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Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

9 November 2023

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

Candidate session number

2 hours 15 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 **[72 marks]**.

21 pages

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Section A

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

1. Mammalian tissues use circulating nutrients including glucose, amino acids and various intermediate metabolites for respiration. The concentration in the blood of glucose and other metabolites is regulated as a part of homeostasis. The concentration of a metabolite remains constant if it is absorbed from arterial blood and consumed by metabolism at the same rate as it is produced by metabolism and released into venous blood.

Circulatory turnover flux (F_{circ}) is the rate at which a metabolite in the blood is both consumed and produced, with the concentration in the blood remaining constant.

Circulatory turnover fluxes were measured in fasting mice that had not fed for 8 hours. The table shows data for metabolites that had the highest circulatory turnover fluxes. Alanine, glutamine and glycine are amino acids.

Metabolite	**Mean F_{circ} / nmol g^{-1} min^{-1}**	**Mean blood concentration / mmol L^{-1}**
Lactate	374.4	2.4
Glucose	150.9	9.0
Acetate	72.7	0.4
Alanine	70.2	0.2
Pyruvate	57.3	0.1
Glycerol	53.3	0.5
Glutamine	45.6	0.4
Palmitic acid	24.6	1.6
Glycine	21.9	0.1

[Source: adapted from Hui, S., Ghergurovich, J., Morscher, R. et al., 2017. *Nature* (551), pp. 115–118. https://doi.org/10.1038/nature24057.]

(a) Circulatory turnover flux values are shown per gram of mouse body mass. State **one** advantage of this. [1]

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(Question 1 continued)

(b) Identify the metabolite with the highest circulatory turnover flux and the amino acid with the highest blood concentration. [2]

Metabolite with the highest circulatory turnover flux: . . . . . .

Amino acid with the highest blood concentration: . . . . . .

(c) Deduce, giving a reason for your answer, which type of molecule is likely to remain in circulation for longest before being absorbed by a cell. [1]

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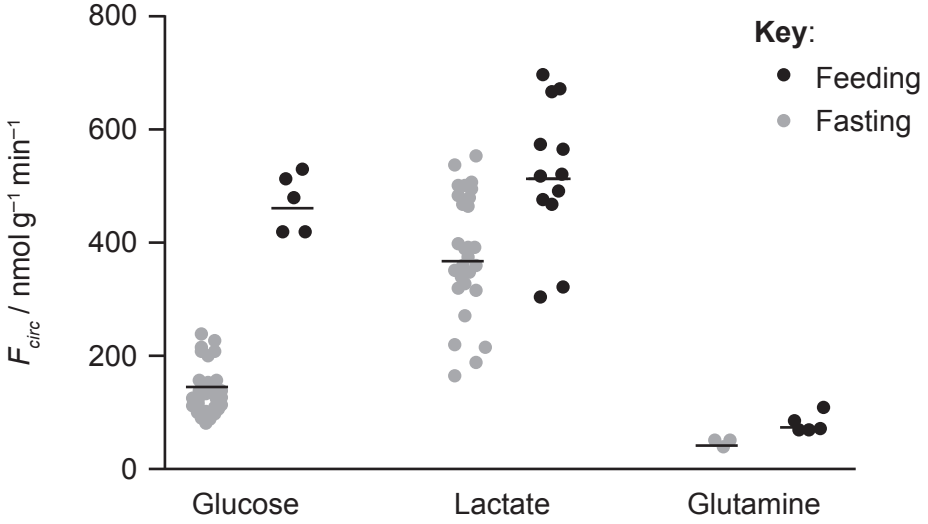
(This question continues on page 5)

Please **do not** write on this page.

Answers written on this page
will not be marked.

(Question 1 continued)

Circulatory turnover fluxes were also measured in mice that had been feeding instead of fasting. The graph shows the results for glucose, lactate and glutamine in both fasting and feeding mice. Mean results are indicated by horizontal lines on the graph and the circulatory turnover flux for each mouse by an individual data point.



[Source: adapted from Hui, S., Ghergurovich, J., Morscher, R. et al., 2017. *Nature* (551), pp. 115–118. https://doi.org/10.1038/nature24057.]

