Study Materials

UNIT I

Introduction to Haematology

The word of haematology comes from two words, the Greek haima (means blood) and logos (means discourse); therefore, haematology is the science of study blood cells components and coagulation.

Haematology is the branch of medicine concerned with the study of blood, blood-forming tissues, and disorders related to them. This field encompasses the following areas:

- **Blood Composition**: Blood consists of cells (red blood cells, white blood cells, and platelets) suspended in plasma.
- **Blood Disorders**: Includes anemia, leukemia, lymphoma, and clotting disorders.
- **Blood Functions**: Essential functions include oxygen transport, immune response, and clotting.

2. Laboratory Organization

Laboratory Organization refers to the systematic arrangement and management of a clinical or research lab to ensure efficient operation and accurate results:

- **Lab Layout**: Labs are usually divided into areas for specimen collection, processing, analysis, and storage.
- **Roles and Responsibilities**: Include lab technicians, scientists, pathologists, and administrative staff, each with specific duties.
- **Quality Control**: Procedures to ensure accuracy and reliability of lab results, including regular equipment calibration and proficiency testing.

3. Lab Safety and Instrumentation

Lab Safety: Ensures the well-being of lab personnel and the environment by implementing safety protocols:

- **Personal Protective Equipment (PPE)**: Includes gloves, lab coats, goggles, and masks.
- **Handling Biohazards**: Proper procedures for handling blood and other potentially infectious materials to prevent exposure.
- **Waste Disposal**: Safe disposal of biological, chemical, and sharps waste.

Instrumentation:

Refers to the tools and machines used for analyzing blood:

- **Microscopes**: For examining blood smears and cell morphology.
- **Hemocytometers**: For counting blood cells.
- **Automated Analyzers**: For complete blood counts (CBC) and other hematological tests.
- **Centrifuges**: To separate blood components based on density.

Microscope

Haemocytometer

Automated Analyser

Centrifuge

4. Composition and Functions of Blood

Blood Composition: Blood is made up of several components:

- **Red Blood Cells (RBCs)**: Carry oxygen from the lungs to the body's tissues and return carbon dioxide to the lungs.
- **White Blood Cells (WBCs)**: Part of the immune system, defending against infection.

- **Platelets**: Help with blood clotting to prevent excessive bleeding.
- **Plasma**: The liquid component that carries cells, nutrients, hormones, and waste products.

Functions of Blood:

- **Transportation**: Delivers oxygen, nutrients, hormones, and removes waste products.
- **Regulation**: Maintains pH balance, temperature, and fluid volume.
- **Protection**: Fights infections through immune responses and clots to prevent bleeding.

5. Collection & Preservation of Blood for Various Haematological Investigations

Collection: Proper collection techniques are crucial for accurate test results:

- **Venepuncture**: The most common method, involving drawing blood from a vein using a needle.
- **Capillary Blood Collection**: Used for small samples, typically from a finger stick.

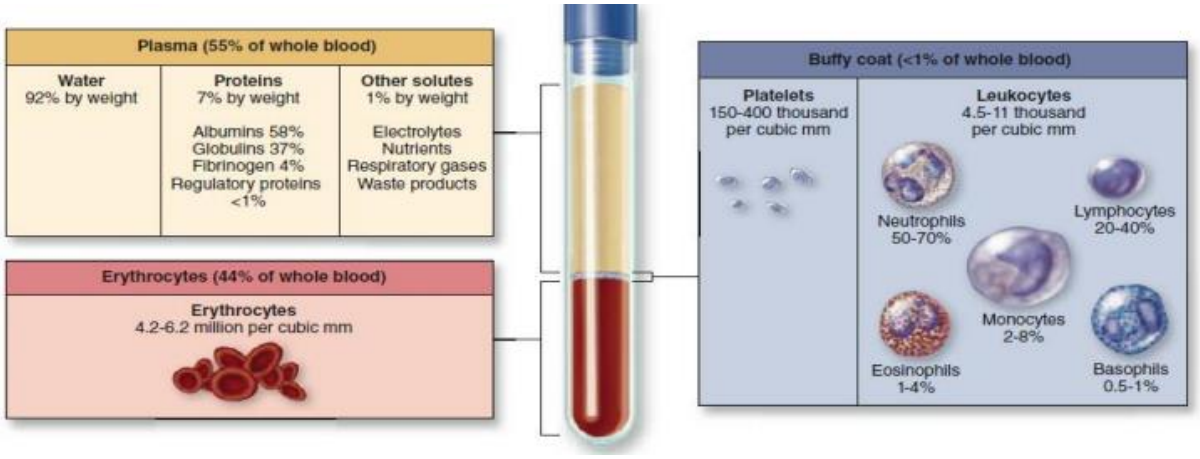
Preservation: Ensures that the blood sample remains stable until testing:

- **Anticoagulants**: Chemicals added to prevent clotting; examples include EDTA (ethylenediaminetetraacetic acid), heparin, and citrate.
- **Storage Conditions**: Blood samples are often stored at specific temperatures and times depending on the test. For instance, CBC samples are usually processed within 24 hours, while some tests may require immediate processing.

