Grade 11 Biology

Diversity of Living Things

Class 1

Diversity of Living Things

Overall Expectations

- Analyze the effects of various human activities on the diversity of living things
- Investigate the principles of scientific classification using appropriate sampling and classification techniques
- Demonstrate an understanding of the diversity of living things, in terms of both the principles of taxonomy and phylogeny

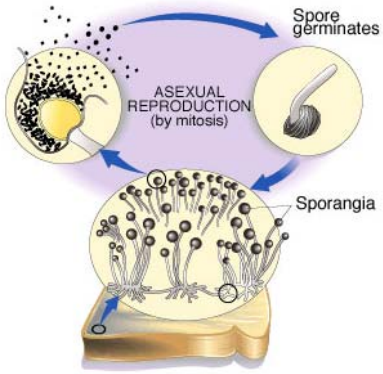
Biodiversity

- Biodiversity – the number and variety of species and ecosystems on Earth
  - Earth may be home to as many as 15 million different kinds of living things

Species

- **Species** – all organisms capable of breeding freely with each other under natural conditions
- **Hybridization** – the cross-breeding of two different species; relatively uncommon under natural conditions

- For organisms that reproduce asexually, the traditional species definition does not apply
- Species for asexual organisms are based on **morphology** – the physical appearance and characteristics of an organism



Variability of Species

- Individuals of any given species may show subtle differences but they still belong to the same species (individual variability)
- Species can change over time (evolutionary changes), separate and form entirely new species
  - Occur over long periods of time and over long distances

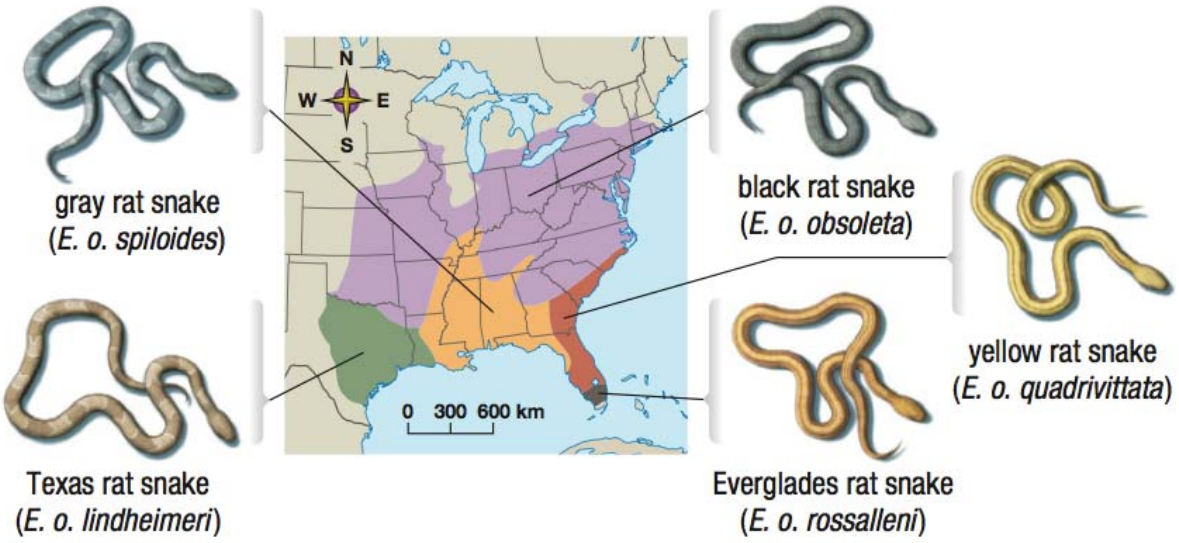
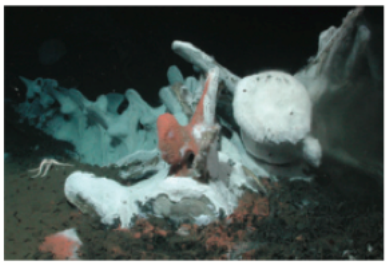


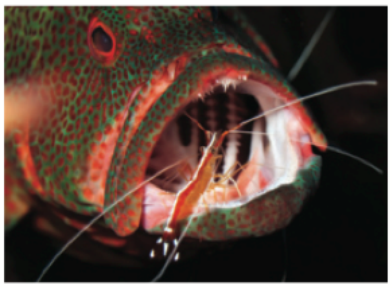
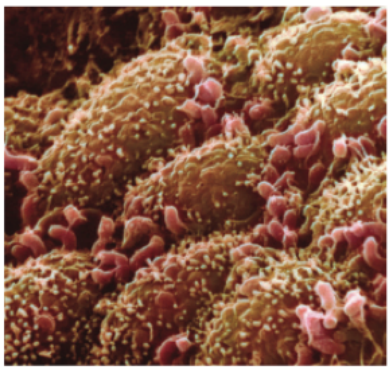
Figure 3 Five subspecies of rat snakes. These snakes are all considered members of the same species. They exhibit differences in colour and the presence or absence of stripes, depending on their geographic location.

