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**AP Biology Exam Review: Cell Signaling (Unit 5)**

**Helpful Videos and Animations:**

1. Bozeman Science: Cell Communication
2. Bozeman Science: Signal Transduction Pathways
3. Bozeman Science: Signal Transmission and Gene Expression
4. Bozeman Science: Effects of Changes in Pathways
5. Bozeman Science: Evolutionary Significance of Cell Communication
6. Bozeman Science: Plant and Animal Defense

**Unit Vocabulary:**

-Reception

-Transduction

-Response

-Ligand

-Intracellular Receptor vs. Plasma Membrane Receptor

-G-Protein Coupled Receptor

-Adenylyl Cyclase

-cyclic AMP / cAMP

-Second Messengers

-Protein Kinases

-Phosphorylation Cascades

-Protein Phosphatases

-Receptor Tyrosine Kinases

-Nuclear Response vs. Cytoplasmic Response

-Transcription Factors

-Plasmodesmata

-Quorum Sensing

-Neurons (dendrites, cell body, axon, axon terminals / buds, myelin sheath / Schwann cells, Nodes of Ranvier)

-Saltatory Conduction

-Sensory Neurons

-Motor Neurons

-Interneurons

-Reflex Arc / Reflex Loop

-Resting Potential / Resting Membrane Potential

-K+ / Potassium Ion

-Na+ / Sodium Ion

-Sodium-Potassium (Na+ / K+) Pump

-Action Potential

-All or None / All or Nothing Principle

-Threshold / Threshold Potential

-Depolarization

-Voltage-Gated Na+ Channels

-Repolarization

-Voltage-Gated K+ Channels

-Hyperpolarization / Undershoot

-Refractory Period

-Synapse / Synaptic Cleft

-Presynaptic Neuron

-Postsynaptic Neuron

-Voltage-Gated Calcium (Ca2+) Channels

-Neurotransmitters

-Ligand-Gated Ion Channel (ex: Ligand-Gated Na+ Channel)

-Excitatory Neurotransmitter

-Inhibitory Neurotransmitter

-Endocrine System

-Glands

-Types of Hormone Molecules (steroid vs. amine vs. peptide)

-Negative Feedback

-Positive Feedback

-Nonspecific / Innate / Natural Immune Response

-Hypersensitivity Response (in plants)

-External Barriers (Physical vs. Chemical)

-Leukocytes / Phagocytes / Macrophages

-Inflammatory Response (includes fever)

-Specific / Acquired Immune Response

-Antigen Presenting Cell (APC)

-Antigen

-Pathogen

-Antibody

-Helper T Cell / Helper T Lymphocyte

-B Cells / B Lymphocytes

-Plasma B Cells

-Memory B Cells

-Humoral Immunity

-Cytotoxic T Cells / Killer T Cells / Cytotoxic or Killer T Lympocytes

-Active Cytotoxic T Cells

-Memory Cytotoxic T Cells

-Perforins

-Cell-Mediated Immunity

-Primary Immune Response vs. Secondary Immune Response

-Autoimmune Diseases

**Topic Outline:**

***Unit 5 Notes, Part 1: The Basics of Cell Signaling***

1. There are three main steps in cell signaling
* Reception (target cell’s detection of a signal molecule)
* Transduction (conversion of the signal to a form that can bring about a particular cell response)
* Response (the specific cellular response to the signal molecule)
1. Reception
* Ligand (signal molecule) binds to receptor
1. Intracellular receptors (for hydrophobic molecules like steroids that can pass through the cell membrane)
2. Plasma membrane receptors (for hydrophilic molecules that cannot pass through the cell membrane)

Ex: G protein coupled receptor or receptor tyrosine kinase (see notes to recall how these work)

1. Tranduction
* Tranduction involves amplifying the signal (making it stronger) and converting it to a form the cell can respond to
1. Second messengers (ex: calcium ions – Ca2+ -- or cyclic AMP) carry the signal from the receptor and may be used to activate protein kinases or other key molecules in the transduction process… second messengers amplify the signal because multiple second messengers are created from one ligand received and these second messengers can activate multiple kinases
2. Phosphorylation cascade (protein kinases activate molecules by adding a phosphate group, these molecules then activate other molecules, and ultimately you activate a molecule that causes the specific cell response)
3. Response
* Regulating Synthesis of Proteins: Transduction may activate transcription factors that initiate transcription of particular genes in the nucleus (by enabling the binding of RNA polymerase to start creating mRNA from DNA)
* Regulating Activity of Proteins: ex: In the epiphrine pathway in liver cells that initiates breakdown of glycogen to produce blood glucose to fuel the fight or flight response, protein kinases activate the enzyme phosphorylase, which chops apart glycogen

