AQA A-LEVEL · 7402

BIOLOGY



EXAM QUESTION PACK

3.6.1.2 RECEPTORS

SCORE	PERCENTAGE
/102	%

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Q1.

Read the following passage.

Complete achromatopsia is a form of complete colour blindness. It is caused by having only rods and no functional cone cells. People with complete achromatopsia have difficulty in seeing detail. Complete achromatopsia is caused by an autosomal recessive allele and is usually very rare in populations with only one in 40 000 being affected. However on the Pacific island of Pingelap ten percent of the population are affected.

One form of red-green colour blindness is caused by a sex-linked recessive allele which affects more men than women. People with this red-green colour blindness are unable to distinguish between red and green, and also between other colours. They have green-sensitive cones but the photoreceptive pigment they contain does not function.

Scientists investigated the use of gene therapy to correct red-green colour blindness in monkeys. They injected viruses containing the gene for the green-sensitive pigment directly into the eyes of the monkeys. Although the monkeys maintained two years of colour vision, there is debate on whether this form of gene therapy is worthwhile. No clinical trials of this procedure have been carried out on humans. Current research into the treatment of red-green colour blindness involves the use of induced pluripotent stem cells (iPS cells). The use of iPS cells could have advantages over the use of gene therapy.

Use the information in the passage and your own knowledge to answer the following questions.

(a) People with complete achromatopsia have difficulty in seeing detail (lines 2–3).

Explain why.

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(3)

(b) Ten percent of the population on the Pacific island of Pingelap are affected by complete achromatopsia (lines 3–6).

Use the Hardy-Weinberg equation to calculate the percentage of this population who are heterozygous for this disorder.
Show your working.

Answer = _____ %

(2)

(c) Red-green colour blindness affects more men than women (lines 7–8).

Explain why.

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(2)

(d) People with red-green colour blindness are unable to distinguish between red and green, and also between other colours (lines 8–10).

Explain why.

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(3)

(e) Current research into the treatment of red-green colour blindness involves the use of induced pluripotent stem cells (iPS cells) (lines 17–19).

Suggest how iPS cells could correct red-green colour blindness.

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(2)

(f) The use of iPS cells could have advantages over the use of gene therapy to correct red-green colour blindness (lines 19–20).

Using the information from the passage, suggest and explain reasons why.

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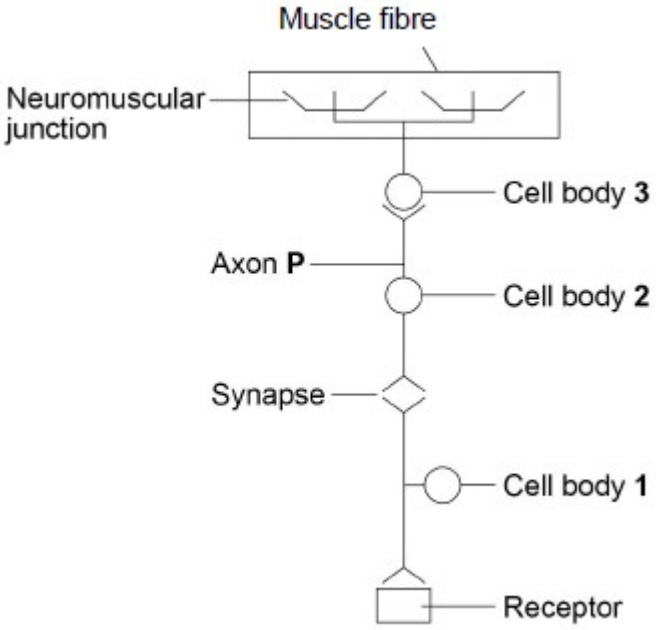
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(3)

(Total 15 marks)

Q2.

The diagram below shows a nerve pathway in an animal.



(a) The nerve pathway shown in the diagram may be regarded as a simple reflex arc.

Use the diagram to explain why.

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_____

(1)

(b) Suggest **two** advantages of simple reflexes.

