CHAPTER 1

General Physiology

CELL PHYSIOLOGY

1. What is a cell?

Ans. Cell is defined as structural and functional unit of an organism.

2. Mention the main components of a cell.

Ans. The main components of a cell are:

- Nucleus
- Cell membrane
- Cytoplasm.

3. Name the organelles present in the cytoplasm of a typical mammalian cell.

Ans. • Endoplasmic reticulum (ER)
- Mitochondria
- Golgi apparatus
- Centrosome
- Lysosomes
- Peroxisomes
- Ribosomes

4. What are the functions of endoplasmic reticulum?

Ans. It is of two types: Granular and smooth endoplasmic reticulum. Granular endoplasmic reticulum produces protein substances. Smooth endoplasmic reticulum produces steroid substances. The proteins and steroids are packed into membrane bound granules which are emptied into the Golgi apparatus.

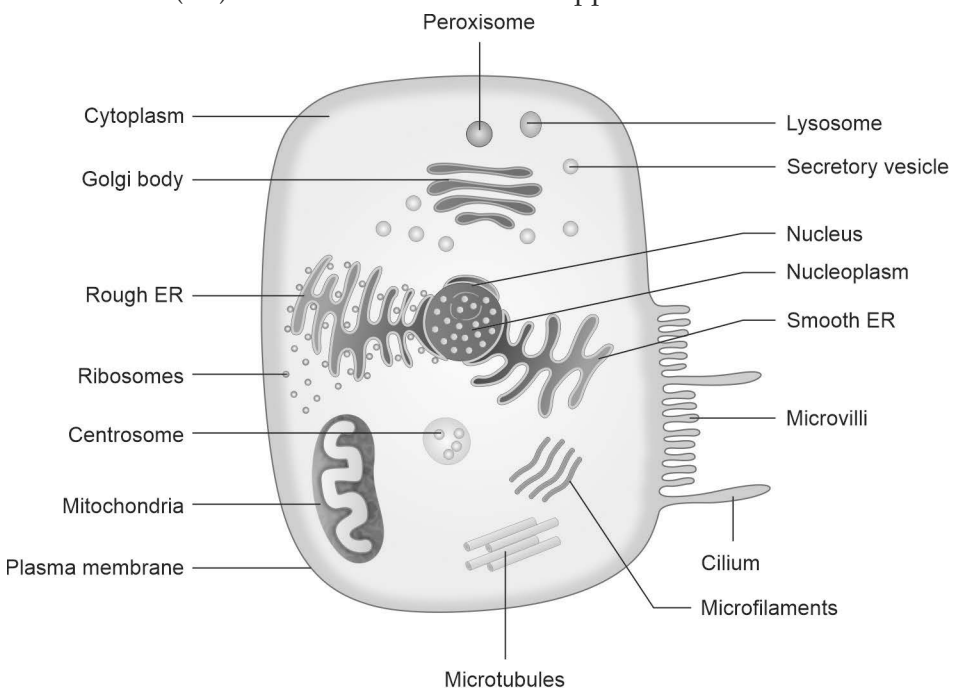

Fig. 1.1: Typical human cell

In muscles, it is concerned with the **calcium dynamics** (Sarco-tubular system).

5. What are the functions of mitochondria?

Ans.
- The sausage shaped mitochondria vary in numbers depending on the activity of a cell.
- They mainly participate in the production of ATP during aerobic metabolism.
- **Mitochondrial DNA** control certain characteristics of an individual.

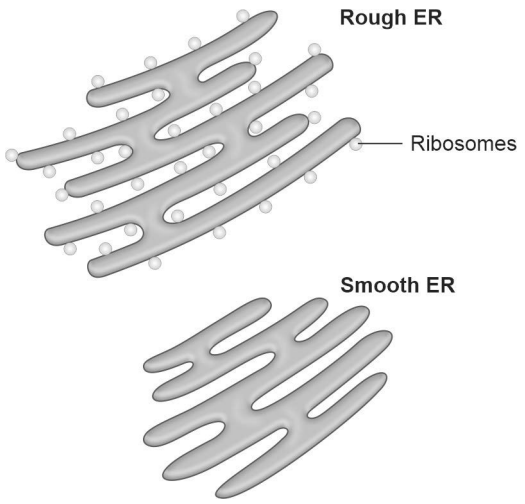

Fig. 1.2: Endoplasmic reticulum (ER)

6. What are the functions of Golgi apparatus?

Ans.
- Golgi apparatus resembles that of dinner plates arranged one above the other.
- This accepts the various substances synthesized by the endoplasmic reticulum and packs them into membrane bound vesicles like: 1. Secretory granules; 2. Lysosomes; 3. Peroxisomes, etc.

