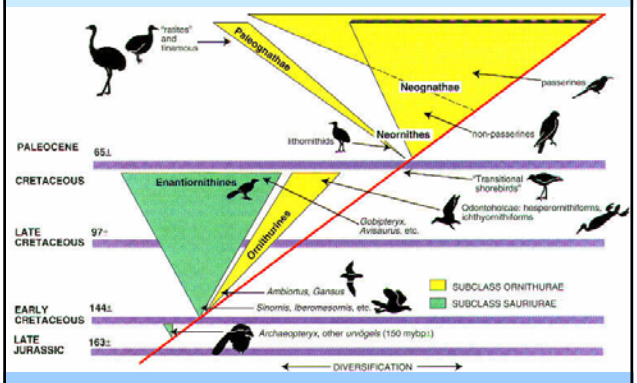
Avian Systematics

- 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)

Avian Systematics

- **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

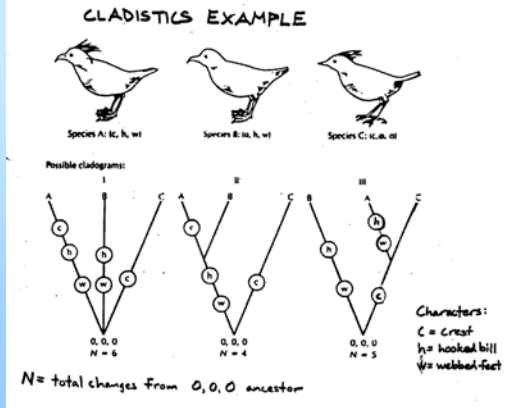
- Morphology = physical characteristics
  - historical method by which phylogenies derived
  - still a common method, particularly for fossil birds
- Biochemical Evidence = closely related birds should have more similar genes than more distantly related birds
- Supplementary Evidence

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.

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.



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

Penguins – southern Hemisphere

Auks – northern Hemisphere

New World Warblers

Australian Warblers/Thornbills

Biochemical Evidence

- *Protein Electorphoresis* = 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.