

# **Proposal for a Program of Graduate Studies in Mathematical, Computational and Systems Biology**

**Submitted by the Drafting Committee**

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## **Executive Summary**

The biological sciences are entering a new era in which scientific advancement requires a quantitative understanding of large-scale and complex systems. Thus, there is a tremendous need to provide quantitative training for biologists and biological training for mathematicians, physical and computer scientists and engineers. To help to meet this need, we propose a stand-alone graduate program in Mathematical, Computational and Systems Biology (MCSB) leading to M.S. and Ph.D. degrees. The stand-alone MCSB program proposed here builds on the success of the current graduate gateway program in Mathematical and Computational Biology (MCB) and leverages the strengths of UCI, which include a NIH-funded National Center of Excellence in Systems Biology, an undergraduate training program in mathematical and computational biology (MCBU), a strong record of interdisciplinary collaboration at the interface between the physical, engineering, computational and biological sciences, and a considerable number of extramurally funded graduate trainee positions. The proposed MCSB program will preserve the current MCB structure, while presenting new options to graduate students. Specifically, the new program will provide more extensive interdisciplinary training than currently available. Once the MCSB program is approved, the current MCB gateway graduate program will become the “Department Option” of the MCSB program, through which students complete their graduate training in a traditional department setting. However, through the new “M.S.” or “Ph.D.” options, the MCSB program will now permit students to complete their graduate training in a fully interdisciplinary setting, at the conclusion of which they will receive a MCSB degree. All of the program’s core courses are already taught regularly. In the MCSB program, there will be two categories of faculty participants: (1) Faculty who participate solely in the Department Option and (2) Faculty who participate in the M.S. and Ph.D. Options. The latter group of faculty members will be expected to make funding commitments to their MCSB trainees according to guidelines established in this document. A modest amount of funding is requested for start-up and annual costs. The MCSB graduate program is not planning to request additional FTE faculty positions.

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## I. Introduction

### 1. Rationale

There are many in the scientific community who feel that biology is in the midst of a revolution, not unlike the molecular biology revolution that radically transformed the discipline between the 1950s and the 1980s. In fact, the present revolution can be seen as a direct response to the successes and failures of the last one. In the successes column, molecular biology gave us great power to identify, sequence and manipulate genes. It produced an intellectual framework for understanding biology that was based fundamentally on molecular mechanisms, typically presented in terms of linear pathways of causality (the ubiquitous “wall-charts” and “arrow diagrams” that fill molecular biology textbooks).

In the failures column, molecular biology sought so hard to reduce biology to a compendium of isolated physico-chemical mechanisms that it neglected the complexities introduced by networks, dynamics, mechanics, etc. It focused so narrowly on “how” (as in how things work) that it suppressed inquiry into “why” (as in why things are the way they are). It sought to relegate the more holistic traditions of physiology, ecology and evolutionary biology to the intellectual sidelines. That these are serious failings has become increasingly clear in recent years thanks to the rise in “high-throughput” approaches to data gathering in biology. As a result of these technological breakthroughs, it is now clear that most genes and gene products interact in massively interconnected networks; that dynamics and stochastics play a critical role in determining how these networks behave; and that high-level engineering concepts, such as “design”, “strategy” and “optimization” must be a necessary component of any fruitful theory of the way biological systems are organized.

In 2009, the National Research Council of the U.S National Academy of Sciences (US-NAS) appointed a committee to investigate the early progress of the *current* biological revolution, and make recommendations on how academic organization, research infrastructure and personnel training might be altered to take advantage of the changing scientific landscape. Entitled, “The New Biology of the 21<sup>st</sup> Century”, the committee remarked in their introduction that,

*“the essence of the New Biology...is integration—re-integration of the many sub-disciplines of biology, and the integration into biology of physicists, chemists, computer scientists, engineers, and mathematicians to create a research community with the capacity to tackle a broad range of scientific and societal problems. Integrating knowledge from many disciplines will permit deeper understanding...”*

In effect, the committee recognized that the forces currently transforming biology were inherently *interdisciplinary*, and they were bringing into biology a set of approaches and methodologies more diverse than those ushered in by any previous biological revolution (or, arguably, any scientific revolution since the Renaissance). They also recognized that the goal of such interdisciplinarity was not merely the acquisition of new knowledge but

the synthesis of new and deeper understanding. They portrayed the “New Biology” not just as a novelty field, but as a fundamental re-alignment of the priorities of biology overall. They made a variety of specific recommendations, including the establishment of a national inter-agency initiative to accelerate the emergence and growth of the New Biology, to foster the development of information technologies and other foundational infrastructure, and to support the creation and implementation of interdisciplinary curricula, graduate training programs, and educator training needed to create and support New Biologists.

In fact, at the time of the US-NAS report, U.S. funding agencies, notably the National Institutes of Health (NIH) and the National Science Foundation (NSF), had already been promoting interdisciplinary initiatives at the interface between biology and other sciences. The consequence of this is that although the term “New Biology” has not generally been adopted—“Systems Biology” seems to have won the revolutionary name game—the spirit of the US-NAS recommendations has been adopted. Initiatives to promote Systems Biology are blossoming around the world, with the U.S., Europe and Japan leading the way. Textbooks, new journals, new departments, new international meetings have all sprung up in a relatively short time. Among the most recognizable features of current research in Systems Biology are:

(1) *A strong focus on dynamics and modeling.* Math, physics, chemistry, engineering, and computer science have developed sophisticated tools for analyzing and modeling complex, dynamical systems. Until recently, only a small fraction of biologists have used such tools. The drive to understand complex, large-scale biological organization is rapidly changing this. Along with an influx of practitioners from each of these fields into biology, we are seeing a dramatic increase in the amount of modeling and computation in the biological literature.

(2) *Quantitative experimentation.* Only through the collection of sufficiently precise, quantitative data can modeling, analysis and computation be exploited to their full potential. Accordingly, a push for more quantitative experimentation has become a hallmark of Systems Biology.

(3) *Incorporation of concepts from control engineering.* Nobody understands design principles better than engineers. Within engineering, the field of control offers a conceptual framework that is especially appropriate for understanding biology, as well as an extremely powerful set of modeling, analysis, and optimization tools.

(4) *Informatics and statistics.* Complexity arises in biology from two sources: intricacy (small numbers of elements with complicated interconnections) and massiveness (enormous numbers of elements). The need to manage (store, search, mine, update) massive data sets has drawn large number of computer scientists to the informatics side of Systems Biology. The need to explore such data sets in the context of multiple sources of variation and uncertainty has required the active participation of statisticians as well.

Given the increasing demand for researchers with new skills and knowledge that such changes have brought about, it is not surprising that graduate degree programs have, over the past few years, been springing up around the world at the interface between mathematics, computation, physical sciences, and engineering and biology, including

programs specifically focused on Systems Biology. A collection of such programs is given in **Appendix 2**. Related to this effort, a 2005 Howard Hughes Medical Institute (HHMI) Interfaces Initiative (organized jointly with the NIH) sought to stimulate the establishment of new training programs for interdisciplinary graduate education in the biomedical sciences. More than half of these awards (listed in **Appendix 4**) supported the development of programs with a mathematical, computational or systems biology focus, including a program based at UCI, that provided early support for the highly successful MCB gateway program (described below), out of which the present proposal has evolved. Very recently, HHMI also awarded funding to the Center for Complex Biological Systems (CCBS) at UC Irvine for a regional workshop held in January 2013 focusing on the best practices of teaching Systems Biology. Finally, several individual institutes within the NIH have recently called for applications for new training programs in the area of Systems Biology.

## ***2. History of mathematical, computational and systems biology at UCI***

UCI has emerged as a leader in mathematical, computational and systems biology thanks to effective interdisciplinary collaborations, and strong support from extramural funding agencies and the UCI Administration. The first attempt to organize Systems Biology at UCI was spearheaded by the former-Interim Executive Vice Chancellor Susan Bryant, who developed a proposal for a California Institute of Systems Biology, in response to the governor's call for Institutes for Science and Innovation in 2000. Although the proposal was not funded (The UCI/UCSD collaboration that became Cal-IT<sup>2</sup> was chosen instead), it was shortly followed by the official incorporation of the already-functioning *Institute for Genomics and Bioinformatics (IGB; <http://www.igb.uci.edu/>)* as an organized research unit (ORU). IGB, which focuses on the interface between computer science and biology, has thrived as an ORU, and was particularly successful in attracting training funds, in the form of a large NIH-sponsored Bioinformatics Training Grant (BIT).

In 2001, an informal center, the *Center for Complex Biological Systems (CCBS; <http://ccbs.bio.uci.edu/>)* was organized to foster interactions among researchers focusing on systems biology, including synthetic biology, genomics, molecular biology, bioengineering, computational biology, and mathematical biology. CCBS initially came together to apply for a \$450,000 NIH planning grant in Complex Biological Systems research, which it received in 2002. These funds were used to support infrastructure development and collaborations that led to several large research awards to teams of biologists and mathematicians.

In 2007, CCBS was awarded an NIH grant to fund a National Center of Excellence in Systems Biology. This 5-year, \$15M grant supported research projects, infrastructure development, and graduate training in Systems Biology. UCI was the first UC campus, and the first in the southwestern region of the U.S., to receive a National Center of Excellence in Systems Biology. UCI is now one of 18 such centers, including recently established centers at UCSF, UCSD, and Berkeley (see **Appendix 3**). In Fall 2012, the 5-year grant to CCBS was competitively renewed for an additional five years.

In 2009, CCBS faculty members were awarded a prestigious Grand Opportunity grant by the National Cancer Institute of NIH. This 3-year, \$2M grant supported research, computational infrastructure, and graduate and postdoctoral training at the interface between mathematics, computation and the systems biology of cancer.

In summer 2010, the UCI Institute for Clinical & Translational Science (ICTS) received a 5-year \$20M NIH grant to facilitate the transformation of scientific discoveries into medical advances for patients. This grant provides support for research in translational science as well as for training of graduate students and clinicians. Provisions were outlined in the ICTS grant proposal to make training offered through the MCSB program available to ICTS scholars.

In summer 2011, CCBS was awarded a five year \$850,000 NIH grant to support a three-week “short course” in Systems Biology to be offered annually to students, postdoctoral fellows, academic faculty, and industry researchers from around the world.

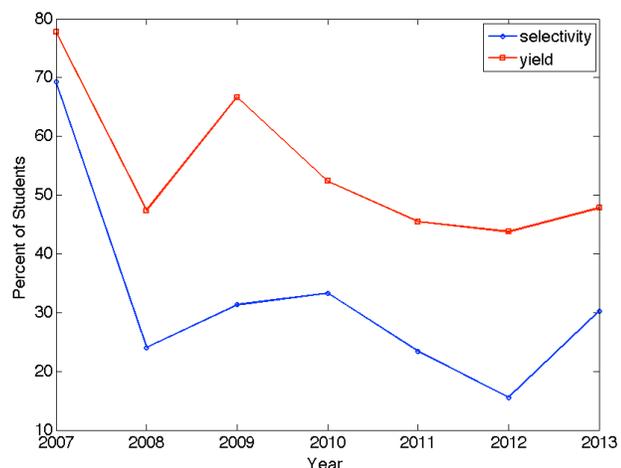
In fall 2011, CCBS faculty members were awarded a 5-year \$800,000 grant to establish a Mathematical and Computational Biology Program for Undergraduate Students (MCBU). This program provides undergraduate students training and research experience at the interface of biology, mathematics and computational science. This program provides both summer and academic year support for undergraduate students.

The UCI Administration also recognized the excellence of the UCI program in 2008 by awarding CCBS 7 FTE for the recruitment of faculty members in systems biology. All 7 faculty members have now been recruited.

### ***3. Training in mathematical, computational and systems biology at UCI***

With financial assistance from a 3-year, \$1M grant in 2006 from the Howard Hughes Medical Institute (HHMI) to support new graduate training initiatives at the interfaces between biology and the quantitative sciences (see section 1D), UCI took the first steps toward developing a training program plan that culminates in the present proposal.

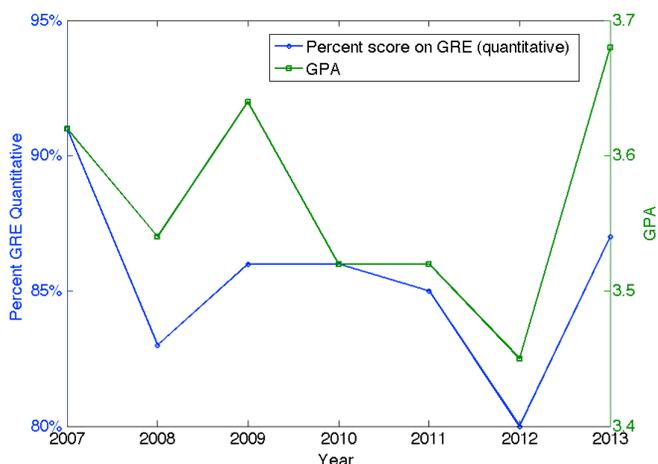
The first stage of this plan was to implement a “gateway” graduate program, entitled *Mathematical and Computational Biology (MCB*; <http://mcsb.bio.uci.edu/>), which was approved by graduate council, and admitted its first



**Figure 1. Selectivity (blue) and yield (red) for the current MCB graduate gateway program.**

class of students in Fall 2007. This program enlists the training support of faculty in 10 departments (Biological Chemistry, Biomedical Engineering, Chemistry, Computer Science, Developmental & Cell Biology, Ecology & Evolutionary Biology, Molecular Biology & Biochemistry, Microbiology & Molecular Genetics, Mathematics, Physics & Astronomy) in 5 schools (Biological Sciences, Engineering, Information and Computer Sciences, Medicine, Physical Sciences), and provides an avenue by which students from a variety of undergraduate backgrounds (e.g., math, physics, chemistry, engineering, computer science, biology) can focus on common themes in mathematics, computation and systems biology during their first year of training, followed by thesis research in a traditional department (leading to a departmental degree).

Thus far, the MCB program has been very successful, as measured quantitatively by a number of factors. In **Fig. 1**, the selectivity (percent of applicants who are admitted) and the yield (percent of admitted students who enroll) are shown for the MCB gateway program since its inception in 2007. Except for the first year where the program was just getting underway, about 25% of the applicants were admitted while about 50% who were admitted actually enrolled.



**Figure 2. Averaged GPA (green) and GRE (quantitative, blue) scores for students entering the MCB gateway program.**

Our selectivity measure is larger than campus averages (about 20%) because our applicant pool self-selects more efficiently than applicant pools of other programs. For example, because our requirements are sufficiently stringent and transparent (e.g., students need the ability to handle serious math and biology courses), many students who aren't appropriate for the MCB gateway program know this right away and do not bother to apply. In contrast, other programs get a lot of inappropriate applicants who are then rejected. As can be seen from **Fig. 2**, our enrolled students are highly qualified, as measured by their GRE scores and GPAs. As a cautionary note, we believe that selectivity should not be used to compare across programs with very different applicant pools and different transparency of requirements.

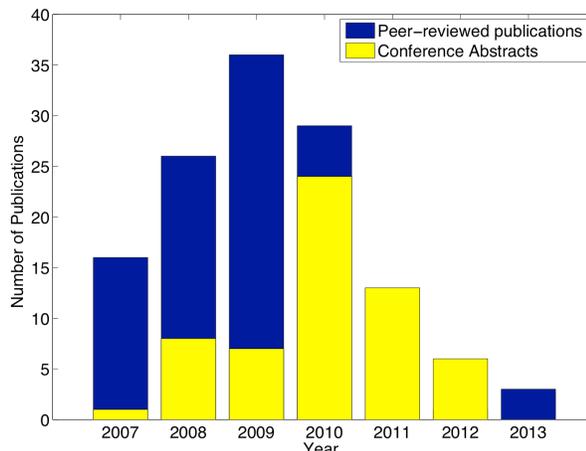
From 2007-2013, the MCB gateway program received 13, 79, 65, 63, 93, 104, and 76 applications while the actual number of enrolled students during this period was 7, 9, 14, 11, 10, 7 and 11 respectively. The MCSB program has so far enrolled 69 students, 19% of whom self-identify as URM and 33% are women.

MCB students have excellent undergraduate records as evidenced by their high GPAs and GRE (quantitative scores) as shown in **Fig. 2**. Average student GPAs range from about 3.45 to nearly 3.7 (out of 4.0) and the GRE scores range from about 80% of the total

possible score (not percentile) to nearly 95%. In fact, by these measures, the 2013 class promises to be the best yet.

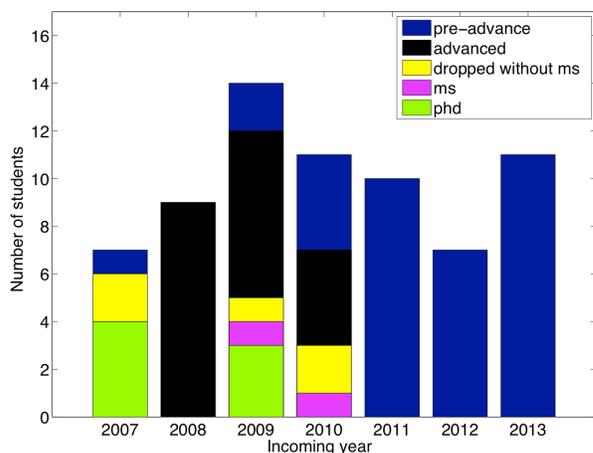
Thus far, three MCB students have been awarded NSF graduate fellowships, and several others have received honorable mention. In addition, two students are supported by UC-MEXUS grants, and one student is supported by an AAUW fellowship. Several other students are

supported by campus fellowships and NIH training grants. Since students in the MCB gateway program are currently being strongly encouraged to apply for extramural graduate fellowships, the number of extramural fellowship applications from students in the MCB gateway program is increasing every year. This, combined with the information sessions organized by Graduate Division, leads us to expect that the rate of success by MCB students in acquiring extramural graduate fellowships will increase. Once students enter the MCB gateway program they are highly productive. In **Fig. 3** below, we show the numbers of publications by students in the gateway program as a function of their entering year. The numbers of student publications in peer-reviewed publications are shown in blue, while yellow denotes the number of published abstracts. Thus far, students in the MCB program have an exemplary publication record. The student cohorts entering years 2008-2010 have each published more than 25 peer-reviewed papers and abstracts. As the remaining students finish their studies, the number of publications is expected to increase correspondingly. For example, we expect that a significant fraction of the conference abstracts will ultimately be expanded and published in peer-reviewed journals. Further, the large number of conference abstracts also suggests



**Figure 3. Publications by students in the current MCB gateway program, by entering-year cohort. Blue: peer-reviewed, Yellow: Conference abstracts.**

that the research that our students are producing is having a significant impact on the scientific community. MCB students are also publishing in first-rate journals. More than 26 papers published by MCB students have appeared in journals with impact factors of about 4 and higher, including Proceedings of the National Academy of Sciences (6 papers), Nature (2 papers) and Nanoletters (2 papers).



**Figure 4. MCB gateway program outcomes.**

The outcomes of the MCB gateway

program are shown in **Fig. 4** below. Although the program has only been admitting students since 2007, already 9 students have received degrees—7 Ph.Ds (BME—2 students, Dev.Cell—2 students, Math—3 students) and 2 MS (Eco.Evo and Dev.Cell). Of the 69 students who enrolled in the program, only 5 have left without a degree (approximately 7%). Of these 5, all successfully finished the MCB gateway year. The 2009 MCB class is exceptional with 4 students receiving degrees in four years (3 PhD, 1 MS). Note that since students achieve their degrees through traditional departments, the rates at which students progress, after their MCB gateway year, strongly depend on individual department requirements.

Students in the current MCB gateway program need to be interdisciplinary and yet must satisfy traditional department requirements. For example, MCB students normally do not start fulfilling department requirements until their 2<sup>nd</sup> year at UCI, which is their 1st year in a traditional department program. Thus, interdisciplinary students sometimes need a little more time because we are asking them to stretch themselves intellectually more than in other programs. Nevertheless, by exposing students to research in mathematics, computation and experimental biosciences early on (through their coursework and laboratory rotations), the MCB gateway program can help to accelerate the students' progression to and completion of their dissertation research, once they have fulfilled course and exam requirements.

We believe that student time-to-degree (**TTD**) will be improved with an independent degree program. Students who wish to work at the boundary between disciplines will not be slowed down by the need to complete department requirements that are less relevant for their chosen program of study. In many cases, this could reduce the TTD by one year. For departments, such as mathematics where the graduate program is exam-heavy, this could even reduce the TTD by two years.

The MCB program graduates have done very well. Eight out of the 9 program graduates are currently employed in either postdoctoral positions in prestigious universities/research labs (e.g., Pierre-Marie Curie University in Paris, University of Hawaii, Salk Institute) or in positions in industry (e.g., Intel, Genzyme, Audience Inc.) in the US and abroad. In addition, three out of the 5 students who left UCI without a degree are currently employed in industry and a fourth is in the Business School at Stanford University. In all cases, the students' interdisciplinary training was key to their post-graduation employment and success.

In 2009, CCBS received two NIH graduate training grants totaling \$2.4M, to support students in mathematical, computational and systems biology; and students in the area of systems biology applied to developmental biology. These grants support a total of 13 students annually, most of who come from the MCB program. In addition, for the past 10 years, the IGB has held a \$5.6M NIH Grant (2007-2012) for training students in the biomedical information sciences (BIT training grant). This grant has supported up to 18 students a year in the past (currently it supports 6), with several of the traineeships going to MCB students each year. Recently, UCI was awarded an NSF training grant (IGERT) in Biophotonics, an interdisciplinary area that has consistently attracted several MCB

students in each class.

**Appendix 5** lists the current institutional training grant support available to all faculty members, departments and programs at UCI. From this it can be seen that the training slots associated with these three training grants have consistently constituted a substantial portion of all Ph.D. training grant support at UCI. These awards provide additional validation of the quality, direction and leadership of the UCI effort in the field of mathematical, computational and systems biology.

There is now an undergraduate training component in mathematical and computational systems biology (MCBU) at UCI, which is supported by a 5-year NSF Grant. Opportunities for the MCBU students include: foundational courses in biology, mathematics and computation, a year-long interdisciplinary course in Mathematical Modeling in Biology with emphasis on ties to current research, summer training boot camp in systems biology, year-long mentored interdisciplinary research led by a team of math and biology faculty, and attendance and participation at interdisciplinary mathematical biology and modeling conferences. The MCBU program includes a new major and minor in computational mathematical biology in the mathematics department.

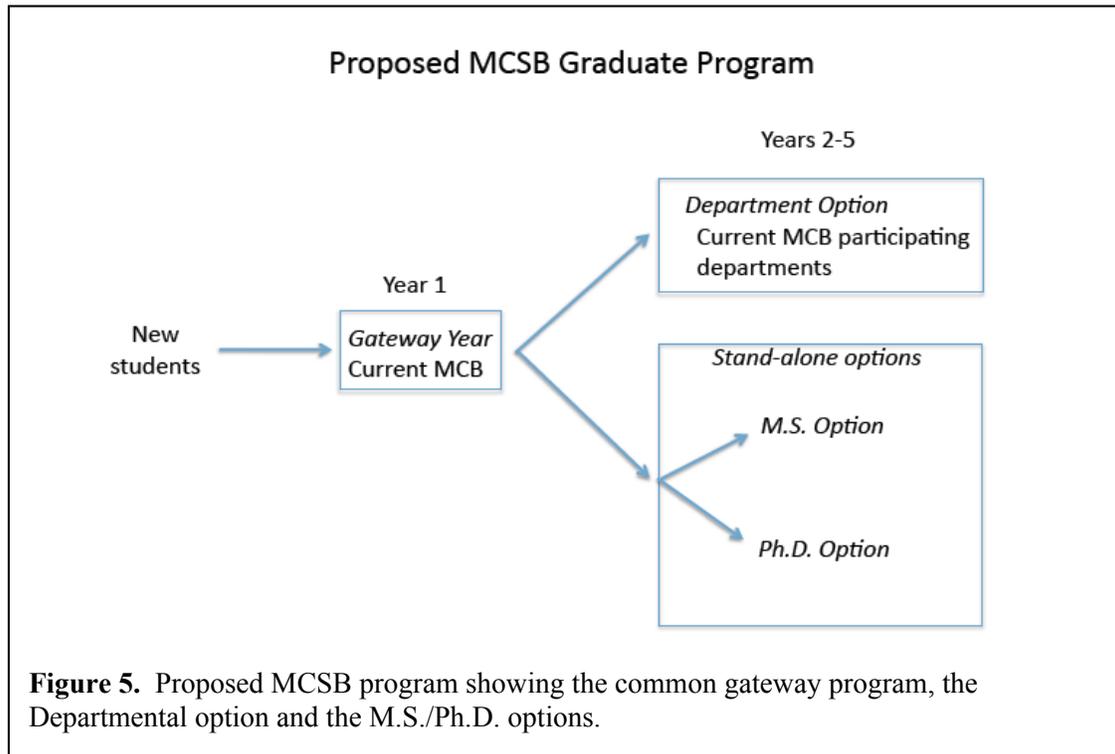
The program proposed in the present document builds on the success of the MCB graduate gateway program, and fulfills the second phase of the plan initially outlined in the HHMI proposal. As discussed further below, when the new program is approved, the MCB gateway program will become the “Department Option” of a larger *Mathematical, Computational and Systems Biology* (MCSB) program, which will also include “M.S.” and “Ph.D.” options that provide trainees with sustained interdisciplinary training throughout their graduate studies.

