

A Proposal from the Colleges of Biological Sciences and Mathematical and Physical Sciences

Mathematical Biosciences:

Executive Summary

In recent years, there have been remarkable advances in the biological sciences, from the completion of the human genome project to the fight against diseases of the brain, such as Alzheimer's and Parkinson's. Society is eager to see basic research and technological advances translated into better diagnostic tools for health problems. This can be achieved via mathematical and statistical modeling. However, most biologists are not skilled mathematicians or statisticians and few mathematicians understand the language of the life sciences. The Mathematical Biosciences Institute (MBI), funded by the NSF, was created in 2002 in order to provide a national forum to address these challenges.

The next five years represent the window of opportunity for OSU to emerge as a dominant player in mathematical biosciences. The best U.S. programs in basic mathematical biology have only small faculty groups (5-7), but each includes several world-class leaders. With existing strengths, OSU would require the addition of only a few outstanding mathematical biology faculty to achieve our research goals and rise into the elite group of programs. However, hiring from the pool of talented people who can bring a qualitative transformation to our mathematical biology program will be difficult. There are few senior mathematical biology researchers, and they are firmly entrenched. Junior faculty are highly sought after and most often are successfully recruited to institutions where there already exists a critical mass in mathematical biology. We believe that exceptional new faculty can be attracted to OSU precisely because of the presence of the MBI, and of the elements that the MBI employs to foster interdisciplinary research, such as prominent visitors, workshops, post-docs, GRAs, and support for release time to faculty.

We plan to make The Ohio State University the nation's leading institution in the mathematical biosciences and to insure that the MBI remains at OSU for the long term. The two goals are coupled. OSU's strengths in basic mathematical biology are distributed across departments and programs within the Colleges of Biological Sciences (CBS) and Mathematical and Physical Sciences (MAPS). The MBI presence on campus has provided critical expertise and logistics to foster the integration of existing strengths, positioning OSU to become one of the national leaders in mathematical biosciences. Concurrently, having a world-class program in mathematical biosciences will make OSU and the MBI even more competitive with NSF in the 2007-2012 round of renewals, and beyond.

Both CBS and MAPS have made substantial resource commitments to national leadership in the mathematical biosciences including cross-college joint faculty appointments, faculty release time, space allocations, and matching funds for MBI curriculum development initiatives. These commitments will be critical in enabling OSU to successfully compete for renewal of the MBI by NSF in 2007. We propose a targeted investment in excellence that will accelerate faculty hiring and facilitate interdisciplinary research and educational programs. The core programs targeted in this proposal are in the Departments of Evolution, Ecology & Organismal Biology (EEOB), Molecular Genetics, Mathematics, and Statistics. This investment will leverage existing commitments and dramatically improve our ability to be the national leader in the mathematical biosciences. Indeed, without an accelerated program of this sort, we risk losing the opportunity to raise OSU's status into the elite of mathematical biosciences programs, and even risk forfeiting the prestige and benefit of the MBI at OSU as early as 2007.

The Importance of Mathematical Bioscience in Science and Society

Over the past 15 years, dramatic technological innovations have made possible increasingly smaller-scale and denser laboratory measurements. These innovations have revolutionized research in the life sciences. For example, researchers now delve into human DNA, using theoretical tools to identify genetic causes of

diseases that afflict society, and map these diseases within the human genome. Biologists identify new organisms, using tools of molecular biology and mathematics to accurately place these organisms within the Tree of Life. Ecologists work with geologists, meteorologists and mathematical scientists to understand the role humans are playing in the long-term patterns of climate change. Partnerships of biological and mathematical scientists are required to capitalize on these new technologies because interdisciplinary teams can formulate mathematical models of important biological phenomena, obtain data to statistically inform the unknown aspects of these models based on experimental data, and use the models to make new predictions about the biology to guide further laboratory research. At Ohio State, such research is central in the College of Biological Sciences (CBS).

Because of widespread recognition of the benefits of interdisciplinary research, the mathematical sciences and computational biology are receiving very high priority from the federal funding agencies. Among federal agencies providing funding support are the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF), and the National Institutes of Health (NIH), who sponsor joint research programs in mathematical biology. In addition, NSF provides funds for curriculum development in mathematical biology and, through the IGERT program, for graduate training initiatives in mathematical biosciences. The Department of Energy (DOE) and Department of Defense (DOD) each support computational biology. Other programs at the National Oceanographic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA) include possibilities for funding projects that emphasize or include mathematical biosciences. Private foundations are also involved in funding areas of mathematical biosciences. The Sloan Foundation supports a number of academic programs in neuroscience. The Burroughs Wellcome Fund, through its Institutional and Career Awards at the Scientific Interface program, has made a major investment in the training and support of young investigators with backgrounds in the physical, chemical, or computational sciences whose work addresses biological questions. The Howard Hughes Foundation has interests in promoting curriculum development in mathematical biosciences.

