Biology Class 03

Previous Class Topic

- Discussion on non-communicable diseases.
- Overview of disease types: congenital and acquired.

Communicable Diseases

- Communicable diseases are caused by pathogens that transfer from one person to another.
- Pathogens include bacteria, viruses, fungi, protozoa, and worms (helminths).
- Diseases are classified based on the pathogen responsible, such as bacterial, viral, fungal, protozoan, and helminthic diseases.
- The pathogen is the **core factor** transferred during disease transmission.
- Only bacteria and fungi can be cultured in artificial synthetic mediums; viruses require living cells for growth.

Types of Pathogens Causing Communicable Diseases

Pathogen Type	Description/Examples
Bacteria	Unicellular, prokaryotic; TB, typhoid
Viruses	Require living host cells; COVID-19, HIV
Fungi	Multicellular/unicellular; ringworm
Protozoa	Unicellular, eukaryotic; malaria
Worms (Helminths)	Multicellular animals; roundworm

Modes of Transmission

- **Communicable diseases** are transmitted through specific modes, including air, water, soil, food, direct contact, vectors, zoonotic means, and fomites.
- Multiple modes can apply to one disease; for instance, conjunctivitis spreads through both contact and fomites.

Modes and Examples

Mode of Transmission	Examples of Diseases	Notable Details
Airborne	COVID-19, tuberculosis (TB), chickenpox (also contact)	Spread via coughing, sneezing, droplets
Water	Cholera, typhoid, hepatitis A/E	Water or food contamination is common
Soil	Hookworm, tetanus	Soil-borne, entry via injuries or oral route
Food	Amoebiasis (food poisoning)	Often overlaps with water contamination
Direct Contact	Common cold, chickenpox, eye flu	Person-to-person, includes skin and respiratory contact
Blood/Body Fluids	AIDS (HIV), hepatitis B and C, syphilis, gonorrhea	Transmission via blood transfusion, unprotected sex/needles
Zoonotic	Rabies, plague, bird flu, swine flu	From animals; carrier animal usually suffers disease
Vector-borne	Malaria, dengue, chikungunya, kala-azar	Carried by insects/arthropods, such as mosquitoes
Fomite	Eye flu, chickenpox, skin diseases	Through non-living contaminated objects like cups, blankets

Detailed Points

- **Airborne**: Pathogens are transmitted by droplets; TB affects lungs primarily.
- **Water/Food**: Contaminated sources can cause diarrheal diseases; food poisoning, often due to protozoa like amoeba.
- **Soil**: Worms and bacteria can enter through unclean wounds, leading to infections like hookworm and tetanus.
- **Direct Contact**: Disease spreads through close physical contact; cold, chickenpox, and conjunctivitis are examples.
- **Blood/Body Fluids**: HIV/AIDS and hepatitis B/C require exposure to infected fluids.
- **Zoonotic Transmission**:
- Pathogens come from animal reservoirs where the animal itself suffers from the disease (e.g., rabid dog giving rabies).
- **Vector Transmission**:
- Vectors are carriers (mosquitoes, cockroaches). Transmission can be:*Mechanical*: Pathogen carried on external body (cockroach).
- *Biological*: Pathogen within the vector's body, e.g., malaria, dengue via mosquito bites.
- Vectors themselves are not affected by the disease.
- **Fomite**: Contaminated objects (cups, blankets, pillows) transfer pathogens unknowingly.

Classification of Communicable Diseases by Pathogen

Bacterial Diseases

- Caused by unicellular prokaryotes (kingdom Monera).
- Examples: Tuberculosis, leprosy, typhoid, tetanus, cholera, anthrax.

Tuberculosis (TB)

- Caused by*Mycobacterium tuberculosis*.
- Primarily affects lungs (pulmonary TB); can affect other organs (extra-pulmonary).
- India has high new case numbers annually; government programs for TB control exist.
- **Mode of Spread**: Airborne droplets from coughs and sneezes.
- **Main symptoms**:
- Persistent cough (>2 weeks)
- Afternoon fever
- Weight loss (notably observed in historical figures like M.A. Jinnah with advanced TB)
- Blood-stained sputum
- Night sweats
- **Diagnosis**: Sputum test (presence of*Mycobacterium tuberculosis*), X-ray (but nonspecific).
- **Stigma and malnutrition**: Impacts patient's social life and susceptibility.
- **Treatment**:
- Antibiotics (first-line: rifampicin), which must be taken for long durations (6-9 months).
- Strict adherence is crucial to avoid antibiotic resistance.