#### ***4. Aims and objectives of the proposed program***

As described in the US-NAS report on “A New Biology for the 21<sup>st</sup> Century”<sup>3</sup>, it is anticipated that biologists will increasingly work at the interface with disciplines such as mathematics, computer science, physics and engineering. Obtaining appropriate training for such activities poses challenges for traditional training programs. In particular, the traditional organization of graduate programs around single departments tends to limit the range of training a student may receive. The MCB gateway program was initiated as the first phase of a solution to this problem. MCB provides intense, one-year, interdisciplinary training that allows students to join traditional departments with a breadth of skills and knowledge that enhance their ability to contribute to the “New Biology”.

This approach serves the needs of many students, as attested to by the great success (both in terms of student numbers and quality) that the MCB program has enjoyed since its inception. However, for some students, particularly those seeking to undertake the most creative, forward-looking research, the requirement to complete a Ph.D. within a traditional department can be a hindrance. For such a student, the curricular requirements of no single department may be appropriate.

The MCSB program proposed here (see **Fig. 5** below) is developed, in part, to serve the needs of such students, among whom the leaders of the “New Biology” are especially likely to come. In addition, the MCSB program is designed to serve the needs of students who, for various reasons, would benefit by a short-term M.S. degree program in mathematical, computational and systems biology.



In fulfilling these functions, the MCSB program will be able to attract new, highly qualified students to UCI, beyond those now already enrolling in MCB, and to provide them with a unique academic experience of the highest quality and greatest societal and career relevance. In particular, the MCSB program will provide three options:

- A new integrative M.S. degree that is attractive to those headed toward industrial research, is attractive to existing professionals (such as those with Ph.D.’s in other areas), and provides a stepping-stone for future studies, such as the Ph.D. or other degrees in fields where systems biology may be expected to play an important role in the future (e.g. medicine, business, communications, and law);
- A new kind of Ph.D. degree that fully integrates training in the biological, physical, computer, and engineering sciences, and is attractive to those seeking leadership positions in top academic, governmental and industrial research environments.
- A traditional M.S. or Ph.D. degree through one of the departments that currently

participates in the MCB graduate gateway program<sup>1</sup>.

Students who enter the program will be apprised of their options early and often through information sessions and advising from their faculty mentors.

The MCSB program can be expected to increase UCI's already strong visibility in mathematical, computational and systems biology, and should enhance the ability of UCI faculty in many departments and schools to compete for and obtain research and training grants from extramural sources.

### ***5. Timetable for development of the program***

The program will become operational as soon as it is approved.

Faculty: The program will start with the faculty listed in Section IV, below. The program will not request FTE allocations, as an allocation for Systems Biology has already been awarded through the Provost's Programs of Excellence Initiative, as indicated above. We also expect that the number of faculty in the program will likely grow as additional faculty are recruited through the normal departmental hiring, and as the research interests of existing faculty change over time to become more aligned with the goals of the program.

Students: As soon as the MCSB program is operational, any students currently enrolled in the MCB gateway program will have the option to continue either under current MCB rules and guidelines, or under the new rules and guidelines outlined here. We will hold information sessions for current students apprising them of their options. Beginning immediately after approval, the MCSB program will also begin accepting applications for its first year of operation. In future years, the MCSB admissions process will supplant the current MCB admissions process.

During the first MCSB admission cycle, some students who had previously moved from the MCB program to traditional departments might wish to transfer to the Ph.D. option of the MCSB program. Such moves will be handled in the same way as other graduate program transfers at UCI, following all appropriate guidelines of the Graduate Division.

Based on the current MCB gateway numbers, and allowing for increased intake due to the greater range of options provided by the MCSB program, we anticipate a typical first-year MCSB class size consisting of about 15 Ph.D. students and 4 M.S. students (if additional faculty members join the program, student numbers may grow proportionally). Of these 15 Ph.D. students, we expect that about one half to two thirds will choose the

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<sup>1</sup> The ten Departments participating in the current MCB gateway program are: Computer Science (ICS), Biomedical Engineering (Eng.), Dev. & Cell Biol. (Biosci.), Ecol. & Evol. Biol. (Biosci.), Mol. Biol. & Biochem. (Biosci.), Microbiol. & Mol. Genetics (SOM), Biol. Chem. (SOM), Chemistry (PS), Math (PS), Physics & Astron. (PS).

departmental option at the end of their first academic year, with the remainder continuing on in the extra-departmental, interdisciplinary “Ph.D. option” (**Figure 5**).

Courses: All of the program’s courses (listed in **Section V**) are already being taught regularly. All of these courses are listed under one or more departments, depending upon the departmental homes of the teaching faculty. The corresponding departments plan to continue offering the core courses every year as indicated in **Appendix 15** where each of the Department Chairs have provided a Memorandum of Understanding regarding the continuance of the core courses.

Most of the program’s courses serve students in existing departmental programs including those in biology, mathematics, physics, biomedical engineering, and computer science. Over time, we expect that additional new courses may be introduced.

Staff and facilities: The program will have a Program Director, one or more Associate Directors, an Administrator, a Gateway Committee, an Executive Committee (a subset of the Gateway committee plus several at-large members), a Dean’s Advisory Committee (consisting of the Deans of the Graduate Division, Biological Sciences, Information and Computer Sciences, Engineering, Medicine, and Physical Sciences) and 2-member student advisory committees. The positions will be filled and the committees constituted as soon as the program is approved (see bylaws, **Appendix 1**). Facilities available to the program include administrative and teaching space allocated by the School of Biological Sciences to the Center for Complex Biological Systems (CCBS); training space allocated by the School of Physical Sciences to the Center for Mathematical and Computational Biology (CMCB); and computational facilities operated by CCBS, CMCB and the Center for Computational Morphodynamics.

## ***6. Relation of the proposed program to existing programs***

As described in **Section I.3**, a graduate gateway program in Mathematical and Computational Biology (MCB) has been in existence at UCI since 2007. The activities of MCB would remain largely unchanged as a result of this proposal, but they would be renamed the “Departmental Option” of the MCSB program (**Fig. 5**).

The departments that currently participate in MCB (see **Appendix 1, Article III**) each have their own graduate programs, and each has some potential for overlap with the MCSB program. These include programs in Cellular and Molecular Biosciences, Developmental and Cell Biology, Ecology and Evolutionary Biology, Molecular Biology and Biochemistry, Biological Chemistry, Microbiology and Molecular Genetics, Mathematics, Physics, Computer Science, and Biomedical Engineering. Several of these departmental programs allow a limited number of MCSB courses to satisfy elective requirements. Overall, however, the MCSB curriculum, as outlined below, differs greatly from the core curricula of every individual graduate program at UCI.

## ***7. Interrelationship of the program with other UC institutions***

Many campuses of the University of California now offer graduate programs in fields related to mathematical and computational biology and/or systems biology. These range from concentrations in specific programs within existing Departments, sometimes accompanied by an interdisciplinary designated emphasis, to several stand-alone graduate programs. For example, at UCLA there is a Biomathematics Department, which is located in the School of Medicine. Stand-alone graduate programs exist at UC Berkeley (Biophysics, Biostatistics), UC San Diego (Bioinformatics and Systems Biology), UC Merced (Quantitative and Systems Biology), UCSF (Biological and Medical Informatics, Integrative Program in Quantitative Biology), and UCSB (Biomolecular Science and Engineering Program).

The large number and rapid growth of such programs at UC campuses attests the growing importance of quantitative, interdisciplinary approaches in biology. The UCI MCB program is already one of the largest and most established of these programs. With approval of MCSB, UCI will acquire a pipeline for interdisciplinary training that will be exceptionally broad and deep, providing students with training opportunities that are unique among UC campuses, and within the nation overall.

#### ***8. Department or group that will administer the program***

A brief summary of the administrative structure of MCSB is provided here. A more detailed description can be found in the program bylaws given in **Appendix 1**.

The MCSB program will have

- A Program Director;
- A Gateway Committee;
- An Executive Committee;
- A Dean's Advisory Committee;
- A Program administrator.

The Gateway Committee will supervise the first (gateway) year of the program, and provide ongoing mentoring to students who choose the Department Option. This committee will also provide representation, from the current MCB participating departments, in program governance and admissions.

The Executive Committee, which will be a subset of the Gateway Committee plus at-large members, will supervise the M.S. and Ph.D. options, and will be responsible for selection and approval of student advisory committees. The Executive Committee will serve as the primary governing body of the program. The specific duties of the Program Director, Gateway and Executive Committees are described in **Appendix 1, Article IV**. The Program Administrator will help with day-to-day operations and act as a student affairs officer.

The Dean of Graduate Division will oversee the MCSB program, consistent with the guidelines for interdisciplinary graduate programs established by the UCI Graduate Council<sup>2</sup>. The Graduate Dean and all the School Deans are amenable to this arrangement (see the Dean's support letters in **Appendix 9**). In consultation with the MCSB Executive Committee, the Graduate Dean will appoint a Program Director. The initial appointment will be for a three-year term, renewable given satisfactory performance. The Program Director will act as the Chief Executive Officer and Chief Financial Officer of the MCSB program. The Program Director will report directly to the Dean of the Graduate Division. The Program Director will appoint one or more Associate Directors with specific responsibilities as outlined in the bylaws given in **Appendix 1**.

A Dean's Advisory Committee consisting of the Deans of the participating Schools—Biology, Information & Computer Science, Engineering, Medicine and Physical Sciences-- will meet annually with the Program Director and the Dean of the Graduate Division to discuss the state of the MCSB graduate program, identify the best practices and suggest potential improvements. See attached letters from the Deans of the participating schools confirming their interest in participating on the Dean's Advisory Committee (**Appendix 9**).

### ***9. Plan for evaluation of the program***

UCI has a policy of regularly reviewing graduate programs every 7 - 10 years. The MCSB M.S. and Ph.D. program will be reviewed as part of the normal review process. In addition, as long as CCBS remains a national center of excellence in systems biology, CCBS will perform a review of the MCSB program as part of its annual review process. Further, one of the NIH training grants (**Appendix 5**) is targeted specifically for the MCSB program and thus an evaluation of that training grant will also serve as an evaluation of the MCSB program. Finally, program-learning outcomes will be identified and plans for assessment of these outcomes will be developed

The following data will be gathered to aid in the review of the M.S. and Ph.D. 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
- Preliminary and qualifying exam results

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<sup>2</sup> <http://www.senate.uci.edu/Councils/GC/IGP-rev%2007.2010.pdf>

- Rotation reports
- Advising committee reports
- Attrition rates

#### **Student Outcomes.**

- Honors
- Awards
- Publications
- Time to degree
- Subsequent employment

### ***10. Diversity***

The current MCB gateway program has a strong track record of recruiting, training, and promoting the careers of under-represented minorities (URM) in Systems Biology. The MCSB program has so far enrolled 69 students, 19% of whom self-identify as URM and 33% are women who are considered URM in the mathematical, computer and engineering sciences. The retention of URMs in the gateway year has so far been 100%, although 1 URM student declined to transfer to a UCI department after the first year and instead chose to pursue a business degree at Stanford. We aim to continue making special efforts at recruiting and retaining URMs in the proposed M.S. and Ph.D. programs.

**Recruitment efforts.** Through a national network of contacts and access to recruitment venues via UCI Graduate Division, we are able to contact (and recruit) students from a range of institutions and graduate preparation programs including the **McNair Scholars Program**, the Minority Access to Research Careers (**MARC**) program, and the Minority Biomedical Research Support (**MBRS**) program. Participating faculty members frequently participate in graduate recruitment fairs at UC and Cal State University campuses. We also send student and faculty representatives to recruitment fairs/research conferences that target URM students in the STEM disciplines, such as **SACNAS** (Society for the Advancement of Chicanos and Native Americans) and **ABRCMS** (Annual Biomedical Research Conference for Minority Students). The Center for Complex Biological Systems at UCI (**CCBS**) hosts the annual **SoCal SysBio Conference**, which brings students and researchers from 12 UC and Cal State Institutions to UCI; 5 of these, including UCI, are considered US Gov Title III-V eligible “minority serving institutions.” CCBS-supported outreach activities like the Undergrad Student Initiative for Biomedical Research engage URM community college students. Locally, participating faculty members are also institutional planning committee members and active recruiters/presentation judges/conference participant mentors in the **California Forum for Diversity in Graduate Education**, which takes place twice yearly.

**Retention efforts.** The recruitment of underrepresented groups alone, however, is not sufficient to address the issue of underrepresentation in teaching and research. Student success depends critically on the academic and social environment, which is defined primarily by the active interest and initiatives of the administration, faculty, and staff, and the motivation and high expectations they instill in students as teachers, mentors, and role

models. The current MCB gateway program has strived to create a nurturing atmosphere for its graduate students through faculty mentoring, summer bootcamps, a common first-year curriculum, research rotations and yearly retreats. These efforts will continue in the proposed M.S. and Ph.D. programs.

In addition, we also encourage students to take advantage of the UCI-wide resources. For example, the UCI Graduate Resource Center (**GRC**), administered by the Graduate Division, functions as a central hub for all graduate student support services at UCI. The GRC runs quarterly workshops on professional and career development, graduate-level writing, funding workshops, work/life balance and diversity programs through a Diverse Educational Community and Doctoral Experience (**DECADE**) program, sponsored by a Department of Education FIPSE Comprehensive grant. The GRC also conducts graduate preparation services for UCI undergraduates interested in pursuing an advanced degree. In addition, the UCI Cross-Cultural Center offers a supportive social and academic atmosphere for all students and provides a study lounge, office space for clubs and organizations, a conference room, and supports annual special events that celebrate campus diversity.

## **II. Program and courses**

### ***1. Undergraduate preparation for admission***

Potential graduate students for the MCSB Program will apply through the Office of Graduate Studies (OGS) and indicate on their applications their interest in the Program. Applicants will specify that they wish to pursue a M.S. or a Ph.D. degree. Upon completion of the M.S. Degree, those M.S. students who may wish to pursue a Ph.D. may request to be evaluated together with the pool of prospective Ph.D. candidates for admission to the Ph.D. program.

Applicants are expected to hold a Bachelor's degree in one of the Science, Technology, Engineering, and Mathematics (STEM) fields.

Applicants will be evaluated on the basis of their prior academic record and their potential for creative research and teaching, as demonstrated in submitted application materials. These materials will include official university transcripts, letters of recommendation, GRE scores, and Statement of Purpose.

***2. Foreign language requirement:*** None

### ***3. Program of study***

***(a). Specific fields of emphasis:*** None

***(b). Plans: Department Option (current MCB gateway graduate program), Stand-alone Option: M.S., Ph.D.***

***(c). Unit requirements:***

***Department Option (current MCB gateway graduate program):*** 7 courses (28 units), in addition to a first-year Bootcamp, and at least 2 laboratory rotations, as detailed below.

***Stand-alone Options:***

***M.S.:*** There are two options for the M.S. degree: (i) a research thesis option (which requires 9 courses—36 units) and a (ii) literature thesis option (which requires 12 courses—48 units), in addition to a first-year Bootcamp. In both options, students must be supervised by a training faculty participating in the MCSB Ph.D. option and their choice of research or literature thesis must be approved by the MCSB Executive Committee in consultation with the Program Director and their faculty supervisor. The normative time to the M.S. degree is two years, and the maximum time to the M.S. degree is 3 years.

**Ph.D.:** 12 courses (48 units), in addition to a first-year Bootcamp, 2 laboratory rotations, and a dissertation. The normative time to the Ph.D. degree is 5 years, and the maximum time to the Ph.D. degree is 7 years.

***(d). Course requirements***

In the first (gateway) year, students in the Department Option and the Stand-alone Ph.D. Option will take the same courses and have the same requirements.

***Department Option (current MCB gateway graduate program):***

*Required:* Attendance at Bootcamp just prior to the start of the student's first year in the program.

*Required:* 7 core courses from the Biology Core I-III and the Math/Comp Core I-III, and the Critical Thinking course. See below.

*Required:* A minimum of two laboratory rotations to be taken either in the Fall, Winter and Spring quarters during the student's first year in the Program (it is expected that most students will choose to complete three rotations)

Students who successfully complete the first (gateway) year of study (See **Appendix 1, Article V**) who choose the Department Option must identify a participating host Department (See **Appendix 1, Article III**) and a faculty member in the host Department who is willing to supervise their Ph.D. training and dissertation research (including making whatever financial support commitments are normally required of dissertation supervisors in the host Department). Per the terms of departmental participation in the program, students who fulfill these requirements are automatically eligible for enrollment in the Ph.D. program of the host Department, without need for further application or review.

***Stand-alone M.S. Degree Option:***

*Required:* Attendance at Bootcamp just prior to the start of the student's first year in the program.

*Required:* 7 core courses. See below.

*Required elective courses:* 2 electives (research thesis option) or 5 electives (literature thesis option). The elective courses may be selected from Categories I, II or III listed below.

In rare cases, students may request to transfer from the Ph.D. Program to the M.S. Program. In such cases, the student must spend at least one year in the M.S. Program before receiving the M.S. degree, unless an exception is made by the Program Director in consultation with the Executive Committee.

### ***Stand-alone Ph.D. Degree Option:***

*Required:* Attendance at Bootcamp just prior to the start of the student's first year in the program.

*Required:* 7 core courses. See below.

*Required elective courses:* 5 courses selected only from Categories I and II.

*Required:* Two laboratory rotations to be taken either in the Fall, Winter and Spring quarters during the student's first year in the Program.

Courses applied to the M.S. Degree (except for those in Category III) can also be applied to the Ph.D. degree. Students who have taken similar courses while a graduate student at another university may petition the Executive Committee to apply these courses to the Ph.D. requirements, but will not be exempted from more than 2 courses (9 units) per UCI policy.

### ***Bootcamp Courses***

These are intensive lecture- and laboratory-based short courses designed to help fill in gaps in student preparation. They are offered in August/September prior to the start of the official school year; students are provided with housing and their regular stipends while in attendance. Bootcamps can last between 3 days and two weeks, and are tailored to the needs of the incoming class. For example, in 2013, a one-week bootcamp in mathematics and computation and a 3-week bootcamp in biology were held. A typical bootcamp day consists of lectures from 9-12, a break for lunch, and laboratory exercises or demonstrations in the afternoon. In the computational bootcamp, trainees received tutorials and exercises in *Matlab* and *Mathematica*.

### ***Laboratory Rotations***

Rotations allow students to conduct limited (10-week) research projects in the laboratories/groups of the training faculty. At least one of the rotations that each student selects must be in a research group that is judged by the student's advisory committee as being substantially different from the student's background. For example, students with backgrounds primarily in theory will be required to select at least one rotation in an experimental lab; those with backgrounds primarily in experimentation will be required to select at least one rotation with a theory-oriented group.

Students are expected to complete a minimum of two rotations during the first year. In some cases, students may arrive during the summer months (July and August) to start a rotation early, or finish a rotation prior to the start of the classes. In general, students are expected to complete rotations by the end of spring quarter of their first academic year. In exceptional cases, upon recommendation of the Executive Committee (based on an evaluation of the student's performance and needs), the period of rotations may be extended for one or two additional quarters, provided that appropriate funding arrangements are in place.

Students will be strongly encouraged by their advisory committees and rotation advisors to apply for extramural graduate fellowships such as the NSF Graduate Fellowship and the NIH Kirschstein Graduate Fellowship. Typically the laboratory rotations will provide students with sufficient preliminary research experience to write competitive proposals. Students will also be directed to workshops organized by the Graduate Division to further aid them in proposal preparation.

**Core Courses** (all courses are 4 units)

- *Bio Core 1: Biophysics of Molecules and Molecular Machines* (Physics 230A, Fall).
- *Bio Core 2: Systems Cell Biology* (Dev. Bio. 232, Winter).
- *Bio Core 3: (A). Population Dynamics* (Eco. Evo 251, Spring) **OR** (B). *Developmental Systems Biology* (Dev. Bio. 203C, Spring)
  
- *Math/Comp. Core 1: (A). Mathematical and Computational Biology I* (Math 227A, Fall) **OR** (B). *Dynamical Systems in Biology and Medicine* (BME 233, Fall).
- *Math/Comp. Core 2: Mathematical and Computational Biology II* (Math 227B, Winter).
- *Math./Comp. Core 3: (A) Computational Systems Biology* (ICS 284C, Spring) **OR** (B) *Mathematics and Computational Biology III* (Math 227C, Spring).
  
- *Critical Thinking in Systems Biology* (Dev Cell 203A, Fall).

The corresponding departments plan to continue offering these core courses every year. See **Appendix 15** for Memoranda of Understanding from the Department Chairs regarding the continuance of the MCSB core courses.

**Breadth Courses**

The breadth courses for the MCSB M.S. and Ph.D. program listed below are divided into three categories according to their subject matter with Category I being mathematics-related, Category II being biology-related, and Category III being biotechnology-related. In Categories I and II, we denote by ‘star’ (\*) courses that may be used either as core or elective courses. All courses are 4 units.

**Category I (Mathematics, Computation and Modeling)**

- *Mathematical and Computational Biology I* (Math 227A, Fall)\*
- *Dynamical Systems in Biology and Medicine* (BME 233, Fall)\*
- *Representations and Algorithms for Molecular Biology* (ICS 284A, Fall).
- *Quantitative methods in ecology and evolutionary biology* (EE 207, Fall).
- *Continuum Mechanics* (Physics 222, Fall).
- *Computational Methods* (Physics 229A, Fall).
- *Representations and algorithms for molecular biology* (Computer Science, 284A, Fall)

- *Statistical Methods for Data Analysis I* (Statistics 201, Fall).
- *Computational Partial Differential Equations* (Math 226B, Winter)
- *Probabilistic Modeling of Biological Data* (ICS 284B, Winter).
- *Quantitative Physiology: Organ Transport Systems* (BME 221, Winter).
- *Biophysics of molecules and molecular machines* (Physics 230B, Winter).
- *Introduction to Numerical Analysis and Scientific Computing* (Math 225C, Spring).
- *Introduction to Computational Biology* (MBB 223 Spring)
- *Computational Systems Biology* (ICS 284C, Spring)\*
- *Mathematics and Computational Biology III* (Math 227C, Spring)\*

### **Category II (Biology and Biomedical Engineering)**

- *Protein Structure and Function* (Mol. Bio. 204, Fall).
- *Introduction to Proteomics* (Physiol. & Biophys. 252, Winter)
- *Cell and Tissue Engineering* (BME 210, Winter).
- *Cell Biology* (Dev. Bio. 231B, Winter).
- *Chromatin Function* (Biol. Chem 225, Winter)
- *Advanced Developmental Genetics* (Dev. Bio. 210, Spring).
- *Regulation of Gene Expression* (Mol. Bio. & Mol. Gen. 206, Spring).
- *Advanced Molecular Genetics* (Biol. Chem. 207, Spring).
- *Signal Transduction and Growth Control* (BC212, Spring).
- *Population Dynamics* (Eco. Evo. 251, Spring)\*
- *Developmental Systems Biology* (Dev. Bio. 203C, Spring)\*

### **Category III (Biotechnology and Entrepreneurship)<sup>3</sup>**

- *Statistics for management* (MBA 201A, Fall)
- *Biomedical microdevices* (BME 261, Fall)
- *Foundations of Clinical and Translational Science* (PH 290, Fall)
- *Entrepreneurship for scientists and engineers* (ENG 280, Winter)
- *Technology for life* (ENG 260A, Winter)

As there may be other courses suitable for students in the MCSB program, students may receive credit for courses not on the list above with the approval of the MCSB Executive Committee.

