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Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Friday 07 June 2024

Morning (Time: 1 hour 45 minutes)

Paper reference **WBI15/01**

Biology

International Advanced Level
UNIT 5: Respiration, Internal Environment, Coordination and Gene Technology

You must have:
Scientific article (enclosed), scientific calculator, ruler, HB pencil

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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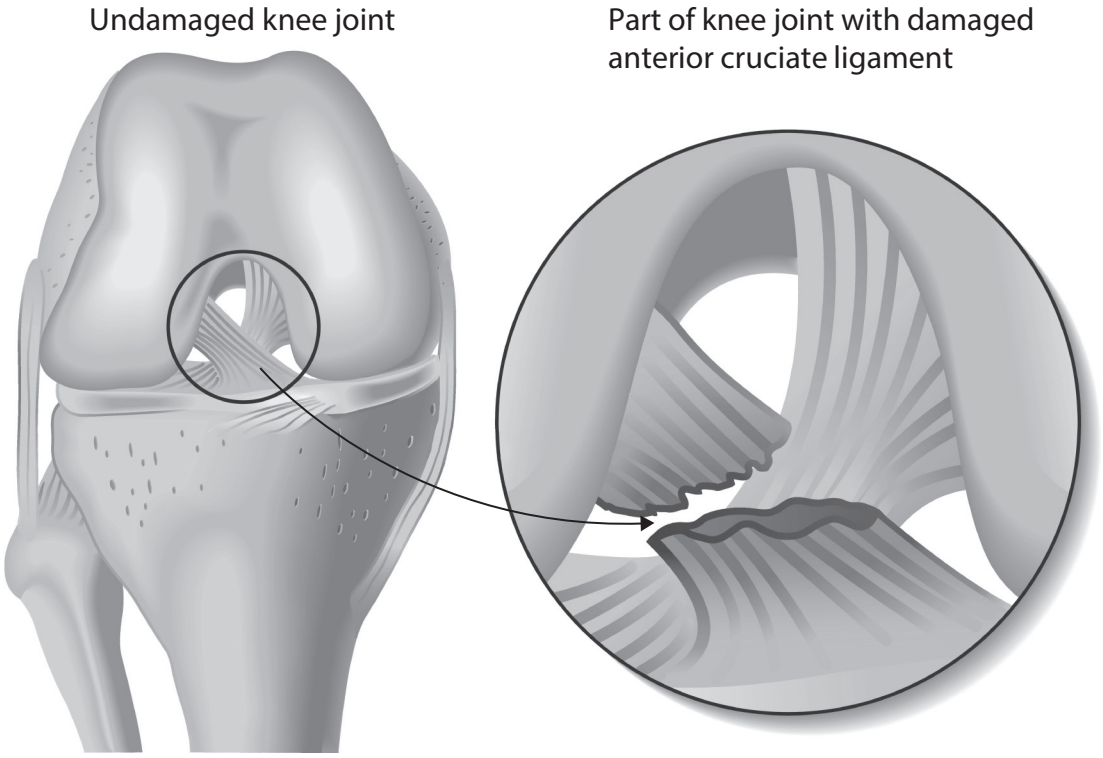
Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Muscles, tendons and ligaments interact to enable movement.

(a) The diagram shows an undamaged knee joint and part of a knee joint with a damaged anterior cruciate ligament.



(Source: © rob3000/Alamy Stock Vector)

(i) Which structure would the anterior cruciate ligament be attached to?

(1)

☒ A bone

☒ **B** cartilage

☒ **C** muscle

☒ **D** tendon

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(ii) Damage to anterior cruciate ligaments can be detected using magnetic resonance imaging (MRI).

Describe how MRI can show damage to the anterior cruciate ligament.

(2)

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(iii) In one country, there were 77 anterior cruciate ligament repairs for every 100 000 males in one year.

The population of this country in that year was 67 000 000 and 56% of the population were female.

Calculate the number of anterior cruciate ligament repairs in males that year.

(2)

Answer .....

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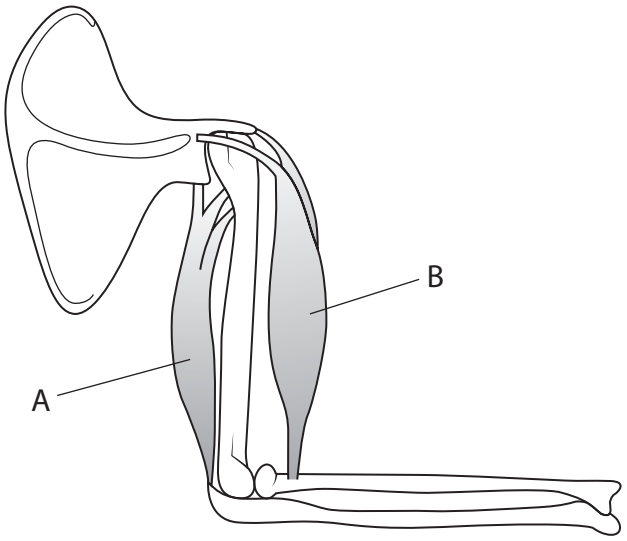
(b) The diagram shows some muscles in an arm.



