

Biology Higher level Paper 3

13 May 2024

Zone A afternoon | Zone B afternoon | Zone C afternoon

С	andida	ate ses	sion r	umbe	er

1 hour 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is [45 marks].

Section A	Questions
Answer all questions.	1 – 3

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 14
Option C — Ecology and conservation	15 – 19
Option D — Human physiology	20 – 24





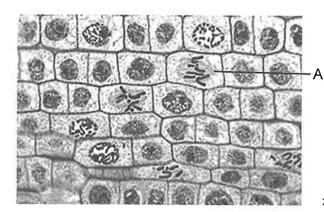




Section A

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

1. (a) The photomicrograph shows a section of onion (Allium cepa) root tip cells.



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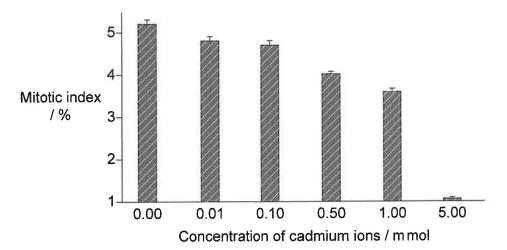




(Question 1 continued)

Cadmium is a heavy metal that can cause environmental problems. Cadmium ions are released from various human activities such as the release of sewage sludge, mining and industrial processes. Plants take up cadmium ions and they enter food chains.

A study was carried out to look at the effect of various concentrations of cadmium ions on the mitotic index of the apical meristem of root cells from 4-day-old wheat (*Triticum aestivum*) seedlings.



(b) (i) State the effect of cadmium ion concentration on the mitotic index of root cells from wheat seedlings.

[1]

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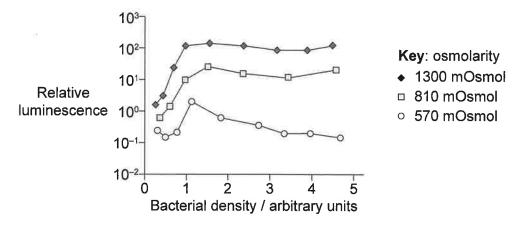
(ii)	Suggest the effect the change in mitotic index would have on the wheat plant.	[1
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Turn over

Vibrio fischeri is a bioluminescent (light-producing) bacterium in the Pacific Ocean. V. fischeri grown in the laboratory often has less luminescence. An investigation was carried out to look at the effect of the external osmolarity (in mOsmol) on the bacterium's luminescence, at different densities of bacteria. V. fischeri cultures were grown in three different concentrations of artificial seawater. Relative luminescence is the total luminescence divided by the density of bacteria.



(a)	Define osmolarity.	[1]
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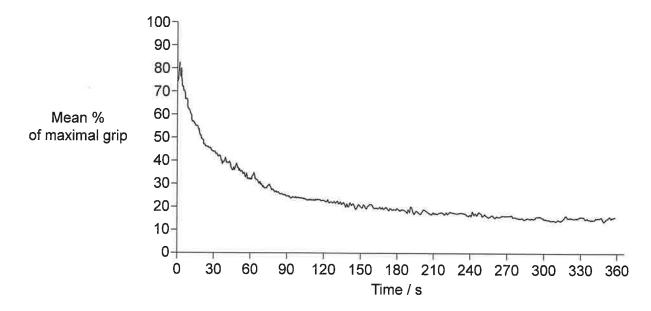
(Question 2 continued)

(c)	Student osmosis experiments often involve putting plant tissue such as potato cylinders in several salt solutions of different concentrations and measuring the mass before and after immersion. Outline how data collected from such an experiment could be used to estimate the osmolarity of the plant tissues.	[2]
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3. (a) A study using 14 people was carried out to examine how much force they could sustain over 6 minutes. The participants were asked to hold a hand grip sensor with as much force as possible throughout this time period. Hand grip strength was measured using the hand grip sensor and related software.



(i)
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(ii)	Suggest a reason for the shape of the graph.	[1
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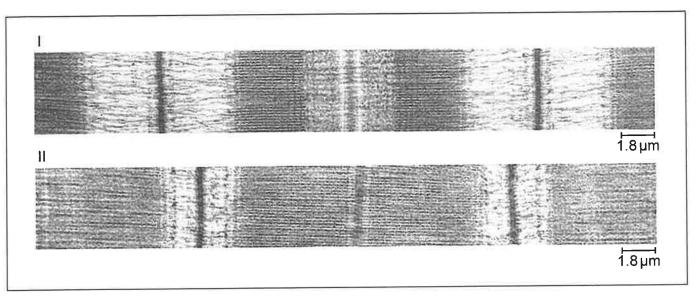
(This question continues on the following page)





(Question 3 continued)

(b) The electron micrographs show sections of muscle fibre in two different states.