#### **4. Transition from year 1 to year 2**

**Department Option (current MCB gateway graduate program):** As described in the existing MCB bylaws, and re-iterated in **Appendix 1**, departments must agree, as a condition of their participation in the program, to accept into their Ph.D. programs any

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<sup>3</sup> Additional courses may be selected from new programs as appropriate. New programs in Engineering & Management (MS) in the School of Engineering and the Biotechnology Program (MS, Biological Sciences, Department of Molecular Biology and Biochemistry) are likely to provide a source of new courses in this area.

MCSB student who has completed the gateway year in good academic standing, and who has identified a departmental faculty member who is willing to serve as the student's thesis advisor. Upon such acceptance, such students will formally join the departmental program, and be subject to departmental requirements. However, they will remain affiliated with MCSB program, will be invited to participate in voluntary MCSB activities, and will continue to meet on a regular basis with their MCSB advisory committees (see **Appendix 1**).

***M.S. Degree:*** Upon successful completion of the first year, M.S. students are expected to identify a thesis advisor to supervise completion of either a research thesis or literature thesis. A research thesis advisor must provide an environment in which the candidate may conduct research for one additional year. In the event that no thesis supervisor can be found, the student will only be permitted to pursue a literature thesis, and the MCSB program director will serve as, or designate, a thesis supervisor.

***Ph.D. Degree:*** In order to pursue the interdisciplinary Ph.D. option, a student must identify a faculty member from among participating MCSB training faculty, who will commit to serving as the student's thesis advisor. This may include commitment of financial support by the advisor, as detailed elsewhere in this proposal. If a student is unable to find an appropriate advisor, the program may, pending availability of funds, support the student for an additional one or two quarters of rotations, so that an appropriate advisor may be found.

### ***5. Preliminary exam***

***Department Option (current MCB gateway graduate program):*** Subject to the requirements of the participating Department.

***Stand-alone M.S. Degree Option:*** None.

***Stand-alone Ph.D. Degree Option:***

- 1) Once a student has taken at least 10 of the 12 courses, if he/she received a minimum grade of B+ and held an average grade of A- or better, then the preliminary exam is waived.
- 2) Otherwise, an oral exam by a committee of four members (training faculty participating in the MCSB Ph.D. option) will be conducted based on the materials of the twelve courses.
- 3) Each student can take the preliminary exam at most TWICE. Students who fail the preliminary exam twice will not be eligible to continue in the Ph.D. program.
- 4) A student must pass the preliminary exam before the start of the year 3. The normative time to pass the exam will be at the end of the Winter quarter of Year 2.

## **6. Advancement exam**

**Department Option:** Subject to the requirements of the participating Department.

**Stand-alone M.S. Degree Option:** None.

**Stand-alone Ph.D. Degree Option:**

The normative time for students to advance to candidacy is in year 3. The advancement exam must be passed before the end of the 4<sup>th</sup> year. The Advancement to Candidacy exam consists of a written proposal for the dissertation and an oral presentation of the proposed dissertation, followed by a question and answer period. Faculty members who are training faculty in the MCSB Ph.D. option should comprise a simple majority of the exam committee. At least one member of the committee must be from outside this group. It is expected that one or both of the members of an MCSB trainee's mentoring committee will serve on the trainee's advancement committee. Shortly following the advancement exam, the composition of the student's dissertation committee will be established, by the student in consultation with his/her thesis supervisor, and will typically consist of three or more members of the advancement exam committee.

As the program matures to the point where a substantial number of advanced students are in residence, we anticipate instituting a "buddy system", whereby trainees nearing advancement are paired with more senior trainees to assist them in preparing their thesis topic defense.

## **7. Thesis and/or dissertation:**

**Department Option (current MCB gateway graduate program).** Subject to the requirements of the participating Department.

**Stand-alone M.S. Degree Option.** As described above, a M.S. candidate may choose to pursue either a research thesis option or a literature thesis option. Typically, research activity toward completion of a research thesis would commence during the summer after the first year. In both cases, M.S. students will be advised by a faculty committee selected by the student and his/her thesis advisor, and subject to the approval of the MCSB executive committee.

**Stand-alone Ph.D. Degree Option.** A dissertation is required for all Ph.D. candidates. The dissertation must be conducted under the supervision of the student's advisor and dissertation committee (see item 6, above).

## **8. Final examination:**

**Department Option (current MCB gateway graduate program).** Subject to the requirements of the participating Department.

**Stand-alone M.S. Degree Option:** M.S. candidates who choose the research thesis option must present the results of their research in a presentation open to the academic community. The research thesis is subject to unanimous approval by the student's advisory committee. M.S. candidates who choose the literature thesis option must submit a written thesis, which is subject to unanimous approval by the student's advisory committee.

**Ph.D. Degree:** Ph.D. candidates must present the results of their dissertation in a presentation open to the academic community. The dissertation is subject to unanimous approval by the student's dissertation committee.

### ***9. Special requirements over and above Graduate Division requirements:***

The M.S. Program requires 9 courses (36 units) for the research thesis option (i) and 12 courses (48 units) for the literature thesis option (ii), and attendance at a Bootcamp prior to the students' first year in the program. This exceeds the Graduate Division requirement of 7 courses (28 units). In addition a research or literature thesis may also be required, depending upon student choice. These requirements are commensurate with other M.S. Degree requirements at UCI and other programs in similar universities.

The Stand-alone Ph.D. Option requires 12 courses (48 units) and attendance in the 1<sup>st</sup> year Bootcamp. The Graduate Division requirements do not require any minimum. In addition, the program requires students to perform at least 2 laboratory rotations in the first year of study. These requirements are commensurate with other Ph.D. Degree requirements at UCI and other programs in similar universities.

### ***10. Expected distribution of trainees***

We anticipate a typical first-year MCSB class size consisting of about 15 Ph.D. students and 4 M.S. students (if additional faculty members join the program, student numbers may grow proportionally). We expect that most MCSB students will seek Ph.D. training, whether through the Departmental or "Ph.D. option" mechanisms. We expect that students seeking M.S. training will typically constitute less than one fourth of program enrollment.

Of those students seeking the Ph.D. degree, we expect that one-third to one-half will select the "Ph.D. option" (5-8 students), with the remainder choosing the Departmental Option. These estimates are based on an informal survey of current MCB students. Actual proportions of students choosing different options may differ from these, as well as vary over time.

The first year in the program is the same for the Department option and the Stand-alone Ph.D. option, and is very similar for the Stand-alone M.S. option as well (although no rotations are required for the Stand-alone M.S. Degree option, with additional elective courses taking their place). Differences among the programs occur in later years. For

example, in the Department Option, students enroll in Degree programs in Participating Departments while in the Stand-alone Ph.D. option students continue to take courses, exams, and work on their dissertation.

Some students who initially desired to pursue a Ph.D. may end up pursuing a M.S. Degree either by choice or by virtue of the fact that they may not be allowed to continue in the Ph.D. Program due to failure to meet its requirements (e.g. failing exams, etc.). In such cases, a formal request to switch from the Ph.D. degree option to the M.S. degree option made by the student may be granted subject to the approval of the Executive Committee. In such cases, the student must spend one year specifically enrolled in the M.S. Program before receiving the M.S. Degree, unless an exception is made by the Program Director in consultation with the Executive Committee.

We also anticipate that a small number of students may wish to pursue the Ph.D. after first receiving an M.S. Degree from the program. These students will be evaluated together with the pool of prospective Ph.D. candidates for admission to the Ph.D. program. If they are admitted, their successfully completed courses, with the exception of Category III courses, would normally be applied to the Ph.D. Degree course requirements.

### ***11. Special preparation for careers in teaching***

Under current UCI rules, the MCSB graduate program is not expected to control any TA positions. Nevertheless, MCSB students will be encouraged to teach, and will be available to departments for TA service. For example, the Departments of Biomedical Engineering, Computer Science, Developmental & Cell Biology, Ecology & Evolutionary Biology, Mathematics, and Physics & Astronomy, have all offered to provide TA slots to the MCSB program, based on each department's needs and student backgrounds, if a teaching component is required for the MCSB program. See the attached letters from the Department Chairs (**Appendix 8** and **Appendix 15**).

Special opportunities for teaching also arise regularly as a result of activities within the program and through the Center activities of CCBS. For example, MCB students have commonly served as mentors and tutors for the MCB bootcamp program (which will continue as part of the MCSB program). Several such students have also served as TAs and lab assistants for the National Short Course in Systems Biology that CCBS sponsors annually.

### ***12. Mentoring***

Once a student is admitted to the program, he/she is asked to fill out a short questionnaire to assess his/her preparation in the core areas of biology, mathematics and computation. The questions vary from "Can you download data using a genome browser?" to "What is an epithelium?" to "How do you determine whether a dynamical system has more than one stable state?" Based on a review of an applicant's admission file, and the answers to these questions, the Director and the Gateway Committee (see **Appendix 1, Article IV**

below) select two faculty advisors to serve as mentors for the student during his/her first year. These two faculty mentors form the Student’s Advisory Committee. The Gateway Committee also decides which “boot camps” to recommend that the student take (see below).

In the MCSB Program, there will be two types of faculty members: (1) Participating faculty in the Department Option and (2) Participating training faculty in the MCSB Stand-Alone Option, who are a subset of those members in group 1. This distinction is made because the Stand-Alone Option requires a more focused research direction as well as additional time and financial commitments than does the Department Option. See **Appendix 1, Article II**. The initial faculty mentors will be members of group (1). The faculty mentors will repeatedly apprise students of the options available to them at the end of the gateway year (e.g., Department and Stand-alone M.S./Ph.D. degree options) so that students will have sufficient opportunities to make informed decisions about their futures.

After a student successfully completes the first (gateway) year (see **Appendix 2, Article V**), the student may then choose a Department Option in which the student enters the graduate program of a participating Department, in which to complete their graduate work. Alternatively, students may also choose the stand-alone M.S. or Ph.D. Option and pursue their graduate work solely in the MCSB Program. Students will be advised repeatedly about their options.

Those students who chose the stand-alone M.S./Ph.D. option are required to find a faculty member who is a participating member of the M.S./Ph.D. Program (see **Section IV and Appendix 1, Article II**). The faculty member must agree in writing to supervise their thesis activities (see **Section V and Appendix 7**), and in the case of the stand-alone Ph.D. option, must agree to provide funding for the student.

The faculty mentors will also strongly encourage students to apply for extramural graduate fellowships including the NSF graduate fellowship and the NIH Kirchstein graduate fellowship. The faculty advisors will also direct students to workshops organized by Graduate Division regarding fellowship preparation.

Upon choice of faculty advisor, the Advisory Committee may be reconfigured, with the student’s advisor as chair. This will be done in consultation with the student’s advisor, the Program Director and Executive Committee, for students in the Stand-alone M.S./Ph.D. Option, or the Gateway Committee for students in the Department Option. Note that students choosing the Department Option will retain an MCSB interdisciplinary advisory committee throughout their graduate training.

**13. Sample program:**

***Department Option (current MCB gateway graduate program):***

<i>Year 1</i>	<i>Fall</i>	<i>Winter</i>	<i>Spring</i>
Bootcamp prior to	Biology Core 1 Math/Comp Core 1	Biology Core 2 Math/Comp Core 2	Biology Core 3 Math/Comp Core 3

start of fall term	Critical Thinking  ----- Rotation I	----- Rotation II <i>Or</i> One more optional course	-----  Rotation III <i>Or</i> One more optional course
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***M.S. Program, option (i) [research thesis]:***

Bootcamp prior to start of fall term	<b><i>Fall</i></b>	<b><i>Winter</i></b>	<b><i>Spring</i></b>
<b><i>Year 1</i></b>	Biology Core 1 Math/Comp Core 1 Critical Thinking	Biology Core 2 Math/Comp Core 2 1 optional course	Biology Core 3 Math/Comp Core 3 1 optional course
<b><i>Year 2</i></b>	Journal Club Research	Journal Club Research	Research Write and Submit Thesis

***M.S. Program, option (ii) [literature thesis]:***

Bootcamp prior to start of fall term	<b><i>Fall</i></b>	<b><i>Winter</i></b>	<b><i>Spring</i></b>
<b><i>Year 1</i></b>	Biology Core 1 Math/Comp Core 1 Critical Thinking	Biology Core 2 Math/Comp Core 2 1 optional course	Biology Core 3 Math/Comp Core 3 1 optional course
<b><i>Year 2</i></b>	Journal Club 2 Elective courses	Journal Club 1 Elective course Thesis writing	Write and Submit Thesis

***Ph.D. Program:***

<b>Year</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4-5</b>
Fall	Biology Core 1 Math/Comp Core 1 Critical Thinking  ----- Rotation 1	Journal Clubs 1-2 courses	Pre- advancement Research Journal Clubs	Thesis Research
Winter	Biology Core 2 Math/Comp Core 2	Journal Clubs	Advancement Exam	Thesis Research

	----- Rotation 2	1-2 courses  Preliminary Exam	Journal Clubs	
Spring	Biology Core 3 Math/Comp Core 3  ----- Rotation 3 <i>Or</i> One more optional course	Journal Clubs 1-2 courses	Thesis Research Journal Clubs	Thesis Research
Summer				

### **Year 1: Additional information**

**Rotations:** As students in the Department and Stand-alone Ph.D. Options progress through first year rotations with program faculty, they prepare rotation proposals (at the start of each quarter) and rotation reports (and the end of each quarter). Their rotation supervisors also file reports at the end of the quarter. The faculty reports are read by the student’s mentoring committee, and the program director, who look for any signs that a student is having academic or personal problems (and take whatever action is necessary) and work to ensure that rotations are serving the goal of fostering interdisciplinary training and research.

**Journal Clubs, Seminars, Symposia:** First year students are invited to participate in weekly journal clubs, interest groups, occasional seminars, and annual symposia that focus on Systems Biology. As the organization of these activities falls largely to the more advanced students (the first year students are kept fairly busy with classes and rotations), these are discussed in detail in the following sections.

### **Year 2: Additional information (M.S. and Interdisciplinary Ph.D.)**

**Advisory committees and initiation of thesis research:** Based on a student’s choice of thesis lab, the composition of a student’s mentoring committee may be adjusted. If the thesis advisor is one of the student’s previously assigned mentors, a new mentoring committee member will be selected by the Director and Executive Committee to take his/her place. Other adjustments may be made based on the area of the student’s research, or by request of the student, thesis advisor or committee member. It is expected that the advisory committee members will continue to advise the student until graduation.

### **Year 3 and above: Additional information (Interdisciplinary Ph.D.)**

**Thesis research and continued training:** MCSB students are required to actively participate in MCSB activities. Activities in which continued participation will be

required are:

- Regular meetings with mentoring committees
- Participation in an Annual Program Retreat
- Journal Clubs, each quarter

Activities in which continued participation is encouraged include:

- Systems Biology Seminar Series
- Modeling Interest Group
- Translational Systems Biology Interest Group
- Participation in Teaching and/or Mentoring of junior MCSB students

**Professional development and career guidance:** It is expected that participation in journal clubs and the above-listed interest groups will help hone the speaking skills of students, as will their presentations (oral and poster) at the annual retreat. As students move into the upper years of training (years 3-5), we will initiate a research-in-progress seminar series, similar to that offered in many departments, at which students give 30 minute presentations on their research to a group of peers and mentors. Writing skills will also be fostered by participation in the Opportunity Award program at each year's retreat, which encourages teams of students to submit seed grant applications for novel interdisciplinary research.

Timely career skills information will also be provided to students (and postdocs) through a series of lectures organized annually by the UCI ADVANCE program, which promotes institutional transformation toward gender equity by increasing the representation and advancement of women faculty across entire campus, as well as by workshops and tutorials organized by the Graduate Resource Center. These are usually extremely well attended by students in many departments.

#### ***14. Normative time from matriculation to degree***

The trainees should be full-time students. The normative time for the Stand-alone M.S. Program is 2 years. The normative time for passing the preliminary exam is 2 years. The normative time for passing the Advancement to Candidacy is 3 years. The normative time from matriculation to MCSB Ph.D. degree is 5 years. The normative time is the same for students who enter with an advanced degree.

### *III. Projected Need*

#### *1. Student demand for the program*

Student demand for the program is expected to be strong, given the strong 6-year record of the current gateway MCB program and the need for researchers and educators to be trained in this area. . It is important to note that some students who declined admission to the MCB program did so precisely because we do not currently have a stand-alone degree program.

Over the past two years, we have been actively recruiting students from prestigious Undergraduate Programs across the country, including the Undergraduate Research Program at the Mathematical Biosciences Institute—a NSF funded national center for mathematical biology. This is a highly competitive national program for undergraduates. Although they understood that the MCSB interdisciplinary graduate program was not yet approved, the students were very excited about the prospect of a stand-alone degree program. Our targeted recruitment efforts have already started to pay off. In 2013, we admitted our most qualified incoming class to date (**Fig. 2**).

We plan to expand our targeted recruitment strategies to other NSF sponsored centers including the National Institute for Mathematical and Biological Synthesis (NIMBioS), Statistical and Applied Mathematical Sciences Institute (SAMSI), the Institute for Pure and Applied Math (IPAM), and the Institute for Math and its Applications (IMA). All of these centers have summer research programs for undergraduates. We will also target national and international conferences such as the Annual International Conference on Systems Biology, the Society for Industrial and Applied Mathematics (SIAM) annual meeting on Life Science, etc. As discussed in **Sec. I.10**, we also send student and faculty representatives to recruitment fairs/research conferences that target URM students in the STEM disciplines.

Further, the applicant pool will also increase because initiatives to promote systems biology are blossoming around the world, with the U.S., Europe and Japan leading the way (see **Appendix 2**). Textbooks, new journals, new departments, new international meetings have all sprung up in a relatively short time. Indeed, one of the most compelling arguments for student demand for the MCSB stand-alone M.S./Ph.D. program is the rapid proliferation of systems biology programs across the country over the past ten years or so. For example, in 2005 there were only programs at Harvard and MIT. Now, there are dozens of programs in California and across the country. See **Appendix 2**. Informal surveys of the systems biology programs at Harvard University (Department of Systems Biology) and the University of Chicago (Genetics, Genomics and Systems Biology, Ph.D. program) reveal that these programs have about 100 applicants per year, each of the past three years, and that many more have indicated an interest in their programs. For instance, U. Chicago documented over 300 inquiries by students in their program over the past two years. These numbers are comparable with those obtained in our MCB

program over the same time period. While not all of these students ultimately apply to systems biology programs, this certainly indicates strong student interest in the area of systems biology.

On a broader scale, data from the US Department of Education<sup>4</sup> that shows significant increases in the number of students studying STEM-related fields. For example, the number of bachelor's degrees conferred in the biological sciences rose 31% from 2004–05 to 2009–10, while the number of degrees in the physical and engineering sciences rose by 22% and 12%, respectively.

These trends are expected to continue, given the significant increases in the number of high school graduates who have completed advanced mathematics and science courses. For example, the percentage of graduates who had completed calculus increased from 7% to 16% between 1990 and 2009, while those completing chemistry and physics increased from 49% to 70% and from 21% to 36%, respectively.

Because the MCSB program is unique in already possessing a strong track record, as well as in its emphasis on a particularly close connection between biology and mathematics, and its strong ties to CCBS, which is a National Center of Excellence in Systems Biology, and its wide range of training options for students, we expect to be highly competitive in recruiting the best students seeking training at the interface between the physical, biological, computing and engineering sciences. *We anticipate a typical first-year MCSB class size consisting of about 15 Ph.D. students and 4 M.S. students* (if additional faculty members join the program, student numbers may grow proportionally). Of these 15 Ph.D. students, we expect that about one half to two thirds will choose the departmental option (7-10) at the end of their first academic year, with the remainder continuing on in the extra-departmental, interdisciplinary Ph.D. option (5-8). These estimates are based on an informal survey of current MCB students. Actual proportions of students choosing different options may differ from these, as well as vary over time.

## ***2. Opportunities for placement of graduates***

There are many opportunities for graduates in mathematical, computational and systems biology. These include positions in academic departments, including traditional departments of biology, medicine, engineering, mathematics, computer science, physics, etc.; systems biology departments; research institutes; national laboratories; the National Institutes of Health, etc. Although there have been no formal studies on the numbers of positions available in these areas, recent experience shows that candidates training in quantitative, interdisciplinary and systems biology are in high demand (for example, a large proportion of advertisements for faculty positions now specifically refer to systems biology as a field of preparation). Opportunities also exist for placement of students in

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<sup>4</sup> US Dept of Education  
National Center for Education Statistics  
[http://nces.ed.gov/programs/digest/d11/ch\\_3.asp](http://nces.ed.gov/programs/digest/d11/ch_3.asp)

industry, including the pharmaceutical, bioinformatics, biomedical informatics, biomedical device, biotech, and insurance industries.

### ***3. Importance to the discipline***

As described earlier (see **Sections I.1-I.3**) mathematical, computational and systems approaches are widely seen as crucial to the future of the biological sciences, and serious efforts to foster research at the interface between these disciplines are currently underway all around the world. Providing a workforce for such interdisciplinary research is inherently challenging. The realization that it cannot be easily accomplished within traditional academic graduate degree programs has driven the development of several interdisciplinary graduate programs, such as UCI's MCB graduate gateway program. Currently, the MCB program provides substantial opportunities for cross-training during the initial, gateway year, but it still requires that trainees fulfill the academic requirements of a traditional department. In some cases, such a training path fills the workforce need well—since many trainees will eventually find themselves doing research within traditional departments. However, biology also needs some individuals whose training is more thoroughly interdisciplinary, and who therefore need greater flexibility in their curricular requirements than a single traditional department would be inclined to provide. The proposed program will provide this flexibility, without sacrificing the departmental degree option that existing MCB students currently enjoy.

### ***4. Ways in which the program will meet the needs of society***

Many of the greatest challenges facing society—health care, environmental management, energy management, and meeting the world's need for food—involve understanding and controlling complex biological systems. One of the major lessons of the past half-century has been that, to achieve a useful, predictive understanding of these issues, it is necessary to understand biological systems at the level of dynamics, engineering principles, and emergent behaviors. By training students who operate, and collaborate, at the interface between biology and physics, statistics, computer science, engineering and mathematics, the MCSB program stands to contribute significantly to the training of those who will tackle society's greatest challenges.

### ***5. Relationship of the program to research and/or professional interests of the faculty***

All of the associated faculty members are active researchers in some aspect of mathematical, computational and systems biology. Indeed, under the organization of CCBS, UCI possesses an exceptionally rich community of quantitative- and systems-biology-oriented faculty. In addition, the program dovetails with recent campus initiatives in the area of systems biology.

### ***6. Program differentiation***

As described earlier (see Section I), programs have been emerging throughout the nation in recent years to provide graduate training in biology with interdisciplinary components in mathematics, computer science, engineering or physics. **Appendix 2** lists several of these programs.

