MEDICINE
KING SAUD UNIVERSITY

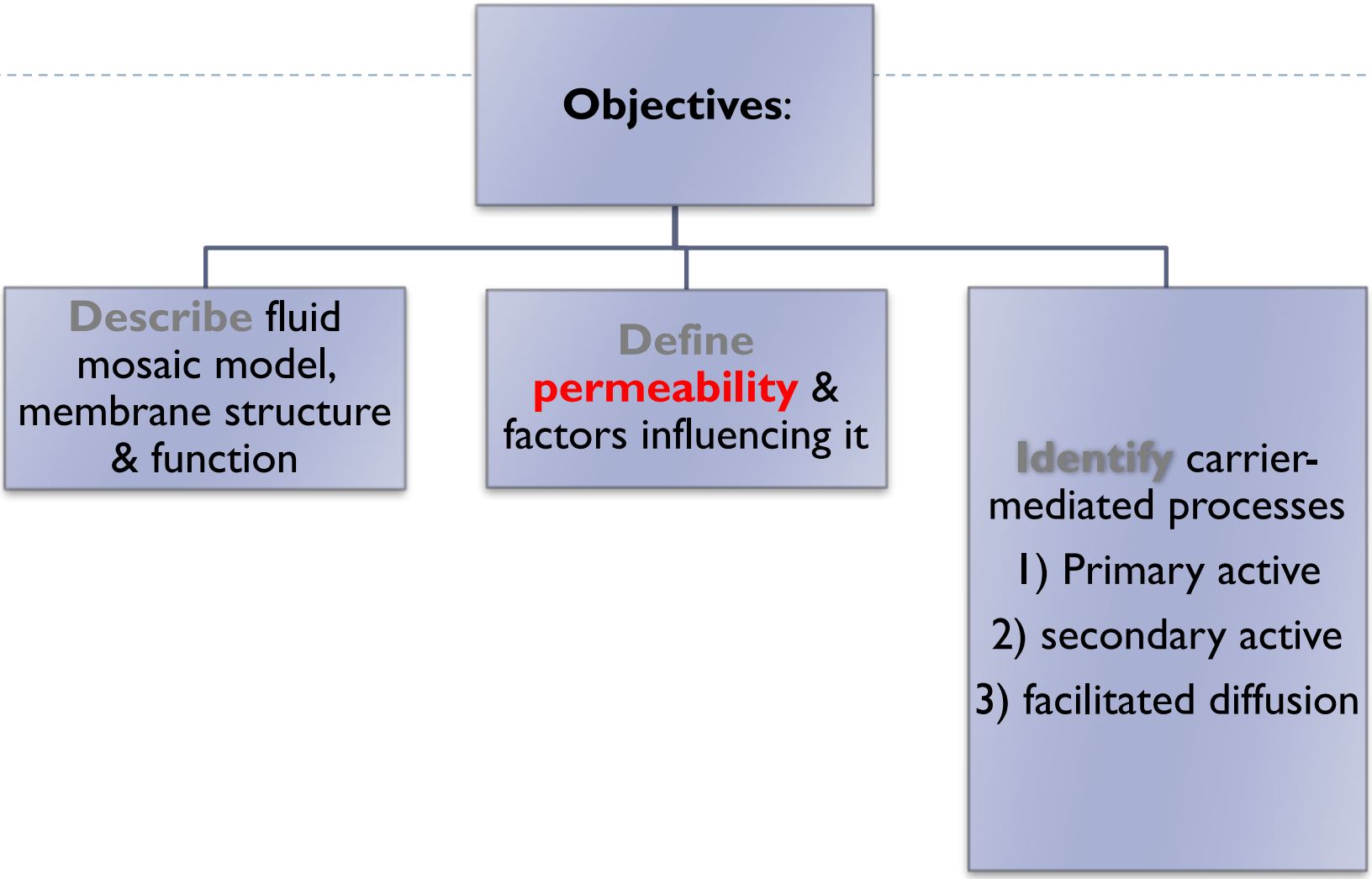
Physiology Team 436

Cell Membrane and Transport

Red: very important.
Green: only found in males' slides.
Purple: only found in females' slides.
Gray: notes.

Physiology Team 436 – Foundation block lecture 2

Lecture: If work is intended for initial studying.
Review: If work is intended for revision.


Objectives:
Describe fluid mosaic model, membrane structure & function
Define permeability & factors influencing it
Identify carrier-mediated processes
1) Primary active
2) secondary active
3) facilitated diffusion

Structure of the cell membrane (Plasma membrane)

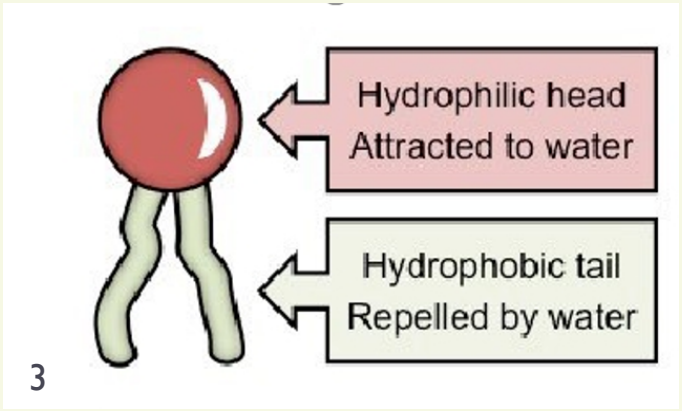
- **Characteristics:**

1. It covers the cell
2. Thickness: 7.5-10 nm
3. Selectively permeable
4. It is fluid, not solid
5. Composed of:

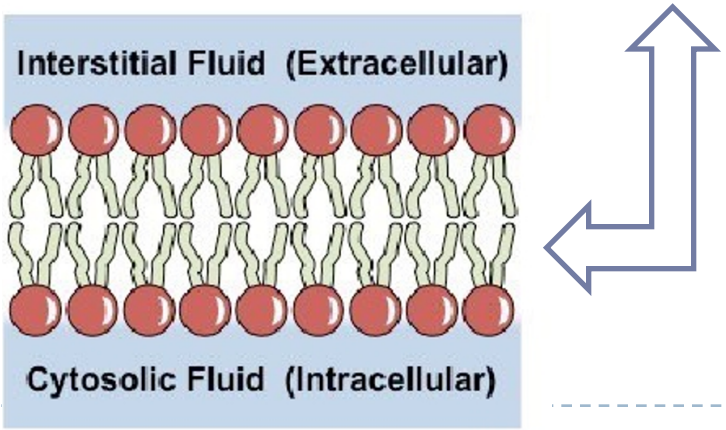
- 55% proteins
- 42% lipids
- 3% other (Can be carbohydrates)

1-Phospholipids (most abundant) 25%
2-Cholestrol 13%
3-Other 4% (Can be Glycolipid)

Phospholipid:
Head: Phosphate / Glycerol Tail: fatty acid



Interior of the **Phospholipid bi-layer**:
amphipathic (Hydrophilic head+ hydrophobic tail)



REMEMBER

- Cell membrane is composed of a lipid bilayer
- Cell membrane = plasma membrane

What does Selective Permeability mean?

- The membrane allows some substances to cross it but not others.

A. Through proteins: Water-soluble substances (Glucose, ions)
B. Directly through the bilayer: Fat-soluble substances (O2, CO2, OH)

- This controls the type & amount of substances entering and leaving the cell.
- It arises from the membrane structure.

Membrane Proteins (Two categories)

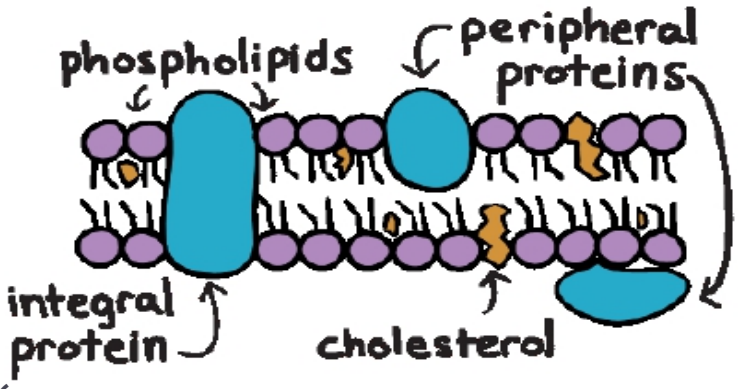
Integral

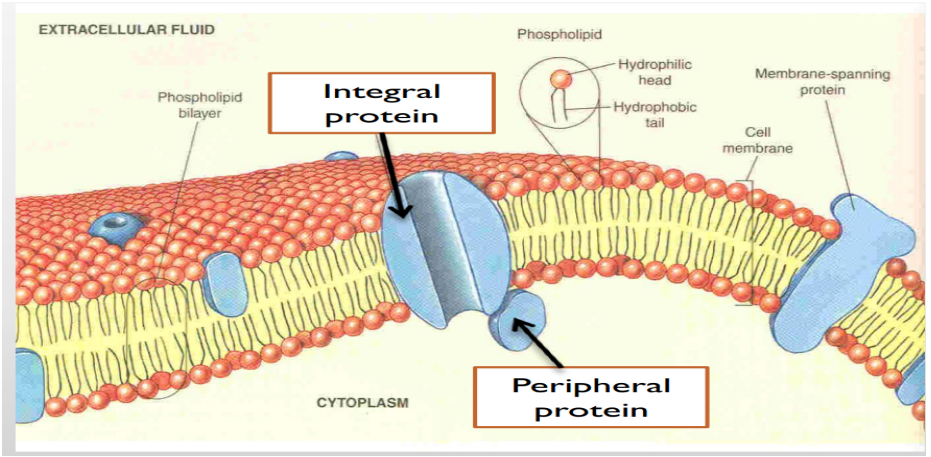
- Span the thickness of the membrane
- Function:

1. Channels (or pores)
2. Carrier proteins
3. Receptors

Peripheral

- Only attach to the surface of the membrane (or attached to integral proteins)
- Function: Hormone receptors and Enzymes

