### Biomedical Computation (BMC)

Completion of the undergraduate program in Biomedical Computation leads to the conferral of the Bachelor of Science in Engineering. The subplan "Biomedical Computation" appears on the transcript and on the diploma.

**Mission of the Undergraduate Program in Biomedical Computation**

Quantitative and computational methods are central to the advancement of biology and medicine in the 21\(^{st}\) century. These methods span the analysis of biomedical data, the construction of computational models for biological systems, and the design of computer systems that help biologists and physicians create and administer treatments to patients. The Biomedical Computation major prepares students to work at the cutting edge of this interface between computer science, biology, and medicine. Students begin their journey by acquiring foundational knowledge in the underlying biological and computational disciplines. They learn techniques in informatics and simulation and their numerous applications in understanding and analyzing biology at all levels, from individual molecules in cells to entire organs, organisms, and populations. Students then focus their efforts in a depth area of their choosing, and participate in a substantial research project with a Stanford faculty member. Upon graduation, students are prepared to enter a range of disciplines in either academia or industry.

### Requirements

#### Mathematics

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 unit minimum, see Basic Requirement 1</td>
<td></td>
</tr>
<tr>
<td>MATH 19</td>
<td>3</td>
</tr>
<tr>
<td>MATH 20</td>
<td>3</td>
</tr>
<tr>
<td>MATH 21</td>
<td>4</td>
</tr>
<tr>
<td>CS 103</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 109</td>
<td>3-5</td>
</tr>
</tbody>
</table>

#### Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>17 units minimum, see Basic Requirement 2</td>
<td></td>
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<tr>
<td>PHYSICS 41</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 31M</td>
<td>5</td>
</tr>
<tr>
<td>or CHEM 31B</td>
<td></td>
</tr>
<tr>
<td>CHEM 33</td>
<td>5</td>
</tr>
<tr>
<td>BIO 82</td>
<td>4</td>
</tr>
<tr>
<td>BIO 83</td>
<td>4</td>
</tr>
<tr>
<td>BIO 86</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Engineering Fundamentals

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 106B</td>
<td>5</td>
</tr>
</tbody>
</table>

#### Additional Requirements

- **Technology in Society**
  - One course required, see Basic Requirement 4; course used must be on the School of Engineering Approved Courses list in the UGBH the year taken. **3-5**

- **Engineering**
  - CS 107 Computer Organization and Systems **3-5**
  - CS 161 Design and Analysis of Algorithms **3-5**
  - Select one of the following: **3**
    - CS 270 Modeling Biomedical Systems
    - CS 273A The Human Genome Source Code
    - CS 274 Representations and Algorithms for Computational Molecular Biology
    - CS 275 Translational Bioinformatics
    - CS 279 Computational Biology: Structure and Organization of Biomolecules and Cells
  - CME 209 Mathematical Modeling of Biological Systems **6**
  - Research: 6 units of biomedical computation research in any department **6**

- **Engineering Depth Concentration**
  - (select one of the following concentrations): **7**

  - **Cellular/Molecular Concentration**
    - Mathematics: Select one of the following:
      - CME 100 Vector Calculus for Engineers
      - STATS 141 Biostatistics
      - MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications
    - One additional Engineering Fundamental **4**
    - BIO 104 Advance Molecular Biology: Epigenetics and Proteostasis
    - CHEM 141 The Chemical Principles of Life I (or CHEM 171) **4**
    - Cell/Mol Electives (two courses) **5,6**
    - Informatics Electives (two courses) **5,6**
    - Simulation Electives (two courses) **5,6**
    - Simulation, Informatics, or Cell/Mol Elective (one course) **5,6**

  - **Informatics Concentration**
    - Mathematics: Select one of the following:
      - STATS 141 Biostatistics
      - STATS 203 Introduction to Regression Models and Analysis of Variance
      - STATS 205 Introduction to Nonparametric Statistics
      - STATS 215 Statistical Models in Biology
    - One additional Engineering Fundamental **4**
    - Informatics Core (three courses):
      - CS 145 Data Management and Data Systems
      - or CS 147 Introduction to Human-Computer Interaction Design
      - CS 221 Artificial Intelligence: Principles and Techniques
      - or CS 228 Probabilistic Graphical Models: Principles and Techniques
      - or CS 229 Machine Learning
    - One additional course from the previous two lines
    - Informatics Electives (three courses) **5,6**
    - Cellular Electives (two courses) **5,6**
    - Organs Electives (two courses) **5,6**
  - **Programming Abstractions**
    - For the second required course, see concentrations **4**

- **Organizers**

**BIOMEDICAL COMPUTATION UNDERGRADUATE MAJOR**

**COVID-19-Related Degree Requirement Changes**

The BMC Program counts all courses taken in academic year 2020-21 with a grade of ‘CR’ (credit) or ‘S’ (satisfactory) towards satisfaction of undergraduate degree requirements that otherwise require a letter grade. Students are encouraged to enroll in the letter grade option for degree requirements whenever possible.

