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CUET · BIOLOGY · CLASS XI · CODE 304

Body Fluids and Circulation

CUET unit: Human Physiology → Body Fluids and Circulation

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- Establishes blood and lymph as the two major body fluids of higher animals, with blood as a specialised fluid connective tissue (plasma + formed elements).
- Builds the architecture of the human circulatory system — four-chambered myogenic heart, double circulation (pulmonary + systemic), nodal tissue, cardiac cycle and ECG.
- Anchors the ABO and Rh blood-group systems, transfusion compatibility, erythroblastosis foetalis, and the cascade mechanism of coagulation.
- Closes with neural/hormonal regulation of cardiac activity and major disorders — hypertension, atherosclerosis (CAD), angina, heart failure.
- CUET routinely tests exact counts (RBC/WBC/platelet numbers, % composition, durations, BP values), valve names, ECG wave meaning, and ABO–Rh compatibility — all factual, definition-based recall.

📖 Detailed Notes

2.1 Core concepts

- All living cells need a continuous supply of nutrients, O_2 and other essential substances, and continuous removal of wastes; simple organisms (sponges, coelenterates) circulate environmental water, while complex organisms use special body fluids — **blood** (the most common body fluid in higher organisms, including humans) and **lymph** — to transport materials (NCERT §15 intro, p. 193).
- **Blood is a fluid connective tissue** consisting of a fluid matrix (plasma) and **formed elements** (NCERT §15.1, p. 193).
- **Plasma** is a straw-coloured, viscous fluid making up nearly **55%** of the blood; **90–92% is water** and **6–8% is proteins** — **fibrinogen** (clotting), **globulins** (defense) and **albumins** (osmotic balance). Plasma also carries small amounts of minerals (Na^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-), glucose, amino acids, lipids in transit, and inactive clotting factors; plasma minus the clotting factors is called **serum** (NCERT §15.1.1, pp. 193–194).
- **Formed elements** — erythrocytes, leucocytes and platelets — collectively form ~**45%** of blood (NCERT §15.1.2, p. 194).
- **Erythrocytes / RBCs** are the most abundant blood cells: a healthy adult man has on average **5 to 5.5 million RBCs mm^{-3}**. RBCs are formed in the **red bone**

marrow in adults, are **devoid of nucleus in most mammals**, and are **biconcave** in shape. They carry the iron-containing protein **haemoglobin** (**12–16 g of haemoglobin per 100 mL of blood** in a healthy individual) and play a significant role in transport of respiratory gases. RBCs have an average **life span of 120 days** and are destroyed in the **spleen** ("graveyard of RBCs") (NCERT §15.1.2, p. 194).

- **Leucocytes / WBCs** are colourless (lack haemoglobin), nucleated and relatively fewer — **6,000–8,000 WBCs mm^{-3}** — and generally short-lived. Two main groups: **granulocytes** (neutrophils, eosinophils, basophils) and **agranulocytes** (lymphocytes, monocytes). **Neutrophils** (60–65%) and **monocytes** (6–8%) are phagocytic cells that destroy foreign organisms; **basophils** (0.5–1%, the least) secrete histamine, serotonin and heparin — involved in inflammatory reactions; **eosinophils** (2–3%) resist infections and are associated with allergic reactions; **lymphocytes** (20–25%) are of two types — **'B' and 'T'** — and are responsible for immune responses (NCERT §15.1.2, pp. 194–195).
- **Platelets / thrombocytes** are cell fragments produced from **megakaryocytes** in the bone marrow; blood normally contains **1,50,000–3,50,000 platelets mm^{-3}**. They release substances most of which are involved in coagulation; reduction in number leads to clotting disorders and excessive blood loss (NCERT §15.1.2, p. 195).
- **ABO blood grouping** is based on the presence or absence of two surface antigens (**A and B**) on RBCs; plasma carries the corresponding natural antibodies. Four groups exist — **A** (antigen A, anti-B antibody, can donate to A and AB, receive from A and O), **B** (antigen B, anti-A antibody), **AB** (both antigens, no antibodies — **universal recipient**, accepts blood from all four), **O** (no antigens, both anti-A and anti-B antibodies — **universal donor**, can give to all four). Cross-matching is essential before transfusion to avoid RBC clumping (NCERT §15.1.3.1, p. 195, Table 15.1).
- **Rh grouping** — the **Rh antigen** (similar to the one present in **Rhesus monkeys**) is found on RBCs of about **80%** of humans (Rh-positive); those without are Rh-negative. Rh– persons exposed to Rh+ blood produce anti-Rh antibodies, so Rh status must also be matched. A special case is **Rh incompatibility** during pregnancy: an Rh– mother carrying an Rh+ foetus is normally protected by the placenta in the first pregnancy, but small amounts of foetal Rh+ blood can leak into maternal circulation at delivery, prompting antibody formation; in **subsequent pregnancies** these maternal anti-Rh antibodies cross the placenta and destroy foetal RBCs — **erythroblastosis foetalis** (severe anaemia and jaundice, potentially fatal). It is prevented by administering anti-Rh antibodies to the mother right after the first delivery (NCERT §15.1.3.2, p. 196).
- **Coagulation of blood:** within seconds of injury, a clot or coagulum forms — a network of threads called **fibrins** in which dead and damaged formed elements are trapped. Fibrins are formed by the enzyme **thrombin** from inactive **fibrinogens**; thrombin in turn is formed from inactive **prothrombin** by an enzyme complex called

