

PEARSON EDEXCEL A-LEVEL BIOLOGY A • 9BN0

BIOLOGY



EXAM QUESTION PACK

TOPIC 7: RUN FOR YOUR LIFE

SCORE

/161

PERCENTAGE

%

STEMUP

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Q1.

The scientific article you have studied is adapted from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

Explain how 'a cancer-causing mutation' could increase the rate of division in stem cells (paragraph 14).

(3)

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(Total for question = 3 marks)

Q2.

A person arrived at hospital having eaten some poisonous berries.

An electrocardiogram (ECG) was recorded for this person.

One of the poisons in the berries can bind to acetylcholine receptors on the surface membrane of cells in the SAN. This prevents acetylcholine binding to the receptors if it is in low concentration.

This person was treated with a drug that stopped acetylcholinesterase from being released into the synaptic gap.

Explain how this drug lowered the heart rate of this person.

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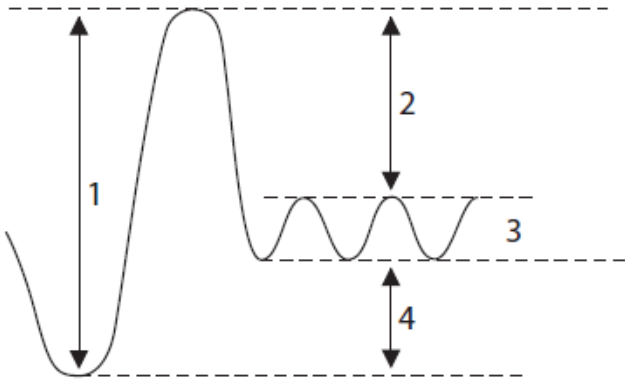
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(Total for question = 3 marks)

Q3.

A spirometer can be used to study aspects of the human respiratory system.

The diagram shows a trace produced using a spirometer.



Which of the following parts of the spirometer trace could be used to determine the maximum volume of air that can be exhaled?

(1)

- ☒ **A** 1 only
- ☒ **B** 2 and 3 combined
- ☒ **C** 3 only
- ☒ **D** 3 and 4 combined

(Total for question = 1 mark)

Q4.

As levels of activity increase, the heart can respond to the changing demand for oxygen.

Which term describes the ability of heart muscle to contract without external stimulation?

(1)

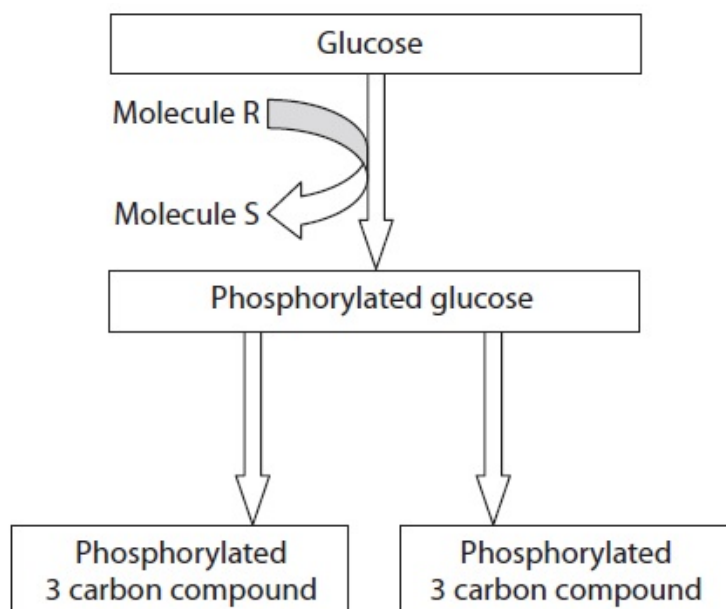
- ☐ **A** autonomic
- ☐ **B** cardiac
- ☐ **C** myogenic
- ☐ **D** systolic

(Total for question = 1 mark)

Q5.

Respiration is a vital process in living organisms. All organisms carry out glycolysis. The Krebs cycle also occurs in some organisms.

(a) The diagram below shows some of the stages in glycolysis, using the hexose sugar glucose.



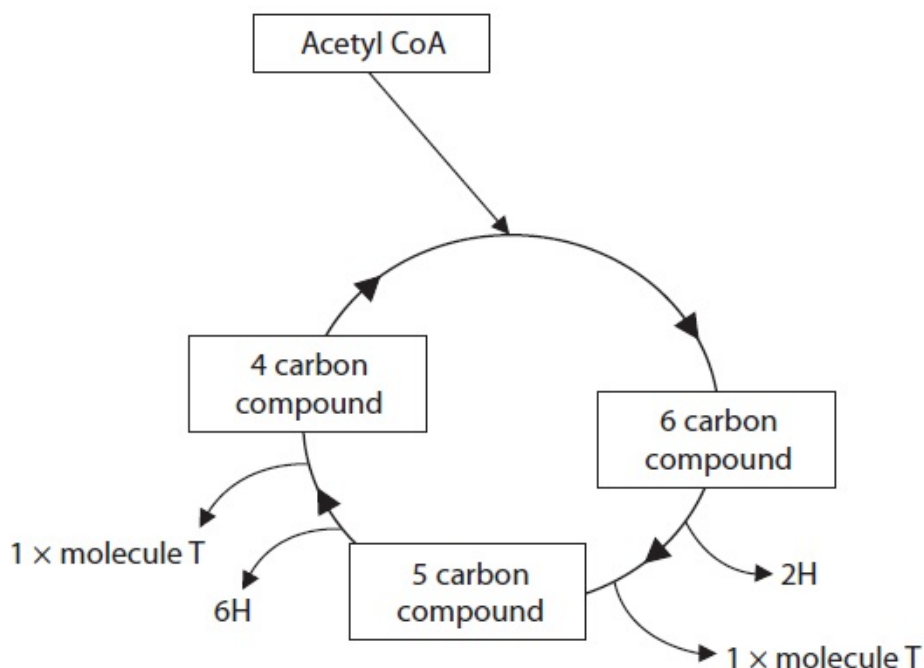
Name the molecules R and S shown in the diagram.

(2)

Molecule R

Molecule S

(b) The diagram below shows some of the stages in the Krebs cycle.



(i) Name molecule T and use the information in the Krebs cycle diagram to give a reason for your answer.

(2)

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(ii) Using information in the diagram, suggest what would happen in the Krebs cycle if acetyl CoA became unavailable.

(3)

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(b) The hydrogen (H) from the Krebs cycle enters the electron transport chain and oxidative phosphorylation occurs.

Explain what is meant by the term **oxidative phosphorylation**.

(3)

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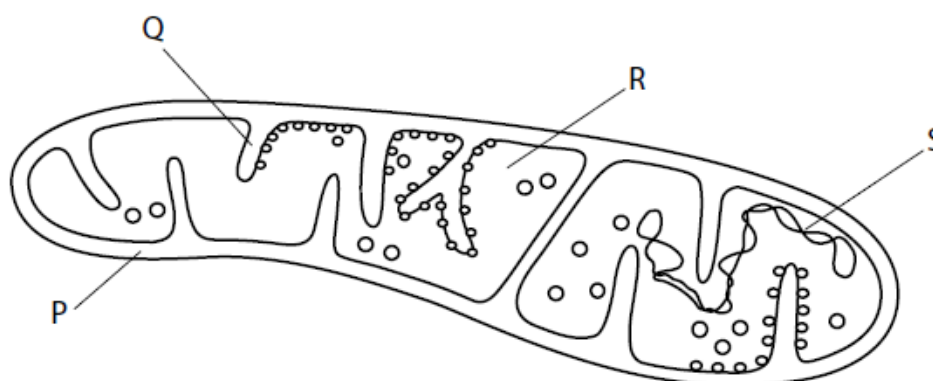
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(Total for question = 10 marks)

Q6.

Aerobic respiration is a series of reactions that occur in the cytoplasm and mitochondria of animal and plant cells.

(a) The diagram shows a mitochondrion.



Which row of the table shows where each process takes place in a mitochondrion?

(1)

	Diffusion of hydrogen ions / production of ATP in chemiosmosis	Production of reduced NAD
☐ A	P	Q
☐ B	Q	R
☐ C	R	S
☐ D	S	P

(b) The link reaction takes place in mitochondria.

Which row of the table shows the correct substances produced by the link reaction?

(1)

	Carbon dioxide	ATP	Reduced NAD
☐ A	no	no	no
☐ B	no	yes	no
☐ C	yes	yes	yes
☐ D	yes	no	yes

(c) The number of ATP molecules synthesised in mitochondria from one molecule of acetyl CoA is

(1)

- ☐ A 11
- ☐ B 12
- ☐ C 22
- ☐ D 24

(Total for question = 3 marks)

Q7.

