

Cluster Hiring Proposal : Integrative Biophysics

Chemistry, Biochemistry and Molecular Biology, Biology, and Physics
*Lynmarie Thompson (Chemistry), Lila Gierasch (BMB), Eric Bittman (Biology),
Lori Goldner and Jennifer Ross (Physics)*

The Departments of Physics, Chemistry, Biochemistry and Molecular Biology (BMB), and Biology at the University of Massachusetts-Amherst together present a ripe opportunity for true preeminence in the interdisciplinary field of *biophysics*. Existing strength coupled with felicitous hiring prospects combine to allow these programs to build synergistically. These departments are already working together to coordinate hiring and create multidepartmental excellence in **integrative biophysics**. In this cluster hire proposal, we summarize each department's goals, current strengths, and departmental endorsements of this cluster, as well as providing overall rationale for investments in the biophysics area.

Briefly, the Physics Department seeks to hire one assistant professor in the area of biophysics to complement recent hires in single molecule imaging and measurements and the recent senior hire. The Chemistry Department seeks to hire a biophysics assistant professor working on spectroscopy of biomacromolecules. The BMB Department seeks to hire a junior level biophysicist to whose research focus will complement the planned hire of a senior full professor in the field of systems biology and biophysics (see cluster hire proposal from BMB, Computer Science, and Mathematics). The Biology Department seeks to hire an assistant professor who uses biophysical techniques to study the nervous system.

As outlined below, the University of Massachusetts Amherst has a strong presence of biophysics, with former presidents of the Biophysical Society and highly honored biophysicists on our campus. Yet, the link between the biophysicists of various departments is still tenuous. Recent new hires in biological physics by the Department of Physics have helped to bridge the biophysicists of the other departments with Physics. We aim to continue this trend with a cluster hire in biophysics between the departments of Physics, Chemistry, Biochemistry and Molecular Biology, and Biology. With the hiring of new research professors through collaborative input from several departments, the integrative molecular biophysics group, which spans so many departments, can become more cohesive on the University of Massachusetts Amherst campus. This cohesion will ultimately result in higher impact science funded by larger collaborative grant opportunities.

Established Excellence. The requested cluster hires in Biophysics build on an area of established excellence at the University of Massachusetts, Amherst (see attached biographical sketches). Several leading researchers on campus are lynchpins of this thrust, among them Distinguished Professor Lila Gierasch, Hughes Professor Patricia Wadsworth, and Gluckstern Professor Adrian Parsegian. In addition, the importance of this area to the participating departments is reflected in their recent hiring activities. Biographical sketches for all participating faculty are appended.

The Department of Physics has recruited two outstanding biophysicists who use single molecule imaging to address fundamental questions in biology. Dr. Lori Goldner was recruited from that National Institute of Standards and Technology to join the physics department in September of 2008; she is well known for her work in near-field and single molecule microscopy and has recently secured funding from the National Science Foundation (NSF). Dr. Goldner is also spearheading an effort to obtain \$3.5M from DOE for an interdisciplinary effort involving biophysicists in Chemistry, Physics, Mechanical Engineering, and BMB; her preproposal was well received, leading to an invitation for a full proposal, which was recently submitted. Dr. Jennifer Ross, while early in her career, is already well known for her work in cytoskeletal dynamics, with several high-profile publications. She has secured funding from the March of Dimes Foundation and was recently awarded a grant from the Armstrong Fund for Science from UMass. Together with Dr. Pat Wadsworth in Biology, the new Physics faculty members have garnered major funding (totaling \$1M) for a live cell single molecule system from the Major Research Instrumentation program of the NSF. In addition to Drs. Ross and Goldner, Dr. Adrian Parsegian was recently recruited to serve as the Gluckstern Chair in biophysics. Dr. Parsegian's career at the NIH is long and distinguished and, in addition to his intellectual excellence, he will bring considerable visibility to the program here. The one requested hire in Physics fulfills half of a commitment made to Dr. Parsegian. Within Physics, the biophysics effort has considerably synergy with an excellent and long-established effort in soft condensed matter physics. Dr. Muthukumar (adjunct in Physics, primary appointment Polymer Science & Engineering) leads an outstanding research program in polymer physics and biomolecular systems; he has played a major leadership role in the biological initiative in Physics and is committed to continuing to do so.

