Body Fluids and Circulation

1 BLOOD VASCULAR SYSTEM

Constituents: Blood + Blood vessels + Heart

- Synthesised in Red bone marrow
- **Components:**

(A) Plasma (matrix, 55%)

- **Water:** 90-92%
- **Proteins:** 6-8%
  - Fibrinogens – Clotting
  - Albumins – Osmotic balance
  - Globulins –Defense
- **Minerals:** Na^{+}, Ca^{+2}, Mg^{+2}, HCO_3^{-}, Cl^{-}
- **Nutrients:** Glucose, amino acids, lipids

Functions performed:

- Transport of nutrients, O_2, glucose *etc*
- Removal of harmful substances

Medium of transport:

- **Water:** Sponges & coelenterates
- **Blood & lymph:** Humans

(B) Formed Elements (45%)

Parameter	RBCs/Erythrocytes	WBCs/ Leucocytes	Platelets/Thrombocytes
Number	5-5.5 million/mm^3	6000-8000//mm^3	1,500,00-3,500,00/mm^3
Colour	Red due to iron containing Hb (12-16 gm/100 ml)	Colourless	Colourless
Nucleus	Absent	Present	Absent
Life span	120 days	Generally short lived	Short lived
Function	Transport of gases	Defense	Coagulation of blood. If number drops, can lead to loss of blood from body

Types of WBCs

	Granulocytes			Agranulocytes	
	Basophils	Eosinophils	Neutrophils	Monocytes	Lymphocytes
% of total WBCs	0.5 - 1%	2 - 3%	60 - 65%	6 - 8%	20 - 25%
Shape of nucleus					
Function	Involved in inflammatory reactions	Resist infections, associated with allergic reactions	Phagocytic in action		Involved in immune response of body

- RBCs are biconcave and enucleated in most mammals
- Platelets are cell fragments of **megakaryocytes**
- Graveyard of RBCs - spleen
- Basophils secrete heparin, histamine, serotonin

2 BLOOD CLOTTING/ COAGULATION

- In response to injury/ trauma, clotting prevents loss of blood from body.
- **Events involved:**

Injured tissue / Platelets → Release chemicals → **(Cascade process)** → Formation of Thrombokinase (enzyme complex) → Prothrombin → Thrombins → Fibrinogens → Fibrins + entangled formed elements (Coagulam/reddish brown clot)

Plasma – Clotting factors = Serum

- **Ca^{2+}** ions play an important role in clotting
- **Clotting factors** in blood are in **inactive form**

4 BLOOD GROUPS

Based on: **ABO grouping** / **Rh grouping**

Parameter	Natural Antigen	Natural Antibodies
Definition	Chemicals that induce immune response	Proteins produced in response to antigens
Present	On RBC	In plasma
Type	A, B	Anti- A, B

Parameter	Rh+ve	Rh–ve
Rh factor Present	✓ on RBC	× ×

80% humans are Rh +ve

- Blood group and Rh factor compatibility of donor and recipient is done before transfusion to avoid clumping of RBCs

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

- Universal Donor
- Universal Recipient

Rh^{-ve} person upon exposure to Rh^{+ve} blood will form Rh specific antibodies

Special case of Rh incompatibility

Mother Rh^{-ve} ← Foetus Rh^{+ve}

1st **baby normal**, as during pregnancy, no mixing of blood due to separation by placenta

↓

During delivery, there are chances of mixing of blood

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Rh^{-ve} mother makes antibodies against Rh antigen

↓

Antibodies cross placenta in subsequent pregnancy

↓

Severe anemia and jaundice in baby

↓

Erythroblastosis foetalis

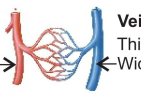
Administer anti Rh antibodies to the mother immediately after 1st delivery, save baby

3 BLOOD VESSELS

Layers in wall:

Name	Position	Composition
Tunica externa	Outermost	Fibrous connective tissue & collagen fibres
Tunica media	Middle	Smooth muscle & elastic fibres
Tunica intima	Innermost	Squamous endothelium

	Artery	Vein
Tunica media	Thick	Thin
Lumen	Narrow →	← Wide



5 CIRCULATORY PATHWAYS

	Open	Closed
Sinuses	Present	Absent
Regulation of blood flow	Imprecise	Precise
Examples	Arthropods, molluscs	Annelids, chordates

Vertebrates	Auricle(s)	Ventricle(s)	Circulation
Fishes	1	1	Single
Amphibians, most reptiles	2	1	Incomplete
Crocodile, Aves Mammals	2	2	Double

Fishes pump deoxygenated blood to gills for oxygenation.

