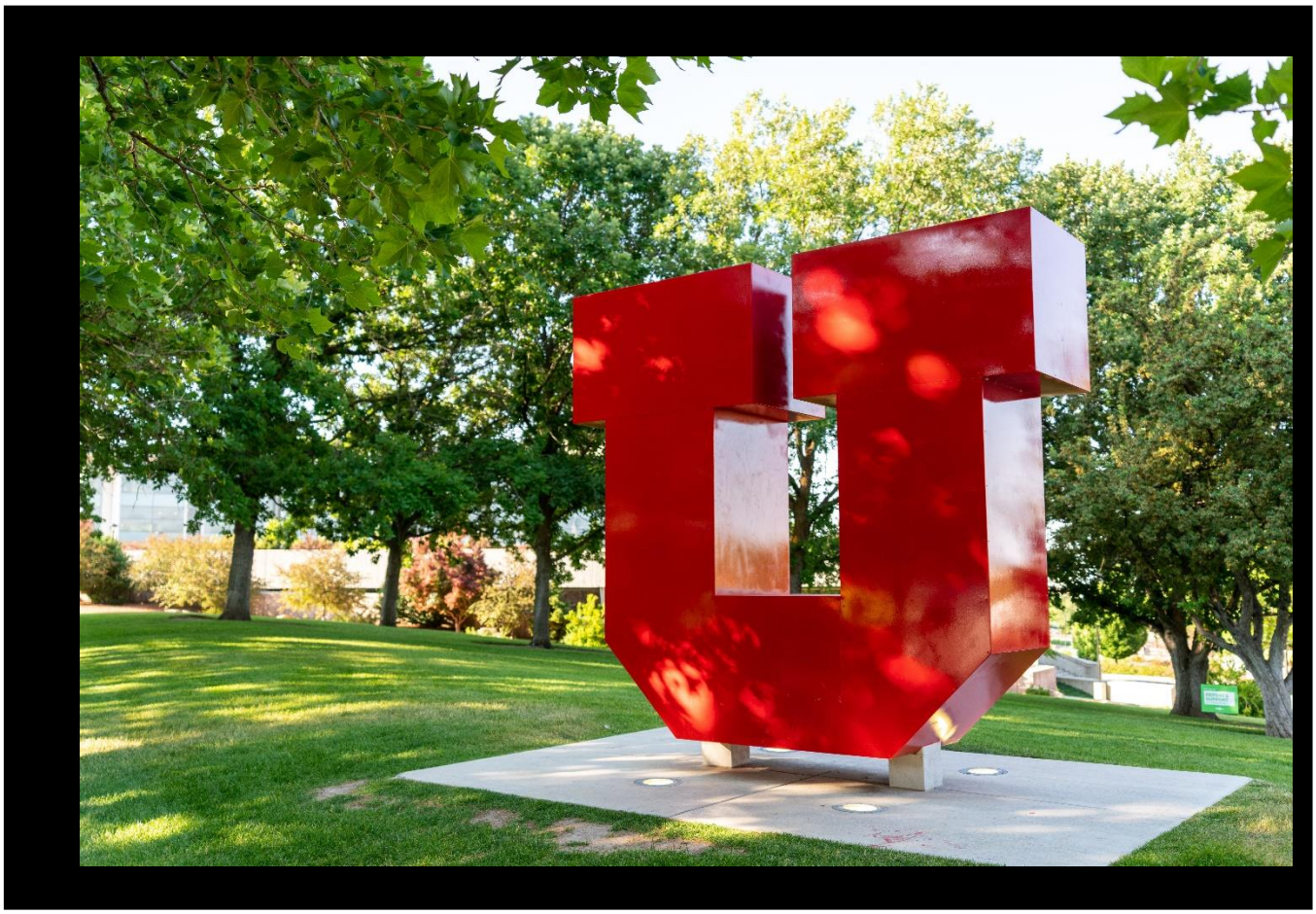

University of Utah

Department of Biomedical Engineering

Graduate Program Handbook
Version 2023 – 07/01

Welcome to the Department of Biomedical Engineering!

The Department's M.S. and Ph.D. degree programs are designed and intended to be transient but intensive professional technical training experiences, best pursued and completed as directly and expediently as possible. Efficient student progression through various requirements and diverse opportunities offered by our graduate programs 1) ensures best use of student time and faculty resources, and 2) minimizes the "opportunity cost" of time away from the workplace. As such, our training program is neither a vocation nor a job. Each advanced degree from our department must be earned. Award of our graduate degree comes with new entitlements and privileges resulting from our formal recognition of new technical and workplace skills and Biomedical Engineering capabilities endowed to each of our graduates by virtue of their program accomplishments. Our Department's Graduate Handbook provides the road map to our graduate program requirements, expectations, best practices, and deadlines for student performance and progress. The Chair expects adherence to the prescriptive requirements of the graduate programs as described in the Handbook, and a direct, disciplined and motivated path to the student's future workplace as enabled by the program checkpoints, milestones and expectations.

The Utah graduate school experience is expected to be enriching, enabling and rigorous; our graduate students are expected to be productive, professional, focused and efficient. Financial support provided to our graduate students during graduate training is awarded as a stipend at the discretion of our faculty advisors, with specific technical objectives, deliverables and intellectual products anticipated and expected. Such support is a privilege for study; hence, student research productivity is an expected deliverable in return. It is not a wage since program participation is not formal employment; it is support for completion of the program requirements, a training experience and a productive student-mentor relationship that produces research results and progress: progress both in student capabilities relevant to a career, and in applications of biomedical principles to compelling world problems. This student-advisor relationship is best augmented by fulfilling the formal M.S. or Ph.D. didactic training components, the essential research requirements, and by regular critical review and input of the student's graduate supervisory committee. Effective communication and technical dissemination are expected learnings. Teaching and mentoring are also a formal expectation of all students: capabilities to assist others in team-based approaches is a real-world asset. Professional service is also an important opportunity: outreach, service learning, and efforts beyond the campus program are essential to our discipline.

As the Department can only improve its performance and impact through the collective work and dedicated group efforts involving our students and faculty, consistent student participation in the wide variety of required and elective department activities is encouraged and expected of all students. Student leadership, initiative and visible contributions to Department progress and growth can take numerous forms. In addition to student research productivity, additional student-based efforts in teaching/curriculum improvement, inter-student and peer networking and morale-building exercises, seminar attendance, research support and grant writing, interfacing with various graduate and student groups, faculty committees and College leaders, and outreach services to our off-campus lay-persons and on-campus undergraduate communities are some possible opportunities to assist the Department's continual quest for improved impact, visibility and international recognition.

We hope that this Biomedical Engineering Graduate Handbook provides all resources necessary to efficiently and effectively guide and expedite graduate student progression through our various graduate degree opportunities and expectations. We also hope that program training and milestones produce graduates highly qualified, confident and capable to improve the world around us in their diverse future careers.

David W. Grainger, Ph.D., Department Chair

Department of BIOMEDICAL ENGINEERING
COLLEGE OF ENGINEERING | THE UNIVERSITY OF UTAH

BME GRADUATE PROGRAM HANDBOOK

Table of Contents

I. OVERVIEW

This handbook should serve as a guide to help graduate students, graduate advisors, supervisory committee members, and other faculty and staff to understand the overall goals and requirements of the BME department's graduate program. Additionally, this vital reference identifies resources to help students navigate the training and experiences integral to the graduate program and details the administrative steps required for students to complete their degrees.

The degree requirements in this handbook apply to students who began their first semester in the BME graduate program after the date listed on the front page. Students who matriculated into the program before that date are bound by the degree requirements of the handbook active on the first day of their first semester in the program.

Department policies and procedures in this handbook are accurate on the date listed on the front page. These policies and procedures may change at any time under the authority of the University of Utah, the College of Engineering, or the Department of Biomedical Engineering.

I.A. DEPARTMENT OF BME

The Department of Biomedical Engineering at the University of Utah is an internationally renowned center of basic and applied interdisciplinary research. We are one of the oldest Biomedical Engineering Departments globally, descending from the University's Division of Artificial Organs and Institute for Biomedical Engineering, founded over 50 years ago. We prepare graduate students to lead the next era of bioengineering and medical innovation by teaching them the core knowledge of our field and collaborating with them on novel biomedical engineering research and development projects in over a hundred affiliated research laboratories.

The mission of the Department of Biomedical Engineering is to

- advance human understanding, health, and quality of life through internationally recognized research, discovery, and invention in the area of biomedical engineering;
- educate world-class Ph.D. scientists and engineers for accomplishment in research, academics, medicine, and industry;
- educate nationally-recognized B.S. and M.S. graduates for success and leadership in industry and in preparation for future study in medicine, science, and engineering;
- transfer scientific discoveries and biomedical technology to the private sector nationwide; and
- train students throughout the College of Engineering to create biobased solutions to traditional engineering problems and apply their specialty to biological and biomedical science.

I.A.1. BME GRADUATE PROGRAM

The BME department offers Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) programs, as well as multiple dual-degree programs through the Graduate School at the University of Utah. These programs prepare graduate students to function independently, competently, and technically in various settings, including academic, research, technical, administrative, business management, legal, regulatory, and investment career tracks. The BME department accomplishes these goals through formal didactic courses, seminars and journal clubs, laboratory research rotations, technical projects, and thesis and dissertation research. Faculty and staff seek to assist graduate students in completing these programs in a timely fashion.

I.A.2. Contact Information

Department of Biomedical Engineering
Sorenson Molecular Biotechnology Building (SMBB), Suite 3100
36 South Wasatch Drive, Salt Lake City, Utah 84112 Phone: 801.581.8528
Website: bme.utah.edu

Dr. David Grainger, Chair, Department of Biomedical Engineering
Office: 3227 SMBB, Email: david.grainger@utah.edu, Phone: 801.587.9263

The Department Chair oversees all research, academic, service, and administrative functions of the BME department. The chair is responsible for setting the BME department's strategic direction and ensuring that resources are provided for its different functions in serving the university mission.

Dr. Alan (Chuck) Dorval, Director of Graduate Studies
Office: 4535 SMBB, Email: chuck.dorval@utah.edu, Phone: 801.587.7631

The Director of Graduate Studies (DGS) oversees policies and procedures for all graduate degrees offered through the BME department. Throughout a student's stay in the graduate program, the DGS serves as an advocate for the student. The DGS is always available to answer questions about the graduate program and to provide recommendations on coursework. They also serve as the default faculty advisor for new students who have not yet identified their own.

Laura Olsen, Graduate Academic Advisor
Office: 3223 SMBB, Email: laura.l.olsen@utah.edu, Phone: 801.581.8559

The Graduate Academic Advisor assists students in all aspects of the BME graduate program, including applications, admissions, policies and procedures, graduation, tuition benefit, and student health insurance. Students are expected to meet regularly with the Graduate Academic Advisor to ensure that procedures and forms are completed properly and submitted on schedule.

Sheila Olson, Administrative Manager
Office: 3226 SMBB, Email: sheila.olson@utah.edu, Phone: 801.581.8953

The Administrative Manager works with faculty advisors to manage paid graduate students' fellowships, scholarships, stipends, and salaries. All students should correspond regularly with the Administrative Manager and Graduate Academic Advisor concerning compensation, tuition benefits, and eligibility.

I.A.3. BME Department Faculty

The Department of Biomedical Engineering faculty is dispersed across the University of Utah campus. All facilities are located on a single, continuous plot of land nestled against the western front of the Rocky Mountains and constituting the northeast corner of Salt Lake City. The offices and laboratories of our approximately 30 primary faculty are housed in the Sorensen Molecular Biotechnology Building (SMBB), the Warnock Engineering Building (WEB), the Merrill Engineering Building (MEB), and the Biomedical Polymers Research Building (BPRB). Our approximately 80 adjunct faculty members are located across the academic Main Campus, the Health Sciences Campus, and the Research Park campus, including in University Hospital, Primary Children's Hospital, the Orthopedic Specialty Hospital, the Veterans Affairs Medical Center, and the Huntsman Cancer Institute. Up-to-date primary and adjunct faculty contact information is available on the BME Faculty Directories.

I.A.4. BME Graduate Student Groups

Students in the BME department have created a vibrant culture of peer mentorship and camaraderie. The following student groups, focused primarily on BME students, work together to foster a community in which graduate students from all backgrounds can develop, thrive, and thoroughly enjoy their time at the University of Utah:

Graduate Student Advisory Committee (GSAC)

The Graduate Student Advisory Committee (GSAC) is run by BME graduate students to support BME graduate students, liaise between students and the BME Department, and organize events to strengthen our BME community. GSAC supports our BME department and graduate student community by:

- Organizing the annual Utah Biomedical Engineering Conference (UBEC);
- Coordinating the prospective Biomedical Engineering graduate student visit weekend;
- Planning student and student-faculty social events; and
- Volunteering for local science and engineering outreach activities.

Graduate Women in Biomedical Engineering (GWBE)

The Graduate Women in Biomedical Engineering (GWBE) is run by BME graduate students and aims to encourage diversity and equality through departmental community building, professional development, and outreach. GWBE aims to create a productive, inclusive environment in which women and other biomedical engineering students can:

- Seek peer and faculty mentorship;
- Engage in career development with academic and industry professionals; and
- Connect with the surrounding community through STEM outreach and research dissemination.

Professional Society Student Chapters

The BME department hosts active student chapters of the two professional societies with the broadest coverage of all biomedical engineering subdisciplines: the BioMedical Engineering Society (**BMES**) and the IEEE Engineering in Medicine & Biology Society (**EMBS**). Both chapters collaborate — with each other, GWBE, GSAC, and USAC (Undergraduate Student Advisory Committee) — to strengthen our local biomedical engineering culture. They host invited speakers from academia and industry, promote professional development, and encourage social cohesion. Graduate students are encouraged to join either or both student chapters and to present their research at annual conferences of the BMES and EMBS.

I.B. ADMISSIONS TO BME

Graduate students must have received, before commencing graduate study, a Bachelor's degree from an accredited institute, college, or university. Although no single field of undergraduate specialization is required, applicants to the program should have a thorough background in engineering and life sciences.

I.B.1. ACCEPTANCE STANDARDS

The BME department employs a holistic review process to evaluate applicants to the graduate program. Therefore, no simple performance metrics make one eligible or ineligible for admissions; the entirety of an application will be considered during the evaluation process. However, successful applicants typically have at least a cumulative GPA of ~3.5 and GRE scores of ~156 verbal, ~165 quantitative, and ~4 analytical writing. In addition, international students should meet English proficiencies benchmarks — minimum scores of 90 on TOEFL, 7.5 on IELTS, or 125 on DuoLingo — and meet all other requirements of the University of Utah Graduate School.

Most applicants have an undergraduate-level mastery of a life science or engineering discipline, and the strongest applicants have both. Before students begin graduate study, they are expected to have basic knowledge in:

- Mathematics: statistics & calculus through linear algebra & differential equations
- Physics: calculus-based mechanical and electrical physics
- Chemistry: basic chemistry through organic chemistry biochemistry
- Materials science: introductory materials or strength of materials
- Biology: cell & molecular biology, physiology, or human anatomy

As part of the holistic review process, achievements beyond academic success are critical components of a strong application. Research experience is highly valued, particularly when supported by evidence of research dissemination and strong evaluations from principal investigators or faculty advisors. Engineering internships, volunteer efforts in medical settings, entrepreneurial endeavors, and other beneficent extracurricular activities strengthen an application. Letters of support from professors and senior supervisors are critical components of the evaluation process. The BME department encourages applicants to seek letter writers who know them personally and can speak to their strengths without merely rephrasing their resume. Finally, while the department considers all aspects of both M.S. and Ph.D. applications, acceptance into the Ph.D. program — and its financial benefits — is harder to attain.

I.B.2. APPLICATION PROCEDURE

Applicants are required to use the online SLATE system. Below is a list of materials you will need to complete the process, but please follow instructions within SLATE to ensure a complete application.

- **Transcripts for Applicants:** Unofficial copies of transcripts from all colleges and universities attended should be uploaded into the SLATE system at the time of application. For foreign institutions, include transcripts in the original language, plus official English translations if the original language is not English. Upon acceptance to the program, official transcripts must be sent directly from the academic institutions to the Graduate School Admissions Office:

  University of Utah Office of Admissions
  201 S. 1460 East, Rm 250 S.
  Salt Lake City, Utah 84112

- **GRE Scores:** Test scores are generally required for the graduate program. If applicants are unable to take the GREs, please contact the Graduate Academic Advisor, Laura Olsen, to request an exception. Otherwise, scores may be self-reported on your SLATE application. Upon acceptance to the program, an official report of scores from the General Test of the Graduate Record Exam (GRE) should be sent directly by the Educational Testing Service (ETS) to the Graduate School Admissions Office at the above address. Please use the institutional code for the University of Utah, **#4853**. Note: MCAT scores may be accepted in lieu of GRE scores.

- **Letters of Reference:** Applications must include at least three letters of personal reference from course instructors, research supervisors, or employers familiar with your abilities and performance. Please include your references' names and contact information in the SLATE application. Once your application is submitted, your reference letter writers will be automatically notified to submit their recommendations through the SLATE system.
- **Statement of Purpose:** A one-page personal statement (~500 words) outlining your background, research interests (including possible faculty advisors), career goals, and reasons for applying to our graduate program.
- **Resume or CV:** A professional resume or academic curriculum vitae is required.
- **Writing Sample** *(optional)*: A sample of original writing —a brief article, abstract, or essay — may be submitted with the rest of an application. However, a writing sample is optional and may be skipped without penalty.
- **Potential Research Areas:** Applicants should select one or more Graduate Track Specializations and identify faculty members with whom they may be interested in working. See the Directory of Faculty by Research Areas.
- **For International Students only**: *(check with the International Student Office for details)*
    - **TOEFL scores**. An official report of scores from the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). You will need to use code **#4853**.
    - **I-20 Certificate of Eligibility**. Upon acceptance to the graduate program, applicants seeking an I-20 must provide the following items for full admission to the University and I-20 certification:
        - a financial statement with supporting documents showing a minimum amount in U.S. dollars to cover the first-year tuition and living expenses,
        - a copy of the first page of the applicant's current passport or national ID card, and
        - other documents may be required. See the International Admission Office for details.

I.C. IMPORTANT DEADLINES

Deadlines for various events change on an annual basis. Links to the most relevant deadlines are included below.

I.C.1. DEPARTMENTAL DEADLINES

Progress Reports

All graduate students in the BME department must submit semi-annual progress through the College of Engineering Graduate Student Progress Tracker. This database allows students to upload the various forms and other documents that verify the completion of their graduate program milestones, and for their faculty advisor, track director, and the Director of Graduate Studies to monitor their progress through graduate school. Each year, progress reports are due on *May 15* and *November 15*.

Application Deadlines

Ph.D. application deadline is December 15: eight months prior to intended fall enrollment or thirteen months prior to intended spring enrollment. Applications received after that will continue to be considered on a space-available basis through the University deadline of April 1. However, the department offers limited Ph.D. funding to first-year students: applicants seeking funding in their first year should consider December 15 a hard deadline, whether they plan to enroll the following fall semester or the subsequent spring.

