Applied Mathematics Graduate Studies

University of California, Merced

http://appliedmath.ucmerced.edu/

Five-Year Strategic Plan

06 November 2008

1 Overview

Applied Mathematics Graduate Studies (AMGS) at UC Merced explores the applications of mathematics in the development of natural sciences, engineering and social sciences. AMGS offers a multidisciplinary research and training program for Master of Science (MS) and Doctor of Philosophy (PhD) students who want to study applied mathematics. Course work will provide training in the fundamental tools of applied mathematics, including ordinary- and partial-differential equations, asymptotics and perturbation methods, numerical analysis and scientific computing. AMGS offers opportunities for students interested in multidisciplinary mathematics projects at the interface with life sciences, physical sciences, engineering and social sciences.

Applied mathematical science involves the use of analytical and computational mathematics to solve real-world problems. Its core is made up of modeling, analysis and scientific computing. Using that core, applied mathematical scientists study a spectrum of problems across many disciplines. In fact, applied mathematicians are connected more closely through their shared approach and attitude toward interdisciplinary research rather than a shared interest in any particular set of problems. Moreover, an explicit goal of applied mathematical science is to contribute significantly to another discipline. Hence, the objective of applied mathematics is to foster multidisciplinary research and education.

Applied mathematical science is inherently interdisciplinary. Applied mathematicians collaborate with other scientists and engineers to learn where they can make contributions. The lack of disciplinary barriers at UC Merced is an ideal environment for multidisciplinary research and education. Hence, UC Merced has an excellent opportunity to develop top-notch applied mathematical science academic programs. Because applied mathematical scientists contribute to other disciplines through their research, the development of applied mathematical sciences may implicitly help to grow other programs.

AMGS admitted its first students in Fall 2005. The current student body consists of 5 MS students and 7 PhD students. AMGS is currently composed of 7 Core Faculty and 8 Affiliate Faculty that span the schools of Natural Science, Engineering, and Social Sciences, Humanities & Arts. Michael Sprague is currently serving as faculty coordinator. Maria Pallavicini, Dean of the School of Natural Sciences, is the Lead Dean for AMGS.

2 Faculty Membership: http://appliedmath.ucmerced.edu/personnel-grad.html

A focus of AMGS is to be highly interdisciplinary with contributions from faculty throughout the UC Merced campus. To facilitate this, AMGS faculty is composed of Core Faculty and Affiliate Faculty. Core faculty are responsible for AMGS administration, teaching the core curriculum, advising students, and serving on thesis committees. Affiliate faculty are expected to contribute to the program by either teaching special topics courses that are cross-listed as AMGS, advising AMGS students, and/or serving on thesis committees. Currently, AMGS is composed of seven Core Faculty and eight Affiliate Faculty.

2.1 Lead Dean

Maria Pallavicini, Dean for the School of Natural Sciences, began serving as Lead Dean for AMGS in the 2006/2007 academic year. The Lead Dean serves as an advocate for space and budgetary support for graduate students in AMGS.

2.2 Core Faculty & Research Interests

(Key: NS – School of Natural Sciences; ENG – School of Engineering; SSHA – School of Social Sciences, Humanities & Arts)

Harish Bhat, Assistant Professor, NS: wave phenomena in electromagnetic media and compressible fluids studied using applied/computational analysis and geometric mechanics.

François Blanchette, Assistant Professor, NS: computational and theoretical multiphase fluid dynamics with applications to sedimenting systems and surface tension dominated flows

Boaz Ilan, Assistant Professor, NS: nonlinear analysis applied to control of intense lasers beams and high-precision measurements of frequency and time

Arnold Kim, Associate Professor, NS: wave propagation in random media applied to biomedical optical imaging and wireless communications

Kevin Mitchell, Assistant Professor, NS: dynamical systems applied to atomic, molecular and optical physics

Michael Sprague, Assistant Professor, NS: computational mathematics of fluid and structural mechanics

Mayya Tokman, Assistant Professor, NS: computational science, numerical analysis, mathematical modeling applied to plasma physics

2.3 Affiliate Faculty & Research Interests

Alberto Cerpa, Assistant Professor, ENG: computer networking and distributed systems areas

Raymond Chiao, Professor, NS & ENG: quantum mechanics, general relativity, differential geometry, electromagnetic and gravitational radiation

Ajay Gopinathan, Assistant Professor, NS: analytical treatment and computational modeling of biomembrane dynamics, cell motility, cytoskeletal dynamics, polymer translocation, anomalous diffusion in polymer systems, chemotaxis

Thomas C. Harmon, Professor, ENG: contaminant transport in aquatic systems, soil and groundwater remediation, development and use of environmental sensors

Marcello Kallman, Assistant Professor, ENG: geometric modeling, computer graphics, computer animation, autonomous agents, robotics and artificial intelligence

Shawn Newsam, Assistant Professor, ENG: image processing, computer vision, pattern recognition, machine learning, content-based information retrieval, digital libraries, data mining, and knowledge discovery in spatio-temporal, multimedia and scientific datasets

Katie L. Winder, Assistant Professor, SSHA: labor economics, applied econometrics, economics of gender, poverty

Jeffrey Yoshimi, Assistant Professor, SSHA: philosophy of mind, philosophy of cognitive science, phenomenology (especially Husserl) and neural networks

3 Applied Mathematical Sciences Research

Applied mathematicians are inherently interdisciplinary. They must be well trained in fundamentals of mathematics to model, analyze and compute solutions to real-world problems. Applied mathematics research is usually assessed through two criteria: (1) sophistication of the mathematics used and (2) novelty and importance of the application. A strong group of applied mathematicians can be a great asset to any number of scientific and engineering programs within the university where they can provide the theoretical/quantitative support or foundation.

We do not seek to build a program comprised of a specific set of sub-fields. Instead, we seek to build a strong program comprised of world-class researchers, who contribute to the applied mathematical sciences program and a number of different programs at UC Merced. Hence, the over-arching theme encompassing the research of the founding faculty is mathematics applied to real-world phenomena. This brings applied mathematicians together with the intent to contribute to other programs of study on campus. There are many opportunities at UC Merced for interdisciplinary research under this research theme. There are several large funding sources for applied mathematics research and education. Federal sources provide funding for both education and research programs. The current faculty members (7 + 1 in progress) are well are on their way toward developing a strong research program including undergraduates, graduate students and postdoctoral researchers.

Although the existing faculty has deep expertise in the applied mathematical sciences and breadth across several disciplines, new faculty hires are needed to deepen the base of expertise and broaden the range of application areas. For example, we are seeking new hires in stochastic modeling, mathematical biology, biomedical sciences, mathematical economics and atmospheric science, among others, to forge new links with economics and management, environmental systems, the Sierra Nevada Research Institute and the developing Systems Biology Institute and Energy Institute.

4 Student Training

Upon completion of the AMGS program, students will be expected to understand the fundamental analytical and computational tools of applied mathematics, to be able to apply these methods to a real-world problem, to communicate methods and results in an effective manner, and to teach effectively. Students are expected to achieve these goals through appropriate course work, writing and defending a research thesis, serving as a Graduate Student Instructor, and attending and giving technical seminars.

4.1 Course Work: http://appliedmath.ucmerced.edu/grad-courses.html

AMGS MS and PhD students are required to complete the following six core courses with a grade of B or better:

- Partial-Differential Equations I and II (MATH 221 & MATH 222);
- Numerical Solution of Differential Equations I and II (MATH 231 & MATH 232);
- Asymptotics and Perturbation Methods (MATH 223);

These courses constitute training in the techniques and theories that are considered fundamental in an applied mathematics graduate education. All students in the group must also successfully complete at least two additional graduate courses exclusive of research that are appropriate to the student's research area. Suggested courses include linear and nonlinear wave propagation, integral equations, dynamical systems, waves in random media, and fluid dynamics. Other graduate-level courses appropriate to the student's specific field of research, including Directed Independent Study may be used to meet the two-course minimum requirement with consent of the student's faculty committee.

4.2 PhD Dissertation & MS Thesis

PhD students are required to write and defend a dissertation that must be creative and independent work that can stand the test of peer review. The expectation is that the material will serve as the basis for publication(s) in a peer-reviewed journal. M.S. students can choose between a thesis (Plan I) or non-thesis (Plan II) plan of study. Plan I students must write and defend a thesis discussing original research. Plan II requires more course work and students must write an acceptable written document presenting research accomplished under a faculty advisor. The Plan II research project is significantly shorter than that required of a thesis under Plan I.

4.3 Graduate Student Instructors

PhD and MS AMGS students are required to serve as Graduate Student Instructors for 2 and 1 semesters, respectively.

4.4 Technical Seminars: http://appliedmath.ucmerced.edu/events-seminars.html

AMGS offers weekly technical seminars (MATH 291) by experts in applied mathematics. AMGS students enrolled in MATH 291 are required to attend the seminars offered to obtain exposure to the current topics in state-of-the-art applied mathematics. Further, as part of their training, all PhD students in the Applied Mathematics group are required to present an open technical seminar during their residence in the graduate group. The topic of the seminar may be the student's own research or it may be any other topic that falls within the areas of study spanned by the group, broadly defined.

5 Student Recruitment

Applied mathematics at UC Merced is different from similar programs at most other universities where applied mathematics is a specialization within, or along side a larger "pure" mathematics program. Furthermore, the applied mathematical sciences program at UC Merced is developing along side other innovative programs rather than after all these programs are in place. The opportunity to develop applied mathematics at UC Merced is attractive to students seeking an interdisciplinary mathematics graduate education. Because applied mathematicians are trained essentially in two or more disciplines, graduate students with that education have several options in the competitive academic job market. Moreover, the greater job market beyond academia is responding quickly and positively to graduate students with an interdisciplinary mathematics education.

The AMGS student body is currently comprised of 7 PhD and 5 MS students. The recruitment goal is to enroll at least five new students each year for the next five years. In addition to the recruiting efforts of the Graduate Division, the AMGS graduate coordinator's recruiting efforts include communication with department chairs of relevant programs (e.g., mathematics, physics, engineering) throughout the UC and CSU systems.

New graduate students in the Applied Mathematics are offered stipend support in the form of either Teaching Assistantships (TAs) or Research Assistantships (RAs). Students in their first year of residence usually serve as TAs for appropriate courses in the School of Natural Sciences. Based on available funding for 2008-2009, funding for 2009–2010 is anticipated to provide support for at least ten TAs, which we can offer as guaranteed funding for the first year of a student's residence.

6 Resource Needs

6.1 Faculty Hires

Although the founding faculty have deep expertise in the applied mathematical sciences and breadth across several disciplines, new faculty hires are needed to deepen the base of expertise and broaden the range of application areas. For example, we are seeking new hires in stochastic modeling, mathematical biology, biomedical sciences, mathematical economics and atmospheric science, among others to forge new links with economics and management, environmental systems and the Sierra Nevada Research Institute. Our objective is to hire excellent applied mathematicians under the general research theme of applied mathematics to solve real-world problems who contribute also to

other programs developing on campus.

All applied mathematics faculty contribute to delivering undergraduate and graduate curricula. New faculty hires are needed to deliver and support the curricula as the demand due to our growing student population increases.

At a bare minimum, 20 FTEs will be needed for this applied mathematical sciences program including the undergraduate and graduate academic programs. Table 1 shows our projected growth over the next five years beyond our current faculty assuming our current searches are successful.

Table 1: Projected growth of applied math faculty.

	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-1014
FTEs	7	8*	10**	12	14	16

* Includes our current search for professor (open rank).
** Includes Visiting Assistant Professor (see §6.2)

6.2 Visiting Assistant Professors

According to APM-230-4, the title of Visiting Assistant Professor (VAP) is for one appointed temporarily to perform the duties of Assistant Professor. Hence, the teaching load is equivalent to that of an assistant professor in our school (see the School of Natural Sciences Proposal for a Fair and Equitable Teaching Load). The appointment is for two years. A VAP is not a member of the academic senate. A person holding a VAP title is unable to acquire tenure or security of employment.

We propose VAP program for two specific reasons. First, a stable VAP program will continually bring young and talented applied mathematicians to contribute substantially to the applied mathematics research program. Second, VAPs will provide a consistent and substantial way to meet our ever-increasing teaching demands in a way that ensures teaching excellence.

With an established VAP program at this early stage of this school's development we will create a pipeline into UC Merced that provides a consistent cycle of excellent, young researchers. These young applied mathematicians will also provide a critical service to this school through their teaching. We will provide them a dynamic place to grow and develop during this critical point in their academic careers.

Even though VAPs will fulfill a critical need in the short-term, we propose the adoption of VAPs over the long-term. Within the applied mathematics academic program, we are striving for excellence across the entire spectrum of higher education. This "vertical" spectrum includes undergraduate students all the way up to professors. An integral portion of this spectrum includes fostering excellence at the post-doctoral level. Creating these positions now is leverage for gains in the development of a top-notch applied mathematics program. It provides a means for other applied mathematics programs to recognize UC Merced as a place to foster applied mathematicians. Moreover, it provides UC Merced a means to attach its name onto bright, young researchers going out to the academic job market.

6.3 Cross-School Faculty

A cross-school tenured hire in applied mathematics and mechanical engineering is supported by both AMGS core Faculty and Graduate Studies in Mechanical Engineering and Applied Mechanics (MEAM).

6.4 Space & Facilities

Applied mathematicians do theoretical and computational research. Hence, new applied mathematics hires typically only need office space for their group. However, it should be noted that for applied mathematicians office space also doubles as "lab space": the office is where applied mathematicians spend nearly 100% of their research time. It is also where office hours are conducted. Therefore, it is essential for Applied Mathematical Sciences to have offices that are conducive for doing research, computing, and office hours. This includes office space for summer undergraduates, graduate students and postdocs. Currently, our twelve graduate students are occupying four offices in Academic Office Building, and have access to a common room (AOB 114) shared with theoretical physics students. Over the next five years, we plan to admit 20-30 graduate students, of which approximately 15 will be Teaching Assistants. Both Teaching Assistants and Graduate Research Students in Applied Mathematics will need continued access to secure offices and common space that is conducive for doing their research and holding office hours. The ability to offer adequate space is extremely important when recruiting both graduate students and faculty.

Because high-performance computing is a rich area for applied mathematical sciences research, planning is required for space, hardware-acquisition, and administration. Our faculty, together with Professor Lara Kueppers, have purchased a 66-node/264-processor parallel-computer cluster. This cluster will become an integral part of our graduate course MATH 233 *Scientific Computing*. Sufficient space has been allocated for the cluster in the Science & Engineering building.

Undergraduate and graduate studies in applied mathematics also require open access to a computer lab for course work and research. Currently, our students have open access to the instructional computer lab in the Science and Engineering building. Applied Math students also have access to four workstations located in AOB 114, which have been provide by the School of Natural Sciences. In the future, an open access workstation-based computer lab for graduate studies would best accommodate the computing needs of our graduate students, other students enrolled in our computational courses, and potentially other courses as well.