What is Blood?

It is a specialized connective tissue, that is a body fluid in humans and other animals, which delivers nutrients and gasses (O2 and CO2) to the cells, also transports metabolic waste away from those same cells, it propelled mainly by rhythmic contractions of the heart, within the closed circulatory system.

Blood components: after centrifugation of blood samples with anticoagulant factor: that produce three layers:



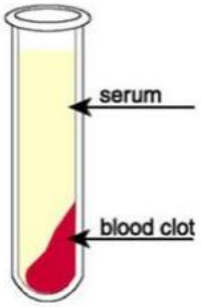
Physical features of blood:

1-Color: red because contain hemoglobin on RBC surface

2-Temperature: it has same degree of body 37C˚

3-Density: which depend on solutes concentration in plasma of blood and cellular concentration

(RBC, WBC, platelets) in whole blood.



Normal values of density:

Male: 1.057 --- 1.067 gm/cm3

Female: 1.051 --- 1.061 gm/cm3

4-Viscosity: that result from friction of blood with vessels wall, and depend on proteins

concentration (specialized fibrinogen)

Normal values of viscosity: 5-6 times more than water, measure by m2/sec

5-Osmotic pressure: which come from crystals of salts in plasma and it's important to maintain

equilibrium between salts and liquid between inside and outside (blood vessles) of cells,

osmotic pressure for plasma 5000 --- 5200 mm/hg.

6-Power of hydrogen (PH): blood is alkaline in normal range, artery blood has 7.4, but in vein 7.35, and in cell blood has 7 – 7.2 because CO2

7-Volume: 5-6 L in adults (Infants have a larger blood volume in proportion to body weight than adults).

Blood contain plasma, cells and platelets:

1-Plasma: is yellow liquid part of blood which contain cells of blood and configure 55% from

blood, have density 1.027 gm/cm3

Components of plasma:

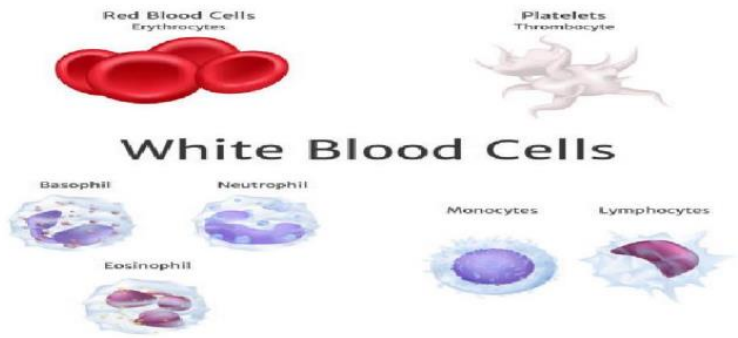
a) Water: 90%
b) Organic materials: 9% that include: Proteins (albumin 55%, globulin 38% and fibrinogen 7%) configure 8-6% from plasma. Non-protein materials include secretary materials (such as creatinine and uric acid) and nutrition (such as glucose and lipid).
c) Non-organic materials: includes ions such as (Fe++, K, Na, Ca, Mg, Cl- and HCO3).

2-Cells:

a) **Erythrocyte (Red blood cells RBC):** RBC that wrong called cells because don't has features of cells, don't has nucleus, it biconcave shaped, it was get energy by anaerobic oxidation of glucose because doesn’t contain mitochondria, which has very important rolls in the life because contain hemoglobin (gave red color) that responsible for gases transport to survive. It was lack organelles to provide surface for vital function (transporters), and without ability to divided and generation. Normal value of RBC: (number of cell per million in one milliliter of blood sample) Male: 4.7 – 6.1 million/mil and Female: 4.2 – 5.4 million/mil.

b) **Leucocyte (White blood cells WBC):** the normal range of WBC 4000-11000 cell/mm3include two types granular (basophil, neutrophil and acidophil) and a granular (monocyte and lymphocyte).

c)**Platelets:** circular bodies, unlike cells that don't contain nucleus and other organelles normal value of: 150,000 - 450,000 per microliter or 150-400 × 10/ L.



