C.P. BIOLOGY – UNIT 8
BACTERIA/VIRUSES
AND THE HUMAN IMMUNE SYSTEM

MAIN IDEA: BACTERIA ARE PROKARYOTE CELLS

OBJECTIVE 1: DIFFERENTIATE AMONG ARCHAEBACTERIA AND EUBACTERIA AND THEIR SUBCATEGORIES

A. Prokaryotes are simple cells with no organelles. Bacteria are microscopic prokaryotes. Many scientists think that prokaryotes were the first organisms on Earth, and today they have many functions.
1. Prokaryotes are important in the human body, food production, industry, and the environment.
2. Today prokaryotes are the most numerous organisms on Earth and are found EVERYWHERE.

B. Prokaryotes are divided into two domains – Bacteria and Archaea.
1. Domain Bacteria contains the Kingdom Eubacteria
   a. Eubacteria are found everywhere but extreme environments, have strong cell
   b. Some eubacteria, like cyanobacteria are photosynthetic.
2. Domain and Kingdom Archaebacteria
   a. Found in hostile environments like sulfur springs, thermal vents and around volcanoes.
      Subcategories are based on physical characteristics (Ability to survive extreme temperatures, acidic pH's, salt or if they make methane gas)

C. The two domains differ in their cell wall structure and they have different lipids in their plasma membranes. Also they differ in their ribosomal proteins and RNA. Archaebacteria have ribosomal proteins similar to eukaryotic cells.

OBJECTIVE 2: DESCRIBE THE STRUCTURE OF PROKARYOTES AND METHODS USED TO IDENTIFY THE DIFFERENT TYPES

A. Although bacteria are very small and lack membrane bound organelles, they still need to carry out life functions. (see fig 18.3, page 518)

B. Chromosomes – genes are found on a large, circular chromosome in an area of the cell called the nucleoid. Many prokaryotes also have at least one smaller, circular piece of DNA called a plasmid.

C. Capsule – A layer of polysaccharides around the cell wall secreted by the prokaryote. It helps attach the cell to surfaces in its environment, keeps the cell from drying out, prevents the bacteria from being engulfed by white blood cells, and shelters the cell from the effects of antibiotics.

D. Pili – Submicroscopic, hairlike structures made of protein, found on the outer surface of some bacteria. Pili help bacteria attach to surfaces, serve as a bridge between cells during a form of sexual reproduction called conjugation.

E. The size of bacteria is so small they are hard to see using a light microscope. Their small size allows them to rely on diffusion to transport nutrients and wastes. (see fig. 18.4, page 518).

OBJECTIVE 3: COMPARE THE TWO METHODS OF REPRODUCTION USED BY PROKARYOTES AND VARIOUS WAYS PROKARYOTES OBTAIN NUTRIENTS FOR ENERGY

A. Most prokaryotes reproduce using binary fission, a type of asexual reproduction in which the cell is divided into two genetically identical cells. (See fig. 18.6, page 520)

B. Some prokaryotes use a form of reproduction called conjugation, in which two prokaryotes attach to each other and exchange genetic material. The pilus is the structure for attachment of the two cells so there can be genetic transfer and thus genetic recombination.

C. Eubacteria and Archaebacteria are grouped on how they meet their energy needs. They can be classified as either heterotrophs or autotrophs.

D. Many eubacteria are saprobes and they get their energy by decomposing organic molecules from dead organisms or organic waste.

E. Autotrophic bacteria can be classified as photosynthetic or chemosynthetic.
   1. Photosynthetic bacteria, called cyanobacteria, use sunlight to make organic molecules to use as food. They are ecologically important because they are the base of some food chains and they release oxygen into the environment.
   2. Chemosynthetic bacteria do not require light but instead break down and release inorganic compounds that contain nitrogen and sulfur. They are ecologically important as they help to keep nitrogen containing compounds cycling through ecosystems.

F. Bacteria also vary in their ability to grow in the presence of oxygen.
OBJECTIVE 4: DESCRIBE SURVIVAL MECHANISMS OF BACTERIA AT BOTH THE INDIVIDUAL AND POPULATION LEVELS.
A. Bacteria have many ways to help them survive environmental challenges like lack of water and nutrients, and extreme temperature changes.
   1. endospores – somewhat like a dormant cell it helps bacteria survive conditions that usually would kill them (extreme heat, cold, dehydration and u.v. radiation). Even if the bacterium dies, the endospore remains and then the endospore grows into a new bacterium when the environment is again favorable (see fig. 18.8, page 521).
   b. Not considered a form of reproduction since it usually produces only one endospore.
   2. mutations – because bacteria reproduce quickly and their population grows rapidly, genetic mutations can help bacteria survive in changing environments.

