UNIT – V
CARDIOVASCULAR SYSTEM

Presented By

Mr. Manesh B. Kokani

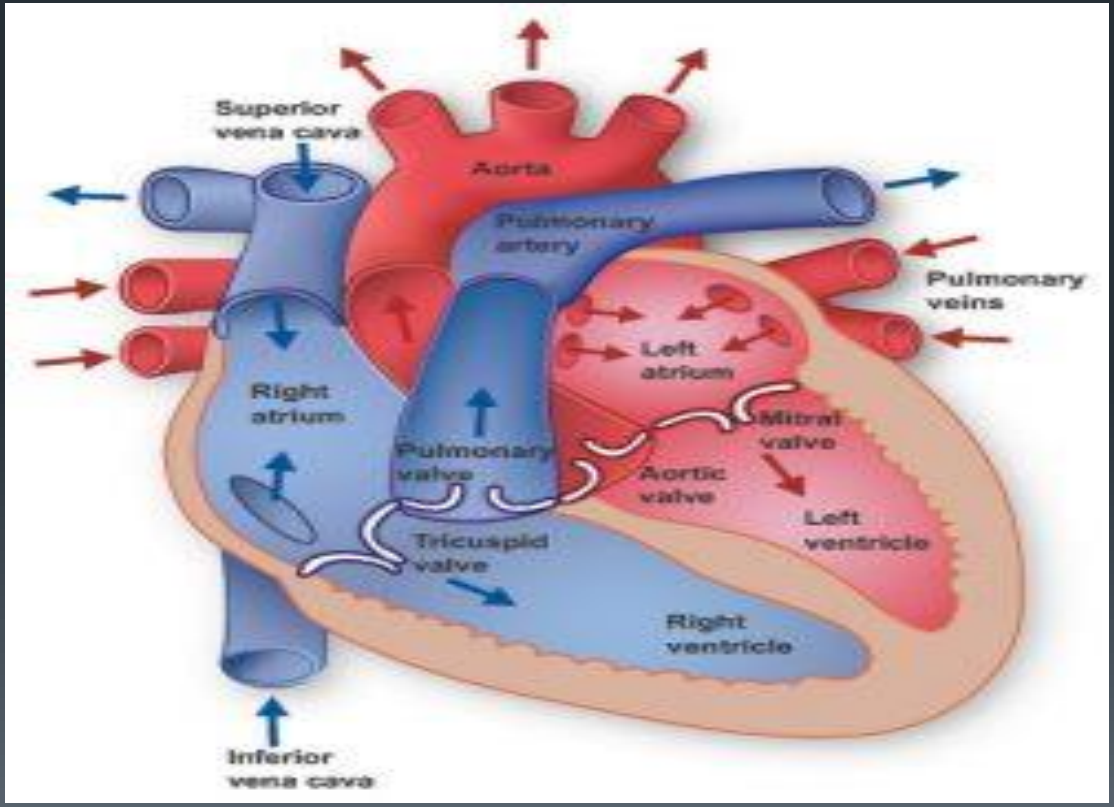
Dept. of Pharmacology

Assistant Professor

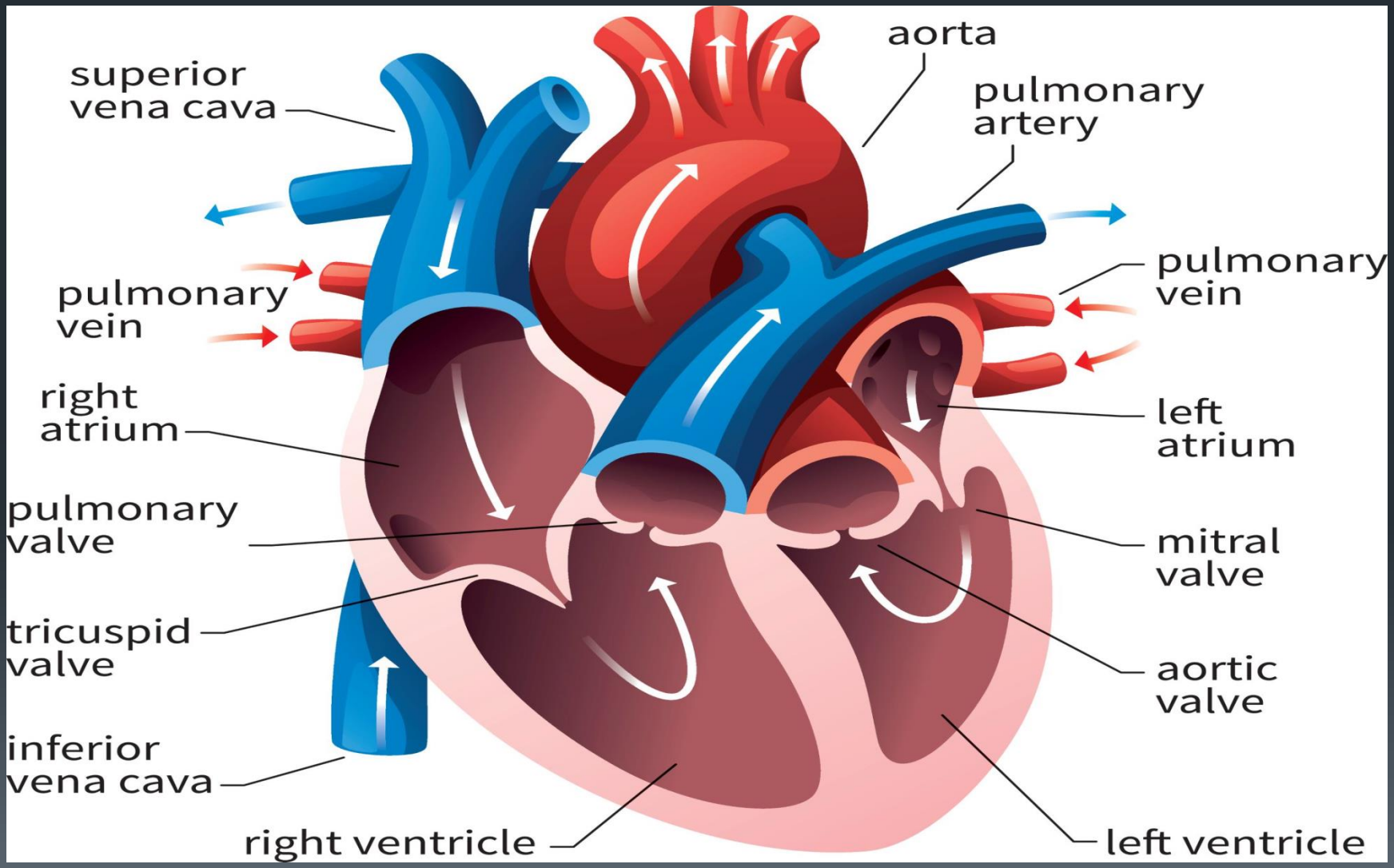
Jijamata College of Pharmacy, Nandurbar.

HEART

Cardiology: It is the branch of science that deals with study of heart & disease of heart



HEART ANATOMY



- Shape: Cone shaped
- Weight: 250gm in adult females, 300gm in adult males.
- Size: Approximately the size of closed fist
- Location: Above the diaphragm, Near the middle of thoracic cavity, Between the lungs.

Dimensions

- 12 cm long
- 9 cm wide
- 6 cm thick

Parts

- Four chambers
- 2 Atria
- 2 Ventricles.

COVERINGS OF HEART: PERICARDIUM

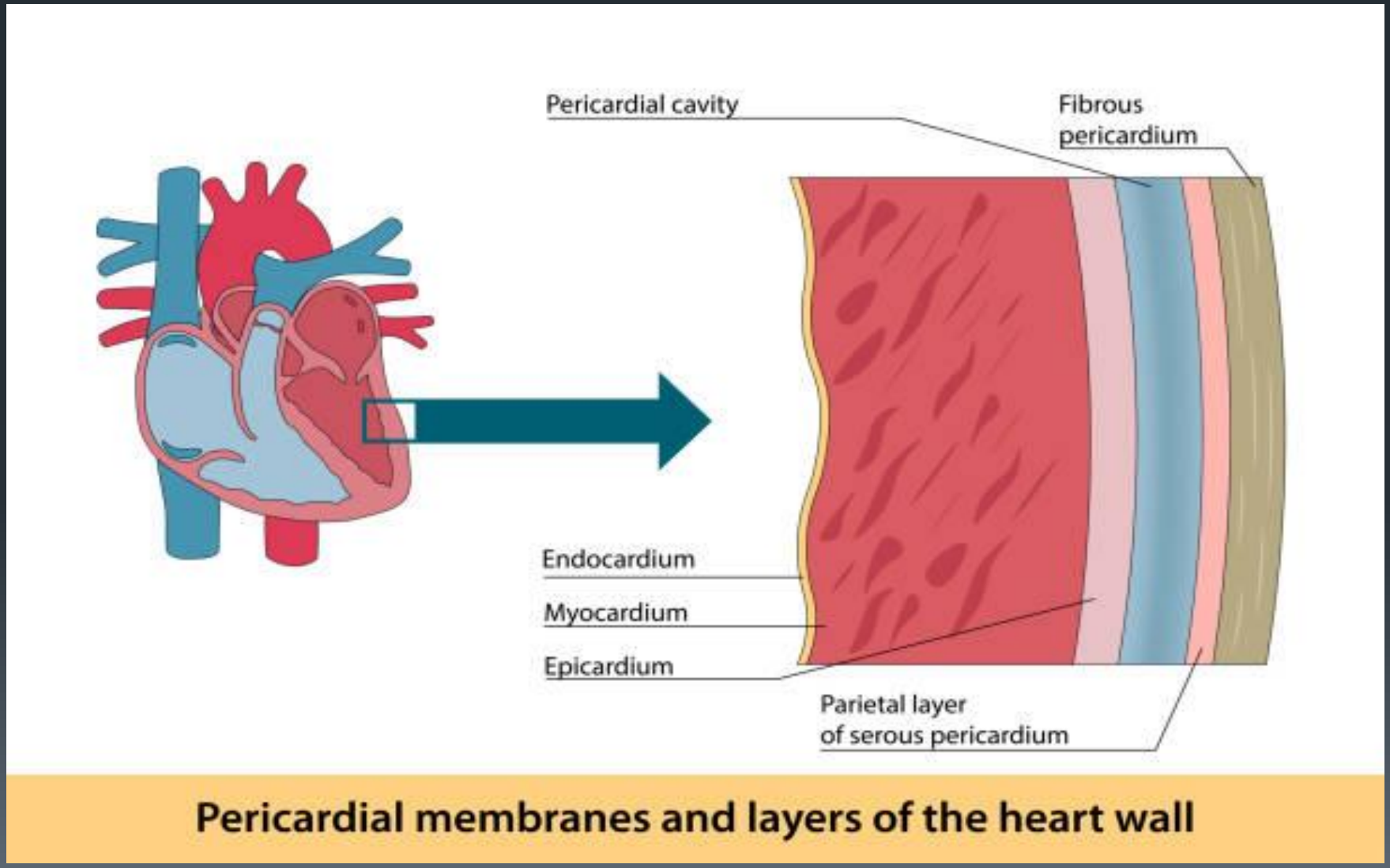
- Pericardium – Double walled membrane that surrounds & protects the heart

- It confines the heart to its position & allows sufficient freedom of movement for contraction.