Within the state of California, we have identified (see **Appendix 2**) the following programs:

UC Berkeley (Biophysics, Biostatistics, Computational and Genomic Biology emphasis)  
UC Davis (Mathematics; Ecology; Biophysics; Biostatistics)  
UC Irvine (Biomedical engineering)  
UCLA (Department of Biomathematics)  
UC Merced (Quantitative and Systems Biology)  
UCR (Genetics, Genomics and Bioinformatics)  
UCSD (Bioinformatics and Systems Biology; Bioengineering)  
UCSB (Biomolecular Science and Engineering Program)  
UCSC (Bioinformatics)  
UCSF (Biological and Medical Informatics; Biophysics; Bioengineering, Integrative Program in Quantitative Biology)  
Caltech (Department of Control and Dynamical Systems)  
Stanford University (Chemical and Systems Biology)  
USC (Computational Biology and Bioinformatics Program)

Most of these programs are focused more narrowly than the proposed MCSB program. For example, several are primarily focused on bioinformatics and/or the intersection between computer science and biology. Others are focused primarily on biomathematics; others on bioengineering; others on chemical biology; and others on biophysics.

Only a few programs attempt broad coverage of mathematical, computational and systems biology in the manner of the proposed MCSB program. Examples include the Integrative Program in Quantitative Biology (**IPQB**) at UCSF, the Quantitative and Systems Biology Program at UC Merced, and the Bioinformatics and Systems Biology Program at UCSD. The MCSB program distinguishes itself from these programs in several important ways.

First, the breadth of training faculty in the MCSB program is greater. The participating UCI faculty members provide greater coverage of Mathematics, Physics, Computer Science and Engineering than is available in the UCSF IPQB program; greater coverage of Mathematics, Physics and Biology than is available in the UCSD Bioinformatics and Systems Biology Program; and greater coverage of Mathematics, Physics and Computer Science than is available in the UCM Quantitative and Systems Biology program.

Second, MCSB training faculty members provide unique research depth in areas that are key for the development of the field of Systems Biology, especially the area of spatial dynamics (the dynamics of complex biological systems in both space and time).

Third, the MCSB program emphasizes the fundamental importance of mathematics and dynamical systems analysis in the study of complex biological systems, to an extent greater than other training programs in California.

Fourth, the MCSB program provides students with access to unique research and training opportunities organized under CCBS, such as retreats, symposia, interest groups, opportunity awards, etc. (see **Section II.12**).

It should also be noted that, by virtue of being an extension of the existing MCB gateway program—already one of the largest and most-established quantitative and systems biology programs in the State—the proposed MCSB program builds upon a track record of training that is arguably one of the strongest in the nation (as evidenced by the quality of the applicant pool, and the extramural training grants that have been obtained so far).

#### ***IV. Participating Faculty***

##### **I. Faculty Participating in the Department Option (Current MCB faculty participants). Listed by Participating Department.**

###### **Biological Chemistry (SOM)**

Bogi Andersen

Pierre Baldi (also Computer Sci., Dev. and Cell and BME)

Xing Dai

Peter Kaiser

Haoping Liu

Suzanne Sandmeyer, (also Microbiology & Molecular Genetics)

Robert Steele

Kyoko Yokomori

Lan Huang

###### **Biomedical Engineering (Engineering)**

Pierre Baldi (also Computer Sci., Dev. and Cell and Biological Chem.)

Bruce Blumberg (also Dev. and Cell and Pharm. Sci.)

Elliot Botvinick

James Brody

Dan Cooper (also Pediatrics, ICTS)

Charles Fowlkes (also Computer Sci.)

Steve George

Enrico Gratton (also Physics, Dev. and Cell)

Anna Grosberg

Steve Gross (also Physics, Dev. and Cell)

Jered Haun

Elliot Hui

Christopher C. Hughes (also Mol. Bio. and Biochem.)

Joyce Keyak

Arash Kherardvar

Michelle Khine  
Arthur Lander (also Dev. and Cell)  
Chang Liu  
Wendy Liu (also Chem. Eng. and Mater. Sci.)  
John Lowengrub (also Math, Chem. Eng. and Mater. Sci.)  
Ray Luo (also Mol. Bio. and Biochem.)  
Zoran Nenadic  
Qing Nie (also Math)  
Phillip C-Y Sheu  
Padhraic Smyth (also Computer Sci.)  
Bruce Tromberg  
Vasan Venugopalan (also Chem. Eng. and Mater. Sci.)  
H. Kumar Wickramasinghe

**Chemistry (PS)**

Ioan Andricioaei  
Craig Martens  
Shaul Mukamel  
James Nowick  
Eric Potma  
Douglas Tobias  
Cheryl Tsai (also Mol. Bio. and Biochem.)  
Gregory Weiss (also Mol. Bio. and Biochem.)  
A. J. Shaka

**Computer Science (ICS)**

Pierre Baldi (also Dev. and Cell, Biol. Chem., Biomed. Eng.)  
Charless Fowlkes (also Biomedical Engineering)  
Alexander Ihler  
Harmut Luecke (also Mol. Biol. and Biochem., Phys. Biophys.)  
Eric Mjolsness, (also Math)  
Padhraic Smyth (also Biomed. Eng.)  
Xiaohui Xie, (also Dev. and Cell)

**Developmental and Cell Biology (BioSci)**

Kavita Arora  
Pierre Baldi (also Computer Sci, Biomed. Eng., Biol. Chem.)  
Lee Bardwell  
Bruce Blumberg, (also Biomed. Eng., Pharm. Sci.)  
Anne L. Calof  
Ken Cho  
Olivier Cinquin  
Enrico Gratton (also Physics, Biomed. Eng.)  
Steve Gross (also Physics, Biomedical Engineering)  
Arthur Lander, (also Biomedical Engineering)  
J. Lawrence Marsh

Ali Mortazavi  
Edwin Monuki (also Pathology)  
Maksim Plikus  
Susanne Rafelski  
Thomas Schilling  
Rahul Warrior  
Xiaohui Xie (also Comp. Sci.)

**Ecology and Evolutionary Biology (BioSci)**

Albert Bennett  
Robin Bush  
J.J. Emerson  
Steve Frank  
Brandon Gaut  
Natalia Komarova (also Math)  
Anthony Long  
Matt McHenry  
Adam Martiny (also Earth. Sys. Sci.)  
Jose Ranz  
Kevin Thornton  
Domink Wodarz (also Math)

**Mathematics (PS)**

Long Chen  
German Enciso  
Patrick Guidotti  
Natalia Komarova (also Ecol. and Evol. Bio.)  
John Lowengrub (also Biomed. Eng., Chem. Eng. and Mater. Sci.)  
Eric Mjolsness (also Comp. Sci.)  
Qing Nie, (also Biomed. Eng.)  
Knut Solna  
Frederic Y.M. Wan  
Dominik Wodarz (also Ecol. and Evol. Bio.)  
Jack Xin  
Hongkai Zhao

**Microbiology and Molecular Genetics (SOM)**

Ruslan Aphasizhev  
Klemens Hertel  
Anthony James (also Mol. Biol. and Biochem.)  
Suzanne Sandmeyer (also Biological Chem)  
Yongsheng Shi  
Ming Tan  
Marian Waterman

**Molecular Biology and Biochemistry (BioSci)**

Melanie Cocco  
Christopher Hughes (also Biomed. Eng.)  
Anthony James (also Microbiol. and Mol. Genetics)  
Harmut Luecke (also Comp. Sci., Phys. Biophys.)  
Ray Luo (also Biomed. Eng.)  
Sheryl Tsai (also Chem.)  
Gregory Weiss (also Chem.)

**Physics (PS)**

Philip Collins  
Michael Dennin  
Enrico Gratton (also Dev. and Cell, Biomed. Eng.)  
Steven Gross (also Dev. and Cell)  
Thorsten Ritz  
Zuzanna Siwy  
Peter Taborek  
Clare Yu

**Faculty participating in the Department Option (current MCB faculty participants) who do not reside in a participating department**

Wesley Johnson (Statistics, ICS)  
Hung Nguyen (Chem. Eng. Mater. Sci., Engineering)  
Janos K. Lanyi (Physiol. & Biophys., SOM)  
Elizabeth Read (Chem. Eng. Mater. Sci., Engineering)  
Babak Shahbaba (Statistics, ICS)  
Hal Stern (Statistics, ICS)  
Xiaoshia Yu (Statistics, ICS)

**2. Faculty Participating in the Interdisciplinary Ph.D. program (listed alphabetically, with primary department shown)\***

Jun Allard (Asst Prof., Mathematics and Physics, Phys. Sci.)  
Bogi Anderson (Prof., Biological Chemistry, SOM)  
Kavita Arora (Assoc. Prof., Dev & Cell, BioSci)  
Pierre Baldi (Chancellor's Prof., Comp. Sci, ICS)  
Elliot Botvinick (Assoc. Prof., Biomed Eng., Eng)  
Anne Calof (Prof., Anatomy & Neurobiology, SOM)  
Ken Cho (Prof., Dev. & Cell, BioSci)  
Olivier Cinquin (Asst. Prof., Dev & Cell, BioSci)  
Dan Cooper (Prof., Pediatrics, SOM) \*\*  
Xing Dai (Assoc. Prof., Biol. Chem., SOM)  
JJ Emerson (Asst Prof., Ecol & Evo, BioSci)  
German Enciso (Asst Prof., Mathematics, PhysSci)  
Charless Fowlkes (Asst Prof, Computer Science, ICS)

Steve Frank (Prof., Eco & Evo, BioSci)  
Enrico Gratton (Prof., Biomed. Eng., Eng)  
Anna Grossberg (Asst Prof., Biomed. Eng., Eng)  
Steve Gross (Assoc Prof., Dev & Cell, BioSci)  
Chris Hughes (Prof., Mol. Biol & Biochem, BioSci)  
Elliot Hui (Asst Prof, Biomed Eng., Eng)  
Joyce Keyak (Assoc Prof., Orthopaedic Surgery, SOM)  
Natalia Komarova (Assoc Prof, Mathematics, PhysSci)  
Arthur Lander (Prof, Dev & Cell, BioSci)  
Chang Liu (Asst Prof., Biomed Eng, Eng)  
Haoping Liu (Assoc Prof, Biological Chemistry, SOM)  
Anthony Long (Prof, Eco & Evo, BioSci)  
John Lowengrub (Prof, Mathematics, PhysSci)  
Ray Luo (Assoc Prof, Mol Biol & Biochem, BioSci)  
Matthew McHenry (Asst Prof, Eco & Evo, BioSci)  
Ali Mortazavi (Asst Prof, Dev & Cell, BioSci)  
Eric Mjølness (Prof., Computer Science, ICS)  
Zoran Nenadic (Prof, Biomed Eng, Eng)  
Qing Nie (Prof, Mathematics, PhysSci)  
Maxim Plikus (Asst Prof, Dev & Cell, BioSci)  
Eric Potma (Asst Prof, Chemistry, PhysSci)  
Susanne Rafelski (Asst Prof, Dev & Cell, BioSci)  
Elizabeth Read (Asst Prof., Chem Eng & Mater Sci, Eng)  
Thorsten Ritz (Assoc Prof, Physics, PhysSci)  
Susanne Sandmeyer (Prof, Biol. Chemistry, SOM)  
Tom Schilling (Assoc Prof, Dev & Cell, BioSci)  
Padhraic Smyth (Prof, Computer Science, ICS)  
Kevin Thornton (Asst Prof., Ecol & Evo, BioSci)  
Bruce Tromberg (Prof., Biomed Eng, Eng)  
Vasan Venugopalan (Assoc Prof, Chem Eng Mater Sci, Eng)  
Fred Wan (Prof, Mathematics, Phys Sci)  
Rahul Warrior (Asst Prof, Dev & Cell, BioSci)  
Marian Waterman (Assoc Prof, Microbiol & Mol. Genetics, SOM)  
Gregory Weiss (Prof, Chemistry, PhysSci)  
Dominik Wodarz (Assoc Prof, Eco & Evo, BioSci)  
Xiaohui Xie (Asst Prof, Computer Science, ICS)  
Jack Xin (Prof, Mathematics, PhysSci)  
Kyoko Yokomori (Assoc Prof, Biol. Chemistry, SOM)  
Clare Yu (Prof, Physics, PhysSci)

\* faculty commitment letters available upon request

\*\*awaiting confirmation

## V. Courses

### Required courses:

*Bio Core 1. Biophysics of Molecules and Molecular Machines* (Physics 230A, Fall) (4) This introductory course to molecular-level phenomena is taught by members of the physics department, which gives it a uniquely quantitative flavor. Dr. Ritz has modified the class specifically for the MCSB program, although students in other programs also attend the class. The syllabus for 2007 includes: The central dogma of molecular biology, amino acids, proteins; diffusion; ionic transport; molecular dynamics; membrane pores and channels; surface charge; active transport; free energy; ratchets; motors; action potentials/Hodgkin-Huxley model; nano-biotechnology.

*Bio Core 2. Systems Cell Biology* (Dev. Bio. 232, Winter). (4) This course was developed specifically for MCSB by Drs. Bardwell, Lander, Yi and Gross. The syllabus includes: *Signaling Networks*: cells, genes, proteins, binding saturating and partition functions, enzyme kinetics and cell signaling, ultra-sensitivity, cooperativity, Hill equations. *Sensing and Responding*: G-Proteins, sensing, cell polarity, chemotaxis; *Gene regulation*; *Developmental Morphogenesis*: principles of developmental biology; differentiation; control of cell fate and number; pattern formation; *Cytoskeleton and transport*: microtubules and actin; motors; coordination.

*Bio Core 3a. Population Dynamics* (Eco. Evo 251, Spring). (4) This course was adapted for MCSB by the faculty of the Ecology and Evolutionary Biology Department, and stresses the dynamics of population events in biology, from the level of viruses to ecosystems. The syllabus includes: Single species dynamics; competition and predation; infectious disease epidemiology; apparent competition; in vivo dynamics of virus infections – HIV; somatic evolutionary dynamics - cancer initiation/progression.

### OR

*Bio Core 3b. Developmental Systems Biology* (Dev. Bio 203B, Spring) (4) This course was developed for MCSB by Drs. Cinquin and Lander. The class focuses on strategies used by organisms to undergo development. There are 5 themes: cell differentiation, control of tissue growth, local coordination of cell differentiation, large-scale tissue patterning, and evolution of development.

*Math/Comp Core 1a Mathematical and Computational Biology I* (Math 227A, Fall). (4) This course, specifically developed for MCSB by Dr. Wan, was test-taught in 2006 (for the MCSB affiliates), then introduced to the MCSB program in 2007. The syllabus includes: Dynamic systems; ordinary differential equations; linear stability analysis; bifurcation; oscillators; phase portraits; boundary value problems; existence and uniqueness; Green functions; applications to HIV modeling, morphogen gradients, genetic instability, and cancer growth.

**OR**

Math/Comp Core 1b. Dynamical Systems in Biology and Medicine (BME 233, Fall) (4) This course, which was developed specifically for the MCSB program by Dr. Nenadic, covers many of the same themes as in Math 227A, but from a more engineering-oriented perspective, stressing for example topics of control and robustness. The syllabus stresses modeling of various dynamic systems using Lotka-Volterra, Hodgkin-Huxley and Morris-Lecar equations, Belousov-Zhabotinsky chemical oscillators.

Math/Comp Core 2. Mathematical and Computational Biology II (Math 227B, Winter). (4) This course, specifically designed for MCSB by Drs. Nie, Wan, Komarova and Lowengub, was test-taught in 2007 (for the MCSB affiliates), then introduced to the MCSB program in 2008. The syllabus includes: partial differential equations; reaction-diffusion equations; separation of variables; stability of steady-state; Turing instability; linear stability of moving boundaries; computational differential equations: numerical stability, explicit and implicit methods, method of lines, iterative methods for steady states, and applications to spatial dynamics of morphogen systems, Turing patterning, and tissue growth.

Math/Comp Core 3a. Computational Systems Biology (ICS 284C, Spring). (4) This is an existing course that was adapted for MCSB by Dr. Mjolsness. The syllabus includes: composition of models; inference of parameters and structure; +/- feedback in graphs; attractors; interaction vs. reaction graphs; elementary graph theory; algorithmic processes and graphs; Markov random fields; stochastic processes; master equations; branching processes. examples: cell cycle; amino acid synthesis; MAPK signaling; transcriptional regulation in *Drosophila* development.

**OR**

Math/Comp Core 3b. Mathematical and Computational Biology III (Math 227C) (4) This course was developed for MCSB by Drs. Wan and Xie that was taught for the first time in Spring 2011. The topics include an introduction to probability theory; statistical estimation; least square regression; maximum likelihood, Bayesian estimation; principal component analysis; stochastic processes; Markov chains; continuous time Markov processes; stochastic differential equations; Ito's calculus; diffusion, Fokker-Plank equations.

Critical Thinking in Systems Biology (Dev Cell 203A, Fall) (4) This special 10-week discussion course is required of, and limited to, first year MCSB students. It is structured so as to strengthen *cohesion* and *collaboration* among trainees, while at the same time helping them build a clear picture of what Systems Biology is. Each week, the students are assigned a pair of papers carefully selected from the Systems Biology literature. The papers are chosen primarily for their didactic value, and may be new or old. Prior to the single 2.5-hour class meeting each week, the students are instructed to work in teams to decipher and critique the week's papers. At the class meeting, two faculty members sit

around a table with the students and work together to draw out what they have learned. Using a Socratic approach, the instructors encourage the students to reconstruct how the paper came about, to find its strengths and weaknesses, and to place it in the larger context of Systems Biology. Sample weekly themes are: Models and model exploration; synthetic biology; non-linear dynamics; dynamics in time and space; robustness and control; mining data; global network properties; noise and stochastic behavior; and evolution.

The corresponding departments plan to continue offering these core courses every year. See **Appendix 15** for Memoranda of Understanding from the Department Chairs regarding continuance of the core courses.

Other courses:

### **Category I (Mathematics, Computation and Modeling)**

*Representations and Algorithms for Molecular Biology* (ICS 284A, Fall). (4)

This course presents computational approaches to understanding and predicting the structure, function, interactions, and evolution of DNA, RNA, proteins, and related molecules and processes.

*Quantitative methods in ecology and evolutionary biology* (EE 207, Fall). (4)

This course is designed to cover principles of experimental design and statistical analysis and is appropriate for PhD students in the biological sciences and related fields who have some background in statistics.

*Representations and algorithms for molecular biology* (Computer Science, 284A, Fall)  
(4)

This course provides an introduction to computational methods in molecular biology, aimed at those interested in learning about this interdisciplinary area. Covers computational approaches to understanding and predicting the structure, function, interactions, and evolution of DNA, RNA, proteins, and related molecules and processes. Prerequisite: a basic course in algorithms, or a basic course in molecular biology, or consent of instructor.

*Statistical Methods for Data Analysis I* (Statistics 201, Fall). (4)

This course gives an introduction to statistical methods for analyzing data from experiments and surveys. Methods covered include two-sample procedures, analysis of variance, simple and multiple linear regression.

*Continuum Mechanics (Physics 222, Fall)* (4)

Introduction to the continuum limit and stress and strain tensors. Hydrodynamics of perfect fluids; two-dimensional problems, motion of incompressible viscous fluids, Navier-Stokes equations. Basic elasticity theory. Description of viscoelastic materials. Introduction to nonlinear behavior instabilities.

*Computational Methods (Physics 229A, Fall)*. (4)

Lecture, three hours; laboratory, six hours. Mathematical and numerical analysis using Mathematica and C programming, as applied to problems in physical science.

Computational PDEs (Math 226B, Winter).

This course provides an introduction to numerical methods for PDEs. Topics include: Finite Element Methods (FEM); Numerical Methods for Nonlinear Elliptic Problems; Adaptive Methods; Numerical Methods for Convection-Dominated Equations; Finite Volume Method (FVM).

Biophysics of molecules and molecular machines (Physics 230B, Winter). (4)

This course presents physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision. Concurrent with Physics 146A-B.

Introduction to Numerical Probabilistic Modeling of Biological Data (ICS 284B, Winter). (4)

This course provides a unified Bayesian probabilistic framework for modeling and mining biological data. Graphical models; Markov models; Stochastic grammars; Neural networks; Structure prediction; DNA arrays single and multiple gene analysis

Quantitative Physiology: Organ Transport Systems (BME 221, Winter). (4)

This course presents a quantitative and systems approach to physiological systems. Systems covered include the cardiopulmonary, circulatory, and renal systems.

Analysis and Scientific Computing (Math 225C, Spring). (4)

This course provides an introduction to numerical analysis. Topics include Numerical Linear Algebra; Spectral Methods and Applications; Parallel Computing; Numerical Methods for Reaction-Diffusion equations; Nonlinear Optimizations; Monte-Carlo Simulations; Computational Biology.

## **Category II (Biology and Biomedical Engineering)**

Protein Structure and Function (Mol. Bio. 204, Fall). (4)

This course focuses on the structure and properties of proteins, enzymes, and their kinetic properties.

Introduction to Proteomics (Physiol. and Biophys. 252, Winter). (4)

This course introduces students to concepts and methods of proteomics including protein identification, expression proteomics, and protein-protein interactions.

Cell and Tissue Engineering (BME 210, Winter). (4)

This course introduces students to a biochemical, biophysical, and molecular view of cell biology. Topics include the biochemistry and biophysical properties of cells, the extracellular matrix, biological signal transduction, and principles of engineering new

tissues. Prerequisite: graduate standing or consent of instructor.

Cell Biology (Dev. Bio. 231B, Winter). (4)

This course provides an advanced, integrated view of cell biology. Topics include the cell cycle, the cytoskeleton, the extracellular matrix, cell death, protein localization, signal transduction, and the cell biology of cancer.

Chromatin Function (Biol Chem 225, Winter) (4)

This course focuses on current topics in chromatin regulation and nuclear dynamics in eukaryotes. Topics include histone and DNA modifications and modifying enzymes, non-coding RNA, chromatin assembly and remodeling, higher-order chromatin organization, and chromatin-mediated transcriptional regulation in stem cell differentiation, development, neuronal function, and in human diseases.

Advanced Developmental Genetics (Dev. Bio. 210, Spring). (4)

This is an advanced course on the use of genetic analysis to identify the genes that control cell behavior and development. Formal discussion, by instructor, of genetics and the relationship between genotype and phenotype, followed by student-led discussion based on assigned readings.

Regulation of Gene Expression (Micro. Biol. Mol. Genetics 206, Winter). (4)

This course discusses aspects of gene expression including the organization of the eukaryotic nucleus in terms of protein-nucleic acid interaction (i.e., chromatin and chromosome structure); comparisons between prokaryotic and eukaryotic gene expression, the enzymology and regulation of RNA transcription in *E. Coli* and other prokaryotes. Enzymology of transcription in eukaryotes.

Advanced Molecular Genetics (Biol. Chem. 207, Spring). (4)

The course uses yeast as a model system to illustrate how powerful genetic and molecular approaches have led to the current understanding of some conserved regulations of biological processes. It will also introduce recent genomic approaches for gene discovery and functional analysis in the post-genomic era.

Signal Transduction and Growth Control (Biol. Chem. 212, Spring). (4)

This course covers various eukaryotic signaling pathways (tyrosine kinase, Ras-Raf-MAPK, TGF-beta, Wnt, JAK-STAT, and FAS) with an emphasis on the experimental underpinnings. The material is covered in lectures and discussions of pertinent papers.

**Category III (Biotechnology and Entrepreneurship)**

Statistics for management (MBA 201A Fall) (4)

This course deals with methods of statistical inference, emphasizing applications to administrative and management decision problems. Topics: classical estimation and hypothesis testing, regression, correlation, analysis of variance, decision analysis, and

forecasting. Prerequisite: basic statistics with probability.

Biomedical microdevices (BME 261, Fall) (4)

This course provides an in-depth review of microfabricated devices designed for biological and medical applications. Studies of the design, implementation, manufacturing, and marketing of commercial and research bio-MEMS devices.

Foundations of Clinical and Translational Science (PH 290, Fall) (4)

This course introduces the rationale and imperative for clinical and translational science, which seeks to speed up discoveries into healthcare practices. The course will compare and contrast current impediments to clinical research with the potential of translational science. This course will include critical reviews of literature and analyses of selected case studies from CTSA projects around the country.

Technology for life (ENGR 260A, Winter) (4)

This course provides students exposure to engineering techniques including physics, chemistry, biology, and micro/nano technology for enabling life sciences research in the areas of genomics/proteomics, cells, tissues/organs, and biomolecules.

