

UCSD Division of Physical Sciences

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CHARTING THE COURSE III

DIVISION OF PHYSICAL SCIENCES

2004/05 – 2006/07

I. Introduction

The sciences formed the core of UCSD at the time this campus was founded. Initial faculty appointments were dazzling and the growth of the reputation of the university was unusually rapid if not totally unprecedented. Early leaders such as Roger Revelle, Harold Urey, Herbert York, and Maria Mayer exemplify the vision that continues to fuel the Division of Physical Sciences. Discovery, research, and education within the Division delve into scientific and computational issues that are of critical relevance and interest to all levels of society. We are working on new frontiers of science that not only impact the present but will also solve highly complex problems for future generations. Just as it was at its founding, the Division of Physical Sciences is extraordinarily broad in scope and is inherently interdisciplinary at all levels of the research enterprise. This breadth cuts across the entire UCSD campus, includes leadership within the local research community, and provides training for future generations of scientists.

The Division's future must be consistent with the pioneering tradition established in the 1960s by Roger Revelle—the founder of UCSD. Revelle recruited scientific luminaries who were able to crossdisciplinary boundaries and establish new fields of basic research. The Division must also focus on future applied research and the educational needs of California's rapidly growing technology sector. As basic scientists, our ability to reach the frontiers of knowledge depends on our successes in breaking down the disciplinary walls and rebuilding seamless and overlapping scientific fields. In addition to bridging disciplines, we must address the concerns of policymakers and a society concerned with maintaining a sustainable environment and economy.

This is a critical point in time for the Division. During the past six years, our physics, chemistry, biochemistry, and mathematics research programs have undergone unprecedented growth in both the numbers of students served, and in funding. Since 1998, funding for Mathematics has increased 112 percent; funding for Physics, 65 percent; and 43 percent for Chemistry and Biochemistry. These increases have allowed us to recruit stellar junior and senior faculty members including Efim Zelmanov, a Fields Medalist and a world renowned researcher in algebra; Michael Norman, the world's leading computational astrophysicist; Peter Wolynes, a world authority in theoretical chemistry, and Mario Molina, a world-renowned atmospheric scientist and recipient of the 1995 Nobel Prize in Chemistry.

Our plan represents an on-going dialogue that follows in the path of goals stated in our Charting the Course II document: “build upon existing greatness, amplify existing strengths, and expand into new areas.” It lays out a steady-state vision for the Physical Sciences while at the same time provides a focus for the next three years. Our dialogue encompasses discussion within the Physical Sciences, the UCSD Campus, and the local scientific community.

II. Accomplishments

Since the year 2000/01, the Division of Physical Sciences has successfully appointed 25 new faculty. Sixteen of these appointments were at the Assistant Professor level, two at the Associate Professor level, six at the full Professor level, and one at the level of LPSOE. Our recruitments have been spectacular and include the appointment of Field's Medalist Dr. Efim Zelmanov and Nobel Prize winner Dr. Mario Molina, a world-renowned atmospheric scientist. These appointments are summarized in Table 1.

	<u>Rank</u>		<u>Field</u>
<u>Chemistry/Biochemistry</u>			
Burkart, Michael	Asst	II OS	Organic
Hoffman, Alex	Asst	II OS	Biochem
Kobayashi, Yoshi	Asst	II OS	Organic
VanNiewenheze, Michael	Asst	III OS	Organic
Wang, Wei	Asst	II OS	Bioinformatics
Yang, Jerry	Asst	II OS	Organic, Materials
Zhou, Huilin	Asst	II OS	Biochem, LUDWIG INST
Molina, Mario	Prof	AS	Physical, Nobel Medalist
Opella, Stan	Prof	AS	Biochem
Prather, Kim	Prof	II OS	Environmental Chemistry
<u>Mathematics</u>			
Cheng, Li-Tien	Asst	I OS	Numerical Analysis
Gan, Wee Teck	Asst	III OS	Representation Theory
Ni, Lei	Asst	III OS	Geometry
Popescu, Cristian	Asst	IV OS	Number Theory
Tesler, Glenn	Asst	II OS	Bioinformatics
Eggers, John	LPSOE		Instruction
Harel, Guershon	Prof	IV OS	Education
Zelmanov, Efim	Prof	AS	Algebra, Fields Medalist
<u>Physics</u>			
Diventra, Massimiliano	Assoc	II OS	Computation
Wuerthwein, Frank	Assoc	I OS	Particle
Fogler, Michael	Asst	II OS	Condensed Matter
Keating, Bruce	Asst	II OS	Astro
Murphy, Tom	Asst	II OS	Astro
Padoan, Paolo	Asst	II OS	Computation
Butov, Leonid	Prof	II OS	Condensed Matter, Materials

During the reporting period, we successfully retained four outstanding scientists – all of whom continue to make substantive contributions to the research profile of UCSD. They are Michael Holst in Mathematics, Elizabeth Komives in Chemistry and Biochemistry, Michael Sailor in Chemistry and Biochemistry, and Dimitri Basov in Physics. The Division is currently engaged in the recruitment of twenty positions.

As was the case at the founding of UCSD, the Division of Physical Sciences continues its leadership in interdisciplinary research and education. Leading the way in interdisciplinary research, we have made successful appointments of two faculty in the area of Bioinformatics (Glenn Tesler and Wei Wang), two in the Environmental Sciences (Kim Prather and Mario Molina) and several in the Computational Sciences (Mike Norman, Massimiliano DiVentra, and Paolo Padoan).

