School of Natural Sciences
Five-year Strategic Plan
March 23, 2005

AY 2005/2006 through2010/2011

Founding Faculty - School of Natural Science

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I. Introduction

Vision

The scientific discoveries of the past four centuries have profoundly improved human well being and transformed our view of our place in the universe. Since the days of Galileo and Newton, research universities have been the primary source of new scientific knowledge and society continues to look to universities for solutions to its most pressing problems. The School of Natural Sciences at UC Merced has been created at a unique time in history, when the solutions to the most important scientific questions transcend traditional disciplines. The Founding faculty in the School of Natural Sciences are creating academic and research programs that encompass traditional disciplines of biology, chemistry, earth and environmental sciences, mathematics, and physics, but are organizing them to facilitate multi- and inter-disciplinary education and research. By developing multidisciplinary and inter-disciplinary research programs and innovative undergraduate and graduate curricula, the School of Natural Sciences can distinguish itself among established science programs and provide the best possible preparation for its students as they address the many scientific challenges of the 21st century.

Process for Strategic Plan Development

The School of Natural Sciences strategic plan was developed by its Founding Faculty, including faculty currently hired or committed to the faculty of the School as of December 31, 2004. The expertise of these faculty spans nearly all of the traditional scientific disciplines and most have experience in multidisciplinary/inter-disciplinary science. Senate faculty participating in the process were Professors Keith Alley, Miriam Barlow, Jinah Choi, Michael Colvin, Henry Forman, Jessica Green, Anne Kelley, David Kelley, Arnold Kim, Kevin Mitchell, Peggy O'Day, David Ojcius, Rudy Ortiz, Maria Pallavicini, Sam Traina and Roland Winston, along with recently hired faculty, Monica Medina and Jennifer Manilay. Adjunct faculty Wil Van Breugel and Anthony van Buuren from Lawrence Livermore National Laboratory also participated in the strategic planning process. The strategic planning process alternated between subgroups working on strategic research initiatives, enrollment projections, and resource needs and policies. Deliberations were vetted and integrated at meetings and retreats of the faculty in the School of Natural Sciences. Input was requested from the Schools of Engineering and Social Sciences, Humanities and the Arts during the initial planning and then during the revision, however none was received (most likely due to the tight timelines during which the academic plans from all schools were developed). The strategic research initiatives, together with undergraduate and graduate curricula needs, and enrollment projections were used to identify and prioritize resource allocation for the forthcoming five years. Additionally, input from experts outside of UC Merced was sought to ensure that the choices made were informed by the best available ideas and thinking.

The Natural Science Faculty voted on the Strategic Plan and the Academic Resource Request.

Plan	Senate		Non-Senate	
	Yes	No	Yes	No
5-Year Strategic Plan	19	0	3[a]	0
2005-2006 Academic Resource Request	18	0	4	0

Total Senate Faculty Members: 19
Total Non-Senate Faculty Members: 4
a. One non-senate member unavailable to vote, but did participate in the Strategic Planning process.

II. MISSION

1) Excellence in scholarship. *The top priority of the School of Natural Sciences is scientific excellence*. Programs of scientific excellence form the foundation for continued success in recruiting the best faculty, encouraging students, and providing multiple pathways to improve and higher education and economic opportunities. The school recognizes the value of disciplinary depth, as well as interdisciplinary and multidisciplinary academics and research.

2) Academic excellence in training scientists and citizens. *The School of Natural Sciences places a high priority on increasing the scientific literacy of all students and increasing the pool of students in UC Merced's academic programs in math, science and engineering.* There is an increasing need for well-trained scientists, for scientifically trained decision makers and for a scientifically literate public to meet the global and technological challenges of the 21st century Academic programs that encourage recruitment and retention of students into math and sciences, while maintaining the highest academic standards are a high priority. Innovative curricula and appropriate support systems for students in Natural Science majors and non-majors enrolled in Natural Science courses are essential for student success.

3) Recognition of the special responsibilities incumbent on a new school of sciences. *The School of Natural Sciences recognizes that as the first new school of sciences in the 21st century it has a special responsibility to be innovative in its research, teaching, and relationships with its partners and communities***.** Building a new research university from the ground up presents many challenges, but beginning with a blank slate is also a tremendous opportunity that occurs only once in an institution's history. For this reason, the School of Natural Sciences is developing unique multi and inter-disciplinary research and academic programs.

III. SCHOOL OF NATURAL SCIENCES – CURRENT STATUS (AY2005-2006)

The School of Natural Sciences is making excellent progress towards its goals of building world-class academic and research programs. Beginning with hiring an excellent Founding Faculty, who have established innovative undergraduate degree programs and are playing principal roles in establishing three graduate groups, and designing innovative research programs to establish the reputation of the School of Natural Sciences.

A. Founding Faculty: The faculty is key to fulfilling the promise of the school and university. The School of Natural Sciences will offer its academic programs in Fall of 2005 with 20 Founding Faculty members. In keeping with the university's multidisciplinary principles, the Natural Sciences faculty is not subdivided into departments, but instead the faculty is viewed in broad inter-disciplinary groupings that bridge life sciences, environmental science and physical and mathematical sciences. Table 1 shows the distribution of faculty in the School of Natural Sciences into academic/research areas. Several faculty members cross even these broad areas, reflecting the School's commitment to both inter-disciplinary and multi-disciplinary programs. The School of Natural Sciences has been highly successful in achieving its goals in both the numbers and diversity of faculty. As of December, 2004, the school had hired 15 of 20 members of the Founding Faculty, as well as one (and possibly two) UC Presidential Postdoctoral Fellows and several adjunct faculty members. The remaining five searches are well underway and are

Table 1. Distribution of Founding Faculty 2005-2006

Life Sciences	Environment/ Life	Environment/ Physical Sciences	Physical Sciences/Life Sciences	Physical Sciences	Mathematical Sciences
M. Colvin (1)	*J. Green (1)*	P. O'Day (1)	*M. Meyer (1)*	A. Kelley (1)	*A. Kim (1)*
J. Manilay (1)	*M. Medina (1)*	S. Traina [a] (0)		D. Kelley (1)	*Tbh[b] (0)*
J. Choi (1)	Microbial Ecol (1)			*K. Mitchell (1)*	Tbh (1)
M. Barlow (1)	*Ecosystem Sci (1)*			R. Winston (0.5)	*Statistics (1)?*
K. Alley [a](0)				Physics (1.5)	
M. Pallavicini [a] (0)					
R. Ortiz [b] (0)					
H. Forman (1)					
D. Ojcius (1)					

[a] Faculty with full time administrative responsibilities. /** is there some reason why the Life Sciences list is not arranged alphabetically? **/
[b] UC Presidential Post-doctoral Fellows Program
Italics- junior faculty- assistant professor

Anticipated to be completed during Spring, 2005. The current profile of the faculty of the School of Natural Sciences is highly diverse: 48% female (8/18.5), with 16% (3) from under-represented groups (Chicano/Hispanic and Asian Pacific Islander). The ranks include approximately 50% senior professors and 50% assistant professors (plus one associate professor). The School of Natural Sciences is working to continue its success in recruiting outstanding scholars, including women and individuals from under-represented groups, to create a faculty that reflects the student body of the 21st century and is welcoming to students of all backgrounds.

B. Research Programs: The Faculty is committed to excellence in scholarship as the foundation for the first new school of science in a major research university of the 21st century. The scholarship of current faculty is outstanding. Indeed, since the first faculty members arrived in July 2003, the School of Natural Sciences has generated more than $4.3M from peer-reviewed research grants from federal and state funding agencies. Since arriving at UC Merced, faculty members of the School of Natural Sciences have published more than 40 scientific articles with UC Merced by-lines in peer-reviewed journal, two books and one US letters patent. The commitment to multi and inter-disciplinary programs is reflected in active faculty participation in inter-disciplinary graduate groups, cross-cutting and innovative undergraduate curriculum and collaborations across disciplines (e.g., mathematics-biology, earth systems-engineering, chemistry-biological sciences, etc). The school faculty is actively planning how to maintain depth in the disciplines, while promoting inter-disciplinary collaborations, and to strategically develop research initiatives that will bring UC Merced to the forefront in discovery and applications of technologies.

C. Research Facilities: An array of resources including instrumentation, fabrication, computing, sample collections, machine shops, as well as the highly skilled support staff needed to maintain these capabilities is key to the success of a modern School of Natural Science. (The facilities needs for the individual research initiatives are described in Appendices A-G) Although not all scientific disciplines require the same level of resources, the School must develop and maintain a rich mix of disciplines and promote interactions for future growth. In many fields, such as biology and physical sciences, the school's research infrastructure is essential for successful recruitment of outstanding faculty. The plans for programmatic growth in the School of Natural Sciences are based upon a balance between activities within disciplines and across disciplines, with a mix of theoretical and laboratory and field research. At present the Faculty of the School of Natural Sciences has devoted a significant fraction of their start-up funding to shared facilities and a number of grant proposals have been funded, submitted, or are in development for additional resources. The Faculty is developing multidisciplinary research centers and institutes in areas such as computational biology, systems biology, energy and health sciences, which could possibly attract large facilities grants or gifts to build or equip research space. The development of an excellent set of research facilities is essential for the success of this School and therefore must be a priority for the School and campus senior leadership at UC Merced.

D. Undergraduate Education: The first UC Merced course for undergraduates, *Contemporary Biology,* was offered during the 2004 summer semester by School of Natural Sciences faculty. Beginning in 2005, the School of Natural Sciences will offer three majors on opening day: Bachelor of Science degrees in Biological Sciences and Earth Systems Science, and a Bachelor of Arts degree in Human Biology. These undergraduate majors integrate quantitative sciences with life and environmental sciences in innovative curricula that will prepare students to contribute to the increasingly inter-disciplinary workforce and compete for graduate and professional schools. All of the Natural Sciences undergraduate degree programs use an innovative "core + emphasis" model that consists of a set of core courses that provide a solid foundation in the major, followed by additional courses in an emphasis area for more depth in a particular topic. This model allows the School to address a very wide range of student interests with the most efficient use of the School's small faculty. Each of the undergraduate and graduate degree programs, as well as the research programs, involve faculty from one or more of these groupings, as well as faculty from other schools.

E. Graduate Education: The Faculty in the School of Natural Sciences is engaged in graduate education and mentoring through interdisciplinary graduate groups. All of the first 15? UC Merced graduate students enrolled in M.S. and Ph.D. programs in 2004-2005 were in the Quantitative Systems Biology (4?) and Environmental Systems graduate groups (11?), which are supported by NS faculty. During the 2004-2005 academic year, 8 graduate classes were taught to QSB and ES graduate students. The graduate group structure enables faculty from within and among schools to come together to create unique graduate programs that are a signature feature of UC Merced. Each of the strategic research areas (discussed below) support existing or new graduate groups as an integral part of their development.

IV. Strategic Plans - AY 2005-2010

The faculty of the School of Natural Sciences plan to continue development of innovative undergraduate curricula, to enhance graduate education through the inter-disciplinary graduate group model, and to distinguish UC Merced science through innovative, cross-cutting, multi/inter-disciplinary research programs.

A. Undergraduate education

It is recognized that the School of Natural Sciences encompasses all the sciences, and therefore current and planned undergraduate programs include both low- and high-enrollment majors. In 2005 the School of Natural Sciences will offer majors in Biological Sciences, Earth Systems Science and Human Biology. These majors were selected because they were impacted at other campuses in the UC system and/or were important to the region that UC Merced serves, to California, and to the nation**.** The popularity of these initial majors is reflected in the large fraction (26%) of freshman and transfer student applicants in the 2005 applicant pool for UC Merced indicating interest in majors offered by the School of Natural Sciences.

The current undergraduate degree planning in the School of Natural Sciences is based on the principle of providing students with a strong, broad foundation in the unifying concepts of each discipline through a set of core courses following by more specialized courses in distinct "emphasis tracks" during their junior and senior years. This "core + emphasis" model (also discussed in section III.D.) reflects the philosophy to minimize barriers for students to change majors during the freshman year and early part of the sophomore year and to delay the need for students to decide on areas of specialization until well into the junior year. This approach maximizes flexibility for the students and allows them opportunities to explore options without delaying progress to degree.

This model distinguishes the academic planning at the undergraduate level from other Schools at UC Merced. Instead of developing a continuously growing set of distinct majors (reflected in some UC campuses having 30 or more science majors and a tendency towards discipline-based departments), the school plans to create six broad majors covering the primary disciplines of natural science in the first two years (see Table 2). Additionally, the School of Natural Sciences plans to work with the other two schools to develop a highly multidisciplinary "New Energy" major that would cover the science, engineering, economics, and public policy issues associated with energy production and use. The New Energy major is planned to begin in AY 2007-2008 and would also follow the "core + emphasis" model. The diversity of degree options will then be expanded by offering more emphasis tracks based on student and faculty interest and faculty expertise. The emphasis tracks envisioned for each major are listed below. In most cases these involve three additional upper division courses from a list of "selectives". In many cases the emphasis tracks in one major have been designed to be "symmetric" with those in another major, for example the Computational Biology emphasis in the Biological Sciences major and the Biology track in the Mathematical Sciences major. Such symmetry will increase student options in designing their major (e.g. they could choose to be a biologist with a strong math background

Table 2. Current and Planned Undergraduate Majors

AY	Major and Degree
2005-2006	Biological Sciences, B.S. Earth Systems Science, B.S. Human Biology, B.A.
2006-2007	Chemical Sciences, B.S. Physics, B.S. Mathematical Sciences B.S.
2007-2008	New Energy, B.S.
	Additional emphasis tracks
2008-2009	Additional emphasis tracks
2009-2010	Additional emphasis tracks

or a mathematician with a strong biology background) and will act to mix upper division students from different disciplines. The exact timing of these tracks will be determined based on student numbers and faculty hires. Eventually, some emphasis tracks could evolve into distinct majors based on a clear need for a new set of core courses to support a discipline. However, this is not envisioned to occur during the period covered by this five year plan.

The emphasis tracks for each of the current majors in the School of Natural Sciences follow:

Biological Sciences:
- Molecular Biology
- Cell Biology and Development
- Bioinformatics/Computational Biology
- Microbiology/Immunology
- Ecology and Evolutionary Biology

Earth Systems Science:
- Geochemistry and Biogeochemistry
- Hydrologic and Climate Sciences
- Ecosystem Science
- Atmosphere and Climate Sciences

Human Biology:
- Psychology/Cognitive Science
- Economics

Planned offerings of new majors and potential emphases that the faculty in the School of Natural Sciences is considering are shown below. Clearly, several of these emphases include potential contributions from faculty in the Schools of Engineering and Social Sciences, Humanities and the Arts. We look forward to working with appropriate faculty in each School as expertise in these areas comes on board.

<u>Chemical Sciences:</u>
- Chemistry
- Materials Chemistry
- Biological Chemistry
- Environmental Chemistry

<u>Mathematical Sciences:</u>
- Physics
- Biological Sciences and Bioengineering
- Earth Systems Science and Environmental Engineering
- Computer Science And Engineering
- Economics And Management
- Cognitive Psychology

<u>Physics:</u>
- Atomic/Molecular/ Optical Physics
- Mathematical Physics
- Biophysics
- Geo and Planetary Physics

<u>New Energy (potential multi-school major)</u>
- Energy Sciences
- Energy Systems Engineering
- Energy Economics and Policy
- Energy and the Environment

B. Graduate education

Natural Sciences faculty are major contributors to the current graduate groups in Quantitative Systems Biology, Molecular Science and Engineering, and Environmental Systems, and are likely to be involved in other groups that will be initiated over the next five years. The breadth of disciplines spanned by these groups provides our students with valuable cross-disciplinary perspectives and flexibility in pursuing their individual interests, but it also requires that we offer a number of different courses at the graduate level in order to meet their diverse educational needs. Our unique graduate group approach incorporates elements of traditional graduate programs found in biology, chemistry, physics, Earth and environmental sciences, and engineering, typically with multiple degree offerings in each of these areas. The amount of formal course work required in our current graduate programs, and in such programs elsewhere, varies from 4-8 semester courses per year before advancement to candidacy, depending on the program. The heavy graduate course load for physical sciences places a large burden on the need for faculty to teach these courses. The diversity of courses needed in biology and environmental systems, coupled with the large undergraduate teaching load in life sciences, places a large burden on these faculty members as well. In order to offer credible Ph.D. programs across this range of disciplines, students must be able to enroll in multiple graduate courses per semester at the outset and have more diverse course offerings as our graduate student population grows, even if we make our courses as broad and generic as possible without sacrificing rigor. The number of graduate students needing any given course may be small, and where feasible these graduate courses will be co-listed with upper-division undergraduate courses. The Ph.D. is primarily a research degree, and the main contribution of our faculty to graduate education will come in forms other than teaching structured courses: research supervision, service on thesis committees and advancement to candidacy exams, and conducting seminar and independent study courses.

C. Research Programs of Distinction

The opportunity to rapidly develop excellence in areas targeted for research distinction is possible by recruitment of outstanding faculty whose expertise and interests are both complimentary and synergistic and who can make discoveries that will unravel the workings of complex systems, apply new knowledge to address issues affecting humankind. In addition to recruiting programmatically to meet research needs and teaching demands across innovative curricula, hiring in the School of Natural Sciences with a small faculty must encompass- the breadth of disciplines and expertise. The School of Natural Sciences faculty is addressing these challenges by creating highly innovative, inter-disciplinary research initiatives that would evolve from a commitment of ftes within the School of Natural Sciences, as well as from contributions across Schools. While some of the programs map completely onto existing graduate groups, others will evolve into new graduate groups.

Development of the initiatives occurred in a series of faculty and small group meetings and was guided by the following questions:

- Is the proposed program unique? Does it provide opportunities to develop a UC Merced signature?
- What are the funding opportunities for the proposed research program?
- What is the contribution of the proposed program to the educational mission (graduate and undergraduate)?
- How does the program contribute to meeting needs in the region?
- What is the fit of the proposed research initiative with existing programs within NS, across-school and within Institutes?
- What is the “Business Plan” (ftes, opportunities, student enrollments, and projected timelines)?

Seven proposals to develop programs of distinction for UC Merced were developed and vetted with the faculty of the School of Natural Sciences, and shared with the Schools of Engineering and Social Sciences, Humanities and the Arts. The research initiatives included Life Sciences; Atomic, Molecular, and Optical Sciences; Condensed Matter Chemistry and Physics; Earth and Environmental Systems Science; Mathematical Sciences; Astronomy and Astrophysics; Health, Infectious Agents, and the Environment. These initiatives were broadly grouped into four strategic categories: Physical and Chemical Sciences, Earth and Environmental Sciences, Life Sciences, and Mathematical Sciences with potential emphasis areas (Table 3).