The Department of Chemistry has clear strength in biophysical chemistry, with over 10 faculty working in this area (Chambers, Gierasch (joint with BMB), Hardy, Holden, Kaltashov, Knapp, Maroney, Martin, Thompson, Vachet, Weis). This group of biophysics faculty has a record of excellence with a strong record of publications in highly visible journals as well as outstanding funding from sources including NSF and NIH. Together, the Chemistry biophysics group has received numerous awards for excellence for research. This interactive group along with biophysical faculty in BMB has been a core strength of the Chemistry-Biology Interface (CBI) Training Program, which is supported by one of only three NIH-funded training grants on campus. These biophysical faculty also contribute substantially to other interdepartmental initiatives, including the Cellular Engineering IGERT program (Gierasch, Hardy) and the DOE Genomes to Life bioremediation program (Weis).

The Department of Biochemistry and Molecular Biology (BMB) currently has five biophysical faculty members (Gierasch (joint with Chemistry), Heuck, Theis, Garman, and Chien). The latter four represent a conscious investment over the past six years, which included the establishment of the first campus facility for macromolecular crystallography, a major enabling technology for molecular biophysics. Dr. Gierasch is a leading biophysicist, past-President of the Biophysical Society and a current holder of an NIH Pioneer Award. Despite their recent arrival at UMass, all of the other BMB biophysics faculty have received major funding and have numerous publications in major journals. All participate actively in the CBI training program, and several are central to the Institute for Cellular Engineering. Drs. Garman and Theis together with Dr. Hardy from Chemistry oversee the Macromolecular Crystallography Facility.

The Department of Biology currently has 7 faculty working in biophysics at the cellular level (Wadsworth, Lee, Baskin, Patek, Bezanilla, Hepler, Kunkel) as well as 8 (Downes, Jensen, Bittman, Connor, Schwartz, Dumont, Patek, Karlstrom) whose interest in biophysics incorporates multicellular systems and levels of organization. Over the past 5 years, these members of the Biology department have published more than 150 papers and garnered more than \$9 million in federal support (direct costs) for their research.

The Physics, Chemistry, BMB, and Biology Departments have already been discussing new teaching strategies for biological physics on campus. Dr. Ross is starting a new course in optics aimed at bringing biologists closer to physicists in the classroom. The Physics optics course (Phys 553) will be cross-listed with Chemistry and Biology courses. The lab will consist of building a microscope as a model optical system. In addition, Dr. Lila Gierasch is spear-heading a Five-College Biophysics initiative. Last year, Drs. Bittman and Chambers co-taught electrophysiology simulation laboratories in the Neuroscience and Behavior core course (NSB692C). Our campus has received an HHMI grant to support undergraduate education with the objective "to integrate the applicable principles of physics, chemistry, mathematics, and bioinformatics into the biology curriculum in both the classroom and laboratory setting." Several faculty in the biophysics area are key members of this initiative. Dr. Weis plays an important role in bringing quantitative sciences (and physics) into the biology curriculum. The optical course by Dr. Ross course will be part of the Howard Hughes Medical Institute: Experiments program.

Interdisciplinary Nature. Biophysicists apply the physical quantitative measurement techniques of physics and chemistry to the life sciences, and thus the field of biophysics is inherently interdisciplinary. Each of the participating departments has identified biophysics as a priority area for hires over the next five years. Physics has made a concerted effort to move into biological physics. They currently have three professors. Biophysics has been a priority area for hiring in BMB, with the additional departmental goal of connecting molecular and cellular research in life sciences and harnessing the combined tools of molecular biology and physical sciences. The Chemistry Department is interested in hiring a biophysical faculty member with interdisciplinary expertise who can utilize either single molecule or NMR spectroscopic approaches to probe dynamic mechanisms of biomolecules. A single molecule spectroscopist would join this growing area of strength on campus, bridging between faculty in Physics focused principally on biomolecules (Goldner, Ross) and faculty in Chemistry focused on understanding properties of novel materials (Barnes). Alternatively, an NMR spectroscopist would build our structural biology group in Chemistry (Hardy, Thompson) and BMB (Garman, Gierasch, Theis) and provide powerful tools and insights into the role of dynamics in mechanisms of biomolecules. Biology seeks to hire an assistant professor in physiology, possibly someone who combines electrophysiological and optical techniques for the study individual neurons and synaptic interactions in networks of cells. This junior faculty member will have synergy with groups in Chemistry (Chambers, Holden) and Physics (Parsegian) who work on the properties of biological membranes and interfaces.

