Neuroscience BIO-311

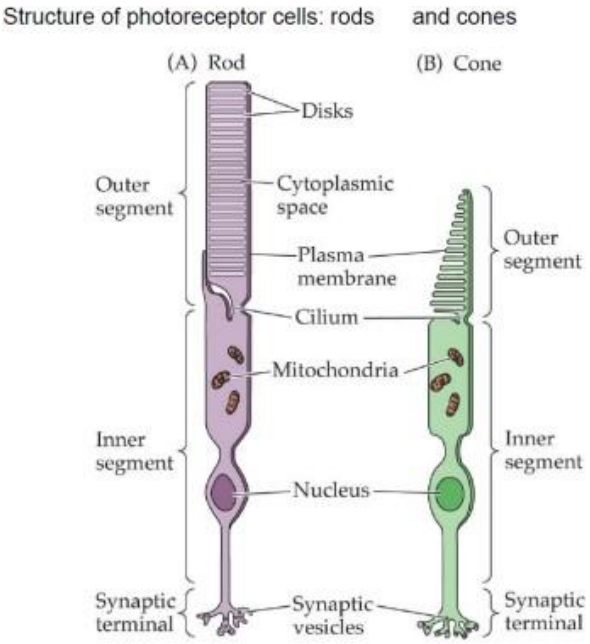
Exercises

Vision – the retina

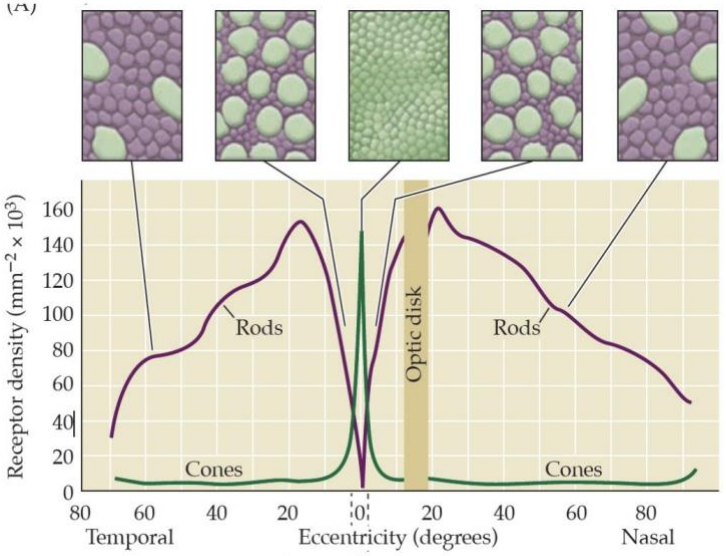
1) Name two types of photoreceptors. What are their primary roles in vision? What do they look like, and where are they found? What is the difference between retinal rhodopsins and ChannelRhodopsins?

Rods: scotopic vision (under low-light conditions) due to their higher sensitivity to light, but fast saturation.
Cones: color vision, high acuity.

retina photoreceptors vs CsChr: both used for light detection. Photoreceptors: used for vision, specific detection of features. CsChr: response to light in general but not specific features. Present outside of the retina, involved e.g. in circadian rhythm.



Purves Fig. 11.5



Rod system:
- Low spatial resolution
- High light sensitivity

Cone system:
- High spatial resolution (high "acuity")
- Lower light sensitive

In the fovea there is a high density of **cones**

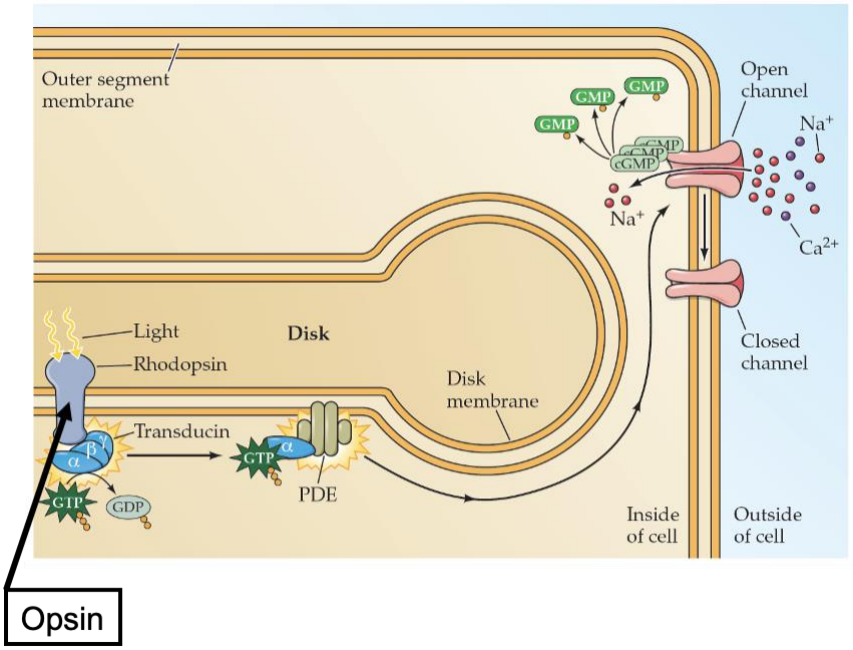
2) Explain the process of <u>primary sensory transduction</u> (conversion of the adequate physical stimulus [here: photons] into an electrical membrane signal in the photoreceptor cell), and where this takes place.

