Introduction to Haematology

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Objective:

- Introduce the students to the study of blood and its relevance in the diagnosis of diseases and conditions.

Format of the lecture.

1. Definition
2. Blood: function and composition
3. Haemoglobin
4. Blood cells
5. Methods of obtaining blood from a patient
6. Some examples of haematogical tests

Haematology

- Is the study of:

1. The **Cellular** constituents of the blood- their **number** of concentration, the relative **distribution** of various types of cells, and
2. The **structural** or **biochemical abnormalities** of cells that **result in disease**.

- **Examination** of the blood important in relation to the **care of patients** only as findings are correlated with the **entire** clinical condition.

The Blood.

- Blood is a **tissue/organ.**
- Examined in practically **every phase** of medical practice, including **blood forming tissues**.
- Examined whenever even the **slightest suggestion** of a disorder affecting the blood **directly** or **indirectly**.
- Certain observations of **peripheral blood universally** regarded as **indispensable** to the examination of **all** patients.

Volume.

- Approx **5 liters** of blood for an average sized **adult male**.
- **Size** matters.
- On average, for an adult male it is about **75 m**L/kg [**5.625**L] , for woman **65** mL/kg [**4.875**L].

- Accounts for **8%** of the human body weight, with an average density of approximately **1,060** kg/m^3 .

Functions of blood.

- Include:

a) **Supply of oxygen** to tissues.

b) **Supply of nutrients** such as glucose, amino acids, and fatty acids.

c) **Removal of waste** such as carbon dioxide, urea, and lactic acids.

d) **Immunological functions**: circulation of **white blood cells**, and detection of foreign material by **antibodies**.

e) **Coagulation.**

f) **Messenger functions**: the transport of **hormones** and the signaling of tissue damage.

g) **Regulation** of body **pH**.

h) **Regulation** of core **body** temperature.

i) **Hydraulic functions**

Composition of blood.

- Comprises:

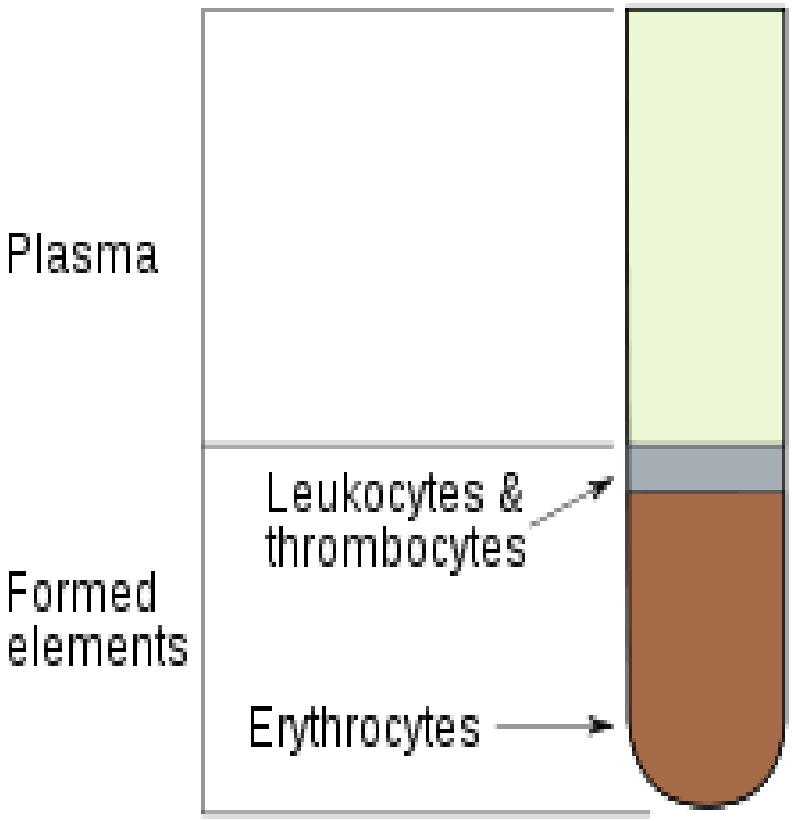
1. **Plasma** (Liquid portion).
2. **Blood cells** (Solid portion) :

a) Mainly **erythrocytes** (red blood cells),

b) Leukocytes (white blood cells),

c) Platelets (thrombocytes)

Blood components.



Plasma.