1. _____

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_____

2. _____

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(2)

(c) In the nerve pathway in the diagram, synapses ensure that nerve impulses only travel towards the muscle fibre.

Explain how.

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(2)

(d) Axon **P** was found to conduct impulses much faster than other axons in the nerve pathway shown in the diagram.

Describe and explain **one** feature of axon **P** that might cause this difference.

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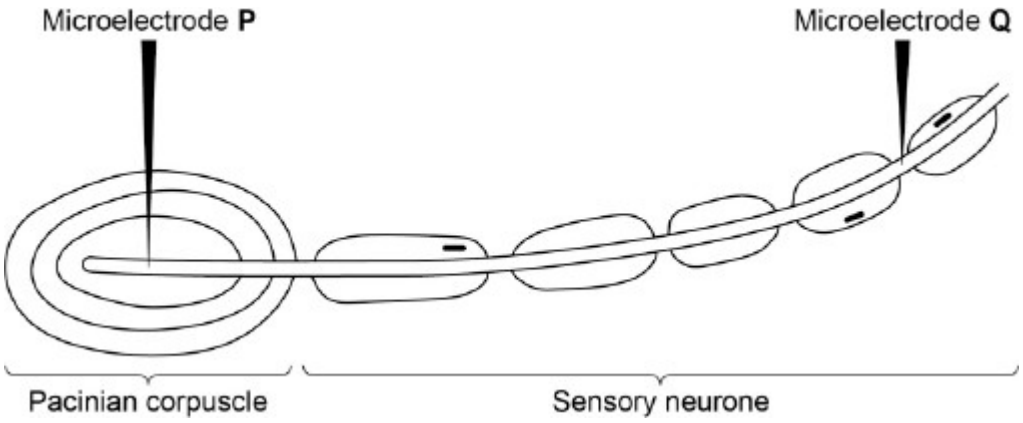
(2)

(Total 7 marks)

Q3.

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

(2)

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

(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)

Q4.

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)

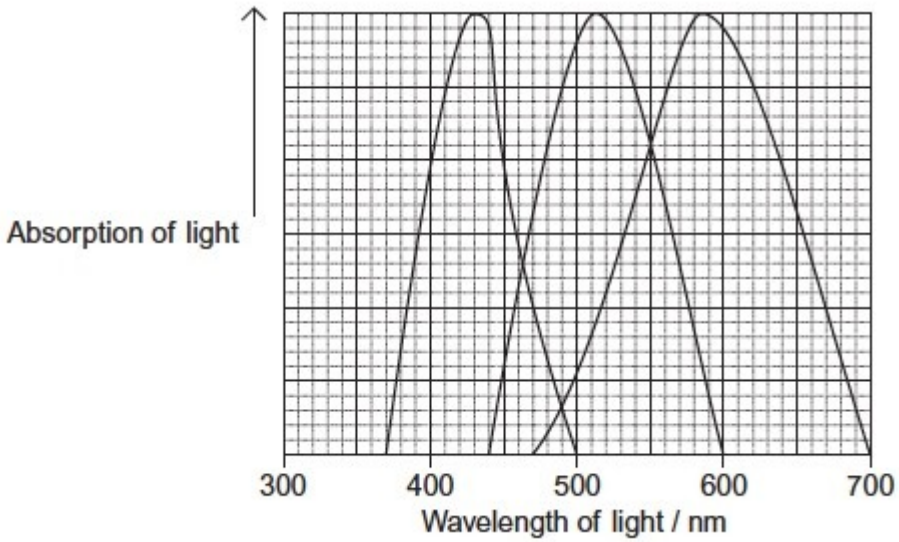
(Total 7 marks)

Q5.