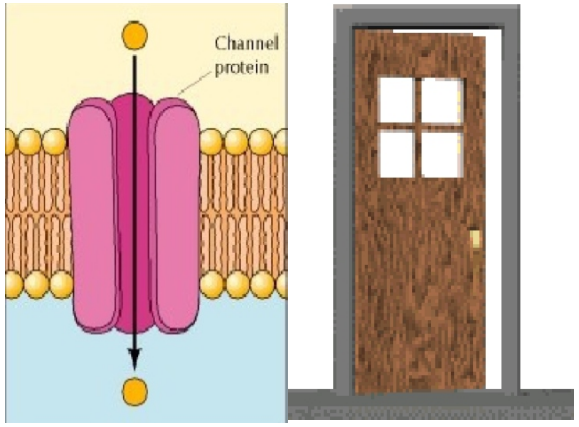




Channel vs. Carrier Proteins

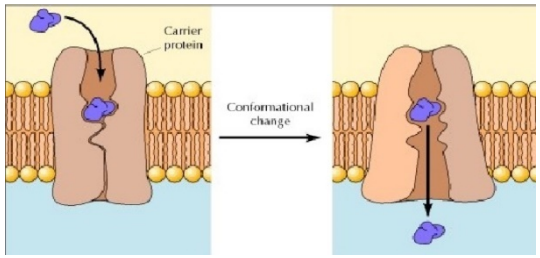
Channel proteins

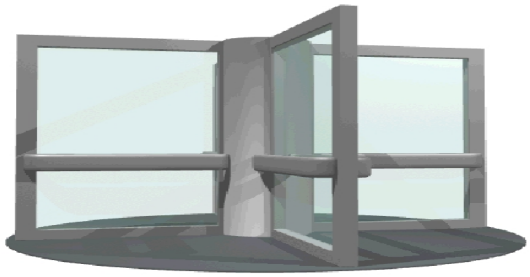
- Form open pores that allow molecules of the appropriate size (e.g. Ions) to pass the membrane.
- Similar to a normal door.



Carrier proteins

- Selectively bind the small molecule to be transported and then undergo a conformational change to release the molecule on the other side of the membrane.
- Similar to electronic door.





Carbohydrates of the Cell Membrane

- *Carbohydrates CHO's* membrane carbohydrates are on the surface bounded to lipids or proteins of the membrane

If attached to Proteins → Glycoproteins (mostly)
Lipids → Glycolipids
If bound together by proteins → Proteoglycans

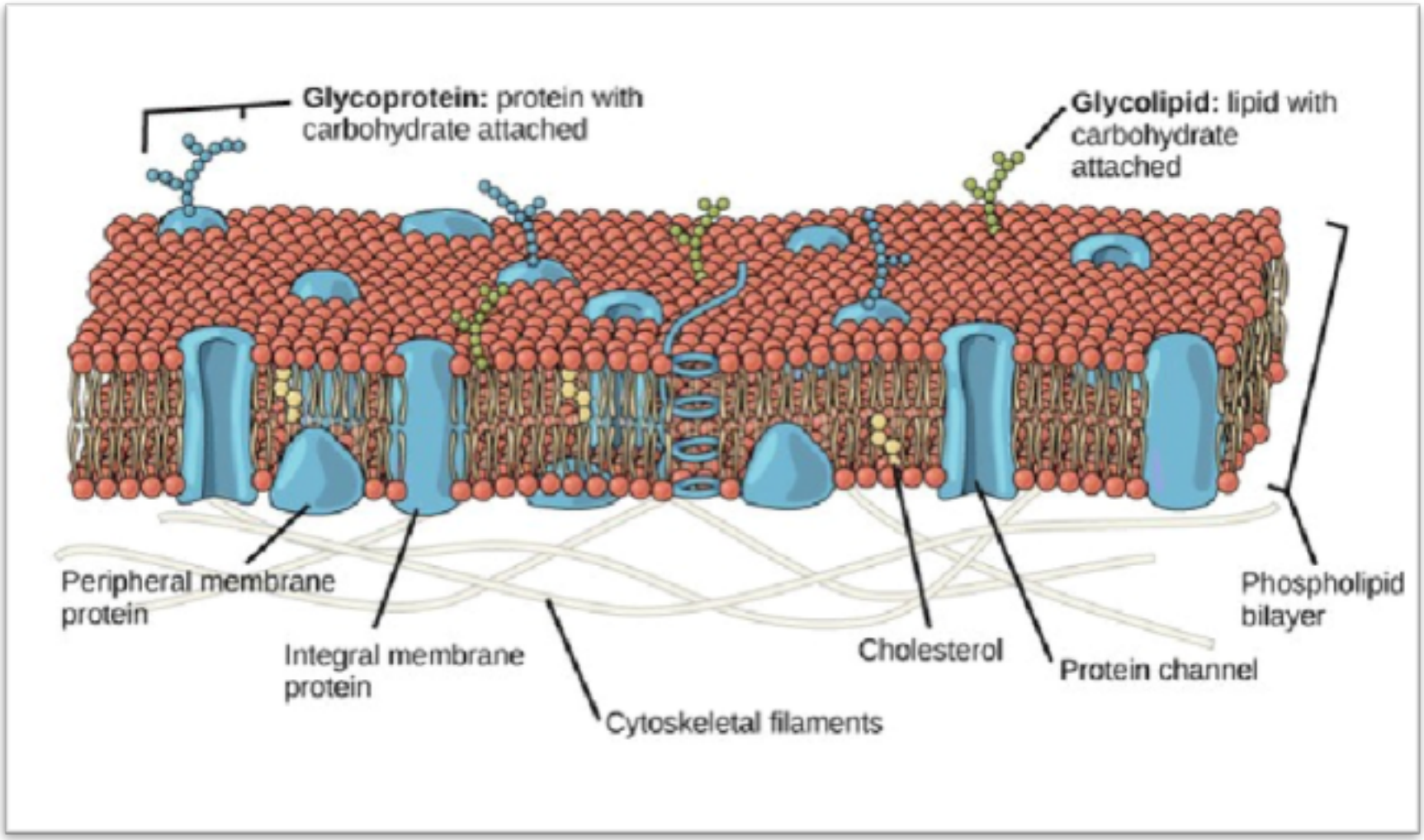
Function:

1. **Receptors**
2. **Attach cells to each other (Cell Adhesion)**
3. **Immune reaction (They help protect the cell by differentiating host friendly cells from enemy cells)**
4. **Give most of cells overall negative surface**

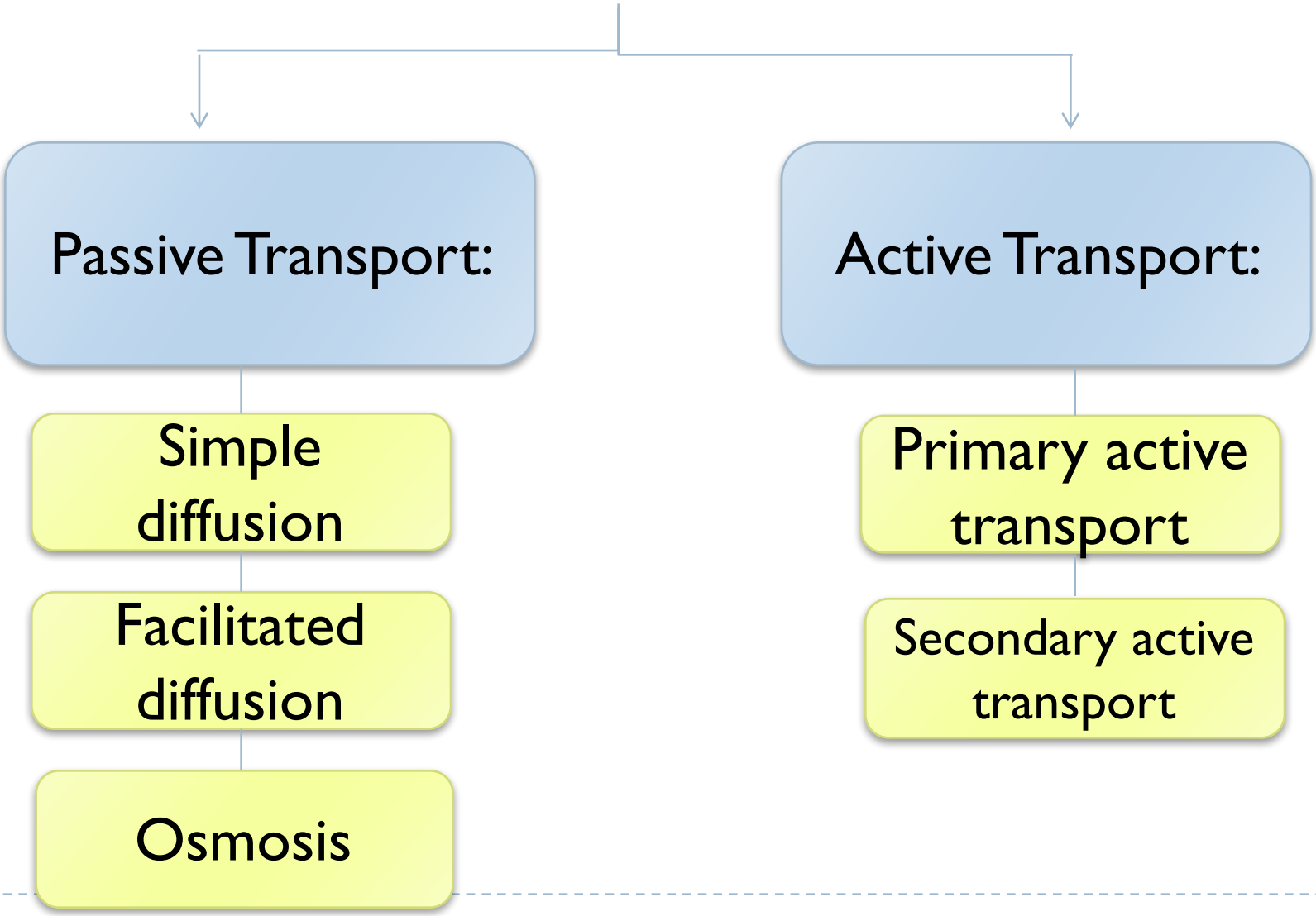
Glycocalyx:

a loose coat of carbohydrate molecules outside the cell. Functions as a first layer of defense

