Biology Class 04

Previous Class Topic

- **Immunity**: Innate and acquired immunity, including the role and mechanisms of B-lymphocytes.

Hepatitis Viruses and Modes of Transmission

- **Hepatitis B virus** is transmitted in a manner similar to HIV, involving blood and body fluids.
- Unlike hepatitis C, hepatitis B does have an effective vaccine; hepatitis C lacks a vaccine.
- Globally, the number of people infected with hepatitis B and C is higher than those with HIV.
- Some individuals infected with hepatitis B or C may remain asymptomatic for many years.

Immunity and Immunological Memory

Innate and Acquired Immunity

- **Immunity** is the ability of the body to resist infections by pathogens.
- **Acquired immunity** includes the development of immunological memory via exposure to antigens.

Mechanism of Immunological Memory

- B lymphocytes are activated when the body encounters an antigen.
- B cells recognize and bind to the antigen, then produce specific antibodies against it.
- The initial response is slow and of low intensity, but B cells store information about the antigen.
- On subsequent exposure to the same antigen, B cells rapidly produce large quantities of antibodies, resulting in a fast and high-intensity immune response.
- This forms the basis for “immunity” or being “immune” to certain diseases, such as chickenpox.

Example: Chickenpox

- Primary chickenpox infection results in symptoms and immune activation.
- Post-recovery, immunological memory prevents re-infection for a prolonged period.
- Reinfection is rare because of the stored memory enabling quick antibody production.

Vaccination: Concept and Mechanism

Definition of Vaccination

- **Vaccination** is a process to make a person immune or resistant to infectious diseases.
- This is achieved by stimulating the body’s own immune system, inducing antibody production and memory formation.

Working of Vaccines

- When the body encounters an antigen for the first time, a slow and low-intensity antibody response is seen, and B cells remain sensitized.
- Immunological memory is created, enabling a subsequent fast and high-intensity response upon re-exposure.
- Vaccines use this principle by introducing antigens in a modified form to stimulate memory formation without causing disease.

Limitations of Immunological Memory and Vaccine Applicability

- Not all diseases confer lifelong immunity after infection.
- Diseases with short-lived immunological memory (e.g., malaria, common cold) may recur frequently.
- The duration of memory varies with pathogens; some confer lifelong protection, while others last only months.
- Diseases ideal for vaccines are those where immunological memory is long-lasting or sufficient to prevent reinfection.
- Vaccine development must avoid causing the actual disease; thus, antigens are modified before administration.

Types of Vaccines

Type of Vaccine	Description	Example(s) (of Vaccine)
Live Attenuated	Pathogen is alive but weakened; does not cause disease but retains capacity to grow.	Oral polio, BCG
Inactivated/Killed	Pathogen is killed; retains antigenic structure to trigger immune response.	Injectable polio, Covaxin
Subunit	Only specific proteins or polysaccharides from pathogen are used as antigens.	Novavax (COVID-19)
Conjugate	Combines two parts (like protein + polysaccharide) to enhance immune response.	Pneumococcal conjugate

Live Attenuated Vaccines

- Live but weakened pathogens are introduced to stimulate the immune system without causing disease.
- B cells recognize the weakened pathogen and build memory.
- Used in vaccines like oral polio drops and BCG.

Inactivated/Killed Vaccines

- Pathogens are killed/inactivated before use.
- Still recognized by B cells due to preserved antigenic structures.
- Examples include inactivated polio vaccine and Covaxin.

Subunit Vaccines

- Only specific antigens (e.g., proteins, polysaccharides) from the pathogen are used.
- Sufficient to stimulate immune response without risk of disease.
- Example: Novavax COVID-19 vaccine.

Conjugate Vaccines

- Two different pathogen components (e.g., protein and polysaccharide) are administered together.
- Increases chance of immune recognition and response.
- Example: Pneumococcal conjugate vaccine.

Pathogen-Specific Challenges in Vaccine Development

Variation among Pathogens

- Different pathogens may respond to different vaccine strategies; not all types are suitable for all organisms.
- Some pathogens remain infectious even when weakened, making live attenuated vaccines unsuitable.

