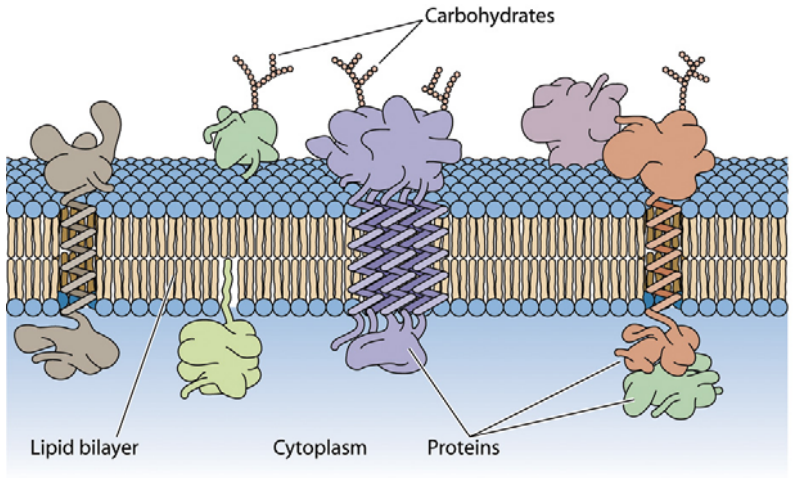
Chapter 7

Cells Maintain Their Internal Environments

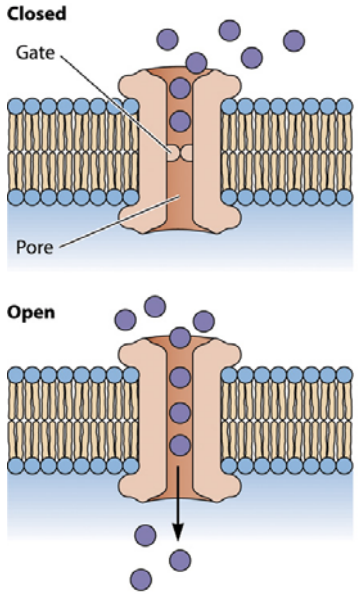
Cell Membrane

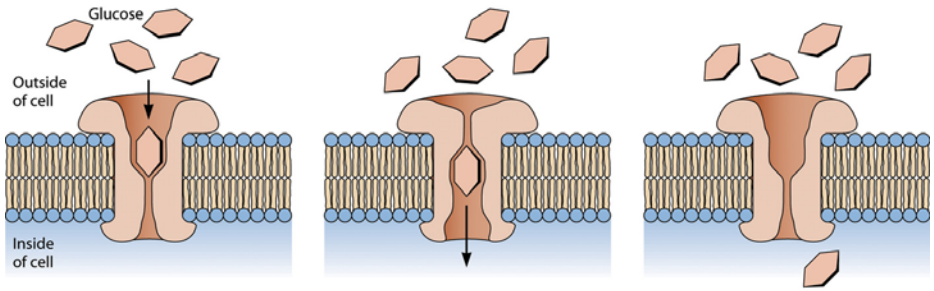
- Components of cell membrane
  - Lipid: phospholipids, sterols
  - Proteins : Receptor, adhesion proteins, recognition protein, transport protein
    - Membrane-spanning domain
      - Hydrophobic surface and hydrophilic core
      - Transport of sugars, amino acids, ions
    - Attachment to cytosolic or exterior face of membrane



Transport Across Membrane

- Diffusion
  - Free diffusion by concentration gradient
  - Hydrophobic substance, nonpolar molecules (O_2, CO_2), small polar molecules (water, ethanol)
- Transport proteins
  - Channel proteins
    - Transport of ions (Na^+, K^+, Ca^{2+}, Cl^-) along their concentration gradients
    - Aquaporin: channel for water
    - Gated channel
  - Carrier proteins
    - Escort metabolic building block along the concentration gradients





Transport Across Membrane

- Active Transport
  - Pump
    - Transport against concentration gradient
      - high Na^+ outside of cell, high K^+ inside of cell
    - Energy source
      - ATP : e.g. Na^+/K^+ ATPase
      - Concentration gradient of ions

