Biological membranes

I. Basic physiological concepts

A. Levels of organization in the body

- cells -- tissues -- organs -- systems -- organism

  - cells are in contact with privately maintained internal environment as opposed to external environment that surrounds body
  - cells can only function when bathed by extracellular fluid with very specific composition and properties
  - chemical composition and physical state of the internal environment can only deviate within very narrow limits

B. Homeostasis

- homeostasis is the ability for the body to maintain an ever-changing internal environment, yet keep change within tightly regulated ranges -- many cells, organs, body systems involved in maintenance of homeostasis

- homeostasis is essential for the survival of each cell, and each cell, through its specialized activities, contributes as part of a body system to the maintenance of the internal environment shared by all cells

- negative feedback is common regulatory mechanism in body for maintaining homeostasis

II. Biological membranes -- introduction

- cell membranes enclose the cell, defines its boundaries.

A. General functions

  1. Physical isolation
  2. Regulation of exchange with environment
  3. Resting membrane potential
  4. Communication between cell and environment
  5. Structural support
B. General structure

- predominantly lipid and protein held together by noncovalent interactions; small amount of CH$_2$O.

C. Fluid-mosaic model

- lipid bilayer with inserted proteins.
  1. Lipid bilayer -- basic structure, structural backbone
  2. Protein molecules -- mediate most other functions of membrane.
  3. CH$_2$O attached to ECF side -- to proteins and lipids.

II. The lipid bilayer.

- a trilaminar structure by TEM -- due to arrangement of membrane lipids

A. Membrane lipids are amphipathic -- phospholipids predominate.

B. Complexes formed by phospholipids -- exclusion of water principle

  - micelles
  - bilayers
  - liposomes

C. Fluidity of bilayer depends on its temperature and composition.

  1. hydrocarbon chain size/cis-double bonds
  2. cholesterol

D. Lipid composition of plasma membrane is diverse.

  1. cholesterol
  2. four major phospholipids

    - phosphatidylcholine
    - sphingomyelin
    - phosphatidylinerine
    - phosphatidylethanolamine
  3. why are there so many different lipids in membrane?
E. Lipid bilayer is asymmetrical
- outer layer vs. inner layer
- functional importance

III. Membrane proteins

A. Membrane protein association with lipid bilayer
   1. transmembrane proteins
   2. attached to bilayer via covalently attached fatty acid chain.
   3. attached to transmembrane protein noncovalently.
   4. attached to bilayer via oligosaccharide.

B. Transmembrane protein structure
   1. cytoplasmic and extracellular domains polar
   2. membrane spanning domain - non-polar amino acids
      a. membrane spanning domain forms α-helix
      - single pass and multipass membrane proteins
      b. multiple transmembrane strands arranged in β-sheet in form of closed barrel - β-barrel

C. Functions of transmembrane proteins
   1. Structural elements
      a. Cell adhesion molecules (CAMs)
      b. Specialized cell junctions
         - desmosomes
         - tight junctions
         - gap junctions
   2. Enzymes
      - membrane associated enzymes
- enzymes on cytoplasmic side of membrane -- role in signal transduction.

3. Receptors
- signaling cascades in membrane with generation of second messengers

4. Transporters
- move lipophobic molecules across cell membrane -- selective permeability.
- role in creating and maintaining RMP
  a. carriers
  b. channels

5. Role in glycocalyx.

IV. Membrane carbohydrates
- sugar chains on outer membrane surface bound to membrane proteins and to membrane lipids forming glycoproteins and glycolipids
- outer surface of membrane covered with a dense carbohydrate coat, the glycocalyx
- roles of glycocalyx
  - role in recognition of self and cell-cell interaction -- cells of a specific type have similar sugar chains projecting from surface membrane proteins -- cell identity, cells of same type grouping together to form tissues
  - regulation of tissue growth
  - other roles in cell to cell interaction -- immunosurveillance of NK cells, macrophages
  - cell adhesion