Entrepreneurship for scientists and engineers (ENGR 280, Winter) (4)

This course provides science and engineering students with a real-world introduction to the theory and practice of entrepreneurship. Through a series of presentations by entrepreneurs and industry leaders, coupled with discussions sessions highlighting the key entrepreneurial business themes raised in the presentations, students will explore various organizational, strategic and financial challenges facing entrepreneurs.

## ***VI. Resource Requirements***

### ***1. FTE faculty (\$0)***

The program is not planning to request additional FTE faculty positions. A campus excellence initiative has already allocated 7 FTEs for the area of systems biology (not tied to any particular department). All seven positions have now been filled and the current faculty should meet the resource needs of the proposed MCSB program.

### ***2. Library acquisition (\$0)***

No additional significant library acquisition is expected.

### ***3. Computing Costs (\$0)***

No additional computers for program administration are expected, although funds for laptop computers for students are requested below.

### ***4. Equipment (\$0)***

No additional equipment is expected.

### ***5. Space and capital facilities (\$0)***

There is adequate space for first year students; most will be working in the laboratories of the faculty members overseeing the quarterly lab rotations. Beyond the first year, students will be housed in the laboratory of their thesis advisor or in departmental offices.

### ***6. Other operating costs***

Costs are estimated for the first year of the program (assumed to be 2014). In some categories, a 2% increase annually is expected.

#### ***A. Student Computers and Software (\$28,740)***

Funds are requested to provide students with laptop computers. (15 students *times* \$1358/MAC laptop = \$20,370). Funds are also requested to purchase the mathematical software packages Mathematica and Matlab for the students' laptop computers for the first two years the students are in the MCSB program. (30 students (15 per year) x \$279 = \$8,370). No increase in cost annually is expected. This is a critical component of the training program as these computers are used to provide students with common software and a computing platform.

In the current MCB gateway program, computer and software costs are borne by a combination of sources including the NIH P50 Grant for a Center of Excellence for Systems Biology and temporary funding from the UCI Office of Research. As the MCSB

program grows this is not sustainable in the long-term and thus we request a permanent source of funding for computers and software for students.

***B. Director Remuneration (\$10,000)***

Funds are requested to compensate the Director for the added responsibility of overseeing the program. Currently, the MCB gateway program Director receives funding for one course release as part of the educational core of the NIH P50 Grant for a Center of Excellence for Systems Biology. In the new MCSB program, the MCB gateway program Director will become an Associate Director responsible for the Department Option of the MCSB program. The MCSB Director will be responsible for the full program. We thus request a permanent source of funding to support this additional effort. The Director may share the funds with the Associate Director(s). The funds may be used for salary, research or to purchase course releases. No increase in cost annually is expected.

***C. Staff: Student Affairs Officer II - (Salary – \$48,866; Benefits (37%) – \$18,080 = \$66,946)***

Funds are requested to provide support for an administrator to manage graduate admissions and training grant administration, arrange graduate student recruiting trips, plan social activities for students, track progress toward degrees, maintain a historical database of students after graduation and to provide general support for the Program Director, Associate Director and Gateway and Executive Committees. A 2% increase annually is estimated.

In the current MCB gateway program, there is no Student Affairs Officer. The duties of the Officer are currently performed by two administrators from the Center for Complex Biological Systems (CCBS) who have to balance this effort with their other administrative responsibilities at CCBS including grants administration, personnel appointments, organizing the National Short Course, annual retreats, etc. This scenario is not sustainable in the long-term as the MCSB program will grow in size because students will remain in the program to conduct their M.S. and Ph.D. studies. We thus request a permanent source of funding to support a student affairs officer dedicated to the MCSB graduate program.

***D. Web maintenance (\$0)***

The reporting Dean (Graduate Dean) will provide funds for maintaining the MCSB program's website as part of the normal allocation of funds to the program.

***E. Recurring Office Expenses (\$4,040)***

Telephone and Fax Line	\$600	
Mail Delivery (shared with CCBS)	\$440	
Paper Supplies: Copy paper, toner, name badges, labels, envelopes		\$3,000

A 2% increase annually is estimated. Currently these costs are borne by a combination of sources including the NIH P50 grant and temporary funding from the UCI Office of Research. We thus request a permanent source of funding for recurring office expenses.

***F. Recruiting costs – (\$0)***

The reporting Dean (Graduate Dean) will provide funds for student recruitment as part of the normal allocation of funds to the program.

***G. Bridge funds (\$0)***

The reporting Dean (Graduate Dean) will provide limited funds to temporarily support students if they are not able to find an advisor by their first summer in the MCSB program or in the event that there is an unanticipated funding gap for the student, which is unable to be closed by another means.

***7. Estimated 5-year budget for implementing the Ph.D. in 2014 (2014-2019)***

	Computers & Software	Director & Assoc Director remuneration	Student affairs officer (II)	Office expenses	Totals
Year 1	\$28,740	\$10,000	\$66,946	\$4,040	\$109,726
Year 2	\$28,740	\$10,000	\$68,285	\$4,121	\$111,146
Year 3	\$28,740	\$10,000	\$69,651	\$4,203	\$112,594
Year 4	\$28,740	\$10,000	\$71,044	\$4,287	\$114,071
Year 5	\$28,740	\$10,000	\$72,465	\$4,373	\$115,578
Totals	\$143,700	\$50,000	\$348,391	\$21,024	\$563,115

***VII. Graduate student support***

Students will be provided fellowships for their first year of graduate study from training grants, CCBS funds, UCI Block Grant, campus fellowships, and extramural fellowships such as the NSF Graduate Fellowship and the NIH Ruth L. Kirschstein Research Awards etc. The amounts will be competitive with market rates in the Biological Sciences. This “MCSB rate” will be established annually by the director in consultation with the executive committee.

Students in the MCB gateway program are currently supported by a combination of the sources listed above. In particular, the Graduate Dean provides Block funds at a base rate of \$20,000 for ten students totaling \$200,000. The Graduate Dean will continue to provide these Block funds for the new MCSB program. In addition, the Graduate Dean may raise the rate for each additional student enrolled, above the ten originally allocated. For example, in 2013-2014, the new rate is \$35,000 for each additional student above the base. Because we anticipate that the program will increase in size (15 Ph.D. students and 4 M.S. students) and because the Graduate Dean's new rate for students may increase, the funds provided in the MCSB Block grant are expected increase significantly. This will help to provide a permanent source of funds for the MCSB program that can aid to buffer unanticipated changes in funding from extramural grants that could create funding gaps.

In addition, the Departments of Biomedical Engineering, Computer Science, Developmental & Cell Biology, Ecology & Evolutionary Biology, Mathematics, and Physics & Astronomy, have all offered to provide TA slots to the MCSB program, based on each department's needs and student backgrounds, if a teaching component is required for the MCSB program. See the attached letters from the Department Chairs (**Appendix 8**). This provides another potential source of funds for the MCSB program that could also help to cover gaps in extramural funding should they arise (including TA positions for first year students).

Through their faculty mentors and advisory committees, students will be strongly encouraged to apply for extramural fellowships (e.g., NSF, NIH, etc.), which could also provide potential sources of extramural funding for the MCSB program.

Other sources of income for the program include \$4,000 per student, as part of the NRST funding that will be returned to the MCSB program. We also plan to explore donations and other sources of development funds for graduate fellowships both through CCBS and through the Graduate Division to provide additional sources of funding that are independent of federal grants.

In summary, we expect that there will be sufficient sources of funds to guarantee the MCSB program's long-term sustainability.

In order to continue after the first year in the Ph.D. Option, a MCSB student must demonstrate that there is a faculty member willing to take financial responsibility for that student for as long as the student remains in good academic standing and within maximal time to degree. This includes fees/tuition and a stipend. Faculty advisors will be required to sign a letter of agreement that confirms this responsibility. A sample letter is provided as **Appendix 6**.

Given that the faculty participating in this program represent a variety of disciplines with different cultures and traditions regarding amounts and schedules for graduate student compensation, it is appropriate that there be flexibility in student stipends, e.g. to avoid having graduate students in a single laboratory who are supported at very different stipend levels. At the same time, it is important that students in this program are fully

informed, prior to considering joining a laboratory, about the compensation packages they can expect. To deal with these issues, the following policy will be implemented:

At the beginning of each academic year (e.g. October), each faculty member who is participating in the Ph.D. Option will complete and sign a form (**Appendix 7**) indicating which of two options they designate as their formula for graduate student support effective the following July:

Option 1: The student stipend will be that set annually by the MCSB program (the amount will typically be listed on the form; see **Appendix 7**).

Option 2: The student stipend will be in accord with the formula set by the faculty member's department for support of students in that departmental Ph.D. program. If the faculty member belongs to multiple departments, they must designate on the form, the department from which the rate or formula will be determined.

The option chosen on this form will determine the stipend rate that applies to any *new* student who enters the faculty member's lab or group, e.g. at the end of the academic year. In addition, for students in the MCSB program that are already in the faculty member's lab or group, the stipend for the next academic year will correspond to the greater of (a) the option currently in place for that student, and (b) the option selected on the form.

The information on these forms will be made available to all first-year students by the start of their period of laboratory rotations. Other information on additional requirements at the discretion of the advisor, such as participation in department seminar series in addition to MCSB requirements, will also be made available to students.

We recognize that it may happen that a faculty member may be unable to honor financial agreements regarding student support, e.g. because of loss of funding or departure from the program or campus. In case of a possible funding gap, the faculty should inform the student and MCSB Director sufficiently early and work with them to secure support for the students. In such a case, the Program Director may negotiate with participating MCB gateway Departments for the temporary use of a TA slot. The Program Director, in consultation with the MCSB Executive Committee and the Graduate Dean, may provide bridge funding, if such funds are available and needed. The student may also choose, if eligible, to switch to the stand-alone M.S. degree program. Under such circumstances, the Director may grant a request for an exception to the rule that students transferring into the M.S. program must spend a full year in it.

Finally, we anticipate that a few students in the Ph.D. option may not be able to find a faculty mentor by the end of their first academic year. In such cases, students may submit a petition to the MCSB Executive Committee for bridge funding to obtain support for one or two additional quarters. If no suitable faculty mentor is found at that point, the student may seek to pursue the Departmental Option, or the M.S. option instead, subject to the rules of and regulations associated with those options.



*VIII. Changes in senate regulations*

None.

## **Appendix 1: Bylaws of the Mathematical, Computational and Systems Biology Program**

### **Article I. Purpose**

The primary purpose of the Program is to administer a graduate program of instruction and research leading to the M.S. and Ph.D. degrees in Mathematical, Computational and Systems Biology (MCSB) in accordance with the rules of the Graduate Council of the Academic Senate of the University of California, Irvine. The program will have two options— (1) a Department Option in which MSCB students transfer to the Ph/D. degree program of a Participating Department (see Article III below) after one year (gateway year) in the program to complete their graduate studies and (2) a MCSB Stand-Alone Option to complete their graduate study toward a M.S. and/or Ph.D. degree by way of the MSCB curriculum proposed herein. Since the faculty members involved in this effort are distributed among several academic units, this Program will also serve to facilitate interaction among them and encourage joint research projects, seminars and teaching.

### **Article II. Membership**

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, 52 faculty members have been identified and indicated their interest as participants as Ph.D. trainers; they are listed in **Section IV**.

In the MCSB Program, there will be two types of faculty members: (1) Participating faculty in the Department Option and (2) Participating training faculty in the MCSB Stand-Alone Option. This distinction is made because the Stand-Alone Option requires a more focused research direction as well as additional time and financial commitments than does the Department Option. The only criteria for a faculty member to be a participant in the *Department Option* is that

- They hold primary or joint appointments in a participating department;

whereas a participating member of the *Stand-Alone Option* must

- Demonstrate that they maintain or are starting up an active research program suitable for Ph.D. training in mathematical, computational and systems biology. This may require showing the existence of research funding and/or a track record of past research in the area.

Applications by faculty members to participate in either Option will be reviewed and approved by the MCSB Executive Committee.

Participating faculty are responsible for advising graduate students, serving on student advisory committees, and ad-hoc committees when asked to do so by the Executive

Committee (see Article IV below). It is expected that they will be involved in teaching the core courses. It is also expected that participating faculty will contribute to student recruitment efforts as needed. In addition, participating faculty members of the M.S./Ph.D. Option are expected to serve on preliminary and advancement exam committees and as Ph.D. research supervisors.

The Program Director, in consultation with the Executive Committee, will review the appropriateness of the participation of faculty members every three years. The review may result in a discontinuation of the Participating Faculty status 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 queried annually to indicate whether they wish to continue as participants in the program.

### **Article III: Department participation (in the Department Option)**

A Participating Department in the MCSB Department Option 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 Department Option of the MCSB 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). In addition,

1). The Department must have an existing Ph.D. degree program with a significant mathematical/computational component or with a significant biology component.

Further,

2). 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 3 below) that would be required of any student who moves from MCSB 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 MCSB program.

3). The imposition of significant “additional criteria” (see item 2 above) 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.

4) A student enrolling in a Participating Department after a gateway year is a full-fledged member of that department. The department provides an admitted MCSB student an equal opportunity to receive financial support (e.g. block grant fellowships, teaching assistantships, etc.), and at a stipend level normally extended to other Ph.D. students in that department.

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

The ten current participating departments of the MCB Gateway Program are automatically participating departments of the Department Option of the MCSB Program. Any department not current listed as a Participating Department (see below) may join by application or invitation from the Program Director with the concurrence of the Executive Committee. Participation follows confirmation by the Program Director and Gateway Committee (see Article IV.1). Agreement to all the above terms will be provided in writing by the department chair prior to joining the program.

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.

#### **Article IV: Governance**

Though focused on biology, the MCSB Program is interdisciplinary in nature. It is proposed that the MCSB Program be administered through the Graduate Division and the MCSB Program Director reports to the Graduate Dean. The gateway year of the MCSB Program, currently administered by the School of Biological Sciences should be relocated in the Graduate Division with the existing MCB Gateway Program becoming the Department Option of the new MCSB Program.

The program will be governed by a Director, who will be assisted by one or more Associate Directors, a Program Administrator, a Dean's advisory committee and faculty committees. A MCSB Executive Committee will help to oversee the MCSB Program and a Gateway Executive Committee (the Executive Committee of the MCB Program renamed) will help to oversee the Department Option in accordance with the rules and regulations in the MCB Bylaws.

##### **1. Composition of the Gateway Committee**

- Each participating department is responsible for providing a departmental representative to the Gateway Committee. The representative is to be appointed by the Department Chair to serve as a member of the MCSB Gateway 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 Gateway Committee for the following academic year as are needed to replace members whose term are expiring. Department Chairs may not themselves serve on the Gateway

Committee. Until the MCSB Program is fully operational, the current MCB Executive Committee will fulfill the role of the Gateway Committee.

- If a department has a small number of participating faculty members (3 or fewer) in any given year, it may withdraw its Gateway Committee member, decline to contribute a member for that year, or join together with another department to provide a shared member.
- The Director, in consultation with the MSCB students, will choose a student member, per campus policy.
- The Gateway 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 Gateway Committee would recommend appropriate amendments to the bylaws.
- No faculty member who is already serving on the Gateway 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.

## **2. Composition of the MCSB Executive Committee**

The MCSB Executive Committee will consist of a subset of the Gateway Committee (4 members), plus several at-large members (4) chosen from the entire MCSB membership appointed by the Director and ratified by MCSB participating faculty, plus one student member appointed by the Director in consultation with the MCSB students. The purpose of the at-large membership is to provide appropriate representation of faculty members who are MCSB participating training faculty but are not necessarily in a participating Department.

## **3. Duties and Responsibilities of the Committees**

### **Gateway Committee:**

- Oversees student recruitment;
- Acts as the admissions committee for admitting students (or delegates the responsibility);
- Assigns student advisory committees for incoming first-year students and assigns replacement members for students who choose the Department Option;
- Makes recommendations to the Program Director and Executive Committee concerning the dismissal of students who fail to fulfill requirements of the program during the first academic (gateway) year;
- Makes recommendations to the Program Director regarding the addition of participating departments;
- Meets as frequently as necessary to carry out the above duties.

### **MCSB Executive Committee:**

- Selects /reviews applications for faculty membership;
- Reviews applications for Department membership;
- Sets academic standards, and establishes any other requirements, for continued student enrollment in the program;
- Approve Advancement to Candidacy Committees;
- Makes recommendations to the Program Director and Dean of Graduate Studies concerning dismissal of students who fail to fulfill requirements of the program after the first year;
- Administrative oversight of the graduate 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 guides 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. Procedures of the Committees**

- Decisions/Resolutions of the Executive and Gateway Committees will be passed by a simple majority vote of the membership of said committee, or if a vote is taken at a regular meeting of the Committees, by a simple majority of those present, provided that a quorum consisting of at least 50% of the committee members are present.
- In the event that a vote leads to a tie, the MCSB Program Director will be empowered to cast a tie-breaking vote for the Executive Committee. The MCSB Associate Director will provide the tie-breaking vote for the Gateway Committee. Otherwise, the Program Director and Associate Director will not participate in voting of the Executive and Gateway Committees.
- A tentative calendar of Executive and Gateway Committee meetings will be established at the beginning of each academic year and provided to all Committee members.
- In other matters, the Committees will be expected to adopt procedures consistent with Robert's rules of order.

### **5. The Program Director**

### Recruitment and Appointment of the Program Director:

In consultation with the Executive Committee, the Graduate Dean will appoint a Program Director for the MCSB 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 Graduate Dean or to whoever else may be specified by campus policies and regulations, when the Program becomes operational.

### 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 MCSB Program and the UCI Administration, the Academic Senate, campus committees, Departments, students and outside organizations;
- Administers extramural and intramural funds for the program;
- Coordinates with the Associate Director to make offers of admission to student applicants;
- Recruits, appoints and supervises the Program Administrator;
- Supervises the administration of the MCSB graduate program, including reviews of student progress and faculty participation;
- Appoints at-large members of the MCSB Executive Committee.

### **6. Associate Director(s)**

- The Program Director will appoint one or more Associate Directors for three-year terms, which may be renewable for a second term assuming satisfactory performance;
- An Associate Director will act as a deputy of the Program Director and assume the responsibilities of the Program Director in the Director's absence.
- An Associate Director will Chair the Gateway Committee meetings, will supervise the admissions process, coordinate with the Director to make offers of admission to student applicants, and be responsible for handling first-year student concerns.

### **7. Dean's Advisory Committee**

A Dean's Advisory Committee consisting of the Deans of the participating Schools—Biology, Information & Computer Science, Engineering, Medicine and Physical

Sciences-- will meet annually with the Program Director and the Dean of the Graduate Division to discuss the state of the MCSB graduate program, identify the best practices and suggest potential improvements. See attached letters from the Deans of the participating schools confirming their interest in participating on the Dean's Advisory Committee (**Appendix 9**).

## **8. Other Committees**

Whenever needed, the Executive and Gateway Committees will appoint other standing and ad hoc committees, including an ad hoc committee to assist the Director to review and process student complaints and appeals.

## **9. Program Administrator**

A salaried staff member will be recruited and appointed as a program administrator by the Program Director. This individual will report to the Program Director and 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
- Organizing retreats for review and planning
- Administering all grants, contracts and other extramural and intramural funds
- Serving as secretary at meetings of the Executive Committee and meetings of any other committees as determined by the Director.

## **10. Plebiscites**

Although the Executive Committees 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 MCSB M.S./Ph.D. training faculty members. Once proposed, the MCSB Executive Committee will make the text of the proposed changes available to all participating M.S./Ph.D. faculty for a period of time sufficient for careful review. The MCSB Executive Committee will then schedule and hold a vote of the program membership (e.g., all participating MCSB M.S./Ph.D. faculty members). 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 participating MCSB M.S./Ph.D. training faculty initiating a supporting petition signed by at least 25% of the participating MCSB M.S./Ph.D. faculty members can propose that an officer of the program (such as Program Director, Associate Director or members of the Executive Committees) be removed from office. Once proposed, the MCSB Executive Committee would notify the participating MCSB faculty, and provide adequate opportunities for faculty discussion and review. The MCSB Executive Committee would then schedule and hold a vote of the participating MCSB faculty members. A two-thirds majority of all participating MCSB M.S./Ph.D. 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 MCSB Executive Committee may select an interim officer from any of the participating faculty.

## **11. 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.

### **Article V: Successful completion of the Program**

The successful completion of the MCSB Program consists of two parts. The first part is the successful completion of the first (gateway) year of the program.

The successful completion of the first-year (gateway) part 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.

The second part of the program is the successful completion of the Ph.D. degree in a traditional department (Department Option) or the successful completion of the M.S. or Ph.D. degrees granted by the MCSB program (Stand-alone Option). Students who do not successfully complete the first-year (gateway) part of the program are not eligible to choose the Stand-alone M.S./Ph.D. Option. For students who choose the Stand-alone M.S./Ph.D. Option, a M.S./Ph.D. degree is conferred only after successful completion of the relevant program (as prescribed in Section II).

For students who wish to choose the Department Option, matriculation into a departmental Ph.D. program is at the sole discretion of that department if the student has not successfully completed the first (gateway) year of the Program.

Students who choose the Department Option and are enrolled in Departmental degree programs are expected to complete any additional requirements mandated (in accordance with **Article III**) by that faculty member's department. These students are encouraged to continue to attend the MCSB Research Seminar Series. Other activities such as annual retreats and research in progress seminars to be considered later on by the Gateway Committee will also provide opportunities to maintain contact between the Department Option (Gateway) and MCSB students.

### **Article VI: Student Admissions and recruitment**

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

The Program Director oversees the admissions process and receives the completed applications from the OGS. The Director works with the entire Gateway Committee, or in consultation with the Gateway Committee, may choose to appoint a separate **Admissions Committee** to assist and advise them on the selection of applicants. It is the responsibility of the Gateway Committee to set academic standards for admissions and review the final list of applicants to be admitted.

Following an initial screening of the applicants by the Gateway Committee or Admissions Committee, the Program Director usually invites highly qualified applicants for an interview at UCI. In consultation with the Gateway or Admissions Committee, the Program Director arrives at a list of applicants to be admitted to the Program consistent with feedback from interviews and applicants' dossiers. The Director then presents each applicant an admission offer package (including an offer of *a standard twelve month financial support package*<sup>5</sup>). The package may be supplemented or replaced by a package from other sources such a Eugene Cota-Robles Fellowship, an extramural fellowship or traineeship. Financial support will generally not be provided for M.S. students.

The Program Director is responsible for administering the funds available for advertising and recruitment. The Program Administrator will carry out the administrative duties associated with recruitment.

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<sup>5</sup> Typically, financial support for the three summer months after the first academic year at UCI will be through research funding provided or arranged by a student's primary thesis advisor. In the event a student is not able to find an advisor by this time, bridge funding may be provided, if available and needed.

## **Article VII: Student Advising**

### **1. Composition of Student Advisory Committees**

Each student will be assigned an Advisory Committee by the Gateway Committee upon enrollment in the MCSB Program. The Advisory Committee will consist of two participating faculty members with one designated as the Committee Chair. Both Department Option and M.S./Ph.D. participating faculty members may serve on the Advisory Committee. During the first (gateway) year of the MCSB Program, the Committee will meet quarterly with the student.

For students who choose the Department Option, this committee will meet with the student once per year to follow the student's progress and provide an additional resource of support and guidance. However, the committee membership may be changed (see below).

For students who choose the Stand-alone Option, the student's thesis advisor will assume the role of the Committee Chair when a participating MCSB faculty member has been asked and has agreed to accept that role. At this point, other members of the Advisory Committee may be replaced as is deemed necessary (see below). Typically the Committee will meet with the student twice per year. It is expected that the Advisory Committee will continue to meet twice per year until the student has formed an Advancement to Candidacy Committee, which will then take over the duties until the M.S. or Ph.D. defense. The MCSB Executive Committee, in consultation with the Director, will approve all Advancement to Candidacy Committees.

