Taxonomy

The Classification of Organisms

Why classify?

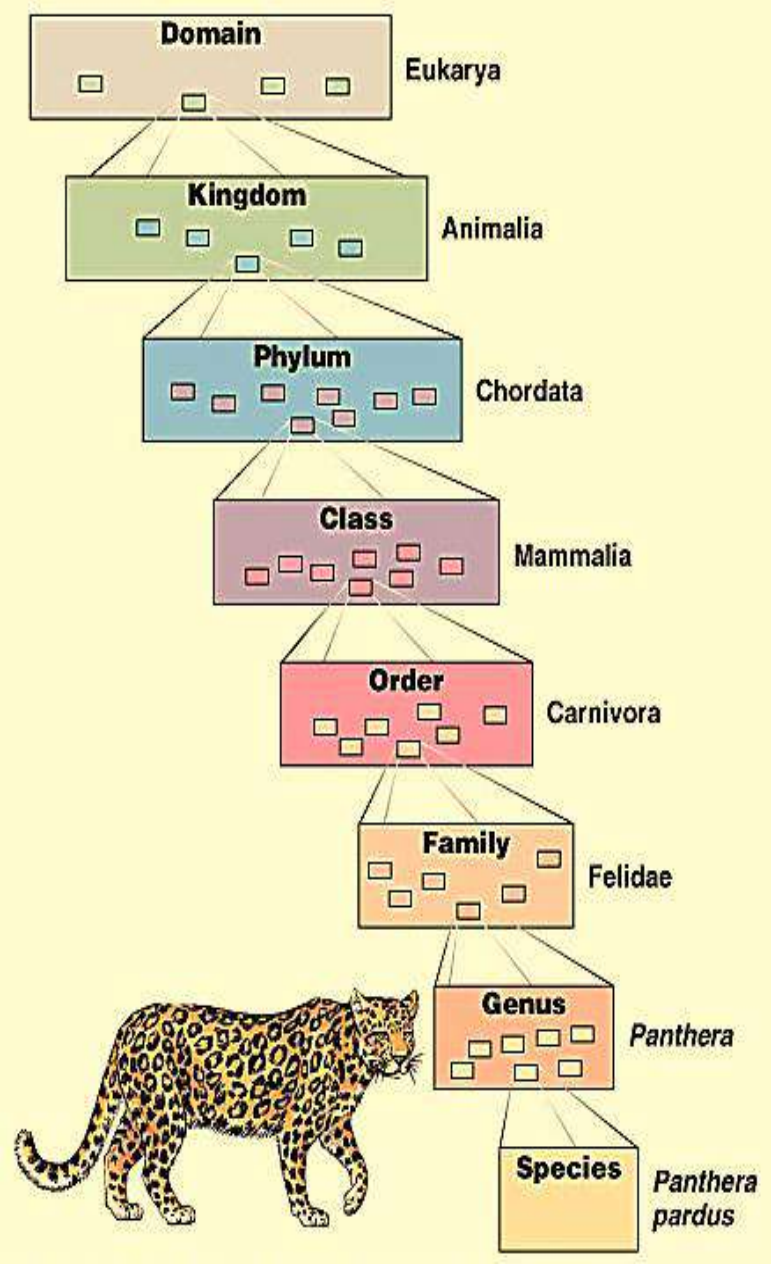
- Lots of diversity!
  - 5,200 Prokaryotes
  - 100,000 Fungi
  - 290,000 Plants
  - 52,000 Vertebrates
  - 1,000,000 Insects

Classification

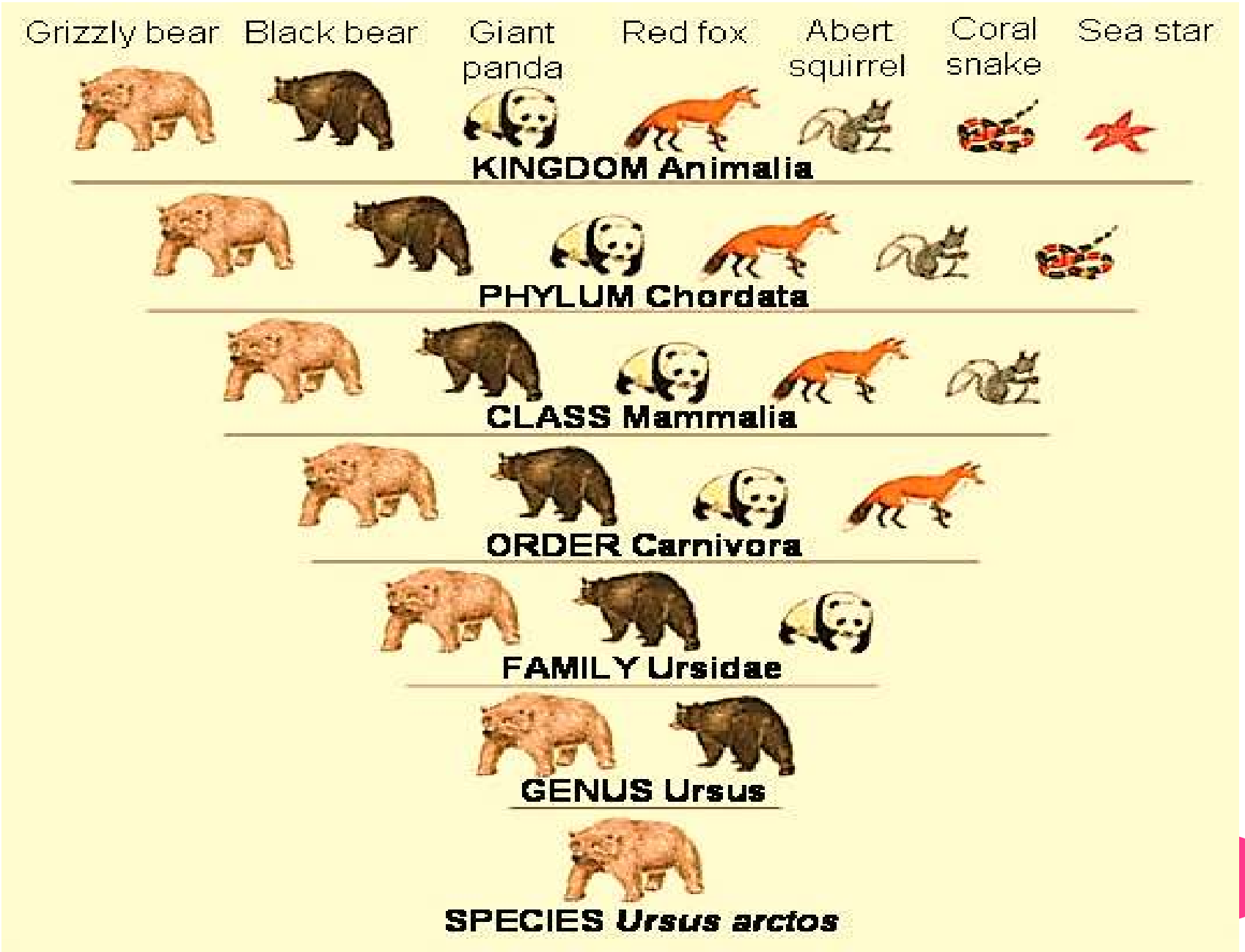
- Carolus Linnaeus (1707 – 1778) – the Swedish physician and botanist who founded taxonomy
  - Taxonomy is the part of biology concerned with naming and classifying organisms
- Linnaeus developed the two part, "binomial" system based on Latin for naming organisms
  - In fact, he used this system with himself. He grew up as Carl von Linne, but changed his name to Carolus Linnaeus later.

