C2.1 Chemical signalling [63 marks]

1. [Maximum mark: 1]
What activates a tyrosine kinase pathway in a cell following binding to a receptor?

A. Odorant molecules

B. Epinephrine

C. Taste molecules

D. Insulin [1]

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2. [Maximum mark: 1]
What conveys messages from the central nervous system to an endocrine gland?

A. Sensory neurons

B. Hormones

C. Interneurons

D. Motor neurons [1]

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3. [Maximum mark: 1]
What results from an unspecialized cell experiencing gradients of signalling chemicals?

A. Cell differentiation

B. Meiosis

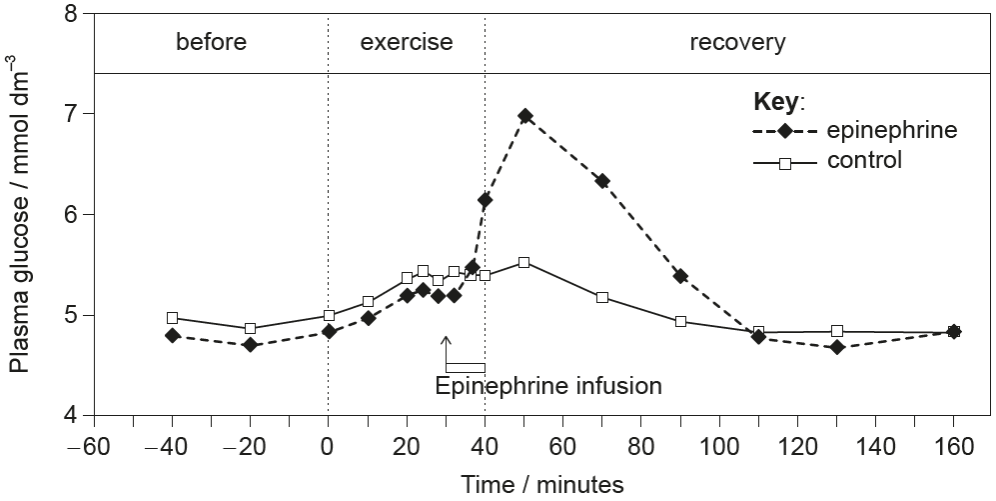
C. Saltatory conduction

D. DNA replication

[1]

4. [Maximum mark: 1]

The graph shows changes in blood plasma glucose concentration before exercise, during exercise and during recovery with and without epinephrine (adrenaline) infusion. Epinephrine infusion was started 30 minutes into the exercise routine.



[Source: Kreisman, S.H., Ah Mew, N., Arsenault, M., Marliss, E.B., et al., 2000. *AJP Endocrinology and Metabolism* 278(5): E949–57. https://doi.org/10.1152/ajpendo.2000.278.5.E949. Reference redacted. Source adapted.]

Which action of epinephrine would result in the observed changes to plasma glucose concentration?

A. Second messenger is deactivated.

B. A G protein is activated, and cyclic AMP (cAMP) is produced.

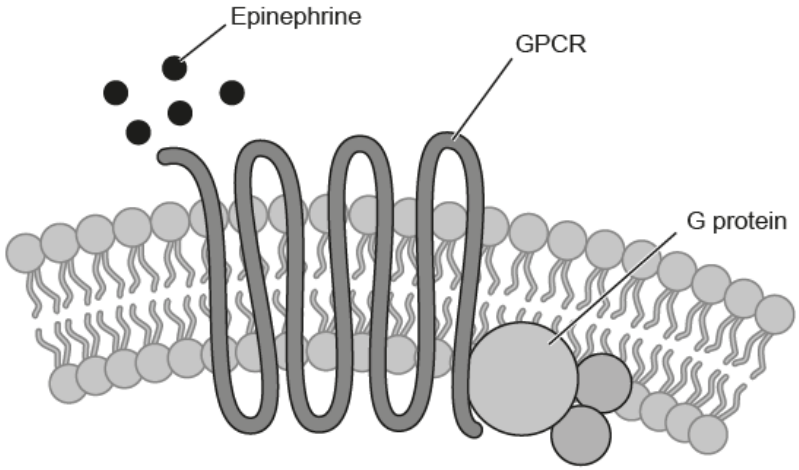
C. Second messenger stimulates the production of ATP.

