Introduction

We use this lab in Patterns and Processes, Evolution of Past & Present Ecosystems, and Tropical Marine Ecology. This exercise illustrates the creativity involved in taxonomy and the roles form and function, ancestral traits and derived characters play in generating classification schemes. It can also serve as an introduction to topics in evolution and paleontology. We have noticed that in the field, after completing this exercise, students begin to recognize distinctions and similarities in fauna which they may have not noticed before.

Terms for Discussion

Phylogeny	Divergence	Convergence
Linnaeus	Heirarchy	Evolutionary Tree
Homologous Structure	Morphology	Function

Background

It has become apparent to scientists that the biosphere consists of, at a minimum, 1.5 million described species. Some researchers estimate that there may be upwards of 40 million species (Go here for an Index of Animal Phyla) alive today! The species alive today are only a very small percentage of the perhaps billions of species which have lived on this earth since life first evolved over 3.5 x 109 years ago. Over 75% of the described extant species belong to the Phylum Arthropoda, which includes such diverse organisms as lobsters, barnacles, hermit crabs, crabs, scorpions, shrimp, horseshoe crabs, spiders, mites, millipedes, and insects. The insects are by far the most abundant arthropods. How are the many species of insects (for that matter, all animals and plants) arranged, categorized, and classified? How does the classification scheme reflect phylogenetic relationships? It can be a bewildering yet extremely interesting problem. Taxonomy (Gr. *taxis*, "arrangement, order", *nomos*, "law") is the science, laws, or principles of classification (Latin, *classis*, "a class", *facere*, "to make").

The Role of Taxonomy

1. Taxonomy works out for us a vivid picture of the existing organic diversity of the earth.

2. Taxonomy provides much of the information permitting a reconstruction of the phylogeny of life.

3. Taxonomy reveals numerous interesting evolutionary phenomena.

4. Taxonomy supplies classifications which are of great explanatory value in most branches of biology and paleontology.

For More Info and Excellent Resources on Taxonomy, please see: Internet Resource Guide for Zoology: Systematics, taxonomy & nomencalture

Rules of the Game

Without a set of international rules to follow, the results of taxonomy would be confusing at best. The rules of zoological nomenclature are contained in a document known as the International Code of Zoological Nomenclature (ICZN). The object of the code is to promote stability and universality in the scientific names of animals. All names must be unique, universal, and show stability.

Uniqueness Every name has to be unique. If several names have been given to the same taxon, priority decides which name will be the valid name.

Universality Zoologists have adopted, by international agreement, a single language to be used on a worldwide basis. All animals are given a generic and specific name in Latin. These names are in italics or are underlined (i.e. *Homo sapiens*).

Stability The ICZN attempts to prevent the frequent changing of names to provide stability.

Classifications - The Linnaean Hierarchy

Although rudimentary biologic classification may predate civilization, the questions of how classifications are to be constructed and even to what use they should be put are by no means settled. Carl Linnaeus, in 1758, published *Systema Naturae.* This marks the beginning of the modern classification of plants and animals. He devised practical techniques for the naming of groups of organisms and their ranking and ordering. He developed a system of binomial nomenclature - the scientific name of an organism consists of a collective generic name and a specific or species name. His techniques are basically intact today. Of course, there are numerous philosophies and methods of classification which are in use today which help add to the overall confusion in the world of taxonomy. Linnaeus' great contribution was to provide order in the method used in the classification of living organisms.

Animals are classified according to the Linnaean system. This consists of the following scheme, for example, in the classification of several edible invertebrates. Each organism is uniquely identified using a combination of its genus and species names. Species are grouped into genera, families, orders, classes, and phyla, depending upon similarities and inferred evolutionary relationships.