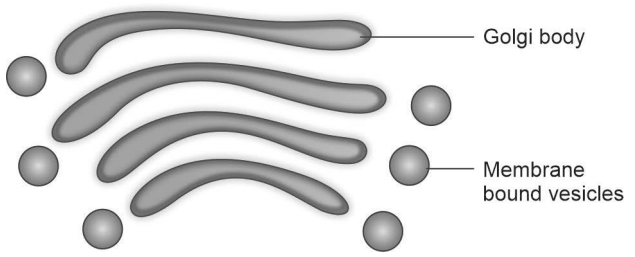

Fig. 1.3: Golgi complex

7. What are the functions of lysosomes/lysozymes?

Ans. Lysosomes contain a variety of hydrolytic enzymes called lysozymes.
- Participates in cell digestion.
- Participates in removing old senile organelles.
- Destruction of pathogens during phagocytosis.
- Called suicidal bags as they cause autolysis of the cell.

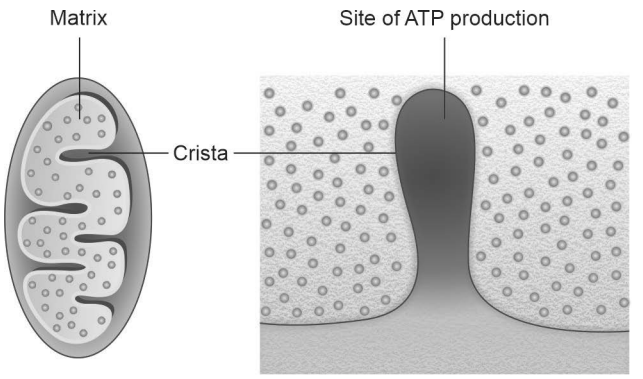

Fig. 1.4: Mitochondria

8. What are the functions of ribosomes?

Ans.
- Ribosomes are made up of RNA and proteins.
- They are concerned with synthesis of proteins.

9. What are the functions of nucleus?

Ans.
- Nucleus is the chief controlling organelle of the cell that controls all the cellular activities.
- The genes of chromosomes are made up of Deoxyribonucleic acid (DNA).
- Genes control the hereditary characteristics of a given organism.

10. Name another organelle that contains DNA apart from the nucleus.

Ans. Mitochondria contains DNA that helps its own synthesis of protein and its multiplication.

CELL MEMBRANE

11. What is the latest concept about the structure of cell membrane?

Ans. The cell membrane is considered as a fluid mosaic (**Singer and Nicholson, 1972)**.

It is basically a bimolecular lipid layer with embedded protein molecules in both layers.

12. What are the components of cell membrane? Mention their functions.

Ans. The components of cell membrane are: 1. Cholesterol, 2. Phospholipids, 3. Carbohydrates, and 4. Proteins.

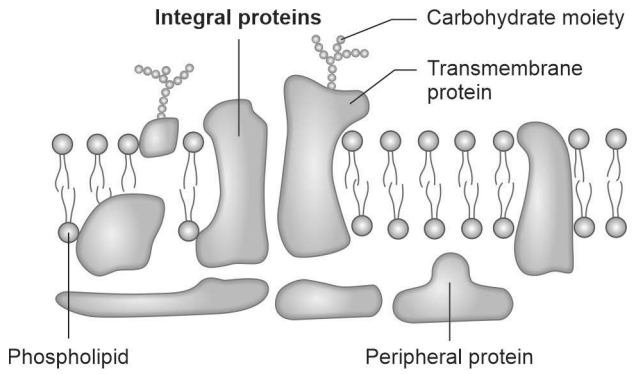

Fig. 1.5: Structure of cell membrane

13. What are the functions of the cell membrane?

Ans.
- Forms a protective boundary for the cell organelles.
- Controls diffusion of electrolytes and various other substances.
- Participates in the genesis of bioelectric potentials.
- Provides surface contact for hormones, drugs and enzymes.
- Links adjacent cell by intercellular junctions to form tissues.

14. Name the intercellular junctions and their functions.

Ans. The intercellular junctions are: i. Desmosome, ii. Tight junction, iii. Gap junction.

