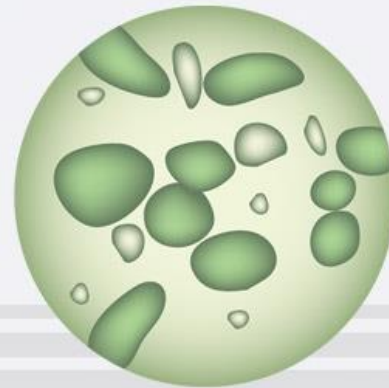


# Principles of Cell and Molecular Biology

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<http://facultymembers.sbu.ac.ir/esfandiari>

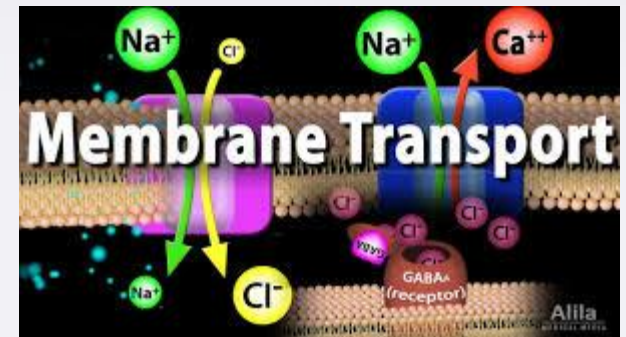
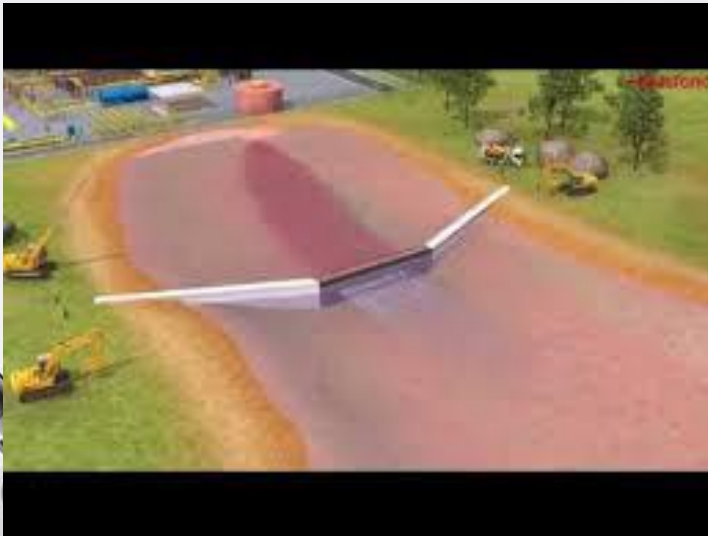


# Membrane Transport

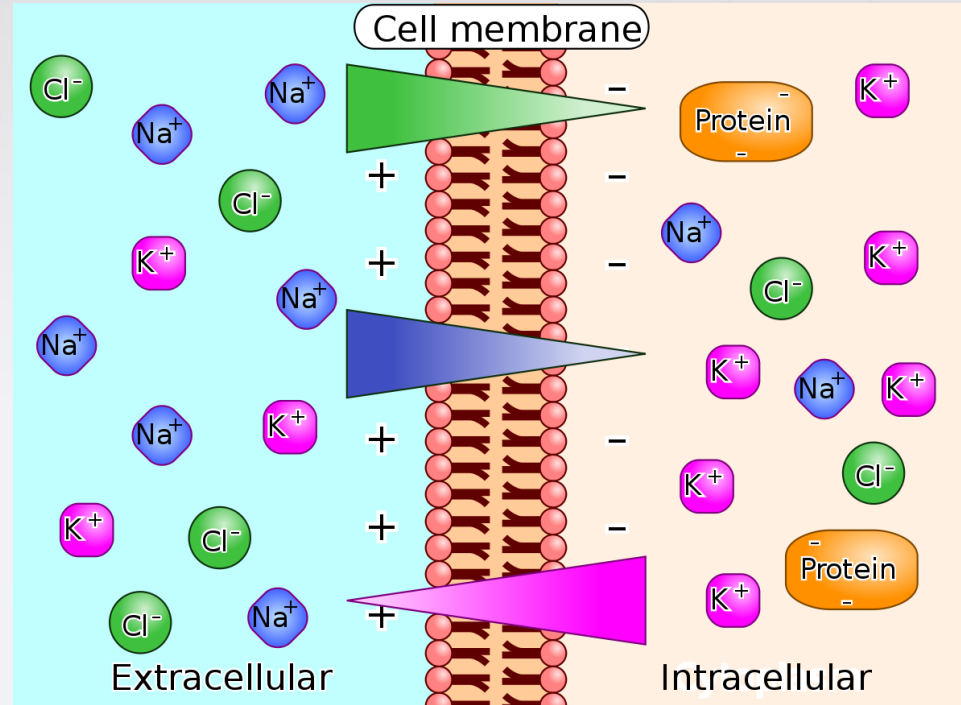


# Membrane Transport

- Permeability barrier
- Membrane transport proteins



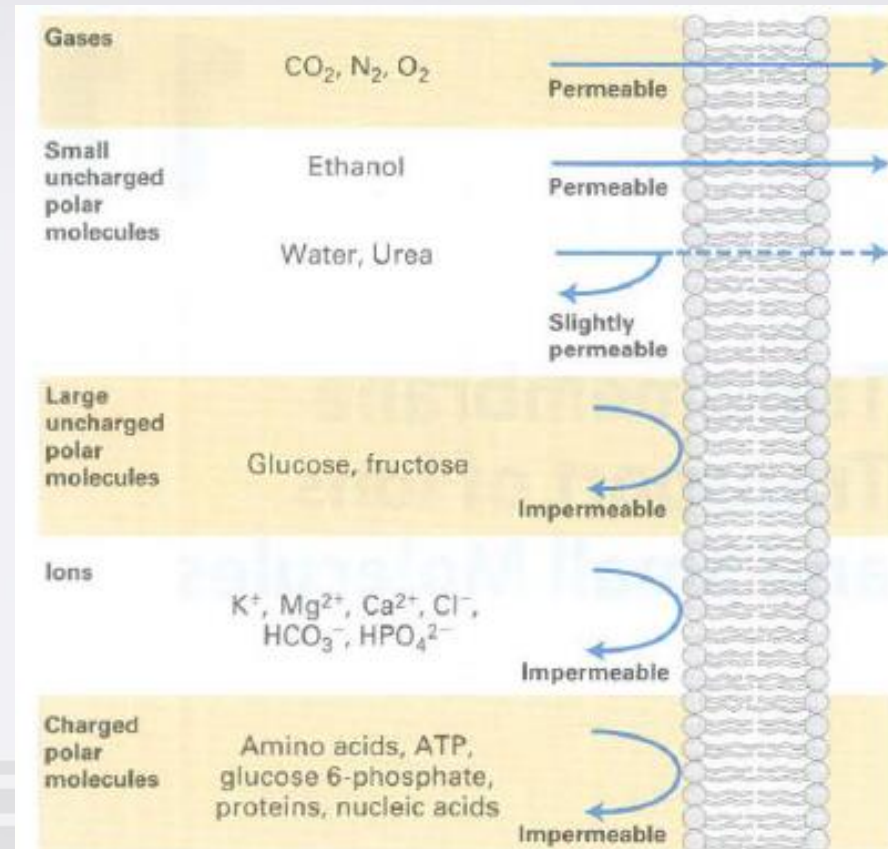
- The **Ion Concentrations** Inside a Cell are very different from those Outside
- **Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Cl<sup>-</sup>, and H<sup>+</sup>**



The membrane transport proteins  
The permeability characteristics of the lipid bilayer itself

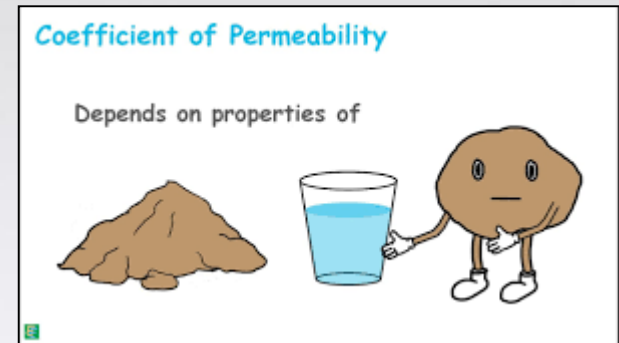
# Simple Diffusion

- $O_2$  and  $CO_2$ ,  $N_2$ ,  $NH_3$
- Small uncharged polar molecules  
(urea and ethanol,  $H_2O$ )

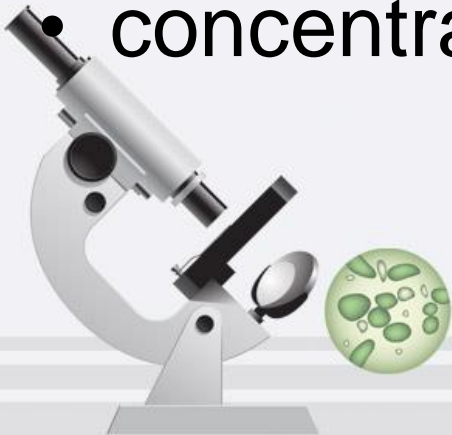


# *Permeability coefficient*

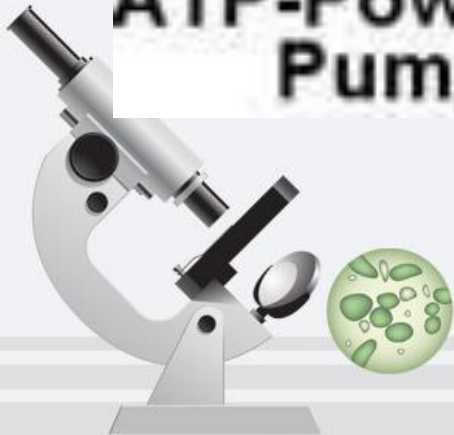
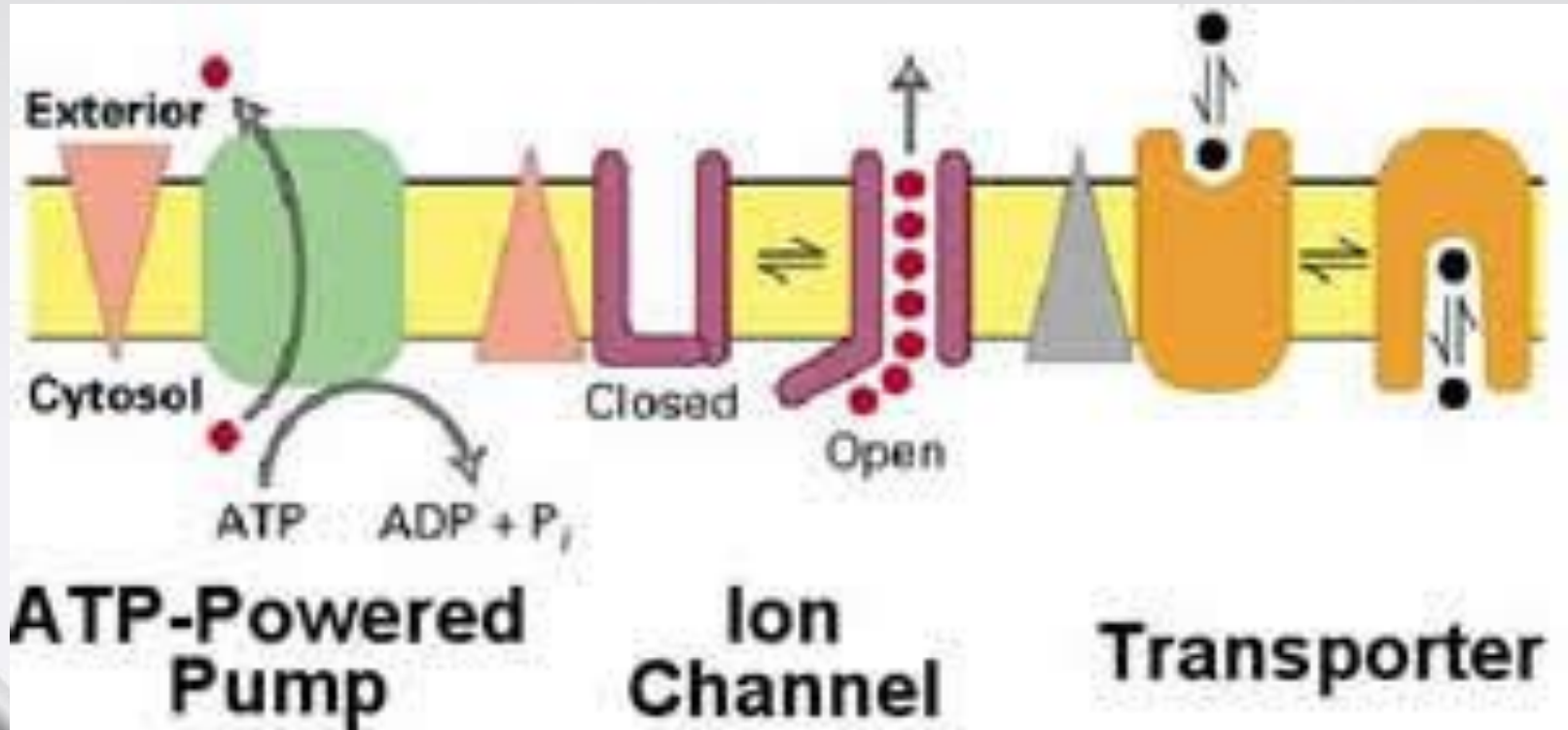
- Thickness
- Fluidity
- Particle Size (radius)
- Viscosity
- Hydrophobicity
- concentration gradient



