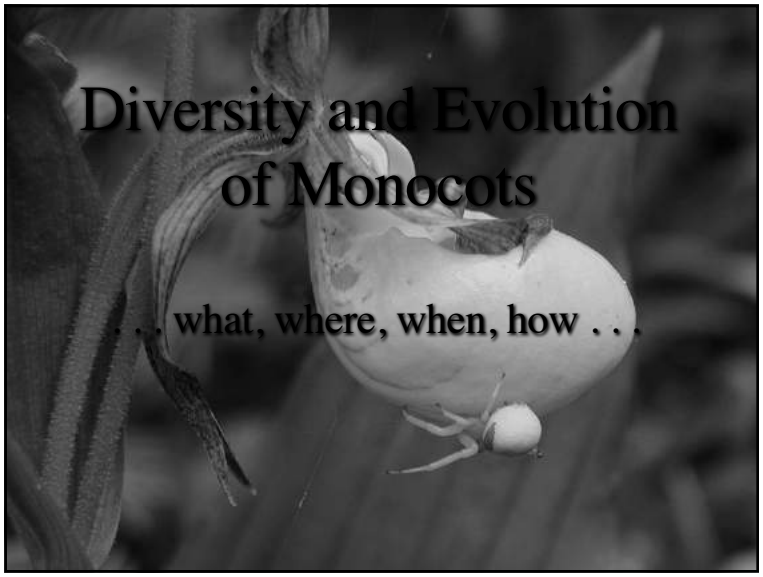
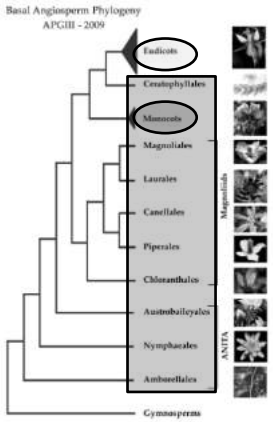


Monocots!



We will finish our survey of angiosperms by examining the monocots - a lineage of basal angiosperms

Basal angiosperm lineage, but is appearing to be closer to eudicots than most other basal angiosperms

Monocots!

- Large group: ~ 60,000 species!
- Old lineage: ~134 mya
- Great diversity: habit, habitat, pollination, morphology
- Adaptive radiations:

  (orchids–21,950 spp; grasses–10,035 spp)
- Smallest & largest seeds: orchids; *Lodoicea maldivica*
- Largest inflorescences (titan arum, palms, bromeliads)
- Smallest fruit, flower & flowering plant (*Wolfia*)



Diversity in ecology

- "Trees", grasses, rosettes, vines, epiphytes…
- Carnivores, mycotrophs…
- Habitats: dry, wet, aquatic…
- Pollination: water, wind, zoophily

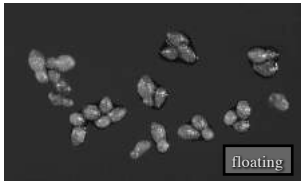


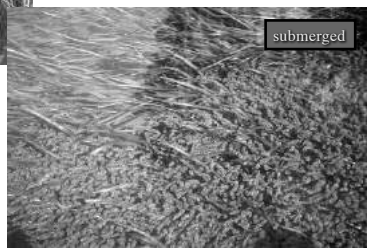



Diversity of aquatic habits

Emergent, floating, or submerged aquatic group of monocots

These are the first diverging monocots





Monocot "trees"

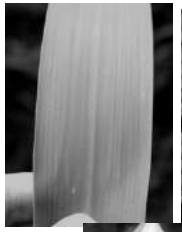
No vascular cambium activity ⇒ no true secondary growth (wood)

Anomalous secondary growth ⇒ "trees"