To be a national leader in future biological research, and compete more successfully for the requisite external funding, it is critical that OSU enhances the opportunity for strong collaborations between biologically-oriented mathematical scientists and mathematically-oriented biologists, particularly experimentalists and those involved in basic non-clinical research. In addition to the purely scientific benefit of such collaborations, the existence of a closely cooperating interdisciplinary group will facilitate OSU attempts to obtain external funding for curriculum development and graduate training programs.

Targeted Investment in Excellence: Mathematical Bioscience

There are pockets of excellence in mathematical bioscience in departments and programs scattered across MAPS and CBS, with special strength in the Departments of Evolution, Ecology and Organismal Biology (EEOB), Mathematics, Entomology, Statistics, and Physics, and individual faculty in Biochemistry, Molecular Genetics, Plant Cellular and Molecular Biology (PCMB), and Microbiology. There are other research groups in the Colleges of Medicine and Public Health, Veterinary Medicine, and Engineering that would contribute to and benefit from a mathematical biosciences program. Some groups of mathematical bioscientists on campus have a history of research collaboration and accomplishment. For example, faculty from Statistics are currently participating in four separately funded training grants and research projects involving epigenetics, the identification of micro-RNA targets, and the discovery of chemical structures linked to micro-RNA expression. Mathematics faculty are involved in externally funded projects in modeling tumor growth and neural patterns of the sleep-wake cycle.

Both CBS and MAPS are committed to making OSU the national leader in the mathematical biosciences. This goal is feasible. The best mathematical bioscience programs in the U.S. are the University of Utah, and UC Davis. Each involves a small number of faculty (5-7), but includes several first-class leaders. Thus, if only a small number of new faculty in mathematical bioscience are added to the current mathematics and statistics faculties at OSU, we have the ability to achieve substantial movement towards

the goal of attaining a nationally-recognized program in mathematical bioscience. Hiring the talented people necessary to implement the mathematical biology program will be exceedingly difficult because of the small number of outstanding senior mathematical biology researchers in the world. Junior faculty in mathematical biology are actively recruited by many institutions, and are most likely to be attracted to places where a critical mass in mathematical biology already exists.

The keystone that permits the creation of a nationally recognized mathematical biology program is the Mathematical Biosciences Institute (MBI), which was awarded to OSU in a national competition for mathematical institutes held by NSF in 2001. The national mission of the MBI is to bring together mathematical and statistical scientists and bioscientists from the U.S. and abroad, to work together on significant problems in the biosciences, and to educate a new generation of mathematical biologists. Thus, the MBI serves as a national resource to enhance the mathematical biosciences. However, because the MBI is based on our campus, it offers The Ohio State University a unique opportunity to develop a world leading program in mathematical biosciences and in quantitative biology.

Through its extensive workshop series, summer programs, and special emphasis years, and a program of distinguished visitors, the MBI creates the vibrant research climate characteristic of top programs. In particular, its short- and long-term visitor programs for mathematically oriented faculty bring cutting-edge research to campus thus benefiting OSU faculty, students, and post-docs.

Our proposal builds on these OSU strengths. The next two sections list existing commitments and proposals for addition resources to leverage them and achieve the goal of national leadership.

CBS, MAPS, and the University Commitments to Mathematical Bioscience

Various units at OSU have recognized the importance of an interdisciplinary approach to mathematical biosciences by making the following commitments.

1. The appointment of two faculty in positions jointly funded by the Department of Mathematics and one or more departments in CBS, most likely EEOB. One position would be an 80% / 20% appointment in Mathematics and EEOB, with tenure residing in Mathematics; the second position would be a reciprocal 20% / 80% Mathematics and EEOB position, with tenure in EEOB. The exact focus of research has not been determined but will be determined by the response to the recruitment process. The departments involved are encouraged to couple the two positions in such a way that the individuals appointed to these positions would be linked in terms of research interests, encouraging an active interaction between departments, and hopefully drawing other faculty into this interface of the two disciplines.
2. The appointment of one faculty jointly funded by the Department of Statistics and one or more departments in CBS, again most likely EEOB. The position would be an 80% / 20% appointment in Statistics and EEOB, with tenure residing in Statistics. One important interdisciplinary focus for the new faculty would be in the area of systematics and taxonomic theory; this is an active research topic that overlaps with the interests of several faculty members already present within both Statistics and EEOB and would strengthen the interactions between these separate groups. It is hoped that an additional joint position might be allocated in the future in a reciprocal manner, analogous to the positions in Mathematics.
3. The appointment of one senior faculty member in a position jointly funded by the Department of Mathematics and a department in CBS, most likely the Department of Molecular Genetics. The position would be an 80% / 20% appointment in Mathematics and Molecular Genetics, with tenure residing in Mathematics. Candidates are currently being interviewed for this position.

