Aim: What is the process of active transport?

Amoeboid movement

summary

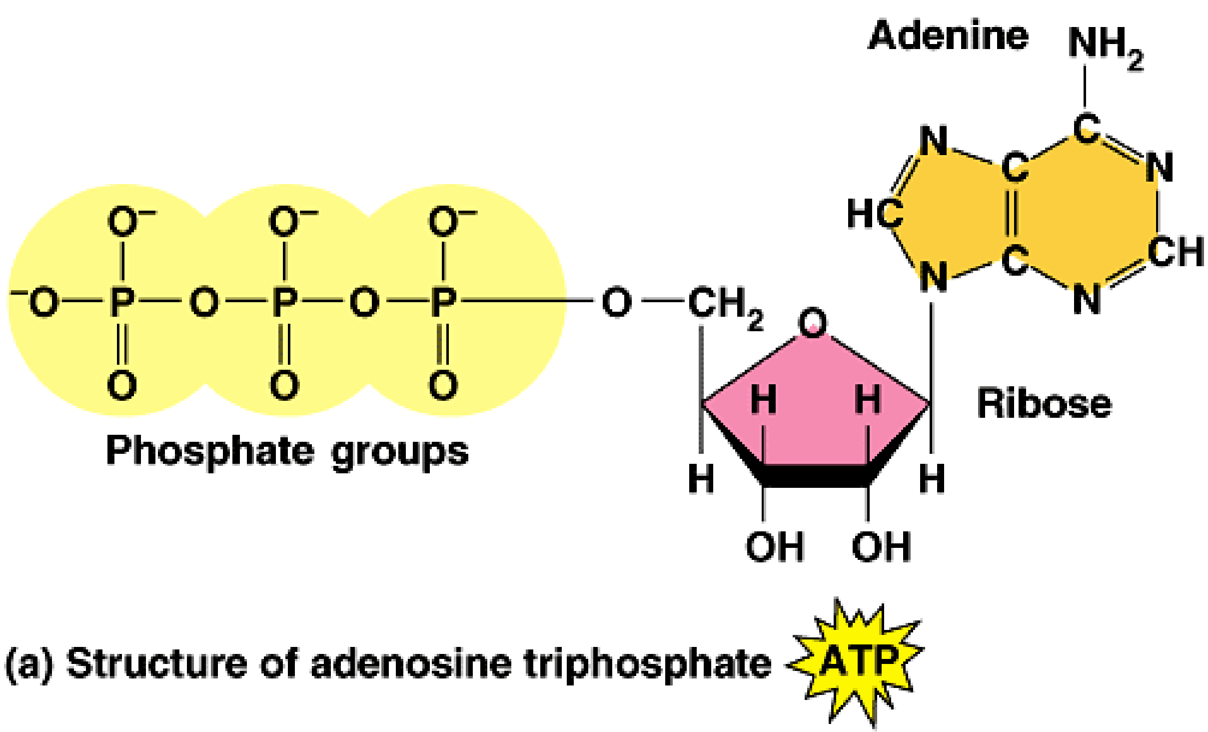
Active transport is the pumping of solutes against their gradients

- Some facilitated transport proteins can move solutes *<u>against their concentration gradient</u>*, from the side where they are less concentrated to the side where they are more concentrated.
- This **active transport** requires the cell to expend its own metabolic energy.
- Active transport is critical for a cell to maintain its internal concentrations of small molecules that would otherwise diffuse across the membrane.

