Past-paper walk-through

Responses to the Environment ▪ 8.1

eXercise

Questions in this set

- 2026 Q1
- 2023 Q3
- 2018 Q2
- 2017 Q1
- 2017 Q2
- 2015 Q1
- 2015 Q5
- 2015 Q7
- 2015 Q8
- 2014 Q2

Questions in this set

- 2014 Q6
- 2014 Q7

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 1

2026 ▪ Q1

Molecules known as dinucleoside polyphosphates, a type of nucleotide, are signaling molecules that accumulate in plant cells during dry or stressful conditions.
The following information applies to parts B, C, and D.
Stomata are pores on the surface of leaves that open when exposed to light and regulate the flow of carbon dioxide, oxygen, and water vapor in and out of a plant. In response to dry environmental conditions, many plants close their stomata, which reduces water loss.
Scientists hypothesized that the dinucleoside polyphosphates Ap_4A and Cp_4C bind to DORN1 receptors on the plasma membrane of plant cells and initiate signaling cascades that cause stomata to close. The scientists exposed plants to light to open the stomata and then placed samples of the leaves in buffer alone or in buffer

Question 1

containing one of three different compounds: Ap_4A, Cp_4C, or abscisic acid (ABA), a molecule that causes stomata to close.
The scientists measured the size of the stomata in each sample and calculated their sizes relative to the size of the stomata in the sample kept in buffer alone, as shown in Figure 1.
Figure 1. Effect of Ap_4A, Cp_4C, and ABA on Relative Stomatal Size (Error Bars Represent $\pm SE_{\bar{x}}$)
[Bar graph; y-axis "Relative Size of Stomata (width/length)" from 0.0 to 1.1 in increments of 0.1; x-axis "Treatment" with four bars: Buffer, Ap_4A, Cp_4C, ABA. Approximate bar heights with error bars: Buffer $\approx 1.0 \pm 0.05$; $Ap_4A \approx 0.65 \pm 0.05$; $Cp_4C \approx 0.62 \pm 0.05$; ABA $\approx 0.70 \pm 0.05$.]
(a) Describe the three structural components of a nucleotide.

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2026 ▪ Q1

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(b)(i) Identify the dependent variable in the scientists' first experiment.

(b)(ii) Based on Figure 1, **describe** the relative size of the stomata in the Cp_4C treatment group as compared with the size of the stomata in the group treated with buffer alone.

(b)(iii) Justify the use of buffer alone as a control in the scientists' experiments.

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(c)(i) In a second experiment, the scientists used plants that were identical to those in the first experiment except that the gene encoding the DORN1 receptor was mutated. The scientists repeated the procedure of the first experiment. Their results are shown in Figure 2.

Figure 2. Effect of Ap_4A, Cp_4C, and ABA on Relative Stomatal Size in DORN1 Mutants (Error Bars Represent $\pm SE_{\bar{x}}$)

Question 1

[Bar graph; y-axis "Relative Size of Stomata (width/length)" from 0.0 to 1.2 in increments of 0.1; x-axis "Treatment" with four bars: Buffer, Ap_4A, Cp_4C, ABA. Approximate bar heights with error bars: Buffer $\approx 1.0 \pm 0.05$; $Ap_4A \approx 1.1 \pm 0.1$; $Cp_4C \approx 0.70 \pm 0.05$; ABA $\approx 0.60 \pm 0.05$.]

Justify the scientists' treating one sample of leaves with ABA in the experiments.

(c)(ii) Based on Figure 2, **describe** the difference between the effects of Ap_4A and Cp_4C treatments on the size of stomata in plants with mutated DORN1 receptors.

(c)(iii) Activation of DORN1 receptors induces plant cells to produce certain molecules that cause the stomata to close. Based on the data in Figures 1 and 2 for cells treated with Ap_4A, **predict** the relative production of the molecules by DORN1-mutated cells in comparison to the production by nonmutated cells.

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(d)(i) The DORN1 receptor transmits signals that result in an increase in the transcription of genes involved in plant defenses. The scientists then developed DORN1-mutant plants in which the DORN1 receptor lacked most of its intracellular domain.

In cells homozygous for this mutation, **predict** the effect of Ap_4A treatment on transcription of the genes involved in plant defenses relative to the effect of Ap_4A on nonmutated cells.

Question 1

(d)(ii) Justify your prediction.

Question 3

2023 ▪ Q3

Sand lances of the genus *Ammodytes* are small fish that function as keystone organisms in several coastal ecosystems. These sand lances are prey fish that support organisms at higher trophic levels. Scientists performed experiments to examine how sand lance populations are likely to be affected by the rising temperatures and CO_2 levels associated with climate change.

Sand lance embryos typically develop and mature into adult fish at low temperatures (approximately $5°C$) and stable, low CO_2 levels (approximately 400 μatm). Over the course of two years, the scientists measured the survival rate of sand lance embryos allowed to develop and mature in a laboratory at three different temperatures, $5°C$, $7°C$, and $10°C$, with the level of CO_2 maintained at 400 μatm, 1,000 μatm, and 2,100 μatm for each temperature.

Question 3

(a) Describe the effect of increased biodiversity on the resilience of an ecosystem in a changing environment.
(b) **Justify** the scientists' selecting 5°C as the lowest temperature and 400 μatm as the lowest CO_2 level in their study of sand lance embryo survival.
(c) State a null hypothesis for the experiment.
(d) The scientists claim that a reduction in the population size of the *Ammodytes* sand lances will affect the stability of the entire coastal ecosystem. Provide reasoning to **support** the scientists' claim.