It takes place in the outer segment of photoreceptor cells.
Photoreceptor cells express **cyclic nucleotide-gated channels (CNG ch., non-selective cation channels)** which are constitutively open in the **absence of light**, depolarizing the cell to **~-40mV** and **making them constantly release glutamate**

In the presence of light:

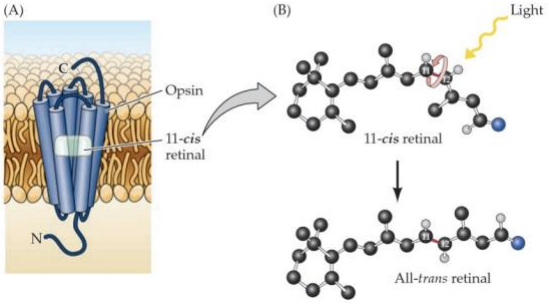
I) Incoming photon is absorbed by **11- cis retinal** (prosthetic group of **rhodopsin)**.
II) 11-cis Retinal undergoes transformational change all-trans retinal.
III)Then, rhodopsin activates **transducin**, a G protein coupled to rhodopsin.
IV) Transducin activates **PDE**(phosphodiesterase)
V) PDE lowers intracellular concentration of **cGMP.**
VI) CNG channels close
VII) Cell membrane is hyperpolarized and glutamate stops being released

(C)



Opsin

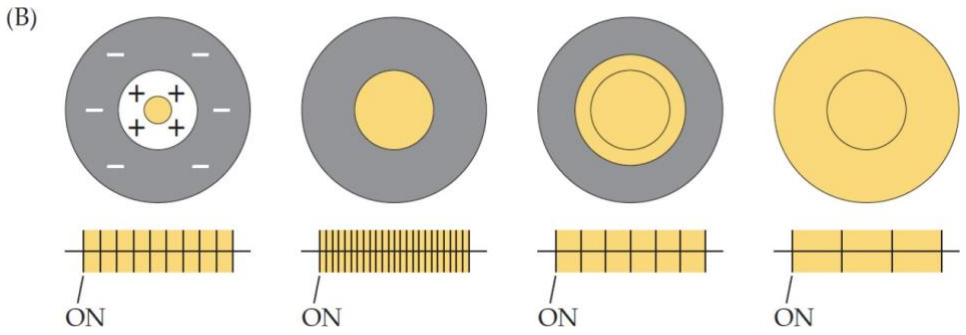
Rhodopsin
(**opsin** & retinal)



- A photon causes 11-*cis* retinal in **rhodopsin** to become all-*trans* retinal
- This leads to a conformational change in the Opsin

