Proposal for a

Graduate Certificate Program

In

Nanoscience & Technology:

Nanobiology emphasis

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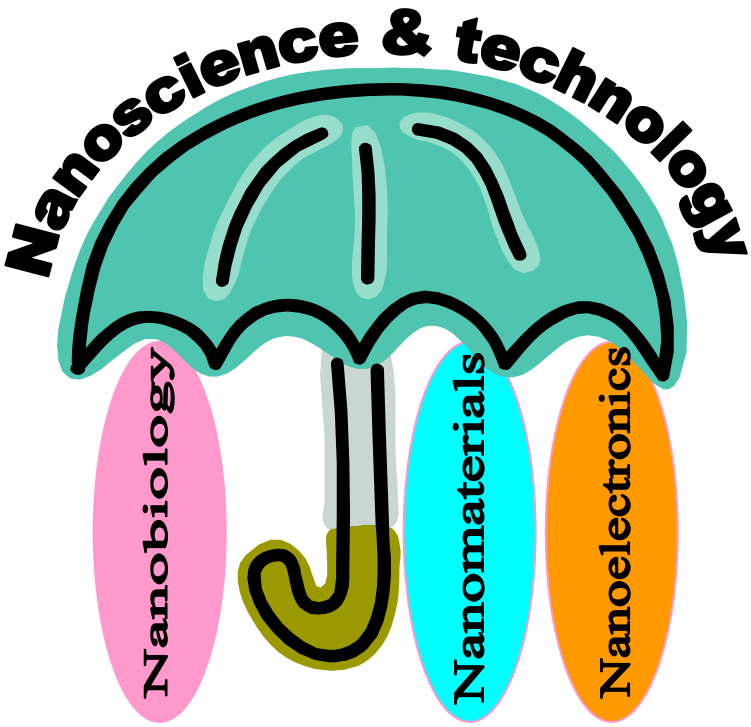
1. Program conception and objectives

1a. Rationale and Mission

Nanoscience and technology are being driven by a remarkable convergence of disparate fields including: chemistry, material science, applied physics, optics, computational analysis, and modeling. Three years ago, a University faculty committee working with the Office of the Vice President for Research recommended that the University concentrate on three nanotechnology areas. At that time, and continuing today, the university community had well developed research programs in nanomaterials, nanoelectronics and nanobiology. All of these "flavors" of nanoscience form an interdisciplinary network of research programs and teams that comprise the Nanoscience and technology area at the University. This research spans at least five schools and colleges, COE, LSA, Med School, Pharmacy and Natural Resources, more than 15 departments and 100's of researchers. Despite the growing prominence of nanoscience, it is unusual for universities to grant degrees in this field because it is not considered a core discipline. Some universities, such as the University of Washington, offer dual degree programs in which a Ph.D. is one of the degrees taken simultaneously with a core discipline. However, this approach has not yet been demonstrated as necessary based on market need. Because nanoscience spans so many disciplines and departments, students need guidance in understanding how to develop a high-level competency in a broader range of subjects than is the norm for their Ph.D. discipline. They will also benefit from a program that brings students from different disciplines together around this common theme.



The goal of this proposal is to create a Rackham certificate in Nanoscience and Technology. Within this overarching framework, there is the recognition that nanoscience is broad and that students will typically obtain expertise in only a subfield of the entire enterprise. This proposal is meant to form a framework by which students can be accredited in one of a number of subareas.

To accommodate the wide range of sub-specialties, the overarching Nanoscience Certificate Program will be broken into separate concentration areas. This will allow a student to have an emphasis in one of a number of subareas. Currently, within the University, there are three clearly identifiable areas that a student could concentrate in: nanobiology,

nanomaterials, or nanoelectronics (see Figure 1). A student wishing to obtain a Rackham certificate in Nanoscience and Technology would need to declare an area of emphasis and satisfy the requirements for that area. Each individual concentration will have its own academic oversight and requirements to be satisfied before a student would obtain a Certificate.

This proposal focuses on the nanobiology concentration and will serve as a template for other two future areas, nanomaterials, and nanoelectronics. Although there will be differences in the requirements of the various concentrations, the common philosophy, research methodology, and the importance of interdisciplinarity to nanoscience, drive us to take this holistic approach rather then simply having separate certificates for each area of emphasis. The overarching theme of the certificate, and the concentrations, is the interdisciplinary nature of the research. **The objective of this certificate program is to allow students to develop high-level competency in a broader range of subjects than is the norm for their Ph.D. discipline.** In recognition of a student's greater range of experience and competence, the Rackham Nanoscience certificate would be awarded.

1b. Nanoscience Certificate: Nanobiology emphasis

One of the most exciting applications of nanotechnology is to the field of biology, where nanoscale analytical, computational, and synthetic approaches offer the possibility of understanding and manipulating complex biological systems. With the tools now available, it is possible to dissect the structure and function of cells and to begin thinking about the "reverse engineering" problem of reassembling functional biological machines that will permit exciting advances in the life sciences and medicine. In order to realize this potential, it is essential that we train a new generation of scientists and engineers who have a broad understanding both of nanomaterials and biological systems.

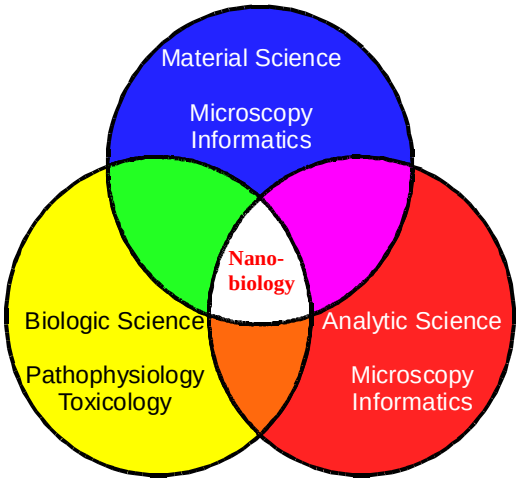
Nanotechnology research is defined as much by its manifestly interdisciplinary nature as by any other factor. The tools, techniques, and ideas needed to investigate current problems cut across the traditionally defined academic disciplines. Researchers from diverse areas are needed to understand the issues and develop solutions. To prepare for the nanotechnology workforce, students must be educated and trained broadly in multiple disciplines that form the roots of nanotechnology.

