Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Monday 23 October 2023

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 questions labelled with an **asterisk** (*) marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

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

Turn over ▶

Pearson

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 The image shows a section of a recombinant DNA molecule.

(a) (i) Which enzyme is used in the production of recombinant DNA?

(1)

☒ **A** acetylcholinesterase

☒ **B** amylase

☒ **C** restriction endonuclease

☒ **D** RNA polymerase

(ii) DNA is present in bacterial cells.

Where is DNA found in a bacterial cell?

(1)

☒ **A** nucleus only

☒ **B** plasmid only

☒ **C** plasmid and cytoplasm

☒ **D** plasmid and nucleus

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(iii) Which bond joins nucleotides together in a **single** strand of DNA?

(1)

- ☒ **A** hydrogen
- ☒ **B** ionic
- ☒ **C** peptide
- ☒ **D** phosphodiester

(b) Describe how genes can be switched **off** by transcription factors.

(3)

(Total for Question 1 = 6 marks)

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2 The photograph shows the eyes of a meerkat.

(Source: Jeremy Pardoe / Alamy Stock Photo)

(a) Describe how the pupil of an eye dilates and contracts in response to changes in light intensity.

(4)

(b) Photoreceptors stimulate nerve transmission in the eye.

(i) Which of the following pairs of molecules forms the photoreceptor in an eye?

(1)

☒ **A** auxin and retinol

☒ **B** lysozyme and ribose

☒ **C** opsin and retinal

☒ **D** phytochrome and opsin

(ii) Which of these drugs would increase nerve transmission?

(1)

☒ **A** ecstasy (MDMA) and lidocaine

☒ **B** ecstasy (MDMA) and nicotine

☒ **C** lidocaine and nicotine

☒ **D** lidocaine only

(iii) In direct sunlight the diameter of the pupil was 4 mm.

In complete darkness the area of the pupil was 38.75 mm^2.

Calculate the increase in diameter of the pupil when moving from direct sunlight to complete darkness.

(2)

Answer ..... mm

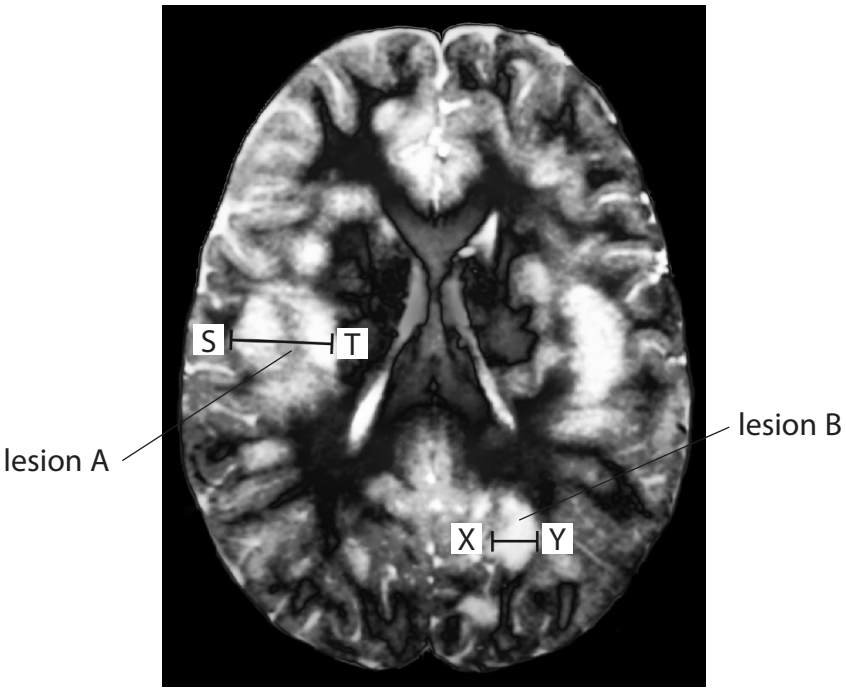
(Total for Question 2 = 8 marks)

3 Acute disseminated encephalomyelitis (ADEM) causes the destruction of the myelin sheath around neurones.

The destruction is the result of inflammation.

