OCR A-LEVEL BIOLOGY A · H420

BIOLOGY



EXAM QUESTION PACK

5.1.3 NEURONAL COMMUNICATION

SCORE	PERCENTAGE
/48	%

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Answer **all** the questions.

1. Animals receive different stimuli from their environment. Their synapses can manage multiple stimuli, often resulting in one response (such as a muscle twitching).

This action of the synapse is an example of

A spatial summation
B all or nothing response
C temporal summation
D cell signalling

Your answer ☐

[1]

2. Which of the following describes the process that happens during **repolarisation** of a neurone during the action potential?

	Sodium channels	**Potassium channels**	**Membrane potential**
A	closed	open	decreasing
B	open	closed	decreasing
C	open	closed	increasing
D	closed	open	increasing

Your answer ☐

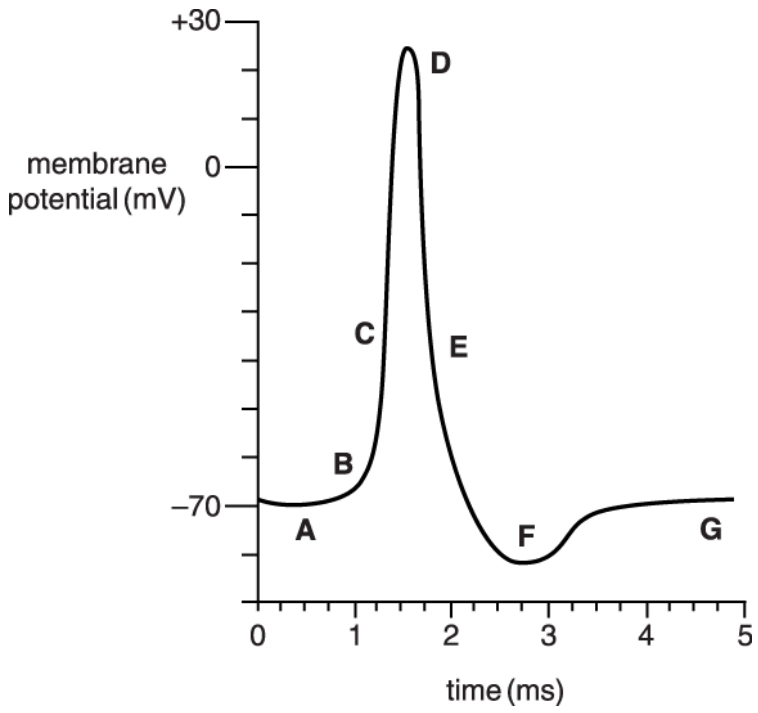
[1]

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3. The figure represents the voltage across the membrane of an axon and the changes that take place during the generation and transmission of an action potential.



Indicate the **letters, A** to **G**, when each of the following occurs.

A letter may be used once, more than once or not at all.

(i) Voltage-gated sodium ion channels are open.

---

[1]

(ii) Repolarisation.

---

[1]

(iii) Sodium ions are actively pumped out of the neurone.

---

[1]

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4(a). The skin is important in enabling the body to detect changes in the environment. This allows the body to respond to these changes.

Various types of sensory receptor are located in the skin.

Fig. 2.1 is a photomicrograph of a **transverse section** through a pressure receptor known as a Pacinian corpuscle.

