AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.6.2.2 SYNAPTIC TRANSMISSION

SCORE	PERCENTAGE
/203	%

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Q1.

(a) 1. (Dopamine) diffuses across (synapse);

2. Attaches to receptors on postsynaptic membrane;
Ignore name/nature of receptor e.g. cholinergic

3. Stimulates entry of sodium ions **and** depolarisation/action potential;
Accept Na^+ for sodium ions
Accept generator potential for action potential

3

(b) 1. Morphine attaches to opioid receptors;
Reject reference to active site

2. (More) dopamine released (to provide pain relief);
Reject receptors release dopamine

2

(c) 1. (Inside of postsynaptic) neurone becomes more negative/hyperpolarisation/inhibitory postsynaptic potential;
Ignore K^+
Accept -75mV or any value below this as equivalent to more negative
Accept 'decrease in charge'

2. More sodium ions required (to reach threshold)
OR
Not enough sodium ions enter (to reach threshold);
Accept Na^+ for sodium ions

3. For depolarisation/action potential;
Context must covey idea that depolarisation / action potential is less likely

3

[8]

Q2.

(a) 1. Correct answer of 19.4 / 19.41%
OR
19.47 / 19.5% = **2 marks**;
2. Incorrect answer but shows increase of 1,048,320 **OR** 1,051,200 = one mark;
Accept: 19.46% for one mark.

2

(b) 1. Less / no acetylcholine broken down;
2. Acetylcholine attaches to receptors;
3. (More) Na^+ enter to reach threshold / for depolarisation / action potential / impulse;
1. Accept: more acetylcholine present / remains.

1 and 2. Accept: remains attached for longer = 2 marks.

3. Must be sodium ions.

3

(c) 1. Isolated **so** inbreeding / low genetic diversity / small gene pool;
2. Allele inherited (through generations) from (common) ancestor;

1. Ignore: Founder effect.

1. Accept: no interbreeding with other populations.

1. Reject: interbreeding within the population.

2

(d) 1. AD / symptoms develops late / at 49;
2. Have already reproduced;

Note: 'It' is not equivalent to AD / symptom as the question stem relates to the mutation.

2

(e) 1. Epigenetics / environment / named factor e.g. stress, alcohol, toxins, diet, exercise, smoking;
2. methylation (of genes)
OR
acetylation (of histones);

1. Ignore: gender and lifestyle.

2. If further details are provided the context must be correct e.g. increased methylation or decreased acetylation inhibit gene expression / transcription.

2

(f) 1. One person was homozygous dominant / has two dominant alleles = **2 marks**;
2. For one mark has two alleles / chromosomes;

1. Accept; homozygous dominant genotype e.g. 'one person has AA' for 2 marks.

2. Accept: is diploid or has two copies of the gene.

2

(g) 1. (GCA / triplet) is common / found in other places;
2. Would not know if it was the mutation / allele / gene
OR
Produces 'false positives'

1. Accept: Probe will bind elsewhere.

2

[15]

Q3.

(a) 1. (Nerve impulse / depolarisation of membrane) causes Ca^{2+} channel (proteins) to open;
2. Ca^{2+} enter by (facilitated) diffusion;
3. Causes (synaptic) vesicles to fuse with (presynaptic) membrane;

Accept single reference to ions to cover 1 and 2

Penalise once for no reference to ions

1. Reject carrier proteins

3. Reject ref to release of vesicles

3. *Ignore vesicles bind to membrane (but accept merge with)*

3

(b) 1. Myosin head attaches to actin **and** bends / performs powerstroke;
2. (This) pulls mitochondria past / along the actin;
3. Other / next myosin head attaches to actin (and bends / performs powerstroke);

1. Accept change shape / change angle

2. Ignore pulls actin along

2. Ignore refs to cytoskeleon

Accept plural or singular statements

2 max

(c) 1. (Mitochondria) supply (additional) ATP / energy;
2. To move vesicles / for active transport of ions / for myosin to move past actin
OR
Re-synthesis / reabsorption of neurotransmitter / named neurotransmitter;

1. Reject produces energy

2. Ignore ref. to ATP for opening calcium ion channels/making vesicles fuse with membrane

2

[7]

Q4.

(a) Only 3 neurones / nerve cells (in reflex arc)

1

(b) 1. Rapid;

2. Protect against damage to body tissues;

3. Do not have to be learnt;

4. Help escape from predators;

5. Enable homeostatic control.

2 max

(c) 1. Neurotransmitter only made in / stored in / released from pre-synaptic neurone;

2. (Neuro)receptors only on the post-synaptic membrane;

2

(d) 1. Axon **P** is myelinated;

2. So shows saltatory conduction / impulses jump between nodes of Ranvier

OR

3. Axon **P** has a larger diameter;

4. So less resistance to flow of ions.

*Mark as 1 & 2 **OR** 3 & 4*

2

[7]

Q5.

(a) 1. Calcium ions diffuse into myofibrils from (sarcoplasmic) reticulum;
2. (Calcium ions) cause movement of tropomyosin (on actin);
3. (This movement causes) exposure of the binding sites on the actin;
4. Myosin heads attach to binding sites on actin;
5. Hydrolysis of ATP (on myosin heads) causes myosin heads to bend;
6. (Bending) pulling actin molecules;
7. Attachment of a new ATP molecule to each myosin head causes myosin heads to detach (from actin sites).

5 max

(b) 1. Releases relatively small amount of energy / little energy lost as heat;

Key concept is that little danger of thermal death of cells

2. Releases energy instantaneously;

Key concept is that energy is readily available

3. Phosphorylates other compounds, making them more reactive;
4. Can be rapidly re-synthesised;
5. Is not lost from / does not leave cells.

