

**Done by:**

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## OBJECTIVE SUMMARY - QUICK REVIEW

**● Shape of Rodes & Cones:**

Outer segment “Modified cilia”	Inner segment
<ul style="list-style-type: none"> <li>● Has a disks full of photosensitive pigment <b>(Rhodopsin)</b></li> </ul>	<ul style="list-style-type: none"> <li>● Full of <b>mitochondria</b>, thick in cones.</li> </ul>
<ul style="list-style-type: none"> <li>● In <b>cones</b> is conical, small and contain <b>3 types of rhodopsin</b>.</li> <li>● In <b>rods</b> it is rode, big like and contain <b>one type of rhodopsin</b>.</li> </ul>	<ul style="list-style-type: none"> <li>● Has <b>Na-K pump</b>.</li> </ul>
<ul style="list-style-type: none"> <li>● Has <b>Na channels</b>.</li> </ul>	

**● Cones and Rodes:**

<u>Cones</u>	<u>Rodes</u>
<ul style="list-style-type: none"> <li>● Abundant <b>in &amp; around fovea</b>.</li> <li>● Best for <b>bright light</b> conditions.</li> <li>● See <b>all colors</b>.</li> <li>● The saccules of the cones are formed by <b>infolding of the membrane</b> of the outer segment.</li> <li>● Respond to <b>high levels of light intensity</b> (illumination)</li> <li>● We have <b>10</b> types of cones bipolar cells.</li> </ul>	<ul style="list-style-type: none"> <li>● Abundant <b>in the periphery of the retina</b>.</li> <li>● Best for <b>low light (Dimlight)</b> conditions.</li> <li>● See <b>black/white</b> and shades of gray.</li> <li>● Each rod contains a stack of disk membranes that are <b>flattened membrane-bound</b> intracellular organelles. <b>(Double-membranes discs)</b></li> <li>● Respond to levels of light intensity (illumination) <b>below</b> threshold levels for cones.</li> <li>● We have <b>one</b> type of rod bipolar cell.</li> </ul>
<p>Rodes &amp; cones potentials are graded, local potential <b>(generator potential)</b></p>	

● **Convergence:-**

<u>Low convergence in cones</u>	<u>High convergence of rods</u>
<ul style="list-style-type: none"> <li>Each foveal cone synapse with →one bipolar cell →one ganglion cell →single optic nerve fiber. (One-to-One)</li> </ul>	<ul style="list-style-type: none"> <li>Several rods about 300 synapse with → one bipolar cell →one ganglion cell.</li> </ul>
Value of low convergence	Value of high convergence
<ul style="list-style-type: none"> <li><b>Increases</b> visual acuity → integrated information from <b>small area of retina</b>.</li> </ul>	<ul style="list-style-type: none"> <li><b>Decreases</b> visual acuity → integrated information from <b>large area of retina</b>.</li> </ul>
Disadvantage:	
<ul style="list-style-type: none"> <li><b>Decreases</b> sensitivity to light. → need <b>high threshold</b> of illumination to stimulate cones</li> </ul>	<ul style="list-style-type: none"> <li><b>Increases</b> sensitivity to light. → need <b>low light threshold</b> stimulates the rods.</li> </ul>

● **Photosensitive compound (rhodopsin):**

<b>In Cones:</b>	<b>In Rods:</b>
<ul style="list-style-type: none"> <li>formed of :- (<b>Opsin protein</b>+<b>Retinal</b> (retinene 1=aldehyde form of Vit A)</li> </ul>	<ul style="list-style-type: none"> <li>formed of :- (<b>Scotopsin protein(opsin)</b>+<b>Retinal</b> (retinene 1 = aldehyde form of Vit A) = <b>visual purple</b>.</li> </ul>
<ul style="list-style-type: none"> <li>There are <b>3</b> types of <b>rhodopsin (iodopsine)</b> in cones (<b>photopsine I,II,III</b>)</li> </ul>	<ul style="list-style-type: none"> <li>There is <b>one</b> type of <b>rhodopsin</b> in rods,</li> </ul>

**ELECTROPHYSIOLOGY OF VISION ( PHOTOTRANSDUCTION)**

<b>At Dark ( scotopic vision, Dimlight vision)</b>	<b>Incident light ( PHOTOPIC VISION)</b>
<p>1- Rhodopsin in <b>11-cisretinal</b> (inactive form)</p> <p>2- (5-GMP) → (c-GMP) form</p> <p>3- (<b>c-GMP</b>) → bound to proteins at Na channel → Open.</p> <p>4- <b>Pathway Dark current (Na current):</b> opening of Na channels → allow Na influx → <b>depolarization</b> → increased <b>glutamate</b> → depolarization p. (<b>off-center bipolar cells</b>) → depolarize ganglion cells → AP in optic nerve → vision at dark .</p> <p>6- <b>hyperpolarize</b> → ON- center bipolar cells.</p> <p>7- <b>depolarize</b> → OFF-center bipolar cells</p>	<p>1- <b>Pathway:</b> Rhodopsin 11-cisretinal → <b>all-trans isomer (metarhodopsin II)</b> → (<b>transducin</b>) → <b>phosphodiesterase enzyme</b> → c-GMP to 5- GMP → Decrease c-GMP → closure of Na channel.</p> <p>2- Na pump out of inner segment → Hyperpolarization → decreased <b>glutamate</b> → Generator potential in <b>amakrine cells</b> &amp; ganglion cells (depolarize ) → AP → optic nerve → optic pathway.</p> <p>3- <b>depolarize</b> → ON- center bipolar cells.</p> <p>4- <b>hyperpolarize</b> → OFF-center bipolar cells ( inactive)</p>

