1. MEMBRANE TRANSPORT

- small soluble molecules;
- inorganic ions and small water-soluble molecules;
- large particles.

2. CELL JUNCTIONS

MEMBRANE TRANSPORT

I. small soluble molecules (hydrophobic/nonpolar) -<u>without</u> specialized transmembrane proteins (simple DIFFUSION)

II. inorganic ions and small water-soluble molecules – <u>with</u> specialized transmembrane proteins:

- “carrier” p.–moving parts (active/passive);

Energy source - ATP/ion gradients;

- “channel” p .–form a narrow hydrophilic pore (passive – facilitate diffussion);

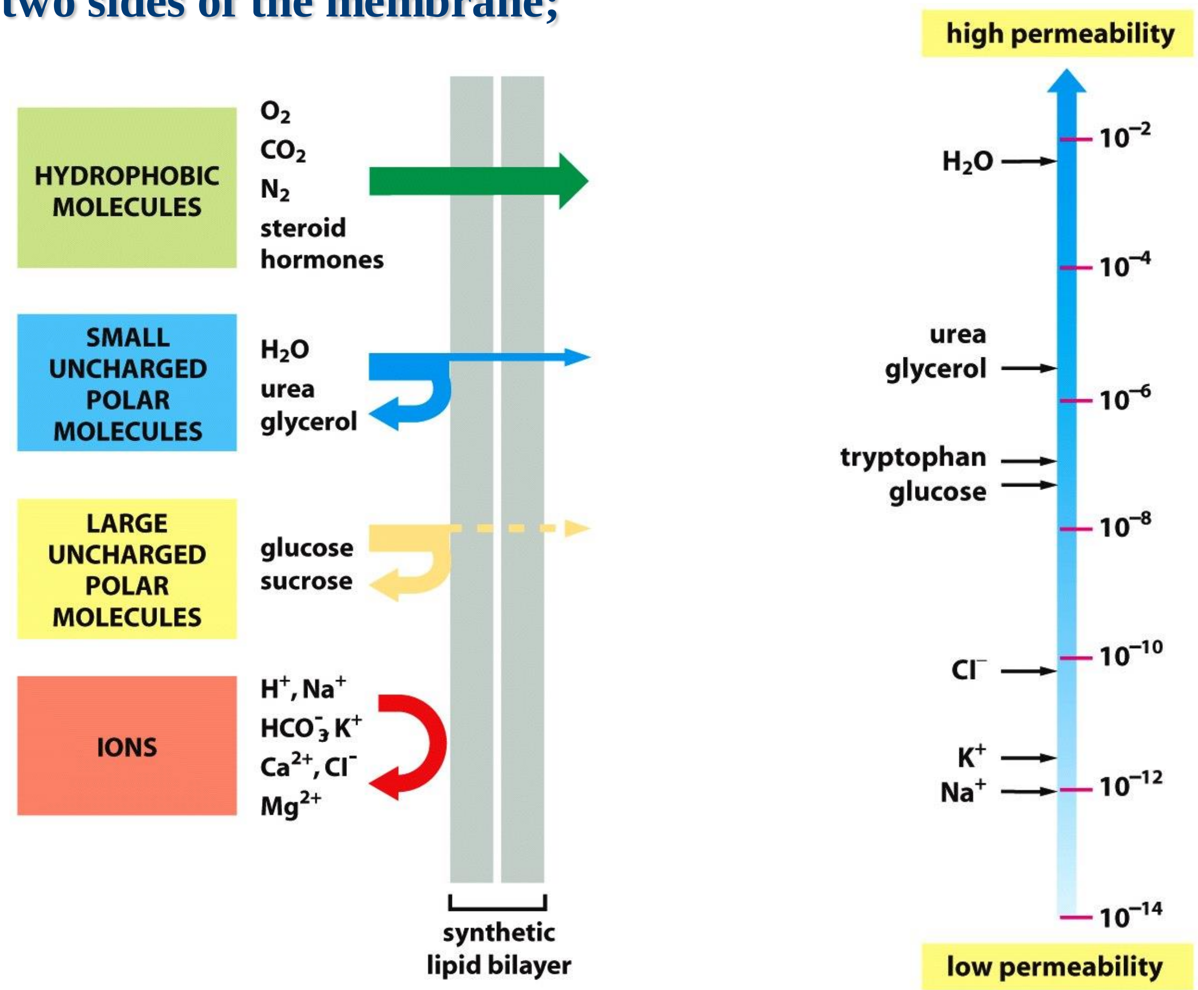
III. large particles <= vesicules

- endocytosis;

- exocytosis;

I. simple DIFFUSION across a protein-free lipid bilayer down its concentration gradient

- the rate of flow of a solute across the bilayer is directly proportional to the difference in its concentration on the two sides of the membrane;
- reduced specificity;



II. A. TRANSPORTERS (Carriers/Permeases)

- **undergo a series of reversible conformational changes to transfer the bound solute across the membrane.**

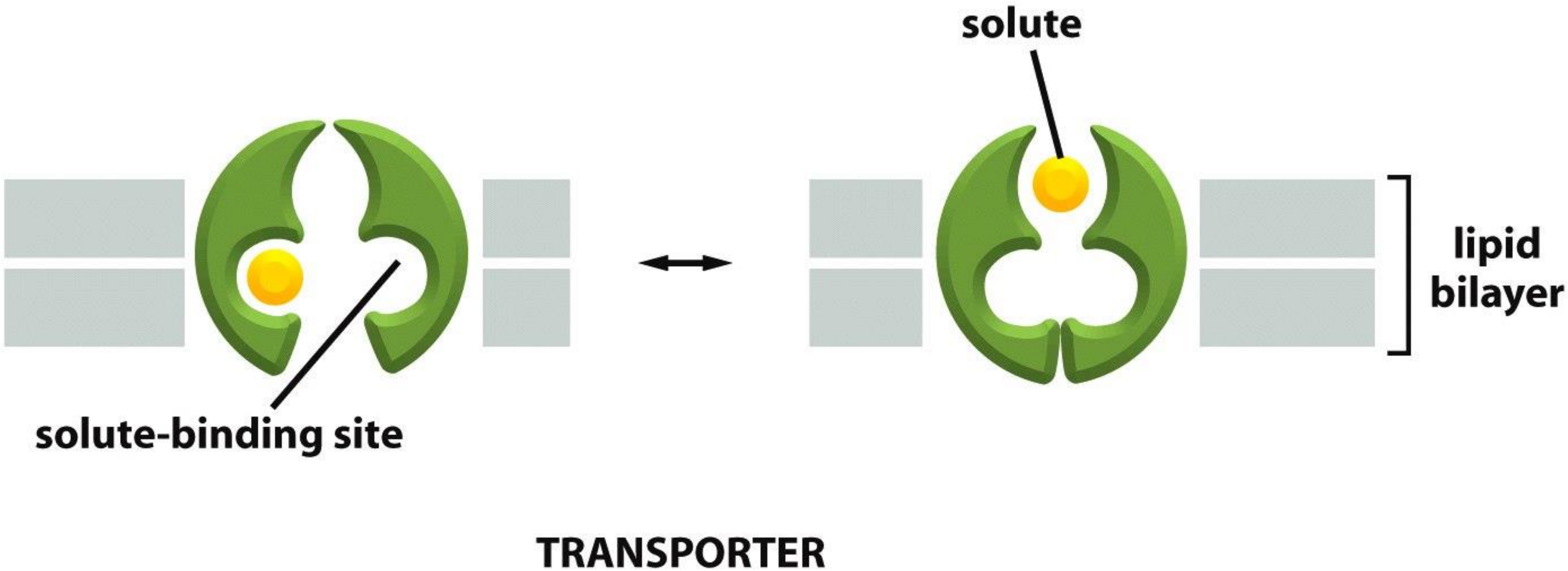


Figure 11-3a *Molecular Biology of the Cell* (© Garland Science 2008)

II.A. TRANSPORTERS (Carriers/Permeases)

A. +/- energy source - transport

- active (“uphill") – “pumps” (ATP/ion gradient)
- passive ("downhill") – passive transport, or facilitated diffusion, concentration gradient;

