UPDATE TO THE 2010-11 DIVISIONAL ACADEMIC PLAN

OFFICE OF THE DEAN

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Executive Summary

In 2001, the Division of Physical and Biological Sciences submitted an integrated academic plan with an ambitious vision for the sciences at UC Santa Cruz in 2010. The first decade of the third millennium has offered UCSC a rare and precious opportunity, at a time of very rapid campus growth, to imagine and build research programs that address the new environmental, health, and technological challenges facing California, our nation, and the world, and to design new undergraduate and graduate level instructional programs that will help our students engage with these challenges. Unfortunately, the early years of the decade also brought a deep economic downturn to California and the University that has made it difficult to take advantage of the opportunities afforded by growth.

Now, in 2005, the picture for the division is mixed. We have moved forward on several high-priority interdisciplinary projects, building the new department of Environmental Toxicology, expanding our activities in high energy and particle astrophysics, and developing several research focus areas under the umbrella of the Institute for Geophysics and Planetary Physics. New degree programs have been added in Applied Physics, Astrophysics, Ecology & Evolutionary Biology, Health Sciences, Marine Biology, Molecular, Cell & Developmental Biology, Neuroscience & Behavior, and Plant Sciences. Divisional enrollments have grown on pace with overall campus enrollments, and the number of graduate students has increased. External research sponsorship has also increased markedly.

These successes hide deep concerns. Between 2000 and 2004, there was no increase in the number of payroll faculty. The division, reasonably expecting faculty growth to accompany student growth, invested in new programs, causing important core programs to actually shrink as teaching workload soared. Morale is low among faculty who expected that their personal investments in planning and building new programs would be followed by resources and growth, and threats to retention and recruitment appear to be growing.

We now stand at the midpoint of the implementation window of the decennial plan. The opportunities for excellence that were outlined five years ago remain compelling, and UC Santa Cruz retains the flexibility, enthusiasm, and interdisciplinary instinct that could make this campus an innovative leader in a broader range of scientific research and in science education. We believe that it is not too late to make the serious investment of new resources that will be needed to build these programs, and that the investment — which, while not pain free, is within available resources — will within a few years leave the campus more secure financially and much closer to its institutional goals. However, we also believe that the division and campus are at real risk of rapid and significant harm if investment is further delayed. Stasis is not an option. The science division of 1999 was barely adequate for a campus 70% of our current size. It cannot indefinitely support the campus of 2011 or even that of 2006 without sacrificing, perhaps permanently, either the quality of our educational offerings or our research excellence.

The campus has reaffirmed its expectations for the size of the division in 2011. Here we reaffirm our plan for the shape of the division in 2011. It is time that we move to make vision into reality.

Stephen E. Thorsett
Interim Dean
Introduction

Divisional Overview

The Division of Physical and Biological Sciences (PBSci) comprises six comprehensive departments offering a full range of bachelor’s, master’s, and doctoral degrees (Ecology & Evolutionary Biology, Molecular, Cell & Developmental Biology, Chemistry & Biochemistry, Earth Sciences, Mathematics, and Physics); three smaller departments offering graduate degrees in interdisciplinary fields (Astronomy & Astrophysics, Environmental Toxicology, and Ocean Sciences); and one small graduate professional program (Science Communication). It is the principal home of four major organized research units (the Institute for Geophysics and Planetary Physics, the Institute of Marine Sciences, the Santa Cruz Institute for Particle Physics, and the University of California Observatories/Lick Observatory) as well as a number of smaller research centers.

By the standards of major research universities, including our sister campuses in the UC system, the PBSci division at UCSC is very small, numbering just 131 payroll faculty in 2004-05 (compared with 130 payroll faculty in 1999-00). Although the division has, by necessity, focused on a limited number of research areas, we have achieved remarkable success in size-adjusted measures: for example, in recent years the Institute for Scientific Information has ranked UCSC as the top US university in citation rates in both astrophysics and space sciences, and second in the physical sciences. Our faculty raised $50.9M in external contract and grant support, bringing $10M in indirect cost returns to support campus infrastructure and nearly $5M to support graduate education.

Our faculty teach nearly 3500 student FTE per year, with a student enrollment workload per faculty member second only to the Division of Social Sciences. Students in each of our majors have an option for a senior capstone involving original research, and the innovative and popular new biomedical major places all of its students into community internships. Last year, the division had 435 graduate students, awarding about 40% of the Ph.D. degrees on campus, and employed 165 postdoctoral scholars — more than 80% of campus totals.

Summary of the 2001 Divisional Plan

In 2001, what was then the Division of Natural Sciences submitted a ten-year academic plan outlining an ambitious but achievable expansion of our research program, structured around the broad theme of “service to society.” Building on a strong interdisciplinary tradition, the plan outlines research opportunities in three general areas: biomedical and health sciences, the study of regional and global environmental processes, and the development and application of new technologies to societal problems and to fundamental research. In each of these areas, the pace of advancement and change has created opportunities for a young, rapidly growing program to compete effectively against more established departments elsewhere, giving UCSC a real chance to build programs that will compete nationally, and each area is a high priority for external funding sources. Furthermore, in each area UCSC already has at least some focused programs that are recognized internationally for their quality, which can form the nucleus for broader programs of excellence.

Three key instructional objectives were also identified: to sustain current and develop new instructional programs to train leaders and innovators in our technological society, to continue supporting co-curricular activities, and to increase our enrollments through a variety of approaches.

As this document is intended to update, not replace, the earlier planning document, we will not repeat the extensive analysis that led to the identification of these objectives, but will focus primarily on changes in emphasis, on phasing and timing of our initiatives, on analyzing how our proposed programs are related to our current campus goals, and on proposed accountability measures.
It is important to understand that the 2001 plan was predicated on growth to about 200 payroll faculty FTE (and 213 budgeted FTE). Most of this growth was expected to occur by now (2005-06): an increase of 53 faculty FTE (a 37% increase in budgeted FTE) and nearly 30 staff FTE (19% increase), including 15 new clerical and professional support staff (15% increase) and 8 new research lab staff (29% increase). In fact, this growth has not occurred, even though the workload (as measured by undergraduate and graduate enrollments as well as by contract and grant activity) has increased as projected. Although the number of budgeted faculty FTE has grown slightly, the number of payroll FTE has not, and the number of divisional support staff has actually decreased in some areas because of budget cuts. (Because campus I&R funding is now distributed along with faculty FTE, rather than more directly with instructional or research workload, the failure of the division to grow is doubly challenging: the faculty are not here to teach the courses, and the I&R funds are not here to hire temporary academic staff in their place, nor support staff to help manage the workload.)

Nevertheless, despite the temporary setbacks, we believe that the strategy outlined in the 2001 plan remains sound. The current projection for the build-out size of the PBSci division, 207 faculty, will allow growth of the payroll faculty to about 186 FTE, within 5-10% of the 2001 assumptions.

Progress Towards Specific 2001 Planning Targets

The division made no progress between 2000-01 and 2004-05 at increasing its payroll faculty size, primarily because of space constraints and the difficult budget environment. Indeed, the total payroll FTE dropped from 138 to 131 faculty over this period, although the budgeted FTE rose from 153 to 162. As discussed at much greater length below, this has forced us to defer the great majority of the planned growth in new research areas, and has left several of our programs temporarily stranded well below critical mass. Nevertheless, with the promise that growth is coming, our existing faculty and staff made remarkable progress in advancing the division in some important accountability metrics that were specified in the 2001 plan.

Enrollment

The 2001 plan defined a target student-faculty ratio of 18.0, envisioning an increase from 2804 student enrollment FTE in 2000-01 to a total of 3618 FTE in 2010-11, when the division was projected to be at 201 faculty. In fact, more than 75% of this anticipated enrollment growth has already occurred, with the division reaching 3436 FTE in 2004-05, even as the number of faculty in the division actually dropped. The result was a surge in the student enrollment workload per payroll FTE by nearly 30%, with enormous impact on individual instructors.

Student workload FTE in PBSci grew by nearly a third over the last five years, even through the number of faculty decreased slightly. (Source: Instructional Load Summary)
PBSci has maintained its share of campus enrollments despite significant growth in the School of Engineering, and despite a substantial decrease in the divisional share of budgeted FTE. Both the number of students per budgeted faculty FTE and per payroll faculty FTE are higher than in any other division except Social Sciences. The average number of students taught per payroll faculty member has increased by about 30% over this period. (Source: Instructional Load Summary)

In addition, the division has a significant number of enrollments in courses offered during the summer. In summer 2005, there were a total of 1699 enrollments in PBSci courses, accounting for 30% of the total campus enrollments.

Graduate growth

The number of graduate students in PBSci rose from 368 in 2000-01 to 435 in 2004-05, corresponding to an increase from 2.7 enrolled students per faculty member to 3.3. The target set in the 2001 plan was 575 graduate students at the time we reached 201 faculty, or 2.9 students per faculty, so the division is far ahead of the required targets at our current faculty size. Our graduate enrollments now account for 15% of our student workload FTE, consistent with campus targets.

It is important to note that our 24% increase in graduate student numbers was accomplished with only an 11% increase in the number of budgeted teaching assistantships and a 9% increase in the actual numbers of TAs (because the division was forced to reduce the number of non-centrally funded TA positions during the budget cuts). This is a testament to the increased effort faculty have put into raising external graduate support (discussed below), and the success of our students at winning prestigious internal and particularly external fellowships. Unfortunately, because undergraduate enrollments have increased far faster than TA funding, the undergraduate workload per TA has significantly increased.

The number of graduate students in the division has increased significantly, even without faculty growth. Graduate student enrollments are now 15% of our total student FTE enrollments. (source: graduate enrollment numbers presented by P&B to AAC)
New instructional programs

The 2001 plan outlined a set of specific instructional programs being considered for implementation over the next decade. A number of these programs have already been established, and achieved significant success:

**B.S. degree in Health Sciences:** Approved for admission beginning fall 2003, Health Sciences is quickly becoming one of the most popular science majors. Two unique features distinguish it from other biology majors. First, students in the program must acquire fluency in Spanish and complete a course in medical Spanish (Spanish 5M). Second, students must complete an internship (Biology 189) in a community health care setting under the academic supervision of a faculty member. The internship program allows students to personally experience the issues facing health care providers, while engaging in meaningful community service.

**B.A/B.S. degrees in Neuroscience and Behavior:** The Neuroscience and Behavior major was approved effective fall 2001. It replaced the Psychobiology major; Psychobiology was phased out. Neuroscience and Behavior provides a more rigorous program than the former Psychobiology major and better prepares students for graduate work as well as for employment in the biotechnology and behavioral science worlds.

**B.S. degree in Plant Sciences:** The new major, approved for admission in fall 2001, clarified and formalized the existing “Plant Sciences Concentration” in Biological Sciences. The major provides a sound, fundamental background in plant science with the option to focus on one of several areas of specialization. This consolidation and restructuring of existing resources formed an infrastructure and cohesiveness among faculty in three departments. The new major also coincided with and supported programmatic changes being made at the Arboretum and resulted in more effective use of campus resources such as the greenhouses and the UCSC Natural Reserve.

**B.S degree in Applied Physics:** The major was approved for admission starting in winter 2004. Designed to prepare students for careers in industry, the program provides them with the necessary depth and breadth of physics course work as well as the technological and business background that is valued in the work place.

**B.S. degree in Physics (Astrophysics):** In response to strong student interest, the Physics Department established an undergraduate major in Physics (Astrophysics). The major was approved effective winter 2002. Partnering closely with the Department of Astronomy & Astrophysics in both the development of the major and delivery of the curriculum, the new degree program represented an upgrade to the existing Astrophysics pathway in Physics.

**M.S./Ph.D. degrees in Bioinformatics:** The Bioinformatics programs are administered by the School of Engineering with enthusiastic participation from the Physical and Biological Sciences via a memorandum of understanding. The departments of MCD Biology and Chemistry & Biochemistry provide regularly offered courses in support of these programs, and faculty from both departments participate as members of the program faculty.

Several of the programs envisioned in the 2001 plan are still under review. Graduate groups in biomedical science, materials science, and planetary science are all still the subject of active discussions, but no formal proposals have been made. No decisions have been made regarding the establishment of an undergraduate program in environmental health, nor in the Department of Ocean Sciences; neither is a divisional priority in the next few years. There is no longer any active discussion with the Humanities Division on their proposed program in Science, Medicine, and Technology studies, though PBSci continues to welcome the possibility of collaboration if the program remains a priority for Humanities.
Organized research programs

PBSci has three large, mature organized research units that have long provided considerable visibility and prestige to the campus. The oldest such unit that was established locally, the Institute of Marine Sciences (IMS), is a broadly cross-disciplinary organization supporting more than 50 campus researchers interested in marine research and facilitating interactions with many other research organizations around the Monterey Bay region. IMS scientists are involved in numerous research initiatives, including the Partnership for Interdisciplinary Study of Coastal Oceans (PISCO), a four-university collaboration funded primarily by the Packard and Moore Foundations. Other recent IMS highlights include the establishment with Moore Foundation funding of a Marine Microbiology Laboratory.

Actually predating the campus is what is now called the University of California Observatories/Lick Observatory (UCO/Lick). The only systemwide Multicampus Research Unit headquartered at UCSC, UCO/Lick develops and manages astronomical instrumentation and facilities for faculty on all campuses, including the telescopes at the historic site on Mt. Hamilton as well as the UC share of the twin Keck 10-m telescopes. Arguably the leading optical observatory in the world, UCO is centrally involved in planning and technology development for the Thirty-Meter Telescope, identified as the next national priority for ground-based astronomy. UCSC is the home of an NSF Science and Technology Center, the Center for Adaptive Optics (CfAO), as well as of the new Laboratory for Adaptive Optics. The work of the CfAO has established new interdisciplinary connections for UCO, including engineering faculty as well as biomedical scientists around the country working in vision research. Other current UCO projects include the construction of the 2.4-m Rocky Planet Finder telescope at Mt. Hamilton that will be dedicated to the search for terrestrial extrasolar planets.

The Santa Cruz Institute for Particle Physics (SCIPP) is affiliated with Physics. For 25 years, SCIPP has supported both experimental and theoretical research in fundamental high energy physics. It remains at the forefront in this area, with involvement in ATLAS, one of the two primary detectors for the Large Hadron Collider currently being constructed in Europe, and a leading group working on string theory, early Universe cosmology, and science “beyond the standard model.” SCIPP is also actively building interdisciplinary connections, having just delivered the primary detector for NASA’s next large satellite mission, GLAST, and established numerous collaborations in x-ray and gamma-ray astronomy. Researchers at SCIPP are also using their device expertise in collaboration with nanotechnologists and neurobiologists to study the function of the retina.

In addition to these “big three” research units, PBSci has a number of smaller research centers, such as the renowned Center for the Molecular Biology of RNA, that were described in the 2001 plan. It also participates in several new initiatives, including:

- The Institute for Science, Technology, Engineering, Policy, and Society (STEPS), was established in 2002 as an initiative of PBSci together with SoE and Social Sciences to foster interdisciplinary research in environmental science and to translate that research into innovative policy. STEPS has already had significant success in establishing and supporting interdisciplinary graduate education, and hosts workshops and lectures to bring researchers and policymakers to campus.

- The UCSC branch of the UC Institute for Geophysics and Planetary Physics (IGPP) was established in 1999-00. It includes four research centers: the Center for Dynamics and Evolution of the Land-Sea Interface, the Center for Origin, Dynamics, and Evolution of Planets, the Center for the Study of Imaging and Dynamics of the Earth, and the recently established Center for Remote Sensing.

- The Center for Biomedical Science and Engineering (CBSE), a joint initiative of PBSci and SoE, was established five years ago to promote interdisciplinary research in the study of genomic information and structural biology.

Resources

External funding is crucial to the division for support of research and of graduate education. In 1999-00, divisional faculty brought in $33.2M (processed through PBSci and UCO), against a “conceivable” target in the 2001 plan of $75M annually. Despite the grim budgetary situation, decreased faculty size, and greatly increased teaching workload, the dollar value of awarded proposals rose by a remarkable 53%, to $50.9M in 2004-05. Funding per faculty member ($390k/year) already exceeds the level needed to reach $75M of total divisional funding for a faculty of the size envisioned in the 2001 document. Over the last six years, the division and UCO have submitted an average of nearly 500 proposals per year, or about 3.6 each year per payroll FTE.

Direct contract and grant awards administered by the PBSci and UCO business offices.

Of course, the return of indirect costs is important both to the division and the campus, and by this metric our success has been even greater, with a 69% increase in awarded indirects over the five-year period, from $5.9M to $10.0M, equivalent to $77k total awarded per faculty member. Most of the indirect cost funds are returned to the campus and used for general campus priorities.

Awarded indirect costs have increased by 70% over the last five years.

Private support, particularly foundation support, has also been increasingly important to the division, as to the campus. Since fiscal year 1999-00, PBSci has received matches, pledges, and outright gifts totaling $69.2M, amounting to 46% of the total received over this period by the campus.
Donations to PBSci, including matches, pledges, and outright gifts.

**Areas of Significant Shortfall**

**Faculty hiring**

The most obvious shortfall from our 2001 plan has been in the area of faculty growth, and consequently in our progress towards goals relating to increasing our breadth of research.

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The table shows the number of filled ladder faculty positions in each department in 2000-01 and 2004-05, according to the divisional faculty profile prepared by Planning and Budget, together with two models for departmental growth described in the 2001 plan. Clearly, very little progress has been made in any area, and some departments (notably MCD Biology) showed decreases during this period of rapidly increasing enrollment. Some progress has been made in 2005-06, for example with three successful recruitments in MCD Biology and two in Earth Sciences, and we anticipate additional modest growth in 2006-07. Nonetheless, we will remain far behind anyone’s expectation for divisional size at this stage of the campus expansion.

**Staffing**

The 2001 academic plan projected a growth of 37 staff positions (23% growth), with the great majority arriving by 2005-06. About half of these positions were professional and clerical support, and a quarter were technical and lab support.

In fact, because of state budget cuts the division made very little if any progress on expanding the staff to handle the increased workload that came with enrollments. Division level support staff were cut, reducing support for our de-
partment staff, and some core technical support facilities were cut (e.g., the glass shop was closed). Recently, the centralization of business services and information technology has moved a significant number of staff positions out of the division. Although nominally the work was also transferred, the result was a substantial reduction in our divisional flexibility: relatively low-priority positions that were held open after budget cuts to fund higher-priority positions were transferred away along with the open provision money, and historical merit and equity adjustments were retained as a permanent future cost to the division even for the staff who were transferred away, leaving us no opportunity to recover salary savings on retirement or separation.