In 2002, the Division was awarded a \$10-million grant from the National Science Foundation to establish the world's leading center in the emerging field of theoretical biological physics. In the true interdisciplinary tradition of Roger Revelle, this new Center brings together a core group of chemists, physicists, mathematicians and biologists from the Division, the San Diego Supercomputer Center, The Scripps Research Institute and The Salk Institute for Biological Studies with experimentalists and theoreticians from around the world. The purpose of this Center is to advance research and educate scientists in a new discipline that uses the theoretical tools of physics to understand the fundamental principles governing complex biological systems. This interdisciplinary approach provides biologists with a better understanding of the underlying mechanisms governing complex biological systems, such as networks of neurons or biochemical pathways in the assembly of proteins. It also allows physicists to develop new principles and models for complex systems based on biological phenomena.

In 2003, a major five-year, \$35 million grant from the National Institute of General Medical Sciences (HIGMS) was awarded under the leadership of Professor Edward Dennis. It will support more than 30 researchers at 18 universities, medical research institutes, and companies across the United States, who will work together in a detailed analysis of the structure and function of lipids.

Developing innovative educational programs for future scientists has been one of the hallmarks of our Division. In recent years, divisional faculty members have led the development of new multidisciplinary undergraduate majors in environmental science and bioinformatics. All three departments, Chemistry and Biochemistry, Mathematics, and Physics, have played a major role in the development of the new Ph.D. program in bioinformatics, established in 2001. In addition, we are currently leading the development of multidisciplinary programs in computational science, molecular synthesis, medical physics, and are at the forefront of mathematics and sciences learning through the Mathematics and Science Education Program.

III. Research Profile and Faculty FTE Growth

As stated earlier in this plan, our recruitment objectives continue to focus on expansion of existing strengths while leveraging these strengths with those present across the campus to include the Division of Biological Sciences, Jacobs School of Engineering, Division of Social Sciences, San Diego Supercomputer Center, Cal (IT)², School of Medicine, Scripps Institution of Oceanography as well as the local scientific community to include TSRI, the Salk Institute and the Burnham Institute. In addition, our plan identifies opportunities for improving our national rankings and for bringing our instructional workload to levels that are consonant with the General Campus.

In 1995, the National Research Council released the results of a major national study that ranked graduate programs on the basis of faculty quality. The results for programs in the Physical Sciences are summarized as follows:

	Biochemistry	Chemistry	Mathematics	Physics
Rank	9	18	17	16

Our goal is to improve upon these rankings and seize upon opportunities in Chemistry and Biochemistry, Mathematics, and Physics to make significant progress to the top-ten list. With noted subsequent hires that include Field's Medalist Efim Zelmanov, Nobel Laureate Mario Molina, National Academy members Mike Norman and Peter Wolynes, and world-renowned structural biochemist Stan Opella, we believe that planning for a number of very strategic senior hires will take us far in improving these rankings. In a featured article in *The Chronical of Higher Education*, the issue of elevating the rankings and quality of a research university was highlighted. A conclusion of that study was that selected senior hires were viewed as the single most critical activity that a campus can do to gain the external visibility important to the elevation of university standings. Given limited resources, the selection of such senior hires must be done with extraordinary focus and consideration. Given that there is not an infinite reservoir of such hires they must be made in such a manner that they exact the maximum benefit. Our past senior hires have served such a purpose and this Charting the Course timeline will continue that plan and trajectory. In section V.A., we describe the mix of junior to senior positions that we consider necessary to get there.

Our three-year and steady-state plans also seek to bring our student:faculty ratio in-line with that of the General Campus. We are guided by the facts that, since 1995/96, the Division of Physical Sciences has consistently carried 20% of the General Campus instructional workload with averages of 31% of lower division student fte, 10% of upper division student fte, and 14% of graduate student headcounts. We presently constitute 14% of the faculty and remain slightly short of our FTE count of 1990/91 – largely due to the volume of retirements experienced through the VERIP years.

In Section III.A, we discuss our philosophy and strategy for interdisciplinary research and hires. Section III.B summarizes the individual plans of the departments. Complete departmental plans are included as Appendices 1-3.

A. Interdisciplinary Initiatives

The philosophical basis for our interdisciplinary hires is best captured by the Revelle Plan. It is eloquently described in UCSD's historical work, *Improbable Venture*, as a founding philosophy that the University would not be collection of traditional stovepipes, but rather an integrated campus where exchange between the disciplines was seamless. Our plan is a twofold recognition of this history. The following is a listing of areas of particular note to the Division's goals. It should be stated that these are broad and overlapping. For example, bioinformatics and computational science represent disciplinary intersections. Major advances in our understanding of the environment at the regional and planetary level may depend upon new advances in nanotechnology. Proteomics is an area where the next generation of discovery will come from individuals trained in biology/physics/chemistry and mathematics. Our Division has, since its inception, lead the way in recruitment of individuals whose research areas were not considered mid-stream in any given field. Our own Department of Chemistry and Biochemistry was one of the first departments at UCSD. Nobel Laureate Harold Urey was the first recruit and as a chemist was investigating the formation of the moon; while Hans Suess was studying the origin of the elements, Stanley Miller the origin of life, and James Arnold, cosmic rays. These are investigations that could easily have been at home in a department of physics, astrophysics, or planetary science. This is our history and it is a direction we will continue to pursue.

