WELCOME
University of Baghdad
College of Nursing
Department of Basic Medical Sciences

Overview of
Anatomy and Physiology – II
Second Year Students

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Electrolyte and Mineral Physiology
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2012 - 2013
Brief Contents
1- Cardiovascular System
2- Blood
3- Lymphatic System
4- Urinary System
5- Male Reproductive System
6- Female Reproductive System
7- Sensory Function

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Text book

References:
BLOOD
Contents:
BLOOD

1- Overview of the blood.
2. Functions of the Blood.
3. Plasma
5. Leukocytes (White Blood Cells).
6. Platelets (Thrombocytes).
7. Hemopiesis (Hematopoiesis).

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FIFTH LECTURE
Blood

1- Overview of the blood.
2. Functions of the Blood.
3. Plasma
5. Leukocytes (White Blood Cells).

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OVERVIEW OF BLOOD

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**COMPOSITION OF BLOOD** 624

*BLOOD* is a fluid connective tissue composed of:

1- Plasma 55%
2- Formed elements 45%

   a- Erythrocytes (Red Blood Cells) 44%
   b- Leukocytes (White Blood Cells) < 1%
   c- Platelets < 1%

**NOTE:**

*Serum: plasma without fibrinogen and clotting factors*

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FIGURE 14-1
Measurement of the hematocrit—the percentage of blood volume that is erythrocytes—by centrifugation. The presence of a thin layer of leukocytes and platelets between the plasma and red cells explains why, in this example, the value for plasma determined by centrifugation should actually be slightly less than 55 percent.
FUNCTIONS OF BLOOD

Functions of the blood 624

1- Transportation: O2, CO2, nutrients, waste, hormones, heat ...

2- Regulation: pH (7.35-7.45), ions (electrolyte), fluids, temperature (38°C, or 98.6°F)...

3- Protection: by WBCs, Antibodies, platelets ...

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CONTENTS:

2. Plasma
### Composition and Functions of Plasma Constituents

<table>
<thead>
<tr>
<th>Plasma component</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1- Water</strong> 92%</td>
<td>Solvent</td>
</tr>
<tr>
<td><strong>2- Plasma proteins 7%</strong></td>
<td>Blood osmotic pressure, Transport fatty acid, hormones.</td>
</tr>
<tr>
<td>a- Albumin 58%</td>
<td></td>
</tr>
<tr>
<td>b- Globulins 37%</td>
<td>Alpha, transp. Lipid and metal ions.</td>
</tr>
<tr>
<td>c- Fibrinogen 4%</td>
<td>Beta, transp. Lipid and iron</td>
</tr>
<tr>
<td>d- Regulatory protein &lt; 1%</td>
<td>Gamma, synthesis antibody</td>
</tr>
<tr>
<td></td>
<td>Help with blood clotting</td>
</tr>
<tr>
<td></td>
<td>Consist of enzymes, proenzymes, And hormones</td>
</tr>
<tr>
<td>Plasma component</td>
<td>Functions</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3- Other solutes</td>
<td></td>
</tr>
<tr>
<td>a- Electrolytes</td>
<td>Maintaining:</td>
</tr>
<tr>
<td></td>
<td>a- membrane potential</td>
</tr>
<tr>
<td></td>
<td>b- cell oxygenation</td>
</tr>
<tr>
<td></td>
<td>c- acid-base balance</td>
</tr>
<tr>
<td></td>
<td>d- urine formation</td>
</tr>
<tr>
<td></td>
<td>e- regulation of osmosis</td>
</tr>
<tr>
<td></td>
<td>f- regulate exocrine secretion</td>
</tr>
<tr>
<td></td>
<td>g- redox potential</td>
</tr>
<tr>
<td>b- Nutrients</td>
<td>Energy source.</td>
</tr>
<tr>
<td>c- Respiratory gases</td>
<td>Oxygen and carbon dioxide.</td>
</tr>
<tr>
<td>d- Wastes, creatinine,</td>
<td>Removed by kidney and liver</td>
</tr>
<tr>
<td>lactic acid, urea,</td>
<td></td>
</tr>
<tr>
<td>ammonia, bilirubin.</td>
<td></td>
</tr>
</tbody>
</table>
CONTENTS: (FORMED ELEMENTS)

