Circulatory system

Circulatory system is transporting system of the body that transported different substances from tissue to tissue. It also maintains the constant physical environment and chemical composition of body fluid. It consists heart, blood and blood vessels.

[Note: Types of Circulatory system:

a. **Open Type:** In this type; the blood flows for some time into the large spaces called sinuses. There are absent of capillaries between the arteries and the veins. It occurs leeches, arthropods, most of the molluscs and ascidians.
b. **Closed Type:** In this type, the blood remains inside the blood vessels and does not come out. It occurs in most of the Annelids, Cephalopods and Vertebrates including man.

Functions of the Circulatory System

- It delivers oxygen to the cells and removing carbon dioxide from them.
- It carries digested food substances to the cells of the body.
- It disposes of waste products and poisons that would harm the body if they accumulated.
- It helps to protect the body from disease.
- It provides a mode of transport for hormones and help in cellular communication.
- It also regulates the temperature of body of mammals and help in thermoregulation mechanism.]

Heart:

a. External structure:

It is a pear shape, reddish brown color, hollow, muscular pumping organ that situated mid ventrally in thoracic cavity in between two lungs. The narrow apical end of the heart is slightly displace to the left side. It is about 12 cm in length, 9 cm in breadth and 250-300 grams in weight. It covers by a double-layered transparent membranous sac called pericardium. In between two pericardial membranes, there is presence of a pericardial fluid. The pericardial fluid absorbs mechanical shock that protects heart from injuries and allows free movement to the heart.

Heart consists of anterior broad part, the auricular part and posterior narrow part, the ventricular part. These two parts are demarcated by a transverse, shallow groove called coronary sulcus. It is present far-anterior, making auricular part smaller than ventricular part. The auricular part divides into large right auricle and small left auricle by a longitudinal inter-auricular sulcus. The superior and inferior venacavae open towards the dorsal surface of right auricle. They bring the deoxygenated blood from different parts of body except lungs. Four pulmonary veins open towards the dorsal surface of left auricle. They bring oxygenated blood from lungs. The auricular part receives the blood. The ventricular part is also divided into right and left ventricles by a longitudinal inter ventricular groove. The ventricular part sends out

blood. The systemic aorta arises from the anterio-ventral part of left ventricle and the pulmonary aorta arises from the anterio-ventral part of right ventricle. They carry the blood out of the heart.

b. Internal structure:

The human heart consists of four chambers. The upper two chambers are right and left atria or auricles. The lower two chambers are right and left ventricles. The auricles are thin-walled and separated from each other by a thin longitudinal inter-auricular septum. The right auricle has the openings of superior and inferior venacavae at its dorsal surface and the openings are guarded by the valves. They bring the deoxygenated blood from the body except lungs. A small, spongy mass of specialized cardiac muscle present near the opening of superior venacava called Sino-Auricular Node (SA node) which is self-excitatory in nature and generate the wave of contraction for heartbeat. Left auricle is having four openings for pulmonary veins to receive oxygenated blood from two lungs and the openings lack valves. Right and left auricles open into respective ventricles through right and left auriculo-ventricular apertures (AV apertures). The left AV aperture is guarded by Bicuspid valve or Mitral valve. [It consists of two flaps or cusps] The right AV aperture guarded by Tricuspid valve. [It consists of three flaps or cusps] The tricuspid and bicuspid valves allow the unidirectional flow of blood from auricles to ventricles and prevent backward flow.

The two ventricles are separated by a thick longitudinal inter-ventricular septum. The inter-ventricular septum runs obliquely at right side at the apex, making right ventricle smaller than left ventricle. Ventricles have thick walled than atria. The left ventricle has thicker walled than right ventricle for forcefully pumping the blood to the body. Inner surface of ventricular wall consists of low irregular ridges, the columnae carneae and depression, the fissures. Few large conical elevations arise from columnae carneae called papillary muscles. The papillary muscles are connected with a tough strands of connective tissue called chordae tendineae. The chordae tendineae are connected with AV valves and prevent the AV-valves from being force upward during ventricular contraction. From anterio- ventral surface of right ventricle and left ventricle arise pulmonary aorta and systemic aorta respectively. At the base of pulmonary aorta and systemic aorta, there are pulmonary semi lunar and aortic semi lunar valves. [The semilunar valves are made up of three flaps attached to inside of arterial wall.] These valves allow only unidirectional flow of blood from ventricle to artery and prevent backward flow.