- 1. Bioinformatics:** Recent appointments of Wei Wang and Glenn Tesler have contributed to the success of the campus Bioinformatics initiative.
- 2. Computational Science and Theory:** Computational Science continues to be a major focus area of the Division of Physical Sciences and, once again, was identified by all three departments as important to their future growth. Our Division has emerged as a leader in this broad field with the presence of faculty such as Peter Wolynes, Andy McCammon, Michael Holst and Jose Onuchic. As a General Campus target area in Charting the Course I, we made the extraordinary appointment of Mike Norman. For Charting the Course II, the Division continued this focus and independently set aside one position which resulted in the appointment of two young scientists in physics, Massimiliano DiVentra and Paolo Padoan. We have every expectation that the push to build in computational science and theory, along with our initiatives to build a Theory Center and to establish a graduate program in Computational Science, will enhance a continued escalation in the rankings of UCSD. These goals overlap considerably with other divisions (JSOE, Biological Sciences) as well as with the San Diego Supercomputer Center.
- 3. Environment:** The recent appointment of Mario Molina culminates our efforts to establish UCSD as the center of environmental research. Drawing upon the intellectual resources of UCSD's Divisions of Physical and Biological Sciences, Jacobs School of Engineering, Scripps Institution of Oceanography, School of Medicine, International Relations and Pacific Studies and the Division of Social Sciences our campus is world renowned in atmospheric chemistry, climate change, biology, human health and international relations and public policy to examine the environmental, societal and human health impacts of global aerosol emissions.

4. Materials/Nanotechnology: With the presence of Cal (IT)² and existing strengths, continued expansion in this area remains a priority. We have had successes in these areas that add to our considerable strengths with the recent appointments of Jerry Yang and Leonid Butov. Broad objectives inherent in these fields span the traditional physical science disciplines, and successfully addressing these challenges will require contribution and collaboration from chemists, physicists, mathematicians, and engineers.

5. Medicinal Chemistry – Natural Products: The Department of Chemistry and Biochemistry, Scripps Institution of Oceanography, and the School of Pharmacy and Pharmaceutical Sciences are developing an initiative in Medicinal Chemistry and Natural Products. This focus area would combine the general areas of natural products chemistry, medicinal chemistry and pharmaceutical discovery.

6. Proteomics: The accelerating determination of genome sequences and their interpretation (genomics) has brought with it one of the most daunting challenges to modern bioscience: the concomitant determination of the structure, function, and expression of all of the corresponding proteins that are encoded therein. The addition of Huilin Zhou has been very positive for the growth of proteomics at UCSD and additional faculty are needed to complement the current core.

B. Departmental Research and Recruitment Profiles

The individual departmental hires are discussed in detail in the ensuing sections. A review of the literature in *Science and Nature* clearly demonstrates the extraordinary degree of disciplinary intermixture. For example, the fields of biology and biochemistry have advanced in theory and measurement where complex mathematical approaches are now crucial in unraveling the most intimate details of the chemistry, biology, and function of molecules. Similarly, nanotechnology transitions between chemistry, physics, and engineering and applications range from medicine to environmental sensing to space applications. The field of computational science impacts bioinformatics, molecular design and synthesis, financial mathematics and economics, astrophysics, particle physics, and climate to highlight a few. This Division lies at the fundamental center of such activities. To lead the way in future generations, recruitments of the highest caliber, broadest thinking individuals is essential. It is our goal to continue our founding traditions and bring to the Division such scientists.

1. Department of Chemistry and Biochemistry

The Department of Chemistry and Biochemistry continues to play a leading role in the evolution of UCSD with research that spans the spectrum from basic research on fundamental problems to interdisciplinary efforts that define new fields of scientific inquiry. The faculty work closely with colleagues from the Schools of Medicine and Engineering, Division of Biological Sciences, San Diego Supercomputer Center, Scripps Institution of Oceanography as well as many neighboring research institutes and industrial laboratories located on the Torrey Pines Mesa. A stated goal is to become one of the top departments in the nation in research in the chemical sciences and the training of graduate and undergraduate students. The department's instructional workload remains one of the highest on the General Campus with a Penner ratio of 1.83. The department's expansion plans are as follows:

a. Biochemistry: The Division of Biochemistry has made significant hires in many of the areas identified in Charting the Course II to include bioinformatics and proteomics with the recruitments of Alex Hoffman, Wei Wang, and Huilin Zhou. Current recruitments target the areas of structure of supramolecular machines, biological mass spectrometry, carbohydrates, and quantitative modeling of systems. Priorities for the coming recruitment cycle are:

i. Molecular Evolution/Protein Design: This focus will leverage current strengths that include analysis of the structure and function of natural proteins and nucleic acids. A new hire in this area will synergize with all other divisions within the department as a result of interfaces with organic synthesis of ligands and substrates, bioinorganic and fast optical spectroscopy, and computational prediction of structure and dynamics.

ii. Signaling at Membranes: Many of the functions of membrane proteins are unique, especially because of their roles in signaling as a result of binding effector molecules. These are important biological roles that lead to their importance as receptors for drugs. Expansion in this area would be interdisciplinary in nature combining studies with both theoretical and experimental methods of structural biology and intensive interactions with biochemistry and functional genomics.

iii. Chemical Approaches to Novel Biological Processes: The division seeks to recruit an individual who is applying chemical and/or quantitative approaches to novel biological processes such as the function of micro RNAs, organellar trafficking, recently discovered post-translational modifications, chemotaxis, etc. A hire in this area would complement existing expansions in structural characterization and quantitative analysis/modeling of supramolecular assemblies.

