Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

13 May 2025

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

Candidate session number

2 hours 30 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.

24 pages

2225 – 6015
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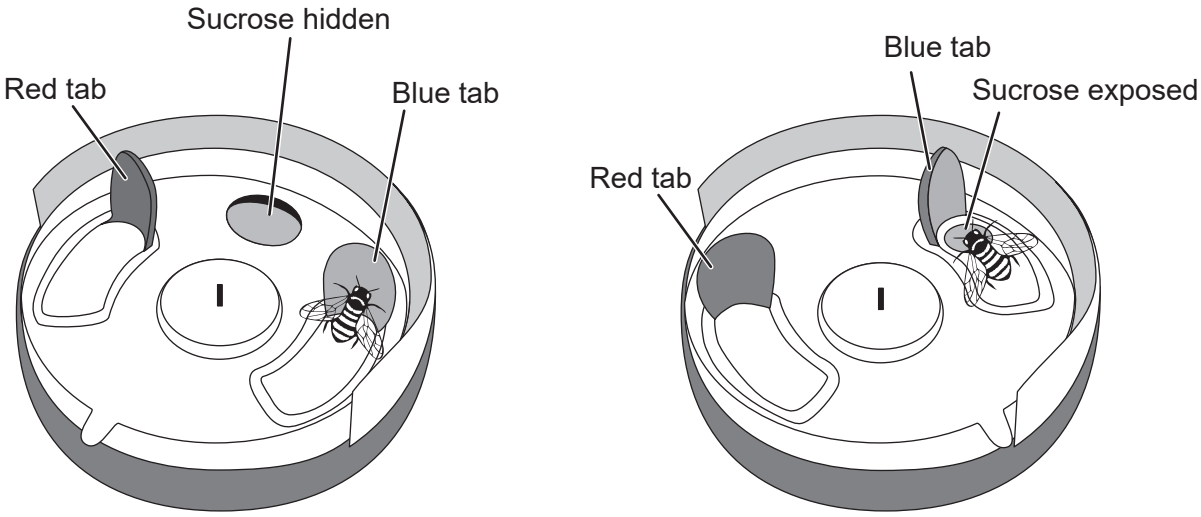
Section A

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

1. Bumblebees (*Bombus terrestris*) are insects that have both individual and social learning capacities. Scientists trained individual bumblebees to push either a blue tab or a red tab on a puzzle box to rotate the lid, exposing a reward consisting of a sucrose solution.



Individual trained bumblebees were then mixed with untrained bumblebees to determine if the trained ones could teach the untrained ones how to expose the sucrose solution. All groups had the same number of bumblebees.

Experimental groups:

- **B**: 1 bumblebee trained to open the **blue** tab plus untrained bumblebees
- **R**: 1 bumblebee trained to open the **red** tab plus untrained bumblebees
- **C (control)**: no trained bumblebees, only untrained bumblebees

The bumblebees in each group were allowed to try and open the puzzle box. Untrained bumblebees were considered to have become “learners” when they opened the puzzle box twice.

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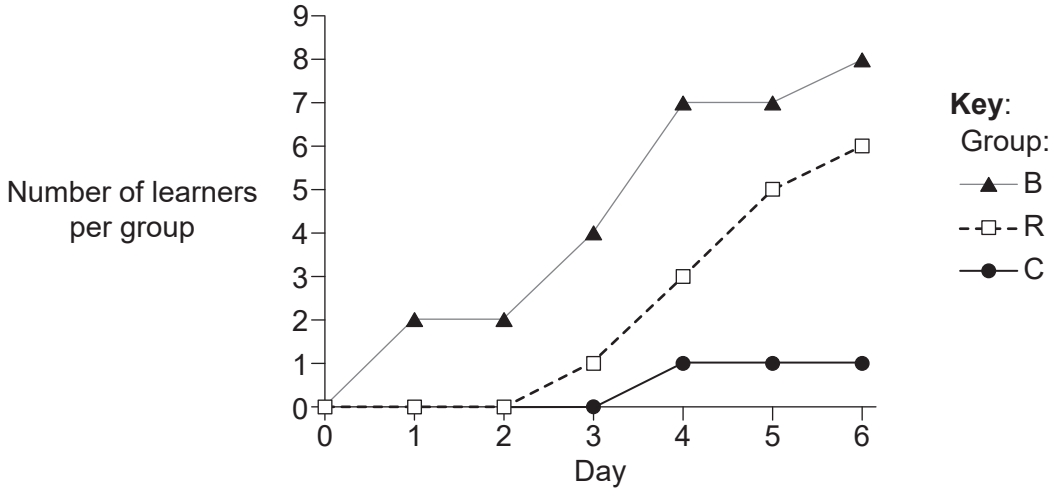
(Question 1 continued)