- It is composed of:

1. A superficial fibrous pericardium
2. A deep serous pericardium:
3. Parietal layer
4. Visceral layer

DIAGRAM OF PERICARDIUM



PERICARDIUM

✓ Fibrous pericardium:

- It is made of tough inelastic, dense irregular connective tissue.
- It prevents over stretching of heart, provides protection & holds the heart at particular position.

✓ Serous pericardium:

- Is a thinner, more delicate membrane that forms double layer around the heart.
- Outer parietal layer fused with fibrous pericardium.
- Inner visceral layer called as epicardium (external layer of heart wall)
- Space between parietal & visceral layer is called as pericardial cavity and filled with pericardial fluid.

FUNCTION OF PERICARDIUM

- Protects & anchors the heart
- Prevents overfilling of the heart with blood
- Allows the heart to work in a relatively friction-free environment

Heart Wall

✓ Wall of heart consists of 3 layers;

- Epicardium (External layer)
- Myocardium (Middle layer)
- Endocardium (Inner layer)

✓ Epicardium:

- Outermost, thin, transparent layer of heart wall.
- Also called as visceral layer of serous pericardium.
- Composed of delicate connective tissue that imparts smooth, slippery texture to outer surface of heart.

Heart Wall

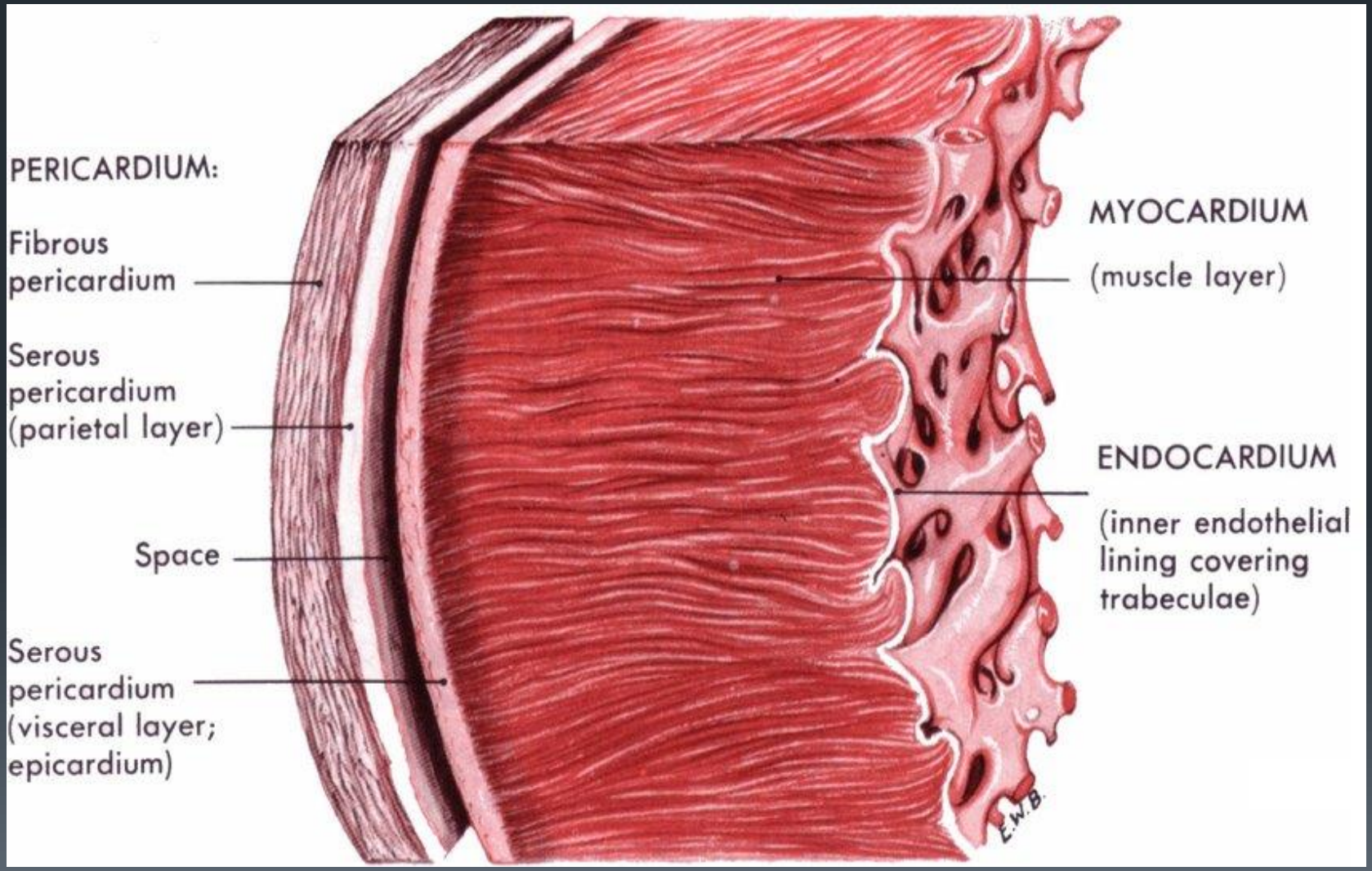
✓ Myocardium:

- Middle layer, made up of cardiac muscle tissue, make up the bulk of heart.
- Responsible for pumping action

✓ Endocardium:

- Inner layer of heart wall made up of endothelial cells
- Provides smooth lining for the chambers of heart & covers the valve of heart.

DIAGRAM OF HEART WALL



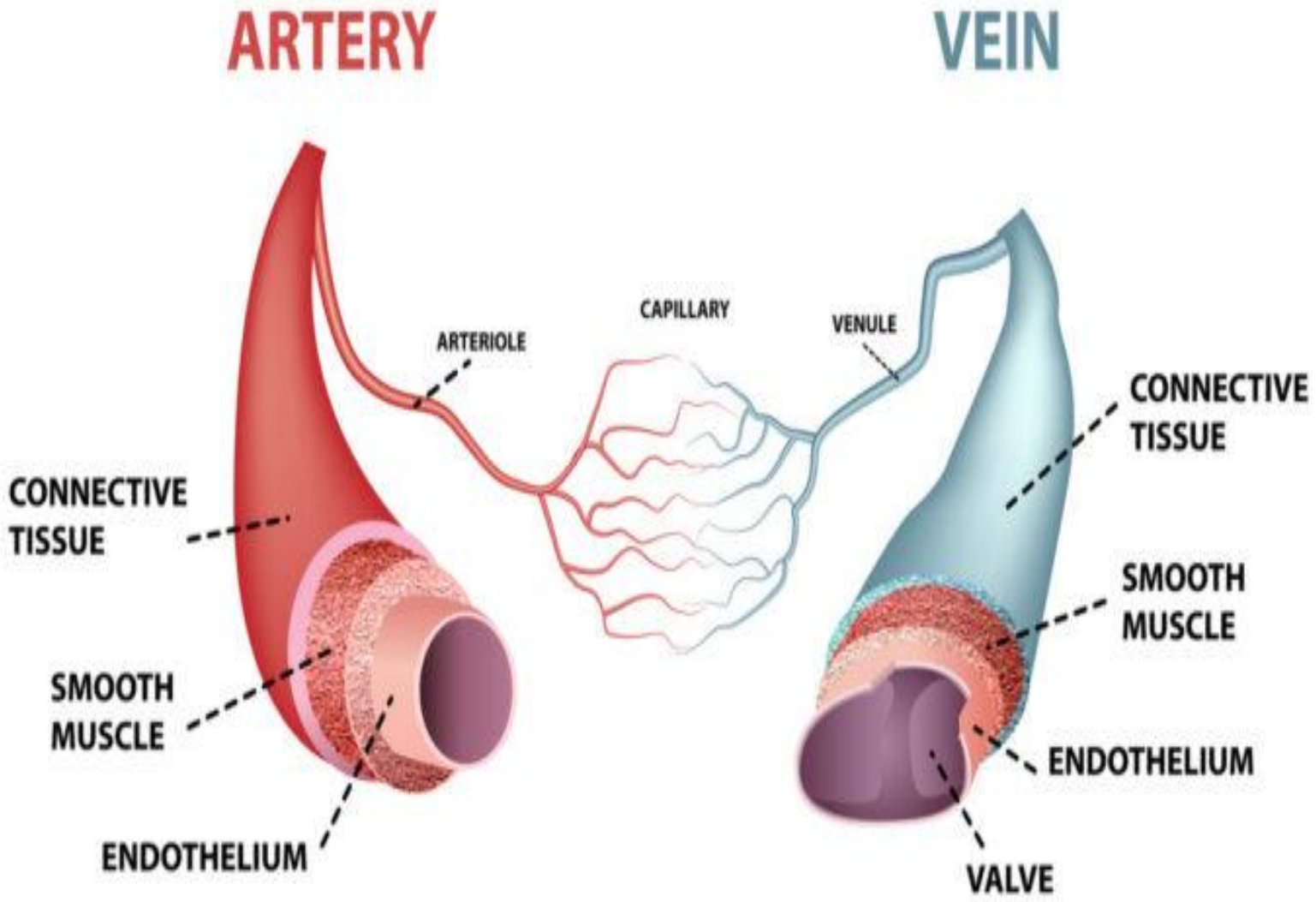
Blood Vessels

- Five types of blood vessels

  (Taking blood to the tissues & back)

1) Arteries
2) Arterioles
3) Capillaries
4) Venules
5) Veins

STRUCTURE OF BLOOD VESSELS



Blood Vessels

Arteries

Arterioles carry blood away from the heart

Elastic Fibers

Smooth

Capillary

where gas exchange takes place.

