PH.D. IN BIOMEDICAL ENGINEERING

OVERVIEW

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The Doctor of Philosophy in Biomedical Engineering at the University of Toledo is a joint program between the College of Engineering and the College of Medicine and Life Sciences. The program is open to qualified students with B.S. degrees in engineering or in science fields such as biology, chemistry, physics, mathematics, or computer science. Since prospective students have a variety of backgrounds, the requirements for admission vary.

The degree is conferred based on high scholarly attainment in the field of biomedical engineering. This program incorporates a formal entrepreneurship component in collaboration with the College of Business and Innovation (COBI) to encourage Ph.D. students to commercialize the biomedical technology they may develop as part of their dissertation research. The curriculum also provides a Ph.D. program for M.D. students from undergraduate engineering backgrounds that are interested in pursuing a dual degree and careers as physician scientists.

ADMISSIONS REQUIREMENTS

The entrance requirement for the PhD program in Biomedical Engineering is the B.S. degree in engineering or in science fields such as biology, chemistry, physics, mathematics, or computer science. Students with non-engineering undergraduate degrees desiring entry into this PhD program must have completed 1 year of engineering physics; 1 year of biology; 1 year of general chemistry; 2 years of calculus through differential equations; and at least 12 semester credit hours of undergraduate engineering/science course work (appropriate to the area of research interest of the candidate) to be considered for admission. Credit received for undergraduate coursework required for admission will not be applied toward the graduate degree.

To be competitive for admission, all applicants should have a grade point average of at least 3.0/4.0 for all previous undergraduate work and 3.3/4.0 for all previous graduate work. In some cases, additional prerequisite courses related to the program of study may be required (see Provisional Admission). Course credits for meeting undergraduate prerequisites are not applied toward the graduate degree.

The GRE exam is required for all students who do not hold either a B.S. or M.S. degree from a US institution; international students are required to provide proof of English language proficiency. Minimum accepted scores for the GRE are set by the program faculty; minimum scores for the English language proficiency exams are set by the College of Graduate Studies.

Application requirements:

- **Degree:** Applicants must hold a four-year bachelor's degree from an accredited college or university
- **GPA:**Applicants must have at least a 3.0/4.0 grade point average from previous undergraduate coursework or a 3.3/4.0 for previous graduate coursework
- **Application:** UToledo application required
- **GRE:** Required for applicants whose B.S. or M.S. degree is from a non-US institution. Minimum scores are 300 combined for the verbal and quantitative sections.
- **Transcripts:** Required
- **Statement of Purpose:** Required
- **Letters of Recommendation:** 3
- **Proof of English language proficiency:**Required for students from non-English speaking countries. See University graduate admissions for minimum test score requirements and exceptions.

Application priority deadlines for admissions and funding decisions:

- **Fall:** January 15
- **Spring:** October 1
- **Summer:** January 15

In addition to coursework requirements, continuation within the Ph.D. program requires that the student pass two major examinations:

1. Ph.D. Qualifying Exam and
2. Dissertation Research Proposal defense.

Completion of the Ph.D. degree requires the writing and defense of the Dissertation and the writing of a business commercialization plan and/or publication of the research findings.

CURRICULUM

A minimum of 90 semester credit hours of approved graduate coursework are required beyond the B.S. degree. For students directly admitted into the Ph.D. program with a B.S. degree, the minimum coursework requirements specified below must be satisfied.

- Register and attend a weekly seminar series in the College of Engineering or the College of Medicine and Life Sciences. Registration and attendance is mandatory every semester.
- Complete 13 hours of core coursework.
- Complete 12 hours of engineering/life sciences elective coursework.
- Complete 3-6 hours of entrepreneurship elective coursework.
- Complete 15 hours of other engineering/science elective coursework.
- Complete at least 45 semester hours of dissertation research. A student can register for dissertation research only after passing the *Qualifying Exam*.

In order to be awarded the PhD in Biomedical Engineering degree, the student must have at least a B average (a minimum GPA of 3.0/4.0) for all graduate course credits in the program of study as well as for the entire graduate transcript. Only credit hours obtained with a letter grade of “C”

or higher, or an "S" grade for the limited number of classes offered on a satisfactory or unsatisfactory basis, will fulfill degree requirements.

Program Requirements

The core courses include the following:

Code	Title	Hours
Computational Physiology		
A math course at the 7000 or 8000 level as a prerequisite for the mathematics core course		
MIME 8100	Advanced Engineering Mathematics II	
or MATH 8510	Partial Differential Equations	
INDI 8020	On Being a Scientist	
Select at least three credit hours from the following:		
BMSP 8330	Curr Prob Res App Protein Str	
BMSP 8340	Curr Prob Res App Genes/Genome	
BMSP 8350	Cell Biology & Signaling	
BMSP 8360	Curr Prob Cell Membranes	
MPHY 8040	Diag Radiological Physics (or equivalent)	

Students emphasizing the biological sciences must complete at least 5 credit hours of biomedical sciences program (BMSP) courses.