Yeast is a single-celled organism that can respire aerobically.

Mitochondria are the sites of aerobic respiration in yeast cells.

(i) Name two molecules needed for aerobic respiration that can move into the mitochondria.

(2)

1

2

(ii) The outer mitochondrial membrane is not permeable to hydrogen ions (H⁺).

Explain the importance of this feature of the membrane.

(4)

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(Total for question = 6 marks)

Q8.

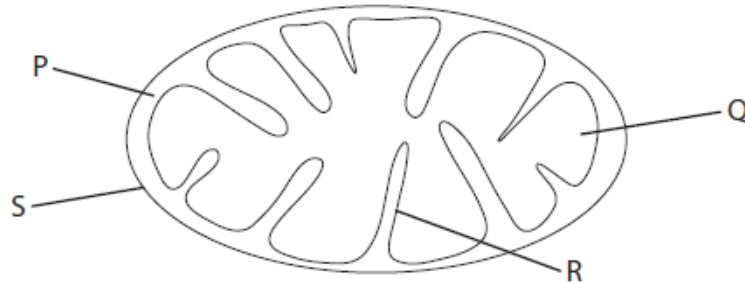
Answer the questions with a cross in the boxes you think are correct ☐. If you change

your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Yeast is a single-celled organism that can respire aerobically.

Mitochondria are the sites of aerobic respiration in yeast cells.

The diagram shows a mitochondrion.



(i) Which labelled component in the diagram is the site of the Krebs cycle?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(ii) Which labelled component in the diagram is the site of oxidative phosphorylation?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(iii) Yeast cells can have many small mitochondria.

Calculate the magnification of the diagram if the maximum length of the mitochondrion is 0.5 μm .

(2)

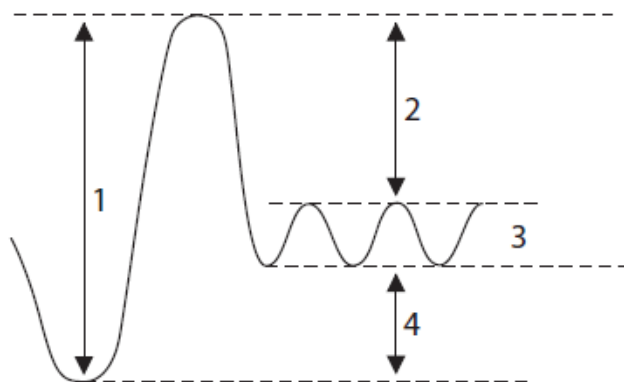
Answer

(Total for question = 4 marks)

Q9.

A spirometer can be used to study aspects of the human respiratory system.

The diagram shows a trace produced using a spirometer.



The availability of oxygen in the air is lower at high altitudes because of the lower air pressure.

Populations of humans that have lived at high altitude for many generations have adapted to these conditions.

One adaptation these people have is a larger thorax than people living at lower altitudes.

A student made the following hypothesis:

People with this adaptation will have a lower breathing rate as their tidal volume will be greater than those without the adaptation.

(i) Devise a valid investigation, using a spirometer, to test this hypothesis.

(4)

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(ii) Another adaptation to living at high altitude is to have more red blood cells circulating in their blood.

Explain how a bone marrow stem cell can give rise to red blood cells.

(4)

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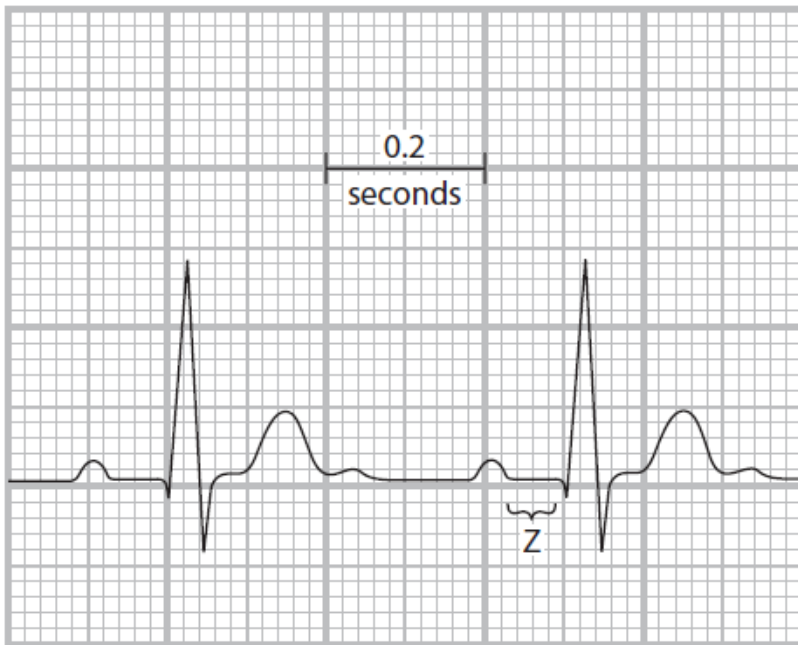
(Total for question = 8 marks)

Q10.

A person arrived at hospital having eaten some poisonous berries.

An electrocardiogram (ECG) was recorded for this person.

The diagram shows part of the ECG obtained.



(i) Tachycardia for an adult is defined as a heart rate above 100 beats per minute.

Calculate the percentage increase above 100 beats per minute for the heart rate of this person.

(2)

Answer %

(ii) The length of time labelled Z on the ECG was shorter than for a person with a normal heart rate.

Which of the following is shown by label Z on the diagram?

(1)

- ☐ **A** the time that the atria are contracting
- ☐ **B** the time for the atrioventricular (AV) valves to open
- ☐ **C** the time that the atrioventricular node (AVN) delays depolarisation
- ☐ **D** the time that the ventricles are contracting

(Total for question = 3 marks)

Q11.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Moving a limb involves the interaction of muscles, tendons and ligaments.

Tendons and ligaments are important structures in elbow and knee joints.

(i) Which of the following identifies the structures that join bones to bones in an elbow joint?

(1)

- ☐ **A** ligaments only
- ☐ **B** ligaments and tendons
- ☐ **C** tendons only
- ☐ **D** neither ligaments nor tendons

(ii) One type of joint injury is a torn ligament. This may be treated by adding a piece of tendon to the ligament. This is because after a period of time, the tendon tissue changes and responds in the same way as a ligament.

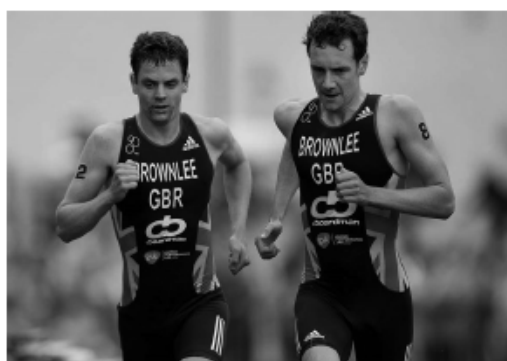
Which of the rows in the table correctly describe the changes in this piece of tendon?

(1)

Row	Piece of tendon shows a change in its	The change is
1	genotype	an anatomical adaptation
2	genotype	a physiological adaptation
3	phenotype	an anatomical adaptation
4	phenotype	a physiological adaptation

- ☐ **A** row 1 only
- ☐ **B** row 3 only
- ☐ **C** rows 1 and 2
- ☐ **D** rows 3 and 4

*(iii) The photograph shows athletes competing in the modern triathlon.



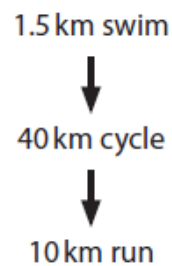
© Gonzalo Arroyo Moreno/Stringer

The modern triathlon involves three sports: swimming, cycling and running.

An investigation was carried out to compare the level of demand on the body of these three sports during a triathlon.

The investigation involved 12 athletes who were all males of the same age.

Each athlete carried out the triathlon as shown in the flow diagram. There was no rest period between each sport.