Dragon tree – a lily relative


Woody palm

Monocot leaves

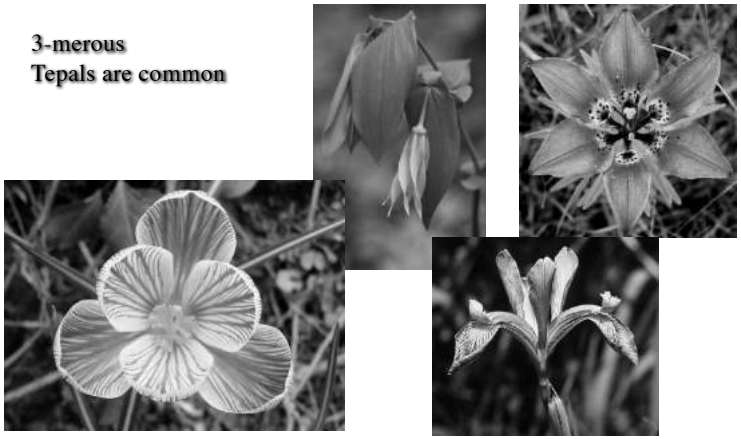


- Parallel venation (or derived forms) vs. pinnate or reticulate venation as in most dicots
- (more on this later)



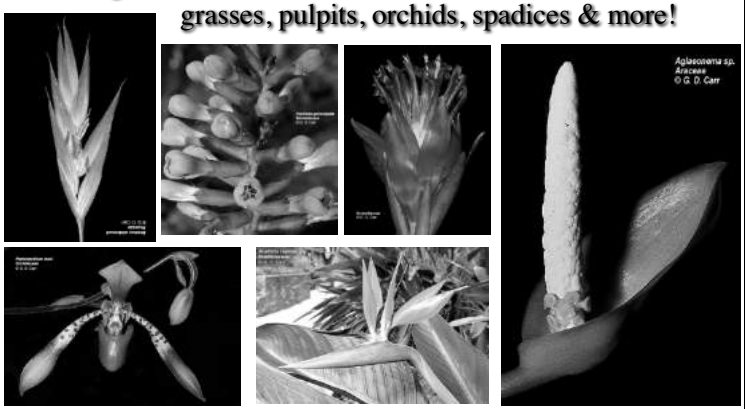
Monocot flower: common theme

3-merous
Tepals are common



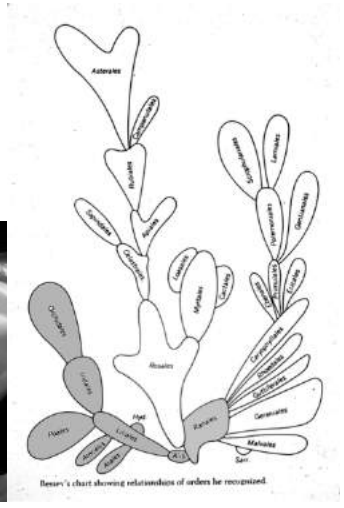
Diversity in pollination

Striking modifications & bracts:
grasses, pulpits, orchids, spadices & more!



Monocot Origins

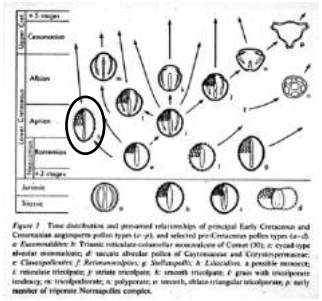
Monocots have usually been considered as derived out of basal angiosperms - Ranales in the Bessey system or subclass Magnoliidae with Cronquist

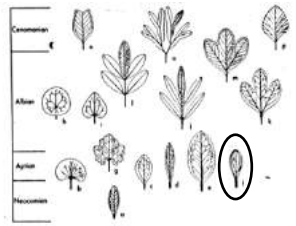


Bessey's chart showing relationships of orders he recognized.