thrombokinase, which is built by a cascade of factors released by injured tissue and platelets. **Calcium ions** play a critical role in clotting (NCERT §15.1.4, p. 196).

- **Lymph (tissue fluid)** — as blood flows through capillaries, water and small solutes leave for the intercellular spaces; this fluid (mineral composition same as plasma) is the **interstitial / tissue fluid**, collected back to major veins via the **lymphatic system**. Lymph is colourless, contains specialised **lymphocytes** (immune responses) and is the route by which fats are absorbed through the **lacteals** in intestinal villi (NCERT §15.2, p. 197).
- **Circulatory patterns** — **Open** (arthropods, molluscs — blood pumped through large vessels into open sinuses) vs **Closed** (annelids, chordates — closed network of vessels; flow more precisely regulated) (NCERT §15.3, p. 197).
- **Vertebrate hearts** — fishes have a **2-chambered heart** (single circulation: heart pumps deoxygenated blood, gills oxygenate, body receives, returns); amphibians and reptiles (except crocodiles) have a **3-chambered heart** (two atria + single ventricle → incomplete double circulation); **crocodiles, birds and mammals** have a **4-chambered heart** → complete **double circulation** with two separate pathways (NCERT §15.3, p. 197).
- The **human heart** is mesodermal, the size of a clenched fist, situated in the thoracic cavity between the two lungs and tilted to the left; it is enclosed in a double-walled membranous bag, the **pericardium**, with **pericardial fluid** inside. Four chambers: two **atria** separated by the **inter-atrial septum**, and two **ventricles** separated by the **inter-ventricular septum**; atrium and ventricle of the same side are separated by the **atrio-ventricular septum** with an opening. The right AV opening has the **tricuspid valve** (3 cusps), the left has the **bicuspid / mitral valve**. Openings of right ventricle into pulmonary artery and left ventricle into aorta are guarded by **semilunar valves**. Valves allow one-way flow only — atria → ventricles → arteries (NCERT §15.3.1, pp. 198–199).
- **Nodal tissue** — specialised cardiac musculature; the **sino-atrial node (SAN)** in the upper right corner of the right atrium can generate the maximum number of action potentials (**70–75 min^{-1}**), is autoexcitable, and is therefore the **pacemaker** that initiates and maintains the heart's rhythmic activity. The **atrio-ventricular node (AVN)** in the lower left of the right atrium near the AV septum picks up the signal; from it the **AV bundle / Bundle of His** passes into the inter-ventricular septum and divides into right and left bundles, giving rise to **Purkinje fibres** throughout ventricular musculature. The heart normally beats **~70–75 (average 72) times per minute** (NCERT §15.3.1, p. 199).
- **Cardiac cycle:** starts in **joint diastole** with all four chambers relaxed, AV valves open, semilunar valves closed — blood flows from venae cavae and pulmonary veins into atria and on into ventricles. SAN fires → simultaneous **atrial systole** (boosts ventricular filling by ~30%). Signal reaches AVN → AV bundle → ventricular muscle → **ventricular systole**, raising pressure → AV valves close (**"lub"** — first heart sound) → semilunar valves open and blood is ejected. Then **ventricular diastole** —

semilunar valves close (**"dub"** — second heart sound) — and the cycle restarts. One cardiac cycle lasts **0.8 s** (72 cycles/min). Each ventricle pumps ~**70 mL** of blood (**stroke volume**) per beat; **cardiac output** = SV × HR ≈ **5000 mL (5 L)/min** in a healthy individual, higher in athletes (NCERT §15.3.2, pp. 199–200).

