

Body Fluids and Circulation

Syllabus

Body fluids and circulation: Composition of blood, blood groups, coagulation of blood; Composition of lymph and its function; Human circulatory system-Structure of human heart and blood vessels; Cardiac cycle, cardiac output, ECG, Double circulation; Regulation of cardiac activity; Disorders of circulatory system-Hypertension, Coronary artery disease, Angina pectoris, Heart failure.

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- Circulatory system consists of a heart (pumping organ), arteries and arterioles, and venules (bring blood back to heart) and capillaries (connecting arterioles and venules). Circulation is of two types :
- 1. **Single Circulation:** When blood flows through heart only once during its course of circulation *e.g.* invertebrates and fish.
- 2. **Double Circulation :** When blood flows through heart twice during its course of circulation *e.g.* amphibians, reptiles, birds and mammals.
- In amphibians and reptiles, the left atrium receives oxygenated blood from the gills/ lungs/skin and the right atrium gets deoxygenated blood from other body parts.
- However, they get mixed up in the single ventricle which pumps out mixed blood (incomplete double circulation).
- In birds and mammals, oxygenated and deoxygenated blood received by the left and right atria respectively passes onto the ventricles of the same sides.
- The ventricles pump it out without any mixing up *i.e.* two separate circulatory pathway are present in these organisms, hence, these have complete double circulation.
- Depending upon the medium of transportation circulatory system is divided into:
 - (a) **Water vascular system :** Water is the medium of transportation. *e.g.* In sponges (water canal system), in *Hydra* (Gastro-vascular system) and in star fish (Ambulacral system).

- (b) **Blood vascular system:** Blood is the medium of transportation. It is of two types:
- (i) **Open circulatory system :** Blood flows through vessels which open into tissue spaces or membrane lined sinuses, *e.g.*, arthropods, non-cephalopod molluscs and tunicates.
- (ii) **Closed circulatory system:** Blood flows through heart, vessels and finely branched capillaries, without coming in direct contact with body tissues or body cavity. It was discovered by **William Harvey**.

Comparison of Open and Closed Circulatory Systems

Open Systems	Closed Systems
1. These are usually low pressure systems. 2. Blood is conveyed directly to the organs without formation of capillaries. 3. Distribution of blood to different organs is not well regulated. 4. Blood returns to the heart slowly. 5. Found in leeches, most arthropods, non-cephalopod molluscs and tunicates.	1. These are usually high pressure systems. 2. Blood is conveyed directly to the organs through capillaries. 3. Distribution of blood to different organs is well regulated. 4. Blood returns to the heart rapidly. 5. Found in annelids (except leeches), cephalopods (octopus, squids) and vertebrates.

TYPES OF HEART

(a) On the basis of type of blood

- (i) **Venous Heart:** Receives deoxygenated blood only. *e.g.*, fishes (as heart receives deoxygenated blood from all over body except gills).
- (ii) **Arterio-venous Heart :** Receives deoxygenated blood from body and oxygenated blood from the lungs/gills. *e.g.*, amphibians, reptiles, birds, mammals.

(b) On the basis of origin of Impulse, the hearts are of two types

- (i) **Myogenic :** Impulse for heart beat originates in heart muscles (pace maker) *e.g.* Chordates and Molluscs (Octopus)
- (ii) **Neurogenic :** Impulse for heart beat is brought about by nerves *e.g.*, most Invertebrates.

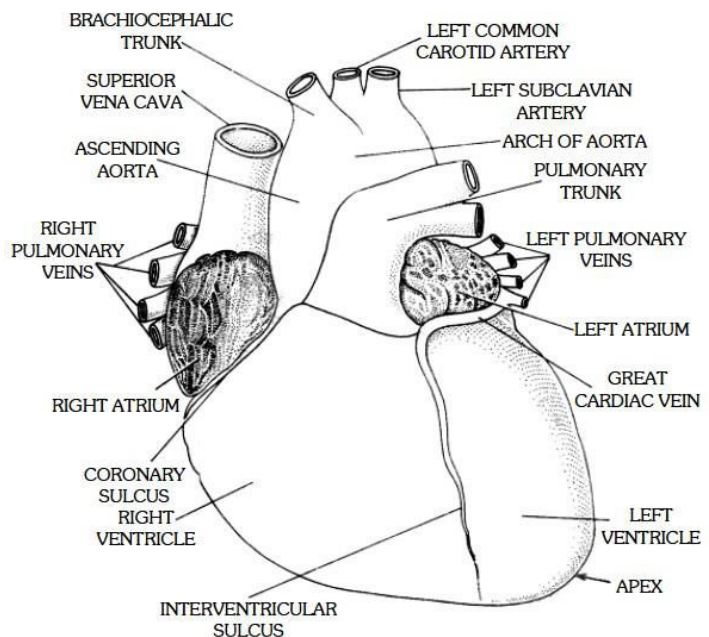
(c) On the basis of structure, the hearts are of following types

- (i) Tubular Hearts -*e.g.* Insects (cockroach -13 chambered heart)
- (ii) Pulsating Vessels -Annelids, Holothurians and *Amphioxus*.
- (iii) Chambered Hearts -Hearts of vertebrates and Molluscs.
- (iv) Ampullar accessory hearts -Branchial hearts of cephalopods (*e.g.* *Octopus*), insects, heart bulbils of *Amphioxus*, lymph hearts of frog.

HEART

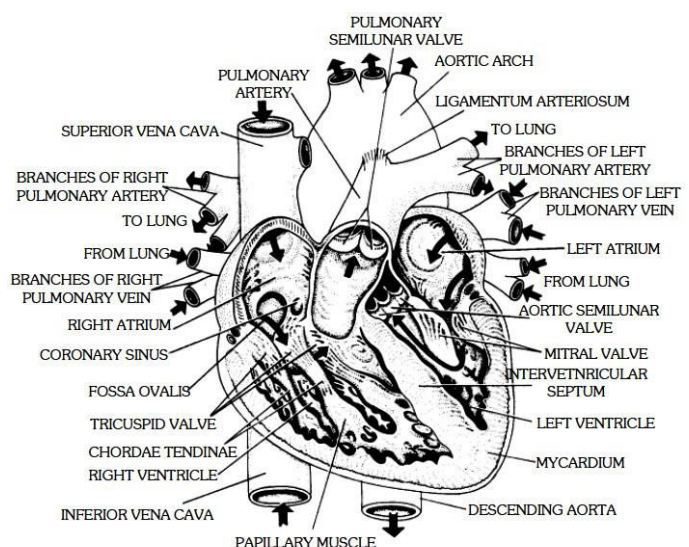
- Heart is situated in the **pericardial cavity**, in mediastinal space.
- Its covering is called **pericardium** which is double walled -outer parietal pericardium and inner visceral pericardium.

- In between these two is present pericardial cavity filled with pericardial fluid.
- Wall of heart is made up of 3 layers.
- Outermost is **epicardium**, middle **myocardium** (consisting of cardiac muscles) and innermost lining is **endocardium**.
- Cardiac muscle is syncytium in functional terms because of intercalated discs.
- These are function points between two muscle spindles with an electrical resistance of 1/400th than any membrane.



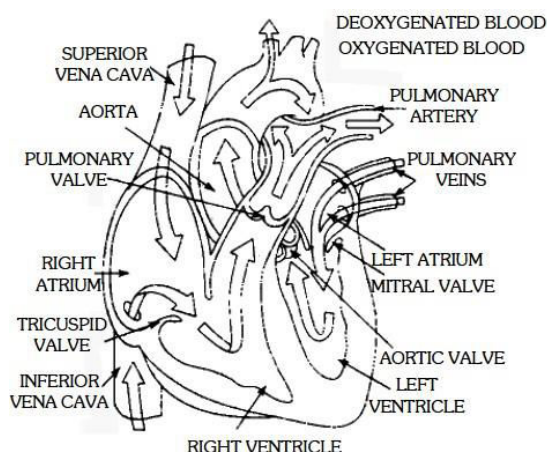
Human heart in front view

- Heart is four chambered.
- Sinus venosus and conus arteriosus are not present with human heart.
- Auricle or atrium is divided by an interatrial septum into right and left auricles.
- On this septum a depression **fossa ovalis** is present which is remnant of embryonic **foramen ovale**, an aperture present between right and left auricles.
- Three large veins pour blood in the right auricle by separate pores.
- **Eustachian valve** guards the opening of post caval.
- A **coronary or thebesian valve** is present at the opening of coronary sinus.
- Two pulmonary veins bring oxygenated blood into left auricle.
- The opening of pulmonary vein is without any *valve* as its opening is oblique, which prevents back flow of blood.
- Ventricle is also divided by an interventricular septum.
- Auricles open into ventricles by separate atrioventricular apertures.
- In the right side is present **tricuspid valve** and in the left side is present **bicuspid or mitral valve**.
- The cuspid *valves* are connected below to the walls of ventricles by **chordae tendinae** which terminate on the papillary muscles.



Internal Structure of Human Heart

- Right ventricle receives the deoxygenated blood from the right atrium and pumps it into pulmonary trunk arising from it.
- Pulmonary trunk bifurcates to form right and left pulmonary arteries which supply deoxygenated blood to the lungs of the respective side.
- Left ventricle receives oxygenated blood from the left atrium and sends it into ascending aorta which puts blood into the coronary arteries and the systemic circulation of the body.
- Origin of pulmonary trunk and ascending aorta is guarded by a set of three semilunar *valves* in each.
- This **Internal Structure of Human heart** is to prevent the back flow of blood.
- The inner surface of ventricle has a number of irregular muscular ridges called **trabeculae carneae** or **columnae carneae**.
- Large protrusions -**papillary muscles** also present.
- These are inserted at ventricular wall at one end and continued at the other end with collagenous cords called **chordae tendinae**.
- These prevent the pushing of flaps into atrium during ventricular contraction.
- In the right ventricle, a muscular band connects the interventricular septum with the parietal wall of the ventricle.
- It is called **moderator band** which is a component of larger septomarginal trabecula.
- Left ventricle has the thickest muscles because it pumps the blood to the whole body.



