Classification of Living Organisms

I. General

A. Scientists have described and named a total of 1.5 million species. It is estimated that the total number of species is about 10 million. Life on earth is constantly evolving and changing slowly over time. Scientists attempt to order the natural world by grouping and classifying all living organisms. As technologies improve, so have our systems of classification.

B. A Summary of Darwin's Theory of Evolution
1. Organisms produce more offspring than can survive. Of the offspring that do survive, many will never reproduce.
2. Because more organisms are produced than can survive, there is intense competition for limited resources, such as food, water, and shelter.
3. Individuals that are best suited to their environment survive, reproduce, and pass their traits on to their offspring. Other organisms that are less suited for their environment often die, or will not be reproductively competitive. This is the process of "natural selection" and causes the many species of organisms on Earth to change over time.
4. The species that are alive on Earth today are descended with modification from ancestral species that lived in the past.

C. For 3.5 billion years, life on Earth has been constantly changing. Natural selection has led to a staggering diversity in organisms. To study this diversity, scientists must give each organism a name and sort them into groups.

D. To study the diversity of life, biologists use a classification system to name organisms and group them in a logical manner.

E. Taxonomy: The branch of biology that classifies organisms and assigns each organism a universally accepted name.

II. Early Attempts at Classification

A. Organisms were first classified more than 2000 years ago by the Greek philosopher, Aristotle.
1. Aristotle first sorted organisms into two groups – plants and animals.
2. He divided animals into three groups:
   a) land dwellers
   b) water dwellers
   c) air dwellers
3. He divided plants into three groups, based on differences in their stems:
   a) herbs
   b) shrubs
   c) trees

B. By the 15th and 16th centuries, it became obvious that there were many problems with this system of classification.
1. Many organisms were placed in groups to which they had no real relationship with the other members of the group.
2. The use of common names was very confusing. For example: catfish or jellyfish.
3. Many new organisms were being discovered and needed to be classified.

C. In response to the need for a better system of classification, the Swedish naturalist, Carolus Linnaeus, developed the system of classification that we still use today.

III. Carolus Linnaeus (1707-1778)

1. Linnaeus set up a classification system based on structural similarity. He thought that the organisms that looked alike were the most closely related.
2. Linnaeus developed a system that placed an organism in a particular group and assigned it a scientific name.
3. He developed a naming system called binomial nomenclature that is still in use today.
4. Binomial Nomenclature: The system of assigning a scientific name that consists of two parts.
5. He first divided all organisms into large groups that he called kingdoms. He based his classification on two kingdoms: plant and animal.
6. A kingdom would be further subdivided into smaller groups. Each subdivision of a kingdom is called a ***phylum*** in the animal kingdom, or a ***division*** in the plant kingdom.
7. Each subset was further subdivided until he had developed 7 levels of classification.

8. Levels of Classification:

   Kingdom
   Phylum
   Class
   Order
   Family
   Genus
   Species

   a) Organisms are placed in the same species if they can mate and produce fertile offspring.
   b) A species contains only one type of organism.

   NOTE: In the system developed by Linnaeus, the kingdom was the biggest, broadest group. More recently scientists have added an additional level above the kingdom called a "domain".

IV. Rules of Binomial Nomenclature (Linnaeus)

A. The scientific name always consists of two words: the genus and the species.
B. All scientific names are in Latin. It is understood by all scientists.
C. The genus name is always capitalized. The species name is never capitalized.
D. The two names are always written in italics or underlined.
E. No two organisms can have the same name.

V. Modern Taxonomy

A. Phylogeny

1. Modern taxonomists consider the phylogeny of an organism when attempting to classify it.
2. Phylogeny is the evolutionary history of an organism.
3. To show the evolutionary relationship between different groups of organisms, scientists construct phylogenic trees.
4. A phylogenetic tree is a family tree that shows the evolutionary relationships thought to exist among different groups of organisms.

