CLASSIFICATION: Circumscription, positioning, and ranking of taxa, and the hierarchical system resulting from those activities.
Classification is one of the principal goal of systematics and the main mechanism of communicating the evolutionary units of diversity to science and society; today, based on phylogenetic principles.

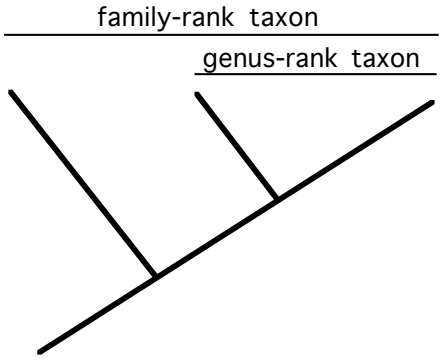
Classifications are hypotheses of relationship and botanists are free to propose their own classifications as long as they obey the rules of naming groups, as laid out by the *International Code of Botanical Nomenclature* (revised every 6 years).

A. **Circumscription (delimitation)**: Literally, "encircling," or grouping -- to determine the membership of taxa. In modern systematics, monophyly is a fundamental criterion for grouping. Not all monophyletic groups are necessarily recognized as taxa; recognition of monophyletic groups often limited to those that are well-supported, biologically or economically important, or traditionally recognized (stability of classification consideration).

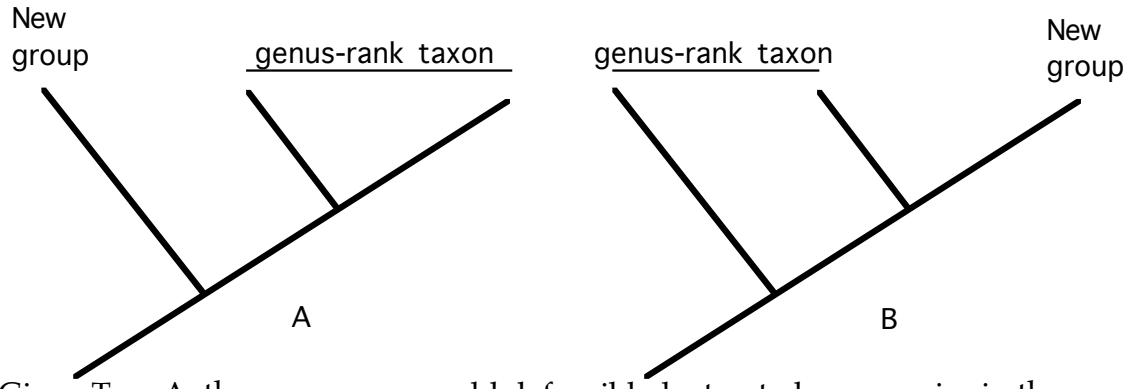
B. **Ranking** of taxa: decision of which category or rank to assign to the group. Must use established ranks of hierarchical system, developed over last 250 years (seven primary categories):

Categories	Taxa (taxon; example sunflower)	
Kingdom	Viridiplantae	High level
Division (Phylum)	Embryophyta	
Class	Angiospermopsida	
Order	Asterales	
Family	Asteraceae	
Genus (plural, genera)	Helianthus	
Species	Helianthus annuus	Low level

Criteria for ranking
1. Rank of taxon should be lower than rank of group in which the taxon is nested phylogenetically (taxon cannot be assigned to more than 1 taxon at same rank)



2. Rank of taxon should be consistent with the rank of sister-group (but non-equivalence widespread -- e.g., genera often sister to subset of species of paraphyletic genera)



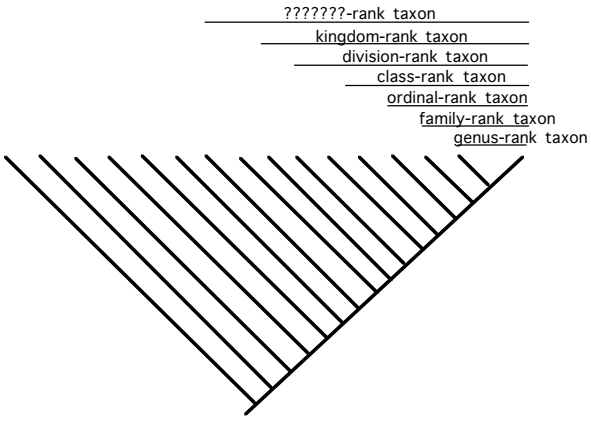
Given Tree A, the new group could defensibly be treated as a species in the same genus as the other two lineages or as the sole representative of a new genus. Given Tree B, the new group should be treated in the genus of the other two lineages (unless more taxonomic instability is to be introduced).

