

BIOMEDICAL ENGINEERING, PHD

Biomedical Engineering (BME) has emerged as one of the most exciting interdisciplinary research fields in modern science. Biomedical engineers apply modern approaches from the experimental life sciences in conjunction with theoretical and computational methods from the disciplines of engineering, mathematics, and computer science to the solution of biomedical problems of fundamental importance. The Biomedical Engineering Graduate Program of the Johns Hopkins University is designed to train engineers to work at the cutting edge of this exciting discipline. There are two graduate programs in biomedical engineering. The masters program is supported by the Whiting School of Engineering and leads to a Masters of Science degree. The Ph.D. program is supported by the School of Medicine and leads to a Ph.D. in Biomedical Engineering.

Ph.D. in Biomedical Engineering

The cornerstone of the Program is our belief in the importance of in-depth training of students in both life sciences and modern engineering. In-depth training in life sciences is achieved in one of two ways. Many of our incoming Ph.D. students enroll in classes that are part of the first-year basic sciences curriculum of the Johns Hopkins University School of Medicine. That is, they learn human biology with the medical students. This is a unique and intensive curriculum covering a broad range of topics including molecules and cells, human anatomy, immunology, physiology, and neuroscience. This curriculum is an excellent way to build a broad and solid foundation in the life sciences. Alternatively, students may take graduate-level biology and life sciences courses from the many exceptional biosciences departments at Johns Hopkins. This option is often of particular value to students who enter the program already having a strong background in the life sciences. In-depth training in engineering, mathematics, and computer science is achieved through elective courses that are taken in the first and second years.

All students are fully supported during their time in the PhD program. This covers tuition and provides a stipend for the duration of their Ph.D. Because of the interdisciplinary nature of Biomedical Engineering, students can choose to perform their dissertation research in almost any laboratory in the University (subject to the approval of the program directors). Some students choose their research lab before matriculating, and some students have the opportunity to do research rotations among several labs during their first academic year. The opportunities to do research rotations are generously funded by multiple training grants supported by the National Institutes of Health.

Emphasis is placed on original research leading to the doctoral dissertation. The research may be experimental or computational - the breadth of research in Biomedical Engineering is large, and we encourage students to attend various seminars to learn about cutting edge approaches. To explore the current range of research by labs within the Biomedical Engineering department, see here (<https://www.bme.jhu.edu/research/research-areas/>); in addition, many of our students work in labs outside the Biomedical Engineering department.

Program Directors

Rachel Karchin, Ph.D. and Patrick Kanold, Ph.D.

Financial Aid

All BME PhD students (regardless of citizenship or national origin) are supported (tuition, stipend, health and dental insurance) for the duration of their PhD. U.S. citizens and Permanent Residents are eligible for support from training grants from the National Institutes of Health (NIH). Students are also encouraged to apply for individual graduate fellowships from the National Science Foundation, NRSA awards from the NIH, and fellowships from private foundations. Only online applications for admission are accepted, and must be received by December 1.

Admission Requirements

Note: up-to-date admissions requirements are maintained on the Biomedical Engineering website (<https://www.bme.jhu.edu/academics/graduate/phd-program/>), and applications are submitted through the School of Medicine's application system (<https://www.hopkinsmedicine.org/som/education-programs/graduate-programs/>).

The Program accepts applications for the Ph.D. program until December 1st of each year. We typically recruit students in seven areas: Biomedical Data Science, Biomedical Imaging & Instrumentation, Computational Medicine, Genomics & Systems Biology, Immunoengineering, Neuroengineering, and Translational Cell & Tissue Engineering. The program is unique in that it offers the BME student the strengths of one of the best medical schools in the world. If you wish to combine engineering with cutting edge research in medicine, this may be the program for you.

Our students have the option of taking many of the same courses as the medical students, including human anatomy, molecular and cellular biology, immunology, and pharmacology. Our students also take advanced engineering courses. Our admitted students come from many backgrounds and majors, and not all were undergraduate engineering majors. However, all have demonstrated a strong quantitative training, as well as sufficient background in biology (typically at least two introductory courses). Depending on their preferred research focus area, relevant preparation for that focus area should be evident in their application.

The admissions are reviewed by research focus area committees. The applicant should specify which area(s) they are interested in, and write about the kind of research they are considering. The faculty in each area vote and rank the applicants. The final pool of applicants is reviewed and approved by the whole program faculty. We use a holistic review process; for example, the median GPA is typically ~3.8, but we have no minimum GPA or GRE thresholds for review. Don't think that one bad grade or a tough semester stands in your way. We review the whole application and evaluate the potential of the person that wrote it, not just a set of numerical metrics.