Energy for active transport

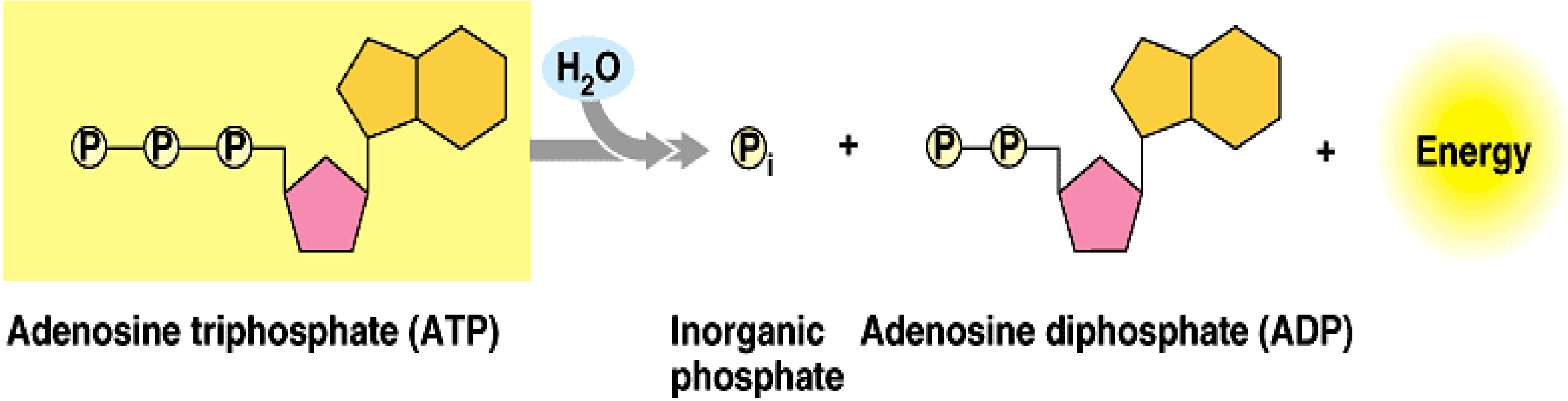
- ATP supplies the energy for most active transport.
  - Often, ATP powers active transport by shifting a phosphate group from ATP (forming ADP) to the transport protein.
  - This may induce a conformational change in the transport protein that translocates the solute across the membrane.

•**ATP (adenosine triphosphate)** is a type of nucleotide consisting of the nitrogenous base adenine, the sugar ribose, and a chain of three phosphate groups.



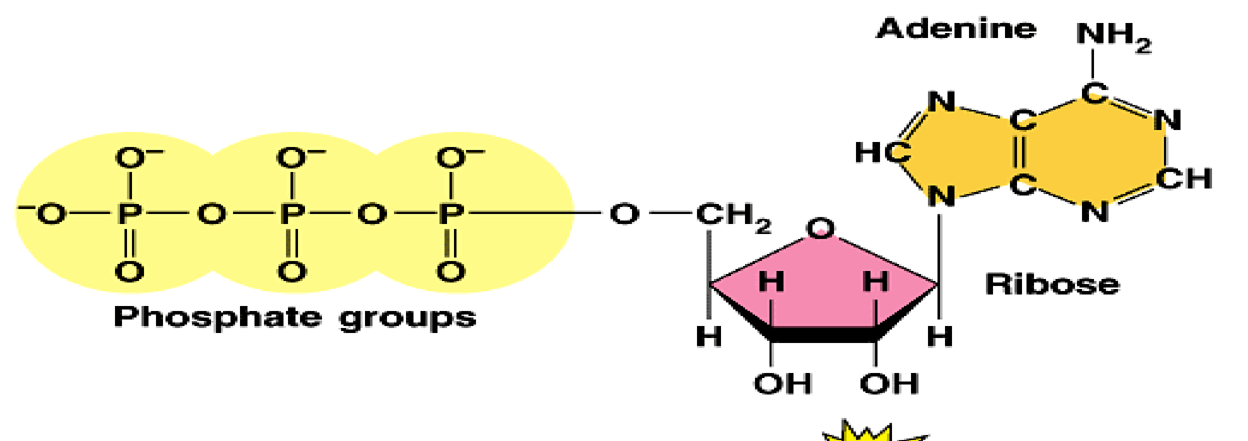
(a) Structure of adenosine triphosphate

- The bonds between phosphate groups can be broken by hydrolysis.
  - Hydrolysis of the end phosphate group forms adenosine diphosphate [ATP -> ADP + P_i] and releases 7.3 kcal of energy per mole of ATP under standard conditions.
  - In the cell, ATP hydrolysis releases 13 kcal of energy per mole.