Course of Blood Circulation

Blood circulation in human is a double circulation type i.e., blood flows twice times through the heart in a complete cycle, once through the left side and another through right side. This type of circulation is due to the complete separation of 4-chambers of heart with each other. Course of blood circulation consists of following,

a) Circulation of blood in heart

The heart works like a pump i.e., it acts as suction pump to draw the blood in the auricles and force pump to propel the blood from ventricles to the aorta. Right auricle and right ventricle are the chambers for deoxygenated blood, while left auricle and left

ventricle are the chambers for oxygenated blood. The deoxygenated blood from anterior and posterior parts of body except lungs enters into the right auricle through superior and inferior venecavae. During auricular contraction, deoxygenated blood passes to right ventricle through right auriculo-ventricular aperture. During ventricular contraction, deoxygenated blood pumps into pulmonary aorta for oxygenation in lungs. Oxygenated blood from lungs carry to left auricle by four pulmonary veins. During auricular contraction, oxygenated blood passes to left ventricle through left auriculo-ventricular aperture. During ventricular contraction, oxygenated blood pumps into systemic aorta to distribute into the body.

b) Pulmonary circulation

Circulation of blood between heart and lungs is called Pulmonary circulation. The deoxygenated blood from right ventricle pumps into pulmonary aorta during ventricular contraction. The pulmonary aorta divides into right and left pulmonary arteries that supply blood to right and left lungs respectively for oxygenation. After oxygenation, oxygenated blood returns to left auricle through four pulmonary veins.

c) Systemic circulation

Circulation of blood between heart and body except lungs is called systemic circulation. In this circulation, oxygenated blood from left ventricle pumps into systemic aorta during ventricular contraction. Systemic aorta divides into arteries that enter into different organs of body to supply oxygenated blood. In these organs, arteries divide into arterioles and then into capillaries to exchange gases and nutrients with tissues and cells. Finally, the deoxygenated blood flows through venules and then veins. The deoxygenated blood from different parts of body is returned to right auricle through the superior and inferior venacavae.

Working mechanism of heart or Physiology of heart

Heart acts as double pumps i.e., it acts as suction pump for drawing the blood from different parts of body through large veins to the auricles and it acts as force pump for propelling the blood from ventricles to the aorta. This action of heart is result from its continuous and rhythmic contraction and relaxation processes. The contraction phase of heart is called systole and relaxation phase of heart is called diastole. During auricular diastole phase, both right and left auricles receive the blood. Deoxygenated blood from body except lungs enters into right auricle through openings of superior and inferior venacavae and oxygenated blood from lungs enters into left auricle through the four openings of pulmonary veins. At end of auricular diastole phase, the impulses for contraction of heart are generate in the form of electrical waves in Sino-auricular node (SA node). SA node is a small, spongy mass of special cardiac muscle, which is self-excitatory in nature and present near the opening of superior venacava in the upper region of right auricle. The electrical waves generated by SA-node are radiated in all the direction of the auricular walls and cause the contraction of both auricles simultaneously. The contraction of auricles causes the closure of openings of superior and inferior venacavae by the valves in right auricle and constriction of openings of pulmonary veins in left auricle and open the tricuspid valve present in

right auriculo-ventricular aperture and bicuspid valve present in left auriculo-ventricular aperture. Thus, deoxygenated blood from right auricle pours into right ventricle through right auriculo-ventricular aperture and oxygenated blood from left auricle pours into left ventricle through left auriculo-ventricular aperture. At this time, both ventricles are in diastolic phase. After that, both auricles undergo into the diastolic phase.

The electrical waves for contraction from auricles cannot pass over the ventricles directly as their muscles are not continuous. The impulses travel from auricles to ventricles over a bridge called Auriculo-ventricular node (AV node). AV node is similar to SA node in composition and locate in posterior side of right auricle. From it arises a bundle of specialized cardiac muscle fibers, known as Bundle of His. It is divides into right and left bundle branches at base of interventricular septum. Each branch enters into wall of its respective side of ventricle through interventricular septum and terminates in thin fibers called Purkinje fibers, which reach the ventricular muscle fibers. The impulses picked up by the AV node from SA node, are passed along the bundle of His and its branches and then Purkinje fibers that distribute impulses to each and every muscle fibers of ventricles and causes the contraction of ventricles. Thus, ventricular systole delays of approximately 0.15 second than atrial systole. The contractions of ventricles push the tricuspid and bicuspid valves upward, leading the closure of right and left AV apertures respectively and opening of semilunar valves present at the base of pulmonary aorta and left systemic aorta. The deoxygenated blood presents in right ventricle pumps to pulmonary aorta and oxygenated blood from left ventricle pumps to left systemic aorta. Then, both ventricles undergo diastolic phase. The auricles are again filled up with blood and after a very short rest, the wave of contraction generates again and same process is repeated.