Electrochemical gradient

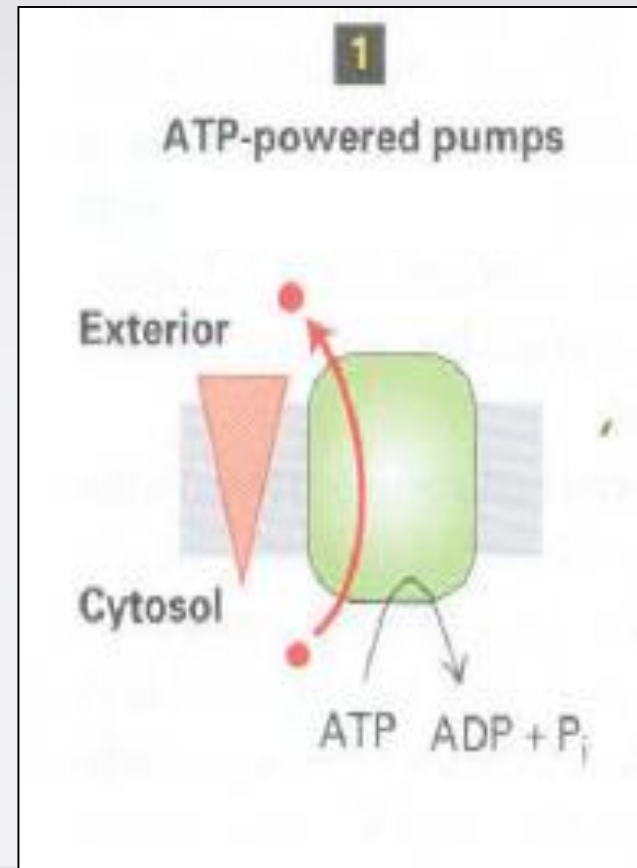


# Three Main Classes of Membrane Proteins



# 1. ATP-powered pumps

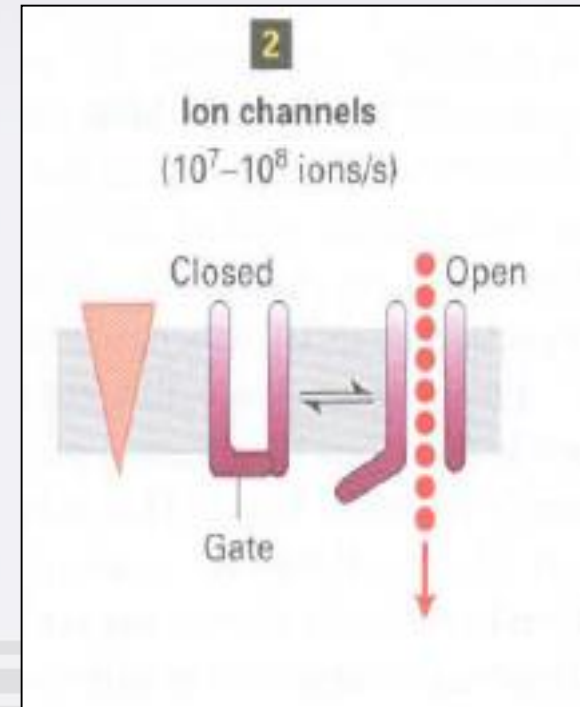
- Against a chemical concentration gradient, an electric potential.
- **Active transport**



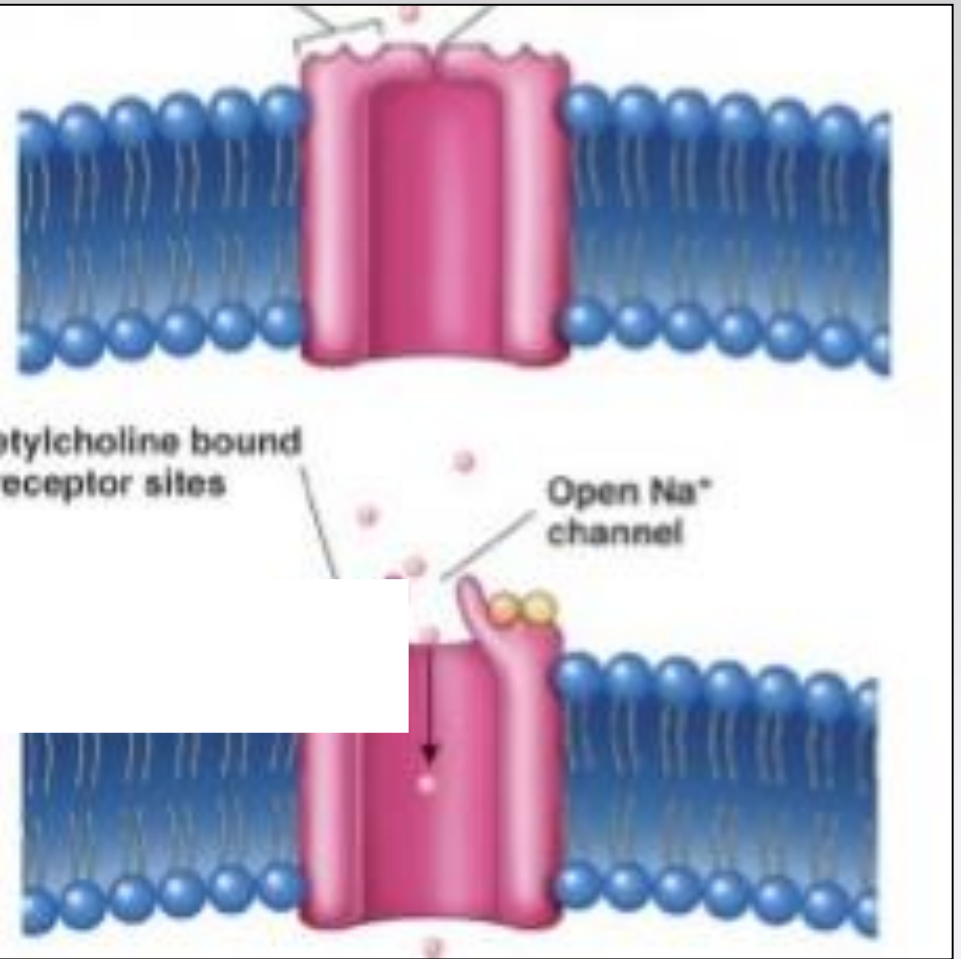


## 2.Channels

- ❑ Water, specific ions or hydrophilic small molecules
- ❑ Down their concentration or electric potential gradients.
- ❑ Facilitated transport

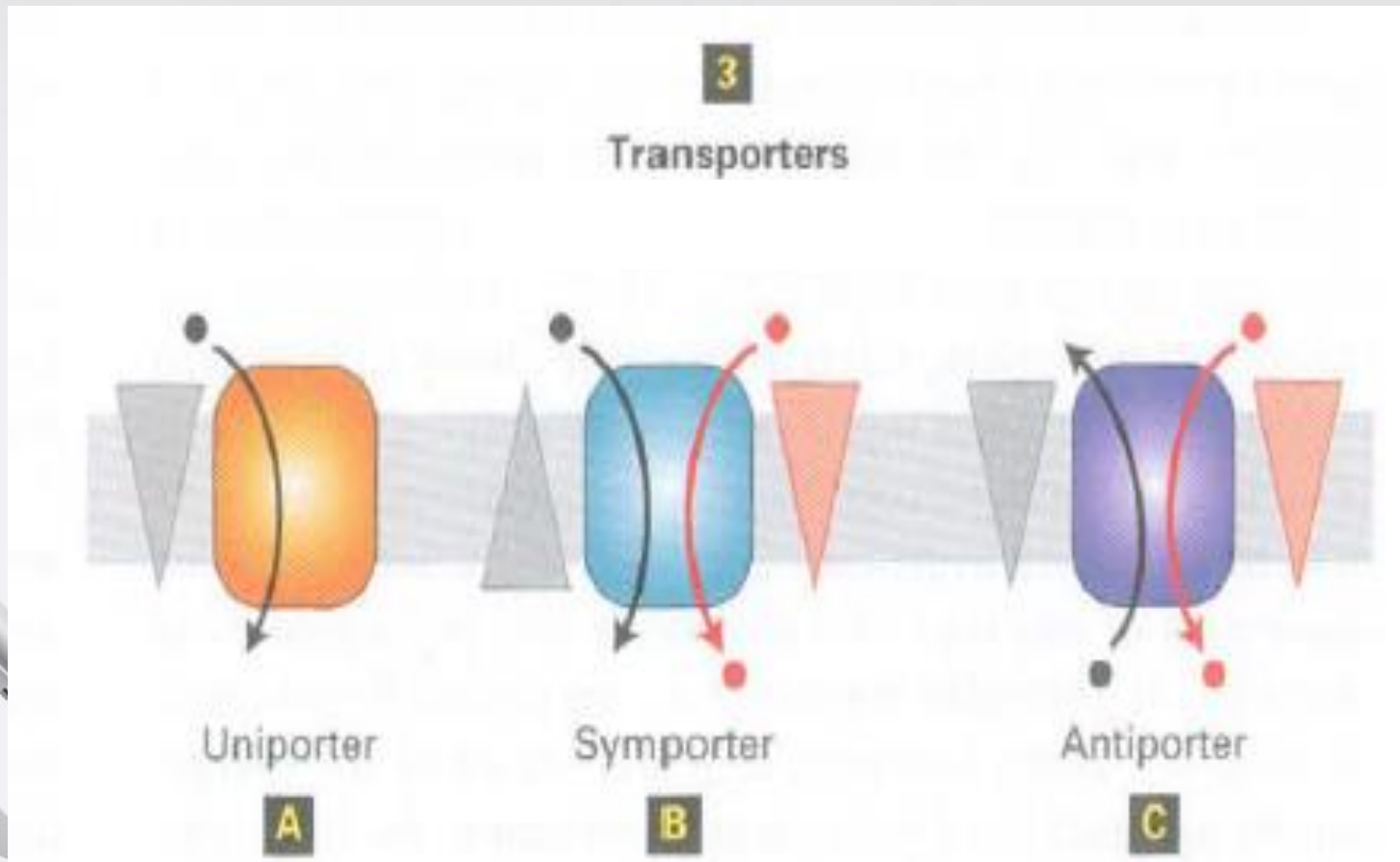


# □ Non-gated channels



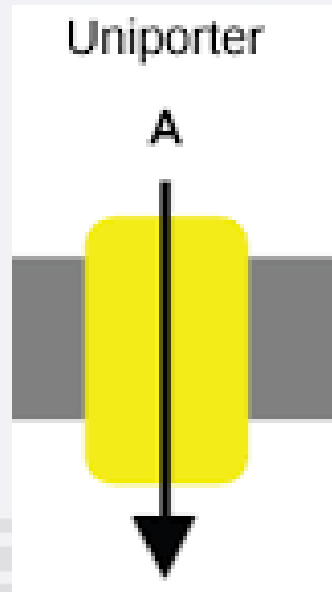
# 3. Transporters (carriers)

- A wide variety of ions and molecules



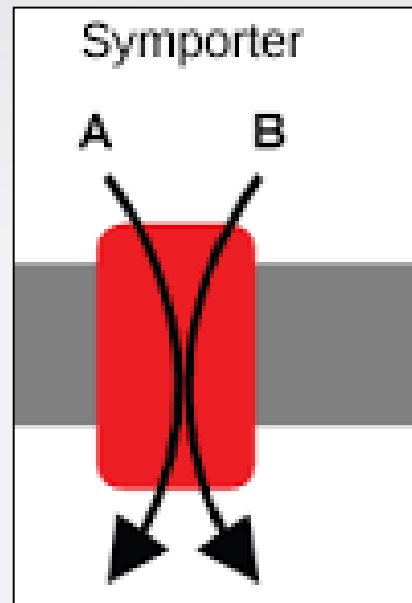
# 3.1. Uniporters

- ❑ Transport **a single type** of molecule **down** its **concentration gradient**.
- ❑ **Glucose** and **amino acids**
- ❑ Sometimes called ***facilitated transporters***



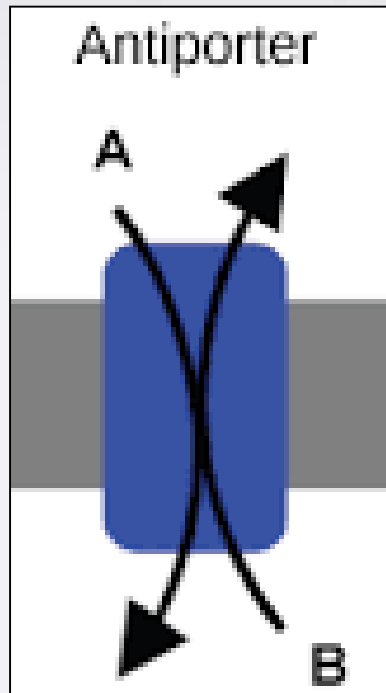
## 3.2. *Symporters*

- Co-transported substrate move in the same direction.

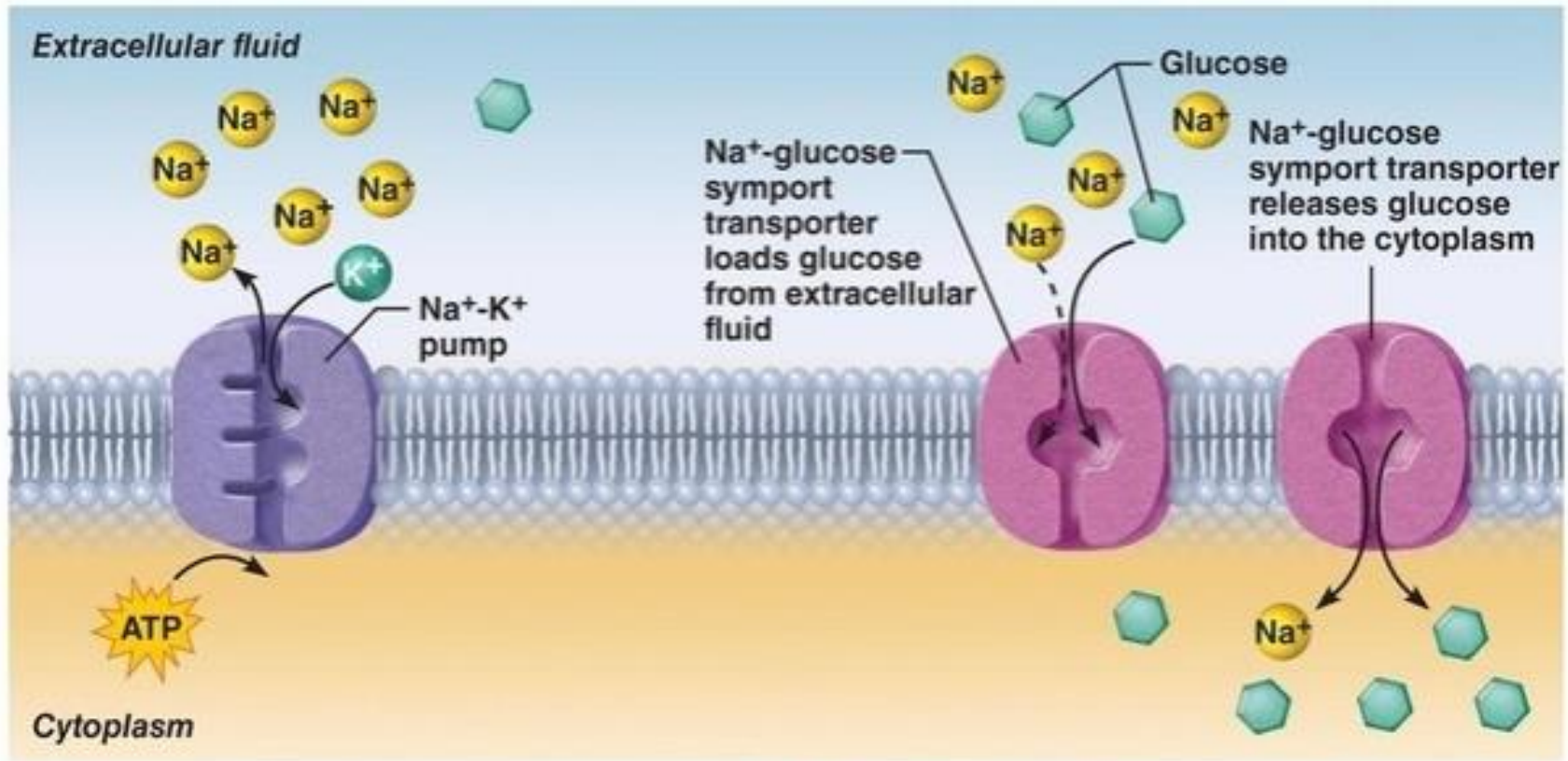


## 3.2. Antiporter

- Antiporters transport molecules in opposite directions.