Diversity of Interactions

- Ecosystems are made up of different species and their physical environment
- Species depend on each other to survive, which contributes to their stability and productivity
- **Species Diversity** – describes the variety of species in an ecosystem and the number of individuals within each of those species

Table 1 Species Interactions

Interaction	**Examples** (Organisms shown in the photos are bolded.)	
Food supply: Complex relationships exist between species and their food.	• **Boneworms feed exclusively on the bones of dead whales** that sink to the bottom of the ocean. • Photosynthetic micro-organisms live inside the bodies of giant clams and coral animals on reefs. They perform photosynthesis and supply the clams and corals with a steady supply of food.	
Protection: Many species depend on others for shelter and protection.	• Hermit crabs use the shells of dead snails for a protective home. • **Certain species of ants live within the trunks of *Cecropia* trees.** The trees provide shelter for the ants. The ants protect the tree by biting and stinging any herbivores that try to eat from it.	
Transportation: Many species move from place to place with the help of another species.	• Some flower mites climb onto the bills of hummingbirds moving from flower to flower feeding on nectar. • **Many seeds have hooks that allow them to stick to passing animals.** They can then be carried long distances before they fall off and begin growing.	
Reproduction: Many species depend on other species for their own successful reproduction.	• Trilliums produce seeds with fleshy tissues that attract ants. The seeds are then gathered and dispersed by the ants. If the ants do not feed on this outer seed tissue, the seeds cannot germinate. • Many bird species build their nests in the abandoned **tree cavities made by woodpeckers for their own nests.**	

Hygiene: Some species help maintain the health of another species.	• Coral reefs have "cleaning stations" where **large fish come to have external parasites removed by small fish and shrimp.** • The bacteria that naturally live on our own skin help protect us from other bacterial and fungal infections.	
Digestion: Species living within digestive tracts are essential for the digestion of food.	• Termites consume wood but are almost entirely incapable of digesting it themselves. Instead, a variety of bacteria and other micro-organisms living within the termites' guts do the digestion for them. • **Bacteria living in the large intestines of humans** produce vitamins that are absorbed into the circulatory system.	

Diversity of Habitats

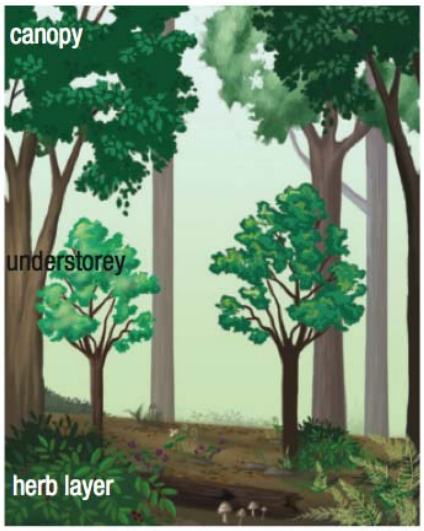


Figure 5 This mature forest has abundant structural diversity.

- **Structural Diversity** – the range of physical shapes and sizes within a habitat or ecosystem
  - Creates microhabitats for greater biodiversity

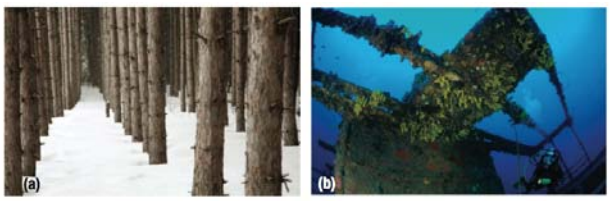


Figure 6 (a) Even-aged tree plantations, often established after clear-cutting, exhibit almost no structural diversity. (b) Artificial reefs made from sunken ships or aircraft increase the structural diversity of the ocean bottom.

Biodiversity at Risk

- Loss of biodiversity
  - Threatens our food supply when entire species and plant varieties are lost
  - Eliminates sources of natural medicines and potential new medicines
  - Has a significant economic impact on tourism and forestry
  - Has the potential to cause serious disruptions in biogeochemical cycles (i.e. carbon cycle)

- Extinction is a natural process but human activity is increasing the rate of extinction
  - Agriculture, forestry, urban development, invasive species, over-harvesting, pollution
- Estimated that extinction rate is 27 000 species per year

Biological Classifications

- The systematic grouping of organisms into biological categories based on physical and evolutionary relationships

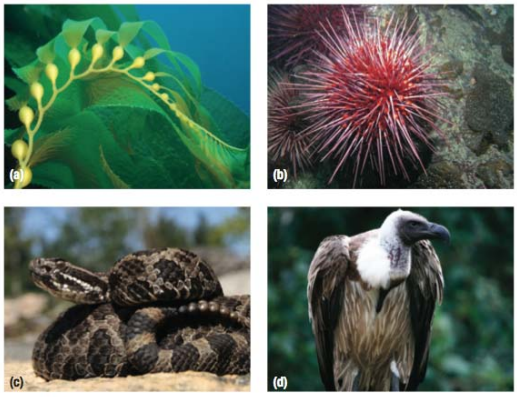
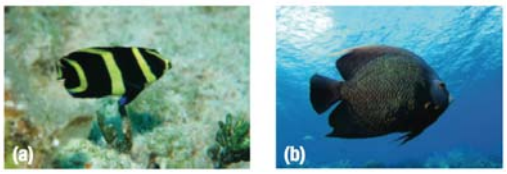


Figure 2 Scientists often classify organisms according to their role in ecosystems: (a) kelp is a producer, (b) a sea urchin is a herbivore, (c) a massasauga rattlesnake is a predator, and (d) a vulture is a scavenger.

Taxonomy

- **Taxonomy** – the science of classifying all organisms; both living and fossil species based on morphology, behavior and geographic location
- Challenges:
  - Numerous species
  - Males differ from females
  - Change in appearance due to age, location, evolution



Genera

- Swedish naturalist, Carl Linnaeus introduced a way to group species according to their shared physical similarities into categories called **genera**
- Created the **Binomial Nomenclature** – the formal system of naming species in which the *Genus* name is followed by the *species* name

  Ex: *Ursus americanus* and *Ursus maritimus*

Binomial Nomenclature

- A scientific name of an organism contains two parts:

  1) Genus 2) Species

Rules:

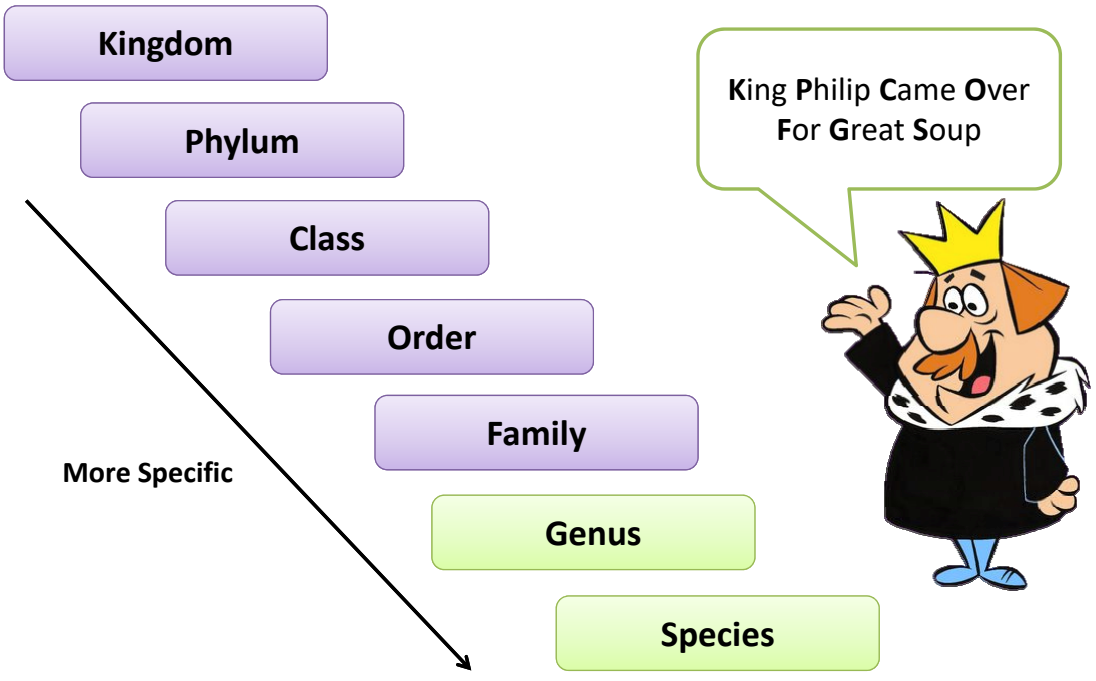
- The first letter of the Genus name must be capitalized
- The first letter of the species name is not capitalized
- Both names must be underlined or *italicized*

Ex: *Homo sapiens* OR Homo sapiens

Traditional Taxonomic Levels

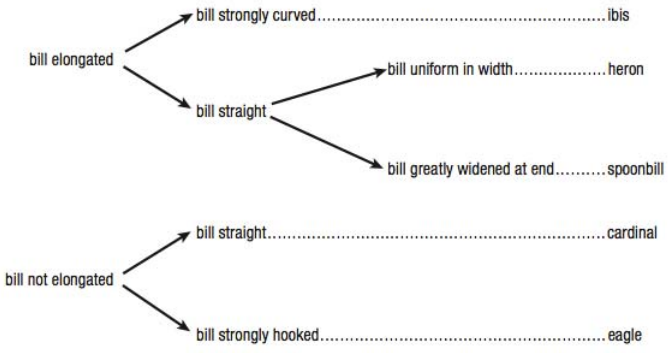
Table 2 Traditional Taxonomic Ranks of Classification

Taxon	Human	Walrus	Bald eagle	Honey bee
kingdom	Animalia	Animalia	Animalia	Animalia
phylum	Chordata	Chordata	Chordata	Arthropoda
class	Mammalia	Mammalia	Aves	Insecta
order	Primates	Carnivora	Accipitriformes	Hymenoptera
family	Hominidae	Odobenidae	Accipitridae	Apidae
genus	*Homo*	*Odobenus*	*Haliaeetus*	*Apis*
species	*Homo sapiens*	*Odobenus rosmarus*	*Haliaeetus leucocephalus*	*Apis mellifera*



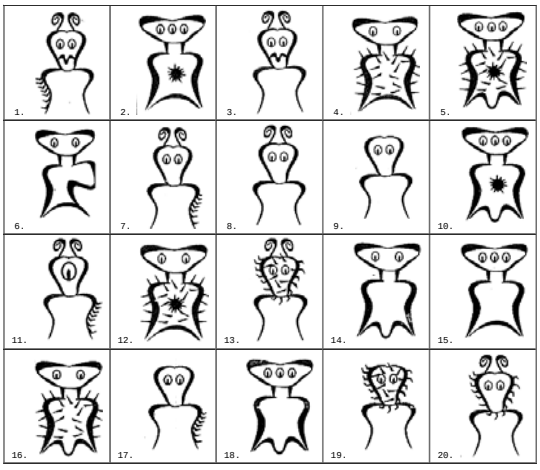
Dichotomous Keys

- **Dichotomous Key** – a series of branching, two-part statements used to identify organisms (or objects)



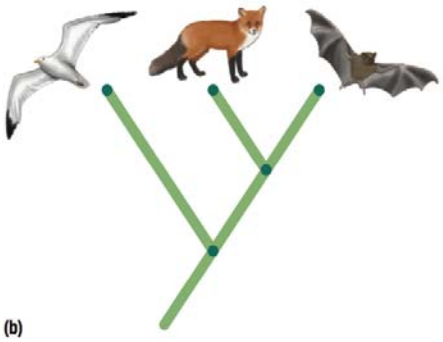
Checkpoint

Use the dichotomous key on the worksheet to identify the following creatures:



Phylogeny and Modern Taxonomy

- Evolution – the scientific theory that describes changes in species over time; descended from a common ancestor
- **Phylogeny** – the study of evolutionary relatedness between and among species
  - Relatedness can be presented in a **phylogenetic tree**



- Species are grouped into **clades** – a taxonomic group that includes a single common ancestor and all its descendants