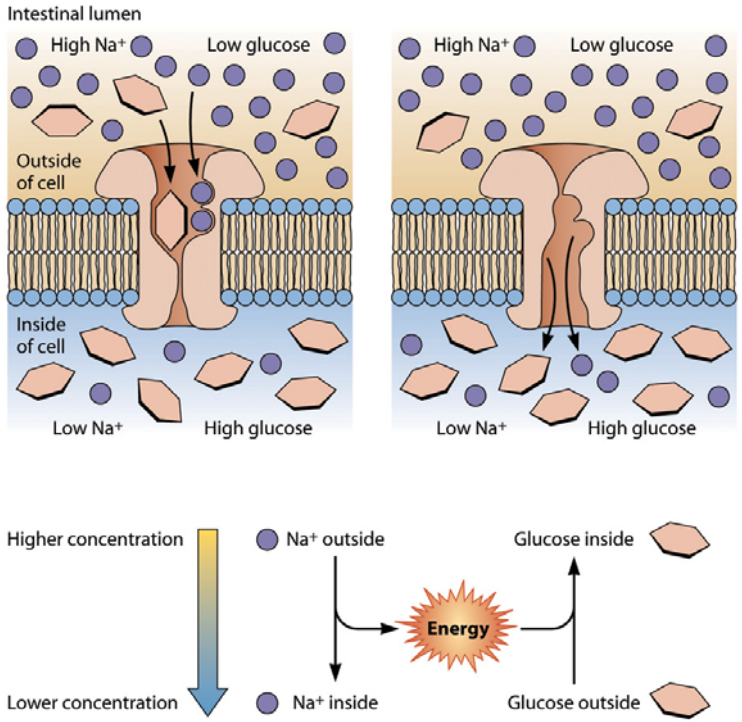


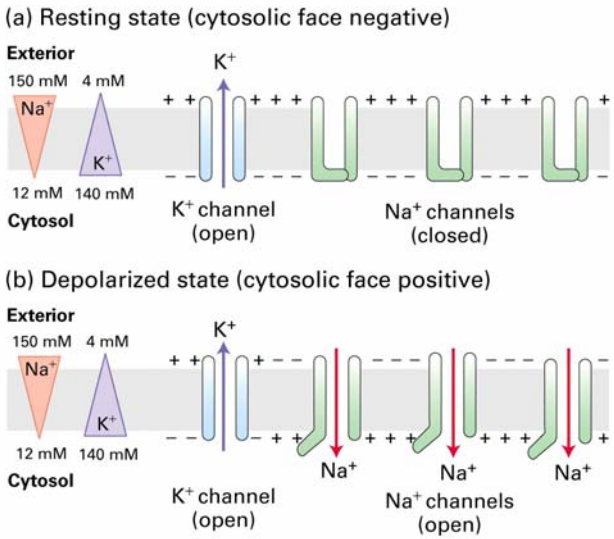
Table 7.1 Approximate concentrations of ions in intracellular and extracellular fluids

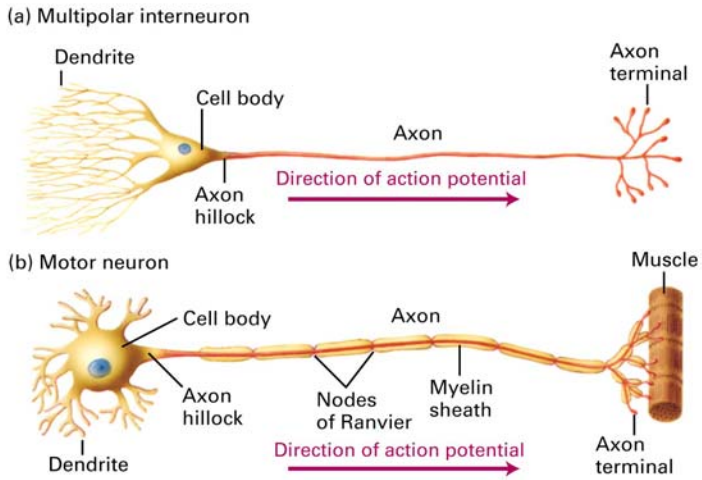
Ion[a]	Intracellular concn (mM)	Interstitial concn (mM)
Sodium (Na^+)	10	145
Potassium (K^+)	150	5
Calcium (Ca^{2+})	0	3
Chloride ($C1^-$)	5	110

[a]The most abundant ions in interstitial fluid are sodium and chloride ions, which are the components of table salt.

