Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 14 January 2025

Afternoon (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.*
- In the question 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.

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Answer ALL questions.

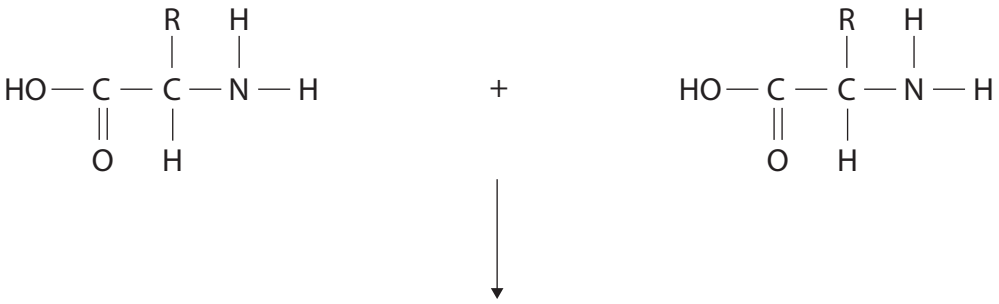
Write your answers in the spaces provided.

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 Proteins are one type of biological molecule.

(a) (i) Complete the diagram to show the molecules formed when these two amino acids join together.

(2)



(ii) Which is the type of reaction that joins these two molecules together?

(1)

☒ **A** condensation

☒ **B** decarboxylation

☒ **C** hydrolysis

☒ **D** phosphorylation

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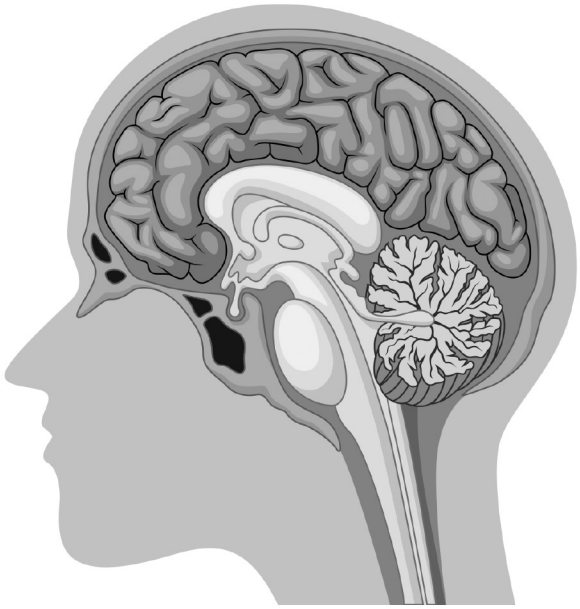
(b) Excess proteins are broken down into amino acids.

Describe what happens to these amino acids.

(3)

(Total for Question 1 = 6 marks)

2 The diagram shows a cross-section of the human brain.



(Source: © Rendix Alextian / Shutterstock)

(a) **Label the diagram** to show the locations of the pituitary gland (**P**), cerebellum (**C**) and hypothalamus (**H**).

(3)

(b) Complete the table to show **one** function of each part of the brain.

(3)

Part of the brain	Function
hypothalamus	
medulla oblongata	
pituitary gland	

(Total for Question 2 = 6 marks)

3 The kidney is an organ in the human body that is involved in blood filtration and the production of urine.

(a) (i) The afferent arteriole leading to the glomerulus is wider than the efferent arteriole leaving the glomerulus.

Which describes the effect that this produces?

(1)

- ☒ **A** it increases pressure in the glomerulus for ultrafiltration
- ☒ **B** it increases water movement by osmosis into the Bowman's (renal) capsule
- ☒ **C** it reduces the risk of capillary damage, due to high pressure
- ☒ **D** it reduces water reabsorption from the proximal tubule

(ii) In each hour, the kidneys will filter 6 000 cm^3 of blood.

How much blood will be filtered in 24 hours?

(1)

- ☒ **A** 124 dm^3
- ☒ **B** 144 cm^3
- ☒ **C** 144 dm^3
- ☒ **D** 1 440 cm^3

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(b) The table shows the relationship between the ADH concentration in blood, concentration of urine and the rate of urine production.

Percentage of maximum ADH concentration in blood (%)	Concentration of urine / a.u.	Rate of urine production / cm^3 $minute^{-1}$
0	90	20.0
25	700	8.0
50	950	4.0
75	1050	1.5
100	1150	1.0

(i) Calculate the volume of urine produced in **one** day with an ADH concentration of 75%.

Assume that the concentration of ADH stays constant throughout the day.

Give your answer in standard form.

(2)

Answer ..... cm^3

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(ii) Describe the effect of ADH concentration on the concentration of urine and the rate of urine production.

(2)

(c) Explain how ADH affects the movement of water from the lumen of the collecting duct into the blood.

(3)

(Total for Question 3 = 9 marks)

4 Sodium and potassium ions are involved in the transmission of nerve impulses along an axon.

(a) Describe how an action potential is produced in an axon.

