

BOARD OF HIGHER EDUCATION

REQUEST FOR COMMITTEE AND BOARD ACTION

COMMITTEE: Academic Affairs

NO: AAC 18-30

COMMITTEE DATE: June 12, 2018

BOARD DATE: June 19, 2018

**APPLICATION OF THE UNIVERSITY OF MASSACHUSETTSLOWELL TO AWARD
THE DOCTOR OF PHILOSOPHY in APPLIED BIOLOGY**

MOVED: The Board of Higher Education hereby approves the application of **University of Massachusetts Lowell** to award the **Doctor of Philosophy in Applied Biology**.

Upon graduating the first class for this program, the University shall submit to the Board a status report addressing its success in reaching program goals as stated in the application and in the areas of enrollment, curriculum, faculty resources, and program effectiveness.

Authority: Massachusetts General Laws Chapter 15A, Section 9(b)

Contact: Winifred M. Hagan, Ed.D.
Associate Commissioner for Academic Affairs and Student Success

BOARD OF HIGHER EDUCATION

June 2018

University of Massachusetts Lowell Doctor of Philosophy in Applied Biology

INTENT AND MISSION

The University of Massachusetts System's mission is to provide an affordable and accessible education of high quality and to conduct programs of research and public service that advance knowledge and improve the lives of the people of the Commonwealth, the nation and the world.

The University of Massachusetts Lowell (UML) intends that the proposed Doctor of Philosophy in Applied Biology (PhD/AB) program will contribute to this mission by advancing research productivity at UML, providing highly trained graduates ready to contribute to a diverse array of public and private professional opportunities available in the Life Sciences field, and by providing excellent teaching assistants to educational programs at UML. It is further anticipated by UML that growth of the life sciences and the expansion of the biotechnology/life sciences business sector in the Merrimack Valley region, demands more scientists trained at the doctorate level in the biological sciences. The Department of Biological Sciences at UML has been engaged in an aggressive plan to expand its faculty and research portfolio over the past several years. These investments lead UML to the proposed program in response to the need for human resources to further develop and grow research programs.

UML intends that the proposed PhD/AB program will directly contribute to the goals outlined in *UMass Lowell 2020: A Strategic Plan for the Next Decade* that included the need to develop new degree programs including distinctive doctoral programs, especially those that are interdisciplinary. Another strategic goal is to develop national and international recognition as a research university by enhancing research and scholarship. Toward that end the UMass Lowell 2020 committee concluded that new graduate programs must be developed in order to strengthen the University's position as a doctoral research center. The proposed interdisciplinary PhD/AB is expected to serve as a focal point, bringing together life science research throughout UML. This is intended to foster collaboration, generate new joint-funding opportunities, and expand the overall scope of life sciences research at UML. The proposed PhD/AB program is further intended to enhance all five Pillars of Excellence at UML, with particular focus on strengthening Pillars I. Transformational Education, and III. Innovative Research & Entrepreneurship.

UML asserts that the growth in undergraduate enrollment has positioned the institution to recruit accomplished scientists to the Department of Biological Sciences. There is an increased number of faculty who are active tenured and tenure-track. The growth of other biology-related disciplines on the UML campus, contributes to an active community of biologists conducting research. The purpose of the proposed program is to provide a means to identify and recruit outstanding students to contribute to life sciences research as well as to the teaching mission of at UML.

The proposed program has obtained all necessary governance approvals on campus and was approved by the University of Massachusetts Board of Trustees on April 13, 2018. The required letter of intent was circulated on April 9, 2018¹. No comments were received.

NEED AND DEMAND

National and State Labor Market Outlook

Life sciences research in general is rapidly growing. Biology-related research represents 3 of the 4 most cited fields in science as tracked by Thomson Reuters from 2003-2013². The sectors identified to grow the US economic performance were in the scientific, technical and professional services, and Massachusetts and California lead the national performance in these sectors³. In preparing the proposal, the UML Ph.D. Program Development Committee (PPDC) consulted with scientists in leadership positions in the biotechnology and pharmaceutical industries. These interactions contributed to the Committee's plan to include a significant professional skills component in the program and confirmed the workforce demand for work-ready Ph.D. graduates in the Life Sciences. UML provided an extensive log of testimonials from industry leaders representing multiple employers and including; strategic initiatives leaders at BioNJ, Thermo Fisher Scientific, VIMAC Ventures, Merrimack Pharmaceuticals Inc., Onkaido Therapeutics, Pfizer, CBSET Inc., Genentech Inc., Shire Pharmaceuticals, and OnDeckBiotech.

UML reports that the rapid growth in undergraduate enrollment in the biological sciences is driven by overall growth in the life sciences Industry, which provides more than 113,000 jobs in Massachusetts, having experienced 27% growth from 2001-2011 with an additional 17% growth projected through 2016⁴, with no evidence that this trend will slow beyond 2016⁵. The growth and success of other biology-related disciplines across UML are dependent on the presence of an active community of biologists. Doctoral students, unlike undergraduate or master's level students, are able to engage in complex and ambitious research projects that may require several years to complete, and these students are often the critical facilitators of viable long-term interdisciplinary collaborations. Additionally, in August 2016, the state-wide unemployment rate dropped to 3.9 percent, its lowest unemployment since 2008, and Massachusetts added 5,900 jobs during that month⁶. In a recent jobs trend forecast published by the *MassBioEd* (the Massachusetts Biology Education Foundation) for the period 2015-2018 in Massachusetts, a

¹ *The University of Massachusetts Presidents Office submitted the LOI for circulation on December 4, 2017. An electronic error prevented it from being circulated until April 2018.*

² *The World's Most Influential Scientific Minds 2015*, Thomson Reuters: http://images.info.science.thomsonreuters.biz/Web/ThomsonReutersScience/%7B37a987a9-e378-4888-8baa-d4ba20efdbfd%7D_tr_scientific_minds_online_final.pdf

³ 2014, Massachusetts Labor Market and Economic Review . (September 2015), Massachusetts Executive Office of Labor and Workforce Development

⁴ Barry Bluestone and Alan Clayton-Matthews. Dukakis Center for Urban & Regional Policy. Massachusetts Life Sciences Employment: 2010-2012: http://www.masslifesciences.com/wp-content/uploads/Bluestone_MLSC-Jobs-Impact-Slides-2014-FINAL.pdf

⁵ Massachusetts Life Sciences Center, Fiscal Year 2014 Annual Report. *Massachusetts: The Global Leader in Life Sciences*: <http://www.masslifesciences.com/wp-content/uploads/2014-Annual-Report-FINAL.pdf>

⁶ Mass.gov: The Official Website of the Executive Office of Labor and Workforce Development (EOLWD) http://lmi2.detma.org/Lmi/News_release_state.asp.