One cell thick

Serves the Respiratory System

Veins

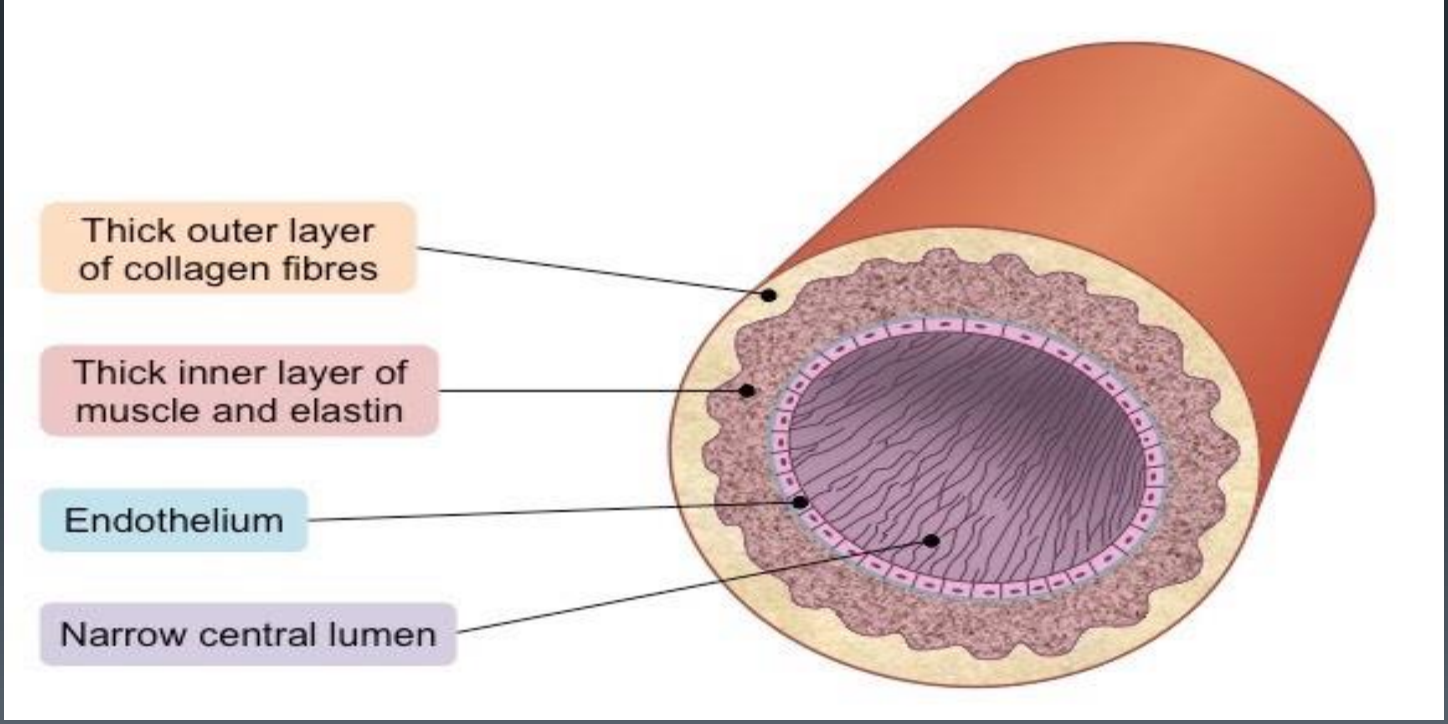
Venules moves blood towards the heart

One way valves

When they break - varicose veins form

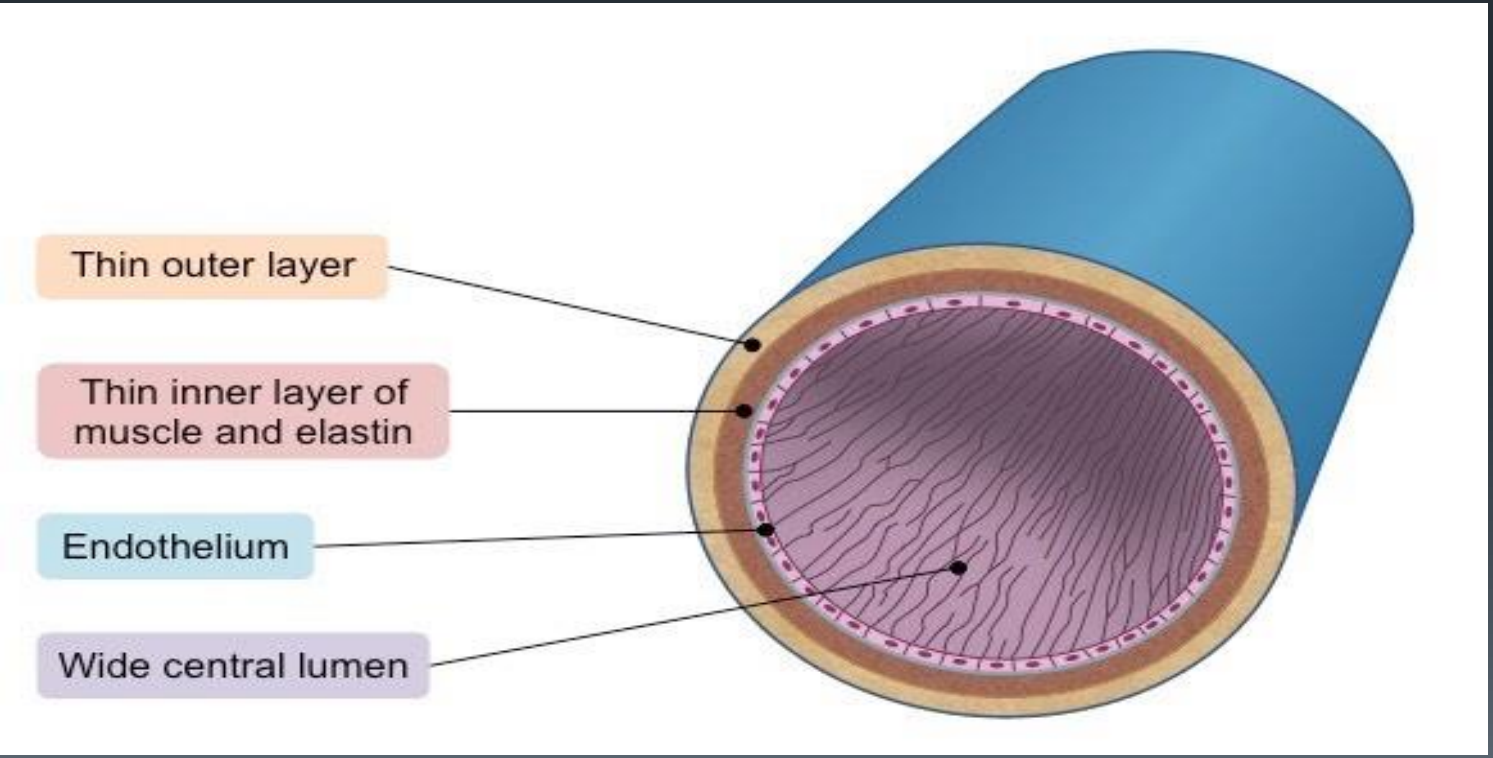
THE ARTERY

- Arteries carry blood away from the heart.
- The elastic fibres allow the artery to stretch under pressure.



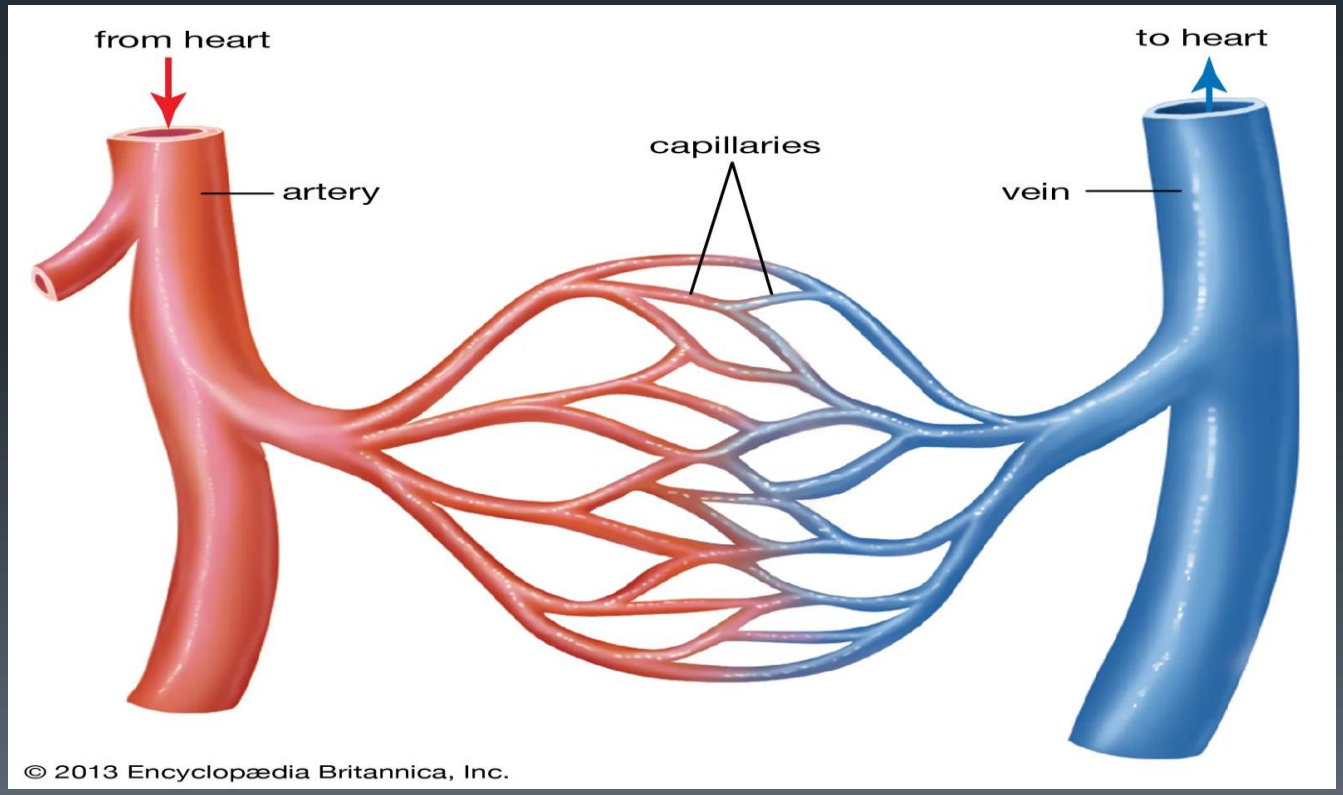
The Vein

- Veins carry blood towards the heart.
- veins have valves which stop the blood from going in wrong direction.



