

AP BIOLOGY

UNIT 4

**Cell
Communication
and Cell Cycle**



10–15%
AP EXAM WEIGHTING



~9–11
CLASS PERIODS



Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topic and skills.

Personal Progress Check 4

Multiple-choice: ~25 questions

Free-response: 2 questions

- Interpreting and Evaluating Experimental Results (partial)
- Analyze Data

Cell Communication and Cell Cycle



Developing Understanding

BIG IDEA 2

Energetics **ENE**

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

BIG IDEA 3

Information Storage and Transmission **IST**

- How does the cell cycle aid in the conservation of genetic information?
- Why and in what ways do cells communicate with one another?

In Unit 4, 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 Unit 5, students will move on to learn about heredity.

Building Science Practices

1.A 1.B 3.D 4.A 6.A 6.B 6.E.b

Students build on their abilities to describe and explain biological concepts and processes by describing the cell cycle regulation. Students should now be able to explain the relationships between structure and function for all organelles and cellular components on both the subcellular and the cellular level.


By performing laboratory investigations focused on the concepts of cell cycle, students should develop an understanding of how to formulate and devise a plan to investigate the answer to a scientific question—critical skills for scientific inquiry. Students continue to build skills in communicating the results of scientific inquiry. This is a unit where students can be given opportunities to practice their graphing skills.

Preparing for the AP Exam

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.

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods
			~9–11 CLASS PERIODS
IST-3	4.1 Cell Communication	1.B Explain biological concepts and/or processes.	
	4.2 Introduction to Signal Transduction	1.A Describe biological concepts and/or processes.	
	4.3 Signal Transduction	6.C Provide reasoning to justify a claim by connecting evidence to biological theories.	
	4.4 Changes in Signal Transduction Pathways	6.E.b Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	
ENE-3	4.5 Feedback	6.E.b Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	
IST-1	4.6 Cell Cycle	4.B.b Describe data from a table or graph, including describing trends and/or patterns in the data. 5.A.e Perform mathematical calculations, including percentages.	
	4.7 Regulation of Cell Cycle	6.E.a Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.	
 Go to AP Classroom to assign the Personal Progress Check for Unit 4. Review the results in class to identify and address any student misunderstandings.			

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are intended to give you ideas of ways to incorporate varied instructional approaches in the teaching of this course. You do not need to use these activities or approaches and are free to alter or edit them in any way you choose. The following examples were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 171 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	4.1	<p>One-Minute Essay</p> <p>Have students do research online (provide reputable websites for them to use) to learn about diseases that result from a breakdown in cell communication. Assign students a one-minute essay with a prompt that allows the formative assessment of their understanding, such as, "Describe an example of communication between two cells."</p>
2	4.2	<p>Ask the Expert</p> <p>Students can be divided into three groups. Each group will complete one of the three sections of the Signal Transduction POGIL. The teacher can debrief with each group to clarify misconceptions. Students will then rotate between groups so that they share their understandings of the model they studied and learn from one another. The teacher can follow up with a debrief to clarify any outstanding misconceptions.</p>
3	4.4	<p>Fishbowl</p> <p>Students can read a case study about cell signaling and then answer any questions that may accompany the case study. Alternately, teachers can provide appropriate questions and/or assignments to ensure that students understand the concepts addressed in the case study. Students can then do a fishbowl to discuss their learnings from the case study and applications to real life.</p>



Unit Planning Notes

Use the space below to plan your approach to the unit. Consider how you want to pace your course and your methods of instruction and assessment.

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SUGGESTED SKILL *Concept Explanation***1.B**

Explain biological concepts and/or processes.

**AVAILABLE RESOURCES**

- Classroom Resource > [Cell-to-Cell Communication—Cell Signaling](#)

ILLUSTRATIVE EXAMPLES**Cell-to-Cell Contact****IST-3.A.1**

- Immune cells interact by cell-to-cell contact, antigen-presenting cells (APCs), helper T-cells, and killer T-cells.
- Plasmodesmata between plant cells allow material to be transported from cell to cell.

Cell Communication Using Local Regulators IST-3.B.1

- Neurotransmitters
- Plant immune response
- Quorum sensing in bacteria
- Morphogens in embryonic development

IST-3.B.1.a

- Insulin
- Human growth hormone
- Thyroid hormones
- Testosterone
- Estrogen

TOPIC 4.1**Cell Communication****Required Course Content****ENDURING UNDERSTANDING****IST-3**

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

LEARNING OBJECTIVE**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.

