

## **CARDIOVASCULAR SYSTEM:**

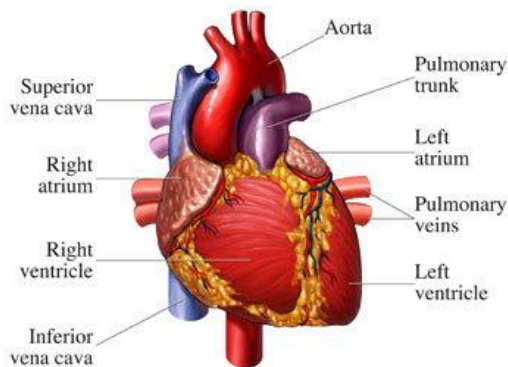
Every tissue in the body requires an adequate supply of oxygen, nutrients and hormones. The waste products should be removed from the tissue from time to time. These functions are carried out by the blood. The blood is pumped out by the heart into the Aorta from which it is distributed to all parts of the body.

### **THE HEART:**

- It is a hollow muscular organ, which is situated in the middle mediastinum in the thorax. It lies between the lungs and just above the diaphragm.
- The heart is slightly larger as a clenched fist.
- The heart measures about 12 x 9 cm and weighs about 300gram in males, and 250gram in females.
- The heart is a cone shaped organ.

### **RELATIONS OF THE HEART:**

- Anterior – Sternum, costal cartilage and ribs.
- Posterior – Esophagus, thoracic duct, Azygos vein.
- Superior - Superior vena cava.
- Inferior – Lungs.



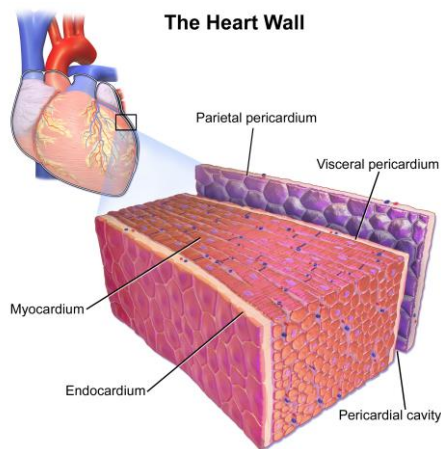
### **EXTERNAL FEATURE OF THE HEART:**

- Coverings of the heart – the wall of the heart consists of 3 layers:
  - a) Endocardium
  - b) Myocardium
  - c) Pericardium
- a) Pericardium – It is a double wall sac around the heart composed of
  - i) A superficial fibrous pericardium
  - ii) A deep two layer serous pericardium

- iii) The parietal layer lines the internal surface of the fibrous pericardium.
- iv) The visceral layer surface of the heart.

They are separated by the fluid filled pericardial cavity.

- b) Myocardium – It is a middle muscular layer. It is the thickest layer and forms the main mass of the heart. It is responsible for the contraction of the heart.
- c) Endocardium – It is the innermost layer of the tissue that lines the chambers of the heart. They are made up of epithelium tissue.



### **BASE, APEX AND SURFACES OF THE HEART:**

- The heart has a base, an apex and 3 surfaces – Sternocostal, the diaphragmatic, pulmonary surfaces. It has 4 borders – right, left, sup and inf.
- The base of the heart is located posteriorly and is formed mainly by the left atrium.
- The apex of the heart is formed by the left ventricle – it is located posterior to the 5<sup>th</sup> left intercostals space in adults.
- The sternocostal surface of the heart is mainly formed by the right ventricle.
- The diaphragmatic surface if the heart is mainly formed by both ventricles.
- The pulmonary or the left surface if the heart is formed by the left ventricle.

### **CHAMBERS OF THE HEART:**

- The heart has 4 chambers, 2 atria, and 2 ventricles.

- The right atrium – it forms the right border of the heart, between the SVC & IVC. It receives venous blood from the superior and inferior vena cava and coronary surface.
- The interatrial septum separates the right atrium from the left atrium.
- The Sino -atrial node ( S.A. NODE) lies in the wall of the right atrium. It is the natural pacemaker of the heart.
- Tricuspid valve is located between the R.A. and the L.A.

### **RIGHT VENTRICLE:**

- It is the largest part of the sternocostal surface.
- There are numerous irregular muscle bundle, papillary muscles, within the ventricles. A number fibrous threads called chorda tendineae.
- The right atrioventricular valve or tricuspid valve guards the right atrioventricular orifice.
- The pulmonary valve consist of 3 Semilunar cusps, guards the pulmonary orifice.

### **THE LEFT ATRIUM:**

- It forms the base or posterior of the heart.
- Four pulmonary veins enter the posterior wall of the left atrium.
- The bicuspid ( left atrioventricular valve) is located between the left atrium and the left ventricle.

