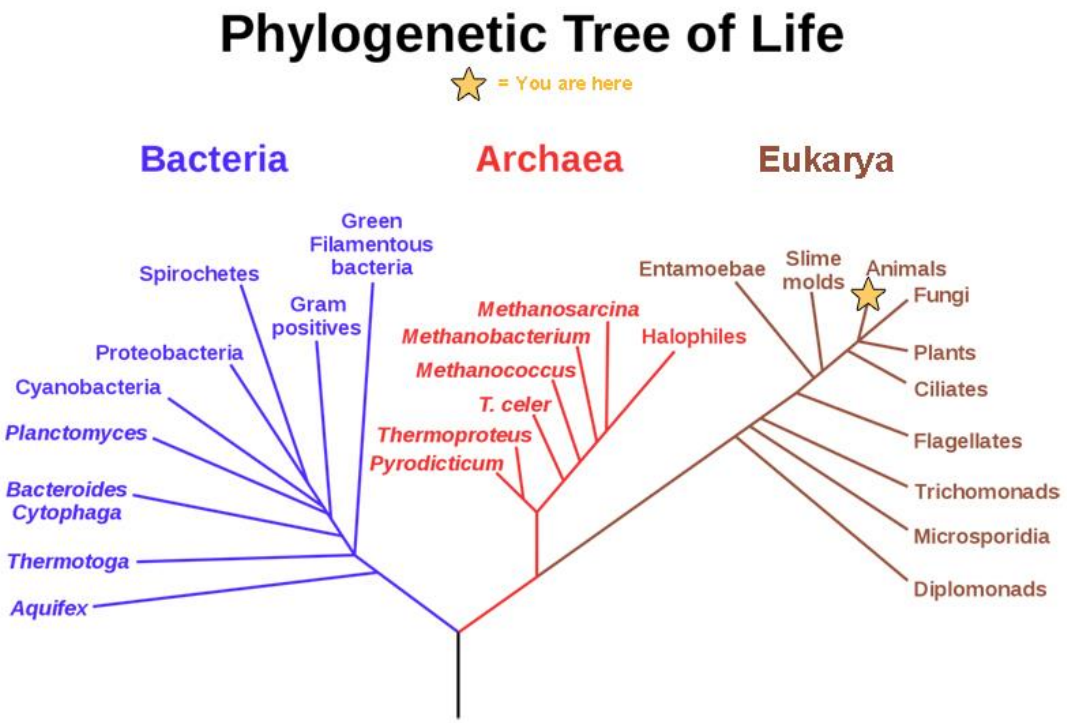
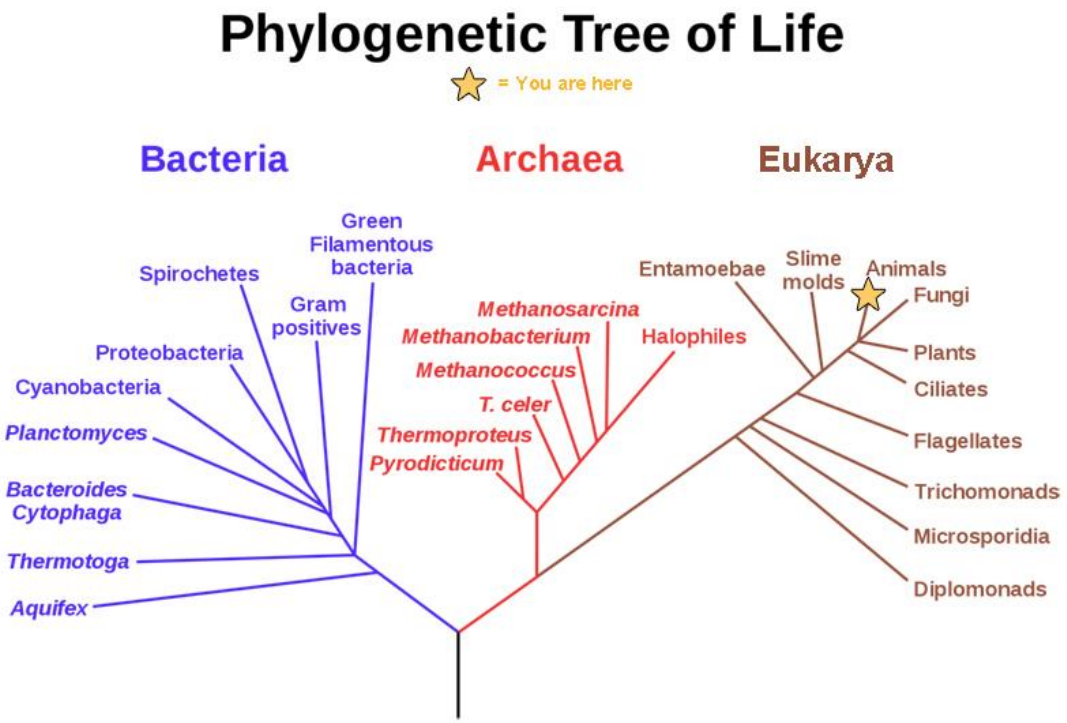
# Biology

Diversity of Life

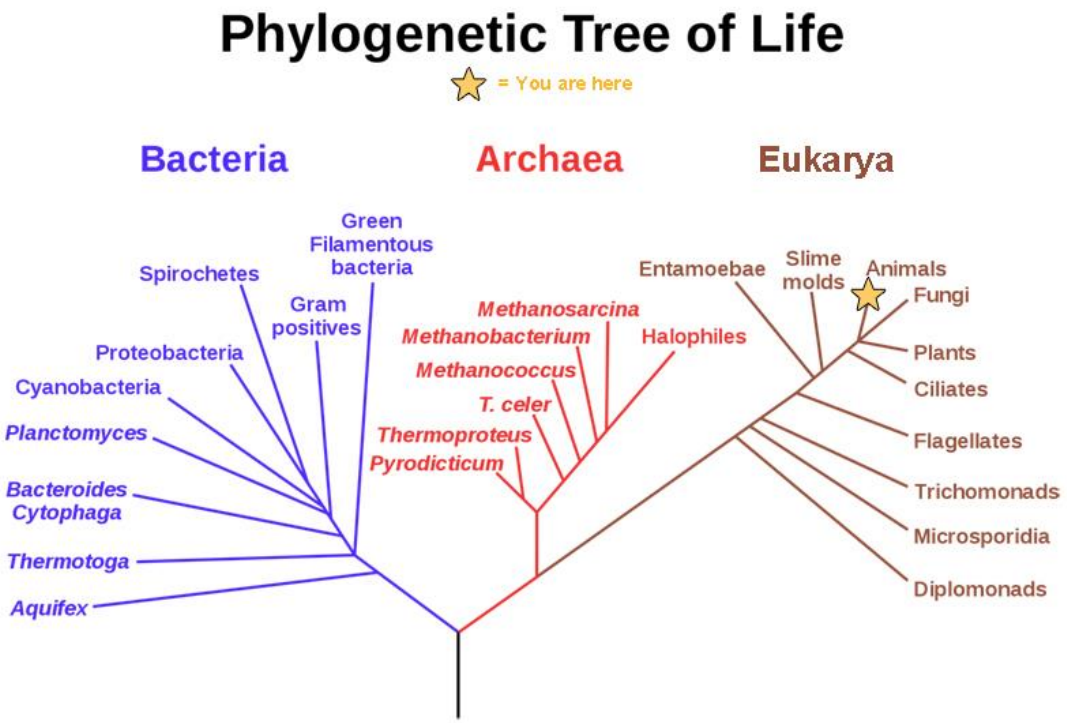
# Organization and Classification of Life



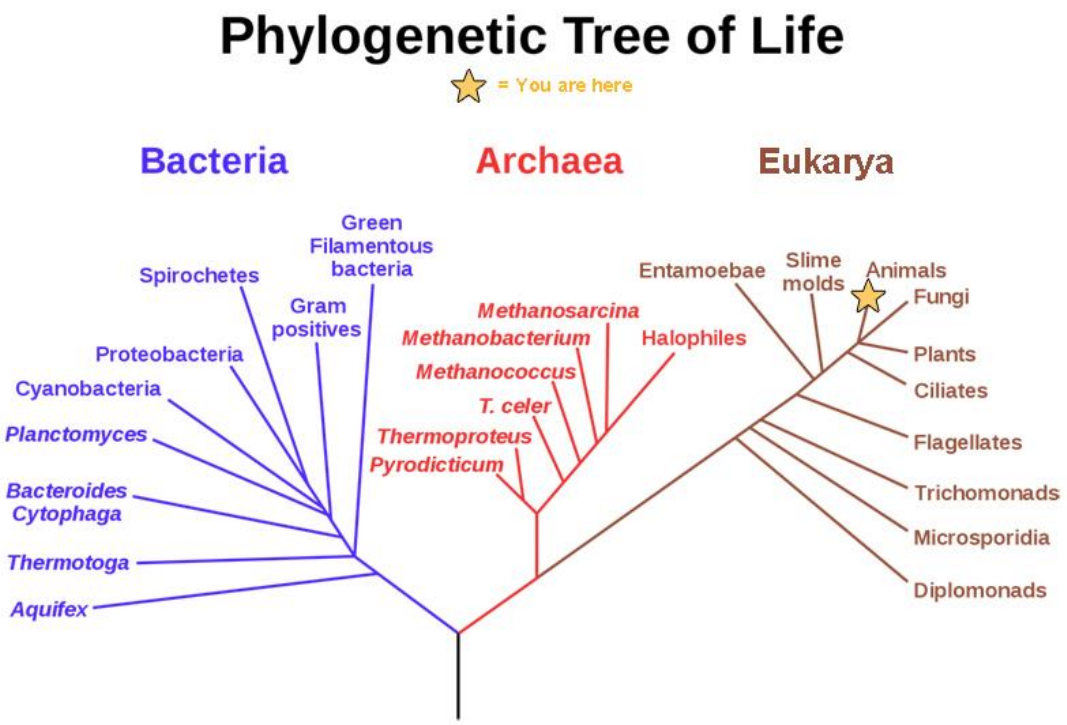

- All life on Earth evolved from a common ancestor
- Biologists map how organisms are related by constructing phylogenetic trees
- In other words, a “tree of life” can be constructed to illustrate when different organisms evolved and to show the relationships among different organisms




- A phylogenetic tree is a diagram used to reflect evolutionary relationships among organisms or groups of organisms

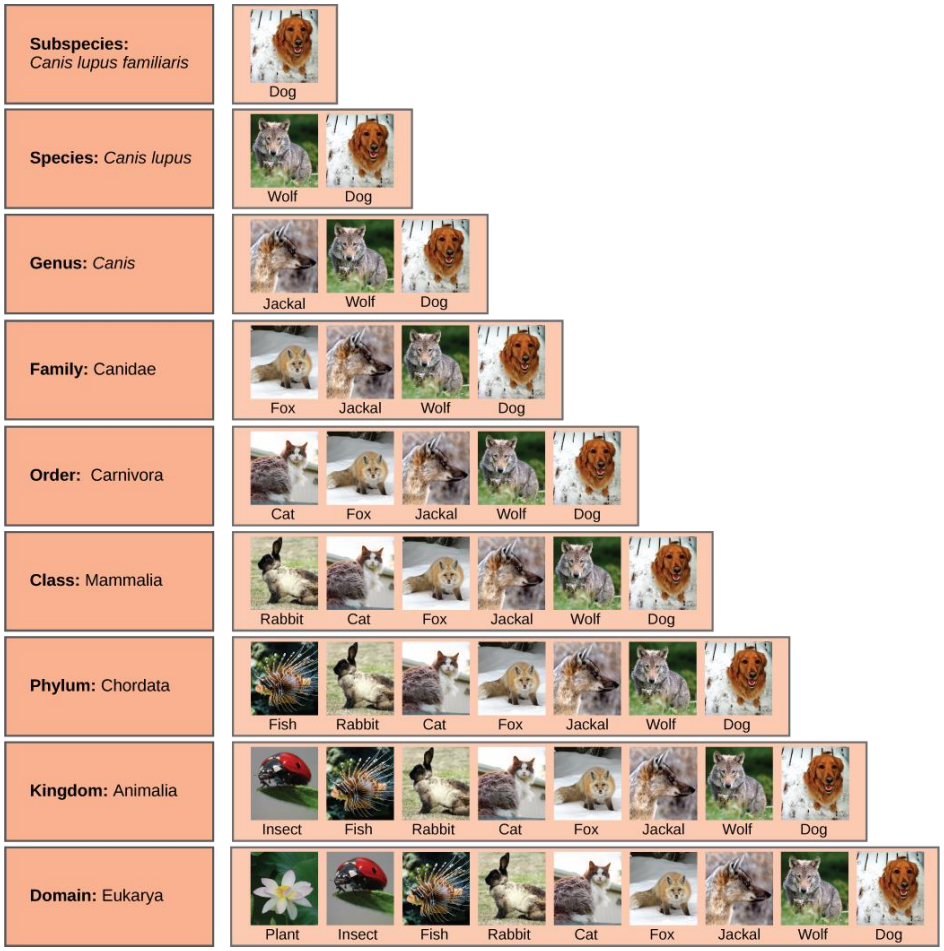



- The phylogenetic tree illustrates the pathway of evolutionary history
- The pathway can be traced from the origin of life to any individual species by navigating through the evolutionary branches between the two points



