



# 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.



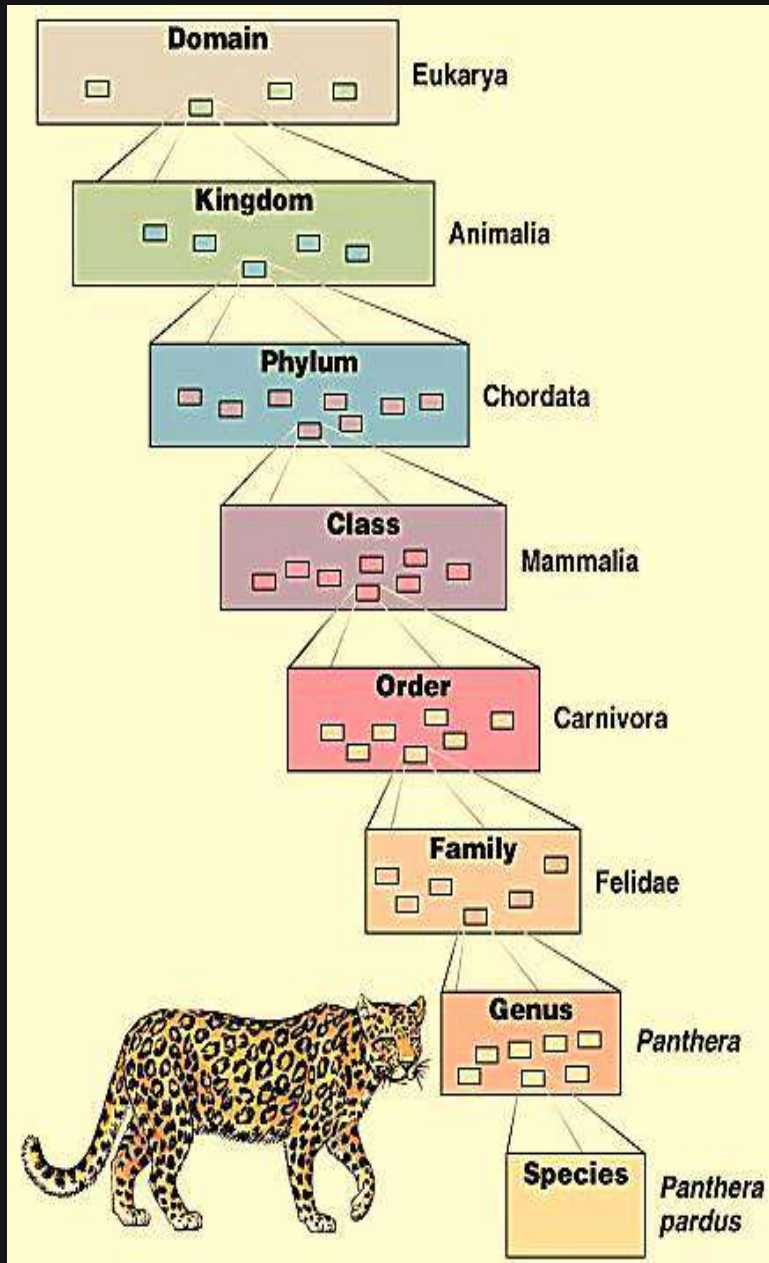
# Hierarchy

- ✧ 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**

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**PHYLUM Chordata**

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**CLASS Mammalia**

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**ORDER Carnivora**

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**FAMILY Ursidae**

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**GENUS Ursus**

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**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

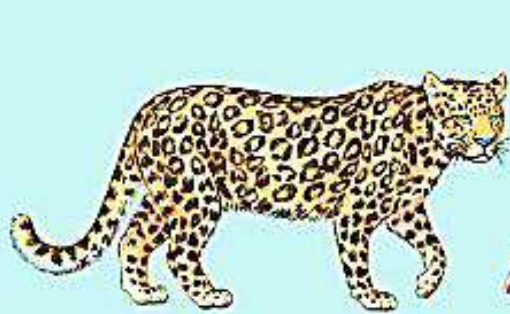


# Picture it as a series of umbrellas grouped under each other.

- \* 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.

