AP BIOLOGY · UNIT 4 · TOPIC 4.1

Cell Communication

Learning objective 4.1.A Explain how cell communication is critical for multicellular organisms.

Name: Date: Period:

Use the tool **Who Is Listening**. Parts 1 to 3 use the **Send a signal** tab, Part 4 uses **Same signal, different answer** and Part 5 uses **Counting each other**. Throughout, keep two questions separate: **did the signal reach this cell**, and **can this cell read it**. Most questions in this topic depend on keeping these two questions separate.

Part 1 · How far each mode goes

Select each signaling mode in turn, with any signal. For each cell, record its distance from the sender, shown above the cell, and whether each mode reaches it (Yes or No). A cell that is reached is colored, whether or not it responds. Ignore the receptors for now. This Part is only about **reach**.

Cell	Distance	Contact	Paracrine	Synaptic	Endocrine
Liver cell next door					
Cell two positions away					
Airway smooth muscle					
Muscle fiber at the end of the axon					
Heart muscle, in another organ					
Cell with no epinephrine receptor					

1. Direct contact and paracrine signaling both reach only cells close to the sender, but for different reasons.
(a) Describe what limits the reach of direct contact.

(b) Describe what limits the reach of paracrine signaling.

2. In the Part 1 table, the synaptic signal reaches the muscle fiber 5 units from the sender but does not reach four cells that are closer. Explain why synaptic signaling reaches the muscle fiber but not the closer cells.

Part 2 · Which cells can read which signal

Now ignore the modes. Select each of the four signals in turn. A cell that has a receptor for the selected signal shows a curved notch at its top edge, whether or not the signal reaches it. Record Yes or No for each cell and each signal. This Part is only about **the receptor**.

Cell	Growth factor	Neurotransmitter	Epinephrine	Surface marker
Liver cell next door				
Cell two positions away				
Airway smooth muscle				
Muscle fiber at the end of the axon				
Heart muscle, in another organ				
Cell with no epinephrine receptor				

3. One cell in the Part 2 table has no receptor for any of the four signals. This cell is 1 unit from the sender, so direct contact, paracrine and endocrine signals all reach it. Explain why this cell does not respond to any of the four signals.

4. A receptor protein is specific: it binds only certain signaling molecules.
(a) Identify the feature of a receptor protein that its specificity depends on.

(b) Explain how this feature makes the receptor specific.

Part 3 · Putting the two filters together

For each row, select the mode and the signal shown. Then record whether the signal reaches the cell named in that row, whether that cell has a receptor for the signal, and whether the cell responds.

Mode	Signal	Cell	Reached?	Has receptor?	Responds?
Endocrine	Epinephrine	Cell with no epinephrine receptor			
Paracrine	Epinephrine	Heart muscle, in another organ			
Endocrine	Epinephrine	Heart muscle, in another organ			
Paracrine	Growth factor	Airway smooth muscle			

5. In rows 1 and 2 of the Part 3 table, the cell does not respond, for a different reason in each row.
(a) Identify the reason that the cell in row 1 does not respond.

(b) Identify the reason that the cell in row 2 does not respond.

6. Identify the two conditions that must both be met for a cell to respond to a chemical signal.

7. Insulin is released into the blood and reaches every cell in the body, yet only some cells respond to it. Explain why only some cells respond to insulin.

Part 4 · One signal, three answers

Switch to **Same signal, different answer** and click each of the three targets in turn. Record what the tool shows for each.

Target	Signal it receives	Concentration it receives	What it does
Liver cell next door			
Airway smooth muscle			
Heart muscle, in another organ			

8. In the Part 4 table, two columns are the same for all three targets, and one column is different for each target.
(a) Identify the two columns that are the same for all three targets.

(b) Explain what this comparison shows about what determines the response of each target cell.

9. Epinephrine is released from one gland. Explain how this one hormone can coordinate a set of matched changes in different organs across the whole body.

Part 5 · Counting each other

Switch to **Counting each other**. Move the Population slider to each value in the table. Record the Signal concentration readout and whether the Coordinated behavior readout is on or off.

Population	Signal concentration	Behavior on or off?
1		
20		
39		
40		
100		

10. (a) Describe quorum sensing.

(b) A bacterium cannot count the cells around it. Explain how a bacterium can still change its behavior depending on the number of bacteria present.

11. With the population set to 1, a single bacterium secretes the signaling molecule continuously but never switches the behavior on.
(a) Explain why the single bacterium never switches the behavior on.

(b) Describe what this result shows about the difference between an individual bacterium and a population.

12. Many pathogenic bacteria use quorum sensing to control when they release toxins. Explain one advantage to the bacteria of waiting until the population is large, rather than releasing toxins as soon as the first cells arrive.

What the model simplifies

Distance is in arbitrary units on a straight line. Real tissue is three-dimensional and signals diffuse through it unevenly, so the sharp edge of the paracrine range here is a boundary the model draws rather than one a cell would experience.

Receptors are shown as present or absent. In a real cell the number of receptors matters too: a cell with few receptors responds weakly to a concentration that saturates a cell with many, and cells adjust their receptor numbers over time.

The quorum threshold is drawn as a single number. Real quorum sensing involves a positive feedback loop in which the signal switches on its own production, so the transition is sharper than a simple threshold and harder to reverse. Topic 4.4 is about loops of that kind.

Epinephrine's three responses are real and are the standard textbook example. The mechanism by which one signal produces different outcomes in different tissues depends on what sits downstream of the receptor, which is Topic 4.2 and Topic 4.3.