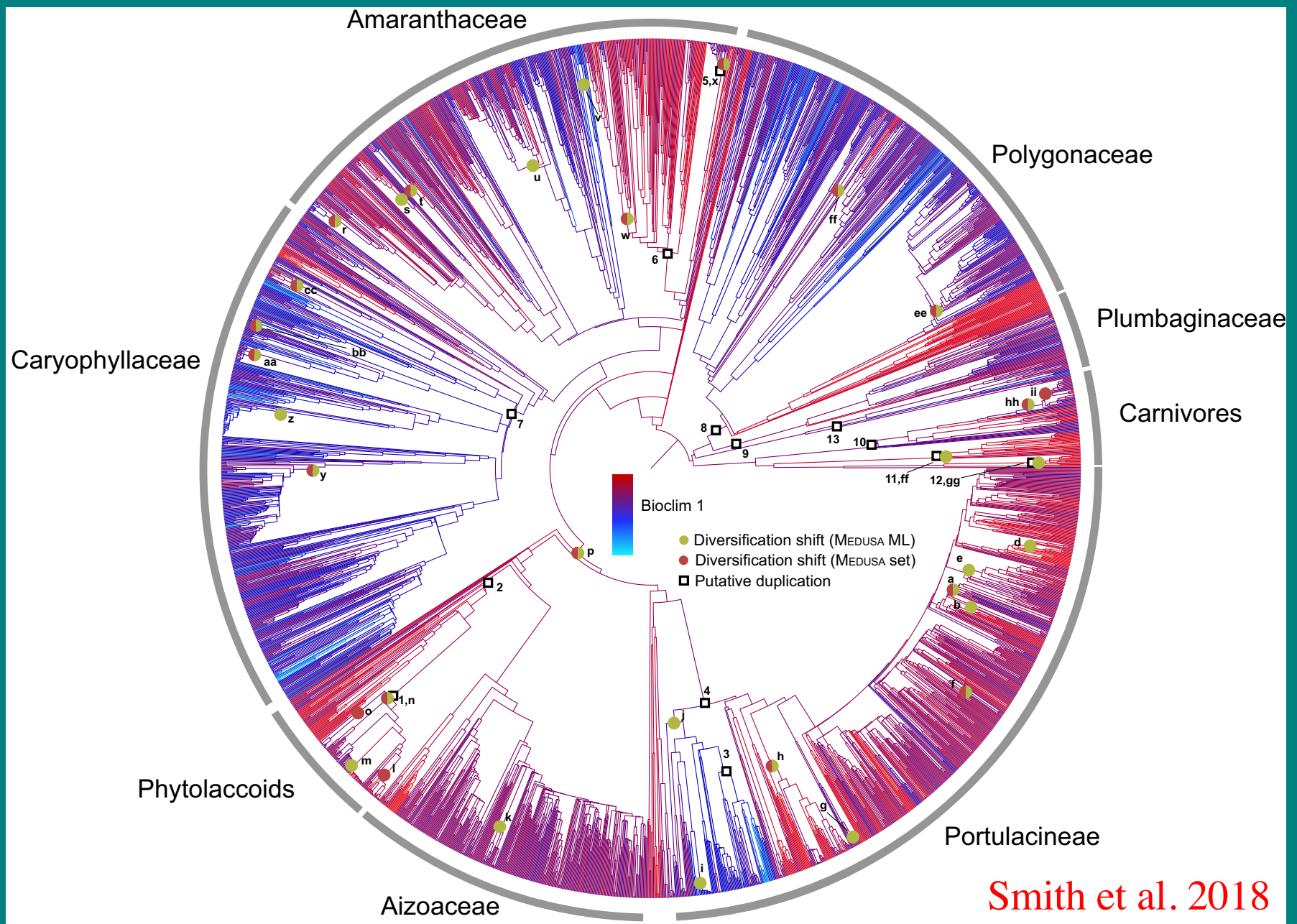






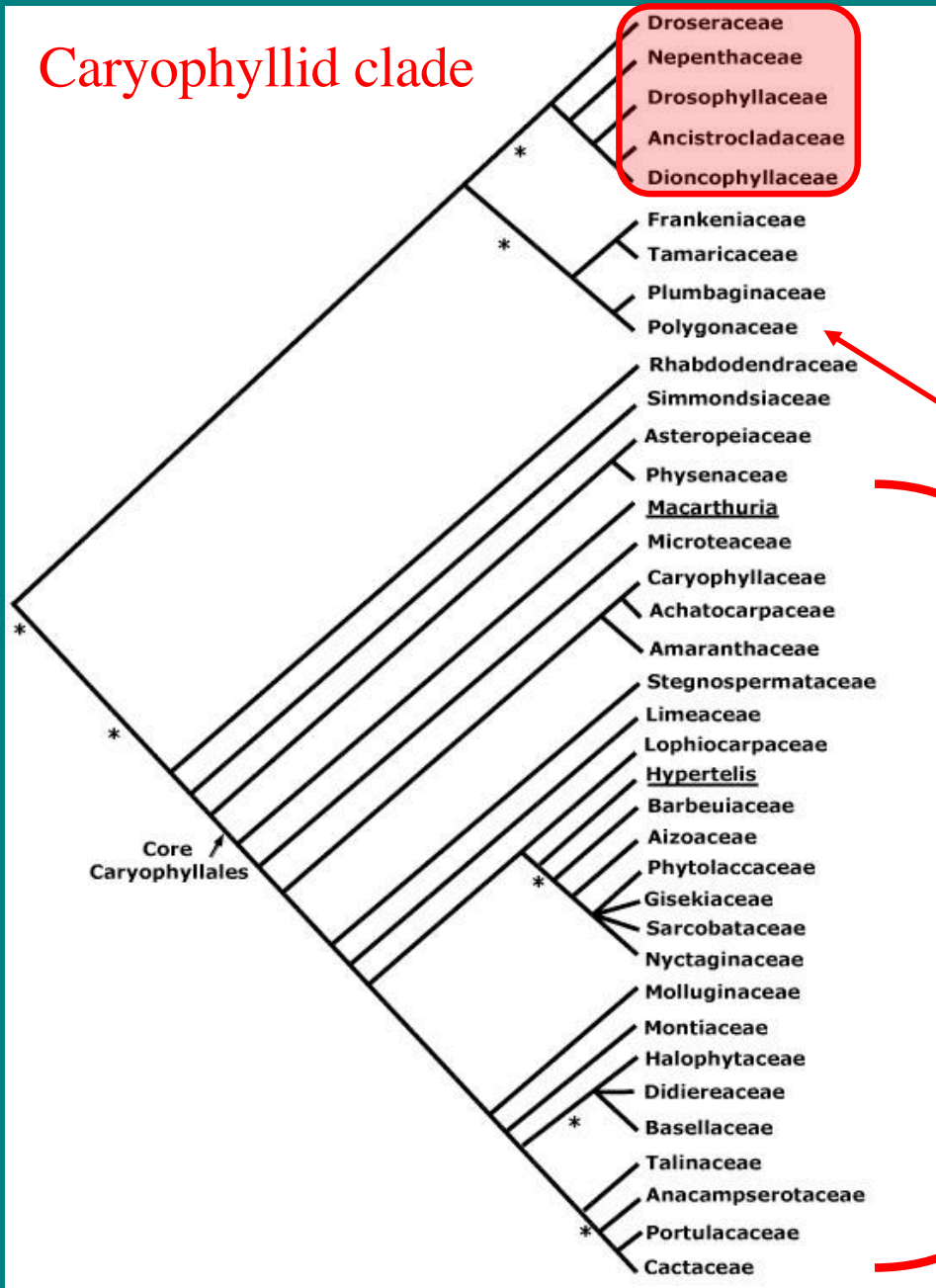
- why this incredible diversity – ecology, physiology, habit, color?





- why this incredible diversity – ecology, physiology, habit, color?
- whole genome duplications & diversification shifts?

# Caryophyllids



- examine all **carnivorous** plants later – Halloween lecture!

[check out botanical Halloween costumes for Extra Credit]

- also look at Polygonaceae - smart weed family
- focus on “core Caryophyllales”

**Core Caryophyllales**

**Angiosperm Phylogeny Website**

[www.mobot.org/MOBOT/Research/APweb/welcome.html](http://www.mobot.org/MOBOT/Research/APweb/welcome.html)