The line graph shows the number of learners per day in the different groups.



(a) State the number of learners in the R group on day 6. [1]

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(b) Compare and contrast the trends in the number of learners for the B group and R group over the course of the investigation. [2]

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(c) Calculate the percentage increase in the number of learners in the R group between days 3 and 6. [1]

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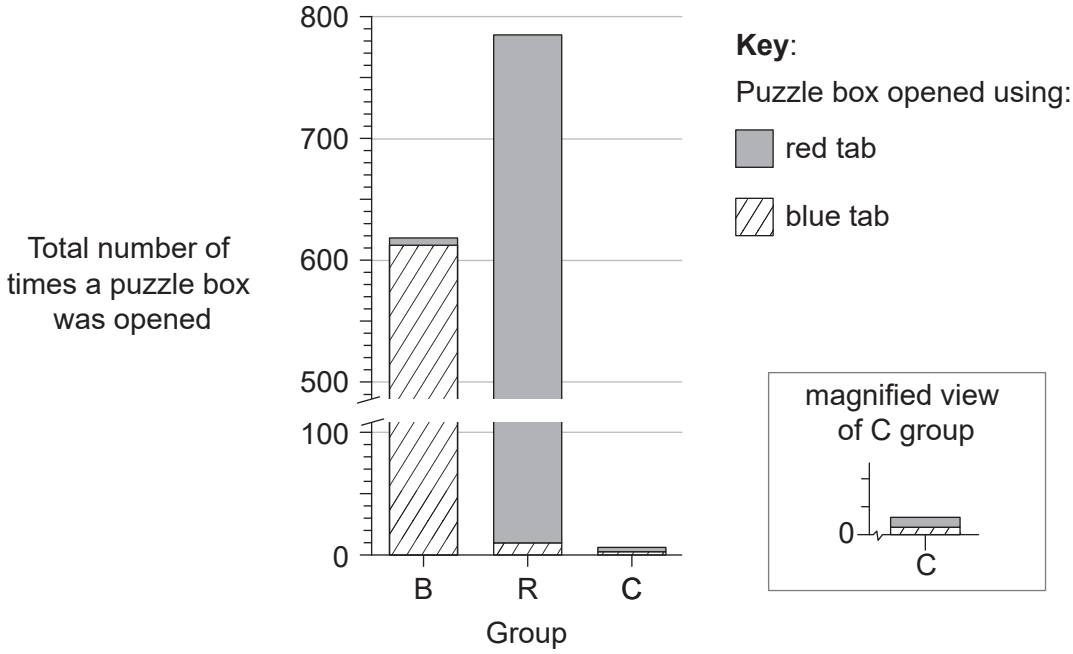
will not be marked.

(Question 1 continued)

The total number of times a puzzle box was opened to expose the sucrose solution by pushing either the blue tab or the red tab was recorded for each group after 6 days.



