bio letters

Biology
Higher level
Paper 1B

12 May 2025

Zone A afternoon | **Zone B** morning | **Zone C** afternoon

Candidate name

2 hours [Paper 1A and Paper 1B]

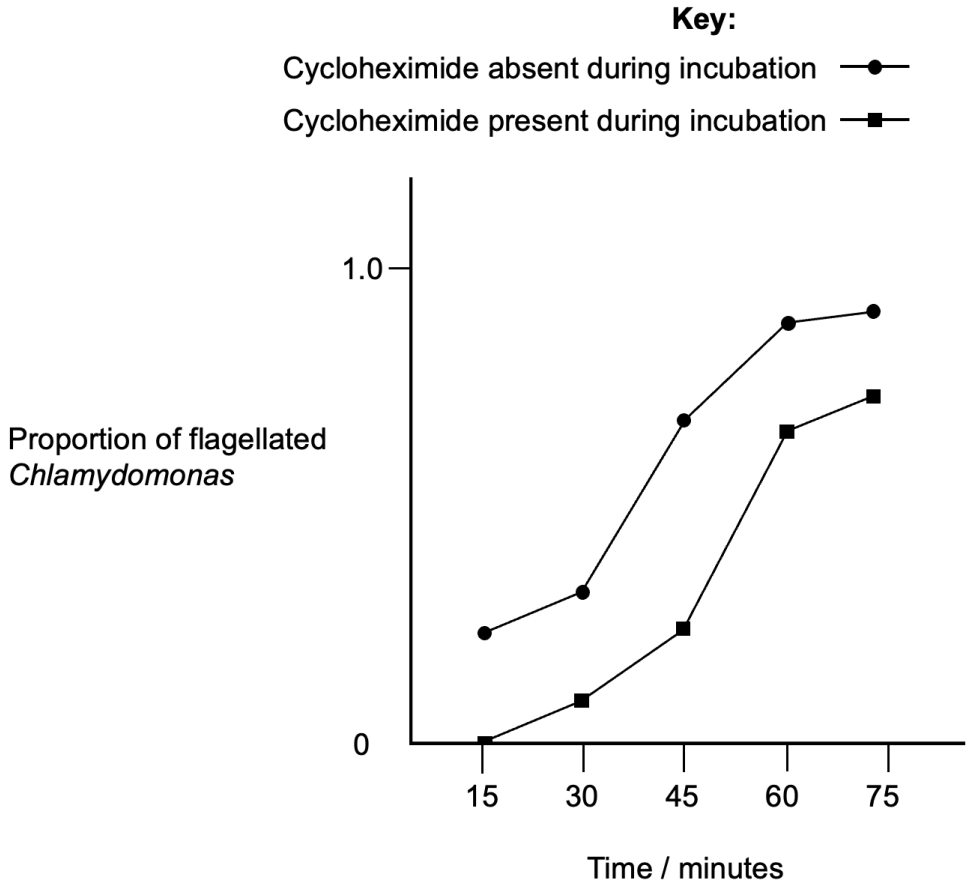
Instructions to candidates

- Write your candidate name in the boxes above.
- Do not open this mock examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for paper 1B is **[35 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.

Answer **all** questions. Answers must be written within the answer boxes provided.

1. Flagella in *Chlamydomonas* are composed of α and β tubulin dimers that form the microtubules responsible for the eukaryote's mobility. Researchers grew two cultures of *Chlamydomonas* on a medium, and supplied one of the cultures with cycloheximide, a reversible protein synthesis inhibitor. Before incubating the cultures for 2 hours in their media, *Chlamydomonas* was deflagellated.

After 2 hours, the two cultures were transferred to media containing no cycloheximide and allowed to grow. Every 15 minutes, a sample was taken from each culture and the proportion of flagellated *Chlamydomonas* was observed under a light microscope and recorded. The results are displayed on the graph for each time interval.



(a) State the independent and dependent variables. [1]

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(Question 1 continued)

(b) Suggest why the cultures were first deflagellated and then grown onto an inhibitor-free medium after incubation. [2]

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(c) Compare and contrast the two curves in the graph. [3]

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(d) Actinomycin D inhibits the transcription of mRNA coding for tubulin proteins.