OBJECTIVE 5: DESCRIBE WAYS THAT BACTERIA MAY BE BOTH BENEFICIAL AND HARMFUL TO HUMANS
A. Many bacteria are beneficial and help to fertilize fields, recycle nutrients, protect the body and produce foods and medicines.
   1. Bacteria are decomposers returning vital nutrients to the environment.
   2. Nitrogen-fixing bacteria on a plant root nodule are able to remove nitrogen from the air and convert it into a form the plant can use. Allows less fertilizer to be used!
   3. Most bacteria that live on you and in you are harmless, called normal flora. They compete with harmful bacteria and keep them from taking hold and causing disease.
      One form of E. coli that lives in your intestine makes vitamin K which is used in blood clotting.
   4. Bacteria help make cheese, yogurt, pickles and chocolate. Bacteria are used in the production of vitamin B12 and some commonly prescribed antibiotics were originally made by bacteria.
B. Some bacteria are disease causing (see table 18.1 page 524) but the percentage is very small.
   Disease is caused in two different ways.
   1. Some bacteria multiply really fast at the site of infection before the immune system can destroy them. In serious infections the bacteria spreads to other parts of the body.
   2. Some bacteria release a toxin or other substance that can cause harm.
   3. Bacteria can also infect plants, not just animals.

MAIN IDEA: VIRUSES AND PRIONS ARE SMALLER AND LESS COMPLEX THAN BACTERIA; THEY INVADE CELLS AND CAN ALTER CELLULAR FUNCTIONS
OBJECTIVE 6: DESCRIBE THE GENERAL STRUCTURE OF VIRUSES
A. Most viruses are smaller than most bacterium and are considered to be nonliving particles; they have no organelles to take in nutrients and use energy, they can't make proteins, they can't move, and they can't replicate on their own.
B. Viruses are really small (10,000 could fit on this .) and many cause disease (see table 18.2, page 525).
C. The origin of viruses is uncertain, but it is thought that they came from parts of cells. Viral genes are similar to cellular genes and somehow managed to exist outside the cell.
D. Viruses consist of a core of RNA or DNA surrounded by a protein coat called a capsid. A layer called an envelope that is made of phospholipids and proteins may enclose the capsid. Depending on their nucleic acid content, viruses are classified as either DNA or RNA but are often named after the diseases they cause or the tissues they are found in.

OBJECTIVE 7: DESCRIBE REPLICATION OF A VIRUS DIFFERENTIATING BETWEEN A LYTIC AND LYSOGENIC CYCLE
A. To replicate, a virus must first recognize a host cell, then attach to it, and finally enter the host cell and take over its metabolism.
   1. Attachment occurs first and most viruses are species specific.
B. A virus can only replicate once it has entered the host cell and taken over its metabolism.
   1. A virus has two ways to get into a cell.
      a. It can inject its DNA into the host cell
      b. After attachment, the plasma membrane of the host cell surrounds the virus in a vacuole.
         The virus will burst out of the vacuole and release its nucleic acid into the cell.
C. Viral replication can follow two pathways. (see page 529)
a. During a **lytic cycle**, a virus uses the host cell’s energy and raw materials to make new viruses. Once replicated, the virus bursts out of the host killing the cell. These viruses often produce active infections with symptoms appearing 1-4 days after exposure.

b. In a **lysogenic cycle**, a virus’s DNA is integrated into a chromosome of the host cell and replicates with it for a while before entering a lytic cycle. It may be months or years before the lytic cycle is activated, often due to stress.

**OBJECTIVE 8: EXPLAIN WHAT A RETROVIRUS IS AND HOW ITS RELATED TO HIV**

A. **Retroviruses** are RNA viruses with a complex replication cycle because RNA is the only genetic material. (see fig. 18.4, page 530)
   1. They have a protein caspid surrounded by a lipid envelope which is taken from the plasma membrane of the host cell.
   2. An enzyme, **reverse transcriptase**, transcribes the viral RNA into DNA.
   3. The viral DNA becomes a **provirus** (Viral DNA integrated into the host cells chromosome).
   4. The provirus steadily produces small numbers of new viruses without immediately destroying the cell.

B. In an HIV infected person, white blood cells, which are an essential part of a human's immune system, are eventually destroyed by HIV proviruses that enter a lytic cycle.