D. Cyclic AMP (cAMP) deactivates the G protein.

[1]

5. [Maximum mark: 6]

The diagram shows a G protein, bound to a G protein-coupled receptor (GPCR), a transmembrane receptor which responds to epinephrine (adrenaline).



[Source: Joshua Li et al, The Molecule Pages database, *Nature*, Dec 12, 2002, Springer Nature.]

(a) State which molecule is the ligand. [1]

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(b) Explain how epinephrine exerts its effects in the cell. [3]

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(c) Describe **two** ways in which epinephrine in the body facilitates intense muscle contraction.

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2. .....
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[2]

6. [Maximum mark: 1]
What occurs during the transmission of an impulse at a synapse?

I. Acetylcholine is released into the synaptic cleft by exocytosis when calcium ions enter the presynaptic neuron.

II. Acetylcholine diffuses across the synaptic cleft and binds to receptors on the postsynaptic membrane.

III. Acetylcholine is broken down by cholinesterase and resorbed into the presynaptic neuron once an impulse has been initiated on the postsynaptic membrane.

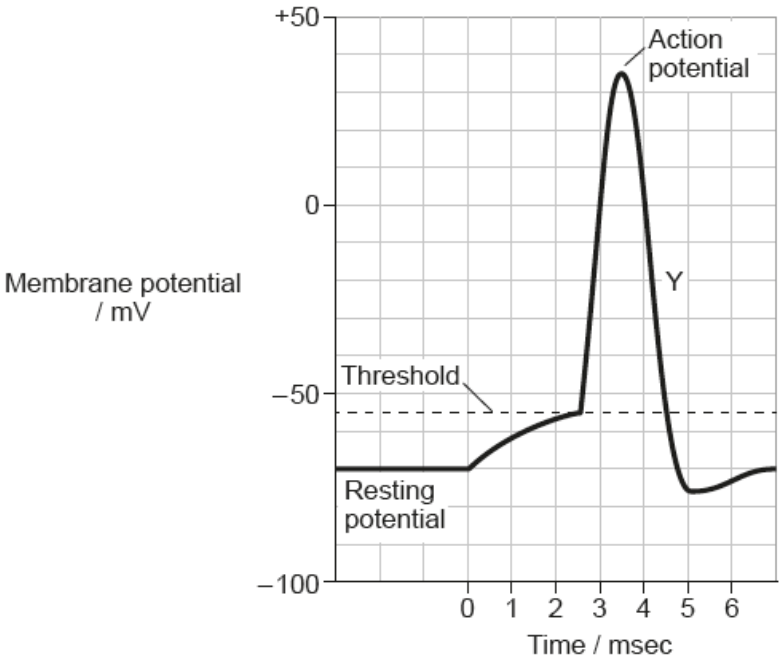
A. I and II only

B. II and III only

C. I and III only

D. I, II and III [1]

7. [Maximum mark: 1]
Changes in membrane potential during nerve transmission along an axon involve the movement of sodium and potassium ions across the axon membrane.



What explains the membrane potential at Y in the trace? [1]