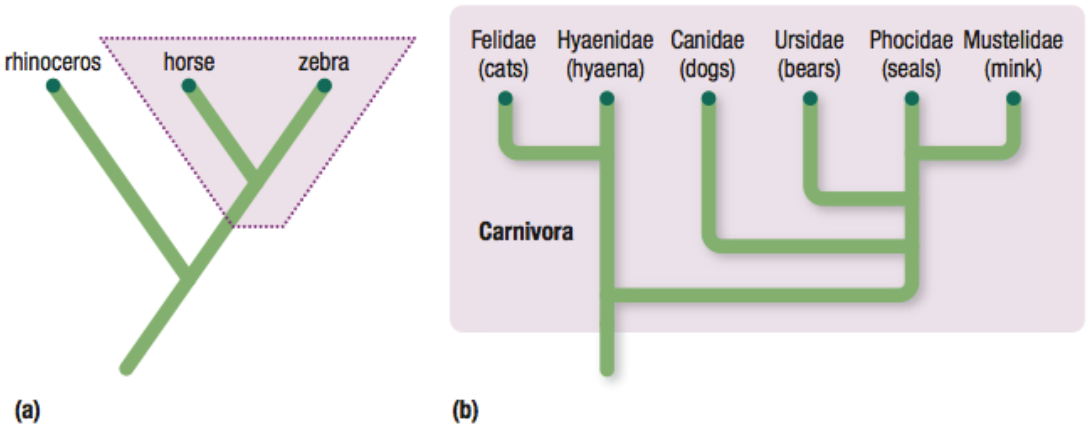
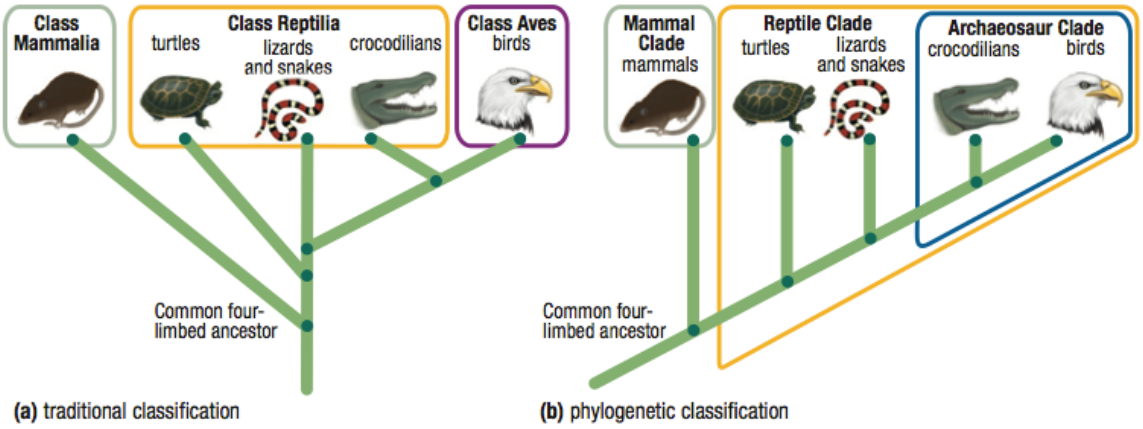


Figure 2 (a) The horse family is a small clade that includes the modern horse and zebra but not the rhinoceros. (b) The order Carnivora is a larger clade that includes many different families and is within the class Mammalia. Note that not all members of each clade are shown.



- Phylogenetic analysis allows organisms to be grouped into different-sized clades that are not limited to a set number of taxonomic ranks

STOP **Checkpoint** STOP

Figure 3 shows a simple phylogenetic tree. How closely are the rhinoceros, horse, and zebra related?

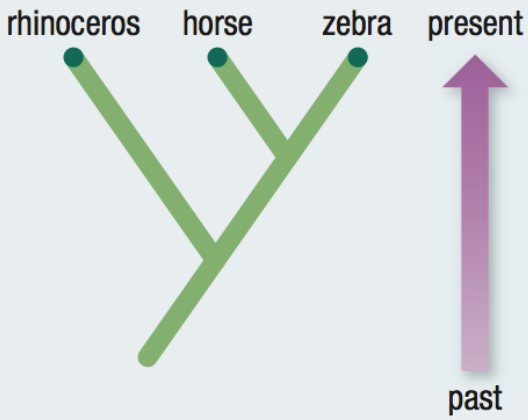


Figure 3 A simple phylogenetic tree

International Barcode of Life (iBOL)

- Use of DNA technology to create a DNA barcode of every species
- Launched in 2010, project's hub is at the University of Guelph
- Allows for low-cost, routine sampling and monitoring of species diversity

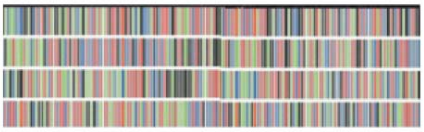


Figure 9 The barcode for the frog-eating bat *Trachops cirrhosus*.

