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 CSM 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.

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>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL5XX</td>
<td>CELL BIOLOGY AND BIOCHEMISTRY</td>
<td>4.0</td>
</tr>
<tr>
<td>BIOL5XX</td>
<td>APPLIED BIOINFORMATICS</td>
<td>3.0</td>
</tr>
<tr>
<td>BIOL5XX</td>
<td>SYSTEMS BIOLOGY</td>
<td>3.0</td>
</tr>
<tr>
<td>CBEN432</td>
<td>TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS</td>
<td>3.0</td>
</tr>
<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>
</tr>
<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>
</tr>
<tr>
<td>CEEN566</td>
<td>MICROBIAL PROCESSES, ANALYSIS AND MODELING</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN570</td>
<td>WATER AND WASTEWATER TREATMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGN429</td>
<td>BIOCHEMISTRY II</td>
<td>3.0</td>
</tr>
<tr>
<td>CSCI562</td>
<td>APPLIED ALGORITHMS AND DATA STRUCTURES</td>
<td>3.0</td>
</tr>
<tr>
<td>CSCI575</td>
<td>MACHINE LEARNING</td>
<td>3.0</td>
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</tbody>
</table>
The Doctor of Philosophy degree requires a minimum of 72.0 hours of coursework and research credits. This includes coursework, independent study, research, and project credits. The student must also submit a thesis and pass the Thesis Defense examination before the Thesis Committee.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH572</td>
<td>Mathematical and Computational Neuroscience</td>
<td>3.0</td>
</tr>
<tr>
<td>MEGN531</td>
<td>Prosthetic and Implant Engineering</td>
<td>3.0</td>
</tr>
<tr>
<td>MEGN532</td>
<td>Experimental Methods in Biomechanics</td>
<td>3.0</td>
</tr>
<tr>
<td>MEGN535</td>
<td>Modeling and Simulation of Human Movement</td>
<td>3.0</td>
</tr>
<tr>
<td>MEGN536</td>
<td>Computational Biomechanics</td>
<td>3.0</td>
</tr>
<tr>
<td>MEGN537</td>
<td>Probabilistic Biomechanics</td>
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<tr>
<td>MTGN570</td>
<td>Biocompatibility of Materials</td>
<td>3.0</td>
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<tr>
<td>MTGN572</td>
<td>Biomaterials</td>
<td>3.0</td>
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<tr>
<td>PHGN433</td>
<td>Biophysics</td>
<td>3.0</td>
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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. 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.

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.

Doctor of Philosophy in Quantitative Biosciences and Engineering

The Doctor of Philosophy degree requires a minimum of 72.0 hours of coursework and research credit including at least 24 credits in coursework and at least 24 credits in research: 24.0

Combined Undergraduate/Graduate BS/MS Degree (“4+1”)
The interdisciplinary biology degree programs will offer Mines undergraduate students the opportunity to begin work on the Graduate Degree while completing the requirements of their Bachelors Degree. The purpose is to give students a head start on graduate education and enable them to finish their Masters degree in one year after their Bachelors. Admission into a Combined Undergraduate/Graduate degree program is available only to current Mines undergraduate students. Students need to plan with their advisor what classes they would like to take and which prerequisites might be required in order to be able to fit the classes into their undergraduate curriculum.

**Advising Faculty**

Joel Bach  
Cecilia Diniz Behn  
Steven Boyes  
Nanette Boyle  
John Bradford  
Kevin Cash  
Dylan Domaille  
Christopher Higgins  
Judith Klein-Seetharaman  
Melissa Krebs  
Amy Landis  
Karin Leiderman-Gregg  
Terry Lowe  
David Marr  
Keith Neeves  
Steve Pankavich  
Tony Petrella  
Andrew Petruska  
Matt Posewitz  
James Ranville  
Susanta Sarkar  
Josh Sharp  
Anne Silverman  
Dendy Sloan  
John Spear  
Jeff Squier  
Amadeu Sum  
Brian Trewyn

Shubham Vyas  
Hua Wang  
Kim Williams  
Xioli Zhang

**Teaching Faculty**

Linda Battalora  
Kristine Csavina  
Cynthia Norrgran  
Josh Ramey  
Jeffrey Schowalter