Report of the Committee to Explore the Future of Biological Physics in the Department of Physics and Astronomy

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I - Introduction

In the Fall of 1998 the Chair appointed a committee to advise the Department on Biological Physics. The charge to the committee is to be found in Appendix A. We also note that the 1997 report of Faculty Recruiting Strategy (FRS) concluded that there was "a rather broad consensus within the Department to add a position in Biological Physics".

The committee considered in particular, the following:

i) The rationale for an appointment in Biological Physics in a department of Physics and Astronomy

ii) The environment at the University of Rochester in support of activity in Biological Physics

iii) The funding opportunities in Biological Physics

iv) The impact of a position in Biological Physics upon the Department

To address these questions the committee invited several distinguished researchers in the field of Biological Physics to visit campus as colloquium speakers, and to consult with the committee (see Appendix B for a list of these visitors). The committee further carried out an extensive set of meetings with faculty at the University in other departments, both in the College and in the Medical Center, whose research activities have a strong overlap with Biological Physics (see Appendix C for a list of faculty consulted).

As a result of these meetings the committee concludes that:

Biological Physics is an exciting and rapidly growing sub-field of physics that is actively being pursued by a large fraction of the top physics departments in the country.

that:

A very favorable environment currently exists at the University for a successful appointment by the Department in the field of Biological Physics.

and therefore recommends that:

The field of Biological Physics be given high priority for the next available faculty recruitment.

The remainder of this report is organized as follows: In section II we outline some of the recent scientific developments in the field of Biological Physics that have made it a clear growth area for top physics departments worldwide. In section III we summarize ongoing research activities at the University that serve as natural intellectual support, and potential research collaboration, for an appointment in Biological Physics. In section IV we discuss the prospects for external funding. In section V we present our recommendations for a recruitment in Biological Physics.

II - Recent Developments in Biological Physics

The last decade has seen an explosion of growth in the application of the methods and ideas of physics to systems of biological interest. Many leading universities -- Princeton, Cornell, Chicago, Stanford, Rockefeller, Caltech, Berkeley -- are aggressively seeking to establish major cross-disciplinary initiatives in this direction [1]. Physics Nobel Laureate, and UR Trustee, Steven Chu (B.S. physics/math '70) has been one of the leaders of this effort at Stanford.

A brief list (obtained by personal contacts, scanning ads in Physics Today, online sources) of other physics departments that have recently recruited, or are presently recruiting, in the area of biological physics include: Ohio State, U. Minnesota, U Illinois-UC, U. Pennsylvania, Purdue, Syracuse, Northeastern, U. Texas at Austin, U. Arizona, Dartmouth, Michigan State U, Rice, Vanderbuilt, Dartmouth, U. Guelph, U. Missouri-Columbia, U. British Columbia. In preparing its report in 1997, the FRS contacted the chairs of 14 representative physics departments and reported, "Almost all of the departments contacted are interested in starting or expanding programs in Biophysics." After attending this year's Meeting of the Physics Chairs of Midwestern Universities, Bodek reported a similar wide spread interest in establishing programs in Biological Physics among the represented departments.

Not only has physics shown an increased interest in biology, but there has correspondingly been an increasing realization in the biomedical community, and at the federal funding agencies [2,3,4], of the expanded role that physicists can play in biological/medical research. To quote from former director of NIH Harold Varmus' address to the Centennial meeting of the American Physical Society in March 1999, "... the NIH can wage an effective war on disease only if we ... harness the energies of many disciplines, not just biology and medicine. These allied disciplines range from mathematics, engineering, and computer sciences to sociology, anthropology, and behavioral sciences. But the weight of historical evidence and the prospects for the future place physics and chemistry most prominently among them.... I would argue that we need to show our appreciation of physics-based technology by investing NIH funds more aggressively in its development." [3]

This recent growth of physics into biology is due primarily to two complementary developments:

(i) Biological mechanisms are increasingly being studied at the molecular level; one seeks to identify the molecular structures responsible for key reactions, and then to relate their properties to the behavior of the larger biological structure. Traditionally, this is an area that has been advanced by the procedures and technology arising in experimental physics, such as x-ray crystallography and magnetic resonance spectroscopy.

In recent years, new physical techniques have been developed that allow for the direct observation and manipulation of individual macromolecules and complexes of large molecules. The ability to study individual molecules (in contrast to previous methods that only measure averages of statistical ensembles) is particularly important for biomolecular applications where heterogeneous environments are common and where molecules may be found in different configurations or folded states. Single molecule techniques further allow for the direct study of time dependent processes without the need to synchronize the behavior of a large ensemble. Stochastic fluctuations, which may play an important role in the function of particular biomolecules, can also be directly studied. Finally, the manipulation of single molecules offers the promise of constructing artificial molecular machines.

