Unit 05: Cell Communication and Cell Cycle

Content Area: **Science**
Course(s): **AP Biology**
Time Period: **December**
Length: **4 weeks**
Status: **Published**

Transfer Skills

In the cell communication and cell cycle unit, students continue to learn about the role of cells, focusing on how cells use energy and information transmission to communicate and replicate. Through systems of complex transduction pathways, cells can communicate with one another. Cells can also generate and receive signals, coordinate mechanisms for growth, and respond to environmental cues. To maintain homeostasis, cells respond to their environment. They can also replicate and regulate replication as part of the cell cycle that provides for the continuity of life. In the following unit, students will move on to learn about heredity.

For the AP Exam, students must have a deep understanding of the significance of the steps in cell signaling, the amplification of the signal, the recycling of relay molecules between activated and inactivated forms to regulate the cellular response, and the multiple roles of the same molecules in providing specificity. Using the principles of cell signaling, students should be able to explain—using claim, evidence, and reasoning—how a drug works or how the symptoms of a chronic disease arise. Students should understand that signal molecules bind to receptors and that gene expression can be stimulated by signal transduction. Students may be expected to predict the effect on a cell if there is a disruption in the cell cycle. A common error on the exam is failure to explain the purpose and timing of the cell cycle checkpoints. Students should also be prepared to answer a comparative question about mitosis and meiosis.

Enduring Understandings

Cells communicate by generating, transmitting, receiving, and responding to chemical signals.

Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.

Heritable information provides for continuity of life.

Essential Questions

In what ways do cells use energy to communicate with one another?

Why and in what ways do cells communicate with one another?

How does the cell cycle aid in the conservation of genetic information?

Content

Types of cell communication (direct contact, short and long distance)

Non-specific and specific responses of the immune system

Negative and positive feedback loops in the endocrine system

Signal transduction pathways (G-protein mod vs. phosphorylation cascade)

Events of the cell cycle

Control of the cell cycle and cancer (loss of control)

Learning Objectives

IST-3.A Describe the ways that cells can communicate with one another.
IST-3.B Explain how cells communicate with one another over short and long distances.
IST-3.C Describe the components of a signal transduction pathway.
IST-3.D Describe the role of components of a signal transduction pathway in producing a cellular response.
IST-3.E Describe the role of the environment in eliciting a cellular response.
IST-3.F Describe the different types of cellular responses elicited by a signal transduction pathway.
IST-3.G Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.
ENE-3.A Describe positive and/ or negative feedback mechanisms.
ENE-3.B Explain how negative feedback helps to maintain homeostasis.
ENE-3.C Explain how positive feedback affects homeostasis.
IST-1.B Describe the events that occur in the cell cycle.
IST-1.C Explain how mitosis results in the transmission of chromosomes from one generation to the next.
IST-1.D Describe the role of checkpoints in regulating the cell cycle.
IST-1.E Describe the effects of disruptions to the cell cycle on the cell or organism.

Standards

IST-3.A.1 Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling—

a. Cells communicate by cell-to-cell contact.

IST-3.B.1 Cells communicate over short distances by using local regulators that target cells in the vicinity of the signal-emitting cell —

a. Signals released by one cell type can travel long distances to target cells of another cell type.

IST-3.C.1 Signal transduction pathways link signal reception with cellular responses.

IST-3.C.2 Many signal transduction pathways include protein modification and phosphorylation cascades.

IST-3.D.1 Signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell—

a. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one-to-one relationship.

b. G protein-coupled receptors are an example of a receptor protein in eukaryotes.

IST-3.D.2 Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression—

a. After the ligand binds, the intracellular domain of a receptor protein changes shape initiating transduction of the signal.

b. Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.

c. Binding of ligand-to-ligand-gated channels can cause the channel to open or close.

IST-3.E.1 Signal transduction pathways influence how the cell responds to its environment.

IST-3.F.1 Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis).

IST-3.G.1 Changes in signal transduction pathways can alter cellular response—

a. Mutations in any domain of the receptor protein or in any component of the signaling pathway may affect the downstream components by altering the subsequent transduction of the signal.

IST-3.G.2 Chemicals that interfere with any component of the signaling pathway may activate or inhibit the pathway.

ENE-3.A.1 Organisms use feedback mechanisms to maintain their internal environments and respond to internal and external environmental changes.

ENE-3.B.1 Negative feedback mechanisms maintain homeostasis for a particular condition by regulating physiological processes. If a system is perturbed, negative feedback mechanisms return the system back to its target set point. These processes operate at the molecular and cellular levels.

ENE-3.C.1 Positive feedback mechanisms amplify responses and processes in biological organisms. The variable 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.

IST-1.B.1 In eukaryotes, cells divide and transmit genetic information via two highly regulated processes.

IST-1.B.2 The cell cycle is a highly regulated series of events for the growth and reproduction of cells—

a. The cell cycle consists of sequential stages of interphase (G1, S, G2), mitosis, and cytokinesis.

b. A cell can enter a stage (G0) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.

IST-1.C.1 Mitosis is a process that ensures the transfer of a complete genome from a parent cell to two genetically identical daughter cells—

a. Mitosis plays a role in growth, tissue repair, and asexual reproduction.

b. Mitosis alternates with interphase in the cell cycle.

c. Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase).

IST-1.D.1 A number of internal controls or checkpoints regulate progression through the cycle.

IST-1.D.2 Interactions between cyclins and cyclindependent kinases control the cell cycle.

X *Knowledge of specific cyclin-cdk pairs or growth factors is beyond the scope of the course and the AP exam.*

IST-1.E.1 Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis).

Resources

College Board AP Central: https://apcentral.collegeboard.org/courses/ap-biology/course

College Board AP Biology course and exam description manual: https://apcentral.collegeboard.org/pdf/ap-biology-course-and-exam-description-0.pdf

AP Biology Lab Manual:

https://apcentral.collegeboard.org/pdf/ap-biology-teacher-lab-manual-fall-2019.pdf?course=ap-biology

AP Biology Classroom Resources: https://apcentral.collegeboard.org/courses/ap-biology/classroom-resources?course=ap-biology

Khan Academy AP Biology: https://www.khanacademy.org/science/ap-biology

Bozeman Science AP Biology videos: http://www.bozemanscience.com/ap-biology

HHMI Biointeractive: https://www.biointeractive.org/