1 An investigation was carried out to study the effect of light on the mammalian retina.

Part of the retina of a young rat was removed and kept in the dark for two hours. This allowed the pigment in the rod cells to recover from bleaching caused by exposure to light.

(a) Suggest what happens in the rod cells during this two hours of darkness.

(5)

(b) When the retina had recovered from bleaching, the resting potential of the bipolar neurones in the retina was found to be –43 mV.

The retina was then exposed to a range of light intensities. Each light intensity caused the bipolar neurones to depolarise. The peak voltage of the depolarisation for each light intensity was recorded.

All other variables were kept constant.

The investigation used retinas from an additional 14 rats.

The mean results are shown in the table below.

Light intensity / arbitrary units	**Mean peak voltage of depolarisation / mV**
1	11
3	18
6	19
9	20
12	20

(i) Using the information in the table, describe the effect of light intensity on the mean peak voltage of depolarisation.

(2)

(ii) Suggest an explanation for the effect of light intensity on the mean peak voltage of depolarisation in these neurones.

(4)

(c) Suggest **two** reasons why some people might have objections to the use of rats in this investigation.

(2)

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(Total for Question 1 = 13 marks)

2 Rod cells in the eye are linked to the brain by neurones.

(a) Place a cross in the box ☒ to identify the answer that correctly completes each statement.

(i) The pigment in a rod cell is made of opsin and

(1)

☒ **A** retina

☒ **B** retinal

☒ **C** retine

☒ **D** retinol

(ii) When light stimulates a rod cell the pigment changes.
This pigment is

(1)

☒ **A** iodopsin

☒ **B** phytochrome far red

☒ **C** phytochrome red

☒ **D** rhodopsin

(iii) Once the pigment has changed, the concentration of sodium ions inside the rod cell

(1)

☒ **A** decreases

☒ **B** does not change

☒ **C** increases

☒ **D** reaches equilibrium with the outside of the cell

(iv) After changing, the pigment takes time to become functional again.
This is because

(1)

☒ **A** it has to bleach

☒ **B** the membrane has to be polarised

☒ **C** the rod cell needs to reset

☒ **D** two components have to be rejoined

(v) The cell that links a rod cell to a sensory neurone is

(1)

☒ **A** a bipolar neurone

☒ **B** a multipolar neurone

☒ **C** a unipolar neurone

☒ **D** an optic nerve

(b) Decreasing the intensity of light entering the eye causes pupil dilation. Describe the roles of the circular and radial muscles in pupil dilation.

(2)

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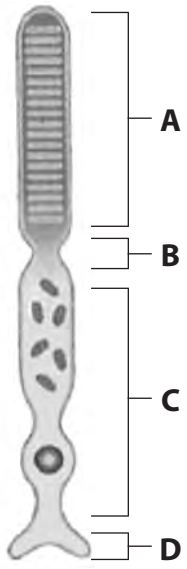
(Total for Question 2 = 7 marks)

3 The retina of the eye is sensitive to light. It contains rod cells.

The diagram below shows a rod cell. Parts of this cell are labelled **A**, **B**, **C** and **D**.



(a) The table below gives three descriptions of parts of the rod cell. Place a cross ☒ in the box to identify the part of the rod cell described.

(3)

Description	Part of the rod cell			
	A	**B**	**C**	**D**
Nearest the pupil of the eye	☒	☒	☒	☒
Containing the photosensitive pigment	☒	☒	☒	☒
Has a pre-synaptic membrane	☒	☒	☒	☒

(b) When light reaches a rod cell the voltage across the cell surface membrane can change. This can lead to the formation of an action potential in an optic neurone.

(i) Describe how light causes a change in the voltage across the cell surface membrane of a rod cell.

(4)

(ii) Suggest why a change in voltage across the cell surface membrane of a rod cell may not lead to the formation of an action potential in an optic neurone.

(2)

(Total for Question 3 = 9 marks)

4 (a) The picture below shows the human eye with the black pupil in the centre.
The pupil can change size to allow either more or less light into the eye.
Its size is controlled by the iris muscles surrounding it.

Magnification ×2

(i) Suggest why the pupil appears black.