6.5 Computational Administrative Support

While faculty start-up funds have been used for building a modern parallel-computation cluster, long-term financial support for its administration is required. Having an Information Technology person on-site to support the computational administration of the applied mathematics cluster, and potentially others, will ensure an optimal use of our resources and will benefit both our educational and research missions. The School of Natural Sciences has hired a full-time system administrator to set up databases and infrastructure for all academic programs. It is expected that faculty research grants and start-up funds will be used to help pay for around 10% of the system administrator's time for administration of the applied mathematics cluster.

6.6 Technical Seminars

The Applied Math Seminar Series[1] has been held on a regular basis since Fall 2005. The seminar series is a critical asset in the establishment of a strong reputation for our program in the applied mathematics community. Through our invited speakers, we are building connections with universities throughout the University of California system and across the world.

The seminar series is currently supported in part by the course budget associated with the graduate course MATH 291 (see §4.4) and the School of Natural Sciences. Faculty start-up funds are also being used to provide dinner for speakers with the applied math faculty, which has been an important time for strengthening connections. A long-term funding mechanism is required to maintain the seminar series, which is very important to the establishment of our program.

7 Funding Opportunities

The research theme of applied mathematics to study real-world phenomena is one that represents current funding opportunities in mathematical sciences. Individual faculty members will seek individual grants to fund their research and support graduate students and postdoctoral researchers. National funding agencies such as the National Science Foundation, the Department of Defense, the Department of Energy, the Army Research Office, the Naval Research Laboratory and the Air Force Office for Scientific Research among others fund applied mathematics researchers across a broad range of research areas.

There are several larger grants for which AMGS will seek funding. In 2005–2006, we proposed a "Center for Applied Mathematics" through the Department of Energy. This proposal included education and research projects for undergraduates, graduates and postdoctoral fellows. It brought together several faculty members from across all three schools. It included a cooperative educational program in collaboration with the UC Merced Division of Student Affairs. In addition, it suggested several opportunities for outreach to the greater Central Valley community in collaboration with the UC Merced Center for Educational Partnerships. Although this proposal was not funded, we are encouraged from the reviews and will seek additional opportunities of this sort. For example, the National Science Foundation has a program entitled *Enhancing the Mathematical Sciences Workforce in the 21st Century*. In particular, we will propose funds through their "Research Training Groups in the Mathematical Sciences" sub-program to support undergraduate, graduate, postdoctoral and faculty education and research programs at UC Merced.

Moreover, there are several funding opportunities that seek explicitly to link mathematics research with other research areas. Just within the National Science Foundation, there exist grant opportunities in collaborative programs such as *Collaboration in Mathematical Geosciences* for which we can collaborate with the Environmental Systems program and the Sierra Nevada Research Institute. The *Joint Initiative to Support Research in the Area of Mathematical Biology* is an opportunity for us to collaborate with the Quantitative Systems Biology program, the Center for Computational Biology and the emerging Systems Biology Institute. The program entitled, *Innovations at the Interface with the Physical and Computer Sciences and Engineering* is an opportunity for the AMGS to collaborate with physical sciences programs such as Atomic, Molecular and Optical physics program, the emerging energy institute, the Computer Science and Engineering program among other

[1] see http://appliedmath.ucmerced.edu/events-seminars.html

programs in engineering that are under discussion.

8 Assessment & Success Metrics

8.1 Research Programs

The success of UC Merced AMGS involves many components. First and foremost, is the success of the individual faculty in producing important research results leading to recognition, high-impact publications and continued research support. However, another metric for success will be UC Merced's effectiveness in developing unique, multidisciplinary research programs based on the cross-disciplinary principles of the university. Success in this metric will make the program competitive for special funding for research centers and training programs, and will also help attract strong faculty, post-docs and graduate students to UC Merced.

8.2 Academic Programs

An important metric in evaluating the success of our academic AMGS program is the graduate enrollment numbers. Assessment of the success of the AMGS program will involve monitoring both the competitiveness of the graduate student applicants to the programs and the long term career success of its graduates. The most important near-term metric regarding the success of AMGS is the proportion of students entering that attains a MS or PhD degree. Another important near-term metric is the number of students that gain post-doctoral or academic appointments or employment in industry.

9 CCGA Approval

The core faculty plan apply to CCGA for approval for stand-alone status in Spring 2009, which would be the sixth semester of the program's existence.

5-Year Strategic Plan
For
Graduate Program/Group in Biological Engineering and Small-scale Technologies
January, 2009

I. Overview

The engineering sciences are undergoing a vast and fundamental metamorphosis from isolated disciplines to more integrative and multidisciplinary topics. The Biological Engineering and Small-scale Technologies (BEST) Graduate Group at UC Merced offers a multidisciplinary research and training program for masters degree and doctoral students who want to be at the forefront of this revolution in biologics engineering and nanotechnology. Research projects are available on topics ranging from fundamental characterization of materials to tissue engineering, and coursework will provide a solid background in the tools of biologics, biosensors, and integration of modern materials. The graduate group will offer opportunities for students interested in multidisciplinary projects at the interface between biological engineering, nanotechnology, bioelectrical engineering, mechanical engineering, computer science, and materials characterization and design.

During it second year as an active graduate program, BEST graduate group already has grown to 16 faculty from both the School of Natural Sciences and the School of Engineering and 15 graduate students with research projects that fall into the four research themes (described below). The growing graduate group and expected research synergy implies the need for additional faculty to deepen the research base within these research themes. The current BEST faculty would be spread across many departments and schools in a traditionally organized university. While this diversity of disciplinary expertise should be a strength in developing innovative research programs, it is essential that the group develop a critical mass of expertise in a selected set of areas to allow it to recruit top students and faculty and to be competitive for large research and training grants.

II. Research Themes in the Biological Engineering and Small-scale Technologies

As described in the introduction, there are many exciting research opportunities within the broad area of Biological Engineering and Small-scale Technologies. The research interests of the founding faculty have fostered a focus broadly research areas that include Bioengineering and Materials. These themes are all examples of the integration and overlap the research in these two broad areas.

Research Themes

1) Tissue/Biological Materials Engineering

The area of tissue engineering is, by nature, cross disciplinary in that it employs cell culture methods combined with identification and development of appropriate materials, scaffolding architecture, technologies for cell delivery, and nutrient transport strategies while also synergizing with nanobioengineering and bio-inspired materials.

2) Biological/Physiological Modeling and Control

Biological Modeling and Control is an interdisciplinary research area combining the fields of engineering, cell biology, and chemistry. Examples include the design of components for biomedical devices and tissue engineering, and chemical optimization of molecules with biological properties.

3) Biosensor Design and Fabrication

Sensors and “bots” that can replace defective physiological counterparts in humans and animals; implants and prosthetics constructed from nanocomposites that closely resemble natural tissue; and biosensors, which can be designed to nanodimensions, mounted on a single chip and used in remote diagnoses

4) Micro/Nano Fabrication

Microfabrication for development of micro-array platforms for cell signaling and analysis is a cutting edge area of research for single cell analyses. Much convergence between engineering and biology are also at the nanoscale level – the level of biological molecules, molecular aggregates and cellular processes – has begun to offer new, rich areas of study and commercialization. Examples of the devices, processes, interactions and

materials that are of interest include self-assembly of materials, structures and devices, interactions between nanoparticles and biological tissue.

Resource Needs for the BEST Graduate Group

Three out of four of our research themed-FTE requests will require at least 400 square feet of lab space for junior researchers and up to 1,000 square feet for senior researchers with large laboratories. This is justified by the existence of very large funding sources for life sciences research. Federal agencies provide approximately $30 billion per year and research funding is also available from many foundations and private companies. These funding sources are all highly competitive and successfully acquiring funding requires a strong research program. The 4 research themes described above build on excellence in the foundational sciences, but also are well aligned with the newest academic and research priorities of the funding agencies and foundations. Most major research universities are also creating research programs in bioengineering and materials, but their natural advantages in having already established research programs and facilities may be somewhat offset by having larger institutional barriers to building multidisciplinary research efforts.

Faculty

The BEST critically needs new faculty hires to enable the research programs described above. The BEST faculty are presently drawn from the Schools of Natural Sciences and Engineering. Many of the BEST priorities for faculty hires are represented in the strategic plans from these two schools. Specifically, the BEST faculty endorse the hiring requests for the bioengineering, materials, electrical engineering and mechanical engineering research programs, including the areas of tissue engineering, biology modeling, bio-microfacbrication, and nanotechnology. The BEST faculty would also place a special emphasis on future faculty recommendations in areas that bridge traditional disciplines and faculty whose research involves integrating multiple techniques to solve problems in materials and bioengineering.

Hiring priorities

1. Tissue/Biological Materials Engineering: This is our top priority if space is available.

2. Physiological Modeling: This is our second priority, but may have advantages in that this researcher may not require as much wet lab space.

Tissue Engineering

The Tissue Engineering position could also compliment and synergize with the research of a number of faculty in the areas of Stem Cells, Vascular Tissue Engineering, Biomaterials, Nanotechnology, and Microfluidics/Microchip design. We expect that this faculty hire would contribute to our growing undergraduate programs in Materials Science, Bioengineering, Mechanical Engineering, Electrical Engineering, and Life Sciences and the graduate program in Quantitative and Systems Biology. In addition, this faculty position could potentially contribute to helping build a Stem Cell Program at UCM and synergizes with the top priority in QSB to hire a senior stem cell researcher.

The field of tissue engineering is an emerging and ambitious area of research in which scientists seek to build devices that would replace diseased tissues/organs with their biological equivalents, thus completely restoring tissue/organ functionality. This area has been termed Tissue Engineering and/or Regenerative Medicine. The area of tissue engineering is, by nature, cross disciplinary in that it employs cell culture methods combined with appropriate materials, scaffolding architecture, technologies for cell delivery, and nutrient transport strategies while also synergizing with nanobioengineering by employing the use of small nanoparticles or nonocomposite scaffolding materials. For this reason, the tissue engineer would also be expected to contribute significantly to our undergraduate program in Materials Science.

The space need for this position is expected to be wet lab space around 400-1,000 sq ft. This faculty member is expected to teach undergraduate classes in bioengineering or other area and graduate classes in BEST graduate group.

Physiological Modeling

We have been experiencing unprecedented advances into the complex nature of biological systems in recent years. Current advances in biology, genomics, proteomics, cellular level modeling methods, simulation capabilities, new technologies for imaging and measuring biological phenomena and molecular level interfacial characterization tools present the engineering community with unique opportunities to advance the understanding of these biological or even ecological systems to deliver desired functions. Currently the lack of involvement of engineering has hindered the complete understanding of the complex biological systems. Furthermore, there is a need to understand how the desired or additional functionality can eventually be accomplished and integrated over larger scales and complexities from cellular, organism to human level. Systematic modeling incorporating various engineering concepts such as optimization, database management, control and network formation based on large body of experimental results would lead to complete understanding of the non-linear nature of biological/ecological systems. Being an interdisciplinary field between engineering and biology, BEST has a strategic advantage in engineering to address this unique challenge and opportunity.

Modeling expertise at multiple levels is needed to tackle more complex biological projects. This requested multiple-scale modeling position will be at junior level. This faculty member is expected to collaborate with the current faculty members to link various research areas to study specific biological/physiological problems from system point of view. This position will develop quantitative modeling and simulation methods that faithfully represent the complexity of biological/ physiological systems based on experimental data and deal creatively with the hierarchical and nonlinear nature of living systems. This position will integrate knowledge from various research fields to serve a focal point for faculty members to collaborate on projects that can not be addressed from the view point of a single discipline.

The space need for this position is expected to be dry lab space around 400 sq ft. This faculty member is expected to teach undergraduate classes in bioengineering or other area and graduate classes in BEST graduate group.

III. BEST Academics

Overview

In its first 2 years, the BEST Graduate Group recruited and accepted 14 graduate students, 2 have already passed their qualifying examinations. Based on the growth of increasing this number by 8 students each year, we expect to have approximately 30 doctoral graduates students enrolled in the program in 5 years time. Another source of growth for BEST will be graduate programs for M.S. students. A very high percentage, approximately 30%, of our current Bioengineering undergraduates have expressed interest in the M.S. program and are already actively conducting research in various laboratories at UC, Merced. It is reasonable to expect that these students (approximately 7-10 per year) will enroll in the BEST M.S. program beginning in Fall 2009, leading to a total of 45 graduate students in the BEST program by its 5-year anniversary.

Academic Resource Needs

A central part of a successful graduate program is the diversity of advanced courses offered by the program. The BEST graduate program requires 4 full graduate courses for its Ph.D. program, and it is expected that many students will take more than this minimum. In its first 2 academic years, BEST has offered the 2 “core” graduate courses (BEST 200: Special Topics in Bioengineering and BEST 201: Special Topics in Materials) as well as 3 optional graduate level courses (BEST 217: Lab on a Chip, BEST 214: Tissue Engineering Design, and BEST 210: Structure and Properties of Materials). In order to provide additional graduate training, the BEST faculty have been leading individualized study sections (BEST 299), although this is option neither ideal nor sustainable.

Courses approved:
BEST 200: Special Topics in Bioengineering

BEST 201: Special Topics in Materials
BEST 210: Structure and Properties of Materials

BEST 217: Lab on a Chip (Microfabrication)
BEST 214: Tissue Engineering Design

Additional BEST Courses planned:
Biophysics
Electrophysiology of the Cell
Biotransport
Entrepreneurship
Biomolecular and Cellular Rate Processes
Cellular and Tissue Biomechanics
Bionanotechnology
Medical Imaging

We have been unable to offer a larger selection of courses due to very low faculty numbers in core areas of the program (Materials and Bioengineering). We have only 4 faculty in Material Science and 4 faculty in Bioengineering and are all overcommitted with undergraduate teaching. We also plan to develop "biological engineering" and "materials" tracks in the growing program, but we do not have faculty available to teach graduate level courses. We will need a least 4 more faculty, 2 each in these 2 "core" areas before we can build our planned "tracks" into the academic program or apply for a permanent graduate group status.

IV. Milestones and Assessments for the BEST Graduate Group

Research Programs

The success of the UC Merced BEST Graduate Group involves many components. First and foremost, is the success of the individual faculty in producing important research results leading to recognition, high-impact publications, patents, program growth in faculty and student numbers, technology transfer, and continued research support. However, another metric for success will be UC Merced's effectiveness in developing unique, multidisciplinary research programs based on the cross-disciplinary principles of the university. Success in this metric will make the program competitive for special funding for research centers and training programs, and will also help attract strong faculty, post-docs and graduate students to UC Merced. Another long term metric will be the impact of the research programs at UC Merced on the community.

Other important near-term metrics regarding the success of the BEST graduate program is the proportion of students entering that attains a doctoral degree, as well as students winning competitive awards and fellowships. Another important near-term metric is the number of students that gain post-doctoral appointments and employment in industry.

As previously mentioned, the BEST faculty envision developing 2 "emphasis tracks" for graduate students including a "Materials" and "Bioengineering" track that would closely match traditional training programs. Unfortunately, this development is not possible until larger due faculty numbers are available to contribute to teaching BEST courses.