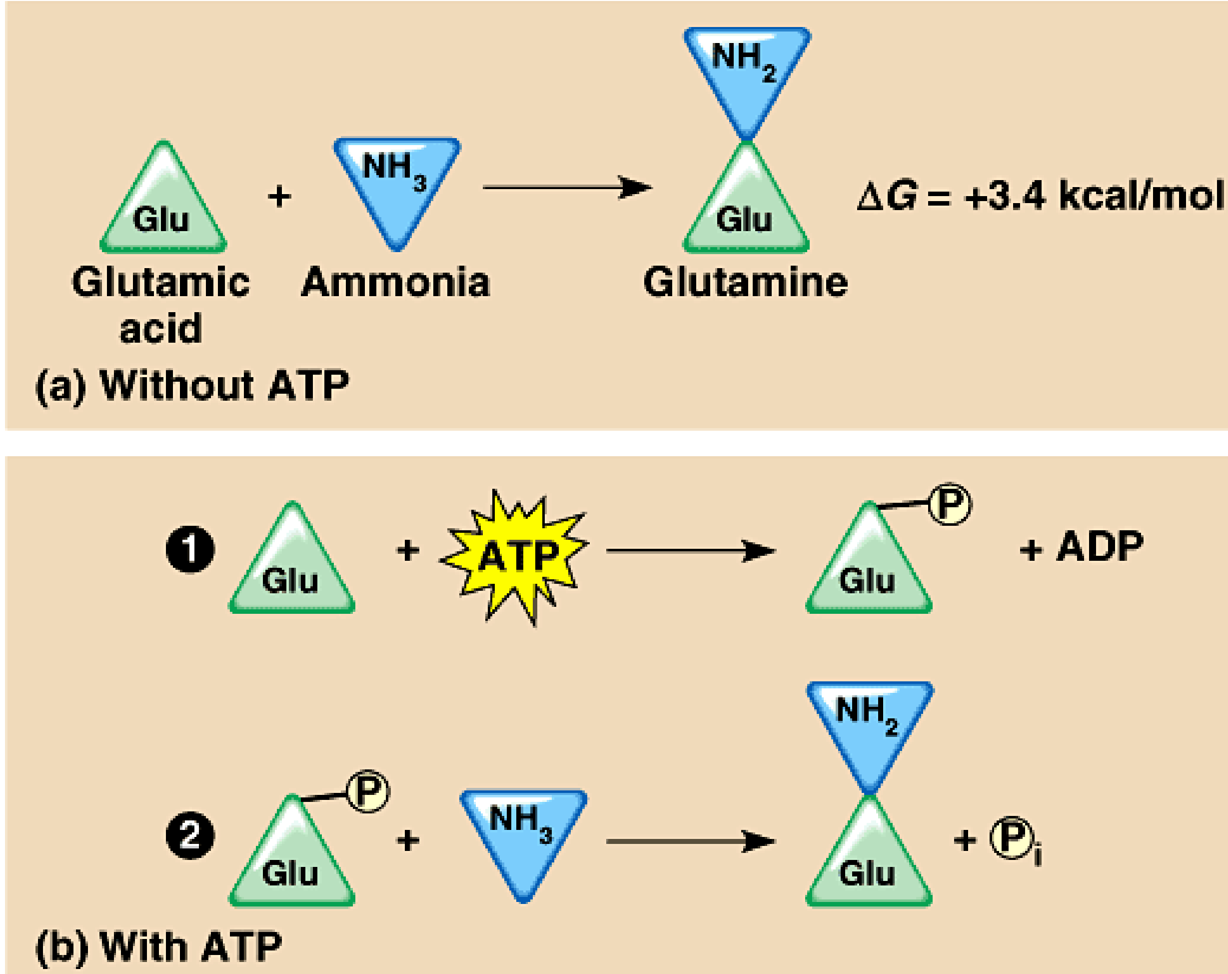
(b) Hydrolysis of ATP

- While the phosphate bonds of ATP are sometimes referred to as high-energy phosphate bonds, these are actually fairly weak covalent bonds.
- They are unstable however and their hydrolysis yields energy as the products are more stable.
- The phosphate bonds are weak because each of the three phosphate groups has a negative charge
- Their repulsion contributes to the instability of this region of the ATP molecule.