Examples of such single molecule techniques include: laser induced fluorescence spectroscopy, in which fluorescent probes (often a small dye molecule) are covalently bonded to specific sites of larger biomolecules. Analysis of location, polarization, time dependence and spectral content of the emitted photons provides structural and dynamical information about the molecule's diffusion, conformational state, and biological activity; laser traps (also known as optical tweezers) in which tightly focused laser beams are used to trap tiny dielectric plastic beads which have been linked to biomolecules of interest. By manipulating the laser beams to pull or push on the beads, one can make precision measurements of the mechanical properties of the biomolecules. Optical tweezers have been applied to studies of enzyme-DNA interactions, molecular motors, and protein folding; scanning probe techniques, in which one probes the nanometer scale interactions between a surface of interest, and a sharp tip that is scanned across it. Scanning tunneling microscopy (STM) has been used to make direct real space images of biomolecular conformations, as well as to manipulate molecules to create supramolecular assemblies. Atomic force microscopy (AFM) has been used to measure mechanical properties of biomolecular forces to pico-newton sensitivity. Examples of current work in the area of single molecule techniques can be found in recent special issues of *Science* [5] and of *Chemical Physics* [6].

Leading groups in this area include Chu [7], Block [8] and Moerner [9] (Stanford), Quake (Caltech) [10], Bensimon (Ecole Normal) [11], Weiss (LBL) [12], Libchaber (Rockefeller) [13].

Also in the realm of new physical techniques in the service of Biological Physics is the use of artificially fabricated micro- and nano-scale environments for studying biological systems. Groups in this area include Craighead (Cornell) [14] and Austin (Princeton) [15].

(ii) There is an increasing appreciation of the fundamental role that statistical concepts and complex networked interactions play in biological systems, and in the problem of analyzing large and complex data sets to infer these underlying interactions. Statistical and condensed matter physics has experienced an increasing migration into biological areas related to such issues.

Problems in this category include understanding the neural networks by which the brain and nervous systems of higher organisms process and store information; the functioning of membranes and protein-membrane interactions; understanding the protein and enzyme networks that control cell functioning; protein folding and the relation between structure and biological function ("proteomics"); the relation between gene sequence and function ("genomics").

The latter topic, often referred to as "bioinformatics", has been greatly stimulated by new DNA microarray technologies which allow the simultaneous "measurement of the extent to which different genes are read to form RNA (and subsequently protein) in different tissues and under different environmental conditions" [3]. Such microarray experiments have resulted in a glut of data, the quantitative understanding of which poses new theoretical challenges for biologists.

The generic and conceptual statistical issues arising in understanding such biological networks, such as optimization, partitioning, pattern recognition and data clustering, share many common themes with ideas concerning complex and critical behavior in statistical physics. The growing interest within the statistical and condensed matter physics community in such topics is witnessed by the fact that two of the premier national conference centers of physics have recently hosted workshops in this area: "Genetic and Biochemical Networks" Jan. 23-29, 2000 at the Aspen Center for Physics, and "Statistical Physics and Biological Information" Jan. 16 - June 15, 2001 [16], and "Dynamics of Neural Networks" July 23 - Dec. 22, 2001 [17], both at the Institute for Theoretical Physics, UCSB.

Leading experimental groups in this area include Leibler (Princeton) [18], Libchaber (Rockefeller) [13], Kas (Texas-Austin) [19], Kleinfeld (UCSD) [20]; in theory they include Shakhnovich (Harvard) [21], Onuchic (UCSD) [22], Hwa (UCSD) [23], Siggia (Rockefeller) [24], Maritan (SISSA).

III - Related Research at the University of Rochester

To explore the local activity at the University that could act in support of a position in Biological Physics, the committee conducted over the past year an extensive series of meetings with faculty from other departments, both on the River Campus and at the Medical Center. The committee was greatly impressed with both the breadth of this activity, and with the general enthusiasm that was displayed at the prospect of an appointment in Biological Physics in the Department of Physics and Astronomy. Below we summarize some of this existing activity, as well as the impressions we gathered from our meetings.

A - River Campus

Chemistry Department

In many respects chemistry provides a natural bridge between physics and biology. Physical chemists have scientific and analytical training similar to that of physicists, yet they are accustomed to dealing with the more complex molecular problems such as are encountered in biology. At the UR, several faculty have direct research interests in topics relating to Biological Physics. <u>Turner</u> studies RNA folding and prediction of RNA secondary structures, with applications to questions involving bioinformatics (he is a co-PI on the University's MD/PhD training grant, and has other close collaborations with the Medical Center). Krugh and Bren conduct NMR studies of DNA and RNA structure, and metallo-protein folding, respectively. Miller's group is involved with the design of small molecules capable of specific binding to selected protein, RNA, and DNA sequences. Krauss is a new experimentalist studying the optical properties of nanometer scale materials (nanocrystals, nanotubes), including their potential for use as markers for imaging in biological systems. Mukamel is well known theorist working on ultrafast dynamics and relaxation processes in large molecules and biological complexes. Dellago is a young theorist carrying out simulations of dynamics in complex systems, such as chemical reactions in solution and conformational changes in biomolecules. Krauss and Dellago both have their PhD's in physics. Turner, Krugh, Bren and Miller are members of the Medical Center's cluster on Biophysics and Structural Biology (see below). In our meeting, Turner, Krugh and Bren spoke positively of their interactions with the Medical Center and felt that the climate at Rochester was conducive to interdisciplinary interactions. Mukamel expressed his view that a program in single molecule methods would be a natural choice for a Biological Physics position at the UR.

