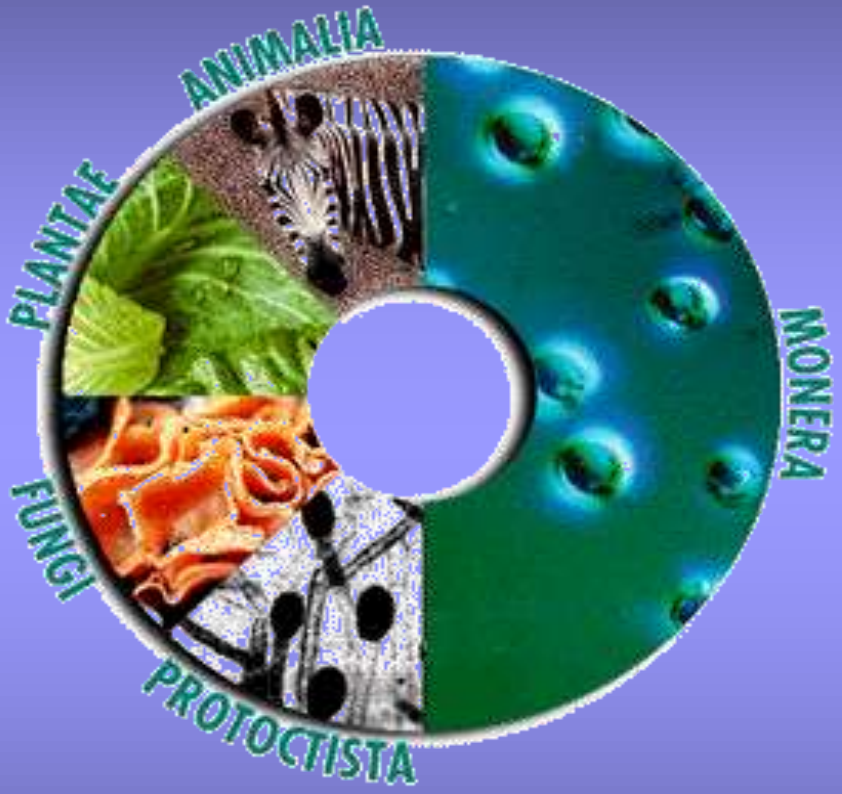
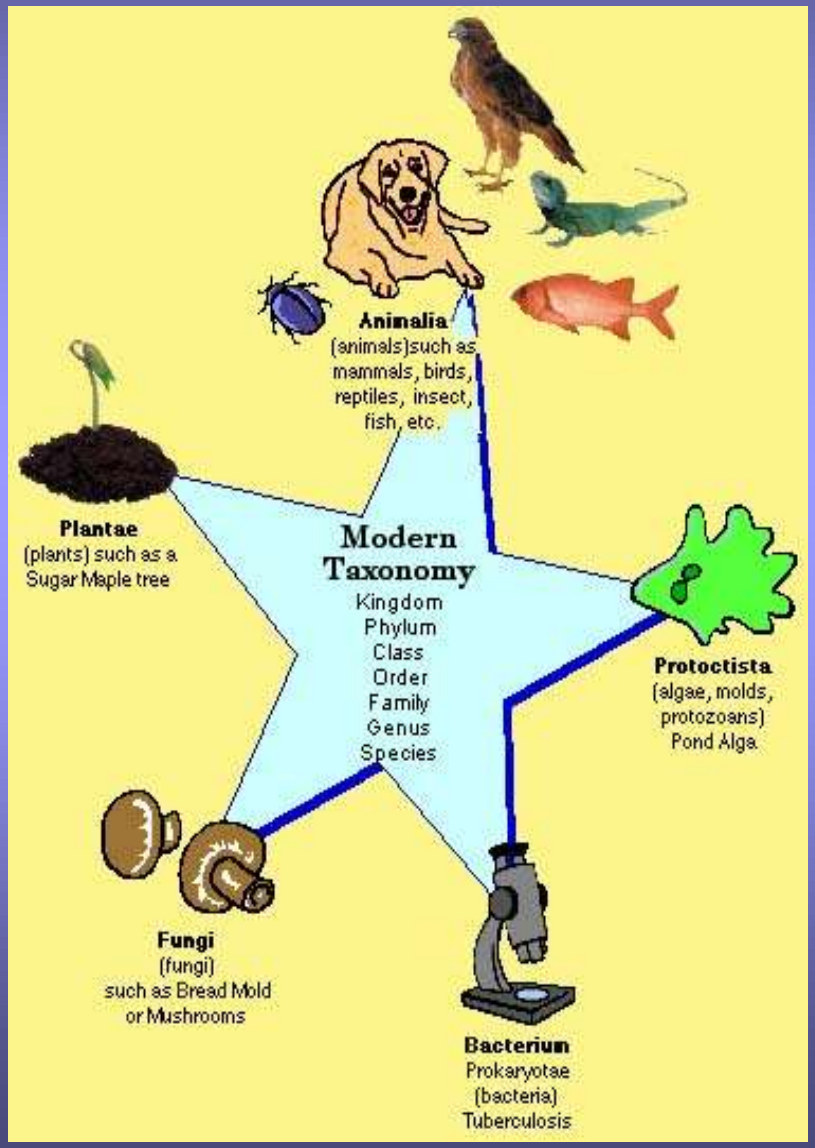
Classification & Introduction to Taxonomy