C. Some retroviruses may cause some forms of cancer. They convert or transform normal cells into tumor cells.

**MAIN IDEA: PATHOGENS ARE DISPERSED BY PEOPLE, OTHER ANIMALS, AND OBJECTS**

**OBJECTIVE 9: DESCRIBE THE RELATIONSHIP BETWEEN PATHOGEN AND INFECTIOUS DISEASE**

A. The main sources of pathogens are contaminated soil, contaminated water, and infected animals including people.
   1. An **infectious disease** is caused by the presence of **pathogens** that disrupts homeostasis to the organism’s body.
   2. Pathogens may include bacteria, viruses, protozoans, fungi, and parasites.

**OBJECTIVE 10: DEFINE THE TERM RESERVOIR, EXPLAIN HOW TRANSMISSION OF DISEASE OCCURS, WHAT CAUSES THE SYMPTOMS OF DISEASE, DISEASE PATTERNS, AND WAYS TO TREAT AND FIGHT DISEASES**

A. A **reservoir** can be the living organism or inanimate matter (like soil) in which an infectious agent normally lives and multiplies.
   1. humans, animals, environmental sources (see table 37.1, page 1078)
      a. Humans that are symptom free but capable of passing the pathogen on are called carriers.

B. Diseases can be transmitted to humans from reservoirs in various ways:
   1. direct contact during touching, kissing, and sexual contact. It is a major mode of transport.
   2. indirect contact
      a. inanimate objects (glass, telephone)
      b. airborne transmission by droplets of water or dust
   3. insects and other arthropods

C. Symptoms of disease are caused by direct damage to the cells, by toxins produced by the pathogen, or are triggered by the immune system.

D. As outbreaks of diseases spread, certain patterns may be observed. Some agencies and health departments like the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) monitor disease patterns to help control the spread of disease.
   1. **endemic** diseases like the common cold are continually found in small amounts of the population.
   2. Sometimes a disease will have a large outbreak in an area and affect many people, causing an **epidemic**.
   3. If an epidemic is widespread throughout a large region like a country or continent, it is described as **pandemic**.

E. Treatment of infectious diseases includes the use of antibiotics and antiviral drugs.
MAIN IDEA: THE IMMUNE SYSTEM HAS TWO MAIN COMPONENTS: NONSPECIFIC AND SPECIFIC IMMUNITY

OBJECTIVE 11: DESCRIBE NONSPECIFIC IMMUNITY

A. Your nonspecific **innate immunity** is made up of your body’s earliest line of defense against pathogens. It helps slow down the progression of disease while the specific immune system begins to develop its defenses. Nonspecific immunity comes in many different forms:

1. Skin and body secretions (chemicals) act as barriers in areas where pathogens may enter the body.
   a. Skin is the first barrier of defense. Some bacteria that live symbiotically on our skin digest skin oils to secrete acos that inhibit many pathogens. Cuts and abrasions compromise the barrier effect of skin.
   b. Tears, saliva and nasal secretions all protect against pathogens because their secretions contain enzymes called lysozyme which break down bacterial cell walls, killing the pathogen. Another chemical barrier is mucus, which is secreted by many inner surfaces of the body. It keeps bacteria from sticking to the inner epithelial cells and infected mucus from the lungs triggers coughing and sneezing, moving it out of the body. HCl secreted in the stomach is a third chemical defense because it can kill microorganisms found in food that can cause disease.

2. Cellular defense
   a. White blood cells engulf and destroy pathogens
   b. Macrophages are WBC’s that move out of the blood vessels and attack anything considered foreign. First to arrive at the site of an infection.
   c. Complement proteins (about 20) are found in the blood plasma and aid phagocytosis by helping the phagocytic cells bind better to the pathogen and enhance destruction of the cell wall of the bacteria. (see fig. 37.9, page 1085). Others drill holes in the cell wall to destroy pathogens.

3. **Interferon** is a protein that can protect us against viral attack.
   a. Interferon is produced by the infected body cell and diffuses to neighboring uninfected cells to prevent the virus from multiplying. It acts like an “alarm system.”

4. Inflammation of body tissues
   a. a complex series of defense that involves chemicals and immune cells that enhance the overall immune response.
   b. Chemicals are released by the invader and cells of the body. These chemicals attract phagocytes to the area., increase blood flow to the infected area, and make blood vessels more permeable to allow WBC to escape to the infected area.
   (1) Characterized by redness, swelling, pain, and heat

OBJECTIVE 12: DESCRIBE SPECIFIC IMMUNITY AND THE STRUCTURE AND FUNCTION OF THE LYMPHATIC SYSTEM

A. When pathogens get passed the nonspecific defense mechanisms, the body will has a second line of defense, but specific response, involving the tissues and organs of the lymphatic system takes time to develop.

