Visual Perception

Lecture 1 Questions

Find and download the following article:

Nilsson, D.-E. and Pelger, S. (1994). A pessimistic estimate of the time required for an eye to evolve. *Proceedings of the Royal Society of London B: Biological Sciences*, Vol. 256, No. 1345, pp. 53—58.

(Hint: Use aub.aau.dk, click on E-tidsskrifter, click on e-JournalFinder, then search for the journal.)

Read the article and answer the following questions.

1. Why is it difficult to estimate the number of generations required to evolve complete organs and complex structures?
2. How do Nilsson and Pelger avoid the problem of explaining how the photoreceptors evolved?
3. What did Nilsson and Pelger use as a fitness function? That is, what value must increase on each evolutionary generation?
4. In what way was Nilsson and Pelger's model "pessimistic"?
5. How many generations did their model require in order to evolve a focused lens eye?
6. What are the two ways in which spatial resolution can be gradually introduced?
7. Which of these two ways of increasing spatial resolution leads to the greatest benefit in the early stages of evolving an eye from a flat patch of light-sensitive cells?
8. What is "photon noise" and how and why does this change as the aperture constricts?
9. What is "posterior nodal distance"?
10. In a lensless eye, how is a distant light source imaged on the retina?
11. Do biological lenses typically have the same refractive index throughout their structure?
12. What are the advantages of a graded-index lens such as that in fish and cephalopods?
13. If an animal lives in a very dark environment, would you expect its eye aperture (pupil) to be large or small relative to the size of its eye? (Use Figure 1 (b).)
14. Explain how a lens might evolve from a lensless eye.
15. What is Mattiessen's ratio and speculate as to why it is commonly observed in biological eyes.
16. In Nilsson and Pelger's model, at what point does the lens start moving towards the centre of curvature of the retina?
17. In what sense is the determination of a 1% phenotypic change subjective?
18. How is refractive index increased in Nilsson and Pelger's model?
19. In Figure 3, how do Nilsson and Pelger measure optical performance? In a large eye used in high illumination, will the number of image points in the last stage of evolution be higher or lower than that shown in Figure 3?

20. How many 1% steps are required for the entire model sequence? In nature, would one expect each of these steps to happen one after the other? Taking this into consideration, would you expect the process to be quicker or slower in nature?
21. What quantities do Nilsson and Pelger have to assume values for in order to estimate the percentage change per generation? What is the estimated percentage change per generation that they end up with? How many generations does it take for a lens eye to evolve according to Nilsson and Pelger's model?
22. Explain Nilsson and Pelger's argument for why the evolution of a lens with an ideal distribution of refractive index is not miraculous.
23. Explain why the model's failure to account for an adjustable iris, ciliary muscles etc. is not a weakness.
24. If a lens eye can evolve so quickly, why don't all animals have lens eyes?