Past-paper walk-through

Nucleic Acids ▪ 1.6

eXercise

Questions in this set

- 2026 Q1
- 2017 Q6

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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(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 $\pm SE_{\bar{x}}$)

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[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.

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(d)(ii) Justify your prediction.

Question 6

2017 ▪ Q6

[Figure 1: Diagram titled "Comet assay to detect double-stranded breaks in DNA," showing three sequential panels connected by labeled steps. Panel 1: "Cell with DNA Damage" — a large irregular circle (the cell) containing a smaller circle (the nucleus) with a tangled DNA symbol inside, with two lines extending from the nucleus to a small circle in Panel 2. Panel 2: "Individual Nucleus Placed on Slide" — a rectangle (representing the slide/gel) containing a single small filled circle (the nucleus). An arrow labeled "Electrophoresis" points from Panel 2 to Panel 3. Panel 3: "Intact DNA Remains in the Head and Damaged DNA Is in the Tail" — a rectangle with a "−" (minus) label on the top-left corner and a "+" (plus) label on the top-right corner, containing a shape labeled "Head" (a larger dark circular/oval region on the left, representing intact DNA) connected to a smaller lighter oval labeled "Tail"

Question 6

(representing damaged DNA fragments) extending to the right, toward the "+" electrode.]

A comet assay is a technique used to determine the amount of double-strand breaks in DNA (DNA damage) in cells. The nucleus of an individual cell is placed on a microscope slide coated with an agarose gel. An electric current is applied to the gel that causes DNA to move (electrophoresis), and the DNA is stained with a fluorescent dye. When viewed using a microscope, undamaged DNA from the nucleus appears as a round shape (the head), and the fragments of damaged DNA extend out from the head (the tail). The length of the tail corresponds to the amount of the damage in the DNA (see Figure 1).

(a) To explain the movement of DNA fragments in the comet assay, **identify** one property of DNA and **provide reasoning** to support how the property contributes to the movement during the comet assay technique.

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(b) In a different experiment, cells are treated with a chemical mutagen that causes only nucleotide substitutions in DNA. **Predict** the likely results of a comet assay for this treatment.

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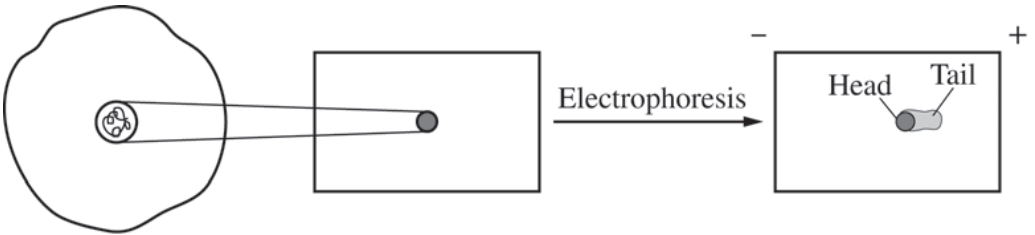
−
+
Electrophoresis
Head
Tail
Cell with
DNA Damage
Individual Nucleus
Placed on Slide
Intact DNA Remains in
the Head and Damaged
DNA Is in the Tail

Solution 6

(a)

Mark scheme

- Both points must come from the same row. Row 1 — Identification: DNA has a (negative) charge; Reasoning: DNA moves toward the positive/oppositely charged pole during electrophoresis. Row 2 — Identification: DNA fragments can be different sizes; Reasoning: different-size DNA fragments move at different rates through the gel, so smaller damaged fragments migrate farther into the tail while intact DNA stays in the head.

Solution 6

(b)

Mark scheme

- A mutagen causing only nucleotide substitutions (point mutations, not double-strand breaks) does not fragment the DNA, so the comet assay shows only a head with no tail (or, equivalently, a tail shorter than that of a cell with double-stranded breaks).