AP BIOLOGY · UNIT 4 · TOPIC 4.2

Introduction to Signal Transduction

Learning objective 4.2.A Explain how signal transduction allows cells to respond to external signals.

Name: Date: Period:

Use the tool **Three Steps In**. Part 1 uses **Which door does it use**, Part 2 uses **Three stages** and Parts 3 and 4 use **Break the chain**. Part 1 uses the membrane permeability rule from Topic 2.4, so work out each answer from the rule rather than from memory.

Part 1 · Predict the receptor before you look

For each molecule, fill in the three properties and **predict** where its receptor must be: in the plasma membrane or inside the cell. Then select the molecule in the tool and check your prediction against the Where its receptor is readout.

Signaling molecule	Small?	Nonpolar?	Uncharged?	Predicted receptor	Correct?
Epinephrine					
Insulin					
Neurotransmitter					
Testosterone					
Estrogen					
Nitric oxide					

1. Describe the rule that determines whether the receptor for a signaling molecule is in the plasma membrane or inside the cell.

2. A neurotransmitter is a small molecule, yet it cannot cross the plasma membrane.
(a) Explain why the neurotransmitter cannot cross the membrane.

(b) Describe what this result shows about using size alone to predict whether a signaling molecule crosses the membrane.

3. Testosterone and epinephrine are both hormones carried in the blood. Explain why testosterone is detected inside its target cells but epinephrine is detected at their surface.

Part 2 · The three stages

Switch to **Three stages**. It opens on Reception. Press Next stage to move to Transduction and then to Response. For each stage, record what happens and what has changed in the cell by the end of the stage.

Stage	What happens	What has changed in the cell so far
Reception		
Transduction		
Response		

4. (a) Describe what happens during reception.

(b) In the Three stages model, the signaling molecule does not enter the cell. Explain how information passes from outside the cell to inside the cell during reception.

5. Explain why a signal transduction pathway has a transduction stage, rather than the receptor carrying out the response itself.

Part 3 · Where does the signal stop?

Switch to **Break the chain**. Press Nothing broken, then press each Knock out button in turn. For each row, record the Steps that still run, Reception occurs? and Response occurs? readouts.

Knocked out	Steps that still run	Reception occurs?	Response occurs?
Nothing			
Signaling molecule			
Receptor			
First relay protein			
Second relay protein			
Response protein			

6. (a) Describe what happens to the components upstream of a break in the pathway.

(b) Describe what happens to the components downstream of the break.

7. In the Part 3 table, the cell with the receptor knocked out and the cell with the response protein knocked out both give no response. Describe how the state of the cell differs between these two cases.

Part 4 · Diagnose the fault

Each row below describes a cell that does not respond. Using the Part 3 table, identify the faulty component in each row. In the How you know column, give the reasoning for your identification.

What is observed	Which component is faulty	How you know
The signal is present in normal amounts; no relay protein inside the cell is ever activated.		
Both relay proteins are activated normally; the cell still does not respond.		
The receptor binds the signal normally; the first relay protein is never activated.		

8. A researcher finds a cell that does not respond to insulin.
(a) Identify two different faults in the signaling pathway that could cause this.

(b) Describe an observation that would distinguish between the two faults.

9. Some cancers involve a relay protein that is locked permanently in its active shape.

(a) Predict the response of a cell with this relay protein when no signal is present.

(b) Justify your prediction.

What the model simplifies

The pathway is drawn with two relay proteins. Real pathways have anywhere from one relay to a dozen, and often branch, so that one signal produces several responses at once and several signals converge on one.

Ligand properties are given as three yes-or-no facts. Real membrane permeability is a matter of degree, and a molecule that is only slightly polar crosses slowly rather than not at all.

The course framework does not require the individual steps, intermediates or enzyme names of any particular pathway, so this tool counts stages and tests dependencies instead of naming molecules. What it does expect is that you can explain what each stage achieves and predict what happens when one is disrupted.

Receptors are drawn as single proteins that change shape. Many real receptors work as pairs that come together when the ligand binds, and some are ion channels that open rather than relays that change shape. The consequence, a change inside the cell caused by binding outside it, is the same.