Biology Class 05

Previous Class Topic

- **Structure of blood**, blood plasma, and blood cells
- **Circulatory system functions**

Oxygen Transport in the Human Body

- Oxygen enters the body through the lungs, where it moves from alveoli into the blood and is transported to tissues.
- Tissues are defined as groups of cells; oxygen from the blood is delivered to every tissue for cellular respiration.
- Oxygen is essential for respiration, which enables energy production in the body.

Composition of Blood

Components of Blood

Blood consists of a liquid part called plasma and various types of cells.

Plasma

- Plasma, the liquid component, appears yellowish when cells are removed.
- Contains special proteins called **plasma proteins**.

Plasma Proteins

Plasma Protein	Function
Globulin	Provides defense mechanism; immunity
Albumin	Maintains blood pressure
Fibrinogen	Essential for blood clotting

Blood Cells

There are three main types of blood cells:

- **Red Blood Cells (RBCs or erythrocytes)**
- **White Blood Cells (WBCs or leukocytes)**
- **Platelets (thrombocytes)**

Red Blood Cells (RBCs)

- RBCs carry hemoglobin; their main function is oxygen transport.
- Hemoglobin contains iron, giving blood its red color.
- RBCs transport oxygen bound to hemoglobin, while nutrients are dissolved in plasma.

Platelets (Thrombocytes)

- Initiate the clotting process to prevent blood loss when vessels are injured.
- Trigger formation of blood clots via activation of clotting factors, especially in the presence of Vitamin K.
- Diseases like dengue can reduce platelet numbers, leading to risk of internal bleeding.

White Blood Cells (WBCs or Leukocytes)

- WBCs are immune cells that fight diseases and are part of the body's immune system.
- They are distinguished by the presence (*granulocytes*) or absence (*agranulocytes*) of granules in the cytoplasm.
- WBC count increases during infection, measured using the Total Leukocyte Count (TLC).

Types of White Blood Cells

WBC Category	Type	Function
Agranulocytes	Monocytes	Innate immunity
Agranulocytes	Lymphocytes	Acquired immunity (B cells: antibodies, T cells: cell-mediated)
Granulocytes	Neutrophils	Part of innate immunity
Granulocytes	Basophils	Involved in inflammation
Granulocytes	Eosinophils	Deal with allergies

Blood Groups

Classification Systems

- Blood groups are classified using two systems: **ABO** and **Rh type**.

ABO System

- Four groups based on antigens on red blood cells: A, B, AB, O.
- Antigen A → Group A
- Antigen B → Group B
- Both Antigens A and B → Group AB
- Neither antigen → Group O

Rh System

- Based on the presence of the Rhesus (Rh) antigen:
- Rh antigen present → Rh positive
- Rh antigen absent → Rh negative

Antigen and Antibody Relationships

- Antigens stimulate the immune system; the immune system does not attack self-cells.
- In transfusions, foreign antigens from donor blood can stimulate the recipient's immune system to produce antibodies.
- The antibodies produced correspond to absent antigens in one's own blood.

Antigen and Antibody Presence in Blood Groups

Blood Group	Antigens Present	Antibodies Present
A	A	Anti-B
B	B	Anti-A
AB	A and B	None
O	None	Anti-A and Anti-B

For the Rh system, Rh positive individuals have the antigen and cannot make anti-Rh antibodies; Rh negative individuals can make anti-Rh antibodies if exposed to the Rh antigen.

Blood Transfusion

- Blood transfusion is the process of giving blood from a donor to a recipient.
- The recipient can only receive blood with antigens that will not stimulate their own antibody production.

Rules for Safe Transfusion

- Consider the donor's antigen presence and the recipient's potential antibody production.
- If the donor's blood contains an antigen the recipient can make antibodies against, an immune reaction will occur, causing rejection and possible death.

Example Scenarios

- Donor A → Recipient B: Antigen A will lead recipient B to form anti-A antibody, destroying the transfused blood.
- Donor Rh negative → Recipient Rh positive: No antigen from donor, so no reaction; transfusion is safe.

Universal Donor and Recipient

Universal Donor	Universal Recipient
O negative	AB positive

- O negative blood has no antigens, making it safe for all recipients.
- AB positive blood produces no antibodies, allowing it to receive all blood types.

