# BODY FLUIDS AND CIRCULATION

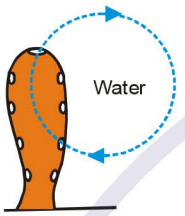
Nutrients, $O_2$, essential substance

Cells ⇄ Circulatory System ⇄ Various systems

Waste/harmful substances

Fluid

**Simple**
- Sponges
- Coelenterates




**Special fluids**

**Blood**
Blood vascular system
(Human circulatory system)
(1) Blood
(2) Muscular chambered heart
(3) Network of closed branching blood vessels

**Lymph**
Lymphytic system
(1) Lymph (Tissue fluid)
(2) Lymphatic capillaries/vessels/ducts
(3) Lymphatic tissue/organ

## BLOOD

Special connective tissue (Fibre free fluid matrix)

**Plasma**
- Matrix
- Straw coloured
- 55% of blood

**90-92% water**

**Other**

Proteins (6-8%)
- → Fibrinogen :-
  - Needed for clotting/coagulation of blood (other clotting factor are also present in plasma in inactive form)
  - Serum = Plasma – Clotting factor
- → Globulin :- Primarily involved in defence mechanism (Antibodies)
- → Albumin :- Help in osmotic balance (BCOP)

Minerals (small amount) ($Na^+$, $Ca^{++}$, $Mg^{++}$, $HCO_3^-$, $Cl^-$)

Nutrients (Glucose, Amino acids, Lipids)

**Formed Elements**
- 45% of Blood

→ **Erythrocytes/RBC :-**
- Most Abundant
- Count (Adults) :- 5 – 5.5 million/$mm^3$
- Formed in red bone marrow
- Devoid of nucleus
- Biconcave in shape
- Have red coloured, iron containing gases transporting pigment heamoglobin (12-16 gm Hb/100 ml blood)
- Average life span = 120 days (Destroyed in spleen/graveyard)

→ **Platelets (Thrombocytes) → Cell fragments**

- Produced from megakaryocytes (special cells in bone marrow)
- Count = 1.5-3.5 Lakh platelets/$mm^3$
- Involved in coagulation/clotting of blood
- Reduction in their number → Clotting disorders (Excessive loss of blood)

**Leucocytes/WBC :-**
- Relatively less in number
- Nucleated
- Life span = short lived
- 2 main categories
- Colourless due to lack of Hb
- Count (Adult) = 6000-8000/$mm^3$

**Granulated**
- Eosinophil = 2-3% = Resist infection, allergic reactions

- Basophil = 0.5-1% = Histamin, Serotonin, Heparin

- Neutrophil = 60-65% = Phagocytic

**Agranulated**
- Monocyte (6-8%) = Phagocytic

- Lymphocytes (20-25%) ⇄ T, B = Responsible for immune response

# BLOOD GROUPS

Blood of human beings differ in certain aspects

Various types of grouping has been done

2 such grouping

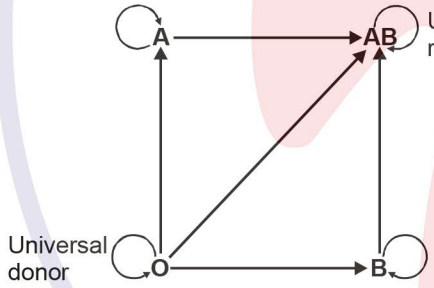
## ABO Grouping

**Based on**

Presence/Absence of 2 surface antigens A & B
(Antigen :- chemicals than can induce immune response)
+
Presence of 2 natural antibodies Anti-A & B
(Antibody :- Proteins produced in response to antigen)

**4 Blood Groups**

| Blood Group | Antigens on RBCs | Antibodies in Plasma | Donor's Group |
|---|---|---|---|
| A | A | anti-B | A, O |
| B | B | anti-A | B, O |
| AB | A, B | nil | AB, A, B, O |
| O | nil | anti-A, B | O |

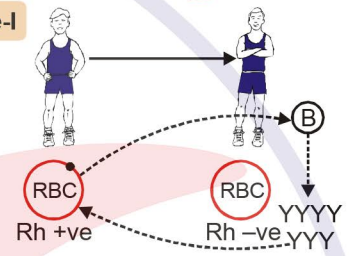



## Rh Grouping

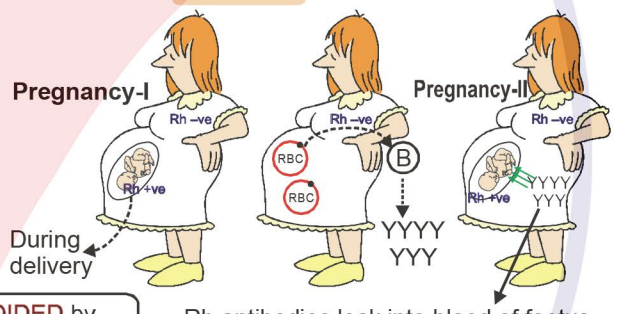
80% humans → RBC (Rh-Antigen (as in Rhesus Monkey)) = Rh +ve

