

CHAPTER 2 : Blood Circulatory System of Man

- ↳ A system by which blood carries nutrients throughout the body through arteries, veins and capillaries.
- ↳ Nutrients along with blood is transported all over the body.
- ↳ It is closed type circulatory system.

Components/Characteristics of blood circulatory system:

- ↳ Circulatory pump → Heart
- ↳ Circulatory fluid → Blood
- ↳ Circulatory Vessels → Arteries, Veins, capillaries

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* Human Heart:

• Location:

It is present in Mediastenum (the region between the two lungs). It is present in the thoracic cavity.

• Size:

It is the size of an adult human fist. It varies with the size of body.

• Pericardium:

It is a closed sac that surrounds the heart.

- It has inelastic nature.
- It prevents heart from being over-stressed or over-filled with blood.
- Pericardium has a fluid called pericardial fluid which

is present between pericardium and heart. It reduces friction. It is also called serous fluid.

→ It is a fibre membrane.

→ It also holds the heart in its position.

→ It has two parts called visceral ^{and} parietal parts which are outer and inner parts respectively.

→ It also prevents heart from over-expansion.

• Layers/Walls of Heart:

Heart consists of three layers

→ Epicardium (Outer most layer made up of connective tissues)

→ Myocardium (Middle layer made up of cardiac muscle)

→ Endocardium (Inner layer, made of endothelium tissue)

• Cardiac Muscles:

Cardiac muscles are:

→ Striated/Involuntary muscles

→ Generally, are uninucleated but sometimes have more than one nucleus.

→ Branched

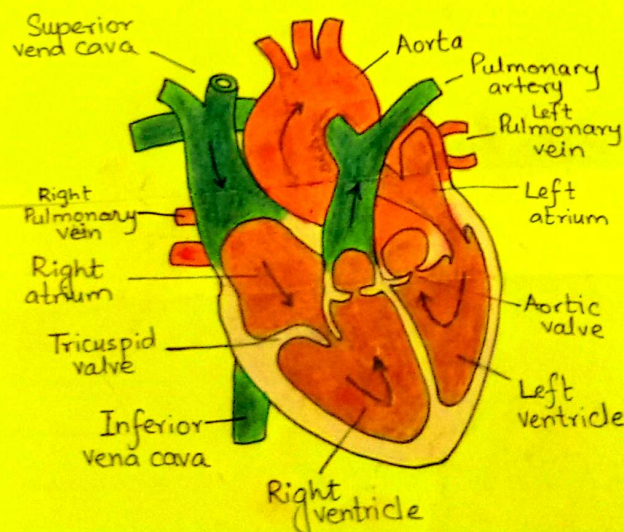
→ Have light and dark bands



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Arteries of Heart:-

- Aorta (Main artery)
 - Brachiocephalic artery
 - Right Carotid Artery (To right side of head and neck)
 - Left Carotid artery (Oxygenated blood to head and neck)
 - Left Subclavian artery (Oxygenated blood to shoulder and arms)
- Right Subclavian Artery (To left shoulder & arm)

→ Pulmonary Artery (Deoxygenated blood to lungs)
(2)

→ Coronary Artery (Oxygenated blood to heart walls)

Veins of Heart:-

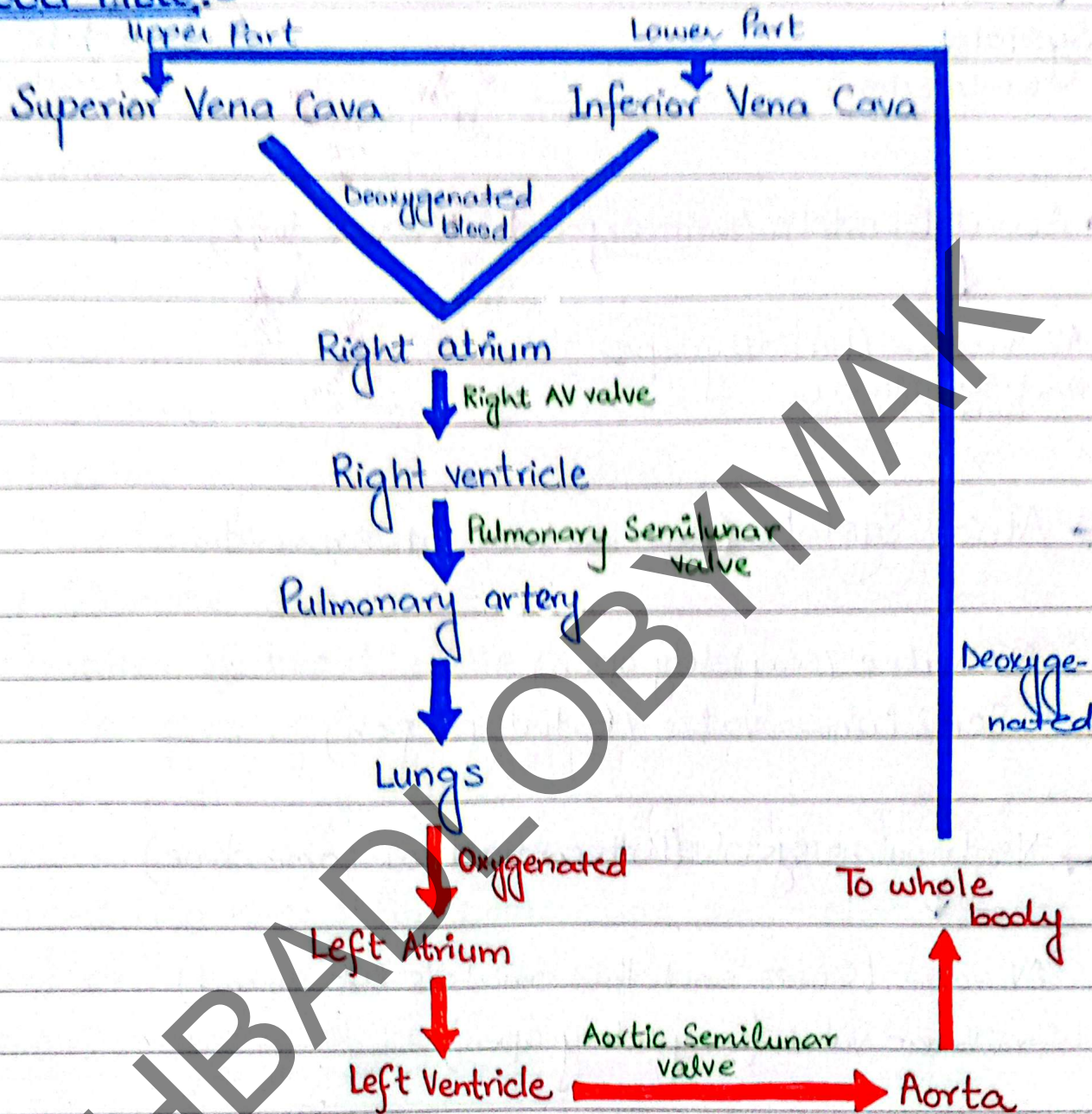
- Superior Vena Cava (Deoxygenated blood from upper body to right atrium)
- Inferior Vena Cava (Deoxygenated blood from lower body to right atrium)
- Pulmonary Veins (Oxygenated blood from lungs)
(2)
- Cardiac Vein (Receives deoxygenated blood from heart walls)

