CH 11

CELL COMMUNICATION

SUMMARY

Overview

- Cell signaling evolved early in the history of life
- Communicating cells may be close together or far apart
- The three stages of cell signaling are reception, transduction, and response

Signal Reception and the Initiation of Transduction

- A signal molecule (ligand) binds to a receptor protein, causing the protein to change shape
- Most signal receptors are plasma-membrane proteins

Signal-Transduction Pathways

- Pathways relay signals from receptors to cellular responses
- Protein phosphorylation, a common mode of regulation in cells, is a major mechanism of signal transduction
- Certain small molecules and ions are key components of signaling pathways (second messengers)

Cellular Responses to Signals

- In response to a signal, a cell may regulate activities in the cytoplasm or transcription in the nucleus
- Elaborate pathways amplify and specify the cell's response to signals

3 STAGES OF CELL SIGNALING:

1. Signal reception - signal binds to a receptor protein

2. Signal Transduction - the binding of the signal causes a message to be conveyed to the cell's cytoplasm and amplified

3. Cellular Response- cell changes its activity in response to the cell signal

FYI: *Caffeine acts in different ways in different tissues. A tired person's brain produces adenosine molecules that bind to specific receptor proteins resulting in decreased brain activity and increased drowsiness. Caffeine's molecular structure is similar to that of the adenosine molecule, so it occupies the adenosine receptors without inhibiting all brain function and alertness is restored. Then, in the heart and liver, caffeine stimulates a pathway inside cells so that they do not need hormonal stimulation. In the heart, the result is an increased rate of beating; the liver is stimulated to release glucose into the bloodstream.*

SECOND MESSENGERS- special small molecules which initiate a series of events that amplify the signal

Examples of second messengers: cyclic AMP (cAMP) and Ca^{2+} both diffuse through the cytosol and help broadcast signals

(Signal molecules, usually called a ligand)

Physical- light, odors, touch, sound, magnetic poles
Chemical

- To respond the cell must have a specific receptor protein that can bind to the signal
- Cells receive signals (mostly chemical) from their extracellular fluid environment. Most of these chemical signals come from other cells
- Chemical signals: hormones, neurotransmitters reach target cells by local diffusion or by circulation within the bloodstream

Ex: 2 signal molecules in plants

1) Ethylene – gas stimulates fruit to ripen
2) Brassinolide – steroid that stimulates plant growth

2 signal molecules in animals

1) Epinephrine – hormone stimulates blood pressure & glycogen breakdown
2) Glucagon – peptide stimulates glucose synthesis in the liver

Autocrine signals affect the cells that make them

Paracrine signals diffuse to nearby cells

Synaptic signals – neurotransmitter diffuses across synapse (nerve cell to nerve cell)

Hormonal signals travel to distant cells through the circulatory system

Range from opening an ion channel, to heal a wound, moving to a new location in the embryo to form a tissue, activating transcription factors (proteins that turn on genes), cell growth, cell division, regulate enzyme activity, sending messages to the brain……

Whether the receptor protrudes from the plasma membrane surface or is located in the cytoplasm, the result of ligand binding is the same:

The receptor protein changes its 3D structure and initiates a cellular response

$$R + L \rightleftharpoons RL$$ "knock at the door"

NOTE: binding is reversible
release of the ligand is important or receptor will be continuously stimulated

TYPES OF RECEPTORS (most are plasma-membrane proteins)

- ✓ Ion Channel Receptor "gates" open or close and allow Na^+, K^+, Ca^+, or Cl^- to enter or leave

- ✓ Protein Kinases – some eukaryotic receptor proteins become kinases when they are activated. They catalyze the transfer of a phosphate group from ATP to a protein. Phosphorylation cascades, add phosphate groups an activates chain reactions until an enzyme removes the phosphate group. (This is how the signal is amplified in the cytoplasm)

- ✓ G Protein-linked receptors – group of receptors that can either activate or inhibit an effector

Ex: activate response – the receptor for epinephrine (adrenaline) hormone made by the adrenal gland in response to stress or heavy exercise. This hormone binds to its G protein-linked receptor → activates G protein then cAMP is sent as a second messenger and gets glucose for energy and for muscle contraction

Ex: Inhibition – epinephrine binds to its receptor in smooth cells surrounding blood vessels lining the digestive tract. This causes the target enzyme to be inhibited and therefore muscles relax.

- ✓ Cytoplasmic Receptors – Signal molecule (ex: steroid hormone) diffuse through membrane to bind with a receptor protein in the cytoplasm. Binding causes the receptor to change shape so that it can enter the cell nucleus, where it acts as a transcription factor EX: Lipid hormones and nitric oxide (NO)

CELL COMMUNICATION BY DIRECT CONTACT:

- ❖ Gap Junctions
- ❖ Plasmosdesmata