Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 4 June 2026

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.*
- 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 Scientists use genetic modification to improve food crops such as drought-resistant maize.

The photograph shows a field of genetically modified (GM) maize.



(Source: © Pearson Asset Library)

(a) DNA is made up of mononucleotides.

(i) Which are found in a DNA mononucleotide?

(1)

☒ **A** deoxyribose sugar and uracil

☒ **B** deoxyribose sugar and thymine

☒ **C** ribose sugar and uracil

☒ **D** ribose sugar and thymine

(ii) Which bonds join mononucleotides together to form a single polynucleotide chain?

(1)

☒ **A** glycosidic bonds

☒ **B** hydrogen bonds

☒ **C** peptide bonds

☒ **D** phosphodiester bonds

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(b) A biotechnology company used the CSP8 gene from bacteria to genetically modify maize.

The CSP8 gene codes for a protein that protects plants from the effects of drought.

(i) Describe the role of **enzymes** in the production of recombinant DNA for use in genetic modification.

(2)

(ii) Discuss the advantages **and** disadvantages of growing drought-resistant genetically modified maize.

(4)

(Total for Question 1 = 8 marks)

2 The photograph shows the eyes of a tarsier.



(Source: © Pearson Asset Library)

Several species of tarsier are found in Southeast Asia.

(a) (i) The eyes of this species of tarsier are spherical.

Each eye has a diameter of 16 mm.

Calculate the volume of **one** eye.

The equation for the volume of a sphere is:

$$V = \frac{4}{3}\pi r^3$$

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

(2)

Answer ..... mm^3

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(ii) In another species of tarsier the volume of one eye is 2.0 cm^3 and the volume of its head is 14.0 cm^3.

Calculate the percentage volume of the tarsier's head that is occupied by both of its eyes.

(1)

Answer ..... %

(iii) The photograph of the tarsier was taken in daylight.

Tarsiers are animals that feed at night.

Suggest how the size of the eyes of the tarsier enables it to feed at night.

Use the information in the photograph to support your answer.

(2)

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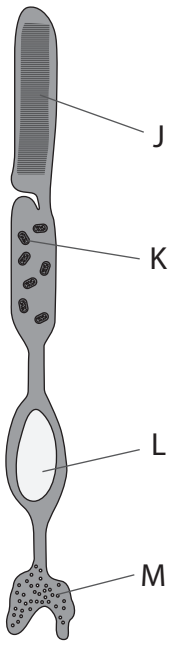
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(b) The diagram shows a rod cell.



(i) Which letter identifies the structure that provides energy in this rod cell?

(1)

☒ **A** J

☒ **B** K

☒ **C** L

☒ **D** M

(ii) The retina of the tarsier has a very large number of rod cells.

Explain how rod cells enable tarsiers to have good night vision.

(2)

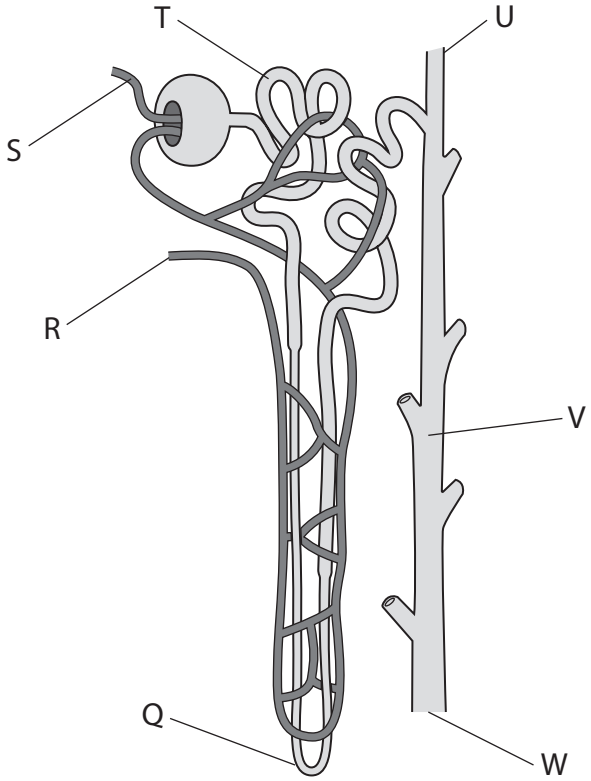
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3 The kidney is an organ responsible for the removal of waste materials and osmoregulation.