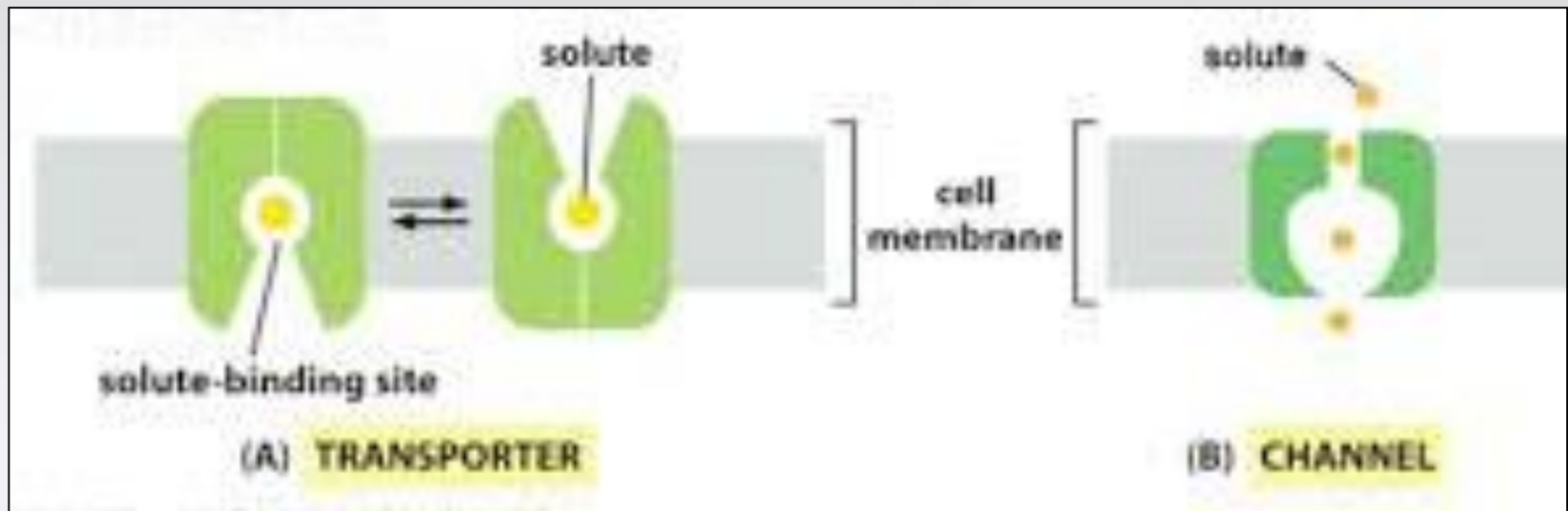
*Cotransporters*



① Primary active transport

② Secondary active transport

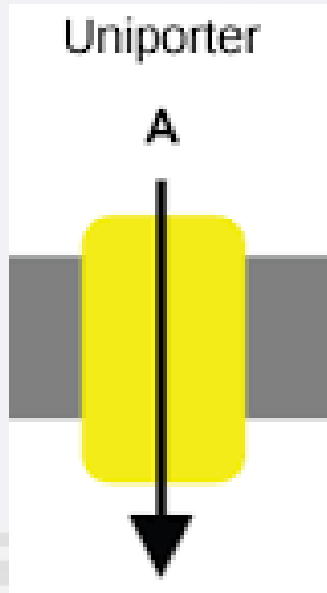






# Some Key feature of uniporters

- *Facilitated transporters*
- *Specificity*
- *Transfer speed*
- *Change the direction of transmission*



## Transport Mechanism

Property	Passive Diffusion	Facilitated Diffusion	Active Transport	Cotransport*
Requires specific protein	[ ]	[ ]	[ ]	[ ]
Solute transported against its gradient	[ ]	[ ]	[ ]	[ ]
Coupled to ATP hydrolysis	[ ]	[ ]	[ ]	[ ]
Driven by movement of a cotransported ion down its gradient	[ ]	[ ]	[ ]	[ ]
Examples of molecules transported	O <sub>2</sub> , CO <sub>2</sub> , steroid hormones, many drugs	Glucose and amino acids (uniporters); ions and water (channels)	Ions, small hydrophilic molecules, lipids (ATP-powered pumps)	Glucose and amino acids (symporters); various ions and sucrose (antiporters)



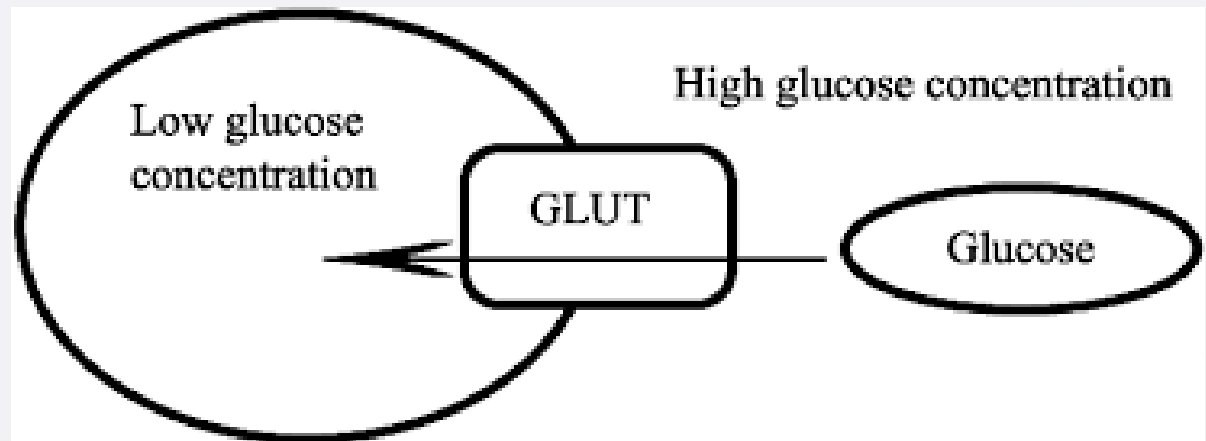
### Transport Mechanism

Property	Passive Diffusion	Facilitated Diffusion	Active Transport	Cotransport <sup>*</sup>
Requires specific protein	-	+	+	+
Solute transported against its gradient	-	-	+	+
Coupled to ATP hydrolysis	-	-	+	-
Driven by movement of a cotransported ion down its gradient	-	-	-	+
Examples of molecules transported	O <sub>2</sub> , CO <sub>2</sub> , steroid hormones, many drugs	Glucose and amino acids (uniporters); ions and water (channels)	Ions, small hydrophilic molecules, lipids (ATP-powered pumps)	Glucose and amino acids (symporters); various ions and sucrose (antiporters)



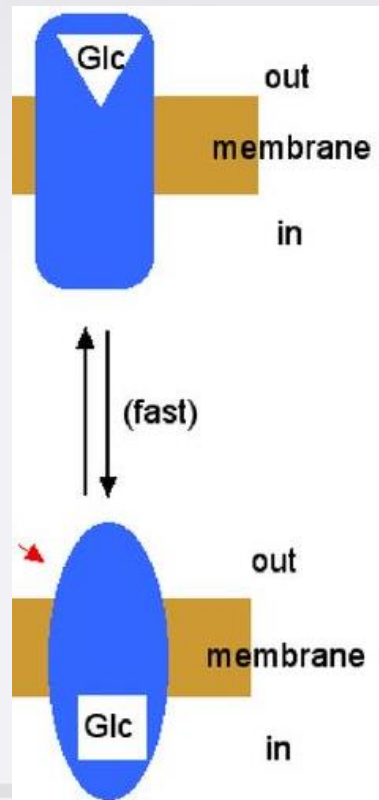
# Facilitated Transport of Glucose

- Uniporter
- Maximum transport rate
- Transport is reversible
- Transport is specific



# Glucose transporter 1 (GLUT1)

- Like other uniporters, GLUT1 alternates between two conformational states.

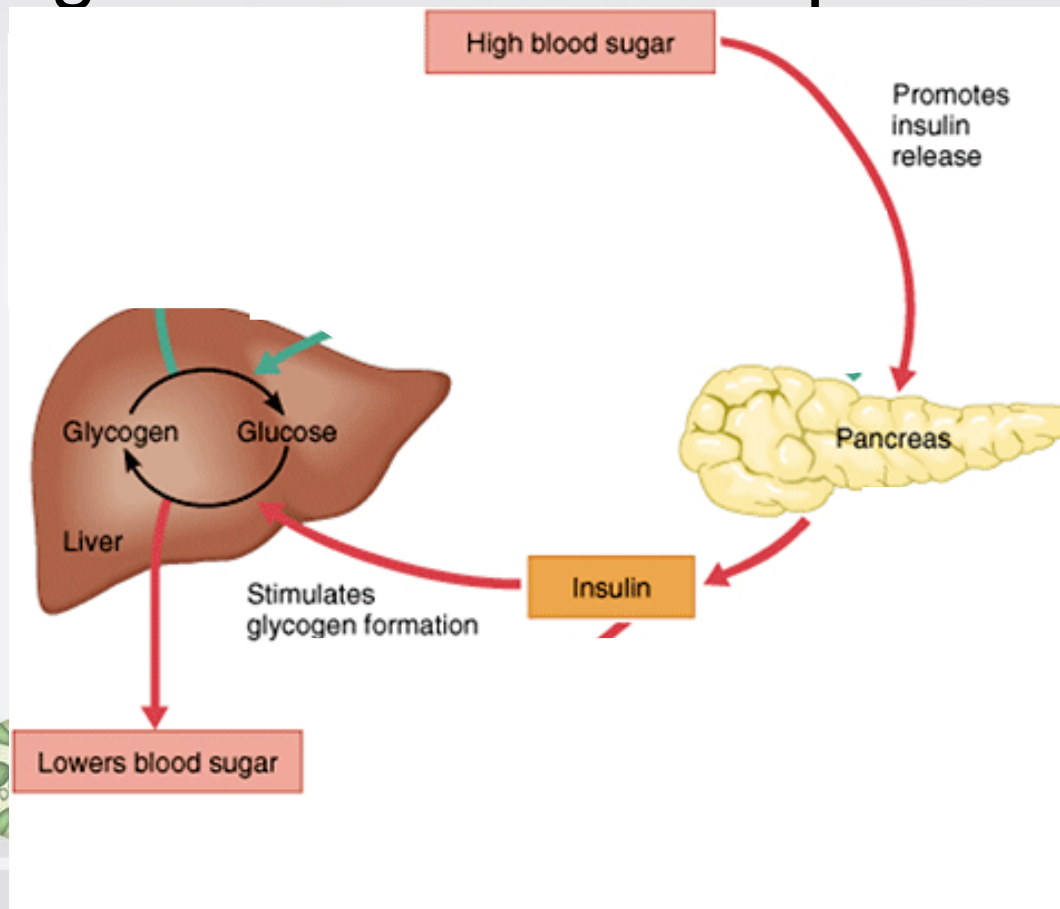


- Isomeric sugars **D-mannose** and **D-galactose**.
- After glucose is transported into the erythrocyte, it is **rapidly phosphorylated**.
- Genome encodes at least 14 highly homologous GLUT proteins, **GLUT1-GLUT14**.
- Contain **12 membrane-spanning a helices**

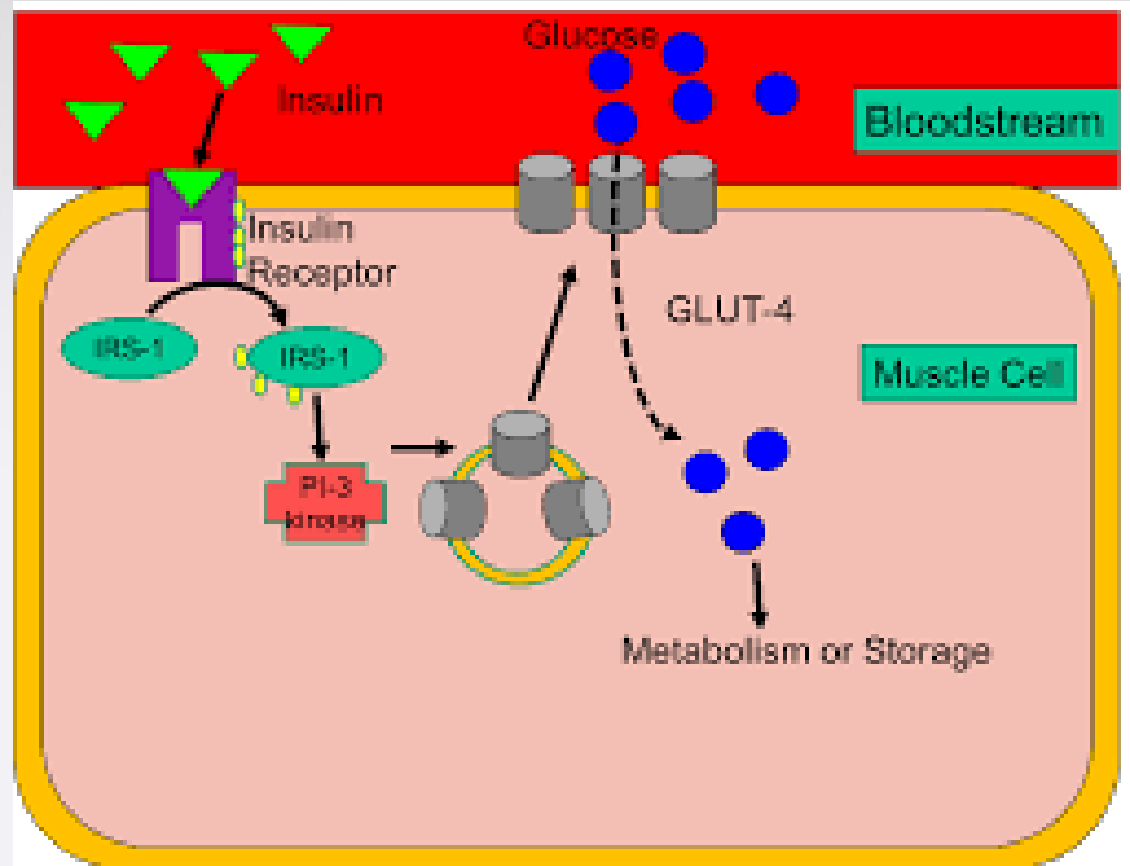


□ **GLUT1**: RBC, BBB (blood–brain barrier )

□ **GLUT2**: liver cells and the insulin-secreting islet  $\beta$ -cells of the pancreas.

