Blood Physiology

-Blood fluid that is pumped by the heart through a closed system of blood vessels. It is composed of cells (red blood cells, white blood cells and platelets " thrombocytes " preventing blood loss),which are suspended in a fluid portion is called plasma.

Characteristics of Blood:-

1- bright red (oxygenated).
2- dark red / purplish (unoxygenated).
3- much more dense than pure water.
4- pH range from 7.35 to 7.45 (slightly alkaline).
5- slightly warmer than body temperature 100.4 F.
6- typical volume in adult male 5-6 liters.
7- typical volume in adult female 4-5 liters.
8- typically 8% of body weight.

The functions of the circulatory system are as follows:

Transport

• Blood carries oxygen from the lungs to all of the body's tissues, while it picks up carbon dioxide from those tissues and carries it to the lungs to be removed from the body.
• It picks up nutrients from the digestive tract and delivers them to all of the body's tissues.
• It carries metabolic wastes to the kidneys for removal.
• It carries hormones from endocrine cells to their target organs.
• It transports a variety of stem cells from the bone marrow and other origins to the tissues where they lodge and mature.

Protection

• Blood plays several roles in inflammation, a mechanism for limiting the spread of infection.
• White blood cells destroy microorganisms and cancer cells and remove debris from the tissues.
• Antibodies and other blood proteins neutralize toxins and help to destroy pathogens.
• Platelets secrete factors that initiate blood clotting and other processes for minimizing blood loss, and contribute to tissue growth and blood vessel maintenance.

Regulation

• By absorbing or giving off fluid under different conditions, the blood capillaries help to stabilize fluid distribution in the body.
• By buffering acids and bases, blood proteins help to stabilize the pH of the extracellular fluids.
• Cutaneous blood flow is extremely important in dissipating metabolic heat from the body. Shifts in blood flow help to regulate body temperature by routing blood to the skin for heat loss or retaining it deeper in the body to conserve heat.

Plasma

Plasma is a part of the extracellular fluid of the body. Pale yellow up of 91% water and 9% others.
The normal plasma volume is about 4-5% of the body weight.
Plasma consist of an aqueous solution of proteins, electrolyte and small organic molecules.

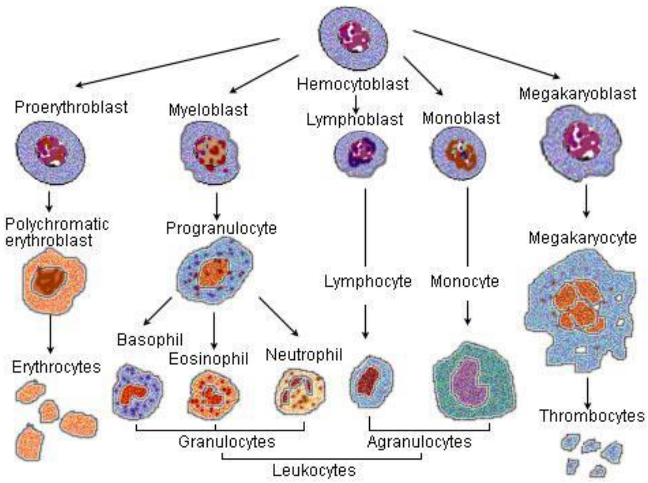
Plasma Proteins

Its concentration is about 7 mg/dl. The major types of protein and their average normal concentration present in the plasma are : 1- Albumin, 4.5 g/dl, 58% of plasma proteins.
2- Globulins, 2.5 g/dl, 38% of plasma proteins.
3- Fibrinogen, 0.3 g/dl, 4% of plasma proteins.

Hemopoiesis or Hematopoiesis

Hemopoiesis or Hematopoiesis :- Process of blood cell production.

- Proerythroblasts :- Develop into red blood cell.
- Myeloblasts :- Develop into basophils, neutrophils and eosinophils.
- Lymphoblast :- Develop into lymphocytes.
- Monoblast :- Develop into monocytes.
- Megakaryoblast :- Develop into platelets.