Origin and Conduction of heart beat:

Human heart is a myogenic type. The heart beat starts in a tiny, spongy mass of special cardiac muscle present near the opening of superior venacava in the right auricle, called as Sino-auricular node (SA-node). It is self-excitatory in nature. When it is excited, it generates the electrical waves that are transmit in all the direction of the auricular walls and cause the contraction of both auricles simultaneously. Therefore, SA node is called natural pacemaker. A similar kind of node is present in posterior side of right auricle called Auriculo-ventricular node (AV node). A bundle of specialized cardiac muscle fibers, the Bundle of HIS originates from the AV node. It is divided into right and left branches at the base of interventricular septum. Each branch of bundle of HIS enters into the wall of its respective side of ventricle through interventricular septum and terminates in thin fibers called Purkinje fibers that reach to all ventricular muscle fibers. The impulses picked up by the AV node from SA node, are passed along the bundle of His and its branches and then Purkinje fibers that distribute impulses to all the muscle fiber of ventricles and cause the contraction of ventricles. While the ventricles contract, the auricles are in relax. This sequence is repeated again. The whole system- the SA node, the AV node, bundle of HIS and the

Purkinje fiber constitute the conducting system of the heart. The stimulus for the contraction of auricles and ventricles is electrical.

Some terms related to Circulation system

1. **Single circulation**: Blood flows only once through the heart in a complete cycle. Heart pumps deoxygenated blood only and blood flow is slow with low pressure. For example, fishes.
2. **Double circulation**: Blood flows twice through the heart in a complete cycle. Heart pumps deoxygenated blood to lungs from right side and oxygenated blood to the body from left side. Blood flow is fast with high pressure.
3. **Myogenic heart:** Heart in which wave of contraction generates within itself is called myogenic heart. For example, human heart.
4. **Heart beat:** The rhythmic contraction and relaxation of the heart is known as heartbeat. The contraction phase of heart is known as systole and relaxation phase is called diastole. One heart beat is completed in about 0.8 second time.
5. **Heart rate (HR):** It is the number of heart beats per minute. In the normal adult, it is about 70 to 80 times. In an average, it comes to be 72 times.
6. **Stroke volume (SV):** It is the volume of blood pumped out per heartbeat. It is about 70 ml of blood.
7. **Cardiac output (CO):** It is the volume of blood pumped out per minute. It is the product of stroke volume and heart rate and it is about 5040 ml.
   CO=SV*HR
8. **Cardiac cycle:** Rhythmic contraction and relaxation of cardiac chambers in one heartbeat is known as cardiac cycle. A complete cardiac cycle consists of four stages i.e., Atrial systole, Atrial diastole, Ventricular systole and ventricular diastole.

a. **Atrial systole:** The contraction of right and left auricles simultaneously is called atrial systole. It lasts for about 0.1 second. During this phase right auricles pumps deoxygenated blood to right ventricle and left auricle pumps oxygenated blood to left ventricle.

b. **Atrial diastole:** The relaxation of right and left auricles is called atrial diastole. It lasts for about 0.7 second. It begins after auricular systole. During this phase, right auricle receives deoxygenated blood from body through superior and inferior venacavae and left auricle receives oxygenated blood from lungs through the four pulmonary veins.

c. **Ventricular systole:** The contraction of right and left ventricles is called ventricular systole. It lasts for about 0.3 second. During this phase, right and left auriculo-ventricular apertures are closed by tricuspid and bicuspid valves respectively, right ventricle pumps deoxygenated blood to lungs through pulmonary aorta and left ventricle pumps oxygenated blood to body through left systemic aorta.

d. **Ventricular diastole:** The relaxation of right and left ventricles is called ventricular diastole. It lasts for about 0.5 second and it begins after ventricular systole. During this phase, semilunar valves close the openings of pulmonary and systemic aorta. At end of ventricular diastole, both ventricles receive blood from their respective auricles.

