Course Title: BIOENG 499 – Systems and Synthetic Biology

Instructor: Herbert M Sauro

Credits: 3

Course Description

Spring 2007. This course is designed for seniors and/or graduates who have an interest in bioengineering at the cellular network level. Students will be introduced to the field of synthetic biology and it's applications in systems biology and applied engineering. Emphasis will be placed on understanding the control functions of cellular motifs so that students will, by simple visual inspection of a network structure, be able to make some statements on the network's possible dynamic behavior. In addition, the importance of single cell studies and stochastic behavior will also be emphasized.

Students will register for 3 credits and be expected to attend two 1½ hour classes weekly. Computer based practicals will be held roughly once every two weeks. Assignments will be given once a week and will be expected to take roughly three hours each to complete.

Prerequisites by Topic

Matlab programming or other programming experience, basic mathematics (differential equations and matrix algebra and some numerical analysis), cell and molecular biology. BIOEN 485, though not a prerequisite, provides a good foundation for this course.

Textbooks: None, yet. However, course material will be developed on a dedicated Wiki at

http://www.sys-bio.org/sbwWiki/doku.php?id=uw:bioeng_synthetic_biology_class

Course Objectives

To understand in quantitative terms the basic principles of operation of regulation at the cellular level, including metabolic, signaling and gene networks. To discover how cellular networks can be reengineered, taking examples from the iGEM competitions and applications such as metabolic engineering. To learn how to build computer models of cellular networks with particular emphasis on the correct choice of rate laws. An appreciation that cellular systems are very noisy, particularly bacterial systems and how these can be modeled and studied experimentally. By the end of the course I expect that students will, by simple visual inspection of a network structure, be able to make statements on the network's possible dynamic behavior. This ability is a prerequisite for engineering new networks.

Topics Covered

1) Continuous and stochastic models; 2) Rate laws; 3) Stoichiometric constraints; 4) Control of pathways, general principles; 5) Engineering synthetic networks, population and single cell studies, monitoring network outputs; 6) Complex networks, feedback and feed-forward motifs; 7) Studies on engineered networks; 8) Student contributions (using published articles) with class discussions on applications, research, technologies and ethics

Class Schedule

11am to 12.20 pm Tuesday and Thursday. N140 (Computer room), three hours contact time and three hours assignment time.

Computer Use

Classes will take place in the N140 computer room, students are expected to have access to computer resources outside class. Class practical will use open source software (and Matlab in some cases).

There will be class work every two weeks based on computer simulation work. This will require in some cases programming expertise and in other cases building models using open source modeling tools.

Laboratory Projects: In the first year of operation there will be no laboratory projects, however if continued, there is planned at least one lab projects.

Course Outcomes and Assessment:

At the end of the course I student should be able to design simple networks with desired behaviors. Assessment will include weekly assignments (20%), practical work (20%), student discussion and presentations (35%), term paper (25%).

Relationship of course to Departmental Objectives:

This course fits very well into the Computational and Integrative Bioengineering thrust area, it complements existing courses such as BIOEN 485 by emphasizing the engineering aspects of systems biology, namely synthetic biology. The course requires an interdisciplinary approach, combining areas from molecular biology, mathematics, computer science, engineering and control. In addition to academic and applied topics the course also considers some of the ethic issues surrounding synthetic biology and possible applications both current and future.