/i)	Label a sarcomere on electron micrograph I.	[1]
(I)	Label a salconiere on electron micrograph i	L'i

(ii) Deduce what events occur in muscle fibres to change them from the state shown in electron micrograph I to the state shown in electron micrograph II. [2]

in electron micrograph I to the state shown in electron micrograph II.	_[_





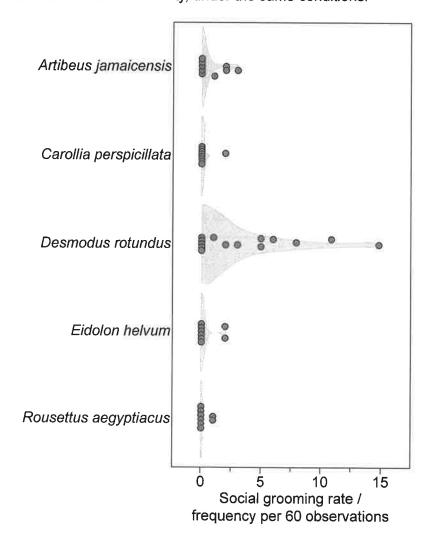
Turn over

Section B

Answer **all** of the questions from **one** of the options. Answers must be written within the answer boxes provided.

Option A — Neurobiology and behaviour

4. A study was carried out to compare social grooming rates in a species of vampire bat, Desmodus rotundus, with four species of non-vampire bats. Social grooming is a behaviour pattern seen in animals that live in groups, where members of the group clean each other's coats. The bats were kept in single-species groups. The groups were kept apart from each other but were housed in the same facility, under the same conditions.







(Option A, question 4 continued)

(a)	Compare and contrast the social grooming behaviour between the five species.	[2]
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(b)	Suggest how social grooming might be related to altruistic behaviour shown by vampire bats.	[3]
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Healthy controls and stroke survivors performed a basic shoulder/elbow reach while being scanned by fMRI.

-	Control	Stroke best motor function	Stroke worst motor function
Left Lateral premotor area			Right
Supplementary motor area			
		x	





(Option A, question 5 continued)

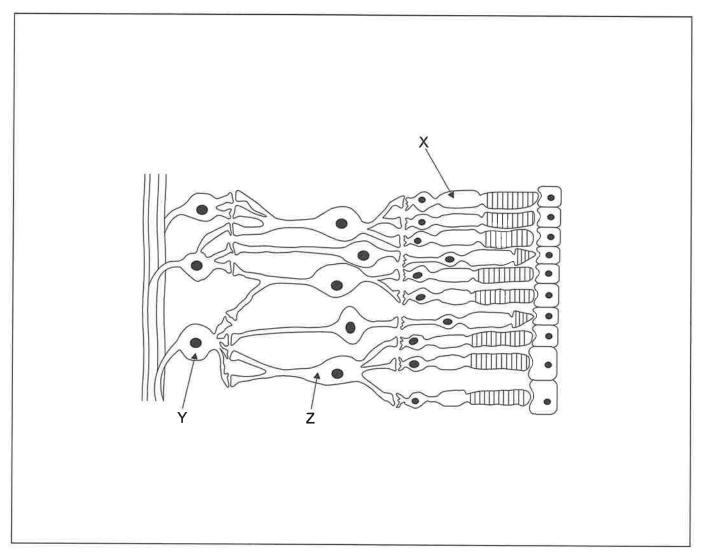
	Compare and contrast the scan results for the healthy controls with the scans for the stroke survivors.	
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(c)	Outline a characteristic of the nervous system that would help a stroke survivor recover.	
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(d)	Identify the name and function of X indicated in the image.	





Turn over

6. (a) The diagram shows a section through the retina.



- (i) Annotate the diagram to indicate the **functions** of the structures labelled X, Y, Z. [3]
- (ii) Draw an arrow to indicate the direction of light. [1]
- (b) Outline how red-green colour blindness differs from normal trichromatic vision. [2]

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(a)	Distinguish between innate behaviour and learned behaviour.	
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(b)	Discuss conditioning as a form of learning.	
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(Option A continues on page 15)





Turn over

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Answers written on this page will not be marked.





