To: MCS College Council

From: Gordon S. Rule

Date: December 2, 2004

Subject: Revised Document: Proposed Ph.D. Program in Molecular and Cellular Biophysics

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A revised document describing a Ph.D. program in molecular and cellular biophysics is attached. Sections of the text that are new, or have been substantially modified, are indicated by a vertical bar in the margin.

This program has been designed to function in a parallel manner to a similar program that has been approved and is operational at the University of Pittsburgh. I am requesting approval of this program from College Council such that we can begin to actively recruit graduate students for the fall semester of 2005.

Proposed Ph.D. Program in Molecular and Cellular Biophysics.

1. Introduction:

This document serves to outline the implementation of an interdisciplinary program in molecular and cellular biophysics at Carnegie Mellon University. The goal of this program is to train students in the broad inter-disciplinary areas of structural biophysics, computational biophysics, quantitative biochemistry, and imaging. Several of these areas have been identified as important growth areas in a recent report by the National Research Council entitled "Trends in the early careers of life scientists". Carnegie Mellon can take advantage of its unique inter-disciplinary nature to prosper in this environment. It is anticipated that as we enter the area of structural genomics and functional imaging such individuals will be very competitive for both industrial and academic positions.

The biophysics program at Carnegie Mellon will partner with an equivalent program at the University of Pittsburgh. The anticipated size of the incoming class will be approximately 6 students. A total of 2 will be admitted to the program in the Mellon College of Science (MCS) and 4 students will be admitted through the University of Pittsburgh. Consequently, we anticipate to have 30 to 35 students in the program at any given time.

Benefit of the Program to the CMU Community

This program will benefit the member departments in MCS (Biology, Chemistry, Physics) as well as the University in several ways:

- This program will foster inter-departmental, and hence inter-disciplinary, communication between faculty. The need for this type of communication is clearly stated in the University Strategic plan.
- The program will provide a formal mechanism to consolidate teaching efforts in this area by faculty members. Thus potentially *reducing* the teaching load of participating faculty. In addition, this will greatly strengthen the training of *all* graduate students with an interest in biophysics, regardless of their home department/program.
- This program will facilitate the recruitment of graduate students; it has been difficult for our traditional graduate programs to attract students who are interested in inter-disciplinary training in biophysics.
- A vigorous inter-university program will be well positioned to acquire a NIH training grant. The successful acquisition of a training grant will provide an additional source of support for graduate students in MCS.
- This program will provide a natural path to the development of additional inter-departmental undergraduate majors in certain areas, e.g. a MCS wide track in biophysics/biochemistry.

Organizational Overview

The program will be autonomous, existing outside of the current department structure. Thus, the program will be formally housed in the MCS Dean's office. There are several compelling reasons for this arrangement:

- The existence of the program outside departments permits a *uniform* but *flexible* treatment of formal course requirements for all students in the program.
- It will promote a sense of community among the biophysics students and faculty in the Pittsburgh community.

The existence of such an autonomous program implies the following:

- Creation of an educational program with core and advanced courses in specific areas of biophysics.
- Ability to grant a Ph.D. degree in biophysics.
- Separate budget.

- Representation, when appropriate, at the Department Heads Meeting and on College Council.
- Representation, when appropriate, on departmental search committees for hires that are broadly related to biophysics.
- Recognition of faculty teaching within the biophysics program as part of a faculty member's normal teaching responsibility.

A central issue in the development of this program is the involvement with the University of Pittsburgh. Carnegie Mellon University has a significant presence in many areas of modern biophysics and it is possible to proceed in an autonomous fashion at this time. However, the University of Pittsburgh has developed an equivalent program in biophysics and it would be desirable to take advantage of this opportunity to develop a strong graduate program in biophysics within the Pittsburgh community. There are several programmatic issues that are best solved by working with the University of Pittsburgh, including:

- Graduate recruiting. Prospective students are attracted by diversity in graduate programs. The larger the pool of potential mentors, the more attractive the program.
- Teaching. Any viable and attractive program must have a solid curriculum that provides significant coverage of the discipline. It will be difficult to accomplish this goal solely with CMU due to existing demands on our faculty as well as limitations in subject area.
- Administrative. The administrative duties associated with this program can be shared between both programs, reducing the cost and effort associated with these duties.