Lesions form in the brain where the myelin is destroyed.

The image is a magnetic resonance imaging (MRI) scan of a person with ADEM, showing lesions in the brain.



(Source: © ZEPHYR/SCIENCE PHOTO LIBRARY)

(a) (i) Lesion A is spherical and has a diameter (S–T) of 1.97 cm.

Calculate the volume of lesion A.

Use the formula:

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

Give your answer to 2 decimal places.

(2)

Answer ..... cm^3

(ii) Calculate the actual width of the lesion labelled B between points X and Y.

Give your answer to 2 significant figures.

(2)

Answer ..... cm

(b) An MRI scan can be used to diagnose a brain tumour.

Suggest why a dye might be given during the MRI scan.

(1)

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(c) A person with ADEM has problems with walking.

Explain why ADEM causes problems with walking.

(2)

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(Total for Question 3 = 7 marks)

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4 The mean resting heart rate varies between species of mammal.

The table shows the mean resting heart rate and mean lifespan for seven mammals.

Mammal	Mean resting heart rate / bpm	Mean lifespan / years
mouse	595	1
monkey	275	15
cat	120	17
giraffe	82	19
human	72	80
elephant	41	23
whale	15	29

(a) Describe **two** conclusions that can be drawn from these data.

(2)

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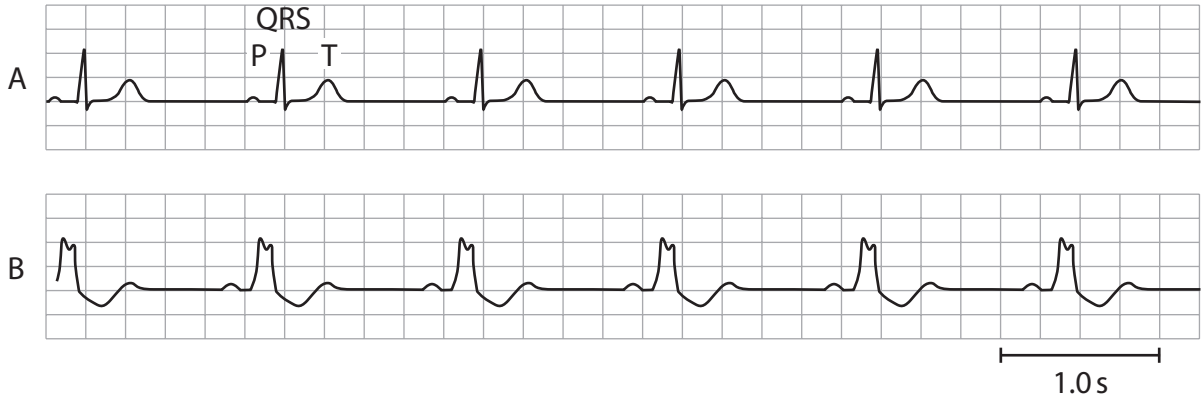
(b) An electrocardiogram (ECG) is used to identify abnormal heart rhythms.

Trace A shows a normal heart rhythm and trace B shows an abnormal heart rhythm.



(i) Which is the heart rate shown in trace A?

(1)

- ☒ **A** 6 bpm
- ☒ **B** 48 bpm
- ☒ **C** 60 bpm
- ☒ **D** 75 bpm

(ii) Describe **two** differences shown between trace A and trace B.

(2)

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(c) Cardiac muscle is unable to regenerate or repair itself. Mammalian heart muscle can beat only a certain number of times in a lifetime.

Humans have a mean resting heart rate of 72 beats per minute and a mean lifespan of 80 years.

(i) Suggest **two** reasons why humans can have a different lifespan from other mammals.

(2)

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(ii) State why cardiac output provides more information than the resting heart rate.

(1)

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(iii) An African giraffe has the longest stride of all land mammals and can run at a speed of up to 60 km hr^{-1}.