2 max

[7]

Q6.

(a) 1. Membrane more permeable to potassium ions and less permeable to sodium ions;
2. Sodium ions actively transported / pumped out and potassium ions in.

2

(b) 1. (Pressure causes) membrane / lamellae to become deformed / stretched;
2. Sodium ion channels in membrane open and sodium ions move in;
3. Greater pressure more channels open / sodium ions enter.

3

(c) 1. Threshold has been reached;
2. (Threshold or above) causes maximal response / all or nothing principle.

2

(d) 1. Less / no saltatory conduction / action potential / impulse unable to 'jump' from node to node;
2. More depolarisation over length / area of membranes.

2

[9]

Q7.

(a) 0.32.

Correct answer = 2 marks

Accept 32% for 1 mark max

Incorrect answer but identifying 2pq as heterozygous = 1 mark

2

(b) 1. Mutation produced *KDR minus* / resistance allele;
2. DDT use provides selection pressure;
3. Mosquitoes with *KDR minus* allele more likely (to survive) to reproduce;
4. Leading to increase in *KDR minus* allele in population.

4

(c) 1. Neurones remain depolarised;
2. So no action potentials / no impulse transmission.

2

(d) 1. (Mutation) changes shape of sodium ion channel (protein) / of receptor (protein);
2. DDT no longer complementary / no longer able to bind.

2

[10]

Q8.

A Vesicle;

B Neurotransmitter;

C Synaptic cleft;

***B** Accept named neurotransmitter*

[3]

Q9.

(a) Any **two** from:

- light
- pressure
- touch
- temperature
- chemicals
- (loud) noise
- smell;

Two required for 1 mark

Do not accept unqualified reference to dust / particles / objects

Accept (rapid) movement (of particles / air) towards the eye

Accept humidity / moisture / tears

1

(b) 1. Standard deviations / standard errors;

2. (So) likely to overlap;

2

(c) 1. Would not know the patient's / human's normal blink rate so unable to make a comparison;

2. Blink rate could be affected by stress of seeing a doctor;

3. Many factors could affect blink rate so it would be difficult to tell if blink rate was due to illness

2 max

(d) 1. Not possible to predict intermediate values;

2. Only one result for each time period / not mean values;

2

(e) Collected paired data;

1

(f) 1. No / low influx of sodium ions;

2. So no depolarisation / action potential;

2. 'so no impulses' insufficient

2

(g) 1. Allows calcium ions in;

2. At end of presynaptic neurone;

3. Causing release of neurotransmitter;

1. Accept Ca^{2+}/Ca ions but not Ca/Ca+

2. The idea of the end of the presynaptic neurone must be given e.g. presynaptic knob

3

(h) 1. Reference to large group size;

2. Reference to matching a specific, named variable;

3. Applying a statistical test to the data;

1. Accept '≥ 20 / many / lots' but not 'several / less than 20'

2. Accept any named variable other than age.

3. Accept 'use SE / 95% confidence limits'

3

[16]

Q10.

(a) 1. Complementary to receptor for acetylcholine;

2. Binds to receptor;

3. On postsynaptic (membrane);

4. Prevents acetylcholine from binding;

5. No action potential in postsynaptic neurone;

2. Accept description of 'binds'

3. Must be in context of membrane

5. Accept 'depolarisation' but not 'impulse'

3 max

(b) 1. Takes longer to become unconscious than it does to stop blinking;

2. No overlap of standard error;

1. Accept reference to 0.24/0.28 and 0.48/0.44 in place of longer

2

(c) Different body masses but need to have comparable effects;

Do not accept 'same' effects or unqualified references to 'bias / comparison / fair test'.

1

[6]

Q11.

(a) (i) C;

1

(ii) D;

1

(b) (Synaptic) vesicles (only) found in presynaptic (part of synapse);

Accept bulb of synapse for presynaptic

*Reject vesicles **in** the membrane*

1

(c) (i) Has similar shape/structure to dopamine

OR

Complementary (to binding site on receptor);

Ignore competitive inhibitor

Accept tertiary structure

Reject active site

*Reject **same** shape as dopamine/as receptor*

1

(ii) 1. (Binding) does not lead to opening of sodium ion channels;

2. (So) no depolarisation / threshold not reached / sodium ions do not diffuse in;

OR

3. Opens chloride ion channels;

4. Causing hyperpolarisation / preventing depolarisation

*Mark either 1 and 2 **OR** 3 and 4*

1. Accept stops dopamine opening sodium ion channels

1. Reject sodium unqualified

2. Accept no generator potential

3. Reject chlorine

2

[6]

Q12.

(a) One suitable suggestion; explained;
E.g.

1. Action potentials travel more slowly / don't travel;

   Accept: fewer / no saltatory movement of potentials

2. So delay in muscle contraction / muscles don't contract / muscles contract slow(er);

OR

3. Action potentials / depolarisation 'leaks' to adjacent neurones;

   Accept: neurones not insulated

4. So wrong muscle (fibres) contract.

2 max

(b) Lipid-soluble / pass through phospholipid bilayer.

Not just 'pass through membranes'

1

(c) 1. Prevents influx of calcium <u>ions</u> (into pre-synaptic membrane);

Need idea of <u>moving into</u> pre-synaptic membrane / synaptic knob

Accept Ca^{++} / Ca^{2+}

2. (Synaptic) vesicles don't fuse with membrane / vesicles don't release neurotransmitter;

Accept vesicles don't release acetylcholine

3. Neurotransmitter does not diffuse across synapse / does not bind to receptors (on post-synaptic membrane);

Accept: sarcolemma / muscle membrane for post-synaptic membrane

4. No action potential / depolarisation (of post-synaptic membrane) / sodium (ion) channels do not open / prevents influx of sodium <u>ions</u>.

