Biomedical Informatics

Courses offered by the Program in Biomedical Informatics are listed under the subject code BIOMEDIN on the [ExploreCourses web site](http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=BIOMEDIN&filter-catalognumber-BIOMEDIN=on) of Stanford Bulletin’s [ExploreCourses web site](http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=BIOMEDIN&filter-catalognumber-BIOMEDIN=on).

The program in Biomedical Informatics emphasizes research to develop novel computational methods that can advance biomedicine. Students receive training in the investigation of new approaches to conceptual modeling and to development of new algorithms that address challenging problems in the biological sciences and clinical medicine. Students with a primary interest in developing new informatics methods and knowledge are best suited for this program. Students with a primary interest in the biological or medical application of existing informatics techniques may be better suited for training in the application areas themselves.

**Graduate Programs in Biomedical Informatics**

The Biomedical Informatics Program is interdepartmental and offers instruction and research opportunities leading to M.S. and Ph.D. degrees in Biomedical Informatics. All students are required to complete the core curriculum requirements, and also to elect additional courses to complement both their technical interests and their goals.

The core curriculum is common to all degrees offered by the program but is adapted or augmented depending on the interests and experience of the student. Deviations from the core curriculum must be justified in writing and approved by the student’s Biomedical Informatics academic adviser and the chair of the Biomedical Informatics Executive Committee. The program is intended to provide flexibility and to complement other opportunities in applied medical research that exist at Stanford. Although most students are expected to comply with the basic program of study outlined here, special arrangements can be made for those with unusual needs or those simultaneously enrolled in other degree programs within the University. Similarly, students with prior relevant training may have the curriculum adjusted to eliminate requirements met as part of prior training.

The University requirements for the M.S. degree are described in the "Graduate Degrees ([http://exploredegrees.stanford.edu/archive/2013-14/graduatedegrees](http://exploredegrees.stanford.edu/archive/2013-14/graduatedegrees) )" section of this bulletin.

**Master of Science in Biomedical Informatics (Academic)**

This degree is designed for individuals who wish to undertake in-depth study of biomedical informatics with research on a full-time basis. Normally, a student spends two years in the program and implements and documents a substantial project during the second year. The first year involves acquiring the fundamental concepts and tools through course work and research project involvement. All first- and second-year students are expected to devote 50 percent or more of their time participating in research projects. Research rotations are not required, but can be done with approval of the academic adviser or training program director. Graduates of this program are prepared to contribute creatively to basic or applied projects in biomedical informatics. This degree requires a written research paper to be approved by two faculty members.

**Master of Science in Biomedical Informatics (Professional/Honors Cooperative Program)**

This degree is designed primarily for the working professional who already has advanced training in one discipline and wishes to acquire interdisciplinary skills. All classes necessary for the degree are available online. The professional M.S. is offered in conjunction with Stanford Center for Professional Development (SCPD), which establishes the rates of tuition and fees. The program uses the honors cooperative model (HCP), which assumes that the student is working in a corporate setting and is enrolled in the M.S. on a part-time basis. The student has up to five years to complete the program. Research projects are optional and the student must make arrangements with program faculty. Graduates of this program are prepared to contribute creatively to basic or applied projects in biomedical informatics.

**Master of Science in Biomedical Informatics (Coterminal)**

The coterminal degree program allows Stanford University undergraduates to study for a master’s degree while completing their bachelor’s degree(s) in the same or a different department. Please refer to the "Coterminal Degrees" section in this bulletin for additional information.

The coterminal Master of Science program follows the same program requirements as the Master of Science (Professional) program, except for the requirement to be employed in a corporate setting. The coterminal degree is available only to current Stanford undergraduates. Coterminal students are enrolled full-time and courses are taken on campus. Research projects are optional and the student must make arrangements with program faculty. Graduates of this program are prepared to contribute creatively to basic or applied projects in biomedical informatics.


**Core Curriculum and Program Requirements in Biomedical Informatics**

**Core Curriculum in Biomedical Informatics**

Students are expected to participate regularly in BIOMEDIN 201 Biomedical Informatics Student Seminar and a research Colloquium, such as BIOMEDIN 200 Biomedical Informatics Colloquium or BIOMEDIN 205 Precision Practice with Big Data. In addition, all students are expected to fulfill requirements in the following five categories:

1. **Core Biomedical Informatics (17 units)**

   Students are expected to complete the core offerings in biomedical informatics:
   a. BIOMEDIN 212 Introduction to Biomedical Informatics Research Methodology
   b. and 4 of the following:
3. Social and Ethical Issues (4 units)

Students are expected to be familiar with issues regarding ethical, legal, social, organizational, and behavioral impacts of the aspects of biomedical informatics technologies on society in general. They should select courses broadly from University offerings to explore one or more of these aspects more deeply. Choose courses that fulfill this requirement by entering bmi::ethics in the Explore Courses search box. Students are required to take MED 255 The Responsible Conduct of Research, or the equivalent.