Hierarchy

- A hierarchical classification will group species into broader taxonomic categories.
- Species that appear to be closely related are grouped into the same genus.
  - For example, the leopard, Panthera *pardus*, belongs to a genus that includes the African lion (Panthera *leo*) and the tiger (Panthera *tigris*).



Genera are grouped into progressively broader categories: family, order, class, phylum, kingdom, and domain


Grizzly bear
Black bear
Giant panda
Red fox
Abert squirrel
Coral snake
Sea star
KINGDOM Animalia
PHYLUM Chordata
CLASS Mammalia
ORDER Carnivora
FAMILY Ursidae
GENUS Ursus
SPECIES Ursus arctos

…more Classification

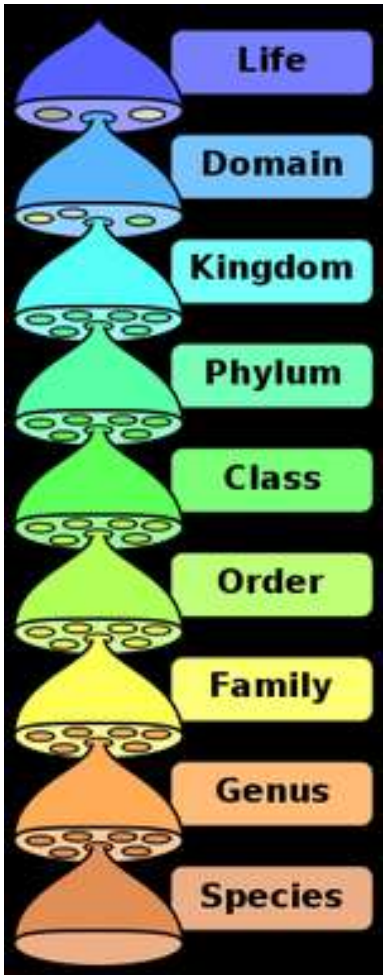
- Since Linnaeus' time, the levels of classification have been broadened
- From the most broad to the most specific:
  - Domain - Eukarya
    - Kingdom - Animalia
      - Phylum - Chordata
        - Class - Mammalia
          - Order - Carnivora
            - Family - Canidae
              - Genus - Canis
                - Species – *familiaris*

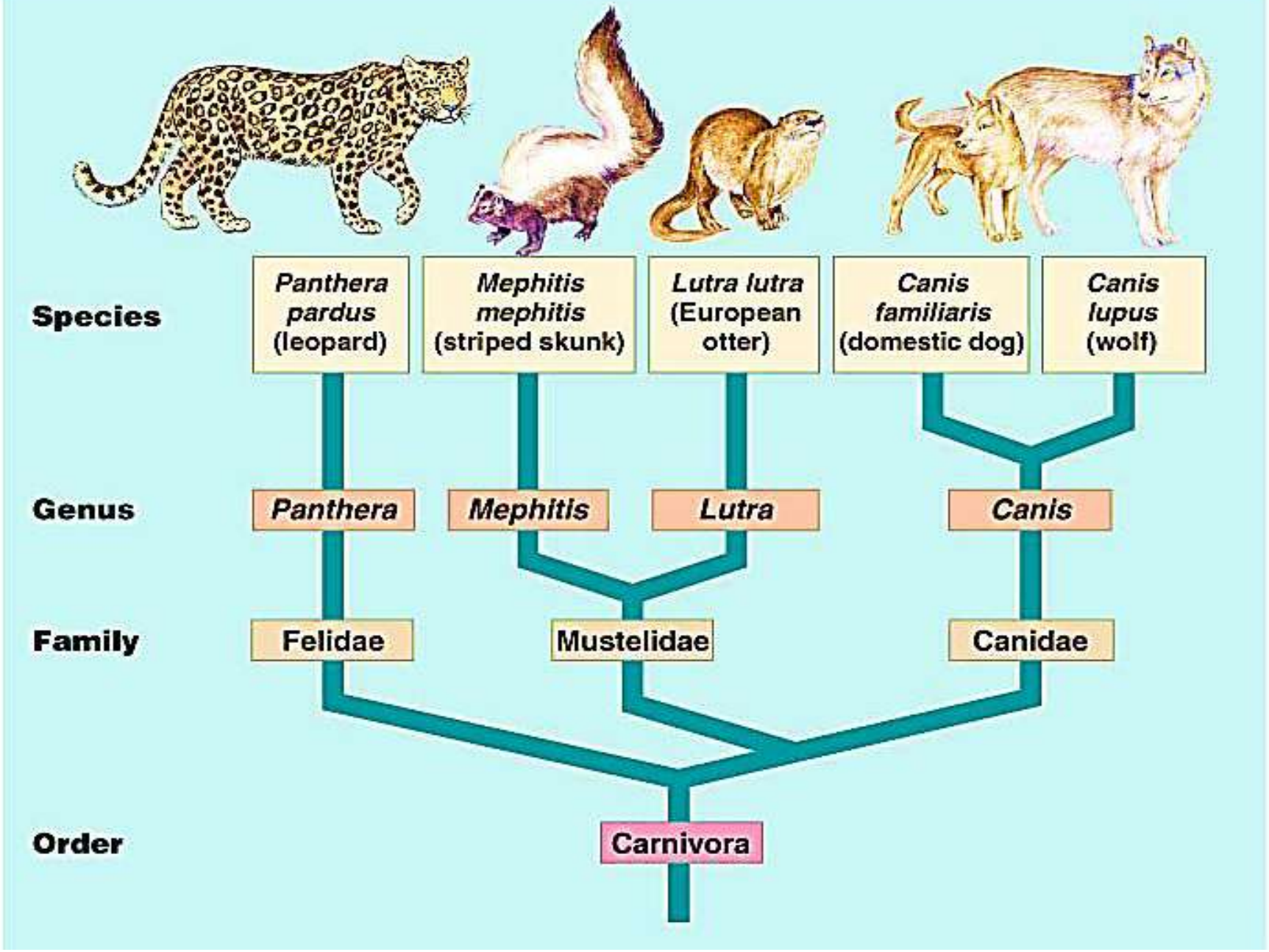
Canis *familiaris*

Species names are **ALWAYS** in italics, with the genus capitalized and the species lowercase

Picture it as a series of umbrellas grouped under each other.