## 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.

## 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.



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



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

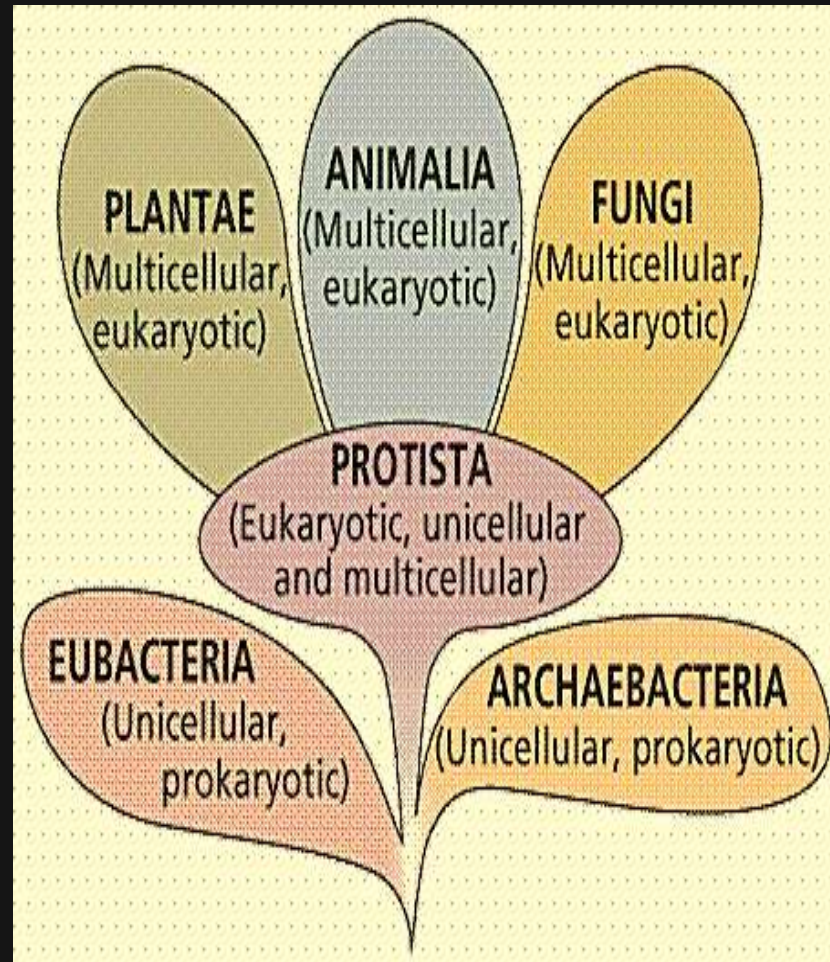


**Kingdom Animalia** consists of multicellular eukaryotes that ingest other organisms.



# 6 Kingdoms of Life

- \* **Archaeobacteria**
- \* **Eubacteria**
- \* **Protista**
- \* **Fungi**
- \* **Plantae**
- \* **Animalia**



# What happened to Kingdom Monera?

- ✧ **Eubacteria** and **Archaeobacteria** used to be grouped into one kingdom: **Monera**
- ✧ Developments in RNA and DNA sequencing revealed that **Archaeobacteria** are more closely related to eukaryotes than **Eubacteria**.