Red blood cells (erythrocytes)

* Structure : Biconcave, non – nucleated.
* Component : a- Hemoglobin. b- Lipids. c- ATP. d- Carbonic anhydrase.
* Function : Transport oxygen from lung to tissue and carbon dioxide from tissue to lung.

White blood cells (Leukocytes)

WBCs are divided into :-

1- Granulocytes :- 10-15 micrometers in diameter are three types according to the nature of their specific staining granules :

- Neutrophils (granules stain with acid and basic dyes).
- Eosinophils (granules stain with acid dyes).
- Basophils (granules stain with basic dyes).

* Their nuclei are lobulated, they are called polymorph nuclear leukocytes.

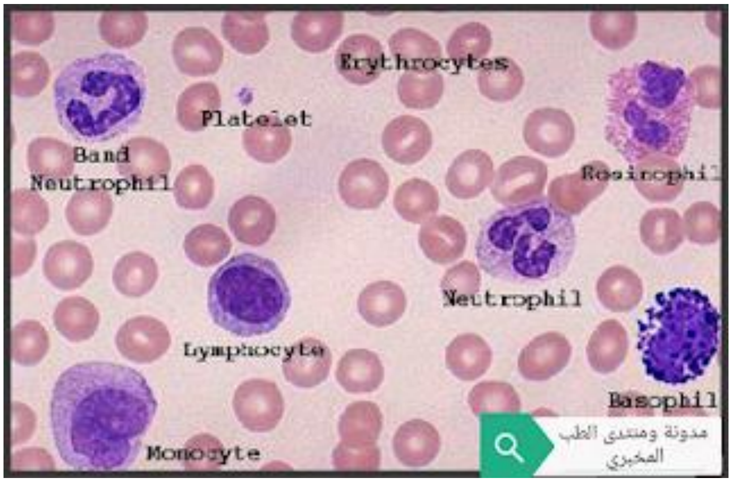
2- Non granulocytes, which are :

- Lymphocytes : the lymphocytes is small, about 6-16 micrometer in diameter. The lymphocyte has a large nucleus and scanty cytoplasm and there are three main types : (T-lymphocytes, B-lymphocytes & natural killer (NK) lymphocytes.
- Monocytes :- The monocytes is the largest WBC, it has abundant cytoplasm , and kidney – shaped or round nucleus, about 15-20 micrometer in diameter.

White blood cells (Leukocytes)

- Neutrophils (50 – 70 %).
- Lymphocytes (20 – 40 %).
- Monocytes (2 – 8 %).
- Eosinophils (1 -4 %).
- Basophils (0.4 %).

* Leukocytes : protect body against microorganisms and remove dead cells and debris.



Peripheral blood smear stained with wright-giemsa stain

Blood types (Blood groups)

A blood type is a classification of blood, based on the presence and absence of antibodies and inherited antigenic substances on the surface of red blood cells. These antigens may be proteins, carbohydrates, glycoproteins, or glycolipids, depending on the blood group system.

Determined by antigen on surface (RBCs). Antibody (agglutinins) can bind to RBC antigens resulting clumping or hemolysis (rupture) of RBCs.

ABO Blood Groups

Blood Groups	RBC Antigen	Plasma Antibody	Blood that can be received
AB	A and B	None	A, B, AB and O
B	B	Antibody A	B and O
A	A	Antibody B	A and O
O	None	Antibody A and Antibody B	O

Rh Blood Group

- First studied in (rhesus monkeys).

Types :- A- Rh positive :- Have antigens present on surface RBCs .

B- Rh negative: - Do not have these antigens present.