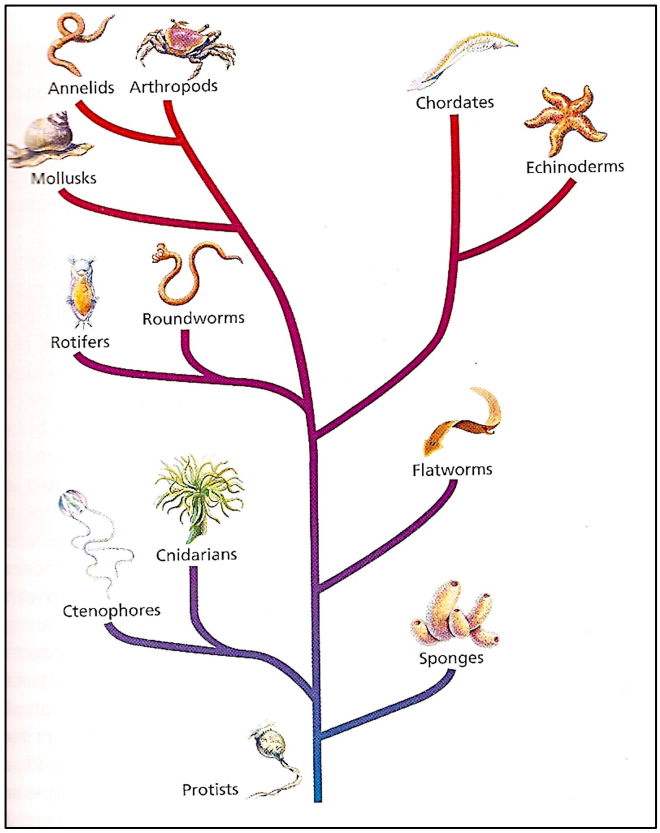
The phylogenetic tree to the right shows a few of the phyla of the Animal Kingdom.

What is the common ancestor of all organisms shown on this tree?

Are the Cnidarians more closely related to the sponges or to the comb jellies (Ctenophores)?

What is the closest relative to the Rotifers?

What does a branch point represent?



B. Traditionally, the morphology (structure) of the organism was the basis for its classification. Modern taxonomy now takes into account other types of evidence when attempting to classify an organism.

VI. Modern Taxonomy is Based On:

A. Morphology (Structural Similarities)

1. Morphology is classification based on the structures possessed by the organism.
2. This was the basis for Linnaeus' system of classification.
3. The average person would use color and size, but these are the least important in classification.
4. Homologous structures: Have same structure, but different functions. Example: The bones found in the wing of a bird, the wing of a bat, the forearm of a human and the flipper of a whale are homologous to one another.
5. Analogous structures: Similar in function but not in structure. Analogous structures are not derived from a common ancestor. Example: The wing of a bird and the wing of a butterfly have the same function, but there is nothing in common in their structure.
6. Vestigial Structure: A structure that is reduced in size and seems to be "left over" from a previous ancestor. Example: Appendix
7. The greater the number of homologous structures two organisms share, the more closely related they are thought to be.

B. The fossil record gives us many clues as to the morphology of ancient species, but it is an incomplete record. Other lines of evidence must be considered when classifying an organism. Below are 5 additional areas of consideration.

C. Cellular Organization
   1. Similarity in cell structures provides evidence that organisms may be related.
   2. Examples: What kinds of plastids are present? Does the cell possess a nucleus? Is there a cell wall present? What is the cell wall composed of?

D. Evolutionary Relationships
   1. Fossils show that organisms alive today are similar to organisms that are now extinct.
   2. Example: 25 breeds of dogs all came from a wolf-like ancestor

E. Biochemical Similarities
   1. Similarities of chemical compounds found within cells can be used as evidence to show relationships between organisms.
   2. A comparison between the proteins of two organisms serves as a "molecular clock." Simple mutations occur all the time, causing slight differences in the DNA and the proteins being built. When the proteins of two different organisms are compared, the number of differences in amino acid sequences is a clue as to how long ago two species diverged from a shared common ancestor.

