Modern Cell Theory

- All living organisms are composed of cells.
  - the simplest structural and functional unit of life.
  - cells are alive
- An organism’s structure and functions are due to the activities of its cells.
- Cells come only from preexisting cells
  - i.e., all life traces its ancestry to the same original cells
- Cells of all species have many fundamental similarities in chemical composition and metabolic mechanisms.

Generalized Cell Structures

- Three principle parts of a cell
  1. Plasma membrane = cell membrane
  2. Cytoplasm = everything between the membrane and the nucleus
     - cytosol = intracellular fluid
     - organelles = structures with specific functions
  3. Nucleus = genetic material of cell

Plasma Membrane

- Extracellular surface of the cell
- Intracellular surface of the cell
- Peripheral proteins
- Channel proteins
- Glycolipids
- Glycoproteins
- Transmembrane proteins
- Phospholipid bilayer
- Cholesterol
- Proteins of the cytoskeleton
- Glycans

Not all cells contain all of these organelles.
Membrane Protein Functions

- Receptor: A molecule that binds chemical messengers such as hormones sent by other cells
- Enzyme: An enzyme that breaks down a chemical messenger and terminates its effect
- Ion Channel: A channel protein that is constantly open and allows ions to pass into and out of the cell
- Gated ion channel: A gated channel that opens and closes to allow ions through only at certain times
- Cell-surface marker: A glycoprotein acting as a cell-identity marker distinguishing the body’s own cells from foreign cells
- Cell-adhesion molecule (CAM): A cell-adhesion molecule (CAM) that binds one cell to another

Cell Surface - Second Messenger System

A messenger binds to a receptor

- Receptor
- adenylate cyclase

First messenger

- G protein binds to an enzyme, adenylate cyclase
- converts ATP to cyclic AMP (cAMP), the second messenger.

3. Receptor releases G protein,

- ATP
- P_i

Inactive kinase

- cAMP activates a cytoplasmic enzyme called a kinase.

4. cAMP (second messenger)

Activated kinase

- Inactive enzymes
- Various metabolic effects

- Kinases add phosphate groups (P_i) to other enzymes. This activates some enzymes or deactivates others, leading to varied metabolic effects in the cell.

5. Activated enzymes

Activated enzymes

- How things get in the cell

- Diffusion
- Dye placed in water
- Molecules move from a high concentration to region of lower conc.
- Equilibrium reached in the far right cylinder

Cell Surface

- Glycoproteins and Glycolipids
  - unique in everyone

- Functions
  - protection
  - immunity to infection
  - defense against cancer
  - transplant compatibility

The Selective Permeable Membrane!!

- Permeable to some molecules but not all
- Filtration (coffee filter)
- Diffusion and Osmosis
- transmembrane proteins act as specific channels for some particles
- Protein carriers
- Vesicles can transport in and out

Cell surface - Cilia

- Cilia – respiratory tract, uterine tubes, ventricles of the brain, efferent ductules of testes

- Flagella

  - Cilia and flagella composed of Microfilaments.
Diffusion Rates

- Factors affecting diffusion rate through a membrane
  - temperature
  - molecular weight - larger molecules move slower
  - steepness of concentrated gradient
  - membrane surface area
  - membrane permeability

Osmosis

- Movement of water through a selectively permeable membrane from an area of high water conc. to area of lower water conc.
  - Water moves through the phospholipid bilayer
  - Transmembrane proteins can function as water channels (Aquaporins)

Osmosis: The movement of water across a semi-permeable membrane

Attraction of water to solute particles forms hydration spheres

Aquaporins - channel proteins specialized for passage of water
Osmotic Pressure

- **Osmotic Pressure**: amount of pressure required to stop osmosis (amt of hydrostatic pressure)
- **Hydrostatic pressure**: physical pressure generated by a liquid

![Figure 3.15b](image)

Osmolarity

- **One osmole**: 1 mole of dissolved particles
  - 1M NaCl (1 mole Na⁺ ions + 1 mole Cl⁻ ions) thus 1M NaCl = 2 osm/L
- **Osmolarity**: number of osmoles of solute per liter of solution (i.e., number of solutes/l solution)
- **Osmolality**: number of osmoles of solute per kilogram of water (i.e., number of solutes/kg of H₂O)
- Physiological solutions are expressed in milliosmoles per liter (mOsm/L)
  - blood plasma = 300 mOsm/L
  - osmolality similar to osmolarity at concentration of body fluids

