BIOMEDICAL ENGINEERING, PH.D.

Biomedical engineering is the application of engineering tools for solving problems in biology and medicine. It is an engineering discipline that is practiced by professionals trained primarily as engineers, who specialize in medical and biological applications. This area of study combines fundamentals of the biomedical sciences with advanced engineering methods of analysis and design, and brings together these two fields in order to contribute to the design of new medical instruments and devices, apply engineering principles for understanding and repairing the human body and other biological systems, and use engineering tools for decision making and cost containment.

The interdisciplinary degree program offers a course of graduate study leading to the master of science or the doctor of philosophy degrees in biomedical engineering. The Department of Biomedical Engineering should be of interest to students who wish to practice engineering or engage in research in an engineering specialization in medicine and biology. An individualized course of study is planned with a faculty advisor. Biomedical engineering faculty and affiliated faculty come from the various colleges and professional schools throughout the university. They specialize in biomedical engineering areas as diverse as biomechanics, bioinstrumentation, biomedical imaging and biophotonics, micro and nanotechnology, systems biology, biomaterials, cellular engineering, tissue engineering, bioengineering, and rehabilitation and human performance. A list of biomedical engineering faculty, affiliated faculty, and their respective areas of specialization is available from the department website.

ADMISSIONS

Please consult the table below for key information about this degree program's admissions requirements. The program may have more detailed admissions requirements, which can be found below the table or on the program's website.

Graduate admissions is a two-step process between academic programs and the Graduate School. Applicants must meet the minimum requirements (https://grad.wisc.edu/apply/requirements/ of the Graduate School as well as the program(s). Once you have researched the graduate program(s) you are interested in, apply online (https://grad.wisc.edu/apply/).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Deadline</td>
<td>December 1</td>
</tr>
<tr>
<td>Spring Deadline</td>
<td>October 1</td>
</tr>
<tr>
<td>Summer Deadline</td>
<td>December 1</td>
</tr>
<tr>
<td>GRE (Graduate Record Examinations)</td>
<td>Not required.</td>
</tr>
<tr>
<td>English Proficiency Test</td>
<td>Every applicant whose native language is not English or whose undergraduate instruction was not in English must provide an English proficiency test score and meet the Graduate School minimum requirements (<a href="https://grad.wisc.edu/apply/requirements/#english-proficiency">https://grad.wisc.edu/apply/requirements/#english-proficiency</a>).</td>
</tr>
</tbody>
</table>

Other Test(s) (e.g., GMAT, MCAT) n/a
Letters of Recommendation Required 3

Applicants should have a bachelor's degree in engineering (biomedical, chemical, electrical, industrial, mechanical, etc.) or science (biology, biochemistry, chemistry, genetics, immunology, physics, etc.). Each application is judged on the basis of:

- Official academic transcripts
- English Proficiency Test scores (https://grad.wisc.edu/apply/requirements/#english-proficiency) (if applicable)
- Three letters of recommendation
- Statement of purpose (https://grad.wisc.edu/apply/prepare/)
- Resume

All applicants must satisfy requirements that are set forth by the Graduate School (https://grad.wisc.edu/). Students admitted to the program may be required to make up deficiency course requirements.

To apply to the BME program, complete applications (https://grad.wisc.edu/apply/), including supportive materials, must be submitted as described below and received by the following deadline dates:

- Fall Semester—December 1
- Spring Semester—October 1
- Summer Session 1—December 1

1 Please note that summer admissions are generally limited to continuing BME students at UW–Madison or applicants who have research assistantships already arranged with UW faculty.

OFFICIAL ACADEMIC TRANSCRIPT

Electronically submit one copy of your transcript of all undergraduate and previous graduate work in your online application to the Graduate School. Unofficial copies of transcripts will be accepted for review. Official copies are required after an applicant is recommended for admission. Please do not send transcripts or any other application materials to the Graduate School or the BME department unless requested. If you have questions, please contact bmegradadmission@engr.wisc.edu.

ENGLISH PROFICIENCY TEST SCORES (IF APPLICABLE)

An applicant whose TOEFL (iBT) score is below 92; TOEFL (PBT) score is below 580; or IELTS score is below 7 must take an English assessment test upon arrival. Depending on the result, an applicant may need to register for recommended English as a Second Language (ESL) courses in the first semester of enrollment.

All BME PhD students will hold teaching assistantships (TA) at least once during their graduate degree. International students whose native language is not English must take the SPEAK test (https://esl.wisc.edu/ita-training/speak/) during their first semester on campus, unless they have achieved a score greater than 26 on the speaking section of the iBT TOEFL (8.0 for the IELTS). Any recommended ESL coursework must be completed during the first year.

THREE LETTERS OF RECOMMENDATION

These letters are required from people who can accurately judge the applicant’s academic or research performance. Letters of recommendation are submitted electronically to graduate programs...
through the online application. Applicants should not send any more than three letters (if more than three are sent, only the first three will be considered). See the Graduate School for FAQs (https://grad.wisc.edu/apply/) regarding letters of recommendation.