(a) Structure of adenosine triphosphate

- In the cell the energy from the hydrolysis of ATP is coupled directly to endergonic processes by transferring the phosphate group to another molecule.
  - This molecule is now **phosphorylated**.
  - This molecule is now more reactive.
- Endergonic reactions require energy in order to occur. Exergonic reactions release energy



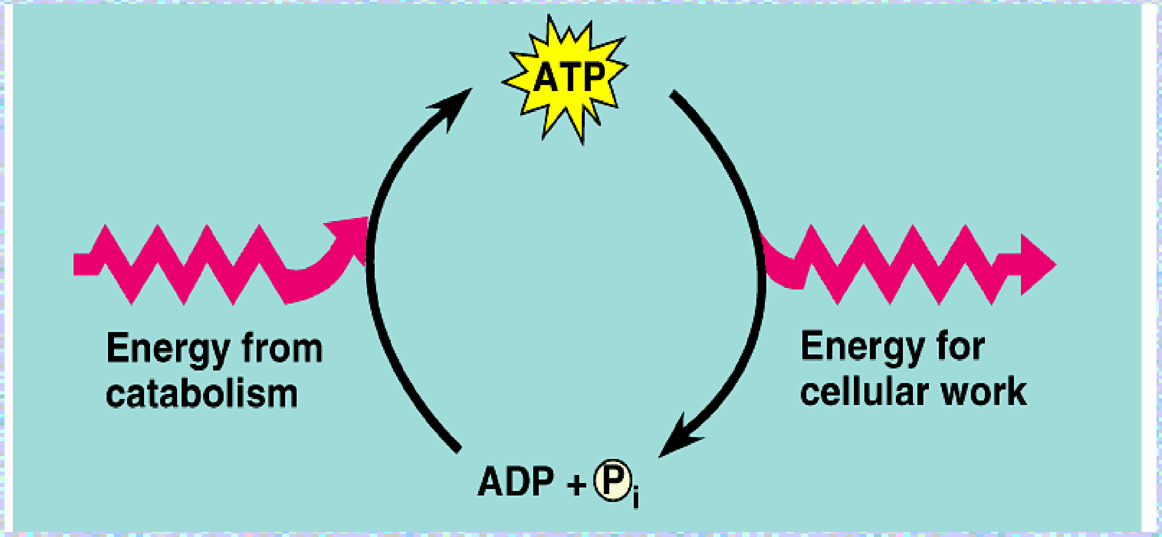
$$\text{Glu} + NH_3 \longrightarrow \text{Glu—}NH_2 \qquad \Delta G = +3.4 \text{ kcal/mol}$$

$$\text{ATP} \longrightarrow \text{ADP} + Ⓟ_i \qquad \Delta G = -7.3 \text{ kcal/mol}$$