Tonicity

- **Tonicity**: ability of a solution to affect fluid volume and pressure in a cell
  - depends on concentration and permeability of solute
- **Hypotonic solution**: has a lower concentration of solutes than intracellular fluid (ICF)
  - high water concentration
  - Cells lyse
- **Hypertonic solution**: has a higher concentration of solutes
  - low water concentration
  - Cells crenate
- **Isotonic solution**: concentrations in cell and ICF equal
  - no changes in cell volume or shape

Effects of Tonicity on RBCs

1. Simple diffusion
2. Diffusion through a channel
3. Carrier Mediated Transport uses a transporter protein.

Membrane Carriers (proteins)

- **Uniport**: carries one solute at a time
- **Symport (Cotransport)**: carries >2 osolutes simultaneously in same direction
- **Antiport (Countertransport)**: carries ≥2 or more solutes in opposite directions
  - e.g., sodium-potassium pump
- carriers employ two methods of transport
  - facilitated diffusion
  - active transport
Diffusion Through Membrane Channels

- Each membrane channel specific for ions (e.g., K⁺, Na⁺, or Ca²⁺)
- Channels may be open or gated

Filtration and osmosis

Facilitated Transport: Glucose example

- Glucose binds to transport protein
- Transport protein changes shape
- Glucose moves down the concentration gradient

Transport Across the Plasma Membrane

- So far -

Active Transport

- Movement of stuff against its concentration gradient
- Requires energy from ATP
- Enables movement into cell against a concentration gradient

Transport Vesicles (another way of getting things in and out)

- Vesicles are round sacs of membrane that surround stuff (Requires ATP)
- Endocytosis = vesicles bringing something into cell
- Exocytosis = vesicles release something from cell

Endocytosis:
1) receptor-mediated endocytosis
2) Phagocytosis
3) Pinocytosis = droplets of extracellular fluid

2. Cytoplasm = everything between membrane and nucleus
1. cytosol = intracellular fluid
2. organelles = special structures with specific functions
1. Cytosol = Intracellular fluid

- 55% of cell volume
- 75-90% water
  - organic molecules (carbs, lipids, sugars, proteins, enzymes), ATP, waste products, and ions
  - Dissolved (solutions)
- Site of many important chemical reactions

2. Cell Organelles

- Some organelles lack membranes others are surrounded by one or two phospho-lipid bilayer membranes

Cytoskeleton

- Network of protein filaments throughout the cytosol
- Functions:
  - support and shape
  - organization of cell contents
  - cell & organelle movement

The Cytoskeletal Filaments

1. Microfilaments
2. Intermediate filaments
3. Microtubules

Centrosome

1. Centrioles
2. Pericentriolar material
  - Found near nucleus
  - Important site during mitosis
  - Microtubule formation!

Ribosomes – Protein Makers

- Sites where protein is made!!!!!!!!!!!!!
- Tiny packages of ribosomal RNA (rRNA)
  - synthesize proteins (plasma membrane & for export)
1. Free ribosomes are loose in cytosol
  - synthesize proteins used inside the cell
2. On Surface of Endoplasmic Reticulum (mitochondria, synthesize mitochondrial proteins)
**Endoplasmic Reticulum**
- Network of membranes forming flattened sacs (Cisterns)
  - 2 types:
    - **Rough ER**
      - continuous with nuclear envelope & covered with ribosomes
      - synthesizes, processes & packages proteins for export
    - **Smooth ER**
      - no attached ribosomes
      - synthesizes phospholipids, steroids and fats
      - detoxifies harmful substances (alcohol)

**Golgi Complex**
- Flattened curved membranous sacs (cisterns)
- Modify, sort, packages proteins produced by rough ER

**Lysosomes**
- Membranous vesicles
  - formed in Golgi Complex
  - digestive enzymes
- Functions
  - digest foreign substances
  - autophagy
    - recycle own organelles

**Peroxisomes & Proteasomes**
- Membranous vesicles
- small
- contain enzymes
- Peroxisomes: oxidize toxic chemicals
- Proteasomes: break down proteins (metabolic breakdown)
Mitochondria
- Double membrane bound organelle
- Function
  - generation of ATP!!!!!! (Adenosine triphosphate)
  - Cellular respiration
- Can self-replicate

Nucleus
Function: Directs all cell activities
- Double membrane (aka: nuclear envelope)
- Contains our genetic stuff: chromosomes (DNA)
  - Nucleolus: where ribosomes are produced