# 3 Super-kingdom Domains

## \* Bacteria

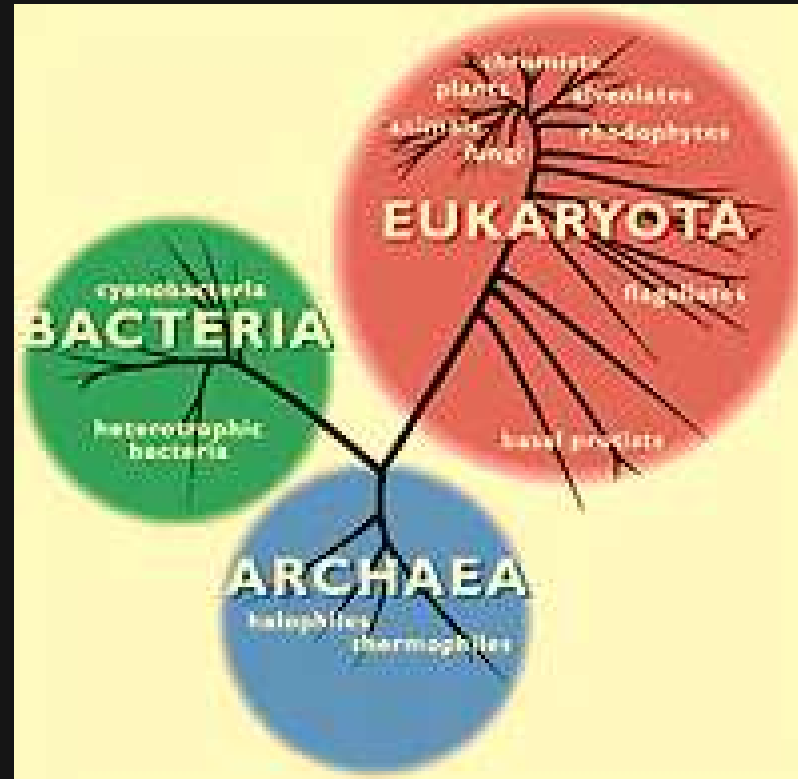
- Eubacteria

## \* Archaea

- Archaeobacteria

## \* 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



✧ **Domain: Bacteria**

✧ **Kingdom: Eubacteria**

✧ **Organization:**

- **Cell type:** prokaryotic
- **Cell structure:** cell wall - peptidoglycan
- **Body type:** unicellular

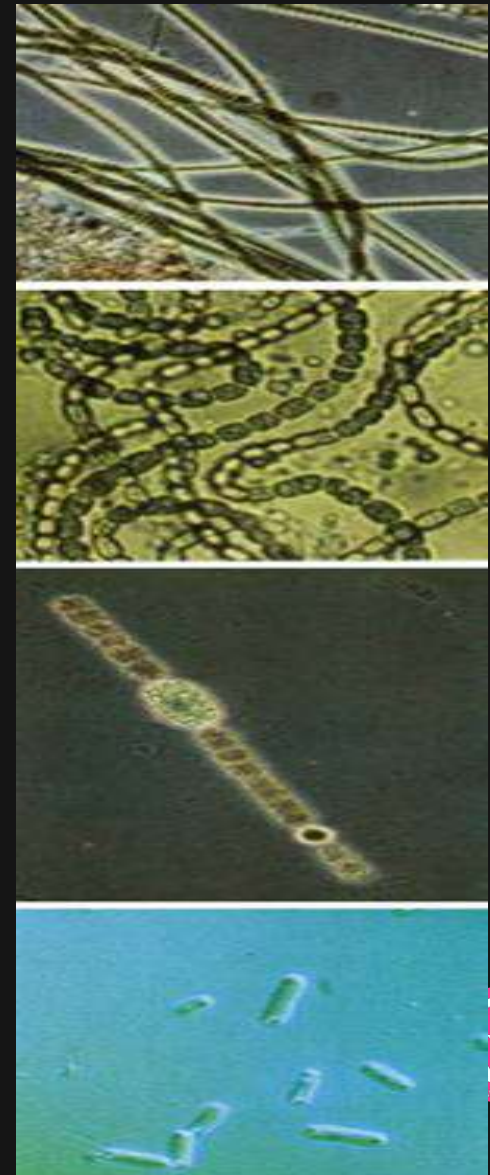
✧ **Nutrition:** autotrophic and heterotrophic

✧ **Reproduction:** asexual: binary fission

✧ **Most commonly known bacteria**

✧ **12 different phyla**

# Eubacteria



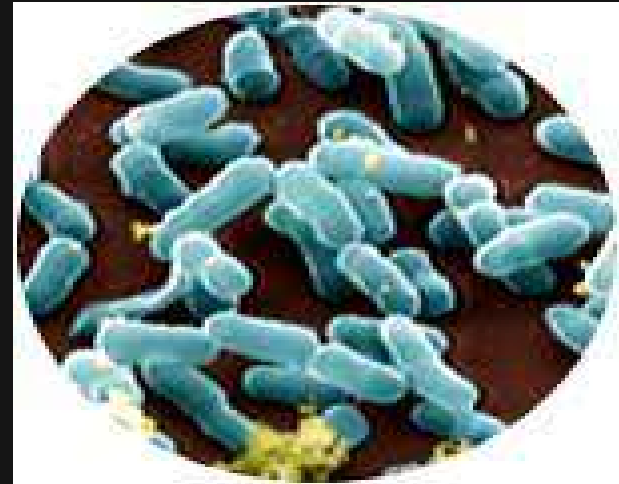
# Eubacteria

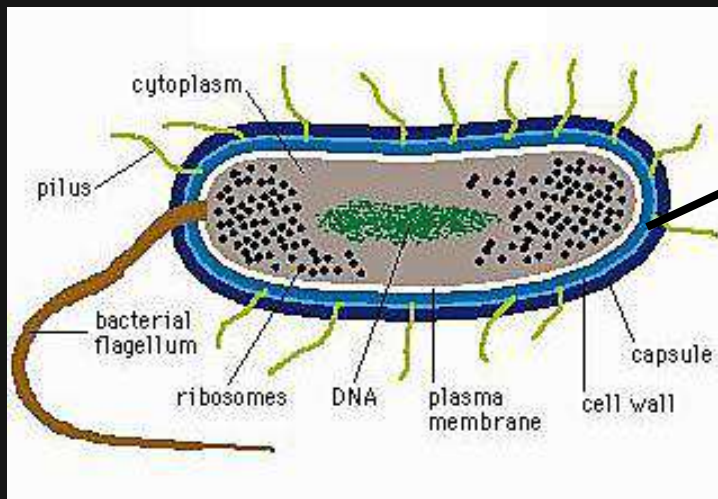
## \* Environmental Significance:

- 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 of peptidoglycan**

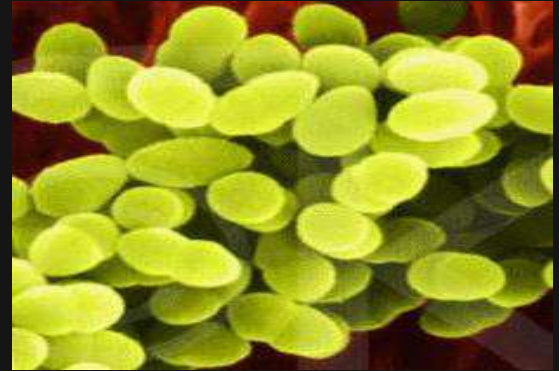
- A bacteria with a cell wall containing a large amount of **peptidoglycan** is classified as “gram-positive”
- A bacteria with a thin layer of **peptidoglycan** is “gram-negative”
- When dyed purple, gram-positive bacteria retain the purple... gram-negative bacteria usually lose the stain and look pink



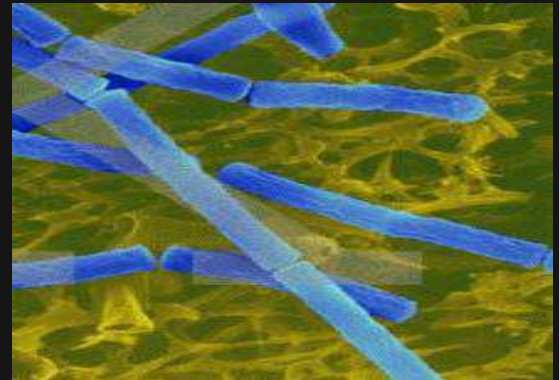


# Eubacteria are classified by shape

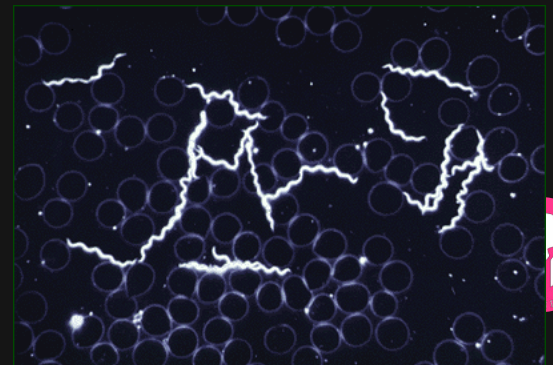
✧ **Coccus** – round cell



✧ **Bacillus** – rod-shaped cell

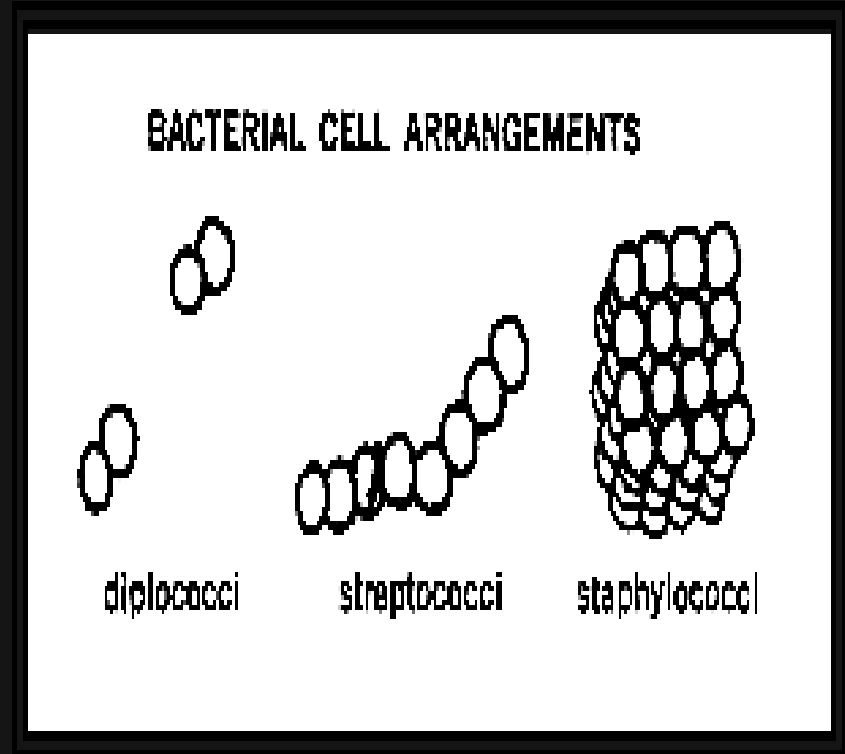


✧ **Spirillum** – spiral-shaped cell



# Also classified by clustering:

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



