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BLOOD AND OTHER BODY FLUIDS

INTRODUCTION

- **Blood is a body fluid with the following functions:**
  - ***Carrying nutrients*** **made available by the digestive tract, to body tissues;**
  - ***Carrying oxygen*** **from the lungs to the tissues;**
  - ***Carrying carbon dioxide*** **from tissues to the lungs;**
  - ***Carrying waste products*** **from various tissues to the kidneys for excretion;**

INTRODUCTION

- **Blood is a body fluid with the following functions:**
  - **Carrying *hormones* from endocrine glands to other organs of the body for action;**
  - ***Temperature control*****, by transporting heat from deeper structures to the surface of the body;**
  - ***Water balance*** **is maintained partly by the blood;**

INTRODUCTION

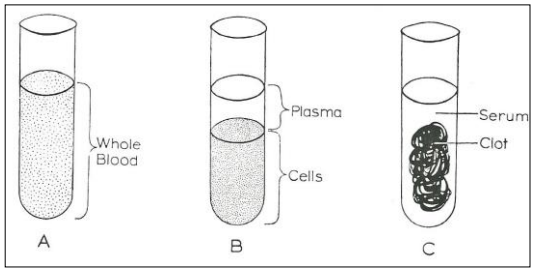
- **Blood is a body fluid with the following functions:**
  - ***Buffers,* for example, the bicarbonate buffer in the blood, help maintain a constant pH of tissues and body fluids;**
  - **Ability *to clot* in case of injury, to prevent excess loss of blood;**
  - **Contains important *factors for defence* of the body against disease.**

COMPOSITION

- **Blood consists of two main parts, namely,**
  - **the formed elements and**
  - **fluid (plasma).**
  - **The formed elements include**
    - **red blood cells (RBC),**
    - **white blood cells (WBC), and**
    - **blood platelets.**

In the mammals, the RBC and platelets lack nuclei, these are therefore not typical cells.

Blood



THE FORMED ELEMENTS

- ***Red Blood Cells (erythrocytes)***
- **The RBC average 7.5µm in diameter and specialize in *oxygen transportation*.**
- **They are *biconcave discs*, having a thick 1.5µ circular margin, and a thin centre.**

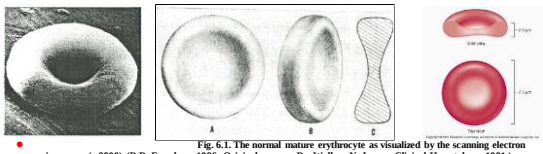
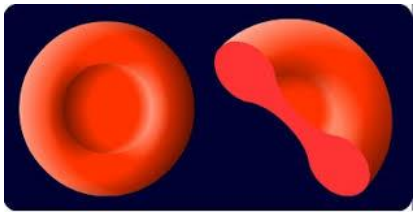
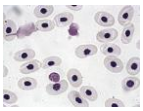
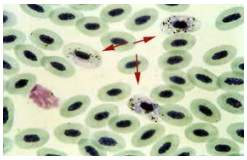
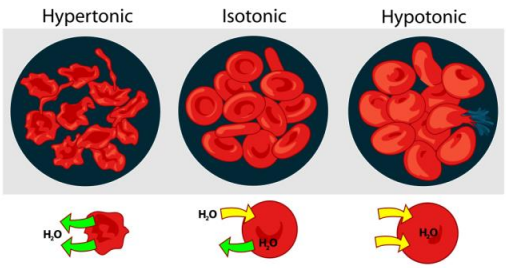


Fig. 6.1. The normal mature erythrocyte as visualized by the scanning electron microscope (x 9800). (R.D. Frandson, 1986. Original source: Dr. Wallace N. Jensen, Clinical Hematology, 1981.)

