Taxonomy and Pylogenetics

Taxonomy - Biological Classification

• First invented in 1700’s by Carolus Linneaus for organizing plant and animal species.
• Based on overall anatomical similarity.
• Similarity due to the “blueprint” of Creation.

Through classification we discover the great plan of Creation.

Taxonomy

• Arranging organisms into a hierarchy of categories.

Kingdom   Animalia
Phylum     Chordata
Class      Mammalia
Order      Primates
Family     Hominidae
Genus     Homo
Species    sapiens

Note: species name has two parts (binomen). Only genus is capitalized, but both are italicized.
Taxonomy
• Arranging organisms into a hierarchy of categories.

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Animalia</th>
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<tbody>
<tr>
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<tr>
<td>Genus</td>
<td>Homo</td>
</tr>
<tr>
<td>species</td>
<td>erectus</td>
</tr>
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Evolution - The idea that species are related by descent.
• New species have arisen from existing species.
• Species appear with new adaptations through time.
• Similarities between species reflect their history of descent.
• Species look alike because they share a common ancestor.

Erasmus Darwin (1731-1802)  Jean Baptiste de Lamarck (1744-1829)

Organisms modify themselves to suit their immediate needs.
These modifications are passed on to the offspring.

The modern theory of evolution was first developed by Charles Robert Darwin (1809-1882).
• Darwin saw the similarities shared between species as evidence for having evolved from the same ancestor species.
• Darwin realized that all species could be traced back through time to an original, shared, ancestor.

“...from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved.”
Darwin himself pointed out that if all species are related to one another by evolutionary descent, then the only basis for classification that was meaningful was one based on evolutionary ancestry or **Phylogeny**.

In spite of their new evolutionary view of life, Darwin’s contemporaries continued to classify species the way Linneaus did - by grouping species into a hierarchy of categories based on their anatomical similarities.

**Linnaean or Phenetic Classification**

**Phenetic (Linnean) Classification**

- Compatible with evolution because closely related organisms tend to have similar traits.
- However, overall similarity can often hide evolutionary relatedness and criteria chosen are often arbitrary.

<table>
<thead>
<tr>
<th>Alligator</th>
<th>Sparrow</th>
<th>Tyran. rex</th>
<th>Lizard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animalia</td>
<td>Animalia</td>
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</tr>
<tr>
<td>Chordata</td>
<td>Chordata</td>
<td>Chordata</td>
<td>Chordata</td>
</tr>
<tr>
<td>Reptilia</td>
<td>Aves</td>
<td>Reptilia</td>
<td>Reptilia</td>
</tr>
<tr>
<td>Crocodylia</td>
<td>Passeriformes</td>
<td>Saurischia</td>
<td>Squamata</td>
</tr>
<tr>
<td>Crocodylidae</td>
<td>Fringillidae</td>
<td>Tyrannosauridae</td>
<td>Iguanidae</td>
</tr>
<tr>
<td>Alligator</td>
<td>Melospiza</td>
<td>Tyrannosaurus</td>
<td>Iguana</td>
</tr>
<tr>
<td>A. mississipp.</td>
<td>M. melody</td>
<td>T. rex</td>
<td>I. iguana</td>
</tr>
</tbody>
</table>
In the 1950’s a German entomologist named Willi Hennig began outlining a new approach to classifying organisms that was based strictly on evolutionary relatedness.

- Phylogenetic Classification (Cladistics)
  - Cladistics compares selected traits among a group of species to determine their pattern of evolutionary descent.
  - Was controversial at first.
  - Method is testable and falsifiable!
  - Now universally accepted and used.

Willi Hennig

Cladogram
- a classification
- a hypothesis of descent

Class Aves
- Sparrow

Class Reptilia
- Alligator
- T. rex
- Lizard

- common ancestor
- common ancestor
- common ancestor
- time

Cladistic Analysis
Character matrix for 3 reptiles and a bird

<table>
<thead>
<tr>
<th>Character</th>
<th>Alligator</th>
<th>Lizard</th>
<th>Sparrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three toed foot (1)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Antorbital fenestra (2)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Two holes in skull (3)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Evolution of 1, 2, 3
Loss of 1
Evolution of 1, 2, 3
T. rex
Alligator
Lizard
Sparrow
Three toed foot (1) + + +
Antorbital fenestra (2) + + +
Two holes in skull (3) + + + +

Total steps = 6

Evolution of 1, 2, 3
Loss of 1, 2
Evolution of 1, 2, 3
T. rex
Alligator
Lizard
Sparrow
Three toed foot (1) + + +
Antorbital fenestra (2) + + +
Two holes in skull (3) + + + +

Total steps = 6

Evolution of 1, 2, 3
Evolution of 1
Evolution of 2
Evolution of 3
Lizard (3)
T. rex (1, 2, 3)
Alligator (2, 3)
Sparrow (1, 2, 3)

Total steps = 4

Homoplasy
Independent evolution of the same character in two groups
Three toed foot (1) + + +
Antorbital fenestra (2) + + +
Two holes in skull (3) + + + +
Phylogenetic Classification ("cladistics")
- Only basis for grouping species (classification) is degree of evolutionary relatedness.
- Similarities are the clues that point to relatedness.
- Similar traits shared between species represent evolutionary events.
- Gaining or losing a trait counts as a step in evolution.
- Species are arranged on a "tree" showing their relative evolutionary relatedness.
- Many trees are possible, only one is correct.
- The tree that requires the least number of evolutionary steps is most probably the correct one.
- Simplest tree or cladogram is the most parsimonious.

Phenetic (Linnean) Classification
Class Reptilia is Paraphyletic
= it excludes some descendants

Cladistic Classification

Class Reptilia

Diapsida
Archosauria
Dinosauria

Lizard
Alligator
T. rex
Sparrow
Aves

Pterosaurs

3 toed foot
antorbital fenestra
two openings in rear of skull

Cladistic Classification
**Phenetic (Linnean) Classification**

- Phylum Chordata
- Subphylum Vertebrata
- Class Aves  
  *Melospiza melodia*

**Phylogenetic Classification**

- Diapsida
  - Archosauria
    - Ornithodira
      - Dinosauria
  - Ornithodira
    - Aves
      - *Melospiza melodia*  

Path of Evolutionary Descent