(1)

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(ii) There are two sets of iris muscles, the radial muscles and the circular muscles.
They work antagonistically to alter the size of the pupil.

Explain why these two sets of muscles need to be antagonistic.

(3)

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(iii) The pupil increases in diameter in dim light.
Explain how neurones enable this response to occur.

(3)

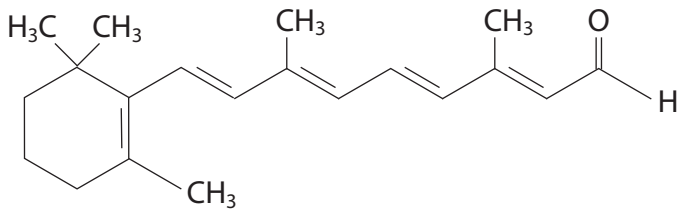
(b) Tropicamide is a drug used in eye drops.
Tropicamide has an effect on the diameter of the pupil in the eye.
This makes it easier for the doctor to examine the retina or lens in the eye of a patient.

Suggest how tropicamide in the eye drops makes it easier to examine the retina.

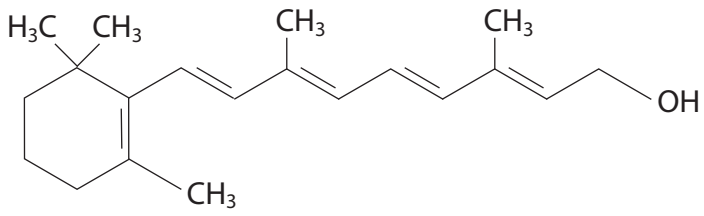
(3)

(c) The diagrams below show the structure of two molecules, retinal and retinol.

Retinal



Retinol



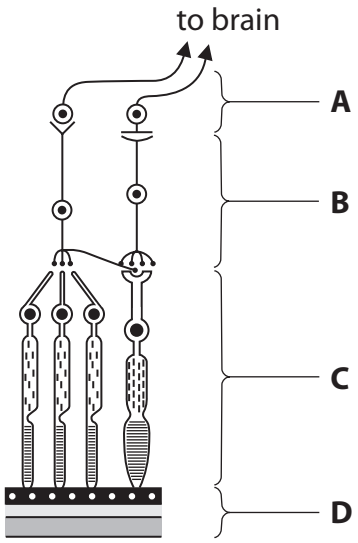
Retinol is the most common form of dietary vitamin A and retinal is part of the structure of rhodopsin.

Suggest how a deficiency of vitamin A would adversely affect a person's vision.

(3)

(Total for Question 4 = 13 marks)

5 The diagram below shows the position of some of the cells in the retina of the eye.



(a) Place a cross in the box ☒ next to the correct letter to complete each of the following statements.

(i) Rod cells are found in the layer labelled

(1)

☒ **A** ☒ **B** ☒ ☒

(ii) The neurones of the optic nerve begin in the layer labelled

(1)

☒ **A** ☒ **B** ☒ ☒

(iii) In this diagram of the retina, the light would pass through from

(1)

☒ **A** bottom to top

☒ **B** left to right

☒ **C** right to left

☒ **D** top to bottom

(b) The macula is the central part of the retina in the eye.
Macular degeneration is a common cause of blindness.

Recent research has shown that macular degeneration in adult mice can be successfully treated. This involves injecting embryonic stem cell-derived photoreceptors into their retinas.

(i) Suggest why this sort of treatment might not restore vision in people with macular problems who have been blind from an early age.

(3)

(ii) Suggest why this type of treatment for blindness in humans could be regarded as controversial.

(2)

(c) A group of scientists proposed to investigate a treatment for people who have been blind from an early age.

This investigation involves kittens having their eyes kept shut immediately after birth. After 12 weeks, their eyes will be opened and stem cells injected into the cerebral hemispheres of their brains.

These kittens will then be raised for two years in a constant environment and the development of their retinas will be compared with a control group.

(i) Suggest why the stem cells will be injected into the cerebral hemispheres.

(2)

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(ii) Suggest why the environment should be kept constant in this investigation.

(2)

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(Total for Question 5 = 12 marks)