1. **Desmosomes** act like a rivet or spot welding between the cells and provides a strong union between the cells.
2. **Tight junctions** provide a strong union between the cells.
   They participate in the formation blood-brain–barrier, blood–testis-barrier.
3. **Gap junctions** are communicating junctions contributed by **connexon** protein channels.
   These permit free passage of ions, sugars, aminoacids between the adjacent cells and helps in The formation of syncytium, e.g. cardiac muscle, smooth muscle, etc.

TRANSPORT ACROSS CELL MEMBRANE

15. What is the difference between passive and active transport processes?

Ans. Passive transport does not require energy and active transport is dependent on energy ATP (**glut-1 and glut-4**).

16. What are the different transport mechanisms which transport substances through the cell membrane?

Ans. Transport mechanisms—Two types: Passive and active transport mechanisms.

Passive transport—i. Simple diffusion, ii. Facilitated diffusion, iii. Osmosis, iv. Filtration

Active transport—i. Primary active transport, ii. Secondary active transport, iii. Endocytosis-phagocytosis and pinocytosis, iv. Exocytosis.

Passive Transport

17. What is diffusion? Mention the factors that influence diffusion of a given substance.

Ans. Substances pass through the membrane along the electrochemical gradient due to the kinetic energy of the continuously moving particles.

Factors that influence diffusion are:
- Concentration gradient
- Temperature
- Lipid solubility
- Surface area of the membrane.

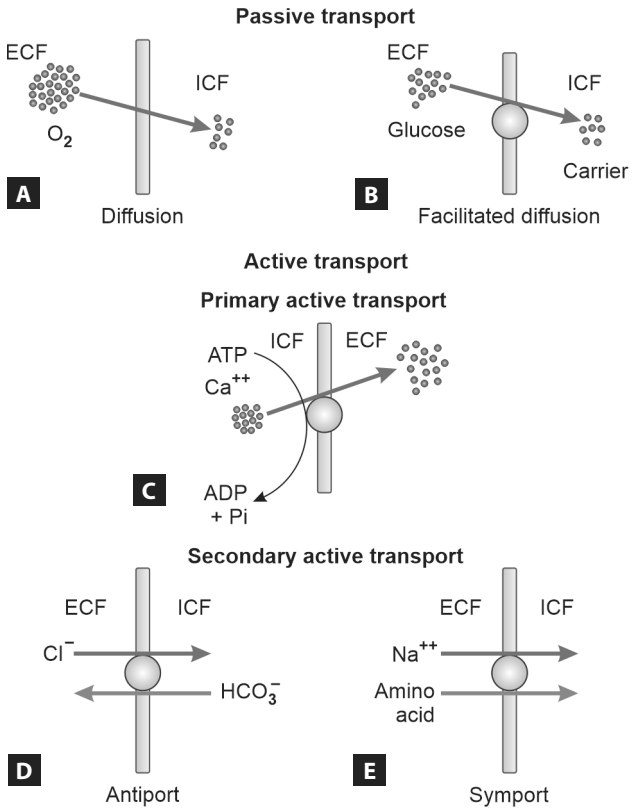

Fig. 1.6A to E: Transport across cell membrane

There is a direct relation between these factors and rate of diffusion.
- Thickness of the membrane.
- Molecular size –these are inversely related to the rate of diffusion.

18. Differentiate between simple diffusion and facilitated diffusion.

Ans. Simple diffusion takes place along the electrochemical gradient passively by the kinetic energy of dissolved particles, e.g. diffusion of molecules through the membrane.

Facilitated diffusion is carried out with the help of carrier protein, e.g. glucose transport into the RBC and muscles **glut-1 and glut-4**. It exhibits saturation.

19. What is osmosis?

Ans.
- Passive flow of solvent through a semipermeable membrane from lower solute concentration to a higher concentration of solute.
- The pressure required to prevent the movement of solvent from lower to higher concentrated

region through semipermeable membrane is called osmotic pressure.

- The osmotic pressure of a given solution is called osmolality or osmolarity.
- The osmolality of a given solution is measured by milli Osmoles (mOsm).
- Normal osmolality of human plasma is 290 mOsm/L.

20. What is colloidal osmotic pressure?

Ans. Colloidal osmotic pressure also called oncotic pressure is expressed in mm Hg.

Osmotic pressure of plasma proteins is called colloidal osmotic pressure.

It is about 25 mm Hg (<2 mOsm/L).

