

What Happened to Asclepiadaceae?

Understanding the Science Behind Changes in
Plant Taxonomy

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Asclepiadaceae



Apocynaceae

The Flora of Nebraska

Kaul, Sutherland, and Rolfsmeier



Apocynaceae

Changes not adopted by Kaul et al.

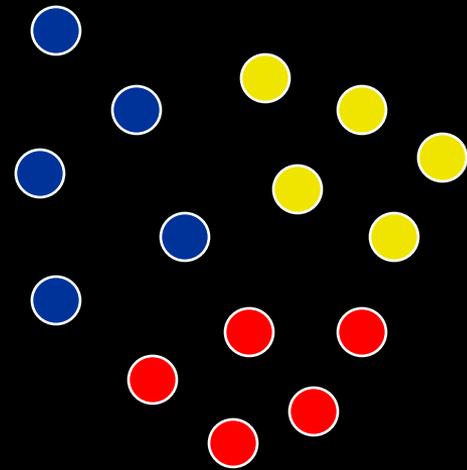
<i>The Flora of Nebraska</i>	Angiosperm Phylogeny Group II APGII (2003)
Liliaceae	Liliaceae, Alliaceae, Asparagaceae, Melanthiaceae
Papaveraceae, Fumariaceae	Papaveraceae
Scrophulariaceae	Scrophulariaceae, Plantaginaceae, Orobanchaceae, Phrymaceae

Outline

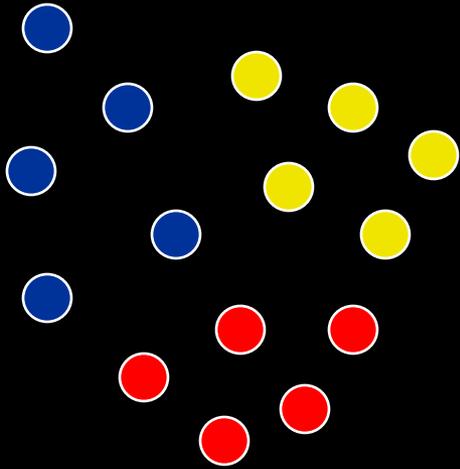
- What is a classification?
 - Artificial
 - Natural
 - Monophyletic
- How do we discover monophyletic groups?
- What happened to Asclepiadaceae.

What is a classification?

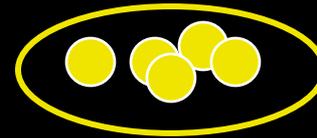
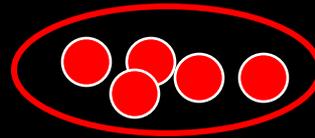
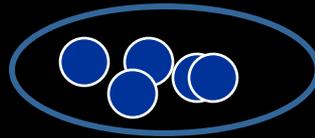
- Hierarchy of groups.
- Each group at a lower level in the hierarchy is included in one group at each higher level.
- There is no overlap between groups at the same hierarchic level.



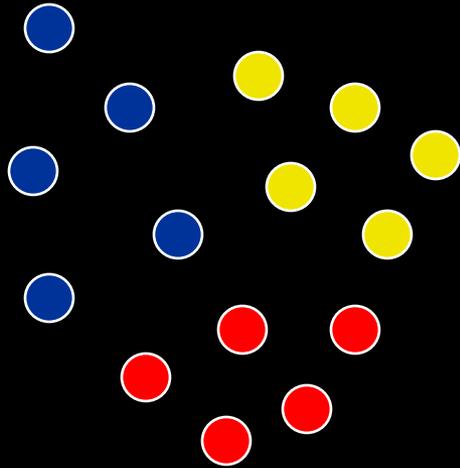
Individuals grouped into species



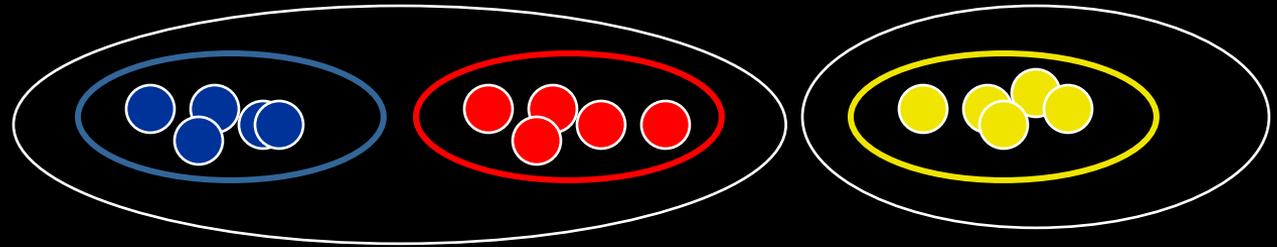
species



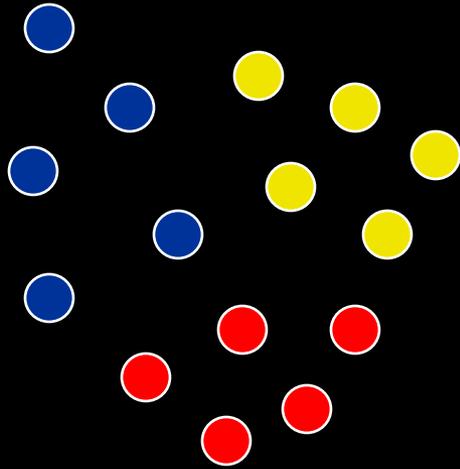
Species grouped into genera



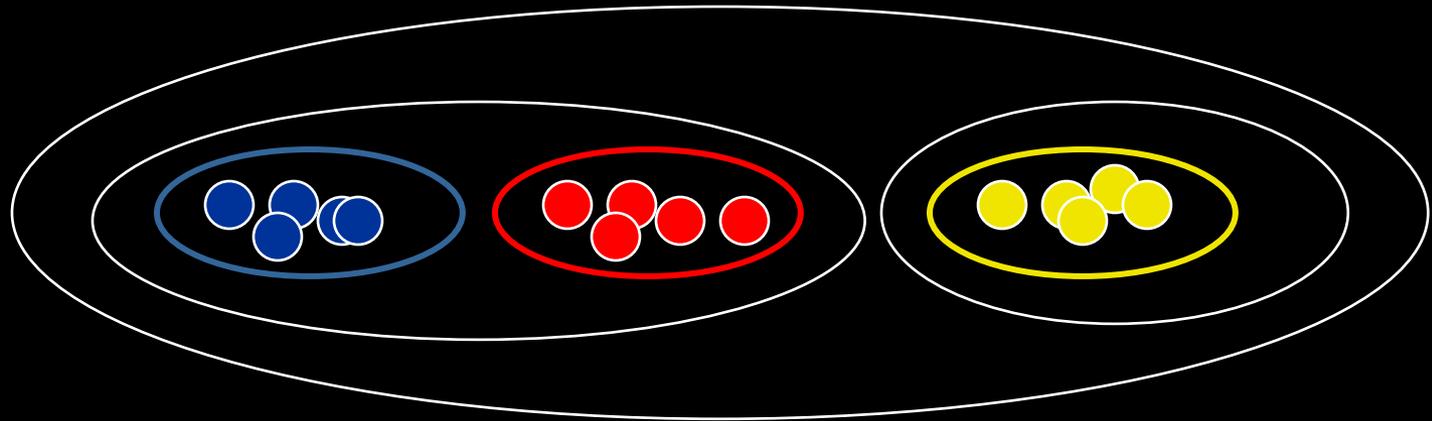
genera



Genera grouped into families



family



The levels in the biological classification are ranked.