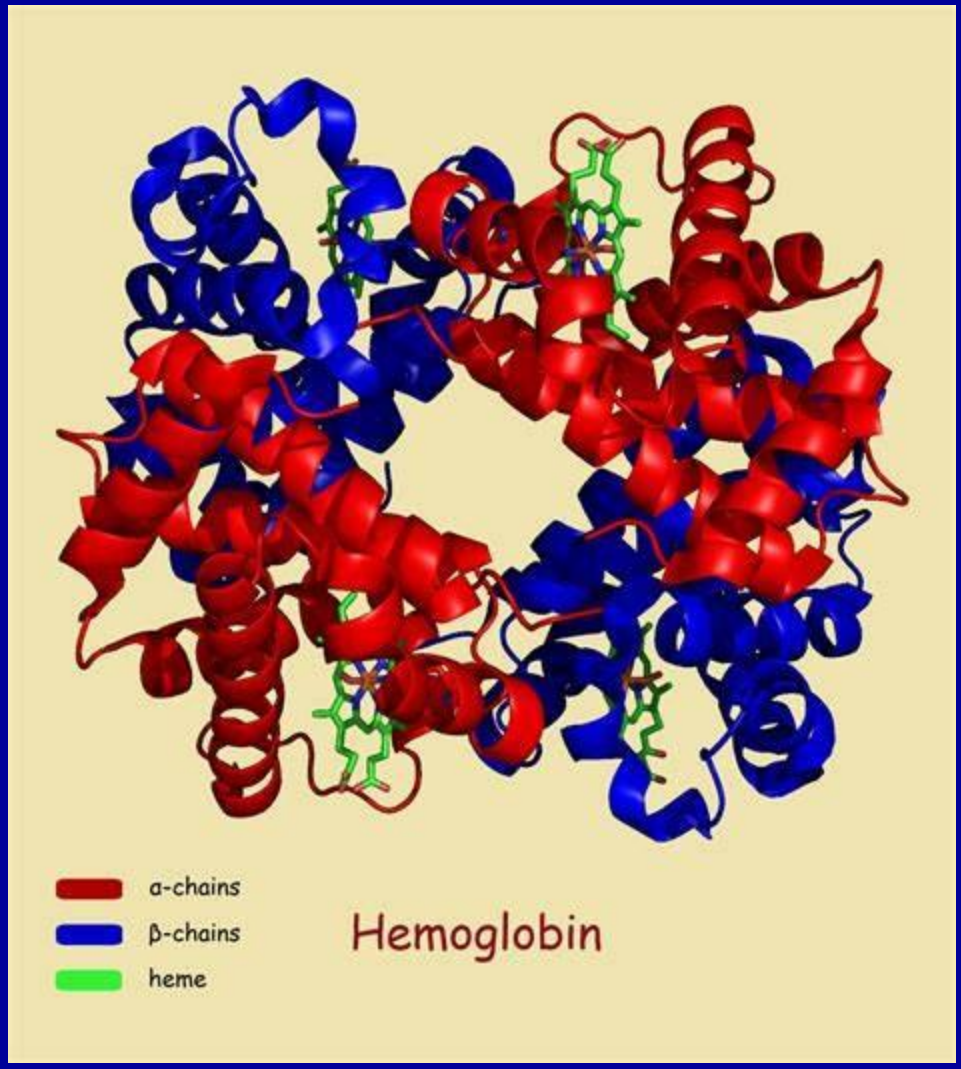
- Constitutes **55%** of blood,
- Mostly water (**92%** by volume), and contains **proteins**, **glucose**, **mineral ions**, **hormones**, **carbon dioxide.**
- **Albumin,** the main protein in plasma, and functions by regulating the colloidal **osmotic pressure** of blood.

Serum.

- When blood **coagulates**, the resultant fluid after separation of the **clot** called **Serum**.
- Serum differs from plasma mainly by loss of the protein **fibrinogen**, converted to **insoluble fibrin** strands in the process of **coagulation**.
- Serum and Plasma used for many tests in **clinical chemistry** and **Immunology.**

Haemoglobin.

- **Hb** or **Hgb**
- The **iron**-containing **oxygen-transport metalloprotein** in the **red blood cells (RBCs).**
- Carries **oxygen** from the lungs to the rest of the body and collects **carbon dioxide** back to the lungs for disposal.