(4)

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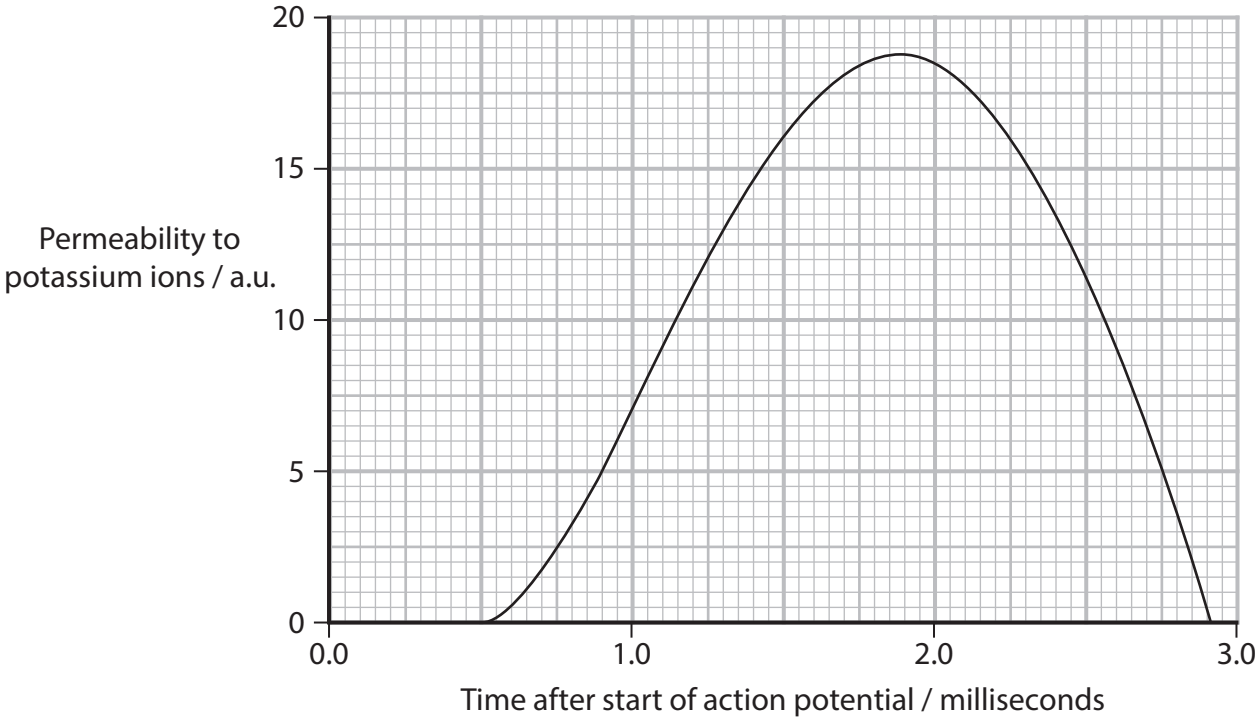
(b) Axon membranes are permeable to potassium ions.

The graph shows the permeability of an axon membrane to potassium ions after the start of an action potential.



Calculate the **maximum** rate of **increase** in permeability to potassium ions.

Give your answer to **two** significant figures with appropriate units.

(2)

Answer .....

(c) The resting potential in a neurone is the result of the difference in concentration of ions on the outside and inside of the axon when no impulse is being transmitted.

The table shows the concentration of ions outside and inside an axon.

(1)

Ion	Outside concentration / mol dm^{-3}	Inside concentration / mol dm^{-3}
Sodium (Na^+)	145	12
Potassium (K^+)	4	155
Chloride (Cl^-)	120	4

Which is the ratio of potassium ion concentration outside and inside an axon?

- ☒ **A** 0.026 : 1
- ☒ **B** 0.3 : 1
- ☒ **C** 0.083 : 1
- ☒ **D** 30 : 1

(d) (i) Explain the effect of an increase in temperature on the speed of a nerve impulse along an axon.

(2)

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(ii) The effect of axon diameter and myelination on the speed of an impulse in four neurones was investigated.

The table shows the results of this investigation.

Neurone	Axon diameter / μm	Myelination	Speed of impulse / ms^{-1}
A	2.5	yes	7.0
B	2.5	no	3.8
C	1.5	yes	4.0
D	1.5	no	2.5

Describe **two** conclusions that can be made from this data.

(2)

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(Total for Question 4 = 11 marks)

5 Insulin is a peptide hormone produced by the pancreas.

Insulin plays a crucial role in regulating blood glucose levels and maintaining homeostasis in the body.

(a) State what is meant by the term **homeostasis**.

(1)

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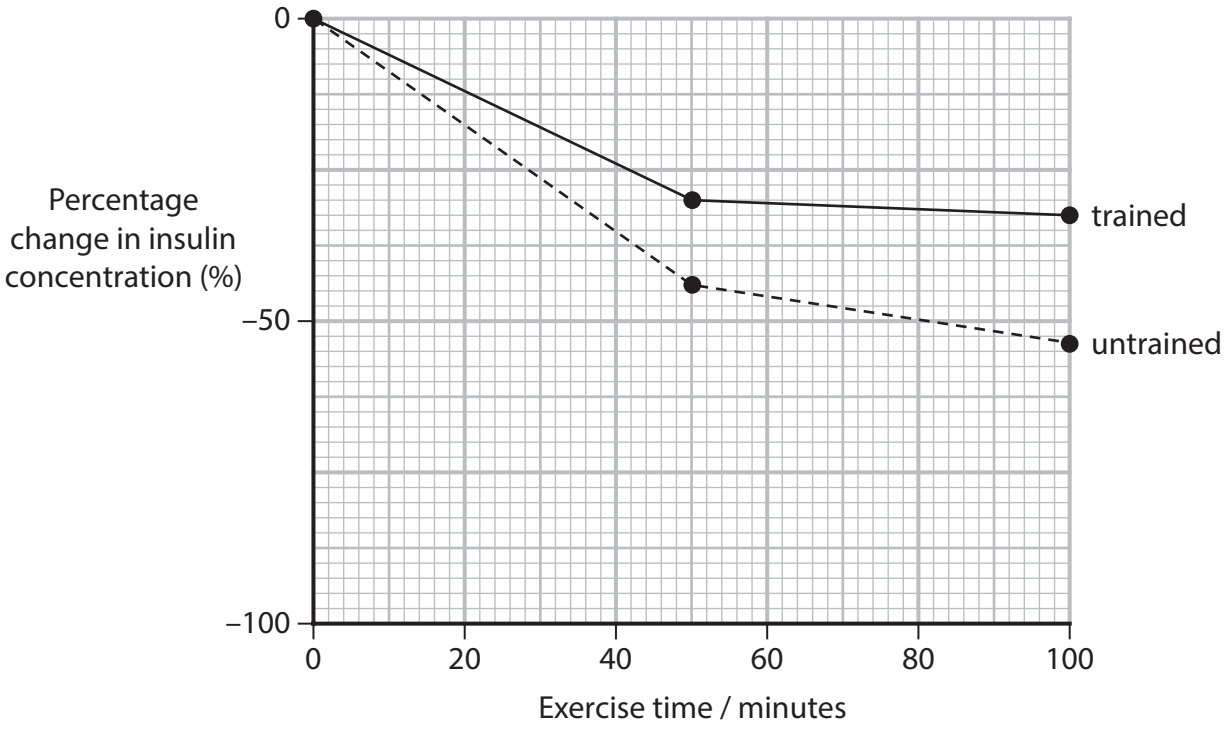
(b) The insulin concentration in blood is affected by many variables.