In the current funding model, I&R support funding follows faculty rather than enrollments. The result was a double blow to the division. Even as enrollments rose, our inability to hire faculty was compounded by an inability to hire departmental support staff, advisors, and others to cope with the increased workload.

Space
A major constraint on growth in the division in the last decade has been available space. Well-equipped laboratory space, both dry labs and wet labs as well as space for core and shared facilities, is essential for supporting growth. One of the greatest disappointments of the last half decade has been our lack of progress on advancing building projects quickly enough to provide necessary space for the division in the next decade.

It is important to remember that the last major growth building constructed on campus for the division was the Earth and Marine Sciences Building. This building was occupied in December 1993, giving a tremendous addition of wet lab space for our scientists. While the Interdisciplinary Sciences Building and CfAO have been completed within the last few years, there has been little net gain of asf for the division, as the division vacated approximately 10,000 asf of trailer space when the new Engineering 2 Building was sited.

The 2001 divisional plan expected the construction of three new buildings on science hill, totaling just under 200,000 asf. The first of these, the Physical Sciences Building (PSB), was expected to add 60,000 asf in 2003, and two additional buildings were expected to be completed by 2010.

In fact, PSB was substantially delayed and the other buildings both delayed and reduced in size. PSB is expected to open this year, but at opening only three research labs remain unassigned, providing little new flexibility to meet the division’s goals of investing in the expansion of the biomedical sciences. It is estimated that the division will only be able to accommodate another eight faculty in the biomedical sciences.

The next expansion space for PBSci will be the Biomedical Sciences building scheduled for completion in 2009, and then the Environmental Sciences building in 2013. The two buildings together total about 100,000 asf. As discussed below, this will be (barely) adequate for the projected size of the division at the end of this planning period, though without space for new research centers or the flexibility for optimal arrangement of interdisciplinary groups. And the building delays imply that space will be the primary limit on the division’s ability to grow rapidly to handle the enrollment growth that has already occurred, much less to take advantage of new opportunities. The division will not reach its target size before the middle of the next decade unless a way is found to significantly accelerate the Environmental Sciences building. Even completion of both buildings will leave the division short of growth space for new research centers or other research growth that outpaces faculty growth.

The Campus Charge for Revised Plans and Summary of Revision Process
On 30 August 2005, VPAA Galloway issued a call for revisions to the 2001 academic plans, requesting that each division “build upon and refine” its previous proposal. Each unit was asked to reassess its vision of where its disciplines would be in 2010-15 and to develop an implementation plan, given available resources, that would allow the disci-
plines to achieve those visions. PBSci was further informed, in a letter from CP/EVC Kliger on 16 November, that it could assume a commitment of 6 new faculty FTE in 2006-07, 6 in 2007-08, 10 in 2008-09, 11 in 2009-10, and 13.3 in 2010-11, bringing the total number of budgeted faculty in the division to 206.6.

With this charge and these constraints, together with the 2001 plan, Interim Dean Thorsett developed initial target size ranges for each unit, adjusting 2001 targets to allow for the somewhat smaller growth envelope, existing campus and divisional commitments to interdisciplinary groups, shifts in enrollment, and judgments about research opportunity and direction, with some adjustments after consultation with individual department chairs. Departments were asked to prepare revised departmental plans, which were collated together with white papers produced by ad hoc task forces studying biomedical science, materials science, planetary science, and coastal and marine policy, and with earlier reports generated in 2001. Several rounds of consultation with divisional department chairs focused on planning principles, and then on our specific hiring plan, and several additional meetings between the deans of PBSci and SoE, with additional faculty involvement, focused on the biomedical and materials science plans.

This document, then, reflects the plans and the priorities of the entire division, with significant cross divisional contributions, and it is the result of many hours of work by many people, particularly the department chairs, the task force chairs, and the staff of the Dean’s Office, not to mention those involved in the original 2001 planning document. Final judgment calls and priority decisions were made by the Interim Dean. We look forward to working further with the other divisions, the VPAA, and the CP/EVC to synthesize a comprehensive campus academic plan.
Divisional Goals

Reaffirmation of 2001 Planning Principles

The 2001 divisional planning document represents the result of years of departmental, interdepartmental, and divisional discussions about our scholarly aspirations. It contains a faculty hiring plan, a resource plan, and a summary space plan that together outline an ambitious but achievable path to a research vision comprising three primary focus areas where UCSC can achieve national and international distinction: environmental science, biomedical science, and advanced technology. It also includes growth in innovative instructional programs, and affirms a campus commitment to excellence through diversity of our students, our staff, and our faculty.

In 2006, we reaffirm the basic principles of our 2001 plan. Although there have been some changes in detail, driven by unforeseen research opportunities, unanticipated enrollment shifts, changing space plans, and other external factors, our overall image of the division in 2011 is remarkably similar, though with the slow start in faculty hiring our target year may now be closer to 2015. This document, then, is not a replacement for the earlier document, which remains our defining divisional plan. Our purpose is to summarize areas of change, and to provide clearer links to the campus goals that have more recently been articulated.

In this section, we summarize some of our own divisional goals. The next section contains the detailed hiring plan, which is our formal response to the call for an “academic plan.” The final section discusses how our divisional goals and our proposed implementation plan contribute to the broader campus goals. The main text of this document focuses on pan-divisional and interdisciplinary goals, plans, and activities. Department-by-department summaries of academic aspirations, contributions to campus and divisional goals, challenges, and proposed accountability are included in the Appendices. It is important that those summaries be understood to be a central part of this document, despite their placement at the end!

The Critical Need for Faculty and Staff Growth

Many of the divisional and campus goals for program quality, capacity, and resource generation are directly tied to the size of the departments in PBSci. As noted in the previous section, PBSci faculty now carry the second largest average enrollment workload on campus — a workload that has increased by 30% in the last five years. They also train the most graduate students, supervise the great majority of all postdoctoral scholars, write the most proposals, raise the most research and private funds, bring in the bulk of the campus’s indirect cost return money, and manage large and complex labs, center, and institutes.

Until last summer, essentially no growth had occurred in the size of the PBSci faculty for five years, implying that the important contributions that PBSci made to campus enrollment and resource goals was due only to the fact that our existing faculty increased their productivity by essentially every measure, while they and their departments deferred progress towards their academic aspirations. The 2001 plan envisioned over 200 PBSci faculty by 2011, and the target size CP/EVC Simpson proposed was nearly as high. Yet we remain far short of that target.

It is therefore with cautious optimism that we renew our planning efforts, with campus targets again just over 200 faculty. Growth in PBSci remains important to the division, and to the campus, for the progress it will allow us to make towards campus goals. But it has also become an imperative, as enrollment pressures have led to clear declines in instructional quality in heavily oversubscribed and understaffed classes and to increasing faculty calls for formal enrollment caps. Growth and, finally, progress towards our long-established academic goals is also imperative for the morale, and ultimately for the recruitment and retention of outstanding faculty.
**Goal (Divisional Growth):** The division will grow to 171 payroll faculty FTE by 2011 and 184 payroll faculty FTE by 2015. The division will grow to 206.6 budgeted faculty FTE by 2011.

**Goal (Departmental Growth):** The division will strategically increase department sizes to build and sustain quality.

**Goal (Quality Measure):** Every department in the division will be a “top quartile” program in the NRC rankings (or equivalent), and every department will have one or more focus areas that are distinguished nationally and internationally.

What is the right size for the science division at UCSC? There is, of course, no single answer to that question, but several lines of argument converge around 200 payroll faculty.

One method is bottom-up planning from the departments. This was done as part of the 2001 planning exercise, leading to a request for 211 faculty positions. Another is to argue from analogy, noting that a typical science division on our sister UC campuses teaches about the same fraction of the liberal arts and engineering students and comprises about a quarter of the faculty in those areas. Again, this leads to around 200 faculty for our projected build-out student numbers.

An interesting alternative is to try to start from our goals for the quality of our instructional and research programs, and to explore the relationship between these goals and program size.

Scientific research is, most typically, a collaborative activity. Teams range from small groups that may comprise a single student and mentor to large collaborations that may include dozens of investigators from a broad range of fields, each of whom brings a unique skill set and perspective to a problem. The importance of bringing science faculty together in central lab facilities was recognized even during the earliest days at UCSC, when most other faculty and instructional activities were dispersed among the colleges.

Even more important than enabling direct faculty-to-faculty interactions, achieving a core critical mass of active research scientists is crucial to the development of strong graduate programs, without which science cannot thrive. Most graduate students are admitted to a program, rather than to a particular advisor, and they are attracted to a program by the breadth of opportunity that it provides. For example, the decision a few years ago by Astronomy & Astrophysics to invest faculty FTE in non-optical astronomy was motivated in large part by the realization that having one of the world’s very finest optical observation and instrumentation groups was not enough for today’s students, who need exposure to the full range of modern techniques.

It is very difficult to quantify exactly what is meant by the phrase “critical mass,” although examples of bare minima in individual fields can be given. In the case of Astrophysics, a first-rate department certainly must have researchers familiar with observations in all wave bands, both analytic and computational theorists, and researchers working in each of planetary, stellar, and galactic astronomy as well as cosmology. MCD Biology departments need scientists working with each of the major model organisms, strength in structural and chemical biology, chromosomal biology and genetics, and neuroscience, and expertise with technologies from NMR and microscopy to microarrays and other tools of bioinformatics. And the same sort of tour could be done around any discipline, or indeed across any active interdisciplinary field. The key point is that scientists depend for their own work on the breadth and quality of their colleagues and collaborators, and graduate students depend on training and exposure to the full range of modern tools in their fields. Although UCSC originally built its outstanding reputation in the sciences through very focused,

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1 *Kenneth V. Thimann: Early UCSC History and the Founding of Crown College*, oral history project, 1997, Randall Jarrell
opportunistic hiring in a limited number of fields, that strategy is simply no longer tenable as scientific investigations become larger in scale and broader in interdisciplinary scope.

One way to attempt to quantify the importance of critical mass is to look at the National Research Council’s rankings of program quality. In the chart above, the average program size (measured in faculty FTE) is shown in each of four broad areas, broken down by quartile in “scholarly quality of program faculty.” Such an analysis must be taken with some caution, as large departments more often benefit in perceived quality from the presence of a few well-known researchers. However, the variation with program size is very striking. Of particular interest is the difference between fields, with a factor of only 1.4 in size separating the first and third quartiles in the Arts and Humanities, compared to a factor 1.8 in the physical and social sciences and 2.5 in the biological sciences. This is probably largely due to the differing importance of collaborative work in different fields.

In most cases, our current “mature” programs (excluding the very small Environmental Toxicology and Ocean Sciences) are comparable in size to average programs in the 3rd quality quartile. The exceptions are Astronomy & Astrophysics, which is near the top quartile mean for similar programs when the UCOP-funded Astronomer positions are included, and Mathematics, which at 17 faculty is smaller even than the 20 faculty member mean for 4th quartile mathematics programs. It is perhaps not altogether surprising that Astronomy was the highest ranked department in the division.

Of course, UCSC will never be large enough to compete in total faculty numbers with the largest UC campuses or other large public institutions. One possible strategy is to simply increase the fraction of faculty hired in the sciences. This is the approach taken, for example, by Princeton, which faces a similar challenge of building world class programs within a total faculty size of about 700: the math and physics departments there are both over 40 active faculty, while the MCD biology department has about 50. The price they have decided to pay is smaller departments outside the sciences, even though their students are even more heavily weighted than ours to the non-science fields.

Another strategy is the one we have used at UCSC: creative specialization in key fields of opportunity and encouragement of cross-departmental interactions to build the “effective department size.” This has worked extraordinarily well. Every one of our departments was ranked in the last NRC survey substantially higher than would have been predicted from their sizes alone. However, we must recognize that there are limits to what can be done in a small department: only two UCSC programs (Astronomy and Earth Sciences) were ranked in the top quartile (with MCD Biology just at the top of the second quartile). The unusual nature of our achievements can be seen by studying the

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detailed rankings. For example, only 6 of the 51 programs ranking above UCSC’s MCD Biology department were as small. Unfortunately, our MCD Biology department has further shrunk since those rankings were done — as low as 16 faculty as of last summer, though new faculty arrived last fall and this winter. Only three programs that small were ranked better: all wealthy private institutions (Harvard, Stanford, and Rockefeller), all with medical schools that increase collaborative possibilities. It seems deeply unrealistic to expect that our department can climb significantly higher without a substantial increase in size. Our physical sciences programs other than Astronomy and Earth Science were ranked in the second quartile, and our major biological sciences programs other than MCD Biology were ranked near the median.

To bring all of our existing programs (except Environmental Toxicology, Ocean Sciences, and Science Communication) up to the mean size for second quartile programs would require a total commitment of around 230 payroll FTE, or 255 budgeted FTE. If we “credit” all of the faculty in Environmental Toxicology and Ocean Sciences to other departments, to account for their contributions to “effective” critical mass, it would still require around 210 payroll FTE and 230 or more budgeted FTE to reach this second quartile size target. Although the numbers are rough, this seems to be a reasonable target if we aim to place all of our core science programs in the top quality quartile — an appropriate goal for a University of California campus. These numbers are still higher than we can expect to reach during the current planning period, but are certainly achievable under reasonable long-term growth models.

**Goal:** The division will use a portion of new permanent I&R resources to alleviate critical staffing issues that have arisen with program growth, and to support core research activities with broad impact.

The double challenge of state budget cuts at a time of soaring enrollments and significant growth of divisional research activity has left us understaffed in almost every area. Working conditions are extremely difficult in some areas hardest impacted by student growth, and the division has been unable to respond to sometimes urgent needs for technical and lab staffing, limiting, in some cases, our ability to expand into new research areas. Recently, we have seen some restoration of I&R funding, although much of the increase was used to offset the cost of business services centralization and to backfill permanent cuts taken against one-time fund sources.

With campus growth and the campus I&R distribution formula (as well as the expected Opportunity Fund growth), the division anticipates finally being able to make progress on critical staffing issues, particularly if the campus is also able to help address portions of our structural deficit. A first priority will be to cover the additional costs of instructional support in impacted programs. A second priority will be for support of key shared research facilities, with a preference to providing bridge funding for staffing in areas where a large NSF, NIH, or DOE Center proposal could eventually provide long-term infrastructure support.

**Strengthen Interdisciplinary Connections**

Each of PBSci’s three research themes — environmental and health sciences and advanced technology — is inherently multidisciplinary. The 2001 plan described rich cross-connections between departments, which have continued to inform departmental hiring decisions. Here we focus on just a few areas of particular divisional or campus concern.

**Biomedical science**

The life sciences at UCSC are loosely grouped into two broad interdisciplinary themes: the environmental sciences with a particular focus on environmental health, and the biomedical sciences with a particular focus on fundamental science questions of relevance to human health. Each of these areas addresses questions of profound importance for the people of California and globally, each is an area of great interest to students at all levels, and each is an area where UCSC has activities that have achieved international recognition and acclaim.
The biomedical sciences at UCSC are broadly distributed, with significant amounts of National Institutes of Health funding in PBSci, Engineering, and Social Sciences. In our division, essentially all of the faculty in MCD Biology are biomedical researchers, as are significant portions of Chemistry and Environmental Toxicology. In Engineering, the department of Biomolecular Engineering is entirely focused on biomedical research. There are also active faculty in many other departments across campus, notably Electrical Engineering, Physics, and Psychology.

In early 2005, the deans of PBSci and Engineering commissioned a task force to help prepare a coordinated plan for growth in the biomedical sciences, and CP/EVC Kliger and the Senate have since reiterated a request for a planning document. The task force issued an interim report in spring 2005, and a final white paper \(^3\) in late 2005 that inventories much of the existing research activity, identifies some of the resource challenges, and outlines some potential focus areas for future research. The white paper is not exhaustive. In particular, discussion of bioengineering is taking place primarily in the context of the academic plan for the School of Engineering, where most of the faculty growth in that area will occur.

Informed by the white paper and by departmental planning in both divisions, it is intended that the present document together with its counterpart from Engineering constitute our formal response to the administrative request for a plan for biomedical sciences. Here we discuss the interdisciplinary focus areas that have emerged as our priorities for establishing and sustaining areas of excellence in biomedical science at UCSC; we discuss the divisional part of the implementation plan below, in the context of our departmental hiring priorities.

Goal: The division, together with the School of Engineering, will coordinate hiring in MCD Biology, Chemistry & Biochemistry, Environmental Toxicology, and Biomolecular Engineering to sustain and strengthen three identified areas of research opportunity in the biomedical sciences: chromosomal biology and genetics, neuroscience, and structural and chemical biology.

Our focus areas for growth have been the subject of widespread discussion and consultation, and have been selected for the promise of true distinction given our existing strengths and our likely resources. They are:

**Structural Biology:** The groundbreaking work done by Harry Noller and the members of the Center for the Molecular Biology of RNA is internationally recognized — the brightest light in a small but very strong interdepartmental group based primarily in MCD Biology and Chemistry who use a variety of physical and spectroscopic techniques to determine the structure and mechanisms of biological molecules. Colleagues in Biomolecular Engineering bring additional expertise in computational methods of structure prediction. Core shared NMR and (new) x-ray facilities provide support.

Our aspirations in structural biology are three-fold: to sustain our existing areas of excellence, with renewal hiring that needs to occur before anticipated senior retirements; to extend our strengths with carefully targeted hires in closely related areas such as protein structure, and in emergent areas such as the biophysics of dynamic structures; and to connect our specialists in structure and chemical biology to scientists in biomolecular design, who include some of the expected hires in Biomolecular Engineering as well as faculty in Chemistry, Physics, or Engineering interested in biomaterials.

**Chromosomal Biology:** The general area of genome expression is central to some of the most pressing questions of modern biology — and also to some of our strongest existing groups. UCSC’s participation in the human genome project and related studies has made the bioinformatics group in Biomolecular Engineering one of the campus’s ma-

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\(^3\) Biomolecular Research at UCSC, Konopelski et al., 16 December 2005.
jor, and perhaps most widely recognized, strengths. In MCD Biology, our chromatin biology group (strengthened with two recent hires) ranks among the best on the west coast, and with a few additional recruitments we believe we have the opportunity to build one of the strongest chromosome groups in the United States. Both groups work closely with the structural biologists in the RNA Center.

Our most pressing needs in this area are to add faculty in epigenetics, the application of chromatin studies to disease, and to take advantage of the exciting opportunities of stem cell biology. Already, the campus has successfully competed for funding for a training grant in stem cell work, and a lab will be established as soon as space is available after the Physical Sciences Building opens. Bridge faculty working on the structural biology of gene expression will also help connect these two areas of research excellence.