Human heart showing flow of blood

Working of Human Heart

- The heart shows alternate contraction and dilation of its chambers. Contraction is known as **systole** while dilation is called **diastole**.
- The heart is said to be in the state of joint **diastole** when all its four chambers are in relaxed state.
- In this state the atria receive blood. Atrial systole forces the blood from atria into the ventricles, the left ventricle receives the oxygenated blood whereas the right ventricle receives deoxygenated blood.
- As the ventricular systole starts, the cuspid valves close, and the blood from the ventricles is forced into the great arteries.
- Oxygenated blood from left ventricle enters aortic arch and is carried to all parts of body except lungs.
- The deoxygenated blood from right ventricle reaches the pulmonary arch and is carried to the lungs.

- As the ventricles begin to relax, the semilunar valves close and prevent the return of blood from the two arches.
- The action potential of heart muscle differs from that of skeletal muscle.
- One heart beat completes in 0.8 second (Atrial systole = 0.1 s; Atrial diastole = 0.7 s; Ventricular systole = 0.3 s, and Ventricular diastole = 0.5 s). Thus, there are 72 heart beats per minute on an average when a person is performing normal work.

Cardiac Cycle

- During a heart beat, there is contraction and relaxation of auricles and ventricles in a specific sequence.
- The contraction phase is known as **systole** while relaxation phase is known as **diastole**. Various series of events that occur during a heart beat is known as **cardiac cycle**.
- During joint diastole phase, the blood flows into the right auricle from the superior vena cava and inferior vena cava.
- The blood also flows from the auricles to their respective ventricles through the atrio-ventricular valves.
- There is no flow of blood from the ventricles to the aorta and its main arteries as the semilunar valves remain closed in this phase.
- At the end of joint diastole, the auricles contract or they come into the **systolic phase**. In this phase, it now forces most of its blood into the ventricles which is still in the diastolic phase.
- During auricular systole, the blood cannot pass back into the superior and inferior vena cavae because they are compressed by the atrial contraction.
- Thus atrium acts as a main vessel to collect and pump the venous blood into the ventricles. Thus at the end of atrial systole, the atria get empty.
- After the atrial systole is over, the atrial muscles relax and it enters into **atrial diastolic phase**.
- During atrial diastole, it again gets filled up with the venous blood coming from the superior and inferior vena cavae.
- Along with the atrial diastole, the **ventricular systole** starts.
- This results in an increased pressure of blood in the ventricle and it rises more than the pressure of blood in the atria.
- Soon the atrio-ventricular valves are closed and thus the back flow of blood is prevented.
- **This closure of AV-valves at the beginning of ventricular systole produces a sound "lubb" and is known as the first heart sound.** Initially, when the ventricle starts contracting, the pressure of blood within it is lower than the pressure of blood within the aorta and so the semilunar valves do not open.
- Therefore, the ventricles now contract as closed chambers. As the ventricular systole progresses, the pressure of blood within the ventricles increases more than that of aorta.
- As a result, the semilunar valves now open and blood flows (with a speed) into the aorta and its main branches.
- The period between closure of AV valve and opening of semilunar valve is called **Isovolumetric systole/contraction**.

- The back flow of blood in the atria is prevented as the AV-valves remain closed .
- Now at the end of ventricular systole, **ventricular diastole** starts.
- As the atria are still in diastole, so all the four chambers are now in diastole.
- This is known as **joint diastole**.
- In the ventricular diastolic phase, the pressure of blood in the ventricles falls below the pressure of blood in the aorta, so the semilunar valves gets closed to prevent the back flow of blood from the aorta to the ventricles.
- **This closure of semilunar valves at the beginning of ventricular diastole produces a sound "dup" and is known as the second heart sound.**
- After the closure of the semilunar valves, the ventricles become closed chambers again. Also, as the ventricular pressure is more than the atrial pressure, so the AV-valves remain closed.
- However, as the ventricular diastole continues, the pressure of blood in the ventricles falls below the pressure of blood in the atria.
- At this point, the AV-valves open and blood starts flowing again from the relaxed atria to the relaxed ventricles.
- The duration between closure of semilunar valves and opening of AV-valves is called **Isovolumetric diastole/relaxation**.
- When the joint diastole is over, the atrial systole starts and the blood is pumped into the ventricles.
- Ventricular filling of the blood can be divided into three phases :
 - (i) **First Rapid Filling:** With the beginning of ventricular diastole, intraventricular pressure declines and AV valves open. Due to it, blood already stored in atria, rushes into ventricles rapidly. This also creates a sound -3rd sound of heart.
 - (ii) **Diastasis/Slow Filling:** After the first rapid rushing of blood, blood keeps on entering ventricles, though at a slow rate -diastasis.
 - (iii) **Second Rapid Filling:** This occurs with the atrial systole which again causes rapid squeezing of blood into the ventricles. This creates 4th sound of heart.

Concept Builder

1. Cardiac output rises during exercise. In very severe exercise, it may rise to even 20 litres per minute, about four to five fold the normal resting value of about 5 litres per minute. The rise in the cardiac output helps the body in exercise by enhancing manifold the supply of nutrients and oxygen to the contracting muscles.
2. **HDLs (High Density Lipoproteins) :** High levels of HDL in the blood may help to reduce our risk of coronary heart diseases. HDLs are the good lipoproteins. They contain 40-45% proteins, 5-10% triglycerides, 30% phospholipids and 20% cholesterol, they remove excess of cholesterol from body cells and the blood and transport it to the liver for elimination. Because HDLs prevent accumulation of cholesterol in the blood, a high HDL level is associated with decreased risk of coronary artery disease.

3. **LDLs (Low Density Lipoproteins)** : LDLs contain 25% protein, 5% triglycerides, 20% phospholipids and 50% cholesterol. When present in excessive numbers, LDLs deposit cholesterol in and around smooth muscle fibres in arteries, forming 'fatty plaques' that increase the risk of coronary artery disease. For this reason, the cholesterol in LDLs is known as "bad" cholesterol.

Conceptual Questions

Some babies are born with a hole in the septum between the atria or ventricles. Based on what you know about blood flow through the heart, explain why this condition would be harmful to the baby.

A man's arm is cut by a piece of glass. Blood comes out of the wound in rapid spurts. Which type of vessel was cut?

- Ans.** 1. Such a baby is called as blue baby. The deoxygenated blood might mix with oxygenated blood and hence would not get enough oxygen.
2. An artery was cut.

Heart Beat

Physiological properties of cardiac (heart) muscle:

- Excitability and contractility.
- It obeys all-or-none principle.
- It has longer refractory period therefore it never develops fatigue.
- It does not show summation or tetanus.
- It shows conductivity and rhythmicity.

Origin of Heart Beat:

- The mammalian heart is a **myogenic heart**, *i.e.*, the heart beat originates from the muscles (however, it is regulated by nerves).
- In the right atrium, near the region where superior vena cava opens, a specialised group of muscle fibres called **sinu-auricular node** (SA-node) is present from where the heart beat originates.
- It is also called **pace maker** and is richly supplied with blood capillaries. A wave of contraction (systole) originates from it and spreads over to the whole heart.

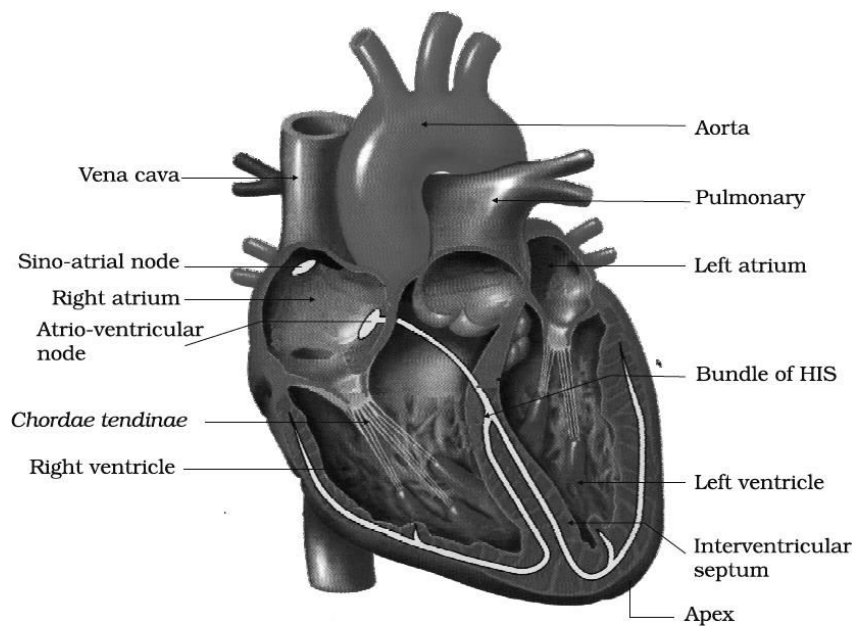
Conduction of Heart Beat :

- At the junction of right atrium and right ventricle, a tissue called **auriculo-ventricular node** (AV-node) is present that picks up the wave of contraction propagated by SA-node.
- This is also known as **bundle of His**.
- Its branches spread over the ventricles forming the Purkinje system.
- The wave of contraction spreads over the ventricle through AV-node and its Purkinje system.

Regulation of Heart Beat:

- Normal activities of the heart are regulated intrinsically, *i.e.*, auto regulated by specialised muscles (nodal tissue), hence the heart is called **myogenic**.

- A special neural centre in the medulla oblongata can moderate the cardiac function through autonomic nervous system (ANS).
 - Neural signals through the sympathetic nerves (part of ANS) can increase the rate of heart beat, the strength of ventricular contraction and thereby the cardiac output.
 - On the other hand, parasympathetic neural signals (another component of ANS) decrease the rate of heart beat, speed of conduction of action potential and thereby the cardiac output.
 - This happens because these nerves release chemicals (hormones) when stimulated. Adrenal medullary hormones can also increase the cardiac output.
- (i) High levels of potassium and sodium ions decrease heart rate and strength of contraction.
 - (ii) An excess of calcium ions increases heart rate.
 - (iii) Increased body temperature during fever increases heart rate.
 - (iv) Strong emotions such as fear, anger and anxiety increase heart rate, resulting in increased blood pressure.
 - (v) Mental states such as **depression** and **grief** decrease heart rate.
 - (vi) The heart beat is somewhat faster in females.
 - (vii) The heart beat is fastest at birth, moderately fast in youth, average in adulthood and above average in old age.



Section of human heart

Heart Sounds

- These are caused due to sudden closure of the valves of heart. There are mainly two sounds.
- (i) **First Sound** : Occurs at the onset of ventricular systole and is caused due to the sudden closure of AV valves and the ejection of blood from the ventricles. It is dull and pronounced as **L -U -B**.
 - (ii) **Second Sound** : Occurs at the onset of ventricular diastole and is caused by sudden closure of the semilunar valves of the aorta and pulmonary artery. It is short and sharp like the word **D -U -P**.