$$\text{Net } \Delta G = -3.9 \text{ kcal/mol}$$

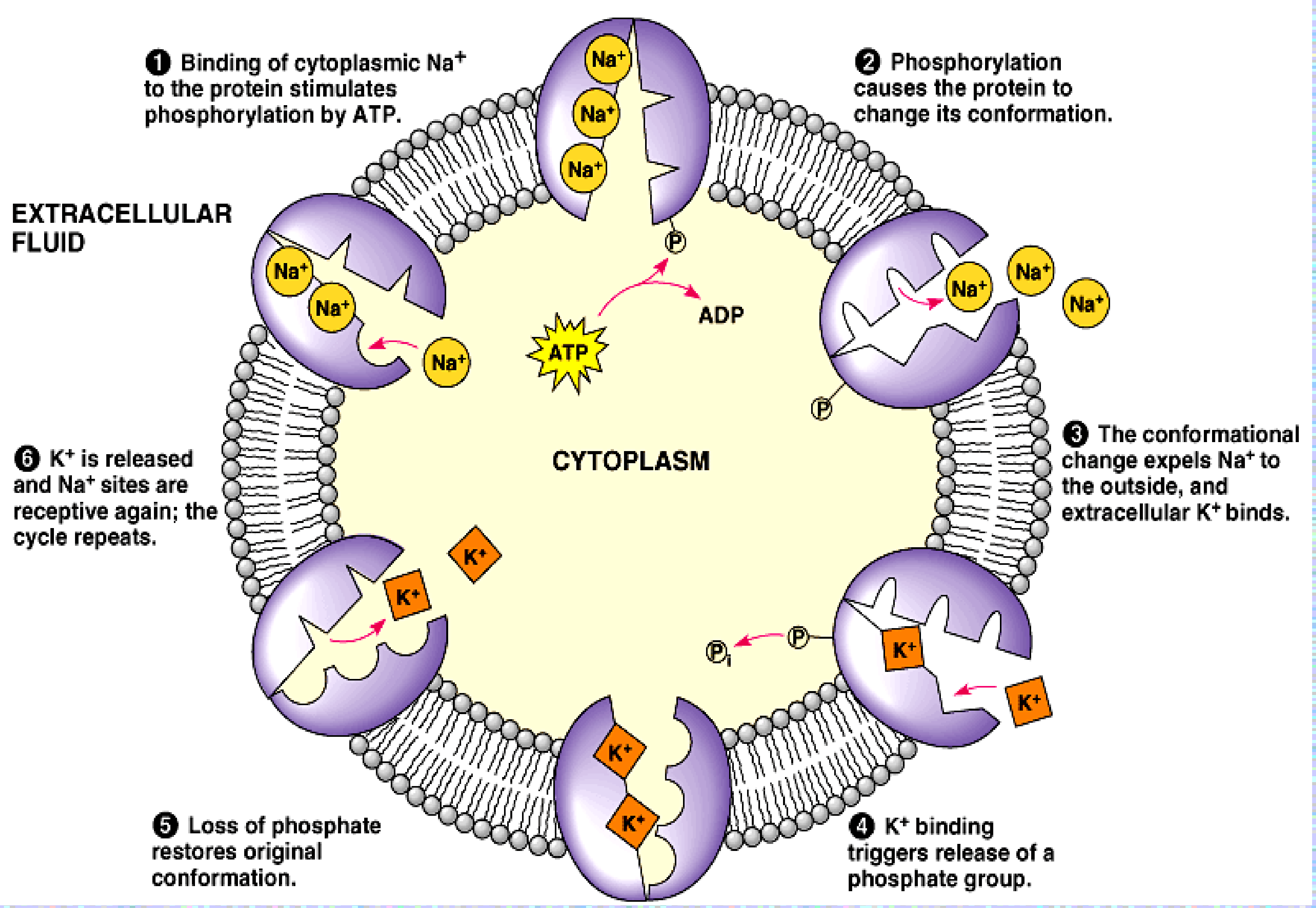
(c) Free energy change with ATP

- **ATP is a renewable resource that is continually regenerated by adding a phosphate group to ADP.**
- **Regeneration, an endergonic process, requires an investment of energy, the addition of 7.3 kcal of energy per mole.**