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

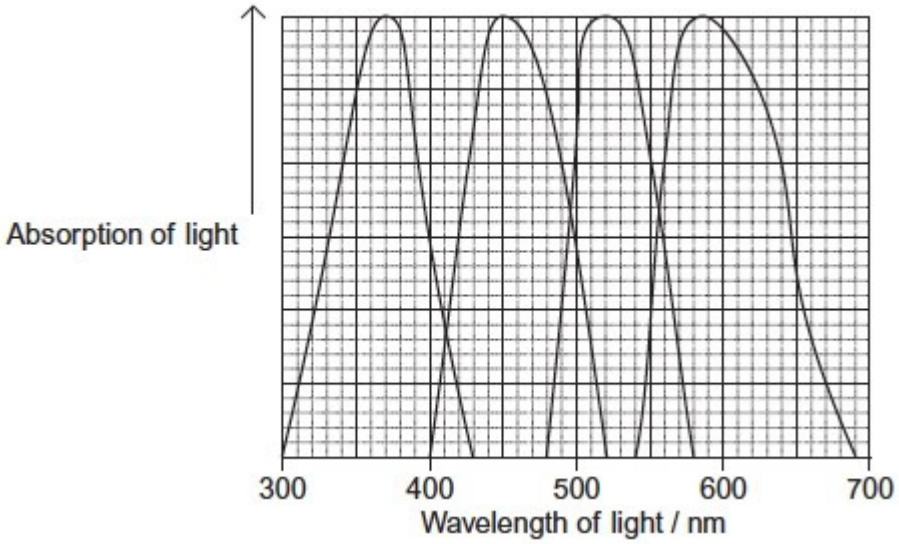
A scientist recorded the absorption of light of different wavelengths by different types of human cone cells. Her results are shown in **Figure 1**. Each curve shows the absorption of light by one type of cone cell.

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.

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(2)

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

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(1)

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

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(3)

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

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(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)

Q6.

(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.

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(2)

(c) Some diseases cause changes in blink rate. Doctors do **not** often use blink rate to

diagnose these diseases. Suggest **two** reasons why.

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2

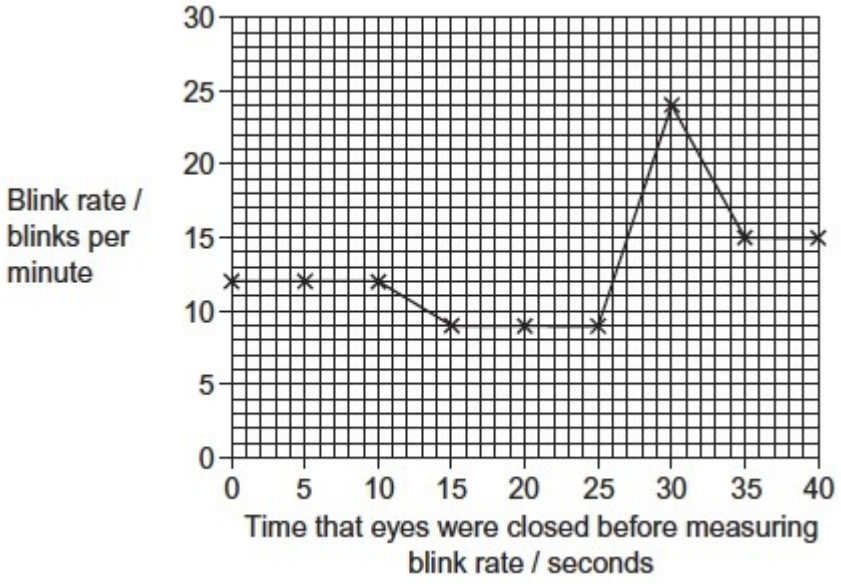
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(2)

(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

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_____

2

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(2)

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

Explain why.

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(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.

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(2)

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

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(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.

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(3)

(Total 16 marks)

Q7.

