Cell Communication Notes

- Cell Communication= External signals are converted into responses within the cell  
  o All cells (prokaryotes and eukaryotes) communicate Examples:

- Cells (in multicellular organisms) communicate by a variety of chemical signals. Some examples are:
  1. Hormones, such as insulin- Produced in one tissue, travel through bloodstream, interact with certain cells to change cell activity.
  2. Neurotransmitters, such as dopamine- Released by one nerve cell (neuron), travels very short distance to adjacent neuron, stimulates nerve cell activity

Signal Transduction Pathways
- Convert signals on a cell’s surface into cellular responses

How do different organisms use cell communication?
Single cells- Yeast cells (Single Cells) identify their mates by cell signaling; bacteria respond to population density
Multicellular Organisms-
  o Examples:
    1. Epinephrine stimulation of glycogen breakdown in mammals
    2. Temperature determination of sex in some vertebrate organisms, such as some turtles, American alligator, etc.
    3. DNA repair mechanisms

- Cell Junctions- Multicellular Organisms- Plant and animal cells have cell junctions that directly connect the cytoplasm of adjacent cells
- Direct contact- Animal cells; examples: Immune cells such as antigen-presenting cells helper T-cells and killer T-cells.
- Local Regulators- Short distances. Animal cells; examples: Paracrine and Synaptic
- Long distance signaling- Both plants and animals use hormones; examples: neurotransmitters, plant immune response, embryonic development, quorum (population control) sensing in bacteria

Sutherland suggested that cells receiving signals went through three processes:
  1. Reception
  2. Transduction
  3. Response

Reception- A signal molecule binds to a receptor protein, causing it to change shape
  • The binding between signal molecule (ligand) and receptor is highly specific
  • A conformational change in a receptor is often the initial transduction of the signal
  • Intracellular receptors are cytoplasmic or nuclear proteins
  • Signal molecules that are small or hydrophobic and can readily cross the plasma membrane use these receptors

There are three main types of membrane receptors:
  1. G-protein-linked receptors
  2. Tyrosine kinases receptors
3. Ion channel receptors

G- Protein linked receptors
3 components- all allosteric proteins that can change shape in response to signal:
   1. Receptor proteins- spans plasma membrane, has receptor site on outside, binding site for G-protein on inside
   2. G- protein- loosely attached to inner membrane
      a. Acts like on-off switch
      b. Inactive form when bound to GDP
      c. Active form when bound to GTP
      d. G-protein soon breaks GTP down to GDP, so “on” stat switches back to “off”
   3. Target- usually a membrane bound enzyme
      a. Enzyme is inactive until activated by active G-protein

Examples that use G-proteins:
- Many hormone receptors
- Many neurotransmitters
- Vision and smell in humans
- Bacterial infections (botulism, cholera, etc.) produce toxins that interfere with G-proteins, leading to disease symptoms
- As many as 60% of all medicines sold today act by influencing G-protein pathways

Transduction- Cascades of molecular interactions relay signals from receptors to target molecules in the cell
   1. Protein Phosphorylation
      - Multistep pathways- can amplify a signal and provide more opportunities for coordination and regulation
      - At each step in a pathway
        - The signal is transduced into a different form, commonly a conformational change in a protein
        - Include phosphorylation cascades
      - A series of protein kinases (enzymes) add a phosphate to the next one in line, activating it
        - Phosphatase enzymes then remove the phosphates
        - Kinases are often linked: Kinase 1 activates kinase 2, which activates kinase 3, etc to final target.
   2. Second Messengers
      - Second messengers- are small, non-protein, water-soluble molecules or ions
      - Example= cyclic AMP (cAMP)
      - cAMP is made from ATP by enzyme adenyl cyclase (often activated by G-protein)
      - cAMP acts like an intracellular hormone, stimulating variety of effects that differs from tissue to tissue
      - Many G-proteins trigger the formation of cAMP, which then acts as a second messenger in cellular pathways
      - Ca^{++} is an important second messenger because cells are able to regulate its concentration in the cytosol
      - Other second messengers such as inositol triphosphate and diacylglycerol
        - Can trigger an increase in calcium in the cytosol

Response: Cell signaling leads to regulation of cytoplasmic activities or transcription
• Cells use multi step pathways for amplification
• Each activated component can turn “on”, or activate multiple copies of many different target molecules
• The more steps involved, the bigger the final number of activated products = activation cascade.
• The different combinations of proteins in a cell give the cell great specificity in both the signals it detects and the responses it carries out
• Other pathways regulate genes by activating transcription factors that turn genes on or off
• Signal response is terminated quickly by the reversal of ligand binding

Changes in Signal Transduction pathways can alter cellular response
  - Conditions where signal transduction is blocked/defective
    - Examples:
      o Diabetes, heart disease, neurological disease, autoimmune disease, cancer, cholera
      o Effects of neurotoxins, poisons, and pesticides
      o Drugs

So why do we care?
• Allows humans to modify and manipulate biological systems and physiology.
• Human example: Knowing about the endocrine system allowed for the creation of birth control pills and medicines to control blood pressure, depression, and metabolism
• Other examples: Agricultural production and modifying ripening in fruit