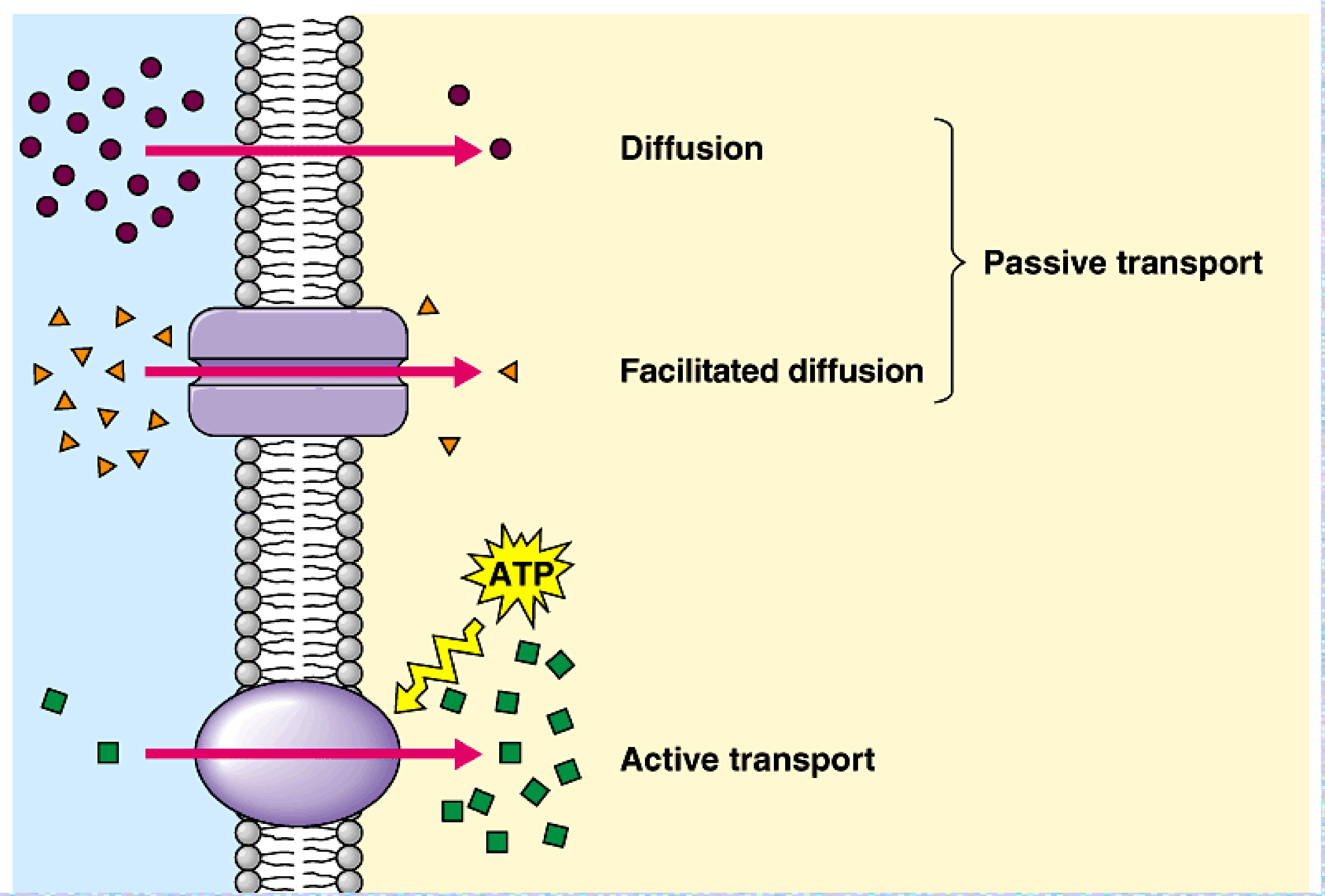


Examples of active transport

- The **sodium-potassium pump** actively maintains the gradient of sodium (Na^+) and potassium ions (K^+) across the membrane.
  - Typically, an animal cell has higher concentrations of K^+ and lower concentrations of Na^+ inside the cell.
  - The sodium-potassium pump uses the energy of one ATP to pump three Na^+ ions out and two K^+ ions in.



http://www.youtube.com/watch?v=GTHWig1vOnY


Diffusion
Passive transport
Facilitated diffusion
ATP
Active transport

In co-transport, a membrane protein couples the transport of two solutes

- A single ATP-powered pump that transports one solute can indirectly drive the active transport of several other solutes through **cotransport** via a different protein.
- As the solute that has been actively transported diffuses back passively through a transport protein, its movement can be coupled with the active transport of another substance against its concentration gradient.

•Plants commonly use the gradient of hydrogen ions that is generated by proton pumps to drive the active transport of amino acids, sugars, and other nutrients into the cell.

- The high concentration of H^+ on one side of the membrane, created by the proton pump, leads to the facilitated diffusion of protons back, but only if another molecule, like sucrose, travels with the hydrogen ion.