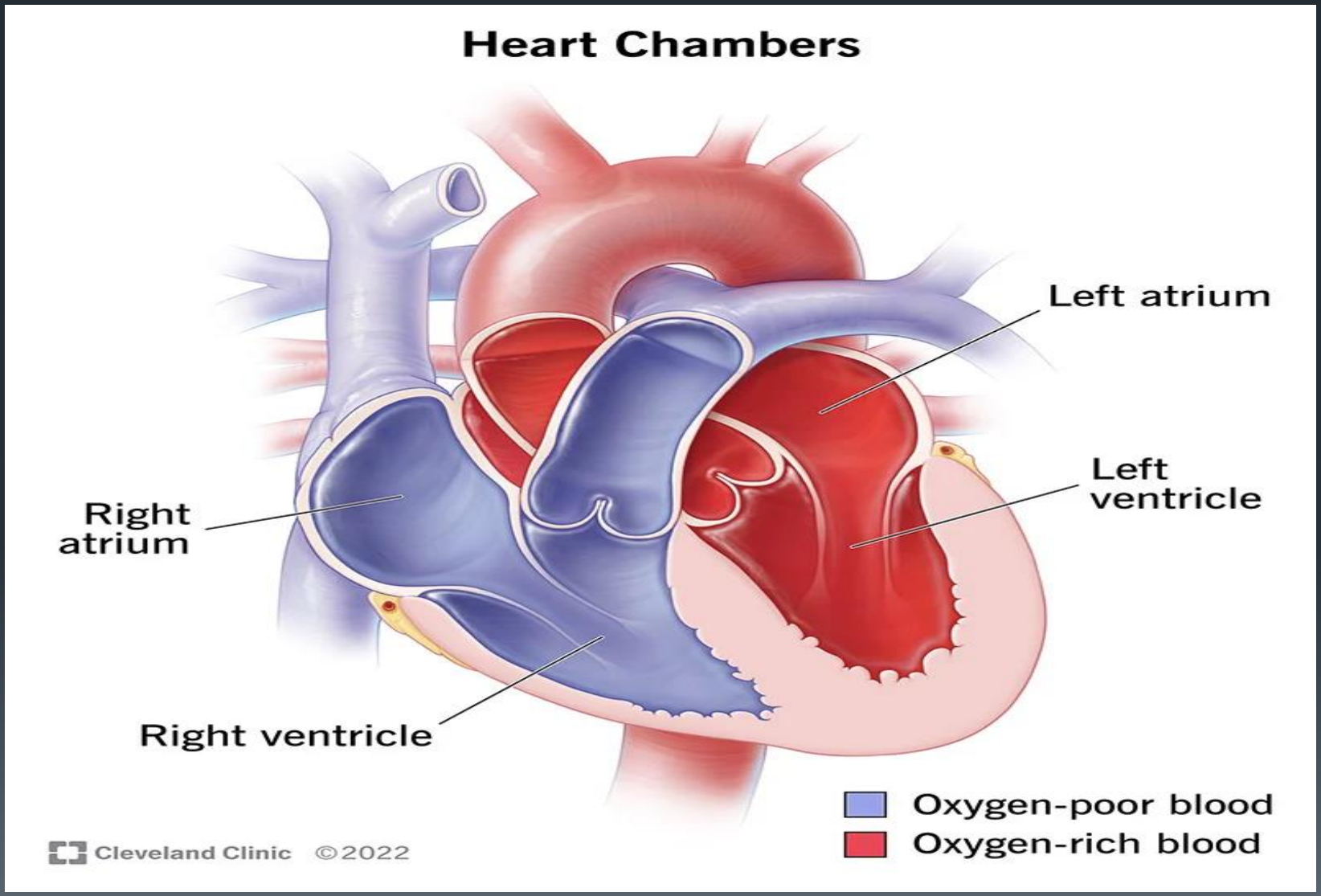
The Capillary

- Capillaries link Arteries with Veins
- They exchange materials between the blood and other body cells.



	ARTERIES	VEINS
Direction of flow	Blood Away from Heart	Blood to Heart
Pressure	Higher	Lower
Walls	THICKER: Tunica media is thicker	THINNER: Tunica external is thinner
Lumen	Smaller	Larger
Valves	No valves	Valves

CHAMBERS OF HEART



Chambers of the Heart

4 chambers of heart

- 2 ventricles & 2 atria
- Right atrium (RA): collects blood from systemic circulation
- Right ventricle (RV): pumps blood to pulmonary circulation
- Left atrium (LA): collects blood from pulmonary circulation
- Left ventricle (LV): pumps blood to systemic circulation

Right Atrium (RA)

- Atria are the receiving chambers of the heart
- RA is roughly quadrangular in shape.

- Divided into 2 parts;
- Upper part
- Lower part

- Superior vena cava present at the upper part
- Inferior vena cava present at lower part

Right Ventricle (RV)

- Ventricles are the pumping chambers of the heart.
- It is convex & forms large part of heart.
- The wall of RV is much thinner than LV.

Left Atrium (LA)

- Smaller in shape than RA
- Roughly cuboidal in shape
- Four pulmonary veins open at the upper part of LA

Left Ventricle (LV)

- It functions as a powerful pump operating at high pressure.
- The walls are three times more thicker as that of RV.
- Cone shaped, longer and narrower than RV

Heart Valves

- As each chamber of heart contracts, it pushes a portion of blood into a ventricle or out of heart through an artery.
- To prevent back flow of blood, the heart has valve.
- Made up of dense connective tissue covered by endocardium

2 types of valve

- Atrioventricular valve (AV valve)
- Tricuspid valve
- Bicuspid valve
- Semilunar valve (SL valve)

Atrioventricular (AV)

- Atrioventricular (AV) valves lie between the atria and ventricles
- AV valves prevent backflow of blood into the atria when ventricles contract

2 types

- Tricuspid valve
- Bicuspid valve

ATRIOVENTRICULAR (AV)

- Tricuspid valve:
- It is present between RA and RV is called as tricuspid valve

Consist of 3 cuspid (flaps)

- Septal cuspid
- Anterior cuspid
- Posterior cuspid

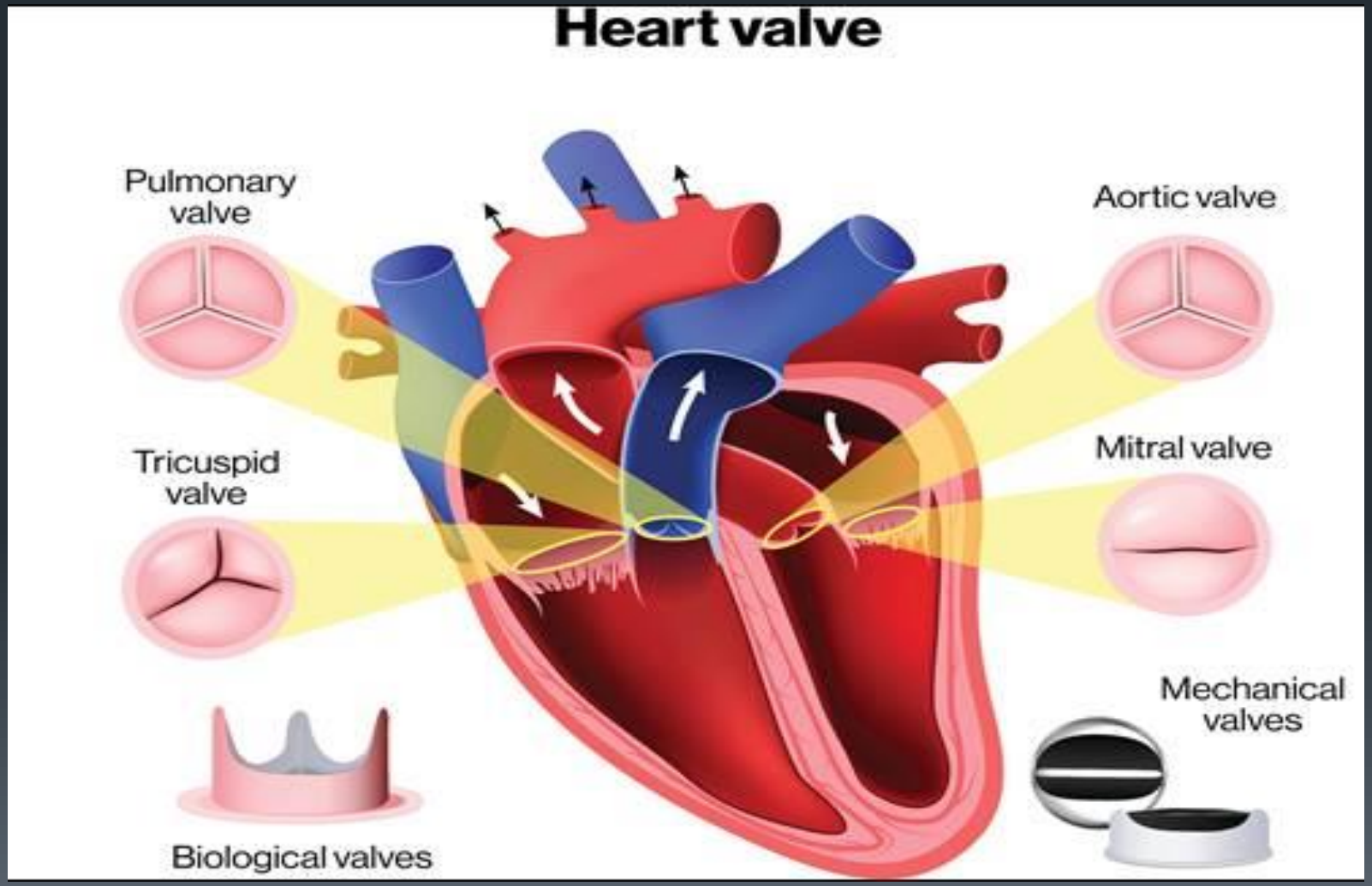
Bicuspid valve

- It is present between LA and LV is called as bicuspid valve.
- Consist of 2 cusps.
- Also called as mitral valve.