Transport Proteins in Animals

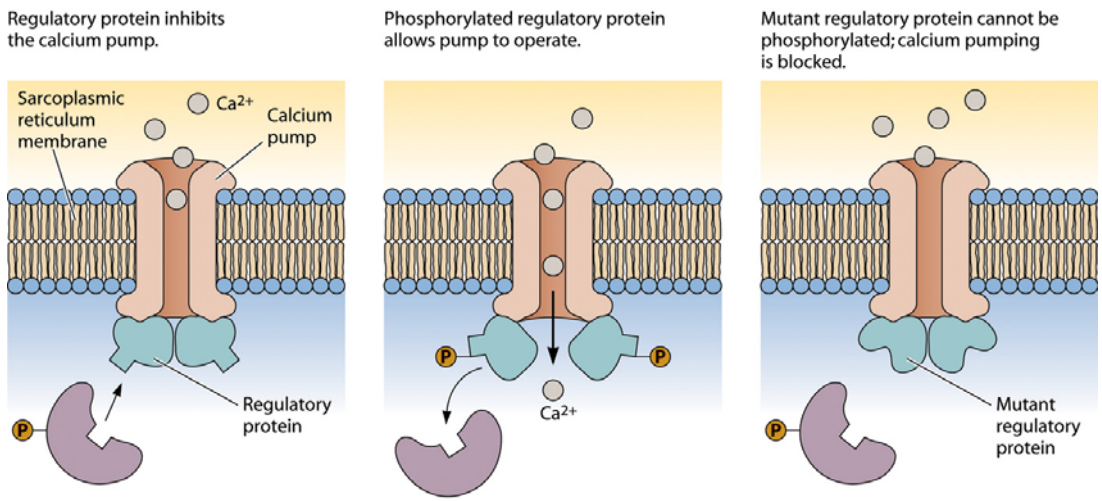
- Nerve Impulses
  - Resting membrane potential of -70mV (~E_K=RT/ZFln[K_{out}]/[K_{in}]
  - Opening of Na^+ channel by stimulation
    - Generation of action potential of 50 mV
  - Opening of voltage-gated K^+ channel
    - Repolarization of membrane potential
  - Restoration of membrane potential by Na^+/K^+ ATPase





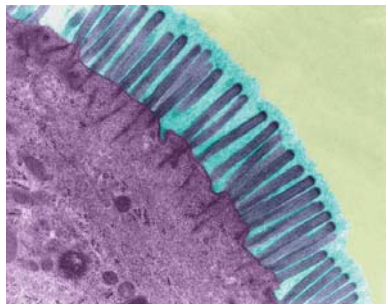
When Gradient Fail

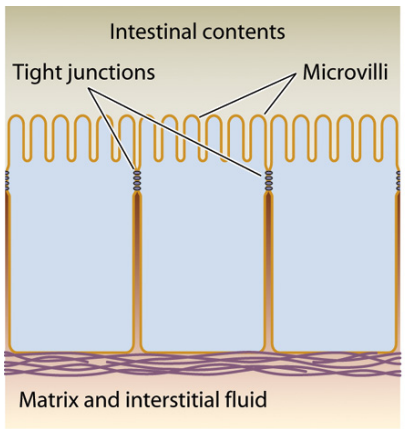
- LongQT (LQT) syndrome
  - Long recovery periods before new heart contraction
  - Cell to cell variation of recovery periods
    - Can cause arrhythmia (lack of rhythm)
  - Defects in K^+ or Na^+ channels
- Inherited heart failure
  - Mutation in the regulatory protein of Ca^{2+} channel in SR



