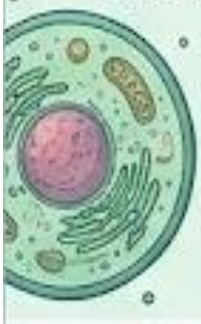
# CSIR-NET / SET

# LIFE SCIENCES

## COMPLETE REVISION NOTES

• Concepts • Important Facts • Mechanisms • Pathways • Quick Revision

### Your complete revision companion for CSIR-UGC NET & SET Life sciences examination



✓ Designed for aspirants preparing for:

- JRF – Junior Research Fellowship
- LS – Lectureship / Assistant Professor Eligibility

A comprehensive, exam-oriented collection of high-yield Life Sciences revision notes, developed to help you revise important concepts quickly, systematically and effectively.

### WHAT THESE REVISION NOTES PROVIDE

✓ **HIGH-YIELD CONCEPTS**
Simple, structured, easy-to-revise format.

✓ **IMPORTANT FACTS**
Key facts, definitions, examples, terminology.

✓ **MECHANISMS & PATHWAYS**
Flowcharts → Stepwise Mechanisms → Pathways → Diagrams → Key Points.

✓ **COMPARATIVE TABLES**
Differences and classifications.

✓ **FORMULAS & NUMERICAL**
Equations, relationships, and concepts.

✓ **SPECIAL FEATURES**
Concise, important concepts highlighted, quick revision points, biological mechanisms, flowcharts, comparison tables, diagrams, formulas, numerical concepts, important terminology.

✓ **EXAM-ORIENTED APPROACH**
LEVEL 1 FOUNDATION (Understand), LEVEL 2 CONCEPTUAL (Connect & Apply), LEVEL 3 ADVANCED (Analyze & Solve).

✓ **REVISION IN 3 LEVELS**
Focus on Part B conceptual and Part C analytical questions.

✓ **SMART REVISION STRATEGY**
READ → UNDERSTAND → REVISE → PRACTICE → ANALYZE → REVISE AGAIN

✓ **YOUR ACADEMIC GOAL**
JRF - Junior Research Fellowship, LS - Lectureship / Assistant Professor Eligibility

✓ **FUTURE OPPORTUNITIES**
Research, Teaching, Ph.D., Higher Education, Life Sciences, Biotechnology

✓ **THE COMPLETE LIFE SCIENCES REVISION RESOURCE**
14 MAJOR AREAS, HIGH-YIELD CONCEPTS, IMPORTANT FACTS, MECHANISMS & PATHWAYS, DIAGRAMS & FLOWCHARTS, COMPARATIVE TABLES, QUICK REVISION POINTS