# Core Caryophyllales

Caryophyllid clade

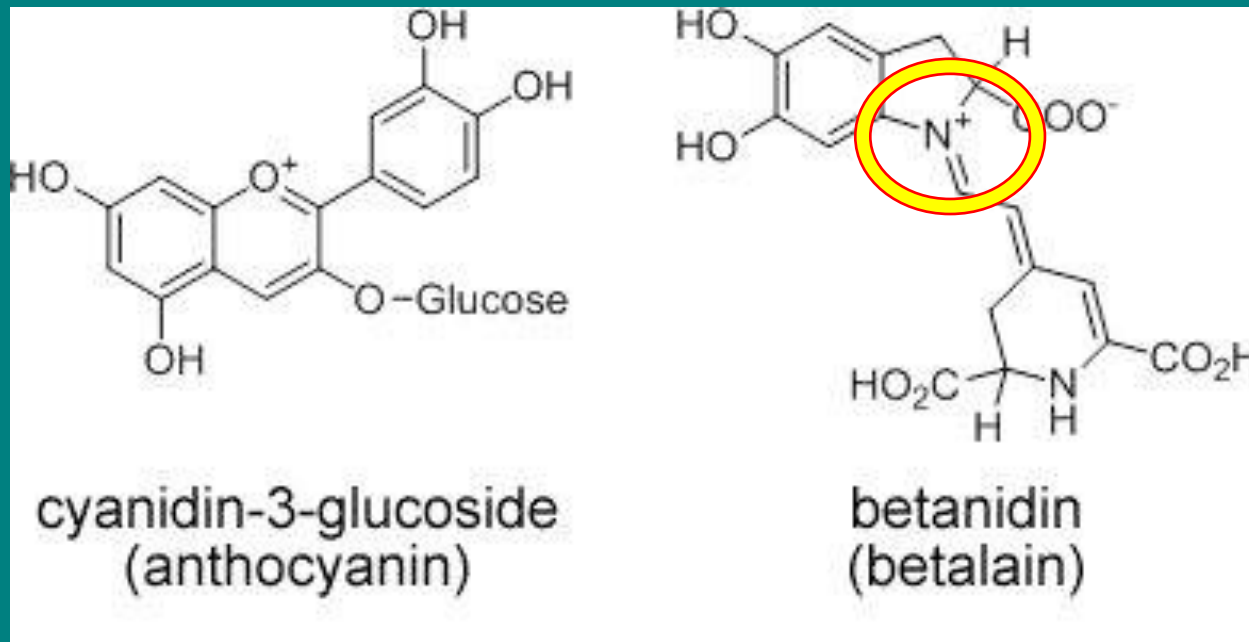


- defined by 5 features but with some reversals

Core Caryophyllales

# Core Caryophyllales

## 1. betalains



Carnation -Caryophyllaceae

anthocyanin



Sea fig -Aizoaceae

betalain

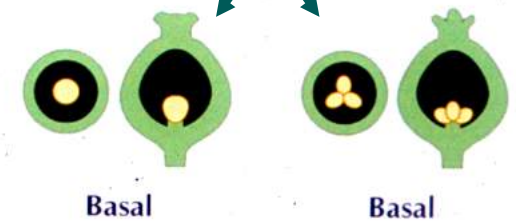
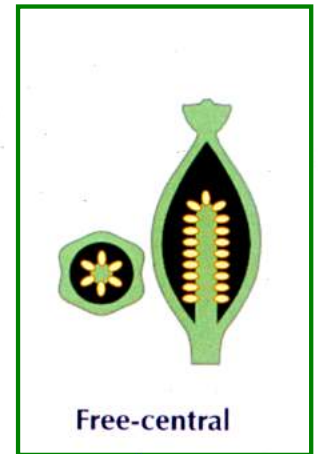


**N containing** – very different from flavonoids



# Core Caryophyllales

2. free-central placentation (or basal) = “Centrospermae”



# Core Caryophyllales

2. free-central placentation (or basal) = “Centrospermae”

. . . generates capsule fruits



capsule



pyxis



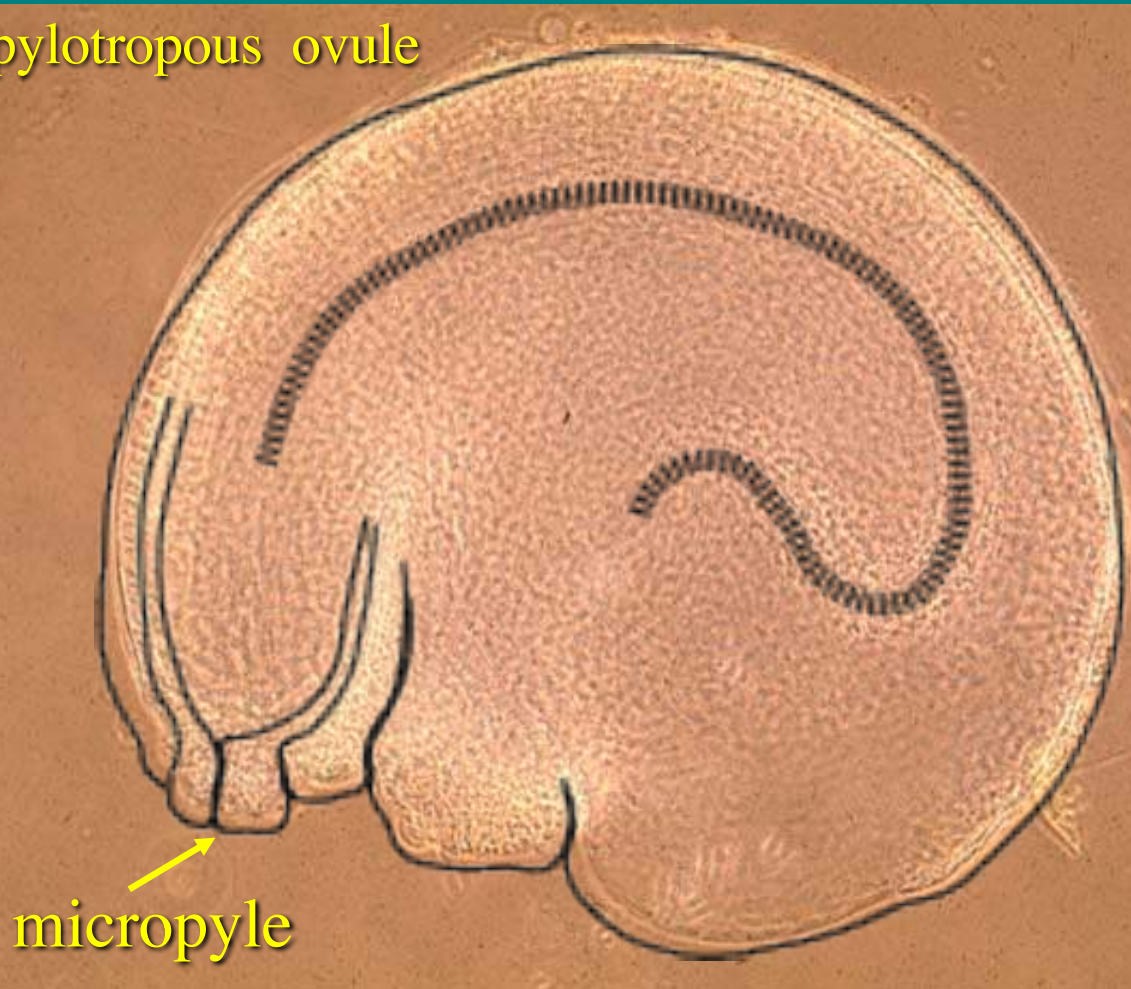
utricle



# Core Caryophyllales

3. curved embryo in ovule =  
campylotropous

campylotropous ovule

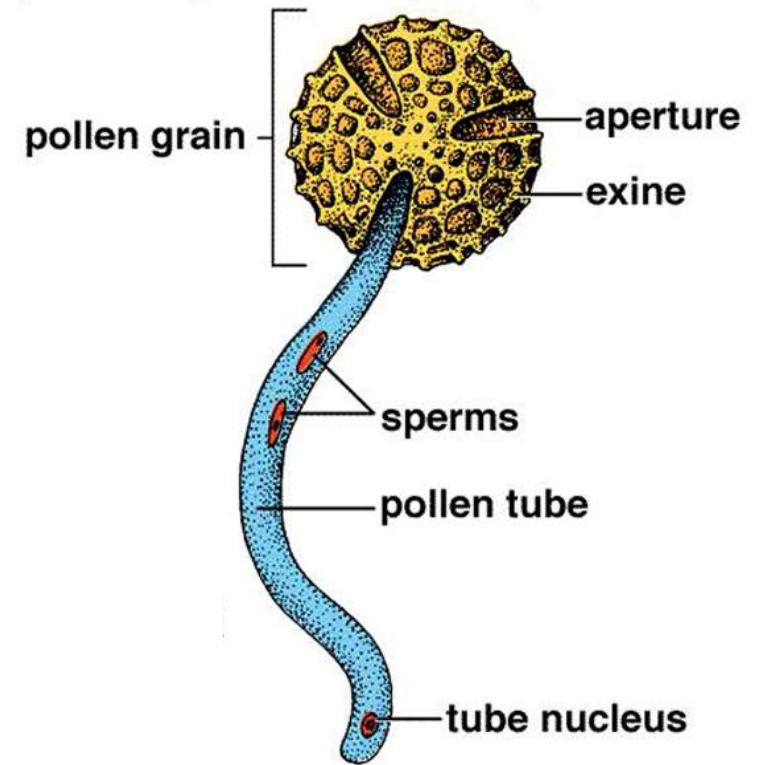
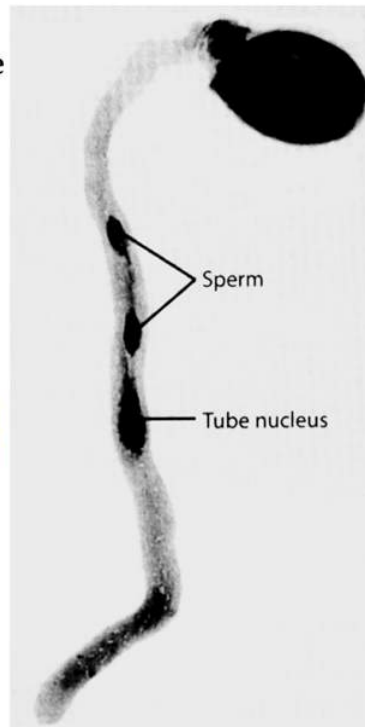
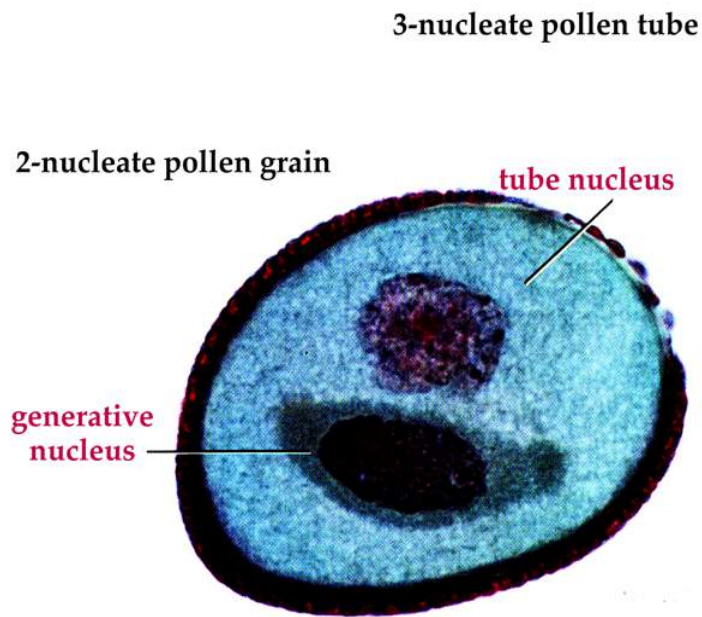