(a) The diagram shows a mammalian kidney tubule (nephron).



(i) Which letter identifies the structure responsible for the selective reabsorption of solutes?

(1)

☒ **A** Q

☒ **B** S

☒ **C** T

☒ **D** V

(ii) Give the letter that identifies the structure that carries blood:

1. into the nephron
2. away from the nephron.

(1)

1. .....

2. .....

(iii) Describe how glucose is selectively reabsorbed in this kidney tubule.

(3)

(b) The table shows the ratio of thickness of the medulla compared with the thickness of the cortex in a kidney in five mammals.

Mammal	Habitat	Ratio of medulla : cortex
Fennec fox	dry desert	5.4 : 1
Kangaroo rat	dry desert	7.0 : 1
Camel	dry desert	4.7 : 1
Cow	temperate grassland with plenty of rainfall	1.7 : 1
Beaver	freshwater wetlands	1.3 : 1

(i) The meerkat is another mammal that lives in a dry desert habitat.

Estimate a value for the medulla : cortex ratio in a meerkat.

(1)

Answer .....

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(ii) The fennec fox lives in hot deserts with very little water.

The fennec fox has a diet mainly of insects and plants.

Suggest how the kidney tubules enable the fennec fox to survive in a habitat with very little water.

(3)

(Total for Question 3 = 9 marks)

4 Emperor penguins live in very cold conditions in the Antarctic.

The photograph shows some adult emperor penguins and their chicks.



(Source: © Pearson Asset Library)

(a) A low surface area to volume ratio is an advantage for thermoregulation in these animals.

(i) The mean surface area of an adult emperor penguin is 1.037 m^2.

The mean volume of an adult emperor penguin is 0.0706 m^3.

Calculate the surface area to volume ratio (SA : V) of an adult emperor penguin.

Give your answer to **two** decimal places.

(1)

Answer ..... : 1

(ii) Emperor penguins are birds.

Give **one other** adaptation of emperor penguins, shown in the photograph, that also reduces heat loss.

(1)

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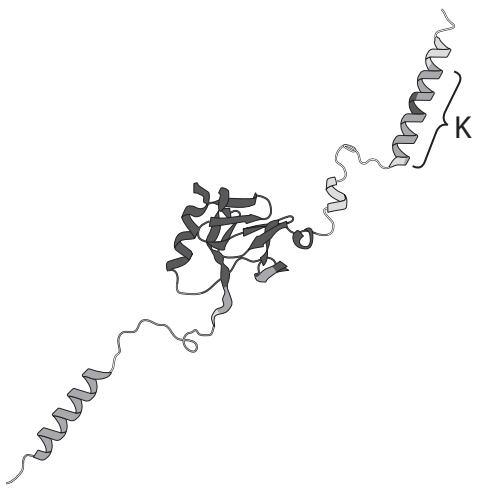
(iii) Suggest how the nervous system of an emperor penguin could be involved in maintaining a constant body temperature.

(3)

(b) Emperor penguins have a peptide hormone called arginine vasotocin (AVT).

In birds, AVT has the same role as antidiuretic hormone (ADH) in mammals.

The diagram shows the structure of AVT.



(i) Which type of structure does the part labelled K represent?

(1)

- ☒ **A** globular
- ☒ **B** microfibril
- ☒ **C** primary
- ☒ **D** secondary

(ii) The peptide hormone AVT is produced in the hypothalamus of birds.

This hormone stimulates the production of water channels (aquaporins) in the cells of the collecting duct.

Describe how AVT produced in the hypothalamus could stimulate production of water channels in the collecting ducts of the kidney.