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

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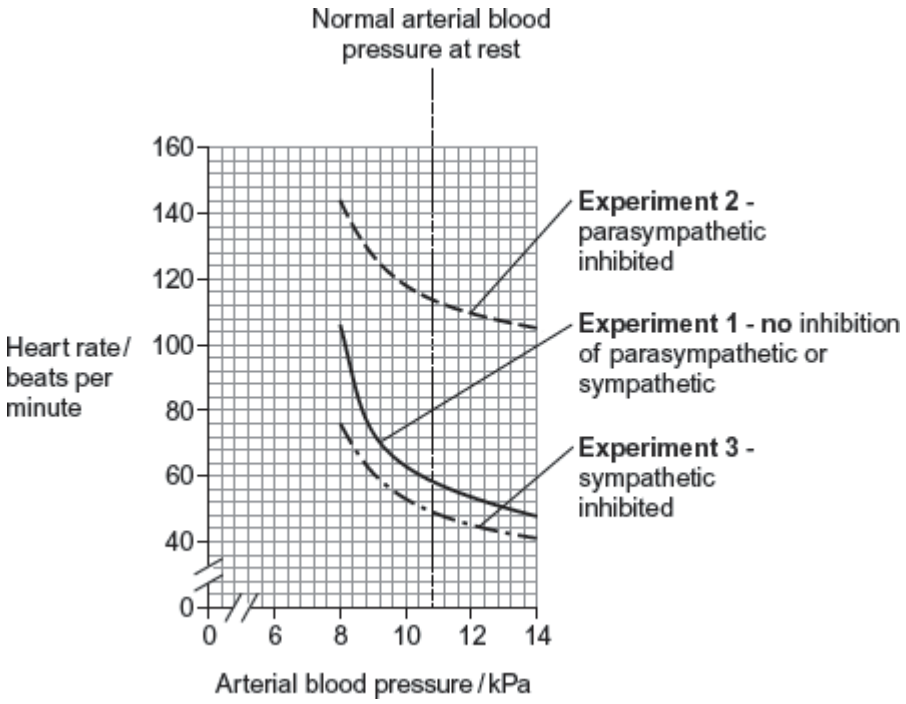
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(3)

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?

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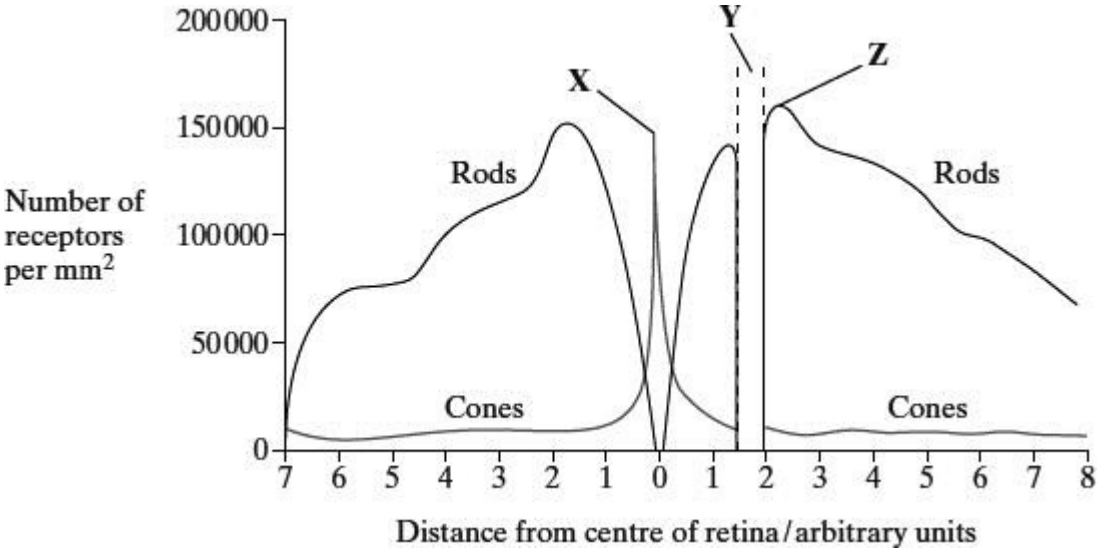
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(3)
(Total 8 marks)

Q8.