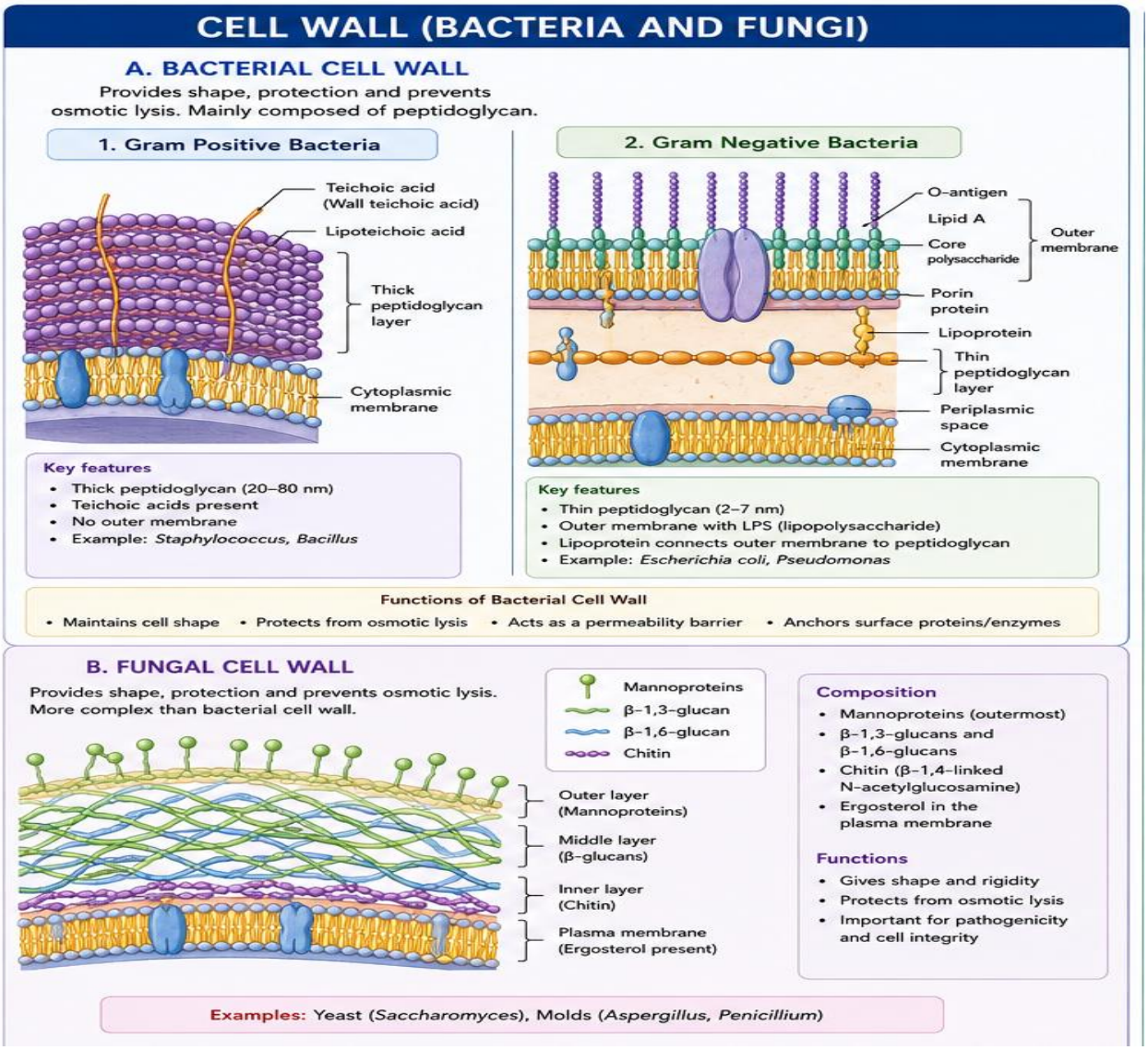
**FROM CONCEPT TO QUALIFICATION:**
CONCEPTS → REVISION → MCQs → PYQs → MOCK TESTS → ANALYSIS → QUALIFICATION

# CSIR-NET/SET Life Sciences
# Revision Notes
## (These notes are written in a CSIR-NET Life Sciences revision format with conceptual explanations, important facts, memory tricks, examples, and previous-year exam concepts)
## 2. CELLULAR ORGANIZATION

**A. Cell wall and cell membrane: structure and function :** Cell wall, physical structure of model membranes in prokaryotes and eukaryotes, lipid bilayer, membrane proteins, diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. A. CELL WALL

### Introduction

The **cell wall** is a rigid, non-living layer present outside the plasma membrane in plants, fungi, algae, and bacteria. Animal cells do not possess a cell wall. Its primary role is to provide structural support, protection, and maintain cell shape.



**Functions of Cell Wall**

**1. Mechanical Support**

- Gives rigidity and definite shape.
- Prevents deformation of cells.

**2. Protection**

- Protects against mechanical injury.
- Acts as a barrier against pathogens.

**3. Prevents Osmotic Lysis**

- Prevents bursting when water enters the cell in hypotonic conditions.

**4. Cell-to-Cell Communication**

- In plants, plasmodesmata connect neighboring cells.
- Allows movement of water, ions, hormones, and signaling molecules.

**5. Determines Cell Morphology**

- Responsible for characteristic shapes of bacteria (coccus, bacillus, spirillum).