M.S. applications deadline is April 1: 4 months prior to intended fall enrollment or nine months prior to intended spring enrollment. Late applications are subject to a $30 late fee and may be considered on a space-available basis.

B.S./M.S. applications for summer/fall semester are due April 1: 13^{+} months prior to a transition into graduate school.
B.S./M.S. applications for spring semester are due November 1: 13^{+} months prior to a transition into graduate school.

I.C.2. UNIVERSITY DEADLINES

Academic calendar deadlines:
https://registrar.utah.edu/academic-calendars

International Teaching Program deadlines:
https://gradschool.utah.edu/ita/important-dates-and-deadlines

University Fellowship deadlines, including Teaching Assistantship & Research Assistantship deadlines:
https://gradschool.utah.edu/tbp/graduate-fellowship-opportunities

Thesis Office manuscript submission deadlines:
https://gradschool.utah.edu/thesis/calendar

Graduation deadlines:
https://registrar.utah.edu/graduation

II. DEPARTMENT GRADUATE PROGRAMS

The Department of Biomedical Engineering bestows graduate degrees at the master's and doctoral levels. To earn their degree, students must specialize in one of many Biomedical Engineering Track Specializations. For mentorship and to help them proceed through their graduate career, students select a graduate Faculty Advisor and a Supervisory Committee from the available faculty. Graduate school requires both coursework and extra-curricular achievements commensurate with the degree attained. This section details the degrees, tracks, mentorship, coursework, and additional expectations for graduate students in the Department of Biomedical Engineering.

II.A. GRADUATE DEGREES

The Department of Biomedical Engineering offers both Masters of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees. These can be earned simultaneously with other degrees by students in the B.S./M.S., M.S./M.B.A, and M.D./Ph.D. joint programs. Students must select one of seven Graduate Track Specializations.

- bioInnovate
- Biomaterials & Therapeutics
- Biomechanics
- Cardiovascular Engineering
- Data Science & Computation
- Imaging
- Neuroengineering

Each specialization is led by a track director who advises all of its students, with an emphasis on those in their first year. Because students enter with a variety of backgrounds, individual programs of study must be uniquely tailored: a task best performed with the help of advisors specializing in a student's academic focus. Thus, students are directed to identify a faculty advisor and supervisory committee as soon as possible. Students should meet with their faculty advisor weekly and must convene their supervisory committee annually: more frequent meetings are encouraged.

II.A.1. MASTER OF SCIENCE (M.S.) PROGRAM

The master's program is targeted at students seeking a breadth of knowledge in biomedical engineering and mastery over a specialized subfield thereof. The M.S. degree program takes 1–2 years to complete the minimum 30 credit hours of graduate study and demonstrate mastery within their chosen subfield. Students will be mentored through the process by a supervisory committee that they must select in their first year, as described below.

M.S. Supervisory Committee

Students must form a (minimum) three-member supervisory committee within the first semester of their M.S. program. The committee chair — the faculty advisor — must have an appointment in the BME department. If the student seeks to complete research in an affiliated laboratory, the faculty advisor should be the lab's Principal Investigator; otherwise, the faculty advisor should be the student's track specialization director. Students are responsible for contacting prospective committee members about their willingness and availability to serve as supervisory committee members. The student forms a committee by filing a Request for M.S. Supervisory Committee form with the Graduate Academic Advisor for approval by the Director of Graduate Studies.

Committee Membership

The supervisory committee must comprise at least three faculty members affiliated with the University of Utah. The Graduate School requires that *1)* a majority of the committee members hold tenure-line appointments within the BME Department, and *2)* the chair of the committee holds a tenure-line appointment within the BME Department. Students may file petitions for exceptions to either, but not both, of those requirements, according to the following:

1) The BME Department will consider petitions to the tenure-line majority rule if at least three of the committee members, constituting no less than three-fourths of the committee, hold their primary faculty appointments —

career-line or tenure-line — in the BME Department. *Note that the committee chair must have a tenure-line appointment in BME.*

2) The BME Department will consider petitions to the tenure-line committee chair rule if the committee chair has an appointment — career-line or adjunct — in the BME Department. *Note that the majority of the committee members must have tenure-line appointments in BME.*

Supervisory committees are responsible for guiding their students through their graduate degree process, including approving most of the milestones thereof. They arbitrate disputes, resolve conflicts, or mitigate difficult strategic programming decisions between students and their faculty advisors. The supervisory committee exists to support the student, and its members serve at the student's pleasure. With the consent of their faculty advisor, a student may replace members of their supervisory committee, including the faculty advisor themself, at any time by filing a Change Supervisory Committee form with the Graduate Academic Advisor for approval by the Director of Graduate Studies.

Committee Meetings

Students must convene their full supervisory committees at least once annually and are encouraged to meet more frequently. Meeting privately with individual committee members is encouraged but is not a substitute for regular meetings of the entire supervisory committee. The purpose of these meetings is for the committee as a whole to review the student's academic progress and discuss strategies for continued success. The student must ensure that the discussions and outcomes of these meetings are retained via one of the parties — themselves or a committee member — taking notes or video recording. The student must generate written minutes from the notes or recordings, distribute them to the committee within two weeks of each meeting, and upload them as a permanent record in the COE Progress Tracker. Because the Project Presentation and Thesis Defense are oral examinations, students are not responsible for recording or generating minutes for either of those extraordinary committee meetings.

M.S. Degree Options

To earn an M.S. degree in Biomedical Engineering, students must demonstrate mastery within a subfield of their choosing. Students demonstrate this subfield-specific mastery through one of the following three optional pathways.

Thesis Option M.S.

This option requires at least 9 credit hours of thesis research (BME 6970), culminating in an M.S. Thesis. Students must effectively apply the scientific method, demonstrate the significance of their contribution to the field, and professionally communicate their results in both written and oral form. Thesis option M.S. students must successfully defend their thesis in a public forum according to the Department of Biomedical Engineering and Graduate School rules. The student's supervisory committee will evaluate both the written thesis and its oral defense to determine whether the student has demonstrated topical mastery sufficient to merit an M.S. degree.

The written thesis must conform to the Graduate School requirements and be provided to each supervisory committee member at least two weeks before its oral defense. University thesis regulations are available in "A Handbook for Theses and Dissertations," which can be downloaded from the Graduate School Thesis Office website. At least two weeks before their public defense, students must inform the Graduate Program Coordinator of its location and time, and their thesis title and abstract. The student presents their thesis at the defense and then fields questions from the general audience. Immediately following the public defense, the student will undertake an oral examination administered in a closed session by the supervisory committee. The oral examination should focus on scientific knowledge and engineering processes relevant to the thesis. Immediately following the oral examination, the majority opinion of the supervisory committee determines whether or not the student passes their thesis defense: thesis option M.S. students have two opportunities to pass the thesis defense.

Project Option M.S.

In lieu of thesis research, this option requires at least 9 credit hours of advanced coursework (6000 level or above) within a Biomedical Engineering track specialization culminating in an M.S. Project. Each student selects a project related to their specialization to serve as the foundation for their M.S. scholarly work. Though the basis of the project

can derive from a class, laboratory, or internship, the student must utilize graduate-level scientific-or-engineering principles or methods to develop their project beyond the sophistication level expected within regular courses.

To demonstrate a depth of knowledge within the field, a student must present their projects to their supervisory committee through both a written technical report and an oral presentation.

- The technical report must be 1) a manuscript published, or fit to be published, in a scientific or engineering journal, or 2) a technical document detailing the design, construction, or testing of the M.S. project. The student should work with their supervisory committee to ensure that the report format is appropriate for the project. The student must submit the technical report to their supervisory committee two weeks before the oral presentation.
- The oral presentation should begin with a ~45-minute formal presentation of the M.S. project. This meeting is not open to the public, though the student may invite non-committee members at their discretion. The student must demonstrate that they can integrate the scope and necessary details from their technical training into a cogent, professional presentation. Following the presentation, the supervisory committee administers a closed session oral examination to last an additional ~45 minutes. The oral examination should cover material drawn from the student's BME Core Curriculum as listed on their Program of Study — including both their Life Science Fundamentals and Track Specialization Fundamentals — with particular attention to topics relevant to their M.S. project. Immediately following the oral examination, the majority opinion of the supervisory committee determines whether or not the student passes their project presentation: project option M.S. students have two opportunities to pass the project presentation.

Course Option M.S.

In lieu of a thesis or project, this option requires at least 9 credit hours of advanced coursework (6000 level or above) within a Biomedical Engineering track specialization culminating in a comprehensive examination. To demonstrate breadth of knowledge in biomedical engineering and depth of expertise within their track specialization, students may satisfy the comprehensive examination by passing either a written exam offered by their track specialization or an oral exam administered by their supervisory committee. Course option M.S. students have two opportunities to pass the comprehensive exam, regardless of whether they take the written or oral format.

- Written examinations are offered once annually, typically in August or September. These are the same examinations offered as Written Qualifying Exams to Ph.D. students. For more information, see the track-specialization guidelines for each exam in the subsequent Ph.D. Program section. Course Option M.S. students seeking to take the written examination must notify the Graduate Program Coordinator of their intentions by the end of the spring semester preceding the exam. Faculty members within the track evaluate the written examinations to determine whether or not each student passes their comprehensive examination.
- Oral examinations by the supervisory committee can occur throughout the year. This ~90-minute exam should cover material drawn from the student's BME Core Curriculum as listed on their Program of Study, including their Life Science Fundamentals and Track Specialization Fundamentals. Material from additional courses that are important for the student's academic goals may be included in the exam, but only if the student and supervisory committee agree to include the additional courses ahead of time. Immediately following the examination, the majority opinion of the supervisory committee determines whether or not the student passes their project presentation: project option M.S. students have two opportunities to pass the project presentation.

M.S. Degree Requirements

To earn an M.S. degree in Biomedical Engineering, students must successfully complete a minimum of 30 credit hours of graduate study (5000 level and above) — including at least 9 credit hours at the advanced graduate level (6000 level and above) — and demonstrate mastery within a subfield of their choosing. While the specific requirements vary by track specialization and M.S. option, the following general guidelines apply to all M.S. students.

M.S. Program of Study

The M.S program of study lists all courses taken beyond the baccalaureate degree — including any research credits (BME 6970) if appropriate — and applied toward the M.S. degree. Subsequent sections of this handbook detail the BME Core Curriculum and Graduate Track Specialization requirements. The academic coursework comprises the BME core curriculum and other graduate-level science and engineering courses relevant to the student's research focus and career goals. Before selecting specific courses, the student should consult with their faculty advisor and supervisory committee to ensure compliance with the BME department and their track specialization. By the end of their first semester, each M.S. student must submit an official Program of Study, approved and signed by their supervisory committee, to the Graduate Academic Advisor.

Thesis-Option M.S. Programs of Study must contain:

- 21 credit hours of coursework (minimum), including:
  - At least 13 credits hours of Core Curriculum (or approved substitutes);
  - At least 8 credit hours of graduate-level science and engineering elective courses.
- 9 credit hours (minimum) of dedicated research: BME 6970, M.S. Thesis Research.

Project-Option and Course-Option M.S. Programs of Study must contain:

- 30 credit hours of coursework (minimum), including:
  - At least 13 credits of Core Curriculum (or approved substitutes);
  - At least 9 credits of advanced (6000 level) courses within a track specialization;
  - At least 8 credit hours of graduate-level science and engineering elective courses.

M.S. Milestones

Students must complete the following milestones to receive their degree. These achievements must be registered in the College of Engineering Progress Tracker by uploading the appropriate forms or other documentation.

- Establish a Supervisory Committee
- Finalize a Program of Study
- Pass a Final Comprehensive Exam

II.A.1a. BME B.S./M.S. Dual Degree Program

This dual degree program allows students to begin their M.S. studies while still enrolled as undergraduates at the University of Utah. This program enables students to complete their M.S. degree in only one year beyond the time required for their B.S. degree. Students who complete this program receive their B.S. and M.S. degrees simultaneously.

B.S./M.S. Degree Requirements

Students in this joint program must meet all requirements specified by the Department of Biomedical Engineering and the University of Utah Graduate School. Unless otherwise stated, students must abide by all requirements for the standard B.S. in Biomedical Engineering, as listed in the Undergraduate Handbook. Students should reference the handbook that correlates with their catalog year, i.e., the academic year of their admission to major status. Similarly, students must abide by all requirements for the standard M.S. in Biomedical Engineering, as listed in this handbook. The following stipulations supersede credit hour requirements for students in only the B.S. program or the M.S. program.

- Before advancing to graduate student status, undergraduates must complete a minimum of 122 credit hours that meet the Biomedical Engineering B.S. requirements;
- Students must complete a minimum of 30 graduate-level credit hours — beyond the 122 designated for their B.S. degree — that meet the Biomedical Engineering M.S. requirements;
- A maximum of 12 graduate-level credit hours — of the required 30 designated for their M.S. degree — may be completed while students are still in undergraduate status.

B.S./M.S. Application Eligibility and Procedures

To be eligible, students must be U.S. citizens or Permanent Residents, with full major status in the Biomedical Engineering B.S. program, have completed a minimum of 90 undergraduate credit hours by the end of the semester of application, have not yet completed the Senior Thesis I course (BME 4991), and have a minimum 3.0 cumulative GPA.

Admission into the B.S./M.S. program requires two separate applications. The Department application allows students to join the program before their senior year while maintaining full undergraduate status and privileges: undergraduate financial aid, tuition rates, etc. The University of Utah Graduate School application is required for promotion to graduate student status, as is necessary for them to complete the M.S. portion of their degree.

Step 1: Department Application Procedure:

Before applying to the B.S./M.S. program, students are encouraged to meet with the Department B.S./M.S. Program Academic Advisor and the Graduate Academic Advisor. The application form and instructions can be found on the Biomedical Engineering Graduate Studies website. The application deadlines are April 1 for fall semester admission and November 1 for spring semester admission. Students submit the application to the Graduate Academic Advisor. Supporting documents will include a one-page Personal Statement, an unofficial Transcript (or DARS), and a professional résumé or CV. Additionally, applicants with a cumulative GPA between 3.000 and 3.499 will be required to provide three letters of recommendation, including at least one from a Biomedical Engineering core faculty member. Applicants are not required to submit GRE scores for admission to the B.S./M.S. Dual Degree program.

Step 2: University Application Procedure

Students apply for graduate status after completing at least 122 semester credit hours of qualified studies. Students must follow regular University of Utah Graduate School application procedures to apply online using the SLATE application system. Once students attain graduate status, all Graduate School rules apply, e.g., graduate tuition structure, tuition benefit program (TBP), health insurance program, etc. When deciding on the timing for their status change from undergraduate to graduate, students should read the TBP guidelines and weigh the pros (e.g., tuition benefit and health insurance) against the cons (e.g., no scholarships, more costly tuition).

Step 3: Petitioning for Graduate Credit

Students may request up to 12 credit hours of coursework taken as undergraduates to be applied to their M.S. Program of Study. All courses must be at the 5000 level or above, and students must submit the "Request for Graduate Credit in the B.S./M.S. Program" to the Registrar's office during their first semester in graduate status. The Biomedical Engineering Graduate Academic Advisor will review this form before submitting it to the Office of the Registrar. The Registrar's Office will update the DARS from all B.S./M.S. students, noting that the requested courses have been reserved for graduate credit. When completed, these updates are final and cannot be reversed. Requested courses that have been approved by the Office of the Registrar be "Reserved" on the student's undergraduate record and are no longer applicable toward the B.S. degree. However, they will be eligible for credit toward the M.S. degree and may be included in the student's M.S. Program of Study for approval consideration from their supervisory committee.

Criteria for inclusion of graduate courses taken as an undergraduate into the graduate program of study:

- The requested courses must have a letter grade of B or better;
- The requested courses may not be used to fulfill requirements for any other degree, including B.S. core courses. However, up to 6 credit hours may come from the undergraduate elective requirements approved by the Director of Undergraduate Studies;
- Once requested courses have been approved through the Office of the Registrar, students who subsequently withdraw from the B.S./M.S. program will not be allowed to apply those reserved credits toward their B.S. degree and will be restricted in the extent to which they may apply them toward future M.S. degree requirements;
- B.S./M.S. candidates must maintain two separate enrollment records (undergraduate and graduate) and register for the remaining undergraduate courses on their undergraduate enrollment and graduate courses under their graduate enrollment.

B.S./M.S. Program Completion

After successfully completing all requirements in both degree programs, the B.S. and M.S. degrees are conferred simultaneously. Therefore, students must apply for graduation in the same semester for both degrees. See the Graduation Office website for application deadlines, etc.: https://registrar.utah.edu/graduation/index.php. The M.S. degree will not be awarded to any student who has not completed all requirements for the B.S. program.

Students who request to exit the B.S./M.S. dual-degree program may do so without penalty while remaining an undergraduate. Upon promotion to graduate student status, qualified coursework will be applied toward the traditional B.S. and M.S. degree requirements. Students with graduate status who seek to leave the program without completing the M.S. portion will need to complete the full cadre of coursework expected of traditional B.S. students. They may petition the BME department to request that courses designated for their M.S. degree be included in the department's evaluation of their undergraduate coursework.

B.S./M.S Typical Course Load

To complete both programs within five years requires a standard course load for the first three years of study, plus additional credit hours in the fourth and fifth years. One possible example timeline is included below:

Year Four:
Fall Semester: Normal course load for BME BS students (15 credits), plus 0.5 extra MS core credits;
3.0 of the BS credits plus the 0.5 MS credits will be reserved for the MS degree.
Spring Semester: Normal course load for BME BS students (15 credits), plus 0.5 extra MS core credits;
3.0 of the BS credits plus the 0.5 MS credits will be reserved for the MS degree.
Summer Semester = 3 credit hours of MS electives or thesis research.

Year Five:
Fall Semester = 10 credit hours (3.0 MS core + 7.0 MS electives and/or thesis research).
Spring Semester = 10 credit hours (3.0 MS core + 7.0 MS electives and/or thesis research).

II.A.1B. BME M.S./M.B.A. Dual Degree Program

This dual degree program enables students to earn both a two-year Biomedical Engineering Master of Science (M.S.) degree and a two-year Master of Business Administration (M.B.A.) degree in as little as 2.5 years. This program combines students' applied interests and training in engineering with comprehensive business exposure, providing them the professional flexibility to transition between technical and commercial domains. Graduates are qualified to direct and manage the creation, transition, and improvement of products, processes, and systems from the laboratory to the boardroom. Students who complete this program receive their M.S. and M.B.A. degrees simultaneously. For additional information on the M.B.A. portion of this program, please visit the David Eccles School of Business website.

M.S./M.B.A. Degree Requirements

- Students must apply and be accepted to both the Biomedical Engineering M.S. and full-time M.B.A. programs to complete these degrees simultaneously.
- Students must complete at least 74 credit hours: 24 exclusively in Biomedical Engineering, 44 exclusively in Business Administration, and 6 Capstone credits applicable to both programs.
  - Biomedical Engineering minimums: 6 credits of Life Science Fundamentals, 6 credits of Biomedical Engineering Fundamentals, 1 credit of Department Seminar (BME 6090), and 11 credits of supervisory committee-approved electives;
  - Business minimums: 32 MBA Core credit hours and 12 Business Elective credit hours (at 6000 level or above);
  - Joint/Combined minimums: 6 credit hours of Capstone courses.
- The Biomedical Engineering M.S. requirements for this program are the same as the standard M.S. requirements listed in this handbook, except for the 6 credit hours of Capstone courses shared with the M.B.A. program and applied to both Programs of Study.