curved (peripheral)  
embryo around  
perisperm



# Core Caryophyllales

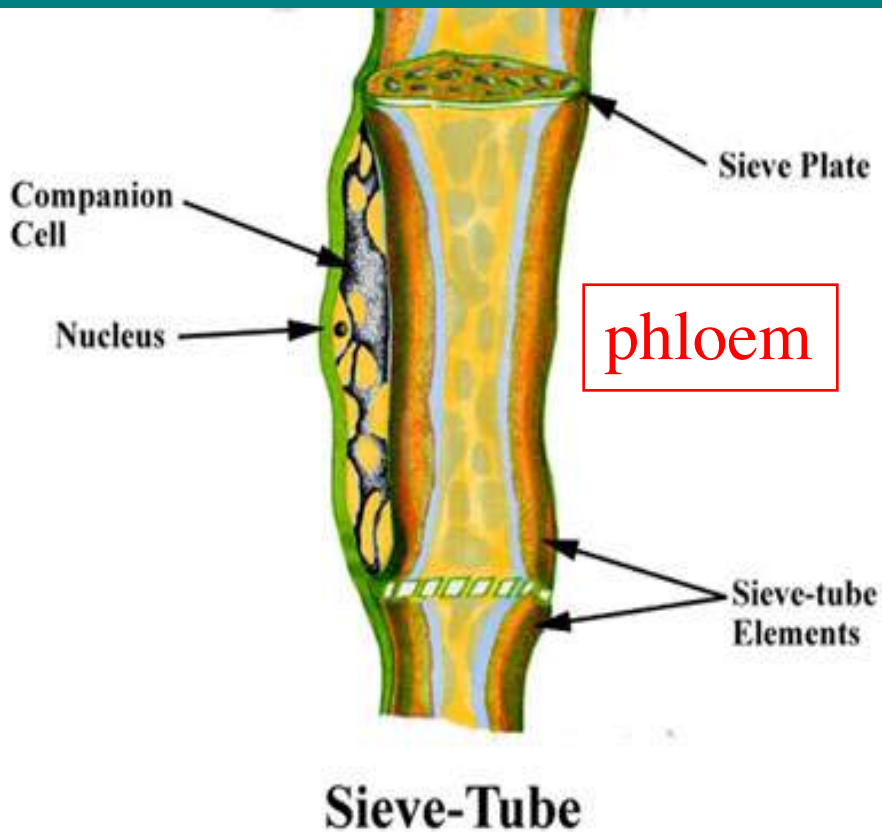
4. pollen shed in trinucleate stage  
vs. most common 2-nucleate



