Viruses, Bacteria, & Immunity
Viruses

- THEY ARE NOT CELLS
- Not organisms
- Cannot reproduce without a host
- Examples: measles, mumps, AIDS, chicken pox, polio
- First discovered in 1935
Structure of Viruses

- All have an outer coat of protein (called a CAPSID) that encloses a nucleic acid (DNA or RNA)
- Too small to be seen with a light microscope
  - Seen with an electron microscope
- Shapes: spherical, rodlike, cubical, polyhedral
- No cellular structure (no cytoplasm, no organelles or membrane, do not carry out life processes except reproduction)
Viral Cycles

- **Lytic Cycle**
  - Virus recognizes host
    - viral coat must match specific receptor site on host cell membrane
  - Virus attaches itself to host cell membrane
  - Viral DNA injected into host cell
    - Sometimes entire virus enters host cell
  - DNA released from protein coat
**Viral Cycles**

- **Lytic Cycle**
  - Viral DNA takes over cell
    - Uses ribosomes, enzymes, ATP to make more viruses
  - Viral DNA replicated & transcribed to mRNA
  - Transcribed mRNA codes for viral coat proteins & enzymes
    - Some enzymes assemble new viruses
    - Some enzymes lyse (break open) host cell
  - Viruses escape lysed cell & each attack new host cell
Viral Cycles

- Lysogenic Cycle
  - Provirus: viral DNA that becomes integrated into host cell’s chromosome
    - Discovered in 1953
  - After infected with provirus, cell continues normal functions for a short while
  - Host cell reproduced with provirus
    - May cause changes in host’s appearance
    - Prevents other viruses from entering & destroying host
Viral Cycles

- **Lysogenic Cycle**
  - When cell is exposed to environmental factors (X-rays, UV light, some chemicals) provirus is triggered (becomes active)
  - Viral DNA takes over cell
  - New viruses manufactured
  - Host cell lyses
  - New viruses released to invade other cells
  - Cells containing proviruses are lysogenic (subject to lysing)
Viral Cycles
RNA Viruses

- Go through same lytic & lysogenic cycles as DNA viruses
  - RNA replicates to make more viral RNA
  - RNA acts as mRNA
  - Host cell lyses when new viruses have been assembled

- RNA viruses in lysogenic cycle
  - Reverse transcriptase: enzyme that allows DNA to be made from RNA
    - DNA incorporated into host cell DNA $\rightarrow$ provirus
    - Reverse (backwards) transcript (transcription) -ase (enzyme)
  - Retrovirus: performs transcription backwards
    - Example: HIV
Bacteria

- Prokaryotic (no nucleus)
- Plasmids
  - Small, circular DNA found in the cytoplasm
Structure of Bacteria

- No nucleus or membrane-bound organelles
- Cell wall – protects bacterium & helps maintain osmotic balance
- Cell wall may be surrounded by outer capsule
  - Offers additional protection
  - Make it possible to infect human by escaping destruction of body’s defenses
- Some have flagella – locomotion
Structure of Bacteria

- One of 3 shapes
  - Spherical
  - Rod-shaped
  - Spiral-shaped

- Endospore: highly resistant, dormant structure produced by bacteria in unfavorable conditions
  - Protects bacterium’s DNA & some cytoplasm
  - When conditions become favorable again, endospore develops into an active cell
Reproduction of Bacteria

- Asexual reproduction: production of 1 or more genetically identical offspring by a single parent
- Binary Fission: method of asexual reproduction used by bacteria, simple division of 1 cell into 2 cells
Nutrition in True Bacteria

- Heterotrophs: must obtain energy/food from other sources
  - Absorb food from surroundings
    - Parasites: live in or on other organisms (hosts), cause harm to host
    - Saprophytes: feed on dead organisms or other organic wastes, help recycle nutrients
Nutrition in True Bacteria

- **Photosynthetic Autotrophs**: make their own energy/food from photosynthesis
  - Blue-green bacteria: helped generate O$_2$ in early Earth
- **Chemosynthetic Autotrophs**: make their own energy/food from chemosynthesis
  - Trap energy released from breakdown of inorganic molecules
Nutrition in Ancient Bacteria

- All Anaerobic autotrophs

- Methane-producing bacteria: obtain energy by chemosynthesis
  - $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_4$ (methane)

- Salt-loving bacteria: live in salt lakes
  - Only prokaryotic organisms to inhabit the Great Salt Lake & the Dead Sea