In addition, the BEST graduate program and has been, very successfully, coordinating with the QSB graduate program in supporting a research seminar series that invites speakers every Friday during the academic year. This is especially beneficial while BEST grows as a program and while the funding situation for research seminars remains very low. We hope that as BEST grows as a program, and as the funding situation improves, BEST and QSB can both support individual seminar series.

Academic Programs

An important metric in evaluating the success of our academic life sciences programs will be the graduate and undergraduate enrollments. Assessment of the success of the BEST program will involve monitoring both the competitiveness of the graduate student applicants to the programs and the long term career success of its graduates. Despite its newness and small size, the BEST graduate group at UC Merced is attracting academically strong students. This Fall 2008, the BEST graduate group a made 12 offers to graduate student applicants with 6 students accepting (50%) and have now joined our graduate program. The average undergraduate GPA for our graduate students in Academic Year 2008-2009 was 3.49 and the average Quantitative GRE was 767, which is at approximately at the 85th percentile. The current average GPA for our BEST graduate students from their work at UCM is approximately 3.8, with many students with a 4.0 GPA. We also had 2 students advance to candidacy during fall, 2008 and are anticipating graduating our first 2 M.S. students this spring/summer 2009. With the exception of 1 graduate student that is struggling a little academically, all of our BEST graduate students are currently excelling in their programs at UCM.

EECS Strategic Plan with FTE priorities for 2009-10

November 17, 2008

Introduction

Electrical Engineering & Computer Science at UC Merced currently includes Assistant Professors Stefano Carpin, Miguel Carreira-Perpinan, Alberto Cerpa, Marcelo Kallmann, Shawn Newsam, David Noelle, Songhwai Oh and Ming-Hsuan Yang. Additionally, Professor Steve Kang, currently serving as University Chancellor, is affiliated with the EECS group. The group currently has a total of 18 graduate students enrolled in the PhD program.

Since the campus opened in fall 2005, one student has graduated with an MS degree and two PhD students have advanced to candidacy. We expect several more students to advance to candidacy during the 2008-9 academic year and also expect to admit a number of graduate students to begin in fall 2009, mostly at the PhD level.

This document describes the strategic plan of the graduate program with emphasis in EECS. It lists the faculty hiring priorities in the context of the guidelines below.

Guidelines

All major universities in the world offer strong graduate programs in Electrical Engineering, Computer Science and related disciples. EECS graduate programs are particularly robust in the campuses of the UC system. Table 1 indicates the enrollment percentages that EECS graduate programs constitute as part of the Schools/Colleges of Engineering [2] and as part of the campuses overall [1]. In this table, EECS is taken to include graduate programs in Electrical Engineering, Electrical and Computer Engineering, Computer Engineering, Computer Science and Engineering, and Computer Science. EECS graduate enrollments range from 29.2% to 80.8% of engineering graduate enrollments and from 12.0% to 30.7% of campus-wide graduate enrollments in the UC system. The EECS emphasis area at UCM currently constitutes 10% of the campus-wide graduate enrollment, well below the UC average of 20%, and thus has significant potential for growth.

The goal of the EECS faculty is to achieve a first class graduate and research program through the following specific objectives:

1. **Strategic Domains:** The group has decided to pursue concentrations of researchers in specific emerging domains, rather than trying to cover all areas in EECS.

Table 1: Row 1: EECS graduate enrollment at UC campuses [2]; row 2: engineering graduate enrollment [2]; row 3: EECS graduate enrollment as a percentage of engineering graduate enrollment; row 4: campus graduate enrollment [1]; row 5: EECS graduate enrollment as a percentage of campus graduate enrollment.

	UCSB	**UCB**	**UCR**	**UCSC**	**UCD**	**UCSD**	**UCLA**
EECS enrollment	409	520	206	252	392	593	708
Engineering enrollment	674	1,780	308	312	1,124	1,213	1,388
EECS percentage	60.7%	29.2%	66.9%	80.8%	34.9%	48.9%	51.0%
Campus enrollment	2,981	10,317	2,214	1,444	7,017	3,952	11,548
EECS percentage	22.6%	17.3%	13.9%	21.6%	16.0%	30.7%	12.0%

2. **Innovative Curriculum:** The group plans to offer a novel and attractive graduate program by focusing on modern areas and leveraging unique opportunities for establishing strong interdisciplinary tracks in conjunction with Cognitive Science, Applied Math, Environmental Engineering and Mechanical Engineering.

3. **Covering Immediate FTE Needs:** In order to cover the minimum required undergraduate and graduate CSE/EECS course offerings for the 2010-11 academic year, the group would need to increase from the 10.5 currently hired and allocated faculty positions to approximately 14.5 faculty positions.

These guidelines are elaborated on in the following sections.

Strategic Domains

The group seeks to develop depth before breadth and is therefore pursuing concentrations of researchers in specific EECS domains, rather than trying to initially cover all sub-disciplines. The research interests of the current faculty include: image processing, computer vision, computer graphics, computational geometry, computer animation, robotics, artificial intelligence, computational cognitive neuroscience, machine learning, sensor networks, wireless communication and distributed systems.

These domains can be grouped roughly into three main focus areas: **Learning**, **Autonomy**, and **Systems**. These three areas are all interrelated to generic Intelligent Systems, and directly promote the association with other graduate groups, in particular Cognitive Science and Applied Math. Exciting research areas in Learning, Autonomy, and Systems include:

- Virtual Reality and Human Computer Interaction
- Autonomous Robotics
- Computer Games and Artificial Intelligence
- Tracking and Computer Vision

- Image Processing and Analysis
- Sensor and Actuator Networks
- Wireless Communication Networks
- Machine Learning

The group aims to recruit faculty with related and complementary research interests in these areas, in order to build a strong and focused program that can attract top graduate students, offer modern and compelling programs for both undergraduate and graduate students, successfully compete for funding, and achieve national and international recognition and visibility in research.

Innovative Curriculum

The group plans to offer novel and attractive undergraduate and graduate educational programs. Two main complementary actions are being taken in order to accomplish this.

First, the group would like to focus courses and research on modern applications (as listed in the previous section) that nurture creativity and the discovery of new applications of technology. This is a response to the observed lack of interest in Computer Science which has become incorrectly viewed as mere training in computer programming instead of a scientific discipline [3]. Second, the group is exploring the option of having interdisciplinary tracks in order to identify novel and attractive areas of emphasis. For instance, Professor Noelle is currently a member of and Professors Carpin, Carreira-Perpinan, Kallmann, and Newsam are currently affiliated members of the Cognitive Science graduate group; Professors Kallmann, Newsam and Cerpa are affiliated members of Applied Math graduate group; and Professors Carpin and Kallman are affiliated members of the Mechanical Engineering and Applied Mechanics group. It is expected that these cross-discipline efforts will naturally lead to emphasis areas within the EECS graduate program that could be complemented with courses or research from other graduate groups.

Covering Immediate FTE Needs

In order to cover the minimum required undergraduate and graduate course offerings for the 2010-11 academic year, the group will be required to grow from the 10.5 currently hired and allocated faculty positions to approximately 14.5 faculty positions. This request is based on the following:

- The current UCM enrollment is 2,700 students.
- The campus-wide student body growth is approximately 800 students net per year.
- The SoE comprises 20% of the student body (undergraduate and graduate).

- 33% of SoE students are enrolled in CSE (undergraduate) and EECS (graduate). EECS undergraduate and graduate programs constitute the following percentages of School/Colleges of Engineering at other UC campsus [2]: Berkeley–29.1%, San Diego–33.7%, Davis–34.3%, Los Angeles–43.6%, Riverside–50.4%, Santa Barbara–56.3%, and Santa Cruz–69.6%.

- The student-to-faculty ratio is 19.8.

Request for faculty positions

The faculty hiring priorities for the graduate group are currently driven by the goal to establish concentrations of researchers in select EECS domains. This goal correlates with the hiring strategy for the CSE undergraduate program as described in the School of Engineering strategic plan. In particular, the following four positions are requested by the EECS group with the first two positions CSE-11 and CSE-12 given high priority in order to fill important CSE areas needed to complement current teaching and research programs.

CSE-11: Security Senior Position. This position will target the following areas: security, ubiquitous computing, distributed sensing and monitoring, and similar areas. Considering the composition of the current EECS faculty, the requested rank is at the associate or full level. The space needs for the CSE-11 position is expected to be similar to that of the current EECS faculty: a modest level of dry lab space for several computer and/or experimental research workstations. The exact space needs will depend on the research area of the selected candidate.

CSE-12: Algorithms & Theory Senior or Junior Position. This position will target algorithms & theory. The EECS group currently lacks expertise in this area which is critical for the future of the program. While preference is for a senior candidate considering the composition of the current EECS faculty, we would be willing to hire an outstanding junior candidate. The space needs for CSE-12 are expected to be low due to the nature of the research; deskspace for graduate students is often sufficient for researchers in this area. This makes this an attractive area to target given the current space constraints on campus.

CSE-13: Embedded Systems Senior Position. This position will be instrumental to bridge possible research and teaching gaps between Electrical Engineering and Computer Science. Possible research topics include, but are not limited to, embedded systems, robotics hardware, sensor networks and the like. The space needs for the CSE-13 position are expected to be similar to that of the current EECS faculty working in systems related areas: a dry lab space for several computer and/or experimental research workstations, and workspace for assembling and testing devices. The exact space needs will depend on the research area of the selected candidate.

EE-2: Smart Devices Senior position. This position is needed to build the Electrical Engineering undergraduate major under planning. This new position will therefore

be instrumental not only to jump-start the undergraduate program in Electrical Engineering but also to strengthen the EECS graduate program under development. Considering the current situation in Electrical Engineering, i.e. one open search with broad scope, we feel the new search should be broad as well. If possible, the following research areas will be targeted: smart energy infrastructure; and novel computational paradigms and devices. The space needs for the EE-2 position are expected to be similar to that of the current EE-1 position; a dry lab space for several computer and/or experimental research workstations, and possibly workspace for assembling and testing devices. The exact space needs will depend on the research area of the selected candidate.

References

[1] UC Campus Websites.

[2] American Society for Engineering Education. http://www.asee.org/.

[3] Peter J. Denning and Andrew McGettrick. Recentering computer science. *Communications of the ACM*, 48(11):15–19, 2005.

U N I V E R S I T Y O F C A L I F O R N I A

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UNIVERSITY OF CALIFORNIA, MERCED
ENVIRONMENTAL SYSTEMS GRADUATE PROGRAM

To: Professor Wolfgang Rogge
School of Engineering Resources Committee

From: Professor Thomas Harmon, Chair
Environmental Systems Graduate Program

Cc: Environmental Systems Faculty, Dean Jeff Wright, Dean Maria Pallavicini, Dean Hans Bjornsson, SNRI Director Roger Bales, EVC Keith Alley

Date: November 18, 2008

Re: Environmental Systems input on FTE priorities for 2008-09 Strategic Plan

The Environmental Systems faculty held group meetings on October 17 and 31 to develop this plan. We began by revisiting the ongoing faculty searches and then discussed future priorities. Discussion and prioritization has since taken place via email through both the group and through the closely related Sierra Nevada Research Institute strategic planning process. The following positions emerged as priorities for strengthening the ES group's position in terms of graduate research quality and competitiveness, from the perspective of near-term and longer-term Central Valley, California, national, and global research issues and opportunities.

The Environmental Systems (ES) program strives to equip graduate research students with the knowledge and skills necessary to improve the scientific understanding of coupled Earth systems--atmosphere, hydrosphere, lithosphere and biosphere--and to use this understanding to (1) manage natural resources, (2) engineer the restoration of impaired environments, and (3) inform environment-public health decisions. This improvement in understanding is gained through the systematic study of biological, chemical and physical processes, and through rigorous individualized research programs in natural and engineered environments. Courses are designed to provide the scientific principles underlying the function and sustainability of natural and engineered environmental systems and the socioeconomic and political forces that shape decisions

about these systems. The ES program places the principles of natural science and engineering in the context of (1) ascertaining fundamental processes and properties of environmental systems, (2) integrating physical, chemical and biological cycles, (3) pollution prevention, treatment and ecosystem restoration and (4) resource management and decision making.

Our decadal vision for ES is to be an internationally recognized research and graduate program and our graduate students are known for their innovative and interdisciplinary approach to solving environmental issues. In addition, Environmental Systems is posed to contribute to the stated goals of the campus to increase our recognition as a research institute, promote the success of our junior faculty and to increase graduate student enrollment.

Accomplishments 2007-2008

The 2007-8 accomplishments of Environmental Systems graduate program, include the following: (1) we became the first and remain the only graduate group at UCM to achieve system approval for our graduate degrees, (2) we graduated our first PhD student and brought our total number of MS graduates to four, and (3) with the recruitment and addition of new faculty (Stephen Hart and J. Elliott Campbell, Asmeret Behre, Teamrat Ghezzehei, Wolfgang Rogge) the program now has a foundational elements in microbial ecology, sustainability, soil sciences and air pollution. This year (2007-2008), the total number of graduate students in the program grew to 28, total number of faculty to 23 and total number of research dollars to $5,790,629 (assigned on basis of PI affiliation with ES). We continue to offer a well-attended seminar series that covers the breadth of ES interests.

Goals 2008-2009

Issues of environmental sustainability: climate, ecosystems and energy have been highlighted in the proposed campus-wide Strategic Plan. Environmental Systems is poised to lead UCM in these areas. To that end, ES faculty have developed some short-term goals:

- Increase graduate enrollment 20% and expand our course offering to meet the breath and depth that address our graduate student needs [***Note:*** *to support more rapid graduate student enrollment growth, the ES faculty strongly endorses attainment of an graduate student fellowship endowment as a priority campus-wide development effort.*]
- Maintain sustained growth in research activity and to expand the ecology and ecosystems research to a level comparable to the climate, hydrology, and biogeochemistry research
- To increase the presence of our atmospheric dynamics/air pollution research efforts in California, nationally, and internationally (see requester? request for? reauthorization at the end of this document)

- Increase the base for graduate student support and improve administrative support for graduate program
- Continue to build links with other graduate programs and lay the foundation for the development of new graduate programs (e.g. management and public health) as well as enhance the profile of the Sierra Nevada Research Institute

To achieve these goals, we request the following positions (see Table 1 for resource implications):

Natural resource management. It is recommended that a tenured faculty member at the full or associate professor level be hired in this area. It is expected that this person would help lead the planning for a natural resources management track within the proposed management school. A research emphasis on water, forest, or range would complement existing faculty and help fill an important niche in the UC system. This person could also contribute to the Earth Systems Science degree in the School of Natural Sciences, to a Center for Spatial Analysis that is being investigated by faculty in SoE and SSHA, and to a possible Geography degree at UCM. At the graduate level, a number of discussions have taken place around starting a program in National Park Management, and this person could also contribute strongly to that program.

Rationale and Potential School Affiliation(s). UC Merced has proposed a school of management, and this FTE is needed if ES is to develop a major research thrust in this area. Relevant faculty would reside primarily in SoE or SoM (once it is developed). The graduate and upper division courses taught by this faculty member would contribute to the ES program, as well as to engineering economics and Earth systems science courses.

