ENGR 1320: Biologically Inspired Design

Proposed Catalog Description:

Engineers in all fields are increasingly looking to nature for inspiration in the design of structures and processes to solve problems in engineering practice. This course is designed to help students better understand the natural systems and processes that lead to adaptive solutions and to give them a foundation of the application of biomimicry across engineering disciplines. Students will learn how to evaluate biomimetic solutions not only in the context of efficiency or problem solving but also with respect to the ethical implications of their designs; commiserate with their obligations to society and the environment.

Required Materials:

Students will be required to purchase a customized course pack. Additional required readings and materials can be made available via the TTU Library. The required readings for each topic are peer reviewed publications and primarily review articles to allow for accessibility among all the engineering students. I have listed two examples of these below – once further developed, the course would require ~12 readings from the primary literature for the lecture topics and an additional 5 for the Team Design Project.

Examples:

Photonics and structural color

Parry, Ahu & Savin, Thierry. (2016). Recent advances in the biomimicry of structural colours. Chem. Soc. Rev.. 45. 10.1039/C6CS00129G.

Biomimicry, genetic algorithms and decision making in complex adaptive systems

Lee, M. (2017). Decision Making Approaches for Complex Adaptive Systems in Built Environments.

Course Content Schedule & Description:

Theme	Week	Learning Module	Description
Foundations and Definitions	1	What is Biomimicry?	An exploration of the terms and concepts of biomimicry, bio-inspired design, bio hybrids along with a brief historical review.
	2	Evolution and the engineering design process	A review of the mechanisms and process of evolution and natural selection and how it parallels the engineering design process.
	3	Ecological Systems and the Cradle to Cradle paradigm	Introduction to systems ecology and emergent properties and how these ecological foundations are related to the Cradle to Cradle design paradigm.

	4	Structural vs. Process Biomimicry	What is the difference between structural and process biomimicry and what kind of ethical considerations should take place within the design process?
Structural Biomimicry	5	Advances in energetic efficiency	Case studies reviewed will include whale tubercles and wind turbine blades and kingfisher anatomy and the Shinkansan bullet train design.
	6	Phototonics and structural color	Biomimetic applications of structural color in nature including photovoltaic design and situational camouflage.
	7	Micro-surfaces	Case studies reviewed will include biomimetic applications of lotus leaf microstructures and the microstructure of gecko foot pads.
	8	From compound eyes to solar cells, laser sights and drone tracking	A review infinite depth of perception and wide range of visual perception found in insect eyes and the biomimetic development of solar cells, efficient laser sighting and visual acuity of drones.
	9	Biohybrids in medical applications	An introduction to how cell cultures and other cellular propagation techniques are being used in combination with engineered structures to solve biomedical challenges.
Process Biomimicry	10	The importance of context	Discussion of the importance of the individual in human society vs. the disposable nature of the individual in non-human species in nature. An introduction to the ethical questions that should be asked in process biomimetic design.
	11	Autonomous vehicles	A discussion of the paradigm shift between early adoption (biomimicry of human drivers) and late acceptance (biomimicry of other animal movements)
	12	Biomimetic Architecture	An introduction to green architecture and the case study of the East Gate Center in Zimbabwe.
	13	Biomimetic decision making in complex adaptive systems using genetic algorithms.	An introduction to Genetic Algorithms, a computational method that mimics genetic evolutionary paths and is used in problem solving and optimization fields, especially with large data sets.

	14	Biomimicry and Artificial Intelligence applications	How biomimetics are being integrated into artificial decision making, artificial learning and the societal implications of those.
Synthesis and Reflections	15	Team Design Presentations and Reflections	Last week of class – Team Design Project presentations and final reflections.

Assessment:

Method of Assessment	**Percent of Grade**
1. Quizzes over required readings	15%
2. Weekly discussions	10%
3. Weekly homework	15%
4. Team Design Project (TDP)– *Proposal*	10%
5. TDP – *Annotated Bibliography*	20%
6. TDP – *Presentation and Design*	30%

Team Design Project in Biomimicy (Capstone Assignment)

Component	**Description**	**% of Grade**
Proposal	After preliminary research, each student team submits a proposal describing the engineering challenge or problem to be solved. It must be a real-world problem with current implications and consequences.	10
Annotated Bib.	Student teams research biomimetic solutions and after deciding on the best approach, read and complete an annotated bibliography on 5 peer reviewed sources that support the proposed biomimetic design.	20
Project Presentation	Student teams prepare a presentation that accurately explains the structure or process being mimicked, the engineering challenge being addressed and how their chosen biomimetic strategy is a potential solution.	30