6.7% increase in jobs in the biotechnology sector is anticipated⁷. Between 2010 and 2014, the number of job listing in the biopharmaceutical industry grew by 38% in Massachusetts.

It is expected that graduates from the proposed program will fill numerous regional positions in the biotechnology sector, addressing a growing local need in the northeast region of the state. This region has been defined as a life sciences super-cluster whose employment needs are currently not being met. The northeast sector of Massachusetts currently has 100+ life science companies, with that number growing every year. Companies that have newly created or have established satellites in the defined northeast sector of the state include Charles River Laboratories, Pfizer, Smith & Nephew, Merck & Company, Medtronic, Parexel, Raytheon, Bruker Corporation, Amgen and Quest Diagnostics, to name a few.

UML cited a market analysis by the Hanover Research Group UML cited, *“Massachusetts-based professionals in the pharma and in the diagnostics, tools, and related products and services industries will be more likely to hold doctoral degrees (20 percent and 23 percent, respectively) than professionals in the medical devices sector (2 percent). Life sciences workers with doctoral degrees will benefit from significantly higher annual earnings than professionals with lower-level degrees. In Massachusetts, for example, professionals with doctoral degrees in the pharma, medical device, or scientific R&D sectors can expect to earn annual salaries of between \$112,000 and \$249,000, while professionals holding bachelor’s degrees in these sectors are likely to earn between \$85,000 and \$99,000 annually”*.

Student Demand

UML expects that the proposed program will meet a demand from baccalaureate and master’s degree students who seek employment in life science industries (biotechnology, pharmaceutical, medical device), at biomedical facilities (hospitals, clinics, private research laboratories) or within academia. Based on an internal survey of biology master’s degree students and current BMEBT⁸ Ph.D. students on campus UML is confident that there is an important demand on campus for the proposed program. In addition, several students were interviewed by the PPDC Chair and many indicated that they chose to apply to the BMEBT PhD program as a means to conduct doctoral research in a biology faculty member’s lab. That is, the BMEBT program was not a perfect fit for these students but it was the only one available for them to pursue the life sciences research that interested them. There have also been instances where students who were interested in pursuing doctoral research in a UML lab, chose not to come to the University because of lack of an appropriate program. An example cited from 2017 is that in two instances prospective Ph.D. students were offered funded positions in a biology faculty member’s laboratory, yet they decided to pursue their studies elsewhere because they did not feel that the available Ph.D. programs were well matched to their applied biology interests.

⁷ The Digest of Biotech Job Trends in Massachusetts. 2016. The Massachusetts Biotechnology Education Foundation. https://www.massbioed.org/writable/files/annual_job_trends_report.pdf

⁸ The University of Massachusetts Biomedical Engineering and Biotechnology Program is offered jointly by the campuses at Boston, Dartmouth, Lowell and Worcester. The Ph.D. Program brings together expertise in related fields, and emphasizes a multidisciplinary, team approach in course/seminar presentations across the campuses, laboratory rotations, and joint research projects prior to dissertation specialization. The program is open to a wide range of bachelor degree recipients with strong quantitative skills and engineering/physical science, life/clinical science and related backgrounds

OVERVIEW OF PROPOSED PROGRAM

The PhD/AB proposal was prepared by the PPD committee, composed of faculty members from the Department of Biological Sciences. In preparing the proposal PPDC consulted with faculty throughout UML as well as with scientists in leadership positions in the biotechnology and pharmaceutical industries. These interactions contributed to the Committee's plan to have tracks that would encompass a wide range of research areas so as to be inclusive of faculty in several departments and colleges. Chairs of ten different departments across three Colleges including Chemical Engineering, Chemistry, Biomedical and Nutritional Sciences, Computer Science, Environmental, Earth & Atmospheric Sciences, Mathematical Sciences, Mechanical Engineering, Physics & Applied Physics, and Public Health have indicated their enthusiasm and support for the proposal. In addition, the faculty within the Department of Biomedical and Nutritional Sciences have agreed to serve as a co-sponsor of this program to ensure that it meets its goals to establish new and enhance existing collaborative relationships across the campus leading to the expansion of life sciences research at UML. The PhD/AB program is planned to be administered by the Department of Biological Sciences and the active research faculty within the Department will be primary participants. In addition, it is planned that faculty throughout UML will have the opportunity to participate at all levels. The UML current list of participating faculty includes 15 from the Department of Biological Sciences and 16 from other departments at UML representing the Kennedy College of Sciences, the Francis College of Engineering and the Zuckerberg College of Health Sciences.

UML expects to establish a standing Applied Biology Program Committee comprised of four faculty members from the Department of Biological Sciences and two to four faculty members from the participating departments at UML. This committee will be chaired by the Graduate Coordinator for Biological Sciences. The committee will regularly evaluate program curriculum and policies; assign and monitor qualifying exam and dissertation advisory committees; and assist in mediating issues that may arise between students and faculty. UML also anticipates that an external advisory board will be comprised of two leading scientists from other universities who are actively engaged in graduate program administration, two executives from the biotechnology/life science industry who will provide insight into workforce needs, and one scientist from the NIH.