Based on a student's choice of thesis lab after the first year of training, the composition of a student's advisory committee may be adjusted for students in both the Department and Stand-alone Options. If the thesis advisor is one of the student's previously assigned mentors, a new mentoring committee member will be selected by the Director and MCSB Executive Committee to take his/her place. Other adjustments may be made based on the area of the student's research, or by request of either the student, Advisor or committee member.

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.

### **2. Duties of Student Advisory Committees**

Each committee will meet with its advisee, prior to their enrollment in the first year of MCSB Program, to discuss course and research related issues, and to advise students of their options at the end of their first academic year. 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 previous quarter will be discussed and classes/lab rotations for the coming quarters adjusted as necessary.

Students will be re-apprised of their options at the end of the first academic year. The committee will also hear from the student any concern and complaint that the student may have, investigate the concerns and possibly report and discuss them with the Program Director and/or Associate Director for possible response and action. The committees will also strongly encourage students to apply for extramural graduate fellowships and direct students to information sessions organized by the Graduate Division.

In the event a student receives a grade lower than a B in any course during any quarter, or an unsatisfactory rotation grade for research, 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. For first-year students, the committee will inform the Gateway 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. For students in the Stand-alone M.S./Ph.D. Option beyond the first year, the committee will inform the Executive Committee and that Committee will confer with the Director and the Advisory/Advancement Committees to recommend action(s) to remedy the situation, including expulsion from the program.

### **3. Reporting**

The chair of each advisory committee will report quarterly to the Gateway committee on the progress of each first-year student. After the first year, for students who choose the Department Option, the advisory committee will provide yearly reports. For students who choose the Stand-alone M.S./Ph.D. Option, the advisory committee will provide reports twice per year to the MCSB Executive Committee.

### **4. Appeal**

A student may appeal recommendations or decisions on their status in the MCSB program (such as probation status) in writing to the Program Director. Upon reviewing the facts 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 MCSB internal appeal process through the Office of the Graduate Studies.

### **5. Dissolution**

For students in the Department Option, the responsibilities of the Advisory Committee end when the student receives their degree or has left the degree program.

For students in the Stand-alone M.S. Option, the responsibilities of the Advisory Committee end when the student's M.S. Thesis Committee is formed. The duties of the M.S. Thesis Committee end when the student receives their M.S. degree or has left the degree program.

For students in the Stand-alone Ph.D. Option, the responsibilities of the Advisory Committee end when the student's Advancement to Candidacy Committee is formed. The duties of the Advancement to Candidacy Committee end when the student forms a Thesis Committee. The duties of the Ph.D. Thesis Committee end when the student receives their Ph.D. degree or has left the degree program.

## **Appendix 2: Select Current Mathematical, Computational Biology and Systems Biology Graduate Degree Programs in the US**

Most US institutions offer graduate programs in fields related to mathematical and computational biology and systems biology. These range from concentrations in specific programs within existing Departments, sometimes accompanied by an interdisciplinary designated emphasis, to stand-alone graduate programs.

### UC Campuses and Select California Institutions

UC Berkeley (Biophysics, Biostatistics, Computational and Genomic Biology emphasis)  
UC Davis (Mathematics; Ecology; Biophysics; Biostatistics)  
UC Irvine (Biomedical engineering)  
UCLA (Department of Biomathematics)  
UC Merced (Quantitative and Systems Biology)  
UCR (Genetics, Genomics and Bioinformatics)  
UCSB (Biomolecular Science and Engineering Program)  
UCSC (Bioinformatics)  
UCSD (Bioinformatics and Systems Biology; Bioengineering)  
UCSF (Biological and Medical Informatics; Biophysics; Bioengineering, Integrative Program in Quantitative Biology)

Caltech (Department of Control and Dynamical Systems)  
Stanford University (Chemical and Systems Biology)  
USC (Computational Biology and Bioinformatics Program)

### Other Institutions (partial list)

Arizona State University (Computational Biosciences Program)  
Brandeis University (Department of Mathematics (Biomathematics), IGERT Program in Physics and Chemistry of Biological Systems, Bioinformatics)  
Brown University (Computational Biology; Computer Science)  
CMU-Pitt Ph.D. Program in Computational Biology  
Carnegie Mellon M.S. in Computational Biology  
Claremont Graduate University (Computational and Systems Biology Program, School of Math Sciences)  
Columbia University (Computational Biology Specialization in Program in Cellular, Molecular and Biomedical Studies)  
Cornell University (Computational Biology Program)  
Cornell/Sloan-Kettering/Weill-Cornell (Tri-Institutional): Ph.D. in Computational Biology  
Dartmouth College (MD-Ph.D Program in Computational Biology)  
DIMACS Center for Discrete Mathematics and Theoretical Computer Science  
Florida State University, Biomedical Mathematics  
Harvard University (Systems Biology)

Illinois State University, Biomathematics Program  
Indiana University (Biocomplexity, Systems Biology and Computational Biology Program)  
Iowa State University (Bioinformatics and Computational Biology)  
MIT (Computational and Systems Biology Program)  
North Carolina State University, Biomathematics Graduate Program  
Northwestern University (Computational Biology and Bioinformatics Program)  
The Ohio State University, Department of Mathematics  
Oregon State University, Ecoinformatics minor  
Princeton University (Quantitative and Computational Biology Program)  
Santa Fe Institute  
University of Arizona, Department of Mathematics  
University of Cincinnati (Systems Biology and Physiology)  
University of Oregon, Computer and Information Science, Computational Biology  
University of Pennsylvania, Bioinformatics and Genomics and Computational Biology Program  
University of Pittsburgh, Computational Biology  
University of Tennessee, The Institute for Environmental Modeling  
University of Texas A&M Health Science Center (Systems Biology/Translational Biology Track)  
University of Texas, Austin, Center for Nonlinear Dynamics, and Computational Biology and Bioinformatics Program  
University of Utah, Department of Mathematics  
Vanderbilt University Mathematical Biology  
Virginia Tech, Department of Entomology and Bioinformatics and Computational Biology Program)  
University of Washington (Seattle), Center for Studies in Demography and Ecology, Molecular and Cellular Biology Department, Computational Molecular Biology Program  
Yale University (Computational Biology and Bioinformatics Program)

### **Appendix 3: Current Centers of Excellence in Systems Biology**

The primary mission of the NIGMS (National Institute of General Medical Sciences) supported [National Centers for Systems Biology](#) is to promote institutional development of multidisciplinary research, training, and outreach programs that focus on systems-level studies of biomedical phenomena within the [NIGMS mission](#). The centers are expected to establish themselves as recognized leaders of research and education in systems biology.

**Duke University:** Duke Center for Systems Biology

**Harvard University:** Center for Modular Biology

**Institute for Systems Biology:** Center for Systems Biology

**Johns Hopkins University:** Center for Systems biology of Retrotransposition

**MIT:** Center for Cell Decision Processes

**MIT:** Synthetic Biology Center at MIT

**Mount Sinai School of Medicine:** New York Center for Systems Biology

**Princeton University:** Center for Quantitative Biology

**Stanford University:** Stanford Center for Systems Biology

**The Jackson Laboratory:** Center for Genome Dynamics

**University of California, Berkeley:** Center for RNA Systems Biology

**University of California, Irvine:** Center for Complex Biological Systems.

**University of California, San Diego:** San Diego Center for Systems Biology

**University of California, San Francisco:** Center for Systems and Synthetic Biology

**University of Chicago:** Chicago Center for Systems Biology

**University of Oregon:** Microbial Ecology and Theory of Animals Center for Systems  
Biology

**University of New Mexico:** New Mexico Center for the Spatiotemporal Modeling of  
Cell Signaling

**Medical College of Wisconsin:** Virtual Physiological Rat

#### **Appendix 4: Summary of awards from the 2006 Howard Hughes Medical Institute Initiative**

The following recipients of the HHMI awards to stimulate the establishment of new degree programs for interdisciplinary graduate education were chosen from 132 applicants in 2005. These awards were three years in duration with approximately \$1M in direct costs.

**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. There is a commitment in the proposal to develop a stand-alone MS/Ph.D program with the MCB gateway being the first phase of development. (see Section I.4).

**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

**Appendix 5: Current List of Institutional Training Grant Support Available to Participating Faculty Members, Departments, or Programs at UCI<sup>6</sup>**

<b>Title of Training Grant</b>	<b>Funding Source Including Identifying Number</b>	<b>Active or Pending Project Period</b>	<b>Program Director (Department)</b>	<b>Number of Graduate Trainees Supported This Year</b>	<b>Total # of Participating Faculty</b>
Training in the Neurobiology of Aging	NIH/NIA T32 AG-00096	09/82-04/13 Pending Renewal	Cotman, Carl	4	26
Translational Research In Cancer Genomic Medicine	NIH/NCI T32 CA-113265	09/07-08/12 Pending Renewal	Lee, Wen-Hwa	3	18
Medical Scientist Training Program	NIH/NIGMS GM-08620	07/99-06/14 Pending Renewal	Goldin, Alan	6	46
Biomedical Informatics Training Program	NIH /NIGMS	Pending	Baldi, Pierre	6	33
UCI CIRM Training Grant II	CA CIRM TG2 -01152	09/09-08/15	Donovan, Peter	8	43
Molecular Biology of Eukaryotic Viruses	NIH/NIAID T32 AI-07319	09/88-08/13 Pending Renewal	Semler, Bert	3	13
A Training Program in Cancer Biology & Therapeutics	NIH/NCI T32 CA-09054	07/08-04/14 Pending Renewal	Fan, Hung	4	29
Mathematical, Computational and Systems Biology	NIH/ NIBIB T32 EB009418	04/09 -03/14	Lander, Arthur	6	45
Training Program in Systems Biology of Development	NIH/NICHD T32 HD060555	05/09-04/14	Lander, Arthur	7	31

<sup>6</sup> Information updated 12/16/13 with data from Office of Research Development, School of Biological Sciences.

ICTS TL-1 Scholars Training Program	NIH/NCRR RR-031984	07/10-03/15	Cooper, Dan	3	Any/all faculty are considered potential mentors
Immunology Research Training Program	NIH/NIAID T32 AI060573	07/04 – 08/15	Casali, Paolo	3	29
Interdisciplinary Training Program in Hearing Research	NIH/NIDCD T32 DC010775	07/10-06/15	Metherate, Raju	2	19
Graduate Fellowships for Chemical and Biochemical Engineering and Materials Science Engineering – A Multidisciplinary Proposal	Dept of Education P200A100123	08/10-08/13	Mcartney, Martha	3	28
Graduate Fellowship for Interdisciplinary Training in Neurobiology	Dept of Education	09/12-08/15	Cramer, Karina	3	22
Graduate Assistance in Areas of National Need in Lifechips	Dept of Education	09/12-08/15	Li, Guann-Pyng	3	17
GAANN Fellowship Program in Pure and Applied Mathematics	Dept of Education	09/12-08/15	Lowengrub, John S.	6	17
Graduate Assistance in the Areas of National Need Targeting Developmental Biology and Genetics	Dept of Education	09/12 – 08/15	Mauzy-Melitz, Debra	3	12
Graduate Assistance in Areas of National Need	Dept of Education P200A090107	08/09-08/15	Mueller, Laurence	6	34

Graduate Fellowships for Training in Chemical Synthesis	Dept of Education	09/12-08/15	Van Vranken, David	6	22
IGERT: Biophotonics Across Energy, Space and Time (BEST)	NSF IGERT: 1144901	06/12-05/17	Venugopalan, Vasana	10	20
Minority Biomedical Research Support	NIH R25 MBRS IMSD	09/96-02/13	Moto-Bravo, Luis	5	113
Training Program in Cardiovascular Applied Research and Entrepreneurship	NIH T32 HL116270	06/13-05/18	George, Steven	4	14
Translational Stem Cell Research Training Program for Neurological Disorders	NIH T32 NS082174	09/13-08/18	Thompson, Leslie	4	21
Training Program in Chemical and Structural Biology	NIH/NIGMS	Pending	Poulos, Thomas/Tobias, Douglas	6	25
Training Program in Exposure Biology & Epidemiology	NIH/NIEHS	Pending	Bartell, Scott	2- 1 <sup>st</sup> year; 4- 2 <sup>nd</sup> yr; 6 – 3 <sup>rd</sup> yr.	2

Total Number of Trainees: 116

Total Number of Graduate Trainees (BIT, MCSB and Systems Biology) – 19

## Appendix 6. Sample letter guaranteeing support for a designated student

Date

Dear <Faculty>:

<Student>, a graduate student in the MCSB program, has indicated interest in having you supervise their Ph.D. thesis. We are writing to inform you of some of the responsibilities required of you in supervising a Ph.D. thesis in the MCSB Program.

First, you need to arrange financial support for this student from Year Two through Year Five at the rate you have designated this academic year, or higher. Support for the academic year should be at 49% and the summer months at the same rate, but summer support can be adjusted up to 100% as long as the student maintains good academic standing and demonstrates satisfactory research progress. As the student advances towards a Ph.D. degree, the rate may not be decreased below that which you have designated for the current academic year. The rate may be increased, however, following UCI rules and guidelines.

Second, you must guide this student through the completion of their dissertation. The key milestones that you need to remember are that by <Date>, the student must pass the preliminary exam (or be exempted from taking it), by <Date> the student must form a graduate advisory committee and pass the Advancement to Candidacy exam. Details on the composition of the graduate advisory committee and the qualifying examination can be found in the MSCB Program Student Handbook. The Advancement to Candidacy exam tests the student's knowledge of their subject area, the quality of their Ph.D. thesis proposal and their research competence. The Advancement to Candidacy exam consists of a written proposal for the dissertation and an oral presentation of the proposed dissertation, followed by a question and answer period.

If you are interested in supervising <Student's> Ph.D. research, please sign below and return to <MCSB Program Administrator> no later than <Date>. The Program Administrator will follow up with details on paying tuition, fees and stipends.

Sincerely,

<MCSB Program Director>

<Faculty>

**Appendix 7. Sample letter of faculty financial commitment to advise students**

Date

Dear <Faculty>

As a participating faculty member in the Ph.D. Option of the MCSB graduate program, please designate the level of funding you wish to provide to students who start as your trainees next academic year (<Academic Year>). You may also provide this level of funding to continuing students under your supervision provided that the amount is not less than that the continuing students are currently receiving. Please check one box below, sign and return to <MCSB Program Administrator> no later than <Date>. If you designate your home department support, please provide the name of the department.

at the rate or formula normally used by my home department <department name> to provide support for students.

at the rate or formula set by the MCSB program to provide support for students, which is \$<to be filled in each year> for the academic year <Academic Year>.

Sincerely

<MCSB Program Director>

<Faculty>

**Appendix 8: Letters of support from MCB participating departments and the INP  
and CMB Interdisciplinary Graduate Programs**

See below.

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THE HENRY SAMUELI SCHOOL OF ENGINEERING  
Department of Biomedical Engineering

3120 Natural Sciences II  
Irvine, CA 92697-2715

April 10, 2013

John Lowengrub  
Chancellor's Professor of Mathematics, Biomedical Engineering,  
Chemical Engineering and Materials Science  
540H Rowland Hall  
University of California, Irvine

Dear John,

I am happy to offer my support for the Mathematical, Computational and Systems Biology (MCBS) interdisciplinary program change you and the drafting committee has proposed. The addition of a new option to allow students to choose to remain in the interdisciplinary program rather than continue with the departmental 'tracks' will give the students more options in terms of forming a program to better meet their needs. I see this change as a positive step in meeting students' future career needs in a way that hasn't been done in the past.

Sincerely,

A handwritten signature in cursive script, appearing to read "Abraham P. Lee".

Abraham P. Lee, PhD  
William J. Link Professor and Chair  
Department of Biomedical Engineering  
Director, Micro/Nano Fluidics Fundamentals Focus (MF3) Center  
University of California at Irvine  
Office: 3120 Natural Sciences II, Irvine, CA 92697-2715  
Phone: (949) 824-8155, (949) 824-8155  
BME website: <http://www.eng.uci.edu/dept/bme>  
Lab website: <http://biomint.eng.uci.edu>  
MF3 website: <http://www.inrf.uci.edu/mf3>

October 28, 2013

**To: John Lowengrub Professor of Mathematics, Biomedical Engineering, Chemical Engineering & Materials Science**

I am writing to express my support for the proposed M.S. and Ph.D. degrees in Mathematical, Computational and Systems Biology. I understand that the proposed MCSB program will preserve the structure of the current, highly successful Mathematical and Computational Biology (MCB) graduate gateway program, while presenting some new options to graduate students. In the proposed program, students may choose to join one of the affiliated departments or, as an alternative, to remain in the interdisciplinary program and receive a degree in Mathematical, Computational and Systems Biology.

The proposed program appears to provide expanded research and training opportunities for students and faculty members in the computer science department, working with others in the proposed program. In addition, I anticipate that the educational mission of this program can be sustained into the future, assuming it continues along the proposed approach of utilizing existing courses that are already being offered as a part of the graduate programs provided by the affiliated departments and schools.

In the event that a Computer Science department-offered teaching component is required for the MCSB program, the Department of Computer Science will consider assigning TA slots to MCSB students in support of this component, after CS Department needs have been met and if suitable CS students cannot be found to cover these courses.

Sincerely,



Alex Nicolau  
Professor and Chair  
Department of Computer Science



Department of Developmental and Cell Biology  
School of Biological Sciences  
2011 Biological Sciences III  
Irvine, California 92697-2300

Telephone: 949-824-1969  
Fax: 949-824-4709  
Website: <http://devcell.bio.uci.edu>

4/11/13

Dear John,

Thank you for allowing Developmental & Cell Biology (Dev & Cell) to review and comment on your proposal for a graduate program in MCSB. Following our discussion and the revisions we find the proposal to be thorough, well justified and it will expand an important niche. The governance plan is well formulated and we particularly support the requirement for biannual meetings for students in the stand-alone program.

In the event a teaching component is required for this program, graduate student TA slots in Dev & Cell may be assigned to students in the stand-alone program based on Departmental needs and student background.

We look forward to working with students from this program who elect to enter the labs of our faculty, either as members of the Departmental program or in the stand-alone program.

Sincerely,

A handwritten signature in black ink that reads "Diane O'Dowd".

Diane O'Dowd  
HHMI Professor and Chair  
Developmental and Cell Biology

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LAURENCE D. MUELLER

Department of Ecology & Evolutionary Biology  
Irvine, CA. 92697-2525  
Phone: (949) 824-4744  
FAX: (949) 824-2181  
e-mail: [ldmuelle@uci.edu](mailto:ldmuelle@uci.edu)  
<http://darwin.bio.uci.edu/~mueller>

17 October 2013

Dr. John Lowengrub  
Chancellor's Professor of Mathematics, Biomedical Engineering, Chemical Engineering and Materials  
Science  
540H Rowland Hall  
University of California, Irvine

RE: Proposed MCSB M.S./Ph.D. Program

Dear Dr. Lowengrub:

I have reviewed the materials you sent me about the new stand alone, interdisciplinary graduate program in Mathematical, Computational and Systems Biology (MCSB). It looks like it could be a valuable addition to an already successful program. In the event that a teaching component is required for the MCSB program, we would consider assigning TA slots to MCSB students based on Department needs and student backgrounds. I believe this program will continue to flourish independently of the particular funding mechanisms we have in place. I would certainly support its implementation. Let me know if I can provide any further assistance.

Sincerely,

A handwritten signature in cursive script that reads "Laurence D. Mueller".

Laurence D. Mueller  
Professor and Chair  
Ecology & Evolutionary Biology

John,

I'm not sure I ever got back to you on this. MB&B has no concerns about the launch of this program and we wish you the best of luck. Let me know if I can be of any assistance.

Cheers,

Chris

=====

Christopher C.W. Hughes, Ph.D.  
Professor & Chair

Department of Molecular Biology and Biochemistry  
UC Irvine

=====

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DEPARTMENT OF MICROBIOLOGY AND MOLECULAR GENETICS  
SCHOOL OF MEDICINE



---

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---

IRVINE, CALIFORNIA 92697-4025

April 18, 2013

John Lowengrub  
Chancellor's Professor of Mathematics, Biomedical  
Engineering, Chemical  
Engineering and Materials Science  
540H Rowland Hall  
University of California, Irvine

Dear John,

The faculty of the Department of Microbiology and Molecular Genetics in the School of Medicine are happy to support the proposed MCSB Interdisciplinary Graduate Program. We look forward to assisting with the development or implementation of this program in any way that may be useful to you.

Sincerely,

A handwritten signature in black ink, appearing to read "Rozanne M. Sandri-Goldin".

Rozanne M. Sandri-Goldin, Ph.D.  
Professor and Chair



SCHOOL OF MEDICINE  
DEPARTMENT OF BIOLOGICAL CHEMISTRY

IRVINE, CALIFORNIA 92697-1700  
[HTTP://WWW.UCIHS.UCI.EDU/BIOCHEM/](http://www.ucihs.uci.edu/biochem/)

April 15, 2013

John Lowengrub  
Chancellor's Professor  
Department of Mathematics  
540H Rowland Hall  
University of California,  
Irvine, CA 92697-3875

Dear John:

After discussions with several of the faculty members in the Department of Biological Chemistry, we are supportive of your department's program of Graduate Studies in Mathematical, Computational and Systems Biology. The direction of today's research in biomedicine is requiring an increase in the quantitative understanding of large-scale and complex systems. In order to have qualified professionals to serve this need, your program will be able to fulfill this growing need. We commend you and the Department of Mathematics.

Good luck with the program.

Sincerely,

A handwritten signature in cursive script that reads "Eva YHP Lee".

Eva YHP Lee, PhD  
Chancellor's Professor  
Chair, Department of Biological Chemistry

Dear Professor Lowengrub,

The Department of Chemistry strongly supports the proposal to create a Program of Graduate Studies in Mathematical, Computational and Systems Biology.

Formalizing networks to encourage interdisciplinary research will be an important goal and outcome of the proposed program.

More specifically, chemistry faculty engage in a number of collaborations with their colleagues in this program. We expect the new program to benefit these

collaborative research programs by attracting outstanding students. Therefore, I enthusiastically endorse the proposal, and hope to see it approved.

Scott Rychnovsky

Scott Rychnovsky, Ph.D.

Professor and Chair

Department of Chemistry

1102 Natural Sciences II

University of California, Irvine

Irvine, CA

92697-2025

Phone: (949) 824-6018

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srychnov@uci.edu

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Fax (949) 824-7993  
[www.math.uci.edu](http://www.math.uci.edu)

October 22, 2013

Council on Educational Policy  
Academic Senate  
University of California, Irvine

Dear CEP members,

I have read the description of and requirements for the proposed interdisciplinary Program of Graduate Studies in Mathematical, Computational and Systems Biology (MCSB). The Mathematics Department endorses this proposal.

When the Mathematics Department needs additional Teaching Assistants beyond our own graduate students, qualified MCSB students are eligible to be considered for those positions.

Sincerely,

A handwritten signature in cursive script that reads "Karl C. Rubin".

Karl Rubin  
Professor and Chair  
Department of Mathematics  
University of California, Irvine

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SCHOOL OF PHYSICAL SCIENCES  
DEPARTMENT OF PHYSICS AND ASTRONOMY

IRVINE, CALIFORNIA 92697-4575  
4129 FREDERICK REINES HALL  
Phone (949) 824-6911

October 16, 2013

Letter of support for the graduate program in MCSB

The Department of Physics and Astronomy strongly supports the new stand-alone interdisciplinary graduate program in Mathematical, Computational and Systems Biology (MCSB). Our faculty have taught courses in the previous gateway MCB program and we plan to continue our teaching commitment to the program in MCSB. In particular, we plan to offer Physics 230A, Biophysics of Molecules and Molecular Machines, every year. Our Department regards quantitative biology as a growth area, and the graduate program in MCSB is an excellent way to recruit students from a variety of disciplines. The program in MCSB will also provide an intellectual center to coordinate the activities of researchers that are spread over several Departments and Schools. In the event that a teaching component is required for the program, the Department of Physics and Astronomy would consider assigning TA slots to MCSB students based on Department needs and student backgrounds.