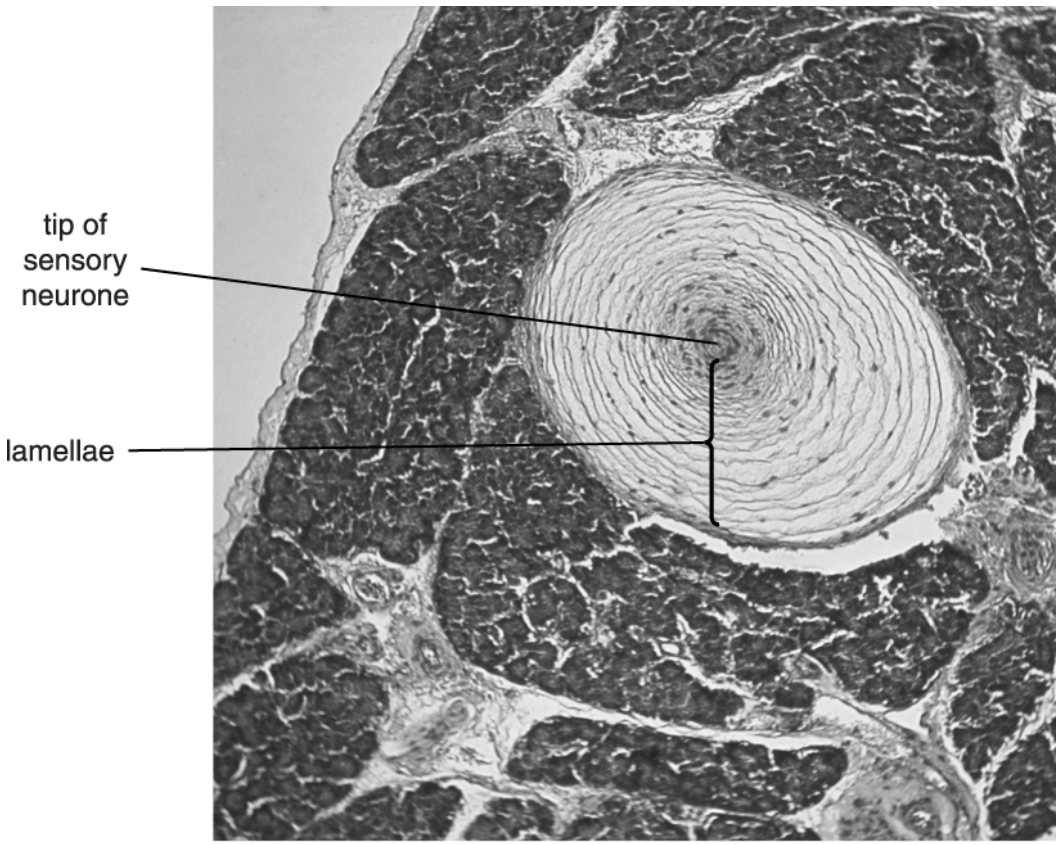


Fig. 2.1

Fig. 2.2 is a diagram of a **longitudinal section** through a Pacinian corpuscle. The tip of the sensory neurone is not covered by the myelin sheath.

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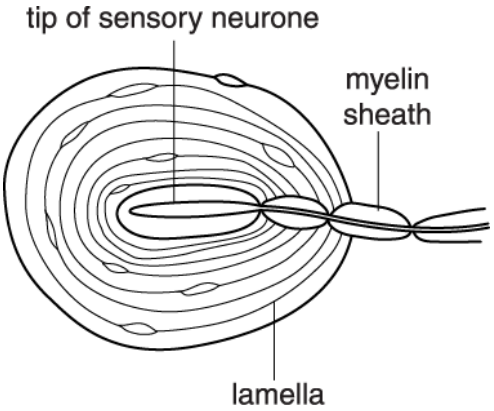


Fig. 2.2

The Pacinian corpuscle is a type of biological transducer.

- As a pressure stimulus is exerted on the corpuscle, the lamellae are compressed and exert pressure on the tip of the sensory neurone.
- The plasma (cell surface) membrane of the tip of the neurone becomes deformed and more permeable to sodium ions (Na^+).
- This region of the neurone becomes depolarised, reaching the threshold potential, and an action potential is generated.

(i) Why is the Pacinian corpuscle described as a transducer?

---**[1]**

(ii) Deformation of the plasma membrane of the tip of the neurone causes the membrane to become more permeable to Na^+.

Suggest why.

---**[1]**

(iii) The generation of an action potential follows the 'All-or-Nothing' law.

Explain what this means.

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---**[1]**

(iv) Describe how information about the strength and intensity of a stimulus is communicated to the brain.

---**[2]**

(b). When clothes are first put on the body, a constant gentle pressure is applied to the pressure receptors in the skin. After a short time, action potentials are no longer generated unless there is a change in pressure as the clothes move over the surface of the skin.

Suggest an explanation for the fact that action potentials are not generated constantly whilst wearing clothes.

---**[1]**

(c). Synapses are an integral part of the nervous system.

Outline the roles of synapses in the nervous system.

---**[3]**

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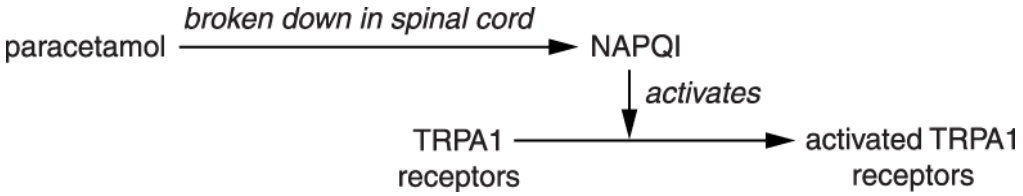
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5. Paracetamol is a drug that is commonly used as a painkiller. For many years, scientists have been uncertain about the way in which paracetamol works.

A recent study has shown that:

- paracetamol is broken down in the spinal cord into a compound called NAPQI
- NAPQI activates a receptor protein called TRPA1
- TRPA1 is found on the plasma (cell surface) membranes of neurones
- the activated receptor protein, TRPA1, interferes with the transmission of the nerve impulses from one neurone to the next.