4. The appointment of up to three additional junior faculty positions in Mathematics, with the possibility of joint appointments within one of the departments of CBS. These positions will be in the area of mathematical biosciences, but the appointments may involve only the Department of Mathematics.
5. 9,000 assignable square feet of space in Jennings Hall for the MBI and proportionate cost for renovations.
6. \$200,000 for curriculum development. These funds will be used to develop new courses and teaching materials to be incorporated into undergraduate and graduate courses in CBS and MAPS. Members of CBS and MAPS have submitted a \$2M proposal to the Hughes Foundation to make the entire undergraduate biology curriculum more mathematically oriented, with outreach to K-12 and AP high school programs.

Requested Targeted Investment Funds

To accelerate the growth of mathematical bioscience at Ohio State University we request the following funds.

1. \$1,350,000 in setup packages associated with the seven interdisciplinary faculty positions itemized in 1, 2, 3, and 4 above.
2. \$200,000/year for 20 quarters of release time per year, to be used by faculty in MAPS and CBS to allow the faculty members to spend quarters in residence at the MBI in order to facilitate collaborative research in mathematical biology.
3. \$250,000/year for MBI Distinguished Visitors. We seek to bring one internationally eminent faculty member to OSU for the entire year and three other internationally eminent visitors for shorter periods of about one quarter.
4. \$250,000 for interdisciplinary workshops involving OSU faculty, post-docs, and graduate students that further mathematical bioscience.

Project Organization, Management, and Assessment

The project is organized into two major areas of responsibility: hiring faculty and fostering interdisciplinary research, education and training. The colleges and relevant departments are responsible for the faculty hiring described in this project and for curriculum development initiatives. A Memorandum of Understanding will be signed by the Deans of CBS and MAPS that will guide the logistics of the joint hiring, composition of committees to create undergraduate and graduate curriculum, and related duties. The MBI is responsible for organizing the scientific interaction between the mathematical and biological researchers. In its four years of existence, the MBI has a track record of successes in bringing to fruition interdisciplinary collaborations using special emphasis years, designated visitor programs, post doc support and training, workshop series, and summer training programs.

The management structure within the MBI, which will guide the structuring of the research education and training portions of this initiative, will be an Executive Committee consisting of the chairs of relevant departments (EEOB, Mathematics, Molecular Genetics, Statistics) and the Director of the MBI (Avner Friedman). The Executive Committee will consult closely with the Deans of CBS and MAPS, the Associate Directors of the MBI, members of the existing MBI Local Scientific Advisory Committee, and other relevant faculty, as needed. Through the Deans of CBS and MAPS, the Executive Committee will report annually to the Provost. The report will include an analysis of progress toward the goal of national leadership in mathematical bioscience, as measured by metrics discussed below, and the role played by the Targeted Investment in Excellence funds in that progress.

Course release time to support activities such as preparation of grant proposals, curriculum development, participation in MBI programs, and mentoring MBI postdocs, as well as selection of MBI Distinguished Visitors, will be proposed by Associate Directors of MBI and relevant department chairs and approved by the Executive Committee.

We will assess the success of the initiative using the following metrics:

- The renewal of MBI in 2007
- Progress within the OSU community in preparing other initiatives for funding the MBI beyond 2012
- Acquisition of undergraduate, graduate and/or postdoctoral training grants in mathematical bioscience within the next three years
- Development and implementation of undergraduate and graduate curriculum development projects within the next two years
- Implementation of a mathematical biology minor within the next two years
- Increased funding in mathematical biosciences, compared to the baseline funding now in place within MAPS and CBS, as measured by OSURF Sponsor Totals
- An increase in the number of publications in the research area of mathematical biosciences from OSU faculty and postdoctoral fellows, compared to the baseline publication rates now in place within MAPS and CBS
- An increase in the number of graduate applications to the programs in mathematical biosciences
- Quality of post-OSU placement of our students and postdocs in research universities and institutions
- Increased enrollment in courses identified as involving mathematical biosciences content

Impact of an Accelerated Mathematical Biosciences Program

In the words of Dr. Rita R. Colwell, former Director of the National Science Foundation, in testimony before the House Science Committee, “Mathematics is a powerful tool for insight and a common language for science and engineering.” Combining a broad array of mathematical tools with biological science will be required for the next generation of great biological advances. This Targeted Investment in Excellence puts OSU at the forefront of such interdisciplinary activity. Specifically,