Monocot Origins

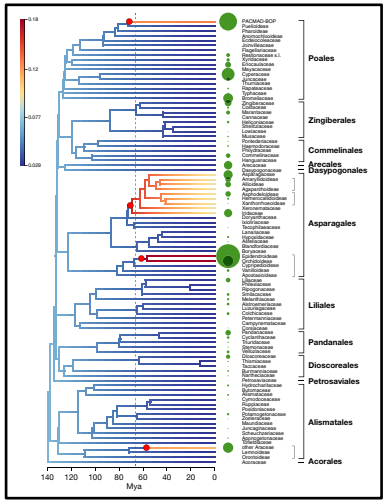
Crown group radiation: ~135+ mya [based on DNA evidence]
Pollen & leaf: possible early Aptian (Early Cretaceous), 113-125 mya
Oldest unambiguously assigned fossil: Araceae, 110-120 mya





Monocot Origins

- cpDNA genome phylogeny (Givnish et al. 2018)
- rapid radiation at base
- four large burst in species diversification



Monocot leaf evolution

Classic idea of pre-monocot characteristics – Cronquist's view:

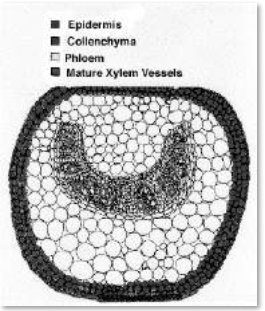
1. Herbs
2. Aquatic
3. Perianth not specialized
4. Uni-apperturate pollen
5. Apocarpy
6. Laminar placentation

} Nymphaeales Only non-monocot order with all these characteristics

Monocot leaf evolution

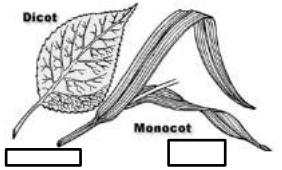
- monocot leaf morphology due to aquatic ancestry
- aquatic ➔ terrestrial ➔ aquatic pathways

Monocot leaf evolution

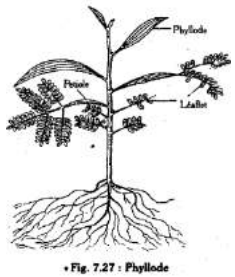


celery (left) and tomato (right) asterid petioles showing parallel vascular traces

- monocot leaf is derived from an expanded bladeless petiole



Monocot leaf evolution



• Fig. 7.27 : Phyllode

Phyllode theory: original monocot lacked a true leaf; only expanded petiole

Phyllodes: expanded blade-less petioles best seen in arid adapted woody legumes such as *Acacia*

Monocot leaf evolution

loss of blade & expansion of tissue between parallel veins of petiole

variable expansion of tissue between parallel veins

in aquatic habitat

Acorus sweet flag

cross veins & 'reticulated' blades

Monocot leaf evolution

loss of blade & expansion of tissue between parallel veins of petiole

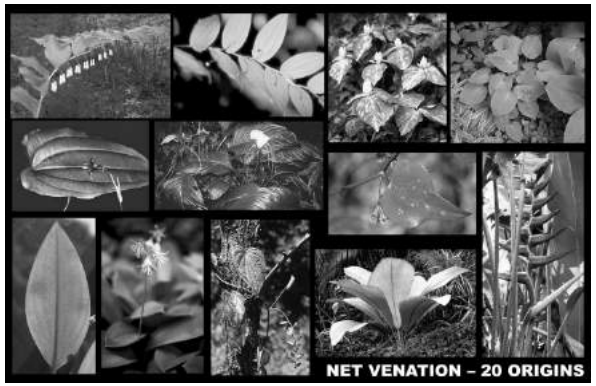
variable divergence of parallel veins to leaf edge