(i) Explain, on a molecular level, why adding actinomycin D to the cycloheximide treatment during the 2 hour incubation might have little to no effect on the curve representing the culture treated with cycloheximide. [2]

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(Question 1 continued)

(ii) Based on your answer in part (d) (i), suggest one structural feature of tubulin mRNA. [1]

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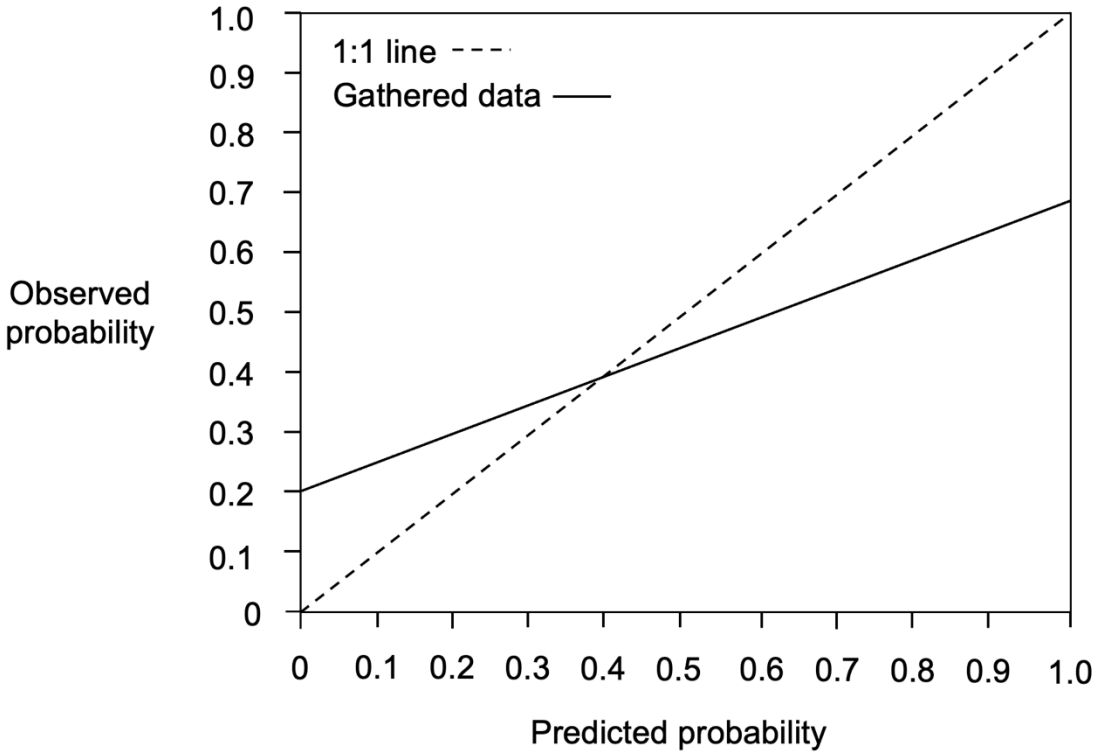
(e) Colchicine is an irreversible protein inhibitor. On the graph, draw the curve you would expect to see if *Chlamydomonas* was treated with colchicine. [1]

2. Ecological niche modelling (ENM) involves using abiotic and biotic data of a species' niche to predict its geographic distribution. In an ENM study, researchers gathered niche data of *Collinsia sparsiflora*, a native California plant, and tested their model by planting *C. sparsiflora* in 100 quadrats within a natural reserve. They collected abiotic and biotic data for each quadrat and assessed whether their ecological niche model accurately predicted the probability of which quadrats supported *C. sparsiflora* and which did not. The predicted and observed probabilities of all the quadrats are shown in the graph.



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(Question 2 continued)

(a) Distinguish between a fundamental and realized niche. [1]

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(b) Prior to moving *C. sparsiflora* to quadrats, the scientists collected a few plants from the wild, allowed them to undergo one round of self-fertilization, and then grew the F1 generation in a controlled greenhouse before transferring this generation to the quadrats. Explain the need for this. [2]

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(c) Suggest what the positive y-intercept may indicate about the factors limiting the geographic distribution of *C. sparsiflora*. [1]

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(d) State the slope of the curve for the gathered data if R^2 is zero. [1]

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(Question 2 continued)

(e) Analyze the results of this experiment. [3]