In infraspecific plant taxa, the rank needs to be stated in the name because (unlike in zoology) two infraspecific ranks exist: subspecies and variety (not just subspecies).
e.g., Planta alba subsp. alba

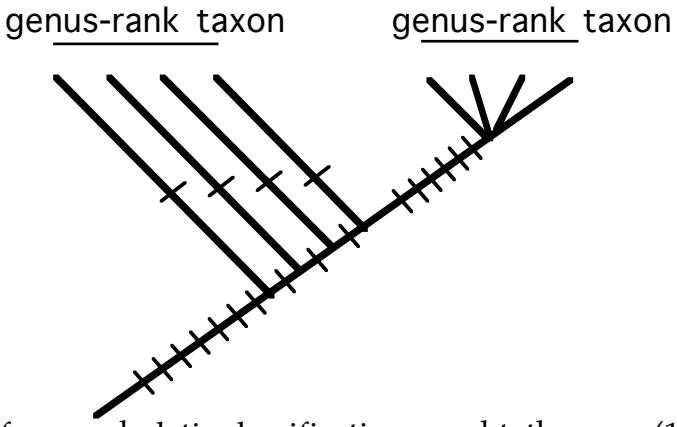
Position of taxa: Under which more inclusive group does the plant belong? Hopefully clear from phylogeny. Needs to be explicitly dealt with in names of infrageneric taxa (= taxa at ranks lower than genus) only. For example, the species name Helianthus annuus indicates that the position of the species is within the genus Helianthus; the genus name Helianthus, however, does not indicate which family Helianthus belongs to.

Application of names to plant groups is dictated by the International Code of Botanical Nomenclature (ICBN).

Problems with classification system
1. Not enough ranks for all possible clades (but code allows for creation of new ranks), e.g., phalanx in Astragalus, a genus of > 2000 spp.

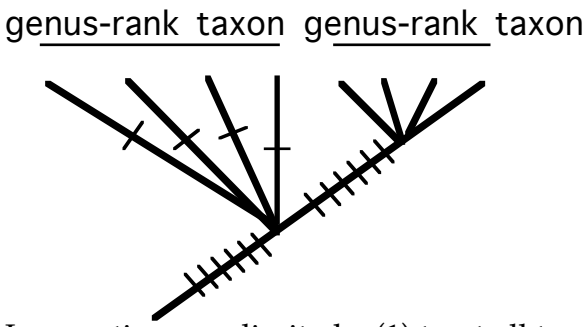


2. Non-equivalency of ranks essentially unavoidable -- problem for floristic/diversity studies of all kinds. Comparisons between sister-group taxa of same rank biologically tenable (especially if *crown groups of sister lineages are of equivalent age); comparisons across more distantly related groups of same rank nonsensical (e.g., nothing biologically in common between all taxa at rank of genus). For such comparisons to be meaningful, ranks would need to be standardized to a time scale.
[*Crown group=The most recent common ancestor (MRCA) of all extant members of a clade and all of that MRCA's descendants]
3. Mandatory categories:
- All species must be assigned to a genus (genus name is part of species name) and most taxonomists frown on non-assignment of taxa to all of the primary seven ranks.
- Consequences:
a) Can't recognize some distinctive lineages at genus rank without creating paraphyletic group that can be difficult to dissect into component monophyletic genera (barely diagnosable groups).



If monophyletic classification sought, then can (1) treat all taxa within one genus (losing generic recognition for the smaller well-supported monophyletic group) or (2) recognize 5 genera (4 with only one species each and barely discernable from one another, in addition to retaining generic recognition for the small well-supported monophyletic group)

b) Recognition of distinctive lineages especially problematical if lack of resolution of relationships in other parts of the overall group.



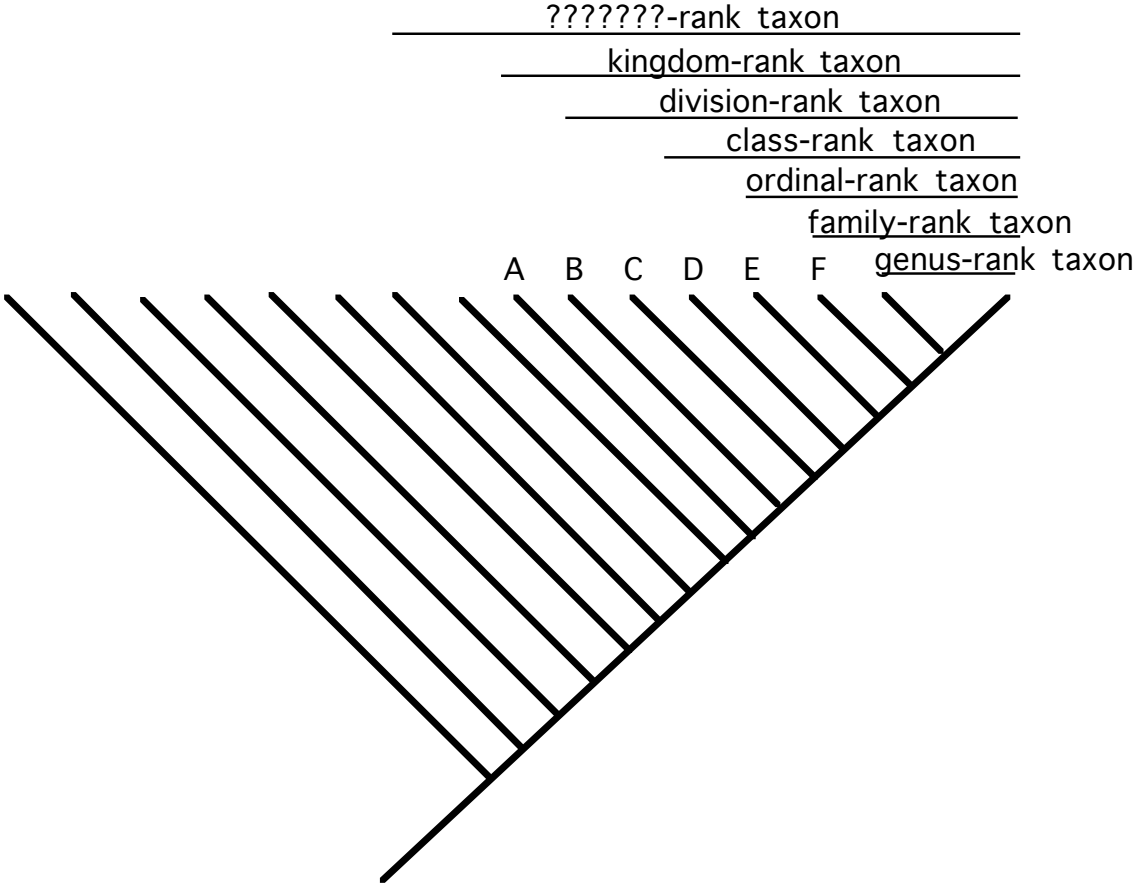
Here, options are limited – (1) treat all taxa within one genus or (2) continue to recognize the small well-supported monophyletic group name genera for each of