B. Systems

- uniport: one type of molecule;
- coupled → Symport – *Co-transporters*
  → Antiport – *Exchangers*

A. +/- energy source - transport

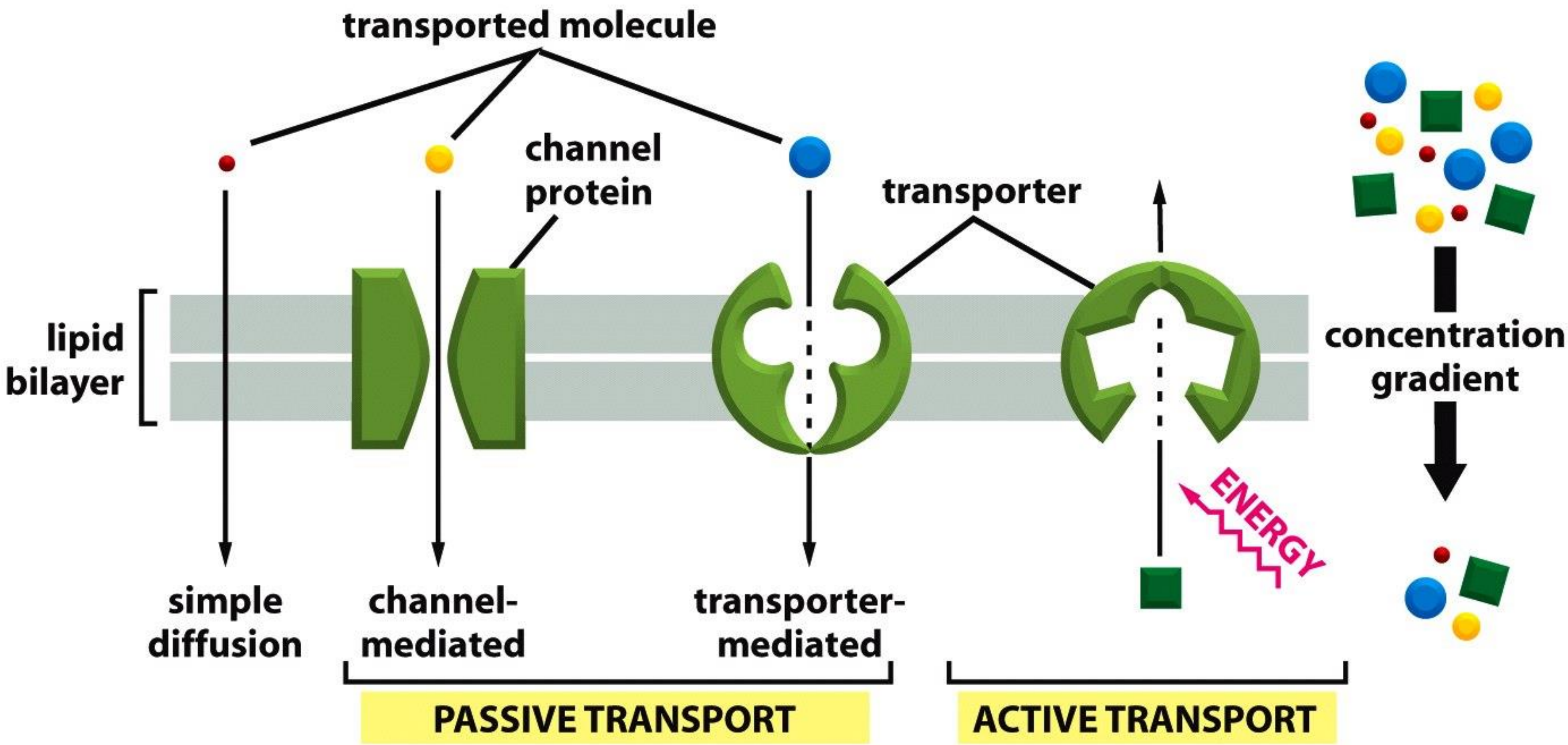


Figure 11-4a *Molecular Biology of the Cell* (© Garland Science 2008)

B. Uniport/coupled

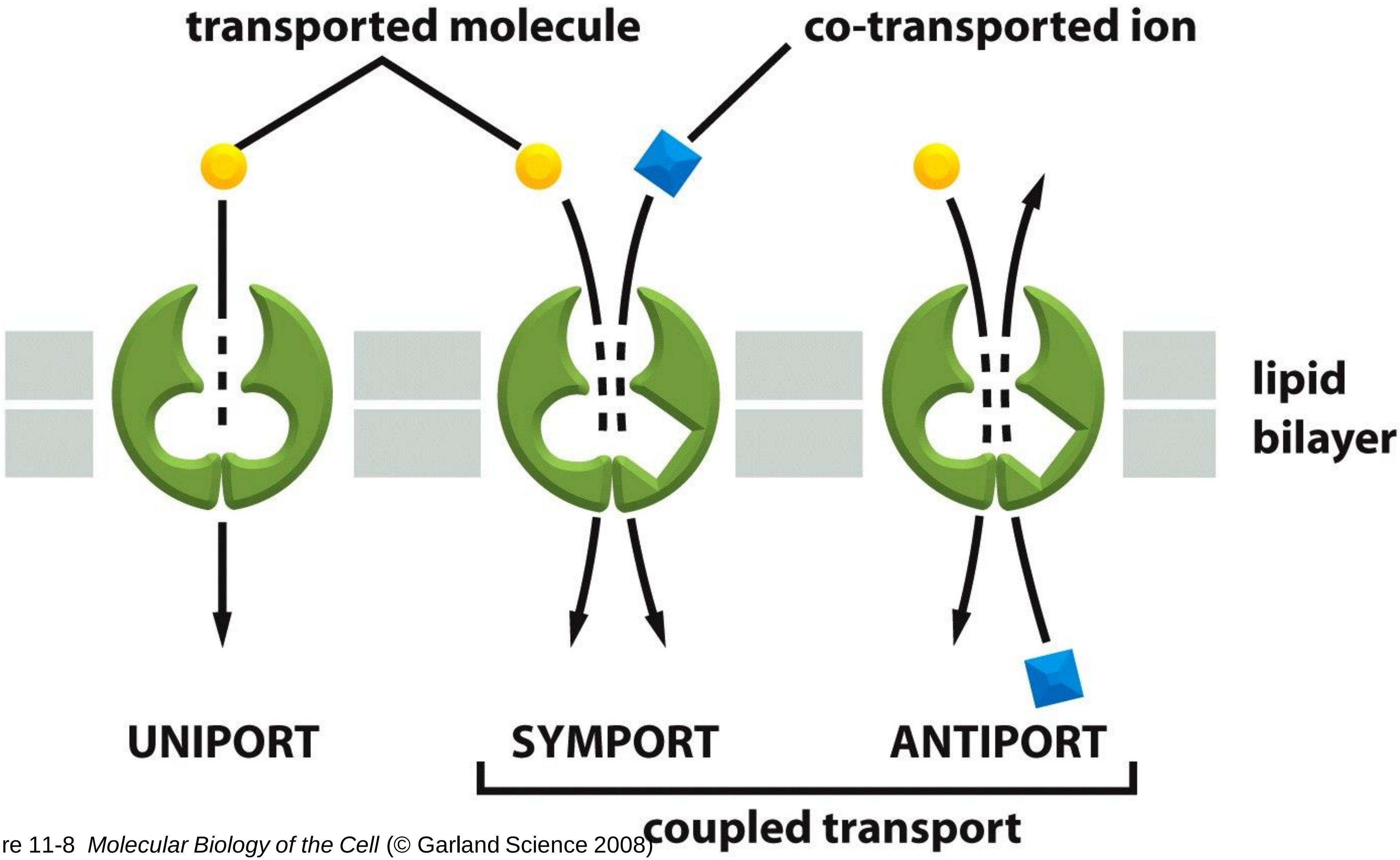


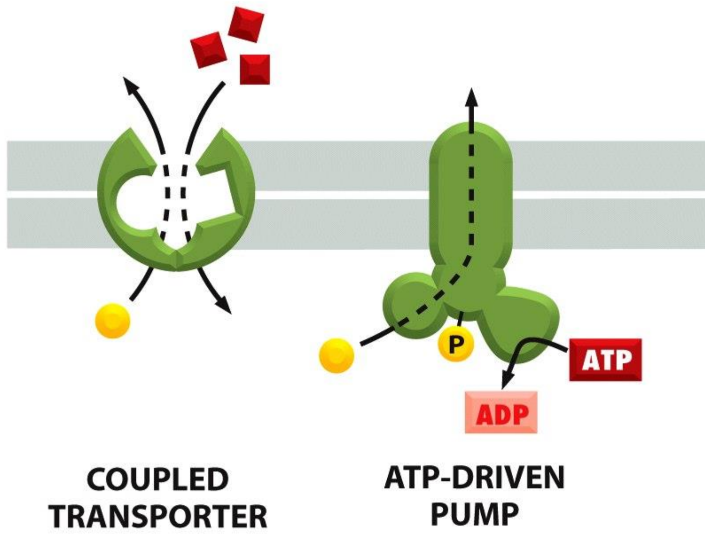
Figure 11-8 *Molecular Biology of the Cell* (© Garland Science 2008)

