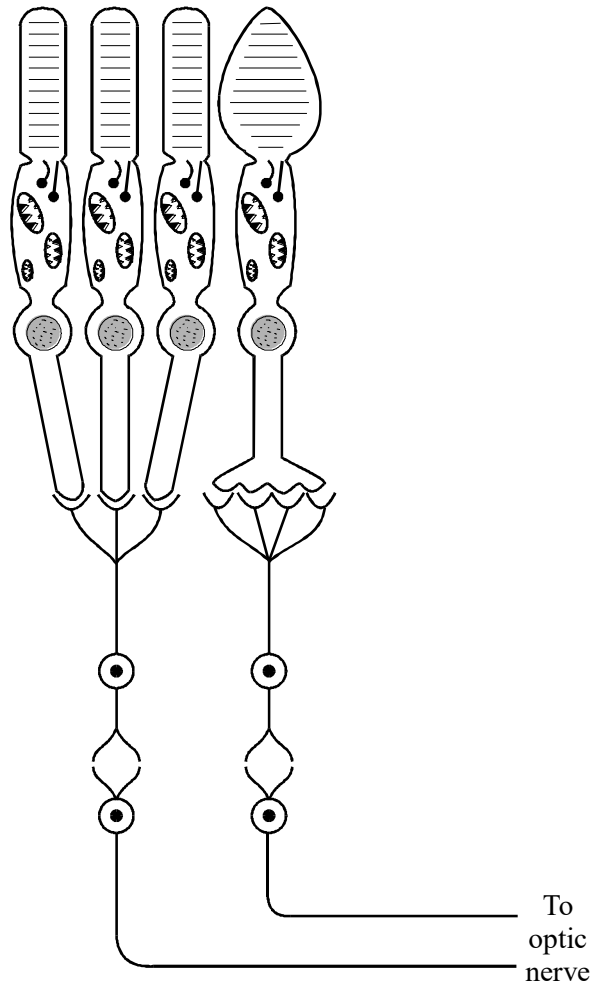


1. The diagram shows the distribution of rods and cones in the retina of a human eye.



- (a) Using information in the diagram, explain how:

- (i) rod cells enable us to see in conditions of low light intensity;

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(2)

(ii) cone cells enable us to distinguish between objects close together.

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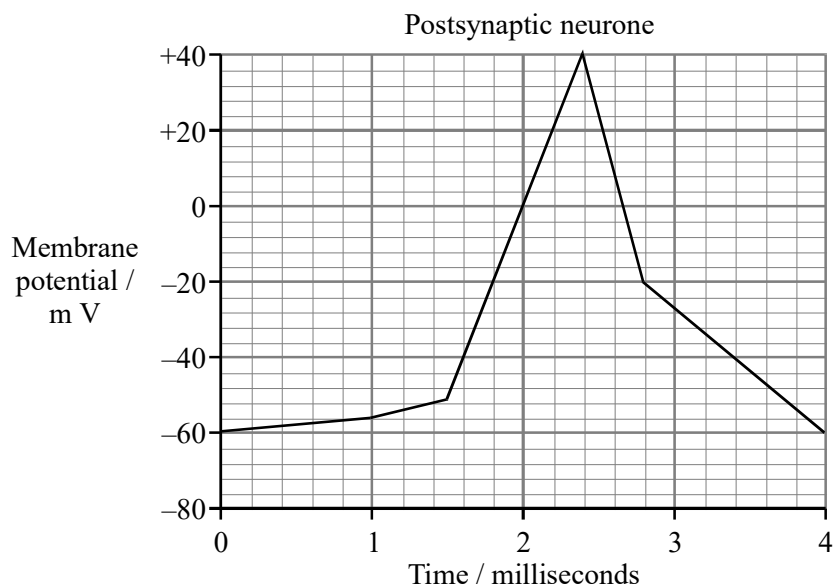
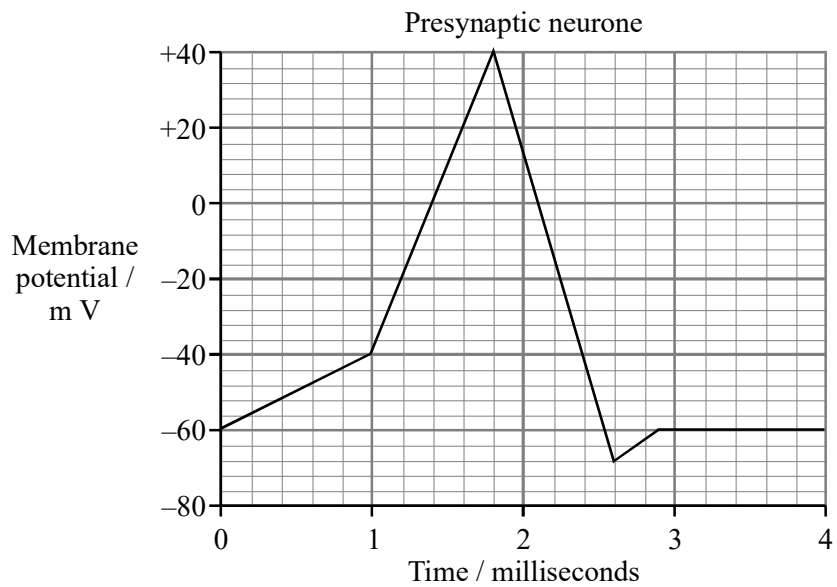
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(2)

(b) The graphs show the changes in membrane potential in a presynaptic neurone and a postsynaptic neurone when an impulse passes across a synapse.