(i) Name **one** chemical that transfers a nerve impulse from one neurone to another.

---

[1]

(ii) Suggest the part of the neurone where the plasma membrane has TRPA1 receptors.

Explain your answer.

part of neurone

---

explanation

---

[2]

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6. Nicotine molecules have a shape that is complementary to acetylcholine receptors. As a result, nicotine interferes with the nervous systems of insects and mammals by binding with these receptors.

(i) Where, precisely, are acetylcholine receptors found?

---------- **[1]**

(ii) The way that nicotine is thought to work is outlined in Fig. 7.1.

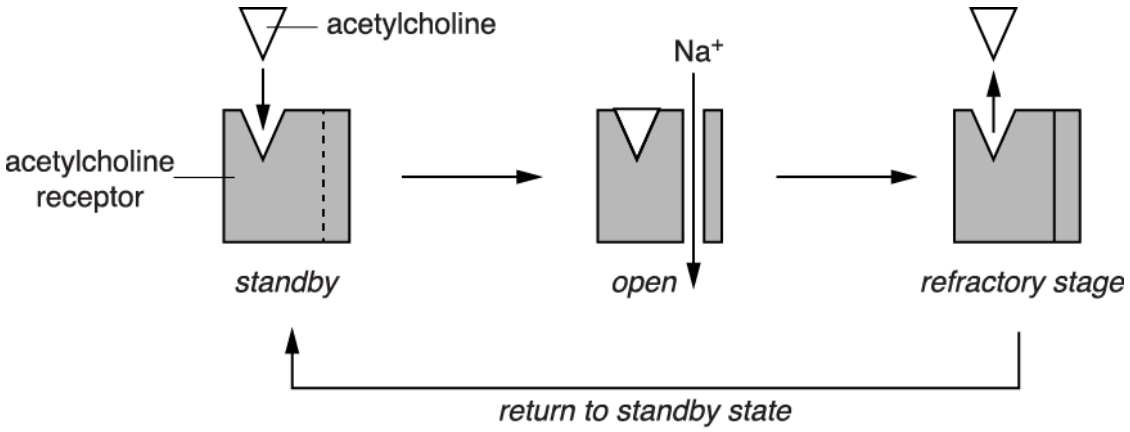


Fig. 7.1(a) When nicotine absent

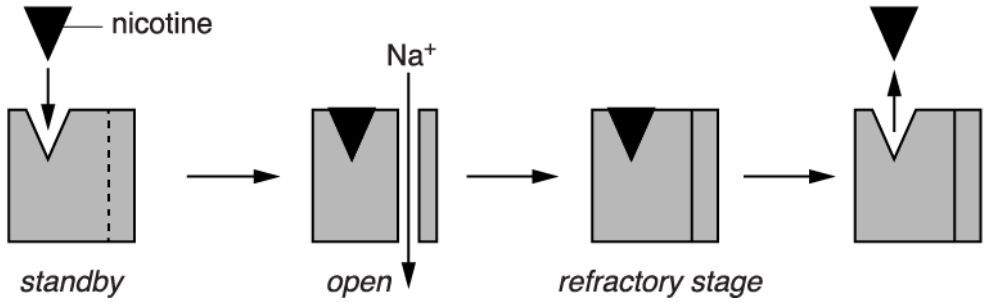


Fig. 7.1(b) When nicotine present

Using the information in Fig. 7.1(a) and Fig. 7.1(b), suggest and explain the effect that nicotine has on the nervous system.

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---[3]