Institute of Optics

The institute of Optics has made two recent appointments in areas relevant to Biological Physics. Novotny is building a laboratory to do near-field microscopy of nanoscale materials, including biomolecules. Berger (PhD in physics) is building a laboratory to use Raman spectroscopy as a method for analyzing the content of tissue, blood samples, and living subjects. Novotny was very enthusiastic about potential collaboration should a position in Biological Physics be in the area of single molecule methods. Both Berger and Novotny are examples of the sort of small scale single-investigator type programs that a position in Biological Physics is likely to be; both seem to have gotten off to very promising starts at the University, receiving federal funding and easily finding contacts for potential interdisciplinary collaborations. The new director of the Institute of Optics, Wayne Knox, is reportedly interested in expanding the number of appointments in biomedical optics within the Institute.

Center for Visual Sciences

Committee members met with David Williams, Director of the Center for Visual Science and Prof. of Brain and Cognitive Sciences, and Allyn Chair of Medical Optics. The center is a broad interdisciplinary effort involving the departments of Brain and Cognitive Sciences and Computer Science on the River Campus, and the departments of Neurobiology and Anatomy, Neurology and Ophthalmology in the Medical Center. Roughly half of its 26 members are in River Campus departments, and half are at the Medical Center. The center serves as a good example of effective collaboration across Elmwood avenue. The center has umbrella training and core grants from NIH which help to support seven support staff members. Research at the center ranges from development of the visual system to the interaction between visual perception and memory. Williams own area of research involves optical techniques to study the structure of the eye and the optical and neural limits of human vision. Williams was enthusiastic about interactions with the Department of Physics and Astronomy, and mentioned as possible areas of overlap the general field of neuroscience, the physics of NMR applications in biological tissue, and adaptive optics.

Other Departments

The committee also met with **Biology** chair Angerer. While generally positive, Angerer did not mention any specific areas of interaction that seemed promising to him. However Orr and Huelsenbeck's work in evolutionary biology has potential overlap with the area of bioinformatics. In **Computer Science**, Ogihara's work on biological computing similarly has overlap with bioinformatics. The **Brain and Cognitive Science** department, and the newly created **Biomedical Engineering** department both have strong overlap with the field of neuroscience (see more below). Biomedical engineering also has McGrath, who studies cell mechanics and motility, and Waugh, who studies mechanical properties of cell membranes and other subcellular components.

B - Medical Center

The presence of our expanding Medical Center has the potential to be a truly major advantage that Rochester has over many other Universities, when it comes to trying to recruit in Biological Physics. It is not just the presence of first rate research activities that is a draw, but specifically it is their *close* proximity to campus. A recent candidate for a position in bioinformatics at the Medical Center particularly stressed what a great asset it was if a researcher could conveniently walk from his academic base on campus, where he teaches and holds office hours, to the medical center which may serve as a base for some of his research activities. He pointed to his present situation at Washington University, where parking issues alone (the Wash U Medical Center is about 2 miles from campus) set up substantial obstacles to smooth collaborations between the Medical Center and academic departments.

Our committee held several meetings with faculty in the Medical Center, including members of the new research centers housed in the Aab Institute of Biomedical Sciences [25]. We have been impressed with the many current and emerging opportunities for collaborations with physicists, and with the enthusiasm with which our inquires were greeted. Three areas in the medical center were identified as being particularly promising.

Structural Biology and Biophysics

The field of structural biology uses physical tools to determine the structure of biological macromolecules (proteins, RNA, DNA) and macromolecular complexes. X-ray crystallography and NMR spectroscopy are the principal tools used in this research. Optical methods are often used to probe fluctuations in macromolecular structure. Rochester has an active and fairly large effort in this area that includes faculty from the Department of Biochemistry and Biophysics in the Medical Center and from the Department of Chemistry (Bren, Krugh, Miller, Turner). These faculty are formally linked through the Medical School's "GEBS" (Graduate Education in the Biological Sciences) cluster in Biophysics and Structural

Biology [26]. This particular cluster is responsible for the PhD degree program in Biophysics. Our committee met with Bill Bernhard, director of the cluster and a Biochemistry and Biophysics faculty member. Bernhard enthusiastically stated that hiring a physicist working on biological problems at the molecular level would be a significant asset to the biophysics cluster, and stated that he would be happy to promote interactions, including possible membership for such a person in the cluster. He thought that recruiting one person in this area made sense because of the many possible collaborators and the existing infrastructure. He mentioned techniques such as optical tweezers, atomic force microscopy, and spectroscopy of protein dynamics, that he thought would be promising. He cautioned, however, against someone whose primary concern was too specifically on instrumentation. He expressed his view that NIH was very supportive of interdisciplinary research, and recognized the importance of bringing in physics.