Describe how the nervous system affects cardiac output to enable the giraffe to run at this maximum speed.

(4)

(Total for Question 4 = 12 marks)

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5 Dopamine, serotonin and acetylcholine are neurotransmitters in the human nervous system.

(a) Describe how a neurotransmitter allows an impulse to be transferred to an adjacent neurone.

(4)

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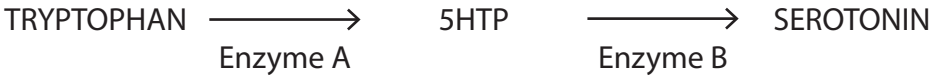
(b) The diagram shows how serotonin is produced from tryptophan.



Enzymes A and B are found in the Madagascar periwinkle.

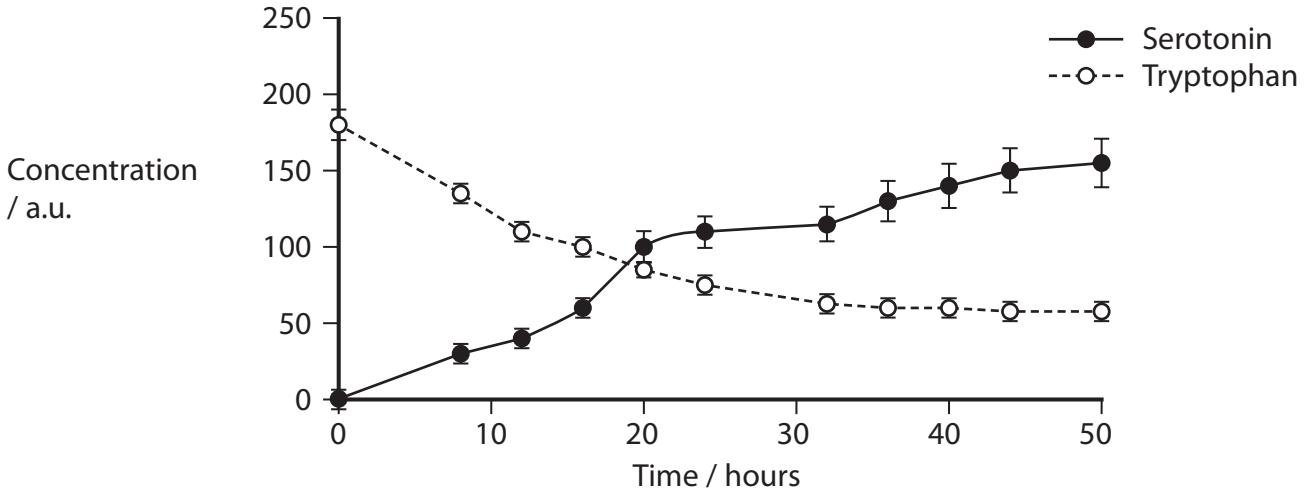
Medical serotonin can be produced by genetically engineered *E.coli* bacteria.

Describe how *E.coli* could be genetically engineered using the Madagascar periwinkle to produce serotonin.

(4)

(c) The genetically engineered *E. coli* was grown in a liquid culture.
The concentrations of tryptophan and serotonin in the culture were measured.

The graph shows the results.



Discuss the changes shown in the graph.

Use the information in the question to support your answer.

(4)

(Total for Question 5 = 12 marks)

6 Some processes in plants and animals are under the control of chemicals.

(a) (i) Which row in the table shows the effect of an increase in adrenaline in a mammal?

