Cardiovascular System
(Heart Anatomy & Physiology)
(Part 1)

- ✓ Introduction
- ✓ Heart Anatomy
- ✓ Blood Circulations
- ✓ Heart Physiology

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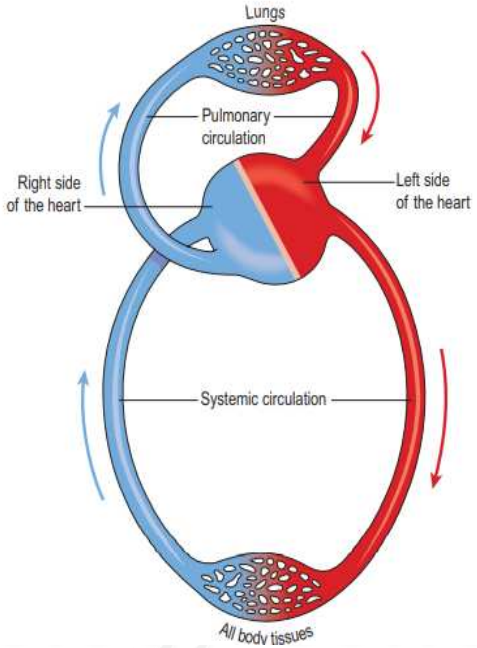
Cardiovascular System

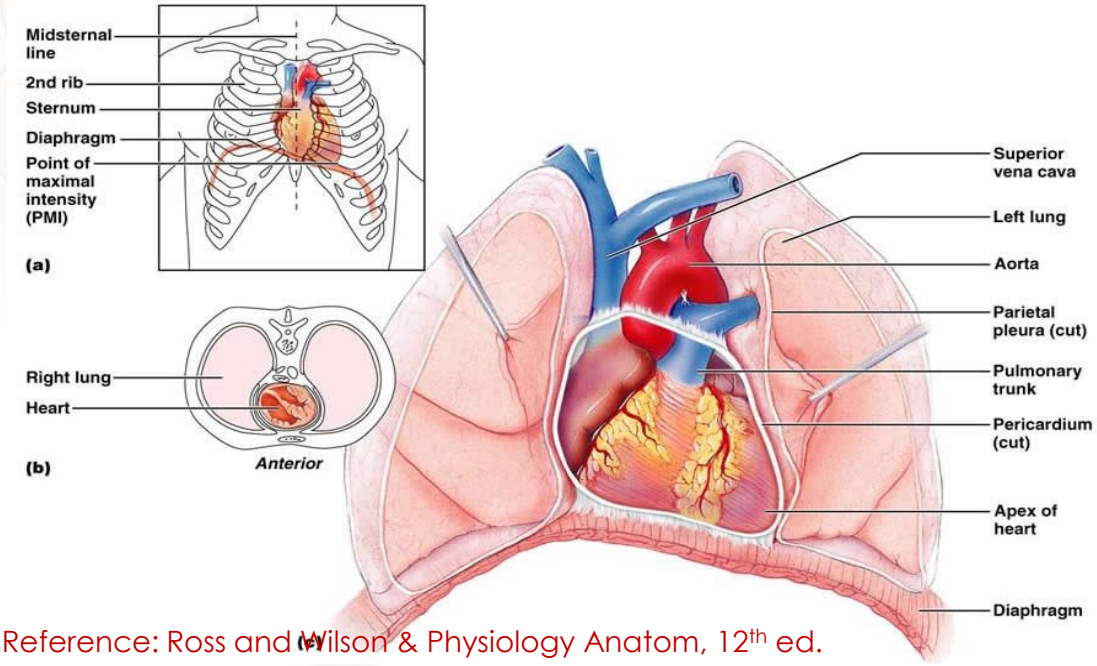
- **Cardiovascular system** is part of circulatory system which divided into two major parts:
  - **Heart:** Pumping Machine
  - **Blood vessels**: Pipe line
- **Heart:** The heart is the motor of the circulation. By its pumping action it maintains a steady blood flow.
- **Blood vessels:** The blood circulates through a closed system of elastic pipes, the **vascular system**, which can be divided into the following segments:
  - **Arteries**, which lead blood away from the heart and distribute it
  - **Capillaries**, in which the exchange of substances takes place
  - **Veins**, which return the blood to the heart



Human Heart

Position-

- The heart is a hollow muscular organ, lying in a *connective tissue space* (*mediastinum*) between the vertebral column and the sternum.
- It is completely enveloped in a membrane, the ***pericardium*** that extends between the pleural cavities, the diaphragm, and the great vessels.

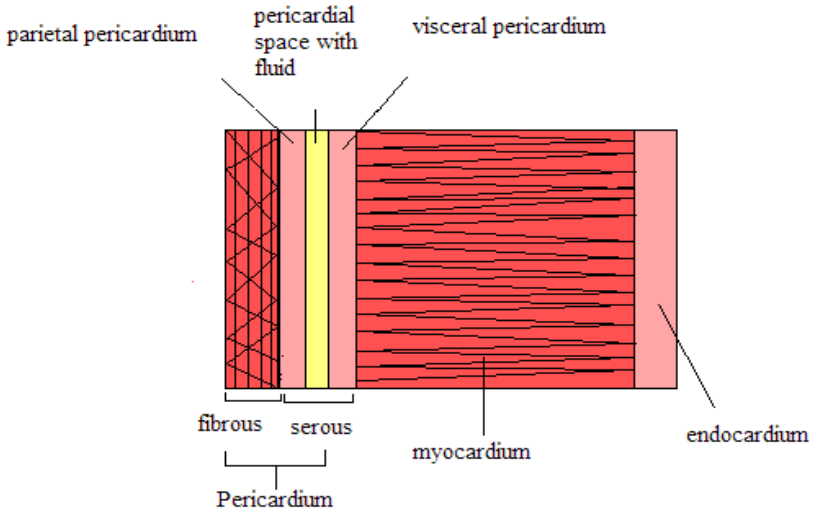


Reference: Ross and Wilson & Physiology Anatom, 12th ed.

