Who is listening, and how far away

60 minutes • 4.1.A, 4.1.B • Chapters 1, 2, 3

Signaling by contact, by local regulators and by hormones, sorted by distance, then quorum sensing in bacteria

BY THE END, STUDENTS CAN

- [ ] Describe how cells communicate by direct contact: gap junctions, plasmodesmata and immune cells that touch 4.1.A
- [ ] Explain how local regulators and hormones reach target cells over short and long distances 4.1.B
- [ ] Explain how bacteria use quorum sensing to switch genes on together once their population is dense enough 4.1.A 4.3.A

TIMING

0–6	6 min	**Do now: three messages**	
6–16	10 min	**Cells that touch**	
16–25	9 min	**Near or far**	
25–40	15 min	**Signal by distance**	
40–52	12 min	**Bacteria that count**	
52–60	8 min	**Exit**	
	60 min	**One lesson**	

STARTER

6 min

Do now: three messages

"You need to tell a friend something. They are sitting beside you; they are across the school; they are in another country. How do you reach each one, how fast, and who else might hear?" Pairs write three answers and keep them for the card sort.

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the

lesson's slides have the same figures, step by step, in the order of this plan.

01 Cells that touch to talk

CHAPTER 01 IN THE SLIDES

Play the animation, Signaling by contact. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. The shortest reach: **direct contact**. In animal tissues such as heart muscle, neighboring cells are joined by **gap junctions**, channels that link their cytoplasm.
2. Ions and small signal molecules pass straight from one cell into the next, with no receptor on the way. The message arrives almost at once, but only in a cell that is joined.
3. Ions and small signal molecules pass straight from one cell into the next, with no receptor on the way. The message arrives almost at once, but only in a cell that is joined.
4. Signal molecules move along them from cytoplasm to cytoplasm, and on from cell to cell.
5. Signal molecules move along them from cytoplasm to cytoplasm, and on from cell to cell.
6. **Cell-surface contact.** An antigen-presenting cell holds a piece of antigen on its surface. A T cell whose receptor does not fit touches it and moves on.
7. A T cell whose **receptor fits** binds, and it is activated. The signal never left the surface of the sending cell: its reach is one cell.

> **Predict box:** A drug blocks the gap junctions of one heart muscle cell. The signal to contract reaches its neighbors as usual. What does the blocked cell do? Hands up or mini whiteboards first.
>
> **Answer C: It misses the beat, because the ions cannot pass into it**

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02 Near or far

CHAPTER 02 IN THE SLIDES

Play the animation, Local regulators. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. A **local regulator**. This cell releases a growth factor by **exocytosis**: vesicles fuse with its membrane and empty to the outside.
2. The molecules **diffuse** through the fluid between the cells. This is **paracrine** signaling: they reach cells a short way off within seconds.
3. Only nearby cells **with the receptor** respond, here by dividing. A neighbor without the receptor does not, and further away the signal is too dilute and is broken down.
4. **Synaptic signaling** is more local still. A nerve impulse reaches the end of a motor neuron, beside a muscle fiber.
5. Vesicles release a **neurotransmitter**. It diffuses across the synaptic cleft, only about 20 nm, in under a millisecond.
6. It binds to receptors on the muscle cell, ion channels open and the fiber **contracts**. An enzyme then breaks the neurotransmitter down: a brief signal, to one cell.

Play the animation, Near or far: compare them. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. The longest reach: **endocrine** signaling. Beta cells in the pancreas release the hormone **insulin** into the blood.
2. The blood carries it to every part of the body, a meter or more away, in about a minute.
3. It passes almost every cell, but only cells **with the insulin receptor**, such as liver and muscle cells, respond. A cell without the receptor does nothing.
4. A hormone arrives more slowly than a nerve impulse, but it reaches the whole body and its effect lasts longer.
5. Plants signal over long distances too, through their vascular tissue. **Cytokinin** made in the root tips travels up in the xylem, and **auxin** made in the shoot tip moves down towards the roots.
6. Again only cells with the right receptor respond: a side bud grows out, and a new root branches. Longer reach, slower signal, wider spread.