(4)

(Total for Question 4 = 10 marks)

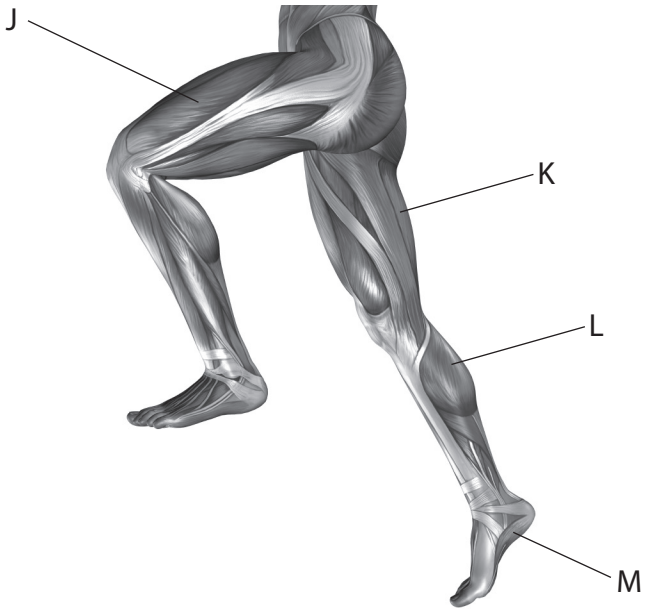
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5 Muscles are required for movement.

(a) For movement, pairs of antagonistic muscles must work together.

The diagram shows some leg muscles.



(Source: © Gehrke/Shutterstock)

(i) Which letter represents an extensor muscle?

(1)

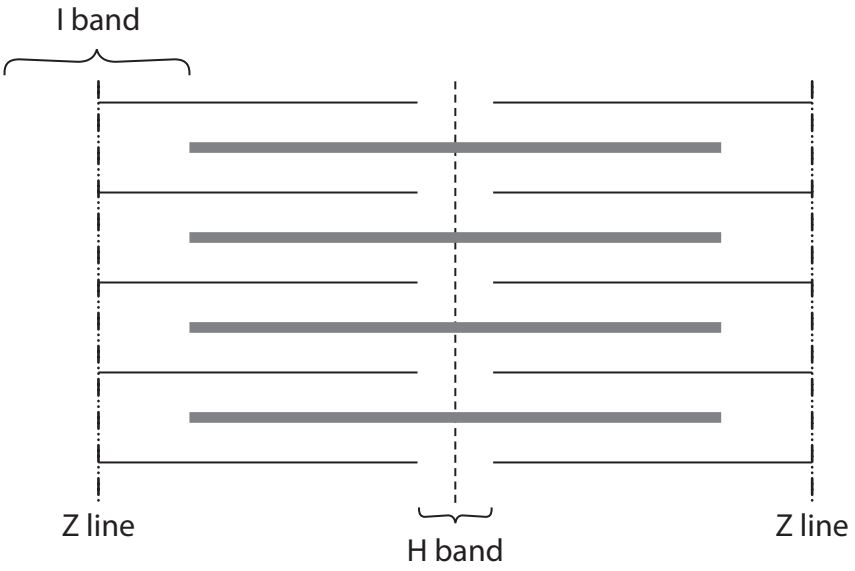
☒ **A** J

☒ **B** K

☒ **C** L

☒ **D** M

(ii) The diagram shows one sarcomere.



Which combination of statements is correct about sarcomeres in a muscle that is contracting?

1. each sarcomere will have become shorter
2. the H band will have become wider and the I band narrower
3. the distance between the Z lines will have become shorter

(1)

☒ **A** statements 1 and 2

☒ **B** statements 1 and 3

☒ **C** statements 2 and 3

☒ **D** statements 1, 2 and 3

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(b) The hearts of athletes can produce large stroke volumes.

An athlete has a heart rate of 128 beats min^{-1} and a cardiac output of 37 dm^3 min^{-1}.

Calculate the stroke volume of this athlete.

Use the equation:

cardiac output = stroke volume × heart rate

Give your answer in cm^3.

(2)

Answer ..... cm^3

(c) There are two main types of muscle fibre, slow twitch and fast twitch.

The table shows the muscle fibre composition of the muscles of a distance runner, a sprinter and a non-athlete.

Type of athlete	Muscle fibre composition (%)	
	Slow twitch	Fast twitch
Distance runner	70 to 80	20 to 30
Sprinter	25 to 30	70 to 75
Non-athlete	47 to 53	47 to 53

Deduce why a sprinter has the muscle fibre composition shown in this table.