In addition to the four departments listed in this cluster hire proposal, we also have strong synergistic interactions with several other departments including Polymer Science and Engineering (NSM), Computer Science (NSM), Chemical Engineering (ENG), Mechanical and Industrial Engineering (ENG), Kinesiology (SPHHS), and Veterinary and Animal Science (NRE).

The departments involved in this proposal, along with others at UMass, have demonstrated their commitments to this interdisciplinary effort in integrative biophysics via their long-range plans and through their recent hiring decisions and programs. Recent funding proposals have included many interdisciplinary efforts – successful bids include a recent MRI between physics and biology and a recent American Chemical Society grant between chemistry and physics. Programs such as the Institute for Cellular Engineering, the Molecular and Cellular Biology program, and the Neuroscience and Behavior Program, have established shared graduate programs as the preferred training model for interdisciplinary areas such as biophysics. In the future, funding will be sought specifically for interdisciplinary training in biophysics.

The existing groups have already begun to organize teaching efforts, as described above. It is natural for this group of biophysicists to work together to organize hiring efforts to create a synergistic group of researchers. The organization will be governed by a group with representation from each of the departments included: Dr. Adrian Parsegian from Physics, Dr. Lila Gierasch from BMB, Dr. Lynmarie Thompson from Chemistry, and Dr. Eric Bittman from Biology. The faculty hired in this cluster will be hired within the separate departments and will be subject to the commitments arranged by their home department, including teaching and service expectations. The hires in the cluster will be expected to participate in interdisciplinary efforts to secure funding for joint research among the biophysics community at the University of Massachusetts Amherst and within the University system.

Existing Support for Biophysics. As briefly described above, the departments included in this cluster proposal are committed to growing the biophysics effort at the University of Massachusetts Amherst and to the synergy of a multidisciplinary thrust. In the *Department of Physics*, a concerted effort has ensued over the last 5 years to establish a biological physics group. Efforts included a significant renovation with new HVAC for chemical hoods and new wet-lab space on the third floor of Hasbrouck Laboratory. Two new professors, Dr. Jennifer Ross and Dr. Lori Goldner, are currently in the renovated space. Dr. Ross was an Amherst 250 hire. The Gluckstern Chair in Biological Physics is currently being negotiated with Dr. Adrian Parsegian. As part of Dr. Parsegian's hire, laboratory renovations to the second floor of Hasbrouck and some minor outfitting to the third floor will be done. In addition, two assistant professor hires in the field of Biophysics were promised to the Department of Physics to attract Dr. Parsegian to come to UMass. The Department of Physics is requesting that **one** of these obligated positions be filled with this cluster hire. Other resources already committed to biophysics include a 30% match from the University (split between the Office of Research and the Dean of the College of Natural Science and Mathematics) for a live cell single molecule imaging microscopy system, soon to be awarded by the National Science Foundation's Major Research Instrumentation (MRI) program.

The Department of Chemistry has a long history of investment and support of biophysical chemistry, beginning with the first faculty hires when the department embarked on a new thrust into biological chemistry in the mid-1980's and continuing through our most recent faculty hires (3 of the 4 most recent faculty hires form part of this group). The result of this long-term commitment is that the majority of Chemistry faculty working on biological molecules employ biophysical methods.

As noted above, the *Department of Biochemistry and Molecular Biology* has placed hiring in biophysics at the top of its priority list for the past half dozen years, in a focused effort to build on existing strength and to respond to a widespread acknowledgement that the next generation of life sciences research challenges demands the tools and theoretical underpinnings of the physical sciences. A concrete illustration of the departmental commitment was the establishment of the Macromolecular Structure Facility, which required purchase of an X-ray diffractometer (\$430,000, shared expense with the Dean) and renovation of space on the 10th floor of LGRT, along with the hiring of two faculty members who direct research programs in structural biology. Additionally, major investments were made to recruit Dr. Heuck, who uses fluorescence methods to study membrane proteins and Dr. Chien, who applies both biophysics and genetic methods to study translational regulation of protein levels in *Caulobacter*.

In the *Biology Department*, major renovations are underway to prepare the laboratory of Dr. Sheila Patek, a biophysicist who will arrive from the University of California at Berkeley in the fall of 2009. Dr. Patek's work on the physical constraints and structural adaptations that control generation of sounds for animal communication, and power amplification of muscle movements will extend UMass' strength in biophysics to the organismal and evolutionary level.

