Mathematical and Computational Biology Graduate Program

Bylaws

January 24, 2006*

Modified: April 30, 2009

Submitted by: Frederic Y. M. Wan

Prepared in collaboration with

- Vittorio Cristini (Biomedical Engineering)
- Arthur Lander (Developmental & Cell Biology)
- Rui (Ray) Luo (Molecular Biology & Biochemistry)
- Qing Nie (Mathematics)
- Thorsten Ritz (Physics)

With the participation of

- Nancy L. Allbritton (Physiology & Biophysics)
- Pierre Baldi (Computer Science)
- Steven P. Gross (Developmental & Cell Biology)
- John Lowengrub (Mathematics)
- Eric Mjolsness (Computer Science)

*May 1, 2006 (removing a few typographical errors)
Table of Contents

Section 1. PREAMBLE

Section 2. INTRODUCTION AND STATEMENT OF PURPOSE

Section 3. DEPARTMENT AND FACULTY PARTICIPATION

Section 4. GOVERNANCE

4.1 Executive Committee
   4.1.1 Composition
   4.1.2 Duties and Responsibilities
   4.1.3 Procedures

4.2 The Program Director

4.3 Associate Director

4.4 Committees

4.5 Program Administrator

4.6 Plebiscites

4.7 Program Calendar

Section 5. CURRICULUM

5.1 First Year Requirements
   5.1.1 Core Courses
   5.1.2 Research Laboratory Rotations
   5.1.3 Research Seminar Series

5.2 Continuing Training
   5.2.1 Selection of a Thesis Advisor and Department
   5.2.2 Journal Club

Section 6. SUCCESSFUL COMPLETION OF THE PROGRAM

Section 7. ADMISSIONS AND STUDENT RECRUITMENT

Section 8. ADVISING
APPENDIX I. Potential Participating Faculty

APPENDIX II. Data for Annual Review

APPENDIX III. Mathematical and Computational Biology Graduate Programs

APPENDIX IV. Additional Educational Information

APPENDIX V. NIGMS Funds Complex Biomedical Systems Research Centers

APPENDIX VI. NIH and NSF Team Up to Link Math and Biology

APPENDIX VII. Examples of Available Funding (Partial Listing)

APPENDIX VIII. HHMI Awards $10 Million for Interdisciplinary Graduate Education (November 22, 2005)

APPENDIX IX. Letters of Commitment from Participating Departments
SECTION 1. PREAMBLE

The biological sciences are entering a new era in which scientific advancement requires a quantitative understanding of large-scale and complex systems. Advances in mathematical modeling, nonlinear and stochastic analysis, numerical simulations, statistics and other areas of mathematical sciences will play an increasingly important role in the future as tools to understand biological processes and to predict their outcomes\(^1\)\(^2\). Thus, there is a tremendous need to provide quantitative training for biologists and biological training for mathematicians and computer scientists\(^1\)\(^2\). While it is difficult for a single scientist (biologist, mathematician, or computer scientist) to develop the depth needed to address problems at the research frontier in an interdisciplinary way, collaborative efforts among groups of scientists with complementary skills who are also trained to understand the language of one another can and will make progress at the frontiers of research. The graduate program we envision in Mathematical and Computational Biology aims to provide this vital training for students, to foster interdisciplinary research collaboration and thus to provide the scientific community with scientists who possess the knowledge and skills to meet the major integrative biological challenges faced by our society.

Biology and mathematics have historically benefited from exchange and collaboration. A famous example is the pioneering work of the renowned English logician and mathematician A. Turing on the chemical basis of morphogenesis in biology (1952). This work energized the field of developmental biology and lead to the development of new mathematics and new biological understanding. By mid twentieth century, a number of monographs [1-7] were published to record in a coherent way the substantial body of quantitative developments in the biological sciences. About that time, archival journals such as the Journal of Theoretical Biology, Biological Cybernetics, Journal of Mathematical Biology and the Bulletin of Mathematical Biology began to emerge, and they remain vibrant to this day. There have also been a sufficiently large group of active researchers in this field to support the continuous existence of the Society of Mathematical Biology (and its counterparts abroad) for past forty years.

The field of mathematical biology has become far more sophisticated in methodology and biological contents since the mid twentieth century. While we can cite a number of significant texts in this area since that period to document this observation, it suffices to note the two volume treatise on mathematical biology by J.D. Murray [8,10] and the slimmer volume by M.A. Nowak and R.M. May [9] to illustrate the breadth and depth the field of mathematical biology has attained since the fledgling days of the discipline. Coincidentally, these three authors all held at different times the Chair of Professor of Mathematical Biology at Oxford University. The existence of such a Chair since the early nineteen eighties provides a validation of the intellectual contents of this relatively new discipline. The institutional recognition of the intellectual contents of mathematical

---


biology has since gone well beyond establishing endowed chair professorships and recruiting faculty in this field. Graduate degree programs have sprung up around the world in this area. Included in Appendices 3, 4, and 5 are several lists taken from the Website of the Society of Mathematical Biology. Appendix VIII summarizes this year’s awards from the recent Howard Hughes Medical Institute Initiative to stimulate the establishment of new degree programs for interdisciplinary graduate education (with a UCI proposal headed by Arthur Lander, an MCB participating faculty, receiving one of the ten awards).

At the same time, and concomitant with the increasing availability of high performance computing, the focus of the field of Mathematical Biology has broadened to include many research projects on complex biological phenomena not approachable previously. These include the simulation of complex molecular interactions, the numerical exploration of dynamic systems with large parameter sets, and the analysis of genome sequences and data based on the gathering of genome- and proteome-wide data. The descriptive term "Mathematical and Computational Biology" is gaining in usage, as there is increasing recognition of the importance of computation in the analysis of complex biological systems.

We support the use of this term, because it emphasizes the synergistic interaction between Mathematics and Computation. Mathematical analysis not only provides a guide to efficient computing, it also often provide definitive answers to generic biological issues—whereas computing, like experimentation, offers results to a specific scenario on any issue. For example, mathematical modeling and analysis can delimit the range of values of various biological parameters. Computing specific scenarios can suggest a likely solution to a problem and allow analysts to formulate and prove the appropriate theorems. The outcomes of the interaction between computation and analysis often guide biologists toward experiments that provide durable insights into biological phenomena.

The synergistic relationship between mathematical analysis and computation is now generally recognized and reflected in the design of federal research support initiatives that date back at least to the 1980's, with the initiation of a mathematical biology program in the Division of Mathematical Sciences at National Sciences Foundation. Although that program remained relatively modest until the end of the last century, it was followed by the three year old NSF-NIMGS (National Institute of General Medical Sciences) Joint Initiative on Mathematical Biology, which increased the joint NSF-NIH investment in the area several fold. More recently, the NIGMS initiated a program to invest more than $25 million over the course of five years to establish Centers of Excellence in Complex Biomedical Systems Research (later renamed "Centers of Excellence in Systems Biology"; see Appendix 5). In the words of Dr. Judith H. Greenberg, the acting director of NIGMS, "We anticipate that the new centers will develop creative approaches to address significant biomedical problems by combining the expertise of outstanding scientists working across disciplinary boundaries. We also expect these centers to lead the way in training the next generation of researchers in computational biology." Equally significant are two other three year old initiatives in the CISE Directorate of NSF, one on Collaborative Research in Computational Neuroscience (CRCNS) and the other on Quantitative Systems Biology (for innovative
software for analyzing large-scale cellular biological systems). With such initiatives, the NSF and NIH investments have become a significant factor in promoting research in mathematical and computational biology. A three year planning grant from the NIGMS initiative on Complex Biomedical Systems and several R01 type grants from the joint NSF-NIMGS Initiative on Mathematical Biology are currently supporting several faculty groups at UCI.

Concurrent with the increased investment in research support for mathematical and computational biology are numerous calls for more high quality trained personnel for this type of collaborative approach to interdisciplinary research. Various solicitations such as the NIH Mentored Quantitative Research Career Development Award (PA-02-127, 2002-2005) and the $35 Joint Howard Hughes Medical Institute (HHMI) - National Institute of Biomedical Imaging and Bioengineering (NIBIB) of the National Institutes of Health to support graduate training programs that integrate the biomedical sciences with the physical sciences and engineering (see Appendix VIII), as well as those of other sources of fellowship/traineeship opportunities (see Appendix VII), indicate a serious shortage of the type of individuals needed for mathematical and computational approaches to research in the biological sciences. Evidently, high quality interdisciplinary graduate programs and postdoctoral training opportunities are very much needed in this area. The HHMI awards to UCI and two other UC campuses about two months ago (see Appendix VIII) not only validate the quality and direction of the UCI effort but also confirm the need of more than one such program even within the UC Systems.