Colloidal osmotic pressure prevents the accumulation of fluid in the interstitial space (prevents edema).

21. What is filtration?

Ans. Fluid is transferred across the membrane along the pressure gradient. This is called filtration.

22. What is an isotonic fluid? What is its clinical significance?

Ans. Solutions that have the same osmolality as plasma are called isotonic fluids, e.g. 0.9% NaCl, 5% glucose.

Significance: Isotonic solutions are given clinically to restore the blood volume in hemorrhage and tonicity and volume of ECF in dehydration.

Active Transport

23. What are the features of active transport?

Ans.
- It is mediated by a carrier protein.
- **Specificit**y: The carrier is specific for a particular substance, e.g. calcium pump.
- **Saturation**: The carrier gets saturated with the substance. Hence the transport of substance across the membrane is limited.
- **Competitive inhibition**: Two substances competing for a single carrier exert mutual. Inhibition called competitive inhibition.

24. How does primary active transport different from secondary active transport?

Ans.
- **Primary active transport** uses energy directly from ATP hydrolysis, e.g. Na^+–K^+ pump, Ca^{2+} pump, etc.
- **Secondary active transport** indirectly uses energy from ATP hydrolysis. This uses potential energy generated by concentration gradient, which depends on ATP. Seen in GIT, e.g. glucose is absorbed in the presence of Na^+ by the renal tubules.

25. What is co-transport? Mention the types.

Ans. Transport of two substances across the membrane simultaneously is called co-transport.

It is two types:

1. **Symport**: Two substances are transported simultaneously across the membrane to the same side, e.g. Na-glucose co-transport (SGLT).
2. **Antiport**: Transport of second substance in the opposite direction to the first one, Na-H pump in the renal tubules

26. What are the features of Na^+–K^+ pump?

Ans.
- It is present in all the cell membranes.

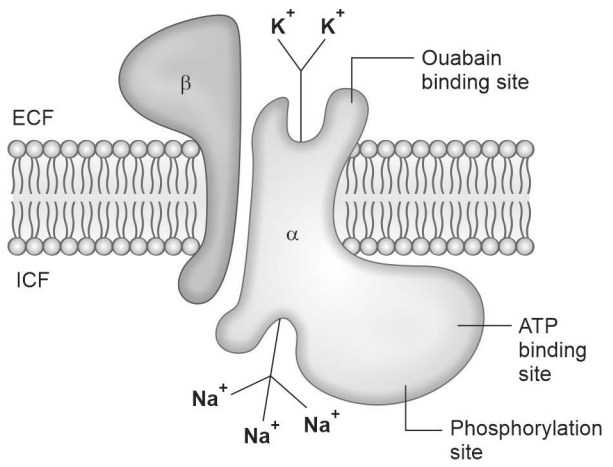

Fig. 1.7: Na^+–K^+ ATPase

- This is the main contributor to basal metabolic rate.
- Maintains ionic concentration gradient across the membrane, which is the basis for the resting membrane potential.
- Helps in passive absorption of HCO_3^- and H_2O.
- Regulates the cell volume.
- Activated by thyroid, insulin, and aldosterone hormones.
- Inhibited by hypoxia, metabolic poisons, digitalis and low temperature.

27. What is vesicular transport?

Ans. Some large molecular substances which cannot diffuse or pass through the protein channels are either taken in **(endocytosis)** or taken out of the cell **(exocytosis**). This is carried out by membrane bound vesicles. This type of transport is called **vesicular transport**, for example, (i) Phagocytosis; (ii) Pinocytosis; (iii) Exocytosis (cell vomiting).

- Disease causing pathogens are taken in by phagocytosis.
- Water soluble immunoglobulins are taken in by pinocytosis.
- Hormones, enzymes, etc. are released by exocytosis.

28. What is phagocytosis and pinocytosis?

Ans. Phagocytosis: This is also called cell eating seen in neutrophils and macrophages. On contact with a solid particle the cell membrane invaginates. The invaginated cell membrane is taken into the cell as a membrane bound vesicle. It fuses with a lysosome in the cytoplasm.