The effect of exercise on the concentration of insulin in the blood of trained and untrained individuals was investigated.

The graph shows the results of this investigation.

The graph compares the changes in insulin levels in an untrained individual and a trained individual.



Compare and contrast the changes in concentration of insulin in the blood of these two individuals.

(3)

(c) Diabetes is a disease that affects millions of people across the world.

Human insulin is a small molecule that consists of two polypeptide chains linked by disulfide bridges.

Insulin from animals can be used to treat diabetes.

Human insulin can now be synthesised using genetically modified bacteria.

(i) Describe how enzymes can be used to genetically modify the bacteria to produce human insulin.

(3)

(ii) Suggest **two** advantages of producing **human** insulin using genetically modified bacteria compared with insulin produced from animals.

(2)

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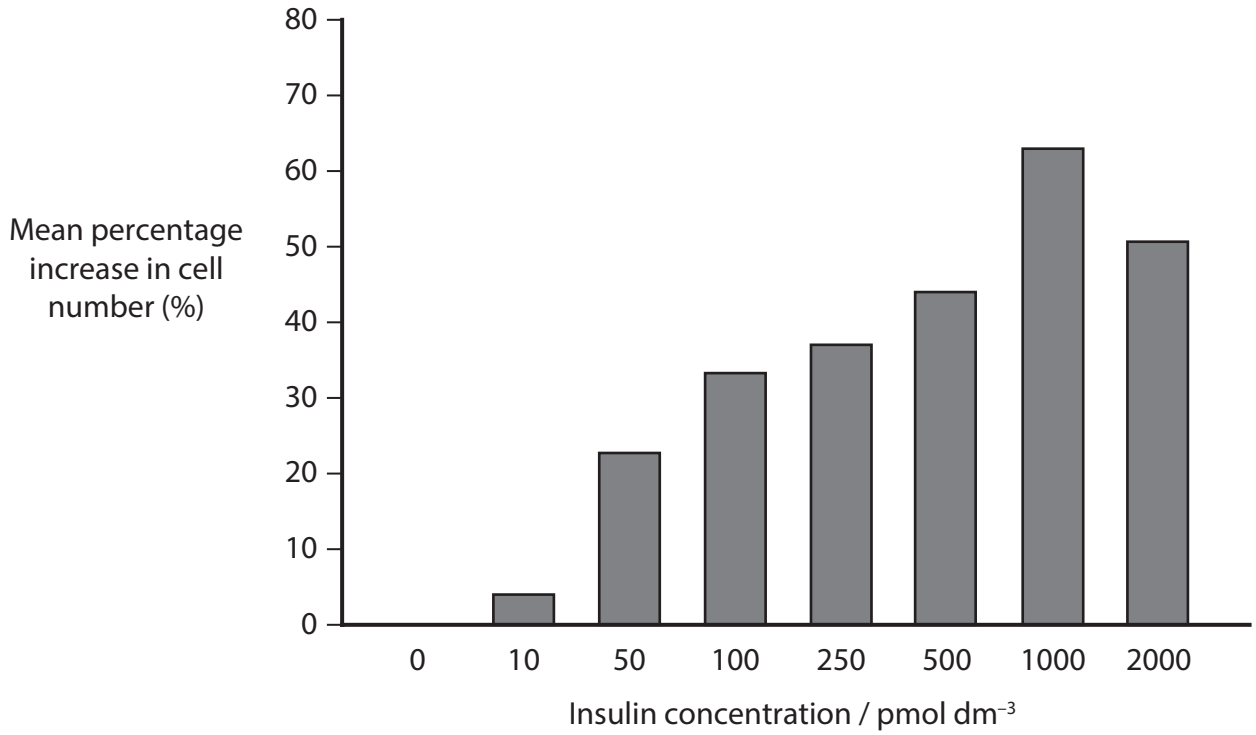
(d) Insulin is a peptide hormone that can stimulate cell division.

In an investigation, cells were incubated in solutions containing different concentrations of insulin.

After 48 hours, the increase in cell number was measured.

The results are shown in the graph.



(i) Give **one** reason why there is no bar on the graph for an insulin concentration at 0 pmol dm^{-3}.

(1)

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(ii) Describe how the investigation was designed so that error bars could be produced.

(2)

(iii) State how the error bars can be used to interpret the results of this investigation.