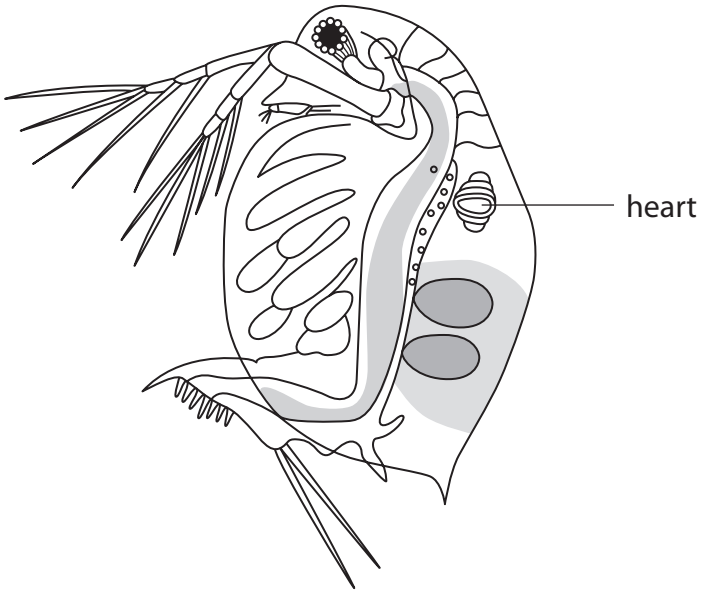
(1)

		breathing rate	heart rate
☒	**A**	decreases	increases
☒	**B**	increases	decreases
☒	**C**	increases	increases
☒	**D**	decreases	decreases

(ii) Nicotine is a drug found in tobacco products.

The effect of changing the concentration of nicotine and adrenaline on the mean heart rate of Daphnia was investigated.

The diagram shows a Daphnia.



The results are shown in the table.

Concentration of nicotine / mmol dm^{-3}	Mean heart rate / bpm		
	No adrenaline	Concentration of adrenaline 0.001 mmol dm^{-3}	Adrenaline 0.1 mmol dm^{-3}
1000	84	81	104
10	96	99	110
0.1	103	105	113
0.01	108	109	127
0.001	106	107	151
0.00 (control)	146	160	

Deduce the effect of the combination of these chemicals on the heart rate of Daphnia.

(3)

(b) Which is a description of a gibberellin?

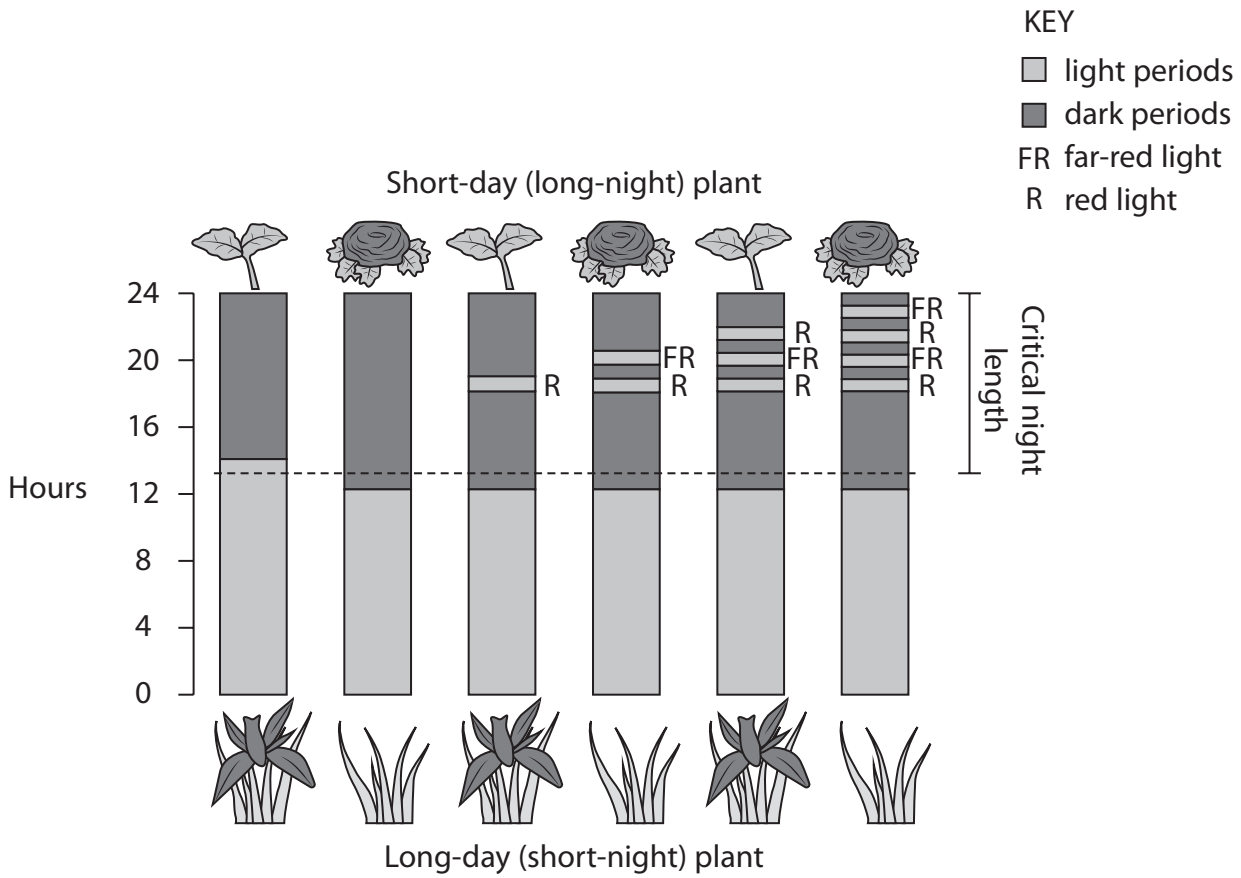
(1)