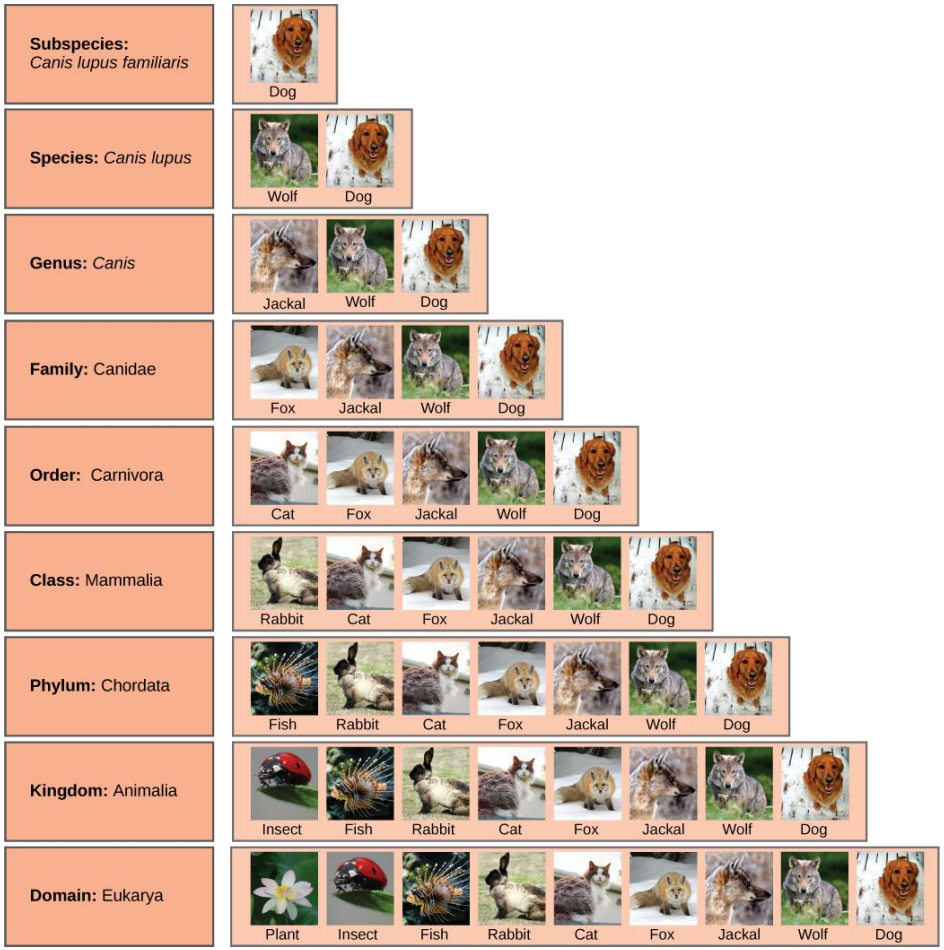

- A **phylogeny** is the evolutionary history and the relationships among a species or group of species.
- The study of organisms with the purpose of deriving their relationships is called **systematics**.

# Figure 12.3



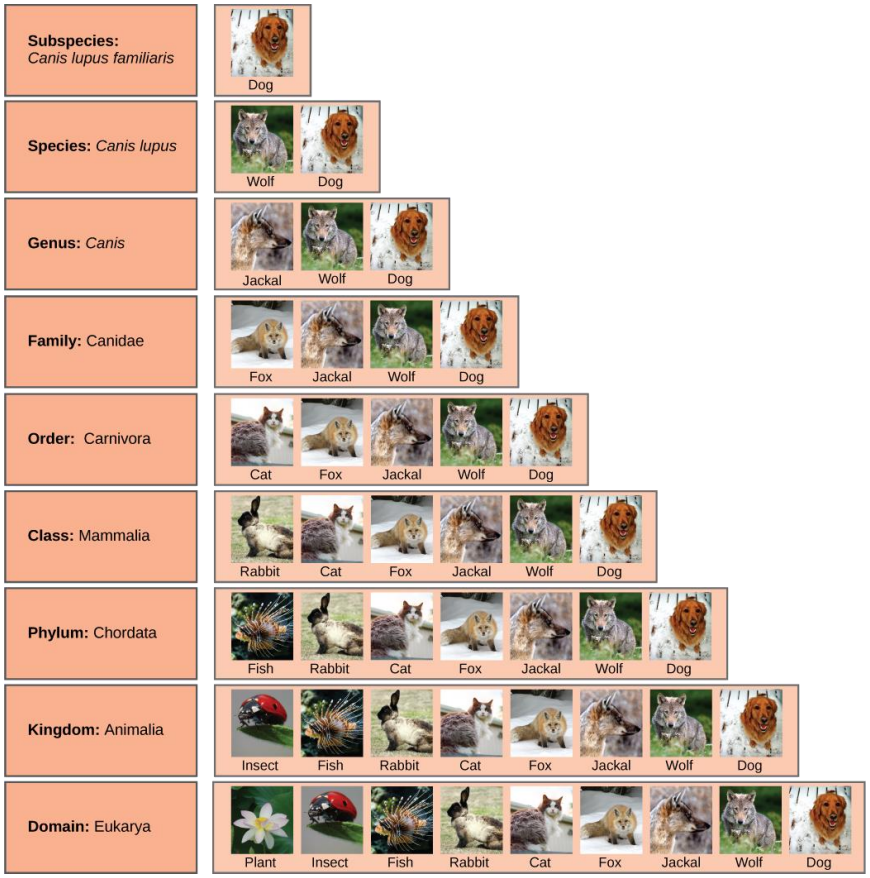

- **Taxonomy** (which literally means “arrangement law”) is the science of naming and grouping species to construct an internationally shared classification system.
- The taxonomic classification system (also called the Linnaean system after its inventor, Carl Linnaeus, a Swedish naturalist) uses a hierarchical model.

# Figure 12.3

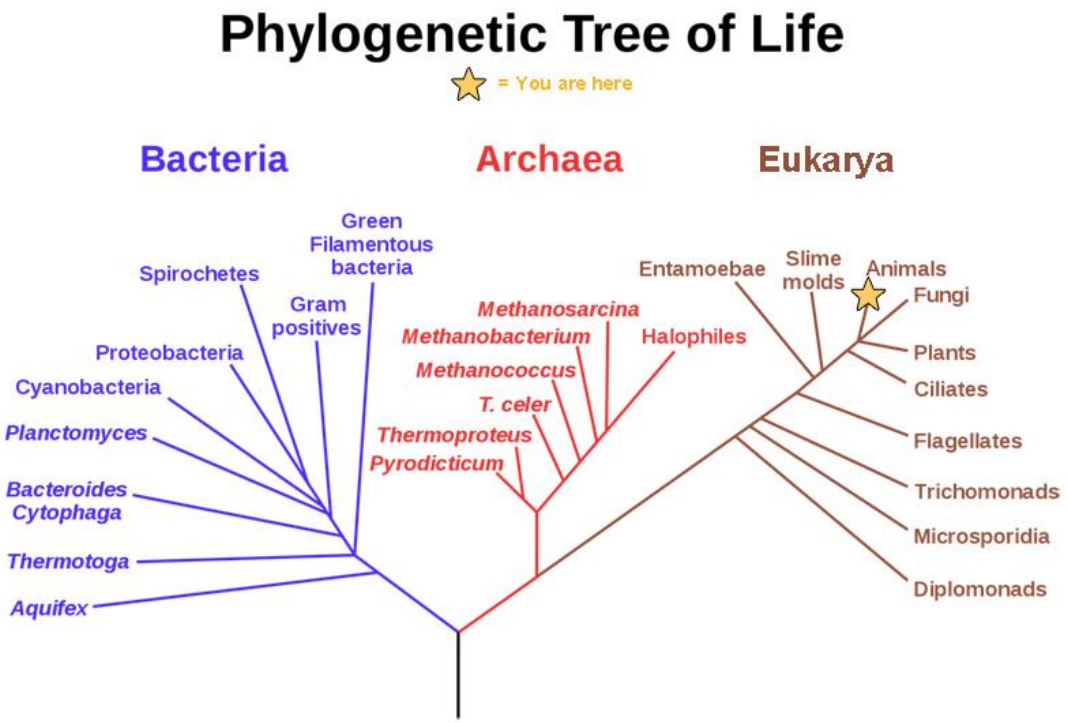



- A hierarchical system has levels and each group at one of the levels includes groups at the next lowest level, so that at the lowest level each member belongs to a series of nested groups.

Figure 12.3

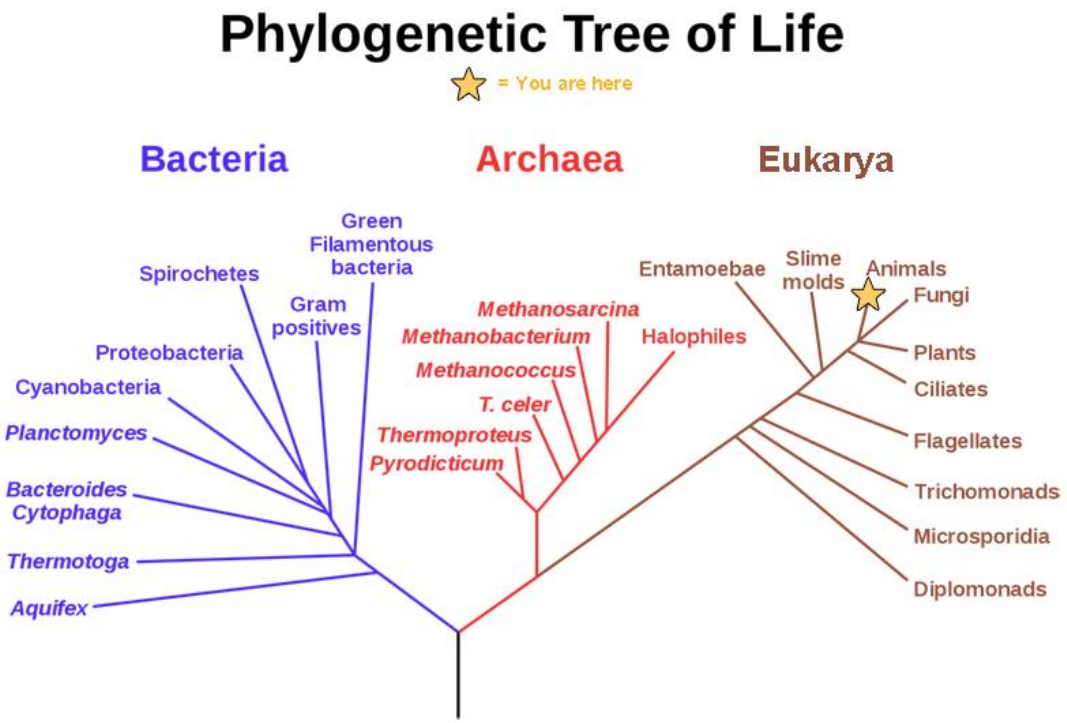



- In the most inclusive grouping, scientists divide organisms into three domains:
  - Bacteria,
  - Archaea,
  - and Eukarya.
- Within each domain is a second level called a kingdom. Each domain contains several kingdoms.
- Within kingdoms, the subsequent categories of increasing specificity are: phylum, class, order, family, genus, and species




- In the most inclusive grouping, scientists divide organisms into three domains:

- Bacteria
- Archaea
- Eukarya




- Scientists now recognize three domains of life, the Eukarya, the Archaea, and the Bacteria.

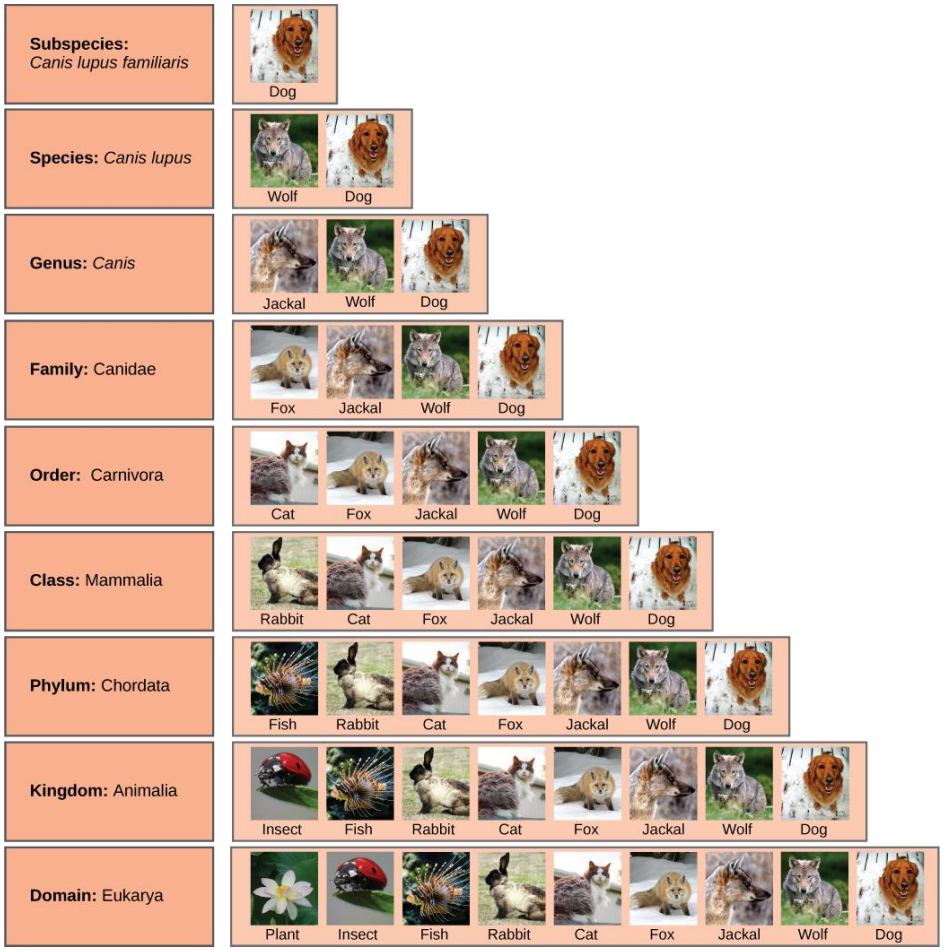
# Domains

- The domain Eukarya contains organisms that have cells with nuclei
  - It includes the kingdoms of fungi, plants, animals, and several kingdoms of protists
- The Archaea, are single-celled organisms without nuclei and include many extremophiles that live in harsh environments like hot springs
- The Bacteria are another quite different group of single-celled organisms without nuclei

