

PEEBEDU Signal Transduction Visualizer

Unit 4: Cell Communication
and Cell Cycle

Name: _____ Period: _____ Date: _____

Open peebedu.com and navigate to **Signal Transduction Visualizer**. Click **Start Exploring** to dismiss the introduction popup. Read the introduction, which describes how to select pathways, control animations, and highlight components. Begin with the **GPCR/cAMP** pathway selected.

Part 1 – Model Evaluation (MAPP Framework)

Scientific models are simplified representations of complex biological phenomena. Use the MAPP framework below to evaluate the Signal Transduction Visualizer as a scientific model.

M – Mode

What type of model is the Signal Transduction Visualizer? Describe how this computational simulation represents signal transduction pathways. In your answer, identify at least three specific simulation elements and explain what each one is designed to show about cell signaling.

A – Accuracy

(a) Identify two things this simulation represents **accurately** about signal transduction. For each, name the specific simulation feature and explain what aspect of cell signaling it demonstrates.

(b) Identify two things this simulation **oversimplifies or leaves out** about signal transduction. Consider what you cannot observe in the simulation that would be important for a complete understanding of how cells communicate.

P – Purpose

What is the learning goal of this simulation? Explain how the Signal Transduction Visualizer is designed to help you understand how a ligand binding to a receptor initiates a cascade of molecular interactions that amplify the signal and produce a cellular response. In your answer, connect at least one specific simulation feature to a biological function of signal transduction.

P – Permanency

Could this model change with new scientific evidence? Describe one way that new discoveries might change or improve a simulation like the Signal Transduction Visualizer. Explain why scientific models, including computational simulations, are revised as new evidence becomes available.

Small-Group Discussion

With your group, discuss the following:

- What are the strengths of this simulation as a model for signal transduction?
- What are its limitations?
- If you could add one feature to improve this simulation, what would it be and why?
- How does comparing the three pathways help you understand differences in how cells respond to signals?

Part 2 – NGSS Questions

1.

*Simulation Task: Select the **GPCR/cAMP** pathway and click **Start Signaling**. Reduce the animation speed to the slowest setting. Watch as the signaling molecule binds to the receptor on the cell membrane and observe how the signal passes from one molecule to the next inside the cell.*

Describe the sequence of events that occurs after the signaling molecule binds to the receptor on the cell surface. Explain how each step in the pathway activates the next molecule, and why this series of molecular interactions is necessary for the cell to respond to an outside signal.

HS-LS1-2

2.

*Simulation Task: With the **GPCR/cAMP** pathway running, watch the Amplification counter at the bottom of the screen. Note how the number increases as the signal moves through each step. Also observe the Active Molecules counter and how many molecules become active at each stage of the cascade.*

Explain how a single signaling molecule binding to one receptor can lead to the activation of thousands of molecules inside the cell. Describe how each step in the cascade multiplies the number of active molecules and why this amplification is important for producing a strong cellular response.

HS-LS1-2

3.

*Simulation Task: Select the **GPCR/cAMP** pathway and click **Show Cascade** to highlight the entire relay chain. Watch how adenylyl cyclase converts ATP into cAMP molecules (yellow particles) and how those cAMP molecules then activate PKA (green rectangles).*

Explain the role of the small molecules produced during the signaling cascade in carrying the signal from the membrane to other parts of the cell. Describe how one activated enzyme near the membrane can generate many of these small molecules and why that step is critical for spreading the signal throughout the cell.

HS-LS1-2

4.

*Simulation Task: Select the **Epinephrine** pathway, reset, and click **Start Signaling**. Observe the three cellular responses that appear at the end of the cascade: the beating heart, the widening airways, and glycogen breakdown. Compare these responses to the general response shown in the GPCR/cAMP pathway.*

Describe the specific cellular responses triggered by the epinephrine signaling pathway shown in the simulation. Explain how these responses work together to prepare an organism for a fight-or-flight situation and why it is important that a single signaling molecule can trigger multiple responses in different tissues at the same time.

HS-LS1-2

5.

*Simulation Task: Select the **Steroid Hormone** pathway, reset, and click **Start Signaling**. Watch where the signaling molecule goes after it reaches the cell. Notice that it passes through the cell membrane and binds to a receptor inside the cell rather than on the surface. Follow the hormone-receptor complex as it enters the nucleus.*

Compare the location of the receptor in the steroid hormone pathway to the location of the receptor in the GPCR/cAMP pathway. Explain why the steroid hormone is able to cross the cell membrane directly while the signaling molecule in the GPCR pathway cannot, and describe how the difference in receptor location leads to a different type of cellular response.

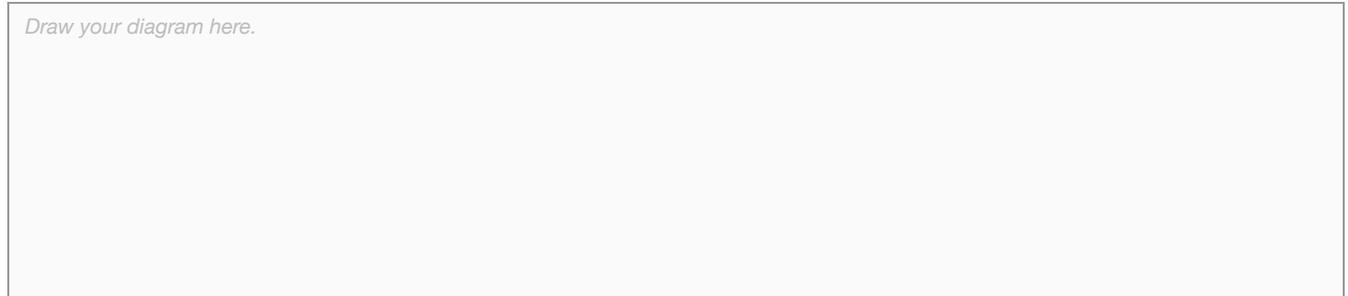
HS-LS1-3

6.

*Simulation Task: Run the **Steroid Hormone** pathway at the slowest speed. Follow the complete sequence: the hormone crossing the membrane, binding its receptor in the cytoplasm, the complex entering the nucleus through a nuclear pore, DNA being read, mRNA exiting the nucleus, and ribosomes producing new proteins.*

In the box below, draw a diagram showing the complete steroid hormone signaling pathway from the moment the hormone enters the cell to the production of new proteins. Label the following: cell membrane, steroid hormone, receptor, nucleus, DNA, mRNA, ribosome, and new protein.

Draw your diagram here.



HS-LS1-3

7.

Simulation Task: Run all three pathways one at a time and observe the final cellular response in each. In the GPCR/cAMP and Epinephrine pathways, the response involves activating existing proteins. In the Steroid Hormone pathway, the response involves producing entirely new proteins through gene expression.

The steroid hormone pathway ends with the production of new proteins by turning on specific genes. Explain how a signaling molecule from outside the cell can ultimately determine which genes are expressed inside the nucleus. Describe why different cell types in the same organism can respond differently to the same signal, even though all cells contain the same DNA.

HS-LS3-1