INTRODUCTION TO CELL PHYSIOLOGY

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Physiology - 2nd stage

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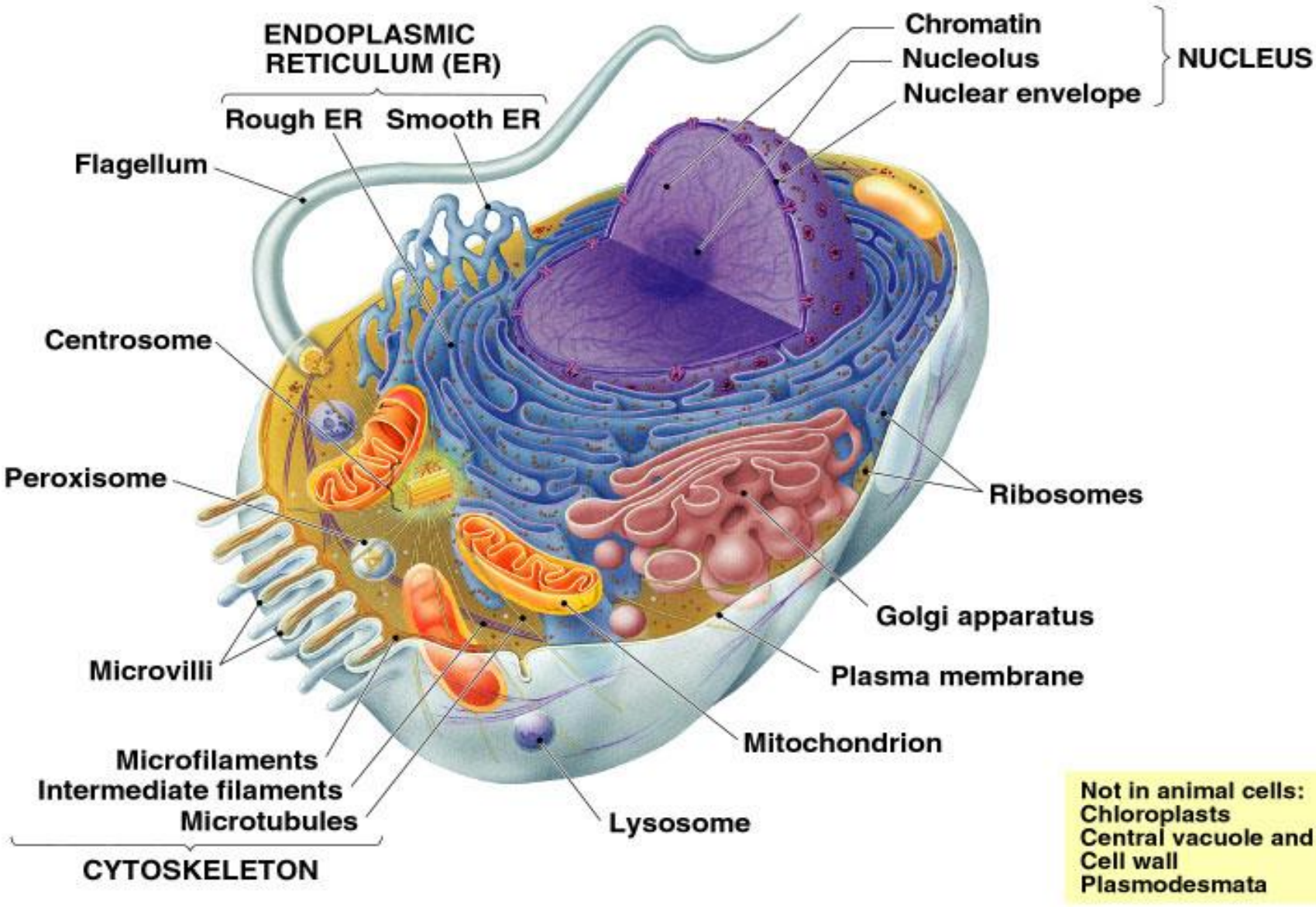
INTRODUCTION TO CELL PHYSIOLOGY

The cell composition
Nucleus
Contains most of the cell's genetic material
Composed of:
Nuclear envelope
Chromatin
Nucleolus

Nuclear envelope

- Double membrane system enclosing genetic material

Outer and inner with space of 20-40 nm
Each membrane is lipid bilayer with associated proteins
Perforated by ***pores (~ 100 nm diameter)***
Each ***pore is lined by pore complex (protein structure)***
Function: allows some large macromolecules andparticles to pass through



Cell structure

Nuclear envelope

- Double membrane system enclosing genetic material

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Ribosomes

- Non-membranous organelle
- Made of two subunits *Free ribosomes*

Free ribosomes:

Found suspended in cytosol

Make proteins that function within cytosol

- *Bound ribosomes*

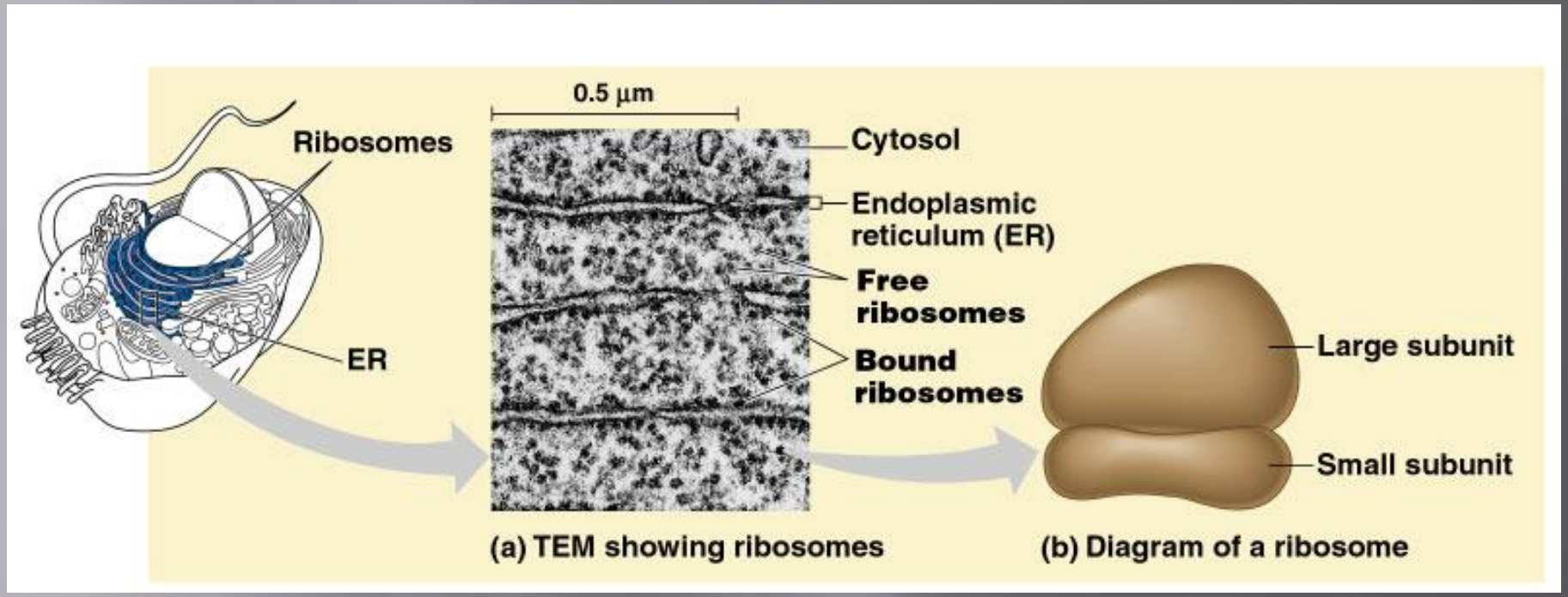
Found attached to outside of ER or nuclear envelope

Make proteins used in:

Membranes synthesis

Packaging within certain organelles (e.g. lysosomes)

For export from cell (secretion)



Endomembrane system

- Members:

Nuclear envelope
Endoplasmic reticulum (ER)
Golgi apparatus
Lysosomes
Vacuoles
Plasma membrane

Endoplasmic reticulum (ER)

- Network of connected or continuous membranous tubes and sacs (*cisternae)*
- Membranes made of phospholipids and proteins
- **½ the membranes in the cell**
- ER membranes or cisternae are directly connected with the nuclear envelope

Endoplasmic reticulum (ER)

Cisternal space: internal compartment/ room
separated by ER membrane from the cytosol
Cisternal space is continuous with space between
the two membranes of the nuclear envelope
Directly connected

Functions of *Smooth ER*

- Involved in diverse metabolic processes (rich in enzymes)

. Synthesis of lipids (oils, phospholipids, steroids)
Secretion of steroids
Secretion of sex hormones
. Metabolism of carbohydrates
Catalyze removal of OPO3
- group

Rough ER

- Abundant in those cells that secrete proteins
- Function:

1. Manufacture of secretory proteins

Example: ***glycoproteins***

Glycoproteins: polypeptides attached to small polymer of sugar units (*oligosaccharide)*

Glycoproteins can be transported the cell in:within *transport vesicles formed by specialized region of ER* (***transitional ER)***

2. Synthesis of membranes

Membrane bound proteins are synthesized directly into the membrane

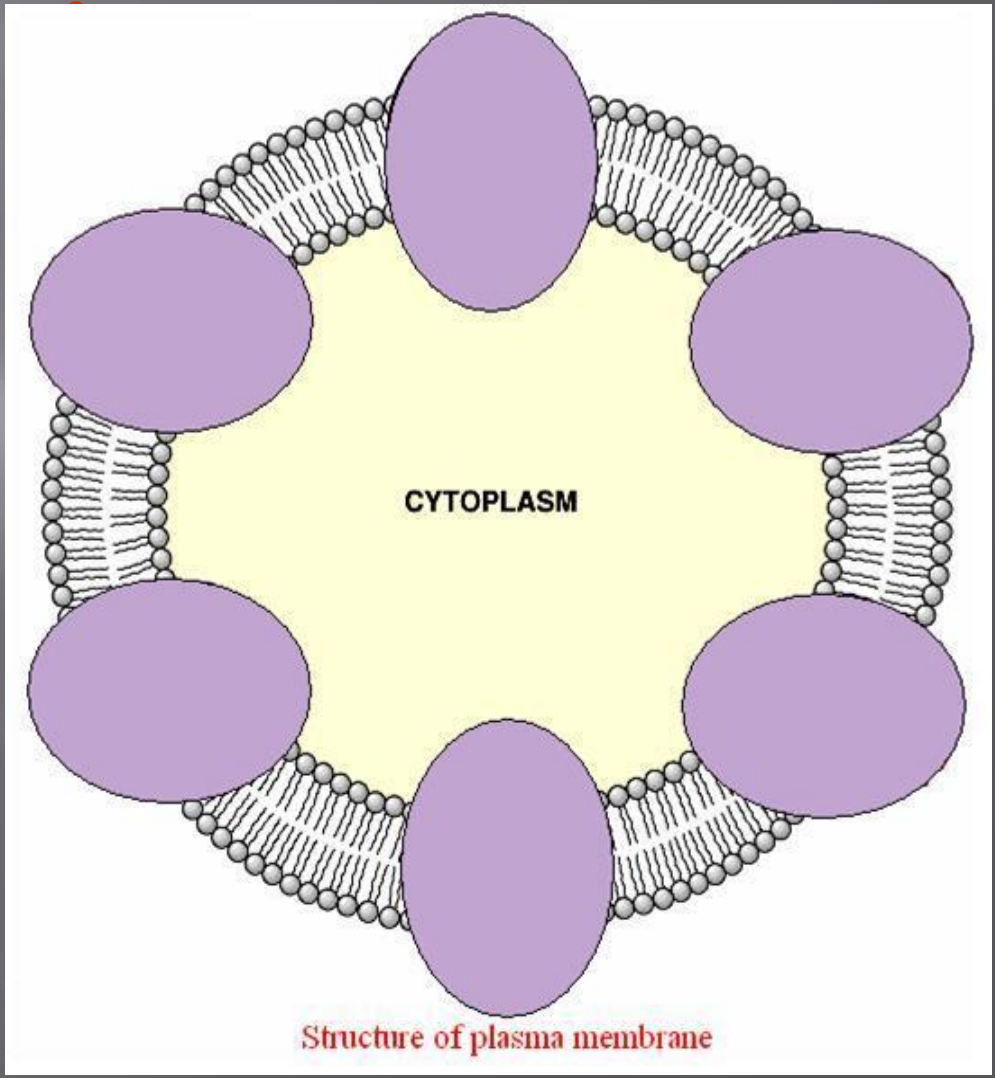
Enzymes in the rough ER also synthesize phospholipids from precursors in the cytosol