Duplication

UML carefully reviewed the biology Ph.D. programs on the websites of Boston College, Boston University, Brandeis University, Clark University, Harvard University, Massachusetts Institute of Technology, Northeastern University, Tufts University, and Worcester Polytechnic Institute. UML found that generally, biology doctoral programs at these schools follow traditional academic lines with emphasis on specific biology sub-disciplines or that they are broadly interdisciplinary across many departments. By contrast, the proposed PhD/AB program is distinguished by a focus on preparedness of our graduates for immediate entry into the Life Science workforce because the curriculum emphasizes practical application of technical and professional communication skills. UML also surveyed the Ph.D. programs at the other UMass campuses. This underscored the distinctive nature of the UML program in its emphasis on direct preparation of entry into the workforce. For example, UMass Amherst participates in the Intercampus Marine Science doctoral program and offers interdepartmental Ph.D.'s in Molecular and Cellular Biology, and Neuroscience and Behavior. UMass Amherst also has separate traditional research doctoral programs in Food Science, Microbiology, Organismic and Evolutionary Biology, Plant and Soil Sciences, and Plant Biology through the College of Natural

Sciences. UMass Boston has separate Ph.D. programs in Environmental Sciences, Marine Science and Technology (intercampus), and Molecular, Cellular, and Organismal Biology, and a college-wide doctorate in Integrative Biosciences. UMass Boston also shares the multicampus Ph.D. in Biomedical Engineering and Biotechnology with UMass Dartmouth, Lowell, and Worcester. Doctoral degrees at UMass Dartmouth are offered in the aforementioned intercampus Biomedical Engineering and Biotechnology, and Marine Science and Technology programs. In addition, UMass Dartmouth also has a separate Chemistry and Biochemistry Ph.D. program. Doctoral degrees at the UMass Medical's Worcester Graduate School of Biomedical Sciences emphasize medical applications to human disease in a number of specialized disciplines. UMass Medical in Worcester is a member of the multicampus Biomedical Engineering and Biotechnology Ph.D. program. A number of UML students in this program have conducted research at the UMass Medical School laboratories for completion of their dissertation requirement.

ACADEMIC AND RELATED MATTERS

Admission

Specific requirements for admission to the proposed PhD/AB program are in addition to the standard requirements⁹ for graduate admission described by the UML Graduate Admissions office.

Specific Requirements

Sponsorship: All applicants must identify two potential advisors prior to submitting an application to the PhD/AB program. Evidence of sponsorship will be provided by potential advisors on an internal document to the AP Program Committee, that will be retained by the Graduate Coordinator for Biology. This is expected to ensure that funding will be available to support admitted students. Students will have the opportunity to select a different permanent advisor during year 1, but it is anticipated that one of the potential advisors will often serve as the permanent dissertation advisor.

First Year Students & Transfer Students

Transcripts: First year and transfer students will be required to show evidence of having earned a bachelors or master's degree in biology or a related discipline (e.g., biochemistry, botany, environmental biology, marine biology, zoology) with a minimum 3.0 GPA. International applicants will be required to have earned a comparable degree and GPA as verified by the Center for Educational Documentation (CED). A Master's degree with evidence of a strong background in biology may be used in lieu of a degree in Biology or a related discipline for students who earned their undergraduate degree in a different field of science or engineering.

Exams: All applicants will be required to take the general Graduate Record Exam and earn a minimum score of 300, achieving at least 150 on both quantitative and verbal portions. Foreign applicants from countries where English is not an official language must also take the TOEFL (Test of English as a Foreign Language) exam and earn a minimum score of 90. The TOEFL may be waived under select conditions.

⁹ <https://www.uml.edu/Grad/Process/>

Personal Statement: A personal statement will be required that describes the student's educational background, research experience, and career goals. The student will be required to identify at least two potential principal investigators in the statement. Applicants will be strongly encouraged to have established contact with their potential advisors before applying. Particular attention will be given to students who have research experience and display a commitment to pursuing excellence in science.

Letters of Recommendation: Three letters of recommendation from professional sources must be submitted at the time of application. Sources may include academic professionals or supervisors/colleagues from a current or previous employer.

Transfer of graduate credits into the proposed PhD/AB program, are expected to be allowed in accordance with UML policy.

Curriculum (Attachment A)

In order to provide students an area of focus within the broad field of biology the proposed PhD/AB program is planned to include options. These are Biomedical Science, Developmental & evolutionary biology, quantitative & biophysics and cellular & molecular biology. UML anticipates that students will select their option anytime during their first two years. Each option will contain a list of approved graduate courses that are currently offered at UML. New advanced courses will be added over time in the specialty areas of growing faculty. Students will be required to complete at least four advanced courses in their option and two courses outside of their option (certain core competency courses can be used for this purpose). Students will be expected to complete a minimum of 32 credits of coursework by the end of their second year. In addition to coursework, it is planned that students will earn credits towards degree completion through an optional industry internship, and thesis credits. At the end of the program, it is planned that students will earn a total of 60 credits through coursework and research, and will present a doctoral dissertation containing original publishable findings that make a significant addition to new knowledge in their field of study. All but four of the required and elective courses already exist and have maintained sufficient student enrollment through other graduate programs (i.e., MS programs in Biology). Three required courses (1 credit each) will be developed and one advanced core competency course (3 credit) will need to be developed.

Resources

Budget (Attachment B)

UML has designed the proposed program to require no additional resources to add faculty or dedicated new facilities. All but 4 of the proposed biology courses currently exist and run regularly with sufficient graduate student enrollment. UML does not anticipate any program income from student tuition. The availability of qualified Ph.D. students to contribute to faculty research is expected to have a positive effect on UML's ability to compete for external research funding. UML plans to coordinate the size of the program with the estimated number of available research assistantships among participating faculty. This is planned to be based on existing external research grants associated with the proposed program. UML estimates that based on current research expenditures, the proposed PhD/AB program expects to have 3-6 new students join the program per year with a total student population topping off at 20-25 students. UML plans to develop a strategy to establish endowed fellowships that would provide 50%

stipend support for first-year students. During the first year, students often do not have the time nor are they fully prepared to serve as full-time teaching assistants. Similarly, they are not prepared or available to dedicate significant time on a faculty funded research project as a research assistant. UML proposes to fund first-year students by having them serve as ½ time teaching assistants and ½ time research assistants, paid by internal fellowships during year 1. Subsequently, UML plans that students will be supported by a combination of teaching assistantships and research assistantships from external grants.

