

Guidelines for the Quantitative Biology Interdisciplinary Ph.D. Program

Motivation

There is a national consensus that much of the university education system is entrenched along traditional disciplinary lines, while a great deal of academic research, industrial activity, and job opportunities require a broader educational background. For interdisciplinary science to be most effective, a key component will be bridging the communication gap between biologists and physical/mathematical/computational scientists. Without real communication we will be doing the obvious, which everyone can identify. But our goal must be to break new ground and develop research areas that are unique and competitive for funding available from NIH.

The Quantitative Biology interdisciplinary Ph.D. Program (see <http://biomodel.msu.edu>) is designed to promote more, and more effective, synergistic interactions across the Computer Science/Physics/Math/Chemistry/Biology interfaces, and at the same time to train a new breed of student who can really speak two languages, understand two cultures and therefore catalyze these interactions. For each student, the program centers on an interdisciplinary research project with two faculty mentors, one each from biological and non-biological disciplines. Organized as a dual-major Ph.D. program, the QB program requires students to belong to one of nine primary departments (i.e., Biochemistry, Chemical Engineering, Chemistry, Computer Engineering, Mathematics, Microbiology, Physics, Plant Biology, or Statistics) in addition to the QB program. We hope to later extend this opportunity to other departments, such as Physiology or Animal Sciences. Large emphasis is placed on interdisciplinary training through interdisciplinary teamwork, crossing-training from student to student, laboratory rotations, and QB interdisciplinary student community and activities. QB Ph.D. graduates will be identified as being proficient in a traditional discipline (as fundamental training to ensure their future job prospects) as well as having expertise in the rapidly growing area of quantitative biology. It is envisioned that such a training program will attract exceptional students and be a powerful recruiting tool, if properly advertised and supported as it is by the central administration with fellowship funds. The primary goal is to provide a training program that will make the students more innovative scientists and competitive in the future job market.

Program Outline

Under current university guidelines, research-based graduate degrees can be designed across disciplines/graduate programs, with the concurrence of the graduate programs involved (see "Dual Major Doctoral Degrees" in the MSU Academic Programs Guide). The template used for the QB program is very similar to the template used for the dual-major Ph.D. degrees already existing between Biochemistry and Physics & Astronomy; Biochemistry and Chemistry; and Biochemistry and Computer Science & Engineering). QB students will belong to a primary department in addition to being enrolled in the QB program. Because QB is developed as a dual-major program, students will have two possible application mechanisms: (i) they can initially apply to one of the associated departments; once accepted, they can later apply to the QB program; or (ii) they can apply directly to the QB program; in that case, the QB faculty will identify the most

appropriate partner department and work with that department to evaluate whether the student is accepted into both programs. Admission requirements to graduate school will be those of the primary department. The QB faculty will select highly motivated applicants with excellent credentials who are clearly interested in interdisciplinary studies.

The student's coursework will be split 60%:40% between the primary department and QB, with no more than 125% of the typical course load of a single Ph.D. degree being required for the interdisciplinary degree. The degree is called, for example, a Ph.D. in "Biochemistry and QB", where the primary affiliation for the Ph.D. is Biochemistry (i.e., always the primary department) and the secondary affiliation is QB. Obligations for teaching are met in the primary department. Comprehensive (preliminary) exams are also arranged according to the guidelines of the primary department, and must meet the standards of a guidance committee that includes members of the primary department, biologists and non-biologists, and at least two QB-affiliated faculty members. A project-based preliminary exam like the one in Biochemistry is ideally suited for this. In a department such as Mathematics, the preliminary exam requirements for a QB student will be modified so that the standard six cumulative examinations are reduced (or modified to include biological topics) to allow for more interdisciplinary training. Details for these agreements are not yet established, but the non-biology department chairs have agreed that such modifications are needed and can be arranged. If a student decides to leave the interdisciplinary degree program, he/she can revert to the requirements of his primary affiliation.

Course Requirements

Consider the following as a sample template for an interdisciplinary Ph.D. program in which Biochemistry is the primary department, and replace as needed by the relevant information for the departments of interest.

A typical course plan for a traditional Biochemistry Ph.D. student is BCH 801 (3 cr), 802 (3 cr), 803 (2 cr), 821 (3 cr), 829 (2 cr), 978 (1 cr, taken for approximately 3 cr total), and NSC830 (1 cr), with additional courses as advised by the guidance committee to complement the student's research. The following interdisciplinary coursework requirements are based upon requiring no more than 125% of this 17-credit traditional plan and reflect the 60%:40% coursework ratio desired for interdisciplinary Ph.D. training.

At least four graduate courses will be taken in Biochemistry, usually at the 800 or 900 level, totaling 12 (or more) credits. Rotation requirements are flexible, especially if the student decides on a joint program at the outset, and teaching responsibilities are the same as for a traditional Biochemistry Ph.D. student. At least four courses (9 or more credits) will be taken in QB, including QB 826, 827, and 828 (non-biologists) or QB 826, 827, and 829 (biologists).

- QB 826, Introduction to Quantitative Biology Techniques (1 cr), a one-week workshop conducted before the start of fall semester.
- QB 827, Problems in Quantitative Biology (2 cr), offered in the fall.

- QB 828, Introduction to Biology (3 cr), offered in the spring to the non-biologists.
- QB 829, Introduction to Physical/Mathematical/Computational Methods (3 cr), offered to the biologists.

Laboratory rotations

Students in the life sciences Ph.D. programs complete up to three ten-week biology laboratory rotation projects during their first graduate year. The biology-trained QB students will have the added option of doing rotation projects in mathematical, computational, chemical, or physical laboratories. QB students coming from non-biological disciplines will also be encouraged to do one or more wet lab rotations to develop a more interdisciplinary perspective. Additional demands present within certain departments (e.g., teaching assistant needs and course schedule constraints) might require that these rotation projects be shorter and occur during the summer.

Expected Outcomes

We expect this Program to make MSU more competitive for funding from NIH and NSF in their new thrust areas of quantitative biology and interdisciplinary training, and to attract and train students (and faculty) that will function effectively in the interdisciplinary research environment of the future.