The sequence of both these sounds is like this : first sound → second sound → pause; first sound → second sound → pause; so on. Sometimes if damage occurs as in **rheumatic fever**, blood may leak out through the valves and a characteristic sound **mur-mur** is produced.

Pulse Rate

- The blood is pumped from the ventricles of the heart into the aorta to be distributed to all the parts of the body.
- This happens during the ventricular systole and is repeated after every 0.8 seconds.
- The blood from aorta then goes to other arteries of the body.
- This causes a rhythmic contraction of the aorta and its main arteries and is felt as regular jerks or pulse in them.
- It can be felt in the regions where arteries are present superficially like wrist, neck and temples.
- The pulse rate is, therefore, same as that of heart beat rate.

BLOOD VESSELS AND COURSE OF CIRCULATION OF BLOOD

Arterioles :

- Arterioles are small arteries that deliver blood to capillaries. Arterioles also have smooth muscles on their walls.
- Contraction and relaxation of these muscles alter the diameter of arterioles and thereby respectively reduce and increase the blood flow through them.

Capillaries :

- Capillaries were discovered by **Malpighi in 1661**.
- Capillaries are the smallest blood vessels in the body.
- Capillary has no muscular wall.
- Its wall is made of a single layer of flat endothelial cells and is consequently very permeable to water and small solutes, but not to proteins and other macromolecules.
- The diameter of lumen of capillaries is from 7.5 µm to 75 µm. Only about 5 to 7% of the total volume of blood is contained in the capillaries.

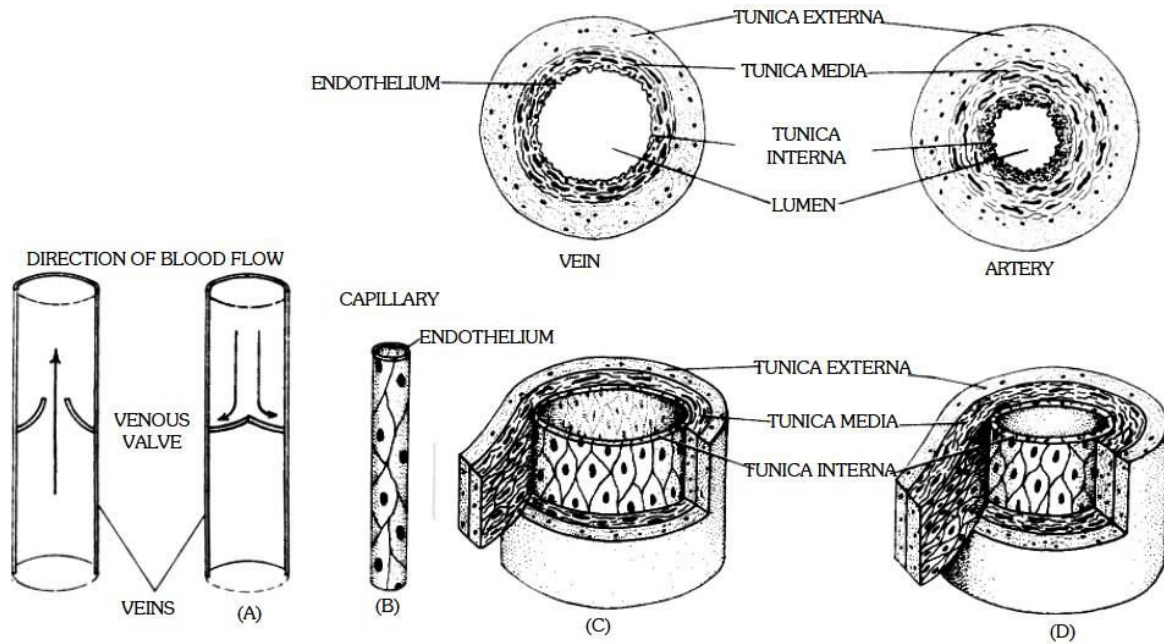
Venules :

- Venules are small vessels that continue from capillaries and merge to form veins. They drain blood from capillaries into veins.

Veins:

- Veins have less elastic tissue and smooth muscle than arteries.
- One major difference between an artery and vein is that vein has a thin muscular wall.
- Veins contain valves to prevent backflow of blood.
- Valves are necessary in veins but not in arteries because pressure in veins is low to push the blood.
- Weak valves can lead to varicose veins or **haemorrhoids**.
- All veins carry deoxygenated blood except **pulmonary veins**.
- Pulmonary veins carry oxygenated blood from lungs back to heart.
- Blood vessels that carry blood from lungs to heart are called pulmonary veins.
- Wall of veins is collapsible (non collapsible in arteries).

- Lumen of vein is wider and narrower than arteries.
- Most veins are located close to skin (deep in body in case of arteries).

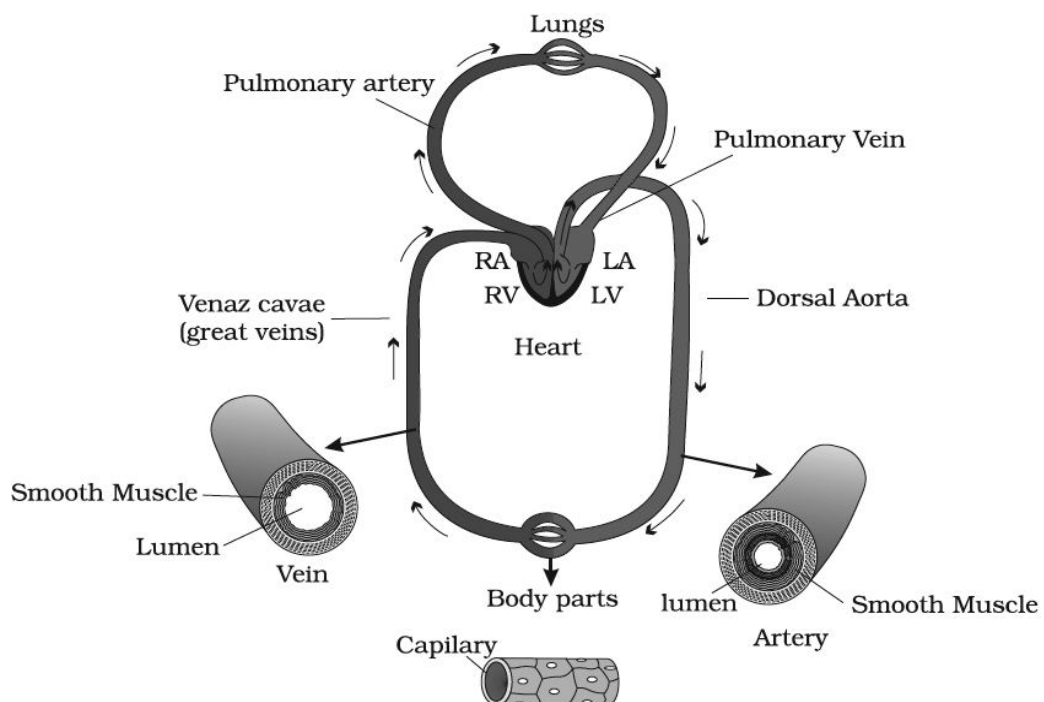


(A) Venous valves, (B-D) Histology of the blood vessels

- **Vasa Vasorum** : Blood vessels which supply blood to blood vessel are 'vasa vasorum'.

Course of Circulation of Blood

- There are three types of circulation :
 - (a) Pulmonary circulation: from heart to the lungs and back.
 - (b) Systemic circulation: when blood is passed to different parts of the body.
 - (c) Portal circulation



Schematic plan of blood circulation in human

Main Arteries and Veins w.r.t. Organ

	Supplying artery	Organ	Collecting vein
	Carotid	→ Head	→ Jugular vein
	Subclavian	→ Arms	→ Subclavian vein
	Intercostal artery	→ Intercostal muscles	→ Intercostal vein (Azygous vein)
	Phrenic artery	→ Diaphragm	→ Phrenic vein
	Hepatic artery	→ Liver	→ Hepatic vein
Coeliac artery Lienogastric artery	Gastric	→ Stomach	→ Superior mesenteric
	Splenic	→ Spleen	→ Splenic vein
	Superior mesenteric artery	→ Small intestine	→ Superior mesenteric
	Inferior mesenteric artery	→ Colon	→ Inferior mesenteric vein
	Renal artery	→ Kidney	→ Renal vein
	Gonadal artery	→ Gonads	→ Gonadal vein
	Ext. Iliac artery	→ Legs	→ Ext. Iliac vein
	Int. Iliac artery (Hypogastric)	→ Urinary bladder	→ Int. Iliac vein

Hepatic portal vein

Self Assessment

Cardiac output is

- (1) Volume of blood pumped by each ventricle in each cardiac cycle
- (2) Volume of blood pumped out by each ventricle per minute
- (3) 5 litres in a healthy individual
- (4) Both (2) & (3)

Which of the following is mismatched?

- (1) Lub First heart sound associated with closure of tricuspid and bicuspid valves
- (2) Cardiac output Stroke volume multiplied by heart rate
- (3) Dup Second heart sound, due to opening of semilunar valves
- (4) Duration of cardiac cycle 0.8 seconds

Atrial systole

- (1) Increases the flow of blood into the ventricles by 70 percent
- (2) Is due to generation of action potential in AVN
- (3) Increases the flow of blood into the ventricles by 30 percent
- (4) Coincides with ventricular systole

Purkinje fibres arise from

- (1) Apex of ventricles
- (2) Middle of ventricles
- (3) Anterior part of atria
- (4) Posterior part of atria

The opening between the right atrium and right ventricle is guarded by a valve called

- (1) Bicuspid valve (2) Mitral valve (3) Tricuspid valve (4) Both (2) & (3)

Which of the following is known as natural pacemaker of the heart?