Functions of blood:

1- Respiratory: transport O2 from lungs tissues to all cells of body by artery, also transport CO2 from body cells to lungs.

2- Nutritive: also blood transport nutrition from digestive system to cells and deliver metabolic wastes to decretory organs.

3- Regulation of body temperature: distributed heating energy in all body by movement in all blood vessels.

4- Regulation of metabolism: by transport hormones from manufactured place to all body cells that regulated catabolism and anabolism.

5- **Defenses:** this function specialized for WBC, which have ability to engulfs microbes, also blood contain important antibodies against antigen.

6- Water balances: transport and excretion high amount of water from kidney and urinary tract.

7- Buffering: regulate concentration of hydrogen ions, by contain specific components for process.

Collection & preservation of blood for various haematological investigations :

1. Collection of Blood:

a. Preparation:

- **Personnel:** Ensure that the person collecting the blood is trained and uses proper techniques.
- **Materials:** Sterile needles, syringes or vacuum tubes, tourniquet, antiseptic wipes, and gloves should be ready.

b. Procedure:

1. **Patient Preparation:** Explain the procedure to the patient. Ensure they are seated comfortably.
2. **Site Selection:** Typically, blood is drawn from the antecubital vein in the arm. Select a site with a large, visible vein.
3. **Cleaning:** Clean the site with an antiseptic wipe and allow it to dry to prevent contamination.
4. **Tourniquet Application:** Apply a tourniquet above the site to engorge the vein.
5. **Needle Insertion:** Insert the needle at a 15-30 degree angle to the skin. Once blood flow is established, withdraw the required amount of blood.
6. **Tube Filling:** If using vacuum tubes, fill them according to the order of draw to avoid cross-contamination of additives.

c. Order of Draw:

1. Blood Cultures (if needed)
2. Coagulation Tests (e.g., PT, APTT) – typically collected in blue-topped tubes
3. Serum Tests (e.g., chemistry panels) – collected in red-topped or gold-topped tubes
4. EDTA Tubes (for hematology) – lavender or purple-topped tubes
5. Other Additives (e.g., glucose tests in gray-topped tubes)

2. Preservation and Transport:

a. Handling:

- **Mixing:** Gently invert the tubes (except those with serum) to mix the anticoagulant with the blood. Avoid vigorous shaking.
- **Separation:** For serum or plasma tests, centrifuge the sample as soon as possible to separate the components.

b. Storage:

- **EDTA Samples:** Typically stable at room temperature (18-25°C) for 24 hours for most hematological tests.
- **Serum Samples:** Can be stored at 2-8°C for up to 48 hours. For longer periods, they should be frozen at -20°C or lower.

c. Transport:

- **Temperature:** Maintain the appropriate temperature during transport. Most samples are transported at room temperature, but some tests may require refrigeration or freezing.
- **Timing:** Aim to transport samples to the laboratory promptly to minimize degradation.

3. Special Considerations:

a. Avoid Hemolysis:

- This can occur if the blood is drawn too quickly or with too small a needle. Handle the samples gently.

b. Patient Factors:

- Ensure the patient is not fasting unless required for specific tests. Inform patients of any pre-test requirements.

c. Documentation:

- Label all samples accurately with the patient’s details, date, and time of collection to avoid mix-ups.

d. Compliance:

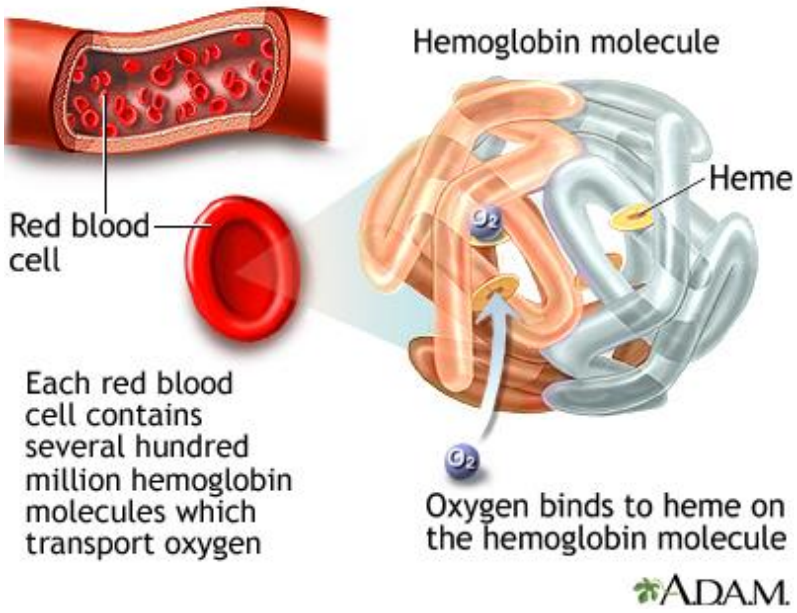
- Follow the specific guidelines provided by the laboratory or testing facility, as protocols can vary.