(d) Estimate the total number of times the puzzle box was opened using the red tab in the B group. [1]

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(e) Using all the data provided, suggest with a reason which group is more efficient at opening the puzzle box. [1]

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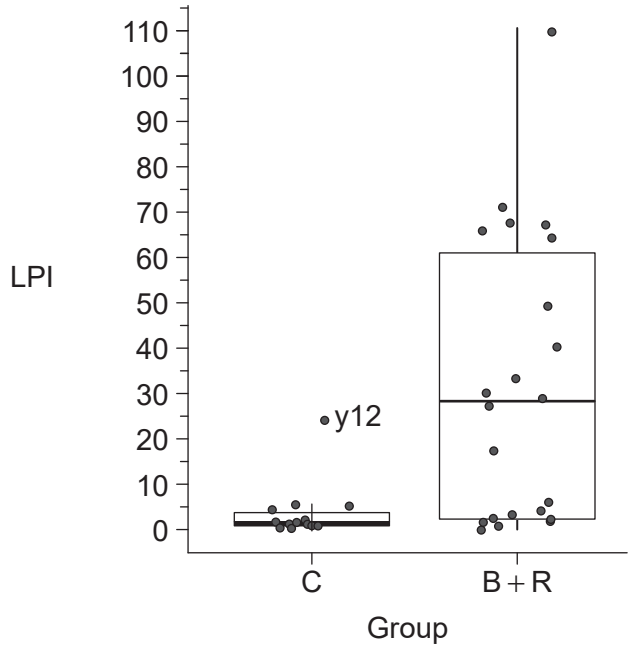
(Question 1 continued)

The bumblebees were allowed to open the puzzle box for a total of 12 days, and the number of times the puzzle box was opened with either colour tab was recorded. Blue tab learners and red tab learners were combined.

Learner proficiency indexes (LPI) were calculated for each individual learner as follows:

$$\text{LPI} = \frac{\text{Total times a puzzle box was opened}}{\text{Number of days to become a learner}}$$

The results for the learners in the B and R groups were combined (B + R) and compared with the control group (C). The box-and-whisker plot shows the LPI for each individual bumblebee in groups B + R and C.



(f) Determine which percentage of the B + R group had an LPI of 28 or less. [1]

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(Question 1 continued)

The most proficient learner in the C group, bumblebee **y12**, was an outlier with 216 box openings recorded during the experiment.

(g) (i) State the LPI for bumblebee **y12**. [1]

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(ii) Calculate the number of days it took bumblebee **y12** to become a learner. [1]

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Scientists concluded that puzzle box opening could arise spontaneously in the absence of social learning, but found that bumblebees that learned from trained bumblebees were significantly more proficient at puzzle box opening than learners from untrained (control) groups.

(h) Justify this conclusion using all the data provided. [3]

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will not be marked.

2. Water is the medium in which most processes of life occur.

(a) Distinguish between the physical properties of water and air. [2]

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The ringed seal (*Pusa hispida*) can be found in the Arctic and sub-Arctic regions of the Pacific, Atlantic and Arctic Oceans.

(b) Describe **two** physical adaptations of the ringed seal to live in water. [2]

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Ringed seals belong to more than one trophic level as they feed on zooplankton and fish. They are secondary consumers when they feed on zooplankton.

(c) State the trophic level of zooplankton. [1]

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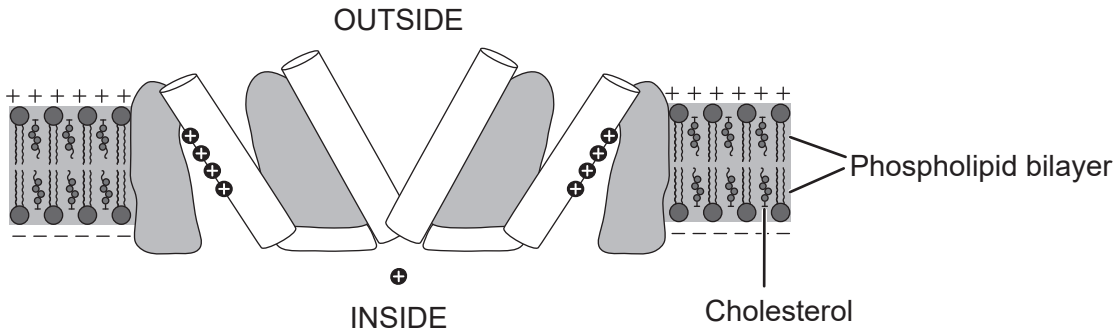
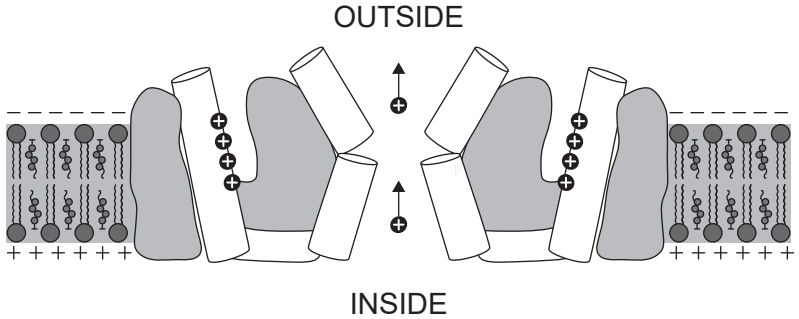
3. Voltage-gated ion channels are proteins that are embedded in the phospholipid bilayer of plasma membranes. They conduct ions at high rates, regulated by the voltage across the membrane. The diagram shows a typical voltage-gated potassium (K^+) channel when it is closed and when it is open.