9. **Natural Pacemaker:** The Sino-Auricular Node (SA node) is called as natural pacemaker because it initiates the heartbeat and acts as the stimulus for the next beat.
10. **Artificial Pacemaker:** If SA node is injured or damaged, heart cannot beat properly and drop in blood pressure. To prevent this, artificial pacemaker is implanted in the chest region to regulate the heart rhythm. The artificial pacemaker is a small electrical device that consists of a pulse generator and an electrode. The pulse generator is a sealed box, containing lithium batteries for pulse production and is implanted into subcutaneous region below the clavicle. The electrode is fine metallic string that transmits the impulse to heart. It remains connected to the portion of the heart where impulse to be transmitted. It may function continuously, stimulate the heart at a fixed rate and increase the rate during exercise. It can be programmed to detect an overly long pause between heartbeats and then stimulate the heart.
11. **Heart sounds:** Sudden closure of valves present in heart produce sound during heart beat is called heart sound. It is important to know the working condition of valves of heart. The defects in valves may lead to back flow of blood from ventricles to auricles or from aorta to ventricles. Such defects are easily detected by changing the nature of heart sound called murmur. The defects in valves may be caused by disease like syphilis and rheumatic fever etc. The heart sound can be amplified and record in Phonocardiogram.

i. **First heart sound**- The first heart sound is 'Lubb'. It produces due to the sharp closing of atrioventricular valves like the bicuspid and tricuspid valves at the beginning of ventricular systole. It is louder but dull and lasts little longer about 0.14 second.
ii. **Second heart sound** – The second heart sound is Dubb. It produces due to the closing of semilunar valves present at the base of systemic aorta and pulmonary aorta. It occurs at the end of ventricular systole. It is less loud but sharp and lasts for about 0.11 second.
iii. **Third heart sound-** Vibration of ventricular wall soon after ventricular systole produces third heart sound. It is not audible.
iv. **Fourth heart sound-** Due to rapid rush of blood from auricles to ventricle at end of ventricular diastole. It is not audible.

12. **Blood pressure (BP):** It is a force exerted by blood against the wall of arteries in the form of wave due to heartbeat. It is of two types, Systolic and Diastolic blood pressure.

a. Systolic blood pressure: It is maximum pressure exerted by blood against the wall of arteries in the form of wave during contraction of ventricles. The normal adult person has 120-mmHg systolic blood pressure. The range of systolic blood pressure is 100 to 140 mmHg. The systolic blood pressure undergoes considerable fluctuation and increases during excitement, stress, exercise and meal etc. and it is decreased during the sleep.
b. Diastolic blood pressure: It is minimum pressure or force exerted by blood against the wall of arteries in the form of wave during the relaxation of ventricles. The normal adult person has 80-mmHg diastolic pressure. The range of diastolic blood pressure is 55 to 80 mmHg. Diastolic pressure undergoes less

fluctuation and remains within limited range. Increase in diastolic pressure indicates that the heart is approaching towards its failure.

Blood pressure is depended on age (increase with age), gender (female has comparative less BP than male before menopause), cardiac output (increase with increase in cardiac output), elasticity of blood vessels (BP inversely proportional to elasticity of blood vessels. Elasticity of blood vessels decrease with increase in age) and peripheral resistance offer by blood vessels to blood etc.

There are different methods are used to measure BP, but commonly use method is auscultatory method by using Sphygmomanometer.

Significance or Importance of BP

- It is needed to maintain a significant pressure head to keep flow of blood in blood vessels.
- It requires for keeping the motive force of filtration at the capillary beds to assure the supply of nutrients, gases, hormones etc. to tissues.
- It provides correct information about the state of circulatory system and functional condition of tissues and organs.

[Note: Problems related to BP

- **Hypertension or high BP:** It is the condition when the systolic and diastolic blood pressure is 150/90 or above persistently. Causes due to the imbalanced diet, cholesterol rich food and obesity**,** Smoking, Alcohol consumption**,** Stress, anxieties, Loss of elasticity of arteries, arthrosclerosis**,** Coronary thrombosis and Kidney failure
- **Hypotension or low BP:** It is the condition when the systolic and diastolic blood pressure is 100/60 or below persistently. Causes due to the unbalanced diet, less nutrient food, Loss of blood or less volume of blood and Vasodilation**]**

13. **Pulse Pressure:** Difference between systolic and diastolic blood pressure.
14. **Pulse:** Pulse is the contraction in wall of arteries in the form of wave due to pump out of the blood forcefully from left ventricle to arteries during ventricular contraction. It is easily felt where arteries pass closure to skin surface. The rate of pulse corresponding to the rate of heart beat. It is about 100-140 per minute in infant, children- 80-120/minute, adult 70-80/minute and older people 60-70/minute.