UMass Lowell offers Teaching and Research Assistantships (TA/RA) for graduate students during the academic year. Full TA/RA ships provide a full tuition waiver and a graduated stipend based on the student's stage in their program. Current stipend levels are \$13,800, \$15,680, \$17,005 per academic year for Levels 1-3 respectively. Students are expected to work 18 hours per week when paid on a full TA or RA. Half-time TA/RAs would be expected to commit 9 hours per week to their teaching or research activities. TAs in the Applied Biology Ph.D. program would generally be assigned to teach undergraduate teaching laboratory sections in the Department of Biological Sciences under the guidance of a faculty instructor. Waiver and stipend amounts are governed by the union agreement between the University and the UAW/Graduate Employees Organization.

To ensure that assistantships are awarded to the most qualified individuals, UML has established requirements that: no TA/RA may be awarded to a graduate student with incompletes, F's, or U's on his or her transcript; no TA/RA may be awarded to a graduate student who fails to maintain a grade point average of 3.0 on the official transcript; no UML-funded TA/RA may be awarded to a master's degree candidate if s/he has completed the total number of credits required for his/her program; Level III TA/RA may only be awarded to graduate students who have reached the candidacy stage of the doctoral program. TA/RA's are awarded on either a semester or a yearly contract. The current negotiated agreement between the UML Board of Trustees and the Graduate Employee Organization as well as current stipends are posted on the UML Human Resources website.

In an analysis of biology doctoral programs at regional as well as peer and aspirant institutions, UML determined that it must provide a firm commitment for full 12-month stipend support and tuition and fee waivers in order to compete for talented students. The goal is to provide a guarantee of stipend support for all students at the time of admission to the proposed program. As the program grows along with biology-based research at UML, applications for national training grants from, for example, the NIH and NSF, are expected to provide funds for doctoral student stipends. Students in the proposed program will be expected to complete a proposal writing course and will be encouraged to submit applications for individual graduate fellowships to various federal and private funding agencies.

UML has identified several local biotechnology/biopharmaceutical companies that have a strong workforce need for new Ph.D. graduates trained in applied biology. It is expected that once the new applied biology program is approved, UML will begin discussing mechanisms for these companies to fund graduate research. Current examples of UML partnerships of this type are planned to be used as models. In addition, the Associate Dean of Research, Innovation and Partnerships in the Kennedy College of Sciences, and faculty member of the Applied Biology Ph.D. program, has recently been appointed to the steering committee of MassBio (the Massachusetts Biotechnology Council). Expanding relationships between the industry and

academia in MA is a central goal of MassBio, a not-for-profit organization that represents and provides services and support for the Massachusetts life sciences industry. The steering committee aims to develop templates and policies that will facilitate establishing partnerships between corporations and academic institutions. UML plans to use this and other means to provide funding to support student research in the Applied Biology Ph.D. Program.

Program Enrollment Projection

	Year 1	Year 2	Year 3	Year 4 ¹⁰
New Full-Time	4	5	6	6
Continuing Full-Time	4	9	15	21
New Part-Time	0	0	0	0
Continuing Part-Time	0	0	0	0
Totals	4	9	15	21

Faculty and Administration (Attachment C)

UML is a public state university classified as a STEM-dominant high research university. UML has experienced an increase of undergraduate enrollment by ~60% from 2007 to 2016. UML has also seen an increase in research activities over this same period with research expenditures of \$68.5 million in 2016. Faculty are engaged in a broad range of biomedical-related research areas including molecular, cellular and developmental biology, bioinformatics, structural biology, biomechanics, microbiology, bioengineering, bio-manufacturing, and nutrition. Research in the Department of Biology is supported by several grants from federal and private organizations.

Facilities, Library and Information Technologies

Resources, equipment and facilities associated with individual program faculty research labs, the libraries and within the growing core facilities at UML are expected to provide the necessary resources to support the proposed program. No specific new resources are being requested to launch this program.

It is expected that students and faculty will require access to a wide range of scientific journals in the fields of biology, biochemistry, biophysics, physiology, genomics and other related fields.

¹⁰ The long-term strategic plan for UMass Lowell includes growth in the number of research-active faculty in the life sciences/biology fields. It is expected that the enrollment projections will continue to grow beyond year 4. As the program matures it is expected that it will reach a steady state where it is taking in 8-10 new students per year with a full-time student population of 35-50 students.

UML libraries subscribe to a number of the major journals, and also provide access through inter-library loans to journals that are not available on campus. UML libraries have on-line subscriptions to most of the journals for which full text access is needed: *Science*, *Nature*, *Cell*, *the PLoS journals*, *the BMC journals*, *J Biological Chemistry*, *Genomics*, *J of Am Chemical Society*, *J Cell Biology*, *Proc Natl Acad of Sci*, and others. In addition, students and faculty need to be able to access internet-based search engines such as PubMed to find appropriate published work, as well as to use resources such as protein structure databases and genomic databases. UML also has institutional subscriptions to a wide range of software packages including End Note, MATLAB, Stata, SPSS, LabVIEW, MS Office, and the Adobe Creative Cloud. In order to make full use of these databases, analyze results, and to catalog scientific information. Program students and faculty are also able to access several review book series including: *Ann Rev of Cell Biology*, *Ann Rev of Biochemistry*, and the *Annals of the New York Academy of Sciences*. It is planned that all students in the program will also have access to University supported email and computational resources including access to the Massachusetts Green High-Performance Computing Center.

