AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.6.1.2 RECEPTORS

SCORE	PERCENTAGE
/102	%

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Q1.

(a) 1. No (functional) cones
OR
Only rods;

2. Cones are connected to a single neurone
OR
Several rods connected to a single neurone;

Accept correct reference to retinal convergence

Accept 'bipolar/nerve cell' for neurone

Accept 'many' 2 or more for 'several'

3. (Cones) Separate (sets of) impulses to brain
OR
(Rods) Single (set of) impulse/s to brain;

Accept 'optic nerve' for brain

Reject 'signals', 'messages' for 'impulses'

Accept 'action potential'

3

(b) 1. Correct answer in range 42 – 44% = 2 marks;;

2. Incorrect answer but shows that understanding that 2pq = heterozygous/carriers = 1 mark;

Accept 1 – (p^2 + q^2)

Accept understanding of 2pq by using calculation involving 2 × two different numbers

2

(c) 1. (Gene/allele) is on the X chromosome;

2. Females require two alleles/females can be heterozygous/carriers **and** males require one allele;

Reference to allele is essential but only required once

*Reference to females **and** males required*

Reject dominant allele

2

(d) 1. Green sensitive pigment/cones non-functional
OR
Cones that detect green light non-functional;

2. Three different types of pigment/cone;

3. Other/different colours ('seen') due to stimulation of more than one cone/pigment;

1, 2 and 3. Reject reference to 'green cones'/ 'blue cones / 'red cones' but once only

1, 2 and 3. Reject reference to 'green pigment'/ 'blue pigment/ 'red pigment but once only and only if 'green cones' etc, (see above) has not been rejected.

3

(e) 1. (iPS cells) divide;

2. (iPS cells) develop/differentiate into (green sensitive) cones;

Accept 'produce'/'specialise' 'turn in to' / 'genes switched on' / 'turned on' for 'develop' but ignore 'grow'

Reject develop into 'green cones'/blue' cones'/'red cones'

Ignore develop/differentiate into (blue/red sensitive) cones;

Reject reference to develop in to 'green pigment'/ 'blue pigment/ 'red pigment

2

(f) 1. (Use of iPS cells) long-term;

Accept 'gene therapy short-term' or 'only two years'

Accept 'permanent'

2. (Use of iPS cells) less chance of rejection/immune response;

3. (Use of iPS cells) single treatment;

Accept 'gene therapy 'regular/frequent treatment"

4. Harm/side effects from using viruses (in gene therapy);

3 max

[15]

Q2.

(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]

Q3.

(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]

Q4.

(a) The colour of the square has no effect on the duration of the afterimage / there is no difference in the duration of the afterimage **with** squares of different colours;

Accept other ways of expressing the null hypothesis but reference must be made to colour of square and the duration of the afterimage

*Reject 'there is no difference in the duration of the afterimage **and** the colour of the square'*

1

(b) Standard error (with 95% confidence limits)/t test because looking for differences between means / measurements (from different samples);

Test <u>and</u> reason required for the marking point

1

(c) 1. (When staring at purple) red (sensitive) and blue (sensitive) cones are stimulated / green (sensitive) cones are not stimulated;

2. Red and blue cone cells become exhausted / stop working;

3. (Afterimage due to) green (sensitive) cone cells working;

Allow 1 extra mark up to the maximum of 3 for additional detail to marking point 2 e.g. exhaustion of pigment, exhaustion of neurotransmitter, exhaustion of ATP

3

(d) 25% = 2 marks;

15-12/12 × 100 = 1 mark;

2

[7]

Q5.

(a) 1. Three peaks / three maximum values / three maxima;

2. At different wavelengths / different colours / blue, green and red;

Accept 'at 430nm, 515nm, 585nm' (±5nm for all)

2

(b) Overlap between different types of cone cells / some wavelengths / colours are detected by more than one type of cone cell;

1

(c) 1. Birds have four peaks, humans have three peaks;

2. Birds and humans have types (that peak) at 515 nm/green and 585 nm/red;

3. (Similar type) but (peak) at 430 nm in humans and 450 nm in birds;

4. Birds have a peak / can see at 370 nm / shorter wavelength / UV range;

1. Birds have four different types of cone, humans have three

Accept all numbers read from the graph within ±5 nm.