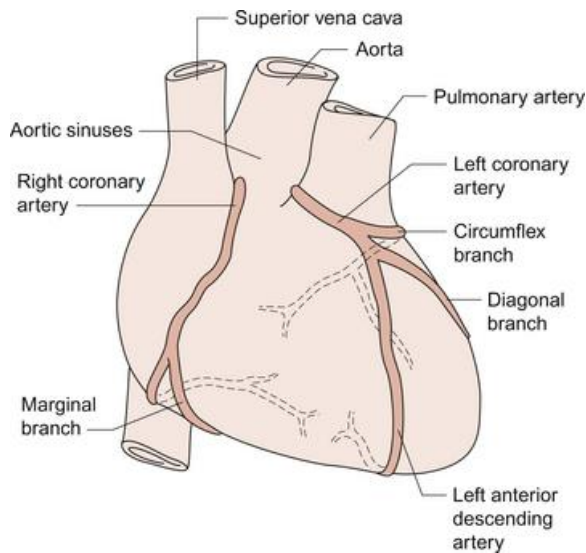
### **LEFT VENTRICLE:**

- It forms the apex of the heart.
- The wall of the left ventricle is twice as thick as that of the right ventricle, because the left ventricle performs more work than the right ventricle.
- The left atrioventricular valve or Mitral valve or bicuspid valve guards the left atrioventricular orifice.
- The left ventricle is separated from the right ventricle by a thick, interventricular septum.

### **BLOOD SUPPLY OF THE HEART:**

- Arterial supply – The heart gets it's nutrient and oxygen from two arteries- The right and left coronary arteries.
- These are the first branches of aorta.
- The right and left coronary arteries are called “coronary” because they encircle the base of the ventricle somewhat like a crown.

- The right coronary artery ( RCA) – It arises from the right aortic sinus. Branches of right coronary artery are – Posterior Interventricular branch  
Marginal branch
- The left coronary artery ( LCA) – It arises from the left aortic sinus. Branches of the left coronary artery are - Anterior interventricular branch  
Circumflex branch



### **VENOUS DRAINAGE OF THE HEART:**

- The walls of the heart are drained by veins that empty into the coronary sinus.
- Tributaries of the Coronary sinus –  
The great Cardiac vein  
Middle cardiac vein  
Small cardiac vein
- Some venous blood of the heart drained by anterior cardiac vein or Thebesian veins. It opens directly into the right atrium.

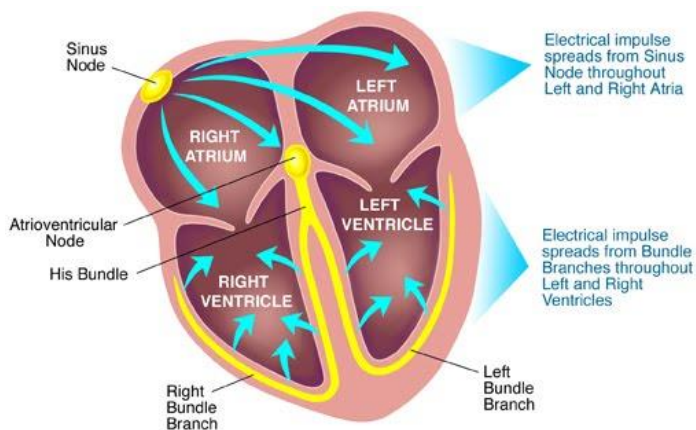
### **NERVE SUPPLY OF THE HEART:**

- The heart is supplied by Autonomic nerve fibers.
- Parasympathetic fibers are derived from both vagus nerves. Sympathetic fibers are derived from sympathetic trunks.
- Both these fibers are from a network called the Cardiac plexus.

### **CONDUCTING SYSTEM OF THE HEART:**

- This system consists of the specialized cardiac muscle cells, that can initiate impulses and conduct them rapidly through the heart.

- The co-ordinate the contractions of the 4 chambers of the heart.
- Parts of the conduction system –
  1. The Sino- atrial or S.A.node – it is the ‘natural pacemaker ‘ of the heart, because it initiates the impulses for contraction.
  2. The atrioventricular or AV node – it is located in the interatrial septum.
  3. The atrioventricular bundle - it is called Purkinje fibers. This bundle lies in the interventricular septum.
  4. Right & left branches of AV bundle – within the interventricular septum, the AV bundle - within the interventricular septum, the AV bundle divides into and left limbs and branches.



## VALVES OF THE HEART:

### 1. Tricuspid Valve

- Has three leaflets or cusps.
- Separates the top right chamber (right atrium) from the bottom right chamber (right ventricle).
- Opens to allow blood to flow from the right atrium to the right ventricle.
- Prevents the back flow of blood from the right ventricle to the right atrium.

Related valve problems include: [tricuspid atresia](#), [tricuspid regurgitation](#), [tricuspid stenosis](#)

### 2. Pulmonary Valve (or Pulmonic Valve)

- Has two leaflets.
- Separates the right ventricle from the pulmonary artery.
- Opens to allow blood to be pumped from the right ventricle to the lungs (through the pulmonary artery) where it will receive oxygen.
- Prevents the back flow of blood from the pulmonary artery to the right ventricle.