The Ph.D. in Biomedical Engineering includes an entrepreneurial component which is nurtured through close interaction with the COBI. Each student in this degree program completes the course EFSB 6590 New Venture Creation as part of the approved elective coursework. Students may also elect to complete the additional graduate level COBI course EFSB 6690 Technology Commercialization.

Qualifying Examination

The Qualifying Examination is an oral exam used to assess a student's critical thinking skills and understanding of the foundational material essential for success in the doctoral program. For students accepted into the Ph.D. program, the Ph.D. Qualifying Exam will occur after the completion of the required first year coursework comprising the core courses in physiology, mathematics and the courses from the College of Medicine and Life Sciences. The students rotate through 3 different examination topics which are mediated by 2-3 faculty members. Each testing topic lasts no more than 25 minutes; each student is asked questions of increasing difficulty until the perimeter of the student's knowledge is determined. All students are tested on the common areas of mathematics and physiology. Each student selects the third test segment from the three broad specialization areas of biomechanics, bioprocessing/molecular & cellular biology, and bioelectrical systems.

Following the finalization of the examination outcomes, the Program Co-Director immediately notify the students tested in writing of the testing outcome. If retesting is required, the student is also informed of the date of testing and the topic(s) to be retested. Students who do not receive an outright pass on the first examination have one opportunity to retest with a passing score or are dismissed from the program.

Ph.D. Dissertation Committee

Following the successful completion of the Qualifying Examination, students are expected to form their dissertation committees with the advice and consent of their research advisors. Each committee must consist of at least five UT Graduate Faculty. Affiliated Faculty must constitute the majority on each committee. Each committee must include at least one Affiliated Faculty member from the College of Engineering, one from the College of Medicine and Life Sciences, and one external faculty member usually from the College of Business and Innovation.

Doctoral Candidacy

All doctoral students must meet the following requirements before being admitted to doctoral candidacy:

- Pass the Biomedical Engineering Qualifying Examination
- Select a dissertation committee
- Obtain at least a 3.0/4.0 for all graduate level coursework

Prior to initiating dissertation research, each student must complete and file a Graduate Research Advisory Committee Approval and Assurances Form (GRAD) with the College of Graduate Studies. Students must complete this form and receive the required approvals prior to beginning any research for a thesis involving humans, animals, radiation, or bio hazardous substances.

Dissertation Research Proposal Examination

The dissertation research proposal is a document written by the student describing the research to be undertaken for the dissertation. The oral examination consists of the presentation of the written proposal by the student to the dissertation committee in a closed forum. The dissertation research proposal must be written and presented within one calendar year of passing the Qualifying Examination. A student may request an extension of up to one additional calendar year with the approval of the faculty advisor.

The dissertation research proposal should describe the background, goals, hypotheses, and general methods of the proposed research. The proposal should be structured in a manner similar to an NIH grant application. Copies of the proposal must be given to all members of the dissertation committee at least two weeks before the oral presentation. The dissertation proposal must then be formally presented to the dissertation committee and defended to their satisfaction.

Entrepreneurship Component

Each student will integrate his/her COBI coursework with his/her research discoveries and submit a formal business plan to commercialize the dissertation research. This plan must be presented and approved by the dissertation committee prior to the final approval of the dissertation. The committee, which includes one faculty member from the COBI, may seek the advice of others in evaluating the submitted plan.

In recognition of the fact that some students will focus on more fundamental scientific research which may have limited commercial value, a student may request from the dissertation committee a substitution of the business plan by a research equivalent of this requirement. An example of such an equivalent requirement would be evidence of submission and/or publication of two peer-reviewed journal articles.

Ph.D. Dissertation and Defense

When the dissertation research is completed to the satisfaction of the faculty advisor, the student prepares a complete draft of the Ph.D. dissertation. The student must submit the final draft of the dissertation to each committee member for his or her critical evaluation and review at least two (2) weeks prior to the defense. The dissertation defense consists of a 45 minute formal oral presentation by the student, followed by open and closed question sessions. The dissertation committee then votes, and a majority of the committee must concur on the final decision. If the student does not pass the dissertation defense, then the dissertation committee, in consultation with the Program Director, will decide a course of future action.

Time Limit

Doctoral candidacy automatically terminates five (5) years after admission to candidacy. All requirements for the doctoral degree must be completed within seven (7) years of admission to the Ph.D. program (registration for first doctoral level class). To continue beyond the time limit, a written request for extension to the research advisor and the two Co-Directors of the Biomedical Engineering Committee must be submitted and approved. Upon approval through the required channels of The College of Engineering, the extension request must be forwarded to The College of Graduate Studies for final review and approval.

- PLO 1. Solve problems using advanced mathematics, engineering and biomedical sciences
- PLO 2. Communicate research rationale and results in scientific presentations, grant proposals, patents and refereed publications
- PLO 3. Identify research questions and commercialization opportunities in biomedical research
- PLO 4. Independently design, conduct and direct laboratory research
- PLO 5. Lead research or project teams without additional supervision
- PLO 6. Review scientific literature to identify and obtain rationale for new research areas
- PLO 7. Teach undergraduate engineering courses