Parts of rough ER can be transferred as transport vesicles to other components of the endomembranous system

Biological membranes:

phospholipid bilayer surrounding cells and organelles

➢ ***Selectively permeable*** or ***semi-permeable***



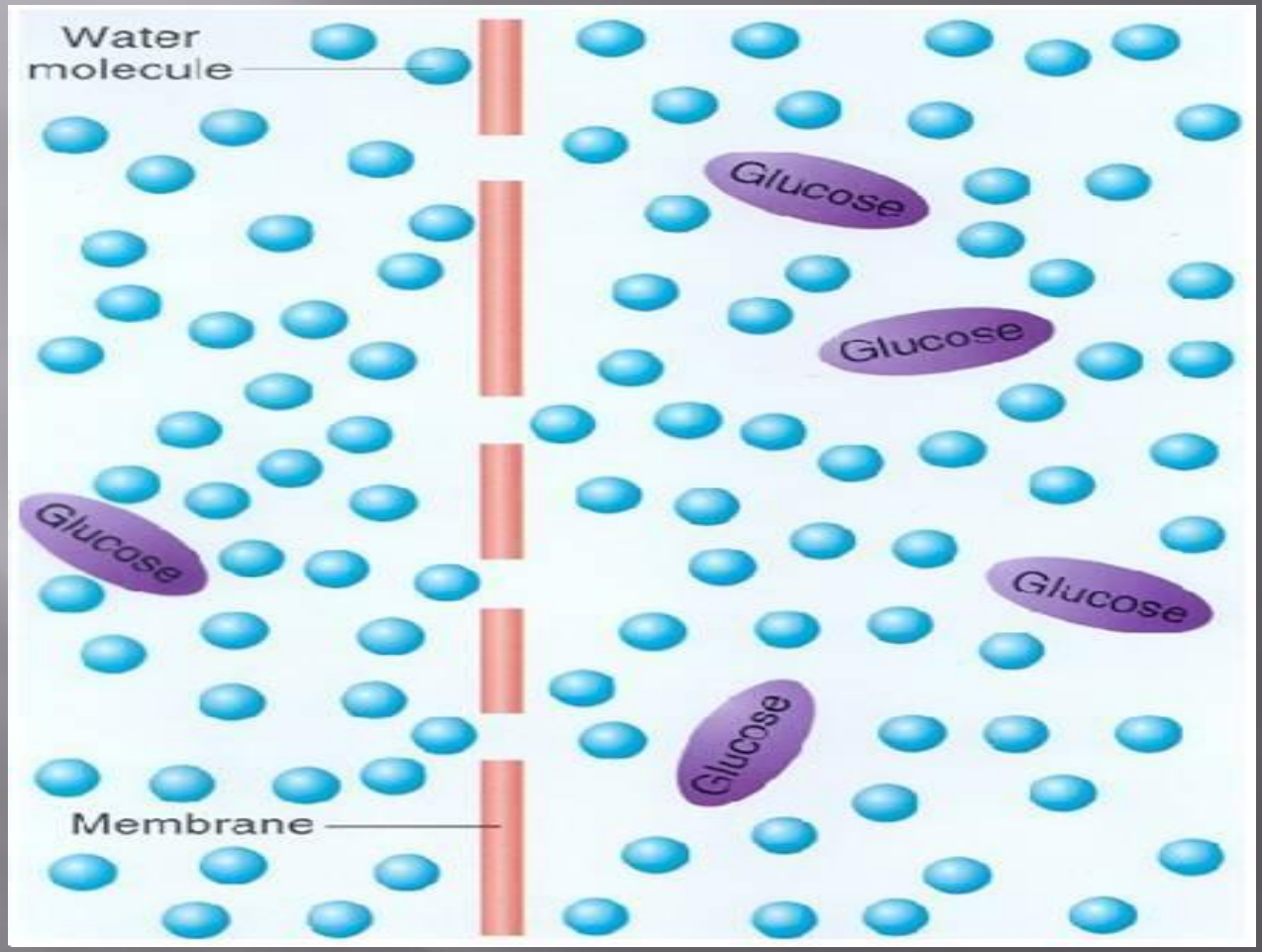
Structure of plasma membrane

OUTCOMES

- Know the semipermeable property of biological membranes
- Osmosis concept
- Understand the effect of size on the movement of some ions and molecules

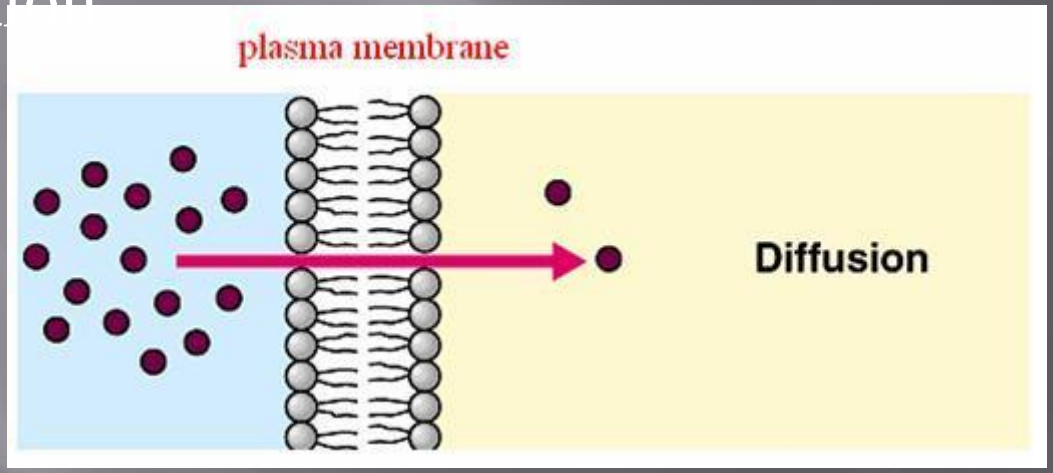
Understanding isotonic, hypotonic and hypertonic solutions concept .