A. Potassium channels open and allow potassium ions to move to the outside of the axon membrane.

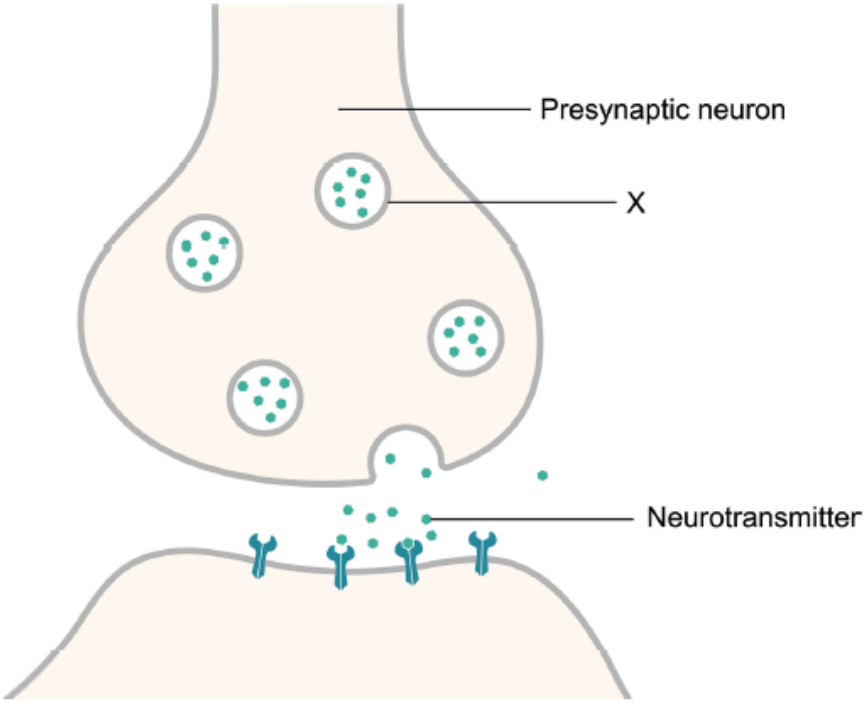
B. Potassium channels allow potassium ions to enter the axon.

C. When the threshold voltage is reached, the sodium pump begins to pump sodium ions to the outside of the axon membrane.

D. Potassium and sodium channels are closed, so there is no movement of ions across the axon membrane.

8. [Maximum mark: 6]

The diagram shows the release of a neurotransmitter across a synapse.



[Source: Splettstoesser T., 2015. *SynapseSchematic* [diagram online] Available at : https://commons.wikimedia.org/w/index.php?curid=41349083 [Accessed 14 January 2023].]

(a) Identify the structure labelled X. [1]

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(b) Outline how the neuron is stimulated to release the neurotransmitter. [2]

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(c) Explain the action of neonicotinoid pesticides in insects. [3]

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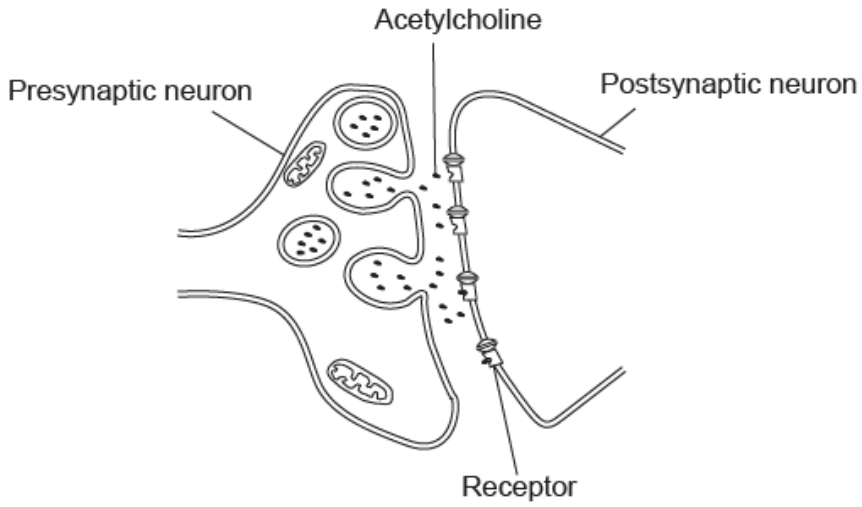
9. [Maximum mark: 1]

The diagram shows the synaptic transmission of nerve impulses by the neurotransmitter acetylcholine.