b. Inorganic Chemistry: Inorganic chemistry is by its very nature a branch that crosses many disciplines. The inorganic division has grown to represent major strengths in historical core areas including magnetochemistry, mechanistic inorganic chemistry, electrochemistry and electron transfer, photochemistry, x-ray crystallography, and metal cluster chemistry. It is one of the few inorganic divisions in the nation with an emphasis in environmental chemistry. There are also significant strengths in materials and solid state chemistry, actinide chemistry, bioinorganic chemistry, and nanoscience and sensor technology. Recruitment priorities include:

i. Bioinorganic Chemistry: There is currently only one faculty member devoted to this area. In view of the strength of UCSD in biology, dynamic opportunities exist on campus for bioinorganic chemistry. These include medicinal chemistry, metal-containing enzymes, magnetic resonance imaging, metal ion regulation of gene expression, mechanisms of metal ion toxicity, and marine bioinorganic chemistry. The division proposes two appointments (one Senior and one Junior) in this area.

ii. Inorganic Electronic, Magnetic, and Optical Materials: Research opportunities in materials science and engineering at UCSD

continue to grow and the creation of Cal (IT)² has led to a major focus on materials and devices. A junior level inorganic materials chemist in one of the emerging areas such as spintronics would thrive in the UCSD environment.

iii. Inorganic Synthesis: A third area of growth for the inorganic division is the area of inorganic synthesis. Synthetic inorganic polymer chemistry, the synthesis of new solid state materials, and the synthesis of nanomaterials represent key growth areas.

c. Organic Chemistry: Organic chemistry has traditionally been described as the chemistry of carbon-containing compounds and is at the core of numerous fields ranging from chemical biology to materials science. It is also the foundation of the pharmaceutical industry. A critical recruitment has been that for a Senior Organic Chemist which has been on the books and a priority for some years. A successful appointment will partially offset recent losses of senior faculty (McMorris, Harvey, and Siegel). Over the past few years, the division has had remarkable successes recruiting junior faculty. For the upcoming cycle, the division proposes two growth positions.

i. Bioorganic and Medicinal Chemistry: A recruitment in this area will leverage partnerships already established with the School of Pharmacy, School of Medicine, Scripps Institution of Oceanography, Division of Biological Sciences, and Bioengineering. Medicinal Chemistry represents a significant focus area for the Division of Physical Sciences and is discussed in Section II.3.

ii. Materials Chemistry: Expansion in Materials crosses disciplines within the department and across the UCSD campus. It too is a Physical Sciences' focus area and is discussed in Section III.A.

d. Physical Chemistry: Bridging physics, biophysics, biochemistry, mathematics, materials science, and engineering, physical chemistry is considered to be the most interdisciplinary branch of chemistry. The division has made super hires in recent years with the appointments of Kim Prather, Peter Wolynes, and most recently Nobelist Mario Molina. Age distribution is of particular concern for the division and there is a need to replenish their ranks at the junior level. In Charting the Course II, the Physical Chemistry Division identified environmental chemistry, biological chemistry, material chemistry, and computational/theoretical chemistry as focus areas. Their hiring proposal for the next three years calls for three new FTE in the following areas.

i. Biophysical Chemistry: At a time when enormous strides are being made in the biophysical sciences, the loss of several senior physical chemists in this area over the past few years has left significant gaps in the experimental arena.

ii. Materials Chemistry: This cross disciplinary area also occupies an essential focus in the Physical Chemistry Division. The study of

materials is not complete without a strong base in chemistry and a recruitment in this area might be in optical communications or single molecule spectroscopy.

iii. Computational/Theoretical Chemistry: The Division of Physical Sciences is leading the way in this interdisciplinary field under the senior leadership of faculty in all three of our departments. With the recent NSF award for the Center for Theoretical Biological Physics and the NIH renewal of the National Biomedical Computation Resource, the division would like to recruit junior level faculty.

iv. Atmospheric/Environmental/Analytical: With the recent additions of Kim Prather and Mario Molina, there is a strong complement of faculty with interests in these areas. This core is the beginning of a very high profile program in atmospheric/environmental/analytical chemistry and future interactions with recent and future hires at SIO and JSOE, will certainly get this program national recognition.

2. Department of Mathematics

The Department has a unique recruitment strategy where there is a preference to hire with an emphasis on the quality of the individual, rather than on discipline. There are two reasons this works for Mathematics, but not for other disciplines. First, mathematicians change fields several times over a successful career. Secondly, the computer-based nature of mathematics research provides greater flexibility. I fully support this hiring strategy. This approach has worked extraordinarily well in the past and has not led to over-concentration in any specific area. The department requests 10 faculty positions plus 1 LSOE over the next 3-year time period with consideration given to the following areas:

a. Analysis: All leading mathematics departments have strong analytic representation and it is important we remain competitive. Although the department has not hired any pure analysts in recent years, the additions of Bill McEneaney and Lei Ni have been helpful to the analysis group which proposes to hire one to two junior faculty in the coming cycle.

b. Statistics/Biostatistics/Statistical Genomics: The statistics group has been depleted over the years with the loss of John Rice, Richard Olshen, Murray Rosenblatt, John O'Quigley, and the anticipated retirement of Len Haff. Restoration of this group will require the hiring of one to two new faculty.

c. Number Theory, Representation Theory, and Algebra: Despite the recent hires of Wee Teck Gan, Christian Popescu and Efim Zelmanov, age distribution remains a serious concern for this group. In the next five years we anticipate the retirement of several senior faculty. If a concerted effort is not undertaken to add young mathematicians to this group, a ten-year timeframe would seriously erode its strengths.