Neurobiology: Neuroscience is a major research area in modern biology where many campuses have entire departments. We have chosen instead to build a neuroscience program as a strongly multidisciplinary effort, with faculty from MCD Biology, Chemistry, Environmental Toxicology, Physics, Electrical Engineering, Computer Engineering, and Psychology. Our core group of MCD Biology neurobiologists is small but distinguished, with one an Investigator of the Howard Hughes Medical Institute. Two additional recruitments are ongoing.

Our campus has two somewhat distinct aspirations in neurobiology. Our primary divisional goal is to strengthen our core group in neuroscience and vertebrate biology, which is not yet at critical mass, focusing first on neural development and cellular neurophysiology. Addition of a specialist in neural stem cells would take advantage of our local opportunities while helping to connect this group to stem cell scientists in the gene expression group, and addition of expertise in neurotoxicology will help connect, through the Environmental Toxicology department, the two major divisional themes: human and environmental health.

The second campus focus area is in application of neurobiology to bioengineering, and particularly to vision science. A major focus of Engineering is in the area of neural prostheses, and we have existing strengths in technologies important to retinal studies in both the Center for Adaptive Optics and in SCIPP. Although we expect that future growth of faculty whose primary interest is in these and related areas of bioengineering will take place in the School of Engineering, the planned growth in PBSci in neuroscience (and in structural biology) will allow us to continue to collaborate fruitfully with SoE faculty in applied bioengineering.

Goal: The division will provide curricular support for the School of Engineering initiative in bioengineering.

Along with their planned growth in bioengineering, it is our understanding that a significant goal of the School of Engineering is the establishment of an instructional program in bioengineering. Because we believe close connections between applied and basic biomedical scientists benefit our students as well as our research activities, PBSci supports this goal, recognizing that we are likely to carry a significant fraction of the service teaching load.

Goal: The division, together with the School of Engineering, will develop a graduate group in biomedical sciences or establish other mechanisms for support of interdisciplinary graduate study.

The interdisciplinary nature of modern biomedical research has led many institutions to reconsider their graduate curricula. A graduate group provides a structure within which student movement from one research area to another is eased, and can be much more attractive to prospective students than traditional “silo” department structures.

The 2001 plan identified the possible development of a biomedical graduate group as a divisional priority. Since that time, little progress has been made on campus in developing policy and practice that would allow such a group to be
easily established. Nevertheless, many of the advantages of a graduate group structure have already been achieved through the MCD Biology-sponsored rotation system, which includes participation by non-departmental faculty.

Formalizing the current structure continues to be attractive, however, both to allow more equitable use of block grant funds for participating students, and to allow better marketing of the program to prospective students.

Materials science

**Goal:** The division, together with the School of Engineering, will coordinate hiring in Chemistry & Biochemistry, Electrical Engineering, Physics, and possibly MCD Biology and Biomolecular Engineering, to strengthen its research focus in materials science.

External review committees for both the departments of Chemistry and Physics have identified the importance of strengthening and broadening our materials science programs at UCSC. The need is particularly acute in Physics, where a recommendation for growth in condensed matter physics from the 1998 external review panel was strengthened into an urgent call in 2005, with an admonition that “the stakes are high.” In both Chemistry and Physics, the need for growth in materials-related areas is largely being driven by local programmatic needs (including both overall enrollment growth and needed graduate program breadth). But as the review committees note, even with the expected levels of growth it will be desirable for the departments to work together with each other and the department of Electrical Engineering to reach a critical mass capable of expanding beyond single-investigator grants to large-scale center-level funding.

To help plan a coordinated effort, a task force was jointly charged by the deans of PBSci and SoE, returning a white paper in June, 2005, that summarized our existing strengths in materials-related science and technology and recommended a number of steps to increase interaction and collaboration between faculty in the three departments. There is now a consensus in the two divisions that bringing basic condensed matter science, materials chemistry and synthesis, and application development together in a limited number of areas of focus is the most promising way to establish a leading materials group at UCSC, and work is now underway to identify and refine several such areas for a proposal for an NSF Materials Research Science and Engineering Center in 2007.

One area identified for growth in collaborative research is biomaterials, where additional connections occur to the departments of Biomolecular Engineering, MCD Biology, and Environmental Toxicology, and to researchers in SCIPP. As an example, vision science is an area of considerable strength already at UCSC, which leads naturally to research in areas like the biotic/abiotic interface and to connections with the SoE nanotechnology initiative at NASA Ames.

**Goal:** The division, together with the School of Engineering, will consider the establishment of a graduate group or similar structure in materials science.

On many campuses, materials science would find a primary home in a department of chemical engineering. Given the wide distribution of materials scientists at UCSC, there is some belief that a graduate group would provide a useful umbrella organization to coordinate graduate education and facilitate collaborative research, possibly in conjunction with a MRSEC-funded research center. Given the small current size of the materials science faculty, planning for such a group seems premature, but a viable program might be possible and attractive within a few years.

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Planetary science

**Goal:** The division will strengthen its research focus in planetary science and provide attractive pathways for Ph.D. students in planetary science.

The 2001 divisional plan identifies planetary sciences as a key research focus area and a graduate group in planetary sciences as an instructional goal. The discovery in recent years (largely with UCSC-built instrumentation) of scores of extrasolar planetary systems, the renewed NASA focus on solar-system exploration, and planned facilities such as the *Space Interferometry Mission* and the *Terrestrial Planet Finder* have made this an exciting research area. UCSC has interested faculty in Astronomy, Earth Sciences, and Applied Math, and established strengths including the detection of extrasolar planets, planetary dynamics, planetary interiors, impact processes, and planetary climate modeling. UCO/Lick is currently constructing a $6.5M fully automated 2.4-m planet hunting telescope on Mt. Hamilton, and planetary scientists are actively involved in the successful NSF MRI high-performance computing proposal. This is an area of very high potential for prominence at UCSC on a short timescale, particularly if existing connections to scientists at NASA Ames can be strengthened and leveraged. The establishment of the Center for the Origin, Dynamics, and Evolution of Planets in 1999-00, as part of the Institute for Geophysics and Planetary Physics, provided a structure for collaborative planning, and a hiring plan was established through the campus initiative process, including seven new positions. About half the associated hiring has been completed, and the division intends to complete the expansion within the next few years.

The departments of Astronomy and Earth Sciences (which recently voted to renamed itself Earth and Planetary Sciences) have identified five key research focus areas where interdisciplinary synergies either already exist or can be developed given current faculty specialties and planned hires: planetary origins, using comparisons of the properties of extra-solar planetary systems to properties of the Solar System; the dynamical evolution of planetary systems; the structure and evolution of giant planet interiors; the geologic evolution of satellites, asteroids, and Kuiper Belt objects; and the emergence of life.

The development of one or more graduate pathways in planetary science remains a high priority. A graduate group is still a possibility, but in the short term the departments are designing an Interdisciplinary Research Program with planetary sciences tracks in both Ph.D. programs, requiring campus but not system-wide review. Pending Senate review, the programs may advertise as early as next fall for students entering in 2007. Even without a formal program, nearly 30 students a year interested in planetary science are applying to Ph.D. programs at UCSC, and the majority of accepted students choose to come to UCSC. Courses are cross-listed between departments, and cross-advising is common. Only a few new courses will be required for a full program (most notably an Overview course and the revival of Stellar Atmospheres). The goal within a decade is to fully compete with the best programs in the country (Arizona and Caltech), though we will never reach the size of the Arizona program, and to enroll about 20 Ph.D. and 10 M.S. students in steady state.

To help build cohesion and visibility for activities here, a group of faculty in Applied Math, Astronomy, Earth Sciences, and Physics have proposed the establishment of an annual graduate-level summer school in Santa Cruz, on mathematical methods, which they hope to begin on a small scale as early as next summer (2007).

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Particle and quantum astrophysics and cosmology

**Goal:** The division will strengthen our research at the boundary between particle physics and astrophysics.

Two of the most highly regarded research programs in the division are in astrophysics and cosmology (with faculty in Astrophysics and Physics), and in high energy particle physics (with faculty in Physics and additional researchers in SCIPP). The campus is therefore particularly well placed to exploit the boundary area of particle and quantum astrophysics and cosmology. Techniques and instrumentation from high energy physics is increasingly used (in orbit or on the ground) for study of very energetic radiation from astrophysical sources, as well as non-electromagnetic radiation (neutrinos and gravitational waves). Theoretical particle physics increasingly turn to cosmology to constrain theories that can’t be tested in the lab, and observations of dark matter and dark energy bind the cosmos to the accelerator.

A proposal to add faculty in this area was submitted as part of CP/EVC Simpson’s initiative process, and a commitment was later made by the campus to add four positions in Physics. Two positions have been filled: a theorist studying astrophysics and inflationary cosmology, and an x-ray observer and experimentalist who bridges between the gamma-ray detector group in SCIPP that has built the flight hardware for the Gamma Ray Large Area Space Telescope and the compact object scientists in Astrophysics. The division remains committed to adding an additional two positions to strengthen our research program in gamma-ray astrophysics, dark matter, dark energy, and cosmology.

Graduate students working in this area come from both Physics and Astrophysics, and the two departments have a good history of cross-advising and collaborative research. There are no plans for a separate graduate group.

Coastal and marine policy

**Goal:** Subject to further resource analysis and Senate review and approval, the division will establish a graduate program in coastal and marine policy, possibly in conjunction with either the School of Social Sciences or the proposed professional policy school.

A formal proposal is well along to create a graduate program in coastal and marine policy based on the need for both a sophisticated understanding of the role and limits of science in the policy process and an equally sophisticated understanding of the institutions and institutional processes necessary to resolve the coastal and marine problems we face today. Designed to train students and professionals with a variety of natural and social science backgrounds, the program would be inherently interdisciplinary. It would build on the strengths of several departments and research units, two academic divisions, and numerous co-located state and federal agency marine or coastal management and policy programs to further enhance the campus’s reputation in marine sciences and environmental sciences.

California is a coastal-dependent state, yet the economic value of its marine resources is largely under-appreciated. Concerns with the oceans, particularly the coastal oceans, will continue to increase in California, and practitioners are needed to work with regional, state, and federal agencies and programs to deal with these issues. Our coastal recreation and tourism, our fisheries and harbors, and our use of coastal lands and waters will continue to be key economic and environmental policy issues for California.

UCSC has as many as 20 faculty with related research and/or professional interests and another 18 faculty who might choose to affiliate with the program, thereby providing the physical and biological sciences coursework needed for such a program. Still, it is anticipated that three new FTE are needed with expertise in marine policy, management, planning, and/or economic disciplines.
Specific Instructional Goals

**Goal:** The division will increase our capacity for majors, service courses, and general education courses in proportion to campus growth

UCSC shares with the other UC campuses the fundamental responsibility to provide an outstanding education to the population of the state. Under the Master Plan, UC primarily draws its undergraduate students from the top 12.5% of graduating California high school seniors. It draws its professional and graduate students from across the country and around the world. UCSC reflects its “uncommon commitment” to undergraduate education through a strong commitment to disciplinary depth and rigorous breadth. PBSci shares with the campus a responsibility to expand our educational programs with the expanding population of eligible students.

Undergraduate enrollment patterns can be unpredictable and dynamic. Student interests vary strongly with perceptions of career opportunities and of the economic cycle, as well as with unpredictable fashions on a national and local level. Some trends are cyclical, while others follow long-term or permanent changes in society or the economy. The changing external perceptions of UCSC relative to its sister campuses in UC, as shaped by our publicity materials, the news media, and high school guidance counselors, can also drive the mix of interests among incoming students. PBSci departments serve undergraduate students in a variety of ways, with each seeing a different mix of majors and nonmajors. Some departments, including Astronomy & Astrophysics and Ocean Sciences, serve very large numbers of non-science majors, pressed by campus general education requirements and drawn by broad interdisciplinary introductory courses. Other departments, including Mathematics and Chemistry & Biochemistry, have very heavily subscribed service courses that are taken predominantly by students pursuing majors in other departments or divisions. Some departments, such as those in the Biological Sciences, have very popular majors that produce heavy demand on smaller advanced courses as well as on expensive lab courses.

In recent years at UCSC, cyclical fluctuations in student interest and longer term trends have both been swamped by sharp secular enrollment increases driven by the overall enrollment growth on campus. Between 1999-00 and 2003-04, the fraction of undergraduate enrollments served by the PBSci division has remained essentially fixed, moving from 22.4% to 22.3% of the total campus undergraduate enrollment. (Although it might seem surprising that PBSci has not seen a significant drop in enrollments during a period of rapid growth in the School of Engineering, we note that growth in SoE may actually increase demand on service courses in PBSci.) Because of campus growth, divisional undergraduate enrollments rose by 32.4% over the four year period. The fraction of head-count majors grew by 29.5% over the same period. Our current fraction of the total campus workload is near the systemwide average. We see no reason to believe that students at Santa Cruz are fundamentally different in their mix of interests than the general population of UC students, and we think it is reasonable to expect that PBSci undergraduate enrollments will continue to grow at least as fast as overall campus enrollments.

It is expected that PBSci, which has taught 30-33% of the summer enrollments over the last few years, will participate in campus efforts to raise summer enrollments. We will use a diverse strategy to achieve this, with expansion of our current general education offerings, as well as the addition of summer offerings in impacted gateway courses. In part to help with recruitment and retention of students from high schools without adequate advanced math and science curricula to fully prepare to embark on a science major, we would also like to expand our offerings in a “jumpstart” program of math and introductory science. Detailed planning for expansion of our summer curricula beyond a straightforward scaling of our existing programs must await further campus discussions on resources and on policies for ladder faculty participation.
The PBSci division seeks to provide students with a high level of direct involvement with research faculty, and to provide undergraduates the opportunity to participate in high-quality research, both important campus priorities articulated by the Millennium Committee and others. Every department also offers its students an opportunity to complete a meaningful capstone requirement in their major fields of study with a senior thesis, as recommended by the WASC review team (though some require students to qualify for the option). In fact, such research experiences are required for the Chemistry & Biochemistry and Physics majors. The new Health Sciences major requires students to complete an internship, and several departments have extensive field studies programs for undergraduates. A few of these programs are expensive, and all of them are time consuming for the faculty. As the number of undergraduate majors has increased by a third without corresponding faculty growth, it has become increasingly difficult to continue to offer these options.

A clearly articulated campus goal is a substantial increase in doctoral production. An increase specifically in advanced degrees in math, science, and engineering is a state-level goal, reflecting the importance of these fields to California’s economy, and annual reports on degree production in these fields is a condition of UC’s Compact with the Governor. In PBSci, graduate students are also valued junior colleagues in research labs, and important contributors to our educational programs.

Although Ph.D. enrollments will scale roughly with faculty numbers (and with external funding), it is unlikely that each program will grow proportionate to faculty growth. However, we expect that new interdisciplinary graduate initiatives (e.g., in planetary, materials, and biomedical sciences) will drive significant growth, and our overall number of Ph.D. students should scale to roughly 600–650 at build-out.

As important as increasing the numbers is to maintain and increase the quality of our applicant pools. Although our undergraduate students are primarily from California, it is important to our faculty, to our research programs, and to the State of California that we effectively compete nationally and internationally to attract the best students to UCSC. This will require us to ensure that our financial offers are commensurate with the local cost of living, and that we work with the campus and the UC system to overcome barriers to the enrollment of foreign students.

Increasingly, advanced work after the Ph.D. is a necessary part of the training of future academic scholars. In some fields, the complexity of front-line research requires additional training. In others, the opportunity for extended work in a different lab can help scientists develop crucial skills for interdisciplinary work, and postdocs can also bring valuable skills from other labs that improve the quality of our research programs. Very frequently, postdoctoral scholars are closely connected to graduate student training, developing their own teaching and management skills while providing high-quality graduate instruction.

The AAU has adopted the number of postdoctoral scholars as one proxy for institutional research activity. It is the intent and expectation that PBSci will increase the number of postdocs as the faculty grows.
**Goal:** The division will target new professional and pre-professional programs at the science/society interface.

Graduate enrollment in PBSci is, and will continue to be, focused primarily on doctoral and postdoctoral education. However, the division has an additional responsibility to engage actively with societal concerns. An example is our outstanding certificate program in Science Writing (within the program in Science Communication). Targeted at students with science degrees (usually advanced degrees), this program produces science journalists able to communicate important scientific issues and discoveries to the public. It is possible that a broader program could be developed in conjunction with the School of Public Media that has recently been proposed on campus. The need for scientific involvement in important public policy questions and debates similarly motivates our interest in developing policy connections, whether with a broad School of Public Policy, or a focused program in Coastal and Marine Policy.

Undergraduate training is also increasingly focused on innovative preprofessional preparation. The Health Sciences major is an example of a program designed to meet the core curricular needs of students interested in any of a number of medicine related professions, while also preparing the students to participate effectively in a multilingual state.

An important new initiative, emerging from the Compact with the Governor, is the California Teach program, aimed at producing 1000 new “highly-qualified” secondary school math and science teachers from across the system. At UCSC, PBSci is the lead unit in developing this program, working closely with the Senate and the Education department on curricular design. Although some details of the curriculum remain uncertain, as do some long-term budgetary questions, we are committed to the core goals of California Teach: to develop attractive pathways that allow science and math majors to complete both their primary major and the equivalent of an Education minor, giving them the core preparation for a teaching career. (It remains uncertain whether a fifth year master’s will be required, or whether UC will provide additional pedagogy instruction through, for example, summer programs.)

### Advance Diversity at All Levels

**Goal:** The division will improve our faculty diversity relative to the candidate availability pools.

Historically, science departments have been slow to achieve true diversity, as has been true at UCSC. The problems are complex and deeply rooted, and will not be successfully addressed by us alone. But we must do what we can.

In recent years, the division’s efforts have been modestly successful: 44% of the faculty hired in the past five years have been women and minorities. However, even though our under-utilization relative to availability pools shows a dramatic decrease from a shortfall of 21 women in 2001-02 to 8.7 in 2005-06 as well as a decrease from a shortfall of 6 to 1.9 members of minority groups in that same time period, the percentage of divisional faculty who are women and minorities has remained fairly constant at 18% and 15.5% respectively. This suggests problems with the reliability of the availability data. We therefore seek to not only improve relative to our candidate pools, but even more importantly to increase the number and fraction of faculty positions held by women and minorities.