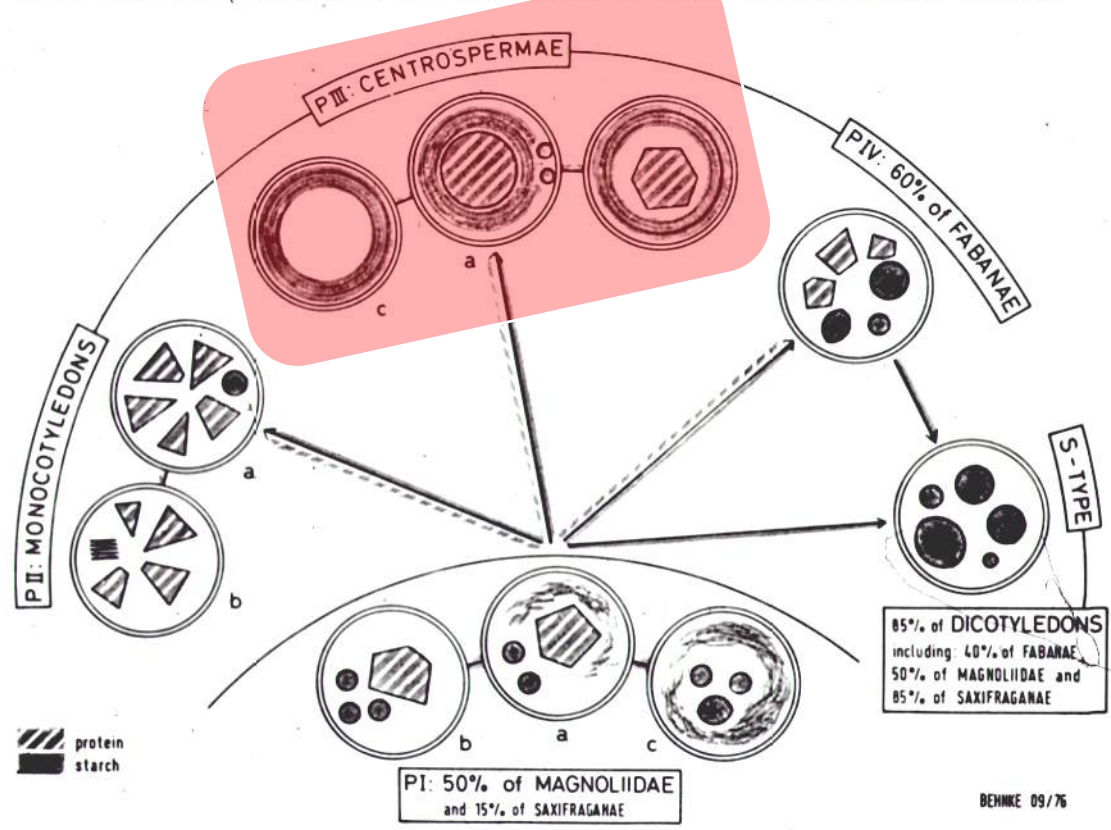


# Core Caryophyllales

5. sieve tube plastids with crystal proteins surrounded by protein filaments



INTERRELATIONSHIPS BETWEEN PROTEIN AND STARCH ACCUMULATING SIEVE-ELEMENT PLASTIDS



# Core Caryophyllales

Caryophyllid clade



- problematic for family circumscription / recognition
- examine 3 groups

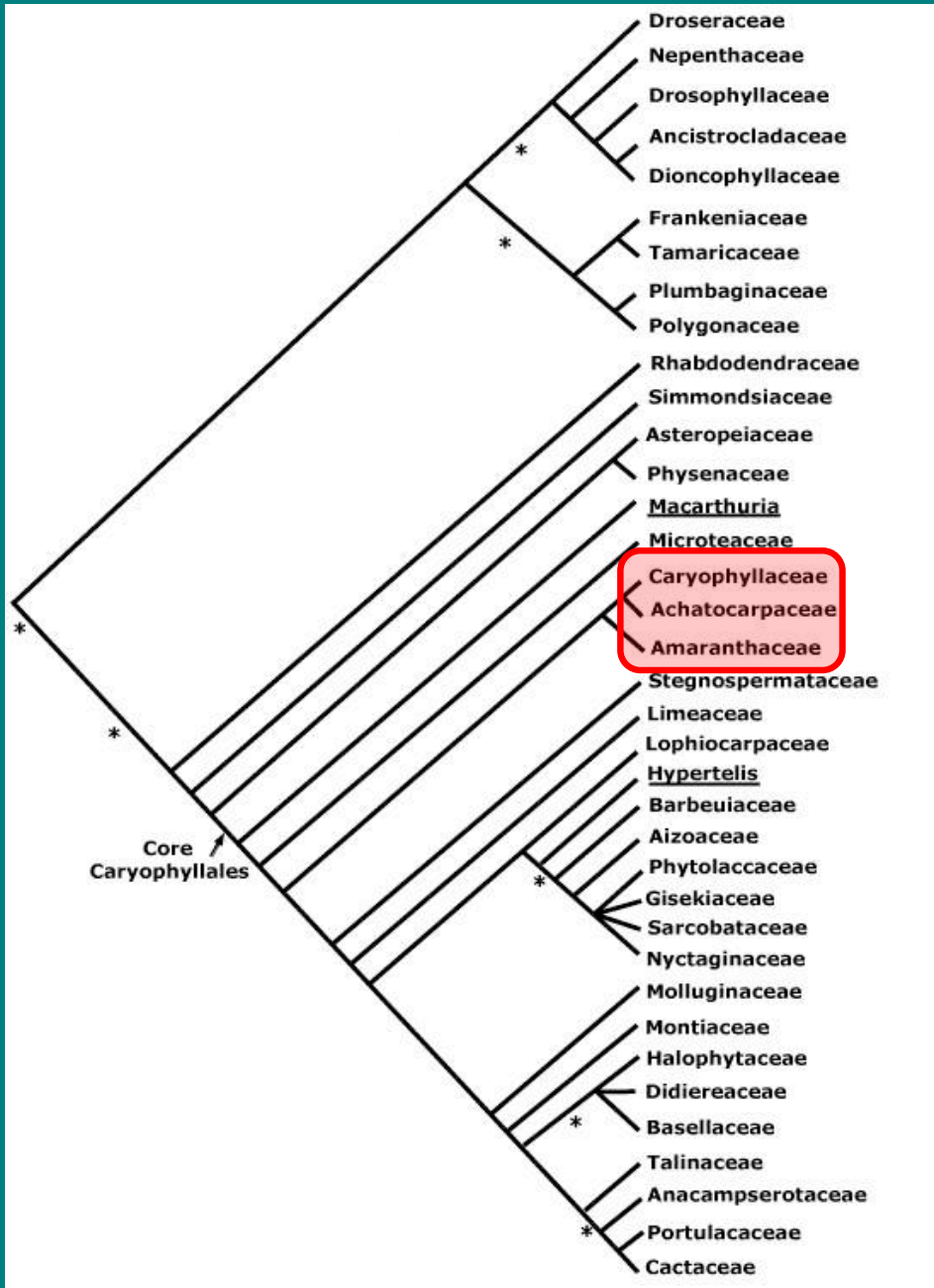
Core Caryophyllales



# \*Caryophyllaceae - Carnations

- carnation or pink family - herbs, often weedy

*Lychnis coronaria* - mullein pink





# \*Caryophyllaceae - Carnations

- **dichasium** inflorescence – usually a **cyme**



Note 3 way split, middle branch is oldest flower

*Minuartia* - sandwort

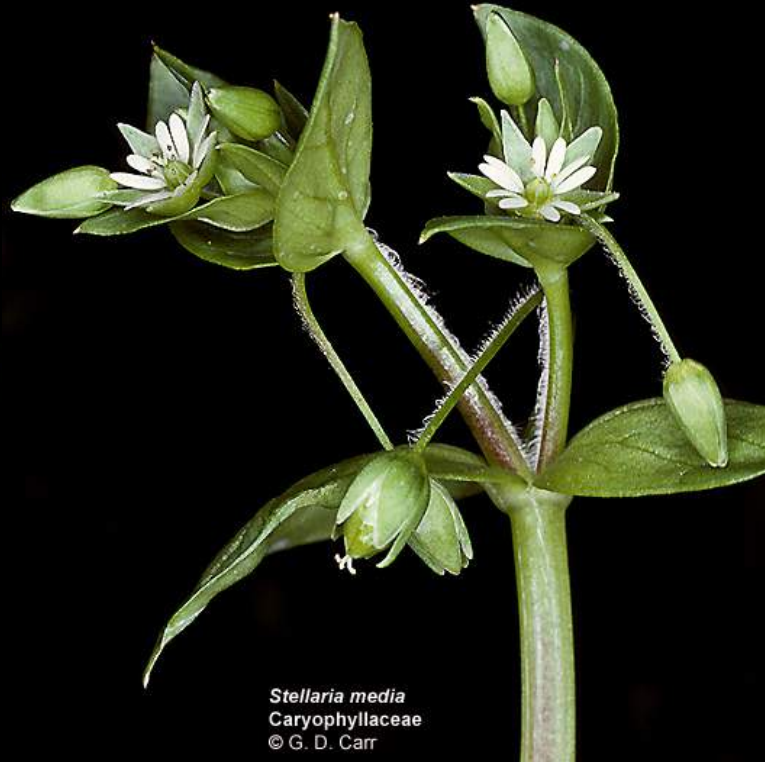


# \*Caryophyllaceae - Carnations

- **dichasium** inflorescence – usually a **cyme**
- leaves opposite, swollen nodes



*Dianthus caryophyllus*  
Caryophyllaceae  
G. K. Linney



*Stellaria media*  
Caryophyllaceae  
© G. D. Carr

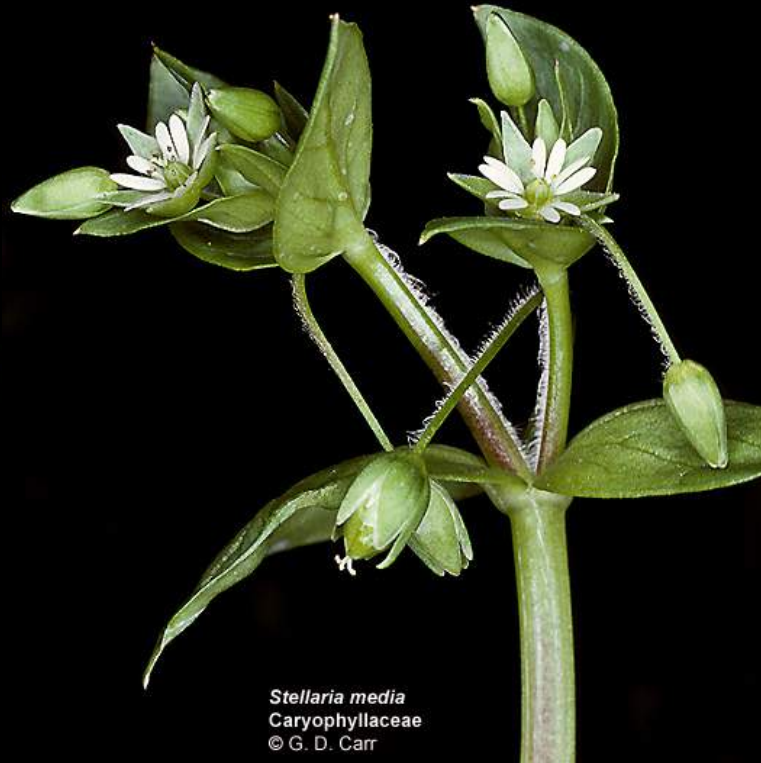
# \*Caryophyllaceae - Carnations

CA 5, (5) CO 5 A 5,10 G (2-5)

- 5 merous flowers, calyx fused +/-
- corolla not fused, often lobed (**staminal origin?**)



*Dianthus caryophyllus*  
Caryophyllaceae  
G. K. Linney



*Stellaria media*  
Caryophyllaceae  
© G. D. Carr





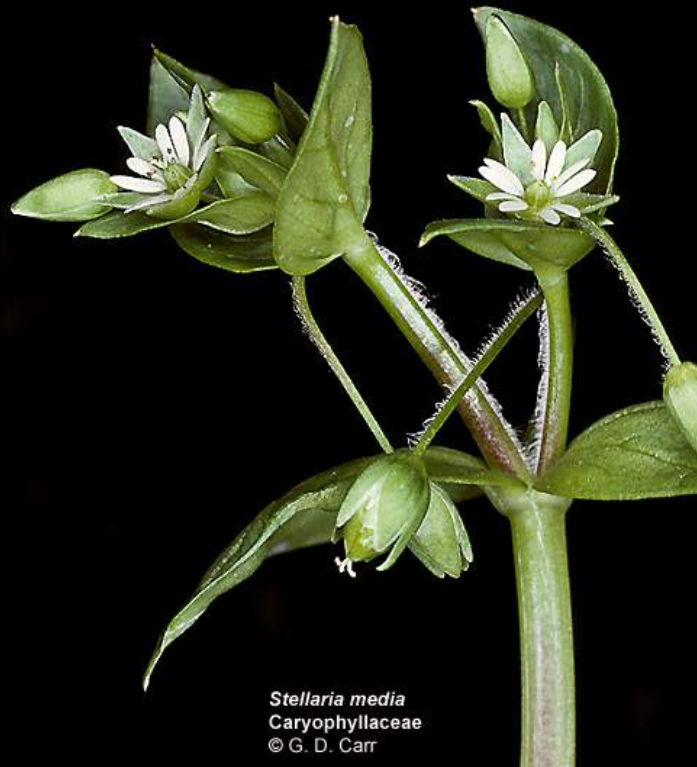
# \*Caryophyllaceae - Carnations

CA 5, (5) CO 5 A 5,10 G (2-5)

- anthers of 1-2 whorls
- 1 pistil of 2-5 carpels



*Dianthus caryophyllus*  
Caryophyllaceae  
G. K. Linney



*Stellaria media*  
Caryophyllaceae  
© G. D. Carr



*Cerastium vulgatum*  
Caryophyllaceae  
Gerald D. Carr

# \*Caryophyllaceae - Carnations

CA 5, (5) CO 5 A 5,10 G (2-5)

- **free-central** or axile placentation
- **capsule** fruit opening by teeth or valves



*Dianthus* sp.  
Caryophyllaceae  
G. K. Linney





# \*Caryophyllaceae - Carnations

Huge family, 87 genera, 2300 species; widespread but characteristic of temperate and warm temperate regions of the Northern Hemisphere.

