Membrane Transport

Facilitative Diffusion

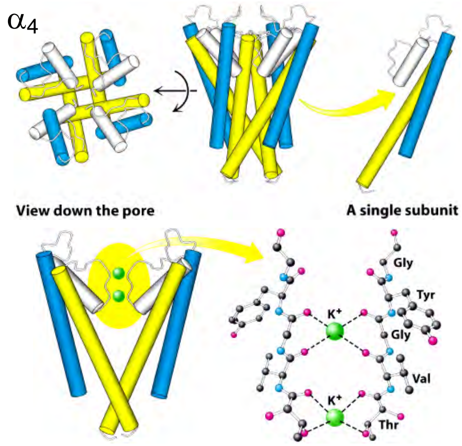
Membrane Transport

Examples:

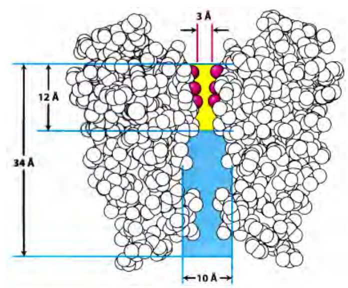
- Facilitative Diffusion
  - Ionophore
  - Maltoporins
  - GLUT1 transprter
  - Aquaporin
  - Selective ion channel for potassium (K-channels)
- Active Transport
  - Primary (1°)
    - Na/K
    - ABC
  - Secondary (2°)
    - Na/Glc
    - Bicarb/Cl
  - Group Translocation
    - Bacterial phosphotransferase system (PTS)

Membrane Transport

Examples of Facilitative Diffusion



Potassium Channel KcsA K^+ allows specific passage of this ion through membranes



Membrane Transport

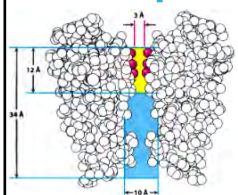
K channel

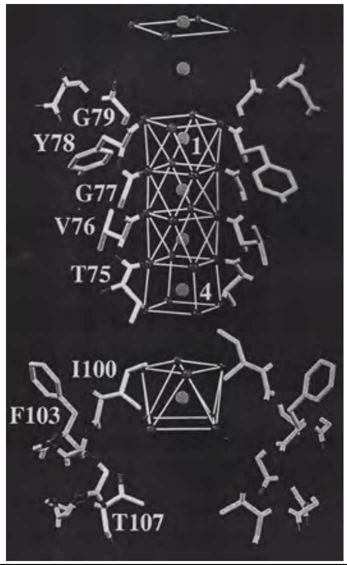
https://www.youtube.com/watch?v=IXPmgprE8rg&feature=youtu.be

KcsA K^+ channel in complex with a monoclonal Fab antibody fragment

Membrane Transport

Examples of Facilitative Diffusion



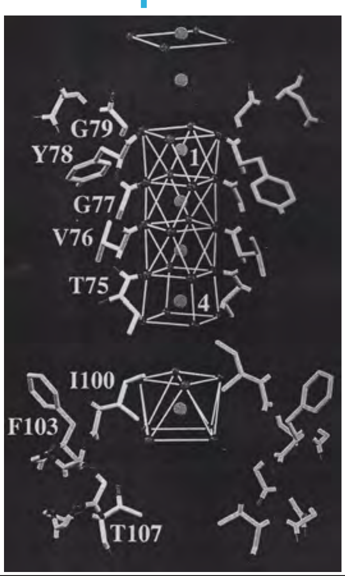


How is the >100X specificity for K^+ achieved?

