Systems and Integrative Biology (SIB) Training Grant
An NIGMS Training Grant in Mathematical and Computational Biology

Formal Training Requirements

The goal of this training program is to support pre-doctoral students who seek a balanced and rigorous training in mathematics and biology/biomedicine with a special emphasis on research in mathematical modeling in biology or biomedicine. The early training includes formal course work, research rotations with participating faculty, and attendance and participation in seminar series.

Trainees are not expected to be already fully proficient in both biology and mathematics at the start of this program. However, it is expected that trainees are currently pursuing a graduate program in either a mathematical or biological discipline and already have a minimal level of undergraduate background in the other discipline (see the Trainee Selection Guidelines below). As summarized in the following sections, an aim of the didactic portion of this training program is for trainees to demonstrate a minimum of 20 quarter units of advanced courses in quantitative methods and 20 quarter units in biological sciences. Although the goal is graduate level competence in these areas, students can petition to have 8-10 units in each group satisfied by upper-division courses.

1. Trainees must develop with their advisor(s) a coherent plan for quantitative training that includes completion of five courses (total of 20 quarter units), with at least two courses from a series in Core Methodology and two from a series in Modeling Applications in Biology. The Core Methodology series covers basic modeling and computational techniques in the following areas: (1) deterministic modeling (2) stochastic modeling (3) statistical modeling (4) computation/algorithms/numerical methods (5) optimization and (6) other applied mathematics. Courses in the Modeling Applications in Biology series demonstrate the application of core methodologies to biological or medical research and have substantial mathematical and biological content and exposure to current research problems. The Appendix presents examples of suitable graduate courses in both series currently offered by a variety of mathematical, engineering, and natural science programs. These examples are not exhaustive, and the Advisory Committee will review suggestions from participating faculty and update the lists on an annual basis. Moreover, in developing a plan for quantitative training, trainees may petition the Advisory Committee to allow substitution of 8 of the 20 quarter units with upper division courses.

2. Trainees who are not already in a doctoral program in a biological or biomedical specialty must develop with their advisors a coherent plan for biological training that includes completion of at least 20 quarter units of upper division and graduate courses. At least half should be at the graduate level. The Advisory Committee will maintain suggestions for coherent course sequences, including those already developed by Biomathematics for students interested in specialty training in Human Genetics, Microbiology Immunology and Molecular Genetics, Molecular Biology, Molecular Cellular and Integrative Physiology, the Neuroscience Interdepartmental Program, or OBEE (Organismic Biology, Ecology and Evolution). One notable example is the ACCESS
program at UCLA, which offers a common first year curriculum for graduate students interested in research specialization in the molecular, cellular, and integrative life sciences.

3. To help prepare trainees for their dissertation research and professional development, trainees are required to go through **at least one quarter per year of directed research in the laboratories of the participating faculty members.** A special trainees seminar will be held at a suitable time in Winter Quarter in conjunction with a social gathering of trainees and participating faculty. Each trainee who has had a directed research experience will make an oral presentation of the results of that research, and participating faculty will provide commentary and feedback on the presentations. Trainees must also attend a **seminar series** on computational biology usually held Fall and Spring quarters. These requirements will give the trainees a broad perspective on how mathematical modeling is being applied in a variety of biological/medical areas and provide opportunities for trainees to establish personal contacts with active researchers in various fields. This exposure is especially helpful for those who do not yet have a research topic. The advisor or mentor for each trainee, of course, is expected to play an important role in guiding the trainee to select a topic that suits the trainee’s scientific interests and aptitude.

4. In addition, all trainees are required to take a class on **ethics in biological/medical research.**

**Training Timetable**

Trainees are expected to take courses required by their departments/programs concurrently with the ones required by this training program. They are expected to complete the curriculum requirements of the training program in 2 years, although up to an additional year may be requested by petition to complete the requirements under special circumstances, e.g., course series offered every other year or conflicts with requirements of the home department. Courses for the training program will naturally overlap with courses required by the department/program with which the trainee is affiliated, reducing the actual number of extra courses that the trainee will need to take. Moreover, the training program will help trainees to decide on research topics and carry out their dissertation research. Thus, the extra training time added to the regular time-to-degree from their home department is expected to be less than a year.

