

Receptors

These practice questions can be used by students and teachers and is

Suitable for AQA A Level 7402 Biology Topic Question

Level: AQA A LEVEL 7402

Subject: Biology

Exam Board: AQA A Level 7402

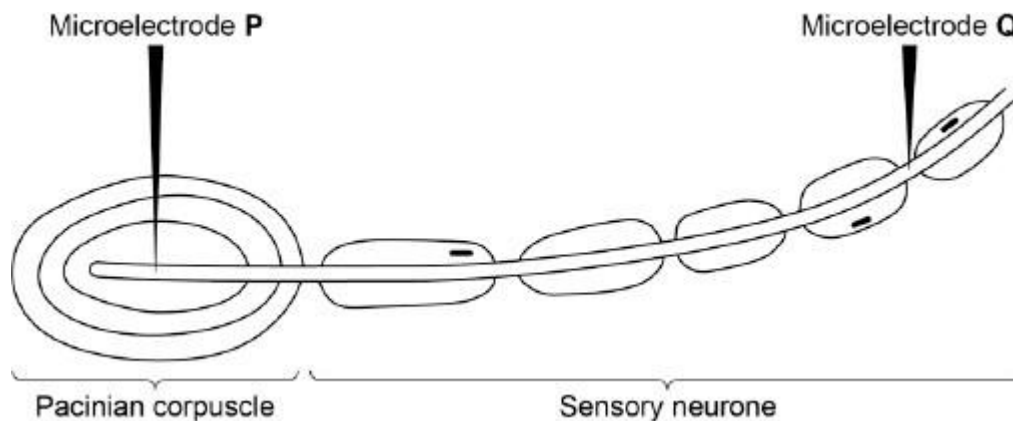
Topic: Receptors

A biologist investigated the stimulation of a Pacinian corpuscle in the skin of a fingertip.

1

She used microelectrodes to measure the maximum membrane potential of a Pacinian corpuscle and its sensory neurone when different pressures were applied to the fingertip.

The figure below shows the Pacinian corpuscle, its sensory neurone and the position of the microelectrodes.



The table below shows some of the biologist's results.

Pressure applied to the fingertip	Membrane potential at P / millivolts	Membrane potential at Q / millivolts
None	-70	-70
Light	-50	-70
Medium	+30	+40
Heavy	+40	+40

(a) Explain how the resting potential of -70 mV is maintained in the sensory neurone when no pressure is applied.

- (b) Explain how applying pressure to the Pacinian corpuscle produces the changes in membrane potential recorded by microelectrode **P**.

(Extra space)

(3)

- (c) The membrane potential at **Q** was the same whether medium or heavy pressure was applied to the finger tip. Explain why.

(2)

- (d) Multiple sclerosis is a disease in which parts of the myelin sheaths surrounding neurones are destroyed. Explain how this results in slower responses to stimuli.

(2)
(Total 9 marks)

2

The human retina contains three types of cone cells:

- cone cells sensitive to red light
- cone cells sensitive to green light
- cone cells sensitive to blue light.

Staring at a white card causes all three types of cone cells to be stimulated.

A student investigated the duration of afterimages using red squares and purple squares. His results are shown in the table.

Colour of square	Cone cell(s) stimulated	Colour of afterimage	Mean duration of afterimage / seconds
Red	Red	Blue-green	15
Purple	Red and blue	Green	12

(a) Suggest a null hypothesis for this investigation.

(1)

(b) Suggest a statistical test that would be appropriate for this investigation. Give a reason for your answer.

Statistical test _____

Reason for choice _____

(1)

(c) After the student had stared at a purple square, he saw a green afterimage. Suggest why.

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(3)

- (d) Use the results in the table to calculate the percentage increase in the mean duration of the afterimage after staring at the red square compared with the purple square.