Human Heart

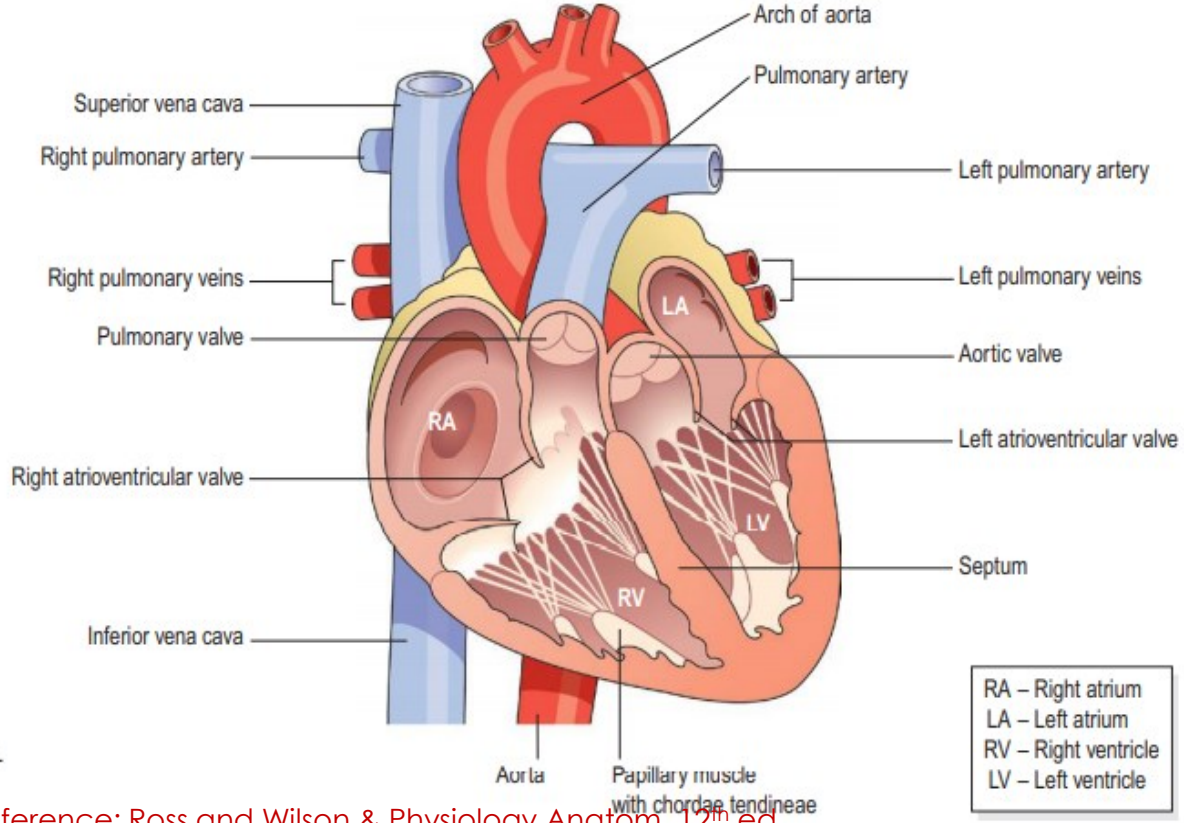
Structure-

- The heart is composed of three layers of tissue *pericardium, myocardium & endocardium* and made up by four chambers two **atria** & two **ventricles.**
- The atria are filling chamber and therefore, they have thin walls and the ventricle are emptying chamber and so they have thick wall to push the blood in circulatory system.
- The **interventricular septum** completely divides the heart into a "**right heart**" for the pulmonary circulation and a "**left heart**" for the systemic circulation. Each half has an **atrium** and a **ventricle**



Human Heart

Structure-



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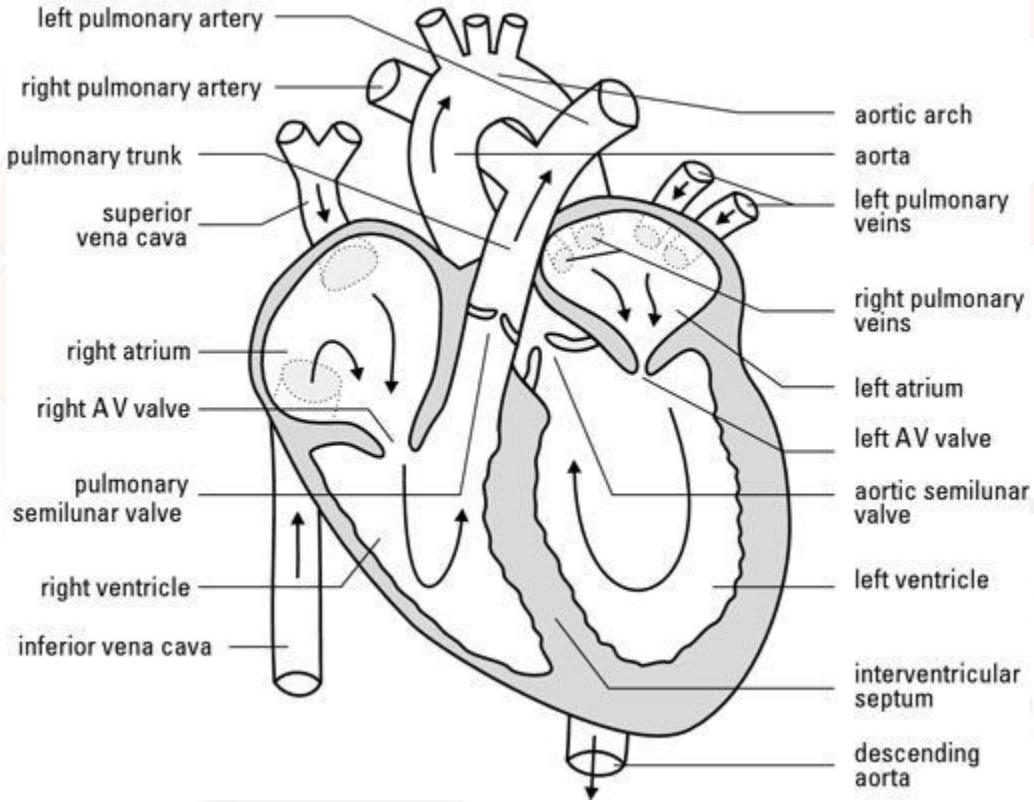
Human Heart