Accordingly, it is an opportune time to build upon the individual and small group activities of the many participating faculty members of this proposal, and mount an organized, systematic and visible graduate program in computational and mathematical biology. We should do so to benefit from the economy of scale, to provide beneficial intramural and extramural support and recognition for our students, and to increase the number, quality and preparation of students trained at UCI in the area.

In the following document, we provide the outlines of a proposed graduate gateway program that we believe will not only be an effective vehicle for training Ph.D. students in Mathematical and Computational Biology, but also unique in its approaches to integrating research-level mathematical analysis, scientific computing and fundamental biology. It also constitutes the initial phase of our effort to meet the UCI commitment to the recent HHMI award described in Appendix VIII.

References

SECTION 2. INTRODUCTION AND STATEMENT OF PURPOSE

The field of Mathematical and Computational Biology (MCB) is an inherently broad and multidisciplinary area of scientific pursuit and scholarship. It has intellectual links to numerous and diverse fields in biology, medical science, mathematics, physics, chemistry, engineering, and computer science. Although it is not a new field, it is becoming increasingly important to progress in the biological sciences. This reflects the increased focus of many biologists on system-level approaches, in which complex network architectures, non-linear dynamics, and large data sets must often be explored and understood.

The breadth, multi-disciplinarity, and growing importance of MCB make it an attractive and important area for graduate study. However, this breadth also creates challenges for Universities seeking to train graduate students in this endeavor. In particular, the traditional organization of graduate training programs around single departments can limit the range of academic options a student may explore. On the other hand, it may be argued that training programs built around single departments are best for providing the focus that students/trainees entering such a broad field need.

In response to this dichotomy, this document proposes the formation of a new one-year MCB training program for PhD students. The MCB would function in concert with existing departmental programs, such that a student successfully completing the one year of MCB training would then be automatically directed into a departmental program for the remainder of his/her PhD training. In this way, the MCB would serve not as a degree-granting program, but as a "gateway" program, broadly similar in structure to other gateway programs already operating at UCI (such as the Interdepartmental Neuroscience Program and the Program in Molecular Biology, Genetics and Biochemistry).

In fulfilling this function, the MCB would seek both to attract new, highly qualified students to UCI, and to provide them with an academic experience of the highest quality. In particular the MCB will:

- Provide students with an opportunity to begin their training in Mathematical and Computational Biology with a broad academic introduction;
- Provide students with an opportunity for individualized attention to curricular needs;
- Provide students with an opportunity to conduct initial research projects with a large and diverse group of faculty in a wide variety of departments;
- Provide students with an opportunity to choose and conduct thesis research in any of a large and diverse group of laboratories in a wide variety of departments;
• Provide UCI Faculty in Biological Sciences, Engineering, Medicine, Information and Computer Science, and Physical Sciences with enhanced opportunities to compete for and obtain training grants from extramural sources.

The following pages outline the bylaws of the proposed MCB program. We anticipate that the form of the MCB Gateway Program will evolve over time, as organizational lessons are learned and training disciplines change. Accordingly, these bylaws include mechanisms for evaluating the success of the program in fulfilling its goals, and mechanisms for adjusting both the composition and the administrative structure.

This document was drafted by a committee of faculty from the Departments of Biomedical Engineering, Developmental & Cell Biology, Mathematics, Molecular Biology and Biochemistry, and Physics, with the participation of additional faculty members from Computer Science, Developmental and Cell Biology, Mathematics, and Physiology and Biophysics. It has been circulated for review, feedback and ratification by the participating faculty members listed in Appendix I.
SECTION 3. DEPARTMENT AND FACULTY PARTICIPATION IN THE PROGRAM

3.1. Department Participation

There are requirements for department participation in the MCB Program. Participation follows confirmation by the Executive Committee (see Subsection 4.1) that the following requirements have been met.

1) The Department must have an extant Ph.D. degree program with a significant mathematics component or with a significant biology component.

2) The department must agree and commit to admit into its Ph.D. program any student who successfully completes the (one year) course and lab rotation requirements of the MCB Program, who is accepted for Ph.D. training and dissertation research by a member of that department, and who fulfills such additional criteria as may be elaborated in full by the department (see item 5 below). It is expected that imposition of significant “additional criteria” by departments will occur sparingly, and will serve the purpose of ensuring that students do not enter the departments with gaps in their training that would further hinder their progress. Additional requirements are not meant to subvert the efforts of the admission committee, but rather to aid students in their progress.

3) The department must agree to extend to admitted MCB students whatever financial commitments (e.g. block grant fellowships, teaching assistantships, etc.), and stipend levels as are normally extended to other Ph.D. students in that department.

4) The department must agree and commit to remain participating in the MCB Program for at least three academic years. Withdrawal can only occur at the end of an academic year.

5) The department must agree and commit to provide at the beginning of each academic year a description of any additional academic requirements and/or curricular achievements (see item 2 above) that would be required of any student who moves from MCB program to that department at the end of the said academic year. These requirements may not be increased for said student(s) even if the department subsequently withdraws from the MCB program.

Agreement to all the above terms will be provided in writing by the department chair prior to joining the program. Any department not listed as a Founding Department (see below) may join upon invitation by the Executive Committee.
As of the inception of the MCB Gateway Graduate Program, there are eight founding participating departments listed below in alphabetical order:

1) Biomedical Engineering (Engineering)  
2) Chemistry  
3) Computer Science (ICS)  
4) Developmental & Cell Biology (BioSci)  
5) Ecology and Evolutionary Biology (BioSci)  
6) Mathematics (PhysSci.)  
7) Microbiology and Molecular Genetics (COM)  
8) Molecular Biology & Biochemistry (BioSci)

Additional departments wishing to participate should apply by contacting the Chair of the Executive Committee.

Continued participation of any department is contingent on upholding these bylaws. After its initial three-year commitment to the program, any department may elect to withdraw from the Program but can do so only at the end of an academic year. Any students who have already joined a department at the time of its withdrawal from the program will remain Ph.D. students in that department, and any academic requirements (such as the counting of such students’ coursework in the program toward departmental degree requirements) will remain in force.

### 3.2. Faculty Participation

UCI faculty who are members of the academic senate, and who fulfill all other campus requirements for serving as the primary mentor for a Ph.D. student, may participate in the Program. As of the inception of the Program, over 40 faculty members have been identified and indicated their interest as participants; they are listed in Appendix I.

Additional faculty members may become participants in the program if both of the following two conditions are met:

1) They hold primary or secondary appointments in a participating department.  
2) An application to become a participating faculty member is approved by the Executive Committee.

Participating faculty are responsible for serving on Student Advisory Committees and ad hoc committees when asked to do so by the Executive Committee (see Subsection 4.1 below). It is also expected that participating faculty will contribute to student recruitment efforts as needed.

The Executive Committee will review, on a periodic basis, the appropriateness of the participation of faculty members in the program, and may decide to
discontinue the participation of any faculty member at the end of an academic year. It is expected that such discontinuations will occur only rarely and only after a thorough review and consultation. In addition, all participating faculty will be asked annually to indicate whether they wish to continue as participants in the program.
SECTION 4. GOVERNANCE

Because the program focuses on Biology (and because the recent HHMI grant is housed in Biological Sciences), it is proposed that the MCB Gateway Program be administered through the School of Biological Sciences which already takes administrative responsibility for both the Molecular Biology, Genetics and Biochemistry Program (MBGB) and the Interdisciplinary Neuroscience Program (INP).

The program will be governed by an Executive Committee and a Program Director, who will be assisted by an Associate Director, a Program Administrator and faculty committees.

### Organizational Structure

![Organizational Structure Diagram]

**EXECUTIVE COMMITTEE**

- **Director**
- **Associate Director**
- **Administrator**
- **3-member Student Advisory Committees**

### 4.1. Executive Committee

The Executive Committee will serve as the primary governing body of the program.

**4.1.1. Composition of the Executive Committee:**

- Each participating department is responsible for providing a departmental representative to the Executive Committee of the MCB Program. The representative is to be appointed by the Department Chair to serve as a member of the Executive Committee for a three year term except at the inception of the Program (see below).

- Prior to the end of each academic year, Department Chairs (in consultation with their faculty) will be responsible for appointing new members to the Executive Committee for the following academic year as are needed to replace members whose term are expiring. Department Chairs may not themselves serve on the Executive Committee. At the program's inception, one third of the Executive Committee members will be assigned 2-year terms, and one third will
be assigned 1 year terms, to allow for a staggered schedule of replacement.