By adhering to these practices, you ensure that blood samples remain viable for testing, leading to accurate and reliable hematological results.

Physiological Variations in Hemoglobin (Hb), Packed Cell Volume (PCV), Total Leukocyte Count (TLC), and Platelets :

1. Hemoglobin (Hb):

Hemoglobin is a protein in red blood cells that carries oxygen. The hemoglobin test measures how much hemoglobin is in our blood.



Hemoglobin is the most important component of red blood cells. It is composed of a protein called heme, which binds oxygen. In the lungs, oxygen is exchanged for carbon dioxide. Abnormalities of an individual's hemoglobin value can indicate defects in the normal balance

between red blood cell production and destruction. Both low and high values can indicate disease states.

    - **Normal Ranges:** Typically 13.8–17.2 g/dL for men and 12.1–15.1 g/dL for women.
- **Variations:** Can vary with age, sex, altitude, and health status. Pregnant women may have lower Hb levels due to increased blood volume.

- **Packed Cell Volume (PCV):**
    - **Normal Ranges:** 40-54% for men and 37-47% for women.
    - **Variations:** Can be influenced by hydration status, altitude, and certain medical conditions.
- **Total Leukocyte Count (TLC):**
    - **Normal Ranges:** 4,000–11,000 cells/μL.
    - **Variations:** Can increase in response to infections, inflammation, or stress, and decrease in conditions like bone marrow disorders.
- **Platelets:**
    - **Normal Ranges:** 150,000–450,000/μL.
    - **Variations:** Can vary with age, and in response to various conditions, including infections, anemia, or bone marrow disorders.

2. Hemoglobinometry

Hemoglobinometry refers to the measurement of hemoglobin levels in the blood. The methods used include:

- **Colorimetric Methods:** Use reagents that react with hemoglobin to produce a color change. The intensity of the color is proportional to the concentration of hemoglobin.
    - **Cyanmethemoglobin Method:** Uses potassium ferricyanide to convert hemoglobin to cyanmethemoglobin, which is then measured spectrophotometrically.
- **Electrochemical Methods:** Employ electrodes to detect hemoglobin concentration.
- **Hemoglobin Electrophoresis:** Separates different types of hemoglobin based on their electric charge and size, useful for identifying hemoglobinopathies.

3. Various Methods of Estimation of Hb

- **Sodium Lauryl Sulfate (SLS) Method:**Hemoglobin is converted into a stable form, which absorbs light at a specific wavelength, allowing quantification.
- **HemoCue Method:** Uses a microcuvette and a portable photometer to measure hemoglobin levels.
- **Spectrophotometric Methods:** Measure the absorbance of light by hemoglobin at a specific wavelength, usually with a colorimetric reagent.

4. Errors Involved and Standardization of Instruments

- **Errors:**
    - **Instrumental Errors:** Calibration issues, reagent quality, and environmental factors (e.g., temperature and light conditions) can affect results.
    - **Sampling Errors:**Hemolysis, improper mixing, or contamination of the sample can lead to inaccurate measurements.
    - **Operator Errors:** Incorrect technique or misinterpretation of results can introduce errors.
- **Standardization:**
    - **Calibration:** Regular calibration of instruments using standard solutions is essential for accurate measurements.
    - **Quality Control:** Use of control samples with known concentrations of hemoglobin to verify accuracy.
    - **Maintenance:** Regular maintenance and servicing of instruments to ensure their proper functioning.

