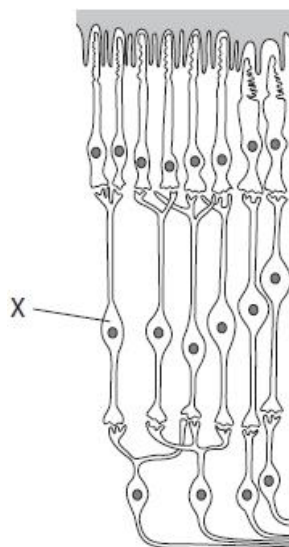


**Questions**

Q1.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross .

The diagram shows a section of a human retina.



Which of the following is the name of the cell labelled X?

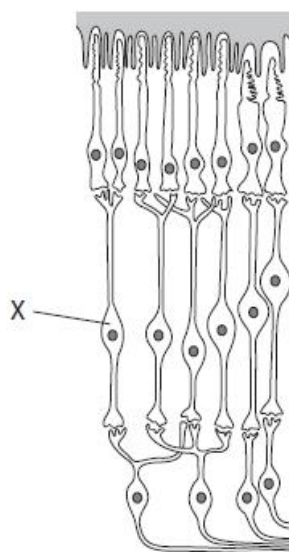
- A bipolar neurone
- B ganglion neurone
- C motor neurone
- D optic neurone

(1)

**(Total for question = 1 mark)**

Q2.

The diagram shows a section of a human retina.



Explain the role of rhodopsin in the generation of a nerve impulse in cell X when light falls on the retina.

(3)

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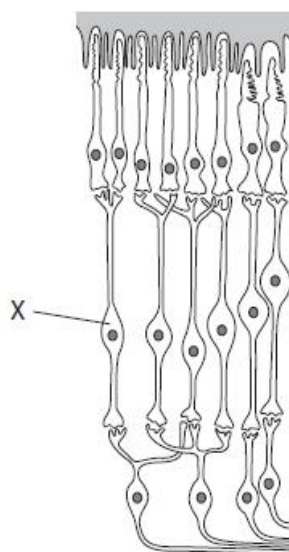
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(Total for question = 3 marks)

Q3.

\* The diagram shows a section of a human retina.

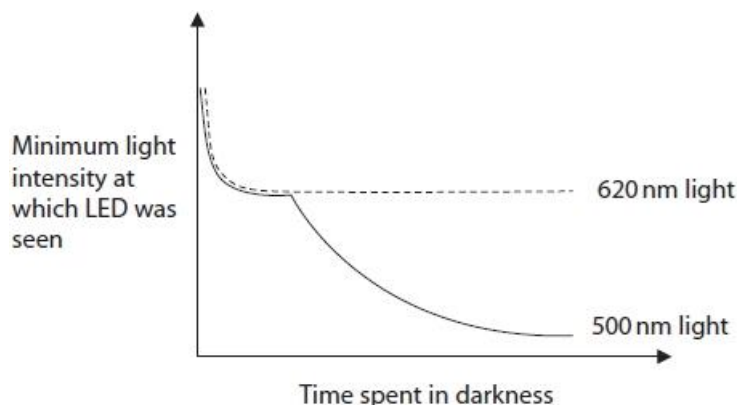


A scientist investigated the effect of how the length of time a volunteer spent in darkness affected the sensitivity of their retina to light.

This is the method used:

- the volunteer sat in a room illuminated with white light for twenty minutes
- the lights were switched off and the room was placed into total darkness for one minute
- an LED emitting light of wavelength 500 nm at low light intensity was switched on
- the light intensity was gradually increased until the volunteer was able to see the LED and this minimum light intensity was recorded
- this was repeated with increasing lengths of time that the volunteer was kept in total darkness
- the investigation was then repeated with an LED that emitted red light with a wavelength of 620 nm.

The graph shows the results of this investigation.





**Q4.**

When a mouse is put in a new environment, it will move around to find a safe place to live. This is called exploratory behaviour.

A student investigated exploratory behaviour by putting a mouse into a large box.

The bottom of the box was marked into squares. There were four corner squares (C), two middle squares (M) and six side squares (S).

The marked bottom of the box is shown in the diagram.

C	S	S	C
S	M	M	S
C	S	S	C

The mouse moved about on the bottom of the box. The square occupied by the mouse was recorded every 10 seconds for 10 minutes.

The table shows the results of this investigation.

Total number of times square occupied by the mouse		
Corner square	Middle square	Side square
42	6	12

The student tested the null hypothesis that mice show no significant preference for corner, middle or side squares.