***Hemolytic Disease of the Newborn (HDN):-**

Pregnant women may carry a fetus with a blood type which is different from their own. In those cases, the mother can make IgG blood group antibodies. This can happen if some of the fetus' blood cells pass into the mother's blood circulation (e.g. a small fetomaternal hemorrhage at the time of childbirth or obstetric intervention), or sometimes after a therapeutic blood transfusion. This can cause Rh disease or other forms of hemolytic disease of the newborn (HDN) in the current pregnancy and/or subsequent pregnancies. Sometimes this is lethal for the fetus; in these cases it is called hydrops fetalis. If a pregnant woman is known to have anti-D antibodies,

Blood Disease

1- Jaundice: - It's the yellowish discoloration of skin and mucous membranes resulting from an increased bilirubin concentration in the body fluid. It is detectable when plasma bilirubin level rises above 2 mg/dl).

2- Anemia :- Anemia means deficiency of hemoglobin in the blood.Which can be caused by either too few red blood cells or too little hemoglobin in the cells. Some types of anemia and their physiologic causes are following :-

A- Blood Loss Anemia. B- Aplastic Anemia, C- Megaloblastic Anemia, D- Hemolytic Anemia.

3- Polycythemia :- It is an increase concentration of erythrocytes in the circulation blood that is above normal for sex and age.
4- Leukemia :- The term "Leukemia", literally "White blood", refers to a group of cancerous conditions involving overproduction of abnormal (white blood cell) from bone marrow.
5- Leukocytosis :- When total (WBC) count is higher than 11000 cell/mm3 of blood, which could be due to pathological causes (bacterial infection) or physiological causes (exercise & pregnancy).
6- Leukopenia :- When total (WBC) count is lower than 4000 cell/ mm3 of blood, which occurs for example viral infection & typhoid fever.

Coagulation

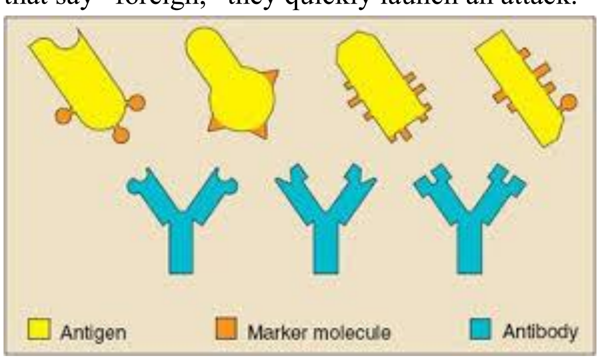
Coagulation, also known as clotting, is the process by which blood changes from a liquid to a gel, forming a blood clot. It potentially results in hemostasis, the cessation of blood loss from a damaged vessel, followed by repair. The mechanism of coagulation involves activation, adhesion and aggregation of platelets along with deposition and maturation of fibrin. Disorders of coagulation are disease states which can result in bleeding (hemorrhage or bruising) or obstructive clotting (**thrombosis**).

THE IMMUNE SYSTEM الجهاز المناعي

The immune system is a network of cells, tissues, and organs that work together to defend the body against attacks by "foreign" invaders. When the immune system hits the wrong target or is crippled, however, it can unleash a torrent of diseases, including allergy, arthritis, or AIDS. The immune system is amazingly complex. It can recognize and remember millions of different enemies, and it can produce secretions and cells to match up with and wipe out each one of them. The secret to its success is an elaborate and dynamic communications network. Once immune cells receive the alarm, they undergo tactical changes and begin to produce powerful chemicals. These substances allow the cells to regulate their own growth and behavior, enlist their fellows, and direct new recruits to trouble spots.

Self and Non self

The key to a healthy immune system is its remarkable ability to distinguish between the body's own cells (self) and foreign cells (non self). When immune defenders encounter cells or organisms carrying markers that say "foreign," they quickly launch an attack.



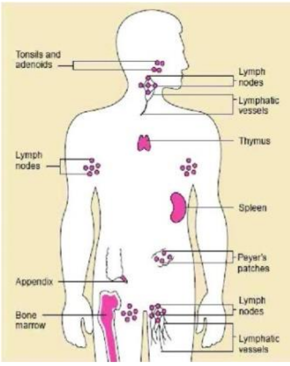
Antigens carry marker molecules that identify them as foreign.