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• Blood Flow:-



* Heart Beat:-

• Definition:

One heart beat is one time collection of blood and one time pumping of blood by the heart.
Heartbeat consists of lub and dub.

• Cardiac Cycle:

Sequence of events during the completion of one heart beat.

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= Events of Cardiac Cycle:

Systole

(contraction)
shrink

Diastole

(relaxation)
expand

↳ Atrial Diastole (Both expand at same time)



AV valve (Partially open)
and Semilunar
valve

↳ Atrial Systole (Both contract at same time)



AV valve (completely open)
and Semi lunar valve (Partially open)

↳ Ventricular systole (Both contract at same time)



AV valve (Closes and this makes lub sound)
Semilunar valve (completely open)

↳ Ventricular diastole



Semilunar valve (Suddenly close to make dub sound)
AV valve (Partially open)

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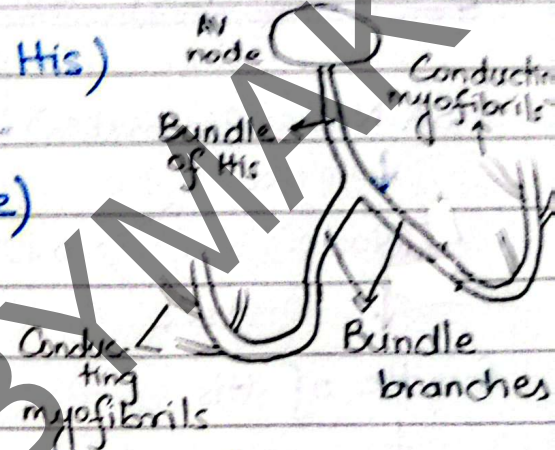
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* Conduction System of Heart:

Conduction System is the system which controls the cardiac cycle or heartbeat.

Components:-

- ↳ Sino atrial node (SA node/pacemaker of Heart)
- ↳ Atrio ventricular node (AV node)
- ↳ Atrio ventricular bundle (Bundle of His)
- ↳ Bundle branches
- ↳ Conducting myofibril (Purkinje fibre)



Q Why SA node is called pacemaker of heart while AV node is not called pacemaker of heart?

Ans SA node is actually cluster of modified cardiac fibres. It is the centre of origin of electric impulses. The main impulses generated for contraction and relaxation of heart are generated by SA node. That is why it is called pacemaker of heart. On the other hand, impulse by AV node is not originated at first, so it is not called pacemaker.

⇒ Sino Atrial Node (SA node/pacemaker of Heart)

• Location:

It is situated in the upper wall of right atrium.

• Consist of:

It consists of clusters of modified cardiac fibres/cardiac cells.

• Function:

They are modified for the generation of electrical impulse.

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• Myogenic:

