**BIO-INSPIRED DESIGN / 3-0-3 BIOS / ME / MSE / BMED / ISYE 4740 / BIOL 8803 / ID 4843**

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Georgia Institute of Technology

Fall 2018 / Tuesday Thursday: 1:25-2:55 Cherry Emerson 204

**Introduction**

The course provides an opportunity for students in Biological Sciences, BioMedical Engineering, Industrial Design, Mechanical Engineering, and Material Sciences Engineering to work with students from the School of Architecture and the School of Industrial Design.

**Course Overview**

This course introduces students to the emerging and exciting field of Biologically Inspired Design (BID) through a scaffolded engagement with biological concepts; different modes and methods of scientific inquiry and design exploration; and current approaches to BID research and practice in engineering, science, design, and art.

Its motivating questions are:

How could science and design engage in a productive dialog?

How could biology inform and inspire design?

How does one translate biological concepts, specimens, and behaviors into  design proposals and engineered artifacts?

**Learning Goals**

*Bio Literacy.* Ability to observe, understand, analyze biological concepts, phenomena, artifacts, and scientific literature: (evolution, homeostasis, physiology, bio-mechanics, bio-materials, sensory systems);

*Design Literacy.* Ability to translate scientific knowledge into compelling design proposals and propositions.

*Interdisciplinary Literacy.* Familiarity with diverse methods, approaches, tools, representations, and data.

**Course Requirements**

All assignments are posted on T-Square. Please review assignments in advance of their due dates and ask any questions.

All assignments are to be uploaded to T-Square. Completed assignments will be discussed and reviewed in class.

All assignments must be completed to receive a passing grade.

**Course Readings and Resources**

All readings and resources for the assignments are uploaded to T-Square.

**Attendance** No unexcused absences. Given the compressed schedule, missing class will affect the quality of the work you produce. Unexcused absences in more than two classes will result in a grade penalty.

**Retention of Work**

Georgia Tech has the right to retain any student project, whether it is for display, accreditation, documentation, or any other educational or legal purpose.

**Grade Scale**

The grade scale for all individual components of the course as well as for completion of the final course grade will be as follows:

Points Grade Description

90-100 A Excellent

80-89 B Good

70-79 C Satisfactory

60-69 D Minimally Passing

0-59 F Failing

There will be no incompletes awarded without appropriate reason nor without a prior meeting, in person, of the student and the instructor.

**Academic Integrity**

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please see *The Georgia Institute of Technology 2012-2013 Catalog* at http://www.catalog.gatech.edu/. Refer specifically to section XVIII entitled “Academic Honor Code” at http://www.catalog.gatech.edu/rules/1.php for the principles, policies, and procedures governing issues of academic integrity.

   

**Student and Instructor Conduct**

All persons in the classroom are expected to behave with courtesy towards others and in a way that does not interfere with the regular conduct of the class. Students are expected to be on time for class. Cell phones are to be turned off when students enter the classroom and should remain off for the duration of class; use of laptop computers will also not typically be permitted.

**Accommodation of Disabilities**

Any student with a disability that may require accommodation should contact ADAPTS (Access Disabled Assistance Program for Tech Students) at (404) 894.2564 or http://www.adapts.gatech.edu/ to make an appointment to discuss his or her special needs and obtain an accommodations letter. He or she should also schedule an appointment to speak with the instructor.

**Nota Bene**

With the exception of grade and attendance policies, parts of this syllabus are subject to change with advance notice, as deemed appropriate by the instructor.

WEEKLY SCHEDULE  
  
Week 1: Aug. 21, 23 [Aug. 24: last day to drop class]

a. Class activity:

Auction to select first organism to study.

Assignment 1: due Aug. 23:

Please find out as much as you can about the organism that you won in the auction. Focus on a particular aspect of great interest to you and try to understand how the organism is able to perform that behavior, what parts of its body it uses to execute the behavior, and why, in the evolutionary sense, is this behavior helpful for its survival. Maximum 2pp uploaded on T square.