7. Fig. 3.3 is a diagram representing the neuromuscular junction in mammals.

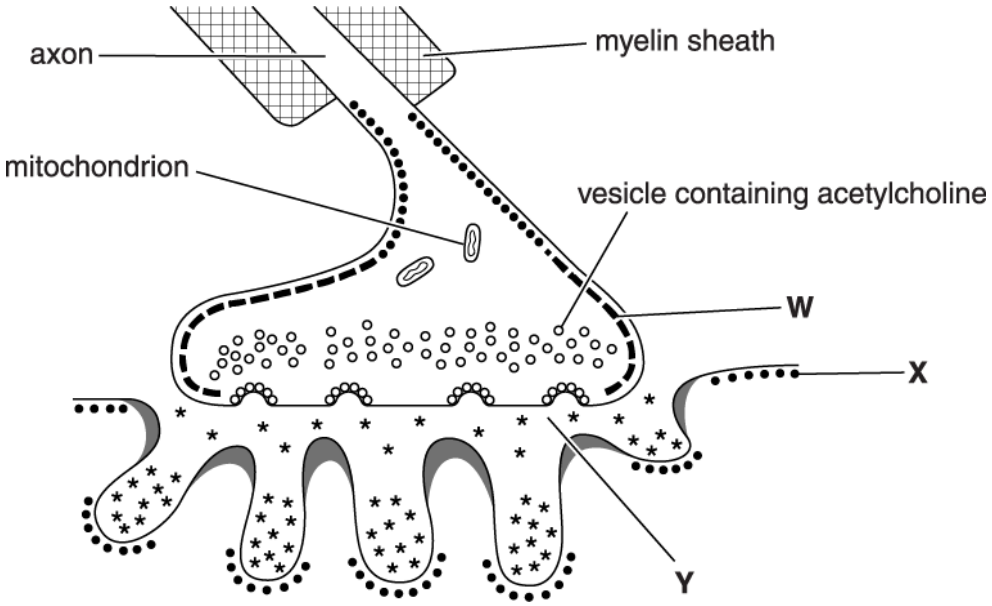


Fig. 3.3

(i) What type of molecule forms ion channels **W** and **X**?

---[1]

(ii) Identify region **Y**.

---[1]

(iii) Name the enzyme found in region **Y**.

---[1]

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8(a). Outline the ways in which the **structures** of a sensory neurone and a motor neurone are **similar**.

In your answer, you should use appropriate technical terms, spelled correctly.

[4]

(b). The table below lists a number of statements about the functions of neurones. Indicate whether each statement refers to:

- sensory neurones only **(S)**
- motor neurones only **(M)**
- sensory **and** motor neurones **(B)**.

Statement	**S** or **M** or **B**
Have a resting potential of approximately −70 mV	B
Transmit nerve impulses from the CNS	
Connect to other neurones via synapses	
Connect to effectors	

[3]

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9(a). Squid are an order of aquatic animals. Many species of squid show a reflex response to changes in their body position.

- A sensory receptor called a statocyst detects changes in the body position of the squid in their aquatic environment.
- The reflex response corrects the squid's body position.

(i) Describe the components and events involved in a reflex arc.

---

[3]

(ii) Suggest one benefit to the squid of the reflex response described above.

---

[1]

(iii) A statocyst sensory receptor is shown in Fig. 2.1.

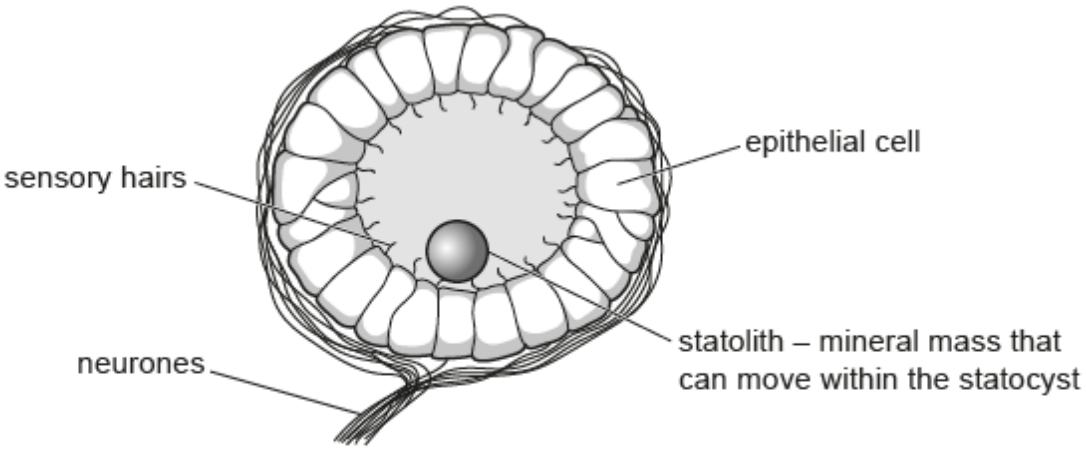


Fig. 2.1

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What can you conclude from Fig. 2.1 about the mechanism by which a statocyst acts as a transducer?

[3]

(b). Lobsters and sea cucumbers also have statocysts. From this information, the student concluded:

'I think this means squids, lobsters and sea cucumbers evolved from a recent common ancestor and are probably classified in the same phylum.'

Evaluate the extent to which the information about lobsters and sea cucumbers supports the student's conclusion.

[2]

(c). Fig. 2.2 shows a representation of a human neurone.