(i) What is the resting potential of the presynaptic neurone?

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(1)

(ii) Explain what causes the change in the membrane potential in the presynaptic neurone between 1 and 1.8 milliseconds.

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(3)

(iii) How long is the delay between the maximum depolarisation in the presynaptic and the maximum depolarisation in the postsynaptic membrane?

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(1)

(iv) Describe the events that occur at the synapse during this delay.

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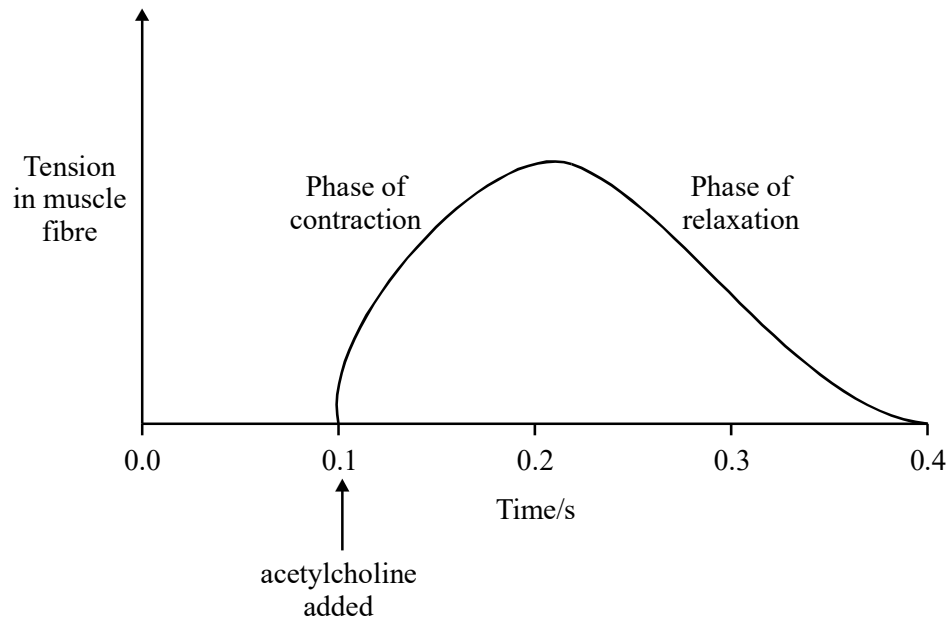
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(3)

- (c) The point at which an individual neurone makes contact with a striated muscle fibre is called a neuromuscular junction. Acetylcholine solution was added to a neuromuscular junction. The graph shows the effect of the acetylcholine on the length of the muscle fibre.



Acetylcholine is normally hydrolysed by an enzyme at the neuromuscular junction. Some insecticides inhibit this enzyme. Suggest how these insecticides are effective in killing insects.

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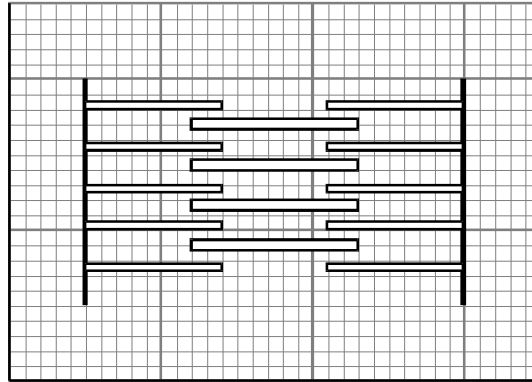
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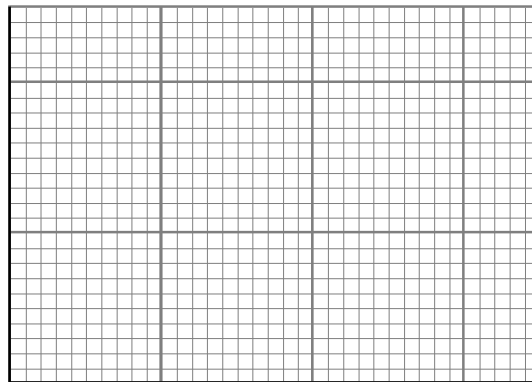
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(3)

- (d) The diagram shows the positions of the muscle proteins, actin and myosin, in a non-contracted sarcomere.



Using the same scale as in the diagram, draw on the grid below, a sarcomere after contraction.



(1)

- (e) Explain the role of the following during muscle contraction.

- (i) Calcium ions

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(2)

(ii) Mitochondria

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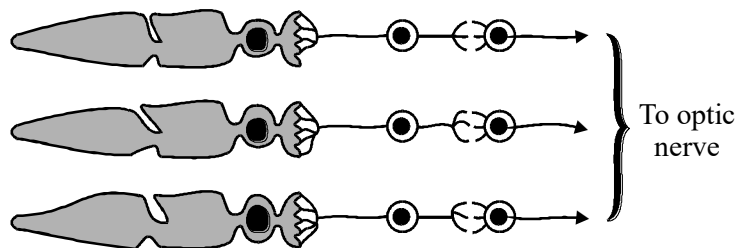
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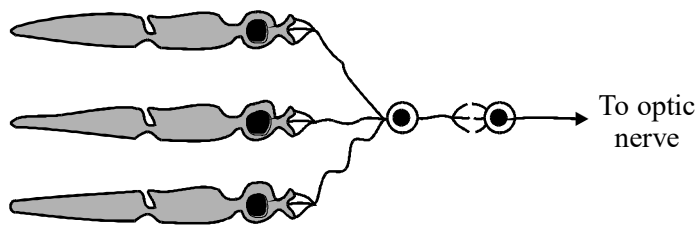
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(2)  
(Total 20 marks)

2. The diagrams show the connections between light sensitive cells and neurones leading to the optic nerve of the eye. The connections will result in either greater acuity or greater sensitivity of vision.



