Unit Seven – Blood and Immunity

I. Introduction

A. Definition – Blood is a sticky fluid that is heavier and thicker than water. Blood is a type of connective tissue, whose cells and suspended in a liquid intercellular material. It functions in transportation of substances throughout the body and provides a response mechanism to protect the body.

B. The blood is composed of two portions:

1. __55%__ percent of blood is plasma (liquid)
   - A. Plasma is a clear liquid containing mostly water, amino acids, proteins, carbohydrates, lipids, vitamins, hormones, electrolytes and waste from cells.

2. __45%__ percent of blood is made up of formed elements (solids)
   - A. The formed elements are mostly made in the bone marrow and consist of red blood cells, white blood cells and cellular fragments called platelets.
   - B. An outline of the formed elements:
     
     | I. Erythrocytes (red blood cells) |
     | II. Leukocytes (white blood cells) |
     | a. Granular leukocytes (granulocytes) |
     | 1. Neutrophils |
     | 2. Eosinophils |
     | 3. Basophils |
     | b. Agranular leukocytes (agranulocytes) |
     | III. Platelets |

3. Diagram of a blood sample:

   ![Smear of peripheral blood](URI)  ![COMPOSITION OF WHOLE BLOOD](URI)
C. Facts about Blood

1. Volume of body weight is about ______ percent blood.
2. The average human has about _____ L of blood.  
   male 5-6 L  
   female 4-5 L
3. In one drop of blood (1 cubic millimeter) there are about 5 million red blood cells, 8,000 WBC, and 250,000 platelets.
4. The process of forming new blood cells is called _______. Hemopoiesis takes place in the marrow of the humerus and femur; flat bones such as the sternum, ribs and cranial bones; the vertebrae and the pelvis.
5. All blood cells originate from hemocytoblasts, ___ cells that undergo differentiation into the major types of blood cells.
6. pH Range: _______.
7. Percentage of water in blood: _______.

55% plasma (90-92% plasma made from H2O) 
= 0.495 x 100% = 49.5% water

After division some cells remain stem cells.

Multipotent hematopoietic stem cell (hemocytoblast)

The remaining cell goes down one of two paths depending on the chemical signals received.

Myeloid stem cell

Lymphoid stem cell

Megakaryoblast  Proerythroblast  Myeloblast  Monoblast

Megakaryocyte  Erythrocyte  Basophil  Neutrophil  Eosinophil  Monocyte

Platelets

Lymphoblast

Natural killer cell (Large granular lymphocyte)

Small lymphocyte  T lymphocyte  B lymphocyte

Macrophage

Plasma cell
II. Functions of the Blood

A. Transportation

1. Blood transports oxygen \((O_2)\) from the **lungs** to the cells of the body and carries carbon dioxide \((CO_2)\) from the cells of the body to the lungs.

2. Blood carries **nutrients** (food) from the **gastrointestinal** tract (stomach and intestines) to the cells and carries heat and waste away from the cells.

3. Blood is used to carry **hormones** from the endocrine glands to target cells throughout the body.

B. Regulation

1. Blood regulates **pH** through buffers.
   
   What is a buffer? A chemical agent added to a sol’n so that it will resist changes in pH.

2. Blood regulates **body** temperature by varying the rate of blood flow to the skin; excess heat can be given off from increased surface area of vessels near the skin’s surface.

C. Protection

1. White blood cells (WBCs) protect the body against microbes and other foreign **substances** (i.e. bacteria and viruses).

2. Platelets protect the body against **blood loss** through clotting.

III. Erythrocytes (Red Blood Cells)

A. Structure of Erythrocytes

1. Tiny, **round** disks, which are thin near the center and thicker around their edges.

2. Mature cells are very simple in structure and they do not have a **nucleus** and have few organelles.

3. Hemoglobin gives the RBC its red color and is responsible for binding with oxygen. It makes up about one-third of a RBC.
   
   a. Oxyhemoglobin - when oxygen is combined with **hemoglobin** giving the blood a bright **red** color.
b. Deoxyhemoglobin - when the \textcolor{red}{O_2}\textcolor{black}{\textendash} is released to the cells giving the blood a \textcolor{red}{dark}\textcolor{black}{\textendash} red or burgundy color.