> **Predict box:** A neuron releases a neurotransmitter and the pancreas releases insulin at the same moment. Which reaches its target cells first, and why? Hands up or mini whiteboards first.
>
> **Answer B: The neurotransmitter, because it has a gap of only 20 nm to cross**

03 Bacteria that count heads

CHAPTER 03 IN THE SLIDES

Play the animation, Bacteria counting each other. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. A few **Vibrio fischeri** cells in seawater. Each releases a little of a signaling molecule, an **autoinducer**, but it drifts away. The cells stay dark.
2. The cells divide, and more of them are making the autoinducer.
3. The molecules now arrive faster than they drift away, so the **concentration builds up**. Each cell is measuring how many cells are around it.
4. At a **threshold** concentration the signal binds receptors in every cell and switches on the genes for light: **quorum sensing**.
5. Lit cells make even more autoinducer, so the whole population switches on together. Move the slider to start with more or fewer cells.

> **Predict box:** A flask of *Vibrio fischeri* has just begun to glow. You dilute it tenfold with fresh seawater. What happens to the light? Hands up or mini whiteboards first.
>
> **Answer A: It fades, as the autoinducer is now below the threshold**

THE LESSON

10 min — Cells that touch

Chapter 1's predict box first, on whiteboards: the heart cell with its gap junctions blocked. Then chapter 1's film, one shot at a time: gap junctions, plasmodesmata, then the APC meeting two T cells. Ask why only one of the T cells is switched on.

9 min — Near or far

Chapter 2's two films: a growth factor and a synapse, then insulin round the body and plant hormones in the xylem and phloem. Switch the reach and read the strip under the film each time: distance, time, cells reached. Then the hormone table: students say which cells are targets and why.

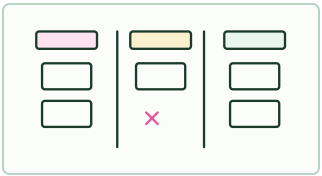
15 min — Signal by distance

The card sort below: pairs sort the example cards into direct contact, local regulator and hormone, then add the do-now messages to the right columns. Each pair defends one card the class disagrees on.

12 min — Bacteria that count

Chapter 3's predict box (the diluted flask), then the quorum film. Have students set the starting cells low and high and time when the light comes on. Land on what the cells measure: the concentration of the signal, not each other.

ACTIVITIES



CARD SORT

Signal by distance

Sixteen cards, each a real signal: gap junctions in heart muscle, plasmodesmata, an APC and a helper T cell, a killer T cell and an infected cell, acetylcholine at a muscle, a growth factor at a wound, a cytokine between immune cells, insulin, human growth hormone, thyroid hormones, testosterone, estrogen, epinephrine, a plant hormone in the phloem, ethylene between fruits, a bacterial autoinducer. Pairs sort them into direct contact, local regulator and long distance, then pick the two hardest to place and say why.

Needs: a set of sixteen cards per pair, three column headings.

PLENARY

8 min

Exit

On paper: "Insulin in the blood reaches nearly every cell in the body. Explain why only some cells respond to it" (2 points). Then chapter 2's predict box for anyone who finishes.

WHAT STUDENTS GET WRONG

"A hormone only goes to its target cells." The blood takes it nearly everywhere; only cells with the receptor respond.

"Direct contact means no chemicals are involved." Ions cross gap junctions, and an APC signals with a molecule on its surface; what is direct is that nothing crosses the fluid between cells.

STRETCH AND SUPPORT

Stretch: explain why a squid would gain nothing from bacteria that glowed one at a time, and what quorum sensing saves the bacteria.

Support: a three-column table (contact, local, long distance) with the first example of each filled in.

For revision: students can drill this unit's key terms on Cramly.

IN THE GUIDE

1 Cells that touch to talk
2 Near or far
3 Bacteria that count heads
All The whole guide, with the figures that play
PPTX This lesson's slides, in the order of this plan

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on 4.1 to 4.3 each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?program=ap&units=U4&ced=4.1,4.2,4.3&paper=quiz&marks=15&src=ep

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- Tarsia puzzle, dominoes and picture reveal on Unit 4, built from its key terms and ready to print
- A pub quiz with rounds on Unit 4, to present or run with no projector
- The Silent Relay Station escape room, or an escape room built from the question bank on Unit 4

ALREADY ON THE SITE FOR UNIT 4

- Quiz: Cell Communication & Signal Transduction
- Quiz: Signal Transduction Pathways
- Exam questions: Unit 4 in the exam maker, a paper with scoring guidelines

CARD SETS ON SPLYCR

Open a set to host it as a class game, or make a copy to edit.

- Unit 4: Cell Communication (part 1)
- Unit 4: Cell Communication (part 2)

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.