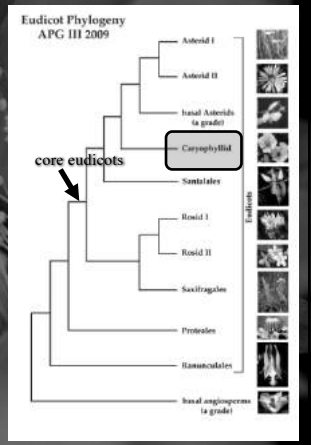
Diversity and Evolution of Caryophyllids

. . . carnations, cacti, chenopods . . .

Caryophyllids

What are caryophyllids?

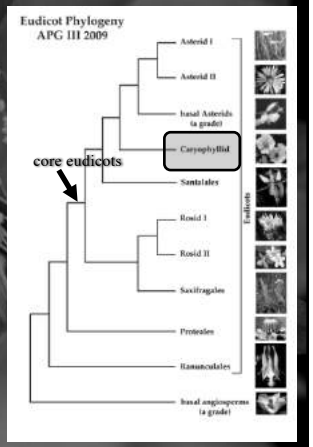
- First of the core eudicots we will examine: Caryophyllids, Rosids, Asterids
- = order Caryophyllales
- APG III in 2009 places caryophyllids as sister lineage to the asterids – but probably dates back to 110-100 mya



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



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

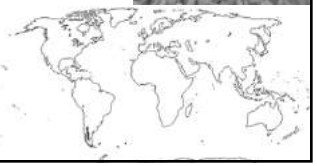
Tamarix - tamarisk
Tamaricaceae

Caryophyllids

What are caryophyllids?

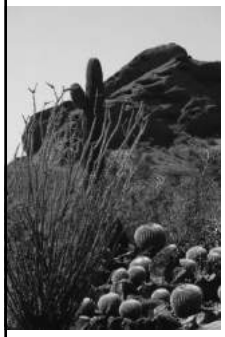
- "new" (unplaced) members to the group include desert families

Halophytum
Halophytaceae

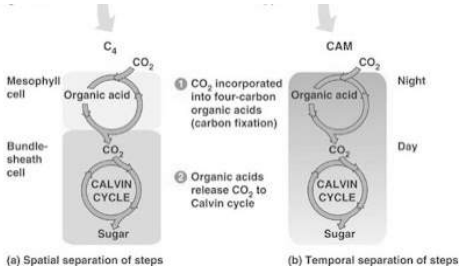


Caryophyllids

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

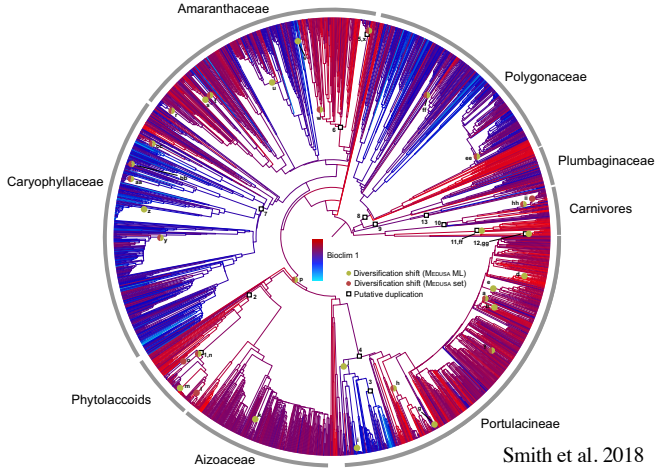
What are caryophyllids?

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

Sundews - Droseraceae

Asian pitcher plant

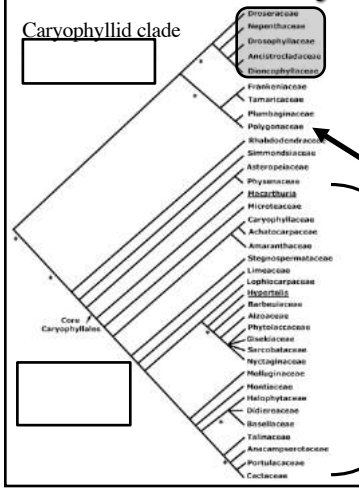
- why this incredible diversity – ecology, physiology, habit, color?