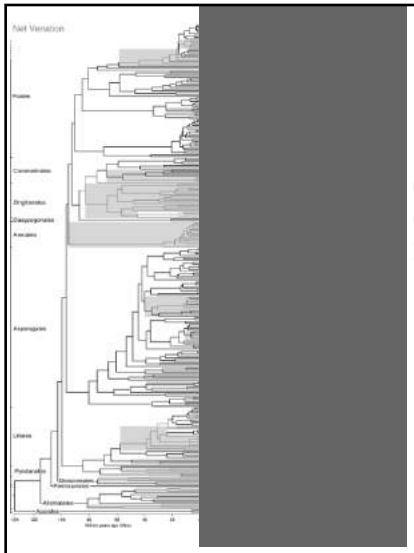
in aquatic habitat

'parallel-pinnate' venation of palms and bananas

Monocot leaf evolution

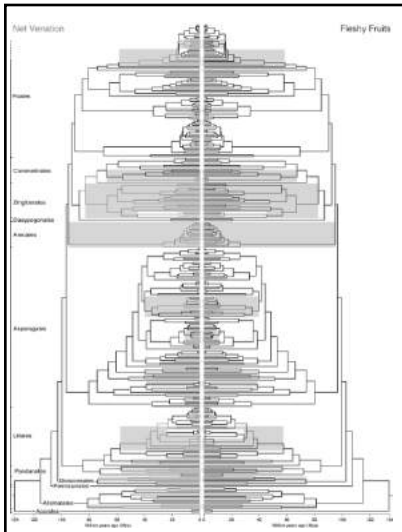
functional ecological arguments for evolution of broad leaves and fleshy fruits of monocots in shady understory conditions (T. Givnish, 1984, 1999, 2002)





Concerted convergence

Occurrences of net venation are overlain on this monocot phylogeny



Concerted convergence

Occurrences of net venation and fleshy fruits are overlain on this monocot phylogeny

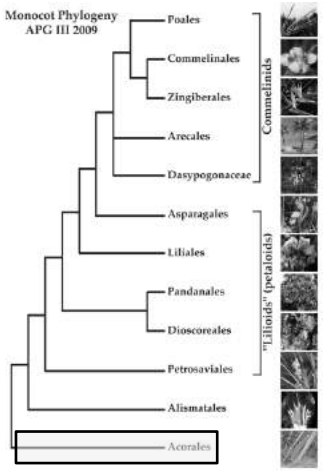
Both features:

- arise multiple times
- are correlated with each other
- arise in understory clades

Survey of monocots

4 main groups:

- Acorales - sister to all monocots
- Alismatales
  - inc. Aroids - jack in the pulpit
- "Lilioids" (lilies, orchids, yams):
  - non-monophyletic
  - petaloid
- Commelinids
  - Arecales – palms
  - Commelinales – spiderwort
  - Zingiberales –banana
  - Poales
    - pineapple
    - grasses & sedges

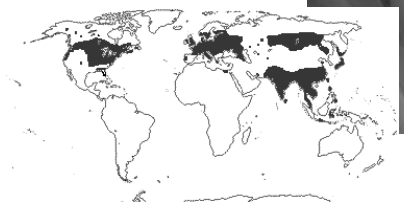


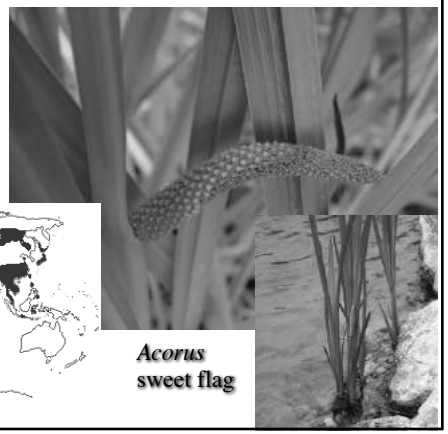
Acorales (*Acoraceae - sweet flag)

- Emergent aquatic plants with ethereal oils and no raphides

2 species:

Acorus calamus, Old World
A. americanus, New World
Both species in Wisconsin





Acorus
sweet flag

*Acoraceae - sweetflag

Flat filaments

$P^6 \quad A^6 \quad \underline{G}^{(3)} \quad \infty$ seeds

- Inflorescence with 'spathe' and spadix
- Flowers bisexual

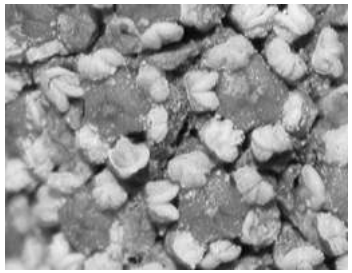
Acorus americanus - sweet flag

*Acoraceae - sweetflag

Flat filaments

$P^6 \quad A^6 \quad \underline{G}^{(3)} \quad \infty$ seeds

- Inflorescence with 'spathe' and spadix
- Flowers bisexual

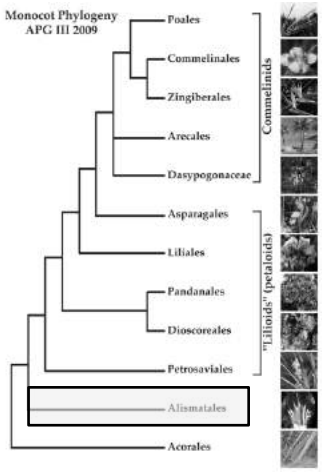


Acorus americanus - sweet flag

Alismatales

4 main groups:

- Acorales - sister to all monocots
- Alismatales
  - inc. Aroids - jack in the pulpit
- "Lilioids" (lilies, orchids, yams)
  - non-monophyletic
  - petaloid
- Commelinids
  - Arecales – palms
  - Commelinales – spiderwort
  - Zingiberales –banana
  - Poales
    - pineapple
    - grasses & sedges



Alismatales - aquatics

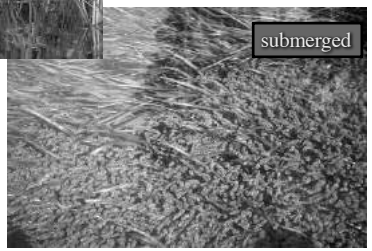
Recurring themes:

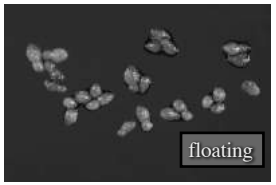
Aquatic ⇒ brackish ⇒ marine habitats

Insect ⇒ water pollination

Alismatales - aquatics

Emergent, floating, or submerged aquatic group of monocots





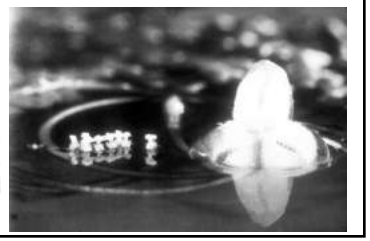
Alismatales - aquatics

Showy flowers, insect-pollinated

Associated with the aquatic habit is the trend from insect-pollinated, showy flowers to water-pollinated, reduced flowers . . .

and increasing effort to vegetative rather than sexual reproduction

Reduced unisexual flowers, water-pollinated



Alismatales - aquatics

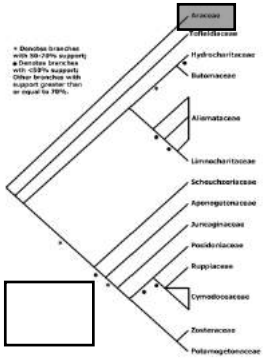
Showy flowers, insect-pollinated

72% of Alismatales are unisexual - monoecious or dioecious

132 species are hydrophilous (*how many origins?*) – answer later

Reduced unisexual flowers, water-pollinated

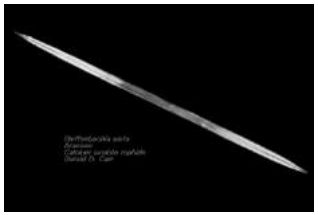
*Araceae - aroids



104 genera
2,550 species

- Sister family to other Alismatales
- Tropical (to temperate)
- epiphytes, herbs, aquatic

*Araceae - aroids



- raphides in vacuoles with mucilage
- Ca-oxalate (endo-osmosis)

- defining characteristic is the inflorescence of spathe and spadix
- spathe (or bract) is common in monocots

*Araceae - aroids

Inflorescence a fleshy spadix, surrounded by bract called the spathe

CA 0 CO 0 A 6- G (2-3)

Flowers unisexual or perfect
Fruits berries clustered on spadix

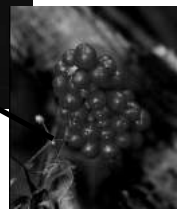
spadix

spathe (cut away)

Symplocarpus foetidus - skunk cabbage

Arisaema triphyllum - jack-in-the pulpit

*Araceae - aroids



L:female
R:male

Arisaema triphyllum - jack-in-the pulpit
[or jill-in-the-pulpit ?]