Sincerely yours,

A handwritten signature in black ink that reads "Peter Taborek".

Peter Taborek  
Professor and Chair  
Department of Physics and Astronomy  
University of California, Irvine



David A. Fruman, Ph.D.  
Professor, Department of Molecular Biology & Biochemistry  
Director, PhD Program in Cellular & Molecular Biosciences  
dfruman@uci.edu

3242 McGaugh Hall  
Irvine, CA 92697-3900  
(949) 824-1947 TEL  
(949) 824-8551 FAX

September 27, 2013

John Lowengrub, Ph.D.  
Chancellor's Professor of Mathematics, Biomedical Engineering, Chemical Engineering and  
Materials Science  
540H Rowland Hall  
University of California, Irvine

Dear Professor Lowengrub,

I am pleased to write in strong support of your proposal for a graduate program in Mathematical, Computational and Systems Biology (MCSB). Thanks to the vision of diverse UC Irvine faculty and administrators, our university is now a world leader in the emerging science of systems biology. Through the efforts of this interdisciplinary group we have established a rigorous curriculum for graduate training and obtained significant extramural support for predoctoral students. The new program that you propose builds on the strengths of the existing Ph.D. gateway program in Mathematical and Computational Biology (MCB). I am confident that the proposed program will improve the quality of graduate students in these disciplines that we can recruit to UC Irvine, while providing more flexibility for these students to optimize their course choices. I see several advantages of the proposed MCSB program:

- 1) The Ph.D. option that is not departmentally based will allow students to choose coursework based on their interests, guidance from mentors, and the needs of their dissertation project. Currently, students must transfer to a department after the first year gateway program and the requirements of those departments sometimes do not serve the needs of individual students.
- 2) The M.S. option provides another path for students who seek careers in systems biology that do not require the lengthy and independent Ph.D. pathway.
- 3) It is likely that the program will be more successful in recruiting the best applicants, by offering the additional choices.
- 4) It is important that the current format (departmental option) is retained in the proposal. For some Ph.D. students this will remain the preferred option, as having a department "home" has advantages such as retreats, research-in-progress seminars and the like.

In summary, I consider the proposed MCSB program to be another step towards establishing UC Irvine as a top destination for exceptional training in systems biology and related fields. As Director of the PhD program in Cellular & Molecular Biosciences, I applaud your initiative in maximizing the quality and visibility of our graduate programs.

Sincerely,

A handwritten signature in cursive script that reads "David Fruman".



Marcelo A. Wood, Ph.D.  
University of California, Irvine

Associate Professor, Dept. of Neurobiology & Behavior  
Director, Interdepartmental Neuroscience Program  
Fellow, Center for the Neurobiology of Learning & Memory

301 Qureshey Research Laboratory  
Irvine, CA 92697-3800  
P: 949-824-2259  
mwood@uci.edu

March 16th, 2013

Dear John,

This letter is to formally support the proposal to create an interdisciplinary program of graduate studies in Mathematical, Computational, and Systems Biology (MCSB). As biology research continues to evolve, the requirement for a quantitative approach to understanding large-scale and complex systems is more necessary than ever. The MCSB program provides the necessary infrastructure and training for graduate students leading to MS and PhD degrees. Much of the infrastructure for this program already exists at UCI from the gateway program in Mathematical and Computational Biology (MCB) as well as the National Center of Excellence in Systems Biology. This is a terrific opportunity to leverage these outstanding programs to create the MCSB program, which will enhance interdisciplinary training and allow students to receive MCSB degrees. This is a significant step forward in providing excellent and timely graduate training affecting not only the training of the students, but the reputation and standing of our graduate studies as a whole at UCI. Thus, I am in full support of this new MCSB program.

Best regards,

A handwritten signature in black ink, appearing to read "M. A. Wood".

Marcelo A. Wood, PhD

**Appendix 9: Letters of support from the Deans of the Graduate Division and of the participating schools**

See below.



Office of the Hana and Francisco J. Ayala Dean  
School of Biological Sciences

5120 Natural Sciences II  
Irvine, CA 92697-1450  
(949) 824-5315  
Fax: (949) 824-3035

October 11, 2013

Dear Professor Lowengrub and the MCSB Drafting Committee,

I enthusiastically endorse your proposal for a stand-alone M.S./Ph.D. Program in Mathematical, Computational and Systems Biology (MCSB). The proposed extensions of the current MCB gateway program are exciting and should provide further interdisciplinary research collaborations for faculty in the School of Biological Sciences and new interdisciplinary training opportunities for students.

I am comfortable with the reporting mechanism whereby the Program Director would report to the Graduate Dean. I am confident that my successor as Dean would be agreeable to serving on a Dean's committee that would meet once per year with the Program Director, the Deans from the other participating schools and the Graduate Dean.

There is strong support for this proposal from faculty in the Biological Sciences. Moreover, there have been a number of recent hires in the School of Biological Sciences of faculty with expertise in systems biology due in part to the interdisciplinary hiring initiative in systems biology led by the Center for Complex Biological Systems. Thus, I anticipate that the program can be sustained into the future.

In the event that a teaching component is required for the program, the School of Biological Sciences would consider assigning TA slots to MCSB students based on School needs and student backgrounds.

Sincerely,

Handwritten signature of Albert F. Bennett in cursive.

Albert F. Bennett  
Hana and Francisco J. Ayala Dean

Handwritten signature of R. Michael Mulligan in cursive.

R. Michael Mulligan  
Associate Dean of Graduate Studies

October 17, 2013

**JOHN S. LOWENGRUB, CHANCELLOR'S PROFESSOR  
MATHEMATICS, SCHOOL OF PHYSICAL SCIENCES**

**RE: M.S. /Ph.D. Program in Mathematical, Computational and Systems Biology (MCSB)**

I am happy to endorse your proposal for a stand-alone M.S. /Ph.D. Program in Mathematical, Computational and Systems Biology (MCSB). The proposed program is well thought out and the stand-alone option should help to fill an important niche in interdisciplinary training for computational and biology students. The new program also has the potential to enhance interdisciplinary research collaborations for faculty in the School of Information and Computer Sciences.

The reporting mechanism whereby the Program Director would report to the Graduate Dean seems appropriate to me. I would be happy to serve on a Deans' Oversight Committee that would meet once per year with the Program Director, the Deans from the other participating schools and the Graduate Dean.

There is support for this proposal from faculty in the School of Information and Computer Sciences. A number of our faculty members have active and excellent research programs in systems biology and related fields. Thus, I believe there is sufficient expertise in the School to support and sustain our contribution to the proposed program in the future.

In the event that a teaching component is required for the program, the School of Information and Computer Sciences would consider assigning TA slots to MCSB students based on School needs and student backgrounds.

Sincerely,



Hal Stern  
Ted and Janice Smith Family Foundation Dean

Cc: Jim McKenzie, Assistant Dean

UNIVERSITY OF CALIFORNIA

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SANTA BARBARA • SANTA CRUZ

STUDENT AFFAIRS  
THE HENRY SAMUELI SCHOOL OF ENGINEERING

305 Rockwell Engineering Center  
Irvine, CA 92697-2710

October 10, 2013

Dear Professor Lowengrub and the MCSB Drafting Committee,

I enthusiastically endorse your proposal for a stand-alone M.S./Ph.D. Program in Mathematical, Computational and Systems Biology (MCSB). The additions of the new stand-alone M.S./Ph.D. tracks will enhance the program and should provide further interdisciplinary research collaborations for faculty in the School of Engineering and new training opportunities for students.

I am comfortable with the reporting mechanism whereby the Program Director would report to the Graduate Dean. Either I or Dean Washington would be happy to serve on a Dean's committee that would meet once per year with the Program Director, the Deans from the other participating schools and the Graduate Dean.

Sincerely,

A handwritten signature in cursive script that reads "John C. LaRue".

John LaRue, Associate Dean

Cc: G.W. Washington, Dean



Ralph V. Clayman, M.D.  
Dean, School of Medicine  
Professor, Dept of Urology  
University of California, Irvine

252 Irvine Hall  
1001 Health Science Road  
Irvine, Ca 92697-3950  
(949) 824-5926 office  
(949) 824-2676 fax

October 15, 2013

John Lowengrub  
Chancellor's Professor of Mathematics, Biomedical Engineering,  
Chemical Engineering and Materials Science  
540H Rowland Hall

Dear Professor Lowengrub and the MCSB Drafting Committee,

I enthusiastically endorse your proposal for a stand-alone M.S./Ph.D. Program in Mathematical, Computational and Systems Biology (MCSB). The proposed MCSB program builds upon the success of the existing graduate gateway program in Mathematical and Computational Biology (MCB) in new and important ways. Further, the program should enhance interdisciplinary research collaborations for faculty in the School of Medicine and new training opportunities for students.

I am comfortable with the reporting mechanism whereby the Program Director would report to the Graduate Dean. I would be happy to serve on a Dean's committee that would meet once per year with the Program Director, the Deans from the other participating schools and the Graduate Dean.

Sincerely,

Handwritten signature of Ralph V. Clayman in black ink.

Ralph V. Clayman, MD  
Dean, School of Medicine  
Professor, Department of Urology

Handwritten signature of Klemens J. Hertel in black ink.

Klemens J. Hertel, PhD  
Assoc. Dean for Graduate Studies  
Professor, Department of Microbiology & Molecular Genetics

cc: Al Goldin

IRVINE: SCHOOL OF PHYSICAL SCIENCES  
OFFICE OF THE DEAN

October 14, 2013

Dear Professor Lowengrub and the MCSB Drafting Committee,

I enthusiastically endorse your proposal for a stand-alone M.S./Ph.D. Program in Mathematical, Computational and Systems Biology (MCSB). The proposed program builds on the highly successful Mathematical and Computational Biology (MCB) graduate gateway program and provides new and attractive options for graduate students. The new program should also enhance interdisciplinary research collaborations for faculty in the School of Physical Sciences and new interdisciplinary training opportunities for students.

I am comfortable with the reporting mechanism whereby the Program Director would report to the Graduate Dean. I would be happy to serve on a Dean's committee that would meet once per year with the Program Director, the Deans from the other participating schools and the Graduate Dean.

There is strong support for this proposal from faculty in the School of Physical Sciences. Moreover, there have been two recent hires in the School of Physical Sciences as part of the interdisciplinary hiring initiative in systems biology led by the Center for Complex Biological Systems. Thus, I anticipate that the program can be sustained into the future.

In the event that a teaching component is required for the program, the School of Physical Sciences would consider assigning TA slots to MCSB students based on School needs and student backgrounds.

Sincerely,



Kenneth C. Janda  
Dean

c: James Rutledge, Associate Dean

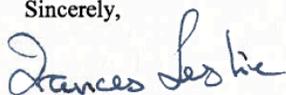
January 15, 2014

JUTTA HECKHAUSEN, CHAIR  
GRADUATE COUNCIL

I am writing to express my strong support for the proposed graduate program in Mathematical, Computational, and Systems Biology (MCSB). I believe the program will provide a high level of integrative preparation in quantitative and biological training and research, building on the success of the current graduate gateway program in Mathematical and Computational Biology (MCB). The interdisciplinary program is designed to produce graduates that will engage in independent research careers in academic institutions, teach at advanced levels of instruction, and lead research efforts in health agencies and industry. Furthermore, a graduate program in MCSB is consistent with the UCI Strategic Plan, and will contribute significantly to the research community in an interdisciplinary collaboration between physical, engineering, computational, and biological sciences.

I have agreed to be the reporting Dean for student affairs for the graduate program and anticipate that it will provide a robust and dynamic academic experience. I will also coordinate with Deans of participating academic units to ensure a seamless academic experience for the students. I will provide financial administrative support consistent with all other programs. Graduate students in the MCSB program will receive the same opportunities for benefits and support available to other UC Irvine graduate students in the form of fellowships and research and teaching assistantships. The program will also receive block fellowship support from the Graduate Division, as well as some funds for recruitment, student travel, and for temporary, bridge support for unfunded students. I believe the proposed graduate program in MCSB will provide an important contribution to graduate education, and look forward to approval of this significant interdisciplinary program at UC Irvine.

Sincerely,



Frances M. Leslie  
Dean of the Graduate Division

C: Peter Krapp, Chair, Academic Senate  
Luisa Crespo, Executive Director, Academic Senate  
Jill Kato, Senior Analyst, Academic Senate

## Appendix 10: Letter of support from the EVCP



OFFICE OF THE PROVOST AND EXECUTIVE VICE CHANCELLOR  
UNIVERSITY of CALIFORNIA • IRVINE

January 21, 2014

**FRANCES LESLIE, DEAN  
GRADUATE DIVISION**

**RE: Proposal for an M.S. and Ph.D. in Mathematical, Computational and Systems Biology**

My office has reviewed the proposal for a new M.S. and Ph.D. program in Mathematical, Computational and Systems Biology (MCSB), to be housed in the Graduate Division. This program is consistent with the standards and scope of campuswide academic planning and is a valuable addition to UC Irvine's graduate program.

If approved by the Senate, the proposed program will be administered by the Dean of the Graduate Division, who will be expected to support it at a level comparable to that of similar programs administered in Graduate Division; the dean can address any program-specific needs within the general budget process.

A handwritten signature in black ink, appearing to read "Howard Gillman".

Howard Gillman  
Provost and Executive Vice Chancellor

C: Senior Vice Provost Clark  
Senate Chair Krapp



## Appendix 11: CPEC Questionnaire

**1. Name of Program:** Mathematical, Computational and Systems Biology (MCSB)

**2. Campus:** Irvine

**3. Degree/Certificate:** MS/PhD

**4. CIP Classification (to be completed by the Office of the President):**

**5. Date to be started:** The MCSB program will start as soon as it is approved.

**6. If modification of existing program, identify that program and explain changes:**

A graduate gateway program in Mathematical and Computational Biology (MCB) has been in existence at UCI since 2007. The activities of MCB would remain largely unchanged as a result of this proposal. In particular, the proposed MCSB program will preserve the current MCB structure, while presenting new options to graduate students. Specifically, the new program will provide more extensive interdisciplinary training than currently available. Once the MCSB program is approved, the current MCB gateway graduate program will become the “Department Option” of the MCSB program, through which students complete their graduate training in a traditional department setting. However, through the new “M.S.” or “Ph.D.” options, the MCSB program will now permit students to complete their graduate training in a fully interdisciplinary setting, at the conclusion of which they will receive a MCSB degree.

**7. Purpose (academic or professional training) and distinctive features (how does this program differ from others, if any, offered in California?)**

As described in the US National Academy of Sciences report on “A New Biology for the 21<sup>st</sup> Century”, it is anticipated that biologists will increasingly need to work at the interface with disciplines such as mathematics, computer science, physics and engineering. Obtaining appropriate training for such activities poses challenges for traditional training programs. In particular, the traditional organization of graduate training programs around single departments tends to limit the range of training a student may receive. The MCB gateway program was initiated in 2007 as the first phase of a solution to this problem. MCB provides intense, one-year, interdisciplinary training that allows students to join traditional departments with a breadth of skills and knowledge that should enhance their ability to contribute to the “New Biology”.

This approach clearly serves the needs of many students, as attested to by the great success (both in terms of student numbers and quality) that the MCB program has enjoyed since its inception. However, for some students, particularly those seeking to undertake the most creative, forward-looking research, the requirement to complete a Ph.D. within a single, traditional department can be a hindrance to progress. For such a

student, the curricular requirements of no single department may be appropriate. Indeed, some students who declined admission to the MCB program did so precisely because we do not currently have a stand-alone degree program. The MCSB program proposed here is developed, in part, to serve the needs of such students, among whom the leaders of the “New Biology” are especially likely to come. In addition, the MCSB program is also designed to serve the needs of students who, for various reasons, would benefit by a short-term M.S. degree program in mathematical, computational and systems biology.

In fulfilling these functions, the MCSB program will be able to attract new, highly qualified students to UCI, beyond those now already enrolling in MCB, and to provide them with a unique academic experience of the highest quality and greatest societal and career relevance.

Many campuses of the University of California, and other Universities in California, now offer graduate programs in fields related to mathematical and computational biology and/or systems biology. These range from concentrations in specific programs within existing Departments, sometimes accompanied by an interdisciplinary designated emphasis, to several stand-alone graduate programs. For example, at UCLA there is a Biomathematics Department, which is located in the School of Medicine. Stand-alone graduate programs exist at UC Berkeley (Biophysics, Biostatistics), UC San Diego (Bioinformatics and Systems Biology), UC Merced (Quantitative and Systems Biology), UCSF (Biological and Medical Informatics, Integrative Program in Quantitative Biology), UCSB (Biomolecular Science and Engineering Program), Caltech (Control and Dynamical Systems), Stanford University (Chemical and Systems Biology), USC (Computational Biology and Bioinformatics Program).

The large number and rapid growth of such programs at UC campuses, and other campuses in California, attests the growing importance of quantitative, interdisciplinary approaches in biology. The UCI MCB program is already one of the largest and most established of these programs. With approval of MCSB, UCI will acquire a pipeline for interdisciplinary training that will be exceptionally broad and deep, providing students with training opportunities that are unique among UC campuses, other Universities in California and within the nation overall.

#### **8. Type(s) of students to be served:**

Applicants are expected to hold a Bachelor’s degree in one of the Science, Technology, Engineering, and Mathematics (STEM) fields.

#### **9. If program is not in current academic plan give reason for proposing program now:**

The biological sciences are entering a new era in which scientific advancement requires a quantitative understanding of large-scale and complex systems. Thus, there is a tremendous and urgent need to provide quantitative training for biologists and biological training for mathematicians, physical and computer scientists and engineers.

Obtaining appropriate training for such activities poses challenges for traditional training programs. In particular, the traditional organization of graduate programs around single departments tends to limit the range of training a student may receive.

The current MCB gateway program was initiated as the first phase of a solution to this problem. MCB provides intense, one-year, interdisciplinary training that allows students to join traditional departments with a breadth of skills and knowledge that enhance their ability to contribute to the “New Biology”. This approach serves the needs of many students, as attested to by the great success (both in terms of student numbers and quality) that the MCB program has enjoyed since its inception. However, for some students, particularly those seeking to undertake the most creative, forward-looking research, the requirement to complete a Ph.D. within a traditional department can be a hindrance. For such a student, the curricular requirements of no single department may be appropriate.

Thus, we believe that it is time to develop a stand-alone interdisciplinary graduate program in Mathematical, Computational and Systems Biology (MCSB) leading to M.S. and Ph.D. degrees. This effort also dovetails with other campus initiatives in this area.

The MCSB program proposed here is developed, in part, to serve the needs of students who wish to work at the boundaries between disciplines, among whom the leaders of the “New Biology” are especially likely to come. In addition, the MCSB program is designed to serve the needs of students who, for various reasons, would benefit by a short-term M.S. degree program in mathematical, computational and systems biology.

In fulfilling these functions, the proposed MCSB program will be able to attract new, highly qualified students to UCI, beyond those now already enrolling in MCB, and to provide them with a unique academic experience of the highest quality and greatest societal and career relevance.

**10. If program requires approval of licensure board, what is the status of such approval?**

N/A

**11. Please list special features of the program (credit for experience, internships, lab requirements, unit requirements, etc.):**

Prior to the start of their first year, students are required to attend an introductory bootcamp, which involves intensive lecture- and laboratory-based short courses designed to help fill in gaps in student preparation in biology, mathematics and computation. In addition, 2 Laboratory rotations are to be taken either in the Fall, Winter and Spring quarters during a student’s first year in the Program.

Students who transfer from the Ph.D. Program to the M.S. Program must spend one year in the M.S. Program before receiving their degree, unless an exception is made by the Program Director, in consultation with the Executive Committee.

**12. List all new courses required:** No new courses are required.

**13. List all other required courses**

Core courses

- *Bio Core 1: Biophysics of Molecules and Molecular Machines* (Physics 230A, Fall).
- *Bio Core 2: Systems Cell Biology* (Dev. Bio. 232, Winter).
- *Bio Core 3: (A). Population Dynamics* (Eco. Evo 251, Spring) **OR** (B). *Systems Biology of Development* (Dev. Bio. 203B, Spring)
- *Math/Comp. Core 1: (A). Mathematical and Computational Biology I* (Math 227A, Fall) **OR** (B). *Dynamical Systems in Biology and Medicine* (BME 233, Fall).
- *Math/Comp. Core 2: Mathematical and Computational Biology II* (Math 227B, Winter).
- *Math./Comp. Core 3: (A) Computational Systems Biology* (ICS 284C, Spring) **OR** (B) *Mathematics and Computational Biology III* (Math 227C, Spring).
- *Critical Thinking in Systems Biology* (Dev Cell 203, Fall).

The corresponding departments plan to continue offering the core courses every year. See **Appendix 15** for Memoranda of Understanding from the Department Chairs regarding the continuance of the MCSB core courses.

*M.S. Degree:* 2 required elective (existing) courses for the research thesis option (i) and 5 required elective (existing) courses for the literature thesis option (ii).

*Ph.D. Degree:* 5 required elective (existing) courses.

A list and description of the elective courses can be found Sections II and V of this document.

**14. List UC campuses and other California institutions, public or private, which now offer or plan to offer this program or closely related programs:**

Many campuses of the University of California, and other Universities in California, now offer graduate programs in fields related to mathematical and computational biology and/or systems biology. These range from concentrations in specific programs within existing Departments, sometimes accompanied by an interdisciplinary designated emphasis, to several stand-alone graduate programs. For example, at UCLA there is a Biomathematics Department, which is located in the School of Medicine. Stand-alone graduate programs exist at UC Berkeley (Biophysics, Biostatistics), UC San Diego (Bioinformatics and Systems Biology), UC Merced (Quantitative and Systems Biology), UCSF (Biological and Medical Informatics, Integrative Program in Quantitative Biology), UCSB (Biomolecular Science and Engineering Program), Caltech (Control and

Dynamical Systems), Stanford University (Chemical and Systems Biology), USC (Computational Biology and Bioinformatics Program).

The large number and rapid growth of such programs at UC campuses, and other campuses in California, attests the growing importance of quantitative, interdisciplinary approaches in biology. The UCI MCB program is already one of the largest and most established of these programs. With approval of MCSB, UCI will acquire a pipeline for interdisciplinary training that will be exceptionally broad and deep, providing students with training opportunities that are unique among UC campuses, other Universities in California and within the nation overall.

**15. List any related program offered by the proposing institution and explain relationship**

In 2007, UCI started a graduate gateway program in Mathematical and Computational Biology (MCB). This combines training efforts from 10 departments in 5 schools 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. After the first year, students in the current MCB program choose to enter a particular Department in which to complete their graduate studies. The activities of MCB would remain largely unchanged as a result of this proposal. In particular, the proposed MCSB program will preserve the current MCB structure, while presenting new options to graduate students. Specifically, the new program will provide more extensive interdisciplinary training than currently available. Once the MCSB program is approved, the current MCB gateway graduate program will become the “Department Option” of the MCSB program, through which students complete their graduate training in a traditional department setting. However, through the new “M.S.” or “Ph.D.” options, the MCSB program will now permit students to complete their graduate training in a fully interdisciplinary setting, at the conclusion of which they will receive a MCSB degree.

The departments that currently participate in MCB Graduate Gateway Program each have their own graduate programs, and each has some potential for overlap with the MCSB program. These include programs in Cellular and Molecular Biosciences, Developmental and Cell Biology, Ecology and Evolutionary Biology, Molecular Biology and Biochemistry, Biological Chemistry, Microbiology and Molecular Genetics, Mathematics, Physics, Computer Science, and Biomedical Engineering. Several of these departmental programs allow a limited number of MCSB courses to satisfy elective requirements. Overall, however, the MCSB curriculum differs greatly from the core curricula of every individual graduate program at UCI.

**16. Summarize employment prospects for graduates of proposed program. Give results of job market survey if such have been made.**

There are many opportunities for graduates in mathematical, computational and systems biology. These include positions in academic departments, including Systems Biology Departments, National Laboratories, the National Institutes of Health, etc. Numerous opportunities exist for placement of students in industry, including the pharmaceutical,

bioinformatics, biomedical and insurance industries. Job opportunities for graduates likely exceed the supply in both academia and industry.