The Fluid Mosaic Model of Plasma Membrane



Types of Membrane Movement:



Transport Mechanisms:

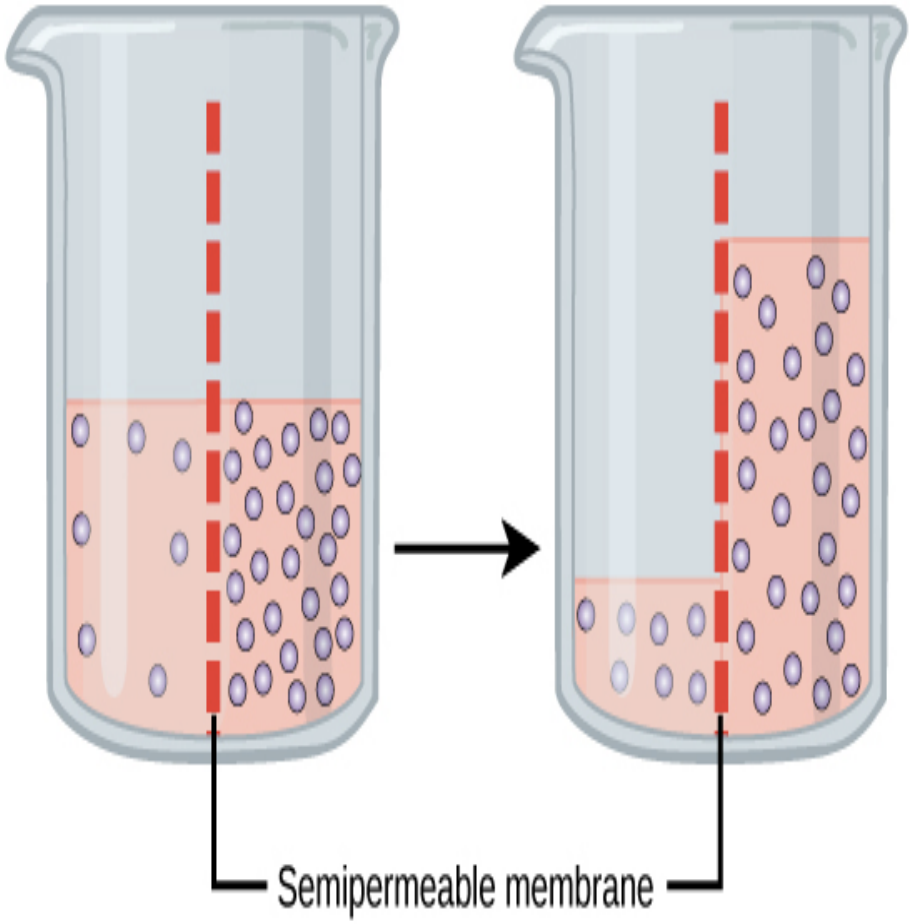
The transport of material between body or cellular compartments can be divided into:

- Molecules move **down or along** their energy gradient.
- **Does not require energy.**

- Molecules move **against** their energy gradient.
- **require energy.**

Passive Transport (Osmosis)

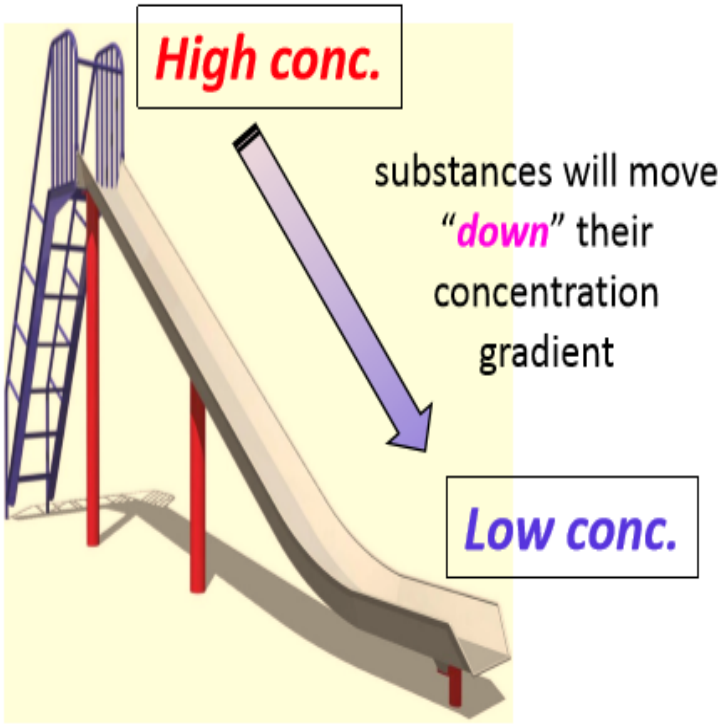
Osmosis :
Movement of water from an area of **low solute concentration (hypotonic)** to an area of **high solute concentration (hypertonic)**



Passive Transport (Diffusion)

- Diffusion: Random movement of substance either through the membrane directly or in combination with carrier protein **down** concentration gradient.

- This gradient can be:
  - Concentration.
  - Electrochemical.
  - Pressure.



Passive Transport (Types of Diffusion)

Simple diffusion

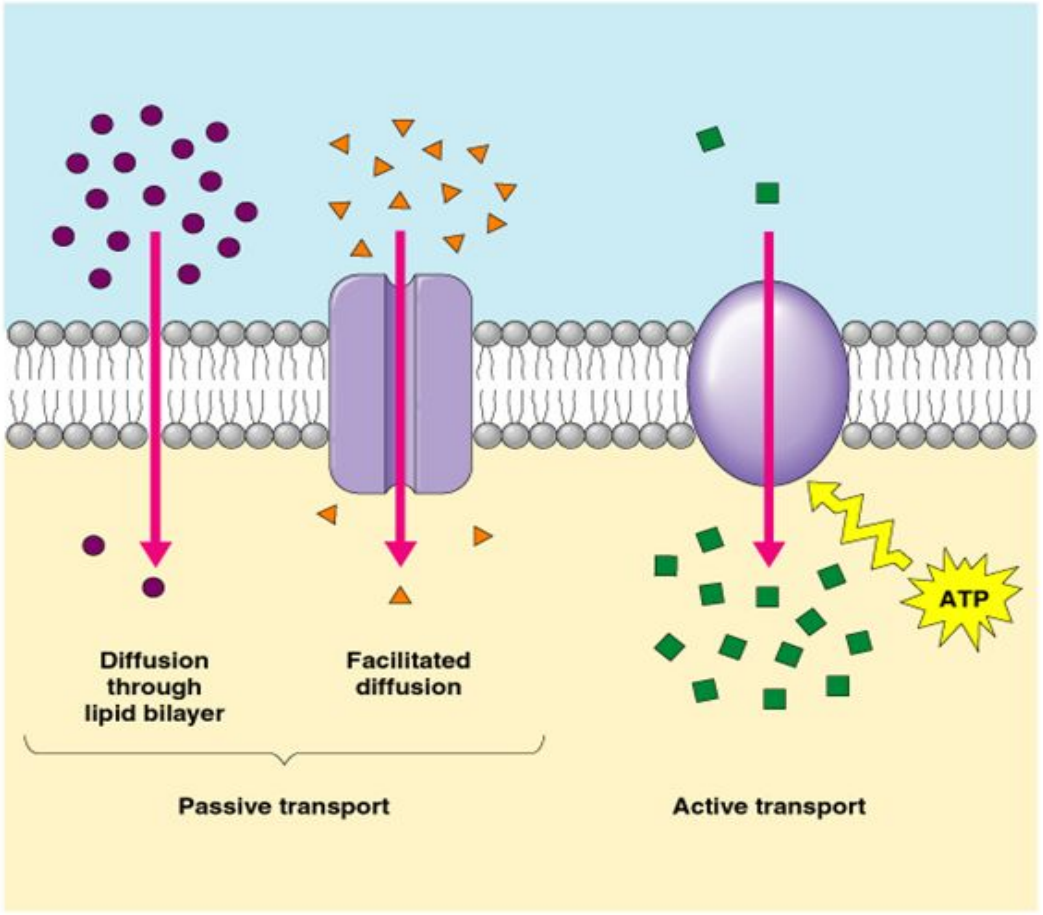
The movement of molecules through the intermolecular spaces **or** membrane openings (channels) **without** the necessity of binding **to a carrier protein** on the membrane.

Facilitated diffusion

The transported molecule binds to a **carrier protein** which then undergoes a conformational change allowing the molecule to pass through to the other side of the cell membrane.