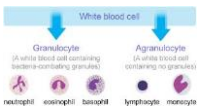


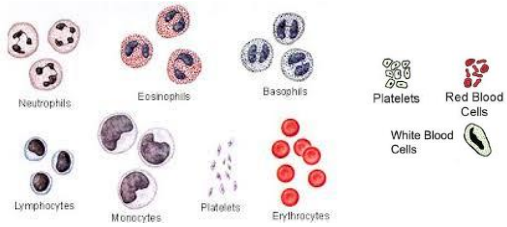


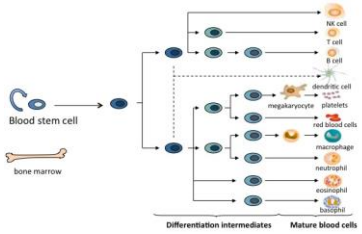



Hypertonic
Isotonic
Hypotonic
H2O
H2O
H2O
H2O


HALT
POLICE
POLICE
White Blood Cell


White blood cell
Granulocyte
Agranulocyte
neutrophil
eosinophil
basophil
lymphocyte
monocyte





Blood Colour

The red color of blood is due to the substance called *haemoglobin (Hb)*

- **which enables the *transportation of oxygen*.**
- **Chemically, Hb is a *complex organic compound* composed of *four red* porphyrin pigments (hemes),**
- **Each of which contains an *atom of iron (Fe)* and**
- ***globin*, which is a *globular protein* consisting of *four amino acid chains*.**

Blood

The presence of Fe in the ferric state (Fe^{2+}) is essential for oxygenation.

Haemoglobin (Hb) combines with oxygen (O_2) to form oxyhaemoglobin (HbO_2),

but this is a very loose bond and

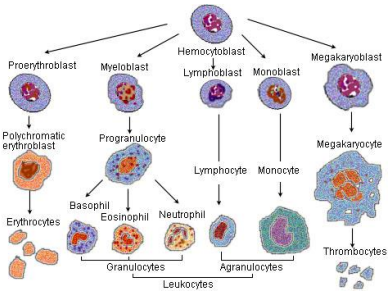
oxygen is readily given up to tissue cells within the body.

Blood - RBC

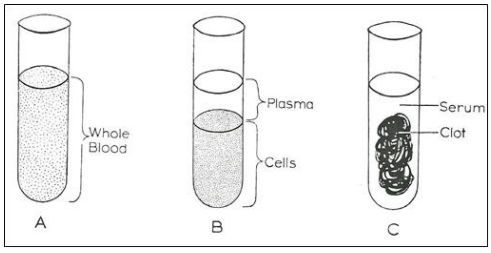
Because of the presence of Hb, blood can carry up to about *60 times* as much *oxygen* as the quantity of *hydrogen* under similar conditions.

During oxygenation, the *combined oxygen* is *proportional* to the *amount of Fe* present, with *two atoms of O2* combined with each atom of Fe.

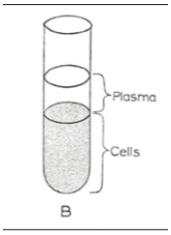
When the blood reaches *tissues deficient in* oxygen, the *loosely held oxygen* of the haemoglobin is *readily given up*.



Blood Plasma



Blood Plasma



- 92% water and 8% other substances (
- include **proteins** [major portion],
- **glucose, lipids, amino acids**,
- **hormones**, inorganic mineral salts such as **NaCl**,
- **waste products** such as **urea, uric acid,** and **creatine**.

Functions of Plasma

- *Carrier function*: plasma substances that are **insoluble in water** are solubilized eg. iron, thyroxine, insulin-like growth factor (IGF), hormones.

- *Immunity function*: eg. **gamma gobulin fraction** of the plasma proteins
  - increases after vaccination and during recovery from diseases

Functions of Plasma

- provides the *immune response*, i.e. **antibodies** to react with **antigens** such as bacteria or foreign proteins,
  - to either **neutralize** the antigen or to help to **break it down**.
- *Buffering function*: plasma proteins prevent excessive changes in blood pH
  - by either **accepting** or **donating hydrogen ions** to the plasma.