- If a department has a small number of participating faculty members (3 or fewer) in any given year, it may withdraw its Executive Committee member, decline to contribute a member for that year, or join together with another department to provide a shared member.

- The Executive Committee periodically reviews procedures for making appointments to that committee. If adjustment should be needed (e.g., more strictly tying representation to relative numbers of faculty participants in different departments), the Executive Committee would recommend appropriate amendments to the bylaws.

- No faculty member who is already serving on the Executive Committee will be asked to give up his/her membership prior to the normal expiration of his/her term, solely because of changes to the bylaws.

### 4.1.2. Duties and Responsibilities of the Executive Committee

- Selects /reviews applications for faculty membership.
- Oversees student recruitment.
- Acts as the admissions committee for admitting students (or delegate the responsibility).
- Sets academic standards, and establishes any other requirements, for continued student enrollment in the program.
- Makes recommendations to the Dean of Graduate Studies concerning dismissal of students who fail to fulfill requirements of the program.
- Oversees management of funds.
- Creates ad hoc and other standing committees.
- Gives charges to committees, appoint members to committees, and receives and exercises approval authority over committee recommendations.
- Organizes and run plebiscites as needed.
- Arranges for and guide the continued evaluation of the program.
- Oversees/organizes events and program-wide activities, such as "town hall" discussions, retreats, etc.
- Meets as frequently as necessary to carry out the above duties.

### 4.1.3. Procedures of the Executive Committee

- Decisions/Resolutions of the Executive Committee will be passed by simple majority vote of the membership of said committee, or if a vote is taken at a regular meeting of the Executive Committee, by a simple majority of those present, provided that a quorum consisting of at least 50% of the committee is present.
In the event that a vote leads to a tie, the program director will be empowered to cast a tie-breaking vote. Otherwise, the program director will not participate in Executive Committee voting.

A tentative calendar of Executive Committee meetings will be established at the beginning of each academic year and provided to all Executive Committee members.

In other matters, the Executive Committee will be expected to adopt procedures consistent with common parliamentary practice.

4.2. The Program Director

4.2.1. Recruitment and Appointment of the Program Director: In consultation with the Executive Committee, the appropriate dean(s) (Dean of Biological Sciences or the Dean of Graduate Studies or jointly) will appoint a Program Director for the MCB Program. The initial appointment will be for a three-year term, renewable for a second term assuming satisfactory performance. The program director will act as the Chief Executive Officer and Chief Financial Officer for the program. Independent of the appointee’s academic home, the Program Director will report to the administrative dean for the MCB Program designated when the Program becomes operational.

4.2.2. Duties and Responsibilities of the Program Director:

- Serves as an ex officio member and Chair of the Executive Committee.
- Acts as the main liaison between the MCB Program and the UCI Administration, the Academic Senate, campus committees, MCB students and outside organizations.
- Coordinates any outside funding the program may obtain.
- Recruits, appoints and supervises the Program Administrator.
- Supervises the admissions process, including the making of offers of admission to student applicants.

4.3. Associate Director

- Prior to the start of each year, the Executive Committee will elect one of its members to serve as Associate Director for that year
- The Associate Director will chair Executive Committee meetings in the absence of the Director
• The Associate Director will assume responsibilities of the Director in the Director’s absence

• The Associate Director will assume responsibilities delegated by the Program Director. Examples of such responsibilities include handling student concerns and complaints, receiving and processing student appeals.

4.4. Committees

Prior to the start of each year the Executive Committee will appoint one Student Advisory Committee for every incoming student for that year (See Section 8). Whenever needed, the Executive Committee will appoint other standing and ad hoc committees, including an ad hoc committee to assist Associate Director to review student appeals.

4.5. Program Administrator

• A salaried staff member will be recruited and appointed as a program administrator by the Program Director. This individual will be responsible for the program operations and carrying out administrative duties associated with running the program, including but not limited to:
  
  • Recruiting
  • Admissions
  • Budget
  • Faculty Membership
  • Correspondence
  • Tracking students
  • Website
  • Generating data for reports
  • Student handbook
  • Retreats for review and planning

• The program administrator will report to the Director.

• The program administrator will serve as secretary at Executive Committee meetings.

4.6. Plebiscites

Although the Executive Committee and Director will be responsible for most issues of program governance, two types of decisions will be made only through a vote by all participating faculty:

• Changes to the bylaws: Changes to the bylaws can be proposed either by the Executive Committee or by a supporting petition signed by at least 25% of the participating faculty. Once proposed, the Executive Committee will make the text of the proposed changes available to all participating faculty for a
period of time sufficient for careful review. The Executive Committee will then schedule and hold a vote of the program membership (i.e. all participating faculty). A simple majority of those faculty members who cast votes will be required to ratify the proposed changes.

- **Removal of officers:** Either the Executive Committee, or any group of faculty obtaining a supporting petition signed by at least 25% of the participating faculty, can propose that an officer of the program (Program Director, Associate Director or members of the Executive Committee) be removed from office. Once proposed, the Executive Committee would notify the participating faculty, and provide adequate opportunities for faculty discussion and review. The Executive Committee would then schedule and hold a vote of the program membership. A two-thirds majority of all participating faculty members (not just those who vote) would be required to remove an officer from office. Once an officer is removed, the same process that was initially used to appoint him/her will be used to appoint a successor. If there should be a significant delay in replacing an officer, the Executive Committee may select an interim officer from any of the participating faculty.

4.7. **Program Calendar**

The Program will follow the calendar of the academic year. All elections, appointments, etc. (with fixed terms) will normally take place no later than three (3) months prior to the start of the academic year.
SECTION 5. CURRICULUM

The curriculum is designed to teach students at the beginning of their graduate studies the necessary mathematical, computational, and biological knowledge for successful research at the interface between these disciplines. The needs of students with a variety of backgrounds can be met provided that they had mathematical training comparable to a year course in calculus and some elementary differential equations and linear algebra. Exceptional students not meeting these pre-requisite can be admitted to the program on the condition that they make up the deficiencies by taking courses during the first fall quarter of their graduate study or the summer preceding, and pass with a grade B or better. The MCB activities are organized to enable and encourage early enrollment in the summer prior to their first UCI fall quarter.

5.1. First Year Requirements

Core courses: All first-year students normally take the six four-unit MCB core quarter courses below, three in mathematical and computational methods for biology and three in biological sciences:

<table>
<thead>
<tr>
<th>BIOLOGY</th>
<th>MATHEMATICAL AND COMPUTATIONAL BIOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Quarter: Biophysics and Physical Biochemistry</td>
<td></td>
</tr>
<tr>
<td>• Fundamentals of biological molecules</td>
<td></td>
</tr>
<tr>
<td>• Biophysics/physical biochemistry</td>
<td></td>
</tr>
<tr>
<td>• Enzyme mechanism and kinetics, ligand-receptor interaction</td>
<td></td>
</tr>
<tr>
<td>• Experimental methods</td>
<td></td>
</tr>
<tr>
<td>(Physics and/or MB&amp;B to take primary responsibility)</td>
<td></td>
</tr>
<tr>
<td>1st Quarter: Statistics &amp; Scientific Computing</td>
<td></td>
</tr>
<tr>
<td>• Statistical methodology</td>
<td></td>
</tr>
<tr>
<td>• Symbolic computation packages</td>
<td></td>
</tr>
<tr>
<td>• Visualization</td>
<td></td>
</tr>
<tr>
<td>• Molecular Dynamics</td>
<td></td>
</tr>
<tr>
<td>• Monte Carlo simulations</td>
<td></td>
</tr>
<tr>
<td>(Mathematics to take primary responsibility for the entire sequence)</td>
<td></td>
</tr>
<tr>
<td>2nd Quarter: Cell and Developmental Biology</td>
<td></td>
</tr>
<tr>
<td>• Cell structure and function</td>
<td></td>
</tr>
<tr>
<td>• Transcription/translation</td>
<td></td>
</tr>
<tr>
<td>• Transport</td>
<td></td>
</tr>
<tr>
<td>• Signaling</td>
<td></td>
</tr>
<tr>
<td>• The cell cycle</td>
<td></td>
</tr>
<tr>
<td>• Developmental biology</td>
<td></td>
</tr>
<tr>
<td>• Morphogenesis</td>
<td></td>
</tr>
<tr>
<td>(Dev &amp; Cell to take primary responsibility)</td>
<td></td>
</tr>
<tr>
<td>2nd Quarter: Ordinary Differential Equations</td>
<td></td>
</tr>
<tr>
<td>• Initial value problems (theory, analytical &amp; numerical methods)</td>
<td></td>
</tr>
<tr>
<td>• Dynamic systems/control theory</td>
<td></td>
</tr>
<tr>
<td>• Boundary value problems (theory, analytical &amp; numerical methods)</td>
<td></td>
</tr>
<tr>
<td>• Applications: enzyme kinetics, cell cycle, signaling networks</td>
<td></td>
</tr>
<tr>
<td>• Solving non-linear equations</td>
<td></td>
</tr>
<tr>
<td>• Stochastic methods</td>
<td></td>
</tr>
<tr>
<td>3rd Quarter: Physiology, Pop. Biology, Evolution</td>
<td></td>
</tr>
<tr>
<td>• Neurophysiology</td>
<td></td>
</tr>
<tr>
<td>• Organ systems physiology (e.g. cardiovascular, Pulmonary)</td>
<td></td>
</tr>
<tr>
<td>• Population Biology and Genetics</td>
<td></td>
</tr>
<tr>
<td>• Evolution, and evolutionary theory</td>
<td></td>
</tr>
<tr>
<td>(BME, N&amp;B, or E&amp;E to take primary responsibility)</td>
<td></td>
</tr>
<tr>
<td>3rd Quarter: Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>• Classification of PDE’s</td>
<td></td>
</tr>
<tr>
<td>• Biological applications (diffusive transport, wave propagation in cells, pattern formation)</td>
<td></td>
</tr>
<tr>
<td>• Theory and analytical solution methods</td>
<td></td>
</tr>
<tr>
<td>• Numerical methods</td>
<td></td>
</tr>
<tr>
<td>• Stability analysis, eigenvalue problems</td>
<td></td>
</tr>
<tr>
<td>• Stochastic methods</td>
<td></td>
</tr>
</tbody>
</table>
The sequence in mathematical and computational methods will be credit courses in Mathematics and that in biology will be offered by the School of Biological Sciences. As such, they will be factored into the workload of these academic units and their hiring plan. In addition, new FTEs have been awarded to interdisciplinary degree programs such as bioinformatics which will draw students from the MCB gateway program. Some of the faculty members hired into these FTEs will also be available to teach these courses.

**Research Laboratory Rotations:** Laboratory rotations constitute an important component of the first year training program, providing students with intensive introductions to experimental design and quantitative data analysis as well as familiarizing them with available research opportunities. Students are expected to conduct three rotations in different labs prior to choosing a thesis advisor. Because of the interdisciplinary nature of the MCB Program and the diversity of the participating students, it is important that students become familiar with both “wet” experimental biology labs as well as with mathematical/computational labs. Therefore students are expected to do at least one rotation in each environment. Students are also encouraged to pair up for interdisciplinary, collaborative work experiences. Summer research in participating labs can count towards the required rotations.

**Research Seminar Series:** Participating MCB faculty will present their research, including ample discussions with students. These presentations will be a key mechanism by which students become familiar with the various potential research areas prior to choosing research lab rotations and a thesis advisor. All first year students are required to attend these seminars. To maximize student exposure to a wide range of research areas before selecting lab rotations, the Research Seminar Series is planned to be a year around activity. This planned practice will encourage new student enrollment in the summer prior to their first UCI fall quarter.

### 5.2. Continuing Training

**Selection of a Thesis Advisor and Department:** At the end of the first year, each student will choose a primary thesis advisor from among the participating faculty. The primary advisor’s department will be responsible for awarding the degree and the student needs to satisfy the course, examination, and other requirements set by the department for students entering through the MCB Program. *The primary thesis advisor will provide or arrange for the advisee financial support for three summer months following the student’s first nine months at UCI.*

To ensure interdisciplinarity of the thesis project, a student chooses a secondary thesis advisor from a department complementary to the primary thesis advisor’s department. In general, a student with a primary advisor in a biology department is required to choose a secondary advisor from any of the other participating departments and vice versa. However, the Executive Committee can allow other combinations requested by a student and endorsed by both prospective advisors.

---

1 Modification accepted by participating faculty votes: April 2009
Students are required to report their progress at least twice a year to their secondary advisor. It is the primary advisor’s responsibility to ensure compliance of the student with this reporting requirement. It is expected that the secondary advisor will serve on the student’s advancement and thesis committee (but not in lieu of the usual required outside member of the advancement committee).

**Journal Clubs:** Participating MCP students in closely related research areas are encouraged to organize journal clubs to meet regularly for discussion of relevant articles in research journals to broaden their research capacity and/or to seek dissertation research topics. The involvement of at least one participating MCB faculty should be sought to provide advice and guidance for the club activities. Faculty attendance at the club meetings will be important to the success of the journal club activities.
SECTION 6. SUCCESSFUL COMPLETION OF THE PROGRAM

Successful completion of the program requires:

1. Achieving a B+ (3.3) average in the core courses, and
2. Achieving satisfactory grades in all rotations, and
3. Identifying a participating faculty mentor willing to serve as thesis advisor, and
4. Completing any additional requirements mandated (in accordance with Section 3.1) by that faculty member’s department.

Matriculation into a departmental Ph.D. program of a student who completes most but not all of these requirements at the end of one academic year may occur at the sole discretion of that department.

MCB students enrolled in degree programs will be encouraged to continue to attend the MCB Research Seminar Series. Other activities such as annual retreats and research in progress seminars to be considered later on by the Executive Committee will also provide opportunities to maintain contact between the Gateway Program and MCB students after they have completed the program requirements.
SECTION 7. TRAINEE ADMISSIONS AND RECRUITMENT

Potential graduate students of the MCB Program will apply through the Office of Graduate Studies (OGS) and indicate on their applications their interest in the Program.

The Executive Committee and the Director will receive the completed applications from the OGS and act as the admissions committee. The Executive Committee may choose to appoint a separate Admissions Committee to assist and advise on the selection of applicants. However, it is the responsibility of the Executive Committee to set academic standards for admission and establish any other requirements for continual student enrollment in the program.

Following an initial screening of the applicants, the Executive Committee will usually invite applicants for an interview at UCI. The Program Director will be empowered to present to an applicant an admission offer package (including offer of a standard twelve month financial support package\(^1\&^2\)), put together from the recommendations of the interviewing faculty and the Executive Committee, as well as a separate Admissions Committee if one has been constituted.

The Director is responsible for administering the funds necessary for advertising and recruitment. The Program Administrator will carry out the administrative duties associated with recruitment including organizing current MCB students to participate in the recruitment process.

\(^{1}\) Typically, financial support for the three summer month after the first academic year at UCI will be through research funding provided or arranged by a student’s primary thesis advisor.

\(^{2}\) Modification accepted by participating faculty votes: April 2009
SECTION 8. TRAINEE ADVISING

8.1 Composition of Student Advisory Committees

Each student will be assigned an Advisory Committee by the Executive Committee upon enrollment in the MCB Program. The Advisory Committee will consist of two participating faculty members with one designated as the Committee Chair. The role of the Committee Chair will be assumed by the student’s thesis advisor when a participating faculty has been asked and agreed to accept that role. It is expected that the term of the Committee will continue until the student completes or leaves his/her degree program in mathematical/computational biology. If an Advisory Committee member cannot complete his/her term, the Executive Committee will appoint a replacement. It is the responsibility of all participating faculty to serve, when asked, on at least one Advisory Committee each year.

8.2 Duties of Student Advisory Committees

Each committee will meet with its advisee, prior to his/her enrollment in the one year MCB Program, to discuss course and research related issues. Subsequent meetings will occur twice during the year, once at the end of the fall quarter and once in the end of the winter quarter. At each meeting, lab and course performance for the just completed quarter will be discussed and classes/lab rotations for the coming quarters adjusted as necessary. The committee will also hear from the student any concern and complaint that he/she may have, investigate them and possibly report and discuss with the Program Director and/or Associate Director for possible response and action.

In the event a student receives a grade lower than a B in any course during any quarter, or an unsatisfactory rotation grade, this will result in the student being recommended for academic probation. The committee will discuss the situation with the advisee and may also confer with relevant course instructors or rotation advisors regarding the trainee’s performance. The committee will inform the Executive Committee of the academic probation, and recommend action(s) that should be taken to remedy the situation. Such recommendations may vary from proposing remedial work to expulsion from the program.

In the event that a trainee fails to successfully complete the program – as defined in Section 6 – the trainee will not be automatically assured admission to continued graduate training in each of the participating departments or any other academic unit at UCI.