Remaining humans → RBC = Rh –ve

**(1) Case-I**




**(2) Case-II**




Rh antibodies leak into blood of foetus

↓

destroy foetal RBCs

↓

severe anaemia & jaundice to baby

↓

Fatal to foetus (Erythroblastosis foetalis)

CAN BE AVOIDED by administering anti-Rh antibodies to the mother immediately after delivery of first child

# COAGULATION OF BLOOD

**Blood exhibits coagulation/clotting in response to an injury/trauma**

↓

**Prevent excessive loss of blood from the body**

**Injury/Trauma**

↓

Stimulates platelets in Blood — Tissue at site of injury

↓

Release certain factors

↓

Initiate series of linked enzymatic reactions (cascade process) involving number of factors present in plasma in an inactive state

↓

Formed an enzyme complex (thrombokinase)

↓ $Ca^{+2}$

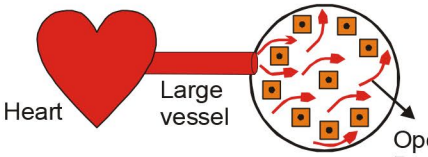
**Prothrombin** → **Thrombin**

↓ $Ca^{+2}$

**Fibrinogen** → **Fibrin** [Its network + dead damaged formed elements of Blood are trapped in it = Clot/coagulam (Reddish brown scum)]

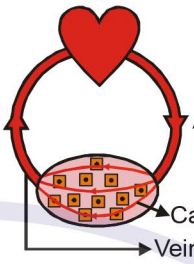
## CIRCULATORY PATHWAYS

OPEN




Ex. Arthropods molluscs

CLOSED




= Closed network of blood vessels

Ex :- Annelids chordates

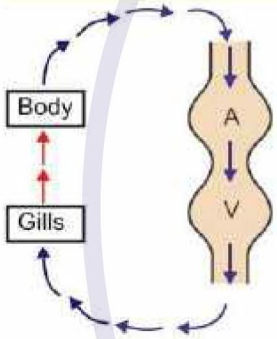
Flow of blood can be more precisely regulated

More advantages

## HEART IN VERTEBRATES

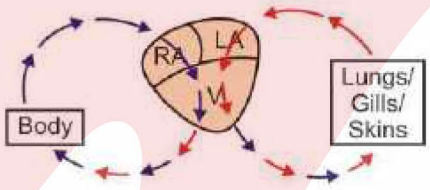
(MUSCULAR CHAMBERED HEART)

