Classification, Evolution and Cladograms

I. Classification and Evolution

A. Why do we classify? a. because it is handy to have names for objects and groups of similar objects — we do the same with inanimate objects. b. we do it to help us learn more biology — if organisms are similar in some ways, they may be similar or different in other ways, and the study of those similarities and differences gives us more biological knowledge.

B. How do we classify? by similarity or by evolutionary relationships, and if by evolutionary relationships, how do we define the latter?

C. Phenetic classification — put the numbers in a computer, and it will come up with a number you can use as a difference measure. The more characters, the better the work, say pheneticists. Can use mean character difference or other methods. Phenetics is NOT EVOLUTIONARY, though in many, even most, cases gives the same results as evolutionary groupings. Why? because characters are the product of evolution.

D. Cladistic classification (also called phylogenetic): concerned with only the branching points. Classification is based on shared derived characters (synapomorphies). similar characters are divided into analogous and homologous characters, analogous are not used. Homology is shared character that was also present in the common ancestor (embryology and fossil record used to help decide). Shared homologies can be either ancestral (found in a group and some, but not all, of its descendants) or derived (found in a group and its common ancestor, but no further back in time). Only shared derived homologies have phylogenetic meaning, that is, can be used to group species.

Monophyletic groups, paraphyletic and polyphyletic groups. Monophyletic groups have a common ancestor unique to itself. Polyphyletic groups are the result of convergent evolution; paraphyletic groups contain some, but not all, of the descendants of a common ancestor. In cladistics, the category "lobe-finned fish" includes humans, the category "ray-finned fish" does not. The category "fish" cannot include perch and coelacanths but not cows, because cows and coelacanths share a more recent common ancestor than do coelacanths and ray-finned fish.

E. Evolutionary classification: A synthesis of phenetics and cladistics. This is the familiar classification scheme, where we have the traditional Linnean groupings, but the groupings represent evolutionary relationships as nearly as possible.

F. All classifications end up being hierarchic, because the history of life is branching (i.e., divergent). This divergence probably comes about due to competition being most intense in the most similar species, and hence we get character displacement.

II. Cladistic Definitions

A. Cladogram: a representation of the branching phylogeny of a group of organisms

B. Cladistic species is the set or organisms between two branching points; it has nothing to do with morphology or ability to interbreed.

C. Character: a morphological, behavioral or other kind of trait

D. Homology: character shared by a set of species due to its presence in a common ancestor (example: the 2 eyes of a bat and the 2 eyes of a bird; their reptilian common ancestor also had two eyes)

E. Analogy: character shared by a set of species but not present in their common ancestor (example: wings of a bat and winds of a bird; their reptilian common ancestor did not have wings)

F. Plesiomorphy: a character in its ancestral state

G. Apomorphy: a character is its derived state

H. Symplesiomorphy: shared ancestral trait

I. Synapomorphy: shared derived trait

J. Character state: one of the alternate forms of a character ("red" and "blue" might be the character states of the character "color")

III. Cladogram Construction

A. pick your group of organisms

B. pick an outgroup

C. define characters and character states for your organisms — try for binary (two-state) characters rather than multi-state characters

D. use your outgroup to polarize the character states (determine which state is plesiomorphic and which is apomorphic — the plesiomorphic state is the one shared by the outgroup)

E. Separate your group of organisms into two groups by choosing a character for which all but one of the organisms is apomorphic. Construct a two-branch cladogram.

F. Sequentially add characters by adding the character for which all but two of your organisms are apomorphic, then the character for which all but three of your organisms are apomorphic, etc.

G. Hint #1: the most basal organisms in your cladogram will have the most plesiomorphic character-states; the most removed organism in your cladogram will have the most characters in the apomorphic state.

H. Hint #2: If you have a simple cladogram exercise, in which every character yields a branch point, you can simple construct the cladogram by looking at the number of apomorphic characters in each organism — the organism with the fewest is the most basal (nearest to the outgroup), the organism with the most apomorphic characters is the most removed from the outgroup.

IV. Try to construct cladograms on your own. Each of the next two pages contain data to practice cladogram construction.

For a group of cactus plants, the characters are:

seed black, seed yellow
seed flat-ovoid, seed reniform
stem not jointed, stem clearly jointed
stem with prominent tubercules, stem without prominent tubercules
central spine hooked, central spine straight
fruit long-persistent, fruit not long-persistent
fruit soft, fruit firm
anthers green, anthers yellow
stem flattened, stem round

The species of Opuntia (O.) are to be arranged in a cladogram; *C. gigantea* is the outgroup.

Species	Seed Color	Seed Shape	Stem Joints	Stem Tubercules	Central Spine	Fruit Persistence	Fruit texture	Anther Color	Stem shape
O. bigelovii	black	reniform	no	yes	hooked	short	soft	green	round
O. ramossissima	black	flat	no	yes	straight	short	firm	yellow	round
O. littoralis	black	reniform	no	yes	straight	short	firm	yellow	round
O. fragilis	yellow	reniform	no	yes	hooked	short	soft	green	round
O. tetrancista	black	reniform	no	yes	straight	short	soft	yellow	round
O. basilaris	yellow	reniform	yes	yes	hooked	short	soft	green	flat
O. acanthocarpa	yellow	reniform	yes	yes	hooked	short	soft	green	round
C. gigantea	black	flat	no	no	straight	long	firm	yellow	round

Construct a fully resolved cladogram for the 7 members of the *Asclepias* genus shown below, using *Sarcostemma vitusii* as the outgroup. Between each branch of your cladogram, write in the new trait (such as milky sap, short leaf or whatever) that evolved.

Species	Milky Sap?	Leaf Width?	Leaf Length?	Plant Form?	Fruit Bracts?	Stigma lobes?	Hood Points?
Asclepias albicans	yes	broad	short	erect	yes	2	2
Asclepias californica	no	narrow	long	erect	no	3	1
Asclepias erosa	yes	broad	long	erect	yes	2	1
Asclepias fruiticosa	no	broad	long	erect	yes	2	1
Asclepias lactifolia	no	broad	long	erect	yes	3	1
Asclepias physocarpa	no	broad	long	erect	no	3	1
Asclepias tuberosa	yes	broad	short	erect	yes	2	1
Sarcostemma vitusii	no	narrow	long	vine	no	3	1