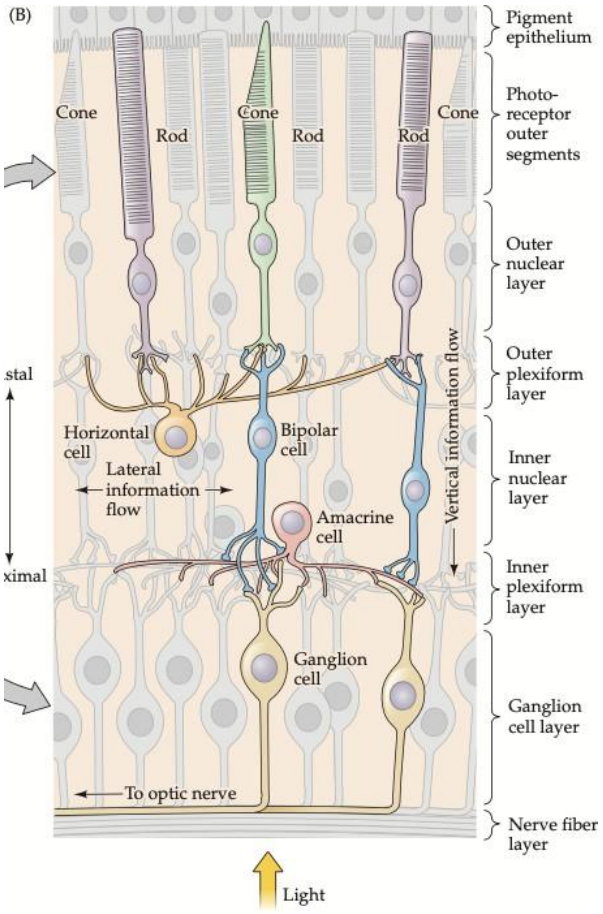
Opsin: group of 7-Helix receptors or GPCRs

3) Draw the receptive field of an ON-ganglion cell in the retina. Remember how a "receptive field" of a sensory neuron in the somatosensory system looks like (Unit 4). Now state the general definition of "receptive field of a sensory neuron".



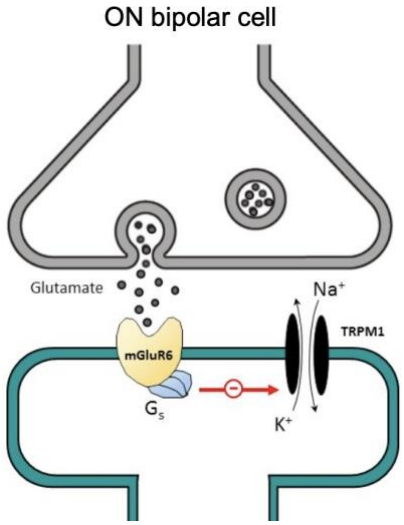
ii) The receptive field is a portion of the sensory space that can elicit the response of a sensory neuron, when there is a sensory stimulus in that portion of the sensory space.

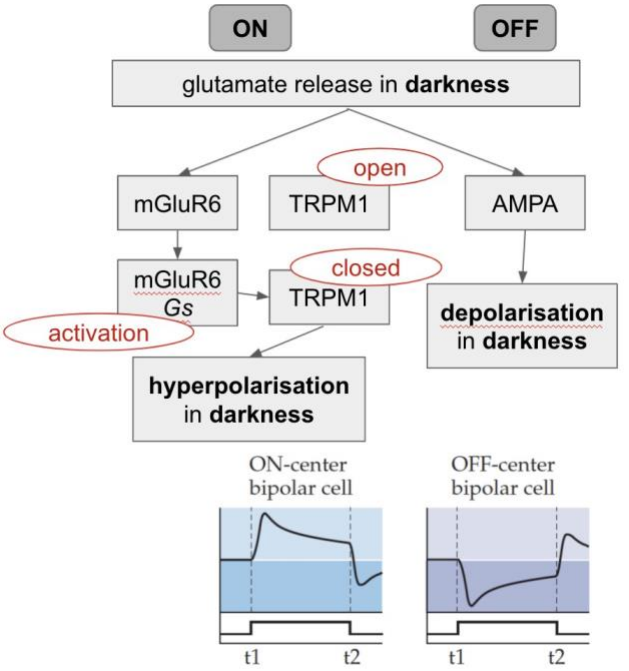
4) Name 5 basic classes of neurons in the retina. Which type of neurons in the retina is capable of firing an action potential?



ii) Amacrine and ganglion cells

5) Explain the difference between an ON- and an OFF-bipolar cell. Why does the ON bipolar cell depolarize with light, whereas the OFF bipolar cell hyperpolarizes with light?





6) Explain in a drawing how the retinal circuit (ON- and OFF- system with horizontal cells) enhances contrast.