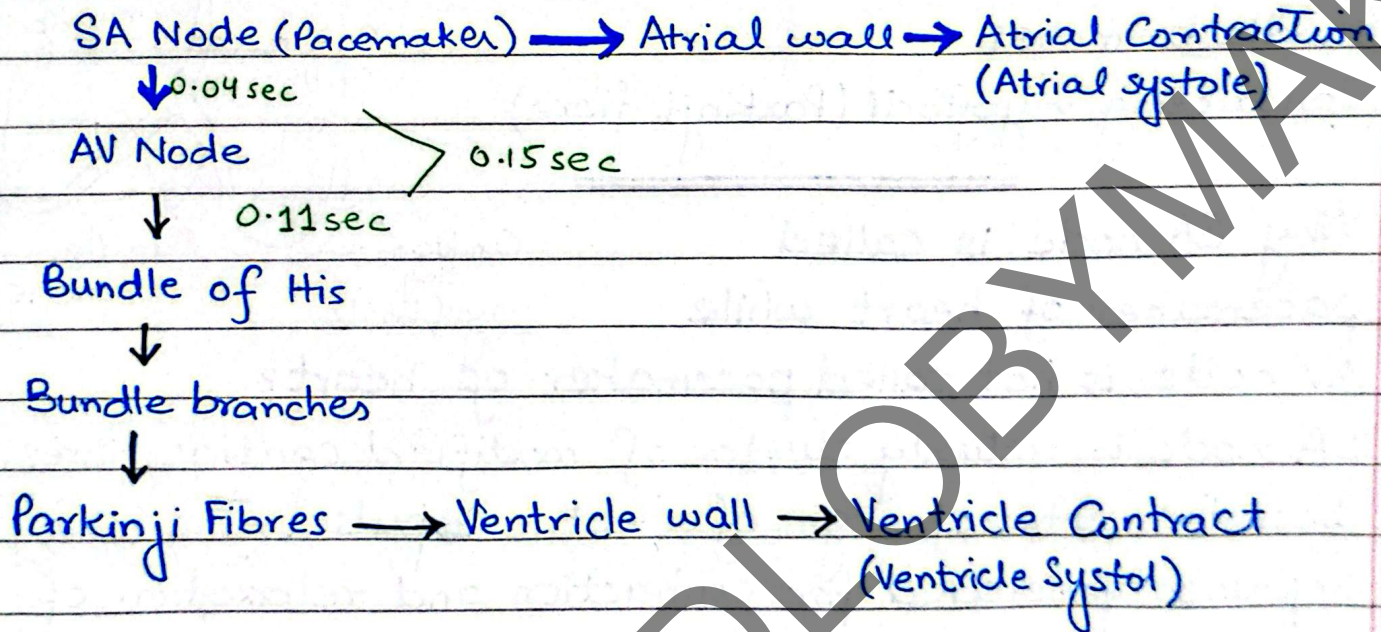
Heart is myogenic i.e. impulses for the contraction and relaxation originates from within the heart (intrinsic).

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⇒ Mechanism of Conducting System of Heart:



SA Node = Wave of depolarization = Atrial systole

AV Node = Wave of depolarization = Ventricular systole

AV Node = Wave of repolarization = Ventricular diastole

Atrial and Ventricular diastole take place at the same time.

↓ Filling of blood ↓ Caused by impulse

* Electrocardiogram (ECG) :-

• Definition:

Graphical representation of electrical activities of SA node and AV node in cardiac cycle.

• Usage/Benefit:

It is useful to diagnose various abnormalities in heart functioning.

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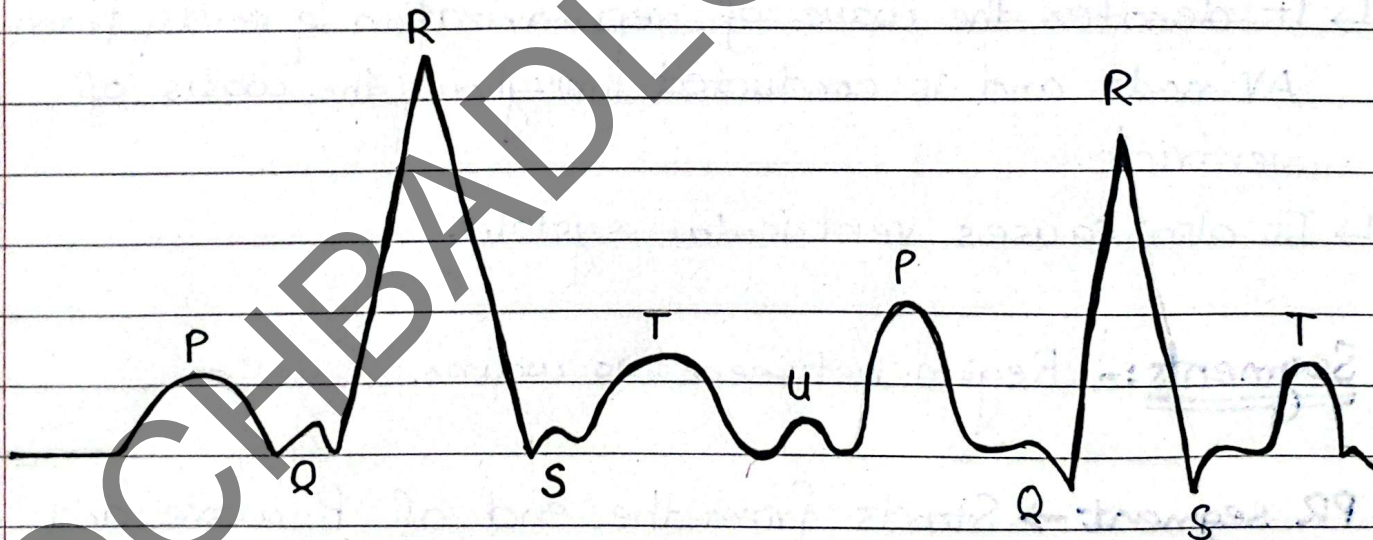
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y-axis $\rightarrow$ electrical potential

1 $\square$ = 0.1 mV

x-axis $\rightarrow$ time

1 $\square$ = 0.04 sec



P Wave $\rightarrow$ SA node

$\rightarrow$ Atrial depolarization. It denotes a wave of depolarization spread from SA node and is conducted throughout the atrial wall.

$\rightarrow$ It causes atrial systol.