Established Leadership. Dr. Lila Gierasch (Biochemistry), Dr. Adrian Parsegian (physics), Dr. Lynmarie Thompson (Chemistry) and Dr. Patricia Wadsworth (Biology) have already established themselves as leaders of the interdisciplinary biological physics effort within their departments, on campus, and/or within the larger scientific community. Drs. Parsegian and Gierasch are past-presidents of the Biophysical Society. Dr. Adrian Parsegian will lead a planned "Center for Biological Physics" in the Physics department, and we expect that each department will continue to provide leadership in the hiring and organization of the biophysics cluster on-campus.

Ability to Attract Funding. As described above, the biophysics group has done an excellent job at securing funding as single investigators and as interdisciplinary teams (TABLE). There are several types of additional funding that the biophysics cluster can attract with the aid of more, strong researchers in this cluster hire: training grants, instrumentation grants, foundation awards, group grants.

Training Grants: An important research strength at UMass Amherst is our overlapping complementary network of interdisciplinary training programs at the quantitative end of the life sciences. We obtained one of the first Chemistry-Biology Interface (CBI) training grants in 1995, and are now one of about 20 such programs nationwide. The Institute for Cellular Engineering (ICE) built on this strength while expanding into new areas and new (non-duplicative) training mechanisms, obtaining an NSF Integrative Graduate and Education Research Traineeship (IGERT) in 2007. The Neuroscience and Behavior Program and the Center for Neuroendocrine Studies each administer an NIH Training grant; biophysics is an essential part of the curriculum and members of the Biology, BMB and Chemistry departments who are listed in this proposal contribute to research and instruction in electrophysiology and other biophysical aspects of the function of neurons and the nervous system.

Why is a Biophysics program the logical next step? UMass Amherst is ideally positioned for productive training at the interface of life sciences with synthetic/mechanistic chemistry (CBI), with engineering (ICE) and with physical science (Biophysics). As elaborated above, the University of Massachusetts is very competitive and successful at obtaining these grants, which can total several million dollars. We would likely pursue an NIH training grant in biophysics as a collaborative group. The biophysics group will also obtain grants for undergraduate training through the Research Experience for Undergraduates (REU) program at the NSF. We propose cluster hires in biophysics that would build on existing strength in multiple departments (Physics, Chemistry, BMB, Biology) and fill gaps to reach critical mass for a obtaining NIH or NSF funding for a new training program.

Instrumentation Grants: The biophysics group has current overlap in optical imaging techniques, and we would be interested in growing the imaging and instrumentation group with hires that have these skills. The group, which includes collaborators from Physics, BMB, Chemistry, and Biology, successfully secured funding for a live cell single molecule microscope system totally ~\$1M. The new microscope will be set-up as a user facility with major and minor users in all the cluster departments, as well as other collaborating departments. With the hiring of more molecular biophysicists, the biophysics cluster will be able to build upon this success to secure more funding for future instrument development and acquisition proposals.

Foundation Funding: Several interdisciplinary groups of members within biophysics have applied for foundation funding.

Group Proposals: Ultimately, the biophysics group would like to pursue an NIH program project proposal on one of the many scientific areas of strength within the group, such as protein folding, membrane proteins, or cytoskeletal dynamics.

Establishing UMass Leadership. UMass Amherst already has the core of an excellent program in biophysics, and we believe that the University is at the cusp of becoming a world lead in Biophysics. In order to push us into the spotlight of biological physics, we request these positions to fill out our program and complete the establishment of a world-class center for biological physics. The cluster hire proposed here is a key step that will facilitate the integration of multiple departments under the banner of integrative biophysics. To establish and sustain leadership we require these hires and the continuation of programs already in place. One important development we envision is the establishment of the Center for Biological Physics, under the leadership of Adrian Parsegian, which is already in the process of establishment.

Best Case. Should we be allowed to hire the four new biophysics faculty members requested for the four departments included in this collaborative cluster, a immediate and marked enhancement would result for an area that is already one of the campus strengths in life sciences. These hires would collaborate with each other and with the biophysicists already in residence in the same departments, as well as building stronger bridges between departments. This group would gain substantial leverage to fund its research through government and foundation awards to individual and small groups of researchers. New instrumentation grants for user facilities will be obtained. Further, an NIH training grant in molecular biophysics could be successfully sought to fund the research of biophysics students. Finally, within five years, the group will be applying for NIH program project grants to support the integrative research of the biophysics cluster.