Neuroscience

Neuroscience research at Rochester is strong, broad and highly collaborative [27]. It is represented in both the Medical Center (Department of Neurobiology and Anatomy, Center for Aging and Developmental Biology) and on the River Campus (Department of Brain and Cognitive Sciences, Center for Visual Sciences). Based on this strength, an initiative in "Perceptual and Neural Systems" is one of three main programs within the new Department of Biomedical Engineering. Nationally and internationally, problems in the neurosciences have emerged as an important area of fundamental and applied biological physics. The committee met with Howard Federoff, who directs the Aab Institutes Center for Aging and Developmental Biology, and with Gary Paige, Chair of Neurobiology and Anatomy. Both were very interested in the possibility of collaboration with Physics. Federoff mentioned existing collaborations his group has with Miller and Rothberg in Chemistry, and with Ogihara in Computer Science. Paige was particularly enthusiastic. He pointed out to us that a recent search in his department had produced three applicants with deep training in physics, and it was his perception that a joint appointment and perhaps even some shared research space was not out of the question for a new appointment in Biological Physics. Both Federoff and Paige offered to help review candidates if we have a search that proceeds in this direction

Bioinformatics and Computational Biology

This is the least developed and the most poorly defined of the three areas, but it deserves mention because of its potential significance for Biological Physics. While there currently is no formal bioinformatics group in the Medical Center, it has been recognized that the formation of such a group is vital to the mission of the new research centers. A search committee has been formed that includes Dr. Richard Insel, director of the Aab Institutes Center on Human Genetics and Molecular Pediatric Disease and Deborah Cory-Slechta, Associate Dean for Research in the Medical School. Recruitment of 5-6 faculty in this area is anticipated, and several applicants have visited campus earlier this year. Of these, two of three had either a current or previous direct background in statistical physics. The medical Center appears to be interested in the participation of River Campus departments in this process, and Teitel has been invited with other River Campus representatives to meet with visiting candidates.

IV - Funding Prospects

The prospects for obtaining external funding in support of a program in Biological Physics appear at present to be excellent. Shown in Appendix D is a chart of federal research funding for different disciplines from 1970 to 2000, compiled by American Association for the Advance of Science. It shows that while funding for physical sciences or engineering remains almost constant (~$5 billion) throughout the three decades, funding for life sciences during the same period has tripled, from ~ $5 billion to $17 billion in constant FY 2001 dollars. In Appendix E we list recent federal funding obtained by some of the prominent groups discussed in section II. NSF funding for these groups appears quite high, and one is impressed by the broad scope of the NSF programs through which funding has been obtained.

As indicated in the quotation from Harold Varmus at the beginning of section II, and as supported by the conversations we had with faculty at the Medical Center, NIH is also a major, and presumably increasing source of funding for physics based Biological Physics research. Six of the nine experimentalists listed in Appendix E have NIH funding. An example of NIH movement to fund in this area is a recent new initiative on "Single Molecule Detection And Manipulation" [28].

Most of the investigators listed in Appendix E are senior. Some however, such as Quake and Kas, are more junior. As further evidence of the ability of young investigators in this field to get funding, we list in Appendix F the NSF funding obtained by both the recent biologically oriented appointments in the Institute of Optics. Berger has been at the UR only about 8 months. Novotny has been at the UR about a year and a half. Both succeeded in getting NSF funding on their first tries.

In addition to funding sources targeting specifically Biological Physics, the molecular scale of the systems of interest make such research programs natural competitors for funding under new nanoscience initiatives that have been launched by both NSF and DOE.

Finally, the field of Biological Physics is also supported by private foundations such as the Whitaker Foundation [29] and the Keck Foundation [30] which offer grants to young investigators. Kas from Texas-Austin, for example, has grants from both the Witaker and Keck Foundations.

V - Recommendations

In its 1997 report, the Faculty Recruiting Strategy Committee listed a set of "golden rules" that it felt should guide recruitments into the department. These rules included: (1) "Respond to scientific urgency"; (2) "Make timely investments in new fields"; (3) "Preserve funding stability of our groups"; (4) "Maintain critical mass and replace key personnel"; (5) "Preserve both the quality and supply of superior graduate students".

We believe that all the above rules unequivocally argue that an appointment in Biological Physics should be made as soon as possible.

Biological/biomedical research is clearly a field in scientific ascendance. Along with the growth in scientific interest there has been, and will continue, a corresponding growth in the availability of external research funding. One needs only to look at the expansion of research at our Medical Center and the creation of the new Biomedical Engineering Department here at the UR to see the reality of this. As outlined in section II, the tools and ideas of physics now place our field on the threshold of being able to make important new contributions in the biological/biomedical area. That Biological Physics is an exciting and rapidly growing field has attracted the attention and the investment of virtually all the top physics departments in the country. We believe that an appointment in Biological Physics thus satisfies golden rules (1), (2) and (3).

