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Vision: Phototransduction in Rods & Cones

Exam — Vision

High school / pre-med / IB questions that teach phototransduction: what light does inside rods and cones, the cGMP pathway, neurotransmitter changes, bleaching, adaptation, and key rod/cone differences.

30 items — Printable Exam

Free & Open-Source

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1 **In complete darkness, which situation best describes a rod photoreceptor?**

A cGMP is low, cGMP-gated channels are closed, the rod is hyperpolarized

B cGMP is high, cGMP-gated channels are open, the rod is relatively depolarized and releases glutamate

C cAMP is high, voltage-gated Na^+ channels open, the rod fires action potentials

D Glutamate release stops completely because rods are inactive in darkness

E The Na^+/K^+ pump reverses direction to generate light

2 **After a photon is absorbed by rhodopsin in a rod, which sequence MOST accurately leads to the electrical response?**

A Light -> cAMP rises -> cAMP-gated channels open -> rod depolarizes -> glutamate release increases

B Light -> 11-cis retinal becomes all-trans -> transducin activates PDE -> cGMP decreases -> cGMP-gated channels close -> rod hyperpolarizes

C Light -> all-trans retinal becomes 11-cis -> transducin is inhibited -> cGMP increases -> channels close -> rod depolarizes

D Light -> voltage-gated Na^+ channels open -> rod fires action potentials to the optic nerve

E Light -> acetylcholine is released from rods -> pupil constricts

3 **In rod phototransduction, phosphodiesterase (PDE) most directly causes which change?**

A Hydrolyzes cGMP, lowering its concentration

B Hydrolyzes ATP to ADP, powering channel closure

C Hydrolyzes glucose into pyruvate

D Converts all-trans retinal back to 11-cis retinal

E Directly opens cGMP-gated channels by adding phosphate groups

4 Compared with darkness, shining light on a rod photoreceptor causes the rod membrane potential to:

A Depolarize because Na^+ channels open

B Hyperpolarize because cGMP-gated cation channels close

C Stay exactly the same because rods cannot change membrane potential

D Generate action potentials at higher frequency

E Depolarize because glutamate binds back to the rod

5 When light hits a rod, what happens to glutamate release from the rod terminal?

A It increases because the rod depolarizes

B It decreases because the rod hyperpolarizes

C It stays constant because neurotransmitter release is unrelated to membrane potential

D It switches from glutamate to acetylcholine

E It becomes zero permanently after the first photon (bleaching destroys synapses)

6 A light spot increases illumination in the center of a receptive field. Which bipolar cell type is designed to depolarize when photoreceptors reduce glutamate release?

A ON bipolar cell

B OFF bipolar cell

C Rod photoreceptor

D Ganglion cell axon

E Ciliary muscle cell

7 In darkness, photoreceptors release more glutamate. Which statement best matches the typical effect on ON vs OFF bipolar cells?

A Both ON and OFF bipolar cells depolarize strongly

B ON bipolar cells tend to be hyperpolarized, while OFF bipolar cells tend to be depolarized

C ON bipolar cells depolarize, OFF bipolar cells hyperpolarize

D Neither ON nor OFF bipolar cells respond to glutamate

E Bipolar cells use rhodopsin and directly detect light without synapses

8 Which statement correctly compares rods and cones in terms of sensitivity and typical function?

A Cones are more sensitive than rods and dominate night vision

B Rods are more sensitive and dominate dim-light vision; cones dominate color and high-acuity vision in bright light

C Rods provide color vision; cones provide only black-and-white vision

D Rods and cones have identical sensitivity and function

E Cones contain rhodopsin; rods contain three photopsins

9 **Where are the light-absorbing photopigments (rhodopsin/photopsins) located within rods and cones?**

A In the nucleus of the photoreceptor

B In mitochondria of the inner segment

C In membranes of the outer segment (discs or folds)

D In the synaptic cleft between rods and bipolar cells

E In the vitreous humor

10 **Rhodopsin can be thought of as which combination?**

A A carbohydrate + a lipid

B Opsin (protein) + retinal (vitamin A-derived molecule)

C Hemoglobin + heme

D DNA + histones

E Transducin + phosphodiesterase

11 **The FIRST chemical change triggered by photon absorption in a rod is typically described as:**

