Mock Question 8 (ii) — WBI15/01

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

Pre-release article: *Beyond tired: Why fatigue sets in and how to tackle it*

The scientific article you have studied is adapted from 'Beyond tired: Why fatigue sets in and how to tackle it' by Dana G. Smith in *New Scientist*.

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

8. The article discusses the causes of fatigue and possible treatments.

(a) The article states that chronic fatigue affects 'nearly 1 per cent of the global population' (paragraph 4). The world population was approximately 8.1×10^9 in 2024.

Calculate the number of people affected by chronic fatigue. Give your answer in standard form.

(1)

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(b) The article describes how the vagus nerve provides 'a direct link from the organs of the body to the brain's insula' and that receptors for this nerve 'are particularly prevalent in places where pathogens enter the body, like the lungs, the oesophagus and the gut' (paragraphs 26–27).

(i) The vagus nerve contains myelinated neurones.

Describe how a nerve impulse is transmitted along a myelinated neurone.

(3)

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(ii) The article states that 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' (paragraph 26).

Suggest why inflammation of the vagus nerve could result in continuous nerve impulse transmission to the brain.

(2)

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(c) The article describes an experiment in which healthy volunteers performed tedious memory and attention tasks for long periods. Their performance declined over time. However, when offered a monetary bonus, 'they become reincentivised to put in more effort, and they subsequently perform better and show increased brain activity again' (paragraph 11).

(i) Suggest one variable that should have been controlled in this experiment.

(1)

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(ii) The article states that 'in the brain, this shows up as a decrease in activity and connectivity in that fatigue network' (paragraph 11).

Name the type of brain scan that could be used to measure changes in brain activity during this experiment. Give a reason for your answer.

(2)

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(d) The article describes hyperbaric oxygen therapy as a treatment for fatigue in people with long covid. In this treatment, patients 'breathe pressurised oxygen-rich air while in a hyperbaric chamber' (paragraph 18).

(i) Explain how increasing the partial pressure of oxygen in inhaled air would affect the loading of oxygen onto haemoglobin in the lungs.

(3)

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(ii) The article states that 'early results suggest that the treatment reduces fatigue, pain and brain fog' (paragraph 18).

Suggest why an increase in oxygen delivery to cells would reduce fatigue.

(2)

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(e) The article describes cytokines as 'proteins called cytokines that help ready the rest of the immune system for action' (paragraph 19). Cytokines are produced by cells of the immune system.

Describe how the base sequence of a gene leads to the production of a cytokine protein.

(3)

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(f) The article describes how Miller is using anti-inflammatory drugs to treat chronic fatigue. He states that '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' (paragraph 29).

Using information from the article, explain why anti-inflammatory drugs would only reduce fatigue in some patients.

(3)

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(Total for Question 8 = 20 marks)

MARK SCHEME

Mock Question 8 (ii) — WBI15/01 — Pre-release: Fatigue

8(a) [1 mark]

• 8.1×10^7 **(1)**

ACCEPT 8×10^7 / 81 000 000 / 81 million

DO NOT ACCEPT 8.1×10^8 or other incorrect standard form / incorrect order of magnitude

8(b)(i) [3 marks]

A description that includes **three** of the following points:

• {depolarisation / action potential} {travels along / is propagated along} the axon **(1)**

• by {saltatory conduction / jumping between} {nodes of Ranvier / gaps in the myelin sheath} **(1)**

• at the nodes, {sodium ion (Na■) channels open / sodium ions move into the axon / membrane is depolarised} **(1)**

• the myelin sheath acts as an {electrical insulator / prevents ion exchange} (between the nodes) **(1)**

• this {increases the speed of / speeds up} transmission of the nerve impulse (compared to unmyelinated neurones) **(1)**

ACCEPT description of depolarisation–repolarisation at nodes

IGNORE references to synapses

8(b)(ii) [2 marks]

A suggestion that includes **two** of the following points:

• inflammation could {stimulate receptors / activate ion channels} on the vagus nerve {continuously / repeatedly} **(1)**