(1)

(Total for Question 5 = 13 marks)

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6 Neurotransmitters are involved in the transmission of a nerve impulse across a synapse.

(a) Which chemical would increase the likelihood of a nerve impulse being initiated at a post-synaptic membrane?

(1)

- ☒ **A** auxin
- ☒ **B** dopamine
- ☒ **C** gibberellin
- ☒ **D** statin

(b) Heart muscle cells obtain over 95% of their energy from oxidative phosphorylation.

When heart muscle cells are cultured in a low oxygen concentration they die.

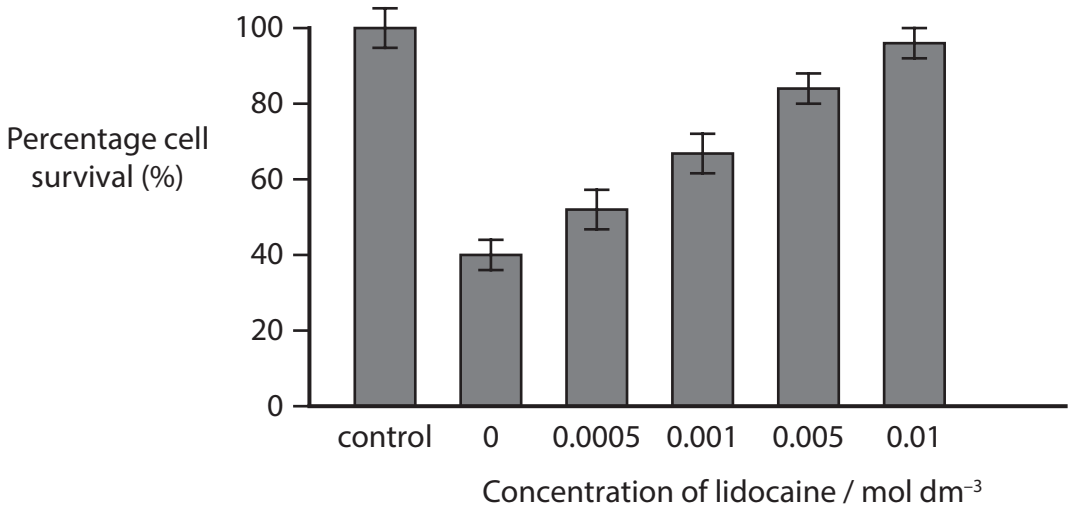
It has been suggested that lidocaine can be used to protect heart muscle cells from this cell death.

Lidocaine works by blocking the movement of sodium ions through the membranes surrounding the neurones. This prevents the initiation and conduction of impulses along the neurone.

In an investigation the effect of lidocaine on the cell survival of heart muscle cells cultured in a low oxygen concentration was investigated.

The control culture was given an excess of oxygen and no lidocaine. The other cultures had a low oxygen concentration and different concentrations of lidocaine.

The results are shown in the graph.



(i) Assess the effects of lidocaine on cell survival.

(3)

(ii) Heart muscle cells are myogenic.

Which describes the term **myogenic**?

(1)

☒ **A** a hormone that initiates differentiation

☒ **B** cardiac muscle that is able to contract with no external stimulus

☒ **C** how a heart beat is initiated in the atrioventricular node

☒ **D** how muscles work in pairs

(iii) Suggest how lidocaine protects heart muscle cells from effects of low oxygen.

(2)

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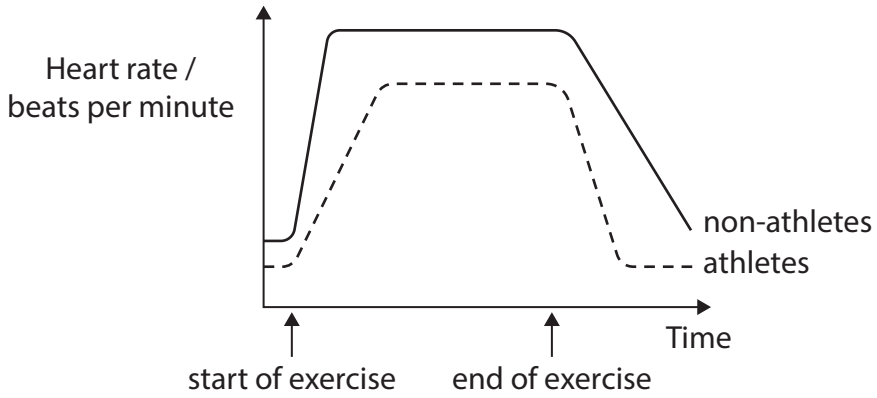
*(c) Cardiovascular disease (CVD) is one of the biggest causes of death in the world. In 2021, nearly 25% of all deaths were attributed to CVD.

Exercise can help prevent the onset and development of CVD.

In an investigation, the heart rates of athletes and non-athletes were measured before, during and after exercise.

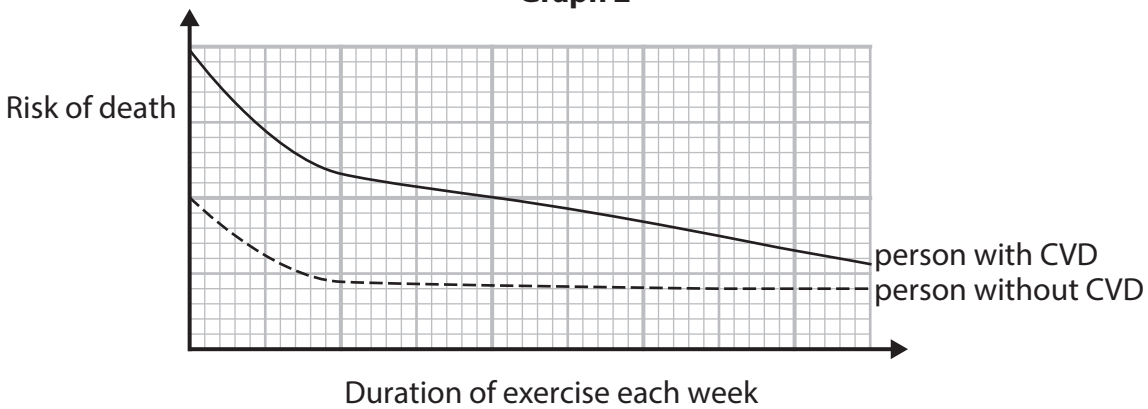
Graph 1 shows the relationship between heart rate and exercise for non-athletes and athletes.