Classification

- The grouping of objects or information based on similarities
- There are more than 1 million described species of plants and animals
  - Many millions still left undescribed



Taxonomy



- Taxonomy is the branch of biology concerned with the grouping and naming of organisms
- Biologists who study this are called taxonomists
- **Science of classification (grouping things)**
  - **Process of classifying biodiversity based on evolutionary relationships**
  - **Means to organize biological diversity**
  - **Groups and names**

- **Taxonomy** (taxis = arrangement, nomos = law)
- To study biological nomenclature, the discovery and identification of taxa, and the assignment of organisms to particular taxonomic groups.
- e.g., beetles to the Order Coleoptera, lampreys to the Class Agnatha, foxes to the family Canidae.

- **Systematics**
- involves the reconstruction or inference of historical, evolutionary or genealogical relationships among taxa (involves comparative studies of differences and similarities). Methods are used to decipher the historical patterns of speciation of life, or generate phylogenetic trees or hypotheses of life.
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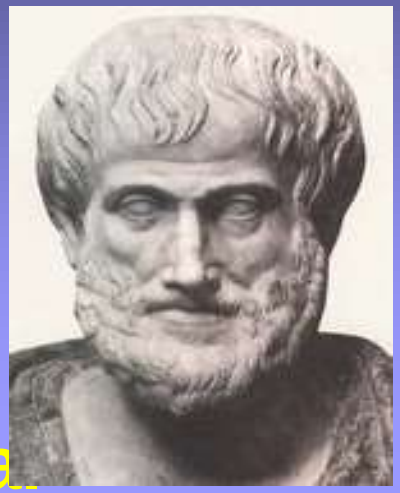
- **Classification**

generating arrangements of biological nomenclature in a hierarchical fashion. combination of the fields of taxonomy and systematics produced in a hierarchical pattern that represents some kind of relationship. Biological classifications are generally thought of as hierarchical classifications.

- Greek and Roman naturalists, medieval herbalists; folk taxonomists: *vernacular names*
- Pre-Linnaean naturalists:
  - ✓ names in Latin
  - ✓ *nomina specifica*; binominal, trinominal or even polynominal names (e.g. *Iris perpusilla saxatilis Norbonensis a caulis ferme*)
  - ✓ names inconsistent and often paragraphs long (diagnosis, description, identification

Early Taxonomic Systems



- **Aristotle (350 B.C.)**
  - Developed the 1st widely accepted system of biological classification
  - Everything grouped as plant or anima

- Swedish botanist who introduced the now
- accepted hierarchical classification of living
- organisms and binomial nomenclature of

species (for this Linnaeus was designated

- First presented in Leiden in 1735, Systema
- Naturae was based on **Aristotle's** system of progressive subdivision on groupings of

organisms

- Introduced the concepts of kingdoms,

Early Taxonomic Systems

- Carolus Linnaeus (1753)- use of a species name
- Based on looking at **physical and structural** similarities
    - Revealed relationships of organisms
- <u>Binomial nomenclature</u>
    - Gave each species 2 names (scientific name)
    - Genus and species
    - Genus is a group of similar species
- Developed the modern system of taxonomy

- **Latin was the language used**
  - **Genus name→ always capitalized**
  - **species name→ always lowercase**
  - **both names MUST be underlined or italicized**
  - **Ex: Canis lupus (wolf)**

  - **Ex: Homo sapiens (human)**

- **Ex: Felis domesticus (housecat)**
  - **Felis domesticus var.**
    - **Indicates more than one variety**

- **Scientific names are often:**
  - **Descriptive (Acer rubrum→ red maple)**
  - **Named after someone (genus→ Linnea)**
  - **Descriptive of where an organism lives (D. californica)**
  - **Named after person who first described the organism (D. californica Torr)**

Significance of binomial nomenclature

- **Many organisms have common names**
  - **Can be misleading**
  - **Can have more than 1 common name,**

Downward and Upward Classification:

Downward classification:

- Cesalpino (1519- 1603) and Carolus Linnaeus (1707-1778),
- Based mainly on logical divisions.
- It consisted in dividing a larger group of dichotomy into two subordinate groups.
- For example, animals with or without blood, animals with blood, then hairy or not hairy, and so on.