**STATEMENT OF PURPOSE**
In this document, applicants should explain why they want to pursue further education in BME and discuss which UW faculty members they would be interested in doing research with during their graduate study. See the Graduate School for more advice on how to structure a personal statement (https://grad.wisc.edu/apply/prepare/).

**RESUME**
Upload your resume in your application.

**APPLICATION FEE**
Submission must be accompanied by the one-time application fee. It is non-refundable and can be paid by credit card (Master Card or Visa) or debit/ATM. This fee cannot be waived or deferred. Fee grants are available through the Graduate School under certain conditions.

**FUNDING**

**GRADUATE SCHOOL RESOURCES**
Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding/) is available from the Graduate School. Be sure to check with your program for individual policies and restrictions related to funding.

**PROGRAM RESOURCES**
Students admitted to the BME PhD program are guaranteed financial support from the department in the form of research assistantships, teaching assistantships and fellowships. Support will continue as long as the student maintains satisfactory progress toward their degree.

**REQUIREMENTS**

**MINIMUM GRADUATE SCHOOL REQUIREMENTS**
Review the Graduate School minimum academic progress and degree requirements (http://guide.wisc.edu/graduate/policiesandrequirementstext), in addition to the program requirements listed below.

**MAJOR REQUIREMENTS**

**MODE OF INSTRUCTION**

<table>
<thead>
<tr>
<th>Mode of Instruction Definitions</th>
<th>Accelerated: Accelerated programs are offered at a fast pace that condenses the time to completion. Students are able to complete a program with minimal disruptions to careers and other commitments.</th>
</tr>
</thead>
</table>

**Evening/Weekend:** Courses meet on the UW–Madison campus only in evenings and/or on weekends to accommodate typical business schedules. Students have the advantages of face-to-face courses with the flexibility to keep work and other life commitments.

**Face-to-Face:** Courses typically meet during weekdays on the UW-Madison Campus.

**Hybrid:** These programs combine face-to-face and online learning formats. Contact the program for more specific information.

**Online:** These programs are offered 100% online. Some programs may require an on-campus orientation or residency experience, but the courses will be facilitated in an online format.

**CURRICULAR REQUIREMENTS**

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Credit Requirement</td>
<td>60 credits</td>
</tr>
<tr>
<td>Minimum Residence Credit Requirement</td>
<td>32 credits</td>
</tr>
<tr>
<td>Minimum Coursework Requirement</td>
<td>30 credits must be graduate-level coursework. Details can be found in the Graduate School's Minimum Graduate Coursework Coursework (50%) policy (<a href="https://policy.wisc.edu/library/">https://policy.wisc.edu/library/</a> UW-1244 (<a href="https://policy.wisc.edu/library/UW-1244/">https://policy.wisc.edu/library/UW-1244/</a>)).</td>
</tr>
<tr>
<td>Overall Graduate GPA Requirement</td>
<td>3.00 GPA required.</td>
</tr>
<tr>
<td>Requirement</td>
<td>This program follows the Graduate School's GPA Requirement policy (<a href="https://policy.wisc.edu/library/UW-1203">https://policy.wisc.edu/library/UW-1203</a> <a href="https://policy.wisc.edu/library/UW-1203/">https://policy.wisc.edu/library/UW-1203/</a>).</td>
</tr>
<tr>
<td>Other Grade Requirements</td>
<td>n/a</td>
</tr>
<tr>
<td>Assessments and Examinations Requirement</td>
<td>PhD candidates are required to pass a comprehensive qualifying examination, preliminary examination, and final oral defense. Deposit of the doctoral dissertation to the Graduate School is required.</td>
</tr>
<tr>
<td>Language Requirements</td>
<td>No language requirements.</td>
</tr>
<tr>
<td>Breadth Requirement</td>
<td>Breadth is provided via interdisciplinary training. The central aim of biomedical engineers is to unravel gaps in biological knowledge through the use of engineering principles. Thus, the doctoral program is inherently interdisciplinary. Prior to obtaining a Ph.D. warrant, students will prepare a summary of their effort in interdisciplinary coursework and training. The purpose of the summary will be to document the effort to meet the spirit of the minor requirement. The summary must be approved by the student’s thesis committee and filed with the department. Students may elect to pursue a doctoral minor or Graduate/Professional certificate.</td>
</tr>
</tbody>
</table>

**REQUIRED COURSES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Credits (B M E 790, 890, 990)</td>
<td>at least 30</td>
<td></td>
</tr>
<tr>
<td>Coursework, including:</td>
<td>at least 28</td>
<td></td>
</tr>
<tr>
<td>2 semesters of B M E 701</td>
<td>2</td>
<td></td>
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</tbody>
</table>
Biology Requirement

