



EDINBURGH UNIVERSITY
NEUROLOGICAL SOCIETY



WEEK 5: ELECTRICAL EXCITABILITY AND NEUROTRANSMISSION

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Multiple Choice Questions

MCQ 1)

Which of the following can be found in the dorsal root ganglion?

- A. Upper motor neuron cell bodies
- B. Lower motor neuron cell bodies
- C. Sensory neuron cell bodies
- D. Upper motor neuron axons
- E. Lower motor neuron axons
- F. Sensory neuron axons

MCQ 2)

Which type of glial cell myelinates multiple axons within the central nervous system?

- A. Astrocytes
- B. Schwann cells
- C. Oligodendrocytes
- D. Microglia
- E. Radial glial cells

MCQ 3)

Which of the following does not influence the velocity of action propagation down an axons?

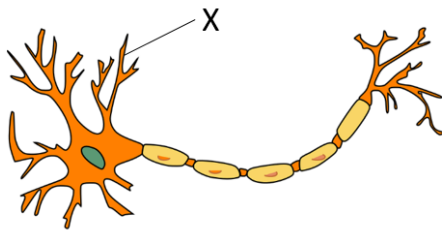
- A. Axon length
- B. Axon diameter
- C. Degree of myelination
- D. Temperature

MCQ 4)

Myasthenia gravis is associated with autoantibodies to which of the following components of the neuromuscular junction?

- A. Presynaptic calcium ion channels
- B. Presynaptic vesicle docking proteins
- C. Acetylcholinesterase
- D. Acetylcholine receptors
- E. Postsynaptic sodium channels

MCQ 5)



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Which of the following statements describes the function of X?

- A. Integration of incoming signals and action potential generation
- B. Collation of the electrical signals and passage of this information towards the cell body
- C. Passes the electrical signal from the cell body to dendrites of another cell or an effector cell
- D. Increases the speed with which nerve impulses are conducted along the axon

MCQ 6)

Which of the following statements regarding reflexes in health and disease is true?

- A. Spinal reflexes are completely independent of cerebral function
- B. Lower motor neuron lesions result in hyperreflexia
- C. Damage to upper motor neurons does not affect reflex function
- D. Transection of the spinal cord results in an initial areflexia followed by a sustained hyperreflexia.
- E. Altered reflexes necessitate a motor lesion

MCQ 7)

Which of the following best describes the Neuron Doctrine proposed by Santiago Ramon Cajal?

- A. Neurons are the autonomously excitable cell type in humans
- B. Axons can only conduct neuronal signals in one direction
- C. Each neuron releases only a single type of neurotransmitter
- D. The nervous system is composed of discrete functional units – neurons
- E. Neurons are the most important cell type in the body

MCQ 8)

Which of the following statements regarding the neuromuscular junction is true?

- A. Acetylcholine acts as an inhibitory neurotransmitter
- B. Acetylcholine is actively transported back into the pre-synaptic terminal
- C. Acetylcholinesterase binds to receptors on the muscle fibre to inhibit acetylcholine
- D. Acetylcholine is produced by the reaction between choline and acetyl CoA

MCQ 9)

Which of the following statements regarding action potentials is false?

- A. Action potentials can be thought of as the basic unit of information in the nervous system
- B. The amplitude of action potentials encodes information on stimulus strength
- C. Action potentials from motor neurons can trigger muscle contractions
- D. Firing action potentials use cellular energy

- E. Action potentials arise when the neuronal membrane potential exceeds a threshold voltage

MCQ 10)

Which of the following neurotransmitters could initiate an inhibitor post-synaptic potential (IPSP) when binding to its receptor on the post-synaptic membrane in an adult human?

- A. Dopamine
- B. Adrenaline
- C. Acetylcholine
- D. Glutamate
- E. GABA

MCQ 11)

Which of the following correctly describes the difference between ion channels and ion pumps?

- A. Ion channels are passive, ion pumps are active
- B. Ion channels are selective for specific ion types, ion pumps only discriminate based on ionic charge
- C. Ion channels move ions up their concentration gradients, ion pumps move ions down their concentration gradients
- D. Ion channels are found on dendrites and the soma, ion pumps are found on axons
- E. Ion channels are ligand-gated, ion pumps are voltage-gated

MCQ 12)

Which of the following statements regarding the sodium-potassium pump is true?