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**Composition of Cell Wall**

| Organism | Main Components |
|---|---|
| **Plants** | Cellulose, hemicellulose, pectin |
| **Fungi** | Chitin, glucans |
| **Gram-positive bacteria** | Thick peptidoglycan + teichoic acid |
| **Gram-negative bacteria** | Thin peptidoglycan + outer membrane containing LPS |
| **Animals** | No cell wall |

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**Peptidoglycan- Also called murein.**

**Structure**

- Polymer of N-acetylglucosamine (NAG)
- N-acetylmuramic acid (NAM)
- Cross-linked by peptide bridges

**Function:**

- Provides rigidity
- Prevents osmotic bursting

**Gram-Positive vs Gram-Negative Bacteria**

| Feature | Gram Positive | Gram Negative |
|---|---|---|
| **Peptidoglycan** | Thick | Thin |
| **Outer membrane** | Absent | Present |
| **LPS** | Absent | Present |
| **Teichoic acid** | Present | Absent |
| **Gram stain** | Purple | Pink |

**Important Facts**

- Teichoic acid is present only in Gram-positive bacteria.
- Lipopolysaccharide (LPS) is present only in Gram-negative bacteria and acts as an endotoxin.

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**Memory Trick**

- **Positive = Thick + Teichoic**
- **Negative = LPS + Outer Membrane**

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**B. CELL MEMBRANE:** The plasma membrane is a thin, flexible, selectively permeable membrane surrounding every living cell.

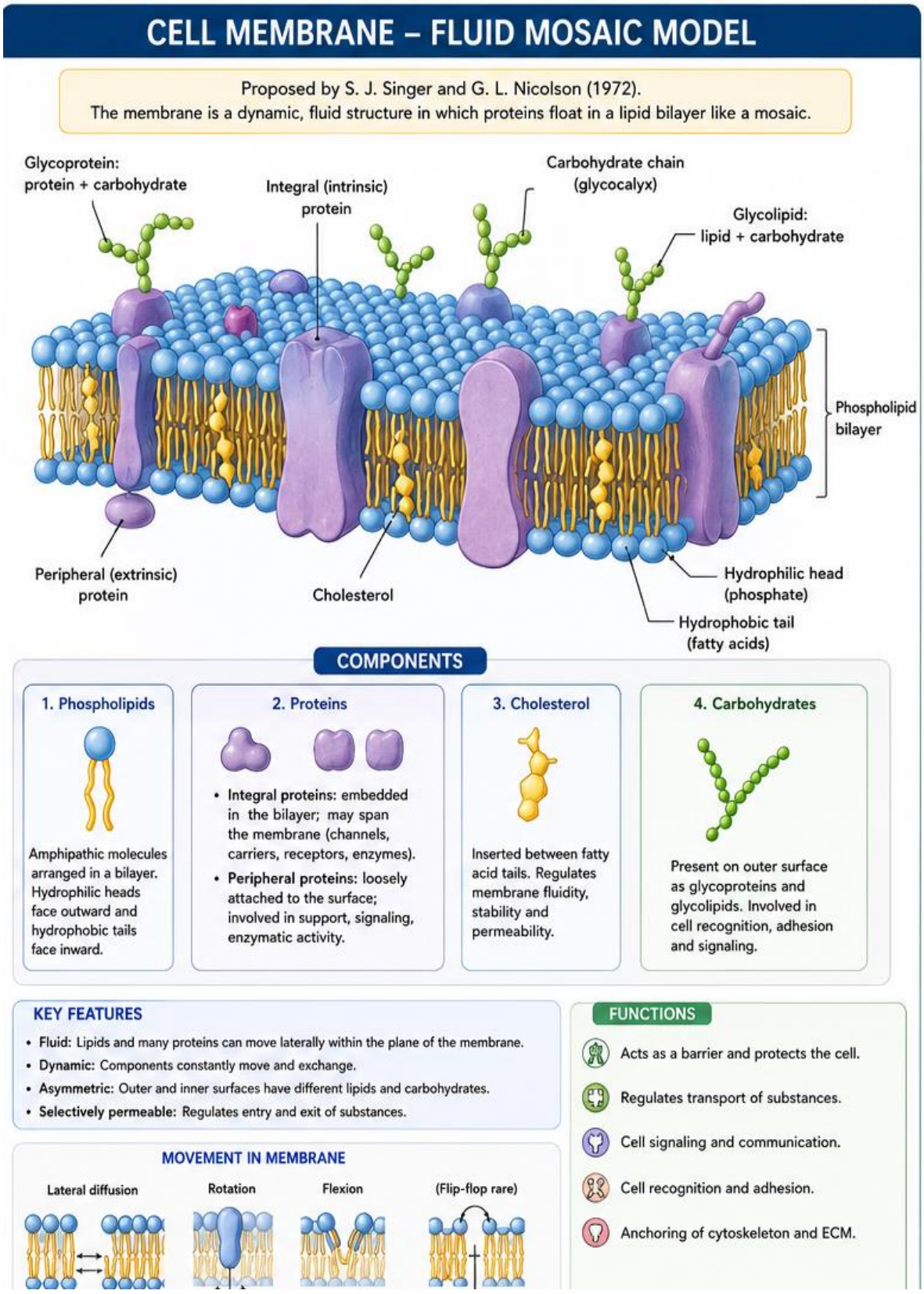
Major functions:

- Separates intracellular and extracellular environments.
- Controls movement of substances.
- Cell communication.
- Signal transduction.
- Cell recognition.

**Fluid Mosaic Model :** Proposed by **Singer and Nicolson (1972).**

**Important Points**

- Membrane is dynamic.
- Lipids move laterally.
- Proteins float within lipid bilayer.
- Membrane is fluid rather than rigid.




**Components of Plasma Membrane**

**1. Phospholipids**

- Form the lipid bilayer.

- Amphipathic molecules:
    - Hydrophilic phosphate head
    - Hydrophobic fatty acid tails

**2. Proteins**

Two types:

- Integral proteins
- Peripheral proteins

**3. Cholesterol:** Present mainly in animal cells.

Functions:

- Regulates membrane fluidity.
- Increases membrane stability.
- Prevents membrane crystallization.

**4. Carbohydrates**

Present as:

- Glycoproteins
- Glycolipids

Functions:

- Cell recognition
- Immune response
- Cell adhesion

**Lipid Bilayer**

**Arrangement**

- Hydrophilic heads → face water
- Hydrophobic tails → face inward
- This arrangement forms spontaneously in aqueous environments.

**Factors Affecting Membrane Fluidity**

**1. Temperature**

- High temperature → Fluidity increases.
- Low temperature → Fluidity decreases.

**2. Unsaturated Fatty Acids**

- More double bonds → Higher fluidity.

**3. Cholesterol**

- High temperature → Stabilizes membrane.
- Low temperature → Prevents membrane from becoming too rigid.

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**Integral vs Peripheral Proteins**

| Integral Proteins | Peripheral Proteins |
|---|---|

| | |
|---|---|
| **Embedded in bilayer** | Attached to surface |
| **Difficult to remove** | Easily removed |
| **Transporters** | Enzymes |
| **Receptors** | Structural support |

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**Important Facts**

- Fluid Mosaic Model → Singer & Nicolson (1972)
- Gram-positive bacteria contain **teichoic acids**.
- Gram-negative bacteria contain **LPS (endotoxin)**.
- Lipid bilayer forms spontaneously due to amphipathic phospholipids.
- Cholesterol regulates membrane fluidity.
- Integral proteins span the membrane, while peripheral proteins remain attached to its surface.

**1. Diffusion**: Diffusion is the **passive movement of molecules from a region of higher concentration to a region of lower concentration** until equilibrium is reached.

**Characteristics**

- Passive process (no ATP required)
- Occurs along the concentration gradient
- Continues until equilibrium

**Types of Diffusion**

**A. Simple Diffusion:** Molecules directly cross the phospholipid bilayer.

**Characteristics**

- No ATP required
- No carrier protein
- Moves down the concentration gradient

**Examples**

- Oxygen (O2)
- Carbon dioxide (Co2)
- Nitric oxide (NO)
- Steroid hormones

**B. Facilitated Diffusion:** Movement occurs through membrane proteins.

**Characteristics**

- No ATP required

- Carrier or channel protein required
- Highly specific
- Saturable process

**Examples**

- Glucose (GLUT transporters)
- Amino acids
- Ions through channels

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**Simple vs Facilitated Diffusion**

| Feature | Simple | Facilitated |
|---|---|---|
| **ATP** | No | No |
| **Protein required** | No | Yes |
| **Specificity** | Low | High |
| **Saturation** | No | Yes |
| **Example** | $O_2$ | Glucose |