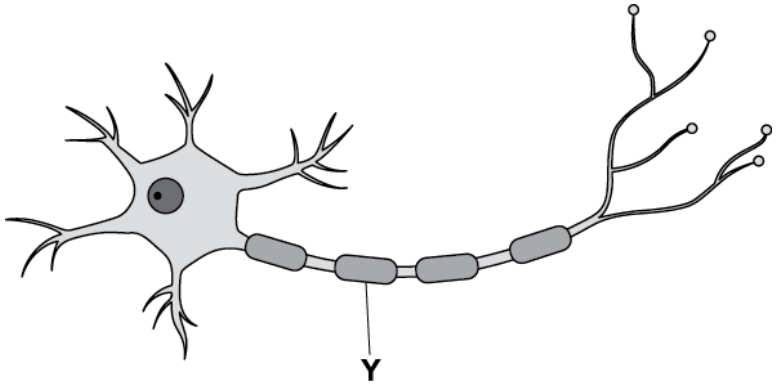


Fig. 2.2

(i) Name the type of neurone shown in Fig. 2.2.

---

[1]

(ii) State the function of **Y** in Fig. 2.2.

---

[1]

(d). *The amplitude and duration of the action potentials in a single neurone are always the same. However, the amplitude and duration of action potentials can vary between different types of neurone.

Fig. 2.3 shows action potentials in two different types of neurone.

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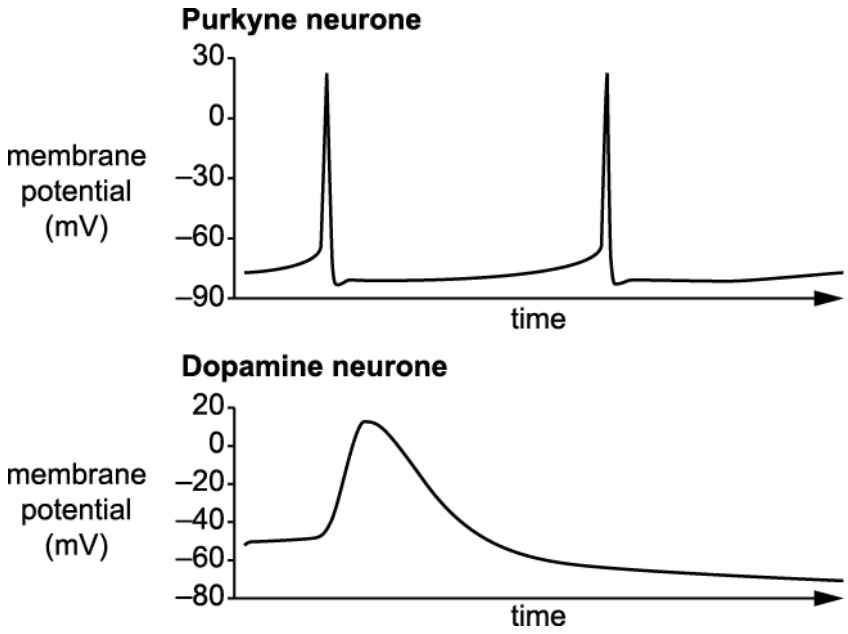


Fig. 2.3

Describe the differences between the two action potentials **and** suggest explanations for the differences you have described.

[6]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			A	1	
			Total	**1**	
2			A	1	
			Total	**1**	
3		i	(B and) C;	1	**Mark the first answer(s).** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **Examiner's Comments** Most candidates answered this correctly, although some did only mention B and so were not awarded the mark.
		ii	D **and** E;	1	**Mark the first 2 answers.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **IGNORE** F **Examiner's Comments** Candidates often only stated E, less frequently D alone, while both were required for the mark.
		iii	**all** individual letters A to G / A to G / A – G;	1	as the pump runs continuously **CREDIT** F **and / or** A **and** G as these are the places where the pump has greatest effect **IGNORE** B if given as an additional answer to an otherwise correct answer **Examiner's Comments** Candidates did not appreciate that the sodium ion pump is not voltage-regulated and so is actively pumping the whole time. Allowance was made for this in the mark scheme and various combinations of letters were credited.

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Question			Answer/Indicative content	Marks	Guidance
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
4	a	i	it converts energy (mechanical) into, another / different, form of energy (electrical);	1	If type of energy is specified, it must be as indicated in the brackets **ACCEPT** 'converts one form of energy into another' **IGNORE** pressure **Examiner's Comments** While many candidates understood that the Pacinian corpuscle is described as a transducer because it transforms one form of energy into another, they often negated their answer by naming the wrong from of energy, such as kinetic or chemical. Inadequate responses stated that the corpuscle would transform the stimulus into an electrical impulse.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*idea that deformation of membrane will allow more Na^+ through because* **1** (the increased pressure) causes sodium (ion) channels to open; **2** (temporary) gaps / holes / spaces, appear, between the phospholipids / in the bilayer;	1 max	**1 CREDIT** Na^+ channels **DO NOT CREDIT** Na channels **DO NOT CREDIT** ref to voltage(-gated) channels **2 IGNORE** weakened **DO NOT CREDIT** '*breaks* in the bilayer' **DO NOT CREDIT** 'pores' for 'gaps' **DO NOT CREDIT** idea of additional, channels / carriers, inserted **Examiner's Comments** The reason why deformation of the plasma membrane of the tip of the neurone causes the membrane to become more permeable to Na^+ was frequently poorly understood. The most common correct response was that deformation would open the sodium ion channels. While some candidates appreciated that the bilayer might develop temporary gaps, they did not specify the phospholipid bilayer. Answers that suggested that the voltage gated channels would open, or that the channels, or the plasma membrane, would be damaged or denatured by the pressure exerted upon them did not gain credit.