The emphasis of this training program will be on the early years of graduate training. After completing the curriculum requirements of the program, a trainee is expected to have decided on a dissertation research area, selected a laboratory or setting under which to do the work, and chosen a dissertation research mentor or co-mentors. At that time, no later than the end of the third year, the responsibility for the trainee’s financial support is expected to shift to the affiliated laboratory. Because theoretical research may not be performed in a traditional laboratory setting, students pursuing such research with limited access to funding can petition to apply for further extension of training grant support into their research dissertation years. The evaluation of all exceptions will be made on a case-by-case basis by the Advisory Committee, taking into account the competitive basis for evaluation of all new trainees and renewals.
Trainee Selection

Every student applying to the training program is asked to submit (1) GRE scores (2) transcripts covering his/her most recent academic degree or program involvement (3) a statement of purpose and research interests, and (4) letters of recommendation. For incoming students we will accept three letters of recommendation used for their application to a UCLA graduate program. For continuing students we expect two letters of recommendation, at least one of which is from their current faculty advisor or mentor.

In evaluating incoming students we are mindful of some ideal standards of undergraduate preparation for the dual areas of training required in this program. In mathematics these include exposure to multivariate calculus, linear algebra, ordinary differential equations, and probability and statistics. In biology we would expect to see a year long introduction to biological principles as well as a course in biochemistry/molecular biology. Evidence for successful performance in upper division courses in both areas is helpful for judging that timely completion of the formal requirements is likely. However, in our experience exceptional strengths in one area can balance deficits in the other.

Monitoring and Evaluation

As noted earlier, the progress and performance of each trainee is monitored closely by his/her advisor, with whom members of the Executive Committee will communicate at least quarterly. Yearly, the progress of each trainee will be reported (in writing and orally) to the Advisory Committee, which determines whether progress is satisfactory, whether adjustment is needed, and whether support should be continued. The yearly evaluation and ranking of current trainees for renewal will be done competitively and at the same time as evaluation and ranking of new students for entry into the training program (see below). The competitive ranking of renewing students will also take into account their rate of progress. Students petitioning for exceptions, e.g., course work beyond the second year or continuation of support into the dissertation years, will have to show compelling cause as well as outstanding academic and research progress.
APPENDIX
Examples of Graduate Courses for Quantitative Training

Note: Trainees must develop with their advisor(s) a coherent plan for quantitative training that includes completion of five courses (total of 20 quarter units), with at least two courses in Core Methodology and two in Modeling Applications in Biology. The following examples are not exhaustive, and the Advisory Committee will review suggestions from participating faculty and update the list on an annual basis. Trainees may petition the Advisory Committee to allow substitution of 8 of the 20 quarter units with upper division courses.

a) Core Methodology

(1) Deterministic Modeling
Biomath 201 - Deterministic Models in Biology
Chem. Engineering 282A - Nonlinear Dynamic Systems
Math 266 A - Applied Ordinary Differential Equations
Math 266 B,C - Applied Partial Differential Equations

(2) Stochastic Modeling
Biomath M203 - Stochastic Models in Biology
Statistics M220 A,B - Applied Probability

(3) Statistical Modeling
Biomath 204 - Biomedical Data Analysis
Statistics 200 A,B - Statistical Theory
Statistics M230 - Statistical Computing

(4) Computation/Algorithms/Numerical Methods
Biomath CM208C - Introduction to Neural Networks
Chemistry C226A - Computational Methods for Chemists
Computer Science 280A-ZZ - Algorithms
Computer Science 270A - Advanced Numerical Methods
Math 269 A,B,C – Advanced Numerical Analysis

(5) Optimization
Biomath 210 - Optimization Methods in Biology
Chem. Engineering M280C - Optimal Control
Chem. Engineering 284A - Optimization in Vector Spaces

(6) Other Applied Mathematics
Biomath 202 - Fourier Analysis in Biology
Electrical Engr. 211 A,B – Digital Image Processing
Math 274 A,B,C – Asymptotic Methods; Perturbation Methods
Physics 231 A,B – Methods of Mathematical Physics
b) Modeling Applications in Biology

Biomath 206 - Introduction to Mathematical Oncology
Biomath 207A - Theoretical Genetic Modeling
Biomath 207B - Applied Genetic Modeling
Biomath 208 (A or B) - Modeling in Neurobiology
Biomath M211/Human Genetics M211 – Mathematical and Statistical Phylogenetics
Biomath 220 – Kinetic and Steady State Models in Pharmacology & Physiology
Biomath M230 - Computed Tomography: Theory and Applications
Biomath/Physics M243 – Condensed Matter Physics of the Cell
Biomed. Engineering M296D - Introduction to Computational Cardiology
Biomed. Physics 210 - Principles of Medical Imaging
Molecular & Medical Pharmacology M248 – Introduction to Biological Imaging
OBEE C219 – Mathematical Ecology