Core Research Facilities:

UML's Core Research Facilities (CRF) offer access to over 100 instruments within 6 core labs. These include the Materials Characterization Lab, The Biomolecular Characterization Lab, The NERVE Center, The Nanofabrication Laboratory, the Nuclear Magnetic Resonance Spectroscopy Facility and the Thermal Analysis & Mechanical Properties Lab. Access to modern microscopy resources such as Scanning Electron Microscopy, Transmission Electron Microscopy, Laser Scanning Confocal Microscopy, and Image Flow Cytometry are expected to be of particular interest to students and faculty. There are also tools for proteomic, genomic and transcriptomic analysis such as Liquid Chromatography Mass Spectrometry (LC-MS), Matrix Assisted Laser Desorption-Ionization Time of Flight Mass spectrometry (MALDI-TOF MS), High Performance Liquid Chromatography (HPLC), Illumina Next Generation Sequencing, DNA and RNA Bioanalyzers, and Real-Time PCR. For analysis of molecular interactions, the CRF provides access to Surface Plasmon Resonance, Atomic Force Microscopy and some additional chromatography resources. Access to ultrapure water (Milli-Q), liquid nitrogen, dry ice, autoclaves, dishwashers, superspeed- and ultra-centrifuges, autoclaves, and other standard resources to support their research is also provided by UML. The Department maintains common labs on the 5th and 6th floor of Olsen Hall that provide access to equipment such as real-time PCR machines, digital gel imaging stations, fluorescent, UV and VIS plate readers, a cell culture facility, NanoDrop spectrophotometer, two automated Cellometer cell counters, a shaker-incubator, and scintillation and gamma counters. Taken together UML is positioned to be able to provide all the necessary technological resources to support the research done by students in the proposed PhD/AB program.

Affiliations and Partnerships

UML has obtained letters of commitment from several distinguished leaders and research scientists in the biology fields and UML provided professional biographies and affiliations for each individual within the proposal. Affiliations include the Massachusetts Institute of Technology, the Boston University School of Medicine, Immunome (a biotechnology company leveraging tumor immunology to develop cancer therapeutics), Codiak Biosciences Inc. (a company developing proprietary medicines for diseases with high unmet medical need), and the National Institute of Neurological Disorder and Stroke, NIH. Advisors were invited and selected because of their leadership experience at universities, biotechnology/pharmaceutical

companies, and federal research institutes. All members are shown to have established records of training outstanding Ph.D. students and in working with recent Ph.D. graduates. UML shared a draft of the proposal with potential members the planned External Advisory Board and incorporated their suggestions into the final version.

PROGRAM EFFECTIVENESS

Goal	Measurable Objective	Strategy for Achievement	Timetable
3-6 new students enrolled per year	Attract high quality students	<ol style="list-style-type: none"> 1. Recruit regionally, nationally, and internationally at conferences. 2. Obtain federal funding to support students (training grant) 3. Market program via regional companies and prominent alumni 	<ol style="list-style-type: none"> 1. 6 months prior to program initiation 2. 3 years 3. within first year
Retention and on-time graduation	Rate of retention, graduation within 5-6 years	<ol style="list-style-type: none"> 1. Provide secure funding to students 2. Recruit high quality students 3. Match students with appropriate faculty <p>Good advising and mentoring (PhD committee)</p>	5-6 years
Graduates entering the workforce	High graduation, employment rates	<ol style="list-style-type: none"> 1. Provide high quality training. 2. Require publication for graduation 3. Connect students with local companies through alumni networks and/or internship opportunities. 4. Include professional skills training in the curriculum. 	5-6 years
Gain national prestige	National ranking; international recognition	<ol style="list-style-type: none"> 1. Recruit outstanding faculty 2. Publish in high quality journals 3. Increase research funding 4. Promote faculty and student presentations at national and international conferences. 	3-5 years

EXTERNAL REVIEW AND INSTITUTIONAL RESPONSE

The proposed program was reviewed by Elazer R. Edelman, M.D., Ph.D., the Thomas D. and Virginia W. Cabot Professor of Health Sciences and Technology at MIT and Professor of Medicine at Harvard Medical School; Thomas D. Gilmore, Ph.D., Professor of Biology at Boston University; and Linda E. Hyman, Ph.D., Associate Provost for the Division of Graduate Medical Sciences and Professor of Microbiology at the Boston University School of Medicine.

The reviewers found the proposal to be well crafted with well-justified needs. They found it to support the overall mission of the institution and to address a need with the infrastructure to support the request and to engage faculty in meaningful ways. The team noted that overall, the proposal is a timely and thoroughly researched, and will complement other technically directed graduate programs at UML. Moreover, it was found to address local and national workforce needs. The proposals broad list of possible mentors for an accepted 3-6 students per year was underscored as an important contributing factor to an increase in the research productivity and profile of biology faculty at UML. The external reviewers identified the significant strengths of the proposal to include the enhanced graduate-level training elements direct impact on research productivity; a robust curriculum drawing from an existing framework and also establishing new courses that are designed specifically for this effort; the experiential learning component internship opportunities; and the fact of the workforce need being so well-documented.

The review team noted that this is an important program for UML, and also for the Merrimack Valley particularly because there are currently no other Ph.D. programs at UML that are specifically focused on training students in biology/life sciences. A Ph.D. program is a needed aspect of university involvement in the explosive growth of life sciences, the attraction of life sciences industry to the Merrimack Valley region, and the growing faculty in the Department of Biological Sciences at UML. The team found that a Ph.D. program is essential to the growth and maintenance of the Biology faculty, to interact with industry, and in attracting the best students. The external reviewers emphasized that UML has been an important part of the revitalization of the Merrimack Valley and in particular, its interaction with the biotechnology industry further validates the need for such a graduate program. A graduate program in applied biology was found to fit a workforce need and to include powerful new and advanced curriculum that will provide students with insight into mechanisms of biological processes and with the skills needed to apply this knowledge to manipulate biological processes for human benefit. They stated that the proposed program will surely have immense impact on the community and school.

