BIOMEDICAL INFORMATICS

Courses offered by the Program in Biomedical Informatics are listed under the subject code BIOMEDIN on the Stanford Bulletin’s ExploreCourses web site.

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 complete additional course work to fulfill degree requirements and pursue their technical interests and goals as specified for each degree program.

The program can provide flexibility and can complement other opportunities in applied medical research at Stanford. Special arrangements may 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/graduatedegrees)” section of this bulletin.

Advising

Upon entering the program, each student is assigned an academic advisor to help with course selection and monitor progress towards program milestones and degree requirements. Each research-track MS and PhD student conducts research under the primary mentorship of a faculty supervisor, who guides their scholarly and professional development. Further details about the advisor roles and responsibilities are found in the BMI Student Handbook.

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 a substantial project by the end of the second year. The first year involves acquiring the fundamental concepts and tools through course work and research project involvement. Academic M.S. 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. Although many classes necessary for the degree are available online, some requirements may be fulfilled through implementation of an alternative plan to be approved by the program. 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 program (HCP) model, 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; if interested, 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. See the "Coterminal Degrees (http://exploredegrees.stanford.edu/cotermdegrees)” section of this bulletin for additional information. For University coterminal degree program rules and University application forms, see the Registrar’s web site (https://registrar.stanford.edu/students/coterminal-degree-programs/applying-coterm).

The coterminal Master of Science program follows the same program requirements as the Master of Science (Professional), 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; if interested, 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.

Application to the Coterminal Program

For complete information, see the program’s Coterminal Master’s Degree (http://bmi.stanford.edu/prospective-students/masters-degree-coterm-biomedical-informatics.html) page.

1. Submit the University Coterminal Online Application (https://applyweb.com/stanterm).
2. Submit the program’s Coterminal Supplemental Application Form (http://bmi.stanford.edu/prospective-students/FilesProspectiveStudents/CotermSupplementApp.doc).
3. Submit your academic resume or curriculum vitae.
4. Submit a one-page Statement of Purpose describing how and why the BMI program is well matched to your interests.

Applicants to the coterminal M.S. programs are not required to submit GRE scores. GRE scores are recommended, especially if you have relatively little prior course work in quantitative and computational areas. The TOEFL is not required.

University Coterminal Requirements

Coterminal master’s degree candidates are expected to complete all master’s degree requirements as described in this bulletin. University requirements for the coterminal master’s degree are described in the “Coterminal Master’s Program (http://exploredegrees.stanford.edu/cotermdegrees)” section. University requirements for the
master's degree are described in the "Graduate Degrees (http://
exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of
this bulletin.

After accepting admission to this coterminal master’s degree program,
students may request transfer of courses from the undergraduate to the
graduate career to satisfy requirements for the master’s degree. Transfer
of courses to the graduate career requires review and approval of both
the undergraduate and graduate programs on a case by case basis.

In this master’s program, courses taken three quarters prior to the first
graduate quarter, or later, are eligible for consideration for transfer to
the graduate career. No courses taken prior to the first quarter of the
sophomore year may be used to meet master’s degree requirements.

Course transfers are not possible after the bachelor’s degree has been
conferred.

The University requires that the graduate adviser be assigned in the
student’s first graduate quarter even though the undergraduate career
may still be open. The University also requires that the Master’s Degree
requirement is on the BMI website. The following are required:

- Core Biomedical Informatics (15 or more units)
  Students are expected to complete the core offerings in biomedical
  informatics. These courses should be taken for a grade.
  a. BIOMEDIN 212 Introduction to Biomedical Informatics Research
     Methodology
  b. and four of the courses listed below. Additional core course
     requirements are listed under the M.S. degree program.

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>BIOMEDIN 210</td>
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<td>BIOMEDIN 214</td>
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<td>BIOMEDIN 215</td>
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<td>BIOMEDIN 217</td>
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<tr>
<td>BIOMEDIN 260</td>
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</table>

- Computer Science, Statistics, Mathematics & Engineering (18 units)
  Students are expected to create a program of study with graduate-
  level courses in computer science, statistics and other technical
  informatics-related disciplines to achieve in-depth mastery. The
  program of study may focus on aspects of these disciplines
  including machine learning, statistical modeling, artificial intelligence,
  data mining, image analysis, human-computer interaction and
  data visualization. A complete list of courses accepted for this
  requirement is on the BMI website. The following are required:
  a. CS 161 Design and Analysis of Algorithms
  b. STATS 200 Introduction to Statistical Inference

- Social and Ethical Issues (4 units)
  Students are expected to be familiar with issues regarding
  responsible conduct of research, reproducibility of research, and
  ethical, legal, social, organizational and behavioral aspects of the
  impact of biomedical informatics technologies on society. Courses
  that fulfill this requirement can be found by entering "bmi::ethics" in
  the Explore Courses search box. PhD students and Academic M.S.
  students should take MED 255 The Responsible Conduct of Research
  in their first year. These courses may be taken on a Satisfactory/No
  credit basis.
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.