This proposal seeks approval for a new graduate certificate program in Nanoscience with emphasis on nanobiology. Through the creation of this certificate program, our overall objective is to fundamentally change the mindset of physical and biomedical scientists and engineers. In contrast to engineering disciplines, where there is a long history of truly interdisciplinary collaboration, the majority of physical and biomedical scientists work in relatively small research groups. Our certificate program is structured to support, and in some cases, to require, significantly greater in-depth collaboration between research groups. One measure of the success of our effort will be

the extent to which this program brings about a genuine change in the level of collaboration between research groups in the physical and biomedical communities.

1c. What is Nanobiology?

Great strides have been made during the past 50 years in understanding many of the nanoscale biological structures that make up proteins, DNA, RNA, and lipids. However, it is only with recent advances in the physical sciences that it has become possible to analyze and manipulate these structures at nanometer scales. In parallel, advances in computational molecular science allow for predictive modeling and simulation of biological structures in native form (aqueous solution). Simultaneously, the materials research community has developed the ability to synthesize and characterize similarly sized nanoparticles from a wide array of substances including organic and inorganic polymers, ceramics, and metals that may be either bio-inspired or have biological applications. Nanomaterials and many biologic structures are approximately the same size, thus allowing for unique interactions between biological and synthetic materials. The application of nanoscale analytical, computational and synthetic approaches to understanding and manipulating complex biological systems offers incredible potential for scientific advances. This emerging area of science is what we mean when we use the term "nanobiology". Although "nanobiology" runs the risk of being viewed as a mere cliché, we believe that it represents a truly distinct area of scientific investigation – the unique area of investigation situated at the intersection of materials, analytic, and biologic sciences, as shown in the illustration.



We are fortunate at the University of Michigan to have developed a broad interdisciplinary group of researchers focused on forefront problems in nanobiology. In recognition both of past successes and of the importance of this area of research for the future, in April 2005, the Regents of the University of Michigan chartered the Michigan Nanotechnology Institute for Medicine and Biological Sciences (M-NIMBS). The goal of M-NIMBS is to harness nanoscale science and engineering for biological and medical applications, as well as to use bio-inspired nanostructures to develop new forms of materials, sensors, and electronics. M-NIMBS is a strong supporter of the creation of a nanoscience certificate program and has pledged to assist with the resources needed to develop and run the nanobiology concentration.

1d. Need for a New Training Program

Although nanobiology research at Michigan is quite successful, the graduate education program has lagged behind in development. Student appointments have been

ad hoc and in some cases, educational opportunities for students to interact with the research have been missed. Often, it is the case that students participate in truly interdisciplinary training over the *objections* of their Ph.D. programs. Our goal is not to create a new Ph.D. program, but rather to provide a cross-cutting certificate program that will prepare students from biological disciplines to undertake modern nanotechnology research and that will prepare students from physical science disciplines to undertake modern biological research. We propose to integrate students from a number of existing graduate programs within this interdisciplinary research structure and thereby to provide a coherent strategy for educating students more broadly in nanobiology while still maintaining intellectual depth in a core discipline.

When developing a new interdisciplinary program, there is a natural tension between depth in a well developed core discipline and the breadth needed to address new research topics. We have developed our proposed certificate program from the philosophical point of view that it is important for every graduate student to have a firm grounding in an academic discipline. However, we also believe that the interdisciplinary nature of the program should start from the first day. Can this be accomplished while still having students graduate in a reasonable time? Yes, we have structured the program in a way that allows students to largely satisfy the requirements of the certificate by utilizing select existing courses as cognates.

1e. The role of the Nanoscience: nanobiology Certificate at Michigan

Currently, the University of Michigan has several units, COE, LSA and Medical School, that can provide graduate students for the new certificate program. Letters of support for this certificate proposal have been obtained from each of these colleges respective Associate Dean, see appendix A. There are a large number of graduate programs and departments that will supply students who desire the certificate: Applied Physics, Biophysics, Chemical Biology and Bioinformatics programs and, Material Science and Engineering, Biomedical Engineering, Mechanical Engineering, Chemical Engineering, Chemistry and Physics departments. Letters of support from these programs and departments can be found in Appendix B. Each of these Ph.D. programs or departments has its own academic requirements for their graduate students. The new Certificate will provide a means to knit together the students, post-docs, faculty, and courses concerned with nanobiology to provide a more interdisciplinary experience without sacrificing the needed intellectual depth in any one of the core areas.

2. A Certificate Program in Nanoscience: nanobiology emphasis

2a. The Proposed Certificate Program

A new program is proposed to train graduate students to undertake research in nano-biological systems. This research is often characterized by a focus on the mechanical and dynamical properties of both macromolecular complexes and larger biological structures. Particular emphasis will be placed on sub-cellular structures, on biomolecular aggregates, and on synthetic nano-biosystems. This certificate program is modeled after extremely successful interdisciplinary training programs already in place at the University of Michigan, such as Complex Systems, but is distinguished from these by its novel focus on biological systems and by its partnership with an interdisciplinary research institute (M-NIMBS) for support with some portion of the graduate research training. This program will leverage the strength of Michigan faculty in synthesizing, characterizing and utilizing nano-biological systems. Students will be recruited both from biological (biology, biochemistry) and from physical science (physics, chemistry, engineering) graduate programs and may earn a Ph.D. degree either in traditional disciplinary areas (e.g., Physics, Chemical Engineering) or in one of several interdisciplinary Ph.D. programs (e.g., Biophysics, Applied Physics) depending on the specifics of their research interests. **The three key features of the new training program will be the breadth of the required course work, a requirement for multidisciplinary research experience, and the creation of a new student-led seminar program.** They are:

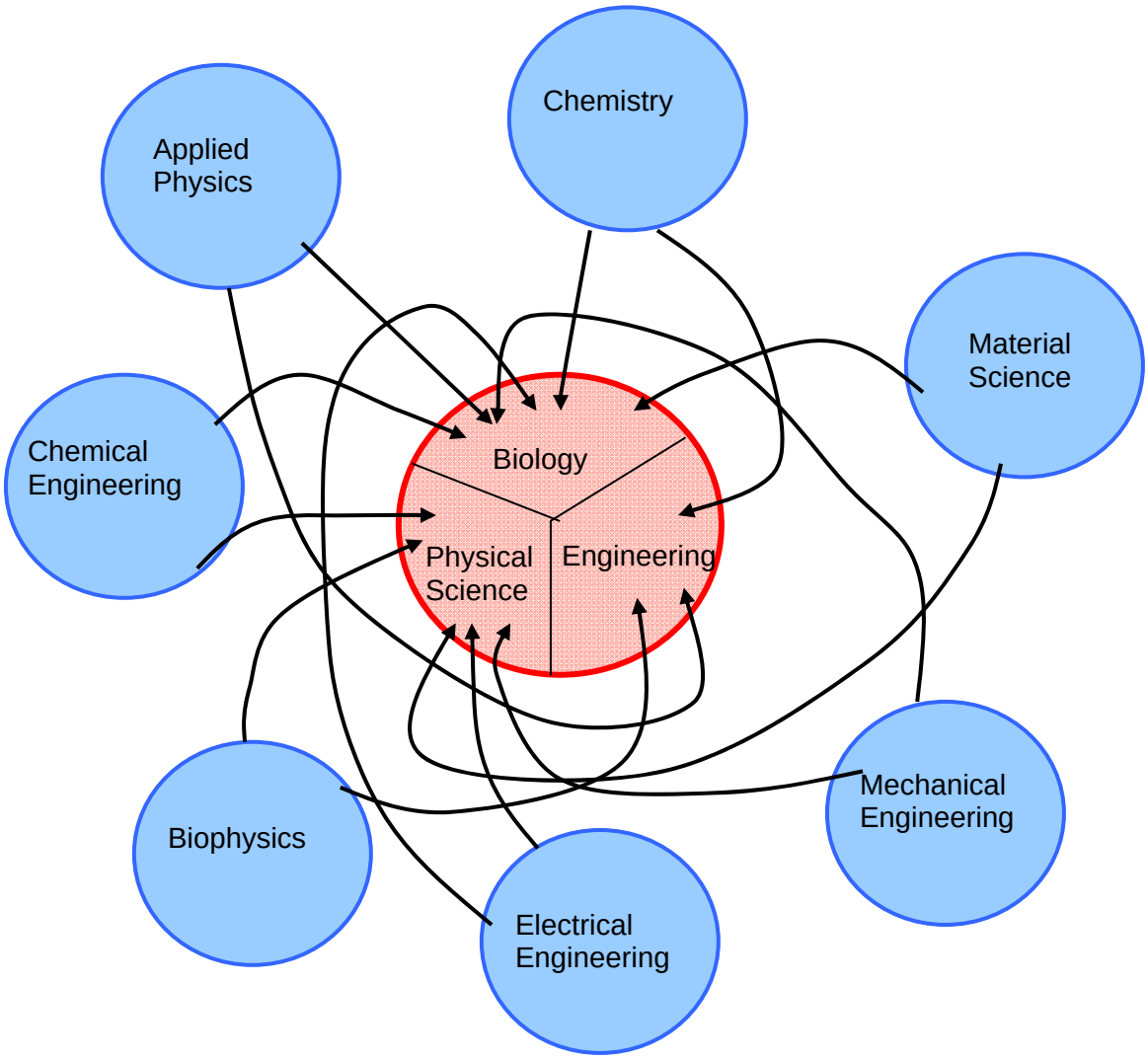
- Complete a nanoscience class within his or her Ph.D. area (3 credits). Complete two complementary nanoscience classes outside of his or her specific Ph.D. area (6 credits)
- Perform collaborative research in a second laboratory or with a second research group
- Attend student-organized seminar series (2 credits/semester, 3 semesters)

These requirements are examined in detail below.

2b. Required courses

Each feeder Ph.D. program has defined the fundamental courses necessary for a person trained in that discipline. An incoming graduate student would enter the nanoscience certificate program through one of these existing graduate programs. The student's home program would serve to define the core area and the foundation courses that would be expected of that student. The nanobiology certificate will use two free electives and cognate requirements to open opportunities for the student to study more broadly. Students in the nanobiology emphasis will be expected to take additional courses that complement his or her Ph.D. curriculum. This coursework will expose the student to ideas and techniques that are important to the pursuit of nanobiology research, but outside of his or her discipline. These activities will serve to generate a truly unique and transformative graduate education experience.

Types of cognate courses needed to achieve a Nanobiology certificate for students entering from different Ph.D. programs.



We will require students to use cognate or free elective courses to expand their academic exposure beyond the traditional boundaries of their chosen Ph.D. discipline. For example, a physical science student will take biology and engineering classes and vice versa. The schematic diagram above tries to represent some of the participating programs and where their students would take complementary classes to complete the nanobiology certificate.

The relevant course material can roughly be broken down into three categories: biology, physical sciences, and engineering. These distinctions are certainly only approximate and physical science courses are often taught by Engineering faculty and occasionally vise versa. So the breakdown is not by department or college, but rather by content of the course. Below is a list of some, but certainly not all, of the relevant courses offered at the University.