(i) Name the **two** types of skeletal muscle that are contracted when the arm is held in this position.

(1)

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(ii) Describe how the arm could be straightened by the muscles labelled A and B.

(2)

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(Total for Question 1 = 8 marks)

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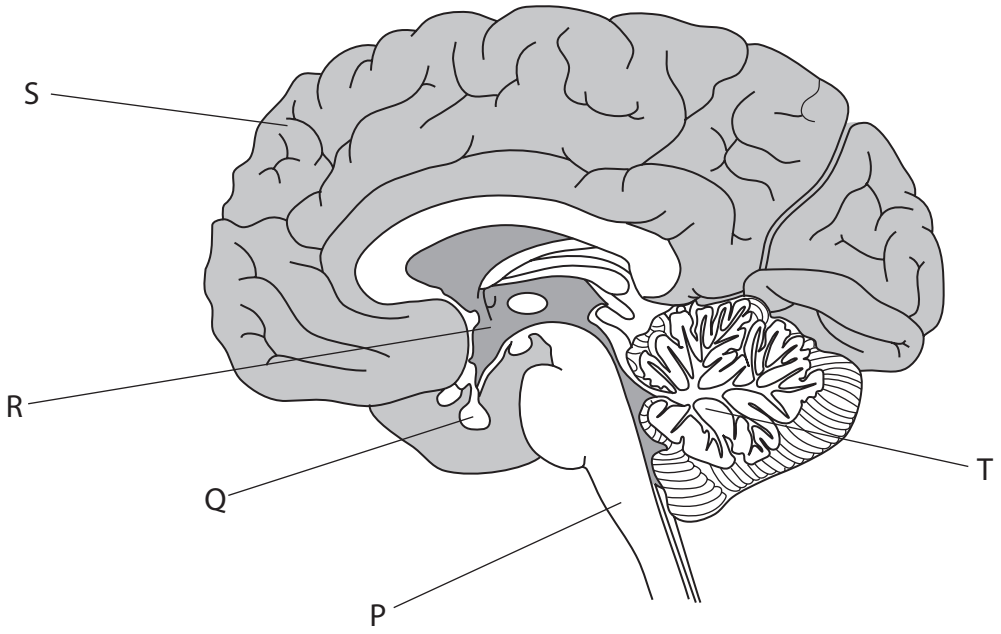
2 The human brain controls many functions.

(a) The diagram shows a section through the human brain.



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(i) Which labelled part of the brain contains the cardiovascular control centre?

(1)

- ☒ A P
- ☒ **B** Q
- ☒ **C** R
- ☒ **D** S

(ii) Which labelled part of the brain would control balance and coordinate movement?

(1)

- ☒ A P
- ☒ **B** Q
- ☒ **C** R
- ☒ **D** T

(iii) Which labelled parts would be involved in controlling the solute concentration of blood plasma?

(1)

- ☒ A P and Q
- ☒ **B** Q and R
- ☒ **C** P and R
- ☒ **D** S and T

(b) Dopamine and serotonin are chemicals produced in the brain that are essential for good health.

(i) Which of the following statements about dopamine is correct?

(1)

- ☒ A dopamine can pass from the bloodstream into neurones in the brain
- ☒ **B** dopamine is a neurotransmitter
- ☒ **C** high levels of dopamine are linked to depression
- ☒ **D** low levels of dopamine cause the breakdown of myelin

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(ii) Drugs called selective serotonin re-uptake inhibitors (SSRIs) affect the reabsorption of serotonin at synapses in the brain.

This may help to reduce depression.

Explain why SSRIs can be used to treat depression.

(3)

(Total for Question 2 = 7 marks)

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3 Animals and plants respond to changes in their environment.

(a) The mammalian eye contains photoreceptor cells which respond to light.

The photographs show a grey-bellied night monkey and a squirrel monkey.



Grey-bellied night monkey

(Source: © rod williams/Alamy Stock Photo)



Squirrel monkey

(Source: © Jesse Kraft/Alamy Stock Photo)

The grey-bellied night monkey is active at night and the squirrel monkey is active during the day.

Rod cells are photoreceptors located in the retina. Rod cells detect low light intensities.

Cone cells are also photoreceptors located in the retina. They are responsible for colour vision and require higher light intensities.

The numbers of different photoreceptors in the retina of one eye of each of these two species of monkey were compared.
The results are shown in the table.

Species	Number of photoreceptors in the retina	
	Cone cells	Rod cells
Grey-bellied night monkey	6.0×10^6	1.4×10^8
Squirrel monkey	7.0×10^6	3.5×10^7

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(i) A section of squirrel monkey retinal tissue contained a total of 5 000 photoreceptors.

Calculate how many of these photoreceptors would be rod cells.

Assume an even distribution of rod cells and cone cells in the retina.

(2)

Answer .....

(ii) Explain why there is a difference in the numbers of rod cells and cone cells in the retinas of the grey-bellied night monkey and the squirrel monkey.