Graph 1



Graph 2 shows how exercise can reduce the risk of death depending on whether the person has CVD or not.

Graph 2



Discuss how exercise reduces the risk of death from CVD.

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

(6)

(Total for Question 6 = 13 marks)

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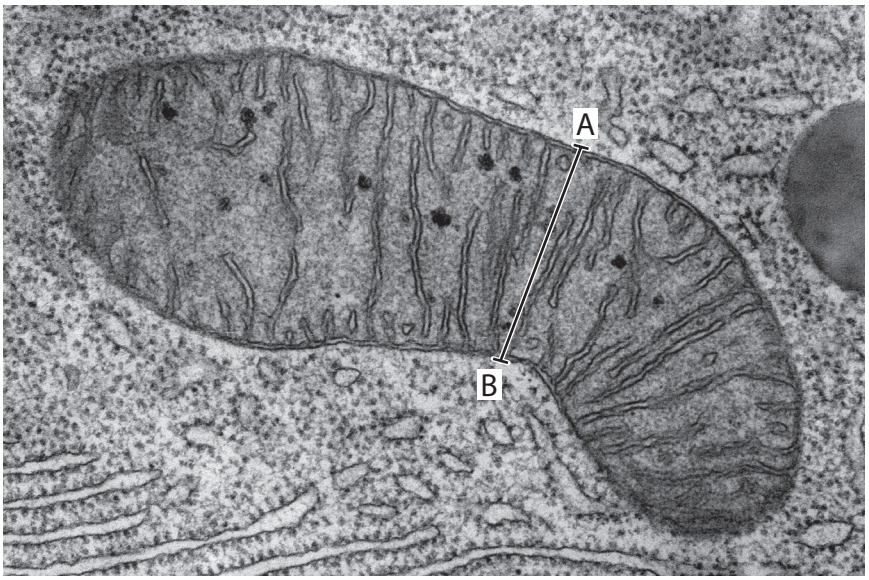
7 The photograph shows a mitochondrion.



(Source: © Science History Images/Alamy Stock Photo)

(a) The magnification of this photograph is ×23 500.

(i) Name the type of microscope that would be used to produce this image.

(1)

.....

(ii) Calculate the actual width of this mitochondrion between points A and B.

Give your answer in μm to **three** significant figures.

(2)

Answer ..... μm

(b) Respiration in a cell is composed of several processes.

(i) Which describes how ATP is synthesised by chemiosmosis?

(1)

☒ **A** hydrogen ions are pumped from the matrix to the intermembrane space through ATP synthase

☒ **B** hydrogen ions diffuse from the intermembrane space to the matrix through ATP synthase

☒ **C** hydrogen ions diffuse from the intermembrane space to the stroma through ATP synthase

☒ **D** hydrogen ions jump from the inner membrane to the outer membrane and out through ATP synthase

(ii) Amytal is a drug that inhibits the electron transport chain in respiration.

Which row of the table shows the changes caused by amytal when it is present in a cell?

(1)

	Oxygen used	Krebs cycle activity
☒ **A**	decreases	increases
☒ **B**	decreases	decreases
☒ **C**	increases	increases
☒ **D**	increases	decreases

(iii) Which molecule is required in the conversion of pyruvate to a 2 carbon compound in the link reaction of respiration?

(1)

☒ **A** oxidised NAD

☒ **B** oxidised NADP

☒ **C** reduced NAD

☒ **D** reduced NADP

(c) Name **three** products of Krebs cycle.

(2)

