Taxonomy & Classification of Organisms
What is Classification?

- Classification is the grouping of information or objects based on similarities.
- Taxonomy is the science of grouping and naming organisms.
Classification in Everyday Life

- Think about classification that is used in everyday life
- What would happen if grocery stores did not use a classification system?
- What about libraries, movie stores, department stores, etc.?
How Many Species Are There?

- About 1.8 million species have been given scientific names - nearly 2/3 of these are insects.
- Total number of living species is estimated to be between 13 and 14 million, with most being insects and microscopic life forms in tropical regions.
- However, we may never know how many there really are because many of them will become extinct before being counted and described.
Why Classify Organisms?

- To represent relationships among organisms
- To make things easier to find, identify, and study
- To understand our own evolution!
Devil Cat
Mountain Lion
Screaming Cat

Reference:
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Puma
Florida Panther
Cougar
There are at least 50 common names for the animal shown on the previous 7 slides.

Common names vary according to region.

So......why use a scientific name?
Why Use a Scientific Name?

- We use scientific names to avoid confusion.
- Many common names vary from region to region and country to country.
- Using a single standard Latin name for each species avoids any chance of confusion.
Classification Game

- In the following few slides, you will find 14 different organisms, each of them labeled with a letter.
- In your groups, write down two main classification types (example red/green).
- Then place the corresponding letters under the correct classification.
- After making the two main categories, try to narrow each of those down into sub-categories
For Example

- These organisms have been classified by their color.

**Green**
- Tree
- Avocado
- Turtle

**Red**
- Crab
- Rose
Possible Solutions

Plants

C  D  E  F  G  I  L

Animals

A  B  E  H  J  K  N

M

?????
Any Problems?

- There were actually several different ways to go about classifying these 14 organisms.
- You might have done color, shape, size, number of legs... the possibilities are endless.
- You might have encountered one or two that really did not fit into either of your two classifications, what should you do when this happens?
- Make a new classification of course! And this is what scientist have done as well through the years.
Aristotle

- Greek philosopher that proposed all creatures be arranged in a hierarchy of complexity
- Sponges and simple organisms occupy the lowest rung, while humans, nature’s most advanced organisms, occupy the top rung
- The dominance of humans over all living things was described as the *scala naturae*, or “ladder of nature”
A Swedish botanist/physician named Carl Linnaeus (1707 – 1778) adopted a system of classifying and naming. Linnaeus attempted to describe the entire known natural world and gave every species a two-part name. Linnaeus modified a system of naming that was used in various forms about two hundred years before his time. Binomial nomenclature became extremely common and currently is still in use. Linnaeus is often known as “The Father of Taxonomy”.
Binomial Nomenclature

What is it?

A two name system for writing scientific names

1. Genus name – written first and always capitalized
2. Species name – written second and never capitalized

• Both words are to be italicized if typed, or underlined if handwritten
  • Example: *Felis concolor* or *F. concolor*
  • Which is the genus? Which is the species?

The species name usually relates to some characteristic of the species or to the person who found the original. For example, the scientific name for humans is *Homo sapiens*. (Genus *Homo* = man, *sapiens* = thinking. Literally, in Latin, thinking man.)
Advantages to Binomial Nomenclature

- Indicates similarities in anatomy, embryology, and evolutionary ancestry

Example:

- The system suggests that the North American black bear (*Ursus americanus*) and the grizzly bear (*Ursus horribilis*) are closely related

- Similar organisms are grouped into the same genus – in this case, *Ursus*
Levels of Classification

7 levels known as taxa (sing. taxon)

1. Kingdom
2. Phylum
3. Class
4. Order
5. Family
6. Genus
7. Species

King Philip Can Order For German Students

Come up with your own mnemonic for the 7 taxa
A Closer Look at the Taxa

• As one goes from the Kingdom to the Species (DOWNWARD)…An increase in the similarity between organisms occur

• There are fewer numbers of different kinds of organisms
Categories Within Kingdoms