4. Certain proteins called \textit{antigens} on the surface of red blood cells are responsible for creating the different blood types: \textcolor{red}{A}, \textcolor{red}{B}, \textcolor{red}{AB}, \textcolor{red}{O} and RH \textcolor{red}{+} or \textcolor{red}{-}\textcolor{black}{.}

<table>
<thead>
<tr>
<th>Red Blood Cell Type</th>
<th>Group A</th>
<th>Group B</th>
<th>Group AB</th>
<th>Group O</th>
<th>RH +</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigens Present</td>
<td>A-antigens</td>
<td>B-antigens</td>
<td>A\textcolor{red}{\textendash}B Antigens</td>
<td>\textcolor{red}{NO} antigens</td>
<td>Rh antigen</td>
</tr>
</tbody>
</table>

\text{Rh factor simply a protein in the surface of RBC's} \downarrow \text{inherited factor or trait}

B. Function of Erythrocytes

1. \textit{Hemoglobin} on the surface of RBCs combines with \textcolor{red}{O_2} by diffusion at the lungs and is carried to all the cells of the body. The oxygen is used by the \textit{mitochondria} of the cell in the process of \textit{cellular respiration} to create ATP.

\textbf{Breathing}

\textbf{Cellular Respiration}

\text{\textcolor{red}{C}_6\text{\textcolor{red}{H}}_{12}\text{\textcolor{red}{O}}_6 (glucose) + 6 \text{\textcolor{red}{O}}_2 + 6 \text{\textcolor{red}{C}}\text{\textcolor{red}{O}}_2 + 6 \text{\textcolor{red}{H}_2}\text{\textcolor{red}{O}} + 36 \text{ATP (ENERGY)}}
2. RBCs pick up some CO₂ created by the cells during cellular respiration and bring it back to the lungs, but most of the CO₂ is carried back to the lungs in the blood plasma and leaves the lungs due to **diffusion** into the alveoli from the capillary beds and then exhaled from the lungs.

3. RBCs have **NO** nucleus, which increases their capacity to carry hemoglobin and hence O₂.

4. RBCs do not have **mitochondria** and have to generate ATP anaerobically, thus they do not need to use any of the O₂ they are transporting.

C. Life Span and Destruction of Erythrocytes

1. RBCs only live about **120** days because of damage on their membranes as they squeeze through capillaries.

2. Worn out RBCs are phagocytized by macrophages (phagocytes) in the spleen and liver.

3. Hemoglobin from the worn out RBC is broken down into heme (iron portion) and globin (a protein).

4. The **heme** is broken down into iron and biliverdin → **bilirubin** which is then transported in the blood to the liver.

5. The iron is stored in the liver until it is released from storage, then sent to the bone marrow to make new hemoglobin for new erythrocytes.

6. **Bilirubin** is converted to bile in the liver and is excreted into the small intestine where it is further broken down by intestinal bacteria eventually to be removed in the feces, giving it the characteristic brown color.

Flow Chart of Erythrocyte Breakdown:
D. Formation of Erythrocytes

1. Erythropoiesis - the process by which red blood cells (RBCs) are formed.

2. The number of red cells destroyed must be equaled by the new cells produced. The body must produce about 2 million new RBCs per second.

3. Erythropoietin - when oxygen levels become low the kidneys increase the release of the hormone erythropoietin which circulates to the bone marrow increasing erythropoiesis.

IV. Leukocytes (White Blood Cells)

A. General Information about Leukocytes

1. Leukocytes combat microbes by engulfing or antibody production.

2. WBCs do most of their work outside the circulatory system, but use the blood for transportation. Leukocytes allow them to slip in and out of blood vessels.