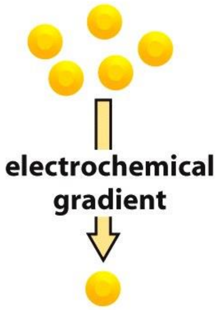
II.A. TRANSPORTERS (Carriers/Permeases)

ACTIVE MEMBRANE TRANSPORT

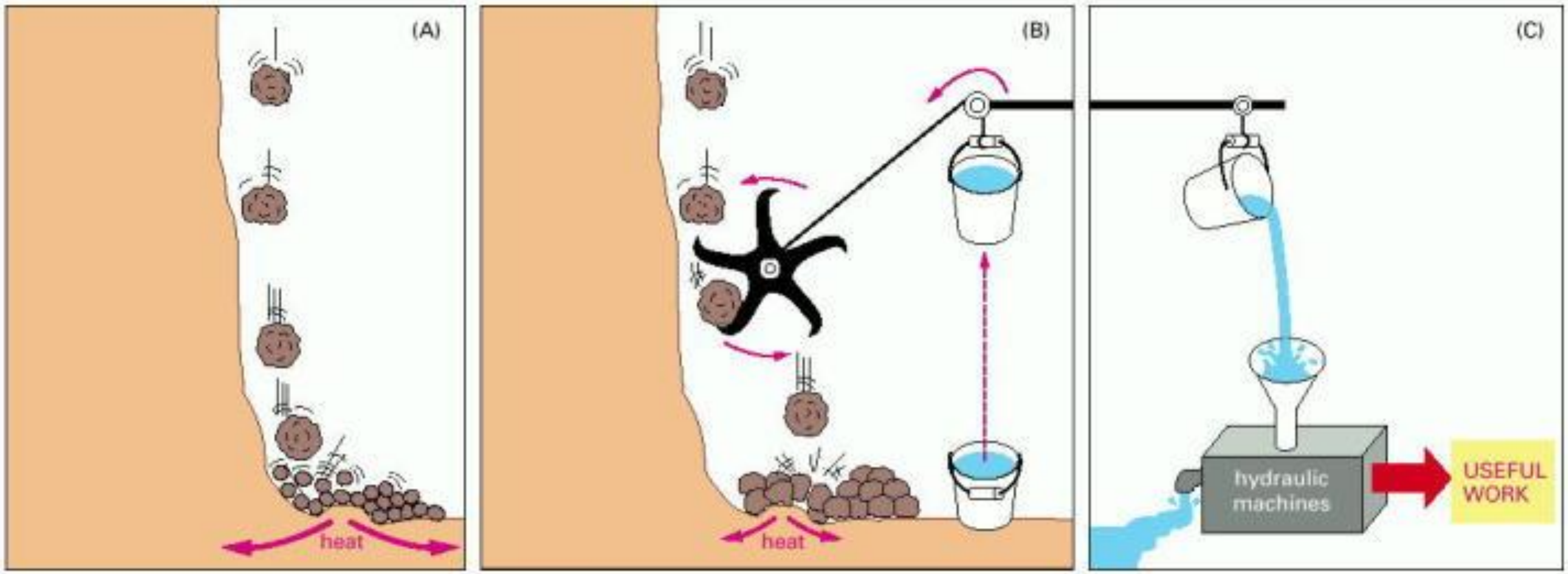
1. **Coupled transporters** couple the uphill transport of one solute across the membrane to the downhill transport of another;

2. **ATP-driven pumps** couple uphill transport to the hydrolysis of ATP





Energy conversion



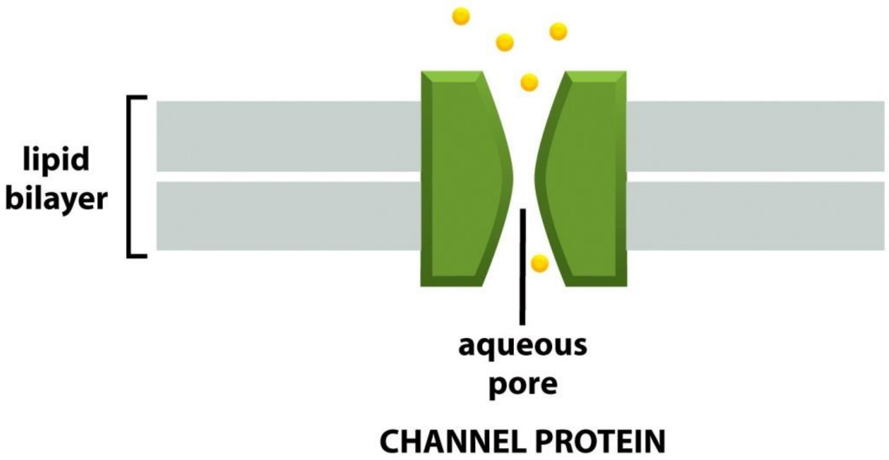
kinetic energy transformed into heat energy only

part of the kinetic energy is used to lift a bucket of water, and a correspondingly smaller amount is transformed into heat

the potential kinetic energy stored in the raised bucket of water can be used to drive hydraulic machines that carry out a variety of useful tasks

II. B. ION CHANNELS

- interact with the solute to be transported much more weakly;
- form aqueous pores that extend across the lipid bilayer;
- when open, these pores allow specific solutes (usually inorganic ions of appropriate size and charge) to pass through them and thereby cross the membrane;
- one class of channel proteins found in virtually all animals forms gap junctions between two adjacent cells



II. B. ION CHANNELS

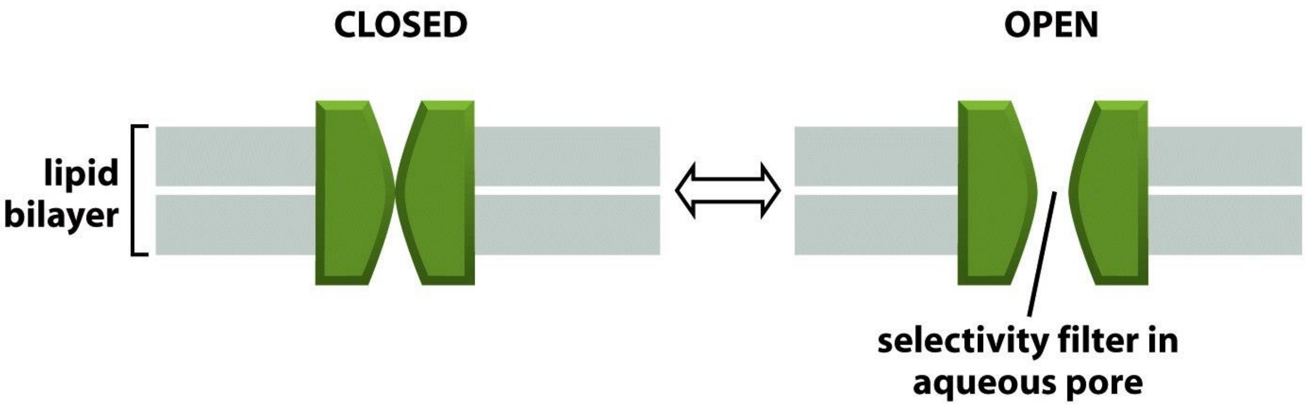
- transport through channels occurs at a much faster rate
  – 100 milion ions/seconds – 10^5 faster than a carrier protein;
- higly selective pores – primarily Na+, K+, Ca2+, or Cl-;
- can close and open rapidly;
- ALWAYS PASSIVE (downhill)!!!
- Fluctuate between open and closed states.