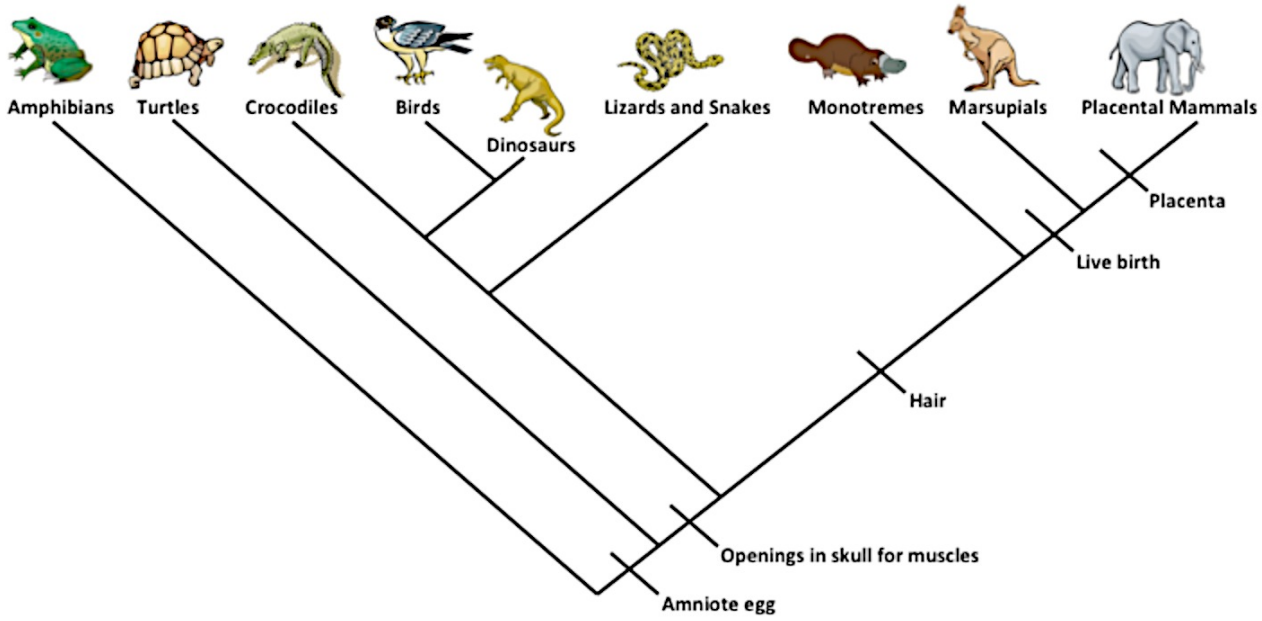
F. Genetic Similarities
   1. Do the two organisms being compared have the same number of chromosomes? The same type of chromosomes?
   2. Two organisms that bear no resemblance to one another anatomically may still be related to one another. Two different "looking" organisms may have similar genes in their DNA.
   3. Example: Humans have a gene that is the code for building a protein called myosin. This protein is a primary component of our muscles. Yeasts (which have no muscles) have the same gene. The gene in yeasts produces the same myosin protein as it does in humans. In yeasts, this protein is used to materials around the inside of the cell.
   4. This genetic similarity is an indication that yeasts and humans share a common ancestry.

G. Embryological Similarities
   1. Similarities in embryological development provide evidence of phylogenetic relationships.
   2. Some organisms show no similarities as adults, but are very, very similar as embryos.

VII. Cladistics

A. Cladistics is a relatively new method of classifying organisms.
B. Cladistics uses features called "shared derived characters" to establish evolutionary relationships.
C. A "derived character" is a feature that evolved only within the group under consideration.
D. An example might be the feathers of birds. Birds are the only animals to have feathers. It is therefore assumed that feathers evolved within the bird group and were not inherited from a distant ancestor.
E. Shared derived characters are strong evidence of common ancestry between the organisms that share them.
F. Cladogram: A diagram that shows the evolutionary relationships among a group of organisms.

G. Cladogram



What are the "derived characters" shown in this cladogram? Amniote egg, openings in skull for muscles, hair, live birth, and placenta.