- Heat- and Acid-Loving Bacteria: occupy hot & acidic areas
  - Near underwater volcanoes & thermal vents
  - Sulfur Springs - Yellowstone
Ancient Bacteria vs. True Bacteria

- Cell walls & lipids in plasma membrane differ
- Base sequences in tRNA & rRNA differ
- Ancient bacteria react differently to antibiotics
Importance of Bacteria

- Most of Earth’s decomposers
  - Recycle materials
- Used for industrial processes
  - Yogurt, buttermilk, cheese, linens, ropes, leather, antibiotics
  - Milk (bacteria live in cows’ digestive systems)
- But... they can be dangerous, too!
Bacterial & Viral Agents of Disease

- Pathogens
  - Incorrect definition:
    “microorganisms that cause disease”
  - Correct definition: an AGENT of disease
    - Does not have to be an ORGANISM (viruses!)

- Infectious Disease: a disease caused by a pathogen that can be spread from one organism to another
Bacteria & Disease

- **Louis Pasteur (1800s):** formulated “Germ Theory of Disease” (bacteria can cause disease)
  - Pasteurization (milk) is a process that destroys most pathogenic microorganisms
Transmission of Bacterial Diseases

- Mode of transmission is related to the symptoms the disease causes
  - **Airborne**: carried through the air on small liquid droplets
    - Droplets produced when infected person sneezes or coughs
    - Ex. Strep Throat
  - **Waterborne**: carried in untreated water that was once contaminated with human waste
    - Ex. Cholera
    - Cholera bacteria are carried in an infected person secreted wastes
Transmission of Bacterial Diseases

- Other modes of transmission
  - Direct Contact: touching where the bacteria are living
  - Sexual Contact
    - Ex. Sexually transmitted infections
  - Arthropods: carry disease and transmit when they bite
    - Ex. Ticks carry Lyme disease
Causes of Bacterial Diseases

- **Exotoxins**: poisonous chemical released by living bacteria
  - Travels through bloodstream & affects tissues
  - OR acts locally

- **Endotoxins**: poisonous chemical released by dead bacteria
  - Released when bacterial cells rupture
  - EnDo = Dead bacteria
Viruses & Disease

- Many transmitted in the same way as bacterial pathogens
- Some viruses can infect humans AND other animals
  - Can be spread between species
  - Ex. Rabies
Evolution of Disease

- Disease have evolved
  - Increased chance of survival in host
  - Different modes of transmission

Child with Mumps
Defending Against Pathogens
Nonspecific Defense Mechanisms

- **Skin & Membranes of Body Openings**
  - First line of defense
  - Stand Guard at/near entranceways
  - Outer layer of skin = dead cells that microorganisms cannot penetrate (unless skin is broken/cut)

- **Membranes = more vulnerable**
  - Ex. Inside of nose
  - Adaptations
    - Hair in nose filters air
    - Mucous in nose traps and destroys microorganisms
    - Saliva & tears have substances that kill microorganisms
**Nonspecific Defense Mechanisms**

- **Inflammatory Response**
  - Second line of defense
  - **Histamine**
    - Increased blood flow
    - Increased permeability of capillaries (WBCs, macrophages & fluid escape)
      - Macrophages: scavenger WBCs, engulf & digest pathogens
  - Increased temperature to area
    - Interferes with pathogen reproduction

*Cause of Inflammation*
Nonspecific Defense Mechanisms

- Inflammatory Response Reactions
  - Fever: caused by protein released by WBCs
  - Pus: tissue fluid containing macrophages, WBCs & dead pathogens
    - Forms with bad infection
Specific Defense Mechanisms

- Immune Response: recognition & destruction of a particular pathogen
  - Third line of defense
  - Antigen: any foreign chemical (specific)
    - Protein in membrane of bacteria or coat of virus
    - Chemical secreted by pathogen (toxin)
  - Lymphocytes: WBCs that recognize antigens & begin to destroy specific pathogens
    - Produced by bone marrow
    - B Cells: mature in bone marrow
    - T Cells: mature in thymus gland
      - Seek out pathogens hiding in body
Specific Defense Mechanisms

- **Immune Response**
  - Macrophages: once mature, reside in lymph, spleen, & tonsils
  - Lymph: fluid containing lymphocytes, macrophages, foreign particles, & microorganisms
    - Lymph nodes act as filters
      - Macrophages in lymph nodes trap & destroy pathogens
  - Spleen: detects & destroys pathogens in blood
  - Tonsils: traps pathogens that enter through nose or mouth
B Cells & Antibody Formation