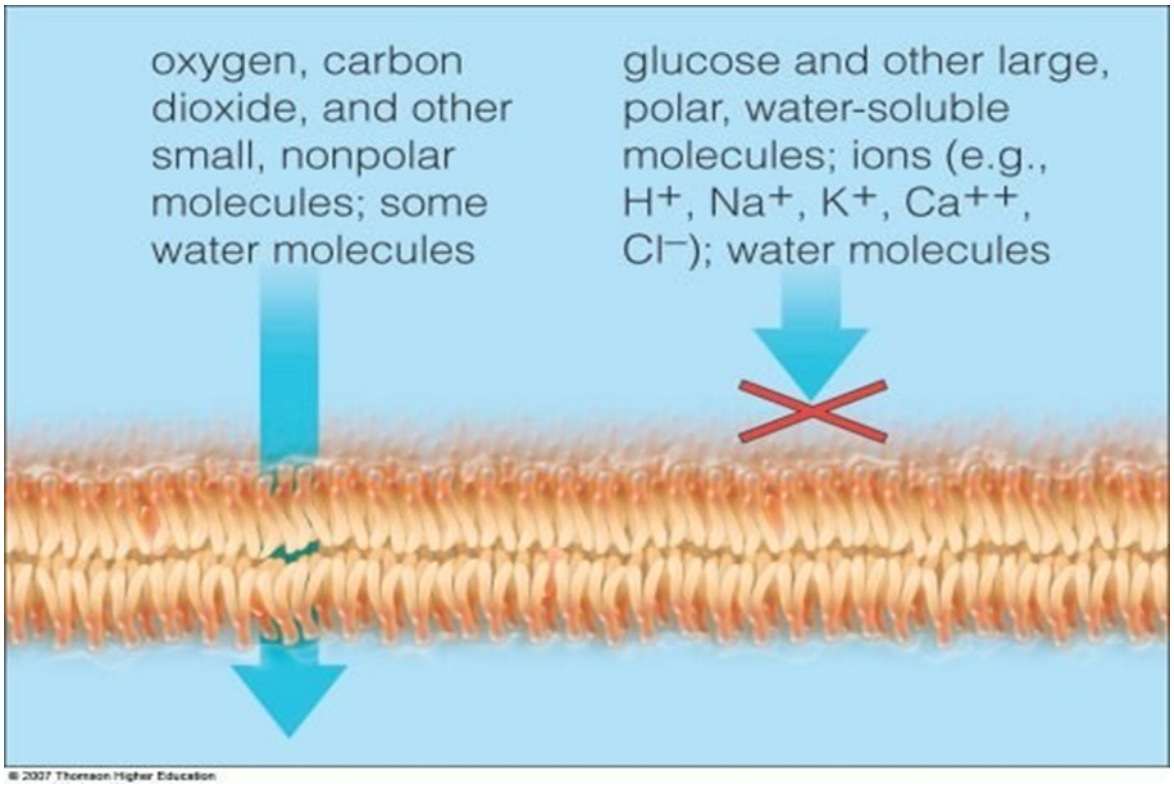
The carrier **facilitates** passage of the molecule through the CM.

Three Types of Cellular Transport



Amazing video summarizing cellular transport: https://m.youtube.com/watch?v=UgN76naeA1Q

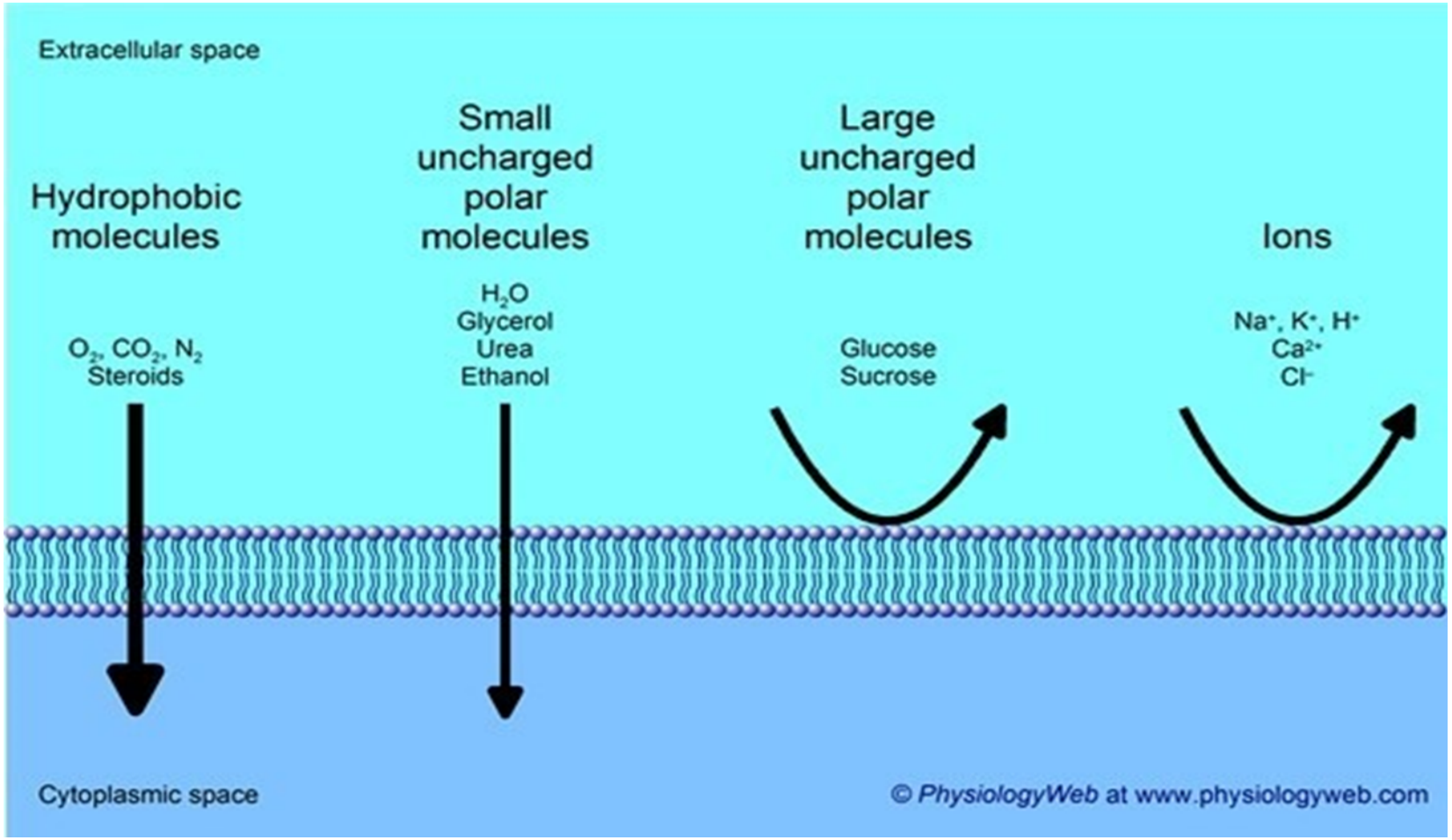
Substances that can cross the Cell Membrane



Cross freely by diffusion

Cross through membrane proteins

Substances that can cross the Cell Membrane



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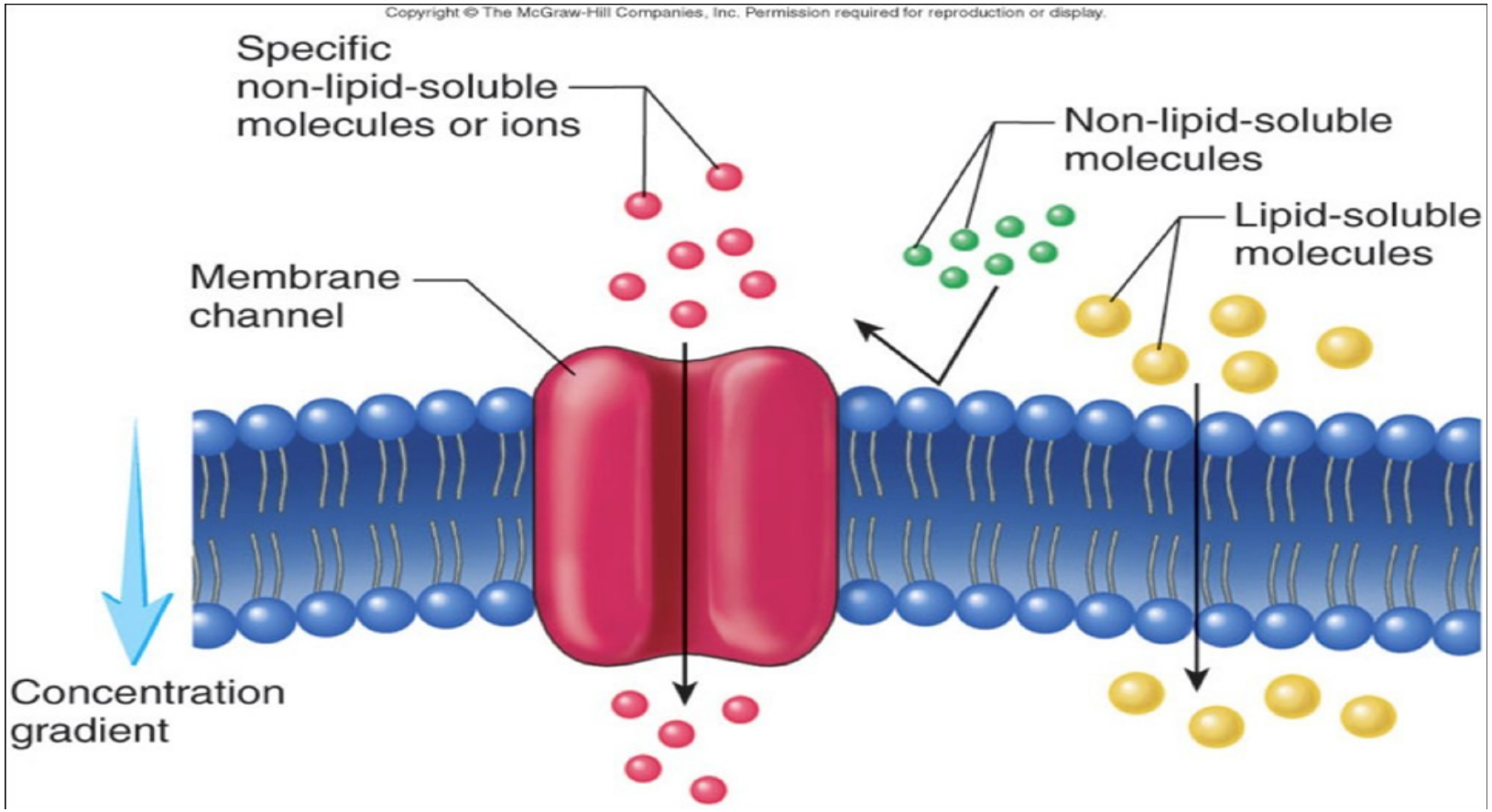