Kingdoms are divided into groups called phyla

Phyla are subdivided into classes

Classes are subdivided into orders

Orders are subdivided into families

Families are divided into genera

Genera contain closely related species

Species is unique
Human Classification

- Kingdom : Animalia (animal in Latin)
- Phylum : Chordata (spinal cord)
- Class : Mammalia (mammary glands)
- Order : Primates (two mammary glands)
- Family : Hominidae (bipedalism)
- Genus : *Homo*
- Species : *sapiens*
<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Bobcat</th>
<th>Lion</th>
<th>Shaggy mane mushroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylum/division</td>
<td>Animalia</td>
<td>Animalia</td>
<td>Fungi</td>
</tr>
<tr>
<td>Class</td>
<td>Mammalia</td>
<td>Mammalia</td>
<td>Basidiomycota</td>
</tr>
<tr>
<td>Order</td>
<td>Carnivora</td>
<td>Carnivora</td>
<td>Homobasidiomycetae</td>
</tr>
<tr>
<td>Family</td>
<td>Felidae</td>
<td>Felidae</td>
<td>Agaricales</td>
</tr>
<tr>
<td>Genus</td>
<td>Lynx</td>
<td>Panthera</td>
<td>Coprinaceae</td>
</tr>
<tr>
<td>Species</td>
<td>Lynx rufus</td>
<td>Panthera leo</td>
<td>Coprinus comatus</td>
</tr>
</tbody>
</table>
New Species

- Work in pairs to create a new animal species.
- Imagine that you have discovered a new species of animal that has never been seen before.
- Draw a picture of your animal.
- Describe its physical and behavioural characteristics and its habitat.
- Come up with a name for it that would fit into the system of binomial nomenclature.
- Use your imagination!
We classify people in many ways; for example, by race, religion, physical appearance, ethnic origin, profession, life style, and so on.

In which ways can classification of human beings be helpful?

In which ways can it be harmful?
Classifying Organisms

- **Phylogenetics** – based on common evolutionary descent
  - **Phylogeny** – a representation of organisms based on and describing evolutionary relationships. It is the cornerstone of a branch of biology called systematic taxonomy.
  - **Systematics** – the study of the evolution of biological diversity
Phylogeny - based on various evidence, including form and structure (observable traits). Must be based on homologous, not analogous structures

a. **Homologous structures** - similarity in structure due to common descent, not reliant on function. E.g. vertebrate forearms: human hand, bat wing, whale fin, cat leg.

b. **Analogous structures** - similarity in structure based on adaptation for the same function, not common descent. E.g. wings have developed independently in insects, reptiles, birds, and bats.
Homologous Structures

All have the same bones, but are used in different ways and for various functions - remember, homologous structures have common ancestry!
Homologous Structures

- Penguin: Humerus, Radius, Ulna, Carpals, Metacarpals, Phalanges
- Alligator: Humerus, Radius, Ulna, Carpals, Metacarpals, Phalanges
- Bat: Humerus, Radius, Ulna, Carpals, Metacarpals, Phalanges
- Human: Humerus, Radius, Ulna, Carpals, Metacarpals, Phalanges
Analogous Structures

Wings of bat, bird, and insect have the same function, but are not from the same descent
Comparison Between Homology and Analogy

![Diagram showing homology and analogy between different animal limbs]
Comparison cont.

Homology and analogy

Homology
- Bat wing
- Mouse forelimb

Analogy
- Bat wing
- Butterfly wing
- Bird wing
Phylogenetics is usually based on a combination of these lines of evidence:

- Fossil record
- Morphology
- Embryological patterns of development
- Chromosomes and DNA

How do you think these lines of evidence help to determine evolutionary relationships?
Fossils
Morphology

The study of form and structure
Embryology

The formation and early development of living organisms

Fish Salamander Tortoise Chick Rabbit Man
Chromosomes and DNA

Analyze to find links between organisms
A phylogenetic tree is a family tree that shows a *hypothesis* about the evolutionary relationships thought to exist among groups of organisms. It does not show the actual evolutionary history of organisms.

Why a hypothesis?
Why a Hypothesis?

First, what is a hypothesis?

A scientist's best estimation, based on scientific knowledge and assumptions, of the results of an experiment. It usually describes the anticipated relationship among variables in an experiment.

So, scientists reach assumptions through various types of evidence since they are not able to witness the evolution of every species.
Like family trees, phylogenetic trees represent patterns of ancestry. However, while families have the opportunity to record their own history as it happens, evolutionary lineages do not—species in nature do not come with pieces of paper showing their family histories. Instead, biologists must reconstruct those histories by collecting and analyzing evidence, which they use to form a hypothesis about how the organisms are related—a phylogeny.
Phylogenetic Tree

What organism is most primitive?