# Domains

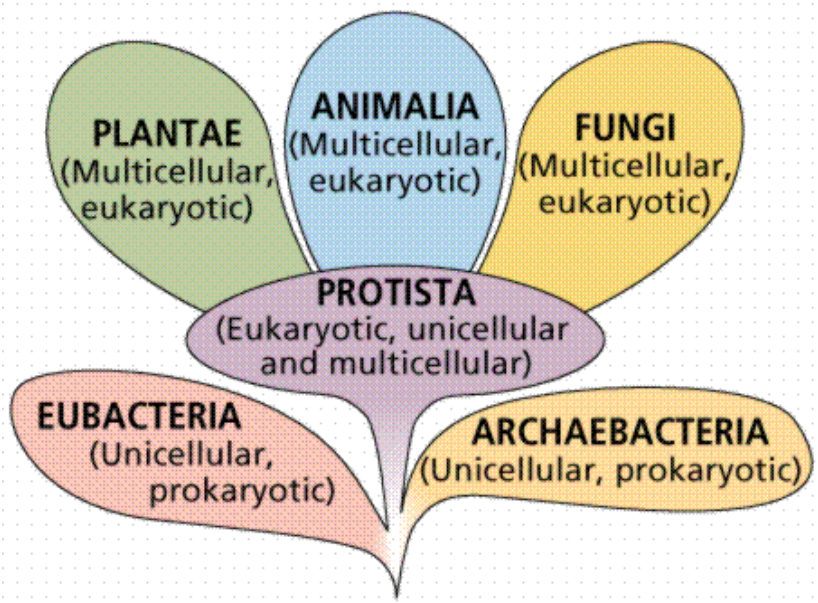
- Both the Archaea and the Bacteria are prokaryotes, an informal name for cells without nuclei
- Eukaryotes are organisms with cells that contain a nucleus
  - *When we studied cell structure and function, we focused on eukaryotic cells*

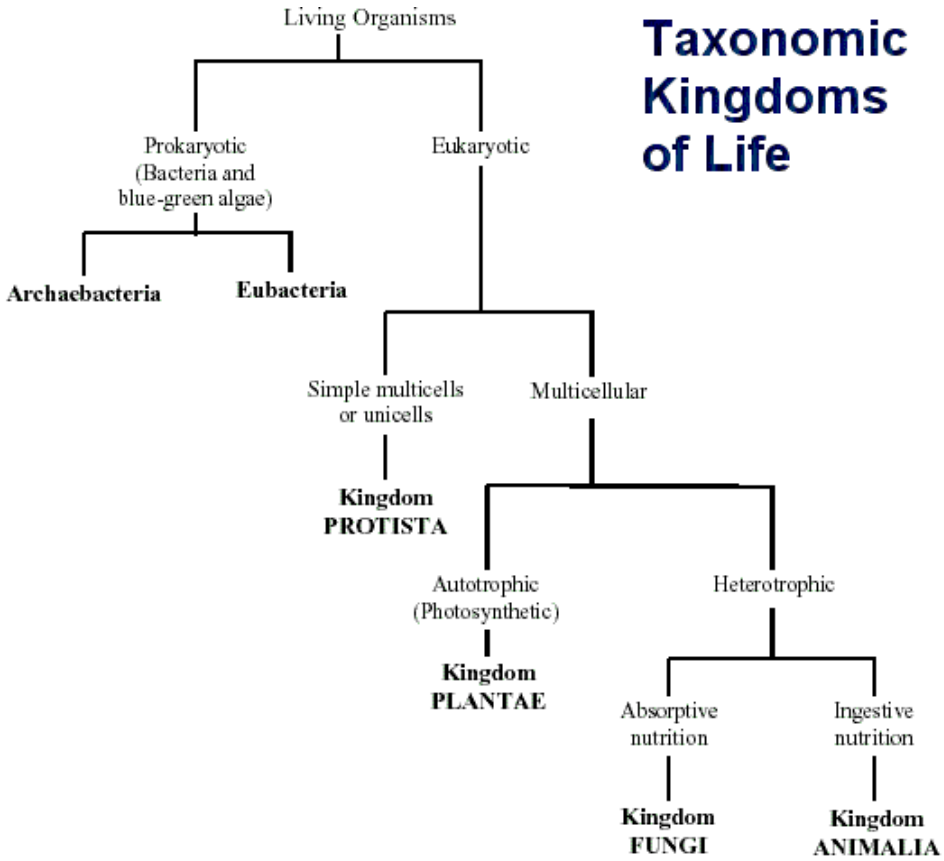
# Figure 12.3



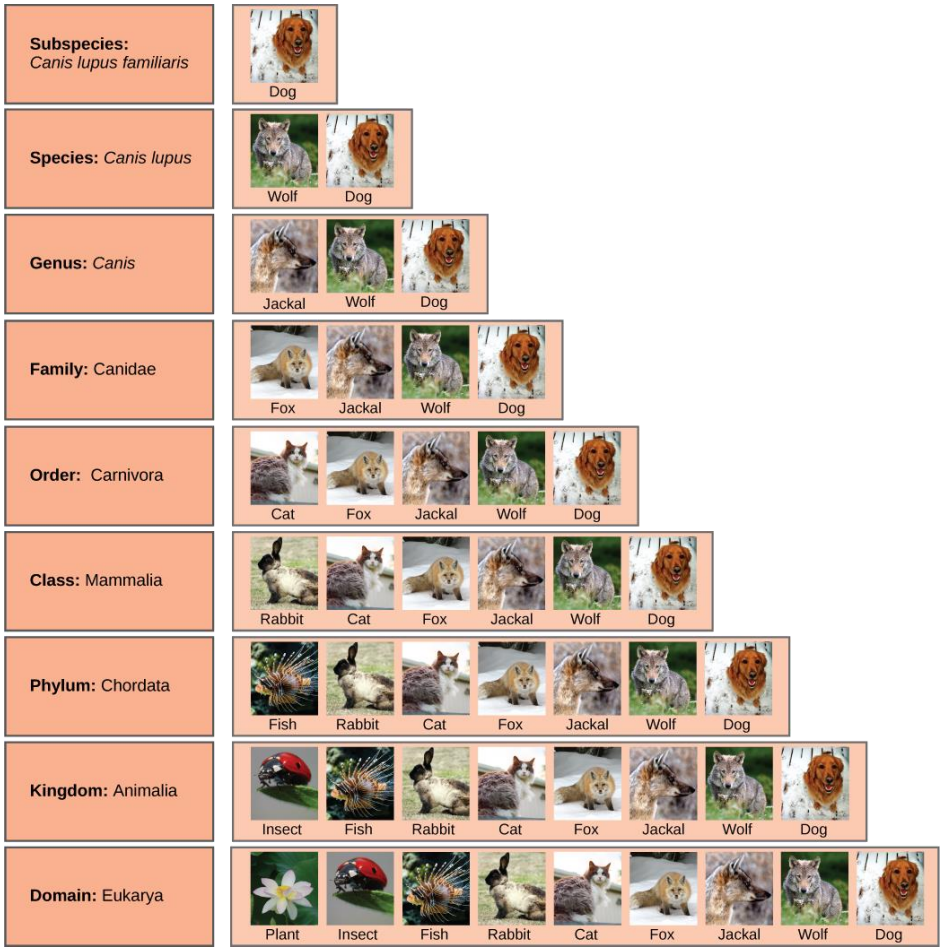

- Within each domain is a second level called a kingdom. Each domain contains several kingdoms

# Kingdoms


PLANTAE
(Multicellular, eukaryotic)
ANIMALIA
(Multicellular, eukaryotic)
FUNGI
(Multicellular, eukaryotic)
PROTISTA
(Eukaryotic, unicellular and multicellular)
EUBACTERIA
(Unicellular, prokaryotic)
ARCHAEBACTERIA
(Unicellular, prokaryotic)

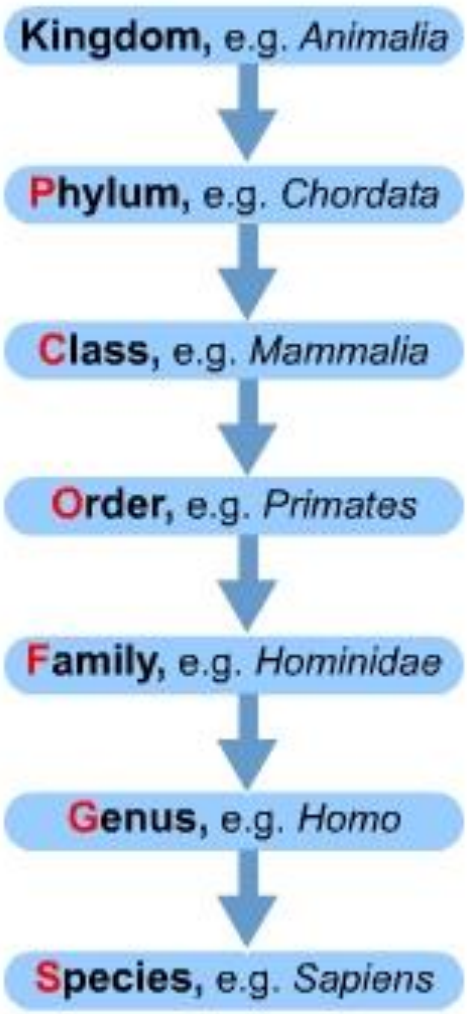

Taxonomic Kingdoms of Life
Living Organisms
Prokaryotic (Bacteria and blue-green algae)
Eukaryotic
Archaebacteria
Eubacteria
Simple multicells or unicells
Multicellular
Kingdom PROTISTA
Autotrophic (Photosynthetic)
Heterotrophic
Kingdom PLANTAE
Absorptive nutrition
Ingestive nutrition
Kingdom FUNGI
Kingdom ANIMALIA

# Figure 12.3

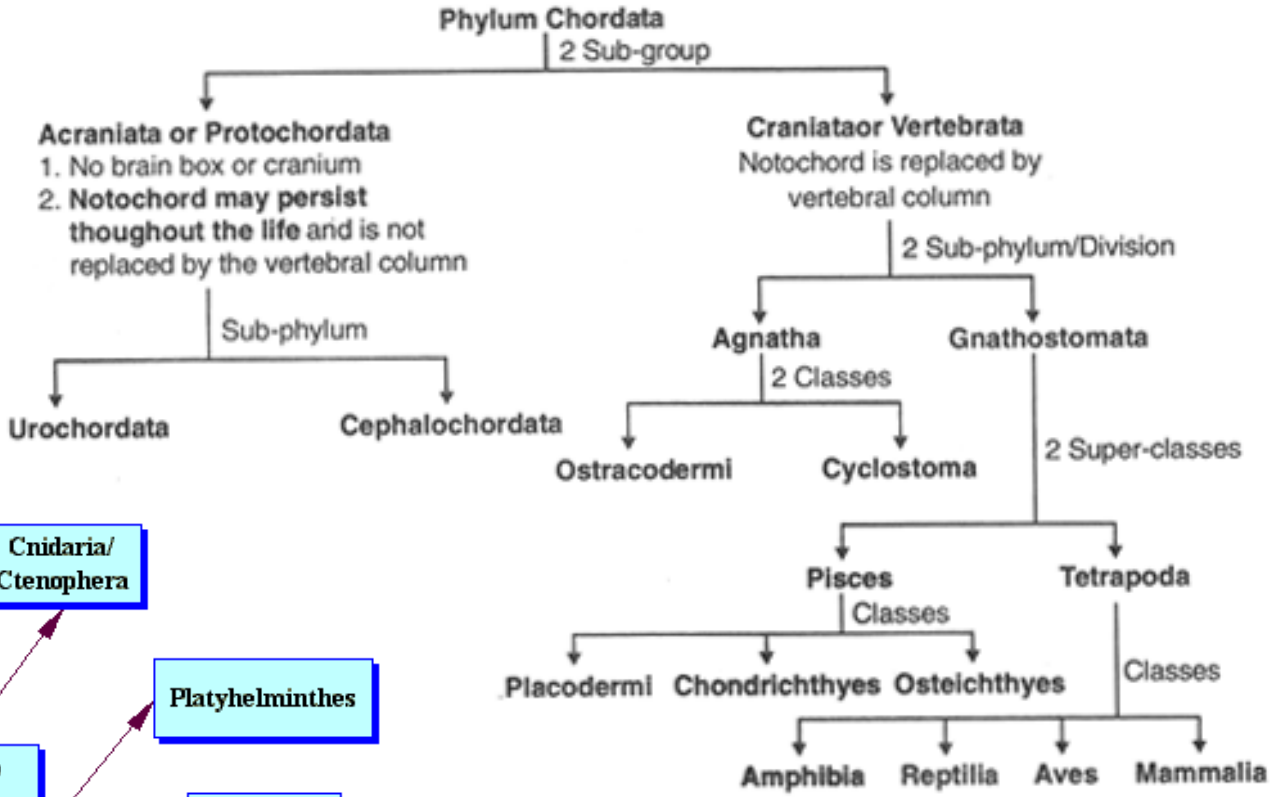


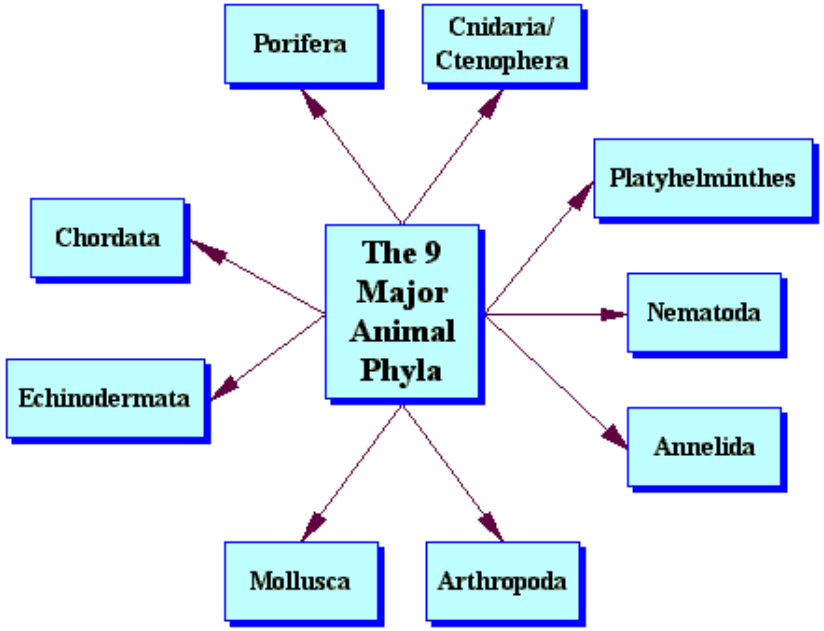

- Within kingdoms, the subsequent categories of increasing specificity are:
  - Phylum
  - Class
  - Order
  - Family
  - Genus
  - Species

