NAME _____ CLASS _____ DATE _____

AP BIOLOGY · 4.1 TO 4.3

Cell communication and signal transduction

Notes to fill in alongside the guide. Each numbered block matches a chapter of the guide, and of the lesson slides. Write in the gaps, answer the cues, annotate the figures, and sum up each section in your own words.

BY THE END YOU 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
- [ ] Describe how a ligand binds the ligand-binding domain of its receptor one to one, and where receptors sit for hydrophilic and hydrophobic ligands 4.2.B
- [ ] Describe the parts of a signal transduction pathway, and how kinases and phosphatases switch relay proteins on and off 4.2.A
- [ ] Explain how a G protein-coupled receptor, a second messenger and a ligand-gated channel relay and amplify a signal 4.2.B
- [ ] Describe how signals from the environment change gene expression, cell function and phenotype, or trigger apoptosis 4.3.A
- [ ] Predict how a mutation or a chemical that changes one part of a pathway changes the cell's response 4.3.B

01 Cells that touch to talk 4.1.A

CUES

Predict: 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?

What is meant by gap junctions?

What is meant by plasmodesmata?

What is meant by antigen-presenting cell?

NOTES

1 Animal cells side by side can be joined by _____: a ring of proteins in each membrane, the two rings lined up to make a tunnel from one cytoplasm into the next.

2 Plant cells are boxed in by walls, but the walls are crossed by _____: narrow channels lined with plasma membrane, so the cytoplasm of one cell runs on into the next.

3 In your immune system an _____ (APC) shows a fragment of a pathogen on its surface.

4 A _____ whose receptor fits that fragment binds it and is switched on; one whose receptor does not fit passes by.

5 _____: protein tunnels between animal cells.

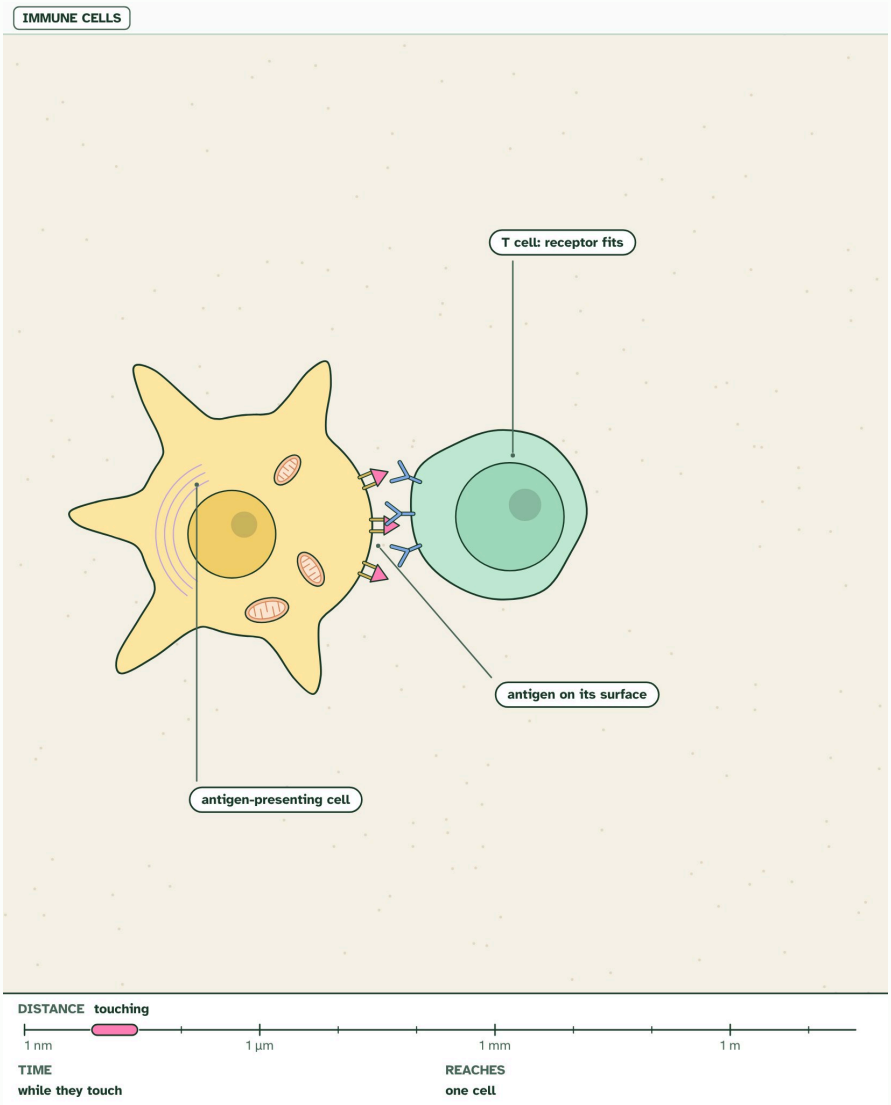
6 _____: channels through plant cell walls.

What is meant by helper T cell?

Your own notes

ANNOTATE THE FIGURE

Annotate this still from the animation (Signaling by contact): what is happening, and why?



SPOT THE MISTAKE

What do students often get wrong about cell communication by direct contact? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 01 in two or three sentences of your own.