We intend to work towards our goal as follows:

- We will maintain pipeline programs designed to enhance the diversity of future availability pools (as discussed in a later section).

- We will ensure our searches are done broadly with extensive outreach and ads written to attract individuals who will contribute to our diversity efforts, and by the dean’s active involvement in the review of outreach strategies and search materials and meetings with serious candidates.
• We will ensure the composition of search committees is diverse and includes members from more than one department to promote interdisciplinary hires whenever possible as well as providing committees and department chairs with the tools, training and resources necessary to achieve successful outcomes.

• We will strive to support competitive start-up packages and faculty recruitment allowances to assist with housing and childcare related expenses to the extent that is fiscally feasible.

• We will actively participate on committees and in campus efforts devoted to the critical housing, partner hire and compensation issues that currently face the campus. We believe that these are the primary factors hindering our success in faculty recruitments, especially with women and minority scientists for whom the recruiting environment is exceptionally competitive.

Of course, the division will require campus support to advance initiatives that address housing, compensation and partner hire issues and in providing sufficient resources to fund not only adequate but competitive start-up packages and infrastructure needs.

**GOAL:** The division will improve the climate for faculty and staff, paying particular attention to issues of special concern to junior faculty members and members of underrepresented groups.

The division welcomes the campus efforts this year to address climate issues. We look forward to working with the campus to identify initiatives and implement programs that will be informed by the fall forums and winter surveys conducted by the Committee on Affirmative Action and Diversity. Existing divisional efforts in this area, which will be continued and expanded, have focused primarily in three areas: an assessment of the climate for our women faculty; ways to reach out to and support our junior faculty; and, recognition of our faculty.

**Women in Science:** In spring 2003 the Dean commissioned a divisional survey of climate for ladder-rank women faculty; 18 of our 28 women faculty were individually interviewed. Interviews invited comments on a variety of issues including: job satisfaction, mentoring, work/life balance, perceived gender-related advancement, pay, and workload inequities, and recommendations for improving the climate and ways to help women scientists feel and be successful.

In spring 2005, a task force was convened to review relevant studies and literature along with the results of the survey and make recommendations of priorities for next steps to support the desired outcomes. Recommendations that have been implemented to date include:

• explicitly charging divisional assistant deans with oversight for aspects of faculty diversity, mentoring and divisional atmosphere;
• supporting the grant proposal to the NSF Advance Program that was prepared and submitted under the direction of Vice Provost and Dean of Graduate Studies Sloan;
• dean’s meetings with search committee and department chairs to ensure they have necessary tools, training and resources to seek out and attract candidates from underrepresented groups, including support for providing or requesting resources to bring additional candidates for interviews when doing so would further diversify the pool;
• dean’s advocacy with central administration to authorize recruitments earlier to enable greater opportunities for more extensive outreach, taking advantage of summer conferences, etc., and to ensure adequate time is available to negotiate partner hire arrangements when needed; and,
• provision of additional temporary academic staffing funds to departments to backfill for faculty requesting childbearing or parental leave or Active Service Modified Duties with the hope more faculty will feel they can take advantage of these benefits if doing so does not create a burden on their colleagues.

Additional recommendations were made, some of which require divisional action and some which require efforts at the campus level (e.g., housing, childcare and compensation issues).

While retention of our women faculty has not yet become a serious problem, it appears morale may be at an all-time low given the demands, especially on younger women scientists, to successfully balance their professional careers with personal demands. This has been exacerbated by the lack of faculty growth in the sciences in recent years resulting in a sharp increase in workload per faculty member as described earlier in this document. With the still small numbers of women and minority faculty, a greater burden falls to them in terms of mentoring women and minority students and colleagues, and with service commitments since their participation is necessary to ensure diverse representation on numerous search and senate committees. Contributing to these pressures is the difficulty in effectively stopping the tenure clock for a scientist, or indeed of taking leave at any point of one’s career: research grants and large laboratories have momentum that is difficult to interrupt without serious career risk, no matter how supportive one’s colleagues and University policy. Add lack of affordable housing and childcare facing young families, and the lack of campus policy to provide additional resources to help address these issues, and the barriers can seem daunting. Clearly, the division must continue to put high priority on the search for flexible and innovative mitigations if we are to ensure a diverse and successful faculty workforce.

**Mentoring Junior Faculty:** As a result of the 2003 divisional survey of women and the task force efforts last spring, a number of valuable recommendations were made for enhancing the climate and retention of all junior faculty. One activity that has been well received is the opportunity for junior faculty to meet with the dean in small group settings. At these informal sessions the dean is able to share information about the division and the campus from a broader perspective with the faculty encouraged to ask questions in any area of interest or concern.

A divisional goal for this year is to develop an orientation outline for new department chairs and research institute directors. A component of this orientation will address effective mentoring of junior faculty with attention paid to special challenges faced by women and minorities.

The division encourages department chairs and senior faculty to actively engage in mentoring opportunities with junior faculty. A more formal and coordinated orientation for new faculty across the division involving senior faculty could also be effective in promoting on-going mentoring opportunities.

**Faculty Recognition:** The division strives to routinely acknowledge our faculty for their special achievements and contributions. Announcements of awards and prizes are made regularly at meetings of our department chairs, directors and managers. The division cosponsors with the School of Engineering and the Science Library an annual event, “Honored Faculty, Honored Books” for all faculty who have been promoted in the past year. We have been successful in nominating several members of our faculty (and staff) to receive Excellence in Diversity awards for their significant contributions in mentoring students and for efforts in highly effective pipeline programs. We continue to encourage departments to address in personnel reviews faculty efforts to enhance diversity on our campus and in their fields.

The divisional development office is charged with working together with the dean, chairs, and faculty to nominate our faculty for prestigious and high profile external awards when appropriate.
**GOAL: The division will develop a staff and faculty leadership team that reflects the diversity of the division.**

The division currently has two women serving as department chairs (out of nine) and three women serving as directors of our research programs (out of ten). It is expected that the number of women serving as chairs next year will be three. Divisional academic departments and research institutes are all administratively managed by women and three women serve as assistant deans. The majority of our business units and auxiliary programs are also administratively managed by women. Two important goals are to strive to increase both the ethnic and gender diversity of our divisional leadership team and to ensure all chairs, directors and managers embrace diversity, fairness, equal access, and demonstrate a commitment to build a supportive academic community. Achieving this will require dedicated efforts in the areas of education, training, and mentoring to prepare individuals for these roles as well as instituting mechanisms to assure meaningful acknowledgment and tangible support that will enable already overburdened faculty and staff to participate effectively in these leadership efforts.

**GOAL: The division will continue to support co-curricular programs with an established record of enhancing the diversity of our student population, and will support development of new programs.**

Faculty and staff in PBSci continue their commitment to a variety of programs in support of undergraduate excellence and student access and success. The programs, their faculty sponsors, and the staff coordinators all share the common goal of contributing to student aspiration, motivation, and learning within the sciences. The division is committed to sustaining our current level of support for these programs.

Our largest direct financial commitment is to the Academic Excellence Program (ACE), a well-established and nationally recognized program designed to increase the diversity of graduates in math and science. ACE offers workshop-style discussion sections and academic peer mentoring for math and science courses, combining collaborative learning techniques with high expectations, enhanced content, and personalized guidance.

The NIH-funded Minority Access to Research Careers and Minority Biomedical Research Support programs give targeted minority students an opportunity to gain experience in laboratory research and to interact more closely with the world of academic science.

The California Alliance for Minority Participation is part of a statewide NSF-funded program providing cooperative learning opportunities, internships, faculty-mentored summer research experience, and travel opportunities to professional conferences to support and encourage undergraduates from underrepresented minorities to complete the B.S. degree in science, math, or engineering.

The Department of Chemistry & Biochemistry administers the Summer Undergraduate Research Fellowship Program. As NSF Fellowship recipients, undergraduate students first study a research problem and then learn the necessary techniques or strategies to vigorously pursue the problem, interacting with graduate students and postdoctoral fellows during the summer program.

The state-funded UC LEADS program is administered through the Division of Graduate Studies for educationally or economically disadvantaged undergraduates studying science, math, or engineering who are likely to succeed in graduate school. Activities include undergraduate mentorship, academic career planning and development of research skills, a summer research program, involvement in professional and scientific societies, and travel opportunities.
In cooperation with the School of Engineering, the division cosponsors membership in MentorNet, an e-mentoring network to enhance diversity in engineering and science, addressing retention and success of students, postdocs, and early career faculty.

Faculty also participate in K-14 educational outreach programs. The pre-college residential California State Summer School in Mathematics and Science, administered by the Educational Partnership Center, gives high school students access to the laboratories of UCSC scientists and engineers via short courses in astronomy, earth sciences, mathematics, ocean sciences, etc., subjects not traditionally taught in high school.

The Mathematics, Engineering, Science Achievement Schools Program, also administered by the EPC, works with teachers in Santa Cruz, Monterey, and San Benito counties to develop academic and personal skills, raise educational and career expectations, promote success, and instill confidence in the MESA students. The majority of students served are Hispanic, economically and educationally disadvantaged, and with limited career expectations.

The SCIPP K–12 Outreach Project is an initiative to strengthen the scientific background of K–12 teachers of science, focusing on science and curriculum questions with teachers in the San Francisco Bay and Monterey Bay regions. The program also sponsors various fun physics-related on-site demonstrations at schools and events.

A partnership between UCSC and four community colleges (Cabrillo, Gavilan, Hartnell, and Monterey Peninsula College), the ACCESS Program (Baccalaureate Bridge to the Biomedical Sciences) is designed to increase transfer rates of underrepresented students. The program includes study sessions for science courses, seminars and workshops, lab tours at UCSC, and a summer internship program at UCSC.

The Center for Adaptive Optics runs an active outreach program that has been ranked as among the best in the nation by the NSF reviewers of this Science and Technology Center. A hallmark of their programs is the training of graduate students in advanced experiential learning techniques. In addition to programs for local high school and community college students, CfAO sponsors programs at Maui Community College serving Native Hawai’ian students.

The Monterey Bay Area Mathematics Diagnostic Testing Project is one of ten regional sites in California (sponsored by the California Academic Partnership Program) offering local middle school and secondary teachers free mathematics achievement, diagnostic testing and analysis services for their students. The UCSC site serves North Monterey and Santa Cruz counties with tests designed to assist teachers in measuring student readiness for a broad range of mathematics courses.

The Monterey Bay Area Mathematics Project is one of 17 sites of the California Mathematics Project providing professional development opportunities for teachers of mathematics in grades K-14 by enhancing their subject matter preparation and teaching strategies; it serves Monterey, San Benito, and Santa Cruz counties.

**Development of Non-State Resources**

The development of non-state funding has been identified as a critical campus goal if we are to achieve our ambitious scholarly and instructional objectives. Direct support for research, student support, and indirect cost recovery to fund campus infrastructure are all areas where PBSci is already having significant success, but it is important that we continue to augment our non-state resources.
**GOAL: The division will increase extramural contract and grant income proportionate to faculty growth.**

Direct support for research is not by itself a direct proxy for research quality; just as differences exist between the sciences and other disciplines in both the availability and need for funds for research, so there are significant differences between and within the science departments in funding levels and needs. It is possible in some fields to do world-class research without a large budget. Nevertheless, when averaged across departments and the division, funding (particularly federal funding) is a useful metric that is related to national and peer-review priorities and to scientific productivity. Furthermore, external research funding is critical to supporting our graduate and postdoctoral students, and increase of these populations is a goal of both the campus and the state.

The faculty in PBSci, as noted above, are currently responsible for about $50M in external contract and grant funding. Further increases will depend on faculty growth in two ways. First, it is reasonable to assume a proportionate increase in research activity and funding as the faculty grows, at least with some allowance for the changing seniority demographics. Second, the approach to critical mass in departments and interdisciplinary groups makes it possible to further leverage the development of compelling center-based proposals, similar to the Center for Adaptive Optics (funded as an NSF Science and Technology Center). This is true for traditional centers, as well as for Integrative Graduate Education and Research Traineeship grants, and grants for major shared research instrumentation.

**GOAL: The division will increase indirect cost returns proportionate to faculty growth.**

In addition to direct research support, external research funding produces a stream of indirect cost return funds that can be used to support any of the campus’s high priority goals. The reason for that deserves explanation, as it is certainly true that funding agencies do not fully fund the true indirect cost of research. However, the importance of research to the core mission of the University has led the state to subsidize research in a variety of ways, including through construction of lab facilities. The net result is that federally funded research provides not just direct support of research and graduate education, but also a flow of unrestricted money that can be used for general campus priorities. After 6% of funds are held at UCOP for system-wide initiatives, and 20% of the rest (“Off the Top funds”) set aside towards the costs of research administration, about three quarters of awarded indirect dollars arrive on campus as either University General Funds (the greater portion) or Opportunity Funds (the lesser portion). Although some fraction of OF dollars are returned to the division or to the Office of Research to support the costs of research, the remainder as well as all of the UGF dollars are held for campus priorities.

The divisional goal of increasing these funds as a way to build research infrastructure is therefore in close alignment with the campus goal of increasing flexible non-state funds.

**GOAL: The division will increase external support for graduate and postdoctoral education.**

If the campus goal is to increase our doctoral degree production, we must carefully consider how these students will be supported. There will be some increase in teaching assistant support as undergraduate enrollments rise, but the first priority for TA funding must be to support the undergraduate teaching effort rather than to subsidize graduate education. Increases in fellowships are also important, but private funding growth is likely to be slow, and campus funding for graduate fellowships comes at the expense of other priorities. Significant growth is likely to occur only with significant new sources of flexible funding, as from indirect cost returns. (This point is discussed further below.)

The most straightforward way to increase graduate enrollments is to raise external funds for graduate student researchers. Already, nearly $5M per year is raised by PBSci faculty for this purpose — close to the total campus budget...
for block fellowships, Cota-Robles fellowships, and Dean’s and super-fellowships combined. Further increasing this funding will be key to meeting campus and divisional goals.

**GOAL:** The division will increasingly focus private development efforts on infrastructure development, research support, and graduate and postdoctoral fellowship opportunities.

As the state funding climate becomes more challenging, it will be increasingly important that we develop private funding sources for capital projects and for support of our research enterprise. Through the Cornerstone Campaign, the campus has been making significant strides in raising scholarship funds for undergraduates. Now it is important that both the campus and the division step up to the challenge of raising funds for other institutional priorities. We believe that the PBSci division, with its research themes focused in areas of intense societal interest and with its strong and growing faculty, has a compelling message to share with potential partners and supporters.
Hiring Plan

Summary and General Principles

**PRINCIPLE:** The division will invest faculty FTE with the primary objective of building and sustaining programmatic excellence. Considerations will include graduate program size and quality, funding opportunities, and record of accomplishment. Curricular needs, particularly for core major and service courses, will also be considered, but enrollment levels are not a primary factor.

**PRINCIPLE:** The division will use temporary academic support funds, rather than permanent FTE, to ameliorate mismatches between department size and instructional needs, and to balance short-term enrollment fluctuations.

Because enrollment is only one of many factors determining department size, there is no expectation that ladder-faculty/student ratios will be balanced between departments, nor that departments will gain or lose faculty in response to student enrollment trends. The division has implemented new formulae for the distribution of flexible TAS funds to help offset enrollment imbalances, and intends that an increasing fraction of TAS funding be spent for this purpose. TAS funding is also used for lab sections and courses such as introductory math where pedagogical or resource issues make it advantageous to employ lecturers rather than ladder faculty.

**PRINCIPLE:** The division will explore the use of Lecturer SOE appointments when appropriate as an alternate to Lecturer appointments for long-term needs.

PBSci currently depends on a number of excellent continuing Lecturers to deliver labs and certain other introductory courses (particularly in Mathematics). When such courses are expected to be permanent parts of the curriculum, the Division will discuss with departments whether soft-funded Lecturer appointments or hard-funded Lecturer SOE appointments are more appropriate.

Outline of Proposed Growth and Phasing

**GOAL:** At build-out, the division anticipates departments reaching the following size ranges, with the average department reaching approximately the midpoint of the range.

<table>
<thead>
<tr>
<th>DEPARTMENT</th>
<th>2001 SIZE</th>
<th>2011 SIZE (PROJECTED)</th>
<th>BUILDOUT SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy &amp; Astrophysics</td>
<td>7 (+2.4 UCO)</td>
<td>9 (+2.8 UCO)</td>
<td>10-11 (+2.8 UCO)</td>
</tr>
<tr>
<td>EE Biology</td>
<td>15</td>
<td>20</td>
<td>22-26</td>
</tr>
<tr>
<td>MCD Biology</td>
<td>19</td>
<td>26</td>
<td>28-32</td>
</tr>
<tr>
<td>Chemistry &amp; Biochemistry</td>
<td>20</td>
<td>27</td>
<td>27-31</td>
</tr>
<tr>
<td>Earth Sciences</td>
<td>18.5</td>
<td>21</td>
<td>22-25</td>
</tr>
<tr>
<td>Environmental Toxicology</td>
<td>4</td>
<td>9</td>
<td>7-10</td>
</tr>
<tr>
<td>Mathematics</td>
<td>16</td>
<td>20</td>
<td>19-20</td>
</tr>
<tr>
<td>Ocean Sciences</td>
<td>7</td>
<td>10</td>
<td>11-12</td>
</tr>
<tr>
<td>Physics</td>
<td>17.3</td>
<td>22.5</td>
<td>22.5-24.5</td>
</tr>
</tbody>
</table>

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Note: 2.8 UCO FTE = campus share of 14 Astronomers with 20% Professor appointments
It has been requested that we outline growth positions by year, including subdisciplines. Our current best estimate is as follows, subject to uncertainties discussed in the next section:

2006-07:
1. Astronomy: Planetary/computational
2. MCD Biology: RNA biology
3. Chemistry: Organic chemistry
4. Chemistry: Physical chemistry/materials
5. Earth Sciences: Geobiology/paleobiology
6. Physics: High energy/particle astrophysics

2007-08:
1. EE Biology: Evol. dynamics/species interact.
2. MCD Biology: Vertebrate MCD biology
3. Chemistry: Organometallic chemistry
4. Env. Tox.: Environmental chemistry
5. Math: Numerical analysis
6. Ocean Sciences: Physical or biochemical oceanography

2008-09:
1. Astronomy: Planetary/observational
2. EE Biology: Evol. theory/mathematical bio
3. EE Biology: Ecol. dynamics/species interact.
4. MCD Biology: Structural biology/biophysics
5. Chemistry: Structural biochem/biophysics
6. Chemistry: Computational biomolecular chem
7. Earth Science: Planetary atmospheres
8. Env. Tox.: Molecular toxicology
9. Physics: High energy/particle astrophysics
10. Physics: Condensed matter experiment

2009-10:
1. Astronomy: First light/galaxy assembly/ISM
2. EE Biology: see note 1
3. MCD Biology (2): see note 2
4. Earth Science: Surface processes
5. Chemistry (2): see note 3
6. Env. Tox.: Pathogen transmission
7. Math: algebraic geometry
8. Physics: condensed matter theory
9. (C&MP): see note 4

2010-11:
1. EE Biology: see note 1
2. MCD Biology (3): see note 2
3. Chemistry (2): see note 3
4. Earth Science: biogeochemistry or planetary
5. Env. Tox.: Microbial biodegradation of organic contaminants
6. Math: Low-dimensional topology
7. Ocean Sciences: Physical or biochemical oceanography
8. Physics: condensed matter experiment
9. (C&MP, 2): see note 4

Note 1: Priorities for EE Biology after 2009 include behavioral dynamics of species or species interactions; evolutionary biology; physiological ecology; ecology; and behavioral biology.