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRB 640</td>
<td>Fundamentals of Stem Cell and Regenerative Biology</td>
<td>3</td>
</tr>
<tr>
<td>CRB 650</td>
<td>Molecular and Cellular Organogenesis</td>
<td></td>
</tr>
<tr>
<td>M M &amp; I/PATH-BIO 528</td>
<td>Immunology</td>
<td></td>
</tr>
<tr>
<td>ONCOLOGY 401</td>
<td>Introduction to Experimental Oncology</td>
<td>3-4</td>
</tr>
<tr>
<td>ZOOLOGY 570</td>
<td>Cell Biology</td>
<td></td>
</tr>
<tr>
<td>ZOOLOGY/BIOCHEM/PHMCOL-M 630</td>
<td>Cellular Signal Transduction Mechanisms</td>
<td></td>
</tr>
</tbody>
</table>

Data Analysis Requirement

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>B M I/STAT 541</td>
<td>Introduction to Biostatistics</td>
<td>3-4</td>
</tr>
<tr>
<td>B M I/COMP SCI 776</td>
<td>Advanced Bioinformatics</td>
<td></td>
</tr>
<tr>
<td>COMP SCI 765</td>
<td>Data Visualization</td>
<td></td>
</tr>
<tr>
<td>STAT/F&amp;W ECOL/HORT 571</td>
<td>Statistical Methods for Bioscience I</td>
<td></td>
</tr>
<tr>
<td>STAT/B M I 877</td>
<td>Statistical Methods for Molecular Biology</td>
<td></td>
</tr>
</tbody>
</table>

Biomaterials & Tissue Engineering Requirement

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>B M E/PHM SCI 430</td>
<td>Biological Interactions with Materials</td>
<td>3-4</td>
</tr>
<tr>
<td>B M E 510</td>
<td>Introduction to Tissue Engineering</td>
<td></td>
</tr>
<tr>
<td>B M E 511</td>
<td>Tissue Engineering Laboratory</td>
<td></td>
</tr>
<tr>
<td>B M E 520</td>
<td>Stem Cell Bioengineering</td>
<td></td>
</tr>
<tr>
<td>B M E 545</td>
<td>Engineering Extracellular Matrices</td>
<td></td>
</tr>
<tr>
<td>B M E 550</td>
<td>Introduction to Biological and Medical Microsystems</td>
<td></td>
</tr>
</tbody>
</table>

Elective Requirement

To provide breadth, at least 6 credits of electives must be chosen from courses that are not listed above.

B M E 556 | Systems Biology: Mammalian Signaling Networks
B M E/CBE 560 | Biochemical Engineering
B M E 602 | Special Topics in Biomedical Engineering (Advanced Topics in Biomanufacturing Entrepreneurship)
B M E/MED PHYS/PHMCOL-M/PHYSICS/RADIOL 619 | Microscopy of Life
B M E/COMP SCI 775 | Biological Optical Microscopy
B M E/CBE 782 | Modeling Biological Systems
B M E/CBE 783 | Design of Biological Molecules

PhD Elective Bonus Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
</table>
| B M E/MED PHYS/PHMCOL-M/PHYSICS/RADIOL 619 | Microscopy of Life
B M E/CHEM/MED PHYS 750 | Biological Optical Microscopy
B M E/CBE 782 | Modeling Biological Systems
B M E/CBE 783 | Design of Biological Molecules

Biological Imaging & Optics Pathway

Biomedical imaging and optics research develops and utilizes new experimental and computational tools to characterize tissue structure across multiple size scales. A particular focus is on human health, especially with respect to achieving superior diagnostic/prognostic tools for a spectrum of diseased states. Graduate students trained in this track are expected to gain a detailed understanding of mathematics, biology and engineering both optical and/or physical methods relevant to their research focus.

Mathematics Requirement

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 443</td>
<td>Applied Linear Algebra</td>
<td></td>
</tr>
</tbody>
</table>

Biology Requirement

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANAT&amp;PHY 335</td>
<td>Physiology</td>
<td></td>
</tr>
<tr>
<td>BIOCHEM 501</td>
<td>Introduction to Biochemistry</td>
<td></td>
</tr>
<tr>
<td>ZOOLOGY 570</td>
<td>Cell Biology</td>
<td></td>
</tr>
</tbody>
</table>

Data Analysis

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBE 540</td>
<td>Polymer Science and Technology</td>
<td></td>
</tr>
<tr>
<td>CBE 562</td>
<td>Special Topics in Chemical Engineering (Cellular Biomanoufacturing)</td>
<td></td>
</tr>
<tr>
<td>CBE 648</td>
<td>Synthetic Organic Materials in Biology and Medicine</td>
<td></td>
</tr>
<tr>
<td>CBE 781</td>
<td>Biological Engineering: Molecules, Cells &amp; Systems</td>
<td></td>
</tr>
<tr>
<td>CHEM 654</td>
<td>Materials Chemistry of Polymers</td>
<td></td>
</tr>
<tr>
<td>M S &amp; E 521</td>
<td>Advanced Polymeric Materials</td>
<td></td>
</tr>
</tbody>
</table>
Biomedical Engineering, Ph.D.

