Syllabus: Physics of Living Systems

Instructor:	Hunter King	**Email:**	hking@uakron.edu
Time:	M & W 8:45 – 10am	**Place:**	GDYR 217

Course Information

Course Description:
This course provides an introduction to the interdisciplinary study of biological systems through the lens of the physical sciences. It will demonstrate how discovery-driven research between biology and physics can lead to biomimetic insight, even without the directed intent of application-based biomimicry. The content is crudely broken into three modules: The optics module will provide a background in the physical nature of light and demonstrate how the basic principles of ray and wave optics are utilized by organisms for (visual and non-visual) perception as well as communication (eg. luminescence and structural color). The interfaces module will demonstrate how surface tension and van der Waals forces are manipulated for traction, underwater adhesion, and prey capture. The final module will introduce the concept of emergence: how complex, collective properties and behaviors derive from simple elements with simple interactions. We will explore how organisms utilize emergence in geometry and mechanics to achieve their goals: in swarm motion and construction; in metamaterial synthesis; in design of passive mechanisms in biological structures.

Prerequisites: None

Objective: To understand: how light is generated and manipulated; how images are formed and colors generated by structural elements; concepts of surface tension, adhesion; how complex mechanics and dynamics emerge from simple elements; and how evolution of biological systems incorporates these concepts in navigating ecological trade-offs.

Textbook: None required, but content will draw from journal articles and the following books:

- *Animal Eyes*, by Land and Nilsson
- *The Optics of Life - A Biologist's Guide to Light in Nature*, by Sonke Johnson.
- *College Physics*, by Paul Peter Urone
- *Capillarity and Wetting Phenomena*, by P.-G. de Gennes, F. Brochard-Wyart, D. Quere.
- *Materials Science and Engineering: An Introduction*, by William Callister

Topic outline:

Week	Topic
1	Introductions: applied physics and natural selection
	Manipulation of **Light**
2 3	Ray behaviors: refraction, imaging and eye evolution
4 5	Wave behaviors: diffraction, color production and perception
	Manipulation of **Interfaces**
6 7	Capillarity: liquid surfaces and wet contacts
8 9	Long-range forces: friction and dry adhesion
	Emergence in behaviors and materials
10 11	Swarms and grains
12 13	Construction and passive actuation
14	Project presentations

Evaluation and Assessment

Breakdown of final grade:

1. **Reading commentaries** (30%):
   Supplementary reading will be assigned weekly. The material will be discussed out-of-class in teams assigned in-class. Thoughtful commentary on the content (critique, open questions) will be collected from each team and coursely assessed.

2. **Quizzes** (30%):
   Brief in-class assignments will done approximately once a week. Students will be able to discuss the questions, but will individually turn in answers in class. These assignments will be primarily be used to stimulate discussion and aid digestion of lecture material, but will also be evaluated for a grade.

3. **Presentation** (20%):
   Within the first half of the course, teams will be formed for a final research project. Each team will choose a topic of research within the scope of the course, but not explored in the lectures. Each team will present its topic in the form of informal research seminar, and will be evaluated by its effectiveness, clarity, and accessibility.

4. **Final exam** (20%):
   One traditional exam will be given at the end of the semester, which will measure comprehension of concepts and retention of key information from the course.