Science Inquiry

Science Instructional Lesson Type

Uncommon Schools | Change History.

Do Now & Launch → **Build Evidence** → **Discuss** → **Stamp** → **Apply** → **Assessment**

Lesson Plan Background	
Teacher:	**Lesson:** U4L2 (50 min)
Course: AP Biology	**Unit:** 4

Objectives	
Skills/Content: SWBAT describe the components of a signal transduction pathway and the role of the components of the signal transduction pathway in producing a cellular response.	**Standard:** IST-3.C IST-3.D

Lesson Goals

Guiding Question: How do cells receive, transduce, and respond to signals?

In the previous lesson, students saw an overview of the various types of cell signaling and explained why both short-distance and long-distance signaling are important to maintain homeostasis. In today's lesson, students will analyze a general model of the signal transduction pathway and use the model to summarize how cells receive, transduce, and respond to signals. In the discussion, students will utilize evidence from the model to describe the components of the signal transduction pathway.

Planning

Planning

Vocabulary:

- Reception
- Transduction
- Response
- Receptor
- Ligand
- Phosphorylation
- Amplification
- Relay/Cascade
- Gene expression
- Secretion

Key Understanding/Skill:

The signal transduction pathway consists of the following three steps:

- Reception: Signaling begins with the recognition of a chemical messenger (a ligand) by a receptor protein on a target cell. The ligand-binding domain of a receptor recognizes a specific chemical messenger in a specific, one-to-one relationship. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.
- Transduction: Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals through the phosphorylation of proteins. Multiple activation sequences allow for more points of control throughout the process.
- Response: The end of the signaling cascade results in the appropriate response by the cell which includes cell growth, secretion of molecules, or gene expression.

Setup/Materials

No special setup.

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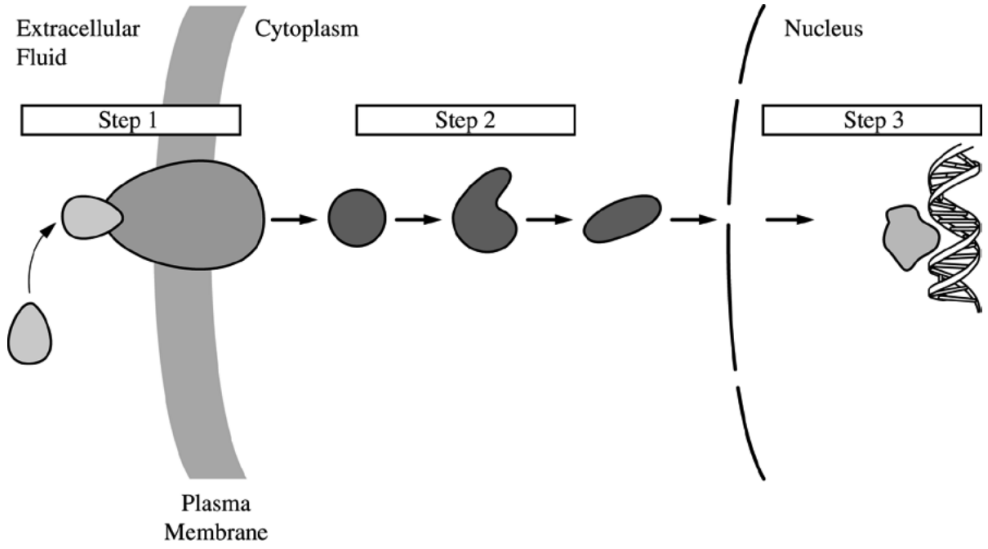
Exit Ticket

Exemplar

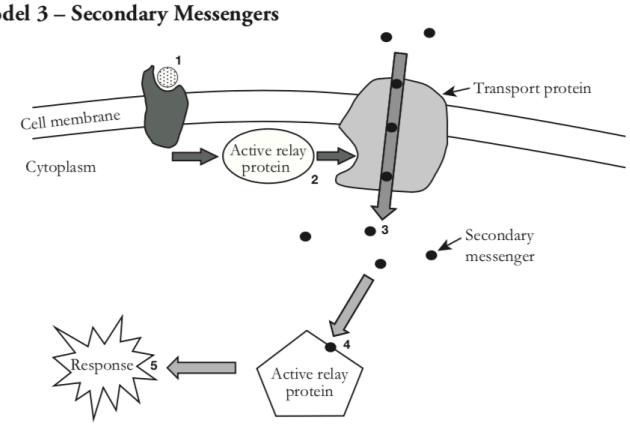


1

1. The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression.

Step 1: Hormone/ligand binds to a receptor to initiate signaling.
Step 2: An intracellular cascade amplifies/transduces the signal from the membrane to the nucleus.
Step 3: Expression of target gene is stimulated or repressed.