M.S./M.B.A. Typical Course Load

To complete both programs within 2.5 years requires a course load of 16-18 credits hours each semester, as follows:

Year One:
Fall Semester = 18 credit hours (14.5 MBA core + 3.5 MBA electives)
Spring Semester = 17 credit hours (13.5 MBA core + 3.0 MBA electives + 0.5 MS core)
Summer Semester = MBA Internship Strongly Recommended

Year Two:
Fall Semester = 16 credit hours (7.0 MBA core + 6.0 MS core + 3.0 MS electives)
Spring Semester = 15 credit hours (2.5 MBA core + 6.5 MS core + 6.0 MS/MBA Capstone)
Summer Semester = MBA Internship Strongly Recommended

Year Three:
Fall Semester = 8 credit hours (8.0 MS electives)

While the Graduate School limits most graduate students to a maximum of 16 credit hours per semester, M.S./M.B.A. students can take up to 18. Registration above 18 credit hours requires a petition to the Graduate School.

II.A.2. Doctor of Philosophy (Ph.D.) Program

The doctoral program targets students seeking a breadth of knowledge in biomedical engineering and world-class expertise within a specialized subfield thereof. Students must meet all requirements specified by the University of Utah Graduate School and the BME Department. Students with no graduate school experience typically complete the Ph.D. degree program in 4–6 years; students with an existing M.S. degree in Biomedical Engineering should complete the Ph.D. degree program in 3–4 years.

Ph.D. Supervisory Committee

In the first year of their Ph.D. program, students must form a (minimum) five-member supervisory committee. The chair of that supervisory committee — often known as the faculty advisor — must have an appointment in the BME department. In their first semester here, if not before, Ph.D. students should find a department-affiliated laboratory in which to conduct the research necessary for their dissertation. By accepting the student into that research laboratory, its Principal Investigator agrees to serve as the student's faculty advisor. Unless the student has their own funding, the faculty advisor must provide an offer letter committing the lab to support the post-BS student until they have been in the graduate program for five years, or the post-MS student until they have been in the program for three years.

The student should work with their faculty advisor to identify potential supervisory committee members appropriate to their research goals. Students are responsible for contacting prospective committee members about their willingness and availability to serve. The student forms a committee by filing a Request for Ph.D. Supervisory Committee form with the Graduate Academic Advisor for approval by the Director of Graduate Studies.

The supervisory committee must comprise at least five faculty members. At least one supervisory committee member must have a primary appointment outside the BME Department. The Graduate School additionally requires that *1)* a majority of the committee members hold tenure-line appointments within the BME Department, and *2)* the chair of the committee holds a tenure-line appointment within the BME Department. Students may file petitions for exceptions to either, but not both, of those requirements, according to the following:

1) The BME Department will consider petitions to the tenure-line majority rule if at least three of the committee members, constituting no less than four-sevenths of the committee, hold primary faculty appointments — career-line or tenure-line — in the BME Department, and if at least two of the committee members, constituting no less than two-sevenths of the committee, hold tenure-line appointments in the BME Department. *Note that for this exception, the committee chair must have a tenure-line appointment in BME.*
2) The BME Department will consider petitions to the tenure-line committee-chair rule if the committee chair has an appointment — career-line or adjunct — in the BME Department. *Note that for this exception, the majority of the committee members must have tenure-line appointments in BME.*

Supervisory committees mentor students through the program and ensure that their achievements are consistent with the work expected of those with a doctoral degree in biomedical engineering. Supervisory committees advise and consent to a student's academic program of study, evaluate and approve their research proposal, read and accept their written dissertation, and administer and judge their oral dissertation defense. To facilitate these interactions, students must convene a supervisory committee meeting at least once per year. Students who fail to do so will be put on academic probation for up to 12 weeks, until they meet with their committee. Students on probation who fail to convene a supervisory committee meeting within that 12-week period may be dismissed from the program.

In addition, supervisory committees should help arbitrate disputes, resolve conflicts, and mediate difficult strategic programming decisions between students and their faculty advisors. The supervisory committee exists to support the student, and its members serve at the student's pleasure. With the consent of their supervisory chair, a student may replace members of their supervisory committee, including the supervisory chair themself, at any time by filing a Change Supervisory Committee form approved by the Director of Graduate Studies.

Ph.D. Academic Program

To earn a Ph.D. in Biomedical Engineering, students must complete a minimum of 72 credit hours of graduate study and demonstrate expertise within a subfield of their choosing. The ultimate goal of this program is for students to demonstrate the ability to apply the scientific method to perform independent, impactful research that advances the state of knowledge within their specific subfield.

Academic Credit Hours

The Biomedical Engineering Ph.D. program requires at least 72 credit hours beyond the baccalaureate level, including at least 38 credit hours of dissertation research (BME 7970) and at least 30 credit hours of academic courses. The minimum allowable grade for any course counted toward a Ph.D. in Biomedical Engineering is a B-. Dissertation research involves significant, independent, peer-reviewed, original research, and constitutes most of the credit hour requirements. Essential to obtaining any doctoral degree, students earn teaching mentorship credits by serving as a teaching assistant for 1–2 semesters.

The Ph.D. program of study lists all courses taken beyond the baccalaureate degree and applied toward the Ph.D. Subsequent sections of this handbook detail the BME Core Curriculum and Graduate Track Specialization requirements. The academic coursework comprises the BME core curriculum (at least 17 credit hours of fundamental courses or approved substitutes) and at least 13 credit hours of additional graduate-level science and engineering courses relevant to the student's research focus and career goals.

Ph.D. Programs of Study must contain at least 72 credit hours:

- 30 credit hours of coursework (minimum), including:
  - At least 17 credits hours of Core Curriculum (or approved substitutes);
  - At least 13 credit hours of graduate-level science and engineering elective courses.
- 38 credit hours (minimum) of dedicated research: BME 7970, Ph.D. Dissertation Research.
- 4 additional credit hours: teaching mentorship (BME 7880), dissertation (BME 7970), or academic coursework.

For most Ph.D. students, the standard or extended Tuition Benefit Program (TBP) pays the cost of these courses. For Utah residents, there is no cap on the total number of credits TBP may cover; in practice, the number of eligible credits is set by limits on the time to graduation. Further, all domestic graduate students must become Utah residents early in their graduate student tenure (see section *III.A.1. Enrollment Residency Requirement*). For international students however, TBP for coursework is limited to 84 credits. ***International students should complete all of their coursework before they reach 84 credits.*** After that point, TBP will only apply to dissertation research credits (BME 7970). International students will pay their own tuition for all coursework — and teaching mentorship if applicable — in the semester they exceed 84 credits, and thereafter.

Before selecting specific courses, students should consult with their faculty advisor and supervisory committee to ensure compliance with the BME Department and their track specialization. The supervisory committee may require students to take additional courses depending on their academic preparedness, performance on the written qualifying exam or research proposal, or other factors. Up to 30 credit hours previously applied toward an M.S. degree in

Biomedical Engineering or a related field may be included in the Ph.D. program of study. However, every student must meet all departmental and track-determined course requirements. For example, if a student took a graduate level physiology course during their M.S. program, their committee may approve a petition to waive their taking a separate physiology course for their Ph.D. If the supervisory committee and Director of Graduate Studies approve any prior courses as substitutes within the program of study, those courses must be listed on all relevant forms as having been taken for zero credits.

By the end of their second spring semester, each Ph.D. student must submit a Preliminary Program of Study, approved and signed by their supervisory committee, to the Graduate Academic Advisor. This preliminary plan establishes a set of academic courses, including the semesters in which they were, or will be, taken. Students must submit their Final Program of Study to the Graduate Academic Advisor during the semester immediately preceding that in which they defend their dissertation. This final program must detail all credits taken for the Ph.D., including dissertation research (BME 7970) credits and their corresponding semesters. *Note: the Continuous Registration course (BME 7990) does not count toward fulfilling the Ph.D. degree and should not be listed on the program of study.* After receiving all necessary approvals, the final program of study is reviewed by the Graduate School.

Written Qualifying Exam

Ph.D. students must demonstrate expertise of the subject matter within their track specialization. After completing the relevant coursework, they meet this requirement by passing a written qualifying exam within their track. This exam satisfies the Graduate School Written Qualifying Exam requirement. Exams for all track specializations are given simultaneously on a single day — typically in August. Each 8-hour exam comprises a pair of 4-hour sessions, divided by a one-hour break for lunch. Books and notes are not allowed in the exam. After submitting a Preliminary Program of Study, students inform the Academic Graduate Advisor of their intent to take the exam at least three months before the exam date. Students must attempt an exam before the end of their fifth non-summer semester in the program.

Each exam is prepared and graded by a committee of Biomedical Engineering faculty members with expertise in the relevant graduate track specialization. The exam format varies between tracks but generally consists of in-depth questions from the specialization field that may rely on comprehensive knowledge from the Biomedical Engineering core. Some track-specific guidance is available in the Graduate Track Specialization section, and students may contact their track director to discuss the exam format.

Students have two opportunities to pass the written qualifying exam before being removed from the program. Passing this exam qualifies the students to receive a milestone M.S. degree once they have also completed the coursework required for a Course Option M.S. For more information, see the Inline Promotions section below.

Ph.D. Research Efforts

Ph.D. students must complete at least 38 credit hours of dissertation research, BME 7970, and advance the state of knowledge in their chosen field. They must design and propose a research project, complete the proposed research effort, disseminate their research results in peer-reviewed manuscripts, present their results at scientific meetings, and write and defend their dissertations before their supervisory committee and the public.

Research Proposal

Students must develop a plan for the research that will constitute their dissertation. The Research Proposal is a two-step process — a written proposal and an oral proposal — through which students formally propose their dissertation plan to the public and their supervisory committee. To pass the research proposal, students must demonstrate adequate preparation to begin effective independent research. They must be well-versed in the fundamentals, have sophisticated familiarity with the primary literature in the proposed area of research, and demonstrate an ability to design and effectively communicate a competent, sound research plan.

Students must take two courses — BME 7070 and BME 7071, typically in their 4th and 5th non-summer semesters — that help them prepare for both portions of the research proposal. Students are expected to complete their research proposal by the end of their third year in the program; students who fail to pass their research proposal by the end of their fourth year will lose their tuition benefit eligibility. Students are responsible for scheduling their oral proposal — including securing the requisite physical or virtual space — in coordination with their committee members' availability.

Students must deliver their complete written proposal to the supervisory committee at least two weeks before their oral proposal. Students must notify the Graduate Academic Advisor at least one week prior to their oral proposal, including information necessary for a public announcement: proposal title, project summary or abstract, faculty advisor, location, date, and time.

The written portion of the research proposal shall follow the same style and contain the same sections as the NIH R01 and R21 grant proposals: Project Summary, Specific Aims (1 page or less), Research Strategy (6-12 pages), Literature Cited; and if relevant, Protection of Human Subjects, and a Vertebrate Animal section. The Research Strategy shall contain the following subsections:

Significance (suggested length: 3 pages or less):

- Explain the importance of the problem or critical barrier to progress that the proposed project addresses.
- Describe the strengths and weaknesses in the rigor of the prior research (both published and unpublished) that provide key support for the proposed project.
- Explain how the proposed project will improve scientific knowledge, technical capability, or clinical practice in one or more broad fields.

Innovation (suggested length: ~½ page):

- Explain how the application challenges and seeks to shift current research or clinical practice paradigms.
- Describe any novel theoretical concepts, approaches or methodologies, instrumentation or interventions to be developed or used, and any advantage over existing methodologies, instrumentation, or interventions.
- Explain any refinements, improvements, or new applications of theoretical concepts, approaches or methodologies, instrumentation, or interventions.

Approach:

- Describe the overall strategy, methodology, and analyses to accomplish the project's specific aims. Describe plans to address weaknesses in the rigor of the prior research that serves as the key support for the proposed project. Describe the experimental design and methods proposed and how they will achieve robust and unbiased results. Include how the data will be collected, analyzed, and interpreted.
- Discuss potential problems, alternative strategies, and benchmarks for success anticipated to achieve the aims.
- If the project is in the early stages of development, describe any strategy to establish feasibility, and address the management of any high-risk aspects of the proposed work.
- Explain how relevant biological variables, such as sex, are factored into research designs and analyses for studies in vertebrate animals and humans.

NIH provides guidance on the Specific Aims and Research Strategy sections in the PHS 398 instructions here: https://grants.nih.gov/grants/how-to-apply-application-guide/forms-e/general/g.400-phs-398-research-plan-form.htm

The oral portion of the research proposal must be a public, formal presentation of the proposed research. The student must be registered for classes in the semester that they propose; i.e., if a student intends to propose during a summer semester, they must register for classes during that summer, typically by taking 3 credits of BME 7970. Immediately following a formal presentation of the proposed research, the student will field questions from the public audience. The student should plan for the combined presentation and public question-and-answer session to last an hour. Subsequently, the supervisory committee will dismiss the public and the committee chair to finish the examination portion of the oral proposal in a closed-door session. The committee will examine the student's knowledge in their proposed research area and test their ability to respond cogently to critiques of the research plan.

By unanimous consent, the supervisory committee may allow its chair to remain present and log the other committee members' recommendations for and adjustments to the proposed research. In such cases, the committee should remember that this question-and-answer session is an examination only for the student. Therefore, the committee may not address questions or comments to the committee chair; and the committee chair may not assist the student in answering questions or clarifying any aspects of the proposed research.

The supervisory committee — excluding the supervisory committee chair — will vote separately on the written and oral proposals. Both votes will be recorded in the Research Proposal Examination form, which students should have

prepared for their oral proposal. The committee may choose to pass the candidate, fail the candidate, or pass the candidate contingent upon them successfully responding to issues with their proposal (written, oral, or both). Contingencies can include written proposal revisions, supplemental coursework, new supporting data or analyses, and additional oral presentations. Ph.D. students have two opportunities to pass the Research Proposal — comprising both the written proposal and oral proposal — in accordance with Graduate School policies.

Doctoral Dissertation

Dissertations must embody original insights, motivations, and results of the Ph.D. candidate's independent creative scientific conduct and scholarly research. They must show a mastery of relevant literature and be presented in a style approved by the BME department. Above all, dissertations must provide clear evidence of the candidate's scientific maturity, unique expertise, innovation, and ability to perform independent research and contribute new knowledge. Students must prepare a written dissertation and orally present and defend that dissertation publicly and before their supervisory committee.

External Reviewer. The review of the Ph.D. dissertation by an external reviewer is not required but can be encouraged by the supervisory committee. The Ph.D. candidate and their supervisory committee should consider this option, notably if expertise on the dissertation topic is lacking at the University of Utah in general and on the supervisory committee in particular. The external reviewer, who must hold an academic appointment at an institution outside the University of Utah, should submit a written evaluation of the dissertation to be read at the time of defense.

Written Dissertation. The Approved Dissertation Style Guide for the Department of Biomedical Engineering is registered with the thesis and dissertation editor, who approves dissertations in accordance with department and Graduate School policy. Preparation of the dissertation must adhere to University of Utah Graduate School requirements. Detailed policies and procedures are contained within A Handbook for Theses and Dissertations, published by the Graduate School, and additional information is available from the Thesis Office.

Typically, a dissertation comprises one or two introductory chapters, a series of original research manuscripts — each constituting its own chapter — and one or two concluding chapters. The introductory chapter(s) should provide context to the biomedical problems being addressed and include a sophisticated academic review of the existing knowledge within the field. They may also include methodological or engineering details that were critical to the research but did not appear in other forms. The middle chapters should detail original research that may be published or in press; with the publisher's approval, these chapters may be inserted into the dissertation as published (i.e., complete publisher's galley proof or journal off-print) and with additional amendments or supplements as desired. This dissertation core typically comprises at least three peer-reviewed, first-author publications, as detailed in Peer-Reviewed Publications. The concluding chapter(s) should frame the dissertation in terms of what it adds to our understanding of biomedical science, our ability to interact with human physiology, and our likelihood of improving the human condition. The conclusion may also identify weaknesses in the research and propose future efforts to overcome them.

Ph.D. candidates must submit their dissertation to their faculty advisor and external reviewer (if applicable) at least three weeks before the dissertation defense. Additionally, they must submit their dissertation to their supervisory committee members and the Graduate Academic Advisor at least two weeks before the dissertation defense. The BME Department staff will make a copy of the dissertation available for public viewing.

Oral Defense. The Ph.D. candidate must successfully defend their dissertation in a public forum in accordance with the rules of the BME department and the Graduate School. The student should plan for the combined presentation and public question-and-answer session to last an hour. Students must notify the Graduate Academic Advisor at least two weeks prior to their oral defense, including information necessary for a public announcement: proposal title, project summary or abstract, faculty advisor, location, date, and time. The oral presentation is followed by general questions from the public audience in an open session. If relevant, the external review of the dissertation is presented near the end of the public session. If possible, the external reviewer should deliver the review themself; otherwise, the faculty advisor may read the review aloud. Following the public defense, the research supervisory committee further examines the candidate in a closed session — the external reviewer can be included in the closed session by supervisory committee invitation.

To successfully defend the dissertation, the candidate must effectively apply the scientific method, demonstrate the significance of their contributions to the state of the field, and professionally communicate the results in written and oral form. Following the defense, the supervisory committee and the external reviewer (if any) dismiss the candidate and meet privately to discuss the candidate's work and defense performance. Votes to pass the candidate on both the dissertation and the oral defense are recorded by the committee alone; the external reviewer does not vote.

The committee may pass the candidate, fail the candidate, or pass them contingent upon the candidate successfully responding to issues with their defense (written, oral, or both). Ph.D. candidates have two opportunities to pass the dissertation defense in accordance with Graduate School policy. As recommended or required by the committee, changes to the dissertation must be incorporated into the student's dissertation document before obtaining final dissertation reading approval from the supervisory committee on the Final Ph.D. Examination form. After completion, department chair approval is necessary for submission to the Graduate School thesis editor.

Ph.D. Milestones

Students must complete the following milestones to receive their degree. These achievements must be registered in the College of Engineering Progress Tracker by uploading the appropriate forms or other documentation.

- Principal Investigator Offer Letter
- Establish a Supervisory Committee
- Preliminary Program of Study
- Written Qualifying Exam
- Research Proposal Exam
- Teaching Assistant Mentorship
- Seminar Presentation
- Final Program of Study
- Dissertation Defense
- *& Annual Committee Meetings*

Committee Meetings

Students must convene their supervisory committees at least once annually — and are encouraged to do so more frequently — to facilitate supervisory committee involvement. Meeting privately with individual committee members is encouraged but is not a substitute for regular meetings of the entire supervisory committee. The purpose of these meetings is for the committee as a whole to review the student's academic and research progress and discuss strategies for continued success. The student must ensure that the discussions and outcomes of these meetings are retained via one of the parties — themself or a committee member — taking notes or video recording. Subsequently, the student must generate written minutes from the notes or recordings, distribute them to the committee within two weeks of each meeting, and upload them as a permanent record in the COE Progress Tracker. Because the Research Proposal and Dissertation Defense are oral examinations, students are not responsible for recording or generating minutes for those two extraordinary committee meetings.