Answer = _____ %

(2)

(Total 7 marks)

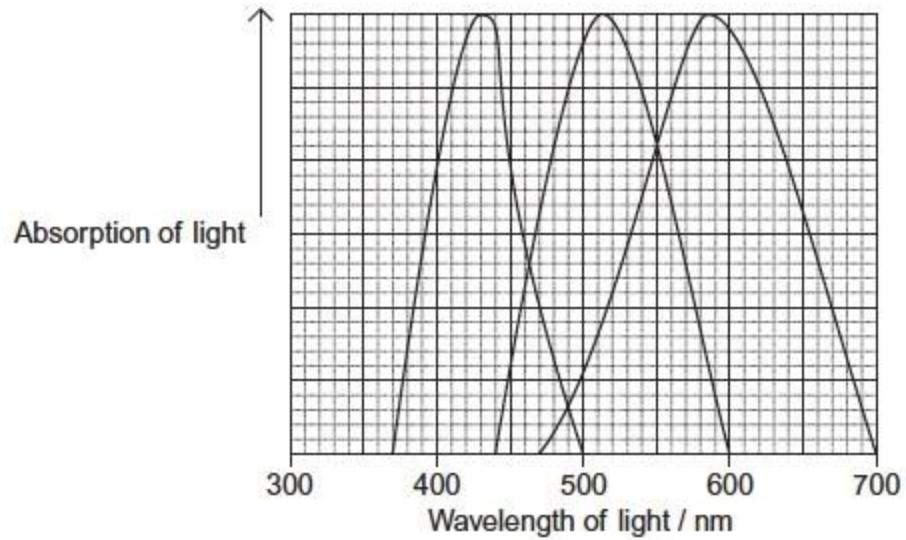
3

The retinas in the eyes of humans and birds have cone cells that absorb light of different

wavelengths.

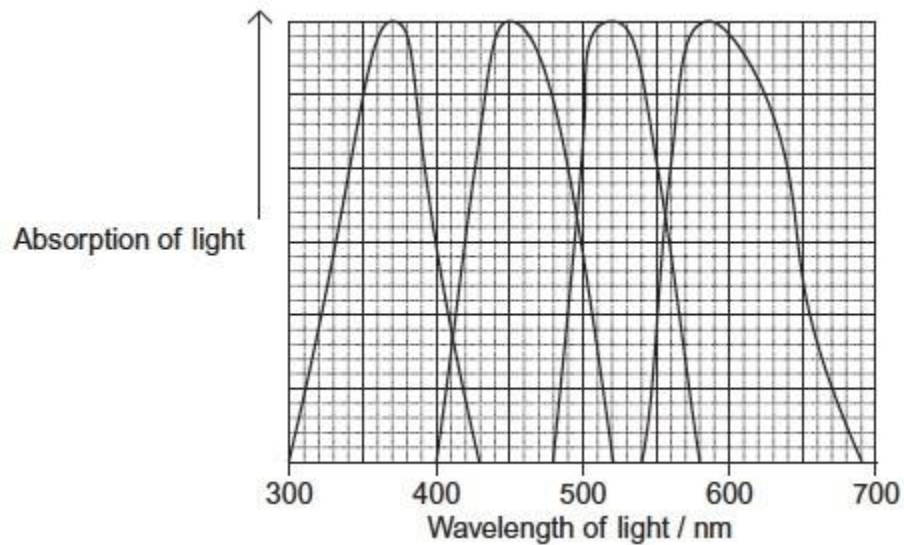
A scientist recorded the absorption of light of different wavelengths by different types of human cone cells. Her results are shown in **Figure 1**. Each curve shows the absorption of light by one type of cone cell.

Figure 1



She also recorded the absorption of light of different wavelengths by different types of bird cone cells. These results are shown in **Figure 2**. Each curve shows the absorption of light by one type of cone cell.

Figure 2



Human colour vision has been explained by the trichromatic theory, meaning that it is based on three colours.

- (a) Explain how the evidence from **Figure 1** supports this theory.

(2)

- (b) Humans see more than three colours.
Use evidence from **Figure 1** to suggest how.

(1)

- (c) Compare and contrast the wavelengths of maximum absorption by the cone cells in birdretinas and human retinas.

(3)

- (d) Cone cells give higher visual acuity than rod cells.Explain how.

(2)

- (e) The cone density is highest on the fovea in the centre of the retina. In a human fovea there are 150 000 cones per mm^2 . The diameter of a human fovea is 1.4 mm. Calculate the number of cones on the human fovea.