4 one-species lineages of uncertain relationship. Most systematists would be very uncomfortable with option 2.

c) Arbitrary changes in rank are commonplace, especially changes between variety and subspecies, with no change in circumscription or position. Instability introduced with no increase in information from the change.

Planta alba subsp. *alba* changed to *Planta alba* var. *alba*

d) Redundancy of taxa inevitable, e.g., creation of monotypic (= only one component taxon included) higher-level groups that represent taxa of identical circumscription at different ranks.



In above tree, Species A needs a name at genus-rank, family rank, ordinal rank, class rank, and division (phylum) rank. Each of those taxa has the same exact circumscription. *Ginkgo biloba* is a real vascular-plant example of such a situation.

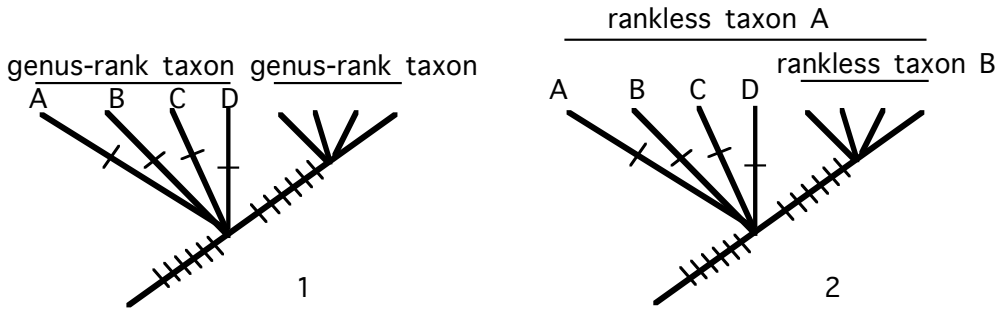
Recently proposed solution: Rank-free taxonomy (Phylocode is most widely accepted alternative to ICBN, but still not sanctioned by plant systematists in general)

Benefits

Improved ability to name new clades as they are discovered without as many impacts on classification of related groups (ranks inextricably tie taxa together in unfortunate ways; cascade effects, as described above). Proponents of rank-free taxonomy claim that such a system has the advantages of:

a. Promoting naming of new groups: Less effort required to name new groups because no need to re-name taxa outside the group of interest (whose names must be changed to accomodate ranking issues, see above)

b. Increase nomenclatural stability: No need to rename groups simply to accomodate rank issues, taxonomic names would not need to change as often, to the benefit of science and society, which depend to some extent on stability of names. Lack of stability of names means breakdown in ability to communicate units of diversity.



Scenario 1: Rank-based taxonomy (traditional system) requires difficult solutions discussed above.

Scenario 2: Rank-free taxonomy solution results in naming all well-supported groups without needing to name any other groups, apart from each minimal taxon (terminating each terminal branch).

Problems?:

Rank-free and rank-based taxonomy are both likely to persist for a long time, so could have inhibiting effect on systematists proposing new classifications when they have to choose between the two camps or else treat taxa in both systems.

Detractors of rank-free taxonomy point out that need to reference a tree for positional information, e.g., currently if we know that a lower-level taxon belongs to a higher-level taxon of a particular rank, then we know that the lower-level taxon in question does not belong to any other higher-level taxon of the same rank – organisms can only belong to one taxon at a particular rank.