- (1) Sinu atrial node (2) Atrio ventricular node
(3) Bundle of His (4) Purkinje fibres

All veins carry deoxygenated blood **except**

- (1) Renal artery (2) Hepatic vein
(3) Hepatic portal vein (4) Pulmonary veins

Pulmonary artery differs from pulmonary vein in having

- (1) Thick wall (2) Thin wall (3) Valves (4) Both (2) & (3)

Papillary muscles occur in

- (1) Ventricles (2) Auricles
(3) Atrioventricular valves (4) Pulmonary valves

Origin of heart beat and its conduction is represented by

- (1) AV bundle → Bundle of His → SA node → Purkinje fibres
(2) SA node → Purkinje fibres → AV node → Bundle of His
(3) Purkinje fibres → AV node → Bundle of His → SA node
(4) SA node → AV node → Bundle of His → Purkinje fibres

Ans. Q.1 (4), Q.2 (3), Q.3 (3), Q.4 (1), Q.5 (3), Q.6 (1), Q.7 (4), Q.8 (1), Q.9 (1), Q.10 (4)

PORTAL SYSTEMS

Hepatic portal system –

- Inferior mesenteric, superior mesenteric, duodenal and lienogastric veins join to form hepatic portal vein.
- It pours blood from digestive system into the liver.
- This blood is collected by hepatic veins and poured into post caval to be returned to the heart.
- In fishes and amphibians, **renal portal system** is also found which is reduced in reptiles and birds and is absent in mammals.

Hypophyseal portal system.

- A hypophyseal portal vein collects blood from hypothalamus and enters the anterior lobe of pituitary.

Coronary Circulation

- Two coronary arteries-right and left-branch from the ascending aorta.
- The **left coronary artery** passes inferiorly to the left auricle and divides into the anterior interventricular and circumflex branches.
- The **anterior interventricular branch or left anterior descending (LAD) artery** is in the anterior interventricular sulcus and supplies oxygenated blood to the walls of both ventricles and the interventricular septum.

- The **circumflex branch** lies in the coronary sulcus and distributes oxygenated blood to the walls of the left ventricle and left atrium.
- The **right coronary artery** supplies small branches (atrial branches) to the right atrium.
- It continues inferiorly to the right auricle and divides into the posterior interventricular and marginal branches.
- The **posterior interventricular branch** follows the posterior interventricular sulcus and supplies the walls of the two ventricles and the interventricular septum with oxygenated blood.
- The **marginal branch** in the coronary sulcus transports oxygenated blood to the myocardium of the right ventricle.
- Most parts of the body receive branches from more than one artery and where two or more arteries supply the same region, they usually connect.
- The connections called **anastomoses** provide alternate routes for blood to reach a particular organ or tissue.
- The myocardium contains many anastomoses, connecting branches of one coronary artery or extending between branches of different coronary arteries.
- In a resting person, heart muscles can remain alive if they receive as little as 10 -15% of its normal blood supply, but the person may have little ability to engage in activities.

Coronary Veins

- As blood passes through the coronary circulation, it delivers oxygen and nutrients and collects carbon dioxide and wastes.
- It then drains into a large vascular sinus on the posterior surface of the heart called the **coronary sinus**, which empties into the right atrium.
- A vascular sinus is a venous space with a thin wall that has no smooth muscle to alter its diameter.
- The principal tributaries carrying blood into the coronary sinus are the **great cardiac vein**, which drains the anterior aspect of the heart and the **middle cardiac vein**, which drains the posterior aspect of the heart.

Blood Pressure

- If a person has persistent above 140 mm Hg systolic and above 90 mm Hg diastolic blood pressure, he is said to have high blood pressure or **hypertension**.
- There are a number of factors responsible for it.
- Over-eating and obesity are the most important factors for hypertension.
- Physical and emotional stresses like fear, worry, anxiety, sorrow etc. also cause hypertension.
- People living in big cities usually suffer from hypertension.
- Smoking is also a cause.
- Physical and mental rest is most essential for a patient suffering from hypertension.
- Sometimes, cholesterol starts depositing on the walls of blood vessels when there are high levels of cholesterol in the blood.
- This causes the arteries to lose their elasticity and they become stiff.

- This is known as **arteriosclerosis** or hardening of arteries and as a result the blood pressure rises. This is one of the main causes of **heart attack**.
- **Frank - Starling law** : Two great physiologists Frank and Starling said, greater the heart muscle is stretched during filling phase, greater will be the quantity of blood pumped into the aorta.

LYMPHATIC SYSTEM

- It comprises of lymph, lymphatic capillaries, lymphatic vessels, lymphatic ducts and lymphatic nodes.

1. **Lymphatic capillaries:** They lie close to the blood capillaries but end blindly. They have extremely thin walls. They are composed of a single layer of endothelial cells.

2. **Lymphatic vessels** : The lymphatic capillaries unite to form larger lymphatic vessels. They are composed of an outer coat of fibrous tissue, middle coat of muscular tissue and an inner lining of endothelial cells. The lymphatic vessels have numerous valves. The lymph vessels of intestinal regions absorb the digested fats. They are milky in appearance and are called **lacteals** (laetos : milk).

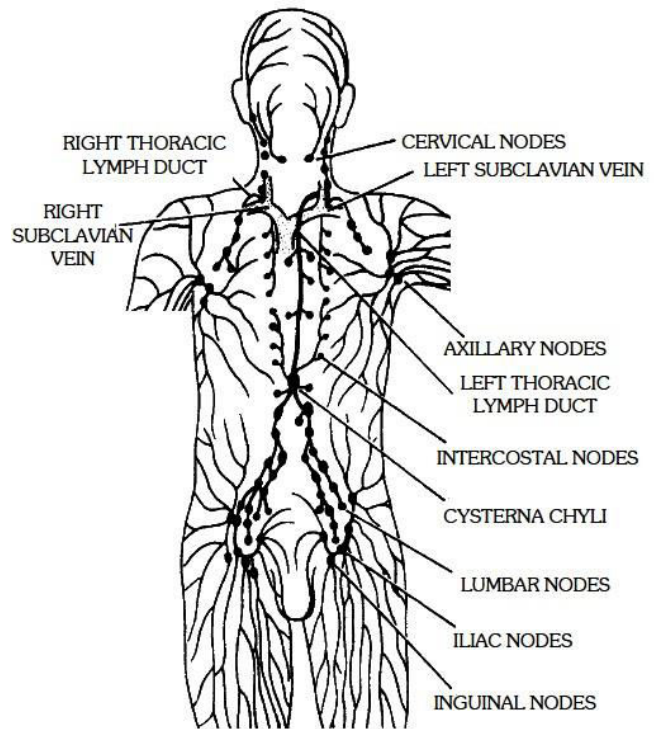
3. **Thoracic duct:** The lymphatic vessel of left side begins at the **cisterna chyli** , present at the level of (anterior to) the first and second lumbar vertebrae. It discharges its lymph into the **left subclavian vein**.

4. **Right lymphatic duct:** The lymphatic vessels of the right side of the thorax, head and neck unite to form the **right lymphatic duct**. It discharges its lymph into the **right subclavian vein** .

5. **Lymphatic nodes:** The lymphatic vessels bear lymph nodes at intervals and are abundant in the neck, armpit and groin. The lymph is filtered through lymph nodes which contain phagocytic white blood corpuscles and macro phages which eat harmful microorganisms and foreign particles from the lymph. Lymph nodes also add lymphocytes and antibodies.

Lymph Movement: The lymph flows slowly and moves from lymphatic vessels, lymphatic ducts to the venous system. Blocking of lymph flow causes oedema.

Lymphoid Organs : The organs which secrete lymph are called lymphoid organs. Besides the lymph nodes, tonsils, thymus gland, Peyer's patches, liver and spleen are the other lymphoid organs that secrete lymph.



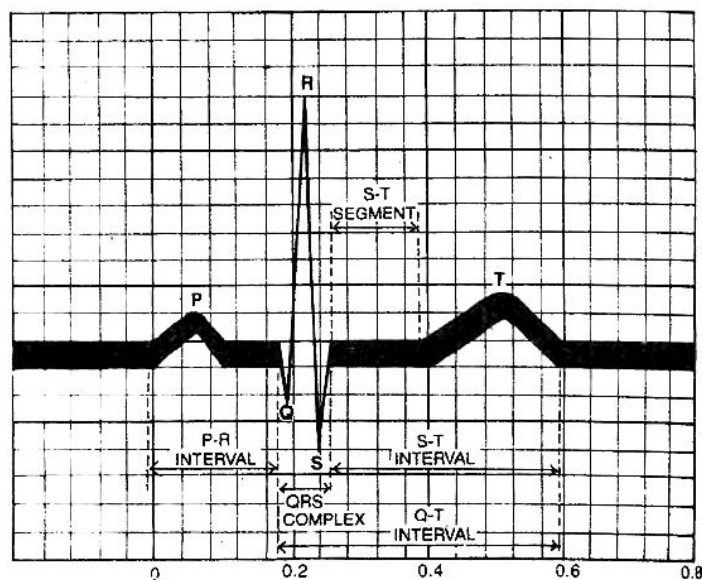
Human Lymphatic System

Functions of Lymph

1. Lymph acts as a "middle man" which transports various proteins, hormones, etc., to the body cells and brings carbon dioxide and other metabolic wastes, from the body cells and finally pours the same into the venous system.
2. Lymph nodes produce lymphocytes. Lymph takes lymphocytes and antibodies from the lymph nodes to the blood.
3. It absorbs and transports fat and fat soluble vitamins from the intestine. Lymph capillaries present in the intestinal villi are called lacteals which are associated with absorption and transportation of fat and fat soluble vitamins.
4. It brings plasma protein macromolecules synthesized in the liver cells and hormones produced, in the endocrine glands to the blood. These molecules can not pass into the narrow blood capillaries but can diffuse into the lymphatic capillaries.
5. Lymph maintains the volume of the blood. As soon as the volume of the blood reduces in the blood vascular system, the lymph rushes from the lymphatic system to the blood vascular system.

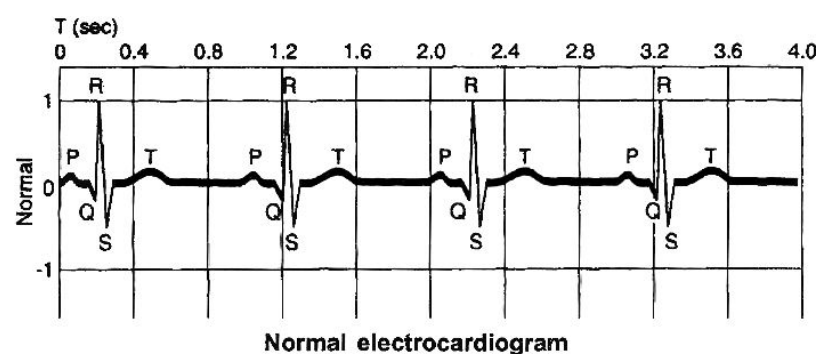
ECG (ELECTROCARDIOGRAM)

- Electric changes of the cardiac chambers follow a specific sequence.
- These changes can be recorded with the help of an apparatus-electrocardiograph.
- The record is called **ECG**.
- It is represented as PQRST; where P = depolarisation of atria; QRS = depolarisation of ventricles and T = repolarisation of ventricles.
- Defects in cardiac function or structure are recorded in the ECG.
- For the purpose of recording, metal electrodes or leads are attached in each arm and leg with the help of straps after cleaning and putting a special jelly, which improves electrical conduction.



