Avian Systematics

- Systematics deals with evolutionary relationships among organisms. Allied with classification (or taxonomy).
- All birds are classified within the single Class Aves
  - 2 Subclasses
  - 4 Infraclasses

Class Aves

- Subclass Sauriurae
  - Infraclass Archaeornithes - Archaeopteryx
  - Infraclass Enantiornithes - Opposite birds
- Subclass Ornithurae
  - Infraclass Odontornithes - New World toothed birds
  - Infraclass Neornithes
    - Superorder Paleognathae - ratites and tinamous
    - Superorder Neognathae - all other birds

Avian Phylogeny based on Feduccia (1995)

- Living birds comprise approximately:
  - 30 Orders
  - 193 Families
  - 2,099 Genera
  - 9,700 species
Avian Systematics

• Basic unit of classification = Species
  – Biological Species Concept = a species is a group of similar looking individuals that are capable of interbreeding successfully
  – Molecular Species Concept = a species is a group of organisms that are diagnosably different genetically from other groups of organisms

Avian Systematics

• In practice, it can be difficult to delineate species from subspecies (geographical variants) by both definitions of species.
• 2 Schools of Thought on differentiating species:
  – Lumpers = tend to group similar forms into a single species
  – Splitters = tend to differentiate species when only minor variation present

Avian Systematics

• The goal of systematics (and classification) is to provide a correct phylogeny (evolutionary family tree) for organisms.
• Avian systematics deals with how the phylogeny of modern birds is established.

Bases for Classification

• Morphology = physical characteristics
  – historical method by which phylogenies derived
  – still a common method, particularly for fossil birds
• Biochemical Evidence = closely related birds should have more similar genes than more distantly related birds
• Supplementary Evidence
**Morphology**

- Physical characteristics used for establishing phylogenies must be *shared derived characters*, rather than *primitive characters*.
- If two birds share a derived character, we can hypothesize that they shared a common ancestor with that same derived character.

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**Morphology**

- **Cladistics** = a method of using a number of characters to establish a cladogram, which presumably outlines the evolutionary relationships among species based on these characters.
- **Caution:** a cladogram is only as good as the characters that are put into it, so careful choice must be used in entering characters into the model.

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**Morphology**

- Morphological evidence alone is not sufficient to derive correct phylogenies.
- One problem is *convergent evolution* = two species which are not closely related may look similar because they are adapted to similar lifestyles or environments.
- Examples:
  - Auks (N hemisphere) vs. Penguins (S hemisphere)
  - New World Warblers and Australian Thornbills

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*Cladistics Example*:

```
<table>
<thead>
<tr>
<th>Species</th>
<th>Character A</th>
<th>Character B</th>
<th>Character C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
```

No total changes from 0,0,0 ancestor.
Biochemical Evidence

- **Protein Electrophoresis** = method of separating proteins in an electric field depending on their charge, which reflects their amino acid sequence.
  - Ideally, this should measure the genetic distance between 2 birds, because the amino acid sequence is dependent on the DNA sequence.
  - Not used much anymore.

Biochemical Evidence

- **DNA/DNA Hybridization** = also an attempt to measure amount of genetic similarity. More direct than using proteins.
  - Fragments of single stranded DNA from 2 species associated under specific conditions. Forms 2-stranded hybrid complex.
  - Hybrid complex then heated until dissociation.
  - Higher numbers of shared base pairs lead to increased thermal stability, so the more similar the DNA, the higher the heat required for dissociation.
**Biochemical Evidence**

- Problems with DNA/DNA Hybridization
  - Differences may reflect adaptive radiation (and associated rapid DNA change) rather than distant ancestry
  - Natural selection acts on phenotype not on genotype (convergence is also possible within DNA)
  - There is some argument over how accurately thermal stability reflects actual DNA sequences.
- DNA/DNA hybridization not used much anymore.

**Biochemical Evidence**

- *DNA Sequencing* = measures genetic similarity of a portion of the genome (usually certain specific genes) directly.
- Measures nucleotide sequences of certain genes directly (often use mitochondrial DNA)
- Most direct measure of genetic similarity and the common method for deriving phylogenies currently.
- Usually will use several genes to verify phylogeny.

**Supplementary Evidence**

- *Behavior* = related species should show similar unique (derived) behaviors
  - Example: New World Vultures historically assigned to Falconiformes based on morphology.
  - Share unique habit of urinating on legs to increase heat loss when hot with storks (Ciconiiformes).
  - DNA evidence supports relationship with storks.
- *Biogeography* = ranges of closely related forms should be geographically closer than more distantly related forms.

**Supplementary Evidence**

- *Karyotypes* = shapes and numbers of chromosomes. Again, should be most similar between closely related species.
- *Ectoparasites* = external parasites are often specific for a particular species of bird.
  - Closely related birds should have similar ectoparasites since they evolved along with the birds.
- **TAKE HOME** = systematics is not a static science, but is dynamic, changing as new information comes to light.