***Unit 5 Notes, Part 2: The Nervous System***

1. The Nervous System
* function: sensory input, motor function, regulation
* structure: neuron, axon, dendrites, synapse
* Polarized neuron: Na+ outside, K+ and Cl- inside
* Depolarization moves Na into neuron, generating an action potential
* Repolarization exchanges Na+ and K+ through the sodium-potassium pump
* At synapse, calcium channels open to allow calcium to rush in, stimulating release of neurotransmitters
* Neurotransmitters released into synapse to generate action potential for motor neuron or muscle cell
* A typical neuron has a cell body, axon and dendrites. Many axons have a myelin sheath that acts as an electrical insulator.
* The structure of the neuron allows for the detection, generation, transmission and integration of signal information.
* Schwann cells, which form the myelin sheath, are separated by gaps of unsheathed axon over which the impulse travels as the signal propagates along the neuron.

***Unit 5 Notes, Part 3: The Endocrine System***

1. The Endocrine System
* Negative feedback mechanisms maintain dynamic homeostasis for a particular condition (variable) by regulating physiological processes, returning the changing condition back to its target set point.
* Positive feedback mechanisms amplify responses and processes in biological organisms. The condition initiating the response is moved farther away from the initial set-point. Amplification occurs when the stimulus is further activated which, in turn, initiates an additional response that produces system change.
* Be able to describe the basic mechanism of action of the endocrine system – secretion of hormones into the bloodstream and travel to different target cells
* Be able to describe the advantages and disadvantages of using the endocrine system – one signal molecule can have multiple target cells / tissues / organs but it is a slow method of signaling
* Be able to distinguish between the different types of hormone molecules—steroid, amine, and peptide—and the different types of receptors—plasma membrane and intracellular.

***Unit 5, Part 4 Notes: Defense (The Immune System)***

1. Plants, invertebrates and vertebrates have multiple, nonspecific immune responses, ex: phagocytes (i.e. macrophages) engulf and digest pathogens with the help of lysosomes
2. Mammals use specific immune responses triggered by natural or artificial agents that disrupt dynamic homeostasis.
* The mammalian immune system includes two types of specific responses: cell mediated and humoral.
* In the cell-mediated response, cytotoxic T cells, a type of lymphocytic white blood cell, target‖intracellular pathogens when antigens are displayed on the outside of the cells.
* In the humoral response, B cells, a type of lymphocytic white blood cell, produce antibodies against specific antigens.
* Antibodies are proteins produced by B cells, and each antibody is specific to a particular antigen.
* A second exposure to an antigen results in a more rapid and enhanced immune response.

**Practice “Thinking” Questions**

1. The following diagram shows an action potential of a neuron. For each question, you can answer with one letter or multiple letters.

1. At which letter would you find Na+ voltage gated channel OPEN?



1. At which letter(s) would you find the Na+/K+

pump WORKING?

1. At which letter(s) would you find K+ voltage gated channels OPEN?
2. At point F, would there be a more positive charge on the INSIDE or OUTSIDE of the neuron?
3. At point B, would you find more Na+ on the INSIDE or OUTSIDE of the neuron?
4. Tetrodotoxin is a neurotoxin that blocks Na+ voltage gated channels. How would the function of the neuron be altered by the presence of this toxin?



2. Refer to the diagram at the right to respond to the following questions.

1. Is the hormone hydrophobic or hydrophilic? How do you know?
2. Explain how the action of the hormone might be different if it could move through the cell membrane.
3. Explain what is happening in this picture (on the previous page) and make a prediction about what will be the end result in the cell to which this hormone has bound.

3. One student described an action potential in a neuron by saying “As more gates open the concentration of sodium inside the cell increases and this causes even more gates to open.” Is this an example of a positive or negative feedback loop? Justify your reasoning.



4. The figure to the right shows the feedback mechanism for regulating blood glucose.

1. Is this a positive or negative feedback loop? Explain your answer.
2. Individuals that suffer from Type I diabetes do not have functional insulin-producing cells. Describe how their blood will differ from that of a healthy individual after a glucose-rich meal.

5. Refer to the images at the right to answer the following:

1. Which immune response in shown: cell mediated or humoral? Explain how you know.
2. What are the “Y” shaped molecules called? What is their role in the immune response?
3. Describe how the “Y” shaped molecules relate to the graph displayed.

**Practice Long Response Question**

1.  Communication occurs among the cells in a multicellular organism. Choose THREE of the following examples of cell-to-cell communication, and for each example, describe the communication that occurs and the types of responses that result from this communication.

1. communication between two plant cells
2. communication between two immune-system cells
3. communication either between a neuron and another neuron, or between a neuron and a muscle cell
4. communication between a specific endocrine-gland cell and its target cell