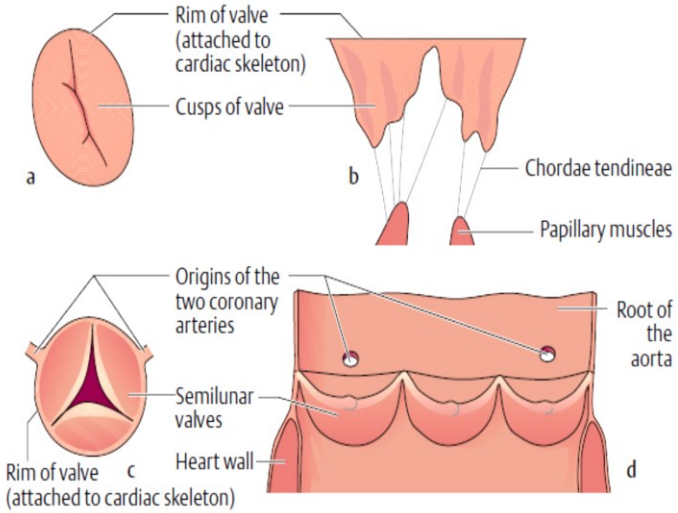
Structure-



Human Heart

The specific feature of heart-

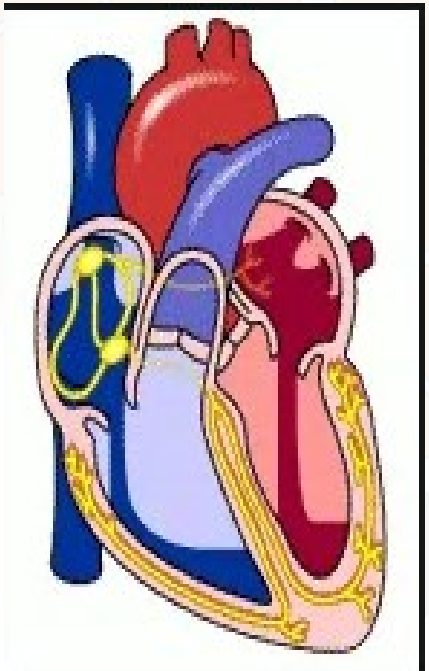
- Atrium & ventricle are divided by an atrioventricular valve.
- A-V valve are formed by double fold of endocardium strengthened by a little fibrous tissue.
- Right A-V valve (tricuspid valve) has three cusps and left A-V valve (mitral valve) has two cusps.
- A-V valve are allow to pass the blood from atria to ventricle and preventing backward flow of blood during ventricular systole(contraction).
- The valves are prevented from opening upward into the atria by tendinous cords, called *chordate tendineae*.
- Systemic aorta & pulmonary trunk have semilunar valves (three curved semilunar cusps) which prevent the backward flow of blood to ventricles.
- **Heart Valves**
  a) Mitral valve
  b) Open cusps of mitral valve
  c) Aortic valve (se-milunar valve)
  d) Opened aortic valve

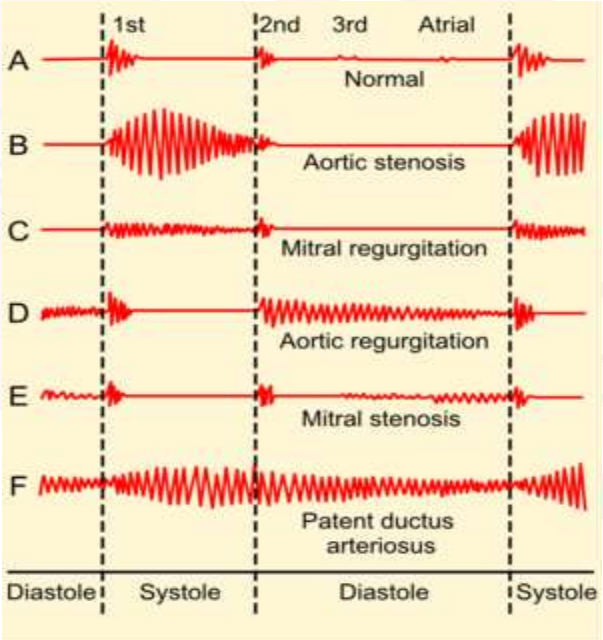


Human Heart

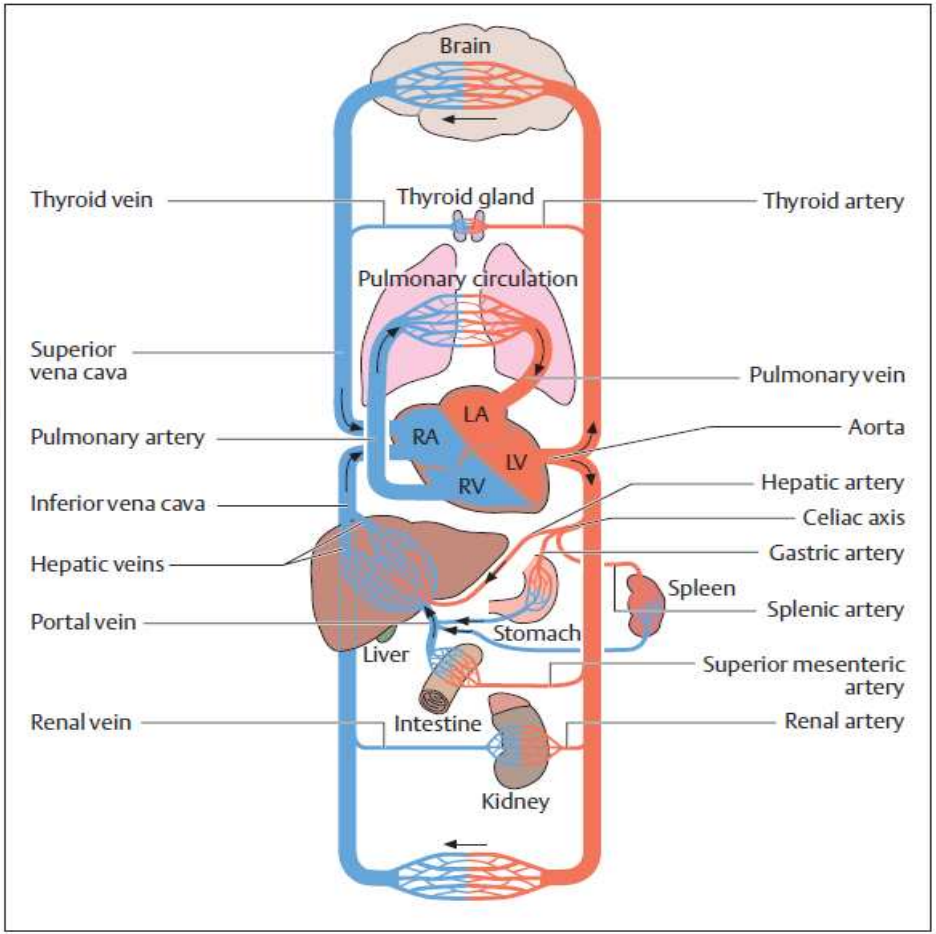
Heart Sound: "Lub-Dub"

