**Anatomy and Physiology**

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| **Semester II** | **Hours of Instruction/week : 5** |
| **18BPEC04** | **No. of Credits: 3** |
| **Unit III Cardiovascular and Respiratory System** |
| Functions of blood, Composition of blood, Lymph and its functions-structure of the heart, |
| Systematic, Pulmonary, Coronary circulation. Respiratory system: Definition of respiration, |
| Structure and functions of the respiratory system, Mechanics for respiration, Lung volumes. |

**Blood**

Single drop of blood contains millions of red blood cells, white blood cells, and platelets.

* Blood is a fluid connective tissue that consists of plasma, blood cells and platelets.
* It circulates throughout our body delivering oxygen and nutrients to various cells and tissues.
* It is made up of cellular elements and an extracellular matrix.
* The cellular elements—referred to as the formed elements—include red blood cells (RBCs), white blood cells (WBCs), and cell fragments called platelets.
* Blood makes up 8% of our body weight.
* An average adult possesses around 5-6 litres of blood.
* The extracellular matrix, called plasma, makes blood unique among connective tissues because it is fluid.

**Functions of Blood**

The **primary function** of blood is to deliver oxygen and nutrients and to remove wastes from body cells.

The **specific functions** of blood also include defence, distribution of heat, and maintenance of **homeostasis** (A healthy state that is maintained by the constant adjustment of biochemical and physiological pathways)

**Blood is responsible for the following body functions:**

### Fluid Connective Tissue

Blood is a fluid connective tissue composed of 55% plasma and 45% formed elements including WBCs, RBCs, and platelets. Since these living cells are suspended in plasma, blood is known as a fluid connective tissue and not just fluid.

### Provides oxygen to the cells

Blood absorbs oxygen from the lungs and transports it to different cells of the body. The waste carbon dioxide moves from the blood to the lungs and exhaled.

### Transports Hormone and Nutrients

The digested nutrients such as glucose, vitamins, minerals, and proteins are absorbed into the blood through the capillaries. The hormones secreted by the endocrine glands are also transported by the blood to different organs and tissues.

### Homeostasis

Blood helps to maintain the internal body temperature by absorbing or releasing heat.

### Blood Clotting at Site of Injury

The platelets help in the clotting of blood at the site of injury.

### Transport of waste to the Kidney and Liver

Blood enters the kidney where it is filtered to remove nitrogenous waste out of the blood plasma.

The toxins from the blood are also removed by the liver.

### Protection of body against pathogens

The White Blood Cells fight against infections. They multiply rapidly during the infections.

## Components of Blood

## There are many cellular structures in the composition of blood.  When a sample of blood is spun in a centrifuge machine, they separate into the following constituents: Plasma, Buffy coat and erythrocytes.

### Plasma

Plasma can be defined as an extracellular and liquid portion of a blood

 Plasma is transparent and pale yellow or straw-colour.

Plasma is composed of clotting factors (salts, nutrients, water and enzymes) & other protein molecules.

Plasma in blood mainly comprises 80 to 90 percent of water

The other 10 percent is composed of salts, lipids, nutrients, enzymes and hormones.

Plasma constitutes 50 to 55 percent of total blood volume.

Blood plasma transfusions are given to patients with liver failure and life-threatening injuries.

Plasma in blood cells is rich in proteins, immunoglobulin, clotting factors and fibrinogen

### Red Blood Cells (RBC) or Erythrocytes

Red blood cells consist of Haemoglobin, a protein.

Erythrocytes, also referred to as Red Blood Cells (RBCs) are a significant cellular component of blood.

These cells circulate in the blood carrying oxygen from the lungs to all the tissues of the body.

It is responsible for imparting blood with its characteristic colour.

Mature erythrocytes in humans are rounded, small and biconcave, as though dumbbell-shaped.

### White Blood Cells (WBC) or Leukocytes.

White blood cells are responsible for fighting foreign pathogens (such as **bacteria, viruses, fungi**) that enter our body.

They circulate throughout our body and originate from the bone marrow.

The WBC is also labelled as Leukocytes.

They serve as a defence against all pathogens in human body.

WBC creates a different sort protein called antibodies that recognize and counter the foreign agents

The WBC in the cells comprises recognizable granule-like structures.

Thus their name is Granulocytes and they do not contain granulocytes.

WBCs account for 1 per cent of the total quantity of blood and they are colourless, since these lack haemoglobin.

## Various types of WBC

The WBC is classified as five distinct types, which are categorized depending on the existence and absence of granules. The five kinds of WBC are described below.

### Lymphocytes- A lymphocyte is a type of white blood cell in the immune system of jawed vertebrates

The two main lymphocyte types are

* B lymphocytes
* T lymphocytes

### Monocytes - Monocytes are a type of leukocyte, or white blood cell. Monocytes are a type of white blood cell that fight certain infections and help other white blood cells remove dead or damaged tissues, destroy cancer cells, and regulate immunity against foreign substances.