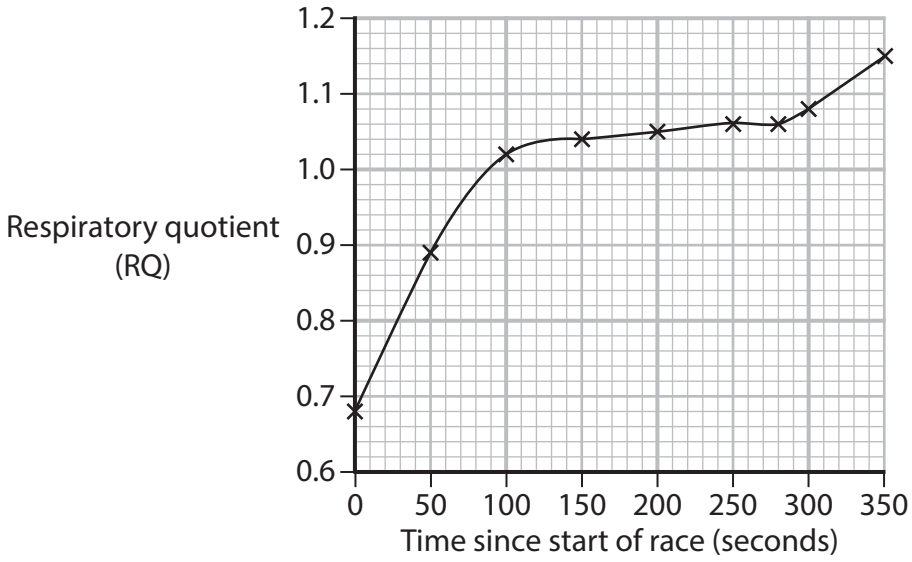
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(d) During a 1500 m race, the respiratory substrate used by the muscles of an athlete will change.

The graph shows the change in respiratory quotient (RQ) of an athlete during a 1500 m race.



(i) State the meaning of the term **respiratory quotient (RQ)**.

(1)

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(ii) Calculate the change in RQ in the last 50 seconds of the race.

(1)

Answer .....

(iii) The table shows the RQ values for some respiratory substrates.

Conditions	Respiratory substrate	Respiratory quotient (RQ)
Aerobic respiration	Lipid	0.7
	Carbohydrate	1.0
Anaerobic respiration	Carbohydrate	>1.0

Suggest why the RQ changes during the 1500 m race shown in the graph.

(3)

(Total for Question 5 = 12 marks)

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6 The nervous system is a rapid communication system within animals.

Scientists have studied how conduction velocity of impulses along a neurone is affected by axon diameter and myelination.

The table shows some of the results of these studies in five animals.

Animal	Axon diameter / μm	Myelination	Conduction velocity / $m\,s^{-1}$
Lobster	400	No	20
Earthworm	60	No	10
Frog	20	Yes	30
Human	15	Yes	120
Cat	10	Yes	50

(a) Describe **three** conclusions that can be drawn from the data in the table.

(3)

(b) Myasthenia gravis is an autoimmune neuromuscular disorder where the immune system destroys some acetylcholine receptors.

(i) Describe how the neurotransmitter, acetylcholine, causes membrane depolarisation in a post-synaptic neurone.

(3)

(ii) The symptoms of myasthenia gravis include muscle weakness.

Explain how loss of acetylcholine receptors in myasthenia gravis results in muscle weakness.

(2)

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(iii) Acetylcholinesterase is an enzyme in the synapse that breaks down acetylcholine.

Drugs that inhibit this enzyme can be used to treat myasthenia gravis.

Explain how these drugs help to reduce the muscle weakness caused by this disorder.

(2)

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(Total for Question 6 = 10 marks)

7 Plants have molecules that help to regulate their responses to environmental stimuli.

(a) Phytochromes are a group of molecules with roles in the germination of seeds.

(i) Which row in the table is correct for phytochrome Pfr (P_{730}) and phytochrome Pr (P_{660})?

(1)

		Breaks down in the dark	Absorbs red light
☒	**A**	Pfr	Pr
☒	**B**	Pfr	Pfr
☒	**C**	Pr	Pfr
☒	**D**	Pr	Pr

(ii) In an investigation, five groups of seeds were each exposed to different sequences of light treatments.