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



Use the diagram to explain why

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

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(1)

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

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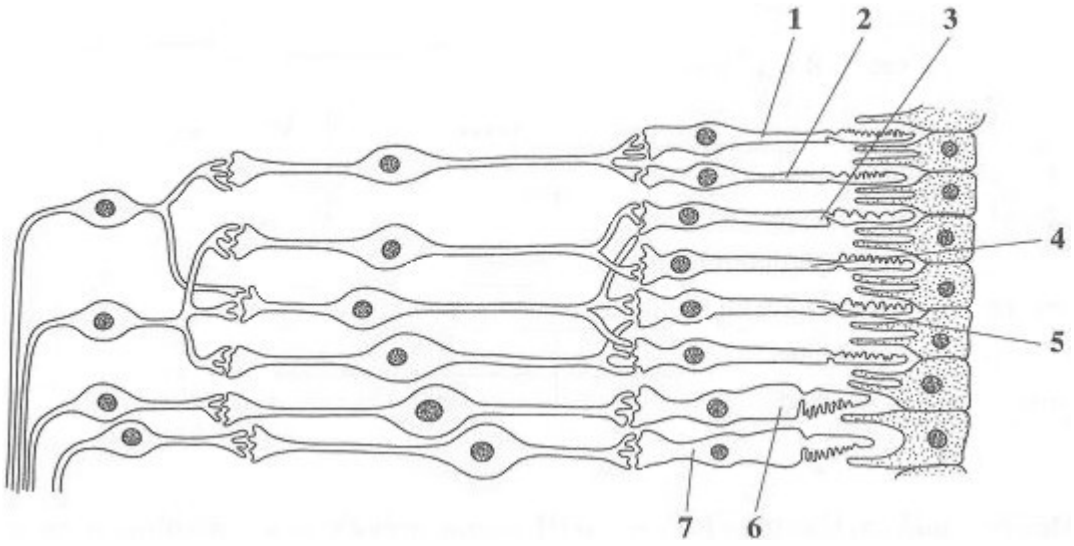
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(2)
(Total 3 marks)

Q9.

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



(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.

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_____

(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.

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(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;

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_____

(1)

(ii) to have high visual acuity.

_____

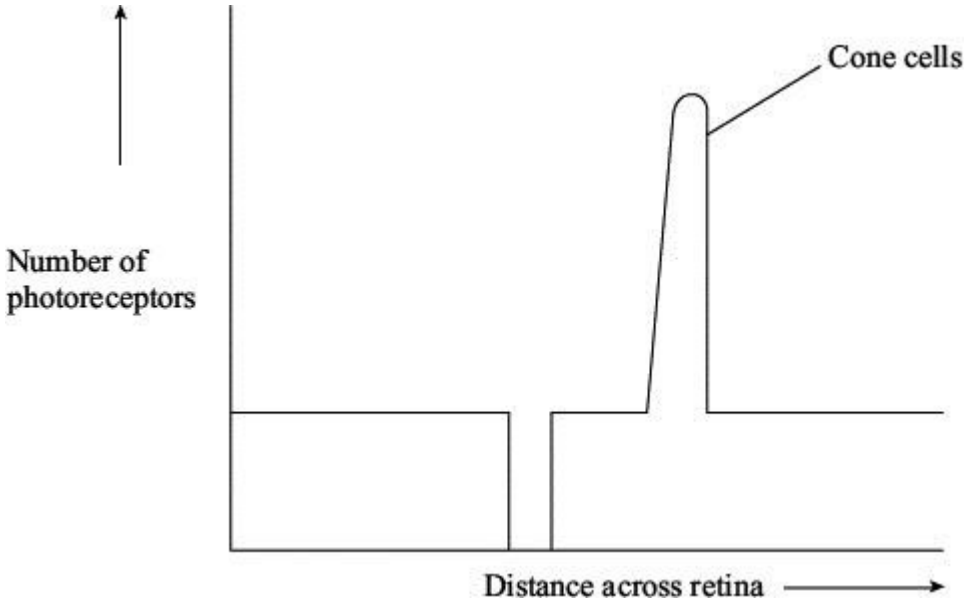
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(1)

(Total 6 marks)

Q10.

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



(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.