A ATP is converted to cAMP

B 11-cis retinal isomerizes to all-trans retinal

C cGMP rises sharply

D Glutamate is produced by glycolysis

E Voltage-gated Na^+ channels open in the optic nerve

12 **In simple terms, 'bleaching' of visual pigment most accurately refers to:**

A Permanent destruction of photoreceptors after exposure to any light

B A temporary loss of light sensitivity because the pigment has changed form and must be regenerated

C Opening of cGMP-gated channels in bright light

D The pupil becoming smaller

E The optic nerve firing faster because it is 'bleached'

13 **A student walks into a dark cinema after being outside in bright sunlight. It takes minutes for their vision to improve. Which process best explains this time course?**

A The cornea slowly thickens to let in more light

B Regeneration of rod photopigment (rhodopsin) and increasing rod sensitivity (dark adaptation)

C The optic nerve grows new axons

D The retina moves forward to be closer to the lens

E Bipolar cells switch from electrical to chemical synapses

14 **In very bright light, rods often contribute little to vision because rods:**

A Stop containing photopigment after childhood

B Become saturated/bleached and cannot increase their response further, so cones dominate

C Are only located in the optic nerve

D Require vitamin C to work in sunlight

E Only detect green light

15 **Vitamin A is essential for normal vision mainly because it is required to:**

A Make neurotransmitter glutamate in photoreceptors

B Regenerate 11-cis retinal for visual pigments (rhodopsin/photopsins)

C Produce melanin in the iris for pupil constriction

D Increase the number of rods in the retina each day

E Convert oxygen into ATP in the lens

16 **In darkness, cGMP levels in the rod outer segment are kept relatively high mainly because:**

A Phosphodiesterase (PDE) constantly produces cGMP

B Guanylate cyclase synthesizes cGMP from GTP when the phototransduction cascade is inactive

C Transducin hydrolyzes cGMP into GMP

D Light continuously activates rhodopsin even in darkness

E cGMP is stored inside the nucleus and released only at night

17 **Rods use MORE ATP in darkness than in bright light mainly because:**

A Darkness turns on glycolysis, while light turns it off

B The dark current brings Na^+ into the cell, requiring active pumping to maintain ion gradients

C Light forces rods to fire action potentials repeatedly

D In darkness, rods stop releasing neurotransmitter, requiring ATP to restart release

E ATP is only produced in the outer segment when light is present

18 A mutation locks rod cGMP-gated cation channels CLOSED permanently. In complete darkness, the rod would most likely be:

A Depolarized with high glutamate release (like normal darkness)

B Hyperpolarized with low glutamate release (like being exposed to light)

C Unaffected because channels are not involved in phototransduction

D Firing action potentials to compensate for closed channels

E Producing extra rhodopsin to reopen the channels

19 A drug inhibits phosphodiesterase (PDE) in rod outer segments. When light shines on the rods, the most likely result is:

A cGMP will fall more than normal, causing extra hyperpolarization

B cGMP will not fall normally, so cGMP-gated channels stay more open and the light response is reduced

C Rods will depolarize more in response to light than normal

D Rhodopsin will be unable to absorb photons

E Glutamate release will increase in response to light

20 **Transducin is best described as:**

A A voltage-gated Na^+ channel

B A G-protein that becomes active when it binds GTP

C An enzyme that directly converts 11-cis retinal to all-trans retinal

D A neurotransmitter released by rods

E A structural protein that forms the lens

21 **Light adaptation in photoreceptors involves feedback from Ca^{2+}. Which statement is MOST accurate?**

A Light opens cGMP-gated channels, increasing Ca^{2+} entry, which increases sensitivity

B Light closes cGMP-gated channels, lowering Ca^{2+} entry; the fall in Ca^{2+} helps increase cGMP production and partially restores channel opening

C Light has no effect on Ca^{2+} movement in photoreceptors

D Ca^{2+} enters mainly through voltage-gated Ca^{2+} channels in the optic nerve

E Ca^{2+} feedback is only used by cones, never by rods

22 **Cones typically recover faster than rods after bright light exposure. The best explanation is that cones generally:**