Case Study: Malaria Vaccine – Challenges

- Malaria is caused by several species of Plasmodium (e.g., P. vivax, P. falciparum).
- Humans are intermediate hosts for Plasmodium where asexual reproduction occurs.
- Natural infection does not confer long-term immunity; reinfection is common.
- Multiple species complicate vaccine design, requiring coverage for all major types.
- The most significant barrier is the lack of durable, long-term immunity following either infection or vaccination.
- Recent malaria vaccines can confer short-term protection but require repeated doses.

Types of Acquired Immunity

- Active
  - Natural
  - Artificial
- Passive
  - Natural
  - Artificial

Type	Source of Antibody/Antigen	Natural or Artificial	Examples
Natural Active Immunity	Infection leads to antibody production	Natural	Recovery from chickenpox, measles
Artificial Active Immunity	Vaccination induces antibody formation	Artificial	Vaccines (polio, hepatitis, etc.)
Natural Passive Immunity	Antibodies pass from mother to child (e.g., milk)	Natural	Antibodies in mother's milk to newborn
Artificial Passive Immunity	Lab-produced antibodies administered externally	Artificial	Anti-snake venom, monoclonal antibodies for viruses

Active Immunity

- Antibodies are produced in the body after exposure to an antigen.
- Subtypes:
- **Natural active**: Occurs after natural infection and recovery.
- **Artificial active**: Induced by vaccination.

Passive Immunity

- Ready-made antibodies are provided to an individual.
- Subtypes:
- **Natural passive**: Antibodies obtained via mother's milk.
- **Artificial passive**: Lab-produced antibodies administered (e.g., for snakebites or rapid immune aid against diseases).

Vaccine Side Effects and Immune Response

- The immune system cannot distinguish between a real infection and a vaccine-induced stimulus; both trigger similar immune responses.
- Side effects such as fever or mild pain post-vaccination indicate active immune system engagement.
- A robust immune response to a vaccine can manifest more strongly in younger individuals due to more responsive immune systems.
- These symptoms reflect effective activation rather than adverse effects.

Human Body Organ Systems

Digestive System

Overview and Function

The digestive system breaks down food into simple, usable forms using enzymes at various stages. Major steps include ingestion, digestion, absorption, and egestion.

Sequence of Organs and Functions

Mouth

- Entry point for food.
- Saliva from salivary glands contains amylase to break down carbohydrates.

Esophagus

- Food pipe that connects mouth to stomach; no digestion occurs here.

Stomach

- Contains hydrochloric acid and protease enzymes for protein digestion.
- Acidic environment (gastric juice) aids breakdown.
- Sphincters at both ends prevent acid leakage; improper closure results in acidity or acid reflux.
- Ulcers develop when the protective stomach lining is damaged, allowing acid to harm the stomach wall.

Small Intestine

- Site of final digestion and major nutrient absorption into the blood.
- Receives three digestive fluids:
- Intestinal juice with enzymes (peptidase for proteins; sucrase, maltase, lactase for carbohydrates).
- Pancreatic juice (protease, amylase, lipase).
- Bile from the liver (stored in the gallbladder) that aids in fat digestion but contains no enzymes.
- Absorption of nutrients into the blood occurs here.

Liver and Gallbladder

- The liver produces bile, which is stored temporarily in the gallbladder.
- The gallbladder's role is storage and release of bile; removal does not affect digestion substantially, only efficiency.
- Jaundice occurs when the liver fails to process pigments (e.g., bilirubin), not due to gallbladder issues.

Pancreas

- Produces pancreatic juice containing digestive enzymes for fats, proteins, and carbohydrates.

Large Intestine

- Absorbs water from remaining undigested food.
- Waste is compacted and expelled through the rectum and anus as feces.

Role of Fiber (Roughage)

- Fiber is indigestible and adds bulk to food, aiding digestion, the feeling of fullness, and smooth movement through the digestive tract.
- Found in plant-based foods (fruits, vegetables, whole grains).
- The difference between whole wheat and refined flour (maida) is primarily the fiber content.
- Fiber helps regulate bowel movements and prevent constipation.

Nutrient Utilization and Storage

- Proteins are used for repair, growth, and immunity.
- Carbohydrates serve as primary energy sources; excess is stored as glycogen (limited) or converted to fat.

Weight and Dietary Considerations

- Excess carbohydrates, especially in populations with sedentary lifestyles, can lead to obesity and related health issues.
- Glucose not used for energy is stored as glycogen (with limited capacity); excess is converted to fat.

