**Focus Topics for Unit 9: Phylogeny**

Clades (monophyletic, paraphyletic, and polyphyletic trees)

Bacteria (characteristics and evolution)

Archaea (characteristics and evolution)

Viruses (characteristics and evolution)

Protists (characteristics and evolution)

Fungi (characteristics and evolution)

Lytic vs Lysogenic pathways of viruses

Reproductive cycles of Fungi

**Clades (monophyletic, paraphyletic, and polyphyletic trees)**

A clade is a group of species that includes an ancestral species and all its descendants

A valid clade is monophyletic, signifying that it consists of the ancestor species and all its descendants

A paraphyletic grouping consists of an ancestral species and some, but not all, of the descendants

A polyphyletic grouping consists of various species that lack a common ancestor

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**Bacteria (Characteristics and Evolution)**

-Prokaryotes. No nucleus/membrane bound organelles

-Small in size: Most prokaryotic cells are 0.5–5 µm, much smaller than the 10–100 µm of many eukaryotic cells

-Reproduce by binary fission

- Most prokaryotes are unicellular, although some species form colonies

- An important feature of nearly all prokaryotic cells is their cell wall, which maintains cell shape, protects the cell, and prevents it from bursting in a hypotonic environment

- Some prokaryotes have fimbriae, which allow them to stick to their substrate or other individuals in a colony

- A polysaccharide or protein layer called a capsule covers many prokaryotes

-The three most common shapes are spheres (cocci), rods (bacilli), and spirals

- Prokaryotic cells have a variety of shapes

-Earth’s first organisms were likely prokaryotes

- Pili (or sex pili) are longer than fimbriae and allow prokaryotes to exchange DNA

- The prokaryotic genome has less DNA than the eukaryotic genome

-Most of the genome consists of a circular chromosome

-The chromosome is not surrounded by a membrane; it is located in the nucleoid region

-Some species of bacteria also have smaller rings of DNA called plasmids

- Many prokaryotes form metabolically inactive endospores, which can remain viable in harsh conditions for centuries

- Prokaryotes reproduce quickly by binary fission and can divide every 1–3 hours

-Key features of prokaryotic reproduction:

-They are small

-They reproduce by binary fission

-They have short generation times

-Prokaryotic DNA from different individuals can be brought together by transformation, transduction, and conjugation

- A prokaryotic cell can take up and incorporate foreign DNA from the surrounding environment in a process called transformation

-Transduction is the movement of genes between bacteria by bacteriophages (viruses that infect bacteria)

-Conjugation is the process where genetic material is transferred between prokaryotic cells

-In bacteria, the DNA transfer is one way

-A donor cell attaches to a recipient by a pilus, pulls it closer, and transfers DNA

-A piece of DNA called the F factor is required for the production of pili

- Bacterial cell walls contain peptidoglycan, a network of sugar polymers cross-linked by polypeptides

- Gram-positive bacteria have simpler walls with a large amount of peptidoglycan

-Gram-negative bacteria have less peptidoglycan and an outer membrane that can be toxic

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**Archaea (Characteristics and Evolution)**

-Archaea contain polysaccharides and proteins but lack peptidoglycan

-Some archaea live in extreme environments and are called extremophiles

-Extreme halophiles live in highly saline environments

-Extreme thermophiles thrive in very hot environments

-In recent years, genetic prospecting has revealed many new groups of archaea

-Some of these may offer clues to the early evolution of life on Earth

-Almost since their origin 3.5 billion years ago, prokaryotes have evolved in two separate lineages, the bacteria and archaea. The first prokaryotes that were classified in the domain Archaea are known as extremophiles and live in extreme environments.

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**Protists (Characteristics and Evolution)**

**Algae:** Algae are aquatic, photosynthetic protists.

Examples types include:

-Euglenoids: These protists use their flagella to swim around their fresh water habitats. Euglenoids have triple-membrane, green chloroplasts for photosynthesis when there is light, and in the dark feed on organic matter.,

-Dinoflagellates: Dinoflagellates are characterized by two flagella. They use them to whirl around in the ocean. Some are photosynthetic, some live inside animals such as jellyfish, and some are bioluminescent. They can overgrow and produce toxins, causing red tides.

-Diatoms: have yellowish pigments for photosynthesis and are abundant in all moist habitats. Their cell walls are very intricate and give them unique shapes.

-Golden algae: are unicellular or colonial autotrophs in light and heterotrophs in the dark.

-Brown algae: are the largest and most complex protists. They form giant underwater kelp forests.