Achieved through a trans-membrane protein: carrier/transporter/channel

Passive Transport (Simple Diffusion):

1-Simple Diffusion:

1- directly through the lipid bilayer

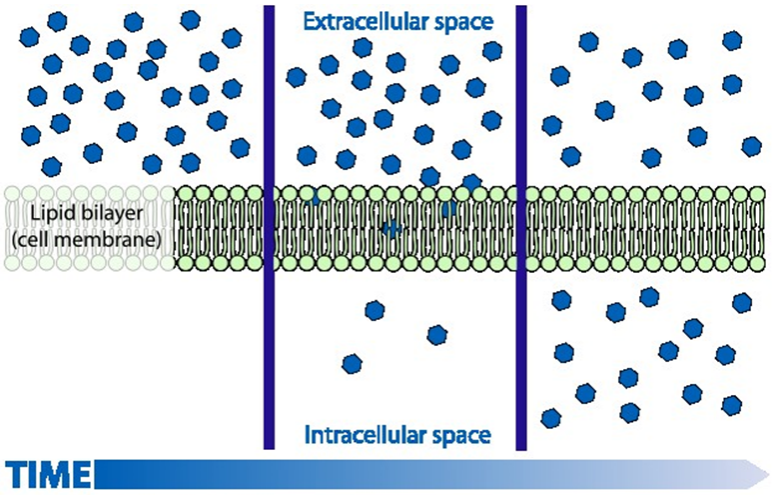
- Pass through the interstices of the lipid bilayer

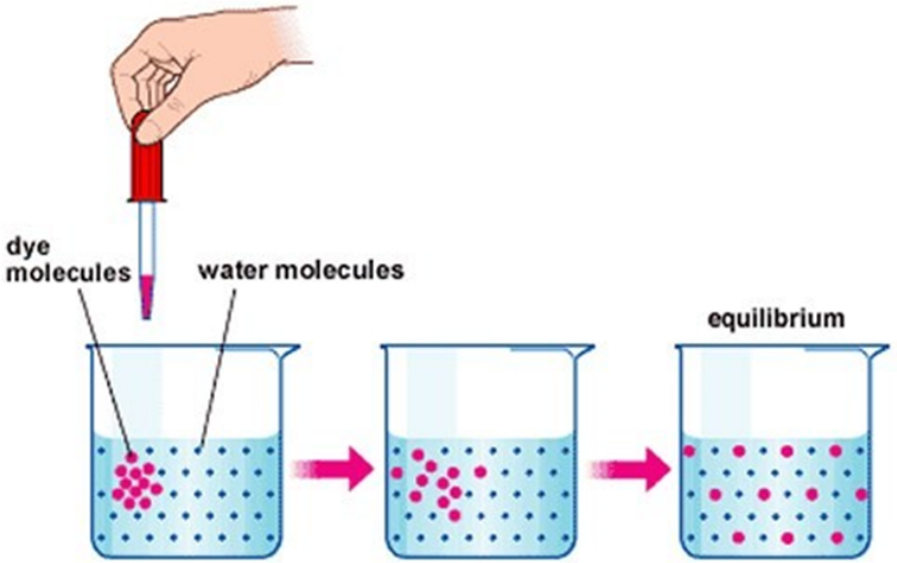
EX : **small lipid-soluble substances** (uncharged substances, O2, CO2, alcohol, steroid and general anesthetic).

2- through the channel protein

- Its require transport protein (channel protein).
  - EX: 1- Large and lipid-insoluble substances (charged molecule).
    2-**Water-soluble substances (water, ions) pass through channels that penetrate through the cell membrane.**

Passive Transport (Simple Diffusion):



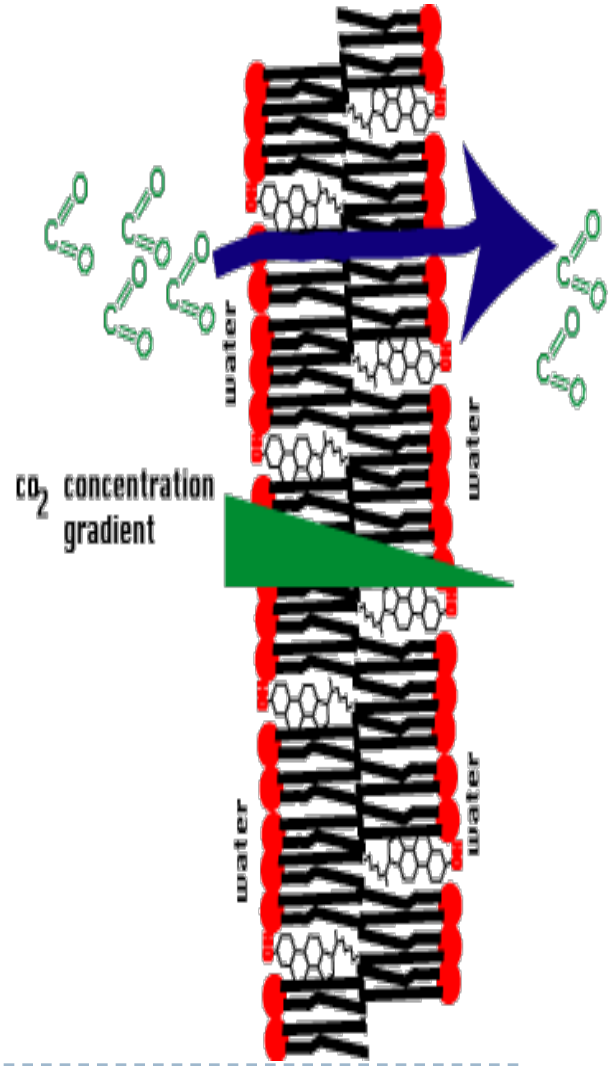


Passive Transport (Simple Diffusion)

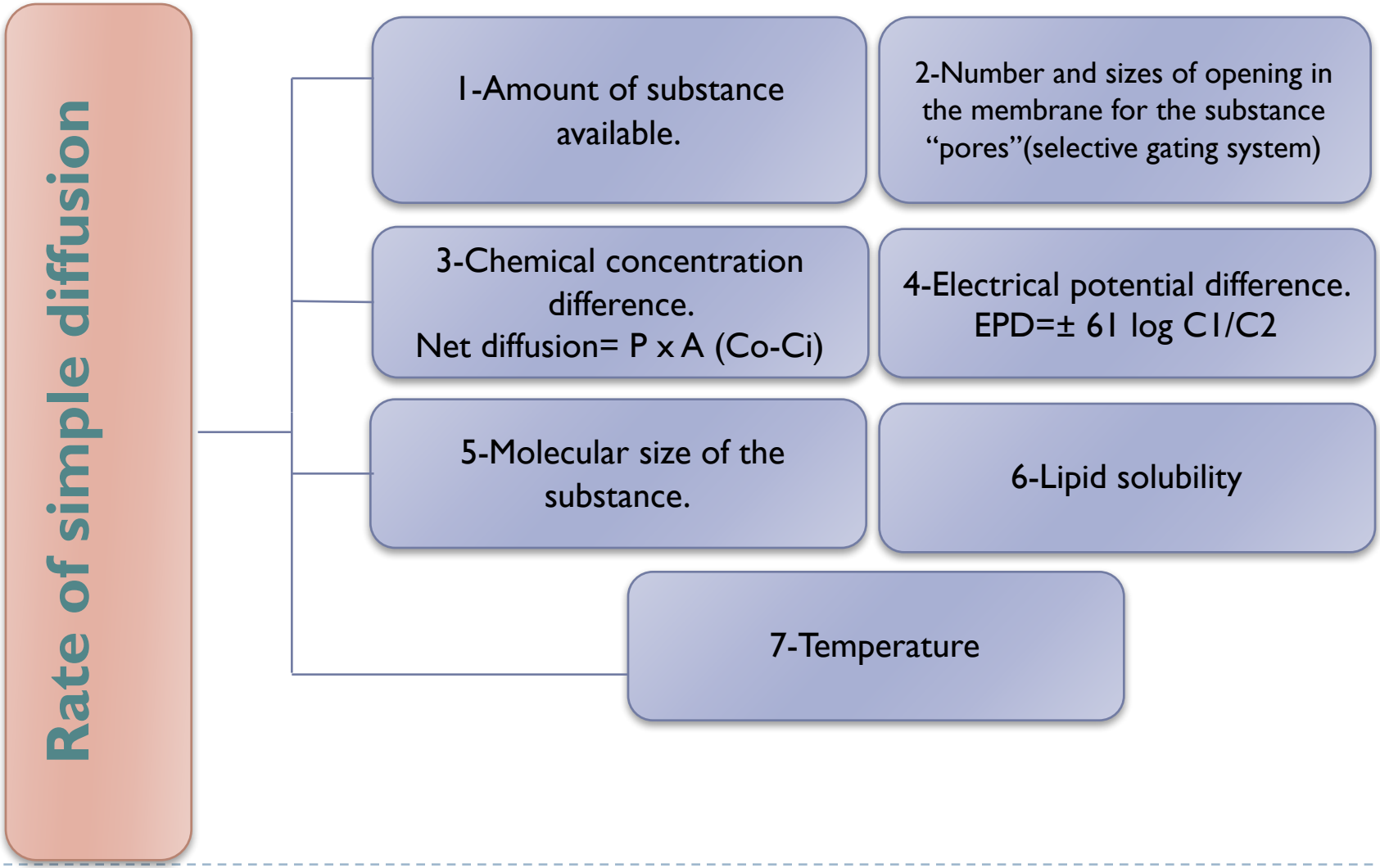
- **Non-carrier:** mediated transport down an electrochemical gradient.

- **Diffusion of non-electrolytes:** (uncharged) from high concentration to low concentration.

- **Diffusion of electrolytes:** (charged) depends on both chemical as will as electrical potential difference.