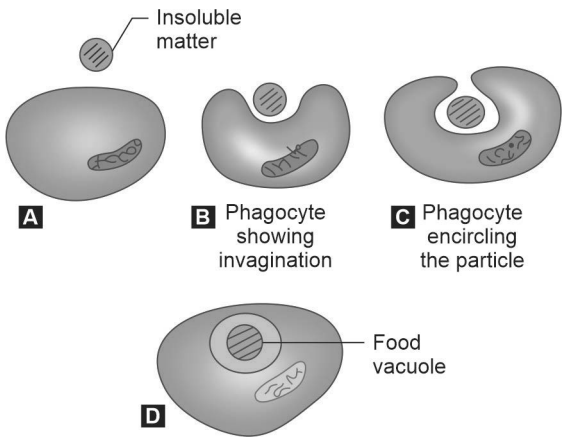

Fig. 1.8A to D: Endocytosis-phagocytosis

Pinocytosis: Water soluble substances like immunoglobulins, and other proteins are taken into the cell. As membrane bound vesicles which fuse with lysosomes.

29. What is exocytosis?

Ans. Exocytosis is also called cell vomiting. It is a reverse pinocytosis seen in all the cells that secret protein compounds. The membrane of the granule fuses with the cell membrane and the region of the fusion breaks down leaving the contents outside the cell. This is called exocytosis.

HOMEOSTASIS

30. Define homeostasis.

Ans. Maintenance of a constant internal environment is called homeostasis. Volume, electrolyte composition, pH and temperature of ECF is regulated. The word homeostasis is given by Cannon and **'milieu interieur'** is given by Claude Bernard.

31. How is homeostasis regulated?

Ans. It is regulated by feedback mechanisms:

- Negative feedback mechanism
- Positive feedback mechanism

Negative feedback mechanism: This reacts in such a way as to arrest the change or reverse the direction of the change with the final response just opposite to the initiating stimulus, e.g. regulation of BP.

$$\uparrow \text{BP} \rightarrow \downarrow \text{BP}$$
$$\downarrow \text{BP} \rightarrow \uparrow \text{BP}$$

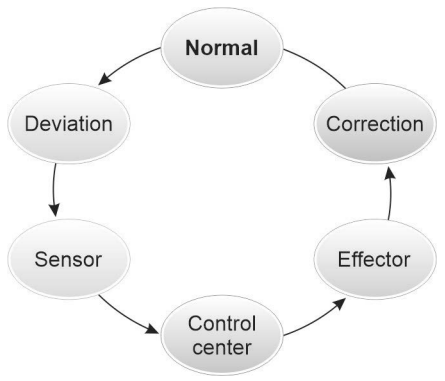

Fig. 1.9: Components of homeostasis system

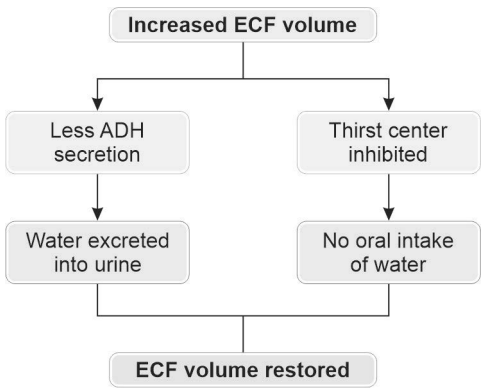

Fig. 1.10: Regulation of ECF volume

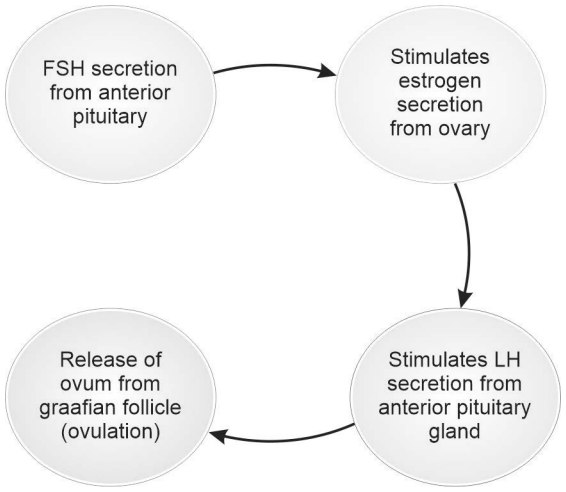

Fig. 1.11: Ovulation by positive feedback mechanism

Positive feedback mechanism: This amplifies the initial change in the same direction as that of initiating stimulus till the final response is obtained, e.g. (i) Ovulation; (ii) Clotting of blood.

$$\text{FSH} \rightarrow \uparrow \text{estrogen} \rightarrow \uparrow \text{LH} \rightarrow \text{ovulation}$$

BODY FLUIDS AND pH

32. Name the different compartments of total body water and their normal values.

Ans.