(d) Outline the changes to circulatory turnover fluxes that would occur in a fasting mouse that started feeding. [2]

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(e) Using your understanding of insulin secretion, explain the change in glucose circulatory turnover flux between feeding and fasting mice. [3]

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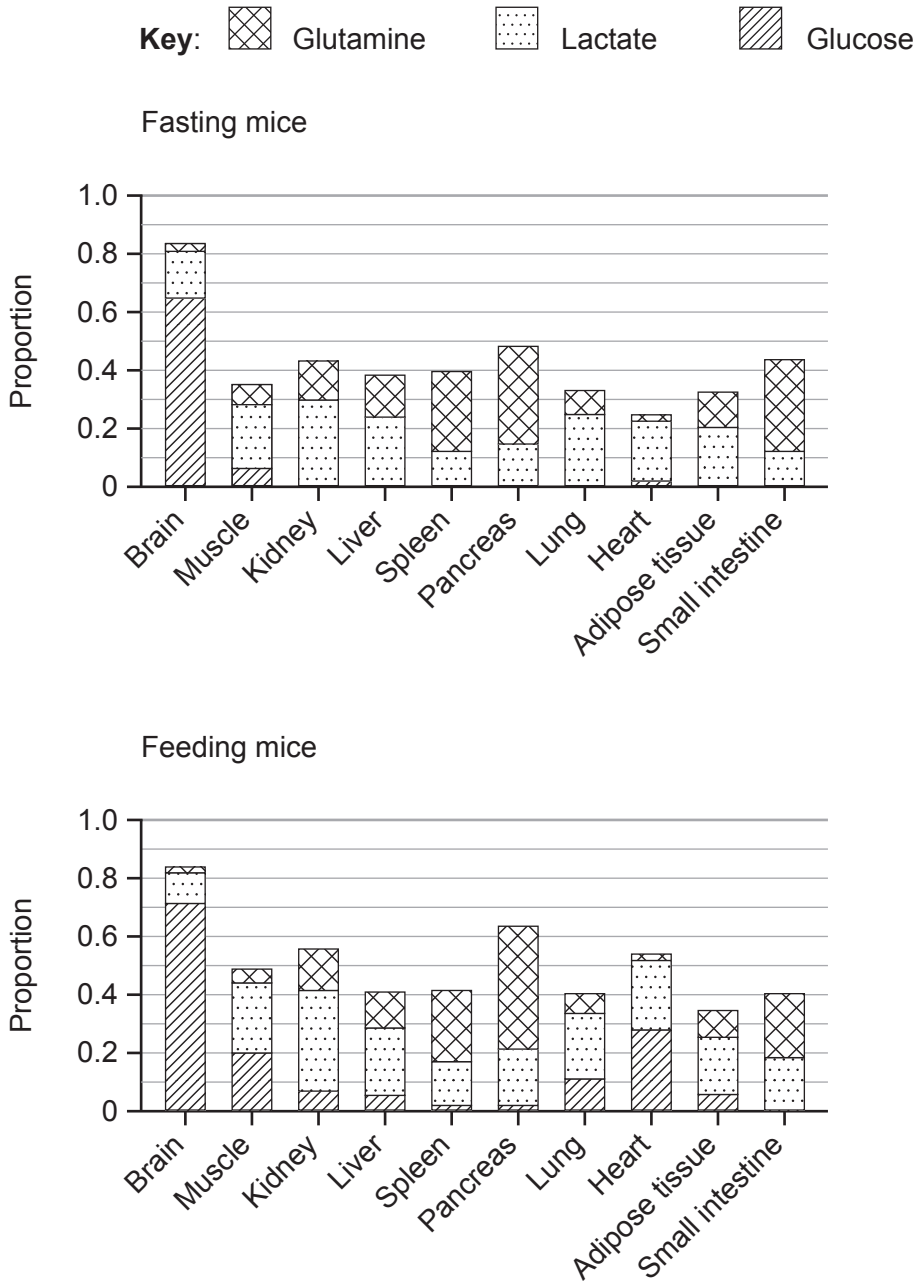
(Question 1 continued)

Groups of fasting and feeding mice were infused with radioactively labelled lactate, glucose or glutamine. Radioactive labelling of Krebs cycle intermediates (such as malate and succinate) was then monitored, to determine the relative quantities of the three metabolites that were being absorbed from blood and used in the Krebs cycle.

The bar charts show the contribution of each metabolite to carbon entering the Krebs cycle as a proportion of the total, in different parts of the body.



[Source: adapted from Hui, S., Ghergurovich, J., Morscher, R. et al., 2017. *Nature* (551), pp. 115–118. https://doi.org/10.1038/nature24057.]