Glands and Hormones

Introduction to Glands

A gland is any organ producing specific chemicals. Types are based on chemical delivery methods.

Types of Glands

Gland Type	Delivery Method	Example
Exocrine gland	Secretes via ducts/tubes	Liver (bile secretion)
Endocrine gland	Ductless, secretes to blood	Thyroid, pituitary
Mixed (both)	Has both exocrine and endocrine functions	Pancreas

Hormones are secretions of endocrine glands, entering the bloodstream directly to act on distant target organs. The endocrine system controls internal communication and regulation via hormones, regulating when and how organs function.

Endocrine System

The Endocrine System and Its Glands

- The endocrine system is a network of ductless glands that secrete hormones for chemical control and coordination.
- Essential glands include the hypothalamus, pituitary, thyroid, parathyroid, adrenal, pancreas, ovaries, and testes.

Hypothalamus and Pituitary Gland

Hypothalamus

- Located in the brain; controls the pituitary gland.
- Produces releasing hormones (stimulate pituitary secretion) and inhibiting hormones (suppress pituitary secretion).

Pituitary Gland

The pituitary gland is divided into anterior and posterior parts, each producing different hormones.

Anterior Pituitary

Hormone	Target Organ	Function
Thyroid Stimulating Hormone (TSH)	Thyroid	Stimulates thyroid hormone production
Prolactin	Mammary glands	Assists in milk production
Adrenocorticotropic Hormone (ACTH)	Adrenal cortex	Stimulates adrenal hormone release
Follicle-Stimulating Hormone (FSH)	Gonads	Stimulates sperm/egg production
Growth Hormone	Body tissues	Promotes growth and development
Luteinizing Hormone (LH)	Sex organs (gonads)	Stimulates hormone production in gonads

Disorders in these hormones can lead to various physiological issues such as infertility, abnormal growth, or glandular dysfunction.

Posterior Pituitary

Hormone	Function
Antidiuretic Hormone (ADH)/Vasopressin	Facilitates reabsorption of water and minerals from kidneys back into blood
Oxytocin	Involved in labor contractions and bonding; released during childbirth

Roles and Disorders Associated with Pituitary Hormones

ADH/Vasopressin

- Controls water reabsorption in the kidneys.
- A deficiency leads to excess urination and dehydration (*Disease: Diabetes Insipidus*).
- Diabetes Insipidus is not related to blood sugar regulation.

Oxytocin

- Responsible for uterine contractions during childbirth.
- Also released during intimate physical interactions.

Thyroid and Parathyroid Glands

Thyroid Gland

- Requires iodine to synthesize its hormone (thyroxine).
- Regulates metabolism of carbohydrates, proteins, and fats.
- **Hyperthyroidism** (overactive thyroid): rapid metabolism, weight loss, high temperature, increased heart rate, excessive sweating.
- **Hypothyroidism** (underactive thyroid): slow metabolism, weight gain, lethargy, feeling cold.

Parathyroid Gland

- Produces parathyroid hormone.
- Regulates calcium and phosphate metabolism, essential for bone health and metabolic processes.
- The parathyroid gland functions independently of the pituitary gland; it has no associated tropic hormone.

Drug and Vaccine Administration

- Oral vaccines/medicines sometimes survive digestion and are absorbed in the small intestine, entering the bloodstream.
- The fraction that survives digestion is measured as **bioavailability**.
- Not all drugs can be given orally due to breakdown during digestion; some require injection.

Adrenal Gland

Structure and Hormones

Located above the kidneys, the adrenal gland consists of two parts: the adrenal medulla and adrenal cortex.

Adrenal Medulla

- Produces adrenaline and noradrenaline.
- These are emergency hormones released during fear, excitement, and anxiety.
- Facilitate the*"fight or flight" response*, increasing alertness and readiness.

Adrenal Cortex

Hormone	Type	Function
Aldosterone	Mineralocorticoid	Controls water and mineral balance, maintains blood pressure
Cortisol	Glucocorticoid	Regulates carbohydrate metabolism; increases during stress, can cause increased hunger and weight gain

Prolonged high cortisol levels can result in sleep disturbances like insomnia.

Pancreas

Exocrine and Endocrine Functions

The pancreas is a mixed gland: its exocrine part secretes digestive enzymes, and its endocrine part produces hormones.