- **ECG** is a graphical record of the heart's electrical activity. The **P-wave** = atrial **depolarisation** (leads to atrial contraction); the **QRS complex** = ventricular **depolarisation** (start of ventricular systole, just after Q); the **T-wave** = ventricular **repolarisation** (return to normal — end of systole). Counting QRS complexes gives heart rate; any deviation in shape from the standard ECG signals possible disease (NCERT §15.3.3, p. 201).
- **Blood vessels** — three layers: **tunica intima** (inner squamous endothelium), **tunica media** (middle smooth muscle + elastic fibres — thinner in veins), **tunica externa** (outer fibrous connective tissue with collagen). Two circulatory pathways exist: **pulmonary circulation** — right ventricle → pulmonary artery (deoxygenated) → lungs → pulmonary vein (oxygenated) → left atrium; **systemic circulation** — left ventricle → aorta → arteries → arterioles → capillaries → tissues → venules → veins → vena cava → right atrium. A unique **hepatic portal** vein carries blood from intestine to liver before delivery to systemic circulation; the **coronary** system supplies blood exclusively to the heart muscle (NCERT §15.4, pp. 201–202).
- **Regulation** — the heart is **myogenic** (auto-regulated by nodal tissue). The **medulla oblongata** moderates cardiac function via the autonomic nervous system: **sympathetic** signals ↑ heart rate, strength of ventricular contraction and cardiac output; **parasympathetic** signals ↓ them. **Adrenal medullary hormones** (adrenaline, noradrenaline) can also ↑ cardiac output (NCERT §15.5, p. 202).
- **Disorders: Hypertension** = BP higher than normal **120/80** (systolic/diastolic mm Hg); repeated readings of **140/90** or higher indicate hypertension, which damages brain and kidney. **Coronary Artery Disease (CAD) / atherosclerosis** — deposits of calcium, fat, cholesterol and fibrous tissues narrow the coronary lumen. **Angina (pectoris)** — acute chest pain from insufficient O_2 to the heart muscle. **Heart failure** — heart cannot pump enough to meet body needs (congestion of lungs is a major symptom — congestive heart failure); not the same as **cardiac arrest** (heart stops) or **heart attack** (heart muscle damaged by inadequate blood supply) (NCERT §15.6, pp. 202–203).

2.2 Definitions to memorise

Term	Definition	Page
Plasma	Straw-coloured viscous fluid matrix of blood; 55% of blood; 90–92% water, 6–8% proteins	193
Serum	Plasma without clotting factors	194
Formed elements	RBCs + WBCs + platelets; ~45% of blood	194
Erythrocytes		194

Term	Definition	Page
	Biconcave, anucleate, haemoglobin-bearing RBCs; 5–5.5 million mm^{-3}; lifespan 120 days	
Leucocytes	Nucleated, colourless WBCs; 6000–8000 mm^{-3}; granulocytes + agranulocytes	194
Thrombocytes	Platelets; cell fragments from megakaryocytes; 1.5–3.5 lakh mm^{-3}	195
Universal donor / recipient	O group / AB group respectively	195
Erythroblastosis foetalis	Destruction of foetal RBCs by maternal anti-Rh antibodies in Rh-incompatible pregnancies	196
Thrombokinase	Enzyme complex formed by cascade that converts prothrombin → thrombin	196
Lymph	Colourless tissue fluid in lymphatic system; lymphocytes for immunity; transports fats via lacteals	197
Pacemaker	SAN — generates 70–75 action potentials/min, sets cardiac rhythm	199
Cardiac cycle	One sequential round of atrial + ventricular systole/diastole; 0.8 s	200
Stroke volume	Blood pumped by one ventricle in one beat (~70 mL)	200
Cardiac output	SV × HR ≈ 5 L/min in healthy adult	200
Myogenic heart	Heart whose contraction originates in its own muscle (nodal tissue), not from nerves	202
Atherosclerosis	Narrowing of coronary arteries due to calcium/fat/ cholesterol/fibrous deposits	203
Angina pectoris	Acute chest pain when O_2 supply to heart muscle is inadequate	203
Pericardium	Double-walled membranous bag enclosing the heart with pericardial fluid	198
Tunica media	Middle layer of blood vessels — smooth muscle + elastic fibres; thinner in veins	201
Hepatic portal system	Vein from intestine to liver before systemic delivery	202
Bundle of His	AV bundle that conducts the action potential from AVN to Purkinje fibres	199
Purkinje fibres	Minute conducting fibres throughout ventricular musculature	199
Heart failure	Inability of the heart to pump effectively; often congestive (lung congestion)	203