Table 3. Summary of Strategic Areas for Research Excellence

Strategic Categories	Research	Emphasis Areas
Physical and Chemical Sciences	Atomic, Molecular, Optical	ultrafast optics, fundamental quantum processes, atomic cooling and trapping, precision measurements
	Condensed Matter,Chemistry and Physics	basic science underlying photovoltaics, organic electronics, nanoscale electronics, “smart materials’; broad support of energy
	Astronomy/astrophysics	active black holes, galaxy formation, nano/microscale particles in extreme environments
Earth and Environmental Sciences	Earth Systems	watersheds, climate, resources, scaling, landscapes, ecosystem function, atmospheric sciences
	Health and the Environment	health, infectious disease, climate & environmental factors, and complex diseases
Life Sciences	Systems Biology	predictive understanding of cell fate decisions (including stem cells), evolution-based analysis of biological processes, cell signaling and response, control of complex biological processes, chemical biology
Mathematical Sciences	Applied Mathematics	multi-scale analysis, fluid mechanics, scientific computing, dynamical systems, modeling, wave propagation and other areas of applied mathematics that interface with and contribute to other research programs."

A detailed description of the individual initiatives that comprise each category can be found in Appendices A-G.

1. Physical and Chemical Sciences

Three specific strategic initiatives: atomic/molecular/optical, condensed matter chemistry/physics, and astronomy/astrophysics comprise the broad strategic category of Physical and Chemical Sciences.

a.Atomic, Molecular and Optical Sciences

The modern trend in Atomic, Molecular, and Optical (AMO) science is toward greater control over quantum systems such that quantum coherence is maintained and quantum processes can be resolved. Modern techniques can now routinely address single atoms, single photons, and single qubits (the quantum analog of a bit.) With the exception of Berkeley, AMO science is poorly represented at UC campuses, thus presenting an opportunity for UC Merced to serve as an organizing center for AMO research within California and to synergize and leverage resources available at UC Berkeley. Expertise in AMO science, especially optics, would support and enhance most other science and engineering initiatives, including energy science, physical chemistry, materials and nano science, computer science, biology, and earth systems science. Since optics has historically generated many high tech and economically important business ventures, a program in AMO science could contribute to the long term economic health of the valley. Undergraduate and graduate students would have hands-on research opportunities centering on small scale “table top" experiments, involving lasers, optics, vacuums, refrigeration, etc. The faculty hired will span the areas of ultrafast optics, fundamental quantum processes and engineering, atomic cooling and trapping, and ultra-precise measurement (Appendix A).

b.Condensed Matter Chemistry and Physics

The foundation of this initiative is experimental and theoretical research aimed at understanding how the optical, electrical, mechanical, and transport properties of condensed phases and molecular assemblies arise from the fundamental properties of their constituent molecules and the manner in which those molecules interact. The basic scientific question is the following: can a fundamental understanding of microscopic, molecular-level properties, obtained either from experiment and/or theory, allow predictions of a material’s macroscopic properties? The ability to make this connection can be exploited to design new materials for applications including energy conversion, optics, information storage and transmittal, and structural materials. The faculty hired for this program will span the disciplines of synthetic chemistry, physical chemistry, solid state physics, theoretical and computational chemistry and physics, and surface science and materials characterization (Appendix B).

c.Astronomy and Astrophysics

Astronomy is a popular broad and interdisciplinary area of research with new discoveries about our Universe in the news almost every day. These discoveries are made possible by a wealth of major observatories in space and on the ground. The University of California is a world leader in this field: it designed and co-operates the world’s largest, twin 10-m Keck telescopes, and has a new 30-m telescope on the drawing boards. While 'classical' astronomy is being pursued at other UC campuses, and indeed throughout the world, there is no single research group that combines disciplines of astronomy, physics, chemistry, biology and materials sciences to investigate the physics and chemistry of materials in space. The program at UC Merced will investigate how the physical and chemical properties of large molecules and nano/micron-sized particles are modified by the exposure to the harsh environment of space (vacuum, low temperature, high energy radiation and Cosmic Rays), and how these changes influence the origin and evolution of planets, stars and galaxies in the universe. In particular the effects of high energy density environments of star forming regions, supernova remnants, forming galaxies and in the vicinity of active, super-massive black holes on the properties of large molecules and nano/micron sized particles and the impact of these molecules on the emergence of life in space will be investigated. The faculty that would need to be hired for this program would come from the disciplines of astronomy, physics, chemistry, biology and materials sciences (Appendix C).

2. Earth and Environmental Sciences

A central philosophy of programs within the Earth and Environmental Systems strategic area is an integrated approach to the study of physical, chemical, and biological processes as applied to natural and engineered environmental systems. Most of the recent advances and current significant problems in environmentally related research fall at the interface of disciplines within natural sciences and typically involve engineering, social, and economic components. For example, understanding health and fate of ecosystems and biodiversity relies on the integration of physical and chemical environmental processes with biological function; shifts in regional temperature and precipitation patterns as a result of global climate change influence hydrologic processes that affect water availability, quality, and resource management; understanding and mitigating health effects of regional air pollution involve aspects of physical transport, particulate and atmospheric chemistry, biological response, and health economics. Targeted research themes in which to build academic excellence include: *Water, Watersheds, Climate, and Resources; Scaling, Landscapes, and Ecosystem Function; Air Quality and Atmospheric Studies* (see Appendix D for a full description). A critical factor for success in any of these strategic research areas is the ability to hire sufficient faculty (natural scientists, engineers, and social scientists) to provide the range of expertise needed to tackle complex environmental problems and to compete for interdisciplinary research funding (Appendix D).

3. Life Sciences

The School of Natural Sciences is developing a life sciences program that builds on the principal themes of modern biology: quantitative bioanalytical measurements, systems-level analysis, evolutionary context and computational modeling. These broad themes underlie the specific proposed research initiatives in life sciences as well as the undergraduate and graduate training programs. The life sciences research initiatives are fully described in Appendix G, and include three currently being implemented by the founding faculty: 1) *Predictive Understanding of Cell Fate Decisions*; 2) *Evolution-based Analyses of Biological Processes*; and 3) *Cell Signaling and Response*. Additionally, we are in the preliminary stages of planning three more research initiatives: 1) *Complex Disease States;* 2) *Control of Biological Processes;* 3) *Chemical Biology*. All of these have been chosen to be highly fundable, attractive to new faculty and students, and to build on a common base of facilities and expertise. The school is opening with two life sciences undergraduate degrees, a B.S. in Biological Sciences and a B.A. in Human Biology. Based on the preliminary UC Merced applications, these will both be very popular majors, attracting 16.5% and 5.6% of the total applicants, with Biological Sciences the most popular major overall for UC Merced applicants. The life sciences graduate program is contained within the Quantitative and Systems Biology Graduate Group that started with 3 graduate students in

2004-2005 and is expected to add 10-15 students in 2005-2006. The faculty that would need to be hired for this program would come from the disciplines of biology, biochemistry, and computational modeling (Appendix E).

4. Health, Infectious Agents, and the Environment

We have also identified an important area that spans biological sciences, health sciences and the environment: *Health, Infectious Agents, and the Environment.* This initiative bridges between growing strengths in biological/biomedical sciences and Earth and environmental systems science. Faculty supporting this initiative would contribute to biological sciences, human biology, and Earth and environmental systems undergraduate and graduate programs (Appendix F).

5. Mathematical Sciences

Mathematical science is the study of analytical and computational mathematics to solve problems in social science, natural science and engineering. It is inherently interdisciplinary. At its core is a solid foundation in applied analysis. Along with that foundation, applied mathematicians seek problems to study that benefit from a rigorous mathematical treatment. People making up mathematical science are connected closely through their shared approach and attitude to interdisciplinary research. Historically, applied math programs have developed after a need for them has been identified. In contrast, building mathematical science along side the other research programs is a unique opportunity for UC Merced. Moreover, applied mathematicians shall be able to participate directly and impact significantly in a variety of areas due to the open structure across the three schools. Hence, this mathematical science program is well-poised to lead the charge for interdisciplinary research and education at UC Merced. Having a critical number of faculty members to teach the undergraduate and graduate courses needed for this program is the key issue in building mathematical sciences. Faculty hired for this program will be involved in broad research areas including continuum mechanics, numerical analysis and scientific computing, nonlinear analysis and dynamical systems, and modeling among others. See Appendix A for a full description (Appendix G).

V. Faculty Recruitment, Retention and Five-Year Faculty Hiring Plan

There are a number of challenges in creating breadth and depth across the disciplines and across research areas that the faculty in the School of Natural Sciences wishes to develop. These challenges include limited fte resources, distributions of the fte resources within the school to cover a breadth of disciplinary and inter-disciplinary areas, the desire to build outstanding research programs with limited resources and infrastructure, and uneven student interest across all disciplines. Addressing these challenges requires that the faculty of the School embrace common principles for resource allocation to meet short-term needs and achieve long-term objectives. To ensure success in achieving its mission (Section II) the faculty adopted the following philosophy and guiding principles for faculty hiring:

A. Guiding Principles and School Philosophy

The School of Natural Sciences should have faculty representation across a spectrum of science disciplines, including mathematical, physical, environmental and life sciences.

- Faculty in the School of Natural Sciences are expected to build excellent research and graduate programs, excel in individual scholarship and contribute to the community of research programs in the School of Natural Sciences and other schools at UC Merced.

- The School of Natural Sciences has a responsibility to undergraduates in the School to provide mentorship and rich educational experiences in their area of study, with sufficient faculty support to deliver high quality courses throughout the curriculum.

These guiding principles strive to create an environment where both research and teaching are valued. The faculty fte requests are based upon strategically building research programs of excellence, fulfilling teaching needs to provide a rich educational experience, and creating an environment in which all faculty members have the opportunity to be successful.

B. Increasing Faculty Diversity

UC Merced's goal is to recruit faculty who have demonstrated outstanding accomplishments and/or potential as scholars and teachers and who reflect the diversity of its potential student body. Because of the ambiguity associated with the term "faculty diversity", we felt it prudent to define it for the context of this document. A diverse faculty in the School of Natural Sciences will include individuals of both genders who span a broad range of cultural, ethnic, and socioeconomic backgrounds. Our current faculty recognizes and appreciates the importance of aspiring to achieve as diverse a faculty as possible while maintaining the high quality and standards that define the University of California. A diverse faculty provides role models for students from under-represented groups in science and can provide both unique and broad perspectives important for problem solving.

With the expectation that UC Merced will be a minority serving institution in the very near future, it is imperative that our faculty is committed to achieving the goal of increasing faculty diversity. Important steps toward attaining a diverse faculty include 1) increasing the diversity of the candidate pool, 2) increasing recruitment efforts of highly qualified candidates from under-represented groups, and 3) instituting programs such as MARC, MBRS, MORE, BRIDGES, UC Leads, and CAMP that are designed to encourage minority students to pursue careers in the sciences. Although we recognize that qualified minority candidates in several disciplines are scarce, we are committed to increasing the diversity of the candidate pool. One mechanism to increase the pool of minority candidates is to increase UC Merced's presence and visibility at major conferences and specifically at conferences that target minority groups such as the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) and the Annual Biomedical Research Conference for Minority Students (ABRCMS). Secondly, UC Merced can increase recruitment by obtaining lists of minority candidates from post-doctoral programs sponsored by NIH, UCOP, Ford Foundation, Welcome-Burroughs Fund, and NAACP to name a few. Appropriate candidates from these lists can be contacted directly and encouraged to apply without obligating the university to any further action. In addition, the implementation of minority programs for undergraduate and graduate students such as MARC and MORE will enhance our efforts to attract candidates from under-represented groups. These programs are attractive because they provide a mechanism to help financially support undergraduate and graduate students, and thus provide an opportunity for minority students that would not otherwise be available. These programs also increase our potential to attract minority candidates since the likelihood of minority candidates familiar with at least one of these programs is very high. Lastly, we can compile a list of department chairs with strong ties to minority groups and solicit them for recommendations of minority candidates as they come available for faculty positions.

Creating a diverse recruitment pool is an essential step to attain a diverse faculty that begins with appointment of the search committee, progresses through creation of a list of faculty for serious consideration, a short list for interviews, and ultimately selection of the appropriate candidate.

<u>Increasing the diversity of the candidate pool</u>

1. Appointment of search committee. The search committee is appointed by the Dean and should include, as much as feasible, members who are committed to attaining a diverse faculty. The Dean meets with the committee at their first meeting to emphasize and discuss diversity in the search process.
2. Development of a recruitment plan. The search committee will develop a plan for recruitment that includes attracting the best scholars including those from under-represented groups. An example of such a plan created by a recently formed search committee is shown below.
3. Approval of recruitment plan by school faculty and Dean
4. Broad advertising to minimize exclusion of faculty applicants based on narrow criteria in the written advertisement.
5. Active engagement of all faculty members to bring forward names and recruit faculty with outstanding scholarship from all backgrounds.

Sample Plan from Search Committee to Increase Faculty Diversity

1. The advertisement for the position will be written very broadly to attract as wide as possible a group of applications. This broad description of the position will first be placed in *Science*, a very wide-distribution journal that will be available at all research institutions, and the newsletter of the American Society for Cell Biology, the professional society that includes many stem cell biologists as members. The advertisement ends with the sentence: "UC Merced is an equal opportunity employer with a strong institutional commitment to the achievement of diversity among its faculty, staff, and students."

2. A list of 30-50 laboratory heads that study stem cells was compiled from descriptions of stem cell projects that were funded by NIH (CRISP database) and from corresponding authors of articles on stem cells published within the last year in the journals *Science* and *Nature*. Letters will be sent to these laboratories, inviting postdoctoral fellows and colleagues to send applications. All the letters will include the statement that applications from under-represented groups and women are encouraged. Care will be taken to include a large fraction of laboratories that are supervised by women and minorities.

3. Attempts will be made to advertise the position with a number of associations that serve minorities and women, including the Association of Women in Science, the American Association of University Women, and Minority Access to Research Centers (MARC), and the Society for Advancement of Chicanos and Native Americans in Science (SACNAS). The chairs of minority subdivisions of other national scientific societies will also be contacted to obtain member mailing lists.

4. Letter will be sent to post doctoral fellows (and runners-up, if available) who currently have fellowships associated with increasing diversity, such as the UC President's Postdoctoral Fellowships.

In summary, the faculty of the School of Natural Sciences recognizes the importance and benefits associated with increasing faculty diversity, and realize that this goal can only be achieved if highly qualified candidates are available. We will not sacrifice the quality of our scholarship and science regardless of the candidate's ethnicity and gender. However, because of the paucity of highly qualified minority candidates in many disciplines, we recognize the importance of increasing the School's efforts to target under-represented groups. We are confident that the steps outlined here in addition to our regular mechanisms of advertising for particular positions will increase the diversity of the candidate pool, which will ultimately assist our efforts to increase the diversity of our faculty.

C. Mentoring

The senior faculty members of the School of Natural Sciences strongly support the premise that the School, through its senior faculty, must provide each of our Assistant Professorial hires with a nurturing environment that will enable their development as researchers and scholars. This is particularly important in our current start-up mode where there are endless opportunities for diversion from those areas that are the necessary elements in successful promotion and tenure decisions.

The School of Natural Sciences is in the process of developing a mentoring plan intended to provide meaningful guidance and time needed to develop competitive research programs for all assistant professors. This plan includes a number of elements. One element of the developing program is facilitating establishment of ongoing counseling relationships with a senior faculty mentors. The senior faculty member will be a strong source of career guidance and will help assistant professors to make informed choices regarding their involvement in committee work and teaching activities that can reduce their commitment to research. Perhaps, most importantly, the mentor should help to facilitate the development of meaningful research collaborations both here and at other campuses.

Second, the faculty has agreed to a differential teaching load for junior and senior faculty members. In order to provide the most favorable circumstances for the junior faculty retention and success, the School has chosen to provide a reduced teaching load for all Assistant Professors during their first year of appointment. During this time, the teaching load is half that of their senior counterparts. This provides additional time for faculty members to establish and develop their laboratories and research programs-- essential elements of success in the School of Natural Sciences.

It should be noted that implementation of this mentorship plan will be difficult if the initial goal of building a strong foundation of senior faculty is derailed as a result of budgetary limitations. Most established campuses have a preponderance of tenured faculty from which to draw appropriate mentors. At UC Merced, after the initial recruitment of senior faculty, most of the subsequent hires have been concentrated at the junior level. Continuation of this will dilute the School's ability to provide a meaningful mentorship program and hamper effective mentoring.

D. Drivers for FTE Resources Allocations to the School

The University of California is noted for its status as the country's premier, public research university. The Merced campus will only attain this level of excellence and recognition by implementing a balanced program of faculty hiring that explicitly acknowledges the full breadth of demands on faculty time. The School of Natural Sciences is committed to excellence in undergraduate and graduate education, in the mentoring of its students, postdoctoral researchers and faculty, to university, professional and societal service and to research programs of distinction. Each of these drivers has been considered in the development of our proposed hiring plan.

1. Faculty for Undergraduate Student Instruction and Advising

Projections for student enrollments in courses offered by the School of Natural Sciences were based on campus enrollment targets, extrapolations from the AY2005-2006 applicants (freshman and junior transfers) pool indicating student interest in majors in the School of Natural Science, and assumptions on retention rates. Table 4 shows excerpts from the spreadsheet used by the School of Natural Sciences to plan for enrollments in its courses and majors. (The complete spreadsheet is included in Appendix H.) This spreadsheet uses the official projections for the total undergraduate population at UC Merced and assumes a fixed retention rate of 80% of students per year. The percentage of total students in NS majors is assumed to be 12%, 7% and 7% in *Biological Sciences*, *Earth Systems Science*, and *Human Biology*, respectively, which has been adjusted from the applicant distribution of 16%, 1% and 6% (and 3% undeclared). The projection does not include students enrolled in new majors, such as chemical sciences and applied mathematics. The fraction of junior transfers was assumed to be 11% the first year and then 20% thereafter (to yield an upper division class that is approximately 1/3 transfers—similar to other UC campuses). The final totals are given in terms of the total numbers of students enrolled in School of Natural Sciences courses and denoted "student-courses". Majors in other schools taking foundational or general education courses in the School of Natural Sciences are a large component of the predicted student-course enrollments. This situation allows the School of Natural Sciences to develop majors that may have relatively fewer majors, yet require faculty with depth in the scientific discipline (i.e., chemistry, physics, and mathematics). These enrollments are based on the faculty's best estimates from their experience at other universities and assume overall that students outside of the school will take an average of 2.7 classes in the School of Natural Sciences during their four years at UC Merced, which is reasonable given the large science course requirements of the engineering majors and the need for all students to take science general education and mathematics courses. Overall this spreadsheet predicts the following student-course numbers for 2005-2006: math 826; chemistry 588; physics 261; science general education 899 (note that the enrollments for biology and earth systems courses grow rapidly after the first year as the students advance to upper division courses). The target student: faculty ratio for the school was set at 17:1 for 2005-2007 and then 18:1 for 2008-2010. Based on these figures and starting from an initial base of 20 Founding Faculty, the school expects to have undergraduate student numbers sufficient to add 13 new faculty members in 2006, with an average of 10 new faculty members per year for the next five years. However, it is recognized by the School and the campus administration that student enrollment should not be the only driver in fte resource allocation. The additional faculty responsibilities for graduate student teaching and mentoring and its contribution to the total projected faculty are described in the following section.