Related valve problems include: [pulmonary valve stenosis](#), [pulmonary valve regurgitation](#)

### 3. Mitral Valve

- Has two leaflets.
- Separates the top left chamber (left atrium) from the bottom left chamber (left ventricle).
- Opens to allow blood to be pumped from the lungs to the left atrium.
- Prevents the back flow of blood from the left ventricle to the left atrium.

Related valve problems include: [mitral valve prolapse](#), [mitral valve regurgitation](#), [mitral valve stenosis](#)

### 4. Aortic Valve

- Has three leaflets, unless it's abnormal from birth, i.e., bicuspid aortic valve.
- Separates the left ventricle from the aorta.
- Opens to allow blood to leave the heart from the left ventricle through the aorta and the body.
- Prevents the backflow of blood from the aorta to the left ventricle.

Related valve problems include: [aortic regurgitation](#) (also called aortic insufficiency), [aortic stenosis](#)

## CIRCULATION OF THE HEART:

- The Cardiovascular system is composed of two circulatory paths; the pulmonary circulation and the systemic circulation.
- Systemic circulation – systemic circulation is the movement of blood from the heart through the body to provide oxygen and nutrients and bringing deoxygenated blood back to the heart .
- Pulmonary circulation – pulmonary circulation is the movement of blood from the heart to the lungs for oxygenation then back to the heart again.

## EVENTS OF CARDIAC CYCLE:

The stages of the cardiac cycle can be roughly divided into the **four stages**:

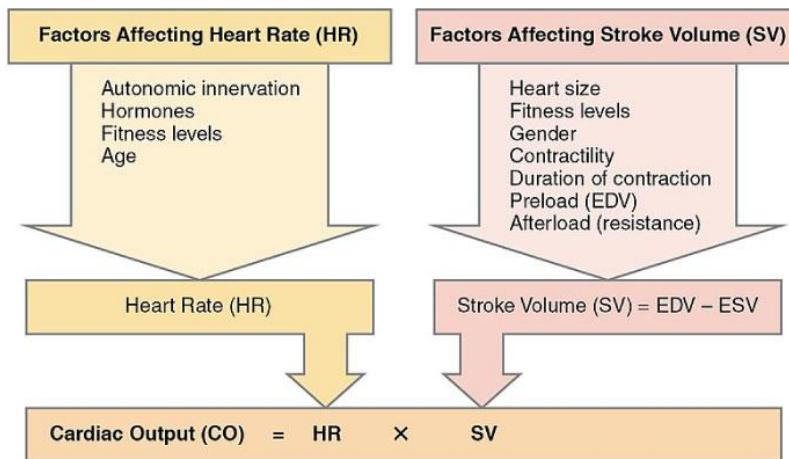
- **Filling phase** – the ventricles fill during diastole and atrial systole
- **Isovolumetric contraction** – the ventricles contract, building up pressure ready to pump blood into the aorta/pulmonary trunk
- **Outflow phase** – the ventricles continue to contract, pushing blood into the aorta and the pulmonary trunk. Also known as systole
- **Isovolumetric relaxation** – the ventricles relax, ready to re-fill with blood in the next filling phase

## FACTORS AFFECTING CARDIAC OUTPUT:

**“Cardiac output refers to the volume of blood pumped out per ventricle per minute.”**

Cardiac output is the function of heart rate and stroke volume. The amount of blood pumped by the left ventricle in one compression is called the stroke volume.

Cardiac Output is an excellent example to exhibit the efficiency of the [human heart](#). It is related to the amount of blood pumped by the heart per minute. A normal cardiac output would be about five litres of blood per minute in a healthy individual.



The cardiac output comprises 2 vital components:

- **Heart rate:** It refers to the number of times the heart beats per minute (bpm).
- **Stroke volume:** It refers to the quantity of blood pumped out of each ventricle with every heartbeat.

Factors Determining Cardiac Output

The following factors determine the cardiac output of a human heart:

Venous Return

This is the amount of blood that enters the heart through the veins per minute. After a certain time interval, the venous return becomes equal to the cardiac output.

Force of Contraction

The stroke volume and the cardiac output increases with the increase in the force of contraction.

Heart Rate

The cardiac output increases with the increase in heart rate.

Cardiac Output Formula

The equation for cardiac output is:

**Cardiac Output (CO) = HR x SV**

## Cardiac Output Calculation

For example: If the heart rate is 70 bpm and stroke volume is 70 ml.

Using the formula: **HR X SV**

= 70 X 70

= 4900 ml/min or 4.9 liters per minute.

## Cardiac Output Measurement

There are different merits and demerits of measuring cardiac output using methods in an invasive and non-invasive manner. At present, there is no standard comparison system available for these methods using a reference measurement or standards.

The invasive systems are well accepted, but there is progressing evidence that these systems are neither accurate nor effective in guiding therapy.

Some of the methods to measure cardiac output are listed below:

- Doppler ultrasound
- Echocardiography
- Transcutaneous
- Transoesophageal

Low output results in heart failure, a severe infection or [heart diseases](#).

The high output may be an indicator of blood infections.

### References:

*Science of medicine*

*American Heart Association*

*Byju's classes*