The formula for calculating the area of a circle is πr^2 .

Answer = _____

(2)

(Total 10 marks)

4

- (a) The blink reflex is caused by stimulation of receptors in the eye or eyelid.

Suggest **two** types of stimuli to which these receptors might respond.

1. _____

2. _____

(1)

- (b) In humans, resting blink rate varies widely from 8 to 24 blinks per minute. This variation could result in the investigations into effect of stimulation on blink rate producing means that are **not** significantly different. Explain why.

(2)

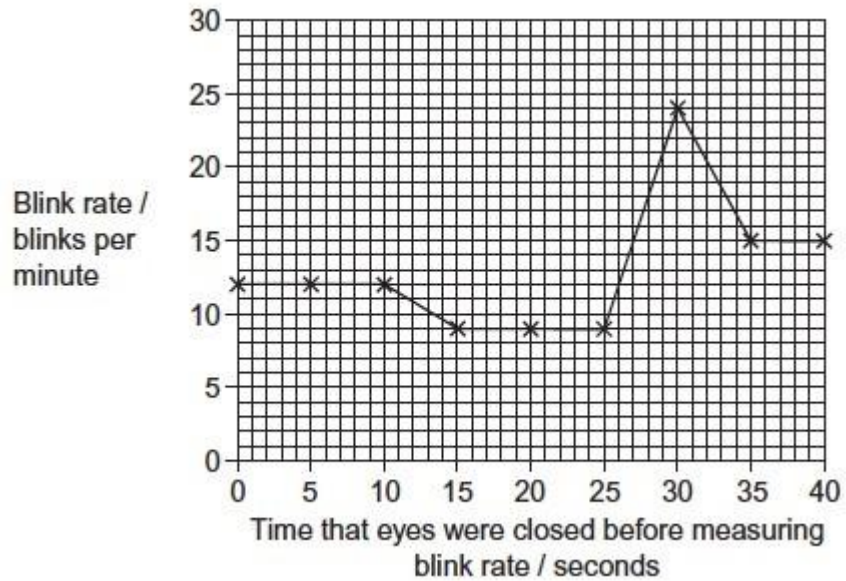
- (c) Some diseases cause changes in blink rate. Doctors do **not** often use blink rate to diagnose these diseases. Suggest **two** reasons why.

1 _____

2 _____

(2)

(d) A student completed an investigation to determine if the length of time eyes are closed before opening them affected blinking rate. His results are shown below.



The student did **not** draw a line of best fit. Suggest **two** reasons why.

1 _____

2 _____

(2)

- (e) The student did **not** carry out repeats. He was still able to carry out a statistical test. Explain why.

(1)

- (f) The blink reflex can be stopped by drugs which prevent the opening of sodium ion channel proteins in the axons of motor neurones. Suggest how these drugs affect the passage of nerve impulses along the axons.

(2)

- (g) The blink reflex involves synapses. Channel proteins on presynaptic neurones are involved in reflex responses. Explain how.

(3)

- (h) A student wanted to investigate the resting blink rate in people 60 years of age and people 15 years of age. Describe how the student could find out whether there was a significant difference in blink rates between the two age groups.

(3)

(Total 16 marks)

5

- (a) Describe how a Pacinian corpuscle produces a generator potential when stimulated.