● **Synaptic mediators in retina:-**

In Dark:	In Light:
<ul style="list-style-type: none"> <li>● <b>Depolarization</b> of receptors → <b>Increase release of glutamate</b> → depolarize bipolar cell (OFF-center) → generator potential → AP in ganglion cells.</li> </ul>	<ul style="list-style-type: none"> <li>● <b>hyperpolarization</b> of the receptors → <b>decrease glutamate release</b> → hyperpolarize bipolar cells (OFF-center) gradual depolarize (on –center cells), depolarize amacrine cell → generator potential → AP in ganglion cells.</li> </ul>

● **Adaptation:-**

Dark adaptation:	Light adaptation:
<ul style="list-style-type: none"> <li>● From light to dark environment.</li> <li>● Will see about <b>20 min.</b> (Only gross features but no details or colors)</li> <li>● <b>Rhodopsin</b> in darkness is essential for depolarization of rods.</li> </ul>	<ul style="list-style-type: none"> <li>● From dark to light environment.</li> <li>● level of brightness in <b>5 min.</b></li> <li>● Cones start to function.</li> <li>● Rods are knocked out of action.</li> </ul>

● **Dark adaptation has 2 components:-**

Rapid:	Less rapid:
<ul style="list-style-type: none"> <li>● <b>(about 5 minutes)</b> drop in visual threshold.</li> <li>● Fast dark adaptation of <u>cones</u>, only fovea.</li> </ul>	<ul style="list-style-type: none"> <li>● <b>(till 20 min)</b> drop in visual threshold.</li> <li>● Dark adaptation of <u>rods</u> in the peripheral retina.</li> </ul>

● **Three Types of Retinal Ganglion Cells and Their Respective Fields:-**

X-Cell	Y-Cell	W-Cell
<ul style="list-style-type: none"> <li>● Sensitive for <b>detecting directional movement</b> in the field of vision.</li> </ul>	<ul style="list-style-type: none"> <li>● Transmission of the Visual Image and Color → <b>Color Vision.</b></li> </ul>	<ul style="list-style-type: none"> <li>● To <b>Transmit Instantaneous</b> &amp; rapid Changes in the Visual Image, either rapid movement or rapid change in light intensity.</li> </ul>

**Check your understanding!**

1- Which molecules are responsible for rhodopsin regeneration at dark?

2- Less rapid drop in visual threshold (till 20 min) stimulates dark adaptation of:

A	11 cis-Retinal + metarhodopsin II	A	Ganglion cells
B	11 cis-Retinal + scotopsin	B	Bipolar cells
C	All trans-retinal + opsin	C	Rods
D	Metarhodopsin II + all-trans-retinal	D	Cones
<b>3- Nyctalopia is mainly caused by:</b>		<b>4- which type of retinal ganglion cells is sensitive for detecting directional movement in the field of vision?</b>	
A	Vitamin A deficiency	A	W cells
B	Genetic large eye ball	B	X Cells
C	Weak lens system	C	Y Cells
D	Uneven corneal curvature	D	Z Cells
<b>5- At light, hyperpolarization of receptors decreases glutamate release at photoreceptor ends, which leads to:</b>		<b>6- Which of the following is responsible for opening the Na channels in the outer segment ?</b>	
A	hyperpolarizing ON-center bipolar cells	A	c-AMP
B	depolarizing OFF-center bipolar cells	B	5-GMP
C	depolarizing ON-center bipolar cells	C	c-GMP
D	A + B	D	A + C
<b>7- If the convergence of a photoreceptor is low:</b>		<b>8- Which of these cells capable of generating action potential</b>	
A	Increased visual acuity	A	ON Center bipolar cell
B	Increased sensitivity to light	B	OFF Center bipolar cell
C	Decreased visual acuity	C	Rods & Cones
D	Low threshold	D	Ganglion cell
<b>9-What is the active form of Rhodopsin?</b>		<b>10- In the inner segment there is</b>	
A	11-cis-retinal	A	Mitochondria
B	Metarhodopsin II	B	Na channels
C	All trans retinal	C	Na / K pump
D	11-cis-retinol	D	A + C

## Answers :

1- B	2- C	3- A	4- A	5- C	6- C	7-	8- D	9- B	10- D
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