3. Leukocytes are produced in the bone marrow.

4. There are two types of leukocytes (see introduction).

B. Granular Leukocytes

1. There are three kinds of granular leukocytes, they are about twice the size of a RBC, have a short life span (about twelve hours), and are identified on the basis of how their granules stain.

   a. Neutrophils - combat invaders by engulfing; they are small phagocytes, usually respond first to bacterial invasion and make up a little more than half of all WBCs.

   b. Eosinophils - release enzymes such as histaminase to combat inflammation and allergic reaction. Make up only 1 to 3 percent of all WBCs.

   c. Basophils - involved in inflammatory and hypersensitivity reactions, make up less than 1 percent of all WBCs.
C. Nongranular Leukocytes

1. Monocytes (macrophages) - can **wander** and dispose of dead cells; they clean up cellular debris following an infection.
   a. 3 to 9 percent of all WBCs
   b. live for several weeks to months

2. Lymphocytes - found in lymphatic system (housed in lymph nodes), overall responsible for immune responses.
   a. 25 to 33 percent of all WBC's
   b. long life spans (some many years)
      i. T Lymphocytes can be **helper** cells or **memory** cells activated by antigens.
         → attack viruses, fungi, etc.
      ii. B Lymphocytes make **antibodies** to be released and attack foreign antigens.
         → destroy bacteria, inactivate their toxins

D. Differential white blood cell counts:

<table>
<thead>
<tr>
<th>Cell (WBC)</th>
<th>% counted Relative #</th>
<th>Absolute # ABS</th>
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<tbody>
<tr>
<td>Neutrophil</td>
<td>55-70</td>
<td>2500-8000</td>
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<tr>
<td>Lymphocyte</td>
<td>20-40</td>
<td>1000-4000</td>
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<td>Monocyte</td>
<td>2-8</td>
<td>100-700</td>
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<td>Eosinophil</td>
<td>1-4</td>
<td>50-500</td>
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<tr>
<td>Basophil</td>
<td>0-2</td>
<td>25-100</td>
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Blood Donations are Based on Safe Antigen/Antibody Interactions:

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Summary of Reactions:

Note: An individual that is Rh (+) can receive blood from someone Rh (+) or (-).
An individual that is Rh (-) can ONLY receive blood from an Rh (-) individual.

V. Thrombocytes (Platelets)

A. Structure of Thrombocytes

1. Platelets are **NOT** complete cells; they are fragments of cytoplasm developed from large cells called megakaryocytes.

2. Platelets are disc-shaped and do not contain a nucleus.

3. Platelets have short life spans, only five to nine **days**.

B. Function of Thrombocytes

1. Platelets prevent blood loss by initiating a chain of reactions that results in blood clotting with the use of **fibrinogen** protein in the blood.

   → converted to fibrin by thrombin **(enzymatically)**
VI. Blood Plasma

A. Blood plasma is the part of blood left when RBCs, WBCs and platelets are removed. It is a clear \underline{thin} liquid. It is \underline{90-92} percent water and contains plasma proteins, nutrients (amino acids, glucose, and various lipids) gases (O\textsubscript{2} and CO\textsubscript{2}), electrolytes (sodium and chloride ions amount others), waste products of metabolism (urea), enzymes, and hormones.

VII. Disorders and Development

A. Sickle Cell – crescent shaped RBC’s → O\textsubscript{2} has difficulty binding (lack of O\textsubscript{2}), shorter life-spans, malaria resistant, tends to be found in those of African descent, hereditary

B. Hemophilia – inability for blood to clot, hereditary → individuals tend to bleed longer, internal damage & surgeries can be fatal

C. Anemia – lack of iron in the blood, leads to a ↓ in O\textsubscript{2} levels = fatigue

D. Thrombus – blood clot or platelet plug

E. Leukemia – increase or abnormal amount of WBC’s in the bloodstream

F. Embolus – blood clot that blocks blood flow within blood vessels