**Pattern A**



**Pattern B**

(a) **Pattern A** results in greater visual acuity. What is meant by *visual acuity*?

.....

.....

(1)

- (b) **Pattern B** means that there are far fewer neurones in the optic nerve than photoreceptors in the retina. This is known as retinal convergence. Explain how this enables a person to see in dimly lit conditions.

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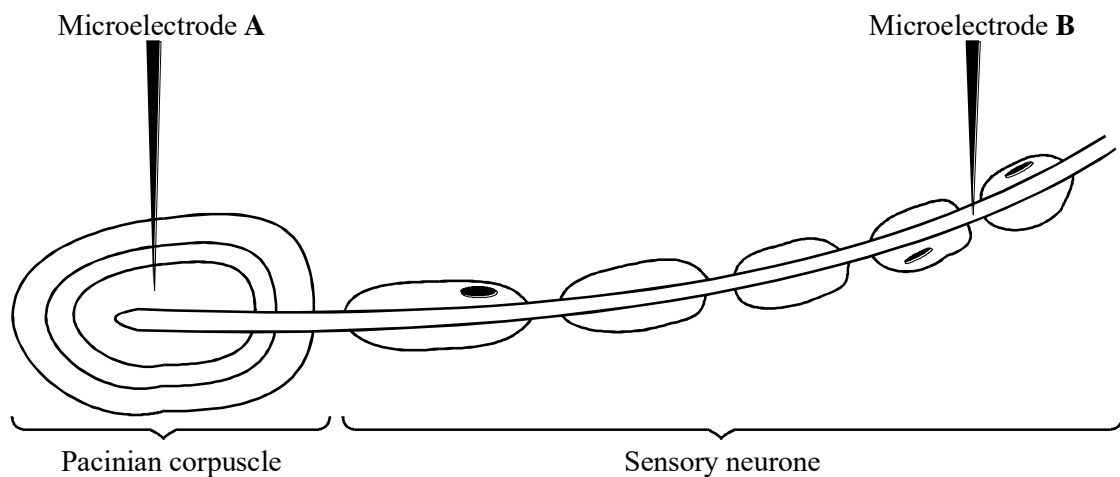
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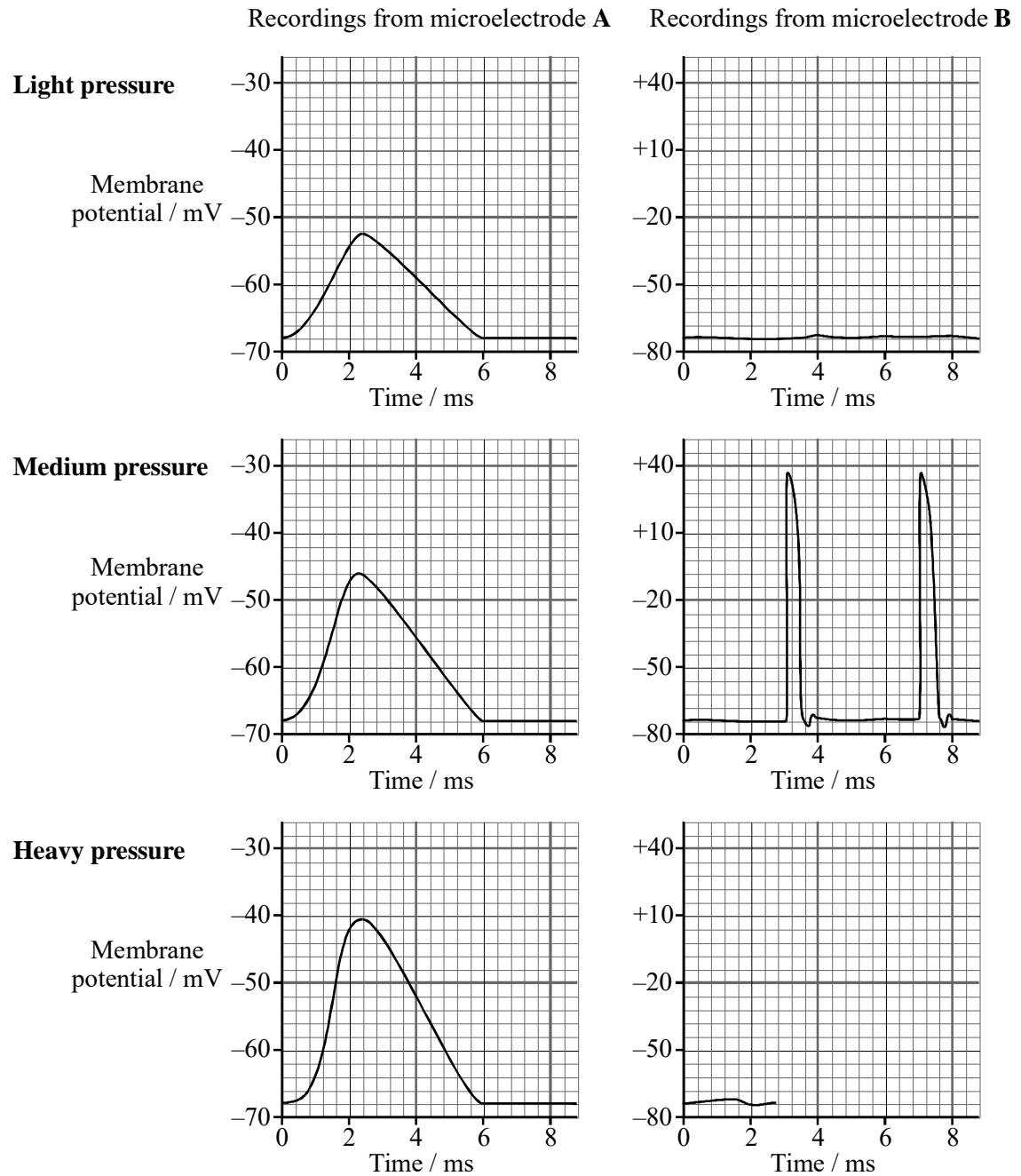
(2)  
(Total 3 marks)