Ion	Radius (Å)
Li^+	0.6
Na^+	1.0
K^+	1.3
Rb^+	1.5
Cs^+	1.7

Membrane Transport

Examples of Facilitative Diffusion



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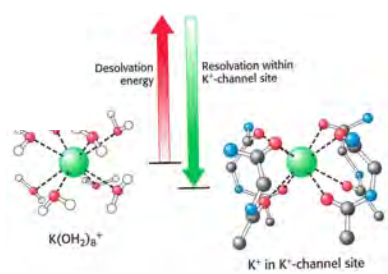
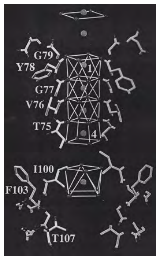
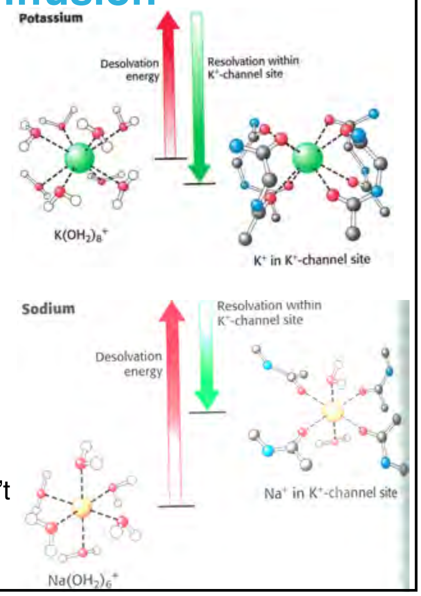


Membrane Transport

Examples of Facilitative Diffusion



Ion	Radius (Å)	Energy of dehydration (kcal/mole)
Li^+	0.6	– 98
Na^+	1.0	– 72
K^+	1.3	– 55
Rb^+	1.5	– 51
Cs^+	1.7	– 47



While specificity for Na^+ over K^+ can be achieved by the size of the binding site, that won't work the other way around. To get specificity of K^+ over Na^+, the protein takes advantage of the higher (30%) energy of dehydration. It takes more energy to dehydrate Na^+ than K^+ and the protein doesn't make as good bonds to metal as does water shell (see off-set oxygens in polygon).

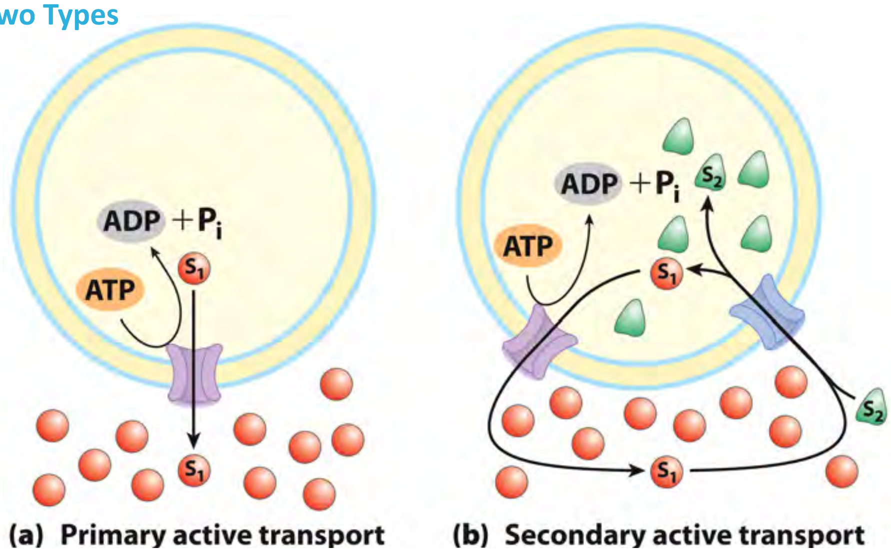
Membrane Transport

Active Transport

Membrane Transport

Examples of Active Transport

Two Types



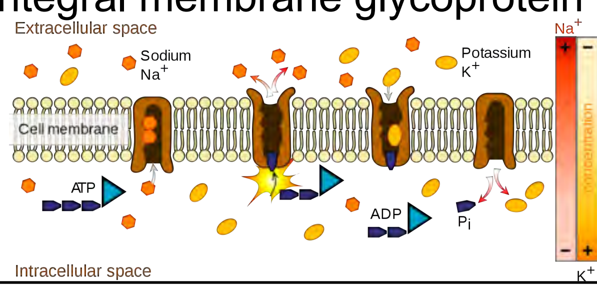
Membrane Transport

One of the best and most important examples of Active Transport (primary):

The **sodium–potassium (Na^+–K^+) pump** is primary active transport.

Found in all animal cells.