Normal ECG of a single heart beat

- An additional electrode is placed on the chest with the help of a rubber suction cup.
- Then, the electrocardiograph is switched on.
- The electrical current of the heart is detected and amplified by the machine and is transmitted to the recording pen that draws a wavy line, called the **deflection waves** (electrocardiogram).
- A normal electrocardiogram is composed of a P wave, a QRS complex and a T wave.
- The QRS complex has three separate Q, R and S waves.
- The P wave is a small upward wave that indicates the depolarisation of the atria or the spread of impulse from the sinus node throughout the atria.
- The second wave, *i.e.*, the QRS complex, begins after a fraction of a second of the P wave.
- It begins as a small downward deflection (Q) and continues as large upright (R) and triangular wave, ending as downward wave (S) at the base.
- This is the expression of the ventricular depolarisation.
- The potential generated by the recovery of ventricle from the depolarisation state is called the **repolarisation** wave.
- In electrocardiography, P-Q interval (also called **PR interval**) is the time taken by the impulse to travel through atria, AV node and the rest of the conducting tissues.
- **During rheumatic fever and in arteriosclerotic heart disease** (*i.e.*, the formation of plaques and calcification), **the P-Q interval lengthens.**
- **This is due to the inflammation of atria and atrioventricular node.**
- **The normal PR interval lasts for 0.16 second.**
- **The enlarged Q and R waves are the indication of myocardial infarction.**
- **The ST interval is the representation of time between the end of the spread of impulse through ventricles and its repolarisation.**
- **The S-T segment is elevated in acute myocardial infarction and depressed in a condition when the heart muscles receive insufficient oxygen.**
- **The ventricular repolarisation is represented as T wave.**
- **When the heart muscles receive insufficient oxygen, then the T wave is flattened.**



PACEMAKER

- During the pumping action of the heart, the atria and the ventricles contract rhythmically.
- The impulse of this wave of contraction begins every time from the SA node (sinus node) present in the right atrium.

- Thus, it can be said that SA node controls the heartbeat and hence, it is the **natural pacemaker** of the heart.
- Pacemaker, in fact, is the rhythmic centre, which establishes a pace of activity.
- Sometimes, a component of the impulse conduction system is disrupted, causing irregularity in the heart rhythm, like failure of receiving the atrial impulse by ventricle or completely independent contraction of the atria and the ventricles.
- Such types of patients are provided with an artificial electronic device, which regularly sends small amount of electrical charge for maintaining the rhythmicity of the heart.
- This device is known as **artificial pacemaker**, which is implanted subcutaneously in the upper thoracic region having a connection with the heart.
- In the patients having the symptoms of **ventricular escape (Stokes, Adams syndrome)**, in which the atrial impulse suddenly fails to be transmitted to the ventricle, which may last for few seconds to few hours even, the artificial pacemaker is connected to the right ventricle for controlling its rhythm.
- The artificial pacemaker consists of a pulse-generator containing cell (solid state lithium cell) to produce electrical impulse, the lead in the form of a wire, which transmits the impulse and an electrode, which is connected to the portion of the heart where impulse is to be transmitted.

Self Assessment

- Q.11 Which of the following wave in ECG represents depolarisation of the atria?
 (1) P wave (2) Q wave (3) QRS wave (4) T-wave
- Q.12 Which of the following wave in ECG marks the end of ventricular systole?
 (1) P-wave (2) Q wave (3) QRS wave (4) T-wave
- Q.13 In ECG, ST segment is elevated in
 (1) Acute myocardial infarction (2) Myocardial ischaemia
 (3) Insufficient supply of oxygen to the heart muscles
 (4) Both (2) & (3)
- Q.14 What would happen if there is failure of receiving the atrial impulse by the ventricles or completely independent contraction of the atria and the ventricles?
 A – Ventricular escape B – Stokes -Adams syndrome
 C – Irregularity in heart rhythm D – Arteriosclerosis
 (1) A only (2) A and B (3) A, Band C (4) A, B, C and D
- Q.15 High blood pressure can potentially harm the vital organs like
 A – Heart B – Brain C – Kidneys D – Lungs
 (1) A and B only (2) Band Conly (3) A, Band C (4) A, B, C and D
- Q.16 The main difference in the structure of arteries and veins is in
 (1) Tunica intima, made up of simple squamous epithelium
 (2) Tunica media
 (3) Tunica externa
 (4) Tunica adventitia

The difference between systolic and diastolic blood pressure is called

- (1) Hypertension (2) Hypotension (3) Pulse pressure (4) Mean blood pressure

Which of the following system returns the blood from intestine and breaks into portal system of capillaries in the liver?

- (1) Renal portal system (2) Hepatic portal system
(3) Lymphatic system (4) Systemic circulation

Lymph

- (1) Transports oxygen to brain
(2) Transports carbon dioxide to lungs
(3) Returns interstitial fluid back to heart
(4) Contains RBCs, leucocytes and more proteins as compared to blood

Which of the following statement is not true about blood pressure?

- (1) Blood pressure is measured with an instrument called sphygmomanometer
(2) If the blood pressure of an individual is 140/90 mm Hg or higher, it shows hypertension
(3) The normal systolic pressure is 120 mm Hg and diastolic pressure is 80 mm Hg.
(4) Hypertension is caused by vasodilation which results in increased resistance to blood flow

Ans. Q.11 (1), Q.12 (4), Q.13 (1), Q.14 (3), Q.15 (3), Q.16 (2), Q.17 (3), Q.18 (2), Q.19 (3), Q.20 (4)

DISEASES OF HEART

Disorders of Circulatory System

High Blood Pressure (Hypertension) :

- Hypertension is the term for blood pressure that is higher than normal (120/80).
- In this measurement, 120 mm Hg (millimetres of mercury pressure) is the systolic, or pumping, pressure and 80 mm Hg is the diastolic, or resting, pressure.
- If repeated checks of blood pressure of an individual is 140/90 (140 over 90) or higher, it shows hypertension.
- High blood pressure leads to heart diseases and also affects vital organs like brain and kidney.

Coronary Artery Disease (CAD) :

- Coronary Artery Disease, often referred to as **atherosclerosis**, affects the vessels that supply blood to the heart muscle.
- It is caused by deposits of calcium, fat, cholesterol and fibrous tissues, which makes the lumen of arteries narrower.

Angina:

- It is also called '**angina pectoris**'.
- A symptom of acute chest pain appears when no enough oxygen is reaching the heart muscle.
- Angina can occur in men and women of any age but it is more common among the middle-aged and elderly.
- It occurs due to conditions that affect the blood flow.

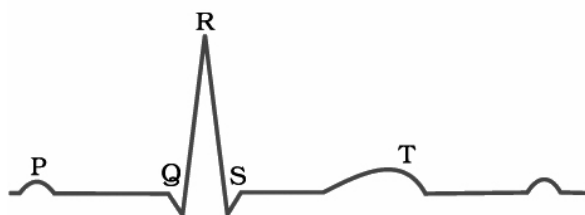
Heart Failure:

- Heart failure means the state of heart when it is not pumping blood effectively enough to meet the needs of the body.
- It is sometimes called congestive heart failure because congestion of the lungs is one of the main symptoms of this disease.
- Heart failure is not the same as cardiac arrest (when the heart stops beating) or a heart attack (when the heart muscle is suddenly damaged by an inadequate blood supply).

Self Assessment

- Q.21 When the heart of frog is cut out and kept in petridish, it will
- (1) Continue to beat for a long time if kept moist
 - (2) Continue to beat for a long time if kept dry
 - (3) Stop beating after some time
 - (4) Not beat at all, as it is a neurogenic heart
- Q.22 Rise in heart beat, increase in the cardiac output, blood pressure and blood sugar occurs during emergency, by the hormone
- (1) Aldosterone
 - (2) Antidiuretic hormone
 - (3) Epinephrine
 - (4) Oxytocin
- Q.23 Decrease in the rate of heart beat, speed of conduction of action potential and thereby the cardiac output is under the control of
- (1) Neural signals through the sympathetic nerves
 - (2) Neural signals through the parasympathetic nerves
 - (3) Adrenaline
 - (4) ANS
- Q.24 Human heart is
- (1) Myogenic
 - (2) Neurogenic
 - (3) Venous
 - (4) Both (1) & (2)
- Q.25 If we give an injection of acetylcholine to a person, rate of heart beat will
- (1) Increase
 - (2) Decrease
 - (3) Increase first then decrease
 - (4) No effect on heart beat
- Q.26 Artificial pacemaker is required when a person is suffering from
- (1) Arteriosclerosis
 - (2) Atherosclerosis
 - (3) Irregularity of heart beat
 - (4) Hypertension
- Q.27 When the heart is **not** pumping the blood effectively enough to meet the needs of the body, it is called
- (1) Heart failure
 - (2) Cardiac arrest
 - (3) Heart attack
 - (4) Angina
- Q.28 A symptom of acute chest pain when enough oxygen is not reaching the heart muscle is called
- (1) Heart attack
 - (2) Angina
 - (3) Cardiac arrest
 - (4) Coronary artery disease

Q.29 Given below is the ECG of a normal human. Which of its components is correctly interpreted below?