Which group on the cladogram arose first? Amphibians

Do amphibians have an amniote egg? No

Do turtles have an amniote egg? Yes

Which two groups on the cladogram seem to be most closely related? Birds and dinosaurs

List the groups that have hair. Monotremes, marsupials, and placental mammals.

List the groups that give live birth to their young. Marsupials and Placental Mammals

What are the derived characters of the monotremes? Amniote egg, openings in skull, hair,

Which two groups have the most shared derived characters? Marsupials and Placental mammals

VIII. Kingdoms and Domains

A. As new discoveries have been made, the systems of classification had to be changed. The first attempt at scientific classification was Linnaeus with his 2-kingdom system. Since the time of Linnaeus, many changes have been made in the ways that scientists classify organisms.

B. As we discuss these changes in classification, fill in the table below:

A Brief History of Classification Kingdoms						
First Introduced	**Names of Kingdoms**					
1700's	Plantae					Animalia
Late 1800's	Protista			Plantae		Animalia
1950's	Monera		Protista	Fungi	Plantae	Animalia
1990's	Archaebacteria	Eubacteria	Protista	Fungi	Plantae	Animalia

C. A change to the 5 and 6-kingdom systems is the evidence that all living things seem to fall naturally into three broad groups. In recent years, this led to the establishment of a 3-domain system. Domains are essentially super kingdoms, a taxonomic level even higher than the kingdom level.

The 6-kingdom system

Kingdom Eubacteria	Kingdom Archaebacteria	Kingdom Protista	Kingdom Plantae	Kingdom Fungi	Kingdom Animalia
Domain Bacteria	Domain Archaea	Domain Eukarya (eukaryotes)			

The 3-domain system

The domain Bacteria contains the Kingdom Eubacteria.

The domain Archaea contains the Kingdom Archaebacteria.

The domain Eukarya contains the Kingdoms Protista, Plantae, Fungi, and Animalia.

IX. Kingdom Comparison!

All Living Things						
Domain	**Bacteria**	**Archaea**	**Eukarya**			
Kingdom	**Eubacteria**	**Archae-bacteria**	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell Type	prokaryotic	prokaryotic	eukaryotic	eukaryotic	eukaryotic	eukaryotic
Cell Structures	Cell walls composed of peptido-glycans	Cell walls do not contain peptido-glycans "Ancient" organisms. Very primitive	Cell walls composed of cellulose in some organisms. Some have chloroplasts.	Cell walls are composed of chitin. No chloroplasts.	Cell walls composed of cellulose. Chloroplasts are present.	No cell walls. No chloroplasts.
Cell Organization	Unicellular	Unicellular	Most unicellular. Some colonial. Some multi-cellular.	Most multi-cellular. Some unicellular.	Multicellular	Multicellular
Food Getting?	Autotroph or Heterotroph	Autotroph or Heterotroph	Autotroph or Heterotroph	Heterotroph	Autotroph	Heterotroph
Examples	Strep Staph E. coli	Methanogens Halophiles	Ameba Paramecium Algae Slime molds Giant kelp	Mushrooms Yeasts Puffballs Molds Mildews Smut Rust	Mosses Ferns Liverworts Cone-bearing plants Flowering plants	Sponges Worms Mollusks Arthropods Fish Reptiles Birds Amphibians Mammals

X. Barriers between the species: What factors keep the species apart?

A. Physical Characteristics
1. Mating is impossible under natural conditions for many organisms.

B. Mating occurs, but the offspring do not survive.
1. Bullfrog eggs may be fertilized by the sperm of the leopard frog. The eggs develop to a point, but do not survive. There is too much difference in the chromosomes.