ESSENTIAL KNOWLEDGE**IST-3.A.1**

Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling—

- 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—

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

TOPIC 4.2

Introduction to
Signal Transduction

SUGGESTED SKILL

 *Concept Application***1.A**

Describe biological concepts and/or processes.



AVAILABLE RESOURCES

- Classroom Resource > [Cell-to-Cell Communication—Cell Signaling](#)

Required Course Content

ENDURING UNDERSTANDING

IST-3

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

LEARNING OBJECTIVE

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.

ESSENTIAL KNOWLEDGE

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—

- 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.
- 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—

continued on next page

LEARNING OBJECTIVE**IST-3.D**

Describe the role of components of a signal transduction pathway in producing a cellular response.

ESSENTIAL KNOWLEDGE

- After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.
- Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.
- Binding of ligand-to-ligand-gated channels can cause the channel to open or close.

TOPIC 4.3

Signal Transduction

SUGGESTED SKILL
 *Argumentation*
6.C

Provide reasoning to justify a claim by connecting evidence to biological theories.

**AVAILABLE RESOURCES**

- Classroom Resource > [Cell-to-Cell Communication—Cell Signaling](#)

ILLUSTRATIVE EXAMPLES Using Signal Transduction to Respond to the Environment

- Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (quorum sensing)
- Epinephrine stimulation of glycogen breakdown in mammals

IST-3.F.1

- Cytokines regulate gene expression to allow for cell replication and division.
- Mating pheromones in yeast trigger mating gene expression.
- Expression of the *SRY* gene triggers the male sexual development pathway in animals.
- Ethylene levels cause changes in the production, of different enzymes allowing fruits to ripen.
- HOX genes and their role in development.

Required Course Content

ENDURING UNDERSTANDING**IST-3**

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

LEARNING OBJECTIVE**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.

ESSENTIAL KNOWLEDGE**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).

SUGGESTED SKILL *Argumentation***6.E.b**

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.

**AVAILABLE RESOURCES**

- Classroom Resource > [Cell-to-Cell Communication—Cell Signaling](#)

TOPIC 4.4

Changes in Signal Transduction Pathways

Required Course Content

ENDURING UNDERSTANDING**IST-3**

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

LEARNING OBJECTIVE**IST-3.G**

Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.

ESSENTIAL KNOWLEDGE**IST-3.G.1**

Changes in signal transduction pathways can alter cellular response—

- 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.

TOPIC 4.5

Feedback

SUGGESTED SKILL

 *Argumentation*

6.E.b

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.



AVAILABLE RESOURCES

- Classroom Resource > [Cell-to-Cell Communication—Cell Signaling](#)

ILLUSTRATIVE EXAMPLE

ENE-3.B.1

- Blood sugar regulation by insulin/glucagon

ENE-3.C.1

- Lactation in mammals
- Onset of labor in childbirth
- Ripening of fruit

Required Course Content

ENDURING UNDERSTANDING

ENE-3

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

LEARNING OBJECTIVE

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.

ESSENTIAL KNOWLEDGE

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.

SUGGESTED SKILLS

 *Representing and Describing Data*

4.B.b

Describe data from a table or graph, including describing trends and/or patterns in the data.

 *Statistical Tests and Data Analysis*

5.A.e

Perform mathematical calculations, including percentages.

**AVAILABLE RESOURCES**

- AP Biology Lab Manual > [Mitosis Lab](#)

TOPIC 4.6

Cell Cycle

Required Course Content

ENDURING UNDERSTANDING

IST-1

Heritable information provides for continuity of life.

LEARNING OBJECTIVE

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.

ESSENTIAL KNOWLEDGE

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—

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

- Mitosis plays a role in growth, tissue repair, and asexual reproduction.
- Mitosis alternates with interphase in the cell cycle.
- Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase).

TOPIC 4.7

Regulation of Cell Cycle

SUGGESTED SKILL

 *Argumentation*

6.E.a

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.

Required Course Content

ENDURING UNDERSTANDING

IST-1

Heritable information provides for continuity of life.

LEARNING OBJECTIVE

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.

ESSENTIAL KNOWLEDGE

IST-1.D.1

A number of internal controls or checkpoints regulate progression through the cycle.

IST-1.D.2

Interactions between cyclins and cyclin-dependent kinases control the cell cycle.

EXCLUSION STATEMENT—*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).

