Chapter 15: Body Fluids and Circulation

Comprehensive Study Notes

Class 11 Biology - NCERT Based

EXAM SPRINT - Complete Coverage for NEET and Board Examinations

Introduction

All living cells require continuous supply of nutrients, oxygen, and essential substances while waste products must be removed for healthy tissue function. Different animal groups have evolved various transport mechanisms:

Simple Organisms: Sponges and coelenterates circulate water through body cavities **Complex Organisms:** Use specialized body fluids like blood and lymph for transport

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15.1 BLOOD

Blood is a specialized connective tissue consisting of:

- **Fluid matrix:** Plasma
- **Formed elements:** RBCs, WBCs, and Platelets

15.1.1 Plasma

Composition:

- Constitutes 55% of blood volume
- 90-92% water
- 6-8% proteins

Major Proteins:

1. **Fibrinogen:** Required for blood clotting/coagulation
2. **Globulins:** Defense mechanisms of body
3. **Albumins:** Maintain osmotic balance

Other Components:

- **Minerals:** Na^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-
- **Organic substances:** Glucose, amino acids, lipids
- **Clotting factors:** Present in inactive form
- **Serum:** Plasma without clotting factors

15.1.2 Formed Elements

Constitute 45% of blood volume, including:

Red Blood Cells (RBCs/Erythrocytes)

Characteristics:

- Most abundant blood cells
- Count: 5-5.5 million/mm^3 in healthy adult males
- Formation: Red bone marrow in adults
- Structure: Biconcave, nucleus absent in mammals
- Lifespan: 120 days
- Destruction: Spleen (graveyard of RBCs)

Function:

- Contain hemoglobin (12-16 gms/100ml blood)

- Iron-containing protein for gas transport
- Red color due to hemoglobin

White Blood Cells (WBCs/Leucocytes)

General Features:

- Colorless (lack hemoglobin)
- Nucleated cells
- Count: 6000-8000/mm^3
- Generally short-lived
- Defense function

Classification:

1. Granulocytes:

- **Neutrophils:** 60-65%, phagocytic, destroy foreign organisms
- **Eosinophils:** 2-3%, resist infections, allergic reactions
- **Basophils:** 0.5-1% (least abundant), secrete histamine, serotonin, heparin

2. Agranulocytes:

- **Monocytes:** 6-8%, phagocytic cells
- **Lymphocytes:** 20-25%, two types (B and T), immune responses

Platelets (Thrombocytes)

Features:

- Cell fragments from megakaryocytes

- Count: 150,000-350,000/mm^3
- Function: Blood coagulation
- Reduction causes clotting disorders and excessive bleeding

15.1.3 Blood Groups

15.1.3.1 ABO Blood Grouping

Based on presence/absence of surface antigens A and B on RBCs:

Blood Group	Antigens on RBCs	Antibodies in Plasma	Can Donate To	Can Receive From
A	A	anti-B	A, AB	A, O
B	B	anti-A	B, AB	B, O
AB	A, B	None	AB	A, B, AB, O
O	None	anti-A, anti-B	A, B, AB, O	O

Special Classifications:

- **Universal Donor:** O group (can donate to all groups)
- **Universal Recipient:** AB group (can receive from all groups)

15.1.3.2 Rh Blood Grouping

Rh Factor:

- Antigen similar to Rhesus monkeys
- Present in 80% of humans (Rh positive)
- Absent in 20% (Rh negative)

Clinical Significance:

- Rh incompatibility between mother and fetus
- **Erythroblastosis fetalis:** Rh^- mother with Rh^+ fetus
- Prevention: Anti-Rh antibodies after first delivery

15.1.4 Blood Coagulation

Mechanism: Blood clotting prevents excessive blood loss through formation of fibrin network.

Process:

1. Injury stimulates platelets
2. Cascade of enzymatic reactions
3. Prothrombin → Thrombin (via thrombokinase)
4. Fibrinogen → Fibrin (via thrombin)
5. Fibrin network traps blood cells forming clot

Requirements:

- Calcium ions essential
- Multiple clotting factors in plasma
- Platelet factors and tissue factors

15.2 LYMPH (Tissue Fluid)

Formation:

- Water and small soluble substances move out from blood capillaries
- Larger proteins and formed elements remain in blood vessels
- Interstitial fluid formed between tissue cells

Characteristics:

- Same mineral distribution as plasma
- Medium for exchange between blood and cells
- Collected by lymphatic system and returned to major veins

Functions:

1. **Immune function:** Contains specialized lymphocytes
2. **Transport:** Nutrients, hormones
3. **Fat absorption:** Through lacteals in intestinal villi

15.3 CIRCULATORY PATHWAYS

Types of Circulatory Systems

Open Circulatory System

- Found in: Arthropods, molluscs
- Blood pumped into open spaces (sinuses)
- Less regulated fluid flow

Closed Circulatory System

- Found in: Annelids, chordates
- Blood always in closed vessel network
- More precise regulation (advantageous)