II. B. IONS CHANNELS

Ion-Selective and Fluctuate Between Open and Closed States

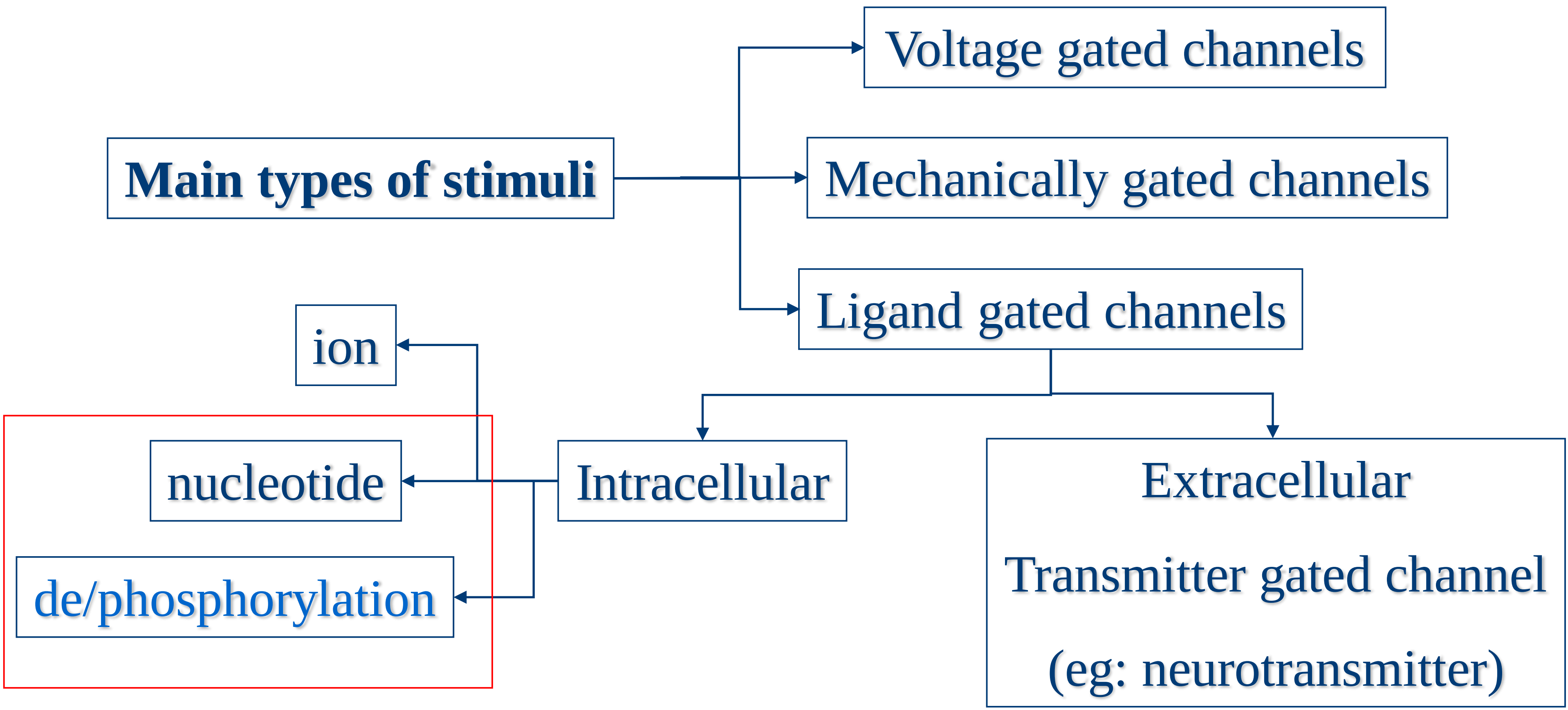
ION CHANNELS *vs* SIMPLE AQUEOUS CHANNELS

- only ions of appropriate size and charge can pass (selectivity filter);
- ion channels are not continuously open, they are gated;
- the gate opens in response to a specific stimulus.



II. B. IONS CHANNELS

- approx. 100 - types



II. B. IONS CHANNELS

PROLONGED (chemical or electrical) STIMULATION, most channels go into a closed "desensitized" or "inactivated" state, in which they are REFRACTORY to further opening UNTIL THE STIMULUS HAS BEEN REMOVED.

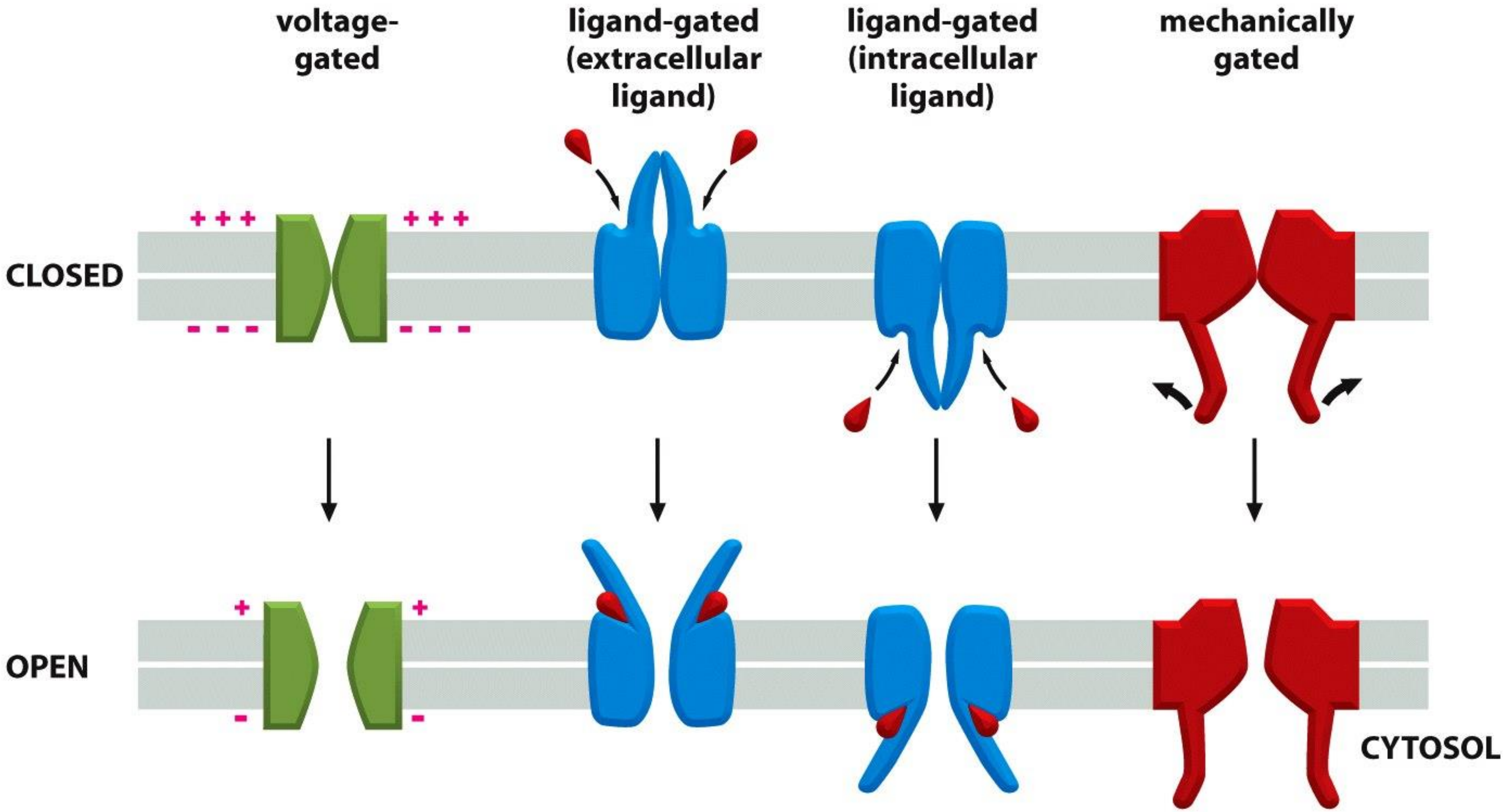
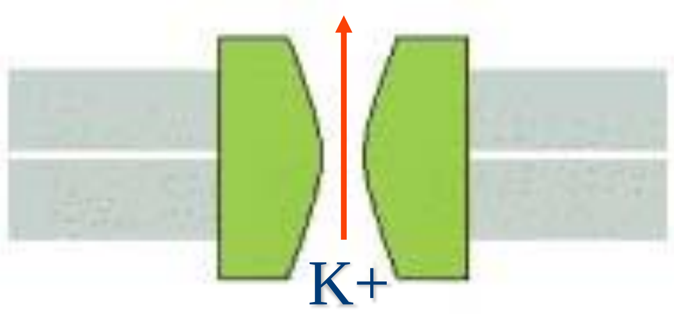
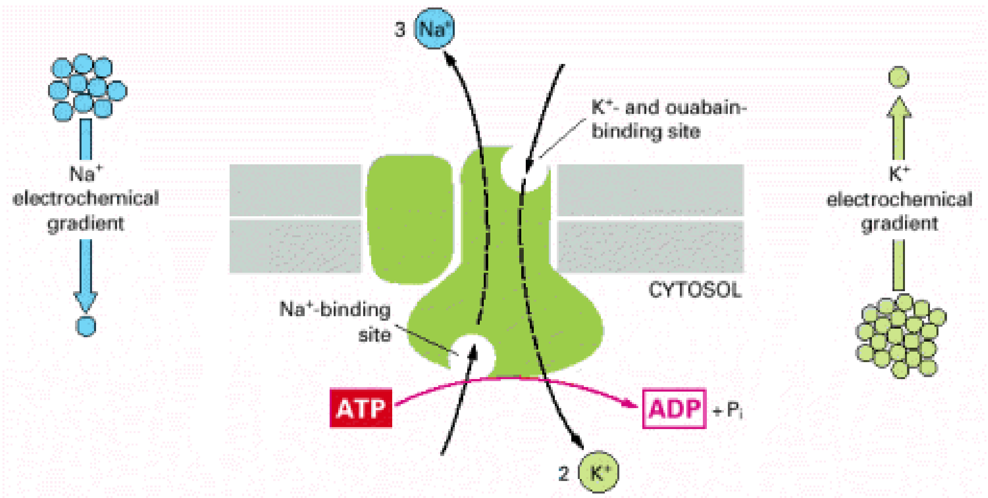