Table 4. Projections of Undergraduate enrollments in NS courses and faculty contributions to undergraduate and graduate education

UC Merced Undergrad Numbers

YEAR	2005	2006	2007	2008	2009	2010
Admitted Undergrads	**900**	**880**	**1104**	**1297**	**1797**	**1926**
Freshmen	800	704	883	1037	1438	1541
Sophomore	0	640	563	707	830	1150
Junior	0	0	512	451	565	664
Junior transfers	100	176	221	259	359	385
Senior	0	80	141	586	568	740
Total	900	1600	2320	3040	3760	4480
TOTAL Undergrad Target	**900**	**1600**	**2320**	**3040**	**3760**	**4480**
Total Undergrad Incr. for target		**700**	**720**	**720**	**720**	**720**
Total Grad Students	90	160	232	304	376	448
Total Students	990	1760	2552	3344	4136	4928
Overall Faculty at 20:1	50	88	128	167	207	246
Percent of upper division students who are Transfers	1.00	1.00	0.41	0.34	0.38	0.38

Numbers of students in NS Majors

Biological Sciences	**108**	**192**	**278**	**365**	**451**	**538**
Human Biology	**63**	**112**	**162**	**213**	**263**	**314**
ESS	**63**	**112**	**162**	**213**	**263**	**314**
Total NS Freshman	208	183	230	270	374	401
Total NS Sophomore	0	166	146	184	216	299
Total NS Junior	0	0	133	117	147	173
Total NS Junior Transfer	26	46	57	67	93	100
Total NS Senior	0	21	37	152	148	192
Total NS Majors	234	416	603	790	978	1165

Projected enrollments

Biology Total Student-Courses	**100**	**1084**	**1601**	**1956**	**2529**	**2893**
Biology Total Student-Courses including BIS 1	**618**	**904**	**1375**	**1690**	**2161**	**2499**

Predicted Course Enrollments

Math Total Student-Courses	**834**	**1223**	**1356**	**1626**	**2142**	**2491**
Chem Total Student-Courses	**614**	**743**	**856**	**1020**	**1366**	**1547**
Physics Total Student-Courses	**267**	**418**	**456**	**548**	**717**	**843**
NS GE Total Student-Courses	**901**	**793**	**994**	**1168**	**1619**	**1735**
NS GE Core Course	**266**	**234**	**294**	**345**	**479**	**513**

Total NS Student-Courses	2982	4496	5557	6663	8851	10022
Total NS Student Units	11927	17983	22228	26652	35405	40088
Total NS FT Students	373	562	695	833	1106	1253
Target Student: Faculty Ratio	17	17	17	18	18	18
Faculty for target ratio	**22**	**33**	**41**	**46**	**61**	**70**
Load for grad. teaching and mentoring	0.40	0.40	0.40	0.40	0.40	0.40
Total Faculty Target	**37**	**55**	**68**	**77**	**102**	**116**

2. Graduate Student Enrollments

As discussed above, the graduate educational needs of students desiring to develop expertise in the basic areas of chemistry, physics and mathematics is very course intensive, requiring faculty to provide instruction at the graduate level, while contributing to the undergraduate programs. The large numbers of students enrolled in undergraduate biology places a large burden on these faculty members to meet the teaching needs of both undergraduate and graduate programs. Based on an analysis and estimate of the graduate curriculum needs for the graduate programs, we estimate that 4-5 graduate courses will be necessary for each of the three graduate groups, Quantitative and Systems Biology, Molecular Sciences and Engineering, and Environmental Systems graduate groups during 2005-2006 and 2006-2007. We estimate that this graduate teaching load, together with the essential function of mentoring graduate students will constitute a 40% teaching load on each faculty member in the School of Natural Sciences. This load is added into the final row of Table 4, to yield a total number of faculty required in the School of Natural Sciences of 37, 55, 68, 77, 102, and 116 starting in AY 2005-2006 and for each of the next five years.

3. Faculty to Develop Distinctive Research Programs

While student enrollment in courses offered by faculty in the School of Natural Sciences is an important driver, targeted recruitment of faculty that would contribute to graduate programs and undergraduate majors, as well as form critical mass for research initiatives, is critical (see detailed strategic initiatives- Appendices). The School of Natural Sciences estimates that the projected growth rate in faculty will provide opportunities to develop world class research programs in the targeted areas, which is one of the major goals of the school. Furthermore, since the School embraces inter-disciplinary research and academics, a number of areas have been identified for potential cross-school faculty recruitments.

The constraints and opportunities, curriculum needs and research initiatives were considered in developing the 5 year faculty hiring plan. Table 5 shows projected faculty hiring mapped in areas defined by the strategic plan. While the areas targeted for recruitment are fairly firm in 2006-2007, subsequent years are less well-defined and dependent upon the fit of the individuals with the teaching needs as well as hiring patterns in the other Schools.

Table 5. School of Natural Sciences- Five Year Faculty Hiring Plan

	2006-2007		2007-2008		2008-2009		2009-2010		2010-2011	
Strategic Areas	**Emphasis**	**FTE**	**Emphasis**	**FTE**	**Emp**	**FTE**	**Emp**	**FTE**	**Emp**	**FTE**
Physical and Chemical Sciences	atomic, molecular, optics condensed matter	5	atomic, molecular, optics condensed matter	4	tbd	4	tbd	2	tbd	4
Earth and Environmental Sciences	atm sci, plant bio, process geomorphology	4	env org chem., conservation	2	tbd	3	tbd	3	tbd	3
Life Sciences	evolutionary bio, cell fate, protein chemistry	5	cell signaling, complex disease, cell fate	5	tbd	3	tbd	4	tbd	3
Mathematical Sciences	multi-scale analysis, fluid mechanics, scientific computing, modeling, wave propagation	3	tbd	3	tbd	3	tbd	3	tbd	3
Potential inter-disciplinary targets	materials (optical, bio,energy-solar), air/atoms sci (chem/phys), bioinformatics, high performance computing, evolution	1	optics, materials, energy, epidemiology, quant biology	2	tbd	2	tbd	2	tbd	2
Total FTE		17 +1		14 +2		13 +2		13 +2		13 +2

*The "+1" FTE shown on **Table 5** reflects commitment to interdisciplinary, cross-school and/or coordinated hires.*

The Deans of the three schools have shared the emerging strategic plans from their respective schools, and have identified areas where on-going discussions are warranted for possible joint or coordinated appointments across schools. These areas include:

- Human biology, health and environment, including management and policy
- Mathematical sciences, applied mathematics, and applied statistics
- Atmospheric sciences, air resources
- Environmental/energy sustainability including policy
- Energy including optics, material sciences, and energy policy
- Management and decision sciences
- Cognitive and computational sciences
- Geography and spatial analysis

VI. SPACE –RESEARCH AND OFFICE

The Dean of the School of Natural Sciences created a Space Policy Committee to develop a plan for space allocations and space reviews. This committee made three recommendations concerning space distribution, location, and review, which were discussed at a faculty meeting. Faculty concurs with the proposed policy. These recommendations should be used as guidelines and flexibility needs to be part of any decision. For example, major differences in the type and quantity of space required exist among the various disciplines.

Space distribution: Space should be independent of rank. Recognizing that the state funded construction is based on approximately 400 sq. ft. for Assistant Professors, 600 sq. ft. for Associate Professors, and 800 sq. ft. for Professors, the committee suggested using an average instead for actual distribution. The committee recommends a minimum amount of space above the faculty office that is equivalent to what is needed for a group of 6, including the faculty member, and equipment. Each faculty member would get a 135 sq. ft. office. For non-lab use, 135 sq. ft. offices or the equivalent in dry lab space would be designated as occupied by two non-faculty personnel. For lab use, 75 sq. ft. of laboratory space (approximately 6 ft of bench space) would be designated per person. Space for refrigerators and centrifuges, and significantly larger than average equipment would be added. Thus, a general formula was established: Total space = 135 + 75 x + 67.5 y + z, where x is the total number of personnel in lab (including the faculty member), y is the total number of personnel using offices (not including the faculty member), and z is the space needed for refrigerators, centrifuges and non-shared oversize equipment. This formulation is meant as a guideline, recognizing that the needs of groups depend upon differences in requirements for laboratory and office space and that some individuals require both. Although there will be variation in the composition of laboratory groups, we urge flexibility in the assignment of office and laboratory space while keeping the recommended allotment as a guideline for minimum and additional space.

Regarding the counting of lab personnel, the committee recommended that undergraduates should be counted in proportion to their time spent in the laboratory and that research experience for undergraduates (REU) support should be taken into account.

Space for refrigerators, freezers, centrifuges, and other similar equipment taking floor space should be provided in addition to the recommended lab and office space. Ideally, desk space for graduate students and postdoctoral fellows, who spend most of their time in the laboratory, would be provided outside the laboratory in recognition of safety rules.

Finally, office and lab space should be provided for visiting scholars and under special circumstances for adjunct faculty.

Location: Issues that should be considered in the assignment of lab location are proximity to hoods, the vivarium, and other laboratories sharing equipment and/or collaborating. Location of laboratories should be assigned by these criteria rather than by school or discipline.

Review: Review of space allocation is considered to be primarily necessitated by the occasional need to downsize. While a regular schedule should be established, additional space needs should not have to wait until a review cycle for consideration. To that end, the need for additional space should be acknowledged in consideration of grant applications and made contingent upon funding.

The following recommendations were made for review by rank: Assistant Professors' space assignments should not be reviewed. Nonetheless, Assistant Professor's having rapid growth of their laboratory group should be considered for additional space as need arise as noted above. Review of space for Associate Professors and Professors should be on a four year cycle. Exceptions would be during years that coincide with promotion to Professor or Professor Step 6 when the review could be delayed by one year.

While several of the research programs use generic wet or dry lab bench space, there are some specialized facility needs for these programmatic initiatives that are not readily accommodated in the first Science and Engineering Building (Table 6).

Table 6. Specialized Laboratory Resource Needs

Categories	New specialized laboratory needs	Core Facilities
Physical and Chemical Sciences	--Microscopy and spectroscopy lab space --Fume hood intensive labs --High field NMR	--Fabrication facilities; characterization facilities --Chemical Analysis/Spectroscopy --Machine shop
Earth and Environmental Sciences	--Cold storage and prep area for field samples --Constant temperature room --Greenhouse	--Environmental Analytical Lab --Imaging and Microscopy facility

VII. Metrics of Success

The success of the School in meeting its goal and objectives can be assessed using a number of metrics, some of which are described below.

A. Research excellence
   1. Peer-reviewed funding
   2. Natural Science contributions in moving UC Merced toward a Tier I AAU research intensive institution
   3. Peer-reviewed publications

B. Recognition of faculty stature and accomplishments
   1. Awards and elected membership in prestigious scientific organizations such as National Academies of Sciences, Society Fellows, etc
   2. Elected scientific society leadership positions
   3. Participation in National and International Science Advisory Committees
   4. National and international speaking engagements

C. Faculty recruitment and retention

1. Normal academic advancement and progression
2. Continued recruitment of outstanding faculty

D. Creating a School that reflects the diversity of California
  1. Moving toward creating a faculty that reflects the diversity of our anticipated student body.
  2. Increasing numbers of students from the region, the state and beyond enrolled in undergraduate science majors and graduate inter-disciplinary graduate programs.

E. Excellence in pedagogy, curriculum innovations, and graduate student mentoring
  1. Measured by student and peer assessment
  2. Evidence of innovation in teaching,
  3. Production of graduate students who develop successful careers in academia, industry, and the public sector.

F. Placement of students in higher education programs such as graduate school and professional programs.

G. Effective university and public service

VIII. Challenges and Constraints to Achieving Success

While there are opportunities for the faculty and students of the School of Natural Sciences to achieve their vision and goals, there are a number of challenges and constraints that will complicate this success. Some of these are described below:

1. **Limited laboratory, office and student space will severely constrain recruitment of outstanding faculty, graduate students and post-doctoral fellows and limit development of excellent research programs**. Putting Natural Sciences and Engineering II on a fast track is essential in building and maintaining excellence in Natural Science, Engineering and interdisciplinary programs on both the undergraduate and graduate levels. It is clear that space will be depleted well before the planned opening of Natural Sciences and Engineering II even when including the 40% of the first Natural Sciences and Engineering Building held initially in reserve and the Castle Facility. Thus, to avoid major constraints on faculty recruitment and student enrollment in Natural Sciences and Engineering, additional space for undergraduate and graduate research, faculty extramural research, offices for teaching assistants, postdoctoral fellows and visiting scientists, and animal quarters, and meeting space for both large and small colloquia must be designed and built as rapidly as feasible.

2. Competitive faculty recruitment packages are essential to attract outstanding faculty. Faculty recruitment packages for the School of Natural Sciences include salary, start-up, summer salary and other items that are typically negotiated on an individual need basis. Starts up packages include support for research, equipment and graduate students. Start up packages generally range from $50K-$600K

3. Absence of a defined family friendly leave policy
An inherent challenge for faculty is how to manage heavy workload responsibilities with personal and social lives outside of work. UC Merced should be at the forefront of developing work/life balance policies to facilitate academic and personal achievement. Developments of such policies are key to the success of current faculty and are also important for the recruitment of new faculty. Some issues that can be discussed include work schedule flexibility, development of UC Merced-sponsored child care programs, parental leave policies, access to counseling or community referral agencies, on-site seminars promoting health and stress management, organization of recreational (fitness) facilities, and procedures for sabbatical leave.

4. Appropriate ratio of senior to junior faculty
Successful mentoring is a key to faculty retention and academic advancement. Implementation of the mentorship plan will be made more difficult if the initial goal of building a strong foundation of senior faculty is derailed as a result of budgetary limitations. This is particularly relevant for Science faculty who are building research programs and establishing laboratories, requiring navigation of both the internal system at UC Merced, UC in general and external state and federal funding agencies. Most established campuses have a preponderance of tenured faculty from which to draw appropriate mentors. At UC Merced, after the initial recruitment of senior (professors and associate professors) faculty, most of the subsequent hires have been concentrated at the junior level. Continuation of this will dilute the School's ability to provide a meaningful mentorship program and hamper effective mentoring. An overall school ratio of 70: 30 senior to junior faculty is critical.

A proposed initiative for atomic, molecular, and optical science

Overview

The following document proposes a research initiative in modern atomic, molecular, and optical (AMO) science. 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), and for the creation of Bose-Einstein condensates (2001; Cornell, Ketterle, Wieman).

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 at 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 is some sense is a "Bose-Einstein" condensate of photons, has impacted almost every area of technology and medicine.

A program in AMO science would complement any program in materials chemistry or materials science. Both would represent the physical sciences at UC Merced, with an emphasis on in-house table-top experiments. However, each program would have its distinct focus. In particular, the AMO program would typically address more fundamental questions, whereas the materials chemistry program would likely be more application oriented.

Comparison with Similar Programs within UC

What is unique?
AMO science is poorly represented within the UC system. With the exception of Berkeley, none of the other physics departments have a significant presence in this area. (UC Davis has one faculty member and Berkeley has about six.) This presents an opportunity for UC Merced to assert itself as an organizing center for AMO research within California. Outside UC, there are several successful and internationally renowned institutes in AMO science, such as Rochester, Oregon, JILA (Boulder), and AMOLF (Amsterdam). Inspiration could be drawn from these institutes.

How will program contribute to UC Merced "signature"?
A strong AMO program would create a distinct research priority at UC Merced which is not present at other UC schools. Even at Berkeley, with the bulk of AMO researchers, the physics department is dominated by experimental and theoretical particle physics and experimental and theoretical condensed matter.

Funding Opportunities

Research will likely be supported primarily from federal grants through NSF, DOE, DOD, etc. This includes grants for both individuals as well as opportunities for larger "center" grants, such as NSF support for the Center for Ultrafast Optics at the University of Michigan. Opportunities also exist for industrial collaboration and support, especially in the area of optics.

Contributions To Educational Mission (Graduate & Undergraduate)

Faculty in AMO science would support the undergraduate program through teaching and research opportunities. Teaching capabilities would cover the physics core courses (Physics I, II, and ICP) as well as upper division courses supporting an applied math/physics major. Depending on the faculty hired, there could be teaching support for majors in the chemical sciences and/or cross-school teaching with engineering. Undergraduates would have the opportunity for hands-on laboratory experience with small scale/table top experiments, with an emphasis on lasers, optics, refrigeration, etc. Theoretical/mathematical projects in support of such experiments would also be available. Faculty would support graduate education through the teaching of graduate level courses and the advising of graduate research. Most research opportunities would be in experimental science, but theoretical projects would also be available.

Contributions to the Region

Optics has historically been one of the top fields of physics to produce spin off companies. This could have a rather obvious impact on the technological and economic base of the region.

Fit with Existing Programs within NS, Cross-Schools & Institutes

Expertise in AMO science would have a natural connection to other present and potential University research programs, notably

(a) The energy sciences program: Optics is of particular importance in current solar energy research.

(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) Any potential materials or nano science program would benefit from advanced optical techniques. Also, many of the issues of quantum control, manipulation, computing, etc. are relevant to nano science just as they are to AMO science.

(d) Computer science: Should quantum computation or information be pursued, there is potential for synergy with computer science.

(e) Biology and Earth systems science: Synergy could potentially arise in the areas of microscopy and advanced detector design.

"Business Plan"

FTEs (junior, senior), space and facility requirements

About five FTEs would be required over the next five years, including about one or two senior researchers. Most faculty would have experimental research programs, requiring laboratory space comparable to that used by current faculty. The main core facility needed would be a machine shop. Theoreticians would only need office space for themselves and students.

Expectations for research themes

Potential research areas include:

- ***ultrafast optics***: pico and femtosecond pulses, time-domain studies, wavepacket dynamics, high harmonic generation
- ***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, superuidity
- ***precision measurement***: atomic clocks, ultrasensitive detectors, high precision spectroscopy

Opportunities for industrial relations, collaborations

Due to its many industrial applications, optics is well supported by industry. The more novel applications of modern AMO physics are less common, but will certainly increase with time along with industrial support. For example, industry has already invested significantly in quantum computation and information theory.

"Moments of Opportunity" - (nearby facilities, collaborators etc)

The proximity to LLNL and the user facilities there is also an excellent opportunity. Also, the Advanced Light Source at Berkeley Lab is an easy drive from Merced. Furthermore, the Linac Coherent Light Source, a next generation light source, should be open by 2009 at the Standford Linear Accelerator Center.

Anticipated teaching workload (include suggested course titles)

Teaching would be equivalent to other faculty in Natural Sciences and would likely be focused on core physics courses, upper division courses in support of the applied math/physics major and graduate level courses.

Expected number of graduate students/post-docs/undergraduate students

Each faculty would likely have from one to five graduate students, indicating a total number of about 15 at any given time. Each faculty would likely have on average one to two postdocs, meaning about eight postdocs. The program would support undergraduates indirectly through the applied math/physics major and directly through undergraduate research projects. The degree of student involvement in undergraduate research will vary, depending on student interest and needs, but it is reasonable to expect each faculty to support one to three undergraduates, meaning about ten undergraduates will be involved in research at any given time.

Assessments/milestones/checkpoints

Initially, success will be largely based on the ability to attract excellent faculty and graduate students into the program. As the program develops, it will also be based on the ability of faculty and graduate students to succeed using the usual measures of academic success: publications, grants, invited talks, etc.