Accept Na^{+}

Accept prevents depolarisation of muscle cell

Ignore: descriptions of events at post-synaptic membrane involving calcium ions and muscle contraction

4

(d) 1. They won't affect synapses in brain;
2. They won't cause problems with the brain's function / won't damage brain;

Accept: suitable named problem e.g. hallucination

Ignore: unqualified references to 'side effects'

Accept: reference to addiction / harm of smoking (cannabis)

3. (So only the) muscle / neuromuscular junctions treated / affected.

2 max

[9]

Q13.

(a) (i) 1. Slower <u>diffusion</u>;

Accept description of diffusion eg 'movement down concentration gradient' but concept of slower is required

2. (Of) ions / Na^+ / K^+;

Reference to ions is required. Reject other named ions, eg calcium ions

Ignore references to synaptic transmission or rates of respiration

2

(ii) 1. Myelination / saltatory conduction;

Accept reference to presence of nodes of Ranvier

2. Axon diameter;

2

(b) Keep everything the same but not in bath / at room temperature / same clothing as for immersion / sitting in empty bath / sitting in water at room temperature;

Accept 'normal' or 'comfortable' as equivalent to room temperature

Ignore reference to body temperature

1

(c) (i) (Find) the most common result / time / the result / time that occurs the most;

1

(ii) Highest and lowest result / time;

Accept 'difference between highest and lowest results / times'

1

(d) 1. (Which is based on) <u>mean</u> of 20 people / large (enough) sample;

This point is possible for students that suggest the difference is significant

2. (But) SE bars / confidence limits overlap;

This point applies whether 1 × SE or 2 × SE is used

3. Reference to 0.297 ± 0.0424 / 0.326 ± 0.0366 / confidence limits = 2 × SE;

This point rewards knowledge of use of 2 × SE (as per Students' Statistics Sheet)

4. (So) difference is **not** significant;

This point is only awarded after marking point 2 or marking point 3 has been given

3 max

[10]

Q14.

(a) 1. Causes sodium ion channels to open;

1. Reject if wrong sequence of events

2. Sodium ions enter (cell and cause depolarisation);

Reject sodium on its own only once

2

(b) 1. (If not removed) keeps binding (to receptors);

Accept answers based on what happens if it is transported out − ie what should happen

2. Keeps causing action potentials / depolarisation (in post-synaptic membrane);

2. Accept keeps Na^+ channels open(ing)

2

(c) 1. Movement in all groups (about) same before MDMA;

Q

2. MDMA increases movement in Group **L**;

*2. Accept normal mice for **L***

3. Group **K** shows MDMA causes movement;

*3. Accept **K** is a control*

4. No / little increase in mice without receptor / Group **M**;

3 max

[7]

Q15.

(a) (i) UGC;

1

(ii) TGCTAC;

1

(b) (DNA) contains introns / non-coding bases / mRNA only contains exons / coding bases;

Assume that 'it' refers to DNA

Neutral: DNA contains introns and exons

Neutral: 'splicing'

Neutral: pre-mRNA contains introns

Ignore refs. to start and stop codons

1

(c) Different primary structure / amino acid sequence / amino acid coded for;

Reject: different amino acids produced / formed

Neutral: refs. to bonds

1

(d) 1. Acetylcholine not broken down / stays bound to receptor;

2. Na^+ ions (continue to) enter / (continued) depolarisation / Na^+ channels (kept) open / action potentials / impulses fired (continuously);

3. (Intercostal) muscles stay contracted / cannot relax;

'Muscles contract' is not enough

Accept: diaphragm stays contracted / cannot relax

3

[7]

Q16.

(a) 1. (Acetylcholine) released from / in presynaptic side;

2. Receptors in postsynaptic (side) / binds on postsynaptic (side);

2. Mark for diffusion only awarded in context of unidirectional movement.

2

(b) (i) 1. Rapid response;

2. Short duration;

Specific wording is not important. It is the principles that matter here.

Points may be made by referring to figures.

2

(ii)

	1	2	3
Percentage	80	0	0

Ignore % sign.

1

[5]

Q17.

(a) (Ion) channel proteins open, sodium in;

Changes membrane potential / makes inside of axon less negative / positive / depolarisation / reaches threshold;

More channels open / positive feedback;

Accept other phrases for ion channel proteins providing that it is clear that it is something through which ions pass.
Reject carrier.

First marking point relates to opening.
Third point must relate to more (channels) opening.

3

(b) Potassium channels open;

Potassium out;

Sodium channels close;

Do not penalise candidate who refers to sodium or potassium. Ions are mentioned in question.
Reject pump

3

(c) Pump / active transport / transport against concentration gradient;

Of sodium from axon / sodium out / of potassium in;

Do not penalise candidate who refers to sodium or potassium. Ions are mentioned in question

2

[8]

Q18.

(a) In table:

D	*All 3 correct = 2 marks;;*
B	*2 correct = 1 mark;*
C	*0 or 1 correct = 0 marks*

2

(b) (i) myelin insulates / prevents ion movement; saltation / described re leaping node to node;

2

(ii) cat has higher body temperature;
ignore references to homoiothermy' / warm-blooded
faster diffusion of ions / faster opening of ion pores / gates / channels;

2

(c) 1 increasing stimulus (potential) causes decrease in potential difference / rise in potential at P;

2 1 or 2 is sub-threshold / 1 or 2 does not give action potential / 3 or 4 is above threshold / 3 or 4 does give an action potential;

3 influx of Na^+ ions; *(not just Na / sodium)*

4 voltage-gated channels (in axon membrane) opens / opens Na^+ channels / membrane more permeable to Na^+
(NOT just Na / sodium);

5 sufficient for stimulation of adjacent region of axon therefore impulse propagated (from P to Q);

5

(d) 1 X / Acetylcholine → opening of Na^+ channels / increases Na^+ permeability and Na^+ ion entry into Z;

2 Y / Cl^- entry - lowers potential / increases potential difference / makes potential more negative;

3 X stimulates and Y inhibits (Z);

4 balance of impulses from X and Y determines whether Z fires action potential / determines whether potential rises above threshold;

4

[15]

Q19.