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Question			Answer/Indicative content	Marks	Guidance
		iii	if the, stimulus is not strong enough / threshold (value) is not reached / depolarisation (of membrane) is insufficient, then, it / an action potential, is not, generated / AW; **ora**	1	**ACCEPT** 'impulses' for 'action potentials' **DO NOT CREDIT** ref to 'strength' of an action potential **IGNORE** ref to numerical value for threshold potential **IGNORE** ref to 'it' or 'action potential' reaching threshold **DO NOT CREDIT** ref to action potentials of different sizes / values **Examiner's Comments** The meaning of the 'All-or-Nothing' law in the generation of an action potential was generally well understood, with most candidates recognizing that the an action potential would only be initiated once the threshold potential was reached or exceeded. However, some incorrectly stated that the action potential would have to reach threshold or simply said that the action potential would either happen or it wouldn't. Some referred to the strength of the action potential, thereby negating their answer.

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Question			Answer/Indicative content	Marks	Guidance
		iv	**1** *idea that* it is represented by the frequency of the action potentials; **2** high, frequency / rate (of generation), of action potentials shows, a strong / an intense, stimulus; **ora**	2	**Note: max 1 if term 'frequent' or derived term NOT used in answer** **ACCEPT** 'impulses' for 'action potentials' **1 CREDIT** represented by how, frequently / often, the action potentials are, transmitted / generated **2 DO NOT CREDIT** ref to speed of, action potentials / impulses **Note**: e.g. 'a high*er* frequency of impulses represents a strong stimulus' = **2 marks** **Examiner's Comments** Good answers showed an appreciation that the information about the strength and intensity of a stimulus is communicated to the brain by way of the frequency of the action potentials. Many commented that a greater stimulus strength would lead to a greater number of action potentials but without reference to a time element, or that they would travel faster. Answers that simply described how action potentials would be relayed to the brain did not gain credit.

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Question			Answer/Indicative content	Marks	Guidance
	b		*action potentials not generated because* **1** sodium (ion) channels (remain) open / resting potential not re-established; **2** *idea of* ions being in the wrong place for correct ion movement (across membrane);	1 max	**IGNORE** lack of (named) neurotransmitter as the Q refers to generation of the action potential in the receptor and not its onward transmission **1 CREDIT** Na^+ channels **IGNORE** 'voltage-gated' **DO NOT CREDIT** Na channels **Examiner's Comments** Few candidates were able to suggest why action potentials are not generated constantly while wearing clothes. Most responses concentrated on how neurotransmitter would run out in the synaptic bulb leading to acclimatisation or that weak stimuli would be filtered out by the synapse, which failed to answer the question. Some candidates suggested that generator potentials would not exceed the threshold or that insufficient sodium ion channels would open. Answers were expected to reflect the context of the question and reference the continual pressure on the membrane and so the fact that the sodium ion channels would remain open and therefore preventing the generation of an action potential.

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Question			Answer/Indicative content	Marks	Guidance
	c			3 max	**ACCEPT** 'action potentials' for 'impulses' **IGNORE** 'messages' and 'signals' throughout
			1 allows, neurones to communicate / cell signalling;		**1** e.g. • passes impulse on to next neurone • passes neurotransmitter on to next neurone
			2 ensure transmission (between neurones) in one direction (only);		**2 Must be transmission *between* neurones** **IGNORE** description unless for clarification
			3 allows, convergence / impulses from more than one neurone to be passed to a single neurone;		**3 IGNORE** 'summation' **ACCEPT** 'neurotranmsitter' instead of 'impulse'
			4 allows, divergence / impulses from a single neurone to be passed to more than one neurone;		**4 ACCEPT** 'neurotranmsitter' instead of 'impulse'
			5 idea that filters (out), 'background' / low level, stimuli **or** ensures that only stimulation that is strong enough will be passed on;		
			6 prevents fatigue / prevents over-stimulation;		
			7 allows many low level stimuli to be amplified;		**7 IGNORE** 'summation'
			8 *idea that* presence of inhibitory and stimulatory synapses allows impulses to follow specific path;		
			9 permits, memory / learning / decision making;		
					Note: 'impulses from more than one neurone can pass to a single neurone' = **2 marks** (mps 1 & 3) **Note:** 'impulses from a single neurone can pass to many neurones' = **2 marks** (mps 1 & 4)
					Examiner's Comments