Projected time-line

Hiring one faculty per year over the next five years would be a healthy rate and would permit UC Merced to create a viable core research group. This would certainly gain the attention of the AMO community.

Condensed Matter Chemistry and Physics Strategic Initiative

Intellectual content of proposed program

We propose a broad interdisciplinary program focusing on condensed matter chemistry and physics particularly that related to materials science. This is essentially the natural science component of the research areas spanned by the Molecular Science and Engineering graduate group. The intellectual foundation of this program is understanding how the optical, electrical, mechanical, and transport properties of condensed phases and molecular assemblies arise from the fundamental properties of their constituent molecules and the manner in which those molecules interact. The basic scientific question this initiative addresses is the following: given a fundamental understanding of microscopic, molecular-level properties, obtained either from experiment or, increasingly, from calculations, can we predict a material's macroscopic properties? The ability to make this connection can be exploited to design new materials for applications including energy conversion, optics, information storage and transmittal, and structural materials. The faculty hired for this program will span the disciplines of synthetic chemistry, physical chemistry, solid state physics, and surface science and materials characterization. Several specific areas that are at the forefront of modern condensed matter science will be targeted. These include organic electronic materials, photovoltaics, photonic materials, and nanoscale electronics.

Organic electronics

Organic materials can be synthesized that have extremely unusual electrical properties: they are conductors or semiconductors. Such materials are now in use or being developed as active elements in diverse electronic and optoelectronic devices. The organic materials span the range from small molecules to oligomers, dendrimers, polymers, and carbon nanotubes. Fundamental scientific issues relevant to these technologies include synthetic methods, the electronic structures of organic molecules, charge generation, transport, and recombination in organic materials, and the relationships between the properties of individual molecules and their aggregated forms including polymers, crystals, and amorphous solids. These questions are addressed by a wide range of disciplines including organic chemistry, physical chemistry, computational chemistry, and solid-state physics.

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. Photovoltaic devices can be grouped into two broad categories, each type having its advantages and disadvantages: solid state (semiconductor) devices and electrochemical cells. Hybrid technologies are being actively pursued and may provide viable devices that will meet our future energy needs. A fundamental understanding of condensed matter charge separation, recombination and transport is essential for continued progress in this area. For this reasons, research into the physics and chemistry of materials used in these devices will continue to be an important field in the physical sciences. This research is performed by a combination of solid state physicists, surface scientists and electrochemists.

Photonic materials
"Photonics" may be broadly defined as the technology of generating and using light and other forms of radiant energy. All photonic technologies rely on the interaction of light with matter. The interacting material may be organic, inorganic, or a composite. 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 to low-threshold lasers, optical filters, polarizers, and waveguides. Research in this area is highly interdisciplinary and spans synthetic chemistry, physical chemistry, solid-state physics, surface science, optical physics, and applied mathematics.

Nanoscale electronics
Moore's Law states a simple, empirically observed relationship: available computing power doubles every 18 months. But recently, we have observed a negative deviation from Moore's Law as silicon lithographic technology is becoming "mature". This is because the intrinsic quantum mechanical characteristics of the charge carriers are starting to limit the complexity of patterned circuits on silicon microchips. As a result, entirely new types of electronic devices are being developed. These devices operate by exploiting the same quantum mechanical phenomena that limit the size and speed of conventional silicon chips. "Molecular electronics" and "nano-electronics" are poised to provide the next technological revolution in computer design. Basic solid state physics, physical chemistry and electrical engineering come together in this rapidly-developing field. The Natural Science component of this research would focus on the fundamental questions to do with the solid state physics, chemistry and surface science of these new technologies.

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 it will continue to be well funded in the foreseeable future. Currently, funding is available from several different agencies and from different programs in these agencies. Specifically, the following programs are now soliciting proposals in Condensed Matter Physics and Chemistry and Materials Science:

NSF Divisions of Chemistry and of Materials Science: standard single-investigator grants.
*NSF Nanoscale Science and Engineering (NSE) program***:** Nanoscale Science and Engineering Centers (2 NSECs in FY 2005, each $2.6M-$4M/year for 5 years, renewable once); Nanoscale Interdisciplinary Research Teams (50-55 NIRT awards in FY 2005, each $250,000-$500,000 per year for four years); Nanoscale Exploratory Research (45-50 awards in FY 2005, one-year nonrenewable, max $160,000).
NSF Materials Research Science and Engineering Centers (MRSEC) program: 12-15 centers, average $1.9M/year, up to 6 years.

AFOSR Broad Area Announcement: programs in Metallic Materials, Ceramic and Nonmetallic Materials, Organic Matrix Composites, Quantum Electronic Solids, Semiconductor Materials, Polymer Chemistry, Surface and Interfacial Science.
ARO BAA: programs in Condensed Matter Physics, Optics, Photonics, and Imaging Science, Organic Chemistry and Organized Media, Polymer Chemistry, Materials Design, Synthesis and Processing of Materials, Physical Behavior of Materials.
ONR BAA: programs in Materials Chemistry and Physics, Polymer Science and Organic Chemistry.
DARPA: solicitation in Synthetic Multifunctional Materials.
DOE: The Materials Sciences and Engineering and Chemical Sciences, Geosciences, and Biosciences divisions of Basic Energy Sciences support this type of research.

In addition to Federal research support, there are also funding opportunities available through industrial collaborators (*e.g.*, Hewlett-Packard) and through LLNL.

Impact on academic programs

There is currently very little in the way of physical science programs in Natural Sciences at UCM. This part of the Strategic Plan will attempt to at least partially fill this void. The faculty hired in this area will also form the much of the basis of the proposed Energy Institute. This part of the Natural Sciences Strategic Plan focuses on faculty hires in chemistry and physics. The research programs established by these faculty, along with those in the school of Engineering, will bring about an interdisciplinary research environment in condensed matter science that will distinguish UC Merced. The effect of this will be to greatly expand and amplify the research capabilities of the existing Molecular Science and Engineering (MSE) Graduate Group. We hope that this emphasis will bring the MSE grad group up to a “critical mass”, in terms of being able to recruit grad students and offer a graduate program. It is the intent of this initiative to be able to recruit graduate students who will be involved in forefront research and will meet UCM’s need for TAs in the chemistry and physics undergraduate laboratories.

These faculty will also be involved in the undergraduate program. Specifically, the faculty hired into this area will teach lower-division courses in chemistry and physics as well as provide the FTEs necessary to offer a Chemical Sciences major and contribute to the Applied Math / Physics major. They could also teach in the Energy major, if and when it is developed. These faculty will teach courses ranging from organic chemistry, to solid state physics, to surface science, depending on their specific area of expertise. The anticipated workload would be the same as is standard for physics or chemistry faculty throughout the UC system: two courses per year.

Prospects for collaboration

The research areas targeted in this initiative (organic electronic materials, photovoltaics, photonic materials, and nanoscale electronics) offer fascinating challenges to fundamental science as well as great opportunities for technology development. 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 and the IBM Almaden research laboratory in San Jose. H-P has a world-class research program in molecular electronics in its Quantum Science Research Institute and these individuals are eager to establish academic collaborations. (Both AMK and DFK have ongoing collaborations with this group.) 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.

Synergy between graduate and undergraduate programs

Academic scientists in this general research area (chemistry/physics/materials science) tend to have small research groups. Typical group size is 2 – 4 students and a postdoc or two. However, a few individuals do have larger groups – up to about 20 students and postdocs. Several typically-sized groups should be able to draw the students needed for chemistry and physics TAs and for the physical science part of the research mission of the University.

As indicated above, there is not yet a "critical mass" of research in the physical sciences at UC Merced; we are not currently able to draw graduate students. Graduate programs in the physical sciences typically require a considerable amount of course work in order to establish the core competencies the students need before they can move forward in independent research. As a result, even if we had the students, we could not offer a credible graduate program without enough faculty to teach the graduate courses. There is a strong synergistic effect here. A credible Ph.D. program, providing the necessary graduate courses and a number of strong faculty research programs within a broad area, is required for successful recruitment of graduate students; having a graduate program will be necessary for the successful recruitment of additional faculty. The recruitment of talented graduate students is particularly essential for junior faculty, since research in this area can be quite "student intensive". A further synergistic effect occurs through the undergraduate program. Graduate students will be needed to staff the undergraduate chemistry and physics labs as soon as Fall '06. Without them, we may have to staff the labs with instructors, further reducing our ability to hire faculty.

Hiring plan and resource needs

It is anticipated this program will involve a mix of several junior and senior hires. Most of these people will have "small scale" research programs (that is, they will do research at UC Merced, rather than at large, off-site facilities). It is reasonable to expect that that these research programs will have resource and space needs similar to those of DFK and AMK. In all cases, basic core facilities will be needed. It must be emphasized that these are very modest resource needs, compared to many other areas in chemistry. For example, research groups involved in the synthesis of bio-active molecules very often have in excess of 20 graduate students and postdocs, and require several thousand of square feet of lab space as well as dozens of fume hoods.

FTEs and Timeline

About 6 additional FTE's are needed to make the existing MSE graduate group viable. One of these may be filled in the upcoming Physics search. It is crucially important that we reach the numbers required to mount a credible program quickly, or risk losing our momentum as a new program in a new institution. This will require several hires as soon as possible. The timeline is further defined by the need for graduate student TAs. As noted above, laboratory TAs will be needed in Fall of ’05 and will be absolutely essential by Fall of ’06.

The FTE requirements for the Condensed Matter Chemistry and Physics Initiative are outlined below. This hiring plan has many of the hires in the next two years. This reflects the need to get up critical mass and develop a graduate program as quickly as possible.

Starting year	*Discipline*	*Number of faculty*
‘06	Organic Chem, Inorganic Chem, Analytical Chem, Solid State Physics, Optics	5
‘07	Organic Chem, Theoretical Chem, Physical Chem	4
‘08	Solid State Physics, Analytical Chem, Theoretical Solid State Physicist	3
‘09	unspecified	2 – 3
‘10	unspecified	2 – 3
5 year total		**15 – 17**

Note: The nature of the unspecified faculty hires depends on several things that are hard to predict at this time. These include the success in filling the positions in the initial years, the number and type of faculty hired into the Atomic, Molecular and Optical Physics Initiative and the enrollment growth in the introductory courses.

The total number of faculty specified (15 – 17) is reasonable in view of the total number of faculty hires expected in Natural Science over the next 5 years and the composition of an appropriate comparison institution, UC Riverside. The UC Riverside Natural Sciences faculty has the following composition:

Biochemistry:	15
Biology:	20
Cell biology and Neuroscience:	15
Chemistry:	24
Physics:	26
Math:	26
Statistics:	6
Earth Science:	13
Environmental Science*:	29

*This is in the College of Agriculture and includes what UCM would call “Environmental Engineering”

UC Riverside has a total of 145 – 174 faculty (depending on how you count the Environmental Science faculty) in the areas that are in Natural Sciences at UC Merced. **Of these, 50 (about 1/3) are in Physics and Chemistry.** With an anticipated hiring rate of 10/year, UC Merced will have about 70 Natural Sciences faculty in 5 years. For 1/3 of these to be in chemistry and physics, we would need to hire about 19 more faculty in addition to the 4.5 we currently have. Combined with the 5 needed for the Atomic, Molecular and Optical Physics initiative, the faculty hires outlined above will put us at about this number.

Astronomy & Astrophysics Strategic Initiative

Content of proposed program

Astronomy is a broad and interdisciplinary area of research. It is also of much interest to the general public, with new discoveries about our Universe in the news almost every day. These discoveries are made possible by a wealth of major observatories in space and on the ground. The University of California is a world leader in this field: it designed and co-operates the world's largest, twin 10-m Keck telescopes, and has a new 30-m telescope on the drawing boards. An Astronomy and Astrophysics group in the School of Natural Sciences at UC Merced would therefore be in an excellent position to serve both education, drawing students to the sciences, and forefront research, using world class facilities. Here we describe how to start building such a group, emphasizing research that provides the greatest synergy with other research interests developing in the Schools of Natural Sciences and Engineering (high energy physics, atomic and molecular physics, chemistry, biology and materials sciences).

Surprising as it may seem, many of the building blocks for new stars, planets and even life are assembled on tiny, but many, nano/micron sized particles ('dust grains') in the extreme environment of the interstellar medium in galaxies, including our own Milky Way. Research in this area is a very recent, fundamentally interdisciplinary endeavour which combines observations, theory and laboratory experiments, and involves astro-physics, astro-chemistry, astro-biology, and 'astro-materials science' (the study of astrophysically relevant materials in space environments). The broad question of the formation and evolution of the universe, galaxies, stars, planets and life - 'From the Big Bang to California!' - forms the corner stone of NASA's 'Origins' programs. These support the many space-based observatories, and have motivated Solar System explorations such as, for example, the search for water/life on Mars, and the Stardust Sample Return Mission which will bring back comet material to find clues to the formation of our Solar System.

UC Merced, precisely because it is a NEW research university, can seize the opportunity provided by these new research directions. This is greatly facilitated by the University of California at large which provides direct access to world class astronomy facilities and to major research laboratories within a few hours from UC Merced (UC's Lawrence Livermore National Laboratory and Lawrence Berkeley National Laboratory, and NASA Ames).

While much 'classical' astronomy is being pursued at the UC campuses, and indeed throughout the world, there is no single research group that combines all these disciplines to investigate the physics and chemistry of materials in space. We propose to begin such a program, the specific aim of which will be to investigate how the physical and chemical properties of large molecules and nano/micron sized particles are modified by the exposure to the harsh environment of space (vacuum, low temperature, high energy radiation and Cosmic Rays), and how these changes influence the origin and evolution of planets, stars and galaxies in the universe. In particular we would investigate how their properties are affected in the high energy density environments of star forming regions, supernova remnants, forming galaxies and in the vicinity of active, super-massive black holes. In addition, the impact of these large molecules and nano/micron sized particles on the emergence of life in space will be investigated. Besides these fundamental science aspects, this program will also lead to a deeper understanding of materials and their properties on the nanoscale.

The faculty that would need to be hired for this program would come from the disciplines of astronomy, physics, chemistry, biology and materials sciences.

Comparisons with similar programs within UC

What is unique?
The combination of astronomy, physics, chemistry, and biology in one program for studies as described above will be unique in California, and the world. In particular, while there are astronomy and astrophysics departments at all other UC campuses, none have the emphasis that we propose in our program
.
How will program contribute to UC Merced 'signature'?
It will be a truly interdisciplinary program that because of its astronomy/astrophysics component will be attractive to incoming students.

Funding opportunities

This can be funded through NASA programs associated with its space based observatories (Hubble Space Telescope etc.) and programs such as the Origins of Solar Systems, Cosmochemistry, Astrophysics Theory, and Astrobiology. In addition there are opportunities to participate in space missions. Further funding opportunities arise through LLNL, through the University Affiliated Research Center administered by the University of California Santa Cruz, and through the National Science Foundation.

Contributions to educational mission (graduate and undergraduate)

Astronomy is of much public interest and provides a natural way to attract students into scientific research. Eventually Astronomy and Astrophysics could be developed into a separate Major but until then faculty in this group would help train undergraduate and graduate students as part of a general Physical Sciences curriculum.

Contributions to the region

UC Merced is the first research university in the Valley and its first task will be to interest students in research. Astronomy and Astrophysics can play an important role in this for the Physical Sciences .

Fit with existing programs within NS, cross-schools and Institutes

This program would provide great synergy with the research interests of UC Merced faculty already on board, including high energy physics, chemistry and biology (Natural Sciences) and materials sciences (Engineering, and Natural Sciences). It will provide considerable 'added value' to other groups that develop within the Schools of Natural Sciences and Engineering.

"Business Plan"

FTEs (junior, senior), space and facility requirements
The nucleus of our proposed program would consist of at least two senior faculty members in the areas of astronomy and astrophysics, to be complemented over time by a mix of junior and senior faculty in the areas of astro-chemistry, astro-biology and materials sciences. While some research will involve limited use of large scale UC-related facilities such as the Keck telescope and LLNL, most of these people will have 'small scale' research programs based at UC Merced. The experimental facilities required will probably of the same scale as those of other faculty in the schools of Engineering and Natural Sciences.

Expectations for research themes
Our research of the physics and chemistry of materials in space is not only of interest for 'pure scientific' reasons – helping understand the formation and evolution of planets, stars and galaxies, and even life – but will also have important applications for the planning of future (robotic and manned) space missions by NASA. There may also be implications from our work that may be of interest to industry.

Opportunities for industrial relations, collaborations
Opportunities for industrial relations and collaborations exist through the new NASA Ames Research Center through the University Affiliated Research Center administered by the University of California Santa Cruz, and through collaborations with LLNL through the LLNL University Relations Program and LLNL/UCM adjunct faculty.

"Moments of Opportunity"- (nearby facilities, collaborators etc)
Faculty at UC Merced will have direct access to the world's largest optical telescopes, the Keck twin 10-m telescopes. A new 30-m class optical telescope is currently being designed in a joint effort between UC and Caltech (to be operational in 2014).

The University Affiliated Research Center administered by the University of California Santa Cruz is a new initiative by NASA, aimed at preparing research at its facilities in collaboration with industry and UC campuses for robotic and manned missions to the Moon and Mars, a focus for future NASA missions as directed by the President of the United States.

At LLNL the Institute of Geophysics and Planetary Physics has initiated active research programs which investigate the effects of high energy particles on materials in space and which will analyze Solar System materials collected from a comet fly-by and to be returned to Earth early 2006 as part of the Stardust Sample Return Mission.

Anticipated teaching workload (include suggested course titles)
Faculty hired into this program could teach basic courses in physics, chemistry, and biology, as well as advanced (undergraduate / graduate) courses in astrophysics, astrochemistry, astrobiology and astromaterials sciences depending on their specific area of expertise. The anticipated workload would be the same as is standard for astronomy, physics or chemistry faculty throughout the UC system: two courses per year.

Suggested titles of courses:

Introductory:
From the Big Bang to California (Astronomy)
Physics of the Cosmos (Astrophysics)
Life in the Universe (Astrobiology)

Advanced (undergraduate or graduate):
Space and Planetary Physics (Astrophysics)
Physics and Chemistry of the Interstellar Medium (Molecular Astrophysics)
Astromaterial science (New)

Expected number of graduate students/post-docs/undergraduate students
Typically faculty working in this program will have 2 – 4 students and 1 – 2 postdocs. Experimental groups under this program would be larger, up to 10 graduate students and postdocs.

Projected time-line
To capture the enthusiasm of the first students coming to UC Merced and interest them in the Physical Sciences it would be preferable to start with hiring two senior faculty in astronomy and astrophysics as soon as possible, to be followed with 2 – 4 junior / senior hires in astro-physics/chemistry/biology in subsequent years.