(3)

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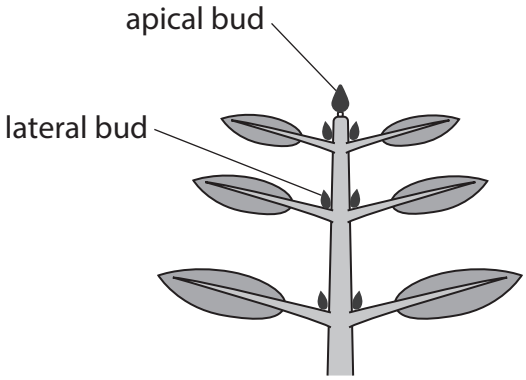
(b) Plants also respond to their environment.

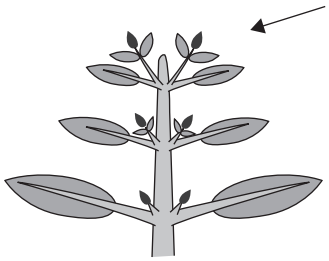
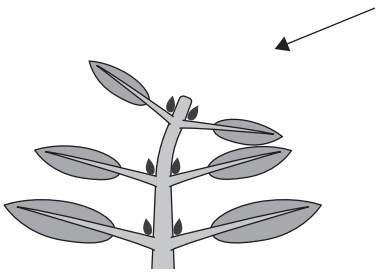
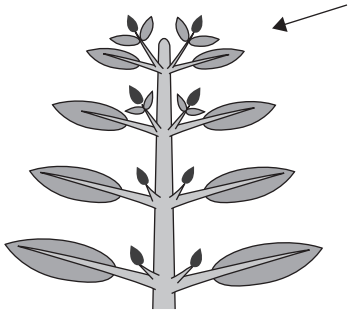
The diagram shows a seedling with the apical bud and a lateral bud labelled.



In an investigation, three genetically identical seedlings, with the same shoot length, had their apical buds removed.

The table shows the treatments for each seedling and their appearance after being grown next to a source of light for five days.

The arrows show the direction of the light.

Seedling 1	Seedling 2	Seedling 3
no further treatment	**auxin applied to the cut top of the seedling**	**gibberellins applied to the cut top of the seedling**
		

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Deduce the effect of each treatment on seedlings that have had their apical buds removed.

Use the information in the table to support your answer.

(3)

(Total for Question 3 = 8 marks)

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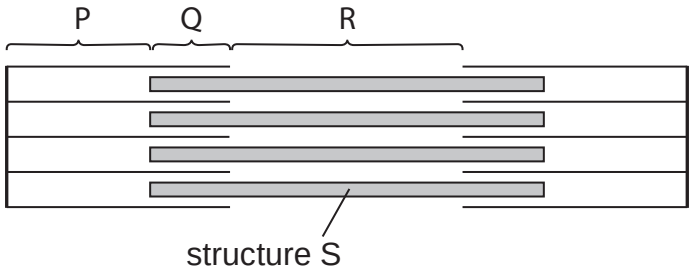
4 The sarcomere is the contractile unit of skeletal muscle fibres.

(a) The diagram shows a relaxed sarcomere.



(i) Which of the following would shorten when the sarcomere contracts?

(1)

- ☒ A region P only
- ☒ **B** region R only
- ☒ **C** regions P and R
- ☒ **D** regions Q and R

(ii) A diagram of this sarcomere, drawn to the same scale, has a length of 50 mm when contracted.

Give the ratio of the lengths of the relaxed sarcomere to the contracted sarcomere.

(1)

Answer ..... : 1

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(iii) Name the major protein component that forms structure S in the diagram.

(1)

(b) Describe the role of troponin molecules in the contraction of a sarcomere.

(4)

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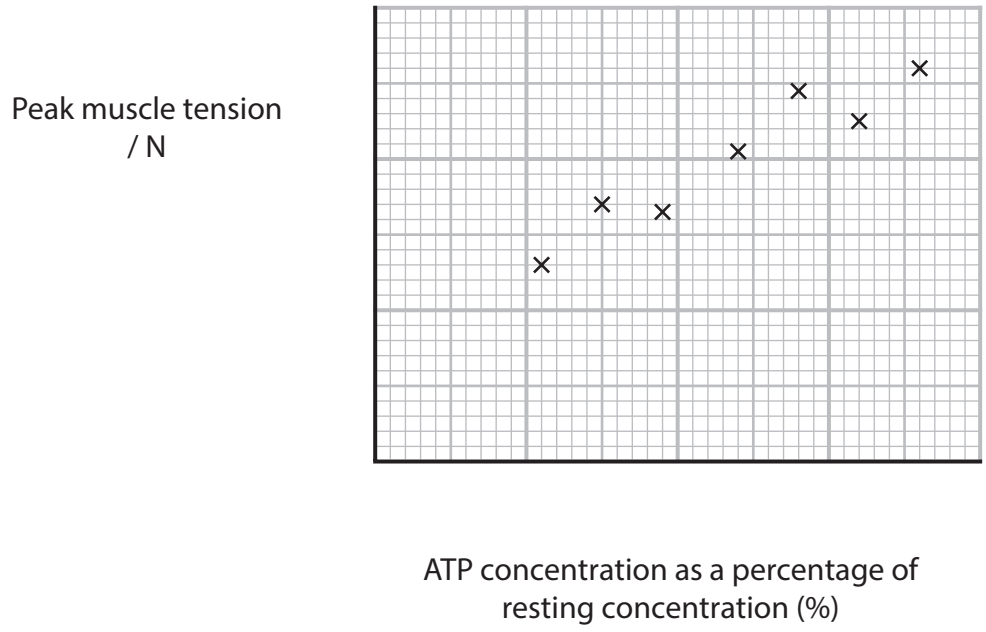
(c) Muscle contraction increases muscle tension.