-Red algae: have photosynthetic pigments that absorb red and blue wavelengths of light. These wavelengths do not dissipate in deep water. People eat red algae and use the agar they produce as a thickening agent in many things.

-Green algae: are a diverse group – some are microscopic, others are large and multicellular. They share many features with plants, including using chlorophyll a and b for photosynthesis and producing starch. In alternation of generations, haploid gametes and diploid zygotes can both grow into adult organisms. This life cycle, alternating between haploid and diploid forms, is only found in green algae and plants.

**Slime molds and water molds:** are heterotrophic protists that have filamentous feeding structures. However, they are only distantly related to fungi in terms of DNA sequence. can exist as single cells or as large masses that behave like a multicellular organism. Cellular slime modes live as haploid cells until resources become limited. They then aggregate into a mobile “slug” and then a fruiting body, which produces spores.

-Plasmodial slime molds are one huge cell. During their feeding stage, plasmodial slime molds form a plasmodium, which is a large cell containing thousands of diploid nuclei.

-Water molds are decomposers and parasites. Water molds are decomposers and parasites. They secrete digestive enzymes into their surroundings and absorb the nutrients. Some water molds ruin food crops, including potatoes, grapes and lettuce. Others grow on weak, dead, or dying aquatic organisms like fish.

**Protozoa**: Most protozoa are one-celled, heterotrophic, and motile. They are grouped together based on morphology and locomotion but are only distantly related to each other. Many resemble the larval stages of invertebrate animals.

-Flagellated protozoa have one or more flagella, which they use to move around. They live in soil, oceans, and fresh water. Some are parasites that live in our bodies.

-Trichonympha lives in the gut of termites. Bacteria that break down wood live in each of these unicellular protists. It is because of these bacteria within a protist that termites are able to digest wood.

-Amoeboid protozoa produce extensions known as pseudopodia, which are important in locomotion and capturing food. The amoeba shown here is consuming a ciliate.

-Entamoeba species invade the human digestive tract and cause fever and severe diarrhea in humans. Infection often occurs through lake water.

-Foraminiferans (Forams) have calcium carbonate shells, which are used to date layers of rock. Huge populations of forams live at the bottom of oceans.

-Radiolarians are among the oldest protozoans. They have intricate shells made of silica.

-Ciliates are mostly unicellular protozoa characterized by abundant hairlike cilia, which propel the organism and sweep food into the cell. They have specialized cell structures such as food vacuoles, contractile vacuoles, and an anal pore. Some have 2 types of nuclei. Some are symbionts that live in cattle or marine animals and help them digest food. Some are parasites, such as the species that causes white spots on fish. Others, such as Paramecium and Stentor, are free-living.

-Apicomplexans have a special cell structure that helps them attach to and invade host cells.

-Cryptosporidium causes waterborne diseases.

-Plasmodium is a protist carried by mosquitoes. When transmitted to humans it infects the red blood cells.

Algae—resemble plant cells

Slime molds/water molds—resemble fungal cells

Protozoa—resemble animal cells

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**Viruses (Characteristics and Evolution)**

-A virus is a small, infectious agent made of nucleic acid and protein.

- Each virus has genetic material inside, surrounded by a protein coat, or capsid.

-The proteins surrounding each virus are shaped to bind with proteins on host cells.

-Each virus has specific target cells that it can match up with to infect.

-The **host range** is the types of cells or organisms a virus can infect.

-Viruses can infect plants, bacteria, and human host cells.

-The organism with the virus is a reservoir host, providing a continual source of the virus

- Rabies virus can infect a variety of hosts. The virus is most often transmitted to humans by infected dogs, but foxes, raccoons, skunks, and bats can all carry and transmit the virus.

- There are four species of influenza viruses (A, B, C, D), which vary in the severity of symptoms they cause and in their host range. Infects birds and mammals including humans and pigs

- Coronaviruses: infects birds and humans and other mammals

-Ebola: Infects bats, humans, and other primates

-Adenovirus: Infects humans and other mammals, birds, reptiles, fish, and amphibians

-Tobacco Mosaic Virus: Infects plants such as tobacco and tomato plants

- Papillomaviruses: Infects many different organisms, including birds, fish, reptiles, amphibians, and cattle, humans, and other mammals

-Zika: Infects humans and other primates

A vaccine contains inactive virus or viral proteins. These molecular components of a virus produce an immune response without causing a disease.

-Vaccines “teach” the immune system to recognize a virus. If you are exposed to the real virus after being vaccinated, your body will be primed to destroy it before it can infect your cells.

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**Lytic vs Lysogenic pathways of viruses**

the **lytic** pathway:

Viral replication:

Virus attaches to host.