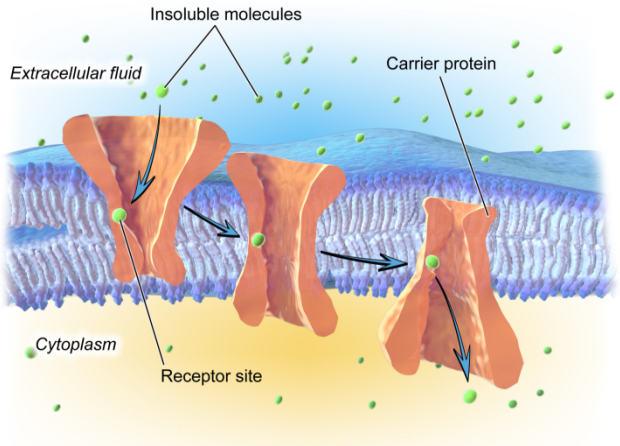
Passive Transport (Simple Diffusion)



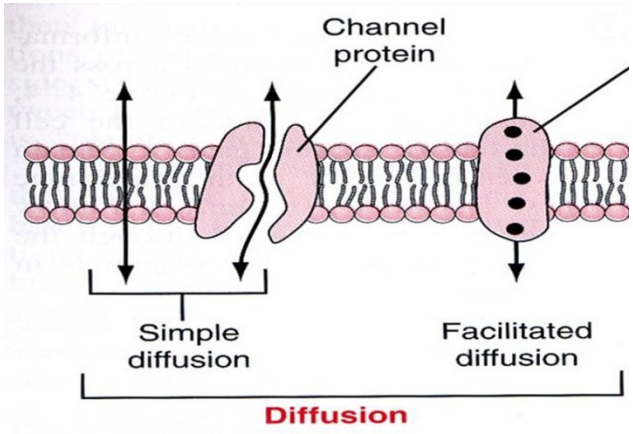
Passive Transport (Facilitated Diffusion)

2- Facilitated diffusion: also called **(Carrier mediated diffusion)**

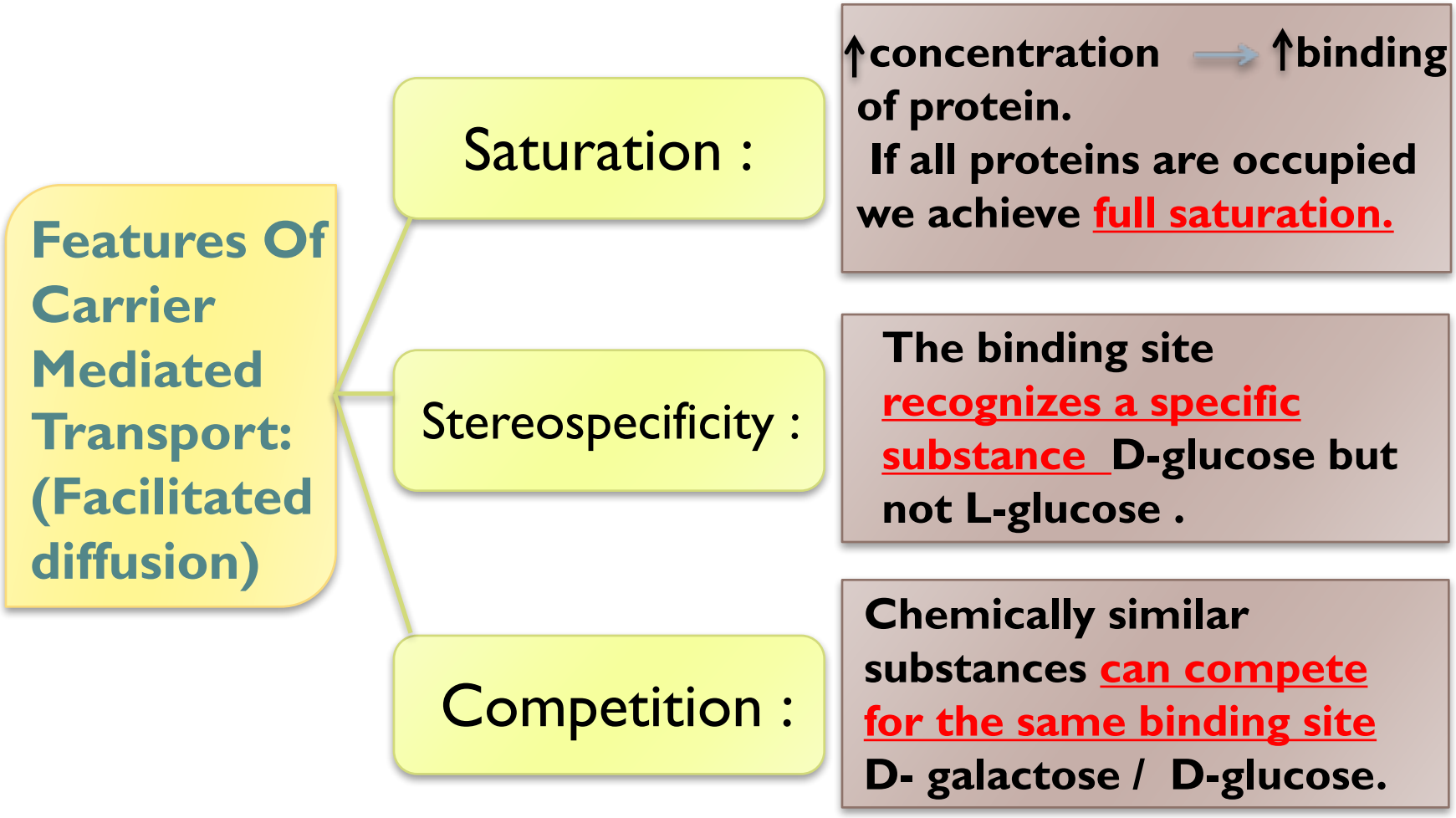
- Diffusion of a substance is "facilitated" by the use of a specific carrier protein.
- Diffusion continues until equilibrium is reached or terminated.
- Examples: Glucose, amino acids.



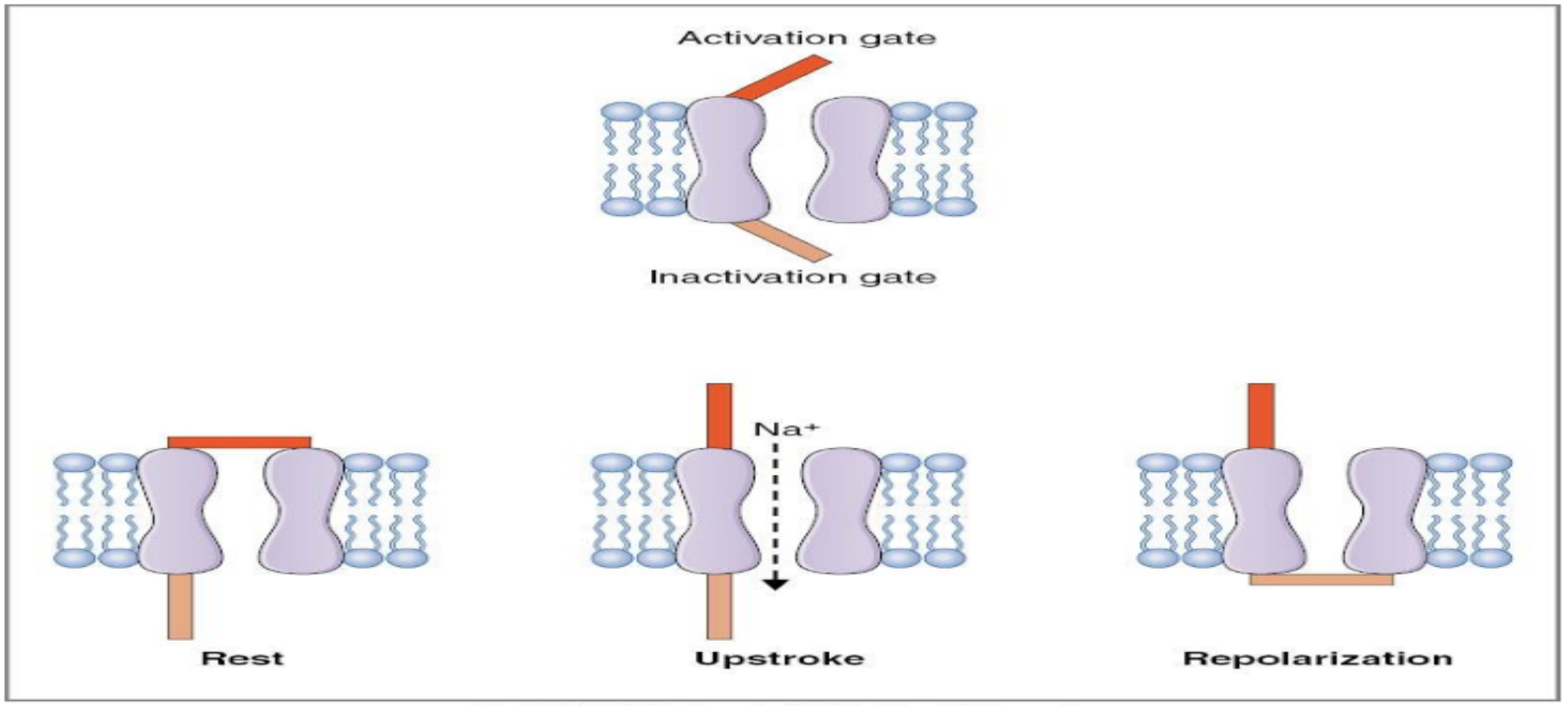
Facilitated Diffusion



Passive Transport (Facilitated Diffusion)



Passive Transport (Facilitated Diffusion)