- d. Geometry, Topology, and Mathematical Physics:** Although the losses of Richard Hamilton and Michael Freedman have weakened this group, we have had successes with the hiring of Lei Ni and Mark Gross.
- e. Probability:** This group proposes the addition of one new faculty position with a possible focus on mathematical finance.
- f. Combinatorics, Logic, Theoretical Computer Science:** This group proposes hiring in two areas: logic and random structures/algorithms.
- g. Computational and Applied Mathematics:** This group consists of five faculty having successfully retained Michael Holst recently. The campus role of this group has become increasingly interdisciplinary with involvement in biology, chemistry, and physics. It will require further staffing to fully engage in related campus initiatives and proposes six hires during Charting the Course III. It is noted that this group has been actively involved in computational science, nanotechnology, and proteomics initiatives of the Division of Physical Sciences.

3. Department of Physics

Building on their earlier successes with the recruitment of Drs. Michael Norman, Doug Smith, and Sunil Sinha, the Department of Physics appointed seven faculty during the Charting the Course II cycle. Four of these were at the Assistant Professor level. The department requests six new FTE over the next three years and continues to look at strategic hiring that considers fields not currently represented in the department, seeks interdisciplinary appointments, and expands represented fields in new areas.

- a. Condensed Matter:** The condensed matter group was ranked 11th in the last *U.S. News and World Report* survey. This group has interest in recruiting in a number of areas which includes fabricating, manipulating, and studying nanostructure; “quantumology”; single molecule imaging; and self-organized condensed matter.
- b. Astrophysics:** The astrophysics group is experiencing substantial advances in instrumentation. There are many areas for targeted recruitments that include observers in the infrared to study star and galaxy formation, in the x-ray and sub-millimeter wavelengths to study the cosmic background radiation, and using neutrinos to study particle cosmology. Theoretical appointments in analytical cosmology and analytical or numerical studies of black holes, compact objects, or galaxy formation are also of interest.
- c. Particle Physics:** The experimental particle physics group works on accelerator based experiments using high energy matter-antimatter collisions to probe the structure of quarks and the forces acting on them. It also studies the mechanism for asymmetries between matter and antimatter, and investigates the origin and nature of mass. New areas may include non-accelerator based experiments, neutrino physics, investigations of dark energy, cold dark matter, proton decay, and ultra high energy cosmic rays.

The particle theory group is working on topics ranging from elaboration of the Standard Model to string theory using a variety of approaches. String theory and recent extensions to “M-theory” suggest interesting surprises for physics beyond the Standard Model including many new kinds of particles, extra space dimensions, and the suggestion that classical concepts of space and time can be altered by quantum gravity effects.

d. Biophysics: Our Physics Department has been a pioneer in Biophysics beginning with research in this area in the 1960’s. It was recently designated as an NSF Center for Theoretical Biological Physics. Future directions are guided by a sense of devising a calculus for networks at three levels: 1) protein-protein interactions, 2) molecular genetics, and 3) multicellular networks.

e. Plasma Physics: Our plasma physics group is distinguished and well-funded. With the United States reentering international negotiations to develop a burning plasma experiment and the International Thermonuclear Experimental Reactor (ITER) the highest priority of the DOE, new opportunities for research and a national need for trained students will be created.

IV. Education

In 2002/03, undergraduate course enrollments in the Division exceeded 42,000, graduate student headcounts neared 400, and the adjusted ratio of students to faculty was 34:1 – well exceeding that of the General Campus which was 25:1. Our courses serve majors from across the campus. For this reason, we expect instructional growth in our Division will be linear with that of the campus. Departmental specific instructional plans are included in Appendices 1-3. Following are highlights of several initiatives that highlight the innovation and cross-disciplinary leadership of our faculty.

A. Environmental Systems (ESYS)

The Environmental Systems (ESYS) Program recognizes the growing demand for environmental specialists and is designed to prepare undergraduates for a variety of environmental careers or graduate programs in the natural sciences, the social sciences, public policy, law and business. Implemented in 2000/01, the program enrolled 66 majors last year and is planning to enroll as many as 80 this year. This program has operated under the slimmest of budgets, sharing staffing and operating costs with the Earth Sciences Program. We anticipate that growth beyond 80 majors will trigger a necessary review of the program’s budgetary requirements. This past year we were fortunate to have hired Dr. Jane Teranes as the Associate Director. Dr. Teranes has a strong commitment to undergraduate education and her scientific background in environmental sciences makes her a perfect complement to the program.

B. Computational Science

The Division of Physical Sciences is taking the lead in the development of this new graduate program at both the Masters and Doctorate levels. Computational Science is a newly emerging field that uses tools from computer science and applied mathematics to

study problems in science and engineering whose solutions require extensive computation.