Semi-permeable membranes



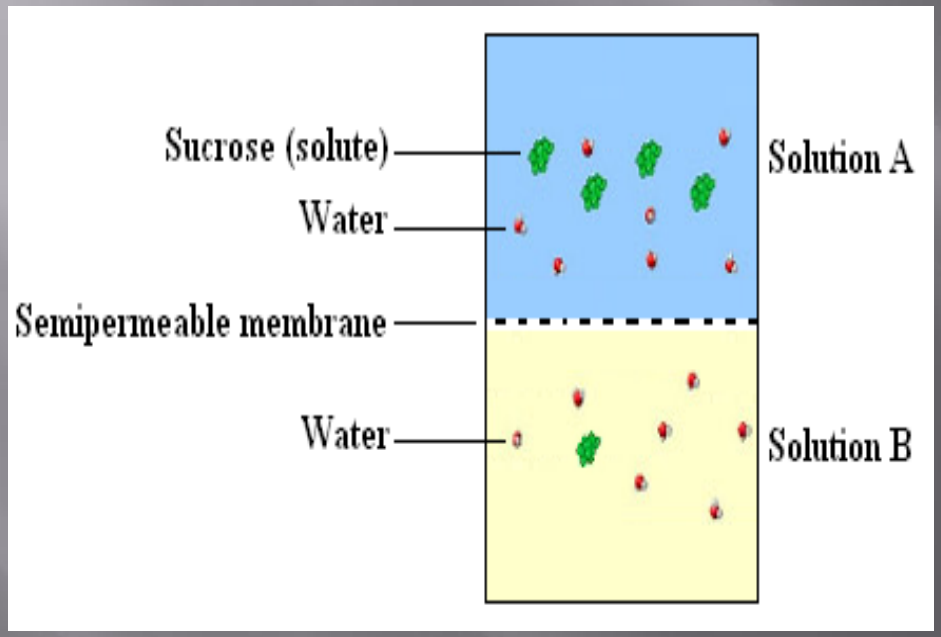
Movement of molecules

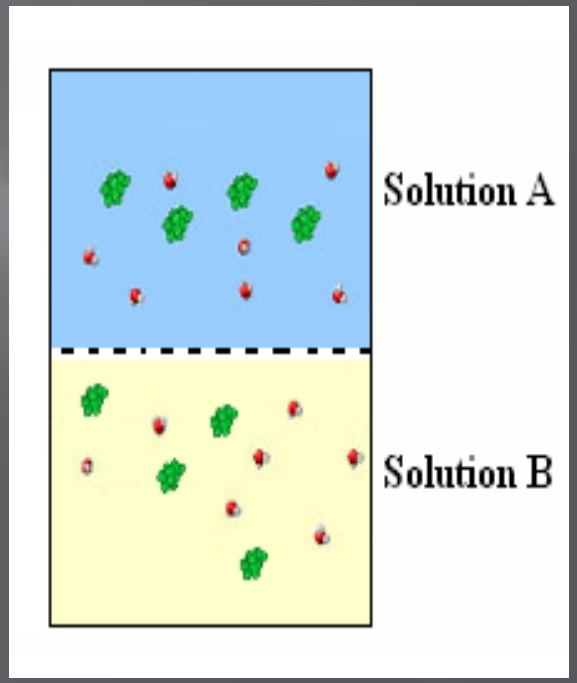
Diffusion: passive, directional movement of molecules from area of higher concentration to area of lower concentration



Osmosis: diffusion of water

- ***Osmosis***: diffusion of water across a semi-permeable membrane in living organisms





The importance of water

-60% of the body is water.

-67% of this fluid is in the cell:intracellular fluid(ICF).

-33% is extracellular (ECF).