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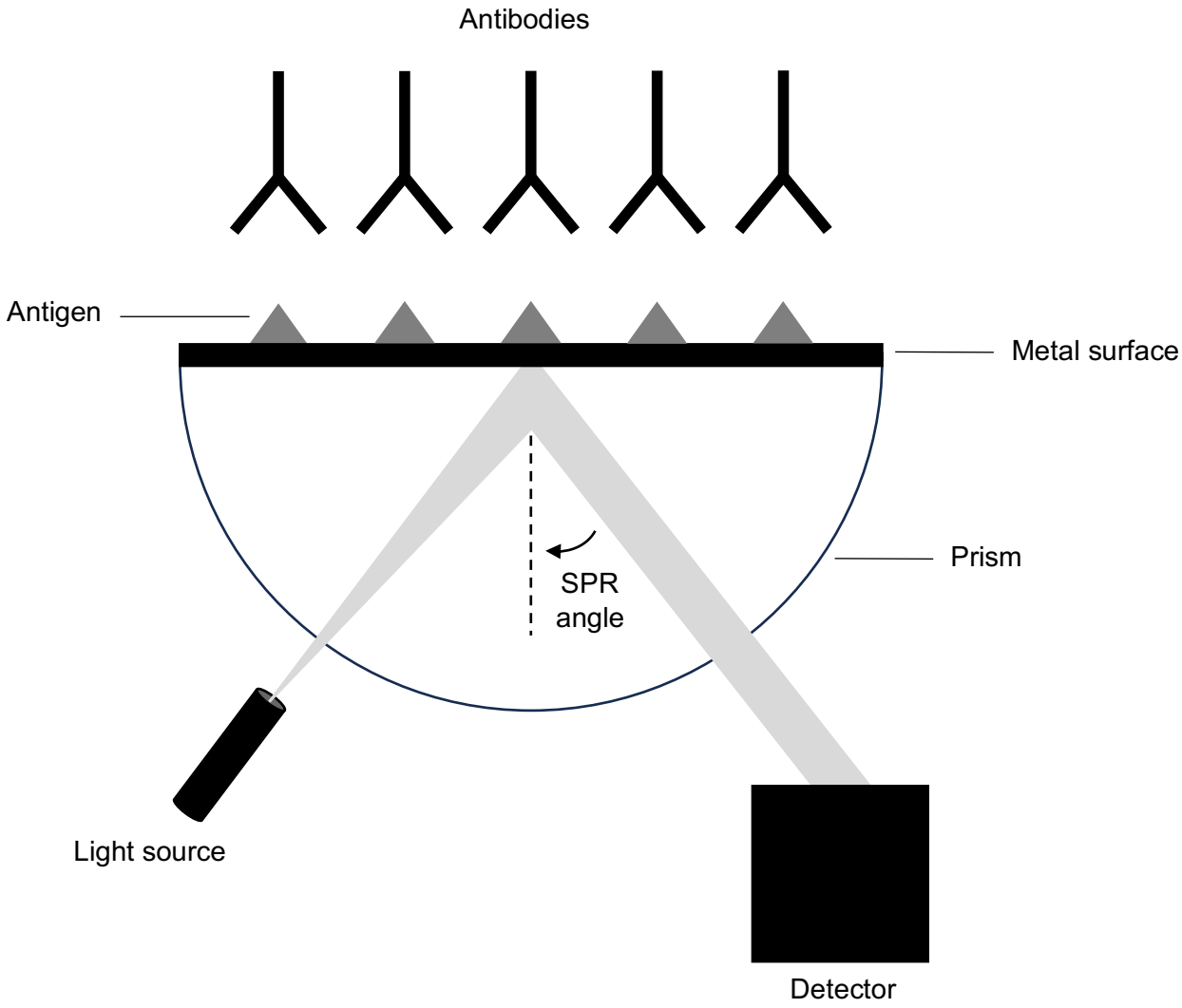
3. Surface Plasmon Resonance (SPR) spectroscopy is a useful technique for studying interactions between antibodies and antigens. Antigens are fixed onto a thin metal surface, and a beam of light is shined, through a prism, onto the metal surface, which is reflected back to a detector at a specific SPR angle. Changes to the SPR angle are proportional to the extent of binding between the antibodies and antigens.

In a study, the effects of a vaccine in a particular individual was tracked. A blood sample was taken every 3 days since administering the vaccine, and an SPR spectroscopy was performed for each sample. The SPR angles for the samples are recorded in the table.