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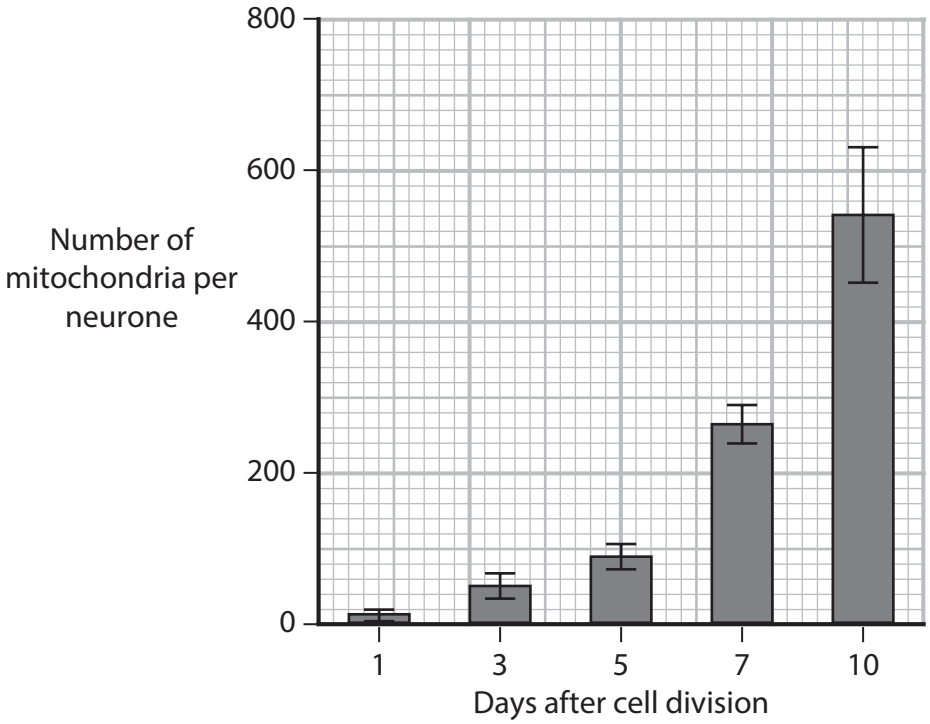
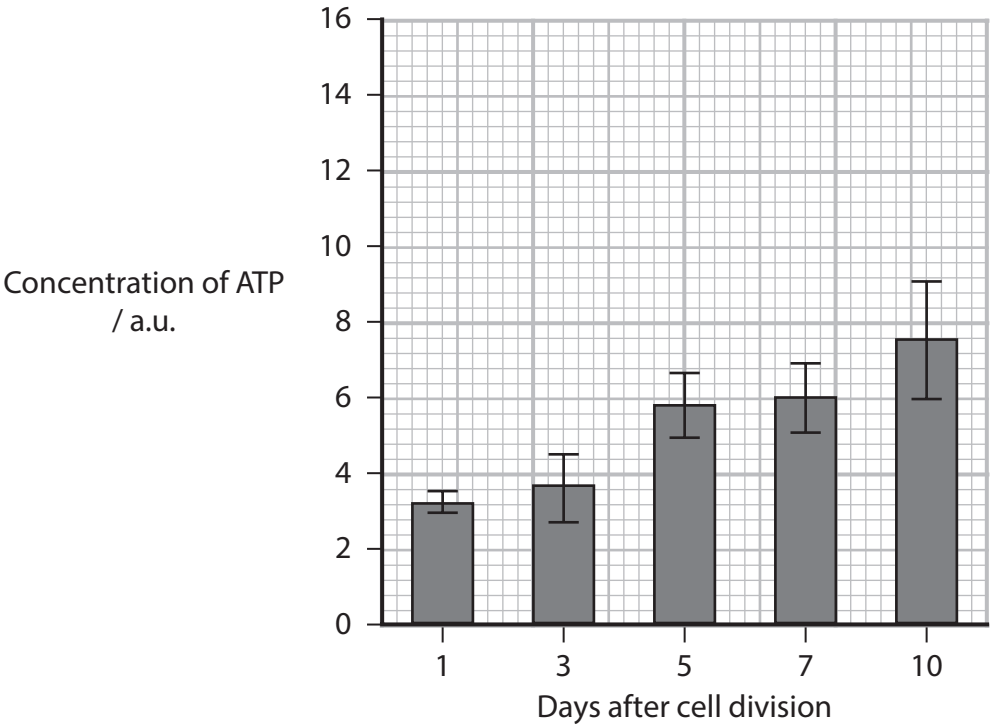
(d) As the brain develops some stem cells divide and differentiate into mature neurones, which requires ATP.

Mature neurones develop axons and form synapses with adjacent cells.

In an investigation, the number of mitochondria and the quantity of ATP made were measured after cell division and during differentiation of brain cells.

The graphs show the results of this investigation.





(Source: https://pubmed.ncbi.nlm.nih.gov/23212379/)

Comment on the conclusions that can be made from this investigation.

(4)

(Total for Question 7 = 12 marks)

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8 The scientific document you have studied is adapted from an article in the New Scientist: Thirsty work.

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

(a) Give **one** reason why 'optimal hydration' is beneficial (paragraph 1).

(1)

(b) Caffeine is a naturally occurring stimulant of the central nervous system.

Explain how caffeine present in an energy drink can affect the cells of the brain (paragraphs 3 and 32).

(3)

(c) Explain **one** reason why a 'typical man' has a larger daily requirement for water compared with a 'typical woman' (paragraph 9).

(2)

(d) Explain how the sodium ion concentration in the blood is kept within a narrow range (paragraph 17).

(5)

(e) Explain why 'cells shrink a bit' when blood electrolyte concentration increases (paragraph 21).

(2)

(f) Suggest how 'a high nitrate content' in beetroot juice can lead to an increased blood flow to muscles (paragraph 29).

(2)

(g) Describe how energy drinks could be shown to cause irregular heart rhythms. (paragraph 34).

(3)

(h) Explain **one** reason why some people are not able to tolerate cow's milk (paragraphs 30 and 31).

(2)

(Total for Question 8 = 20 marks)

TOTAL FOR PAPER = 90 MARKS

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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

Thirsty work

1 Drinking is essential for life, but if you find plain water too boring, there are many alternative drinks that promise optimal hydration or other benefits. How do they measure up, asks David Cox

2 RECENTLY, I have become somewhat obsessed with a new index on my smartwatch that purports to calculate whether I am sufficiently hydrated. The idea is to prompt the wearer to drink enough fluids to avoid dehydration. A watch tracking hydration might sound like a gimmick, but new research suggests there could be lasting health effects to being even mildly dehydrated.

3 One stumbling block I have faced on my hydration mission is that I find plain water, well, plain boring. But these days, there are a myriad other types of fluid available, from sports and energy drinks to coconut water. Then there's my personal favourite: coffee. Aside from taste, are any of these a suitable substitute, in terms of both my health and hydration? Do I even need to think this much about my fluid intake?