Ecological engineering or ecohydrology. We recommend an assistant or associate level search for a faculty member who uses engineering principles to design sustainable systems that integrate human activities with the natural environment**,** with particular emphasis on the linkage between hydrologic and ecological systems. Possible areas of research emphasis include interactions among hydrologic, biogeochemical, physiological, and soil processes; hydrologic ecosystem services, integrating water quality, water cycling; spatial analysis and scaling. Remote sensing, field-based measurements, laboratory experiments and modeling are all of interest. As a discipline, ecohydrology addresses the bi-directional regulation of hydrologic and ecological processes, e.g. the flow regime and pollutant levels of water in wetlands regulate the species and the populations that live in the ecosystem, while ecological processes in the wetland regulate the timing and magnitude of water and nutrient fluxes through the system. Ecological engineering involves the design, construction, restoration and management of aquatic and terrestrial ecosystems that have value to both humans and the environment, using principles from engineering, ecology, economics, and natural sciences. The extensive and large-scale ecosystem restoration efforts planned in the Central Valley provide excellent opportunities for both natural laboratories, and research support through applications partnerships with local landowners and conservation entities. Similar efforts are being carried out and across the Western U.S. This position would have collaborative opportunities and synergy with Bales, Conklin, Harmon, Guo, and Traina in SoE and Aguilar, Dayrat, Duffy, Ghezzehei , Kueppers, and O'Day in SoNS.

Rationale and Potential School Affiliation(s)**.** A large number of faculty in ES are actively engaged in national observatory initiatives which are already bringing long-term,

high-impact projects to UC Merced (e.g., NEON, Critical Zone Observatories, and WATERS Network Test Bed projects). The ES Group sees this hire as necessary to position the campus competitively in this new research domain. Major initiatives, including investments in research institutes and academic units, are currently being launched at several major research universities, another sign of the increasing prominence of this subject. Such an individual could reside in any of the Schools, or jointly between schools, depending on their specific expertise. The graduate and upper division teaching contribution by this faculty member would be within the ES program as well as in fundamental engineering, environmental engineering, and Earth systems science courses.

There are major opportunities for research on topics pertaining to ecohydrology concerned with habitat restoration and related issues in California, nationally, and internationally. In California alone, for example, continued allocations to the CALFED program (see website: http://www.calwater.ca.gov/index.aspx) and new allocations to the San Joaquin River Restoration, in support of the 2006 SJR Settlement Agreement (http://www.lao.ca.gov/analysis_2007/resources/res_05_anl07.aspx), will likely be exceed $250 million over the next few years. Given our strategic location and the current ES faculty makeup, an ecohydrologist would be well-positioned to play a major role in this work, bringing both state and national attention to the ES program and UC Merced as a whole.

Environmental health or epidemiology. This position contributes to an environmental health/air pollution focus. This person should be either a biostatistician/epidemiologist and/or molecular epidemiologist. Priorities would be for research focusing on asthma, lung cancer or cardiovascular disease as these are major problems associated with air pollution, which are the leading causes of health problems with major financial impact on the San Joaquin Valley. This position is an excellent complement to research of Forman, Traina, Leppert, and as well as the two other proposed environmental health positions. The teaching role for this person could be in statistics, molecular biology or physiology dependent upon their expertise. As this would be the first epidemiologist, a senior position is recommended.

Rationale and Potential School Affiliation(s). A significant air pollution-related research effort aimed at the understanding and mitigating the escalating air quality problems in the Central Valley, Sierra Nevada, and elsewhere is expected form UC Merced and has already been initiated in the ES group (Professors Rogge, Chen, and Leppert, and a pending air pollution hire) and in NS (Professor Forman). Professor Chen focuses on modeling spatiotemporal emissions distributions under various air pollution control policies. Professor Leppert examines physical-chemical properties of particulate pollution, while NS Professor Forman examines the physiological effects of air pollution on lung tissue. Epidemiology is clearly a gap in this cluster of activity. ES envisions that this position would reside in NS or NS-Management (when in place).

Table 1. Summary of teaching areas and resource requirements for requested faculty lines affiliated with Environmental Systems.

FTE	Primary undergrad teaching	Secondary undergrad teaching	Secondary graduate program	Startup needs	Space Needs
Natural resource management (assoc/full level)	Management (when instituted)	Environmental engineering or Earth systems science	Management (when instituted)	Postdoc support; computational resources	400 sq ft computational lab/student and staff office space
Ecological engineering or ecohydrology (asst/assoc level)	Environmental engineering or Earth systems science	Biology	Quantitative Systems Biology	Postdoc support; field equipment	Field equipment staging space (200 sq ft); wet lab (400 sq ft);
Environmental health or epidemiology (assoc/full level)	Management or Biology (depending on emphasis)	Biology or Management	Quantitative Systems Biology or Management	Postdoc support; computational resources	400 sq ft computational lab/student and staff office space

Addendum: Confirmation of Prior FTE Allocation: Air Pollution/Atmospheric Dynamics

The ES Group wishes to reconfirm its support for a previously allocated cross-school search in the area of atmospheric dynamics. This search has resulted in strong applicant pools in the past, owing to the extensive and unique opportunities for researchers here in the Central Valley. Offers to both a senior and junior candidate were declined, and the ES group voices a strong consensus that this position be searched again in order to build critical mass in this area as quickly as possible.

Atmospheric Dynamics. Atmospheric dynamics will continue to be long term research driver in the context of climate change and air quality management issue atmospheric dynamics involves observational and theoretical analysis of all motion systems of meteorological significance, including global- to regional-scale circulations. Research problems include many topics related to climate change, climate variability, stratospheric dynamics, and the general circulation. Problems in atmospheric chemistry evolve due to natural events, biological and anthropogenic activities, and are linked to the oceans, the solid earth and the biota. Anthropogenic perturbations such as land-use and industrial activities have profoundly modified the chemical composition of the troposphere and stratosphere, with potentially important consequences on future climate and living organisms. Examples of such changes including the formation of an ozone

hole over Antarctica since the late 1970s, the observed trends in long-lived greenhouse gases, the change in the concentrations of tropospheric ozone and acidic deposition due to growing emissions of hydrocarbons, nitrogen oxides and persistent chemicals in industrialized regions.

Rationale and Potential School Affiliation(s). UC Merced has the nucleus for a strong atmospheric dynamics group, but more FTEs are needed if ES is to develop a major research thrust in this area. Relevant faculty would reside primarily in SoE or NS, depending on their specific expertise. The graduate and upper division teaching contributions by this faculty member would contribute to the ES program as well as to fundamental engineering, environmental engineering, and Earth systems science courses.

Teaching Contributions: As discussed previously, this position would teach in the environmental engineering and Earth systems science undergraduate programs in addition to the Environmental Systems graduate program.

Resource Needs: Researchers in this area typically use computation models to understand and predict reactive atmospheric transport behavior. Hence, this faculty member would need support for postdoctoral staff to help initiate his/her research program, computational facilities and workspace (400 sq ft), and office space for his/her graduate students and staff.

DRAFT

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School of Engineering
University of California, Merced
P.O. Box 2039
Merced, CA 95344

June 1, 2009

To: Jeff Wright, Dean, SOE and Lead Dean of MEAM

From: Carlos F. M. Coimbra, Chair
Mechanical Engineering and Applied Mechanics Graduate Program

Re: MEAM Strategic Plan for AY 2009-10

Mechanical Engineering and Applied Mechanics represent two distinctive but overlapping research areas that together form some of the most fundamental pillars of the academic enterprise. While the various disciplines that compose the field of Applied Mechanics are associated with rigorous and rapidly developing branches of human thought, Mechanical Engineering is currently undergoing a fundamental transformation at several distinct levels. At the design level, computer aided engineering and fast prototyping automated tools are revolutionizing the way new products are conceptualized, evaluated and deployed into the market. At a more fundamental level, computational methods that are based on judicious use of advanced concepts in Applied Mechanics (including stochastic evolutionary methods, uncertainty analysis, artificial cognition, etc.) have expanded the portfolio of research methodologies much beyond the usual designer-based experience. Today, Mechanical Engineering is evolving into a discipline where more emphasis is placed on teaching a machine how to design, other than using the machine to optimize a pre-selected design. In other words, instead of using the engineering methodology to optimize a pre-existing concept, MEAM research is transitioning to a new paradigm where only the goals and constraints of the object are known to the designer, and a stochastic algorithm uses a variety of advanced computational methods to explore the complete space of solutions that satisfy the goals and constraints of the problem at hand.

The MEAM group at UC Merced emphasizes this new approach to Mechanical Engineering, and therefore is unique among all UC campuses in placing a much higher emphasis on advanced computational methods. Being only recently formed (August of 2007), the MEAM group is composed of eight faculty members from various disciplines, including Mechanical Engineering, Electrical Engineering, Physics, Applied Mathematics and Computer Science and Engineering.

2. Research Themes in the Mechanical Engineering and Applied Mechanics Group

Research programs

As mentioned above, there are many exciting research opportunities within the context of the MEAM program, and we have prioritized research areas that would better complement and add value to the overall research and educational mission of UC Merced. The chosen research themes also add a unique flavor to our program not only within the UC system, but also in comparison to other programs in the nation. The MEAM program will initially focus on two major themes, which are described below.

Research Themes

I) ***Energy Systems*** — Mechanical engineering is a core discipline for the development of energy conversion technologies, and the MEAM program at UC Merced is well poised to take the lead on the renewable energy initiative in our campus. Profs. Winston, Sun, Coimbra, and Diaz have all established track records in research funding in the energy research area. There is very strong synergy between the MEAM graduate program and the Merced Energy Research Institute (MERI), as well as with UC CITRIS (Center for Information Technology Research in the Interest of Society) and the new CITRIS initiative C-GRACE (CITRIS Global Research Alliance for Climate and Energy). Within the Energy Systems theme, the main areas of activities of the MEAM program include: solar concentrators, solar availability mapping, renewable fuel conversion, fuel cell technology, concentrator controls, direct solar conversion, and solar power applications to environmental health monitoring. The MEAM program has several overlapping research projects with other graduate groups within the energy systems theme, including Environmental Systems (ES) and Electrical Engineering and Computer Science (EECS). The MEAM faculty has been very successful in attracting sizeable research grants in this area.

II) ***Biologically Inspired Technologies*** — Although one of the primary goals of this MEAM research theme is in the development of advanced computational methodology, there is important synergy with experimental methods in bio-controls, mechatronics, multi-scale material properties, and complex fluids that will enable the maturation of this area into a new paradigm of engineering design. A strong computational component on novel genotype optimization methods will allow us to explore bio-inspired solutions beyond the traditional bio-mimetic approach. However, it is the concurrent and parallel experimental development of advanced materials (and the associated understanding of complex constitutive relations) that will enable the development of a full spectrum of engineering solutions for complex problems for engineered materials (as opposed to biological materials). An important component of the MEAM strategic plan is to build critical mass in this research theme. There is a very good opportunity for future collaboration between several graduate programs at UC Merced in this area, including Biological Engineering and Small Technologies (BEST), Electrical Engineering and Computer Science (EECS), Quantitative and Systems Biology (QSB), and Applied Mathematics (AM).

The two research themes above reflect a sensible compromise between depth, breadth, impact and quality of MEAM research. Equally relevant is our effort to combine the needs of the very popular undergraduate program in Mechanical Engineering with the development of a strong research program in MEAM.

3. Synergistic Growth with the Undergraduate Program in Mechanical Engineering

The mechanical engineering (ME) undergraduate major was launched during Fall 2006 accepting only freshman students. The plan was to start accepting transfer students only in the Fall 2008. However, a large number of current upper division students at UC Merced have approached ME faculty or the engineering student counselors to explore the possibility of transferring to the ME

major before they complete their degree. There is increasing evidence that ME will become one of the most popular engineering majors at UC Merced. For instance, out of 300 freshman students accepted in engineering for fall 2007, 53 students (17.7%) chose ME. Last year, a significant fraction of the undeclared students decided to enroll in ME, so we expect a similar trend for this year. Currently in its second year, the ME program has already the second largest enrollment in the SOE with more than 160 students, a six-fold increase from the first year, when we had 26 ME students. ME also has currently the largest student-to-faculty ratio in the SOE by a large margin.

In order to evolve into a top ME program, it is absolutely necessary to develop a strong and comprehensive foundation in key areas, with a sufficient number of faculty to build a modern program with state-of-the-art research infrastructure. In addition, because ME is a key component of any modern engineering academic program in serving key and foundational needs for many engineering sub-disciplines. Delaying the hiring of ME faculty will dramatically constrain the growth of our engineering program and could significantly impair the image and reputation of the ME program and the college of engineering as a whole.

Currently, ME provides service to other majors by teaching a number of engineering fundamentals courses that include: ENGR 57 (Dynamics), ENGR 151 (Strength of Materials), ENGR 130 (Thermodynamics), ENGR 135 (Heat Transfer), and others. This situation increases dramatically the teaching load of ME faculty.

From the outset, there was a concerted effort to provide a seamless experience to SOE undergraduate students interested in pursuing post-graduate education in the MEAM program. The MEAM program offers research opportunities for students interested in projects at the interface between Complex Analysis, Mechanics, Manufacturing, Bio-Inspired Engineering, Applied Computational Sciences, Mechatronics, Advanced Materials, Energy Conversion, and Controls. Due to the interdisciplinary nature of the topics covered in MEAM courses, a number of these courses serve graduate students from many different disciplines. This also increases the teaching load of ME/MEAM faculty. For instance, in the past the following courses were populated by graduate students from other programs: ME 135/ES 235 (Heat Transfer), MEAM 201 (Advanced Dynamics), ME 210 (Linear Controls), and MEAM 251/ES 237 Viscous Flows.

There are currently five FTE positions filled in mechanical engineering (listed here in order of hiring): Professor Diaz, Professor Coimbra, Professor Sun, Professor Modest and Professor Ma. The expertise of the current faculty covers a relatively unbalanced portion of the overall research area in Mechanical Engineering and Applied Mechanics since 4 out of the 5 faculty hired have main expertise in Thermofluids, and only one faculty (Prof. Sun) has expertise on Solid Mechanics.

A total of eight desired positions have been identified and described below in descending level of priority for both the ME and the MEAM programs (Roman numerals in parenthesis indicate the corresponding research theme for the MEAM program in Section 2):

1) Bio-Controls (I)
2) Computational Engineering (I and II)
3) Bio-Inspired Mechanics (I)
4) Energy (with emphasis in Fuel Cells or Hybrid Systems) (II)
5) Nonlinear Analysis (I and II)
6) Computational Fluid Dynamics (I and II)
7) Mechatronics (I and II)
8) Turbulence (I and II)

The ME requested positions for AY 2008/2009 were described as:

- **ME-6: Senior/junior position complementing research of existing ME faculty**
- **ME-7: Senior/junior position complementing research of existing ME faculty**

The program is also requesting ***two security-of-employment instructors***. One will concentrate on the engineering fundamentals (ENGR) courses that serve all programs in the SOE, and the other on ME electives that may serve BIOE, ES, ME, MSE and CSE students, as well as to serve as an industry liaison for the capstone design competitions.