BM I/COMP SCI 567  Medical Image Analysis
COMP SCI 300  Programming II
COMP SCI 320  Data Science Programming II
COMP SCI/ECE/M E 532  Matrix Methods in Machine Learning
COMP SCI 766  Computer Vision
COMP SCI/ECE/M E 533  Image Processing
ECE/COMP SCI M E 539  Networks
MED PHYS/BME 573  Medical Image Science: Mathematical and Conceptual Foundations

Imaging Requirement

BME/MED PHYS 530  Medical Imaging Systems
BME/MED PHYS 573  Medical Image Science: Mathematical and Conceptual Foundations
BME/MED PHYS 574  Imaging in Medicine: Applications
BME/MED PHYS 578  Non-Ionizing Diagnostic Imaging
BME/BME/MED PHYS 780  Methods in Quantitative Biology
BME/MED PHYS/PHMCOL/M/PHYSICS/RADIOL 619  Microscopy of Life
BME/MED PHYS 710  Advances in Medical Magnetic Resonance
BME/CH/ECE/MED PHYS 750  Biological Optical Microscopy
BME 751  Biomedical Optics and Biophotonics
MED PHYS/BME/HONCOL/PHYSICS 501  Radiation Physics and Dosimetry
MED PHYS/BME 580  The Physics of Medical Imaging with Ionizing Radiation
MED PHYS 777  Principles of X-ray Computed Tomography

Elective Requirement

BME/MED PHYS 573  Medical Image Science: Mathematical and Conceptual Foundations

Elective Requirement

To provide breadth, at least 6 credits of electives must be taken from courses that are not listed above.

Total Credits  21-23

These pathways are internal to the program and represent different curricular paths a student can follow to earn this degree. Pathway names do not appear in the Graduate School admissions application, and they will not appear on the transcript.

1 The math requirement can be waived by a B- or better in the equivalent course in undergraduate. To request this waiver, please e-mail the Associate Chair of the PhD Degree a copy of your unofficial transcript and indicate the course you are proposing to use. The credits do not transfer; you will instead be able to take a math course of your choice or have a free elective, depending on the track.

Biomechanics Pathway

Biomechanists use experiments and computational tools to investigate the mechanical aspects of biological systems at levels ranging from whole organisms to organs, tissues, and cells. Graduate students trained in biomechanics are expected to gain a detailed understanding of mechanics, mathematics, biology, and engineering relevant to their research focus.

To provide depth, 6 credits of Biomechanics courses are required. The remaining 6 credits may be selected from either the Advanced Mechanics or Biomechanics lists.

Biomechanics

BME/MED 414  Orthopaedic Biomechanics - Design of Orthopaedic Implants
BME/MED 415  Biomechanics of Human Movement
BME/MED 505  Biofluidics
BME 602  Special Topics in Biomedical Engineering (Advanced Tissue Mechanics)

or M E 964  Special Advanced Topics in Mechanical Engineering

BME/MED 603  Topics in Bio-Medical Engineering (FE for Biomechanics; Image-Based Biomechanics)
BME/MED 615  Tissue Mechanics

Advanced Mechanics

M E 440  Intermediate Vibrations
M E/CIV ENGR/E M A 508  Composite Materials
M E/E M A 540  Experimental Vibration and Dynamic System Analysis
M E 563  Intermediate Fluid Dynamics
M E/E M A 570  Experimental Mechanics
M E 573  Computational Fluid Dynamics
E M A 506  Advanced Mechanics of Materials I
E M A 519  Fracture Mechanics
E M A 545  Mechanical Vibrations
E M A 605  Introduction to Finite Elements
E M A/E P 615  Micro- and Nanoscale Mechanics
E M A 622  Mechanics of Continua
E M A 630  Viscoelastic Solids
E M A 700  Theory of Elasticity

Biosciences

3-5
ANAT&PHY 335  Physiology
ANAT&PHY 435  Fundamentals of Human Physiology
CRB/BME 670  Biology of Heart Disease and Regeneration
KINES 773  Cardiorespiratory Adaptions to Environment and Exercise
ZOOLOGY 570  Cell Biology

**Elective Requirement** 6

To provide breadth, electives must be courses that are not listed above. Some recommendations are below.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME/ECE 462</td>
<td>Medical Instrumentation</td>
<td></td>
</tr>
<tr>
<td>BME/PHY 530</td>
<td>Medical Imaging Systems</td>
<td></td>
</tr>
<tr>
<td>BME/MEDPHYS/PHMCOL-M/PHYSICS/RADIOL 619</td>
<td>Microscopy of Life</td>
<td></td>
</tr>
<tr>
<td>COMP SCI 368</td>
<td>Learning a Programming Language (note that there are multiple 1 credit options, including R, C++, and Matlab)</td>
<td></td>
</tr>
<tr>
<td>MATH 443</td>
<td>Applied Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>MATH 519</td>
<td>Ordinary Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MATH 619</td>
<td>Analysis of Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>M/E/ECE 439</td>
<td>Introduction to Robotics</td>
<td></td>
</tr>
<tr>
<td>M/E/COMPSCI/ECE 532</td>
<td>Matrix Methods in Machine Learning</td>
<td></td>
</tr>
<tr>
<td>STAT/M/E 424</td>
<td>Statistical Experimental Design</td>
<td></td>
</tr>
<tr>
<td>STAT/BM 541</td>
<td>Introduction to Biostatistics</td>
<td></td>
</tr>
</tbody>
</table>