2c. Nanoscience courses

I Biology

Civil Engineering	582	Environmental Microbiology
Chemistry	501/502	Chemical Biology
Biomedical Engineering	418	Quantitative Cell Biology
Civil Engineering	693	Environmental Molecular Biology
Biology	427	Molecular Biology
Biology	428	Cell Biology
BiolChem	415/515	Intro Biochemistry

II Physical Science

Chemical Engineering	538	Statistical and Irreversible Thermodynamics
Applied Physics/EECS	513/540	Applied Quantum Mechanics
Physics	406	Statistical and Thermal Physics
Physics	511	Quantum Physics
Physics	520	Condensed Matter Physics
Materials Science	500	Materials Physics and Chemistry
Chemistry	535	Physical Chemistry of Macromolecules
Chemistry/Mat. Sci.	511/510	Materials Chemistry
Biophysics	520	Energetics, Interactions, Dynamics Biomacromolecules
Biophysics	521	Physical Methods for the Study of Biomacromolecules
Chemistry	454	Biophysical Chemistry II
Mechanical Engineering	631	Statistical Thermodynamics
Chemical Eng/Mat. Sci.	557	Computational Nanoscience of Soft Materials

III Engineering

Pharmaceutical Chemistry	758	Methods of Computational Chemistry
Biophysics	608	Biophysical Principles of Microscopy
Material Science	512	Polymer Physics
Civil Engineering	583	Surfaces and Interfaces in Aquatic Systems
Civil Engineering	594	Environmental Soil Chemistry
Civil Engineering	692	Biological and Chemical Degradation of Pollutants
Chemical Engineering	557	Computational Nanoscience of Soft Matter
Biomedical Engineering	556	Cellular and Molecular Biomechanics
Nuclear Engineering/MSE	590/662	Advanced Electron Microscopy Laboratory
Electrical Engineering	598	Photonic Crystals
Material Science	693	Nanostructured Matls for Energy Conversion and Storage
Chemistry/Macro	436/536	Laboratory in Macromolecular Chemistry
Mechanical Engineering	539	Heat Transfer Physics
Biomedical Engineering	561	Biological Micro-and Nanotechnology
Biomedical Engineering	599	Biomembranes, Transport and Signaling

A student seeking a Rackham certificate in nanobiology would be required to meet with the program director and have the three nanoscience courses approved: one in the Ph.D. area, and two complementary courses. This degree of individualization is necessary due to the vastly differing backgrounds of the students, as well as, the diversity

of Ph.D. research that they will be performing. It is impossible to develop a simple algorithm that can encompass all the possible permutations. However, the course requirements can be summarized in this short statement: **"To obtain a Rackham Nanoscience Certificate with emphasis in nanobiology, a student must satisfactorily complete three nanoscience courses (9 cr.), two of which must be outside of the classes required by his or her Ph.D. department or program. These two classes must be in complementary areas of research as to broaden the student's education. Upon completion of the Certificate, it is expected that students will have taken at least one course from each of the three nanobiology research areas. The choice of the two cognate certificate classes must be approved by the program director."**

2d. Required Collaboration

An important cornerstone of nanoscience is its interdisciplinary nature. Thus, while performing thesis research, the student will be required to collaborate with at least one research group other than that of the advisors. This requirement is so fundamental to the research area that it needs to be codified and emphasized as a "way of life" when performing nanoscience research. It is expected that any student who is interested in developing competency in this area will need to have extensive interactions with researchers outside of his or her advisor's research group. For example, a computational student might collaborate with the experimentalists acquiring data on a physical system, or an experimentalist could perform research in several different laboratories. For a significant percentage of Ph.D. students working in nanobiology, such a level of collaboration is already the norm.

The final decision as to whether the student has had sufficient interaction to fulfill this requirement will be determined by the Director in consultation with the steering committee. Evidence of interaction will be demonstrated by production of joint papers, joint data included in thesis, participation in the group meetings. It will be important that a student's thesis advisor accepts and understands this aspect of the certificate requirement when his or her student enrolls in the program. Without an advisors support this requirement will be difficult or impossible to satisfy.

For some students, the collaborative research will be undertaken within the MNIMBS. Although research in the Institute is not a requirement of the Certificate, MNIMBS is a natural location for faculty from different departments to form collaborations on nanobiology research. Over the past several years, six faculty members in the physical sciences and engineering have utilized the extensive biological and medical research capabilities of this Institute to further their research. Many graduate students from LSA and COE have worked in the Institute, which is located on the medical school campus, and reported that quite productive interactions have taken place. With the formation of an official nanobiology certificate, MNIMBS has agreed to increase its participation with the training of graduate students.

It is expected that the required student collaborations will occur naturally and not be forced or artificial. A highly beneficial byproduct of these student interactions will be increased faculty collaboration.

2e. Required Seminar

In order to ensure intellectual cohesion and exchange of knowledge between students within the training program, a student-organized research seminar will be required. All student participants will give research presentations and feedback on presentations that they view. We piloted this type of program last summer with a group of physics, applied physics, and astronomy students. The format was very successful. Students appreciated the opportunity both to practice speaking before an audience and to learn about other types of research that students are working on. It is expected that as the program reaches steady-state (~20 students), research presentations will be given once a week. Faculty will also give talks at the meetings, both to inform students, but also to attract them to their research. The seminars will be held in BSRB which is located between central and north campuses. Oversight of the seminar series will be provided by the Director of the certificate, Prof. Brad Orr. To obtain a Rackham certificate in nanobiology a student would register for this seminar course for a total of three terms totally 6 credits.