The relationship between increasing ATP concentration and peak muscle tension was investigated.

The results are shown in the table.

ATP concentration as a percentage of resting concentration (%)	Peak muscle tension / N
110	26
150	34
190	33
240	41
280	49
320	45
360	52

The incomplete graph shows the results of this investigation.



(i) Add an appropriate scale to the axes of the graph and draw a line of best fit.

(2)

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(ii) Calculate the gradient of the line of best fit.

(1)

Answer ..... N per percentage increase

(Total for Question 4 = 10 marks)

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5 The Chamorro people of Guam eat flying foxes, a type of bat, as part of their diet.

The photograph shows a flying fox.



(Source: © H Lansdown/Alamy Stock Photo)

Scientists in Guam suggested there was a link between the diet of these people and the high incidence of the neuro-degenerative disease amyotrophic lateral sclerosis (ALS) in their population.

(a) In one investigation, scientists looked at the accumulation of the neurotoxin BMAA in the food chain of the Chamorro people.

The table shows some of the data.

Tissue	Concentration of BMAA / μg per gram
Seeds of cycad trees	37
Fat of flying fox	3 556

Calculate the percentage increase in BMAA per gram from the seeds of the cycad trees to the flying foxes.

Give your answer to **two** significant figures.

(1)

Answer ..... %

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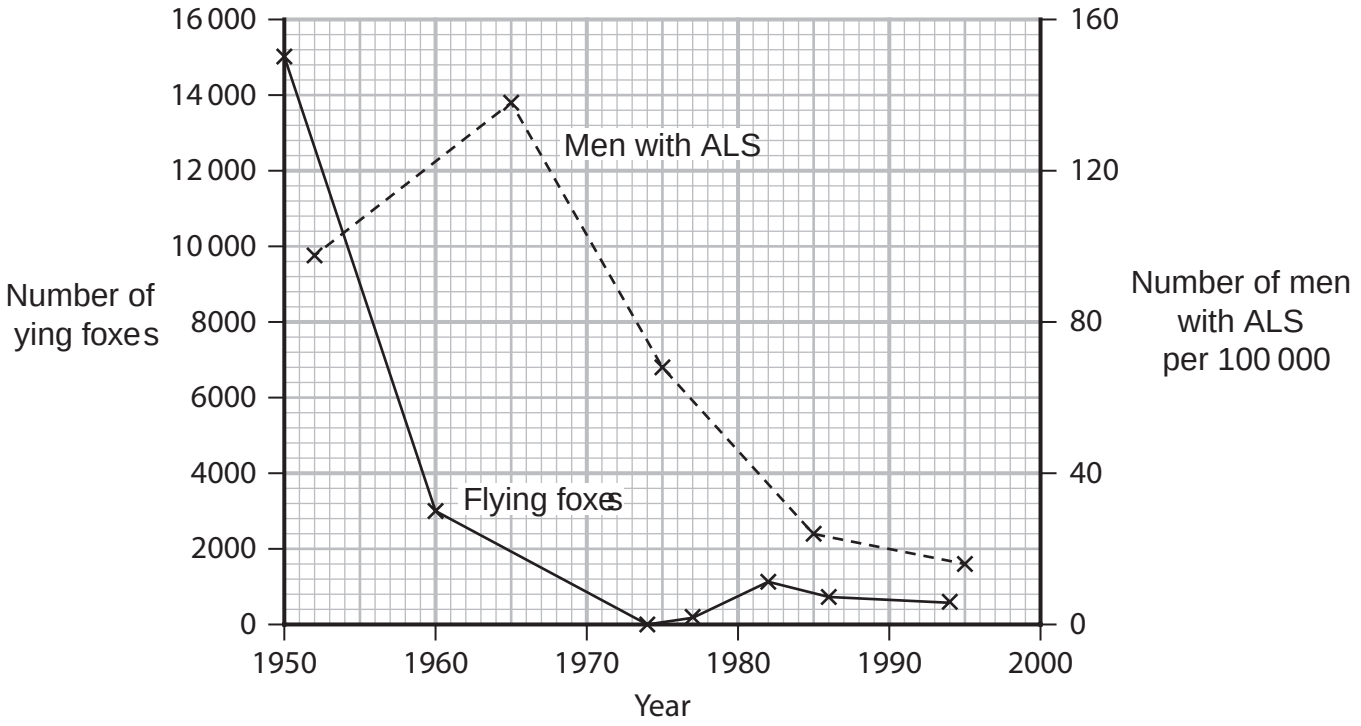
(b) In a second investigation, the scientists looked at the flying fox population and the number of men diagnosed with ALS.