The table shows the sequence of light treatments for each group and the effect on germination of the seeds.

Group	Sequence of light treatments				Percentage germination (%)
1	Dark				4
2	Red	Dark			88
3	Red	Far red	Dark		2
4	Red	Far red	Red	Dark	98
5	Red	Far red	Red	Far red	4

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Which of the following conclusions can be made from this data?

(1)

1. the first light treatment in the sequence determines whether germination of the seeds occurs
2. Pfr causes germination of the seeds
3. Pr causes germination of the seeds

☒ **A** 2 only

☒ **B** 3 only

☒ **C** 1 and 2 only

☒ **D** 1 and 3 only

(iii) Describe how the active form of a phytochrome can promote germination in seeds.

(3)

(b) Auxin (IAA) is a growth factor found in the roots of plants.

The effect of auxin (IAA) on the growth of the roots of plants kept at normal light intensity or low light intensity was investigated.

The masses of the roots, their length and the number of side roots formed were recorded and the means determined.

The table shows the results of this investigation.

Light intensity	Mean root mass / mg	Mean root length / cm	Mean number of side roots
Normal	80	47.5	28.0
Low	56	30.7	28.0

(i) Calculate the percentage difference in the mean length of the roots from plants grown at normal light intensity compared with plants grown at low light intensity.

$$\text{percentage difference} = \left(\frac{\text{difference between two means}}{\textbf{mean} \text{ of the two means}} \right) \times 100$$

Give your answer as a whole number.

(2)

Answer ..... %

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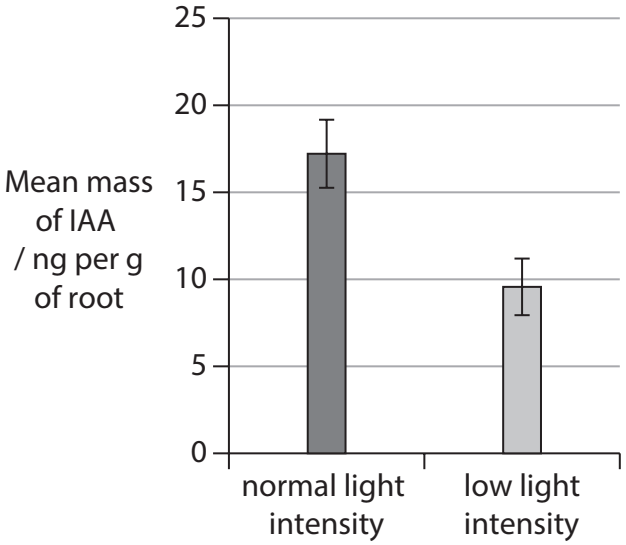
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QUESTION 7(b)(ii) BEGINS ON THE NEXT PAGE

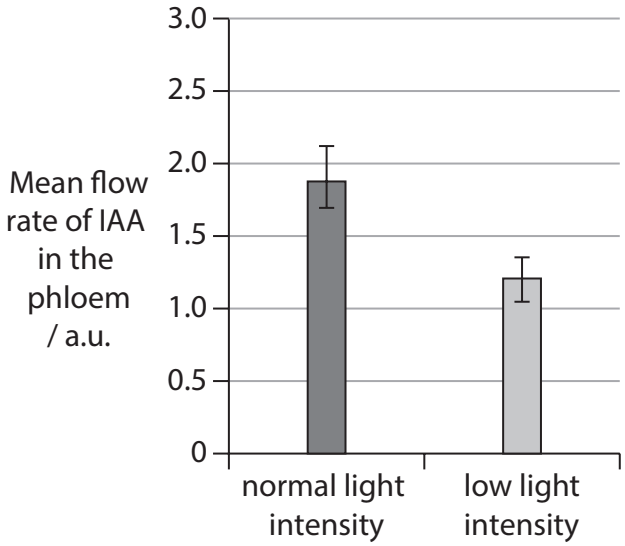
*(ii) Data on the IAA in the roots of plants growing at normal or low light intensities was also collected.

Graph 1 shows the mean mass of IAA per gram of root.



Graph 1

Graph 2 shows the mean flow rate of IAA in the phloem at normal and low light intensities.