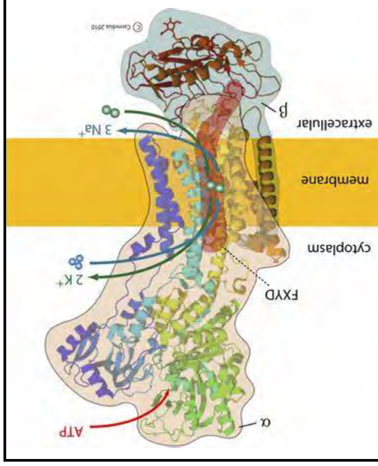
The pump is an integral membrane glycoprotein (an antiporter).

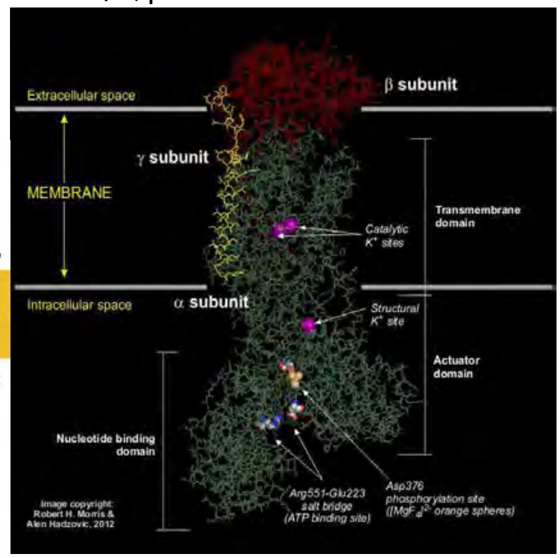


Membrane Transport

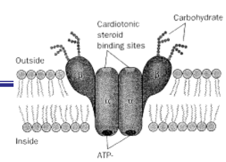
Sodium–potassium (Na^+–K^+) pump

$\alpha_2\beta_2\gamma$ pentamer

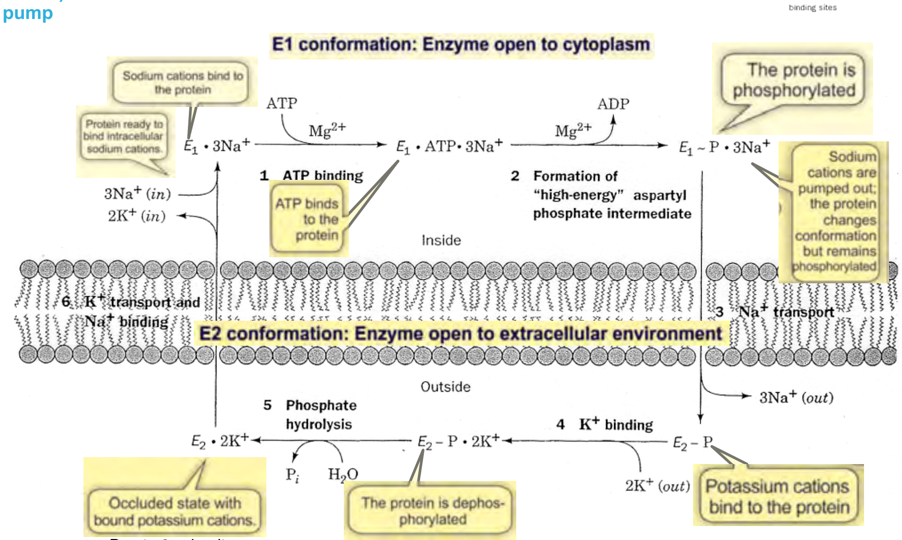




Membrane Transport



Sodium–potassium (Na^+–K^+) pump



Due to β subunit

Membrane Transport

Sodium–potassium (Na^+–K^+) pump

Potassium binding causes change to E1, which then causes P_i hydrolysis

https://youtu.be/M6_NCdV7YO8 cartoon

Membrane Transport

Sodium–potassium (Na^+–K^+) pump

Calls secondary active transport "facilitative diffusion"