# Ex) of Classification - Humans

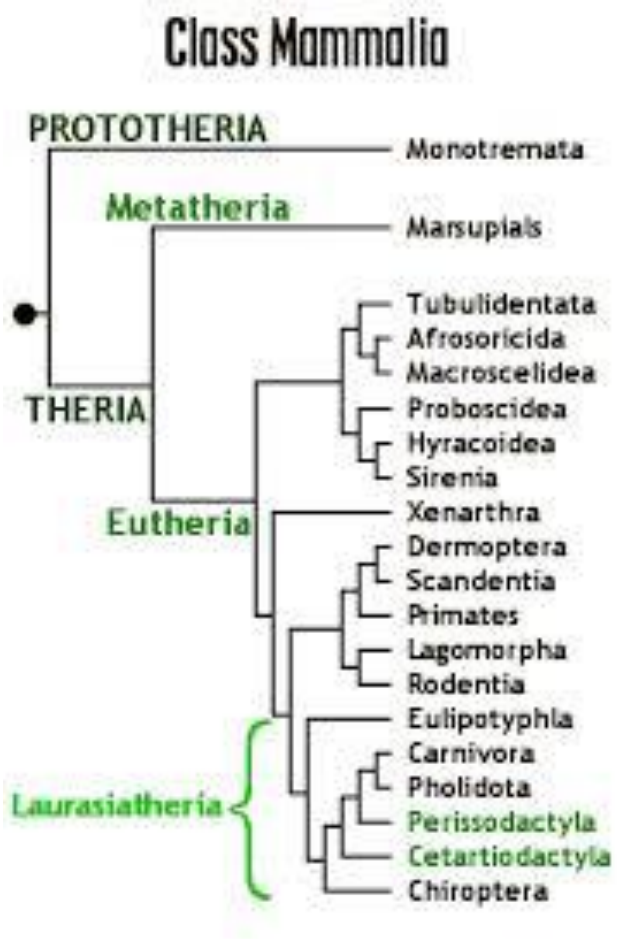


# Phylum

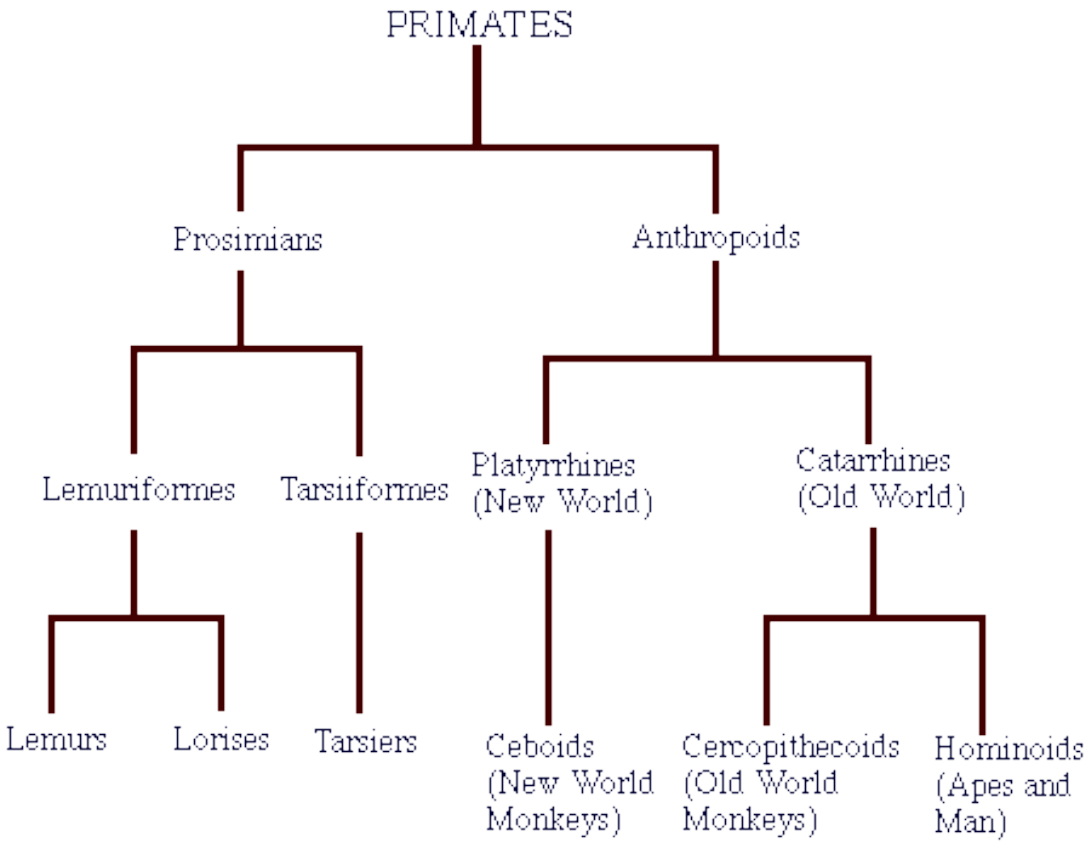

Phylum Chordata
2 Sub-group
Acraniata or Protochordata
1. No brain box or cranium
2. Notochord may persist thoughout the life and is not replaced by the vertebral column
Sub-phylum
Urochordata
Cephalochordata
Craniataor Vertebrata
Notochord is replaced by vertebral column
2 Sub-phylum/Division
Agnatha
Gnathostomata
2 Classes
Ostracodermi
Cyclostoma
2 Super-classes
Pisces
Tetrapoda
Classes
Placodermi
Chondrichthyes
Osteichthyes
Classes
Amphibia
Reptilia
Aves
Mammalia


Porifera
Cnidaria/ Ctenophera
Platyhelminthes
Chordata
The 9 Major Animal Phyla
Nematoda
Echinodermata
Annelida
Mollusca
Arthropoda

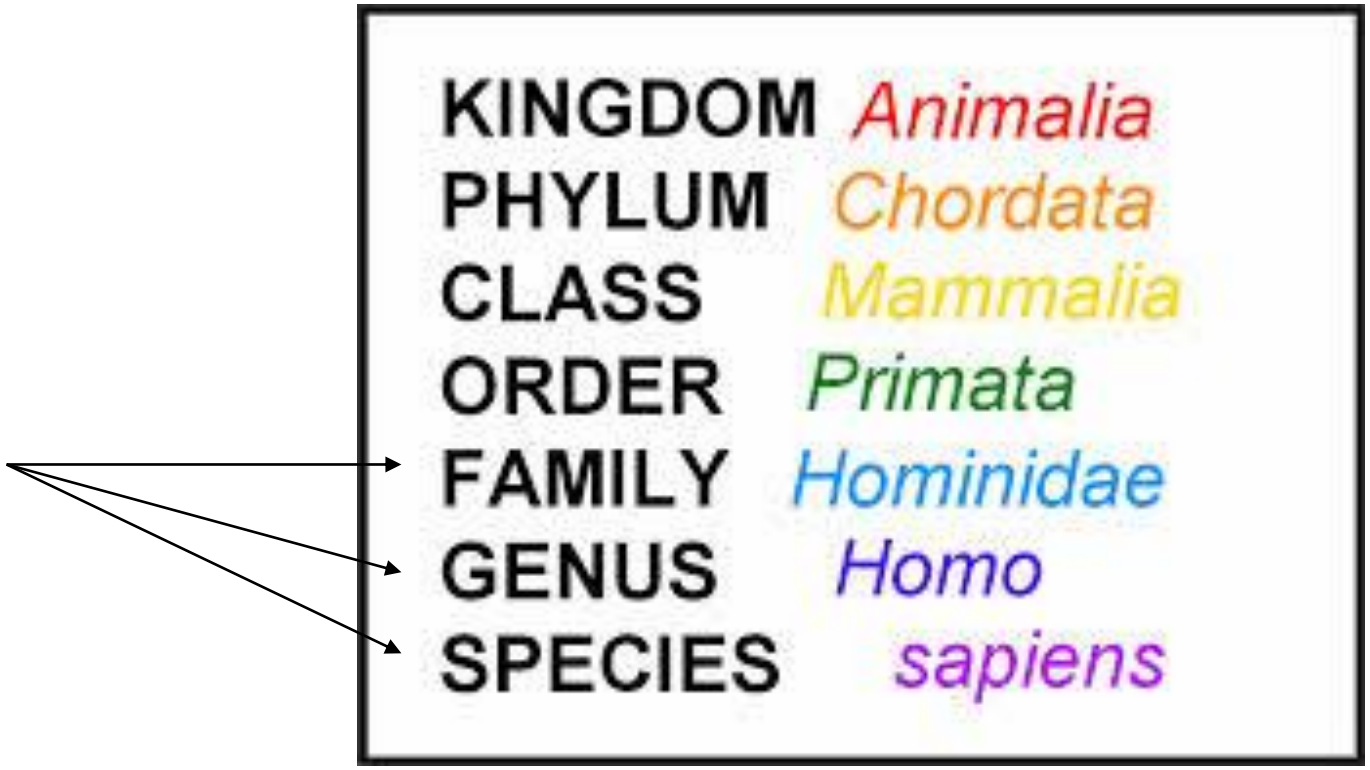
# Class


Class Mammalia
PROTOTHERIA
Monotremata
Metatheria
Marsupials
THERIA
Tubulidentata
Afrosoricida
Macroscelidea
Proboscidea
Hyracoidea
Sirenia
Eutheria
Xenarthra
Dermoptera
Scandentia
Primates
Lagomorpha
Rodentia
Eulipotyphla
Carnivora
Pholidota
Laurasiatheria
Perissodactyla
Cetartiodactyla
Chiroptera

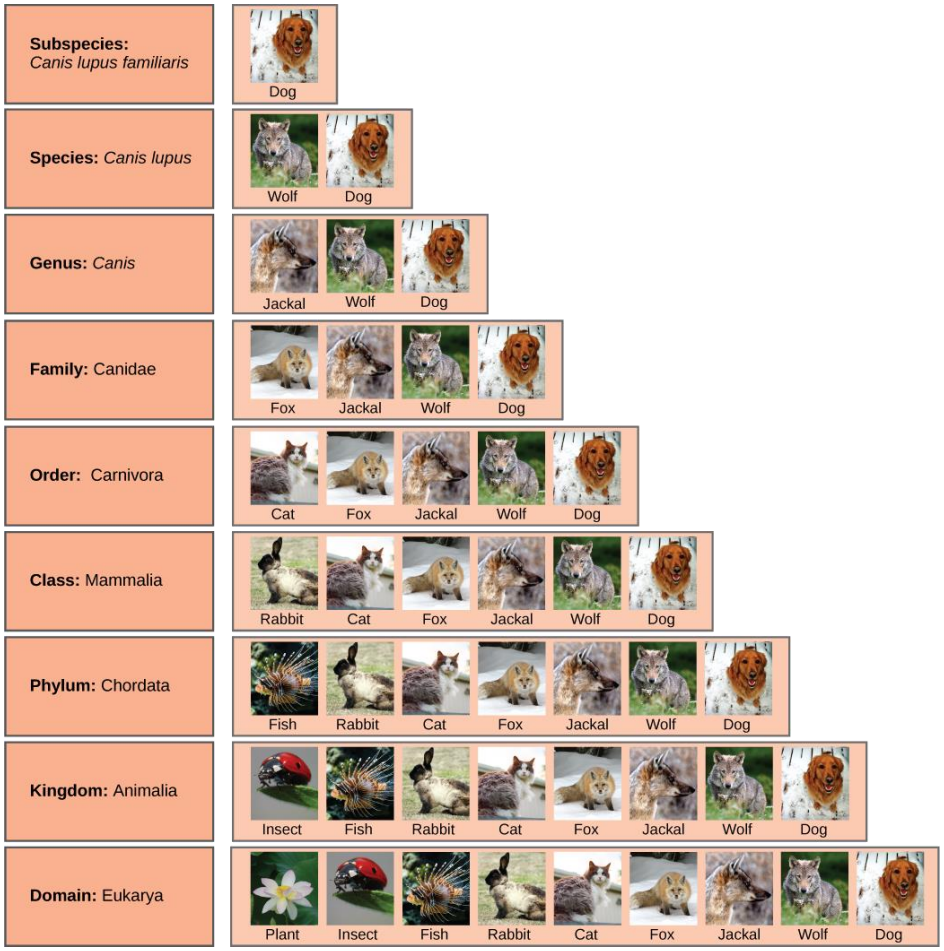
# Order


PRIMATES
Prosimians
Anthropoids
Lemuriformes
Tarsiiformes
Platyrrhines (New World)
Catarrhines (Old World)
Lemurs
Lorises
Tarsiers
Ceboids (New World Monkeys)
Cercopithecoids (Old World Monkeys)
Hominoids (Apes and Man)