Family: Apocynaceae

Genus: *Asclepias*

Species: *Asclepias syriaca*



Classifications are MADE by humans.

“[A classification] is a tool by the aid of which the human mind can deal effectively with the almost infinite variety of the universe. It is not something inherent in the universe, but is . . . a conceptual order imposed on it by man for his own purposes.”

J. S. Gilmour cited in J. Cullen and S. Max Walters (2006).
in *Taxonomy and Plant Conservation*. E. Leadley and S. Jury, eds.

What is the purpose of biological classification?

A means to store and retrieve information about organisms.

- 1) Easy to use
- 2) Stable
- 3) An aid to memory
- 4) Predictive
- 5) Concise

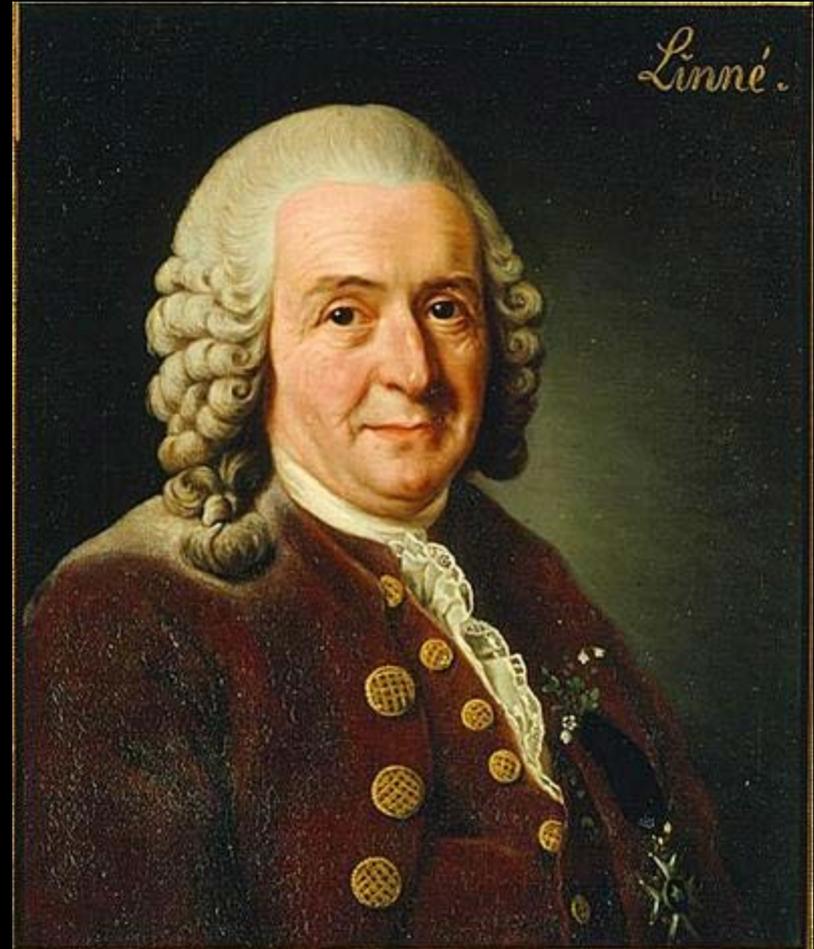
“NATURAL”



Andreas Caesalpinus, Italian
1519-1603

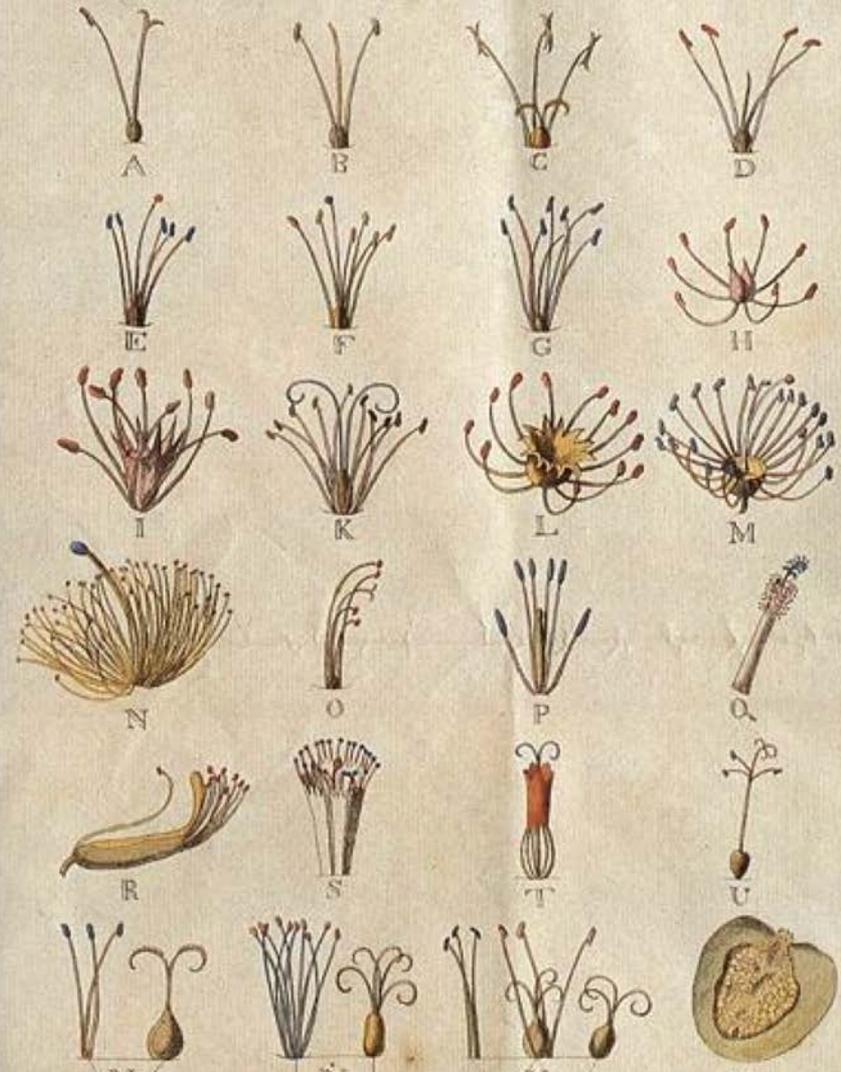
Artificial Classification

- Groups are defined a priori on the basis of characters
- Inclusion in a group is determined by presence of the defining group character
- Linnaeus's "Sexual System"
- Dichotomous keys



Carolus Linnaeus, 1707-1778, Swedish

Clariss: LINNÆI. M. D.
METHODUS plantarum SEXUALIS
in SISTEMATE NATURÆ
descripta



“The Sexual System”

All genera are placed into Classes based on stamen number and arrangement.