8.	Discuss how drugs can affect the release and reception of chemical messengers at synapses.	[6]
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End of Option A





Option B — Biotechnology and bioinformatics

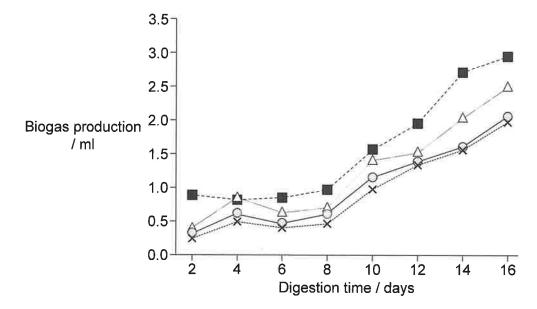
9. Biogas production has been increasing in most parts of the world.

(a) State	one	benefit	of	usina	biogas.
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[1]

[2]

(b) An experiment was conducted to look at the effect on biogas production of mixing cow dung (feces) with other substrates. Two-litre bottles were used as digesters for anaerobic fermentation. Different combinations of waste were used with 50 % waste and 50 % water in each bottle. The pH was maintained between 6.3 and 6.7 and the temperature at 35°C. Biogas production was measured daily for 16 days.



Key: --**■**- Cow dung --△- Cow dung and grass

Cow dung and fruit wasteCow dung and vegetable waste

(i) Compare and contrast gas production from the different combinations of waste.





(Option B, question 9 continued)

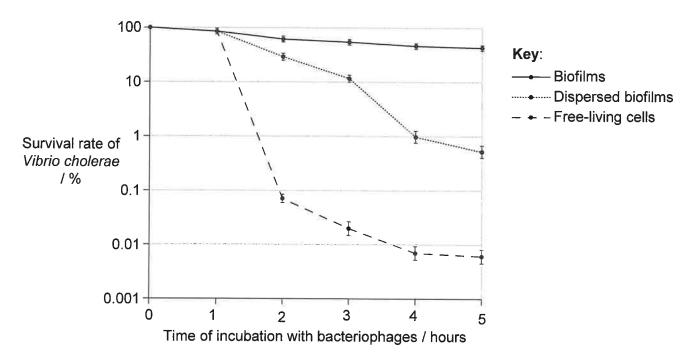
 (ii)	Determine with a reason whether this was an example of batch or continuous fermentation.	[1]
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(c) Ou	tline how pathway engineering is used in industrial fermentation.	[2]
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Turn over

10. The bacterium *Vibrio cholerae* is found in aquatic ecosystems mostly in a biofilm-associated state. However, these cells can naturally become the active, free-living form through various mechanisms. They then multiply and can cause epidemics of cholera. An investigation was conducted to study the possible effects of environmental bacteriophages on the survival of *V. cholerae* in three states: in biofilms, in dispersed biofilms (shaken to break them up) and as active free-living forms.



(a)	Identify in which state V. cholerae is most susceptible to bacteriophages.	[1]
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(b) Suggest how properties of biofilms could account for the survival rate shown in the graph. [3]





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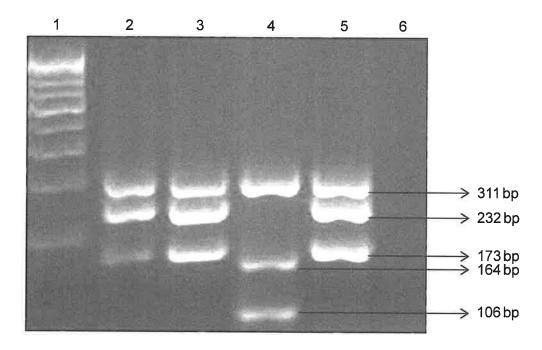


Turn over

12. Rapid, low cost detection and identification of influenza virus types and subtypes would be very useful in controlling infections and preventing transmission. A study was conducted to assess the use of reverse transcriptase PCR assays to detect multiple types of influenza A viruses.

Molecular size marker / number of base pairs	Influenza type / subtype
106	A / N1 subtype
164	A / H1 subtype
173	A / N2 subtype
232	A / H3 subtype
311	A / all subtypes

Gel electrophoresis was carried out on the PCR products of different viral samples (lanes 2–6). Lane 1 contains DNA fragments of known size to act as size markers.