The graph shows the results of this investigation.



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(i) Explain the results of this investigation.

Use information from the question to support your answer.

(4)

(ii) The diagnosis of ALS is made using positron emission tomography (PET) scans and computed tomography (CT) scans of the brain and nervous tissue.

Compare and contrast these two techniques.

(3)

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(c) Neurotoxins can affect the potential differences generated across the membranes of motor neurones.

(i) Draw a myelinated motor neurone and label **two** structures.

(3)

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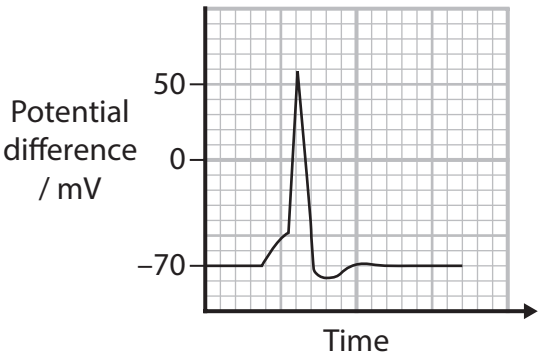
(ii) A different neurotoxin called tetrodotoxin inhibits the transmission of nerve impulses along axons.

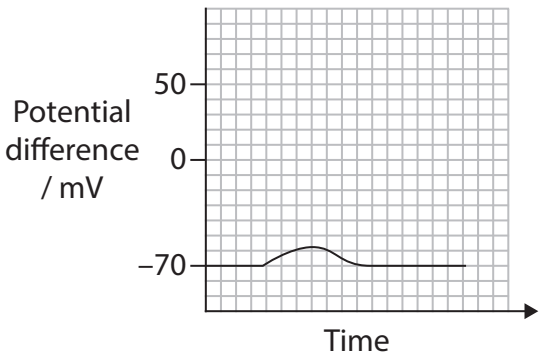
In an experiment, axons of motor neurones were stimulated in the absence of tetrodotoxin and in the presence of tetrodotoxin.

The graphs show the potential differences obtained in this experiment.

Absence of tetrodotoxin



Presence of tetrodotoxin



Explain how tetrodotoxin inhibits the transmission of a nerve impulse along the axon.

(3)

(Total for Question 5 = 14 marks)

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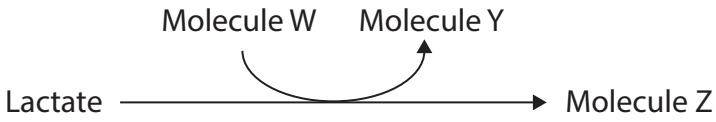
6 Mammals produce ATP by anaerobic and aerobic respiration.

(a) The effect of exercise intensity on the lactate concentration in human blood was investigated.

- An athlete and a non-athlete performed the same exercise at the same intensity for three minutes.
- Their blood lactate concentrations were measured as soon as they finished exercising.
- This was repeated for different intensities of exercise.

(i) The diagram shows what happens to the lactate following exercise.



Which row shows the molecules in this diagram?

(1)

		Molecule W	Molecule Y	Molecule Z
☒	A	oxidised NAD	reduced NAD	pyruvate
☒	B	oxidised NAD	pyruvate	reduced NAD
☒	C	reduced NAD	oxidised NAD	pyruvate
☒	D	reduced NAD	pyruvate	oxidised NAD

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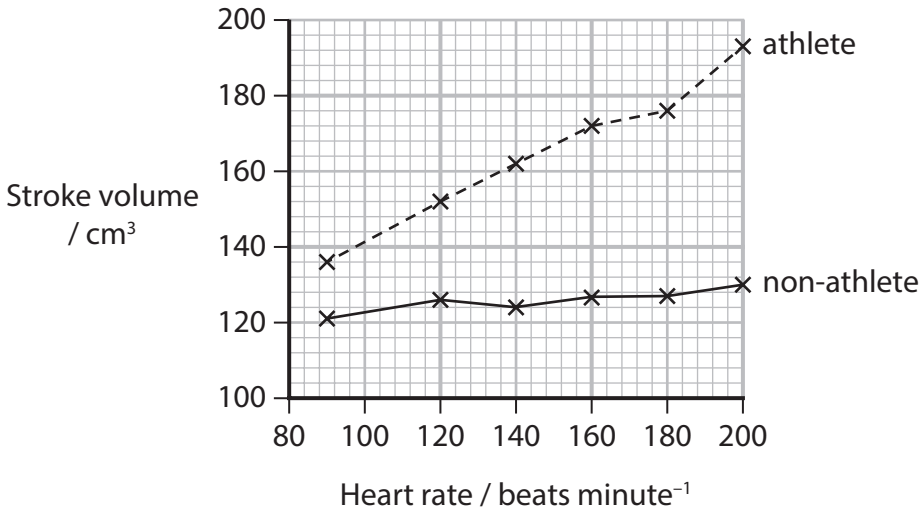
*(ii) The table and graph show some of the results of this investigation.