**Tip:** Both are passive transport mechanisms, but only facilitated diffusion requires membrane proteins.

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**2. Osmosis:** Osmosis is the **movement of water across a selectively permeable membrane from lower solute concentration (higher water potential) to higher solute concentration (lower water potential).**

**Types of Solutions**

**Hypotonic Solution**

- Lower solute concentration outside
- Water enters the cell
- Animal cells may lyse
- Plant cells become turgid

**Isotonic Solution**

- Equal solute concentration
- No net movement of water
- Cell size remains unchanged

**Hypertonic Solution**

- Higher solute concentration outside
- Water leaves the cell

- Animal cells undergo **crenation**
- Plant cells show **plasmolysis**

**Important Terms**

- Turgidity- Water enters plant cells causing expansion.
- Plasmolysis- Shrinkage of cytoplasm away from the cell wall due to water loss.
- Crenation- Shrinkage of animal cells in hypertonic solution.

**3. Ion Channels:** Ion channels are transmembrane proteins that allow rapid movement of ions across membranes.

**Characteristics**

- Highly selective
- Very fast transport
- Passive (along electrochemical gradient)

**Types**

1. **Voltage-Gated Channels:** Open in response to changes in membrane potential.

Examples:

- Sodium channels
- Potassium channels

2. **Ligand-Gated Channels:** Open after ligand binding.

Example: Acetylcholine receptor

3. **Mechanically Gated Channels:** Open due to pressure or stretch.

Example: Touch receptors

**Biological Importance**

- Nerve impulse conduction
- Muscle contraction
- Hormone secretion
- Signal transduction

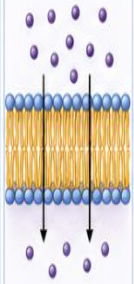
# 1. DIFFUSION

Diffusion is the net movement of molecules or ions from a region of higher concentration to a region of lower concentration until equilibrium is reached.

## TYPES OF DIFFUSION

### A. Simple Diffusion

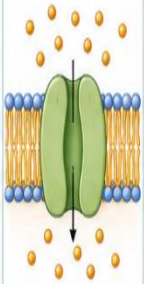
Movement of small nonpolar molecules directly through the lipid bilayer.



Example: $O_2$, $CO_2$, $N_2$

### B. Facilitated Diffusion

Movement of polar molecules or ions through membrane proteins down their concentration gradient.



Example: Glucose, amino acids, $Na^+$, $Cl^-$

### C. Gradient

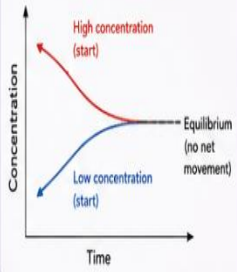
Movement continues until the concentration is equal on both sides (dynamic equilibrium).

No net movement

## FACTORS AFFECTING DIFFUSION RATE

- Concentration gradient
- Temperature
- Molecular size
- Membrane permeability
- Surface area & thickness

## DIFFUSION OVER TIME



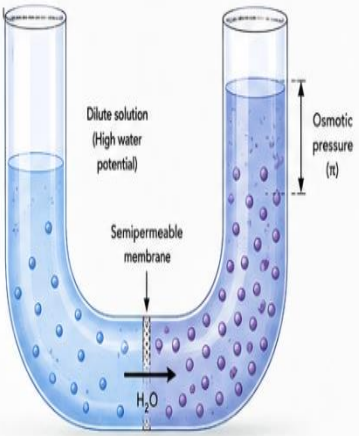

## EXAMPLES IN BIOLOGY

- Exchange of gases in lungs ($O_2$ in, $CO_2$ out)
- Absorption of lipid-soluble vitamins
- Diffusion of neurotransmitters across synapse

# 2. OSMOSIS

Osmosis is the movement of water (solvent) molecules through a selectively permeable membrane from a region of higher water potential (lower solute concentration) to a region of lower water potential (higher solute concentration) until equilibrium is reached.

