Model Answers: Medium

1a

(a) Insulin being a globular protein means the following for its mechanism of action…

Any **three** of the following:

- It is water soluble / it dissolves in water / it will interact with water; [1 mark]
- (Due to having) hydrophilic regions located around the outside / coming into contact with surroundings; [1 mark]
- (It) cannot pass between the (hydrophobic) fatty acid tails of the cell surface membrane / cannot cross the phospholipid bilayer; [1 mark]
- It binds to receptors on target cells; [1 mark]
- It activates a second messenger within target cells; [1 mark]

[Total: 3 marks]

The amino acids in a globular protein are arranged in such a way that hydrophobic regions are located in the centre of the protein while hydrophilic regions are located around the outside. These hydrophilic regions will interact with water, meaning that globular proteins are water soluble. They cannot, however, interact with the hydrophobic fatty acids in the centre of a phospholipid bilayer, meaning that they cannot pass through cell surface membranes and so they influence cell behaviour by binding to receptors on target cells and initiating action via a second messenger molecule.

1b

(b) Contrasting features of the endocrine and nervous systems include…

Any **three** of the following:

- The parts of the endocrine system are the endocrine glands **WHILE** the parts of the nervous system are the brain, spinal cord, and neurones; [1 mark]
- The endocrine system sends hormone/chemical signals **WHILE** the nervous system uses electrical signals/impulses; [1 mark]
- The endocrine system sends messages via the blood **WHILE** the nervous system sends messages via the neurones; [1 mark]
- The endocrine system can target many cell types **WHILE** the nervous system targets muscle cells or glands; [1 mark]
- The endocrine system is (relatively) slow to act **WHILE** the nervous system is fast to act; [1 mark]
- The effects of the endocrine system can be long lasting **WHILE** the effects of the nervous system can be short-lived; [1 mark]
- The effects of the endocrine system can vary on the basis of hormone concentration **WHILE** nerve impulses are 'all-or-nothing'; [1 mark]
- The endocrine system brings about only involuntary responses **WHILE** the nervous system is involved with voluntary and involuntary responses; [1 mark]

[Total: 3 marks]

1c

(c) (i) The type of cell in Fig. 1 is a…

- Motor neurone; [1 mark]

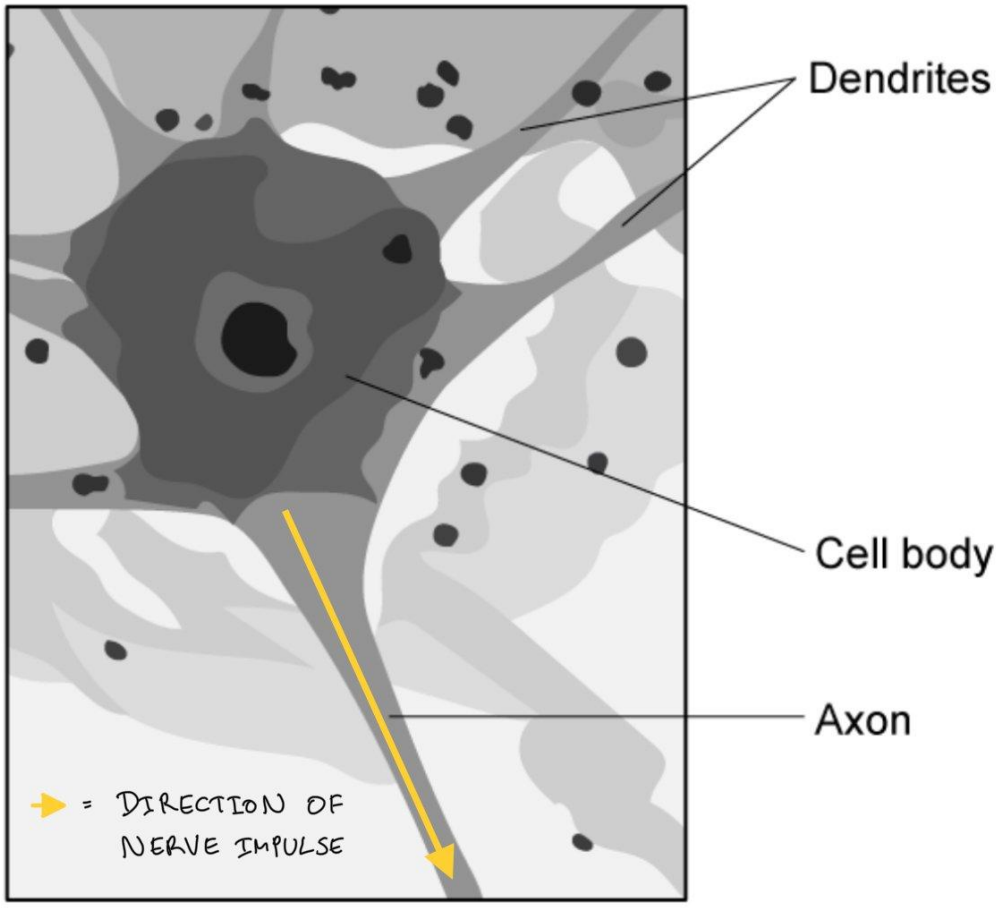
The cell in Fig. 1 has its cell body **within the CNS**, marking it as a **motor neurone**; it sends signals from the CNS to effectors. Sensory neurones do not have cell bodies within the CNS