### (1) Fishes



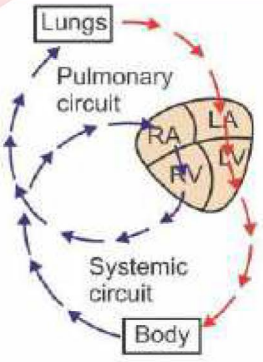

- Single circuit
- Venous/Branchial heart

### (2) Amphibians and Reptiles (Except crocodiles)




- Incomplete double circuit
- Arterio-venous heart

### (3) Crocodiles, Birds, Mammals

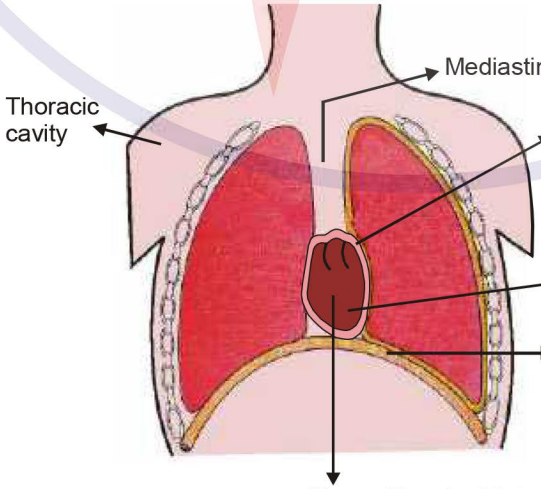


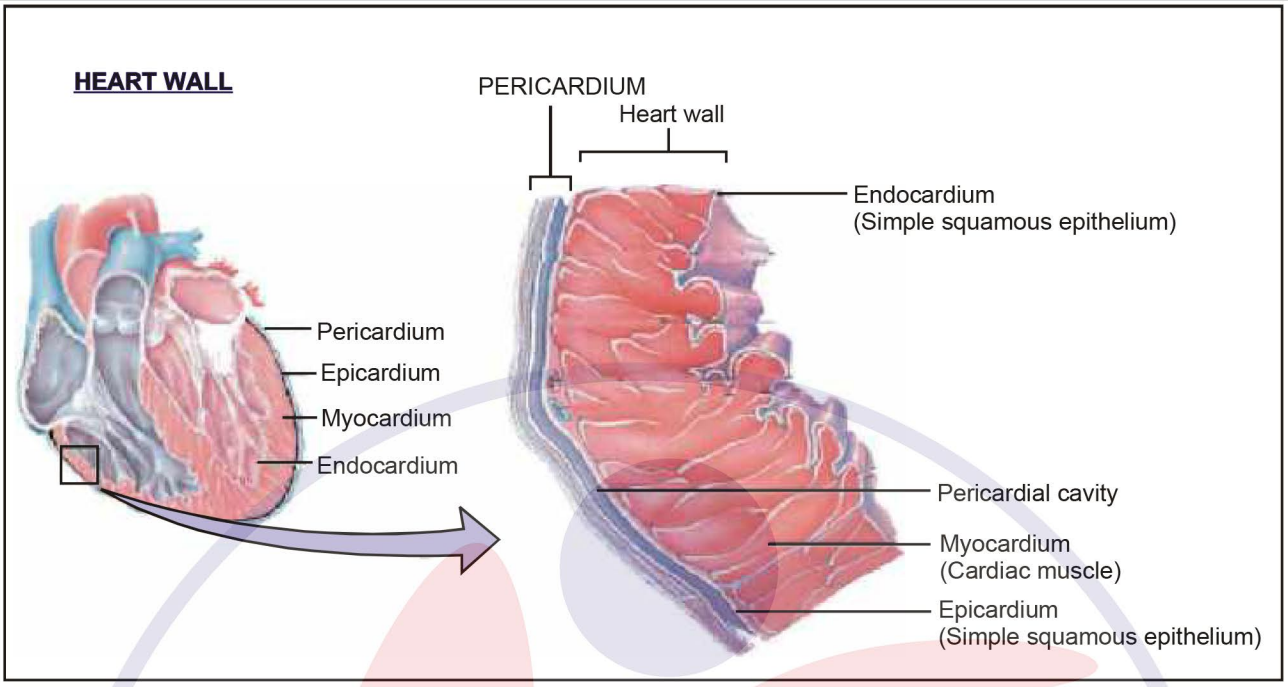

- Complete double circuit
- Arterio-venous heart

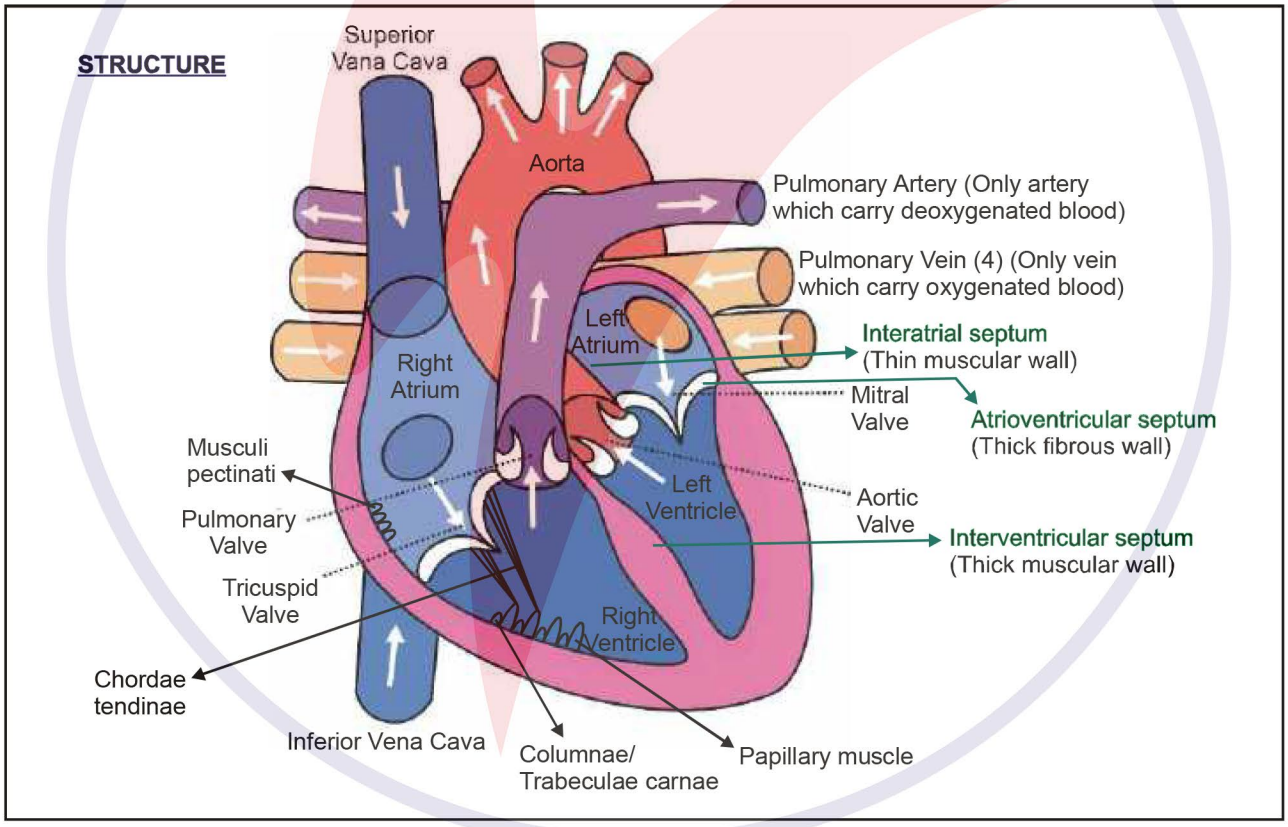
## HUMAN HEART

(Mesodermally derived organ)

**LOCATION**





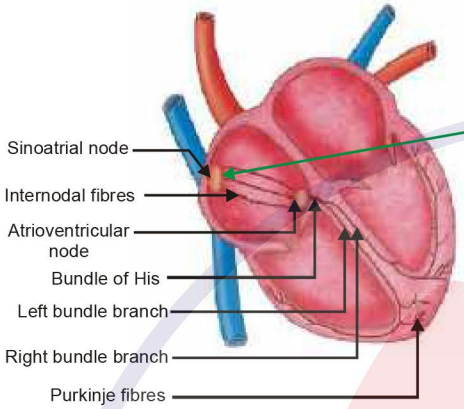

- Total number of valves in adult human heart = 4
- Valves prevent the backflow of blood i.e. from ventricles to atria and from arteries to ventricles.
- Chordae tendinae prevent the reverse opening of AV valves during ventricular systole.

## CONDUCTION PATHWAY (NODAL TISSUE)

HEART