- Similar species are combined into a genus
- Similar genera are united into a family
- Similar orders are collected into a class
- Similar classes are united into a phylum
- Similar phyla are collected into a kingdom
- Similar kingdoms are grouped into a domain.




Species
Panthera pardus (leopard)
Mephitis mephitis (striped skunk)
Lutra lutra (European otter)
Canis familiaris (domestic dog)
Canis lupus (wolf)
Genus
Panthera
Mephitis
Lutra
Canis
Family
Felidae
Mustelidae
Canidae
Order
Carnivora

Evolutionary History in Classification

- **Phylogeny** - an organism's evolutionary history
  - Many scientists study phylogeny using cladistics.
    - Infers relationships based on characters
  - **Ancestral character** - shared character between two groups
    - Example: the backbone of birds and mammals is an ancestral character.
  - **Derived character** - character that evolved in an ancestor of one group, but not the other
    - Example: feathers of birds, but not mammals

The Three Domains

DOMAIN BACTERIA

Bacteria are the most diverse and widespread prokaryotes and are now divided among multiple kingdoms. Each of the rod-shaped structures in this photo is a bacterial cell. 4 µm

DOMAIN ARCHAEA

Many of the prokaryotes known as **archaea** live in Earth's extreme environments, such as salty lakes and boiling hot springs. Domain Archaea includes multiple kingdoms. The photo shows a colony composed of many cells. 0.5 µm

DOMAIN EUKARYA

Protists (multiple kingdoms) are unicellular eukaryotes and their relatively simple multicellular relatives. Pictured here is an assortment of protists inhabiting pond water. Scientists are currently debating how to split the protists into several kingdoms that better represent evolution and diversity. 100 µm

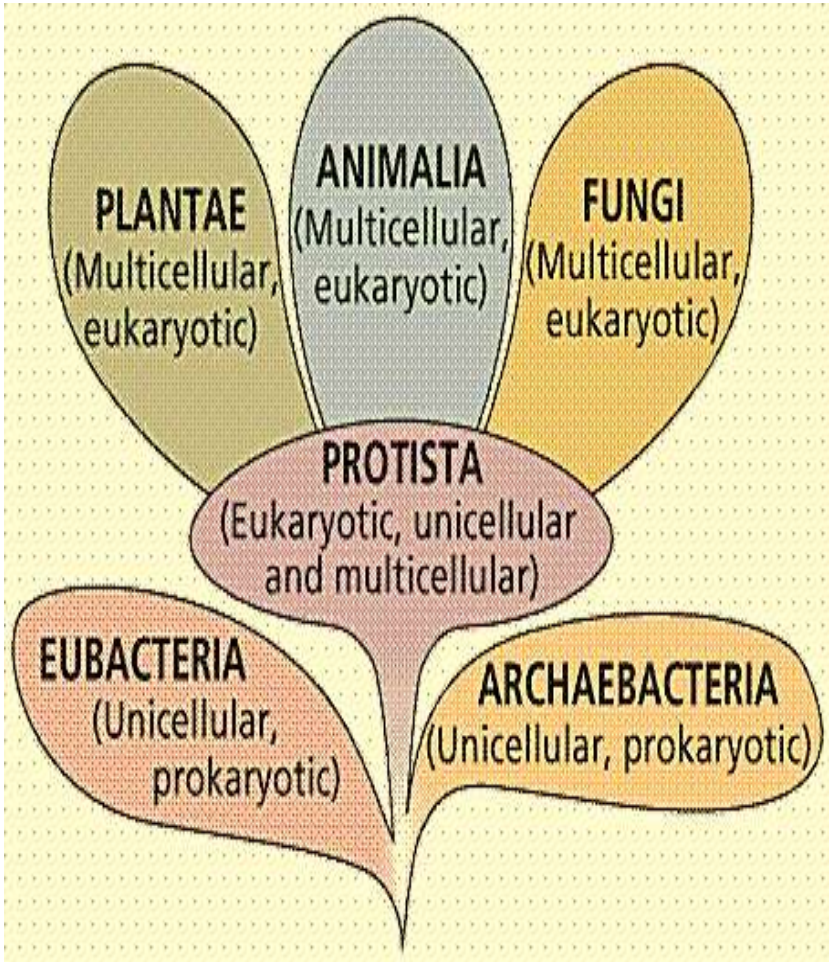
Kingdom Plantae consists of multicellular eukaryotes that carry out photosynthesis, the conversion of light energy to food.

Kindom Fungi is defined in part by the nutritional mode of its members, such as this mushroom, which absorb nutrients after decomposing organic material.

Kindom Animalia consists of multicellular eukaryotes that ingest other organisms.

6 Kingdoms of Life

- Archaebacteria
- Eubacteria
- Protista
- Fungi
- Plantae
- Animalia



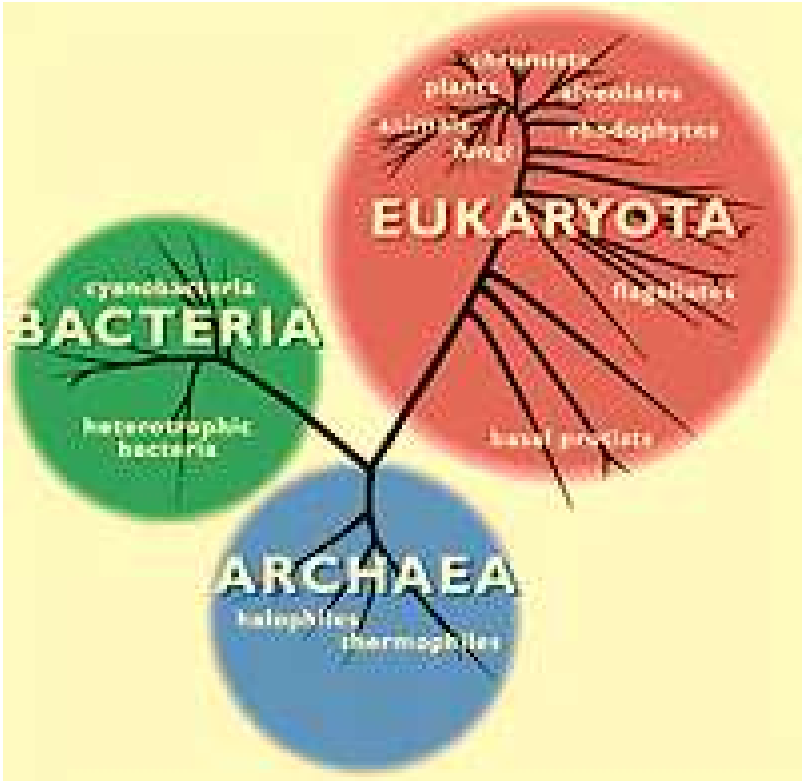
What happened to Kingdom Monera?