# Archaeobacteria

✧ **Domain: Archaea**

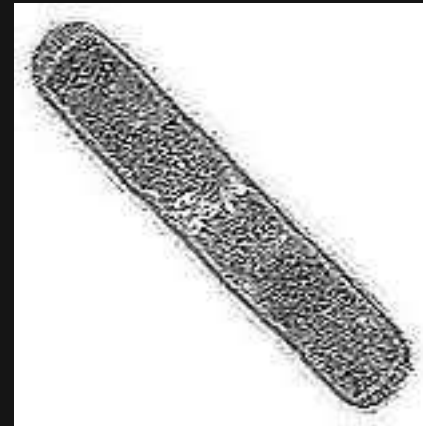
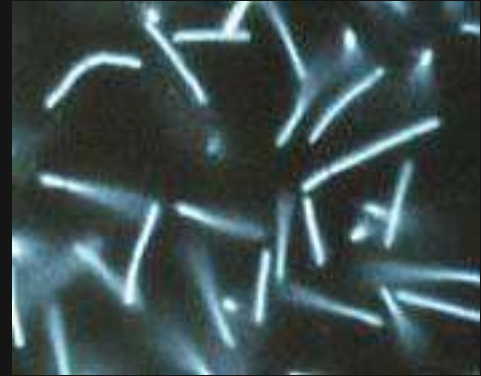
✧ **Kingdom: Archaeobacteria**

✧ **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.**

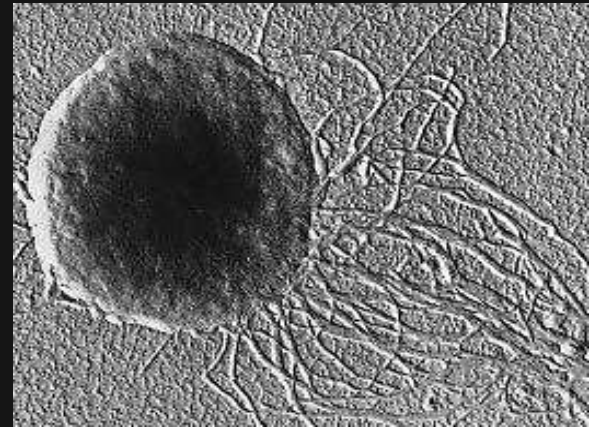


# Archaeobacteria

## ✧ 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**

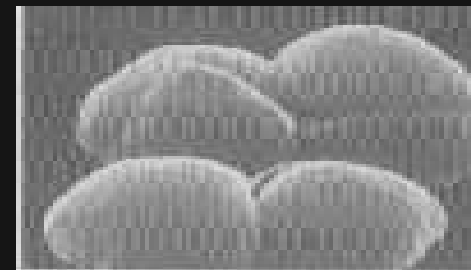
- \* Convert CO<sub>2</sub> into methane (many live in the intestines of animals)

## \* **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

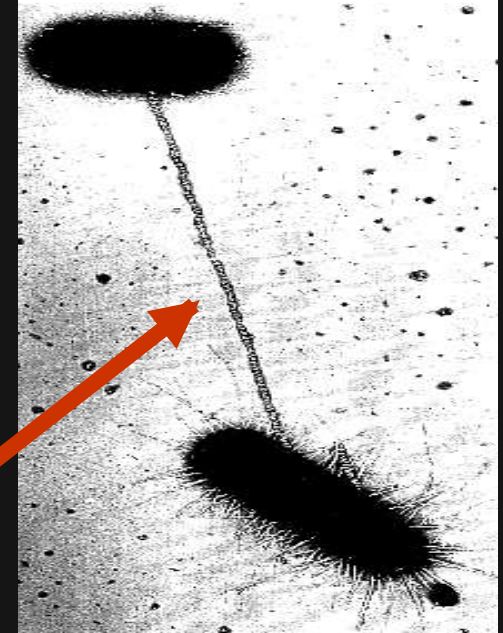
- Many live in the soil and get their energy by “fixing” nitrogen, in a process called **nitrification**
- Nitrification takes ammonia and turns it into nitrate, a form of nitrogen that plants can use