Inline Promotions

Milestone M.S. Passing this Written Qualifying Exam enables students to receive a milestone M.S. degree once they have also completed the coursework for a Course Option M.S. After their coursework is properly reflected in their official Preliminary Program of Study, Ph.D. students may file with the University for graduation with an M.S. degree, bestowed while they continue their doctoral research. However, students who are (or are likely to be) funded as Graduate Fellows should wait until they have received two full years of tuition benefit from the standard Tuition Benefit Program before filing for their M.S. degree. To maximize their tuition benefit eligibility, students should consult the Academic Graduate Advisor before applying to receive their milestone M.S. degree.

Ph.D. Candidacy. Students in any Ph.D. program at the University of Utah advance from Ph.D. students to Ph.D. candidates upon passing both their written and oral examinations. Within the BME Department, the Written Qualifying Exam satisfies the written exam requirement, and the Research Proposal satisfies the oral exam requirement. Although

students typically pass the written qualifying exam before completing their research proposal, these two requirements may be met in either order. Once a student has passed both requirements, they become a Ph.D. candidate.

Seminar Presentation

Students must deliver at least one oral podium presentation or seminar before applying to defend their dissertation. While the public defense ensures the students can present their work orally, this seminar requirement provides additional experience conveying scientific and engineering results to a general audience through public speaking in a formal setting. Generally, students should deliver a podium presentation at a regional, national or international conference or a seminar at an external university as an invited speaker. Poster presentations at such conferences do not satisfy this requirement. Conferences hosted at the University of Utah can meet this requirement so long as they are not strictly internal affairs. For example, the BME Department hosts an annual Utah Biomedical Engineering Conference (UBEC), which includes students and faculty from other universities throughout the Mountain West — students who deliver a podium presentation at UBEC have met the seminar presentation requirement.

Peer-Reviewed Publications

The primary requirement of the Ph.D. program is for students to demonstrate competency in independent research and advance the state of knowledge in biomedical engineering. To complete this requirement, a Doctoral Dissertation typically includes three or more peer-reviewed publications written by the candidate that have (or are expected to) appeared in supervisory committee-approved journals. While the candidate may contribute to additional publications during their graduate school experience, they should be the first author on at least three. Please see the University Policy on Determining Authorship for guidance on contributions meriting authorship. There is no explicit requirement that three manuscripts be published or even accepted for publication prior to the doctoral defense or final approval of the written dissertation. However, the quality and quantity of the dissertation must be commensurate with three peer-reviewed manuscripts, as determined by the supervisory committee. Therefore, the supervisory committee should be consulted for their expectations regarding the publication status of results before convening a dissertation defense.

Teaching Mentorship

Every Ph.D. student must fulfill the teaching mentorship requirement by completing 4 credit hours of the Teaching Assistant Mentorship course (BME 7880) by the end of their eighth non-summer semester. Students should coordinate with course instructors to reserve available teaching assistant slots in future semesters. However, teaching assignments are handled by the Director of Graduate Studies. They will be determined based on the department needs first, graduate track specialization second, and graduate student and course instructor preference third.

To earn TA Mentorship credit, a student may do one of the following:

- Complete two semesters as a Half TA (2 credits each) of BME 7880 with an approved course: an average time commitment of 10 hours per week for the duration of each semester. This option is especially attractive for students seeking to TA the same class in two consecutive years.
- Complete one semester as a Full TA (4 credits) of BME 7880 with an approved course: average time commitment of 20 hours each week for the duration of the semester.

The department discourages students from serving as a TA before their fifth non-summer semester in graduate school; the first four non-summer semesters should be reserved for taking classes and initiating research projects in their chosen labs. With the required course load diminishing in their third year of graduate school, students have the extra time to commit to teaching. Students who have not secured one or more courses to TA by the end of their sixth non-summer semester will be assigned courses to TA by the Director of Graduate Studies.

Teaching Assistantship requirements also include:

- TAs must be proficient in the English language to interact with students effectively. The Graduate School requires all non-native English-speaking graduate students to be cleared by the International Teaching Assistant Program before any teaching is allowed. Thus, this clearance is compulsory for all international Ph.D. students in BME.
- TAs must strictly abide by the regulations outlined in the Family Educational Rights and Privacy Act or FERPA. This federal law protects the privacy of educational records of students. Information regarding FERPA is available at www.registrar.utah.edu/faculty/ferpa-resources.php.

- TAs must attend mandatory training provided by the College of Engineering (COE) near the start of each semester. The student must ascertain the time and location of this once-per-semester offering from the COE.
- TAs must meet with their assigned course instructor(s) before the beginning of the semester to initiate organization and identify the expectations of the TAs' roles and duties.
- Unless otherwise instructed, TAs are expected to attend all their assigned course(s) lectures and be sufficiently familiar with the course materials to tutor the students effectively.
- TAs are expected to contribute in a substantive professional way to the pedagogical needs of their assigned course(s). The instructor and the nature of the course determine these needs. For example, TAs should expect to undertake the following activities: 1) deliver one or more course didactic lectures, 2) lead problem-solving or discussion sessions, 3) prepare laboratory equipment and supplies, and 4) grade homework, reports, and exams.
- Generally, this TA requirement is for credit. Most Ph.D. students are not eligible for paid TA positions until their four BME 7880 credit hours have been completed. However, Ph.D. students who were not Graduate Researchers (GRs) for the first semester of their Ph.D. program may be compensated while serving as a TA. If a student is supported as an RA, that support should typically continue during their TA assignments.

Unsatisfactory student TA performance, either paid or through the BME 7880 requirement, will be subject to review and possible punitive responses, including repeating the TA requirement. TA workshops and online teaching resources are available through the Center for Teaching and Learning Excellence at the University of Utah.

II.A.2a. M.D./Ph.D. Program

The M.D./Ph.D. program provides an outstanding education for future physician-scientists. Students develop clinical skills and engage in rigorous scientific training. Through our top medical program and exceptional BME doctoral program, we prepare students for careers as biomedical researchers and clinician-scientists.

M.D./Ph.D. Admissions

The M.D./Ph.D. program admissions criteria are the same as the M.D. program but with a greater emphasis on research experience. Please refer to the Preparing for Medical School website for details about premedical coursework and eligibility. The MD-PhD Program Admissions website includes detailed information on admissions standards, policies, and procedures.

Initial M.D./Ph.D. program applications must be submitted to the American Medical College Application Services (AMCAS) and are only available to U.S. citizens or permanent U.S. residents. We encourage applications from qualified students nationwide. Applicants will complete two additional essays for the M.D./Ph.D. Program application: the MD-PhD Essay and a Significant Research Essay.

Applicants must have MCAT scores of 500 or higher and grade point averages above 3.0; GRE scores are waived in lieu of MCAT scores. Competitive applicants will have substantial experience in community/volunteer service, leadership, physician shadowing, patient exposure, and an academic career with a strong research focus.

If admitted by the School of Medicine, an additional application for admission to the BME department Ph.D. program must be submitted through the SLATE electronic application system by April 1 of the year the student intends to begin their Ph.D. — i.e., typically during their second year of medical school. See the BME department Application Procedure for details.

M.D./Ph.D. Curriculum

In addition to the courses required by the Medical School, M.D./Ph.D. students must complete at least 14 credit hours of BME coursework and 38 credit hours of Dissertation Research (BME 7970). The 14 credit hours of coursework must include the (minimum 6 credit hours of) Biomedical Engineering Fundamentals required for their chosen track specialization. The Medical School curriculum satisfies the Life Science Fundamentals (6 credit hours) and the Scientific Communication Fundamentals (5 credit hours) requirements of the BME program, as well as 5 credit hours of graduate electives. The TA Mentorship requirement (BME 7880) is waived for M.D./Ph.D. students. Although students are encouraged to TA, credits earned for BME 7880 will not count toward the requisite 14 BME coursework credits.

Typical M.D./Ph.D. Students Timeline

Summer 0	*- Lab rotation with Biomedical Engineering faculty (optional but encouraged)*
Academic Year 1	- Medical School Year 1
Summer 1	- Lab rotation with Biomedical Engineering faculty
Academic Year 2	- Medical School Year 2 - Select PhD faculty advisor, lab & project and submit SLATE application to the BME Department - Complete STEP 1 exam and request Leave of Absence from MD program
Summer 2	- Work on PhD research - Establish PhD Supervisory Committee
Academic Year 3	- Work on PhD research - Start PhD coursework* and Submit Preliminary Program of Study** - Prepare for PhD Written Qualifying Exam
Summer 3	- Work on PhD research - Pass for PhD Written Qualifying Exam
Academic Year 4	- Work on PhD research - Finish PhD coursework and submit Final Program of Study - Complete PhD Research Proposal***
Summer 4	- Work on PhD research - Present a Seminar or oral conference presentation
Academic Year 5	- Complete PhD research - Defend PhD Dissertation (by the end of Spring 5)
Summer 5	- Finalize PhD Dissertation review/release process with the Thesis Office
Academic Year 6	- Medical School Year 3
Summer 6	- Optional Post-Doc work in mentor's lab
Academic Year 7	- Medical School Year 4 - Graduate with M.D. and Ph.D. degrees

** MD/PhD students may participate in the eXtended Tuition Benefit Program (xTBP) if paid from qualifying grants and meet the xTBP eligibility requirements. The xTBP program may support up to 24 credit hours of tuition per year: 9-12 per academic semester and 0-6 per summer — details at gradschool.utah.edu/tbp/guidelines.*

*** By the end of Academic Year 3, each student is expected to form a 5-member PhD supervisory committee, with 3 BME tenure-line faculty members, 1 MD/PhD Operations Committee faculty member, and one outside faculty member. Additionally, they will select a Biomedical Engineering Graduate Specialization Track.*

**** MD/PhD students must present their Research Proposal no later than the Spring semester of year 4.*

II.B. BME CORE CURRICULUM

The Biomedical Engineering Department's core curriculum builds upon course material introduced in undergraduate biology, chemistry, physics, mathematics, and engineering. Building on that undergraduate knowledge, students must complete the graduate core curriculum (or committee-approved substitutes) as part of the required 30 course credit hours minimum beyond the baccalaureate level.

Coursework should align with students' educational goals and track specialization, and be an approved part of their program of study. Supervisory committees may require students to take additional courses to supplement their academic background, qualifying exam performance, or knowledge in their research focus area. The minimum allowable grade for any course counted toward the requirements for a student's graduate degree in Biomedical Engineering is a B-. For information on using previously earned credit hours toward a current degree program, please see the Graduate Program Transfer Credits section.

Students should take the core curriculum and all other courses through BME Department, designated with a "BME XXXX" course number, whenever possible. If a BME graduate student takes a course cross-listed with another department or program, they must register for the "BME XXXX" version; courses taken under the cross-listed department or program number will not be eligible for Program of Study consideration.

II.B.1. Life Science Fundamentals

Graduate students with a documented background in the life sciences must take a minimum of 6 credit hours of advanced life science courses (6000 level), including at least 3 credits of systems physiology coursework and 3 credits of cell-and-molecular biology coursework. Approved courses for each category are listed below.

Some graduate students may have already taken, and earned exemplary grades in, courses commensurate with the nominally required graduate-level physiology or cell-and-molecular biology courses listed below. Those students may substitute required physiology or cell-and-molecular biology for equivalent credits from other life science courses.

Graduate students without a background in the life sciences — e.g., those with undergraduate degrees in mathematics, physics, or an engineering discipline other than biomedical — are expected to take another 3 credits, for a total of at least 9 credit hours of advanced life science courses.

Approved Systems Physiology Courses

BME 6000	Systems Physiology: Cardiac, Respiratory & Renal	4 credits
BME 6430	Systems Neuroscience	4 credits

*Potential Substitutes for Students with Substantial Prior Exposure to Physiology**

BME 6003	Cellular Electrophysiology and Biophysics	3 credits
BME 6230	Functional Anatomy for Engineers	3 credits
BME 6460	Electrophysiology & Bioelectricity of Tissues	3 credits

**Substitutions require a petition approved by Supervisory Committee and Director of Graduate Studies.*

Approved Cell or Molecular Biology Courses

BME 6303	Cell and Tissue Engineering: Stem Cells in Tissue Eng.	3 credits
NEUSC 6040	Cellular and Molecular Neuroscience	4 credits

*Potential Substitutes for Students with Substantial Prior Exposure to Cell & Molecular Biology**

BME 5306	Genetic Engineering and Synthetic Biology	3 credits
BME 6002	Molecular Biophysics	3 credits
BME 6305	Cell & Tissue Engineering: Organ Design	3 credits

**Substitutions require a petition approved by Supervisory Committee and Director of Graduate Studies.*

All substitutions must be approved by the student's supervisory committee and, subsequently, the Director of Graduate Studies. When considering substitutions, committees may ask for relevant transcripts and syllabi.

Committees should consider the breadth of a student's life science background, the sophistication depth of the courses taken, the student's performance in those courses, and the relevance of the substitute life science courses to the student's program of study and career goals. Committees should exercise considerable restraint when entertaining substitutions for students with minimal life science experience and, conversely, should exercise considerable flexibility when entertaining substitutions for students with solid life science backgrounds.

II.B.2. Scientific Communication Fundamentals

All graduate students must take at least 1.0 credit hours of the BME Department Seminar (BME 6090), offered for 0.5 credits every semester. M.S. students must take this course in each of their first two semesters.

BME 6090	BME Department Seminar	0.5 Credits
BME 6090	BME Department Seminar	0.5 Credits

Additionally, Ph.D. students must take a 4.0 credit hour writing and presentations course sequence. Students should take the first of these (BME 7070) in their second spring semester and the second (BME 7071) in the subsequent fall semester. In these courses, students write fellowship proposals for external funding and develop the oral component of the Research Proposal.

BME 7070	Proposal Writing and Presentations I	2 Credits
BME 7071	Proposal Writing and Presentations II	2 Credits

Substitutions for the BME Department Seminar will be considered only under extenuating circumstances — e.g., for a student on an otherwise accelerated timeline with a required course time conflict — and must be replaced with another seminar course of commensurate load and sophistication. Substitutions for either course in the writing and presentations sequence will be considered rarely and only if a student has wholly passed their research proposal. M.D/Ph.D. students are exempt from the 4.0 credit hour writing and presentation requirement.

II.B.3. Track Specialization Fundamentals

Each BME track specialization requires graduate students to take at least 6 credit hours of engineering fundamentals courses appropriate for their track, as detailed in the Graduate Track Specialization section. Some graduate students may have taken, and earned exemplary grades in, courses commensurate with those nominally required by their track specialization. Those students may substitute their track fundamentals credits for an equivalent number of credits relevant to their academic pursuits. Regardless of track, a student's program of study must include at least 6 credit hours of track fundamentals or approved substitutions.

Graduate students without a background in engineering or the technical sciences — e.g., those with undergraduate degrees in biology or chemistry — may be required to complete independent self-study or prerequisite coursework before enrolling in their engineering track fundamentals courses. Additionally, students in this category are expected to take an additional 3 credits from the track, for a total of at least 9 credit hours of engineering track fundamentals. Note that this additional requirement does not apply to all track specializations because some tracks require 9 or more credits of engineering track fundamentals for all of their graduate students.

II.B.4. Core Curriculum Substitutions

Some students may have preexisting knowledge or expertise equivalent to the BME Department's requirements in the core curriculum, typically from previous degrees or academic experiences. Such students may consider alternative courses, still relevant to the fundamental areas of study, that would better meet their needs and interests. Any core curriculum substitutions must be requested in the form of a petition to be approved by the supervisory committee before evaluation by the Director of Graduate Studies. Substitution petitions should indicate the following:

- The student's experience/background in the core area, including a list of specific courses and when taken.
- The reason(s) the proposed course(s) meets the aim/scope of a fundamental requirement in that area.
- The student's research focus and why the proposed course(s) would be in their best interest.

Petitions will be attached to and submitted with the M.S. Program of Study (or Ph.D. Preliminary Program of Study) for their supervisory committee's approval. Once signed by all committee members, the combined paperwork should be submitted to the Graduate Academic Advisor, who will ensure its consideration by the Director of Graduate Studies.

II.B.5. BME Department Seminar

During the academic semesters, the department hosts topical seminar speakers every 1-2 weeks. These speakers are leaders in their fields from both the University of Utah and outside institutions. All graduate students are expected to attend whether or not they are registered for the BME 6090 course. This seminar is an integral part of our biomedical engineering community; many good ideas come from listening to seminars on topics outside the student's dissertation research area. Although attendance is not taken at these seminars, it is clear to the faculty, committee members, and the BME department administration who attends the seminars and how often. All biomedical engineering graduate students are expected to attend these seminars without exception.

II.C. GRADUATE TRACK SPECIALIZATION

The graduate program provides an educational framework that encourages students to excel in a chosen track specialization by building relevant technical competence. The graduate track specializations form the basis of Ph.D. writing qualifying exams and M.S. programs of study. Each graduate track specialization is led by a track director who must be a primary faculty member of the BME department. The track director guides the track's curricular content, establishes and oversees track courses, develops track requirements, recruits prospective graduate students, and advises students preparing for their M.S. comprehensive exam or their Ph.D. written qualifying exam. Because those exams are structured around the track specializations, courses completed within the track serve as partial preparation.

Students should take track specialization and all other courses through BME Department, designated with a "BME XXXX" course number, whenever possible. If a BME graduate student takes a course cross-listed with another department or program, they must register for the "BME XXXX" version; courses taken under the cross-listed department or program number will not be eligible for Program of Study consideration.

II.C.1. BIOINNOVATE

Dr. Robert Hitchcock, Track Director

- Medical Device Design and Development
- Translational Strategy Development

The bioInnovate track aims to provide a comprehensive biomedical device design training program using a multidisciplinary, hands-on teaching approach in classroom, clinical, and laboratory settings. The track focuses students on clinical problem identification, medical device innovation, and commercial translation; all within the regulatory framework of the FDA. Students immerse themselves within clinical environments and learn to evaluate observed procedures and medical devices to uncover unmet clinical needs. Student teams further develop these ideas into testable prototypes and potential businesses by refining these needs into feasible medical device products with commercial potential. Upon completion of the bioInnovate track, students will be able to: 1)Understand and apply 21 CFR 820.30 (Design Control) and ISO 13485 7.3 (Design and Development) in the design and development of medical devices; 2) Develop a business strategy, identify potential funding sources, and outline a business model for a medical device startup company; 3) Understand how medical devices interact with complex biological systems; 4) Develop a medical device using various design tools and methods; 5) develop and implement a regulatory strategy for FDA submission.

Students in the bioInnovate track are expected to have general knowledge in the field. General knowledge includes: Observe and identify unmet needs in clinical environments; Apply relevant standards for a new medical product; Evaluate a new medical product using ISO 14971 (Application of Risk mgt for Medical Devices); Evaluate the intellectual property landscape for a new medical device idea; Develop a verification and validation plan for a new medical product; Develop and implement a regulatory strategy; Work effectively in multidisciplinary teams in asynchronous environments.