**Neurogenic**
Need external stimulus for generation of action potential

**Myogenic**
Muscle
↓
Gain nerve like properties
↓
Can generate action potential
↓
Neuro muscular/nodal tissues




**SAN (Sinoatrial node)**
↓
Can generate the maximum number of action potentials
↓
Responsible for initiating and maintaining the rhythmic contractile activity of the heart
↓
Therefore, it is called PACEMAKER

- **Heart beat** = Rhythmic contraction and relaxation of heart
- **Heart beat per minute** = Heart rate (70-75 beats/min) (avg. 72 beats/min)
- **Tachycardia** = Temp.↑, loss of blood, exercise
- **Bradycardia** = Temp.↓, Athlete

## REGULATION OF CARDIAC ACTIVITY

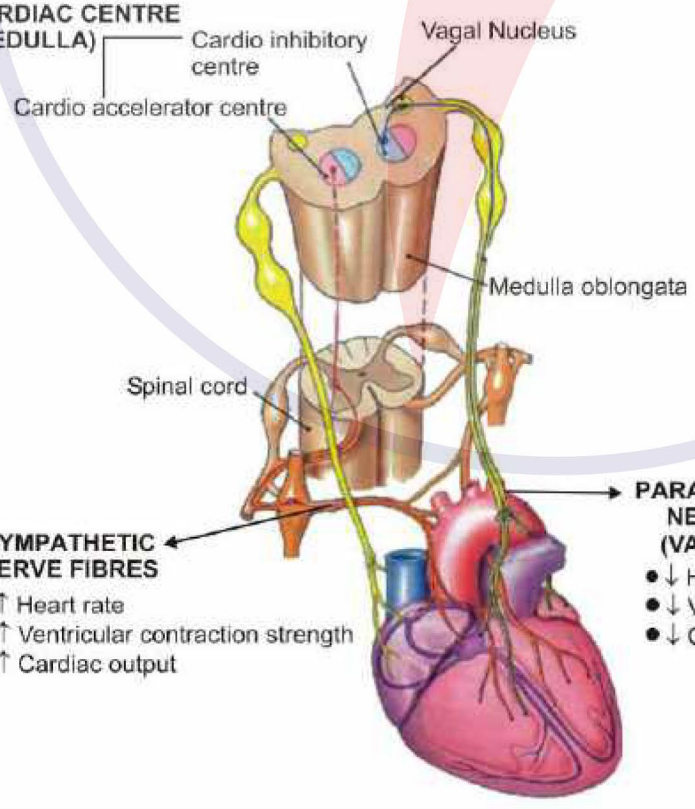
**[A special neural centre in the medulla oblongata can moderate the cardiac function through autonomic nervous system (ANS)]**