Model 3 – Secondary Messengers



2

2. Model 3 above represents how some signals trigger secondary messengers to enter the cell. **Describe** how secondary messengers enter the cell.

A receptor protein in the membrane is activated by a ligand. The receptor protein activates a relay protein. The active relay protein attaches to the transport protein and opens the protein channel, allowing the secondary messengers to enter the cell.

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<table>
<tr><td rowspan="2">Do Now & Review

(5 min./5)</td><td>Start to Class</td></tr>
<tr><td>
Do Now (3 minutes):
1: Diffusion is when small, nonpolar molecules pass directly through the cell membrane down their concentration gradient. Facilitated diffusion is when molecules that cannot pass directly through the membrane (such as polar molecules) move down their concentration gradient through a protein channel.

2: C – Enzymes have substrate-specific active sites. The shape of the active site is specifically shaped to fit the substrate molecule. Starch has a different structure compared to lipids, and so lipids cannot fit into the active site of an enzyme that breaks down starch.

Monitoring Laps:
<table>
<tr><th>#...</th><th>...for:</th><th>If mastery is...</th><th>...respond by:</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Comparing molecule polarity</td><td>>70%</td><td>Move on to Lap 2</td></tr>
<tr><td><70%</td><td>Stop the Show (<45 sec)</td></tr>
<tr><td>2</td><td>Reasoning: enzymes have shape-specific active sites</td><td colspan="2">Note trend in mastery, common error and students to call on.</td></tr>
</table>
Review:

Show-call correct answer to question 1.
Have students T&T to question 2: How do enzymes ensure that they only react with the intended substrate?

</td></tr>
<tr><td></td><td>
Mini-Stamp:

Enzymes have substrate-specific active sites that are shaped to specifically fit the substrate. The shape is determined by the protein’s tertiary and quaternary structure.

</td></tr>
<tr><td>Daily Drill</td><td>N/A</td></tr>
<tr><td>Launch
(2 min./7)</td><td>
Guiding Question: How do cells receive, transduce, and respond to signals?

T: Yesterday we saw several examples of communication between cells, from neurotransmitters between nerve cells, to quorum sensing between bacteria, and hormone signaling in the body.

T&T: What did all the types of cell communication have in common? (COLD CALL: Signaling molecule and a response.)

We saw that all the processes involved a signaling molecule, a receptor, and a specific response. This is called the signal transduction pathway and is similar in all types of cell communication. Understanding how the signal transduction pathway works allows us to then be able to manipulate the pathway to elicit a desired response. For example, because scientists know the signaling pathway that causes fruit to ripen, fruit companies are able to pause or accelerate that process in fruit to their advantage.

Bright Line: Today we are going to analyze a general model of the signal transduction pathway and use the model to explain the different components of the pathway.
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Inquiry (26 min./33)

Summary:

- Students analyze two models of the signal transduction pathway and answer questions 1-9 independently. Students respond to question 10 (the guiding question) before engaging in discourse. Students will use their responses from the inquiry as evidence during the discourse to explain the process of signal transduction.

Setup (22 min):

- (2 min): *Take 1 minute to independently read model 1… now share with your partner: What do you observe occurring in Model 1?*
- (4 min) Questions 1-3
- (1 min): Review questions 1-3, make sure all students are on the same page.
- (2 min): *Take 1 minute to independently read model 2… now share with your partner: What do you observe occurring in Model 2?*
- (6 min) Questions 4-6
- (2 min): Review questions 4-6, make sure all students are on the same page.
- (4 min) Questions 7-9
- (1 min): Review questions 7-9, make sure all students are on the same page.
- (3 min) Question 10
-

Academic Monitoring:

Question #	Monitor For	Common Error	How to Respond
1	Correct assignment of number to model.	Labelling just the ligand as I	Stop the show: *When does the ligand actually initiate signal transduction?*
2	Proposed definition of transduction.	Incorrectly defining transduction.	Stop the show and ask: *what do you observe in the model?*
3	Amplification activates multiple proteins.	Incorrectly describing amplification.	Stop the show: *What does the term amplification mean in general? How does this arrow show amplification?*
4	Proteins are activated by adding a phosphate group.	Students may say adding ATP.	Stop the show: *Is the entire ATP molecule being added to the protein? What do we see in the model?*
5a	4, 5, and 7	Stating that 6 is a phosphorylation step.	Stop the show: *What is occurring to the protein in Step 6? Is it being activated?*
6a, b, c	Correctly assigning steps to each part of signal transduction pathway	Stating that 7 is part of the transduction, or that 2 is part of reception.	Stop the show: *What is the final response of the cell? What do you observe occurring in the model?*
7	Deactivation by removing a phosphate group	Student may say removing an ATP.	Stop the show: *How did we activate proteins?*
8	Show protein transitioning from active to inactive state because of PP.	Students may add a PP in the pathway itself or reverse the pathway.	Stop the show: *Add the protease phosphatases to molecules not in the signaling pathway.*
9	Receptors are shape specific.	Students may say that the hormone only travels to targeted areas.	Stop the show: *Hormones travel throughout the bloodstream and come into*