(i) Binds to receptor / proteins; and opens Na^+ channels;
Na^+ enter and make membrane potential less negative / depolarised

2

(ii) (Vesicles containing) neurotransmitter only in presynaptic membrane / neurone;
receptor / proteins only in postsynaptic membrane / neurone;

2

(iii) GABA opens K^+ and Cl^- channels so K^+ passes out and Cl^- passes in;
Membrane potential more negative / hyperpolarised;
Requires increased stimulation / must open more Na^+ channels / allow more Na^+ to enter;
To reach threshold;

4

[8]

Q20.

(a) action potential arrives / depolarisation occurs;
calcium ions enter synaptic knob;
vesicles fuse with membrane;
acetylcholine diffuses (across synaptic cleft);
binds to receptors;

4 max

(b) inside becomes more negatively charged / hyperpolarised; stimulation does not reach threshold level / action potential not produced;
depolarisation does not occur / reduces effect of sodium ions entering;

3

(c) (i) inhibits enzyme (which breaks down GABA);
more GABA available (to inhibit neurone);

OR

binds to (GABA) receptors;
inhibits neuronal activity / chloride ions enter (neurone);

2 max

(ii) receptors have different tertiary / 3D structure / shape not complementary;
GABA cannot bind; inhibition of neuronal activity does not occur / chloride ions do not enter;

3

(d) motor area;
left cerebral hemisphere;

2

[14]

Q21.

(a) 1. automatic (adjustments to changes in environment) / involuntary;
2. reducing / avoiding damage to tissues / prevents injury / named injury e.g. burning;
3. role in homeostasis / example;
4. posture / balance;
5. finding / obtaining food / mate / suitable conditions;
6. escape from predators;

(ignore 'danger' or 'harm' unless qualified)

3 max

(b) (i) 1. (impulse causes) calcium ions / Ca^{++} to enter axon;
2. vesicles move to / fuse with (presynaptic) membrane;
3. acetylcholine (released);
4. (acetylcholine) <u>diffuses</u> across synaptic cleft / synapse;
5. binds with receptors on (postsynaptic) membrane;

(reject active sites, disqualify point)

6. sodium ions / Na^{+} enter (postsynaptic) neurone;
7. depolarisation of (postsynaptic) membrane;
8. if above threshold nerve impulse / action potential produced

6 max

(ii) neurone to neurone and neurone to muscle;
action potential in neurone and no action potential in muscle / sarcolemma;
no summation in muscle;
muscle response always excitatory (never inhibitory);
<u>some</u> neuromuscular junctions have different neurotransmitters;

(penalise 'nerve' once)

2 max

[11]

Q22.

(a) membrane relatively impermeable / less permeable to sodium ions / gated channels are closed / fewer channels;
sodium ions pumped / actively transported <u>out</u>;
by sodium ion carrier / intrinsic proteins;
inside negative compared to outside / 3 sodium ions out for two potassium ions in;

(if sodium mentioned but not in context of ions, negate 1 mark)

4

(b) (i) 1.6;

1

(ii) 18 ÷ 1.6 = 11.25;
multiply by 1000 to convert from ms to s / 11 250;

(correct method = 1 mark, i.e. $\frac{distance}{time}$ *or × 1000)*
(correct answer based on (b)(i) = 2 marks)

2

(iii) time for transmission / diffusion across the neuromuscular junction / synapse;
time for muscle (fibrils) to contract;

1 max

(c) movement by diffusion;
binding to receptors on (post-synaptic) membrane;
causing sodium channels to open / sodium ions to move in to muscle (cell);

3

(d) (i) toxin binds to / competes for / blocks the acetylcholine receptors;
acetylcholine can not depolarise the membrane / the toxin does not cause depolarisation;

(allow references to generating action potentials instead of depolarisation, do not allow references to impulses in muscles)

2

(ii) acetylcholinesterase is unable to breakdown acetylcholine;
acetylcholine still available to depolarise the membrane / generate action potentials in the membrane;

2

[15]

Q1.

(a) This question proved to be an effective discriminator. Approximately 48% of students gained at least two out of the three marks available, however 21% scored zero. The most frequently awarded marking point related to the diffusion of dopamine across the synaptic gap. Many students also linked the entry of sodium ions to depolarisation. A significant number of students referred to the opening of sodium ion channels but failed to mention the entry of sodium ions into the neurone. Similarly, many students stated that dopamine attaches to receptors but did not state that the receptors were located on the postsynaptic membrane. Consequently, only one in six students provided a sufficiently detailed explanation for maximum marks.

(b) This question was answered well, with 88% of students obtaining at least one of the two marks available. This mark was usually awarded for stating that morphine stimulates the release of dopamine. Many students (63%) also gained credit for stating that morphine attaches to opioid receptors. Failure to gain this second mark was often due to omitting the term opioid or for suggesting that morphine attaches to an active site on the receptor.