- Sound-1 (Lub): Caused by closer of atrioventricular valve (mitral valve and tricuspid valve closure) during .
- Sound-2 (Dub): Due to closure of aortic valve and pulmonary valve





Human Heart



Blood Circulation-

- The human circulatory system has three divisions:
- **Systemic circulation-** It is a long circuit that start from the left ventricle, supplies the blood to all part of the body.
- **Pulmonary circulation-** It is a short circuit which arises from the right ventricle and carries the venous blood to the lungs for purification.
- **Coronary circulation-** It is a circulation of blood to the heart.

Human Heart

Physiology of Heart (Properties of cardiac tissue)

- **Excitability-** Property of tissue to respond to a stimulus (through conductivity electrical fiber cells).
- **Contractility-** Heart muscle contracts in response to a stimulus (through contractile muscles fibers).
- **Automaticity-** Intrinsic properties of cardiac muscle to generate impulse by **SA NODE (pacemaker),** and impulse conducted through other junction tissue to the whole heart within no time.
- **Rhythmicity-** Heart contract & relax at particular rate 70-80 per min. due to automaticity and conductivity.
- **Tonicity-** Cardiac muscle keep up certain amount of constant tension on the blood. It contains- ATP, Oxygen, Sodium ion, Calcium ion, Potassium ion

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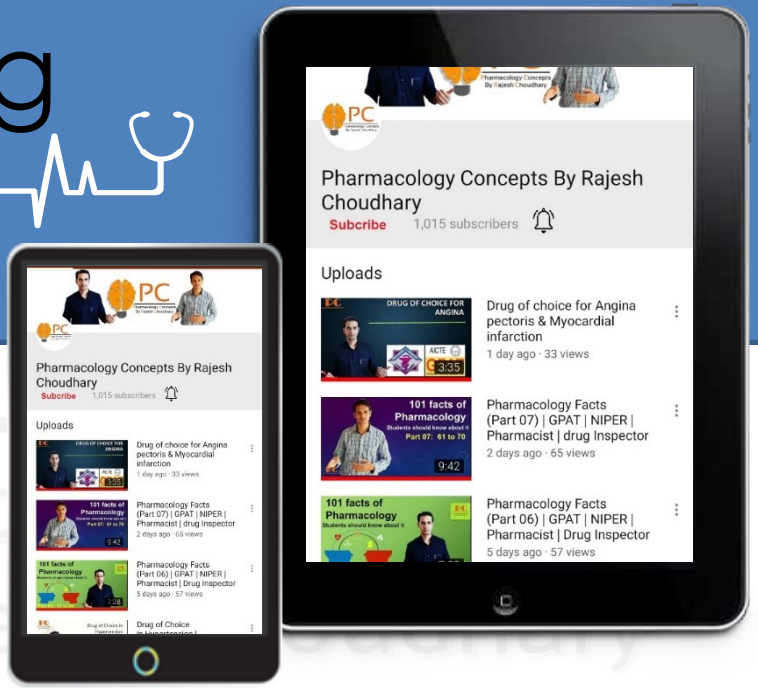

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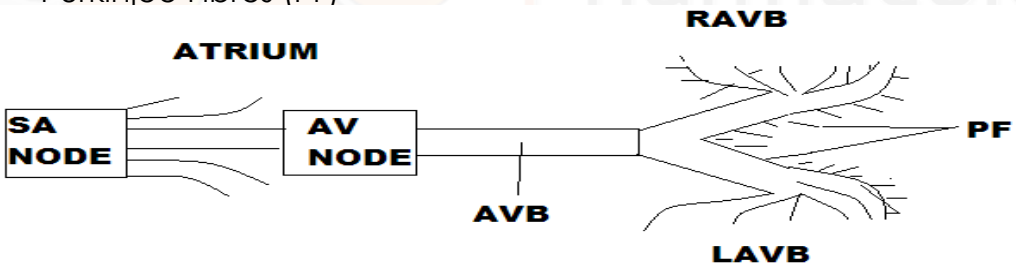
Cardiovascular System (Part 2)

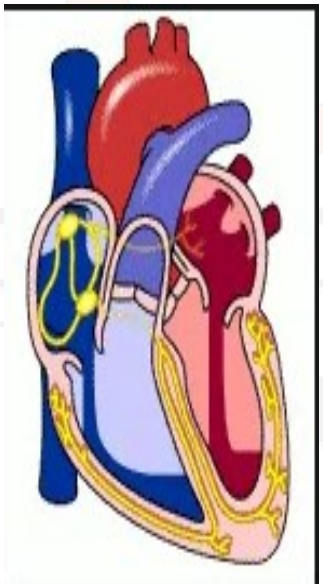
- ✓ Conduction System
- ✓ Heart Rate & Cardiac Output
- ✓ Neuronal Control
- ✓ Cardiac Cycle
- ✓ ECG
- ✓ Disorders

Human Heart

CONDUCTING SYSTEM OF HEART

- The heart has also conducting electrical fibers to carry the impulse throughout the heart wall
- The heart has an intrinsic system to generation and conduction the impulse.
- The cardiac muscle is automatically stimulated to contract without the need for external stimulation. This property is called autorhythmicity and this intrinsic system can be stimulated or depressed by nerve impulses initiated in the brain and by chemicals, including hormones
- **Junctional Tissue of Heart**
  - SA Node
  - AV Node
  - Atrio-ventricular Bundle(AVB) or Bundle of HIS
  - Right and left branches of AVB
  - Purkinjee Fibres (PF)