## \* 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 multicellular

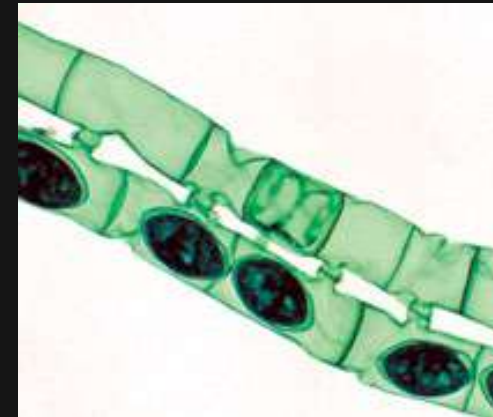
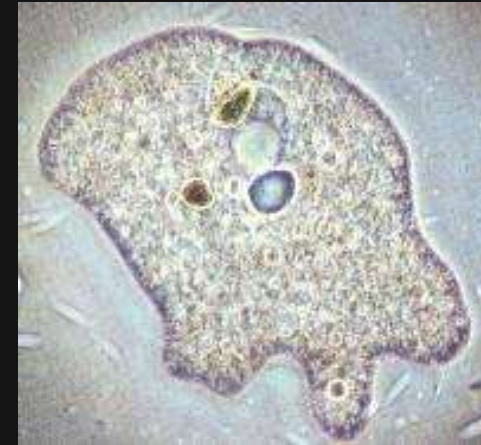
\* **Nutrition:** autotrophic

(photosynthesis) and heterotrophic

(absorb food, engulf smaller  
organisms)

\* **Reproduction:** asexual and sexual

(some can undergo meiosis and  
reproduce with sperm and eggs!)





## Environmental Significance:

- Important producers in ocean/pond food chain
- Phytoplankton component that is major oxygen producer