## OSMOSIS IN A SEMIPERMEABLE MEMBRANE




## EFFECTS OF OSMOSIS ON CELLS

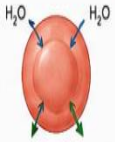
### A. Hypotonic solution

(Lower solute outside cell)


Cell swells (may burst in animal cells)

### B. Isotonic solution

(Equal solute inside and out)




No net movement Normal cell

### C. Hypertonic solution

(Higher solute outside cell)


Cell shrinks

## IMPORTANCE OF OSMOSIS

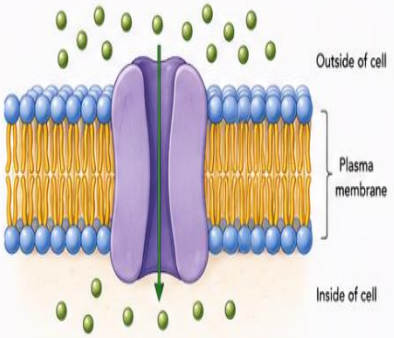
- Absorption of water by plant roots
- Maintenance of cell turgor in plants
- Water reabsorption in kidneys
- Cell volume regulation in animals and microbes

**WATER POTENTIAL ($\Psi_w$) = SOLUTE POTENTIAL ($\Psi_s$) + PRESSURE POTENTIAL ($\Psi_p$)**

Water moves from higher $\Psi_w$ to lower $\Psi_w$

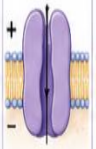
# 3. ION CHANNELS

Ion channels are integral membrane proteins that form hydrophilic pores, allowing specific ions to pass through the membrane down their electrochemical gradient.




## TYPES OF ION CHANNELS

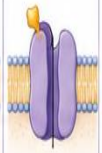
### A. Voltage-gated channels




Open or close in response to changes in membrane potential.

Example: $Na^+$ channels in nerve cells

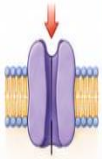
### B. Ligand-gated channels



Open or close in response to binding of a specific ligand.

Example: ACh receptor channels

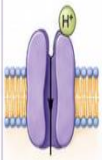
### C. Mechanically-gated channels



Open or close in response to mechanical stimuli (stretch, pressure).

Example: Channels in inner ear hair cells

### D. Chemically-gated channels




Open or close in response to changes in pH or chemicals.

Example: pH-gated $K^+$ channels

## SELECTIVITY OF ION CHANNELS

Each channel is highly selective for specific ions due to its size, shape and charge.