Solution 3

(a)

Mark scheme

- Increased biodiversity increases the resilience of an ecosystem in a changing environment — i.e., an ecosystem's resilience (ability to recover from or withstand disturbance/change) is greater when biodiversity is higher.

Solution 3

(b)

Mark scheme

- 5°C and 400 μatm CO2 were chosen because they represent the normal/current environmental conditions under which sand lance embryos typically develop and mature; using these as the baseline lets the researchers use them as a basis of comparison to evaluate the effects of increases in temperature and CO2 (i.e., climate-change-associated changes) on embryo survival relative to current, unaltered conditions.

Solution 3

(c)

Mark scheme

- A null hypothesis for the experiment (any one of): climate change (increased temperature and/or CO2) will have no effect on sand lance embryo survival/development or on the size of sand lance populations; equivalently, there will be no difference in sand lance embryo survival rates/development measured at the different (or all) temperatures and CO2 levels tested.

Solution 3

(d)

Mark scheme

- Reasoning to support the claim (either): a reduction in sand lance population size will have a negative effect on organisms at other trophic levels because sand lances serve as a food source (prey) for many other species — fewer sand lances means less food/energy available for predators; or, there would be reduced energy transfer to higher trophic levels, destabilizing the coastal food web/ecosystem since sand lances are a keystone prey species.

Question 2

2018 ▪ Q2

Question 2

[Figure 1: Diagram of cellular response to infection by pathogenic bacteria. At the top is a double-line "Cell Membrane" with two small vertical channel/pore segments embedded in it, arrows converging up into the pore from below (labeled with circled "3"), and one arrow pointing up and out through the membrane at the far left (from the Active Interleukin). Below the membrane, left region: "Inactive Interleukin" (drawn as a triangle attached to an oval) is converted via a step labeled circled "2" into "Active Interleukin" (an oval with a triangle nearby, arrow pointing up out of the membrane, showing the active portion is released from the cell). Middle-right region: "N-terminal Gasdermin" (a small rectangle/bracket shape) sits just below the membrane pore; "Gasdermin" (a rectangle attached to a filled black square) is converted via a step labeled circled "3" into N-terminal Gasdermin, which is shown assembling into the membrane pore. Bottom-left region: "Inactive Caspase-1" (a filled circle attached to an oval) is converted via a step labeled circled "1", triggered by "Bacterial Infection" (arrow pointing up into step 1), into "Active Caspase-1" (an oval with a filled circle nearby); Active

Question 2

Caspase-1 then has arrows pointing to both step 2 (activating Interleukin) and step 3 (activating Gasdermin). Caption: "Figure 1. Cellular response to infection by pathogenic bacteria."]

Question 2

Some pathogenic bacteria enter cells, replicate, and spread to other cells, causing illness in the host organism. Host cells respond to these infections in a number of ways, one of which involves activating particular enzymatic pathways (Figure 1). Cells normally produce a steady supply of inactive caspase-1 protein. In response to intracellular pathogens, the inactive caspase-1 is cleaved and forms an active caspase-1 (step 1). Active caspase-1 can cleave two other proteins. When caspase-1 cleaves an inactive interleukin (step 2), the active portion of the interleukin is released from the cell. An interleukin is a signaling molecule that can activate the immune response. When caspase-1 cleaves gasdermin (step 3), the N-terminal portions of several gasdermin proteins associate in the cell membrane to form large, nonspecific pores.

Question 2

Researchers created the model in Figure 1 using data from cell fractionation studies. In the experiments, various parts of the cell were separated into fractions by mechanical and chemical methods. Specific proteins known to be located in different parts of the cell were used as markers to determine the location of other proteins. The table below shows the presence of known proteins in specific cellular fractions.

CELL FRACTIONS CONTAINING DIFFERENT CELLULAR PROTEINS

	Aconitase (Krebs cycle protein)	**DNA poly-merase**	**GAPDH (glycolytic protein)**	**Sodium-potassium pump**	**NF-κB (Immune response protein)**
Whole cell sample	+	+	+	+	+
Fraction 1	+				
Fraction 2		+			+
Fraction 3			+		+
Fraction 4				+	

Question 2

- = presence of protein

(a) Describe the effect of inhibiting step 3 on the formation of pores AND on the release of interleukin from the cell.

Question 2

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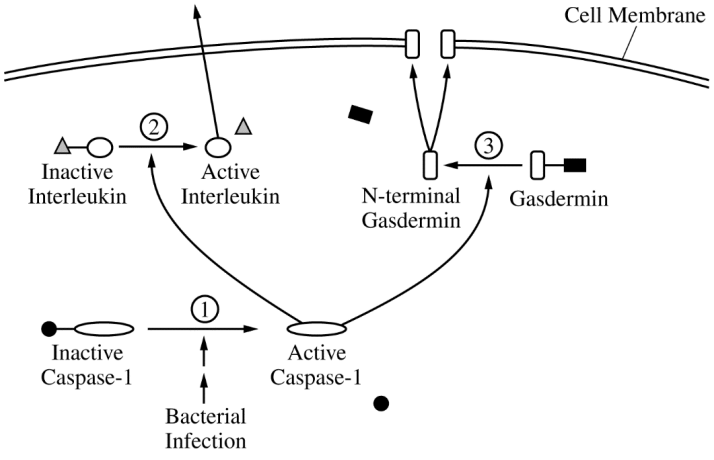
Whole cell sample	+	+	+	+	+
Fraction 1	+				
Fraction 2		+			+
Fraction 3			+		+
Fraction 4				+	
+ = presence of protein					

Question 2


Cell Membrane
2
Inactive
Interleukin
Active
Interleukin
3
N-terminal
Gasdermin
Gasdermin
1
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Question 2

2018 ▪ Q2

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