*Araceae - aroids

Cabbage-like leaves emerge later in the spring

Foetid smelling spathe and spadix emerges early in spring or late winter; attracts carrion flies by heating up and volatizing off the odor

Symplocarpus foetidus - skunk cabbage

*Araceae - aroids

Symplocarpus foetidus - skunk cabbage

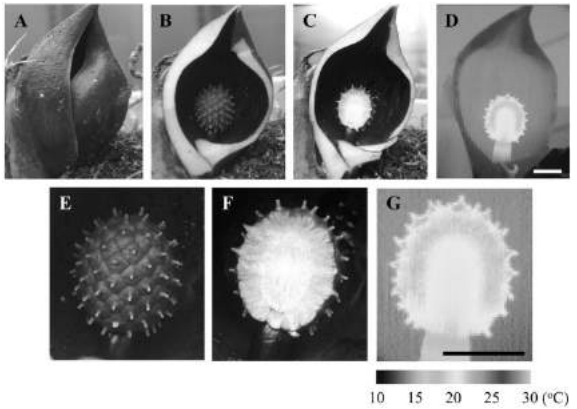
flesh flies – *Sarcophagidae*

sapromyophily pollination

carrion flies – *Calliphoridae*

gnats - *Mycetophilidae*

Endogenous heating of skunk cabbage (*S. renifolius*) spadix



Onda Y. et.al. Plant Physiol. 2008:146:636-645

*Araceae - aroids

Calla palustris - water arum

Only emergent aquatic member of the family in Great Lakes

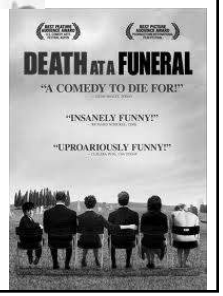
*Araceae - aroids

Monstera - tropical aroid

*Araceae - aroids

Zantedeschia
arum lily

funeral plants!



Spathiphyllum

*Araceae - aroids

other strange aroids:

Amorphophallus - titan arum

Pistia - water lettuce

"Lemnaceae" - duckweeds

*Araceae (Lemnaceae - duckweeds)

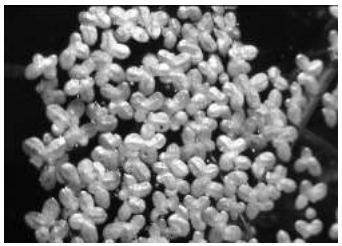
Floating or submersed aquatic *family* almost cosmopolitan in distribution; Vegetative reproduction primarily

Now known to be derived from within the Araceae

Lemna minor - small duckweed

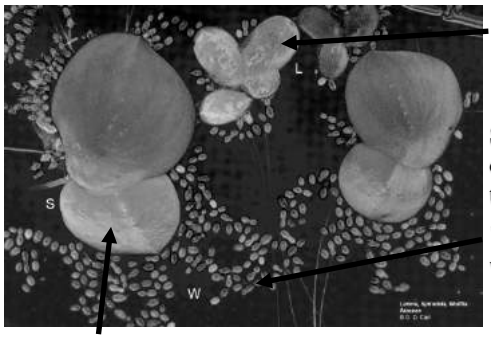
Includes the smallest angiosperm, and the smallest flower

Inflorescence reduced to 1 female and 1-2 male flowers



Lemna turionifera - perennial duckweed

*Araceae (Lemnaceae - duckweeds)