- (1) Peak P and Peak R together Systolic and diastolic blood pressure
- (2) Peak P Initiation of left atrial contraction only
- (3) Complex QRS One complete pulse
- (4) Peak T Initiation of total cardiac contraction

Ans. Q.21 (1), Q.22 (3), Q.23 (2), Q.24 (1), Q.25 (2), Q.26 (3), Q.27 (1), Q.28 (2), Q.29 (3)

Concept Builder

1. Lowest level of glucose is in hepatic vein.
2. Highest levels of amino acids are present In hepatic vein.
3. Highest level of urea is in hepatic vein and towest in renal vein.
4. Largest vein in human body-Inferior vena cava.
5. Largest Artery-Aorta.
6. Smallest blood vessel in the body-Blood capillary.
7. The giraffe's blood pressure may be the highest of all animals because it has to pump the blood to the head through long neck.
8. One species of Antarctic fish is the only fish known to have white blood. It has no red pigment in its blood.
9. Frog has two pairs of lymph hearts to pump lymph back into veins.
10. Thrombopenia: Decrease in biood platelet count.
11. Erythropoietin: Hormone secreted by the juxta-glomerular cells of the kidneys.
12. **Circulatory shunts in foetus.**

Foetus bypasses pulmonary system through two shunts-foamen ova le (opening in interatrial septum) and ductus arteriosus (connection between dorsal aorta and pulmonary arCh). Shunts are sealed after birth.

13. Lung fish has 3 chambered heart: two auricles and one ventricle.
14. Crocodiles, alligators and gavialis have four chambered heart (two auricles and two ventricles).
15. The heart of fish is called venous heart because it receives and pumps deoxygenated blood.
16. In human heart, auricles are called **atria** (Sing. atrium).
17. *Nereis* and *Amphioxus* do not have heart. Heart of prawn contains oxygenated blood.
18. There is single blood circulation in fish heart. Hearts of amphibians, reptiles, birds and mammals have double blood circulation. Foramen of Panizzae is present in between two systemic arches (they arise from the heart) of the heart of lizard and crocodiles. Average human heart is about 12 cm. Average weight of human heart-male 300g, female 250 g. The

opening of the coronary sinus into the right atrium is guarded by Thebesian valve. The opening of inferior vena cava into the right atrium has Eustachian valve. Fossa ovalis is a depression on the interatrial septum.

19. **Coronary angiography** : When the contrast medium dye is injected in coronary arteries (arteries of heart) and pictures are taken, it is known as **coronary angiography**.
20. Excess calcium ions cause increased heart beat.
21. RBCs fail to mature if there is a deficiency of vitamin B₁₂ and folic acid.
22. Papillary muscles are found in heart of mammals.
23. Keber's organs or pericardial glands discharge excretory products into the pericardial cavity in the fresh water mussel.
24. A "Blue baby" is the name given to an abnormal human baby who has a hole in the auricular or ventricular septum so that oxygenated and deoxygenated blood mixing takes place.
25. An insect larva has red blood. The larva of genus *Chironomus* called 'Blood worm'. The red colour of this larva is due to haemoglobin, which has the power of attracting and storing oxygen and giving it off to the tissues as they require it. Such larva are able to live in burrows constructed by it in the mud.
26. Vasa Vasorum are blood vessels which supply blood to the blood vessels itself.
27. **Blue Whale** has the largest heart.
28. **Cardiomegaly** is heart enlargement.
29. **Angiology**: Study of blood vascular and lymphatic systems.
30. Venoms of Bee and Cobra contain **lecithinases** which when injected into the blood stream by sting or bite break down lecithins and produce lysolecithins which in turn cause rupturing of RBC cell-membrane (cell-lysis).
31. **Marey's law**: Heart rate is inversely related to the systemic B.P.

Summary

- All vertebrates and a few invertebrates have a closed circulatory system.
- Our circulatory system consists of a muscular heart, a network of vessels and blood.
- Heart has two atria and two ventricles.
- Cardiac musculature is auto-excitabile.
- Sino-atrial node (SAN) generates the maximum number of action potentials per minute (70-75/min) and therefore, it sets the pace of the activities of the heart.
- Hence, it is called the Pacemaker.
- The action potential causes the atria and then the ventricles to undergo contraction (systole) followed by their relaxation (diastole).
- The systole forces the blood to move from the atria to the ventricles and to the pulmonary artery and the aorta.
- The cardiac cycle is formed of sequential events in the heart which are cyclically repeated.
- A healthy person shows 72 such cycles per minute.
- About 70mL of blood is pumped out by each ventricle during a cardiac cycle and is called the stroke or beat volume.
- Volume of blood pumped out by each ventricle of heart per minute is called the cardiac output and is equal to the product of stroke volume and heart rate (approx 5 litres).
- The electrical activity of the heart can be recorded from the body surface by using electrocardiograph and the recording is called **electrocardiogram** (ECG) which is of clinical importance.
- We have a complete double circulation, *i.e.*, two Circulatory pathways, namely, pulmonary and systemic.
- The pulmonary circulation starts by the pumping of deoxygenated blood by the right ventricle which is carried to the lungs where it is oxygenated and returned to the left atrium.
- The systemic circulation starts with the pumping of oxygenated blood by the left ventricle to the aorta which is carried to all the body tissues and the deoxygenated blood from there is collected by the veins and returned to the right atrium.
- Though the heart is auto excitable, its functions can be moderated by neural and hormonal mechanisms.

Exercise – 1

Section -A

There is no capillary system in case of most of the invertebrates except

- (1) Crustaceans (2) Cephalopods (3) Insects (4) Gastropods

Which of the following can't be taken as a feature of open type circulatory system?

- (1) Low pressure system
(2) Well regulated blood supply to different organs
(3) Blood returns to the heart slowly
(4) Non-formation of capillaries

In cockroach, the dorsal chamber of haemocoel is called

- (1) Pericardial sinus (2) Perivisceral sinus
(3) Perineural sinus (4) Peritoneal sinus

A pair of triangular muscles in each segment, present on either side of heart in cockroach, is of

- (1) Alary muscles (2) Tergosternal muscles
(3) Intercostal muscles (4) Phrenic muscles

Which is not a function of blood in cockroach?

- (1) Transport of nutrients (2) Transport of gases
(3) Reservoir of water (4) Main hydrostatic pressure

In cockroach, the anterior end of heart opens into

- (1) Pericardial sinus (2) Perivisceral sinus (3) Perineural sinus (4) Head sinus

Single type of circulation of blood is found in

- (1) Fish (2) Frog (3) Man (4) Lizard

Fishes have venous heart. The heart receives deoxygenated blood from all over the body except

- (1) Fins (2) Hindlimbs (3) Gills (4) Forelimbs

Find the odd one out

- (1) Prawn and insects (2) Frog and snails
(3) Snails and mussels (4) Prawn and mussels

Blood is red but no RBCs are found in

- (1) Frog (2) Rabbit (3) Man (4) Earthworm

If one litre of blood is drawn out of 5 litres from the body of man, how much blood would be left by the next day?

- (1) 5 litres (2) 4.5 litres (3) 4 litres (4) 3 litres

Ringer solution contains

- (1) Iodine and salt (2) Acetic acid and wax
(3) Sodium and potassium ions (4) Water and acid fuchsin

Which of the following has a neurogenic heart?

- (1) Cockroach (2) Octopus (3) Frog (4) Both (1) & (2)

Which layer of the heart is responsible for differential thickness of different chambers?

- (1) Epicardium (2) Myocardium (3) Endocardium (4) Pericardium

The two auricles are demarcated externally from the ventricle by an irregular groove called

- (1) Inter-auricular septum (2) Inter-ventricular septum
(3) Coronary sulcus (4) Inter-ventricular groove

Which of following pulmonary bypass are present in the circulatory system before birth?

- (1) Foramen ovale (2) Ductus arteriosus (3) Conus arteriosus (4) Both (1) & (2)

Opening of superior vena cava is guarded by

- (1) Semilunar valves (2) Columnae carnae (3) Principal septum (4) None of these

The opening of pulmonary vein is without valve because

- (1) It is a very small aperture (2) It has low blood pressure
(3) Its opening is oblique (4) None of these

The aperture between right auricle and right ventricle is guarded by one way valve called the

- (1) Semilunar valve
- (2) Tricuspid valve
- (3) Bicuspid valve
- (4) Valve of inferior vena cava

Chordae tendinae in the heart are found in

- (1) Ventricle (2) Left auricle (3) Right auricle (4) None of these

One of the following lies in the wall of right auricle

- (1) Purkinje fibres (2) Bundle of His (3) SA node (4) Chordae tendinae

Ventricular systole is stimulated by

- (1) SA node (2) AV vawe (3) AV node (4) AV aperture

Centre for heart beat regulation is present in

- (1) Pons Varolii (2) Cerebrum (3) Cerebellum (4) Medulla

A cardiac cycle involves

- (1) Joint diastole-ventricular systole-auricular systole
- (2) Auricular systole-ventricular systole-complete cardiac diastole
- (3) Auricular systole-joint diastole-ventricular systole
- (4) Auricular systole-ventricular diastole-joint diastole

Mammals are said to have a double circulatory system. It means that

- (1) There are two types of blood vessels attached to every organ e.g. , an artery and a vein
- (2) There are two systems, one from the heart to the lungs and back to the rest of the body via heart
- (3) The blood circulates twice in the heart
- (4) Both (2) & (3)

The duration of the ventricular diastole in a normal cardiac cycle is

- (1) 0.3 second (2) 0.5 second (3) 0.4 second (4) 0.7 second

Time interval between the closure of semilunar valve and closure of AV valve is (1)

- 0.3 sec (2) 0.5 sec (3) 0.1 sec (4) 0.7 sec.

The wall of arteries and veins differ from each other mainly w.r.t.

- (1) Tunica adventitia (2) Tunica media (3) Tunica externa (4) Tunica intima

The course of blood from the heart to the lungs and back to the heart is called

- (1) Systemic circulation
- (2) Pulmonary circulation
- (3) Single circulation
- (4) Double circulation

Superior mesenteric artery supplies blood to

- (1) Pancreas and ileum
- (2) Hepatic and lienogastric arteries
- (3) Both (1) & (2)
- (4) Caecum and proximal half of large intestine

The blood from diaphragm is collected by

- (1) Phrenic vein
- (2) Iliac vein
- (3) Hepatic vein
- (4) Renal vein

Hypogastric artery supplies blood to

- (1) Urinary bladder
- (2) Pancreas
- (3) Abdominal body wall
- (4) Both (2) & (3)

A portal system is one in which

- (1) A vein starts from an organ and ends up in heart
- (2) A vein starts from an organ and ends up in another organ
- (3) A vein starts from heart and ends up in lungs
- (4) None of these

Hepatic portal system is present in

- (1) Fishes, Amphibians and Reptiles
- (2) Reptiles and Birds
- (3) All mammals
- (4) All vertebrates

The middle man of the body is

- (1) Blood
- (2) Plasma
- (3) Lymph
- (4) Serum

Lymph differs from blood in possessing

- (1) More proteins and less waste products
- (2) Less proteins and more waste products
- (3) More proteins and more waste products
- (4) Less proteins and less waste products

Section -B

Lymphatic vessels from lower body part forms

- (1) Right lymphatic duct
- (2) Thoracic duct
- (3) Carotid duct
- (4) Jugular duct

Thoracic duct opens into

- (1) Right subclavian artery
- (2) Left subclavian artery
- (3) Right subclavian vein
- (4) Left subclavian vein

Which of the following wave of ECG shows ventricular depolarization?