Applications should be complete when submitted. In order to be considered a complete application, we must have:

- Official transcripts from each college or university attended. We no longer require applicants to submit official transcripts to OGSA via mail or electronically. Applicants may upload transcripts to the online application for review. Applicants who receive an offer or accept an offer of admission are required to submit official transcripts to OGSA via mail or electronically to GradAdmissions@jhmi.edu
- Previously, we have required official Graduate Record Examination (GRE) scores or MCAT scores, which can be arranged through the Office of Graduate Affairs. As of June 2021, we are actively reviewing this and you should look to the most up-to-date information

on the BME website (<https://www.bme.jhu.edu/academics/graduate/phd-program/>). The GRE code for applying to graduate programs at the Johns Hopkins School of Medicine is 5316. The BME PhD program **does not rely heavily** on the GRE exam in making admission decisions. Research experience, course grades, and recommendations carry more weight.

- Three letters of recommendation – these letters should come directly from faculty members who are acquainted with you and your academic work. These letters should comment on your aptitude and promise for independent research.
- Personal statement – a typewritten statement (one page maximum) indicating the basis of your interest in graduate study and your career objectives. Included should be a discussion of any research experience you have had.
- A CV - this is your opportunity to list all relevant experiences and achievements
- TOEFL scores (for foreign students only; official copy)

Applicants for admission must fulfill the following course prerequisites:

- One year of college-level biology (may include quantitative biology or physiology)
- One semester of organic chemistry is required for students interested in the Immunoengineering or Translational Cell & Tissue Engineering research areas
- Sufficient mathematical training, typically including differential equations or other relevant mathematical preparation

If you are interested in applying and do not yet have the prerequisite courses, you may want to submit your application with an explanatory note indicating that, if accepted, you will make arrangements to take the prerequisites before matriculation. In the past, applicants have taken the prerequisites at their present schools, local community colleges, etc. Courses taken at any accredited college or university are acceptable.

Each applicant must have received a BA or BS degree or its equivalent prior to matriculation. A Master's degree is not required for admission to our program.

Process: The PhD program admissions committee will not consider any application until it is complete. Applicants may check the status of their application by logging into their online account.

Interview: The admissions committee will review completed applications and invite selected applicants to come to Johns Hopkins for a personal interview with faculty. Applicants who are residents of North America must come for an interview to be considered for admission. For residents outside of North America, for whom such a trip is not possible, a Zoom or telephone interview will be conducted. Final admission decisions will be made from the pool of interviewed applicants. Interview invitations will be sent out to applicants via email by the third Monday in January, or earlier if feasible. Videoconference interviews may be conducted, and personal interviews will be conducted on campus in February and/or March.

Acceptance: Applicants will be notified via email by late March with the outcome of their application. A full offer of admission to the program will include a yearly stipend, full tuition, matriculation fee, and individual medical and dental insurance. This applies to every accepted applicant, regardless of citizenship or national origin unless the applicant receives a conditional acceptance. Those offered admission will be asked to

communicate their decision as soon as possible. In any case, we must have the applicant's decision by April 15.

Program Requirements

- Complete 30 credits of coursework in life sciences, engineering, mathematics, applied math, and/or computer science. Courses must be passed with a grade of B- or higher. Of the 30 credits, at least 12 credits must be in the life sciences and at least 12 credits must be in quantitative sciences. More detailed requirements can be found at our page on PhD degree requirements (<https://www.bme.jhu.edu/academics/graduate/phd-program/phd-degree-requirements/>)
- Complete at least 8 hours of face to face research ethics training
- Successfully pass the Doctor of Philosophy Board Oral Examination (this is a University-wide requirement)
- At least one year as a resident student at JHU (this is a University-wide requirement)
- Dissertation must be approved by at least two readers and certified by them to be a significant contribution to knowledge and worthy of publication
- Certification by the Program Director that all requirements have been fulfilled
- Submission of a dissertation to the library that adheres to the Doctor of Philosophy Board Dissertation Guidelines
- The program may determine the allowable time to complete degree requirements but in no case may that time exceed 9 years. Any approved leave of absence would not count toward the 9 years.

Integrated M.D.-Ph.D. Program

Candidates for the Ph.D. in Biomedical Engineering who wish to apply jointly for the M.D. degree must apply directly to the MSTP program (<https://mdphd.johnshopkins.edu/>) through the School of Medicine. Typically, MSTP students complete their PhD between their 2nd and 3rd medical school years, and in addition can do research during their 1st year summer. Good preparation in biology and chemistry as well as mathematics, engineering, and the physical sciences is essential. Life science graduate requirements are met by the first-year program of the School of Medicine. This program is more arduous than the Ph.D. program alone, but it may have marked advantage for students interested in clinical research and applications in hospital systems and in the delivery of health care. The catalogue for the School of Medicine should be consulted for admissions requirements and procedures.

Information about applying to the combined M.D.-Ph.D. program can be found at the the MSTP program (<https://mdphd.johnshopkins.edu/admissions/>) website, and applications are reviewed a separate MD-PhD Review Committee; a separate Graduate School application is not necessary, unless the student wishes to also be considered for the PhD program only. If offered admission by the MSTP program, students may choose to take part in the Biomedical Engineering PhD program, as long as they have sufficient background to succeed in the quantitative courses required by the program; matriculants and current MSTP students should schedule a meeting with the Program Director to discuss joining the program.