5. Blood Group Systems: ABO and Rhesus (Rh)

- **ABO Blood Group System:**

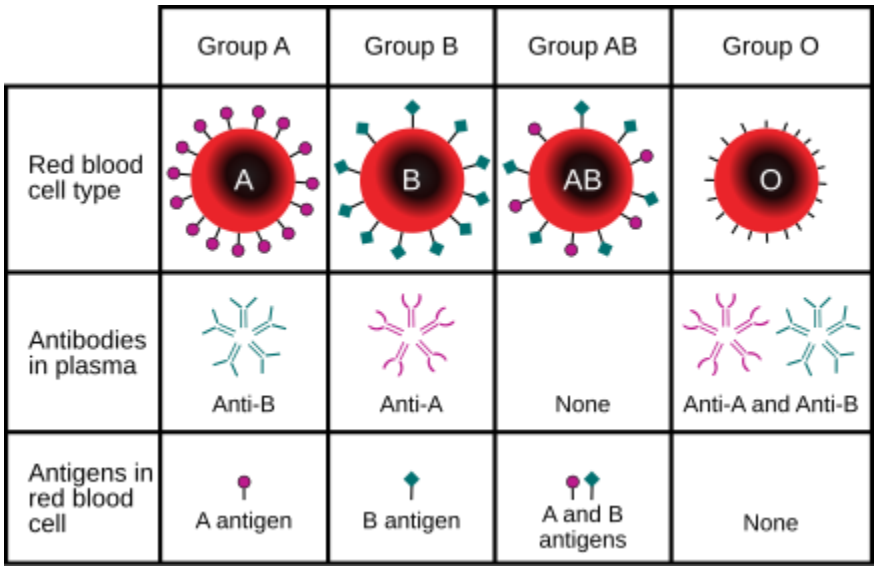
  Group A – contains antigen A and antibody B.

  Group B –contains antigen B and antibody A.

  Group AB –contains both A and B antigen and no antibodies (neither A nor B).

Group O – contains neither A nor B antigen and both antibodies A and B.

The ABO group system is important during blood donation or blood transfusion as mismatching of blood group can lead to clumping of red blood cells with various disorders. It is important for the blood cells to match while transfusing i.e. donor-recipient compatibility is necessary. For example, a person of blood group A can receive blood either from group A or O as there are no antibodies for A and O in blood group A.



- **Rhesus (Rh) Blood Group System:**
    - **Rh Factor:** Positive (Rh+) or Negative (Rh-), depending on the presence or absence of the Rh antigen (D antigen) on red blood cells.
    - **Significance:** Important in pregnancy and blood transfusions. Rh incompatibility can lead to hemolytic disease of the newborn (HDN).

6. Hemoglobin: Synthesis, Function, and Degradation

- **Synthesis:**
    - **Location:** Occurs in the bone marrow.
    - **Process:** Involves the synthesis of heme and globin chains. Iron is a critical component for heme synthesis, and the globin chains (alpha, beta, gamma, delta) combine with heme to form hemoglobin.
- **Function:**
    - **Oxygen Transport:**Hemoglobin binds oxygen in the lungs and releases it in tissues.

    - **Carbon Dioxide Transport:** Transports carbon dioxide from tissues to lungs.
- **Degradation:**
    - **Breakdown:** Occurs primarily in the liver and spleen. Hemoglobin is broken down into heme and globin. Heme is further degraded to biliverdin and then to bilirubin, which is excreted in bile.

7. Hemoglobin Pigments and Their Measurements

- **Hemoglobin Pigments:**
    - **Methemoglobin:**Hemoglobin with oxidized iron (Fe3+) that cannot bind oxygen.
    - **Carboxyhemoglobin:**Hemoglobin bound to carbon monoxide.
    - **Oxyhemoglobin:**Hemoglobin bound to oxygen.
- **Measurements:**
    - **Spectrophotometry:** Measures the absorption spectra of different hemoglobin forms.
    - **Co-oximetry:** A more advanced method that can differentiate between various hemoglobin pigments and their concentrations.

UNIT II

Phlebotomy Room Equipment and Their Principles

1. **Phlebotomy Chair/Bed:**
    - **Principle:** Provides a comfortable and stable position for the donor.
    - **Use:** Allows the donor to be in a reclined position, which can help in making the process smoother and reduce the risk of fainting.
2. **Needles and Blood Collection Tubes:**
    - **Principle:** Needles and tubes must be sterile and appropriately sized to ensure safe and effective blood collection.
    - **Use:** Needles are used to puncture the vein and collect blood into tubes that contain various additives (anticoagulants, preservatives) depending on the tests required.
3. **Tourniquet:**
    - **Principle:** Used to engorge veins, making them more visible and easier to puncture.
    - **Use:** Applied above the intended puncture site for a short period to make veins more prominent.
4. **Alcohol Swabs:**
    - **Principle:** Ensure aseptic technique by disinfecting the skin before needle insertion.
    - **Use:** Clean the puncture site to prevent infection.
5. **Blood Pressure Cuff:**
    - **Principle:** Helps in locating veins and assessing vein condition by increasing venous pressure.
    - **Use:** Sometimes used instead of a tourniquet, or in conjunction with it.
6. **Bandages and Gauze:**
    - **Principle:** Aid in stopping bleeding post-venipuncture.
    - **Use:** Applied to the puncture site after needle removal to prevent bleeding and reduce the risk of hematoma.
7. **Sharps Container:**
    - **Principle:** Provides a safe disposal method for used needles and other sharp instruments.