α-chains
β-chains
heme
Hemoglobin

Hb synthesized in a complex series of steps:

- **Heme** part synthesized in a series of steps in the **mitochondria** of immature red blood cells **(Reticulocytes).**
- **Globin (protein)** parts synthesized by **ribosomes**.
- Production of Hb **continues** in the cell **throughout** its **early** development.

Adult humans

- The commonest **hemoglobin type** - **tetramer** (which contains **4** subunit proteins) called **Hemoglobin A [HbA].**
- Consists of two **α** and two **β** subunits **non-covalent**ly bound.
- Denoted as **α2β2.**

In human **infants**.

- The Hb molecule made up of 2 **α** chains and 2 **γ** chains [**HbF**].
- **γ** chains, gradually replaced by **β** chains as infant grows.

Types of Hb.

In the fetus-infants:

- **Haemoglobin F (α2γ2).**

In adults:

1. **Haemoglobin A (α2β2)** - Commonest with a normal amount **> 95%.**
2. **Haemoglobin A2 (α2δ2)** - δ chain synthesis late in the **third trimester** (pregnant women) -a normal range of **1.5-3.5%.**

- Abnormally high levels in **Sickle Cell Disease** and **Beta-thalassemia.**

3. **Haemoglobin F (α2γ2)** - In adults **HbF** restricted to a limited population of red blood cells called **F-cells.**

- Of **85%** normal adults with **0.3-4.4%** of RBC being F-cells.
- HbF- **0.6%** of total Hb of normal adults.
- Level of **HbF** can be elevated in persons with **sickle-cell disease** and **beta-thalassemia**

Blood cells

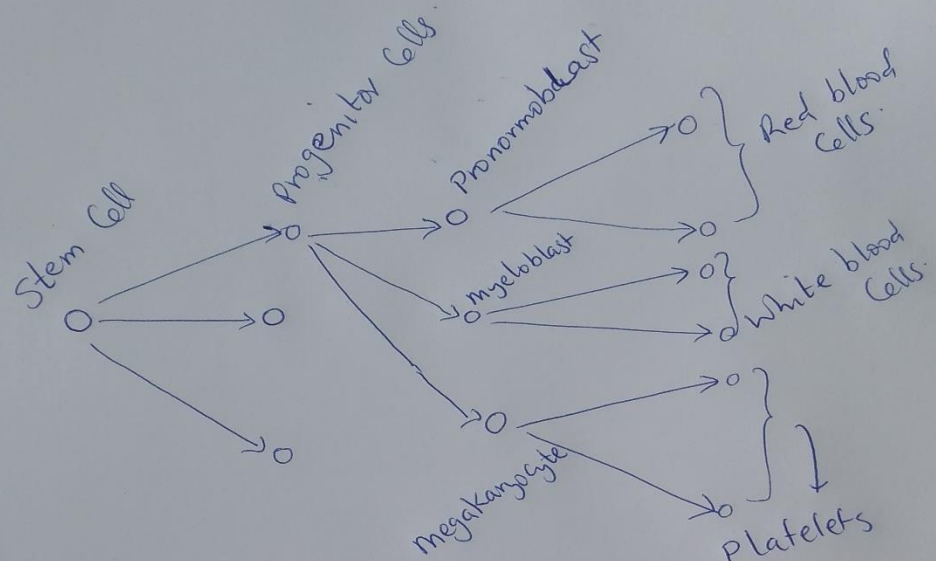
- **Formed** elements of blood.
- **Haemopoiesis** : the process of formation of blood cells.
- The **yolk sac**, and later the **liver** and **spleen**: centres for haemopoiesis in **fetal life.**
- After birth: normal haemopoiesis restricted to the **bone marrow.**

- **Infants** -haemopoietic marrow in **all** bones.
- **Adults** -the **central skeleton** and **proximal ends** of long bones.

- A **common** primitive **stem cell** in the marrow: the capacity to **self replicate**, **proliferate,**
- and **differentiate,** → increasingly specialized **progenitor** cells ,many cell divisions within the **marrow**,
- → form **mature cells** (red blood cells, white blood cells, and platelets) of the peripheral blood.