Human Heart

HEART BEASTS (HEART RATE) AND CARDIAC OUTPUT

- Beats (Systol/dystol) per min is known as **heart rate (HR)**
  - A normal average heart rate in human is about 72 beats/min
  - Normal Range- 60-100 bpm
  - Tachycardia- >80 bpm
  - Bradycardia- < 60 bpm
- **Cardiac output**: total volume of blood pump out or eject per minute
- **Stroke volume**: total volume of blood pump out per beat(systole)

Normal CO = HR x SV = 72 x 70 ml = 5.04 L/min

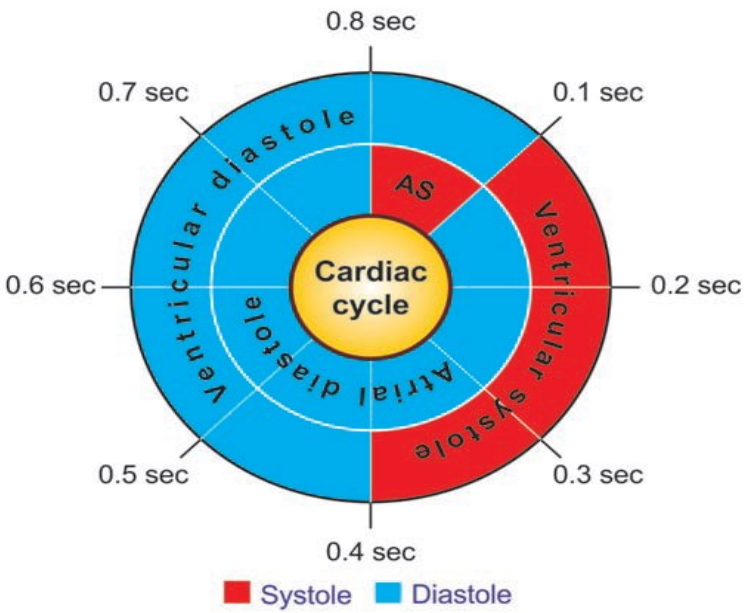
- Normal CO is approx. 5 L/min
- This can be greatly increased to meet the demands of exercise to around 25 L/minute, and in athletes up to 35 L/minute.
- This increase during exercise is called the ***cardiac reserve***

Human Heart

Neurogenic Control on Heart

- The heart is influence by **autonomic nerves** (parasympathetics &sympathetic) originated in the ***cardiovascular centre (CVC)*** in the ***medulla oblongata and*** the **central nervous system** (CNS) (***vasomotor centers in the brainstem***).
- They influence *heart rate* (*chronotropic effect*), *excitability* (*bathmotropic effect*), *force of myocardial contraction* (*inotropic effect*), and *impulse conductivity* (*dromotropic effect*).
- The vagus nerves (**parasympathetic**) supply mainly the SA and AV node and atrial muscle. The parasympathetic stimulation reduce the rate at which impulse are produced, *decreased* the rate and force of the heartbeat.
- The **sympathetic** nerves supply the SA and AV nodes and myocardium of atria and ventricles. Sympathetic stimulation *increases* the rate and force of heartbeat

Human Heart



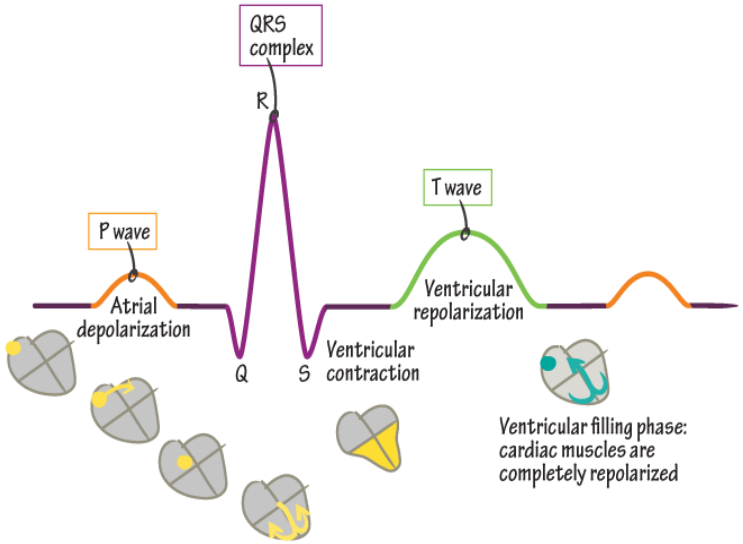
Cardiac Cycle

- Cardiac Cycle: During the each cycle, the heart contract (systole) and Relax (diastole) in a fixed time period. For one beat it required 0.8 sec. (75 bpm)
- Major Stages: Atrial Systole, Ventricle Systole, Complete Diastole
- Time Frame of 0.8 Sec.
  - Ventricle: Systole (0.3 sec.) and Diastol (0.5 second)
  - Atria: Systole (0.1 sec) and Diastole (0.7 Sec)

