Name_____

Section_____

Cladistics (reading and making of cladograms)

Systematics – The branch of biological sciences concerned with classifying organisms

Taxon (pl: **taxa**) – Any unit of biological diversity (eg. Animalia, Reptilia, *Gorilla gorilla*) **Taxonomy** – The practice of naming organisms

Phylogenetic systematics – Classification of organisms based on their evolutionary relationships.

The most famous systematist/taxonomist was Carolus Linnaeus, a Swedish biologist, who introduced a system of classification that has been in use since 1758. This system has 7 major ranked categories (and more ranked categories have been added since). These categories are called **taxa** (singular is **taxon**). The broadest, most inclusive rank is kingdom (though many workers now add an eight level [Domain] above Kingdom) and the narrowest, most exclusive ranking is species. Similar taxa at one rank are grouped together to form the next highest rank. For example, similar species will be grouped together to form a genus and several similar genera are grouped together to form a family and so on.

The Seven Major Ranked Categories of the Linnaean System of Classification

Kingdom

Phylum

Class

Order

Family

Genus

Species

(populations)

This system is strongly entrenched in our educational system (it is probably the system you are most familiar with from high school). However, this system is not used by most workers in the field of systematics today. You are responsible for knowing how to properly write names in the Linnaean system. All the proper

names of taxa are capitalized (eg. Chordata or Mammalia), with the one exception of the species epithet (the second part of a species name). Species names are always given using a binomial name (e.g., *Canis familiaris*, *Tyrannosaurus rex*, *Homo sapiens*). Species and genus names are always italicized or underlined when written. If you are handwriting things in lab then you should underline species names, for typed manuscripts or PowerPoint presentations use italics.

Phylogenetic Systematics or Cladistics

Unlike the Linnaean system, phylogenetic systematics makes a special effort to classify organisms based on evolutionary relationships. In theory, phylogenetic systematics, or cladistics, uses non-subjective, natural criteria for classifying organisms. This ensures that organisms are classified based upon their evolutionary relationships, and not upon arbitrary assignments into ranks. Cladistics recognizes species but does not use the terms genus, family, order, class, phylum or kingdom.

Thus, cladistics has no ranks, but it does have a hierarchy. The hierarchy of this phylogenetic system arises from the fact that some organisms share a more recent common ancestor with each other than they do with other organisms. A taxon that includes an ancestor and all of its descendants is called a ***clade****.*

Definitions for Cladistics.:

Like much of science, cladistics is filled with jargon. You're just going to have to learn some of it. On the plus side, once you know the jargon, scientific papers are written with a goal of being as clear as possible, whereas in other disciplines, workers seem to relish writing prose that is purposefully dense and impenetrable.

Monophyletic Group – A group made up of an ancestor and all of its descendants (same as a **clade**). **Terminal Taxa** – groups at the tips of the branches on a cladogram. A terminal taxon could contain one

species or a clade with millions of species in it.

Cladogram – a diagram that depicts the relative levels of relatedness relationships among groups.

Node – The intersection of two or more branches on a cladogram. The node represents an evolutionary split between lineages as well as a hypothetical common ancestors of all taxa higher on the cladogram.

Evolution – descent with modification.

Character – A heritable attribute of an organism. They are used to reconstruct the phylogeny

(evolutionary history of organisms).

Primitive (Basal) Character (also known as a Plesiomorphy) – An ancestral or primitive character. This is a character that was inherited from a distant or ancient ancestor. These primitive characters can by shared among organisms (sympleseiomorphy), but these shared characters do illuminate relationships among organisms in the taxon.

Novel, New or Derived Character (also known as an Apomorphy) – A derived (new) character. An evolutionary novelty that arises in a taxon, or in the most recent common ancestor of a clade. There are two types of derived characters

> **Shared Derived Character** (also known as a Synapomorphy) – a derived character shared by two or more taxa on the cladogram. It is the only kind of character used to arrange organisms into monophyletic groups.
>
> **Unique or Distinctive Character** (also known as an Autapomorphy) – a derived character that is found in only one taxon in the cladogram. It is not useful for reconstructing the evolutionary relationships among taxa.