Earliest recognizable **precursors**:

- Red blood cell - **pronormoblast .**
- White blood cells-**myeloblast .**
- Platelet- **megakaryocyte.**


Stem Cell
Progenitor Cells
Pronormoblast
myeloblast
Megakaryocyte
Red blood Cells
White blood Cells
Platelets

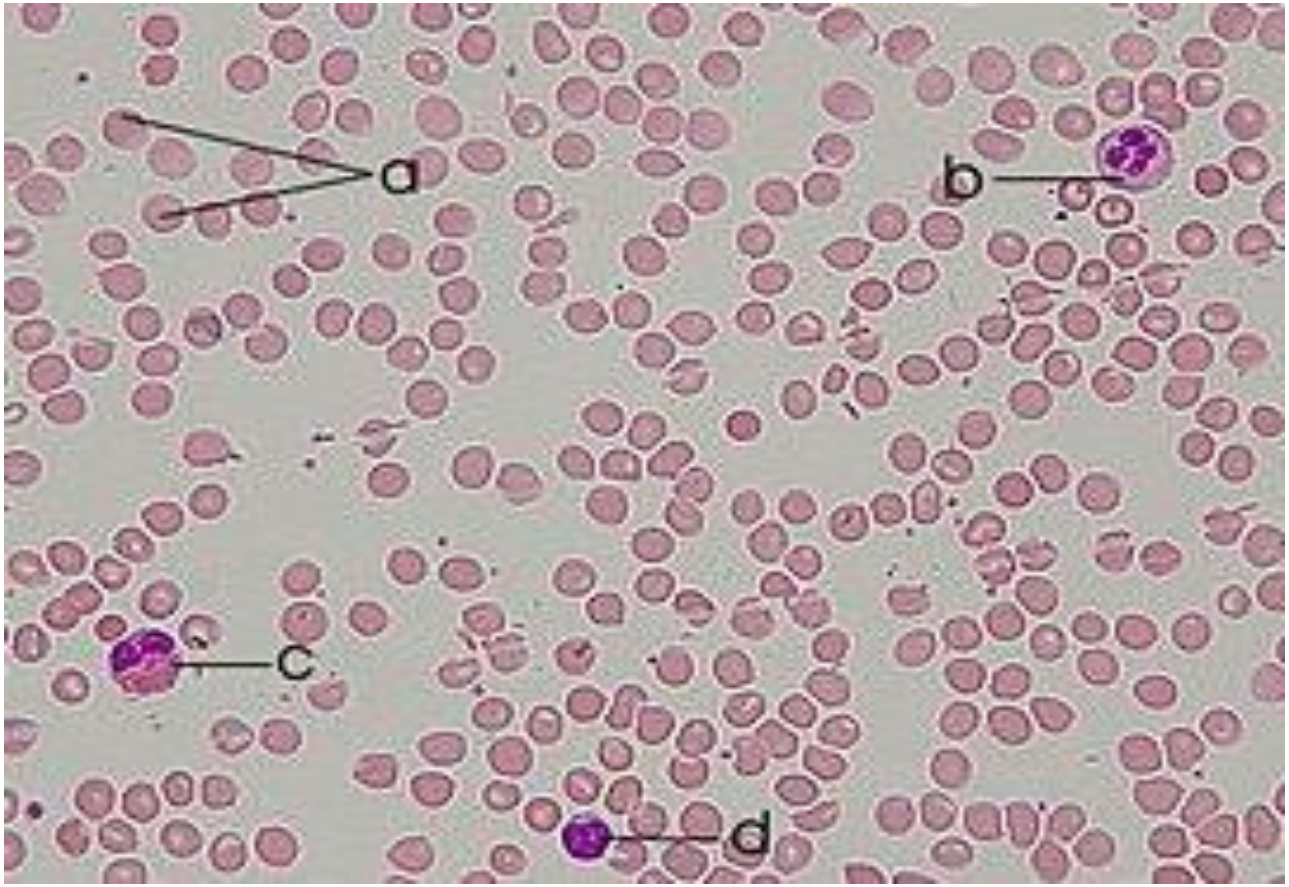
Three categories of blood cells:

1. **Red blood cells**
2. **White blood cells**
3. **Platelets**

- give a total of **45%** of the blood volume.
- Also called **hematocrit*** or **Packed Cell Volume** (PCV) determined by **centrifugation** or **flow cytometry**.

Red blood cells (erythrocytes).