-ICF is high in K^+, Organic anions

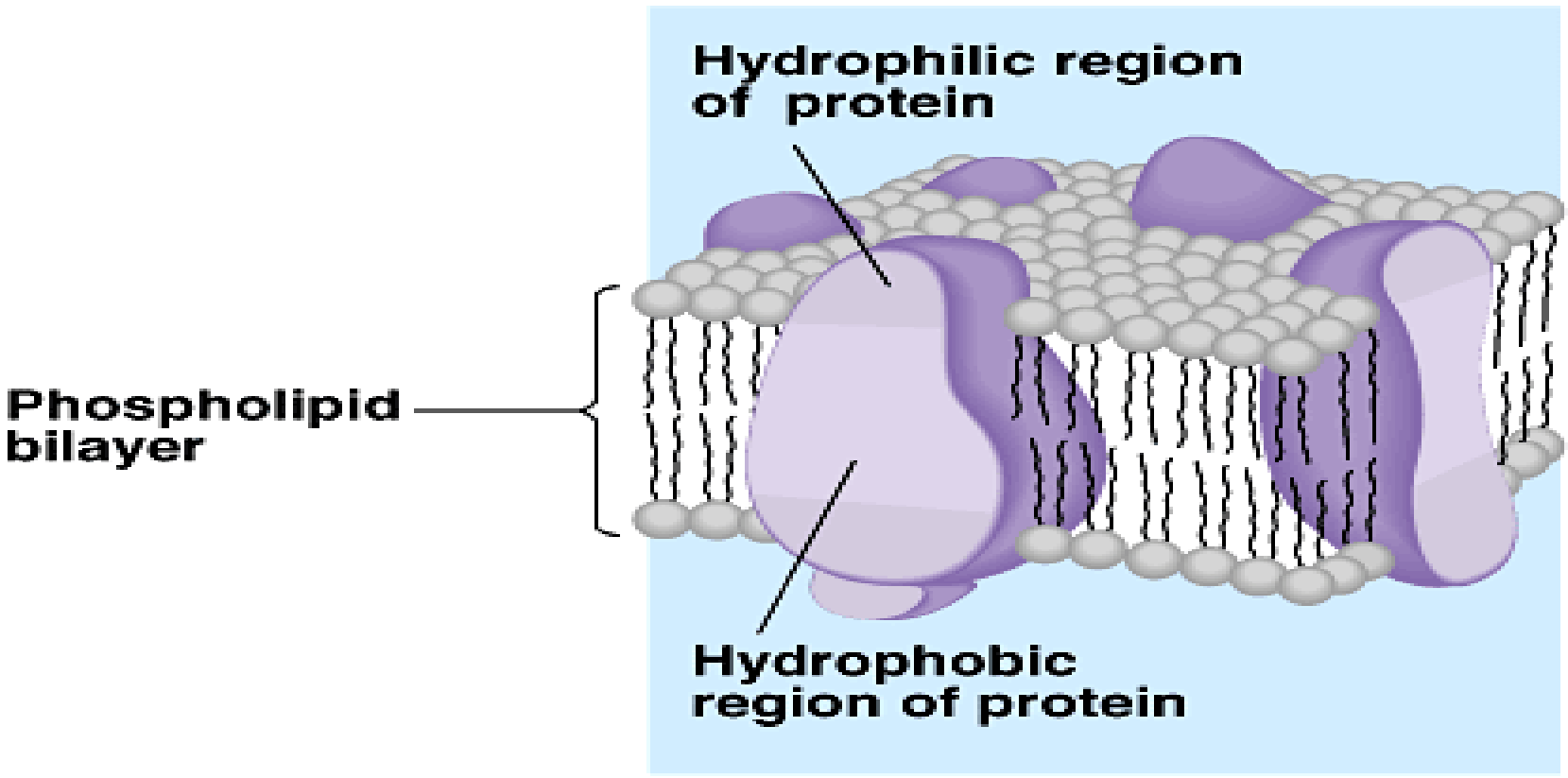
-ECF is high in Na^+ and Cl^-

osmosis

- Human cells or other body fluids contain many dissolvedsubstances (called **solutes) such as salts,**sugars, acids, and bases.
- The concentration of solutes in a fluid creates the **osmotic pressure of** the solution, which in turn determines the movementof water through membranes .

Cell Membrane

- A-Lipid bilayer
- 1-phosphlipids Have glycerol backbone ,which is hydrophilic (water soluble) head and 2 fatty acids tails which are hydrophobic (water-insoluble) .
- The hydrophobic tails face other and form a bilayer.
- Lipid –soluble substances:cross cell membrane because they dissolve in the hydrophobic lipid bilayer (O2,CO2,steroid hormones)
- Water –soluble substances:cannot dissolve in the lipid of the membrane ,but may cross through water filled channels or pores or transported by carriers .



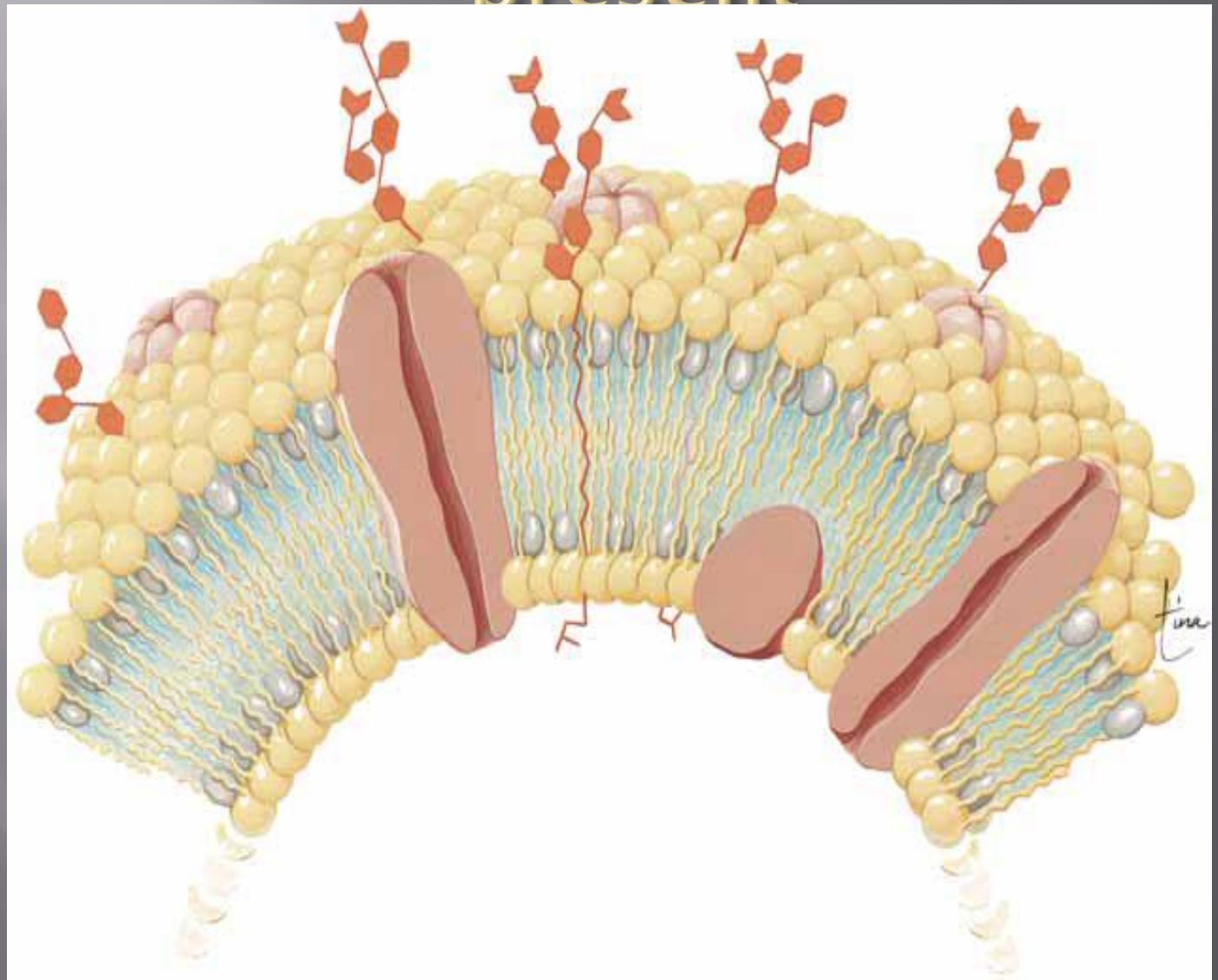
(b) Current fluid mosaic model

B-Proteins:

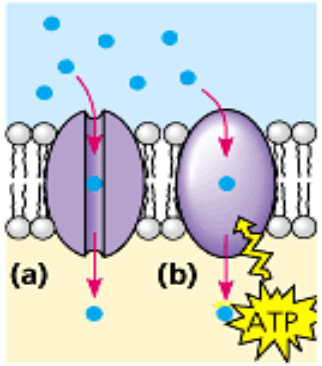
- 1-Integral proteins: are anchored to or imbedded in the cell membrane through the hydrophobic interaction.