[Extra space] _____

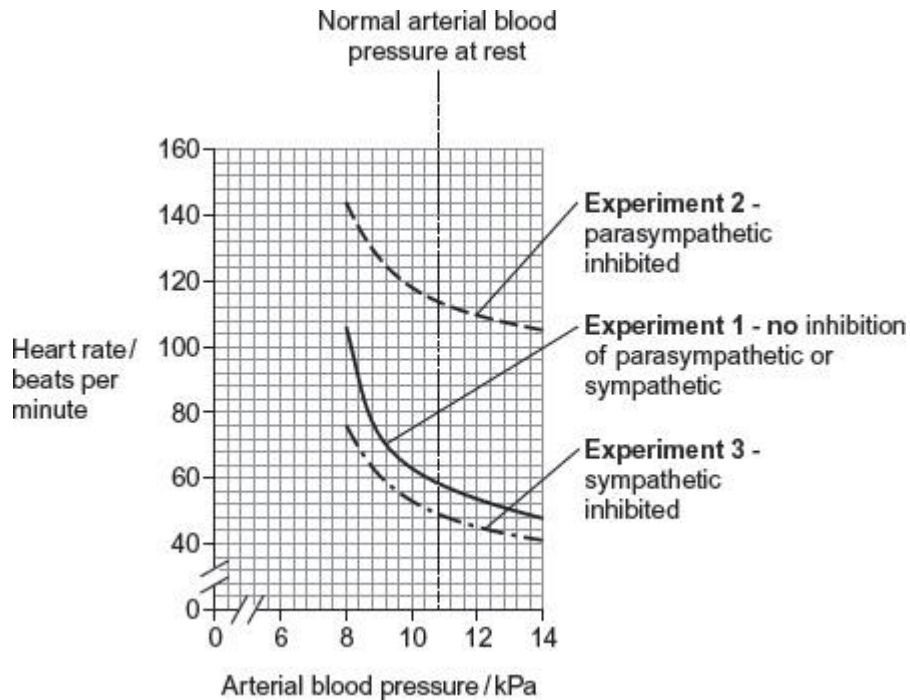
(3)

Doctors investigated the relationship between heart rate and arterial blood pressure. They recruited healthy volunteers. For each volunteer, they recorded their normal arterial blood pressure at rest. With each volunteer, they then carried out the following experiments.



- Experiment 1** They recorded heart rate at different blood pressures.
- Experiment 2** They repeated **experiment 1** after injecting a drug that inhibited the parasympathetic nervous system.
- Experiment 3** They repeated **experiment 1** after injecting a drug that inhibited the sympathetic nervous system.

The graph shows the results for one volunteer.



- (b) Calculate the ratio of heart rate in **experiment 2** to heart rate in **experiment 3** at an arterial blood pressure of 10 kPa. Show your working.

Answer = _____

(2)

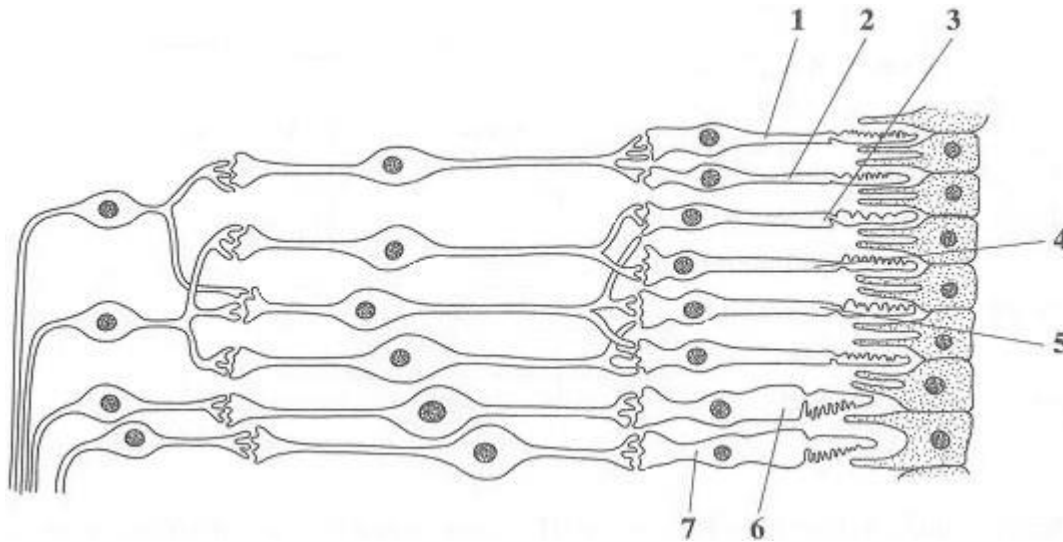
(c) What do these data suggest about the control of heart rate by the parasympathetic and sympathetic nervous systems in response to changes in arterial blood pressure?