Examples: $Na^+$, $K^+$, $Ca^{2+}$, $Cl^-$, $H^+$ channels

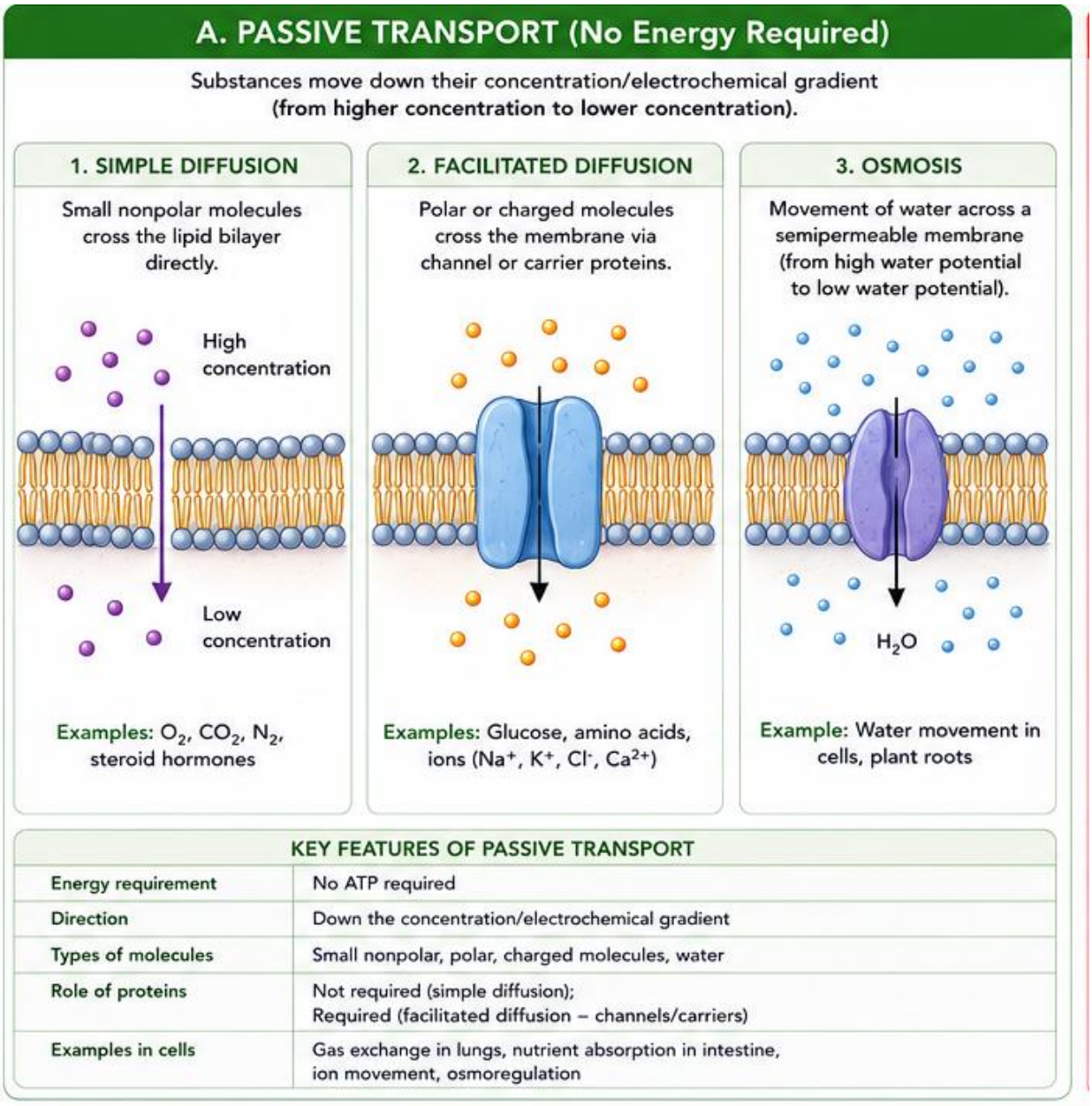

## FUNCTIONS OF ION CHANNELS

- Generation and conduction of nerve impulses
- Muscle contraction
- Secretion of hormones and neurotransmitters
- Regulation of cell volume and osmoregulation
- Maintenance of resting membrane potential

## KEY POINT

Diffusion, osmosis and ion channels are essential for the transport of substances across cell membranes and are fundamental to many physiological processes.

**4. Active Transport:** Active transport is the movement of molecules **against the concentration gradient** using energy.




**Characteristics**

- ATP required (primary transport)
- Carrier protein required
- Specific process
- Storable

**Types**

**1.Primary Active Transport:** Uses ATP directly.

Examples:

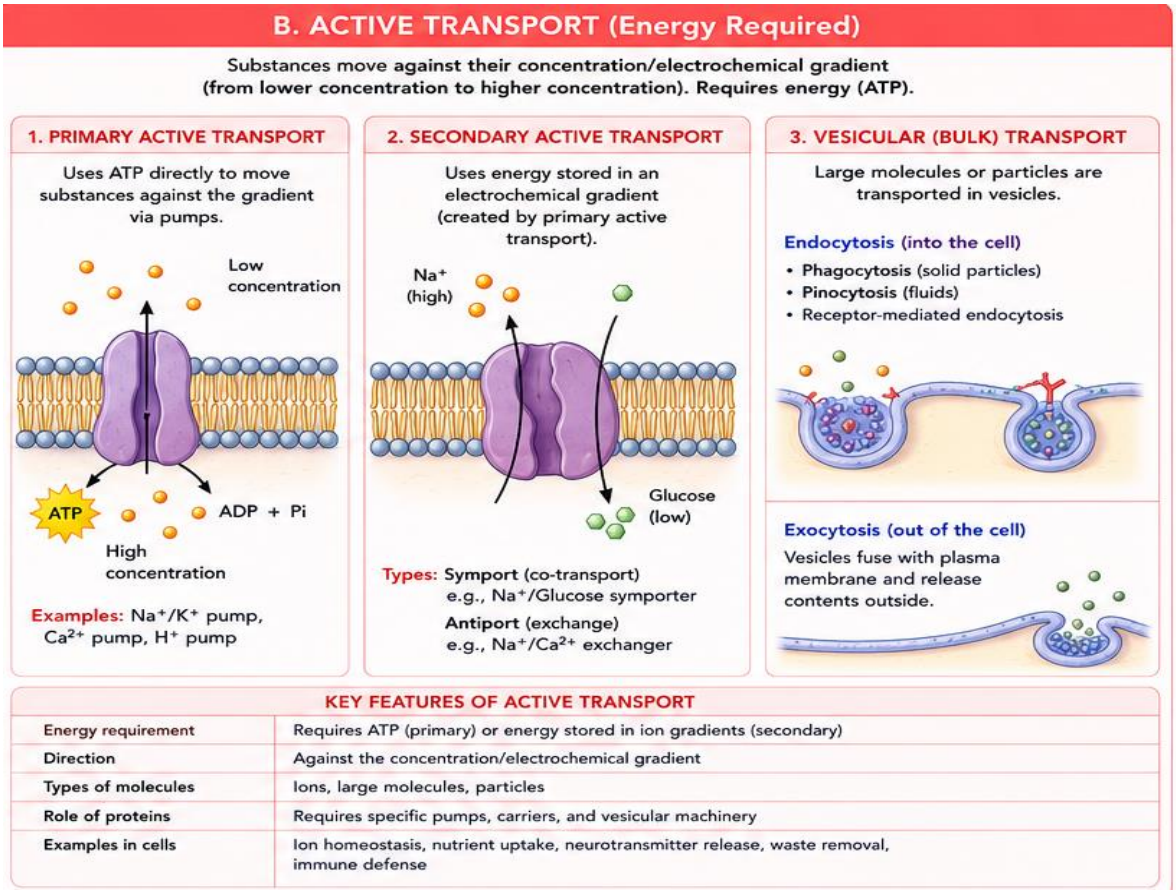
- $Na^+/K^+$ ATPase
- $Ca^{2+}$ ATPase
- $H^+$ ATPase

**2. Secondary Active Transport:** Uses energy stored in ion gradients generated by primary active transport.

- ***Symport-Both molecules move in the same direction.***

  Example:$Na^+$–Glucose symporter
- ***Antiport- Molecules move in opposite directions.***

  Example:$Na^+$–$H^+$ exchanger




| KEY FEATURES OF ACTIVE TRANSPORT | |
|---|---|
| Energy requirement | Requires ATP (primary) or energy stored in ion gradients (secondary) |
| Direction | Against the concentration/electrochemical gradient |
| Types of molecules | Ions, large molecules, particles |
| Role of proteins | Requires specific pumps, carriers, and vesicular machinery |
| Examples in cells | Ion homeostasis, nutrient uptake, neurotransmitter release, waste removal, immune defense |

**5. $Na^+/K^+$ ATPase**

**Mechanism:** For every **1 ATP hydrolyzed**:

- **3 $Na^+$ ions are pumped out**
- **2 $K^+$ ions are pumped into the cell**

**Functions**

- Maintains resting membrane potential
- Regulates cell volume
- Supports nerve impulse transmission
- Maintains intracellular ionic balance

**Mnemonic:"3 Out, 2 In, 1 ATP Wins."**

**6. Membrane Pumps**

**1.Calcium Pump ($Ca^{2+}$ ATPase)**

- Removes $Ca^{2+}$ from cytoplasm
- Important in muscle relaxation

**2. Proton Pump ($H^+$ ATPase)**

- Creates proton gradient
- Essential in ATP synthesis and gastric acid secretion

**Comparison Table**

| Transport | ATP | Protein | Gradient |
|---|---|---|---|
| **Simple diffusion** | No | No | High → Low |
| **Facilitated diffusion** | No | Yes | High → Low |
| **Active transport** | Yes (primary) | Yes | Low → High |

**One-Liners Revision**

- Simple diffusion requires **no ATP and no transport protein**.
- Facilitated diffusion requires **transport proteins but no ATP**.
- Active transport moves substances **against the concentration gradient**.
- $Na^+/K^+$ ATPase exports **3 $Na^+$** and imports **2 $K^+$** per ATP.
- Ion channels are highly selective and allow rapid ion movement.