The reviewers found the proposal to have strong merit and also raised concerns that are not meant to distract from enthusiasm, but rather to offer points that might be considered in moving forward. Concerns included student support with expectations around research and teaching assistantships that are planned to be supported from grant funding. The reviewers emphasized that the funding should be realistic and aligned with program goals, and that teaching loads should be fair and commensurate with a student's preparation and experience. The team pointed out that if students are to be drawn from an international pool, procuring federal funding (the major source of training grants and fellowship) would preclude their eligibility, as these are generally only available to US citizens. Concern was expressed that a minimum required GRE score per se was not a good idea for applicants coming from unusual circumstances, noting that simply submitting scores should be the requirement, allowing UML to make a more composite evaluation of the whole candidate. The team suggested UML consider strengthening the

applied nature of the degree by leveraging other courses at UML, such as a required course in entrepreneurship, business, or project-management to reinforce the unique training goals this program would like to offer. Also increasing opportunities for students to speak about their research in a public setting was suggested as especially important to professional communication skills. The proposed expectation for students to complete two laboratory rotations was thought to be better at three lab rotations, in order to provide a selection for students, for mentoring faculty, and to avoid too much congestion in selected lab matches. The reviewers found the qualifying exam process to be a bit redundant with the courses they will be taking during their first two years. It was recommended that perhaps the third year research thesis proposal should be completed as early as possible, by the end of the fall semester of the third year. Students should have achieved critical thinking skills in their coursework and it is best to get students writing and thinking about their thesis research as early as possible. The team also noted that the five-year completion goal may be compromised if the student does a one-semester internship in the 4th year.

Institutional Response to External Review Team Report

In response to concern for student support with research and teaching assistantships, UML plans for each student to be provided with two years of teaching assistantship (TA) support with the remaining years (~3) being supported on a research assistantship (RA). This mechanism is currently in place for the Biology Department, that has allowed it to grow the number of supported Ph.D. students to the current level of 19. TA support will also provide our students in the program with valuable teaching experience, while still providing sufficient time for them to progress on their dissertation research during these years. UML responded that the pursuit of federal training grants will support domestic students and traditional TA/RA funding will support international students. UML agreed that a formal hard GRE score cut-off may be problematic and will use all information in a holistic manner in making admission decisions. UML responded positively to the possibility of including an entrepreneurship, business or project management course in the curriculum and plans to further develop this opportunity. Regarding consideration of a 3rd laboratory rotation, UML added an option for students to take a laboratory rotation course for two semesters providing 4 rotations, with the proviso that individual pre-assessments in which specific needs will be evaluated will help to determine the optimal number of lab rotations that each student should complete. UML found reviewers comments and suggestions on the qualifying exam to be useful and will ensure they are considered by the Qualifying Examination Committee that will have authority to continue to optimize the examination process as the program evolves.

STAFF ANALYSIS AND RECOMMENDATION

Staff thoroughly reviewed all documentation submitted by the **University of Massachusetts Lowell** and external reviewers. Staff recommendation is for approval of the proposed **Doctor of Philosophy in Applied Biology** program.

ATTACHMENT A: CURRICULUM

Applied Biology PhD Curriculum Outline

Major Required (Core) Courses (Total courses required = 7)		
<i>Course Number</i>	<i>Course Title</i>	<i>Credit Hours</i>
BIOL.6040	Professional Communication in Science & Technology	3
BIOL.6060	Applied Biology I	1
BIOL.6070	Applied Biology II	1
BIOL.6030	Graduate Colloquium Biology	1
BIOL.6030	Graduate Colloquium Biology	1
BIOL.6050	Graduate Proposal Writing Seminar	1
BIOL.7210	Special Problems in Biology	3
	PhD Dissertation Research	23-28
	SubTotal # Core Credits Required	34-39
Other/Elective Course Choices (Total courses required = 7)		
BIOL.XXXX	Competency Course*	3
BIOL/other	Competency Course or Advanced Elective**	3-4
BIOL/other	Special Problems in Biology or Advanced Elective	3
BIOL/other	Advanced Elective**	3-4
BIOL/other	Advanced Elective**	3-4
BIOL/other	Advanced Elective**	3-4
BIOL/other	Advanced Elective**	3-4
	SubTotal # Elective Credits Required	21-26
Curriculum Summary		
Total number of courses required for the degree		14
Total credit hours required for degree		60
Prerequisite or Other Additional Requirements:		

*** Core Competency Courses**

BIOL.5190	Biochemistry I
BIOL.5260	Evolutionary Biology
BIOL.5380	Advanced Genetics
BIOL.5420	Cell Biology
BIOL.5670	Molecular Biology
BIOL.5800	Developmental Biology

Optional Internship Course

BIOL.7070 Internship Biology

**** Advanced Electives can be selected from list based on the specialization option as noted below. Some of these courses are 4 credit lecture/lab courses.**

Advanced Elective Courses Based on Specialization Option

I. Biomedical Science

BIOL.5820	Cancer Biology
BIOL.5620/5630L	Cardiovascular Physiology/Laboratory
BIOL.5890	Practical Protein Crystallography
BIOL.5290	Recombinant Protein Production
BIOL.5179	Vertebrate Animals in Biological Research
BMBT.5000	Introduction to Biomedical Engineering and Biotechnology
BMBT.5250	Introduction to Translational Science
CHEM.6310	Principles of Medical Chemistry I
CHEM.6320	Principles of Medical Chemistry II
CHEN.5550	Biopharmaceutical Regulatory Compliance
CHEN.5860	Biotechnology Processing Project Laboratory
CHEN.5450	Isolation and Purification
MLSC.6130	Infectious Disease
MLSC.5120	Medical Bacteriology
MLSC.5510	Advanced Pathophysiology
MLSC.5800	Clinical Applications of Molecular Genetics
NUTR.5720	Nutrition and Gene Expression
PHRM.6100	Principles of Pharmaceutical Sciences
PHRM.6600	Pharmacokinetics and Drug Metabolism
PHRM.6410	Drug Delivery
PHRM.6501	Drug Discovery
PUBH.3050	Introduction to Epidemiology

II. Developmental & Evolutionary Biology

BIOL.5260	Evolutionary Biology
BIOL.5800/5810L	Developmental Biology Lecture/Laboratory
BIOL.5840	Comparative Vertebrate Embryology
BIOL.5130/5150L	Invertebrate Zoology II Lecture/Laboratory
BIOL.5230	Biology of Global Change
BIOL.5320/5340L	Genomics Lecture/Laboratory
BIOL.5050/5070	Bioinformatics Lecture/Laboratory
BIOL.5370/5390L	Biology and Evolution of Arthropoda Lecture/Laboratory
BIOL.5400	Advances in Plant Biology
BIOL.5570/5590L	Metazoan Parasitology Lecture/Laboratory