02 Near or far

4.1.B

CUES

Predict: A neuron releases a neurotransmitter and the pancreas releases insulin at the same moment. Which reaches its target cells first, and why?

What is meant by local regulator?

What is meant by paracrine signaling?

What is meant by synaptic signaling?

What is meant by neurotransmitter?

What is meant by hormone?

What is meant by endocrine signaling?

What is meant by target cells?

NOTES

1 A _____ acts on cells near the one that released it, over a fraction of a millimeter, and is then broken down or taken up.

2 In _____ a cell releases molecules that diffuse to its neighbors: a growth factor from one cell makes the cells around it divide.

3 In _____ a neuron releases a _____ into a cleft about 20 nm wide, and it reaches receptors on the next cell in well under a millisecond.

4 A _____ goes much further.

5 In _____ a gland releases it into the blood, which carries it round the body in about a minute.

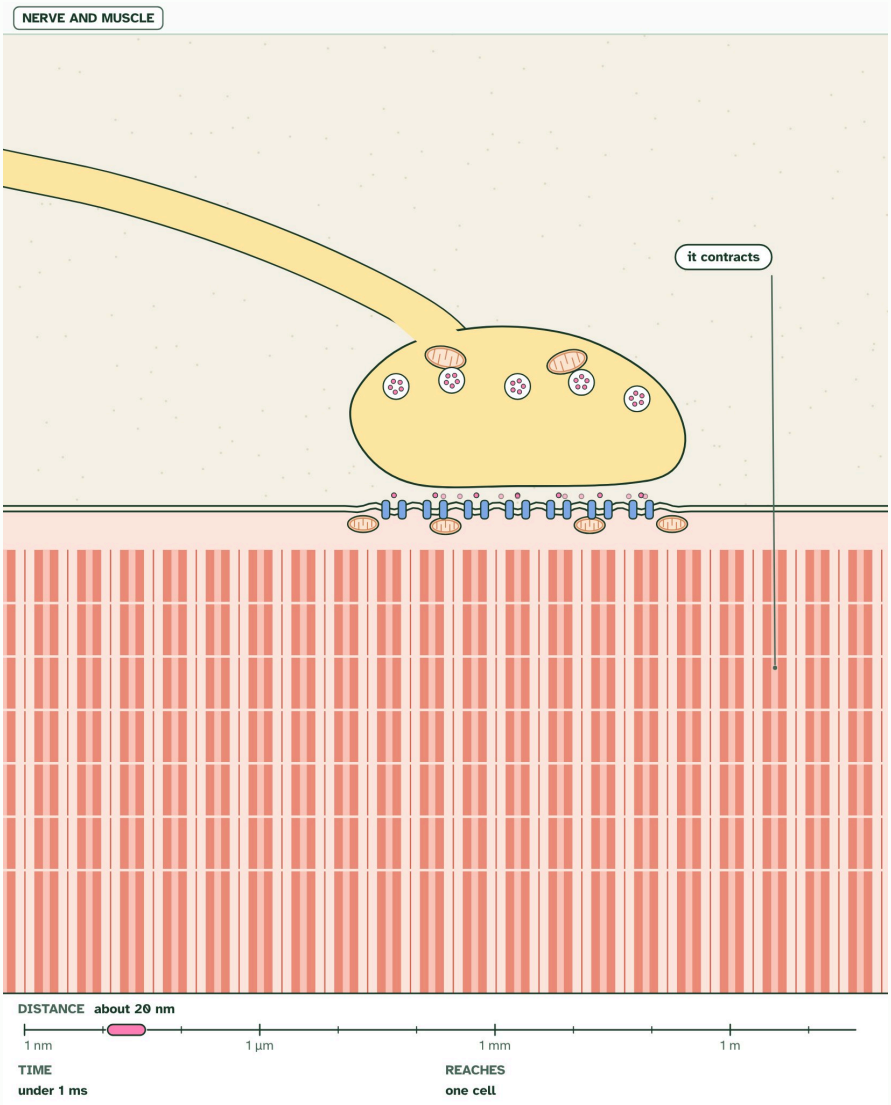
6 It reaches almost every cell, but only its _____, the ones with a receptor for it, respond.