[Extra space] _____

(3)
(Total 8 marks)

The diagram shows part of the retina in a human eye.

6



(a) Explain each of the following observations.

(i) When light falls on cells 1 and 2, only one spot of light is seen. But, when light falls on cells 2 and 3, two spots of light are seen.

(1)

- (ii) When one unit of light energy falls on cell **3**, no light is seen. But, when one unit of light energy falls on cell **3**, one unit falls on cell **4** and one unit falls on cell **5**, light is seen.

(3)

- (b) Cells of the same type as cells **6** and **7** are found in large numbers at the fovea. This results in colour vision with high visual acuity.

Explain what causes vision using the fovea.

- (i) to be in colour;

(1)

- (ii) to have high visual acuity.

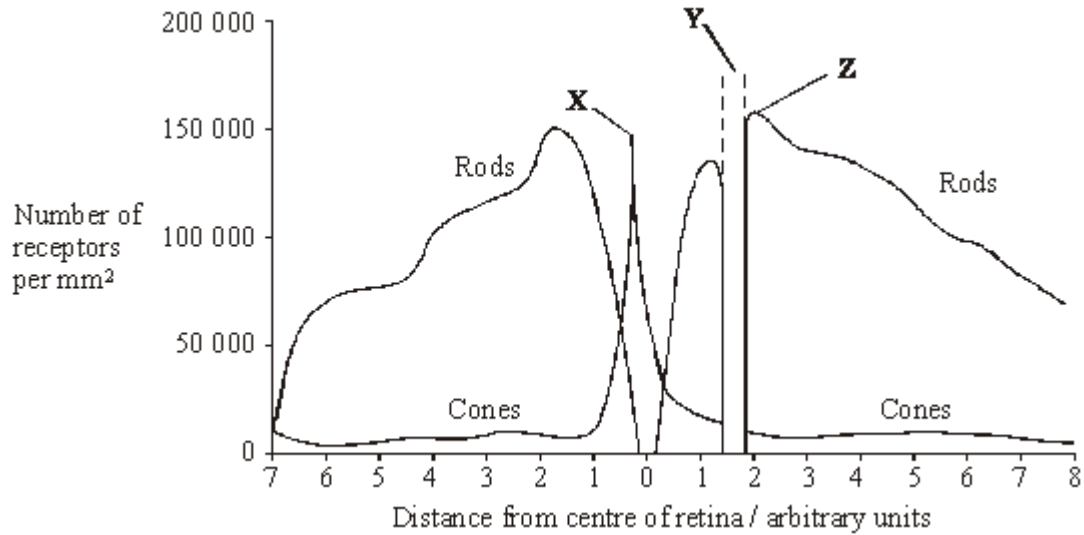
(1)

(Total 6 marks)



The graph shows the distribution of rod cells and cone cells across the retina of a human eye.

7



Use the diagram to explain why

- (i) no image is perceived when light is focused on the retina at Y;

(1)

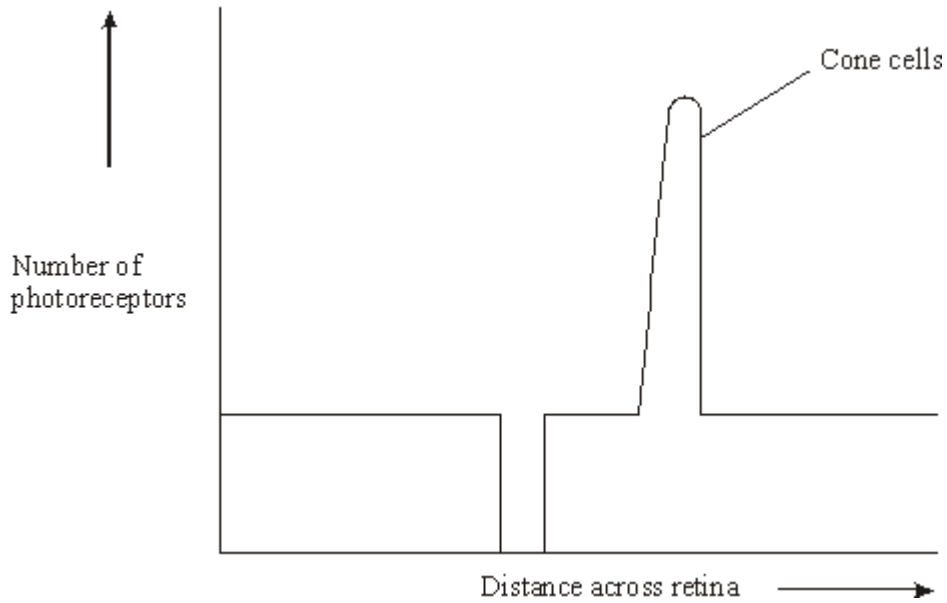
- (ii) an image formed at X is perceived in more detail than an image formed at Z.