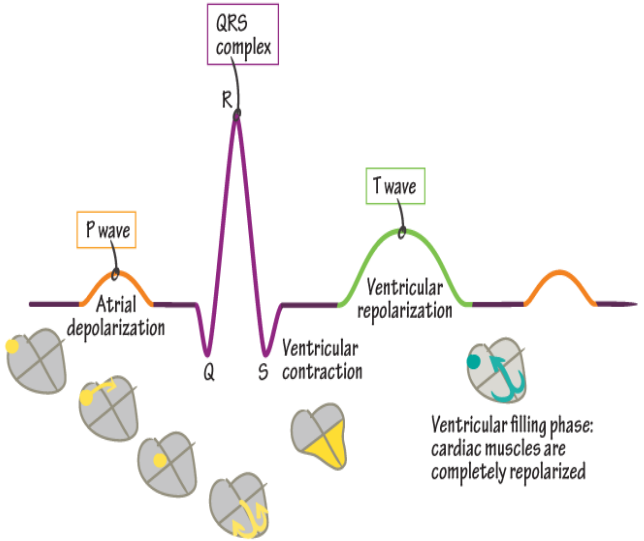
Human Heart

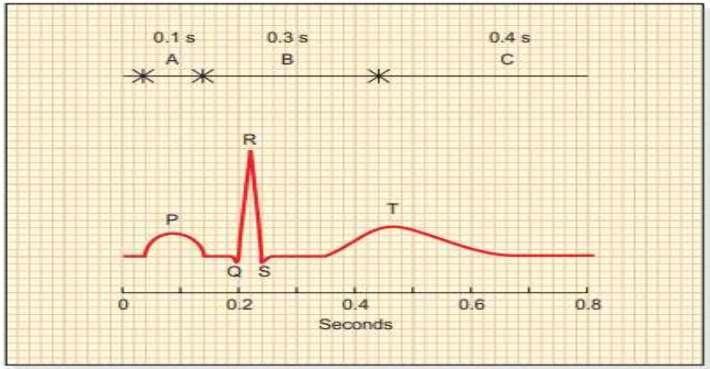
Electrocardiogram (ECG)

- Electrocardiogram (ECG) shows the spread of the electrical signal with in the heart (SA node→Atria→AV node→Ventricle).
- The normal ECG tracing shows five waves which, by convention, have been named P, Q, R, S and T
- **The P wave** arises when the impulse from the SA node sweeps over the atria (atrial depolarisation).
- The **QRS complex** represents the very rapid spread of the impulse from the AV node→AV bundle/Purkinje fibres→ventricular muscle (ventricular depolarisation).
- The **T wave** represents the relaxation of the ventricular muscle (ventricular repolarisation)



Human Heart





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Human Heart

Disorders

- **Hypertension-** Constant Elevation of Blood Pressure
- **Coronary Artery diseases-** Decrease the blood flow to the heart
- **Ischemic Heart Diseases:** Myocardial infarction, Angina Pectoris
- **Cardiac Arrhythmia-** disturbed in heartrate (due to conduction failure).
- Heart Failure: Unable to pumpout the sufficient amount of blood
- **Cardiac Shock**
- Atherosclerosis: Deposition of atheroma in the vascular wall
- Thrombosis: Thrombosis is the formation of a blood clot (thrombus) inside a blood vessel.
- Embolism: Embolism is the blocking of a blood vessel by any mass of material (an embolus) travelling in the blood

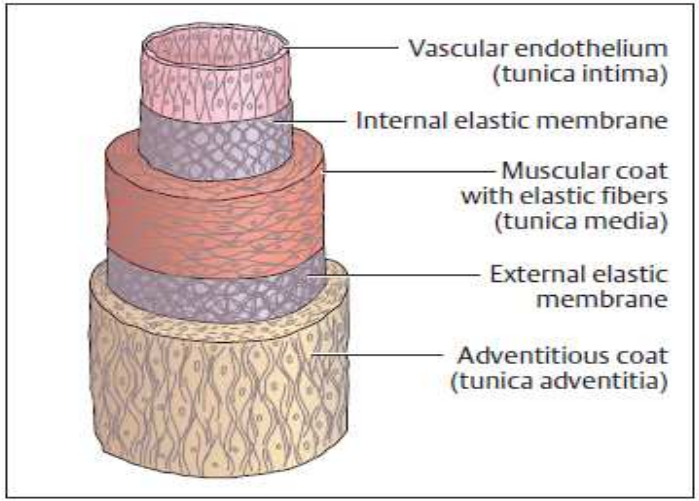
Cardiovascular System
(Blood Vessels)
(Part 3)

- ✓ Blood Vessels
- ✓ Anatomy
- ✓ Physiology
- ✓ Control of vessels

  Diameter

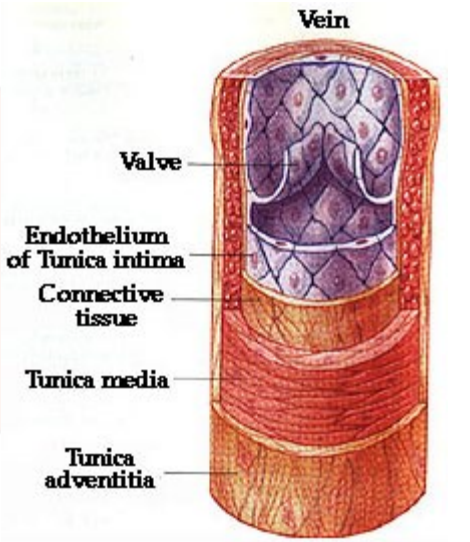
Blood Vessels

- There are several types – Arteries & arterioles, Veins & venules, and Capillaries
- **Arteries & arterioles-** transport blood away from the heart. They have thicker wall than veins and this enables them to withstand the high pressure of arterial blood. Their walls consist three layers of the tissue-
  - *Tunica adventitia* or outer layer of fibrous tissue
  - *T. media* or middle layer of smooth muscles and elastic tissue
  - *T. intima or* inner lining of squamous epithelium called endothelium.
- The large arteries like aorta, the t. media consists of more elastic tissue and less smooth muscles and smaller arteries consists almost entirely smooth muscles and they also called **resistance vessels**.



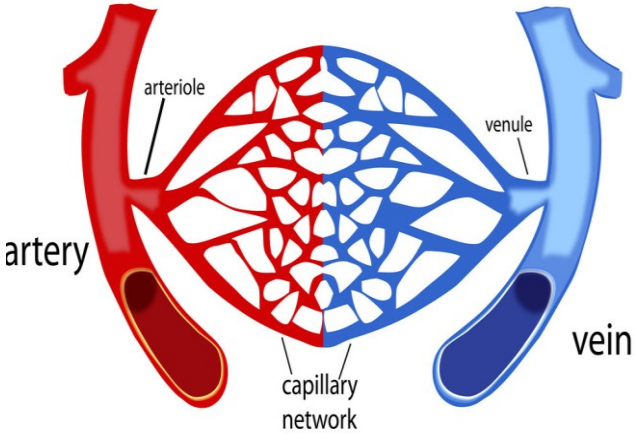
Blood Vessels

- **Veins & venules-** veins are the blood vessels that return blood at low pressure to heart.
- The walls of the veins are thinner than those of arteries because there is a less muscle and elastic tissue intunica media, because veins carry blood at low pressure than arteries.
- Some veins possess valves, which prevent backflow of blood, ensuring that it flows towards the heart. They are formed by fold of tunica intima and strengthened by connective tissue.
- Veins are called **capacitance vessels** because they are distensible, and therefore have the capacity to hold a large proportion of the body's blood