Tetanus

- Bacterial disease transmitted through contaminated soil or non-living objects.
- Requires entry through a wound.

Antibiotics and Drug Resistance

Antibiotic Function

Antibiotics are chemicals that kill or inhibit bacterial growth. They are effective against bacterial diseases if used as directed.

Antibiotic Resistance

- Occurs when bacteria change (mutate) to survive antibiotic presence.
- **Causes**:
- Not completing prescribed antibiotic courses.
- Self-medicating with antibiotics (overuse, underuse, misuse).
- Using incorrect dosages or stopping early after symptoms subside.
- Antibiotics in animal husbandry (livestock receive antibiotics, leading to resistant strains passed to humans via milk or meat).
- Environmental exposure (contaminated water with pharmaceutical waste).
- **Implications**:
- Resistant bacteria survive even after antibiotic therapy.
- Treatment requires switching to second-line drugs (stronger, more side effects, expensive, less available).
- Continued misuse can lead to multi-drug resistance, leaving no effective antibiotics.
- **Particular Issue in TB**:
- TB treatment is prolonged, increasing risk of non-adherence and resistance.
- India has a high incidence of drug-resistant TB due to lengthy therapy and compliance issues.
- **Antimicrobial Resistance (AMR)**:
- The ability of bacteria, viruses, and fungi to withstand treatment by antibiotics (for bacteria), antivirals (for viruses), or antifungals (for fungi).
- AMR is a major global challenge, making standard treatments ineffective and allowing infections to persist and spread.

Fungal Diseases

- Caused by organisms of the kingdom Fungi.
- Examples: Candidiasis, ringworm, athlete's foot.
- **Candidiasis**: Common fungus (*Candida albicans*) resides normally but can cause infection under certain conditions (other diseases, medications, poor hygiene).
- **Ringworm**: Not a worm but a fungus; skin infection favored by warm, moist environments.
- **Athlete's Foot**: Often affects toes due to sweating and closed footwear.
- Fungi prefer dark, moist, warm conditions; monsoon and summer increase risk.
- Emerging issues with antifungal resistance and spread of fungi due to rising global temperatures (climate change creates new environments for fungi).

Helminthic Diseases

- Caused by multicellular worm parasites (helminths: roundworms and flatworms).
- Examples: Ascariasis, taeniasis (tapeworm infection).
- **Mode of entry**: Contaminated soil, water, or food.
- Frequently affect children, whose hygiene practices are less developed.
- Worms live in intestines, absorb nutrients, and can cause nutritional deficiencies, pain, vomiting, and diarrhea.
- Symptoms may be mild or absent in adults but can impact children's growth and development.
- National deworming programs in schools provide regular treatment every six months to children.

Protozoan Diseases

- Caused by unicellular eukaryotes (kingdom Protista), also called protozoa.
- Examples: Amoebiasis, giardiasis, malaria.

Malaria

- Common in tropical and subtropical regions.
- Caused by the protozoan*Plasmodium*(notably*P. vivax*and*P. falciparum*).
- **Vector**: Female Anopheles mosquito.
- **Life Cycle**:
- Mosquito bites human, injects*Plasmodium*.
- Parasite travels to the liver for development.
- Moves into red blood cells (*asexual reproduction*in humans).
- Red cells burst, causing symptoms. Mosquitoes biting infected people pick up the parasite and continue the cycle.
- *Sexual reproduction*takes place in the mosquito (definitive host); asexual in humans (intermediate host).
- **Symptoms**: Related to the destruction of red blood cells.
- **Treatment**: Antimalarial drugs (resistance is a growing concern).
- National and international control programs have led to a reduction in cases.

Viral Diseases

- Viruses require living cells to reproduce; they cannot grow in artificial mediums.
- Examples: Hepatitis (A, B, C, D, E), chickenpox, polio, dengue, AIDS/HIV.
- Viral diseases often receive attention due to outbreaks and emerging infections.

General Approach to Viral Diseases

- Antiviral drugs are limited; most cannot completely eliminate viruses.
- Treatment is usually symptomatic: managing fever, pain, dehydration, and rest.
- The body’s immune system typically clears the virus.
- Hospitalization and antiviral drugs are reserved only for severe cases.