3. Do not accept 'both humans and birds absorb blue'

3 max

(d) 1. (Each cone cell has) separate neurone to brain / separate bipolar neurone /separate ganglion cell;

2. (So) no retinal convergence / impulses from each cone kept separate / no summation of impulses;

Allow converse for rod cells

2. Accept idea that each cone only represents a small area of the retina

2

(e) Between 230 790 to 231 000 = 2 marks;

Area of fovea = 1.54 mm^2 = 1 mark;

Using π as 3.14 or 22/7 or π on the calculator

No credit can be awarded if the area has been incorrectly calculated

2

[10]

Q6.

(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 <u>so</u> unable to make a comparison;

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

3. Many factors could affect blink rate <u>so</u> 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 <u>ions</u>;

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]

Q7.

(a) 1. (Increased pressure) deforms / changes stretch-mediated sodium (ion) channel;

2. (Sodium channels open and) sodium ions flow in;

Accept Na^+

3. Depolarisation (leading to generator potential).

Accept correct description of depolarisation

3

(b) Value between 2.17:1 and 2.29:1;

Accept rounding up to 2.2 or 2.3

Accept: number without : 1

Correct working showing answer but incorrect rounding in answer line = 1

Values between 117 to 119 and between 52 to 54 found but ratio wrong way round = 1 mark.

Wrong way round gives answer between 0.35:1 and 0.46:1

2

(c) 1. Parasympathetic greater effect than sympathetic;

Ignore: descriptions of graph

2. Parasympathetic keeps heart rate down / lower / decreases heart rate (as blood pressure increases);

3. Sympathetic keeps heart rate up / higher / increases heart rate (as blood pressure increases);

2. and 3. Accept converse for blood pressure decreases

4. Parasympathetic greatest / greater effect at high blood pressure / sympathetic greatest effect at low blood pressure.

3 max

[8]

Q8.

(i) no (photo)receptor cells at **Y** / no rods and cones;

1

(ii) **X** has many / only cones / more cones than **Z**;
which each synapse to a single neurone / bipolar cell / no retinal convergence;
OR
Z has mainly rods / more rods than cones;

which share / converge on neurones / bipolar cells;

2

[3]

Q9.

(a) (i) 1 and 2 share neurone but 2 and 3 have separate neurones (to brain);
Ignore wrong names of neurones

1

(ii) 1 unit is sub-threshold / 3 units are above threshold / give sufficient depolarisation;
(1 unit) No impulses / no action potential / in (sensory) neurone / does not stimulate (sensory) neurone / 3 units → impulses;
(Spatial) summation / sufficient neurotransmitter released / from 3 receptors / insufficient N-T from one;
Reject 'temporal'

3

(b) (i) (Three) different types of (cone) cells / types 6 and 7 sensitive to different wavelengths / different frequencies / different colours;

(ii) Impulses along separate neurone from each receptor cell / each receptor cell connects to separate neurone;

2

[6]

Q10.

(a) no rods at blind spot or fovea;
greater distribution of rods at edge;

2

(b) more rods and no / fewer cones present;
rods at the fovea / rods not mainly at periphery;

rods have high sensitivity / show retinal convergence / converse for cones;

rhodopsin 'bleached' at low light intensities / iodopsin 'bleached'; at high light intensities;

3 max

[5]

Q11.

(i) rhodopsin bleached / broken down by light;
time for resynthesis;

2

(ii) rhodopsin / pigment absorbs green light more readily than red / is more sensitive to green light;
(after resynthesis) less (intense) green light needed to break down rhodopsin (than red);

2

(iii) white has (high proportion of) wavelengths to which rhodopsin not sensitive;

1

[5]

Q12.