8.3 Reporting

The chair of each advisory committee will report to the executive committee on the progress of each trainee twice a year.
8.4 Appeal

A student may appeal recommendation or decision on his/her status in the MCB program (such as probation status) in writing to the Program Director. Upon reviewing the fact and issues involved, the Program Director (or the Associate Director if the responsibility has been so delegated) may sustain or modify the recommendation/decision or may constitute a small ad hoc faculty committee to undertake the same task. The student may further appeal the outcome of the MCB internal appeal process through the Office of the Graduate Studies.

8.5 Dissolution

The responsibilities of each Advisory Committee will be concluded when its student has completed all requirements and awarded the PhD degree or has left the degree program.
# Appendix I  Participating Faculty

1. Participating Faculty from the Seven Participating Departments.

<table>
<thead>
<tr>
<th>Biomedical Engineering</th>
<th>Ecology and Evolutionary Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td>James Brody</td>
<td>Robin Bush</td>
</tr>
<tr>
<td>Vittorio Cristini</td>
<td>Steven Frank</td>
</tr>
<tr>
<td>Steve George</td>
<td>Anthony Long</td>
</tr>
<tr>
<td>Noo Li Jeon</td>
<td>Dominic Wodarz</td>
</tr>
<tr>
<td>Ghasaan Kassab</td>
<td></td>
</tr>
<tr>
<td>Andrew Putnam</td>
<td></td>
</tr>
<tr>
<td>Philip Sheu</td>
<td></td>
</tr>
<tr>
<td>Bruce Tromberg</td>
<td></td>
</tr>
<tr>
<td>Vasan Venugopalan</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemistry</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaul Mukamel</td>
<td></td>
</tr>
<tr>
<td>Douglas Tobias</td>
<td></td>
</tr>
<tr>
<td>Gregory Weiss</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Computer Science</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pierre Baldi</td>
<td>Patrick Guidotti</td>
</tr>
<tr>
<td>Dennis Kibler</td>
<td>Natalia Komarova</td>
</tr>
<tr>
<td>Rick Lathrop</td>
<td>John Lowengrub</td>
</tr>
<tr>
<td>Eric Mjolsness</td>
<td>Qing Nie</td>
</tr>
<tr>
<td>Padhraic Smyth</td>
<td>Knut Solna</td>
</tr>
<tr>
<td></td>
<td>Frederic Wan</td>
</tr>
<tr>
<td></td>
<td>Jack Xin</td>
</tr>
<tr>
<td></td>
<td>Hongkai Zhao</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Developmental and Cell Biology</th>
<th>Microbiology and Molecular Genetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee Bardwell</td>
<td>Ruslan Aphasizhev</td>
</tr>
<tr>
<td>Steve Gross</td>
<td>George Gutman</td>
</tr>
<tr>
<td>Lan Huang</td>
<td>Wes Hatfield</td>
</tr>
<tr>
<td>Taosheng Huang</td>
<td>Klemens Hertel</td>
</tr>
<tr>
<td>Arthur Lander</td>
<td>Ming Tan</td>
</tr>
<tr>
<td>J.L. Marsh</td>
<td>Marian Waterman</td>
</tr>
<tr>
<td>Tau-Mu Yi</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Molecular Biology and Biochemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melanie Cocco</td>
</tr>
<tr>
<td>Harmut Luecke</td>
</tr>
<tr>
<td>Rae (Ray) Luo</td>
</tr>
<tr>
<td>Sheryl Tsai</td>
</tr>
</tbody>
</table>
2. Participating Faculty from Other Departments

Anatomy and Neurobiology
   Ivan Soltesz
   Anne Calof

Neurobiology and Behavior
   Frances Chance

Physics
   Philip Collins
   Mike Dennin
   Thorsten Ritz
   Clare Yu

Physiology and Biophysics
   Nancy Allbritton
   Janos Lanyi

Statistics
   Gang Liang
   Hal Stern
APPENDIX II  DATA TO BE GATHERED FOR ANNUAL INTERNAL REVIEW OF THE PROGRAM

Admissions.
- Number of applicants (domestic and foreign)
- Number accepted
- Number enrolled
- Qualifications of applicants, including previous institution, degree and year, GRE scores and GPA
- Diversity

Academic Performance.
- Grades
- Comprehensive exam results
- Rotation reports
- Advising Committee reports
- Attrition rates

Student Outcomes.
- Honors
- Awards
- Publications
- Time to degree
- Subsequent employment
APPENDIX III MCB GRADUATE PROGRAMS in CALIFORNIA

Most universities in the United States offer graduate programs in fields related to mathematical and computational biology. Sometimes the student may have to search for individual professors with MCB research interests. Since MCB can be found in a number of guises, the following key words sorted by typical departments are offered to aid in your students’ search:

<table>
<thead>
<tr>
<th>Mathematics</th>
<th>Mathematical Biology, Pattern Formation and Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Science</td>
<td>Computational Biology, Bioinformatics</td>
</tr>
<tr>
<td>Biology</td>
<td>Theoretical Biology</td>
</tr>
<tr>
<td>Physics</td>
<td>Biological Physics, Nonlinear Dynamics, Complex Systems</td>
</tr>
</tbody>
</table>

(Beware the term "biophysics". This usually implies studies of molecular structure and function.) As indications of the growing interest and investment in this field, we show below MCB graduate programs in major research institutions in the State of California:

The UC System

UC Berkeley
Computational and Genomic Biology Graduate Program (a gateway program)
http://computationalbiology.berkeley.edu/

UC Davis
Center for Neurosciences
http://neuroscience.ucdavis.edu/about/
Neuroscience Graduate Program
http://neuroscience.ucdavis.edu/grad/
Institute for Data Analysis and Visualization
http://www.cipic.ucdavis.edu/
Bioinformatics and Data Analysis Research Group
http://bioinfo.idav.ucdavis.edu/
Visualization and Graphics Research Group
http://graphics.idav.ucdavis.edu/
Research Focus Group (RFG) in Mathematical Biology
http://www.math.ucdavis.edu/~mogilner/RFG.html
Graduate Group in Ecology
http://ecology.ucdavis.edu/

UCLA
Department of Biomathematics
http://www.biomath.medsch.ucla.edu/GraduateProgram/

UC Riverside
Graduate Program in Genetics, Genomics & Bioinformatics
http://www.genetics.ucr.edu/
UC San Diego
Computational Neurobiology Training Program (in the Neurosciences Graduate Program) – http://biology.ucsd.edu/grad/CN_overview.html

UC San Francisco
Center for Computational Proteomics research
http://www.ccpr.ucsf.edu/center.html
Graduate Program in Biological and Medical Informatics
http://www.bmi.ucsf.edu/

UC Santa Barbara
Bioinformatics
Center for Bio-Image Informatics
http://www.bioimage.ucsb.edu/

UC Santa Cruz
Bioinformatics & Computational Biology at UCSC
http://www.cbse.ucsc.edu/research/research_bioinf.shtml

Other Major California Research Institutions

Caltech
Center for Computational Biology
http://www.compbio.caltech.edu/
Bioinformatics and Computational Biology Software
http://sea-urchin.caltech.edu/software/
Computational Physiology (Endocrinology)
http://www.galcit.caltech.edu/~ravi/biology.html

Stanford
Mathematical and Computational Biology Track (in Department of Mathematical and Computational Science)
http://www.stanford.edu/group/mathcompsci/academics.html
Computational Methods for Structural Biology
http://med.stanford.edu/school/structuralbio/

USC
Molecular and Computational Biology
http://www.usc.edu/dept/LAS/biosci/mcb/
Computational molecular biology and bioinformatics
http://www-hto.usc.edu/
Computational Learning and Motor Control Laboratory
http://www-clmc.usc.edu/
Computational Neuroscience and Neural Engineering
http://www.usc.edu/dept/nbio/nqp/research/res-comp.shtml
APPENDIX IV ADDITIONAL MCB EDUCATIONAL AND RESEARCH INFORMATION

We list below educational and research programs at selected non-California major research institutions. We do this in three separate categories: the remaining Pac-10 institutions, selected major research institutions in North America, and a few institutions in United Kingdom.