6 LYMPH (Tissue fluid)

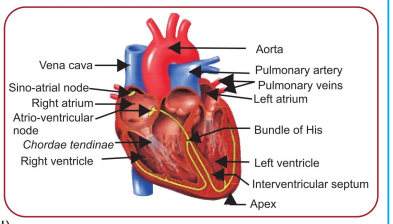
- Colourless
- **Blood - (Larger proteins + most formed elements)**
- Rich in lymphocytes
- Carrier for nutrients, hormones and fats
- Lymphatic vessels drain interstitial fluid back to major veins

Lacteals are lymph vessels in intestinal villi to absorb fats

7 HUMAN CIRCULATORY SYSTEM

Heart

- Mesodermally derived organ present in between lungs, muscular, chambered, tilted to left
- Protected by double walled, membranous bag- **Pericardium** with **pericardial fluid**
- 4 chambers
  - 2 upper, smaller– Auricles
  - 2 lower, larger – Ventricles
- Septum
  - → Between auricles: Inter-atrial (thin, muscular)
  - → Between ventricles: Inter-ventricular (thick walled)
  - → Between auricle & ventricle: Auriculo-ventricular (thick fibrous)



- Cardiac valves
  - → Between right auricle & right ventricle – Tricuspid
  - → Between left auricle & left ventricle – Bicuspid/Mitral
  - → At base of pulmonary artery, → At base of aorta – Semilunar

Valves are muscular flaps or cusps that allow unidirectional flow of blood and prevent its backward flow

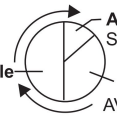
- Cardiac muscles
  - Contractile tissue
  - Nodal tissue **(Auto excitable)**
    - Sino-auricular node/ **(SA node/pacemaker)** – Right upper corner of right atrium
    - Atrioventricular node/ AV node – Left lower corner of right atrium
    - AV bundle – Interventricular septum
    - Purkinje fibres – Divides at apex of ventricle
- SAN – Maximum excitability – 70-75 action potentials/min

8 TYPES OF CIRCULATION

- **Double circulation**
  - **Pulmonary:** Right ventricle → (Pulmonary artery) → Lungs → (Pulmonary veins) → Left auricle
  - **Systemic:** Left ventricle → (Aorta) → Tissues → (Vena cava) → Right auricle
  - No mixing of deoxygenated and oxygenated blood occurs
- **Hepatic portal circulation** – Digestive tract → (Hepatic portal vein) → Liver
- **Coronary circulation** – Blood flow to and from the cardiac musculature

9 CARDIAC CYCLE

- Sequential events in the heart which are cyclically repeated.
- Heart beat rate = 72 beats/min
- Duration of 1 heart beat = 0.8 sec.



(1) Joint diastole

Atrial systole (2) SAN generates action potentials

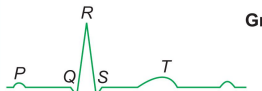
Ventricular systole (3) AV node, AV bundles, bundle of His transmit the action potential further

Events of 1 cardiac cycle

Location/Structure	Joint Diastole	Atrial Systole	Ventricular Systole
Auricle	Relax, filling	Contract, increase flow of blood into ventricles by 30%	Relax
Ventricle	Relax	Relax	Contract, throw out 70 ml of blood/ventricle – **Stroke volume**
Tri & Bicuspid valves	Open	Open	Closed, 1st heart sound **Lub**
Semilunar valves	Closed, 2nd heart sound **Dub**	Closed	Open

10 ELECTROCARDIOGRAPH (ECG)

- ECG is a graphical representation of electrical activities of heart during a cardiac cycle
- **Instrument** – Electrocardiograph
- **Graphical print** – Electrocardiogram
- For a standard ECG – 3 leads are connected to monitor heart activity – Right wrist, left wrist and left ankle



Graphical standards	Represent	Event associated
P wave	Depolarisation of atria	Contraction of atria
QRS complex	Depolarisation of ventricles	Contraction of ventricles
T wave	Repolarisation of ventricles	Relaxation of ventricles

- Number of QRS complexes in a given time period, determine the heart beat rate of an individual
- End of T-wave marks the end of systole
- Any deviation in ECG indicates a possible abnormality or disease *e.g.* ECG machine makes sound pip----pip---pee as patient goes into cardiac arrest.

11 REGULATION OF CARDIAC CYCLE

Activities of heart are regulated intrinsically *i.e* autoregulated as human heart is **myogenic**

Medulla oblongata can moderate

↓

Cardiac functions through

Autonomic nervous system (ANS)

Parameter	Sympathetic	Parasympathetic
Heart beat rate	Increase	Decrease
Strength of ventricular contraction	Increase	Decrease
Cardiac output	Increase	Decrease

Hormones of adrenal medulla increase cardiac output

12 DISORDERS OF CIRCULATORY SYSTEM

Disease	Effects
Cardiac arrest	Heart stops beating
Heart failure	Heart is not pumping blood effectively enough to meet needs of body
Atherosclerosis/(CAD) Coronary artery disease	Deposit of Ca^{+2}, fats, cholesterol in blood vessels that makes arterial lumen narrower
High blood pressure	Repeated checks of blood pressure of an individual ≥ 140/90, leads to heart diseases and also affects vital organs like brain and kidneys.
Angina pectoris/ acute chest pain	Not enough oxygen is reaching heart muscles. It affects blood flow. Common in middle aged and elderly.
Heart attack	Heart muscle is suddenly damaged by an inadequate blood supply.

- Heart sounds (Lub & dub)can be heard by **Stethoscope** and have clinical diagnostic significance.
- **Cardiac output** = Stroke volume × Heart rate = 70 × 72 ≃ 5 litres
- Cardiac output of athletes is higher than a normal man