The mission of the undergraduate program in Biomedical Computation leads to the conferral of the Bachelor of Science in Engineering. The subplan “Biomedical Computation” appears on the transcript and on the diploma.

Quantitative and computational methods are central to the advancement of biology and medicine in the 21st century. These methods span the analysis of biomedical data, the construction of computational models for biological systems, and the design of computer systems that help biologists and physicians create and administer treatments to patients. The Biomedical Computation major prepares students to work at the cutting edge of this interface between computer science, biology, and medicine. Students begin their journey by acquiring foundational knowledge in the underlying biological and computational disciplines. They learn techniques in informatics and simulation and their numerous applications in understanding and analyzing biology at all levels, from individual molecules in cells to entire organs, organisms, and populations. Students then focus their efforts in a depth area of their choosing, and participate in a substantial research project with a Stanford faculty member. Upon graduation, students are prepared to enter a range of disciplines in either academia or industry.
Organs/Organisms Concentration

Mathematics (select one of the following):
- CME 100 Vector Calculus for Engineers
- STATS 141 Biostatistics
- MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications

One additional Engineering Fundamental
- Bio 112 Human Physiology
- CHEM 141 The Chemical Principles of Life I (or BIOE 220)

Two additional Organs Electives
- Simulation Electives (two courses)
- Informatics Electives (two courses)
- Simulation, Informatics, or Organs Elective (one course)

Simulation Concentration

Mathematics:
- CME 100 or MATH 51 Vector Calculus for Engineers
- Linear Algebra, Multivariable Calculus, and Modern Applications
- ME 30 Engineering Thermodynamics (Fulfills 2nd Engineering Fundamental)

Simulation Core:
- CME 102 Ordinary Differential Equations for Engineers
- or MATH 53 Ordinary Differential Equations with Linear Algebra
- ENGR 80 Introduction to Bioengineering (Engineering Living Matter)
- BIOE 101 Systems Biology
- BIOE 103 Systems Physiology and Design

Total Units: 90-104

2. Research projects require pre-approval of BMC Coordinators.
3. Research units taken as CS 191W Writing Intensive Senior Project or in conjunction with ENGR 199W Writing of Original Research for Engineers fulfill the Writing in the Major (WIM) requirement. CS 272 Introduction to Biomedical Informatics Research Methodology, which does not have to be taken in conjunction with research, also fulfills the WIM requirement.
4. One 3-5 unit course required; CS 106A Programming Methodology may not be used. See Engineering Fundamentals list in Handbook for Undergraduate Engineering Programs or on Approved Courses page at ughb.stanford.edu.
5. The list of electives is continually updated to include all applicable courses. For the current list of electives, see http://bmc.stanford.edu.
6. A course may only be counted towards one elective or core requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum Combined GPA for all courses in Engineering Topics (Engineering Fundamentals and Depth courses) is 2.0.
7. A total of 40 Engineering Fundamentals and Core/Depth units must be taken. The core classes only provide 27 Engineering units, so the remaining units must be taken from within the electives.

Honors Program

The Biomedical Computation program offers an honors option for qualified students, resulting in a B.S. with Honors degree in Engineering (ENGR-BSH, Biomedical Computation). An honors project is meant to be a substantial research project during the later part of a student’s undergraduate career, culminating in a final written and oral presentation describing the student’s project and its significance. There is no limit to the number of majors who can graduate with honors; any BMC major who is interested and meets the qualifications is considered.

1. Students apply by submitting the Honors Program Application Webform found on the BMC website and should be prepared to upload a 1-2 page proposal describing the problem the student has chosen to investigate, its significance, and the student’s research plan. This plan must be endorsed by the student’s research and academic advisers, one of whom must be a member of the Academic Council. In making its decision, the department evaluates the overall scope and significance of the student’s proposed work.
2. Students must maintain a 3.5 GPA.
3. Students must complete three quarters of research. All three quarters must be on the same project with the same adviser. A Summer Quarter counts as one quarter of research.
   - Ideally, funding should not be obtained through summer research college sources, but rather through the UAR’s Student Grants Program (http://studentgrants.stanford.edu/). In no case can the same work be double-paid by two sources.
4. Students must complete a substantial write-up of the research in the format of a publishable research paper. This research paper is expected to be approximately 20-30 pages and must be approved by the student’s research adviser and by a second reader.
5. Students submit an electronic pdf of their thesis, including the signature page signed by both readers, to Bioengineering student services. Students should review deadlines on the BMC website. (https://bioengineering.stanford.edu/academics/undergraduate-programs/biomedical-computation/honors/). Students are sent email instructions on how to archive a permanent electronic copy in Terman Engineering library.
6. As the culmination of the honors project, each student presents their results in the Bioengineering Honors Poster Fair in spring quarter of their senior year.

For additional information and sample programs, see the Handbook for Undergraduate Engineering Programs (UAR’s Student Grants Program) (http://ughb.stanford.edu).