2. Scope:

The scope of the program should be sufficiently focused to encourage the development of a close knit group of faculty/students within the program. Nevertheless, we also interpret biophysics in a very broad fashion, including such areas as computational biophysics, structural biology, mechanistic biochemistry, and biological imaging at many scales.

The focus groups of the program are necessarily driven by the faculty who are able to participate in the program. The following potential participants have been identified from the current ranks of various departments in MCS and at the University of Pittsburgh. Additional faculty recruitment in Biology, Chemistry, and Physics, as well as the invitation of faculty from Computer Science, Chemical engineering, and biomedical and health engineering will expand this list, as will participation from the PSC.

Imaging*

Eric Ahrens (Bio)
Chien Ho (Bio)
Fred Lanni (Bio)
Alan Waggoner(Bio)

Computational Biophysics

Ivet Bahar (Sch Med, Pitt)
Maria Kurnikova (Chem)
Mike Erdmann (CS)
Bob Swendsen (Phys)

Cellular Biophysics

Fred Lanni (Bio)

Structural Biology

Mike Cascio (Sch Med., Pitt)
Bill Furey (Sch Med., Pitt)
Chien Ho (Bio)
Tomasz Kowalewski (Chem)
Judith Klein-Seetharaman (Pharm, Pitt)
Miguel Llinas (Chem)
John Nagle (Phys)
Todd Przybycien (Chem E, BHE)
John Rosenberg (Biology, Pitt)
Gordon Rule (Bio)
Pei Tang (Sch Med., Pitt)
Robert Tilton (Chem E, BHE)

Mechanistic Biochemistry

Bruce Armitage (Chem)
Bill Brown (Bio)
Susan Gilbert (Bio, Pitt)
David Hackney (Bio)
Linda Jen-Jacobson (Bio, Pitt)

Biological Spectroscopy

Sanford Asher (Chem, Pitt)
Mike Hendrich (Chem)
Eckard Munck (Chem)
Linda Peteanu (Chem)
David Pratt (Chem, Pitt)
Sunil Saxena (Chem, Pitt)

*Note that several faculty members are listed under more than one research area.

3. Application Mechanism and Support of Students:

Students will apply to either Carnegie Mellon or the University of Pittsburgh, depending on their research interests. It is anticipated that the student will perform their thesis research at the university to which they applied. If a student wishes to perform their thesis research at the other university, we will first encourage joint mentorship. If that is not feasible, then the student will formally transfer to the university of their mentor.

To facilitate the potential transfer of students between universities, we plan on having a joint admissions committee. The committee would consist of two faculty members from Carnegie Mellon, each of which are from a different department in the Mellon College of Science, and four faculty members from the University of Pittsburgh. The composition of the committee is to insure that a matriculated student is acceptable to both programs, in case they elect to transfer between the universities.

At CMU, the incoming class of students will be supported by teaching assistantships (TAs), in their first year. However, they will likely perform their actual TA duties after their first year. Two TAs will be routinely provided to the program from the MCS Dean's office; these would include stipend, tuition, and health insurance. However, it will be possible to request support for an additional student if the pool of applicants is particularly strong. After the first-year, the student will be supported from their mentor's research funds.

4. Language Requirements:

The English language abilities of international students will be assessed by the following mechanism. During the admissions process, the admissions committee will generally only consider candidates with TOEFL score of at least 630. Prior to final acceptance, each student will be given a phone interview, either by the intercultural communication center or by a faculty member in the biophysics program, to further assess their language skills. Once a student arrives on campus they will take the ITA test. Those students who score worse than a 2 will be asked to take language classes and retake the test until they score a 2. Note that one of the goals of this program is to obtain support via a training grant. Hence, the focus will be on recruiting domestic applicants.

5. Proposed Educational Program:

The intent of the program is to train students in interdisciplinary areas in a flexible manner. The goal is to produce students who are trained to function independently in the chosen discipline. We anticipate that this program will attract primarily physical scientists who are interested in becoming more biologically oriented, although individuals with an extensive background in biology or other related disciplines will also be interested in the program. Given the broad range of potential backgrounds it is essential to maintain a high degree of flexibility to ensure that students enter research labs in a timely manner.

The following is anticipated to be a typical program for a biophysics graduate student. This program of study is currently utilized by the Biophysics Program at the University of Pittsburgh and is very similar to the current Ph.D program in the Department of Biological Sciences at Carnegie Mellon.