Functions of Plasma

- *Maintenance of osmotic pressure*:
  - **Large** molecular-weight proteins **(colloids)** and
  - **small** molecular-weight proteins

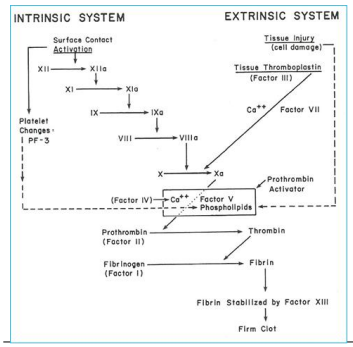
Blood clotting (coagulation)

Occurs in blood that is drawn out of vessels and **allowed to stand** forms;
initially, a **solid red mass**
If it stands **longer**, the clot **contracts**, expressing out a supernatant yellow fluid called **serum.**

Therefore, **serum = plasma - fibrinogen** and most **clotting factors**; or
serum is **defibrinated plasma**.

The **clot** consists of filaments of **fibrin that enmesh red blood cells, white blood cells and platelets**.

Mechanism of Blood Clotting



Clotting begins **15 seconds to 2 minutes** after injury,

complete in about **5 minutes**

process of coagulation involves **actions and interactions** of various substances known as **factors (I – XIII).**

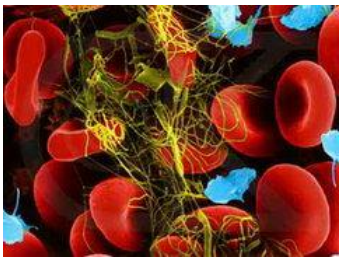
Clotting Process

- **Fibrin** is a substance that forms a loose clot;
- but fibrin cannot be present in its **active form** in the circulating blood.
- its precursor, **fibrinogen** (**Factor I**, synthesized in the liver) is present in plasma as a **soluble protein**.
- Fibrinogen is **converted to fibrin** by the action of an enzyme called **thrombin.**

Clotting Process

- Thrombin also cannot be present in circulating blood in its active form or else coagulation would occur. It, too, has a precursor called **prothrombin** (factor II, formed by the liver in the presence of vitamin K). This factor is an α_2-globulin.
- Prothrombin is acted upon by a complex called **prothrombin activator**
- this splits off the enzyme **thrombin** from **prothrombin**

Clot Formation



Blood cells in mesh of fibrin

Clotting Factors –

Some work to increase the **activity level** of the other factors

Other factors help **set off the chemical cascade** which leads to the development of **fibrin.**

Common List of Clotting Factors

- Factor I (fibrinogen)
- Factor II (prothrombin)
- Factor III (thromboplastin)
- Factor IV (calcium)
- Factor V (labile factor)
- Factor VII (stable factor)
- Factor VIII (Antihaemophilic factor A)
- Factor IX (Christmas factor); antihaemophilic factor B
- Factor X (Stuart-prower factor)
- Factor XI (Antihaemophilic factor C)
- Factor XII (Hageman factor)
- Factor XIII (Fibrin stabilizing factor)