Note 2: Priorities for MCD Biology after 2009 include cancer biology, RNA biology, developmental biology, cell biology, and structural biology or biophysics. At least two positions will be in some aspect of stem cell biology.

Note 3: Priorities for Chemistry after 2009 include theoretical physical chemistry, biochemistry, neurochemistry, and natural products.

Note 4: Positions in 2009-10 and 2010-11 for Coastal and Marine Policy are contingent on divisional approval of the pending resource plan and Senate approval of the curricular plan, and will most likely require additional resources from the campus. It is expected that C&MP would be administered by an existing department (most likely EE Biology or Ocean Sciences), and these appointments would be made in the host department.
In addition to these growth positions, we expect to fill a small number of retirement or separation replacements, including (in 2006-07) positions in EE Biology (evolutionary or ecological physiology) and Env. Tox. (molecular toxicology), and in subsequent years possibly positions in Math, Ocean Sciences and Astronomy (including UCO Astronomer positions). However, except in cases of unusual programmatic urgency, retirement positions in departments that are otherwise growing will be deferred to accrue salary savings to support start-up, and in some cases retirement positions will be reserved for growth after 2011 in fields (particularly EE Biology) that cannot reach their desired size earlier because of space limitations. Space constraints also account for the back-loaded hiring in MCDB. Our retirement models indicate that the above hiring plan will bring the division to approximated 171 payroll faculty in 2011, with above 14 vacant positions to be filled by 2015 and an additional 21 positions (10% of total) permanently held as divisional reserve to support temporary academic staffing. A significant fraction of the reserve is committed to long term TAS needs in Math.

The Need for Flexibility

Although the departments and the division have put considerable effort into developing growth plans and identifying promising subdisciplines for faculty recruitment, it is extremely important that the detailed hiring plan presented above not be treated as inviolate. Particularly during a time of very rapid growth, we have the opportunity to search broadly, to reorder priorities, and to advance or delay positions to take advantage of the strength of the candidate pool and of emergent opportunities such as partner hires or “mini-clusters” of associated researchers. It is also well established that broad searches are important for maximizing the diversity of the final candidate pool.

We therefore encourage both the departments and the administration to focus on the desired shape of our programs five to ten years in the future, rather than on the particular fields and subdisciplines that will be recruited in any given years, and we ask that Planning and Budget and the Senate work with us to flexibly take advantage of opportunities for recruiting outstanding candidates.

Space Assumptions and Constraints

We assume that the Physical Sciences Building will be completed in 2006, and that no significant impediments will be found for renovating and reusing release space on the first floor of Sinsheimer (about 12,000 total asf with nearly 8,200 asf in lab space and lab support areas) and in Thimann (17,260 total asf with approximately 9,500 in laboratory space). Although some research activities (including some Chemistry labs and the Lab for Adaptive Optics) will remain in Thimann, it will increasingly be used as a center for undergraduate teaching and advising. The move of the upper division Physics teaching labs to the ground floor of Thimann will provide expansion space in Natural Sciences 2, primarily for condensed matter physics. The first floor of Sinsheimer will provide expansion space for MCD Biology, as well as space for the new stem cell facility.

Although the divisional growth plan is relatively modest in the first three years, it will fill all available divisional space. The lack of space in the environmental sciences (chiefly housed in E&MS) is a particularly severe constraint.

It is expected that the Biomedical Sciences building will be available for faculty recruited in the 2009-2010 academic year, providing space for 24 faculty and associated students and postdocs (as well as a new vivarium). This is sufficient space to meet our needs for the biomedical sciences, but some temporary space shifts are likely to be needed to allow growth in other departments until roughly 2013, when the Environmental Sciences building is completed. We believe that at that point the division will have enough space to accommodate the growth described here, but other options (such as an additional non-state-funded wing for the Center for Ocean Health) may need to be pursued to provide expansion space for new initiatives.
Because the pace of divisional growth is constrained so tightly by space, we will continue to search for ways to accelerate the Environmental Sciences building within the Major Capital Improvement Program. It is striking to realize that both that building and the Biomedical Sciences building only total about the same 100,000 asf planned for the Natural Sciences 6 building that was originally proposed for construction in the middle of the current decade. In just over five years, our building plans have already slipped by ten.

**Growth after 2011**

As noted in the table above, when unreplaced retirement positions are considered the majority of the departments have not reached even the low end of their projected size range in 2011, with the greatest shortfall in the environmental sciences (because adequate space will not be available until about 2013) and in MCD Biology (because of limits on how fast the department can reasonably grow once the Biomedical building opens).

Growth in these areas will continue through about 2015, using divisionally held FTE (from retirements). We anticipate that about 14 positions will be filled during this period, half of which will be needed for this space-delayed growth and the other half available to flexibly build departments above their projected minimum size, to further build and sustain excellence and to meet divisional goals. The accountability measures that will be considered in the allocation of these positions are summarized in the department profiles in the Appendices.

**Resources for Growth**

The capital investment cost for growing the Division of Physical and Biological Sciences is undeniably high. (An extensive resource model was developed for the 2001 plan; here we limit ourselves to a broader summary.) In recent years, average start-up expenses have been about $300k per position, with costs higher in some laboratory intensive areas and much lower in areas such as mathematics and also in fields like astrophysics and high-energy physics where very substantial campus infrastructure already exists. Despite these costs, we believe growth at the rate outlined above is reasonable, achievable given divisional and campus constraints, and, in the long run, greatly beneficial to the campus.

It is our assumption that nearly all positions over the next five years or more will be filled at the Assistant Professor level, as the only source of upgrade funds is returned salary from the relatively modest number of retirements. In most cases, this would be advantageous anyway, given our current faculty age distribution due to the paucity of recent hires. There will be limited exceptions where recruitment of a senior leader is necessary to preserve continuity of an important unit or program after a separation or retirement. It is expected that divisional growth will, at last, bring significant I&R funding needed to support both our current and future enrollment and research.

We will fund the divisional share of start-up costs using a combination of funds that have been carefully shepherded over the last few years for exactly this purpose (from open provision savings) and funds from provisions that become open over the next few years. Particularly in departments that are adding growth positions, replacements will be deferred by several years. In addition to providing the divisional match for start-up funding, holding provisions open provides us the opportunity to phase divisional growth over a longer period (as was foreseen in the original plan, had we been able to start growing earlier), and will allow us to meet TAS needs and eventually faculty hiring needs in departments that are space-limited until the Environmental Sciences building is complete.

The costs of growth are investments of one-time funds. The permanent benefits to the campus of the increased research and educational capacity and the external support for research and infrastructure are large. The ongoing renewal cost after growth is complete is estimated at seven recruitments per year, or just over two million in start-up costs: a small fraction of the estimated $15M in indirect cost return to campus from the enlarged division.
Interdisciplinary Initiatives

Faculty hiring in the division will occur in departments, but the existing strengths of the division — and achieving many of our goals — depends on interdepartmental and interdivisional planning. Here we summarize how the hiring plan presented above is connected to these interdisciplinary initiatives. These do not represent anything close to a complete picture of interdisciplinary activity in the division, nor of the ways that new recruitments will contribute to enhanced activities in existing areas of interdisciplinary strength such as Environmental Sciences. Instead we focus here only on a few areas of particular campus interest.

**Biomedical science**

The division plans significant growth in biomedical science to meet student demands and to achieve the critical mass necessary to bring our graduate and research programs truly into the top level. Essentially all planned hiring in MCD Biology, as well as a number of positions in Chemistry and Environmental Toxicology, will contribute directly to this initiative. As noted above, our divisional priorities are to strengthen three key research areas: chromosomal biology and genetics, neuroscience, and structural and chemical biology. In each of these areas, the existing close collaboration with Biomolecular Engineering will be strengthened as that department grows and matures. We have carefully developed our plan to avoid unnecessary duplications of efforts between the departments and divisions. For example, we do not intend to add any faculty into the crucial areas of bioinformatics and computational biology, which are identified growth areas in BME, nor do we intend to hire specialists in technical development who might be more appropriately hired on this campus in Electrical Engineering or BME. A decision with major resource implications was, for example, the decision to place future NMR specialists working on structural biology in Chemistry, rather than duplicating instrumentation between the departments. Such decisions are only practical when healthy collaborative relationships are established across divisional and departmental lines, and our faculty are justly proud of their success at this type of interdisciplinary endeavor. Other examples of good cross-divisional collaboration include the initial establishment of the microarray facility, and the successful current effort to establish a stem cell laboratory, which will be housed in PBSci space, funded by a collaborative proposal led by an SoE faculty member, and used by students and researchers in both divisions.

In **chromosomal biology**, significant progress was made last year with the recruitment of strong candidates at both the junior and senior level, doubling the size of the group, and somewhat reducing the immediate pressure for expansion in this area. A biologist working on the role of microRNAs in gene expression is one target area for a search in MCD Biology (year 1), and an x-ray crystallographer studying chromatin modifying enzymes is a possible target area in year 3. Connections to environmental science will be made through Environmental Toxicology, which plans to recruit (year 3) a molecular toxicologist working on the effects of contaminants on DNA damage, repair, or carcinogenesis.

In **structural biology**, MCD Biology plans to recruit in year 3, looking for a biologist or biophysicist who also connects to another priority area. As noted above, this may be chromatin structure, or possibly the mechanism of RNA polymerase, or the structure and function of ion channels in neurons. Chemistry plans two recruitments (one underway, the other in year 3) in structural biochemistry, focusing on a protein crystallographer and a protein NMR specialist.

In addition to the ongoing recruitments, the **neurobiology** program will be strengthened by a recruitment (year 1, using a replacement position) in Environmental Toxicology of a molecular toxicologist expected to work on connections between exposure to environmental agents and the development of genetic disorders including neurotoxicity and neurologic disorders, and (year 2) in MCD Biology of a scientist working in vertebrate systems. After year 3, Chemistry plans to recruit a neurochemist.
The Biomedical building will include the first significant expansion space for the biomedical sciences, as well as an expanded and modernized vivarium. After 2009, we plan for significant additional growth in all of these areas, as we pursue the challenges of building our critical mass for graduate programs and the undergraduate curriculum. Although we have listed recruitment priorities for this period in our plan, it must be understood that the details and particular phasing will depend on uncertainties such as retirement schedules, as well as on emergent opportunities. However, our intent is to continue a strategy for growth as outlined: focusing on building these three research areas while being open to opportunities to bridge between the areas as well as to other campus priorities such as the bioengineering group and environmental science.

An important aspect of our planning is to understand what we are not planning to do, and, in many cases, how we can effectively overcome what might otherwise be limitations given what will always be a relatively small program. Our lack of a medical school means that human subject research will always be done with external collaborators, but we have existing ties with regional and national institutions, perhaps most notably UCSF (e.g., through the QB3 Institute for Science and Innovation). The absence of a medical school need not be an impediment to world class biomedical research, as Caltech and Princeton testify.

There are also research areas where we have chosen not to focus growth. Virology, for example, is an area where we would need unrealistic growth to build a world-class stand-alone group. Our strategy in areas like this is to focus on how to add expertise while building in our key focus areas, looking, for example, for a virologist working on RNA who could find exciting colleagues and research opportunities here even without a large cohort of other virologists.

**Materials science**

An important recruitment for the materials science initiative will be the senior position currently advertised by Electrical Engineering. In most areas of materials science, effective cross-divisional collaboration will be driven from the application domain, requiring significant leadership from SoE faculty or by scientists interested in application of materials science in other problem domains (as is the case for example when biologists use nanotech devices for neurotoxicology research).

Faculty in Physics and Chemistry (both current and new hires) will be crucial to the success of the initiative, however, with Physics leading in theoretical and experimental study of fundamental material properties, and Chemistry leading in material synthesis and characterization. In these departments, scientists are often technique rather than application driven. In Physics, we anticipate hiring two condensed matter experimentalists (in addition to replacements). It is anticipated that one of these will be in “soft” condensed matter, coordinated with the broader biomaterials group. Chemistry will hire a number of faculty in areas relevant to materials science, but predictions of the phasing of hires are extremely difficult given the uncertainty of retirements (over 40% of the faculty are over 62). We expect to recruit next year in materials chemistry, either in the area of microscopy with a focus on nanostructure synthesis and characterization, or in single molecule investigations.

We note again that faculty growth in both PBSci departments is being driven by local programmatic needs, and would need to occur regardless of the presence of an interdisciplinary initiative. The initiative has great value, however, if it succeeds in magnifying our effective mass and making us more competitive for the best scientists, particularly in an area that is not among the campus’s historical strengths. Given the small size of the existing programs in Physics and EE, and the age distribution of the Chemistry faculty, the majority of the faculty who will be working in this area a decade from now are not yet here. Although it is appropriate at this point to identify a broad area of focus like biomaterials, it is premature to overly constrain a materials science plan now. Instead, the most important outcome of the materials science planning process has been the commitment of all three departments to collaborate on faculty hiring and to include interest in and possibilities for cross-departmental collaboration as one qualification for
faculty candidates. Already this year, EE and Physics have a search committee member on the other’s search, and such collaboration will continue throughout the growth period.

Space for divisional materials science hires will, at least for the foreseeable future, be in allocated Physics space and Chemistry space (NS2 and PSB). We support SoE’s request that non-academic business services such as mail and printing be moved from the basement of Baskin Engineering to provide valuable, high-quality growth space for the key materials science hires in EE. We do not see prospects for sufficient space to co-locate the materials science faculty until at least the latter part of the next decade.

**Planetary science**

Two identified growth positions (years 1 and 3) in Astronomy are related to the planetary science initiative. The first is expected to be a computational theorist, and the second a long-wavelength observer. The hiring of the latter is timed to take advantage of the availability of the (NSF funded) Atacama Large Millimeter Array, by far the largest new radio astronomy facility of the last decade or next, which will be a critical facility for studies of star and planet formation. A growth position in Earth Sciences in year 3 is planned as a specialist in planetary atmospheres. This will complete the core faculty needed to implement the planetary sciences Ph.D. program. An additional Earth Sciences position in planetary surface processes or lithospheric dynamics is planned after year 3. Applied Math (in SoE) also has one faculty member closely involved in planning for a graduate program in planetary science, and we have an established pattern of interdepartmental and cross-divisional membership on search committees to help ensure coordination of hiring priorities and decisions.

**Particle and quantum astrophysics and cosmology**

As noted early, two of four promised positions have been filled. We plan to complete this commitment with two additional growth positions in Physics (years 1 and 3). It is anticipated that one recruitment will be for an experimentalist and the other a theorist, with broad searches but a primary focus on areas where connections to current research areas is possible but there are no current ladder faculty. Examples include very-high energy gamma-ray astronomy, leveraging UCSC’s key role in GLAST with new ground-based facilities such as Veritas; astrophysical or terrestrial searches for dark matter or energy; or faculty who could participate in the Large Synoptic Survey Telescope or other comparable surveys with data analysis challenges similar to high energy particle physics experiments.

**Coastal and marine policy**

A proposal for a graduate program in coastal and marine policy is well along, with preliminary analysis of market needs and resource requirements, and a straw-man curricular design. Clearly, such a program is inherently interdisciplinary, and would require significant involvement of both social and environmental scientists. A detailed review of this work will begin this spring, and a detailed resource plan will be developed over the next year. If the resource analysis is positive, Senate review would follow. We anticipate that three additional FTE will be required to start this program, and request that resources at that level be reserved from the pool held centrally for support of professional programs.

An appropriate long-term home for a C&MP program might be a professional policy school, but in our judgment it is more likely that a school will build upon a successful initial seed than that a school will be established ab initio that will later develop a C&MP program. Although interest has been expressed by faculty in the Environmental Studies department in participating in such a program, they judge it unlikely that ES (which is largely terrestrially focused) would host a marine program. However, both EE Biology and Ocean Sciences are interested in providing an administrative home. Clearly, there must be serious considerations about how to hire and support outstanding social scien-
tists in a natural science department before embarking on such a course, but the concerns don’t appear insurmountable.

Despite the significant remaining uncertainties, we are holding in our plan the possibility of three recruitments to support a C&MP program, in the general areas of coastal policy, management, planning, and resource economics. It is anticipated that the first recruitment would be of a senior level program director.
Connecting Divisional, Campus, and State Goals

Over the last decade, a series of campus committees have considered the campus vision, goals, and objectives in light of the opportunities generated by the tremendous demographically-driven growth the campus continues to experience as well as the constraints imposed by state funding cutbacks and by our physical and environmental limitations. The most compelling statement of the campus vision remains that articulated by the Millennium Committee in 1998:

- UCSC must be an outstanding research university with an uncommon commitment to high quality undergraduate education.
- UCSC will serve the people of the region, the state, and the world by the engagement, development, and application of knowledge.
- A UCSC education will enable our students to become tomorrow’s leaders and lifelong learners.
- UCSC will attract, retain, and advance a diverse student body, faculty, and staff from many different communities in the state, nation, and world.
- UCSC will commit itself to high-quality production and transmission of knowledge across all disciplines.
- UCSC will plan its growth and development with attention to sustainability and in consultation with the larger external community.

The Division of Physical and Biological Sciences is fully committed to the vision of UC Santa Cruz articulated by the Millennium Committee. We believe that a strong sciences division is crucial to the strength of our university. We believe that effective education of tomorrow’s leaders depends on high quality education in mathematics and the sciences, to enable our undergraduate and graduate students to engage effectively with the complex challenges that face us. We believe that our research serves the needs and interests of society on many scales, from our basic biomedical laboratories to our environmental field research in the Monterey Bay region and far beyond, and helps all people understand our world and Universe. And we believe that growth of the division, from around 130 to around 200 faculty, will help us meet both divisional and campus goals.