Year I:

- Fall: Core course work, participation in programmatic events, 1st rotation.
- Spring: Core course work, participation in programmatic events, 2nd and 3rd rotation, laboratory and thesis committee selection. Evaluation of student performance.

Year II:

- Fall: Additional course work (if necessary), programmatic events, begin development of thesis project.
- Spring: Additional course work (if necessary), programmatic events, Comprehensive written and oral examination.

Year III-IV

- Programmatic events, thesis research, yearly committee meetings.

Student Evaluations: The Molecular Biophysics Program Committee will meet at the end of the Fall and Spring terms to evaluate the progress of the first year students. This evaluation will include a review of performance in courses as well as written evaluations by the faculty members involved in the laboratory rotations. One of three decisions will be made for each student: A. The student may be advanced to the second year in good standing. B. The student may be conditionally advanced; he/she would then be directed to specific course requirements that would address the committee's concerns. C. The student may be dismissed from the program.

Curriculum Items:

A. Programmatic events:

i) Journal club. All students will be required to attend a weekly biophysics journal club. They will be required to present a scientific paper or their own research once a year.

ii) Molecular Biophysics Seminar. This is already in place and is jointly sponsored by Carnegie Mellon University and the University of Pittsburgh. Seminars are held one a month, usually alternating between an outside speaker and a local investigator.

B. Laboratory Rotations:

The purpose of the rotations is to expose students to several research areas in biophysics, to aid students in the selection of their thesis research laboratory, and to provide a mechanism to assess the performance of students in a laboratory setting.

C. Course Requirement in the First Year:

Fall Courses:	**Credits**
Molecular Biophysics I (Structure & Methods)†	9
Biology graduate core course‡	12
Elective course	9-12
Laboratory research rotations	9
Molecular Biophysics Seminar	3
Spring Courses:	
Molecular Biophysics II (Interactions)†	9
Molecular Biophysics III (Dynamics)†	9
Elective course	9-12
Laboratory research rotations	9
Molecular Biophysics Seminar	3

† Course outlines for Molecular Biophysics I-III are provided at the end of this document. These three biophysics courses have been launched at the University of Pittsburgh this year. In the near future, we would establish Carnegie Mellon course numbers within the Department of Biological Sciences, i.e.

03-7XX. In the future, it is highly likely that we can offer 500 level versions of these courses for upper level undergraduates.

‡ This course is substituted by 03-742, eukaryotic molecular biology, pending the creation of the biology core course.

D. Advanced/Elective Courses.

The above curricular items are designed to give the student a broad education in molecular biophysics. In addition, students will be expected to take a number of the following advanced courses to obtain a deeper understanding of a particular area of biophysics. Courses that are currently in the Carnegie Mellon University course catalog are:

- NMR in Biomedical Sciences (03-533)
- Introduction to Magnetic Resonance Spectroscopy (09-552)
- Magnetic Resonance Spectroscopy (09-752)
- Biological Imaging and Fluorescence Spectroscopy (03-534)
- Computational Chemistry (09-560)
- Computational Biology (03-510)
- Bio-organic Chemistry (09-518)
- Bio-inorganic Chemistry (09-521)
- Physical Chemistry of Macromolecules (09-509)

In addition to the above, it would be desirable to develop additional advanced courses within CMU or jointly with the University of Pittsburgh (e.g. X-ray diffraction, Membrane biophysics, Imaging, etc.)

6. Administrative Issues.

The program would have a single program committee, consisting of 9 faculty, three from Carnegie Mellon, three from the Medical School and three from Arts and Sciences at the University of Pittsburgh. Members of the program committee are chosen by the program directors in consultation with the participating deans and departmental chairs. The current membership of this committee is:

- J. Rosenberg (Pitt, Bio Sci)
- L. Jen-Jacobson (Pitt, Bio Sci)
- M. Casico (Pitt, Med. School)
- G. Walker (Pitt, Chem)
- Bahar (Pitt, Med. School)
- P. Tang (Pitt, Med. School)
- G. Rule (CMU, Biology)
- J. Nagle (CMU, Physics)
- R. Swendsen (CMU, Physics)

Note that CMU participation in this committee to date has been entirely voluntary.

