MAE279B – Dynamics and feedback in biological and ecological systems (4 units)

Description. Lecture & discussion, four hours; outside study and reading, six hours. The course covers mathematical modeling of biological and ecological systems using deterministic approaches. Derivation of kinetic models for control of gene expression, gene networks, cellular signaling, and viral infections. Nonlinear and linearized analysis of feedback mechanisms leading to oscillations and bistability. Modularity and robustness in interconnected networks in the presence of parameter uncertainty and disturbances. Feedback engineering for setpoint regulation of cellular processes and bioproduction.

Prerequisites:
Familiarity with differential equations. E.g. MA 107 Introduction to Modeling and Analysis of Dynamic Systems, or EE 102 Systems and Signals; MAE171 Dynamic Systems and Control, or equivalent classes.

Motivation: Biological and ecological systems are complex systems that may include a multitude of species interacting via feedback loops; these systems are typically nonlinear, and operate far from equilibrium. This course applies techniques from dynamics and feedback control for the purpose of understanding and engineering biological and ecological networks.

Instructor: Elisa Franco, email: efranco@seas.ucla.edu

Textbook:
Biological Feedback Systems. Domitilla Del Vecchio and Richard Murray. Princeton University Press.
Mathematical Models in Biology. Leah Edelstein-Keshet. SIAM Classics in Applied Mathematics.
Support materials: Research articles will be assigned weekly.

Evaluation

1. Homework	30%
2. Midterm	30%
3. Project	40%

TENTATIVE COURSE SCHEDULE

Week 1	Exponential growth and effects of limitation of resources.
Week 2	Background in molecular biology: cells, DNA, RNA & proteins, viruses. Introduction to genetic engineering and synthetic biology.
Week 3	Population dynamics and compartmental models. Modeling transcription and translation
Week 4	Developing models for gene regulatory networks and signaling pathways
Week 5	Equilibrium analysis and linearization
Week 6	Oscillations and bistability in molecular biology
Week 7	Viruses and modeling infections at multiple scales
Week 8	Sensitivity to uncertain parameters in biology
Week 9	Feedback control in biology and ecology
Week 10	Final project presentations
Finals week	Project papers due