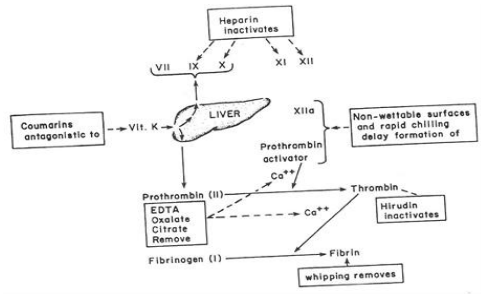
List of Clotting Factors

antithrombin	antithrombin III, antithrombin III, COAGULATION inhibitor, AT-III	regulates thrombin, factor IX, factor X, factor XI, and factor XII to inhibit the coagulation cascade
factor I	fibrinogen	forms fibrin clot after activation by thrombin in the final common pathway
factor II	prothrombin	together with factor Xa prothrombinase converts prothrombin into active thrombin, which in turn helps PLATELET AGGREGATION
factor III	tissue factor	initiates extrinsic coagulation cascade following vascular injury cofactor with factors VII, VIII, and IX in activating factor X cofactor in activation of factor VII
factor IV	calcium	required at several points in the coagulation cascade
factor V	proaccelerin or accelerator globulin	necessary to stop coagulation cascade at the end
factor VI	accelerin, factor Va	activated form of factor V together with factor X converts prothrombin to thrombin in the final common pathway
factor VII	serum prothrombin conversion accelerator (SPCA) or cothromboplastin	activates factor X when calcium and factor III (tissue factor) are present
factor VIII	antihemophilic factor A	activates platelet aggregation and adhesion cofactor with factor IX in activating factor X
factor IX	Christmas factor, antihemophilic factor B, or plasma thromboplastin component (PTC)	cofactor with factor VIII in activating factor X (vitamin K-dependent)
factor X	Stuart factor or Stuart-Prower factor	activated by complex of tenase (factors VII and IX), factor VII, and calcium to enable platelet aggregation Initiates conversion of factor II (prothrombin) to thrombin

List of Clotting Factors

factor XI	plasma thromboplastin antecedent (PTA)	in the intrinsic pathway, activates factor IX when calcium is present
factor XII	Hageman factor	activates factor XI, thereby starting the intrinsic pathway binds to exposed collagen at site of intravascular injury
factor XIII	fibrin stabilizing factor (FSF), fibrinoligase, fibrinase, plasma transglutaminase, Laki-Lorand factor, LL factor, LLF, or protransglutaminase	cross-links and stabilizes fibrin clot after activation by thrombin needs calcium as cofactor
high molecular weight kininogen (HMWK)	contact activation factor, Fitzgerald factor, Flaujeac factor, Williams-Fitzgerald-Flaujeac factor, or Williams factor	activates factor XII early in the intrinsic pathway
prekallikrein	Fletcher factor or prokallikrein	activates factor XII at very beginning of the intrinsic pathway
protein C	anticoagulant protein C	limits functions of factor V and factor VIII with cofactor protein S, inhibits thrombin to block fibrin clot formation
protein S	anticoagulant cofactor protein S	limits functions of factor V and factor VIII as cofactor for protein C, inhibits thrombin to block fibrin clot formation
thrombomodulin	fetomodulin	cell surface receptor that binds excess thrombin, thus inhibiting dangerous clot formation

Anti-Coagulants



Other Body Fluids

- **Lymph**
  - ✓Is a clear colourless liquid carried by the lymph vessels in the tissue spaces.
  - ✓It is derived from blood plasma
  - ✓Contains a few RBC and numerous lymphocytes
  - ✓inorganic salts, glucose,
  - ✓non-protein nitrogen (NPN) substances, and
  - ✓Some proteins.

Other Body Fluids – Integral Body Fluids, excludes functional fluids like milk, saliva, follicular fluid, testicular fluid, ocular fluids, digestive fluids *etc*.

Lymph

- If derived from the **intestine** during **digestion**
- may contain large quantities of **lipids** (resulting from the absorption of lipids into **lacteals** – the small lymphatics of the intestine).
- Eventually, lymph is **returned** to circulation **via large veins** cranial to the heart.

Cerebrospinal Fluid

- Formed in the **ventricles** of the **brain**.
- Circulates throughout the **subarachnoid space**,
- between the **pia mater** and **arachnoid membrane**.
- Resembles blood plasma but has **less protein, glucose and K^+ ions**,
- and few (if any) cells except lymphocytes.
- Serves as a **protective cushion** and **nutritive medium** for the brain and spinal cord.

Synovial Fluid

- This is a thick liquid found in the bone joint cavities.
- Its function is to
  - ❖**reduce friction** in the joints, and to
  - ❖**nourish** the articular cartilage.

Serous Fluids

- Are fluids found in body cavities
- Include;
  - **peritoneal** fluid,
  - **pleural** fluid, and
  - **pericardial** fluid.

- They are present as a thin film that **reduces friction** between **opposed tissue surfaces**.