UMBC UGC New Course Request: BIOL 310L: Modeling in the Life Sciences

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COURSE INFORMATION:

course number(s)	BIOL 310L
formal title	Modeling in the Life Sciences
transcript title (≤24 c)	Modeling in Life Sci
prerequisite	BIOL 300L, STAT 350 or MATH 151 or MATH 155
credits	2
max. repeat credits	0
grading method(s)	☒ Reg (A-F) ☒ Audit ☐ Pass-Fail
GFR designation	☐ AH ☐ SS ☐ MS ☐ L ☐ C

PROPOSED CATALOG DESCRIPTION

Humans possess a superior ability to generate new knowledge by creating and manipulating abstract models of the world and by extrapolating from past experiences. This natural ability reaches its full potential when it is enhanced with the tools of experimental design, mathematics, logic, and computer simulation. BIOL 310L will be offered as a practical guide to creating and using models in the context of life sciences laboratory research. It will include classroom lectures, activities and computer applications intended to illustrate and implement the five basic elements of modeling: experimental design, data acquisition, analysis, model formulation, and simulation. Through the course, students will address a minimum of four concrete biological problems by defining key physical quantities to be measured, applying data visualization techniques to uncover trends, drawing statistically valid inferences, formulating algebraic and analytical models, and performing computer simulations.

RATIONALE FOR NEW COURSE

a) **Why is there a need for this course at this time?** Traditional biology lab courses place particular emphasis on experimental design, data collection and visualization, and statistical inference. BIOL 310L will revisit the same topics from a model building perspective, and then focus on the science of formulating models and computer simulations. This course will enhance quantitative and analytical ability beyond the level of a standard laboratory course, giving students a chance to experiment with "what if" scenarios, to formulate and test hypotheses regarding the importance of model parameters, and to experiment with building models of increasing sophistication and complexity.

b) **How often is the course likely to be taught?** Every year. After a trial offering in Spring 2012, it will be offered in the Fall.

c) **How does this course fit in with your department's curriculum** It fits well with new Biological Sciences curriculum emphasis on strengthening quantitative reasoning skills.

d) **What primary student population will the course serve?** The course will serve as an upper level elective mainly for majors in Biological Sciences, and Bioinformatics and Computational Biology.

e) **Explain the appropriateness of the prerequisites**. In order to improve performance in this course, students will benefit from prior knowledge of algebra, statistics and or calculus, as well as basic knowledge of cell biology, genetics, and foundational laboratory skills, all of which they will acquire by completing the prerequisites.

COURSE OUTLINE[1]**:** In a broad sense, a ***model*** is any abstract representation of a physical phenomenon. The human brain is hard-wired to build models of the world from sensory inputs. We share this ability with many other species, but we also possess a superior ability to generate new knowledge by creating and manipulating abstract symbols, and by extrapolating from past experiences. This natural human ability reaches its full potential when it is enhanced with the tools of experimental design, mathematics, logics, and computer simulation. The course will be conceived as ***a practical guide*** to creating and using models in life sciences research, and will include classroom lectures, activities and computer applications intended to illustrate and implement five basic elements of modeling, namely, ***experimental design, data acquisition, analysis, model formulation,*** and ***simulation***. Traditional biology lab courses place particular emphasis on the first three elements: experimental design, data collection and visualization, and statistical inference. The modeling course will revisit these topics from a model building perspective, and then focus on formulation and simulation.
Acquiring scientifically valid data involves designing controlled situations (experiments) to count or measure physical quantities made of numbers and units of measurement, plus an associated data quality control process. Throughout the course, students will be presented with ***four concrete biological problems*** that have been addressed using controlled experiments. Data will be drawn from a variety of sources, such as other BIOL curriculum labs, BIOL499 student/PI research projects, and the published literature. Starting in the Fall semester 2012, this course will also include an experimental module, in which students will perform their own experiments. Practical data analysis will begin by visualizing the data with graphs and tables to uncover trends (potential functional relationships) between the dependent and experimental variables. This phase will also require comparing measurements of the dependent variable(s) that correspond to different values of the experimental variable(s), and making statistical inferences. Trends and inferences will provide insights leading to ***formulating a model*** in the form of a cartoon, a diagram, a mathematical formula or a computer algorithm. All models amount to a series of encoded instructions, which when applied to the experimental variables in series or parallel, reproduce the measured values of the dependent variables. From each data set students will practice formulating all or several model types. ***Simulation*** represents the last step of the modeling process, which nowadays is carried out with fast digital computers. Simulations are virtual experiments that allow scientists to test how sensitive a model is to changes in model parameters or dependent variables. Simulations are also how modelers can extrapolate from observation to prediction. Ultimately, the practical utility of a model is judged by how accurately it can predict new outcomes or reveal new knowledge. The course will stress the idea of modeling as recursion between experimental design and simulation, which refines and extends every element of the model with each repetition.

COURSE CONTENT

Part I. Foundations

a. Designing experiments to measure physical quantities (data)
b. Measurements and mathematical treatment of experimental errors
c. Visualizing trends in the data
d. Drawing statistically valid inferences from experimental data

[1] Text highlighted in italics and boldface type indicates key concepts that the course will focus on

Part II. Types of models commonly used in the life sciences

a. Insights a model can provide, and why biologists use models

b. Cartoons, flow diagrams, mathematical formulas, and computer simulations

Part III. Birth and death (rate) models

a. Continuous- vs. discrete-time birth & death (rate) models

b. Examples: Population growth, and PCR amplification of DNA

c. Mathematical analysis of population growth and PCR

d. Computer simulations

Part IV. Other models

a. Game theory and evolution: hawks and doves

b. Markov chains and diffusions

c. Computer simulations

LEARNING OBJECTIVES: The goals of this course are:

1. to increase skills in designing experimental conditions for data collection, error propagation, data visualization, and quantitative trend analysis
2. to impart skills in building models based on diagrams, algebra, calculus, and simple computer algorithms
3. to increase skills in communicating experimental results in oral and written forms
4. to encourage students to perform "what if" analysis, parameter optimization and data fitting through the use of spreadsheets, and numerical simulation software

ASSESSMENT PLAN: The final grade for the class will be calculated as follows:

25%: Calculations and data processing problems, and computer modeling exercises

25%: Group presentations on modeling approaches and model performance (what-if analysis, parameter optimization, data fitting). Students will be provided with a rubric beforehand to ensure they are familiar with expectations and grading methods

35%: Individual reports/blogs of in-class and off-class activities. Same as above, students will be provided with a rubric

15%: In-class participation during Q&A periods