- ☒ **A** an enzyme that converts starch to glucose
- ☒ **B** a molecule that converts phytochrome far-red (Pfr) to phytochrome red (Pr)
- ☒ **C** an organic compound that stimulates the action of transcription factors
- ☒ **D** a protein that wraps around DNA

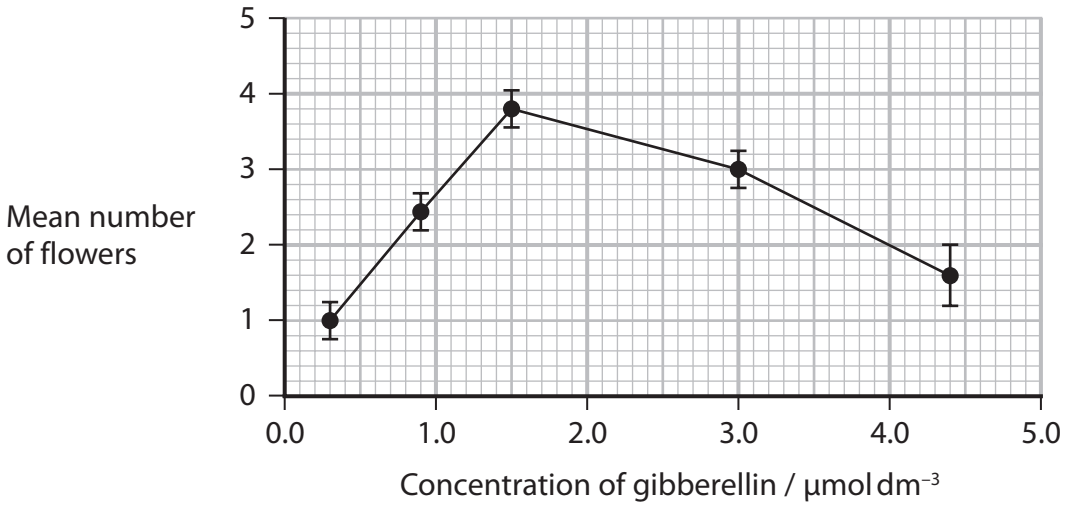
*(c) The quality and length of daylight act as signals to initiate and regulate flowering in plants. This involves phytochromes and the production of gibberellins.

In an investigation, a long-day plant and a short-day plant were exposed to light for different lengths of time. During dark periods they were exposed to flashes of red and far-red light.