3. Red Blood Cells
   “Erythrocytes”

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**ERYTHROCYTE STRUCTURE**

Figure 21.4

*Erythrocyte Structure.* (a) Erythrocytes have the gross structure of a biconcave disc, as shown here in sectional and superior views. (b) SEM of erythrocytes shows their three-dimensional structure and rouleaux.
Strawberries can Increase the Quality of Red Blood Cells in the Body
1- RBCs form 99.9% of the formed elements, and contain hemoglobin (red pigment).

2- RBCs has no nucleus, with biconcave disc, thin central and thick outer margin.

**Why RBC are biconcave**

a- to give RBC large ratio of surface area

b- help to form stack

c- help to move through narrow blood vessels

d- help RBC to flex

3- RBCs lost most of their organelles and nuclei during differentiation period in bone marrow.
4- RBCs maintain energy by anaerobic oxidation of glucose (without mitochondria).
5- Abundance of RBCs are:
   a- in males 5.4 million / mm³ (µl- microliter)
   b- in females 4.8 million / mm³ (µl)
6- Blood of an average adult has about “25” trillion RBCs, which is about one third of all human body cells “75 trillion”.
7- Single drop of whole blood contains about 260 million RBCs.
1- Hb is a protein composed from “4” globular subunits.
2- Each globular subunit bound to a heme molecule, gives RBCs the ability to transport oxygen.
3- Heme is a porphyrin ring containing a central “iron” atom.
4- Hb account in each RBC more than 95% of intracellular proteins.
5- Normal range Hb in males 14-18 gm/dl (100ml).
6- Normal range Hb in females 12-16gm/dl(100ml)
Each Hemoglobin Molecule Composed From:
1- Two alpha globulins chains.
2- Two beta globulins chains.
3- Each globulin chain contain “heme” the blood pigment.
4- Each heme hold an iron ion to interact with oxygen “O2” forming oxyhemoglobin “HbO2”.

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**FIGURE 19-3 The Structure of Hemoglobin.**
Hemoglobin consists of four globular protein subunits. Each subunit contains a single molecule of heme, a ring surrounding a single ion of iron.
STRUCTURE OF HEMOGLOBIN
1- In each RBC there are 280 million Hb molecules.
2- Each Hb molecule contain “4” heme.
3- Each RBC can carry more than billion molecules of “O2”.
4- 98.5% of “O2” carry by the blood bound to Hb inside the RBC.
5- Every system is affected as organ function deteriorates owing to “O2” starvation.
TYPES OF HEMOGLOBIN (Hb)

**Adult Normal Types:**
1- HbA : 2 alpha and 2 beta chains = 97%
2- HbA2: 2 alpha and 2 delta chains = 2%
3- HbF : 2 alpha and 2 gamma chains = 1%

**Fetal Normal Type:**
1- HbF : 2 alpha and 2 gamma chains = 100%

**Adult Abnormal Types:**
1- HbS : 2 alpha and 2 “S” Chains. This type of Hb found in patient with Sickle Cell Anemia.
2- HbF: in 98% (inadequate alpha or beta chains) this type called Thalassemic Anemia.
**BLOOD TYPES**

**BLOOD TYPES: ABO- Rh**

*Percentage*

1- Type A: 40 %
2- Type B: 10 %
3- Type AB: 4 %
4- Type O: 46 %

5- Type Rh + 85 %
6- Type Rh - 15 %
**ABO TYPES:**
1- Type A: antigen(Ag) A + antibody(Ab) B
2- Type B: Ag - B + Ab – A
3- Type AB: Ag- A + Ag- B and (( No Ab ))
4- Type O : ((No Ag)) and Ab A+ Ab B