- **Eubacteria** and **Archaebacteria** used to be grouped into one kingdom: **Monera**

- Developments in RNA and DNA sequencing revealed that **Archaebacteria** are more closely related to eukaryotes than **Eubacteria**.

3 Super-kingdom Domains

- Bacteria
  - Eubacteria
- Archaea
  - Archaebacteria
- Eukarya
  - Protista
  - Fungi
  - Plantae
  - Animalia

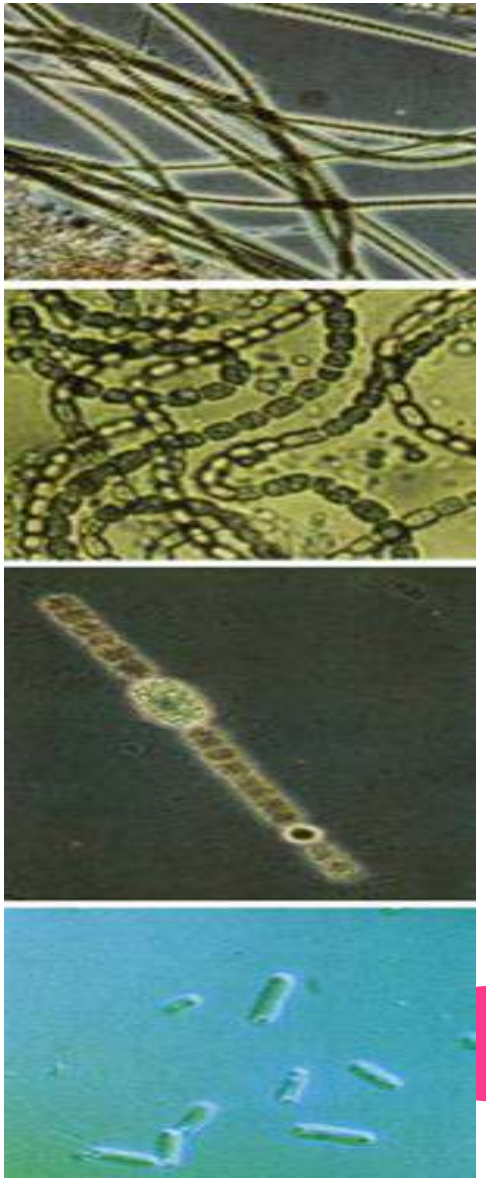


Kingdom Characteristics

- **Organization**
  - **Cell type** (prokaryotic; eukaryotic)
  - **Cell structure** (cell wall)
  - **Body type** (unicellular; multi-cellular)
- **Nutrition** (**autotrophic** - makes their own food); **heterotrophic** – cannot make their own food)
- **Reproduction** (sexual; asexual)
- Environmental significance
- Examples

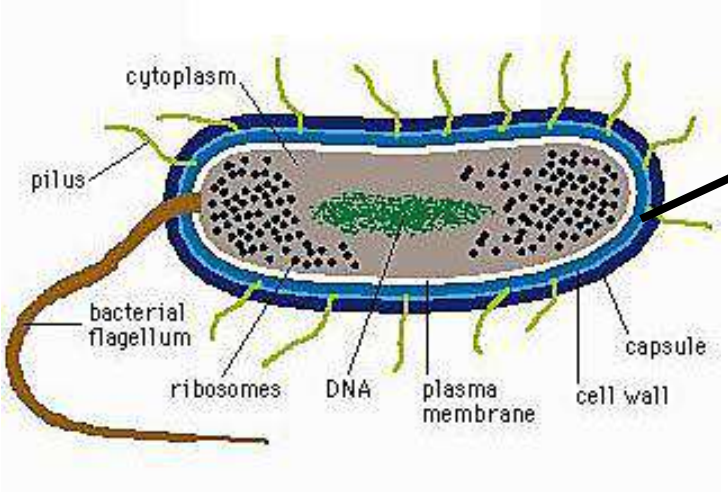
Eubacteria

- **Domain: Bacteria**
- **Kingdom: Eubacteria**
- **Organization:**
  - **Cell type:** prokaryotic
  - **Cell structure:** cell wall - peptidoglycan
  - **Body type:** unicellular
- **Nutrition:** autotrophic and heterotrophic
- **Reproduction:** asexual: binary fission
- **Most commonly known bacteria**
- **12 different phyla**



Eubacteria

- **Environmental Significance:**
  - Most abundant organism on earth
  - Found in almost every environment on earth
  - Often classified by shape
  - Oxygen producers
- **Examples:**
  - E. coli, cyanobacteria, Streptococcus bacteria



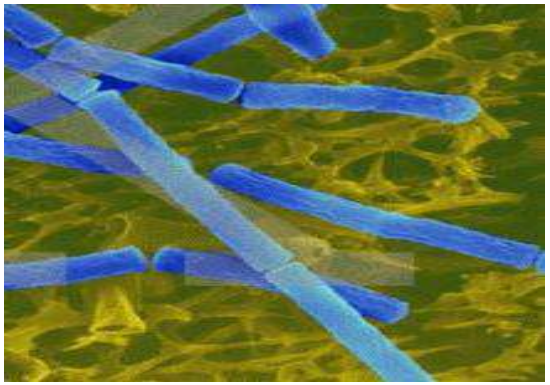
Cell wall is made up peptidoglycan

- A bacteria with a cell wall containing a large amount of **peptidoglycan** is classified as "gram-positive"
- A bacteria with a thin layer of **peptidoglycan** is "gram-negative"
- When dyed purple, gram-positive bacteria retain the purple.... gram-negative bacteria usually lose the stain and look pink