The mouse uses its eyes when exploring in the box.

Describe the role of rod cells in initiating action potentials to the brain of the mouse.

(5)

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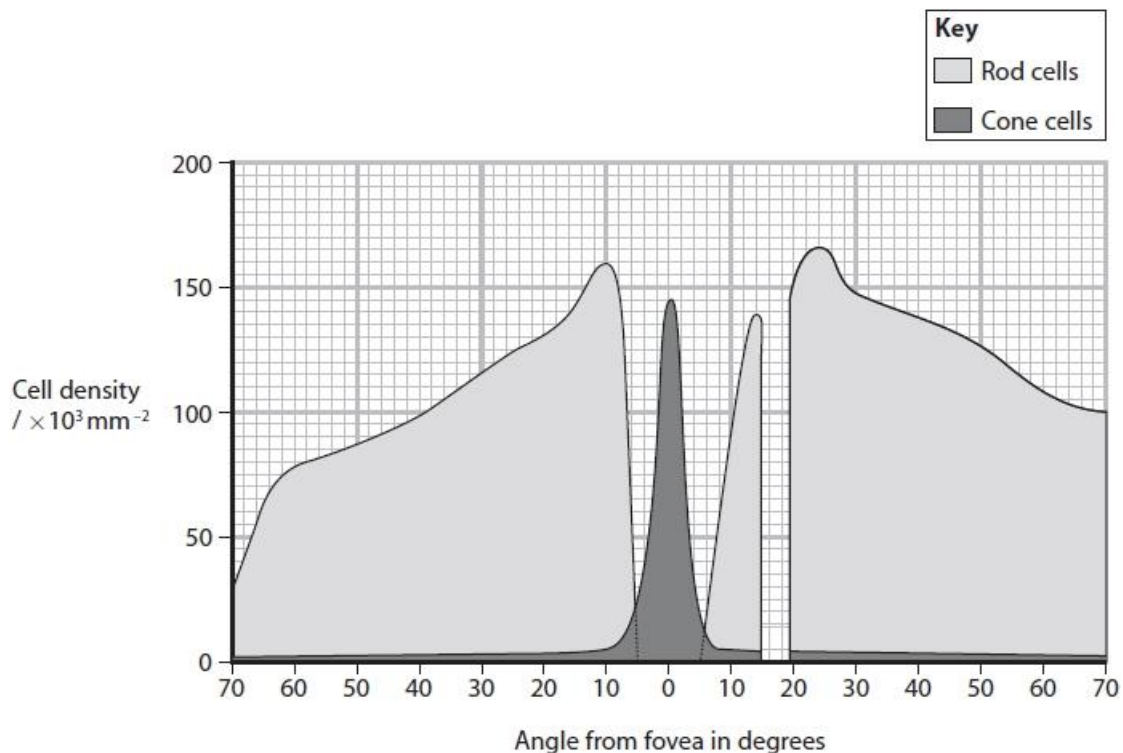
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**(Total for question = 5 marks)**

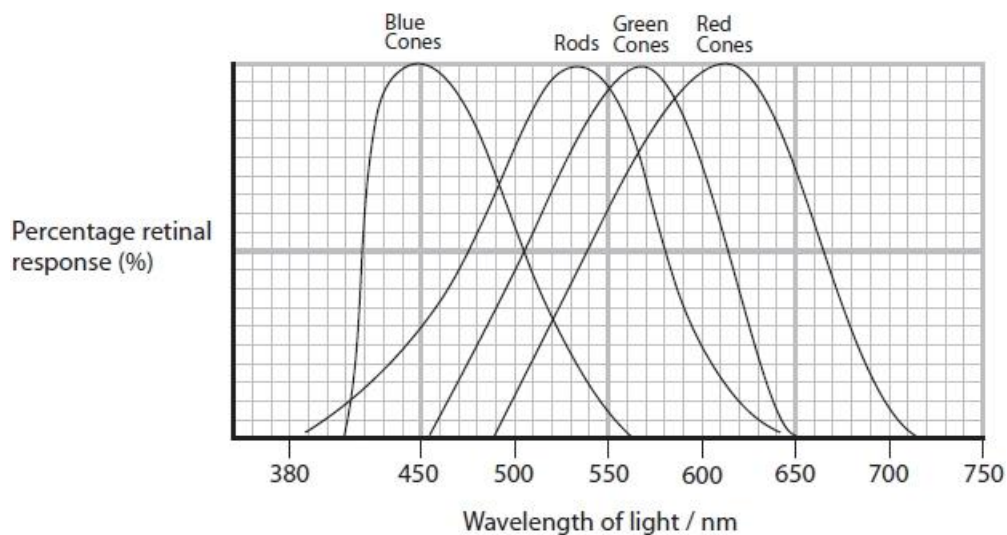
Q5.