Classes divided into orders based on pistil number.

24 groups of genera

Artificial Classifications

- Advantage: groups are homogenous for characters used in the classification, can place an unknown plant by looking at a few pre-determined characters. (easy to use, stable).
- Disadvantage: groups have little or no predictivity for other characters (i.e. those not used to construct classification)

“Polyandria Monogynia” includes cacti and cherries



“Natural” Classification

- Advantage: predictive

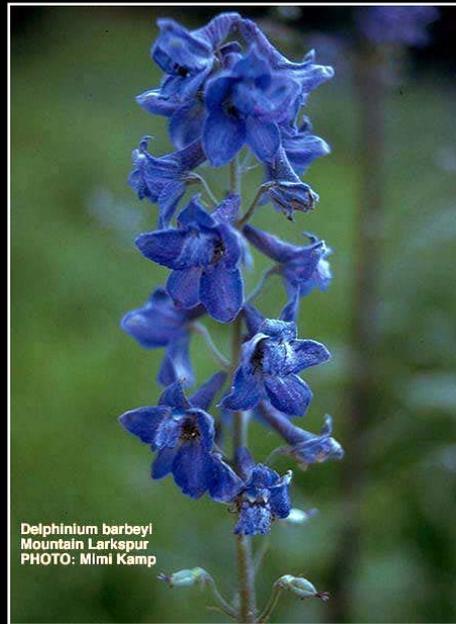
Groups are constructed based on correlations among many characters.

- Disadvantage: harder to use for identification.

No single character is necessary nor sufficient to determine group membership.

“usually”, “generally”, “for the most part”

Ranunculaceae



Delphinium barbeyi
Mountain Larkspur
PHOTO: Mimi Kamp



***Genera Plantarum* (1789)**
first widely adopted “natural”
family classification

Basis for the plant families
that we recognize today



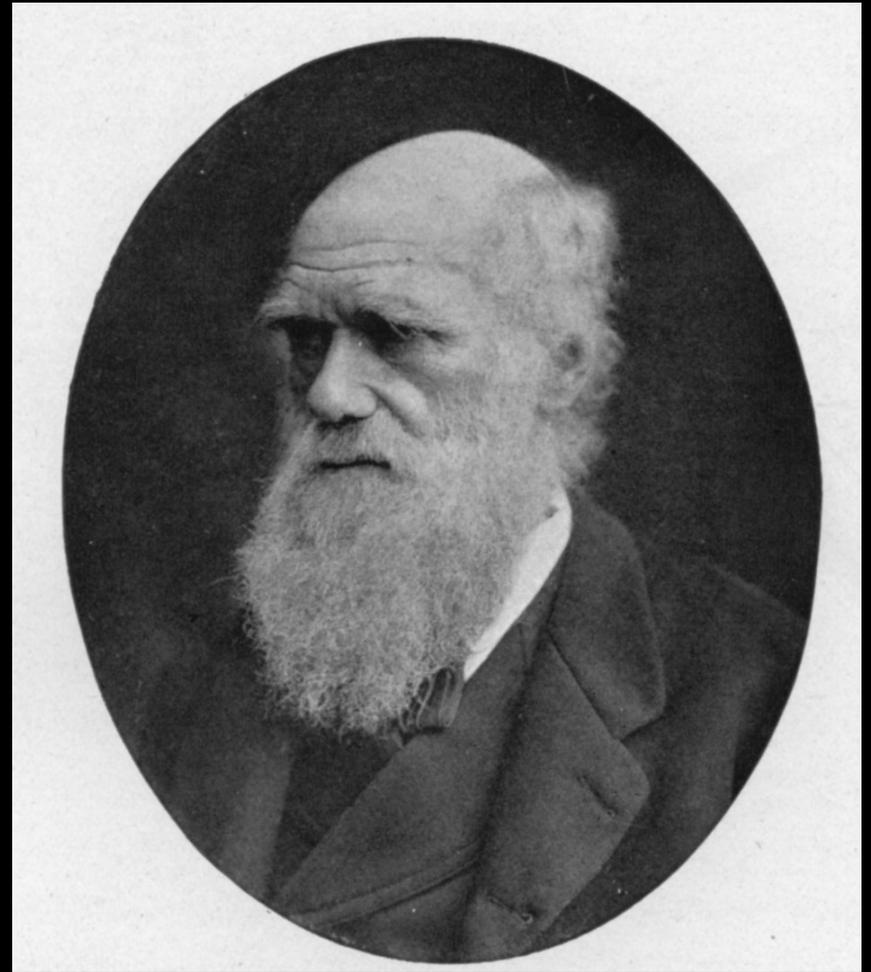
Antoine Laurent de Jussieu
French, 1748-1836

On the Origin of Species
(1859)

Redefined the meaning of
“natural” in classification

Post-Darwin a natural
classification is an
evolutionary classification.

However, ambiguity
remained about how
evolutionary relationship
should be depicted in a
hierarchic classification.



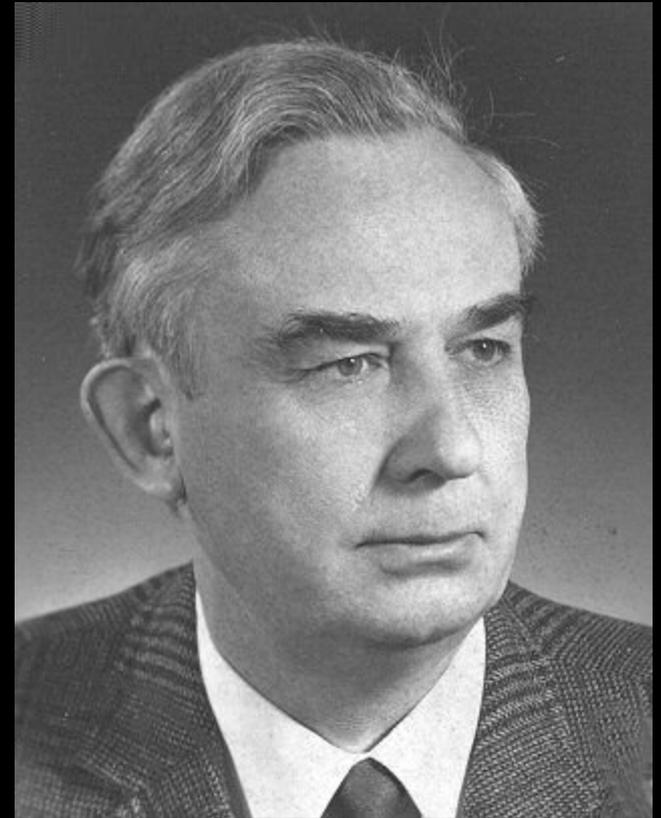
Charles Darwin, English
1809-1882

Monophyletic Classification

Phylogenetic Systematics
(1950, 1966)

Only **monophyletic** groups should be recognized in a classification.