**NEURAL**

**CARDIAC CENTRE (MEDULLA)**
- Cardio inhibitory centre
- Cardio accelerator centre

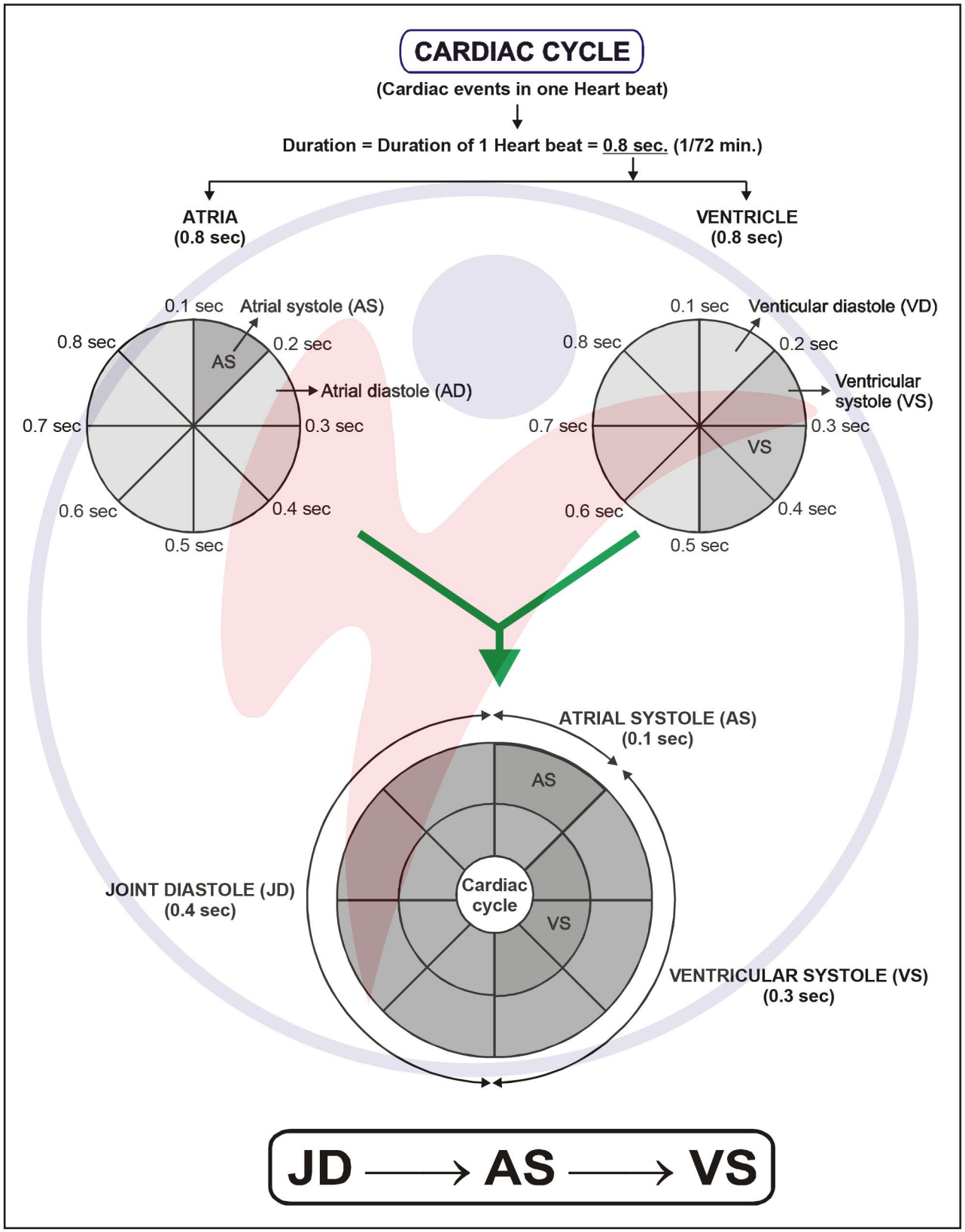
**HORMONAL**

Adrenal medullary hormones can also increase the cardiac output.