- The core curriculum generally entails a minimum of 31 units of course work, but can require more or less depending upon the courses chosen and the previous training of the student.
- M.S. candidates should complete additional course work and program requirements as outlined below. 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. Students design appropriate programs for their interests with the assistance and approval of their Biomedical Informatics academic adviser.
- At least 21 units of formal letter-graded coursework are expected for all MS and PhD candidates.

Programs of at least 45 Stanford units that meet the following guidelines are normally approved:

1. Completion of the core curriculum with overall GPA of 3.0.
2. Unrestricted Electives needed to complete 45 units. Students may fulfill this requirement with any Stanford graduate courses, including courses taken to satisfy program prerequisites.
3. At least 23 units of courses must be at the level 200 or above.
4. Students are expected to participate regularly in BIOMEDIN 201 Biomedical Informatics Student Seminar and a research colloquium.
5. Academic M.S. students who are funded by the program are required to be a teaching assistant for one course; those students may register for 1-3 units of BIOMEDIN 290 Biomedical Informatics Teaching Methods.
6. HCP professional masters students who are local are encouraged to participate in on-campus coursework and seminars.
7. Masters students 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

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 University’s basic requirements for the doctorate (residence, dissertation, examination, and so on) are discussed in the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin.

The Core Curriculum in Biomedical Informatics (31 units) is outlined below. The Ph.D. program requires an additional 21 units of coursework, to complete a total of 52 units.

Core Curriculum in Biomedical Informatics (37 units)

Students are expected to participate regularly in BIOMEDIN 201 Biomedical Informatics Student Seminar and a research colloquium. Regardless of whether they are enrolled, they should attend all meetings throughout their graduate training, and attend a research colloquium appropriate to their interests. All students are expected to fulfill the following requirements:

- Core Biomedical Informatics Courses (9 or more units)
  Students are expected to complete the core offerings in biomedical informatics. These courses should be taken for a grade.
  a. BIOMEDIN 212 Introduction to Biomedical Informatics Research Methodology
  b. and two of the courses listed below.

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<tr>
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<td>Modeling Biomedical Systems: Ontology, Terminology, Problem Solving</td>
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<tr>
<td>BIOMEDIN 214</td>
<td>Representations and Algorithms for Computational Molecular Biology</td>
<td>3-4</td>
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<tr>
<td>BIOMEDIN 215</td>
<td>Data Driven Medicine</td>
<td>3</td>
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<td>BIOMEDIN 217</td>
<td>Translational Bioinformatics</td>
<td>4</td>
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<tr>
<td>BIOMEDIN 260</td>
<td>Computational Methods for Biomedical Image Analysis and Interpretation</td>
<td>3-4</td>
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- Computer Science, Statistics, Mathematics & Engineering (24 units)
  Ph.D. students are expected to create a program of study with graduate-level courses in computer science, statistics and other technical informatics-related disciplines to achieve in-depth mastery. The program of study may focus on aspects of these disciplines including machine learning, statistical modeling, artificial intelligence, data mining, image analysis, human-computer interaction and data visualization. A complete list of courses accepted for this requirement is on the BMI website. The following are required:
  a. CS 161 Design and Analysis of Algorithms
  b. STATS 200 Introduction to Statistical Inference
  c. STATS 315A Modern Applied Statistics: Learning or CS 229 Machine Learning
  d. No more than 9 units in courses numbered 100-199, and the rest should be 200 or above.
  e. CS 106A Programming Methodology and CS 106B Programming Abstractions cannot be counted for this requirement.
  f. All courses should be formal classroom-based courses, not research units.
  g. Up to 6 units of this portion of the core curriculum may be taken on a Satisfactory/No credit basis.

- Social and Ethical Issues (4 units)
  Students are expected to be familiar with issues regarding responsible conduct of research, reproducibility of research, and ethical, legal, social, organizational and behavioral aspects of the impact of biomedical informatics technologies on society. Courses that fulfill this requirement can be found by entering “bmi::ethics” in the Explore Courses search box. PhD students should take MED 255 The Responsible Conduct of Research in their first year. These courses may be taken on a Satisfactory/No credit basis.

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<td>Biosecurity and Bioterrorism Response</td>
<td>4-5</td>
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<td>BIOE 131</td>
<td>Ethics in Bioengineering</td>
<td>3</td>
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<tr>
<td>BIOE 450</td>
<td>Advances in Biotechnology</td>
<td>3</td>
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<tr>
<td>BIOMEDIN 254</td>
<td>Quality &amp; Safety in U.S. Healthcare</td>
<td>3</td>
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<tr>
<td>BIOMEDIN 256</td>
<td>Economics of Health and Medical Care</td>
<td>5</td>
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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:

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<td>BIOMEDIN 260</td>
<td>Computational Methods for Biomedical Image Analysis and Interpretation</td>
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</tbody>
</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

Students are expected to participate regularly in BIOMEDIN 201 (p. 1) 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.

