7 Animal Classification, Phylogeny, and Organization

Lecture Outline

The modern taxonomic system is based on the work of Karl von Linnè

We have identified about 14 million species, three-fourths of which are animals

Typically new species are identified, but recently, a new phylum, Cycliophora brings the phylum total to 36.

Recently, molecular techniques have aided in taxonomic studies

DNA and proteins of presumed related organisms are compared

Taxa are groups of animals that share similar characteristics

Currently, the major taxa recognized are (domain), kingdom, phylum, class, order, family, genus, and species

The binomial (genus and species names) nomenclature is universal, and follows rules from the International Code of Zoological Nomenclature

Typically, a 3 domain , 6 kingdom system is recognized, and members of kingdom Animalia and the animal-like members of kingdom Protista are considered here

The 5 kingdom scheme was designed by Whittaker (1969): Monera, Protista, Plantae, Fungi, and Animalia, and this was based on cellular properties and mode of nutrition

New rRNA studies indicate that bacteria are polyphyletic

rRNA changes very slowly, and is very useful in this type of study

The eukaryotic 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.

Systematics is the arrangement of organisms based on evolutionary relationships

Monophyletic groups include organisms that have arisen from a single ancestral species; polyphyletic groups are more artificial groupings having arisen from separate ancestors

Evolutionary systematics is a traditional approach which looks for similar characters and homologies to group organisms into taxa

Groups that come from the same ancestor are called monophyletic; those groupings that are artificial as they came from different ancestors are polyphyletic.

Numerical taxonomy is based on a quantitative analysis of characters to determine taxa

Phylogenetic systematics analyze both symplesiomorphies (common characters) and synapomorphies (derived characters) to determine cladograms

Cladograms depict the sequence of derived characters

The basic body plans of animals may be analyzed to illustrate evolutionary trends

The most primitive animals are asymmetrical; the cnidarians and echinoderms are radially symmetrical, but most organisms are bilaterally symmetrical

Bilateral symmetry tended to lead to cephalization, an active life style, and movement in one direction

The single celled or colonial organisms exhibit the unicellular (cytoplasmic) level of organization
The simplest organisms such as the cnidarians, with true tissues are diploblastic (2 cell layered)
Most organisms are triploblastic (embryos with three cell layers; ectoderm, mesoderm, endoderm)
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.
Acoelomates have no other body cavity than the gut, and are often called the "solid worms"
The pseudocoelomates are mostly worms as well, and have a body cavity (the pseudocoelom) that is not completely lined with mesoderm
The coelomates (most animals are coelomate) have a coelom lined with peritoneum

<u>Cladistics</u>
Cladograms have changed the traditional taxonomic interpretations
Recent evidence indicates that the traditional "family trees" may not be correct
Major divisions are the protostomes and the deuterostomes based on embryological evidence
The protostomes have spiral, determinate cleavage, and often a trochophore larva, including the Platyhelminthes to the Annelids
The deuterostomes have radial, indeterminate cleavage, and include echinoderms, hemichordates and chordates
However, some groups do not fit well into either category, such as the molluscs and nematodes
Further, some zoologists see three groupings within the animal kingdom, the Mesozoa, the Parazoa, and the Eumatazoa that includes everything else!

Research and Discussion Topics

• What methods do biologists use to estimate the total number of species on the earth? Refer to May, R.M. "How many species inhabit the earth?" *Scientific American*. October 1992. 267 (4): 42-48.

• Approximately how many animal phyla are currently recognized? Which are the phyla that are the most speciose? Which are the least speciose? Why do you think these differences exist?

Teaching Suggestions

• A mnemonic for remembering the taxonomic hierarchy is this: <u>K</u>eep <u>p</u>ots <u>c</u>lean <u>o</u>r <u>f</u>amily <u>g</u>ets <u>s</u>ick.

Lecture Enrichment

• The Tree of Life

Prior to our more complete understanding of genetics, scientists could only make reasonable assumptions when constructing "family trees." Today, however with more sophisticated molecular techniques, we are most likely coming closer to a complete understanding of evolutionary relationships between all kingdoms (and domains) of living things.
Single celled organisms (bacteria and protests) have been the most problematic. But the currently held theory classifies living things into 3 domains; two of which are composed only of prokaryotic organisms. To accomplish this task, protein analyses as well as small subunit ribosomal RNA (SSU rRNA) were used. Both the endosymbiont hypothesis and the autogenous models describe the transition from prokaryotic to eukaryotic life. Many different analyses have suggested that the "tree" of life is not a linear model as Darwin suggested. Many groups believed to have been monophyletic are most likely polyphyletic.
For an interesting "interwoven" tree of life, see Doolittle, W.F. "Uprooting the Tree of Life," *Scientific American,* February 2000: 90-95

• Linnaeus and taxonomy

Karl von Linnè (or Carolus Linnaeus, the Latinized form of his own name, which he preferred) established our current system of nomenclature. Prior to Linneus' work, the "standard" was polynomials, which were long descriptive names, which were anything but standard. Linnaeus' 1758 version of *Systema Naturae* (actually his 10th edition) is the edition used as the basis for classification of animals. In 1901, the International Code of Zoological Nomenclature (I.C.Z.N.) set forth a revised system of nomenclature, and changed Linnaeus' naming system from binomial (two-part names) to binominal (name of two names) nomenclature. Similar codes exist for botanists and microbiologists.