A student's program of study should include a hierarchy of courses selected to develop expertise in a focus area within bioInnovate. A typical plan of study should consist of approximately five specialized courses and the bioInnovate track fundamentals to reach the course credit requirement. The specific courses should be selected individually to maximize expertise in an area closely related to the student's project, thesis, or dissertation.

bioInnovate Students

M.S. students within this specialization must successfully complete the course requirements outlined below, as well as those required for the M.S. degree program.

Ph.D. students in the bioInnovate track specialization must pass the bioInnovate written qualifying exam. The purpose of the Ph.D. written qualifying exam in this track is to verify students' proficiency in the fundamental principles of Biomedical Engineering, regulatory compliance, medical device innovation, and translational strategy development. Students should take the exam in their second year of study. Although the specific content of the exam changes each

year, approximately 50% of the exam covers material from the Bioinnovate track fundamentals courses, and the remaining 50% from student elective classes.

bioInnovate Courses

Life-Science Fundamentals

Students in this track must follow the standard guidelines relevant to their Life-Science Fundamental courses.

bioInnovate Track Fundamentals

Mandated: 2 of 2 required

BME 6081	Biomedical Device Innovation I	4 Credits
BME 6082	Biomedical Device Innovation II	4 Credits

Selected: 2 of 4 required

BME 6250	Biomechanics II	3 Credits
BME 6302	Biomaterials II	3 Credits
BME 6401	Medical Imaging Systems	3 Credits
BME 6440	Neural Engineering	3 Credits

Strongly recommended to take concurrently with BioInnovate (BME 6081-6082)

BME 6181	Clinical Problem Solving Through Strategic Analysis I	3 Credits
BME 6182	Clinical Problem Solving Through Strategic Analysis II	3 Credits

Additional recommended track courses

BME 5110	Regulatory Affairs I	3 Credits
BME 5120	Regulatory Affairs II	2 Credits

bioInnovate Advanced Electives

College of Engineering

BME 6421	Fundamentals of Micromachining	3 Credits
BME 6701	Microfluidic Chip Design and Fabrication	3 Credits
CH EN 6230	Biodevices and Sensors	3 Credits
ME EN 5510	Design of Experiments	3 Credits
ME EN 6010	Principles of Manufacturing Processes	3 Credits
ME EN 6030	Reliability Engineering	3 Credits
ME EN 6040	Quality Assurance Engineering	3 Credits
ME EN 6050	Fundamentals of Micromachining Processes	3 Credits
ME EN 6100	Ergonomics	3 Credits
ME EN 6120	Human Factors in Engineering Design	3 Credits
ME EN 6250	Object-Oriented Programming for Interactive Systems	3 Credits
ME EN 6620	Fundamentals of Microscale Engineering	3 Credits
MSE 5510	Materials Innovation	3 Credits

David Eccles School of Business

ENTP 6810	Venture Foundations	1.5 – 3 Credits
FINAN 5300	New Venture Finance	3 Credits
FINAN 6300	Venture Capital	1.5 Credits
MBA 6860	Technology Commercialization	3 Credits
MKTG 6715	Entrepreneurial Marketing	1.5 Credits
MST 6020	Effective Leadership and Management for Scientists	1 Credit
MST 6022	Production and Operations Management for Scientists	1 Credit
MST 6600	Applied Statistical Techniques	3 Credits
STRAT 5750	Profiles of Leadership	1 – 3 Credits

STRAT 6710	Strategy and Technology	1.5 – 3 Credits

S.J. Quinney College of Law

LAW 7065	Intellectual Property	3 – 4 Credits
LAW 7760	Patent Law	3 Credits

II.C.2. BIOMATERIALS AND THERAPEUTICS

Dr. Tara Deans, Track Director

- Biomedical Polymers
- Biomolecular Engineering
- Synthetic Biology
- Tissue Engineering
- Drug Delivery and Nanomedicine

The Biomaterials and Therapeutics track covers an interdisciplinary field focused on the physical and biological study of biomaterials and drug delivery systems and their applications to modern biomedical problems. It encompasses synthetic materials, macromolecules, bioconjugates, modern drug delivery systems, genetically programmed materials and networks, composites and hybrid materials, cell-material combinations, and self-assembling systems, as well as their interactions with biological environments and physiological systems. Students in the Biomaterials and Therapeutics track should understand the relationships between the structure and designs of biomaterials, synthetic biology, and drug delivery systems and their interactions with complex biological systems.

Biomaterials and Therapeutics Students

M.S. students within this track must complete the course requirements for the program and track as outlined below.

Ph.D. students within this track must complete the course requirements for the program and track as outlined below. The biomaterials track Ph.D. qualifying exam is divided into two sessions. The morning session comprises two questions, both based on the required BME 6302 Biomaterials course. The afternoon session is based on elective courses; it typically includes 8-12 questions of which students need to answer four.

Biomaterials and Therapeutics Courses

Life-Science Fundamentals

Students in this track must follow the standard guidelines relevant to their Life-Science Fundamental courses.

Biomaterials Track Fundamentals

Mandated: 1 of 1 required

BME 6302	Biomaterials II	3 Credits

Selected: 1 of 3 required

BME 6250	Biomechanics II	3 Credits
BME 6401	Medical Imaging Systems	3 Credits
BME 6440	Neural Engineering	3 Credits

Biomaterials and Therapeutics Electives

Biomedical Engineering

BME 6140	Fundamentals of Tissue Engineering	2 Credits
BME 6405	Nanomedicine	3 Credits
BME 7160	Physics Nature of Surfaces	3 Credits

Pharmaceutics

PHCEU 7011	Fundamentals of Pharmacokinetics	3 Credits
PHCEU 7030	Macromolecular Therapeutics and Drug Delivery	4 Credits

PHCEU 7040	Biotechnology	4 Credits

II.C.3. BIOMECHANICS

Dr. Jeffrey Weiss, Track Director

- Molecular, Cell, Tissue, Organ and System Level Biomechanics
- Biosolids, Biofluids, and Biofluid-solid Interactions
- Biophysics
- Computational Biomechanics
- Mechanobiology

Biomechanics is a broad field directed at applying the principles of engineering mechanics, across multiple length scales, to the study of biology and medicine. Topics in biomechanics range from understanding the role of stress in cytoskeleton dynamics as related to cell growth, migration, and adhesion to establishing patient-specific modeling techniques that predict in vivo biomechanical loading environments. The University of Utah has faculty conducting biomechanics research in the following areas: molecular biomechanics, cellular biophysics, cell mechanotransduction, computational biomechanics, hemodynamics, mechanobiology, medical device design, soft tissue mechanics (arteries, cartilage, ligaments), ocular biomechanics, orthopedic biomechanics, cardiovascular biomechanics, tissue engineering, and traumatic brain injury. Given the broad range of biomechanics research at the University of Utah, with faculty spanning numerous departments, there exist ample collaborative opportunities and interdisciplinary projects with faculty in the College of Engineering, College of Science, Huntsman Cancer Institute, School of Medicine, and the Scientific Computing and Imaging (SCI) Institute. The Biomechanics track aims to provide students with a strong, quantitative foundation in engineering mechanics, physiology, and medicine that will serve them equally well for careers in academia or industry.

Biomechanics Students

M.S. students within this track must complete the Biomechanics Track Fundamental Courses. Please note that some courses are offered every other year, so students should plan accordingly.

Ph.D. students within this specialization must successfully complete the Biomechanics Track Fundamental Courses and the Biomechanics Track Elective Courses that support the student's area of research. The written qualifying exam ensures students are competent in biomechanics's theoretical and conceptual fundamentals before undertaking intensive research in their selected field of study. Students are expected to be proficient in the following topics: index and direct notation, finite deformation kinematics, concepts of stress and strain, constitutive relations, linear elasticity, material behavior of biological materials, hyperelasticity, mixture theory, and fluid mechanics. These topics are covered in the Biomechanics Track Fundamental courses, and material for the written qualifying exam will come from these courses. Additional information on the written qualifying exam can be obtained by contacting the track director. Students should take the written qualifying exam after completing the second year of study.

Biomechanics Courses

Life-Science Fundamentals

Following department guidelines, students must take at least one Life-Science Fundamentals course in cell & molecular biology credits. Students in the Biomechanics track must satisfy this requirement with BME 6002:

BME 6002	Molecular Biophysics	3 Credits

Following department guidelines, students must take at least one Life-Science Fundamentals course in systems physiology. Students in the Biomechanics track should take at least one of the following courses:

BME 6000	Systems Physiology	4 Credits
BME 6230	Functional Anatomy for Engineers	3 Credits

Biomechanics Track Fundamentals

Students in this track must complete at least 11 credits of Biomechanics Track Fundamentals. Completing these core courses and proficiency in their content is required to pass the written qualifying exam and the research proposal, which satisfies the University's oral qualifying exam requirement. The Ph.D. qualifying exam and M.S. comprehensive exam will cover topics from these required courses; track faculty will provide guidance on preparing for those exams.

BME 5250	Biomechanics II*	3 Credits
BME 6210	Computational Biomechanics† (*fall semester, even years*)	3 Credits
BME 6220	Biofluid Mechanics† (*spring semester, even years*)	3 Credits
BME 6280	Biomechanics Research (3x)	3 Credits

** Students unfamiliar with Biomechanics I must audit BME 4250 (Biomechanics I) prior to enrolling in BME 5250.*

†In years when either of these courses are not offered, students must confer with their committees to identify acceptable substitutions. Further, M.S. students need to take only one of these courses to satisfy the Biomechanics Fundamentals; however, the remaining 2 credits must still be completed through any of the courses listed below.

Biomechanics Advanced Electives

Optimal course selection will depend on a student's project, thesis, dissertation, or area of interest. Students should choose courses that provide both the scientific background and the technical skills required to conduct their research. A typical set of elective courses would include approximately three specialized courses in addition to the Biomechanics Fundamentals. Some example courses that have been included in programs of study are provided below, organized by the parent department. Note that this list is not comprehensive, and courses outside this list are very commonly included in the program of study. The specific set of courses should be selected on an individual basis, in consultation with the faculty advisor and supervisory committee, to maximize expertise in the area most closely related to the student's interest.

Department of Biomedical Engineering

BME 6303	Cell and Tissue Engineering: Stem Cells in Tissue Engineering	3 Credits
BME 6305	Cell and Tissue Engineering: Organ Design	3 credits
BME 6401	Medical Imaging Systems	3 Credits
BME 6500	Mathematics of Imaging	3 Credits
BME 6702	Introduction to Image-based Modeling	2 Credits
BME 7320	3D Reconstruction Techniques in Medical Imaging	3 Credits

School of Computing

CS 6005	Programming for Engineers	3 Credits
CS 6210	Advanced Scientific Computing I	3 Credits

Department of Mathematics

MATH 5610	Introduction to Numerical Analysis I	4 Credits
MATH 5620	Introduction to Numerical Analysis II	4 Credits
MATH 6420	Partial Differential Equations	3 Credits
MATH 6610	Analysis of Numerical Methods I	3 Credits
MATH 6620	Analysis of Numerical Methods II	3 Credits
MATH 6830	Mathematical Biology I	3 Credits

Department of Mechanical Engineering

ME EN 6510	Applied Finite Elements	3 Credits
ME EN 6515	Theory of Linear FEM	3 Credits
ME EN 6530	Continuum Mechanics	3 Credits
ME EN 6700	Intermediate Fluid Dynamics	3 Credits
ME EN 6720	Computational Fluid Dynamics	3 Credits
ME EN 7540	Advanced Finite Elements	3 Credits
ME EN 7525	Inelasticity	3 Credits

II.C.4. CARDIOVASCULAR ENGINEERING

Dr. Rob MacLeod, Track Director

- Membrane: ion transport, ionic channels, molecular mechanisms
- Cell: action potentials, metabolism, contraction
- Cardiac tissues/whole-heart: spread of excitation, arrhythmias, ischemia, heart failure
- Whole body: electrocardiology, bioelectricity, ECG
- Methods/techniques: experimental, imaging, signal processing, modeling and simulation, data science

Cardiovascular Engineering is a discipline that covers a wide range of topics related to the function of the cardiovascular system, mechanisms and detection of cardiovascular diseases, and their treatment. Cardiovascular engineering includes basic science and translation to clinical use and spans the spectrum from the molecular scale to the complete body. Research in cardiovascular engineering addresses some of the most basic questions of how cells, organs, and the body function. The research also seeks to develop diagnostic approaches, interventions, and biomedical devices that profoundly impact the treatment of patients with cardiac diseases. Despite dramatic improvements in clinical diagnosis and care, cardiovascular diseases remain the leading cause of death in developed countries. Research in cardiovascular engineering uses the most advanced technologies in areas such as molecular and cellular biology, bioinstrumentation, imaging across many modalities, signal and image processing, machine learning, mathematical simulation and modeling, data science, and all aspects of computer technology.

As a result of this diversity of biomedical and technical research, students with graduate training in cardiovascular engineering receive a broad education in physiology, cardiac diseases, and biomedical technology. The graduates will be exceptionally well equipped for careers in academia and industry. The program makes use of background courses from several departments as well as specialized training in the discipline through both courses and extensive laboratory experiences. Because of the outstanding research emphasis on cardiovascular engineering at Utah, there also exist rich opportunities for interaction with a wide range of experts in the field and involvement in interdisciplinary projects within teams of related researchers and students.

Cardiovascular Engineering Students

M.S. students within this specialization must successfully complete the course requirements outlined below, as well as the total course credit hour requirement of the M.S. degree program.

Ph.D. students in this track specialization are expected to have general knowledge of physiology and cell biophysics, tissues and whole hearts, and one special application subfield. For example, a student who applies computational methods to problems in cardiac electrophysiology should have knowledge of computation and electrophysiology. The material for the qualifying exam will be based on topics covered in three required courses: BME 6000, BME 6003, and BME 6460. There will be a strong emphasis on the integration of physiology across scales, explaining, for example, features of the body-surface ECG from cellular and tissue-level behavior of the heart.

Cardiovascular Engineering Courses

Life-Science Fundamentals

In addition to the standard guidelines for their Life-Science Fundamentals, students in this track must take the following course to satisfy the physiology credits of the life-science fundamental requirement.

BME 6000	Systems Physiology I: Cardiovascular, Respiratory and Renal Systems	4 Credits

Cardiovascular Track Fundamentals

Mandated: 2 of 2 required

BME 6003	Cellular Electrophysiology and Biophysics	3 Credits
BME 6460	Electrophysiology and Bioelectricity of Tissues	3 Credits

Selected: 1 required, more recommended

BME 5480	Ultrasound	3 Credits

BME 6002	Molecular Biophysics	3 Credits
BME 6330	Principles of Magnetic Resonance Imaging (MRI)	3 Credits
BME 6401	Medical Imaging Systems	3 Credits
BME 6433	Biological Statistical Signal Processing	3 Credits
BME 6440	Neuro Engineering and Neuro Robotics	3 Credits
BME 6640	Introduction to Image Processing	3 Credits
BME 6900	Programming for Engineers (COMP 5005)	3 Credits

Cardiovascular Engineering Advanced Electives

Biomedical Engineering

BME 5110	Introduction to Regulatory Affairs	3 Credits
BME 7320	3-D Reconstruction Techniques in Medical Imaging	3 Credits

Biology

BIOL 5110	Molecular Biology and Genetic Engineering	3 Credits
BIOL 5210	Cell Structure and Function	3 Credits
BIOL 5910	Mathematical Models in Biology	3 Credits
BIOL 6290	Fundamentals of Biological Microscopy	3 Credits
BIOL 6500	Advanced Statistical Modeling for Biologists	3 Credits

Computer Science

COMP 5360	Intro to Data Science	3 Credits
COMP 5960	Foundations of Data Analysis	3 Credits
CS 6210	Scientific and Data Computing I	3 Credits
CS 6220	Scientific and Data Computing II	3 Credits
CS 6300	Artificial Intelligence	3 Credits
CS 6350	Machine Learning	3 Credits
CS 6353	Deep Learning	3 Credits
CS 6630	Visualization for Data Science	3 Credits
CS 6635	Visualization for Scientific Data	3 Credits
DS 5530	Database Systems	3 Credits
DS 6140	Data Mining	3 Credits

Electrical & Computer Engineering

ECE 5510	Random Processes	3 Credits
ECE 6360	Bioinstrumentation	3 Credits
ECE 6530	Digital Signal Processing	3 Credits
ECE 6960	Deep Learning in Image Analysis	3 Credits

Mathematics

MATH 5040	Stochastic Processes and Simulation I	3 Credits
MATH 5050	Stochastic Processes and Simulation II	3 Credits
MATH 5110	Mathematical Biology I	3 Credits
MATH 5120	Mathematical Biology II	3 Credits
MATH 5410	Introduction to Ordinary Differential Equations	4 Credits
MATH 5440	Introduction to Partial Differential Equations	3 Credits
MATH 5470	Chaos Theory	3 Credits
MATH 5600	Survey of Numerical Analysis	4 Credits
MATH 5610	Introduction to Numerical Analysis I	4 Credits
MATH 5740	Mathematical Modeling	3 Credits
MATH 6720	Applied Complex Variables & Asymptotic Methods	3 Credits

Neuroscience

NEUSC 6040	Cellular and Molecular Neuroscience	4 Credits
NEUSC 6050	Principles of Systems Neuroscience	4 Credits

Physics

PHYS 5730	Statistical and Computer Methods in Physics	4 Credits
PHYS 6720	Introduction to Computing in Physics	4 Credits

II.C.5. Data Science and Computation

Dr. Orly Alter, Track Director

- Cellular Systems Biomedical Engineering
- Cellular Synthetic Biomedical Engineering
- Computational Data Science, and Mathematical and Statistical Modeling
- High-Throughput Molecular Biotechnologies

Data science and computation is an emergent field that combines experimental, computational, and theoretical methods to solve challenging biomedical problems. Data science and computation is based on a holistic approach of integrating large amounts of molecular information to elucidate the relationships between genotype and phenotype. This multi-scale understanding of biological systems will help answer important questions about physiological systems, human disease, and therapeutic strategies. Computational synthetic biomedical engineering is the design and construction of biological systems from molecular biological components for useful purposes. Such systems have applications in a wide range of complex biomedical problems.

Multiscale modeling of biophysical systems integrates structurally and functionally across scales biological organization. It is based on developing and combining simulation methods to elucidate complex relationships across biological processes, that span length and time scales of many orders of magnitude, starting from atoms, molecules and macromolecules, up to cells and organisms. A multi- scale understanding of how biological systems work will help answer important questions about physiology, human disease, and therapeutic strategies, which are key to the progress of biomedical engineering.

These fields' greatest challenges are obtaining, manipulating, and interpreting massive datasets. Research in this area also requires a multi-scale understanding of the system of interest, from molecules to cells, to organisms to ecosystems. Computational systems and synthetic biomedical engineering draw from a wide range of specialties — including mathematical modeling, scientific computing, signal processing, molecular biology, and high-throughput technologies — to provide a unique approach to solving biomedical problems.