3. **Figure 1** shows a Pacinian corpuscle and its sensory neurone which are present in the skin of a fingertip.



**Figure 1**

**Figure 2** shows the electrical activity simultaneously recorded from the Pacinian corpuscle and its sensory neurone when increasing pressure was applied to a fingertip.



**Figure 2**



- (a) Explain how pressure on the Pacinian corpuscle produces the changes in membrane potential recorded by microelectrode **A**.

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(2)

- (b) (i) Draw an arrow on **Figure 1** to show the direction of net movement of potassium ions during repolarisation of the sensory neurone. Label this arrow with the letter **K**.

(1)

- (ii) Complete **Figure 2** to show the expected electrical activity recorded by microelectrode **B** when high pressure was applied to the fingertip.

(1)

- (c) (i) What is the delay between the maximum depolarisation recorded by microelectrode **A** and the first depolarisation recorded by microelectrode **B** when medium pressure was applied to the fingertip?

Answer ..... ms

(1)

- (ii) The distance between microelectrodes **A** and **B** is 8 cm. Use this information together with your answer to (c) (i) to calculate the speed of conduction of an impulse along the sensory neurone, in metres per second. Show your working.

Answer ..... ms<sup>-1</sup>

(1)

(d) Most of the sensory neurone in **Figure 1** is covered by a myelin sheath. This prevents the movement of ions across the axon membrane except at the small gaps in the sheath, called the nodes of Ranvier. Multiple sclerosis is a disease in which the myelin sheaths surrounding the neurones are destroyed so the neurones become de-myelinated.

(i) Explain how de-myelination of neurones produces slow responses to stimuli in people with multiple sclerosis.

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(2)

(ii) The rate of ATP consumption of a de-myelinated neurone is greater than that of a myelinated neurone when conducting impulses at the same frequency. Explain why.

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(2)

(e) Hydra is a small animal which lives in water. It traps food particles by random movement of its tentacles. The rate of tentacle movement is usually slow but becomes faster as more tentacles touch food particles.

(i) Name the type of behaviour described above.

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(1)

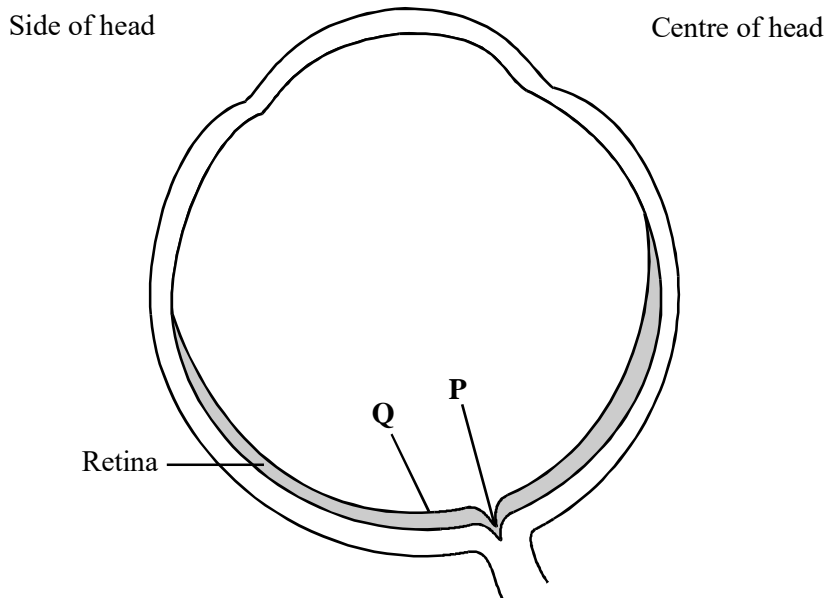
(ii) Give a reason for your answer.