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Question			Answer/Indicative content	Marks	Guidance
					There were some very good accounts of the roles of synapses in the nervous system with well-prepared candidates gaining maximum marks. Many stated that synapses were important in cell signalling and would ensure that the action potential would only be transmitted in one direction, although some then negated their answer by saying that this would be along the neurone, rather than across a synapse. Many also appreciated that low level stimuli could either be filtered out or amplified, depending on the situation, or that synapses would allow convergence or divergence, either stated or described. Other answers referenced the role of synapses in memory or learning, or how they would prevent overstimulation of the postsynaptic neurone. However, some simply described neurotransmitter release at a synapse which was not credited. Candidates are expected to refer to stimuli rather than signals.
			Total	**9**	

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Question			Answer/Indicative content	Marks	Guidance
5		i	acetylcholine;	1	**Mark the first answer**. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **CREDIT** other correct examples e.g. dopamine / noradrenaline / norepinephrine **ACCEPT** ACh **Examiner's Comments** The vast majority of candidates gave the correct answer acetylcholine, although spelling was not always correct. The only alternative answer commonly seen was dopamine. Some did not appreciate that a named chemical was required and gave the general term, 'neurotransmitter', instead.
		ii	***either*** post-synaptic membrane; (TRPA1) prevents attachment of (named) neurotransmitter to its receptor; ***or*** pre-synaptic membrane / (pre)synaptic knob / axon terminal / bouton / synaptic bulb : (TRPA1) prevents, release of (named) neurotransmitter / influx of calcium ions;	2	**Explanation must match correct location for 2 marks.** **If no location stated then explanation can be awarded independently for 1 mark.** **Incorrect location = 0 marks**. **IGNORE** 'interferes' (as in Q) **IGNORE** ref to dendrites / cell bodies / neurone(s) / synapse(s) **CREDIT** causes hyperpolarisation **DO NOT CREDIT** idea that TRPA1 is a free protein that will enter the ACh receptor and block it (rather like a or competitive inhibitor occupying the active site of an enzyme) **ACCEPT** Ca^{2+} **Examiner's Comments** This was a challenging question for candidates. Despite being told in the question stem that TRPA1 is found on the