(c) Interestingly, as with question (a) also based on synaptic transmission, this question was a very effective discriminator. The percentage distribution of marks was also closely related to that on question (a), even though slightly more students gained marks on this question. Most students appreciated that the entry of chloride ions would cause a more negative charge in the postsynaptic neurone. This was described in a variety of ways and the mark scheme was applied with a certain degree of leniency. Fewer students successfully explained that more sodium ions would be required to reach threshold. Again, there were frequent references to the opening of sodium ion channels with no indication of the direction of movement of sodium ions. There were some bizarre explanations of how depolarisation is prevented, which included reference to a wide range of different ions. The idea that sodium and chloride ions combine to form salt occurred on more than one occasion. Nevertheless, there were also some excellent explanations and most students obtained a mark for explaining that depolarisation was less likely to occur.

Q2.

(a) Over a third of students obtained both marks for this question, for answers of 19.41 / 19.4% or 19.47 / 19.5%, depending on whether the student used 7 x 52 (weeks) or 365 as the number of days in a year. Almost a third of students gained one mark for correctly calculating the increase in AD cases per year as being 1 048 320 or 1 051 200, depending on the number of days used. Incorrect rounding to give 19.46% was quite common, to gain one mark.

(b) The majority of students gained at least one mark for stating that less acetylcholine would be broken down, or that more acetylcholine would be present. Almost half of these students obtained a second mark for stating that the acetylcholine binds to receptors. However, only 10% of students obtained maximum marks by describing how an impulse would be produced in the postsynaptic neurone. Many students did appreciate that sodium ion channels would open, but then failed to mention that sodium ions would then enter to cause depolarisation.

(c) Over 50% of students scored zero for this question, usually due to answers lacking complete explanations for the valid suggestions they outlined. Less than 2% of

students gained both marks. The most frequently credited response was that isolation had resulted in a small gene pool or low genetic diversity. Poor use of terminology also prevented many students gaining both marks. Invariably, students referred to the gene or mutation, rather than the allele being inherited from a (common) ancestor. There was also considerable confusion in the use of the terms inbreeding and interbreeding. There were also many responses which referred to genetic bottlenecks, the Founder effect, and an increase in the rate of mutation in isolated areas. A significant number of students suggested that the late onset of AD enabled individuals still to reproduce and pass on the mutation. This would explain why the frequency of the mutation had not been reduced (part d), rather than why there is a high frequency of this mutation to begin with.

(d) Almost a third of students obtained both marks, clearly expressing the idea that, due to the symptoms of AD developing late on, affected individuals would have already reproduced. Over 50% of students scored zero, often providing responses that suggested that the mutation was not harmful, or indeed that it was beneficial. An improvement in health care was also provided as an explanation for the frequency of the mutation not being reduced. Students obtaining one mark often did not refer to the late onset of AD, but did understand that individuals with the mutation could still reproduce and pass on the allele.

(e) Over 50% of students scored zero on this question. Many of these responses suggested that differences in the 'level' of acetylcholine, or exposure to mutagenic agents, caused the variation in the age at which the mutation is expressed. Over a third of students obtained one mark, usually by naming an environmental factor such as diet, smoking or stress. Answers specifically referring to epigenetics for at least one mark were infrequent. These responses often gained a second mark, 10% of students, for mentioning methylation or acetylation. Students who described these processes generally provided correct details.

(f) Almost three out of ten students obtained one mark for explaining the sample size of 204 in terms of two copies of chromosome 14 or two copies of an allele. A common error was to refer to two chromatids. Explaining why there were only 74 potential AD cases when 75 mutations had been detected proved very challenging, with only 2% of students gaining this second mark. Many students suggested that the allele causing AD is recessive, despite line 18 of the comprehension passage stating that it is dominant. A common misconception was that one individual was heterozygous for the condition. Other incorrect responses focused on AD not having yet developed, or attempted to explain the data in relation to the degeneracy of the genetic code.

(g) Over 10% of students did not attempt this question, and over 5% omitted the parts (e) and (f). It seems likely that some students had difficulty completing the paper, but it was also evident that these last three questions were demanding. Only 25% of students obtained a mark on this question. Almost all of these students gained one mark for realising that the GCA triplet would occur in a number of different places. Half of these students then explained that you could not then determine if the mutation was present or not. As in part (f), a number of incorrect ideas were linked to the degenerate nature of the genetic code. The misconception that probes were being used to sequence the whole genome arose, so lots of different primers would be needed and it would be very time consuming and costly. The probe was sometimes thought only to be able to identify the mutation if the gene had been expressed to cause the disease, or that the probe would not bind because the mutation had not occurred yet. A surprising number of students said the sequence of the mutation was not known, so therefore a probe could not be made, or that the mutation was different in different people.

Q3.

(a) This was a factual recall question that discriminated well. Examiners expected students to use appropriate A-level terminology, including references to calcium ions, channel proteins and the (facilitated) diffusion of calcium ions in through the (presynaptic) membrane. Weak answers included statements about calcium crossing the membrane.

(b) This question required application of knowledge of how myosin and actin interact. Many students treated it as a factual recall question, not infrequently referring to shortening of the sarcomere. The best answers (about 12% of students) scored both marks by focusing on the information given and noted that, in this circumstance, myosin moves past actin and pulls the mitochondrion along.

(c) Around half of the students obtained one mark for noting that mitochondria produce ATP. Just over 40% got a second mark, usually for relating the use of ATP to some aspect of recycling of neurotransmitter, or the active transport of an appropriate ion. Some students failed to score the point relating to ATP because of references to 'the production of energy', rather than 'the supply of energy'.

Q8.

This question was exceptionally well answered, with the majority of students gaining at least two marks and a substantial number scoring full marks. Very few students failed to score any marks.

Q9.

Most students gave correct answers to this question. The most common incorrect answer was "dust" without an explanation of what stimulus this would be. Some students named a relevant stimulus and then gave an incorrect answer, which meant that they did not gain a mark since it was a one mark question.