# Family – Genus - Species

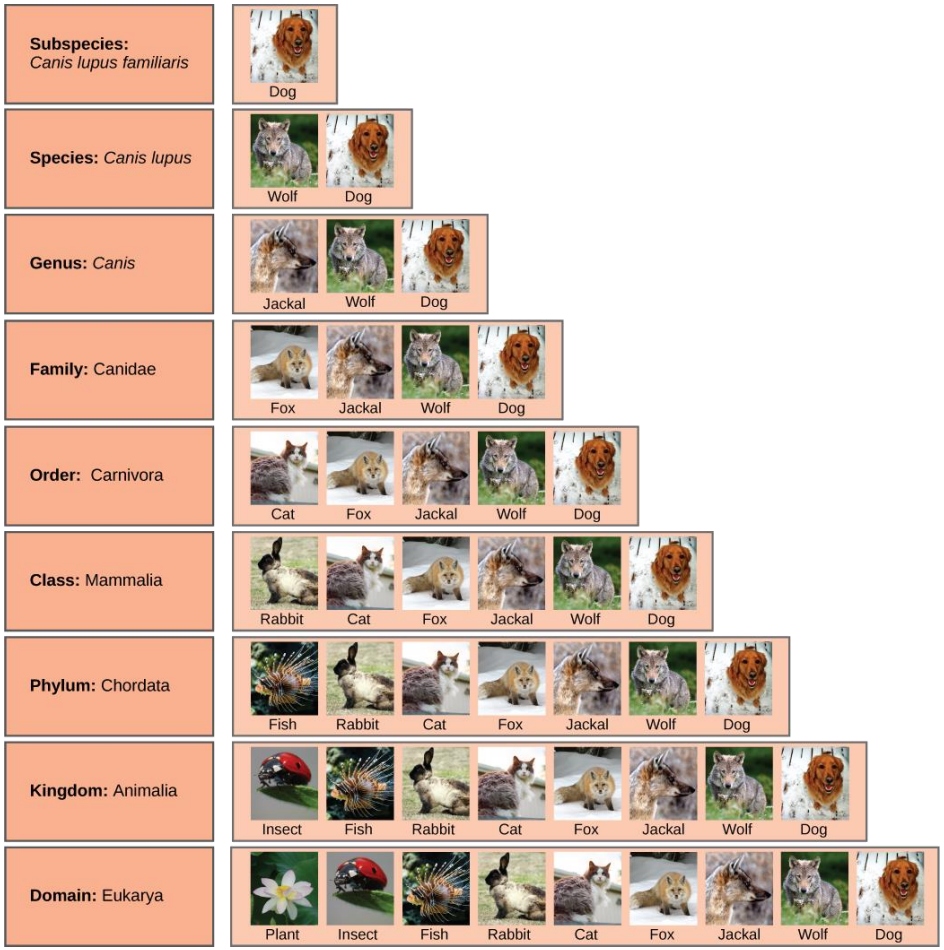


# Figure 12.3




- The group at each level is called a **taxon** (plural: taxa)
- Each taxon name is capitalized except for species, and the genus and species names are italicized
- Scientists refer to an organism by its genus and species names together, commonly called a scientific name, or Latin name
- This two-name system is called **binomial nomenclature**

# Figure 12.3




- At each sublevel in the taxonomic classification system, organisms become more similar
- Dogs and wolves are the same species because they can breed and produce viable offspring, but they are different enough to be classified as different subspecies.

# Diversity of Life

Viruses, Bacteria, and Protists

# Bacteria and Other Prokaryotes

# Characteristics of Prokaryotes

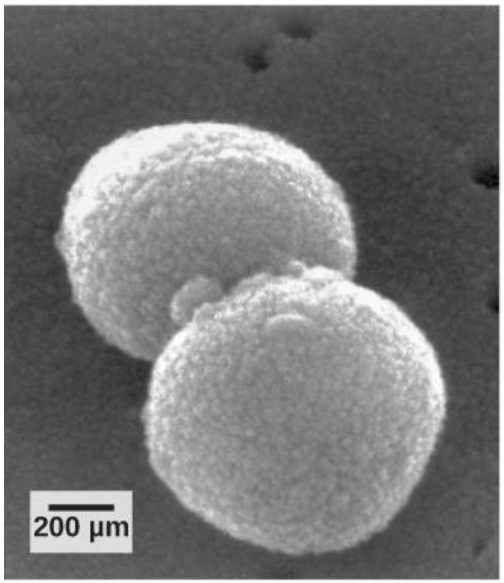
- Prokaryotes are present everywhere. They cover every imaginable surface where there is sufficient moisture, and they live on and inside of other living things
- Some prokaryotes thrive in environments that are inhospitable for most other living things
- Prokaryotes recycle nutrients—essential substances (such as carbon and nitrogen)
- Prokaryotes have been on Earth since long before multicellular life appeared

# Characteristics of Prokaryotes

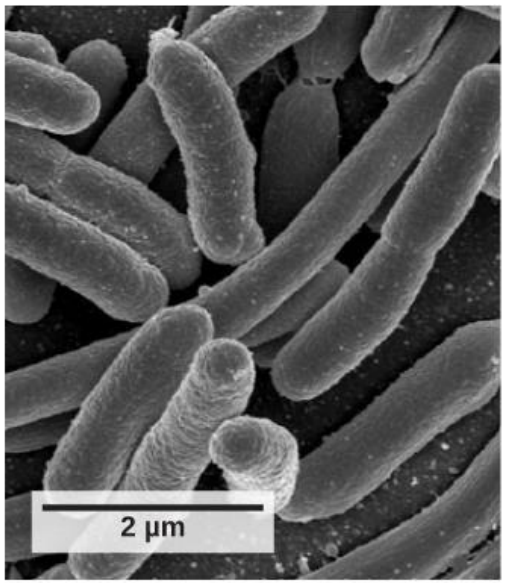
- There are many differences between prokaryotic and eukaryotic cells
- However, all cells have four common structures:
  - a plasma membrane that functions as a barrier for the cell and separates the cell from its environment;
  - cytoplasm, a jelly-like substance inside the cell;
  - genetic material (DNA and RNA); and
  - ribosomes, where protein synthesis takes place

# Classification of Bacteria Based on Morphology

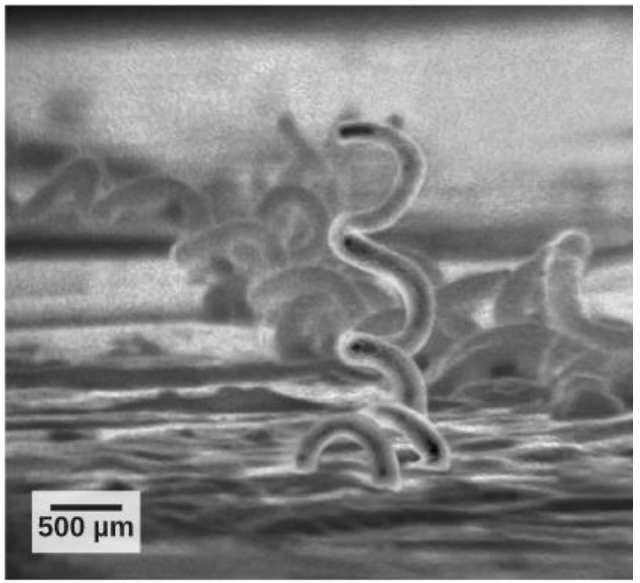
- Prokaryotes come in various shapes, but many fall into three categories:
  - cocci (spherical), bacilli (rod-shaped), and spirilla (spiral-shaped)




(a)




(b)




(c)

# Prokaryotes Cell Wall

- Both Bacteria and Archaea are types of prokaryotic cells
- They differ in the lipid composition of their cell membranes and in the characteristics of their cell walls
- Different types of bacteria also differ in terms of cell wall composition

# Classification of Bacteria Based on Staining

- Bacteria are divided into two major groups:
  - Gram-positive and
  - Gram-negative,
- This is based on their reaction to a procedure called Gram staining
- The different bacterial responses to the staining procedure are caused by differences in there cell wall structure
- Gram-negative bacteria have an additional outer membrane containing lipopolysaccharide (endotoxin), increasing the virulence of these bacteria.

# Classification of Bacteria Based on Staining

- Ziehl-Neelsen stain (acid-fast stain) is used to identify mainly mycobacteria, particularly *M. tuberculosis*. It also can identify *Nocardia* sp.

# Classification of Bacteria Encapsulation

- Some bacteria are enclosed in capsules; for some encapsulated bacteria (eg,*Streptococcus pneumoniae*, *Haemophilus influenzae*)
- The capsule helps protect them from ingestion by phagocytes.
- Encapsulation increases bacterial virulence.

# Classification of Bacteria Oxygen Requirements

- Aerobic bacteria require $O_2$ to produce energy and to grow in culture. They produce energy using aerobic cellular respiration.
- Anaerobic bacteria do not require $O_2$ and do not grow in culture if air is present. They produce energy using fermentation or anaerobic respiration.
  - Anaerobic bacteria are common in the GI tract, vagina, dental crevices, and wounds when blood supply is impaired.
- Facultative bacteria can grow with or without $O_2$. They produce energy by fermentation or anaerobic respiration when $O_2$ is absent and by aerobic cellular respiration when $O_2$ is present.
  - Microaerophilic bacteria prefer a reduced $O_2$ tension (eg, 2 to 10%). Chlamydiae are obligate intracellular parasites that acquire energy from the host cell and do not produce it themselves.

# Reproduction of Prokaryotes

- Reproduction in prokaryotes is primarily asexual
- Bacteria do not undergo mitosis, but replication takes place by process called binary fission
- Binary fission does not provide an opportunity for genetic recombination, but prokaryotes can alter their genetic makeup by transferring DNA from other prokaryotes in the environment.
  - Sometimes viruses that infect bacteria are involved in this process
- Because of these processes and because bacteria divided so readily (minutes in some species), prokaryotes like bacteria can mutate at a very fast rate, allowing them to respond to changes in the environment (such as the introduction of antibiotics)

# Bacterial Disease in Humans

- Devastating pathogen-borne diseases and plagues, both viral and bacterial in nature, have affected and continue to affect humans
- All known pathogenic prokaryotes are Bacteria; there are no known pathogenic Archaea in humans or any other organism
- Pathogenic organisms evolved alongside humans
- Infectious diseases remain among the leading causes of death worldwide, though it is less significant in developed countries since the advent of antibiotics
- Overuse of antibiotics has led to the development of resistant strains of bacteria

# Antibiotic Crisis

- One of the main reasons for resistant bacteria is the overuse and incorrect use of antibiotics (such as not completing a full course of prescribed antibiotics)
- Another problem is the excessive use of antibiotics in livestock
- The incorrect use of an antibiotic results in the natural selection of resistant forms of bacteria
- The antibiotic kills most of the infecting bacteria, and therefore only the resistant forms remain
- These resistant forms reproduce, resulting in an increase in the proportion of resistant forms over non-resistant ones

# Antibiotic Crisis

- *Staphylococcus aureus*, often called “staph,” is a common bacterium that can live in and on the human body
- Staph infections historically were usually easily treatable with antibiotics
- A very dangerous strain, referred to as methicillin-resistant Staphylococcus aureus (MRSA), is resistant to many commonly used antibiotics, including methicillin, amoxicillin, penicillin, and oxacillin.

# Questions – Organization and Classification of Life

- What are the three domains that classify all life on Earth
  - Bacteria
  - Archaea
  - Eukarya
- Which two domains are prokaryotes?
  - Bacteria
  - Archaea
- Which are eukaryotes?
  - Eukarya
- Which domain would plants, animals and insects be listed under?
  - Eukarya
- Which contains a cell nucleus with genetic material (prokaryotes or eukaryotes)?
  - Eukaryotes

# Questions – Organization and Classification of Life

- What is contained in a species name?
  - *Genus species*
- What is this referred to as?
  - Binomial nomenclature
- What is a taxon?
  - A group at each level of the taxonomic classification system
- List the order of the taxonomic classification system from least to most specific
  - Domain
  - Kingdom
  - Phylum
  - Class
  - Order
  - Family
  - Genus
  - Species
- DKP COFGS

# Questions - Bacteria

- What three shapes do bacteria come in?
  - cocci (spherical), bacilli (rod-shaped), and spirilla (spiral-shaped)
- Which are generally more virulent, gram-positive or gram-negative bacteria?
  - Gram-negative
- Are bacteria able to reproduce quickly and easily adapt to their environment?
  - Yes
- What is a common bacteria that lives on and in the human body?
  - *Staphylococcus aureus or staph*
- What is the strain that is antibiotic resisitant?
  - MRSA

# Protists and Fungi

# Protists

- Protists are a tremendously diverse group of eukaryotes ranging from singlecelled protists living in pond water to larger multicelled organisms such as the kelps
- As a collective group, protists display an astounding diversity of morphologies, physiologies, and ecologies

# Protists

- Nearly all protists exist in some type of aquatic environment, including freshwater and marine environments, damp soil, and even snow

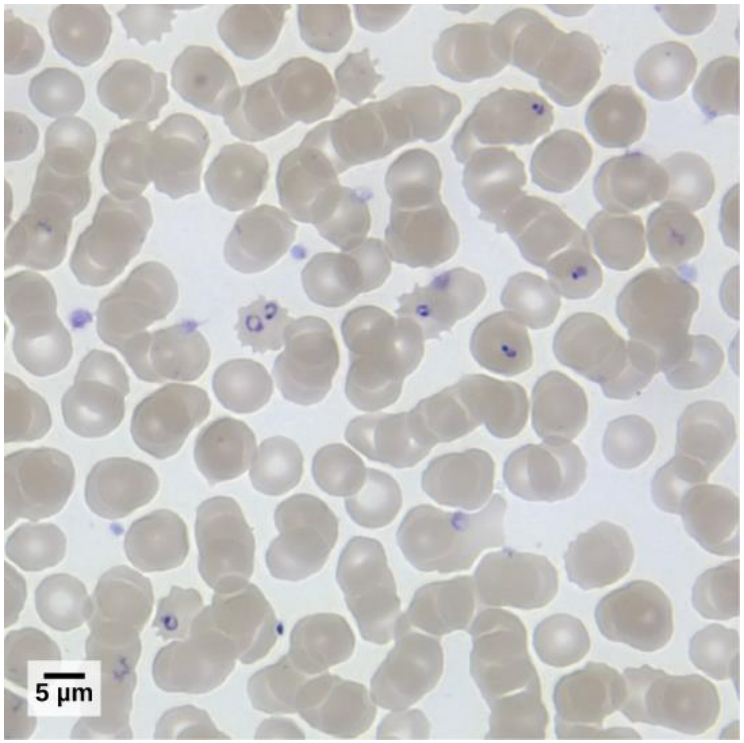
# Pathogenic Protists

- Several protist species are parasites that infect animals or plants.
  - A parasite is an organism that lives on or in another organism and feeds on it, often without killing it.
- Protist parasites include the causative agents of malaria, African sleeping sickness, and waterborne gastroenteritis in humans.
- Other protist pathogens prey on plants, effecting massive destruction of food crop.
- A few protist species live on dead organisms or their wastes, and contribute to their decay.