Strategic Plan: Earth and Environmental Systems

Proposed Program

Earth and Environmental Systems was established as one of the initial areas of research and education excellence at UC Merced. Earth Systems Science (ESS) was designated as one of the first undergraduate majors in Natural Sciences (NS), Environmental Engineering (ENVE) as a first major in the School of Engineering (ENG), the Environmental Systems (ES) graduate group as a joint NS and ENG graduate program awarding M.S. and Ph.D. degrees, and the Sierra Nevada Research Institute (SNRI). Since the arrival of faculty in NS and ENG in summer of 2003, we have sought to define the contours of this program in terms of research foci and opportunities, content of the undergraduate and graduate programs, and partnerships and liaisons with external organizations such as the National Park Service. Given the breath of research and education encompassed under the Earth and Environmental Systems umbrella, a major challenge for program development is to identify and build strategic areas in which UC Merced can excel while providing sufficient program breath to support undergraduate majors and graduate education.

Uniqueness and Signature

A central philosophy of the Earth and Environmental Systems program is an integrated approach to the study of physical, chemical, and biological processes as applied to natural and engineered environmental systems. Research and education components focus on the quantitative understanding of the Earth as coupled systems of atmosphere, hydrosphere, lithosphere, and biosphere. Such integrated studies require a balance of disciplinary expertise and interdisciplinary connections. This requirement translates to a large and diverse faculty assemblage -- one that can support the multifaceted components of the overall program and whose members may also contribute to other majors and programs in NS and ENG. Unique general elements of the program already in place include:

-- Research centered on quantitative analysis of complex environmental questions using cutting-edge methodologies and both interdisciplinary and multidisciplinary approaches
-- Exploitation of new interdisciplinary research areas, particularly at the intersection of physio-chemical and biological sciences
-- An interdisciplinary graduate group well balanced and strongly connected between NS and ENG in a unique area (Environmental Systems) that is not duplicated at other UC campuses
-- Complementary undergraduate majors in NS and ENG (ESS and ENVR) that enable program building through synergistic faculty hires in each school
-- Benefit from and synergy with the Sierra Nevada Research Institute (SNRI), particularly with respect to regional Sierra Nevada/Central Valley science, social science, and engineering issues

<u>Strategic Areas for Research Excellence</u>

As the programmatic area of Earth and Environmental Systems grows, it should be large and multifaceted. As a framework for growth, we identified the following research themes that can be developed at UC Merced based on existing faculty strengths, compelling and relevant research needs, and faculty growth in strategic areas that also supports undergraduate majors and graduate education. All of these themes involve faculty from NS and ENG primarily, but we hope that synergies with SSHA faculty will be developed in appropriate areas.

Water, Watersheds, Climate, and Resources

Water is a critical resource on our plane and an essential component of all cogs of planetary function – biosphere, hydrosphere, lithosphere, and atmosphere – where it serves as a solvent, a transporter, and a reactant. From an anthropogenic perspective, water is a critical resource, for drinking water, agricultural and industrial use, energy production, and recreation, thus making it an important commodity. There is growing awareness that the combination of impending climate changes and increased human demand for water will soon collide, particularly in California and the western U.S. where high quality water is already a limited resource in some areas. Based on current faculty studies and planned research, UC Merced is well poised to have a signature impact on several integrated science, engineering, and management issues related to water as a critical resource, particularly:

-- Relationships between climate change and regional precipitation, snow pack, and surface and groundwater storage
-- Understanding of fundamental molecular, chemical, and biochemical processes the impact water quality, both natural and anthropogenic
-- Quantitative understanding of water and carbon cycles in watersheds based on a combination of discrete and unique field measurements, remotely sensed data, and validated scaling models
-- Integration of science and engineering solutions with water resource management, sustainable agricultural activities, and economic development in the Central Valley

This thematic area already has a strong component in ENG and could easily develop a faculty group in SSHA in economics, policy, and social science. Some current research areas include:

-- Contaminant fate and transport in Sierran Foothill and San Joaquin Valley surface and groundwater.
-- Relationship between mountain block recharge and surface water in Sierran rivers
-- Carbon cycle research in orchard production systems
-- Establishment of an environmental sensor network in the San Joaquin River watershed
-- Establishment of a hydrologic observatory in the Sierra Nevada

Scaling, Landscapes, and Ecosystem Function (See Appendix for full description)

UC Merced can develop a leading program that merges quantitative spatial, geomorphic, and geophysical studies with the analysis of ecosystem biological and biogeochemical processes from the molecular to macroscopic scale. Significant new opportunities exist to move beyond empirical and statistical assessments of ecosystems to mechanism-based, quantitative analysis by merging spatial, geomorphic, geophysical, and geochemical studies with molecular-to-macroscopic biological and ecological studies to develop fundamental understanding and predictive capability of ecosystem fluxes, rates, forcings, properties, and population dynamics.

Advances at this interface involve both fundamental questions and practical applications, such as:

-- Validated approaches for scaling (microscopic to macroscopic; study plots to watersheds; local to regional landscapes) via process-driven, biotic-abiotic models.

-- *Quantitative integration of ecosystem components, including microbiological and biogeochemical processes, soils and geochemical attributes, geomorphic and physical landscape processes, and vegetation, habitat, and community dynamics.*

-- Quantification and model prediction of ecosystem function and evolution based on the advances above, including system response to perturbations, either punctuated catastrophes (e.g., floods, droughts, fires) or longer-term gradual forcings (e.g., climate change, land use changes, biological invasions).

This thematic area has some overlaps with the water and watersheds theme above, which is a strength in terms of identifying faculty hires that can support these areas in different ways. They differ, however, in several ways. First, the scaling, landscapes, and ecosystems theme is centered on discovering answers to fundamental questions about how ecosystems function using an approach that is quantitative and mechanistic, and not traditionally ecological. These discoveries will have valuable impacts and relevance to applied science and technologies, but the latter is not the driving force. While the water and watersheds theme also addresses fundamental science, many of the research areas already have a strong integration with engineering and management activities, and a shorter path from fundamental to applied. Second, it is probable that this area will initially be more centered in NS rather than ENG, whereas Water and Watersheds already has more balance between NS and ENG, and potentially SSHA through the management aspects. This results from the nature, applications, and faculty needs of each theme, particularly with the biological/ecological and geomorphic/geophysical components of scaling, landscapes, and ecosystems, which will be NS centered. Lastly, we hope that this theme will have strong synergies with the development of Applied Math and Physics, with opportunities for research and faculty overlap.

Air Quality and Atmospheric Studies

"Think globally, act locally" is a good mantra for atmospheric studies at UCM. As a planet, the challenge of atmospheric sciences and air pollution engineering is global change, understanding both the natural and anthropogenic contributions to future and past changes. Locally, the Central Valley faces massive air quality problems, providing challenges to understand primary emissions and subsequent atmospheric processes, as well as the human health and ecosystem effects.

Research in atmospheric chemistry and air pollution is focused on understanding the chemically driven processes that affect the Earth's atmosphere, as well as on examining the fate and control of pollutant releases to the atmosphere. Approaches to study these areas range from development of new instruments for measuring the composition of atmospheric trace gases and particulate matter to development of large-scale computer based atmospheric models. Field measurement and laboratory-based programs will provide the data to check atmospheric transport models as well as source-receptor relationships. Calibrated models can be used to study the effect of alternate control strategies, such as the use of renewal energy.

Human and ecosystem exposure to pollutants provides a natural synergism between science, epidemiology, engineering, and social science. Biologists studying effects of fine particulate matter on tissues and the human body need to know the composition and size of the particulate matter. Human health is affected by economic and psychological factors as well. Preliminary studies have indicated that nutrient controls in the Sierra Nevadan aquatic systems may be shifting due to atmospheric deposition of pollutants, as well as to climate change. Teasing out the contributing factors and the long-term consequences will require cooperation between environmental engineers, Earth systems scientists, and social scientists.

This research theme is a natural area in which UCM can develop a presence. We are physically located where there is a population with an abnormally high occurrence of asthma and near an ecosystem that responding to both air pollution and global warming. The current faculty are a nucleus for a multi-disciplinary program (NS, SSHA and ENG) in both human and ecosystem exposure. We are lacking key faculty in the areas of atmospheric chemistry, atmospheric transport modeling, field measurements, and resource management.

Recent and planned research:
-- atmospheric chemistry of polar and alpine snow-covered areas
-- nutrient deposition in the Sierra Nevada: sources, transport and aquatic effects
-- triggers for asthma
-- atmospheric nanoparticles

Health, Infectious Agents, and the Environment (See related initiative for full description)
A related interdisciplinary initiative in the area of Health, Infectious Agents, and the Environment is being proposed that contributes to the broad scope of Earth and environmental systems. This effort would begin as a research focus that bridges between growing strengths in biological/biomedical sciences and Earth and environmental systems science. We propose to initiate this effort by developing strategic research associated with the interaction between environmental factors and infectious agents, particularly microbiological systems. Faculty supporting this initiative would support areas of biological sciences, human biology, and Earth and environmental systems (see below). Future growth of this initiative would not be limited to microbial infectious agents as causes of disease, but may include a range of research thrusts within the broad scope of Health and the Environment.

Funding Opportunities:

Funding for research in this area is provided by a number of federal and state agencies, including the NSF, DOE, EPA, USDA, and DOE. A partial list of opportunities is given below.

NSF: The Biological Sciences, Earth Sciences and Engineering Directorates all have continuing funding available for traditional single investigator grants in this area. Examples of some cross cutting/multidisciplinary programs of note are:

1) *Research in Biogeosciences (BioGeo):* Within the oceans and on land, microbes exert their impact through active interactions with earth materials (including minerals, rocks, hydrates,

soils and dust). Proposers should seek: to increase our understanding of microbial processes at the interface with such materials; to elucidate the geologic record of microbial activity at that interface at any time scale including the co-evolution of the geosphere and biosphere through such interactions; to better understand the impact of microbes on biogeochemical processes operating at that interface; or to develop new methods and research techniques for the study of geomicrobial processes.

2) *Sensors and Sensor Networks (Sensors):* The National Science Foundation (NSF), through the Directorate for Engineering, the Directorate for Geosciences, and the Office of Polar Programs, announces a broad interdisciplinary program of research and education in the area of advanced sensor development. This solicitation seeks to advance fundamental knowledge in engineering of materials, concepts and designs for new sensors; networked sensor systems in a distributed environment; terrestrial, atmospheric, and aquatic environmental analysis; the integration of sensors into engineered systems; and the interpretation and use of sensor data in decision-making processes.

3) *Biology and the Environment (BE):* The BE program is a multi-year investment designed to promote new approaches to investigating the interactivity of biota and the environment. BE includes activities designed to foster research and education on the complex inter-dependencies among the elements of specific environmental systems and interactions of different types of systems. All kinds of organisms-from microbes to humans-fall within the BE framework, as do environments that range from frozen polar regions and volcanic vents to temperate forests and agricultural lands as well as the neighborhoods and industries of urban centers. The key connector of BE activities is complexity -- the idea that research on the individual components of environmental systems provides only limited information about the behavior of the systems themselves.

4) *National Ecological Observatory Network (NEON):* NEON will provide nationally networked research, communication, and informatics infrastructure for collaborative, comprehensive and interdisciplinary measurements and experiments on ecological systems. NEON's synthesis, computation, and visualization infrastructure will create a virtual laboratory that will permit the development of a predictive understanding of the direct effects and feedbacks between environmental change and biological processes. NEON will transform ecological research by enabling studies on major environmental challenges at regional to continental scales.

5) *Earth Sciences Division (EAR):* A recent (Aug. 2004) reorganization of funding programs in the NSF Earth Sciences division seeks to promote physical, chemical, and biological studies of processes at and near the Earth's surface. This effort included the establishment of a new program in Geomorphology and Land Use Dynamics, a program in Geobiology and Environmental Geochemistry, funding for the Earthscope program which is aimed at large-scale geophysical measurements and data dissemination, and development of a new cross-cutting program in GeoInformatics.

***DOE**:* The Office of Basic Energy Sciences (BES) and the Office of Biological and Environmental Research (BER) both operate large research programs that cover many topics common to the Earth and Environmental Systems Initiative. BES programs are more similar to NSF single investigator programs and fund research in the geosciences with particular emphasis on basic geochemistry, geophysics and hydrology. BER programs place a stronger emphasis on interactions between biology and the environment. Research initiatives in this area include, Genomes to Life (GTL), Natural and Accelerated Bioremediation (NABIR), the Environmental Management Science Program (EMSP), and Climate Change Research.

NASA: A number of NASA programs support a significant amount of Earth-based research, including Energy- and Water-Cycle Sponsored Research and Earth Observation programs. NASA supports both basic research in water and energy cycling and applied research in data acquisition, synthesis, and dissemination, particularly satellite and remotely sensed data.

Cooperative Ecosystem Study Unit (CESU): In 2003, the University of California was designated as the lead academic institution in the California Ecosystem Study Unit. This is a cooperative agreement with eight federal agencies to fund ecosystem research related to management issues on federal lands.

CALFED**:** CALFED is a program funded jointly by the federal government and the state of California to conduct physical, chemical, biological, economic and social research on the water and watersheds of the Bay-Delta ecosystem.

California Energy Commission, Public Interest Energy Program: An annual state program that supports a wide range of energy-related research, including studies in which climate is an important component.

Contributions to Educational Mission:

Undergraduate: In the last year, we have established the initial set of core classes and emphasis areas for the ESS undergraduate major. The lower division course requirements include preparatory courses in math/physics, chemistry, statistics, computing, biology, and Earth systems science. The upper division requirements include four core classes that are designed to serve as a base to expose students to quantitative fundamentals in each of the following areas associated with physical, chemical, and biological aspects of Earth systems, respectively: Hydrology and Climate, Environmental Chemistry, and Geomicrobiology. The fourth core class is an integrated field class that links areas together and emphasizes observation and measurement as a means to understanding fundamental concepts and synthesizing diverse information. Emphasis areas are designed to provide students with more depth in a particular sub-field of Earth systems. They are not intended to substitute for the depth of training in a traditional science discipline. Rather, they afford an opportunity for the student to explore a sub-field in more detail and gain a higher level of expertise. The first proposed emphasis areas are *Geochemistry and Biogeochemistry, Hydrologic and Climate Sciences, and Ecosystem Science*. Major requirements also include a course in microeconomics and a course in policy and ethics.

For programmatic development, the emphasis areas within the major reflect research themes and faculty strengths, and these can be added or changed as we increase faculty. We hope that emphasis areas can be used in two ways. First, they serve as mechanisms for supporting some educational depth at the undergraduate level, and allow students to explore subject areas that speak to interdisciplinary challenges. Second, some emphasis areas may operate as a test bed for new undergraduate majors by enabling us to hire faculty in an area, develop a core program, and generate student interest before launching the major in its own right. The development of a new major would not necessarily replace the emphasis area in ESS, which would retain focus on its base in quantitative Earth systems. New majors will complement the ESS major by proposing a new core emphasis, with continuing overlap in selected upper division courses.

Graduate: The Environmental Systems (ES) graduate group has formulated by-laws and policies for its M.S. and Ph.D. programs. The group is planning on submitting documents for official approval of the program to CCGA in Spring 2005. We currently have 9 M.S. and Ph.D. students enrolled in the ES graduate program, by far the most students in of any of the current graduate programs. Faculty support of this graduate group relies critically on synergistic faculty hiring between NS and ENG in support of research themes. A uniqueness and strength of this graduate group is student training in integrated science and engineering approaches in the study and solution of complex environmental problems. In order for this strength to continue, balanced and complementary faculty hires in NS and ENG are a priority. We hope that SSHA faculty in economics, public policy, and related disciplines will participate in this program as well. Presently, students in the ES program are studying a broad range of topics under the environmental umbrella. We anticipate the establishment of other graduate groups in the future that may spawn from ES; for example, a new group in energy-related studies, or perhaps one associated with the Heath and Infectious Agents initiative. Similar to the undergraduate ESS program, an initial, broadly defined ES program can serve as a home for the development of new areas until they have sufficient faculty and student mass to support a distinct graduate group.

Contributions to the Region

The Sierra Nevada is known for its spectacular landscapes and it many recreational and biological resources. The San Joaquin Valley is recognized around the world for its leadership in agricultural production. Together, these regions of California are legendary for their vast natural resources, physical and biological diversity and cultural heritage. However, rapid population growth, competition for natural resources, air, water and soil pollution and competing land uses pose serious threats to the sustainability of these regions.

Over the next twenty years the populations of the San Joaquin Valley and Sierra Nevada Regions are projected to increase by 2.5 million and 1 million residents, respectively, a rate nearly 20% higher than the projected statewide average. Population growth in the San Joaquin Valley could convert 20% of current cropland to urban use by the year 2040. If current development patterns continue, low density housing in the Sierran foothills would consume half of all private land in the region by 2040, fragmenting habitats and creating enormous safety concerns due to wildfire. Public lands are also under increasing pressure. For example, Yosemite National Park now accommodates between three and four million visitors every year, including nearly one-quarter million overnight stays.

Since 1990 there have been repeated calls for a research and education program that could help address regional ecological and social issues by conducting and coordinating regionally-focused, issue-oriented research while disseminating data, information and analytical tools to local stakeholders. Moreover, population growth, land use change, and environmental sustainability are issues not just for California, but for most areas of the globe. Thus, the research and educational efforts of this program will address a range of issues of immediate local import as well as those of global significance.

Synergy with Other Programs

As noted above, there are already healthy overlaps of this program with ENG. A significant number of faculty associated with Earth and Environmental Systems would also support growth of Biological Sciences, particularly within the Health and Infectious Agents area. Growth of Earth and Environmental Systems areas would aid the development of a program in Chemical Sciences, particularly the environmental emphasis. We also hope that this program will have strong connections to the development of the Applied Math program (see table below).

Another synergy to be developed is linkage to economics, public policy, and social sciences and environmental systems. All of the themes outlined above have connections to the public, government, and industry in key areas. Discussions with SSHA to develop faculty expertise in environmentally related economic and policy areas should be pursued.

Plan for Implementation and Growth

None of the thematic areas outlined above will grow into high quality, high impact research and education programs without significant investment in faculty hiring. We estimate that a minimum of 3-4 FTE's per year for 5 years is needed to support this strategic development. These hires should include a balance of junior and senior faculty. Note, however, that each of the faculty identified below support a minimum of two thematic areas, and many have overlaps with biological sciences, chemical sciences, and applied math (see table after the list for overlaps and synergies in multiple research areas). For particular individuals in this matrix, a joint position with ENG or SSHA may be appropriate. Note that this list includes those indicated in the Health, Infectious Agents, and the Environment initiative and are not additional positions (see the table below).

General Area: Physical/Environmental Research

Process geomorphology: Quantitative geomorphology; landform/landscape evolution; tectonic geomorphology; land surface geochronology; sediment transport; land use/ecology interactions; landscape forecasting

Shallow Earth geophysics: Surface and near-surface geophysical methods; applications to soils, vadose-zone processes, hydrogeology, shallow Earth tectonics

Atmospheric chemistry (possibly joint with ENG): Atmospheric particulates; aerosol chemistry; air quality; would support emphasis in environmental chemistry in the chemical sciences major

Atmospheric physics (possibly joint with ENG): Mesoscale atmospheric dynamics; cloud physics; land/atmosphere interactions; water vapor/precipitation physics; could be an applied math person

Organic environmental chemistry (possibly joint with ENG): Organic chemistry and reactions as applied to environmental systems; would support emphasis in environmental chemistry in the chemical sciences major

> *Paleoclimatology/climatology:* Chemical and physical Earth processes that determine changes in the climate in the past and the future; global to regional downscaling and feedbacks

Land use/surface processes: Spatial analysis and processes in ecology, hydrology, surface processes, and land use; applications of remote sensing

General Area: Life Sciences/Environmental Research

Plant biology/biochemistry: Biology and biochemistry of plants; genomics; evolution

Microbial pathogenesis: Microbial systems and disease

Organismal/conservation biology: Physiology, population dynamics, community ecology

Air quality epidemiology (possibly joint with SSHA): Epidemiology associated with air pollution

Environmental/toxicogenomics: Ecological analysis of genes and genomes, either microbial or macrobiological

Vegetation ecology: Plant and vegetation dynamics; vegetation/atmosphere interactions; land use impacts

Environmental/ecological biochemistry/immunology: Natural products toxicology; biochemistry and immunology

Parasitology: Molecular, biochemical, and/or ecological parasitology.