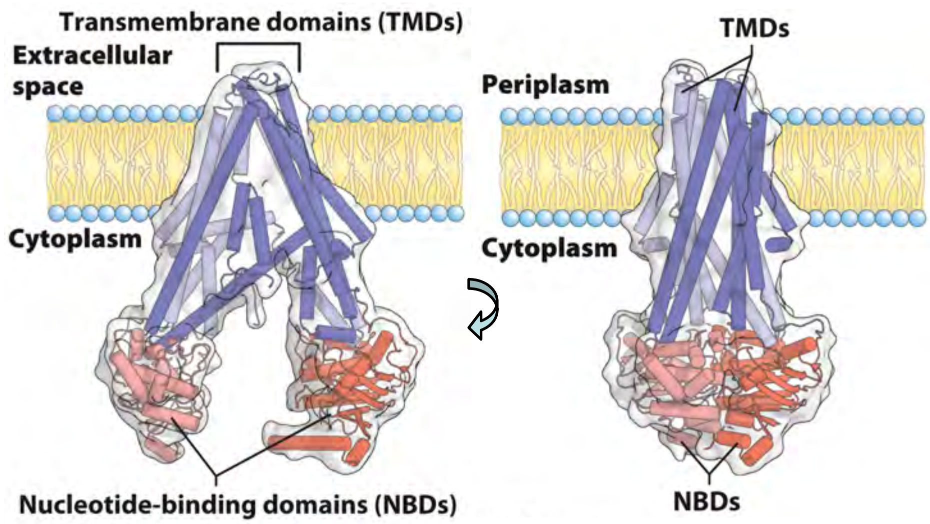
https://youtu.be/IKoKjCL27mA Khan academy