Data Science and Computation Students

This track draws from the rich set of resources available at the University of Utah to provide students with valuable interdisciplinary academic and research experiences. Students receive training in desirable skills, including large-scale data analysis and genomic technologies, making them well-suited for careers in academia, industry, and government.

Because computational systems and synthetic Biomedical Engineering are inherently interdisciplinary, the program supplements a strong Biomedical Engineering core with courses from a variety of departments. Below are summaries of the proposed course and research requirements for the track.

Data Science and Computation Courses

Life-Science Fundamentals

Students in this track must follow the standard guidelines relevant to their Life-Science Fundamental courses.

Data Science and Computation Track Fundamentals

Mandated: 1 of 2 required

BME 6770	Genomic Signal Processing	3 Credits

BME 6780	Data Science for Bioengineers	3 Credits

Selected: 1 of 5 required

BME 6210	Computational Biomechanics	3 Credits
BME 6401	Medical Imaging Systems	3 Credits
BME 6440	Neuro Engineering and Neuro Robotics	3 Credits
BME 6770	Genomic Signal Processing	3 Credits
BME 6780	Data Science for Bioengineers	3 Credits

Data Science and Computation Advanced Electives

Biological Chemistry

BLCHM 6400	Genetic Engineering	2 Credits

Biology

BIOL 5110	Molecular Biology and Genetic Engineering	3 Credits
BIOL 5120	Gene Expression	3 Credits
BIOL 5140	Genome Biology	3 Credits
BIOL 5920	Advanced Eukaryotic Genetics	3 Credits
BIOL 6500	Advanced Statistical Modeling for Biologists	3 Credits

Biomedical Informatics

BMI 6030	Foundations of Bioinformatics	2 Credits
BMI 6420	Advanced Biomedical Computing	2 Credits
BMI 6530	Bioinformatics Data Integration and Analysis	3 Credits

Computer Science

CS 6140	Data Mining	3 Credits
CS 6150	Advanced Algorithms	3 Credits
CS 6220	Advanced Scientific Computing II	3 Credits
CS 6350	Machine Learning	3 Credits
CS 6530	Database Systems	3 Credits
CS 7120	Information-Based Complexity	3 Credits

Electrical and Computer Engineering

ECE 6520	Information Theory	3 Credits
ECE 6530	Digital Signal Processing	3 Credits
ECE 6540	Estimation Theory	3 Credits
ECE 6550	Adaptive Filters	3 Credits
ECE 6570	Adaptive Control	3 Credits

Family and Preventive Medicine

PBHLT 6107	Survival Analysis	3 Credits
PBHLT 7120	Linear and Logistic Regression Models	3 Credits

Human Genetics

H GEN 6500	Human Genetics	3 Credits
H GEN 6503	Clinical Cancer Genetics	3 Credits

Mathematics

MATH 6770	Mathematical Biology I/II	3 Credits
MATH 6810	Stochastic Processes and Simulation I/II	3 Credits
MATH 6845	Ordinary Differential Equations and Dynamical Systems	3 Credits
MATH 6855	Survey of Numerical Methods	4 Credits
MATH 6860	Introduction to Numerical Analysis I/II	4 Credits

Medicine Clinical Research Center

MDCRC 6150	Foundations in Personalized Healthcare	2 Credits
MDCRC 6420	Genetics of Complex Diseases	1.5 Credits

Molecular Biology

MBIOL 6420	G3: Genetics, Genomes, and Gene Expression	3 Credits

II.C.6. IMAGING

Dr. Edward Hsu, Track Director

- Medical Imaging
- Optical Systems, Imaging Methods, and Hardware

Visualization of anatomical and physiological processes of the body plays an indispensable role in today's clinical healthcare and basic science research. The Imaging Track focuses on the interdisciplinary field of imaging, which encompasses hardware instrumentation, acquisition methodology, contrast agent development, post-processing analysis, and applying any combination of the above in biomedical research.

Imaging Students

The Imaging track curriculum covers the breadth and depth of training and prepares students for research in developing or applying biomedical imaging technologies. Students within this specialization must complete the course requirements outlined below and those required for their degree.

M.S. students within this track must successfully complete the course requirements outlined below. A student may petition for substitution(s). Additionally, the total course credit hour requirement of the M.S. degree program must be met.

Ph.D. students within this track are expected to have general familiarity of basic principles of imaging as well as image processing and analysis, and expert-level knowledge and understanding of their field of research including, if applicable, the anatomy and physiology of the organ systems of their studies. The written and oral qualifying exams will be based on (a) standard topics covered in the two required courses: BME 6401 Medical Imaging Systems and BME 6640 Introduction to Digital Image Processing, and (b) open-ended questions to evaluate the breadth and depth of understanding in students' areas of specialization.

Imaging Courses

Life-Science Fundamentals

Students in this track must follow the standard guidelines relevant to their Life-Science Fundamental courses.

Imaging Track Fundamentals

Mandated: 2 of 2 required

BME 6401	Medical Imaging Systems	3 Credits
BME 6640	Introduction to Digital Image Processing	

Selected: 1 of 3 required

BME 6250	Biomechanics II	3 Credits
BME 6302	Biomaterials II	3 Credits
BME 6440	Neural Engineering	3 Credits

Imaging Advanced Electives

Biomedical Engineering

BME 5480	Principles of Ultrasound	3 Credits

BME 6330	Principles of Magnetic Resonance Imaging (MRI)	3 Credits
BME 6500	Mathematical Foundations of Imaging	3 Credits
BME 7310	Advanced Topics in Magnetic Resonance Imaging (MRI)	3 Credits
BME 7320	3D Reconstruction Techniques in Medical Imaging	3 Credits

Pharmaceutics

PHCEU 7110	Molecular Imaging	2 Credits

II.C.7. NEUROENGINEERING

Dr. Rick Rabbitt, Track Director

- Electrophysiology
- Neural Imaging Analysis
- Neuromodulation
- Neuronal Modeling
- Neuroprostheses

The Neuroengineering Track trains students in the fields of basic and applied neuroscience and neuroengineering. This track aims to treat neural dysfunction with engineering approaches and repurpose strategies utilized by biological nervous systems to solve traditional engineering problems. Research specializations of BME faculty in this track include electrical neural interfaces and neuroprostheses; cell and chemical delivery systems for neural tissue; engineering of neural self-repair; neural plasticity; neural coding in sensory and motor systems; neural imaging; and non-traditional modes of stimulating neural tissue (e.g., focused ultrasound and magnetic stimulation)

Neuroengineering Students

Students in this track specialization are expected to have general knowledge in both basic and applied neuroscience.

M.S. students within this track complete the same fundamental courses as the Ph.D. students (see below). However, whereas Ph.D. students must take NEUSC 6040 Cellular & Molecular Neuroscience, M.S. students are given more flexibility to satisfy the Cell & Molecular Biology credits of their Life-Sciences Fundamentals requirement with any supervisory-committee approved cell/molecular biology course. Understanding cellular/molecular neuroscience is nonetheless required for any M.S. comprehensive exams: written, oral, project presentations, and thesis defenses.

Ph.D. students within this track must complete the courses listed below, intended to provide knowledge in the major areas of the field. A student's supervisory committee may grant exemptions to the following course requirements on a case-by-case basis, pending sufficient justification. However, these courses provide considerable assistance in preparing for the Neuroengineering written qualifying exam, which combines topics across courses; e.g., questions regarding cellular or systems neuroscience may be asked from a quantitative perspective. The written qualifying exam will draw from material covered in both required life-science fundamentals courses and all three required track fundamentals courses (excluding NERG). The exam aims to encourage students to approach their graduate education as an experience that transcends the boundaries of single courses; revisit the fundamental principles in basic and applied neuroscience; and consolidate, synthesize, and integrate this material. Students are encouraged to keep their course textbooks and use them to help prepare for the qualifying exam.

Neuroengineering Courses

Life-Science Fundamentals

As options in the standard guidelines for their Life-Science Fundamentals, students in this track must take the following courses to satisfy the physiology and cell/molecular biology requirements.

BME 6430	Systems Neuroscience*	4 Credits
NEUSC 6040	Cellular & Molecular Neuroscience	4 Credits

** Principles of Systems Neuroscience (NEUSC 6050) may not substitute for Systems Neuroscience (BME 6430).*

Neuroengineering Track Fundamentals

Mandated: 4 of 4 required

BME 6003	Cellular Electrophysiology and Biophysics	3 Credits
BME 6005	Computational Neuroscience	3 Credits
BME 6440	Neuro Engineering & Neuro Robotics	3 Credits
BME 6470	Neural Engineering Research Group (NERG) (2x)*	1 Credits

**Students are expected to participate in BME 6470 (NERG) even after completing their credit requirements.*

Neuroengineering Advanced Electives (Recommended)

Biomedical Engineering

BME 5480	Diagnostic & Therapeutic Ultrasound	3 Credits
BME 6000	Systems Physiology I: Cardiovascular, Respiratory and Renal Systems	4 Credits
BME 6002	Molecular Biophysics	3 Credits
BME 6230	Functional Anatomy for Engineers	3 Credits
BME 6330	Principles of Magnetic Resonance Imaging (MRI)	3 Credits
BME 6401	Medical Imaging Systems	3 Credits
BME 6433	Biological Statistical Signal Processing	3 Credits
BME 6460	Electrophysiology and Bioelectricity of Tissues	3 Credits
BME 6640	Introduction to Image Processing	3 Credits
BME 6900	Bioacoustics	3 Credits
BME 6900	Mathematical Tools for Neural Analysis	3 Credits
BME 6900	Programming for Engineers	3 Credits

Electrical & Computer Engineering

ECE 6520	Information Theory	3 Credits
ECE 6540	Estimation Theory	3 Credits

Neuroscience

NEUSC 6050	Principles of Systems Neuroscience	4 Credits
NEUSC 7750	Developmental Neurobiology	1.5 Credits
NEUSC 7790	Microscopy & Imaging	1.5 Credits

Computer Science

CS 6210	Advanced Scientific Computing I	3 Credits
CS 6355	Structured Prediction (machine learning)	3 Credits
CS 6955	Deep Learning (advanced neural networks and applications)	3 Credits
CS 7960	Neuromorphic Architectures (neural networks)	3 Credits

Mathematics

MATH 6070	Mathematical Statistics	3 Credits
MATH 6440	Advanced Dynamical Systems	3 Credits
MATH 6630	Numerical Solutions of Partial Differential Equations	3 Credits
MATH 6740	Bifurcation Theory	3 Credits
MATH 6770	Mathematical Biology I	3 Credits
MATH 6780	Mathematical Biology II	3 Credits
MATH 6790	Case Studies in Computational Engineering and Science	3 Credits

Mechanical Engineering

ME EN 7200	Nonlinear Controls	3 Credits
ME EN 7210	Optimal Controls	3 Credits

II.D. PROGRAM TIMELINES

The timelines for each degree program differ and are summarized below.

II.D.1. M.S. COMPLETION TIMELINE

Students typically graduate within two years of entering the M.S. program. However, some projects and methods require longer time commitments to complete their coursework, project, or thesis.

The time limit for completing the Biomedical Engineering M.S. degree is four years. If a student in good standing has not completed the program in 4 years, an extension may be requested with a letter of support from their faculty advisor to the Graduate School, justifying the reasons for the extension and including a timeline forecast for degree completion. Extensions must be approved by the Director of Graduate Studies and the Dean of the Graduate School.

The following timeline is based on a two-year plan for traditional full-time M.S. students. Students in a dual degree program or part-time M.S. will need to adjust their timeline accordingly.

First Year

- Complete Core Curriculum courses
- Select a Graduate Track Specialization
- By the end of the first semester: submit an official Supervisory Committee
- Thesis students may begin dedicated M.S. research (BME 6970)
- By the end of the second semester: meet with the supervisory committee to report planned M.S. option, seek approval for intended coursework, and overview the timeline for completion.

Second Year

- Complete advanced track elective courses
- By the end of the third semester: meet with the supervisory committee to report progress, approve the program of study, and plan for the comprehensive exam, project presentation, or thesis defense
- Submit a final Program of Study
- Apply for graduation
- Thesis students complete dedicated M.S. research (BME 6970) and write their M.S. Thesis
- Pass Final Comprehensive Exam, either a written exam, oral exam, project presentation, or thesis defense

II.D.2. PH.D. COMPLETION TIMELINE

Students typically graduate within five years of entering the BME Ph.D. program. However, some projects and methods require longer time commitments to complete dissertation work fully.

The official time limit for completing the Biomedical Engineering Ph.D. degree is eight years. If a student in good standing has not completed the Ph.D. program within eight years, a time limit extension may be requested with a letter of support from the student's faculty advisor to the Department Chair and Graduate School, justifying the extension and including a timeline forecast for degree completion. Time limit extensions must be approved by the Director of Graduate Studies and the Dean of the Graduate School.

The following timeline is based on a five-year plan for students entering the Ph.D. program with Bachelor's degree. Please note that students entering with their master's degree will typically follow a more accelerated three- or four-year plan depending on their M.S. degree institution. The following timeline is an approximate guide only: see the Doctor of Philosophy (Ph.D.) Program section for timeline details, milestone explanations, and deadlines.

First Year

- Begin coursework, focused on Core Curriculum
- Select an Area of Specialization/Track
- Identify a Research Advisor: Principal Investigator Offer Letter
- Begin dedicated Ph.D. research (BME 7970)
- Establish a Supervisory Committee and discuss planned coursework, career goals, etc.

Second Year

- Meet with the supervisory committee to finalize course plans and discuss research progress
- Continue coursework, focused on advanced track electives
- Submit Preliminary Program of Study
- Master methods necessary for independent dissertation research
- Prepare for the Ph.D. Qualifying Examination

Third Year

- Meet with the supervisory committee to discuss research aims
- Complete remaining course requirements
- Pass Ph.D. Written Qualifying Exam
- Begin TA Mentorship requirement
- Write and present Research Proposal

Fourth Year

- Meet with the supervisory committee to report research progress
- Seminar Presentation at a National Conference
- Submit first research manuscript for publication
- Conclude TA Mentorship requirement
- Submit Final Program of Study for the Ph.D. degree

Fifth Year

- Meet with the supervisory committee to report dissertation progress
- Submit second research manuscript for publication
- Submit third research manuscript for publication
- Write and present Dissertation Defense
- Submit the final dissertation for the Ph.D. degree to the Thesis Office and Graduate School

III. GRADUATE SCHOOL POLICIES

The Graduate School oversees all graduate programs at the University of Utah, standardizing policies and procedures across campus and offering common resources and services to all graduate students. See the Graduate Student Resources page for a comprehensive detailing of Graduate School policies and resources. The most relevant regulations and guidelines are included below, as applied to the graduate programs in Biomedical Engineering.

III.A. GRADUATE SCHOOL REGISTRATION REQUIREMENTS

To maintain full-time student status, graduate students must take 9 credit hours per non-summer semester until they finish the enrollment residency requirement (see below). For students who have completed that requirement, 3 credit hours of Thesis or Dissertation Research registration (i.e., BME 6970 and BME 7970) qualifies them for full-time status. However, students on the eXtended Tuition Benefit Program must take at least 9 credits in each non-summer semester. Students must have full-time status in the semester they complete their M.S. exam or defend their dissertation.

BME 7990 Continuing Registration is available to Ph.D. students admitted to candidacy who are not using University resources other than the library: i.e., not performing any research on campus, not occupying university space beyond the library, not using faculty or staff time, etc. BME 7990 registration is limited to 4 semesters and does not qualify a student for full or part-time enrollment status for loan deferments or insurance eligibility.

Students may not register for more than 16 credit hours without approval from the Dean of the Graduate School. Students who are not U.S. citizens should refer to the University of Utah International Student Scholar Services office for additional registration requirements.

III.A.1. Enrollment Residency Requirement

Graduate students must satisfy this enrollment residency requirement to remain in good standing.

- Each Ph.D. student must complete at least one year — defined as two consecutive semesters — as a full-time student on the University of Utah campus.
- M.S. students must complete at least 24 credits of resident study at the University of Utah campus.

These requirements do not refer to or fulfill the "Utah Residency for Tuition Purposes" requirements for graduate students from the Graduate School. Per that policy, domestic, out-of-state students must apply for Utah State residency upon completing 40 graduate-level credit hours at the University of Utah. Details on qualifying and applying for Utah residency reclassification are available on the Admissions office website. Please see the Graduate School's Degree Requirements for additional information on the enrollment residency requirement.

III.A.2. Continuous Registration

The Graduate School requires graduate students to be registered for at least one course from the time of formal admission until they have completed all degree requirements unless granted an official leave of absence. Further, the Biomedical Engineering department requires a minimum registration of 3 credit hours per semester for all graduate students through their final exam/defense semester. Summer semesters are excluded from the registration requirement unless students will complete their final exam or defense during the summer semester. Non-compliance with this policy will result in discontinuation from graduate study, and the student will be required to re-apply for admission to the program.

III.A.3. Leaves of Absence

Requests for a leave of absence may be granted for up to one year for circumstances related to the following:

- a serious health condition of the student or family member,
- parental leave to care for a newborn or newly adopted child,
- a call to military service, or
- another compelling reason that the department believes is in the best interests of the student and University.

The form requesting a leave of absence for a current semester must be completed and received in the Registrar's Office by the last day of classes. Leaves of absence are not granted retroactively. Students must officially withdraw from courses in any semester for which a leave is granted; failure to formally withdraw will result in the reporting of either E or EU grades for all classes.

The duration of a leave of absence does not count toward the time allowed to complete a degree. Leaves are granted for a maximum of one year at a time and may be renewed by submitting a new form to Registrar's Office. If a student registers for classes to occur during an approved leave of absence, the leave of absence will be voided for that semester. Please refer to the Graduate School website for additional information on leaves of absence.

III.A.4. International Student F1-Visa Policy

In response to guidance from U.S. immigration authorities, F-1 visa holders may not request part-time status for a vacation in the Spring or Fall semester. Instead, all international students will automatically be granted vacation semesters during the summer semesters. However, international students may still take courses in the summer, and eligible Ph.D. students are encouraged to register for dissertation credits (BME 7990). Additionally, international students may still choose to take courses from another university during their summer semester, as long as they receive permission to attend another school from ISSS.

Automatically granted summer vacation from registration requirements does not extend to employment status or research effort expectations. Importantly, BME graduate students receiving a salary or stipend from a research assistantship position — or fellowship, if applicable — are expected to perform research in their lab over the summer; any vacation time must be approved by the principal investigator overseeing their salary or stipend. Students without a source of income directly related to their academic research may participate in Curricular Practical Training (CPT) or on-campus work during their summer vacation semester. However, they may not participate in full-time CPT or on-campus work during non-summer semesters, except during official university breaks (i.e., fall, winter, & spring break).

III.B. GRADUATE PROGRAM TRANSFER CREDITS

Students enrolled in the BME graduate program may be eligible to transfer a limited number of other course credits into their program of study, including as a substitute for the core curriculum, pending supervisory committee approval.