\*Graph 1 shows the distribution of photoreceptors across the retina.

Graph 2 shows the sensitivity of rod cells and cone cells to light of different wavelengths.



Graph 1



Graph 2

Students investigated the ability to detect beams of light of different colours and intensities.

A student covered one eye and a bright red light (wavelength 670 nm) was placed at different angles in the field of vision of the other eye. The student stated if they could detect the red light.

This was repeated with a dim red light.

This was then repeated with a bright green light and a dim green light (wavelength 525 nm).

The table shows the results of this investigation.

Angle from fovea in degrees	Light detected (Yes/No)			
	Bright light Red	Dim light Red	Bright light Green	Dim light Green
60	N	N	Y	Y
30	N	N	Y	Y
15	N	N	Y	Y
10	N	N	Y	Y
5	Y	N	Y	N
0	Y	N	Y	N
5	Y	N	Y	N
10	N	N	Y	Y
15	N	N	N	N
30	N	N	Y	Y
60	N	N	Y	Y

Analyse the data to explain the results of this investigation.

(6)

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(Total for question = 6 marks)

**Q6.**

The retina contains rod cells and bipolar neurones.

Rod cells contain large numbers of mitochondria.

Rod cells release glutamate, an inhibitory neurotransmitter.

Describe how light causes a change in the release of glutamate from rod cells.

(4)

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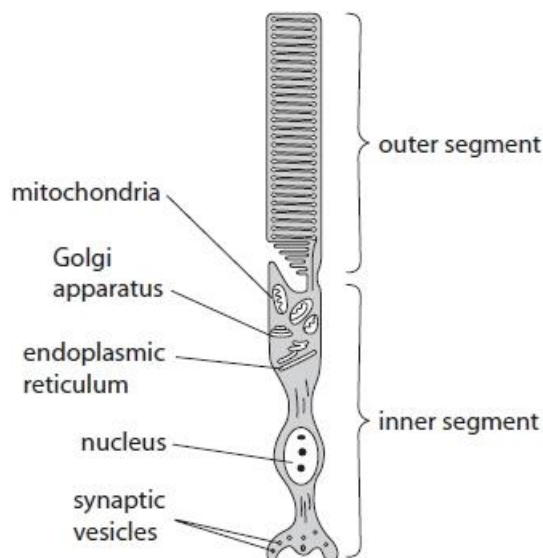
**(Total for question = 4 marks)**



Q7.

Answer the question with a cross in the boxes you think are correct . If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross .

The diagram shows the structure of a rod cell.



(i) How many of the labelled organelles have a double membrane?

(1)

- A** 0  
 **B** 1  
 **C** 2  
 **D** 3

(ii) Which of the following statements about the effect of light on rod cells are correct?

(1)

1. rhodopsin breaks down into opsin and trans-retinal
2. voltage-gated sodium channels open in the membrane
3. more neurotransmitter is released from the presynaptic terminal

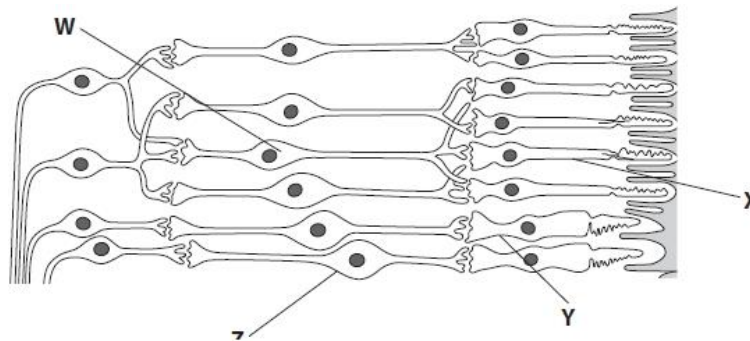
- A** 1 only  
 **B** 1 and 2  
 **C** 1 and 3  
 **D** 2 and 3

**(Total for question = 2 marks)**

**Q8.**

The retina is the light sensitive structure in the eye.

The diagram shows some of the cells in a human retina.



(i) Which row in the table correctly identifies the cells **W**, **X** and **Y**?