The description of the two requested FTE positions for 2008-09 is as follows. We note that these positions were originally advertised in 2009 but were subsequently cancelled due to budget cuts.

a) ME-6: Bio-Controls

Mechanical Engineering sees a need for an FTE working on research in one or more areas of the emerging domain of Bio-Control. This senior/junior position will add an important and strategic area of research in ME to broaden and strengthen its actual capabilities. This position will cover, but will not be limited to, the design and construction of self-assembled structures, bio-mimetic surfaces, sensors and actuators that will allow external control of biological and bio-technology systems. Mechanical Engineering and the MEAM Graduate Group see such a hire as necessary to position the campus competitively in this promising area of research. The undergraduate program in Mechanical Engineering will benefit with courses such as mechatronics (ME 142), vibration and controls (ME-140), and the capstone design (ME-170). The graduate program will benefit with courses in the particular areas of research of this FTE. Natural synergies with other programs include Bio-Engineering, Computer Science and Engineering, and Applied Mathematics. The space needs are expected to be adequate for a senior/junior level position in the wet lab area.

b) ME-7: Computational Engineering

This senior/junior position is an important and strategic area of research in ME and it is intended to strengthen the actual capabilities of ME faculty. It will cover, but will not be limited to, the development of numerical schemes to treat problems in structural, fluids, and/or thermal/fluids systems. It can relate to parallel computing and high performance algorithm development applied to engineering problems. The undergraduate program in Mechanical Engineering will benefit with courses such as FEA (ME 135) and CAE (ME-137). The graduate program will benefit with courses in the particular areas of research of this FTE. Natural synergies with other programs include Computer Science and Engineering, and Applied Mathematics. The space needs are expected to be adequate for a senior/junior level position in the dry lab area.

Clearly, the ME/MEAM program is falling way below the number projected by the School of Engineering Resources Committee on its 2006 5-Year Hiring Plan (see Table 8 below).

Table 8 School of Engineering Faculty 5-year Hiring Plan

Academic Year	ENVE		CSE		BIOE		ME		MSE		EE		ChE		EEM		CE		Cumulaive Faculty FTEs
	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	
	Bales	1.0	Newsam	1.0	Chin	1.0	Diaz	1.0	Viney	1.0	Chiao	0.5							
	Conklin	1.0	Kallmann	1.0	McCloskey	1.0	**Sun**	1.0	Leppert	1.0	EE-2	1.0							
	Harmon	1.0	Cerpa	1.0	Khine	1.0	Coimbra	1.0	Lu	1.0									
	Winston	0.5	Carpin	1.0	BIOE-4	1.0	ME-4	1.0	MSE-4	1.0									
	Guo	1.0	(Bajcsy)	1.0	BIOE-5	1.0	ME-5	1.0	MSE-5	1.0									
	EnvE-6(Air)	1.0	CSE-6*	1.0	BIOE-6	1.0	*ME-6*	0.5											
	EnvE-7(x)	*0.5*	Noelle	0.5	*BIOE-7*	0.5	ME-7	1.0											
	Westerling	0.5	CSE-8*	1.0	BIOE-8	1.0	*ME-8*	0.5											
	Chen	0.5	CSE-9*	1.0	BIOE-9(x)	0.5	ME-9(x)	0.5											
	EnvE-10(x)	0.5	CSE-10	1.0															
	EnvE-11(x)	0.5	*CSE-11*	0.5															
	EnvE-12	1.0	CSE-12(x)	0.5															
			CSE-13(x)	0.5															
			CSE-14(x)	0.5															
AY 05-06	5.5		6.0		4.0		2.0		2.0		0.5		0.0		0.0		0.0		20.0
AY 06-07	7.0		6.5		4.0		3.0		4.0		1.5		0.0		0.0		0.0		26.0
AY 07-08	7.0		7.5		5.0		4.0		4.0		1.5		0.0		0.0		0.0		29.0
AY 08-09	9.0		11.5		8.0		7.5		5.0		1.5								42.5
AY 09-10																			0.0
AY 10-11																			0.0
AY 11-12																			0.0

Underlined (x) denotes cross-School hire - *Italics* denote cross-engineering hires - (Paranthetical) entries denote individuals under consideration - **Bold** denotes senior FTE

3. 2010 Resource needs for the MEAM graduate program and associated ME program

There is a minimum number of specialized faculty members required to deliver a comprehensive program such as Mechanical Engineering in parallel to a successful graduate program in MEAM. Although we are falling short of the projected need for FTEs, an even more pressing problem is space allocation for both instructional and research use. The ME/MEAM faculty believe that the instructional laboratory allocation to ME-lead classes is insufficient for achieving success in the accreditation process with ABET. The resource needs for both faculty and facilities are discussed next.

Faculty

The MEAM group critically needs new faculty hires to enable the research programs described above. The MEAM group is therefore requesting that 1 additional position in Bio-Inspired Mechanics be released for the next academic year. This position will allow the MEAM group to develop a critical mass in an area where the current faculty members have been actively pursuing research funding. A description of the position follows:

ME-6: Bio-Inspired Mechanics

This position will cover, but will not be limited to, the design, construction and testing of bio-inspired locomotion mechanisms for both flight and underwater propulsion. The undergraduate program in Mechanical Engineering will benefit with courses such as mechanisms (ME 190), mechatronics (ME 142), vibration and controls (ME-140), and the capstone design (ME-170). The graduate program will benefit with courses in the particular areas of research of this FTE. Natural synergies with other programs include Bio-Engineering, Computer Science and Engineering, and

Applied Mathematics. The space needs are expected to be adequate for a senior/junior level position, which includes an area between 600sf to 900sf of dry-lab research area.

Core Facilities

Both the MEAM research program and the ME instructional program need adequate lab space and machine shop support to exist. The current machine shop is not supported at a level that will allow Capstone Design and MEAM research programs. This limitation will severely impact the ability of the ME program to be ABET accredited in the coming years. All ME faculty members, in collaboration with the SOE staff, have been actively involved in extracting the most out of the limited instructional lab space available to deliver the ME classes. However, even considering the best use of the instructional labs (which include rotating schedules, sharing of the labs by several different disciplines, and modular educational benches that are put aside after use) it is very clear that the currently available space will not withstand ABET scrutiny. The same is true with the machine shop support.

The MEAM needs in terms of space include extra 5,000sf laboratory space beyond what is available now for ME faculty at the SE building (Castle, modular buildings?), of which about 2,000sf need to be “damp” lab space. Given our emphasis on computational methods, this need is rather modest in comparison to other graduate programs in Mechanical Engineering at other campuses, but it is critical for us in order to attract the few experimentalists needed for reaching critical mass in both energy systems and bio-inspired technologies.

In summary, the MEAM group is requesting (in consonance with the SOE strategic plan), the following resources for AY 2008:

Faculty

a) **ME-6: Bio-Inspired Mechanics**
b) **Two full-time lecturer positions with possibility of S-o-E.**

Facilities

The MEAM program needs additional 5,000sf of laboratory space (at least 2,000sf of “damp” lab space) plus resources to transform our small machine shop into a consolidated research-grade machine shop (which will serve the whole university). Instructional laboratory space for Mechanical Engineering is also an important concern of our faculty.

Graduate Emphasis Area in Physics and Chemistry
Strategic Plan and AY 2010-1011 Hiring Priorities

Introduction

Research in the Physics and Chemistry graduate emphasis area spans the traditional disciplines of chemistry and physics and related interdisciplinary fields. Graduate education within the group is currently divided into three tracks--Physics, Physical Chemistry, and Organic Chemistry--which have different preliminary exams and course work. Thus, students are educated and must demonstrate proficiency in a particular discipline, but have the opportunity to pursue research that spans disciplines if they so desire. This emphasis area currently involves 17 faculty and 20 graduate students. All four of the third- and fourth-year students have successfully advanced to candidacy for the Ph.D.

While interdisciplinary collaboration between physics and chemistry is in many cases natural and desirable, the primary mission of a graduate emphasis area or graduate group (unlike a research institute) is the education of graduate students. The disciplines of physics and chemistry have considerably different cultures and coursework needs in this regard, and we feel that our students would be best served by having separate programs in physics and chemistry. In addition, we have observed that most prospective students are looking for programs in physics *or* chemistry, not a joint program. Our ability to recruit excellent graduate students would be enhanced by having two separate but closely interacting programs. Accordingly, over the past two years we have been moving toward separating many of the functions of the group. When we finally have adequate faculty strength to do so, we will seek system-wide recognition as two separate stand-alone graduate groups, one in physics and one in chemistry. This strategic plan is therefore the concatenation of a physics plan and a chemistry plan.

Below is a combined list of group hiring priorities for AY 10-11. These priorities are based on research and graduate education needs and do not address the vital role that all of these future faculty will play in undergraduate education at UC Merced.

Physics and Chemistry group searches currently underway for AY 09-10

- Organic chemistry, open rank
- Materials chemistry, open rank
- Theoretical/computational chemistry, untenured
- Biophysics, open rank
- Nanoscale physics, tenured
- Condensed matter physics, untenured

Physics and Chemistry group hiring plans for AY 10-11 (NOT in order of priority)

- Analytical chemist, applied to either materials or biology: This position could be either in materials-oriented areas such as electrochemistry, photoelectrochemistry, or surface chemistry, particularly as related to energy conversion and storage, or in biologically oriented areas such as biosensor development, single molecule techniques for monitoring

biological processes (e.g. enzyme catalysis), or the development of *in situ* technologies that non-invasively probe the chemical function of cells.

- Theoretical/computational chemist, applied to either materials or biology: This position seeks applicants who are trained in theoretical chemistry and have research interests that include both the development of new theoretical/computational methods and their application to problems related to materials or biology. Examples include calculations of electronic structure and of energy- and charge-transfer dynamics in extended systems, and large-scale simulations of macromolecular structure and dynamics. We seek candidates whose research interests are complementary to those of the person we hope to hire in this year's theory search.

- Experimental or theoretical biophysicist: This position seeks applicants who are trained in physics with research interests in bio-molecular self-assembly, biological membranes, biopolymers, molecular motors, cell level phenomena such as mitosis, morphogenesis, motility and chemotaxis, biological networks or the development of novel biophysical techniques. We seek candidates whose research is complementary to the work of existing faculty in the School of Natural Sciences.

- Atomic, molecular, and optical scientist: This position seeks individuals who are trained to explore atomic or molecular scale systems and quantum coherence phenomena. Examples of such work include ultrafast optical phenomena, attosecond studies, fundamental quantum processes and engineering, atomic cooling and trapping, precision measurement, and novel imaging techniques. New programs as well as research in areas complimentary to existing UC Merced faculty are both welcome.

- Condensed matter physicist: This position seeks individuals who are trained in condensed matter physics, broadly defined. We will consider both experimentalists and theorists, depending on hiring in the previous year. We aim to recruit at least one more condensed matter experimentalist among our condensed matter faculty. The areas of research of interest include strongly correlated systems, spintronics, quantum information in quantum many body systems, mesoscopic systems, molecular electronics, semiconductor photonics and soft condensed matter physics.

Chemistry

Chemistry is often known as "the central science" because of the key position it occupies in modern science and engineering. Most phenomena in the biological and earth sciences can be described in terms of the chemical and physical behavior of atoms and molecules, and chemical principles also underlie much progress in medicine and engineering. In addition, chemical systems are fascinating and often beautiful in their own right. George Whitesides, in his 2007 Priestley Medal address, states that "Chemistry is now the natural home of many of the most engaging problems in fundamental science and of the problems in applied science about which society cares the most." Herein we give a few examples of how chemistry has had a profound impact on other fields of science and technology. Just several years after the inception of UC Irvine, Sherwood Rowland and Mario Molina (Nobel Prize, 1995) used physical chemistry approaches to unravel the chemical mechanisms of ozone depletion. This discovery, which helped to pull us back from the brink of an environmental catastrophe, played no small part in catapulting Irvine to research powerhouse status. Chemistry plays an essential role in the development of nanoscience and technology due to chemists' expertise in understanding and controlling matter at the atomic and molecular scale. It is no coincidence that almost all the exciting nanomaterials, from quantum dots to carbon nanotubes to semiconductor nanowires, have been pioneered by chemists. The intimate connections between life sciences and chemistry result from the prowess of chemists at manipulating and measuring molecules, the building blocks of life. Recent examples include Bertozzi's chemical manipulation of oligosaccharides in biological systems, which opens up new avenues to understanding and regulating complex cell surfaces. Analytical chemists such as John Fenn (Nobel Prize, 2002), were responsible for developing mass spectrometric analyses of biological macromolecules, a cornerstone in proteomics. The advancement of single molecule spectroscopy by Sunney Xie, a molecular spectroscopist by training, has stirred much excitement in biophysics as it affords access to unprecedented details of life processes at the single molecule level.

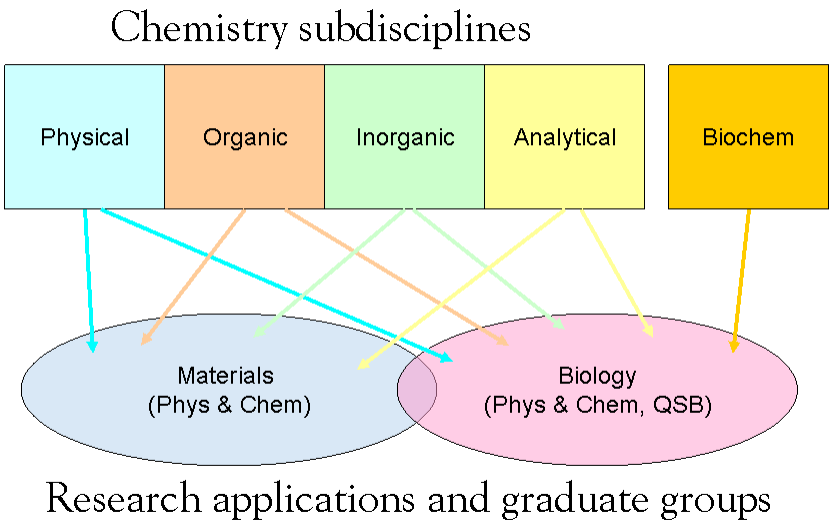
Because of the indispensible role of chemistry as a core discipline in science, one would be hard-pressed to think of any highly respected comprehensive research university that does not have a strong chemistry program that grants both bachelor's and Ph.D. degrees. Chemists may be classified according to their subdiscipline and/or by the nature of the problems on which they work. The four traditional subdisciplines of chemistry are organic, inorganic, physical, and analytical:

- Organic chemistry is the chemistry of carbon-based compounds. Organic chemists are concerned with synthesizing useful chemical compounds, developing new reactions to better achieve challenging syntheses, and determining the physical principles that are responsible for chemical behavior. Organic chemists are actively engaged in the synthesis of new materials for energy harvesting and storage, the manipulation and understanding of biological processes, and the development of efficient and ecologically benign catalysts and reactions.
- Inorganic chemistry is the chemistry of chemical compounds that are not primarily carbon-based. Inorganic chemists determine the structures of inorganic molecules, study their reactions, and develop procedures for their synthesis. The fundamental principles are applied to problems in environmental chemistry, bioinorganic chemistry, and solid-state materials chemistry.
- Physical chemistry applies the fundamental laws of physics to understand the properties of chemical compounds and the basis of chemical reactivity. Physical chemists study the energetics of molecular and macroscopic processes, the dynamics of chemical reactions, quantum chemistry, and interactions of molecules with light (spectroscopy,

photochemistry, and photophysics) using techniques that are experimental, theoretical, and/or computational.