Dichotomous Key

- **Way of identifying organisms by looking at the physical characteristics**
- **Uses a series of questions to group into a hierarchy classification**

1a	Gram-positive	Go to 2
1b	Not Gram-positive	Go to 3
2a	Cells spherical in shape	Gram-positive cocci
2b	Cells not spherical in shape	Go to 4
3a	Gram-negative	Go to 5
3b	Not Gram-negative (lack cell wall)	Mycoplasma
4a	Cells rod-shaped	Gram-positive bacilli
4b	Cells not rod-shaped	Go to 6
5a	Cells spherical in shape	Gram-negative cocci
5b	Cells not spherical in shape	Go to 7
6a	Cells club-shaped	Corynebacteria
6b	Cells variable in shape	Propionibacteria
7a	Cells rod-shaped	Gram-negative bacilli
7b	Cells not rod-shaped	Go to 8
8a	Cells helical with several turns	Spirochetes
8b	Cells comma-shaped	Vibrioids

- **Drawback:**

1. **method of identification** and not of classification, since the arrangement it produced depended on the sequence in which the **differentiating characters**. It was artificial.
2. This method was **incapable of producing order** in a large fauna.

Upward classification

- By the middle of the eighteenth century upward classification gradually surfaced.

- **Assembling** species by inspection into groups of similar or related species and forming a **hierarchy of higher taxa** by again grouping similar taxa of the next lower rank.

- Characters were weighed, not by prior principles, but by a posterior determination of a covariance of characters.
- Buffon, who for the first time stressed upon using the sterility barrier as the species criterion.

- Four developments characterized this period

1. Specialization became more pronounced.

2. Classification became more hierarchical.

3. Philosophical guidelines were rejected.

4. The search for a natural system was intensified.

7 taxonomic categories:

Kingdom → largest, most general group

Phylum → called a division with plants

Class

Order

Family

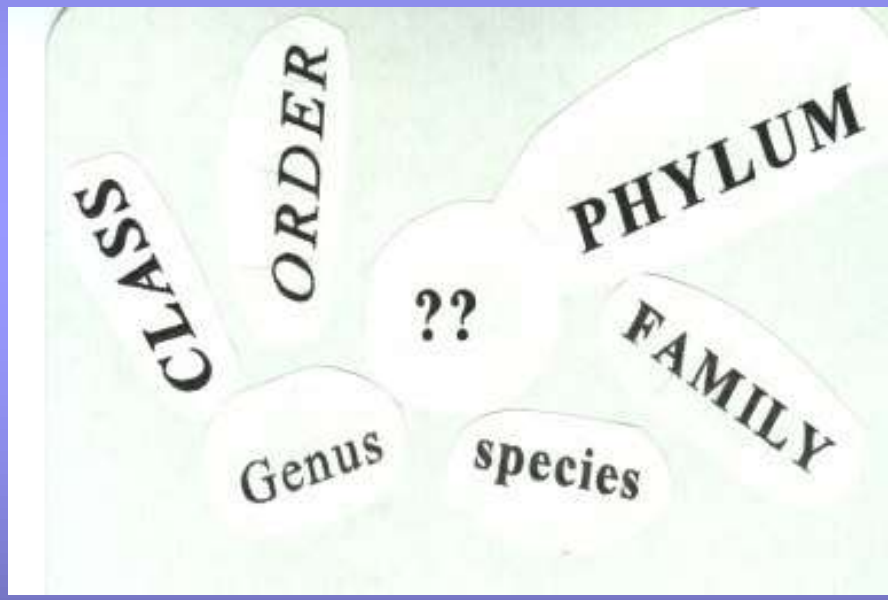
Genus

Species → smallest, most specific group

- Grouped genera into families, families into orders, orders into classes, classes into phyla, and phyla into kingdoms
- Species can interbreed with each other