- A. It is found only in the nervous system
- B. It moves ions against their concentration gradient
- C. It moves three potassium ions in the cell
- D. It moves three potassium ions out of the cell
- E. Each cycle of the pump results in the formation of ATP from ADP + Pi allowing neurotransmission

MCQ 13)

Which statement best describes Ionotropic receptors?

- A. Fast response. Causes G-protein to activate secondary messenger to open ion channel
- B. Fast response. Ligand binding causes change in structure, opening ion channel
- C. Slow response. Causes G-protein to activate secondary messenger to open ion channel
- D. Slow response. Ligand binding causes change in structure, opening ion channel

MCQ 14)

Which of the following statements regarding sensory neuron axon types is false?

- A. The diameter of C fibres is between 1 – 5 micrometers
- B. The conduction velocity of C fibres is less than that of A β fibres
- C. A α fibres are thicker than A δ fibres
- D. A β fibres can originate from mechanoreceptors
- E. C fibres can carry information about temperature

MCQ 15)

Which of the following is not an essential characteristic of a neurotransmitter?

- A. Precursors or synthesis enzymes are located in the presynaptic terminal
- B. The chemical is found in the postsynaptic terminal
- C. Postsynaptic receptors exist that bind to the neurotransmitter
- D. The chemical is released in sufficient quantities from the presynaptic terminal to depolarise the postsynaptic terminal
- E. A method of neurotransmitter inactivation exists

MCQ 16) **BONUS QUESTION – JUST FOR FUN**

The stereotypical nature of action potentials means that information in the neural code can be reduced to variations in neuronal firing rates. True or false?

- A. True
- B. False
- C. Nobody knows

MCQ 17) **BONUS QUESTION – JUST FOR FUN**

Hypothetically – a newly discovered ion (Yolo^+) is found to be important in determining the neuronal cell membrane resting potential (the valency of Yolo is +1). The equilibrium potential for Yolo^+ is -84mV. In a neuron with a resting membrane potential of -65mV, which of the following statements best describes the consequence of specialist Yolo^+ channels opening?

- A. The membrane potential of the neuron increases, depolarising the cell
- B. The membrane potential of the neuron increases, hyperpolarising the cell
- C. The membrane potential of the neuron decreases, depolarising the cell
- D. The membrane potential of the neuron decreases, hyperpolarising the cell
- E. The neuron will fire an action potential

Extended Matching Questions

EMQ 1)

Match each disease to one of the descriptions below:

- A. Facial weakness of unknown origin caused by a lower motor neuron lesion affecting the facial nerve
- B. A disease characterised predisposition to paroxysmal neuronal discharge
- C. There is degeneration of motor and sensory neurons in the peripheral nervous system. The most common inherited neurological disease.
- D. A glove and stocking distribution polyneuropathy
- E. Severe stabbing pain affecting areas of the face. It may be triggered by touch or loud sounds and typically lasts seconds though it may persist for longer.
- F. Degeneration of the sympathetic and parasympathetic neurons. Characterised clinically by poor circulation and decreased gastrointestinal motility
- G. A genetic disorder caused by mutations in the genes involving complexes in the mitochondrial respiratory chain. Clinical features reflect the failure of 'high energy' tissues – namely muscle and neural tissue
- H. A demyelinating disease targeting myelin in the peripheral nervous system
- I. A demyelinating disease classically affecting the central nervous system
- J. A disease of the neuromuscular junction characterised clinically by fatigable muscle weakness. Serology may demonstrate autoantibodies to the postsynaptic ACh receptor in the majority of cases

EMQ 1.1) Multiple Sclerosis

EMQ 1.2) Guillian-Barre Syndrome

EMQ 1.3) Charcot-Marie-Tooth Disease

EMQ 1.4) Bell's Palsy

EMQ 1.5) Trigeminal Neuralgia

EMQ 1.6) Myasthenia Gravis

EMQ 1.7) Diabetic Neuropathy

EMQ 1.8) Autonomic Neuropathy

Multichoice Question (MCQ) Answers

MCQ 1)

The best answer is C – sensory neuron cell bodies. It is arguable that the anatomical region of the dorsal root ganglion will also contain the small regions of sensory neuron axons which leave the cell bodies to innervate their targets but a ganglion is defined as a collection of cell bodies (in contrast to a peripheral nerve for example in which axons are the neuronal component). For those of you are interested (and because I think you have a learning objective about the classification of neurons) the primary sensory neurons of the dorsal root ganglion are bipolar neurons.

