Light, Imaging, Vision: An interdisciplinary undergraduate course

Philip C Nelson[1]

***Short Abstract* — I'll describe an undergraduate course, for students in several science and engineering majors, that takes students from the rudiments of probability theory to the quantum character of light, including modern experimental methods like fluorescence imaging and Förster resonance energy transfer. After a digression into color vision, the course closes with the remarkable signaling cascade in our photoreceptors, and a glimpse of further processing beyond the first synapse. Course materials are available upon request.**

THE vertebrate eye is fantastically versatile instrument. Using eyes as a common thread helps motivate undergraduates to learn a lot of physics, both fundamental and applied to scientific imaging and neuroscience. I'll describe an undergraduate course, for students in several science and engineering majors who have taken one year of introductory physics and math. The course takes students from the rudiments of probability theory to the quantum character of light, including modern experimental methods like fluorescence imaging and Förster resonance energy transfer. After a digression into color vision, we then see how the Feynman principle explains the apparently wavelike phenomena associated to light, including applications like diffraction, subdiffraction imaging, total internal reflection and TIRF microscopy. Then we see how scientists documented the single-quantum sensitivity of the eye seven decades earlier than "ought" to have been possible, and finally close with the remarkable signaling cascade that delivers such outstanding performance. Course materials are available upon request. They are free-standing, independent of another recent book by the author [1]. Two separate resources are available that help students to acquire needed computer programming skills [2,3].

REFERENCES

[1] Nelson P (2015) *Physical models of living systems.* WH Freeman and Co., New York.

[2] Nelson P and Dodson T (2015) *Student's guide to MATLAB for physical modeling.* Free resource available at: https://github.com/NelsonUpenn/PMLS-MATLAB-Guide.

[3] Kinder JM and Nelson P (2015) *Student's guide to Python for physical modeling*. Princeton University Press, Princeton NJ.

Acknowledgements: This work was funded in part by NSF grants EF--0928048 and DMR--0832802.

[1]Physics and Astronomy, University of Pennsylvania. E-mail: nelson@physics.upenn.edu