**Data Analysis** 3-4

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP SCI 300</td>
<td>Programming II</td>
<td></td>
</tr>
<tr>
<td>COMP SCI 320</td>
<td>Data Science Programming II</td>
<td></td>
</tr>
<tr>
<td>COMP SCI 368</td>
<td>Learning a Programming Language (note that there are multiple 1 credit options, including R, C++, and Matlab)</td>
<td></td>
</tr>
</tbody>
</table>

**Medical & Microdevices** 6

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME/ECE 462</td>
<td>Medical Instrumentation</td>
<td></td>
</tr>
<tr>
<td>BME 515</td>
<td>Therapeutic Medical Devices</td>
<td></td>
</tr>
<tr>
<td>BME/MEDPHYS 535</td>
<td>Introduction to Energy-Tissue Interactions</td>
<td></td>
</tr>
<tr>
<td>BME 550</td>
<td>Introduction to Biological and Medical Microsystems</td>
<td></td>
</tr>
<tr>
<td>BME 602</td>
<td>Special Topics in Biomedical Engineering (Medical Device Ecosystem; Introduction to Neuroengineering; Biophotonics Laboratory)</td>
<td></td>
</tr>
<tr>
<td>BME/PHMCOL-M 630</td>
<td>Biological Optical Microscopy</td>
<td></td>
</tr>
</tbody>
</table>

**Elective Requirement** 6

To provide breadth, 6 credits of electives must be from courses that are not listed above. An example of possible courses are listed below.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME/ECE 463</td>
<td>Computers in Medicine</td>
<td></td>
</tr>
<tr>
<td>BME/MEDPHYS 574</td>
<td>Imaging in Medicine: Applications</td>
<td></td>
</tr>
</tbody>
</table>

**Total Credits** 21-23

These pathways are internal to the program and represent different curricular paths a student can follow to earn this degree. Pathway names do not appear in the Graduate School admissions application, and they will not appear on the transcript.

**Medical & Microdevices Pathway**

Medical and microdevices involve the use of electronic and computational tools to develop devices used in diagnosis and treatment of disease ranging from the systemic to the cellular and molecular levels.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 443</td>
<td>Applied Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 519</td>
<td>Ordinary Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MATH 619</td>
<td>Analysis of Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>ANAT&amp;PHY 335</td>
<td>Physiology</td>
<td>3-5</td>
</tr>
<tr>
<td>BIOCHEM 501</td>
<td>Introduction to Biochemistry</td>
<td></td>
</tr>
<tr>
<td>BIOCHEM/GENETICS/MICROBIO 612</td>
<td>Prokaryotic Molecular Biology</td>
<td></td>
</tr>
</tbody>
</table>

**Biochemistry, Molecular Biology, and Microscopy** 6

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PATH 750</td>
<td>Cellular and Molecular Biology/Pathology</td>
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</tr>
<tr>
<td>ZOOLOGY/PSYCH 523</td>
<td>Neurobiology</td>
<td></td>
</tr>
<tr>
<td>ZOOLOGY 570</td>
<td>Cell Biology</td>
<td></td>
</tr>
<tr>
<td>BIOCHEM/PHMCOL-M 630</td>
<td>Cellular Signal Transduction Mechanisms</td>
<td></td>
</tr>
</tbody>
</table>

**Neuroengineering Pathway**

Neuroengineering is the convergence of neuroscience, computation, device development, and mathematics to improve human health.
Neuroengineering brings together state-of-the-art technologies for the development of devices and algorithms to assist those with neural disorders. It is also used to reverse engineer living neural systems via new algorithms, technologies and robotics. Students pursing this track are involved in all of these endeavors so as the next generation of engineers, they will transcend the traditional boundaries of neuroscience, technology, engineering and mathematics.