In summary, the requirements for a student to receive a certificate in Nanoscience with an emphasis in nanobiology are:

- Complete a nanoscience class within his or her Ph.D. area (3 credits)
- Complete two complementary nanoscience classes outside of his or her specific Ph.D. area (6 credits)
- Attend student-organized seminar series (2 credits/semester, 3 semesters)
- Perform collaborative research in a second laboratory or with a second research group

These required courses and the collaborative research experience will serve to complement and broaden a students' Ph.D. education and satisfies the Rackham certificate requirement of 15 credits. Below is an approval form for a student who is requesting a nanobiology certificate. (Note that approval of the courses will have taken place when the student enters the certificate program. This form is meant to document successful completion.)

2f.

Approval form for the Nanobiology Certificate

Name

PhD Program

PhD Advisor

Nanoscience course in area of Ph.D. **_____** **credits __** **□ Completed**

Nanoscience course in cognate area #1 **_____** **credits __** **□ Completed**

Nanoscience course in cognate area #2 **_____** **credits __** **□ Completed**

Nanoscience seminar **Semester, year _____** **credits** 2 **□ Completed**

Nanoscience seminar **Semester, year _____** **credits** 2 **□ Completed**

Nanoscience seminar **Semester, year _____** **credits** 2 **□ Completed**

Research collaboration **Description _____** **□ Completed**

Total credits ____ >14 and <20

I hereby approve the above program of study for _____ and certify he/she has satisfied all the requirements necessary for completion of a Rackham Nanobiology Certificate.

_____	_____	_____
(Director's signature)	(Director's printed name)	(Date)

2g. Example Programs

It is useful to examine in detail how the Nanobiology Certificate would alter a student's graduate program. As examples, we will discuss the programs for two students: An experimentalist who enters through Applied Physics; and another who is in the Materials Science and Engineering doctoral program.

The Applied Physics Ph.D. combines coursework in the fundamentals of physical theory, its applications to modern technology, and practical "hands-on" training in the research laboratories, with coursework completed during the first 1.5 - 2 years. Students are encouraged to become involved in research at the earliest opportunity (usually in the second semester) through the Supervised Research Course (Applied Physics 715). Courses in applied quantum mechanics, electromagnetism, condensed matter, statistical mechanics, and computer instrumentation techniques form the core of the standard curriculum.

In the past, many students have wanted to work in interdisciplinary nanobiology, but this desire has always proven somewhat problematic as Applied Physics was originally designed to couple with engineering disciplines and not with biology or medicine. Under the auspices of the new Certificate, we propose to modify the standard Applied Physics program, replacing Quantum Theory of Light or Condensed Matter Physics with an elective in the biology area (see table below).

Comparison of current and proposed Applied Physics programs (changes are in italics)

Term	**Current Program**	**With Nanobiology Certificate**
Fall Year 1	Electrodynamics I Applied Quantum Mechanics Statistical Mechanics Graduate Seminar	Electrodynamics I Applied Quantum Mechanics **Statistical Mechanics** Graduate Seminar
Winter Year 1	Applied Quantum Mechanics II Electrodynamics II Supervised Research Graduate Seminar	Applied Quantum Mechanics II Electrodynamics II Supervised Research **Graduate Nanobiology Seminar**
Spring/Summer Year 1	Supervised Research Lab course (AP 518) Laboratory Computer Interfacing	Supervised Research Lab course (AP 518) Laboratory Computer Interfacing
Fall Year 2	Condensed Matter Physics Elective Course Research	**Biology 427** Research **Graduate Nanobiology Seminar**
Winter Year 2	2 Electives Research	Elective **Biomedical Engineering 556** Research **Graduate Nanobiology Seminar**

The **bold** courses are required for the nanobiology certificate. Coming from a physical science discipline, this Applied Physics student needed to select electives from the biology and engineering categories, and take the nanobiology seminar.

Turning to the student who has entered the certificate program and intends to obtain a Materials Science and Engineering Ph.D. Degree, there are no formal course requirements for the Ph.D. in Materials Science beyond 68 credits and 2 cognate courses. There are five core courses that most graduate students will take. This structure dovetails very nicely with obtaining a nanoscience certificate. Below is a possible program for a Ph.D. graduate student in Material Science and Engineering who desires to obtain a certificate.

Term	**Current Program**	**With Nanobiology Certificate**
Fall Year 1	Structure of Materials Elective	Structure of Materials **Applied Quantum Mechanics**
Winter Year 1	Materials Physics and Chem Kinetics and Phase Transitions Research	**Materials Physics and Chem** Kinetics and Phase Transitions Research **Graduate Nanobiology Seminar**
Spring/Summer Year 1	Supervised Research	Supervised Research
Fall Year 2	Condensed Matter Physics Elective Course Research	**Biology 427** Research **Graduate Nanobiology Seminar**
Winter Year 2	2 Electives Research	Elective Research **Graduate Nanobiology Seminar**

This student was required to take a biology and physical science elective to complement the engineering courses that form the core of his or her Ph.D. requirement.

Lastly, turning to a student who desires to obtain the Nanobiology Certificate and has enrolled in the Molecular, Cellular and Developmental Biology graduate program with plans to concentrate in cell biology. The first year of the MCDB program is fairly structured and would not be altered. In the second year this student would take the two outside courses in the physical science and engineering areas. The student would also begin to attend the seminar series. The MCDB graduate program and the student's advisor would need to grant permission for these extra courses to be taken.