Lemna

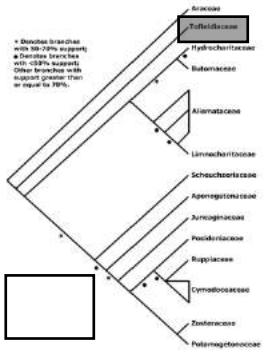
Smallest member of the family and the angiosperms:

Wolffia columbiana - water meal

Spirodela polyrhiza
great duckweed

Largest member of the family

Tofieldiaceae - asphodels




Triantha glutinosa

- Surprising inclusion!
- "Lilioid" flowers (Liliaceae s.l.)
- wet loving small herbs

Butomaceae - flowering rush

- emergent aquatic family
- leaves show no obvious blade and petiole differentiation

Butomaceae - flowering rush

- flowers in umbels
- unsealed carpels - follicles
- introduced - invasive

CA 3 CO 3 A 9 G 6

Butomus umbellatus - flowering rush

Alismataceae - water plantain

Aquatic or wetland family, especially in north temperate regions

Leaves long petioled, often with sagittate-shaped leaves

Tubers starchy, often edible

Alismataceae - water plantain


Sagittaria - arrowhead

CA 3 CO 3 A 6 - ∞ G 6 - ∞

Calyx of 3 green sepals, corolla of 3 white petals

Apocarpic in a head or ring

Perfect, monoecious, dioecious

Alismataceae - water plantain


Sagittaria - arrowhead

CA 3 CO 3 A 6 - ∞ G 6 - ∞

Calyx of 3 green sepals, corolla of 3 white petals

Apocarpic in a head or ring

Achenes (head of achenes here)

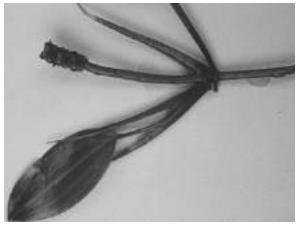
Alismataceae - water plantain

Similar to *Sagittaria*, but with carpels in one ring rather than globose head

Alisma plantago-aquatica - water plantain

Potamogetonaceae - pondweed

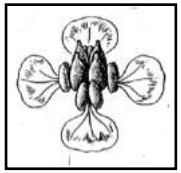
Aquatic plants with dimorphic leaves, 25 species in Wisconsin difficult to identify, hybridize, and some are troublesome weeds



Potomogeton sp. - pondweed

Potamogetonaceae - pondweed

- perianth of 4 clawed segments if present
- gynoecium typically of 4 free, 1-ovuled carpels
- fruit drupe-like



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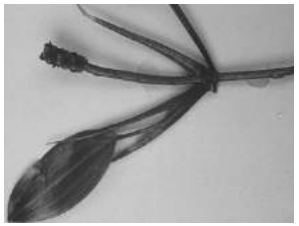
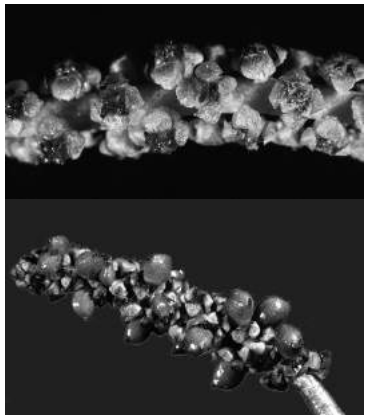


Potomogeton sp. - pondweed

Potamogetonaceae - pondweed



Potomogeton nodosus - pondweed

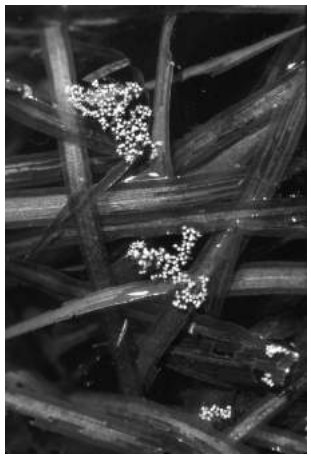
Flowers (top) and fruits (bottom)