III.B.1. Credits Taken From Another Institution

Students who received credit for graduate courses from regionally accredited institutions may petition for those courses to be transferred to the University of Utah to fulfill some BME degree requirements. Restrictions:

- Courses must have been taken at the graduate level, equivalent to the University 5000-level or above.
- Students must have earned a letter grade of B or higher in the transfer courses:
  - "Credit" and "Pass" grades are not acceptable.
- No more than 6 graduate credit hours and two graduate courses may be transferred, i.e.,
  - up to 6 credits spread over no more than two courses,
  - up to two courses totaling no more than 6 credits.
- Transfer credits may be applied to one degree only and cannot have been used to earn a previous degree.
- Course subject matter must be relevant to the BME degree and approved by the supervisory committee.
- Requested transfer credits must have been taken recently:
  - within 4 years of M.S. student's semester of enrollment, or
  - within 7 years of Ph.D. student's semester of enrollment.

III.B.2. Credits Taken While Not Matriculated

Students who completed graduate courses at the University of Utah while not matriculated at the University of Utah may request those courses to be applied to fulfill their BME graduate degree requirements. Restrictions:

- Courses must have been taken at the graduate level, i.e., 5000-level or above.
- Students must have earned a letter grade of B or higher in the transfer courses:
  - "Credit" and "Pass" grades are not acceptable.
- No more than 9 graduate hours of non-matriculated course credit may be applied.
- Non-matriculated credits may be applied to one degree only and cannot have been used for a previous degree.
- Course subject matter must be relevant to the BME degree and approved by the supervisory committee.
- Requested non-matriculated credits must have been taken within 3 years of the student's first semester of enrollment into any graduate program at the University of Utah.

III.B.3. Credits Taken as an Undergraduate

Students who completed graduate courses at the University of Utah during their undergraduate program may petition for those courses to be applied to fulfill their BME degree requirements. Restrictions:

- Courses must have been taken at the graduate level, i.e., 5000-level or above.
- Students must have earned a letter grade of B or higher in the courses:
  - "Credit" and "Pass" grades are not acceptable.
- No more than 6 graduate credit hours and two graduate courses may be transferred, i.e.,
  - up to 6 credits spread over no more than two courses,
  - up to two courses totaling no more than 6 credits.
- Credits used to earn an undergraduate degree cannot be applied toward a graduate degree.
- Course subject matter must be relevant to the BME degree and approved by the supervisory committee.
- Requested credits must have been taken within 3 years of the student's first semester of enrollment into any graduate program at the University of Utah.

III.B.4. Credits Taken in the BS/MS Program

Students in the BS/MS Dual Degree program who completed graduate-level courses from the University of Utah while still officially enrolled as undergraduates should petition for those courses to fulfill their M.S. degree requirements. This petition may be filed after the student has achieved graduate status. Restrictions:

- Courses must have been taken at the graduate level, i.e., 5000-level or above.
- Students must have earned a letter grade of B or higher in the courses:
  - "Credit" and "Pass" grades are not acceptable.
- No more than 12 graduate hours of course credit taken as an undergraduate may be applied.
- Credits used to earn an undergraduate degree cannot be applied toward a graduate degree.
  - Credits must be "Reserved" for the M.S. degree during the first semester as graduate status
- Course subject matter must be relevant to the BME degree and approved by the supervisory committee.
- When discontinuing the BS/MS program, reserved graduate credits may not be applied toward an otherwise completed undergraduate degree. Students in this situation should speak with an undergraduate advisor.

III.C. ACADEMIC PERFORMANCE, STANDARDS, AND STANDING

Students must meet the academic and professional standards set by the Graduate School and the Department.

III.C.1. ACADEMIC STANDARDS AND GOOD STANDING

The Graduate School standards can be found on the University of Utah Graduate School website, including that good academic standing requires maintaining a 3.0 GPA or higher in coursework counted towards degree requirements. Students whose GPA falls below 3.0 will have one semester to correct their deficiency. In addition, Biomedical Engineering students must pass each of the core Biomedical Engineering courses and electives with a B- or better grade. Students who receive a grade below B- in any BME core course will be allowed one attempt for remediation.

Below is a list of common conditions that cause a student to be academically deficient within the BME graduate program. If a student satisfies any of the conditions below, then the student is academically deficient. However, a pre-existing, formalized arrangement signed by the Director of Graduate Studies may permit an approved deviation from the corresponding academic requirement(s). Problem areas for dismissal concerns include the following:

- Failure to maintain a 3.0 GPA as required by the Graduate School.
- Failure to identify a faculty advisor by the end of the first semester of graduate study.
- Failure to establish a supervisory committee by the end of the first year of graduate study.
- Failure to convene a supervisory committee meeting in the past 12 months.
- Failure to meet satisfactory progress or individualized requirements as determined and stipulated in writing by the faculty advisor, supervisory committee, Director of Graduate Studies, or Department Chair.
- M.S. only: failure to graduate within the 4-year time limit from matriculation into the M.S. program.
- Ph.D. only: Failure to take the written comprehensive exam by the end of their second year of graduate study.
- Ph.D. only: Failure to pass the written comprehensive exam by the end of their third year of graduate study.
- Ph.D. only: Failure to present the Ph.D. research proposal by the end of their third year of graduate study.
- Ph.D. only: Failure to pass the Ph.D. research proposal by the end of their fourth year of graduate study.
- Ph.D. only: Failure to complete the TA mentorship requirement by the end of their fourth year of graduate study.
- Ph.D. only: Failure to graduate by the date specified in the student's most recent letter of support, or within the maximum 8-year time limit from matriculation into the Ph.D. program.

Students who are remiss in satisfying any of these categories will not be in good academic standing. When a student loses good academic standing, the Graduate Academic Advisor will send a letter detailing the student's academic probation to the student, faculty advisor, Director of Graduate Studies, and Department Chair. Students on academic probation must correct their deficiency at the first opportunity, e.g., in the subsequent semester for a low GPA or the next time a course is offered for a low grade.

If these students fail to correct their academic performance at the first opportunity, they will lose any benefits and financial support and may be dismissed from the program. In this case, the Director of Graduate Studies will send a letter detailing the dismissal to the student, faculty advisor, and Department Chair. Removal from the BME graduate program shall terminate graduate student support and funding. Students may promptly appeal to the Director of Graduate Studies and Department Chair if they wish to continue in the program.

III.C.2. ACADEMIC, BEHAVIORAL, AND PROFESSIONAL MISCONDUCT POLICIES

All BME students — as well as any students taking a course in, or cross-listed with, BME — must read and understand the BME department Academic Misconduct Policy. In addition, most BME courses require students to sign an associated acknowledgment form at the start of each semester.

Academic misconduct includes, but is not limited to, cheating, misrepresenting one's work, inappropriately collaborating, plagiarizing, fabricating or falsifying information, and facilitating academic misconduct by intentionally helping or attempting to help another commit academic misconduct. The University's complete "Student Code" policy, Policy 6-400: Code of Student Rights and Responsibilities from the Regulations Library, includes the following sections.

- Section I: General Provisions and Definitions – ACADEMIC SANCTION
- Section II: Student Bill of Rights
- Section III: Student Behavior – STANDARDS OF BEHAVIOR
- Section IV: Student Academic Performance
- Section V: Student Academic Conduct
- Section VI: Student Professional and Ethical Conduct
- Section VII: Student Records

"Students at the University of Utah are members of an academic community committed to basic and broadly shared ethical principles and concepts of civility. Integrity, autonomy, justice, respect, and responsibility represent the basis for the rights and responsibilities that follow. Participation in the University of Utah community obligates each member to follow a code of civilized behavior."

"The purposes of the Code of Student Rights and Responsibilities are to set forth the specific authority and responsibility of the University to maintain social discipline, to establish guidelines that facilitate a just and civil campus community, and to outline the educational process for determining student and student organization responsibility for alleged violations of University regulations. University policies have been designed to protect individuals and the campus community and create an environment conducive to achieving the academic mission of the institution. The University encourages informal resolution of problems, and students are urged to discuss their concerns with the involved faculty member, department chair, dean of the college, or dean of students. Informal resolution of problems by mutual consent of all parties is highly desired and is appropriate at any time."

"Section VI. A. Standards of Professional Conduct – To ensure that the highest standards of professional and ethical conduct are promoted and supported at the University, students must adhere to the prescribed professional and ethical standards of the profession or discipline for which the student is preparing, as adopted or recognized as authoritative by the relevant academic program."

"Section VI. B. Professional Misconduct – A student who engages in academic misconduct may be subject to academic sanctions including, but not limited to, a grade reduction, failing grade, probation, suspension or dismissal from the program or the University, or revocation of the student's degree or certificate. Sanctions may also include community service, a written reprimand, and/or a written statement of misconduct that can be put into an appropriate record maintained for purposes of the profession or discipline for which the student is preparing."

III.C.3. Program Suspension and Dismissal Policies

Matriculated graduate students in the program who fail to comply with performance expectations in either their graduate research or didactic coursework, or with codified university policies for graduate conduct can be dismissed from the department's academic program, the Graduate School, or both.

Student academic and research progress is evaluated annually in meetings with their supervisory committee. The student schedules these meetings, the minutes of which must be recorded in a student progress report. Failure to meet at least once annually is a major programmatic deficiency. Should the committee have any concerns that may warrant academic probation, the Academic Graduate Advisor will issue a letter detailing the academic probation terms, with input from the faculty advisor and other supervisory committee members.

Individual faculty members can coordinate with the Director of Graduate Studies to initiate the dismissal process. Acceptable reasons for student dismissal include academic or professional misconduct, and failing to meet the program's academic requirements or the terms of a previously prescribed academic probation. An ad hoc committee of faculty may be called to arbitrate if necessary. Final decisions are provided to the student by the Department Chair.

III.D. LABORATORY PERFORMANCE AND EXPECTATIONS

To succeed in graduate school, students must meet the expectations of their supervisory committee, the BME Department, the Graduate School, the University of Utah, and any private, state, or federal agencies that fund them.

III.D.1. LABORATORY PERFORMANCE AND EXPECTATIONS

Research creativity, consistent productivity, evident progress, independence, and motivation are the hallmarks of successful graduate student performance. Students who perform in their academics and research generally proceed expediently through the graduate program. Unfortunately, unsatisfactory student performance and progress in their graduate research program can result in their dismissal from the program and loss of stipend support. University policy 6-309 Section D (Orderly Dismissal) provides a basis for this evaluation and dismissal process.

Section III.D.1 states:

"Performance Evaluation. Any person appointed according to the provisions of this section may be dismissed for cause. The individual's designated supervisor shall provide timely informal evaluations of the individual's job performance and make conscientious efforts to assist the individual in correcting any unsatisfactory aspects of job performance. If unsatisfactory aspects of job performance persist, the supervisor must provide the individual with a written statement of difficulties and a reasonable time to correct them."

The faculty advisor reserves the right to dismiss students who, after notice of their sub-optimal performance and deficiencies, fail to either perform to expected standards or exhibit an acceptable trajectory of improvement, effort, and motivation. The faculty advisor shall notify the student of their dissatisfaction in a letter documenting their perceived lack of progress through the degree program or poor research performance within the laboratory group.

Upon meeting with the research advisor, the student shall sign this written notice, acknowledging the meeting's occurrence (whether they agree with the assertions); this letter will be placed in their graduate file. If the student disagrees with any assertions in the notice, they may lodge a protest with their supervisory committee and Department Chair. They may also use the University appeal process to counter assertions in the written notice.

Following this meeting, the student will be given a 6-week probationary period to change their performance as prescribed and produce tangible evidence of improvement and productivity. A second student-advisor meeting at this 6-week time-point shall produce a second written evaluation of the student's performance and evidence of improvements, further concerns, or non-improvements as evidence of failure to progress. Another subsequent 6-week period will be the final evaluation period.

After 12 weeks (comprising the two 6-week evaluation periods), the faculty adviser will provide a written notice to the student, either permitting them to continue in their specific research program or dismissing them from the faculty advisor's lab group. A dismissal decision should be based on cited criteria for poor productivity, sub-optimal motivation, or failure to progress.

Should a student be dismissed from a lab group, they may remain in the program, but without financial support, for as long as they remain in good academic standing. However, to complete a Ph.D. dissertation, they must find another willing faculty mentor with whom to produce dissertation-quality research that satisfies the BME program requirements. This policy does not supersede current student rights accorded by the University's Policy and Procedures Manual, and its references to student participation in formal Family Leave or Medical leave policies and procedures.

III.D.2. RESPONSIBLE CONDUCT OF RESEARCH

The NSF and NIH require training in the Responsible Conduct of Research (RCR). Training at the University of Utah is available through the Vice President for Research's Office — Research Education RCR Student Portal. Certification requires completing four required and one additional online module, and must be renewed at least every four years.

All Ph.D. students must complete their RCR certification during their first semester in the program and maintain RCR certification for their graduate program duration. MS students are not required to complete RCR training unless they work in a research lab. All students must be RCR certified before serving as a Research Assistant (RA).

IV. FINANCE & BENEFITS

To enroll at the University of Utah, students must identify a source for their tuition. This tuition source can be their own savings or a tuition benefit provided by serving some role within the University, e.g., Research Assistant. As described in this section, students' financial status and benefits vary widely depending on their role within the University. Biomedical Engineering graduate students may be funded by various mechanisms that provide stipends and tuition support, enabling efficient progression through their graduate experience. Section IV of the handbook only applies to BME graduate students financially supported in one of the following categories.

Admission to the Ph.D. program generally includes a research-based position with stipend and tuition support provided by the faculty advisor. Note: financial support is contingent upon the student making adequate progress toward their degree and is based on the availability of research funding from grants and contracts. A subsidy may be provided for individual health insurance at the faculty advisor's discretion but is not required or expected.

When available, financial support for the period in which the student is conducting research is the responsibility of the student's faculty advisor and is usually derived from research grants. Departmental funds are not available for this purpose: no guarantees for student financial support come from the department, although it attempts to mediate extenuating circumstances and unusual hardships as resources allow. Hence, a funded research position should be considered a privilege lasting only so long as the student continues an expedited pursuit of their graduate degree.

The supervising faculty may rescind financial support for documented failure to progress in research or perform to minimum academic standards. Although this can be a unilateral advisor decision, faculty-student relationships would best enroll the advice of the supervisory committee before withdrawing support. The University Policies and Procedures Manual provides specific recommendations and processes for addressing "failure to progress" and other student deficiencies with documentation, warnings, and written responses.

IV.A. GRADUATE STUDENT STIPENDS

The University of Utah recognizes four categories of financially supported graduate students: Graduate Fellows (GFs), Graduate Researchers (GRs), Teaching Assistants (TAs), and Research Assistants (RAs). Under normal circumstances, Ph.D. students in good standing should be supported in one of these categories: the majority are supported as GRs for their first semester and RAs thereafter. M.S. students are encouraged to find their own graduate fellowships; also, they can be supported as TAs or RAs pending department need or faculty advisor funding, respectively.

The four eligible classifications qualifying a student to receive tuition support:

- Graduate Fellow (GF): Students on a fellowship whose tuition is not necessarily paid by their award. If tuition is included in a student's fellowship award, the student may not also use the University's tuition benefit system. The University must administer the award, which may include a service expectation.
- Graduate Researcher (GR): Students assigned work related to their degree and not covered by any other category. In Biomedical Engineering, most Ph.D. students are assigned this role in their first semester only, to receive a stipend and tuition support before they have identified a research lab and faculty advisor.
- Teaching Assistant (TA): Students with instructional responsibilities as the instructor of record, assistant to the instructor of record, or tutor. International students must be cleared through the International Teaching Assistant Program before being assigned a paid TA position. Note that students teaching for credit (i.e., those taking BME 7880) do not receive stipend or tuition support for doing so; however, they generally do receive support for simultaneously serving as a GR or RA.
- Research Assistant (RA): Students assigned directly to an externally funded research grant or contract, and performing research therefor. Once they have identified a research lab and faculty advisor, most Ph.D. students are supported as RAs for the rest of their graduate tenure, unless and until they attract fellowship support.

IV.A.1. GRADUATE FELLOWS (GF)

Students are encouraged to continually seek out and apply for university, state, national and international fellowships to supplement or replace their stipend support. Fellowships are distinctions earned by the recipients that promote their faculty advisors, the BME department, and the University of Utah. Therefore, to the extent possible, all financial support and benefits should remain the property of the student receiving this honorary award, with stipend support supplemented at the faculty advisor's discretion.

Intramural Fellowships

Several outstanding Biomedical Engineering students receive support each year from fellowship administered through the College of Engineering. The Department Graduate Scholarship Committee nominates these students based on the application information provided, and the Department Chair must support their nomination in writing. Other fellowships are available through the University of Utah Graduate Fellowship Opportunities.

Extramural Fellowships

A current listing of extramural fellowships is available on the Graduate School External Opportunities page. Of relevance, the department strongly encourages Ph.D. students to apply for the National Science Foundation Graduate Research Fellowship (NSF-GRF) and the National Institutes of Health National Research Service Award (NIH-NRSA).

IV.A.2. GRADUATE RESEARCHERS (GR)

Ph.D. students without a supporting fellowship who have not yet identified a research lab and faculty advisor are categorized as GRs. The department supports first-year students in this category with stipends and tuition while they rotate through research labs. For most Ph.D. students, this support is only offered for their first semester. During that semester, students must identify a research lab and faculty advisor who will subsequently support them as an RA.

IV.A.3. TEACHING ASSISTANTSHIPS (TA)

The Department determines which Biomedical Engineering undergraduate and graduate courses will utilize TAs. Duties may include lecturing, holding discussion or problem sessions, conducting laboratory sections, grading, tutoring, and holding office hours. Ph.D. students must first fulfill the 4 required credit hours of TA Mentorship (BME 7880) before accepting a paid Teaching Assistantship. M.S. students are eligible to serve as paid TAs, pending department need.

Teaching Assistantship requirements also include:

- TAs must be proficient in the English language to interact with students effectively. The Graduate School requires all non-native English-speaking graduate students to be cleared by the International Teaching Assistant Program before any teaching is allowed. Thus, this clearance is compulsory for all international Ph.D. students in BME.
- TAs must strictly abide by the regulations outlined in the Family Educational Rights and Privacy Act or FERPA. This federal law protects the privacy of educational records of students. Information regarding FERPA is available at www.registrar.utah.edu/faculty/ferpa-resources.php.
- TAs must attend mandatory training provided by the College of Engineering (COE) near the start of each semester. The student must ascertain the time and location of this once-per-semester offering from the COE.
- TAs must meet with their assigned course instructor(s) before the beginning of the semester to initiate organization and identify the expectations of the TAs' roles and duties.
- Unless otherwise instructed, TAs are expected to attend all their assigned course(s) lectures and be sufficiently familiar with the course materials to tutor the students effectively.
- TAs are expected to contribute in a substantive professional way to the pedagogical needs of their assigned course(s). The instructor and the nature of the course determine these needs. For example, TAs should expect to undertake the following activities: 1) deliver one or more course didactic lectures, 2) lead problem-solving or discussion sessions, 3) prepare laboratory equipment and supplies, and 4) grade homework, reports, and exams.
- The TA requirement is for credit. Ph.D. students are not eligible for paid TA positions until their four BME 7880 credit hours have been completed. If a student is supported by their faculty advisor as a Research Assistant, that support will continue during their TA assignments.