and relay neurones are located entirely within the CNS.

(c) (ii) The direction of nerve impulse travel is...

- Downwards away from the cell body, along the axon; [1 mark]

Nerve impulses travel away from the cell body along the axon of a neurone.



[Total: 2 marks]

1d

(d) (i) A feature of motor neurones that is not labelled in Fig. 1 is...

Any **one** of the following:

- Schwann cells / myelination; [1 mark]
- Mitochondria; [1 mark]
- Vesicles; [1 mark]
- Ribosomes / rough endoplasmic reticulum; [1 mark]
- Golgi apparatus/body; [1 mark]
- Nucleus; [1 mark]

(d) (ii) This feature assists neurone cell function because...

Any **relevant** answer from the following:

- (Schwann cells / myelination) speed up conduction of a nerve impulse / allow for saltatory conduction / allow nerve impulses to jump between nodes; [1 mark]
- (Mitochondria) produce ATP / release energy for the active transport of ions/named ions; [1 mark]
- (Vesicles) store neurotransmitter at synapses / to transmit nerve impulses across synapses; [1 mark]

- (Ribosomes / rough endoplasmic reticulum) allow the synthesis of transport proteins/channel proteins/neurotransmitters/acetylcholinesterase; [1 mark]
- (Golgi apparatus/body) allow the packaging/transport of transport proteins/channel proteins/neurotransmitters/acetylcholinesterase to the cell surface membrane; [1 mark]
- (Nucleus) stores genetic information / DNA / chromosomes from which transport proteins/channel proteins/neurotransmitters/acetylcholinesterase can be transcribed/synthesised;

Reject *references to mitochondria producing or creating energy.*

Note that you need to be able to explain **how** your identified feature specifically aids **neurone function** so just stating the general role of an organelle, e.g. 'mitochondria release energy' is not enough here.

[Total: 2 marks]

2a

(a) (i) Cell A in Fig. 1 is a...

- Presynaptic neurone/cell; [1 mark]

(a) (ii) It is possible to say this because...

- Cell A contains (many) vesicles (which contain neurotransmitter); [1 mark]

[Total: 2 marks]

2b

(b) (i) One feature that would be found on the cell surface membrane of cell B is...

- Receptors / neurotransmitter receptor molecules / receptor proteins; [1 mark]

(b) (ii) These cannot be seen in Fig. 1 because...