OTHER WESTERN STATE INSTITUTIONS

University of Arizona
Mathematical Biology (Department of Mathematics)
http://math.arizona.edu/research/mathematicalbiology.html

Arizona State University
Computational Biosciences
http://lifesciences.asu.edu/compbiosci/text/courses.htm
Southwest Consortium for Theoretical and Mathematical Biology (SCTMB)
http://mtbi.asu.edu/~swc/

University of Oregon
Bioinformatics
http://www.cs.uoregon.edu/research/index.html#link2
Institute of Neuroscience
http://www.neuro.uoregon.edu/ionmain/htdocs/grdbroch/cogn.html

Oregon State University
Northwest Alliance for Computational Science & Engineering
http://www.nacse.org/top/interfaces/teaching.html

University of Washington (Home of James D. Murray)
Computational Molecular Biology
http://depts.washington.edu/cmolbiol/
Computational Biology Research Group
http://compbio.washington.edu/
Mathematical Biology
http://www.amath.washington.edu/~mbjc/links.html
The Department of Bioengineering

The Center for Quantitative Science
The NSF Science and Technology Center for Molecular Biotechnology
(a genome center)
Washington State University (R.H. Dillon)
Genomics, Proteomics, and Informatics
http://research.wsu.edu/missions_dc/genomics.proteomics.informatics/reinholdmann.html
Computational Neuroscience

IVY LEAGUE UNIVERSITIES

Brown University
Ecology and Evolutionary Biology
http://www.brown.edu/Departments/EEB/przeworski/research.htm
Computational Biology
http://www.brown.edu/Administration/Registrar/Concentration/Concentration-26.htm

Columbia University
Genomic Informatics
http://genome4.cpmc.columbia.edu/geno_info.html
Department of Biomedical Informatics
http://www.dmi.columbia.edu/
Biomedical Engineering
http://www.engineering.columbia.edu/students/academics/dept/bioe.php

Cornell University
Mathematical Biology Research Group in T & AM
http://tam.cornell.edu/MathBio.html
Computational Biology Program in CIS http://www.cis.cornell.edu/cb/graduate.htm
http://www.cis.cornell.edu/cb/undergrad2.htm

Dartmouth College
M.D. – Ph.D. Program in Computational Biology
http://www.cs.dartmouth.edu/~mdphd/
Biophysics at Dartmouth
http://www.dartmouth.edu/~biophys/

Harvard University
(Home of Martin Nowak)
Program for Evolutionary Dynamics
http://www.ped.fas.harvard.edu/nowak.htm
HMS Lipper Center for Computational Genetics
DFCI Department of Biostatistical Science
HSPH Biostatistics Department
HHMI HMS Genetics Computational Resources
HMS BBS Graduate Studies
HMS Lipper Center for Computational Genetics
University of Pennsylvania  
Genomics and Computational Biology (GCB)  
http://www.med.upenn.edu/gcb/index.shtml

Princeton University  
(Home of Simon A. Levin, Founder of Society of Mathematical Biology)  
The PEI (Princeton Environmental Institute) Center for Biocomplexity  
http://www.eeb.princeton.edu/~simon/cbc/cbc.html - Simon Levin

Yale University  
Computational Biology & Bioinformatics  
http://www.yale.edu/graduateschool/academics/computationalBiology.html

OTHER SELECTED AMERICAN INSTITUTIONS

(Notes: Many of these excellent institutions have a variety of graduate programs that are worth investigating. The links shown below have either appeared through their connections with mathematical biology web sites, or related interests.)

Brandeis University  
Mathematical Biology Program  
http://www.bio.brandeis.edu/biomath/menu.html

Florida State University  
Biomedical Mathematics  
http://www.math.fsu.edu/%7Equine/biomed.html

North Carolina State University  
Biomathematics Graduate Program

Northwestern University  
Computational Biology and Bioinformatics (CBB)  
http://cbb.cs.northwestern.edu/

DIMAC (Center for Discrete Mathematics and Theoretical Computer Science)  
Special Years on Mathematical and Computational Biology  
http://dimacs.rutgers.edu/Workshops/index-mb.html  
http://dimacs.rutgers.edu/SpecialYears/1997_DNA/  
http://dimacs.rutgers.edu/Workshops/DNAMapping/index.html  
http://dimacs.rutgers.edu/SpecialYears/2002_Epid/  
http://dimacs.rutgers.edu/SpecialYears/2000_2003/

Santa Fe Institute  
http://www.santafe.edu/research/computation.php
University of Texas, Austin,
Center for Nonlinear Dynamics

University of Utah
Department of Mathematics - University of Utah

VPI&SU
Department of Entomology

University of Washington
Center for Studies in Demography & Ecology
Molecular and Cellular Biology Department

Rice University
Keck center for Computational Biology at Rice

University of Pittsburgh
Keck Center for Advanced Studies in Computational Biology

SELECTED FOREIGN INSTITUTIONS

Canada

- McGill University, Concordia University, University of Chicago, University of Ottawa, and University of Waterloo
  Center for Nonlinear Dynamics in Physiology and Medicine.

- University of British Columbia
  Institute of Applied Mathematics

United Kingdom

- Universities of Edinburgh, Strathclyde and Aberdeen, Heriot-Watts and Leeds
  Biomathematics and Statistics Scotland (BioSS).

- Oxford University,
  Centre for Mathematical Biology
  Mathematical Biology Group, Department of Zoology
  http://www.zoo.ox.ac.uk/newsite/groups/mathbiol/math-biol-frontpage.html
  http://www.zoo.ox.ac.uk/newsite/groups/mathbiol/may-bio.html

- University of St. Andrew, Scotland,
  Sea Mammal Research Unit
APPENDIX V

RESEARCH FUNDING
Complex Biological Systems Initiatives
http://www.nigms.nih.gov/funding/complex_systems.html

- Summary of the Initiatives
  http://www.nigms.nih.gov/funding/complex_summary.html

- Publicity Flyer (pdf)

- NIGMS National Centers for Systems Biology
  Request for Applications GM-05-010, September 22, 2004

- NIGMS Funds Center for Quantitative Biology
  News Release, August 31, 2004

- NIGMS Centers of Excellence in Complex Biomedical Systems Research
  Request for Applications GM-03-009, April 29, 2003

- Changing the Face of Biology: NIGMS Funds Centers of Excellence at Harvard and MIT
  Seeking to Unravel the Complexities of Living Systems
  News Release, September 15, 2003

- NIGMS Funds Complex Biomedical Systems Research Centers
  News Release, August 2, 2002

- Mentored Quantitative Research Career Development Award
  Program Announcement PA-02-127, July 10, 2002

- Genetic Architecture, Biological Variation, and Complex Phenotypes
  Program Announcement PA-02-110, May 29, 2002

- Joint DMS/NIGMS Initiative to Support Research Grants in the Area of Mathematical Biology
  http://www.nsf.gov/cgi-bin/getpub?nsf02125
  NSF 02-125, May 13, 2002

- NIGMS and NSF Grants Join Math and Biology
  News Release, August 22, 2002

- Integrative and Collaborative Approaches to Research
  Program Announcement PA-03-127, May 20, 2003
NIGMS Funds Complex Biomedical Systems Research Centers

Contact: Alisa Zapp Machalek, (301) 496-7301
August 2, 2002

To encourage computational approaches that will deepen understanding of biological processes, the National Institute of General Medical Sciences has established Centers of Excellence in Complex Biomedical Systems Research. NIGMS anticipates spending a total of $25.5 million over the course of five years to support the centers.

After decades of research, scientists have amassed a wealth of data on the characteristics and functions of individual biological molecules. The focus now is on investigating how these molecules interact. Central to this effort is modeling and predicting the behavior of complex biological systems, which draws on the expertise and approaches of quantitative scientists—including mathematicians, physicists, computer scientists, and engineers—as well as those of biologists.

"NIGMS is excited about the opportunity to nurture the growth of this important new area of biomedicine," said Dr. Judith H. Greenberg, acting director of NIGMS. "We anticipate that the new centers will develop creative approaches to address significant biomedical problems by combining the expertise of outstanding scientists working across disciplinary boundaries. We also expect these centers to lead the way in training the next generation of researchers in computational biology."

The new NIGMS centers are designed to support the development of multi-investigator teams that can address biomedical complexity through research, training, workshops, symposia and other forms of outreach. The awards promote innovation and permit a larger scope of activity than would be possible via research grants to individual investigators.

Two new center awards, totaling $4.5 million for the first year of funding, were made to:

- University of Washington, Friday Harbor Laboratories in Friday Harbor, San Juan Island, Wash. (Garrett M. Odell, Ph.D., principal investigator)—$2.1 million to investigate how groups of genes control a variety of key biological processes, including the development of embryos and the functional and mechanical organization of cell structure and motion. Outreach activities will include creating and disseminating to the scientific community software to visualize and model data, hosting guest researchers and teaching yearly apprenticeship courses to recruit undergraduate biology students to careers in computational biology.