Closed:



Open:



(a) Explain the action of the voltage-gated potassium channel during a nerve impulse. [3]

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(Question 3 continued)

(b) State another type of gated ion channel. [1]

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(c) Outline the amphipathic characteristic of phospholipid bilayers. [1]

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(d) Outline the effect of cholesterol on the fluidity of membranes. [1]

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(e) Outline the effect of fatty acids on the fluidity of membranes. [1]

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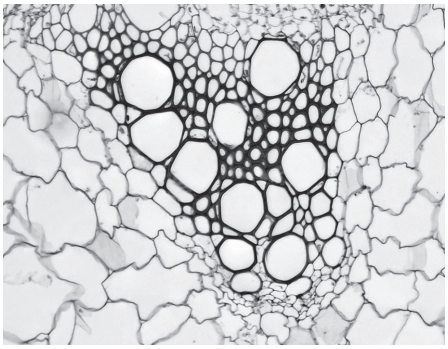
4. The light micrograph shows xylem vessels.



(a) Outline **two** adaptations of xylem vessels for water transport. [2]

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2. . . . . .

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(b) Explain how water is transported from the soil to the leaves when high humidity prevents transpiration. [3]

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5. Adaptive immunity leads to cells that are infected by viruses being killed, resulting in immune memory which is the basis of vaccination.

(a) Distinguish between innate and adaptive immune response. [1]

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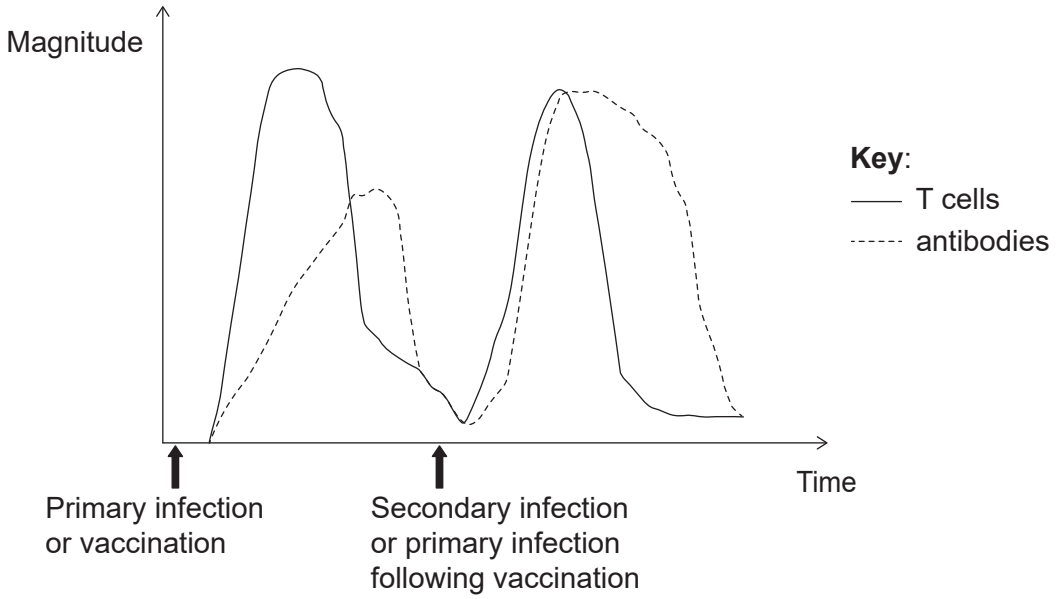
(Question 5 continued)