Smith et al. 2018

- 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

Core Caryophyllales

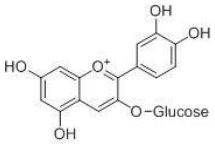
Caryophyllid clade

Core Caryophyllales

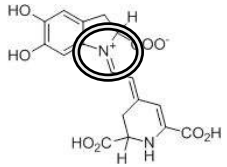
• defined by 5 features but with some reversals

Core Caryophyllales

1. betalains



cyanidin-3-glucoside (anthocyanin)

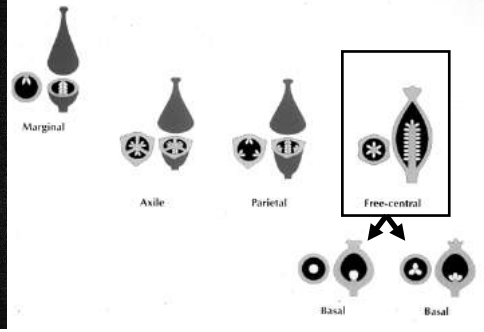


betanidin (betalain)

N containing – very different from flavonoids

Core Caryophyllales

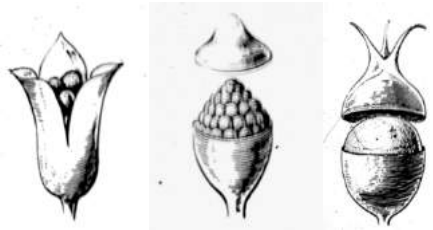
2. free-central placentation (or basal) = "Centrospermae"



Core Caryophyllales

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

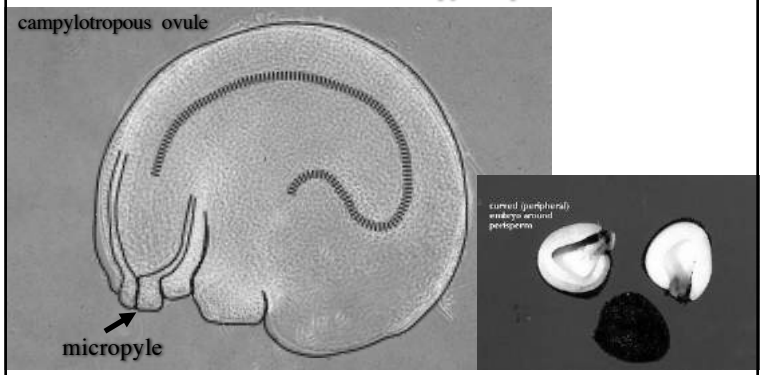
. . . generates capsule fruits



capsule pyxis utricle

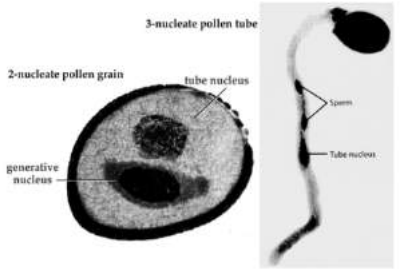
Core Caryophyllales

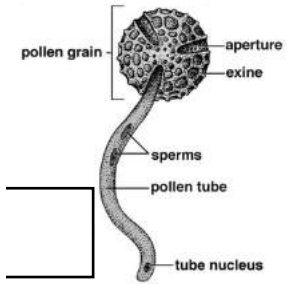
3. curved embryo in ovule = campylotropous



Core Caryophyllales

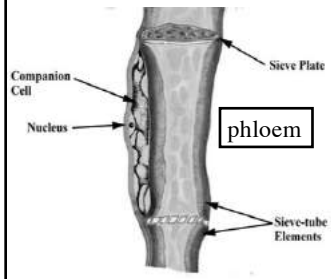
4. pollen shed in trinucleate stage vs. most common 2-nucleate