Polytomy – A polytomy show unresolved relationships between taxa on a cladogram. Instead of a nice dichotomous (2-branched) split from a node, three or more branches all emanate from the same node. This generally means that there is not enough data to determine the relationships here and shows systematists where more work is needed.

Homology – features seen in two or more organisms are considered homologous if they share a common ancestry.

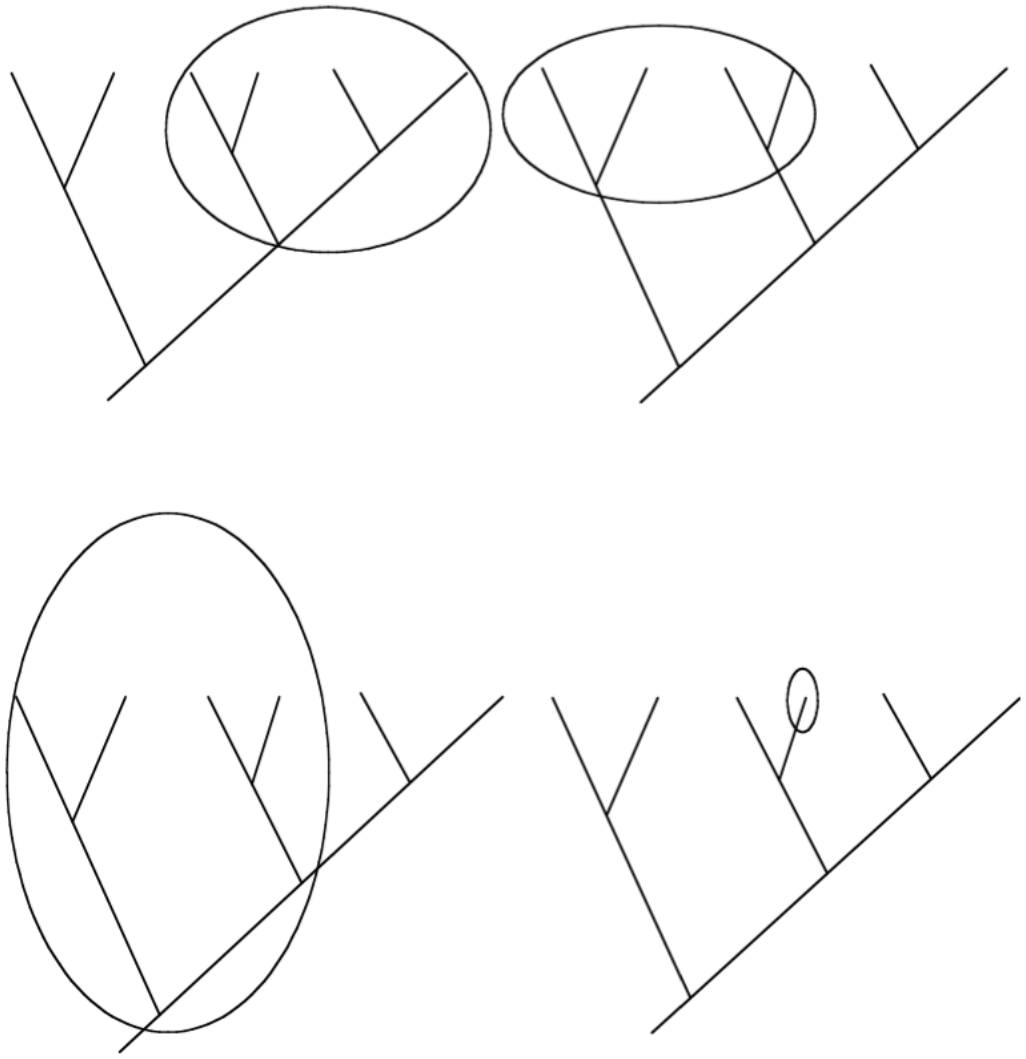
Analogy- This is similarity in form because of similar function, not because of similar ancestry.