Intensity of exercise / a.u.	Lactate concentration in blood / mmol dm^{-3}	
	Athlete	Non-athlete
0	1.0	1.5
60	1.1	2.2
120	1.4	3.7
180	3.2	6.2
240	6.4	10.0

Stroke volume is the volume of blood that leaves each ventricle during ventricular systole.

The graph shows the stroke volumes of the athlete and the non-athlete at different heart rates.



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Explain the results of this investigation.
Use the information in the graph and the table and your own knowledge to support your answer.

(6)

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(b) The photograph shows a coyote.



(Source: © Shaun Cunningham/Alamy Stock Photo)

Some coyotes have been poisoned with cyanide to prevent them from killing the livestock of farmers.

Cyanide inhibits cytochrome oxidase, the last carrier in the electron transport chain (ETC).

Explain how the action of cyanide would kill a coyote.

(4)

(Total for Question 6 = 11 marks)

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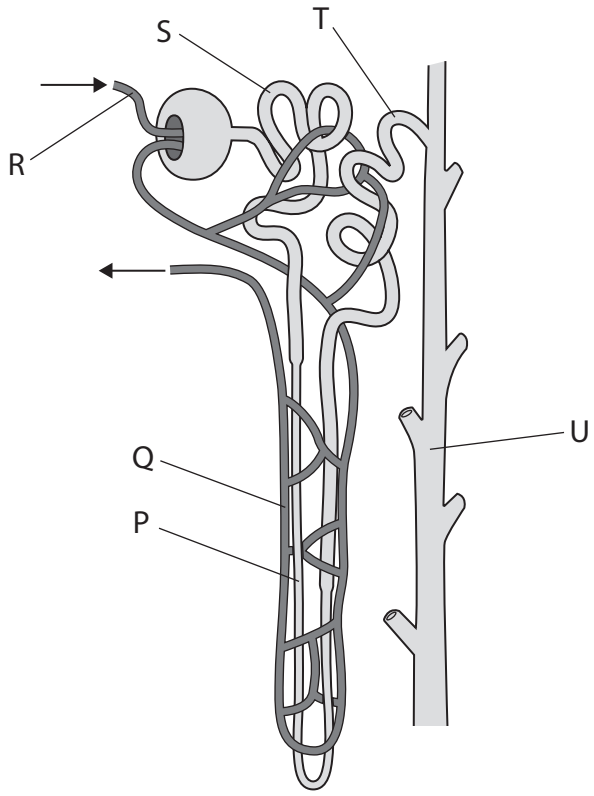
7 The kidney is involved in the reabsorption of solutes and water.

(a) The diagram shows a mammalian kidney tubule (nephron) with its blood supply.



(i) Which labelled structure transports blood to the renal vein?

(1)

- ☒ A Q
- ☒ **B** R
- ☒ **C** S
- ☒ **D** U

(ii) Which labelled structures would be found in the medulla region of the kidney?

(1)

		Structures		
☒	A	P	Q	U
☒	B	R	Q	P
☒	C	R	S	T
☒	D	S	T	U

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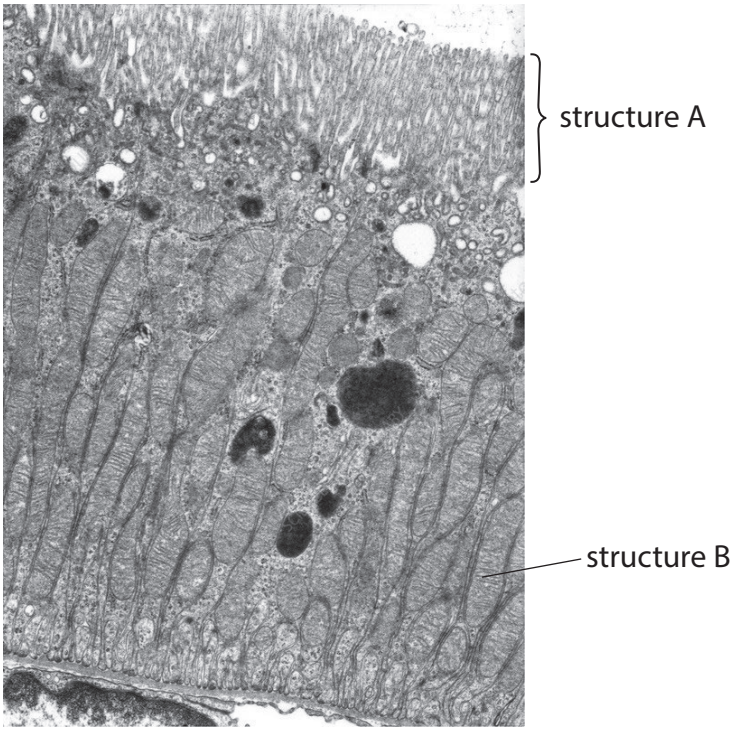
(iii) The electron micrograph shows part of a cell lining the proximal convoluted tubule.