Q10.

This question was generally well answered. Some students failed to gain marks because they confused enzyme terminology, e.g. active site, with specialist language relevant to a molecule binding to a receptor. Some students were unclear about the location of the receptor. Others came close to stating that there would be no action potential in the postsynaptic membrane but did not write an answer that was sufficiently clear to gain credit for that marking point.

Q11.

(a) (i) Just over 60% obtained the mark for identifying opening of sodium ion channels as the event that *starts* depolarization.

(ii) Almost all students identified D as the correct answer.

(b) Many students referred to vesicles being located *in* presynaptic membranes. This was not credited.

(c) (i) 75% of students obtained the mark. Those who didn't often referred to the drug being the <u>same</u> shape as dopamine. Quite a few made incorrect references to active sites and enzyme-substrate complexes.

(ii) This question discriminated well, with 40% obtaining both marks and 27%

getting zero. Weaker answers simply re-stated the stem of the question and said there was no action potential. The examiners did not credit references to *sodium*, rather than *sodium ions*, in answers relating to sodium ion channels. Some students wrote about chloride ion flows and inhibition of action potentials and this approach was given credit.

Q12.

(a) Most students realised that damage to myelin sheaths would adversely affect transmission of nerve impulses / action potentials and about 50 percent of students scored 1 mark for this. Many failed to relate this effect to effects on muscle contraction; they just said that movement would be affected. As a result, only 30 percent obtained both marks. Some answers were marred by references to 'signals' or 'messages', rather than impulses.

(b) This required some basic synoptic knowledge of membrane structure. Just over 40 percent of students correctly observed that the hydrophobic cannabinoids were lipid soluble, or would pass through the phospholipid bilayer.

(c) Many answers to this part illustrated the importance of reading the stem of a question very carefully. The word 'pre-synaptic' was emboldened in the question. Despite this, a significant number of students saw 'calcium ions' and 'muscle' and wrote about muscle contraction, often in great detail. The examiners ignored this material. Amongst those who did read the question carefully, 30 percent obtained all 4 marks. Those who failed to score all the marks often got confused about where calcium ions flowed to, or what was released into the synapse; whether it was vesicles or neurotransmitter.

(d) Most students focused on harmful effects of cannabis on brain tissue or function in this part and obtained 1 mark. Only just over 20 percent obtained a second mark by pointing out that the cannabinoids would only treat the muscle problems.

Q13.

(a) (i) Most students correctly stated that there would be slower diffusion, but only the higher-scoring students scored the second mark for ions. Some students referred to events at the synapse, which was not credited.

(ii) The effect of myelination on transmission speed was well known, but the effect of axon diameter less so. Lower-scoring students suggested the factor to be the diameter or thickness of the axon membrane.

(b) This was answered well by many students. The Marking Guidelines caused a few problems for assessors who had difficulty with the position and meaning of the solidus.

(c) Overall, this question was answered well. Few candidates had difficulty with explaining how to find either the mode or the range.

(d) Many students calculated standard error, stated that the bars overlapped and so understood that the difference was not significant. Thus, they achieved all three marks. Quite a few students did not appreciate that confidence limits are found from twice the standard error.

Q14.

(a) There were many good answers and half of students obtained both marks. There

were quite a number of incomplete answers; for example, writing about sodium ion channels opening but not saying that the ions move into the post-synaptic cell. Some students wrongly wrote about calcium ion and others were penalised once for writing about sodium, rather than sodium ions.

(b) There were many good answers, with students writing about serotonin always binding to its receptor and thus causing continuous depolarisation, or action potentials. Some only scored one mark, because they overlooked the continuous binding. Others strayed into accounts of how neurotransmitters are recycled at the pre-synaptic membrane.

(c) Almost all students scored at least one mark but only a fifth obtained all three marks. There were various elements here that support the conclusion. All of the groups showed the same levels of movement before MDMA was given. This was only noted by a small minority. Most noted the increase in movement in group **L**.Group **K** was a control group that demonstrated that MDMA caused the change observed in group **L**,thus supporting the conclusion. Group **M** showed no change in movement (and had no serotonin receptors), again supporting the conclusion. The question asks '*How do* these results support this conclusion?' Quite a large number of students treated this as 'Evaluate this conclusion'. and launched into rote *How Science Works* responses about correlation not proving causation, not enough mice in the study, only one study, the results wouldn☐t apply to people, there could be other factors, etc. No credit was given for this approach.

Q15.

(a) (i) Most students correctly gave the base sequence of the anticodon as **UGC**.

(ii) Almost all students correctly gave the base sequence of DNA as **TGCTAC**. However, a minority of weaker students failed to read the stem of the question carefully enough. They replaced the thymine bases in this sequence with uracil.

(b) Most students were aware that DNA contains introns or mRNA only contains exons. Weaker students were often let down by vague answers, such as 'mRNA contains exons' and 'mRNA is spliced'.

(c) It was widely appreciated that a change in the base sequence of mRNA could result in different amino acids being coded for or would produce a change in the primary structure of the toxin. A common response seen by a minority of weaker students was 'different amino acids are produced'. This was not credited.

(d) Most students gained at least one mark for stating that acetylcholine would not be broken down. However, the ability to tell the rest of the story correctly proved to be a good discriminator. Weaker students often thought that depolarisation would be prevented, resulting in the muscles not being able to contract. Some students attempted to explain this in terms of the inability to reabsorb acetylcholine into the presynaptic membrane. They thought that this would prevent any further release of acetylcholine. It was usually only better students who went on to describe the opening of sodium ion channels. Similarly, the importance of the 'continuous' aspect of muscle contraction was only appreciated by the best students.