**Rh Types:**
1- Type Rh Positive : Ag- D ( and no Ab )
2- Type Rh Negative: Ab- D ( and no Ag-D )
The ABO blood types

- **Type A**: A antigens in red blood cells, B antibodies in plasma
- **Type B**: B antigens in red blood cells, A antibodies in plasma
- **Type AB**: A and B antigens in red blood cells, neither A nor B antibodies in plasma
- **Type O**: Neither A nor B antigens in red blood cells, A and B antibodies in plasma
Slide prepared for ABO blood typing.
Red Blood Cell Turnover

*FIGURE 19-5 Red Blood Cell Turnover.* The normal pathways for recycling amino acids and iron from aging or damaged RBCs broken down by macrophages. The amino acids are absorbed, especially by developing cells in bone marrow. The iron is stored in many sites. The rings of the heme units are converted to bilirubin, absorbed by the liver, and excreted in bile or urine; some of the breakdown products produced in the large intestine are recirculated.
RECYCLING THE COMPONENTS OF AGED OR DAMAGE ERYTHROCYTE

Figure 21.6
Recycling the Components of Aged or Damaged Erythrocytes. Erythrocytes have an average life span of about 120 days. Their molecular components are then broken down and recycled or eliminated from the body.

1. Erythrocytes form in red bone marrow.
2. Erythrocytes circulate in bloodstream for 120 days.
3. Aged erythrocytes are phagocytized in the liver and spleen.
4. Heme components of blood are recycled.
5. Membrane proteins and globin proteins are broken down into amino acids, some of which are used to make new erythrocytes.

Heme

Heme is converted into biliverdin and then to bilirubin, which is secreted in bile from the liver.

Iron

Iron is transported in the blood by the protein transferrin and stored by the protein ferritin in the liver.

Liver
Spleen
RBCs TURNOVER AND JAUNDICE

Jaundice (icterus); is yellowness of skin, sclerae, mucous membrane and excretion due to bilirubinemia (accumulation of bilirubin in blood) and deposition of bile pigments specially in the brain. Normally Hepatocyte absorb bilirubin from the blood and secrete it with bile secretion. **Jaundice is a symptom of:**

1. Diseases and disorders of the liver, e.g. viral hepatitis, tumor and drugs.
2. Diseases and disorders of gallbladder, e.g. gallstone, cancer of bile duct and pancreas.
3. Hemolytic blood disorders, e.g. leptospirosis, cancer, leukemia, erythroblastosis fetalis.

Normal adult total serum bilirubin is “0.3 – 1.1 mg/dl“

Neonatal total serum bilirubin “6-8 and 10-12 mg/dl-preterm

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JAUNDICE

Types (form) of Jaundice

1- Prehepatic jaundice
2- Intrahepatic jaundice
3- posthepatic jaundice
A. Types of Jaundice

Blood

Hemoglobin etc. → Bilirubin → Production → Uptake → Conjugation → Secretion → Outflow = Cholestasis

Liver

Hemolysis etc.

Conjugated bilirubin

Gall stones, tumors, etc.

Jaundice:

Pre-hepatic

Intrahepatic

Post-hepatic

- Specific syndromes (Gilbert, Crigler-Najjar, Dubin-Johnson, Rotor)
- Acute and chronic liver damage
- Drug side effects
- Estrogens, cystic fibrosis, etc.
ERYTHROCYTES DISORDERS

1- Anemia
2- Polycythemia
3- Jaundice
SICKLE SHAPED ERYTHROCYTE

Sickle-shaped erythrocyte

SEM 400x
4. WHITE Blood Cells
   “Leukocytes”
OVERVIEW OF LEUKOCYTES

1- 5,000 to 10,000 WBCs/ul
2- Conspicuous nucleus
3- Travel in blood and then migrating to connective and lymphatic tissues
4- Protact against pathogen
Figure 33-2

Movement of neutrophils by *diapedesis* through capillary pores and by *chemotaxis* toward an area of tissue damage.
Overview of the cells and mediators involved in a local acute inflammatory response
**LEUKOCYTES (WHITE BLOOD CELLS) 637-642**