A subset of the program committee is responsible for curriculum development, the biophysics seminar series, admissions, and monitoring student evaluation. When necessary, input from additional faculty will be solicited. For example, some of the faculty that have been responsible for the biophysics core-courses are not on the program committee. A total of two faculty have been responsible for the seminar series (one from CMU, one from the University of Pittsburgh), and four faculty from the University of Pittsburgh were responsible for admissions for 2004. As discussed above, we would add two CMU faculty to the admissions committee. The co-directors of the program (e.g. Rosenberg and Rule) would be responsible for monitoring student evaluations, however the yearly evaluation of student progress would require the input from a majority of the program committee as well as the mentors of the students.

Although the involvement of the faculty appears to be extensive, it should keep in mind that much of the faculty cost associated with the initiation of this program has already been paid; the program is essentially in operation at this point. Faculty involvement with graduate recruiting will be somewhat burdensome. However, given the size of the program and the number of faculty on the committee, the time required of each faculty member will be substantially less than for typical departmental admission committees. Although the cost may still seem to be high, the admissions committee will be evaluating and recruiting graduate students for laboratories in the member departments. This will result in a higher number of qualified students in our research programs. Most will agree that this cost is worth the effort, especially considering the limited pool of domestic applicants.

Biophysics Core Course Descriptions:

Molecular Biophysics I (MOLBPH 2001): This course is the first of a series of three courses in molecular biophysics. The main focus of this course is on the structure of biological macromolecules and structure determination methods. Molecular biophysics II and III explore bio-molecular interactions (II) and dynamics (III). A tentative schedule is provided below. The class meets in 343 Crawford Hall, University of Pittsburgh. MWF from 11:00 to 11:50 AM. Course grade is based on on exams (70%), problem sets (15%), and the analysis of current papers in the scientific literature (15%).

Date	Instructor	Topic
Aug 30(M)	Rosenberg	Introduction to biophysics courses/course overview
Sep 1(W)	TBA	Structure of Water/Intermolecular Interactions
Sep 3(F)	Bahar	Proteins I
Sep 8(W)	Bahar	Proteins II
Sep 10(F)	Bahar	Proteins III
Sep 13(M)	Bahar	Proteins IV
Sep 15(W)	TBA	Stucture and stability of nucleic acids
Sep 17(F)	Nagle	Membranes/phase transitions
Sep 20(M)	Nagle	Membrane proteins
Sep 22(W)		**Exam I**
Sep 24(F)	Rule	NMR I
Sep 27(M)	Rule	NMR II
Sep 29(W)	Rule	NMR III
Oct 1 (F)	Rule	NMR IV
Oct 4 (M)	Rule	NMR V
Oct 6 (W)	Rule	NMR VI
Oct 8 (F)	Waggoner	Visible Spectroscopy
Oct 11(M)	Waggoner	fluorescence I
Oct 13(W)	Waggoner	fluorescence II
Oct 15(F)		**Exam II**
Oct 18(M)	Asher	CD
Oct 20(W)	Asher	IR/RAMAN
Oct 22(F)	Walker	AFM
Oct 25(M)	Rosenberg	Structural motifs
Oct 27(W)	Rosenberg	Structural data bases
Oct 29(F)	Kurnikova	Homology Modeling I
Nov 1(M)	Kurnikova	Homology Modeling II
Nov 3(M)	Hendrix	Electron Microscopy
Nov 5(F)	Hendrix	Cryo EM
Nov 8 (M)		**Exam III**
Nov 10(W)	Rosenberg	X-ray diffraction I
Nov 12(F)	Rosenberg	X-ray diffraction II
Nov 15(M)	Rosenberg	X-ray diffraction III
Nov 17(W)	Rosenberg	X-ray diffraction IV
Nov 19(F)	Rosenberg	Diffraction
Nov 22(M)	Rosenberg, Rule	Student review of papers I
Nov 29(M)	Rosenberg, Rule	Student review of papers II
Dec 1 (W)	Rosenberg, Rule	Student review of papers III
Dec 3 (F)	Rosenberg, Rule	Student review of papers IV
Dec 6 (M)	Rosenberg, Rule	Student review of papers V
Dec 8 (W)	Rosenberg, Rule	Student review of papers VI
Dec 10(F)	Rosenberg, Rule	Student review of papers VII