Blood Vessels

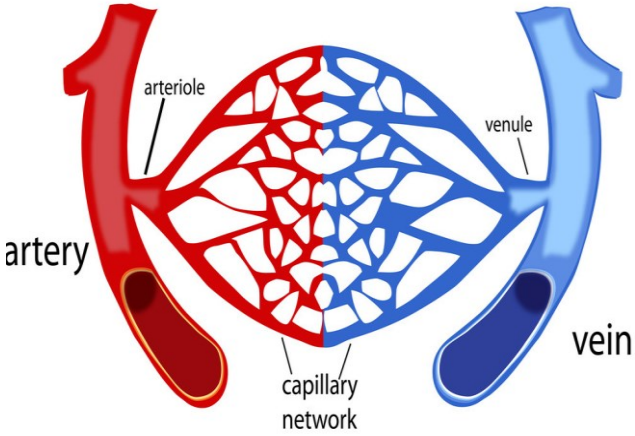
- **Capillaries-** The smallest arterioles break up into a number of minute vessels called capillaries.
- Capillary walls consists of a single layer of endothelial cells sitting on a very thin basement membrane, through which water and other small molecule substances can pass and large molecules like plasma protein do not pass.
- The capillary bed is the site of exchange of substances between the blood and the tissue fluids.
- The outer layer of tissue o thick walled blood vessels receive their blood via **vasa vasorum** & vessels with thin walled and endothelium receive by **diffusion.**



Blood Vessels

Capillary Exchange

- Exchange of gases(o_2 and co_2)- by **diffusion** down conc. Gradients
- Exchange of other substances-by **diffusion** (small molecules such as o_2, co_2, glucose, amino acids, minerals & water etc) and by **osmosis** (water against conc. Gradients)
- **Plasma proteins,** especially **albumin** responsible for osmotic pressure between blood and tissue fluids
- Two forces are responsible for movement across the capillary wall are the **hydrostatic pressure** (blood pressure), responsible for movement of water blood to tissue fluid and the **osmotic pressure,** responsible for movement of water tissue fluid to blood.



Blood Vessels

Control of Blood Vessels Diameter

- All blood vessels except capillaries have smooth muscles fibres in the *t. media* which are supplied by nerve of the ANS (**SYMPATHETICS)**. These nerve arise from the *vasomotor centre* in the *medulla oblongata.*
- Small arteries and arterioles respond to nerve stimulation **not large arteries (aorta**), their lumen diameter depend upon amount of blood which they contain.
- Parasympathetic nerves not supply to blood vessels.
- **Sympathetic** nerve stimulation cause vasoconstriction, thickening the wall, decreased lumen diameter & increased peripheral resistance in arterioles.

BP= CO x TPR

Blood Vessels

Autoregulation

- The accumulation of metabolites of local tissue causes the some degree of dilatation of arterioles and capillaries. Example-
- Exercise; e.g. lactic acid accumulation in muscles and rise in the tissue temp. causes vasodilatation
- Tissue damage; e. g. in inflammation, mediators such as histamine prostaglandins and bradykinin leads to vasodilatation

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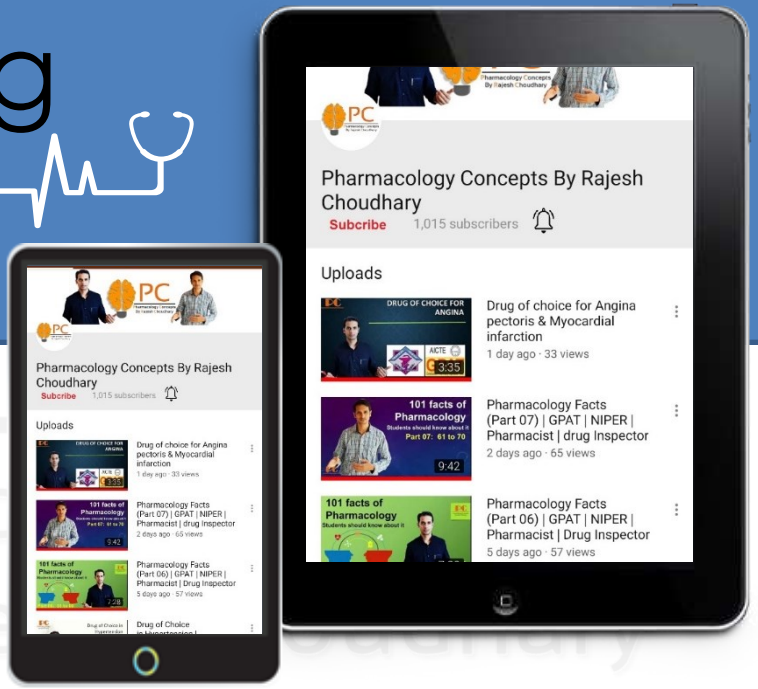

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Cardiovascular System
(Blood Pressure Regulations)
(Part 4)

REGULATION OF BLOOD PRESSURE

BP = Lateral pressure exerted by blood on artery wall. BP = 120/80 mmHg

$BP = CO \times TPR$, $CO = HR \times SV$

BP ∝ CO, TPR, HR, Blood Vol., Venous Return, Flow rate, Blood Viscosity

$\frac{1}{BP}$ ∝ Elasticity & Diameter of vessels

⇒ REGULATORY MECHANISM

I Short term – Nervous Control – Baro/Chemo Receptor

II Long term – Renal Control – RAAS, ADH, Natriuretic peptide

1. Barroreceptors – Response to acute changes in BP

Ⓐ High Pressure BR → located in high-pres. arterial System

↳ Carotid BR – response to both high & low BP & Signal sends via CN-IX Glossopharyngeal Nerve

↳ Aortic Arch BP – responsed only to high BP, Sending it signal through CN-X Vagus Nerve

Ⓑ Low Pressure BR – are present within low pressure Venous System (large venous, pulmonary Vessels and wall of RA & RV.