“migrated cells to connective tissues”

<table>
<thead>
<tr>
<th>Types of leukocyte</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I- Granulocytes</td>
<td></td>
</tr>
<tr>
<td>1- Neutrophils</td>
<td><em>Phagocytize pathogen</em> (bacteria), Release enzyme and chemical.</td>
</tr>
<tr>
<td>2.3 % survival</td>
<td></td>
</tr>
<tr>
<td>2- Eosinophils</td>
<td>phagocytize allergens, Ag-Ab complex, destroy parasitic worms, release chemical.</td>
</tr>
<tr>
<td>2.3 % survival</td>
<td></td>
</tr>
<tr>
<td>3- Basophils</td>
<td>Release histamine (vasodilator) and heparin (anticoagulant) during inflammatory or allergic reactions (response).</td>
</tr>
<tr>
<td>0.4 % survival</td>
<td></td>
</tr>
</tbody>
</table>
### Types of Leukocyte

<table>
<thead>
<tr>
<th>Types of Leukocyte</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>II - Agranulocytes</td>
<td></td>
</tr>
<tr>
<td>1- Lymphocytes 30%</td>
<td>Attack pathogens and abnormal infected cells, coordinate immune cell activity, and produced antibody.</td>
</tr>
<tr>
<td></td>
<td>survive for months to decades</td>
</tr>
<tr>
<td>2- Monocytes 5.3%</td>
<td>Exit blood vessels and become macrophages, phagocytize pathogens, cellular debris, and dead leukocytes.</td>
</tr>
<tr>
<td></td>
<td>survive for months or longer</td>
</tr>
</tbody>
</table>

*Formed Elements in the Blood: Leukocytes (White Blood Cells)*
White Blood Cells: Function

Neutrophils:
- Engulf bacteria and cellular debris

Lymphocytes:
- Produce antibodies and regulate immune response

Monocytes:
- Associated with engulfing cellular debris, antigen processing

Eosinophils:
- Associated with parasitic infection and allergic response

Basophils:
- Associated with hypersensitivity and release histamine
FIGURE 9-4 Phagocytosis of a particle (e.g., bacterium): opsonization, attachment, engulfment, and intracellular killing.
LEUCOCYTES

- Neutrophil
- Eosinophil
- Basophil
- Lymphocyte
- Monocyte
- Granulocytes
- Agranulocytes
Granulocytes: Neutrophil
Granulocytes: Eosinophil
Granulocytes: Basophil
Agranulocyte: Lymphocyte
Agranulocyte: Monocyte
Mediators of antimicrobial and cytotoxic activity of macrophages and neutrophils (inflammatory mediators)

I- Oxygen-dependent killing
   1- Reactive oxygen intermediates
      O$_2^-$ (superoxide anion)
      OH• (hydroxyl radicals)
      H$_2$O$_2$ (hydrogen peroxide)
      ClO$^-$ (hypochlorite anion)
   2- Reactive nitrogen intermediates
      NO (nitric oxide)
      NO$_2$ (nitrogen dioxide)
      HNO$_2$ (nitrous acid)
   3- Others: NH$_2$C (monochloramine)

II- Oxygen-independent killing
   1- Defensins
   2- Tumor necrosis factor (macrophage only)
   3- Lysozyme
   4- Hydrolytic enzymes
Other factors secreted by activated macrophages (inflammatory mediators)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interleukin 1 (IL-1)</td>
<td>Promotes <em>inflammatory responses</em> and fever</td>
</tr>
<tr>
<td>Interleukin 6 (IL-6) and TNF-α</td>
<td>Promote innate immunity and elimination of pathogens</td>
</tr>
<tr>
<td>Complement proteins</td>
<td>Promote <em>inflammatory response</em></td>
</tr>
<tr>
<td>Hydrolytic enzymes</td>
<td>Promote <em>inflammatory response</em></td>
</tr>
<tr>
<td>Interferon alpha (IFN-α)</td>
<td><em>Activates cellular genes</em>, resulting in the production of proteins that confer an antiviral state on the cell</td>
</tr>
<tr>
<td>Tumor necrosis factor (TNF-α)</td>
<td><em>Kills tumor cells</em></td>
</tr>
<tr>
<td>GM-CSF</td>
<td>Promote inducible hematopoiesis</td>
</tr>
<tr>
<td>G-CSF</td>
<td>Promote inducible hematopoiesis</td>
</tr>
<tr>
<td>M-CSF</td>
<td>Promote inducible hematopoiesis</td>
</tr>
</tbody>
</table>
## TYPES OF CIRCULATING *LYMPHOCYTES*