Alternative Outcomes. The outcome of not hiring to strengthen biophysics on campus is a multitude of risks: young faculty in each of the departments would have a much higher flight risk if their interaction opportunities do not grow through these cluster hires, current funding levels of the biophysics faculty on campus would be at risk of not increasing and perhaps even decreasing without hires to build the critical mass, and growth areas in some

departments (like Physics) would be marginalized by not adding additional hires, thus risking mediocrity and discontent.

Trajectory. Based on all of the considerations described in the paragraphs above, it should be clear that UMass, Amherst is positioned to be an international leader in biophysics if the appropriate actions are taken. Broad-based strength in the four departments participating in this cluster proposal together with additional faculty across campus will be readily leveraged to insure an steep upward trajectory of our research stature in this area. Particular areas uniquely present in a synergistic combination here on our campus are the optical approaches to dissect biological molecular machines and substructures at atomic level detail, protein folding and the complexities of its biological context, structural and mechanistic approaches to membrane proteins, and fluorescence spectroscopy to analyze functionally important conformational states. Also included are biophysical approaches to intercellular communication and the operation of neuronal networks, extending to anatomical and physiological analyses of biological organization.

Other Considerations.

Facilities and Space. Since two junior biophysics hires have been promised with the Gluckstern Chair, the *Department of Physics* has established a plan for renovating new space on the second and third floors of Hasbrouck to accommodate these hires. The laboratory space for the hire requested here is contained within this renovation. Planning underway in *BMB* will lead to adequate laboratory and office space for the requested junior hire (see Department Head endorsement). Portions of the *Department of Chemistry* will soon be moving to newly renovated space and this will be opening up new lab space for new junior hires. Many of the classrooms in LGRT will be converted to wet-lab space due to the opening of the Integrated Science Building. The *Department of Biology* expects to renovate laboratory space now available in Morrill South.

Rank. The Departments of Physics, Biology, and Biochemistry and Molecular Biology all seek to hire faculty members via this cluster at the rank of assistant professor. It is important that there be adequate leadership at the senior level for such a broad interdisciplinary initiative as this one, and we feel that this is indeed the case given the presence on campus of Drs. Parsegian, Gierasch, Wadsworth, and Thompson. Thus, the cluster proposal hiring requests described here are biased towards junior level hires where large pools present greater chances of successfully recruiting new talent to campus and smaller start-up packages can be assembled more readily. Note that through another, complementary, cluster proposal (with Computer Science and Mathematics), the BMB department proposes a senior hire who will deploy biophysical and computational methods to tackle major questions in systems biology. In their quest to attract a systems biologist, the departments involved seek a leading researcher who pursues questions that require integration of many components, signals, time and length scales, simultaneously. Thus, the senior hire in BMB is highly synergistic with the biophysics cluster of proposed here.

Faculty Hire Expectations. Each faculty member requested for this cluster will be hired within a single department, either Physics, Chemistry, BMB, or Biology. Traditionally, in the College of Natural Science and Mathematics (NSM), joint positions have been minimized because it is difficult to know which department, and which department's rules, will apply to a joint person during personnel actions. Because these considerations are of most concern for junior hires, we propose that each of the new hires have a home in only one department, and that department will be responsible for their personnel actions.

Assessment of Effectiveness. There are several tangible outcomes to assess the effectiveness of this cluster proposal: 1) increased research proposals and awards from the faculty members in the cluster, either individually or jointly; 2) increased equipment proposals and awards to campus for shared biophysics equipment; 3) increased funding for training (NIH T32 or IGERT or other); increased numbers and quality of graduate students and postdoctoral fellows in the biophysics area; 4) improved stature for this campus national ratings and as measured by faculty awards; 5) increased numbers of publications and invited presentations from the biophysics faculty. While the focus of this thrust is research and graduate education, there will be enhancements achieved in our undergraduate education in biophysics as well, including new and improved course offerings and recruitment of biophysics-oriented students to existing majors. At some point, we envision establishing a biophysics major, either solely at UMass, Amherst or as a Five-College concentration. We are already in elite company via our HHMI undergrad program in which biophysics plays a key role, and we will affirm and enhance our standing in this arena as well.