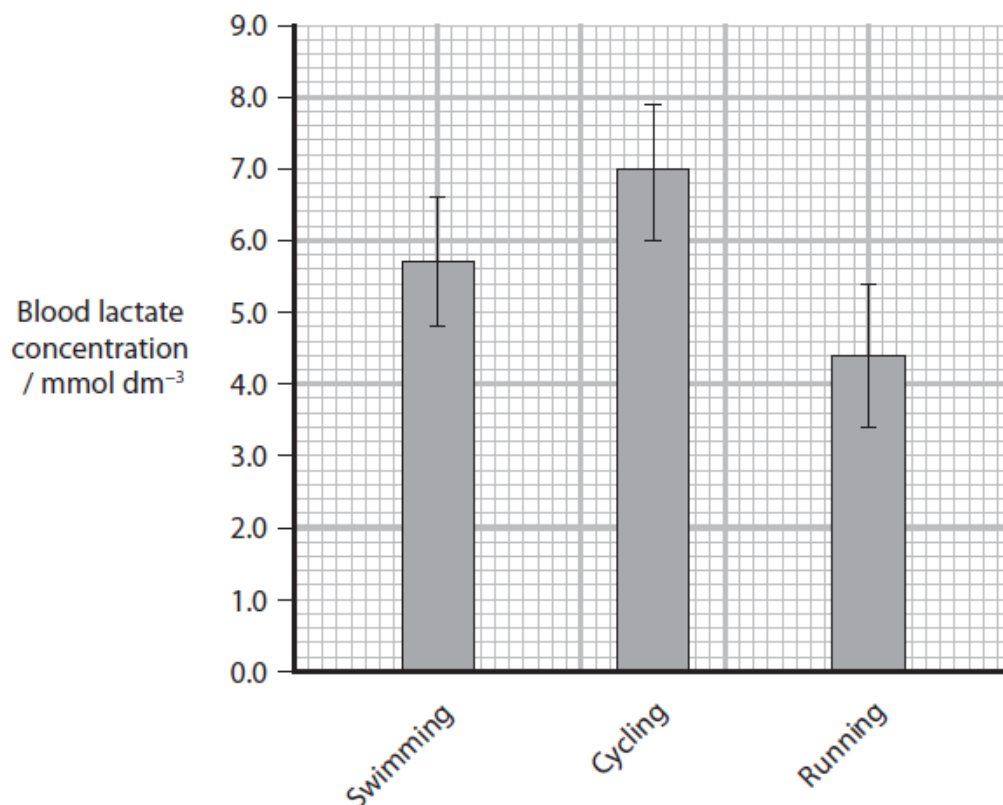
The heart rate for each athlete was measured as they completed each sport.

The mean heart rate for each sport was then calculated and is shown in the table.

Sport	Mean heart rate / bpm
Swimming	163
Cycling	165
Running	159

The blood lactate level for each athlete was also measured as they completed each sport. Means for lactate level after each sport were calculated.

The results are shown in the graph.



It was concluded that cycling was the most demanding of the three triathlon sports. This was followed by swimming and then running.

Evaluate the validity of this conclusion.

(6)

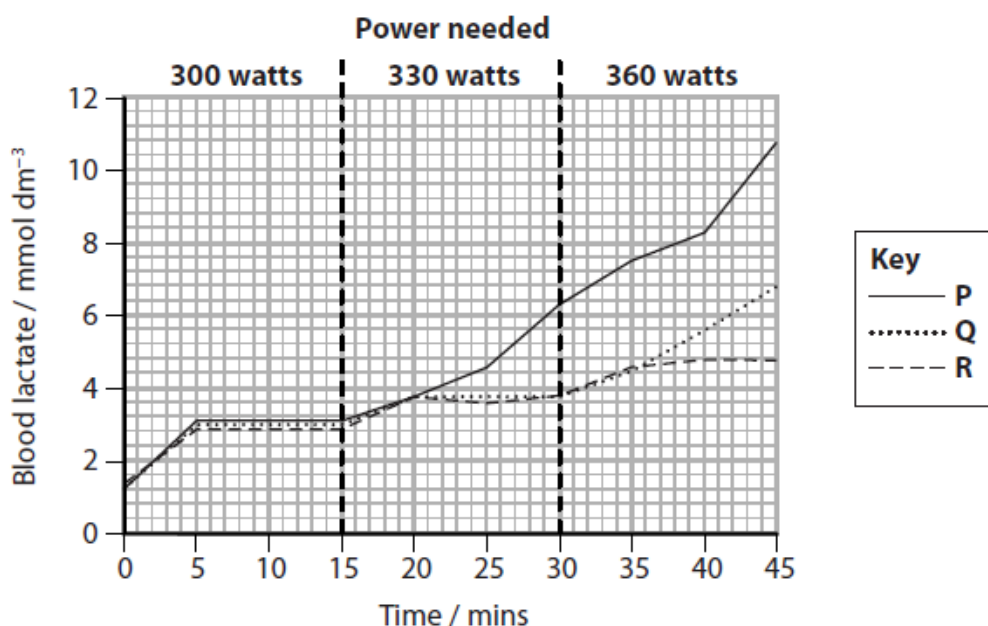
(Total for question = 8 marks)

Q12.

Athletes monitor the effect of different levels of exercise on their blood lactate concentration. This helps them to train effectively.

In a study, three athletes, **P**, **Q** and **R**, used an exercise bicycle for 45 minutes. The power needed to maintain a constant speed was increased every 15 minutes. Their blood lactate concentration was measured at 5-minute intervals.

The results are shown in the graph.



The most effective training involves the greatest power requirement over longer periods of time. Therefore, it is important to avoid high concentrations of blood lactate, which causes muscle fatigue, for as long as possible.

Analyse the data to deduce how each of these three athletes should plan their training.

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(Total for question = 4 marks)

Q13.

Anabolic steroids stimulate muscle development.

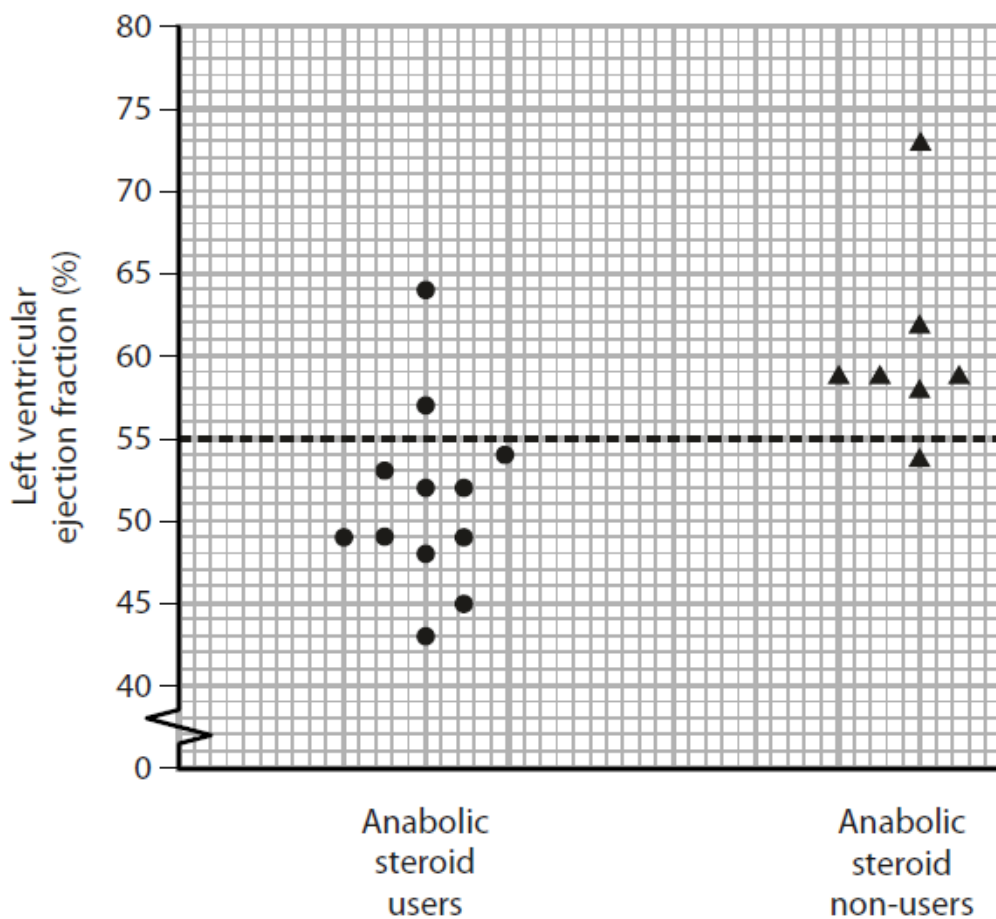
Some athletes use anabolic steroids in an attempt to improve their performance.

The effect of long-term anabolic steroid use on heart function has been investigated.

The left ventricular ejection fraction is the percentage of blood that leaves the left ventricle when it contracts.

The left ventricular ejection fraction for a healthy heart should be greater than 55%.

The results of a small study are shown in the graph.



(i) Analyse the data to determine the effect of anabolic steroid use on heart function.

(2)

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(ii) Some drugs used to treat cancer have also been shown to reduce the ventricular ejection fraction.

Describe how the safe dose of a cancer drug could be determined.

(3)

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(Total for question = 5 marks)

Q14.

Nandrolone is an anabolic steroid, it is a molecule with a similar shape to testosterone. Nandrolone has been used as a performance-enhancing substance by athletes in the past.

A number of investigations with mice have been carried out to study the effect of nandrolone on the structure and function of the aorta.