(This question continues on the following page)

(Question 1 continued)

(f) Identify the organ that metabolizes the most lactate in both feeding and fasting mice. [1]

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(g) The brain is unlike other organs in its use of metabolites for the Krebs cycle. Distinguish between the data for the brain and all the other organs and tissues. [2]

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(h) Using any of the data in question 1, evaluate the hypothesis that the main metabolite absorbed by cells and used in respiration is glucose. [3]

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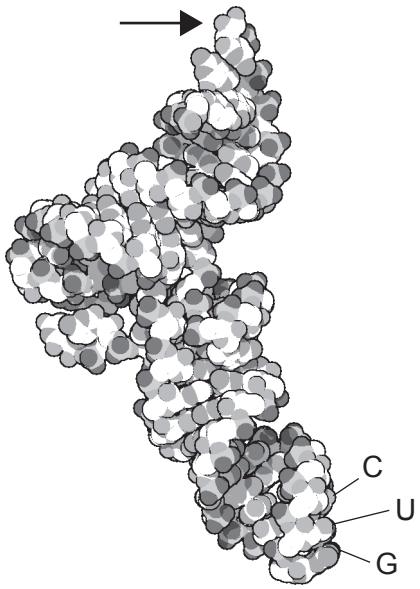
2. The structure of a transfer RNA (tRNA) molecule is shown in the diagram. The attached amino acid, which is aspartic acid, is indicated by the arrow.



(a) Deduce the function of bases CUG. [1]

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(b) Explain how living organisms ensure that the amino acid linked to this tRNA molecule is always aspartic acid. [2]

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(Question 2 continued)

(c) During translation, three binding sites for tRNA molecules are used. Outline how each of these binding sites is used. [3]

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3. This redwood tree (*Sequoia sempervirens*) was blown over in 1936, but five side branches formed new roots and are now separate trees.

(a) State the molecule that trees such as redwoods use as genetic material. [1]

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(b) If the genomes of the five new trees were sequenced, predict with a reason how similar they would be to each other. [2]

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(Question 3 continued)

(c) Outline **one** method that has been used successfully to clone an adult animal. [3]

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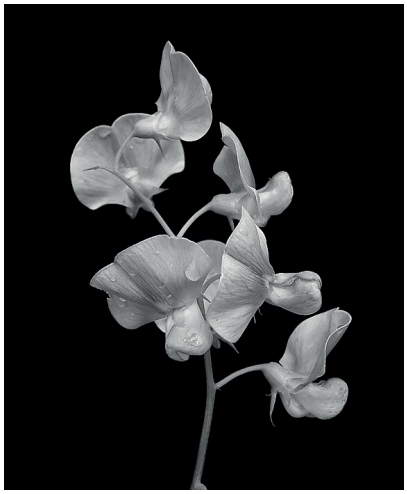
4. Bateson and Punnett carried out a series of genetic crosses using varieties of sweet pea (*Lathyrus odoratus*).



They crossed two varieties that both had white flowers and discovered that the F_1 generation all had purple flowers.

When the F_1 plants were self-fertilized, there was a 9:7 ratio of purple to white in the F_2 generation. Bateson and Punnett deduced that the genotypes of the two white parental varieties were CCrr and ccRR.

(a) State the genotype of the F_1 hybrids. [1]

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(b) Explain how the pattern of inheritance results in the 9:7 ratio in the F_2 generation. [3]

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(c) Predict the outcome of crossing plants with the genotypes Ccrr and ccRr. [1]

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5. Plants have cell walls composed of cellulose.

(a) Describe the structure of cellulose molecules. [3]

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(b) Hydrostatic pressure was measured in onion (*Allium cepa*) epidermis cells bathed in pure water. The mean pressure inside the cells was 250 kPa. Atmospheric pressure is usually close to 100 kPa.

(i) Outline how pressures higher than atmospheric pressure develop inside plant cells. [2]

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(ii) State the importance of cellulose to the plant when the pressure is higher inside the cell than outside. [1]

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(c) When a plant cell grows, the cell wall must expand. Explain the role of auxin in cell wall expansion. [2]

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Section B

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

6. Excretion is one of the functions of life.

(a) Outline how carbon dioxide carried to the lungs in the pulmonary artery is moved to the air outside the body. [7]

(b) Explain how the kidney produces urine with a higher concentration of urea than blood plasma. [5]

(c) Compare and contrast excretion in humans and unicellular organisms such as *Paramecium*. [3]

7. In ecological communities, there are many different relationships between populations.

(a) Describe how populations in communities rely on each other for supplies of energy. [7]

(b) Explain how plant cells originated by endosymbiosis. [5]

(c) Analyse the relationship between plants and their pollinators. [3]

8. Species are groups of organisms that can potentially interbreed to produce fertile offspring.

(a) Outline how new traits in a species can develop over time. [7]

(b) Explain how a new species can be formed abruptly by polyploidy. [5]

(c) Suggest advantages of the system for naming species that scientists use. [3]

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References:

1.(a), (d), (f) Adapted from Hui, S., Ghergurovich, J., Morscher, R. et al., 2017. *Nature* (551), pp. 115–118. https://doi.org/10.1038/nature24057.

2. U.S. Government. https://commons.wikimedia.org/wiki/File:Two-trna-figure.gif. Licensed under Public Domain: https://en.wikipedia.org/wiki/Public_domain.

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