7 Hormones: endocrine, in the blood, to _____ anywhere.

Your own notes

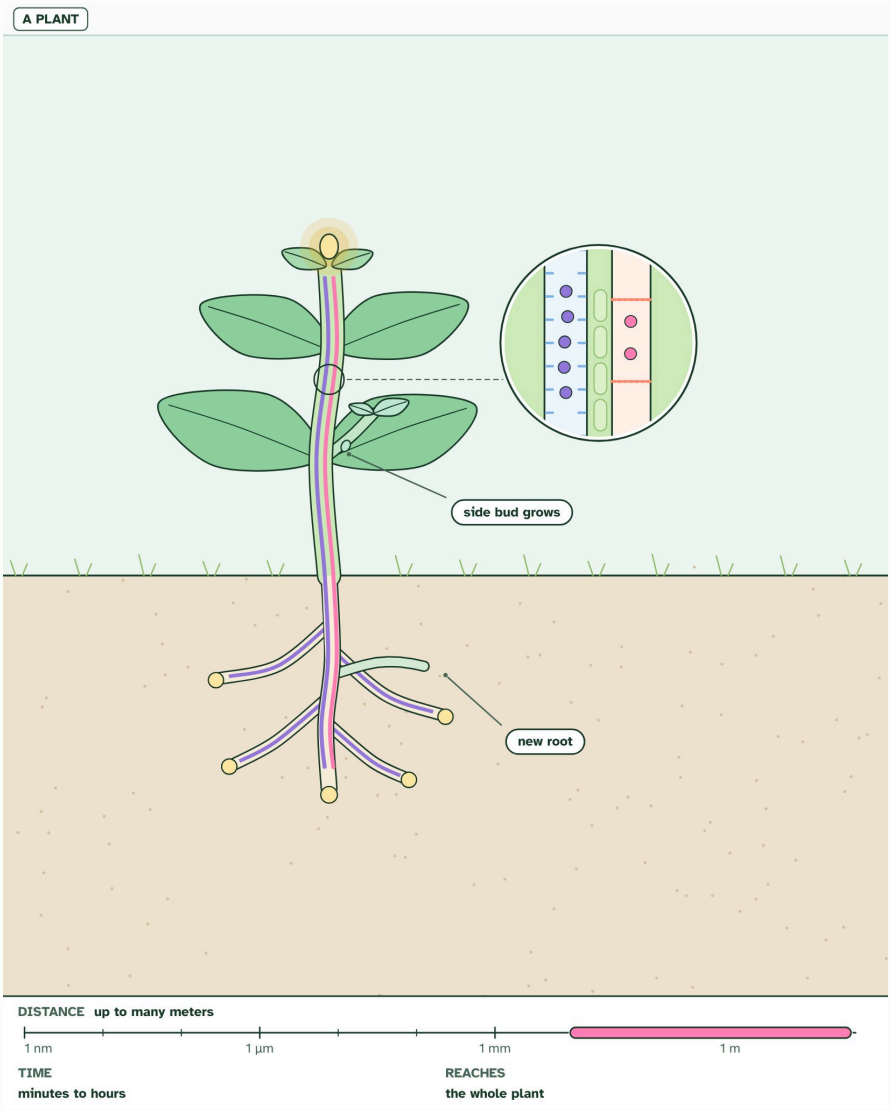
ANNOTATE THE FIGURE

Annotate this still from the animation (Local regulators): what is happening, and why?



ANNOTATE THE FIGURE

Annotate this still from the animation (Near or far: compare them): what is happening, and why?



SPOT THE MISTAKE

What do students often get wrong about signaling over short and long distances? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 02 in two or three sentences of your own.

03 Bacteria that count heads

4.1.A 4.3.A

CUES

Predict: A flask of Vibrio fischeri has just begun to glow. You dilute it tenfold with fresh seawater. What happens to the light?

What is meant by autoinducer?

What is meant by quorum sensing?

NOTES

1 Each cell releases a small signaling molecule, an _____, and carries receptors for it.

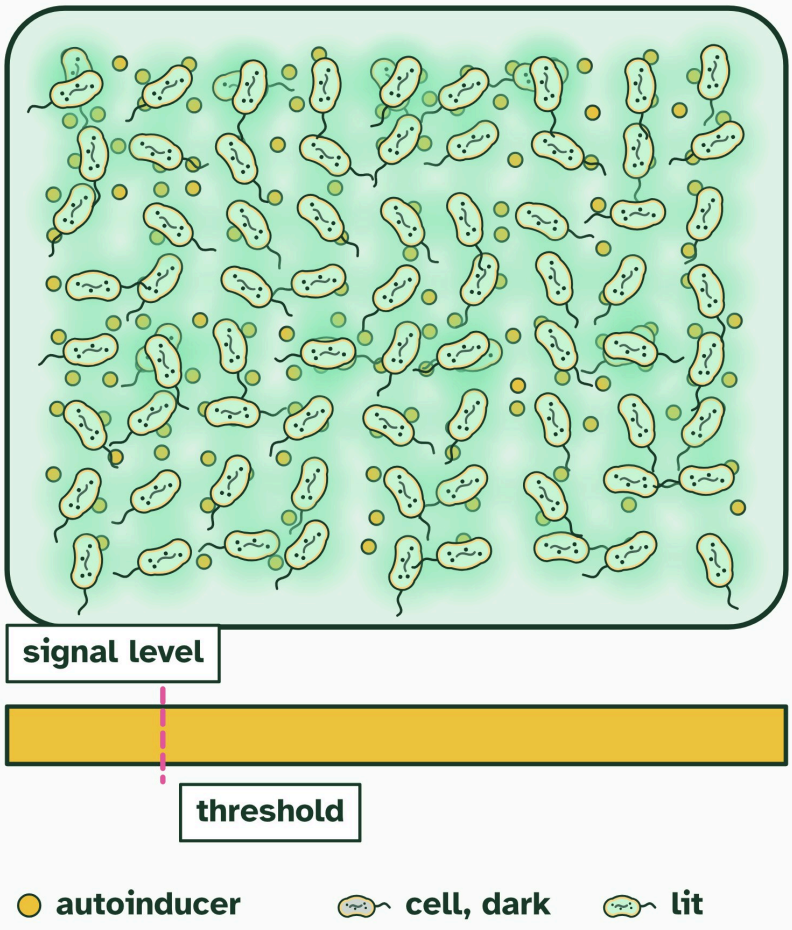
2 This is _____: signaling that measures population density.