Term	Current Program	With Nanobiology Certificate
Fall Year 1	MCDB 614 PIBS 503 MCDB seminar Supervised research	MCDB 614 PIBS 503 MCDB seminar Supervised research
Winter Year 1	MCDB 615 Ph.D. cognate MCDB seminar	MCDB 615 Ph.D. cognate MCDB seminar
Spring/Summer Year 1	Supervised Research	Supervised Research
Fall Year 2	MCDB seminar Research	MCDB seminar Research **Physics 453 Quantum Mechanics** **Graduate Nanobiology Seminar**
Winter Year 2	MCDB seminar Research	MCDB seminar Research **Chem E 557 Computational Nanoscience of Soft Matter** **Graduate Nanobiology Seminar**
Fall Year 3		**Graduate Nanobiology Seminar**

2h. Coordination with existing graduate programs

The graduate coordinators of Chemical Engineering, Chemistry, Physics, Biophysics, Biomedical Engineering, Mechanical Engineering, and Civil Engineering have all expressed interest and support in this graduate certificate. They have reviewed the certificate requirements and determined that they are compatible with their Ph.D. programs. Additionally, they believe that there will be students in their Ph.D. programs who will be interested in, and benefit from the opportunities afforded by the program. Appendix B is a set of letters of support from these departments.

3. Operational arrangements

3.a Administration of the Nanoscience and Technology Certificate

The certificate program will be housed administratively in the Rackham Graduate School, as are all interdisciplinary certificate programs at Michigan. The day-to-day operation of the program will be overseen by Prof. Bradford Orr and the directors of the other areas of emphasis. (Professors Rachel Goldman and Lingjie (Jay) Guohave agreed to lead the programs in materials and electronics, respectively) Their responsibilities will include: recruiting students to the certificate program from within the University of Michigan; recruiting students externally (particularly underrepresented students) to come to Michigan in order to participate in the program; advising students in the program; approving program cognate courses; providing oversight to ensure timely progress through the program (without adding significantly to the students' time-to-degree); and

overseeing the organizational infrastructure necessary to ensure continuation of the Certificate program. Staff support will be provided by the Applied Physics Program.

To initiate the program, Rackham has suggested that a steering committee be formed for the nanoscience and technology certificate. Suggested participants include Prof. Duncan Steel (Biophysics, Electrical Engineering, Physics), Professor James Baker (M-NIMBS, Biomedical Engineering), Prof. Roseanne Sension (Chemistry, Physics), Prof. Rachel Goldman (Material Science and Engineering), Prof. Nicholas Kotov (Chemical Engineering), Prof. Lingjie (Jay) Guo (Electrical Engineering), Prof. Bradford Orr (Physics and Applied Physics) and Prof. David Engelke (Rackham and Biological Chemistry). More information can be found in Appendix C.

3.b Admissions and Enrollment Plan

Students who have been granted admission to the University by one of the feeder Ph.D. programs will be eligible for admission into the Nanoscience and Technology Certificate Program. The director in the relevant area of emphasis will meet with the student and discuss the course sequence that will be appropriate for acquiring the breadth desired by the certificate requirements. After the student's program has been designed, the student would return to his or her home department and obtain approval of the program for the Ph.D. .

We believe that an enrollment of approximately 10 students working on the nanobiology emphasis of nanoscience certificate would constitute a successful steady state. Given the demand for this type of Ph.D. research and the students educated in this manner, we expect that this can be reached with three years.

4. Summary

This proposal for a certificate program in nanoscience with an emphasis on nanobiology is the first in what is to become a comprehensive program in nanoscience. As was discussed in the beginning of this proposal, nanobiology is but a fraction of the entire field of nanoscience. Faculty members have already volunteered to lead the process of developing nanomaterials (Professor Rachel Goldman, Material Science and Engineering) and nanoelectronics (Professor Lingjie (Jay) Guo, Electrical Engineering) foci. This set of themes will allow The University of Michigan to better recruit, train, and credential graduate students in this important interdisciplinary field.

Appendix A. Letters of Support from Colleges and Schools

University of Michigan
P·I·B·S
Program In Biomedical Sciences
1150 W. Medical Center Drive • Box 0619 • Ann Arbor, MI 48109-0619
Phone: 734.647.7005 • Toll Free: 877.294.0120 • FAX: 734.647.7022 • Web: http://www.med.umich.edu/pibs/

David R. Engelke, Ph.D.

November 15, 2007

Dr. Brad Orr
Professor of Physics
Director of Applied Physics
The University of Michigan

Dear Brad,

The Medical School is pleased to endorse the proposal to develop a new Rackham Certificate in Nanobiology. Utilizing the newly formed Michigan Institute of Nanomedicine and Biological Sciences (M-NIMBS) as a research partner, this certificate will allow a far more integrated and interdisciplinary approach to the education of students interested in obtaining Ph.D's in this rapidly emerging area of research. The breadth of expertise represented by the departments participating in the proposal is remarkable. With the colleges of Engineering, Medicine and Literature Science and Arts well represented, graduate students will be exposed to a diverse array of tools, techniques and ideas.

This program will significantly enhance the educational opportunities for graduate students at The University of Michigan. I look forward to the creation of this program that will help us and the student participants take advantage of cutting-edge expertise broadly across the University.

Sincerely,

David Engelke
Professor of Biological Chemistry
Assistant Dean for Graduate and Postdoctoral Studies,
Medical School

A. W. (TONY) ENGLAND
ASSOCIATE DEAN FOR ACADEMIC AFFAIRS
PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, AND
ATMOSPHERIC, OCEANIC AND SPACE SCIENCES

UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING

ROBERT H. LURIE ENGINEERING CENTER
1221 BEAL AVENUE
ANN ARBOR, MICHIGAN 48109-2102
734 647-7020 FAX 734 647-7019
england@umich.edu
http://www.engin.umich.edu/admin/adaa

July 9, 2007

Professor Bradford Orr
Director of Applied Physics
2477 Randall Lab 1120

Dear Brad:

The College of Engineering supports the creation of a new Graduate Certification Program in Nanobiology. This new program compliments our programs in Biomedical Engineering, Materials Science and Engineering, and Electrical and Computer Engineering. The proposed training program would provide an important option for many of our graduate students.