- The resolution / resolving power of the (electron) microscope is not high enough; [1 mark]
- It is not possible to distinguish between two points that are very close together / between the receptors and their surroundings (so all are viewed as a single point); [1 mark]

While electron microscopes have a very high resolution, proteins are still too small to be viewed in this way. It is not possible to distinguish between the proteins and the surrounding membrane and only the membrane is visible in the image.

[Total: 3 marks]

2c

(c) The role of structure C within cell A is to...

Any **two** of the following:

- Produce ATP / release energy (in the process of respiration); [1 mark]
- Producing/recycling neurotransmitter/acetylcholine; [1 mark]
- Active transport/uptake of (broken down) neurotransmitter/acetylcholine (back into the cell from the synaptic cleft); [1 mark]
- Restoring the calcium ion gradient / pumping/actively transporting calcium ions out of the cell; [1 mark]

Reject *references to producing/creating energy*

[Total: 2 marks]

You are not expected to know the exact role of mitochondria inside presynaptic neurones

but you should be able to reach an answer by thinking about some of the processes that need to occur in a presynaptic cell.

2d

(d) The role of calcium ions at a synapse is...

Any **four** of the following:

- An action potential / wave of depolarisation arrives at the end of the (presynaptic) neurone / the membrane of the (presynaptic) neurone depolarises; [1 mark]
- (Voltage-gated) calcium ion channels open (in response to the depolarisation); [1 mark]
- There is a higher concentration of calcium ions outside the neurone than inside; [1 mark]
- Calcium ions move/diffuse into the neurone / there is an influx of calcium ions; [1 mark]
- (Calcium ions cause) vesicles containing neurotransmitter/acetylcholine to move towards the cell surface membrane; [1 mark]
- Vesicles fuse with the cell surface membrane; [1 mark]
- Neurotransmitter is released by exocytosis / into the synaptic cleft; [1 mark]

Accept *mark point 1 in the context of mark point 2, e.g. calcium ion channels open in response to the arrival of an action potential.*

[Total: 4 marks]

This is really a question about the process that takes place at a synapse, but you should focus on the events that are directly linked to calcium ions.

3a

(a) Comparative features of a normal cholinergic synapse and a neuromuscular junction include...

Similarities

A maximum of **two** of the following:

- Both involve vesicles containing (the neurotransmitter) acetylcholine; [1 mark]
- Both release vesicles in response to an influx of calcium; [1 mark]
- Both rely on diffusion of a neurotransmitter across a gap/synapse/cleft; [1 mark]
- Both involve the binding of a neurotransmitter to receptors on the post-synaptic membrane; [1 mark]
- Both involve the opening of sodium ion channels; [1 mark]
- Both involve the depolarisation of the postsynaptic cell as a result of a sodium ion influx; [1 mark]

Differences

A maximum of **two** of the following:

- Depolarisation of a muscle cell passes to the centre of the cell via T-tubules **WHILE** depolarisation of a neurone does not; [1 mark]
- Deporarisation of a muscle cell leads to the release of calcium ions into the cytoplasm (from the sarcoplasmic reticulum) **WHILE** depolarisation of a neurone does not; [1 mark]
- Neuromuscular junctions involve one neurone and one muscle cell **WHILE** normal synapses involve two neurones; [1 mark]

[Total: 3 marks]

The command word **compare** can refer to both similarities and differences, so you should be sure to give a reasonable balance of both in your answer. When describing a difference you must be sure that each mark point contains a comparison of the two types of synapse.

3b

(b) Structures **A**, **B** and **C** are...

- A = sarcomere; [1 mark]
- B = A band; [1 mark]
- C = Z lines; [1 mark]

[Total: 3 marks]

3c

(c) The striped appearance of muscle tissue is due to...

- Myosin filaments are thicker **SO** areas containing myosin (and myosin along with actin) are darker in appearance; [1 mark]
- Actin filaments are thinner **SO** areas containing only actin are lighter in appearance; [1 mark]

[Total: 2 marks]

3d

(d) The drugs in Table 1 reduce the contraction of skeletal muscles by...