**17. Give estimated enrollment for the first 5 years and state basis for estimate**

It is expected that 20 current UCI graduate students will transfer into the MCSB Ph.D. program from either the MCB gateway graduate program or traditional departmental graduate programs most likely from advisors who join the program. In addition, the program will begin accepting applications in its first year of operation. Based on the current MCB gateway numbers, we anticipate an incoming class of 20 students – 15 Ph.D. students and 4 M.S. students. As new faculty members join the program, we anticipate the number of students will grow proportionally. We expect that within 5 years, the program will have roughly 50 students.

**18. Give estimates of the additional cost of the program for 5 years**

**FTE faculty:** None.

**Library acquisition:** None.

**Computing costs:** Funds are requested for software licenses for the Program (see below).

**Equipment:** Funds are requested to provide basic computing equipment for the program and student offices (see below)

**Program Staff:** Funds are requested for a full-time Student Affairs Officer (see below).

**Office Expenses:** Funds are requested for office expenses (see below).

**Summary of operating costs:**

	Computers & Software	Director & Assoc Director remuneration	Student affairs officer (II)	Office expenses	Totals
Year 1	\$28,740	\$10,000	\$66,946	\$4,040	\$109,726
Year 2	\$28,740	\$10,000	\$68,285	\$4,121	\$111,146
Year 3	\$28,740	\$10,000	\$69,651	\$4,203	\$112,594
Year 4	\$28,740	\$10,000	\$71,044	\$4,287	\$114,071
Year 5	\$28,740	\$10,000	\$72,465	\$4,373	\$115,578
Totals	\$143,700	\$50,000	\$348,391	\$21,024	\$563,115

**19. How and by what agencies will the program be evaluated?**

UCI has a regular policy of reviewing graduate programs every seven years. The MCSB M.S. and Ph.D. program will be reviewed as part of the normal review process. In addition, an External Advisory Committee will evaluate the program every 5 years. The

External Advisory Committee will consist of leaders in mathematical, computational and systems biology drawn from industry and academics. Committee members will be invited to spend 1-2 days at UCI for this purpose. During their stay, they will meet with Program faculty and students to assess the performance of the program. They will issue a report that will evaluate the program and indicate possible improvements and enhancements.

## Appendix 12: Graduate Degree Program Summary

### Degree Program:

Degree Objective: M.S./Ph.D.  
Degree (Diploma) Title: M.S./Ph.D. Degree in Mathematical, Computational and Systems Biology  
Degree Concentration:  
Degree Program Code:

Specialization or Emphasis: Mathematical, Computational and Systems Biology

Academic Unit: Interdisciplinary/ Graduate Division

Date Authorized:

Last Updated:

Last Program Review: NA

Normative Time: 2 years for M.S., 5 years for Ph.D.

Application Deadlines: January 15

### Admission Requirements:

Applicants are expected to hold a Bachelor's degree in one of the Science, Technology, Engineering, and Mathematics (STEM) fields. Applicants will be evaluated on the basis of their prior academic record and their potential for creative research and teaching, as demonstrated in submitted application materials. These materials will include official university transcripts, letters of recommendation, GRE scores, and Statement of Purpose.

### Advising:

Each student will be assigned an Advisory Committee by the Gateway Committee upon enrollment in the MCSB Program. The Advisory Committee will consist of two participating faculty members with one designated as the Committee Chair. Both Department Option and M.S./Ph.D. participating faculty members may serve on the Advisory Committee. Each committee will meet with its advisee, prior to their enrollment in the first year of MCSB Program, to discuss course and research related issues, and to apprise them of their options for continuing in the program (Department option, M.S./Ph.D. stand-alone option). 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 previous

quarter will be discussed and classes/lab rotations for the coming quarters adjusted as necessary. The student will also be re-apprised of their options for continuing in the program. Students will also be strongly encouraged to apply for extramural graduate fellowships. The committee will also hear from the student any concern and complaint that the student may have, investigate the concerns and possibly report and discuss them with the Program Director and/or Associate Director for possible response and action.

For students who choose the Department Option, a faculty member in a participating department must agree to serve as the student's thesis advisor. The MCSB advisory committee will meet with the student once per year to follow the student's progress and provide an additional resource of support and guidance. However, the committee membership may be changed (see below). All department advisory committees will be established according to the rules of the participating department.

For students who choose the Stand-alone Option, the student's thesis advisor will assume the role of the Committee Chair when a participating MCSB faculty member has been asked and has agreed to accept that role. At this point, other members of the Advisory Committee may be replaced as is deemed necessary (see below). Typically the Committee will meet with the student twice per year. It is expected that the Advisory Committee will continue to meet twice per year until the student has formed an Advancement to Candidacy Committee, which will then take over the duties until the M.S. or Ph.D. defense.

Based on a student's choice of thesis lab, the composition of a student's MCSB advisory committee may be adjusted. If the thesis advisor is one of the student's previously assigned mentors, a new mentoring committee member will be selected by the Director and Executive Committee to take his/her place. Other adjustments may be made based on the area of the student's research, or by request of the student, thesis advisor or committee member. It is expected that the advisory committee members will continue to advise the student until graduation.

Residence Requirement:

2 years for M.S. Degree

Language/Alternate Skills Requirement:

No language requirement. Students must attend a first-year bootcamp and perform at least 2 laboratory rotations (1 in a wet lab and 1 in a dry lab).

Teaching Requirement: NA

Coursework and Examination Requirements:

Required Courses, Elective Courses:

Department Option: 7 required courses

MS Option: 7 required courses

2 elective courses (Research Thesis Option)

5 elective courses (Literature Thesis Option)

Ph.D. Option: 7 required courses

5 elective courses

Preliminary Exam:

Dept Option: Subject to requirements of participating department

M.S. Option: NA

Ph.D. Option:

- Once a student has taken at least 10 of the 12 courses, if he/she received a minimum grade of B+ and held an average grade of A- or better, then the preliminary exam is waived.
- Otherwise, an oral exam by a committee of four members (training faculty participating in the MCSB Ph.D. option) will be conducted based on the materials of the twelve courses.
- Each student can take the preliminary exam at most TWICE. Students who fail the preliminary exam twice will not be eligible to continue in the Ph.D. program.
- A student must pass the preliminary exam before the start of the year 3. The normative time to pass the exam will be at the end of the Winter quarter of Year 2.

Normative time for passing the preliminary exam (or completing alternatives) is 2 years.

Advancement to Candidacy:

Dept. Option: Subject to requirements of participating department

M.S. Option: NA

Ph.D. Option:

The Advancement to Candidacy exam consists of a written proposal for the dissertation and an oral presentation of the proposed dissertation, followed by a question and answer period.

Faculty members who are training faculty in the MCSB Ph.D. option should comprise a simple majority of the exam committee. At least one member of the committee must be from outside this group.

The normative time for advancement to candidacy is 3 years.

M.S. Plan I Thesis:

Either research thesis or literature thesis Option. M.S. candidates who choose the research thesis option must present the results of their research in a presentation open to the academic community. The research thesis is subject to unanimous approval by the student's advisory committee. M.S. candidates who choose the literature thesis option must submit a written thesis, which is subject to unanimous approval by the student's advisory committee.

M.S. Plan II Comprehensive Exam: NA

Ph.D. Dissertation:

A dissertation is required for all Ph.D. candidates. Ph.D. candidates must present the results of their dissertation in a presentation open to the academic community. The dissertation is subject to unanimous approval by the student's dissertation committee.

## Appendix 13: Website and Catalogue Copy

### Graduate Program in Mathematical, Computational Biology and Systems Biology

Center for Complex Biological Systems 2624 Biological Sciences III; (949) 824-4120  
[mcsb@uci.edu](mailto:mcsb@uci.edu); <http://mcsb.bio.uci.edu/> Director: To be determined; Associate Director:  
To be determined.

The graduate program in Mathematical, Computational and Systems Biology (MCSB) is designed to meet the interdisciplinary training challenges of modern biology and function in concert with existing departmental programs (Departmental Option) or as an individually tailored program (Stand-alone Option) leading to a M.S. or Ph.D. degree. The degree program provides students with both opportunity for rigorous training towards research careers in areas related to systems biology and flexibility through individualized faculty counseling on curricular needs, and access to a diverse group of affiliated faculty and research projects from member departments. Current member departments include Biomedical Engineering, Biological Chemistry, Computer Science, Developmental and Cell Biology, Ecology and Evolutionary Biology, Mathematics, Microbiology and Molecular Genetics, Molecular Biology and Biochemistry, Chemistry, and Physics.

MCSB graduate student applicants are expected to hold a Bachelor's degree in one of the Science, Technology, Engineering, and Mathematics (STEM) fields. Applicants will be evaluated on the basis of their prior academic record and their potential for creative research and teaching, as demonstrated in submitted application materials (official university transcripts, letters of recommendation, GRE scores and statement of purpose).

Enrolled students participate in a common first year "gateway" program and are each assigned an MCSB Advisory Committee consisting of two participating faculty members to oversee course and laboratory work. Subsequently, students select a thesis advisor and choose between the *departmental* or *stand-alone* options for the remainder of their Ph.D. training.

For students who choose the *Department Option*, a faculty member in a participating department must agree to serve as the student's thesis advisor. Completion of the Ph.D. will be subject to the degree requirements of the departmental Ph.D. program in which the student enrolls. Participating departments accept both the course work and research conducted during the "gateway" year in partial fulfillment of such requirements. Students are encouraged to consult with the department of choice for specific information on additional requirements. All department student advisory committees will be established according to the rules of participating department. In addition the student's MCSB Advisory Committee will continue to meet annually to follow progress and provide additional guidance.

For students who choose the *Stand-alone Option*, the student's thesis advisor will assume the role of the Committee Chair when a participating MCSB faculty member has been asked and has agreed to accept that role. Adjustments to the MCSB Advisory Committee may be made based on the area of the student's research, or by request of the student,

thesis advisor or committee members. The student will continue to meet biannually with the Advisory Committee until an Advancement to Candidacy Committee has formed, which then assumes the duties until the M.S. or Ph.D defense.

#### Coursework requirements

- Language requirement: not applicable
- Teaching requirement: not applicable
- Residency requirement: 2 years for M.S. degree
- Attend first-year bootcamp
- Perform at least 2 laboratory rotations (1 in a wet lab and 1 in a dry lab)
- Departmental Option: 7 required core courses plus departmental requirements (varies)
- M.S. Option: 7 required core courses plus 2 elective courses (*research thesis option*) or 5 elective courses (*literature thesis option*) selected from Breadth Categories I, II, III listed below. Courses other than those listed here may be substituted by approval of the MCSB Executive Committee.
- Ph.D. Option: 7 required core courses plus 5 elective courses selected from Breadth Categories I and II listed below. Courses other than those listed here may be substituted by approval of the MCSB Executive Committee.

#### Preliminary Exam:

- Dept. Option: Subject to requirements of participating department
- M.S. Option: NA
- Ph.D. Option: Students will be assessed by an oral exam on the materials from their 12 courses by a committee of four MCSB training faculty members; may be waived in cases of consistent excellence in coursework (minimum grade of B+, average grade of A- and student has taken 10 out of the 12 courses).
- Normative time for passing the exam is winter quarter of Year 2; students may take the preliminary exam twice but must be completed by start of Year 3.

#### Advancement to Candidacy:

- Dept. Option: Subject to requirements of participating department
- M.S. Option: NA
- Ph.D. Option: The Advancement to Candidacy exam consists of a written proposal for the dissertation and an oral presentation of the proposed dissertation, followed by a question and answer period. Faculty members who are training faculty in the MCSB Ph.D. option should comprise a simple majority of the exam committee. At least one member of the committee must be from outside this group.
- The normative time for advancement to candidacy is 3 years.

#### M.S. Plan I Thesis:

- M.S. candidates who choose the *research thesis option* must present the results of their research in a presentation open to the academic community. The research thesis is subject to unanimous approval by the student's advisory committee.

- M.S. candidates who choose the *literature thesis option* must submit a written thesis, which is subject to unanimous approval by the student's advisory committee.
- Normative time to M.S. degree is 2 years

M.S. Plan II Comprehensive Exam: not applicable.

Ph.D. Dissertation:

- A dissertation is required for all Ph.D. candidates. Ph.D. candidates must present the results of their dissertation in a presentation open to the academic community. The dissertation is subject to unanimous approval by the student's dissertation committee.
- Normative time for a Ph.D. degree is 5 years.

*Core Courses.* Bio Core 1: Biophysics of Molecules and Molecular Machines (Physics 230A, Fall); Bio Core 2: Systems Cell Biology (Dev. Bio. 232, Winter); Bio Core 3: (A). Population Dynamics (Eco. Evo 251, Spring) OR (B). Developmental Systems Biology (Dev. Bio. 203C, Spring); Math/Comp. Core 1: (A). Mathematical and Computational Biology I (Math 227A, Fall) OR (B). Dynamical Systems in Biology and Medicine (BME 233, Fall); Math/Comp. Core 2: Mathematical and Computational Biology II (Math 227B, Winter); Math./Comp. Core 3: (A) Computational Systems Biology (ICS 284C, Spring) OR (B) Mathematics and Computational Biology III (Math 227C, Spring); Critical Thinking in Systems Biology (Dev Cell 203A, Fall). The participating departments plan to continue offering the core courses every year. See **Appendix 15** for Memoranda of Understanding from the Chairs of the participating departments regarding the core courses.

*Breadth Courses.* The breadth courses for the MCSB M.S. and Ph.D. program listed below are divided into three categories according to their subject matter with Category I being mathematics-related, Category II being biology-related, and Category III being biotechnology-related. In Categories I and II, we denote by 'star' (\*) courses that may be used either as core or elective courses. All courses are 4 units.

*Category I (Mathematics, Computation and Modeling).* Mathematical and Computational Biology I (Math 227A, Fall)\*; Dynamical Systems in Biology and Medicine (BME 233, Fall)\*; Representations and Algorithms for Molecular Biology (ICS 284A, Fall); Quantitative methods in ecology and evolutionary biology (EE 207, Fall); Continuum Mechanics (Physics 222, Fall); Computational Methods (Physics 229A, Fall); Representations and algorithms for molecular biology (Computer Science, 284A, Fall); Statistical Methods for Data Analysis I (Statistics 201, Fall); Computational Partial Differential Equations (Math 226B, Winter); Probabilistic Modeling of Biological Data (ICS 284B, Winter); Quantitative Physiology: Organ Transport Systems (BME 221, Winter); Biophysics of molecules and molecular machines (Physics 230B, Winter); Introduction to Numerical Analysis and Scientific Computing (Math 225C, Spring); Introduction to Computational Biology (MBB 223 Spring); Computational Systems Biology (ICS 284C, Spring)\*; Mathematics and Computational Biology III (Math 227C,

Spring)\*

*Category II (Biology and Biomedical Engineering).* Protein Structure and Function (Mol. Bio. 204, Fall); Introduction to Proteomics (Physiol. & Biophys. 252, Winter); Cell and Tissue Engineering (BME 210, Winter); Cell Biology (Dev. Bio. 231B, Winter); Chromatin Function (Biol. Chem 225, Winter); Advanced Developmental Genetics (Dev. Bio. 210, Spring); Regulation of Gene Expression (Mol. Bio. & Mol. Gen. 206, Spring); Advanced Molecular Genetics (Biol. Chem. 207, Spring); Signal Transduction and Growth Control (BC212, Spring); Population Dynamics (Eco. Evo. 251, Spring)\*; Developmental Systems Biology (Dev. Bio. 203C, Spring)\*

*Category III (Biotechnology and Entrepreneurship).* Statistics for management (MBA 201A, Fall); Biomedical microdevices (BME 261, Fall); Foundations of Clinical and Translational Science (PH 290, Fall); Entrepreneurship for scientists and engineers (ENG 280, Winter); Technology for life (ENG 260A, Winter)

Program details are available at <http://mcsb.bio.uci.edu>.

## Appendix 14: Letter from the Library

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UC IRVINE LIBRARIES

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September 23, 2013

**TO:** Professor John Lowengrub; Ms. Karen Martin

**FROM:** John Renaud, Assistant University Librarian for Research Resources

**RE:** Library Response to M.S. and Ph.D. in Mathematical, Computational and Systems Biology (MCSB) Degree Proposal

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The UCI Libraries support the draft proposal for the Master's and Doctoral Degree in Mathematical, Computational and Systems Biology (MCSB). This proposal builds upon the existing concentrations in the School of Biological Sciences and the School of Physical Sciences. The UCI Libraries has developed strong library collections that support the existing programs within Biological Sciences, Molecular Biology, Mathematics and Computing, and these collections will provide foundational support to these new degree programs.

However, there may be the need to acquire specialized journals and technical literature in the areas of mathematical biology, bioinformatics, and biomedical engineering. Some of the new research materials that may need to be acquired are journals on systems biology and computational biology. As the graduate program evolves and changes, more journals and databases may be required to address the needs of the faculty and students.

Enhancement of the collection to accommodate new research areas can be initially achieved through the Libraries' existing collection funds.

**Appendix 15: Memoranda of Understanding from Department Chairs for continuance of MCSB core courses**

See below.

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THE HENRY SAMUELI SCHOOL OF ENGINEERING  
Department of Biomedical Engineering

3120 Natural Sciences II  
Irvine, CA 92697-2715

October 21<sup>st</sup>, 2013

Dear Professor Lowengrub and the MCSB Drafting Committee,  
RE: Memorandum of Understanding Regarding MCSB Core Courses

The Department of Biomedical Engineering currently provides a core course for the proposed MCSB Program: Dynamical Systems in Biology and Medicine (BME 233). This course, designed originally for the MCB gateway program, is now part of our normal curricula and has been offered every year since its inception. This course also serves students in Biomedical Engineering as well as other disciplines. We plan to continue offering this course every year.

If it becomes necessary to change the scheduling of BME 233 at some point in the future, we will provide the MCSB Program Director with advanced warning and will work with the MCSB Program Director to ensure continuity of the MCSB core curriculum in dynamical systems applied to biology.

In the event that a teaching component is required for the MCSB program, we would consider assigning TA slots to MCSB students based on current Department processes and student backgrounds.

Sincerely,

A handwritten signature in black ink, appearing to read "Abraham Lee".

Abraham Lee, Ph.D.  
William J. Link Professor and Chair of Biomedical Engineering

Cc: Frithjof Kruggel, Professor, BME

IRVINE: DONALD BREN SCHOOL OF INFORMATION AND COMPUTER SCIENCES  
DEPARTMENT OF COMPUTER SCIENCE

October 21, 2013

Dear Professor Lowengrub and the MCSB Drafting Committee,

RE: Memorandum of Understanding Regarding MCSB Core Courses

The Department of Computer Science currently provides a core course for the proposed MCSB Program: Computational Systems Biology (ICS 284C). This course, which predates the MCB gateway program, was recently redesigned with the MCB gateway program in mind. This course also serves students in Computer Science as well as other disciplines. We plan to continue offering this course every year.

If it becomes necessary to change the scheduling of ICS 284C at some point in the future, we will provide the MCSB Program Director with advanced warning and will work with the MCSB Program Director to ensure continuity of the MCSB core curriculum in computational systems biology.

Sincerely,



Alex Nicolau, Chair  
Department of Computer Science



Department of Developmental and Cell Biology  
School of Biological Sciences  
2011 Biological Sciences III  
Irvine, California 92697-2300

Telephone: 949-824-1969  
Fax: 949-824-4709  
Website: <http://devcell.bio.uci.edu>

October 12, 2013

RE: Memorandum of Understanding Regarding MCSB Core Courses

Dear Professor Lowengrub and the MCSB Drafting Committee,

The Department of Developmental & Cell Biology currently provides 2 core courses for the proposed MCSB Program: Systems Cell Biology (Dev.Bio. 232) and Developmental Systems Biology (Dev.Bio. 203C). These courses, designed originally for the MCB gateway program, are now part of our normal curricula and have been offered every year since their inception. These courses also serve students in Developmental & Cell Biology as well as other disciplines. We plan to continue offering these courses every year.

If it becomes necessary to change the scheduling of Dev.Bio. 232 and 203C at some point in the future, we will provide the MCSB Program Director with advanced warning and will work with the MCSB Program Director to ensure continuity of the MCSB core curriculum in Developmental & Cell Biology.

Sincerely,

A handwritten signature in cursive script, appearing to read "Diane O'Dowd".

Diane O'Dowd, Chair  
Department of Developmental & Cell Biology

Cc: Kavita Arora, Vice Chair, Developmental and Cell Biology



LAURENCE D. MUELLER

Department of Ecology & Evolutionary Biology  
Irvine, CA. 92697-2525  
Phone: (949) 824-4744  
FAX: (949) 824-2181  
e-mail: [ldmueller@uci.edu](mailto:ldmueller@uci.edu)  
<http://darwin.bio.uci.edu/~mueller>

17 October 2013

Dr. John Lowengrub  
Chancellor's Professor of Mathematics, Biomedical Engineering, Chemical Engineering and Materials  
Science  
540H Rowland Hall  
University of California, Irvine

RE: Memorandum of Understanding Regarding MCSB Core Courses

Dear Dr. Lowengrub:

The Department of Ecology & Evolutionary Biology currently provides a core course for the proposed MCSB Program: Population Dynamics (EcoEvo 251). This course, which predates the MCB gateway program, was recently redesigned with the MCB gateway program in mind. This course also serves students in Ecology & Evolutionary Biology as well as other disciplines. We plan to continue offering this course every year.

If it becomes necessary to change the scheduling of EcoEvo 251 at some point in the future, we will provide the MCSB Program Director with advanced warning and will work with the MCSB Program Director to ensure continuity of the MCSB core curriculum in population dynamics.

Sincerely,

A handwritten signature in cursive script that reads "Laurence D. Mueller".

Laurence D. Mueller  
Professor and Chair  
Ecology & Evolutionary Biology

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Department of Mathematics  
340 Rowland Hall  
Irvine, CA 92697-3875

Office (949) 824-5503  
Fax (949) 824-7993  
[www.math.uci.edu](http://www.math.uci.edu)

October 21, 2013

Dear Professor Lowengrub and the MCSB Drafting Committee,  
RE: Memorandum of Understanding Regarding MCSB Core Courses

The Department of Mathematics currently provides 3 core courses for the proposed MCSB Program: Math 227ABC. These courses, designed originally for the MCB gateway program, are now part of our normal curricula and have been offered every year since their inception. These courses also serve students in Mathematics as well as other disciplines. We plan to continue offering Math 227ABC every year.

If it becomes necessary to change the scheduling of Math 227ABC at some point in the future, we will provide the MCSB Program Director as much advance warning as possible and will work with the MCSB Program Director to try to ensure continuity of the MCSB core mathematics curriculum.

Sincerely,

A handwritten signature in cursive script that reads "Karl C Rubin".

Karl Rubin  
Professor and Chair  
Department of Mathematics  
University of California, Irvine

Cc: Patrick Guidotti, Vice Chair for Graduate Studies

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SCHOOL OF PHYSICAL SCIENCES  
DEPARTMENT OF PHYSICS AND ASTRONOMY

IRVINE, CALIFORNIA 92697-4575  
4129 FREDERICK REINES HALL  
Phone (949) 824-6911

October 11, 2013

Dear Professor Lowengrub and the MCSB Drafting Committee,  
RE: Memorandum of Understanding Regarding MCSB Core Courses

The Department of Physics & Astronomy currently provides a core course for the proposed MCSB Program: Biophysics of Molecules and Molecular Machines (Physics 230A). This course, which predates the MCB gateway program, was recently redesigned with the MCB gateway program in mind. This course also serves students in Physics & Astronomy as well as other disciplines. We plan to continue offering this course every year.

If it becomes necessary to change the scheduling of Physics 230A at some point in the future, we will provide the MCSB Program Director with advanced warning and will work with the MCSB Program Director to ensure continuity of the MCSB core curriculum in Biophysics.

Sincerely yours,

A handwritten signature in black ink that reads "Peter Taborek".

Peter Taborek  
Professor and Chair  
Department of Physics and Astronomy  
University of California, Irvine