

C1.2 Cell respiration [104 marks]

1. [Maximum mark: 1]

What distinguishes aerobic respiration from anaerobic respiration in humans?

A. Mitochondria are only used in anaerobic respiration.

B. Aerobic respiration yields lower quantities of ATP.

C. Only aerobic respiration can use glucose as a starting substrate.

D. Only aerobic respiration produces carbon dioxide.

[1]

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2. [Maximum mark: 15]

Various mechanisms can lead to inhibition in biological systems. A toxin is a substance capable of disrupting metabolic processes in organisms.

(a) Describe how toxins such as DDT might concentrate in the bodies of birds.

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(b) Toxins often act as inhibitors. Compare and contrast competitive and non-competitive enzyme inhibition.

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(c) Rotenone is a naturally occurring toxin that blocks the electron transport chain in insects and fish. Outline the consequences of exposure to a toxin like rotenone for cell respiration.

[4]

3. [Maximum mark: 1]
What occurs during the stages of respiration?

[1]

4. [Maximum mark: 1]

What are the product(s) and site of anaerobic respiration in human cells?

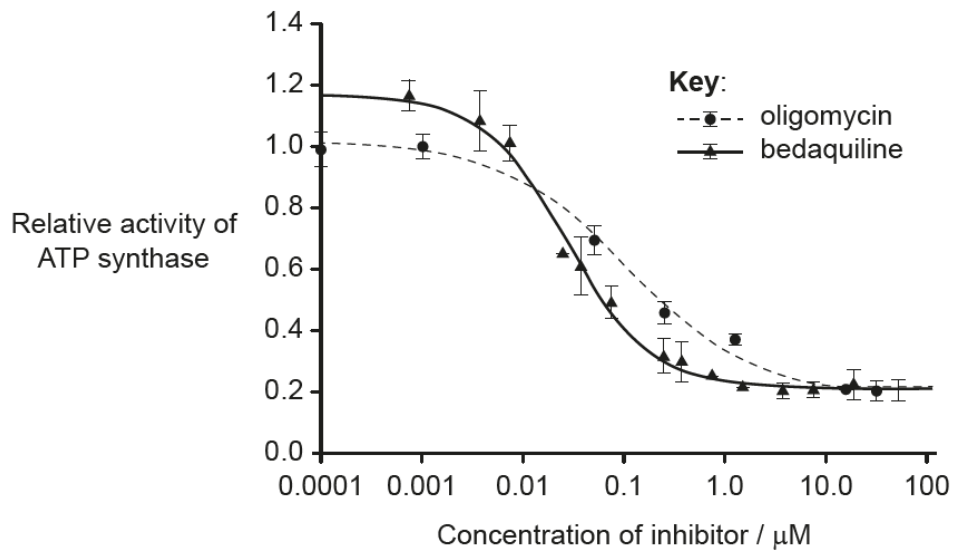
	Product	Site of anaerobic respiration
A.	lactate	mitochondria
B.	carbon dioxide + water	mitochondria
C.	lactate	cytoplasm
D.	carbon dioxide + water	cytoplasm

[1]

5. [Maximum mark: 9]

Some antibiotics are inhibitors of the enzyme ATP synthase in bacteria.

Scientists investigated the effect of varying the concentration of two antibiotics, bedaquiline and oligomycin, on the relative activity of ATP synthase.



[Source: Luo, M., Zhou, W., Patel, H. et al. Bedaquiline inhibits the yeast and human mitochondrial ATP synthases. *Commun Biol* 3, 452 (2020). <https://doi.org/10.1038/s42003-020-01173-z>. <https://creativecommons.org/licenses/by/4.0/>. Source adapted.]

(a) In this investigation, there were two independent variables and many controlled variables.

(a.i) Identify **both** independent variables in this investigation.

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[1]

(a.ii) Outline how temperature could be kept constant in this investigation.

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(a.iii) Explain the reasons for keeping the enzyme concentration constant.

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(b.i) State the type of scale shown on the horizontal axis of the graph.

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(b.ii) Explain the benefit of using this type of scale for the data obtained in this investigation.