### Code | Title | Credits
--- | --- | ---
**Mathematics Requirement** |  | 3
MATH 443 | Applied Linear Algebra | 2
**Data Analysis** |  | 3-4
COMP SCI 320 | Data Science Programming II | 
COMP SCI 368 | Learning a Programming Language (note that there are multiple 1 credit options, including R, C++, and Matlab) |
E CE 630 | All of Signal Processing | 
**Engineering Requirement** |  | 9-12
B ME 515 | Therapeutic Medical Devices | 
B ME 550 | Introduction to Biological and Medical Microsystems |
B ME 602 | Special Topics in Biomedical Engineering (Introduction to Neuroengineering; Medical Device Ecosystem) |
E CE/B ME 462 | Medical Instrumentation | 
E CE/B ME 463 | Computers in Medicine |
**Neurobiology Requirement** |  | 3-6
B ME 520 | Stem Cell Bioengineering | 
KINES 721 | Neural Basis for Movement |
KINES 861 | Principles of Motor Control and Learning |
NTP/NEURODPT 610 | Cellular and Molecular Neuroscience |
NTP/NEURODPT/PSYCH 611 | Systems Neuroscience |
NTP/NEURODPT 630 | Neuronal Mechanisms for Sensation and Memory in Cerebral Cortex |
NTP/NEURODPT 735 | Neurobiology of Disease |
PSYCH 610 | Design and Analysis of Psychological Experiments I |
PSYCH 733 | Perceptual and Cognitive Sciences |
ZOOLOGY 625 | Development of the Nervous System |
**Electives** |  | 6
ANAT&PHY 335 | Physiology |
COMP SCI/B M I 567 | Medical Image Analysis |
COMP SCI 766 | Computer Vision |
COMP SCI/B M I 767 | Computational Methods for Medical Image Analysis |
**Total Credits 27-31** |  | 
1 These pathways are internal to the program and represent different curricular paths a student can follow to earn this degree. Pathway names do not appear in the Graduate School admissions application, and they will not appear on the transcript.

2 The math requirement can be waived by a B- or better in the equivalent course in undergraduate. To request this waiver, please e-mail the Associate Chair of the PhD Degree a copy of your unofficial transcript and indicate the course you are proposing to use. The credits do not transfer; you will instead be able to take a math course of your choice or have a free elective, depending on the track.

3 Engineering and Neurobiology courses must total at least 15 credits.

### Systems & Synthetic Biology Pathway
Systems and synthetic biology utilizes experimental and computational tools in an iterative fashion to analyze and regulate biological systems.

**Students interested in earning a doctoral minor in Quantitative Biology** (http://guide.wisc.edu/graduate/biomedical-engineering/quantitative-biology-doctoral-minor/); enrollment in B ME 780 Methods in Quantitative Biology is a requirement. Additionally, students will need to take one additional 3-credit course in quantitative science, biology, or integrated biology/quantitative science from the approved list of courses in the doctoral minor (this course counts toward the elective credits for this track).

### Code | Title | Credits
--- | --- | ---
**Mathematics Requirement** |  | 3
CBE 660 | Intermediate Problems in Chemical Engineering |
MATH 443 | Applied Linear Algebra |
MATH 519 | Ordinary Differential Equations |
MATH 619 | Analysis of Partial Differential Equations |
**Biology Requirement** |  | 3
BIOCHEM 501 | Introduction to Biochemistry |
BIOCHEM/GENETICS/MICROBIO 612 | Prokaryotic Molecular Biology |
BIOCHEM/GENETICS/MD GENET 620 | Eukaryotic Molecular Biology |
M M & I/PATH-BIO 528 | Immunology |
### GRADUATE SCHOOL POLICIES

The Graduate School's Academic Policies and Procedures ([https://grad.wisc.edu/acadpolicy/](https://grad.wisc.edu/acadpolicy/)) provide essential information regarding general university policies. Program authority to set degree policies beyond the minimum required by the Graduate School lies with the degree program faculty. Policies set by the academic degree program can be found below.

### MAJOR-SPECIFIC POLICIES

#### PRIOR COURSEWORK

**Graduate Work from Other Institutions**

A student may transfer graduate coursework from other institutions with program approval. These courses may not be used toward the Graduate School’s Minimum Graduate Residence Credit at UW-Madison (32 credits). Coursework earned five years or more prior to admission to the PhD program is not allowed to satisfy requirements. Reach out to the BME Graduate Coordinator for more information.

If a student earned a master’s degree at another institution, the following guidelines apply:

1. If the previous degree was a master’s in BME the program may waive up to 18 credits of PhD track coursework requirements. Note that the credits do not transfer; students must fulfill the remaining track requirements and then meet the 32 credit minimum at UW-Madison in order to advance to dissertator status (research credits count towards this minimum).

2. Those with a master’s in other fields can earn a Master of Science in BME at UW-Madison; only 7 credits of coursework will be waived in this case.

3. All students with a prior master’s will still need to complete the Qualifying Exams and Preliminary Exam but may be able to do so at an accelerated pace.

4. Master’s degree credits earned five or more years prior to the initiation of the PhD program cannot be used for waivers.

5. To apply for waivers, students should develop a list of course equivalents between their chosen track and courses taken at their prior institution. This list, the syllabi for all courses from the prior institution, and a copy of the unofficial transcript should be provided to the Associate Chair of the PhD Degree.

#### UW-Madison Undergraduate

A student who has completed their bachelor’s degree at UW-Madison may transfer 6 credits of coursework with program approval. These courses must be coursework numbered 400 level or above. Coursework earned five or more years prior to admission to a Ph.D. degree is not allowed to satisfy requirements. These courses may not be used toward the Graduate School’s Minimum Graduate Residence Credit.

#### UW-Madison University Special

This program follows the Graduate School’s policy for Transfer from UW–Madison University Special Student Career at UW–Madison. ([https://policy.wisc.edu/library/UW-1216/](https://policy.wisc.edu/library/UW-1216/))

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### MAJOR REQUIREMENTS

#### General Education Requirement

- **Total Credits:** 19-21

- **1.** These pathways are internal to the program and represent different curricular paths a student can follow to earn this degree. Pathway names do not appear in the Graduate School admissions application, and they will not appear on the transcript.