3 Every cell releases an _____; more cells, higher concentration.

Your own notes

ANNOTATE THE FIGURE

Annotate this still from the animation (Bacteria counting each other): what is happening, and why?



SUMMARY

Sum up section 03 in two or three sentences of your own.

04 A receptor fits one messenger

4.2.B

CUES

Predict: A new drug is a short chain of amino acids, a peptide, and it must act on liver cells. Where do you expect to find its receptor?

What is meant by ligand?

What is meant by receptor?

What is meant by ligand-binding domain?

NOTES

1 A signaling molecule is a _____, and the protein it binds is its _____.

2 Part of the receptor, the _____, has a shape and a pattern of charges that fit one ligand, the way an active site fits its substrate.

3 The _____ fits one ligand: one to one.

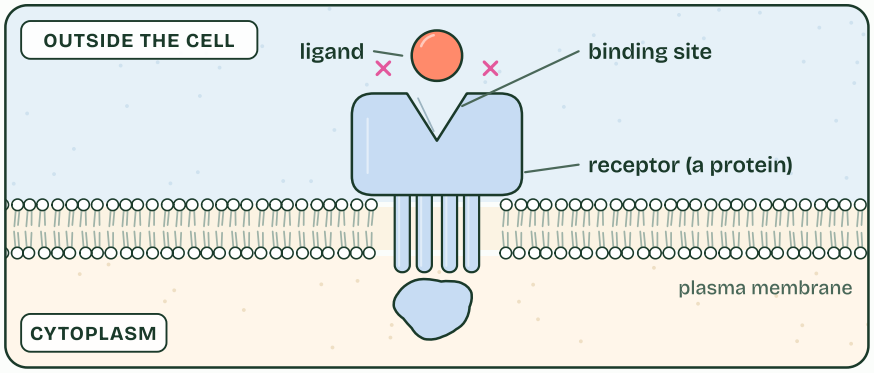
4 Hydrophilic or large _____: a receptor in the membrane.

5 Hydrophobic _____ (a steroid): a receptor inside the cell.

Your own notes

ANNOTATE THE FIGURE

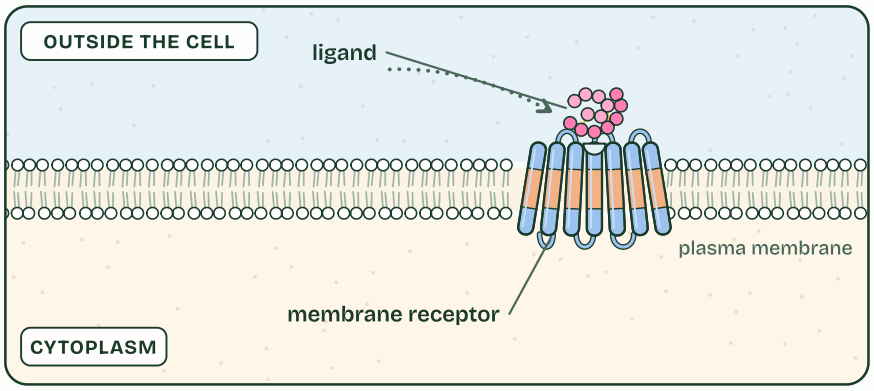
The figure shows it as Circle, Square and Triangle. Note what changes each time.



Circle: the shape does not fit the binding site,
so it does not bind and the receptor stays off.

ANNOTATE THE FIGURE

The figure shows it as Peptide or amine and Steroid. Note what changes each time.



Water-soluble ligand: cannot cross the bilayer.

It binds the outside of a transmembrane receptor.

hydrophilic amino acids hydrophobic amino acids

SPOT THE MISTAKE

What do students often get wrong about ligands and receptors? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 04 in two or three sentences of your own.

05 Reception, transduction, response

4.2.A

CUES

Predict: What does a protein kinase do to the protein it acts on?

What is meant by reception?

What is meant by transduction?

What is meant by response?

What is meant by signal transduction pathway?

What is meant by protein kinase?

What is meant by phosphorylation cascade?

What is meant by protein phosphatase?

