**Bacteria and Archaea Notes 2019**

**Concept: Diverse structural and metabolic adaptations have evolved in prokaryotes**

Prokaryotes thrive almost everywhere, including places too acidic, salty, cold, or hot for most other organisms

Most prokaryotes are microscopic, but what they lack in size they make up for in numbers

There are more in a handful of fertile soil than the number of people who have ever lived

Prokaryotes are divided into two domains: bacteria and archaea

Earth’s first organisms were likely prokaryotes

Most prokaryotes are unicellular, although some species form colonies

Most prokaryotic cells are 0.5–5 µm, much smaller than the 10–100 µm of many eukaryotic cells

Prokaryotic cells have a variety of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

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

Eukaryote cell walls are made of cellulose or chitin

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

Archaea contain polysaccharides and proteins but lack peptidoglycan

Scientists use the Gram stain to classify bacteria by cell wall composition

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

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

Many antibiotics target peptidoglycan and damage bacterial cell walls

Gram-negative bacteria are more likely to be antibiotic resistant

A polysaccharide or protein layer called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ covers many prokaryotes

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

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (or sex pili) are longer than fimbriae and allow prokaryotes to exchange DNA.

In a heterogeneous environment, many bacteria exhibit taxis, the ability to move toward or away from a stimulus. Chemotaxis is the movement toward or away from a chemical stimulus

Most motile bacteria propel themselves by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ scattered about the surface or concentrated at one or both ends

Flagella of bacteria, archaea, and eukaryotes are composed of different proteins and likely evolved independently

Prokaryotic cells usually lack complex compartmentalization

Some prokaryotes do have specialized membranes that perform metabolic functions

These are usually infoldings of the plasma membrane

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 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

There are some differences between prokaryotes and eukaryotes in DNA replication, transcription, and translation

These allow people to use some antibiotics to inhibit bacterial growth without harming themselves

Reproduction and Adaptation

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

Many prokaryotes form metabolically inactive **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, which can remain viable in harsh conditions for centuries

Their short generation time allows prokaryotes to evolve quickly

For example, adaptive evolution in a bacterial colony was documented in a lab over 8 years

Prokaryotes are not “primitive” but are highly evolved

**Concept: Rapid reproduction, mutation, and genetic recombination promote genetic diversity in prokaryotes**

Prokaryotes have considerable genetic variation. Three factors contribute to this genetic diversity:

Rapid reproduction

Mutation

Genetic recombination

Prokaryotes reproduce by binary fission, and offspring cells are generally identical

Mutation rates during binary fission are \_\_\_\_\_\_\_\_\_\_\_, but because of rapid reproduction, mutations can accumulate rapidly in a population

High diversity from mutations allows for rapid evolution

Genetic recombination, the combining of DNA from two sources, contributes to diversity

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

Movement of genes among individuals from different species is called horizontal gene \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Transformation and Transduction:

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 and Plasmids

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 \_\_\_\_\_\_\_ factor is required for the production of pili

Cells containing the F plasmid function as DNA donors during conjugation

Cells without the F factor function as DNA recipients during conjugation

The F factor is transferable during conjugation

A cell with the F factor built into its chromosomes functions as a donor during conjugation

The recipient becomes a recombinant bacterium, with DNA from \_\_\_\_\_\_\_\_\_\_\_\_\_ different cells

\_\_\_\_\_\_\_\_\_\_ plasmids carry genes for antibiotic resistance

Antibiotics kill sensitive bacteria, but not bacteria with specific R plasmids

Through natural selection, the fraction of bacteria with genes for resistance increases in a population exposed to antibiotics

Antibiotic-resistant strains of bacteria are becoming more common

**Concept:** **Diverse nutritional and metabolic adaptations have evolved in prokaryotes**

Prokaryotes can be categorized by how they obtain energy and carbon

-Phototrophs obtain energy from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

-Chemotrophs obtain energy from chemicals

-Autotrophs require CO2 as a carbon source

-Heterotrophs require an organic nutrient to make organic compounds

Energy and carbon sources are combined to give four major modes of nutrition:

-Photoautotrophy

-Chemoautotrophy

-Photoheterotrophy

-Chemoheterotrophy

The Role of Oxygen in Metabolism

Prokaryotic metabolism varies with respect to O2

-Obligate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ require O2 for cellular respiration

-Obligate anaerobes are poisoned by O2 and use fermentation or anaerobic respiration

-Facultative anaerobes can survive with or without O2

Nitrogen Metabolism:

-Nitrogen is essential for the production of amino acids and nucleic acids

-Prokaryotes can metabolize nitrogen in a variety of ways

-In nitrogen \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, some prokaryotes convert atmospheric nitrogen (N2) to ammonia (NH3)

Metabolic Cooperation

Cooperation between prokaryotes allows them to use environmental resources they could not use as individual cells

In the cyanobacterium Anabaena, photosynthetic cells and nitrogen-fixing cells called heterocysts (or heterocytes) exchange metabolic products

In some prokaryotic species, metabolic cooperation occurs in surface-coating colonies called **biofilms**

**Concept: Prokaryotes have radiated into a diverse set of lineages**

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.

Some archaea live in extreme environments and are called extremophiles

Extreme halophiles live in highly saline environments

Extreme thermophiles thrive in very hot environments

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ live in swamps and marshes and produce methane as a waste product

Methanogens are strict anaerobes and are poisoned by O2

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

Bacteria include the vast majority of prokaryotes of which most people are aware

Diverse nutritional types are scattered among the major groups of bacteria

**Concept: Prokaryotes play crucial roles in the biosphere**

Prokaryotes are so important that if they were to disappear the prospects for any other life surviving would be dim

Prokaryotes play a major role in the recycling of chemical elements between the living and nonliving components of ecosystems

Chemoheterotrophic prokaryotes function as **decomposers**, breaking down dead organisms and waste products

Prokaryotes can sometimes increase the availability of nitrogen, phosphorus, and potassium for plant growth

Prokaryotes can also “immobilize” or decrease the availability of nutrients

Symbiosis is an ecological relationship in which two species live in close contact: a larger \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and smaller symbiont

Prokaryotes often form symbiotic relationships with larger organisms

In mutualism, both symbiotic organisms benefit

In commensalism, one organism benefits while neither harming nor helping the other in any significant way

In parasitism, an organism called a parasite harms but does not kill its host

Parasites that cause disease are called pathogens

**Concept: Prokaryotes have both beneficial and harmful impacts on humans**

Some prokaryotes are human pathogens, but others have positive interactions with humans

Mutualistic Bacteria

* + Human intestines are home to about 500–1,000 species of bacteria
  + Many of these are mutualists and break down food that is undigested by our intestines

Pathogenic Bacteria

Prokaryotes cause about half of all human diseases

* + For example, Lyme disease is caused by a bacterium and carried by ticks

Prokaryotes are the principal agents in **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, the use of organisms to remove pollutants from the environment

Bacteria can be engineered to produce vitamins, antibiotics, and hormones

Bacteria are also being engineered to produce ethanol from waste biomass