Figure 11-21 *Molecular Biology of the Cell* (© Garland Science 2008)

K+ leak channels

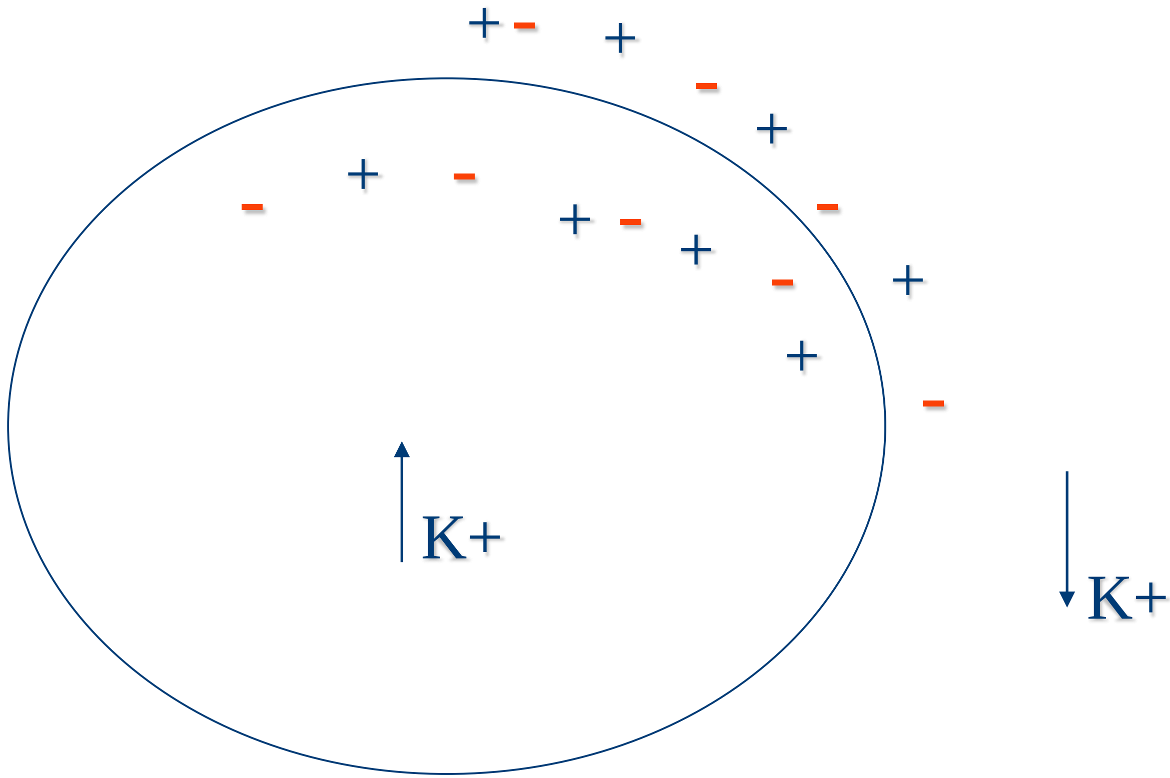
- no stimuli required!
- balancing role => membrane potential across all plasma membranes;





K+ transport across membrane – IDEAL CELL

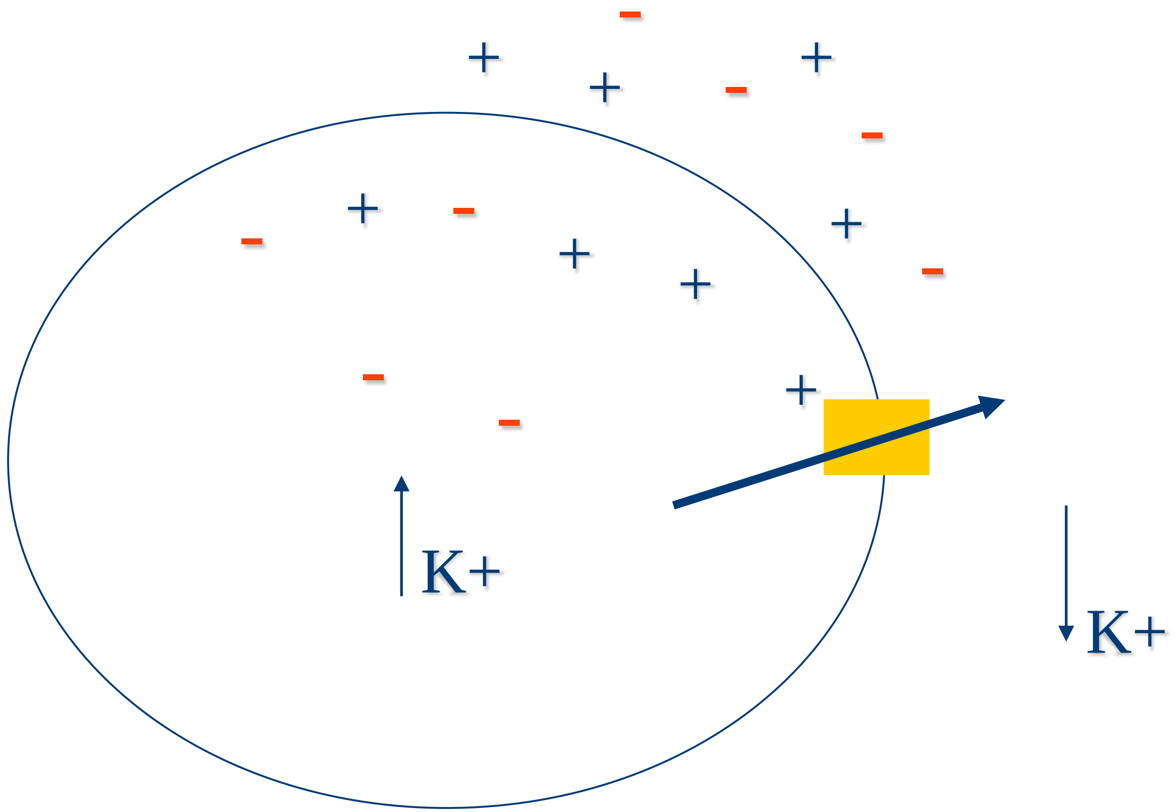
I. If no voltage gradient across the plasma membrane (the membrane potential is zero);



But….