Lesson:

Web of science: We will review how to search for relevant biological information.

Syllabus and requirements: review

b. Class activity:  
Present your organism in SBF language [Structure, Behavior, Function: what, how, why].

Assignment 2: due Aug. 28

Octopus article by Hanlon et al: all read

Functional decomposition: Attached is an example of a FD of this paper. Please prepare another one from the same paper with a different approach or structure.

Prepare a FD of own organism and be prepared to present to class.

Submit pdf of article[s] on your organism and the FD on T-Square [Canvas?].

Week 2: Aug. 28, 30  
  
a. Present FD of your organism.

Assgt 3: due Sept 4

Find 3 related organisms: find papers that tell you some evolutionary history or are in the same phylogenetic classification of your organism. This is called phylogenetic relatedness.

Find other organisms who perform similarly: This is called convergent evolution.

Class activity: We will form teams with people from each discipline to learn how to exchange information between disciplines.

b. Invited speaker: Botany:

Kathryn Kolb will talk about the mathematics of growth in plants.

Week 3: Sept 4, 6

a. Evolution: Dr. Marc Weissburg will explain evolution. Please read articles posted on T2.

Class activity: Present your phylogenetic relatedness and convergent evolution research to class using the terminology of Weissburg.

b. Lesson:

Scientific method vs design method

Koans: “contradictory parameters” in biology/ecology (trade-offs) and in design (wicked problems)

Found Object

Weeks 4,5: Sept 11,13,18,20  
  
Readings and found object: due once a week [Sept. 11, 13, 18, 20]

For the next 2 weeks, we will have 4 invited speakers tell us how they came up w their bio inspired design. We will cover 4 key topics in BID: **locomotion, sensing, materials, and physiology**. For each class, there are readings posted on T2 to help you understand the lectures and promote discussion. Please a. read b. find something in nature that performs one of the actions, and c. prepare 3 questions based on your readings according to posted rubric. Submit on Canvas/T2.

Lectures by:

Sept. 11: Physiology: Marc Weissburg. Readings for Weissburg

Sept. 13: Materials: Jason Nadler. Readings for Nadler

Sept. 18: Locomotion: Simon Sponberg. Readings for Sponberg

Sept. 20: Sensing: TBA. Readings on sensing

Week 6: Sept. 25, 27  
a. Our lesson for today will cover:

Gorb chart: links between nature and design

Morphological matrix [MM]: species vs function [links under function].

Class Work Session: Practice MMs, ask questions, share with team.

Assignment: due

PrepareMMs based on the 5 papers read so far

b. Design – Wayne Li: Design Process and Design Thinking: Conversation about what design is vs. what it is as a profession: Design Process across multiple fields.

Week 7: Oct. 2,4  
a.

Lesson: Analogical reasoning. Show photosynthesis vs solar panel FDs. Why is biological system better than engineered system? How to evaluate the quality of your design transfer.  
Assignment due Oct. 4:

Presentation of biological background: summary of selected biological function: what, how, why. [SBF]: submit a concise, informative, precise paragraph describing the function that you thought was cool along with an insightful image. Note that this paragraph and image [show source] may be included as part of a book on bio inspired design where the left hand page will be a photo of the organism with a blurb about its coolest function and the right hand page will be the engineered design or process with a paragraph that describes how it can be improved by the biological mechanisms.

b. Sketching:

Wayne Li will instruct you how to draw your organism for prototyping purposes. Please collect as many images as you can of your organism as a starting point. Continue to practice over fall break.

Assgt: due Oct. 11

Design dossier: Please submit on T2 a dossier that includes the following information:

Selected functions: what is your organism(s), what does it do in an amazing way, why is it important for the survival of the organism?

FD of current tool: what process or product(s) could be improved if the biological mechanism could be translated into the engineered design? Prepare a FD(s) of that engineered product or process.