A Have no photopigments, so they cannot bleach

B Regenerate photopigment and shut off the transduction cascade faster, allowing quicker return to baseline

C Use hemoglobin to carry oxygen to the retina

D Are located at the optic disc where there is no light detection

E Only function in complete darkness, so bright light does not affect them

23 **Why does the peripheral retina generally detect faint movement better than the fovea in dim light?**

A Peripheral retina has a high density of rods and more convergence, increasing sensitivity at the cost of acuity

B Peripheral retina has more cones and less convergence, increasing sensitivity

C The fovea contains the optic disc and has no photoreceptors

D Peripheral retina receives more light because the pupil is on the side

E Rods are only found in the fovea, where movement is detected

24 **Which statement about electrical signaling is correct for photoreceptors?**

A Rods and cones normally send action potentials directly down the optic nerve

B Rods and cones mainly use graded changes in membrane potential, while ganglion cells generate action potentials

C Only rods use graded potentials; cones fire action potentials

D Photoreceptors cannot change membrane potential; only synapses change

E Bipolar cells are the only cells that detect photons

25 **Which pairing correctly describes the direction of LIGHT travel and the direction of SIGNAL travel in the retina?**

A Light: photoreceptors -> ganglion cells; Signal: ganglion cells -> photoreceptors

B Light: ganglion/bipolar layers -> photoreceptors; Signal: photoreceptors -> bipolar cells -> ganglion cells

C Light and signal both travel: photoreceptors -> optic nerve -> lens

D Light: lens -> optic nerve; Signal: retina -> cornea

E Light never reaches photoreceptors; it is detected by the iris

26 A student stares at a bright RED image for 30 seconds, then looks at a white wall and sees a greenish/cyan afterimage. The best explanation is:

A The pupil stays constricted and blocks red light only

B Red-sensitive cones are temporarily bleached/adapted, so the balance of cone activity shifts toward other cones when viewing white

C Rods suddenly become more sensitive to red

D The optic nerve stops firing for red wavelengths permanently

E White walls emit cyan light after seeing red

27 Two different light sources can look the same 'yellow' even if their wavelengths are not identical (e.g., pure yellow vs red+green mixture). What does this demonstrate about color vision?

A Color is detected by rods only

B Perceived color depends on the relative activation of different cone types, not a single wavelength label

C The lens converts all wavelengths into yellow

D The retina measures wavelength with a single cone type

E Yellow perception requires activation of the optic disc

28 **Why is color vision greatly reduced at night?**

A Cones stop existing at night and regrow during the day

B Rods dominate in dim light and provide little/no color discrimination, while cones require brighter light to be strongly activated

C Rods detect only red and green, not blue

D The pupil becomes too small at night

E The cornea blocks all wavelengths except gray

29 **Phototransduction is highly sensitive partly because it amplifies signals. Which step best represents amplification?**

A One photon directly closes exactly one channel and nothing else

B One activated rhodopsin can activate many transducin molecules, leading to large changes in cGMP and many channels closing

C One photon physically pushes Na^+ out of the cell

D One cone cell divides into many rods when light is dim

E The iris increases sensitivity by generating neurotransmitters

30 **Which statement about the distribution of rods and cones in the retina is correct?**

A The fovea contains mostly rods for night vision

B The optic disc contains many cones for sharp vision

C The fovea is cone-rich for high acuity, while peripheral retina is rod-rich for dim-light sensitivity

D Rods are found only in the optic nerve, not in the retina

E Cones are evenly distributed with the same density everywhere

Answer Key

#	Ans	Answer Text
	B	
2	B	Light -> 11-cis retinal becomes all-trans -> transducin activates PDE ->...
	A	
4	B	Hyperpolarize because cGMP-gated cation channels close
	B	
6	A	ON bipolar cell
	B	
8	B	Rods are more sensitive and dominate dim-light vision; cones dominate co...
	C	
10	B	Opsin (protein) + retinal (vitamin A-derived molecule)
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12	B	A temporary loss of light sensitivity because the pigment has changed fo...
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28	B	Rods dominate in dim light and provide little/no color discrimination, w...
	B	
30	C	The fovea is cone-rich for high acuity, while peripheral retina is rod-r...