# Pathogenic Protists

- Plasmodium Species
  - Members of the genus Plasmodium must infect a mosquito and a vertebrate to complete their life cycle.
  - In vertebrates, the parasite develops in liver cells and goes on to infect red blood cells, bursting from and destroying the blood cells with each asexual replication cycle

# Figure 13.16




- This light micrograph shows a 100x magnification of red blood cells infected with *P. falciparum* (seen as purple). (credit: modification of work by Michael Zahniser; scale-bar data from Matt Russell)

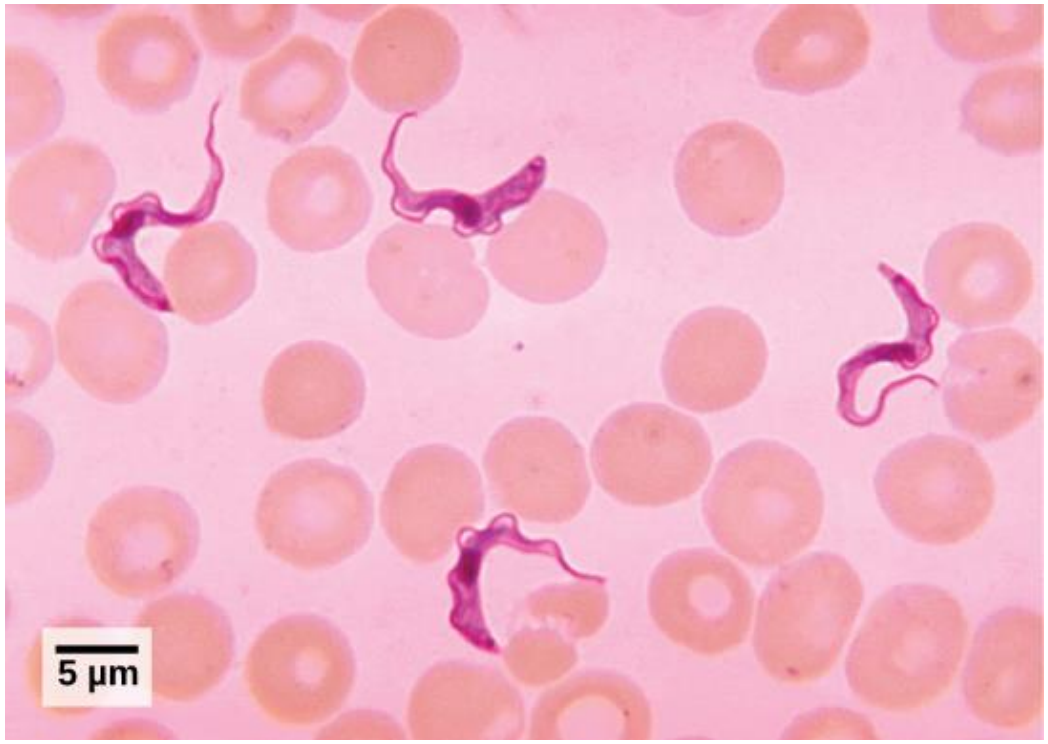
# Pathogenic Protists

- 4 species infect humans
  - *P. falciparum* accounts for 50 percent of all malaria cases and is the primary cause of disease-related fatalities in tropical regions of the world
  - During the course of malaria, P. falciparum can infect and destroy more than one-half of a human's circulating blood cells, leading to severe anemia
  - In response to waste products released as the parasites burst from infected blood cells, the host immune system mounts a massive inflammatory response with delirium-inducing fever episodes, as parasites destroy red blood cells, spilling parasite waste into the blood stream

# Pathogenic Protists

- Trypanosomes species
  - *T. brucei*, the parasite that is responsible for African sleeping sickness, confounds the human immune system by changing its thick layer of surface glycoproteins with each infectious cycle
  - The glycoproteins are identified by the immune system as foreign matter, and a specific antibody defense is mounted against the parasite
  - However, *T. brucei* has thousands of possible antigens, and with each subsequent generation, the protist switches to a glycoprotein coating with a different molecular structure
  - In this way, *T. brucei* is capable of replicating continuously without the immune system ever succeeding in clearing the parasite

# Figure 13.17



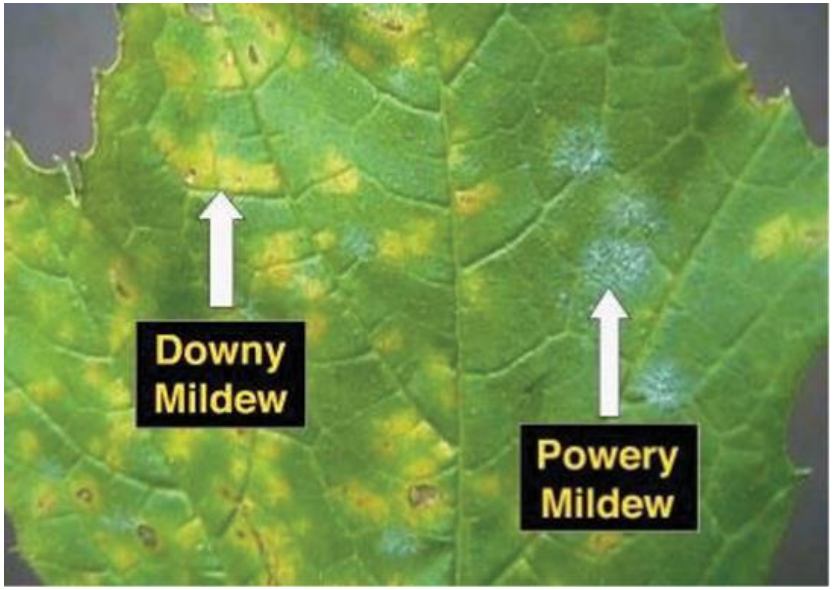

- Trypanosomes are shown in this light micrograph among red blood cells. (credit: modification of work by Myron G. Schultz, CDC; scale-bar data from Matt Russell)

# Immune System, Antigens, and Antibodies

- More will be discussed with the immune response later
- For now, antigens refer to a protein on the cell membrane of a pathogenic invader
- Along the pathway of lymphatic vessels are lymph nodes
  - Lymph nodes contain T-cells and B-cell
  - Antigens cause the proliferation of T-cells and B-cells
  - T-cells leave the lymph nodes, enter the systemic circulation and directly attack the foreign invader
    - This is referred to as cell-mediated immunity
  - B-cells produce proteins called antibodies which leave the lymph nodes, enters the systemic circulation, and are involved with removing the invader
    - This is referred to as antibody- or humoral-mediated immunity

# Plant Parasites

- Protist parasites of terrestrial plants include agents that destroy food crops and other plants in the ecosystem




(a)

(b)

# Beneficial Protists

- Protist food sources
  - Examples include plankton
- Agents of Decomposition
  - Many fungus-like protists are saprobes, organisms that feed on dead organisms or the waste matter produced by organisms
  - Saprobic protists have the essential function of returning inorganic nutrients to the soil and water

# Fungi

- The kingdom Fungi includes an enormous variety of living organisms collectively referred to as Eumycota, or true fungi
- Edible mushrooms, yeasts, black mold, and Penicillium notatum (the producer of the antibiotic penicillin) are all members of the kingdom Fungi, which belongs to the domain Eukarya
- As eukaryotes, a typical fungal cell contains a true nucleus and many membrane-bound organelles

# Fungi

- Fungi are not capable of photosynthesis: They use complex organic compounds as sources of energy and carbon
- Some fungal organisms multiply only asexually, whereas others undergo both asexual reproduction and sexual reproduction
- Most fungi produce a large number of spores that are disseminated by the wind
- Like bacteria, fungi play an essential role in ecosystems, because they are decomposers and participate in the cycling of nutrients by breaking down organic materials into simple molecules

# Pathogenic Fungi

- Fungi often interact with other organisms, forming mutually beneficial or mutualistic associations
- However, other fungi also cause serious infections in plants and animals
  - Ex)Dutch elm (caused by the fungus *Ophiostoma ulmi*) disease is a particularly devastating fungal infection that destroys many native species of elm (Ulmus spp.)

# Pathogenic Fungi

- In humans, fungal infections are generally considered challenging to treat because, unlike bacteria, they do not respond to traditional antibiotic therapy since they are also eukaryotes
- These infections may prove deadly for individuals with a compromised immune system

# Pathogenic Fungi

- Fungi attack animals directly by colonizing and destroying tissues
- Humans and other animals can be poisoned by eating toxic mushrooms or foods contaminated by fungi
- In addition, individuals who display hypersensitivity to molds and spores develop strong and dangerous allergic reactions
- Fungal infections are generally very difficult to treat because, unlike bacteria, fungi are eukaryotes
- Antibiotics only target prokaryotic cells, whereas compounds that kill fungi also adversely affect the eukaryotic animal host

# Pathogenic Fungi

- Many fungal infections ( mycoses) are superficial and termed cutaneous (meaning “skin”) mycoses and are usually visible on the skin of the animal
- Fungi that cause the superficial mycoses of the epidermis, hair, and nails rarely spread to the underlying tissue

# Pathogenic Fungi

- These fungi are often referred to as dermatophytes (dermat/o – skin, phyte – plant) or “ringworms, but they are neither plant nor worm
- These fungi secrete extracellular enzymes that break down keratin (a protein found in hair, skin, and nails), causing a number of conditions such as athlete’s foot, jock itch, and other cutaneous fungal infections, which are usually treated with over-the-counter topical creams and powders, and are easily cleared
- More persistent, superficial mycoses may require prescription oral medications.

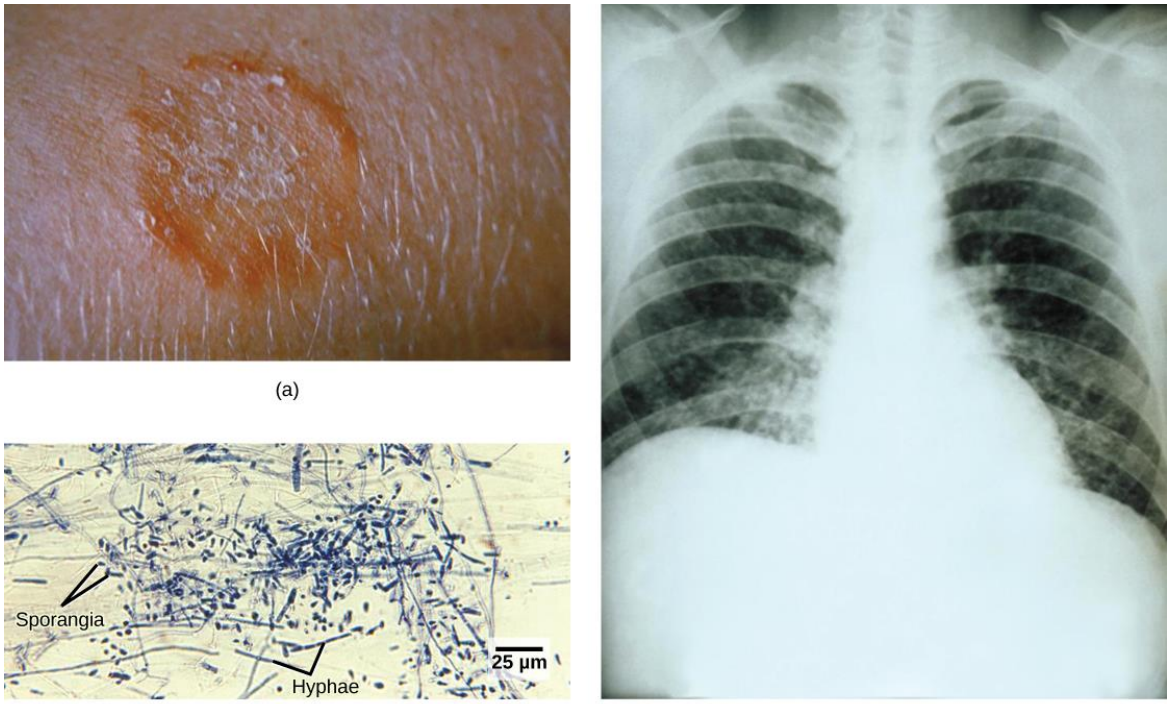
# Pathogenic Fungi

- Systemic mycoses spread to internal organs, most commonly entering the body through the respiratory system
  - Ex) coccidioidomycosis (valley fever) is commonly found in the southwestern United States, where the fungus resides in the dust Once inhaled, the spores develop in the lungs and cause signs and symptoms similar to those of tuberculosis.
  - Ex) Histoplasmosis is caused by the fungus *Histoplasma capsulatum*; it causes pulmonary infections and, in rare cases, swelling of the membranes of the brain and spinal cord
- Treatment of many fungal diseases requires the use of antifungal medications that have serious side effects

# Pathogenic Fungi

- Opportunistic mycoses are fungal infections that are either common in all environments or part of the normal biota. They affect mainly individuals who have a compromised immune system
  - Ex) Patients in the late stages of AIDS suffer from opportunistic mycoses, such as *Pneumocystis*, which can be life threatening
  - Ex) The yeast *Candida spp*., which is a common member of the natural biota, can grow unchecked if the pH, the immune defenses, or the normal population of bacteria is altered, causing yeast infections of the vagina or mouth (oral thrush).