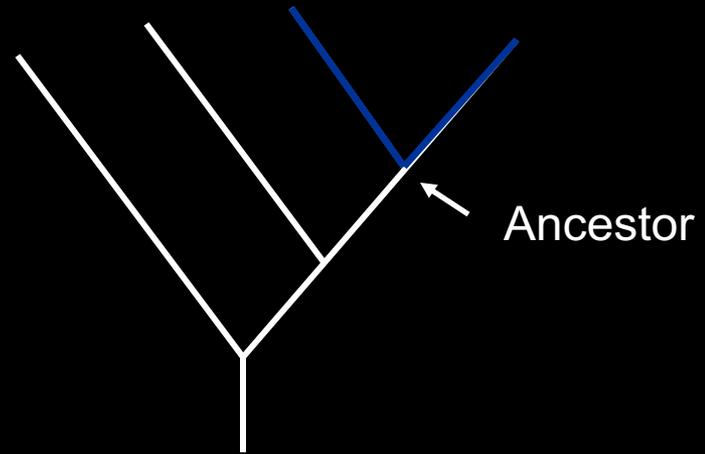
Only a strictly **monophyletic** classification can accurately depict evolutionary relationships.



Willi Hennig, 1913-1976
German

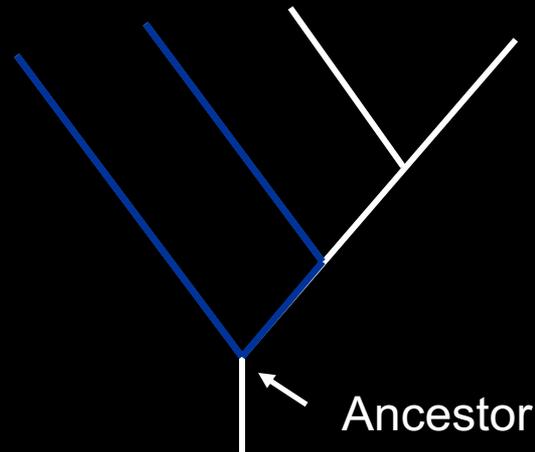
Monophyly

- A monophyletic group includes all the descendants of a particular ancestor.
- All members of the group are more closely related to each other than to any species outside the group.



Non-Monophyly

- A non-monophyletic group excludes some of the descendants of a particular ancestor.
- Some members of the group are more closely related to species outside the group.



Monophyletic Classification

- If only monophyletic groups are named, the classification accurately depicts our understanding of evolutionary relationships.