- (1) P wave
- (2) QRS wave
- (3) T wave
- (4) U wave

Time taken by the impulse to travel through atria, AV node and the rest of conducting tissue is

- (1) P - Q interval
- (2) PQRS interval
- (3) QRS interval
- (4) ST segment

PQ interval gets lengthened during

- (1) Rheumatic fever
- (2) Arteriosclerotic heart (Plaque formation)
- (3) Arteriosclerotic heart (calcification)
- (4) All of these

William Harvey is known for the discovery of

- (1) Blood transfusion
- (2) Blood clotting
- (3) Blood circulation
- (4) Blood purification

Which one of the following does not have an open circulatory system

- (1) Chelone
- (2) Cockroach
- (3) Frog's tadpole
- (4) (1) and (2) both

The heart of a crocodile consists of

- (1) A single auricle and two ventricles
- (2) Two auricles and a single ventricle
- (3) Two auricles and two ventricles
- (4) A single auricle and a single ventricle

Which of the following has myogenic heart

- (1) Frog
- (2) Humans
- (3) Rabbit
- (4) All of the above

Purkinje's fibres are special types of

- (1) Muscle fibres located in heart
- (2) Nerve fibres located in cerebrum
- (3) Connective tissue fibres joining one bone to another bone
- (4) Sensory fibres extending from retina into optic nerve

Regulation of heart beat in mammals is due to

- (1) The volume of blood in the circulatory system
- (2) The presence of excess of oxygen in blood
- (3) The presence of thyroxine in blood
- (4) The presence of pacemaker in the heart

The first heart sound is

- (1) 'Lubb' sound at the end of systole
- (2) 'Dub' sound at the end of systole
- (3) 'Lubb' sound at the beginning of systole
- (4) 'Dub' sound at the beginning of systole

Which one is the correct route through which pulse making impulse travels in the heart

- (1) SA node → Purkinje fibres → Bundle of His → AV node → Heart muscles
- (2) AV node → SA node → Purkinje fibres → Bundle of His → Heart muscles
- (3) AV node → Bundle of His → SA node → Purkinje fibres → Heart muscles
- (4) SA node → AV node → Bundle of His → Purkinje fibres → Heart muscles

If the vagus branch of frog is stimulated, the heart will show

- (1) Stoppage of heart beat
- (2) Decreased heart beat
- (3) Increased heart beat
- (4) No change

During diastole

- (1) Blood enters lungs
- (2) Blood leaves the ventricle
- (3) Blood leaves the heart
- (4) Blood enters the heart

During systole of ventricle

- (1) Blood enters the heart
- (2) Blood leaves the heart
- (3) Blood leaves the ventricle
- (4) Blood enters lungs

Apex beat of heart is synchronous with

- (1) First sound
- (2) Second sound
- (3) Third sound
- (4) Fourth sound

Covering of heart is called

- (1) Pericardium (2) Peritoneum (3) Perineurium (4) Periostium

Post caval in right auricle is guarded by

- (1) Eustachian Valve (2) Bicuspid valve (3) Tricuspid valve (4) Atrio-ventricular valve

Tunica media of an elastic artery is made up of mainly

- (1) Smooth muscle fibre (2) Loose alveolar tissue
(3) Elastic fibres (4) Collagen fibres

How much of the total blood volume is present in heart

- (1) 2.5 % (2) 17 % (3) 9 % (4) 15 %

Pyramidium is part of

- (1) Truncus arteriosus (2) Left atrium (3) Right atrium (4) Ventricles

The coronary sinus in the heart is situated along its

- (1) Left margin (2) Right margin
(3) Diaphragmatic surface (4) Lower boarder of the heart

In all the leads of ECG, all following are positive waves except

- (1) P (2) Q (3) R (4) T

Cardiac output signifies

- (1) The amount of blood entering the heart per unit time
(2) The amount of blood entering the lung per unit time
(3) The amount of blood leaving the heart per unit time
(4) The amount of blood leaving the lung per unit time

Answer Key

Section-A

Q.1	2	Q.2	2	Q.3	1	Q.4	1	Q.5	2	Q.6	4	Q.7	1
Q.8	3	Q.9	2	Q.10	4	Q.11	1	Q.12	3	Q.13	1	Q.14	2
Q.15	3	Q.16	4	Q.17	4	Q.18	3	Q.19	2	Q.20	1	Q.21	3
Q.22	3	Q.23	4	Q.24	2	Q.25	4	Q.26	2	Q.27	2	Q.28	2
Q.29	2	Q.30	1	Q.31	1	Q.32	1	Q.33	2	Q.34	4	Q.35	3
Q.36	2												

Section-B

Q.1	2	Q.2	4	Q.3	2	Q.4	1	Q.5	4	Q.6	3	Q.7	4
Q.8	3	Q.9	4	Q.10	1	Q.11	4	Q.12	3	Q.13	4	Q.14	2
Q.15	4	Q.16	3	Q.17	1	Q.18	1	Q.19	1	Q.20	1	Q.21	3
Q.22	1	Q.23	2	Q.24	2	Q.25	3						

Exercise – 2

Previous Year's Questions

Glucose is carried from digestive tract to liver by [CBSE 1999]

- (1) Hepatic artery (2) Hepatic portal vein
- (3) Pulmonary vein (4) None of the above

Pulmonary artery differs from pulmonary vein in having [CBSE 2000]

- (1) Thick wall (2) Thin wall (3) Valves (4) Both (2) and (3)

Ventricular contraction in command of– [CBSE 1999]

- (1) S.A. Node (2) A.V. Node (3) Pukinje fibers (4) Papillary muscles

Fully digested food reaches to liver by– [CBSE 1999]

- (1) Hepatic portal vein (2) Hepatic artery
- (3) Hepatic vein (4) All the above

Impulse of heart beat originates from [CBSE 2002]

- (1) S.A. Node (2) A.V. Node (3) Vagus Nerve (4) Cardiac Nerve

Which of the following statement is true for Lymph [CBSE 2002]

- (1) WBC adn serum
- (2) All components of blood except RBCs, Platelets and some proteins
- (3) RBCs, WBCs and Plasma
- (4) RBCs, Proteins and Platelets

Bundle of His is a network of - [CBSE 2003]

- (1) Muscle fibres distributed throughout the heart walls
- (2) Muscle fibres found only in the ventricle wall
- (3) Nerve fibres distributed in ventricles
- (4) Nerve fibres found throughout the heart

Systemic heart refers to - [CBSE 2003]

- (1) The heart that contracts under stimulation from nervous system
- (2) Left auricle and left ventricle in higher vertebrates
- (3) Entire heart in lower vertebrates
- (4) The two ventricle together in humans

The cardiac pacemaker in a patient fails to function normally. The doctors find that an artifical pacemaker is to be grafted in him. It is likely that it will be drafted at the site of- [CBSE 2004]

- (1) Purkinje system (2) Sinuatrial node
- (3) Atrioventricular node (4) Atrioventricular bundle

Which of the following has no muscular wall [DPMT 1986]

- (1) Artery (2) Vein (3) Arteriol (4) Capillary

The process of blood clot formation within the circulatory system is [CBSE PMT 1993]

- (1) Thrombosis (2) Thrombocytes (3) Thrombin (4) Thrombocytopenia

When the right ventricle contracts the blood goes into [CBSE PMT 1992]

- (1) Aorta (2) Brain (3) Pulmonary artery (4) None

Splenic artery arises from [CBSE PMT 1990]

- (1) Anterior mesenteric artery (2) Coeliac artery
- (3) Posterior mesenteric artery (4) Intestinal artery

Which of the following carries glucose from digestive tract to liver [BHU 2001]

- (1) Hepatic artery (2) Hepatic portal vein
- (3) Pulmonary vein (4) None of these

Systemic heart refers to [CBSE PMT 2003]

- (1) The two ventricles together in humans
- (2) The heart that contracts under stimulation from nervous system
- (3) Left auricle and left ventricle in higher vertebrates
- (4) Entire heart in lower vertebrates

Carotid artery carries [MP PMT 1995]

- (1) Impure blood from brain
- (2) Oxygenated blood to anterior region of body or to brain
- (3) Impure blood to kidney
- (4) Oxygenated blood to heart

Blood circulation that starts in capillaries and ends in capillaries is called [NCERT 1984]

- (1) Portal circulation (2) Hepatic circulation
- (3) Cardiac circulation (4) None

A portal system is a system in which [NCERT 1978]

- (1) A vein starts from an organ and ends up in heart
- (2) An artery breaks up in an organ and restarts by the union of its capillaries
- (3) The blood from the gut is brought into the kidney before it is poured into posterior venacava
- (4) A vein breaks up in an organ into capillaries and restarts by their union as a new vein in the same organ

Spleen is [CBSE PMT 2001]

- (1) Haemopoietic (2) Lymphoid (3) Reproductive (4) Celluloid

In connection with circulatory system, valves are present [CBSE PMT 1995]

- (1) Not only in heart and blood vessels or vertebrates and invertebrates, but in vertebrate lymphatics as well
- (2) Vertebrate heart only
- (3) Vertebrate heart and invertebrate hearts only
- (4) Vertebrate hearts, invertebrate hearts and their blood vessels

Function of human spleen is to [DPMT 1984]

- (1) Control the pulse rate (2) Secrete hormone
- (3) Stimulate heart (4) Control blood volume

'Bundle of His' is a part of which one of the following organs in humans? [AIPMT 2011]

- (1) Brain (2) Heart (3) Kidney (4) Pancreas

Arteries are best defined as the vessels which :

[AIPMT 2011]

- (1) Supply oxygenated blood to the different organs
- (2) Break up into capillaries which reunite to form a vein
- (3) Break up into capillaries which reunite to form a vein
- (4) Carry blood from one visceral organ to another visceral organ

Given below is the ECG of a normal human. Which one of its components in human is correctly interpreted below

[AIPMT Mains 2008]

- (1) Complex QRS – One complete Pulse
- (2) Peak T – Initiation of total cardiac contraction
- (3) Peak P and Peak R together – Systolic and diastolic blood pressures
- (4) Peak P – Initiation of left atrial contraction only

In a standard ECG which one of the following alphabets is the correct representation of the respective activity of the human heart?