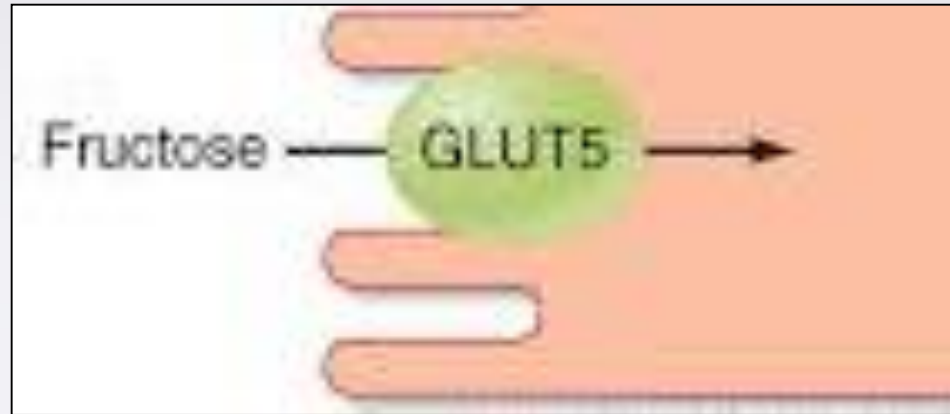


# □ GLUT 4: fat and muscle cells diabetes type II

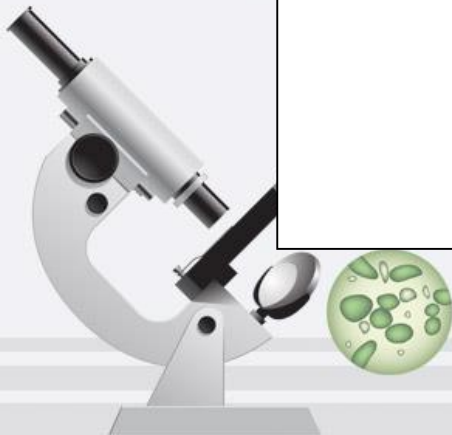
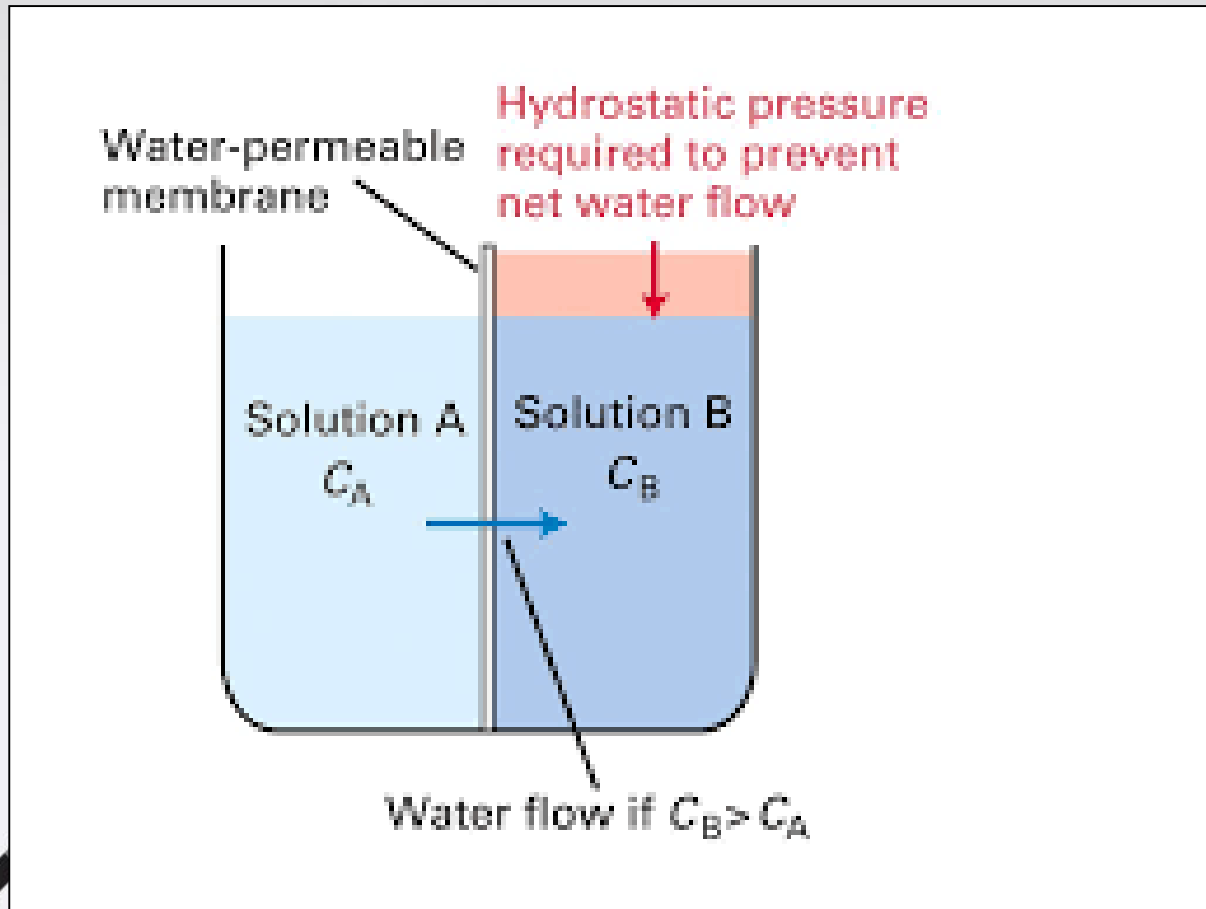




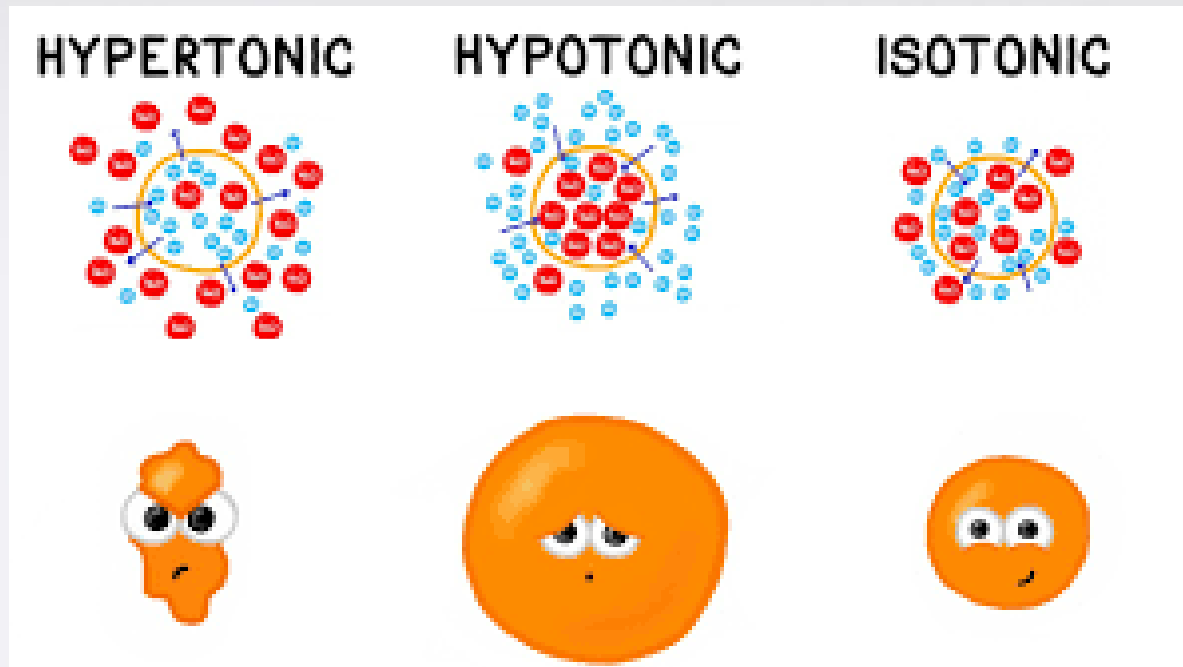
- **GLUT 5** : fructose, epithelial cells

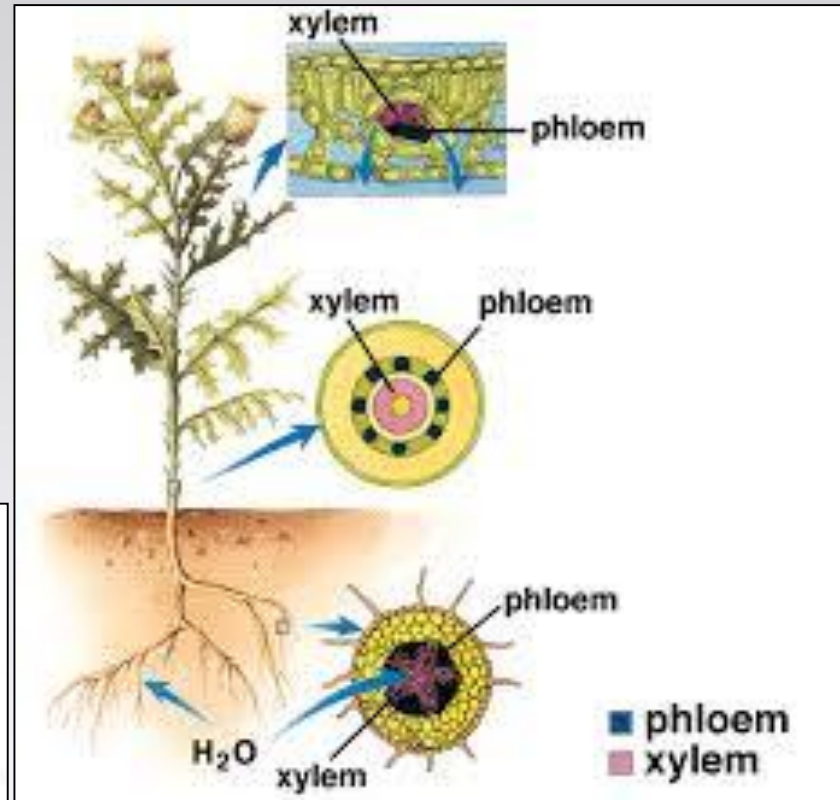
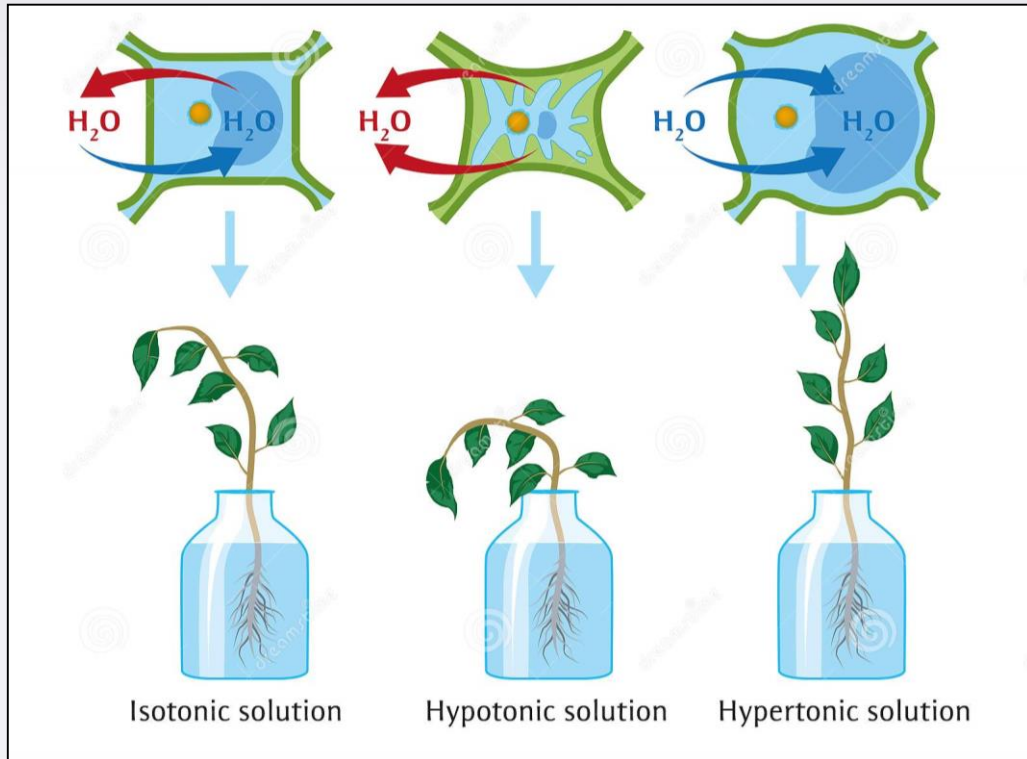