4 Our notions about what we ought to be drinking are confounded by half-truths and questionable health claims. So, here is a guide to modern hydration, cutting through the hype to discover the science about what we really should be drinking — and how much.

5 Water is the main constituent of the human body, making up around half of our adult body mass. The body's balance of water intake and output is tightly regulated to keep the concentration of salts and minerals, or electrolytes, in our blood at a precise level. To prevent dehydration, hormonal and neural mechanisms are activated, stimulating thirst to encourage water intake and increased water reabsorption by the kidneys to decrease water output.

6 The question of whether we are drinking enough for optimal health has been a matter of contention for decades. You may have heard that we should drink eight glasses of water per day, but this figure turns out to have no scientific basis.

7 The first scientific recommendation for our water requirements came from a rough calculation added to a set of dietary guidelines from the US National Academy of Sciences in 1945. It was achieved through estimating that the average male diet involved consuming about 2500 kilocalories of food per day and might require 1 millilitre of water per kilocalorie for digestive purposes, equating to a daily water requirement of 2.5 litres. One problem with this figure is that it arguably overestimates how much water we need to drink, as it doesn't take into account the fluid we ingest from our food, which makes up around 20 to 30 per cent of our intake.

8 Nevertheless, these estimates have stuck, helping to fuel a bottled water industry now worth around $240 billion in global sales. "In the US, it got marketed that everybody needed eight glasses of plain water. That made bottled water [sales] soar, even though water is something that you can get out of a tap for free," says Tamara Hew-Butler at Wayne State University in Detroit, Michigan.

9 To fully understand how much water is needed by the body each day, last year an international consortium tracked water input and loss in more than 5500 people by giving them water to drink labelled with an isotope of hydrogen. "We found a typical man in their mid-20s, in the US or Europe, will require around 1.5 to 1.8 litres per day, and a typical woman will require around 1.3 to 1.4 litres," says John Speakman at the University of Aberdeen, UK. "These are just averages, so if you're active and out a lot in hot weather, you will need more than 2 litres."

10 Drinking more water than you need, above thirst, usually isn't a problem, however, as the kidneys quickly adjust to produce more urine. While it is possible to drink such an excess to cause hyponatremia, where the kidneys are unable to cope and the sodium content of the blood becomes dangerously diluted, Speakman says that, in practice, this is rare.

11 Instead, a more pressing problem appears to be the consequences of repeatedly not meeting our daily water needs. The long-term effects of chronic underhydration haven't been well studied, but new data is starting to emerge. For example, a 2019 study in mice by Natalia Dmitrieva at the US National Institutes of Health and her colleagues showed that long-term suboptimal hydration caused inflammation, as well as accelerated age-related degeneration of the heart, kidneys and central nervous system. It also shortened the animals' lives by around six months, equivalent to 15 years in humans.

Hydration risks

(Source: © Dominka Zarzycka/Alamy)

12 The people who are most likely to experience dehydration probably aren't the ones rushing out to buy the latest hydration drink to hit the shelves: older adults. One study from earlier this year showed that a quarter of over 65s have low-intake dehydration due to consuming insufficient fluid each day. This has been linked to a range of common health problems, from impaired cognition to urinary tract infections.

13 One of the reasons why older people are more vulnerable to dehydration is linked to the thirst reflex. it has long been known that the sensation of thirst steadily deteriorates as we age.

14 On top of this, some medications can encourage fluid loss, and many older adults actively choose to drink less due to worries about accessing a toilet or incontinence, says Lee Hooper at the University of East Anglia in the UK.

15 "Older people also have smaller body water reserves, as body water is found in muscle which declines with age," she says. "They also concentrate urine less well, so they lose additional fluid when they go to the toilet, even when they haven't drunk enough."

16 To tackle this, Hooper believes that we need more public health messaging on the importance of staying hydrated with age, as well as better ways of detecting dehydration. One common recommendation has been to check the colour of your urine, as the darker the colour, the more dehydrated you are. However, given our kidneys are less able to concentrate urine as we age, this test may mistakenly suggest that you are adequately hydrated, says Hooper.

17 Now, Dmitrieva and her colleagues have investigated the impacts in humans of long-term mild dehydration, in which the body's water conservation mechanisms are activated to reduce urine output and blood sodium levels are slightly elevated but still within the normal range.

18 Using data gathered from 11,255 adults over a 30-year period, the researchers found that those with slightly elevated sodium levels displayed greater signs of biological ageing based on how well their heart, lungs, kidneys and immune systems were functioning.

19 "Detrimental effects of chronic underhydration on long-term health outcomes is a relatively new concept," says Dmitrieva. "It seems that insufficient hydration could promote accelerated ageing and therefore increase the risk of developing chronic diseases." Other research backs up this view. One 2020 study, for example, found that underhydration in people aged over 50 – as measured by elevated blood sodium levels and/or concentration of salts in urine – is associated with obesity and chronic diseases. However, it is possible that these biomarkers could be influenced by factors such as diet and the ingestion of sugary beverages.

Thirst quencher

20 How do you know if you are getting enough fluids? For most people, the first sign that you need a drink is thirst, although this isn't a fail-safe, as the so-called thirst reflex wanes as we get older (see "Hydration risks"). Other signs include a dry mouth, tiredness, darker-coloured urine and feeling lightheaded.

21 There are two main types of dehydration. One occurs when you lose fluid and electrolytes by sweating, for example during exercise, or by vomiting or experiencing diarrhoea. The other, known as low-intake dehydration, occurs through not drinking enough. "In this case, your electrolyte levels stay the same, but there's less fluid, so the concentration of your electrolytes rises across cells," says Lee Hooper at the University of East Anglia in the UK. "It means that cells shrink a bit and changes the environment inside them."