(Option B, question 12 continued)

(a)	Suggest the reason that reverse transcriptase PCR was used instead of normal PCR.	[2]
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(b)	State what is used to visualize the bands on the gel electrophoresis.	[1]
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(c)	Distinguish between the virus types shown by lanes 3 and 4.	[2]
(c)	Distinguish between the virus types shown by lanes 3 and 4.	[2]
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Turn over

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14.	Discuss the risks and benefits associated with the introduction of genes for resistance to herbicides, such as glyphosate, into crops.	[6]
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End of Option B





Option C — Ecology and conservation

15. The Corsican nuthatch (*Sitta whiteheadi*) lives only on the island of Corsica in Corsican pine (*Pinus nigra laricio*) forests and groves of Maritime pine (*Pinus pinaster*).

Corsican nuthatch (S. whiteheadi)



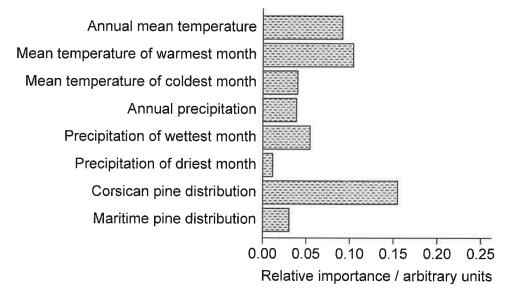
Corsican pine (P. nigra laricio)



Maritime pine (P. pinaster)



A study looked at the relative importance of a range of factors affecting the distribution of the Corsican nuthatch. The relative importance of each factor was derived from how strongly the factor and the distribution of the nuthatch were correlated.







(a)	(i)	Identify which variable is of greatest importance to the Corsican nuthatch.
	(ii)	Suggest one reason for the importance of the variable identified in (a)(i) for the Corsican nuthatch.
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(b)	The	Corsican pine (P. nigra laricio) has suffered large distribution losses due to
(b)	hum likel	Corsican pine (<i>P. nigra laricio</i>) has suffered large distribution losses due to nan activity, intensively managed forests and wildfires. Thus, its realized niche is y to be different from its fundamental niche. Distinguish between realized and damental niches.
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(b)	hum likel	nan activity, intensively managed forests and wildfires. Thus, its realized niche is y to be different from its fundamental niche. Distinguish between realized and
(b)	hum likel	nan activity, intensively managed forests and wildfires. Thus, its realized niche is y to be different from its fundamental niche. Distinguish between realized and
(b)	hum likel	nan activity, intensively managed forests and wildfires. Thus, its realized niche is y to be different from its fundamental niche. Distinguish between realized and
(b)	hum likel	nan activity, intensively managed forests and wildfires. Thus, its realized niche is y to be different from its fundamental niche. Distinguish between realized and damental niches.
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(Option C, question 15 continued)

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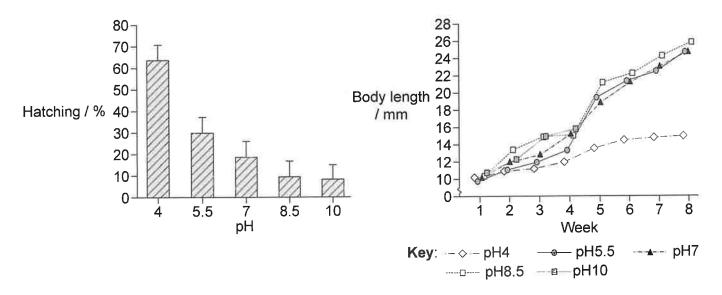
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(Option C, question 16 continued)

Cane toads in their native range in Venezuela breed in clear water with a pH only slightly higher than neutral (pH 7.1–7.6). Fieldwork in northeastern New South Wales, Australia, showed that natural water bodies varied in pH from pH4 to pH10. Laboratory investigations were conducted to look at the effect of this range of pH on the hatching and body length of cane toads.



(b) Using the information provided, discuss whether pH of water bodies is likely to limit the distribution of cane toads in Australia. [3]

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(Option C continues on page 29)





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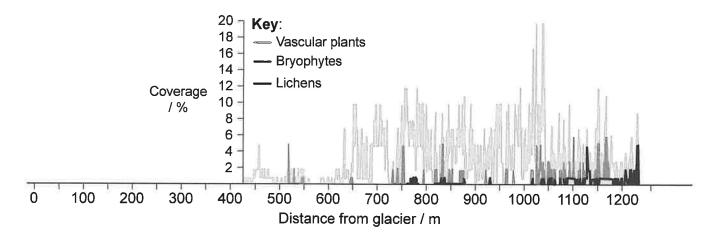
17.	(a)	Define indicator species.	[1]

	(b)	Explain the use of a biotic index.	[3]
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	(c)	Outline the effect of DDT on the environment.	[2]
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18. An investigation was undertaken in Gåsbreen, Norway, in a freshly de-glaciated area to look at the organisms present at different times since the retreating glacier had exposed the land. A linear transect and 1 m² quadrat were used starting at the edge of the retreating glacier. The first producers were recorded at a distance of 426 m from the glacier.



