Biological Classification

• **Taxonomy**: naming & classifying organisms
• **Systematics**: studying relationships among taxonomic groups

### Taxonomy & Linnaean Hierarchy
- Levels called **taxa** (sing., **taxon**: "classification")
  - The more similar two organisms are, the more levels they have in common
  - **a) Kingdom**
  - **b) Phylum (Division)**
  - **c) Class**
  - **d) Order**
  - **e) Family**
  - **f) Genus**
  - **g) Species**

*not in the original Linnaean hierarchy

### IV. Phylogenetic Systems
- Classified based on **presumed** common ancestry
- Levels in common suggests a more recent divergence from a common ancestor.
- But since we don’t actually know the ancestry above the level of genus or maybe family, dependent upon degrees of similarity.
  - Comparative morphology & anatomy
  - Comparative embryology
  - Comparative biochemistry — proteins & DNA
- Much disagreement may be debated regarding which similarities and which differences are most phylogenetically significant!

### Problem: Divergence vs. Convergence
— Homology vs. Analogy

Similarity due to convergence is **analogy**.
(Similar adaptations to similar environments; not shared ancestry.)

### Cladistics
- **Clade** ("branch") — replace traditional taxon
  - Groups of organisms presumed to be derived from a common ancestor are organized by **bifurcating** (two-way splitting) of a branch
  - Each bifurcation is based upon the acquisition of a new, unique character (**apomorphy**).
- **Maximum parsimony**: the branch pattern that can be created with the fewest required steps is most likely the most correct.

### Cladistics
- **A true clade must be monophyletic**
  - must include an ancestor and all of the known descendants of that ancestor.
  - A grouping that only includes an ancestor and some of its descendants is **paraphyletic**.
  - A grouping that includes organisms from different ancestries is **polyphyletic**.
- **Derived apomorphic** characters shared by members of a clade are **synapomorphic**.
- **Ancestral** characteristics inherited prior to the branching of a clade are **plesiomorphic**.
Hair, Carnivorous teeth, Retractable claws, & Ability to purr are all apomorphic characters in the presumed ancestry of the domestic cat.

- Retractable claws is a synapomorphic character for the Family Felidae.
- Hair & Carnivorous teeth are plesiomorphic characters for the Family Felidae.

Assuming this cladogram is correct:
- Carnivorous teeth is a synapomorphic character for the Order Carnivora.
- Hair is a plesiomorphic character for the Order Carnivora.

Assuming this cladogram is correct:
- Hair is a synapomorphic character (synapomorphy) for the Class Mammalia.

Assuming this cladogram is correct:
- The presence of carnivorous teeth in cats and wolves is a homology.

Assuming this cladogram is correct:
- The presence of carnivorous teeth in cats and sharks is an analogy.
  - (in cladistics, also called a homoplasy).
Biological Classification

Cladogram vs. Taxa

Monophyletic clades

Paraphyletic grouping

Not a true clade!

Polyphyletic grouping

Not a true clade!
Not phylogenetic!

Building Cladograms

Major assumptions:
1. The group of organisms is monophyletic
2. The outgroup (used for comparison) is closely related to, but separate from your group
3. You can tell which character states are homologous or analogous.

Assemble a table of character states:

<table>
<thead>
<tr>
<th>Character State</th>
<th>Lamprey</th>
<th>Tuna</th>
<th>Lamprey</th>
<th>Turtle</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Amniotic (shelled) egg</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Four walking legs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hinged jaws</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vertebral column (backbone)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Each bifurcation of the branch is based upon the state (presence/absence) of an apomorphic character.
Biological Classification

Cladograms

Cladograms are made by hypothesizing the sequence of evolution of shared derived (apomorphic) characters.

Building Cladograms

1. Arrange your ingroup species in order of similarity to the outgroup.

2. Arrange apomorphic characters in order of appearance in species most similar to the outgroup.

Rule of Parsimony:

The simplest explanation is the most likely explanation.

But not always!