# Osmotic Pressure

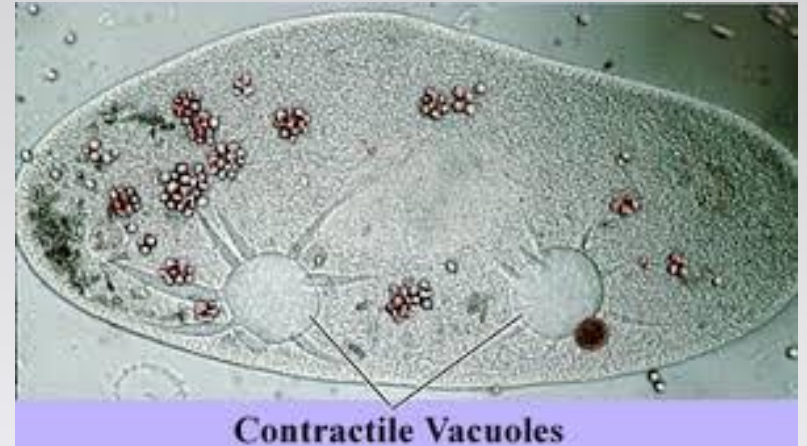
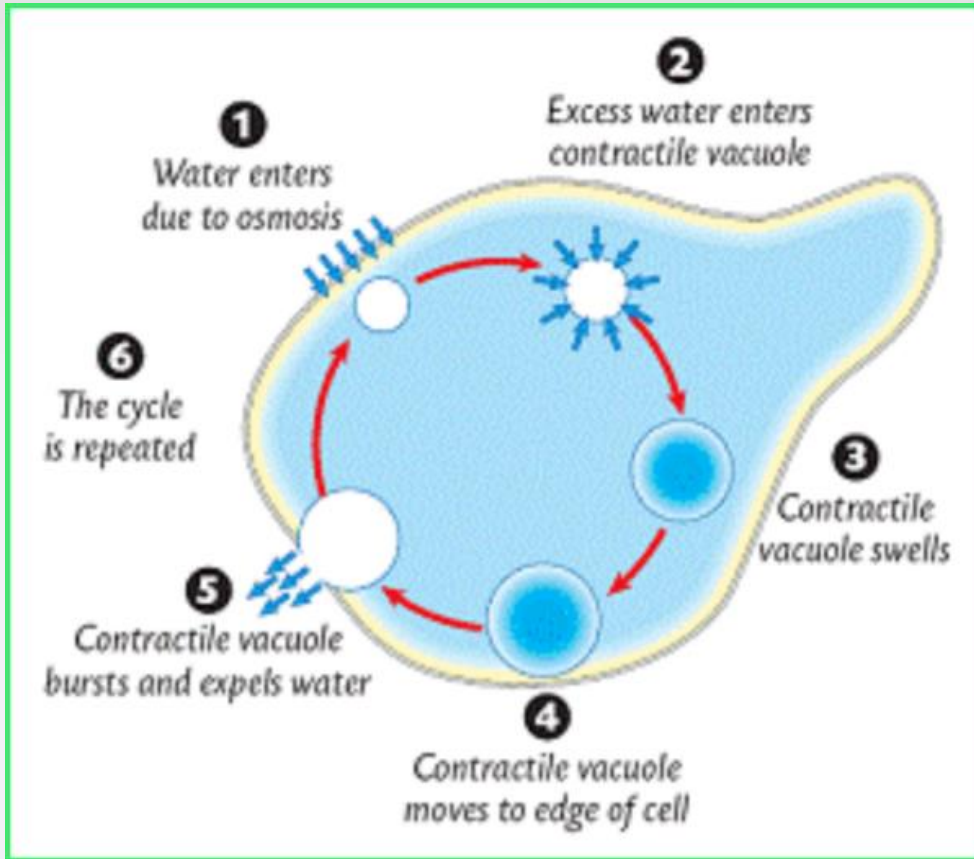


- The volume of individual cells





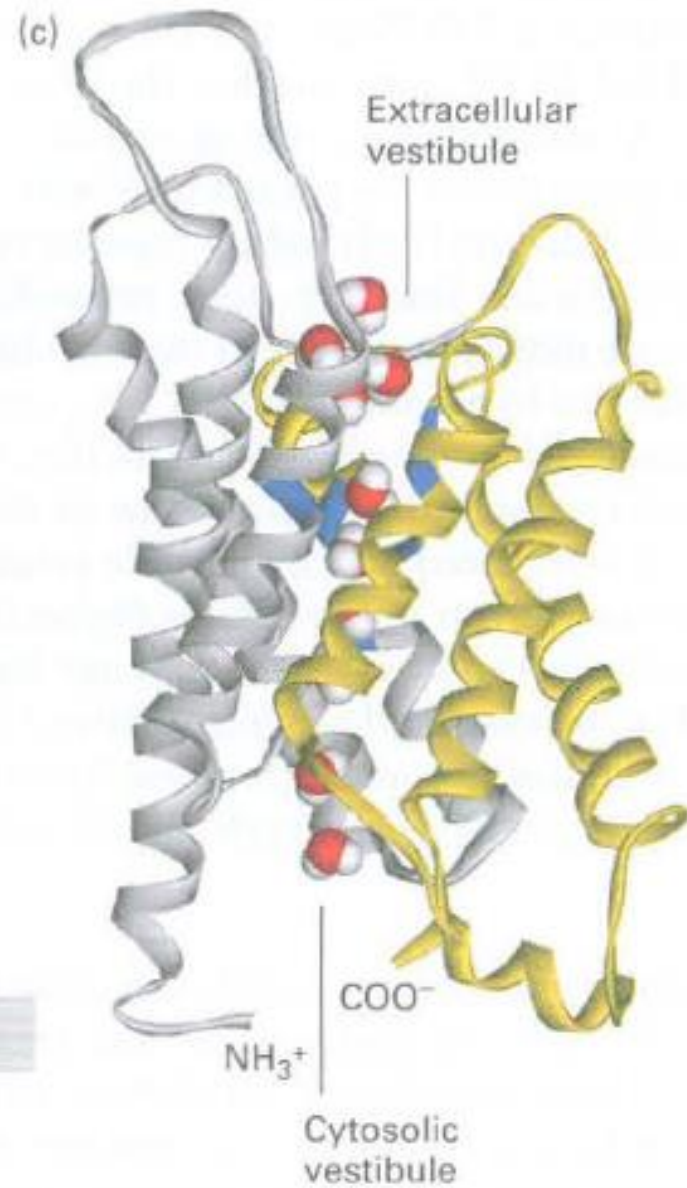
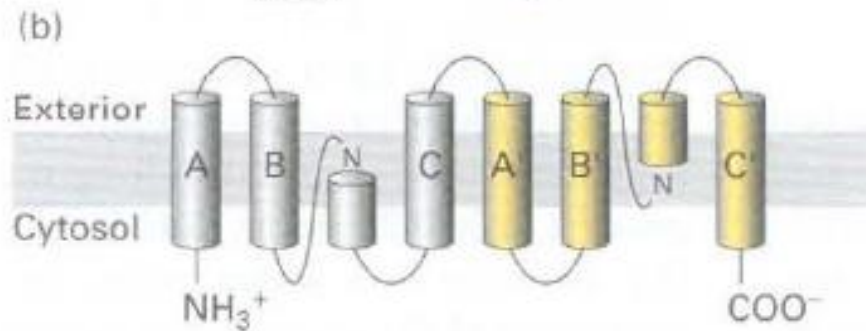
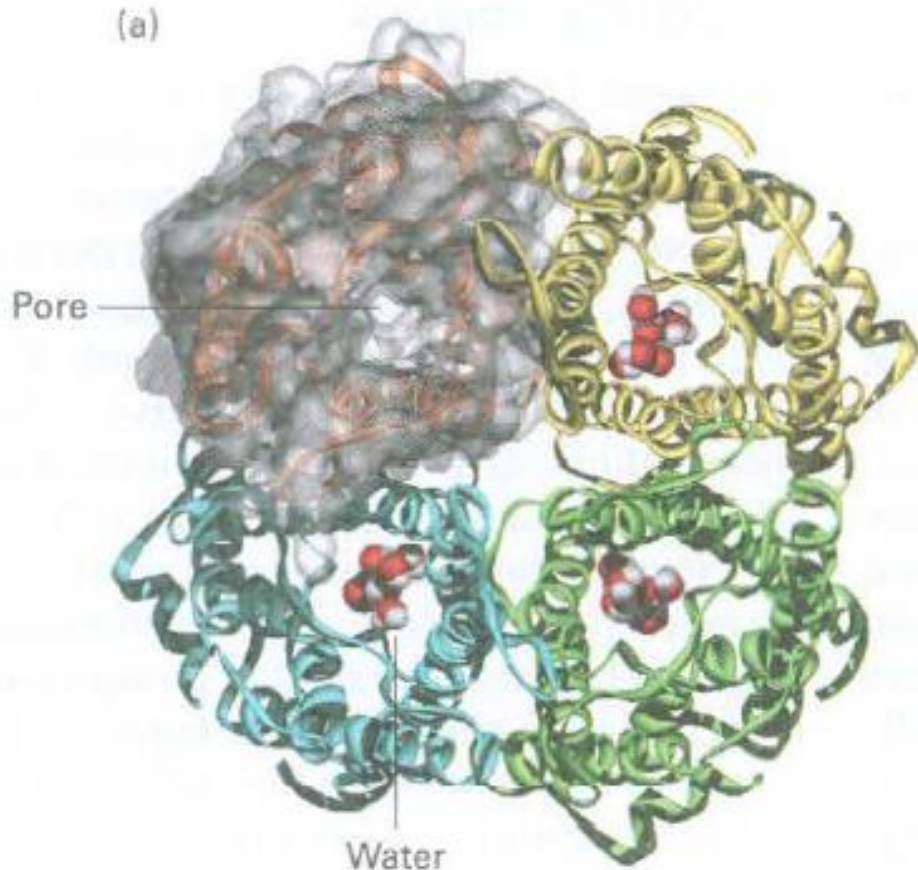
- protozoans



# Aquaporins

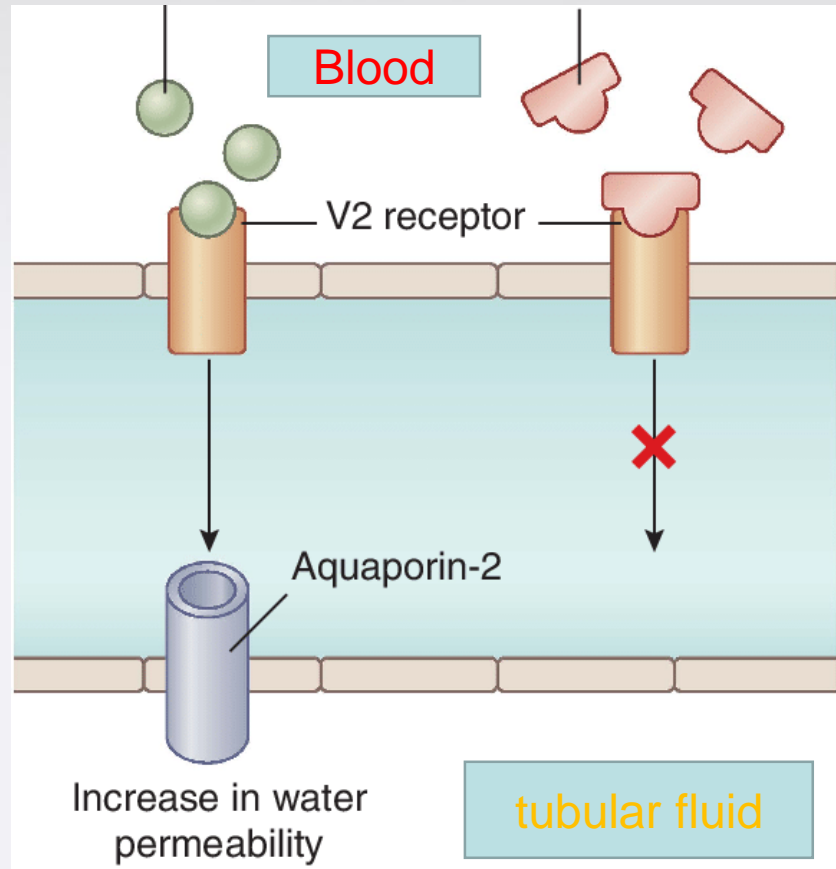
- Aquaporins Increase the Water Permeability of Cell Membranes





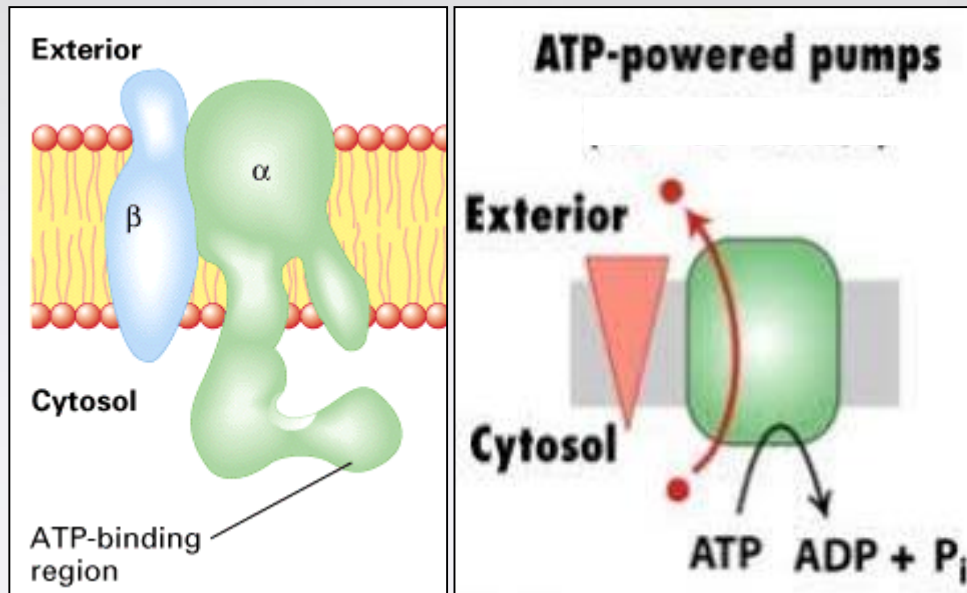
- **Aquaporin 1**: in RBC
  - **Aquaporin 2**: in the kidney epithelial cells
- Antidiuretic (ADH) or vasopressin