- Case Western Reserve University in Cleveland, Ohio (Gerald M. Saidel, Ph.D., principal investigator)—$2.4 million to create the Center for Modeling Integrated Metabolic Systems (MIMS), an effort to mathematically model and simulate metabolism in skeletal muscle, brain and liver tissue in response to stresses associated with exercise, diet and oxygen supply. MIMS will extend its reach beyond Case Western Reserve by establishing a partnership with Cleveland State University, which has a substantial population of undergraduate students.
who are members of minority groups that are underrepresented in biomedical research careers.

In addition, NIGMS will support three planning grants to lay the groundwork for future centers of excellence at:

- **Boston University** (Charles DeLisi, Ph.D., principal investigator)—to conduct a pilot study of the interactions between two signaling pathways controlling cell growth and death in human cells. The effort will also organize a large group of faculty members representing computer science, experimental and clinical science, and statistics to begin planning a cross-disciplinary educational program for undergraduates.

- **University of California, Irvine** (Arthur Lander, Ph.D., principal investigator)—to foster collaborations between research faculty members in cell biology, developmental biology, physiology and medicine. The group plans to devise software engineering principles to simulate large biological systems.

- **University of New Mexico in Albuquerque** (Janet Oliver, Ph.D., principal investigator)—to develop plans to establish the Center for Spatiotemporal Modeling of Cell Signaling Networks. The project's goals are to use computational modeling to understand complex cell signaling circuits and to disseminate knowledge and tools to the broader research community. The center will recruit new faculty to conduct computational biology research and provide training programs for undergraduate, graduate and postdoctoral students to learn how to conduct interdisciplinary research to analyze complex biological systems.

###

NIGMS has recently developed several programs and initiatives in the area of complex biological systems. For a complete listing, see [http://www.nigms.nih.gov/funding/complex_systems.html](http://www.nigms.nih.gov/funding/complex_systems.html)


For more information on NIH's Biomedical Information Science and Technology Initiative (BISTI), see [http://grants1.nih.gov/grants/bistic/bistic.cfm](http://grants1.nih.gov/grants/bistic/bistic.cfm)
The future of biological research depends partly on mathematics.

Math is a key framework for organizing and making sense of the vast amounts of biological data that scientists have generated in recent years. For example, mathematical models are a powerful way to understand complex biological systems.

To bring more mathematicians into biological research, the National Institutes of Health and the National Science Foundation are partnering on a math-biology initiative. A component of this effort is an NSF-NIH symposium on "Accelerating Mathematical-Biological Linkages" on Wednesday, February 12, 2003. The symposium will highlight research opportunities at the math-biology interface and encourage collaboration between mathematicians and biological scientists.

As an illustration of the breadth of topics that mathematicians and biologists can address together, symposium sessions will cover conservation ecology, cell structure and function, and bioinformatics and computational problems. The keynote speaker will be Dr. Joel E. Cohen, head of the Laboratory of Populations at Rockefeller University and Columbia University and a MacArthur Foundation Fellow. His talk is titled "Mathematics Is Biology's Next Microscope ... Only Better; Biology Is Mathematics' Next Physics ... Only Better." Dr. Margaret Palmer, a professor of entomology and biology at the University of Maryland, College Park, will chair the symposium.

The symposium will run from 9:00 a.m. to 5:00 p.m. in Rooms E1/E2 of the Natcher Conference Center (Building 45) on the NIH campus in Bethesda, Md. The event is free, but registration is requested at http://www.bisti.nih.gov/mathregistration. The symposium agenda is at http://www.bisti.nih.gov/mathregistration/MathSchedule.pdf.

The partnership between NIH and NSF takes advantage of the strengths of each agency. NIH supports biomedical research and training, while NSF funds research and education in mathematics, biology and other areas of science and engineering.

The NIH sponsors of the meeting are the Office of the Director, the National Institute of General Medical Sciences and the National Center for Research Resources.

The NSF meeting sponsors are the Directorate for Biological Sciences and the Division of Mathematical Sciences in the Directorate for Mathematics and Physical Sciences.
APPENDIX VII  EXAMPLES OF AVAILABLE FUNDING

FUNDING FOR UNDERGRADUATE STUDENTS, TRAVEL & TEACHING

SMB Landahl travel award
AWM Travel Grants for Women: awm@math.umd.edu
AWM Alice T Schafer Prize for female undergraduates
AWM Louise Hay Award for Mathematics Education
Graduate Student teachers: http://www.nsf.gov/cgi-bin/getpub?pr9912

FUNDING FOR MATH BIOLOGY GRADUATE STUDIES & POST-DOCS

The following agencies are known to fund Mathematical Biology research in North America

N.B. Specific disease foundations have varying tolerances for funding theoretical work, which can be ascertained through the organization itself. Ask, because the foundation may surprise you. From anecdotal evidence, agencies funding cancer, diabetes and even clinical research have supported mathematical research.

American Psychological Association/Neuroscience, US citizens. GS, PD, TG, M
GrantsNet, No citizenship requirements, GS, PD - searchable database
Human Frontier Science Program, (neuroscience). International exchange. PD
Lewis Thomas Fellowships in Computational and Physical Biology, Princeton. PD
Medical Research Council, Canadian citizens. GS, PD
Naval Research Laboratory Postdoctoral Fellowship Program, US citizens. GS, PD
National Institutes of Health, US citizens. GS, PD, M
National Science Foundation, US citizens. GS, PD, M
Natural Sciences and Engineering Research Council, Canadian citizens. GS, PD
The Program in Mathematics and Molecular Biology, no citizenship requirements. GS, PD
Santa Fe Institute Postdoctoral Fellowship in Complex Systems Studies, no citizenship requirements, PD

GS = Graduate Student Fellowships
PD = Post-doctoral
TG = Travel grants
M = Minority awards
APPENDIX VIII    HHMI Awards $10 Million for Interdisciplinary Graduate Education (November 22, 2005)

(http://www.hhmi.org/news/112205.html)

Biomedical science is becoming increasingly interdisciplinary, as reliant on the physical and computational sciences as on biology. But how are the biomedical investigators of the future going to learn to work effectively across disciplinary lines?

U.S. universities will lead the way, using grants of $1 million from the Howard Hughes Medical Institute (HHMI) to initiate fundamental changes in the way Ph.D. scientists are trained. They will use the three-year grants to develop innovative graduate education programs designed to produce a cadre of scientists with the knowledge and skills to conduct research at the interface between the biomedical, physical, and computational sciences.

“Our goal is to facilitate change in doctoral education that will enable biomedical scientists to work well across disciplinary lines.” -- Peter J. Bruns

HHMI is partnering with the National Institutes of Health’s National Institute of Biomedical Imaging and Bioengineering (NIBIB) to ensure sustaining support as well as start-up funds for the new programs. Following a second competition to ensure that the HHMI-funded recipients achieved their original goals, the NIBIB—committed to integrating the physical and life sciences—will support the second phase of this program, which is aimed at sustaining interdisciplinary graduate education.

“The HHMI-NIBIB partnership capitalizes on the special strengths of each organization,” said HHMI President Thomas R. Cech. “HHMI can provide flexible support to catalyze development of new interdisciplinary programs, and the NIBIB will sustain these and related programs once they are developed, as NIH does so well with traditional training grants.”

The recipients of the HHMI awards were chosen from 132 applicants. Their proposed programs are:

**Brandeis University**  -  Quantitative biology: A new curriculum to link the physical and biomedical sciences

**Carnegie Mellon University** (with University of Pittsburgh)  -  A new comprehensive, inter-university Ph.D. program in computational biology

**The Johns Hopkins University**  -  Interdisciplinary graduate research training program in nanotechnology for biology and medicine

**New Jersey Institute of Technology, Rutgers-Newark, the University of Medicine and Dentistry of New Jersey-New Jersey Medical School (equal partners)**  -  Development of a quantitative neuroscience doctoral training program
University of California, Irvine - Mathematical, computational and systems biology
(with a brief description is given at the end of this Appendix)

University of California, San Diego - Multi-scale analysis of biological structure and function

University of California, San Francisco - Integrated program in complex biological systems

University of Chicago - Graduate program in biophysical dynamics and self-organization

University of New Mexico - Program for interdisciplinary biomedical sciences

University of Pennsylvania - Integrated graduate training program in clinical imaging and informational sciences

After HHMI support ends, NIBIB will step in with peer-reviewed institutional training grants. “NIBIB is excited to enter into this historic alliance with HHMI to support training of the biomedical scientist of the future, one skilled in interdisciplinary research,” said Roderic Pettigrew, NIBIB director. “These scientists will be better equipped to advance medical research in the 21st century, solve major challenges, and optimize the delivery of human healthcare.”