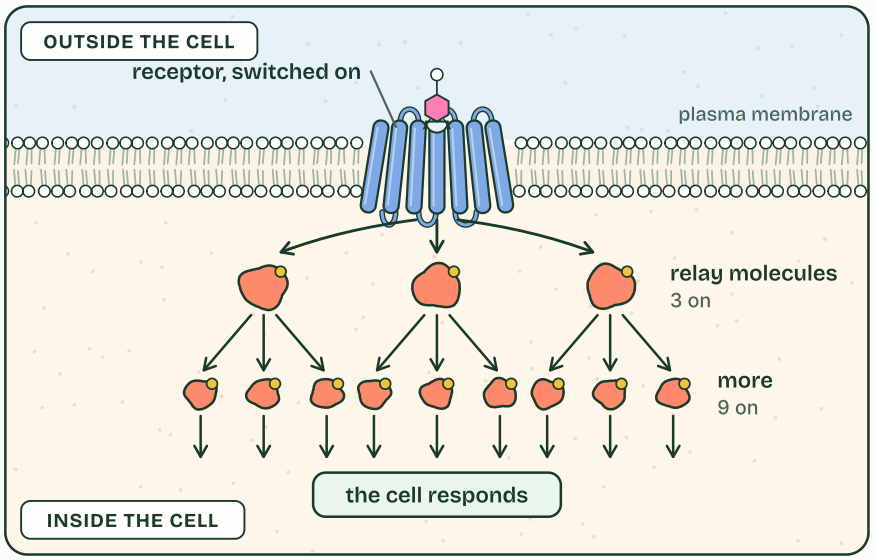
NOTES

1. In _____ the ligand binds its receptor, and the receptor changes shape.
2. In _____ that change is passed along a chain of molecules inside the cell, each switching on the next.
3. In the _____ the last molecules do something: an enzyme starts work, a channel opens, a gene is read.
4. The whole chain is a _____, and it links what the receptor senses to what the cell does.
5. A _____ takes the end phosphate from ATP and adds it to an amino acid of its target.
6. Often the target is itself a kinase, so kinase switches on kinase in a _____, each one acting on many of the next.
7. A _____ takes the phosphate off again, so each relay goes back to rest once the signal stops.
8. _____, transduction, response.

Your own notes

ANNOTATE THE FIGURE

Number the 5 steps on the figure and note what happens at each: 1 ligand; 2 switched on; 3 relay molecules; 4 amplified; 5 response.



REMEMBER IT

The three stages: ring, tell, run

R Ring	T Tell	R Run
R	T	R

SPOT THE MISTAKE

What do students often get wrong about components of a signal transduction pathway? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 05 in two or three sentences of your own.

06 A receptor that wakes a G protein

4.2.B

CUES

Predict: Epinephrine binds its receptor. Which event switches the G protein on?

What is meant by g protein-coupled receptor?

What is meant by g protein?

What is meant by adenylyl cyclase?

NOTES

1 The biggest family of receptors in eukaryotes is the _____ (GPCR).

2 On the inside it meets a _____, made of three parts (alpha, beta and gamma) held to the inner face of the membrane.

3 At rest the G protein holds a molecule of _____ and is off.

4 When a ligand binds, the receptor's intracellular domain changes shape, and the changed receptor makes the G protein let go of its GDP and pick up a _____ in its place.

5 With GTP bound, the alpha part leaves beta and gamma, slides along the membrane to an enzyme, often _____, and switches it on.

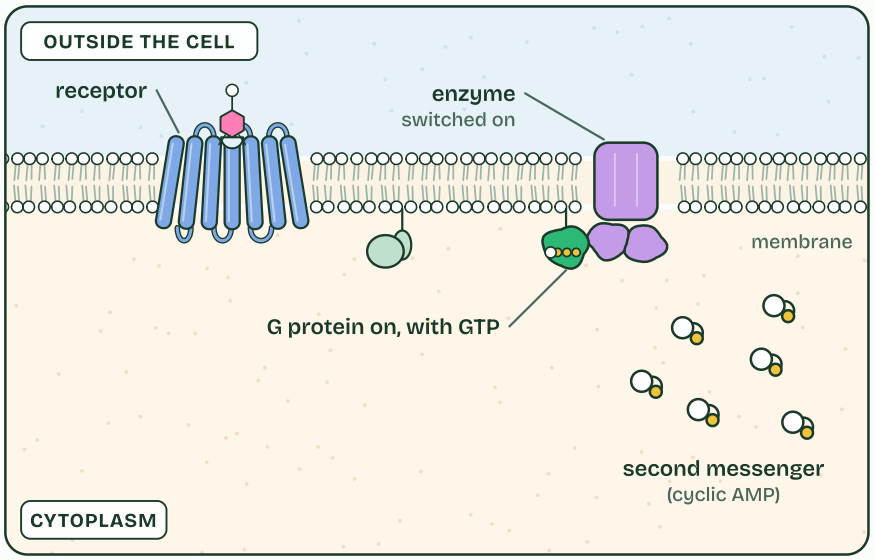
6 _____: off with GDP, on with GTP; the receptor makes it swap.

7 The active _____ switches on adenylyl cyclase.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each: 1 ligand, G protein, GDP; 2 on; 3 swaps GDP for GTP, on; 4 enzyme, second messenger.



SPOT THE MISTAKE

What do students often get wrong about g protein-coupled receptors? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 06 in two or three sentences of your own.

07 One hormone, millions of glucose

4.2.A 4.2.B

CUES

Predict: Epinephrine switches on 10 receptors on a liver cell. If every active molecule in the pathway then switches on 10 of the next, about how many molecules are active three steps on?

What is meant by epinephrine?

What is meant by second messenger?

What is meant by amplified?

What is meant by phosphodiesterase?

NOTES

1 Here is one pathway from start to finish, the example the AP course names: _____ telling a liver cell to break down glycogen.

2 cAMP is a _____: a small molecule the cell makes once the receptor is active, which spreads through the cytoplasm and carries the message on.

3 The signal is _____ at every step, so a few molecules of epinephrine outside release millions of glucose molecules inside, in seconds.