Blood vessels

Blood flows through the system of tubes present in the body called blood vessels. The wall of blood vessel is made of three layers except capillary. They are tunica externa, tunica media and tunica interna.

- Tunica externa: It is an outermost layer that made of loosely arranged elastic and collagen fibers.
- Tunica media: It is a middle layer that made of circular smooth muscle fibers and elastic fibers.

- Tunica interna: It is an innermost layer that made of squamous endothelium.

Types of blood vessels: There are three types of blood vessels present in the body of man.

1. **Arteries:** Those bloods vessels that carry away the blood from heart to different parts of body is called arteries. They have thick wall specially tunica media. Branches of arteries called arterioles and fine branches of arterioles called capillaries.
2. **Veins:** Those bloods vessels that bring the blood from different parts of body to heart is called veins. They have thin wall than arteries and possess valves. They form by union of venules and union of capillaries forms venule.
3. **Capillaries:** They are the finest and thin-walled blood vessels. Their wall composed of single layer of squamous endothelium. Capillaries are permeable for free movement of substances from blood to tissues and vice versa.

Arterial System

Blood vessels that carry away the blood from heart is known as arteries. The network forms by the arteries and their branches for distribution of substances present in blood to different parts of body is called arterial system. It supplies the blood through aortic system and pulmonary system. This system supplies pure blood to body organs and impure blood to lungs.

A. **Pulmonary aorta**- It arises from anterio-ventral part of right ventricle and divides into two branches; right and left pulmonary arteries and they supply impure blood to two lungs.
B. **Systemic aorta**- It arises from anterior ventral part of the left ventricle. It carries oxygenated blood from left ventricle and distributes to different parts of body through many arteries. Main arteries are following;

1. **Coronary arteries**- Systemic aorta gives a pair of coronary arteries to supply pure blood to heart muscle.

Systemic aorta curves left ward, passing ventral to trachea and gives off three arteries: **innominate**, **left common carotid** and **left subclavian** arteries. **Innominate artery** is an anterior, short and stout artery. It divides into **right common carotid** and **right subclavian**. Left common carotid artery originates in middle and left subclavian originates at posterior side.

2. **Right and left common carotid arteries**- They ascend up through neck and divide into two branches near to jaw angle; outer **internal** and inner **external carotid**.

- Internal carotid- it supplies pure blood to brain, eyes, fore head etc.
- External carotid- it supplies to low jaw, tongue, face and neck region.

3. **Right and left Subclavian arteries**- Subclavian artery runs outward and give **vertebral, internal mammary and auxiliary** arteries.

- Vertebral artery- shoulder, neck, vertebral column etc.,
- Internal mammary artery- ventral thoracic wall

- Auxiliary artery- enters into the forelimb (hand) and becomes brachial artery and supplies blood to forelimb.

4. **Dorsal aorta**- The systemic aorta loops around the left bronchus to become dorsal to heart and runs downward mid dorsally just beneath vertebral column. It is now known as the **dorsal aorta**. It penetrates the diaphragm, enters into abdominal cavity and extends up to tip of the toes of body. On its way, it gives many branches.

In thoracic region, dorsal aorta gives following branches:

5. **Bronchial arteries** – They supply blood to connective tissue and bronchi.
6. **Oesophageal artery**- It supplies blood to oesophagus.
7. **Intercostal arteries**- A pair of intercostal arteries supply blood to intercostal muscles and ribs.

In abdominal region, dorsal aorta gives following branches:

8. **Inferior phrenic arteries**- One pair of inferior phrenic arteries supply blood to the lower part of diaphragm.
9. **Coeliac artery**- It divides into the **hepatic, left gastric and splenic arteries**.

- **Hepatic artery** supplies blood to liver.
- **Left gastric** artery supplies blood to stomach
- **Splenic artery** supplies blood artery spleen.