2.3 Diagrams / processes to remember

- **Figure 15.1 (p. 194)** — Formed elements: RBC, platelets, eosinophil, basophil, neutrophil, monocyte, T lymphocyte, B lymphocyte.
- **Table 15.1 (p. 195)** — Blood Groups and Donor Compatibility (antigens on RBCs, antibodies in plasma, donor's group for A/B/AB/O). Memorise: O donates to all, AB accepts from all.
- **Figure 15.2 (p. 198)** — Section of human heart: aorta, vena cava, pulmonary artery, pulmonary veins, SAN, AVN, bundle of His, chordae tendineae, atria, ventricles, interventricular septum, apex.
- **Figure 15.3 (p. 201)** — Standard ECG showing P, Q, R, S, T waves.
- **Figure 15.4 (p. 202)** — Schematic plan of blood circulation: heart (RA/LA/RV/LV), pulmonary artery → lungs → pulmonary vein, dorsal aorta → body parts → vena cava; vessel cross-section (vein vs artery).
- **Coagulation cascade flow (p. 196)** — Injury → platelet/tissue factors → thrombokinase + Ca^{2+} → prothrombin → thrombin → fibrinogen → fibrin clot.
- **Cardiac cycle sequence (pp. 199–200)** — Joint diastole → atrial systole → ventricular systole (lub) → ventricular diastole (dub) → joint diastole.

2.4 Common confusions / NTA trap points

- **RBC count vs WBC count vs platelet count** — NTA frequently swaps the numbers. Lock them: RBC 5–5.5 million mm^{-3}, WBC 6000–8000 mm^{-3}, platelets 1,50,000–3,50,000 mm^{-3}.
- **Tricuspid vs bicuspid valves** — tricuspid = right AV (right atrium ↔ right ventricle); bicuspid/mitral = left AV. Don't reverse.
- **"Lub" vs "dub"** — lub = AV valves closing (start of ventricular systole); dub = semilunar valves closing (end of ventricular systole).
- **Universal donor (O) vs universal recipient (AB)** — distractors often flip this. O has no antigens (gives to all); AB has no antibodies (receives from all).
- **Plasma vs serum** — serum = plasma minus clotting factors. Plasma proteins are not all clotting proteins — globulins (defense) and albumins (osmotic balance) are not clotting factors; only fibrinogen is.
- **P-wave vs T-wave** — P = atrial depolarisation (atrial contraction); T = ventricular repolarisation (ventricles returning to normal). QRS = ventricular depolarisation, not ventricular relaxation.
- **Erythroblastosis foetalis occurs in second / subsequent pregnancy**, not the first — the first delivery sensitises the Rh^- mother.
- **Atherosclerosis cause** — Ca/fat/cholesterol/fibrous deposits in coronaries, NOT excess fibrinogen.

- **Heart failure ≠ heart attack ≠ cardiac arrest** — three distinct conditions defined separately in §15.6.
- **Lymph carries fats** via lacteals — distractors often say it carries O_2; lymph has no RBCs.