Day	0	3	6	9	12	15	18
SPR angle / °	25.0	25.7	28.2	29.1	29.4	29.5	29.5

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(Question 3 continued)

(a) Calculate the percentage difference of SPR angles between days 3 and 6 and days 9 and 12. [2]

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(b) Explain how antibodies defend against disease. [3]

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(c) Using SPR spectroscopy data and your calculations from part (a) to support your answer, discuss how the composition of blood plasma changes from days 0 – 18. [4]

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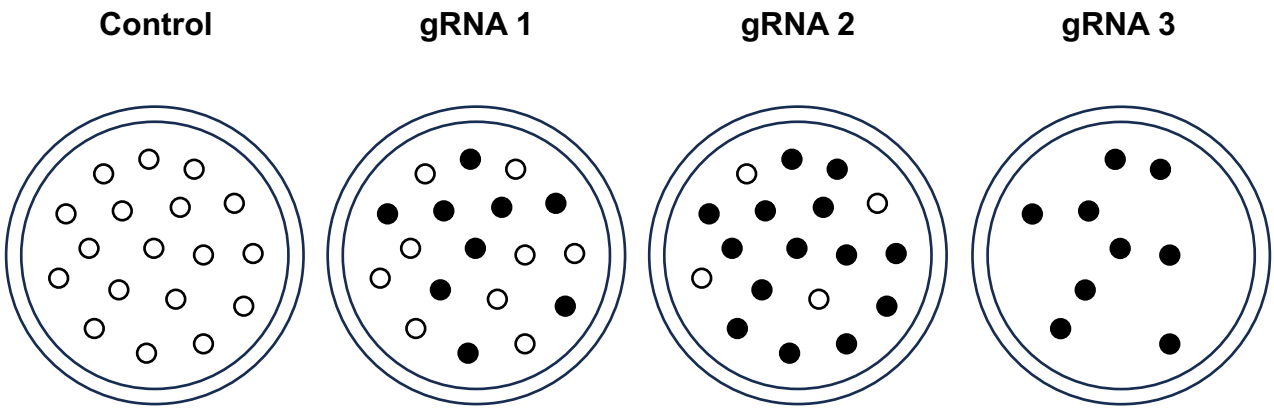
4. The *ADE2* gene in *Saccharomyces cerevisiae* (yeast) is involved in synthesizing adenine. Loss of function of *ADE2* disrupts this synthesis pathway and causes the accumulation of an intermediate with a red pigment, which makes yeast more easily visible for laboratory techniques.

Researchers used CRISPR-Cas9 to inactivate the *ADE2* gene using three different gRNA molecules. They then measured gRNA efficiency by plating the genetically modified yeast on agar and counted the colonies shown in the image after 48 hours of incubation. The shaded colonies are red-colored and the non-shaded colonies are normal-colored yeast.



(a) Outline **two** possible ways by which the *ADE2* gene can be inactivated using CRISPR-Cas9. [2]

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(Question 4 continued)

(b) Describe how a double-stranded break can be introduced by CRISPR-Cas9 to inactivate the *ADE2* gene. [4]

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(c) Identify the most efficient gRNA molecule, justifying your answer. [2]

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References:

1. Mitchell, Beth Ferro, and Mary R Graziano. “From organelle to protein gel: a 6-wk laboratory project on flagellar proteins.” *CBE life sciences education* vol. 5,3 (2006): 239-46. doi:10.1187/cbe.05-07-0089
2. **image:** 0301491 © Mark Turner.vwww.turnerphotographics.com
   data: Wright, Jessica W., W., et al. “Experimental Verification of Ecological Niche Modelling in a Heterogenous Environemnt.” *Ecology*, by Ecological Society of America, vol. 87, no. 10, Ecological Society of America, 2006, pp. 2433–39. Webdoc.agsci.colostate.edu/mckaylab/publications/wright_etal_2006.pdf.
3. Sari Sabban. Development of an *in vitro* model system for studying the interaction of *Equus caballus* IgE with its high-affinity Fc receptor. PhD Thesis. September 2011. https://etheses.whiterose.ac.uk/id/eprint/2040/2/Sabban%2C_Sari.pdf.
4. Sankaran SM, Smith JD, Roy KR.2021.CRISPR-Cas9 Gene Editing in Yeast: A Molecular Biology and Bioinformatics Laboratory Module for Undergraduate and High School Students. J Microbiol Biol Educ.22:10.1128/jmbe.00106-21.https://doi.org/10.1128/jmbe.00106-21.