			contact with all cells. When does a hormone actually induce the signal transduction pathway?
10	Ligand binding to a receptor causes a shape change, triggering the transduction pathway (phosphorylation cascade). The ultimate goal of the transduction pathway is the response (switching a gene on/off, manufacturing a protein, or resulting in cell division/death).	Students may not state the purpose of the transduction pathway.	*Note student responses to leverage in the discussion.*

Exemplar:

1: Ligand – I, Receptor Protein – II, Activated Relay Protein I – III, Response – IV

2: Transduction is a series of activated proteins from the receptor to the cell target.

3: Amplification means to "make larger." In the context of signal transduction, one protein activates multiple proteins. This is beneficial because the cell can respond to the signal faster.

4: Protein kinases are activated by adding a phosphate group from ATP.

5a: 4, 5, 7

5b: The phosphate groups come from ATP molecules.

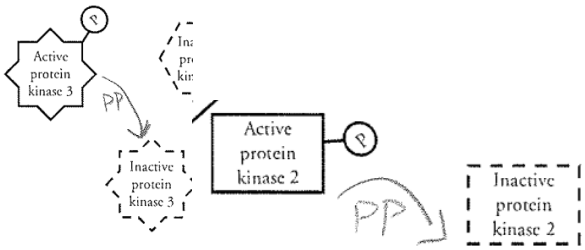
6a: Reception – 1

6b: Transduction – 2, 3, 4, 5, 6

6c: Response – 7

7: Protein kinases could be deactivated by removing a phosphate group.

8: See diagrams below.



9: Intended target cells have shape-specific receptor proteins to accept specific ligands.

10: Cells receive signals when receptor proteins on the membrane surface bind to shape-specific ligands. This causes a shape change in the intracellular domain of the protein, and initiates signal transduction. Signal transduction consists of a series of steps where proteins are activated through phosphorylation. Signal transduction can also involve amplification, where one protein can activate multiple proteins. At the end of the transduction pathway, a

	response is initiated that could be turning on or off a gene, manufacturing a protein, or causing the cell to divide or die.

Discuss (8 min./41)	**Discourse Overview:**
	• Students utilize their responses to questions 1-10 as evidence to explain the components of the signal transduction pathway.
	
	Show-Call Student Work or Relevant Diagram:
	• Model 2 (on page 3)
	
	Overarching Question:
	• T&T: *How do cells receive, transduce, and respond to signals?*
	• After students T&T…
	  ○ Call on 3-4 students to share out before teacher intervenes.
	  ○ Encourage students to agree/disagree/build after each response.
	  ○ Encourage students to provide specific evidence from the model to support their response.
	  ○ Only use elicit evidence questions if necessary.
	  ○ Once multiple students have shared out the steps of the signal transduction pathway, use one or more of the reasoning questions to strengthen the response.
	
	Elicit the Evidence:
	• *What is the difference between reception and transduction?*
	• *What is the difference between transduction and response?*
	• *What are some examples of cellular responses?*
	
	Deepen the Reasoning:
	• *Why is it important that the receptor and ligand are shape specific?*
	• *Where might errors occur in this process?*
	• *Why is signal amplification an advantage?*
	• *Signal transduction consists of multiple proteins being activated in sequence. Why is this advantageous?*

Stamp the Under-standing (3 min./44)	**Stamp: How do cells receive, transduce, and respond to signals?** The signal transduction pathway consists of the following three steps: • Reception: Signaling begins with the recognition of a chemical messenger (a ligand) by a receptor protein on a target cell. The ligand-binding domain of a receptor recognizes a specific chemical messenger in a specific, one-to-one relationship. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal. • Transduction: Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals through the phosphorylation of proteins. Multiple activation sequences allow for more points of control throughout the process. • Response: The end of the signaling cascade results in the appropriate response by the cell which includes cell growth, secretion of molecules, or gene expression.
Apply	**N/A**
Reference	Teachers are encouraged to read Teach Like a Champion: 49 Techniques that Put Students on the Path to College by Doug Lemov, an Uncommon Schools publication, to better understand the methods of teaching employed in this lesson.

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