Virus injects its nucleic acids into the cell.

Host transcribes and translates viral DNA as if it were its own.

New viruses assemble.

Viruses leave the cell.

the **lysogenic** pathway

Viruses following the **lysogenic** pathway “hide” as they replicate, without damaging the host cell.

Virus injects its nucleic acids into the cell.

Viral DNA incorporated into host chromosome as prophage

Chromosome replicates as cell divides

Cells carry integrated viral DNA

Virus injects its nucleic acids into the cell.

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**Fungi (Characteristics and Evolution)**

-Fungi are the closest relatives of animals. Fungi and animals share many metabolic and chemical features. For instance, both are heterotrophs and use glycogen to store carbohydrates.

-Fungi are the planet’s garbage processors. They break down dead plants and animals, releasing nutrients to be recycled.

-All fungi feed by external digestion. They excrete digestive enzymes and absorb minerals and nutrients.

**-Chytridiomycetes** (chytrids) are thought to resemble the earliest fungi. They produce motile spores called zoospores that swim using flagella. Some chytrids are single cells. Others have slender hyphae. The structures at the ends of these hyphae produce gametes. Chytrids produce enzymes that break down molecules in animal, plant, and fungal cells. Some live in cow digestive tracts, where they digest cellulose in the grass cows eat. These chytrids feed on keratin protein in frog skin. The frog loses its ability to breathe through its skin, and dies.

World frog populations have been declining for years due to a chytrid epidemic.

**-Zygomycetes** fungi include molds that grow on bread, fruit, and vegetables. They are common in the soil where they feed on decaying plants and animals. This group of fungi produce a distinctive structure when 2 hyphae fuse to form a diploid zygote. Hyphae fuse to form a diploid zygospore with a spiny coat, which produces haploid spores. Each hypha produces spore sacs by mitosis. All spores are genetically identical.

**-Glomeromycetes** produce large, asexual spores. This group of fungi do not have a sexual life cycle, which makes them difficult to place in the family tree. Glomeromycetes spores are unusually large. Some are hundreds of nanometers in diameter, and can be seen by the naked eye. Glomeromycetes only live in association with plant roots. A fungus-plant root combination is called a **mycorrhiza**. The fungus exchanges minerals and nutrients with the plant root at structures called arbuscules. Mycorrhiza are mutually beneficial. Hyphae absorb water and nutrients from the soil and share them with the plant. The plant produces sugars that the fungus uses for energy.

**-Ascomycetes** is the largest group of fungi, containing more than 50,000 species. The red bread mold below is a valuable model organism. Some decompose organic matter. Others live in symbiosis with other organisms, either as parasites or mutualists. The fungus can be carnivorous. Ascomycetes that humans use include edible fungi, yeasts used for fermenting alcohol, and fungi that produce medicines. These truffles and morels are considered delicacies. A few species cause diseases in plants and animals. Others grow on our food and homes. Their spores can make it difficult to breathe. Separate haploid hyphae fuse, forming a dikaryotic cell. The nuclei eventually fuse, forming a diploid zygote. The zygote produces sets of eight haploid spores inside an elongated sac called an ascus. Many asci together form a fruiting body. During asexual reproduction, a hypha produces identical haploid spores, each of which germinates into a haploid hypha.

**-Basidiomycetes** include mushrooms and other fungi. Basidiomycetes disperse spores in many ways. The putrid odor of the stinkhorn’s slimy spore mass attracts flies,

which carry the spores on their feet. Raindrops splash the spore-laden “eggs” out of a bird’s nest fungus. Puffballs disperse spores in the wind. Mushrooms are sometimes edible, although they can also be poisonous or can induce hallucinations.

**-Lichens** are fungi with green algae or cyanobacteria living among their hyphae.

The fungi absorb minerals and water while the algal cells produce sugars by photosynthesis.

They secrete acids that break down rock, which starts to develop into soil.

Many harbor nitrogen-fixing bacteria needed by plants.

Animals such as caribou eat lichens.

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**Fungi Reproductive Cycles:**

-Basidiomycetes reproduce sexually

-Most of the life cycle is devoted to sexual reproduction.

-Haploid hyphae grow from spores and fuse, forming a dikaryotic cell. Mitosis of the dikaryotic cell produces a dikaryotic mycelium.

-The dikaryotic mycelium grows into a mushroom.

-The mushroom cap contains gills on which club-shaped cells called basidia form.

-Within each basidium, the two haploid nuclei fuse into a diploid zygote.

-The zygote then divides by meiosis, forming four haploid, genetically unique basidiospores.

