**Proceedings of the Conference on
Promoting Undergraduate Research in Mathematics**

Undergraduate Biology and Mathematics Programs

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Introduction

At the PURM conference, we had a breakout session discussing undergraduate biology and mathematics programs. We wanted to inform the mathematics community about interdisciplinary programs involving research experiences for undergraduates. This includes several REU programs, in particular the programs at Arizona State University and Loyola Marymount University were represented in our group. We also discussed new programs for interdisciplinary research work and curriculum development involving students in mathematics and biology. The particular programs that we discussed were the NSF Interdisciplinary Training for Undergraduates in Biological and Mathematical Sciences (UBM) and the NSF STEM Talent Expansion Program (STEP).

Below we briefly describe the goals of the UBM program and describe a particular program at Murray State University. We also describe the NSF-STEP Talent Expansion in Quantitative Biology program at East Tennessee State University (ETSU).

UBMs

The goal of the NSF Interdisciplinary Training on Undergraduate Biology and Mathematics (UBM) program is to enhance undergraduate education and training at the intersection of mathematics and biology and to better prepare these students for careers in interdisplinary work in these areas. The main activity involves long-term research experiences for balanced teams of students, representing both mathematics and biology. Faculty members from mathematics and biology are involved in these programs as mentors. To influence the academic programs for a broad range of students, curriculum development may be a significant part of the effort. Through a mentored experience, undergraduates will gain insight into the connections between biology and mathematics.

The first of these UBM programs were funded as supplements to existing NSF research grants in mathematical biology and most of the work consisted of the research experiences part of this program for two years (about 2002). Full UBM programs with research experiences and curriculum and program development were

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funded under this NSF program starting in 2004. Currently there are 24 UBM programs, and these efforts represent a large amount of current work in undergraduate research in mathematics. See the articles about the programs at University of Tennessee and at Truman State University elsewhere in this proceedings.

UBM at Murray State University

The UBM program at Murray State University in Murray, Kentucky, is titled "BioMaPS," Biology and Mathematics in Populations Studies, and is directed by Renee Fister. The goal is to create a research environment for mathematics and biology students to study the designs and patterns that exist in populations at the organismal and cellular levels. The objective is to equip 25 students over a five-year period with the skills to understand these patterns and to develop accurate models of biomedical and ecological phenomena. The students and faculty work together as research teams on integrative projects, asking innovative questions from both biological and mathematical viewpoints. The projects include modeling of ecological and evolutionary processes relating to fecundity, parameter identification, developmental stability, biodiversity, anthropogenic disturbances, and population fluctuations.

A defining aspect of the project is the collaboration of four female and three male mentors across two disciplines, who have the ability to attract a diverse group of students based on their different but complementary backgrounds. These mentors will also be team teaching some courses, including restructuring the Math Modeling course to have a biological emphasis. The BioMaPS program builds on existing partnerships with Rocky Mountain Biological Laboratory and St. Jude Children's Research Hospital. A minor in mathematical biology is being developed.

East Tennessee State University STEP and Symbiosis Program

During the summers of 2004 and 2005, ETSU ran a UBM program as a supplement to an NSF-CCLI grant. The PIs were Istvan Karsai (Biology) and Jeff Knisley (Mathematics). Sixteen students conducted interdisciplinary REU-style research in a team environment where each project was co-directed by one person from each department, and featured both dry- and wet-lab experiences. This project was overseen by the umbrella organization *The Institute for Quantitative Biology.* UBM activity ceased after the summer of 2005, even though, paradoxically, the projects described in the next two paragraphs *were very appropriate for and could very well have been funded by UBM.*

The overarching goal of the NSF-STEP program is to increase the number of US students pursuing and completing degrees in STEM fields. The majority of STEP programs across the nation have multiple disciplines represented. While many of them do feature undergraduate research, it can be conducted in any of several disciplines. At ETSU, however, our focus is on quantitative biology and the five year (2005–2010) $1M project is accordingly titled *Talent Expansion in Quantitative Biology* (TEQB). The PI is Godbole, while co-PIs are Lev Yampolsky and Hugh Miller (Biology), Jack Rhoton (Curriculum and Instruction) and Jay Boland (Math and Honors Programs Director). Three cohorts of 20 students will start with a bridge program between high school and college. The five week program features a course in computational biology and hands-on projects in computational biology. Students earn a $500 stipend over the summer, and tuition is paid. Students declare

a major in either mathematics or biology (the quantitative biology track in each case) at the end of the summer. Over the next four years, participants receive *four distinct* undergraduate research experiences: They participate in a year round freshman lab rotation (the labs may be in math or biology) for which a $1500 stipend is earned. During the summer following their sophomore year, they participate in a UBM-style two month research program ($2500) and we will place them in an external REU or UBM program at the end of their junior year. Last but not least, students will write a senior thesis in quantitative biology.

Reviewers of the STEP proposal had several queries. Most significantly, they wanted to know what the curriculum for the students was going to be. Other members of the Institute for Quantitative Biology are working on this aspect. They were Istvan Karsai (PI), Karl Joplin, and Darrell Moore (Biology); and Jeff Knisley, Edith Seier and Michel Helfgott (Mathematics). Godbole and Moore from the STEP project are senior personnel on the corresponding curricular Howard Hughes Medical Institute proposal, which was funded for $1.7M for the period 2006–2010. The HHMI project, titled *Symbiosis*, features the development of a totally integrated first year and sophomore curriculum in math and biology which will be taken by the second and third cohorts in the STEP program. The curriculum will be redesigned as follows: Biology 1,2, and 3; Calculus 1; Probability and Statistics (Calculus-based); and parts of Calculus 2 and Linear Algebra will be deleted from the curriculum and replaced with an integrated team-taught series of three courses (6 credits each). These will be titled Symbiosis 1, 2, and 3, and the ultimate goal is to blur the lines between our disciplines. More curriculum reform at the upper level is also under way, but is not part of the Symbiosis project.

STEP and Symbiosis are major undertakings and have indeed transformed our two departments and the interactions between them. We hope to report on project outcomes in the next PURM proceedings.

Concluding Comments

A measurement of success of these programs includes the number of students that go onto graduate programs, not just the students who go onto mathematics graduate programs. Training students for an interdisciplinary graduate program is different from traditional training for a pure mathematics program.

We also call attention to a new NSF program in interdisplinary training. The goal of Computational Science Training for Undergraduates in the Mathematical Sciences (CSUMS) is to enhance computational aspects of the education and training of undergraduate students in the mathematical sciences – mathematics and statistics – and to better prepare these students to pursue careers and graduate study in fields that require integrated strengths in computation and the mathematical sciences.

When considering involvement in a variety of interdisciplinary activities with students, we recommend consulting the following two publications:

Math & Bio 2010 Linking Undergraduate Disciplines, editor L. A. Steen, Mathematical Association of America, 2005.

Bio 2010: Transforming Undergraduate Education for Future Research Biologists, National Research Council, 2002.

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