4 Then it stops: when epinephrine leaves, the G protein breaks its GTP down, _____ turns cAMP into AMP, and phosphatases take the phosphates off.

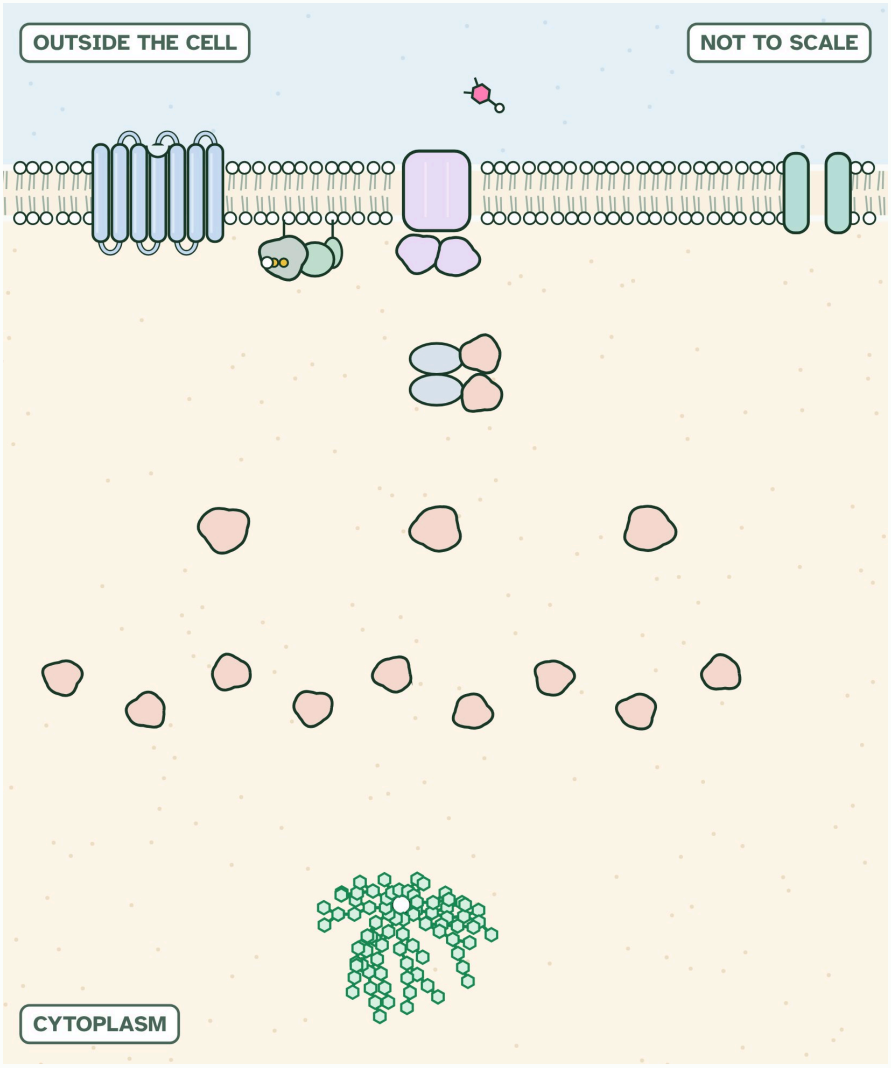
5 cAMP is the _____; epinephrine is the first and stays outside.

6 _____ and phosphatases switch the pathway off.

Your own notes

ANNOTATE THE FIGURE

Annotate this still from the animation (Epinephrine, receptor to response): what is happening, and why?



REMEMBER IT

The epinephrine pathway in order: Real Gamers Always Collect Keys

R Real	G Gamers	A Always	C Collect	K Keys
R	G	A	C	K

SPOT THE MISTAKE

What do students often get wrong about epinephrine, cAMP and the cascade? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 07 in two or three sentences of your own.

08 A receptor that is a gate

4.2.B

CUES

Predict: Acetylcholine opens the channels and positive ions flow into the muscle fiber. What happens to the voltage across its membrane?

What is meant by ligand-gated ion channel?

What is meant by depolarizes?

NOTES

1 A _____ is a receptor and a channel in one protein.

2 Where a motor neuron meets a muscle fiber, the neuron releases _____.

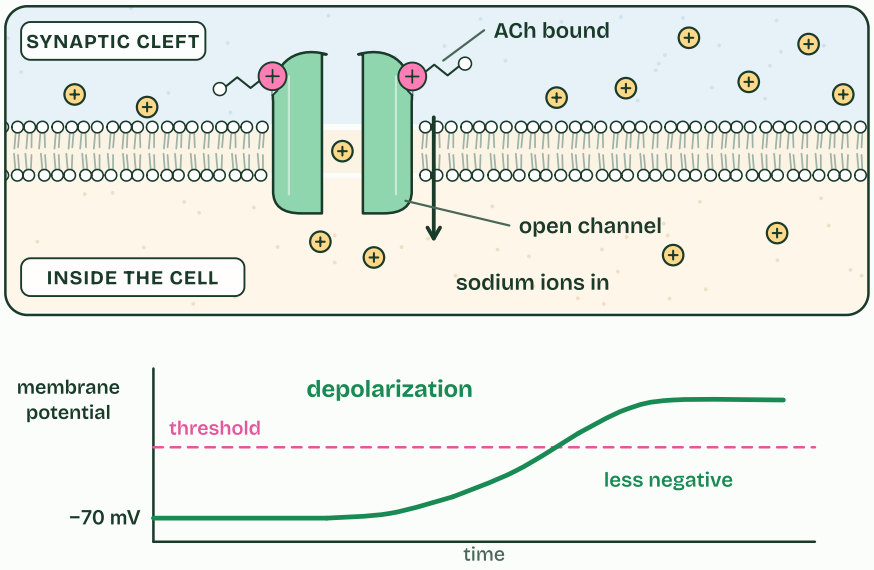
3 The inside of the fiber, about −70 mV at rest, becomes less negative: it _____.

