Quantitative Biosciences and Engineering

Degrees Offered

- Master of Science in Quantitative Biosciences and Engineering (Thesis)
- Master of Science in Quantitative Biosciences and Engineering (Non-Thesis)
- Doctor of Philosophy in Quantitative Biosciences and Engineering

Program Description

The graduate program in quantitative biosciences and engineering brings together faculty across the Mines campus working on diverse areas of biology to educate students, with at least a Bachelor of Science degree in engineering or science, in the diverse field of biology. Biology deals broadly with life on this planet, the human organism and its health, and harnessing biological processes to produce fuels, chemicals, and consumer products. Thus, biology in general and human health and well-being in particular are important application areas for virtually all other areas of science, technology and engineering. This is reflected in the fact that any academic discipline exists today with a bio-prefix, such as biophysics, biochemistry, bioengineering, mathematical biology, computational biology, systems biology, structural biology, biomedicine, biomaterials, biomechanics, bioinformatics, biological chemistry, geobiology, environmental biology, microbiology to name just a few. Similarly, health is included in many labels, e.g. digital healthcare, health economics, health informatics. Educating students at the interfaces of biology, health and engineering with other disciplines is a primary goal of this program.

Many departments at Mines jointly administer this cross-departmental program in interdisciplinary biosciences. The program co-exists alongside strong disciplinary programs, in chemistry and geochemistry, chemical and biochemical engineering, physics, computer science, mathematics and statistics, mechanical engineering and metallurgical and materials engineering, civil and environmental engineering, economics, geology and geological engineering and geophysics, and thus draws from the strengths of these programs through close links and joint courses. For administrative purposes, the student will reside in the advisor's home academic department. The student’s graduate committee will have final approval of the course of study.

Fields of Research

Research at Mines in this rapidly growing field currently includes but is not limited to the following general areas:

- Laser Design and Imaging
- Biofuels and Metabolic Engineering
- Omics and Systems Biology
- Environmental Toxicology and Microbiology
- Biosensors and Devices
- Biotechnology
- Biomechanics
- Biofluid mechanics
- Bioinformatics and Computational Biology
- Tissue Engineering & Biomaterials
- Physical Biochemistry
- Biophysics and Analytical Methodology Development
- Digital Healthcare
- Mathematical Biology

More than 45 faculty members across the Mines campus participate in this program, which will in the future also involve faculty of nearby collaborating institutions and scientists from the biotech/healthcare industry.

Program Requirements

For admission, students may enter with biology or health related undergraduate degrees of with a technical degree, e.g. in engineering, mathematics, or computer science. Ideally, students with a technical major will either have one of the biology related minors form Mines, or demonstrate the equivalent background, e.g., through a biology or health related minor at another institution. Current Mines undergraduate students have the option to apply to the Office of Graduate Studies for the 4+1 combined program while pursuing their undergraduate degree.

Each of the three degree programs (non-thesis MS, thesis-based MS, and PhD) require the successful completion of three mandatory core courses for a total of 10 credit hours.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Description</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>BIOL5XX</td>
<td>CELL BIOLOGY AND BIOCHEMISTRY Course not yet created. See advisor for course numbers.</td>
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<tr>
<td>BIOL5XX</td>
<td>APPLIED BIOINFORMATICS Course not yet created. See advisor for course numbers.</td>
<td>3.0</td>
</tr>
<tr>
<td>BIOL5XX</td>
<td>SYSTEMS BIOLOGY Course not yet created. See advisor for course numbers.</td>
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Total Semester Hrs 10.0

List of Electives:

Students must also take different numbers of electives, as per the degree chosen (see below). The current list of available electives is shown here but is dynamic. We expect the number of graduate level electives to increase over the time as this and other bio-related programs on campus evolve and expand. This list will therefore be updated annually subject to approval by the program's curriculum committee.