[Source: Zhang, X. A Mathematical Model of a Neuron with Synapses based on Physiology. *Nat Prec* (2008). https://doi.org/10.1038/npre.2008.1703.1 available at https://www.nature.com/articles/npre.2008.1703.1 Source adapted.]

What is the fate of acetylcholine immediately after binding to the receptor?

A. It is pumped into the postsynaptic neuron.

B. It diffuses into the presynaptic neuron.

C. It is broken down in the synaptic cleft.

D. It binds to another receptor in the postsynaptic neuron. [1]

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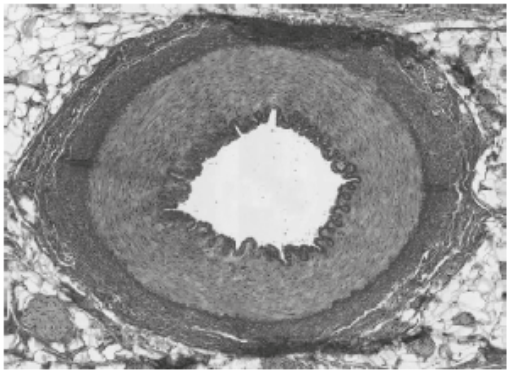
10. [Maximum mark: 6]

(a) This micrograph shows a transverse section of an artery.



x 100

[Source: OpenStax College, 2013. Comparison of artery and vein. [image online] Available at: https://en.wikipedia.org/wiki/File:2102_Comparison_of_Artery_and_Vein.jpg Attribution 3.0 Unported (CC BY 3.0) https:/creativecommons.org/licenses/by/3.0/deed.en [Accessed 11 March 2020].]

Explain how the specialized structures of arteries help them to achieve their functions. [3]

(b.i) State **one** process that produces ATP. [1]

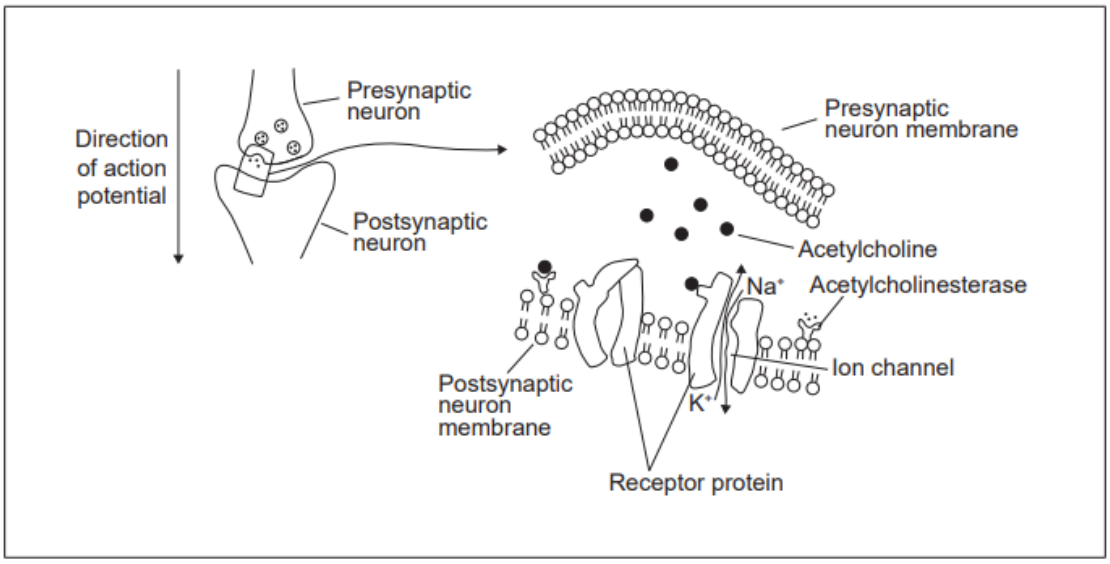
(b.ii) Outline the use of ATP. [1]

(c) State **one** function of epinephrine in the human body. [1]

11. [Maximum mark: 11]

Cholinergic synapses use acetylcholine as their neurotransmitter. They are widespread in the body, passing on signals to muscle cells. These synapses are affected by neonicotinoid pesticides.