Hydrocharitaceae - frog bit

- submersed or floating aquatic plants
- various forms of water pollination present

Elodea canadensis - waterweed

Hydrocharitaceae - frog bit



Vallisneria (tapegrasses, eelgrasses) are composed of two species, one New World, one Old World

Vallisneria americana - tapegrass (with *Hydrilla verticillata*)

Vallisneria americana - tapegrass

Hydrocharitaceae - frog bit

Vallisneria spiralis - tapegrass (OW)

Note the floating male flowers and one large female with 3 stigmatic areas on a long peduncle

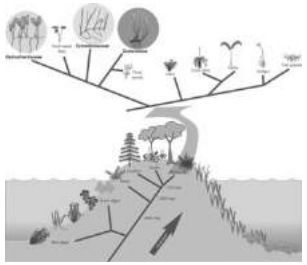
- male flowers in clusters; female flower single
- pollen water boat floats and attaches to 3 broad stigma of the female flower
- flower retracts and forms fruit under water

Vallisneria americana - tapegrass

Evolution of Sea Grasses

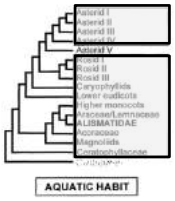
Don Les' story of plants going back to the oceans 450 million years later

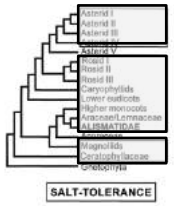
. . . another story of convergence and divergence

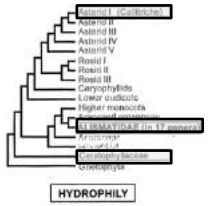


Evolution of Sea Grasses

Aquatic ⇒ Salt Tolerant ⇒ Hydrophily







Aquatic plants found in most lineages

Salt tolerance also wide-spread

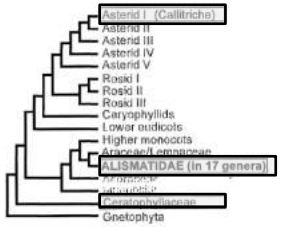
Water pollination restricted

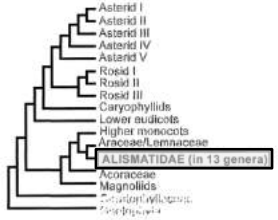
Callitriche

Ceratophyllum

Evolution of Sea Grasses

⇒ Hydrophily ⇒ Marine

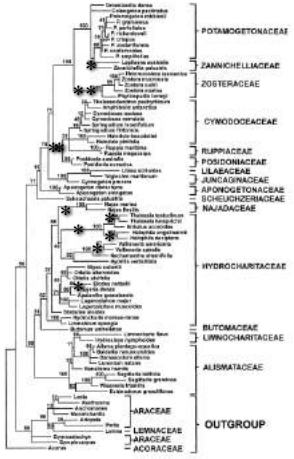




Seagrasses found in only one lineage of these aquatic, salt tolerant, and water pollinated lineages (order Alismatales)

A single origin of seagrasses?

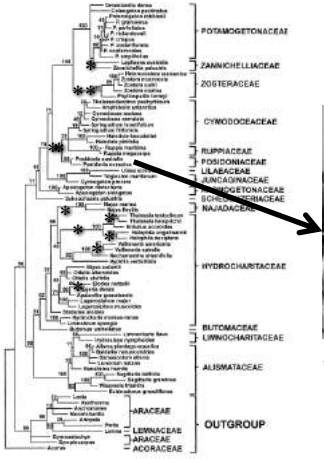
Evolution of Sea Grasses



- hydrophily originated 10 times in angiosperms
- 8 of these times independently in Alismatales!
- marine habitat originated 3 times independently in Alismatales!
- marine habitat correlated with hydrophily

DNA based tree of Alismatales with water pollination and seagrasses mapped on

Evolution of Sea Grasses



- oldest known clonal organism – 200,000 years old !

Posidonia oceanic L.