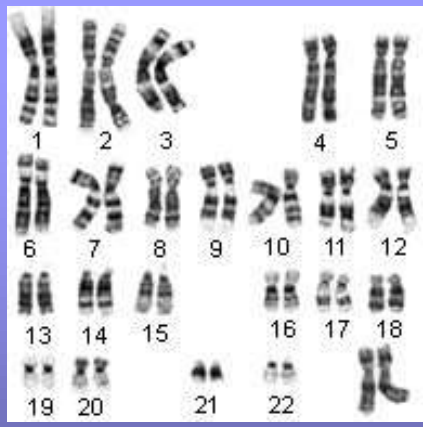
How Living Things are Classified

- Groups of organisms called **taxa** or taxons
- Organisms arranged in groups ranging from very broad to very specific characteristics
  - **Broader taxons** have more general characteristics and more species within it
  - Smallest taxon→ Species
  - Largest taxon→ Kingdom



Modern Taxonomy

- Now based on evolutionary relationships
- Taxonomists study:
  - Structural similarities
  - Chromosomal structure (karyotypes)
  - Reproductive potential
  - Biochemical similarities
    - Comparing DNA and amino acids
  - Embryology/development
  - Breeding behavior
  - Geographic distribution



Kinds of Classification:

Phenetics: weightage to similarity.

Cladistics: preference to the lines of descent.

- Based on this, classification may be:
- (a) Evolutionary taxonomy:

  oldest, traditional approach

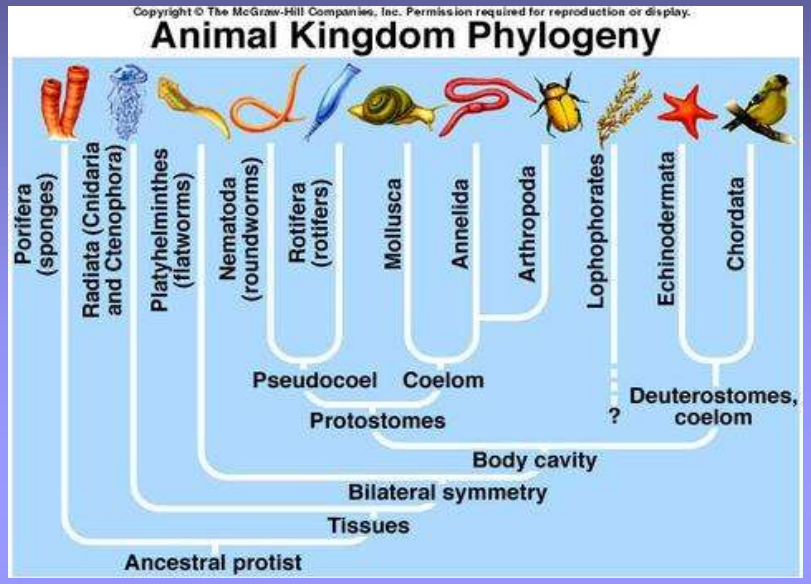
"organisms closely related to an ancestor will resemble that ancestor more closely than they resemble distantly related organisms

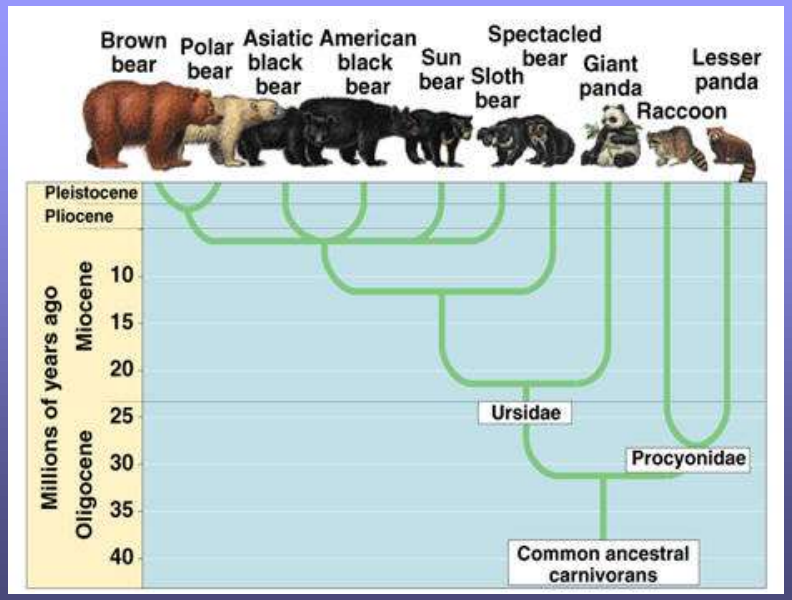
- Homologies and Analogies

- (b) **Numerical taxonomy**
- Mathematic models, computer aided techniques
- Don’t rely on homologies and analogies
- Deals mostly with closely related taxa

