The Cell Membrane

Overview
- Cell membrane separates living cell from nonliving surroundings
  - thin barrier = 8nm thick
- Controls traffic in & out of the cell
  - selectively permeable
    - allows some substances to cross more easily than others
      - hydrophobic vs hydrophilic
- Made of phospholipids, proteins & other macromolecules

Phospholipids
- Fatty acid tails
  - hydrophobic
- Phosphate group head
  - hydrophilic
- Arranged as a bilayer

Phospholipid bilayer
- polar hydrophilic heads
- nonpolar hydrophobic tails
- polar hydrophilic heads

Phospholipid bilayer
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More than lipids...
- In 1972, S.J. Singer & G. Nicolson proposed that membrane proteins are inserted into the phospholipid bilayer

The Fluid Mosaic Model
- “A sea of phospholipids with floating icebergs of protein”
- Membrane composed of different components
- Asymmetrical b/c of different proteins on either side of membrane
- Lateral protein movement (Frye & Edidin Heterocaryon Expt)
  - proteins do NOT flip-flop
  - membrane is always changing its look
The Fluid Mosaic Model

- **Freeze-Fracture Technique**

Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer

- **Extracellular fluid**
- **Glycoprotein**
- **Glycolipid**
- **Cholesterol**
- **Cytoplasm**
- **Filaments of cytoskeleton**

Membrane fat composition varies

- **Fat composition affects flexibility**
  - membrane must be fluid & flexible
  - about as fluid as thick salad oil
  - % unsaturated fatty acids in phospholipids
  - keep membrane less viscous
  - cold-adapted organisms, like winter wheat
  - increase % in autumn
  - cholesterol in membrane

Membrane Proteins

- **Proteins determine membrane’s specific functions**
  - cell membrane & organelle membranes each have unique collections of proteins
- **Membrane proteins:**
  - **Peripheral proteins**
    - loosely bound to surface of membrane
    - cell surface identity marker (antigens)
  - **Integral proteins**
    - penetrate lipid bilayer, usually across whole membrane
    - transmembrane protein
    - transport proteins
    - channels, permeases (pumps)

Why are proteins the perfect molecule to build structures in the cell membrane?

Classes of amino acids

**What do these amino acids have in common?**

- **Nonpolar & hydrophobic**
Classes of amino acids

What do these amino acids have in common?

Polar & hydrophilic

Proteins domains anchor molecule

- **Within membrane**
  - nonpolar amino acids
    - hydrophobic
    - anchors protein into membrane
  - On outer surfaces of membrane
    - polar amino acids
      - hydrophilic
      - extend into extracellular fluid & into cytosol

Examples

- Water channel in bacteria
- Retinal chromophore
- α-helices in the cell membrane
- Proton pump channel in photosynthetic bacteria
- β-pleated sheets
- Bacterial outer membrane

Many Functions of Membrane Proteins

- Outside
  - Plasma membrane
  - Transporter
  - Enzyme activity
  - Cell surface identity marker

- Inside
  - Cell adhesion
  - Attachment to the cytoskeleton

Membrane carbohydrates

- Play a key role in cell-cell recognition
  - ability of a cell to distinguish one cell from another
  - antigens
  - important in organ & tissue development
  - basis for rejection of foreign cells by immune system

Any Questions??
Diffusion

- 2nd Law of Thermodynamics governs biological systems
  - universe tends towards disorder (entropy)

Movement across the Cell Membrane

Diffusion

- movement from high → low concentration

Diffusion across cell membrane

- Cell membrane is the boundary between inside & outside...
  - separates cell from its environment
  - Can it be an impenetrable boundary? NO!

Diffusion through phospholipid bilayer

- What molecules can get through directly?
  - fats & other lipids
  - water & small polar molecules
- What molecules can NOT get through directly?
  - Large polar molecules
    - glucose, amino acids
  - ions
  - salts
  - large molecules
    - starches, proteins

Channels through cell membrane

- Membrane becomes semi-permeable with protein channels
  - specific channels allow specific material across cell membrane
Facilitated Diffusion
- Diffusion through protein channels
  - channels move specific molecules across cell membrane
  - no energy needed
- Open channel = fast transport
- High to low = facilitated diffusion

Active Transport
- Cells may need to move molecules against concentration gradient
  - shape change transports solute from one side of membrane to other
  - Protein "pump"
  - "costs" energy = ATP

Getting through cell membrane
- Passive Transport
  - Simple diffusion
    - diffusion of nonpolar, hydrophobic molecules
    - Lipids
    - High to low concentration gradient
  - Facilitated transport
    - diffusion of polar, hydrophilic molecules
    - through a protein channel
    - High to low concentration gradient
- Active transport
  - diffusion against concentration gradient
  - Low to high
  - Uses a protein pump
  - Requires ATP

Transport summary
- Simple diffusion
- Facilitated diffusion
- Active transport

How about large molecules?
- Moving large molecules into & out of cell
  - through vesicles & vacuoles
  - Endocytosis
    - Phagocytosis = "cellular eating"
    - Pinocytosis = "cellular drinking"
  - Exocytosis
Endocytosis

- phagocytosis: fuse with lysosome for digestion
- pinocytosis: non-specific process
- receptor-mediated endocytosis: triggered by molecular signal

Osmosis is diffusion of water

- Water is very important to life, so we talk about water separately
- Diffusion of water from high concentration of water to low concentration of water
  - across a semi-permeable membrane

Concentration of water

- Direction of osmosis is determined by comparing total solute concentrations
  - Hypertonic: more solute, less water
  - Hypotonic: less solute, more water
  - Isotonic: equal solute, equal water

Managing water balance

- Cell survival depends on balancing water uptake & loss
  - Hypotonic solution: shrivelled
  - Isotonic solution: normal
  - Hypertonic solution: plasmolyzed

Managing water balance

- Isotonic
  - animal cell immersed in mild salt solution
    - example: blood cells in blood plasma
    - problem: none
      - no net movement of water
      - flows across membrane equally, in both directions
      - volume of cell is stable
**Managing water balance**

- **Hypotonic**
  - A cell in fresh water
  - Example: *Paramecium*
  - Problem: gains water, swells & can burst
  - Water continually enters *Paramecium* cell
  - Solution: contractile vacuole
    - Pumps water out of cell
    - ATP
  - Plant cells
    - Turgid

- **Hypertonic**
  - A cell in salt water
  - Example: Shellfish
  - Problem: lose water & die
  - Solution: take up water or pump out salt
  - Plant cells
    - Plasmolysis = wilt

**Water regulation**

- **Contractile vacuole in Paramecium**
  - ATP

**Aquaporins**

- Water moves rapidly into & out of cells
  - Evidence that there were water channels

**Osmosis...**

- Cell (compared to beaker) hypotonic or hypertonic
- Beaker (compared to cell) hypotonic or hypertonic
- Which way does the water flow? In or out of cell

**Any Questions??**