**Department of Bioengineering**

**BNG255 Biology for engineers**

**Syllabus Fall 2011 Semester**

**3 credits: SENG 114, MWF 12-12:50**

**Materials posted on mycourses**

Instructors: Paul Calvert Ext: 8355 Textiles Room 214, pcalvert @umassd.edu

Office Hours: MWF 11-12pm

Tracie Ferreira Ext 6537 Textiles Room 212, [tferreira@umassd.edu](mailto:tferreira@umassd.edu)

Office Hours: M-11-12p.m, W-3:30-4:30, Th- 12-1p.m or by appt

Course credit: 3 Contact hours: Lecture 3 hours/week

Course Overview

The aim of this course is to educate all engineers in the principles of biology at the biology/engineering interface. It is widely agreed that biology will be of first importance in the engineering developments of the next 20 years and that understanding biological concepts will provide a framework for engineering that can benefit all biological systems spanning from the environment and our planet, to the humans that populate the planet. The course will illustrate how biological principles can help us transition to a softer form of engineering that functions more effectively with mankind and the environment. Topics for study include evolutionary design, the mechanics of soft systems, biochemical approaches to improve energy sources and waste management, and potential for wider use of sensing systems in engineered structures.

Course-Specific Learning Outcomes

Having successfully completed this course, the student will have a basic understanding of how biology and engineering will come together to improve and sustain our world rather than operating in two separate regimes with limited overlaps. This course compares and contrasts the engineering principles we can see in biological systems with those we use in manufactured systems. It will cover the biological parallels for all forms of engineering: including, among others, mechanical, electrical, computer, systems and materials aspects. The principles learned will be of use in areas such as biomedical engineering, biotechnology, health sciences, environmental engineering and biomimetic engineering. The students will have discernment of biological functions and how organisms at all levels impact the health of our planet and the humans that live here. Starting from energy and materials management in organisms, they will see how to address the challenges in designing cleaner, more efficient systems.

University Studies Learning Outcomes

*Cluster 2B: Science in the Engaged Community-* After completing this course, students will be able to:

1. Analyze and evaluate the use of scientific information in the context of social, economic, environmental or political issues with a particular focus on foreseeing and enabling new appropriate technologies.

2. Apply quantitative scientific knowledge to real-world problems.

3. Effectively communicate scientific information in writing.  Students will engage in the design of a biomimetic "solution" to a current day engineering problem. They will research and analyze their topic, apply concepts provided in the class and design a plan of action. This will require them to identify real-world problems and synthesize the knowledge into a coherent research plan. This will require generating a written report that includes extensive background information on the problem and a well-written plan of action.

Prerequisites

None

Readings

Online notes will be made available after class.

Readings will be made available online and will be drawn from current event topics

*Examples:*

A set of examples can be found under the heading "Neat stuff" at our website:

http://www.bngumassd.org/

These include 3D printing, monoclonal antibodies, altruism, prosthetics, biomimetic materials, evolutionary puzzles and others.

**Example assignments:**

The cluster 2B learning outcomes are assessed throughout the course. Course evaluation will include several quizzes and multiple writing assignments. Several writing assignments are described below and grading rubrics are attached.

Three writing assignments will be assigned to promote investigation into current areas of bioengineering. Learning outcomes #1 and 3 will be assessed through these assignments. Emphasis will be placed on students identifying how each innovation impacts the social, economic, political and in some cases environmental issues of the current day. Furthermore, students will be expected to search scientific literature and cite sources thoroughly and in proper format. Sequential assignments are designed to promote more in depth understanding of topics as the semester progresses.

***1. Early semester assignment:(grading rubric attached)***

Search and read online and complete a review paper with "500" word for each topic listed below: references should be cited

A. Biofilm energy production potential B. Self-repairing systems

These examples address two current issues.

Biofilms are bacterial films that are familiar as dental plaque and many slimy deposits that form wherever there is water. They are of intense scientific interest because they represent a step from independent cells towards a multicellular animals. They are also responsible for many antibiotic-resistant infections such as MRSA that are a major worry. This particular exercise would be directed towards the possibility of exploiting such films but of photosynthetic bacteria to generate biofuel.

Self-repair is an engineering goal aimed at mimicking the healing properties of bone and tissue. Experiments are continuing on mixing resin capsules into concrete so that cracking will cause the capsules to release resin and close the crack. Self-healing bridges would be much safer.