The diagram shows the results of this investigation.



The graph shows the results of an investigation into the effect of gibberellin concentration on the flowering of another type of plant.



Discuss how phytochromes and gibberellins affect flowering in plants.

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

(6)

(Total for Question 6 = 11 marks)

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7 When antagonistic muscles contract, they move skeletal bones.

(a) (i) Energy is needed when a muscle contracts.

Which row in the table shows the energy use in muscle contraction?

(1)

		Energy in muscle contraction is used to		
		break the myosin–actin cross bridge	**remove calcium ions from the sarcoplasm**	**release ADP and Pi from ATP**
☒	**A**	✓	✓	✓
☒	**B**	✓	✓	✗
☒	**C**	✗	✗	✓
☒	**D**	✗	✗	✗

(ii) Describe the sliding filament theory of muscle contraction.

(4)

(b) Two types of ostrich, the South African Black and the Zimbabwean Blue, are farmed in South Africa.

Ostrich muscle is a source of dietary protein.

Scientists compared the mean masses of three muscles from the ostriches.

Muscle	Mean mass of muscle and standard deviation / kg	
	South African Black (n = 34)	Zimbabwean Blue (n = 2)
T	0.69 ± 0.10	0.88 ± 0.11
G	0.59 ± 0.08	0.74 ± 0.03
F	0.40 ± 0.06	0.50 ± 0.01

(i) State **two** conclusions that can be drawn about the mean mass of muscles shown in the table.

(2)

(ii) Comment on the validity of conclusions drawn from the data for these two groups of ostrich.

(2)

(iii) Calculate the percentage difference in the mean mass of muscle G of the South African Black and the Zimbabwean Blue ostriches.

Use the equation: percentage difference between a and b = $\frac{a-b}{\left(\frac{a+b}{2}\right)} \times 100$

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

(2)

Answer ..... %

(c) The hypothalamus is involved in maintaining a steady internal temperature in the ostrich.

Describe the role of the hypothalamus in maintaining a steady internal temperature.

(3)

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(Total for Question 7 = 14 marks)

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8 The scientific documents you have studied are adapted from articles in *New Scientist* entitled '*Your Second Skin*' (May 2022) and '*Anatomy Fascia*' from *Researchgate* (December 2018).

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

(a) Give the meaning of the term 'sensory organ' (paragraph 2).

(2)

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(b) Fascia is a type of connective tissue.

Use ticks and crosses to complete the table comparing types of connective tissue found in the human body (paragraphs 3 to 7).

(2)

Connective tissue	Contains collagen	Rich in nerves	Surrounds muscle
fascia			
ligaments			

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(c) Describe how the fascia generates a 'diffuse pain' (paragraphs 8 and 9).

(3)

(d) Explain how inflammation in the fascia is caused (paragraphs 8 and 9).

(3)

(e) Describe how fibroblasts within the fascia could be transformed into myofibroblasts (paragraph 13).

(4)

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(f) Explain how lymph is moved in one direction in the lymphatic system (paragraphs 15 and 16).

(3)

(g) Suggest how aging may have an adverse effect on the structure of the lymphatic system (paragraph 17).

(3)

(Total for Question 8 = 20 marks)

TOTAL FOR PAPER = 90 MARKS

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Pearson Edexcel International Advanced Level

Monday 23 October 2023

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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Pearson

Scientific article for use with Question 8

Article 1

Your Second Skin

1. The 19th-century anatomist Erasmus Wilson called this tissue – now known as fascia – a natural bandage. In dissection, that is exactly what it looks like: sheets of white, fibrous connective tissue that are strong yet flexible and perfect for keeping muscles and organs in place. They are also sticky, gloopy and get in the way of looking at the muscles, bones and organs they cover. Which explains why, for years, anatomists cut this tissue off, chucked it away and thought little more about it.

2. Recently, though, researchers have begun to take a fresh look at fascia and are finding that it is anything but an inert wrapping. Instead, it is the site of biological activity that explains some of the links between lifestyle and health. It may even be a new type of sensory organ. "There appears to be more going on in the fascia than is commonly appreciated," says Karl Lewis at Cornell University in Ithaca, New York.