In these investigations, all the mice were of one type and were all supplied with the same amount of food and water. These mice were placed into four groups.

Each group was treated differently for eight weeks. The treatments are shown in the table.

Group	Treatment	
	Allowed to exercise	Given nandrolone
P	No	No
Q	No	Yes
R	Yes	No
S	Yes	Yes

After eight weeks, the aorta of each mouse was studied.

In investigation 1, samples of aorta were put under tension to test elastic recoil.

The tension was removed and the mean maximum percentage recoil for each group was found.

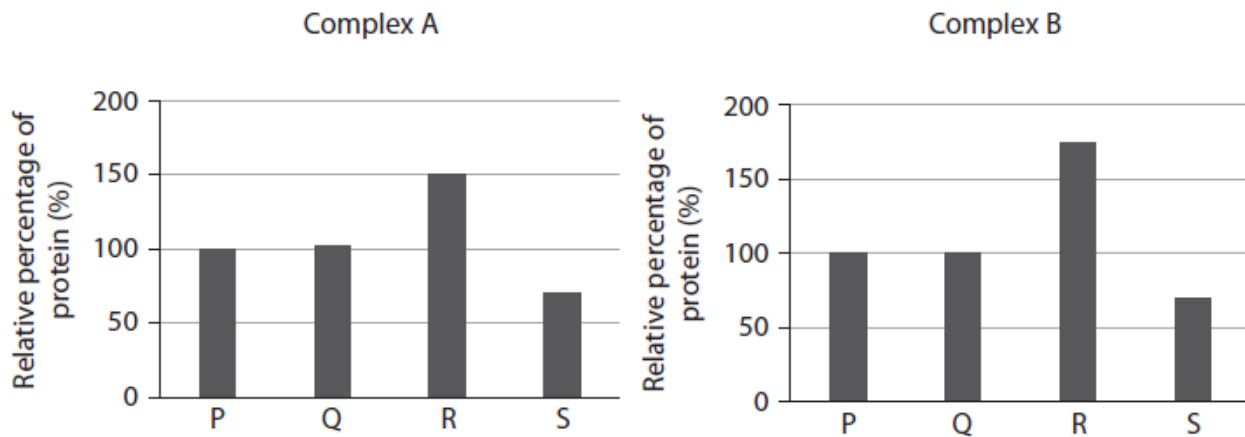
The results are shown in the table.

Group	Mean maximum percentage recoil (%)
P	57
Q	38
R	80
S	53

In investigation 2, some of the cells from the middle layer of the aortas of the mice were removed.

Two protein complexes, A and B, are found in the cells of the middle layer. These protein complexes are involved in the electron transport chain.

The graphs show the relative percentage of these two protein complexes in each group of mice.



The transcription factor Tfam is involved in the production of mitochondria.

In investigation 3, some of the cells from the middle layer of the aortas of the mice were removed. The quantity of mRNA per cell coding for Tfam was measured.

The results are shown in the table.

Group	Quantity of mRNA per cell coding for Tfam / a.u.
P	100 ± 20
Q	75 ± 10
R	170 ± 25
S	85 ± 15

Analyse the data from these three investigations to discuss the advantages of an exercise programme without nandrolone.

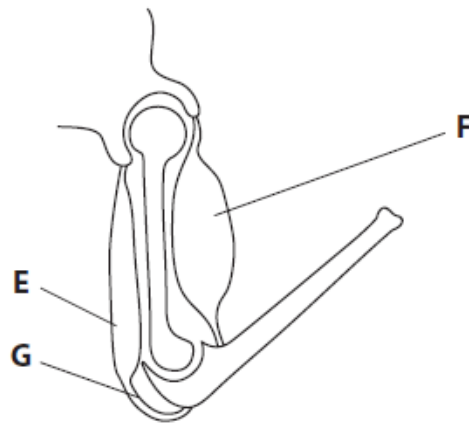
[illegible]

(Total for question = 6 marks)

Q15.

Movement of the arm at the elbow joint results from the contraction of muscles.

The diagram shows some of the structures in a human arm.



(a) Give the term for a pair of muscles that brings about movement at a joint.

(1)

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(b) (i) Give a reason why **F** can be described as a flexor muscle.

(1)

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(ii) Describe how **G** interacts with **E** to enable movement at this joint.

(2)

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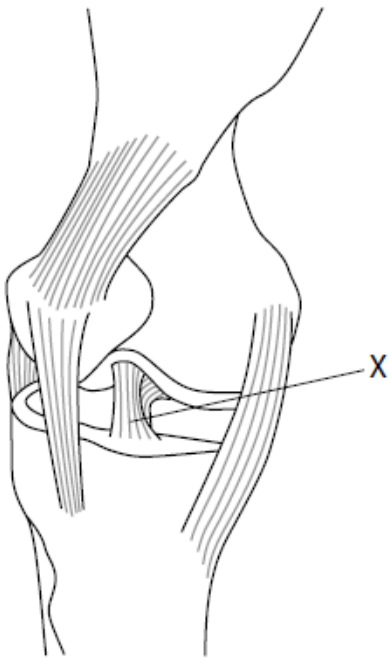
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Q16.

Movement at a joint is brought about by the contraction of antagonistic muscles which contain slow and fast twitch fibres.

The diagram shows a knee joint.



Lateral view of the knee

(a) Which tissue is used to repair structure X using keyhole surgery?

(1)

- ☒ **A** bone
- ☒ **B** cartilage
- ☒ **C** ligaments
- ☒ **D** tendon

(b) Explain why muscles occur in antagonistic pairs.

(2)

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(Total for question = 3 marks)

Q17.

Lipids and carbohydrates are found in both plants and animals.

Although plant material contains a higher proportion of carbohydrate than animal tissues, it has been claimed that carbohydrates are more important to animals than they are to plants.

(9)

[illegible]

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(Total for question = 9 marks)

Q18.

The scientific article you have studied is adapted from articles in New Scientist.

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

(a) Suggest why 'incredibly efficient cellular mechanisms' can increase the chance of obesity (paragraphs 4 and 5).

(2)

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(b) A larger $VO_2\text{max}$ means more oxygen can enter a mitochondrion and therefore more energy can be released from fuel (paragraph 8).

Name **two** substances, other than oxygen, that need to enter the mitochondrion to enable energy to be released from fuel.

(2)

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(c) Describe the structure of glycogen (paragraph 11).

(3)

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(d) Using the information in paragraphs 12 to 14, explain how lowered testosterone levels may help a cyclist to race harder on successive days.

(3)

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(e) Explain why Coyle suggests that greater muscle efficiency may be linked to an increase in the percentage of **slow twitch** muscle fibres (paragraph 20).

(2)

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*(f) Suggest how 'the development of a leak in a specific class of calcium channel in muscle cells' can lead to muscle fatigue (paragraph 23).

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(g) The ACE gene codes for the synthesis of angiotensin converting enzyme (ACE) (paragraph 25).

Complete the table by naming two nucleic acids involved in each of the processes described.

(2)

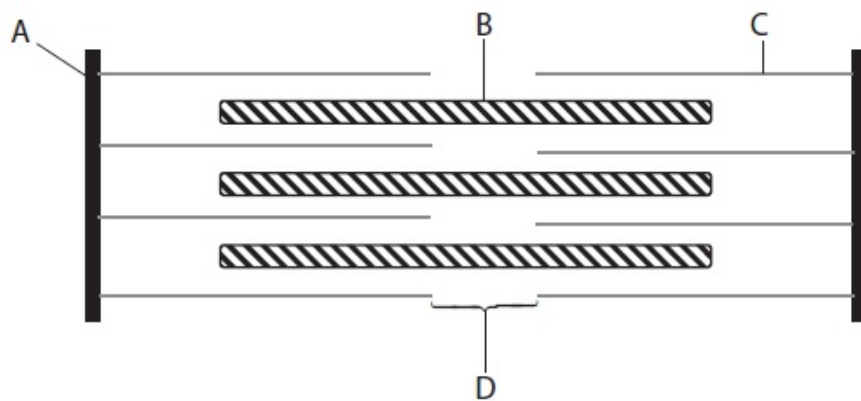
Process	Two nucleic acids involved in the process
Transcription of the ACE gene	1
	2
Synthesis of ACE at a ribosome	1
	2

(h) A variant of the APOE gene could put individuals at increased risk in contact sports. DNA profiling is a technique that can be used in genetic screening.

Suggest how DNA profiling could be carried out to identify this variant of the APOE gene (paragraph 27).

(4)

(i) The titin gene produces a protein that attaches to myosin in a sarcomere (paragraph 30).



Place a cross (☒) in the box that identifies myosin shown in the diagram.

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(j) The colder the water Japanese Ama divers swim in, the higher their resting metabolic rate (paragraph 50).