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Question			Answer/Indicative content	Marks	Guidance
					plasma membranes of neurones, many answered with no specific reference to a membrane at all, referring instead to 'neurone', 'synapse' or 'cell body'. Despite being told that TRPA1 interferes with the transmission of the nerve impulse from one neurone to the next, 'axon' and 'nodes of Ranvier' were suggested by some candidates. For the explanation, many candidates described the general role of the part that they had named in transmission of impulses rather than attempting to describe how the TRPA1 would affect transmission. There was some confusion about the nature of the TRPA1 receptor. Some candidates described it as if it was a free protein that might bind to ACh receptors in a form of competitive inhibition. Others described two TRPA1 components: the TRPA1 protein which binds to the TRPA1 receptor. There also seemed to be confusion about where ACh receptors are located. A minority of candidates continue to confuse 'nerve' with 'neurone'.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
6		i	postsynaptic membrane(s) (in, neurone / neuromuscular junction);	1	**ACCEPT** sarcolemma **DO NOT CREDIT** postsynaptic knob **Examiner's Comments** The majority of candidates gave the precise location of the receptors as being the postsynaptic membrane. A small number realised that this would be the sarcolemmma in this particular case. Both responses gained the mark.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*Effect* Nicotine slows down rate of / stops, transmission of, action potentials / nervous impulses; **Plus any 2 of the following:** *Explain* binds to <u>receptor</u>; (nicotine) has the same response / opens Na^+ channels / causes depolarisation; nicotine remains in receptor for longer; *idea that* <u>receptor</u>, remains in refractory stage for longer / unable to return to standby condition cannot be reactivated;	3 max	**IGNORE** 'nervous system slows down' / 'acts as a depressant' **ACCEPT** competes with acetylcholine for the <u>receptor</u> **DO NOT CREDIT** active site **DO NOT CREDIT** 'acts as competitive inhibitor' **DO NOT CREDIT** binds to receptor permanently **ACCEPT** causes action potential in next neurone / mimics, action / effects, of acetylcholine **IGNORE** 'mimics acetyl choline' alone **IGNORE** delays refractory stage **ACCEPT** permanently in refractory stage **Examiner's Comments** Describing how nicotine is thought to work proved difficult for many. This was usually a result of confusion between this receptor scenario and the action of enzymes, as many references to active sites and nicotine acting as a competitive inhibitor were seen. Correct references to it binding to the receptor causing depolarisation or an action potential gained credit, along with the idea that the receptor was unable to return to the standby state. Other valid ideas included the stopping of action potential transmission altogether or a reduction in the rate of transmission.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
7		i	protein;	1	**ACCEPT** glycoprotein **IGNORE** polypeptide / channel / carrier / transport **Examiner's Comments** This was well answered, with most putting 'protein'. Those that didn't tended to write calcium or sodium ions.
		ii	(synaptic) cleft;	1	**IGNORE** gap **IGNORE** neuromuscular **Examiner's Comments** Tthe majority of candidates correctly identified the region as the synaptic cleft.
		iii	acetylcholine esterase / ACh esterase;	1	**ACCEPT** phonetic spelling and ignore upper / lower case **IGNORE** AChE **Examiner's Comments** Surprisingly, a large number of candidates failed to correctly identify the enzyme. The most common error was to identify it as acetyl choline or acetylcholinerase.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
8	a		*both have* 1 **dendrite**(s); 2 an **axon**; 3 a **cell body** with a, nucleus / named organelle; 4 **myelin** sheath / myelinated / (covered with) **Schwann** cell / nodes of Ranvier; 5 voltage-gated channels / sodium-potassium (ion) pump; **QWC;**	3 max 1	1 **DO NOT CREDIT** if states that motor neurone has dendrites and a dendron 3 e.g. mitochondria / Golgi / SER / RER 4 **CREDIT** may have / can have Award if **3** of the following terms have been used in a correct context with correct spelling: **dendrite(s)** **axon(s)** **cell body(ies)** **myelin** (or derived term) **schwann** *Please insert a QWC symbol next to the pencil icon, followed by a tick (☐) if QWC has been awarded or a cross (×) if QWC has not been awarded.* *You should use the green dot to identify the QWC terms that you are crediting.* **Examiner's Comments** Concise answers achieved full marks, as neurone structure is well known. Few candidates gave details of functions rather than structure, although some supplemented their answer with details of function. Candidates should not imply that a dendron is present in a motor neurone. QWC was normally awarded, although there were the odd mistakes made in the spelling of 'myelin'.

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Question			Answer/Indicative content	Marks	Guidance
	b		**M;** **B;** **M;**	3	**Mark the first answer in each box.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **Examiner's Comments** The majority of candidates obtained these marks, with a small number giving the incorrect answer in the 2nd row.
			Total	**7**	

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Question			Answer/Indicative content	Marks	Guidance
9	a	i	action potential / nervous impulse, in sensory neurone ☐ synapse / described ☐ relay / intermediate, neurone ☐ (nervous impulse in) motor neurone, passes to / AW, effector / muscle ☐	3 max	
		ii	*idea of* maintains balance / efficiency of movement ☐	1	
		iii	kinetic / movement, energy converted ☐ to, electrical energy / action potential ☐ *idea of* movement of statolith moves sensory hairs ☐ membrane of sensory hairs depolarises ☐	3 max	
	b		*Support is weak because* *idea that* clasification based on phylogeny ☐ statocysts could, have evolved on more than one occasion / be an example of convergent evolution ☐	2	
	c	i	motor neurone ☐	1	
		ii	saltatory conduction ☐ increases speed of, impulse / action potential, transmission ☐ insulates axon ☐	1 max	

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Question			Answer/Indicative content	Marks	Guidance
	d		***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level***		

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Question			Answer/Indicative content	Marks	Guidance
			Level 3 (5-6 marks) A comprehensive description of the differences between the two action potentials with some explanations for the differences. *There is a well-developed line of reasoning, which is clear and logically-structured and uses scientific terminology at an appropriate level. All the information presented is relevant and forms a continuous narrative.* **Level 2 (3-4 marks)** A good description of some of the differences between the two action potentials with limited explanation. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented is mostly relevant.* **Level 1 (1-2 marks)** A limited description of some of the differences between the two action potentials with an attempt at some explanation. *The information is communicated with only a little structure. Communication is hampered by the inappropriate use of technical terms.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** *Descriptions* Dopamine neurone: • Is less polarised / has a less negative resting potential • Depolarisation shows less change • Action potential peak is lower/less positive • No clear refractory period • Action potential duration is longer • Repolarisation is slower *Explanations* Resting potential set up by: • Different type/number of sodium/potassium pumps in neuron membrane • Different type/number of potassium ion channels • Steeper sodium ion gradient in the Purkyne neurone • Steeper potassium ion gradient in the dopamine neurone • Different type/more voltage-gated sodium and potassium ion channels in the Purkyne neurone
			Total	**17**	

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