QRS Complex:-

- ↳ Ventricular depolarization
- ↳ It denotes that the wave of depolarization spread from AV node and is conducted throughout the walls of ventricle.
- ↳ It causes ventricular systole

AV Node → Bundle of His → Bundle branches → Purkinji Fibres
↓
Spread in walls of ventricle

T wave:-

- ↳ Ventricular repolarization
- ↳ It denotes the wave of repolarization spreads from AV node and is conducted throughout the walls of ventricle.
- ↳ It also causes ventricular systole.

Segments:- Region between two waves.

PR segment → Starts from the end of P wave and ends at the start of QRS complex.

ST segment → Starts at the end of QRS complex and end at the start of T wave.

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* Intervals:

An interval in an ECG is a duration of time that includes one segment and one or more waves.

→ PR (or PQ) interval:

It starts at the P wave and ends at start of QRS. (0.12 - 0.20 sec)

PR interval = P wave + PR segment

→ QRS interval:

It covers QRS complex from beginning to end. (0.08 - 0.10 sec)

→ QT interval:

It starts at the start of QRS complex and ends at the end of T wave. It denotes the electrical systole of ventricles. (0.4 - 0.43 sec)

→ RR Interval:

It starts from ^{peak point of} one QRS wave and ends at, another QRS wave.

* Blood Vessels :-

1) Arteries:

Arteries are blood distributing vessels. They carry blood away from the heart.

Arteries are muscular, elastic blood vessels that carry oxygenated blood away from the heart to rest of the body. They have thick walls to withstand the high pressure of blood being pumped from the heart.

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2) Veins:

Blood collecting vessels. Veins carry blood towards the heart.

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3) Capillaries:

Capillaries are vessels by which exchange of materials takes place between body fluid (blood) and body cells.

Heart → Arteries → Small Arteries → Arterioles

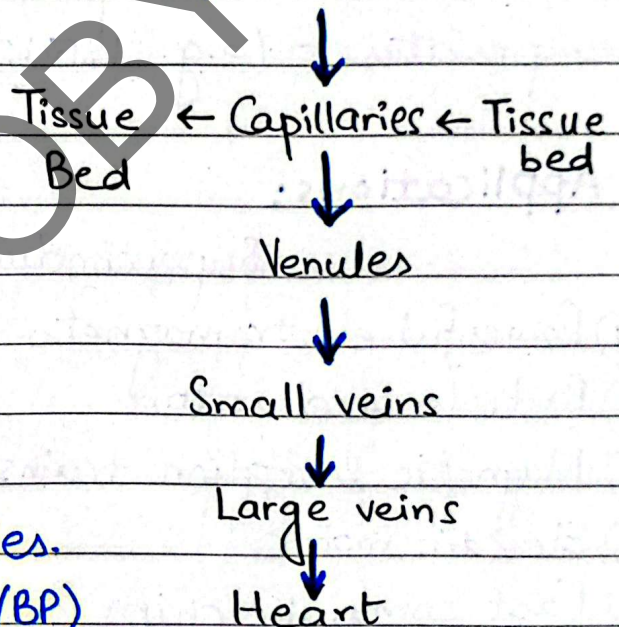
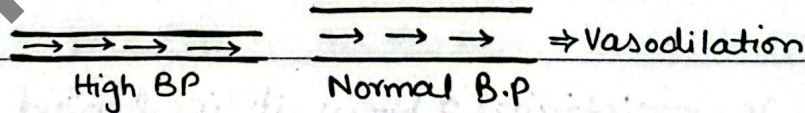
* Vasodilation and vasodilation occurs in arteries/arterioles.

→ Vasodilation:

Vasodilation is the expansion of arteries due to the relaxation of smooth muscles.

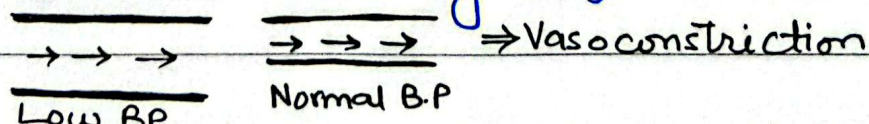
It occurs at high blood pressure (BP)

so a signal is sent to medulla which sends signal for dilation.



→ Vasoconstriction:

Vasoconstriction is the constriction of arteries due to the contraction of smooth muscles. It occurs at low blood pressure (BP) so a signal is sent to Medulla which sends signal for constriction.



b) Veins:

Blood collecting vessels. Veins carry the heart.

These carry deoxygenated blood from body back to the heart. They have thinner walls than arteries and contain valves to prevent blood from flowing backwards, as pressure in veins is much lower.

b) Capillaries:

Capillaries are vessels by which materials take place between body and body cells.

These are the smallest and most numerous blood vessels, forming a bridge between arteries and veins. Their walls are extremely thin, which allows for essential exchange of oxygen, nutrients and waste products (like CO_2 btw blood and body tissues).

Heart → Arteries

Vasoconstriction and vasodilation are also controlled by some hormones.