*Minuartia michauxii*  
sand rockwort



Caryophyllaceae  
©Gerald D. Carr

# \*Caryophyllaceae - Carnations

*Cerastium* - mouse-ear chickweed



*Cerastium vulgatum*  
Caryophyllaceae  
Gerald D. Carr



*Cerastium* sp.  
Caryophyllaceae  
© G. D. Carr





# \*Caryophyllaceae - Carnations

*Silene cucubalus*  
bladder campion



*Silene vulgaris*  
white campion



*Dianthus armeria*  
deptford pink



# \*Caryophyllaceae - Carnations

*Saponaria officinalis* - bouncing bet, soapwort



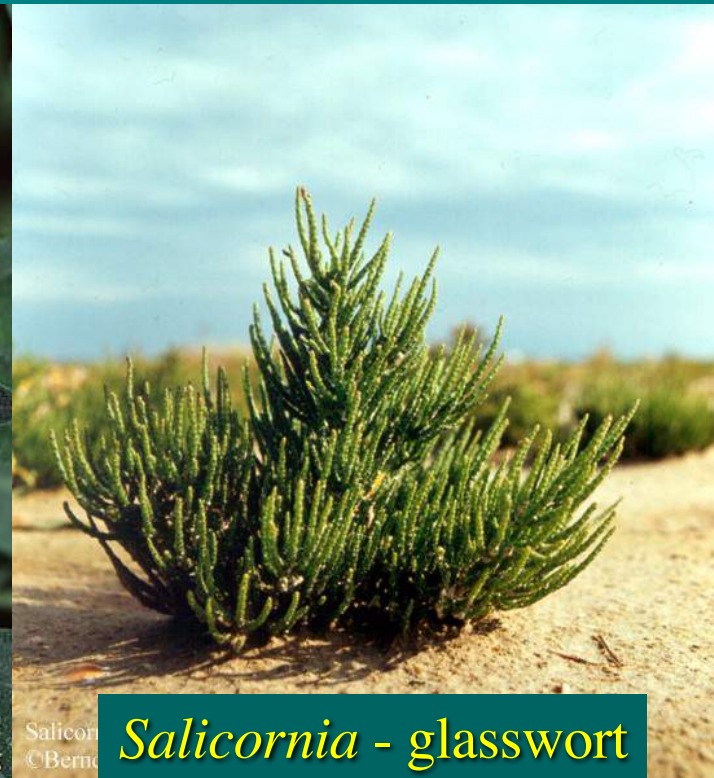


# \*Amaranthaceae - amaranths

- herbs, often **halophytes** or **weeds**, worldwide
- 174 genera & 2,050 species
- includes chenopods (old Chenopodiaceae)



*Chenopodium* - lamb's quarter



Salicornia  
©Bernardini

*Salicornia* - glasswort

# \*Amaranthaceae - amaranths

- flowers small, bracted, congested, lacking corolla

CA 5 CO 0 A 5 G (2-3)

- bisexual or unisexual, monoecious or dioecious



*Chenopodium* - lamb's quarter



# \*Amaranthaceae - amaranths

- fruit is 1-seeded circumscissile capsule (**utricle**) or basal seeded achene
- calyx is persistent around the fruit



utricle





# \*Amaranthaceae - amaranths

- native, weedy, and horticultural species



*Amaranthus* -  
amaranth



*Froelichia* -  
cottonseed



# \*Amaranthaceae - amaranths

- native, weedy, and horticultural species

*Cycloloma atriplicifolium* – winged pigweed





# \*Amaranthaceae - amaranths

- native, weedy, and horticultural species



*Bassia (Kochia)* -  
summer cypress



*Beta vulgaris* -  
beet





# \*Amaranthaceae - amaranths

- native, weedy, and horticultural species

*Celosia* - cock's comb



*Gomphrena* - globe amaranth





# \*Amaranthaceae - amaranths

- desert specialists & tumbleweed invasives

*Atriplex* - saltbush

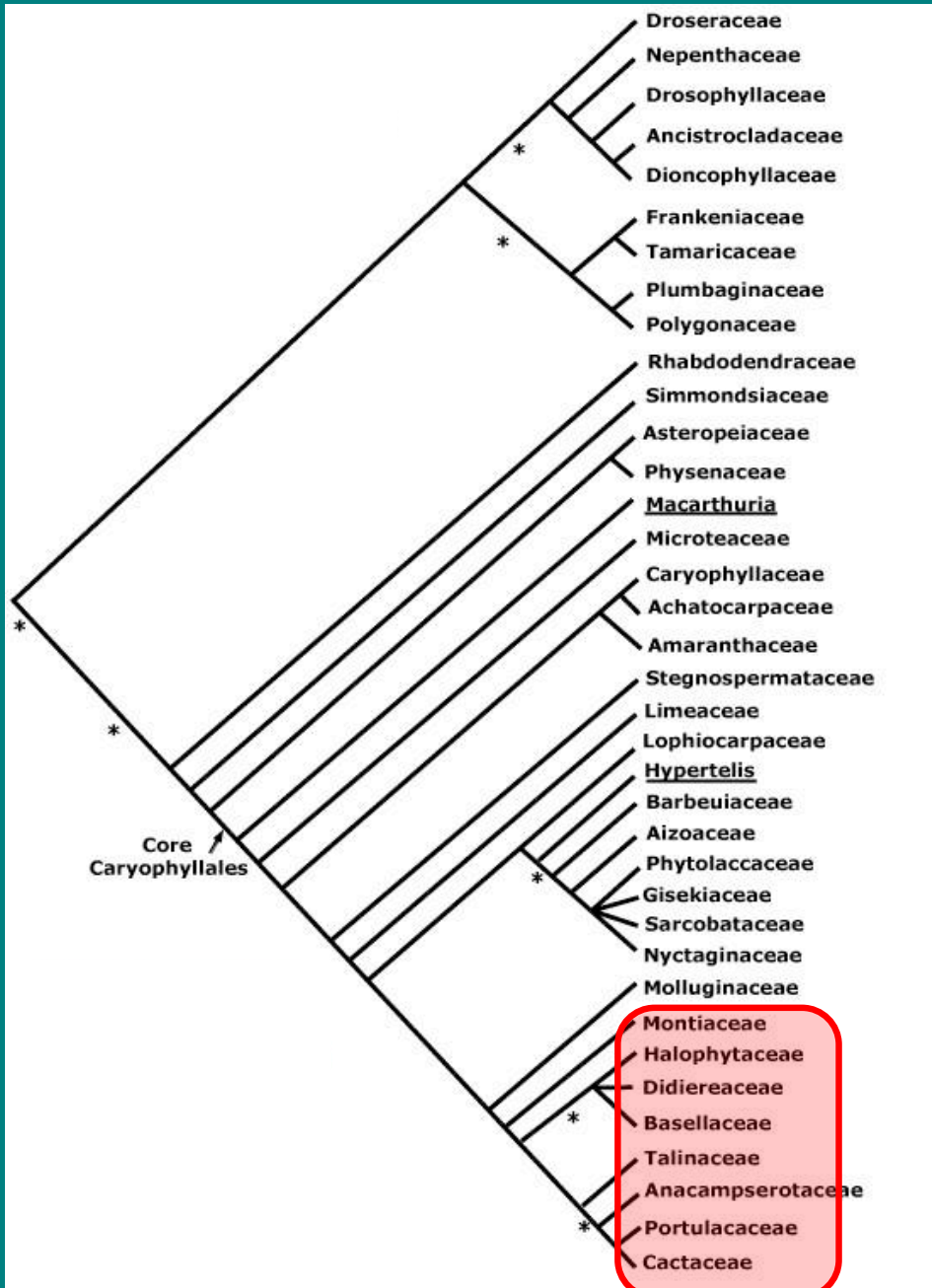
*Salsola* - Russian thistle





# \* 'Portulacaceae' - Purslanes

- belongs to a **succulent** group of families
- family boundaries obscure - e.g. **Montiaceae = spring beauties**





# \* 'Portulacaceae' - Purslanes

- herbs, succulents
- world-wide, especially western N. America, 50 genera, 500 species



*Portulaca oleracea*  
Portulacaceae  
© G. D. Carr



*Portulaca -  
purslane*



# \* 'Portulacaceae' - Purslanes

CA 2 CO 5+ A 5+ G (2-5)

- 5 merous flowers (petals?)
- capsule of various types



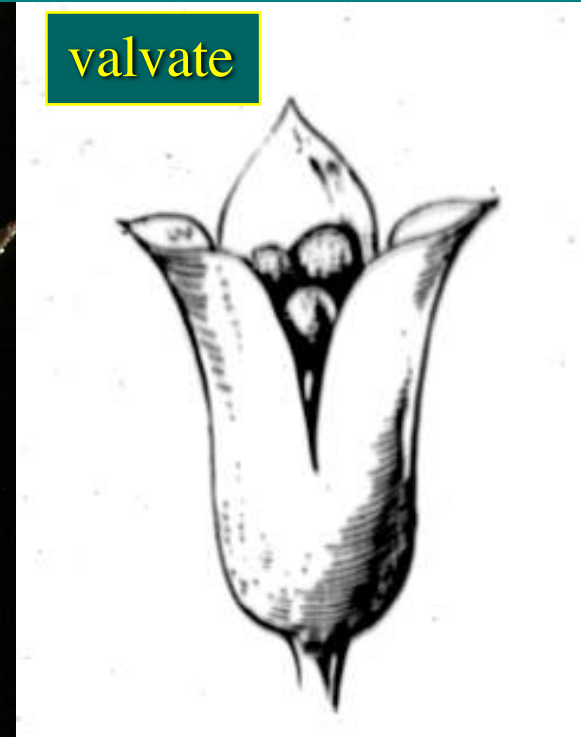
*Portulaca -  
purslane*



*Portulaca oleracea*  
Portulacaceae  
© G. D. Carr



pyxis



valvate



# \* 'Portulacaceae' - Purslanes



*Portulaca grandiflora*  
rock rose (Argentina)

*Claytonia* now in  
family Montiaceae

*Claytonia megarhiza*  
w. NAm alpine

*Claytonia virginica*  
spring beauty





# \* 'Portulacaceae' - Purslanes



*Lewisii*  
bitter-root



*Phemeranthus*  
fame flower



*Phemeranthus*  
*rugospermus*



Montiaceae





# \*Cactaceae - cacti

- **New World** stem succulents protected by spines
- 100 genera / 1400 species





# \*Cactaceae - cacti

- fleshy, **succulent**, often epiphytes
- **no leaves**, except *Pereskia*
- **spines** or glochids at areoles