All codes of nomenclature share the same principles:

1. The three nomenclatures (animal, plant and microbe) are independent of each other. Therefore, it is allowable, but not recommended for a genus name to be used for two different organisms.
2. Each taxon can have only one correct name.
3. Binomens are unique. No organism may have the same genus and species name.
4. Scientific names are treated with the Latin rules of grammar, regardless of their linguistic origin. Many names are Greek, and some are latinized English, French or Spanish terms.
5. The rule of priority states that the first published usage is the correct taxonomic name.

The hierarchical categories recognized by the I.C.Z.N. are:
Kingdom, phylum, subphylum, superclass, class, subclass, cohort, superorder, order, suborder, superfamily, family, subfamily, tribe, genus, subgenus, species and subspecies.

The rules for abbreviating binomens include abbreviating the genus name as *H. sapiens*. If the species name is not known, it is written as *Homo sp.* If more than one species of that genus is included but is not identified as such, it is abbreviated *Homo spp.*

• 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.* I remind my students that if they discover a new species, they should name it after me! Currently, I have a past student working on tropical beetles, who promises that he'll soon name a beetle after me.

• "Evolution" of taxonomy

In the 1735 edition of Linnaeus' *Systema Natura*, all invertebrates except insects were classified in phylum Vermes. Little distinction was made between various "worms." Over time, various worms were removed and put in their own phyla. For example, flatworms were put in order Intestina by the 13th edition. In 1859, they were classified in phylum Platyhelminthes. The changes in phylum Mollusca were those of removal of organisms that aren't molluscs. The old name for the phylum was Malacozoa (hence the study of molluscs is still known as malacology). In the reorganization of this phylum, the barnacles were removed in the 1830s, the tunicates removed in 1866 and the brachiopods in 1900.

• The Sixth Extinction

The current extinction of living things is often called the Sixth Extinction (the other major extinctions were the Ordovician, Permian, Triassic, Cretaceous, and the current era). However, unlike previous extinctions, humans are fueling this mass extinction. One pessimistic biologist called our species the exterminator species.
What is our species doing to cause these extirpations? The list is long: developing the natural landscape into homes, shopping centers, freeways, agricultural monocultures, etc. We clear-cut forests, we channelize streams and rivers. We pollute all bodies of water, including the oceans. We don't even limit our effects to the land, but we are changing the composition of our atmosphere, including air pollution, acid rain and deposition, and depleting the protective ozone layer.

It's an irony that, for example, the official mammal of the state of California, the grizzly bear, is extinct in that state. In Tasmania (off the Australian mainland), Tasmanian tigers became a protected species in 1936, the same year it became extinct. Ancient populations of our species that moved out of Africa into other areas caused a smaller round of extinctions. In Australia, the first *Homo sapiens* arrived between 50,000 to 60,000 years ago. This led to the extinction of the megafauna of the island, including 20 species of giant kangaroos, the marsupial lion, and the diprotodons, which were herbivorous marsupials that looked like cow sized rodents! All we have left are fossils. Similar extinctions were seen in New Guinea and New Zealand, and later in the islands of Hawaii.

On islands, species of plants and animals are often endemic (meaning found no where else), because of the long isolation of the flora and fauna . Further, the invasion of humans and our domestic pets and livestock, and the pests that often accompany them make islands as critically endangered as the tropical forests. The Hawaiian Island chain of the U.S. is a prime example. Even “islands” as big as Australia suffer the same problems.

• Saving Endangered Species

As biologists, we are often asked to justify spending money to study an endangered species, or to aid in rehabilitation of a species or a habitat. As on scientist from the Kew gardens said “Every time we lose a species, we lose an option for the future. We lose a potential cure for AIDS, or a virus-resistant crop. So we must somehow stop losing species, not just for the sake of our planet but also for our own selfish needs and uses. Your thoughts on this?

Animals, as well as plants are facing the possibility of extinction. Two premier botanical gardens, the Kew Gardens in London, and the Missouri Botanical Gardens in the U.S. have active programs involved in plant preservation, primarily seed plants. But, for one example, there is a plant at Kew in which there is only one male plant alive. Without the discovery of a female plant, this species is literally already extinct.

Some mainstream biologists believe that at least 50% of all extant species may be extinct in 100 years. Other biologists predict even more dire results. Estimates of 10% of all bird species shall become extinct within the next few decades. A team of botanists estimates that one in eight plant species is at risk of extinction.

Suggested Readings

Anonymous. “Meet the new bug on the block.” *Science ‘83*. December 1983. 6. A description of the loriciferans, the most recently described phylum.

Marshall, S.A. “Could there be a new species of animal in your back yard? *American Biology Teacher*. February 1990. 52 (2): 99-101. A description of historical taxonomy as well as the procedures for describing a new species, including type specimens.

Gaffney, E.S., L. Dingus, and M.K. Smith. “Why cladistics?” *Natural History*. June 1995. 104 (6): 33-35. A description of the renovation of the American Museum of Natural History to reflect taxonomy– separate halls for the saurischians and ornithischians.