	American Lobster	**Market Squid**	**Blue Mussel**	**Virginia Oyster**	**European Oyster**
Phylum	Arthropoda	Mollusca	Mollusca	Mollusca	Mollusca
Class	Malacostraca	Cephalopoda	Bivalvia	Bivalvia	Bivalvia
Order	Decapoda	Decapoda	Mytiloida	Pterioida	Pterioida
Family	Nephropidae	Loliginidae	Mytilidae	Ostreidae	Ostreidae
Genus	*Homarus*	*Loligo*	*Mytilus*	*Crassostrea*	*Ostrea*
Species	*americanus*	*opalescens*	*edulis*	*virginica*	*edulis*

The names of genera are required by the rules of nomenclature to be unique. But such rules do not apply to other taxons, even though duplicate names should be avoided. For example, in the table above, the order name Decapoda occurs in both arthropods and molluscs, and the species name *edulis* occursin bivalves of different genera. Wouldn't it be nice if duplicate names did not exist?

A **category** designates a given rank or level in a hierarchic classification. Such terms as species, genus, family, and order designate categories. A category is an abstract term. The **organisms** placed in these categories are **concrete** zoological objects.

Organisms, in turn, are not classified as individuals, but as groups of organisms. Words like "bluebirds" or "thrushes" refer to such groups. These are the concrete objects of classification. Any such group of populations is called a taxon if it is considered distinct to be worthy of being formally assigned to a definite category in the hierarchic classification.

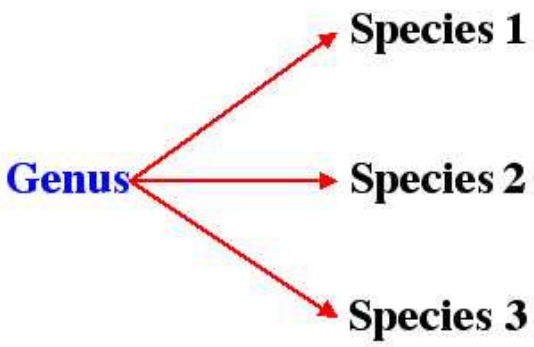
Categories, which designate **rank** in a hierarchy, and **taxa** (plural for taxon), which designates **named groupings** of organisms, are thus two very different kinds of phenomena. Controversy usually reigns supreme over whether or not a particular group is truly distinct enough to be a new taxon. If it is a new taxon, taxonomists then determine which category the taxon will be placed in.

Much of the task of the taxonomist consists of assigning taxa to the appropriate categorical rank. The hierarchy of categories that the classifying taxonomist recognizes is an attempt to express similarity ("characters in common") and recency of common descent. The most closely related species (occasionally subject to intense debate) are combined into genera, groups of related genera into subfamilies and families, these into orders, classes, and phyla. In this procedure there is a drastic difference between the species taxon and the higher taxa (genus on up to phylum). Higher taxa are defined by intrinsic characters. For instance, the Class Aves (birds) is the class of "feathered vertebrates". Any and all species that satisfy the definition of "feathered vertebrates" belong to the Class Aves.

Species Groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups. *May or may not be* morphologically distinct.

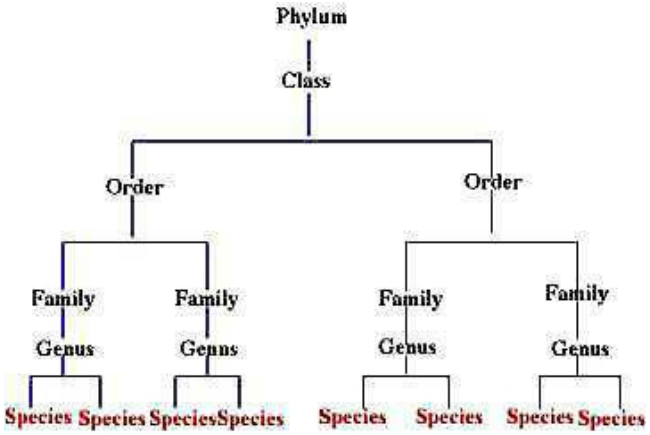
Genus The lowest higher category. A taxonomic category containing a single species, or a monophyletic group of species, which is separated from other taxa of the same rank by a decided gap (behavior, morphology, or some other characteristics).

If these three species belong to the same genus, they are descended from a common ancestor.