B. There are multiple functions of the lymphatic system
   1. The organs and cells filter lymph and blood and destroy microorganisms.
   2. The system absorbs fat.
   3. The system maintains homeostasis by keeping body fluids at a constant level

C. Structures:
   1. a system of vessels that return filtered fluids to the blood from the intercellular fluids
      a. tissue fluid forms when water and dissolved substances diffuse from the blood into the spaces between the cells that make up the surrounding tissues.
      b. Lymph enters lymph capillaries and veins ➔ ducts ➔ returns lymph to bloodstream in the shoulder area after it has been filtered through the lymph glands.
   2. a series of glands filter the lymph
      a. lymph nodes – filter lymph and remove foreign materials from lymph
      b. tonsils – form a protective ring of lymphatic tissue around the nasal and oral cavities keeping harmful materials and bacteria out of the nose and mouth
      c. spleen – stores blood and destroys damaged red blood cells. It also contains lymphatic tissue that respond to foreign substances in the blood.
d. thymus – located above the heart, it has a role in activating a special kind of lymphocyte called T cells. T cells are formed in bone marrow but they mature in the thymus gland.

D. B cell and T cell response are part of specific immunity
1. **Antibodies** are proteins that produced by B lymphocytes that specifically react with a foreign antigen. An antigen is a substance foreign to the body that causes an immune response; it can bind to an antibody or a T cell.
2. B lymphocytes or **B cells**, are located in all lymphatic tissues and are like antibody factories. (see fig. 37.11, page 1087):
   a. Pathogen enters your body through a wound and is attacked by the cells of your innate nonspecific immune system
   b. Antigens of the pathogen are displayed on the surface of the macrophage (WBC)
   c. Helper **T cells**
      (1) destroy foreign antigens on the macrophage
      (2) release chemicals that cause **B cells** to:
         (a) become plasma cells and produce antibodies in opposition to antigens. Antibodies mark antigens for destruction or alter them harmless.
         (b) become **memory cells** that are ready and armed to respond rapidly if the same pathogen invades the body at a later time
      (3) Helper T cells can also bind to and activate a group of lymphocytes called cytotoxic T cells. They release an enzyme, cytokines, directly into the pathogen causing the pathogen to lyse and die. Multiple target cells can be destroyed by a single cytotoxic T cell.

OBJECTIVE 13: DISTINGUISH BETWEEN PASSIVE AND ACTIVE IMMUNITY
A. Acquired immunity to a disease may be either passive or active:
   1. **Passive acquired immunity** develops as a result of getting antibodies generated in another host and can occur in two ways:
      a. Natural passive immunity – antibodies are transferred to a baby through the placenta or breast milk
      b. Artificial passive immunity – injecting into the body antibodies that come from a human or an animal that is already immune to the disease.
   2. **Active acquired immunity** is obtained naturally when a person is exposed to antigens.
      Produce antibodies and memory cells in response. Will be immune if exposed to the pathogen again. Can be induced artificially by **immunization** or vaccines.
      a. Vaccines contain weakened (attenuated) or killed microorganisms that are responsible for a specific infectious disease, or a purified protein or subunit from the microorganism.
      b. Microorganisms can no longer cause disease, but they prompt the body to generate antibodies in opposition to the microorganism.
      c. Antibodies remain to fight the full strength microbe in the even the body is exposed later to the pathogen.
      d. Booster shots increase the immune response, providing further protection from the disease causing organism. Second exposures to the antigen illicit a more rapid response and reaches a higher antibody level than the primary exposure