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>BIOE 131</td>
<td>Ethics in Bioengineering</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 450</td>
<td>Advances in Biotechnology</td>
<td>3</td>
</tr>
<tr>
<td>BIOMEDIN 256</td>
<td>Economics of Health and Medical Care</td>
<td>5</td>
</tr>
<tr>
<td>BIOMEDIN 432</td>
<td>Analysis of Costs, Risks, and Benefits of Health Care</td>
<td>4</td>
</tr>
<tr>
<td>BIOS 224</td>
<td>Big Topics in Stem Cell Ethics</td>
<td>2</td>
</tr>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
<td>4</td>
</tr>
<tr>
<td>CS 181W</td>
<td>Computers, Ethics and Public Policy</td>
<td>4</td>
</tr>
<tr>
<td>GENE 210</td>
<td>Genomics and Personalized Medicine</td>
<td>3</td>
</tr>
<tr>
<td>HRP 209</td>
<td>FDA’s Regulation of Health Care</td>
<td>2-3</td>
</tr>
<tr>
<td>HRP 210</td>
<td>Health Law and Policy</td>
<td>3</td>
</tr>
<tr>
<td>HRP 211</td>
<td>Law and the Biosciences: Neuroscience</td>
<td>3</td>
</tr>
<tr>
<td>HRP 221</td>
<td>Law and the Biosciences: Genetics</td>
<td>3</td>
</tr>
<tr>
<td>HRP 256</td>
<td>Economics of Health and Medical Care</td>
<td>5</td>
</tr>
<tr>
<td>HRP 392</td>
<td>Analysis of Costs, Risks, and Benefits of Health Care</td>
<td>4</td>
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4. Unrestricted Electives (6 units)

Students may fulfill this requirement with any Stanford course, including courses taken to satisfy core curriculum prerequisites.

5. For PhD Students only

Domain Biology/Medicine, Pedagogy, Electives (9 units): In order to reach a total of 54 units of core curriculum, PhD students should take an additional 9 units; this should include 6 units of biology or medicine classes relevant to their research interests, 2 units of BIOMEDIN 290 Biomedical Informatics Teaching Methods and one additional unit of unrestricted elective.

The core curriculum generally entails a minimum of 45 units of course work for master’s students and 54 units of course work for Ph.D. students, but can require substantially more or less depending upon the courses chosen and the previous training of the student.

The following courses may be taken for satisfactory/no credit (S/NC):

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<tr>
<th>Course Code</th>
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<th>Units</th>
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<tbody>
<tr>
<td>BIOMEDIN 200</td>
<td>Biomedical Informatics Colloquium</td>
<td>1</td>
</tr>
<tr>
<td>BIOMEDIN 201</td>
<td>Biomedical Informatics Student Seminar</td>
<td>1</td>
</tr>
<tr>
<td>BIOMEDIN 205</td>
<td>Precision Practice with Big Data</td>
<td>1</td>
</tr>
<tr>
<td>BIOMEDIN 206</td>
<td>Informatics in Industry</td>
<td>1</td>
</tr>
<tr>
<td>BIOMEDIN 299</td>
<td>Directed Reading and Research</td>
<td>1-18</td>
</tr>
<tr>
<td>BIOMEDIN 801</td>
<td>TGR Master’s Project</td>
<td>0</td>
</tr>
<tr>
<td>BIOMEDIN 802</td>
<td>TGR PhD Dissertation</td>
<td>0</td>
</tr>
<tr>
<td>MED 255</td>
<td>The Responsible Conduct of Research</td>
<td>1</td>
</tr>
</tbody>
</table>

The varying backgrounds of students are well recognized and no one is required to take courses in an area in which he or she has already been adequately trained; under such circumstances, students are permitted to skip courses or substitute more advanced work using a formal annual process administered by the BMI executive committee, in which students demonstrate satisfaction of core curriculum prerequisites, and request permission to receive core curriculum credit for classes taken previously in areas of the core curriculum. Students design appropriate programs for their interests with the assistance and approval of their Biomedical Informatics academic adviser. At least 27 units of formal course work are expected for the core curriculum.
Program Requirements for the Academic M.S., HCP Professional M.S., and Coterminal M.S. Degrees

Students enrolled in any of the M.S degrees must complete the program requirements in order to graduate. Programs of at least 45 units that meet the following guidelines are normally approved:

1. Completion of the core curriculum with overall GPA of 3.0.
2. Students are expected to participate regularly in BIOMEDIN 201 Biomedical Informatics Student Seminar and a research colloquium, such as BIOMEDIN 200 Biomedical Informatics Colloquium or BIOMEDIN 205 Precision Practice with Big Data. HCP professional masters candidates who are able to attend classes on campus should also participate regularly.
3. Electives: additional courses to bring the total to 45 or more units taken at Stanford to fulfill the University’s residency requirement.
4. Masters candidates should sign up for BIOMEDIN 801 TGR Master’s Project for their project units after completing their 45-unit residency requirement.