### Neutrophils - Neutrophils are a type of white blood cell (WBC or granulocyte) that protect us from infections, among other functions.

### Eosinophils - Eosinophils are the leukocyte cells that are present in the immune system responsible for combating infections in vertebrate parasites and regulating processes associated with allergy & asthma.

### Basophils - Basophils are a type of white blood cell. Although they're produced in the bone marrow, they're found in many tissues throughout your body.

### Platelets

**Platelets are minute fragments of blood cells that help in the formation of clots in the body to stop bleeding.** Any damage in the blood vessels sends signals to the platelets. The platelets rush to the site of damage and form clots to repair the damage.

The activated platelets stick together to form a platelet plug which in turn activates the coagulation factor. Vitamin K is beneficial for the proper functioning of the coagulation factor.

## Platelets and Coagulation

## ***“Coagulating factors are proteins present in blood plasma that helps in converting fibrinogen to fibrin that strengthens platelet plug.”***

**Hemostasis**

*“Hemostasis is a physiological defensive reaction to an injury or a cut that seals the blood vessels and thus helps in healing.”*

Haemostatic mechanism proceeds in the following series of steps:

* Changes in blood vessel cells
* Blood clot formation
* Platelet plug formation

### Stages of Hemostasis

Hemostasis takes place in two stages:

#### Primary Hemostasis

It is caused when bleeding ceases or gets reduced by contraction of the blood vessels, and thrombin signals for platelet assembly and forms a loose platelet plug.

#### Secondary Hemostasis

It includes the action of blood proteins and coagulation factors in a sequence to reinforce the platelet plug and marks the onset of the healing process.

Blood coagulation is provoked by the extrinsic pathway i.e. tissue damage, but the intrinsic pathway (internal messengers) intensifies the coagulation.

Coagulation of blood is a lengthy process occurring within a few minutes where numerous coagulation factors come into play.

## Lymph

Lymph is a clear to pale-white fluid which circulates throughout the lymphatic system. The main role of the lymphatic system is to act as a filter against microbes, organic wastes and other debris.

Lymph mainly contains white blood cells (mainly lymphocytes).

Lymph carries digested and absorbed fat from intestine and drains excess fluid from extracellular space back into blood. Lymph supplies mature lymphocytes to the blood.

Lymph acts to remove bacteria and other particles. It also maintains fluid balance.

**Function of Lymph**

1. It keeps the body cells moist.
2. It transports oxygen, hormones and nutrients to different parts of the body and removes metabolic waste from the cells.
3. It transports antibodies and lymphocytes to the blood.
4. Maintaining the composition of tissue fluid and the volume of blood.
5. Absorption of fats from the small intestine through lymphatic vessels.
6. Prevents invasion of microbes and foreign substances inside the lymph nodes.

**Heart**

The heart is an organ that pumps blood throughout the body.

The human circulatory system is responsible for the transport of materials inside the human body.

The organs of the circulatory system are the heart, arteries, veins and capillaries.

It comprises four chambers:

* Atria (upper chambers)
* Ventricles (lower chambers)

**Layers of heart**

The wall of the heart is made up of three layers:

* **Epicardium**- This is a protective layer made of connective tissues.
* **Myocardium-** This layer forms the heart muscles.
* **Endocardium**- This is the innermost layer and protects the valves and the heart.

**Function of Heart**

**The heart performs the following important functions:**

* The primary function of the heart is to pump blood throughout the body.
* It supplies oxygen and nutrients to the tissues and removes carbon dioxide and wastes from the blood.
* It also helps to maintain adequate blood pressure throughout the body.

**The heart functions in the following ways:**

1. The arteries receive oxygenated blood from the heart and supply it throughout the body. Whereas, the veins carry the deoxygenated blood from all the body parts to the heart for oxygenation.
2. The right atrium receives blood from the veins and pumps it to the right ventricle.
3. The right ventricle pumps the blood received from the right atrium to the lungs.
4. The left atrium receives oxygenated blood from the lungs and pumps it to the left ventricle.
5. The left ventricle pumps the oxygenated blood throughout the body.

### ****Types of Circulation****

### Pulmonary circulation - **carrying deoxygenated blood away from the heart**, to the lungs and then brings oxygenated blood back to the heart.

* **Systemic circulation** - the **oxygenated blood is pumped from the heart to every organ** and tissue in the body, and deoxygenated blood comes back again to the heart.
* **Coronary circulation** - The oxygenated blood is supplied to the heart. This is important as the heart is responsible for supplying blood throughout the body.

## Respiratory System Definition

***“*Human Respiratory System is the organ system that involves inhaling of oxygen and exhaling of carbon dioxide to meet the energy requirements.”**

The human respiratory system consists of a group of organs and tissues that help us to breathe.

