Lecture Two: Systema Naturae

Why Classify?
An aid to memory: It's easier to remember the characteristics of an entire group of organisms than to recall the characters of individual organisms over and over!
An aid to prediction: If one knows that all members of a particular taxon have a particular set of characteristics, then there's a good bet that a "new" member of that taxon may have some of those (useful?) characteristics, too. (such as antibiotic production, edibility, etc.)
An aid to explaining evolutionary relationships
Provides a relatively stable system of Internationally recognizable names. (A group of organisms classified together at any level is called a taxon.)

A character is some physical aspect of a taxon that gives clues about its evolution:
   morphological (fur color, scale shape, number of toes, etc.)
   molecular (DNA sequence, RNA sequence, amino acid sequence of proteins)

Taxonomy - done by taxonomists, is the science of naming and classifying organisms
Systematics - done by biosystematists, is the science of determining evolutionary relationships among organisms. (Most biosystematists are also taxonomists.)

A taxon’s evolutionary history is its phylogeny, and it can be represented as a branching diagram called a phylogenetic tree.

Earliest studies of biodiversity had nothing to do with evolution:
   • classifications were based on subjective logic
   • system of ordering "like" organisms which reflected a "natural order" (kosmos)
   • scientific names were long, cumbersome sentences that described the organism.

1758 - Carl Linne (Swedish botanist) published Systema naturae, outlining the system of binomial nomenclature we still use today. (He even renamed himself, in the Latinized fashion required of his system, Carolus Linnaeus. Today, we fondly remember him and refer to him as the great Linnaeus.)

A scientific name in Systema naturae consists of Genus and species:
Oryctolagus cuniculus (domestic rabbit), Homo sapiens (human), Canis familiaris, (dog).

Every species has its own, unique scientific name.

WHAT IS A SPECIES? There are many definitions, but the biological definition is:
"A group of similar organisms able to interbreed in nature to produce fertile, viable offspring."
(This means that they are REPRODUCTIVELY ISOLATED from other species: they cannot produce fertile, viable hybrids with other species.)

Remember the old mnemonic device:

"Did King Philip come over from Germany soaked?"
Domain → Kingdom → Phylum → Class → Order → Family → Genus → species

EACH SPECIES IS NESTED IN AN ENTIRE HIERARCHY, FROM DOMAIN (largest, most inclusive taxon+) DOWN THROUGH SPECIES (smallest, least inclusive taxon).
There are **THREE DOMAINS** of living things:
Bacteria – unicellular prokaryotic organisms ("true" bacteria)
Archaea – unicellular prokaryotes more closely related to us than bacteria are
Eukarya – unicellular and multicellular organisms made of eukaryotic cells (protists, fungi, plants, and animals)

**PROKARYOTIC CELL** lacks a membrane-bounded nucleus or membrane-bounded organelles. (Bacteria and Archaea)
**EUKARYOTIC CELL** has a membrane-bounded nucleus and membrane-bounded organelles. (Eukarya: Animalia, Fungi, Plantae and many kingdoms of protists)

Related species are placed in the same **GENUS**. Related Genera (plural of genus) are grouped in the same **FAMILY**. Related Families are all placed in the same **ORDER**. Related Orders are all grouped in the same **CLASS**. Related Classes are placed in the same **PHYLUM**. Related Phyla are classified in the same **KINGDOM**. Related Kingdoms are placed in the same **DOMAIN**.

And those long, complicated species names actually *mean* something!
*Eleutherodactylus planirostris* (Greenhouse Frog)
*eleutheros* = "free" *plani* = "flat" *dactyl" *rostris" -"nose" …this is a little frog with unwebbed toes ("free toes"), and he has a flat nose!

Proper names are okay to use, but they, too, must be Latinized:*Chilomeniscus savagei* : *chilo* = "lip" *meniscus" -*crescent"
This is a little snake with a snub-nosed, crescent shaped lip that reminded the person who described this snake of his mentor, Professor Jay Savage. So he named the snake after Dr. Savage by Latinizing Dr. Savage's name, and making it into the snake's **specific epithet** (that's the species part of the scientific name).

**What do scientists use to classify organisms?**
Fossil record? -Surprisingly NO. The fossil record is not a good tool for this.
  * Comparative anatomy (morphology)
  * Comparison of proteins
  * Comparison of embryonic development
  * Comparison of genetic material (chromosomes, DNA and RNA)

**Primitive versus Derived characters**
A **primitive character** is one that is relatively unchanged from that same character in an ancestral species. A **derived character** is one that is rather different and changed from that same structure in an ancestral species.

**NOTE THAT THESE ARE COMPARATIVE TERMS.** A structure or character can be considered "primitive" or "derived" only if you're comparing it to something else.

**Example**: In comparison to the non-fully opposable thumbs of other primates, the fully opposable thumb of a human is derived. (That is, it's changed from the primitive, ancestral form of the thumb, which was not opposable at all!)

**Another example**: The vertebral column and bony cranium (skull) of a human are both primitive characters that a human shares with all other vertebrates. (That is, the presence of a spinal column and bony cranium is primitive to all vertebrates: like the ancestral vertebrate, all vertebrates have them!)
Homologous versus Analogous characters

AGAIN, THESE ARE COMPARATIVE TERMS. You compare at least two characters (in two species) to say whether they are homologous or analogous to each other. A homologous character is one that is found in two different species, and has been derived from the same ancestral source (which you can tell by following the embryonic development.

Example: The middle fingernail on your hand is HOMOLOGOUS to the hoof on the front leg of a horse! If you follow the embryonic development of a human and a horse you will see that the same cells/tissues that give rise to the fingernail in a human give rise to the hoof in the horse! This means that the most recent common ancestor of the human and the horse (which was a vertebrate, and a mammal) had this original structure, though it has evolved into different things in its human and horse descendants of that common ancestor. An analogous character is one which is found in two different species, serves a similar function in both species, but IS NOT derived from the same ancestral source (which you can again tell by following the embryonic development).

Example: The wing of a bird and the wing of a butterfly both allow the animal to fly. However, the most recent common ancestor of the bird and the butterfly (which was neither a bird nor a butterfly, but something that was little more than a blob of cells with a mouth) did not have wings! This means that the bird wing and the butterfly wing evolved independently, from different embryonic sources, even though they serve the same function.

When two characteristics evolve superficial similarity due to similar environmental pressures, CONVERGENT EVOLUTION is said to have taken place. (Another example: Both the shark and the dolphin have a torpedo shape because this allowed their ancestors to survive well and reproduce in an aquatic environment. However, the most recent common ancestor of shark and dolphin (a fishlike animal) gave rise to sharks on one branch of its family tree, and to terrestrial, four-legged animals on another branch. Dolphins evolved from those four-legged descendants of the fish ancestor and SECONDARILY evolved the torpedo shape, whereas the shark never lost its torpedo shape. Hence, the similar shape of dolphin and shark arose in different ways, and from different ancestors, and is said to be due to CONVERGENCE.)

Once a biosystematist has enough information about a species, s/he can construct a PHYLOGENETIC TREE, which is a diagram of ancestral species giving rise to new species, and which shows the evolutionary relationships of related species. Example: A phylogenetic tree of the vertebrate groups ...which can be considered a working hypothesis, and can change as new information becomes available.

A PHYLOGENETIC TREE shows of hypothetical EVOLUTIONARY RELATIONSHIPS.

A TAXONOMIC KEY is a tool used by a scientist to IDENTIFY SPECIMENS. It may or may not reflect evolutionary relationships. We'll learn about those next, in today's activity, "Identifying the Wild Pasta Species of the United States."