Suggest and explain why this might be an advantage to these divers.

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(k) Pugh noticed the effects of climate change (paragraph 53).

Name **two** greenhouse gases that contribute to climate change. Give **one** source of each of these gases.

(2)

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(l) Using the information in paragraph 55, calculate the percentage increase in Pugh's core body temperature due to his "anticipatory thermogenesis".

Show your working.

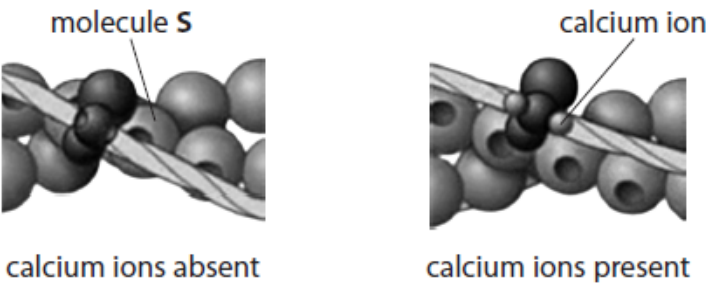
(2)

Answer = ... %

(Total for question = 30 marks)

Q19.

Muscle cells contain myofibrils. The diagrams show the arrangement of some of the molecules present in a myofibril when calcium ions are absent and when they are present.



(i) Describe the changes caused when calcium ions bind to the molecules shown in the diagram.

(2)

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(ii) Explain how these changes cause muscles to contract.

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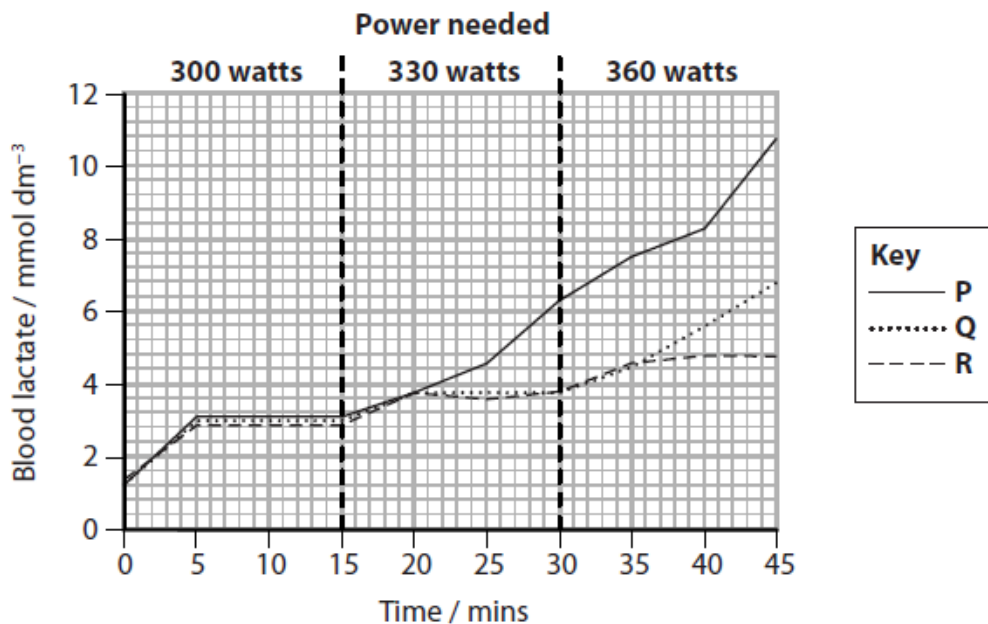
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(Total for question = 6 marks)

Athletes monitor the effect of different levels of exercise on their blood lactate concentration. This helps them to train effectively.

In a study, three athletes, **P**, **Q** and **R**, used an exercise bicycle for 45 minutes. The power needed to maintain a constant speed was increased every 15 minutes. Their blood lactate concentration was measured at 5-minute intervals.

The results are shown in the graph.



Explain the increase in blood lactate concentration observed between 0 and 5 minutes.

(2)

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(Total for question = 2 marks)

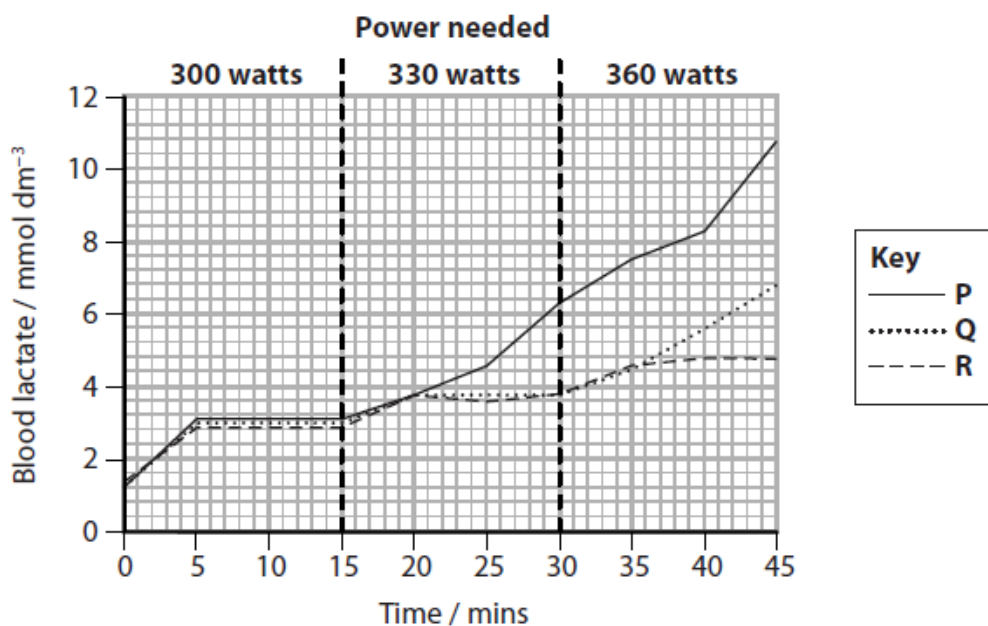
Q21.

Athletes monitor the effect of different levels of exercise on their blood lactate concentration. This helps them to train effectively.

In a study, three athletes, **P**, **Q** and **R**, used an exercise bicycle for 45 minutes.

The power needed to maintain a constant speed was increased every 15 minutes. Their blood lactate concentration was measured at 5-minute intervals.

The results are shown in the graph.



Give reasons why blood lactate concentration remains constant between 5 and 15 minutes.

(3)

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(Total for question = 3 marks)

Q22.

Athletes compete in a range of environmental conditions.

An investigation studied the effects of environmental conditions on athletes.

A group of nine athletes ran for 50 minutes in two sets of environmental conditions:

- warm temperature and high humidity
- cool temperature and low humidity.

All other variables were kept constant including the level of exercise.

The core temperature of each athlete was recorded during the exercise and for 70 minutes following the exercise.

In another investigation, samples of blood were taken from athletes during exercise and after exercise.

The concentration and activity of neutrophils, a type of phagocyte, in the blood were measured.

The table shows the results.

Measurements	During exercise	Immediately after exercise
Mean concentration of neutrophils in blood / 10^6 cells cm^{-3}	3.57	3.42
Mean activity of neutrophils / a.u.	28.4	22.0

(i) The mean body mass of the athletes was 70 kg and the mean volume of blood per athlete was 5 dm^3 .

Calculate how many fewer neutrophils there are in the blood per kilogram of body mass immediately after exercise.

(3)

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(ii) State how these results support the statement that exercise increases the risk of infection.

(1)

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(Total for question = 4 marks)

Q23.

The central nervous system (CNS) is made up of the brain and the spinal cord.

(a) The image below of a human head and neck shows part of the CNS.



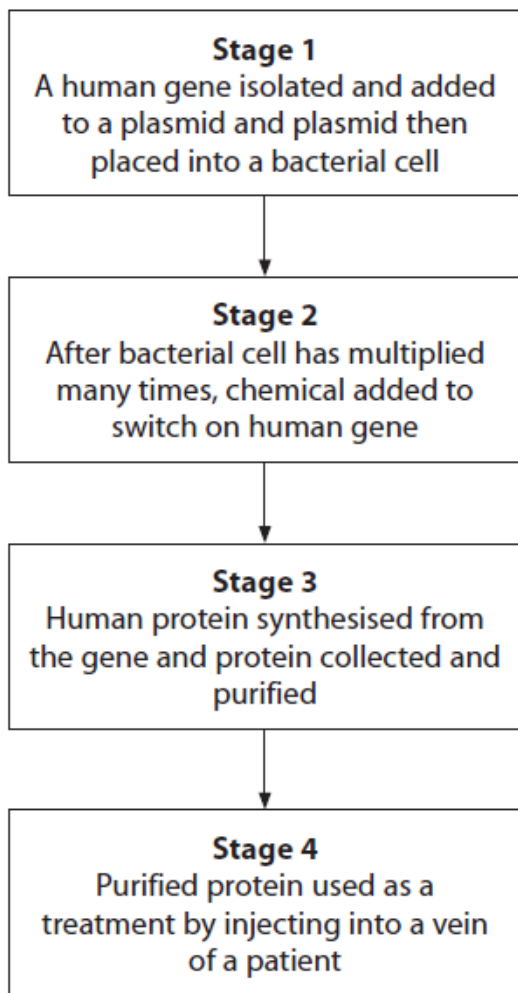
Using the image and your knowledge, complete the table below.