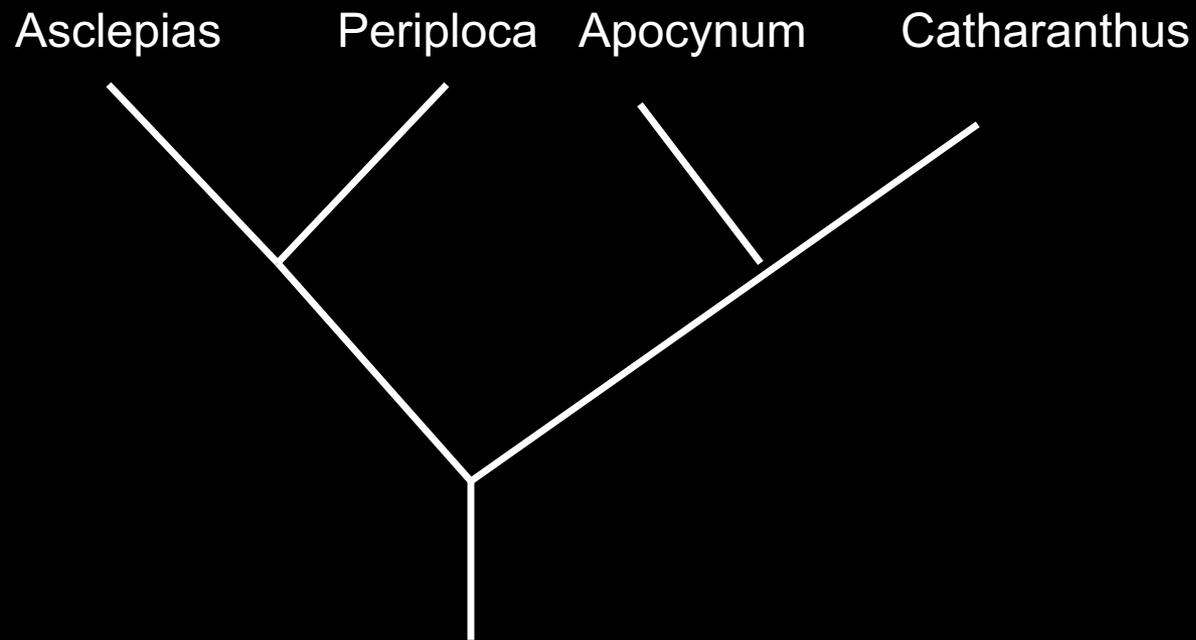
Example

Asclepiadaceae: *Asclepias*, *Periploca*

Apocynaceae: *Apocynum*, *Catharanthus*

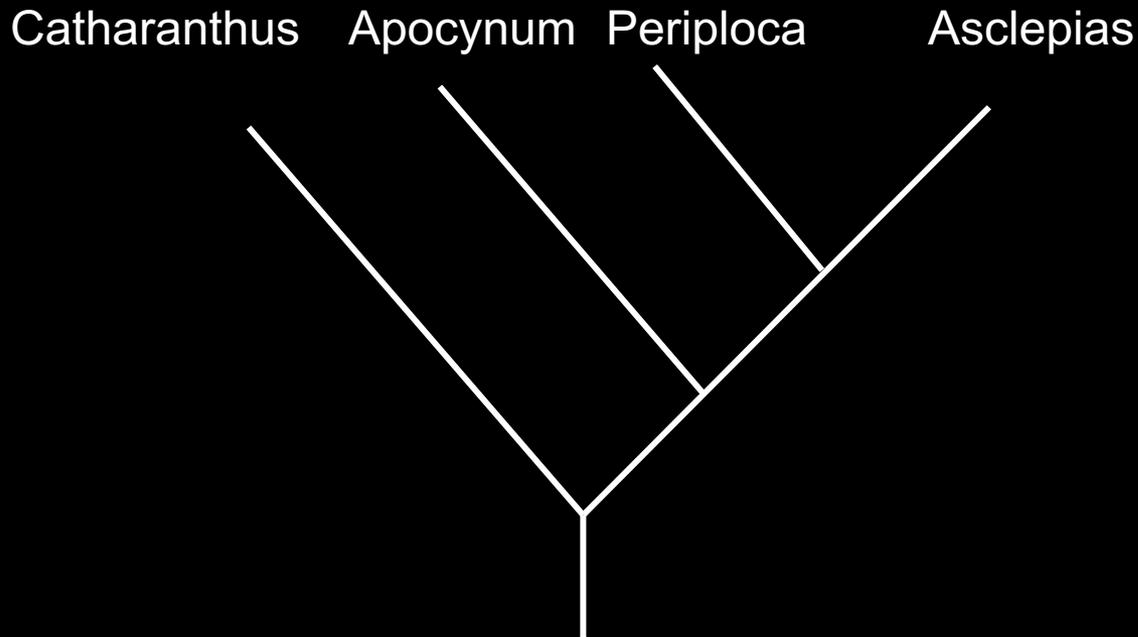
Monophyletic Classification

If Asclepiadaceae and Apocynaceae are monophyletic, the classification accurately communicates the evolutionary tree of the included genera.



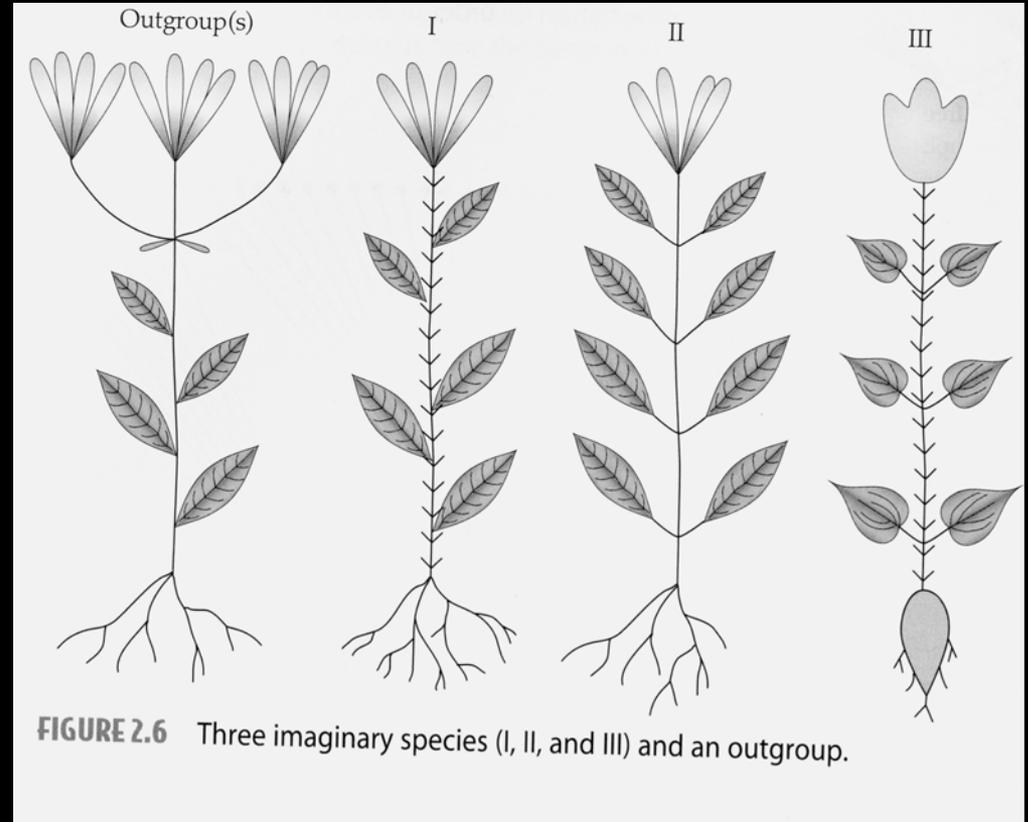
Monophyletic Classification

If Asclepiadaceae and Apocynaceae are not monophyletic, we can't predict the evolutionary tree from the classification.

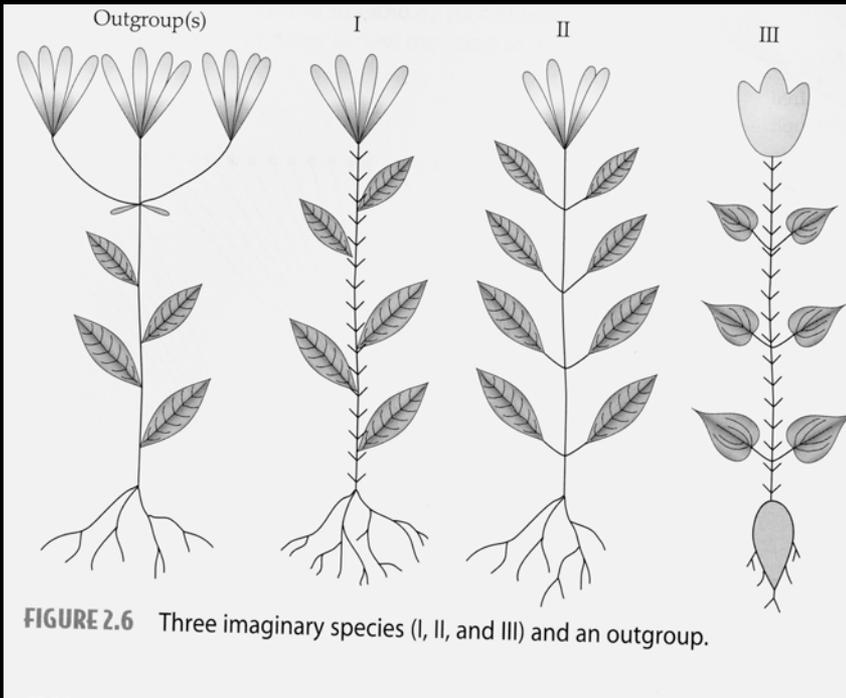


How do we discover monophyletic groups?