Paraphyletic group – a group of taxa that includes an ancestor and some, but not all, of its descendants.

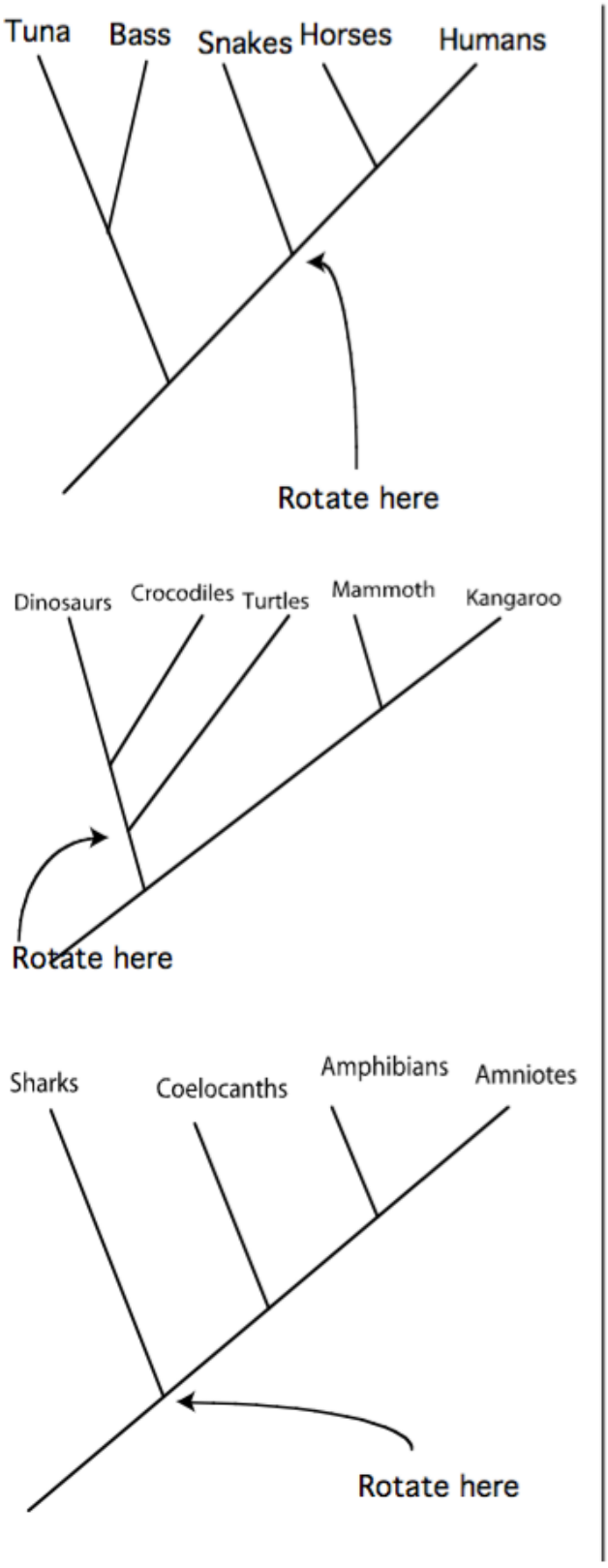
Polyphyletic group – A group of taxa that excludes a common ancestor.

Principle of Parsimony – The most parsimonious (shortest/simplest) hypothesis is most likely the correct one. When dealing with cladograms parsimony dictates that the one with the fewest number of character changes, or steps, is probably the correct one.