The diagrams, which are not drawn to scale, show the synapse between two neurons and a detail of the synaptic cleft.



(a.i) On the diagrams, label with a letter H the hydrophilic end of a phospholipid. [1]

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(a.ii) On the diagrams, label with a letter E a vesicle involved in exocytosis. [1]

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(a.iii) On the diagrams, label with a letter P a location where a neonicotinoid pesticide could bind. [1]

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(b) Outline how depolarization of the membrane of an axon occurs. [2]

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(c) Explain how acetylcholine initiates an action potential in a postsynaptic membrane. [2]

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(d.i) State the action of the enzyme acetylcholinesterase. [1]

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(d.ii) Explain what happens to an enzyme if there is a change of pH. [3]

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12. [Maximum mark: 1]

What happens in the heart when epinephrine is secreted into the blood?

I. Pressure in the heart falls.

II. The pulmonary artery transports oxygenated blood at a faster rate.

III. The sinoatrial node increases the rate of electrical signals.

A. I only

B. I and II only

C. II and III only

D. III only [1]

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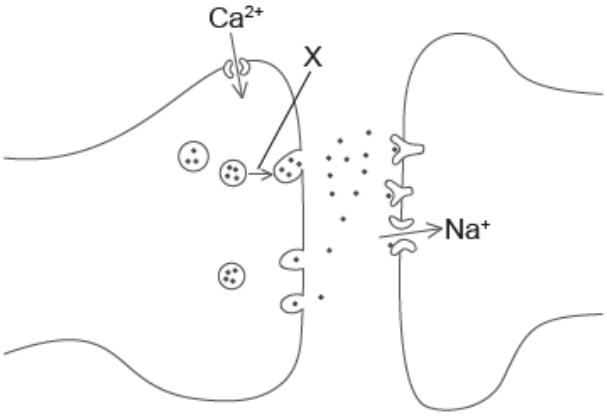
13. [Maximum mark: 6]

The diagram shows part of two neurons.



[Source: © International Baccalaureate Organization 2020.]

(a) Outline how the amphipathic properties of phospholipids play a role in membrane structure. [2]

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(b.i) State the name of the structure shown. [1]

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(b.ii) X indicates the movement of a structure in the neuron. Explain what events trigger this movement and what happens next. [3]

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14. [Maximum mark: 15]

(a) Outline the functions of rough endoplasmic reticulum and Golgi apparatus. [3]

(b) Outline the control of metabolism by end-product inhibition. [5]

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(c) Explain how hydrophobic and hydrophilic properties contribute to the arrangement of molecules in a membrane. [7]

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15. [Maximum mark: 5]

The use of human growth hormone (HGH) to enhance athletic performance is now banned from most major sporting events including the Olympics. To investigate the effect of HGH on athletic performance, doctors in the US looked at changes in body composition and strength in a group of athletes taking the drug. This was compared with a control group of similar athletes who had never taken the drug.

	Mean change in mass compared with control group / kg
Body fat	– 0.3
Muscle	+ 2.1
Maximum mass that can be lifted using arm muscles	– 0.2
Maximum mass that can be lifted using leg muscles	– 0.1

[Source: From *Annals of Internal Medicine*, H Liu and D M Bravata, Systematic Review: The Effects of Growth Hormone on
Athletic Performance, **148**., 10, 747–758. Copyright © 2008 American College of Physicians. All Rights Reserved.
Reprinted with the permission of American College of Physicians, Inc.]

(a) Deduce from the results of the study whether HGH improves strength. [1]

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(b) Suggest **one** reason that it is difficult to detect illegal use of HGH to enhance athletic performance. [1]

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(c) HGH is a peptide hormone. Describe the mode of action of peptide hormones on target cells. [3]