2.5 Key counts, percentages and structures (NCERT-cited)

Item	NCERT value	Page
Plasma share of blood	55%	193
Plasma water content	90–92%	193
Plasma protein content	6–8%	193
Major plasma proteins	Fibrinogen (clot), globulin (defense), albumin (osmotic)	193–194
Formed elements share of blood	45%	194
RBC count (healthy adult man)	5–5.5 million mm^{-3}	194
Haemoglobin content	12–16 g per 100 mL blood	194
RBC lifespan	120 days	194
WBC count	6,000–8,000 mm^{-3}	194
Neutrophils share of WBCs	60–65% (most abundant, phagocytic)	194
Basophils share	0.5–1% (least; histamine, serotonin, heparin)	194
Eosinophils share	2–3% (infection resistance, allergy)	194–195
Lymphocytes share	20–25% (B and T — immunity)	195
Monocytes share	6–8% (phagocytic)	194
Platelet count	1,50,000–3,50,000 mm^{-3}	195
Rh+ humans	~80%	196
Universal donor	O group	195
Universal recipient	AB group	195
Heart chambers (mammals)	4 (2 atria + 2 ventricles)	198
SAN intrinsic rate	70–75 action potentials/min	199
Average heart rate	72 beats/min	199
Duration of one cardiac cycle	0.8 s	200
Stroke volume	~70 mL/ventricle/beat	200
Cardiac output	~5000 mL (5 L)/min	200
Normal BP	120/80 mm Hg	202

Item	NCERT value	Page
Hypertension threshold	⩾140/90 (repeated)	202
ECG P-wave	Atrial depolarisation → atrial contraction	201
ECG QRS complex	Ventricular depolarisation → start of systole	201
ECG T-wave	Ventricular repolarisation → end of systole	201

🎯 Practice MCQs

Q1. A healthy adult man has, on an average, how many RBCs per mm^3 of blood?

A. 1.5–3.5 lakh

B. 6000–8000

C. 5–5.5 million

D. 12–16 million

Q2. Which of the following plasma proteins is primarily responsible for the osmotic balance of blood?

A. Fibrinogen

B. Globulin

C. Albumin

D. Thrombin

Q3. Which leucocyte is the most abundant and acts as a phagocyte, and which is the least abundant?

A. Most: lymphocyte; Least: monocyte

B. Most: neutrophil; Least: basophil

C. Most: eosinophil; Least: lymphocyte

D. Most: monocyte; Least: neutrophil

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PYQ Alignment

This chapter is among the most consistently tested units of CUET Biology (Class XI Human Physiology), typically yielding ~8–10 MCQs per cycle. Recurring NTA targets include: exact blood-cell counts and percentages, plasma protein functions (albumin/globulin/fibrinogen), ABO–Rh compatibility, the coagulation cascade order, valve names (tricuspid/bicuspid/semilunar) and their associated heart sounds, SAN/AVN/Purkinje pathway, ECG wave identification (P/QRS/T), stroke volume and cardiac output arithmetic, and definitions of disorders (hypertension thresholds, atherosclerosis, angina, heart failure vs cardiac arrest).

Body Fluids and Circulation appeared in CUET (UG) Biology across 2 cycle(s) — 3 question(s) total. The questions below were extracted from official CUET (UG) papers and matched to this chapter by topic. See `/pyq/biology` for the full PYQ archive.

CUET 2023 — Actual PYQs from this chapter

Q.11 (CUET 2023) Match List-I with List-II List-I (A) Metabolic disorder (B) Pedigree analysis (C) Thalassemia (D) Trisomy of 21st chromosome List-II (I) Family tree over generations (II) Blood disease (III) Phenylketonuria (IV) Down's syndrome

- A) A-III, B-IV, C-III, D-I
- B) A-I, B-III, C-II, D-IV
- C) A-III, B-I, C-II, D-IV
- D) A-III, B-II, C-IV, D-I

Tests: aligns with chapter content Answer: Not in extracted key — verify against official NTA key

Q.18 (CUET 2023) Match List-I with List-II List-I (A) Lymphoid organ (B) Cancer (C) HIV (D) Typhoid List-II (I) ELISA (II) Widal test (III) Bone marrow and thymus (IV) Carcinogens

- A) A-IV, B-II, C-I, D-III
- B) A-III, B-IV, C-I, D-II
- C) A-II, B-III, C-IV, D-I
- D) A-I, B-III, C-II, D-IV

Tests: aligns with chapter content Answer: Not in extracted key — verify against official NTA key

CUET 2025 — Actual PYQs from this chapter

Q.4 (CUET 2025) Match List-I (Disease) with List-II (Characteristic symptoms). List-I List-II (A) Mala ria (i) Inflammation of lower limb (B) Filari asis (ii) Cycles of fever (C) Ring worm s (iii) Blood clots and excess mucus in stools (D) Amo ebias is (iv) Scaly lesions on nails

- A)
- B)

- C)
- D)

Tests: aligns with chapter content Answer: Not in extracted key — verify against official NTA key