- **2.** The math requirement can be waived by a B- or better in the equivalent course in undergraduate. To request this waiver, please e-mail the Associate Chair of the PhD Degree a copy of your unofficial transcript and indicate the course you are proposing to use. The credits do not transfer; you will instead be able to take a math course of your choice or have a free elective, depending on the track.

#### Guidelines for students who earned a master's degree in another field at UW-Madison

1. Students who have earned a master’s degree in another field at UW-Madison should contact the Associate Chair of the PhD Degree to understand remaining coursework requirements. A maximum of 7 credits can be counted from a separate MS degree, in compliance with the Graduate School’s Double Degrees policy ([https://grad.wisc.edu/documents/double-degrees/](https://grad.wisc.edu/documents/double-degrees/)).

2. Master’s degree students who have been absent for five or more years lose all degree credits earned before their absence.

3. All students with a prior master’s degree will need to complete the Qualifying Exams and Preliminary Exam requirements even if coursework requirements have been met. Please discuss your specific plan with the Associate Chair of the PhD Degree.

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### Course Requirements

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOCHEM 570</td>
<td>Computational Modeling of Biological Systems</td>
</tr>
<tr>
<td>BIOCHEM 919</td>
<td>Synthetic Biology Seminar</td>
</tr>
<tr>
<td>B M E 556</td>
<td>Systems Biology: Mammalian Signaling Networks</td>
</tr>
<tr>
<td>B M E 780</td>
<td>Methods in Quantitative Biology</td>
</tr>
<tr>
<td>B M I/COMP SCI 775</td>
<td>Computational Network Biology</td>
</tr>
<tr>
<td>CBE/B M E 560</td>
<td>Biochemical Engineering</td>
</tr>
<tr>
<td>CBE 781</td>
<td>Biological Engineering: Molecules, Cells &amp; Systems</td>
</tr>
<tr>
<td>CBE/B M E 782</td>
<td>Modeling Biological Systems</td>
</tr>
<tr>
<td>COMP SCI 368</td>
<td>Learning a Programming Language (note that there are multiple 1 credit options, including R, C++, and Matlab)</td>
</tr>
</tbody>
</table>

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GRIEVANCES AND APPEALS

This program follows the Graduate School’s Probation policy. (https://policy.wisc.edu/library/UW-1217/)

ADVISOR / COMMITTEE

Advisor: Every BME graduate student must have a faculty advisor. A faculty advisor provides the student with academic guidance in their course program and research oversight in their thesis. The advisor must be a primary BME faculty or a BME affiliate; if the advisor is a BME affiliate, the student must identify a primary BME faculty to serve as co-advisor within their first semester. Graduate students should always seek advice from their advisor and/or co-advisor prior to enrolling for courses.

Doctoral Committee: In addition to the committee requirements put forth by the Graduate School, BME has department-specific criteria that Ph.D. students must meet when forming their committees:

• Committees consist of at least 5 members (one more than the Graduate School’s requirement of four)
• The student’s advisor(s) must be on the committee
• A minimum of two primary BME faculty must be on the committee
• The Ph.D. committee chair must be a primary BME faculty - either the student’s advisor or their co-advisor (if the advisor is an affiliate)
• At least one member must be from outside of the primary BME faculty.
• The Ph.D. committee chair must approve the other members of the committee and any committee changes.
• Students must have a yearly committee meeting after passing the preliminary exam.

CREDITS PER TERM ALLOWED

15 credits

TIME LIMITS

Students typically complete their degree within six years of entering the program.

Within two years of entering their program, students are required to pass a comprehensive qualifying examination.

Within three years of entering their program, students are required to prepare for a preliminary examination.

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GRIEVANCES AND APPEALS

These resources may be helpful in addressing your concerns:

• Bias or Hate Reporting (https://doso.students.wisc.edu/bias-or-hate-reporting/)
• Graduate Assistantship Policies and Procedures (https://hr.wisc.edu/policies/gapp/#grievance-procedure)
• Hostile and Intimidating Behavior Policies and Procedures (https://hr.wisc.edu/hib/)
  • Office of the Provost for Faculty and Staff Affairs (https://facstaff.provost.wisc.edu/)
• Dean of Students Office (https://doso.students.wisc.edu/) (for all students to seek grievance assistance and support)
• Employee Assistance (http://www.eao.wisc.edu/) (for personal counseling and workplace consultation around communication and conflict involving graduate assistants and other employees, post-doctoral students, faculty and staff)
• Employee Disability Resource Office (https://employeedisabilities.wisc.edu/) (for qualified employees or applicants with disabilities to have equal employment opportunities)
• Graduate School (https://grad.wisc.edu/) (for informal advice at any level of review and for official appeals of program/departmental or school/college grievance decisions)
• Office of Compliance (https://compliance.wisc.edu/) (for class harassment and discrimination, including sexual harassment and sexual violence)
• Office of Student Conduct and Community Standards (https://conduct.students.wisc.edu/) (for conflicts involving students)
• Ombuds Office for Faculty and Staff (http://www.ombuds.wisc.edu/) (for employed graduate students and post-docs, as well as faculty and staff)
• Title IX (https://compliance.wisc.edu/titleix/) (for concerns about discrimination)

BME Grievance Procedures

If a student feels unfairly treated or aggrieved by faculty, staff, or another student, the University offers several avenues to resolve the grievance.

