**BIOMEDICAL COMPUTATION UNDERGRADUATE MAJOR**

**Biomedical Computation (BMC)**

Completion of the undergraduate program in Biomedical Computation leads to the conferment 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 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.

**Requirements**

<table>
<thead>
<tr>
<th>Mathematics</th>
<th>Units</th>
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<tbody>
<tr>
<td>21 unit minimum, see Basic Requirement 1</td>
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<tr>
<td>MATH 19</td>
<td>Calculus (or AP Calculus)</td>
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<tr>
<td>MATH 20</td>
<td>Calculus (or AP Calculus)</td>
</tr>
<tr>
<td>MATH 21</td>
<td>Calculus (or AP Calculus)</td>
</tr>
<tr>
<td>CS 103</td>
<td>Mathematical Foundations of Computing</td>
</tr>
<tr>
<td>CS 109</td>
<td>Introduction to Probability for Computer Scientists</td>
</tr>
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<table>
<thead>
<tr>
<th>Science</th>
<th>Units</th>
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<tbody>
<tr>
<td>17 units minimum, see Basic Requirement 2</td>
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</tr>
<tr>
<td>PHYSICS 41</td>
<td>Mechanics</td>
</tr>
<tr>
<td>or PHYSICS 41E</td>
<td>Mechanics, Concepts, Calculations, and Context</td>
</tr>
<tr>
<td>CHEM 31M</td>
<td>Chemical Principles: From Molecules to Solids (formerly CHEM 31X)</td>
</tr>
<tr>
<td>or CHEM 31B</td>
<td>Chemical Principles II</td>
</tr>
<tr>
<td>CHEM 33</td>
<td>Structure and Reactivity of Organic Molecules</td>
</tr>
<tr>
<td>BIO 82</td>
<td>Genetics (or HUMBIO 2A)</td>
</tr>
<tr>
<td>BIO 83</td>
<td>Biochemistry &amp; Molecular Biology (or BIO 84 or HUMBIO 3A)</td>
</tr>
<tr>
<td>BIO 86</td>
<td>Cell Biology (or HUMBIO 4A)</td>
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<thead>
<tr>
<th>Engineering Fundamentals</th>
<th>Units</th>
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<tbody>
<tr>
<td>CS 106B</td>
<td>Programming Abstractions</td>
</tr>
<tr>
<td>or CS 106X</td>
<td>Programming Abstractions</td>
</tr>
<tr>
<td>For the second required course, see concentrations</td>
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<tr>
<th>Technology in Society</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>One course required, see Basic Requirement 4; course used must be on the School of Engineering Approved Courses list in the UGHB the year taken.</td>
<td>3-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineering</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems</td>
</tr>
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</table>

**CS 161** Design and Analysis of Algorithms 3-5

Select one of the following:

- CS 270 Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
- 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

Research: 6 units of biomedical computation research in any department

**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
  - 6-10

- **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 4
  - Biology (two courses):
    - BIO 112 Human Physiology
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 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://exploredegrees.stanford.edu/soe-ug-majors/biomedicalcomputation/%20http://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 15-20 pages and must be approved by the student's research adviser and by a second reader.

5. As the culmination of the honors project, each student presents the results in a public forum. This can either be in the honors presentation venue of the home department of the student's adviser, or in a suitable alternate venue.

6. Students submit a pdf of their thesis, including the signature page signed by both readers, to the student services officer by May 15. Students are sent email instructions on how to archive a permanent electronic copy in Terman Engineering library.

For additional information and sample programs, see the Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu).

Honors Program

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