Global change ecology: Invasive species; ecosystem responses to natural and anthropogenic perturbations; migratory responses to habitat change; ecosystem dynamics; biodiversity.

Targeted Hires in NS and Thematic Overlaps: Five-year Plan

Theme Area → Targeted Hire ↓	Water, Watersheds, Climate, and Resources	Scaling, Landscapes and Ecosystem Function	Air Quality Research and Management	Health, Infectious Agents, and the Environ-ment	Environ-mental Chemistry	Applied Math & Physics
Process geomorphology	X	X				
Shallow Earth geophysics	X	X				X
Atmospheric chemistry			X		X	
Atmospheric physics			X			X
Organic environmental chemistry	X			X	X	
Paleoclimatol-ogy/climatology	X	X				
Land use/surface processes	X	X	X			
Plant biology/bio-chemistry		X		X		
Microbial pathogenesis	X	X		X		
Organismal/conser-vation biology		X		X		
Air quality epidemiology			X	X		
Environmental/ Toxicogenomics		X		X		
Vegetation ecology	X	X	X			
Environmental immunology		X		X		
Parasitology		X		X		
Global change ecology	X	X		X		

Space and Facility Requirements

Faculty lines are a mix of field and laboratory investigators. Most laboratory positions will require standard chemistry and/or biology laboratory infrastructure but we do not envision the need for animal care facilities. Plant biology faculty would need greenhouse space. Expansion of faculty into physical Earth processes and remote sensing would require research investments in computing informatics and relational database development. Adequate research and laboratory space for faculty and their research groups is essential for program success.

Opportunities for Industrial Relations, Collaborations, and "Moments of Opportunity"

Situated in the trough of the Great Valley, investigators at Merced have easy access to a vast array of biogeographic environments ranging from marine to the west, deserts to the south and montaine and alpine to east. Underlying this ecological and climatic diversity is an actively evolving geosphere with a diversity that is unparalleled anywhere else in North America. The unique geographic location of Merced is an ideal place for an array of field-based investigations. This local is further enhanced by its close proximity to two national laboratories with strong research programs in many of the aforementioned subjects (LBNL and LANL), the presence of several specialized National User facilities (two X-ray light sources, the Center for Accelerator Mass Spectroscopy, and the National Electron Microscope Facility) as well as a research office of the US Geological Survey. Finally, the close partnership between the SNRI, Yosemite and Sequoia/Kings Canyon National Parks will provide unique, pristine environments for many of these activities.

Assessments, Milestones, and Checkpoints

The most critical impediment to the growth of this program is the lack of faculty to support the breath of expertise needed to establish credible, high visibility research and educational components. The growth of faculty, and with it, increases in research grant funding, will be important early indicators of program success. Growth in graduate enrollments and in the undergraduate majors will follow from increases in faculty. There are two specific research projects led by ENG faculty -- a hydrologic observatory in the Sierra Nevada and a network of environmental sensors -- that are proposed or have received pilot funding, and several others under discussion. We have had discussions with researchers at LLNL and LBNL about establishing broader initiatives in watershed and biogeochemical research. An important next step is to nucleate specific research projects and obtain funding within the thematic areas outlined above. We are also exploring funding for graduate student support, potentially in the form of a NSF IGERT proposal and fellowships through the national laboratories. A long-term funding base for graduate student support is another important program goal.

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Life Sciences Research Initiative

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, 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.

This new biology is built on several themes. First, the acquisition of comprehensive, quantitative datasets on living systems, such as whole genome sequences, protein expression rates, and complete maps of metabolic and regulatory pathways. Second, the development of mathematical models for integrating and evaluating such data, with the goal of building models that can predict novel or unexpected properties of biological systems. Third, the recognition of the central role of evolution in studying and understanding organisms, pathways, and genes.

Finally, this "new biology" requires very close partnerships with the physical and mathematical sciences. This need for a highly multidisciplinary approach constitutes an important barrier to progress in quantitative systems biology since few undergraduate or graduate programs provide truly multidisciplinary training. This very need provides UC Merced with an excellent opportunity to develop life sciences programs at the forefront of this field. Although many universities are developing academic programs in systems biology, UC Merced has the advantage of starting its programs from a "blank slate" with no existing institutional barriers. Furthermore, systems biology will be greatly enabled many of the other initial academic programs and research efforts at UC Merced, such as the applied mathematics, earth systems science and bioengineering programs, the Sierra Nevada Research Institute, and the Center for Computational Biology.

<u>Need for Innovative Life Sciences Academic Programs</u>

It is widely recognized that existing academic programs are not adequately preparing students for 21st century biology. {Bio2101, Beyond Bio 101}. Existing undergraduate and graduate curricula fail in many ways. Most critically, they fail to teach enough math and computational sciences. Moreover, many biology courses emphasize memorization of large sets of disconnected facts, rather than teaching unifying concepts that allow students to understand the principles of living systems. A number of reports provide recommendations for improving undergraduate and graduate biology education, but these have proven difficult to implement on top of existing programs. UC Merced has a unique opportunity to create academic programs that prepare students for success in this new biology.

Graduate Programs

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 and less than 1000 were conferred in mathematics. {http://nces.ed.gov/programs/digest/d03/tables/dt254.asp} Moreover, life sciences doctoral programs have a strong record of successfully recruiting women—approximately 45% of life sciences Ph.D.s went to women in 2002, compared with 28% in the physical sciences and 17% in engineering. {http://www.bls.gov/emp/mlrtab2.pdf} (Note however, that the life sciences have been no more successful than other fields in recruiting other minority groups, so that any success at UC Merced in recruiting minority graduate students would be notable.) The large number of biology Ph.D.s is driven by the large size of the biology research community. The US Department of Labor reports a labor pool of 75,000 life scientists in 2002 (exclusive of environmental scientists) and 62,000 medical scientists (who typically get Ph.D.s in the life sciences.) These two groups are expected to grow by 19% and 27% respectively by the year 2012.

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 Quantitative and Systems Biology graduate group at UC Merced will bring 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. Faculty will be drawn from the natural sciences, engineering and social sciences, including molecular and cell biology, genomics, proteomics, signal transduction, experimental technologies, modeling, computation, and cognitive sciences.

QSB students will study the complex interactions of cellular components and the integration of quantitative data into informational pathways and networks. The nature of the biological systems to be studied will depend upon faculty interests, and may include normal development in animals, regulation of cell, tissue and organismal response to changes in external chemical and physical environments, disease phenotypes, and microbial communities. The doctoral program will emphasize advanced molecular and cellular methodologies for quantitative analyses at multiple levels of biologic systems, development and use of novel model systems, and computational and analytical approaches for the study of biological processes.

Undergraduate Programs

Life sciences majors are very popular with undergraduate students. The US Department of Education reports that in the 2001-2002 academic year there were 60,000 biology/life sciences majors and over 70,000 majors in “Health Sciences and Related Professions”. Taken together these majors include more students than any other DoEd categories, except for business (281,000 students). Biology (including biochemistry) is also a popular major at established UC campuses, representing 5.9% of the students at UC Berkeley and 18.5% of students at UC Davis. (See complete Table in final section of this report.) By comparison, chemistry, math and physics comprise less than 3% of students at UC Davis. Assuming that UC Davis is a reasonable model for UC Merced, we would expect ~150 life sciences majors in the initial class, growing to over 700 in five years (combining both freshmen and transfers).

The vast majority of life sciences graduates will enter careers related to healthcare. Department of Labor statistics put employment levels at 6.5 million for healthcare providers and technicians, and an additional 3.3 million healthcare support staff. These numbers are expected to grow by 26% and 38% respectively in ten years, and the healthcare job opportunities are expected to grow even more rapidly in underserved areas such as the Central Valley. In addition to healthcare, the pharmaceutical industry is a very large employer of life sciences graduates. US Department of Labor statistics list pharmaceutical industry employment at 293,000 in 2002, of which 81,000 were technical professionals and 85,000 were in drug manufacturing {http://www.bls.gov/oco/cg/cgs009.htm#related}. The biotechnology industry is also expected to grow (although this industry has shown both up and down swings in recent years.) Estimated worldwide employment in the biotechnology industry was estimated at 225,000 in 2001 (exclusive of the pharmaceutical industry) and is predicted to grow to 400,000 by 2010 {D.G. Jensen, "Commentary: The Worldwide Biotechnology Job Market" *Biochemistry And Molecular Biology Education* **30:**64 (2002)}. Moreover, biotechnologies have an increasing role in many other industries, providing other career opportunities for life sciences majors.

The life sciences degree programs at UC Merced are designed to prepare students for the emerging requirements for careers in research and the healthcare and biotechnology sectors. An important theme in all life sciences is the rapid growth in the role of computers and advanced technologies, which will increase the career opportunities for graduates with strong quantitative skills. UC Merced is opening with two life sciences degrees. The first is a bachelor of sciences degree in Biological Sciences. This degree program uses a "core+emphasis" model that consists of a core of seven courses to provide a solid foundation in the principal areas of biology (see Table below) followed by a student-selected emphasis area that gives much more depth in a particular topic (see Table below). We envision that additional emphasis areas will be added based on student interests and faculty expertise. A signature feature of this major are a large number of mathematics and computations courses, including mathematical biology and an emphasis on quantitative concepts in the biology core curriculum, as well as a requirement for at least one semester unit of research experience for all students.

Core Courses and Emphases for B.S. Degree in Biological Sciences

Core Courses	Biological Sciences Emphasis Areas
Contemporary Biology	Molecular Biology and Biochemistry
Molecular Machinery of Life	Cell Biology and Development
The Cell	Bioinformatics and Computational Biology
Evolution of Diversity	Microbiology and Immunology
Genes and Genomes	Evolutionary Biology (proposed)
Fundamentals of Scientific Modeling	
Computational Biology	

The second program is a bachelor of arts degree in Human Biology that provides a broader range of courses including sociology, psychology and economics. The Human Biology degree differs from the Biological Sciences degree in not requiring a narrowly concentrated emphasis areas; instead, there are three broad tracks planned in natural or social sciences. In each track students are free to select from a broad range of natural or social science courses, respectively.

Relationship to other UC Merced Majors

Courses developed for the life sciences majors and graduate groups are also relevant to a number of majors outside biology. A number of the bioscience core courses, such as *Molecular Biology* and *Biochemistry* will be necessary for other majors such as the Chemical Biology emphasis area in the Chemical Sciences major and the Bioengineering degree to be offered by the School of Engineering. Additionally, the life sciences program offers a number of lower division courses in biology and health that will be of general interest to students from any major.

Development of Life Sciences Research Programs

Research programs

As described in the introduction, there are many exciting research opportunities in systems biology. The research interests of the founding faculty naturally suggest a number of initial life sciences research themes for UC Merced. These themes are all examples of the new systems biology described above and have been chosen to leverage special opportunities available to Merced and to depend on a common core of facilities and expertise. We have identified three life sciences research themes that encompass the expertise and research interests of the current faculty and we also describe three other research themes that seem promising for UC Merced.

Initial Research Themes:

1) Predictive Understanding of cell fate decisions

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, include 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 recent passage of California Proposition 71 makes this are a "special opportunity" for UC Merced. Under this proposition, the state will be providing significantly more research money in this area than was previously available from federal agencies. This will provide new funding opportunities for UC Merced, and will attract research talent to the state.

2) Evolution-based Analyses of Biological Processes

Large-scale, inexpensive DNA sequencing has placed evolutionary approaches at the center of modern biological research. UC Merced founding faculty are using evolutionary biology to understand a range of problems ranging from the origins of invertebrate life, to symbiotic relationships in marine systems, to the emergence of antibiotic resistant microbes. These research areas form a strong foundation for a signature research theme in evolutionary biology at UC Merced. This research program also has the potential for strong linkages to programs in Earth Systems Science and Environmental Engineering.

3) Cell Signaling and Response

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, 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.

Promising Research Themes

4) Complex Disease States

The Central Valley provides a microcosm of the health challenges of the entire state and nation with high rates of "complex" diseases such as asthma and diabetes. These diseases are influenced by genetic, environmental, behavioral and cultural components and therefore can only be fully understood in multidisciplinary approaches. A strong research program in this area would foster collaborations with healthcare providers in the Central Valley. Conversely, the local community would provide unique cohorts for studying strategies for treating or reducing the incidence of these diseases.

5) Control of Complex Biological Processes

The goal of systems biology is a predictive understanding of biological processes. A natural next step is to determine how to use this knowledge to control living systems, from individual biochemical pathways to whole ecosystems. This research would have many applications relevant to the UC Merced area, from designing new agricultural products to ameliorating the response of ecosystems, to climate change and pollution. This new research area could be strongly synergistic with existing UC Merced programs in environmental science and engineering, as well as new programs in bioengineering and environmental health effects.

6) Chemical Biology

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. Chemical biology could have strong synergies with the bioengineering program and applications in earth systems science and environmental engineering.

Resource needs for a modern life sciences program

Faculty

The founding faculty in life sciences will comprise the initial components for the academic and research programs described above, but new faculty hires are needed to broaden the base of expertise into new areas not currently covered and to deepen the base in selected research areas.

Although student enrolments will ultimately influence the number of new faculty, we anticipate a need for 15-20 new faculty over the next five years to deliver the graduate and undergraduate courses and to build the research programs described above. The following table lists specific high priority life sciences hires and indicates the primary needs that each will fulfill. The table at the end of this section lists the numbers of new hires proposed for each of the six identified research themes for the next five years.

Fields for new hires	Initial Research Programs	Undergrad./ Graduate Instruction	Multi-disciplinary Linkages	Special Opportunity
Statistics/Biostatistics	√√	√√	√	
Stem cell biology	√√			√√
Bioinformatics	√	√		
Functional genomics	√	√	√	
Toxicogenomics	√		√√	√
Structural biology	√	√	√	
Protein biology	√	√	√	
Developmental biology	√	√		
Organismal biology		√√		
Immunology	√√	√		
Microbiology		√	√	
Single cell/single molecule biophysics	√		√√	
Synthetic biology		√	√√	

Facilities

Some equipment that could be incorporated into biological core facilities is already scattered through several laboratories at Castle, but do not have staff support and are under increasing demand. Other core facilities that will be required for research of current and incoming faculty do not exist under any form. Primarily, a biosystems core facility will be needed for studies of global gene expression and protein synthesis and activity in eukaryotic cells and microbial organisms under different conditions. The facility would consist of new equipment for high and medium throughput sequencing of genes and microarray analysis of gene expression, imaging and cell flow sorting, proteomics, metabolomics, and bioinformatics. These facilities are indispensable for modern research in most areas of cell biology, immunology, developmental biology (including stem cell biology), cellular biochemistry, and environmental and clinical microbiology. Equipment for proteomics is partially available, but should be expanded and incorporated into a core facility. Equipment for gene sequencing and microarray analysis does not exist. A confocal microscope has been ordered and a single fluorescence microscope is available, but we anticipate more use of fluorescence microscopes in the future. These microscopes could be combined into a core facility that includes cell sorting and analysis equipment, of which a single cell sorter exists at the moment. All of these facilities, along with a center for computational biology, would fit with our goal to promote biological research that emphasizes quantitative analysis and an understanding of how individual components of a system are integrated into the function of the whole organism or environment. A high resolution nuclear magnetic resonance (NMR) facility, including NMR spectrometers capable of doing both liquid and solid state NMR spectroscopy, would allow us to hire faculty members who characterize the structure and function of proteins and other biological molecules, and could help us develop an undergraduate major in chemical biology. A dedicated staff, trained to provide high quality service and training of graduate students and faculty, will be indispensable for the proper functioning all of the above.

Two current faculty members use small animal models for their research, and are relying on animal facilities at Lawrence Livermore National Laboratory for occasional experiments. Fulltime studies of incoming faculty members and planned future hires will require animal facilities for small rodents and the ability to prepare transgenic animals on campus. Likewise, future hires in plant ecology and evolutionary biology will not be possible without a greenhouse and headhouse. A biology collection facilities, consisting of both insects and plants, would allow us to further expand our research programs into the areas of ecology and systematics.

Cross-disciplinary and cross-school linkages

Multidisciplinary research and education are founding principles of UC Merced and the life sciences offer many opportunities for cross-disciplinary and cross-school collaborations. Nearly all aspects of life sciences research has repercussions in the humanities and social sciences: ethics, economics, psychology, philosophy, and cultural studies. These components are strongly emphasized in the Human Biology degree, but there are good prospects for more broad synergies between SSHA and the life sciences. Modern biology is also strongly connected to engineering. There are good prospects for strong connections to the UC Merced School of Engineering's programs in Computer Science, Bioengineering, and Environmental Engineering.

	Cell Fate	Evolutionary Biology	Cell Signaling & Response	Complex Diseases	Biological Control	Chemical Biology
# Current Faculty	3	2	2	2	1	0
# New faculty	3-4	3-4	3-4	2-3	2-3	2-3
UCM collabs	BioEng.	ESS Env. Eng	BioEng	ESS	ESS	Chem. Sci.
Institutes	SBI	SNRI	SBI	WCI, SBI	SNRI, SBI	SBI
Outside collabs	LLNL					
Proteomics (Mass Spec.)	√√		√			
Proteomics (Microarray)	√	√	√√	√√	√√	
Genomics	√√	√√	√		√	
Animal (Vivarium)	√	√	√	√	√	
Animal (Transgenic)	√		√	√√	√	
Imaging	√	√	√		√	
High-field NMR					√	√√

Summary of Faculty and Facilities Needs for Proposed Life Sciences Research Programs (NB: # Current Faculty includes individual faculty counted in more than one category; # new faculty indicates proposed hires over next five years)

Building a Competitive Life Science Research Program at UC Merced

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 six research themes described above 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.

Value to Central Valley Community

In addition to the opportunities that the life sciences programs provide to UC Merced, they will also provide many benefits, direct and indirect, to the local region and the Central Valley. The university in general has a commitment to being an "open" facility that will welcome visits from local schools and organizations, and host educational events to meet the needs and interests of the local population. In this role, the life sciences program can act as a recruitment vehicle to interest Central Valley students in careers in health and biology, and as an outreach mechanism to inform the local population of the value that research and UC Merced bring to the region. A strong life sciences program at UC Merced would benefit the Central Valley community in the following ways:

1) *Improved Healthcare and Health Sciences*

The Central Valley communities face many stresses and challenges. Significant among these are a unique set of health problems, particularly respiratory diseases related to the environmental problems and socioeconomics of the region, and a dearth of targeted research and healthcare providers focused on the community's needs. Comprehensively addressing the health needs of a community is a multi-faceted and progressive endeavor. While physicians, nurses, dieticians, counselors, and other health professionals that directly provide health services are most visible, a large research and training infrastructure underlies premier health care systems. In particular, prestigious research programs in basic and applied health sciences are essential components of top tier medical centers. The proposed UC Merced life sciences research programs represent a first step in creating world-class health sciences facilities and programs for the Central Valley.