The Department of Physics and Astronomy at the UR has had for many years an active program in Biological Physics, through the presence of Bob Knox (a recent winner of the APS prize in Biological Physics) and the joint appointment of Tom Foster. Both have had successful and visible single investigator programs. Knox, though still an active presence in the department, officially retired in 1997 and has since worked only with undergraduate students. Although the department is now considering making additional joint appointments in the area of biological/medical physics, the committee feels that for the department maintain a distinguished program in Biological Physics, a full time faculty appointment is imperative. We believe that an appointment in Biological Physics thus satisfies golden rules (4) and (5). Appendix G lists the major subfields of first-year graduate students in 1997-98 from AIP 1998 Graduate Student Report: First Year Students. By the end of their first year of graduate study, 4% of domestic students and 2% of foreign students have chosen biophysics as their research specialty.

In section III we outlined the environment of existing research at the UR into which a new faculty in Biological Physics would arrive. We believe this environment, spread across the College and the Medical Center, is broad based, is highly conducive to establishing interdisciplinary interactions, and will be attractive to potential candidates (see more below). The presence of Foster, who has appointments in the Medical School, Optics, and Physics, will facilitate such interactions. In section IV we presented evidence of a bright funding outlook for support of new single investigator programs in Biological Physics. We therefore believe that all the ingredients exist to establish a new, successful, program in Biological Physics here at the UR.

Finally, we address the question of whether the establishment of such a successful program in Biological Physics would have a significant positive impact upon the department. One might argue that since Biological Physics is to be relegated to a single FTE in our department, that even a successful program could not make a dramatic impact on the national visibility and ranking of the department. In this respect, we believe that an appointment in Biological Physics represents an investment in the long range future of the department. Not to make such an appointment will leave the department without a presence in one of the major new emerging areas of physics. A successful appointment in this area, on the other hand, may lead to growth and recognition at the national level. The time for such an appointment is now, when the field is still relatively young and growing, rather than later when one will be forced to "catch up" with more established groups elsewhere. The committee believes that the following three specific areas represent the likely best targets for recruitment in Biological Physics:

1. Single molecule techniques: An appointment in this area appears to be a natural choice for Rochester, building upon the department's and the University's reputation and strength in optics. An appointment in this area may also allow for branching out into optical investigations of nanostructures more generally, another hot and growing field. For an appointment to be successful in this area of Biological Physics, however, we believe it is important to find someone who demonstrates a good understanding of the biological questions worth pursuing with such methods, rather than someone whose interests are focused on the technique itself.

2. Neuroscience: We believe that the strong multidisciplinary activity in this area at the University makes it an attractive one. The topics and speakers at the forth coming ITP workshop "Dynamics of Neural Networks" [17] represent good examples of the sort of ways physics can contribute to this field. The presence of physics in this field is perhaps less advanced than it is for single molecule techniques, but this may also be an opportunity for us to get into the field early.

3. Bioinformatics: The mapping of the human genome makes this subject clearly one of the major scientific initiatives of the future. A successful appointment in this area could therefore bring the department into this high impact area. This was the area specifically recommended by Albert Libchaber when he visited UR to advise the committee two years ago. Proceeding in this direction however would be premature until it becomes clear what concrete steps the Medical Center takes to establish a group in this area.

Although the above seem at present to be the best targets, we believe that a recruitment should be broadly advertised for any field of Biological Physics, specifying the above three fields only as potential areas of interest. The goal of attracting an individual of the highest quality should outweigh programmatic concerns. It should however be recognized that a recruitment in Biological Physics can easily extend over more than one year, due to the highly competitive nature of the current market.

The committee therefore recommends that the field of Biological Physics be given high priority for the next available faculty recruitment.

References

[1] L. Garwin, "US universities create bridges between physics and biology", Nature 397, 3 (1999)

[2] Editorial note, "Can physics deliver another biological revolution?", Nature 397, 89 (1999)

[3] H. Varmus, "The impact of physics on biology and medicine", APS News August/September 1999, condensed from lecture at the APS Centennial Meeting, March 1999, available at http://www.nih.gov/welcome/director/varmus.htm

[4] H. Varmus, "Squeeze on Science", op-ed article, Washington Post, Oct. 4, 2000, p. A33.

[5] Science 283, 1593 (1999).

[6] Chemical Physics, Vol. 247 #1 August (1999).