- Evolutionary relationships can't be observed, they have to be inferred.
- Phylogenetics

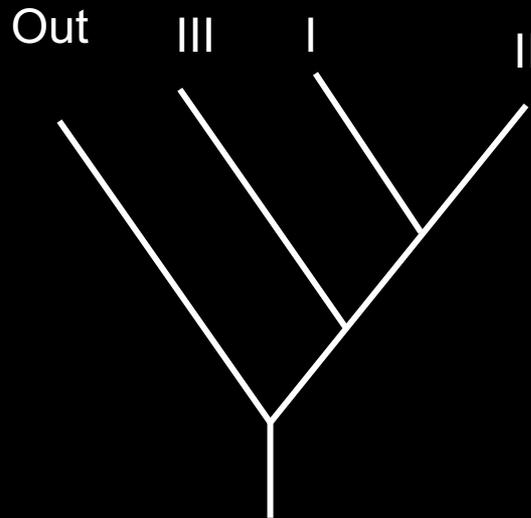
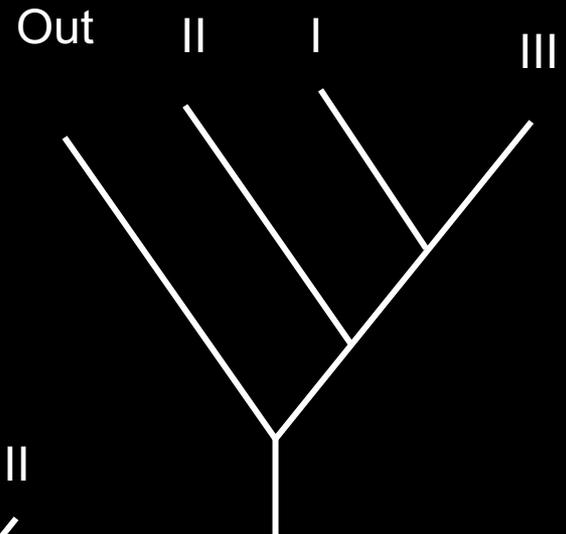
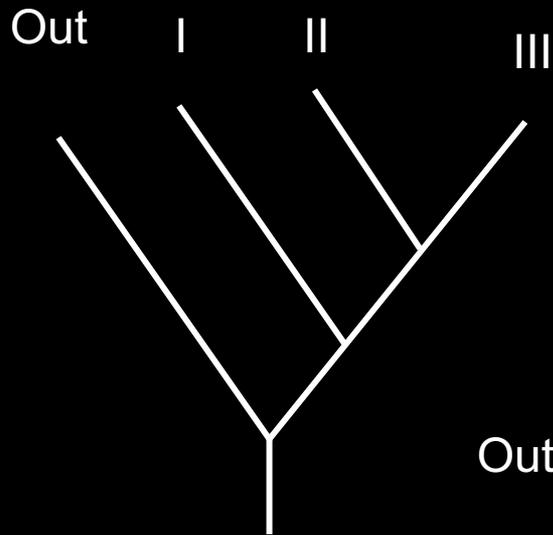


Compare species to define characters and character states



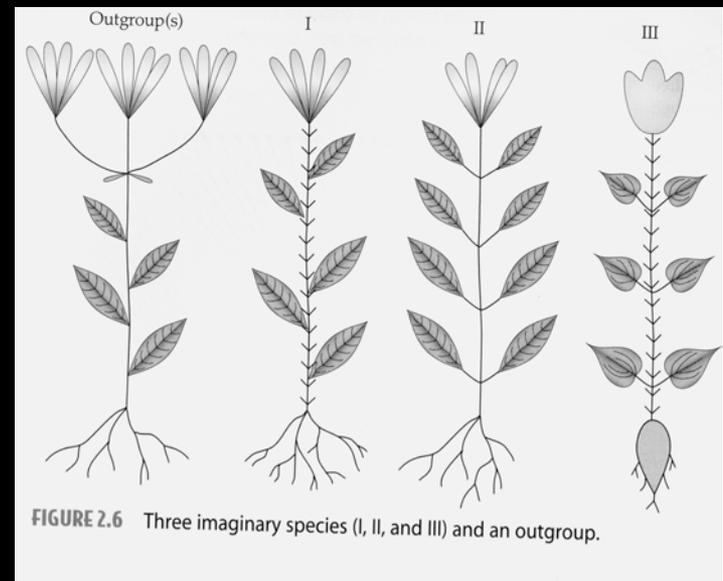
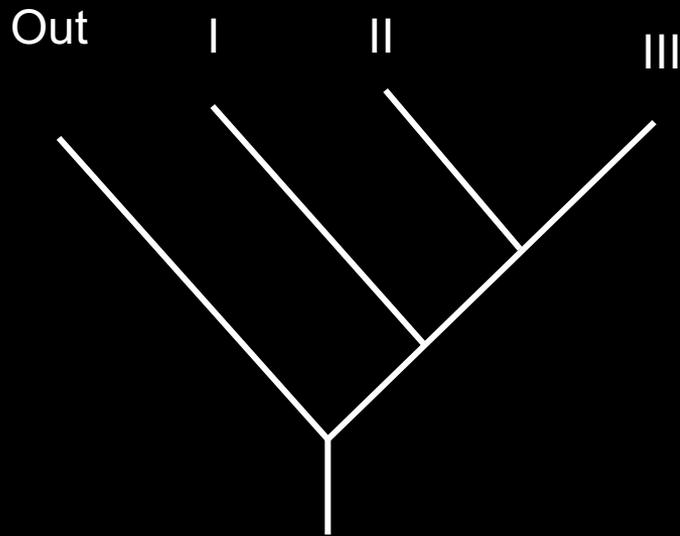
Morphological character	Character state	
	outgroup state (0)	Derived state (1)
1 roots	Fibrous	tap
2 stems	Smooth	prickly
3. leaves	Alternate	opposite
4 petiole	Absent	present
5 leaf shape	Elliptic	Cordate
6 leaf venation	Pinnate	palmate
7 inflorescence	Umbel	Solitary flower
8 petals	Separate	connate
9 petal number	4	3

Construct all possible evolutionary trees and designate an outgroup to root the tree.



Select the tree that best explains the observed similarities between species as caused by common ancestry, i.e. requires the fewest evolutionary changes (steps).

This is your best estimate of the evolutionary tree.



What happened to Asclepiadaceae?

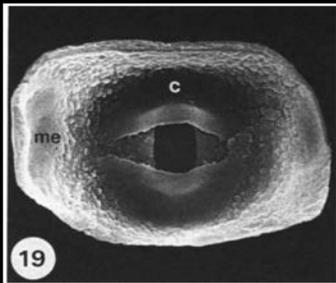
- 1789 A.L. de Jussieu described Apocineae (Apocynaceae)
- 1809 Robert Brown divided Jussieu's Apocynaceae into 2 families:
Apocynaceae in the strict sense and Asclepiadaceae.

Apocynaceae s.s.