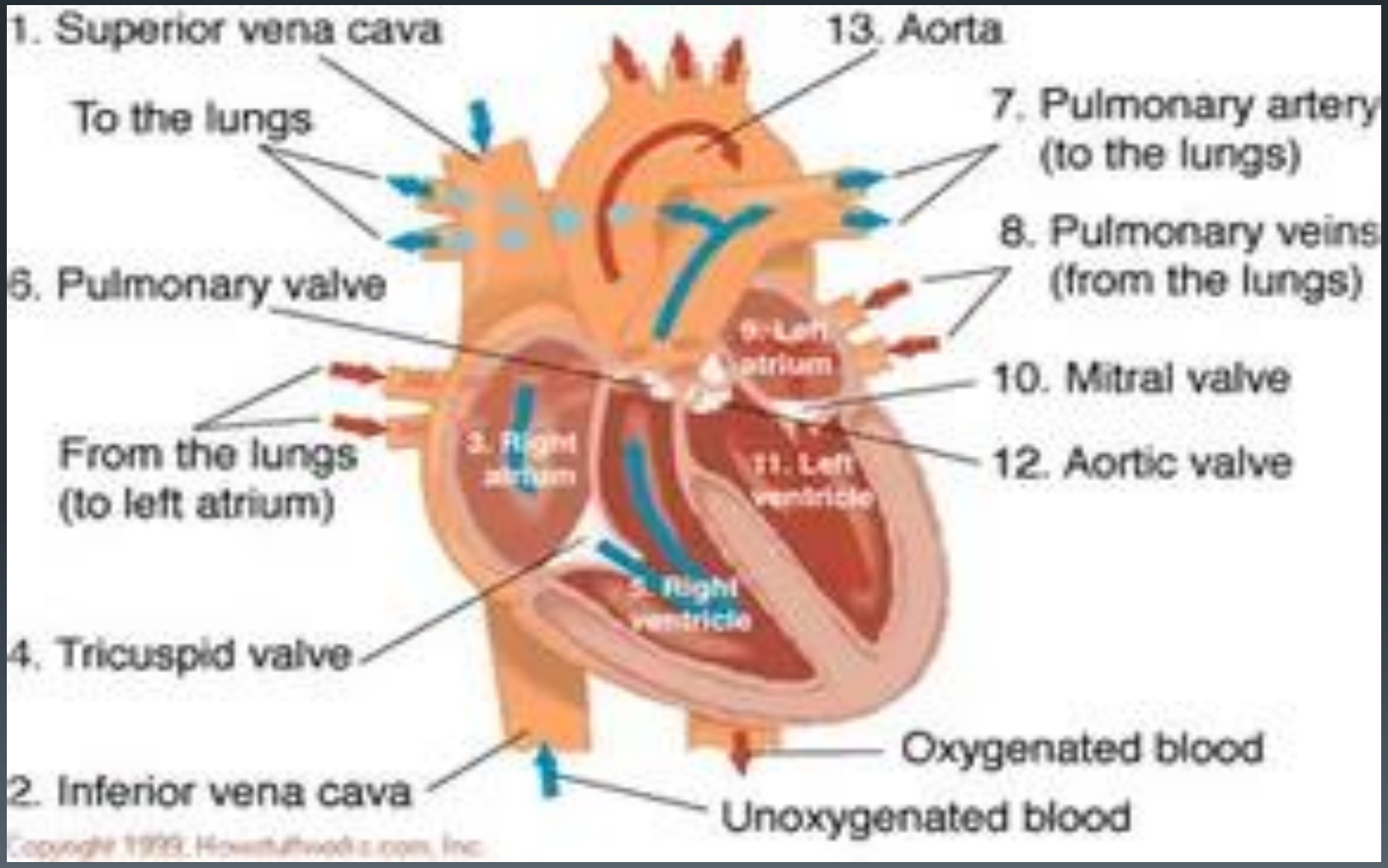
Semilunar Valves

- Semilunar valves prevent backflow of blood into the ventricles
- Aortic semilunar valve lies in the aorta
- Pulmonary semilunar valve lies in the pulmonary trunk
- Both the valves consist of 3 half moon shaped cusps.
- Permits blood flow in only one direction.