(a) (epithelial cell) of tubule cells carry out active transport;
transport chloride / sodium ions out (of filtrate);
against concentration gradient;
into surrounding tissue / tissue fluid;
creates / maintains water potential gradient for water reabsorption;
countercurrent multiplier;

5 max

(b) if water potential of blood falls, detected by receptors in hypothalamus;
leads to ADH released from pituitary gland;
ADH makes cells of collecting duct / distal convoluted tubule permeable to water;

(accept DCT)

water leaves filtrate by osmosis;
smaller volume of urine produced;

(accept converse if water potential of blood rises)

4 max

(c) (autonomic reflex),
autonomic ganglion involved;
extra synapse outside the spinal cord;
inhibitory rather than excitatory neurone;
more neurones involved;

2 max

[11]

Q1.

(a) Despite only 8% of students obtaining maximum marks, this question proved to be an effective discriminator. 90% of students obtained at least one mark, often for stating that only rods or no (functional) cones are present. Slightly more than half of these students gained a second mark, usually for correctly describing the connections of rods and/or cones to a single neurone. However, poor terminology prevented some of these students from obtaining maximum marks. Some students used terms such as 'messages' and 'signals' rather than impulses. Even when students did refer to impulses, they often omitted reference to the optic nerve or brain, resulting in incomplete explanations.

(b) The majority of students (70%) gained at least one mark for recognising that 2pq represented the heterozygous genotype. 39% of students successfully completed the calculation to obtain both marks. Many students scoring zero simply provided the Hardy-Weinberg equation with no annotation. Students obtaining one mark often thought that 0.1 was q rather than q^2, resulting in $2pq = 2 \times 0.9 \times 0.1$. This mark was not awarded when students (commonly) suggested that pq represented the heterozygous genotype.

(c) Almost 70% of students obtained at least one mark for this question, with both of the marking points being awarded in similar numbers. Students who scored zero often correctly stated that red-green colour blindness is sex-linked but did not mention the X chromosome in their explanation. These students often realised that males only required one recessive allele to express the condition, but did not explain that females require two alleles. Some students did refer to males and females, but omitted the term allele. Sex-linked alleles were sometimes said to be on an unspecified sex chromosome, on both X and Y, or just on the Y chromosome preventing females being affected. Females were sometimes thought to be XY and males XX.

(d) The answers to this question were extremely disappointing. Less than 1% of students gained maximum marks and only about a third of students obtained any of the three marks available. The trichromatic theory is a new topic on the specification and many students displayed a poor understanding of how different colours are distinguished. Many students incorrectly referred to green/red/blue cones/pigments rather than green-/red-/blue-'sensitive' cones/pigments. Consequently, fewer than 5% gained a second mark. Although better students did appreciate that 'other colours' were mixtures of different wavelengths of light, they failed to explain that 'other colours' resulted in the stimulation of more than one type of cone at the same time. Students who did gain a mark invariably referred to non-functional green-sensitive pigments or cones. However, this point was often negated as many students suggested that red-sensitive cones were also non-functional or absent, or that all cones were non-functional or absent. It was not uncommon to read answers that provided details on the breakdown of pigments which were not only beyond the requirements of the specification, but were also often inaccurate.

(e) Only 3% of students gained both marks in this question as it was a rarity to see responses that mentioned that iPS cells would divide. Although most students did understand that iPS cells would differentiate, many suggested they formed the 'green-sensitive pigment' rather than cone cells. A significant proportion of students referred to the iPS cells developing into green/red/blue cones, again failing to gain the mark for omitting the term 'sensitive'. There were also answers which referred to iPS 'growing' into cone cells with no indication of development or differentiation.

Some students suggested that rod cells were produced or confused this method with gene therapy and referred to genes being injected into stem cells. Consequently, 48% of students scored zero on this question.