The graph shows the magnitude of the immune response after infection or after vaccination over time.



(b) Explain reasons that the T-cells peak before the antibodies after primary infection or vaccination, but T-cells peak at the same time as the antibodies after secondary infection or primary infection following vaccination. [2]

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(c) Different types of vaccine are used to prevent viral diseases. Justify this statement in terms of the structure of viruses. [2]

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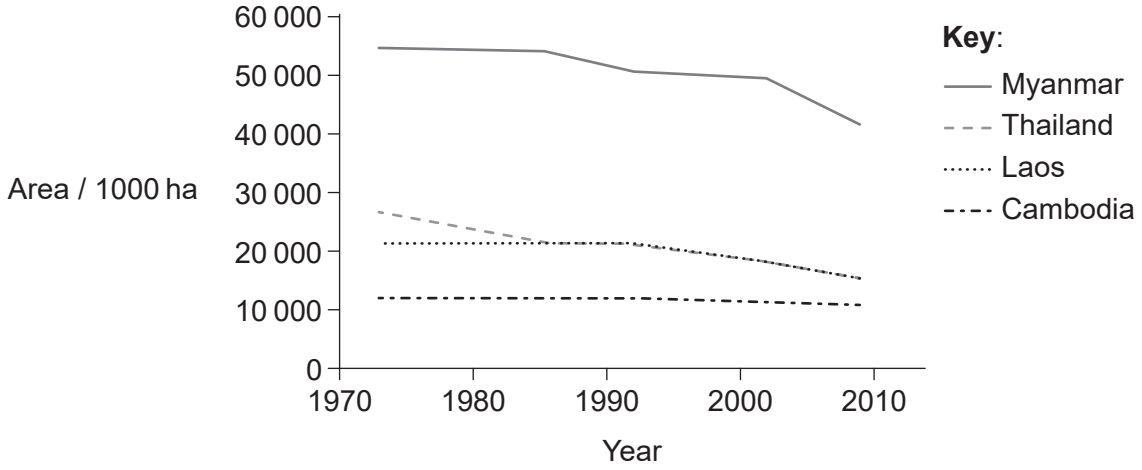
6. The graph shows the change in forest area in Greater Mekong countries in Southeast Asia between 1973 and 2009. This was mainly due to deforestation.



(a) Outline **two** ways in which biodiversity in Myanmar would be affected by deforestation. [2]

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2. . . . . .

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(b) State **one** cause of the current biodiversity crisis, other than deforestation. [1]

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(Question 6 continued)

(c) The EDGE of Existence programme measures Evolutionary Distinctness (ED) and Globally Endangered status (GE).

(i) Outline the importance of the EDGE of Existence programme. [2]

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(ii) Outline **one** method of restoration of natural processes in ecosystems by rewilding. [1]

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7. Duchenne muscular dystrophy (DMD) is a sex-linked genetic disorder caused by a recessive allele resulting from mutations in the X-linked dystrophin gene. This causes the degeneration of cardiac and skeletal muscle. These mutations can include deletions, insertions and base substitution mutations.

(a) Using a Punnett grid, deduce the probability of inheriting DMD if an unaffected male has offspring with a female carrier. [3]

Probability: . . . . . .