10. **Superior or Anterior mesenteric artery**- It supplies blood to small intestine, pancreas, caecum and some part of colon.
11. **Renal arteries**- The right and left renal arteries supply blood to the kidneys and adrenal glands.
12. **Genital arteries**- The genital arteries supply blood to testes in male and ovaries in female.
13. **Lumber arteries**- Four pairs of lumbar arteries supply blood to the wall of abdomen.
14. **Posterior mesenteric artery**- supplies blood to colon and rectum.
15. **Common iliac arteries**- The dorsal aorta divides into two branches called right and left common iliac arteries. Each iliac artery enters into each respective hind limb and divides into **internal and external iliac** arteries.

- **Internal iliac artery** supplies blood to posterior visceral organs and urinary bladder.
- **External iliac artery** supplies blood to hind limb.

Venous System:

Blood vessels that bring the blood to heart from different parts of body is known as veins. The network form by the veins and their branches for collecting the blood from different parts of body is called venous system. This system is for collection of pure blood from lungs and impure blood from rest of the parts of body. The venous system of man is formed by following veins;

A. Pulmonary veins
B. Pre- caval vein or superior venacava

C. Post caval vein or inferior venacava
D. Hepatic portal system

A. **Pulmonary veins**- Four pulmonary veins collect pure blood form lungs and open into left atrium.
B. **Superior venacava**- Superior venacava collects deoxygenated blood from anterior part of body and opens into right auricle. Right and left innominate or brachio-cephalic veins join to form superior venacava. Each innominate is made by union of external jugular, internal jugular and subclavian veins.

1. External jugular vein collects blood from head region such jaw, tongue, and neck.
2. Internal jugular vein collects blood from brain, eyes, fore head etc.
3. Subclavian vein collects blood from fore limb, shoulder and upper part of thoracic region etc. Union of axillary and cephalic veins makes the subclavian vein.

- Axillary vein collects blood from fore limb
- Cephalic vein collects the blood from arm and shoulder.

Subclavian vein receives the internal mammary, superior intercostal vein and inferior thyroid vein etc., during its course.

- Internal mammary collects the blood from certain muscles and mammary gland.
- Inferior thyroid vein collects the blood from thyroid gland.
- Superior intercostal vein collects the blood from of upper part of thorax.

4. Azygous vein is a long, slender vein originating in abdominal region. It collects blood from right side of chest region and opens into Superior venacava.
5. Hemiazygous vein collects blood from left side of chest region and opens into superior venacava.
6. Coronary veins- A pair of coronary veins collect impure blood from heart muscle and opens into superior venacava.

C. **Inferior venacava**-

Two common iliac veins join to make the **inferior venacava** at pelvis region. Internal iliac and external iliac veins unite with each other, forming an iliac vein.

- **Internal iliac vein**- It is short and thin vein that collects blood from posterior visceral organs and pelvic girdle, sacrum etc.
- **External iliac vein**- It collects venous blood from respective leg.

Inferior venacava runs upward mid-dorsally and opens in right auricle. It receives following different veins during course of upward moving.

- Lumbar veins - Four pairs of lumbar veins collect blood from the wall of abdomen.
- Genital veins - The genital arteries supply blood to testes in male and ovaries in female.

- Renal veins - The right and left renal veins collect blood from the kidneys and adrenal glands.
- Hepatic veins- Two short and thick hepatic veins collect blood from liver.
- Inferior phrenic veins - One pair of inferior phrenic vein collect blood from the lower part of diaphragm.

D. **Hepatic portal system**- A portal system is vascular system that begins and ends with capillary beds and has no pumping mechanism between two capillary beds. The portal system that begins with capillaries of alimentary canal and ends with capillaries of liver is called hepatic portal system. The blood collected from different parts of alimentary canal are not directly carried to the heart. It is taken to liver by hepatic portal vein. The hepatic portal vein is formed by union of following veins;

- Gastric vein- It collects blood from stomach.
- Duodenal vein- It collects blood from duodenum.
- Anterior mesenteric vein- It collects blood from small intestine, caecum and parts of colon etc.
- Inferior or posterior mesenteric vein- It collects blood from large intestine.
- Cystic vein- It collects blood from gall bladder.
- Pancreatic vein- It collects blood from pancreas.
- Splenic vein- It collects blood from spleen.

Importance of hepatic portal system

- Stores excess glucose in the form of glycogen
- Converts highly poisonous ammonia into less poisonous urea by deamination process.
- The Kupffer's cells of liver kill Bacteria, germs and other debris etc., from blood and protect from diseases.
- Detoxifies certain poisonous substances absorbed through the food.
- Excretion of unwanted substances.