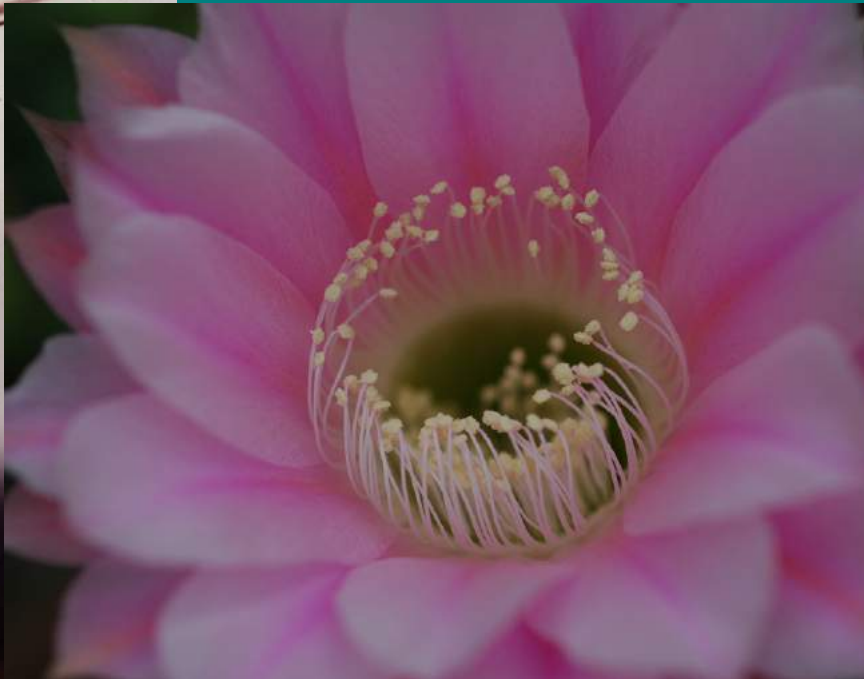




# \*Cactaceae - cacti

$\underline{P \infty} \quad \underline{A \infty} \quad \overline{G} (4)$

- 'hypanthium' with many tepals
- $\infty$  stamens
- epigynous flower





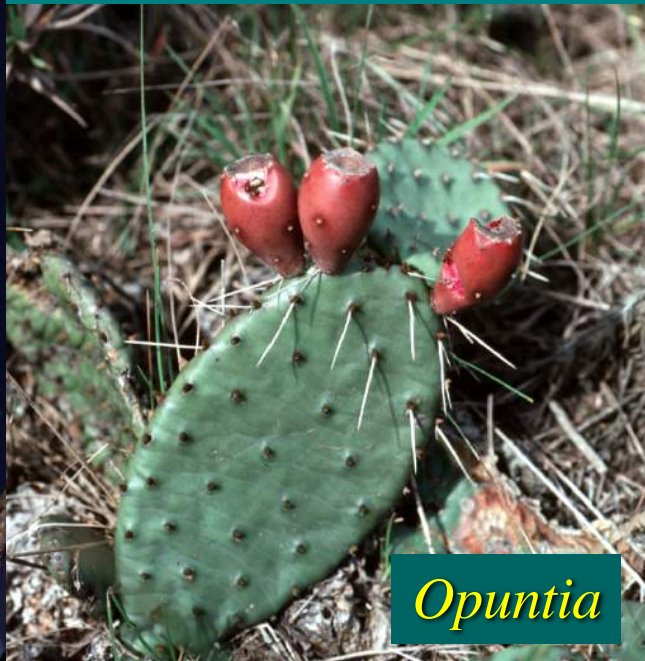
# \*Cactaceae - cacti

$\underline{P \infty} \quad \underline{A \infty} \quad \overline{G} (4)$

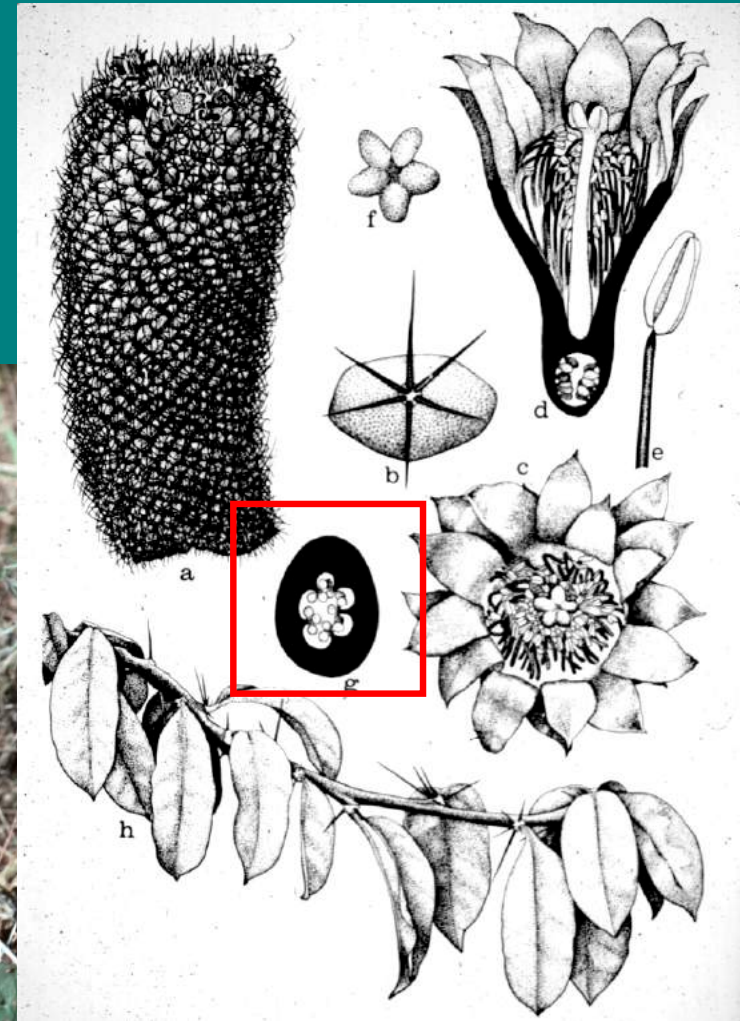
- placentation  
parietal (rare!)
- berry fruit



*Pereskia*



*Opuntia*





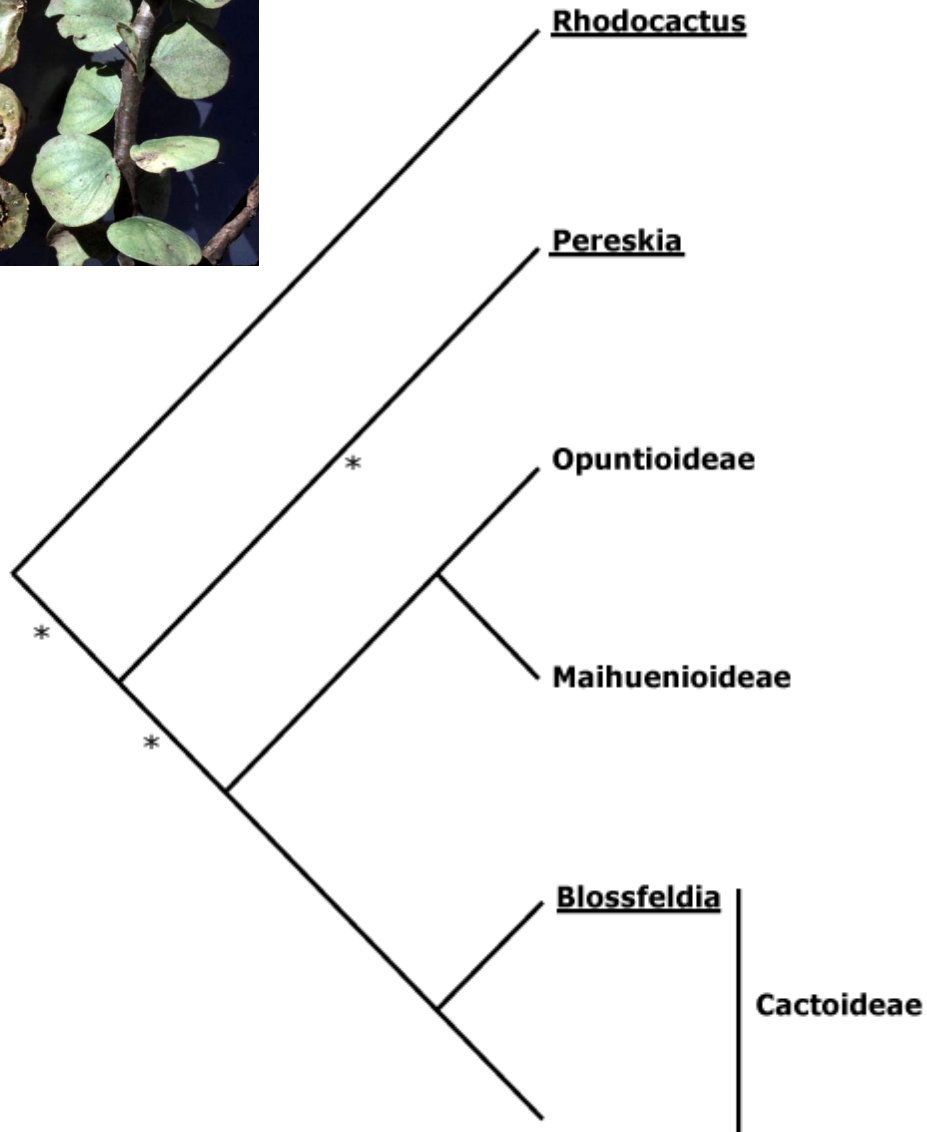
# \*Cactaceae - cacti

- great diversity: columnar, prickly pear, barrel, vines
- relationships emerging