4 Acetylcholine opens channels; Na^+ in; the membrane _____.

Your own notes

ANNOTATE THE FIGURE

Number the 5 steps on the figure and note what happens at each: 1 closed, −70 mV; 2 Acetylcholine; 3 channel opens; 4 Positive ions; 5 less negative, depolarized.



SUMMARY

Sum up section 08 in two or three sentences of your own.

09 Kinase receptors, and receptors inside

4.2.B 4.3.A

CUES

Predict: A cell is treated with a drug that stops transcription. Which of its responses is lost?

What is meant by receptor tyrosine kinase?

What is meant by intracellular receptor?

NOTES

1 A _____ spans the membrane and its intracellular domain is a kinase.

2 Testosterone and estrogen are lipids made from cholesterol: they diffuse through the bilayer and bind an _____ in the cytoplasm or nucleus.

3 Insulin: a _____; ends with GLUT4 moved to the membrane.

4 _____ from the blood reaches its receptor.

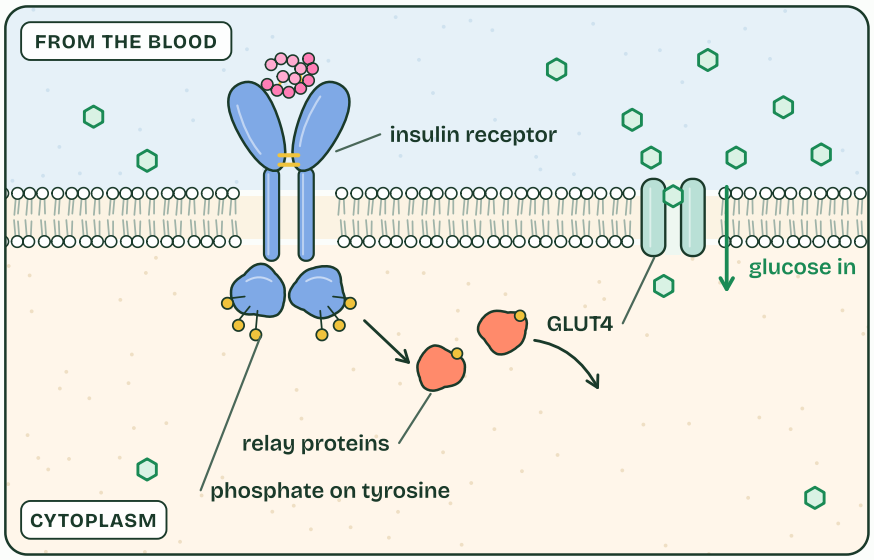
5 The enzyme part of the receptor adds _____.

6 The phosphorylated receptor switches on _____.

Your own notes

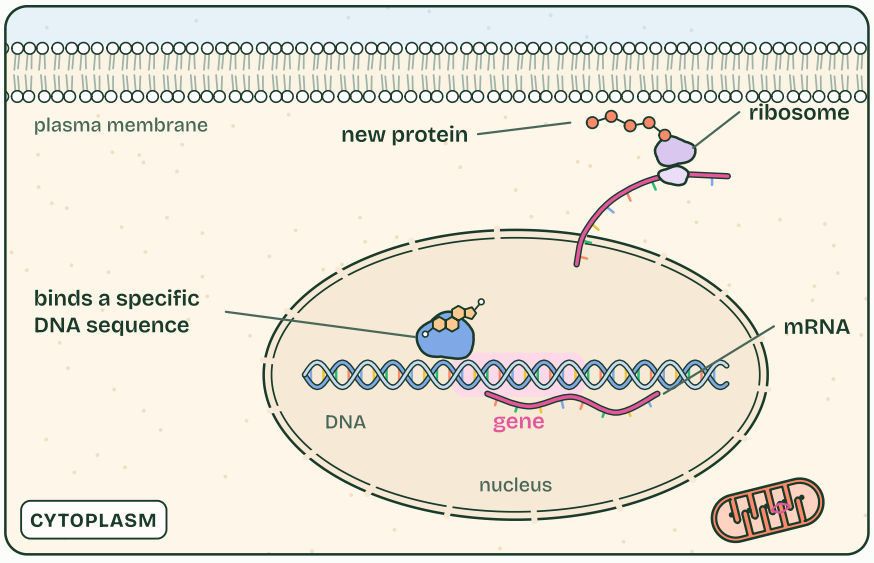
ANNOTATE THE FIGURE

Number the 6 steps on the figure and note what happens at each.