In these and other assignments, there is a technical aspect but there are major economic and social factors also.

***2. Mid semester assignment***

Develop a quantitative assessment on one of the following topics including detailed numbers and a 100 word analysis.

A. The turtle shell as body armor B. The potential for cartilage in mechanical joints

Again two examples. The first addresses our continuing search for lightweight body armor for troops and police. The second addresses the question of "why can't machines be more like animals?". A theme of the course is to encourage students to think about how we might make engineering constructs more like biological animals and plants. Here the emphasis is on providing realistic numbers.

***3. Late semester assignment:***

Search and read online and complete a review paper with "500" word for one topic listed below: references should be cited.

A. Bisphenol A B. Tensegrity: elastic skeletal structures

BisphenolA is the component of can linings and many plastic containers that may be a hormone mimic and affect child development. This brings up many questions related to chemical safety. Nothing can be proved to be safe but harm can only be proved in very few cases. The question then becomes a social one of potential harms and benefits: broken glass vs possible toxicity, for instance.

Tensegrity returns to the biomimetic question. Skeletons are loosely coupled by elastic straps not tightly jointed. Why cannot we engineer in this way? These questions also have an obverse, should we not be making prosthetic limbs or other medical devices on these principles?

**4. Final Assignment (grading rubric attached)**

This assignment is designed to be a synthesis of course concepts and assessment of course learning outcome 2.

Students are expected to develop an action plan for a topic of interest from the course. Provide introductory material outlining the topic. Propose an experiment testing a specific hypothesis you have generated based on your research. Discuss possible outcomes.

**Example: Artificial livers**

Discuss prospects for building a portable oxidative detoxification system for cleanup of natural waters based on the principles of the human liver.

The sequence of these assignments will allow the students to gain experience in critical thinking and identification of current challenges facing society. The assignments will refine their writing skills and prepare them for the more in depth end of term project. The broad scope of these topics and the use of numerous written assignments will support the goals of the University Studies Cluster 2.

**Evaluation** (Approximate Distribution)

Homework 30%

Term research report 25%

Quizzes (2 x 15% ea.) 30% (the two with the lowest score are not counted)

Final Exam 15%

**Attendance and Workload:**

This course will run as a blended course, so some of the teaching will be web-only with 1 hour sessions replacing 1/3rd of the individual lectures. We will try to make sure you have a week advanced notice of which lectures are online but make sure you check the website and e-mail regularly to see which classes are online. The same goes for quizzes.

Students enrolled in MTX255 are expected to attend the in person lectures, occasionally we will take attendance. It is the responsibility of the student to obtain the lecture notes and keep up to date on assignments. You are held responsible for any course changes or assignments made during the lecture period. Lectures will usually involve professorial discussion but can be supplemented by visiting lectures, class demonstrations, videotapes and student participation/discussion involving outside assignments.

**Plagiarism Policy:** All Umass students are expected to maintain high standards of academic integrity and scholarly practice.The University **does not tolerate** academic dishonesty of any variety, whether as a result of failure to understand proper academic integrity or scholarly procedure, or as an act of intentional dishonesty. Please refer to course catalog for detailed guidelines of appropriate behavior. <http://www.umassd.edu/studenthandbook/academicregs/ethicalstandards.cfm>

**Students with Disabilities:** In accordance with University policy, if you have a documented disability and require accommodations to obtain equal access in this course, please meet with the instructor at the beginning of the semester and provide the appropriate paperwork from the Center for Access and Success Office. The necessary paperwork is obtained when you bring proper documentation to the Center for Access and Success Office, which is located in Group I, Room 016; phone: 508-999-8711.

**Sample Course Outline**

Introduction

Online Evolution & Design

Evolution

Early earth

Molecular Genetics

Bacteria

Eukaryotes

Evolutionary genetics & EvoDevo

Viruses, Prions

Gene chips

Bacteria Biofilms

Fungi, Slime molds

Materials overall

Quiz 1

Natural fibers

Toughness

Natural Ceramics

Natural composites

Rubbers & soft composites

online biomech calcs

Skeletal biomechanics readings

Quiz 2

Muscles and actuators

Optimization

Signal transmission in nerves & wires

Chemical synapses

Mechanical sensing

Taste & smell

Energy & Metabolism

Defense and the immune system 1

Cancer

online Self repair

Enzymes 1

Quiz 3

Enzyme kinetics

Kidneys

Enzymes calcs online

Liver

Review

**BNG 255 Grading Rubric**

**Writing Assignment 1. (500 word summary)**

Use of unambiguous meaningful English.