Graph 2

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Explain why the roots of plants grown under low light intensity are shorter than those grown under normal light intensity.

Use the information in all of part (b) and your own knowledge to support your answer.

(6)

(Total for Question 7 = 13 marks)

8 The scientific document you have studied is adapted from an article in *New Scientist* entitled Beyond tired: Why fatigue sets in and how to tackle it (September 2022).

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

(a) Explain how energy is used in muscle contraction during 'a hard workout' when a muscle fibre contracts (paragraph 5).

(3)

(b) Describe how 'a mismatch' can be identified and how negative feedback maintains systems within narrow limits (paragraph 8).

(2)

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(c) Describe **one** method of detecting the brain activity of the volunteers (paragraph 11).

(2)

(d) Explain the role of oxygen in the release of 'more energy to work harder' (paragraphs 13 and 14).

(3)

(e) Explain how the body can increase the transport of more oxygen to active areas (paragraph 16).

(4)

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(f) Explain how inflammation helps the body respond to infection (paragraph 19).

(4)

(g) Suggest why 'the Parkinson's medication L-DOPA' might reduce the symptoms of fatigue (Paragraph 31).

(2)

(Total for Question 8 = 20 marks)

TOTAL FOR PAPER = 90 MARKS

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GradeMax

Pearson Edexcel International Advanced Level

Thursday 4 June 2026

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

Beyond tired: Why fatigue sets in and how to tackle it

1. If it feels like you have been running on empty recently, you aren't alone. Amid the turmoil of the past few years, a bone-weary sense of tiredness has become a familiar part of life for many.

2. Fatigue might be the most universal experience of the pandemic. It is one of the primary symptoms of both covid-19 and long covid, as well as the burnout depression that have accompanied the stress of the past two-and-a-half years. Even Zoom fatigue, exhaustion brought on by video meetings, has become a recognised phenomenon.

3. One silver lining of all this is that it has brought fatigue, both in its everyday and more persistent forms, to the forefront of the scientific agenda. For decades, fatigue was dismissed as a fuzzy symptom with no clear biological origin.

4. Now, research is revealing that it is the result of an ongoing conversation between the body and the brain about how much cellular energy is available. A better understanding of the many pathways involved is bringing hope for tackling it. With chronic fatigue affecting nearly 1 per cent of the global population (a number that could now be an underestimate due to long covid), and 25 per cent of healthy people reporting regular struggles with fatigue, finding new avenues for relief has never been more important.

5. There are many different drains on our energy that can act as triggers of fatigue. Exhaustion can follow a bout of flu, a hard workout, a long day at the office or it can be due to a post viral syndrome such as long covid. While these causes of fatigue are very different, how they manifest in the brain is remarkably similar. The thing that varies is what saps the body's energy and whether there are any barriers that stop it from being restored.

6. "The analogy I always give is if there's a forest fire in front of you, it could have been [caused by] a careless smoker, it could have been a lightning strike or it could have been a firework. But the end result is this forest fire," says Michael VanElzakker, a neuroscientist at Tufts University in Massachusetts.

7. In the brain, there are four key areas that keep track of available cellular energy and work together to predict whether the outcome of performing a task will be worth the investment needed to act.

8. Two of these regions, the insula and the anterior cingulate cortex, are part of the brain's interoception network, which is in charge of monitoring the body's internal state. Their job is to keep track of energy levels and how hard the body and brain are working, and to flag if there is a mismatch. The other two brain regions are the prefrontal cortex, which is important for self-control and future planning, and the striatum, part of the brain's reward network, which signals the potential pay-off.

9. These four regions perform a cost-benefit analysis to determine how much energy is available and whether an action is, biologically speaking, worth the effort. When cellular energy levels are low, the benefit must be higher to outweigh the energy cost. If the sums don't add up, fatigue sets in.

10. This analysis is carried out by the fatigue network, the output of which is motivation. While motivation is a loaded term, in a scientific context it isn't about desire or willpower, it is about managing resources. "The fact that you're not willing to expend effort for a reward doesn't mean that you're lazy," says Andrew Miller, a psychiatrist at Emory University in Atlanta, Georgia. "It means that your body is doing a certain calculus, and that calculus is that I don't have the energy reserves to expend in order to go and do that activity."