(1)

	Cell W	Cell X	Cell Y
<input type="checkbox"/> <b>A</b>	bipolar cell	cone cell	rod cell
<input type="checkbox"/> <b>B</b>	bipolar cell	rod cell	cone cell
<input type="checkbox"/> <b>C</b>	ganglion cell	cone cell	rod cell
<input type="checkbox"/> <b>D</b>	ganglion cell	rod cell	cone cell

(ii) Draw an arrow on the diagram to show the direction of the light passing through the retina.

(1)

(iii) Explain why a higher light intensity is required to produce an action potential in cell **Z** than in cell **W**.

(3)

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**(Total for question = 5 marks)**

**Mark Scheme**

Q1.

Question Number	Answer	Additional Guidance	Mark
	<p>The only correct answer is:  <b>A</b> bipolar neurone</p> <p><i>B is incorrect because ganglion neurones are after bipolar neurones</i>  <i>C is incorrect because motor neurones are not found in the retina</i>  <i>D is incorrect because optic neurone is an incorrect term</i></p>		<b>1 comp</b>

Q2.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to three of the following points:</p> <ul style="list-style-type: none"> <li>• rhodopsin breaks down into opsin and (trans) retinal (1)</li> <li>• causing sodium channels (on the rod cell) to close / to be blocked (1)</li> <li>• leading to the (rod cell) hyperpolarising (1)</li> <li>• so that less { (inhibitory) transmitter / glutamate} is released (1)</li> </ul>	<p><b>Accept</b> cis retinal is converted to trans retinal  <b>Do not accept</b> voltage gated sodium channels  <b>Accept</b> sodium ions stop moving into the cell  <b>Accept</b> blocks cation channels</p> <p><b>Accept</b> membrane becomes more positive outside / more negative inside <b>Accept</b> correct descriptions of hyperpolarising</p>	<b>3 exp</b>

Q3.

Question Number	Indicative Content
*	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <ul style="list-style-type: none"> <li>• spending longer in the dark reduces the minimum intensity at which light is seen / increases sensitivity D</li> <li>• retina is less sensitive to 620 nm light / more sensitive to 500 nm light / D</li> <li>• sensitivity continues to increase over time with 500 nm light / levels off with 620 nm light D</li> <li>• 620 nm light stimulates cones but not rods D</li> <li>• 500 nm light stimulates rod cells and cones D</li> </ul> <ul style="list-style-type: none"> <li>• exposure to light bleaches / breaks down rhodopsin / iodopsin B</li> <li>• trans retinal is converted back to cis retinal in the dark B</li> <li>• rhodopsin / iodopsin is (re)synthesised in the dark B</li> <li>• (cis) retinal binds to opsin (in dark) B</li> <li>• cone cells / iodopsin dark adapt faster than rod cells B</li> <li>• rhodopsin takes longer to be reconverted from opsin and retinal than iodopsin B</li> <li>• rhodopsin is more sensitive than iodopsin B</li> </ul> <ul style="list-style-type: none"> <li>• rod cells are more sensitive / stimulate at lower minimum light R</li> <li>• due to spatial summation / (retinal) convergence of rods R</li> <li>• so that several rod cells are stimulated to overcome a threshold / generate action potential in bipolar cells R</li> <li>• levelling off with 620 nm light shows that cone cells are less sensitive than rod cells R</li> </ul>

Level 0	Marks	No awardable content
Level 1	1-2 (1-3)	<p>An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p> <p><b>1 mark : one point from D, R or B</b></p> <p><b>2 marks : one from D and one from R or B</b></p>
Level 2	3-4 (4-6)	<p>An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.</p> <p><b>D with some of R or B</b></p> <p><b>3 marks: 1D and 2 from R or B OR 2 D and 1 from R or B</b></p> <p><b>4 marks: 2 D and at least 2 from R or B OR 1 D and at least 2 from R or B</b></p>
Level 3	5-6 (7-9)	<p>An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> <p><b>D, B and R</b></p> <p><b>5 marks : at least two descriptions of data and one R and one of B</b></p> <p><b>6 marks : at least two descriptions of data and at least two of R and two of B</b></p>

Q4.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to five of the following:</p> <ul style="list-style-type: none"> <li>• rhodopsin bleached / rhodopsin forms opsin and retinal (1)</li> <li>• closing of sodium (ion) / Na<sup>+</sup> channels (1) / sodium (ion) / Na<sup>+</sup> cannot enter cell / membrane less permeable to sodium (ion) / Na<sup>+</sup> (1)</li> <li>• sodium pump continues (1)</li> <li>• inside more negative / hyperpolarisation / generator potential (1)</li> <li>• release of {neurotransmitter / glutamate} stops (1)</li> <li>• {depolarisation / action potential} in {bipolar cell / ganglion cell / sensory neurone} (1)</li> </ul>	<p><b>DO NOT ACCEPT</b> optic nerve</p>	<p>(5)</p>

Q5.