(4)

Labelled structure	Name of structure	One function
A		
		Feel emotions

(b) Some of the drugs used to treat human disorders are proteins. Some of these proteins can be synthesised by genetically modified bacteria.

The diagram below shows some stages in the production of one of these drugs.



(i) A restriction enzyme is used in Stage 1.

Explain why only one restriction enzyme is used in stage 1.

(2)

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(ii) Suggest how the addition of a chemical causes the human gene to be switched on in stage 2.

(3)

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(iii) Describe the structure of an organelle found in a bacterial cell that is involved in synthesising human protein in stage 3.

(1)

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(iv) Suggest **two** advantages of injecting the protein into a vein rather than an artery in stage 4.

(2)

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(Total for question = 12 marks)

Q24.

The photograph shows a female gymnast on a narrow beam.



(a) The table below refers to two regions of the brain.

Complete the table by describing **one** role of each region of the brain, while she is on the beam.

(2)

Region of the brain	One role while she is on the beam
Cerebellum	
Medulla oblongata	

(b) This gymnast will generate a lot of heat while she is on the beam.

Describe and explain how changes in blood flow in the skin will help her to control her body temperature.

(4)

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(c) Gymnasts can damage their cruciate ligaments. This is an injury that can be repaired using keyhole surgery.

(i) Explain what is meant by the term **cruciate ligament**.

(2)

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(ii) A gymnast was offered keyhole surgery to repair her damaged cruciate ligament.
Suggest and explain **two** reasons why she might choose this type of surgery.

(2)

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(Total for question = 10 marks)

Q25.

The central nervous system (CNS) is made up of the brain and the spinal cord.

(a) The image below of a human head and neck shows part of the CNS.



Using the image and your knowledge, complete the table below.

(4)

Labelled structure	Name of structure	One function
A		
		Thermoregulation

(b) The structure involved in thermoregulation may cause sweat glands to release more sweat. Explain how increased sweating is involved in the regulation of body temperature.

(3)

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(c) The photograph below shows a California sea lion (*Zalophus californianus*), a large marine mammal.



Magnification $\times 0.005$

Domoic acid is a neurotoxin, produced by algae, that harms the brains of these mammals. This neurotoxin damages brain cells that release a neurotransmitter called glutamate.

(i) Describe how a neurotransmitter, such as glutamate, is released from a brain cell.

(4)

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(ii) Scientists have used magnetic resonance imaging (MRI) to provide evidence that domoic acid may damage the brains of California sea lions.

Suggest how MRI can provide this evidence.

(2)

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(Total for question = 13 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • {mutation / change in base sequence} of a gene for {check point protein / cell cycle (control) protein} (1) • no check point (1) • activating oncogenes / deactivating tumour suppressor genes (1) • cell {cycle / division} is no longer inhibited / shortening the cell cycle (1)	IGNORE mitosis ALLOW 'mutation in gene involved in controlling the cell cycle' IGNORE rate of division increases ALLOW shorter S / G stage ALLOW uncontrolled cell division	Expert (3)

Q2.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: - acetylcholine was not broken down (as quickly) (1) - therefore {maintaining / increasing} the concentration of acetylcholine in the synaptic gap (1) - so able to compete with the poison (1) - and so able to bind to receptors (on cell surface membrane of cells of the SAN) (1)	ALLOW acetylcholine remains in the synaptic gap	(3) Exp

Q3.

Question Number	Answer	Mark
	A 1 only <i>The answer is not B as these do not summate to the maximum that can be exhaled (the vital capacity)</i> <i>The answer is not C as these do not summate to the maximum that can be exhaled</i> <i>The answer is not D as these do not summate to the maximum that can be exhaled (the vital capacity)</i>	(1) Comp

Q4.

Question number	Answer	Mark
	The only correct answer is C - Myogenic <i>A is not correct because autonomic refers to the nervous system</i> <i>B is not correct because cardiac refers to the whole heart</i> <i>D is not correct because systolic describes a stage in the cardiac cycle</i>	(1)

Q5.

Question Number	Answer	Mark
(a)	molecule R - ATP / adenosine triphosphate ; molecule S - ADP / adenosine diphosphate ;	(2)

Question Number	Answer	Mark
(b)(i)	1. carbon dioxide / CO₂ ; 2. idea that the C has been removed from C₆ or C₅ ;	(2)

Question Number	Answer	Mark
(b) (ii)	1. cycle would stop / eq ; 2. 4 carbon compound would accumulate / eq ; 3. 6 carbon compound would {run short / not be synthesised} / 5 carbon compound would run short / eq ; 4. idea that {molecule T / H} reduce ;	(3)

Question Number	Answer	Mark
(c)	1. idea of electrons being {passed along / eq} the electron transport chain ; 2. idea of {losing / eq} energy ; 3. (used to) add a phosphate to ADP to make ATP / eq ; 4. reference to ATPase ; 5. idea of chemiosmosis ; 6. idea of oxygen as the final acceptor ;	(3)

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	B		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	D		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	B		(1)

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to two of the following: - pyruvate (1) - oxygen (1) - reduced NAD / ADP (1)		(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to four of the following: - to stop H^+ diffusing out (of mitochondrion) / into cytoplasm (1) (therefore) maintaining a high concentration (of H^+) in the intermembrane space (1) - so {hydrogen ions / protons / H^+} can move down {concentration / electrochemical} gradient (1) (by) chemiosmosis (1) - to synthesise ATP (1)	ALLOW moves out for diffuses out ALLOW enabling/allowing/establishing formaintaining	(4)

Q8.

Question Number	Answer	Mark
(i)	The only correct answer is B Q – the Krebs cycle occurs in the matrix <i>A is not correct because the Krebs cycle does not occur in the intermembrane space</i> <i>C is not correct because the Krebs cycle does not occur on the crista</i> <i>D is not correct because the Krebs cycle does not occur at the outer mitochondrial membrane</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is C – R which labels a crista <i>A is not correct because oxidative phosphorylation does not occur in the intermembrane space</i> <i>B is not correct because oxidative phosphorylation does not occur in the matrix</i> <i>D is not correct because oxidative phosphorylation does not occur at the outer mitochondrial membrane</i>	(1)

Question Number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to the following: - length measured and units (converted correctly)(1) - image size divided by actual size to calculate magnification (1)	Example of calculation e.g. $70\text{mm} = 70\,000\ \mu\text{m}$ e.g. $70\,000 \div 0.5 = 140\,000$ $\times 140\,000$ Correct answer with no working gains full marks	(2)

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to four of the following: - select people with different thorax sizes (1) - select people who are similar in other respects (1) - one relevant variable controlled (1) - measurement of tidal volume from spirometer trace (1) - measure breathing rate as number of {peaks / troughs} in a set time (1)	ALLOW with or without the adaptation, who lived at high altitude and low altitude e.g. same age, same fitness level, same sex e.g. temperature, same level of previous activity, data collected when subjects were at rest ALLOW difference in peak to trough volume gives tidal volume ALLOW – measure breathing rate by counting number of breaths in a set time	(4) Exp

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to four of the following: • (by) differentiation (1) • (due to) certain stimuli (1)		(4) Exp
	• (which causes) {some genes/ gene for haemoglobin} to be activated / some genes to be deactivated (1) • {mRNA / haemoglobin} produced from activated genes (1) • removal of nucleus / produce a biconcave shape (1)	ALLOW some genes switched on / switched off IGNORE genes being turned on / off	

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of heart rate per minute (1) • percentage above 100 beats per minute (1)	Example of calculation $60 \div 0.5 = 120$ 20% Full marks for correct answer without working	(2) Grad

Question Number	Answer	Mark
(ii)	• C that the atrioventricular node (AVN) delays depolarisation <i>The answer is not A because Z is not the time of atrial contraction</i> <i>The answer is not B because Z is not the time it takes for the A-V valves to open</i> <i>The answer is not D because Z is not the time that the ventricles are contracting</i>	(1) Comp

Q11.