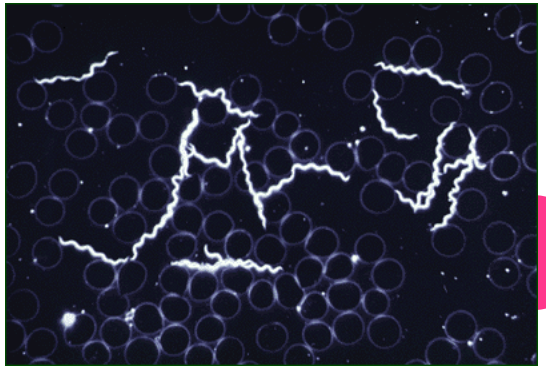
Eubacteria are classified by shape

- **Coccus** – round cell

- **Bacillus** – rod-shaped cell

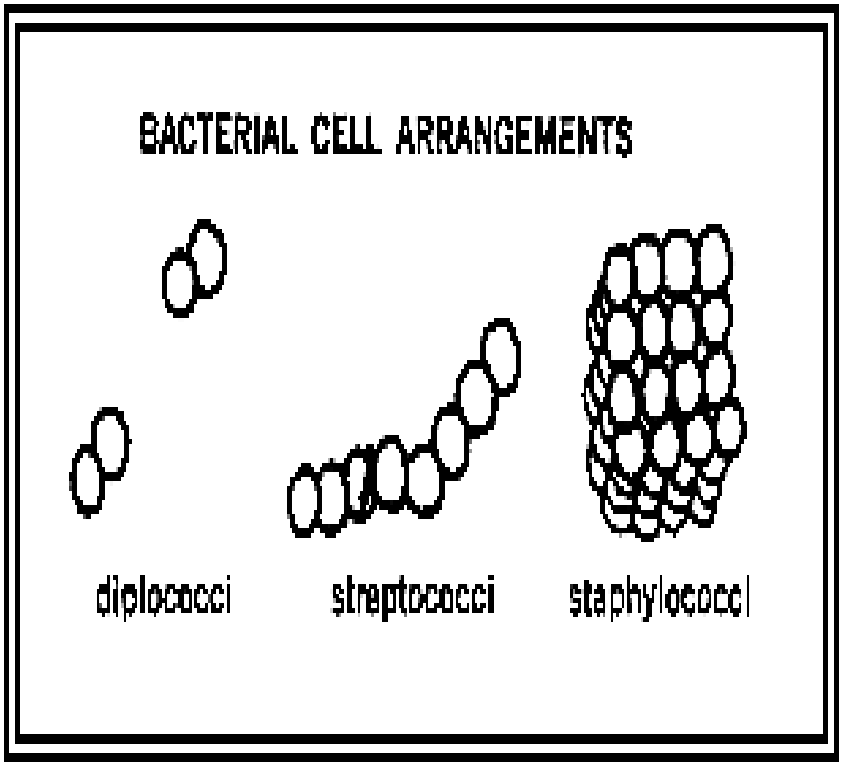


- **Spirillum** – spiral-shaped cell



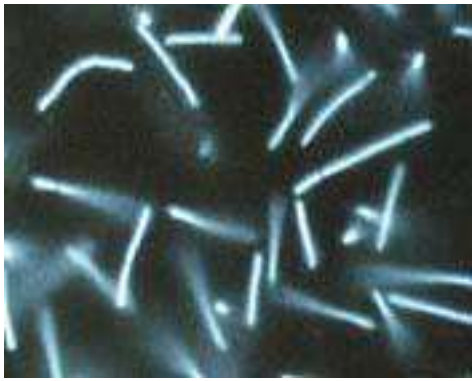
Also classified by clustering:

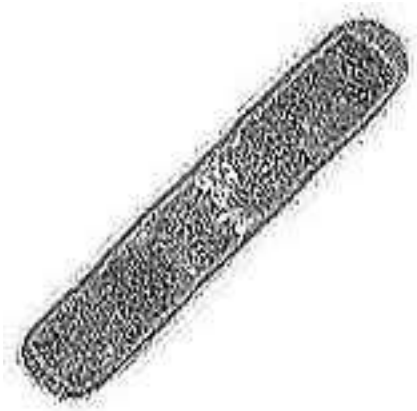
- **Diplo** – pairing of cells
- **Strepto** – string of cells in a filament
- **Staphylo** – clusters of cells



Archaebacteria

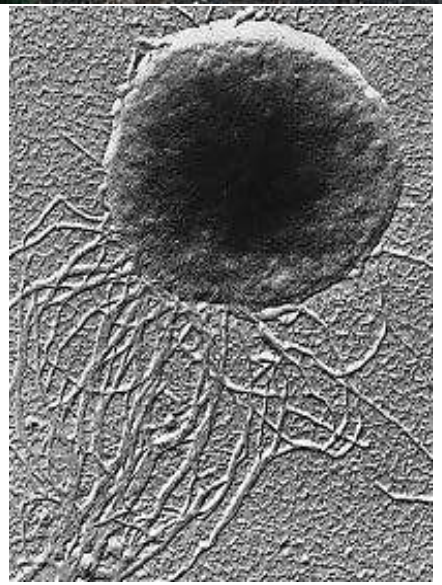
- **Domain: Archaea**
  - **Kingdom: Archaebacteria**
  - **Organization:**
    - **Cell type:** prokaryotic
    - **Cell structure:** cell wall- lipids
    - **Body type:** unicellular
  - **Nutrition:** autotrophic and heterotrophic
    - All are **anaerobic**
    - **Reproduction:** asexual (binary fission, budding, and fragmentation)
    - **Could be ancestors of eukaryotic cells.**



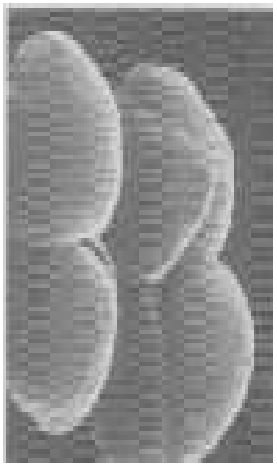


Archaebacteria

- **Environmental Significance:**
  - Found in extreme environments (hydrothermal vents on ocean floor, rock cracks in Antarctic desert)
  - Suggests that they may have evolved during early earth.
  - Produce methane gas
  - Cell walls lack peptidoglycan.