C. Mathematics and Science Education Program (MSED)

The MSED Program is a joint doctoral program with San Diego State University intended for students with Master's Degrees in biology, chemistry, mathematics, or physics who wish to complement their discipline knowledge with studies of how people learn mathematics and science. Faculty from the Divisions of Physical and Social Sciences are actively engaged and efforts are underway to further strengthen the program by exploring opportunities with UCSD's Teaching Education Program. Professors Guershon Harel and Alfred Manaster who are key members of the MSED faculty, received a three year, \$1,500,000 NSF grant in 2003 to conduct mathematics education research. This grant can support up to three MSED graduate students and one postdoctoral fellow each year. There remains several resource concerns which are explained in the MSED Charting the Course document that is attached as Appendix 4.

D. Mathematics, Testing and Placement (MTP)

The MTP office schedules and arranges for administration of mathematics placement tests in cooperation with the six undergraduate colleges, Summer Bridge, OASIS, and other UCSD offices. MTP provides data and recommendation to the Department of Mathematics on student placement issues in beginning math courses. It also correlates placement score ranges with success in the student's math course and adjusts placement score ranges accordingly. More about this important campus service unit can be found in Appendix 5.

E. Medical Physics

Efforts are now underway to develop a graduate program at both the Masters and Doctorate levels in medical physics. This program evolved from ongoing research and technical expertise in the Department of Physics and in the Department of Radiology at the School of Medicine, and we fully anticipate the participation of other departments at UCSD. The proposed program will allow medical students and medical fellows to achieve advanced training in modern instrumentation, diagnostic and analysis techniques. The program will also serve purely research-based graduate students.

F. Molecular Synthesis

The Department of Chemistry and Biochemistry is developing a new interdisciplinary program to train researchers in all aspects of design and synthesis of organic, inorganic, and biological molecules. As the first of its kind in the nation, this program will signal a new direction in the teaching and execution of molecular science and will help meet the increasing need for students trained in molecular synthesis. The program will provide the scientific community with research practitioners at all levels (B.S., M.S. and Ph.D.), trained in an interdisciplinary environment where the principal focus is in molecular synthesis. Graduates of this program will be armed with a foundation in the principles of physical, organic, inorganic and biological chemistry within the context of molecular synthesis and will receive an extensive "hands-on" training in the areas of experimental chemistry. Such students will be well equipped to face the challenges of future science and technology.

V. Diversity and Outreach

A. Diversity

Not unlike other institutions of higher education, the Physical Sciences at UCSD has fallen short of goals to achieve more diversity. The task is a difficult one, but one that we must address. A two-pronged approach has been implemented in the Division that addresses 1) innovative approaches to recruitments and 2) outreach to underrepresented youth. In the case of recruitments, our academic departments seek to advertise positions in multiple arenas for maximum exposure and search committees are in dialogue with the chair and the dean as interview lists are developed. We are cautiously optimistic that the commitments made by faculty and the Dean to diversity will have tangible results.

B. Outreach

The Division's outreach plan has several goals including increasing the visibility of UCSD and the Division in the community and, by demonstrating the relevance of our research, breaking down the "ivory tower" image that many San Diegans have of UCSD's scientists. Some of our outreach programs are specifically designed to promote an understanding and interest in science among precollege students and to encourage more students, especially those in traditionally underrepresented groups, to consider studying science at UCSD.

1. Press Workshops

We have held a number of press workshops in the past to help inform the local and national media about the value of our work and to help improve communication between scientists and journalists. A news conference and website on research related to homeland security, both of which were spearheaded by the Division, and the subsequent positive news coverage that UCSD received was recognized with a Headliners Award last year.

We would like to begin holding press workshops on a regular basis, two or three times per year. We are currently applying for funding from the Dreyfus Foundation for a series of four workshops over two years in areas where UCSD chemists and biochemists are international leaders. The workshops will address air quality, drug design, and nanotechnology, topics which were selected in consultation with a representative from the local media, who confirmed their timeliness and interest to a wide audience. These workshops will be filmed by UCSD-TV for later broadcast to more than 5 million viewers and archiving to the web.

2. Science Curricula and Public Lectures: In the 2000-2001 school year, the Divisions of Physical and Biological Sciences launched Atoms to X-rays and Science Matters, a series of lectures, demonstrations and curriculum guides, funded by a seed grant from the San Diego Foundation, to educate middle school and high school students, teachers and the general public about new developments in the physical and biological sciences respectively. Atoms to X-rays and Science Matters are archived at <http://www.ucsd.tv/atoms> and <http://ucsd.tv/sciencematters>, and remain among the top downloaded programs at UCSD-TV.

We would like to expand the library of Atoms to X-rays programs, highlighting the work of individual researchers as well as major research initiatives, such as the Environmental

Earth Observatory. We will also build on the Atoms to X-rays work by designing multimedia websites with extensive resources for students, teachers and the general public on particular “hot” topics, including environmental monitoring and biodiversity; nanosensors; and the biochemistry of bacteria and viruses. We are seeking funds from foundations as well as education outreach supplements from the National Science Foundation for participating researchers who have NSF funding.

3. Other Outreach Efforts: We are working hard to forge closer ties with other outreach programs on and off campus. Recently, the Division’s staff worked in partnership with the science curriculum coordinators from San Diego City and County Schools as well as SIO, the Division of Biological Sciences and CREATE on a five year, \$5 million proposal to the National Science Foundation to hold teacher summer institutes at UCSD. As part of the proposal, if funded, lectures given by the Division’s scientists about their work to the teachers would be taped by UCSD-TV and broadcast locally and nationally. In partnership with the teachers, we would also develop Atoms to X-rays curricula based on the researchers’ demonstrations of basic scientific principles important to their work. Another noteworthy aspect of this proposal is that it provides opportunities for our graduate students to work with middle school teachers and students, and training to help graduate students better identify and respond to teachers’ and students’ needs. In another program, organized by IR/PS, Division of Physical Science faculty will work with Latin American journalists to enhance their understanding of science.