- 2-Peripheral proteins :are not imbedded in the cell membrane and loosely attached to it by electrostatic interaction.

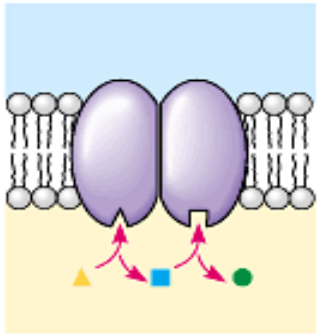
The cell (plasma) membrane depicting the types of molecules present



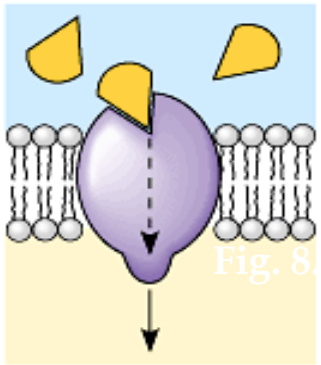
- **The proteins in the plasma membrane may provide a variety of major cell functions.**



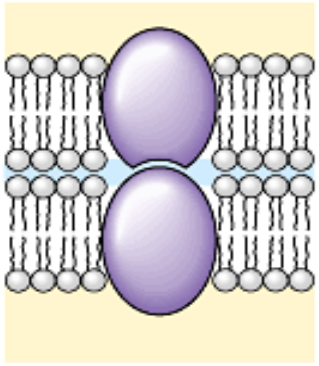
Transport



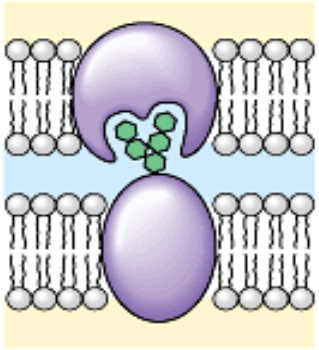
Enzymatic activity



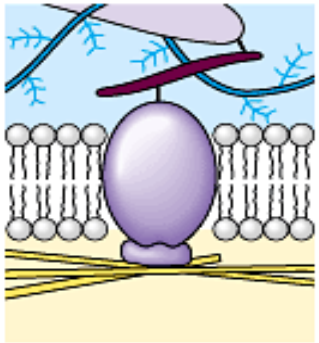
Signal transduction



Intercellular joining



Cell-cell recognition



Attachment to the cytoskeleton and extracellular matrix (ECM)

Transport Across Cell Membranes

Living cells constantly interact with the blood or tissue fluid around them, taking in some substances and secreting or excreting others.

Cellular Transport Mechanisms—the processes by which cells take in or secrete or excrete materials through the selectively permeable cell membrane

There are several mechanisms:

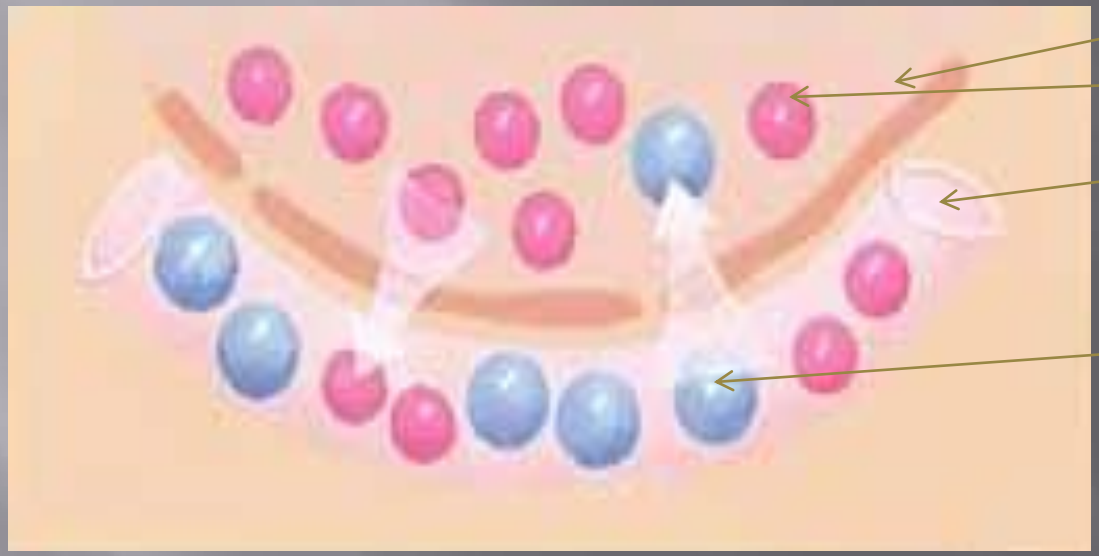
of transport that enable cells to move materials into or out of the cell: diffusion, osmosis, facilitated diffusion, active transport, filtration, phagocytosis and pinocytosis.

Some of these take place without the expenditure of energy by the cells. But others *do* require energy, often in the form of ATP

Diffusion

- **Diffusion** is the movement of molecules from an area of greater concentration to an area of lesser concentration
- (that is, with or along a **concentration gradient**).
- Diffusion occurs because molecules have free
- energy; that is, they are always in motion. Within the body, the gases oxygen and carbon
- dioxide move by diffusion.