22 More research is needed before we have a clear view of the link between mild dehydration and our health. "Can drinking more reduce the risk of kidney stones?" asks Hew-Butler. "Another interesting question about hydration for me is the link to cognition. Does drinking make you more alert? These are things we need to understand more about."

23 Throughout most of human history, people would have replenished fluids by drinking plain water, whereas today, an ever increasing array of different options is available. Earlier this year, actor Florence Pugh spoke for many when she claimed that water is "too boring to drink", preferring elderflower pressé, orange juice and tea. Scientists agree that other options are fine. "Our message is that any [non-alcoholic] fluid is good fluid and if you want to drink tea then that's adding fluid into your body," says Jennie Wilson at the University of West London. "The same is the case for coffee. There is scant evidence for it acting as a diuretic and even if it does, that would require consumption of very large amounts."

24 But a visit to the supermarket reveals a vast array of drink options that claim to give you a boost in other ways, not just hydration. Known in the industry as "functional beverages", two main types take up much of the room on store shelves: energy drinks and sports drinks.

25 Sports drinks are formulated to replace fluids and electrolytes, such as sodium, potassium and calcium, in the body during and after exercise. Originally developed for athletes, many are now marketed to the general public, though it is questionable whether these drinks offer any notable benefits over water for the average person.

26 Water is more than sufficient for the casual jogger or someone who goes to the gym a couple of times a week, says David Rowlands at Massey University, New Zealand. "Most of these sports drinks were designed for high performance," he says. "For most people, exercising half an hour to an hour, they might lose 1 litre of fluid at the most, which can easily be replaced with four cups of water over the couple of hours following exercise."

27 Many sports drinks are isotonic, which means they contain similar concentrations of sugars and salts to blood. However, they are still less effective than water at hydrating the body because the sugars they contain tend to be simple sugars like fructose, glucose and sucrose, which are rapidly digested as soon as they hit the small intestine, creating a higher concentration of sugars in the gut, says Rowlands. "The problem is that the gut can only absorb so much sugar at a time," he says. "The maximum rate seems to be around 1 gram per minute. If there's more sugar than that coming in, the body holds water back, which limits the amount of fluid getting into the body."

Good hydrations

28 For serious amateur or professional athletes, hypotonic drinks – which still contain some carbohydrates and salts, but at a lower concentration than in blood – have been shown in some studies to be the best hydration agents. This is because of a phenomenon called solvent drag, where the steady absorption of carbohydrates and electrolytes through the gut helps draw more water into the bloodstream. Rowlands suggests that coconut water could be an alternative as it contains low concentrations of carbohydrates and electrolytes, similar to the formulation of hypotonic sports drinks.

29 Another drink touted for its ability to boost sports performance is beetroot juice, but this isn't to do with hydration. "This is more something that serious athletes take because it has a high nitrate content, which improves blood flow to the muscles," says Rowlands. "There's some suggestion it can improve performance in high level amateurs."

30 While purchasing sports drinks can be expensive, an effective rehydrating drink – providing both the fluid and nutrients that the body needs to recover from exercise – can be obtained very cheaply: cow's milk. "Milk is actually the best recovery drink of all," says Hew-Butler. "Everyone's looking for this elusive beverage that does everything, but if you can tolerate milk, it ticks all the boxes because it has protein and carbohydrates and other nutrients."

31 Milk and chocolate milk contain carbohydrate in the form of lactose, as well as amino acids to aid muscle synthesis, and both have been shown to assist recovery following exercise. Rowlands says that the sheer number of nutrients within milk bind to water and keep sufficient levels of fluid within the body, rather than being urinated out. But don't expect this news to dent the rise of the increasingly popular sports drink sector any time soon.

32 Energy drinks are another fast growing product, worth around $46 billion globally in 2020. Particularly popular among young people, these are formulated to give an instant energy boost through stimulants such as caffeine, guarana and taurine. Many also contain a high dose of sugar. Red Bull, for example, contains 27 grams of sugar per 250 millilitre can, almost the entire 30 milligrams daily recommended maximum sugar intake for adults in the UK, as well as 80 milligrams of caffeine, which is roughly the same as that in a cup of coffee.

33 However, sugar-free varieties are on the rise. One of the latest is the popular drink Prime Energy, founded by social media stars Logan Paul and KS1, which contains 200 mg of caffeine per 355 ml can sold in the US or 140 mg per 330 ml can in the UK.

(Source: © Nurphoto/Getty Images)

So many different drinks are available, but is water better?

34 While energy drinks may keep you alert in the short term, they are associated with poorer sleep quality and can be problematic for anyone with heart conditions, due to the increased risk of palpitations or irregular heart rhythms – which is why these drinks carry warnings for people sensitive to caffeine and some are restricted to those over the age of 18.

35 Evidence also suggests that sugary energy drinks may have a dehydrating effect as they are hypertonic, meaning they contain a higher concentration of salt and sugar than in blood. "Hypertonic drinks actually draw fluid out of the body to aid in digestion," says Rowlands.

36 Another current trend in the beverage industry is the addition of ingredients such as ginseng, green tea, turmeric, vitamins and even protein to drinks. But Hew-Butler is sceptical about the health benefits. "A lot of it is just marketing," she says. "if you're eating a good diet, they're things that you'll be getting from your food anyway."

37 Where does all this leave me in my mission for better hydration? As a coffee lover, I am particularly pleased to know that it contributes to my daily hydration requirements. And while having a watch with an inbuilt monitor may seem a little excessive, it definitely acts as a useful reminder to consume extra fluids, particularly on busy days when it is easy to go many hours without drinking. As to whether it really makes any difference to my long-term health, I will have to wait and see.

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