OBJECTIVE 14: DESCRIBE THE EFFECTS OF HIV ON THE IMMUNE SYSTEM AND BE ABLE TO DESCRIBE THE FOLLOWING: PROGRESSION OF INFECTION, POSSIBLE EARLY SYMPTOMS OF HIV INFECTION AND OPPORTUNISTIC DISEASES, THE MEANING OF AN HIV POSITIVE AND HIV NEGATIVE ANTIBODY TEST
A. Description of HIV: a retrovirus, containing the enzyme reverse transcriptase, allows the virus to use its RNA to make viral DNA in the host cell.
B. Immune system and HIV: virus hides out and multiplies in Helper T-4 cells and eventually destroys them. The damaged immune system cannot fight off diseases effectively.
C. Progression of HIV infection:
   1. HIV positive test: 2 weeks ➔ 6 months
   2. HIV with symptoms: 6 months to 12 years
   3. AIDS to death: 1-3 years
D. Symptoms:
   1. Early (HIV Positive): fever, fatigue, night sweats, loss of appetite, diarrhea, swollen lymph nodes
2. AIDS: pneumonia (pnuemocystis carcinii), cancer, (Karposi’s Sarcoma), herpes, parasites, yeast and brain infections, dementia

E. Testing:
   1. Negative: truly negative or antibodies not produced yet
   2. Positive: have the HIV antibodies, you are infected and can infect others

F. Body fluids that can transmit HIV: blood, semen, vaginal fluids, breast milk

G. Behaviors at highest risk of HIV transmission:
   1. anal, vaginal, and oral intercourse and other sexual activity in which body fluids are exchanged.
   2. sharing needles
   3. birth from an infected mother, breastfeeding

H. Patients usually die from a secondary infection from another pathogen after about 10 years of being infected with HIV.
   1. Current antiviral drug therapy is aimed at controlling the replication of HIV in the body. The therapy is expensive and its long term results are unknown. Some strains of HIV have become resistant to the drug therapies that are the most common.

I. Statistics of AIDS cases and deaths from 2003:
   1. 43,171 AIDS cases were diagnosed in the U.S.
   2. 18,017 people died of AIDS in the U.S.

J. In 2004, an estimated 40 million people globally were living with HIV infection.

**MAIN IDEA: SOME TYPES OF DISEASES ARE NONINFECTIOUS AND NOT CAUSED BY PATHOGENS**

OBJECTIVE 15: DESCRIBE THE FIVE CATEGORIES OF NONINFECTIOUS DISEASES, SUMMARIZE THE ROLE OF ALLERGENS AND ALLERGIES, AND DIFFERENTIATE BETWEEN ALLERGIES AND ANAPHYLACTIC SHOCK

A. Some disorders are genetic like hemophilia and Down’s syndrome while others are complex and have both a genetic and an environmental cause.
   1. Coronary artery disease (CAD) – families with a history of CAD have a 5-7 times greater risk of developing the disorder but diet can contribute to the disorders development.

B. Some disorders are called degenerative disorders and result in a part of the body wearing out. This can be due to old age but often it occurs sooner in a person’s lifetime than would be expected. Most have a genetic component.
   1. Examples are arthritis and arteriosclerosis.

C. Metabolic diseases result from an error in a biochemical pathway. Some might result in the inability to digest specific amino acids or to regulate body processes.
   1. an example is Type 1 diabetes.
   2. Some can have a genetic component but also involve environmental factors like diet.

D. Cancer is characterized by abnormal cell growth. Control of the cell cycle is lost resulting in tumors. Abnormal cells interfere with normal body functions and can travel throughout the body, developing in any body tissue or organ. Cancer of the blood is called leukemia.
   1. Both genetic and environmental factors have been shown to cause cancer.

E. Inflammatory diseases are those in which the body produces an inflammatory immune response to a common, generally harmless substance.
   1. A response to environmental antigens is called an allergy. These antigens are called allergens and include plant pollen, dust mites, dust, and various foods. (see table 37.4, page 1094).
   2. When a person becomes sensitized to the allergen it may result in swollen, itchy eyes, stuffy nose, sneezing, and sometimes a skin rash.
   3. Symptoms result from a chemical called histamine that is released by certain white blood cells. Antihistamine medications are taken to alleviate the symptoms.
   4. Anaphylactic shock can result from severe reactions to particular antigens. Massive amounts of histamine are released causing the smooth muscles of the bronchiole to contract, restricting airflow into and out of the lungs. Shock causes a drop in blood pressure throughout the body and can result in sudden death.
      (a) Common allergens that cause severe allergic reactions are bee stings, penicillin, and peanuts.
      (b) prompt medical attention is needed as it can be life threatening
      (c) Allergies and anaphylactic reactions are known to have an inherited component.

F. Autoimmunity disorders result from the formation of antibodies to your own proteins or cells, which injure cells.
1. rheumatoid arthritis – antibodies attack the joints
2. rheumatic fever – antibodies attack the valves of the heart
3. Lupus – antibodies attack cell nuclei leaving many organs vulnerable to attack by the body’s own immune system