# Figure 13.26




- (a) Ringworm presents as a red ring on the skin. (b) *Trichophyton violaceum* is a fungus that causes superficial mycoses on the scalp. (c) *Histoplasma capsulatum*, seen in this X-ray as speckling of light areas in the lung, is a species of Ascomycota that infects airways and causes symptoms similar to the flu. (credit a, b: modification of work by Dr. Lucille K. Georg, CDC; credit c: modification of work by M Renz, CDC; scale-bar data from Matt Russell)

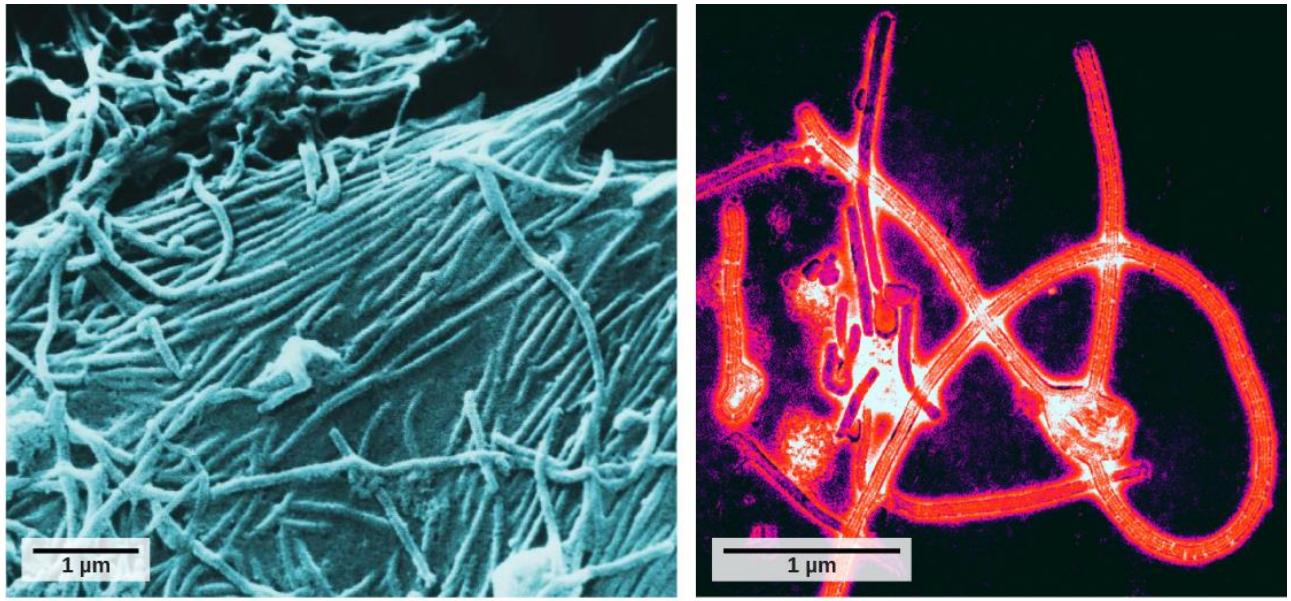
# Beneficial Fungi

- Fungi play a crucial role in the balance of ecosystems. They colonize most habitats on Earth, preferring dark, moist conditions
- They can thrive in seemingly hostile environments, such as the tundra, thanks to a most successful symbiosis with photosynthetic organisms, like lichens
- Like bacteria, they are major decomposers of nature
- With their versatile metabolism, fungi break down organic matter that is insoluble and would not be recycled otherwise
- They also serve as a food source, form symbiotic relationships with plant roots, and allow for food fermentation
- Since they often compete with bacteria in nature and produce natural antibiotic chemicals, many antibiotics are derived from fungi

# Viruses

# Viruses

- Viruses are generally small, acellular entities that usually possess only a single type of nucleic acid and that must use the metabolic machinery of a living host in order to reproduce



# Viruses Introduction

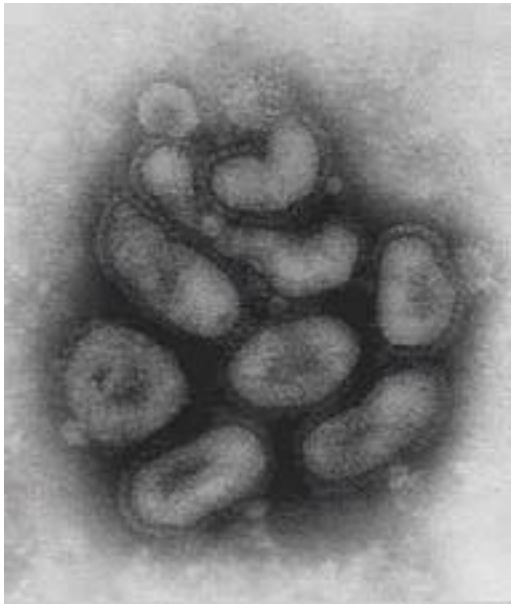
- Viruses are acellular, parasitic entities that are not classified within any domain because they are not considered alive
- They have no plasma membrane, internal organelles, or metabolic processes, and they do not divide
- Instead, they infect a host cell and use the host's replication processes to produce progeny virus particles

# Viruses Introduction

- Viruses infect all forms of organisms including bacteria, archaea, fungi, plants, and animals
  - Living things grow, metabolize, and reproduce
  - Viruses replicate, but to do so, they are entirely dependent on their host cells
  - Therefore, viruses are not considered alive

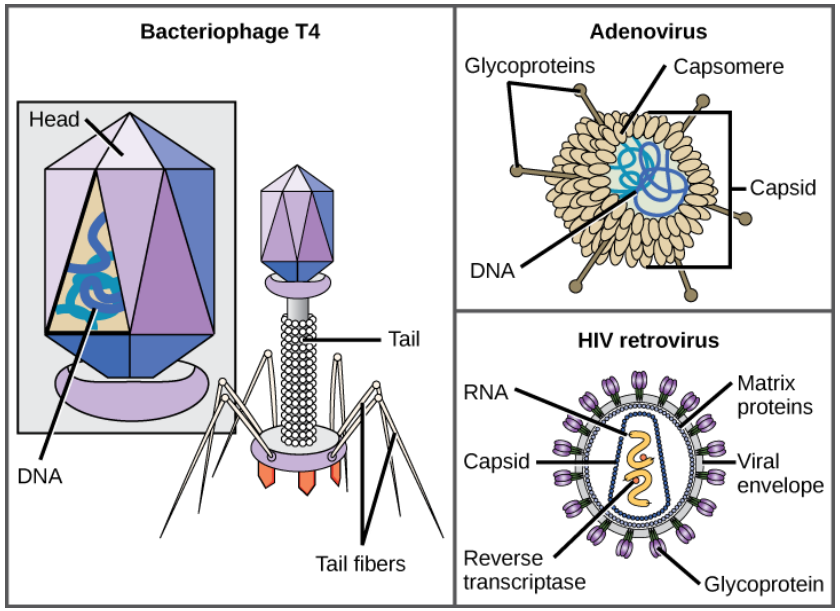
# Virus Reproduction

- Viruses depend on the host cells that they infect to reproduce
- When found outside of host cells, viruses exist as a protein coat or capsid, sometimes enclosed within a membrane
- The capsid encloses either DNA or RNA which codes for the virus elements
- While in this form outside the cell, the virus is metabolically inert; such as the image of the influenza virus on the right



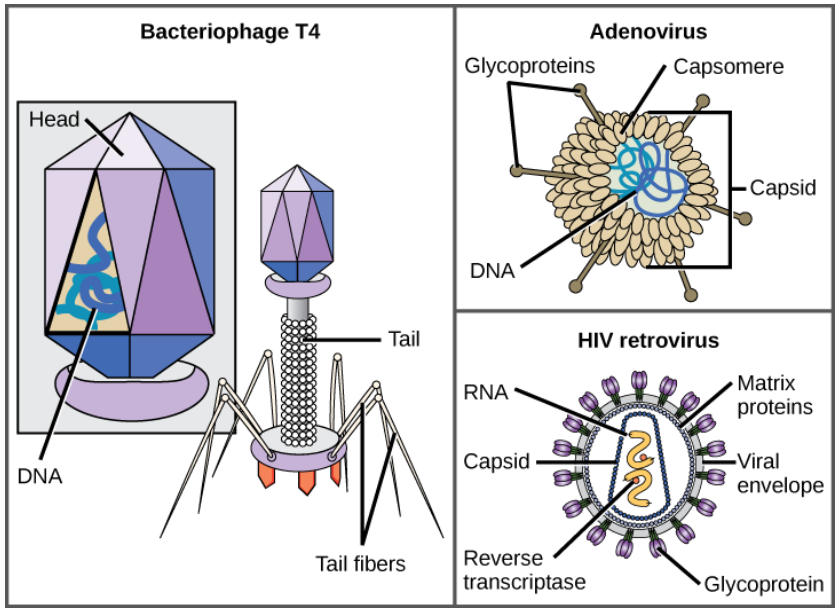
# Virus Reproduction

- When it comes into contact with a host cell, a virus attaches to specific receptors on the host cell membrane and can insert its genetic material into its host, literally taking over the host's functions
- An infected cell produces more viral protein and genetic material instead of its usual products



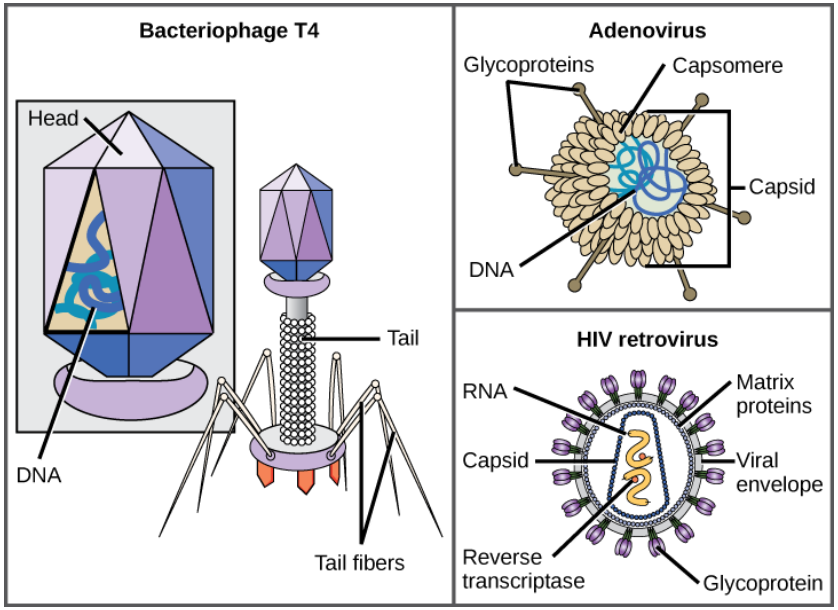
# Virus Reproduction

- Some viruses may remain dormant inside host cells for long periods, causing no obvious change in their host cells
- But when a dormant virus is stimulated, new viruses are formed, self-assemble, and burst out of the host cell, killing the cell and going on to infect other cells

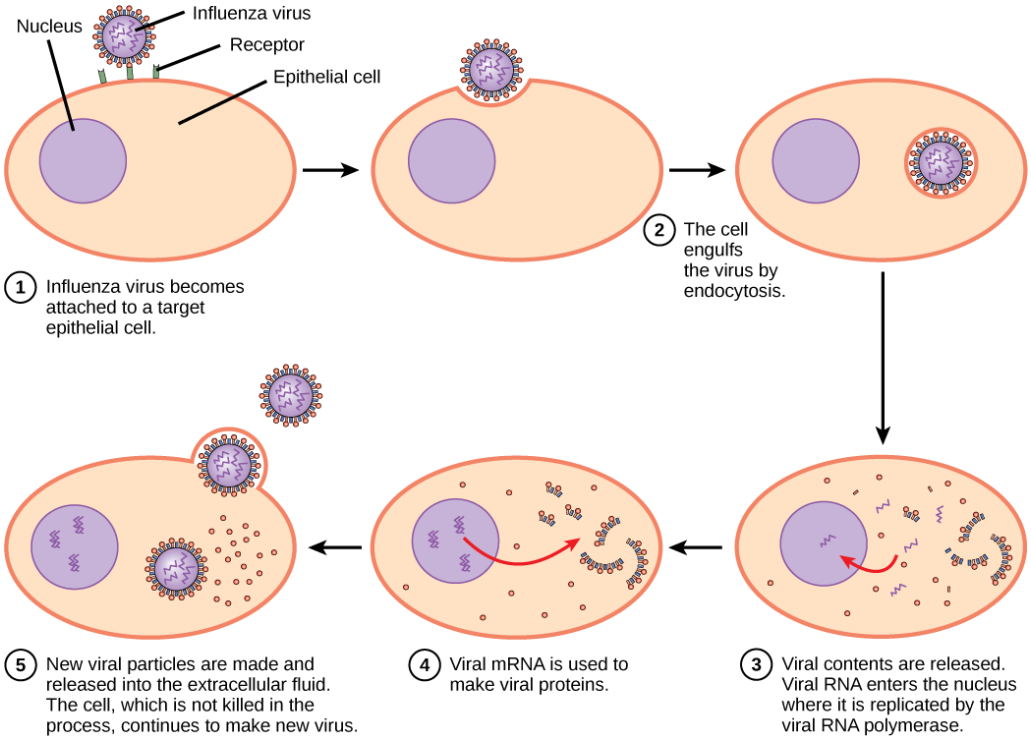


# Virus Shape

- Viruses can be complex in shape or relatively simple
- This figure shows three relatively complex viruses:
  - The bacteriophage T4, with its DNA-containing head group and tail fibers that attach to host cells;
  - Adenovirus, which uses spikes from its capsid to bind to the host cells;
  - And HIV, which uses glycoproteins embedded in its envelope to do so



# Figure 17.6




- In influenza virus infection, glycoproteins attach to a host epithelial cell. As a result, the virus is engulfed. RNA and proteins are made and assembled into new virions.