↳ Epinephrine/Adrenaline → Vasodilator ⇒ Skeletal Muscles

↳ Norepinephrine/Noradrenaline → Vasoconstrictor ⇒ GIT

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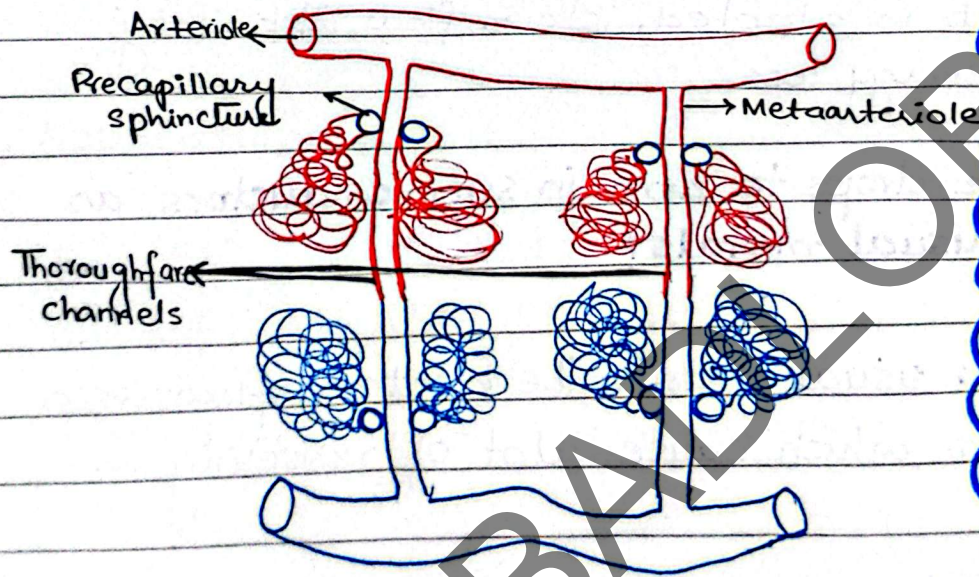
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Kinins (Local Hormones)

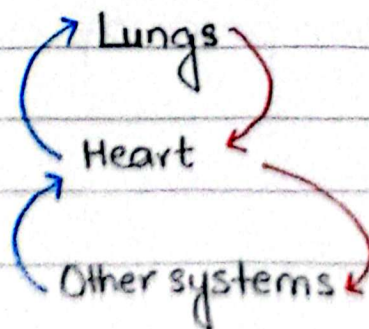
↳ Histamine → Vasodilator

↳ Prostaglandin → Normally vasodilator but some time vasoconstrictor.



Precapillary sphincters are tiny rings of smooth muscle at the entrance to capillary beds. They act as valves that control blood flow into the capillaries. Their main job is to direct blood to the tissues that need it most, such as active muscles during exercise, and to restrict flow to less active areas. This regulation is vital for ensuring that oxygen and nutrients are delivered where they are needed and waste products are removed efficiently.

* In all vertebrates, except Fishes, the heart is called double circuit heart (double pump). In Fishes, heart is single circuit.



Fish have single circulatory system. In this system, blood passes through the heart once during a complete circuit of the body, travelling from heart to gills, then rest of the body and back to heart.

* Pathway of Blood through Pulmonary and Systemic Circulation:-

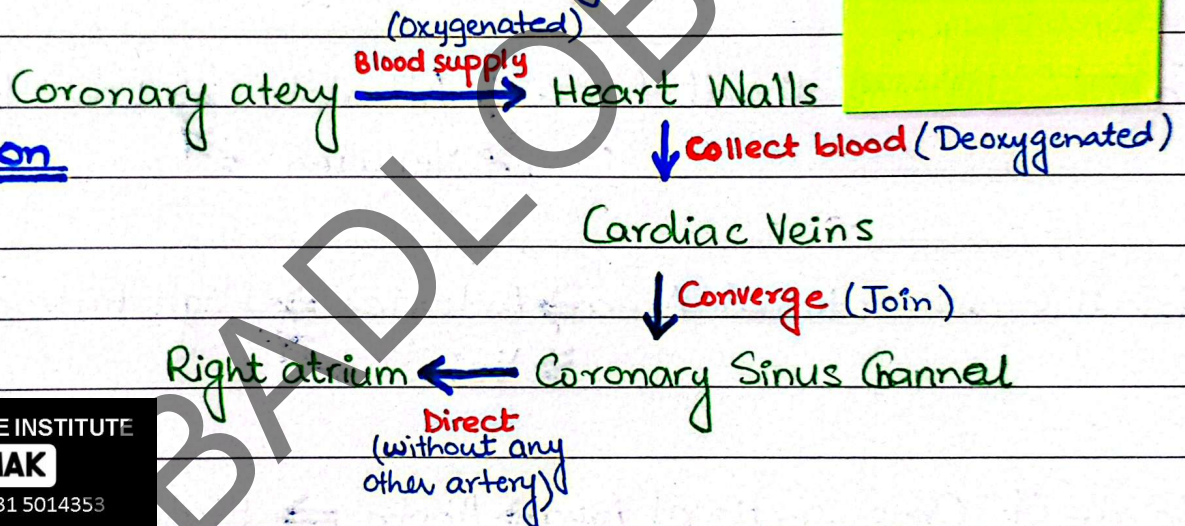
↳ Pulmonary Circulation: (Between heart and lungs)

Pumping of deoxygenated blood from heart to lungs and then collection of oxygenated blood from lungs to heart.

↳ Systemic Circulation: (Between heart and body tissues)

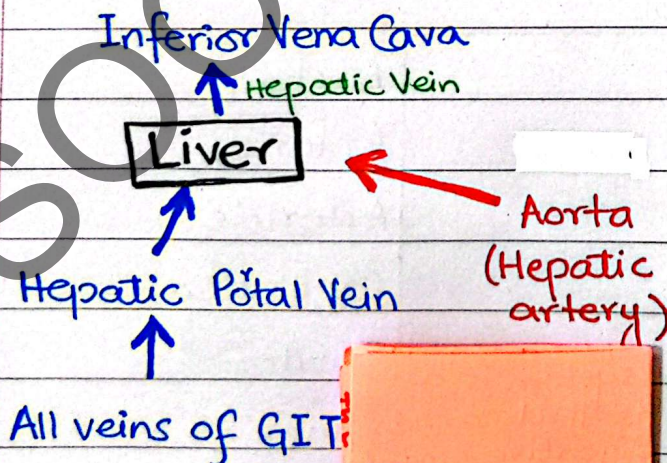
Pumping of oxygenated blood from heart to body tissues/system and the collection of deoxygenated blood from body tissues/system to heart.