(f) Most students (70%) obtained at least one mark for this question. Usually, this mark was awarded for stating that iPS is a long-term treatment or that gene therapy would only last two years. An additional mark was available if students realised that iPS would be a single treatment or that gene therapy would require regular treatments. However, this idea was rarely conveyed in students' answers. Far more students appreciated that one advantage of iPS was that rejection or an immune response was less likely. Although many students mentioned that gene therapy could cause 'harm' or 'side effects', this was often in the context of the 'injection' rather than due to using viruses. Consequently, only 8% of students obtained maximum marks and only 33% gained two or more marks. Many students also mentioned ethical issues, cost and/or the idea that results on monkeys were not necessarily transferable to humans. However, these constraints could also have applied to the use of iPS cells as a treatment.

Q4.

(a) Most responses clearly stated the null hypothesis but there was some evidence of confusion when stating there would be no difference between the duration of the afterimage and the colour of the square.

(b) The vast majority of students selected the correct statistical test and could give the correct reason for their choice.

(c) Many students showed detailed knowledge and understanding to achieve 3 marks here.

(d) This calculation was successfully completed by most students, the occasional error of calculating 3/15 x 100 was seen.

Q5.

(a) The words "peaks" and "maxima" were underlined in the alternatives to mark point 1 and were, therefore, required in the response; references to "curves" were insufficient.

(b) Both mark point options contained "cone cells" so responses that did not refer to these cells were not creditworthy. Simply referring to overlap between the curves on the graph was insufficient to fulfil the marking point.

(c) Many students successfully compared the two graphs with mark points 1 and 4 being common. Some responses were too incomplete to achieve mark points 2 and 3, only referring to one of the two peaks required for each mark point or not accurately reading off the wavelengths of the peaks. Some students focussed on the ranges of the curves rather than the peaks and so did not fulfil the marking guidelines.

(d) Most responses demonstrated good understanding although the terminology was often not ideal.

(e) This calculation was successfully completed by most candidates.

Q6.

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.

Q7.

(a) Just over a third of students obtained 3 marks. The examiners were looking for a reference to stretch-mediated sodium channels. This is the term used in the specification and is appropriate for this pressure receptor. Some students wrote about movement of sodium, rather than sodium ions, or did not state that they moved / diffused / flowed in. Others failed to note that this produces depolarization.

(b) About 30 percent of students obtained 2 marks in this part. As has been noted in other examinations, ratios seem to pose problems for many students. Many do not realize that a ratio should be given as something : 1. Other students did not realize that it mattered in which order the numbers were given when they were asked to give the ratio of heart rate in experiment 2 to that in experiment 3. These problems resulted in about 30 percent obtaining one mark. Many students had no idea how to calculate a ratio.

(c) Nearly 50 percent obtained 2 marks for stating that the parasympathetic slows heart rate and the sympathetic speeds it up. Very few noted from the graph that the parasympathetic has a much greater effect / influence on heart rate than the sympathetic; resulting in only 10 percent obtaining all 3 marks.

Q8.

Unit 6

The question in part (i) was well answered. Only those referring to area **Y** as the ‘blind spot’ failed to gain a mark. In (ii), generally candidates realised the importance of there being cones at **X** and rods at **Z.** Marks were not given when candidates failed to specify which area they were writing about, **X** or **Z**, when explaining that there were more cones. About a third of the candidates failed to gain the second mark. Candidates appeared to be aware of the greater acuity of cones but did not relate this to the neural connections.

Unit 7

In (i), although most were able to explain that region **Y** lacked receptors, some fell short by just describing it as the ‘blind spot’ or as the point where the optic nerve was joined to the retina.

Descriptions of the two types of photoreceptors were sometimes less than precise, with some candidates hinting that there were some rods present at **X** (the fovea) or that there were no cones at point **Z**. In (ii), while most understood about retinal convergence of rods, or lack of it for cones, some had a fundamental lack of understanding and thought that the reason cones gave more precise vision was due to the way they differentiated between different colours of light.

Some candidates included the term ‘acuity’ in their answers but did not explain the basis of this.

Others used inaccurate terminology and referred to cones each being connected to a single ‘nerve’.

Q9.