11. Scientists have seen this relationship between motivation and fatigue in healthy volunteers performing tedious memory and attention tasks. After concentrating for long periods, performance starts to decline and they report feelings of fatigue. In the brain, this shows up as a decrease in activity and connectivity in that fatigue network. However, if at the end of the experiment people are offered a monetary bonus based on their scores, they become reincentivised to put in more effort, and they subsequently perform better and show increased brain activity again. With money on the line, the brain deems the reward to be worth the effort again.

Problems with energy supply

12. Even with incentives, though, after an extended period of concentration, our cellular energy stores become depleted, metabolic by-products begin to build up and performance starts to decline. The same is true for physical effort: people show an initial burst of brain activity in parts of the fatigue network during a test of strength, but there is a decline in activity in the circuit as muscle strength runs out.

13. Usually, this is temporary. After resting, sleeping or eating, energy stores are replenished and you no longer feel fatigued. With chronic forms of fatigue, though, this doesn't happen. Research is beginning to reveal why, by focusing on problems in the production of energy in the cells, or the way the body delivers energy to where it is needed.

14. When you perform a challenging task, either mental or physical, your brain or muscles require more energy to work harder. Part of that extra energy comes from increased blood flow, which carries more oxygen to the active area, and part comes from tapping into the body's glucose reserves.

15. There is evidence that in some cases of myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS), for reasons that aren't known, the body switches from using glucose to a less efficient fuel source, such as fats or amino acids. Other studies have shown that the cells in people with ME/CFS are unable to produce enough energy, both before and during a period of stress, which may explain why fatigue gets worse after physical or mental exertion. It is possible that this happens because cells are unable to get sufficient oxygen and glucose from the blood to make energy in the cells. Or, it could be that the flow of blood around the body is disrupted.

16. Betsy Keller, an exercise scientist at Ithaca College in New York, thinks one explanation may involve the brainstem. Ordinarily, a message is sent from the muscles to the brainstem when more oxygen is needed. The brainstem relays that message to the heart and lungs through the autonomic nervous system, which raises heart rate, blood pressure and respiration to increase delivery of oxygen via the blood.

17. According to Keller, some cases of chronic fatigue could be explained by a problem in the brainstem that results in this message not being communicated properly. Without extra oxygen-rich blood flow, cells can't produce enough energy, so they get fatigued faster and take longer to recover. "Based on what we see clinically, and when you consider how the brainstem impacts blood flow and oxygen delivery to the muscles, they tend to align pretty well; the brainstem is not functioning [properly]," she says.

18. Another possibility is that there is a problem with the blood itself. Recent studies have found that people with current covid-19 infections, long covid and ME/CFS have higher than average levels of microscopic blood clots, which can block small blood vessels and impede oxygen delivery. One treatment that is being explored to alleviate this in people with long covid is hyperbaric oxygen therapy, in which volunteers breathe pressurised oxygen-rich air while in a hyperbaric chamber. Early results suggest that the treatment reduces fatigue, pain and brain fog.

19. Another explanation for chronic fatigue is inflammation, the body's first line of defence against injury or infection. Inflammation involves the release of proteins called cytokines that help ready the rest of the immune system for action. Cytokine release is also stimulated by stress to prepare the body for potential injury in times of danger. Whatever the cause, one of the most notable side effects of all this activity is that is makes you feel lousy: tired, heavy and with a general feeling of "please let me lie on this couch and never move again".

20. "Cytokines are effective in inducing sleep or fatigue, and it's adaptive," says Craig Heller, a neurobiologist at Stanford University in California. "If you have an infection, you want to decrease the amount of energy you're spending on unnecessary activities."

21. Brain imaging studies have shown that a surge in cytokines – such as when people are experimentally injected with an immune-stimulating substance or given cytokines as part of a treatment for viral infections – dampens brain activity in the striatum, leading to reduced incentive to move and a general feeling of malaise. Researchers think this is the result of a signal sent to the brain to conserve energy so that all available resources can be used to fight the infection.

22. "An activated immune system takes up a tremendous amount of energy," says Miller. "The thought of spending any energy to do anything [else] is put into the calculus of what the immune system needs, and the answer that comes out is, 'No, don't have the energy'."

