Mock Question 8 — 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 describes how the brain monitors energy levels using four regions that form a 'fatigue network' (paragraphs 7–9).

(a) The prefrontal cortex communicates with other brain regions using neurones. Communication between neurones involves the transmission of signals across synapses.

Describe the events that occur at a cholinergic synapse when a nerve impulse arrives at the presynaptic neurone.

(4)

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(b) The article states that during prolonged concentration, 'cellular energy stores become depleted, metabolic by-products begin to build up and performance starts to decline' (paragraph 12).

(i) Name the molecule that is the immediate source of energy for cellular processes.

(1)

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(ii) The article suggests that in some cases of ME/CFS, cells may switch from using glucose to using 'fats or amino acids' as a fuel source (paragraph 15).

Explain how glucose is used in aerobic respiration to produce the molecule you named in (b)(i).

(3)

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(c) The article describes how the brainstem communicates with the heart and lungs via the autonomic nervous system to increase oxygen delivery during physical effort (paragraph 16).

(i) State the division of the autonomic nervous system responsible for increasing heart rate.

(1)

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(ii) Explain how an increase in heart rate and ventilation rate helps to maintain aerobic respiration in active muscle cells.

(3)

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(d) The article discusses the role of inflammation and cytokines in causing fatigue during infection (paragraphs 19–21).

(i) The article describes cytokines as 'proteins that help ready the rest of the immune system for action' (paragraph 19).

Explain how cytokines are involved in the specific immune response to a pathogen.

(2)

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(ii) Researchers suggest that the reduction in physical activity caused by cytokines during infection is an adaptive response (paragraph 21).

Suggest why conserving energy during an infection could increase the chance of survival.

(2)

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(e) The article states that people with long covid have 'higher than average levels of microscopic blood clots, which can block small blood vessels and impede oxygen delivery' (paragraph 18).

Explain the effect of blocked blood vessels on aerobic respiration in the affected tissues.

(2)

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(f) One treatment described in the article uses the Parkinson's medication L-DOPA 'to raise activity in the striatum' (paragraph 31). L-DOPA is a precursor to the neurotransmitter dopamine.

Suggest how L-DOPA could increase activity in the striatum to reduce fatigue.

(2)

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(Total for Question 8 = 20 marks)

MARK SCHEME

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

8(a) [4 marks]

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

- action potential arrives at the presynaptic {membrane / knob / neurone} **(1)**
- (causing) calcium ion (Ca^{2+}) channels to open / calcium ions diffuse into the presynaptic knob **(1)**
- (calcium ions cause) vesicles (containing acetylcholine / ACh) to {move to / fuse with} the presynaptic membrane **(1)**
- acetylcholine is released into the synaptic cleft {by exocytosis / by diffusion} **(1)**
- ACh binds to {specific / complementary} receptors on the postsynaptic membrane **(1)**
- (causing) sodium ion (Na^{+}) channels to open / sodium ions diffuse into the postsynaptic neurone **(1)**
- generating a {new action potential / depolarisation} in the postsynaptic neurone **(1)**

ACCEPT neurotransmitter for acetylcholine / ACh throughout
IGNORE references to acetylcholinesterase unless contradictory

8(b)(i) [1 mark]

- ATP / adenosine triphosphate **(1)**

DO NOT ACCEPT energy / glucose

8(b)(ii) [3 marks]

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

- glucose is broken down {in glycolysis / in the cytoplasm} to produce pyruvate **(1)**
- pyruvate enters the {mitochondria / matrix} and is converted to acetyl CoA / enters the Krebs cycle **(1)**
- {Krebs cycle / link reaction and Krebs cycle} produces {reduced NAD / reduced FAD / reduced coenzymes} (and CO_2) **(1)**
- reduced NAD and reduced FAD are used in {oxidative phosphorylation / the electron transport chain} (on the inner mitochondrial membrane) to produce {most of the} ATP **(1)**
- (oxidative phosphorylation involves) electrons passed along carriers / chemiosmosis / H^{+} ions flow through ATP synthase **(1)**

ACCEPT hydrogen carriers for reduced NAD / FAD
ACCEPT named product of glycolysis e.g. 2 ATP, 2 reduced NAD

8(c)(i) [1 mark]

- sympathetic (nervous system / division) **(1)**

DO NOT ACCEPT parasympathetic / somatic / voluntary

8(c)(ii) [3 marks]

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

- increased heart rate increases {cardiac output / rate of blood flow / blood circulation} **(1)**
- increased ventilation rate increases {the rate of gas exchange / oxygen uptake} at the {alveoli / lungs / gas exchange surface} **(1)**
- (therefore) more {oxygen / glucose} is delivered to the {muscle cells / respiring tissues} per unit time **(1)**

• maintaining the supply of {oxygen and glucose} for {aerobic respiration / oxidative phosphorylation} to produce ATP **(1)**

ACCEPT breathing rate for ventilation rate

DO NOT ACCEPT vague 'more blood goes to the muscles' without reference to oxygen or glucose

8(d)(i) [2 marks]

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

• cytokines act as {cell signalling molecules / chemical messengers} that {coordinate / regulate} the immune response **(1)**

• (cytokines) {stimulate / activate} {T cells / B cells / lymphocytes / phagocytes} **(1)**

• stimulate {clonal expansion / B cells to {differentiate into / produce} plasma cells / T cells to divide} **(1)**

• (plasma cells) produce {antibodies / immunoglobulins} **(1)**

ACCEPT interleukins as an example of cytokines

DO NOT ACCEPT vague 'fight infection' without mechanism

8(d)(ii) [2 marks]

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

• {conserves / reduces} energy expenditure so more {ATP / energy} is available for the immune response **(1)**

• the immune system requires a large amount of {energy / ATP} for {producing antibodies / clonal expansion / phagocytosis / cell division of lymphocytes} **(1)**

• reduces the risk of {further injury / exposure to other pathogens} while the body is {vulnerable / immunocompromised / fighting infection} **(1)**

8(e) [2 marks]

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

• blocked blood vessels {reduce / prevent} {blood flow / delivery of oxygen / delivery of glucose} to the {cells / tissues} **(1)**

• without sufficient oxygen, {aerobic respiration / oxidative phosphorylation / the electron transport chain} {cannot occur / is reduced} **(1)**

• {less ATP is produced / cells may rely on anaerobic respiration} which produces {less / insufficient} ATP (for cellular processes) **(1)**

ACCEPT references to lactate build-up if linked to anaerobic respiration

8(f) [2 marks]

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

• L-DOPA is converted into {dopamine / a neurotransmitter} (in the {brain / presynaptic neurone}) **(1)**

• increased dopamine is {released at synapses / binds to (specific / complementary) receptors} in the striatum, increasing {nerve impulse transmission / signalling / activity} **(1)**

• (this could increase) {motivation / the brain's assessment of reward / willingness to expend energy}, reducing the perception of fatigue **(1)**

ACCEPT dopamine increases communication between neurones in the striatum

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TOTAL FOR QUESTION 8 = 20 MARKS