VI. Resources

A. Faculty and LSOE Positions

1. Requests and Approach

The Division of Physical Sciences requests a total of 33 positions for Charting the Course III. Table 3 represents a summary of our FTE status and how these new positions might be dispersed. Table 4 represents a comparison of our instructional workload to that of the General Campus and concludes that, to correct imbalances, our post Charting the Course II faculty count should be in the range of 180 to 190. As described earlier, our plan seeks to elevate our national rankings and to bring our student:faculty ration inline with that of the General Campus.

Of the 33 positions requested, we include 25 ladder rank professorial slots, two LSOE slots, three upgrade and retention slots, and three interdisciplinary slots. We propose that of the 25 ladder rank positions, five are budgeted at the senior level and the remainder at the junior level. It is crucial that we are granted the latitude to recruit at senior levels if we are to cross into the top-ten threshold.

	CHEM	MATH	PHYSICS	DEAN	TOTAL
Filled (1)	41	51	44	-	136
Open (2)	14	8	5	1	27
Requested (3)					
Ladder Rank	10	10	5	0	25
LSOE	-	1	1	0	2
Upgrade, Retention	-	-	-	3	3
Interdisciplinary	-	-	-	3	3
Total Requested	10	11	6	6	33
Post CC3-3 Total	65	70	55	-	190
Steady State (2010/11)	86	78	56	-	220
Steady State (2015/16)	94	86	65	-	245
(1) Includes permanent budgeted ladder rank fte adjusted for campus instructional load calculation and rounded					
(2) Includes active & delayed; CHEM includes 11 full fte ladder rank recruitments, 1 LSOE, 3 partial fte rounded to 1-fte equivalent; & slot for M. Molina; PHYS includes 1 Dynes replacement					

Table 4: Workload Analysis - Growth Projections to Steady State								
	95/96	99/00	00/01	01/02	02/03	06/07	10/11	Steady State
CAMPUS								
All Instruction	16721	18715	19110	20962	22860	26395	29400	30700
UG FTE	14387	16264	16629	18066	19639	22545	24700	24700
GRAD	2334	2451	2481	2896	3221	3850	4700	6000
Faculty FTE	735.97	770.39	797.75	847.12	901.49	1102	1225	1279
Faculty FTE:UG FTE	19.5	21.1	20.8	21.3	21.8	20.5	20.2	19.3
Faculty FTE:GRAD	3.2	3.2	3.1	3.4	3.6	3.5	3.8	4.7
Faculty FTE:INST	22.7	24.3	24.0	24.7	25.4	24.0	24.0	24.0
PHYSICAL SCIENCES								
Instruction Share	20.3%	19.6%	18.7%	19.2%	19.2%	19.6%	19.5%	19.3%
All Instruction	3403	3671	3579	4014	4385	5183	5746	5928
UG FTE Share	21.2%	20.5%	19.4%	20.1%	20.2%	20.6%	20.6%	20.6%
UG FTE	3047	3331	3232	3631	3961	4644	5088	5088
GRAD Share	15.2%	13.9%	14.0%	13.2%	13.2%	14.0%	14.0%	14.0%
GRAD	356	340	347	383	424	539	658	840
Faculty FTE Share	16%	15%	15%	15%	14%	16%	18%	19%
Faculty FTE	117.40	119.36	122.20	124.71	129.38	173	221	247
Faculty FTE:UG FTE	26.0	27.9	26.4	29.1	30.6	26.9	23.0	20.6
Faculty FTE:GRAD	3.0	2.8	2.8	3.1	3.3	3.1	3.0	3.4
Faculty FTE:INST	29.0	30.8	29.3	32.2	33.9	30.0	26.0	24.0
Source: UG FTE: Three-quarter unweighted undergraduate student FTE reports from Campus Planning GRAD: Three-quarter headcounts per OGSR report. Faculty FTE: Three-quarter instructional workload reports from Campus Planning reduced by temporary FTE.								

2. Salary and Startup

Salary and nonsalary costs continue to be a major stumbling block for our Division. We recruit the cream of the crop to UCSD and competition for these scientists is daunting. Over the past four years, our starting salary for Assistant Professors rose from \$54.5K to \$65.5K. We appointed 21 new junior faculty and only one of these came in at the budgeted salary level of Assistant Step II. Our reserve pool is essentially exhausted before we even begin our recruitments while we make up the variance between that which is budgeted and the actual cost. Equally important is the fact that a typical senior appointment requires a starting salary well in excess of \$100K and frequently approaches \$200K.

Nonsalary costs are equally competitive with a typical Assistant Professor package in the lab sciences hitting the \$650K mark. Over the past four years, we've seen packages for

our junior recruitments go as high as \$900K. Costs are exacerbated by renovation needs and, although the new space in the NSB will provide some mitigation, Charting the Course III will see many assignments in Urey and Mayer Halls where renovation can be as high as \$300K.

The campus must take a critical look at recruitment costs.

B. Support Budgets

By all critical measures, the Division of Physical Sciences has increased its productivity. Since 1997/98, undergraduate majors have increased by 26%, course enrollments by 16%, graduate program applications by 46%, Masters level enrollments by 24%, Ph.D. level enrollments by 19%, and postdoctoral fellow by 37%. In addition, our direct research expenditures grew by 34% and our indirect research expenditures by 40%. All while our faculty grew by just 6%. A statement of our productivity is captured in Table 5 which summarizes contract and grant activity for fiscal year 2002/03.