(2)

(Total 3 marks)

The diagram shows the distribution of cone cells across the retina of a human eye.

8



(a) On the diagram draw a line to show the distribution of rod cells across the retina.

(2)

(b) Nocturnal mammals are active at night. Describe how the number and distribution of rods and cones across the retina would differ in a nocturnal mammal from the number and distribution in a human. Explain your answer.

(3)

(Total 5 marks)

After moving from bright light into darkness, it takes several minutes for the rod cells to recover



their sensitivity. Researchers measured the ability of the rod cells to detect small spots of light of different colours and intensity after a person moved into darkness. The results are shown in **Figure 1**.

Figure 2 shows the amount of light of different wavelengths that rhodopsin absorbs.

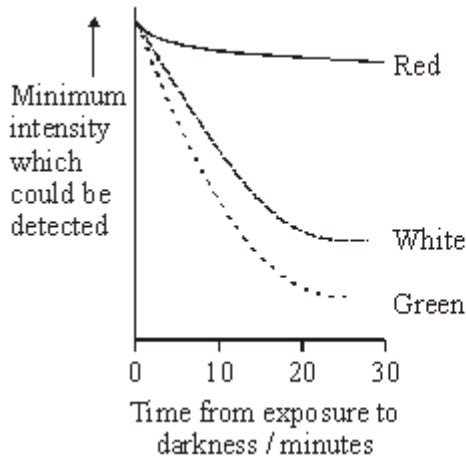


Figure 1

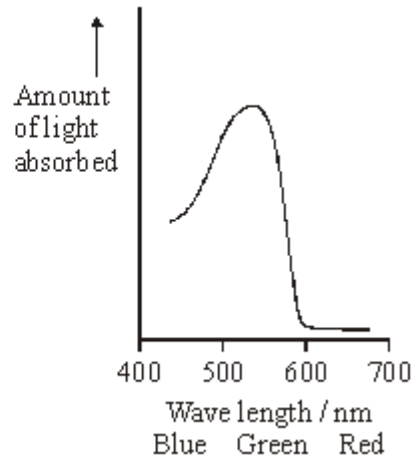


Figure 2

- (i) Explain why it takes time for the rod cells to recover their sensitivity to light after moving into darkness.

(2)

- (ii) Use information in **Figures 1** and **2** to explain the differences in sensitivity of rod cells to red and green light.



(2)

- (iii) Suggest an explanation for the difference in sensitivity of rod cells to the white and greenspots after 30 minutes.

(1)

(Total 5 marks)

Answers should be written in continuous prose, where appropriate.

10

Quality of Written Communication will be assessed in these answers.

The kidney plays an important part in the regulation of blood water potential. This involves control of the amount of water reabsorbed from the filtrate produced in the kidney tubules. The amount of water reabsorbed affects the volume of urine produced, the rate at which the bladder fills and how often it has to be emptied.