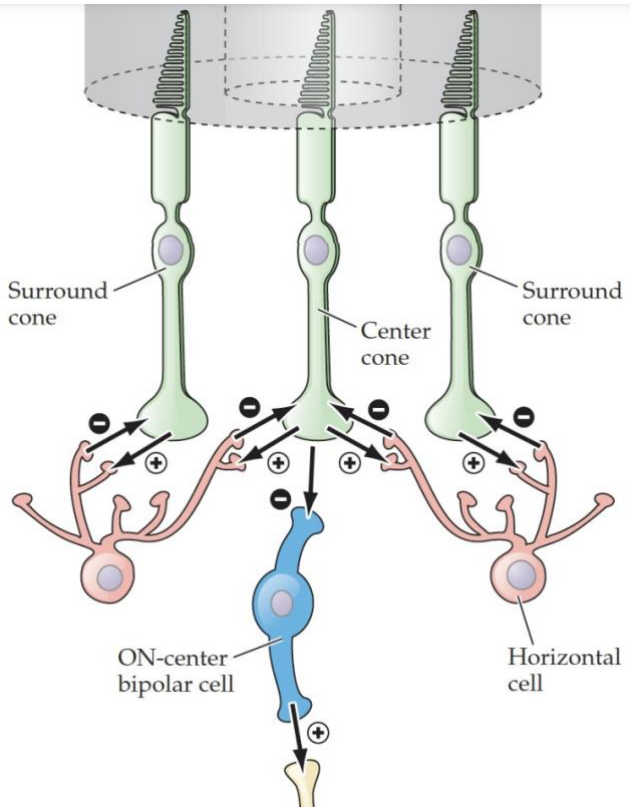
Horizontal cells:

a) GABAergic -> hyperpolarisation
b) Since photoreceptors react through hyperpolarisation, horizontal cells **amplify** the signals normally

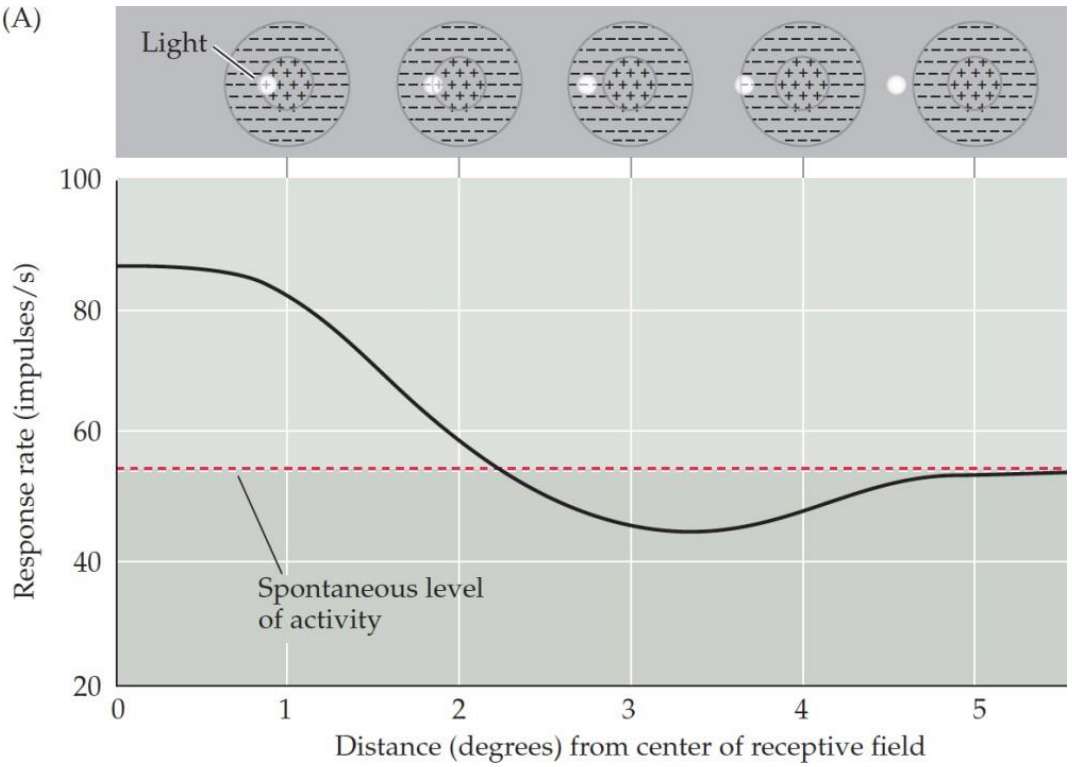
When there is a large spot:

c) hyperpolarisation of photoreceptors
d) hyperpolarisation of horizontal cells
e) reduced GABA release
f) **reduced** sensitivity

Consequence: amplification of the response only when few photoreceptors are active, hence higher response when there is a large contrast.



7) Based on what you have learned about the retina, propose a mechanism through which the visual system can detect the edge of an object. You can make a drawing.



Sensitivity to contrast combined with receptive field → when an object is presented only the cells with fields on the edges respond strongly allowing for edge detection.