REMEMBER: Sensory information goes into the cord via the dorsal roots. Motor information comes out of the cord via the ventral roots. If you need it think dor**S**al for **S**ensory.

MCQ 2)

C is the correct answer. Of the glial cells listed above, only Schwann cells and oligodendrocytes give rise to myelin sheathes. The key differences between these two cell types (at the superficial level we are studying them at here) are where they exist in the nervous system and how many axons they myelinate.

Cell type	Location	Myelination Characteristics
Schwann cells	Peripheral nervous system	One cell myelinates one axon
Oligodendrocytes	Central nervous system	One cell myelinates multiple axons

MCQ 3)

A is the correct answer – axon length does not influence the conduction velocity of action potentials (though it of course influences how long it takes an action potential to travel from its point of origin to its terminus). As the diameter of axons increases, resistance decreases so conduction velocity increases. Remember that thick myelinated proprioceptive axons have very fast conduction velocities but thin unmyelinated C fibres involved in the transmission of pain conduct action potentials at much lower speeds. The more myelin an axon has, the better its insulation and the faster it conducts. The velocity of action potential conduction increases as temperature increases.

MCQ 4)

The correct answer is D – myasthenia gravis (MG) is associated with autoantibodies to the post-synaptic ACh receptor. You might have got this confused with Lambert-Eaton myasthetic syndrome (LEMS) in which antibodies are directed at presynaptic calcium channels.

This is easy enough to remember for a week but when you're asked about this in three years' time you may find yourself struggling! If I'm having a bad day I think LEMS has a lamb in it and lambs come first (before sheep) so LEMS affects the first part of the NMJ you'd hit if you ran distally (the

presynaptic membrane) so it must affect the presynaptic calcium channels. Or you could just remember it...

MCQ 5)

The correct answer is B. X is pointing to the cell dendrites The other options do however describe real parts of a neuron.

- A. Integration of incoming signals and action potential generation – cell body
- B. Collation of the electrical signals and passage of this information towards the cell body – the dendrites
- C. Passes the electrical signal from the cell body to dendrites of another cell or an effector cell – axon
- D. Increases the speed with which nerve impulses are conducted along the axon – myelin

MCQ 6)

The correct answer is D. This might be slightly less well answered than the previous questions so an explanation for each option:

- A. Spinal reflexes are completely independent of cerebral function – they aren't – spinal reflexes are modulated by higher centres (see C)
- B. Lower motor neuron lesions result in hyperreflexia – LMN lesions cause hyporeflexia because the efferent arms of the reflex is damaged. UMN lesions cause hyperreflexia – see below
- C. Damage to upper motor neurons does not alter reflex function – it does because (like for A) the spinal reflexes are modulated by higher centres. In a simplified model there is descending inhibition so UMN lesions result in hyperreflexia. I think this only features briefly in your lectures but it must be one of the most important bits of science you learn this semester so may as well learn the clinical features of UMN and LMN lesions now
- D. Transection of the spinal cord results in an initial areflexia followed by sustained hyperreflexia – this is true (a phenomenon known as spinal shock which is covered in one of your first year lectures but most 4th years still won't know it exists!)
- E. Altered reflexes necessitate a motor lesion – remember there are two components to even the simplest reflex – sensory and motor.

MCQ 7)

Feedback: D is the correct answer. Statement C is also factually correct (known as Dale's Law) though not the answer to this question. B is false - the Law of Dynamic Polarisation was mentioned briefly in Lecture 1 and states that axons can conduct electrical impulses in both directions but in tissue there is a preferred direction of transmission (i.e. impulses are conducted more readily in one direction than another). Shame on you if you opted for E! Remember that of the three types of muscle cardiac muscle is autonomously excitable.

MCQ 8)

The correct answer is D!

- A. Acetylcholine acts as an inhibitory neurotransmitter – False, ACh acts as an excitatory neurotransmitter
- B. Acetylcholine is actively transported back into the pre-synaptic terminal – False, only the choline is transported back into the presynaptic terminal via a choline transporter
- C. Acetylcholinesterase binds to receptors on the muscle fibre to inhibit acetylcholine – False, AChE breaks down Acetylcholine into Choline and Acetic Acid. Choline is transported back into the presynaptic terminal to be used again
- D. Acetylcholine is produced by the reaction between choline and Acetyl CoA – True, Acetyl CoA and Choline form acetylcholine in the presynaptic terminal, catalysed by Choline acetyltransferase

MCQ 9)

An easy question after the last – B is correct. Not much to say about this.

