Biomedical Informatics

Courses offered by the Program in Biomedical Informatics are listed under the subject code BIOMEDIN on the Stanford Bulletin's ExploreCourses website. The program in Biomedical Informatics emphasizes research to develop novel computational methods that can advance biomedical science. 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 in applying informatics methods to clinical settings, biology, or imaging.

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. It should be noted, however, that 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" 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.

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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>BIOMEDIN 210 Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
<td>3</td>
</tr>
<tr>
<td>BIOMEDIN 214 Representations and Algorithms for Computational Molecular Biology</td>
<td>3-4</td>
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<tr>
<td>BIOMEDIN 215 Data Driven Medicine</td>
<td>3</td>
</tr>
<tr>
<td>BIOMEDIN 217 Translational Bioinformatics</td>
<td>4</td>
</tr>
<tr>
<td>BIOMEDIN 260 Computational Methods for Biomedical Image Analysis and Interpretation</td>
<td>3-4</td>
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   C. Any remaining units must be graduate level courses listed under BIOMEDIN.

   D. Note that BIOMEDIN 211 is no longer offered, however it may be used by students who completed it to fulfill a core BMI requirement.

2. **Computer Science, Statistics, Mathematics & Engineering (18 units)**

   Students are expected to create a program of study with a mixture of graduate-level courses in computer science, statistics or other technical informatics-related disciplines that allows them to achieve in-depth mastery of these areas. The programs of study may focus on aspects of these disciplines including (but not limited to): machine learning, artificial intelligence, data mining, image analysis, human-computer interaction, systems engineering, scientific and numerical computing or graphics. In general, this course of study should include no more than 9 units in courses 100-199, and the rest should be 200 or above (unless specifically approved by adviser). CS courses 106, 107 and 108 cannot be counted for this requirement, and all courses should be formal classroom-based courses, unless approved by the executive committee. Up to 6 units of this portion of the core curriculum may be taken on a pass/fail basis, but at least half of the units in this portion of the curriculum must be taken for a grade. BIOMEDIN units above 17 may also be counted for the requirements in this category. Students may petition for quantitative courses in the medical school or Humanities and Sciences to be counted in this section of the curriculum.

3. **Social and Ethical Issues (4 units)**

   Students are expected to be familiar with issues regarding ethical, legal, social, organizational and behavioral aspects of the impact 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. In addition, students are required to take MED 255 The Responsible Conduct of Research, or the equivalent.

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):

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>BIOMEDIN 200 Biomedical Informatics Colloquium</td>
<td>1</td>
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<tr>
<td>BIOMEDIN 201 Biomedical Informatics Student Seminar</td>
<td>1</td>
</tr>
<tr>
<td>BIOMEDIN 205 Precision Practice with Big Data</td>
<td>1</td>
</tr>
<tr>
<td>BIOMEDIN 206 Informatics in Industry</td>
<td>1</td>
</tr>
<tr>
<td>BIOMEDIN 299 Directed Reading and Research</td>
<td>1-18</td>
</tr>
<tr>
<td>BIOMEDIN 801 TGR Master’s Project</td>
<td>0</td>
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<tr>
<td>BIOMEDIN 802 TGR PhD Dissertation</td>
<td>0</td>
</tr>
<tr>
<td>MED 255 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., 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” section of this bulletin.

Individuals 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 (six quarters of study, excluding summers).

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 end of six quarters of study (excluding summers). In addition, reasonable progress in the student’s research activities is expected of all doctoral candidates.

4. During the third year of training, generally in Winter Quarter, each doctoral student is required to give a preproposal seminar that describes evolving research plans.

5. By the end of nine quarters (excluding summers), each student must orally present a written thesis proposal for the written dissertation and must orally defend the 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, 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 committees should include at least one participating BMI 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>
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<tr>
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<tr>
<td>BIOMEDIN 210</td>
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<td>Introduction to Biomedical Informatics Research Methodology</td>
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</table>

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
- Biomedicine
- Other BMI courses from the list above

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 applying for BMI Ph.D. Minor 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), Hunter Fraser (Assistant Professor), Julie Theriot (Associate Professor)
Bioengineering: Russ B. Altman (Professor), Kwabena Boahen (Associate Professor), Markus Covert (Assistant Professor), Hunter Fraser (Assistant Professor), Ingmar Riedel-Kruse (Assistant Professor)

Biology: Dmitri Petrov (Professor)

Chemistry: Vijay Pande (Professor)

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

Computer Science: Serafim Batzoglou (Associate Professor), Gill Bejerano (Assistant Professor), David Dill (Professor), Leo Guibas (Professor), Daphne Koller (Professor), Terry Winograd (Professor)

Developmental Biology: Gill Bejerano (Assistant Professor)

Genetics: Russ B. Altman (Professor), Steven C. Bagley (Senior Research Engineer), Carlos Bustamante (Professor), Mike Cherry (Associate Professor, Research), Stanley N. Cohen (Professor), Ronald Davis (Professor), Teri E. Klein (Senior Research Scientist), Jin Billy Li (Assistant Professor), Stephen B. Montgomery (Assistant Professor), Gavin Sherlock (Associate Professor), Arend Sidow (Associate Professor), Michael P. Snyder (Professor), Hua Tang (Associate Professor)

Health Research and Policy: Richard A. Olshen (Professor), Chiara Sabatti (Associate Professor), Robert Tibshirani (Professor)

Management Science and Engineering: Margaret Brandeau (Professor), Ross D. Shachter (Associate Professor)

Medicine: Russ B. Altman (Professor), Euan Ashley (Assistant Professor), Mary Goldstein (Professor), Hanlee P. Ji (Assistant Professor), Peter D. Karp (Consulting Assistant Professor), Henry Lowe (Associate Professor, Research; Senior Associate Dean for Information Resources and Technology), Mark A. Musen (Professor), Daniel R. Rubin (Assistant Professor), Robert W. Shafer (Professor, Research), Nigam Shah (Assistant Professor), Samson Tu (Senior Research Scientist), P.J. Utz (Associate Professor), Michael G. Walker (Consulting Associate Professor)

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

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

Pathology: Stephen B. Montgomery (Assistant Professor)

Pediatrics: Atul Butte (Associate Professor), Chris Longhurst (Clinical Associate Professor), Henry Lowe (Associate Professor, Research; Senior Associate Dean for Information Resources and Technology), Jonathan Palm (Clinical Assistant Professor)

Psychiatry and Behavioral Sciences: Vinod Menon (Professor)

Radiation Oncology: Lei Xing (Professor)

Radiology: Sam Gambhir (Professor), Sandy A. Napel (Professor), David Paik (Assistant Professor), Sylvia Plevritis (Associate Professor), Daniel L. Rubin (Assistant Professor)

Structural Biology: Michael Levitt (Professor), Vijay Pande (Professor)

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

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