# Virus Genetics

- Unlike all living organisms that use DNA as their genetic material, viruses may use either DNA or RNA as theirs
- The virus core contains the genome or total genetic content of the virus
- Viral genomes tend to be small compared to bacteria or eukaryotes, containing only those genes that code for proteins the virus cannot get from the host cell

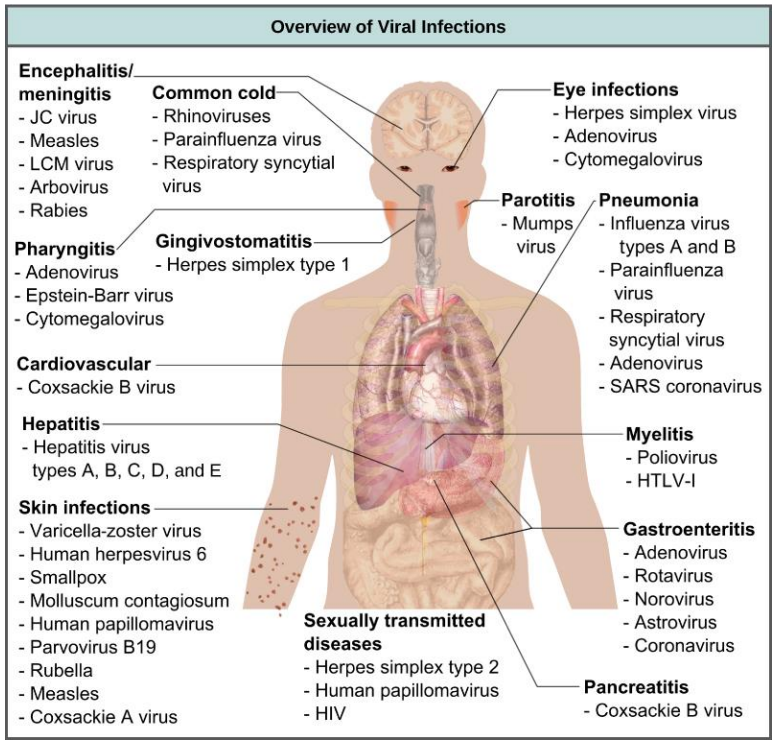
# Virus Genetics

- DNA viruses have a DNA core. The viral DNA directs the host cell's replication proteins to synthesize new copies of the viral genome and to transcribe and translate that genome into viral proteins
- DNA viruses cause human diseases such as chickenpox, hepatitis B, and some venereal diseases like herpes and genital warts

# Virus Genetics

- RNA viruses contain only RNA in their cores
- To replicate their genomes in the host cell, the genomes of RNA viruses encode enzymes not found in host cells
- RNA polymerase enzymes are not as stable as DNA polymerases and often make mistakes during transcription
- For this reason, mutations, changes in the nucleotide sequence, in RNA viruses occur more frequently
- For example, influenza strains change rapidly
- Human diseases caused by RNA viruses include hepatitis C, measles, and rabies
- Retroviruses, such as HIV, have an RNA genome that must be reverse transcribed to make DNA, which then is inserted into the host's DNA

# Figure 17.7




- Viruses are the cause of dozens of ailments in humans, ranging from mild illnesses to serious diseases. (credit: modification of work by Mikael Häggström) 7273213331

# Plant Diversity

# Plant Classification

- Land Plants are classified into two major groups:
  - Nonvascular plants
  - Vascular plants
- Nonvascular plants do not have vascular tissue (specialized cells for the transport of water and nutrients), whereas vascular plants do develop this specialized network.
- Vascular plants are further divided into seedless plants (mosses, horsetails, ferns) and plants that produce seeds.
- Plants that produce seeds are further divided into seed plants with seedpods (angiosperms or flowering plants) and seed plants without seedpods (gymnosperm such as conifers)

# Nonvascular Plants

- Nonvascular plants contain three main groups:
  - Mosses
  - Hornworts
  - Liverworts
- They are collectively known as bryophytes

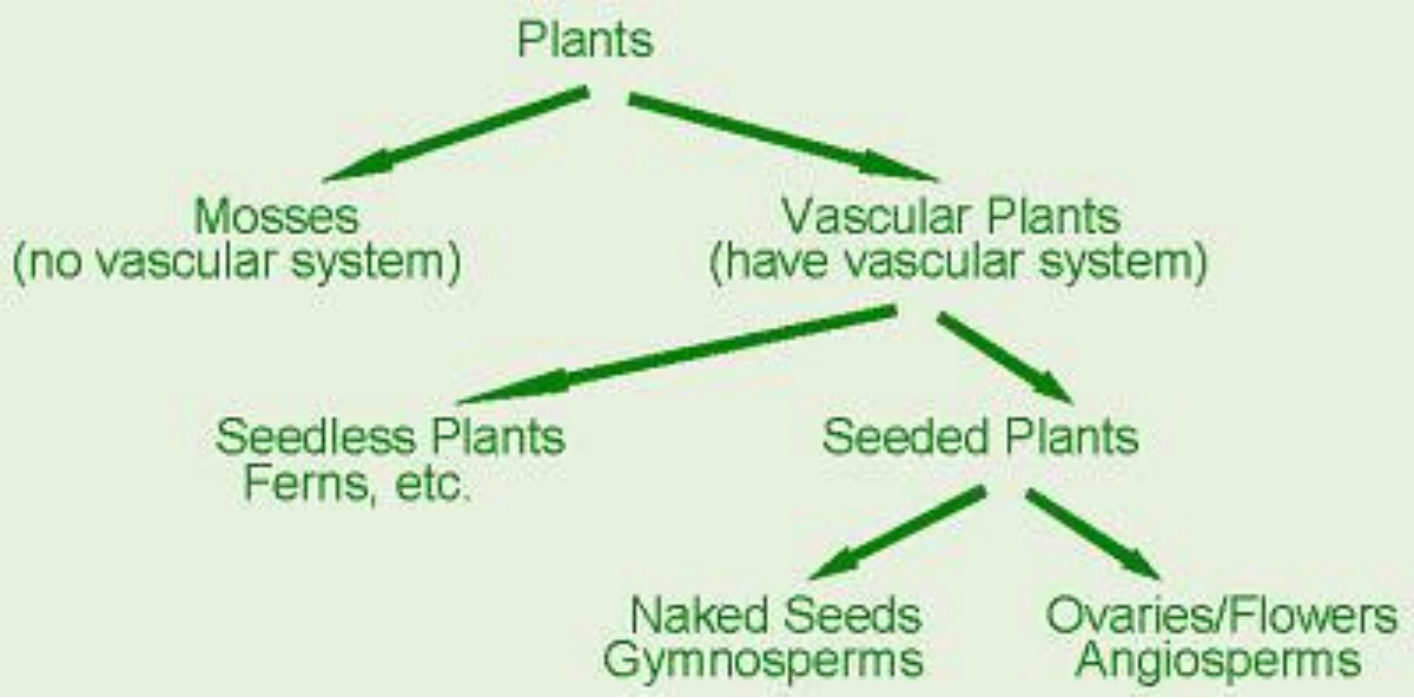
# Gymnosperms

- Gymnosperms consist of four major phylum
  - Conferophyta (conifers)
  - Cycadophyta (cycads)
  - Ginkgophyta or (*Gingko biloba* is the only species)
  - Gnetophyta (includes *Ephedra*)

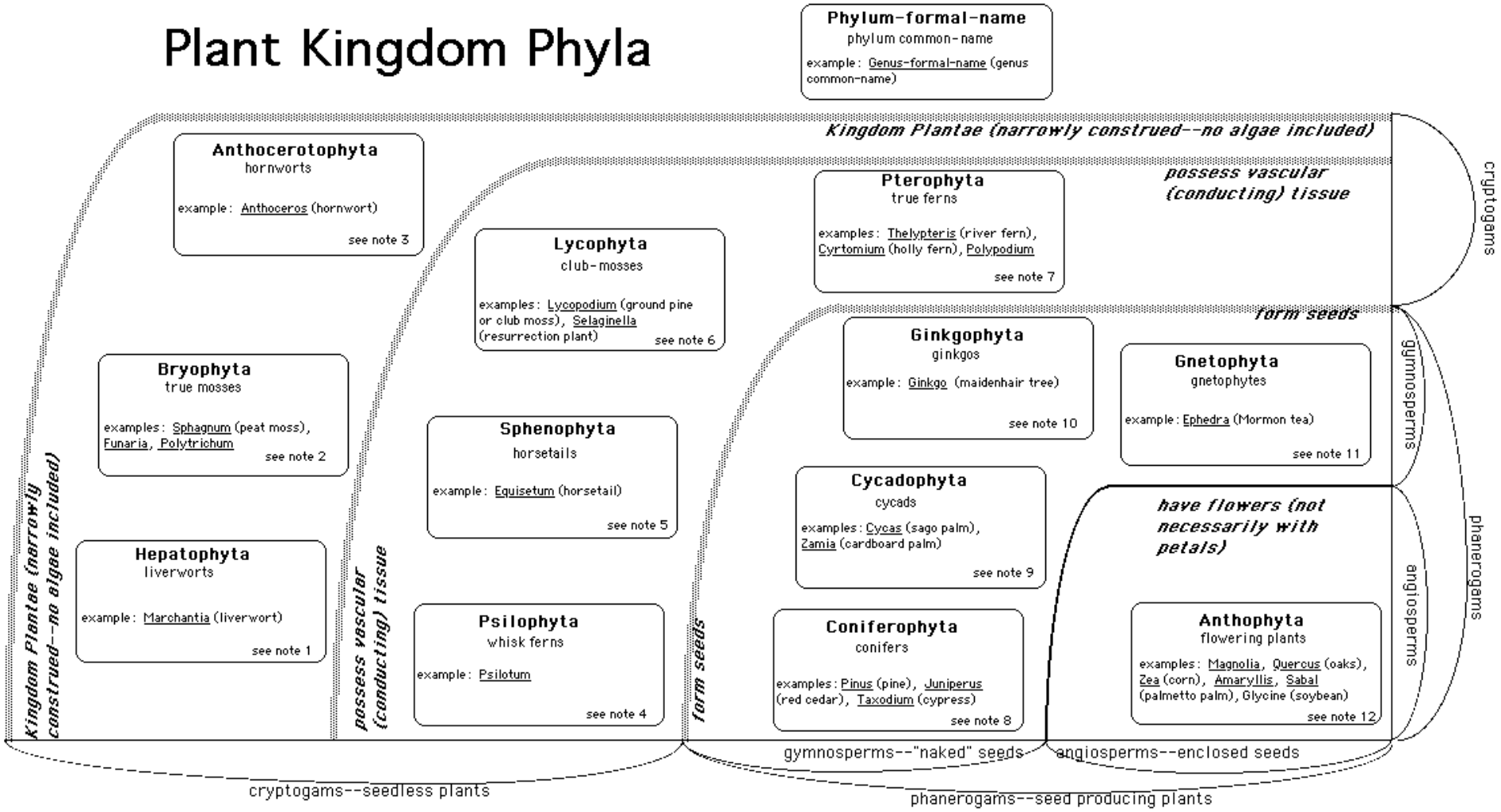
# Angiosperms (Flowering Plants)

- Angiosperms include a staggering number of genera and species; with more than 260,000 species, the division is second only to insects in terms of diversification. 90% of plant species are angiosperms.
- They contain two structures that give them advantage; flowers and fruits.
- They are classified under a single phylum - Anthophyta

# Classification of Plants



# Plant Kingdom Phyla



# Plant Families

- Plant families

## Examples of Taxonomic Classification

- Vascular plants
  - Seedless
    - *Pteridophyta (Pterophyta)* – ferns
  - Seeded
    - *Gymnospermae* – **Gymnosperms** (naked seed plants)
      - *Cycadophyta* – Cycads
      - *Pinophyta (Coniferophyta)* – **Conifers** (cone bearing plants)
        - *Cupressaceae* (cypress family)
          - *Juniperus* spp. – **junipers**
            - *Juniperus horizontalis* (creeping Juniper)
              - *Juniperus horizontalis* 'Blue Chip' (blue chip juniper)
          - *Thuja spp.* – **arborvitae**
        - *Pinaceae* (pine family)
          - *Abies* spp. – **fir**
          - *Larix* spp. – **larch**
          - *Picea* spp. – **spruce**
            - *Picea pungens* – Colorado spruce
              - *Picea pungens* 'Bakeri' – Bakeri Colorado spruce
          - *Pinus* spp. – **pines**
            - *Pinus ponderosa* – ponderosa pine
          - *Pseudotsuga menziesii* – **Douglas-fir**
    - *Angiospermae* – **Angiosperms** (flowering plants) / ***Magnoliophyta (Anthophyta)***
      - *Aceraceae* – Maple family
        - *Acer* spp. – **maples**
          - *Acer platanoides* – Norway maple
            - *Acer platanoides* 'Crimson King' – Crimson King Norway maple
      - *Salicaceae* – Willow family
        - *Populus* spp. – **cottonwood, poplar, and aspen**
          - *Populus deltoides* – eastern cottonwood
            - *Populus deltoides* 'Siouxland' – Siouxland eastern cottonwood
          - *Populus tremuloides* – quaking aspen
      - *Rosaceae* – rose family
        - *Rosa* spp. – **roses**
          - *Rosa rugosa* – Rugosa rose
            - *Rosa rugosa* 'Hansa' – Hansa rugosa rose
        - *Cotoneaster* spp. – **cotoneasters**
          - *Cotoneaster apiculatus* – cranberry cotoneaster

# Plant Parts Relative to Herbalism