Q16.

(a) Those candidates who focused clearly on the relevant aspects of synaptic transmission produced excellent answers. Others, however, produced lengthy accounts that included much that was of, at best, marginal relevance.

(b) Although candidates encountered few problems in extracting the relevant information from the graph in part (i), they experienced much greater difficulty in expressing 8 as a percentage of 10 despite, in some cases, identifying clearly on the graph the relevant numbers.

Q17.

(a) The high standard of the answers to this part of the question indicated that many candidates had an excellent understanding of the role of sodium ions in creating an action potential. Such errors that arose were generally over the direction of ion movement, or concerned the perceived role of active transport in this process. Regrettably, marks were missed through poor Quality of Written Communication as the phrase, "sodium ions enter the membrane" could refer to ions going into or coming out of the axon.

(b) Candidates were also handicapped by their written expression in this part of the question. Here the common error was to write of an influx of ions out the axon. Clearly a contradictory statement of this nature cannot be awarded credit. There were, however, many sound answers that gained significant credit.

(c) Most candidates recognised the importance of ATP in active transport but some either failed to refer to the ions involved or were confused over the directions of their movement.

Q18.

Unit 6

(a) In order to answer this question, candidates needed to consider carefully when, during the course of an action potential, each of the processes of diffusion and active transport of Na^+ and K^+ ions was occurring most rapidly, rather than simply taking place. Many candidates were able to demonstrate their knowledge and understanding of these phenomena.

(b) In (i), although nearly all candidates were aware of the process of saltatory conduction in increasing the rate of impulse transmission, fewer emphasised that the myelin sheath served to insulate the axon prevented the passage of ions. In (ii), there was much use of the terms 'endotherm' and 'ectotherm' with respect to the cat and the lizard but candidates frequently omitted to emphasise that the body temperature of the cat would generally be higher than that of the lizard. Relatively few then went on to emphasise that the rate of diffusion of ions was increased at higher temperatures. Active transport and metabolic processes needed for the redistribution of ions were considered irrelevant to the rate of passage of a single impulse. (Although they were often referred to by candidates).

(c) Given the diagrammatic representation of the effect of different-sized stimulus potentials on the potential difference recorded at two points along an axon, many candidates immediately recognised that stimuli 1 and 2 were sub-threshold whereas 3 and 4 did produce an action potential. More able candidates went on to explain how this worked with reference to opening ion-channels which allowed the influx of Na^+ ions. Some explained that an action potential would then be propagated along the axon to the second recording electrode in accordance with the all-or-nothing nature of nerve impulse transmission. Common errors included mis-use of the terms potential and potential difference and which was increasing or decreasing, and the sudden appearance of the impulse at the second electrode with no reference to its transmission along the axon.

(d) A major problem for many candidates in this section was the presupposition that acetylcholine, being the neurotransmitter of the parasympathetic nervous system, was essentially 'inhibitory' in its action. It is not. More astute candidates were able to explain in detail how acetylcholine released from neurone X would cause the opening of Na^+ channels in the postsynaptic membrane, causing an influx of Na^+ ions, whereas impulses in neurone Y would cause entry of Cl " ions into neurone Z. Hence X was stimulatory and Y was inhibitory upon Z. Very few candidates went on to explain how the balance of impulses from X and Y could then modulate activity in neurone Z. Some candidates thought that X and Y would be antagonistic due to Cl" ions released from Y blocking the acetylcholine-binding sites on the postsynaptic membrane.

Unit 7

(a) It was common to see B and C correctly identified but many candidates thought A represented active transport of sodium and potassium ions rather than D.

(b) There were some pleasing descriptions of saltatory conduction but few candidates made reference to the insulating effect of myelin. However, the synoptic nature of part (ii) provoked an array of responses. The majority selecting to discuss 'warm blooded' versus 'cold blooded' failed to realise that this was irrelevant unless the lizard was actually colder. Other incorrect responses which were common included the facts that the cat was a predator and so needed faster actions, that natural selection had led to faster impulses and that the cat had more fat in its diet and so had more myelin. Several failed to register the same diameter of axon had been used and gave wider axon as their answer. Most of those who did correctly state that the cat would be warmer here did not explain the impact on the rate of ion movement but merely stated that temperature did have an effect.

(c) It was pleasing to find many candidates were able to assimilate the large amount of data provided and use their own knowledge to explain the results. There was a wide appreciation of the threshold value needing to be reached for an action potential to be developed. Many candidates also included references to the opening of sodium ion channels and the entry of sodium ions into the axon, although these responses were often of a general nature rather than an explanation of the experimental data. Also, several failed to gain marks here because they failed to refer to ions. Generally, it was only the better candidates who referred to the 'all-or-none' principle and the propagation of an impulse. The failure to treat experiments 1 and/or 2 separately to 3 and/or 4 was a common error; many also referred to summation. Poor use of scientific terminology was common when explaining depolarisation; candidates confused less negative with there being a 'greater potential difference'.

(d) Most candidates tackled this question at length but responses contained a number of errors. Despite the term 'antagonistic' being used in the stem, several candidates described summation; many others explained that neurone X would be inhibitory because acetylcholine is the neurotransmitter of the parasympathetic system'. Several had the effects of neurone X and Y reversed and it was common to read about chloride ions being described as the neurotransmitter released from neurone Y. Some candidates believed that chloride ions released from Y would block the acetylcholine-binding sites on the membrane of Z. The direct effects of acetylcholine were often omitted; candidates described the occurrence of an action potential and propagation of an impulse instead. Good answers often included extra information about events before the release of neurotransmitter. The marks most commonly gained were those for acetylcholine causing entry of sodium ions into Z and chloride ion entry causing hyperpolarisation.