Doctor of Philosophy in Biomedical Informatics

The University’s basic requirements for the doctorate (residence, dissertation, examination, and so on) are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/archive/2013-14/graduatedegrees) " section of this bulletin. The Core Curriculum in Biomedical Informatics is outlined in the Master’s section (http://exploredegrees.stanford.edu/archive/2013-14/schoolofmedicine/biomedicalinformatics/#masterstext). Individuals wishing to prepare themselves for careers as independent biomedicalinformatics/#masterstext) .

Students wishing to prepare themselves for careers as independent researchers in biomedical informatics, with applications experience in bioinformatics, clinical informatics, or imaging informatics, should apply for admission to the doctoral program. The following are additional requirements imposed by the Biomedical Informatics Executive Committee:

1. A student plans and completes a coherent program of study including the core curriculum and additional requirements as for the master’s program. In the first year, two or three research rotations are encouraged. The master’s requirements should be completed by the end of the second year in the program.
2. Doctoral students are generally advanced to Ph.D. candidacy after passing the qualifying exam, which takes place during the end of the second year of training. A student’s academic adviser has primary responsibility for the adequacy of the program, which is regularly reviewed by the Biomedical Informatics Executive Committee.
3. To remain in the Ph.D. program, each student must attain a grade point average (GPA) of 3.0 for the core curriculum. The student must fulfill these requirements and apply for admission to candidacy for the Ph.D. by the beginning of the third year. In addition, reasonable progress in the student’s research activities is expected of all doctoral candidates.
4. During the third year of training, each doctoral student is required to give a preproposal seminar that describes evolving research plans.
5. By the beginning of the fourth year, each student must orally present a written thesis proposal for the written dissertation and must orally defend the thesis proposal before a University oral examination committee that generally includes at least one member of the Biomedical Informatics Executive Committee. The committee determines whether the student’s general knowledge of the field and the details of the planned thesis are sufficient to justify proceeding with the dissertation.
6. After application for Terminal Graduate Registration (TGR) status and completion of 135 units, the Ph.D. candidate should register each quarter for BIOMEDIN 802 TGR PhD Dissertation so their research effort may be counted toward the degree.
7. As part of the training for the Ph.D., each student is required to be a teaching assistant for two courses approved by the Biomedical Informatics Executive Committee; one should be completed in the first two years of study.
8. The most important requirement for the Ph.D. degree is the dissertation. Prior to the oral dissertation proposal and defense, each student must secure the agreement of a member of the program faculty to act as dissertation adviser. The principal adviser should be approved by the Biomedical Informatics Executive Committee, and all dissertation reading committees should include at least one BMI participating faculty member.
9. At the completion of training, while still matriculated and shortly prior to deposit of the dissertation, the student gives a final talk describing his or her results. No official additional oral examination is required upon completion of the written dissertation. The oral defense of the dissertation proposal satisfies the University oral examination requirement.
10. The student is expected to demonstrate an ability to present scholarly material and research in a lecture at a formal seminar.
11. The student is expected to demonstrate an ability to present scholarly material in concise written form. Each student is required to write a paper suitable for publication, usually discussing his or her doctoral research project. This paper must be approved by the student’s academic adviser as suitable for submission to a refereed journal before the doctoral degree is conferred.
12. The dissertation must be accepted by a reading committee composed of the principal dissertation adviser, a member of the program faculty, and a third faculty member chosen from anywhere within the University. A fourth reader may be added at the discretion of the student and their adviser.

Ph.D. Minor in Biomedical Informatics

For a Ph.D. minor in Biomedical Informatics (BMI), a candidate must complete a minimum of 20 unduplicated units of biomedical informatics course work, including 12 units in BMI core courses from:

<table>
<thead>
<tr>
<th>Units</th>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>3</td>
<td>BIOMEDIN 210</td>
<td>Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
</tr>
<tr>
<td>3</td>
<td>BIOMEDIN 212</td>
<td>Introduction to Biomedical Informatics Research Methodology</td>
</tr>
<tr>
<td>3-4</td>
<td>BIOMEDIN 214</td>
<td>Representations and Algorithms for Computational Molecular Biology</td>
</tr>
<tr>
<td>3</td>
<td>BIOMEDIN 215</td>
<td>Data Driven Medicine</td>
</tr>
<tr>
<td>4</td>
<td>BIOMEDIN 217</td>
<td>Translational Bioinformatics</td>
</tr>
<tr>
<td>3-4</td>
<td>BIOMEDIN 260</td>
<td>Computational Methods for Biomedical Image Analysis and Interpretation</td>
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The candidate must complete the one-unit MED 255 The Responsible Conduct of Research or an approved substitute.