(b) Distinguish between deletion and insertion mutations. [1]

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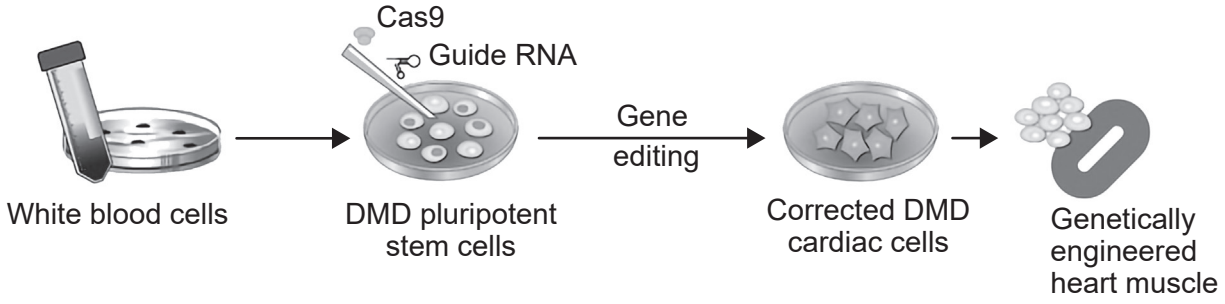
(Question 7 continued)

Gene editing technologies using CRISPR (clustered regularly interspaced short palindromic repeats) can potentially treat various diseases such as DMD. CRISPR-Cas9 can be used to repair the mutated DMD gene, leading to the expression of the encoded protein, dystrophin.

The diagram shows the correction of dystrophin expression by gene editing.



(c) Explain ways in which CRISPR-Cas9 gene editing could be used to change the mutated dystrophin protein produced. [3]

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(d) Suggest **one** reason for the use of pluripotent instead of multipotent stem cells in this process. [1]

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Section B

Answer **two** questions. One additional mark is available for the construction of your answers for each question. Answers must be written within the answer boxes provided.

8. Eukaryotes are a diverse group of organisms, including animals and plants.

(a) Distinguish between structures in animal and plant cells. [3]

(b) Outline adaptations of animals to herbivory and ways in which plants are adapted to resist herbivores. [4]

(c) Compare and contrast the processes of mitosis and cytokinesis in animal and plant cells. [8]

9. Evolution is the change in the heritable characteristics of a population.

(a) Describe the evidence for evolution from homologous structures. [4]

(b) Outline the conditions needed and the use of the Hardy–Weinberg equation to calculate allele frequencies in a population. [3]

(c) Explain how evolutionary relationships and cladograms can be used for classification. [8]

10. There is a relationship between form and function in the diversity of molecules and of systems.

(a) Describe the relationship between codons and polypeptide structure. [4]

(b) Outline the relationship between structure and function in photosystems. [3]

(c) Explain the causes of a decreased blood pH and its effects on the ventilation rate in humans. [8]

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References:

1. Images and graphs: Bridges, A.D., MaBouDi, H., Procenko, O., Lockwood, C., Mohammed, Y., Kowalewska, A., et al., 2023. *PLoS Biol* 21(3), e3002019. https://doi.org/10.1371/journal.pbio.3002019. Reference redacted. Source adapted.

2. NOAA Fisheries Plans Western Alaska Meetings on Ringed Seal “Critical Habitat”, 2015. *Pusa hispida hispida*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Pusa_hispida_hispida_NOAA_2.jpg [Accessed 13 March 2024]. Source adapted.

3. Bezanilla, F., 2005. Voltage-gated ion channels. *IEEE Transactions On Nanobioscience* 4(1). https://doi.org/10.1109/tnb.2004.842463. Source adapted. Reprinted with permission from IEEE.

4. tonaquatic, 2021. *Dicot plants stem show plant vascular tissue under light microscope view for botany education.* [image online] Available at: https://www.gettyimages.co.uk/detail/photo/dicot-plants-stem-show-plant-vascular-tissue-under-royalty-free-image/1326289492?phrase=xylem&adppopup=true [Accessed 5 April 2024]. Source adapted.

5. Data from Jennifer L. Hope, Linda M. Bradley, Lessons in antiviral immunity. *Science* 371, 464–465 (2021). DOI: 10.1126/science.abf6446.

6. WWF. 2013. *Ecosystems in the Greater Mekong: Past trends, current status, possible futures*.

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