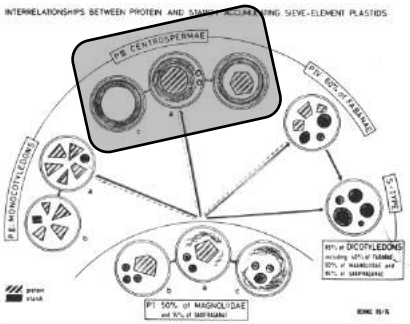




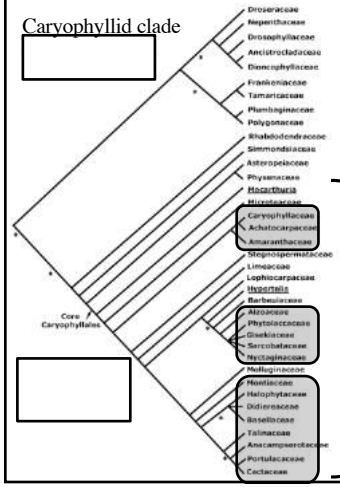
Core Caryophyllales

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





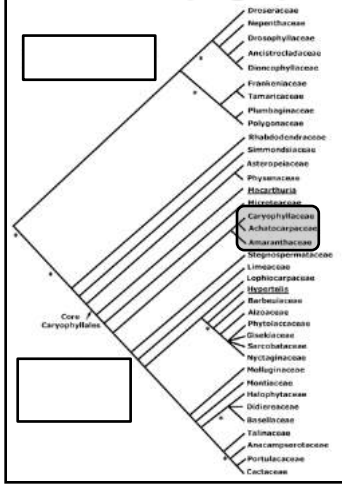
Core Caryophyllales



- 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

*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?)

*Caryophyllaceae - Carnations

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

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

*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

*Caryophyllaceae - Carnations

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

*Caryophyllaceae - Carnations

*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

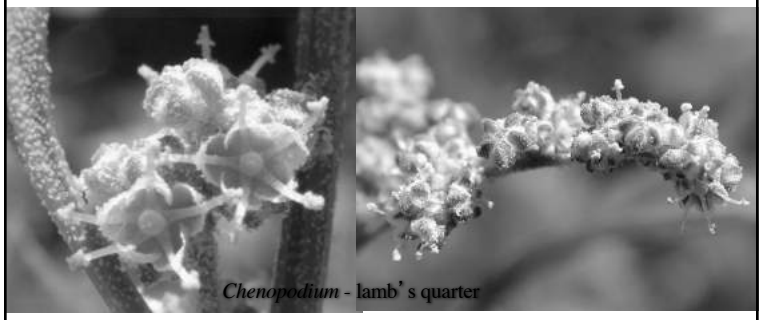
Salicornia - glasswort

*Amaranthaceae - amaranths

- flowers small, bracted, congested, lacking corolla

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

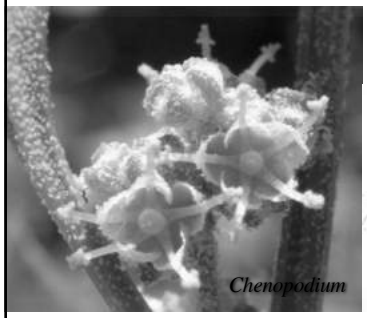
- bisexual or unisexual, monoecious or dioecious



Chenopodium - lamb's quarter

*Amaranthaceae - amaranths

- fruit is 1-seeded circumscissle capsule (utricle) or basal seeded achene
- calyx is persistant around the fruit



utricle

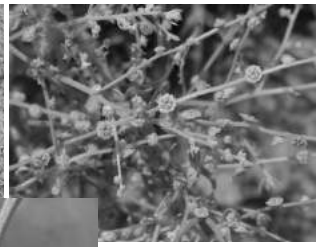
*Amaranthaceae - amaranths

- native, weedy, and horticultural species

*Amaranthaceae - amaranths

- native, weedy, and horticultural species

Cycloloma atriplicifolium – winged pigweed



*Amaranthaceae - amaranths

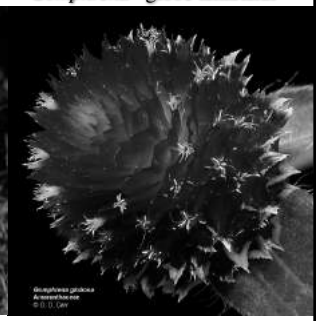
- native, weedy, and horticultural species

