Principles of Taxonomy

1. Why is a system of classification needed?
   a. Organize species into groups and discuss them.
   b. Identify new organisms.
   c. Show relationships between organisms.

2. **Taxonomy** is the science of classifying organisms.
   a. Developed by Carolus Linnaeus (1707-1778), the **Binomial system**, also called **binomial nomenclature**, requires that each organism be given a two part name using Latin as a standard language.
      i. This provides a uniform means of communication for all people and avoids the confusion caused by an organism having different common names in different areas.
      ii. The format is *Genus species* or *G. species*. (*e.g.*, *Castor canadensis* (North American beaver)). The **genus** name is capitalized and may be abbreviated by the first initial. The **species** name is not capitalized and cannot be used alone. (*e.g.*, *C. canadensis)*
      iii. The 2 part name gives clues about relationships between organisms. For instance, *Ursus americanus*, *U. horribilis, U. arctos*, and *U. maritimus* are all related.
      iv. Names were based largely on physical appearances but modern taxonomists use genetic information, molecular biology, and phylogeny (evolutionary relationships) as other criteria for classifying. The work of Charles Darwin introduced the idea of considering evolutionary history.
   b. The binomial classification system is a hierarchy.
      i. The levels of organization are **domain, kingdom, phylum, class, order, family, genus,** and **species**. In plants, fungi and algae phyla also called divisions. Each of these levels is called a **taxon** (plural, taxa).
      ii. Note that the genus and species name are italicized because they are Latin. When handwriting, underline the words. Other levels are capitalized but no special print features are used.
   c. The term **species** is used to describe individuals capable of reproducing with one another. Individuals from different species do not generally reproduce with one another.
      i. Individuals of one species may appear quite dissimilar. For instance think of all the breeds of dogs.
      ii. The genetic diversity in a population means offspring may appear different from one another.
      iii. Estimates of the number of species range from 2 to 100 million species although only about 1.4 million species are currently named and described. Note that this is for eukaryotic species only. It is much more difficult to estimate the number of prokaryotic species.

3. The six kingdoms (3 domains) system
   a. Originally there were only two kingdoms recognized by Linnaeus: animals and plants.
   b. Later, these two were divided into five: animals, plants, fungi, protists, and bacteria. Each kingdom evolved from different single-celled ancestors.
   c. Recent DNA evidence and comparisons of proteins have shown how long groups of organisms have been evolving independently. This has been used to place organisms into domains.
   d. There is currently lack of agreement among taxonomists about how many eukaryotic kingdoms there are. In this course we will use the 6 kingdom system in which all eukaryotes other than fungi, plants, and animals are placed in Kingdom Protista:
      i. Two prokaryotic (formally, Kingdom Monera) groups:
         (1) **Kingdom Archaebacteria** (**Domain Archaea**) are very ancient bacteria. They are found in anaerobic and extreme conditions such as high [salt], high temperature, and/or low pH. These are believed to be the conditions on the early Earth. Earth's early atmosphere did not contain oxygen, therefore the earliest organisms were anaerobic.
         (2) **Kingdom Eubacteria** (**Domain Bacteria**) are more modern bacteria.This group includes the bacteria with which most people are familiar. Eubacteria inhabit nearly every known habitat. The group contains consumers, producers, and decomposers.
         (3) Most are heterotrophs but there are also autotrophic bacteria which use either chemicals as a source of energy (**chemoautotrophs**) or are photosynthetic (**photoautotrophs**).
         (4) While most bacteria are harmless, some do cause disease and do so in one of two ways:
            (a) Damage cells and tissues by breaking down the cells for food. For example, *Mycobacterium tuberculosis* destroys lung tissue; and,
            (b) Releasing toxins that interfere with the normal functioning of the host. For example, *Corynebacterium diphtheriae* releases toxins into the bloodstream where they cause breathing difficulty, heart failure, paralysis, and death.
            (c) Bacterial diseases are prevented and treated in two ways:
               (i) **Vaccines** are small doses of live bacteria, killed bacteria, or parts of bacterial cells which cause an immune response. If you are exposed to that bacterium again in the future, your immune system will launch a strong response to it.
               (ii) **Antibiotics** are compounds that interfere with the normal growth of bacteria.
      ii. Four eukaryotic (**Domain Eukarya**) groups:
         (1) **Kingdom Protista** contains some of the earliest living things on Earth. The first eukaryotic cells are thought to have been protists and they gave rise to the fungi, plants, and animals.
            (a) Most are small, single-celled organisms that are not necessarily even related to one another. Members have been lumped together in this kingdom because they don't seem to fit anywhere else.
            (b) They are so diverse that some taxonomists have abandoned the idea of placing them in a single kingdom. Some feel that protists are too diverse to even fit into our current classification system. Their taxonomy is changing considerably.
            (c) Some show characteristics of animals, some of fungi, and some of