* Coronary Circulation

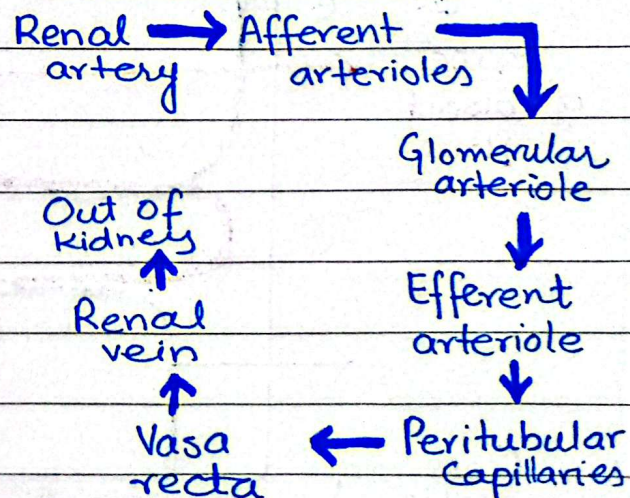


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* Hepatic Circulation:-



* Renal Circulation:-



θ' , depends on angle θ .

Here, from eq (iii), we conclude that the

Flow of Blood through Pulmonary and Systemic

:-

Circulation: (Between heart and lungs)

Pumping of deoxygenated blood from lungs and then collection of oxygenated blood to heart.

Function: To exchange CO_2 for oxygen.

Starts at: Right ventricle

Ends at: Left atrium

Circulation:

Pumping of oxygenated blood from body tissues/system and the collection of blood from body tissues/system to heart.

(Oxygenated)
Pulmonary artery $\xrightarrow{\text{Blood supply}}$ Heart Walls
 $\downarrow$ Collect blood
Cardiac Veins

Function: To deliver oxygen and nutrients to body tissues

Starts at: Left ventricle

Ends at: Right atrium

$\downarrow$ Converge (Join)

Right atrium $\xleftarrow{\text{Direct (without any other artery)}}$ Coronary Sinus Channel

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ation:-

Superior Vena Cava
Inferior Vena Cava

* Renal Circulation:-

Renal artery $\rightarrow$ Afferent arterioles
 $\downarrow$
Glomerular arteriole

Aorta

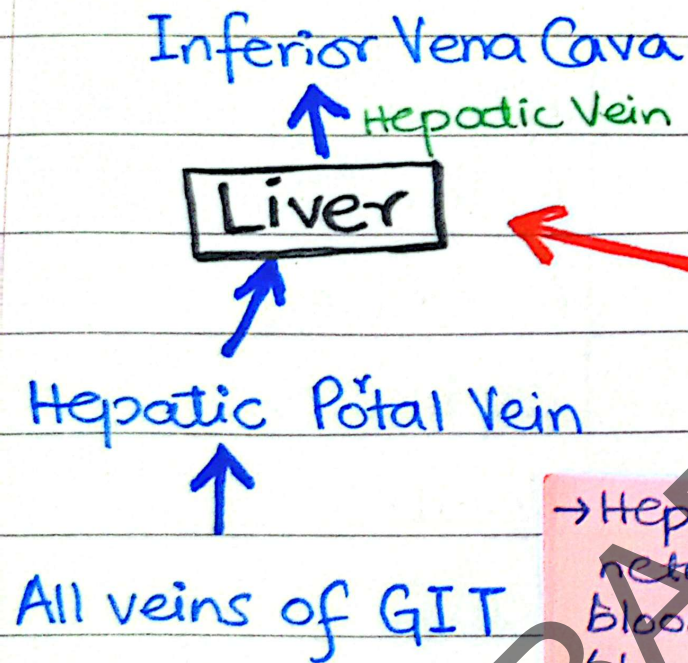
Direct
(without any
other artery)

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Hepatic Circulation:-



* Renal Circulation

Renal artery → Afferent artery

Out of kidney
↑

→ Hepatic portal system is a network of veins that carries blood from the digestive organs (stomach, intestines, spleen and pancreas) directly to the liver.

→ Its primary function is to allow the liver to process and detoxify substances absorbed from the digestive tract before they enter the general bloodstream. This ensures that nutrients are metabolized & toxins or drugs are filtered out, protecting rest of the body.

* Rate of blood flow in blood vessels :-

⇒ Cardiac Output: Flow of blood in one minute.