- **Use:** Ensures safe disposal of sharp items to prevent needle-stick injuries and contamination.

8. **Automated Blood Collection Devices:**
    - **Principle:** Streamline and automate the blood collection process.
    - **Use:** Used in some settings to collect blood more efficiently, often in a more controlled manner.

Emergency Medicines

1. **Epinephrine:**
    - **Principle:** Used in cases of severe allergic reactions (anaphylaxis).
    - **Use:** Administered to rapidly counteract the effects of severe allergic reactions.
2. **Antihistamines:**
    - **Principle:** Treat allergic reactions or mild symptoms of an allergic response.
    - **Use:** Provides relief from itching, swelling, and hives.
3. **Hydrocortisone:**
    - **Principle:** Used to reduce inflammation in allergic reactions.
    - **Use:** Administered to manage severe allergic reactions or other inflammatory responses.
4. **Oxygen:**
    - **Principle:** Provides supplemental oxygen if the donor experiences hypoxia or respiratory distress.
    - **Use:** Ensures the donor's oxygen levels are maintained, especially in cases of fainting or other respiratory issues.
5. **Intravenous Fluids:**
    - **Principle:** Used to maintain hydration and blood pressure.
    - **Use:** Administered if the donor shows signs of dehydration or hypotension.

Pre and Post Donation Screening and Counseling

Pre-Donation Screening:

- **Purpose:** To ensure the donor is healthy enough to donate blood and to assess eligibility.
- **Process:** Includes a health questionnaire, medical history review, and sometimes a physical examination.
- **Counseling:** Educates the donor about the process, potential risks, and benefits. Discusses symptoms to watch for and advises on preparation (e.g., hydration).

Post-Donation Counseling:

- **Purpose:** To ensure donor safety and provide post-donation care instructions.
- **Process:** Includes informing the donor about potential side effects, providing care instructions, and scheduling follow-up if needed.
- **Counseling:** Provides guidance on what to expect after donation, how to handle any issues (e.g., dizziness), and when to seek medical advice.

Bleeding of the Donor and Post-Donation Care

Bleeding:

- **Management:** Immediate care includes applying pressure and a bandage to the puncture site. If bleeding persists or is excessive, further intervention may be required.

Post-Donation Care:

- **Instructions:** Donors are advised to rest briefly, drink plenty of fluids, and avoid strenuous activities for the rest of the day.
- **Monitoring:** Observing the donor for any adverse reactions such as dizziness or fainting.
- **Follow-Up:** If any issues arise, donors are advised to contact the blood donation center for further guidance.

Screening of Blood Units for Mandatory Tests

1. **HIV:**
    - **Purpose:** To detect HIV-1 and HIV-2, preventing transmission through transfusion.

2. **Hepatitis B and C:**
    - **Purpose:** To identify HBV and HCV infections, ensuring safety and preventing transmission.
3. **Syphilis:**
    - **Purpose:** To detect Treponemapallidum infection, which can be transmitted through blood.
4. **Human T-Lymphotropic Virus (HTLV):**
    - **Purpose:** To screen for HTLV-I and HTLV-II, which can be transmitted through blood transfusions.
5. **Blood Typing and Crossmatching:**
    - **Purpose:** To ensure compatibility between donor and recipient, preventing transfusion reactions.

By adhering to these practices and using appropriate equipment, blood collection and donation can be performed safely and effectively, ensuring the well-being of both donors and recipients.

1. Preservation of Donated Blood

Blood Preservation Solutions:

- **Anticoagulants:** Prevent clotting. Common types include CPD (Citrate Phosphate Dextrose), CP2D, and ACD (Acid Citrate Dextrose).
- **Additive Solutions:** Improve the quality and extend the storage time of red blood cells. Examples include ADSOL, OPTISOL, and PAS (Platelet Additive Solutions).

Storage:

- **Red Blood Cells (RBCs):** Typically stored at 1-6°C for up to 42 days with appropriate additive solutions.

- **Platelets:** Stored at 20-24°C with continuous agitation for up to 5 days.
- **Plasma:** Stored at -18°C or lower for up to 1 year.

2. Apheresis Procedures

Apheresis:

- **Definition:** A procedure that separates blood into its components, collects one or more components, and returns the remaining components to the donor.
- **Types of Apheresis:**
    - **Plasma Apheresis:** Collects plasma and returns red cells, white cells, and platelets.
    - **Platelet Apheresis:** Collects platelets and returns red cells, white cells, and plasma.
    - **Leukapheresis:** Collects white blood cells and returns other components.

Preparation of Multiple Products:

- Apheresis machines can prepare multiple components (e.g., platelets, plasma, and red cells) from a single donation, optimizing the use of each donation.