[Note: Immune system: It is defensive system of blood to protect body from different types of diseases, pathogens and toxins etc. **Immunity:** It is power of resistance of body against harmful agents. Withstand against the harmful agents like diseases, pathogens and toxins etc. is called **Immune**.

- **Antigen:** Any substance that capable to stimulate an immune response is called antigen. They are generally large protein or polysaccharides molecules present on wall of bacteria, capsid of viruses or on cell membrane of red blood corpuscles (RBCs) etc.
- **Antibodies:** Protective chemical molecules produce by body in response to foreign antigens is known as antibodies. They are always made-up protein and antigen specific. They are present in plasma of blood

- **Immune reaction**: When same type of antigen and antibody come in contact, clumping or coagulation occur. This process is called antigen-antibody reaction or immune reaction.]

Blood Types or Blood grouping:

Presence or absence of certain antigen on the surface of the red blood cells and antibodies in plasma of blood is called blood group. Although there are a number of different blood group systems, the two main blood group systems are used i.e., ABO blood group system and Rh (*Rhesus*) blood group system.

1. **ABO blood group system:** The ABO system is use to determine the different types of antigens in the red blood cells and antibodies in the plasma. There are four ABO blood groups: A, B, O and AB blood groups. It is importance during blood transfusion. If blood group is not compatible during transfusion, there will be clumping of RBCs due to antigen-antibody reaction and blood clotted block the small blood vessels that disturb the smooth circulation of blood and cause the death of recipient. [Karl Landsteiner in 1900 AD discovered blood groups A, B and O. De Castello and Strule in 1902 AD discovered blood group AB]

Blood group	Antigen on cell membrane of RBC	Antibody in plasma	Blood can give to blood group	Blood can take from blood group
Blood group A	A	Antibody a	A and AB	A and O
Blood group B	B	Antibody b	B and AB	B and O
Blood group O	No antigen	Antibodies a and b	A, B and AB	O
Blood group AB	Both antigen	No antibody	AB	A, B, O and AB

Possible blood groups of parents and their children:

Crossing blood groups of parents	Possible Blood Group of their children	Impossible blood group of their children
A X A	A or O	B, AB
B X B	B or O	A, AB
A X B	A, B, O and AB	None
A X O	A and O	B and AB
B X O	B and O	A and AB
O X O	O	A, B, AB
AB X O	A, B	AB and O
A X AB	A, B and AB	O
B X AB	A, B and AB	O
AB X AB	A, B	AB and O

2. **Rhesus (Rh) factor:**

The red blood cells have an additional antigen known as the D-antigen. Landsteiner and Wiener isolated this antigen in 1940 AD. If a person's red blood cells contains D-

antigen, then he /she has Rh $^{+}$ve blood group and it is found about 80% of people. If a person red blood cells does not contain D-antigen, then he /she has Rh^{-}ve blood group. Rh positive is dominant and Rh-negative recessive.

Role of Rh factor:

a. **During blood transfusion:** Intravenous administration of blood into body of person for restoring normal blood volume is called blood transfusion. When a person loss more than 40% of blood, the person's body unable to regain the lost volume of blood and require blood transfusion. Blood group should be compatible between donor and recipient for transfusion to avoid antigen-antibody reaction and blood clotting in recipient body.
b. **During pregnancy in woman:** The Rh factor does not affect health except during pregnancy. A woman has a negative Rh factor and her partner has a positive Rh factor. This combination can produce a child who is Rh positive. When the blood from the foetus or baby can enter into the mother's system, this can cause the mother to create antibodies against the positive Rh factor. The antibodies of mother body will then attack Rh-positive baby's blood, causing the breaking down of the red blood cells and even death of the baby. It rarely cause a problem in first pregnancies and child can born alive due to less amounts of antibodies in mother's body. From the second pregnancy and onward, there will be death or still babies' birth due to the antibodies in the mother body react with Rh-positive baby's blood. This killing of baby inside the uterus of mother due to antigen-antibodies reaction is called **Erythroblastosis foetalis**.

Importance of blood group

- Need to know the blood group at time of blood transfusion. If incompatible blood is transfer, it can cause death of recipient.
- Certain blood groups are rare at certain locality. If prior know the rare blood group, at time of emergency, these blood group can manage beforehand.
- To find blood related disease and complication
- To solve the question of paternity in society
- Find out the criminal involved in crime.