Anything that can trigger this immune response is called an **antigen**. An antigen can be a microbe such as a virus, bacteria, parasite or even a part of a microbe. Tissues or cells from another person (except an

identical twin) also carry non self-markers and act as antigens. This explains why tissue transplants may be rejected.
In abnormal situations, the immune system can mistake self for non self and launch an attack against the body's own cells or tissues. The result is called an **autoimmune disease**. Some forms of arthritis and diabetes are autoimmune diseases. In other cases, the immune system responds to a seemingly harmless foreign substance such as ragweed pollen. The result is **allergy**, and this kind of antigen is called an **allergen**.

The Structure of the Immune System

The organs of the immune system are positioned throughout the body. They are called lymphoid organs because they are home to lymphocytes, small white blood cells that are the key players in the immune s..



The organs of the immune system are positioned throughout the body.

Bone marrow, the soft tissue in the hollow center of bones, is the ultimate source of all blood cells, including white blood cells destined to become immune cells.
The thymus is an organ that lies behind the breastbone; lymphocytes known asT lymphocytes, or just "T cells," mature in the thymus.
Lymphocytes can travel throughout the body using the blood vessels. The cells can also travel through a system of **lymphatic vessels** that closely parallels the body's veins and arteries. Cells and fluids are exchanged between blood and lymphatic vessels, enabling the lymphatic system to monitor the body for invading microbes. The lymphatic vessels carry lymph, a clear fluid that bathes the body's tissues.
Small, bean-shaped **lymph nodes** are laced along the lymphatic vessels, with clusters in the neck, armpits, abdomen, and groin. Each lymph node contains specialized compartments where immune cells congregate, and where they can encounter antigens.

Immune cells and foreign particles enter the lymph nodes via incoming lymphatic vessels or the lymph nodes' tiny blood vessels. All lymphocytes exit lymph nodes through outgoing lymphatic vessels. Once in the bloodstream, they are transported to tissues throughout the body. They patrol everywhere for foreign antigens, then gradually drift back into the lymphatic system, to begin the cycle all over again.

The spleen is a flattened organ at the upper left of the abdomen. Like the lymph nodes, the spleen contains specialized compartments where immune cells gather and work, and serves as a meeting ground where immune defenses confront antigens.

Clumps of lymphoid tissue are found in many parts of the body, especially in the linings of the digestive tract and the airways and lungs—territories that serve as gateways to the body. These tissues include the **tonsils, adenoids, and appendix**.

Immune Cells and Their Products

The immune system stockpiles a huge arsenal of cells, not only lymphocytes but also cell-devouring phagocytes and their relatives.

The immune system stores just a few of each kind of the different cells needed to recognize millions of possible enemies. When an antigen appears, those few matching cells multiply into a full-scale army. After their job is done, they fade away, leaving sentries behind to watch for future attacks.

All immune cells begin as immature stem cells in the bone marrow. They respond to different cytokines and other signals to grow into specific immune cell types, such as T cells, B cells, or phagocytes. B cells and T cells are the main types of lymphocytes.

B cells work chiefly by secreting substances called antibodies into the body's fluids. Antibodies ambush antigens circulating the bloodstream. They are powerless, however, to penetrate cells. The job of attacking target cells—either cells that have been infected by viruses or cells that have been distorted by cancer—is left to T cells or other immune cells. Each B cell is programmed to make one specific antibody.

T Cells unlike B cells, T cells do not recognize free-floating antigens. Rather, their surfaces contain specialized antibody-like receptors that see fragments of antigens on the surfaces of infected or cancerous cells. T cells contribute to immune defenses in two major ways: some direct and regulate immune responses; others directly attack infected or cancerous cells.

Helper T cells, or Th cells, coordinate immune responses by communicating with other cells. Some stimulate nearby B cells to produce antibody, others call in microbe-gobbling cells called phagocytes, still others activate other T cells.