“We hope that the proposal preparation at many institutions, whether funded or not, initiated conversations across disciplinary groups that might not have occurred otherwise and that will have lasting effects,” said Peter J. Bruns, HHMI vice president for grants and special programs. “Our goal is to facilitate changes in doctoral education that will enable biomedical scientists to work well across disciplinary lines.”

The new graduate training grants mirror HHMI's commitment to collaborative, interdisciplinary research by biologists, physical and computational scientists, and engineers at Janelia Farm, the Institute's new research campus that will open in 2006 in Loudoun County, Virginia.

University of California - Irvine

PD: Arthur Lander

Co-PD: Qing Nie (Mathematics), Eric Mjolsness (Computer Science), Steven George (Biomedical Engineering), Wesley Hatfield (Microbiology & Molecular Genetics), all from UC Irvine.

Core Leadership Team:

Title: Mathematical, Computational and Systems Biology

Systems biology studies organisms as integrated and interacting networks of genes, proteins and biochemical reactions. It is an inherently hybrid discipline that utilizes the tools of engineering, math, and computer science to address biological questions. Such a multi-disciplinary approach poses significant training challenges. To address those challenges, the University of California, Irvine is creating a new Ph.D. program in mathematical, computational, and systems biology (MCSB). Courses will focus on the essentials of biology, math engineering, and computer science, as well as on critical thinking and collaboration skills. MCSB students will also receive individualized mentoring. They will participate in summer workshops and journal clubs, and they will choose student research partners from academic backgrounds different from their own. The goal of MCSB is to produce scientists with sufficient depth to be leaders in their specialized areas, but also have the breadth of knowledge and skills to enable them to know when, how, and with whom to collaborate.
APPENDIX IX  Letters of Commitment from Participating Department

Below are the transcribed copies of the letters of commitment from the seven participating departments (with typos corrected). Images of the originals can be found at <http://ccbs.bio.uci.edu/Resources/MCB_Bylaws_1205.pdf>.

1. Microbiology and Molecular Genetics

Subject: RE: A Gateway Graduate Program in Mathematical and Computational Biology
From: "Bert Semler" <blsemler@uci.edu>
Date: Fri, February 11, 2005 11:21 am
To: adlander@uci.edu
Cc: FWAN@uci.edu

Dear Arthur:

Wes Hatfield forwarded your proposal to me regarding the graduate program in mathematical and computational biology. It looks like a great idea and something for which there is a real need at UCI. Given that there are at least six members of my department that would participate in this program (Wes Hatfield, Marian Waterman, Klemens Hertel, George Gutman, Ming Tan, and Ruslan Aphasizhev), I am requesting that we be considered as one of the founding participating departments. Due to Wes' significant leadership role in bioinformatics on this campus, I think this is an appropriate consideration.

Please contact me if you'd like to have further discussions about our participation in this program.

Thanks,

Bert

Bert L. Semler
Professor and Chair
Department of Microbiology and Molecular Genetics
School of Medicine, Med Sci B240
University of California
Irvine, CA  92697  USA

E-mail: blsemler@uci.edu
Phone: (949) 824-7573
FAX: (949) 824-2694
2. **Mathematics**

February 16, 2005

Professor Fred Wan
Drafting Committee
Mathematical & Computational Biology (MCB) Gateway Program

RE: Department of Mathematics Support of MCB Program

Dear Professor Wan,

The Mathematics Department enthusiastically supports the Mathematical and Computational Biology Graduate Gateway Program. This is an excellent and timely endeavor. The Mathematics Department is proud to be a Founding Participating Department of the Gateway Program and the Department agrees to honor all obligations associated with its participation.

Sincerely,

John Lowengrub
Professor and Chair
Department of Mathematics
3. Biomedical Engineering

May 6, 2005

Professor Fred Wan
Drafting Committee
Mathematical & Computational Biology (MCB) Gateway Program

RE: Department Biomedical Engineering Support of MCB Program

Dear Dr. Wan,
I have received the draft document describing the Mathematical and Computational Biology (MCB) Gateway Program, and would like to enthusiastically offer the endorsement of the Department of Biomedical Engineering as a founding department. BME will have several faculty actively engaged in this program including, but not limited to, Drs. Cristini, Kassab, Nenadic, Meyer, Brody, and myself. In addition, biomedical computation is research thrust for our department, and we have been seeking ways to provide depth in training for our graduate students in our different thrust areas. This concept of a gateway program is very timely. Graduate students entering the biomedical engineering graduate program from the MCB will need to satisfy all of the normal requirements, but I am very optimistic that this can be done in the first year of graduate study, and the BME faculty will attempt to devise such a plan in consultation with drafting committee of the MCB program.

Please let me know if you have any questions or need any additional information, and I look forward to working with on this exciting new graduate program.

Sincerely,

Steven C. George, M.D., Ph.D.
William J. Link Professor and Chair
August 3, 2005

TO: Dr. Arthur Lander, Chair of Developmental and Cell Biology

RE: Proposal for new gateway program in Mathematical and Computational Biology (MCB)

Professor Ray Luo presented the proposal for the MCB program to the faculty of Molecular Biology and Biochemistry (MBB) for comments. We received written comments from two faculty members and verbal responses from several others. We encourage that these comments be incorporated into the final proposal. From all of the responses, MBB is clearly supportive of the proposal and enthusiastically agrees that the application of Mathematical and Computational methods in Modern Biology will be crucial for analyzing the overwhelming amount of data that are generated from modern analytical methods. We have several faculty members who will benefit from being associated with this new and timely program.

Timothy F. Osborne
Professor and Chair
5. Developmental and Cell Biology

UNIVERSITY OF CALIFORNIA IRVINE: MOLECULAR BIOLOGY & BIOCHEMISTRY
Arthur D. Lander
Professor and Chair
Tel: 4-1721 Fax: 4-4709
adlander@uci.edu

August 24, 2005

TO: Frederic Y. M. Wan, Department of Mathematics

RE: Proposed new gateway program in Mathematical and Computational Biology

I am writing to confirm that the Department of Developmental and Cell Biology has discussed the written proposal to launch a graduate “gateway” program in Mathematical and Computational Biology. The Department strongly supports the establishment of this program, and several members of the Department are eagerly awaiting the opportunity to participate in it. The ability to better train graduate students in Mathematical and Computational Biology will be critical to the further development of Systems Biology at UCI, which is one of the Department’s long term goals.

Arthur D. Lander
Professor and Chair
6. **Ecology and Evolutionary Biology**

28 November 2005

Professor Fred Wan  
Mathematical & Computational Biology (MCB) Gateway Program  
Department of Mathematics  

RE: Departmental Support for the MCB Program  

Dear Professor Wan,

The Department of Ecology and Evolutionary Biology enthusiastically supports the Mathematical and Computational Biology Graduate Gateway Program. We would be proud to be among the Founding Departments in this Program and we will honor all obligations associated with membership.

Albert F. Bennett  
Professor and Chair  

---

7. **Computer Science**

November 28, 2005

Professor Fred Wan  
Drafting Committee  
Mathematical & Computational Biology (MCB) Gateway Program  

RE: Department of Computer Science Support of MCB Program  

Dear Professor Wan,

The Computer Science Department gives its enthusiastic support to the Mathematical & Computational Biology (MCB) Gateway Program. Given the inter-disciplinary nature of so much research in computer science, it is becoming increasingly important for us to train graduate students in multiple disciplines. This program provides a welcome mechanism to do so at the intersection of mathematics, computer science and biology. As a department, we agree to fulfill all the requirements to participate in this program.

Sincerely,

Sandy Irani  
Professor and Co-Chair  
Computer Science Department
8. Chemistry

PROFESSOR V. ARA APKARIAN, CHAIR
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CALIFORNIA
IRVINE, CALIFORNIA  92697-2025

January 23, 2006

Professor Fred Wan
Drafting Committee
Mathematical & Computational Biology (MCB) Gateway Program

RE: Department of Chemistry as a Participating Department of the MCB Program

Dear Professor Wan,

The Department of Chemistry is delighted to join the Mathematical and Computational Biology (MCB) Graduate Gateway Program, as a Participating Department. The concept and aims of MCB resonate with ongoing academic and research activities in our Department, and as such have our enthusiastic support. The Chemistry Department agrees to honor all obligations associated with its participation.

Sincerely,

V. Ara Apkarian, Chair
Department of Chemistry, UCI