- Analytical chemistry concerns the chemical analysis of substances. Analytical chemists develop instrumentation and methodologies to determine what chemical compounds are present in a sample and/or how much is present. Modern analytical chemistry is particularly concerned with very small systems, down to the single-molecule level, as well as applications to biology (proteomics, genomics) and environmental monitoring.

At UC Merced, we have the unique opportunity to build a modern chemistry program that combines disciplinary rigor and interdisciplinary reach. Ph.D.-level research in chemistry requires systematic training, and all four subdisciplines should be represented to some extent. Reflecting the expansive nature of chemical research and the interdisciplinary emphasis at UC Merced, the faculty have decided to focus our efforts on recruiting chemists working on problems in two broadly defined areas, biology and materials. The representation of traditional disciplines should not be viewed as an impediment to interdisciplinary research as we intend to recruit chemists who can bring novel chemical solutions and perspectives to materials and biology, just as the aforementioned prominent chemists have done. The figure below summarizes this scheme.



Biochemistry is a discipline closely allied with both chemistry and biology but distinct from both. Some universities have a combined department of chemistry and biochemistry while in others biochemistry is a separate department or is associated with another department. Under the present graduate group structure, it makes more sense for the biochemistry faculty to be associated with the Quantitative Systems Biology group than with Physics and Chemistry. This arrangement may be revisited once chemistry forms its own graduate group.

Current composition of the chemistry subgroup

Primary affiliation (Natural Sciences faculty)

- Anne Kelley, Professor (Physical and Analytical; Materials,)
- David Kelley, Professor (Physical; Materials)
- Erik Menke, Assistant Professor (Physical and Analytical; Materials)
- Matt Meyer, Assistant Professor (Organic and Physical; Biological)
- Meng-Lin Tsao, Assistant Professor (Organic; Biological)
- Tao Ye, Assistant Professor (Physical and Analytical; Materials and Biological)

Secondary affiliation (Engineering faculty)

- Valerie Leppert, Associate Professor (Materials)
- Jennifer Lu, Assistant Professor (Materials)
- Christopher Viney, Professor (Materials and Biological)

Searches are currently underway in organic chemistry (open rank), materials chemistry (open rank), and theoretical/computational chemistry (untenured).

Materials Chemistry research

Materials Chemistry is defined by the American Chemical Society journal in this field, *Chemistry of Materials*, as "Solid-state chemistry, both inorganic and organic, and polymer chemistry, especially as directed to the development of materials with novel and/or useful optical, electrical, magnetic, catalytic, and mechanical properties." Materials chemists may be focused predominantly on synthesis (organic or inorganic chemistry) or characterization (analytical or physical chemistry). These areas offer the possibility of many different types of collaborations, both within UC Merced between Natural Sciences and Engineering and at other nearby institutions including Hewlett-Packard, LLNL, and possibly NASA/Ames in the near future. This type of research is well funded and we expect it will continue to be well funded in the foreseeable future, as materials chemistry will be key to advances in new energy sources. Potential research areas for future Materials Chemistry hires include:

- *organic electronics*: design, synthesis, and physical properties of materials for organic light-emitting diodes (OLEDs), thin film transistors, and liquid crystal displays
- *solar photovoltaics*: design, synthesis, and physical properties of materials for organic, inorganic, or hybrid solid-state devices and/or electrochemical cells
- *photonic materials*: design, fabrication, and properties of materials for frequency conversion of lasers, optical limiting materials, contrast agents in nonlinear optical imaging technologies, electro-optic modulation, and photonic bandgap crystals
- *batteries:* new materials to enable lightweight, high capacity, multiply rechargeable battery technology
- *heterogeneous catalysts*: solid-state materials that catalyze a variety of desired chemical reactions
- *structural materials:* design, synthesis, and characterization of new materials having desirable properties (light weight, high strength, environmentally benign, biocompatible, *etc.*)
- *"smart" materials*: synthesis, characterization, and engineering of materials that can respond adaptively and autonomously to changes in their condition or the environment
- *plasmonics*: materials for, and study of, phenomena based on the coupling of light to the plasma oscillations of conduction electrons in small metallic nanostructures, and their coupling to other materials

Biological Chemistry research

The ACS Division of Biological Chemistry defines this subfield as "using the principals [*sic*] of chemistry to assist in the development of a deeper understanding of biological processes ". Much of the recent dramatic progress in the life sciences has been driven by quantitative approaches and a molecular-level understanding of complex biological systems. Experimental, computational and theoretical methods and techniques from chemistry have played a significant role in these

advances. In addition, the flow of knowledge and inspiration runs both ways: challenges posed by specific biological problems are driving the development of new analytical tools, prompting advances in the physical and chemical sciences. Biological chemistry has undergone explosive growth in recent years as experimental and computational tools from the physical sciences have become widely applied to biological problems. Biological chemistry is explicitly interdisciplinary between the physical and life sciences, and there should be extensive opportunities for collaboration across these groups. In addition, at least some biological chemistry faculty are expected to have research interests that overlap engineering, particularly Bioengineering. The development of a strong presence in biological chemistry would position our school for center grants and other translational research initiatives. Biologically related chemistry is a large area of chemistry research that is well funded, largely by NIH but also through other agencies. Potential areas for future Biological Chemistry hires include:

- *Nucleic acid replication, damage and repair*
- *Novel modes for drug delivery*
- *Development of ultrasensitive bioanalytical techniques, particularly for single molecule/single assembly measurements and/or high throughput screening*
- *Single molecule studies of molecular motors, DNA/RNA dynamics, transcription factor binding/functioning, viral genome packaging, ion channel transport etc.*
- *Organized chemical systems that imitate the functioning of biological cells*
- *DNA and/or other biological macromolecules as scaffolds for fabrication of organized structures*
- *Protein folding*
- *Molecular recognition*
- *Novel uses of combinatorial techniques at the interface of chemistry and biology: aptamers, phage display, novel approaches to screening and combinatorial synthesis*
- *Atomistic modeling of biological systems (channels, membranes, receptors)*
- *Membranes and associated phenomena including fusion, exo/endocytosis, pore formation and functioning, lipid rafts*

Five-year growth plan

The smallest Ph.D.-granting chemistry departments in the U.S. have at least ten full-time faculty. This is a minimum number needed to provide a full set of graduate and undergraduate courses as well as to provide sufficiently broad range of research opportunities for students. The current faculty (primary affiliation) plus the three currently open positions give us a total of nine, bringing us close to the absolute minimum required. We request two new positions for AY 10-11: one in analytical chemistry, a broad area that is popular with students and overlaps the research interests of several of our existing faculty, and a second in theoretical chemistry to strengthen our programs in this important, growing, and non-space-intensive area. Thereafter, approximately one new faculty member per year for the next four years will allow us to diversify our research programs and graduate course offerings. The new hires should be distributed among the four subdisciplines (organic, inorganic, physical, and analytical) and between the two application areas (biological and materials) as summarized below:

<u>Additions for AY 09-10 (this request)</u>

- Analytical chemist, applied to either materials or biology
- Theoretical/computational chemist, application area complementary to current search

Additions for AY 11-12 through 14-15

- Biophysical chemist
- One additional organic chemist, application area complementary to current faculty
- One additional theoretical/computational chemist, application area open
- Inorganic or organometallic chemist, applied to either biology or materials

Whenever possible, all positions should be searched at open rank; however, recruiting top-notch tenured faculty will be very challenging, particularly in experimental fields that are highly resource-intensive. We feel that the most profitable strategy is to attempt to recruit tenured faculty but accept that many of our new hires will have to be made at the Assistant Professor level.

Facilities and space

Laboratory research space poses a huge challenge. Competitive offers will require allocation of significant amounts of laboratory space. This is particularly true for senior-level candidates. SE I will be full with (or before) the current year's faculty hires. Following this year, further space will be needed. There are several options for acquiring this further space. These include acceleration of the timetable for SE II, use of space at Castle, and the use of temporary buildings on campus. The exact mix of these alternatives involves decisions by the UC Merced administration, and is therefore beyond the scope this strategic plan. Theoretical/computational chemists who do not need lab space could be accommodated in temporary office buildings; for experimental chemists, Castle seems the most likely source for the needed lab space.

Physics

Physics is the study of the properties of nature at their most fundamental. It ranges from the study of the very tiniest pieces of matter and energy, including molecules, atoms, photons, and subatomic particles, to the study of the entire universe. Insights in physics have revolutionized our society. It is hard to imagine an area of science or engineering that has not been profoundly affected by fundamental developments in physics. One need only think of the harnessing of electricity, the invention of the transistor, and the discovery of the laser. The present strength in physics at Merced is centered on three broad areas of research, detailed below.

Current composition of the physics subgroup

- Ray Chiao, Professor
- Sayantani Ghosh, Assistant Professor
- Ajay Gopinathan, Assistant Professor
- Linda Hirst, Assistant Professor
- Kevin Mitchell, Assistant Professor
- Jay Sharping, Assistant Professor
- Lin Tian, Assistant Professor
- Roland Winston, Professor

Searches are currently underway in biophysics (open rank), nanoscale physics (tenured), and condensed matter physics (untenured).

Atomic, Molecular, and Optical Physics research

UC Merced is building a strong research emphasis in atomic, molecular, and optical (AMO) physics. Interest and developments in this field have surged in the last ten to fifteen years, primarily due to advanced experimental techniques. These developments have been recognized by several recent Nobel prizes: for ion trapping and atomic clocks (1989; Ramsey, Dehmelt, Paul), for atomic cooling and trapping techniques (1997; Chu, Cohen-Tannoudji, Phillips), for the creation of Bose-Einstein condensates (2001; Cornell, Ketterle, Wieman), and most recently for advances in quantum optics (2005; Glauber, Hall, Haensch).

The modern trend in AMO science is toward greater control over quantum systems such that quantum coherence is maintained and quantum processes can be resolved. This includes working at very low temperatures, at ultrashort time scales, and with very high spectroscopic precision. Modern techniques can now routinely address single atoms, single photons, and single qubits (the quantum analog of a bit).The technological implications for such precise control over the fundamental building blocks of ordinary matter are as yet unimagined, but the promise is great. By analogy, the laser, which in some sense is a "Bose-Einstein" condensate of photons, has impacted almost every area of technology and medicine. The program in AMO physics complements the research programs in condensed matter physics and chemistry.

At present UC Merced has hired five faculty whose research supports the general AMO theme: Roland Winston and Ray Chiao (both split between Natural Science and Engineering), Kevin Mitchell, Jay Sharping, and Lin Tian. . Potential areas for subsequent AMO hires include, but are not limited to:

- *ultrafast optics*: pico-, femto-, and attosecond pulses, time-domain studies, wavepacket dynamics, high harmonic generation, photonic crystals and nanostructures for plasmonics and terahertz dynamics
- *attosecond physics*: fourth generation synchrotron sources, attosecond pulse generation, characterization, and applications
- *fundamental quantum processes and engineering*: quantum control, quantum computing and information theory
- *atomic cooling and trapping*: ultracold gases and plasmas, Bose-Einstein condensates, degenerate Fermi gases, superfluidity
- *precision measurement*: atomic clocks, ultrasensitive detectors, high precision spectroscopy, multi-photon microscopy
- *novel imaging techniques*: sub-diffraction fluorescence imaging, near-field imaging, etc.

Funding potential: Various government funding agencies support physics research, and AMO research in particular, with NSF being the largest sponsor of table-top AMO research. Furthermore, DOE funds several large national user facilities, including three that are strategically located with respect to UC Merced: Lawrence Livermore National Lab, Lawrence Berkeley National Lab, and the Stanford Linear Accelerator Center. Research is supported to a significant extent by the DOE and defense organizations (DARPA, ONR, AFOSR, ARO). In addition, optics research has historically benefited financially from its close connection to industry and industrial applications.

Cross-disciplinary and cross-school linkages

Expertise in AMO science has a natural connection to other present and potential University research programs. This is reflected in the fact that two of the AMO faculty have joint appointments between natural science and engineering. Specific connections include, but are not limited to:

a) The energy sciences program: Optics is of fundamental importance to solar energy collection.
b) Chemical physics/physical chemistry: Current faculty rely heavily on lasers and other optical techniques. They could be well supported by additional expertise in optics and atomic physics.
c) The materials or nanoscience programs would benefit from advanced optical techniques. Also, many of the issues of quantum control, manipulation, computing, etc. are relevant to nanoscience just as they are to AMO science.
d) Computer science: Quantum computation and information processing synergizes naturally with computer science.
e) Biology and Earth systems science: Synergy could potentially arise in the areas of microscopy, advanced detector design, and optics.

Condensed Matter Physics research

The Condensed Matter Physics program in Natural Science is a broad, interdisciplinary program focusing on "condensed" phases of matter. These phases range from simple solids and liquids to metallic and semiconductor nanomaterials to exotic condensed phases such as the superconducting phase exhibited by conduction electrons in certain materials, and the ferromagnetic and antiferromagnetic phases of spins on atomic lattices. The intellectual scope of this program is vast, and includes an understanding of the optical, electrical, mechanical, and transport properties of materials, encompassing the nano- to the macro-scale. Research in condensed matter can be

harnessed to design new materials such as magnets, semiconductors, ferroelectrics, superconductors, polymers, colloidal systems and liquid crystals, used for applications in a wide variety of disciplines including efficient energy conversion, ultra-fast optics, quantum information processing, information display and structural materials, to name a few.

The faculty participating in this program span the disciplines of solid state physics, nanoscale physics, soft matter physics, physical chemistry, surface science and materials characterization. Several specific areas that are at the forefront of modern condensed matter science are targeted. These include photonic materials, nano-scale electronics, quantum information and "smart" materials.

Photonic materials. "Photonics" may be broadly defined as the technology of generating and harnessing light and other forms of radiant energy. All photonic technologies rely on appropriate materials, which may be organic, inorganic, or composites. Materials that respond nonlinearly to light are used in frequency conversion of lasers, as optical limiting materials to protect eyes or optical sensors from laser pulses, and as contrast agents in nonlinear optical imaging technologies. Materials that change their optical properties in response to applied electric fields can be used to fabricate electro-optic modulators for electrical to optical conversion in fiber-optic communications. Photonic band-gap crystals, periodic dielectric structures that forbid propagation of a certain frequency range of light, have potential applications in ultra-low-threshold lasers, optical filters, polarizers, and waveguides. Metamaterials are those that exhibit novel optical properties leading to compact imaging systems and even "cloaking" devices. Research in this area is highly interdisciplinary and spans solid-state physics, surface science, optical physics, physical chemistry and applied mathematics.