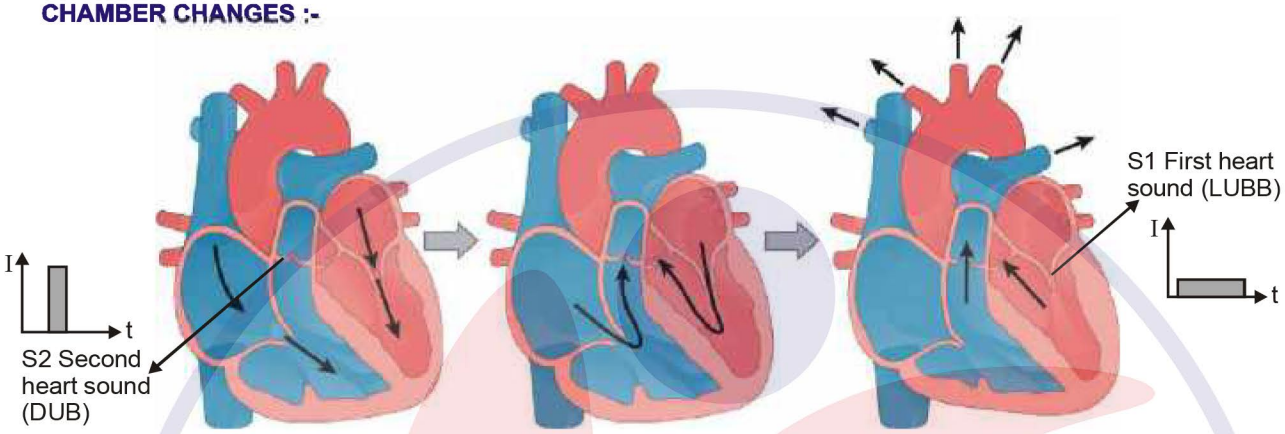



**SYMPATHETIC NERVE FIBRES**
- ↑ Heart rate
- ↑ Ventricular contraction strength
- ↑ Cardiac output

**PARASYMPATHETIC NERVE FIBRES (VAGUS NERVE)**
- ↓ Heart rate
- ↓ Ventricular contraction strength
- ↓ Cardiac output


CARDIAC CYCLE
(Cardiac events in one Heart beat)
Duration = Duration of 1 Heart beat = 0.8 sec. (1/72 min.)
ATRIA
(0.8 sec)
VENTRICLE
(0.8 sec)
0.1 sec
Atrial systole (AS)
0.2 sec
AS
Atrial diastole (AD)
0.8 sec
0.3 sec
0.7 sec
0.6 sec
0.4 sec
0.5 sec
0.1 sec
Venticular diastole (VD)
0.2 sec
Ventricular
systole (VS)
0.8 sec
0.3 sec
0.7 sec
VS
0.6 sec
0.4 sec
0.5 sec
ATRIAL SYSTOLE (AS)
(0.1 sec)
AS
JOINT DIASTOLE (JD)
(0.4 sec)
Cardiac
cycle
VS
VENTRICULAR SYSTOLE (VS)
(0.3 sec)
JD ⟶ AS ⟶ VS

**CHAMBER CHANGES :-**




**Joint Diastole (JD)**

- All four chambers are in relaxed state
- Tricuspid and Bicuspid valves are open
- Semilunar valves are closed

**Atrial Systole (AS)**

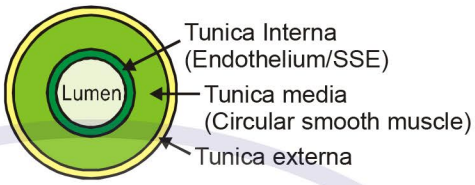
- SAN now generates an action potential
- Atrial contraction (AS) increases the flow of blood into the ventricles by about 30 per cent.

**Ventricular Systole (VS)**

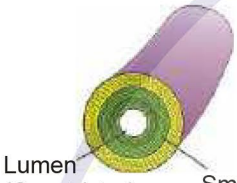
- Action potential is conducted to the ventricular side
- Ventricular systole increases the ventricular pressure causing the closure of tricuspid and bicuspid valves
- As the ventricular pressure increases further, the semilunar valves are forced open

- The ventricles now relax
- Ventricular pressure falls causing the closure of semilunar valves
- Ventricular pressure declines further, the tricuspid and bicuspid valves are pushed open by the pressure exerted by atrial blood
- Ventricles and atria are now again in a relaxed (joint diastole) state as earlier.