Question Number	Answer	Mark
(i)	The only correct answer is A - ligaments only <i>B is not correct because the tendons do not join bones to bones in the elbow joint</i> <i>C is not correct because the tendons do not join bones to bones in the elbow joint</i> <i>D is not correct because the ligaments do join bones to bones in the elbow joint</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is D rows 3 and 4 <i>A is not correct because the tendons showing a change is not a change in genotype</i> <i>B is not correct because the tendons also show a physiological adaptation</i> <i>C is not correct because the tendons showing a change is not a change in genotype</i>	(1)

Question Number	Answer	
* (iii)	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Indicative content Valid because: • {sufficient replicates / 12 individuals} used and a mean calculated • All same gender • Means of both heart rate and blood lactate agree with conclusion • Spread of data (standard deviation / error bars) between cycling and running does not overlap Not valid because: • Insufficient / only 12 individuals involved • Insufficient detail relating to the athletes e.g. they maybe athletes that focus on different sports/have done more than one previous triathlon / more experienced • The three disciplines are always done in the same order / different distances covered • Spread of cycling data (standard deviation / error bars) for blood lactate overlaps with swimming • As no time allowed to recover between sports, some of blood lactate shown for cycling could have been produced during swimming • Agree or not agree with conclusion	(6)

			Additional Guidance
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Considers one area only e.g. comparing mean data or spread of data only Conclusion based on only one set of data or only one sport considered e.g. cycling is most demanding
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers both a valid and an invalid aspect e.g. relevance of spread of data for lactate concentrations overlap in some cases or elements of the study Conclusion given that takes both valid and invalid aspects into account
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Considers both a range of valid and invalid aspects A conclusion based on a range of considered evidence

Q12.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following points: • (athlete) P should exercise at an intensity of 300 watts (1) • (athlete) Q should exercise at an intensity of 330 watts (1) • (athlete) R should exercise at an intensity of 360 watts (1) • as there would be an increase in lactate at the next level of intensity of exercise (1)		(4)

Q13.

Question Number	Answer	Additional guidance	Mark
(i)	An answer the makes reference to the following: • (use of anabolic steroids) reduces {ventricular fraction / ejection fraction / stroke volume / cardiac output } (1) • {83 % / 10 out of 12} of users have ventricular fraction below {55% / the healthy value} (1)	ALLOW less blood leaving the ventricle when it contracts ALLOW more users of anabolic steroids have a ventricular fraction below 55% than non-users ALLOW other valid quantitative values e.g. comparing mean values for each group 51.25 and 60.6%	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer the makes reference to the following: • test the drug on { healthy individuals / animals / cell cultures } (1) • (then) test on group of individuals with cancer (1) • (gradually increasing the dose) to determine dose that does not reduce ventricular ejection fraction (1)	ALLOW test on a group of patients ALLOW to determine the dose that does not cause side effects	(3)

Q14.

Question Number	Answer
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content Investigation 1 - comparison of data for no exercise/exercise without nandrolone: maximum recoil of {aorta / artery} is {higher / 23% greater} - discuss outcome of this difference as an advantage: so {oxygen-rich} blood can flow more rapidly (at the correct pressure) {from the heart / to the muscles} - less likely to get atherosclerosis / CVD / strokes Investigation 2 - comparison of data for P and R for both protein complexes: more present due to exercise - discuss advantageous outcome: so more {oxidative phosphorylation / ATP synthesis / chemiosmosis} so more ATP for muscle contraction / breaking of the bond between actin and myosin (in aorta wall) Investigation 3 - compare P and Q for mRNA coding for Tfam: more Tfam per cell so more mitochondria produced so more {respiration / ATP formed }

Level	Marks	Descriptor	Additional Guidance
0	0	No awardable content	
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	Results of one investigation described e.g. comparing P and R groups General comments about production of ATP or respiration
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Results of at least two investigations considered Discussion of results of one of these investigations in terms of consequences

3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Results of all three investigations discussed Discussion of the consequences of the data from the investigations in terms of respiration / ATP synthesis Links the consequences to muscle contraction
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Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	antagonistic (muscles)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	contraction (of F) {flexes / bends } the arm		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	A description that makes reference to the following: - G (tendon) attaches E to the bone (1) - as G does not stretch, the contraction of E moves the bone (1)		(2)

Q16.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	D		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to: • muscles can only work in one direction (1) Plus one from: • therefore a need to create opposite forces (1) • so must have extensors and flexors (1)		(2)

Q17.

Question Number	Indicative content
*	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Give examples of relevant biological knowledge and understanding: Evidence of isolated elements of biological knowledge: • glucose for respiration in both • starch for energy storage in plants / glycogen for energy storage in animals • cellulose for cell walls in plants Evidence of adequate biological knowledge with linkages made • starch composed of amylose and amylopectin in plants • sucrose as a transport sugar in phloem in plants, glucose in animals • lactose in milk for energy • a judgement on the importance of carbohydrates in plants and animals is made e.g. cellulose as a structural carbohydrate in plants therefore a greater proportion of carbohydrate in plants than animals or animals require more energy, therefore need more carbohydrate Evidence for comprehensive biological knowledge and understanding with sustained linkages • pentose sugars ribose and deoxyribose { in nucleic acids / DNA/ RNA / ATP} in both • ribulose as part of the Calvin cycle in plants • glycoprotein in { mucus / receptors on cell surface membranes / antibodies} • glycolipids in cell membranes • a supported judgement on the relative importance of carbohydrates in plants and animals is given e.g. animals store more energy in lipids than carbohydrate, therefore carbohydrate more important as a storage molecule in plants or the idea of carbohydrates as part of complex molecules or the proportion of carbohydrates present is not the same as importance

Level	Mark	Descriptor	Additional guidance
0	0	No awardable content	
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Glucose for respiration Polysaccharides for energy storage Cellulose for plant cell walls Simple conclusion made
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Branched storage molecules for rapid energy release in starch Roles of sucrose, lactose A judgement on the importance of carbohydrates in plants and animals is made
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	All of the above plus discussion of carbohydrates as part of complex molecules A supported judgement on the relative importance of carbohydrates in plants and animals

Q18.

Question Number	Answer	Mark
(a)	1. idea that less {food /eq} required to deliver energy requirement ; 2. (so) more likely to have extra food not respired / {extra/surplus} energy ; 3. which could be laid down in body as fat / eq ;	(2)

Question Number	Answer	Mark
(b)	Any two from: 1. ADP 2. Pi / inorganic phosphate 3. pyruvate / pyruvic acid / lactate 4. fatty acids 5. NAD / eq 6. acetyl CoA / eq 7. water ; ;	(2)

Question Number	Answer	Mark
(c)	1. many {alpha / eq} glucose monomers ; 2. joined by glycosidic bonds ; 3. detail of glycosidic bonds e.g. 1-4 ; 4. reference to side branches present / 1-6 glycosidic bonds ;	(3)

Question Number	Answer	Mark
(d)	1. more gonadotropins ; 2. {use / muscle uptake} of (excess) fatty acids ; 3. respired to release (much) energy / increased fat metabolism ; 4. idea of reduced requirement to replenish glycogen stores ;	(3)

Question Number	Answer	Mark
(e)	1. (slow twitch muscles) carry out aerobic respiration / full oxidation / eq ; 2. which produces more ATP (than anaerobic) / eq ; 3. 'energy' not locked up in lactate / eq ; 4. idea that it takes longer for lactate levels to build up ;	(2)

Question Number	Answer	Mark
* (f)	QWC – Spelling of technical terms (<i>shown in italics</i>) must be correct and the answer must be organised in a logical sequence) 1. Ca^{2+} leaks out of {cell / <i>cytoplasm</i> / <i>sarcoplasmic reticulum</i>} ; 2. idea of change in Ca^{2+} binding to <i>troponin</i> ; 3. causes displacement of <i>tropomyosin</i> / eq ; 4. idea of change in number of <i>myosin</i> binding sites exposed ; 5. comment on <i>myosin</i> binding to <i>actin</i> ; 6. (loss of Ca^{2+} from cell / cytoplasm) therefore force exerted by muscle is lower than expected OR (more Ca^{2+} in cytoplasm) results in less ATP so less muscle contraction ;	(4)

Question Number	Answer	Mark						
(g)	<table><tr><th>Process</th><th>Two nucleic acids involved in the process</th></tr><tr><td>Transcription of the ACE gene</td><td>DNA & mRNA ;</td></tr><tr><td>Production of ACE at a ribosome</td><td>Any two from: mRNA, tRNA, rRNA ;</td></tr></table>	Process	Two nucleic acids involved in the process	Transcription of the ACE gene	DNA & mRNA ;	Production of ACE at a ribosome	Any two from: mRNA, tRNA, rRNA ;	(2)
Process	Two nucleic acids involved in the process							
Transcription of the ACE gene	DNA & mRNA ;							
Production of ACE at a ribosome	Any two from: mRNA, tRNA, rRNA ;							

Question Number	Answer	Mark
(h)	1. obtain a sample of cells / extract DNA (from cells) ; 2. reference to named enzyme ; 3. idea of how to increase amount of DNA ; 4. reference to electrophoresis ; 5. details of electrophoresis ; 6. use a {DNA / gene} probe ; 7. with a base sequence complementary to that on the {variant / eq} ; 8. idea of matching with known variant profile ;	(4)

Question Number	Answer	Mark
(i)	B ;	(1)

Question Number	Answer	Mark
(j)	1. (higher metabolic rate) means more chemical reactions / eq ; 2. more {energy released / ATP used} / eq ; 3. (which) releases heat / eq ; 4. keeps divers warmer / warm for longer / able to swim without a wetsuit / eq ;	(3)

Question Number	Answer	Mark
(k)	1. carbon dioxide due to {deforestation / land cleaning / burning fossil fuels / correct ref to respiration / eq} ; 2. methane from {rice fields / anaerobic bacterial action / ruminant fermentation / named ruminant} ;	(2)

Question Number	Answer	Mark
(l)	1. $1.4 \div 37 =$; 2. 3.8 (%) ; Correct answer gains both 2 marks	(2)

Q19.