- Lifespan -**120** days.
- Removed by **macrophages** of the **Reticuloendothelial system**.
- Mature red cells - **no** nucleus, ribosomes or mitochondria.
- RBC contains about **65%** water and **33%** Haemoglobin.
- Normal count: ***4.7*** *-* ***6.1*** *million* (male), ***4.2 - 5.4*** *million (female) RBC/ µL.*



Human blood smear:
a – erythrocytes; b – neutrophil;
c – eosinophil; d – lymphocyte (b,c,and d are white blood cells).

Thin Blood film

White blood cells.

- Cells of the **immune system.**
- Defend the body against both infectious diseases and foreign materials.
- **Five** different and diverse types.

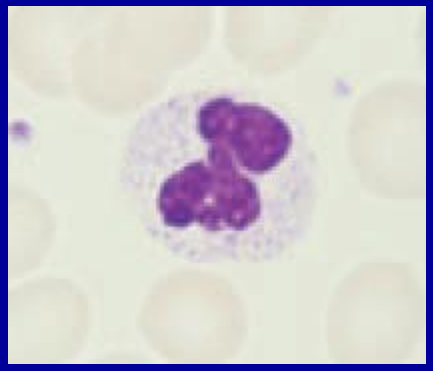
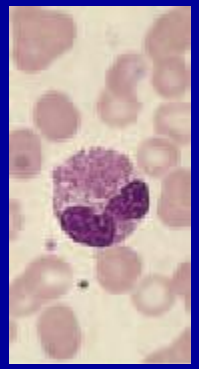
- Lifespan of average **13 to 20** days in the human body.
- Found **throughout** the body, **blood** and **lymphatic** system.
- Normal count: **4,000–11,000** WBC/μL.

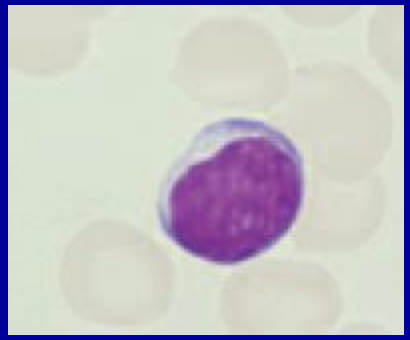
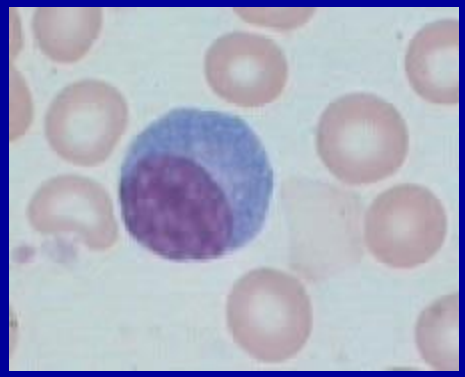
Types of white blood cells.

1. Neutrophils
2. Monocytes/macrophages
3. Basophils
4. Eosinophils
5. Lymphocytes

- Neutrophils, eosinophils, basophils and monocytes/macrophages –**phagocytes** (ingest and destroy **pathogens** , old red blood cells, **abnormal red blood cells**, **cellular debris**).

Top (L-R): Neutrophil, Eosinophil, Basophil, Monocyte
Bottom(L-R): Lymphocyte, Plasma cell.

Neutrophils

- Also called **polymorphs.**
- **Most** numerous peripheral blood WBC
- Concentration may be **lower** in certain races like **black** and **middle eastern** races.

Eosinophils.

- Similar kinetics of production, differentiation to neutrophils.
- Important in response to **parasites** and **allergic** diseases**.**
- Have granules containing **histamine**.

Basophils.

- Closely related to **mast** cells*
- Found ***least*** among peripheral blood WBC
- Granules with **histamine** and **heparin**
- Important in **hypersensitivity** reactions

Monocytes.

- Circulate for **20-40** days
- Enter tissues as **macrophages**
- Principle function-**phagocytosis** and **destruction.**
- Survive many **days –months** in tissue
- Have cytoplasmic projections (communicate).

Lymphocytes.