Table 5: Contract and Grant Activity					
FY 2002/03					
	Phy Sci \$	Other Campus \$*	Total \$	FTE	\$:FTE
Direct Expenses					
Chemistry	\$11,686,156	\$4,613,296	\$16,299,452	37.47	\$435,000
Physics	\$8,334,943	\$3,055,758	\$11,390,701	42.68	\$266,886
Lab Dept Total	\$20,021,099	\$7,669,054	\$27,690,153	80.15	\$345,479
Math	\$1,970,474	\$218,837	\$2,189,311	49.23	\$44,471
Indirect Expenses					
Chemistry	\$4,046,283	\$1,970,105	\$6,016,388	37.47	\$160,565
Physics	\$2,699,687	\$1,238,121	\$3,937,808	42.68	\$92,264
Lab Dept Total	\$6,745,970	\$3,208,226	\$9,954,196	80.15	\$124,195
Math	\$526,853	\$21,261	\$548,114	49.23	\$11,134
* Indicates activity generated by Physical Sciences' faculty through other campus units such as ORU's and the School of Medicine.					

1. Permanent Support and Staffing

Our departments and units have reported their support needs for the upcoming three years. These are presented in Appendices 1-5. Out of a total request of \$1.1M, nearly all dollars are requested to increase the number of staff supporting the research and instructional enterprise. The Division has been hampered by limited incremental resources coming from the previous two allocation cycles as well as by recent budget cuts. Our preliminary analysis, however, suggests that we have made improvements in our position and that results of the algorithm used to allocate resources will be

more favorable to us than it has been in the past. Table 6 summarizes our requests, a few of which are further discussed below.

- a. Instrumentation Specialists – Chemistry & Biochemistry:** The department makes a compelling case (see Appendix 1) for staffing our core research facilities with highly trained technicians. It is clear from recent negotiations with candidates for faculty positions that state-of-the-art instrumentation and well-trained Ph.D. level technicians are critical to their decision-making process. It is also clear from our negotiations that many of our key competitors are well ahead of us in providing this necessary infrastructure. A solution is critical to our ascension to the upper most tier of research institutions and the department proposes a 1:1, \$80K:\$80K cost-share to provide technical staffing for cores in NMR spectroscopy, mass spectroscopy, and x-ray diffraction.

- b. Grantwriter:** On-going expansion of the Division, specifically in the areas of graduate education, outreach, and multi-disciplinary research, requires a corresponding increase in proposals. Although the Division has been quite successful in securing grant support for critical endeavors such as grants for graduate student training, instrumentation, and major centers, we see that the development of additional funding streams are absolutely necessary. A staff-level grantwriter would work with our faculty to pursue funding opportunities and would provide the critically requisite administrative, organizational, and professional writing skills.

C. Space

Space resources are a major problem for our Division. The Department of Chemistry and Biochemistry states it will have difficulty accommodating recruitments through Charting the Course III and the Department of Mathematics requests allocation of ~2,000 asf in AP&M. In addition, the Division anticipates the implementation of a Computational Science graduate program in 2006/07 when it will require office and computer lab space (preferably in AP&M). The Department of Physics is in reasonable condition given the somewhat near-term addition of 45,000 asf with the addition to Mayer Hall. The Mathematics and Science Education Program requests space to house faculty, staff and graduate students. Beyond growth asf resulting from the AP&M and Mayer Hall projects, the only other opportunity is represented by NSB-2 which will not come on-line until 2010/11 at the earliest. We shall continue to pursue our initiative to construct a Theory Center that would house our strengths in such areas as computational science and theory. Such a facility would free up valuable lab space that is currently allocated to theoretical research.

Table 6: Permanent Support Requests				
Department/Need	04/05	05/06	06/07	Total
CHEMISTRY and BIOCHEMISTRY				
Staff				
8.0 FTE Total				
4.0 x 0.5 Instrumentation Specialists	\$80		\$80	
2.0 Undergraduate Lab Technical Staf	\$55	\$55		
2.0 Admin	\$52	\$52		
2.0 Student Affairs	\$52		\$52	
Total Chemistry & Biochemistry	\$239	\$107	\$132	\$478
MATH				
Staff				
3.0 FTE Total				
1.0 Admin	\$52			
1.0 Student Affairs		\$52		
1.0 Programmer Analyst		\$68		
Computing upgrades	\$25		\$25	
Total Math	\$77	\$120	\$25	\$222
PHYSICS				
Staff				
2.2 FTE Total				
1.0 Admin	\$52			
1.0 Writer			\$46	
0.20 Facilities	\$7			
Instructional Program	\$25			
Total Physics	\$84	\$0	\$46	\$130
DEAN & PROGRAMS				
Staff				
1.5 FTE Total (incl New Initiatives)				
1.0 Writer		\$52		
Equity & Retention Pool	\$75	\$50	\$25	
Instructional Support (ESYS)				
ESYS	\$10			
MSED staffing .50 Admin			\$26	
New Initiatives				
Computational Sciences Ph.D. & M.S.				
.50 Admin			\$26	
Start-up and Continuing Operations		\$12		
Total Dean	\$85	\$114	\$77	\$276
TOTAL	\$485	\$341	\$280	\$1,106