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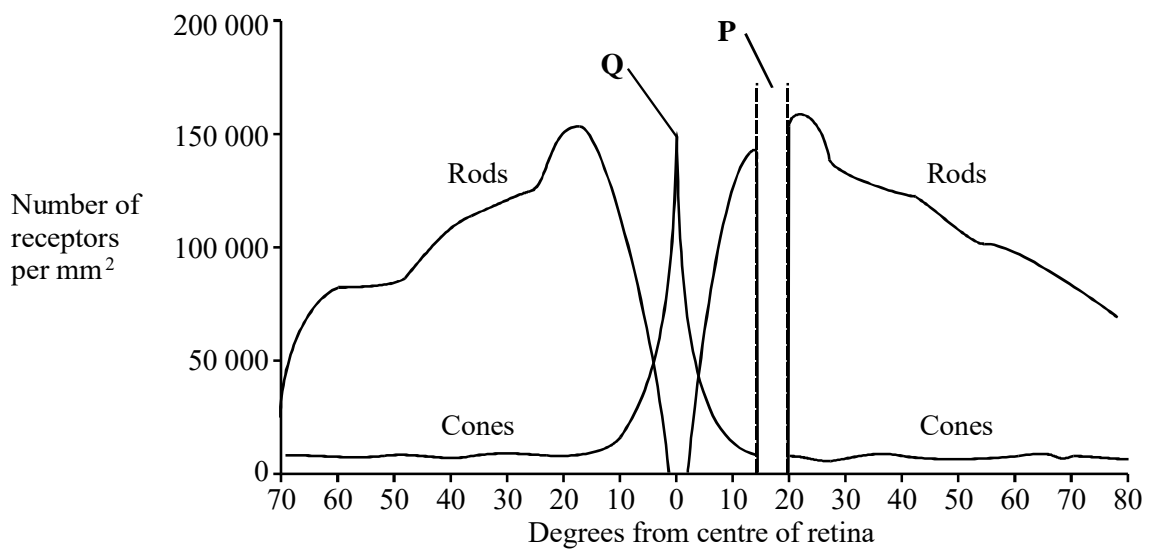
(1)

(Total 12 marks)

4. **Figure 1** shows a section through a human eye. **Figure 2** shows the distribution of rods and cones in the retina of the human eye.



**Figure 1**



**Figure 2**

- (a) Use **Figures 1** and **2** to explain why
- (i) no image is perceived when rays of light strike the retina at the point marked **P**;

.....

.....

(ii) most detail is perceived when rays of light strike the part of the retina labelled Q.

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(1)

(b) Rod cells allow us to see objects in dim light. Explain how the connections of rod cells to neurones in the retina make this possible.

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(3)

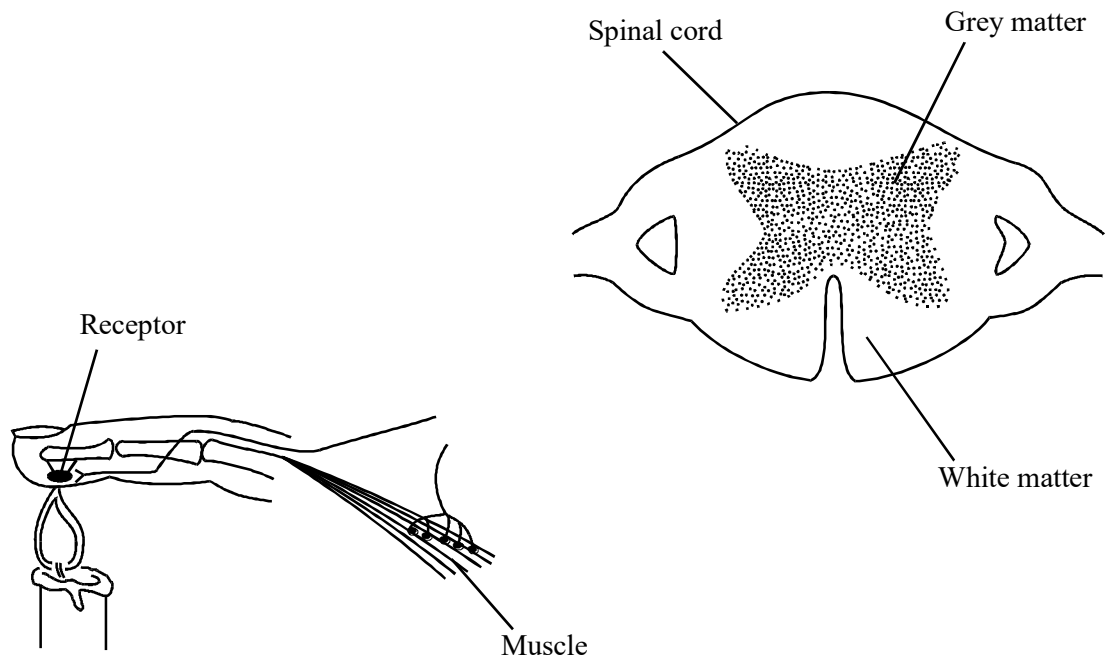
(Total 5 marks)

5. (a) When pressure is applied to a Pacinian corpuscle, an impulse is produced in its sensory neurone. Explain how.

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(2)