(Source: © Jose Calvo/Science Photo Library)

Explain how structures A and B and their locations in the proximal convoluted tubule enable the reabsorption of solutes.

(3)

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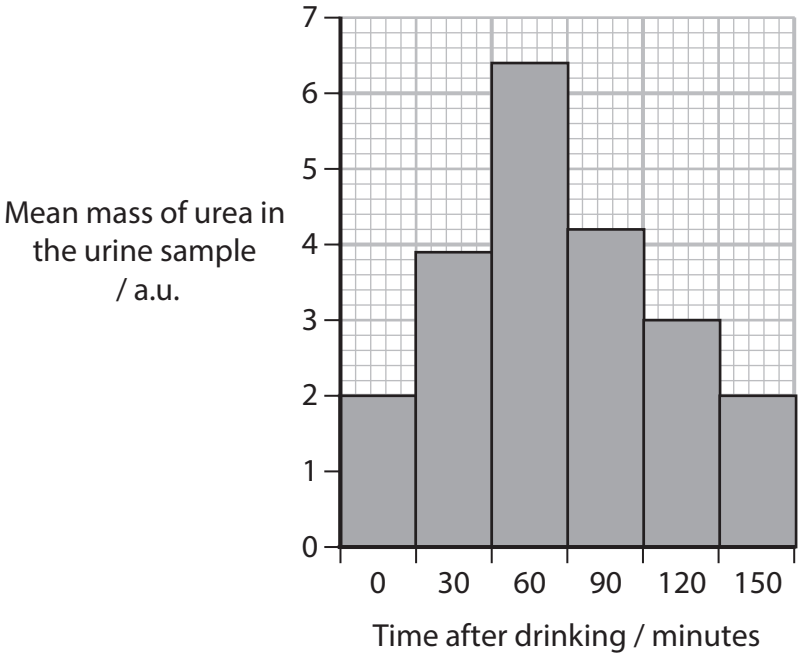
(b) A group of individuals gave a urine sample and then immediately drank 1 000 cm^3 of water.

Urine samples were then collected at 30-minute intervals.

The volumes and composition of urine produced were then recorded.

The table and graph show the results of this investigation.

Time after drinking / minutes	Mean volume of urine produced / cm^3	Mean concentration of ions in urine / a.u.
0	100	6.0
30	195	3.0
60	325	1.8
90	210	2.8
120	150	4.0
150	100	6.0



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Comment on the results of this investigation.

Use the information in the table and the graph and your own knowledge to support your answer.

(4)

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(c) A person with hyponatraemia suffers from excessive production of antidiuretic hormone (ADH) from the pituitary gland.

This causes changes in the sodium ion concentration of the blood.

The table shows the sodium ion concentration of the blood in patients with hyponatraemia.

Condition	Sodium ion concentration of the blood / a.u.
normal	135 to 145
mild hyponatraemia	130 to 134
moderate hyponatraemia	125 to 129
severe hyponatraemia	<125

Explain how the excessive release of antidiuretic hormone (ADH) causes these changes in blood sodium concentrations.

(3)

(Total for Question 7 = 12 marks)

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8 The scientific document you have studied is adapted from articles in *New Scientist* and the *Journal of Consumer Protection and Food Safety*.

Use the information from the scientific document and your own knowledge to answer the following questions.

(a) Explain how Ted Turlings and colleagues could have identified that the *BtPMaT1* gene found in the whitefly was originally a plant gene (paragraph 2).

(3)

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(b) Explain why the frequency of the *BtPMaT1* gene increases in the whitefly population (paragraphs 3 and 6).

(4)

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(c) Explain how populations of fluorescent red zebrafish could be produced for breeding (paragraphs 9 and 15).

(4)

(d) Suggest the risks and benefits of genetically modifying zebrafish (paragraphs 9, 14 and 20).

(3)

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(e) Suggest how the skin cells 'doubled in size to cover the area of the damage' (paragraph 19).

(3)

(f) Explain how a single-celled embryo of a zebrafish, injected with the colour producing gene, could develop into an adult with red skin cells (paragraphs 14, 15 and 17).

(3)

(Total for Question 8 = 20 marks)

TOTAL FOR PAPER = 90 MARKS

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Friday 07 June 2024

Morning (Time: 1 hour 45 minutes)

Paper reference **WBI15/01**

Biology

International Advanced Level

UNIT 5: Respiration, Internal Environment, Coordination and Gene Technology

Scientific article for use with Question 8

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Scientific article for use with Question 8

Article 1

1. One species of whitefly, an aphid-like insect, has incorporated a portion of plant DNA into its genome that protects it from leaf toxins. It seems to be the first known example of so-called horizontal gene transfer between a plant and insect in which the transferred genetic material performs a useful function.

2. While sequencing the genome of the silverleaf whitefly (*Bemisia tabaci*), Ted Turlings at the University of Neuchâtel in Switzerland and his colleagues discovered a gene known as *BtPMaT1*, which is found in plants but never previously seen in insects.