Q19.

Better candidates were still able to score high marks. The failure to gain marks often resulted from a misreading of questions, rather than any apparent lack of knowledge

In part (i), some candidates thought that acetylcholine acts as an inhibitor and blocks the receptor protein sites of other neurotransmitters. Most candidates, however, knew that acetylcholine binds with receptor proteins in the postsynaptic membrane and that this leads to the opening of sodium ion channels allowing sodium ions to enter the postsynaptic neurone. It was pleasing to note an increase in the number of candidates specifically referring to *sodium ions*, rather than just sodium. In (ii), most knew that the neurotransmitter is produced in vesicles only found in the presynaptic knob and that receptor proteins are only found in the postsynaptic membrane. Some, however, just saw the phrase 'transmission in one direction' and disregarded the qualification 'at a synapse' and described how unidirectionality is maintained along an axon. In section (iii), most candidates could see that release of GABA at a synapse causes the potential of the postsynaptic membrane to become more negative, or hyperpolarised. A good number also noticed that GABA causes an increase in the number of potassium ion channels that are open and, as a result, an increase in the efflux of potassium ions. Fewer, however, noticed the opening of the chloride ion channels and the consequent influx of chloride ions. Candidates who had made these observations and deductions then, usually, had no problem in suggesting that threshold stimulation would require an increased number of sodium ion channels to be opened.

Q20.

Although this question provided fewer high scoring marks than Question 8, it was still well answered by the majority of candidates

(a) Synaptic transmission is clearly well known by the vast majority of candidates and many of them obtained maximum marks. However, there were still a few misconceptions or errors by weaker candidates. 'vesicles moving across the synaptic cleft' and references to 'receptor cells' appeared quite often.

(b) This proved to be the most difficult part of Question 9 and proved to be an excellent discriminator. Only the best candidates gained all three marks displaying a full understanding of the inhibitory effect of negatively charged ions on the transmission of nerve impulses. Most candidates did not refer to the inside of the neurone becoming *more* negative although they often gained a mark for realising that depolarisation would not occur. However, only better candidates referred to the threshold level not being reached or to an action potential not being produced.

(c) (i) There were two acceptable suggestions on how the drug vigabatrin could be effective in treating epilepsy. Most candidates gained one mark for describing how this may occur, i.e. by the drug inhibiting the enzyme GABA transaminase or by binding to GABA receptors. However, fewer candidates provided a full explanation for the second mark.

(ii) Most candidates gained one mark for stating that GABA would not be able to bind to the receptors. However, many candidates referred to GABA having the 'same shape ' rather than 'complementary shape' to the receptor. Another very common error was to refer to a receptor possessing 'an active site'. Many candidates did appreciate that chloride ions would not enter the postsynaptic neurones.

Q21.

(a) Generally the question was well answered with most candidates scoring more than half marks.

Most candidates scored two marks for referring to the absence of conscious control and preventing damage to tissue. Often answers were too vague to be given credit, such as 'preventing harm or danger' without more explanation. The majority limited their answers to the example given, and so did not answer the question set, as they made no reference to other types of reflex. Of those who did develop their answer, posture and escape from predators were the most commonly discussed.

(b) (i) There were some excellent answers with many candidate scoring full marks. There were also many confused and inaccurate answers. Many candidates stated that vesicles move across the cleft or did not mention the neurotransmitter. Sometimes pre- and post- synaptic parts of the synapse were not clear. Ion movement was often poorly described, with the direction of movement often omitted or ions being moved into the membrane. Many candidates incorrectly referred to movement of chlorine or sodium ions at the presynaptic knob. The last part of the sequence was often poorly described, with no mention of binding to receptors on the postsynaptic membrane and many references to depolarisation of the neurone rather than the membrane. Production of an impulse in the postsynaptic neurone was often poorly understood, with many candidates failing to mention the need for the change in charge across the postsynaptic membrane having to reach a threshold value before an action potential could be produced.

(ii) Poorly answered, with little knowledge of the differences being shown. Although many correctly described the neurone/neurone and neurone/muscle difference, few were able to give a second difference. Many stated that the transmitter would be different, with noradrenaline being used at all neuromuscular junctions rather than some of them.

Q22.

(a) Most candidates appreciated that the charge inside the neurone would be negative compared with the charge outside and they often gave a clear explanation about the pumping movement of sodium ions being the cause of this difference. The impermeable nature of the neurone membrane to the movement of sodium ions was less well understood and very few candidates gave an adequate explanation which compared the relative amounts of sodium ions on both sides of the membrane.

(b) (i) Surprisingly few candidates used the graph accurately to give the correct time between depolarisation and the beginning of muscle contraction; 1. 5 ms was a common error, which suggested candidates used the scale on the x axis carelessly. Those candidates who constructed lines on the graph to identify the time period usually got the right answer.

(ii) Most candidates understood that speed was calculated as distance over time, but very few correctly converted ms to s.

(iii) This proved to discriminate well. Many candidates gave a valid suggestion about the role of a neuromuscular junction or the time it takes for muscle filaments to move. Unfortunately, a significant number missed the point of the question and discussed different types of neurone, the presence of a myelin sheath, the diameter of neurones, or the distance between nodes of Ranvier.

(c) A significant number of candidates began the description too early by including the

detail about the movement of vesicles containing neurotransmitter towards the presynaptic membrane. Also, some failed to gain a mark by referring to the location of neurotransmitter receptors on the motor end plate rather than on a sarcolemma or a cell membrane. The depolarisation of a muscle fibre by the movement of calcium ions is a common misconception.

(d) Both parts of this question were answered well by a large proportion of candidates.