Killer T cells—also called cytotoxic T lymphocytes or CTLs—perform a different function. These cells directly attack other cells carrying certain foreign or abnormal molecules on their surfaces.

Phagocytes and Their Relatives

Phagocytes are large white cells that can swallow and digest microbes and other foreign particles. Monocytes are phagocytes that circulate in the blood. When monocytes migrate into tissues, they develop into **macrophages**.

Granulocytes are another kind of immune cell. They contain granules filled with potent chemicals, which allow the granulocytes to destroy microorganisms. Some of these chemicals, such as histamine, also contribute to inflammation and allergy.

One type of granulocyte, **the neutrophil**, is also a phagocyte; it uses its prepackaged chemicals to break down the microbes it ingests. **Eosinophils and basophils** are granulocytes that "degranulate," spraying their chemicals onto harmful cells or microbes nearby.

The mast cell is a twin of the basophil, except that it is not a blood cell.

A related structure, the blood platelet, is a cell fragment. Platelets, too, contain granules. In addition to promoting blood clotting and wound repair, platelets activate some of the immune defenses.

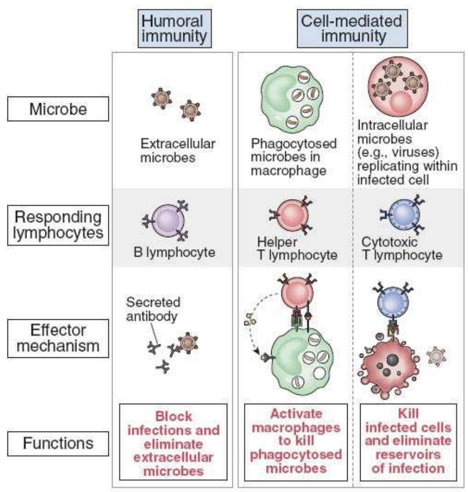
Cytokines

Components of the immune system communicate with one another by exchanging chemical messengers called cytokines. These proteins are secreted by cells and act on other cells to coordinate an appropriate immune response. Cytokines include a diverse assortment of **interleukins, interferons, and growth factors**.

The complement system is made up of about 25 proteins that work together to "complement" the action of antibodies in destroying bacteria. Complement also helps to rid the body of antibody-coated antigens (antigen-antibody complexes). Complement proteins, which cause blood vessels to become dilated and then leaky, contribute to the redness, warmth, swelling, pain, and loss of function that characterize an inflammatory response.

Immunity: Natural and Acquired

Long ago, physicians realized that people who had recovered from the plague would never get it again—they had acquired immunity. This is because some of the activated T and B cells become memory cells. The next time an individual meets up with the same antigen, the immune system is set to demolish it. Immunity can be strong or weak, short-lived or long-lasting, depending on the type of antigen, the amount of antigen, and the route by which it enters the body.



Types of adaptive immunity. In humoral immunity, B lymphocytes secrete antibodies that eliminate extracellular microbes. In cell-mediated immunity, T lymphocytes either activate macrophages to destroy phagocytosed microbes or kill infected cells.

Immunology and Transplants

Each year thousands of American lives are prolonged by transplanted organs: kidney, heart, lung, liver, and pancreas. For a transplant to "take," however, the body's natural tendency to rid itself of foreign tissue must be overridden. One way, tissue typing, makes sure markers of self on the donor's tissue are as similar as possible to those of the recipient.

Bone Marrow Transplants

When the immune response is severely depressed—in infants born with immune disorders or in people with cancer—one possible remedy is a transfer of healthy bone marrow. Introduced into the circulation, transplanted bone marrow cells can develop into functioning B and T cells.

In bone marrow transplants, a close match is extremely important. Not only is there a danger that the body will reject the transplanted bone marrow cells, but mature T cells from the bone marrow transplant may counterattack and destroy the recipient's tissues. To prevent this situation, known as graft-versus-host disease, scientists use drugs or antibodies to "cleanse" the donor marrow of potentially dangerous mature T cells.