Heart Valves



Blood Flow Through Heart & Lungs



Pathway of Blood Through Heart & Lungs

Inferior vena cava

Superior vena cava

↓

Right atrium

↓

Tricuspid valve

↓

Right ventricle

↓

pulmonary semilunar valve

↓

pulmonary arteries

↓

Lungs

↓

Pulmonary Veins

↓

Left atrium

↓

Bicuspid Valve

↓

Left ventricle

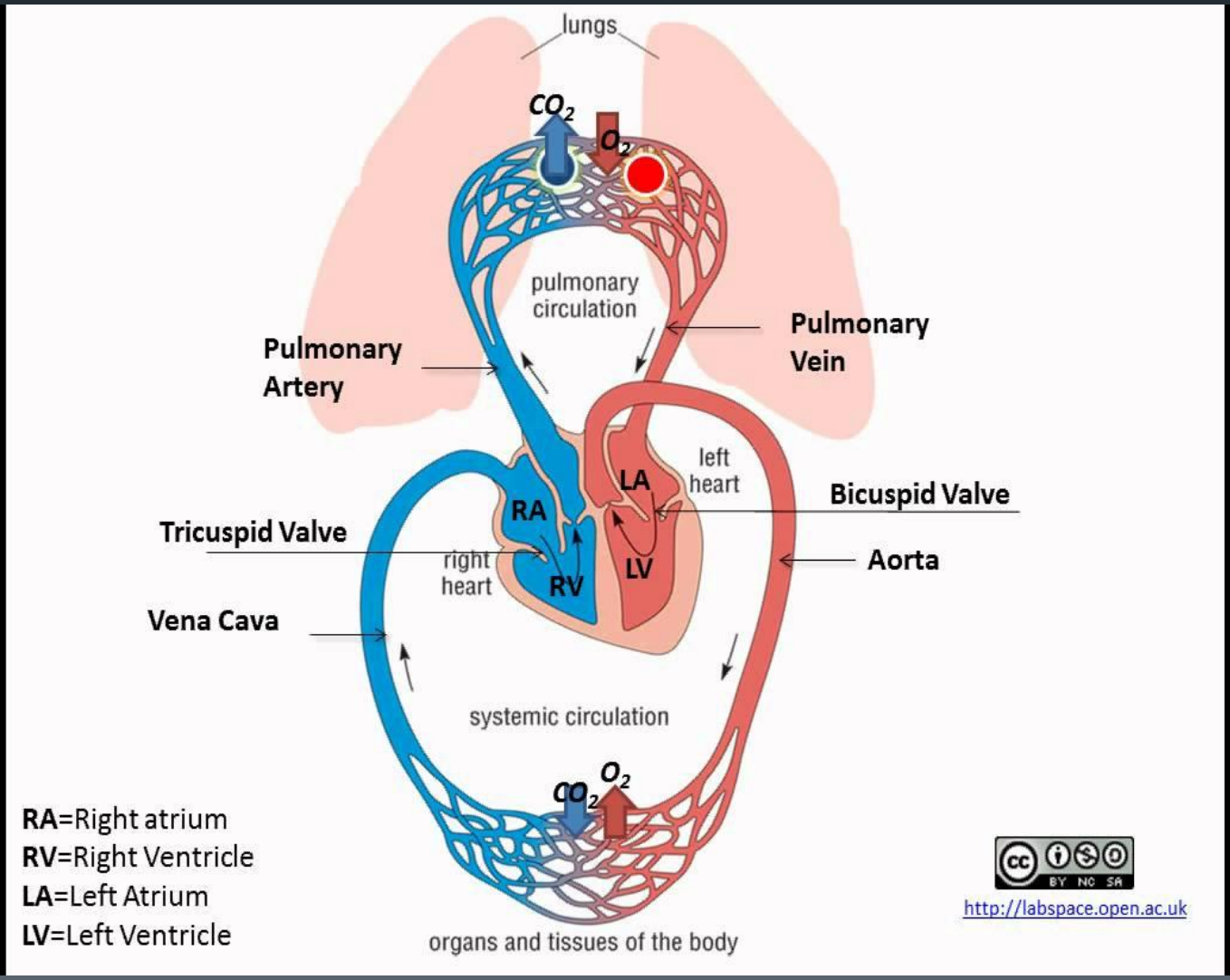
↓

Aortic Semilunar Valve

↓

Aorta

PULMONARY & CORONARY CIRCULATION

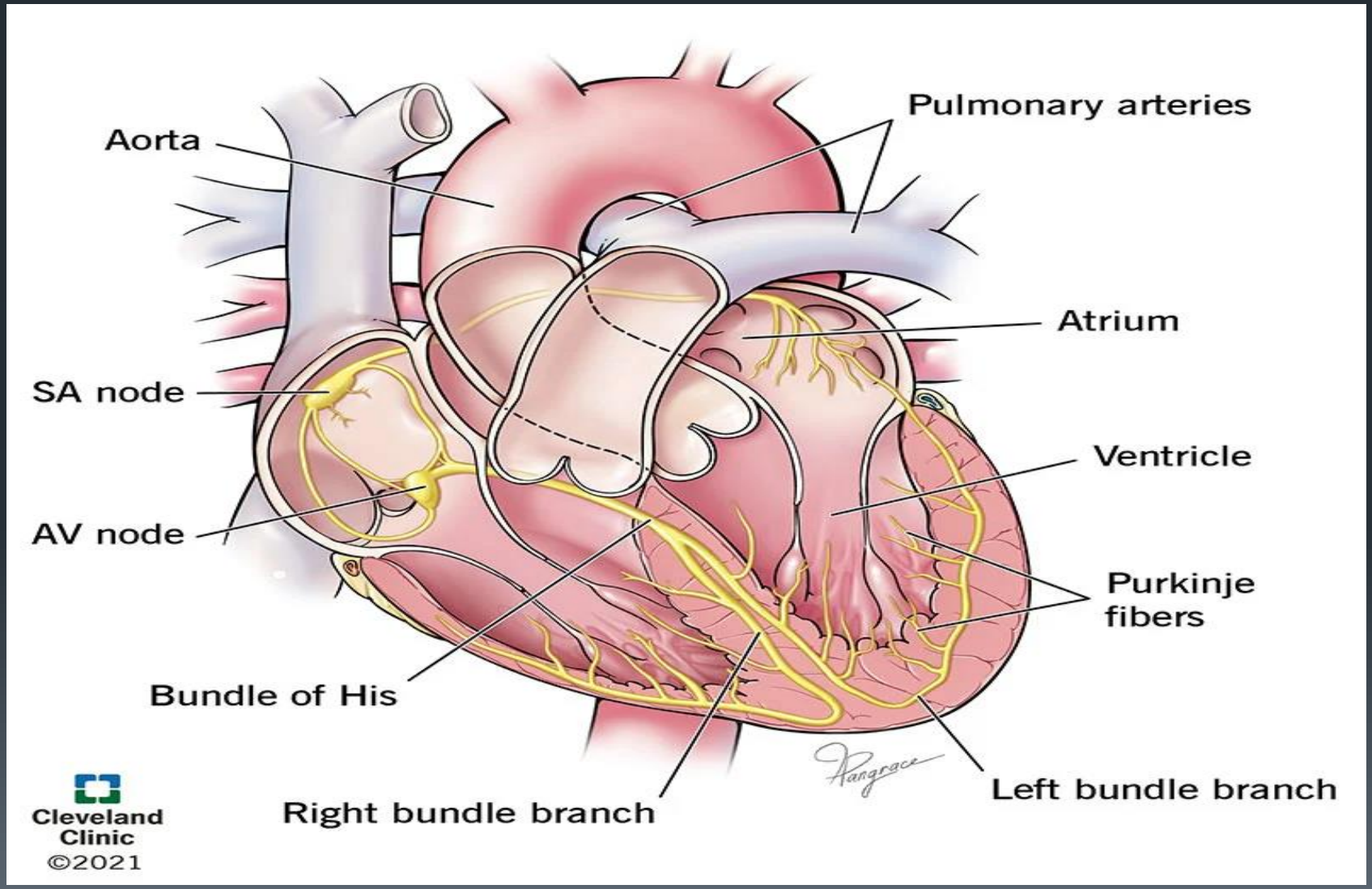


Pathway of Blood Through Heart & Lungs

- The right side of heart pumps blood into the pulmonary circulation.
- Blood returning from the body is relatively oxygen-poor and carbon dioxide-rich
- Blood enters the right atrium and passes into the right ventricle, which pumps it to the lungs via the pulmonary arteries (conduct blood away from the heart)

- In the lungs, the blood unloads carbon dioxide and picks up oxygen (oxygenated)
- The left side of the heart pumps blood into the systemic circuit
- Coronary Circulation
- Coronary circulation is blood supply to the heart muscle itself Arterial Supply Venous Supply

CONDUCTING SYSTEM OF HEART



CONDUCTING SYSTEM OF HEART

- A special system is available in the heart responsible for the rhythmic contraction and conduction of impulses in the heart.

DIVIDED INTO 5 PARTS

- SA Node or Sinoatrial Node
- AV Node or Atrioventricular Node
- AV Bundle (Bundle of His)
- Right & Left Bundle Branches
- Conduction Myofibers (Purkinje Fibers)

CONDUCTING SYSTEM OF HEART

- Sinoatrial (SA) node:
- It is located in the right atrial wall just below the opening of superior vena cava.
- Cardiac excitation begins in the SA node,
- Each SA node impulse travels throughout the heart via the conduction system

- Atrioventricular (AV) node:
- It is located in the septum between the two atria.
- The cardiac impulses spreads from SA node to AV node.

CONDUCTING SYSTEM OF HEART

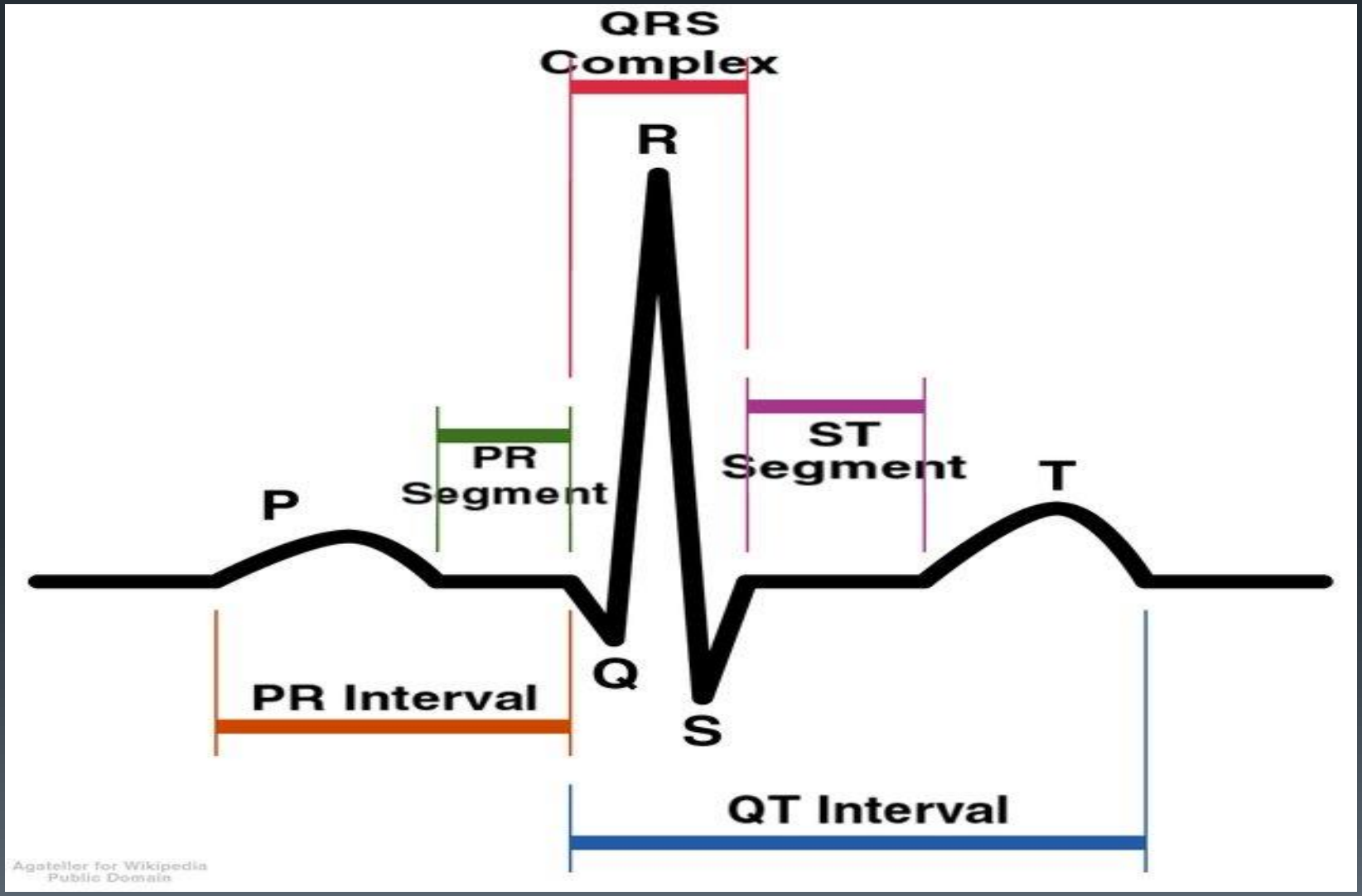
- Atrioventricular bundle (bundle of His):
- From AV node, the impulse enters the Bundle of His, only electrical connection between atria and ventricle.
- AV bundle splits into two pathways
- Bundle branches carry the impulse toward the apex of the heart
- Purkinje fibers carry the impulse to the heart apex and ventricular walls

CONDUCTING SYSTEM OF HEART

- Right & left bundle branches:
- From the bundle branches the impulses then enters the right & left bundle branches that runs towards the apex of the heart.

- Perkinje Fibers:
- The impulse from right and left bundle branches enters into Perkinje fibers.
- These conduct impulses to all parts of ventricles.
- Then the ventricles contracts pushing the blood upwards towards the SA node.

ELECTROCARDIOGRAM



ELECTROCARDIOGRAM

- Conduction of action potential through heart generates electrical currents that can be detected at the surface of the body.

- A recording of electrical changes during each cardiac cycle is called as electrocardiogram (ECG).
- The instrument used to record the change is called as an electrocardiograph.

It consist of 3 waves;

- P wave
- QRS wave
- T wave

ELECTROCARDIOGRAM

- P wave:
- It is small upward wave.
- It represents atrial depolarization which spreads from SA node throughout both atria.

- QRS wave:
- The complex represents 3 separate waves.
- Q wave, R wave and S wave
- The complex begins with downward deflection of Q wave, continues as a large, upright, triangular defection of R wave & ends as a downward deflection of S wave.
- The QRS complex represents ventricular depolarization.

ELECTROCARDIOGRAM

- T wave:
- It represents ventricular repolarisation. Third dome shaped upward deflection
- The T wave is small & more spread out than QRS complex because repolarisation occurs more slow than the depolarisation.

- PQ or PR interval:
- The duration between beginning of P wave & beginning of QRS wave is called as PQ interval.
- It is also called as PR interval because the Q wave is frequently absent.
- It is interval between beginning of contarction of atria & beginning of contraction of ventricles.

ELECTROCARDIOGRAM

- ST Segment:
- It begins at the end of S wave & starting of T wave.

- QT interval:
- The QT interval extends from the start of QRS complex to the end of T wave.
- It is the time from beginning of ventricular depolarization to the end of ventricular repolarization.

ELECTROCARDIOGRAM

- Following conclusions can be made with the altered ECG notes.
- Larger P wave: It indicates enlargement of atrium.
- Enlarged Q wave: It indicates myocardial infarction.
- Enlarged R wave: It indicated enlargement of ventricles.
- Flatter T wave: It indicates insufficient oxygen supply to myocardium.
- Larger PQ interval: It indicates formation of scar tissue in heart due to coronary artery disease.
- Larger ST segment: It indicates acute myocardial infarction when elevated above the baseline & insufficient oxygen supply to heart muscle when depressed below the baseline.