- (c) Cladistic approach where cladogram is constructed, “generation of hypothesis of genealogical relationship among monophyletic groups of organisms”

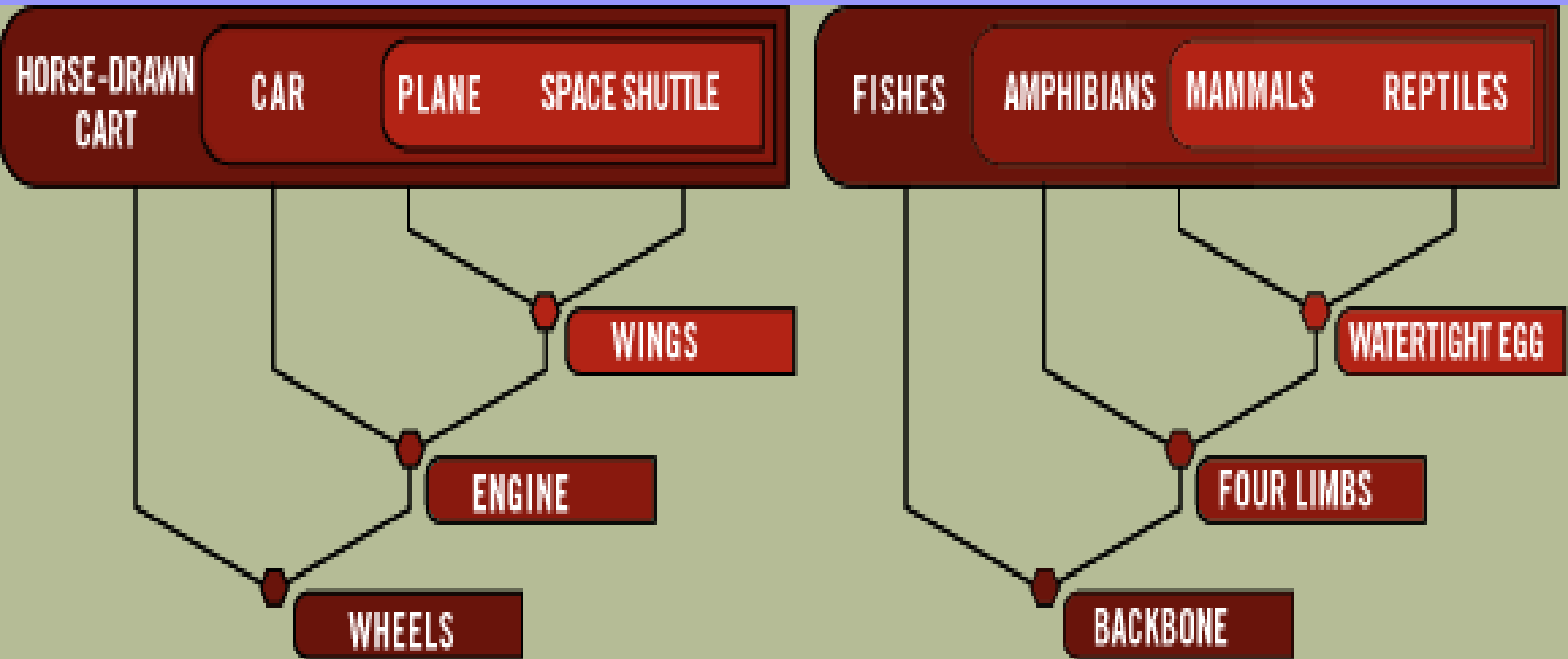
Phylogeny



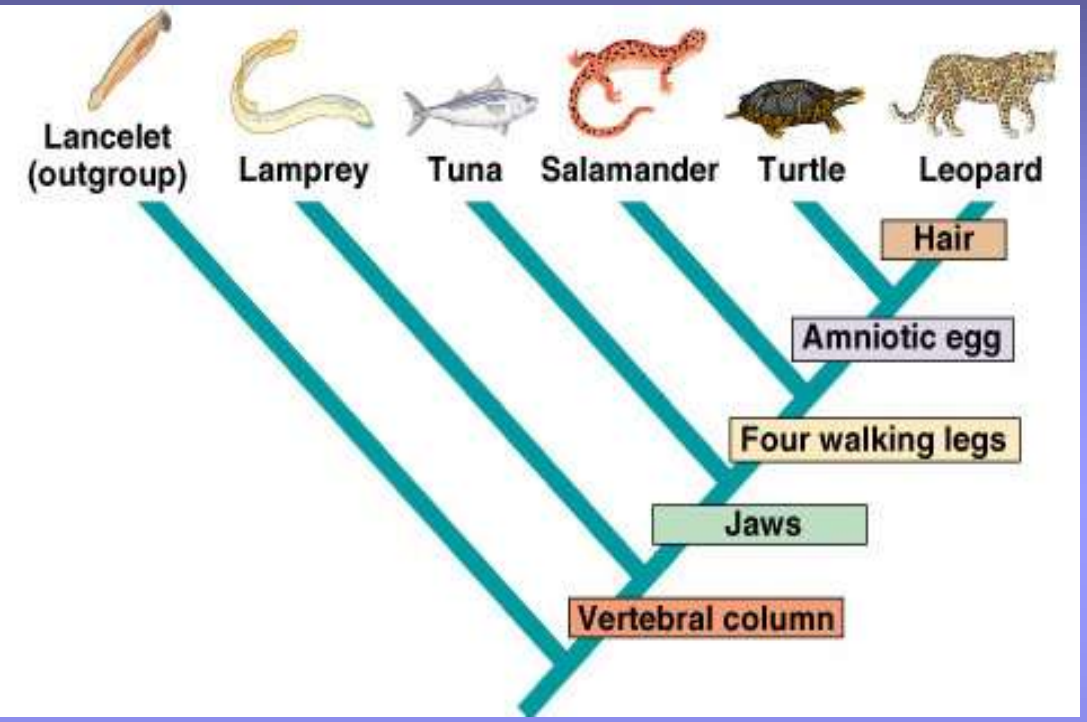


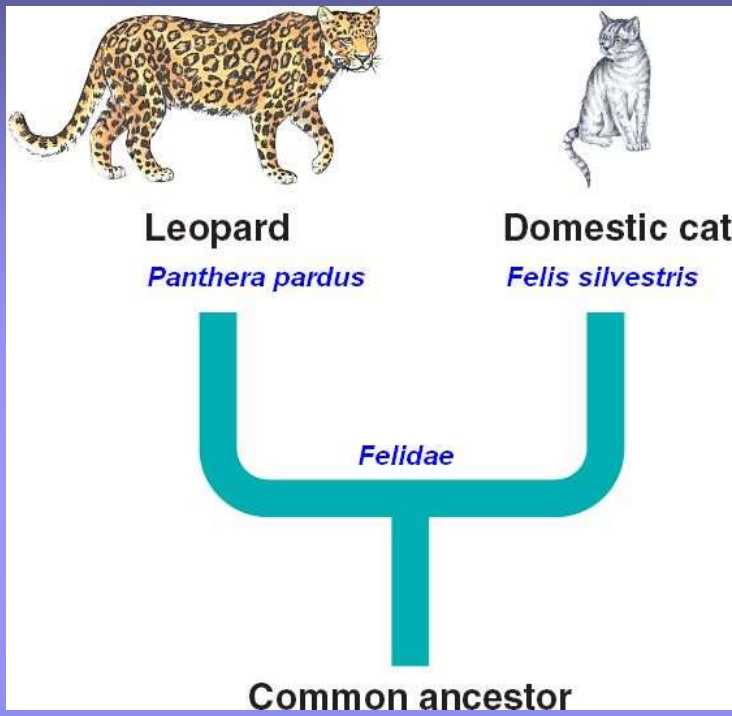
- **a family tree** for the evolutionary history of a species
  - The **root** of the tree represents the ancestral lineage
  - **Tips** of the branches represent descendents of the ancestor
  - Rate of evolution and key characters
  - Speciation: split in the lineage
    - Shown as a branching of the tree

- System of classification based on phylogeny
- Derived characteristics/traits: appear in recent parts of a lineage but not in older members



