Lecture 6: Animal Classification & Phylogeny

Lecture Outline

About 1.4 million species have been identified and named; three-fourths of these species are animals. Each species is given a genus and species name according to the taxonomic system based on the work of Karl von Linnè. The binomial (genus and species names) nomenclature is universal, and follows rules from the International Code of Zoological Nomenclature. Taxonomic categories above the species level are based on the idea of shared ancestry. Currently, the major groups recognized are (domain), kingdom, phylum, class, order, family, genus, and species. Typically, when new organisms are discovered, they represent only a new species, but recently, a new phylum, Cycliophora, was identified, bringing the total number of phyla to 36.

Closely related species are placed in the same genus; closely related genera are placed in the same family, and so on. Taxon is a general term used to represent a name-bearing group of animals at any level of the classification scheme. To decide how closely related one taxon is to another, biologists compare the characters or traits present across groups. The traits used may be morphological or molecular (DNA and proteins of presumed related organisms are compared). The study of the evolutionary relationships between organisms is called systematics. Modern zoologists attempt to correlate taxonomy and systematics and both disciplines often support each other.

Classification of organisms into higher level taxa has changed recently. A 5 kingdom scheme based on cellular properties and mode of nutrition was designed by Whittaker in 1969: Monera, Protista, Plantae, Fungi, and Animalia. Bacteria were placed in the kingdom Monera, but new rRNA studies (rRNA changes very slowly, so it offers conserved characters for the phylogeny of ancient groups) indicate that the bacteria are polyphyletic. Bacteria now belong in two groups: Archaea and Eubacteria. The Archaea live in extreme environments and are the most primitive organisms known. It is believed that this group gave rise to the Eubacteria and the Eukarya about 1.5 million years ago. Living organisms are commonly grouped into a 3 domain, 6 kingdom classification system. However, as occurs with accumulating data and research, some biologists advocate dividing the kingdom Protista into more than one kingdom. Members of kingdom Animalia, along with the animal-like members of kingdom Protista are considered in this text.

Systematics is the arrangement of organisms based on evolutionary relationships indicated by shared characters. The groups formed in modern systematics are designed to be monophyletic; polyphyletic groups are avoided. Monophyletic groups include all organisms that have arisen from a single ancestral taxon; polyphyletic groups are artificial groupings whose members have arisen from separate ancestors. Paraphyletic groups include only some of the members of a lineage. Paraphyletic groupings result
from incomplete knowledge of the entire group. There are 3 main schools of systematics
that differ in their goals and approaches:
1. Evolutionary systematics is a traditional approach which looks for similar
characters and homologies to group organisms into taxa.
2. Numerical taxonomy is based on a quantitative analysis of characters to determine
taxa and does not attempt to distinguish between shared states due to common
ancestry and shared states due to convergence.
3. Phylogenetic systematics (cladists) analyzes both symplesiomorphies (shared
ancestral characters) and synapomorphies (shared derived characters) to evolutionary
relationships and as data to construct cladograms.

Cladograms depict the sequence of evolution that produced modern taxa; they represent
an hypothesis about evolutionary relationships. A cladogram may conflict with the results
of older evolutionary analyses and naming schemes for groups of organisms. One
example of this is the placement of birds (class Aves) into the class of reptiles (class
Reptilia).

Tree diagrams and other figures resulting from systematic studies may often be
misleading because they often depict increasing levels of complexity at higher levels or
branches. Fossil and embryological research have often confirmed cases of reduced
complexity and loss of structures through evolutionary time.

The basic body plans of animals may be analyzed to illustrate evolutionary trends. The
first consideration is body symmetry:
- Animals may be asymmetrical, as in many protists and sponges; such animals lack
  complex sensory and locomotory functions.
- Other animals have radial symmetry, as in the cnidarians. The symmetry of adult
echinoderms is called derived, or secondary, radial symmetry.
- Most organisms are bilaterally symmetrical. Bilateral symmetry is correlated with
  cephalization, an active life style, and movement in one direction.

The second consideration is the level of cellular organization:
- Single celled organisms, or those formed from aggregates of single cells, exhibit the
cytoplasmic level of organization; these cells have very little interdependence and do
  not form tissues.
- Diploblastic organisms, like the cnidarians, have two tissues layers formed from the
  embryonic ectoderm and endoderm. A jelly-like layer called the mesoglea often
  separates the two cell layers. The cell layers are interdependent.
- Triploblastic organisms have 3 tissue layers derived from the embryonic ectoderm,
  mesoderm, and endoderm.

The third consideration is the presence of a body cavity (not the gut cavity, but a cavity
external to the gut):
- Acoelomate triploblasts have no other body cavity than the gut, and are often called
  the “solid worms.”
Triploblastic organisms often have a body cavity partially or completely surrounded by mesoderm. The advantages of possessing a body cavity include more room for organs, more internal surface area, and storage areas. Further advantages include the possession of a hydrostatic skeleton, aiding in elimination of reproductive and excretory products and wastes, and an increase in body size. The pseudocoelomates (triploblasts) have a body cavity (the pseudocoelom) that is not completely lined with mesoderm. They are typically worm-like. The coelomate triploblasts have a coelom lined with peritoneum, an adult derivative of mesoderm. Delete the last sentence in the old instructor's manual.---JRG.---That is unless you reword, perhaps, like this, "Most named animal species are coelomate."

All animals are assumed to have arisen from a single ancestor, but modern biologists search for characters that indicate how the animal phyla are related to each other. The Metazoa includes all multicellular animals, but some zoologists see three groupings within the animal kingdom: the Mesozoa (an odd group of organisms not typically covered in introductory classes), the Parazoa (a group that includes the sponges), and the Eumatazoa (this group includes everything else called an animal).

The Eumetazoa is divided according to symmetry with the radially symmetrical cnidarians and ctenophores forming one group and the bilaterally symmetrical animals forming the other (the Bilateria).

The Bilateria is divided into the protostomes and the deuterostomes based on embryological features such as cleavage pattern and the way that the gut and coelom form:
- The protostomes have spiral, determinate cleavage, and often a trochophore larva. The group may include the Platyhelminthes, Annelida, and Arthropoda among others.
- The deuterostomes have radial, indeterminate cleavage. The group includes echinoderms, hemichordates and chordates.

However, certain taxa (e.g., molluscs and nematodes) do not fit well into either category; some cladistic analyses suggest that the protostomes should be divided into the Lophotrochozoa, most of whose members make a trochophore larva, and the Ecdysozoa, most of whose members molt the cuticle.

The fossil record shows several key periods in history. During the Cambrian explosion, a 100 million year period, all major phyla evolved. Fossils from the Ediacara and Doushantuo beds, dated to 600 million years bp, are all soft-bodied with no evidence of mineralization. There are very few fossils from this period. In the Burgess Shale fossil deposit, dated to about 570 million years bp, all 34 animal phyla can be seen, along with 20 other unassigned forms.

Humor in taxonomy
Some whimsical taxonomic names exist. *Agra vation* is a tropical beetle that was apparently very difficult to collect. Another insect, a true bug, is named *Heerz lukenatcha*. Scientific names are often named after scientists, some historically well known (e.g., Audubon); others more currently popular. A louse that lives on owls has been named *Strigiphilus garylarsoni*; a bacterium bears the name *Salmonella mjordan*, named by a microbiologist who is a basketball fan. Two species of *Amanita* have Freudian overtones: *Amanita phalloides* and *Amanita vaginata*. The names of some amphipod crustaceans exceed 40 letters in length, such as *Polichinellobizarrocomic burlescomagicaraneus*. 