ANNOTATE THE FIGURE

Number the 6 steps on the figure and note what happens at each: 1 steroid hormone; 2 diffuses through; 3 intracellular receptor; 4 nucleus; 5 specific DNA sequence, promotes transcription; 6 translated.



SPOT THE MISTAKE

What do students often get wrong about receptor tyrosine kinases and intracellular receptors? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 09 in two or three sentences of your own.

10 What a signal makes a cell do

4.3.A

CUES

Predict: Gibberellin, a plant hormone, reaches cells in a germinating barley seed. Within hours they are making amylase, which they were not making before. What kind of response is this?

What is meant by phenotype?

What is meant by apoptosis?

NOTES

1 Most change either _____ or _____.

2 In ripening fruit the gas _____ switches on the genes for enzymes that soften the cell walls and turn starch to sugar, and ripe fruit makes more ethylene, so one ripe banana in a bag ripens the rest.

3 Across many cells, either kind can change the _____: the fruit softens, an embryo grows testes.

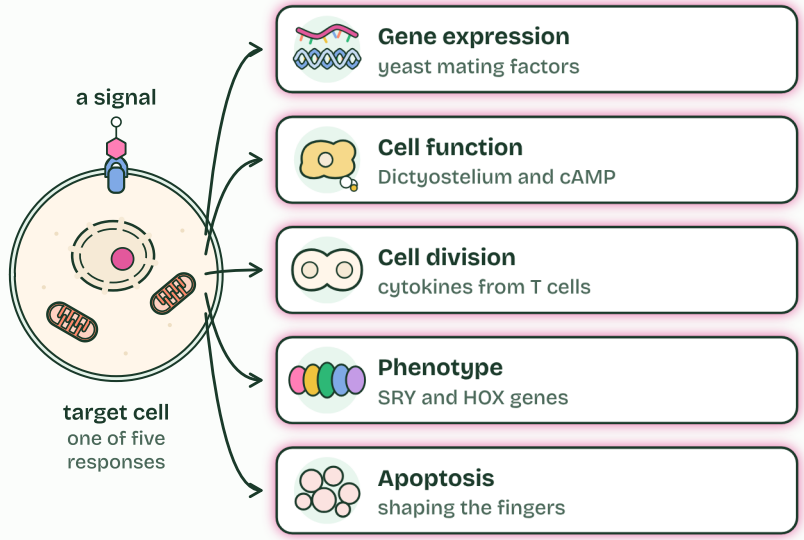
4 A signal can even end a cell's life by _____, programmed cell death, which shapes a body as much as growth does.

5 Responses: gene expression, cell function (and division), _____, apoptosis.

Your own notes

ANNOTATE THE FIGURE

Label each part and say what it does: gene expression, cell function, cell division, phenotype, apoptosis.



SUMMARY

Sum up section 10 in two or three sentences of your own.

11 When a pathway breaks

4.3.B

CUES

Predict: A beta blocker fits the binding site of the epinephrine receptor but does not change the receptor's shape. Epinephrine arrives. What happens to the cAMP in the cell?

NOTES

1 A chemical can do it too: some _____ a part of the pathway, others _____ it.

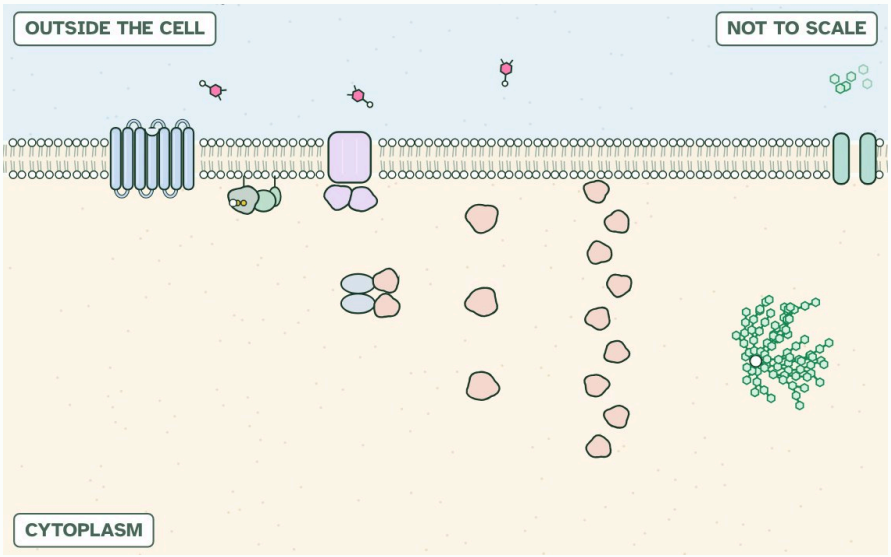
2 Is this part now stuck _____, or stuck _____?

3 Make each prediction below, then set the film's _____ to that change and watch.

Your own notes

ANNOTATE THE FIGURE

Annotate this still from the animation (Break the pathway): what is happening, and why?



REMEMBER IT

The on and off switch: a Kinase Kicks the phosphate on, a Phosphatase Peels it off

K Kicks	P Peels
K	P

SUMMARY

Sum up section 11 in two or three sentences of your own.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on 4.1 to 4.3 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

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

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.