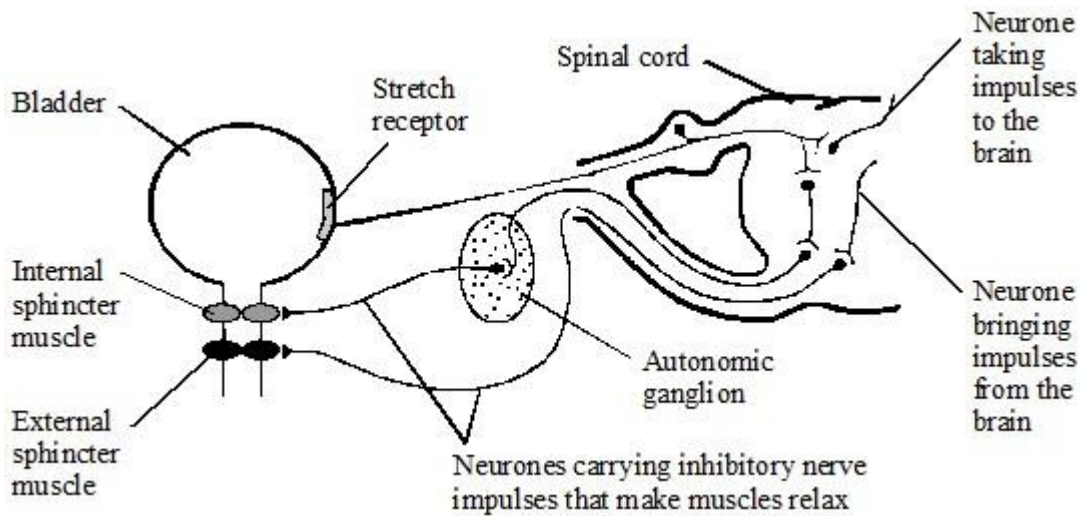
- (a) Explain how the loop of Henle maintains the gradient of ions which allows water to be reabsorbed from filtrate in the collecting duct.

(5)

- (b) Explain how ADH is involved in the control of the volume of urine produced.

(4)

- (c) The diagram shows the systems involved in controlling the emptying of the bladder. In babies, emptying of the bladder is controlled by an autonomic reflex involving the internal sphincter muscle. Conscious control is learnt between the ages of two and three and involves the external sphincter as well.



Using information in the diagram,

explain how the autonomic reflex arc is different from a simple reflex arc involving voluntary muscle;

(2)

(Total 11 marks)

When a person looks directly at an object, its image is focused on the fovea.

11

- (a) When the image is focused on the fovea, the person sees the object in colour. Explain why.

(Extra space) _____

(3)

(b) Vision using the fovea has high visual acuity but low sensitivity to light compared with vision using other parts of the retina.

(i) Explain why vision using the fovea has high visual acuity.

(1)

(ii) Explain why vision using other parts of the retina has high sensitivity to light.

(Extra space) _____

(3)

(Total 7 marks)

Mark schemes

(a) 1. Membrane more permeable to potassium ions and less permeable to sodium ions;

1

- 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] (a) The colour of the square has no effect on the duration of the afterimage / there is no

2

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 and 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;

$15 - 12 / 12 \times 100 = 1 \text{ mark};$

2

[7]

3

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

2. At different wavelengths / different colours / blue, green and red;
Accept 'at 430nm, 515nm, 585nm' (± 5 nm 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/greenand 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]

- (a) Any **two** from:

4

- 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]

5

- (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 bloodpressure increases);
 3. Sympathetic keeps heart rate up / higher / increases heart rate (as bloodpressure 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]

6

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

7

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] (a) no rods at blind spot or fovea;

8

g
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b
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i
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n
o
f
r
o
d

- (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] (i) rhodopsin bleached / broken down by light;

9

- (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] (a) (epithelial cell) of tubule cells carry out active transport;

10

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] (a) Colour detected by cone cells;

11

Fovea contains (only / mainly) cone cells;
Three types of cone / cells described / each sensitive to different wavelength / to red or green or blue;

Max 2 if 'rods' and 'cones' confused consistently

3

- (b) (i) Each receptor (in fovea)/each cone connected to separate neurone / rods/cells in other parts share a neurone;

Accept nerve cell / nerve fibre

1

- (ii) Many rods in other parts of retina;
Rhodopsin / pigment in receptors / rod cells very sensitive to light/ works in low light;
Receptors / rods connected in groups to ganglion cell / neurone;
Summation;
Description of summation, eg if enough light above threshold hits any cells in the group, then get nerve impulses to brain/along optic nerve;

3 max

[7]