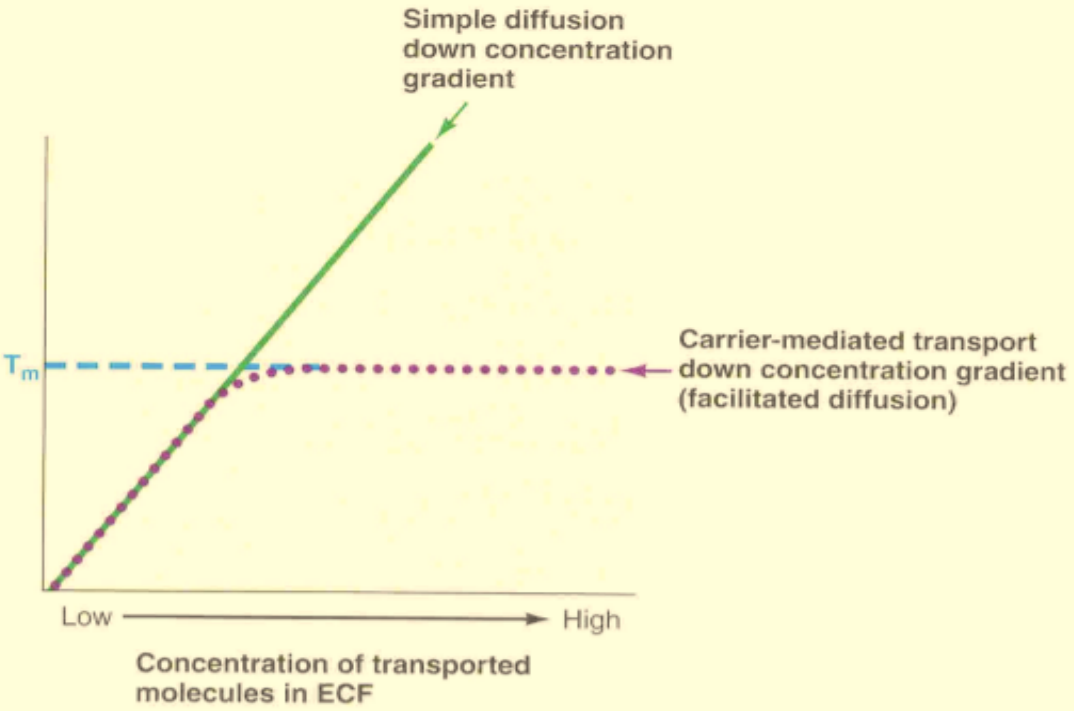
- Substance → binding site → substance protein complex → conformational changes → release of substance.

Passive Transport "rate of diffusion" (Simple Vs. Facilitated)

Simple diffusion	Facilitated diffusion
The rate of diffusion increases proportionately with the concentration of the diffusing substance.	❖ The rate of diffusion increases proportionately with the concentration of the diffusing substance **until it reaches a maximum Vmax.** ❖ At Vmax, an increase in the concentration of the diffusing substance **does not increase the rate.**

Why?

* كل ما زاد التركيز بيزيد معدل دخول الجزيئات، بمجرد يوصل للمرحلة القصوى بيثبت المعدل، لأن هذا النوع يعتمد على الكارير فما راح يقدر يدخل أكثر من طاقتة مهما كان التركيز برا عالي.



The rate at which molecules can be transported by facilitated diffusion **depends on the rate at which the carrier protein molecule can undergo conformational change** back and forth between its bound and unbound state.

Factors Affecting Net Rate of Diffusion:

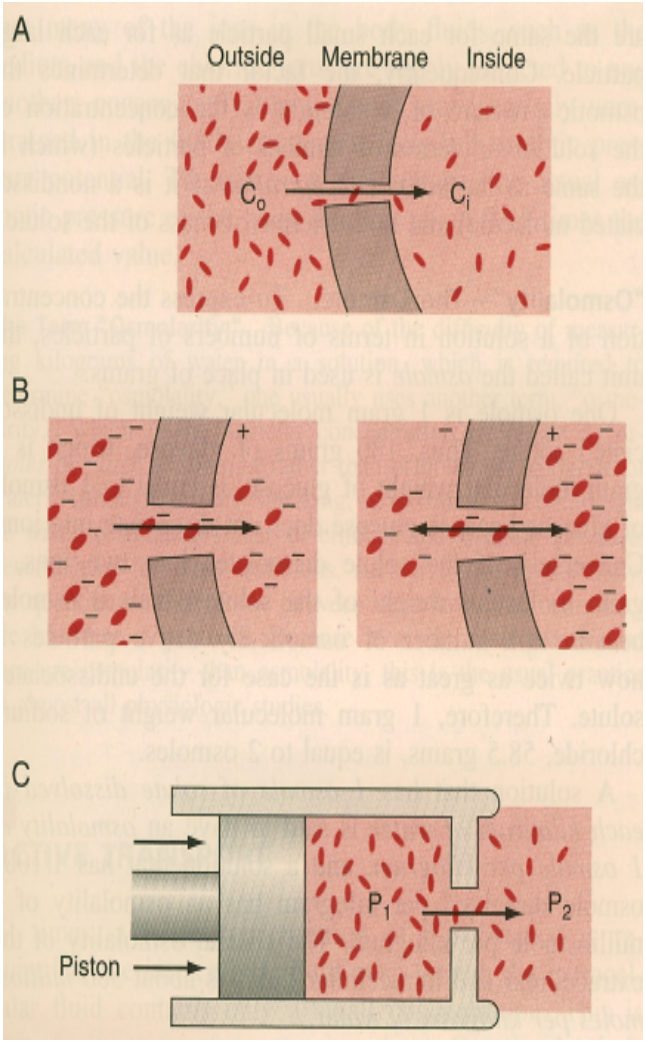
- Size.
- Temperature.
- Steepness of the gradient:

1-Concentration difference.

2-Membrane electrical difference.

3-Pressure difference.

- Charge.
- Pressure.



Active transport

*Occurs when a cell membrane moves molecules or ions **"up-hill"** **against** a concentration gradient*

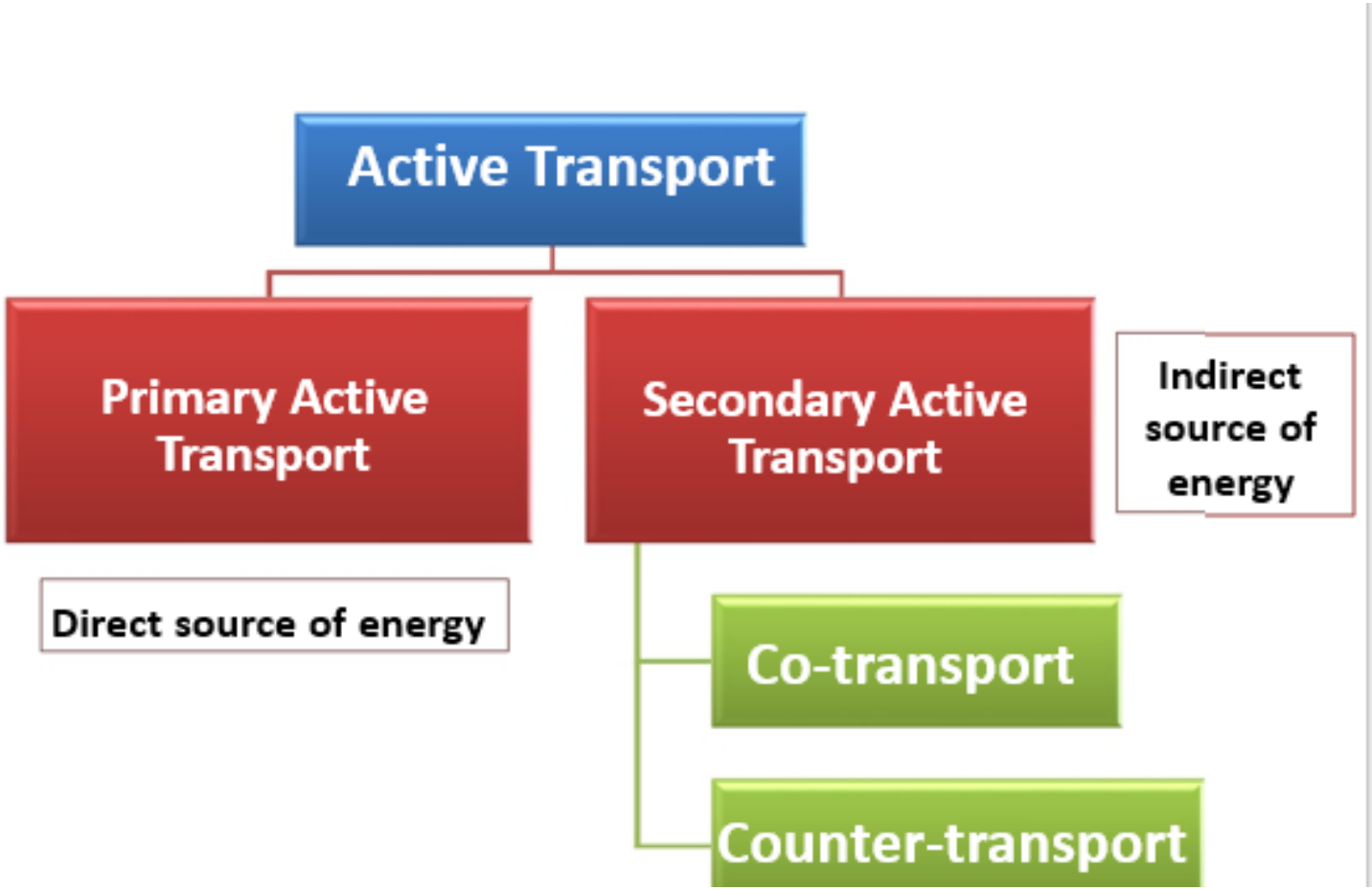
(or "up-hill" against an electrical or pressure gradient).

- ***Examples include***:
  - Ions like: sodium, potassium, calcium, iron, iodine,

    hydrogen ions.
  - Amino acids, glucose and other sugars.