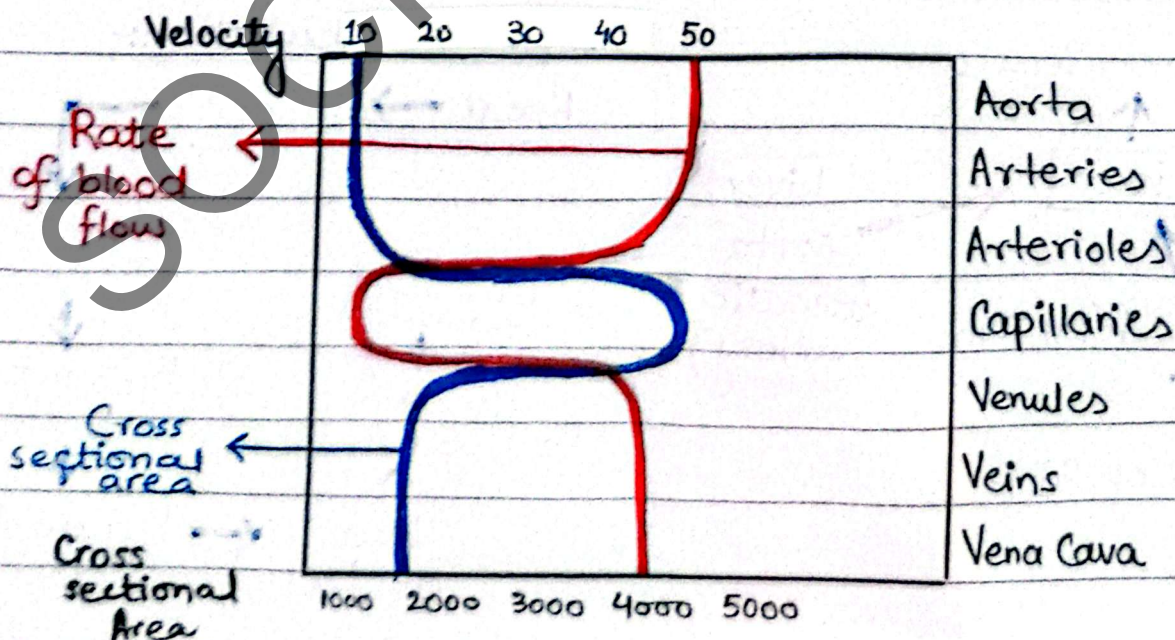
⇒ Stroke volume: Flow of blood in one heart beat.

⇒ Heart Rate: No of heart beats in one minute.

Cardiac Output = Stroke volume $\times$ Heart rate

$$\text{Rate of blood flow} = \frac{1}{\text{Total Cross-sectional area of vessel}}$$

- Highest Cross-Sectional Area $\Rightarrow$ Capillaries $\Rightarrow$ Lowest Rate of flow of blood
- High Cross-Sectional Area $\Rightarrow$ Arterioles $\Rightarrow$ Low Rate of flow of blood
 $\Rightarrow$ Venules $\Rightarrow$
- Small Cross-sectional Area $\Rightarrow$ Arteries $\Rightarrow$ High Rate of flow of blood
 $\Rightarrow$ Veins $\Rightarrow$
- Smallest Cross-sectional Area $\Rightarrow$ Aorta $\Rightarrow$ Highest Rate of flow of blood
 $\Rightarrow$ Vena Cava $\Rightarrow$



* Rate of blood flow in blood vessels :-

→ Cardiac Output : Flow of blood in one minute.

→ Stroke volume : Flow of blood in one heart beat.

→ Heart Rate : No of heart beats in one minute.

$$\text{Cardiac Output} = \text{Stroke volume} \times \text{Heart rate}$$

$$\text{Rate of blood flow} = \frac{1}{\text{Total Cross-sectional area of vessel}}$$

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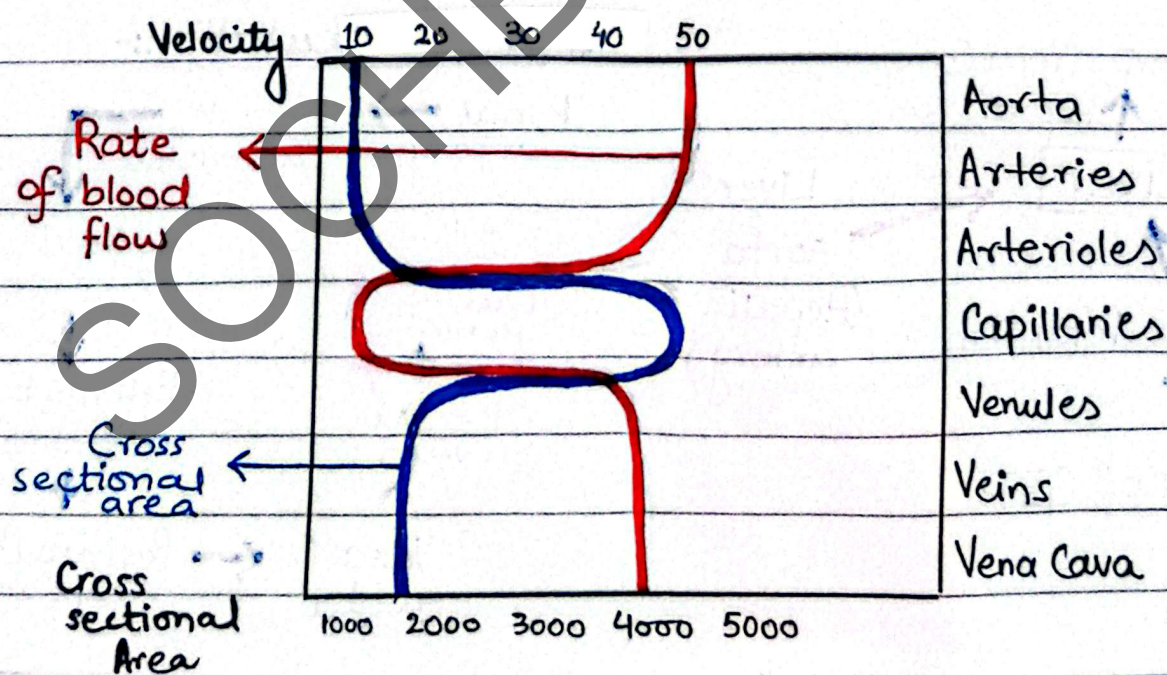
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Highest Cross-Sectional Area → Capillaries → Lowest Rate of flow of blood

High Cross-Sectional Area → Arterioles → Low Rate of flow of blood
→ Venules

Small Cross-sectional Area → Arteries → High Rate of flow of blood
→ Veins

Smallest Cross-sectional Area → Aorta → Highest Rate of flow of blood
→ Vena Cava



* Blood Pressure:-

Blood pressure is the force that blood exerts on the walls of blood vessels.