Diffusion



Facilitated diffusion

- molecules move through a membrane
- from an area of greater concentration to an area of
- lesser concentration, but they need some help to do this.
- Ex: Diffusion of glucose
- into most cells requires a glucose **transporter**, which
- may also be called a **carrier enzyme**.

- Tissue fluid

- These transporters are proteins that are part of the cell membrane .
- Glucose bonds to the transporter
- and by doing so changes the shape of the protein.
- This physical change propels the glucose into the interior of the cell. Other transporters are specific for other organic molecules such as amino acids.

ACTIVE TRANSPORT

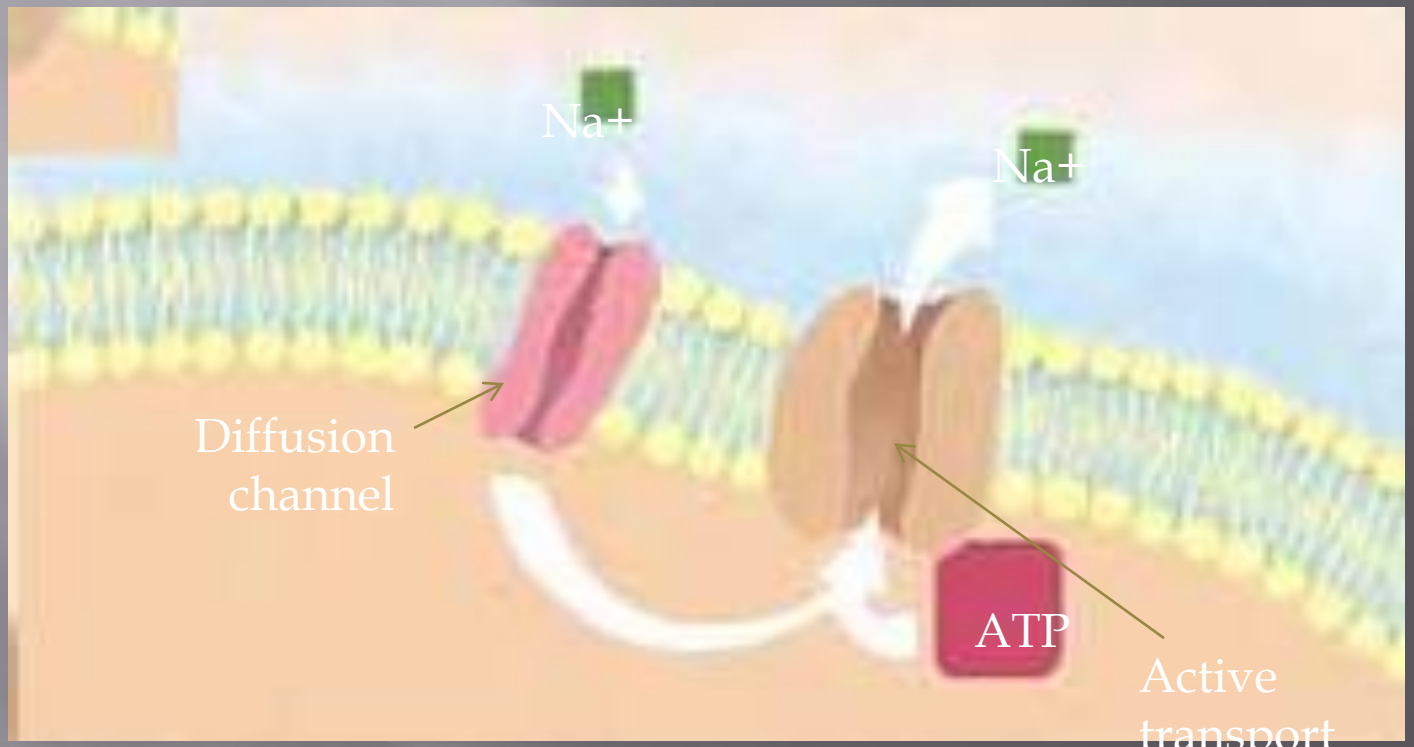
Active transport *requires the energy of ATP to move molecules from an area of lesser concentration to an area of greater concentration.(against a concentration gradient.)*

In the body, nerve cells and muscle cells have "sodium pumps" to move sodium ions (Na+) out of the cells.

Sodium ions are more abundant outside the cells, and they constantly diffuse into the cell (through specific diffusion channels), their area of lesser concentration).

Without the sodium pumps to return them outside : the ***incoming sodium ions would bring about an unwanted nerve impulse or muscle contraction.***

ACTIVE TRANSPORT



Nerve and muscle cells constantly produce ATP to keep their sodium pumps (and similar potassium pumps) working and prevent spontaneous impulses.

Another example of active transport is the absorption of glucose and amino acids by the cells lining the small intestine. The cells use ATP to absorb these nutrients from digested food, even when their intracellular concentration becomes greater than their extracellular concentration.

Primary active transport :

- Occurs against an electrochemical gradient(uphill).
- Require ATP
- Carrier mediated (stereospecifity ,saturation
- and competition) .Ex:Na+ -K+ PUMP

Secondary active transport :