*Requires **energy** and a **carrier protein***

According to the source of energy used to facilitate transport, it can be divided into;



Primary Active

- The energy is derived *directly* from breakdown of *(ATP)* to (ADP)

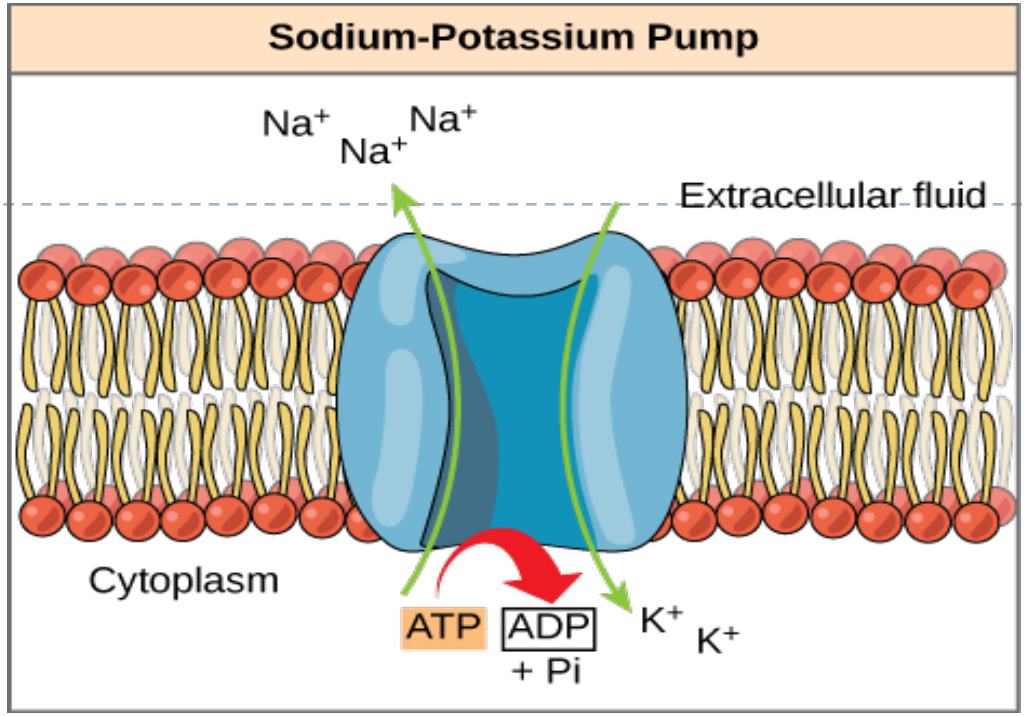
this breakdown will release energy

Examples include:

Sodium-Potassium ATPase pump

Calcium ATPase pump.

Hydrogen ATPase pump.



Functions:

- Maintaining Na+ and K+ concentration difference.
- Establishes –ve potential inside the cell.
- Maintains a normal cell volume.
- It is the basis of nerve signal transmission.

Pump Characteristics:
1- Carrier protein is made of alpha and beta subunits.
2- Na binding site is inside, K binding site is outside.
3- It has ATPase activity

In the first body fluid lecture we decided that the intercellular fluid has more K and less Na, also extracellular fluid has more Na and less K.

If the cell have more Na inside and more K outside that the cell will burst, therefore, this pump functions by moving 3 molecules of sodium OUT and 2 molecules of potassium INTO the cell both against their concentration gradients to maintain the body fluid balance.

More examples:

1- Ca+2 ATPase Pump

- Present in:

A) Sarcoplasmic reticulum in muscle cells

B) Mitochondria

C) Some cell membranes.

Function:

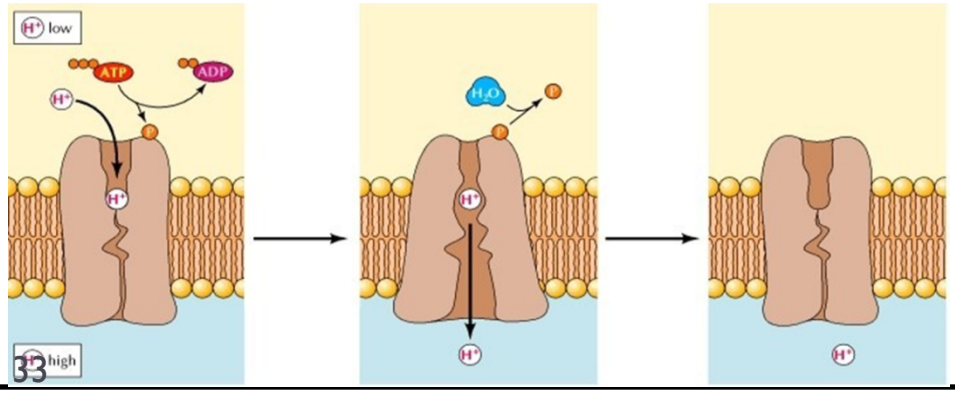
Maintains low Ca+2 concentrations in the cell

2- H+ ATPase (OR H+-K) Pump

- Present in:

A) Parietal stomach cells

B) Intercalated cells of distal renal tubule



Function:

A) Secretes HCL in stomach

B) Excretes acids from the body

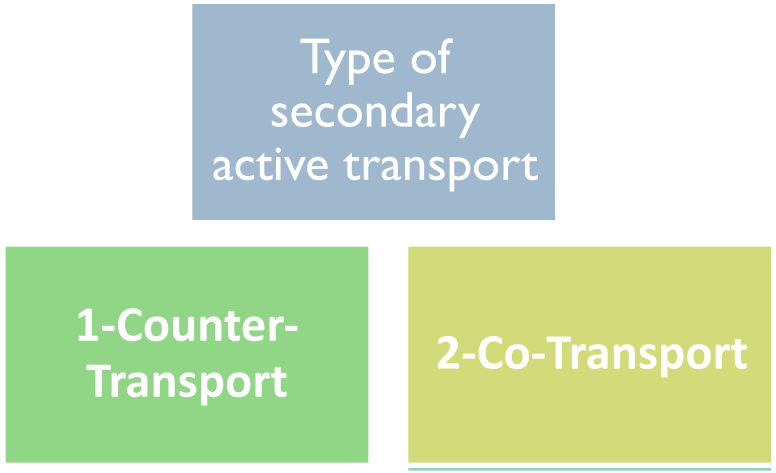
Generally: Pumps H out of the cell into lumen

H+-K ATPase inhibitors treat ulcer disease (omeprazol)

Secondary Active Transport

The energy is derived

indirectly **by using the concentration or electrochemical gradient generated by a primary active transporter.**



More Explanation (Co Transport) :

In primary NA-K pump, the concentration of sodium is more outside the cell, therefore the sodium will move into the cell with it's gradient, and goes back outside to maintain body fluid balance. When Na moves inside, the cell will use energy from the concentration gradient using a carrier, but the carrier has place for another molecule (glucose, against its gradient) to pass with Na, sodium can not move alone.

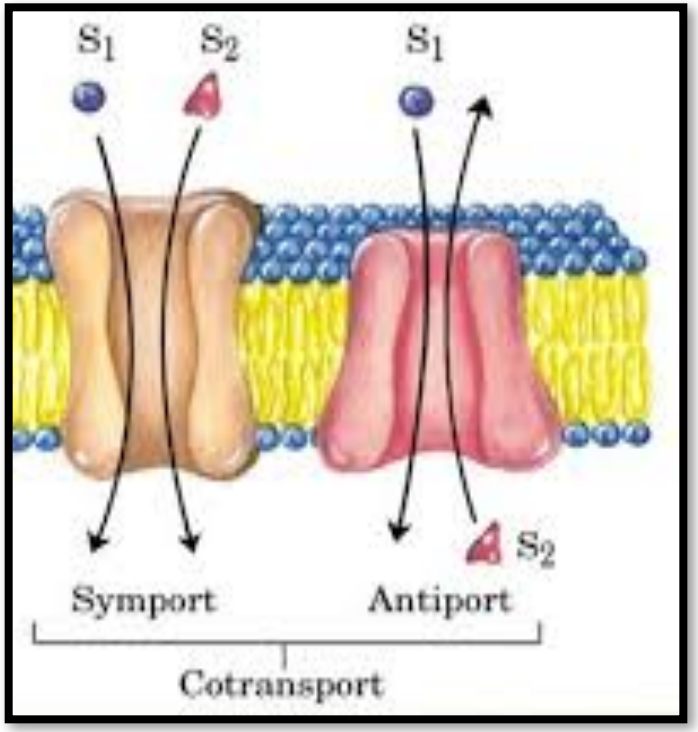
Co-Transport

- When both substances are transported together in the same direction.

Examples: 1- Na+-Glucose

2- Na +-amino acid

3- **In the Kidney**

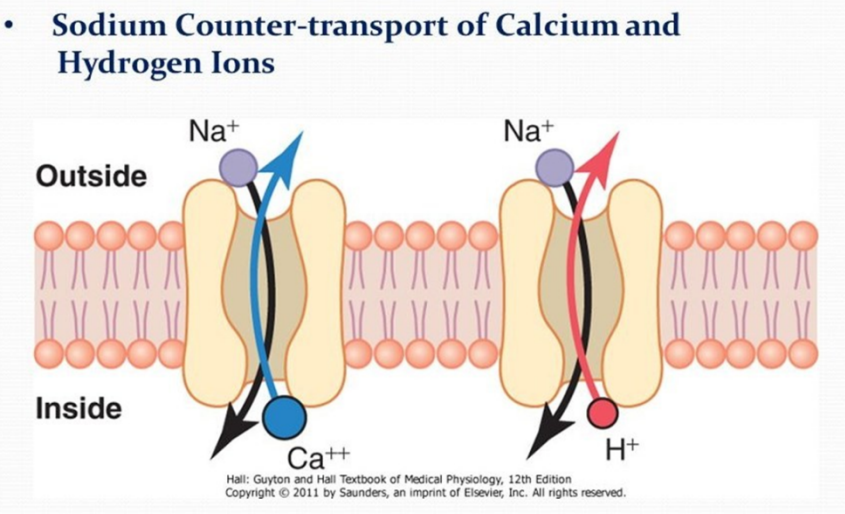


Counter-Transport

- When one substance is transported in the opposite direction to the other substance.

Examples: 1- Na+-H+ **(Kidney)**

2- Na+-Ca+2 **(Many cell membranes)**



Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمعة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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