K+ transport across membrane

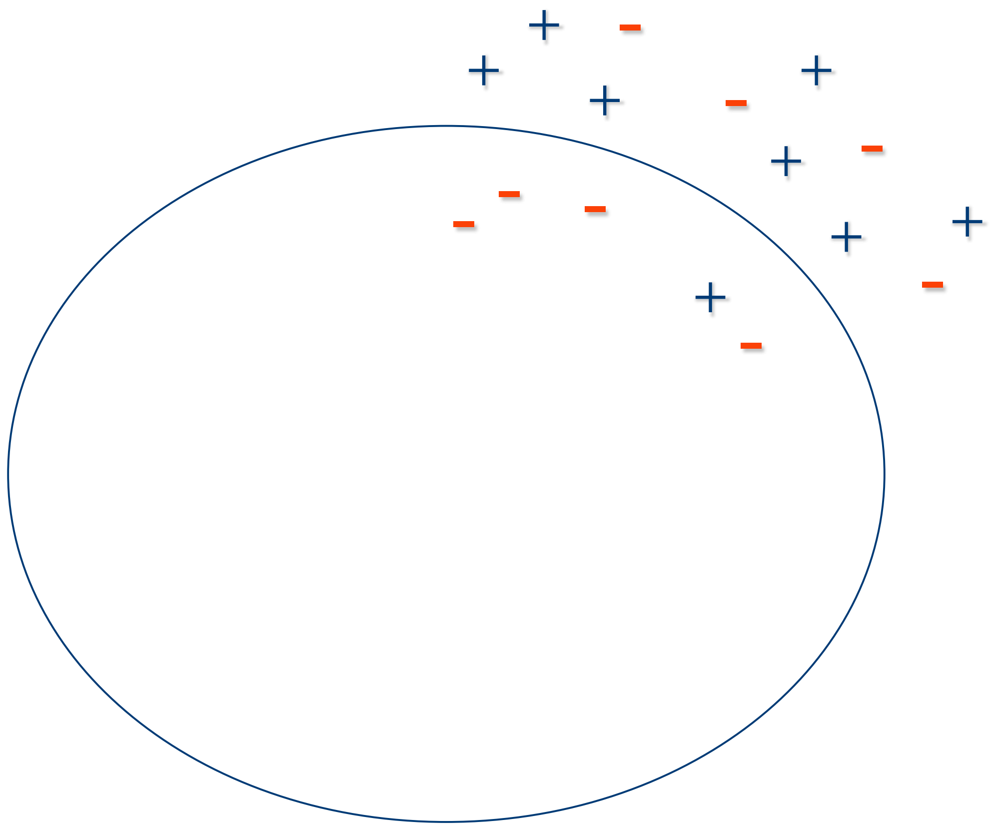
II. K+ will tend to leave the cell through the K+ leak channels, driven by its concentration gradient.



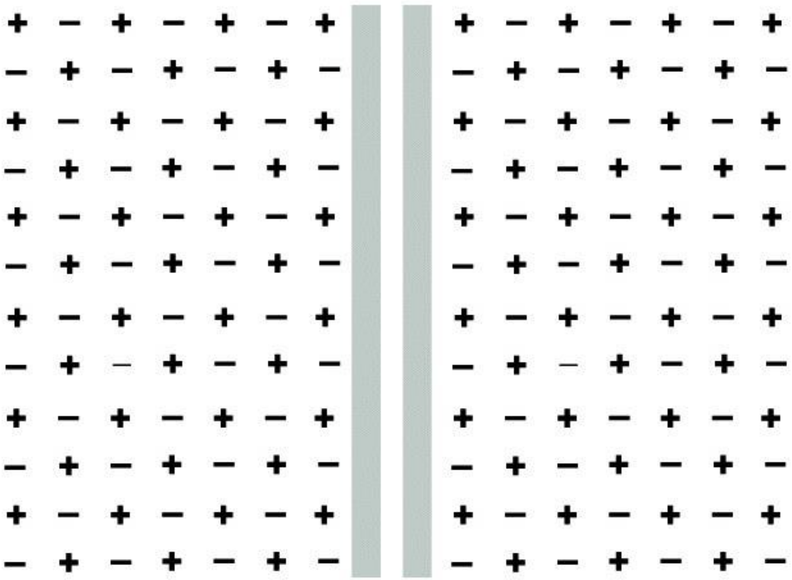
K+ leak channels

K+ transport across membrane

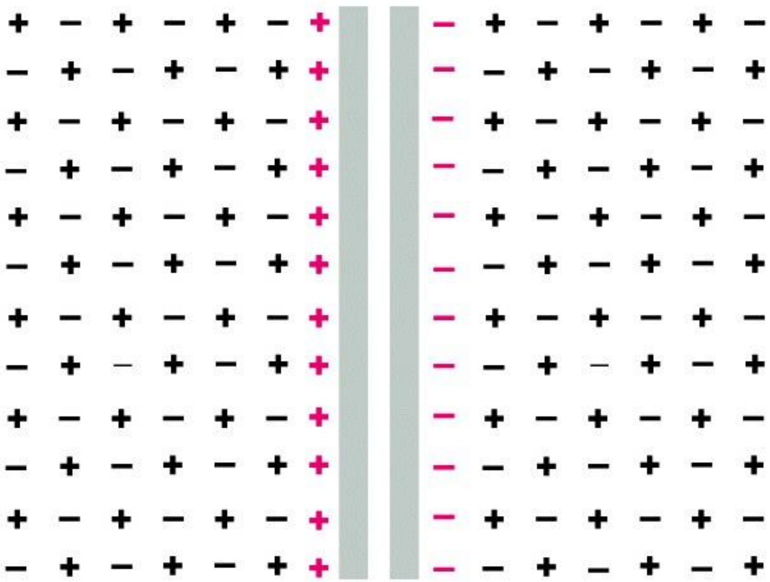
=> K+ leaves behind an unbalanced negative charge <=> electrical field/ membrane potential



OPPOSES the further efflux of K+



exact balance of charges on each side of the membrane; membrane potential = 0



a few of the positive ions *(red)* cross the membrane from right to left, leaving their negative counterions *(red)* behind; this sets up a nonzero membrane potential

Figure 11-22 *Molecular Biology of the Cell* (© Garland Science 2008)

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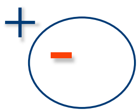
K+ transport across membrane

=> the efflux of K+ STOPS when the membrane potential reaches a value at which this electrical driving force on K+ exactly balances the effect of its concentration gradient

<=> ELECTROCHEMICAL GRADIENT FOR K+ = 0

no net flow of ions across the plasma membrane <=> RESTING MEMBRANE POTENTIAL

MEMBRANE POTENTIAL



- Voltage difference across a membrane due to a slight excess of positive ions on one side and of negative ions on the other;

- The charge differences result both from active electrogenic pumping and from passive ion diffusion.

- Na^+ /K^+ pump helps maintain an osmotic balance across the animal cell membrane by keeping the intracellular concentration of Na^+ low.

=> other cations have to be plentiful there to balance the charge carried by the cell's fixed anions—the negatively charged organic molecules that are confined inside the cell.