*Amaranthaceae - amaranths

• native, weedy, and horticultural species

Celosia - cock's comb

Gomphrena - globe amaranth



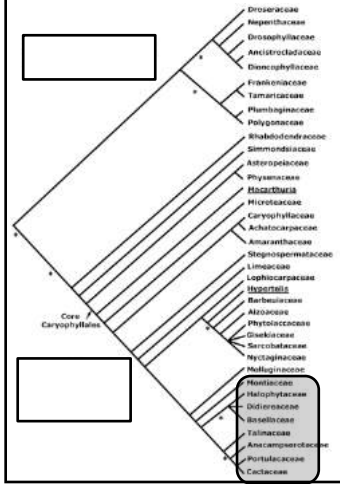
*Amaranthaceae - amaranths

• 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

* 'Portulacaceae' - Purslanes

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

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

valvate

* 'Portulacaceae' - Purslanes

Portulaca grandiflora
rock rose (Argentina)

Claytonia now in family Montiaceae

Claytonia megarhiza
w. NAm alpine

Claytonia virginica
spring beauty

* 'Portulacaceae' - Purslanes

Phemeranthus
fame flower

Montiaceae

*Cactaceae - cacti

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

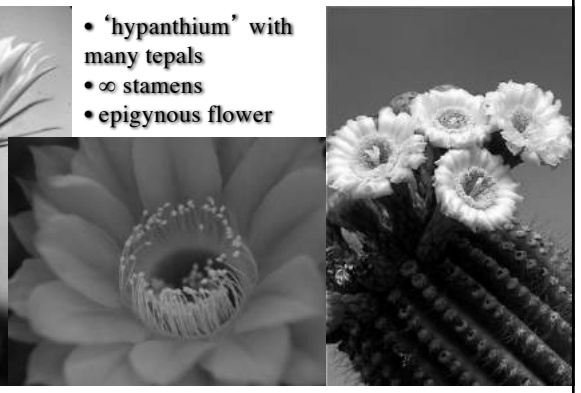
*Cactaceae - cacti

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

*Cactaceae - cacti

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

- 'hypanthium' with many tepals
- ∞ stamens
- epigynous flower



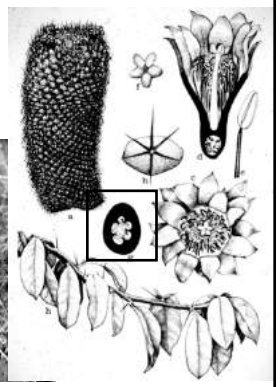
*Cactaceae - cacti

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

- placentation parietal (rare!)
- berry fruit

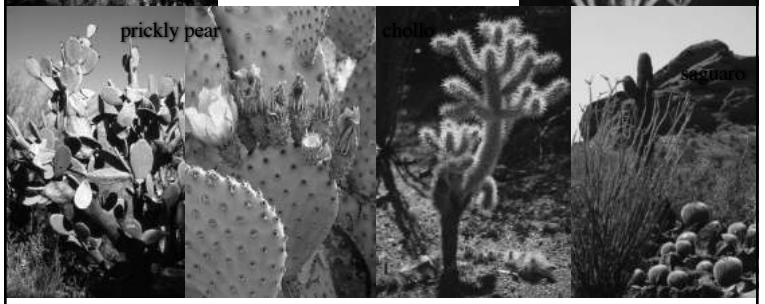
Pereskia

Opuntia



*Cactaceae - cacti

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

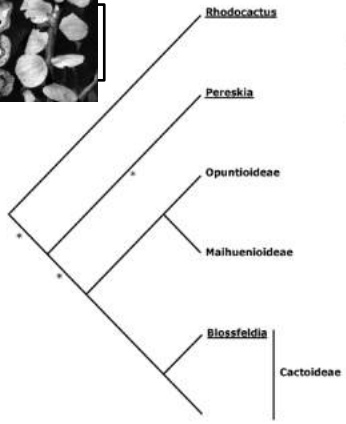


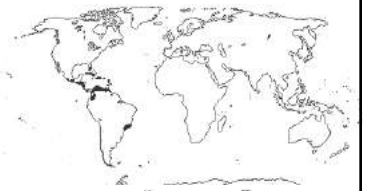
prickly pear

cholla

saguaro

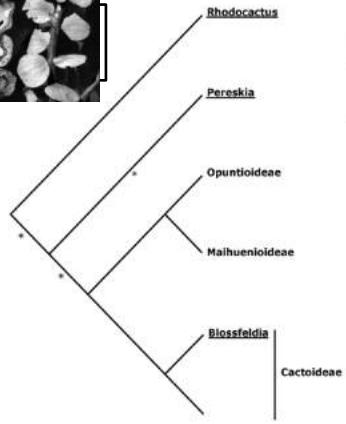