## BLOOD VESSELS




**Artery**



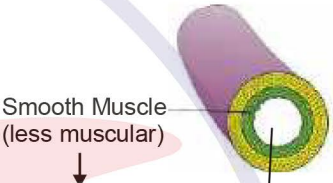

Thick wall
(non collapsable)

- Blood flows : Away from heart (with high pressure and speed)
- Elastic wall
- Valves absent

**Capillary**


- Join arteries and veins
- Single layered
- 'Exchange vessel'

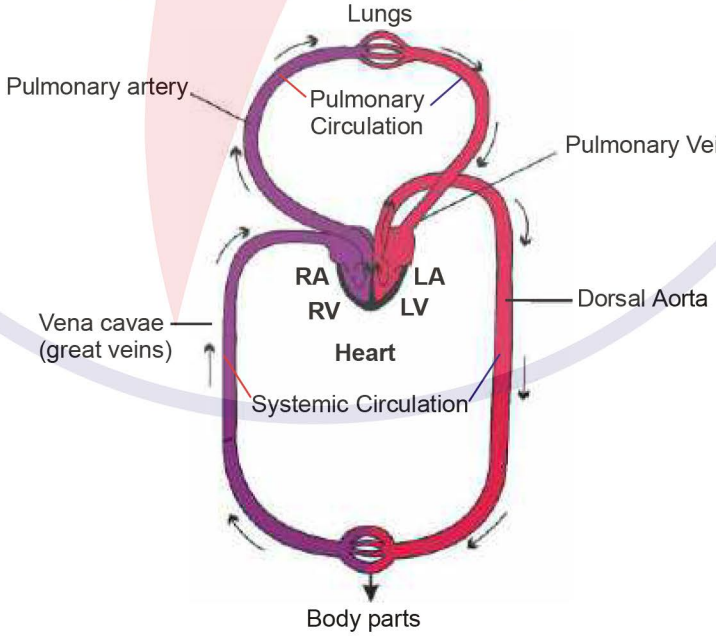
**Vein**




Thin wall
(collapsable)

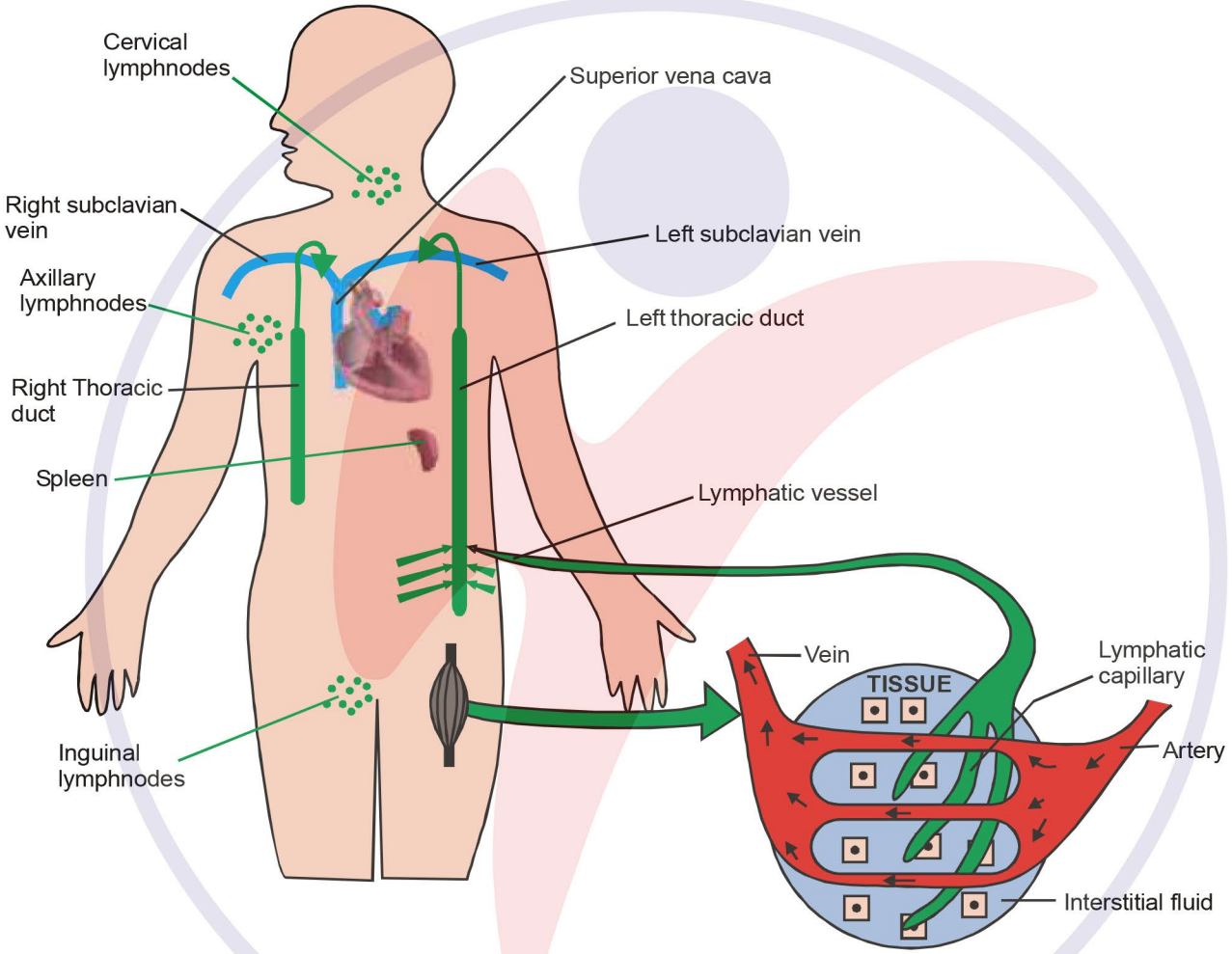
- Blood flows : Towards heart (with low pressure and speed)
- Non-elastic wall
- Valves present