Total body water (60% of body weight)

Extracellular fluid volume (ECFV) (20% of body weight) — 0.2 body weight

Intracellular fluid volume (ICFV) (40% of body weight) — 0.4 body weight

Plasma (25% of ECF)

Interstitial and transcellular fluid (75% of ECF)

33. Name some conditions that lead to dehydration.

Ans. Excess loss of body water leads to dehydration. This is seen in:

- Diarrhea
- Severe vomiting
- Burns
- Excess swetting
- Addison's disease.

34. Mention some clinical symptoms associated with dehydration.

Ans. (i) Low BP, (ii) Rapid pulse rate, (iii) Low CO, (iv) Acidosis, (v) Lethargy, confusion and coma.

35. Why dehydration develops rapidly in infants and in children than adults?

Ans. The ECFV/ICFV ratio is larger in infants and children than in adults but the absolute ECFV in children is smaller than adults.

36. Name some conditions that are associated with edema.

Ans. Excess accumulation body water leads to edema. This is seen in:

- Malnutrition (↓ COP)
- Nephrotic syndrome (Protein loss into urine)
- Heart failure
- Lymphatic obstruction

37. What factors cause edema?

Ans.

- Increase in capillary hydrostatic pressure
- Decrease in blood colloidal osmotic pressure
- Increase in capillary permeability.
- Lymphatic obstruction.

38. What is pitting edema?

Ans. When pressed with a finger, water is displaced causing a pit which takes few minutes to disappear. This is called pitting edema.

39. Define pH. Mention normal blood pH.

Ans. pH is defined as the negative log of H^+ ion concentration.

$pH = -\text{Log}_{10}(H^+)$

Normal blood pH ranges 7.35–7.45.

40. What are the major ions of ECF and ICF?

Ans.

Ion	ECF	ICF
Na^+	142	14
K^+	4.5	150
Cl^-	103	4
HCO_3^-	28	10
Ca^{++}	5	<1

41. What is the blood pH compatible to life?

Ans. The pH compatible to life is 7.7–6.9 clinically blood pH <7.35 is called acidosis and blood pH >7.45 is called alkalosis.

42. What is a buffer? Give examples.

Ans. Buffers are substances that prevent a change in pH either by taking extra H^+ or donating a free H^+ to the solution, e.g. Hb, proteins, HCO_3 act as buffers.

43. What is an osmole and milli osmole?

Ans. One gram molecular weight of non-ionisable substance dissolved in one litre of solution gives an osmotic pressure of one osmole. The unit for the osmotic pressure is osmole one thousandth of an osmole is called Milli osmole.

MEMBRANE POTENTIALS

44. What is equilibrium potential? Mention the normal values for each ion.

Ans. It is the membrane potential at which there is no net movement of a given ion across the membrane.

For example: In neurons - Equilibrium potential.

1. ENa^+ - +60 mV
2. EK^+ - –90 mV
3. ECl^- - –70 mV

45. Name the membrane potentials.

Ans. The membrane potentials also called bio-electric potentials are:

- Resting membrane potential (RMP)
- Action potential (AP)

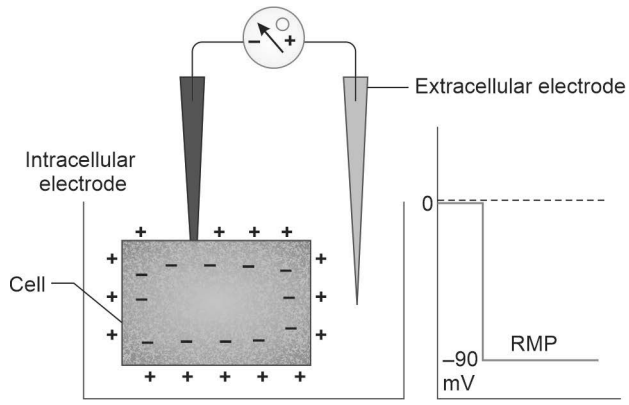

Fig. 1.12: Recording of RMP from a cell

46. What is resting membrane potential (RMP)?

Ans. The potential difference across the membrane at rest is called resting membrane potential. It is also called transmembrane potential. It varies from –10 to –100 mV. Negative inside compared to outside.