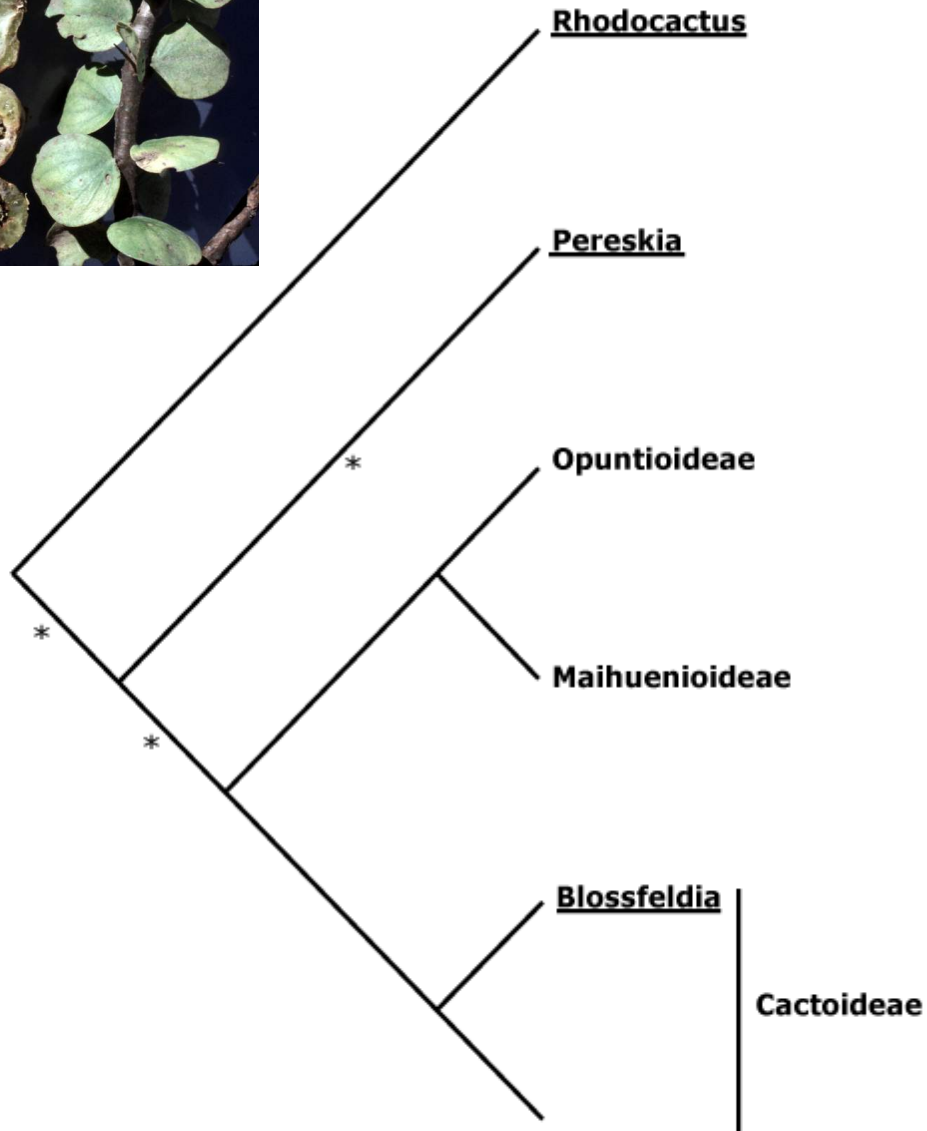


# \*Cactaceae - cacti



- Caribbean “*Pereskia*” at base of family! – now called *Rhodocactus*

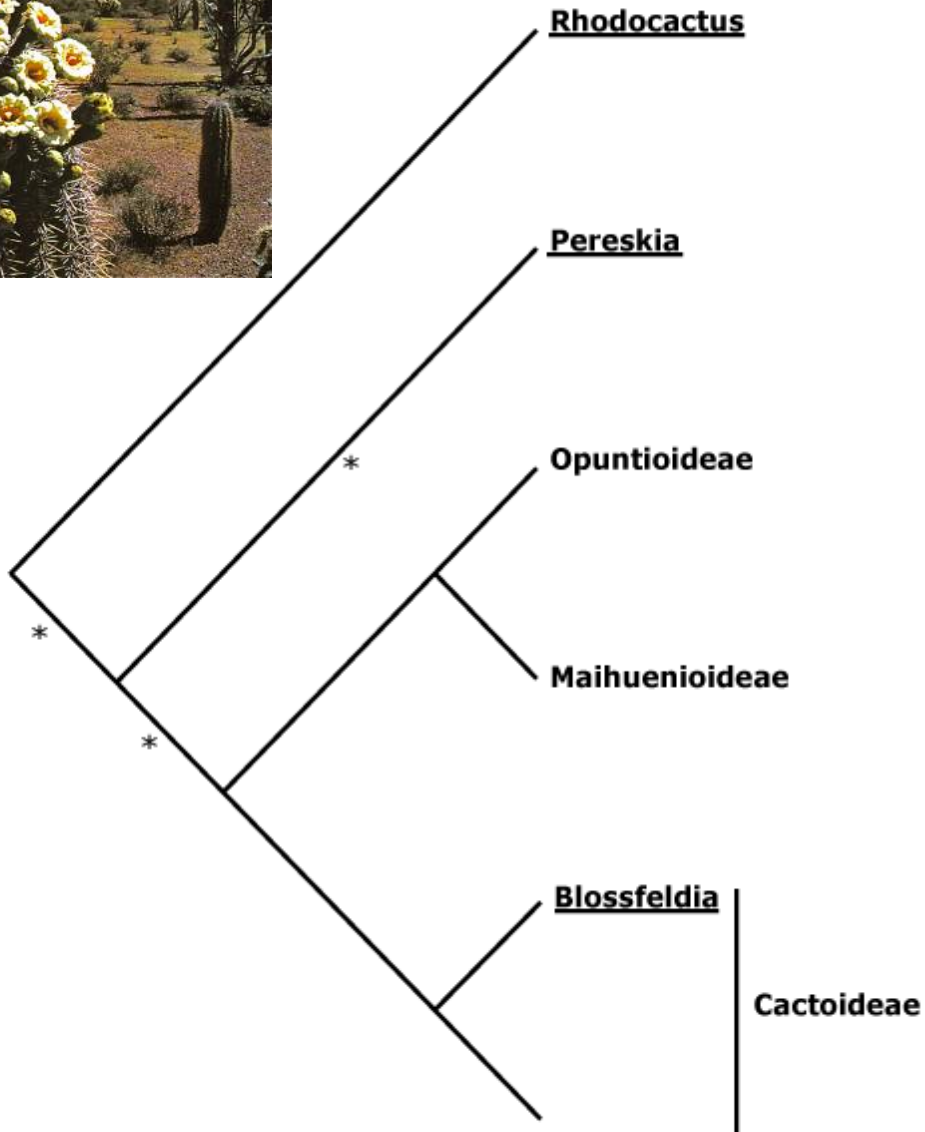
# \*Cactaceae - cacti



- Caribbean “*Pereskia*” at base of family! – now called *Rhodocactus*
- then S. American *Pereskia*



# \*Cactaceae - cacti



- Caribbean “*Pereskia*” at base of family! – now called *Rhodocactus*
- then S. American *Pereskia*
- then the rest of American taxa

# \*Cactaceae - cacti



*Selenicereus grandiflorus*  
Queen-of-the-night  
25 cm diameter flowers!



*Lophophora williamsonia*  
peyote (mescaline)

Botanical Society of America  
(photo by John Bevington)



# \*Cactaceae - cacti

- upper midwest cacti

*Opuntia macrorhiza* -  
plains prickly-pear

*Opuntia humifusa* -  
eastern prickly-pear





# Didiereaceae - African 'cacti'

- Madagascar & east Africa
- convergent also with American Fouquieriaceae (ocotillo)