Evolution of Hearts in Vertebrates

Group	Chambers	Circulation Type
Fishes	2 (1 atrium, 1 ventricle)	Single circulation
Amphibians & Reptiles	3 (2 atria, 1 ventricle)	Incomplete double
Crocodiles, Birds, Mammals	4 (2 atria, 2 ventricles)	Complete double

15.3.1 Human Circulatory System

Components:

1. **Heart:** Muscular, chambered pumping organ
2. **Blood vessels:** Closed branching network
3. **Blood:** Circulating fluid

Heart Structure

Location: Thoracic cavity, between lungs, tilted left **Size:** Clenched fist **Protection:** Pericardium (double-walled bag with pericardial fluid)

Chambers:

- **Atria:** 2 smaller upper chambers
- **Ventricles:** 2 larger lower chambers
- **Septa:** Walls separating chambers

Valves:

- **Tricuspid:** Between right atrium and ventricle (3 cusps)
- **Bicuspid/Mitral:** Between left atrium and ventricle (2 cusps)
- **Semilunar valves:** At exits to pulmonary artery and aorta

- **Function:** Prevent backflow of blood

Cardiac Musculature:

- Ventricle walls thicker than atria
- **Nodal tissue:** Specialized cardiac muscle

Conduction System:

1. **Sinoatrial Node (SAN):**
   - Right upper corner of right atrium
   - Generates 70-75 action potentials/minute
   - **Pacemaker** of heart
2. **Atrioventricular Node (AVN):**
   - Lower left corner of right atrium
   - Receives impulse from SAN
3. **AV Bundle (Bundle of His):**
   - Continues from AVN through septa
   - Divides into right and left branches
4. **Purkinje fibers:**
   - Minute fibers throughout ventricular muscle
   - Complete conduction pathway

15.3.2 Cardiac Cycle

Definition: Sequential events in heart that are cyclically repeated

Phases:

1. Joint Diastole:

- All chambers relaxed
- Tricuspid and bicuspid valves open
- Blood flows from veins to ventricles via atria
- Semilunar valves closed

2. Atrial Systole:

- SAN generates action potential
- Both atria contract simultaneously
- Increases ventricular filling by 30%
- Atria then relax (diastole)

3. Ventricular Systole:

- AVN and AV bundle conduct impulse
- Ventricular muscles contract
- Ventricular pressure increases
- Tricuspid and bicuspid valves close
- Semilunar valves forced open
- Blood pumped to pulmonary artery and aorta

4. Ventricular Diastole:

- Ventricles relax
- Ventricular pressure falls
- Semilunar valves close
- Tricuspid and bicuspid valves open

- Return to joint diastole

Cardiac Output Calculations:

- Heart rate: 72 beats/minute
- Cardiac cycle duration: 0.8 seconds
- **Stroke volume:** 70 mL/beat
- **Cardiac output:** Stroke volume × Heart rate = ~5000 mL/minute = 5 L/minute

Heart Sounds:

- **First sound (lub):** Closure of tricuspid and bicuspid valves
- **Second sound (dub):** Closure of semilunar valves
- Clinical diagnostic significance

15.3.3 Electrocardiogram (ECG)

Definition: Graphical representation of electrical activity during cardiac cycle

Standard ECG Leads: Three electrical leads (both wrists, left ankle)

ECG Waves:

- **P-wave:** Atrial depolarization (atrial contraction)
- **QRS complex:** Ventricular depolarization (ventricular contraction begins)
- **T-wave:** Ventricular repolarization (end of systole)

Clinical Significance:

- Heart rate determination (count QRS complexes)
- Abnormality detection through shape deviation
- Diagnostic importance for heart conditions

15.4 DOUBLE CIRCULATION

Blood Vessel Structure

All arteries and veins have three layers:

1. **Tunica intima:** Inner squamous endothelium
2. **Tunica media:** Middle smooth muscle and elastic fibers
3. **Tunica externa:** Outer fibrous connective tissue with collagen

Note: Tunica media is thinner in veins compared to arteries

Two Circulatory Pathways

1. Pulmonary Circulation

Route: Right ventricle → Pulmonary artery → Lungs → Pulmonary veins → Left atrium **Function:** Oxygenation of deoxygenated blood

2. Systemic Circulation

Route: Left ventricle → Aorta → Arteries → Arterioles → Capillaries → Tissues → Venules → Veins → Vena cava → Right atrium

Functions:

- Supply nutrients, O_2, essential substances to tissues
- Remove CO_2 and waste products

Special Circulations:

- **Hepatic portal system:** Digestive tract → Liver → Systemic circulation

- **Coronary circulation:** Specialized blood supply to cardiac muscle

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15.5 REGULATION OF CARDIAC ACTIVITY

Intrinsic Regulation

- **Myogenic heart:** Auto-regulated by nodal tissue
- SAN sets the pace naturally

Extrinsic Regulation

Neural Control

Location: Medulla oblongata cardiac center

Sympathetic nerves:

- Increase heart rate
- Increase strength of ventricular contraction
- Increase cardiac output

Parasympathetic nerves:

- Decrease heart rate
- Decrease speed of conduction
- Decrease cardiac output

Hormonal Control

- **Adrenal medullary hormones:** Increase cardiac output

15.6 DISORDERS OF CIRCULATORY SYSTEM

Hypertension (High Blood Pressure)

Definition: Blood pressure higher than normal (120/80) **Diagnosis:** Consistently 140/90 or higher **Effects:**

- Heart diseases
- Affects brain and kidney **Reading:** 120 mm Hg (systolic) / 80 mm Hg (diastolic)

Coronary Artery Disease (CAD)

Also called: Atherosclerosis **Cause:** Deposits of calcium, fat, cholesterol, fibrous tissues **Effect:** Narrowing of coronary artery lumen **Result:** Reduced blood supply to heart muscle

Angina (Angina Pectoris)

Symptom: Acute chest pain **Cause:** Insufficient oxygen reaching heart muscle **Risk factors:** Middle-aged and elderly, affects blood flow

Heart Failure

Definition: Heart not pumping effectively to meet body needs **Also called:** Congestive heart failure (lung congestion) **Note:** Different from cardiac arrest (heart stops) or heart attack (muscle damage)

NEET-Specific Important Points

High-Yield Topics for NEET:

1. Blood Components:

- Plasma composition and functions
- Formed elements and their percentages

- Hemoglobin concentration
- Lifespan of blood cells

2. Blood Groups:

- ABO system genetics
- Rh factor inheritance
- Transfusion compatibility
- Erythroblastosis fetalis

3. Heart Structure:

- Chamber names and functions
- Valve types and locations
- Conduction system components
- Pacemaker function

4. Cardiac Cycle:

- Phase sequence
- Valve operations
- Heart sounds
- Calculations (cardiac output, stroke volume)

5. ECG Interpretation:

- Wave meanings
- Clinical significance
- Abnormality detection

Common NEET Question Patterns:

1. Numerical Problems:

- Cardiac output calculations
- Blood cell counts
- Heart rate problems

2. Identification Questions:

- ECG wave identification
- Blood cell recognition
- Heart chamber/valve naming

3. Process Questions:

- Blood clotting mechanism
- Cardiac cycle phases
- Double circulation pathway

4. Clinical Applications:

- Blood transfusion compatibility
- ECG interpretation
- Disease symptoms

Memory Aids and Mnemonics

Blood Cell Types:

"Really Excited Never Leaves Behind Memories"

- RBCs
- Eosinophils
- Neutrophils
- Lymphocytes
- Basophils
- Monocytes

Heart Valves:

"Try Before Mixing Smoothly"

- Tricuspid
- Bicuspid
- Mitral
- Semilunar

ECG Waves:

"People Quietly Rest Silently Together"

- P-wave (atrial depolarization)
- Q-wave (start ventricular depolarization)
- R-wave (peak ventricular depolarization)
- S-wave (end ventricular depolarization)

- T-wave (ventricular repolarization)

Cardiac Cycle Phases:

"Joint Action Varies Continuously"

- Joint diastole
- Atrial systole
- Ventricular systole
- Cycle repeats

Practice Questions for NEET

Multiple Choice Questions:

1. The pacemaker of human heart is: a) AVN b) SAN c) Bundle of His d) Purkinje fibers
2. Universal donor blood group is: a) AB b) A c) B d) O
3. The stroke volume of human heart is approximately: a) 50 mL b) 70 mL c) 100 mL d) 120 mL

Short Answer Questions:

1. Why is SAN called the pacemaker?
2. What is double circulation? Give its significance.
3. Explain the role of platelets in blood clotting.

Long Answer Questions:

1. Describe the cardiac cycle with a neat diagram.
2. Explain ABO blood grouping system with transfusion compatibility.
3. Draw and explain a standard ECG.

Summary Table: Key Comparisons

Feature	Arteries	Veins
Blood type	Oxygenated (except pulmonary)	Deoxygenated (except pulmonary)
Pressure	High	Low
Tunica media	Thick	Thin
Valves	Only at base	Throughout
Lumen	Narrow	Wide

Blood Group	Universal Donor	Universal Recipient
ABO System	O	AB
Can donate to	All groups	Only same group
Can receive from	Only same group	All groups

Evolutionary Significance

Progressive Trends in Circulation:

1. **Open → Closed system:** Better regulation
2. **Single → Double circulation:** Efficient oxygenation
3. **2-chambered → 4-chambered heart:** Complete separation
4. **Mixed blood → Separate pathways:** Higher efficiency

EXAM SPRINT - Master Body Fluids and Circulation with focused study on blood composition, heart structure, cardiac cycle, and circulatory pathways. Regular practice of numerical problems and process explanations is key to NEET success.

Source: NCERT Biology Class 11, Chapter 15 - Comprehensive coverage for NEET preparation