Question number	Answer	Additional guidance	Mark
(i)	A description that makes reference to the following points: - tropomyosin is moved (by troponin) (1) - myosin binding sites (on actin) are exposed (1)	ALLOW tropomyosin moves ALLOW actin-myosin binding site	(2)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to four of the following points: - myosin heads can bind to binding sites (1) (bound) myosin changes shape (1) - actin filaments { slide / pulled } over the myosin (1) (therefore) { muscle fibres / myofibril / sarcomeres } shorten (1) - ATP hydrolysed / ADP and { inorganic phosphate / Pi } released (1)	ALLOW actin – myosin bridges form ALLOW description of head 'nodding' or 'dipping' forward ALLOW actin moves towards the M line ALLOW Ca^{2+} activates ATPase	(4)

Q20.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following points: • (muscles cells release lactate into blood) due to anaerobic respiration (1) • insufficient oxygen for aerobic respiration / aerobic respiration cannot meet the demand for energy (1)		(2)

Q21.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following points: • { increased / sufficient } oxygen supply (1) • for aerobic respiration (1) • because { heart rate / breathing rate } increases (1) • lactate is broken down by the liver / rate of lactate production is balanced by rate of lactate breakdown (1)	ALLOW lactic acid for lactate	(3)

Q22.

Question Number	Answer	Additional Guidance	Mark
(i)	- calculate a difference in the number of neutrophils (1) - calculation of difference in number of neutrophils per athlete either in blood or per kilogram (1) - calculation of number of fewer neutrophils in the blood per kilogram (1)	Example of calculation: $0.15 \times 10^6 = 150\,000$ OR $(3.57 \div 70) - (3.42 \div 70) = 0.002142$ In blood - $150\,000 \times 5000 = 750\,000\,000$ OR per kg - $150\,000 \div 70 = 2142.86$ $750\,000\,000 \div 70 = 10\,714\,286$ OR $2142 \times 5000 = 10\,710\,000$ ALLOW 11×10^6 or 1.1×10^7 or 0.11×10^8 ALLOW ECF - 2 marks for 10.7 or 10.71 Correct answer with no working gains full marks.	(3) Exp

Question Number	Answer	Additional Guidance	Mark
(ii)	there are fewer neutrophils and the activity is reduced		(1) Exp

Q23.

Question Number	Answer			Additional Guidance	Mark
(a)	Labelled structure	Name of structure	One function	ACCEPT for function of A: involuntary muscles or named e.g. swallowing, vomiting, sneezing ACCEPT for cerebrum: frontal lobe / prefrontal / cerebral cortex	(4)
	A	Medulla (oblongata) ;	Controls {breathing / heart / eq} ;		
	C ;	Cerebral hemisphere/ cerebrum / frontal cortex ;	Feel emotions		

Question Number	Answer	Additional Guidance	Mark
(b)(i)	- idea that cuts at a specific sequence of bases ; - idea of (generates) sticky ends ; - so easier to join together / eq ;	ACCEPT to produce {same / complementary / eq} sticky ends (in plasmid and (human) gene)	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. the chemical could be a {transcription factor / hormone} ; 2. idea of interaction at (bacterial) cell (surface) membrane ; 3. idea of transcription factor being activated ; (e.g. transcription initiation complex formed, binds to transcription factor) or counters inhibitor ; 4. reference to promoter region ; 5. idea of transcription occurs e.g. RNA polymerase binds, mRNA produced ;	2. ACCEPT binds to cell surface membrane / passes through	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	(ribosome has) larger and smaller subunit / (ribosomal) protein and rRNA ;	ACCEPT ref to 2 subunits	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(iv)	1. larger lumen so easier to put into blood / eq ; 2. {less muscle / thinner wall} so easier to penetrate / eq ; 3. (blood) pressure less so less damage to vein / eq ; 4. idea that vein is easier to find;	ACCEPT converse when appropriate 3. ACCEPT (blood) pressure less so less blood loss 4. ACCEPT vein nearer the skin surface	(2)

Q24.

Question Number	Answer	Mark						
(a)	<table><tr><th>Region of the brain</th><th>One role while she is on the beam</th></tr><tr><td>Cerebellum</td><td>maintaining balance / coordination of movement / muscle control / eq ;</td></tr><tr><td>Medulla oblongata</td><td>regulation of {breathing / heart beat} / eq ;</td></tr></table>	Region of the brain	One role while she is on the beam	Cerebellum	maintaining balance / coordination of movement / muscle control / eq ;	Medulla oblongata	regulation of {breathing / heart beat} / eq ;	(2)
	Region of the brain	One role while she is on the beam						
	Cerebellum	maintaining balance / coordination of movement / muscle control / eq ;						
	Medulla oblongata	regulation of {breathing / heart beat} / eq ;						

Question Number	Answer	Mark
(b)	1. idea more blood flows near the skin surface / eq ; 2. due to {vasodilation / dilation of arterioles / eq} ; 3. {vasoconstriction / eq} of shunt vessels / eq ; 4. more blood to capillaries / eq ; 5. idea of more heat lost ; 6. via radiation ;	(4)

Question Number	Answer	Mark
(c)(i)	1. {in the knee / behind the knee cap} / {cross- shaped / two ligaments} ; 2. (connective tissue that) connects bone to bone / eq ;	(2)

Question Number	Answer	Mark
(c)(ii)	1. idea of smaller incision reduces chance of infection / eq ; 2. idea of smaller incision reduces recovery time ; 3. idea of smaller incision reduces likelihood of osteoarthritis / knee joint replacement later / eq ; 4. idea of smaller incision so less scar tissue / eq ; 5. idea of smaller incision so less blood loss / eq ; 6. idea of smaller incision so less pain / eq ; 7. use of local anaesthetic means less (associated) risk / eq ; 8. idea of cheaper related to fewer staff needed ;	(2)

Q25.

Question Number	Answer	Mark									
(a)	<table> <tr> <th>Labelled structure</th><th>Name of structure</th><th>One function</th></tr> <tr> <td>A</td><td>cerebellum ;</td><td>coordinates movement / balance / posture / fine motor control ;</td></tr> <tr> <td>D ;</td><td>hypothalamus ;</td><td>Thermoregulation</td></tr> </table>	Labelled structure	Name of structure	One function	A	cerebellum ;	coordinates movement / balance / posture / fine motor control ;	D ;	hypothalamus ;	Thermoregulation	(4)
Labelled structure	Name of structure	One function									
A	cerebellum ;	coordinates movement / balance / posture / fine motor control ;									
D ;	hypothalamus ;	Thermoregulation									

Question Number	Answer	Additional guidance	Mark
(b)	1. heat (energy) from blood in capillaries / eq ; 2. absorbed by sweat ; 3. used to break H bonds in water ; 4. reference to latent heat ; 5. (so) water evaporates ; 6. taking heat from the body / eq ;		(3)

Question Number	Answer	Additional guidance	Mark
(c)(i)	1. reference to arrival of { impulse / action potential / eq } ; 2. calcium ion {channels / eq } open in { pre-synaptic membrane / brain cell membrane / eq } ; 3. calcium ions enter (brain cell) through {diffusion / down concentration gradient } ; 4. causes (glutamate-rich) vesicles to {move towards / fuse with} pre-synaptic membrane / eq ; 5. {neurotransmitter / glutamate} release through exocytosis ;		(4)
Question Number	Answer	Additional guidance	Mark
(c)(ii)	1. idea that the damaged areas can be identified on MRI scan ;		

	2. idea that these damaged areas are known to be areas associated with the release of glutamate ; 3. comparison with and without domoic acid ;	3. ACCEPT in terms of comparison of brain regions or sea lions	(2)
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