Nanoscale electronics. " Nano-electronics" is poised to provide the next technological revolution in computer design. Moore's prediction of rapid miniaturization has already pushed commercial transistors well below 100 nm in size. Developing an in-depth understanding of the fundamental properties of nanoelectronic devices is of crucial importance because Nature behaves quite differently at the nanoscale, and an extrapolation of our knowledge at larger dimensions is not possible. It is not prudent to invest a vast amount of time and effort to try to compete with the immense silicon industry. Instead, it is more attractive to look into nanoelectronic devices that could play a role complementary to the silicon technology, with a strong focus on exploring the possibilities of organic materials, for example in the form of single molecules or self-assembled molecular monolayers. Investigating the use of complex transition-metal oxides in nanoelectronic devices is another field worth exploring since these materials show a wide range of interesting characteristics, including strongly insulating behavior, high-temperature magnetism and superconductivity. Nanoelectronics is the field where physics, material science, chemistry and electrical engineering inevitably meet.

Quantum information science. The tremendous miniaturization of electronic devices has led to the point where the spatial scale has hit the atomic limit. In this regime, the quantum properties of matter dominate, which, at first glance, seems to compromise information processing and storage, since quantum states are unstable and are destroyed by the very act of making a measurement. However, this very fragility of quantum phenomena has the capability of revolutionizing the fields communication and computation. A quantum channel of information transfer is very secure, since any effort to eavesdrop leaves an imprint on the quantum state. Computation power is exponentially enhanced when using quantum bits instead of classical ones due to the property of entanglement, which adds immense parallel processing capabilities. Recently, quantum information processing has started influencing the agenda of condensed matter, and some of the implementable

quantum bits which this field has contributed include superconducting structures (Josephson junctions), single-electron quantum dots and semiconductor photonic devices.

Photovoltaics. As the worldwide demand for energy increases, the need for renewable energy sources will become more and more urgent. Solar energy is the obvious answer, providing an unlimited, pollution-free energy source. Through the use of efficient photovoltaics, a relatively small amount of land area can in principle be used to meet the energy needs of the entire United States. For these reasons, research into more efficient and lower cost ways of turning the energy of sunlight directly into electrical energy is now, and will continue to be, an important field in the physical sciences. Photovoltaic devices can be grouped into two broad categories, each type having its advantages and disadvantages: solid state (semiconductor) devices, which may be organic, inorganic, or hybrid, and electrochemical cells.

The areas described above are particularly attractive because they offer the possibility of many different types of collaborations, both within UC Merced and at other nearby institutions. Potential industrial collaborators include Hewlett-Packard's basic research labs in Palo Alto. There are also collaborative opportunities with LLNL through LLNL/UCM adjunct faculty. We also anticipate that collaborations and funding through NASA/Ames will be available in the near future.

Current faculty in this research area are:

- Sayantani Ghosh (experimental condensed matter physics)
- Raymond Chiao (experimental condensed matter physics)
- Lin Tian (theoretical condensed matter physics and quantum information)
- Ajay Gopinathan (theoretical soft condensed matter physics)
- Linda Hirst (Experimental soft condensed matter physics)

Other faculty across disciplines who could contribute include

- Roland Winston (solar energy, optics)
- David Kelley (experimental chemical physics)
- Anne Kelley (experimental physical/analytical chemistry)
- Tao Ye (nanotechnology)
- Jennifer Lu (materials engineering)
- Valerie Leppert (materials engineering)

Given the necessarily diverse and fundamentally interdisciplinary nature of this group, and the desirability of building on and extending current strengths, we would like to see recruitment of new faculty in fields that encompass and bridge condensed matter physics, physical chemistry, and materials engineering. We need to recruit faculty with related but complementary research interests in order to build a program that can attract graduate students, offer modern and compelling programs for both undergraduate and graduate students, successfully compete for funding, and achieve national and international prominence in research. The condensed matter physics and nanoscale physics searches underway during the current academic year will result in new faculty who would contribute to this research area. It is assumed that these positions will be carried forward if we are unsuccessful at filling them this year.

Funding potential: The level of support available is a primary concern when considering programmatic initiatives. This type of research is very well funded and we suspect will continue to be well funded in the foreseeable future.

Single-investigator or small collaborative group funding in this field is available from a number of different agencies and programs within these agencies. Examples include:

- NSF: programs in Physics and Materials Research divisions.
- AFOSR Broad Area Announcement (BAA): programs in Metallic Materials, Ceramic and Nonmetallic Materials, Quantum Electronic Solids, Semiconductor Materials, Surface and Interfacial Science.
- ARO BAA: programs in Condensed Matter Physics, Quantum Information Science, Surfaces and Catalysis, Electrochemistry and Advanced Energy Conversion, Materials Synthesis and Processing.
- ONR BAA: programs in Electronic Materials, Semiconductor Materials.
- DARPA: solicitation in Nano-Composite Optical Ceramics.
- DOE: Several programs in Basic Energy Sciences: Condensed Matter Physics, Materials and Engineering Physics.

Biological Physics research

Experimental, computational and theoretical methods and techniques from Physics have played a major part in recent advances in our understanding of biological systems. Examples include cutting-edge imaging techniques that have provided snapshots of biological molecules and their complex assemblies in action and have also led to dramatic improvements in medical imaging. The ability to control matter at the smallest scales, using for example optical and magnetic tweezers, has allowed us to study and manipulate biological processes at the single molecule level. Theoretical and computational modeling are leading the way in our efforts to understand protein folding/misfolding, the functioning of molecular motors and enzymes, ion channels, membrane structure and dynamics as well as the dynamics of complex biochemical and neural networks. The result of advances in biological physics will be a better understanding of normal and pathological processes at both the molecular and systems level. Equally important, from a physics perspective, is that studies of biological systems that serve as paradigms of complex, self-assembling, non-equilibrium systems has led to new and interesting physics including emergent properties in dynamical networks, self-assembled, self-replicating systems, the thermodynamics of "active" systems and an atomistic understanding of complex macromolecules. Biophysics is the most rapidly growing area in physics research attracting both seasoned physicists from several different subfields and large numbers of entering students.

To develop a state of the art research program in biophysics requires individuals who have had extensive training in doing biophysical research, hailing from either traditional physics subfields such as condensed matter, polymer or statistical physics or from more interdisciplinary backgrounds including specifically biophysics, materials or bioengineering.

Current faculty in this research area are:

- Ajay Gopinathan (theoretical soft condensed matter physics)
- Linda Hirst (Experimental soft condensed matter physics)
- Jay Sharping (experimental biophotonics)

Other faculty across disciplines who could contribute include

- Mike Colvin (computational biology)
- Tao Ye (nanotechnology)
- Michelle Khine (bioengineering)
- Andy LiWang (biochemistry)
- Patti LiWang (biochemistry)

A core group of at least 6 biophysicists is needed to establish a strong competitive program. Broad areas of interest include biomaterials and biopolymers, membranes and associated phenomena, single cell studies of biomechanics including motility and mitosis, microfluidics with biological applications and protein folding. Several specific research fields are listed below that would allow us to attract the best available candidates with interests in these broad areas.

- Biocompatible organic materials as organ replacements and/or as scaffolds for cell growth (links to Materials program and to Bioengineering)
- Development of ultrasensitive bioanalytical techniques, particularly for single molecule/single assembly measurements and/or high throughput screening
- Single molecule studies of molecular motors, DNA/RNA dynamics, transcription factor binding/functioning, viral genome packaging, ion channel transport etc.
- DNA and/or other biological macromolecules as scaffolds for fabrication of organized structures (links to Materials program)
- Protein folding, experimental and computational methods that quantitatively determine protein structure and folding pathways
- Atomistic modeling of biological systems: channels, membranes, receptors, proteins, enzymes (links to CCB)
- System level studies of mitosis, morphogenesis, cellular motility, cytoskeletal dynamics, viral self-assembly, cellular hydrodynamics, chemotaxis and pattern formation. (links to Systems Biology)
- Membranes and associated phenomena including fusion, exo/endocytosis, pore formation and functioning, lipid rafts. Also biomedical applications of engineered membranes. (links to Materials and Bioengineering).

It is to be noted that many of these areas will have a considerable overlap with research interests in Biochemistry and Molecular Biology. There is also a considerable overlap with the field of soft condensed matter physics in both expertise and methodology. We will seek to hire individuals to enhance this natural synergy and anticipate hiring both theorists and experimentalists in these fields.

Funding potential: Funding for biophysics is growing at an extremely rapid pace. The NSF provides substantial funding for fundamental research in physics including its interfacial areas with biology. Research more directed toward specific problems in the life sciences is supported by the NIH, and also to a significant extent by the DOE and defense organizations (ONR, AFOSR, ARO). Funding for research in biological physics is also available from private foundations (*e.g*. Packard, Hughes, Burroughs-Wellcome) and for-profit companies. Faculty with research interests in this area should have a variety of funding opportunities available to them, although all of these sources are highly competitive.

Cross-disciplinary and cross-school linkages

The fundamental principles of Physics form the foundation for all of modern science and engineering. While there remain exciting unsolved problems in pure physics there is increasing interest in the frontiers that lie at the intersection with other disciplines including the life sciences, earth and environmental sciences, and engineering. The Biological Physics program is explicitly interdisciplinary between the physical and life sciences, and there should be extensive opportunities for collaboration across these groups. In particular, Biological Physics faculty are expected to have research interests that overlap Biochemistry, Molecular Biology, Materials Engineering and Bioengineering. Finally, this research area offers a natural interface with the proposed medical school. Interdisciplinary collaborative science is one of the strengths that UC Merced can leverage as a research institution, and this strength should be fostered as a means of bolstering the resources and potential of both biological and physical science at UC Merced.

Space and Facilities Needs

We expect about a three to one ratio between experimental physicists and theoretical physicists. Thus, most physics hires will be experimentalists. Although the nature and configuration of the space required by different types of physicists are quite different, all of the experimentalists are likely to require an average of at least 1000 sq. ft. of lab space each, plus office space for the PI, postdocs, and graduate students. Established senior faculty will require more space than this. Start-up costs for experimentalists depend on specific research needs but typically fall in the $400,000-$750,000 range.

Experimental condensed matter and AMO physicists sometimes need bench and fume hood space but typically have large pieces of specialized equipment such as cryostats, vacuum chambers, and laser-based setups on large optical tables. They often also have specialized requirements for the space in which these instruments are housed, such as high temperature stability, low vibration, isolation from sources of electrical noise, and light-tightness. Because of the specialized nature of the instrumentation it is often not possible for a single room to be shared by multiple investigators.

Experimental biophysicists tend to have research groups that require a mixture of wet lab space, with fume hoods, and dry space for specialized instruments and depending on the specific field they may require access to core facilities for confocal microscopy, in-house x-ray diffraction, or lithography facilities.

Theoretical and computational hires will require office space and computational facilities for the PI, postdocs, and graduate students.

Five-year hiring plan

At a bare minimum twelve FTEs will be needed to teach the core of the undergraduate and graduate physics curriculum, with more faculty needed to provide depth in our course offerings and to provide a critical mass for an effective research environment. This implies a hiring rate of at least two faculty per year. We currently have seven FTEs dedicated to teaching physics (Profs. Chiao and Winston at 0.5 FTE each and Profs. Mitchell, Ghosh, Gopinathan, Sharping, Hirst and Tian at 1 FTE each.)

Summary of proposed physics faculty hires for the next five years

	2007-2008	2008-2009	2010-2011	2011-2012	2012-2013	2013-2014
FTEs already hired	5	7	11	13	15	17
Active searches	4	3	2	2	2	2
Cumulative	9	11	13	15	17	19

5-Year Strategic Plan for the Quantitative and Systems Biology Graduate Track (QSB)
November 2008

I. Overview

Biology is widely believed to be on the brink of a fundamental transformation from a primarily "descriptive" study of individual components of biological systems, to a science based on creating a comprehensive and ultimately predictive understanding of biological systems. This so-called "systems" approach to biology is already dramatically changing how biological research is done, building on foundations of core disciplines and leading to new connections with the physical and computational sciences. This new biology offers the promise of a much more complete understanding of living systems and ultimately new treatments for complex diseases such as asthma, diabetes, and cancer. The central role of multidisciplinary approaches in systems biology provides UC Merced with an excellent opportunity to develop life sciences research and graduate programs at the forefront of this field. The small size and lack of disciplinary barriers at UC Merced have already been fostering a number of multidisciplinary research programs within QSB (see below). Similarly, although many universities are developing academic programs in systems biology, QSB has the advantage of starting its programs from a "blank slate" with no existing institutional barriers. Furthermore, systems biology will be greatly enabled by many of the new or emerging graduate programs and research efforts at UC Merced, such as the applied mathematics and bioengineering programs, and the Center for Computational Biology.

At present the QSB graduate group consists of 27 faculty, 37 Ph.D. students and 7 M.S. students with research projects that fall into five research themes (described below). The size of the graduate group belies a serious need for additional faculty to deepen the research base within these research themes. Indeed, the current QSB faculty would be spread across many departments and schools in a traditionally organized university. While this diversity of disciplinary expertise should be a strength in developing innovative research programs, it is essential that the group develop a critical mass of expertise in a selected set of areas to allow it to recruit top students and faculty and to be competitive for large research and training grants.

Below is the hiring priority for AY 09-10. Currently, less than 28% of the QSB faculty are at the associate of full professor levels. Hence, the priority is for a senior level hire. The QSB GG is requesting a new senior level position to 1) raise our research university to international prominence, and 2) meet the growing teaching needs of our graduate and undergraduate students. Indeed, the QSB GG is the largest graduate group on campus, yet has only a few stand-alone graduate courses. Furthermore, the teaching needs for undergraduate biology courses are growing rapidly. Notably, our hiring priority can meet these goals with the current limitations on laboratory space and startup funds.

<u>Quantitative and Systems Biology Graduate Group Hiring Priority, AY 09-10</u>

Stem Cell Biologist

This position seeks a senior-level hire with training in molecular, cell and developmental biology who applies their expertise to studying stem cell biology. This position will be part of the Stem Cell Consortium group of faculty (http://stemcells.ucmerced.edu/). Areas of particular interest include embryonic and adult stem cell biology, epigenetics, reprogramming, and applications for regenerative medicine using appropriate model organisms. Expertise in human ESC culture and differentiation and humanized mouse models would be a plus. This senior-level hire would provide leadership to junior level faculty, would be expected to lead initiatives such as training grant applications for graduate students in stem cell biology, and also to create and teach upper division and graduate level courses specifically on stem cell biology. The CIRM has been generous to UC Merced faculty in the awarding of over $9M in research and facility grants since 2006. This hire could fall under the SNS hires projected for 2009 and later in cell biology, cancer biology, and developmental biology. This position is synergistic with the stem cell research interests of the BEST Graduate Group.