3. This gene may have an important function in plants. The plants generate toxins to defend themselves from attack by animals. The team suspects that the *BtPMaT1* gene may help plants store these toxins in a harmless form so the plants don't poison themselves. Similarly, the gene may help the whitefly avoid being poisoned when it eats the plant.

4. Turlings says the gene transfer event occurred between 35 million and 80 million years ago, when the silverleaf whitefly and other whitefly species that lack the gene split from a common ancestor.

5. The gene transfer event may have involved viruses that cause disease in plants and are transmitted via the whiteflies. Some DNA from a plant may have been taken up by a virus, transmitted to the whiteflies and then subsequently assimilated into the insects' genomes.

6. "[Some] viruses basically incorporate their own genome into the cells of their hosts," says Turlings. The research suggests that the extent to which horizontal gene transfer occurs in nature is probably underestimated, says Caitlin Byrt at the Australian National University in Canberra. "What this shows is that where there's a really strong pressure for survival on an organism, it can actually borrow genetic information that helps it do that from other organisms," says Byrt.

7. The researchers demonstrated the function of *BtPMaT1* in whiteflies by selectively interfering with the gene using small molecules of RNA. Disrupting the gene's function made the whiteflies susceptible to compounds known as phenolic glycosides that are present in tomato plants. After feeding on tomato plants that had been genetically modified to produce the RNA molecules, all whiteflies subsequently died.

8. "This demonstrates a mechanism that we could use in engineering crops to basically target plant pests, and target the resistance of crops to plant pests," says Byrt, although she points out that horizontal gene transfer may then allow the pests to evolve resistance to our genetic engineering.

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Article 2

9. GloFish® are fluorescent transgenic zebrafish. These are illegal in many countries. GloFish® are zebrafish containing a *dsRed* gene from a sea coral that makes the fish fluorescent under ultraviolet light. Zebrafish are normally silver and black. There are several versions of the *dsRed* gene, each resulting in a different coloured phenotype, from fluorescent yellow to fluorescent red.

10. As it is illegal to import these transgenic fish into many countries, technology is used to detect them. A PCR-based method has been developed to detect transgenic zebrafish harbouring the gene (*dsRed*) coding for the red fluorescent protein, originally isolated from the marine sponge *Discosoma striata*.

11. Two types of PCR have been performed:

    - PCR to detect amplifiable genomic zebrafish DNA was checked using primers specific for the zebrafish parvalbumin gene;
    - PCR with primers to specifically amplify the *dsRed* gene.

12. In both PCR systems, genomic DNA isolated from wild type zebrafish was used as a control template, in the second PCR system, the plasmid *dsRed2-N1* was used as a positive control.

13. Applying this method to several specimens of presumed GloFish® from traders in the Netherlands and Germany revealed the presence of transgenic fish. In addition, a rapid method for screening zebrafish suspected to be genetically modified has been developed by measuring the fluorescence of water-soluble protein.

Article 3

14. Red and yellow and… at least 70 other colours. A genetically engineered fish has skin cells in all the colours of the rainbow and then some. Its beauty is more than skin deep though – the huge variation in colour could be used to track individual cells as they develop, move and regenerate.

15. The "skinbow" zebrafish was created using a gene that codes for red, blue and green fluorescent proteins, although only one colour is produced at a time. Ken Poss at Duke University in Durham, North Carolina, and his colleagues injected this gene into single-cell fish embryos. In one particular embryo, this gene became incorporated into part of the genome that patterns skin cells.

16. As an adult, this fish looked reddish in colour, but when the team shone a UV light on its skin, it lit up in technicolour. "We didn't know these patterns would develop just in the skin," says Poss. "When you make genetically engineered animals, you can't fully predict the outcome."

17. Poss thinks that each of the fish's skin cells has about 100 copies of the gene. Whether each gene creates a red, green or blue protein is entirely random, he says. "One cell might have 80 red, 10 green and 10 blue proteins, for example," says Poss. Each cell could have one of about 5000 possible colour combinations, although the resolution of Poss's microscope only lets him distinguish 70 different colours among the cells.

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Regeneration and repair

18. The fish and its offspring can be used to track how skin cells move to regenerate tissue and repair injuries – a task normally made difficult by the fact that individual skin cells look so similar to each other.

19. In one experiment, Poss's team took snapshots from one patch of skin, twice a day for 20 days. All the images were fed into a computer, with software that can identify and track each skin cell based on its colour. This allowed the team to work out that the entire population of the fish's skin cells turns over every 20 days or so, and that each cell spends about eight days on the surface of the skin before it wears off. The team also watched how the fish's skin responds to injury. The group snipped off part of a fin – an injury that zebrafish can usually repair. Skin cells in the surrounding area raced to the injury site, and doubled in size to cover the area of the damage. Deeper down, a sheet of new skin cells was created, which rose to the surface within half an hour.

20. "This approach lets us image cell dynamics in a live animal," says Poss. He hopes that the skinbow fish can be used to reveal more about how tissue regeneration occurs – a process that is still mysterious, he says. Christine Pullar, who studies wound healing at the University of Leicester, UK, agrees. "I can imagine that this group will be able to explore skin biology on a new level," she says. "I look forward to seeing more research on skinbow."

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