plants, and they are put into three large taxonomic groups based on how they obtain nutrition:

(i) **Plant-like** protists which are mostly non-motile and photosynthetic. This group includes what we call sea weed.

(ii) **Animal-like** protists which are motile heterotrophs. Several human diseases (*e.g.*, malaria, African sleeping sickness, amebic dysentery), which kill millions every year are caused by animal-like protists.

(iii) **Fungus-like** protists are mostly non-motile heterotrophs.

(2) **Kingdom Fungi**

(a) Although originally classified as plants because the two share some characteristics, fungi have several characteristics that make them different**.**

(i) They lack chlorophyll so they are not photosynthetic. Rather, fungi are heterotrophs that absorb nutrients after extracellular digestion is achieved by secreting digestive enzymes into the environment. Fungi are major decomposers in every ecosystem, breaking down matter into simple nutrients that can be used by other organisms.

(b) Most fungi are multicellular, although there are single-celled species (like yeasts). Many fungi are beneficial. For example, yeasts are used in making bread, wine and beer. The antibiotic penicillin is made by a fungus. Many mushrooms are eaten as food.

(3) **Kingdom Plantae** contains organisms that are multicellular autotrophs.

(a) Basic characteristics of Kingdom *Plantae*

(i) Plants are multicellular, autotrophic, eukaryotes.

(ii) Possess cell walls made of a carbohydrate called **cellulose** and store food in the form of **starch**.

(iii) The cell wall gives the plant cell strength and remains after the cell dies. In trees we call this wood.

(iv) Plants have **chloroplasts** containing **chlorophyll** and other pigments.

(v) Most plants are terrestrial although there are some exceptions.

(4) **Kingdom Animalia** contains organisms that are multicellular heterotrophs that are motile at some stage.

4. **Viruses** are unusual enough that they are not included in any of the six kingdoms. Viruses - Where do they fit?

a. Viruses are tiny structures and are called particles rather than cells and there is considerable debate as to whether they are alive or not.

b. These tiny particles consist of nucleic acid (either DNA or RNA), protein, and in some cases, lipid. The typical virus has the nucleic acid at the core surrounded by a protein coat called the **capsid**. Simple viruses have only a few genes while the most complex still have no more than a few hundred.

c. Reproduction in viruses requires a host cell.

i. Because they have no organelles of their own, they do not divide, but must use the host organelles to reproduce.

ii. The capsid includes proteins that binds to the host cell membrane. Because viruses must attach to specific proteins on the host cell membrane, most are able to infect

only a specific type of cell in a species or closely related species.

iii. Once inside the host cell, the viral genes take over the cell organelles and direct them to make new viruses.

iv. When new viruses are made they must be released

(1) Some viruses cause the cell to burst so that the new virus particles can escape to infect surrounding cells.

(2) Other viruses remain hidden inside the host cell indefinitely and become active only when the right conditions trigger them.

d. Viruses cause disease by attacking and destroying certain cells in the body, producing the symptoms of the disease. Vaccines can be used to prevent viral infections but once infection occurs, it is normally quite difficult to treat.