Kingdoms of Life

- Eubacteria
- Archaea
- Protista
- Animals
- Fungi
- Plants

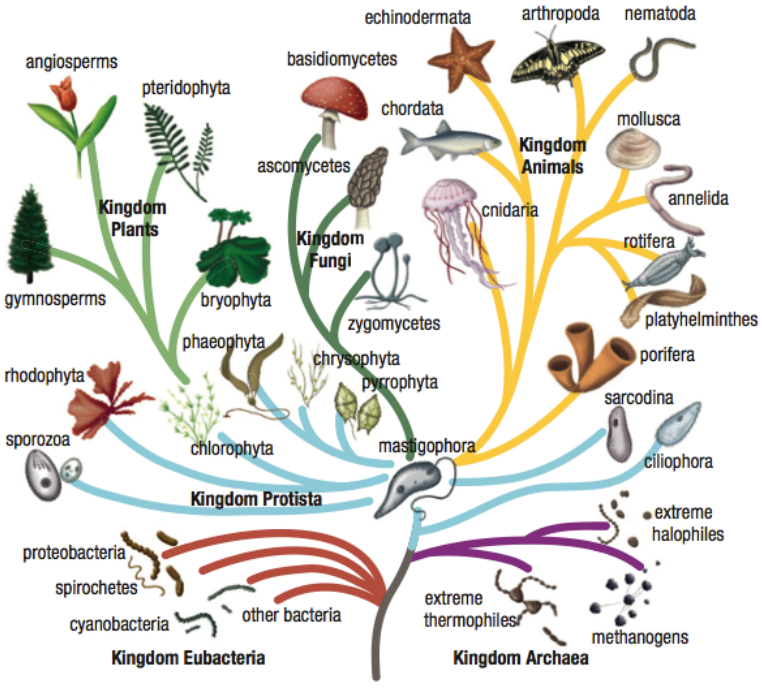
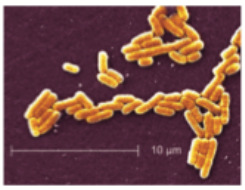
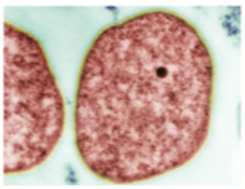
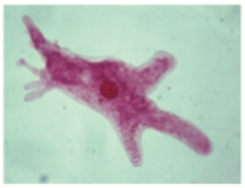
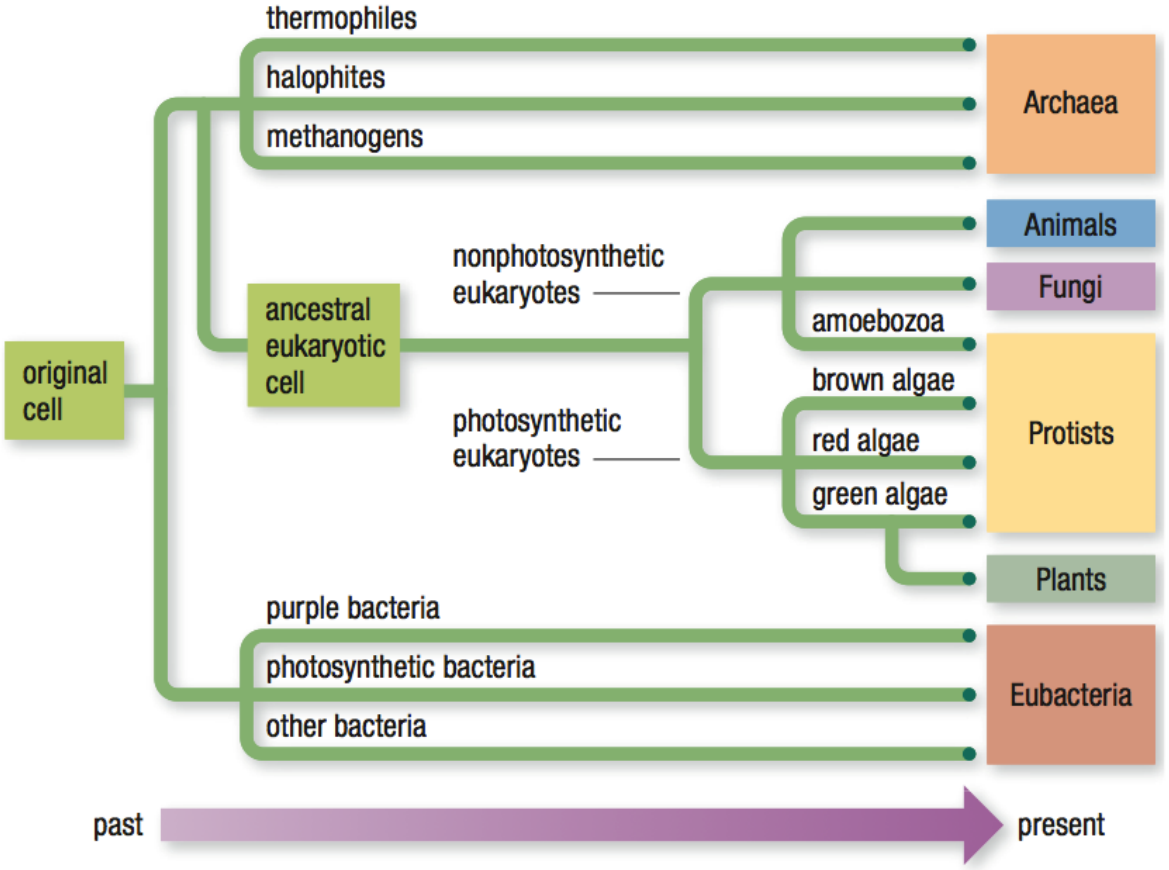


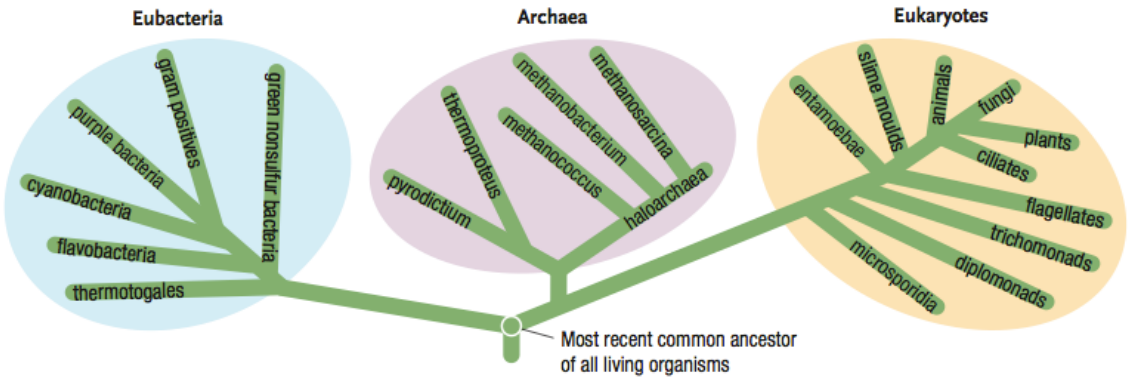
Table 1 Common Characteristics of the Six Kingdoms of Life