<table>
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<tr>
<th>Course Code</th>
<th>Course Description</th>
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<tr>
<td>CBEN432</td>
<td>TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS</td>
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<tr>
<td>CBEN531</td>
<td>IMMUNOLOGY FOR SCIENTISTS AND ENGINEERS</td>
<td>3.0</td>
</tr>
<tr>
<td>CBEN570</td>
<td>INTRODUCTION TO MICROFLUIDICS</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN501</td>
<td>LIFE CYCLE ASSESSMENT</td>
<td>3.0</td>
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<tr>
<td>CEEN560</td>
<td>MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN562</td>
<td>ENVIRONMENTAL GEOMICROBIOLOGY</td>
<td>3.0</td>
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</table>
at least 24 credits in research:
course and research credit including at least 24 credits in coursework and
The Doctor of Philosophy degree requires a minimum of 72.0 hours of
Biosciences and Engineering
Doctor of Philosophy in Quantitative
of acceptable course work and project credits.
The Master of Science degree requires a minimum of 30 semester hours
Students can also opt to enroll in further electives instead of conducting
fledged research project. The case studies can be chosen from projects
Here, the student can opt to conduct a case study instead of a full-
Biosciences and Engineering (Non-Thesis Option)
Here, the student conducts an in-depth research project with one of
the participating faculty members who are currently accepting masters
degree students. The Master of Science degree requires a minimum
of 30 semester hours of acceptable course work and thesis research
credits. The student must also submit a thesis and pass the Thesis
Defense examination before the Thesis Committee.
Core Courses
Electives
BIOL707 Research
Total Semester Hrs
10.0
8.0
12.0
30.0
12.0
Master of Science in Quantitative Biosciences and Engineering (Non-Thesis Option)
Here, the student can opt to conduct a case study instead of a full-
fledged research project. The case studies can be chosen from projects
provided by program faculty, local industry or academic partners.
Students can also opt to enroll in further electives instead of conducting
an independent study where this is more in line with their career goals.
The Master of Science degree requires a minimum of 30 semester hours
of acceptable course work and project credits.
Core Courses
Electives
BIOL599 Independent Study
Total Semester Hrs
10.0
14.0
6.0
30.0
10.0
14.0
24.0
24.0
72.0
Master of Science in Quantitative Biosciences and Engineering (Thesis Option)
Here, the student conducts an in-depth research project with one of
the participating faculty members who are currently accepting masters
degree students. The Master of Science degree requires a minimum
of 30 semester hours of acceptable course work and thesis research
credits. The student must also submit a thesis and pass the Thesis
Defense examination before the Thesis Committee.
Core Courses
Electives
BIOL707 Research
Total Semester Hrs
10.0
14.0
24.0
24.0
72.0
Checklist
The program is interdisciplinary and it is therefore expected that there
will be diverse backgrounds in the students admitted to this program. To
ensure that all fundamental knowledge is adequately present, candidates
may need to complete courses, which depend on the candidates’
backgrounds. For example, a student with an experimental biology
background needs to take programming courses. The courses are thus
individualized for each candidate based on their previous experience and
research activities to be pursued where applicable. Some candidates may
already possess this background information. In such circumstances, the
candidate’s Thesis Committee may award credit for previous experience.
These courses can be at the undergraduate level but do not count
towards the 30 credits in the case of the Masters and 72 credits in case
of the PhD degrees. Students with sufficient background can start taking
graduate level classes counting towards the graduate degree in their
junior year, but the majority will do so in their senior year. The program
will be flexible given the expected diverse backgrounds of the students,
and will offer bootcamp style activities at the beginning of each core class
in order to account for the differences in backgrounds, where students
from one background will help teach students with other backgrounds to
acquire complementary skills.
PhD Qualifying Process
Core Curriculum – The three required core classes must be completed
in the first two full academic years for all doctoral candidates, except
where remedial classes or prerequisites need to be taken prior. Students
must obtain a grade of B- or better in each class and have a cumulative
GPA of 3.0 or higher to be eligible to take the qualifying examination at
the end of the succeeding spring semester. If not allowed to complete the
qualifying examination at the end of the spring semester, students will be
discouraged from the PhD program and encouraged, rather, to finish with
a Masters degree
PhD Qualifying Examination – All first-year Quantitative Biosciences
and Engineering PhD students are expected to successfully complete
the qualifying examination at the end of the first year to remain in good
standing in the program. The examination covers material from the
core curriculum plus the theoretical background of their chosen area
of research. If a student performs below the expectations of the faculty
administering the oral exam, a student may need to finish with a Masters
degree
PhD Thesis Proposal – A student’s PhD thesis committee administers
the PhD Thesis Proposal defense. The PhD proposal defense should
occur no later than the student’s fourth semester. While the proposal
itself should focus on the central topic of the student’s research, during
the proposal defense, candidates may expect to receive a wide range
of questions from the Committee. This would include all manner of
questions directly related to the proposal. Candidates, however, should
also expect questions related to the major concept areas of Biology within
the context of a candidate’s research focus. The Committee formally
reports the results of the PhD proposal defense to the Quantitative
Biosciences and Engineering Program Director using the Committee
Reporting form developed by the Office of Graduate Studies.