diabetes insipidus





# ATP-Powered Pumps

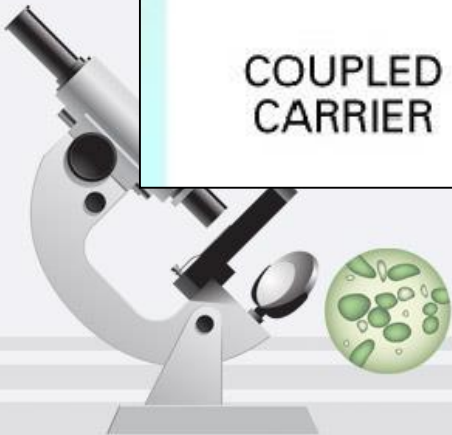
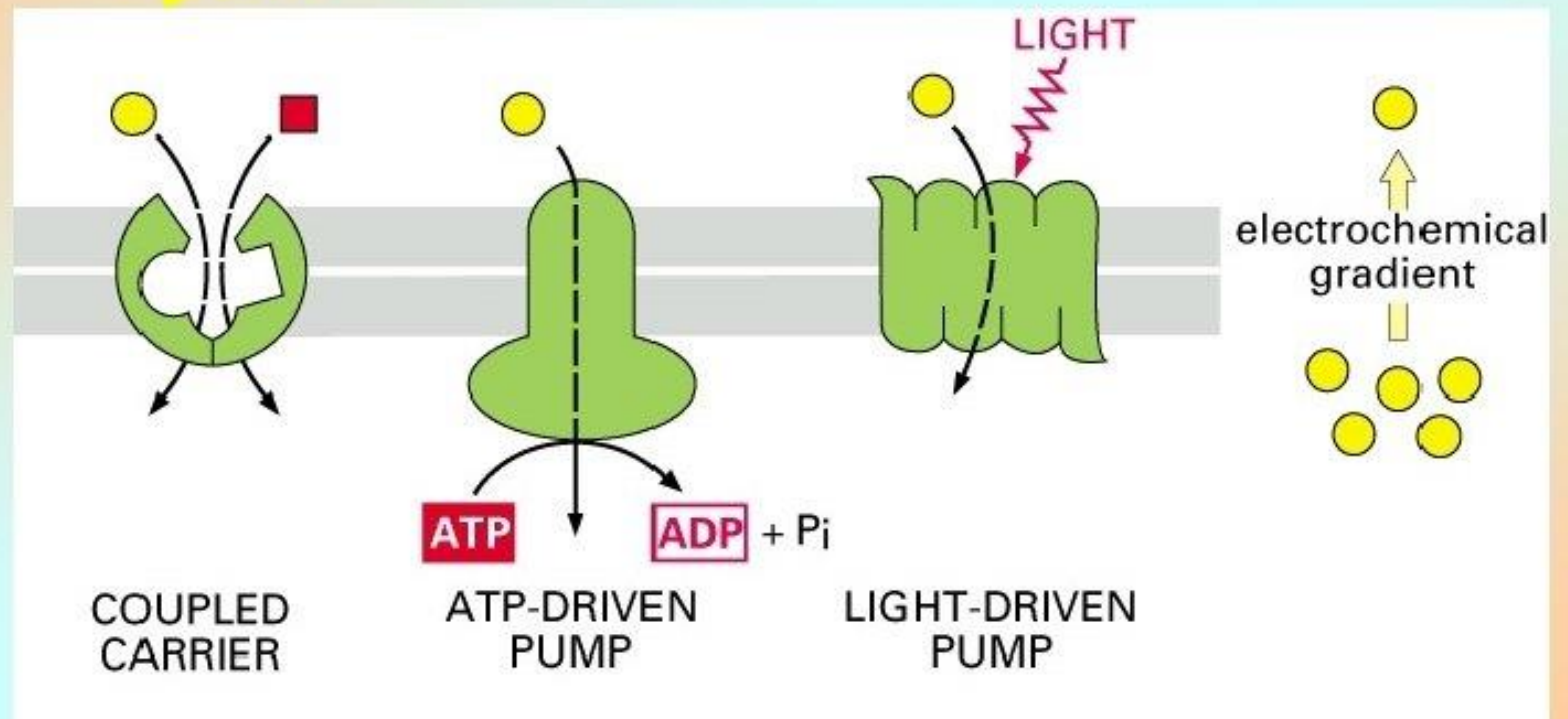


- P class pump
- F class pump
- V class pump
- ABC superfamily

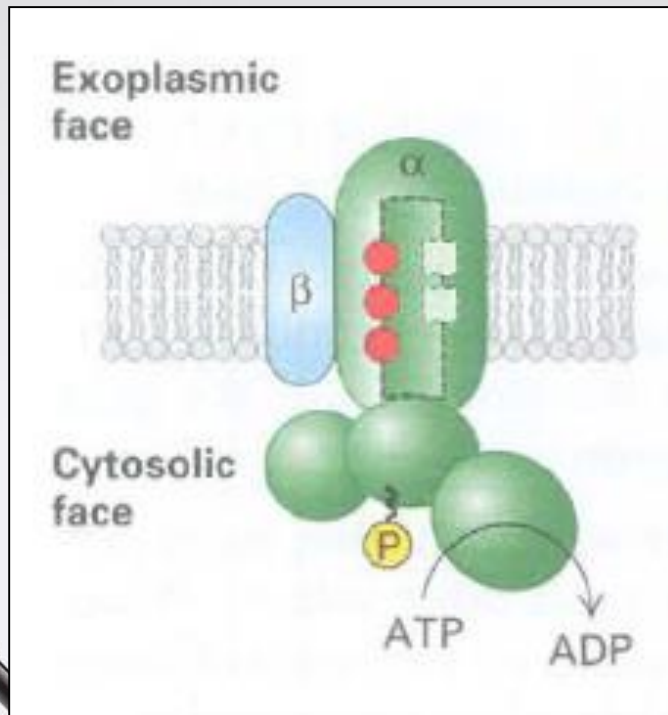


# Active transport

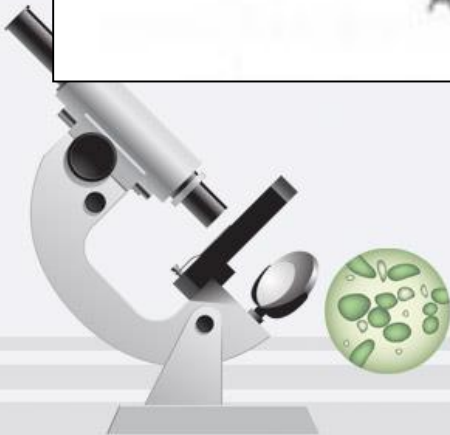
- **Energy** is required



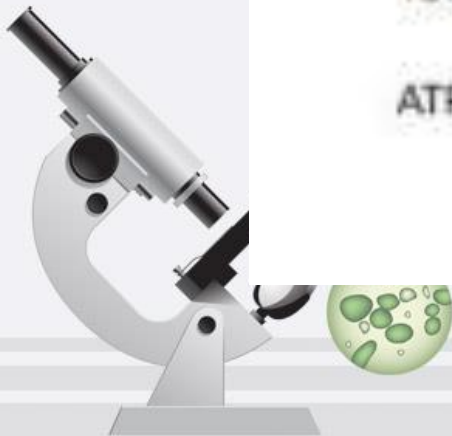
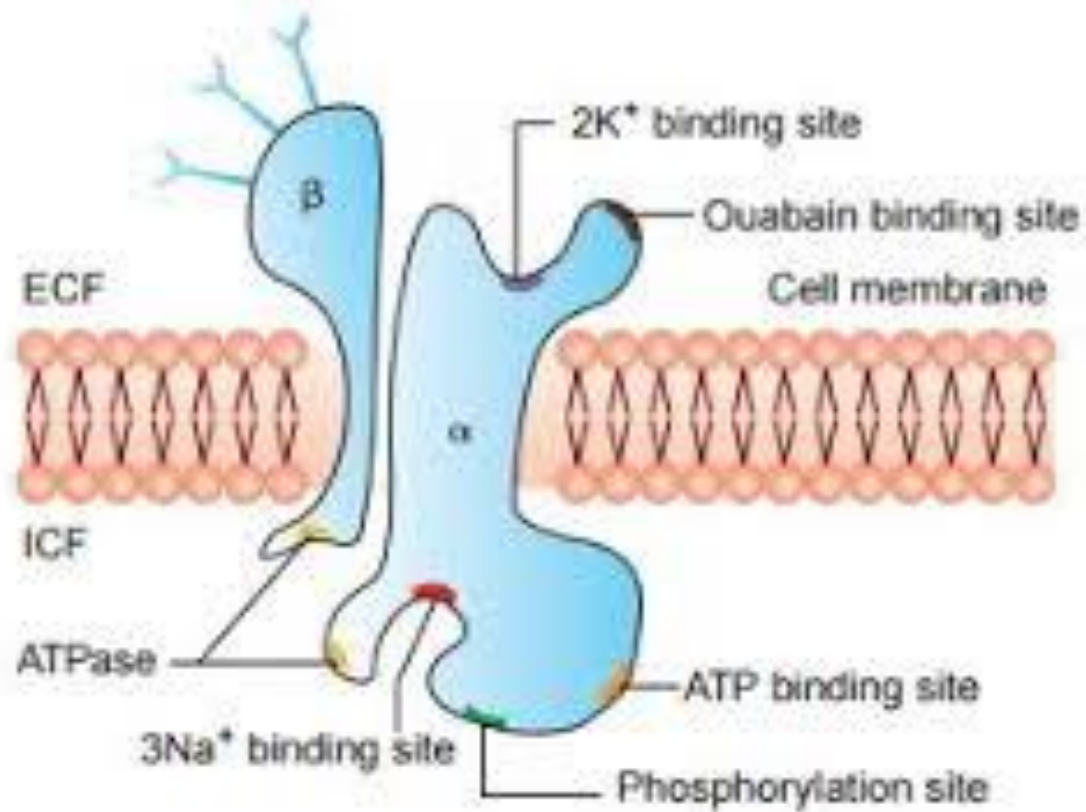
# *P-class ion pumps*

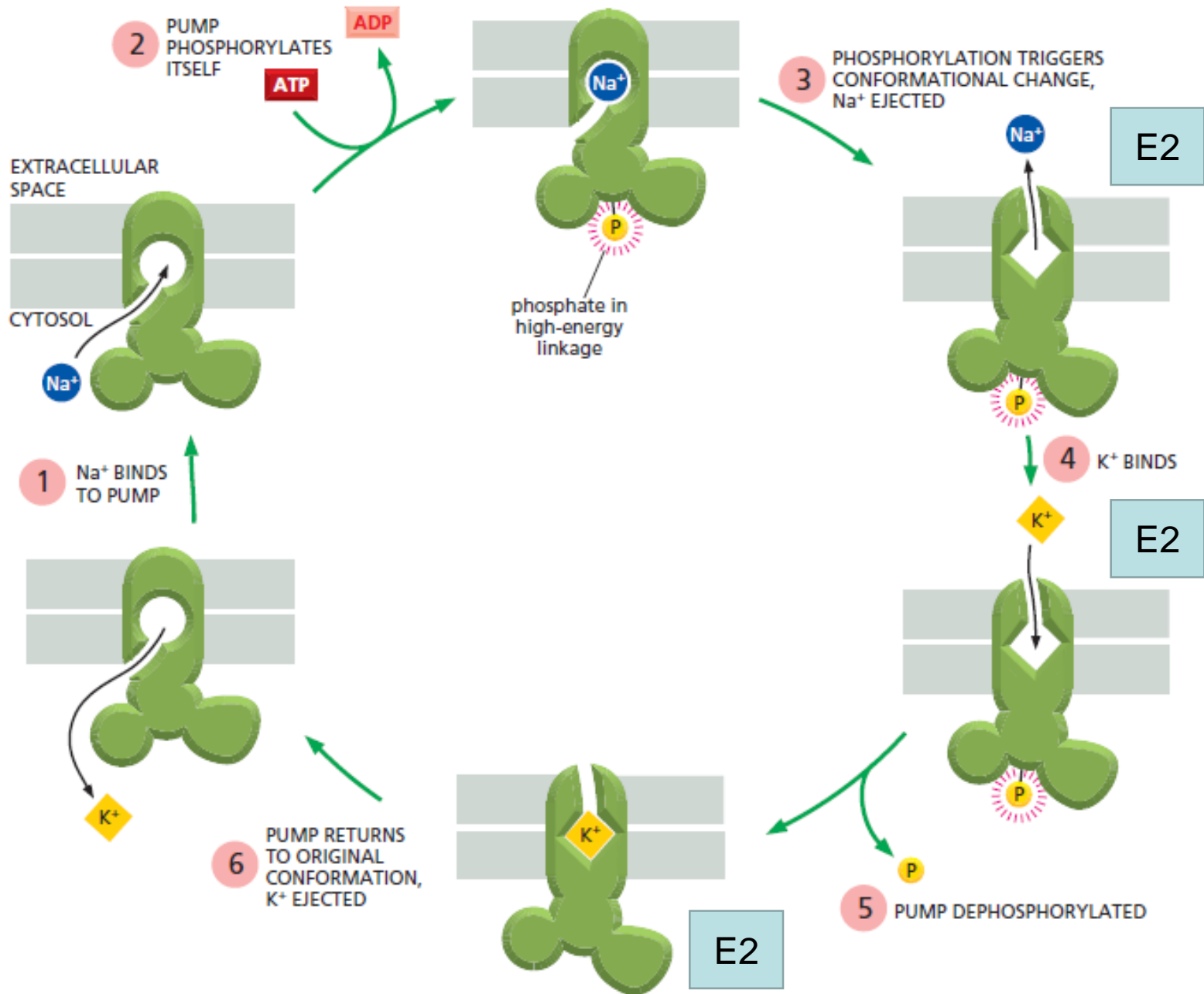


- ❖  $\text{Na}^+/\text{K}^+$  pump
- ❖  $\text{Ca}^{2+}$  pump
- ❖  $\text{H}^+$  pump

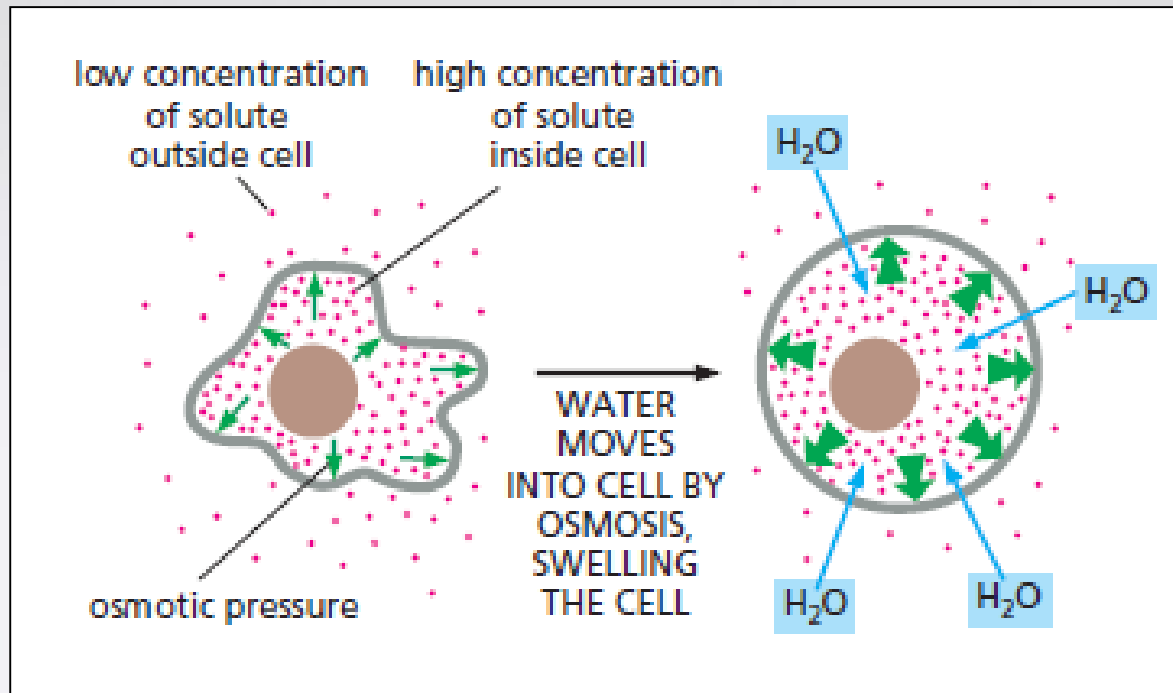


# Na<sup>+</sup>/K<sup>+</sup> pump





- The  $\text{Na}^+\text{-K}^+$  Pump Helps Maintain the Osmotic Balance of Animal Cells