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(c) Describe how the reliability of the results obtained in this investigation is indicated on the graph. [1]

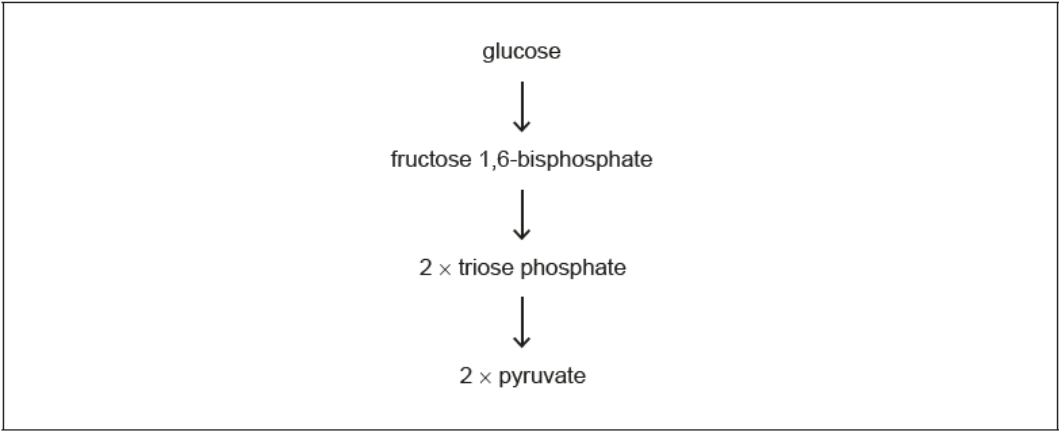
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(d) State the precise location of ATP synthase in mitochondria. [1]

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6. [Maximum mark: 5]

Glucose is converted to pyruvate during the glycolysis stage of respiration.



(a) On the diagram, label

(a.i) with P where phosphorylation occurs; [1]

(a.ii) with O where oxidation occurs. [1]

(b) State where in the cell glycolysis takes place. [1]

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(c) Outline how NAD is made available for glycolysis during anaerobic respiration in animal cells. [2]

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7. [Maximum mark: 15]

All cells require a supply of energy and can transform the energy that they obtain in different ways.

(a) Explain the properties of ATP that make it useful for distributing energy within cells. [3]

(b) Describe how cells in plants use light energy to produce ATP. [7]

(c) Compare and contrast how different types of heterotrophs obtain the energy that they need to produce ATP. [5]

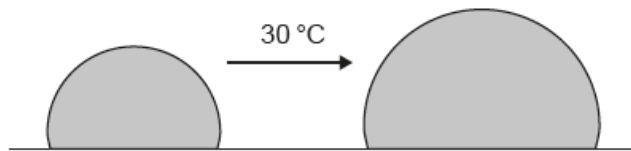
8. [Maximum mark: 15]

All living organisms require energy to survive.

- (a) Outline **three** characteristics of polysaccharides that make them efficient compounds to store energy in organisms. [3]
- (b) Describe how energy passes through a food chain. [4]
- (c) Explain the need for energy in cells and how energy is released through cell respiration. [8]

9. [Maximum mark: 1]

Bread dough is made by mixing flour, water and yeast. If the dough is then kept at about 30 °C, it expands.



What is the main reason for choosing this temperature?

- A. Carbon dioxide expands at this temperature.
- B. This is the optimum temperature for the enzymes used in aerobic cell respiration.
- C. Lactate produced by anaerobic cell respiration causes the release of carbon dioxide at this temperature.
- D. At this temperature, yeast produces carbon dioxide rapidly by anaerobic cell respiration. [1]

10. [Maximum mark: 1]

The diagram shows a reaction that occurs during aerobic cell respiration.