3. One difficulty with studying fascia is that there is disagreement about what it actually is. It comes under the umbrella of connective tissue, which, at its broadest definition includes not only tendons and ligaments, but also bone, skin and fat.

4. Most fascia researchers, however, understand it to be sheets of tissue made up of strong collagen fibres and more stretchy elastin fibres. In many places, these fibrous sheets are separated by "areolar" or "loose" fascia, a form that contains fewer fibres and with the gaps between fibres filled with a slimy substance that allows the surrounding layers to slide over each other. The main ingredients of this slippery soup are hyaluronic acid, for lubrication, and proteoglycans, molecules that provide cushioning. The fascia fibres and the soup are both secreted by specialised cells in the tissue – fibroblasts and the recently discovered fasciacytes.

5. If you were to cut into the body, you would find two obvious layers of this natural cling film: the superficial fascia, which sits directly under the skin, and the deep fascia, which wraps muscles and organs and connects them to each other. Some researchers, however, extend the definition to include the visceral fascia, which lines the body cavity and divides it into compartments for different organs, and also thin layers of connective tissue that line pretty much every part of the body. By this definition, fascia forms a network that pretty much holds us together.

6. Remarkably, until the early 2000s, no one had studied this common tissue in detail. Among the first to do so was Carla Stecco, an orthopaedic surgeon and anatomist at the University of Padova in Italy. She started studying fascia 20 years ago when her father, a physiotherapist called Luigi Stecco, invented a form of physical therapy called fascial manipulation, which he claimed could treat everything from headaches to muscle and joint pain. His system is now one of many physical therapies that hinge on the idea that fascia can become stiff, and that it can be "released" through massage.

7. Since then, she and others have shown that fascia is indeed rich in nerves, and that the information that these relay varies throughout the body. Superficial fascia contains nerves that specialise in sensing pressure, temperature and movement. Deep fascia is involved in proprioception, the body's sense of its position in space, and nociception, the sensing of pain. Because of this sensory role, some researchers say that fascia should be considered a new organ, one that is specialised for communication about the body's internal state. Robert Schleip at the Technical University of Munich in Germany recently estimated that an adult's fascia contains approximately 250 million nerve endings, similar to, or slightly more than the skin. "It is beyond any doubt our richest sensory organ," he says. Others are more cautious. "It's plausible, but there is a strict definition for an organ to do with material organisation, cell types and function, so it sounds like it's a candidate," says Lewis. "But it's early days for making that determination."

8. Organ or not, there is evidence that deep fascia specialises in a different kind of message to other bodily tissues. Experiments in which healthy human volunteers had painful injections into their skin, muscles and fascia showed that while nerves in the skin and muscles produce focused, localised pain, the network of nerves in fascia is linked to a radiating pain, one that is more difficult to pinpoint. This kind of diffuse pain is a feature of several chronic pain disorders, including fibromyalgia, which some studies have linked to inflammation in the fascia. It is also a feature of post-exercise soreness, which has long been blamed on damage to the muscles, but which some researchers now think has more to do with injury or inflammation in the fascia.

9. The bad news for anyone with inflamed fascia is that if it continues for too long, the body responds by altering the composition of fascial nerves to become more sensitive to pain. In rats, the percentage of nociceptive fibres – pain receptors that respond to harmful stimuli – in the fascia increased from 4 per cent to 15 per cent following chronic inflammation of deep fascia in the lower back.

10. This could help to explain why lower back pain is so difficult to treat. Despite being one of the most common causes of work absence and overall movement restriction, 85 per cent of cases worldwide are classified as non-specific, meaning the exact cause can't be established.

11. Given what we now know about nerves in the fascia, the thoracolumbar fascia, a diamond-shaped, multilayered structure in the lower back in which different layers connect to different muscle groups in the trunk, is starting to look like a good place to put the blame for this back pain. "The thoracolumbar fascia is like a big receptor that is able to feel the tension coming from the upper limbs, the spine and the abdomen," says Stecco. The sensory neurons in the fascia may respond to this tension by registering it as pain.