The remaining units must be courses that would count towards the BMI master’s degree, taken from these areas:

- Computer Science, Probability, Statistics, Machine Learning, Mathematics, Engineering
Students are expected to participate regularly in BIOMEDIN 201 (https://exploredegrees-nextyear.stanford.edu/schoolofmedicine/biomedicalinformatics) Biomedical Informatics Student Seminar.

Courses used for the BMI Ph.D. minor may not be double-counted to meet the requirements of a master’s or Ph.D. degree.

All courses used for the BMI Ph.D. minor, except MED 255, must be taken for a letter grade and passed with an overall GPA of 3.0 or better.

Stanford students apply using the Application for Ph.D. Minor and must provide an unofficial Stanford transcript as well as a statement of purpose for adding the Ph.D. minor degree.

This degree offering became effective in Autumn Quarter 2010-11. Courses taken at Stanford prior to that date may be counted towards the BMI Ph.D. minor degree. A minor program adviser is assigned from the Biomedical Informatics Executive Committee or advising faculty.

Committee: Russ B. Altman (Chair and Program Director), Mark A. Musen (Co-Director), Steven C. Bagley (Executive Director), Atul Butte, Teri Klein, David Paik, Daniel L. Rubin, Nigam Shah

Participating Faculty and Staff by Department*

Biochemistry: Douglas L. Brutlag (Professor Emeritus), Rhiju Das (Assistant Professor), Ronald Davis (Professor), James Ferrell (Professor), Julia Saltzman (Assistant Professor), Julie Theriot (Professor)

Bioengineering: Russ B. Altman (Professor), Kwabena Boahen (Associate Professor), Markus Covert (Assistant Professor), Ingmar Riedel-Kruse (Assistant Professor)

Biology: Hunter Fraser (Assistant Professor), Dmitri Petrov (Professor), Jonathan Pritchard (Professor)

Chemical and Systems Biology: Joshua Elias (Assistant Professor), James Ferrell (Professor)

Chemistry: Vijay Pande (Professor)

Computer Science: Serafin Batzoglou (Professor), Gill Bejerano (Assistant Professor), David Dill (Professor), Leonidas Guibas (Professor), Anshul Kundaje (Assistant Professor), Daphne Koller (Professor), Terry Winograd (Professor Emeritus)

Developmental Biology: Gill Bejerano (Assistant Professor), Harley McAdams (Professor, Research)

Genetics: Russ B. Altman (Professor), Steven C. Bagley (Senior Research Engineer), Michael Bassik (Assistant Professor), Carlos Bustamante (Professor), Atul Butte (Associate Professor), J. Michael Cherry (Professor, Research), Stanley N. Cohen (Professor), Ronald Davis (Professor), William Greenleaf (Assistant Professor), Teri E. Klein (Senior Research Scientist), Anshul Kundaje (Assistant Professor), Jinhong Liu (Assistant Professor), Stephen B. Montgomery (Assistant Professor, Research), Jonathan Palma (Clinical Assistant Professor)

Health Research and Policy: Trevor Hastie (Professor), Mark Hlatky (Professor), Hanlee P. Ji (Assistant Professor), Purvesh Khatri (Assistant Professor), Henry Lowe (Associate Professor), Mark A. Musen (Professor), Douglas K. Owens (Professor), Daniel R. Rubin (Assistant Professor), Robert W. Shafer (Professor, Research), Nigam Shah (Assistant Professor), Samson Tu (Senior Research Scientist), P.J. Utz (Professor)

Microbiology and Immunology: Karla Kirkegaard (Professor), Garry Nolan (Professor), Julie Theriot (Professor)

Operations, Information and Technology: Mohsen Bayati (Assistant Professor)

Pathology: Stephen B. Montgomery (Assistant Professor), Arend Sidow (Professor)

Pediatrics: Atul Butte (Associate Professor), Chris Longhurst (Clinical Associate Professor), Jonathan Palma (Clinical Assistant Professor), Dennis Wall (Associate Professor)

Psychiatry and Behavioral Sciences: Vinod Menon (Professor, Research)

Radiation Oncology: Lei Xing (Professor)

Radiology: Sanjiv Gambhir (Professor), Parag Mallick (Assistant Professor, Research), Sandy A. Navel (Professor), David Paik (Assistant Professor), Sylvia Plevritis (Professor), Daniel L. Rubin (Assistant Professor)

Statistics: Trevor J. Hastie (Professor), Susan Holmes (Professor), Art Owen (Professor), Chiara Sabatti (Associate Professor), Robert Tibshirani (Professor)

Structural Biology: Michael Levitt (Professor)

Surgery: Thomas Krumel (Professor)

* Research opportunities are not limited to faculty and departments listed.