Kingdom	**Cell characteristics**	**Other characteristics**	**Examples** (Organisms shown in the photos are bolded.)	
Eubacteria > 10 000 described species	• Prokaryotic • Cell walls contain a unique compound. • Cells are variable in shape and size.	• Diverse means of obtaining energy and nutrients—photosynthetic, chemotropic, or heterotrophic • All can reproduce asexually	***Escherichia coli***, *Salmonella*, nitrogen-fixing bacteria	
Archaea > 400 described species	• Prokaryotic • Cell walls and cell membranes have a unique structure. • Most are extremely small.	• Some colonize extreme environments. • Live in the digestive tracts of mammals and marine environments • All can reproduce asexually.	**extreme thermophiles** (organisms that thrive at high temperatures), methanogens (micro-organisms that produce methane as a byproduct)	
Protista > 100 000 described species	• Eukaryotic • Cells have extreme diversity of cellular structure. • Some have chloroplasts and cell walls.	• May be heterotrophic or photosynthetic, or both • Have variable forms of movement • Usually live in aquatic or other moist environments • Reproduce sexually and asexually	***Amoeba***, kelps, green algae	
Fungi > 100 000 described species	• Eukaryotic • The cell wall is composed of chitin. • Most are multicellular. • Cells have no chloroplasts.	• All are heterotrophic • Most are terrestrial • Reproduce sexually and asexually	**mushrooms**, yeasts, moulds	
Plants > 250 000 described species	• Eukaryotic • All are multicellular • Cell walls are composed of cellulose. • Possess chloroplasts	• Autotrophic and photosynthetic • Most are terrestrial • Reproduce sexually and asexually	mosses, ferns, **conifers**, flowering plants	
Animals > 1.2 million described species	• Eukaryotic • All are multicellular. • Cells have no cell walls or chloroplasts.	• All are heterotrophic • Most reproduce sexually. • Live in terrestrial and aquatic environments	**elephants**, sponges, corals, insects, snails, birds, humans	



Domains of Life

- Proposed by Carl Woese (1996), all organisms can be classified into **domains** – the highest taxonomic level based on differences in genetic makeup



The Prokaryotes

- Organisms in the Domain Eubacteria and Archaea are prokaryotes – single-celled organisms that lack membrane-bound organelles

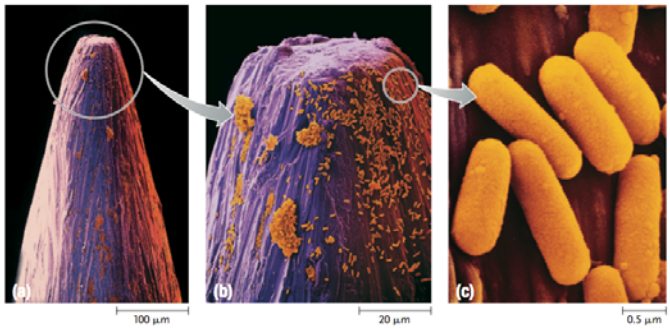


Figure 1 *Bacillus* bacteria on the point of a pin. The images are magnified (a) 70×, (b) 350×, and (c) 14 000×.