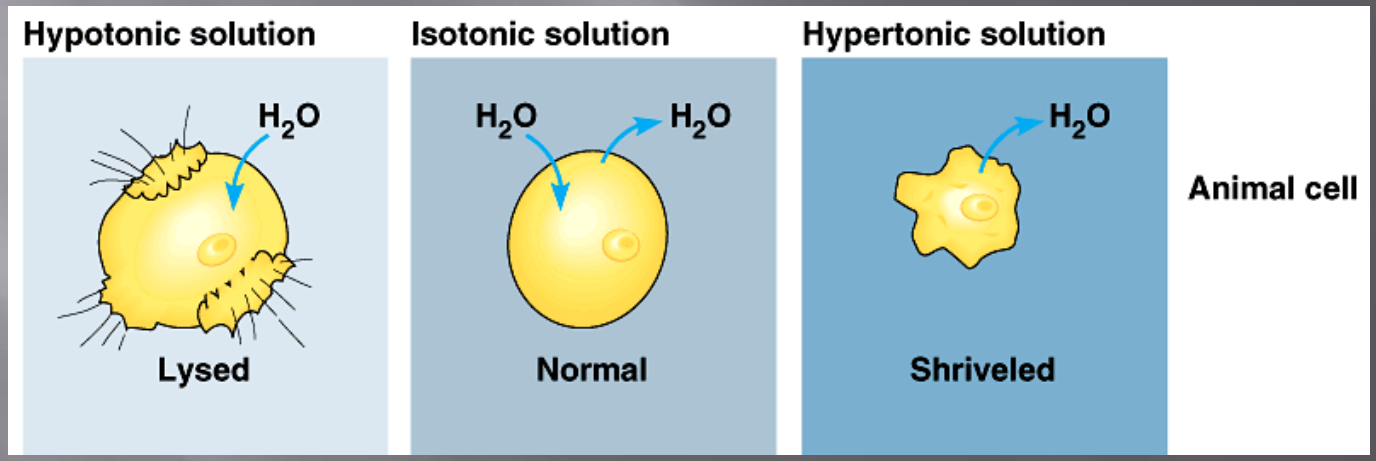
- The transport of 2 or more solutes is coupled
- One of the solutes Na+ is transported downhill
- Providing energy for uphill transport of the other solute.
- If the solutes move in the same direction is called :cotransport or symport .
- Ex:Na+-glucose cotransport in small intestine

- If the solutes move in opposite directions ,it is called :countertransport,exchange or antiport.

Ex:Na^+ -Ca^+exchange and Na^+-H^+exchange

Many cell membranes contain Na^+-Ca^{++} exchanger .Both of these ions move in opposite directions across the cell membrane .

- The same cell is a hypertonic environment will loose water, shrivel, and probably die.
- A cell in a hypotonic solution will gain water, swell, and burst.



Intercellular connection

- 1-Tight junction:(zonula occludens)
- Are attachment between the cells (epithelial cells)
- Intercellular pathway for solutes depending on size charge and characteristic of the junction.
- May be tight (in renal distal tubule) or leaky as in renal proximal tubule .

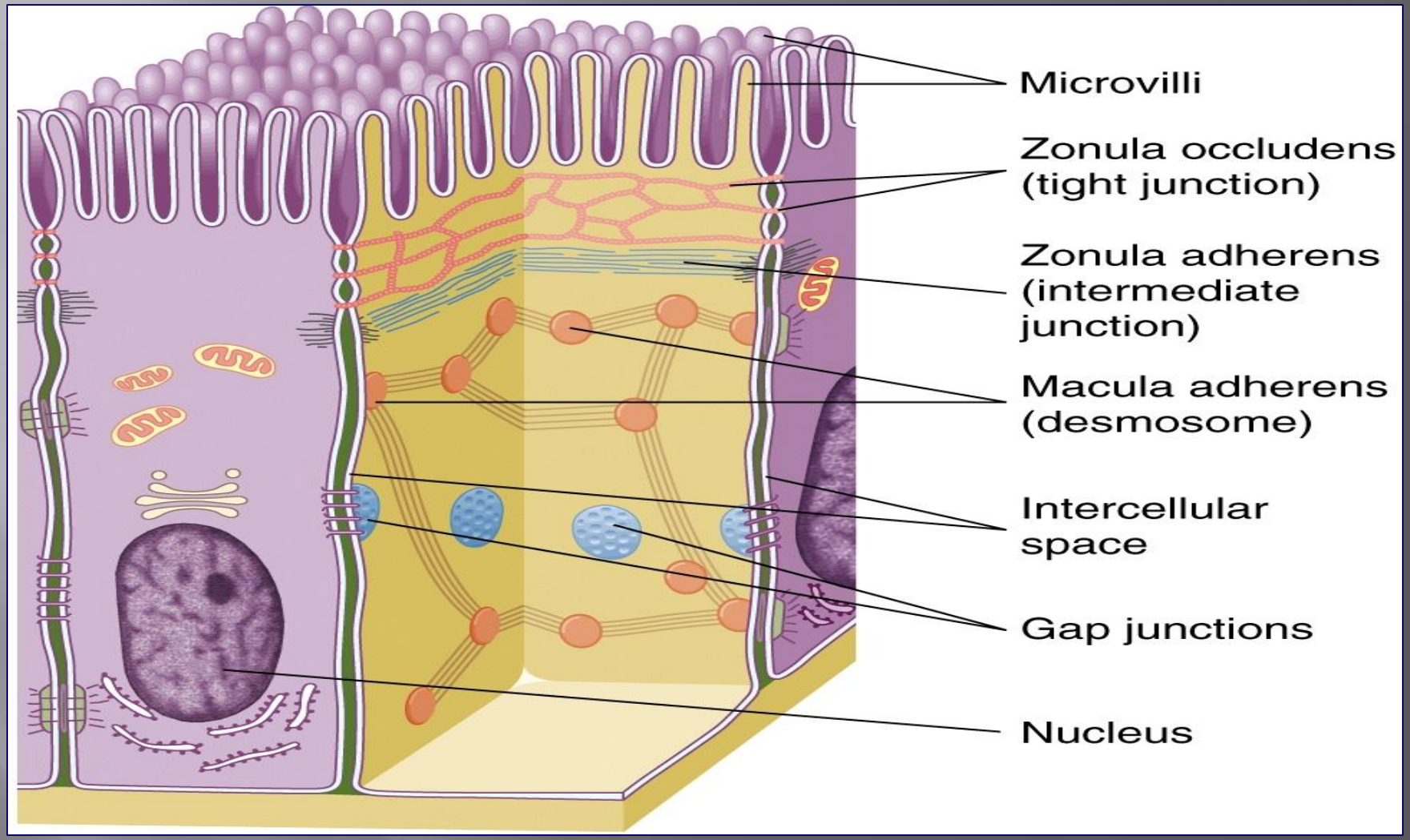
- 2-Gap junctions:
- Are the attachments between cells that

permit intercellular communication .

- Permit current flow and electrical coupling between myocardial cells.

3-Desmosomes(macula adherence):cell to cell spot adhesion present on the lateral membrane of cells ,resists shearing force in the squamous epithelium.

4-Hemidesmosomes:anchor cells to the extracellular matrix .



A hypothetical cell shows different types of junctions.