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(3)

(Total 5 marks)

Q11.

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.

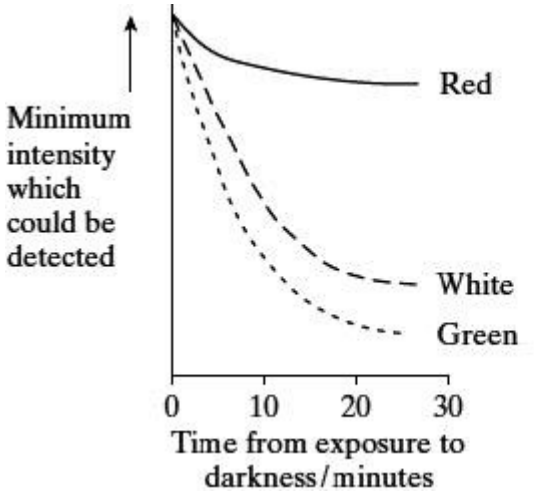


Figure 1

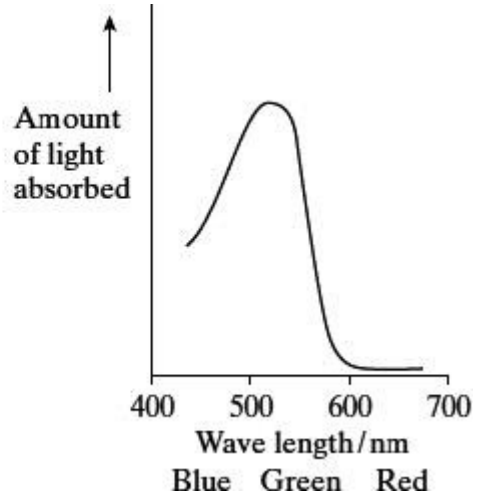


Figure 2

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

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(2)

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

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(2)

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

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(1)

(Total 5 marks)

Q12.

Answers should be written in continuous prose, where appropriate.
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.

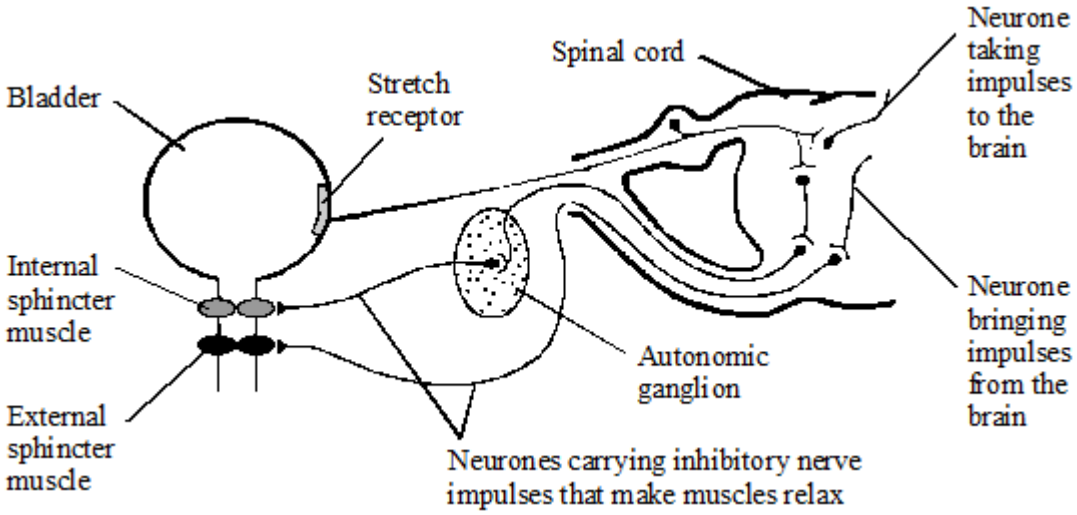
(a) Explain how the loop of Henle maintains the gradient of ions which allows water to be reabsorbed from filtrate in the collecting duct.

(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;

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_____

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(2)

(Total 11 marks)