PBP

Any **two** of the following:

- Myosin heads cannot be released/detach from actin **OR** cross-bridges cannot be broken; [1 mark]
- Myosin cannot re-attach/bind to another binding site further along the actin; [1 mark]
- Sarcomere only gets shorter / muscle only contracts by a very small amount **OR** power stroke cannot be repeated / only occurs once; [1 mark]

Dantrolene

Any **two** of the following:

- Calcium cannot bind to troponin; [1 mark]
- (Troponin and) tropomyosin do not move / change position to expose myosin binding sites (on actin); [1 mark]
- Myosin heads cannot bind to actin / cross-bridges cannot form **SO** power stroke cannot occur / myosin cannot move actin; [1 mark]

[Total: 4 marks]

This question requires you to **apply your knowledge** of the details of muscle contraction to the unfamiliar scenarios of drug action presented.

When ATP is hydrolysed the myosin head detaches from actin, allowing it to form a new cross-bridge further along the actin and repeat the power-stroke. If ATP hydrolysis is prevented then myosin cannot detach from actin and the power stroke will not be repeated. Calcium ions bind to troponin, causing tropomyosin to move away from actin and exposing the binding sites for myosin. In the absence of calcium ions, these events cannot occur.

4a

(a) The roles of sensory receptor cells in the mammalian nervous system are...

Any **three** of the following:

- Detect/respond to (change in) stimulus/stimuli; [1 mark]
- (**Two** examples from, e.g.) light / heat / sound / touch / pressure / pain / chemicals / taste / smell / tension; [2 marks]
- Act as transducers / convert stimulus energy to electrical energy; [1 mark]
- Produce generator/action potential; [1 mark]
- Pass impulses to sensory neurone; [1 mark]

[Total: 3 marks]

It is not enough to say that sensory receptors *sense* or *receive* a *signal* in the environment, they **detect** or **respond to stimuli**.

Note that sensory receptors do not pass stimuli, signals or messages to the central nervous system, just to sensory neurones.

4b

(b) (i) The events are as follows…

- The Na^+/K^+ pump is operating = C **AND** D **AND** E; [1 mark]
- The voltage-gated Na^+ channels are open = C; [1 mark]
- The voltage-gated K^+ channels are open = D; [1 mark]

Note that while the role of the sodium-potassium pump is to establish and maintain resting potential, it operates continuously and does not stop during the depolarisation and repolarisation stages.

(b) (ii) Stimulus A did not result in an action potential being produced whereas stimulus B did because…

- The generator potential…; [1 mark]
- … Does not reach/exceed the threshold; [1 mark]

(b) (iii) The importance of the refractory period in the transmission of action potentials is…

- Limits/controls (the maximum) frequency of action potentials; [1 mark]
- (Action potentials / impulses) travel in one direction; [1 mark]

(b) (iv) Action potentials are transmitted along a myelinated axon by…

Any **four** of the following:

- Local circuit / movement of ions from positive to negative region; [1 mark]
- (Causes) opening of Na^+ channels…; [1 mark]
- …At next node (of Ranvier) / gap in myelin sheath; [1 mark]
- This causes the next/new action potential/depolarisation; [1 mark]
- Saltatory conduction occurs; [1 mark]
- One-way transmission only; [1 mark]
- Myelin (sheath)/Schwann cells insulate axon / prevent (named) ion movement / speed up transmission / lengthen local circuits; [1 mark]

[Total: 11 marks]

5

(a) A cholinergic synapse functions as follows…

Any **seven** of the following:

- Nerve impulse/action potential reach the synaptic knob; [1 mark]
- (Voltage-gated) Ca^{2+}/calcium ion channels open (in the presynaptic membrane); [1 mark]