C. The offspring may survive but they are not fertile.
1. Example: horse + donkey = mule

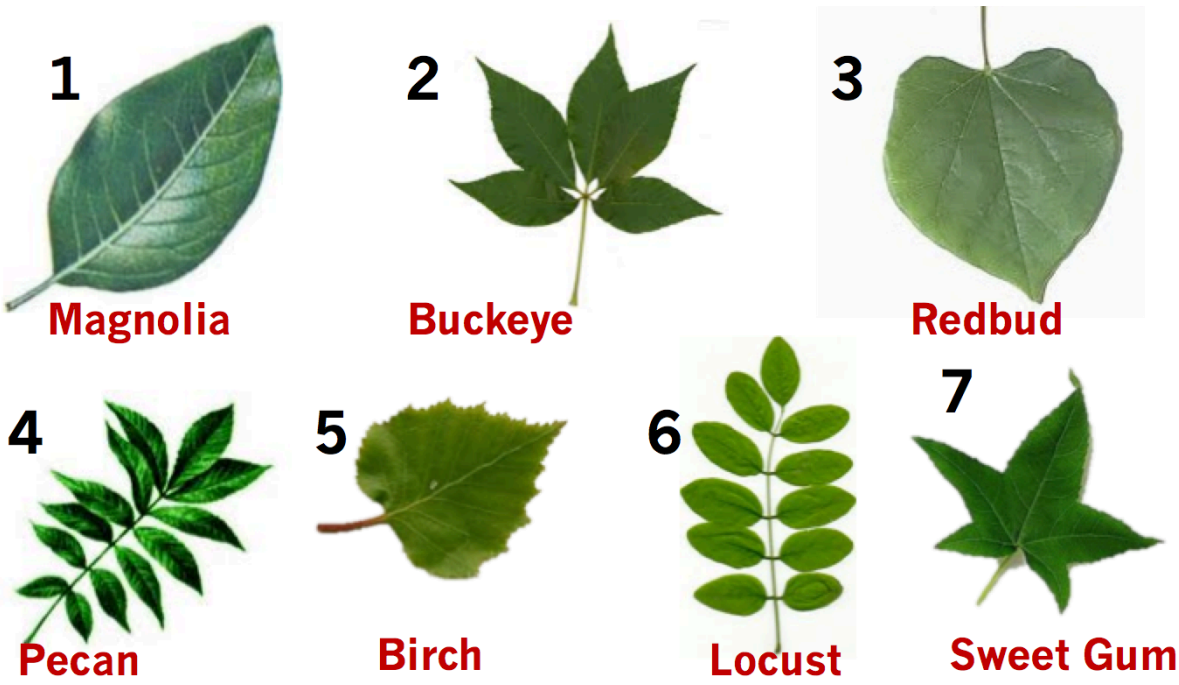
D. Geographical Barriers
1. Many organisms simply do not come into contact with one another.

E. Behavioral Barriers
1. Many organisms, especially in the animal kingdom, will not mate unless certain behaviors are exhibited.

XI. Classifying Organisms Using a Dichotomous Key

A. How to use a dichotomous key:
1. Read the first pair of statements. Decide which statement (1a or 1b) applies to the organism you are trying to identify.
2. Follow the direction at the end of the statement.
3. Continue reading the paired statements and following the directions until you determine the identity of the organism.

B. Use the following dichotomous key to identify the following leaves:



1a. The leaf is a compound leaf; it is divided into leaflets …….. Go to step 2
1b. The leaf is a simple leaf; it is not divided into leaflets …….. Go to step 4

2a. Leaflets are palmate; they are attached at one central point …… Buckeye
2b. Leaflets are pinnate; they are attached at several points ……. Go to step 3

3a. Leaflets taper to pointed tips ……..….. Pecan
3b. Leaflets are oval with rounded tips ……. Locust

4a. Veins branch from one central point …….. Go to step 5
4b. Veins branch from a main vein in the middle of the leaf …….. Go to step 6

5a. The leaf is heart shaped…….. Redbud
5b. The leaf is star shaped ……..…… Sweet gum

6a. The leaf has a jagged edge …… Birch
6b. The leaf has a smooth edge …….. Magnolia

1 – Magnolia
2 – Buckeye
3 – Redbud
4 - Pecan
5 – Birch
6 – Locust
7 – Sweet Gum