## DOUBLE CIRCULATION



## THE LYMPHATIC SYSTEM

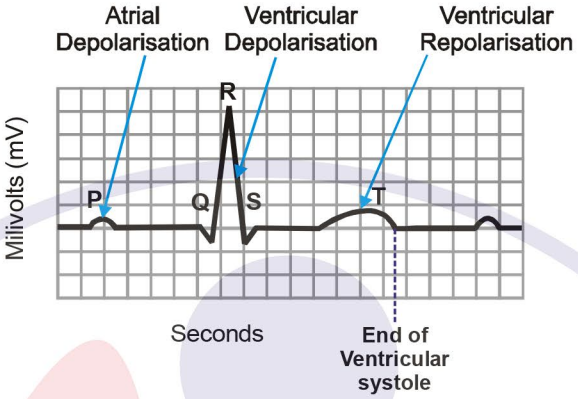
(Lymph/Tissue fluid, Lymph vessel, Lymph Nodes)




| BLOOD | LYMPH |
|---|---|
| • RBC, Platelets — Present<br>• Neutrophil↑<br>• Clotting time (less) | • RBC, Platelets — Absent<br>• Lymphocytes↑<br>• Clotting time (more) |
| • $O_2$/Nutrients↑<br>• Soluble protein↑<br>• WBC↑ | • $CO_2$↑<br>• Insoluble protein↑<br>• WBC↓ |

## ELECTROCARDIOGRAPH (ECG)

(Graphical re-presentation of electrical activity of heart)




- Heart rate can be determined by counting the number of QRS complexes that occur in a given time period.

## DISORDERS OF CIRCULATORY SYSTEM

1. **High blood pressure (Hypertension) :-** Blood pressure that is higher than normal i.e. (140/90)

Blood pressure (BP) ⇒ Pressure exerted by blood on walls of Arteries

| Systolic/Pumping pressure | Diastolic/Resting pressure |
|---|---|
| • Higher limit (during systole) | • Lower limit (during diastole) |
| • 120 mm of Hg | • 80 mm of Hg |

- Normal BP (Adult) = 120/80
- Instrument = Sphygmomanometer
- Brachial/radial Artery

2. **Coronary artery diseases (CAD) :-** Atherosclerosis of coronary artery

| Atherosclerosis | Arteriosclerosis |
|---|---|
| **Cholesterol** calcium fat fibrous tissues deposit in lumen → Narrowing of artery | $Ca^{+2}$ deposition in walls → Hardening of artery |

3. **Angina pectoris :-** Acute chest pain → When no enough oxygen is reaching the heart muscle. (More common among the middle aged and elderly)

4. **Myocardial infarction/Heart attack :-** Sudden death of heart muscle → Due to inadequate blood supply.

5. **Cardiac arrest :-** Heart stop beating

6. **Heart failure :-** Heart not pumping blood effectively → To meet the needs of the body