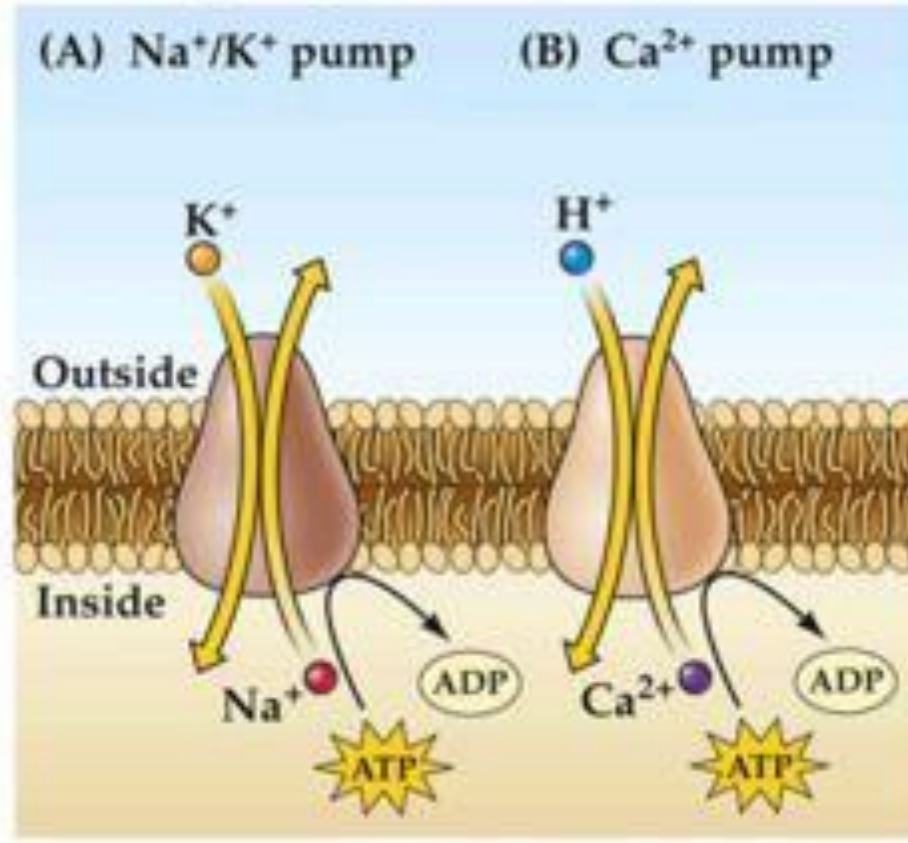


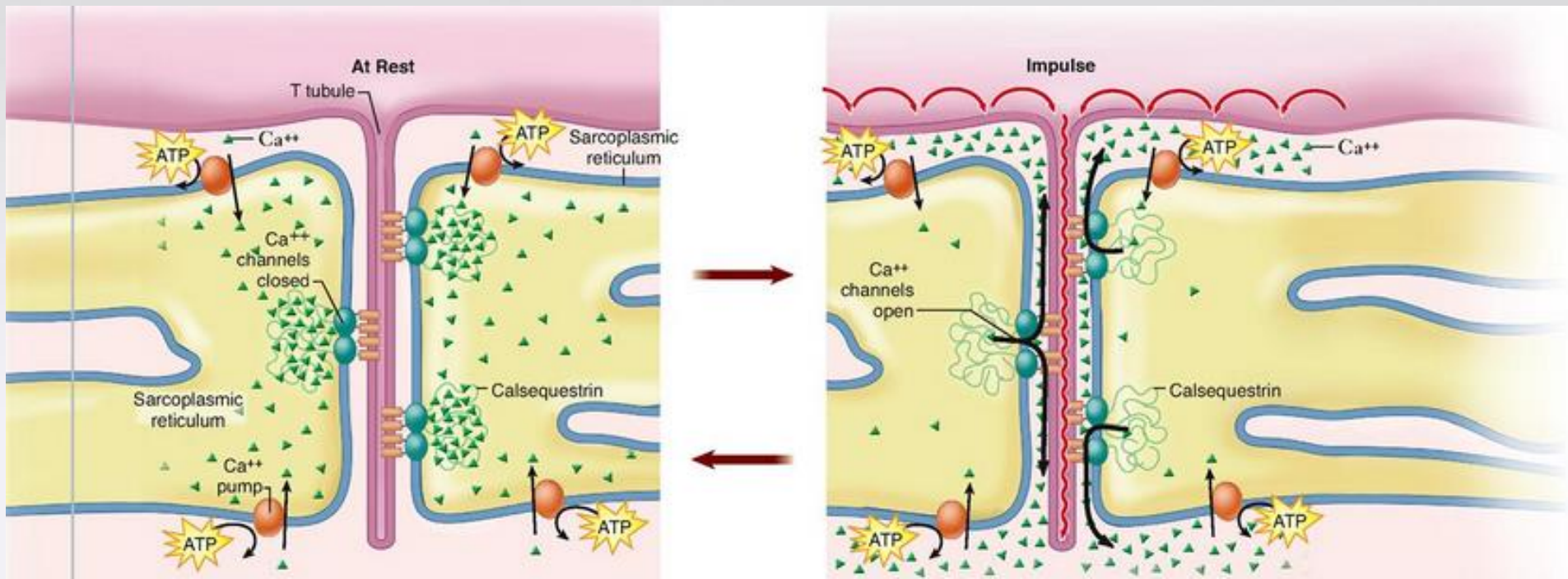
# Ca<sup>2+</sup> pump

## ATPase pumps

(A) Na<sup>+</sup>/K<sup>+</sup> pump

(B) Ca<sup>2+</sup> pump

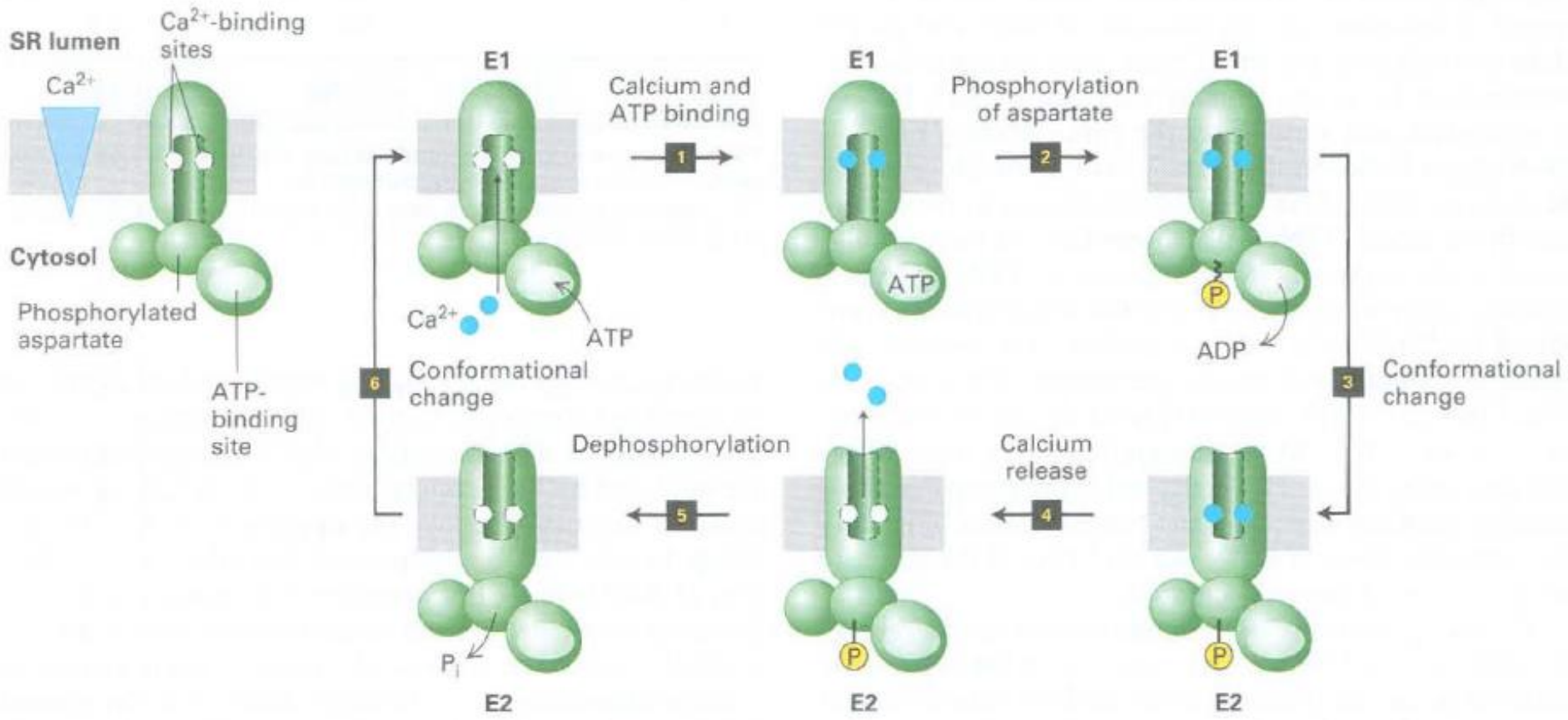


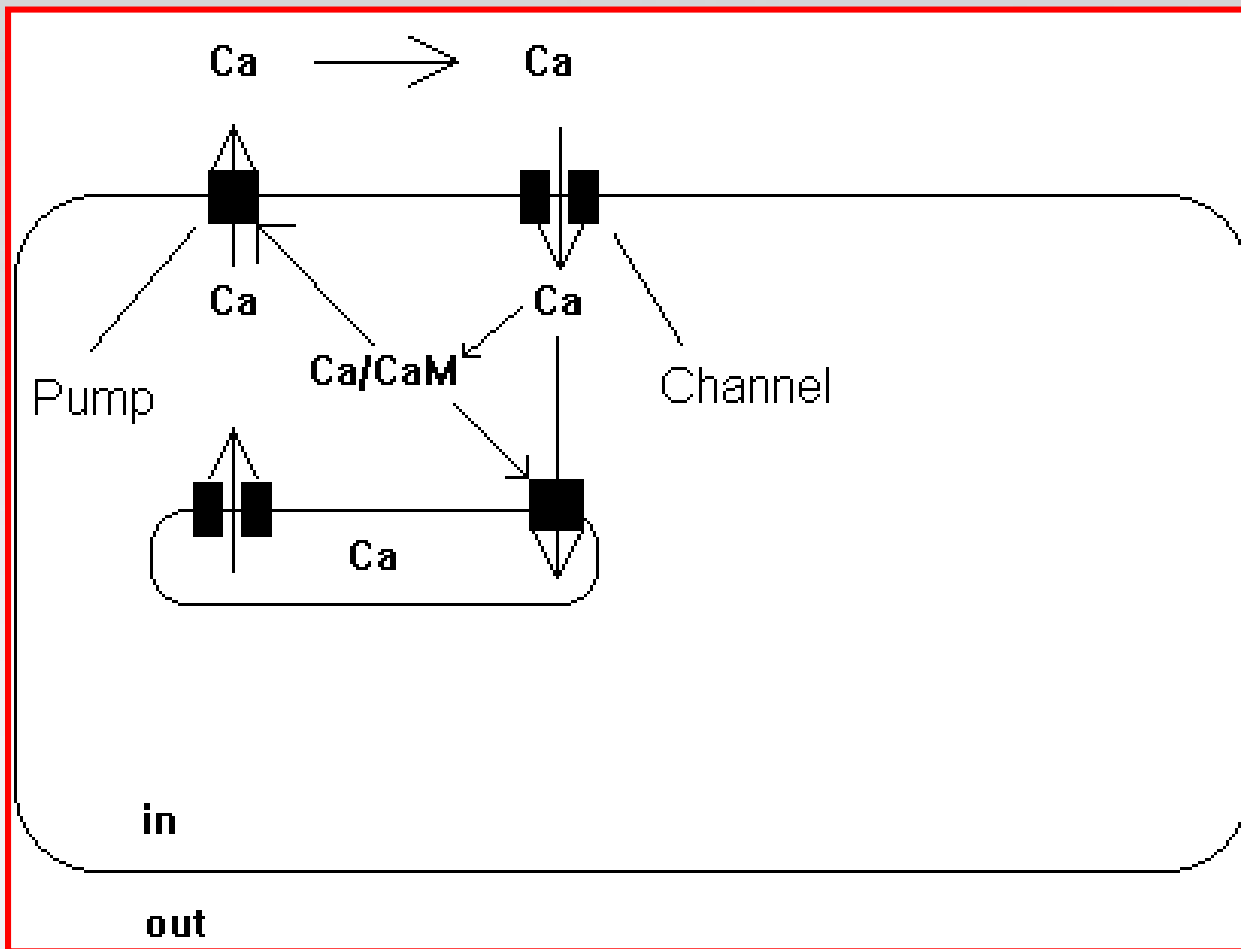


## Sarcoplasmic Reticulum (SR)





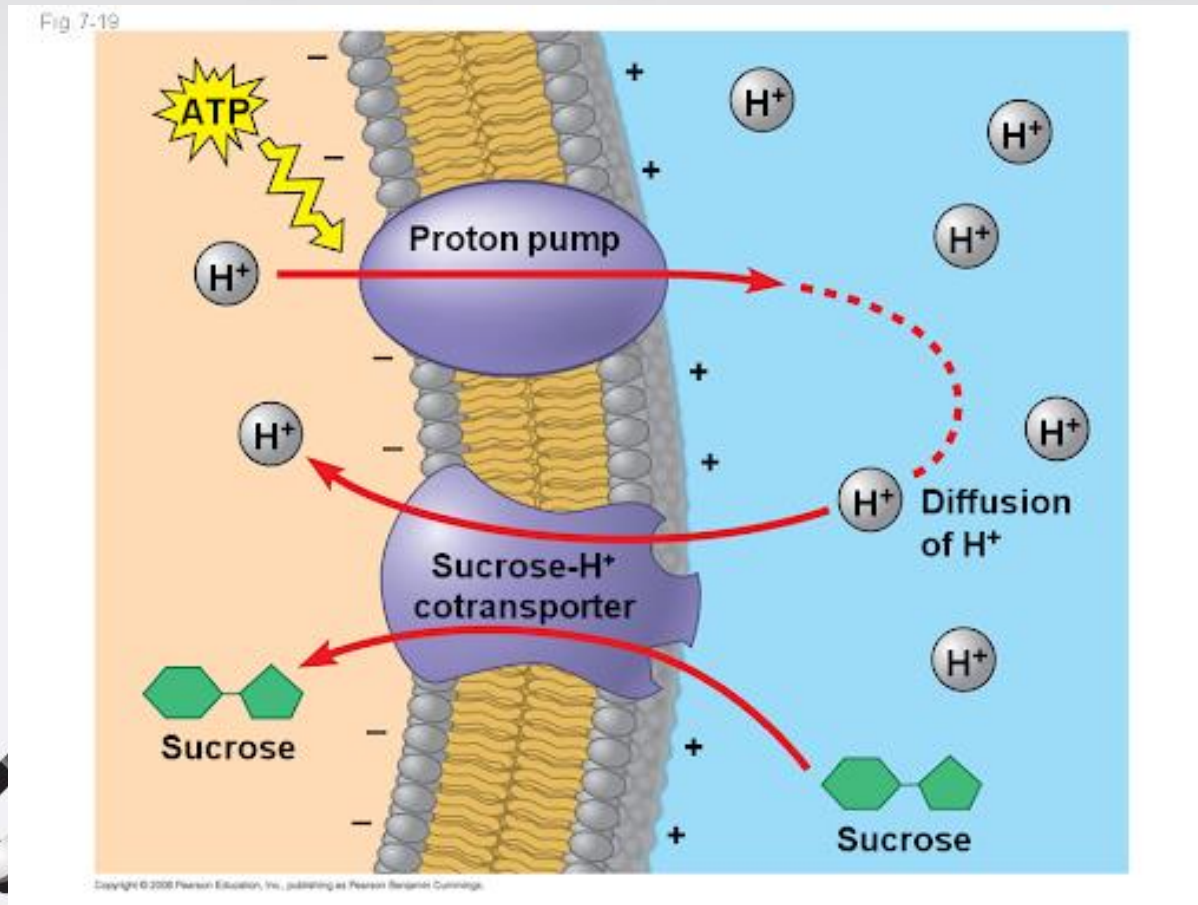


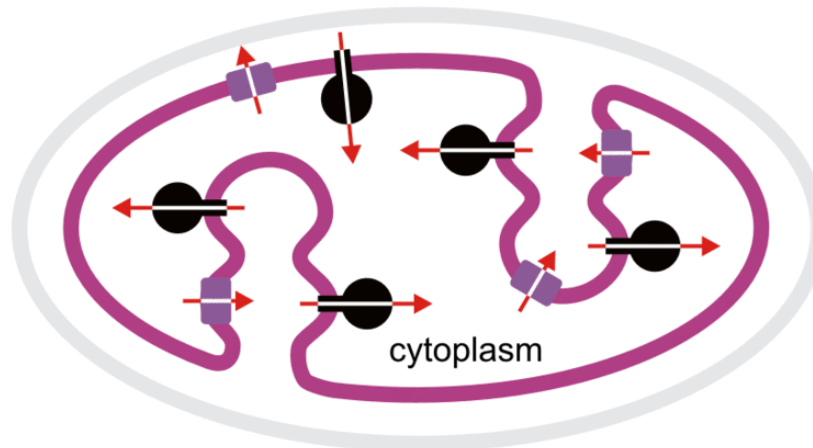
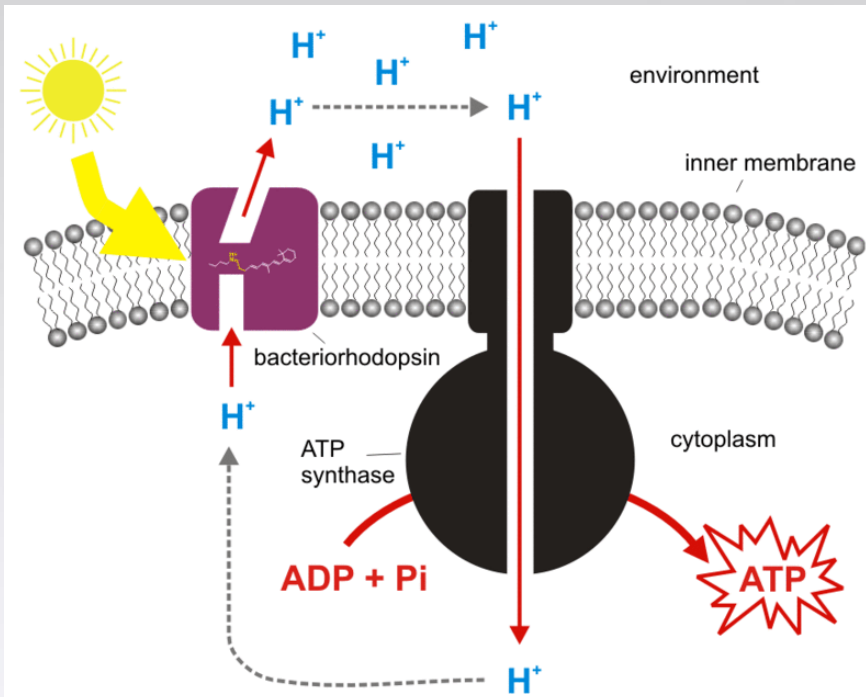


