Ch. 6: Communication, Integration & Homeostasis

Goals

- Describe cell to cell communication
  - Electrical or Chemical only
- Explain signal transduction
- Review homeostasis

N.B.: Running Problem, Diabetes Mellitus

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Cell to Cell Communication

75 trillion cells  (In Scientific Notation??)

4 basic methods of cell to cell communication (p 175):

1. Direct cytoplasmic transfer (Gap Junctions)
2. Contact dependent signals (Surface Molecules)
3. Short distance (local diffusion)
4. Long distance  (through either chemical or electrical signals)

Cell receiving signal = ? receptors
1. Gap Junctions for Direct Cytoplasmic Transfer

- Connexins from each cell form connexon (channel)
- Gate open → cytoplasmic bridges form functional syncytium
  - Ions and small molecules can pass freely
- Transfer of electrical and chemical signals (ubiquitous, but particularly in heart muscle and smooth muscle of GI tract)
2. **Contact-Dependent Signals**

Require cell-cell contact

Surface molecules bind

CAMs – Cell Adhesion Molecules

Bidirectional Communication Possible
3. Short distance (local diffusion)

Paracrines and Autocrines (Chemical signals secreted by cells)
Para- = next to
Auto- = self

- Mode of transport
  - diffusion (slow)
- Histamines, cytokines, eicosanoids (more later)
- Many act as both paracrines and autocrines
4. Long Distance Communication

Body has two control systems:

- **Endocrine system** communicates via hormones
  - Secreted where? Transported where and how?
  - Only react with ____________

- **Nervous system** uses electrical (along the axon) and chemical (at the synapse) signals (APs vs. neurotransmitters and neurohormones [adrenal gland])
4. Long Distance Communication

(a) **Hormones** are secreted by endocrine glands or cells into the blood. Only target cells with receptors for the hormone will respond to the signal.

(b) **Neurotransmitters** are chemicals secreted by neurons that diffuse across a small gap to the target cell. Neurons use electrical signals as well.

(c) **Neurohormones** are chemicals released by neurons into the blood for action at distant targets.
Cytokines for BOTH Local and Long Distance Signaling

- Act as paracrine, autocrine and/or hormone
- Comparison to hormones (sometimes blurry):
  - Broader target range
  - Made upon demand (like steroids, no storage in specialized glands)
- Involved in cell development and immune response
- Terminology: A zoo of factors in a jungle of interactions surrounded by deep morasses of acronyms and bleak deserts of synonyms
Signal Pathways

- Signal molecule (ligand)
  - Ligand = active messenger
- Receptor on target cell membrane, intracytoplasmic or intranuclear
- Intracellular signal
- Target protein
- Response
Three Receptor Locations

- Membrane
- Cytosolic
- Nuclear

- Lipophilic ligands:
  - enters cell and/or nucleus
  - Often activates gene
  - Slower response

- Lipophobic ligands:
  - can't enter cell
  - Membrane receptor
  - Fast response
Membrane Receptor Classes

1. Ligand-gated channel
2. Receptor enzymes
3. G-protein-coupled
4. Integrin

Signal Transduction
Direct Mechanisms via Ligand-gated Channel: Nicotinic ACh receptor

Change in ion permeability changes membrane potential
Signal Amplification

• Activates an Amplifier Enzyme to catalyze reactions
  • Kinase
  • Secondary messengers
  • Examples on table 6-1
Activated receptor alters intracellular molecules to create response

First messenger → transducer → amplifier → second messenger
Most Signal Transduction uses G-Protein

- Hundreds of types known
- Bind GDP / GTP and become activated
- Activated G proteins can
  1. Open ion channels
  2. Alter intracellular enzyme activity, e.g.: via
     1. adenylyl cyclase (amplifier) → cAMP (2nd messenger) → protein kinase activation → phosphorylated protein
     2. Inositol triphosphate → opens Ca$^{2+}$ channels in ER

*G-Protein is a membrane-associated protein that binds to GDP (guanosine diphosphate)*
G - Protein Mediated Signal Transduction

Muscarinic ACh receptor
Epinephrine Signal Transduction

Compare to fig 6-11
Other Signal Molecules

- Not all are proteins
- Ca$^{2+}$ is a common cytosolic messenger
  - Ca$^{2+}$ channel blockers are common drugs
- NO (nitric oxide) is a neurotransmitter
Other Signal Molecules, cont’d

- Lipids, esp. eicosanoids:
  - Produced from arachidonic acid
  - Leukotrienes cause contraction of bronchiolar smooth muscle
  - Prostanoids have several communicative roles, e.g., inflammation
    - NSAIDS inhibit COX enzymes
the end