- **Divisional Goals and Outcome Measures**

  In an earlier section, we outlined a specific set of goals that summarize the departmental milestones that are listed in the Appendices, as well as cross-cutting divisional goals. It is our intent that divisional progress be measured directly against these benchmarks. However, it must also be understood that our progress can occur only if the campus is able to keep its resource commitments, not just for faculty FTE, but for I&R support, for shared investment in lab set-up costs, and for space.

- **Relationship to Campus Goals**

  The Millennium Committee outlined general principles to guide the development of UCSC. During this planning process, we have been asked to focus on six specific academic goals consistent with this broader framework:

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7 *UCSC at the Crossroads: Advisory Report of the Millennium Committee, June 24, 1998*
• Strengthening UCSC’s position as a major research university:

The first goal for the campus must be to build on our existing areas of excellence to become a truly outstanding research university. This divisional plan has identified several key fields where we can take advantage of growth opportunities and our strengths in interdisciplinary work to build research groups that could compete in quality nationally and internationally.

The key phrase is “outstanding research university.” It is often said that the University of California is the research arm of the state. The state’s interest in promoting research at UC was eloquently put forward in a 1970 Regents’ Resolution,\(^8\) which affirmed that “research ... has become an indispensable part of the educational process leading to advanced degrees in all major American universities ... [and] is an all-important part of the learning process.” Furthermore, “research carried out by the University of California makes a vital contribution to the defense of the United States, the social and community needs of the State of California, and its people; and the health and well-being of all mankind.”

This synergistic intertwining of the research, education, and service missions of the University makes strengthening UCSC’s research enterprise particularly important. The Millennium Committee and the Strategic Futures Committee both called on UCSC to develop “top-quality, internationally recognized research programs,” with the latter committee also stressing the importance of UCSC “generating knowledge that is useful to the wider society.” This conviction has informed our divisional choice of research focus areas.

Like all small public universities, we have faced challenges related to the difficulties in building critical mass. As we have discussed, analysis of the NRC departmental quality rankings indicate that the cost of failing to achieve a critical mass is higher in the social sciences and physical sciences than in the humanities, and highest in the biological sciences. We have excellent faculty, and all of our programs rank higher than would be predicted based on their size, but most of our science programs now fall in roughly the 25th to 50th percentile. We believe that growth to around 200 science faculty will allow us to bring all of our major programs into the first quartile in quality, which is a bare minimum if we are to move even from “good” to “great.” Phrased negatively, it is impossible to be an outstanding research university while neglecting core science programs like biology, physics, and chemistry.

• Improving access for the diverse population that comprises California today:

It is our responsibility to ensure that the University of California is a resource available to all students of the state regardless of race, color, national origin, religion, sex, sexual preference, physical or mental disability, age. Nondiscrimination is a legal and moral obligation, and is also the right thing to do to ensure excellence in education of all of our students.

In PBSci, we have a special responsibility that comes from the historic and continuing under-representation of women and members of several minority groups in mathematics and science. Scientific research will be advanced best through the participation of the broadest cohort of outstanding scien-

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\(^8\) http://www.ucop.edu/roahome/cgmanualchap01.html#1-120
tists. Ultimately, it is the people of California and the world who have the most to gain through the resulting social, environmental, medical, and economic benefits that derive from fundamental research.

As outlined above, PBSci has specific divisional goals aimed at many different levels of the “leaky pipeline” that separates the rich diversity of the youth of California to the far less representative group of professional scientists. We support activities such as COSMOS that are directed at engaging high school students before they have made college decisions, as well as academic support programs such as ACE that seek to retain students in science degrees once they are at UCSC. Our academic affirmative action and faculty support plans seek to increase diversity among the faculty who serve as role models and inspiration for our students. And programs such as Cal Teach give us the possibility of reaching first generation college students, who appear disproportionately interested in teaching and who can become valuable role models themselves when they return to teach in public secondary schools.

Our diverse student body today is reflective of the student body that will be more typical nationally a generation from now. As we are “ahead of the curve,” UC and UCSC thus have a special opportunity to make a real impact in expanding diversity in science by training researchers who will be the faculty of universities across the country in the decades to come.

- Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:

UCSC shares with the other UC campuses the fundamental responsibility to provide an outstanding education to the population of the state, but is has long strived towards a unique vision within the system: to provide the intimacy and learning advantages of a small collegiate university with the complementary advantages of a major public research university.

UCSC reflects its “uncommon commitment” to undergraduate education through its unique living-and-learning environment and through a strong commitment to disciplinary depth and rigorous breadth. As the Millennium Committee emphasized, we seek to provide students with a high level of direct involvement with research faculty, and to provide undergraduates the opportunity to participate in high-quality research and to complete a meaningful capstone requirement in their major fields of study (a recommendation of the WASC panel). We are committed to offering a breadth of programs supporting the needs of our students and the state. In recent years, we have in some cases sponsored and in others supported innovative interdisciplinary programs, such as bioinformatics or, to pick an extremely popular example, the new health sciences major. Although we have fewer new undergraduate initiatives planned in the next few years, we expect to participate in the proposed bioengineering program, for example. We have also specifically committed to significantly increasing the number of UC students trained to become secondary school math and science teachers, to meet a critical state shortfall of students trained in both education and a science discipline.

On our young campus, the PBSci graduate programs are relatively mature, and many are already very highly regarded. Our primary goal for graduate education in the next few years is to strengthen and grow the programs in departments that have been below true critical mass. Graduate growth will help the campus meet its goals, and will help meet the state’s needs for a highly trained technical workforce. Our proposed new graduate initiatives have been chosen in areas where truly interdisciplinary graduate education is needed — cross-departmental programs or graduate groups in biomedical sciences, materials sciences, and planetary sciences — and on the science-society boundary, with Coastal & Marine Policy.
• Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:

The phenomenal UCSC growth rate has been driven by the demographics of the so-called “baby boom echo,” which is expected to continue to lead to an increase in UC-eligible high school graduates for the next several years, until numbers plateau at around the 2010 level for some time.

The result has been students arriving faster than the campus, and certainly the division, have been able to properly accommodate them, largely because of the lag in hiring faculty and the coincident budget cuts. We have been left with sharply increased class sizes, decreased TA ratios, de facto capping of critical courses, and undeniably with some (we hope temporary, and we hope modest) decrease in the quality of our instruction. We also face demands from heavily impacted departments that we find ways to limit enrollments and close majors. Because of the great impact that such actions would have on our students, they have so far been resisted, but only with the promise that resources will arrive soon. Both faculty growth and I&R growth are critical.

Our division’s goal is to rapidly put new resources into the most heavily impacted departments. Although enrollment is not the primary driver of final department sizes, the phasing of positions in the divisional plan is such that the most rapid growth will occur in departments such as MCD and EE Biology and in Chemistry, where service course and major workload are the highest. Because the growth envelope that has been assigned to us backloads the largest growth into years four and five, gains are not going to be immediate — for some time we will continue to chase rising enrollments. However, faculty and staff will be more willing to avoid making decisions with long-term detrimental impact on our capacity if they see that real progress is being made, and they believe that additional progress will really arrive.

• Substantially increasing doctoral production:

At the graduate and professional level, we seek to offer graduate programs that meet the needs of our diverse student body and the state. The state, through its compact with UC, has identified as a key goal increasing the number of students earning graduate degrees “in fields that are high priorities for meeting state workforce needs (mathematics, engineering, computer science and other science fields).”

Finding the right balance between the number of undergraduate students and the number of graduate and professional students at UCSC has been the subject of considerable campus discussion. Currently, the fraction of graduate students at UCSC is the lowest in the UC system. The campus has established a goal that graduate enrollments will reach 15% of total enrollments, though how much growth will occur in Ph.D. programs and how much in new or existing professional programs is unclear.

Unless we decide that all graduate growth will be in professional schools, it will not be possible to achieve the campus goals for increasing the number of graduate students without substantially expanding the science departments. One reason for this is obvious: through research grant support, PBSci provides the largest direct support stream for students on campus. Simply scaling the current divisional graduate numbers to 185 faculty would imply a total of about 650 graduate students in our division at build-out, mostly working on Ph.D.s. That is about a quarter of the total campus target of 15% graduate students, if the total enrollment is 17,200. The numbers could be substantially better if currently sub-critical programs are able to attract a broader pool of applicants, or if new graduate groups are established in areas of interdisciplinary research such as biomedical sciences or planetary sciences.
A less often noted contribution of PBSci to graduate enrollment numbers comes through indirect cost return, which provides much of the flexible campus funding, allowing investment in graduate programs that cannot cover their full costs (e.g., by allowing the campus to subsidize TAs). So it is not surprising that the total number of graduate students is very closely connected to the amount of research funding raised. The chart above shows that, when normalized by sponsored research income, UCSC is already very similar to the other UC campuses in our success at building graduate programs. There does not appear to be a significant amount of additional efficiency that we can hope to gain with our existing resource base. If we want to grow our graduate programs, we must increase our external funding, which in turn implies a substantial build up of our science programs.

- **Substantially increasing contract and grant support:**

The primary goals of the academic divisions are, of course, directly related to the quality of the research, instruction, and public service mission of the campus. To achieve these goals, however, it is important that the campus and the divisions remain aware of resource constraints, and find ways to increase the flexible funding that can be used to support our priorities. This is particularly true at a time when state funding of higher education, in California and elsewhere, is being reduced. Further reductions seem likely. UCSC now receives about a third of its budget from the state, which is more than three times the fraction at such “state-supported” schools as Michigan and Virginia. The WASC report emphasized the pressure to develop “the entrepreneurial culture necessary to become less dependent upon state support.”

If our goal is to not only survive but to maintain and build excellence, UCSC must find ways to build its resource base with non-state funding. Substantial tuition and fee increases have, unfortunately, been necessary in recent years. Renewed development efforts aimed at helping our alumni and friends understand the value of the work done at UCSC will be important, and the academic divisions will have an important role to play in communicating that message. But a key part of our strategy must be to substantially increase external support from grants and contracts.

The importance of PBSci’s current level of contract and grant support to our research programs, to our graduate enterprise, and, through indirect cost recovery, to the broader campus have been amply discussed throughout this report. Looking forward, external support will need to be increased broadly across all of the divisions. However, it is chiefly by enlarging and strengthening the science and engineering divisions that we will make real progress in this area.
Membership in the Association of American Universities

It is important for UCSC to ground its internal discussions of campus goals and objectives with occasional comparisons against external standards — not because we should defer to external opinions, but because we should recognize and understand the reasons if we make significantly different choices than our peer institutions. Comparisons are of course done regularly and informally with our sister campuses within the UC system, as we compete for students and resources and work through systemwide bodies on the establishment and review of instructional and research programs. A more formal review is held once each decade with our accrediting agency, the Western Association of Schools and Colleges, promoting internal self-study and facilitating dialogue with external experts in higher education.

Some years ago, UCSC recognized the value in establishing a goal of membership in the AAU, an association of the 62 leading private and public research universities in the United States and Canada. Eligibility for AAU membership, while arguably of little inherent value, serves as a useful proxy for general excellence as recognized by our peers as long as we remember that there are other measures of excellence as well and that the goals and values of the current AAU members are not necessarily in perfect accord with ours.

The AAU has established a set of membership indicators, used to evaluate potential member institutions. The primary (Phase I) indicators of institutional breadth and quality are:

1. Competitively funded federal research support, as measured by the NSF, excluding USDA funding.
2. Faculty membership in the National Academies of Science and Engineering, and in the Institute of Medicine.
3. Faculty quality ratings, as measured by the National Research Council.
4. Faculty awards, fellowships, and memberships that measure achievement primarily in the arts and humanities.
5. Citation numbers, which measure research volume and quality.

The AAU has also established a secondary set of indicators (Phase II), which provide additional measures of research and education programs:

1. Research funding from the USDA and from state and industrial sources.
2. Number of Ph.D. degrees granted annually, in total and tabulated by broad disciplinary categories.
3. Number of postdoctoral appointees, as compiled by the NSF.
4. Commitment to undergraduate education, as measured by a variety of input and output metrics.

A larger, successful Division of Physical and Biological Sciences is the key to improving our campus performance against nearly all of these metrics.
Appendices: Program summaries and milestones

Attached are summary statements, prepared in consultation between the division and faculty, that summarize the research and instructional aspirations of each program in the Division of Physical and Biological Sciences.

Connections between departmental, divisional, and campus goals are included, as are specific accountability measures that summarize both what the department can expect in FTE resources and what the division and campus can expect in return. Ranges are given for department sizes at build-out. It is expected that all departments will reach the low end of the given ranges (though not in all cases before 2011 because sufficient space is not available until 2013 when the Environmental Sciences building is finished). On average, departments will reach the mid-point of the given ranges, assuming that FTE are allocated to the division as CP/EVC Kliger has committed. Final size within the range will depend on progress towards meeting accountability measures, as well as on evolving and emergent opportunities and campus goals.

In most cases, expected quantitative outcome measures are set to scale in a straightforward way with faculty size or enrollments. There is every reason to expect that significantly better results could be achieved as departments reach critical mass and our faculty become more competitive for major center-based grants. However, for the foreseeable future space will continue to be a limiting factor; current campus space planning does not allow for large increases in average lab sizes. PBSci will continue to pursue innovative space strategies, as we have done recently with the Center for Ocean Health and the Center for Adaptive Optics. It is possible, for example, that 2300 Delaware will provide some surge space for researchers. However, departmental expectations are conservatively based only on state-funded capital projects that already appear in the campus Major Capital Improvement Program five-year window.

Notes on the tables: Postdoctoral numbers are headcount, not FTE, and include partial year appointments. Both postdoctoral employees and externally-funded postdocs are included. Funding and postdocs administered by UCO, IGPP, and SCIIP are credited to Astronomy, Earth Sciences, and Physics, respectively, which accounts closely, but not exactly, to affiliations of principal investigators. These quantities for IMS are not easily assigned to a particular department; unallocated fraction is separately listed in footnotes.
Studying galaxies, stars, planets, and an ever-increasing variety of phenomena observed from ground- and space-based observatories, the Astronomy & Astrophysics Department has been at the forefront of both observational and theoretical research in astronomy and astrophysics since it was founded. As the home campus of UC O/Lick Observatory, UCSC has a distinguished history in observational optical astronomy. Non-optical observational astronomy is pursued through the use of national and international facilities. Theoretical work ranges from planet formation to cosmology.

**Scholarly Direction**

Areas of special interest include cosmology, the formation and evolution of stars and galaxies, high-energy astrophysics, active galaxies, supernovae and nucleosynthesis, the motions of stars and galaxies, and all aspects of observational optical and infrared astronomy. Research is enhanced and supported by the close relationship and proximity to the researchers and facilities of UCO/Lick Observatory, the Center for Adaptive Optics, and the new Laboratory for Adaptive Optics. UCO faculty, researchers, and technical staff are key players in the Thirty-Meter Telescope Project, initiated after the 10-Year Plan was submitted. The project is headed for conceptual design and cost review in spring and summer 2006. If the TMT or other large telescope projects go forward with corresponding increases to the UCO budget, proposed FTE numbers for UCO Astronomer positions could significantly increase.

There have been some changes in the scientific, technical, and political landscape that have occurred since the 10-Year Plan was submitted, but the research focus areas remain basically the same. They have been reorganized into five...
areas more closely aligned with how external planning and funding agencies factor the field: star and planet formation, first light/galaxy assembly, physics of the universe, gravitational physics, and high-energy physics.

Contributions to Divisional and Campus Goals

**Strengthening UCSC’s position as a major research university:** As UCSC’s best-known science program, it is still the department’s goal to become a world leader in every field it enters. Their plans have been and continue to be developed to enhance the strength and reputation of the program.

**Improving access for the diverse population that comprises California today:** Attention to diversity is factored into faculty hiring, mentoring minority students, and training graduate students and postdocs. The graduate program has had roughly equal number of men and women for the last few years, and has a growing number of students from underrepresented groups. The CfAO’s Education and Human Resources Program is widely recognized as one of the most successful science education programs created within the National Science Foundation.

**Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:** Faculty will continue to develop innovative teaching methods for introductory courses using technology and inquiry-based science teaching. They will continue to offer Q courses and hope to add introductory W courses. The Physics (Astrophysics) major is chosen by approximately one-fourth of Physics majors. The department continuously evaluates and improves the graduate program. Current areas of attention include increasing curricular connections with Earth Sciences (planetary science) and Physics (high energy astrophysics and cosmology).

**Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:** Departmental service course enrollments have already grown markedly since 2001. They expect to be able to absorb new students with the planned new hires and limited TAS resources.

**Substantially increasing doctoral production:** The department anticipates a significant rise in Ph.D. production due to a combination of FTE growth, retirements of faculty with fewer-than-average Ph.D. students, and measures being taken to reduce the time to degree.

**Substantially increasing contract and grant support:** Astronomy’s success rate is already very high and expected to rise further given the fields of anticipated new hires, participation in large projects like the Thirty-Meter Telescope, and the infrastructure already in place to compete for grants in adaptive optics. UCO has been one of the campus’s most successful focus areas for foundation and private support.

Curricular Contributions

Future development of the graduate program will focus on broadening the curriculum (e.g., planetary sciences) to attract more students.

Though a graduate-only degree program, Astronomy & Astrophysics offers an Astrophysics minor, a series of general survey courses for students majoring outside the sciences, an array of lower division courses designed for students intending to major in a scientific subject, and upper division electives as well as a required astrophysics lab course for students majoring in Astrophysics through the Physics Department.

Specific Challenges

The department faces several significant challenges: the need for new space (mostly office space) on Science Hill, retirement of the majority of the senior theory faculty during the next 10 years, the need to rebuild faculty in both the department and UCO/Lick Observatory, generally tight budgets at the state and national level and the need to seek
major private funding, and identifying resources that will allow the department to play a leading role in theoretical initiatives like the Bay Area Computational Astrophysics Center.

**Accountability Measures**

- Grow to approximately 9 FTE (+ 2.8 UCO) by 2011 and to between 10 and 11 FTE (+ 2.8 UCO) by 2014-15.
- Develop strategic plan for retaining international leadership in observational astronomy in the “post-Keck” era (through 30-m telescope project or alternative)
- Increase extramural support proportionate to faculty growth.
- Increase graduate student numbers proportionate to faculty growth.
- Develop graduate pathways in planetary sciences in collaboration with Earth Sciences.
- Increase contribution to the division’s share of general education instruction proportionate to campus growth.
The curriculum in chemistry is dictated by the American Chemical Society and exposes students to the principal areas of modern chemistry, including organic, inorganic, physical analytical, and biochemistry. The curriculum is designed to meet the needs of students who want a bachelor of arts or science degree as well as those who plan to pursue advanced degrees. Research is closely interwoven with undergraduate and graduate education with many opportunities for student participation.