Endocrine Pancreatic Hormones

Hormone	Function
Insulin	Converts blood glucose to glycogen, lowering blood glucose levels
Glucagon	Converts glycogen to glucose, raising blood glucose levels

- Glucose is the main fuel for energy, stored as glycogen when in excess.
- Balanced activity of insulin and glucagon maintains blood sugar homeostasis.

Diabetes Mellitus

- Deficiency of insulin results in raised blood glucose, known as diabetes mellitus.
- Kidneys try to remove excess glucose by producing more urine, risking kidney failure if prolonged.

Comparison: Diabetes Mellitus and Diabetes Insipidus

Disease	Cause	Main Issue
Diabetes Mellitus	Insulin deficiency	High blood sugar, more urine
Diabetes Insipidus	ADH deficiency	High urine output, dehydration

Blood and Plasma Therapy

- Plasma is separated by removing cells and can be used for therapy involving proteins and antibodies.
- Plasma can be transfused with less risk of immune rejection; however, blood group matching is usually performed.
- Cells cannot be preserved for long without oxygen; plasma and cells have different storage durations under various preservation methods.

Neurotransmitters vs Hormones

- Dopamine and serotonin are neurotransmitters, not hormones.
- Hormones are secretions of ductless glands released into the bloodstream, while neurotransmitters are chemical messengers in the nervous system.

Disease and Healing in Diabetes

- High blood glucose in diabetes impedes the healing process by interfering with cell function.
- Diabetes is a non-communicable disease; complications like prolonged bleeding can occur without adequate platelets.
- Hemophilia is a genetic disease due to the absence of clotting factors and cannot be treated by vitamin K supplementation.

Sleep Disturbance and Hormones

- Elevated cortisol due to stress disturbs sleep by keeping the body alert, leading to insomnia.
- Cortisol levels are normally higher in the morning and should decline by night for restful sleep.

Genetics and Genetic Material

Genetic Material: Basics

- Genetic material (**DNA**) governs all body functions and hereditary transfer.
- DNA is present in all living organisms and in all body cells, stored in the nucleus as chromosomes.

Structure of Nucleic Acids

Component	Details
Pentose sugar	Five-carbon sugar (deoxyribose in DNA, ribose in RNA)
Phosphate group	Common to DNA and RNA
Nitrogenous bases	Purines: Adenine (A), Guanine (G); Pyrimidines: Cytosine (C), Thymine (T), Uracil (U)

- DNA contains A, G, C, and T; RNA contains A, G, C, and U (uracil replaces thymine).
- DNA is double-stranded with complementary base pairing (A-T, G-C); RNA is typically single-stranded.

DNA and Chromosomes

- DNA is highly organized and forms chromosomes inside cell nuclei.
- Chromosomes are rod-like structures containing linear DNA sequences.

Genes

- Genes are segments of DNA coding for specific traits, such as hair or eye color.
- Humans have over 20,000 genes; each gene codes for a specific characteristic.
- All body cells have identical DNA, but only the necessary genes are expressed in each cell type.

Genome, Genomics, and Genome Sequencing

Genome

- A genome refers to the complete DNA set of an organism, including all of its genes and genetic material.

Genome Sequencing

- Determines the exact order of base pairs in a DNA molecule to understand gene functions and detect alterations.
- Used to diagnose diseases, study biological inheritance, and explore evolutionary relationships.
- Human, plant, bacterial, and disease genome sequencing projects help identify genes responsible for traits and diseases.

Applications

- Sequencing is used to identify disease-causing genes, e.g.,*BRCA gene testing for breast cancer risk*.
- Comparative sequencing aids in studying evolutionary relationships; high DNA similarity indicates closer evolutionary links.
- Genome sequencing forms the basis for diagnosing genetic diseases and developing targeted therapies.

Pangenome Concept

- Represents the complete genetic diversity within a species, studied by sequencing multiple individuals.

Gene Expression and Testing

- Despite all cells containing the same DNA, only select genes are expressed in appropriate tissues (e.g., eye-color genes only function in the eyes).
- Genetic testing (e.g., for hereditary diseases) can be performed on DNA from any body cell due to the uniformity of the genome across tissues.

Topic to be Discussed in the Next Class

- Reproduction, hormones, and inheritance
- Genetics and biotechnology: mechanisms of genetic material transmission and applications