- **Methanogens**
  - Convert CO_2 into methane (many live in the intestines of animals)
- **Extreme Halophiles**
  - Require high concentrations of salt to survive (some need it to be 10x saltier than seawater)
  - harmless
- **Thermo-acidophiles**
  - Thrive in environments that are hot and acidic (60 – 80 C, pH 2 – 4)
  - **Sulfer springs in Yellowstone National Park are inhabited by thermo-acidophiles that get their energy from sulfur**

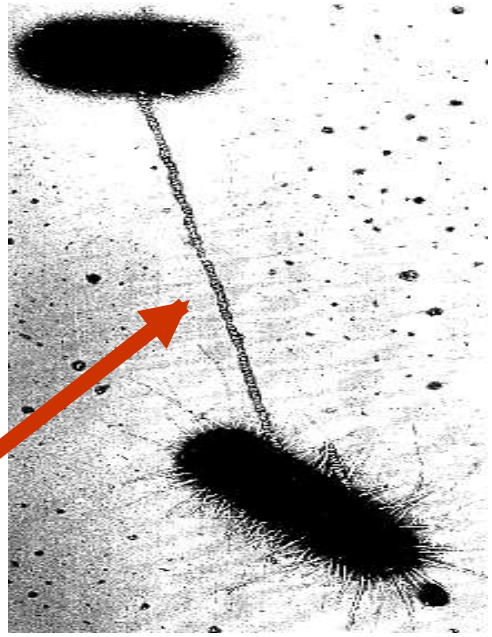


Ways Bacteria Obtain Energy:

- **Photosynthetic bacteria**
  - Get energy from sunlight
  - Ex: **cyanobacteria** → responsible for introducing oxygen into the Earth's atmosphere
- **Chemoautotrophic bacteria**
  - Many live in the soil and get their energy by "fixing" nitrogen, in a process called **nitrification**
  - Nitrification takes ammonia and turns it into nitrate, a from of nitrogen that plants can use
- **Heterotrophic bacteria**
  - **Decomposers** – break down bodies of dead organisms and make the nutrients available for other organisms
  - Some mutant strains have been found to break down synthetic products like nylon and pesticide

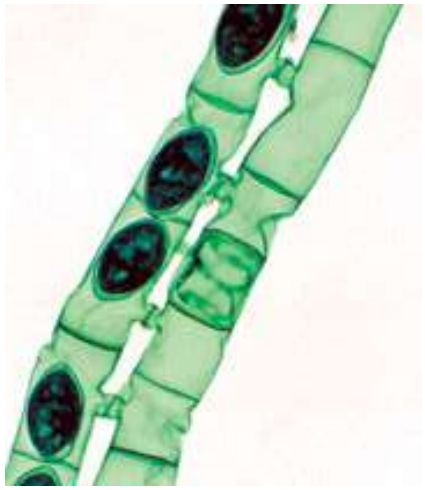
Finishing Bacteria:

- Bacteria reproduce asexually through binary fission
- Some bacteria can reproduce with a very primitive type of sexual reproduction called "conjugation"
  - Conjugation is a simple, direct donation of DNA from one bacteria to another (it is always just one way)
  - A cytoplasmic bridge forms between the two cells, and the DNA passes this way



Protista

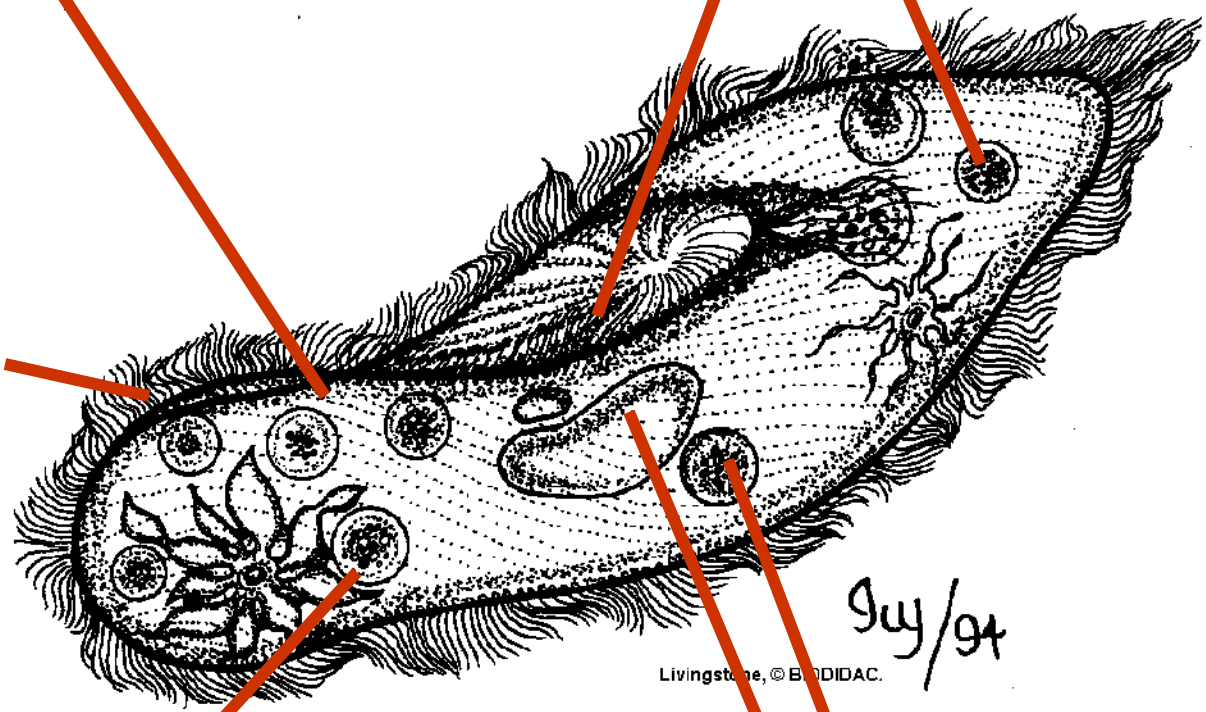
- **Domain:** Eukarya
- **Kingdom:** Protista
- **Organization:**
  - **Cell type:** eukaryotic
  - **Cell structure:** mixed
  - **Body type:** unicellular (most), colonial, and some multi-cellular
- **Nutrition:** autotrophic (photosynthesis) and heterotrophic (absorb food, engulf smaller organisms)
- **Reproduction:** asexual and sexual (some can undergo meiosis and reproduce with sperm and eggs!)