• (inflammation causes) {swelling / damage} that could {affect the myelin sheath / alter the resting potential / prevent repolarisation} **(1)**

• resulting in {continuous / repeated / uncontrolled} generation of {action potentials / nerve impulses} (being sent to the brain) **(1)**

ACCEPT inflammatory chemicals / cytokines stimulate the nerve continuously

8(c)(i) [1 mark]

• any one valid controlled variable, e.g.:

– age of participants / sex of participants / health status / sleep (the night before) / caffeine intake / time of day / type of task / difficulty of task / duration of task / room temperature **(1)**

DO NOT ACCEPT 'same people' without qualification / amount of money (this is the independent variable)

8(c)(ii) [2 marks]

An answer that includes the following points:

• {fMRI / functional MRI / functional magnetic resonance imaging} **(1)**

• because it can show {which areas of the brain are active / changes in blood flow to active brain regions / brain activity in real time} **(1)**

ACCEPT PET / positron emission tomography with appropriate reason (e.g. shows metabolic activity / glucose uptake in brain regions)

DO NOT ACCEPT CT scan / MRI alone (these show structure, not activity) / EEG alone without valid reason

8(d)(i) [3 marks]

An explanation that includes **three** of the following points:

• increased partial pressure of oxygen {in the lungs / in inhaled air / at the alveoli} **(1)**

• increases the {concentration gradient / diffusion gradient / partial pressure difference} of oxygen across the {alveolar membrane / gas exchange surface} **(1)**

• (therefore) more oxygen {diffuses into the blood / dissolves in the plasma} **(1)**

• more oxygen {binds to / associates with / loads onto} haemoglobin, forming oxyhaemoglobin **(1)**

• haemoglobin reaches a {higher percentage saturation / greater saturation} (as shown on the oxygen dissociation curve) **(1)**

ACCEPT reference to oxygen dissociation curve / sigmoid curve

DO NOT ACCEPT 'more haemoglobin is produced'

8(d)(ii) [2 marks]

A suggestion that includes **two** of the following points:

• more oxygen is delivered to {cells / tissues / mitochondria} **(1)**

• increasing the rate of {aerobic respiration / oxidative phosphorylation / the electron transport chain} **(1)**

• (therefore) more ATP is produced (for cellular processes / to meet the energy demands of the brain) **(1)**

8(e) [3 marks]

A description that includes **three** of the following points:

• the gene / DNA is {transcribed / used as a template} to produce {mRNA / messenger RNA} (in the nucleus) **(1)**

• {RNA polymerase / enzyme} joins {complementary / free} RNA nucleotides (to form mRNA) **(1)**

• mRNA {leaves the nucleus / moves to} the {ribosome / rough endoplasmic reticulum / cytoplasm} **(1)**

• {translation occurs / mRNA is translated} / {tRNA / transfer RNA} brings {specific / complementary} amino acids to the ribosome **(1)**

• amino acids are joined by {peptide bonds / condensation reactions} to form the {polypeptide chain / cytokine protein} **(1)**

ACCEPT codons on mRNA are read by complementary anticodons on tRNA

ACCEPT reference to post-translational modification / folding into 3D shape

8(f) [3 marks]

An explanation that includes **three** of the following points:

• fatigue can be caused by {many different factors / different underlying mechanisms} (as described in the article) **(1)**

• e.g. {disrupted energy production in cells / disrupted blood flow or oxygen delivery / problems with brainstem signalling / disrupted nervous system communication} **(1)**

• anti-inflammatory drugs only target {inflammation / the inflammatory response} **(1)**

• (therefore) they would only be effective in patients whose fatigue is {caused by / a result of} chronic inflammation (and not other mechanisms) **(1)**

ACCEPT named examples from the article e.g. long covid, ME/CFS with inflammation, vagus nerve infection

ACCEPT references to specific paragraphs describing non-inflammatory causes

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TOTAL FOR QUESTION 8 = 20 MARKS