

AP Biology

Unit 4 - Communication and Cell Cycle

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1. Cell Communication:

- Amplification: An effect that occurs when the original signal is strengthened by many domino-effect reactions within signal transduction.
- Apoptosis: can be termed as “cell suicide”, occurs as a result of cell signals
- Epinephrine: water soluble ligand molecule; signals the cell to convert glycogen into usable sugar/energy
 - responsible for the onset of the fight or flight reaction
 - also referred to as adrenaline
- G protein: Binds with GTP and works with a G-protein coupled receptor to relay signals from the outside to the inside of the cell
- Gap junction: intercellular junction common between animal cells, allows materials to pass through
- Glycogen: polysaccharide that acts as a storage for glucose; it is common in muscle and liver cells
- Ligand: a molecule that binds to a very specific receptor in the cell membrane; its binding to the receptor is the onset of signal transduction
 - Water soluble ligands require an external receptor, while hydrophobic ligands usually have intracellular receptors
 - Ligand-gated ion channel: channel in the plasma membrane that opens in response to the binding of a specific ligand
- Local regulator: type of cell signal that acts locally
 - Common in short distance cell signaling
- Protein kinase: Enzyme that removes the phosphate from ATP and attaches it to the next protein kinase in a reaction cascade
 - encourages the cascade of reaction during signal transduction
- Protein phosphatase: enzyme that removes the phosphate group from proteins

kinases in signal transduction

- Often used to halt a certain signal that has been cascading
- Receptor tyrosine kinase: Another plasma membrane receptor that functions in cell signaling
 - helps cells in their regulation of cell cycle and cell reproductive signals, as it is able to trigger numerous signal pathways at the same time
- Signal transduction: the processes that include how the cell responds an extracellular (or intracellular) signal
- Testosterone: steroid hormone that works as a ligand for multiple signals that aid in the process of male reproductive system development.
- Transcription factor: A regulatory protein that binds to DNA and affects transcription of specific genes.
- Stages of Cell Communication:
 - reception - ligand binds to receptor
 - transduction - original signal from ligand is amplified through a cascade of reactions
 - response - cell responds when the end of the cascade is reached

2. Introduction to Signal Transduction:

- Hormone: chemical substance that acts as a ligand in signal transduction; common in long-distance communication
- Endocrine function: produces and sends hormones
- Neurocrine function: Hormones transmit the molecular signal from neuron to its axon and then into bloodstream to the distant target cells
- Paracrine function: hormonal signals that act on local cells
- Autocrine function: hormone acts back on the cells of their origin to modulate their own secretion or intracellular processes
- Steroid hormones are made from cholesterol
 - , aldosterone, progestins, vitamin D, estrogens
- Major classes of hormone receptors:
 - Extracellular/membrane receptors: binding of hormonal ligand to an extracellular receptor causes a conformational change, which in turn activates more enzymes that continue the cascade effect of signal transduction. Some common ones are:
 - Adenylyl cyclase
 - cGMP phosphodiesterase
 - Ca²⁺ and K⁺ channels
 - Phospholipase-C, -A₂ or D
 - Nuclear receptors: water-fearing hormones bind to intracellular receptors, and their effect is dependent on the number of hormones/ligands present to kickstart the cell response

3. **Signal Transduction:**

- Intracellular Signals: protein kinases or signal receptors inside the cell that bind to hydrophobic ligands
 - Steroids, hormones
- Transduction: cascades of interactions between protein kinases and ATP that amplify the signal received by the binding of ligand
 - Amplification occurs when a single kinase activates multiple kinases in the next level of the cascade reaction
 - The multiple kinases allow places for control and regulation
 - Signals are constantly transduced (translated) into a different form until another signal is sent to prevent phosphorylation of ATP.
 - Kinases stimulate pathways
 - Phosphatase shuts off pathways
- Dephosphorylation: Occurs when phosphatase enzymes remove the phosphates from the protein.
- Secondary Messengers: Small, non-protein, water-soluble molecules or ions that pass a signal; spread via diffusion.
 - cyclic-AMP: responsible for activating the protein kinase cascade. Often works with adenylyl cyclase
 - Calcium Ions: a common messenger and relays signals in G-Protein and Tyrosine Kinase Receptor pathways.
- Cell signaling leads to a cytoplasmic response or a change in the nucleus that leads to protein production, inciting a cellular response.
- Gene Expression: gene information is used to produce proteins through translation and transcription
 - Transcription: copies DNA into RNA
 - Translation: RNA used to make proteins
- Signal Termination: Signal response is terminated quickly by the reversal of the ligand binding.

4. **Other Signal Involved in Signal Transduction**

- Quorum sensing: cellular communication method common in bacteria where bacteria inform each other of the excess of products in their environment
- Pheromone: chemical signal released externally by animals of the same species
- Antigen-presenting cell (APC): immune system cells that help in regulation
- Helper T lymphocyte (TH): CD4+ cells help in the adaptive characteristic of the immune system
- Plasmodesma: allow small molecules (including signaling molecules) to flow between neighboring cells
- Neurotransmitters: ligand for nerve cells
- Insulin: hormone produced to help the body use sugar

5. **Feedback:**

- Negative Feedback Loop: similar to homeostasis in which a system aims to stay at or close to a set point
- Positive Feedback Loop: signal pathways that move away from a set point; a signal in one direction activates and amplifies in that direction
- Feedback Mechanism: a system in which the products formed by a signal pathway help regulate and inhibit that pathway

6. Cell Cycle:

- Purpose of Cell Division:
 - Unicellular: to reproduce and have their kind continue on
 - Multi-Cellular: growth, repair, replace dying/dead cells
- Parent and daughter cells are identical: DNA, organelles, etc.
- DNA in Cell Division
 - Chromatin: coiled DNA
 - Chromosomes: DNA that is wrapped tightly
 - Mitotic chromosome: a chromosome that has duplicated, often referred to as sister chromatids
- Stages of Cell Cycle
 - Interphase: cells are often in this phase; the longest phase
 - NO division happens here
 - 3 phases of interphase: G1 phase, S phase, G2 phase
 - G0 phase of interphase: optional part of interphase where cells exit the cell cycle and no longer divide
 - G1 of interphase: cells grow after they are "born"
 - S phase of interphase: DNA replicates in preparation for division
 - DNA replicates prior to cell division so each daughter cell gets a full set of DNA
 - G2 phase of interphase: cell finishes growth; prepares to divide by making organelles, proteins, and membranes
- Mitosis: cell division of somatic cells that produces identical daughter cells
 - Prophase: Chromosomes become visible, nuclear envelope dissolves, centrosomes form and spindle fibers attach to chromosomes
 - Metaphase: Chromosomes line up in the middle of the cell; centrosomes move to opposite poles of cell
 - Anaphase: sister chromatids are pulled to opposite sides of cell by spindle fibers and centrosome
 - Telophase: centrosomes disassemble, nuclei reform, chromosomes start to uncoil back into chromatin

- Cytokinesis in animal cells: cleavage furrow
- Cytokinesis in plant cells: cell plate, which then becomes a cell wall that separates the resulting daughter cells

7. **Regulation of the Cell Cycle:**

- Cancer: cell division that is uncontrolled and unregulated
- Benign: form of cancer that produces tumors, but does not metastasize
- Malignant: cancerous tumor that metastasizes
- Chemotherapy: chemical therapy used to treat cancer
- Radiation: another cancer therapy that targets cancer cells with radiation
- Regulatory Proteins: "signals that help the cell know when to duplicate, when to progress through the cell cycle, etc."

