



Interdisciplinary Curriculum Reform in the Biological Sciences

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Teaching integrative thinking

Course: BSCI 207: Principles of Biology III: Organismal Biology

Development team:
Todd Cooke (CBMG), Jeff Jensen (Biology), Brett Kent (Entomology), Joelle Presson (CLFS)

Goals:

- Integration of physics, chemistry, math, and evolution to help students understand how organisms function
- Help students appreciate that all organisms are faced with challenges framed by common physiochemical principles, and they solve these problems within the context of their unique evolutionary histories. Two overarching themes are emphasized throughout the course:
 - **Playing by the rules:** Fundamental scientific principles cannot be broken but they also offer opportunities for life to exploit, and
 - **You can't escape your past:** Organisms generally don't invent completely new solutions to life's challenges, rather they adapt the hand they have been dealt.

Format:

- Required of all Biological Sciences majors in their sophomore year
- Large lecture format (~250 students per class)
- Team taught by faculty from different CLFS departments

History and future plans:

- Implemented in 2005
- Assessment data indicate that the course is a stumbling block for transfer students; interventions are being developed to increase their success
- We hope to eventually add guided study sessions and/or discussion sections

A major curriculum redesign effort, funded in part by a grant from the Howard Hughes Medical Institute Undergraduate Science Education Program, has brought together teams of faculty, postdoctoral fellows and graduate students to infuse all levels of our undergraduate curriculum with current research approaches and increased emphasis on building interdisciplinary connections. To date, these efforts have involved 68 faculty from seven departments, five postdoctoral fellows, and 28 graduate students and have resulted in revisions to different courses in biology, biochemistry, chemistry, mathematics and physics. Several of these efforts have the explicit goal of infusing more quantitative rigor into courses for biological sciences majors.

Table 1. Participating Colleges and Departments

College of Chemical and Life Sciences (CLFS)
Biology
Cell Biology and Molecular Genetics (CBMG)
Entomology
College of Computer, Math and Physical Sciences
Mathematics
Physics
College of Education
Education, Curriculum and Instruction (EDCI)

MathBench: Infusing math into fundamental biology courses

Mathbench.umd.edu

Courses: Modules are integrated into five freshman and sophomore level biology courses (Principles of Biology I, II & III, Principles of Genetics, General Microbiology)

Development Team:
Karen Nelson and William Fagan (Biology)
Denny Gulick (Mathematics)
James Sniezek (Biology, Montgomery College)

Goals:

- Integrate quantitative approaches and mathematics more deeply into the undergraduate biology curriculum in a way that reinforces biological concepts and increases math literacy
- Build upon students' intuitive understanding to help them explore biological concepts using fairly sophisticated mathematical approaches

Format:

- 28 interactive, web-based modules
- Use humor, references to popular culture and interactive elements to engage students

History and future plans:

- First modules piloted in 2005
- 5-10 new modules have been added each year
- In 2008 we obtained NSF CCLI support to partner with local community college faculty to integrate MathBench into their curriculum
- Intensive assessment efforts underway to measure learning outcomes

Flux (amount/unit area/unit time) $J = -D \frac{\Delta C}{\Delta x}$

Multiply both sides of Fick's equation by the entire area (A)

Flow (total amount/unit time) $J_A = -D \cdot A \cdot \frac{\Delta C}{\Delta x}$

1) Dolphins use frequencies up to 140 kHz in their echolocation. Remembering that dolphins use this in water, what is the associated wavelength?

2) Does being in water help or harm the dolphins' ability to "see" with sound?

3) With an ear separation of about 45 cm, what is the dolphin's resolution angle if they use their ears as an interferometer?

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Physics for Biology Students

Courses: PHYS 121 and 122: Fundamentals of Physics

Development team:
Todd Cooke (CBMG), Joe Redish (Physics)
Arthur LaPorta, Wolfgang Losert, Arpit Upadhyaya, Bill Dorland, Heather Dobbins (Physics)
Karen Carleton, Marco Colombini, Jonathan Simon (Biology)
Spencer Benson (CBMG/EDCI)
Janet Coffey (EDCI)
Doron Levy (Mathematics)

Goals:

- Revise existing introductory physics sequence for bio majors by incorporating the best pedagogical practices from contemporary science education
- Starting with the physical and biological intuitions of the students, teach them how to think about the world from the perspective of a physicist (e.g., equations coordinating with and enriching words)
- Help students understand physical phenomena in the typical physical context (e.g., frictionless vacuum) and be able to apply the same physics to biologically important phenomena in the typical biological context (e.g., fluid media)
- Ultimately, we anticipate that the discussions will lead to improving physics content of upper level biology courses and creation of a new biophysics course

Format:

- Two semester sequence
- Large lecture format (~ 200 students) with accompanying laboratory
- Required of all Biological Sciences majors

History and future plans:

- Builds upon the pedagogical expertise of the University of Maryland Physics Education Research Group (PERG) www.physics.umd.edu/perg/
- Interdepartmental discussion and planning began in Fall 2007; course revision was initiated in Summer 2008

Calculus for Life Sciences

www.math.umd.edu/~dlevy/classes/math130/

Courses: MATH 130 and 131: Calculus for Life Sciences

Development team:
Doron Levy, Denny Gulick, Patrick Shipman, Peter Wolfe, Mike Boyle (Mathematics)
Todd Cooke (CBMG)
Jonathan Simon, Bill Fagan, Elise Larson, Christian Castaldo (Biology)

Goals:

- Better integrate mathematics into the training of Biological Science majors by creating a mathematically rigorous course that focuses on the aspects of calculus and mathematics that are particularly applicable to modern biology (e.g., principles of dynamical systems, computer modeling, probability theory, statistical inference)
- Show the relevance of mathematics to biology by focusing on direct applications to important biological problems

Format:

- Lecture course with two weekly problem-solving sessions
- One problem-solving session each week focuses on the mathematical concepts
- Second problem-solving session focuses on biological applications
- Problem-solving sessions are team taught by graduate teaching assistants from the Department of Mathematics and CLFS

History and future plans:

- First course was piloted in Spring 2008 and will be fully implemented in Fall 2008
- Second course is under development and will be piloted in Fall 2009
- Will become a requirement for Biological Sciences majors beginning in Fall 2009

- Suppose you are interested in how the population size of the annual herb *Phlox paniculata* changes in a meadow in Colorado during one year. You are only sure that the population is closed, meaning that there are no immigrants (individuals entering the population) or emigrants (individuals leaving the population) in or out. In this case, the only processes that affect the growth of the population are births and deaths.
- 1) Let's say you know that this population is growing at a rate of 20% per year. Write the differential equation for the population.
- 2) Suppose that you know that each individual in this population flowers in the spring of each year, and bears between 1.2 offspring (on average) before dying (assume you know that although an individual plant cannot have 1.2 offspring a group of plants can). Write the discrete time equation system for the population.
- 3) Compare your results from questions (1) and (2).