Hepatitis

Hepatitis is a disease of the liver; the prefix "hepat-" refers to liver and the suffix "-itis" means inflammation. The symptoms of inflammation include redness, swelling, pain, loss of function, and increased temperature. Different types (A, B, C, D, E) all cause liver inflammation but differ in structure and mode of transmission.

Differences Among Hepatitis Viruses

Virus Type	Transmission	Vaccine Available	Notes
Hepatitis A	Food/water contamination	Yes	Most common cause of viral jaundice in adults
Hepatitis B	Blood, body fluids	Yes	All individuals usually vaccinated
Hepatitis C	Blood, body fluids (blood)	No	No vaccine currently; serious, can be chronic
Hepatitis D	With Hepatitis B (coexists)	No (covered by B)	Does not occur alone; vaccine coverage through Hepatitis B
Hepatitis E	Food/water contamination	Yes	Less common than Hepatitis A

- Hepatitis B vaccine is routine; Hepatitis C lacks a vaccine.
- Hepatitis D only occurs in those with Hepatitis B infection.
- Jaundice can result from hepatitis or non-viral causes; in newborns, it is not typically viral.
- Hepatitis viruses may persist in the body without causing symptoms for extended periods.

Virology Concepts

- Virus replication involves copying genetic material; errors (mutations) create new strains (notably seen in COVID-19).
- Mutation rates vary; high population and spread increase mutation opportunities.

Immunity

- Immunity is the body's defense system against pathogens and other harmful agents.
- It involves both non-specific (innate) and specific (acquired/adaptive) responses.

Overview

Immunity Type	Description	Characteristics
Innate Immunity	First line, non-specific, always present	Immediate, equal protection against all threats
Acquired (Adaptive)	Specific, develops after exposure	Slower, highly specific to pathogen

Innate Immunity

- Non-specific, forms an immediate first line of defense.
- Always present, active throughout life.
- **Components**:
- *Physical barriers*: Skin (prevents entry), mucous membranes (protect internal organs).
- *Chemical barriers*: Chemicals in tears, saliva, stomach acid (HCl).
- *Cellular defenses*: White blood cells (neutrophils, monocytes).

Acquired (Adaptive) Immunity

- Highly specific response to particular pathogens or antigens.
- Develops after exposure; not immediate.

Main Mechanisms

- **Antibody-Mediated Immune Response (Humoral Immunity)**
- Provided by B lymphocytes, which produce antibodies.
- Antibodies are highly specific proteins tailored to the structure of antigens.
- Effective against bacteria, some viruses, and toxins.
- **Cell-Mediated Immune Response**
- Provided by T lymphocytes.
- T cells perform phagocytosis (engulfing and destroying pathogens directly).
- Particularly effective against viruses and certain intracellular pathogens.

Definitions

- **Antigen**: Any agent—such as bacteria, viruses, toxins, foreign cells—recognized as harmful and triggering an immune response.
- **Antibody**: Specific protein produced against an antigen to neutralize or destroy it.

White Blood Cells and their Roles

Cell Type	Site of Maturation	Immune Function
B lymphocytes	Bone marrow	Make antibodies (humoral immunity)
T lymphocytes	Thymus gland	Perform direct killing (phagocytosis)

All blood cells originate from bone marrow. Phagocytosis is a general cell process (also used by amoeba to consume food).

Immunological Concepts and Terms

- Antigen-antibody interaction is highly specific (lock-and-key analogy).
- Phagocytosis is a mechanism where a cell envelops and destroys a pathogen.
- Specialized immune responses are mounted after the pathogen is recognized; this takes time compared to innate immunity.

Application: Disease Categorization (From Lectured MCQs)

Disease	Type	Explanation
Hemophilia	Genetic disease	Due to a DNA defect affecting blood clotting
Diabetes	Hormonal disease	Linked to the hormone insulin
Rickets	Deficiency disease	Due to deficiency of vitamin D (and possibly calcium)
Ringworm	Fungal disease	Skin infection caused by fungus, not a worm

Immunity Analogy

Innate immunity resembles a country's border security force: always present, non-specific, and first to respond. Adaptive immunity resembles calling in specialized military forces: a response tailored to the specific type of invasion.

Topic to be Discussed in the Next Class

- Detailed study of vaccination.
- Introduction to different organ systems of the human body.