Unsatisfactory student TA performance will be subject to review and punitive responses. TA workshops and online teaching resources are available through the Center for Teaching and Learning Excellence at the University of Utah.

IV.A.4. Research Assistantships (RA)

Individual faculty members from the BME department offer RA positions, supported by research grants and contracts, to most Ph.D. students. The department recommends that student stipends align with NIH's pre-doctoral level of support. Students must find a research lab for their dissertation research; M.S. students are encouraged to find a research lab, particularly if they pursue a thesis-option M.S.

During admissions interviews and after acceptance into the graduate program, students are strongly encouraged to arrange discussions with potential faculty advisors to sponsor RA positions. The Director of Graduate Studies and the specialization track director can assist Ph.D. students with identifying potential faculty sponsors. Still, ultimately it is the student's responsibility to secure an RA position with stipend and benefits. After securing an initial RA position, the continuation of salary or stipend and any associated tuition support is contingent upon continuous enrollment, the rules of the Graduate School, and making satisfactory progress in the BME graduate program.

IV.B. GRADUATE STUDENT BENEFITS

Graduate students in one of the aforementioned supported categories are eligible for benefits.

IV.B.1. Student Tuition Support

Students in supported categories will receive a benefit covering 50%, 75%, or 100% of their eligible tuition, depending on their stipend level. Under normal circumstances, Ph.D. students in good standing should receive large enough stipends to ensure 100% tuition support. Students receiving tuition benefit remain responsible for paying all their differential tuition and non-mandatory fees.

Tuition Benefit Guidelines

Tuition support is administered by the BME department and the College of Engineering through the Tuition Benefit Program (TBP) for GFs, TAs, & GRs, and through the eXtended Tuition Benefit Program (xTBP) for RAs. Funds for the TBP are provided by the BME department; funds for the xTBP are provided by the research grants and contracts that support the student as an RA. As mandated by Graduate School policy, the TBP may support a student for an absolute maximum of 5 years; the xTBP includes substantially more flexibility.

Requirements for TBP & xTBP

- Students must be matriculated and in good standing, with a minimum cumulative GPA of 3.0.
- Students must be registered as full-time graduate students taking a minimum of 9 credit hours for both fall and spring semesters.
- Students must meet the minimum financial support levels indicated on the TBP website. These levels vary by semester and year. Financial support must be paid through the University of Utah.
- Non-resident, non-international graduate students receiving the tuition benefit must apply for Utah residency upon completing 40 semester credit hours at the University of Utah per Graduate School policy. This residency requirement avoids billing the university for out-of-state student tuition rates. Additional information is available on the Residency and Meritorious Status website. Students who do not apply for Utah residency upon completing 40 semester credit hours at the University of Utah will be removed from the graduate program.
- Students supported by a tuition benefit who withdraw mid-semester or fail to comply with TBP or xTBP requirements may be required to refund the TBP or xTBP for the tuition bills incurred.

Coverage for TBP & xTBP

- Both tuition benefits support 9-12 credit hours in the fall semester and 9-12 credit hours in the spring semester.
- Both tuition benefits can provide support during the summer:

    - Suppose a student was supported at the 100% level in the spring and the summer. In that case, tuition benefit will support up to 3 credit hours in the summer, so long as the sum of the spring and summer credit hours does not exceed 12.
    - Suppose a student was supported at the 100% level in the fall, spring, and summer. In that case, tuition benefit will support up to 6 credit hours in the summer, so long as the sum of the fall, spring, and summer credit hours does not exceed 24.
    - Summer semesters do not count against the total number of semesters students are eligible for the TBP. Note that there is no limit on the eligibility for xTBP semesters.
- Both tuition benefits cover students' non-resident tuition until they exceed 84 cumulative credit hours. In and following the semester a student exceeds 84 cumulative credit hours, the tuition benefit will cover only resident tuition amounts. To avoid being charged non-resident tuition, non-resident students who have completed their required coursework should only register for 9 credit hours of BME 7970: Ph.D. Dissertation Research, which is always charged at the in-state, resident rate.

Restrictions for TBP & xTBP

- The recommended Full-Time Equivalent (FTE) maximum is 0.50 (20 hrs/week) and cannot exceed 0.74 FTE. Note that other paid positions on campus (internships, tutoring, etc.) are counted toward the student's FTE.
- Courses designated as undergraduate level (i.e., below the 5000 level), contract, audit, repeat, and credit/non-credit will count toward the required minimum of 9 credit hours but will not qualify for the tuition benefit.
- The tuition benefit program will not pay for any withdrawn credit hours. Therefore, if a student's registration falls below 9 credit hours at any time during the semester, they will be billed full tuition for that semester.
- Students may register for a maximum of 16 credit hours but will be responsible for paying all tuition and fee amounts above 12 credit hours.
- Non-matriculated, part-time, or academic probation students are not eligible for either tuition benefit program.

Semester Limits for TBP & xTBP

- Students are eligible for an unlimited number of xTBP semesters; however, standard limitations for how long students may be enrolled in graduate school, and the persistent need to make adequate progress, still apply.
- Students are limited in the number of semesters that they may participate in the TBP. However, those semesters need not be sequential: they can be broken up by semesters on xTBP, unsupported, or on leaves of absence.
    - Students enrolled in the M.S. program are limited to 4 semesters (2 years) of TBP support.
    - Students who enter the Ph.D. program with a bachelor's degree are limited to 10 semesters (5 years) of TBP support.
    - Students enrolled in the Ph.D. program who receive(d) a master's degree from the University of Utah are limited to 10 semesters (5 years) total of tuition benefit support, four semesters (2 years) for a master's degree, and six semesters (3 years) for a doctoral degree. The four semesters of potential TBP designated to the master's degree do not carry over to the Ph.D. Therefore, students who earn a master's degree from the University of Utah are eligible for a maximum of 6 semesters (3 years) of TBP for their Ph.D. program.
    - Students who enter the Ph.D. program with a master's degree from another university are eligible for eight semesters (4 years) of tuition benefit support.

Additional information regarding the Tuition Benefit Program and its policies is available on the Graduate School's website under Fellowships and Benefits.

IV.B.2. Tuition-Associated Costs

Students receiving TBP or xTBP remain responsible for paying all other fees associated with their course enrollment and full- or part-time graduate student status.

Differential Tuition. According to the current College of Engineering policy, all students, regardless of class standing, will be charged an additional College of Engineering differential fee per credit hour for graduate-level courses in the College of Engineering. This differential tuition is not included as part of the Graduate School's tuition benefit and must be paid by the student. Please see the Income Accounting Tuition website for detailed tuition and fee rates.

Special Course Fees. For those courses requiring them, special fees are shown in a column of the course listings. These fees, which must be paid with tuition, are in addition to regular tuition and mandatory fee charges.

Mandatory Fees. Some additional fees are required of all students: ASUU Activity, Athletic, Building, Collegiate Reader Program, Computing, Fine Arts, Utilities, Health, Library, Publication Council, Recreation, Study Abroad, Sustainability, Money Management, and Transportation. The amounts for these fees will vary by year.

IV.B.3. Student Health Insurance

All BME graduate students are required to have documented health insurance.

Subsidized Graduate Student Health Insurance

Subsidized student health insurance is available to TAs and RAs who receive 100% tuition benefit. Students who qualify will be enrolled in the insurance plans by the Tuition Benefit office during the open enrollment period for the semester. The Tuition Benefit office will pay 80% of the insurance premium, and the students will be billed the remaining 20% on their tuition account after the open enrollment period closes.

Insurance coverage is not subsidized for spouses or dependents. However, students may purchase dependent insurance plans at their own expense, directly through United Healthcare for standard health insurance and EMI Health for vision and dental insurance. Additional information regarding Subsidized Graduate Student Health Insurance is available on the Tuition Benefit Office website.

Non-Subsidized Graduate Student Health Insurance

Students who do not qualify for subsidized student health insurance are responsible for obtaining their own health insurance. However, they may buy an insurance policy through the University Student Health Center. Students must be registered for a minimum of 3 credit hours to qualify to purchase the University of Utah contracted student health insurance plans. These plans are the same as the subsidized student health insurance plans.

International Student Health Insurance

The University requires all new, transfer, or readmitted international students to be automatically enrolled in the University of Utah Student Health Insurance Plan administered by United Healthcare Student Resources. For more information about student insurance, including cost, please visit www.uhcsr.com/utah. International students who qualify for and request the subsidized insurance coverage through the TBP or xTBP will be refunded the automatic charge; however, the 20% student portion will still be charged as indicated above.

If you have an existing insurance plan, you may be eligible to apply for a waiver from the insurance requirement. Your existing plan must have coverage equivalent to or better than the plan offered by the University. Travel insurance plans do not qualify. For information regarding the waiver process, contact the International Student Scholar Services (ISSS) office: https://isss.utah.edu/students/orientation-arrival/health-insurance.php

IV.C. LEAVE & EMPLOYMENT

This section details policies covering time away from the university and potential employment outside the university. These policies only apply to graduate students in one of the four supported categories.

Graduate students supported at the 100% level are expected to contribute their full-time effort to the University. Typically, 50% of their effort should be devoted to coursework and 50% of their effort to the position for which they receive a stipend or fellowship. In the latter years of a Ph.D. program, most students will only register for 9-12 credits per semester of Dissertation Research (BME 7970). Those students should be working full-time on their research: 50% for a stipend or fellowship and 50% for academic credit.

IV.C.1. OUTSIDE EMPLOYMENT

The Department of Biomedical Engineering considers a full-time research stipend or salary for graduate support to be a full-time traineeship, with the privilege of support and expectation of long and irregular hours required for successful degree completion. Responsibilities of such conditions of graduate study preclude pursuing other gainful employment without interfering with doctoral program progress.

Therefore, supported students are strongly discouraged from engaging in employment outside of the BME department. However, there are numerous opportunities for intellectual development that may greatly benefit a graduate student's long-term career prospects. These include training that can occur at the University of Utah (e.g., Lassonde internship, Center for Medical Innovation internship, Bench to Bedside competition, etc.) and outside the University of Utah (e.g., internships at private companies and public institutions).

Supported students may not engage in any outside employment or internships without the consent of their faculty advisor and supervisory committee. Arrangements must be pre-approved in writing by both the faculty advisor and the supervisory committee. In such cases, the supervisory committee will monitor whether student employment outside the department interferes with the expectations of and progression through the graduate program. If the outside employment unduly hinders the student's doctoral progress, they may be asked to reduce their outside employment commitments or leave the program.

IV.C.2. LEAVE OF ABSENCE FROM ACADEMIC PROGRAM

Please see the Leave of Absence section above for information regarding leave of absence policies for domestic and international students. Please also refer to the leave of absence policy information on the Graduate School webpage. A leave of absence from the student's academic program for up to one year must be approved by the student's supervisory committee and the Director of Graduate Studies or Department Chair. If additional time is required, another request must be approved and submitted to the Registrar's Office.

IV.C.3. GRADUATE STUDENT VACATION LEAVE

Neither the Graduate School nor the Department of Biomedical Engineering has any official policy regarding vacation leave. However, students should understand their faculty advisor's vacation policies and procedures before they agree to join a research lab. Any vacation days must be approved by the faculty advisor beforehand, and the faculty advisor is under no obligation to approve any request. Furthermore, vacation time may be restricted by the funding sources, particularly for RAs working on externally funded grants or contracts.

IV.C.4. PARENTAL LEAVE POLICIES

The University provides a comprehensive parental leave policy that secures eight weeks of leave for students acquiring a new child through birth, adoption, or foster care. For students receiving tuition benefit, the University policy guarantees eight weeks of stipend or salary during parental leave. (Sustained financial support is available up to twice during a student's tenure in the program.) The department aims for an additional four weeks of extended parental leave, yielding a combined twelve weeks. However, the unique constraints of various funding sources for students in the four supported categories complicate this aim. (Of note, state funds may not be used to support extended parental leave.) Supported students retain all benefits during parental leave, whether or not they receive stipend or salary. In

all cases, students must work with their faculty advisors to determine what parental leave options are available to them; faculty advisors should be mindful of striving for twelve weeks of parental leave support.

To request parental leave, students must submit a Request for Graduate Student Parental Leave form to the Department of Biomedical Engineering prior to the expected arrival of the child. Under normal circumstances, students should arrange parental leave time with their advisor and the department at least 30 days in advance. Upon approval, the parental leave will begin on the date requested: students will be released from professional duties and any expectation to maintain scholarly productivity for the duration of the approved parental leave. The parental leave should be complete within six months of the new child's arrival; generally, extensions of this leave will not be granted. Students who experience a medical condition associated with their pregnancy and need accommodations recommended by their medical provider should review the Pregnancy and Pregnancy-Related Accommodations page, where the Pregnancy Accommodation Request form is available. The Office of Equal Opportunity, Affirmative Action, and Title IX will determine appropriate accommodations for that request. If additional time is required due to medical or other reasons, an unpaid, formal Leave of Absence from the program may be requested.

Extended Parental Leave

Following that initial eight weeks of university-guaranteed parental leave, the Biomedical Engineering Department provides an additional four weeks of extended parental leave, though not necessarily with stipend or salary support.

Graduate Fellow (GF)

Parental leave support for graduate fellows is often provided by their fellowship. Students supported by fellowships from external sources (NIH, NSF, etc.) are subject to the rules and regulations of the granting agency concerning leave from academic and research work. Following an eight-week parental leave, GFs are not guaranteed salary or stipend for a subsequent four-week extended parental leave. However, when the fellowship source provides such benefits, parents are encouraged to take the additional four-week extended parental leave with pay.

The following list includes links to some relevant fellowships' parental leave policies. Note that the extent of some of these benefits may not exceed those available to other GFs in similar positions. The graduate student and faculty advisor should contact the relevant program officer for details.

- NIH-NRSA Fellows: up to eight weeks of paid leave per child, once per year, NOT-OD-18-154.
- NSF-GRFP Fellows: up to twelve weeks of paid leave over the entire three years, NSF 13-084.

Graduate Researcher (GR)

Following parental leave, GRs may take an additional four weeks of extended parental leave, but they are not guaranteed stipend or salary support during that time. By college policy, no funds are available for continued support during the four weeks of extended parental leave. If possible, GRs preparing for the arrival of a child should discuss the situation with their faculty advisor. If the faculty advisor can identify appropriate funding sources, the student may consider switching to an RA position that could provide four weeks of paid, extended parental leave.

Teaching Assistant (TA)

Following parental leave, TAs may take an additional four weeks of extended parental leave, but they are not guaranteed stipend or salary support during that time. By college policy, no funds are available for continued support during the four weeks of extended parental leave. If possible, TAs preparing for the arrival of a child should discuss the situation with their faculty advisor. If the faculty advisor can identify appropriate funding sources, the student may consider switching to an RA position that could provide four weeks of paid, extended parental leave.

Research Assistant (RA)

Following parental leave, RAs may take an additional four weeks of extended parental leave, but they are not guaranteed stipend or salary support during that time. To the extent possible, extended parental leave support for research assistants shall be provided by the faculty advisor's funding sources. The faculty advisor should use their funding, if allowed, or obtain commonly available supplemental funds to support extended parental leave. Barring this option, students may use accrued vacation time to receive salary or stipend during extended parental leave; however, as noted in the Vacation Leave section, RA vacation time is available at the discretion of the faculty advisor and their

lab policies. When none of these options can be made available, the faculty advisor should support extended parental leave from any discretionary sources they have available, including returned research overhead.

Regardless of the support source, any RA-tended project will experience productivity delays during their leave. When appropriate, the principal investigator should formally request accommodations from the funding agencies to account for any delays in project completion. The following list includes links to some relevant funding sources' parental leave policies. Note that the extent of some of these benefits may not exceed those available to other RAs in similar positions. The graduate student and faculty advisor should contact the relevant program officer for details.

- NIH Supported RAs: up to eight weeks of parental leave, NIH Family Friendly Initiatives.
- NSF Supported RAs: up to twelve weeks of parental leave, NSF Career-Life Balance.

International Student Parents

To the extent legally possible, the Department of Biomedical Engineering offers our international graduate students the same rights and privileges as our domestic parents. However, before taking any parental leave, international students and their faculty advisors should consult with the International Student Office to ensure that their parental leave plan conforms to their visa and relevant federal law requirements.

V. STUDENT RESOURCES

This section lists some resources available to BME graduate students through the Department of Biomedical Engineering, the College of Engineering, and the University of Utah. This list is not comprehensive, and other resources can likely be found on the Graduate School Resources Hub and elsewhere.

V.A. STUDENT SAFETY

Student safety is our top priority. In an emergency, dial 911 or seek a nearby emergency phone, located throughout campus. Report any crimes or suspicious people to 801-585-COPS (2677); this number will get you to a dispatch officer at the University of Utah Department of Public Safety (DPS; dps.utah.edu). If at any time, you would like to be escorted by a security officer to or from areas on campus, call DPS for assistance.

The University of Utah seeks to provide a safe and healthy experience for students, employees, and others who use campus facilities. In support of this goal, the University has established confidential resources and support services to assist students who may have been affected by harassment, abusive relationships, or sexual misconduct. A detailed listing of University Resources for campus safety can be found on the Registrar's Office Campus Safety website.

V.B. STUDENT WELLNESS

Your well-being is key to your personal safety. If you are in crisis, call 801-587-3000; help is close. The university has additional excellent resources to promote emotional and physical wellness, including the Counseling Center (https://counselingcenter.utah.edu), the Wellness Center (https://wellness.utah.edu), and the Women's Resource Center (https://womenscenter.utah.edu). Counselors and advocates in these centers can help guide you to other resources to address various issues, including substance abuse and addiction.

The University of Utah and its Graduate School provide various resources and services to support academic and financial concerns, diversity and international student issues, professional development workshops, writing assistance, and more. For a complete listing, please visit the Graduate School Support Services.

The University of Utah and its Center for Student Wellness strive to cultivate a well and safe campus community. We believe that wellness is the foundation of success and that equitable access to inclusive wellness services, education, and support will create a more resilient, thriving environment. We provide resources and services for the campus community, including workshops and training, Victim-Survivor advocacy services, STI/HIV testing, student involvement opportunities, and more. For a complete listing, please visit the Campus Student Wellness page.

The University of Utah and its Office of Equal Opportunity And Affirmative Action are dedicated to providing a fair and equitable environment for all to pursue their academic and professional endeavors and equally access University programs. For information regarding disability access and accommodation, and the Americans with Disabilities Act (ADA), please visit the Office of Equal Opportunity, Affirmative Action, and Title IX. Students requesting accommodations should contact the Center for Disability and Access to schedule an appointment.

VI. HANDBOOK DISCLAIMER

Although some content herein is recommended for best practices as a graduate student in the BME Department, other university and department policies described in this handbook are intended to be read, understood, and followed by all department graduate students. Violations of university and department policies are grounds for immediate dismissal from the program. Policy exceptions may be made in well-justified cases petitioned in writing by the student and supported by the student's committee. No policies or recommendations in this handbook are intended, interpreted, or construed to conflict with or violate standing College or University policies except where allowed. Given such a university conflict without allowance, this Handbook defers to standing universities policies and expectations.