[7] Chu: http://www.stanford.edu/dept/physics/people/faculty/chu_steven.html

[8] Block: http://www.stanford.edu/dept/app-physics/ar/facname.html#Block

[9] Moerner: http://www.stanford.edu/dept/chemistry/faculty/moerner/

[10] Quake: http://thebigone.caltech.edu/quake/research.html

[11] Bensimon: http://www.lps.ens.fr/recherche/biophysique-ADN/

[12] Weiss: http://www.lbl.gov/msd/chemla/members/weiss.html

[13] Libchaber: http://www.rockefeller.edu/labheads/libchaber/libchaber.html

[14] Craighead: http://www.hgc.cornell.edu/index.html

[15] Austin: http://PUPGG.PRINCETON.EDU:80/%7Erha/

[16] http://matisse.ucsd.edu/itp-bioinfo/

[17] http://www-physics.ucsd.edu/neurophysics/itpworkshop.html

[18] Leibler: http://www.molbio.princeton.edu:80/faculty/leibler.php

[19] Kas: http://chaos.ph.utexas.edu/~kas/

[20] Kleinfeld: http://www-physics.ucsd.edu/neurophysics/missionstatement.html

[21] Shakhnovich: http://paradox.harvard.edu/

[22] Onuchic: http://guara.ucsd.edu/

[23] Hwa: http://matisse.ucsd.edu/~hwa/

[24] Siggia: http://www.rockefeller.edu/labheads/siggia/siggia.html

[25] http://www.urmc.rochester.edu/Aab/

[26] http://www.urmc.rochester.edu/GEBS/bsb/

[27] http://broca.bcs.rochester.edu/neuroscience/

[28] http://grants.nih.gov/grants/guide/pa-files/PA-01-049.html

[29] http://www.whitaker.org

[30] http://www.wmkeck.org

Appendix A
Charge of the Committee

Overall Charge:

Should the department plan to have a program in Experimental Biological Physics with only one single Physics faculty appointment and with one or more joint appointments in other departments.

Items for consideration:

1. In the short term, coordinate Biological Physics colloquia(*) with the aim of educating the department about the sub fields of Biological Physics that may be appropriate for our department.

2. Is it required that a Biological Physics program in our department be connected with programs and facilities in other departments, and what should be the nature of that connection?

3. Compile a list of faculty and investigators at the UR and local area institutions are doing Biological Physics related work.

4. What are the funding sources for such a position?

5. What kind of facilities, startup funds etc. are needed?

6. Can a single investigator in the department of Physics and Astronomy make a major impact in the field? Can a single appointment in Biological Physics have an impact on our future national rating? On our future graduate recruiting?

7. Can a small department such as ours plan on a program which relies only on more joint appointments (e.g. the new Chair in medical imaging in Optics) similar to the present plasma physics program in ME and the Laser Lab.?

Verbal interim report to the faculty to be made in September 99. Final report to faculty (written) May 99.

(*) Foster agreed that current budget for seminars in Biological Physics be used instead to help bring colloquium speakers in this field.

Charge as revised by the committee
Overall Charge:

Should the department actively pursue an appointment in the field of Biological Physics as one of the next highest recruitment priorities?

For Consideration:

(1) What is the rational for such an appointment in the Physics & Astronomy Department?

(2) What interactions with other segments of the University Community are necessary for such an appointment to be successful?

(i) What resources/facilities at the University are available/necessary?
(ii) What are the possibilities for collaboration with other researchers at the University? at nearby institutions?

(3) Can the Department have a successful program, that makes an impact in the field, given the limited opportunities for growth of any new subfield as implied by our Department's fixed size?

(4) Can the Department hope to attract an outstanding person in this field? What type of startup funds/resources are needed?

(5) What are the prospects for research funding for such a position?

(6) What would be the overall impact of such an appointment upon the Department? Would it boost our visibility? Would it foster larger interdisciplinary activities? Would it help graduate recruitment?....

Appendix B
Invited Colloquium Speakers in Biological Physics

April 22, 1998
Robert Austin, Department of Physics, Princeton University
Adventures in Flatland
(http://PUPGG.PRINCETON.EDU:80/%7Erha/)

April 28,1999
Albert J. Libchaber, Rockefeller University
DNA Mode d'Emploi
(http://www.rockefeller.edu/labheads/libchaber/libchaber.html)

April 12, 2000
Prof. Watt W. Webb, Dept. of Applied Physics, Cornell University
Biophysics with Multiphoton Microscopy and Correlation Spectroscopy Fluorescence
(http://www.aep.cornell.edu/FFR/Faculty/Webb.html)

April 18, 2001
Prof. Sol Michael Gruner, Dept. of Physics, Cornell University
The Bicontinuous Mesophase Materials: Lessons From Biology
(http://bigbro.biophys.cornell.edu/)

Note: The visit of Austin preceded the official consitution of our committee.

Appendix C
UR Faculty from Other Departments Interviewed by the Committee

Douglas H. Turner, Professor of Chemistry

Thomas R. Krugh, Professor of Chemistry

Kara L. Bren, Assistant Professor of Chemistry

Shaul Mukamel, Professor of Chemistry

Christoph Dellago, Assistant Professor of Chemistry

Todd D. Krauss, Assistant Professor of Chemistry

Robert C. Angerer, Professor and Chair of Biology

Andrew Berger, Assistant Professor of Optics

Lukas Novotny, Assistant Professor of Optics

David Williams, Professor of Brain and Cognitive Sciences, Allyn Chair of Medical Optics, and Director of the Center for Visual Sciences.