Domain: Eubacteria

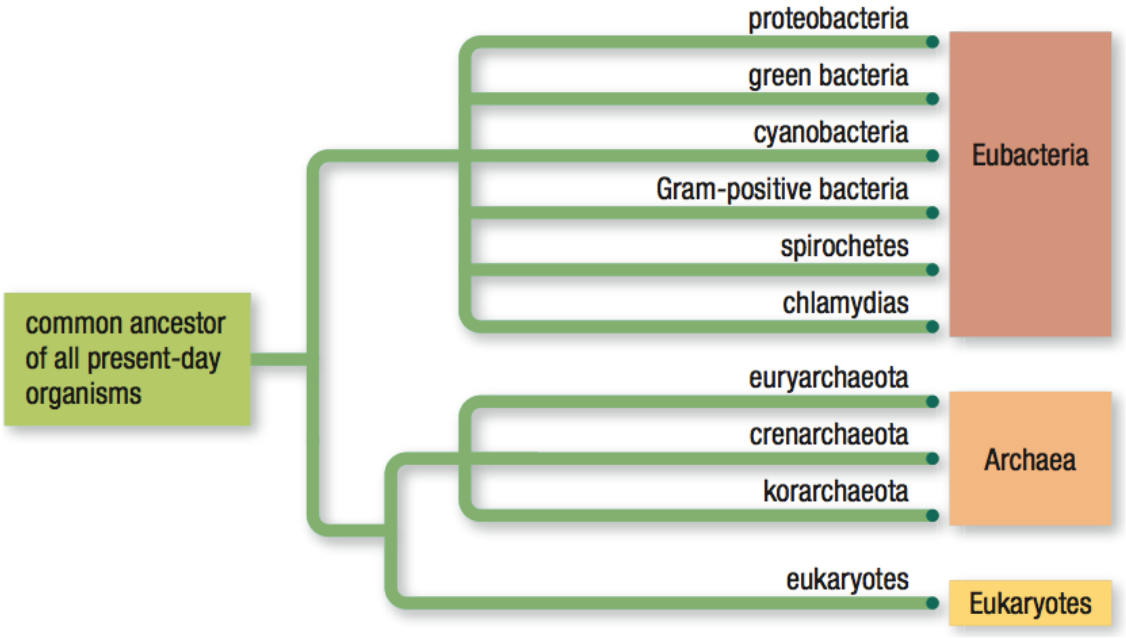


Table 1 Key Features of the Six Major Groups of Bacteria

Group	Key features
proteobacteria (purple bacteria)	• Some are photosynthetic but use a form of photosynthesis that differs from that of plants. • Ancient forms of these bacteria were the likely ancestors of eukaryotic mitochondria. • Some are nitrogen fixing. • They are responsible for many diseases, including bubonic plague, gonorrhea, dysentery, and some ulcers.
green bacteria	• They use a form of photosynthesis that differs from that of plants. • They are usually found in salt-water environments or hot springs.
cyanobacteria (blue-green algae)	• They use a form of photosynthesis similar to plants and other eukaryotes. • Ancient forms of these bacteria were the likely ancestors of eukaryotic chloroplasts. • They play major roles as producers and nitrogen fixers in aquatic ecosystems. • They form symbiotic relationships with fungi.
Gram-positive bacteria	• They cause many diseases, including anthrax, strep throat, bacterial pneumonia, and meningitis. • They are used in food production (for example, lactobacillus is used in yogurt and probiotic products). • Some have lost their cell wall. • One type—mycoplasmas—are the smallest known cells (0.1 µm to 0.2 µm).
spirochetes	• Their spiral-shaped flagellum is embedded in their cytoplasm. • They move with a corkscrew motion. • They cause syphilis. • Symbiotic spirochetes in termite intestines digest wood fibre.
chlamydias	• All are parasites that live within other cells. • They cause chlamydia, one of the most common sexually transmitted infections. • They cause trachoma, the leading cause of blindness in humans.

Characteristics of Eubacteria

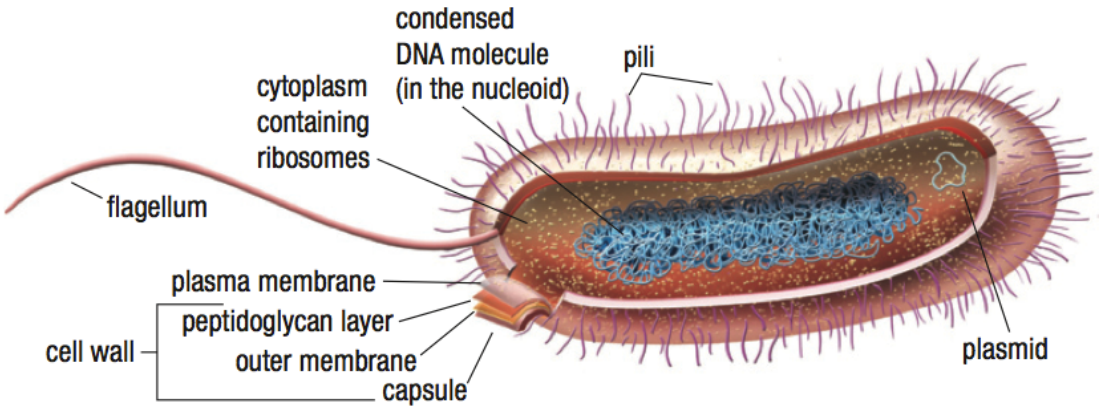
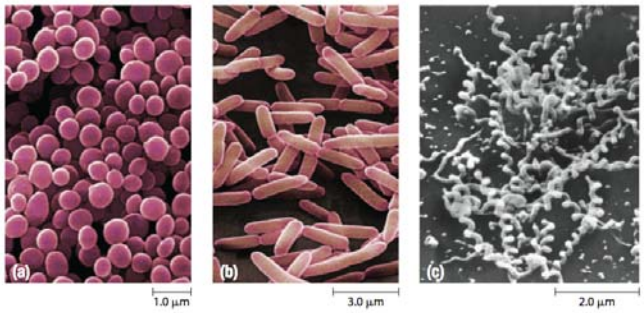


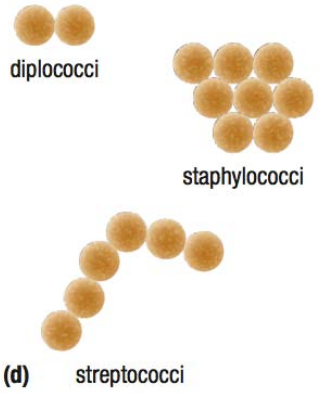
Figure 6 A representative bacterial cell

- Chromosome is a single loop of DNA found in a region called the nucleoid
- Ribosomes used for protein synthesis are scattered through the cytoplasm
- One or more flagella are used for movement
- Pili are small, hair-like projections for adhesion to other cells
- Plasmid is a small loop of DNA that carries some genes that are not essential for cellular function but provide some advantage to the cell (i.e. antibiotic resistance)

- Cells walls are made of peptidoglycan which make it strong and rigid
- Some bacteria have a sticky capsule that reduces water loss, resists high temperatures and helps keep out antibiotics and viruses
- Shapes:
  - Coccus – round
  - Bacillus – rod
  - Spirillum - spiral

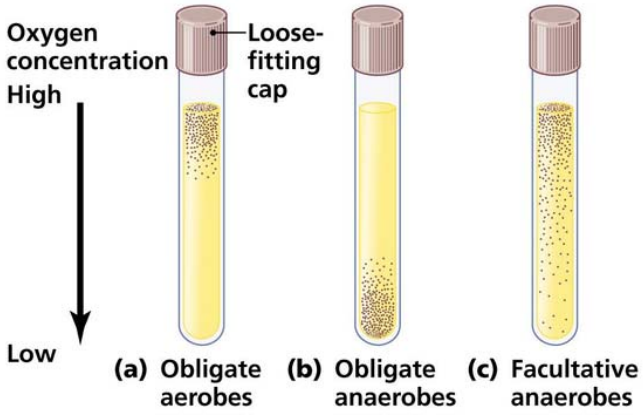


- Arrangements:
  - *Diplo* – pairs
  - *Staphylo* – clumps
  - *Strepto* – strings



- Metabolism
  - Autotrophic bacteria – make their own food using inorganic chemicals like CO_2, H_2O and minerals
  - Heterotrophic bacteria – obtain nutrients from organic chemicals found in living organisms and their remains