- Antibodies: protein molecules on B cells that recognize particular antigens (specific)
  - Y-shaped: can bind 2 antigens, one on each branch
  - Free antibodies released by plasma cells
    - B cell antibody links to antigens, B cell activated, enlarges & divides into memory & plasma cells
      - Plasma cells produce thousands of antibodies per second & release into bloodstream & lymphatic system
B Cells & Antibody Formation

- **Helper T Cells**: recognize & activate B cells
  - Use receptors: proteins that recognize self proteins
- **Suppressor T Cells**: release chemicals that inhibit activity of B cells & macrophages to help control infection
- **Allergies**: pollen acts as an antigen
  - Histamine released causes sneezing and runny nose
T Cells & Cellular Immunity

- Cytotoxic T Cells: act to destroy cell infected by viruses OR foreign cells
Why You Feel Sick

- Adaptations like fever combat pathogens, but make you feel uncomfortable.
- Energy being used to combat illness makes you tired.
Defense Against Cancer

- Cancers: diseases in which cells grow & reproduce uncontrollably
- Cytotoxic T Cells can destroy cancerous cells
- Cancer develops when the immune system fails to detect & destroy cancerous cells
Rejection of Transplants

- Body recognizes transplanted tissue/organ as foreign
- Cytotoxic T Cells try to destroy the foreign tissue/organ
- Drugs can dampen immune response, but make the patient susceptible to other diseases
Autoimmune Disease

- Abnormal response of the immune system to turn on person’s own body
  - Ex. Multiple Sclerosis, Lupus

- Treatment
  - Introduce toxic chemicals to destroy T cells attacking body
  - Introduce substances that bind to proteins being attacked (prevent T cells from binding)

- Monoclonal Antibodies: cells that make only 1 kind of antibody
  - Produced by cloned lymphocytes from mice injected with the antigen
Immunity – Prevention of Disease

- **Active Immunity**: resistance to disease due to memory cells or vaccines
  - **Memory Cells**: Produced when B cells split
    - Allow body to act quickly to destroy same pathogen before it causes symptoms → immune to pathogen
  - **Vaccines**: solutions prepared from weakened or dead microorganisms, viruses, or toxins
    - Cause body to produce antibodies
Immunity – Prevention of Disease

- Passive Immunity: antibodies not made by the infected person
  - Antiserum: solution of borrowed antibodies & blood serum
    - Borrowed antibodies fight disease
  - Quicker than active immunity, but does not last
  - Ex. Baby gets antibodies from mother’s placenta and milk
Immunity: Active and Passive

Active immunity
- Naturally acquired
- Artificially acquired
  - Mumps 12/9/79

Passive immunity
- Naturally acquired
- Artificially acquired
  - Serum
Treatment of Disease

- **Antibiotics:** destroy bacteria
  - Antibiotic Resistance: if antibiotics are overused, bacteria can develop resistance and the antibiotic will no longer be effective

- **Viral Disease Treatment**
  - No antibiotics
  - Some drugs can prevent replication of DNA/RNA or interfere with transcription/translation
  - Some drugs can prevent virus from entering host cells
  - Interferon: protein released by infected host cell & travels to healthy cells, preventing viral reproduction
AIDS

- Acquired Immune Deficiency Syndrome
- Immune system is slowly destroyed
- Fatal
AIDS

- Transmission: caused by HIV (retrovirus), enters bloodstream
  - Sexual transmission
  - Sharing IV drug needles
  - Blood transfusions (mostly before 1985)
  - Pregnancy (passed through placenta)
AIDS

- Infection & Onset of Symptoms
  - Infects & destroys helper T cells
  - Body becomes more susceptible to pathogens
  - AIDS develops once infected person is subject to several infections a healthy person could resist
    - Fatal once onset of AIDS
  - Death is caused by onset of 1 of 3 diseases or heart failure
    - Pneumonia
    - Cancer
    - TB
AIDS

Prevention & Treatment

- No cure
- Preventable if high-risk behaviors avoided
- Can unknowingly transmit because you can have HIV without symptoms
- AZT blocks reverse transcriptase
- Protease inhibitors prevents viral proteins from being packaged into new viruses
- Drugs can slow onset of AIDS, but EXPENSIVE!