Justification: The QSB GG is requesting this new senior level position to 1) raise our university to international prominence, and 2) meet the growing teaching needs of our graduate and undergraduate students. The QSB GG proposes to attract an internationally recognized senior

faculty member in stem cell biology for several reasons. First, the $9M awarded to UC Merced from the California Institute of Regenerative Medicine (CIRM) and the new Stem Cell Research Facility will attract the interest of top flight senior investigators, giving QSB an excellent chance to hire someone with international prominence in spite of current space and startup fund limitations. The new Stem Cell Facility and Stem Cell Consortium will significantly reduce the startup and space needs of a senior hire. Second, the senior hire will provide leadership to the many junior faculty in stem cell research. He/She will organize the junior faculty to submit proposals for federally funded training grants, program project grants, and shared instrumentation grants. Finally, this senior hire will help develop needed graduate courses and relieve the growing burden of teaching undergraduate biology courses.

II. Research Themes in the Quantitative and Systems Biology Graduate Group

Research programs

As described in the introduction, there are many exciting research opportunities within the broad area of Quantitative and Systems Biology. The research interests of the founding faculty have fostered a number of initial life sciences research themes for the QSB graduate group. These themes are all examples of the new systems biology described above and have been chosen to leverage special opportunities available to UC Merced and to depend on a common core of facilities and expertise.

Research Themes

1) Predictive Understanding of Cell Fate Decisions & Cell Signaling and Response

The ontogeny and maintenance of multicellular life involves an exquisitely complex developmental process in which undifferentiated "stem cells" give rise to specialized cell types. Understanding this process promises to provide new treatments for many complex disease states related to developmental failures. Moreover, because of their ability to generate new specialized cells, stem cells hold the potential to treat a vast array of health problems, including spinal cord injuries, Parkinson's disease, diabetes, and many others. Elucidating the complex mechanisms by which extrinsic and intrinsic signals determine the proliferation or differentiation of stem cells is inherently a systems-level challenge, and will require new technologies for collecting data on cell populations and individual cells, and new methods to build models of cell decision processes. The new California Institute for Regenerative Medicine, which will be awarding hundreds of millions of dollars in stem-cell related research funding over the next several years, makes this area a "special opportunity" for UC Merced.

An ultimate goal of cell biology is to achieve a complete understanding of the biochemical pathways controlling cell sensing and response to outside stimuli. New analytical technologies are allowing genomic, proteomic, and metabolomic characterization down to the single cell level. A combination of experimental investigation and modeling of the interacting pathways and the kinetics of the flow of information in those pathways will provide data to determine the mechanisms of cellular responses to infection, oxidative stress and other environmental factors. This knowledge will allow the development of new therapies to treat diseases, including the potential of chemoprotective agents against environmental toxins and aging.

2) Ecology and Evolutionary Biology

Large-scale, inexpensive DNA sequencing has placed evolutionary approaches at the center of modern biological research. Complete genomic sampling of hundreds of eukaryotic and prokaryotic organisms, coupled with partial genomic sampling of all branches and most twigs on the tree of life, opens unprecedented avenues of research, previously available for only a few model organisms, . Expanding biological inquiry to include many levels of organization and all branches of the Tree of Life raises new analytical challenges in comparative and integrative biology. This new approach necessitates transfer of the infrastructure (computational and molecular) available for model organisms to the developing quantitative research systems of 'non-model' taxa and also among the new systems themselves with the goal of attaining a thorough understanding of evolutionary explanations for ecological and organismal phenomena.

UC Merced faculty, from founding faculty to recent hires, have created a strong foundation for a signature research theme in integrative biology, ecology, and evolutionary biology including the origins of

invertebrate life, symbioses, the emergence of antibiotic resistant microbes, and genetic-, species-, and ecosystem-level conservation of biodiversity, including the processes that link these levels (i.e. biocomplexity). Biocomplexity research particularly applies quantitative systems biology techniques to explore the emergence of self-organized, complex behaviors or structures from the interaction of many simple agents in the environment. Such emergent complexity is a hallmark of life, from the organization of molecules into cellular machinery, through the organization of cells into tissues, to the organization of individuals into communities. The study of biocomplexity in the environment requires novel approaches to understanding pattern and process across multiple temporal and spatial scales, and draws upon interdisciplinary efforts at the interface of biology, physics, chemistry, and mathematics. This research program also has the potential for strong linkages to programs in Earth Systems Science and Environmental Engineering.

3) Complex Disease States

A combination of factors including an aging population, changing diets and lifestyles, as well as unknown, possibly environmental, factors, have led to a dramatic increase in diseases such as diabetes, asthma, and cancer. Such diseases can be described as "complex" because they are influenced by genetic, environmental, behavioral and cultural components and can only be fully understood and effectively treated using multidisciplinary approaches. The Central Valley provides a microcosm of the health challenges of the entire state and nation with high rates of "complex" diseases. A strong research program in this area would foster collaborations with healthcare providers in the Central Valley. Moreover, the local community would provide unique cohorts for studying strategies for treating or reducing the incidence of these diseases.

4) Chemical Biology, Biological Chemistry and Physics

The fields of chemistry and biology have had a long and fruitful partnership, leading to a detailed understanding of many of the chemical processes underlying life. Recently, there has started to be a reciprocal flow of information from biology to chemistry with biology providing "metaphors" for new chemical strategies, such as self-replicating chemicals. Ultimately, biological examples could provide more detailed designs and design principles for practical chemical applications such as catalysts or detectors. Likewise, chemistry informs the biological sciences by providing accurate chemical means of monitoring biological systems. From a physics perspective, studies of biological systems that serve as paradigms of complex, self-assembling, non-equilibrium systems leads to new and interesting physics apart from driving technological innovation. Biophysics for its part is the most rapidly growing area in physics research, attracting both seasoned physicists from several different subfields and large numbers of entering students. Chemical biology could have strong synergies with the bioengineering program and applications in earth systems science and environmental engineering.

Much of the recent dramatic progress in the life sciences has been driven by quantitative approaches and a molecular-level understanding of complex biological systems. Experimental, computational and theoretical methods and techniques from Physics and Chemistry have played a significant role in these advances. Cutting-edge imaging techniques have provided snapshots of biological molecules and their complex assemblies in action and have also led to dramatic improvements in medical imaging. The ability to control matter at the smallest scales, using for example optical and magnetic tweezers, has allowed us to study and manipulate biological processes at the single molecule level. The result of advances in biological physics and chemistry will be a better understanding of normal and pathological processes at both the molecular and systems level, which is key for the design of rational approaches to diagnosis and treatment.

5. Gene-Environment Interaction

An interdisciplinary group composed of faculty and students in QSB and ES has formed a center that focuses on the interaction of the environment on gene expression. A major focus is on oxidants and other electrophiles in both damage to organisms and in normal physiology; however, many other environmental variables will be investigated. The present and proposed work includes studies of photobleaching of coral, how Hepatitis C infection is modulated through redox signaling, how elephant seals avoid injury in extreme environments to which they are adapted, how growth factors act through redox signaling, and understanding the recognition of oxidants important to inflammation with the goal of designing anti-inflammatory pharmaceuticals. Reactive oxygen and nitrogen species (which includes free radicals, such as superoxide and

nitric oxide) play essential and ubiquitous roles in biology but they are only part of the complex interactions of the environment with gene expression that is the focus of this group.

Resource needs for the QSB Graduate Group

There are very large funding sources for life sciences research. Federal agencies provide approximately $30 billion per year and research funding is also available from many foundations and private companies. Nevertheless, these funding sources are all highly competitive and successfully acquiring funding requires a strong research program. The five research themes described above build on excellence in the foundational sciences but also are well aligned with the newest academic and research priorities of the funding agencies and foundations. Most major research universities are also creating research programs in quantitative and systems biology, but their natural advantages in having already established research programs and facilities may be somewhat offset by having larger institutional barriers to building multidisciplinary research efforts.

Faculty

The QSB critically needs new faculty hires to enable the research programs described above. The QSB faculty are presently drawn from the Schools of Natural Sciences and Engineering. Many of the QSB priorities for faculty hires are represented in the strategic plans from these two schools. Specifically, the QSB faculty endorse the hiring requests for the life-sciences and bioengineering research programs, including the areas of biomedicine, integrative biology, evolutionary biology, environmental effects of human health, biochemistry, chemical biology, and bioengineering-related nanotechnology. The QSB would also place a special emphasis on future faculty recommendations in areas that bridge traditional disciplines and faculty whose research involves integrating multiple techniques to solve problems in the life sciences and bioengineering.

Core Facilities

The QSB research programs require continued development of research facilities. Good progress has been made over the past year in developing life sciences research resources; however, the facilities require continued development, and several facilities are needed that have yet to be developed. The vivarium opened for animals in Summer 2007 and is used by several QSB faculty utilizing rodent and frog models. CIRM awarded UC Merced a facilities grant to build the Stem Cell Instrumentation Foundry (SCIF) which will contain Class 100 cleanrooms suitable for microfabrication that will be open to the entire UCM faculty. Construction of the SCIF is expected to begin in 2009. Shared instrumentation has been purchased by several groups of faculty that are intended to be part of proposed cores, such as the Genomic Center of Excellence and Quantitative Cytometry Core Facility. These instruments have been purchased through the awarding of equipment grants from NSF, and UCM Graduate and Research Council grants, as well as with faculty start-ups. Formal procedures for recommendation of core facilities as official University research cores was discussed by Graduate and Research Council in AY 2008-09, and are still under review. As current core equipment has been purchased and is now maintained by current faculty start-up funds, new faculty start-up packages could include funds for salary support for core managers and maintenance agreements. University financial support for the salary of core managers, and improved administration, such as recharge set up for UC and non-UC affiliates is key for the success of any research core. The full establishment of core facilities is crucial for the success of research progress, recruitment and retention of faculty and should be a high priority for the School and the Office of Research, under the direction of the Vice Chancellor for Research.

Table 1: Summary of facilities required for QSB research programs. Facilities shown in bold are already under development.

	Cell Fate	Evolution & Biocomplexity	Complex Diseases	Chemical Biology/ Biochemistry	Gene-Environment Interactions
Genomics	√√	√√	√	√	√
Cell Imaging	√	√	√	√	√
Proteomics (Mass Spec.)	√√	√	√	√	√√
Proteomics (Microarray)	√	√	√√	√	√
Animal (Vivarium)	√√	√	√√		√
Animal (Transgenic)	√		√√		√
High-field NMR			√	√√	

III. QSB Academics

Overview

In AY2008-2009, there are 37 Ph.D. Students in the Quantitative and Systems Biology Graduate Group (QSB). Based on the growth in QSB faculty over the past year and the concomitant growth in research funding awarded to UC Merced, we expect to admit at least 15 doctoral students in AY09-10. Another source of growth in the life sciences graduate programs will be M.S. students. We currently have 7 M.S. students and there have been many inquiries about the MS program being offered through QSB, so it may be reasonable to assume that 5% of the graduating Biological Sciences seniors would go on to this program. The evidence from existing programs is that UC Merced has the opportunity to create a substantial graduate program in the life sciences. Nationwide, the pool of biology doctoral students is very large. In 2002 nearly 4,500 life sciences Ph.D.s were conferred—by comparison in the same year 3,800 were conferred in all of the physical sciences combined. [http://nces.ed.gov/programs/digest/d03/tables/dt254.asp].

Most graduate programs in the life sciences are very discipline-oriented, e.g. biochemistry, cell biology, etc. This restricts the type of students entering the program and limits the training opportunities for students in the program. In contrast, the QSB brings together faculty from a wide range of disciplines with broad expertise to investigate the complex systems and networks responsible for the biological functions of cells, tissues and organisms. The current QSB faculty is drawn from both the Schools of Natural Sciences and Engineering covering disciplines including molecular and cell biology, evolutionary biology, genomics, proteomics, signal transduction, experimental technologies, and computational biology. QSB students are involved in a wide range of life sciences research projects, and this will continue to grow as new faculty join the graduate group. The doctoral program emphasizes quantitative analyses at multiple levels of biological systems, development and use of novel model systems, and computational and analytical approaches for the study of biological processes.

Academic Resource Needs

A central part of a successful graduate program are a diversity of advanced courses. The QSB graduate track requires 5 full graduate courses for its Ph.D. program, and it is expected that many students will take more than this minimum. In its first few years, the QSB track has offered just one specialized graduate course each semester (QSB 290, Topics in Quantitative and Systems Biology). To provide other necessary graduate training, the QSB faculty have led individualized study sections (QSB 299) or taught graduate classes that "piggybacked" on upper division courses. Although this was a necessary expedient due to the large undergraduate teaching commitments of QSB faculty, this is neither ideal nor sustainable. Therefore, starting in AY07-08, the QSB graduate track plans to offer at least 1-2 stand-alone graduate courses per semester. The exact course offering will depend on the student needs and faculty availability.

Besides QSB290 and QSB299, the following QSB courses have been approved and are in the catalog:
QSB 200: Advanced Molecular and Cellular Biology
QSB 212: Advanced Signal Transduction and Growth Control
QSB 214: Tissue Engineering Design
QSB 215: Principles of Biological Technologies
QSB 217: Lab on a Chip: Developing 3rd World Diagnostics for Global Health
QSB 220: Cellular microbiology
QSB 227: Virology
QSB 241: Advanced Genomic Biology
QSB 242: Genome Biology
QSB 244: Phylogenetics: Speciation and Macroevolution
QSB 247: Advanced Theory in Ecology and Evolution
QSB 250: Embryos, Genes and Development
QSB 252: Cancer Genetics and Tumor Biology
QSB 261: Human Physiology
QSB 280: Advanced Mathematical Biology
QSB 281: Advanced Computational Biology
QSB 283: Population Genetics

QSB 294: Ethics
QSB 296: Professional Skills Development

IV. Milestones and Assessments for the QSB Graduate Group

Research Programs

The success of the UC Merced QSB Graduate Group involves many components. First and foremost, is the success of the individual life sciences faculty in producing important research results leading to recognition, high-impact publications and continued research support. However, another metric for success will be UC Merced's effectiveness in developing unique, multidisciplinary research programs based on the cross-disciplinary principles of the university. Success in this metric will make the program competitive for special funding for research centers and training programs, and will also help attract strong faculty, post-docs and graduate students to UC Merced. Another long term metric will be the impact of the life sciences programs at UC Merced on the community, both in economic development and in partnering with healthcare providers and health-related community organizations.

Academic Programs

An important metric in evaluating the success of our academic life sciences programs will be the graduate and undergraduate enrollments. In AY08-09, there are 37 graduate students in the QSB, of whom 8 have advanced to candidacy. Graduate enrollment at two of the smaller UC schools (UC Santa Cruz and UC Riverside) represents approximately 10% of the student body. UC Merced will probably be most similar to graduate enrollments at the smaller UC campuses. However, we anticipate that life sciences will be well-represented in the graduate student body because of the strong growth to date of the QSB graduate program at UC Merced. In the long run, we anticipate the percentage of graduate students enrolled in life sciences to at least track the figure for the UC Davis campus (17%).

Assessment of the success of the QSB program will involve monitoring both the competitiveness of the graduate student applicants to the programs and the long term career success of its graduates. Despite its newness and small size, the QSB graduate group at UC Merced is attracting academically strong students.