2) *Economic Development*

The core technologies of the life sciences programs, coupled with the increasing demand for new technologies, are expected to lead to the creation of biotechnology and instrumentation companies in the area, and will attract new companies to the area. Thus, the UC Merced life sciences program could become an economic driver for biotechnology in the region. Indeed, a quarter of the biotechnology firms in California were founded by a UC faculty or staff member and a third are located within 35 miles of a UC campus {http://www.universityofcalifornia.edu/research/biotech.html}. Since the life science program is planned as one component of a future health sciences program at UC Merced, many of the initial areas of study will be oriented towards understanding health-related biological processes—which has historically proven a very successful area for the biotechnology industry.

3) *Institutional Outreach*

It is increasingly recognized that treating the symptoms cannot be dissociated from an understanding and appreciation of contributing factors arising from the individual's socio-economic, cultural, and ethnic background. The demographics of the region and attendant health issues provide unique opportunities to create education programs that will prepare students for the communities in which they will live and in some cases, serve. By sponsoring programs that include the local community, the life sciences program can be an educational resource on the unique health challenges of the Central Valley. The multicultural setting will allow the program to initiate research programs focusing on the ethnic, cultural and societal factors that influence disease predisposition, disease progression, response to treatments, and well-being.

Milestones and Assessments for UC Merced Life Sciences Program

The development of a strong life sciences program at UC Merced is crucial to its ability to enhance the economic viability of California. Recent breakthroughs and growing economic opportunities serve to both stimulate undergraduate and graduate enrollment in life sciences and enhance funding support for research in these fields. Assessment of UC Merced's success in providing a competitive life sciences program is key to improving the program and evaluating the impact of this program on the central valley region of California.

Of primary importance is an estimate of the undergraduate enrollment in life sciences. Anticipated total undergraduate enrollment at UC Merced is 900 students in Fall 2005 with an additional 800 admitted each year thereafter. Because support for life sciences is robust both in the private and public sector, it is anticipated that UC Merced will naturally seek to build a life sciences program that represents a significant part of the overall enrollment. Four UC campuses enroll approximately 15% of their total undergraduate population in the biological sciences (See Table below). UC Merced expects to track or exceed this number. 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 consonant with graduate enrollments at the smaller schools. However, we anticipate that life sciences will be well-represented in the graduate student body because of the relatively large fraction of faculty at UC Merced that is involved in life sciences research. We anticipate the percentage of graduate students enrolled in life sciences to track the figure for the UC Davis campus (17%).

The life sciences program at UC Merced will be attractive to incoming undergraduate and graduate students for three reasons: 1) Merced has a large number of faculty engaged in disease-related research who can prepare students for careers in the pharmaceutical industry, intellectual property law, medical school, and graduate programs. 2) Merced is developing an interdisciplinary approach to education that allows students to tailor their education to current employment opportunities. 3) Merced is local to the central valley, serves the interests of valley residents, and can provide an educational outlet to students who wish to remain in proximity to the valley, which is expected to be an area of unparalleled economic growth in the immediate future.

Assessment of the success of the undergraduate life sciences program at UC Merced will consist of metrics regarding the GPA and SAT scores of incoming students, the number of national and international fellowships (Goldwater, Truman, etc.) granted to undergraduates near the end of their studies, and finally, the graduation rate of undergraduate students. Average high school GPAs for students entering the UC system ranges from 3.46 (UC Riverside) to 3.79 (UC Berkeley) for Fall 2004 admissions. Because UC Merced is a new and unproven resource, we can anticipate that our incoming students will be on the lower end of the GPA scale. Likewise, we can expect to attract students with SAT II scores in the range of UC Riverside and Santa Cruz (see Table below). The obvious goal is to develop our program to the extent that we are able to raise the GPA and SAT II metrics with regard to incoming students. Overall cumulative graduation rates for UC are 38.9% after 4 years, 69.7% after 5 years, and 77.9% after 6 years. UC Merced would like to concentrate on increasing the proportion of students who graduate after

4 years. The overall flexibility of the biological sciences program should facilitate earlier graduation, since it is less likely that a change in the focus of studies would result in substantially more course work.

Assessment of the success of the graduate life sciences program is somewhat more difficult. GRE scores are some indication of student viability for a given graduate program, but recommendation letters and research experience are also key. The most important metric regarding the success of the life sciences graduate program is the proportion of students entering that attains a doctoral degree. Another important consideration is the number of students that gain post-doctoral appointments and employment in industry.

Table. Proportion of graduate and undergraduate students in the biological sciences.

Campus	Berkeley	Davis	Irvine	LA	Riverside	San Diego	Santa Barbara	Santa Cruz
Undergraduate	5%	17%	15%	15%	13%	15%	10%	5%
Graduate	6%	11%	7%	4%	16%	8%	6%	9%

Table. GPA and SAT II scores of incoming freshmen Fall 2004

Campus	Berkeley	Davis	Irvine	LA	Riverside	San Diego	Santa Barbara	Santa Cruz
GPA	3.79	3.66	3.64	3.75	3.46	3.73	3.63	3.66
SAT (writing)	613	585	574	600	539	599	584	575
SAT (math)	631	605	599	618	566	619	594	579

Strategic Initiative: Health, Infectious Agents, and the Environment

Proposed Program

We propose an interdisciplinary initiative in the area of **Health, Infectious Agents, and the Environment**. This effort would begin as a research focus that bridges between growing strengths in biological/biomedical sciences and Earth and environmental systems science. We propose to initiate this effort by developing strategic research associated with the interaction between environmental factors and infectious agents, particularly microbiological systems. This initial focus would serve to nucleate the research program. As this research area develops and grows, it may encompass a broad scope of topics within the framework of Health and the Environment, such as toxicology, evolutionary biology of disease, overlaps with air quality and water resources, and connections to SSHA in economics, policy, and social/behavioral sciences.

In its initial stages, we view this program primarily as a research vehicle, one that uniquely intersects our first two programmatic areas in Natural Sciences in a compelling interdisciplinary area. This initiative can be used to inform and focus faculty hires that would initially support existing undergraduate (Biological Sciences, Human Biology, Earth Systems Science) and graduate programs (Quantitative and Systems Biology, Environmental Systems) while contributing to this interdisciplinary area. As the initiative grows and takes form, it may engender new educational programs, such as a NSF IGERT program or new graduate group, and future undergraduate majors in areas such as environmental microbiology or toxicology, and perhaps larger centers or organizations.

Uniqueness and Signature

The signature of this initiative is to develop integrated, mechanistic research on the role of environmental and ecological factors on the emergence, transmission, and mutation of infectious agents associated with humans, animals, or plants. Although schools of public health and other biomedically oriented institutions are the traditional home of research in human diseases and pathogenesis, these institutions have not historically pursued lines of research that fully integrate environmental sciences, including geochemical, physical, and ecological analysis, into studies of disease and pathogens. Furthermore, recent National Academies reports (1-3) point out the often-weak links between public health and environmental research, ones that are not strongly grounded in addressing fundamental science. Much effort in the area of public health is focused on regulation, epidemiological studies, and mechanisms of disease in humans, while basic questions about the interaction of infectious agents with abiotic and other biological components of the environment is given little consideration.

> *We envision an interdisciplinary program that steps beyond a traditional human biomedical focus to examine fundamental, mechanistic questions about how a variety of pathogens are controlled by, and may also control, their local environment and ecology, and how these biotic-abiotic interactions may translate to larger impacts related to the transmission and dispersion of infectious agents. These pathogens may encompass a broad range of agents and environments, including bacteria, protozoan parasites, phages, viruses, and symbionts in soils, sediments, water, or air, and studies may span*

systems that include humans, animals, and plants. Examples of critical scientific issues that might be addressed include:

-- Environmental factors that influence genetic modification, evolutionary biology, and emergence of new microbiological pathogens
-- Mechanisms of pathogen radiation and dispersion at the molecular- and micro-scale, including intracellular processes and extracellular environmental exchange
-- Effects of climate change on pathogen and vector dispersal
-- Dynamics of air- and water-borne diseases
-- Environmental controls on the evolution of symbionts to and from free-living organisms
-- Metabolic and survival strategies of microorganisms in "extreme" environments (e.g., hydrothermal, cryogenic, desiccated, hypersaline, hyperacidic, hyperalkaline)
-- Role of habitat fragmentation and modification in pathogen emergence and dispersion
-- Role of invasive species and biological migrations in pathogen dispersal

The importance of this research focus as a critical emerging area is manifest in a number of agency reports and new funding opportunities. For example, a recent National Research Council (NRC) report (3) was devoted to the subject of disease and climate change, and enumerated the significant challenges and interdisciplinary nature of coping with the potential consequences of climate change on the spread of infectious diseases. The NRC report states:

"For instance, climate-related impacts must be understood in the context of numerous other forces that drive infectious disease dynamics, such as rapid evolution of drug- and pesticide-resistant pathogens, swift global dissemination of microbes and vectors through expanding transportation networks, and deterioration of public health programs in some regions. Also, the ecology and transmission dynamics of different infectious diseases vary widely from one context to the next, thus making it difficult to draw general conclusions or compare results from individual studies. Finally, the highly interdisciplinary nature of this issue necessitates sustained collaboration among disciplines that normally share few underlying scientific principles and research methods, and among scientists that may have little understanding of the capabilities and limitations of each other's fields."

The growing cost burden for health care associated with infectious diseases, the threat of bioterrorism, the increasing need for disease-free drinking water, and the economic impacts of pathogen-borne disease on agriculture are some examples where fundamental research on infectious agents and the environment connect to economic, social, and political impacts both locally and globally.

To initiate this effort, the School of Natural Sciences can capitalize on its unique assembly of faculty in biological and Earth systems sciences that use modern spectroscopic, microscopic, isotopic, genomic, and biochemical tools in the mechanistic analysis of intracellular, extracellular, and geochemical molecular processes. Through further strategic hires over the next five years, we can leverage existing and new faculty strengths to nucleate a synergistic group well poised to compete for external grants and to train students and post-doctoral researchers in an integrated way in this emerging field.

Funding Opportunities

A research initiative at the intersection of health, pathogens, and environmental sciences would be competitive for funding from a number of interdisciplinary programs at NIH, NSF, DOE, DOD, USDA, and other federal agencies. Examples include:

-- NIH "Exploratory Centers for Interdisciplinary Research"
-- NIH/NIAID "Biodefense and Emerging Infectious Disease" program
-- NIEHS Superfund Basic Research Program (changed in 2004 to an annual competition)
-- Interdisciplinary programs generated under NIH Roadmap Initiatives
-- NSF/NIH "Ecology of Infectious Diseases" program
-- NSF Global Change Research Program
-- Linking with LLNL in Department of Homeland Security grants

As a new interdisciplinary initiative, we would target research programs for small groups of investigators (~3-6) to create synergistic groups among biologists and physical/chemical scientists, and to establish a track record for UCM as a leader in this interdisciplinary field. As the program grows, we would be in a position to compete for larger program funding (e.g., centers, graduate fellowship programs).

To begin formulating a development plan, we are discussing obtaining funds for a workshop (from NIH and/or NSF) with invitees from academia, government, and industry to discuss recent and cutting-edge research and new opportunities within this theme.

Contributions to Educational Mission

In the first 1-3 years of this initiative, we propose to support existing undergraduate majors (Biological Sciences, Human Biology, Earth Systems Science) and graduate groups (Quantitative and Systems Biology, Environmental Systems) while building faculty strength that would contribute to research projects and collaborative funding within this area. As our faculty and research expertise grow, we would examine generating a new graduate group that would embody this focus (perhaps as a NSF-IGERT program or similar interdisciplinary graduate program). Faculty associated with this effort would teach in the existing undergraduate majors, but we anticipate the growth of either new emphasis areas in these majors or possibly the generation of new majors, depending on program evolution and student interest. Possible areas for development include:

-- Environmental microbiology
-- Comparative infectious diseases
-- Ecosystem toxicology
-- Plant biology and genomics

Contributions to the Region

As a research program than intersects health and the environment, we foresee the development of studies that address fundamental science while have local and regional benefits, specifically through the examination of local systems as models for general paradigms. Some potential examples include:

-- Supplying safe water through reservoir systems, from either water-borne pathogens or bioterrorism (e.g., Cryptosporidium)
-- Unique local and regional vectors (e.g., farming practices that favor mosquito proliferation and West Nile virus)
-- Changes in California climate and rainfall that may favor migration of malaria-carrying mosquitoes (e.g., Anopheles, already present in Mexico)
-- Mechanisms of hibernation, emergence, and transmission of soil infectious agents related to agricultural and human pathogens in California
    -- *Emergence of uncharacterized protozoa that infect fish, insects, immuno-compromised humans, etc., and potential emerging diseases (e.g., microsporidia).*

Synergy with Other Programs

This initiative serves as synergistic, interdisciplinary focus among our current growing strengths in cell biology/biochemistry, genomics, microbiology, geochemistry, soil science, and ecosystem science. Our common interest in the mechanistic understanding of processes at the molecular, cellular, and microscopic scales unites biological and physio-chemical research across the biotic-abiotic divide. Current faculty that would potentially contribute to this initiative: Miriam Barlow, Jinah Choi, Mike Colvin, Henry Forman, Jessica Green, Peggy O'Day, David Ojcius, Sam Traina. We also see links to biologists and geochemists at LLNL and LBNL. For example, there is a new biogeochemistry group at LLNL working on coupled biotic-abiotic processes in microbial communities that would be a natural partner.

This focus is a subset of the broader life sciences and Earth and environmental systems programs, and is complementary to other research areas under development. In particular, this initiative brings a health science aspect to water cycle and water resources research among all three schools and SNRI; it extends research in cell biology and genomics to an important environmental application; it would support and complement the development of a program in air pollution and resources; and it may serve as a unique signature program for the future development of biomedical research programs. Although our initial expertise and interest is more centered on the molecular and cellular scale, one extension of some of the potential lines of research noted above would be scaling to larger ecosystems and watersheds. This would serve to develop synergy in the areas of satellite-based remote sensing of ecological conditions, development of Geographic Information System (GIS) analytical techniques for ecosystems and infectious agents, or predictive models of disease emergence and transmission as a function of climate or environmental factors.

Another synergy to be developed is linkage to economics, public policy, and social sciences in the areas of public health and health care, and the environment and ecosystems. The fundamental science topics outlined above have obvious connections to the public, government, and industry in critical areas. A complementary effort with SSHA to develop faculty expertise in these areas would create a very strong program that could have both a science-centric side and an economics/policy-centric side.

Plan for Implementation and Growth

Our plan calls for strategic hires that fill existing gaps in our teaching and research needs while contributing to this interdisciplinary area. As noted above, we have a group of faculty that can nucleate this program, but we have identified key areas where new hires can bolster our efforts. We anticipate that 1-2 strategic hires per year in the following areas over the next 5 years would serve to support this initiative (see the table and discussion in the Earth and Environmental Systems initiative):

Plant biology/biochemistry: Biology and biochemistry of plants; genomics; evolution

Microbial pathogenesis: Microbial systems and disease

Organismal/conservation biology: Physiology, population dynamics, community ecology

Environmental/toxicogenomics: Ecological analysis of genes and genomes, either microbial or macrobiological

Environmental/ecological biochemistry/immunology: Natural products toxicology; biochemistry and immunology

Parasitology: Molecular, biochemical, and/or ecological parasitology.

These future hires would teach classes in biological and/or Earth system sciences where we are currently lacking faculty, and would contribute to graduate education in either QSB and/or ES initially. This list focuses on faculty needs that would most likely be housed in Natural Sciences, or possibly Engineering. Discussions should be held with SSHA to identify potential faculty hires in economics, policy, and social sciences that would support cross-school development of this program.

Opportunities, Assessments, and Milestones

The growth and success of this program rely initially on organizing current faculty around specific research projects and obtaining funding for interdisciplinary research. This could be facilitated by seed research money for graduate student or post-doctoral fellowships to work with faculty on new interdisciplinary projects. In addition to generating a research funding base, a milestone target within the next five years would be to establish a graduate group or IGERT-type graduate program in this area. This could potentially be a popular interdisciplinary graduate group, with applicants enrolling from biological or physical science undergraduate majors. Another goal is to develop a collaborative arrangement with researchers at LLNL, LBNL, and/or the Joint Genome Institute to support the growth of research, to help mentor students, and to serve on graduate student committees.

Space and Facility Requirements

We envision that typical laboratory facilities already in planning will be required for this initiative. The establishment of a genomic facility is a critical aspect. Those individuals working with infectious organisms will require class 2 biocontainment for much of their work.

References:

(1) From Source Water to Drinking Water. Workshop Summary, Board on Health Sciences Policy, Institute of Medicine of the National Academies, National Academy Press, Washington, D.C. 2004.

(2) Rebuilding the Unity of Health and the Environment: A New Vision of Environmental Health for the 21st Century. Workshop Summary, Board on Health Sciences Policy, Institute of Medicine of the National Academies, National Academy Press, Washington, D.C. 2003.

(3) Under the Weather: Climate, Ecosystems, and Infectious Disease. Committee on Climate, Ecosystems, Infectious Disease, and Human Health, National Research Council, National Academy Press, Washington, D.C. 200

Program in Mathematical Science at UC Merced

Content of proposed program

Description of mathematical science
We wish to develop a research program in mathematical science at UC Merced. Mathematical science, or applied mathematics is the study of analytical and computational methods to solve problems in social science, natural science and engineering. Hence, it is inherently interdisciplinary.

Mathematical science research involves four stages. The first stage is finding an interesting problem that may benefit from mathematical analysis. The second stage is developing an abstract model (*i.e.* a "mathematical model") that describes salient features of the problem. The third stage is applying existing analytical and computational methods or developing new methods to solve the mathematical model. The fourth stage is to determine what insight the mathematical model has provided to the original problem.

Different applied mathematicians emphasize different aspects of this description. Some emphasize modeling various systems while others focus on developing novel solutions methods, for example. Nonetheless, this description given above is a unifying framework to which all applied mathematicians adhere. The connection among this group is not necessarily common research interests. Rather it is a shared approach and attitude towards interdisciplinary research and forming multi-disciplinary. In other words, they are all mathematicians who work toward making discoveries in science.

Proposal for a mathematical science program at UC Merced
The description of mathematical science given above encompasses a broad variety of topics. This breadth is its most attractive feature. However, the key to this breadth is a solid foundation in the fundamentals of applied analysis. It is a demanding course of study. We propose here a research program for UC Merced that provides depth in the fundamentals of applied mathematics while allowing for breadth of study in other subjects within social science, natural science and engineering.