K+ transport across membrane

- actively pumped into the cell by the *Na+ /K+ pump*

- can also move freely in or out through the *K + leak channels* in the plasma membrane

---

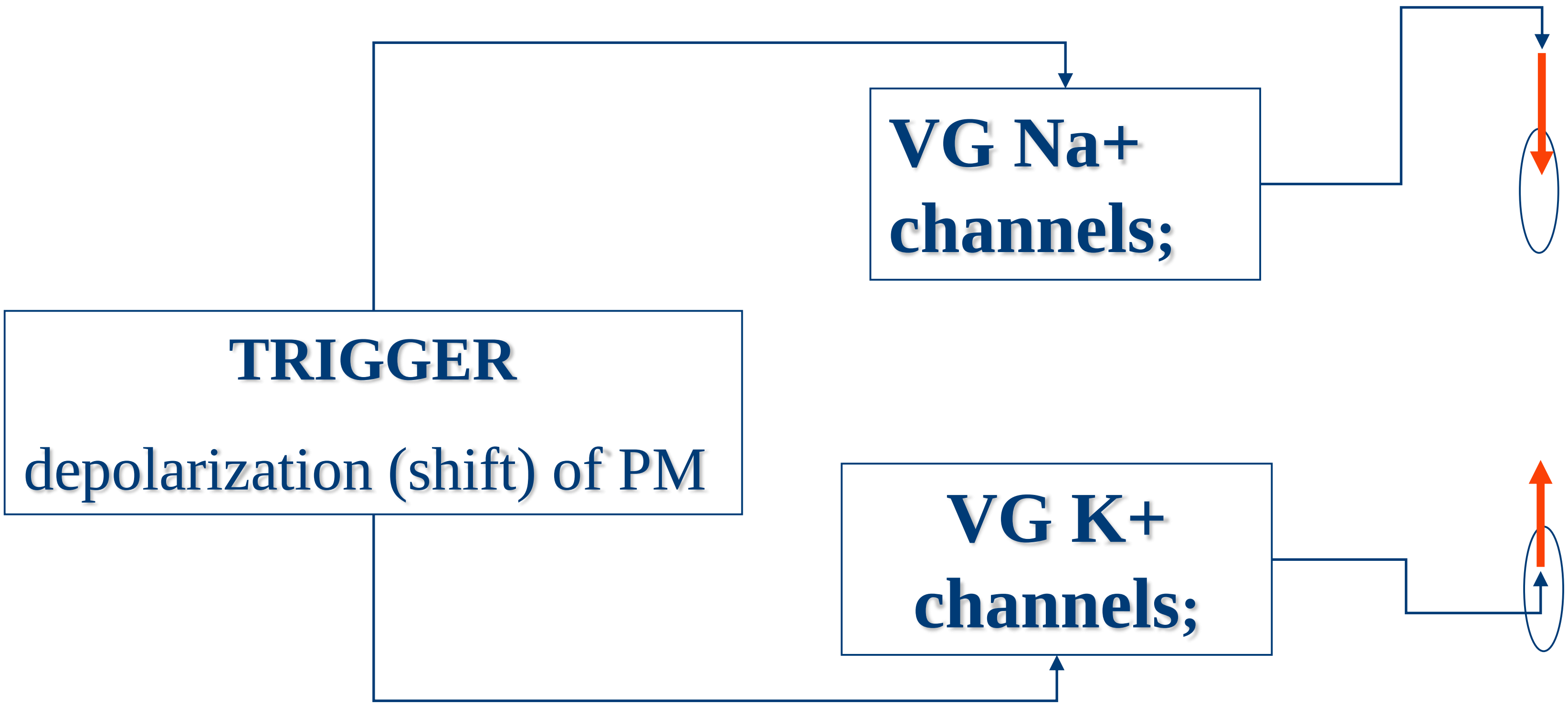
2 types of forces to move K+ => K+ to equilibrium:

- the chemical gradient (high inside/ low outside);

- electrical force exerted by an excess of negative charges attracting K+ into the cell

Voltage-gated (VG) cation channels

-responsible for generating the action potentials;



ACTION POTENTIAL

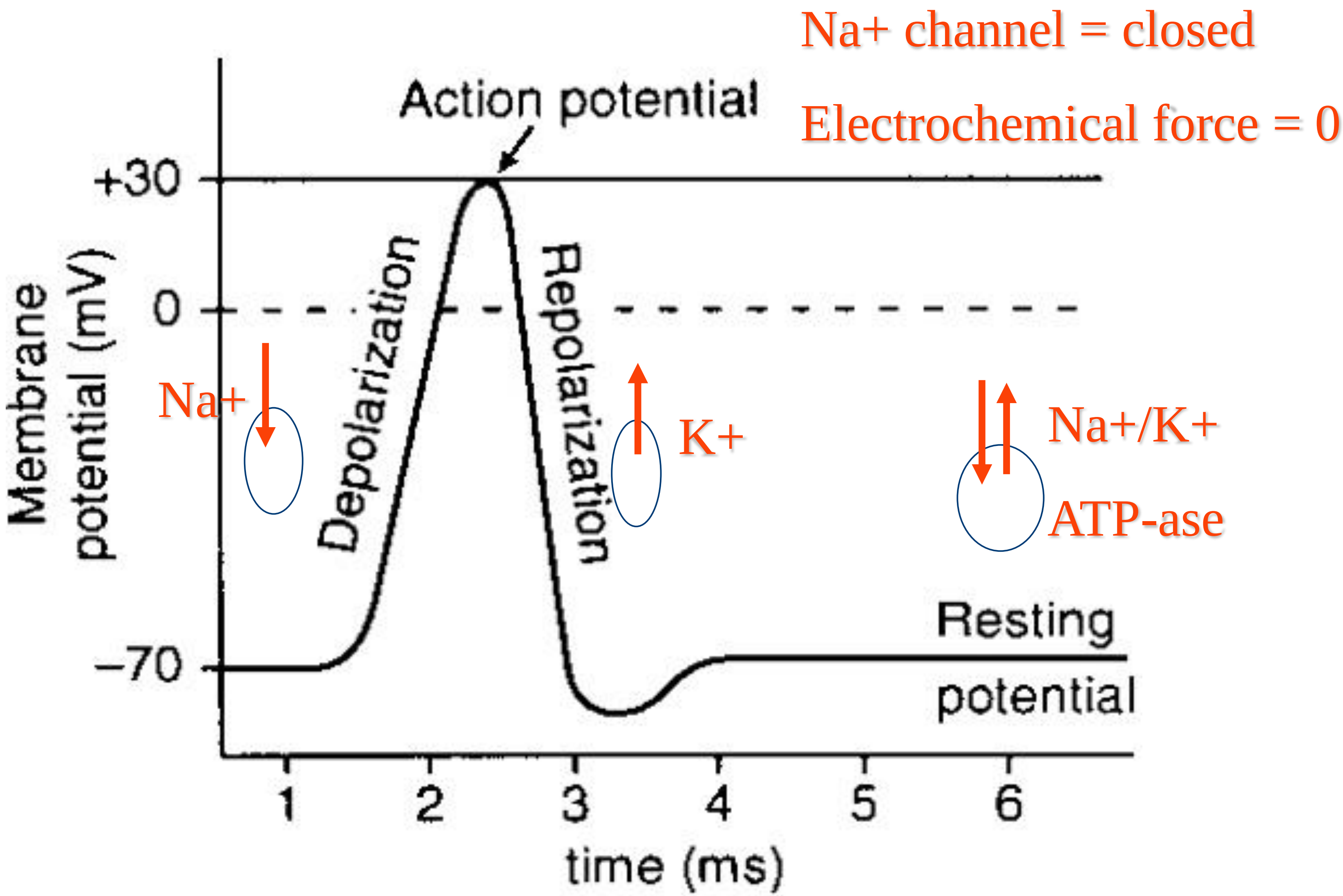
- is a short-lasting event - electrical membrane potential of a cell rapidly rises and falls, following a consistent trajectory;

- occurs in several types of animal cells - called excitable cells:

  - neuron - cell-to-cell communication

  - muscle cells – Ist step in the chain of events - contraction

  - endocrine cells (eg: beta cells of the pancreas- provoke release of insulin);