Measurement:

It is measured in millimeters of mercury (mm Hg) using a sphygmomanometer. The standard reference for blood pressure is 100 mm Hg.

Components:-

Blood pressure has two

components:-

⇒ Systolic Pressure:

This is the highest pressure and occurs when the ventricles of the heart contract and push blood into the arteries.

⇒ Diastolic Pressure:

This is the lowest pressure and occurs when ventricles relax and the heart fills with blood.

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Baroreceptor/Stretch Receptors

High Pressure Receptors

- Carotid Sinus
- Atria walls



Atria

In case of high BP, these receptors will send signal to medulla, as a result vasodilation occurs and arteries expand.

This process is called Baroreflex and it is Negative Feedback mechanism.

Low pressure receptors/volume receptors

- Wall of atria
- Carotid arteries

In case of low BP, these receptors will send signal to medulla, as a result vasoconstriction occurs and arteries contract.

Q What happens in case of high BP?

Ans In case of high BP:-

- Vasodilation occurs
- Heart Rate decreases
- Stroke volume decreases
- Cardiac Input decreases

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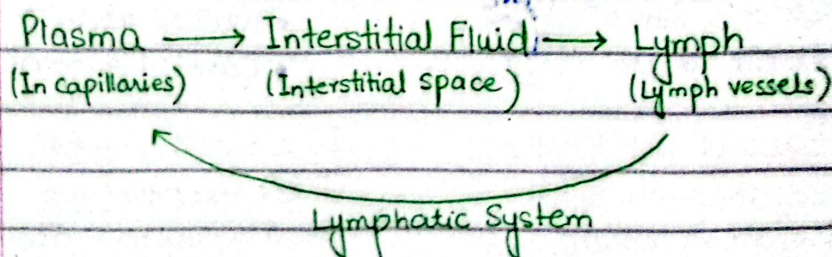
↳ Epinephrine (Vasodilation in Skeletal muscles)
↳ Nor epinephrine (Vasoconstriction in GIT).
Both are released at the same time and have opposite functions.

- ↳ Kinins (Histamine) (Vasodilation)
- ↳ Prostaglandins (Vasodilator but occasionally work as vasoconstrictor)

* Lymphatic System:-

The type of circulatory system which is responsible for returning the lost part of blood (tissue fluid / interstitial fluid) back to the blood circulatory system.

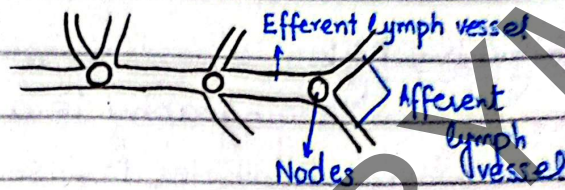
- ⇒ 30L of tissue fluid is lost in 24 hours.
- ⇒ 7L of tissue fluid is returned in 24 hours.
- ⇒ 3L of it is returned by lymphatic system.



• Lymph Vessels:-

- ↳ Lymph capillaries (Lacteal)
- ↳ Small lymph vessel
- ↳ Larger lymph vessel
- ↳ Largest lymph vessel (Thoracic duct)

↓ Enters
Right Subclavian vein
↓
Blood Circulatory System



- Mainly the lymph nodes/lymphoid masses are present at:-

- Axilla (armpit)
- Neck
- Groin (Area b/w legs)

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- Large lymph nodes are:-

- Adenoid (Sides of nasal cavity)
- Tonsils (Neck)
- Thymus (Chest)
- Spleen (Abdominal cavity) → Its function is filtration of foreign and damaged particles.

- Function of lymphatic system:-

- Returns lost part of blood (tissue fluid) back to circulatory system.
- Filtration of blood in form of spleen.
- Absorption of digested products of

lipids.

→ Formation of blood cells. (T lymphocytes, etc.)

⇒ Interstitial fluid is the delivery and waste-collection medium for your cells.

⇒ The lymphatic system the recycling and sanitation crew that manages this fluid.

Angiography:-

Angiography is a medical test where a catheter is inserted into a blood vessel and guided to the heart. A special dye is then injected, which allows doctors to take X-ray pictures of heart's vessels and chambers. This procedure is used to diagnose heart valve disease, check the function of the left ventricle, and, in the case of coronary angiography, detect blocked or narrowed coronary arteries to help guide treatment.

Coronary Bypass:-

Coronary bypass is a surgical procedure that uses a healthy blood vessel from another part of the body to create a new path for blood to flow around a blocked or narrowed coronary artery, restoring blood supply to the heart.

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Angioplasty:-

Angioplasty is a procedure to open blocked or narrowed arteries. A doctor inserts a thin tube with a tiny balloon on the end and guides it to the blockage. Then balloon is then inflated to push the plaque aside and widen the artery. To prevent the artery from closing again, a small mesh tube called a stent is often expanded inside the artery to hold it open.

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Open Heart Surgery:-

Open Heart surgery is a surgical procedure where a patient's chest is opened to allow a surgeon to operate on the heart. During the operation, a heart-lung bypass machine takes over the function of the heart and lungs, allowing the heart to be temporarily stopped so the surgeon can repair heart problems, such as damaged valves or blood vessels.