\_\_\_\_\_ no nonsense +20

\_\_\_\_\_ one non-sense sentence +15

\_\_\_\_\_ two or more non-sense sentences +10

Discuss the defects of the present technology and needs for improvement (+10)

Discuss qualitatively how the future technologies being reviewed improve society in the form of health or infrastructure issues (+10)

Discuss semi-quantitatively how the future technologies being reviewed improve society in the form of health or infrastructure issues (+15)

Include discussion regarding the feasibility of the proposed developments (+15)

Evidence for original thought or new associations of concepts (+15)

Proper in text citation of your sources

\_\_\_\_ correctly cited (+5)

\_\_\_\_ no citations (+0)

Properly formatted Reference list provided. You are required to have at least 3 sources and one MUST be an article published in a scientific journal.

\_\_\_\_ 3 references listed correctly (+10)

\_\_\_\_ only 2 sources (+5)

\_\_\_\_ only 1 source and not including an article from a journal ( +0)

**Writing Assignment 2. (Numbers plus 100 word summary)**

Use of proper formatting, units, errors.

\_\_\_\_\_ less than 2 errors +20

\_\_\_\_\_ less than 10 errors +15

\_\_\_\_\_ more than 10 errors +10

Discuss numerically how these innovations could impact the technical problem (+20)

Discuss how a successful deployment of this technology could impact:

\_\_\_\_\_ national or international political issues (+15)

\_\_\_\_\_ safety and welfare (+15)

Discuss a timescale for the development of this technology with critical milestones (+15)

Proper in text citation of your sources

\_\_\_\_ correctly cited (+5)

\_\_\_\_ no citations (+0)

Properly formatted Reference list provided. You are required to have at least 3 sources and one MUST be an article published in a scientific magazine.

\_\_\_\_ 3 references listed correctly (+10)

\_\_\_\_ only 2 sources (+5)

\_\_\_\_ only 1 source and not including an article from a journal ( +0)

**Writing Assignment 3. (500 word summary)**

Use of unambiguous meaningful English.

\_\_\_\_\_ no nonsense +20

\_\_\_\_\_ one non-sense sentence +15

\_\_\_\_\_ two or more non-sense sentences +10

Discuss the defects of the present technology and needs for improvement (+10)

Discuss qualitatively how the future technologies being reviewed improve society in the form of health or lifestyle issues (+10)

Discuss semi-quantitatively how the future technologies being reviewed improve society in the form of health or lifestyle issues (+15)

Include discussion regarding the feasibility of the proposed developments (+15)

Evidence for original thought or new associations of concepts (+15)

Proper in text citation of your sources

\_\_\_\_ correctly cited (+5)

\_\_\_\_ no citations (+0)

Properly formatted Reference list provided. You are required to have at least 3 sources and one MUST be an article published in a scientific journal.

\_\_\_\_ 3 references listed correctly (+10)

\_\_\_\_ only 2 sources (+5)

\_\_\_\_ only 1 source and not including an article from a journal ( +0)

**Final Assignment.**

Use of unambiguous meaningful English.

\_\_\_\_\_ no nonsense +10

\_\_\_\_\_ one non-sense sentence +5

Use of proper numerical formatting, units, errors.

\_\_\_\_\_ less than 2 errors +10

\_\_\_\_\_ less than 10 errors +5

Discuss the defects of the present technology and needs for improvement (+10)

Discuss qualitatively how the future technologies being reviewed improve society in the form of environmental issues (+10)

Discuss quantitatively how the future technologies being reviewed improve society in the form of environmental issues (+15)

Include discussion regarding the feasibility of the proposed developments (+15)

Evidence for original thought or new associations of concepts (+15)

Proper in text citation of your sources

\_\_\_\_ correctly cited (+5)

\_\_\_\_ no citations (+0)

Properly formatted Reference list provided. You are required to have at least 3 sources and one MUST be an article published in a scientific journal.

\_\_\_\_ 3 references listed correctly (+10)

\_\_\_\_ only 2 sources (+5)

\_\_\_\_ only 1 source and not including an article from a journal ( +0)