Assignment 1

- Please show your work. I am more interested in how you are thinking rather than the final answer. Don't just write the answer. Explain, Explain, Explain.
- Submit before class on 23rd.

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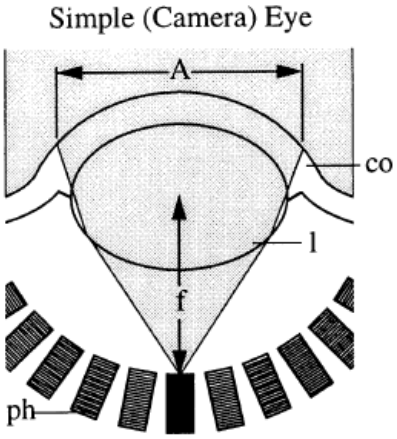
1. Human eyes can resolve at a spatial frequency of 4175/rad (wow! We are good). When you go to an ophthalmologist to get an eye exam, you look at letters 20 feet away. What is the minimum spacing between lines that one can resolve if the lines are 20 feet away? (2)

2. This eye has an aperture A = 3 mm and f = 4.2 mm. The diameter of the photoreceptor is 10 microns and the photoreceptors are closely packed.



a. What is the theoretical resolution of this eye? (2)

b. What is the diffraction limit for this eye? If you get a different answer for the theoretical resolution than the diffraction, explain the possible reasons for the discrepancy? (2)

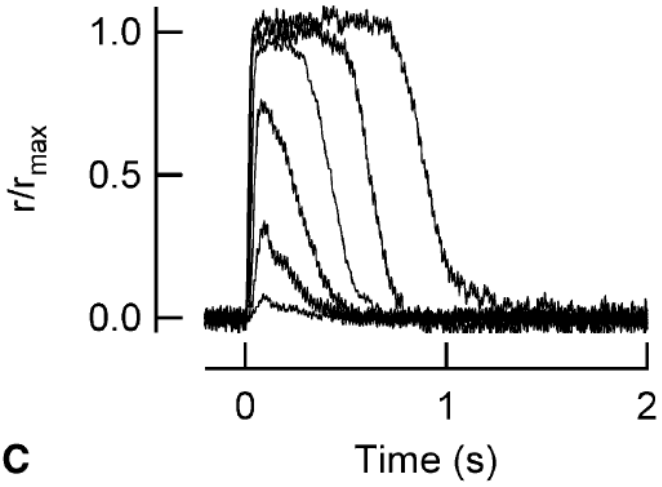
c. The Modulation transfer function for this eye: MTF (f) = $\exp[-24f^2]$. What is the cut-off spatial frequency for this eye? (2)

d. Under a given light condition, there is N photons absorbed by the photoreceptors if the photoreceptors were receiving light from a white paper. What would be the cut-off frequency under these lighting conditions when this eye is looking at a scene with contrast =1. (2)

3. a. Which of the following is/are true for rod phototransduction? (1)

a) The membrane potential decreases in response to light.
b) The concentration of calcium ions increases in response light.
c) The concentration of cGMP decreases in response to light.
d) The concentration of cAMP decreases in response to light.

b. The traces below show the response of a rod photoreceptor to flashes to light. Brief (20 millisecond) flashes of light of increasing intensity produce increasing responses. R_{max} is the maximum response. The traces shown here are normalized to that maximum response. Answer the following questions.



(i) What is the membrane potential of the rods at rest (i.e. in dark or before 0 seconds in this trace)? Briefly, explain your answer. (4)

(ii) Why does it take the response ~100 milliseconds to reach its peak when the flash is only 20 milliseconds long? (2)

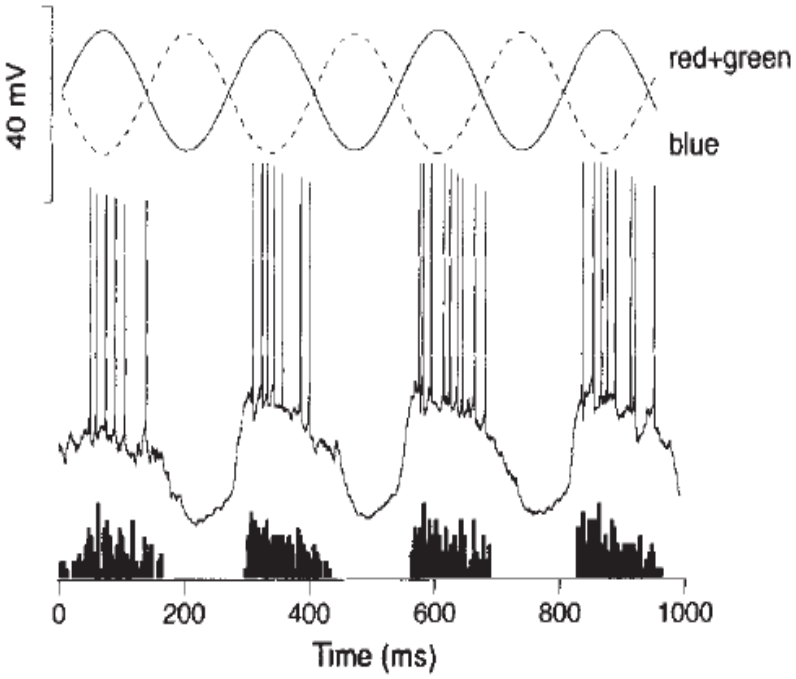
(iii) You can see from the figure that as one increases the light level, the response does not increase. It saturates. Why does it saturate? As one increases the light level beyond the intensity needed to saturate the rods, the response stays

saturated for longer. Why does the response stay saturated for longer? (3)

(4) (a) What is the receptive field of a photoreceptor? (1)

(b) RGC has a center-surround receptive field. What is a center-surround receptive field? (4)

(c) The figure below shows an example of a recording from primate retina. Answer the following questions about the recording below. (i) Just by looking at the recording, you can make a pretty firm conclusion about the cell type being recorded. Make the conclusion and explain why? (ii). Based on the recording below, please draw/describe the receptive field of this cell. (5)



Please read the paper: https://www.pnas.org/content/109/36/E2391. It is also in the assignment folder. We will discuss this paper in the class. Please pay particular attention to the figures and make sure you understand the figures well enough to describe it. (20)