Pumps, Carriers, and Nutrient Distribution

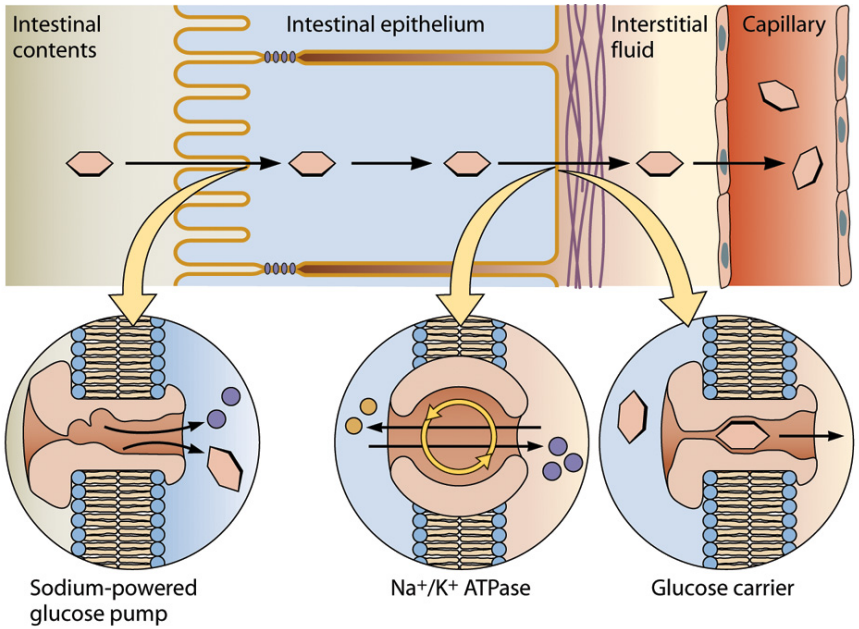
- Epithelial cells
  - Cells cover body surfaces and line internal organs
- Intestinal epithelium
  - Microvilli facing the intestinal track
  - Structure
    - Tight junction between cell: prevent transport of large molecules
    - Extra cellular matrix support epithelial cells





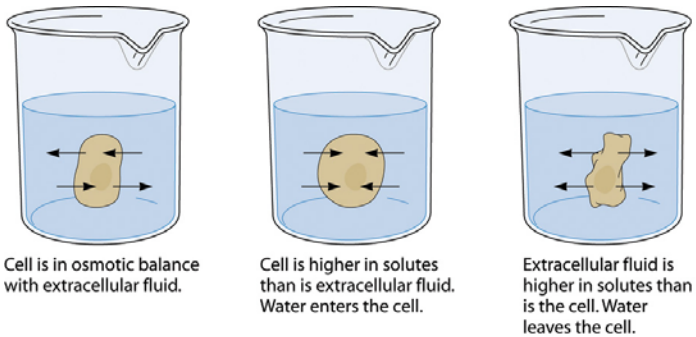
Transport of Nutrients across Epithelial Cells

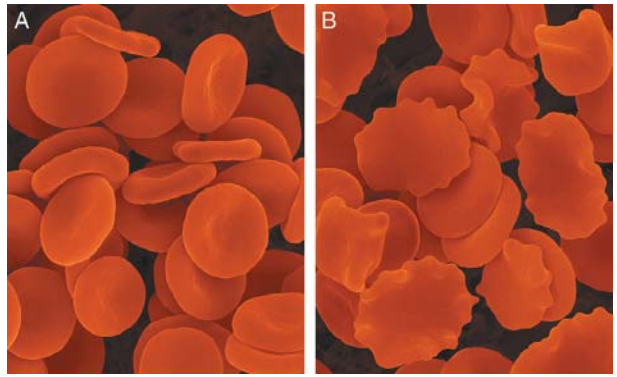
- Intestinal side
  - active transport of glucose powered by Na^+ gradient
  - Co-transport of Na^+ and glucose
- Membrane side: carrier proteins



Cells, Salts, and Water Balance

- Movement of water across the cell
  - Water movement to equalize the total concentration of solutes
  - Osmosis: movement of water across membranes
  - Osmotic balance: A system with no net water movement





  - Osmotic balance of cells
    - Higher concentration of ions outside
    - Cells contain many proteins, amino acids, and other small molecules to keep the osmotic balance

Cells, Salts, and Water Balance

- Water in human body (75 kg)
  - 45 L total
    - 30 L: intracellular
    - 3.75 L: Blood plasma
    - 11.25 L: extracellular fluid

    | Same solute
- Importance of water balance for proper function of a body
  - Lactose intolerance
    - Lack of lactase breaking milk sugar lactose into glucose and galactose
    - No digestion of lactose → movement of water into the intestine
    - Metabolism of lactose by intestinal bacteria → gas production
  - High-magnesium laxative : relieving constipation
  - Cystic fibrosis
    - Mutation in Cl^- channel : reduced water secretion → thick mucus in epithelia of respiratory and gastrointestinal tracts

Biotechnology

- Rehydration therapy
  - Diarrhea: kill 2 million children/year by dehydration
  - Solution of sugar and salt is effective to treat dehydration: e.g. sports drinks
- Enzyme treatments for lactose intolerance
  - Add lactase enzyme in milk or dairy products