- Calcium ions enter (the synaptic knob); [1 mark]
- Vesicles containing acetylcholine move towards / fuse with the presynaptic membrane; [1 mark]
- (Acetylcholine) is released/secreted / exocytosis occurs; [1 mark]
- Acetylcholine diffuses across the synaptic cleft; [1 mark]
- It binds to receptors on the post-synaptic membrane; [1 mark]
- Na^+ channels open **AND** Na^+ enters the post-synaptic neurone; [1 mark]
- The membrane depolarises / an action potential is generated; [1 mark]
- Acetylcholinesterase breaks down / recycles acetylcholine; [1 mark]

Accept *ACh for acetylcholine after the full term has been used correctly once.*

[Total: 7 marks]

Be careful with some of the key terminology when answering this question:

- Calcium **ions** and sodium **ions** are involved; don't just refer to 'calcium' or 'sodium'.
- Vesicles **fuse with** the presynaptic membrane and **release ACh** by exocytosis, the vesicles themselves do not leave the cell.
- Ions move **through** membranes and **into neurones**, not 'into the membrane' (this implies movement into the space inside the bilayer).

6a

(a) The location of the proteins are...

protein	**location**
myosin and actin	B; [1 mark]
actin alone	C; [1 mark]
ATP synthase	A; [1 mark]
ATPase	B; [1 mark]

[Total: 4 marks]

6b

(b) The role of ATP in the contraction of striated muscle is...

Any **five** of the following:

- Myosin head binds to actin / forms cross bridge; [1 mark]
- ADP released causes motion of myosin head; [1 mark]
- Actin moved; [1 mark]
- Power stroke; [1 mark]
- ATP binds to myosin head; [1 mark]
- Myosin head detaches from actin / cross bridge broken; [1 mark]
- (Myosin head / ATPase) causes hydrolysis of ATP / ATP→ ADP + Pi; [1 mark]
- Myosin head moves back to original position; [1 mark]
- (ATP needed) to pump Ca^{2+} back into sarcoplasmic reticulum; [1 mark]

[Total: 5 marks]

The order of events here is important. Remember to focus specifically on what is being asked in the question here. For example any reference to ATP being generated in mitochondria, or

its role in generating an action potential or synaptic transmission cannot gain marks.

7a

(a) A spinal reflex arc functions, and it is an advantage to a mammal, as follows...

Any **nine** of the following:

- Sense organ/receptor detects stimulus; [1 mark]
- e.g. light, sound, heat; [1 mark]
- Very strong stimulus; [1 mark]
- Action potential generated in sensory neurone; [1 mark]
- Sensory neurone connects to spinal cord; [1 mark]
- Synapse with relay/intermediate neurone **OR** action potential passes to relay/intermediate neurone; [1 mark]
- (Relay/intermediate/sensory neurone) synapse with motor neurone **OR** action potential passes to motor neurone; [1 mark]
- Effector / muscle; [1 mark]
- Response; [1 mark]
- Fast(er); [1 mark]
- Automatic / involuntary; [1 mark]
- Response is always the same / stereotypic; [1 mark]
- Protects from harm; [1 mark]

[Total: 9 marks]

Remember that the sensory neurone does not detect the stimulus, the receptor does. Also, make sure you're specific with your wording when it comes to the action potential in the neurone, try to avoid using basic language like impulse, messages, or information passing along the neurone.

7b

(b) The importance of the myelin sheath in determining the speed of nerve impulses is...

Any **six** of the following:

- (Sheath) insulates axon / stops passage of ions; [1 mark]
- Gaps / nodes of Ranvier; [1 mark]
- 1–3 mm intervals; [1 mark]
- Passage of ions can occur (at nodes); [1 mark]
- Depolarisation/action potentials only occur at nodes; [1 mark]
- Local circuits (between nodes); [1 mark]
- Saltatory conduction; [1 mark]
- Faster (speed of nerve impulse); [1 mark]

[Total: 6 marks]