(a)	Outline how a transect and quadrats can be used in ecological fieldwork.	[2]
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(b)	Identify which group of organisms had the highest percentage coverage of the area studied.	[1
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(Option C, question 18 continued)

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Turn over

19.	Discuss the risks and benefits associated with the use of phosphate fertilizers in agriculture.	[6]
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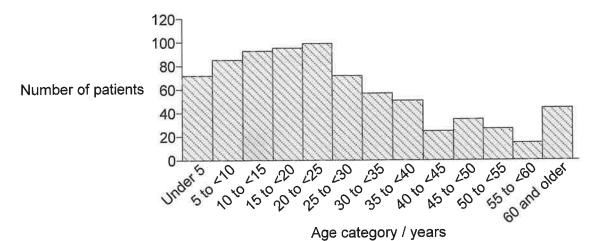
End of Option C





Option D — Human physiology

20. In 2012, Sierra Leone suffered a nationwide cholera epidemic. The graph shows the number of people admitted to cholera wards during a two-month period.



- (a) State the main symptom of cholera that would have resulted in admission to hospital. [1]
- (b) Suggest one reason for the age distribution of patients admitted to cholera wards. [1]
- (c) Outline the processes that occur in the large intestine of a healthy person. [2]



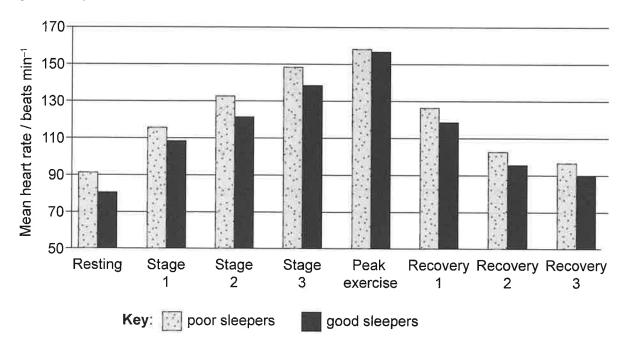


Turn over

[2]

(Option D continued)

21. A study was conducted using 113 healthy individuals to look at the effect of sleep quality on heart rate during exercise. All participants performed a treadmill stress test. Speed and incline of the treadmill increased during the first three stages until peak exercise was reached. This was followed by a recovery period as speed and incline decreased. Sleep quality of participants was assessed using the Pittsburgh Sleep Quality Index (PSQI) questionnaire; 48 subjects were categorized as "poor sleepers" and the rest were grouped as "good sleepers".



(a) Compare and contrast the effect of sleep on heart rate during the various stages of the treadmill stress test.

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(Option D, question 21 continued)

(b) Out	tline the reasons for the heart sounds heard during a heartbeat.	
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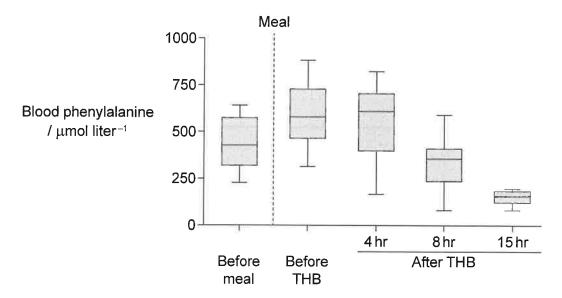
22.	(a)	Outline the	cause of	phenylketonuria	(PKU)
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[2]

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Because of disadvantages with current treatments for PKU, researchers have attempted to develop new treatments. One investigation looked into the effect of tetrahydrobiopterin (THB) given to children with mild phenylketonuria one hour after a meal rich in protein. Blood phenylalanine levels were measured before the meal, after the meal but before THB was given, and at certain intervals after THB was given.







(Option D, question 22 continued)

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23.	(a)	Distinguish between steroid and peptide hormones.	[2]
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	(b)	Explain the role of hormonal mechanisms in the control of gastric juice secretion.	[3]
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	(c)	Outline the role of hormones in the control of milk secretion.	[3]
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24.	Explain the role of red blood cells in the transport of respiratory gases.	[6]
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End of Option D





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