### Scholarly Direction

Principal areas of research in Chemistry & Biochemistry are biomolecular science and materials science. The department maintains close connections with the MCD Biology Department and the RNA Center for research in general and for oversight of the Biochemistry and Molecular Biology major in particular. The department is expanding its interaction with the School of Engineering in the area of biomolecular engineering.

Chemistry and Biochemistry’s goals and aspirations remain much the same as in the 10-Year Plan. The department will have to hire a significant number of new faculty to meet the instructional needs as well as research needs, particularly given the demographics of the faculty (see below). Future alliances may develop across departmental lines in the area of materials/nanotechnology. As with MCD Biology, the outcome of current long-range planning in BME may influence future hiring plans of Chemistry & Biochemistry.
Contributions to Divisional and Campus Goals

*Strengthening UCSC’s position as a major research university:* The department has the highest grant support and indirect cost recovery rates in the division when measured by headcount faculty numbers, and maintains a large and healthy graduate program, critical factors in defining a major research university.

*Improving access for the diverse population that comprises California today:* The department offers a large number of service courses for science and engineering majors. Faculty work closely with the ACE Program which provides discussion sections in both general and organic chemistry, as well as supporting students in learning critical thinking and problem-solving skills. The department administers the Summer Undergraduate Research Fellowship Program, and individual faculty participate in a variety of outreach and co-curricular support programs. (Of particular note is the ACCESS program for community college students, founded by a Chemistry faculty member.) Its graduate program is nearly balanced between men and women.

*Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:* The most recent external review team was impressed with the large proportion of undergraduate students involved in research activities. The same reviewers noted that the graduate curriculum is excellent and the department is “special in providing an interactive, support environment” for graduate students.

*Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:* Chemistry & Biochemistry already has the highest student-to-faculty workload ratio in the division, a ratio also significantly higher than the campus average. Given the growth the department has absorbed in the last decade, an increase in faculty FTE is essential to accommodate additional students. Even now, faculty and staff are reviewing the curriculum and use of lab facilities in order to accommodate the current student demand that is overflowing existing facilities.

*Substantially increasing doctoral production:* The department has already increased their graduate student population to 99, which is 14 greater than their target of 85 in the 10-Year Plan. A further increase will be possible as new faculty are hired.

*Substantially increasing contract and grant support:* Chemistry and Biochemistry’s success rate is already high. An increase in faculty across the division will afford opportunities to compete for cross-departmental large program project grants.

**Curricular Contributions**

Chemistry & Biochemistry continues to provide a substantial service curriculum to the campus at large and to the PBSci Division and School of Engineering in particular. Additionally, the department participates in and administers the interdisciplinary Biochemistry and Molecular Biology major that emphasizes rigorous study of biological systems within quantitative and scientific frameworks.

**Specific Challenges**

With 41% of the faculty at age 62 or older, the department’s hiring plans will have to be reviewed annually and priorities for hiring may be adjusted to ensure the viability of both the instruction and research programs.

Securing adequate space, especially for wet labs, will be a challenge until the biomedical sciences building is complete. Any delay in the timeline for the biomedical sciences building will also delay further hiring in several PBSci departments, including Chemistry & Biochemistry.
Accommodating the enrollment growth the department has experienced in the last two years has been difficult and costly. Significant additional costs were incurred for additional offerings of key courses, increased use of labs, and augmentations of TA and other course support.

**Accountability Measures**

- Grow to approximately 27 FTE by 2011 and to between 27 and 31 FTE by 2014-15.
- Achieve top quarter NRC ranking or equivalent.
- Increase extramural support proportionate to faculty growth.
- Increase graduate student numbers proportionate to faculty growth.
- Participate in development of interdisciplinary biomedical and materials science programs.
The study of Earth Sciences encompasses a broad exploration and understanding of the origin and evolution of Earth and its life forms, unified by the theory of plate tectonics. Earth Sciences instruction includes geology, geochemistry, and geophysics, as applied to surficial and internal processes and to geological oceanography. Both instruction and research are enhanced by the proximity and cooperative relationships with eight local research institutions in the Monterey Bay area, including the Institute of Marine Sciences and the Department of Ocean Sciences at UCSC.

Scholarly Direction

The department plans to maintain its current research strengths in tectonics and landform processes, global environmental change, geophysics and planetary physics, and geochemistry and geology. Recent hires in atmospheric chemistry and planetary sciences expand the intellectual scope of the Department into new sub-disciplines, building on the Department’s strengths in climate studies and geophysics.

The department’s goals are similar to those identified in the 10-Year Plan. Hiring priorities are being identified with consideration for hires planned in related departments and for retirement replacements so the department does not become too highly specialized in two or three subdisciplines by 2015. New plans are being developed for focused

| Current FTE, Including 2005-06 Searches | 20 |
| Proposed FTE by 2014-15 | 22 to 25 |
| Degrees Conferred, 2004-05 | Bachelors: 54.3  Masters and Certificates: 8.0  Ph.D.: 5.0  TOTAL: 67.3 |
| Source: 2004-05 Instructional Load Summary |
| Postdoctoral Students | 24 |
| Source: PBSci Academic Personnel |
| Student Workload FTE | Graduate: 54.8  TOTAL: 321.8 |
| Source: 2004-05 Instructional Load Summary |
| Extramural Awards, 2004-05 | $3,671,752, including IGPP* |
| Source: PBSci Research Resources |
| Indirect Cost Returns, 2004-05 | $939,853, including IGPP |
| Source: PBSci Research Resources |
| Proposed New Programs or Expansion of Existing Programs | Collaborating with Astronomy & Astrophysics to develop an interdisciplinary program in Planetary Sciences. Also considering a M.A.S. program in Remote Sensing and Geographic Info Systems. |

*Earth Sciences researchers also contribute significantly to Institute of Marine Sciences activities, which attracted an additional $7.5M/$1.3M of direct/indirect costs in 2004-05 that are not included in any department summaries, as well as 14 postdocs not counted elsewhere.
growth in two areas: planetary sciences and the study of the Earth’s past and present environment, including adding expertise in geobiology/paleobiology, surface processes and biogeochemistry.

Contributions to Divisional and Campus Goals

*Strengthening UCSC’s position as a major research university:* Earth Sciences is one of the few UCSC departments ranked in the top 25 by the NRC and has a legitimate chance of moving into the top 15 departments in the U.S. in their discipline in the next few years. Such top-ranked departments are an essential element in identifying an institution as a “major research university.”

*Improving access for the diverse population that comprises California today:* For students who are the first in their families to attend college, many choose majors with an eye toward their perceived practical value or potential use as a pre-professional major, hence they do not often look to Earth Sciences. The department’s best efforts at recruiting a more diverse pool of majors are directed at encouraging students to consider the major in their introductory courses. The department chair is considering deploying women faculty to teach these courses to determine if there is a positive effect on recruiting women and underrepresented groups to the major.

*Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:* There appears to be a definite correlation between departments that are perceived as of high quality by the scientific community at large and the successful recruitment of high quality graduate students. Earth Sciences hires excellent faculty, creates and maintains strong, visible research programs, and trains students to be competitive for scientific careers both inside and outside academia.

*Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:* Given the field-intensive upper division courses and the substantive capstone requirement for undergraduates, the department is reaching its teaching limit until faculty resources increase. Growth in graduate students will also accompany an augmentation in faculty size.

*Substantially increasing doctoral production:* The potential planetary sciences program should attract new students to Earth Sciences and/or Astronomy & Astrophysics. More faculty are needed to substantially increase the number of graduate students that faculty can mentor and support.

*Substantially increasing contract and grant support:* The department has already seen a steady overall increase in extramural funding over the past five years, despite a decline in faculty numbers. We expect the trend to continue upward as the most recent hires are intellectually poised to take advantage of significant funding opportunities.

Curricular Contributions

Earth Sciences continues to offer multiple degree pathways and concentrations that provide students with a broad range of opportunities that can be tailored to student interests and career intentions. All upper division courses involve intensive written work, and two upper division field courses are required. The large graduate program is enhanced by the faculty’s close working ties with the United States Geological Survey, the Monterey Bay Aquarium Research Institute, Lawrence Livermore National Laboratory and NASA Ames Laboratory.

Specific Challenges

The demographics of the department are such that four or five faculty could retire within a year or two of one another, posing a significant challenge for curriculum and leave planning even assuming recruitments could be conducted in a timely manner. The order of future recruitments will depend on when these retirements occur. In addition, the order of recruitments in numerous related departments may influence the order of hires in Earth Sciences.
The infrastructure for high-performance computing will continue to require facility development over the next decade.

**Accountability Measures**

- Grow to approximately 21 FTE by 2011 and to between 22 and 25 FTE by 2014-15.
- Increase extramural support proportionate to faculty growth.
- Increase graduate student numbers proportionate to faculty growth.
- Increase general education and majors courses proportionate to campus growth.
- Develop graduate pathways in planetary sciences in collaboration with Astronomy & Astrophysics.
Proximity to varied and easily accessible marine and terrestrial resources for research and support of instruction enhance the success of the Ecology and Evolutionary Biology Department. A marine laboratory and the largest concentration of marine research programs in the country create an ideal marine research and learning environment. Terrestrial biologists have access to all of California’s natural environments through the UC Natural Reserve Systems, the campus diverse habitats of the campus itself, adjacent preserves, associated greenhouses, and the UCSC Arboretum.

Scholarly Direction

The intellectual orientation of the department is aligned along three broad sub-disciplines: ecology, evolution and behavior, and physiology. The groups are not restrictive, and faculty from one group routinely collaborate with those of another. The research environment is enhanced by close interactions with other departments and divisions, especially Ocean Sciences, Earth Sciences, and Environmental Studies, as well as the Institute of Marine Sciences. EEB faculty also have access to the large research community in the San Francisco and Monterey Bay regions, taking advantage of rich collaborative resources such as the Moss Landing Marine Lab, Hopkins Marine Station, MBARI, the Navel Post-graduate School, the Monterey Bay National Marine Sanctuary, the U.S. Geological Service and the National Marine Fisheries Service.

| Current FTE, Including 2005-06 Searches | 17 |
| Proposed FTE by 2014-15 | 22 to 26 |
| Degrees Conferred, 2004-05 |
| Source: 2004-05 Instructional Load Summary |
| Bachelors: 314.5 |
| Masters and Certificates: 5.0 |
| Ph.D.: 9.0 |
| TOTAL: 328.5 |

| Note: Numbers reflect majors administered by both MCD and EE Biology |

| Postdoctoral Students |
| Source: PBSci Academic Personnel |
| 12 |

| Student Workload FTE |
| Source: 2004-05 Instructional Load Summary |
| Graduate: 158.7 |
| TOTAL: 911.5 |

| Note: Numbers reflect student workload FTE for both MCD and EE Biology |

| Extramural Awards, 2004-05 |
| Source: PBSci Research Resources |
| $5,781,826* |

| Indirect Cost Returns, 2004-05 |
| Source: PBSci Research Resources |
| $645,069 |

| Proposed New Programs or Expansion of Existing Programs |
| Undergraduate: Biology major/Education minor (still at the discussion stage) |

*EE Biology researchers also contribute significantly to Institute of Marine Sciences activities, which attracted an additional $7.5M/$1.3M of direct/indirect costs in 2004-05 that are not included in any department summaries, as well as 14 postdocs not counted elsewhere.
Department goals have changed substantially since the 10-Year Plan was submitted, primarily driven by growth in the undergraduate and graduate programs and potential faculty retirements or departures. The department has adopted the strategy of identifying general disciplines for faculty hires with the understanding that if curricular, opportunity, or critical mass needs dictate, they can more narrowly define the FTE. As part of this strategy, they are promoting a general FTE plan while considering new foci for the department. One such focus is coastal conservation.

**Contributions to Divisional and Campus Goals**

*Strengthening UCSC’s position as a major research university:* Marine and environmental sciences are well-known strengths of this campus. EE Biology’s contributions are significant already, enhanced by many affiliated programs (IMS, PISCO, STEPS, etc.). Additional FTE are needed to create new opportunities and further the department’s reputation.

*Improving access for the diverse population that comprises California today:* The department’s programs attract a diverse population, and faculty continue to promote the programs and participate in activities that reach underrepresented populations.

*Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:* Coastal conservation is a potential new focus in the department, one that is already identified as of interest to both undergraduate and graduate students and an area of faculty interest and expertise.

*Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:* Due to space limitations and the resulting delay in hiring most of the planned new FTE, the department’s short-term contributions will be limited to seeking creative ways to increase capacity in service and majors courses while maintaining quality.

*Substantially increasing doctoral production:* At present, EE Biology has the largest ratio of graduate students to faculty FTE in the division. Current FTE and space limitations allow for no more than 10 new students per year.

*Substantially increasing contract and grant support:* The department contributes substantially to the division’s extramural awards total each year. Until new faculty are hired, the rate of awards is unlikely to change significantly.

**Curricular Contributions**

At the undergraduate level, MCD Biology and EE Biology together administer a large and complex academic program. The departments offer nine biological sciences degrees and administer or participate in three interdisciplinary degrees, including the Biochemistry and Molecular Biology (BMB) major, for more than 1,800 proposed and declared majors. Many large undergraduate biological sciences lecture courses are required for degrees offered by other departments in PBSci and the School of Engineering.

At the graduate level, MCD Biology and EE Biology administer separate Ph.D. programs of between 50 and 60 students each.

**Specific Challenges**

The number of FTE needs to increase to meet the existing and future student demand, yet space for new faculty is extremely limited until the Environmental Sciences building is available (year 2013), according to current divisional projections. The department faculty are already split between the Earth and Marine Sciences building on campus and Long Marine Lab off campus, resulting in both instructional and administrative challenges. Further dispersing the faculty to yet another location is not under consideration by the department.
Resources to support lecturers, sufficient teaching assistants, and staffing are considered seriously inadequate. The need for technical staff is particularly important for faculty to have productive access to necessary facilities and equipment.

Accountability Measures

- Grow to approximately 20 FTE by 2011 and to between 22 and 26 FTE after completion of the Environmental Sciences Building.
- Achieve top quarter NRC ranking or equivalent.
- Increase extramural support proportionate to faculty growth.
- Increase graduate student numbers proportionate to faculty growth.
- Increase capacity in service and majors courses proportionate to campus growth.
The Environmental Toxicology Department uses interdisciplinary approaches to identify and solve current and emerging problems in environmental and human health. Bringing together scientists who use a multitude of methods to understand diverse toxic substances, the faculty study living harmful agents as well as chemical agents. Consistent with this approach, the department works collaboratively with departments in the division (MCD Biology, EE Biology, Chemistry & Biochemistry, Earth Sciences, and Ocean Sciences) and plays active roles with other programs including the Institute of Marine Sciences, the Center for Dynamics and Evolution of the Land-Sea Interface (an IGPP research center), and the STEPS Institute for Innovation in Environmental Research.

### Scholarly Direction

The research emphases of the faculty are human health, environmental health, metals, and microbes. Continued growth in Environmental Toxicology will provide enhanced interdisciplinary training in environmental health and microbiology. The department’s proposed hires are aimed at increasing programmatic and disciplinary breadth and depth and increasing linkages and collaboration with faculty in other departments.

The department’s goals remain as in the 10-Year Plan. Despite the limited number of faculty FTE since its inception, the department has achieved significant successes in research, extramural support, and graduate education.
Contributions to Divisional and Campus Goals

*Strengthening UCSC’s position as a major research university:* The department was created to provide graduate education and training in interdisciplinary sciences to address current and emerging problems of environmental contamination with pollutants and pathogens. Existing strengths in environmental and biological sciences at UCSC complement this program, which aims for prominence in an emerging area of interdisciplinary environmental and health science.

*Improving access for the diverse population that comprises California today:* Both the department and individual faculty have an established history of promoting and improving access to higher education for students from diverse backgrounds, hosting and mentoring students in summer programs and academic year research activities. In addition, the graduate student applicant pool is typically comprised of 25-30% underrepresented minorities.

*Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:* The department uses state-of-the-art technologies and instrumentation to pursue important problems in environmental and human health. These include many interdisciplinary collaborative research and teaching efforts.

*Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:* Environmental Toxicology provides research opportunities to undergraduates (often without formal recognition or teaching credit) and has made joint research and teaching arrangements with other departments.

*Substantially increasing doctoral production:* The primary mission of Environmental Toxicology is to provide outstanding graduate education and training. Additional growth in faculty FTE will further enhance their ability to increase doctoral student production.

*Substantially increasing contract and grant support:* Already successful in securing extramural support, growth of the program will complement existing faculty and facilitate additional collaborations among faculty within and outside of Environmental Toxicology.

Curricular Contributions

A graduate-only program, Environmental Toxicology faculty contribute to the division’s general education course offerings and are taking increasing responsibility for teaching the upper division microbiology curriculum in the MCD Biology Department. Faculty have made very preliminary inquiries with other departments (Earth Sciences, Chemistry & Biochemistry, and Biology) about offering undergraduate pathways within their existing majors; all departments have expressed interest in further discussions.

Specific Challenges

Growth to about 10 faculty FTE is still considered necessary for the department to fully develop its graduate program as originally envisioned and match, in the long term, the success they have established in the short term. Due to the small size of the department, they generate only a minimal array of academic support resources, further hampering their efforts to provide the graduate student support and research infrastructure that will enhance their endeavors.

Because Environmental Toxicology has not yet been given the resources necessary to demonstrate an extended record in graduate enrollments and completion, it is premature for the division or campus to agree to a long-term department size. If the department is able to grow to 9-10 faculty, maintain their outstanding research record and funding success, and either build a much larger graduate program or take on a larger undergraduate teaching role (or both), then maintenance at that size or even further growth will be indicated. Otherwise, a slightly smaller core faculty (~7) supporting a broader interdisciplinary graduate group that includes additional closely affiliated faculty in other departments might be a more appropriate and effective long-term model.
Accountability Measures

- Grow to approximately 9 FTE by 2011 and to between 7 and 10 FTE by 2014-15 (see text for explanation of range).
- Increase extramural support proportionate to faculty growth.
- Develop and sustain a comprehensive graduate curriculum to stabilize the number of graduate students.
- Increase graduate student numbers proportionate to faculty growth.
- Formalize the department’s role in teaching the undergraduate curriculum, including through courses in Biology, Chemistry, and Earth Sciences.
The Mathematics Department is engaged in research and instruction as well as K-12 education and community outreach. The undergraduate program offers concentrations in pure mathematics, computational mathematics, and mathematics education. The structure of the Ph.D. program was recently rebuilt in consultation with the Graduate Council and with advice from external faculty experts. The program is now a better fit with existing faculty strengths.