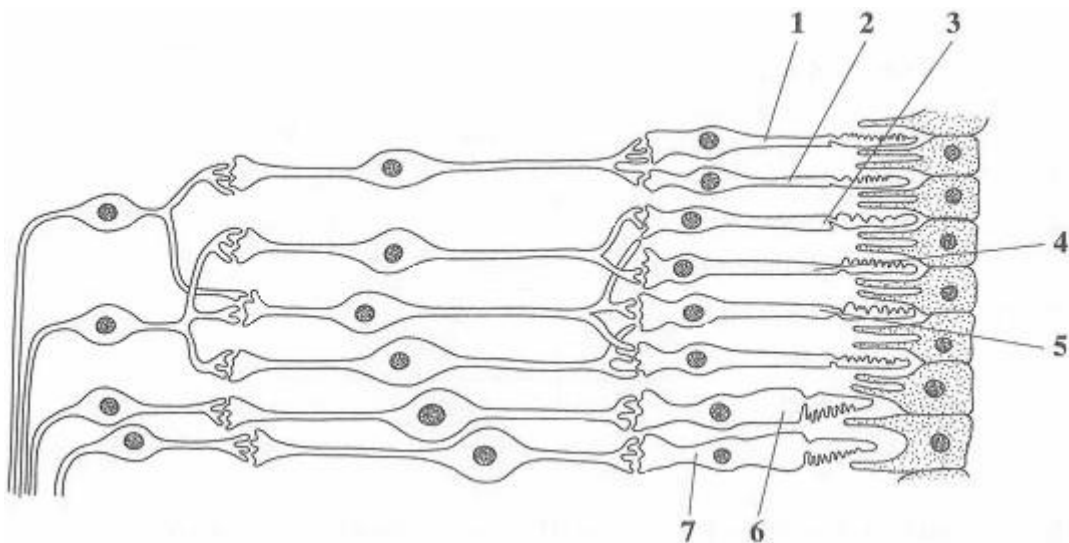
(b) The diagram shows part of a simple reflex arc containing three neurones.



Complete the diagram by drawing in and labelling the structures that conduct impulses into, through, and out of the spinal cord.

(3)  
(Total 5 marks)

6. 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)

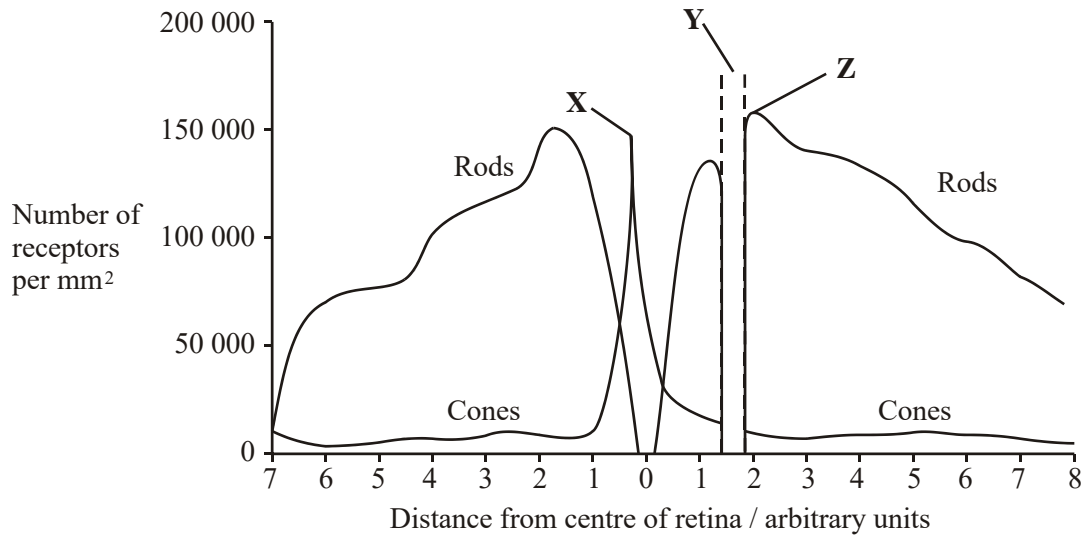
(ii) to have high visual acuity.

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(1)

(Total 6 marks)

7. 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)

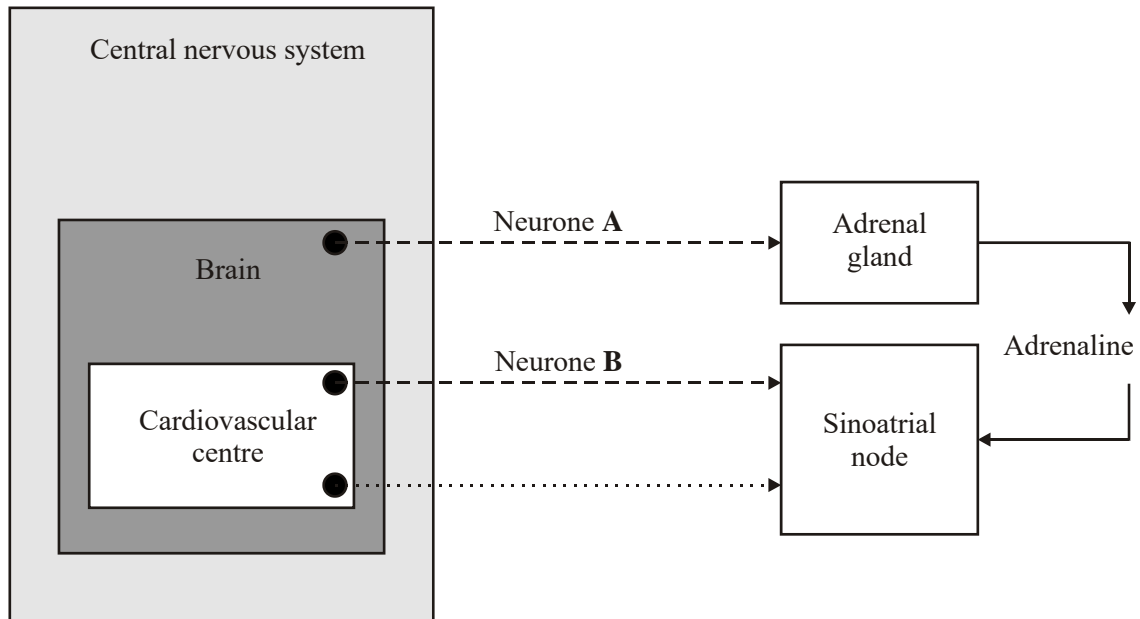
(ii) an image formed at **X** is perceived in more detail than an image formed at **Z**.