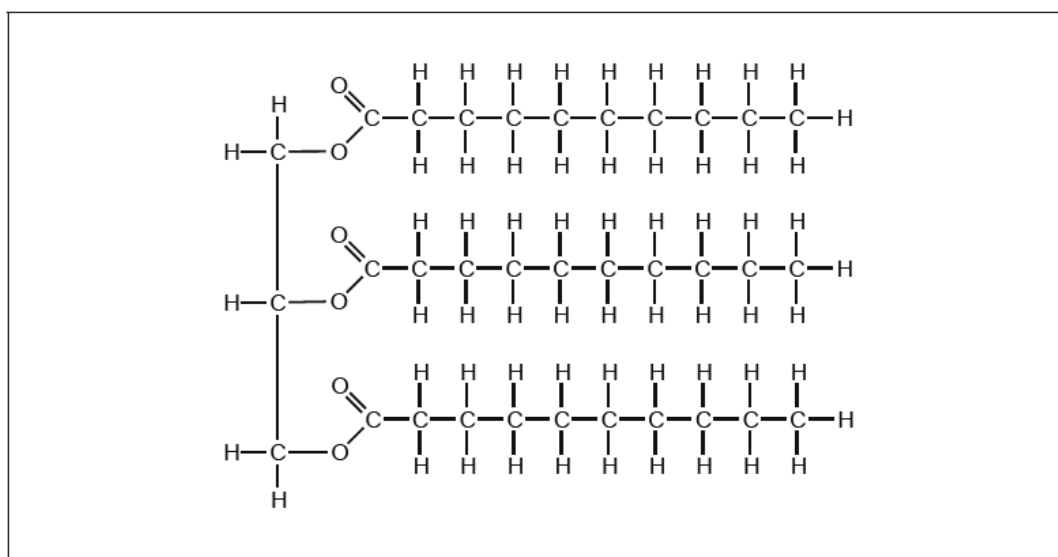


Which type of chemical change happens to malic acid?

- A. Carboxylation
- B. Decarboxylation
- C. Oxidation
- D. Reduction

[1]

- 11.** [Maximum mark: 7]
A triglyceride is shown.



- (a) State the **two** types of molecules that combine to make a triglyceride. [1]

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- (b) Annotate the diagram, using an arrow to show where a condensation bond has formed during formation of the triglyceride. [1]

- (c) Triglycerides can be used in respiration when a process called beta oxidation produces acetyl coenzyme A. State the stage of respiration in which acetyl coenzyme A is used. [1]

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- (d) Explain the reason that more energy is released from one gram of triglyceride than from one gram of glucose in respiration. [2]

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- (e) Suggest possible health risks associated with the type of triglyceride shown in the diagram in the diet. [2]

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12. [Maximum mark: 1]

What applies to chemiosmosis?

- A. It takes place in both cristae and thylakoid membranes.
- B. It involves the movement of water across a semipermeable membrane.
- C. It only takes place in the presence of sunlight and oxygen gas.
- D. It uses ATP to pump hydrogen ions against the concentration gradient.

[1]

13. [Maximum mark: 1]

Which molecules are reactants and products during glycolysis?

	Reactants	Products
A.	pyruvate and ATP	acetyl coenzyme A, carbon dioxide and NAD
B.	glucose and oxygen	pyruvate, carbon dioxide and ATP
C.	glucose and ATP	pyruvate, reduced NAD and ATP
D.	pyruvate and oxygen	ATP and reduced NAD

[1]

14. [Maximum mark: 15]

Carbon dioxide and oxygen are essential gases in many biological processes.

- (a) Outline anaerobic cell respiration.
- (b) Describe conditions necessary in the lungs for efficient gas exchange in humans.

[4]

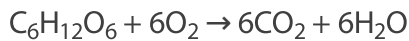
[3]

- (c) With reference to Calvin's experiment, explain the fixation of carbon dioxide in photosynthesis.

[8]

15. [Maximum mark: 1]

Aerobic cell respiration using glucose can be summarized with an equation.



At what stage(s) is carbon dioxide produced?

	Glycolysis	Link reaction and Krebs cycle	Electron transport chain
A.		✓	
B.	✓		✓
C.		✓	✓
D.	✓	✓	

[1]

16. [Maximum mark: 15]

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} / $\text{nmol g}^{-1} \text{min}^{-1}$	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.

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

Metabolite with the highest circulatory turnover flux:

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Amino acid with the highest blood concentration:

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[2]

- (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.

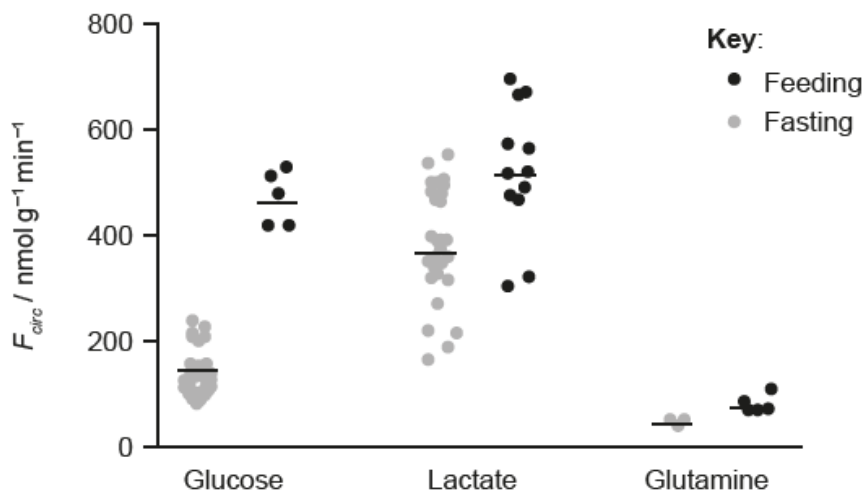
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Circulatory turnover fluxes were also measured in mice that had been feeding instead of fasting. The graph shows the results for glucose, lactate and glutamine in both fasting and feeding mice. Mean results are indicated by horizontal lines on the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