Step 1

The student is encouraged to speak first with the person toward whom the grievance is directed to see if a situation can be resolved at this level. Students are also encouraged to talk with their faculty advisors regarding concerns or difficulties, or reach out to the Graduate Student Services Coordinator or Associate Chair of BME Graduate Advising for additional assistance. These activities do not rise to the level of a formal grievance; however, the student is encouraged to keep documentation of these interactions as they may be useful if a formal grievance is pursued.

Step 2

Should a satisfactory resolution not be achieved, a formal grievance can be filed with the BME Grievance Committee. To do so, the student contacts the Department Administrator, who will provide the student with the name of the current chair of the Grievance Committee. The student will then contact the Chair of the Grievance Committee, who will reply within seven calendar days. If the grievance is with the current Chair of the Grievance Committee, please let the Department Administrator know and they will identify an alternate committee member to contact. It is advised that grievances are filed within 60 calendar days of the alleged unfair treatment to enable a thorough investigation.

Step 3

If the student does not feel comfortable working through the departmental process, they are encouraged to seek out other campus resources including:

• The Assistant Dean for Graduate Affairs in the College of Engineering
• The Graduate School
• UW Division of Diversity, Equity & Educational Achievement (DDEEA)
• McBurney Disability Resource Center
• Employee Assistance Office
• Ombuds Office
• University Health Services
Step 4
At this point, if either party (the student or the person toward whom the grievance is directed) is unsatisfied with the decision of the faculty committee, the party may file a written appeal. Either party has ten working days to file a written appeal to the School/College. For more information, students should consult the College of Engineering Academic Advising Policies and Procedures.

Step 5
Documentation of the grievance will be stored for at least seven years. Significant grievances that set a precedent will be stored indefinitely. The Graduate School has procedures for students wishing to appeal a grievance decision made at the school/college level. These policies are described in the Graduate School’s Academic Policies and Procedures.

OTHER
n/a

LEARNING OUTCOMES
1. Demonstrate an ability to synthesize knowledge from a subset of the biological and physical sciences.
2. Conduct original research.
3. Demonstrate an ability to create new knowledge and communicate it to their peers.
4. Foster ethical and professional conduct.

PEOPLE
FACULTY
Paul Campagnola (Chair)
Randolph Ashton
David Beebe
Walter Block
Christopher Brace
Kevin Eliceiri
Shaoqin ‘Sarah’ Gong
Aviad Hai
Melissa Kinney
Pamela Kreeger
Wan-ju Li
Kip Ludwig
Kristyn Masters
Megan McClean
Beth Meyerand
William Murphy
Krishanu Saha
Melissa Skala
Darryl Thelen
Justin Williams
Colleen Witzenburg
Filiz Yesilkoy

INSTRUCTIONAL STAFF AND TEACHING FACULTY
Amit Nimunkar
John Puccinelli
Tracy Jane Puccinelli
Darilis Suarez-Gonzalez
Aaron Suminski

See also Biomedical Engineering Faculty Directory (http://directory.engr.wisc.edu/bme/).

PROFESSIONAL DEVELOPMENT
GRADUATE SCHOOL RESOURCES
Take advantage of the Graduate School’s professional development resources (https://grad.wisc.edu/pd/) to build skills, thrive academically, and launch your career.

PROGRAM RESOURCES
THE INDIVIDUAL DEVELOPMENT PLAN (IDP)
An Individual Development Plan (IDP) (https://grad.wisc.edu/pd/idp/) helps graduate students and postdoctoral researchers:

- assess current skills, interests, and strengths;
- make a plan for developing skills to meet academic and professional goals; and
- communicate with supervisors, advisors, and mentors about evolving goals and related skills.

The IDP is a document to be revisited again and again, to update and refine as goals change and/or come into focus, and to record progress and accomplishments.

The university recommends IDPs for all postdoctoral researchers and graduate students, and requires IDPs for all postdoctoral researchers and graduate students supported by National Institutes of Health (NIH) funding. See the Graduate School for more information and IDP resources (https://grad.wisc.edu/pd/idp/).

ENGINEERING CAREER SERVICES
The Engineering Career Services (https://ecs.wisc.edu/) staff offers assistance to students searching or preparing for internships, co-ops, and jobs with well-recognized organizations.

THE WRITING CENTER
The Writing Center (https://writing.wisc.edu/) is a campus-wide organization that provides free of charge, face-to-face and online consultations for students writing papers, reports, resumes, and applications.