Graduate students in mathematical science must gain proficiency through coursework in advanced calculus, linear algebra, ordinary and partial differential equations, complex variables and numerical analysis. Other, more specialized courses include asymptotic analysis and perturbation theory, dynamical systems, integral equations and optimization. The success of this program relies on excellent courses in place that cover these topics. These courses are not entirely self-serving. Many other disciplines, especially the physical sciences and engineering, need these courses to train their students as well.

In addition to a solid foundation in the fundamentals in applied analysis, students must gain significant experience within another discipline. Therefore, it is necessary that this mathematical science program provides the flexibility needed for students to take enough courses in other areas so as to develop an application area. It is not sufficient for students to get only a light survey of another subject. They must learn their application area with nearly the same depth as a specialist in that area.

Comparisons with similar programs with UC

Nearly all applied mathematics and/or computational mathematics programs in the other UC campuses are programs or specializations within their respective mathematics department. One exception is UC Santa Cruz. They have an Applied Math and Statistics department in the Baskin School of Engineering that is separate from the Mathematics department in the Division of Physical and Biological Sciences.

Another one is the newly formed Computational Science and Engineering program at UC Santa Barbara. This is a joint program of mathematics, mechanical & environmental engineering, computer science, electrical & computer engineering and chemical engineering. This new and exciting program is a model for what we can build and develop at UC Merced.

At present we have an opportunity at UC Merced to develop mathematical science along side the other innovative programs in physical science, biological science, earth systems science, and computer science among others rather than after all of these programs are in place. This opportunity to develop mathematical science at UC Merced is one substantial way to build interdisciplinary research and education. Because applied mathematicians are trained to be interdisciplinary, they can act as one unifying group on campus who lead the charge for interdisciplinary research and education. Historically, applied mathematics departments and programs have developed after forming a traditional mathematics department[1]. This opportunity to build mathematical science at its onset can be a signature for UC Merced. Through the close ties that will surely develop with other scientists at UC Merced, applied mathematicians will contribute also in developing additional research programs.

Funding opportunities

Mathematical science is not as demanding for resources in comparison to the other research programs in natural science. Consequently, funding resources available are not as plentiful. Nonetheless, there are several institutional-level funding opportunities that the developing program in mathematical science may consider in the future.

One such program is the National Science Foundation (NSF) Grants for Vertical Integration of Research and Education (VIGRE). This grant requires a broad commitment from a team of faculty to develop the educational experiences of undergraduates, graduates and postdoctoral associates by increasing their interactions. This grant is part of the National Science Foundation's emphasis on enhancing the mathematical sciences workforce in the twenty first century. After an initial growth period, the applied mathematics program at UC Merced will be a good fit for this grant since both UC Merced and NSF-VIGRE are designed to prepare students and researchers to meet the challenges that we face in the twenty first century.

Also within the Division of Mathematical Sciences at the NSF, there is the Program for Collaborations in Mathematical Geosciences. This program enables collaborative research at the interface between mathematical sciences and geosciences. It is a good fit for a multi-disciplinary team of researchers in applied mathematics and environmental systems.

There is also a program joint between the Division of Mathematical Sciences, the Directorate of Biological Sciences at the NSF, and the National Institute of General Medical Sciences at the National Institutes of Health for research at the interface between mathematical sciences and biological sciences. This program is designed to facilitate research in mathematics and statistics related to mathematical biology research. It is a good fit for applied mathematics and what is being developed with quantitative systems biology and the center for computational biology.

These are just a few specific examples. Several more opportunities exist. More opportunities will open as the number of faculty increases.

[1] One notable exception is Rensselaer Polytechnic Institute (RPI). This primarily engineering school began with only the department of mathematical sciences which has a long-standing reputation for producing highly skilled undergraduate and graduate students.

Contribution to the educational mission

One of the key educational missions for UC Merced is to develop interdisciplinary programs. Mathematical science is inherently interdisciplinary. At its basis is fundamental analysis and methods in mathematics and scientific computation. These two general skill areas are useful for solving a broad variety of problems in social science, natural science and engineering.

The key to a successful mathematical science program at UC Merced is to have all participants in this program develop multi-disciplinary teams to tackle these problems. UC Merced's organizational structure to facilitate multi-disciplinary research and education is something this program can leverage immediately as a gain for its development and growth.

Even though a big component of this program is to form multi-disciplinary research teams, applied mathematicians are tied together closely as a group through a shared approach and attitude towards problem solving. Mathematical science uses the fundamental tools of mathematics to discover new aspects of our world. This approach to studying problems provides a solid foundation for a stimulating academic environment. Moreover, it is widely becoming recognized by other fields, especially biology, as one way to help meet the needs and challenges for science in the twenty-first century.

Contributions to the region

This program can contribute to the region in the short-term through K-12 educational outreach. Recent statistics show that California high school students have not been performing well on national standards tests[2]. Applied mathematicians are well-poised to help develop outreach programs for local teachers and students. Through applications to other interesting fields such as biology and environmental science, they can provide teachers and students motivation to study and develop mathematics skills.

This program can contribute to the region in the long-term through community and business outreach. A big part of mathematical science education is learning what problems are available to study. These problems are not limited to the university. Rather, there exist several potential mathematical problems within the community that students and researchers can study. A common part of many mathematical science curricula includes a clinic. In this clinic students and faculty work together towards a solution to a problem "donated" by a local business or industry. The development of such a clinic at UC Merced can facilitate the building relationships with people in the area. It also provides a situation for businesses and industries from the area to see student capabilities first-hand.

In the long-term, this program shall produce students well-versed in quantitative analysis and analytical reasoning. These students are well-poised to contribute significantly to community. As the community grows, it will invariably develop a demand for those who have these skills. This program at UC Merced will produce students with these skills to meet that demand.

Fit with existing programs with natural science, cross-schools and institutes

As mentioned above, this program is ideal also for connecting with several of the existing and developing programs in social science, natural science and engineering. Moreover, it is well-poised to interact closely with the Sierra Nevada Research Institute and the emerging Energy Institute, and Life Science Institute that includes the Center for Computational Biology. These connections are significant and impact directly education and research at UC Merced.

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[2] "Report Card on American Education: A state-by-state analysis, 1981-2003," American Legislative Exchange Council, 2004.

Historically, applied mathematicians have worked closely with researchers in physical sciences and engineering. Physical sciences and engineering have long adopted mathematical analysis and methods in their topics. It serves as the language through which physical scientists develop theoretical results and analyze experimental results. At UC Merced we anticipate strong ties with physical sciences and engineering. Moreover, applied mathematicians shall collaborate with researchers and students in the Energy Institute as it develops and grows.

In addition to physical sciences and engineering, mathematical science shall have an important role in biological sciences at UC Merced. Both the undergraduate major in Biological Sciences and the graduate program in Quantitative Systems Biology involve more quantitative reasoning and mathematical modeling than traditional biology programs. Applied mathematicians can impact directly the success of these programs through close collaboration and interaction with biology faculty in research and education.

There are no direct connections between faculty in mathematical science and environmental systems at present. However, this area of collaboration is rich with opportunities. For example, there are several, top-notch applied mathematicians that specialize in atmospheric science, porous media flow, geophysical imaging and remote sensing. Future hires in those and other relevant areas can participate actively in the Earth Systems Science and Environmental Engineering undergraduate majors as well as the Environmental Systems graduate group. Because this collaboration opportunity has such great potential, it is a specific target areas for future hires listed below.

There also exists potential to form collaborations with social science programs at UC Merced, most notably econometrics, management, public policy and cognitive psychology. These represent relatively new areas for interdisciplinary mathematics research. Nonetheless, the "open door" organizational structure at UC Merced facilitates exploring connections among colleagues that may become substantial collaborations in the future.

The business plan

We are currently recruiting up to two new faculty members in mathematical science.

The need for providing the fundamental coursework needed for this program drives the number of mathematical science faculty needed for this program. Faculty in mathematical science typically mentor two to three graduate students and one to two postdocs. Another key demand for hiring mathematical science faculty is to cover the growing demand for undergraduate mathematics courses to meet the tremendous growth of the student population over the foreseeable future. For these reasons we propose ten additional FTEs over the next five years among which at least one is dedicated for a senior faculty position. This proposal represents an estimate of the minimum number of FTEs needed to meet teaching needs to match the projected growth of students over the next five years. The new faculty must demonstrate excellence in research potential, growth and achievement. Some key target areas for research among future hires include the following.

1. Numerical analysis and scientific computing
2. Multi-scale modeling
3. Nonlinear analysis
4. Asymptotic analysis and perturbation theory
5. Dynamical systems
6. Fluid dynamics
7. Wave propagation and its applications
8. Mathematical modeling

9. Optimization

This list is not exhaustive. Nonetheless, these research areas overlap with each other and encompass a broad variety of application areas. For example, specialists in fluid dynamics are most likely specialists in numerical analysis and scientific computing. An important criterion in the hiring process is assessment of a candidate's potential for interacting with the other research programs at UC Merced. As we have mentioned above, we shall be seeking at least one future hire within the next five years that can interact closely with the Environmental Systems and the Sierra Nevada Research Institute as well as the emerging Energy Institute. We shall continue to seek excellent individuals that can help foster the growth of the Quantitative Systems Biology graduate group along with the Center for Computational Biology.

Projections of enrollments in NS courses

UC Merced Undergrad Numbers

YEAR	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Admitted Undergrads	**900**	**880**	**1104**	**1297**	**1797**	**1926**	**2208**	**2431**	**2775**	**2990**
Freshmen	800	704	883	1037	1438	1541	1766	1945	2220	2392
Sophomore	0	640	563	707	830	1150	1233	1413	1556	1776
Junior	0	0	512	451	565	664	920	986	1130	1245
Junior tranfers	100	176	221	259	359	385	442	486	555	598
Senior	0	80	141	586	568	740	839	1089	1178	1348
Total	900	1600	2320	3040	3760	4480	5200	5920	6640	7360
TOTAL Undergrad Target	**900**	**1600**	**2320**	**3040**	**3760**	**4480**	**5200**	**5920**	**6640**	**7360**
Total Undergrad Incr. for target		**700**	**720**	**720**	**720**	**720**	**720**	**720**	**720**	**720**
Total Grad Students	90	160	232	304	376	448	520	592	664	736
Total Students	990	1760	2552	3344	4136	4928	5720	6512	7304	8096
Overall Faculty at 20:1	50	88	128	167	207	246	286	326	365	405
Percent of Upper Division students who are transfers	1.00	1.00	0.41	0.34	0.38	0.38	0.34	0.33	0.33	0.33

Assumptions and Major Percentages

Assumptions

Using undergrad totals from John White
Graduate students will be 10% as a constant.
20% Attrition per year; replenishment of dropouts will be distributed into Freshman and Juniors with indicated ratio
All transfers will be as Juniors.

Freshman-Sophmore Retention	N/A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Sophomore-Junior Retention	N/A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Junior-Senior Retention	N/A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Percentage of Junior transfers	0.11	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Percentage of total students in NS Majors

Biological Sciences	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Human Biology	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
ESS	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Total	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26

Projections of enrollments in NS courses

UC Merced Undergrad Numbers

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TOTAL Undergrad Target	**900**	**1600**	**2320**	**3040**	**3760**	**4480**	**5200**	**5920**	**6640**	**7360**
Total Undergrad Incr. for target		**700**	**720**	**720**	**720**	**720**	**720**	**720**	**720**	**720**
Total Grad Students	90	160	232	304	376	448	520	592	664	736
Total Students	990	1760	2552	3344	4136	4928	5720	6512	7304	8096
Overall Faculty at 20:1	50	88	128	167	207	246	286	326	365	405
Percent of Upper Division students who are transfers	1.00	1.00	0.41	0.34	0.38	0.38	0.34	0.33	0.33	0.33

Assumptions and Major Percentages

Assumptions

Using undergrad totals from John White
Graduate students will be 10% as a constant.
20% Attrition per year; replenishment of dropouts will be distributed into Freshman and Juniors with indicated ratio
All transfers will be as Juniors.

Freshman-Sophomore Retention	N/A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Sophomore-Junior Retention	N/A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Junior-Senior Retention	N/A	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Percentage of Junior transfers	0.11	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Percentage of total students in NS Majors										
Biological Sciences	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Human Biology	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
ESS	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Total	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26

Numbers of students in NS Majors

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Biological Sciences	**108**	**192**	**278**	**365**	**451**	**538**	**624**	**710**	**797**	**883**
Freshman	96	84	106	124	173	185	212	233	266	287
Sophomore	0	77	68	85	100	138	148	170	187	213
Junior	0	0	61	54	68	80	110	118	136	149
Junior Transfer	12	21	26	31	43	46	53	58	67	72
Senior	0	10	17	70	68	89	101	131	141	162
Human Biology	**63**	**112**	**162**	**213**	**263**	**314**	**364**	**414**	**465**	**515**
Freshman	56	49	62	73	101	108	124	136	155	167
Sophomore	0	45	39	49	58	81	86	99	109	124
Junior	0	0	36	32	40	46	64	69	79	87
Junior Transfer	7	12	15	18	25	27	31	34	39	42
Senior	0	6	10	41	40	52	59	76	82	94
ESS	**63**	**112**	**162**	**213**	**263**	**314**	**364**	**414**	**465**	**515**
Freshman	56	49	62	73	101	108	124	136	155	167
Sophomore	0	45	39	49	58	81	86	99	109	124
Junior	0	0	36	32	40	46	64	69	79	87
Junior Transfer	7	12	15	18	25	27	31	34	39	42
Senior	0	6	10	41	40	52	59	76	82	94
Total NS Freshman	208	183	230	270	374	401	459	506	577	622
Total NS Sophomore	0	166	146	184	216	299	321	367	405	462

Total NS Junior	0	0	133	117	147	173	239	256	294	324
Total NS Junior Transfer	26	46	57	67	93	100	115	126	144	156
Total NS Senior	0	21	37	152	148	192	218	283	306	351
Total NS Majors	234	416	603	790	978	1165	1352	1539	1726	1914
Number non-NS students	666	1184	1717	2250	2782	3315	3848	4381	4914	5446
Number non-NS Freshmen	592	521	654	768	1064	1140	1307	1439	1643	1770

Parameters for NS Courses

Percentages in each Bio.Sci. emphasis										
Biol Sci-MCB	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Biol Sci-C&Devel	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Biol Sci-Bioinf	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Biol Sci-Immun	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Biol Sci-Evol Biol	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

%'s of non-NS Freshmen taking NS courses										
BIS 1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
BIS 2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BIS 3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BIS 50	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
BIS 51	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ESS 1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
ESS 5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ESS New GE A	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ESS New GE B	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ESS New GE C	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ESS New GE D	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Chem 1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Chem 2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Chem 8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Math 10	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Math 21	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Math 22	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Phys 8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Phys 9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum of NS courses per non-NS Students	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
B.S. &H.B. % Transfer in soph core courses										
BIS 100	1	1	1	1	1	1	1	1	1	1
BIS 110	1	1	1	1	1	1	1	1	1	1
Math 10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
%Calc1/Phys1 students in ICP	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
%NS Students taking Chem1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
%NS Students taking Physics8 as Freshman	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
%NS Students taking Physics9 as Freshman	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
%Freshman that need prep Math	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
%NS Majors taking Math22 as Freshmen	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Fraction of credit to NS from GE Core	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333

Projected enrollments

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Biology Core Courses										
BIS 100	19	155	149	184	226	292	318	361	401	451
BIS 110	19	155	149	184	226	292	318	361	401	451
BIS 140	19	33	139	135	176	199	259	280	320	350
BIS 141	19	33	139	135	176	199	259	280	320	350
BIS 180	12	21	88	85	111	126	163	177	202	221
BIS 181	0	10	17	70	68	89	101	131	141	162

Students in Biol. Sci. Emphasis courses	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
MCB	2	8	24	45	49	61	73	88	97	109

Cell & Devel	2	8	24	45	49	61	73	88	97	109
Bioinf	2	8	24	45	49	61	73	88	97	109
Immun	2	8	24	45	49	61	73	88	97	109
Evol	2	8	24	45	49	61	73	88	97	109
Biology Total Student-Courses	**100**	**1084**	**1601**	**1956**	**2529**	**2893**	**3379**	**3785**	**4279**	**4693**
Biology Total Student-Courses including Gen Ed	**618**	**904**	**1375**	**1690**	**2161**	**2499**	**2927**	**3287**	**3710**	**4081**
Math Courses										
Math 5	278	245	307	361	500	536	615	677	773	833
Math 21	295	259	325	382	530	568	651	717	818	882
Math 22	181	276	302	363	476	558	624	697	785	864
ICP	67	84	96	114	152	173	195	217	246	269
Math10	13	360	325	406	484	655	706	807	891	1013
Math Total Student-Courses	**834**	**1223**	**1356**	**1626**	**2142**	**2491**	**2791**	**3115**	**3513**	**3860**
Chem Courses										
Chem 1	122	107	134	158	219	234	268	296	337	364
Chem 2	326	287	360	423	587	629	721	794	906	976
Chem 8	166	182	215	255	345	385	436	483	548	596
Chem 10	0	166	146	184	216	299	321	367	405	462
Chem Total Student-Courses	**614**	**743**	**856**	**1020**	**1366**	**1547**	**1745**	**1940**	**2196**	**2398**
Physics Courses										
Physics 8	156	195	223	266	355	405	456	507	574	627
Physics 9	111	223	233	282	362	438	486	546	612	679
Physics Total Student-Courses	**267**	**418**	**456**	**548**	**717**	**843**	**942**	**1053**	**1186**	**1306**
NS General Ed Courses										
BIS 1	282	248	311	365	506	542	622	685	782	842
BIS 2	59	52	65	77	106	114	131	144	164	177
BIS 3	59	52	65	77	106	114	131	144	164	177
BIS 50	59	52	65	77	106	114	131	144	164	177
BIS 51	59	52	65	77	106	114	131	144	164	177
ESS 1	205	180	226	266	368	395	452	498	568	612
ESS 5	59	52	65	77	106	114	131	144	164	177

ESS New GE A	30	26	33	38	53	57	65	72	82	89
ESS New GE B	30	26	33	38	53	57	65	72	82	89
ESS New GE C	30	26	33	38	53	57	65	72	82	89
ESS New GE D	30	26	33	38	53	57	65	72	82	89
NS GE Total Student-Courses	**901**	**793**	**994**	**1168**	**1619**	**1735**	**1989**	**2190**	**2500**	**2694**
NS GE Core Course	**266**	**234**	**294**	**345**	**479**	**513**	**588**	**648**	**739**	**797**
Total NS Student-Courses	2982	4496	5557	6663	8851	10022	11434	12731	14413	15747
Total NS Student Units	11927	17983	22228	26652	35405	40088	45737	50924	57653	62989
Total NS FT Students	373	562	695	833	1106	1253	1429	1591	1802	1968
Target Ratio	17	17	17	18	18	18	19	19	19	19
Faculty for target ratio	**22**	**33**	**41**	**46**	**61**	**70**	**75**	**84**	**95**	**104**
Load for grad. teaching and mentoring	0.4	0.4	0.4	0.4	0.4	0.4				
Total Faculty Target	**31**	**46**	**57**	**65**	**86**	**97**				