Protista

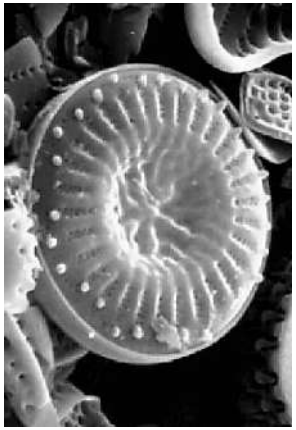
- **Environmental Significance:**
  - Important producers in ocean/pond food chain
  - Phytoplankton component that is major oxygen producer
- **Examples:**
  - Phytoplankton and zooplankton
  - Algae
  - Amoeba
  - Paramecium
- **Main commonality is that they really didn't fit in any other kingdom, thus lending this kingdom to contain the most diversity!!!**

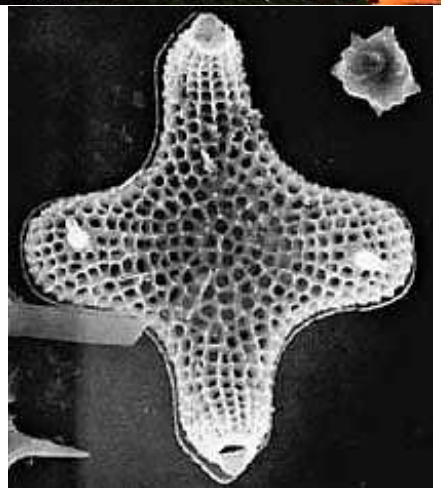
Anatomy (of a paramecium)



- Protists can be either autotrophic or heterotrophic
- Autotrophic protists are called “algae”
- Algae produce 1/3 of the atmosphere’s oxygen
- Most algae are unicellular
  - A type of plankton called phytoplankton (“plant-plankton”)
- Some store their energy as oil, and when they die and settle they form oil deposits

- Diatoms are a type of phytoplankton
  - Have shells made of silica (glass-like)
  - Their shells are used in detergents, insulation, street paint
- Red tides are caused by dinoflagellates
  - These dinoflagellates release toxins into the water



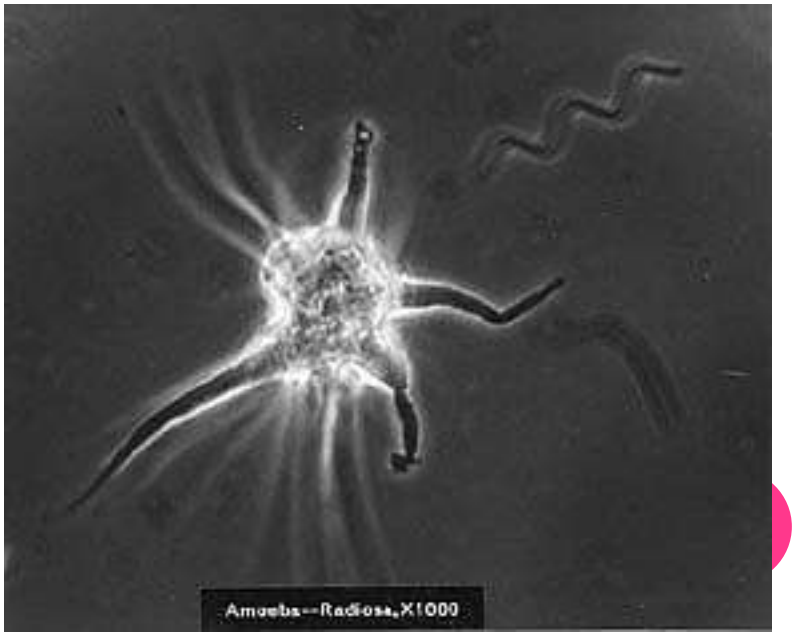


- **Animal-like protists are called protozoa (“first-animals”)**
  - Many believe they are the ancestors of modern animals
  - They are divided into 4 groups based on their form of locomotion:

- **Flagellates:** move with flagella
  - **ex: Trichonympha** – the protozoa that lives in the stomach of termites and digests wood

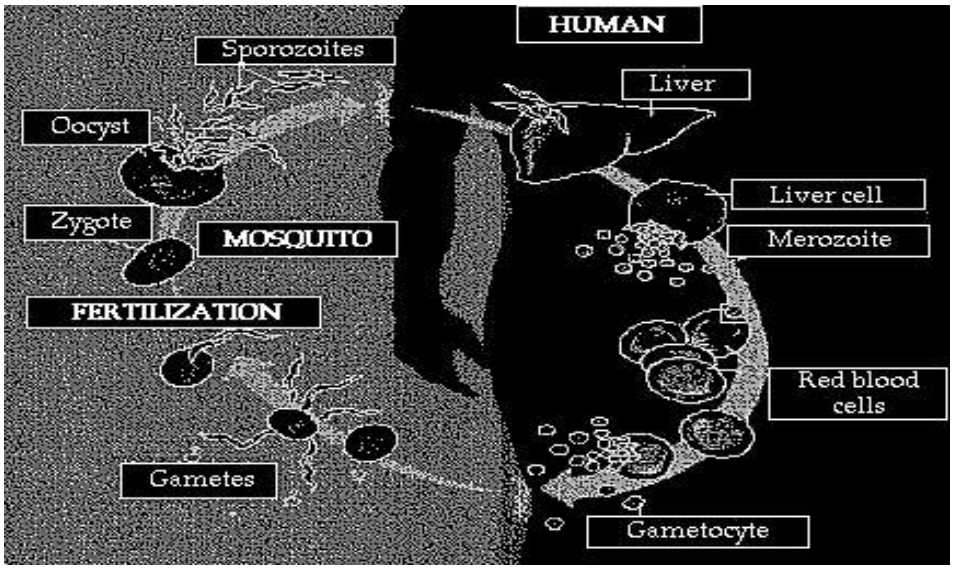
- **Ciliates:** move with cilia
  - **Ex: Paramecium**

- **Amoebas:** move with pseudopodia (false-feet)
  - Use pseudopodia to eat thru endocytosis
- **Sporozoans:** non-motile, spore-forming, unicellular parasites
  - **Ex: Plasmodium**



Diseases caused by Protists…

- Usually transmitted by insects or contaminated water
- Malaria is caused by the protozoan Plasmodium
  - Female mosquitoes of the genus Anopheles (males eat nectar, not blood)
  - Plasmodium go directly to the liver, where they reproduce
- Dysentery
- Giardia
- Sleeping Sickness
- Chagas Disease



Fungi

- **Domain: Eukarya**
- **Kingdom: Fungi**
- **Organization:**
  - **Cell type:** eukaryotic
  - **Cell structure:** cell wall made of chitin
  - **Body type:** unicellular and multicellular
- **Nutrition:** heterotrophic (absorbs food)
- **Reproduction:** asexual (budding, fission) and sexual; spores