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(2)

(Total 3 marks)

8. The diagram shows the control of the heart rate by the autonomic nervous system.



Key:

● - - - - -> Sympathetic neurone

● ······> Parasympathetic neurone

(a) In which part of the brain is the cardiovascular centre located?

.....

(1)

(b) What would be the effect on heart rate of stimulating

neurone **A**; .....

neurone **B**? .....

(1)



- S (c) Describe how an impulse reaches the base of the ventricles of the heart from the sinoatrial node.

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(3)

(Total 5 marks)

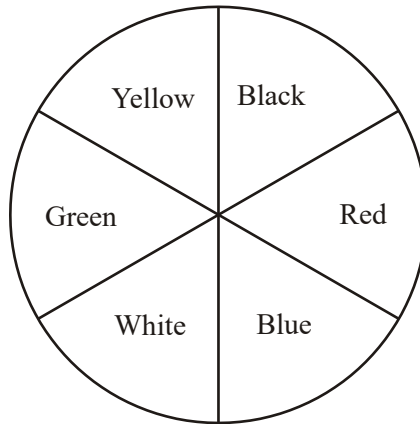
9. *Write an essay on the following topic. You should select and use information from different parts of the specification. Credit will be given for the biological content. It will also be given for the selection and use of relevant information, and for the organisation and presentation of the essay.*

Inorganic ions include those of sodium, phosphorus and hydrogen.

Describe how these and other inorganic ions are used in living organisms.

(Total 25 marks)

10. S In an investigation by a student into the responses of maggots, the bottom of a large box was marked with six coloured segments, as shown in the diagram.



30 maggots were placed on each segment in the box. A transparent cover was put on the box and light bulbs were positioned so that the segments were evenly illuminated. The positions of the maggots were recorded after one hour. The intensity of the light reflected by each segment was measured.

The experiment was repeated three more times. The total number of maggots in each segment from the four experiments is shown in the table.

Colour of segment	Intensity of reflected light / arbitrary units	Total number of maggots
Black	4	154
Red	25	229
Blue	10	178
White	44	47
Green	25	48
Yellow	40	64

- (a) Give **one** conclusion about the responses of maggots which is supported by these results.

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Give the evidence from the table for your conclusion.

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- (b) The chi-squared test was used to analyse the data. For the results obtained, suggest **one** null hypothesis which might be analysed by a chi-squared test.

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(1)

- (c) It was suggested that the movement of the maggots might have been influenced by the Earth's magnetic field. Suggest **one** simple way of repeating the investigation which would avoid this possibility.

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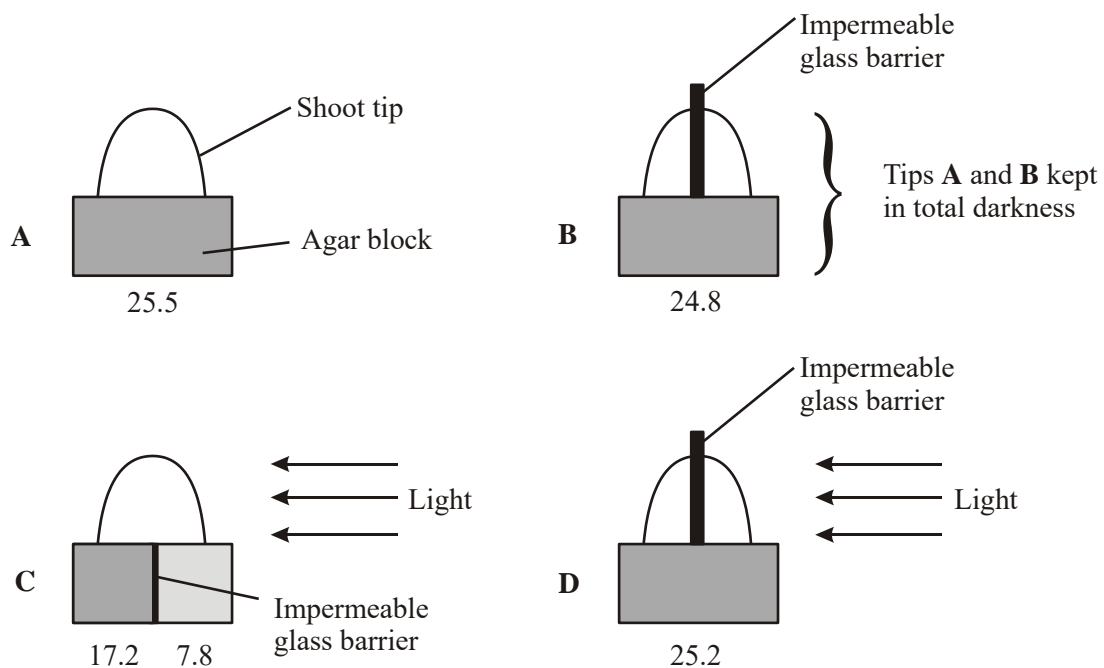
(1)

(Total 4 marks)

11. IAA is a substance that affects the growth of plants. It is produced in the tips of shoots and moves downwards in the stem to the rest of the plant. A series of experiments was performed to investigate the effect of the IAA on the growth of cucumber seedlings.