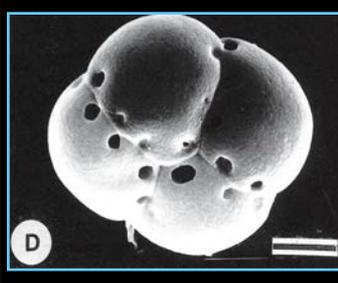
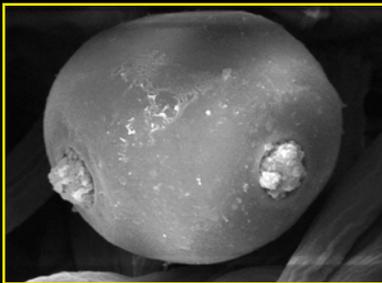
Asclepiadaceae

Solitary pollen grains

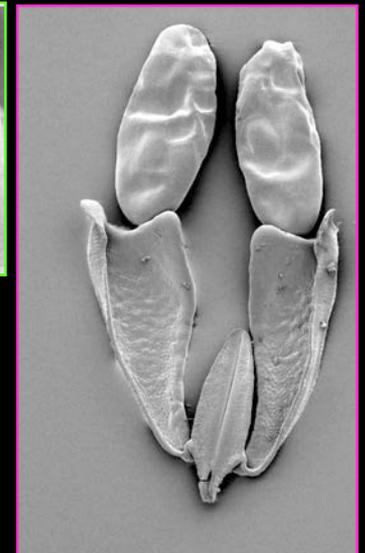
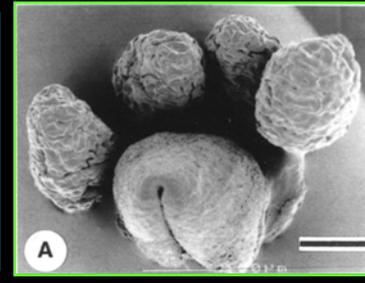
Pollen grains aggregated



from Nilsson (1986)



from Verhoeven & Venter (2001)





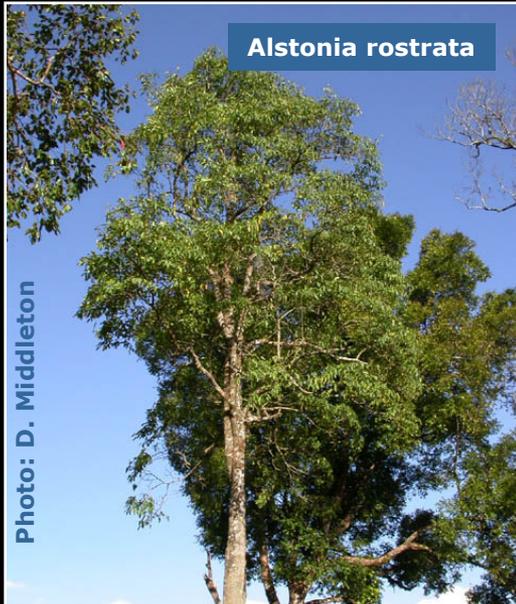
Apocynaceae
in the strict sense



Asclepiadaceae

Diversity of Apocynaceae s.s.