- Essential component of the **immune response.**
- **Types:**

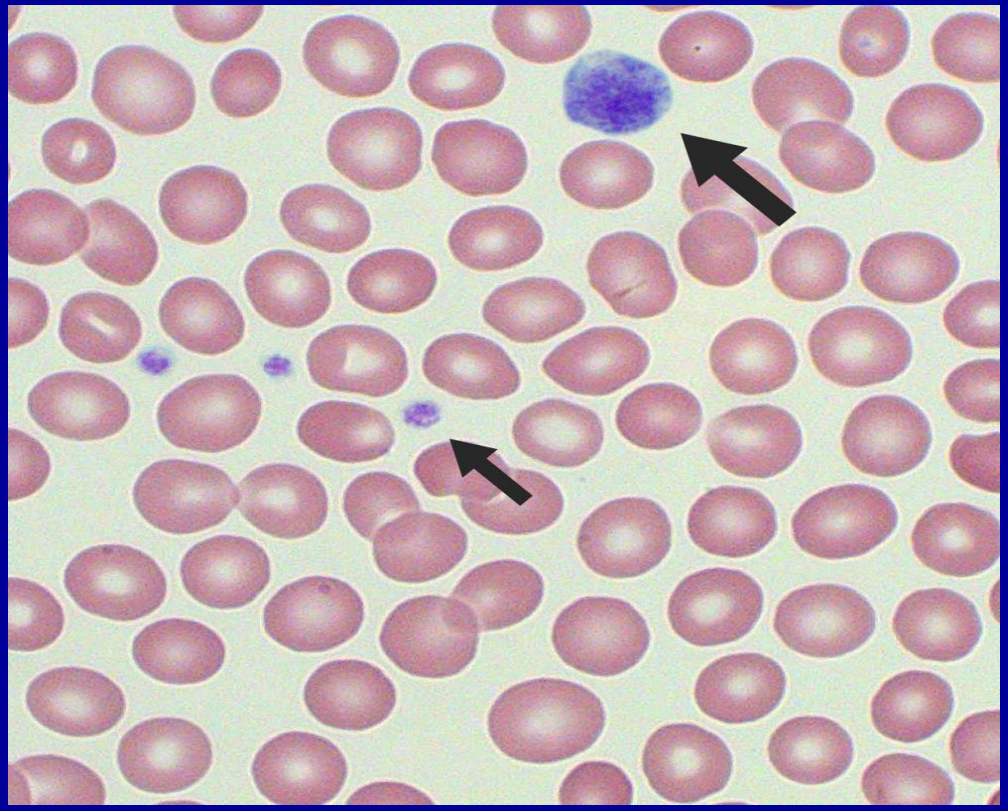
a) **B-lymphocytes**

b) **T-lymphocytes**

- **70%** of lymphocytes in peripheral circulation are **T-lymphocytes**.
- T-cells mature in ***thymus***, B-cells in ***bone marrow***
- T-cells (T-helper-**CD4**, **suppressor**, cytotoxic-**CD8**, **Natural Killer** cells (NK))

Platelets (Thrombocytes).

- Very small, irregularly shaped clear ***cell fragments***,
- Have ***no*** nucleus.
- Average lifespan normally just **5 - 9** days.
- Natural source of **Growth factors***.
- Circulate in the blood, involved in **hemostasis** (clotting system), leading to the formation of **blood clots**.
- Normal count: **200,000-500.000**pl**/µL**.



Methods of collecting blood from a patient.

- Two sources of blood for **haematological examinations:**

1. **Capillary**.
2. **Venous blood**.

- **Capillary blood** more likely **arteriolar** than capillary.
- **Better** site to obtain blood for haematological examination-**vein (venous blood)**.

Sites for collecting Capillary blood:

1. Ear lobe.
2. Palmar surfaces of the tip of the finger,
3. Plantar surfaces of the **big toe** and the **heel**-infants.

Position of obtaining venous blood.

- **Venipuncture**

1. Best to have the patient **lying down**.
2. If sitting the arm should be **firmly** supported.

Venous blood.

Veins used in two ways:

I. A **source of blood** for the many and constantly rising number of blood tests.

II. As an **avenue** for introduction of various **therapeutic agents**, including **blood** itself.

Handling blood for haematological examinations.

- Blood obtained by **venipuncture** collected in bottles or tubes containing a suitable **anticoagulant.**
- Transfer to laboratory **without** delay.
- If no anticoagulant, **blood smear** prepared immediately before clotting occurs.

Anticoagulants.

- The five commonly used:

i. Ammonium - potassium oxalate.

ii. Trisodium citrate.

iii. Ethylene Diamine Tetra acetic Acid (EDTA).

iv. Heparin.

v. Sodium fluoride

Examples of Haematological tests.

a) Haemoglobin concentration
b) Hematocrit.
c) Full Blood count.
d) Blood grouping

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