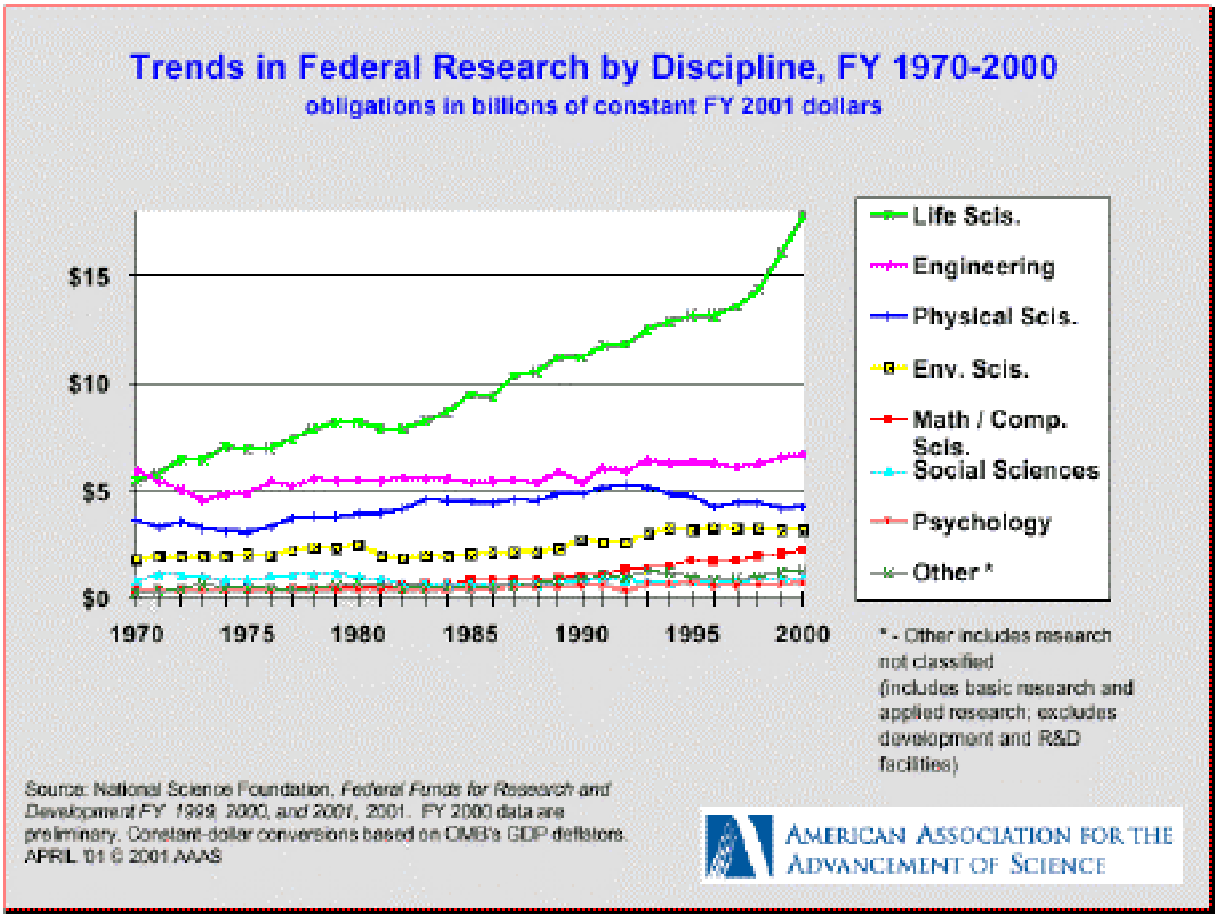
Mitsunori Ogihara, Associate Professor and Chair of Computer Science

William A. Bernhard, Professor of Biochemistry & Biophysics and Director of Biophysics and Structural Biology

Howard J. Federoff, Professor of Neurology, Molecular Medicine and Gene Therapy; Chief, Molecular Medicine and Gene Therapy; Director, Center for Aging and Developmental Biology

Gary D. Paige, Professor of Neurology, Ophthalmology, Neurobiology and Anatomy, Surgery (Otolaryngology) and Brain & Cognitive Sciences; Unit Chief, Sensory Motor Neurology Unit; Chair, Department of Neurobiology and Anatomy

Appendix D
Trends in Federal Research by Discipline



Appendix E
Sources of Funding of Established Groups in Biological Physics

Below is listed the agency, grant title, grant amount, and agency program for recent bioligically related research grants of the listed individuals (note: NIH website did not provide funding levels of grants).

Steven Chu, Stanford
NSF - Polymer Dynamics and Biophysics with Single Molecules
$1,300,000 (1248 Physics-Other)

Steven Block, Stanford
NIH - Transcription Studied at the Molecular Level
(National Institute of General Medical Sciences)

W.E. Moerner, Stanford
NSF - Single-Molecule Optical Probes of Protein Biophysics
$300,000 (1164 Molecular Biophysics)

Stephen Quake, CalTech
NSF - XYZ on a Chip: Integrated Microfluidic Analysis System
$510,000 (1406 Thermal Transport & Therm Proc)
NSF - A Microfabricated Cell Sorter for Molecular Evolution
$109,060 (1402 Biochemical & Biomass Eng)
NSF - CAREER: Polymer Physics with DNA
$407,398 (9134 EDucation & Interdiscip Resear)
NIH - FLuorescent Photobleaching Method For Sequencing Dna
(National Center For Human Genome Research)

Shimon Weiss, LBL
NIH - Development Of Q-Dots As Biological Probes
(National Center For Research Resources)