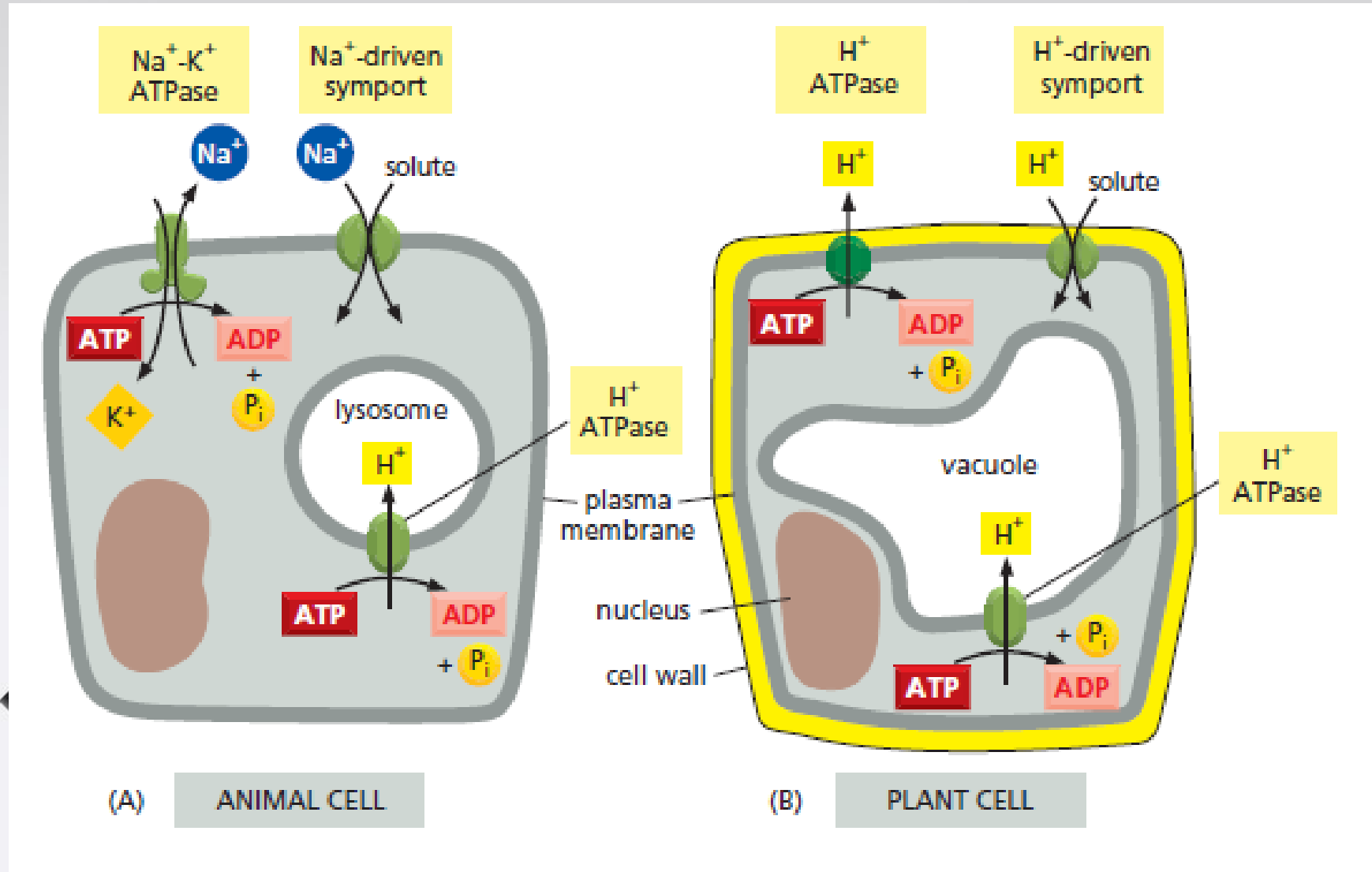
**Calmodulin**



# H<sup>+</sup> pump

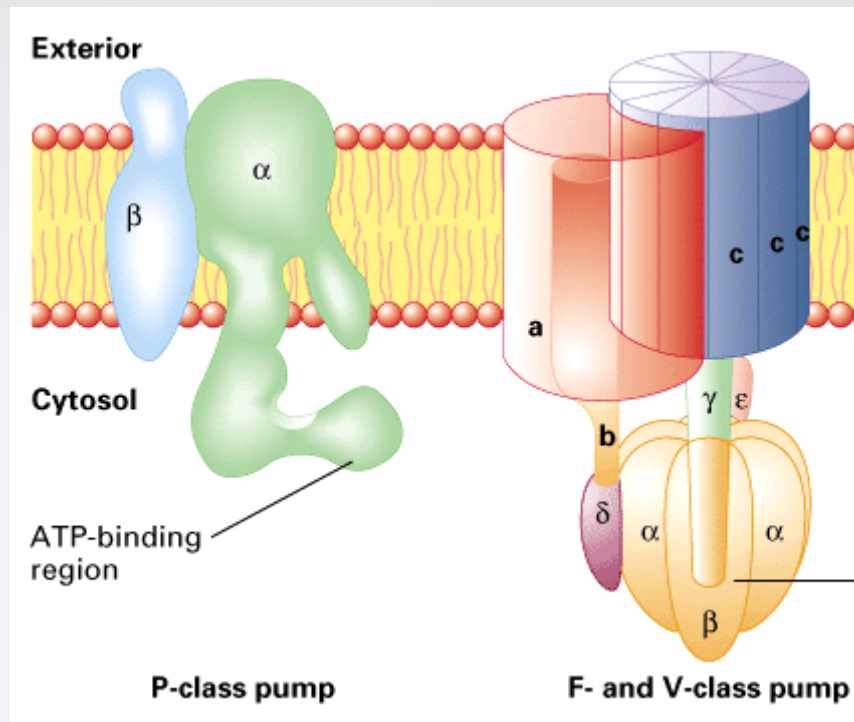


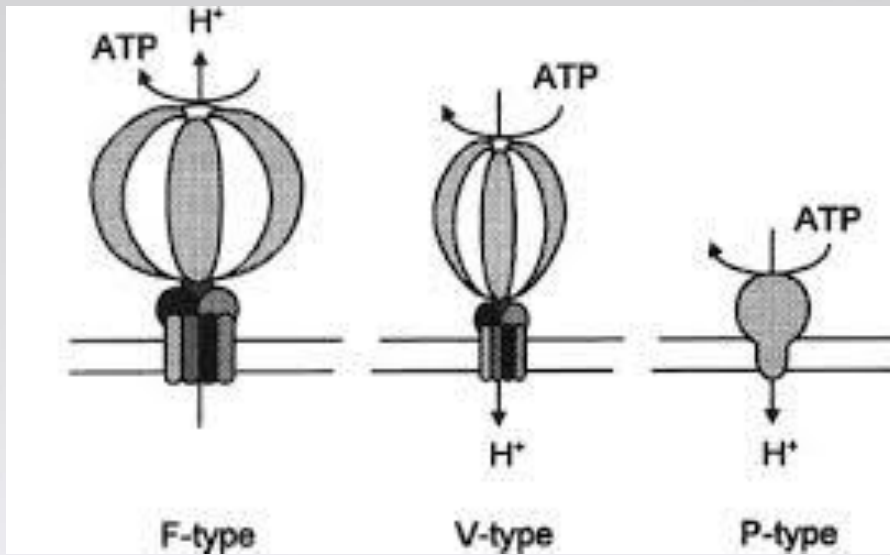




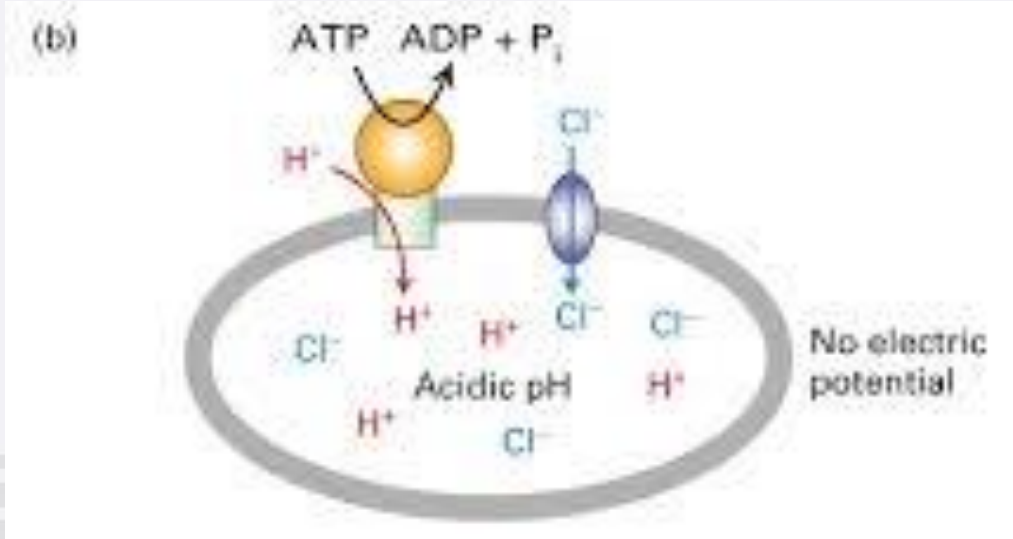
# *V-class and F-class ion pumps*

- V and F pumps transport only H<sup>+</sup>





F-class pumps are found in **bacterial plasma membranes** and in **mitochondria and chloroplasts**.



# ABC superfamily (ATP binding cassette)