Respiratory System

Energy Production and Respiration

The respiratory system facilitates gaseous exchange required for cellular respiration. Cellular respiration takes place in mitochondria using glucose and oxygen to produce energy, carbon dioxide, and water.

- **Aerobic respiration**: Uses oxygen (producing CO_2, water, and energy); occurs in the presence of sufficient oxygen.
- **Anaerobic respiration**: Takes place without oxygen; in humans, this occurs temporarily in muscle cells under strenuous activity, producing lactic acid and leading to muscle cramps. Some organisms routinely perform anaerobic respiration, producing ethanol and carbon dioxide.

Structure of the Respiratory Tract

- Air enters through the nasal cavity or mouth, passing through the pharynx.
- The larynx (voice box) contains the vocal cords.
- The trachea (windpipe) splits into bronchi for each lung, which further divide into bronchioles ending in alveoli.
- Alveoli are small air sacs where gaseous exchange (O_2 in, CO_2 out) with the blood occurs.

Transport of Gases

- Hemoglobin in red blood cells binds oxygen and transports it throughout the body.
- Anemia, a condition marked by a deficiency of hemoglobin, reduces oxygen transport and causes fatigue.

Removal of Carbon Dioxide

- CO_2 produced during cellular respiration is carried by the blood to the alveoli and expelled during exhalation.

Diaphragm and Breathing

- The diaphragm is a muscle below the lungs responsible for breathing movements.
- Hiccups are caused by irritation of the diaphragm.

Excretory System

Function and Organs

- Removes metabolic wastes and regulates water balance.
- The main organ involved is the kidneys.

Process of Excretion

- Blood carries metabolic waste (mostly nitrogenous compounds like urea) and excess water to the kidneys.
- The kidneys filter waste, returning clean blood to circulation.
- Waste and water filtered out form urine.

Urine Composition and Elimination

- Urea is the predominant nitrogenous waste in humans.
- In birds, uric acid is excreted as the major nitrogenous waste.
- Urine is produced by the kidneys, passes via ureters to the urinary bladder for storage, and exits the body via the urethra when full.

Regulation of Water Balance

- The volume and concentration of urine depend on water intake.
- Higher water intake leads to dilute, light-colored urine, whereas lower intake results in concentrated, darker urine.
- A fixed amount of waste is excreted regardless of the water consumed.

Circulatory System

Components and Basic Function

- The circulatory system transports nutrients, gases, waste, and other substances throughout the body.
- Main components include the heart, blood, and blood vessels (arteries, veins, and capillaries).

The Heart

- The heart functions as a muscular pump (approximately fist-sized).
- It contains four chambers: two upper atria (auricles) and two lower ventricles.
- Blood enters the atria from veins, passes to the ventricles, and is pumped out through arteries.

Blood Vessels

- **Arteries**: Carry blood away from the heart. They are generally deep beneath the skin and not visible.
- **Veins**: Carry blood toward the heart. They are located closer to the skin and are often visible as bluish-green lines.

Double Circulation

- The heart operates two parallel circuits:
- **Pulmonary circulation**: Blood flows from the right heart to the lungs for oxygenation and returns as oxygenated blood.
- **Systemic circulation**: The left heart pumps oxygenated blood to the body, and deoxygenated blood returns to the heart.

Q: What is anti-microbial resistance. Discuss the causes of drug resistance in microbial pathogens in India. (10 marks)

Sequence of Blood Flow

- Oxygenated blood from the lungs enters the left atrium via the pulmonary vein.
- It flows from the left atrium to the left ventricle.
- The left ventricle pumps blood into the aorta, which distributes it to body tissues.
- Deoxygenated blood returns from the body to the right atrium via the vena cava.
- It goes from the right atrium to the right ventricle.
- The right ventricle sends blood to the lungs through the pulmonary artery for oxygenation.

Exceptions

- The **pulmonary artery** carries deoxygenated blood from the heart to the lungs (even though arteries usually carry oxygenated blood).
- The **pulmonary vein** carries oxygenated blood from the lungs to the heart (even though veins typically carry deoxygenated blood).

Topic to be Discussed in the Next Class

- Study of blood cells and blood groups.
- Introduction to hormones and hormonal regulation.