III. Quantitative Biology & Biophysics

BIOL.5090 Photobiology

BIOL.5200	Biochemistry II
BIOL.5520	Quantitative Physiology
BMBT.5120	Medical Image Processing
CHEM.5380	Biochemical Mechanisms
CHEM.5510	Biochemistry II
CHEM.5600	Advanced Physical Biochemistry
CHEM.5670	Computational Biochemistry
CHEM.5700	Protein Chemistry
CHEM.5800	Bioanalytical Chemistry
CHEN.5370	Nanomaterials Characterization I
CHEN.5380	Advanced Separations in Biotechnology
CHEN.5410	Nanomaterials Characterization II
CHEN.5450	Isolation and Purification
COMP.5510	Bioinformatics for CS
MATH.5500	Mathematical Modeling
MATH.5550	Applied Math for Life Sciences
MATH.5750	Applied Statistics with R
PHRM.6600	Pharmacokinetics and Drug Metabolism
POLY.5110	Biopolymers

IV. Cellular & Molecular Biology

BIOL.5900	Human Neurobiology
BIOL.5210	Biochemical Techniques
BIOL.5420	Cell Biology
BIOL.5670	Molecular Biology
BIOL.5690	Molecular Techniques
BIOL.5600	Stem Cell Biology
BIOL.5720	Virology
BIOL.5760	Cell Culture
BIOL.5620	Cardiovascular Physiology (Overlaps w/ Quantitative Bio)
BIOL.5930/5950L	Immunology Lecture/Laboratory
BIOL.5040/5060L	Environmental Microbiology Lecture/Laboratory
BIOL.6660	Selected Topics in Molecular and Cellular Biology
CHEN.5350	Cell and Microbe Cultivation

ATTACHMENT B: BUDGET

Campus: UMass Lowell

Program: Applied Biology PhD

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REVENUE ESTIMATES										
	Year 1		Year 2		Year 3		Year 4		Year 5	
	20__		20__		20__		20__		20__	
<i>Full-Time Tuition Rate: In-State</i>	14590		14590		14590		14590		14590	
<i>Full-Time Tuition Rate: Out-State</i>	26370		26370		26370		26370		26370	
<i>Mandatory Fees per Student (In-state)</i>	450		450		450		450		450	
<i>Mandatory Fees per Student (out-state)</i>	450		450		450		450		450	
<i>FTE # of New Students: In-State</i>	2		5		9		13		15	
<i>FTE # of New Students: Out-State</i>	2		4		6		8		10	
<i># of In-State FTE Students transferring in from the institution's existing programs</i>	0		0		0		0		0	
<i># of Out-State FTE Students transferring in from the institution's existing programs</i>	0		0		0		0		0	
Tuition and Fees										
	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs
First Year Students										

Tuition										
In-State	\$29,180	\$0	\$72,950	\$0	\$131,310	\$0	\$189,670	\$0	\$218,850	\$0
Out-of-State	\$52,740	\$0	\$105,480	\$0	\$158,220	\$0	\$210,960	\$0	\$263,700	\$0
Mandatory Fees	\$1,800	\$0	\$4,050	\$0	\$6,750	\$0	\$9,450	\$0	\$11,250	\$0
Second Year Students										
Tuition										
In-State			\$29,180	\$0	\$72,950	\$0	\$131,310	\$0	\$189,670	\$0
Out-of-State			\$52,740	\$0	\$105,480	\$0	\$210,960	\$0	\$263,700	\$0
Mandatory Fees			\$1,800	\$0	\$4,050	\$0	\$6,750	\$0	\$9,450	\$0
Third Year Students										
Tuition										
In-State					\$29,180	\$0	\$72,950	\$0	\$131,310	\$0
Out-of-State					\$52,740	\$0	\$105,480	\$0	\$158,220	\$0
Mandatory Fees					\$1,800	\$0	\$4,050	\$0	\$6,750	\$0
Fourth Year Students										
Tuition										
In-State							\$29,180	\$0	\$72,950	\$0
Out-of-State							\$52,740	\$0	\$105,480	\$0
Mandatory Fees							\$1,800	\$0	\$4,050	\$0
Fifth Year Students										
Tuition										
In-State									\$29,180	\$0
Out-of-State									\$52,740	\$0
Mandatory Fees									\$1,800	\$0
Gross Tuition and Fees	\$83,720	\$0	\$266,200	\$0	\$562,480	\$0	\$972,560	\$0	\$1,466,360	\$0

Grants	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Contracts	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Campus budget allocation	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Other Revenues (specify in cell 54)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total	\$83,720	\$0	\$266,200	\$0	\$562,480	\$0	\$972,560	\$0	\$1,466,360	\$0

Expenditures	Year 1 20__		Year 2 20__		Year 3 20__		Year 4 20__		Year 5 20__	
	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources
Personnel Services										
Faculty	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Administrators	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Support Staff	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Others	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Fringe Benefits ____%	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Personnel	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

Operating Expenses											
Supplies	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Library Resources	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Marketing/Promotional Expenses	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Laboratory Expenses	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General Administrative Overhead	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Other (specify)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Operating Expenses	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Net Student Assistance											
Assistantships	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Fellowships	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Stipends/Scholarships	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Student Assistance	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Capital											
Facilities / Campus recharges	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Equipment	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Other	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Capital	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Expenditures	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

BUDGET SUMMARY OF NEW PROGRAM ONLY

	Year 1	Year 2	Year 3	Year 4	Year 5
Total of newly generated revenue	\$83,720	\$266,200	\$562,480	\$972,560	\$1,466,360
Total of additional resources required for program	\$0	\$0	\$0	\$0	\$0
Excess/ (Deficiency)	\$83,720	\$266,200	\$562,480	\$972,560	\$1,466,360