## Examples:

- Phytoplankton and zooplankton
- Algae
- Amoeba
- Paramecium

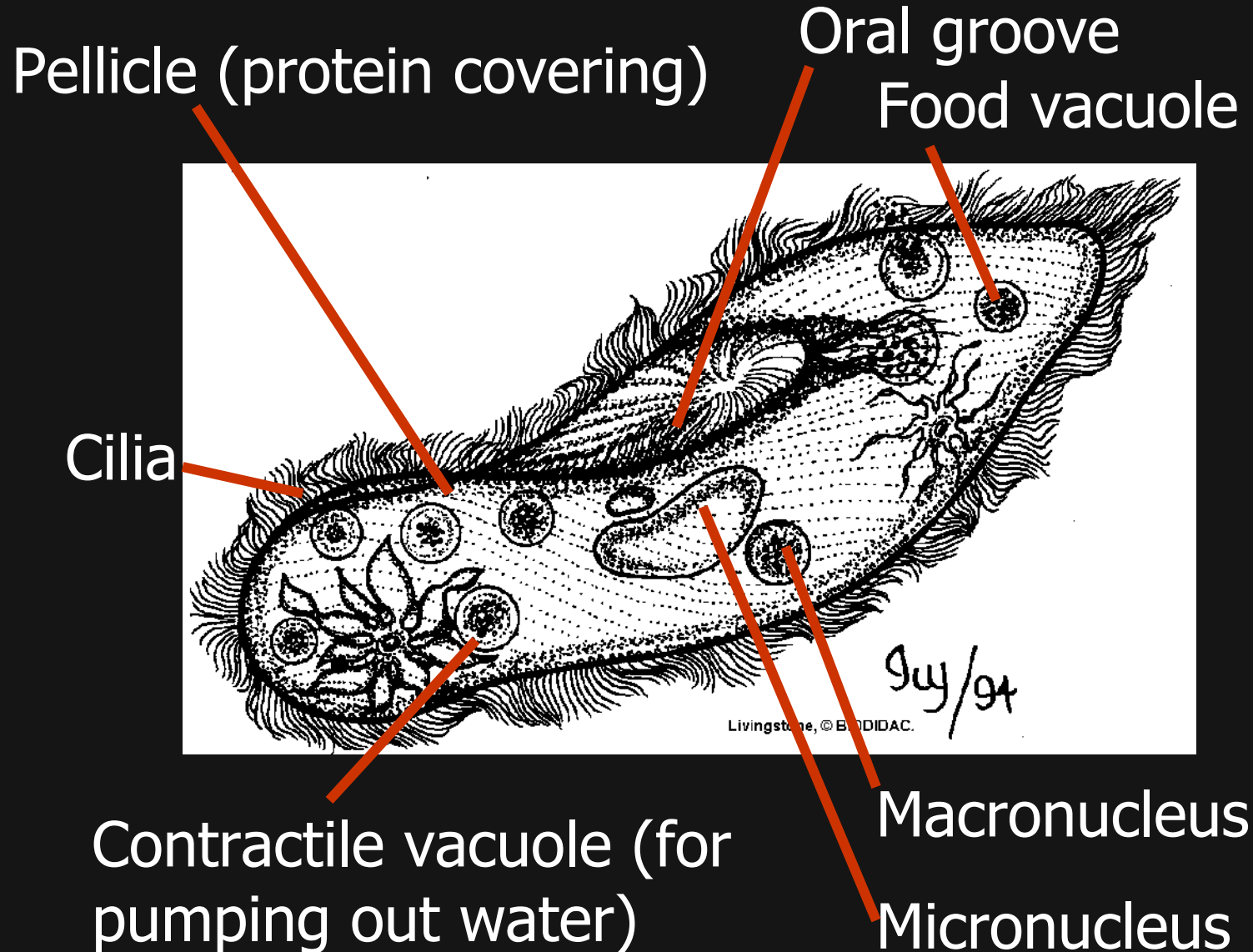


**Main commonality is that they really didn't fit in any other kingdom, thus lending this kingdom to contain the most diversity!!!**