Cladogram



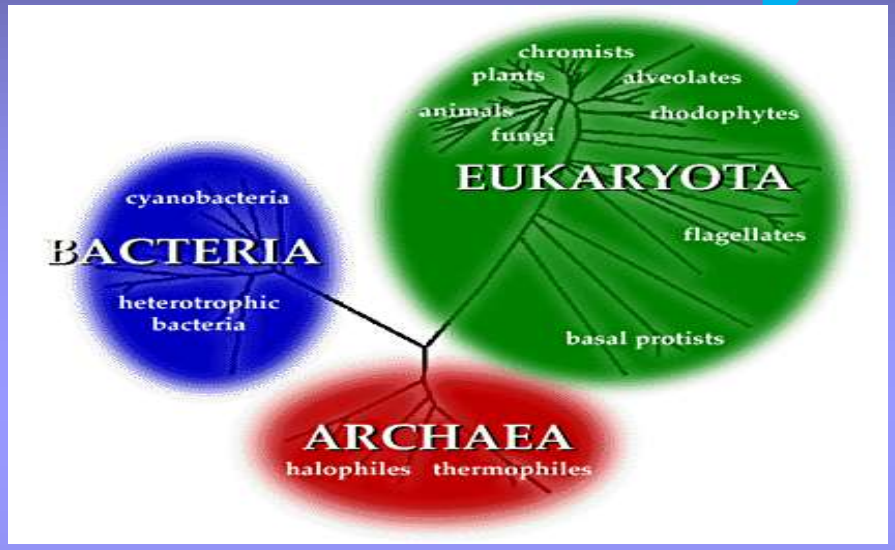


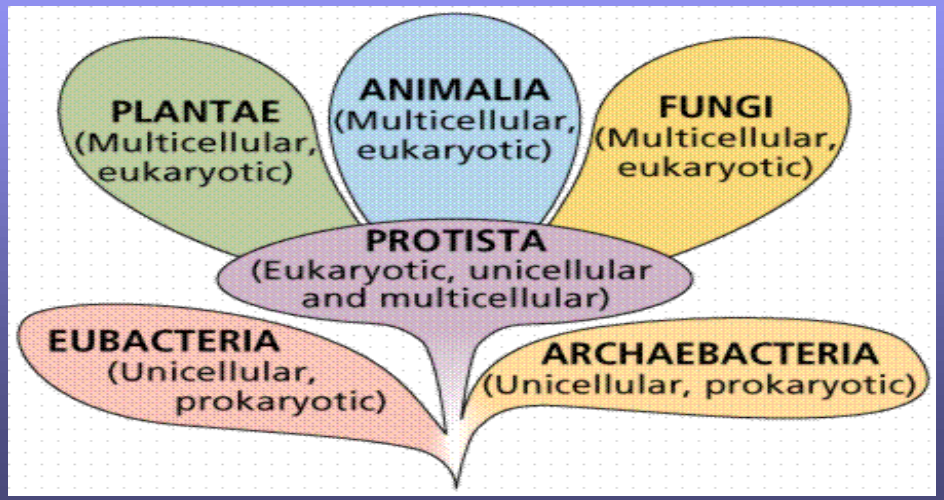
- A branching diagram to show the evolutionary history of a species
- Helps scientists understand how one lineage branched from another in the course of evolution

1969: 5-Kingdom System

- Monera, Protista, and Fungi kingdoms added to the 2 established kingdoms
- Kingdoms defined based on 2 main characteristics
  - Possession of a **true nucleus** (prokaryote or eukaryote)
  - How it **gets food**
    - Heterotroph
    - Autotroph
    - Decomposer