3. Maintenance of Cell Separator Equipment

Maintenance:

- Regular calibration and validation to ensure proper function.
- Routine cleaning and sterilization to prevent contamination.
- Monitoring and replacement of parts subject to wear and tear.

4. Autologous Blood Donation

Definition:

- **Autologous Donation:** Donation of blood by the patient for their own future use, often used in planned surgeries.

Techniques:

- **Preoperative Autologous Donation:** Blood collected weeks before surgery.
- **Intraoperative Blood Recovery:** Blood lost during surgery is collected and reinfused.
- **Postoperative Blood Recovery:** Blood collected from drainage systems after surgery and reinfused.

5. Techniques of Donor Blood Collection

Methods:

- **Whole Blood Donation:** Blood is collected in one go and separated later into components.
- **Component Donation:** Blood components (e.g., platelets) are collected via apheresis.
- **Phlebotomy:** Standard blood collection from a vein using a needle.

Recipient	Donor			
	O	A	B	AB
O	✓	✓	✓	✓
A	✗	✓	✗	✓
B	✗	✗	✓	✓
AB	✗	✗	✗	✓

6. Discarding of Infected and Out-dated Blood

Infected Blood:

- Blood testing for pathogens is crucial. Infected blood is discarded according to protocols to prevent transmission of disease.

Out-dated Blood:

- Blood that has exceeded its shelf life or is no longer usable is discarded according to safety regulations. Proper disposal methods are used to ensure that it does not pose a risk.

Selection of Donor and Component Separation

1. Donor Selection:

- **Eligibility Criteria:** Donors must meet specific criteria related to age, weight, health status, and medical history to ensure the safety of both the donor and the recipient. Common requirements include being between 17 and 65 years old, weighing at least 110 pounds, and having no significant health issues.
- **Pre-donation Screening:** This involves a health questionnaire, physical examination, and possibly tests to screen for infectious diseases and other conditions.

2. Component Separation:

- **Apheresis:** A process where whole blood is drawn from the donor and separated into its components (e.g., red cells, plasma, platelets) using a machine. This allows for the collection of specific components in larger quantities while returning the rest of the blood to the donor.
- **Centrifugation:** Whole blood is centrifuged in a blood bank to separate it into its components. The centrifugal force causes the blood components to separate into different layers, which can then be collected into separate bags.

Selection of Blood Bags for Component Preparation

1. Blood Bags:

- **Types of Bags:** Blood bags come in various configurations depending on the type of component to be collected. They are typically made of plastic and are designed to be sterile.
- **Additives:** Some bags contain anticoagulants and preservatives like CPDA-1 (citrate-phosphate-dextrose-adenine-1) to prevent clotting and extend the shelf life of the blood components.

2. Choosing the Right Bag:

- **Component Requirements:** The choice of bag depends on the intended component (e.g., apheresis bags for platelets, red cell bags for red cell concentrate).
- **Volume and Type:** Bags are selected based on the volume of blood required and the specific additives needed for the preservation of each component.

Blood Component Preparation

1. Red Cell Concentrate:

- **Preparation:** Red blood cells are separated from whole blood or apheresis blood using centrifugation. They are then stored in a bag with additives to extend shelf life.
- **Uses:** Primarily used to treat anemia and blood loss.

2. Fresh Frozen Plasma (FFP):

- **Preparation:** Plasma is separated from whole blood and then frozen within hours of collection to preserve clotting factors.
- **Uses:** Used for patients with clotting disorders and during surgeries requiring blood clotting support.

3. Platelet Concentrate:

- **Preparation:** Platelets are separated from whole blood or apheresis blood and concentrated into a smaller volume.
- **Uses:** Used to treat patients with low platelet counts (thrombocytopenia) due to various conditions like leukemia or chemotherapy.

4. Cryoprecipitate:

- **Preparation:** Plasma is slowly thawed after freezing, and the precipitate that forms, which contains clotting factors, is collected.
- **Uses:** Contains factors VIII and XIII, fibrinogen, and is used to treat hemophilia and other bleeding disorders.

5. Washed Red Cells:

- **Preparation:** Red blood cells are washed with saline to remove plasma and leukocytes.
- **Uses:** Beneficial for patients with severe allergies or adverse reactions to plasma proteins.

6. Frozen Red Cells:

- **Preparation:** Red blood cells are frozen using a cryoprotectant and stored at very low temperatures.
- **Uses:** Used for long-term storage or when red cells need to be preserved for future use.