Unit 6

(a) In (i), some told only half the story and others were clearly muddled, particularly concerning the distinction between a neurone and a nerve (inappropriate terminology was not rewarded). Most, however, were able to deduce from the diagram which pair of rod cells shared a single sensory neurone and which pair was connected via separate neurones.
In (ii), the phenomenon of summation appeared to be well understood, although essential details, such as the attainment of the necessary threshold potential, were sometimes omitted.

(b) Very few candidates were able to express their ideas unambiguously regarding the sensitivity of different cone cells to different ranges of wavelength: many gave the impression that each cone cell was able to respond to a full range of wavelengths of light. Greater success was enjoyed in explaining that visual acuity was achieved via the stimulation of separate neurones leading from the individual cone cells, as illustrated in the diagram.

Unit 7

(a) Part (i) asked for an explanation of two events. Many candidates gave a good description of stimulation of only one or of two bipolar cells and obtained the mark. Some responses only gave an account of the one event and therefore could not obtain the mark. Part (ii) was answered well and many candidates obtained the three marks. In this instance the term bipolar neurone was not demanded though it is worth noting that these cell were variously described as ‘neurones’, ‘nerve cells’, ‘sensory nerves’, ‘interneurones’, ‘relay cells’ and ‘motor neurones’. Candidates should have knowledge that the bipolar cells are sensory neurones.

(b) The most common response to part (i) was the inadequate statement that ‘the fovea has cones’. Better answers referred to the absorption of different wavelengths by different cones. Part (ii) was answered much better and most candidates obtained the available mark.

Q10.

This question produced a wide range of marks and proved to be an effective discriminator.

(a) Although many candidates indicated a lack of rods at the blind spot, far fewer appreciated that there would be either a reduction or an absence of rods at the fovea.

(b) Many candidates gained up to two marks for suggesting that there would be a greater number of rods and fewer cones across the retina of a nocturnal mammal. Very few candidates gained a third mark by referring to retinal convergence or the breakdown of rhodopsin at low light intensities.

Q11.

(i) Most candidates knew that the rhodopsin is broken down in the light and that there is a delay while it is resynthesised after moving into darkness. Some confused their explanation with acuity and the neuronal connections of rod cells.

(ii) This part and the next were designed to test a candidate’s ability to analyse more complex data, and not surprisingly they proved quite demanding. Only the best candidates gave an explanation in terms of the intensity of light required to break

down rhodopsin. Many merely described the data, although quite often the sensitivity to red and green light was the wrong way round. Weaker candidates often referred to cones and the trichromatic theory despite the information given, sometimes insisting that rods are only sensitive to ‘black and white’. The idea that rods could be sensitive to a range of wavelengths without distinguishing colour was obviously confusing to many.

(iii) A rather larger number did realise that white light contains a high proportion of wavelengths to which rhodopsin is not particularly sensitive, whereas it has high sensitivity to green light.

Q12.

(a) This question was a good discriminator, producing a full range of marks but relatively few candidates with all five. Many candidates displayed confusion about which processes occur in the loop of Henle and where. In addition, many ignored the instruction to explain how the loop maintains a gradient of ions and entered into general descriptions of the functions of the kidney tubule. Some candidates confused the functions of the loop of Henle and the collecting duct. Terminology was also a problem for some candidates, especially with regard to failure to refer to water potentials.

(b) This question was a good discriminator, producing a full range of marks but relatively few candidates with all four. Many candidates obtained one or 2 two marks, usually for references to release of ADH from the pituitary gland, the resulting increase in permeability of the collecting duct, or the reduced volume of urine produced (or the converse). There were good answers which followed the whole train of events, starting with the stimulus of a lowering of the water potential of the blood (or a rise, or a change in blood volume and pressure) and its detection by appropriate named receptors. These answers then linked these events to the roles of the hypothalamus and pituitary glands and the release (or reduced release) of ADH.

(c) This was not answered very well by most candidates, primarily because they did not appear to be able to compare the information in the diagram to what they were supposed to know about a simple reflex. It was particularly surprising how few made any reference to the autonomic ganglion shown in the diagram.