Family A taxonomic category including 1 genus or a group of genera of common phylogenetic origin, which is separated from other families by a decided gap.

Currently, there are about 26 known phyla, 80 classes, and 350 orders of extant animals. **As one goes up the hierarchic scale from the species rank up to phylum, each category becomes more inclusive.**



Encourage students to be creative in their classification schemes!

When a species is collected and it is new to science, the most important rules of ICZN cover:

1. Choice of a name - must be Latin, must not be already used, and it must be in binomial form.

2. The name must be published in a well respected, preferably international, scientific journal.

3. The publication must include a description of the new species.

4. Described species must be accompanied by a type or preferably a set of type specimens which must be accessible to scientists from the world over (i.e. the type specimens are placed into a museum which allows access to all).

Terms, Laws, etc.

Law of Priority Except in extreme circumstances, a name proposed first has precedence over all subsequently proposed names.

Type Specimens

Type specimens are selected by the taxonomist to designate individuals which typify the described species. Type specimens are placed in museums for study by taxonomists. Often the type specimen does not represent all the variation within a species (how could it!?). The type specimen becomes the name bearer of the species. I have listed a few different "types" in use by the taxonomist.

Holotype The single specimen indicated as "the type" by the original author at time of publication of the original description.

Syntype One of two or more specimens cited by the author of a species when no holotype was designated or it is any one of two or more specimens originally designated as types.

Isotype A duplicate specimen of the holotype collected at the same place and time as the holotype.

Neotype A specimen selected as type subsequent to the original description in cases where the original types are known to be destroyed.

Finally- The Exercise

We usually use about 15 different hardware items!

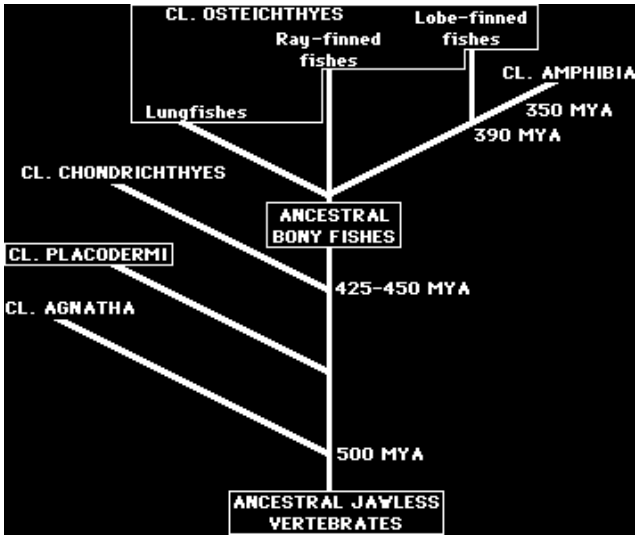
Divide into research teams. You have been handed a bag of various fasteners (nails, staples, screws, etc.) As renowned taxonimists, you are to develop a classification scheme that meets the established rules of the Linnaean system. Be prepared to defend your classification scheme orally. You will also write a one page essay on your classification choices--what roles did form, function, derived characters, and ancestral traits play in your classification scheme?

Tasks:

1. Make a phylogenetic chart of your classification scheme (as shown on this handout) using the poster paper, tape, and objects. Include all of the categories from phylum to species. What rationale (s) did you use to for each category and what criteria did you use to differentiate among categories? Did you rely more on "form" or "function?" Or derived and ancestral traits? Provide descriptive names for each category from phylum, class, order, family, genus and species. Apply names that best describe each object and their heirachical location in your classification scheme.

2. What are some of the difficulties and differences between classifying inanimate objects and living organisms? Is it easier or more difficult to classify living or inanimate objects? Why? If you knew nothing about each object's function, would that have made a difference in your classification scheme?

3-Does your classification scheme reflect the **evolutionary relationships and phylogeny** among taxa? Who evolved from whom? Which "body type" do you consider to be the most primitive? The most advanced? Be sure to include evolutionary relationships in your essay.



From Dr. Gary Anderson's vertebrate evolution page.