Decide if the group that is circled is monophyletic, paraphyletic, or polyphyletic

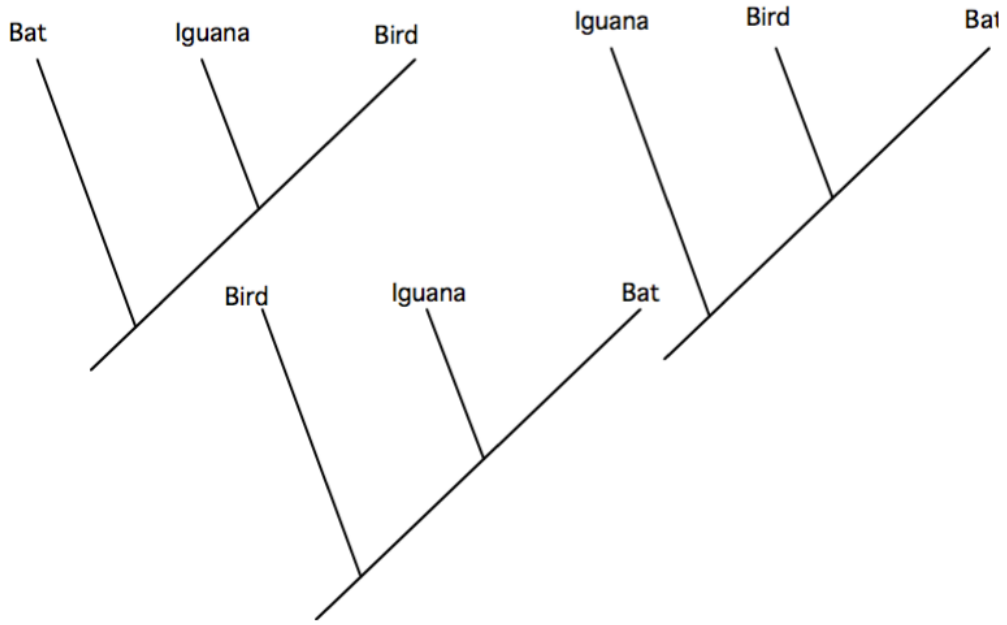


Rotate a node on each cladogram so that the diagram looks different, but retains the same relationships



Place the characters from the table on the cladograms.

Then determine which is the most parsiomonious



Character Number	Character	Bat	Bird	Iguama
1	Feathers			
2	Wings			
3	Egg laying			
4	Warm-blooded			
5	Active in day			
6	Lungs			
7	Green			
8	Hair			
9	Mammary glands			
10	Scales			
11	Teeth			
12	Hemipenes			
13	Cloaca			

Definition vs Diagnosis

Cladistics and Linnaean taxonomy differ in the way they define and diagnose taxa. In Linnaean taxonomy the diagnosis is the definition. The group Aves is diagnosed by several features, feathers, a toothless beak, a wish bone, a keeled sternum, and hollow bones to name a few. In Linnaean taxonomy this is also what defines a group. Ask a Linnaean taxonomist what a bird is and he'll (or she'll) say "A bird is an animal with feathers, a toothless beak, a wish bone, a keeled sternum, and hollow bones."

Problems arise in the fossil record when we find animals with some but not all of the characters that define a group. For example what if we find a fossil of an animal that has feathers and hollow bones but still has teeth? This presents a problem for Linnaean taxonomy. Do we redefine the definition of a bird? If it isn't a bird what is it? Maybe it goes in Reptilia? No, reptiles have scales not feathers. Should we redefine the definition of a reptile?

What if you asked a cladist the same question, what is a bird? The cladist would say a bird is a descendant of the most recent common ancestor of *Archaeopterix* and a modern penguin (or some other living bird). This way you never have to change the definitions of groups (even though people still argue over if the fossil they found is a bird or not). Taxon definitions are ancestor-based instead of character-based. People still diagnose the groups animals belong in by characters, but the group definitions are stable and will never change.

Question

You are in the University of California's Museum of Paleontology collections with your aunt. One of the paleontologist remarks that dinosaurs might have been "warm-blooded." Your aunt asks if that meant that they are not reptiles? The paleontologist assures your aunt that dinosaurs are indeed reptiles. You aunt is confused now because she thought that all reptiles were "cold-blooded." Who is thinking like a cladist and who is thinking like a Linnaean taxonomist? Who just had their idea of Reptilia redefined?