Submit your FD(s) of the organism(s: phylogenetically related, convergent evolution, champion adaptor) and product or process side by side on T2.

Fall break: Oct. 8,9

Week 8: Oct. 11

a. Prototyping

Assignment: due Oct. 16

Make a low fidelity model. We will talk about prototyping fidelity and the pros/cons of why we want to work this way. Prototyping through out the design process.

Week 9: Oct. 16,18

a. Design projects: How do we start to make a prototype?

Assgt: Due Oct. 18

Initial design: give a presentation about your prototype and submit slide show on T2.

b. 3D printing, laser cutting, scanning, 3D drawings, models, market, practical use, materials, costs, utility, other design tools. These are advance tools to refine your low fidelity model.

Week 10: Oct. 23, 25 [Oct. 27: Last day to withdraw W, change from Letter/Grade to Pass/Fail]

a. Prototype plans: specifically analyse the bio-inspiration (how close to metaphor it is).

Assgt: Due Oct. 25

Initial design presentation: submit for prototype review

b. Prototype plans

Improvements and quantitative analyses, scaling, size

Class activity: Discuss your plans in class.

Assgt: Due Nov. 1

Answer the two Quantitative Assgts [QA].

Week 11: Oct. 30, Nov. 1  
  
a. Prototype demo: why doesn’t it work? Problems with scaling, size, what else? OPEN Prototype Review / Working Sessions. Possible improvements and quantitative analyses.

b. Discuss designs for Prototype 2. Discuss answers to QA 1+2.

Week 12: Nov. 6, 8

a. Present designs for Prototype 3. What was improved? Did it work? Why not?

b. Continue: Open Studio

Week 13: Nov. 13, 15

Open Studio: Independent prototyping

Work in class or with teams to finalize bio inspired design for display.

Week 14: Nov. 20 [Nov. 22-23; THANKSGIVING]

Everyone will give their FINAL presentation on their design process. Time will be allocated to the #teams we have per the time we have [4 class periods]. Most importantly, I want to hear what are the next steps. We will decide which bio inspired designs can be shown in the Stubbins exhibit.

Week 15: Nov. 27, 29

Everyone will give their FINAL presentation on their design process. Time will be allocated to the #teams we have per the time we have [4 class periods]. Most importantly, I want to hear what are the next steps. We will decide which bio inspired designs can be shown in the Stubbins exhibit.

Week 16: Dec. 4 [Dec. 4: Final instructional day]

Attached is a document that includes links to many BID labs around the world.

Review them and report on any one that was of most interest to you.

Tell me what lab it is, what it is doing, why is it important to the field of bio inspired design? Submit a 1-2 page essay on T2. What does Bio-Inspired Design mean to you? What is involved in BID?

*Whiteboard Activity:* Report out most intriguing takes on the BID Landscape. Provisionally characterize / categorize different approaches / methods according to disciplines, institutional contexts;

The range of topics is:

BID landscape: links to lab, etc.

Bio inspired Architecture and product design

Alternatively, we may read a paper by Bryan Norton about the value of Nature and have him guide us on understanding all that must be considered when assigning a value to Nature.

Final design report rubric: Attached please find the rubric for your final paper. Please submit your final paper and designs [prototypes] by Dec. 7. Please be on the lookout for a Stubbins exhibit announcement if we decide we have enough to show. Otherwise, we will teach this class similarly over the next fall semesters until we finally have enough cool stuff of which we are proud. The announcement will be sent out to all students in BID.

Design report rubric: for final prototype:

1)      Appearance: Aesthic / gestalt concerns.

2)      Clarity: How clearly the inspiration of bio metaphor is translated

3)      Craftsmanship: How well made it is

Dec. 6: reading period, no exams

Dec. 6-13: final exams [Final paper and product due Dec. 7]

Dec. 17: Grades due by noon

**BioLogically !nspired Design**

BIOS/ME/MSE/BMED/4740+BIOL8803

ID/ARCH 4843

