Lecture 3
Membrane Transport

• Review
  - Homeostasis– cells function best when their environment (extracellular fluid and all its attributes) are kept within narrow limits
  - All systems of the body play a role in homeostasis, usually through negative feedback control systems

Cell membrane

• Lipid bilayer with hydrophobic center limits ability of polar (water-soluble) or large molecules to pass directly through cell membrane
• Membrane proteins (peripheral and integral)

Integral Proteins- Fig 3.3

• Ion channels
  - Selective filters
  - Often gated
• Transporter (carrier proteins)
  - Specific binding and conformational change
• Membrane receptors

Integral Proteins

• Membrane receptors
  - Specificity for a ligand
  - Saturable
  - Competition
• Used to signal cell

Fluid mosaic membrane

• Limited mobility of components
• Dynamic change
  - size and shape of cell
  - # & kind of proteins, lipids
• Transmembrane flux
  • Vocabulary: A membrane is permeable or impermeable to something, whereas a molecule is permeant (permeating) or non-permeant in the membrane.

Check your understanding

• Question: Why could molecules move through ion channels faster than through transporters?

• What is the functional difference between a molecule binding to a transporter and to a receptor?
Transport processes

1. Diffusion (see Fig 3.5)

- Through lipid by-layer (small, non-polar, e.g. O₂, CO₂, water, steroids, ether)
- Through open protein channels (Na⁺, K⁺, Cl⁻, H₂O)
- Facilitated diffusion via transporter

What factors determine rate of diffusion (Flux) across a space or membrane?
- Steepness of concentration gradient (driving force)
- Temperature
- Surface area for exchange
- Distance (membrane thickness)
- Molecular weight
- Membrane permeability

2. Osmosis - special case of diffusion of WATER

- Water moves across a semi-permeable membrane down it's own concentration gradient
- Solute that can't cross the membrane are "osmotically active" because they can "pull" water

Simple Diffusion characteristics

- Movement DOWN a gradient (Fig 3.4)
  - Concentration gradient
  - Electrical gradient
  - Electrochemical gradients (discuss later)
- Why do molecules move down energy gradients?

Vocabulary

- Osmotic concentration
- Osmolarity
- Osmotic pressure (Fig 3.7)
- Tonicity (Fig 3.8)
  - Isotonic
  - Hypotonic
  - Hypertonic
Thought question

• Why would giving a very dehydrated person an IV injection of pure water rather than an isotonic saline solution be potentially lethal?

3. Facilitated Diffusion

• Uses a transporter (=carrier) protein
• Moves down concentration gradient (no energy needed)
• Example: glucose (large and polar) uses GLUT transporters to cross membrane (Fig 3.10)

Carrier or transporter facilitated systems show:

• Specificity
• Competition
• Saturation
• Insulin increases facilitated uptake of glucose by cells. How could it do this?

4. Active Transport

• Can move molecules UP a concentration gradient
• Requires energy (ATP)
• Requires protein transporters

4a. Primary Active Transport

• Specific “pumps”
  - Na\(^+\)/K\(^+\) exchange pump
  - H\(^+\)
  - Ca\(^{++}\)
  - Iodine (thyroid)

Sodium/ Potassium exchange pump (Fig 3.11)

• Maintains low intracellular sodium (high extracellular)
• Maintains low extracellular potassium (high intracellular)
• 3 Na\(^+\) exchanged for 2 K\(^+\) and doesn’t work unless both present
Sodium/Potassium exchange pump (Fig 3.11)

• Negative feedback: more sodium inside the cell, more gets pumped out to keep concentration constantly low
• Metabolic poisons (cyanide, ouabain-an arrow poison)

5a. Secondary active transport

• Two part system
  - 1. Use Na⁺/K⁺ pump and ATP to generate gradient
  - 2. Use energy stored in gradient to move another molecule AGAINST it’s concentration gradient

Secondary active transport

• Symporter: moves sodium and other molecule in same direction
• Antiporter: moves sodium and other molecule in opposite direction
• Doesn’t work unless both molecules bind transporter

How do really big molecules like proteins cross cell membranes?

• Inside vesicles (budded off piece of membrane)
  - Endocytosis (Fig 3.13)
  - Exocytosis
  - Phagocytosis (Fig 3.14)
  - Pinocytosis (Fig 3.15)