*Cactaceae - cacti

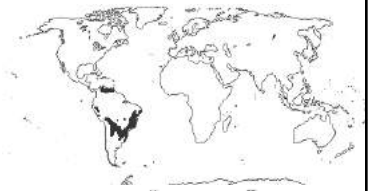




- Caribbean "*Pereskia*" at base of family! – now called *Rhodocactus*

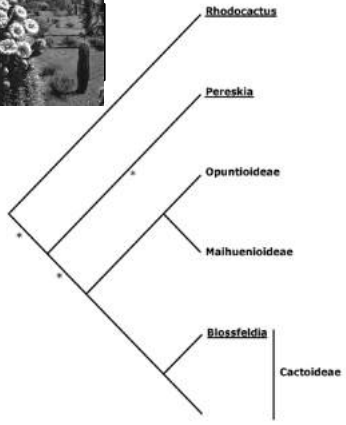
*Cactaceae - cacti





- 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)

*Cactaceae - cacti

• upper midwest cacti

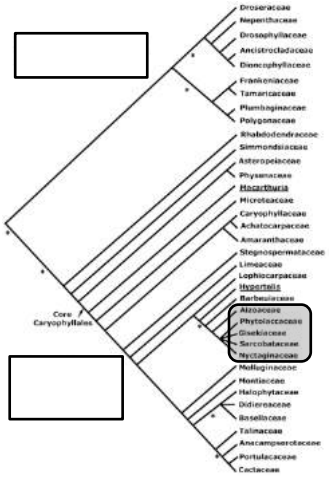
Opuntia macrorhiza - plains prickly-pear

Opuntia humifusa - eastern prickly-pear

Didiereaceae - African 'cacti'

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

*Phytolaccaceae - pokeweed



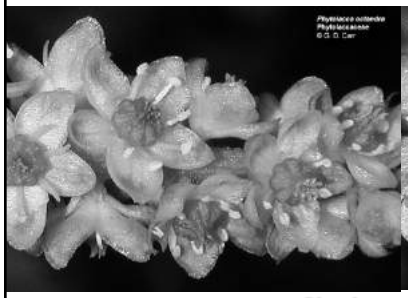
• Small family of trees/shrubs of tropical and temperate regions

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

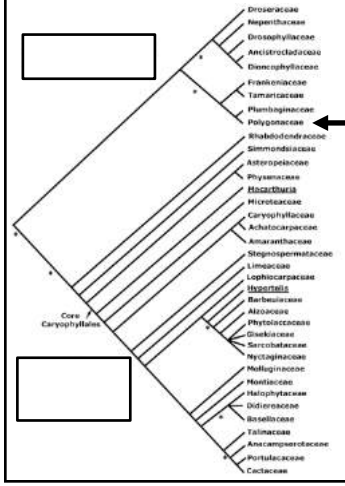
- racemes
- berry fruits
- often poisonous
- dyes (poke = puccoon: Algonquian for red/orange dye)

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

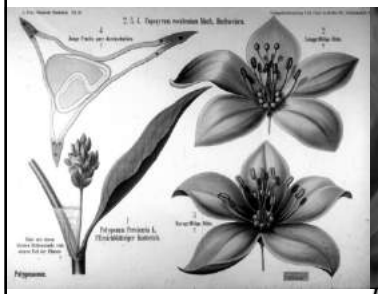
- herbs (few shrubs) of wet or arid regions
- alternate, simple leaves at swollen nodes
- modified stipules as sheath = ocrea

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

Persicaria - smartweed

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

Rumex crispus - curly doc

Rumex orbicularis - water doc

*Polygonaceae - smartweeds

- horticulturally important

Rheum rhabarbarum
Garden rhubarb
locally adventive

Fagopyrum esculentum
buckwheat