Stan Leibler, Princeton
NSF - Physical Aspects of Self-Correcting Assembly and Force Generation in Cytoskeleton Proteins (Libchaber is co-PI)
$1,273,073 (9134 Education & Interdiscip Resear)
NIH - Robustness And Individuality In Bacterial Chemotaxis
(National Institute Of General Medical Sciences)

Robert Austin, Princeton

NSF - XYZ on a Chip: Engineering of Innovative Molecular Sieves on a Chip by Nanoprint Lithography
$459,931 (1519 Integrative Systems)
NSF - NANOSCALE: Nanoscale Magnetics in Biology
$100,000 (1467 Materials Processing & Manufct)
NSF - Microlithographic Manipulation of Macromolecules
$425,000 (1164 Molecular Biophysics)
NSF - Mechanical Rigidity of DNA and its Relation to DNA-Protein Interactions
$298,300 (1144 Biomolec Struct & Funct)

Josef Kas, Texas-Austin
NSF - Microscopic Origin of the Viscoelasticity of the Cytoskeletal Rim and the Impact on Shape and Mechanical Resistance of Cells
$270,000 (1132 Cellular Organization)
NIH - Control Of Cell Elasticity By The Actin Cortex
(Nat Inst Of Arthritis And Musculoskeletal And Skin Diseases)

David Kleinfeld, UCSD
NSF - Imaging Study of Single Neuron Computation in Leech
$300,000 (1162 Computational Neuroscience)
NSF - IGERT Full Proposal: Computational Neurobiology Graduate Program
$2,700,000 (1335 IGERT Full Proposals)
NSF - Third Harmonic Microscopy: Dynamic, High-Resolution, Three-Dimensional Imaging Without Bleaching
$344,773 (1108 Instrumentat & Instrument Devp)
NSF - Role of Propogating Oscillations in Reptilian Visual Cortical Processing
$165,000 (1162 Computational Neuroscience)
NSF - Modern Biophysical Principles and Instrumentation
$259,749 (9134 Education & Interdiscip Resear)
NSF - Two-Photon Laser Scanning Microscope for Developmental/Cell Biologists
$231,544 (1108 Instrumentat & Instrument Devp)
NIH - Optical Imager For Electrical Dynamics In Cortex
(National Center For Research Resources)
NIH - Deep Multi-Photon Imaging Of Brain Structure & Function
(National Inst Of Neurological Disorders And Stroke)
NIH - Motor Modulation Of Sensory Input In Rat Vibrissa Cortex
(National Institute Of Mental Health)

Eugene Shakhnovich, Harvard
NSF - Thermo-mechanical Processes in Chemically Disordered Gels and Networks: Toward Molecular Design of Responsive Materials
$288,000 (1765 Materials Theory)

Jose Onuchic, UCSD

NSF - Computational Laboratory For The Development Of New Approaches To Complex Biological Phenomena
$100,000 (1108 Instrumentat & Instrument Devp)
NSF - Biocomplexity: From Gene Expression To Morphology And ulticellular Organization In Dictyostelium
$2,999,982 (1154 Biochemistry Of Gene Expressio)
NSF - Understanding Protein Folding: Quantitative Connections Between Energy Landscape Theory And Experiments
$750,000 (1164 Molecular Biophysics)
NSF - Understanding Protein Folding: From Lattice Models Towards Real Proteins
$543,000 (1164 Molecular Biophysics)
NSF - Theoretical Methods For Dissecting Electron Tunneling Interactions In Proteins
$285,000 (1164 Molecular Biophysics)
NSF - Electron Tunneling Pathways In Modified And Native Proteins
$253,000 (1164 Molecular Biophysics)

Terence Hwa, UCSD
NSF - Statistical Mechanics of Sequence Matching
$225,000 (1765 Materials Theory)

Eric Siggia, Rockerfeller
NSF - Theoretical Condensed Matter Physics
$411,000 (1765 Materials Theory)

Appendix F
Sources of Funding of Recent Biologically Related Faculty at the Institute of Optics

<u>Andrew Berger</u>
NSF - Biophotonics: Frequency-modulated Raman Spectroscopy of Biological Specimens
$222,295 (5345 Biomedical Engineering)

<u>Lucas Novotny</u>
NSF - Development of a Near-Field Optical Instrument for the Study of Semiconductor Nanostructures and Student Training
$300,000 (1189 Major Research Instrumentation)
NSF - Biophotonics: Near-field Raman Microscopy of Biological Membranes
$269,239 (5345 Biomedical Engineering)

Appendix G
Major Subfields of First-Year Graduate Students

Table 7. Major subfields of first-year students enrolled in a physics or astronomy program who have plans to receive a PhD, 1997-98.

	US Citizens	Foreign Citizens
Undecided	22	24
Astronomy / Astrophysics	18	8
Particles and Fields	13	13
Condensed Matter	12	25
Atomic and Molecular	6	3
Nuclear	4	5
Optics/ Photonics	4	4
Biophysics	4	2
Materials Science	3	3

Source: AIP Statistics Division, 1998 Graduate Student Report.