Lungs are the primary organs of the respiratory system which help in the exchange of gases.

The other main parts of this system include a series of airways for **air passages, blood vessels and the muscles** that facilitate breathing.

**The respiratory tract in humans is made up of the following parts:**

* **External nostrils** – For the intake of air.
* **Nasal chamber** – which is lined with hair and mucus to filter the air and remove dust and dirt.
* **Pharynx** – It is a passage behind the nasal chamber and serves as the common passageway for both air and food.
* **Larynx** – Also known as the soundbox as it helps in the generation of sound and thus helps us in communicating.
* **Epiglottis** – It is a flap-like structure that covers the glottis and prevents the entry of food into the windpipe.
* **Trachea** – It is a long tube passing through the mid-thoracic cavity.
* **Bronchi** – The trachea divides into left and right bronchi.
* **Bronchioles** – Each bronchus is further divided into finer channels known as bronchioles.
* **Alveoli** – The bronchioles end up into the balloon-like structures known as the alveoli.
* **Lungs** – We have a pair of lungs, which are sac-like structures and covered by a double-layered membrane known as pleura

## Mechanism of Breathing

The breathing mechanism involves **two processes**:

* Inspiration
* Expiration

#### Inspiration

In the process of inspiration, there would be a contraction of muscles attached to the ribs on the outer side which pulls out the ribs and results in the expansion of the chest cavity.

Later, the diaphragm, contracts, moves downwards and expands the chest cavity resulting in the contraction of the abdominal muscles.

The expansion of the chest cavity produces a partial vacuum which sucks air into the lungs and fills the expanded alveoli.

#### Mechanism of Inspiration

#### The process of intake of atmospheric air is known as inspiration. It is an active process.

* When the volume of the thoracic cavity increases and the air pressure decreases, inspiration takes place.
* Contraction of external intercostals muscles increases the volume of the thoracic cavity.
* Contraction of the diaphragm further increases the size of the thoracic activity. Simultaneously, the lungs expand.
* With the expansion of the lungs, the air pressure inside the lungs decreases.
* The pressure equalizes and the atmospheric air rushes inside the lungs.

#### Expiration

The expiration process is considered once after the gaseous exchange occurs in the lungs and the air is expelled out. This expulsion of air is called expiration.

During this process, muscles attached to the ribs contract, the muscles of the diaphragm and the abdomen relax which leads to a decrease in the volume of the chest cavity and increases the pressure of the lungs, causing the air in the lungs to be pushed out through the nose.

#### Mechanism of Expiration

* The process of exhaling carbon dioxide is called expiration. It is a passive process.
* It occurs when the size of the thoracic activity decreases and the air pressure outside increases.
* Now the external intercostals muscles relax and the internal intercostals muscles contract.
* As a result, the ribs are pulled inwards and the size of the thoracic cavity is reduced.
* The diaphragm is relaxed and the lungs get compressed.
* Consequently, the pressure increases and the air is forced outside.

 Respiration in humans takes place through the lungs. It is the largest organ of the human respiratory system. The air inhaled moves down the trachea into the lungs where oxygen is exchanged for carbon dioxide from the body tissues. Carbon dioxide is then exhaled out of the lungs through the mouth.

## Respiratory System Functions

The human respiratory system functions are mentioned below:

### Inhalation and Exhalation

The respiratory system helps in breathing, known as pulmonary ventilation. The air inhaled through the nose moves through the pharynx, larynx, and trachea into the lungs. The air is exhaled back through the same pathway. Changes in the volume and pressure in the lungs aid in pulmonary ventilation.

### Exchange of Gases between Lungs and Bloodstream

Inside the lungs, the oxygen is exchanged for carbon dioxide waste through millions of microscopic sacs called alveoli. The inhaled oxygen diffuses into the pulmonary capillaries, binds to haemoglobin and is pumped through the bloodstream. The carbon dioxide from the blood diffuses into the alveoli and is expelled through exhalation.

### Exchange of Gases between Bloodstream and Body Tissues

The blood carries the oxygen from the lungs around the body and releases the oxygen when it reaches the capillaries. The oxygen is diffused through the capillary walls into the body tissues. The carbon dioxide also diffuses into the blood and is carried back to the lungs for release.

### The vibration of the Vocal Cords

While speaking, the muscles in the larynx move the arytenoids cartilage. These cartilages push the vocal cords together. During exhalation, when the air passes through the vocal cords, it makes them vibrate and creates sound.

### Olfaction or Smelling

During inhalation, when the air enters the nasal cavities, some chemicals present in the air bind to it and activate the receptors of the [**nervous system**](https://byjus.com/biology/nervous-system/) on the cilia. The signals are sent to the olfactory bulbs via the brain.