Lecture Outline: Cell Membranes and Transmembrane Transport

I. **Plasma Membrane Structure**

A. **Main Infrastructure: Phospholipid Bilayer**

1. Forms spontaneously because phospholipids are **amphipathic**
2. Each phospholipid has:
   a. **Polar head**: Contains phosphate, is **hydrophilic** (water-loving), faces water
   b. **Non-polar tails**: Made of hydrocarbons (fatty acids), are **hydrophobic** (water-fearing), form the interior of the bilayer

B. **Fluid Mosaic Model**

1. Membrane components (phospholipids, proteins) are **not chemically bonded** to each other and can move independently
2. **Lateral movement** of phospholipids within a layer is very rapid (~10 million times per second)
3. **Flip-flop** (movement between layers) is rare due to energy required to move polar heads through non-polar tails

C. **Membrane Fluidity**

1. Cells maintain correct fluidity based on conditions (e.g., temperature)
2. Adjusted by changing types of phospholipids in the membrane:
   a. **Saturated fatty acids**: Have only single bonds between carbons, are straight, pack tightly, used to **tighten** membrane (e.g., in warm temperatures)
   b. **Unsaturated fatty acids**: Used to make membrane **looser** (e.g., in cold temperatures)
3. **Cholesterol**: Also adjusts membrane fluidity and permeability by filling gaps

D. **Membrane Polarity**

    1. The two sides of the membrane are different from each other
    2. Proteins are more associated with the inner layer than the outer layer

II. **Membrane Proteins**

  A. **Integration and Movement**
    1. Proteins are crucial for substances that cannot pass directly through the phospholipid bilayer
    2. Proteins are held in place by hydrophobic/hydrophilic interactions with phospholipid tails and water
    3. Inserted into the membrane via vesicles from the Rough ER and Golgi apparatus

  B. **Categories of Membrane Proteins**
    1. **Peripheral proteins**: Associated with only one surface (monolayer) of the bilayer
    2. **Integral proteins**: Stick at least partially through the thickness, associated with the hydrophobic tails
      a. **Transmembrane proteins**: A special type of integral protein that sticks all the way through the thickness of the bilayer

  C. **Major Functions of Membrane Proteins**
    1. **Transport**: Facilitate movement of specific substances across the membrane
      a. **Channel proteins**: Form hollow tunnels that allow specific particles to pass through
      b. **Carrier proteins**: Temporarily bind to a particle and change shape to move it across the membrane
    2. **Enzymatic Activity**: Catalyze reactions while bound to the membrane
    3. **Signal Transduction**: Act as **receptors** for chemical signals (ligands)
      a. Signal binding causes a **conformational change** in the protein, relaying the message inside the cell without the signal entering
      b. Requires **transmembrane proteins** to relay signals to the cell interior
    4. **Cell-to-Cell Recognition**: Proteins (often with attached sugars) on the

cell surface allow cells to recognize each other

5. **Intercellular Joining**: Proteins connect adjacent cells together (e.g., in desmosomes)
6. **Attachment to Cytoskeleton and Extracellular Matrix (ECM)**: Anchor the membrane and provide structural support

III. **Transport Processes Across the Membrane**

A. **Three Major Categories**

1. **Passive Transport**
2. **Active Transport**
3. **Vesicular Transport**

B. **Passive Transport (Diffusion)**

1. Does not require additional energy; energy is already built into the system in the form of a **gradient**
2. Moves particles from **high concentration to low concentration** (down the gradient)
3. Based on **random movement** (Brownian motion) but results in net directional movement
4. Requirements for direct diffusion through the phospholipid bilayer:
   a. Particle must be **small enough**
   b. Particle must be **non-polar enough** (e.g., oxygen)
5. Types of Diffusion:
   a. **Simple Diffusion**: Particles move directly through the phospholipid bilayer (small, non-polar substances)
   b. **Facilitated Diffusion**: Requires the help of a **transport protein** (channel or carrier) for particles that are too large or too polar; still passive and moves down the gradient

C. **Active Transport**

1. Requires **additional energy** (e.g., ATP)
2. Moves substances **against their gradient** (from low concentration to high concentration)
3. Always requires a **carrier protein** (cannot use a channel protein)

4. Often referred to as a **pump**
5. Types of Active Transport:
    a. **Primary Active Transport**: Energy (e.g., ATP) is **directly spent** to power the pump and establish a gradient
        (1) Example: **Sodium-potassium exchange pump**: Pumps sodium ions out and potassium ions in, both against their gradients
        (2) Example: **Proton pump**: Pumps hydrogen ions out, creating a proton gradient (stored energy)
    d. **Secondary Active Transport (Co-transport)**: Uses the **energy stored in a pre-existing gradient** (established by primary active transport) to move another substance against its gradient
        (1) Example: **Sucrose-proton co-transporter**: Protons diffuse down their gradient, dragging sucrose against its gradient without direct ATP consumption for sucrose
    f. **Co-transporters**: Transport two different types of particles
        (1) **Symporters**: Move both particles in the **same direction**
        (2) **Antiporters**: Move particles in **opposite directions** (e.g., sodium-potassium pump)

D. **Vesicular Transport**

1. Involves the use of membrane-bound vesicles
2. Types based on direction:
    a. **Endocytosis**: Inward vesicular transport
        (1) **Phagocytosis**: Cell eating (taking in solid particles)
        (2) **Pinocytosis**: Cell drinking (taking in liquid samples)
        (3) **Receptor-mediated endocytosis**: Vesicles form only when specific particles bind to receptors
    e. **Exocytosis**: Outward vesicular transport

IV. **Osmosis and Tonicity**

A. **Osmosis**

1. A special case of **diffusion**

2. Requirements for osmosis:
    a. Movement of a **solvent** (always water in biology)
    b. Movement through a **selectively permeable membrane** (allows water but not solutes)
3. Water moves from a place of **high water concentration** (low solute concentration) to a place of **low water concentration** (high solute concentration), down its gradient
4. Continues until equilibrium or balancing forces (e.g., gravity) are achieved

B. **Tonicity**

1. Refers to the tendency for osmosis to occur through a cell membrane
2. These terms describe the cell's **environment/surroundings**, NOT the cell itself
3. Degrees of Tonicity:
    a. **Hypertonic environment**:
        (1) Has a **higher solute concentration** than the cell (less watery)
        (2) Cell will **lose water** by osmosis
        (3) **Animal cells**: Shrivel (**crenation**), can be fatal
        (4) **Plant cells**: Plasma membrane collapses (**plasmolysis**), fatal
    f. **Hypotonic environment**:
        (1) Has a **lower solute concentration** than the cell (more watery)
        (2) Cell will **gain water** by osmosis
        (3) **Animal cells**: Swell and burst (**lysis**), can be fatal (e.g., red blood cells; aquatic protists use contractile vacuoles to prevent this)
        (4) **Plant cells**: Swell and become **turgid** (pressurized), ideal condition for plant support (erection)
    k. **Isotonic environment**:

(1) Has the **same solute concentration** as the cell (same water concentration)

(2) **No net movement of water**; water enters and leaves at the same rate

(3) **Ideal for animal cells** (e.g., extracellular fluid homeostasis)

(4) **Plant cells**: Can survive but are **flaccid** (limp), not ideal