Membrane Transport

Sodium–potassium (Na^+–K^+) pump

video https://youtu.be/1zvnsrKQ2Jg

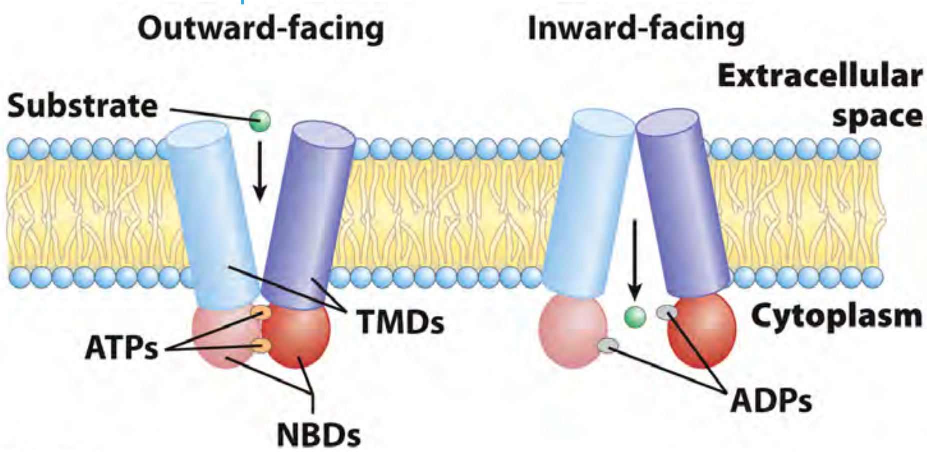
Membrane Transport



ABC Transporters Use ATP Hydrolysis to Drive Transport of Substrates OUT

Membrane Transport

ABC Transporters Use ATP Hydrolysis to Drive Transport of Substrates IN

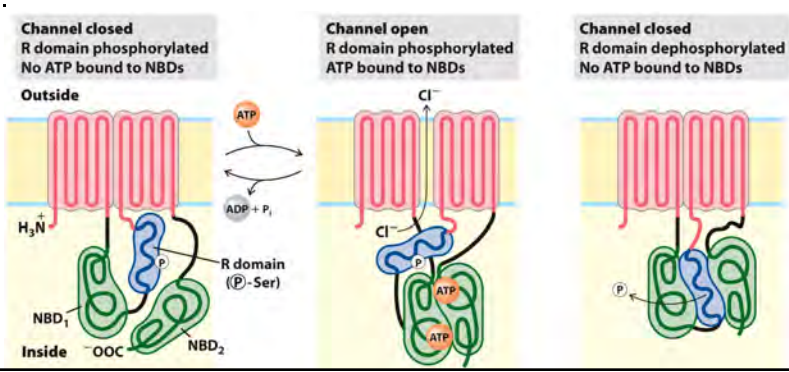


Membrane Transport

Failure of ABC-Transporters Can Lead to Human Disease

- Mutations in the human CFTR transporter (an ABC-type transporter-like channel for chloride ions)(cystic fibrosis transmembrane-conductance regulator) result in the human disease cystic fibrosis.
- Single-amino-acid mutations can render the protein misfolded and/or unable to transport chloride ions, resulting in an imbalance of water across the membrane.

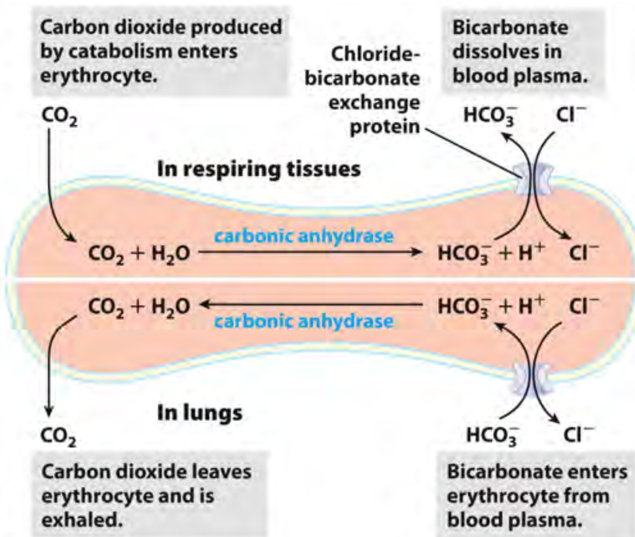
Regulated Facilitative Diffusion



Membrane Transport

Examples of Secondary Active Transport

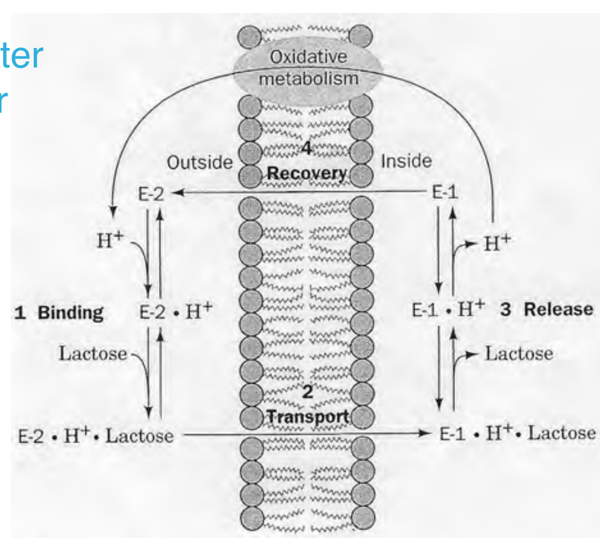
Bicarbonate Transporter is an Antiporter



Maintains the electrochemical potential across the membrane

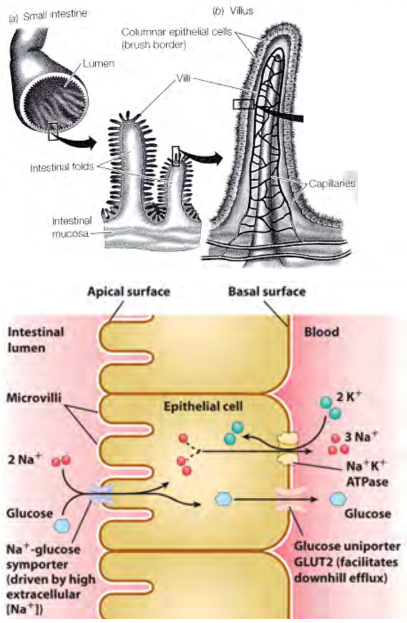
Membrane Transport

The bacterial Lactose Transporter is an Symporter



Uses the power of a proton gradient across the plasma membrane

Membrane Transport



Efficient Import of Glucose uses Multiple Glucose Transporters

- A Na^+-glucose symporter and a glucose uniporter operate on opposite sides of epithelial cells to facilitate movement of glucose from the intestine to the blood.
- Uses the Na/K gradient set up by "the pump."