* Low blood Volume → (+) LPBR → kidney → ADH, RAAS

2. Chemoreceptor – response to chemical changes

BP↓ → ↓ Flow → ↑CO_2, ↓O_2 → ↓PH → Chemoreceptor

* Sympathetic → (+) CVS
* Parasympathetic → (−) CVS

Chemoreceptor → CVC → Vasoconstriction → ↑BP

3. RAAS – Renin-Angiotensin-Aldosterone System

↓BP → Renal hypoperfusion → RAAS → ↑BP

4. ADH (Anti Diuretic Hormone) / Vesopressin

↳ Vasoconstrictor & ↑ Na^+/wate Reabsorption – BP↑

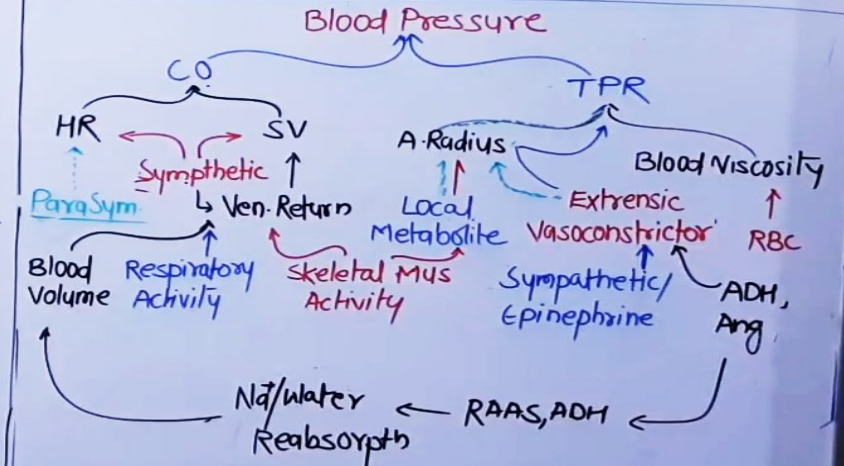
5. Atrial Natriuretic Peptide – Diuresis effect → ↓BP

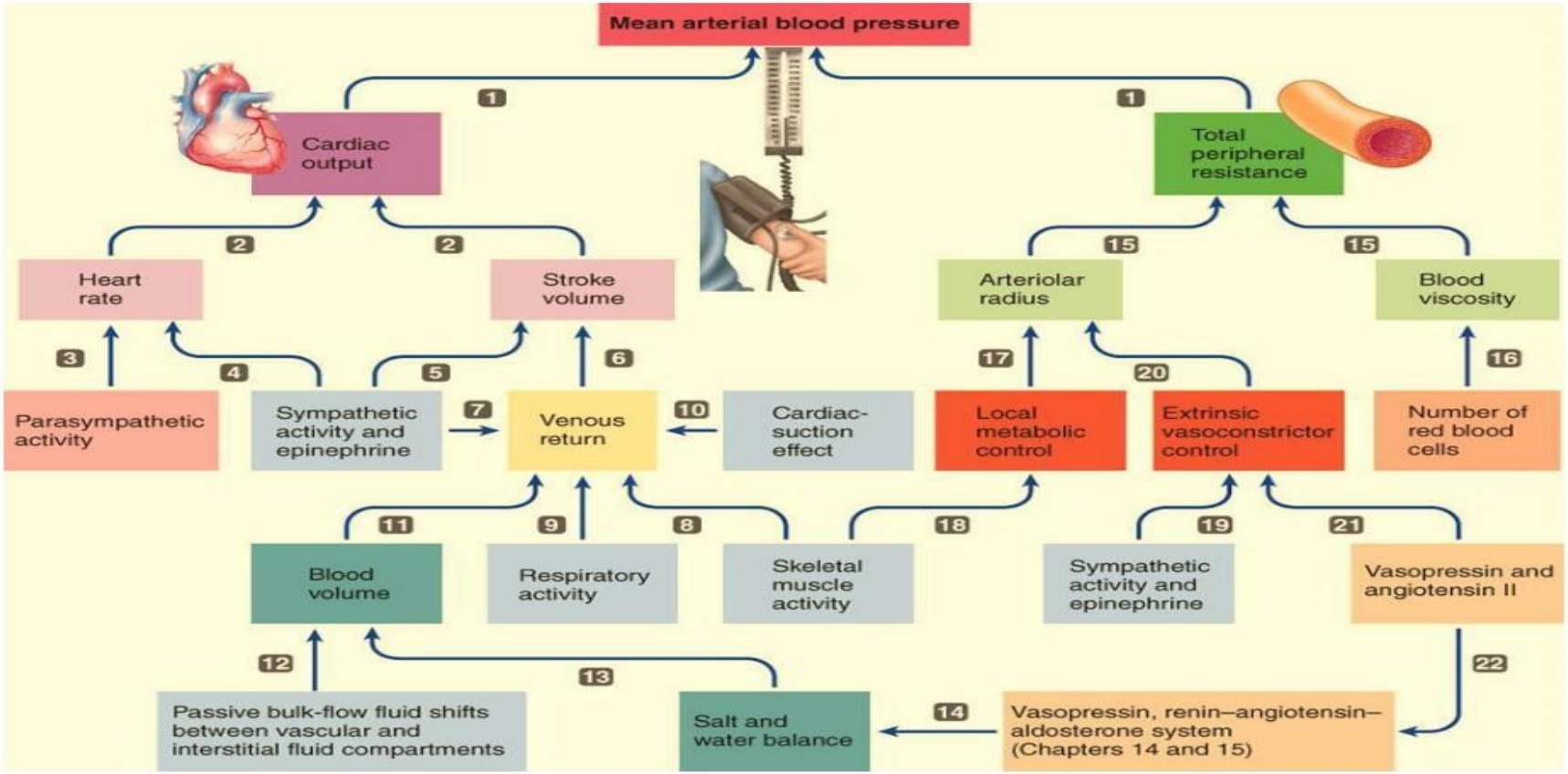
6. Hormones :–

BP↑ by – Adrenaline, Thyroxine, Serotonin, ADH, Aldosterone, Angiotensin,

BP↓ by – Histamine, VIP, Bradykinin, PGs, Ach, Natriuretic Peptides (ANP, BNP, CNP)

7.) Local → EDCF (Endothelin), EDRF (Nitric Oxide)





Determinants of Mean Arterial Blood Pressure

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