12. On top of nerve changes, inflammation in the loose, areolar fascia that is found between fascial layers can make matters worse. Helene Langevin at the US National Institutes of Health in Maryland used ultrasound imaging of the lower back to show that people with chronic lower back pain had thoracolumbar fascia that was 20 per cent stiffer than those without this pain.

13. Injury and inflammation aside, there are many other reasons why fascia may become stiff. Schleip's research hints that activation of the sympathetic nervous system, which is involved in the body's fight-or-flight response, causes the fascia to contract by prompting the fibroblasts within it to transform into myofibroblasts, cells that are part of the inflammatory response to injury, often seen in joint-related problems such as frozen shoulder.

14. The details of how exactly fight-or-flight stress leads to stiffness are still being worked out, but Schleip says that adrenaline seems to increase the expression of an inflammatory substance called TGF-beta. This is then stored in the loose fascia in preparation for the next time the body is stressed. When this happens, fibroblasts "drink [TGF-beta] and they become myofibroblasts in a few hours", he says. "And then they are four times as strong as before. They are contraction machines. So, adrenaline can make fascia stiffer." In fact, the list of things that affect fascial stiffness is getting longer all the time. "Oestrogen is able to create a fascia that is more elastic," says Stecco. "The fascia is a very dynamic tissue that is able to answer to hormonal input, chemical input and mechanical input. Altogether, that defines if our fascia is elastic or rigid."

Article 2

The Lymphatic System

15. The lymphatic system effectively removes the excess of interstitial fluids, solutes, and various cells and guides them towards the bloodstream, maintaining the volume of plasma and interstitial fluids in constant balance. The lymphatic system originates from the interstitial tissue called "initial lymphatics", small capillaries delimited by discontinuous endothelium and basement membrane and low resistance to the flow of fluids and substances (hydrophile molecules, cells, viruses, and bacteria). They attach to the external surface of the cells through collagen fibrils (collagen type VII). This collagen allows the transmission of mechanical forces towards the lumen of the lymphatic vessel; there is an autonomous contraction in some vessels, thanks to the presence of filaments similar to actin. These initial lymphatics become wider, creating collecting ducts that consist of collagen, smooth muscle cells, and elastic fibers. Lymphatic vessels have their tone and, probably, their intrinsic contraction autonomy, according to recent data, with a high ability of sensibility to flow variation (sensory functions). They are surrounded by nerves of the autonomous system, mainly sympathetic fibers, which could act to better coordinate the lymphatic transport.

16. Lymphatic vessels adapt and change their elastic capacity, improving or worsening the function of lymphatic transport. We can identify primary valves, formed by the cytoplasmic extent of the adjacent endothelial cells linked by close connections. The valves of these cells protrude towards the inside; this way, what goes in cannot go out. Finally, in the intraluminal valves (weaker) are two sheets attached to the opposite sides of the lymphatic vessel and connected to zonules (perimeter junction involving a band that surrounds the cell). Lymph flows due to external mechanical compressions, for example, the one caused by muscle contraction, and to its intrinsic contraction abilities.

17. The lymphatic system is subject to aging, losing its elasticity and creating "aneurysms" over time, or decreasing the number of blood vessels or lymphangions (the lymphatic functional unit). Recent evidence reveals that lymphatic vessels are supported by a nervous system, of vagal cholinergic type and sympathetic type, able to modulate the contraction (peristalsis, also helped by the breathing and pulsation of arteries) of vessels endowed with contractile fibers (with an actinlike protein). These thin nerves reach the external layer of the lymphatic vessel and then reach the deepest endothelial layer; this nerve network deteriorates in elderly people. Probably, the presence of both the parasympathetic and the sympathetic systems acts not only as a tension or vessel tone modulator but also as a sensor of the contractile layer of the vessel itself.

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