ATTACHMENT C: FACULTY

Name of faculty member (Name, Degree and Field, Title)	Ten- ured Y/N	Courses Taught Put (C) to indicate core course. Put (OL) next to any course currently taught online.	# of sect- ions	Division or College of Employment	Full- or Part- time in Program	Full- or part- time in other department or program (Please specify)	Sites where individual will teach program courses
Amirkizi, Alireza V. Ph.D. in Mechanical Engineering Assistant Professor	N	<ul style="list-style-type: none"> • Solid Mechanics I • Dynamic Behavior of Materials 	(X)	College of Engineering	Full Time	No	• UMass Lowell
Braunhut, Susan Ph.D. Full Professor	Y	<ul style="list-style-type: none"> • Immunology • Cancer Biology 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Camci-Unal, Gulden Ph.D. in Chemistry Assistant Professor	N	<ul style="list-style-type: none"> • Heat Transfer • Transport Phenomena 	(X)	College of Engineering	Full Time	No	• UMass Lowell
Chain, Frederic Ph.D. in Biology Assistant Professor	N	<ul style="list-style-type: none"> • Bioinformatics 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Cho, MinHyung Ph.D. in Applied Mathematics Assistant Professor	N	<ul style="list-style-type: none"> • Applied Mathematics I • Applied Mathematics II • Mathematical Modeling 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Fish, Jennifer L. Ph.D. in Cell Biology and Genetics Assistant Professor	N	<ul style="list-style-type: none"> • Developmental Biology, Comparative Embryology 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Gage, Matthew Ph.D. in Biochemistry	Y	<ul style="list-style-type: none"> • Biochemistry II • Advanced Physical 	(X)	College of Sciences	Full Time	No	• UMass Lowell

Associate Professor		Biochemistry					
Gaines, Peter C.W. Ph.D. in Molecular Genetics Associate Professor	Y	<ul style="list-style-type: none"> • Stem Cell Biology • Cell Culture 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Garb, Jessica E. Ph.D. in Environment Science, Policy & Management Associate Professor	Y	<ul style="list-style-type: none"> • Genomics • Evolutionary Biology 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Garelnabi, Mahdi Ph.D. in Clinical Biochemistry Associate Professor	Y	<ul style="list-style-type: none"> • Biochemistry of Lipids 	(X)	College of Health Sciences	Full Time	No	• UMass Lowell
Gkikas, Manos Ph.D. in Chemistry Assistant Professor	N	<ul style="list-style-type: none"> • Biomaterials 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Guo, Hwai-Chen Ph.D. in Molecular Biology Professor	Y	<ul style="list-style-type: none"> • Recombinant Proteins • Practical Protein Crystallography 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Hall, Garth Ph.D. in Biology Associate Professor	Y	<ul style="list-style-type: none"> • Human Neurobiology 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Hochberg, Rick Ph.D. in Zoology Associate Professor	Y	<ul style="list-style-type: none"> • Invertebrate Zoology • Evolution of Arthropoda 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Konow, Nicolai Ph.D. in Functional Ecology Assistant Professor	N	<ul style="list-style-type: none"> • Comparative Anatomy 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Liu, Benyuan Ph.D. in Computer Science	Y	<ul style="list-style-type: none"> • Data Communications I • Data Communications 	(X)	College of Sciences	Full Time	No	• UMass Lowell

Associate Professor		II					
Lu, Chung-Dar Ph.D. in Microbiology Professor	Y	• Medical Bacteriology	(X)	College of Health Sciences	Full Time	No	• UMass Lowell
Lyubchenko, Taras Ph.D. in Immunology Associate Professor	Y	• Clinical Immunology	(X)	College of Health Sciences	Full Time	No	• UMass Lowell
Mangano, Kelsey M. Ph.D. in Nutritional Sciences Assistant Professor	N	• Nutrition Assessment • Vitamins and Minerals	(X)	College of Health Sciences	Full Time	No	• UMass Lowell
Moore, Jeffrey R. Ph.D. in Cell & Molecular Biology Associate Professor	Y	• Cardiovascular Physiology • Graduate Proposal Writing Seminar	(X)	College of Sciences	Full Time	No	• UMass Lowell
Myre, Michael A. Ph.D. in Biology Assistant Professor	N	• Cell Biology • Microbiology	(X)	College of Sciences	Full Time	No	• UMass Lowell
Noel, Sabrina E. Ph.D. in Nutritional Epidemiology Assistant Professor	N	• Public Health Nutrition • Community Nutrition	(X)	College of Health Sciences	Full Time	No	• UMass Lowell
Nugent, Matthew Ph.D. in Biochemistry Professor	Y	• Biochemistry II • Professional Communication in Science & Technology	(X)	College of Sciences	Full Time	No	• UMass Lowell
Rooney-Varga, Juliette N. Ph.D. in Microbiology Associate Professor	Y	• Climate Change Science • Biogeochemistry	(X)	College of Sciences	Full Time	No	• UMass Lowell
Sajo, Erno Ph.D. in Physics	Y	• Radiation Biology • Radiation Interactions	(X)	College of Sciences	Full Time	No	• UMass Lowell

Professor and Director		and Transport					
Shea, Thomas B. Ph.D. in Biology Professor	Y	<ul style="list-style-type: none"> • Life Science I • Life Science II 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Xie, Dongming Ph.D. in Biochemical Engineering Associate Professor	Y	<ul style="list-style-type: none"> • Heat Transfer 	(X)	College of Engineering	Full Time	No	• UMass Lowell
Xu, Jin Ph.D. in Biochemistry Associate Professor	Y	<ul style="list-style-type: none"> • Biochemistry I 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Yaroslavsky, Anna Ph.D. in Physics Associate Professor		<ul style="list-style-type: none"> • Introductory Medical Imaging • Advanced Medical Imaging 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Zwanikken, Johannes Ph.D. in Theoretical Physics Assistant Professor		<ul style="list-style-type: none"> • Topics in Polymer Physics 	(X)	College of Sciences	Full Time	No	• UMass Lowell
Hojnacki, Jerome Ph.D. in Biology Professor	Y	<ul style="list-style-type: none"> • Professional Communication in Science & Technology • Biomedical Engineering and Biotechnology Seminar 	(X)	College of Sciences	Part-Time	No	• UMass Lowell