MCQ 10)

The correct answer is E – GABA. GABA is one of the major inhibitory neurotransmitters. Interesting, however, GABA can be an excitatory neurotransmitter in development.

MCQ 11)

A is correct – ion channels are passive whilst ion pumps use energy to move ions across cell membranes. With respect to the other answers:

- B) The ion channels people tend to talk about are relatively selective though non-discriminative ion channels exist.
- C) Ion channels allow ions to move down their concentration gradients over the insulating phospholipid bilayer. They cannot move ions up their concentration gradients because they are passive! The archetypal ion pump – the Na^+/K^+ -ATPase moves ions up their concentration gradients. Other types of pump such as symporters and antiporters however allow some ions to move down their concentration gradient in order to generate energy to allow transport of another ion against its concentration gradient.
- D) This is just wrong!
- E) It is ion channels that may be ligand-gated or voltage-gated.

MCQ 12)

B is correct. The Na^+/K^+ -ATPase is found throughout the body (it is very important in the kidney remember). The specifics can be remembered using the mnemonic toucan (a bird!) which sounds like 2-K-in. So two K^+ ions are moved into the cell for every 3 Na^+ ions that are expelled. As for answer E, this is an ion pump – it consumes energy – so why would it be synthesising ATP? (It wouldn't)

MCQ 13)

B is correct. C described a metabotropic receptor.

MCQ 14)

The correct answer is A – the statement ‘the diameter of C fibres is between 1 – 5 micrometers’ is false. The diameter of C fibres is actually between 0.2 and 1.5 micrometers. Although hard questions could be devised on the Erlanger-Gasser classification (which is mentioned in your lectures) this should have been relatively easy and this knowledge with some elaboration can be used to postulate answers to certain clinical situations such as why people rub sore areas to relieve pain.

Even if you aren’t familiar with the details of the classification you should know what C fibres are involved in pain signalling and are slow making answer B less probable – especially if you remembered A β axons innervate mechanoreceptors which have high conduction velocities. The diameter of the A fibres decreases as you move through the Greek alphabet with A α being the largest diameter axons followed by A β and A δ (C fibres following this). D required specific knowledge to include or exclude and E is true – C fibres carry information on pain and temperature.

MCQ 15)

The correct answer is D. D is not an essential characteristic of a neurotransmitter. While it is required that the chemical is available in sufficient quantity in the presynaptic neuron to affect the postsynaptic neuron the transmitter does not need to cause depolarisation of the postsynaptic terminal. Both excitatory and inhibitory neurotransmitters exist!

MCQ 16) **BONUS QUESTION – JUST FOR FUN**

The correct answer is B – the statement is false. While it is true that action potentials are classically stereotyped the timing of individual spikes (another word for action potentials) is important in determining the neurons response. For a ‘real’ example of this read into long term potentiation. As a simplified example, a neuron may respond differently to the two following situations:

1. The neuron received two action potentials from a neighbouring cell in series
2. The neuron receives two action potentials from neighbouring cells simultaneously

MCQ 17) **BONUS QUESTION – JUST FOR FUN**

The correct answer is D. People will probably find this question harder than some that have preceded it!

When specialised Yolo⁺ channels open Yolo⁺ can move across the cell membrane and will do so in a manner determined by its equilibrium potential. The equilibrium potential of Yolo⁺ (-83mV) is less than the neuron’s resting membrane potential (-65mV) and as a result Yolo⁺ ions will leave the neuron further decreasing the membrane potential towards their -83mV equilibrium point. A further decrease in the potential of the external environment relative to the neuronal compartment in this case hyperpolarises the cell (as the difference in potentials is being increased).

This question was based on theoretical situations considered in the University of Washington’s online course in Computational Neuroscience.

Extended Matching Question (EMQ) Answers

EMQ 1)

EMQ 1.1) Multiple Sclerosis – I

EMQ 1.2) Guillian-Barre Syndrome – H

EMQ 1.3) Charcot-Marie-Tooth Disease – C

EMQ 1.4) Bell's Palsy – A

EMQ 1.5) Trigeminal Neuralgia – E

EMQ 1.6) Myasthenia Gravis – J

EMQ 1.7) Diabetic Neuropathy – D

EMQ 1.8) Autonomic Neuropathy – F