Sincerely,

Tony

Anthony W. England

AWE/lt

Office of the Dean

College of Literature,
Science, and the Arts

University of Michigan

Suite 2109
500 South State Street
Ann Arbor, MI 48109-1382

(734) 647-2762
(734) 764-2697 fax
www.lsa.umich.edu

July 8, 2007

Professor Bradford Orr
Director of Applied Physics
The University of Michigan
Ann Arbor, MI 48109

Dear Brad,

I am writing to confirm the support of the College of Literature, Science, and the Arts for the creation of a new Graduate Certificate Program in Nanobiology. This is an emerging area, at the intersection of Chemistry, Biology, and Physics. The proposed training program should provide important "added-value" for many of our graduate students, and will make good use of a number of courses that we current teach within LSA. I look forward to the development of this Certificate, and of the parallel programs in Nanomaterials and Nanoelectronics.

Sincerely,

James E. Penner-Hahn
Professor of Chemistry
Associate Dean for Natural Sciences

Appendix B. Letters of Support from Departments and Programs

UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

3074 H. H. DOW BUILDING
2300 HAYWARD
ANN ARBOR, MICHIGAN 48109-2136
734 764-2383 FAX 734 763-0459

March 15, 2007

To Whom It May Concern:

I have reviewed the goals and requirements of the proposal Rackham certificate program in nanobiology. This program would be a benefit to several of the researchers in our department both in attracting students and training them for their PhD thesis work. The requirements of a interdisciplinary laboratory course, lab rotation, complementary cognate and seminar class are compatible with our PhD program. Students who satisfy these requirements will have a broader knowledge and skills than is the norm in my department. I believe several of our graduate students will be interested in this certification program and it will help them in their education and in their career. It will also may help recruiting graduate students, and as chair of the graduate program I would encourage appropriate students to consider this certification. I urge that the certificate be approved and made available to interested graduate students.

Sincerely,

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Robert M. Ziff
Professor and Graduate Chair of Chemical Engineering
Member, Michigan Center for Theoretical Physics

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
ENVIRONMENTAL AND WATER RESOURCES ENGINEERING PROGRAM

UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING

1351 BEAL AVENUE
179 EWRE BUILDING
ANN ARBOR, MICHIGAN 48109-2125
734 763-1464 FAX: 734 763-2275
http://www.engin.umich.edu/dept/cee

February 19, 2007

To Whom It May Concern:

I have reviewed the goals and requirements of the proposed Rackham certificate program in nanobiology. This program would be of benefit to some of the researchers in our Environmental Engineering Ph.D. program, both in attracting students and in training them for their dissertation work. The requirements of an interdisciplinary laboratory course, lab rotation, complementary cognate, and seminar class are compatible with our Ph.D. program. Students who satisfy these requirements will have a broader knowledge and set of laboratory skills than they would otherwise obtain from taking courses solely within the CEE department. I endorse the nanobiology certificate program and recommend that it be approved and made available to interested graduate students.

Sincerely,

Christian Lastoskie
Chair, Curriculum Committee
Department of Civil & Environmental Engineering

THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF BIOMEDICAL ENGINEERING

1107 Gerstacker
2200 Bonisteel Blvd.
Ann Arbor, MI 48109-2099
734 764-9194 FAX: 734 936-4218
dnoll@umich.edu

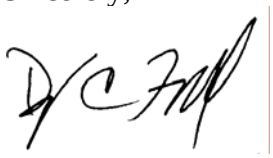
June 27, 2007

Re: Certificate in Nanobiology

To Whom It May Concern:

I'm writing to express my enthusiasm for the proposed Rackham certificate program in nanobiology. I can see that this program will aid us in recruiting high-quality graduate students for the biomedical engineering program. This program will create new and interesting educational opportunities for our students that may help them in their dissertation projects and provide them with a stronger background in the important and growing technological area. I also don't see any major issues with compatibility with our Ph.D. program and I strongly support approval of this program.

Sincerely,



Douglas Noll, Ph. D.
Professor and Interim Chair of Biomedical Engineering
Co-Director, Functional MRI Laboratory

University of Michigan

Department of Chemistry

Anna K. Mapp, Ph.D.
Associate Professor of Chemistry & Medicinal Chemistry

March 16, 2007

To Whom It May Concern:

I have reviewed the goals and requirements of the proposed Rackham certificate program in nanobiology and enthusiastically endorse the program. It would benefit a number of our faculty both for attracting students to our graduate program and as a mechanism for providing more advanced interdisciplinary training. Nanotechnology and its applications in biology is an area of growth in our department and I anticipate it will also be an attractant to potential faculty member. The program requirements of an interdisciplinary laboratory course, a lab rotation, complementary cognate and seminar class are compatible with our Ph.D. program requirements. Students who satisfy these requirements will have a broader knowledge and skills than is the norm in my department. I strongly support the approval of this program and look forward to it being available to our graduate student cohort.

Sincerely,

Anna K. Mapp
Chair, Graduate Committee
Associate Professor of Chemistry and Medicinal Chemistry

The University of Michigan

APPLIED PHYSICS PROGRAM

Bradford G. Orr,
Director

500 E. University
2477 Randall Laboratory
Ann Arbor, Michigan 48109-1120
Office: (734) 936-3609
Fax: (734) 764-2193
orr@umich.edu
http://www-applied.physics.lsa.umich.edu

June 27, 2007

To Whom It May Concern:

The Applied Physics Program is pleased to support the creation of a Rackham nanoscience certificate. Many of our students will be interested in obtaining one of the variants of the certificate. As an interdisciplinary program the philosophy and structure is quite compatible and we look forward to being able to offer this certificate to our students.