- 1. Funding this program will give OSU the resources to rapidly become the nation’s preeminent mathematical biosciences program consisting of top-notch faculty, significantly increased external funding, cutting-edge undergraduate and graduate programs, and significant numbers of high-profile scientific visitors.*
- 2. The chances of the 2007-2012 MBI renewal are enhanced by the presence of a nationally recognized OSU mathematical biosciences program, and by a strong commitment of resources from the highest levels of the university to a campus-wide program in mathematical bioscience. In fact, failure to expeditiously implement the proposed interdisciplinary program may jeopardize the renewal of MBI for the 2007-2012 period.*
- 3. The presence of MBI in 2007-2012 and beyond 2012 will be a sustaining vehicle that enhances OSU’s national excellence in mathematical biosciences.*
- 4. The presence of a world-class program in mathematical bioscience involving CBS and MAPS, and facilitated through the MBI, will provide benefits and enhance research in other units within the university, including the Colleges of Medicine and Public Health; Veterinary Medicine; and Food, Agricultural and Environmental Sciences. An example already in place is the Comprehensive Wound Healing Center, a major new proposal to the NIH headed by Chandan Sen from the Davis Heart and Lung Institute with participation by the MBI and faculty in the Department of Statistics.*

We have a unique opportunity to capitalize on our existing strengths and drive Ohio State to the forefront of research in a rapidly developing area of science and technology. Failure to act decisively now poses serious risks, not least of which is the potential non-renewal of the Mathematical Biosciences Institute, and the concomitant loss of our sustainable competitive advantage in this field.

Again, in the words of Dr. Rita Colwell in testimony before the Senate Health, Education, Labor and Pensions Committee, “NSF’s investments in cutting-edge mathematics and statistics are a perfect example of how investing in core disciplines will sustain new fundamental discoveries and make interdisciplinary activities run on all cylinders.” Recognizing this fundamental principle, OSU must do everything possible to make this interdisciplinary connection a reality.

Budget and Budget Justification

(in multiples of \$1,000)

	FY07	FY08	FY09	FY10	FY11
Faculty Startup Costs	500	500	350		
Faculty Release Time	200	200	200	200	200
MBI Distinguished Visitors	250	250	250	250	250
Interdisciplinary Workshops	50	50	50	50	50
Total	1,000	1,000	850	500	500

Faculty Startup Costs CBS and MAPS are committed to making seven hires in mathematical bioscience over the next five years. Faculty startup packages include different components depending on discipline and rank. The packages for wet lab scientists consist primarily of space and equipment costs, and some postdoc support. Those of more theoretically oriented faculty consist of computing equipment, time release for developing interdisciplinary connections, initial summer support, postdoc and GRA support. The senior 80/20 Math/EEOB faculty member is estimated to cost \$250,000; the junior 80/20 Math/EEOB and Stat/EEOB faculty members \$100,000; the intermediate-junior level 20/80 Math/EEOB faculty member \$600,000; the intermediate-junior Mathematics faculty \$100,000. A total of \$1,350,000 is requested.

Faculty Release Time We request 20 course releases for CBS and MAPS faculty. Buyout costs vary by department and college but we budget an average \$10,000 per course for \$200,000/year. Course releases for CBS and MAPS faculty promote fuller participation in MBI programs that, in turn, strengthen existing scientific collaborations and encourage development of interdisciplinary research projects.

MBI Distinguished Visitors We propose 1 FTE @ \$125,000 for an MBI Long-Term Distinguished Visitor each year. We propose the equivalent of 1 FTE @ \$125,000 each year for three MBI Distinguished Short-Term Visitors. The capacity to bring the world’s leading mathematical and biological scientists to the MBI and to campus is a critical characteristic of a top-flight program. Distinguished visitors increase the overall visibility of the mathematical bioscience program, attract junior researchers to participate in MBI workshops, and provide unique learning and mentoring opportunities for postdocs and graduate students. Currently, the MBI has some funds for this purpose but the experience of the first four years of the MBI has shown these funds to be inadequate to attract the highest caliber visiting researchers for extended stays.

Interdisciplinary Workshops We request \$50,000/year to hold a workshop on a bioscience topic of emerging interest for interdisciplinary mathematical treatment. This workshop will be structured as a retreat for the faculty investigators, post-docs and graduate students in MAPS and CBS associated with the MBI. The workshop will promote a short but intense period of interaction each year to break down barriers of communication, facilitate opportunities to develop new collaborations, and increase

understanding of the issues that each group (biologists and mathematicians/statisticians) finds most in need of investigation.