- Respiration



  - Obligate aerobes – need oxygen
  - Facultative aerobes – perform aerobic respiration in the presence of oxygen; perform anaerobic respiration or fermentation in the absence of oxygen
  - Obligate anaerobes – cannot live in environments where oxygen is present

- Reproduction
  - **Binary Fission** (Asexual Reproduction) – division of one parent cell into two genetically identical daughter cells
  - **Conjugation** (Sexual Reproduction) – one bacterial cell passes a copy of a plasmid to a nearby cell through a hollow pilus

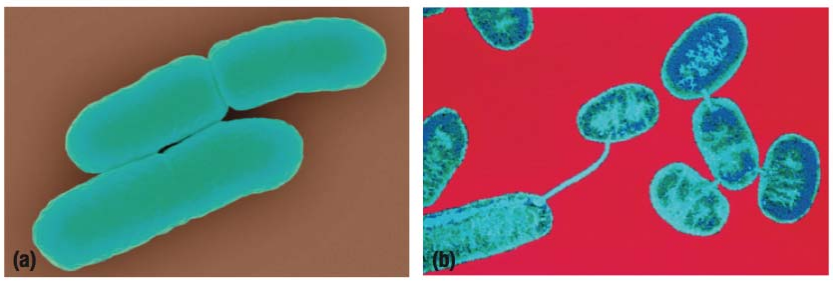


Figure 8 (a) The *E. coli* (*Escherichia coli*) cell on the top is dividing by binary fission. (b) Pairs of bacteria are joined by a pilus and are undergoing conjugation. One cell is transferring a copy of a plasmid to another cell.

– **Transformation** (Sexual Reproduction) – bacteria takes in a loose fragment of DNA from its environment and uses it
  - If the new DNA came from a different species, the process is called **horizontal gene transfer**
– **Endospores** – a highly resistant structure that forms around the chromosome when the cell is under stress; remains dormant until conditions improve

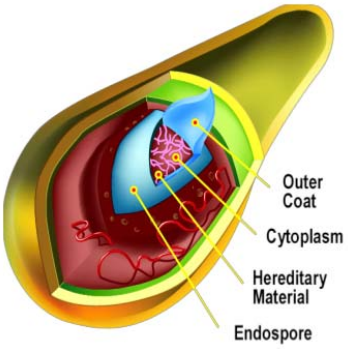
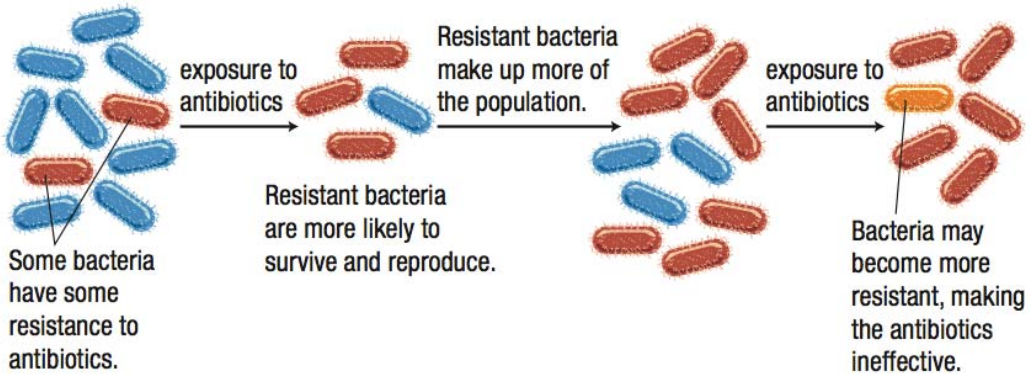


Table 2 Human Bacterial Diseases

Disease	Bacteria species
cholera	*Vibrio cholerae*
diphtheria	*Corynebacterium diphtheriae*
Lyme disease	*Borrelia burgdorferi*
pertussis	*Bordetella pertussis*
Rocky Mountain spotted fever	*Rickettsia rickettsii*
scarlet fever	*Streptococcus pyogenes*
tetanus	*Clostridium tetani*

- Bacterial Diseases
  – Some bacteria release toxins such as botulin which causes muscle paralysis
  – Some bacteria release toxins after the cells dies such as *E. coli* strain O157:H7, which caused water contamination in Walkerton, Ontario in 2000

- Antibiotic Resistance
  - Antibiotics kills bacteria and have saved millions of lives
  - Overuse of antibiotics can cause antibiotic resistance because the surviving bacteria pass on the antibiotic resistance trait to their offspring



Domain: Archaea

Figure 12 The sulfur-rich water of Emerald Hole in Yellowstone National Park has very high temperatures. Archaea can use foul smelling H_2S as a food source in this environment.

- Prokaryotes that do not have peptidoglycan in its cell walls; cell walls resistant to physical and chemical disruptions
- Different genetic makeup than eubacteria
- Inhabit extreme environments

Table 3 Representative Archaea from the Group Euryarchaeota

Euryarchaeota subgroup	Key features

methanogens	• They live in low-oxygen environments, including
	  • sediments of swamps, lakes, marshes, and sewage lagoons
	  • digestive tracts of some mammals (including humans) and some insects
	• They generate energy by converting chemical compounds into methane gas, which is released into the atmosphere.

halophiles	• They are salt-loving organisms that can live in highly saline environments including the Dead Sea and foods preserved by salting. • Most are aerobic and get energy from organic food molecules. • Some use light as a secondary energy source.
extreme thermophiles	• They live in extremely hot environments including hot springs and hydrothermal vents on the ocean floor. • Their optimal temperature range for growth is 70 °C to 95 °C.
psychrophiles	• They are cold-loving organisms found mostly in the Antarctic and Arctic oceans, and cold ocean depths. • Their optimal temperature range for growth is −10 °C to −20 °C.