23. In an ideal situation, the inflammation – and fatigue – resolve once the body has cleared the infection or the source of stress is removed. But if the inflammation becomes chronic, that malaise can set in for the long haul.

24. Miller's work has shown that chronic inflammation is common in people with ME/CFS, and that it correlates both with disrupted activity in the striatum and the fatigue that people report. Curiously, his work also suggests that some people with treatment-resistant depression experience similar inflammation and changes to the fatigue network that are seen with both short-lived ailments and chronic fatigue.

25. It is unclear what triggers the persistent inflammation that can occur in depression. For many types of fatigue, though, one idea is an unresolved viral infection.

26. VanElzakker thinks that in some cases of chronic fatigue, and possibly long covid, the cause is an infection of the vagus nerve. Receptors for this nerve, which provides a direct link from the organs of the body to the brain's insula, are particularly prevalent in places where pathogens enter the body, like the lungs, the oesophagus and the gut. If the vagus nerve becomes inflamed, the insula receives a constant message that there is an infection in the body and energy needs to be conserved.

27. "An infection on or near the vagus nerve that is driving inflammatory signalling up the vagus nerve is one possibility for non-remitting symptoms," says VanElzakker. "We know from autopsy studies that the vagus nerve can get directly infected [with various pathogens]."

New treatments

28. Given the wide range of possible causes, it is good news that a renewed interest in fatigue research, in part inspired by long covid, is providing hope for new treatments. Some of these tackle the root causes of energy depletion while others focus on removing barriers to energy restoration or changing brain activity in some way.

29. For instance, Miller is attempting to address chronic fatigue in people with either ME/CFS or treatment-resistant depression using anti-inflammatory drugs typically used to treat autoimmune conditions. Importantly, he says this won't work for everyone with fatigue; it is only for the subset of people who have inflammation at the root of their exhaustion. Inflammation becomes the target, he says. "It doesn't matter that you have fatigue and lack of motivation in depression, PTSD, schizophrenia or ME/CFS. If you have inflammation, and it's driving that symptom, the treatment is an anti-inflammatory strategy."

30. Other research is focused on treating the energy production problem. A clinical trial of an experimental drug that aims to help cells increase oxygen uptake from the blood in people with ME/CFS launched at Brigham and Women's Hospital in Boston earlier this year.

31. Miller is also investigating the use of drugs like the Parkinson's medication L-DOPA to raise activity in the striatum to nudge the brain's cost-benefit calculation towards action. Another group at the University of California, Los Angeles, is investigating whether targeting the prefrontal cortex using transcranial magnetic stimulation, which influences the brain's electrical activity, may help shift the energy/motivation calculation and relieve fatigue. These treatments are still experimental; only time will tell how effective they are, and for whom.

32. For people needing help with chronic fatigue now, a common treatment option is energy management, or pacing, which involves continuously monitoring how they feel and resisting the urge to push through their fatigue. Similarly, cognitive behavioural therapy can help some people cope with the limitations of their condition.

33. These strategies can be particularly helpful for people who lived an active life before their diagnosis. Lisa Clock, a former collegiate athlete in Georgia who developed ME/CFS after a viral infection in her 20s, learned these lessons the hard way. When fatigue first started to affect her life, she tried to draw on her experiences as an athlete.

34. "I learned in sports that you push through pain, and you create endurance by working and pushing yourself in a strategic way," she says. "And every time I'd say, 'OK, I'm going to do that. I'm going to push through,' I would end up flat on my back with swollen glands and [it was] hard to move. It worked completely in reverse to how it had always been for me."

35. Instead, to manage her symptoms, Clock has learned to pay attention to her energy levels and work in spurts when she feels better, often while lying down on the floor.

36. She is now being treated by Miller with drugs that target some of the possible causes of her fatigue. So far, she has tried L-DOPA, IV fluids with electrolytes and even ketamine, an experimental treatment for depression that boosts activity in the prefrontal cortex. Now she is on the immune-suppressing drug rapamycin to target inflammation. Some treatments work better than others, and she hasn't found a cure yet, but she says she has to keep trying. "You get one life, and I don't want to miss my own life, but it feels like a lot of times I am," she says. "I have to keep trying. I don't want to miss everything."

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