Renin Angiotensin Aldosterone System (RAA)

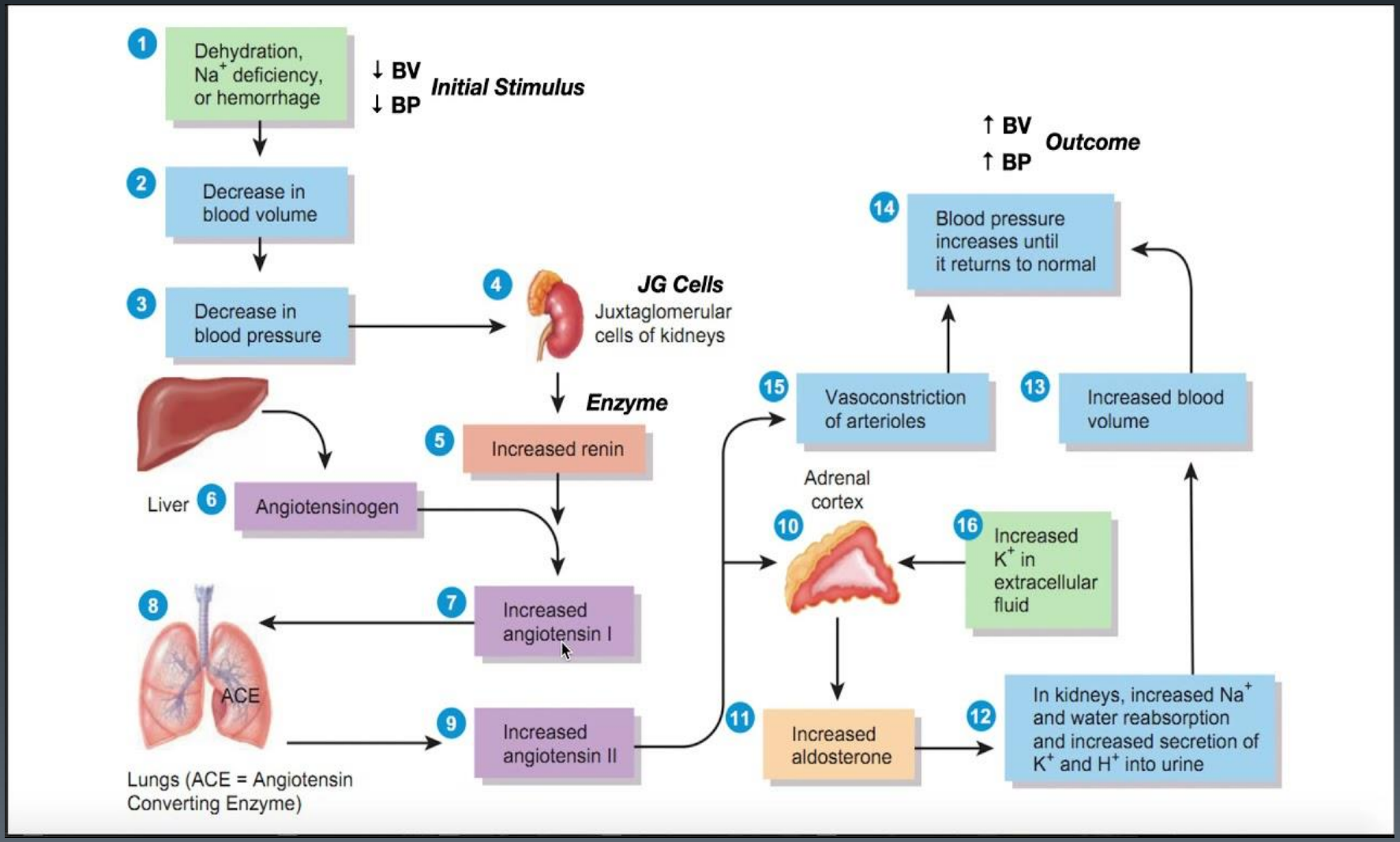
- Renin:
- It is secreted by the juxtaglomerular cells in Kidney
- Angiotensinogen:
- It is a glycoprotein synthesized by liver & secreted into the bloodstream

- Aldosterone:
- It is a mineralocorticoid produced in the adrenal cortex
- It plays a central role in the regulation of blood pressure mainly by acting on the distal tubules & collecting ducts of nephron Renin-Angiotensin-Aldosterone System

- Angiotensin:
- It is a peptide hormone that causes vasoconstriction and a subsequent increase in blood pressure.
- Angiotensin-I
- Angiotensin-II

- Angiotensin converting enzyme (ACE):
- It converts angiotensin I to II (vasoconstrictor) Renin-Angiotensin-Aldosterone System

Renin Angiotensin Aldosterone System (RAA)



BLOOD PRESSURE

- Blood pressure: It is the pressure excreted by blood on the wall of arteries.
- Systolic BP–Ventricular contraction
- Diastolic BP–Ventricles relaxation
- Normal BP = 120/80 mm Hg

- Pressure in blood vessels decreases as the distance from the heart increases
- It is essential to record both BP's as it gives information regarding the status of working heart.
- BP varies from different physiological parameters like age, sex, exercise, posture, sleep during emotions, etc.

METHODS OF BP DETERMINATION

- Oscillatory method
- Palpatory method
- Auscultatory method

(Stethoscope and Sphygmomanometer)

- Blood pressure It depends on the speed of blood coming into a vessel and width of vessel itself. Arteries Speed: high Width: medium Pressure: high Capillaries Speed: medium Width: narrow Pressure: medium Veins Speed: low Width: wide Pressure: low

- Blood pressure An individual’s blood pressure is affected by a number of factors.
- Age – It increases as you get older.
- Gender – Men tend to have higher blood pressure than women.
- Stress - Can cause increase blood pressure.
- Diet – Salt and saturated fats can increase blood pressure.
- Exercise – Exercise lowers the blood pressure Having high blood pressure puts stress on heart. It can lead to angina, heart attacks and strokes.

AUSCULTATORY METHOD

- Initially the cuff is inflated to a level higher than the systolic pressure.
- Thus the artery is completely compressed, there is no blood flow, and no sounds are heard.
- The cuff pressure is slowly decreased. At the point where the systolic pressure exceeds the cuff pressure, the Korotkoff sounds are first heard and blood passes in turbulent flow through the partially constricted artery.
- Korotkoff sounds will continue to be heard as the cuff pressure is further lowered.
- However, when the cuff pressure reaches diastolic pressure, the sounds disappear.
- Now at all points in time during the cardiac cycle, the blood pressure is greater than the cuff pressure, and the artery remains open.

HEART SOUND

- Auscultation – listening to heart sound via stethoscope

- Four heart sounds
- S1 – “lubb” caused by the closing of the AV valves
- S2 –“dupp” caused by the closing of the semilunar valves
- S3 – a faint sound associated with blood flowing into the ventricles
- S4 – another faint sound associated with atrial contraction Heart sounds

- Variations in Blood Pressure Variations in Blood Pressure
- Human normal range is variable

- Normal • 140–110 mm Hg systolic • 80–75 mm Hg diastolic

- Hypotension • Low systolic (below 110 mm HG) • Often associated with illness

- Hypertension • High systolic (above 140 mm HG) • Can be dangerous if it is chronic

CONTROL OF BLOOD PRESSURE

- Blood pressure is controlled in 2 ways:
- Short term control: Mainly involves the baroreceptor reflex, chemoreceptor & circulating hormones
- Long term control: Involves regulation of blood volume by the kidneys and RAA system
- The cardiovascular centre (CVC) is a collection of interconnected neurons in the brain

- The CVC receives, integrates & coordinates inputs from:
- Baroreceptors (pressure receptors)
- Chemoreceptor
- Higher centers in the brain

BARORECEPTORS

- These are nerve endings sensitive to pressure changes (stretch) within the vessel, situated in the arch of the aorta
  - Rise in B.P. in these arteries
  - Stimulation of Baroreceptors
  - Increasing their input to the CVC
  - Increases parasympathetic nerve activity to heart
  - Decreases HR & decreases FC
  - Vasodilation
  - Fall in systemic blood pressure

- Conversely
  - Fall in B.P. aortic arch and carotid sinuses
    - Deactivation of Baroreceptors
      - Decreasing their input to the CVC
  - Increases sympathetic nerve activity to heart
    - Increases HR & FC
    - Vasoconstriction
  - Rise in systemic blood pressure

CHEMORECEPTOR

- These are nerve endings situated in the carotid and aortic bodies.
- Involved in control of respiration.
- Sensitive to changes in the levels of carbon dioxide, oxygen & the acidity of the blood (pH).

Hormonal regulation of BP

- Epinephrine & Nor-epinephrine: Adrenal medulla releases epinephrine and nor-epinephrine. These changes increases CO by increase in the HR & FC.

- Antidiuretic hormone (ADH): It is produced by hypothalamus causes vasoconstriction that increases BP. Hence, it is also called as vasopressin.

- Atrial natriuretic peptide (ANP): It is released by the cells in the atria of heart. ANP lowers BP by causing vasodilation and by promoting the loss of salt & water in urine which reduces blood volume.

Auto regulation of blood pressure

- The ability of a tissue to automatically adjust its blood flow to match its metabolic demands called as auto regulation.
- Two general types of stimuli cause auto regulatory changes in blood flow.

✓Physical change:

- Warming promotes vasodilation & cooling causes vasoconstriction.