*Alluaudiopsis*



*Alluaudia*



*Alluaudia*

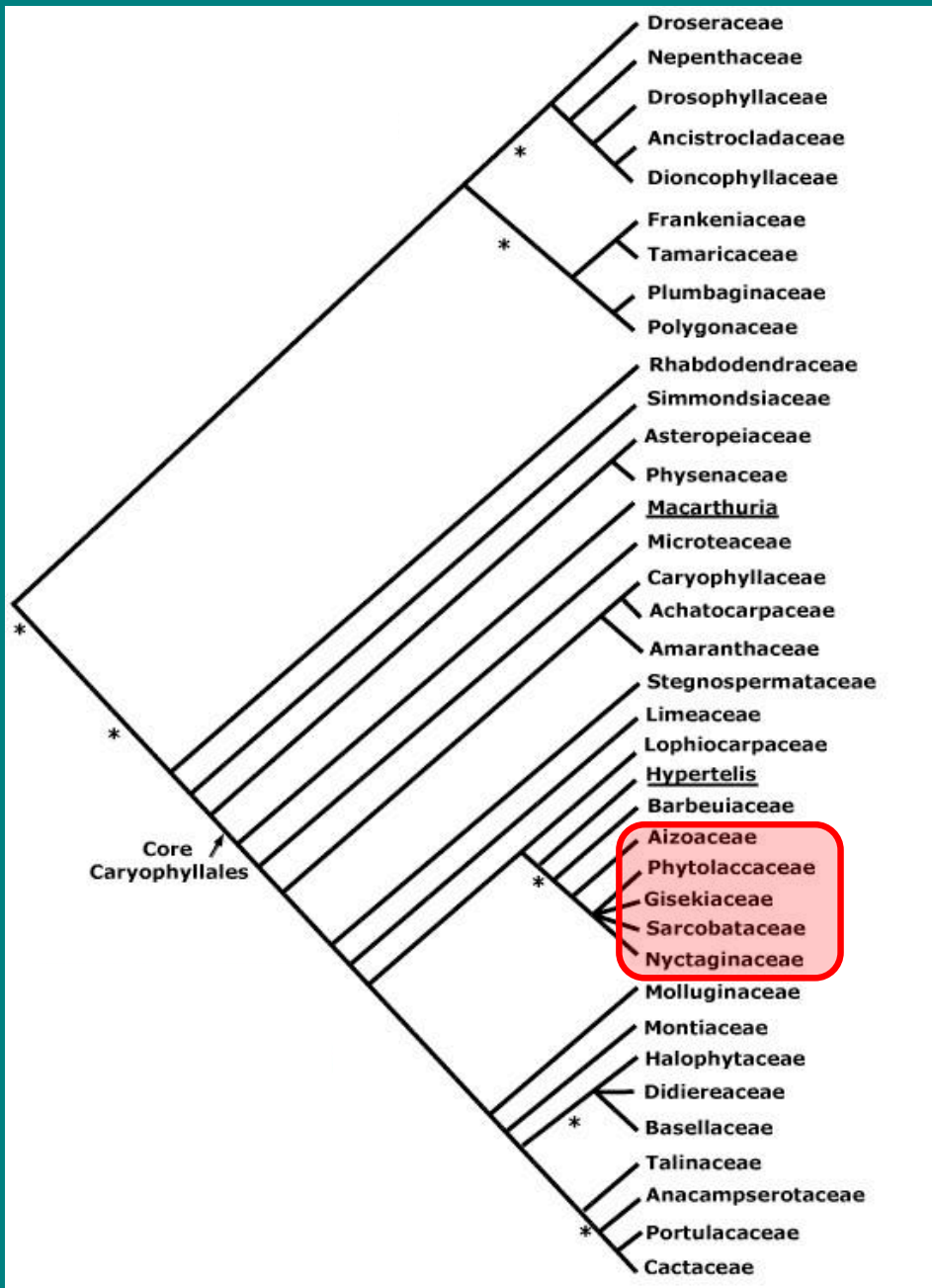


*Didierea*



# \*Phytolaccaceae - pokeweed

- Small family of trees/shrubs of tropical and temperate regions



*Phytolacca americana* - pokeweed



# \*Phytolaccaceae - pokeweed

- small petaloid sepals only
- stamens 2X sepals
- carpels +/- fused, each with one ovule

CA 5 CO 0 A 10 G (5+)



*Phytolacca octandra*



# \*Phytolaccaceae - pokeweed

- racemes
- berry fruits
- often poisonous
- dyes (poke = puccoon: Algonquian for red/orange dye)

CA 5 CO 0 A 10 G (5+)



*Rivinia* - bloodberry



*Phytolacca americana* - pokeweed

# \*Polygonaceae - smartweeds



- also look at Polygonaceae - smart weed family
- 61 genera / 1,100 species



*Persicaria amphibia* –  
water smartweed



# \*Polygonaceae - smartweeds

- herbs (few shrubs) of wet or arid regions



*Persicaria hydropiper* - water  
pepper



*Persicaria amphibia* –  
water smartweed

# \*Polygonaceae - smartweeds

- herbs (few shrubs) of wet or arid regions
- alternate, simple leaves at swollen nodes
- modified stipules as sheath = **ocrea**



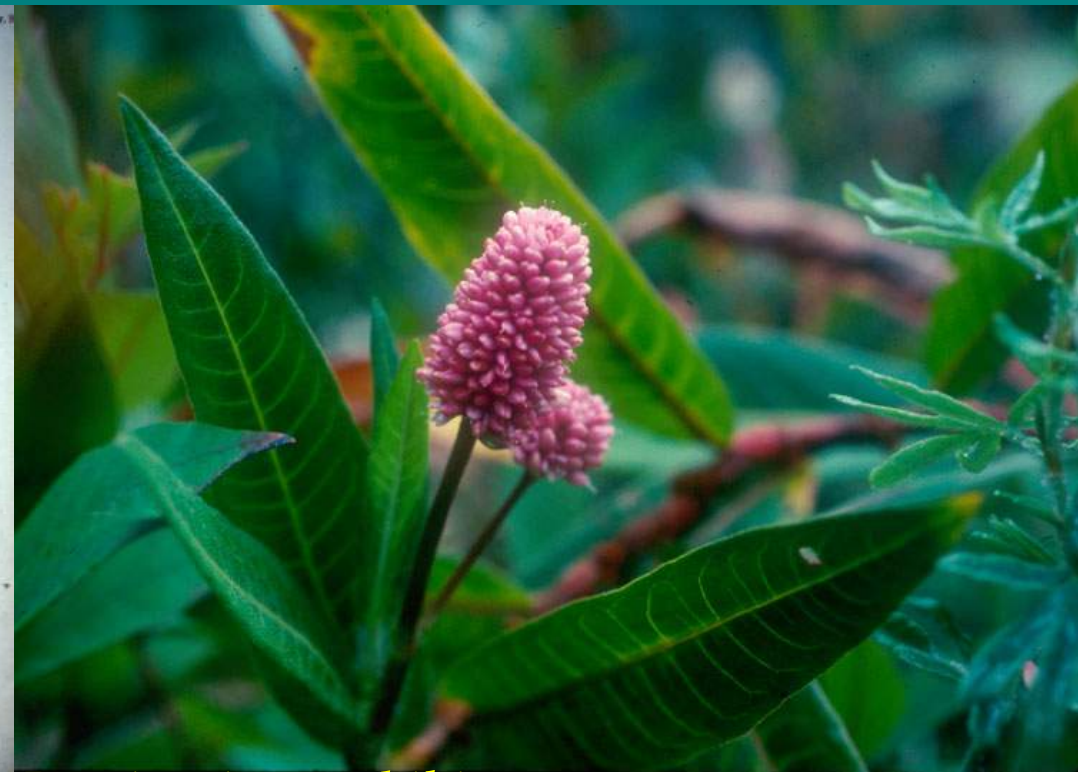
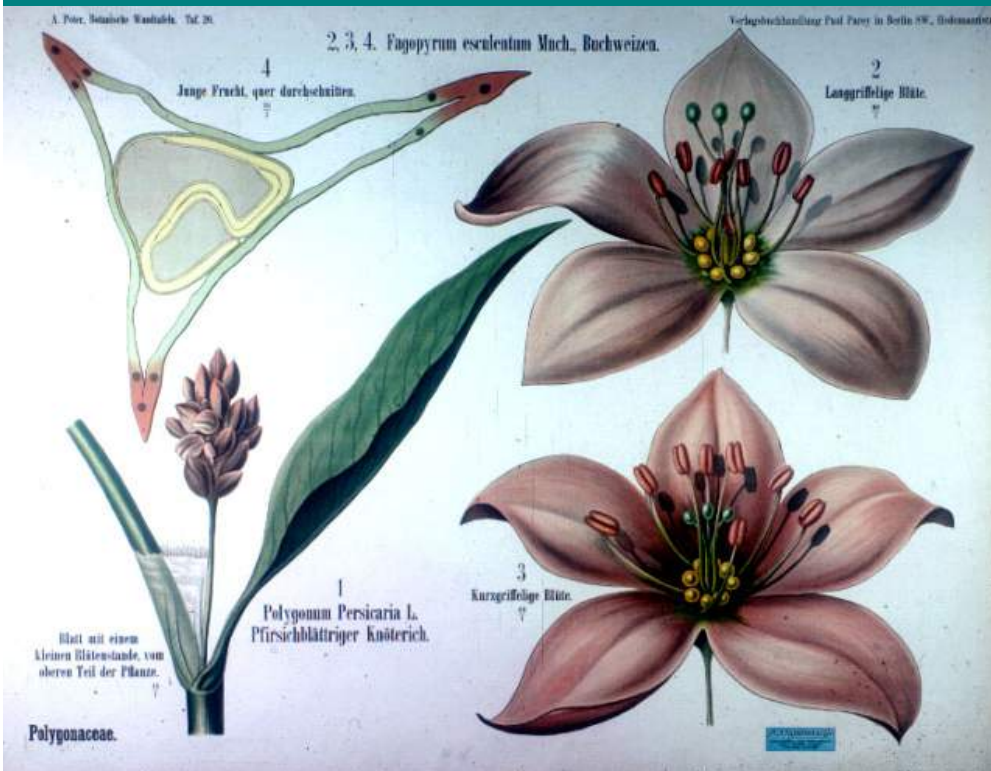
*Persicaria amphibia* –  
water smartweed



# \*Polygonaceae - smartweeds

- flowers congested
- basically 3 merous, tepals petaloid
- one-seeded, three-angled achene

P 3+3 (5) A 3X G (3)




*Persicaria amphibia* –  
water smartweed



# \*Polygonaceae - smartweeds

- *Rumex* and *Persicaria* (*Polygonum*) largest genera



*Persicaria* - smartweed



*Rumex crispus* - curly doc



*Rumex orbicularis* - water doc



# \*Polygonaceae - smartweeds

- horticulturally important

*Rheum rhabarbarum*  
Garden rhubarb  
locally adventive

*Fagopyrum esculentum*  
buckwheat