[CBSE 2009]

- (1) P–depolarisation of the atria
- (2) R–repolarisation of ventricles
- (3) S–start of systole
- (4) T–end of diastole

If due to some injury the chordae tendinae of the tricuspid valve of the human heart is partially non-functional, what will be the immediate effect?

[CBSE 2010]

- (1) The 'pacemaker' will stop working
- (2) The blood will tend to flow back into the left atrium
- (3) The flow of blood into the aorta will be slowed down
- (4) The flow of blood into the pulmonary artery will be reduced

Fastest distribution of some injectable material/medicine and with no risk of any kind can be achieved by injecting it into the :

[CBSE 2010]

- (1) Muscles
- (2) Arteries
- (3) Veins
- (4) Lymph vessels

Which statement is true about the venous blood vessels of frog?

[AMU 2010]

- (1) Lingual and Submandibular unite to form internal jugular
- (2) musculocutaneous and Brachial unite to form the subclavian
- (3) The ventral abdominal vein drains into the posterior vena cava
- (4) The pelvic veins unite to form the renal portal vein

Which of following is not a major organ of lymphatic system?

[MPPMT 2010]

- (1) Spleen
- (2) Kidney
- (3) Thymus
- (4) Lymph nodes

Lymph vessels are united to form

[BHU 2001]

- (1) Lymph heart
- (2) Cisterna chyli
- (3) Thoracic duct
- (4) Jugular vein

Cardiac output is determined by :

[BHU 2008]

- (1) Heart rate
- (2) Stroke volume
- (3) Blood flow
- (4) Both (1) and (2)

In frog heart, there are cardiac muscles which consist of fibres called :

[CPMT 2008]

- (1) Myofibrils
- (2) Telodendria
- (3) Purkinje fibres
- (4) Columnar cells

During high blood pressure, regulations of heart beat and circulation are controlled by [AIIMS 1999]

- (1) Vasodilator and vasoconstrictor centres
- (2) Cardio-stimulatory and vasoconstrictor centres
- (3) Cardio-inhibitory and vasoconstrictor centres
- (4) Cardio-inhibitory and vasodilator centers

Blood pressure is measured by [AIIMS 2000]

- (1) Sphygmomanometer
- (2) Phonocardiogram
- (3) Electrocardiogram
- (4) Stethoscope

All veins have deoxygenated blood except [AIIMS 2001]

- (1) Renal vein
- (2) Hepatic vein
- (3) Hepatic portal vein
- (4) Pulmonary veins

Common thrombosis leading to myocardial infarction is of [AIIMS 1988]

- (1) Right circumflex coronary artery
- (2) Left circumflex coronary artery
- (3) Left anterior descending artery
- (4) Right coronary artery

Thrombosis in which coronary artery is met most frequency in MI [AIIMS 1988]

- (1) Right coronary artery
- (2) Left anterior descending artery
- (3) Left circumflex coronary artery
- (4) Right circumflex coronary artery

Which organ receives only oxygenated blood? [AFMC 2001]

- (1) Gill
- (2) Spleen
- (3) Lung
- (4) Liver

Blood vessel which brings oxygenated blood to left auricle is [AFMC 2000]

- (1) Precaval vein
- (2) Post caval vein
- (3) Pulmonary vein
- (4) Pulmonary artery

Oxygenated blood is carried by [AFMC 1995]

- (1) Pulmonary vein
- (2) Pulmonary artery
- (3) Renal vein
- (4) Hepatic portal vein

The blood vessel which brings oxygenated blood from lungs towards the heart of frog is [AFMC 2000]

- (1) Pre caval
- (2) Post caval
- (3) Pulmonary vein
- (4) Pulmonary artery

All arteries carry oxygenated blood except [AFMC 2003]

- (1) Systemic
- (2) Hepatic
- (3) Pulmonary
- (4) Cardiac

The blood vessel of frog which opens in its right ventricles bringing oxygenated blood is [AFMC 2000]

- (1) Pulmocutaneum artery
- (2) Inferior vena cava
- (3) Pulmocutaneum vein
- (4) Superior vena cava

A yellow substance oozing out from wound has [AFMC 1986]

- (1) Lymph + RBC + WBC
- (2) Lymph + RBC + dead bacteria
- (3) Lymph + WBC + dead bacteria
- (4) Lymph + dead leucocytes

Which organ is considered as "Graveyard of RBC" where most of them are destroyed by macrophages [AFMC 2001]

- (1) Red bone marrow
- (2) Spleen
- (3) Kidney
- (4) Intestine

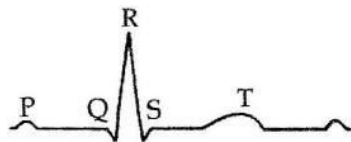
Iliac artery carries blood to [APMEE 1977]

- (1) Hind limb (2) Fore limb (3) Lung (4) Brain

Hypophyseal portal system is found in [AMU 1997]

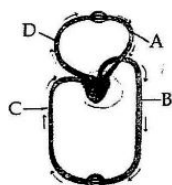
- (1) Kidney (2) Liver (3) Brain (4) Heart

The diagram given here is the standard ECG of a normal person. The P - wave represents the : [AIPMT 2013]



- (1) Initiation of the ventricular contraction (2) Beginning of the systole
(3) End of systole (4) Contraction of both the atria

Figure shows schematic plan of blood circulation in humans with labels A to D. Identify the label and give its function/s. [AIPMT 2013]



- (1) B - Pulmonary artery - takes blood from heart to lungs, $PO_2 = 90$ mm Hg
(2) C-Vena Cava - takes blood from body parts to right auricle, $PCO_2 = 45$ mm Hg
(3) D - Dorsal aorta - takes blood from heart to body parts, $PO_2 = 95$ mm Hg
(4) A-Pulmonary vein-takes impure blood from body parts, $PO_2 = 60$ mm Hg

Person with blood group AB is considered as universal recipient because he has:[AIPMT 2014]

- (1) no antigen on RBC and no antibody in the plasma.
(2) both A and B antigens in the plasma but no antibodies.
(3) both A and B antigens on RBC but no antibodies in the plasma.
(4) both A and B antibodies in the plasma.

How do parasympathetic neural signals affect the working of the heart? [AIPMT 2014]

- (1) Both heart rate and cardiac output increase.
(2) Heart rate decreases but cardiac output increases.
(3) Reduce both heart rate and cardiac output.
(4) Heart rate is increased without affecting the cardiac output.

Answer Key

Q.1	2	Q.2	1	Q.3	1	Q.4	1	Q.5	1	Q.6	2	Q.7	2
Q.8	2	Q.9	2	Q.10	4	Q.11	1	Q.12	1	Q.13	3	Q.14	2
Q.15	3	Q.16	3	Q.17	2	Q.18	1	Q.19	2	Q.20	2	Q.21	4
Q.22	2	Q.23	2	Q.24	1	Q.25	1	Q.26	4	Q.27	3	Q.28	3
Q.29	2	Q.30	3	Q.31	4	Q.32	3	Q.33	2	Q.34	1	Q.35	4
Q.36	3	Q.37	1	Q.38	2	Q.39	3	Q.40	1	Q.41	3	Q.42	3
Q.43	1	Q.44	3	Q.45	2	Q.46	1	Q.47	3	Q.48	4	Q.49	2
Q.50	3	Q.51	3										

In the following questions, a statement of assertion (A) is followed by a statement of reason (R).

- (1) If both Assertion & Reason are true and the reason is the correct explanation of the assertion, then mark (1).
- (2) If both Assertion & Reason are true but the reason is not the correct explanation of the assertion, then mark (2).
- (3) If Assertion is true statement but Reason is false, then mark (3).
- (4) If both Assertion and Reason are false statements, then mark (4).

A : The cardiac impulse which originates from SA node in mammalian heart can not spread directly from atria to ventricles.

R : In mammalian heart there is no continuity between cardiac muscle fibres of atria and those of ventricles except AV bundles.

A : First phase of ventricular filling is rapid and causes 3rd sound of heart. R :

It is because of auricular systole.

A : Dub is a long and sharp sound.

R : It is caused by closing of atria ventricular valves.

A : Portal system consists of veins which start from capillaries and end into capillaries. R :

All vertebrates have hepatic portal system.

A : Arterioles possess smooth muscles on their walls.

R : These smooth muscles help in regulating blood volume flowing through a tissue or organ.

A : The open circulatory system is more efficient than the closed circulatory system.

R : The blood flows far more rapidly in open circulatory system than in the closed one.

A : Heart of fish contains only deoxygenated blood.

R : Oxygenated blood do not return back to the heart in fishes.

A : The cardiac impulse is said to be myogenic.

R : Rate of formation and conduction of cardiac impulse can be changed by the action of nerves.

A : Left ventricle of heart has a thinner wall than that of the right ventricle. R :

Left ventricle needs to pump blood to nearby lungs only.

A : AV bundle is essential for the conduction of cardiac impulse.

R : There is no continuity between the cardiac muscle fibres of the auricles and those of the ventricles.

A : AV node is also called as the pacemaker of the heart.

R : It is because of the fact that AV node determines the rate of heart beat.

A : There is no mixing of oxygenated and deoxygenated blood in the human heart.

R : Valves are present in the heart which allows the movement of blood in one direction only.

A : Hypotension is observed in arteriosclerotic patients.

R : In the condition of arteriosclerosis, the arteries gain their elasticity and get stiffened.

A : EEG is of immense diagnostic value in the cardiac diseases.

R : Defects in cardiac functions can be reflected in changes in the pattern of electrical potential recorded in the EEG.

A : An artificial pacemaker can replace the sinoatrial node of heart.

R : This is because, an artificial pacemaker is capable of stimulating the heart electrically to maintain its beats.

Answer Key

Q.1	1	Q.2	3	Q.3	4	Q.4	2	Q.5	1	Q.6	4	Q.7	1
Q.8	2	Q.9	4	Q.10	1	Q.11	4	Q.12	2	Q.13	4	Q.14	4
Q.15	1												