Plasma Fractionation

1. Process:

- **Plasma Separation:** Plasma is separated from the cellular components of blood.
- **Fractionation:** Plasma undergoes a series of steps including further centrifugation and chemical processes to isolate and concentrate various plasma proteins.

2. Products:

- **Albumin:** Used to treat conditions related to blood volume and protein loss.
- **Immunoglobulins:** Used to provide passive immunity to patients with immune deficiencies or certain infections.
- **Clotting Factors:** Used for treating hemophilia and other bleeding disorders.

3. Applications:

- Plasma fractionation products are critical in treating a wide range of conditions, from autoimmune disorders to blood clotting deficiencies.

1. Principles and Manufacturing of Plasma Derivatives

Principles:

- Plasma derivatives are produced from human blood plasma through a series of complex processes aimed at extracting specific proteins.
- The primary goal is to obtain therapeutic proteins like clotting factors, immunoglobulins, and albumin.

Manufacturing Process:

1. **Collection**: Blood is collected from donors and separated into components.
2. **Plasma Separation**: Plasma is separated from other blood components (e.g., red cells, platelets) using centrifugation.
3. **Fractionation**: Plasma is further processed to isolate specific proteins. Common methods include cryoprecipitation and ion exchange chromatography.
4. **Purification**: Various techniques, such as filtration and affinity chromatography, are used to purify proteins and remove contaminants.
5. **Formulation**: Proteins are formulated into final products, which may involve concentration, stabilization, and packaging.
6. **Quality Control**: Rigorous testing ensures the safety, potency, and purity of the final product.

2. Component Testing

- **Blood Typing**: Determining ABO and Rh blood groups.
- **Compatibility Testing**: Ensuring donor and recipient blood compatibility to prevent transfusion reactions.
- **Microbiological Testing**: Screening for pathogens and ensuring sterility.
- **Potency Testing**: Verifying that the blood component has the required therapeutic activity.
- **Storage Stability Testing**: Assessing how well components maintain their effectiveness over time.

3. Labeling

- **Identification**: Includes donor information, blood type, expiration date, and any special handling instructions.
- **Compliance**: Adhering to regulatory standards and providing critical information for safe use.
- **Barcoding**: Enhances traceability and reduces the risk of errors.

4. Transportation and Storage of Blood Components

- **Temperature Control**: Maintaining appropriate temperatures (e.g., 1-6°C for red cells, -20°C or lower for frozen plasma) to ensure product integrity.
- **Packaging**: Using specialized containers to prevent contamination and physical damage.
- **Transport Logistics**: Ensuring timely delivery and compliance with regulatory requirements.

5. Preparation of Leukoreduced Blood Products

- **Leukoreduction**: The process of removing white blood cells from blood components to reduce the risk of transfusion reactions and improve patient outcomes.
- **Leukocyte Filters**: Specialized filters are used to remove leukocytes during blood collection or processing.

6. Leukocyte Filters and Component Extractors

- **Leukocyte Filters**: Designed to remove leukocytes from blood components during collection or processing.
- **Component Extractors**: Devices used to separate and extract specific blood components, such as platelets or plasma, from whole blood.

7. Metabolic Changes in Blood Components During Storage

- **Metabolic Changes**: Blood components undergo various changes, including:
    - **Red Blood Cells**: Degradation of glucose and production of metabolic by-products.

    - **Platelets**: Reduced functionality and aggregation over time.
    - **Plasma Proteins**: Changes in protein stability and activity.
- **Cytokine Release**: Accumulation of cytokines like TNF-alpha and IL-6, which can be associated with inflammatory responses during storage.

8. Inventory Management and Maintenance of Blood Stock

- **Stock Rotation**: Ensuring older units are used before newer ones to minimize wastage.
- **Real-Time Monitoring**: Tracking inventory levels and expiration dates.
- **Demand Forecasting**: Predicting future needs based on historical data and trends.
- **Quality Assurance**: Regular checks to ensure the integrity and suitability of the blood stock.

9. Irradiated Blood Components

- **Purpose**: Irradiation is used to prevent graft-versus-host disease (GVHD) in immunocompromised patients by inactivating T lymphocytes.
- **Process**: Exposing blood components to gamma rays or X-rays to achieve the desired level of T-cell inactivation.

10. Blood Substitutes

- **Types**:
    - **Hemoglobin-based Oxygen Carriers (HBOCs)**: Products derived from hemoglobin, which carry oxygen in the bloodstream.
    - **Perfluorocarbons (PFCs)**: Synthetic compounds that can carry and release oxygen.
- **Advantages**: Can be used when blood supply is limited or in situations where blood transfusions are not feasible.
- **Challenges**: Ensuring safety, efficacy, and minimizing side effects.