Na+ channel = closed
Electrochemical force = 0
Action potential
+30
0
−70
Membrane potential (mV)
Depolarization
Repolarization
Na+
K+
Na+/K+
ATP-ase
Resting potential
1
2
3
4
5
6
time (ms)

Ligand-gated channels

Ligand gated ion channel - structure and function

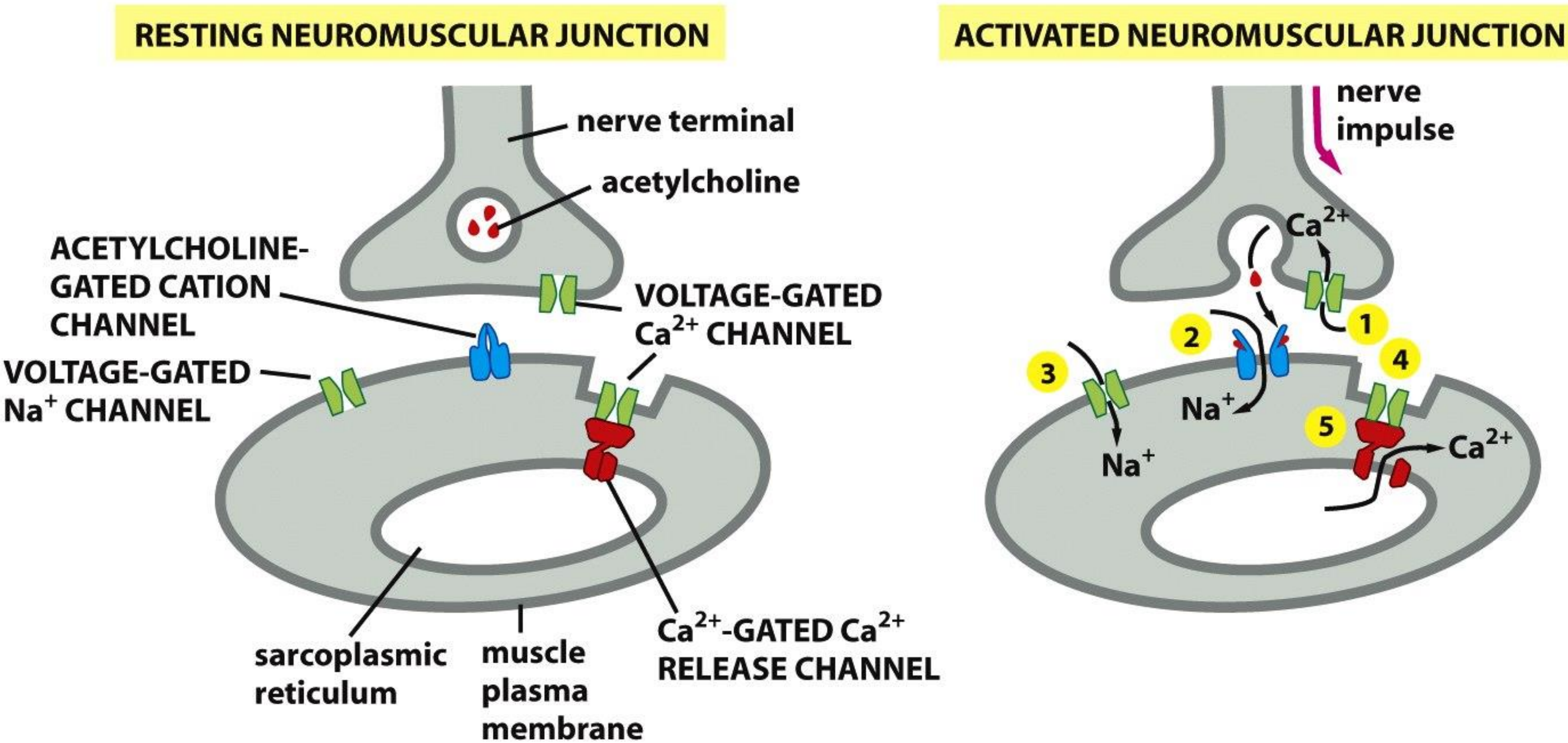


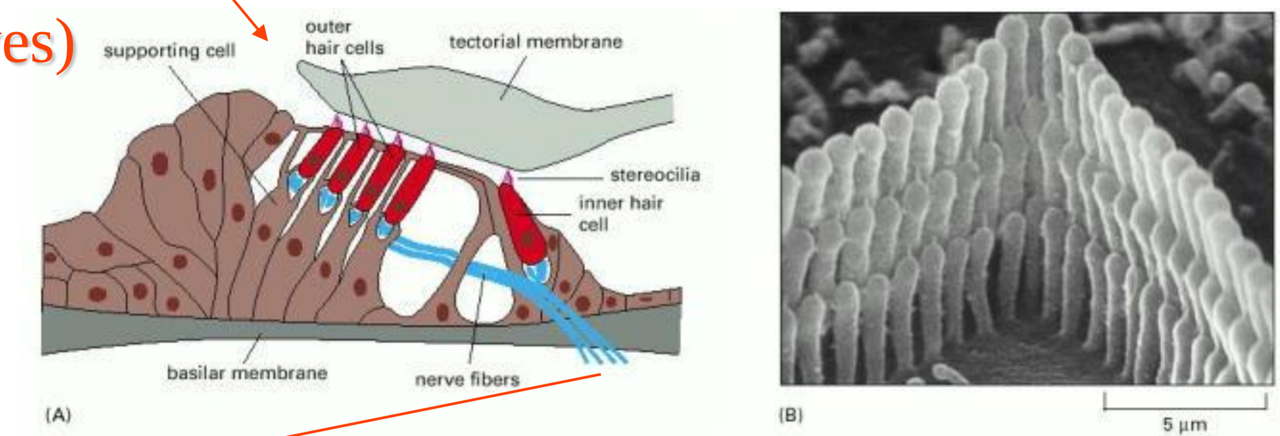
Figure 11-39 *Molecular Biology of the Cell* (© Garland Science 2008)

Motor unit & ion channels

Mechanically gated channels

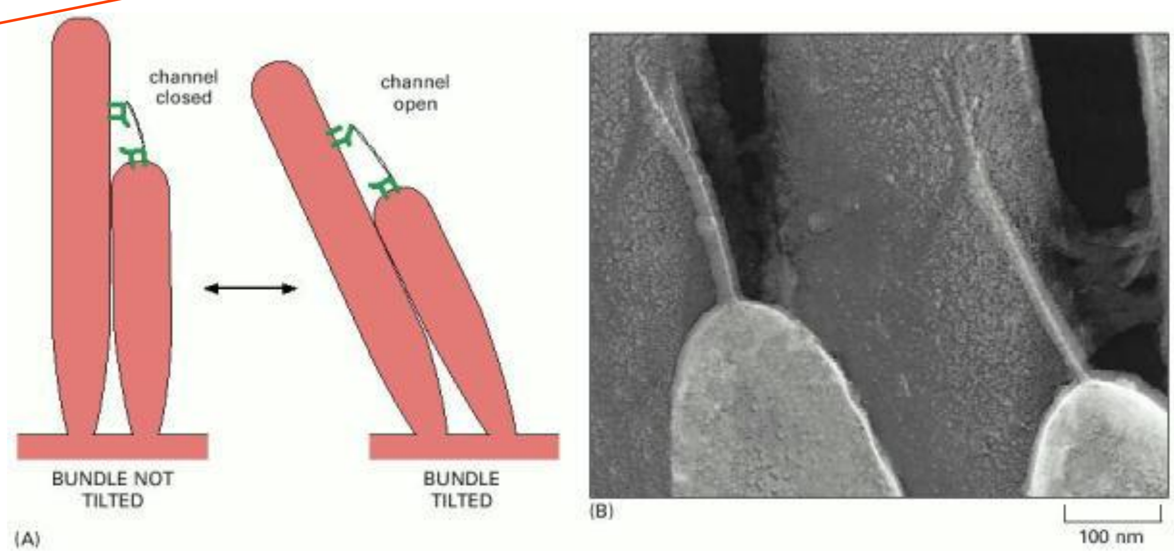
mechanical energy

(sound waves)



Electrical

signals



Mechanically gated channels – K+ channels