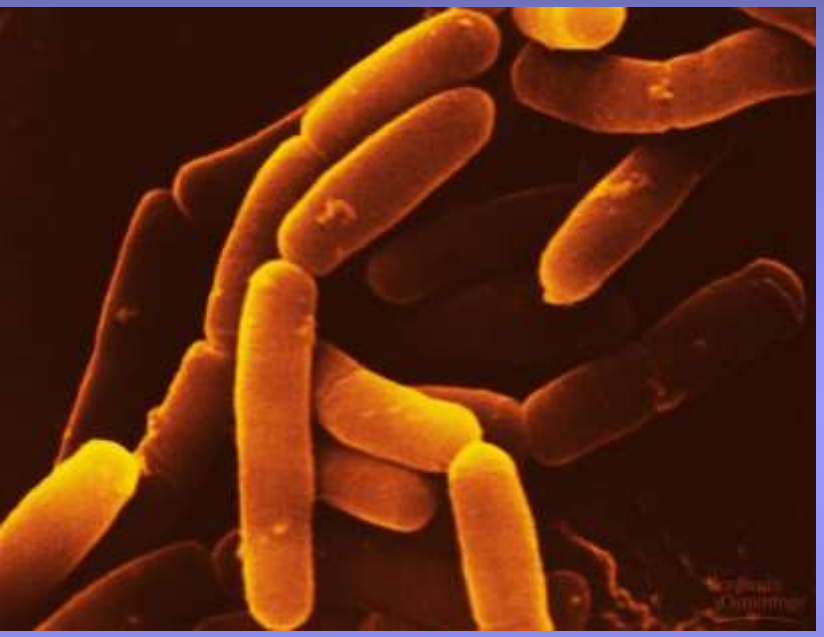
1980's: 3-Domain System

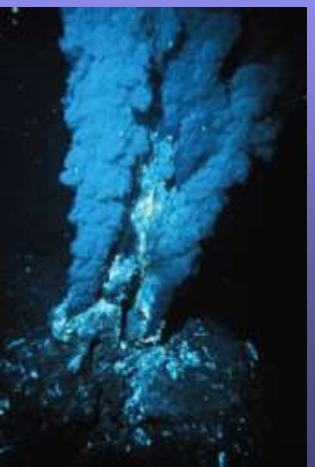




- Bacteria have distinct differences
- All eukaryotic kingdoms grouped into one domain (Eukarya)
- Monera kingdom split into 2 domains (Archaea and Eubacteria)

The Six Kingdoms of Organisms

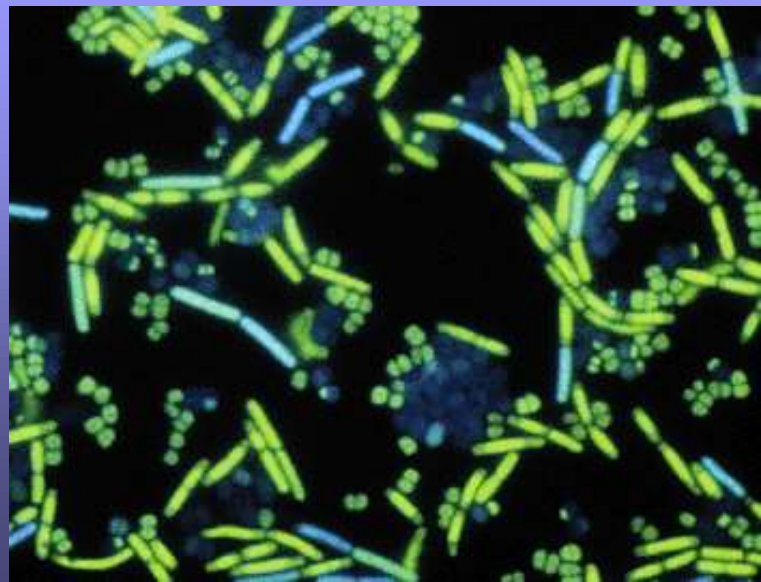




Prokaryotes:

- Microscopic
- Prokaryotic (Lack a nucleus)
- Can be autotrophs (photosynthetic or chemosynthetic) or heterotrophs
- Unicellular

- **2 kingdoms (Archaebacteria and Eubacteria)**
  - **Archaebacteria live in extreme environments like swamps, deep-ocean hydrothermal vents (oxygen-free environments)**
    - **Cell walls not made of peptidoglycan**
    - **Ex: Methanogens, Halophiles**
  - **Eubacteria live in most habitats**
    - **Cell walls made of peptidoglycan**
    - **Ex: E. coli, Streptococcus, cyanobacteria**



The Six Kingdoms of Organisms

Protista

- Eukaryotic (has a nucleus)
- Some have cell walls of cellulose
  - Some have chloroplasts
- Can be autotrophs or heterotrophs (some can be fungus-like)
- Most are unicellular; some are multicellular or colonial
- Ex: amoeba, paramecium,, euglena,
- Lacks complex organ systems
- Lives in moist environments

The Six Kingdoms of Organisms

Fungi

- Eukaryotes
- Cell walls of chitin
- Heterotrophs
- Most multicellular; some unicellular
- Ex: mushrooms, yeast
- Absorbs nutrients from organic materials in the environment
- Stationary

The Six Kingdoms of Organisms

Plants

- Eukaryotes
- Cell walls of cellulose
- Autotrophs
- Multicellular
- Photosynthetic→ contains chloroplasts
- Ex: mosses, ferns, trees, flowering plants
- Cannot move
- Tissues and organ systems

The Six Kingdoms of Organisms

Animalia

- Eukaryotes
- Do not have a cell wall or chloroplasts
- Heterotrophs
- Multicellular
- Ex: sponges, worms, insects, fish, mammals (nurse young)
- Mobile