<table>
<thead>
<tr>
<th>Types</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- B- Lymphocytes (B-Cell)</td>
<td>Differentiate into plasma cells, and secrete <strong>Antibody</strong> called Humoral antibody.</td>
</tr>
<tr>
<td>2- T- Lymphocytes (T-Cell)</td>
<td></td>
</tr>
<tr>
<td>a- Helper T- cells</td>
<td></td>
</tr>
<tr>
<td>b- Cytotoxic T- cells</td>
<td></td>
</tr>
<tr>
<td>c- Suppressor T- cells</td>
<td></td>
</tr>
<tr>
<td>d- Memory T- cells</td>
<td></td>
</tr>
<tr>
<td>3- Natural killer (NK)</td>
<td></td>
</tr>
</tbody>
</table>
CIRCULATING LYMPHOCYTES

Circulating lymphocytes are continuously migrate from the bloodstream, through peripheral tissues, and back to the bloodstream. Circulating lymphocytes represent only a minute fraction of all lymphocytes, for at any moment most of the body lymphocytes are in other connective tissues and in organs of the lymphatic system. Lymphocytes survive for months to decades. Produced in bone marrow and lymphoid tissues.

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Lymphocyte recirculation routes

- Blood lymphocyte pool (30 min)
  - Efferent lymph (52%)
  - Afferent lymph (10%)
- Lymph nodes (12 h)
- Spleen (5 h)
  - (45%)
  - (42%)
- Naive lymphocytes
- Activated lymphocytes
- Tertiary extralymphoid tissue:
  - Mucosal epithelia in gut,
  - Lungs, and genitourinary tracts
  - Liver
  - Brain
  - Skin
- Nonrecirculating cells (?)
- Bone marrow
- Epithelial surface
- Peritoneum
Full blood count (FBC) Called Complete Blood Count (CBC) in the USA.

Main parameters measured
1. Hb concentration.
2. Red cell count (RCC).
3. MCV. (mean corpuscular volume)
4. MCH. (mean corpuscular hemoglobin)
5. MCHC. (mean corpuscular hemoglobin concentration)
6. Haematocrit (Hct) or PCV. (packed cells volume)
7. Red cell distribution width (RDW).
8. White cell count.
9. WBC differential.
## COMPLETE BLOOD COUNT

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red blood cells</td>
<td>4.5–6.0 million/µL</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>12–18 grams/100 mL</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>38%–48%</td>
</tr>
<tr>
<td>Reticulocytes</td>
<td>0%–1.5%</td>
</tr>
<tr>
<td>White blood cells (total)</td>
<td>5000–10,000/µL</td>
</tr>
<tr>
<td>Neutrophils</td>
<td>55%–70%</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>1%–3%</td>
</tr>
<tr>
<td>Basophils</td>
<td>0.5%–1%</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>20%–35%</td>
</tr>
<tr>
<td>Monocytes</td>
<td>3%–8%</td>
</tr>
<tr>
<td>Platelets</td>
<td>150,000–300,000/µL</td>
</tr>
</tbody>
</table>

*The values on hospital lab slips may vary somewhat but will be very similar to the normal ranges given here.*
LEUKOCYTES DISORDERS

1- Leukopenia
2- Leukocytosis
3- Leukemia
LEUKEMIA

(a) Normal bone marrow sample

(b) Bone marrow sample in ALL (acute lymphoblastic leukemia)
THANK YOU