Sincerely,

Brad Orr

Brad Orr
Professor of Physics
Director of Applied Physics

James R. Baker, Jr., M.D.
Director
Ruth Dow Doan Professor
MICHIGAN NANOTECHNOLOGY INSTITUTE FOR MEDICINE AND BIOLOGICAL SCIENCES

November 15, 2007

Brad Orr, Ph.D.
Professor of Physics
Director of Applied Physics
2477 Randall Lab, SPC 1120

Dear Brad,

I am writing to express my strong support for the development of an integrated interdisciplinary graduate certificate in nanobiology at the University of Michigan. To fully understand the University's commitment to this program some history must be presented. Nine years ago, we formed the Center for Biologic Nanotechnology at the University of Michigan. At its core, the Center was formed to take advantage of the advances in the basic sciences and engineering, and apply them to biological systems for medical applications. Participants came with an extremely wide range of expertise: optics, chemistry, biology, applied physics and computation. The Center has successfully competed for funding from a variety of sources, including the NIH Unconventional Innovations Program, NASA, the State of Michigan, and the Bill & Melinda Gates foundation.

Over this period, the interdisciplinary collaboration has proven very successful. A tremendous amount of knowledge has been generated, and equally important, a large range of technology has been developed. Examples include examination of nanoparticle interactions with membranes, synthesis and characterization of nanoparticles as novel targets for cancer treatment and MRI contrast enhancement and development of minimally invasive two photon fiber optic probes for detection and diagnosis of cancer. In each of these cases, the success of our investigation required the interdisciplinary skills provided by a team of researchers drawn from across campus.

Recognizing the success of the Center, the University recently expanded the center into the "Michigan Nanotechnology Institute for Medicine and Biological Sciences" (**M**NIMBS). This Regentially chartered research institute brings together a larger group of interdisciplinary researchers to apply the techniques and knowledge from the physical sciences to biological and medical research.

The Rackham Certificate in Nanobiology is a perfect partner for our Institute. As a research entity, **M**NIMBS provides many opportunities for interdisciplinary studies to be performed by graduate students. We have faculty, postdocs, and graduate students from Applied Physics, Chemistry, Biophysics, Electrical Engineering, Biomedical Engineering and the Medical School working on our projects. This wide range of backgrounds gives us a unique approach to and perspective on the problems we are studying. It is very appropriate for us to partner with these departments and programs to provide a new approach for the education of graduate students.

James R. Baker, Jr., M.D.
Director
Ruth Dow Doan Professor
MICHIGAN NANOTECHNOLOGY INSTITUTE FOR MEDICINE AND BIOLOGICAL SCIENCES

I would like to give one specific example of why I am a strong supporter of your proposal. This involves Dr. Almut Mecke, a student well known to you. Ms. Mecke was a physics student who originally intended to do "string theory." After several years of course work and preliminary research, Almut decided that she wanted to work in a group environment rather than alone and that she wanted to have an impact on the quality of human life. She chose to work with the Center for Biologic Nanotechnology. We were starting our program on targeted cancer therapeutics and Almut originally joined thinking that she would perform molecular dynamics simulations of nanoparticle – membrane interaction. In the end, her Ph.D. thesis contained not only these simulations, but also a wealth of experimental atomic force microscopy data on aqueous particle-lipid layer interactions. She produced a statistical mechanical model that points to the physical mechanism by which these nanoparticles interact with lipid layers. Her studies opened up an entire new area of research for us in nanoparticle toxicity. Her thesis committee was composed of Professors from Applied Physics (Brad, her advisor), Chemistry, Biophysics, Chemical Engineering and me, an M.D. from the medical School. After graduation, her research was selected as the best graduate thesis in the Physics department for 2005.

I have chosen to highlight Ms. Mecke not only because she exemplifies the kind of interdisciplinary research that we do at **M**NIMBS, but also because she illustrates the need for a new interdisciplinary graduate training program. Although Almut was ultimately successful in her research, there were numerous hurdles to overcome before this could be approved by the relevant units. The Certificate that you propose to create will provide a smoother path for future students that choose to explore this sort of interdisciplinary training.

In summary, as Director of **M**NIMBS I strongly support the concept behind the Rackham Certificate and have benefited greatly from working with other researchers and graduate students in an interdisciplinary manner. Your proposal will allow The University of Michigan to develop a truly integrated interdisciplinary approach for graduate students in the physical sciences to learn and contribute to the revolution that is occurring in the biological and medical fields.

Respectfully,

James R. Baker, Jr., MD
Ruth Dow Doan Professor of Biologic Nanotechnology
Professor of Medicine
Chief, Division of Allergy
Director, Michigan Nanotechnology Institute
for Medicine and Biological Sciences

BioPhysics

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biophysics@umich.edu

UNIVERSITY OF MICHIGAN, COLLEGE OF LITERATURE, SCIENCE AND THE ARTS

November 15, 2007

To Whom It May Concern:

I have reviewed the goals and requirements of the proposal for a Rackham Certificate Program in Nanobiology. This program would be a real benefit to several of the faculty researchers in our department both in attracting additional students and in better training them for their PhD thesis work. The requirements of an interdisciplinary laboratory course, laboratory rotation, complementary cognate and seminar class are compatible with the requirements of our PhD program. Students who satisfy these requirements will have a broader knowledge and skills. I strongly support the move to approve the certificate and make it available to interested graduate students.

Sincerely,

Ari Gafni

Ari Gafni
Graduate Chair
Biophysics Graduate Program

Appendix C

Proposed Steering Committee for Nanoscience Certificate Program

James R. Baker Jr., MD
Ruth Dow Doan Professor and Director of Biologic Nanotechnology
Professor of Internal Medicine
Director of the Michigan Nanotechnology Institute for Medicine and Biological Sciences
Chief, Division of Allergy & Immunology
Co-Director, Center for Biomedical Engineering
jbakerjr@umich.edu

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Professor of Biological Chemistry
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Professor of Electrical Engineering and Computer Science
Professor of Physics
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Lingjie (Jay) Guo
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Professor of Physics
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Duncan Steel
Robert J. Hiller Professor
Director of Biophysics
Professor of Electrical Engineering and Computer
Professor of Physics
dst@umich.edu