✓Vasodialating & vasoconstricting chemicals:

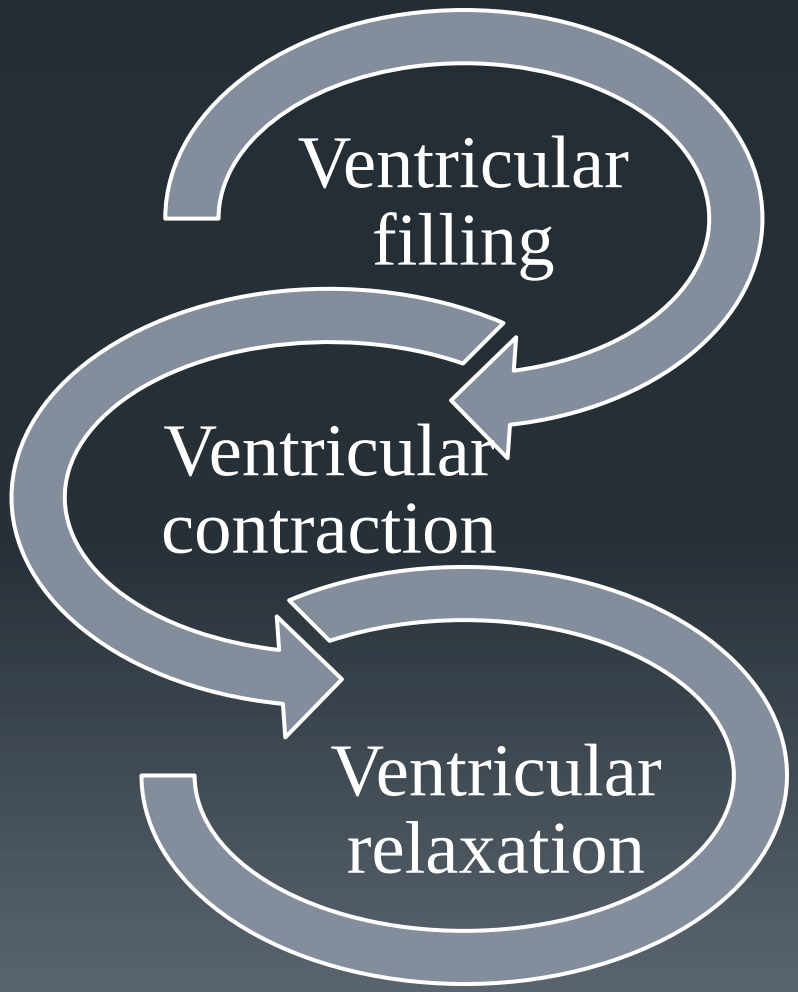
- Several types of cells such as WBC, Platelets, smooth muscle fibers, macrophages, endothelial cells-release a wide variety of chemicals that alters blood vessels diameter.
- Vasodialating chemicals released by metabolically active tissue cells include K+ , H+ , lactic acid & adenosine (From ATP).
- Important vasodilator released by endothelial cell is NO named as endothelium derived relaxation factor (EDRF).

CARDIAC CYCLE

- The event occurring in the heart from the beginning of one heart beat to the beginning of other is called as cardiac cycle.
- In normal cardiac cycle the two atria contracts while the two ventricles relax. Then, while the two ventricles contract, the two atria relax.
- Cardiac cycle consists of systole and diastole of both the atria & ventricles.
- Cardiac cycle refers to all events associated with blood flow through the heart
- Systole – contraction of heart muscle
- Diastole – relaxation of heart muscle

Phases of the Cardiac Cycle

- Cardiac cycle is divided into 3 phases



Ventricular Filling

- During ventricular relaxation, large amount of blood collects in the atria, as the AV valve are closed.
- This increases the pressure in the atria and AV valves get opens and semilunar valve are closed.

- So, the blood flow rapidly into the ventricles.
- First 1/3th time of ventricular filling is called as period of rapid ventricular filling.

- Later on only small amount of blood flows into the ventricles.
- P wave on ECG indicates atrial depolarization

Ventricular contraction

- Period of isovolumetric contraction:
- Immediately after ventricular filling the pressure inside the ventricles rises suddenly.
- This rise in pressure tries to push blood back to the atria and due to this AV valves get closed.
- At this particular junction, the AV valves and SL valves are closed and the volume inside the ventricles does not change called as period of isovolumetric contraction.

Ventricular contraction

- Period of ventricular ejection:
- As further ventricles starts contracting the pressure inside rises sharply.
- When the pressure rises above the aortic pressure and pulmonary trunk pressure SL valve get opens.
- As the SL get opens the blood get ejected out of the ventricles. This period is called as ventricular ejection.
- After this ventricular pressure falls, the period of ventricular relaxation is repeated.

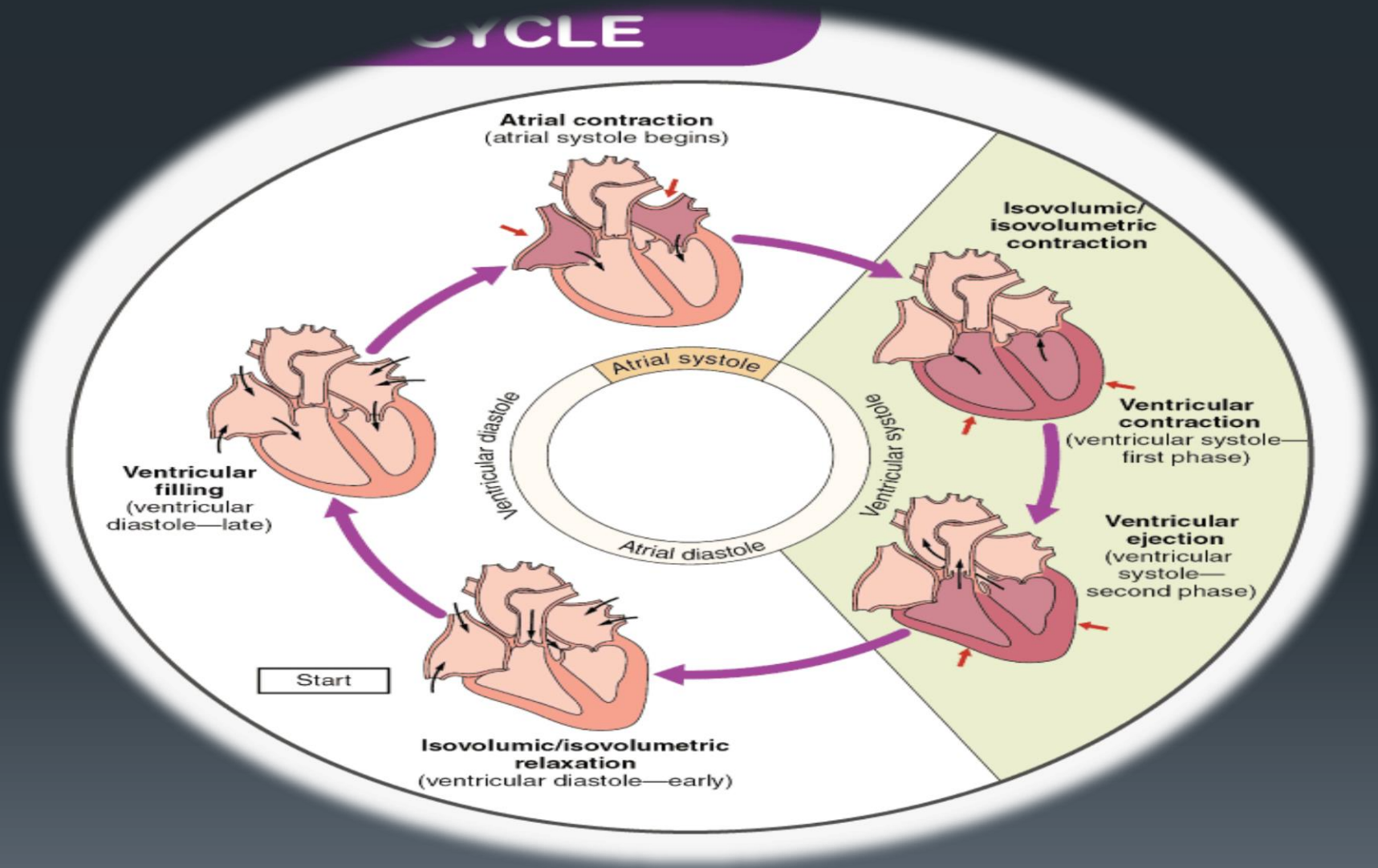
Ventricular relaxation

- Ventricles starts to relax at the end of heart beat.
- At this particular point all the chambers of heart are relaxing.
- This represent T wave on ECG.
- As the ventricles starts relaxing pressure inside the ventricles drops suddenly.
- This drop in pressure leads to back flow of blood from the pulmonary trunk and aorta.
- This forceful back flow of blood closes the SL valves suddenly.

Ventricular relaxation

- This pressure produces a bump called as dicrotic wave.
- At this particular point both the SL valve and AV valves are closed.
- Due to this the ventricular volume does not change and this period is called as isovolumetric relaxation.
- With the further relaxation of ventricles there is further fall in pressure inside the ventricles.
- When this ventricular pressure drops below the atrial pressure AV valves opens and ventricular filling begins.

PHASES OF THE CARDIAC CYCLE



Cardiac Output (CO) and Reserve

- Cardiac Output is the amount of blood pumped by each ventricle in one minute
- CO is the product of heart rate (HR) and stroke volume (SV)

- HR is the number of heart beats per minute
- SV is the amount of blood pumped out by a ventricle with each beat

- Cardiac reserve is the difference between resting and maximal CO
- CO (ml/min) = HR (75 beats/min) x SV (70 ml/beat)
- CO = 5250 ml/min (5.25 L/min)

Stroke Volume

- SV = End diastolic V(EDV) - End systolic V (ESV)
- EDV = amount of blood collected in a ventricle during diastole
- ESV = amount of blood remaining in a ventricle after contraction

Factors Affecting Stroke Volume

- Afterload is the tension developed in the wall of the left ventricle during ejection

- Preload is pressure that stretches the right or left ventricle of the heart to its greatest geometric dimensions under variable physiologic demand

Disorders of Cardiovascular System

✓Congestive Heart Failure (CHF)

- Congestive heart failure (CHF) is caused by:

- Coronary atherosclerosis
- Persistent high blood pressure
- Multiple myocardial infarcts
- Dilated cardiomyopathy (DCM) – main pumping chambers of the heart are dilated and contract poorly

CONGESTIVE HEART FAILURE

✓Causes of CHF

- coronary artery disease, hypertension, myocardial ischemia, valve disorders, congenital defects

- Left side heart failure
- less effective pump so more blood remains in ventricle
- heart is overstretched & even more blood remains
- blood backs up into lungs as pulmonary edema
- suffocation & lack of oxygen to the tissues

- Right side failure
- fluid builds up in tissues as peripheral edema

CORONARY ARTERY DISEASE

- Heart muscle receiving insufficient blood supply
- Narrowing of vessels--- atherosclerosis, artery spasm or clot
- Atherosclerosis--smooth muscle & fatty deposits in walls of arteries
- Treatment
- Drugs, bypass graft, angioplasty, stent