Membrane Transport

TABLE 11-7a Transport Systems Described Elsewhere in This Text

Transport system and location	Figure	Role
IP_3-gated Ca^{2+} channel of ER	12-11	Allows signaling via changes in cytosolic [Ca^{2+}]
Glucose transporter of animal cell plasma membrane; regulated by insulin	12-20	Increases capacity of muscle and adipose tissue to take up excess glucose from blood
Voltage-gated Na^+ channel of neuron	12-29	Creates action potentials in neuronal signal transmission
Fatty acid transporter of myocyte plasma membrane	17-3	Imports fatty acids for fuel
Acyl-carnitine/carnitine transporter of mitochondrial inner membrane	17-6	Imports fatty acids into matrix for β oxidation
Complex I, III, and IV proton transporters of mitochondrial inner membrane	19-16	Act as energy-conserving mechanism in oxidative phosphorylation, converting electron flow into proton gradient
F_oF_1 ATPase/ATP synthase of mitochondrial inner membrane, chloroplast thylakoid, and bacterial plasma membrane	19-25, 20-20a, 20-24	Interconverts energy of proton gradient and ATP during oxidative phosphorylation and photophosphorylation
Adenine nucleotide antiporter of mitochondrial inner membrane	19-30	Imports substrate ADP for oxidative phosphorylation and exports product ATP
P_i-H^+ symporter of mitochondrial inner membrane	19-30	Supplies P_i for oxidative phosphorylation
Malate-α-ketoglutarate transporter of mitochondrial inner membrane	19-31	Shuttles reducing equivalents (as malate) from matrix to cytosol
Glutamate-aspartate transporter of mitochondrial inner membrane	19-31	Completes shuttling begun by malate-α- ketoglutarate shuttle

Membrane Transport

TABLE 11-7b	Transport Systems Described Elsewhere in This Text	
Transport system and location	**Figure**	**Role**
✓ Uncoupling protein UCP1, a proton pore of mitochondrial inner membrane	19-36, 23-35	Allows dissipation of proton gradient in mitochondria as means of thermogenesis and/or disposal of excess fuel
✓ Cytochrome *bf* complex, a proton transporter of chloroplast thylakoid	20-19	Acts as proton pump, driven by electron flow through the Z scheme; source of proton gradient for photosynthetic ATP synthesis
✓ Bacterorhodopsin, a light-driven proton pump	20-27	Is light-driven source of proton gradient for ATP synthesis in halophilic bacterium
P_i-triose phosphate antiporter of chloroplast inner membrane	20-42, 20-43	Exports photosynthetic product from stroma; imports P_i for ATP synthesis
✓ Citrate transporter of mitochondrial inner membrane	21-10	Provides cytosolic citrate as source of acetyl-CoA for lipid synthesis
✓ Pyruvate transporter of mitochondrial inner membrane	21-10	Is part of mechanism for shuttling citrate from matrix to cytosol
✓ LDL receptor in animal cell plasma membrane	21-41	Imports, by receptor-mediated endocytosis, lipid-carrying particles
Protein translocase of ER	27-40	Transports into ER proteins destined for plasma membrane, secretion, or organelles
Nuclear pore protein translocase	27-44a	Shuttles proteins between nucleus and cytoplasm
Bacterial protein transporter	27-46	Exports secreted proteins through plasma membrane

Membrane Transport

Summary

We learned that:

- membranes are composed of various lipids and proteins
- membrane proteins are found in three major classes and play a variety of structural and functional roles, especially in the transport of solutes across the membrane
- Transport is mediated or non-mediated.
- In mediated transport there is a diffusive mechanism or an active transport mechanism
- active transport is either primary or secondary
- Primary active transport of solutes across membranes requires ATP
- The best example of primary active transport is the Na/K ATPase.
- Secondary active transport but can be accomplished in many different ways, but uses the potential energy established by primary active transport