ca. 1800 species



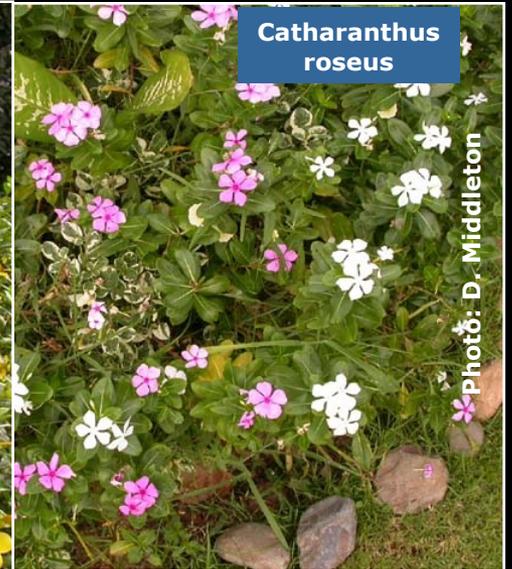
Alstonia rostrata

Photo: D. Middleton



Allamanda cathartica

Photo: D. Middleton



Catharanthus roseus

Photo: D. Middleton



Adenium obesum

Photo: D. Middleton



Beaumontia murtonii

Photo: D. Middleton



Mandevilla hybrid

Diversity of Asclepiadaceae

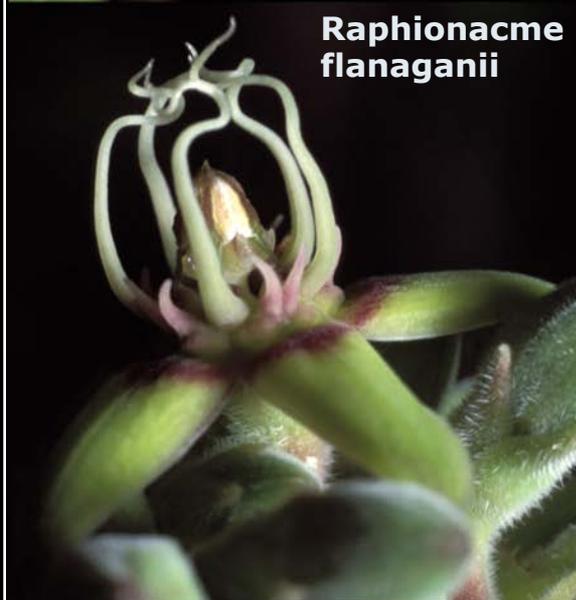
ca. 2500 species



**Asclepias
nivea**



**Gonolobus
stephanotrichus**

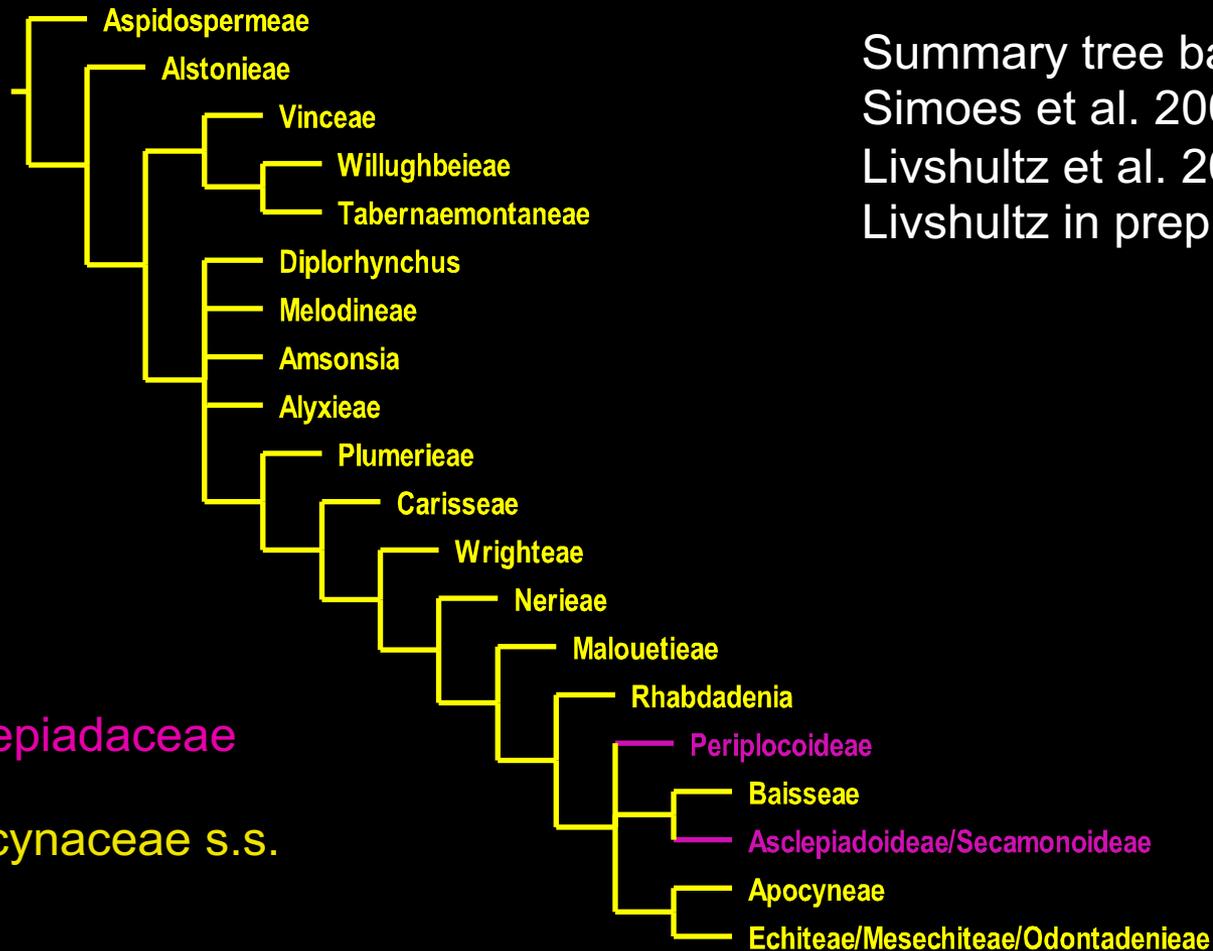


**Raphionacme
flanaganii**



**Hoya
multiflora**

Evolutionary tree of Apocynaceae in the broad sense



Asclepiadaceae

Apocynaceae s.s.

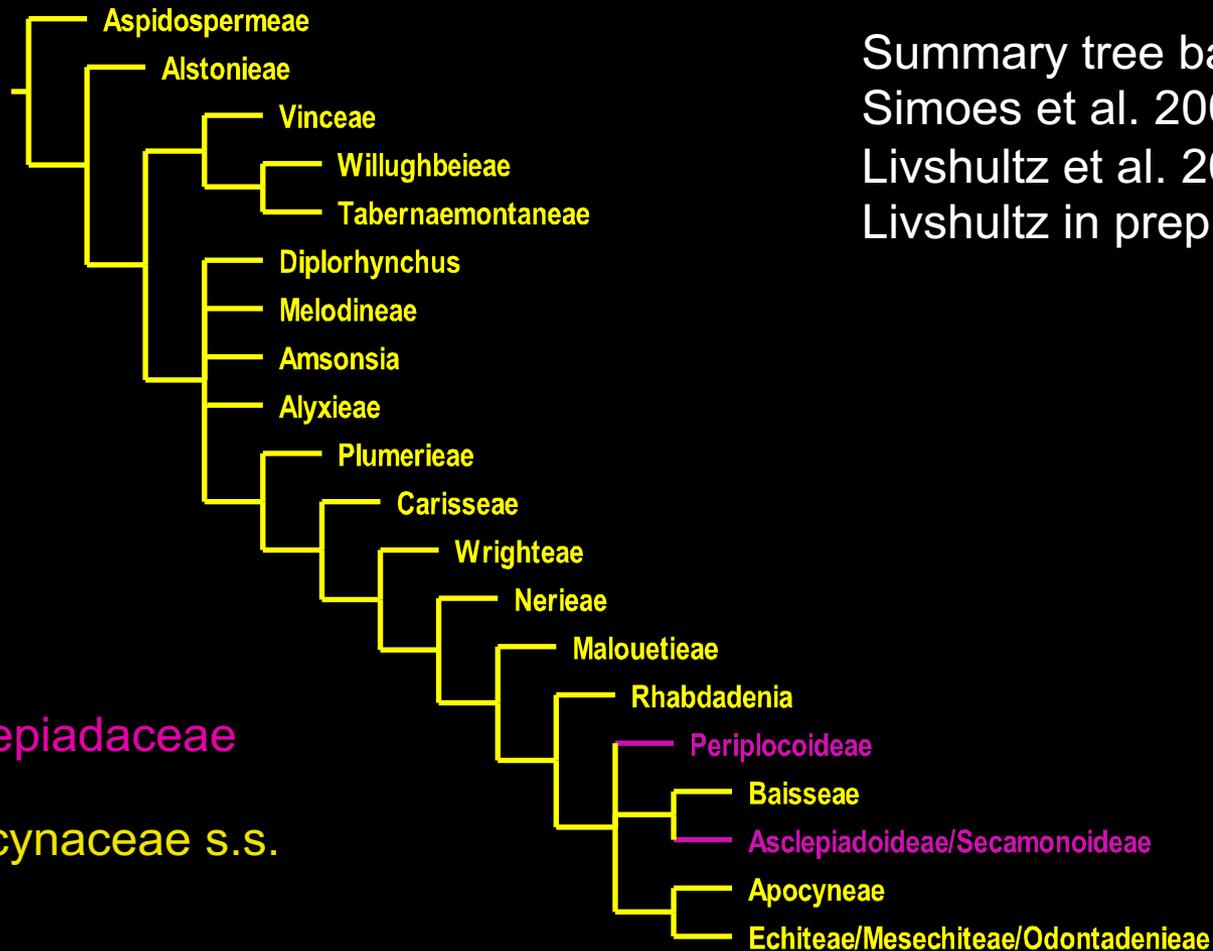
Many possible ways to turn a tree into a monophyletic classification.

- 1) Easy to use
- 2) Stable
- 3) An aid to memory
- 4) Predictive
- 5) Concise



Andreas Caesalpinus, Italian
1519-1603

Evolutionary tree of Apocynaceae in the broad sense



Summary tree based on
Simoes et al. 2007
Livshultz et al. 2007
Livshultz in prep

 Asclepiadaceae
 Apocynaceae s.s.

What happened to Asclepiadaceae?

- Phylogenetic analysis showed that neither Asclepiadaceae nor Apocynaceae are monophyletic.
- First classification principle: families should be monophyletic
- Other classification principles: families should be predictive, easily recognized, not too numerous.

Asclepiadaceae has been synonymized with
Apocynaceae.



Apocynaceae in the broad sense