47. What factors determine RMP?

Ans.
- It is mainly decided by the K^+ ion efflux.
- *Insignificant Na^+ influx.* This reduces the inside negativity.
- *Na^+–K^+ pump (3:2 ratio).* This increases the inside negativity.

48. Define action potential (AP). Mention different parts of AP and their cause.

Ans. The sequence of changes that appear in the membrane potential following application of a Threshold stimulus.

It consists of:
- Depolarization: It is caused by Na^+ influx
- Repolarization: It is caused by K^+ efflux
- After hyperpolarization: It is due to continuation of K^- efflux.

49. How does an action potential develop?

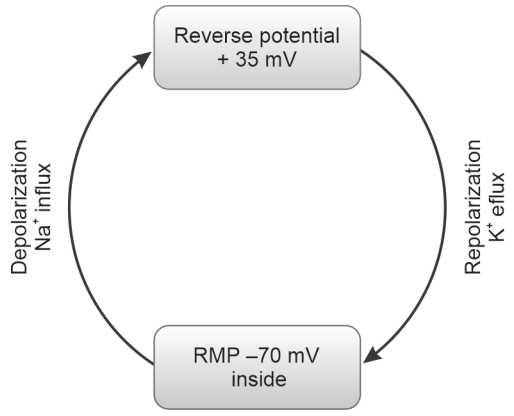

Fig. 1.13: Genesis of action potential

Ans. It may develop by either:
- Na^+ influx (Nerve fiber)
- Blockage of K^+ channel (in islets of Langerhans) or
- Ca^{2+} influx (Smooth muscle).

50. Name the properties of action potential (AP).

Ans. It is a: (i) Self-propagating potential that appears in a tissue on application of threshold stimulus; (ii) Follows all or none law; (iii) Cannot be summated.

Refractory periods:
- **Absolute refractory period (ARP**): It is the period of response to the first stimulus during which AP fails to appear even to the strongest second stimulus. It corresponds to the entire depolarization and 1/3rd repolarization of an AP.
- **Relative refractory period:** It is the period of response to the first stimulus during which a second stronger stimulus can elicit an AP. It corresponds to the later 2/3rds of repolarization.
- **Relation between frequency and stimulus strength:** The frequency of APs is directly. Proportional to the strength of the stimulus above threshold.

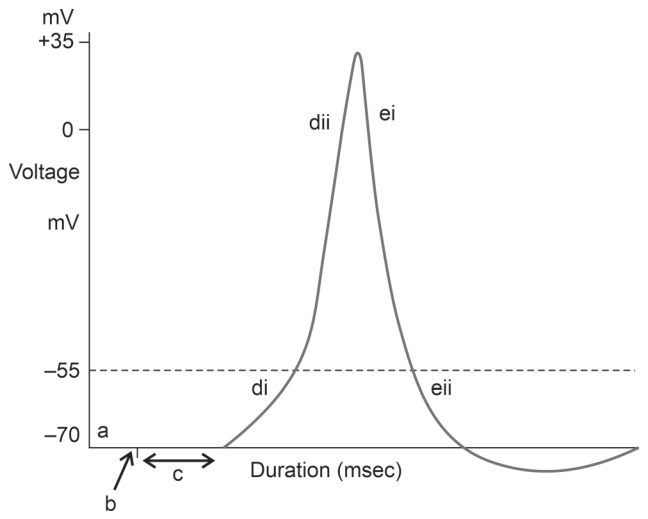

Fig. 1.14: Action Potential: (a) resting level; (b) stimulus artifact; (c) latent period; (di) slow depolarization; (dii) rapid depolarization; (ei) rapid repolarization; (eii) slow repolarization; (eiii) hyperpolarization

RAPID REVIEW POINTS

- Na^+–K^+ pump – Primary active transport ratio – 3:2 (Na:K). It is a **major** contributor to BMR.
- Homeostasis maintained mainly by **negative feedback mechanism.**
- Body water level is **60% of body weight** with **ECF-ICF ratio – 20%:40%**.
- Infant and children go into dehydration rapidly due to **high ECF/ICF ratio**.
- Compatible range of body fluid **pH is 7.7–6.9**.
- Refractory period of **tissue limits its rate of response** to given stimuli.
- RMP ranges from **–10 to –100 mV** and is mainly due to K^+ efflux.
- **0.9% of NaCl (isotonic solution)** commonly used as a substitute for blood in hemorrhage and other conditions.
- Apoptosis is programmed cell death under genetic control. It maintains the number of tissue cells within normal range.