- (a) **Figure 1** shows the results of an investigation into the effect of unidirectional light on IAA.

**Figure 1**



- (i) Give **one** reason for the use of the impermeable glass barriers.

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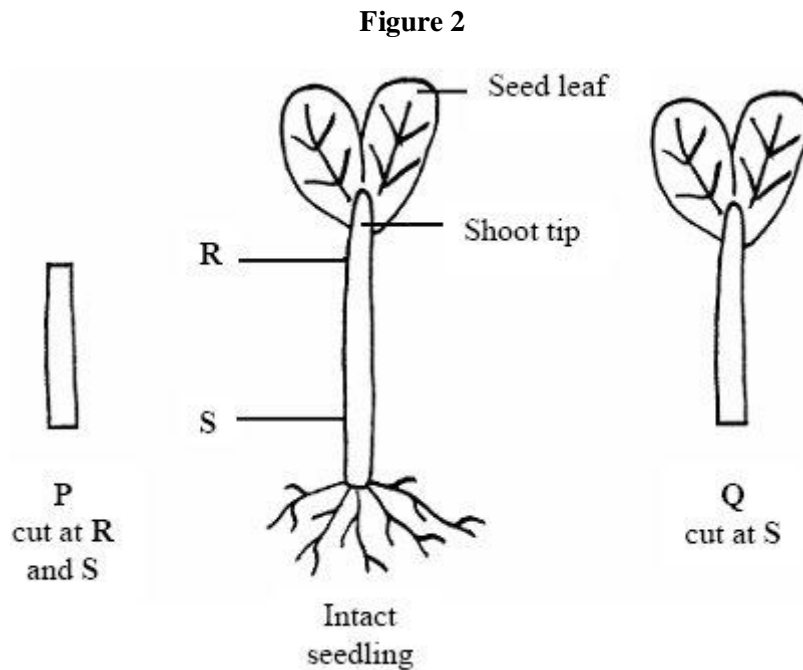
(1)

- (ii) What do the results of this experiment show about the effect of unilateral light on IAA? Use evidence from **Figure 1** to support your answer.

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(3)

- (b) **Figure 2** shows the ways in which two groups of cucumber seedlings were cut before being used in a second investigation



The two types of cut seedlings, **P** and **Q**, were grown in different growth media over a four-hour period. The table shows the results.

Group of cut seedlings used	Growth medium	Mean increase in length/mm	
		Grown in the dark	Grown in blue light
<b>P</b>	1% sucrose solution	1.2	0.8
<b>P</b>	Solution of 1% sucrose and $6 \text{ mg dm}^{-3}$ IAA	3.9	5.2
<b>Q</b>	1% sucrose solution	4.1	3.3
<b>Q</b>	Solution of 1% sucrose and $6 \text{ mg dm}^{-3}$ IAA	4.9	5.7

- (i) The cut seedlings were grown in sucrose solution, rather than in distilled water. Give **one** reason why.

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(1)

- (ii) When they were both grown in the dark, the two groups of seedlings responded differently to the inclusion of IAA in their growth media. Suggest **one** explanation for this different response.

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(2)

- (iii) Describe the effect of blue light on the growth of seedlings **P** and **Q**.

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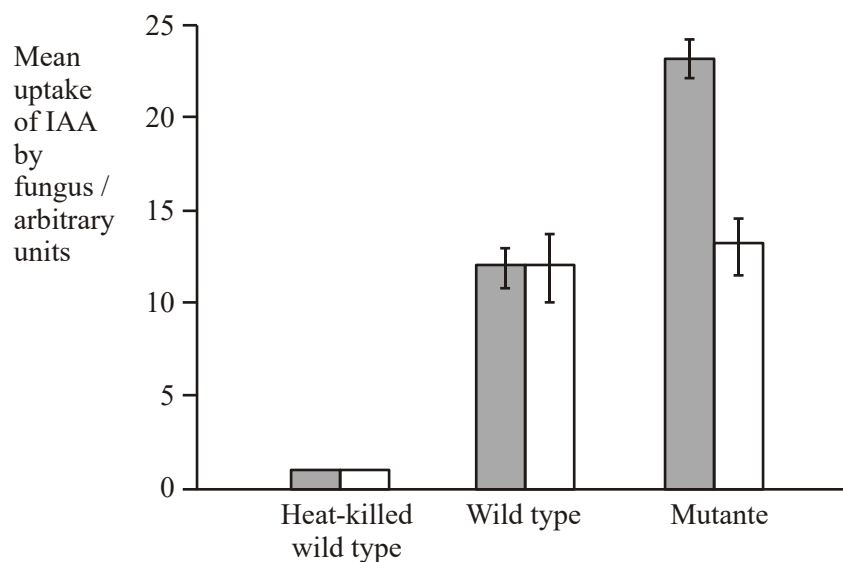
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(3)

- (c) Many fungi are parasites on plants. Uptake of IAA from the host plant affects the ability of these parasitic fungi to invade their plant host.

The uptake of IAA by a particular fungus was investigated. Two phenotypes of the fungus were used, the wild type and a particular mutant.

The bar chart shows the effect of DNP on the uptake of IAA by this fungus. DNP is a drug that affects the gradient of hydrogen ions across mitochondrial membranes.



Key:  Untreated       Treated with DNP       Standard deviation of mean

Using evidence from the information given above and your own knowledge,

(i) explain how IAA is taken up by the cells of this fungus

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(2)

(ii) suggest how the mutation affected the cells of this fungus.

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(3)

**(Total 15 marks)**