What organisms would you say are closely related?
According to this phylogenetic tree, which organism is most closely related to R?
Construct Your Own Phylogenetic Tree
Some Important Terms

- **Autotrophs**
  - Make own food by photosynthesis

- **Heterotrophs**
  - Organisms that use organic materials for every and growth

- **Chemotrophs**
  - Get food by breaking down inorganic matter

- **Prokaryotic**
  - Unicellular
  - No nucleus
  - No membrane-bound organelles

- **Eukaryotic**
  - Contain nucleus
  - Contain membrane-bound organelles
  - Most multicellular
Types of Classification Systems

- First classification system developed by Aristotle.
  - Aristotle divided living organisms into:
    - Plants:
      - Herbs,
      - Bushes,
      - Trees.
    - Animals:
      - Land,
      - Water,
      - Air.
1. Using Aristotle's 3-group system (based on movement), name 2 animals that would fit each of the 3 groups.

2. Discuss whether Aristotle's 3 group system had any built-in problems. Explain any problems that you detect with his system.
Possible Solutions

1. A. walking - cat, dog, human, etc.
   B. flying - bird, bat, butterfly, etc.
   C. swimming - fish, whale, manatee, etc.

2. Aristotle's system did have some problems:
   a. some animals fit into more than 1 group (e.g. duck, alligator, etc.)
   b. his system looked more at behavior, rather than at similarities and differences in form (e.g. bats and birds both fly, but are very different in form)
Carlulus Linnaeus proposed the Two Kingdom Classification in 1758.

The two kingdoms consisted of:

- Plantae
- Animalia
The next classification system that came about consisted of 5 kingdoms.

It was proposed by Robert Whittaker in 1969.

The 5 kingdoms consisted of:

- Plantae
- Animalia
- Fungi
- Protista
- Monera
Robert Whittaker’s Five Kingdom System

- **Plantae**
  - Plants are immobile, multicellular eukaryotes that produce their food by photosynthesis and have cells encased in cellulose cell walls.
  - **Examples:** Ferns, pine trees, roses

- **Animailia**
  - Animals are multicellular, heterotrophic eukaryotes that are capable of mobility at some stage during their lives, and that have cells lacking cell walls.
  - **Examples:** Humans, worms, spiders
Robert Whittaker’s Five Kingdom System

**Fungi**
- Fungi are a eukaryotic, heterotrophic, usually multicellular group having multinucleated cells enclosed in cells with cell walls.
- They obtain their energy by decomposing dead and dying organisms and absorbing their nutrients from those organisms.
- **Examples:** Mushrooms, moulds, yeast

**Protista**
- The most ancient eukaryotic kingdom, protists include a variety of eukaryotic forms.
- Perhaps they are best defined as eukaryotes that are NOT fungi, animals, or plants.
- **Examples:** Paramecium, amoeba, some algae, slime moulds
Robert Whittaker’s Five Kingdom System

Monera

Monera are the only kingdom composed of prokaryotic organisms, they have a cell wall, and lack both membrane-bound organelles and multicellular forms.

Examples: Bacteria, blue-green bacteria (cyanobacteria)
In the 1970’s, microbiologist Carl Woese, among other researchers conducted studies and concluded that a group of prokaryotic microorganisms called archaeabacteria are separate from other monerans.

Therefore, they decided to split kingdom monera into two separate kingdoms:
- Eubacteria
- Archaeabacteria
**Archaebacteria**
- Unicellular
- Prokaryotic
- Exist in extreme environments – they do not need oxygen or light to live
- **Examples:** methanogens, extreme thermophiles, extreme halophiles

**Eubacteria**
- Unicellular
- Prokaryotic
- Heterotrophic, autotrophic, and chemotrophic
- **Examples:** Bacteria, cyanobacteria (blue-green bacteria)
The six kingdom system consists of:

- Eubacteria
- Archaeabacteria
- Protista
- Fungi
- Plantae
- Animalia

Come up with a mnemonic to remember these six kingdoms! – This mnemonic does not need to be in any particular order.
Types of Classification Systems cont.

Discussion Questions:

- Why has there been so much change over time?
- Will the classification system change again?
Types of Classification Systems cont.

- Why so much change over time?
  - As we learn more about organisms, we have to adapt the classification systems to better fit the new information.

- Will the classification system change again?
  - You will certainly see more changes over the next decade. DNA research is providing new information about living things. Based on the new information, scientists may change how organisms are classified.
Activity

- With your new knowledge of the classification systems, create a timeline of the development of each system.
- List each level of classification in each system.
- Try to come up with two examples of organisms in the six kingdom system.