Fungi

- **Environmental Significance:**
  - Decomposers and consumers
  - Parasites
  - Produce antibiotics
- **Examples:**
  - Yeasts
  - Mushrooms
  - Mold, mildew

Plantae

- **Domain: Eukarya**
  - **Kingdom: Plantae**
  - **Organization:**
    - **Cell type:** eukaryotic
    - **Cell structure:** cell wall -cellulose
    - **Body type:** multi-cellular
- **Nutrition:** autotrophic
- **Reproduction:** asexual and sexual

Plantae

- **Environmental Significance:**
  - Food source (producer in most food chains)
  - Medicines and drugs
  - Building material
  - Fuel
- **Examples:**
  - **Angiosperms** – broad, flat leaves
  - **Gymnosperms** – cone bearing, needle leaves
  - **Mosses**
  - **Ferns**

Animalia

- **Domain:** Eukarya
  - **Kingdom:** Animalia
  - **Organization:**
    - **Cell type:** eukaryotic
    - **Cell structure:** no cell wall
    - **Body type:** multicellular
  - **Nutrition:** heterotrophic
  - **Reproduction:** sexual

Animalia

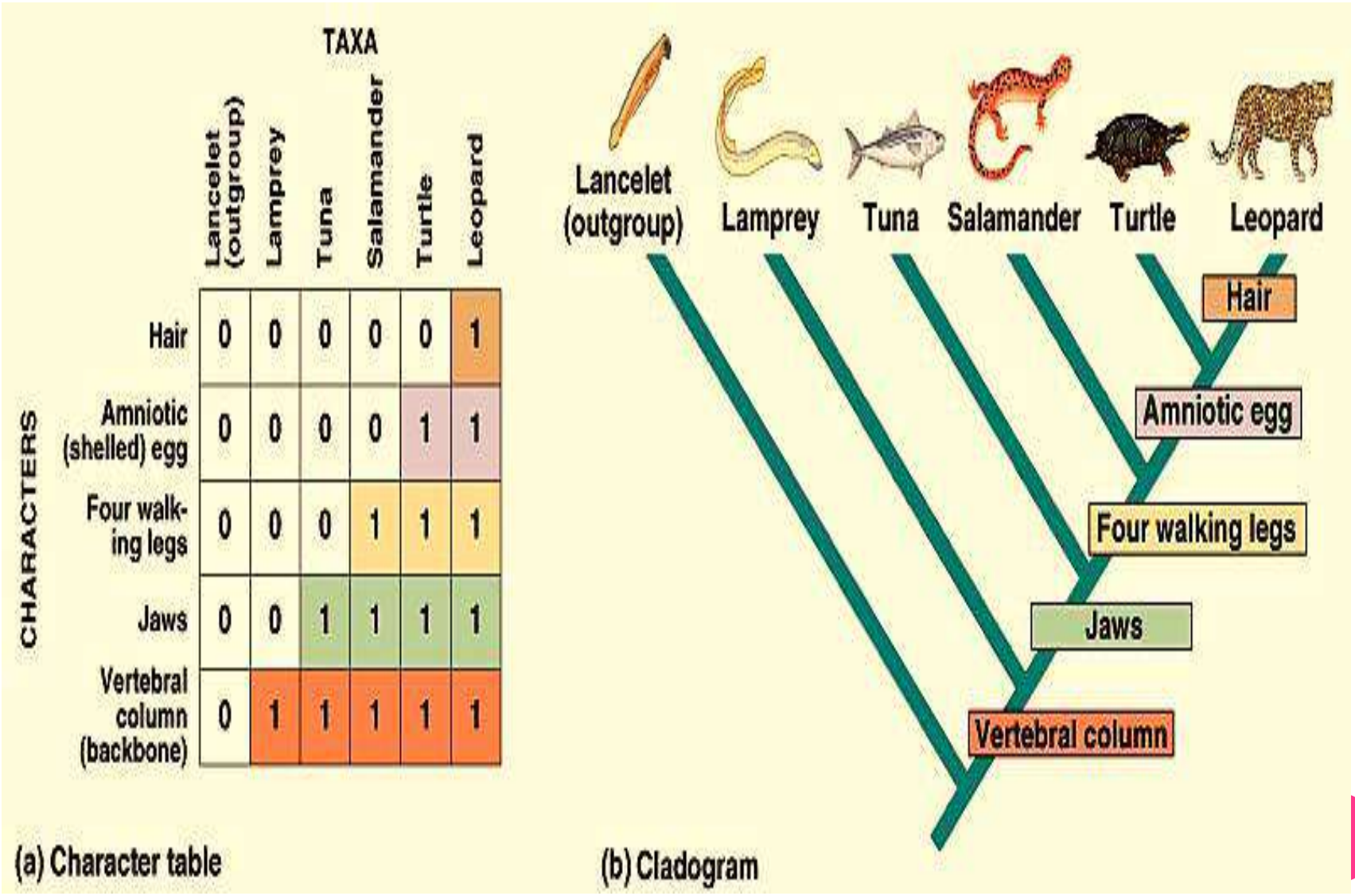
- **Environmental Significance:**
  - Consumer in most food chains (herbivores, carnivores, omnivores)
  - Food source
- **Examples:**
  - Sponges, mollusks, insects, fish, amphibians, reptiles, birds, mammals

Cladistics

- **Cladistics (branch")** is a method of classifying species of organisms into groups called **clades,** which consist of an ancestor organism and all its descendants.
  - **For example:** birds, dinosaurs, crocodiles, and all descendants (living or extinct) of their most recent common ancestor form a clade.
  - In the terms of biological systematics, a **clade** is a single "branch" on the "tree of life".

- **Cladistics** can be distinguished from other taxonomic systems, by its focus on shared derived characters. Systems developed earlier usually employed overall **morphological similarity** to group species into genera, families and other higher level groups **(taxa); cladistic classifications** (usually in the **form of trees** called **cladograms)** are intended to reflect the relative closeness of common ancestry or the sharing of homologous features.

Cladograms


TAXA
Lancelet (outgroup)
Lamprey
Tuna
Salamander
Turtle
Leopard
CHARACTERS
Hair 0 0 0 0 0 1
Amniotic (shelled) egg 0 0 0 0 1 1
Four walk-ing legs 0 0 0 1 1 1
Jaws 0 0 1 1 1 1
Vertebral column (backbone) 0 1 1 1 1 1
(a) Character table
Lancelet (outgroup)
Lamprey
Tuna
Salamander
Turtle
Leopard
Hair
Amniotic egg
Four walking legs
Jaws
Vertebral column
(b) Cladogram