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

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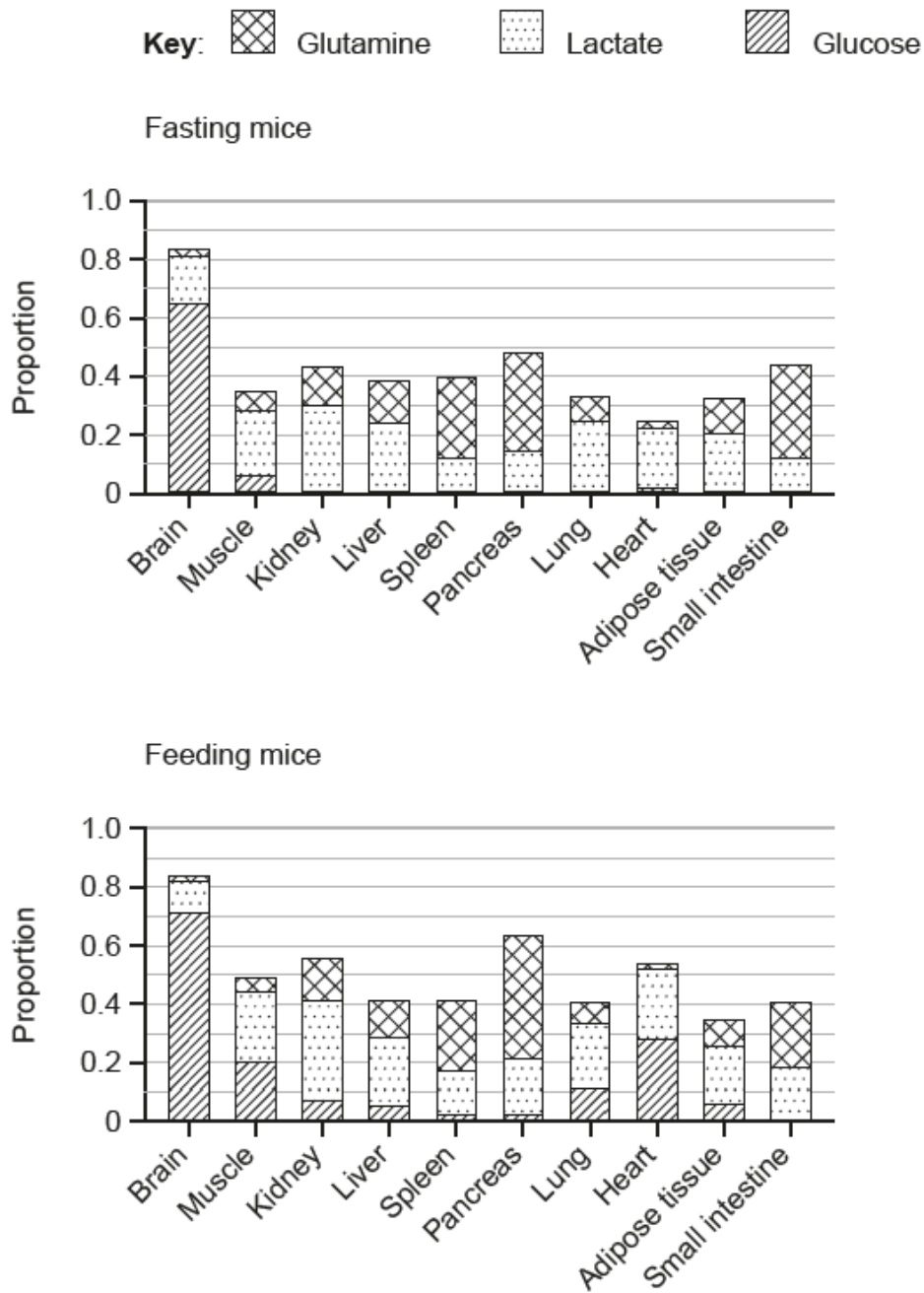
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Groups of fasting and feeding mice were infused with radioactively labelled lactate, glucose or glutamine. Radioactive labelling of Krebs cycle intermediates (such as malate and succinate) was then monitored, to determine the relative quantities of 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>]

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

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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.

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

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