Question Number	Indicative content
*	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <ul style="list-style-type: none"> <li>• no light is seen at 15 degrees (D)</li> <li>• as there are no rods or cones at the blind spot (D)</li>   <li>• cones are less sensitive than rods / can only detect bright light (R)</li> <li>• because they do not have spatial summation / rods have spatial summation (R)</li> <li>• cones are only found in the fovea / between 5° and 5° (R)</li> <li>• rods are not found in the fovea / between 5° and 5° / found everywhere except fovea / between 5° and 5° (R)</li> <li>• rods are stimulated by green light / 525 nm light (R)</li> <li>• rods are not stimulated by red light / 670 nm light (R)</li>   <li>• dim red light / 670 nm light is not seen at any angle because rods cells are not sensitive to red light / light of 670nm (S)</li> <li>• and cone cells are not sensitive enough (S)</li>   <li>• bright red light / 670 nm light is only seen when on the fovea / between 5° and 5° because red cones are only on the fovea / not found outside the fovea (S)</li> <li>• and rod cells can not detect red light (S)</li> </ul>

	<ul style="list-style-type: none"> <li>• bright green light / 525nm light is seen everywhere apart from the blind spot / 15° because cone cells detect it in the fovea (S)</li> <li>• and rod cells detect green light / 525 nm light away from the fovea (S)</li> <li>• dim green light / 525 nm light is seen at angles greater than 10° because rod cells are sensitive to green light / 525 nm light (S)</li> </ul> <p><b>Level 1: Only description (any 1 or 2 from B or R)</b>  <b>Level 2: Elements of description of data and explanation but not fully linked (any 3 or 4 from B, R or S)</b>  <b>Level 3: Description and explanations and linked well and no major errors (any 5 or 6 from B, R, S)</b></p>	
Level	Marks	
Level	Marks	
0	0	No awardable content
1	1-2	<p>An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p>
2	3-4	<p>An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of all pieces of scientific information.</p> <p>The explanation shows some linkages and lines of scientific reasoning with some structure.</p>
3	5-6	<p>An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of all pieces of scientific information.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p>

Q6.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>• rhodopsin involved (1)</li> <li>• retinal changes from cis to trans form / opsin and retinal formed (1)</li> <li>• {Na<sup>+</sup> / cation} channels close / Na<sup>+</sup> stop diffusing into rod cell (1)</li> <li>• Na<sup>+</sup> still moves out / inside cell becomes more negative / hyperpolarisation (1)</li> <li>• stops {glutamate / neurotransmitter} release (1)</li> </ul>	<p><b>ACCEPT</b> blocks sodium channels</p>	<b>(4)</b>

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>C 2</p> <p><i>A is incorrect as the nucleus and mitochondria have double membranes</i>  <i>B is incorrect as the nucleus and mitochondria have double membranes</i>  <i>D is incorrect as only the nucleus and mitochondria have double membranes</i></p>		<b>1</b>

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A 1 only</p> <p><i>B is incorrect because voltage gated channels will not open when light affects rod cells</i>  <i>C is incorrect because less neurotransmitter is released when light affects rod cells</i>  <i>D is incorrect because less neurotransmitter is released when light affects rod cells</i></p>		<b>1</b>



Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>The only correct answer is <b>B</b> (bipolar cell, rod cell, cone cell)</p> <p><b>A</b> is not correct because X is a rod cell and Y is a cone cell</p> <p><b>C</b> is not correct because W is a bipolar cell, X is a rod cell and Y is a cone cell</p> <p><b>D</b> is not correct because W is a bipolar cell</p>		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	an arrow that is directed from left to right		(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• {many / more / 3} {rods / cell X} connect to {cell W / bipolar cell} / one {cone / cell Y} connects to {cell Z / bipolar cell} (1)</li> <li>• therefore (spatial) summation occurs / retinal convergence / add together several generator potentials (1)</li> <li>• so threshold potential / depolarisation occurs in {cell W / bipolar cell} (1)</li> <li>• rods have more pigment than cones / rhodopsin is very sensitive to light (1)</li> </ul>	<p><b>Accept</b> converse for cones / cell Y</p> <p><b>Accept</b> converse for cell Z</p> <p><b>Accept</b> iodopsin (in cones / cell Y) is less sensitive to light</p>	(3)