Scholarly Direction

Areas of particular strength are algebra and number theory; mechanics, symplectic geometry, and dynamic systems; geometric analysis; non-linear partial differential equations and fluids; random matrices; algebraic geometry; and algebraic topology. Several of the department’s requested FTE would further connect Math to other areas of the campus’s research community. In particular, the department anticipates strengthening connections with theoretical physics and engineering.

The goals of the department remain generally the same as the 10-Year Plan. However, in order to meet enrollment demands, the department seeks to grow to 25 faculty rather than the 20 identified in the original plan.

Contributions to Divisional and Campus Goals

*Strengthening UCSC’s position as a major research university:* A strong mathematics department is a hallmark of all major research universities. The department continues to work on strengthening its graduate curriculum to attract the best-qualified graduate students.
Improving access for the diverse population that comprises California today: The department is looking at new ways to address the chronic under-preparation of students coming to UCSC and how best to help them succeed in the introductory classes, thereby ensuring opportunities in science as viable options. Faculty work particularly closely with the ACE program, and are involved in planning for the CalTeach program.

Promoting innovation and enhancing academic quality at both undergraduate and graduate levels: The Math Department is continuing to work on improving their instruction and research environment for graduate students, in consultation with the Graduate Council, after a recent one-year hiatus in graduate admissions. Additionally, department faculty work closely with colleagues in Education to prepare students who want to enter K-12 teaching. It is anticipated that Math faculty will be significant contributors to efforts supporting the new Cal Teach initiative.

Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010: The department is currently dependent on a significant allocation of annual TAS resources to mount the curriculum and support students in the courses. A memorandum of understanding between the Mathematics Department in Physical and Biological Sciences and the Applied Mathematics and Statistics Department in the School of Engineering supports sharing of specific service courses between the two departments.

Substantially increasing doctoral production: The Math Department is not expected to significantly increase doctoral production during this planning period as their graduate program is expected to grow at a slower rate than other science departments.

Substantially increasing contract and grant support: Almost all ladder rank faculty hold NSF grants.

Curricular Contributions
Mathematics is a central tool for science and engineering. Along with statistics, the lower level mathematics curriculum is also essential to Economics, Psychology, and to a lesser extent Sociology. The department thus provides a service to the entire campus and in a more focused way to the Physical and Biological Sciences Division and the School of Engineering. A recent development is the increasing role of the discipline in improving the preparation and knowledge base of future K-12 science and math teachers.

Specific Challenges
Co-existence and coordination with the proposed Department of Applied Math and Statistics in the School of Engineering has been challenging. The campus and the two divisions have not yet established a mechanism for optimum development and delivery of the common curricular elements, such as calculus and pre-calculus. Effective administration and establishment of clear roles and responsibilities for what many see as dual departments need to be carefully considered and negotiated by the campus.

Attracting and retaining a higher quality of entering graduate students is also a challenge for the department.

Accountability Measures
• Grow to approximately 20 FTE by 2011.
• Achieve top quarter NRC ranking or equivalent.
• Increase extramural support proportionate to faculty growth.
• Improve the quality of entering graduate students.
MCD Biology is the only department at UCSC that is devoted exclusively to research and education related to human health. The department maintains close alliances with a subset of the faculty in Chemistry & Biochemistry and Environmental Toxicology as well as faculty in Biomolecular Engineering in the School of Engineering. The faculty oversee productive research labs while administering an NIH-funded graduate training program and one of the largest undergraduate degree programs on campus. Proximity to the RNA Center and the Center for Biomolecular Science and Engineering have enhanced collaborations and joint funding opportunities.

**Scholarly Direction**

Molecular, cell and developmental biology covers a broad range of disciplines, including biochemistry, molecular biology, structural biology, bioinformatics, biophysics, genetics, cell biology, physiology, neurobiology and other fields. Given the small size of the department at UCSC, they have focused on and remain committed to building strength in RNA structure and function, chromosome biology, and neurobiology. In addition, they plan to dramatically expand their representation in the field of vertebrate biology by hiring faculty who utilize mammalian model systems in their research, supported by the new and modern vivarium that will be part of the biomedical sciences building. Several faculty are also plan to expand their research into the emerging field of stem cell biology.
Departmental priorities are similar to those in the 10-Year Plan with modest changes. The department has decided to take a less ambitious approach to building the neurobiology group. Though they hope to recruit additional neuroscientists in the future, they will give equal consideration to vertebrate biology, including virology, cancer biology, and stem cell biology. The department prefers not to conduct narrowly focused searches since that reduces their chances of identifying outstanding women or minority applicants. The outcome of discussions in Biomolecular Engineering may influence MCD Biology hiring plans.

Contributions to Divisional and Campus Goals

**Strengthening UCSC’s position as a major research university:** A health life sciences program is essential for a major research university, and MCD Biology faculty conduct high profile research in some of the most important areas of modern biology. The department also has one of the highest ratios of postdoctoral fellows to faculty of any department on campus, a critical factor for AAU membership.

**Improving access for the diverse population that comprises California today:** Educational programs related to human health are extremely popular with minority students, a driving factor in developing the new Health Sciences major. The department sponsors some of the most diverse programs on campus. In addition, faculty actively participate in co-curricular programs to support underrepresented students.

**Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:** The department has an excellent record for innovation and creativity. Professor Manny Ares, Jr., was recently appointed as an HHMI Professor, providing $1M for development of a unique undergraduate research lab. The Health Sciences major is unique in the UC system, requiring both Spanish language proficiency and an internship in a community health care setting. In 1988 the department created the first graduate rotation program on campus, becoming an interdivisional graduate program supported by an NIH training grant. The MBRS/MARC program is one of the most successful minority training programs in the country.

**Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:** The two biology departments are responsible for the majority of undergraduate degrees awarded by the division. Further expansion is dependent on new faculty resources.

**Substantially increasing doctoral production:** Life sciences programs are responsible for a significant fraction of graduate enrollments on other campuses since they are both popular and self-supporting. Hiring additional faculty in MCD Biology will substantially increase doctoral production at relatively little cost to the campus.

**Substantially increasing contract and grant support:** The department’s record is excellent already, generating a significant fraction of total campus indirect costs. Again, additional faculty are needed in order for the campus to experience a sizable increase from MCD Biology.

Curricular Contributions

At the undergraduate level, MCD Biology and EE Biology together administer a large and complex academic program. The departments offer nine biological sciences degrees and administer or participate in three interdisciplinary degrees, including the Biochemistry and Molecular Biology (BMB) major, for more than 1,800 proposed and declared majors. Many large undergraduate biological sciences lecture courses are required for degrees offered by other departments in PBSci and the School of Engineering. In addition, students from other departments and divisions take MCD Biology courses to satisfy medical school and other professional school admissions requirements.
At the graduate level, MCD Biology and EE Biology administer separate Ph.D. programs of between 50 and 60 students each.

**Specific Challenges**

The NIH, which supports many investigators in MCD Biology, has reduced funding levels. The faculty will need to diversify their sources of extramural support in order to maintain the excellence of their research programs.

The pace of recruitments, given large start-up requirements and potential replacements, will be challenging as well. The increased (and increasing) popularity of the undergraduate programs, especially the new Health Sciences major, make it difficult to cover enrollment growth with the existing number of faculty and even with an enhanced TAS allocation. Assuring students’ adequate access to the Spanish language courses required of the Health Sciences major has been threatened given the apparent funding limitations for the Language Program.

Finally, staff support has been inadequate to cover increased workload driven by significantly higher enrollments.

**Accountability Measures**

- Grow to approximately 26 FTE by 2011 and to between 28 and 32 FTE by 2014-15.
- Achieve top quarter NRC ranking or equivalent.
- Increase extramural support proportionate to faculty growth.
- Increase graduate student numbers proportionate to faculty growth.
- Lead the development of an interdisciplinary graduate group in biomedical sciences on a timescale consistent with opening of the Biomedical Sciences building.
- Participate in developing a coordinated Biology major/Education minor or comparable program in collaboration with the new California Teach initiative.
Oceanography, by definition, is multi-disciplinary and interdisciplinary. The department has structured the thematic areas of emphasis to best leverage existing faculty strengths and to maximize the interactions and interdisciplinary impact of existing faculty and the two most immediate proposed hires. Ocean Sciences and its programs complement the marine biology program in Ecology and Evolutionary Biology and aspects of the Earth Sciences Department. Ocean Sciences also has ties to Applied Mathematics and Statistics in the School of Engineering, especially in ocean ecology and ocean circulation and climate.

**Scholarly Direction**

Academic strengths in Ocean Sciences include biological oceanography, marine microbial ecology, chemical oceanography, marine biogeochemistry, physical oceanography and climatology, biological-physical modeling of the marine environment, and paleoceanography and paleoclimatology. Research collaboration is one of the department’s strengths due to close interactions with the Institute of Marine Sciences (IMS) and the Institute of Geophysics and Planetary Physics (IGPP) and its research centers. In addition, research is well suited to the Monterey Bay area with its many marine and ocean science initiatives and institutions in the region.

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**Ocean Sciences**

| Current FTE, Including 2005-06 Searches | 9 |
| Proposed FTE by 2014-15 | 11 to 12 |
| Degrees Conferred, 2004-05 | Masters and Certificates: 1  
Ph.D.: 3.0  
TOTAL: |
| Source: 2004-05 Instructional Load Summary | |
| Postdoctoral Students | 8 |
| Source: PBSci Academic Personnel | |
| Student Workload FTE | Graduate: 40.9  
TOTAL: 178.5 |
| Source: 2004-05 Instructional Load Summary | |
| Extramural Awards, 2004-05 | $3,973,923* |
| Source: PBSci Research Resources | |
| Indirect Cost Returns, 2004-05 | $651,491 |
| Source: PBSci Research Resources | |
| Proposed New Programs or Expansion of Existing Programs | Developing plans to establish a coursework Master’s program to boost enrollment in the graduate program. |

*Ocean Sciences researchers also contribute significantly to Institute of Marine Sciences activities, which attracted an additional $7.5M/$1.3M of direct/indirect costs in 2004-05 that are not included in any department summaries, as well as 14 postdocs not counted elsewhere.
The department’s goals are consistent with those in the 10-Year Plan. As with other divisional departments, the lack of progress toward those goals is due to the lack of new FTE, soon to be rectified.

Contributions to Divisional and Campus Goals

**Strengthening UCSC’s position as a major research university:** The Ocean Sciences Department has an excellent track record of research and publication, confirmed by their recent external review. As a research and graduate-student focused department, their core activities directly further this goal.

**Improving access for the diverse population that comprises California today:** The diversity of the department faculty provides excellent role models for students. The current graduate program is 68% women and 18.4% minority. The department is focused on not only increasing representation in the department but on providing training that prepares students to work effectively with the diverse California workforce.

**Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:** Ocean Sciences provides a rich interdisciplinary curriculum and strong professional training. The department continually seeks ways to more effectively use regional resources to offer students cross-disciplinary experiences with which they can form unique professional identities.

**Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:** The department continues to provide popular lower division service courses to help students fulfill their general education requirements. In addition, Ocean Sciences faculty teach courses to support upper division undergraduate requirements in other departments, such as Ecology and Evolutionary Biology and Earth Sciences.

**Substantially increasing doctoral production:** The developing Ocean Sciences graduate group is trans-departmental, trans-divisional, and trans-institutional. The department can further enhance their ability to attract outstanding and diverse students from around the country because of the large range of opportunities students find at UCSC and at surrounding institutions and agencies. Ocean Sciences will expand these efforts as their faculty numbers increase.

**Substantially increasing contract and grant support:** The department has an excellent record of support from external agencies such as NSF, NOAA, NASA, and ONR. Their interdisciplinary faculty have been particularly adept at collaborating on multi-disciplinary, multi-PI, multi-institution grants. New faculty hires are proposed in areas with excellent funding opportunities and bright futures.

Curricular Contributions

The department has experienced a gradual shift from primarily Master’s students to primarily Ph.D. students as the program has matured. Faculty are developing plans to establish a coursework Master’s program to boost enrollment in their program.

Though a graduate-only program, Ocean Sciences faculty participate in undergraduate education by offering upper division undergraduate courses that are major requirements or courses that are electives in other programs and through the offering of lower division general education courses.

Specific Challenges

Space is the department’s most pressing concern, not likely to be mitigated effectively until the Environmental Sciences building is completed (proposed for 2013). The department needs space for research labs, faculty offices, graduate student offices, and sections for large introductory courses. In addition, faculty time for program development is limited by the small size of the department and the administrative roles that several faculty are playing.
Accountability Measures

- Grow to approximately 10 FTE by 2011 and to between 11 and 12 FTE by 2014-15.
- Increase extramural support proportionate to faculty growth.
- Increase graduate student numbers proportionate to faculty growth.
- Increase contribution to the division’s share of general education instruction proportionate to campus growth.
The major areas of emphasis are the study of fundamental particles and interactions (high-energy physics), the study of condensed matter physics, and astrophysics/cosmology. Instruction and research in the Physics Department are enhanced by close connection to the Santa Cruz Institute for Particle Physics (SCIPP) and by scientific associations with Stanford Linear Accelerator Center (SLAC) and Stanford Synchrotron Radiation Laboratory (SSRL) at Stanford, the UC Observatories, and various x-ray and neutron scattering centers at national laboratories.

Scholarly Direction

Research is currently conducted in theoretical and experimental particle physics, theoretical and experimental condensed matter physics, materials physics, biophysics, synchrotron radiation, cosmic rays, particle astrophysics, cosmology, and waves in random media. Efforts in high-energy physics are aided by the presence of the SCIPP, where theorists and experimentalists are engaged in research projects around the world. Close proximity with the Department of Astronomy & Astrophysics and UCO/Lick Observatory provides additional opportunities for collaborations between researchers in physics and astronomy.

The department’s goals are similar to those in the 10-Year Plan, with a change to emphasize growth in the area of condensed matter physics with a collaborative and interdisciplinary view.
Contributions to Divisional and Campus Goals

*Strengthening UCSC’s position as a major research university:* Participation in developing a materials science program will contribute to enhancing the campus’s reputation. The ongoing efforts of the Santa Cruz Institute for Particle Physics will continue to bring funding and recognition to the campus.

*Improving access for the diverse population that comprises California today:* The department has had a continuous GAANN program since 1993 and through this program has increased the graduate student representation of women to about one-third, more than twice the national average for physics departments. Physics has an equally impressive representation of women, about one-third, in the undergraduate program. Improving diversity in the department remains a high priority.

*Promoting innovation and enhancing academic quality at both undergraduate and graduate levels:* The department has an excellent record for innovation and creativity. Physics has added new majors in Applied Physics and Physics (Astrophysics) to better serve students. Increasing the number of faculty will allow the offering of a complete particle/astrophysics as well as condensed matter suite of graduate courses.

*Managing the enrollment growth necessary to accommodate 2,800 new student FTE between now and 2010:* Physics is offering summer quarter courses in the introductory series to accommodate additional students as needed. Physics continues to provide service courses for science and engineering departments.

*Substantially increasing doctoral production:* Though already considered a large graduate program, Physics hopes to accommodate 10-15 new graduate students with the proposed increase in faculty FTE.

*Substantially increasing contract and grant support:* Synergistic research across campus in materials science and in the collaborations between SCIPP and Astronomy & Astrophysics provide opportunities for new large research program grants for multiple PIs.

**Curricular Contributions**

The Physics Department offers majors to prepare students for graduate work in physics, astrophysics, and astronomy; for engineering and other technical positions in industry; and for careers in education. The applied physics major is excellent preparation for positions in industry directly upon graduation. Physics provides required courses for many other science majors in Physical and Biological Sciences and in the School of Engineering. Their summer offerings of introductory courses in the Physics 6 and 7 series have been popular.

**Specific Challenges**

An increase in the number of condensed matter faculty is needed to establish depth and strength comparable to the high energy group and to provide the necessary array of condensed matter courses to serve the graduate students. Yet for the health and balance of the department, parallel growth should occur in the areas of condensed matter and high energy particle/astrophysics positions.

**Accountability Measures**

- Grow to approximately 22.5 FTE by 2011 and to between 22.5 and 24.5 FTE by 2014-15.
- Achieve top quarter NRC ranking or equivalent.
- Increase extramural support proportionate to faculty growth.
- Increase graduate student numbers proportionate to faculty growth.
- Increase capacity in service and majors courses proportionate to campus growth.
- Participate in development of interdisciplinary materials science program.
Science Communication

The Science Communication Program at UCSC has been producing professionally trained science writers since 1982. The writing track is an academic year long, plus a summer internship. It is the only graduate science writing program in the nation that requires substantial previous science training. More than 200 graduates of the program now write about science for newspapers, magazines, broadcast media, universities, museums, industries, book audiences, and as freelance writers.

University Extension administers the illustration track of the Science Communication Program.

Programmatic Direction

Unlike conventional master’s programs in communications or journalism, the Science Writing certificate program is intended for people who want to write for the public about science rather than about general breaking news. The program stresses writing and editing in depth rather than spreading students’ attention among such topics as page layout, media law, the history of typography and direct-mail advertising. The curriculum emphasizes feature writing, and longer forms in general, more than reporting the news. Students are engaged primarily in reporting and writing stories for 60–80 or more hours a week throughout the academic year.

Contributions to Divisional and Campus Goals

Training future journalists to write about science in an accurate, nuanced, and engaging way is an important aspect of the social engagement of the division. The Science Communication Program is widely regarded as one of the best science writing programs in the world. “I don’t know of another program that has had as many outstanding graduates year after year,” says Ellis Rubinstein, former editor of Science and now CEO of the New York Academy of Sciences. “It has produced some of the best science journalists we have.”

The program bridges the gap between scientists and the public to learn about new technology, advances against disease, and develop a deeper appreciation of the natural world. Given the program’s success and current pedagogy, it is likely to remain a 10-student program for the immediate future.

Specific Challenges

Student financial support and adequate resources to compensate guest lecturers are the department’s greatest ongoing challenge. An immediate but temporary challenge is replacement of the founder and long-time director of the program, John Wilkes. He has retired and been recalled part-time to continue as program director while a search is conducted for his replacement.