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<tr>
<td>CEEN566</td>
<td>MICROBIAL PROCESSES, ANALYSIS AND MODELING</td>
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<td>CEEN570</td>
<td>WATER AND WASTEWATER TREATMENT</td>
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<td>CHGN429</td>
<td>BIOCHEMISTRY II</td>
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<td>CSC1562</td>
<td>APPLIED ALGORITHMS AND DATA STRUCTURES</td>
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<td>CSC1575</td>
<td>MACHINE LEARNING</td>
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<td>MATH572</td>
<td>MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE</td>
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<td>MEGN531</td>
<td>PROSTHETIC AND IMPLANT ENGINEERING</td>
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<td>MEGN532</td>
<td>EXPERIMENTAL METHODS IN BIOMECHANICS</td>
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<td>MEGN535</td>
<td>MODELING AND SIMULATION OF HUMAN MOVEMENT</td>
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<td>MEGN536</td>
<td>COMPUTATIONAL BIOMECHANICS</td>
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<td>PROBABILISTIC BIOMECHANICS</td>
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<td>MTGN572</td>
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Doctor of Philosophy in Quantitative Biosciences and Engineering
The Doctor of Philosophy degree requires a minimum of 72.0 hours of
course and research credit including at least 24 credits in coursework and
at least 24 credits in research:
Upon completion of these steps and upon completion of all required coursework, candidates are admitted to candidacy. Following successful completion of coursework and the PhD qualifying process, candidates must also submit a thesis and successfully complete the PhD Defense of Thesis examination before the PhD Thesis Committee.

Mines' Combined Undergraduate / Graduate Degree Program

Students enrolled in Mines’ combined undergraduate/graduate program (meaning uninterrupted registration from the time the student earns a Mines undergraduate degree to the time the student begins a Mines graduate degree) may double count up to six hours of credits which were used in fulfilling the requirements of their undergraduate degree at Mines, towards their Quantitative Biosciences and Engineering (QBE) Graduate Program. Any 400+ level courses that count towards the undergraduate degree requirements as "Elective Coursework" or any 500+ level course, may be used for the purposes of double counting at the discretion of the graduate advisor (MS Non-Thesis) or thesis committee (MS Thesis of PhD). These courses must have been passed with a "B-" or better and meet all other University, Department, Division, and Program requirements for graduate credit.

Courses

**BIOL598. SPECIAL TOPICS IN BIOLOGY. 6.0 Semester Hrs.**
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

**BIOL599. INDEPENDENT STUDY. 0.5-6 Semester Hr.**
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

**BIOL707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.**
(I, II, S) Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.

Advising Faculty

Joel Bach, Professor of Mechanical Engineering

Cecilia Diniz Behn, Assistant Professor of Applied Mathematics & Statistics

Steven Boyes, Associate Professor of Chemistry

Nanette Boyle, Assistant Professor of Chemical and Biological Engineering

John Bradford, Professor of Geophysics

Kevin Cash, Assistant Professor of Chemical and Biological Engineering

Anuj Chauhan, Professor of Chemical and Biological Engineering

Dylan Domaille, Assistant Professor of Chemistry

Christopher Higgins, Associate Professor of Civil and Environmental Engineering

Judith Klein-Seetharaman, Director of Biosciences and Bioengineering

Melissa Krebs, Associate Professor of Chemical and Biological Engineering

Lokender Kumar, Research Assistant Professor of Physics

Amy Landis, Professor of Civil and Environmental Engineering

Karin Leiderman-Gregg, Assistant Professor of Applied Mathematics & Statistics

Terry Lowe, Research Professor of Materials and Metallurgical Engineering

David Marr, Professor of Chemical and Biological Engineering

Christine Morrison, Assistant Professor of Chemistry

Steve Pankavich, Associate Professor of Applied Mathematics & Statistics

Tony Petrelia, Associate Professor of Mechanical Engineering

Andrew Petruska, Assistant Professor of Mechanical Engineering

Matt Posewitz, Professor of Chemistry

James Ranville, Professor of Chemistry

James Rosenblum, Research Assistant Professor of Civil and Environmental Engineering

Susanta Sarkar, Assistant Professor of Physics

Josh Sharp, Associate Professor of Civil and Environmental Engineering

Anne Silverman, Associate Professor of Mechanical Engineering

Dendy Sloan, Emeritus Professor of Chemical and Biological Engineering

John Spear, Professor of Civil and Environmental Engineering

Jeff Squier, Professor of Physics

Blake Stamps, Research Assistant Professor of Civil and Environmental Engineering

Amadeu Sum, Professor of Chemical and Biological Engineering

Brian Trewyn, Associate Professor of Chemistry

Shubham Vyas, Assistant Professor of Chemistry

Hua Wang, Associate Professor of Computer Science

Kim Williams, Professor of Chemistry

Xioli Zhang, Assistant Professor of Mechanical Engineering

Teaching Faculty

Linda Battalora, Teaching Professor of Petroleum Engineering

Kristine Csavina, Teaching Professor of Mechanical Engineering

Laura Legault, Teaching Assistant Professor of Computer Science
Cynthia Norrgran, teaching Associate Professor of Chemical and Biological Engineering

Josh Ramey, Teaching Associate Professor of Chemical and Biological Engineering

Jeffrey Schowalter, Teaching Professor of Electrical Engineering