# Protista



# 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



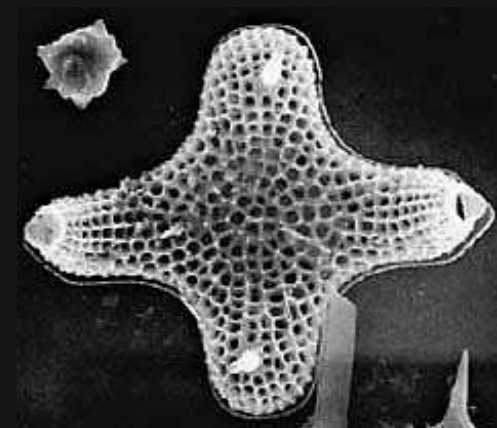
✧ Diatoms are a type of phytoplankton

- 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

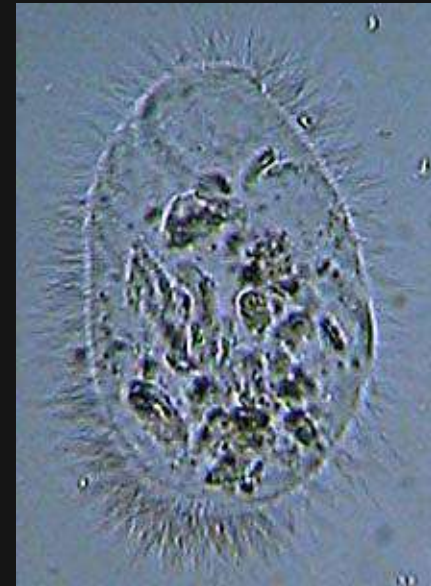


✳ **Animal-like protists are called protozoa (“first-animals”)**

- 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

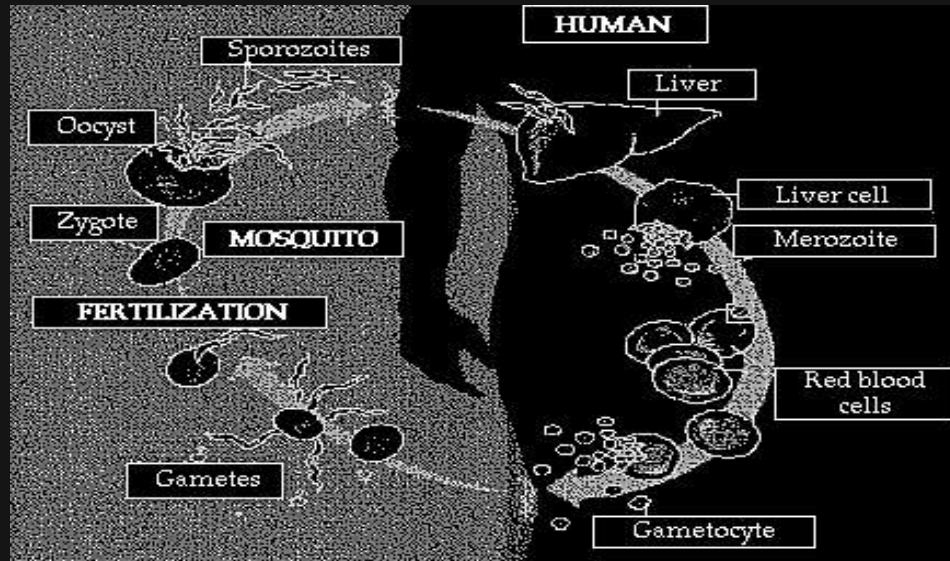
✧ **Sporozoans:** non-motile, spore-forming, unicellular parasites

- **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“.



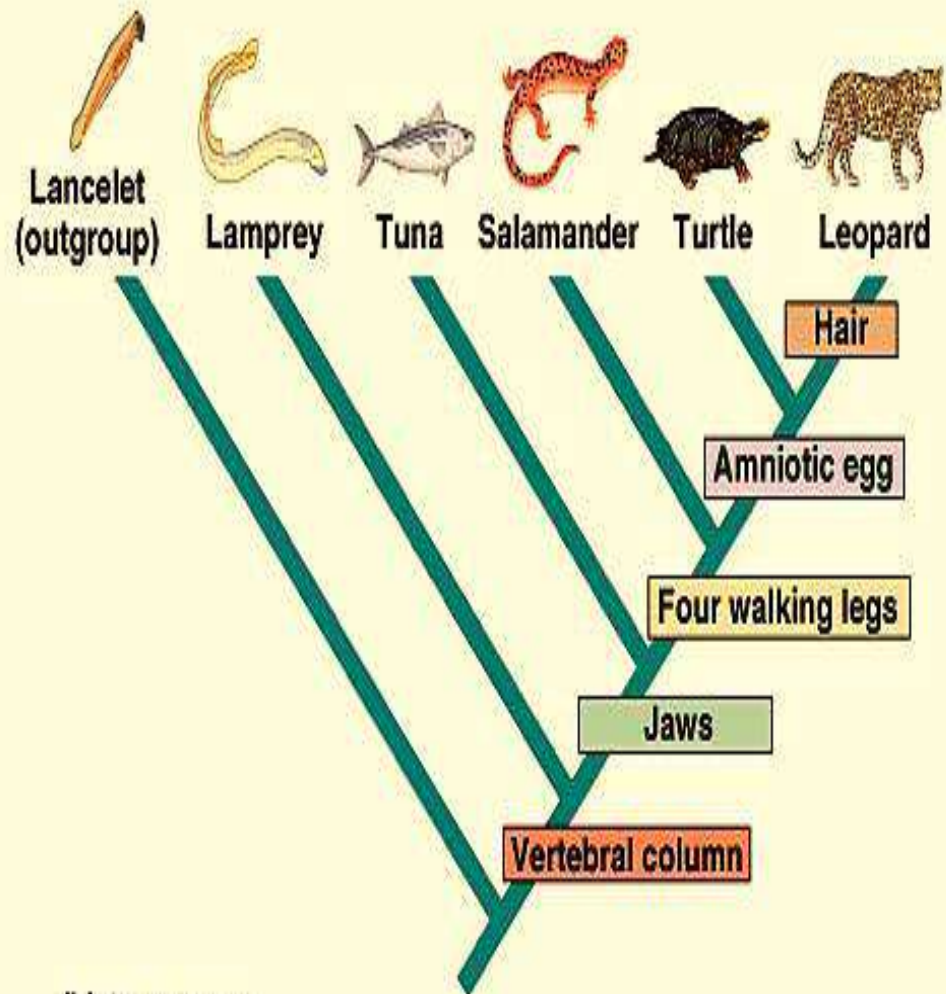
✧ **Cladistics** can be distinguished from other taxonomic systems, by its focus on shared derived characters. Systems developed earlier usually employed overall **morphological similarity** to group species into genera, families and other higher level groups (**taxa**); **cladistic classifications** (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

CHARACTERS	TAXA					
	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Hair	0	0	0	0	0	1
Amniotic (shelled) egg	0	0	0	0	1	1
Four walking 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



(b) Cladogram