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.

Application Process
Stanford Ph.D. students apply using the Application for Ph.D. Minor (https://stanford.app.box.com/v/app-phd-minor) form and must provide an unofficial Stanford transcript as well as a statement of purpose for adding the Ph.D. minor degree. Submit the form and accompanying materials to the Biomedical Informatics program.

Advising
A minor program adviser is assigned from the Biomedical Informatics Executive Committee or advising faculty upon admission to the program.

Graduate Advising Expectations
The Program in Biomedical Informatics is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the adviser and the advisee. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

For a statement of University policy on graduate advising, see the "Graduate Advising (http://exploredegrees.stanford.edu/graduatedegrees/#advisingandcredentialtext)" section of this bulletin.

Committee: Carlos D. Bustamante (Chair and Program Director), Mark A. Musen (Co-Director), Steven C. Bagley (Executive Director), Russ B. Altman, Manisha Desai, Daniel L. Rubin, Nigam Shah, Dennis P. Wall

Participating Faculty and Staff by Department*

Biochemistry: Douglas Brutlag (Professor Emeritus), Rhiju Das (Associate Professor), Ronald Davis (Professor), James Ferrell (Professor), Julia Salzman (Assistant Professor), Julie Theriot (Professor)

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

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

Biomedical Data Science: Russ B. Altman (Professor), Euan Ashley (Associate Professor), Steven C. Bagley (Senior Research Engineer), Carlos D. Bustamante (Professor), Manisha Desai (Professor), Bradley Efron (Professor), Andrew Gentles (Assistant Professor), Olivier Gevaert (Assistant Professor), Trevor Hastie (Professor), Tina Hernandez-Boussard (Associate Professor), Iain Johnstone (Professor), Purvesh Khatri (Associate Professor), Teri Klein (Professor), Philip Lavori (Professor), Ying Lu (Professor), Mark A. Musen (Professor), Aaron Newman (Assistant Professor), Richard Oshlen (Professor Emeritus), Julia Palacios (Assistant Professor), Sylvia Plevritis (Professor), Manuel Rivas (Assistant Professor), Daniel L. Rubin (Associate Professor), Chiara Sabatti (Professor), Julia Salzman (Assistant Professor), Nigam Shah (Associate Professor), Lu Tian (Associate Professor), Robert Tibshirani (Professor), Dennis P. Wall (Associate Professor), Wing H Wong (Professor), James Zou (Associate Professor)

Richard Oshlen (Professor), Chiara Sabatti (Associate Professor), Robert Tibshirani (Professor), Dennis P. Wall (Associate Professor)

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

Chemistry: Vijay Pande (Professor)

Computer Science: Gill Bejerano (Associate Professor), David Dill (Professor Emeritus), Ronald Dorr (Associate Professor), Leonidas Guibas (Professor), Anshul Kundaje (Assistant Professor), Terry Winograd (Professor Emeritus)

Dermatology: Paul Khavari (Professor)

Developmental Biology: Gill Bejerano (Associate Professor)

Electrical Engineering: Kwabena Boahen (Professor)

Energy Resources Engineering: Margot Gerritsen (Professor)

Genetics: Russ B. Altman (Professor), Euan Ashley (Associate Professor), Michael Bassik (Assistant Professor), Ami Bhatt (Assistant Professor), Carlos D. Bustamante (Professor), J. Michael Cherry (Professor, Research), Stanley N. Cohen (Professor), Christina Curtis (Assistant Professor), Ronald Davis (Professor), William Greenleaf (Associate Professor), Karla Kirkegaard (Professor), Teri E. Klein (Senior Research Scientist), Anshul Kundaje (Assistant Professor), Jin Billy Li (Associate Professor), Stephen B. Montgomery (Assistant Professor), Jonathan Pritchard (Professor), Gavin Sherlock (Associate Professor),arend Sidow (Professor), Michael P. Snyder (Professor), Hua Tang (Professor)

Health Research and Policy: Trevor Hastie (Professor), Mark Hlatky (Professor)

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

Mechanical Engineering: Scott Delp (Professor)

Medicine: Russ B. Altman (Professor), Euan Ashley (Associate Professor), Mike Baiocchi (Assistant Professor), Sanjay Basu (Assistant Professor), Ami Bhatt (Assistant Professor), Jayanta Bhattacharya (Professor), Catherine Blish (Associate Professor), Carol Cain (Adjunct Assistant Professor), Jonathan Chen (Assistant Professor), Stanley Cohen (Professor), Christina Curtis (Assistant Professor), Manisha Desai (Professor), Michel Dumontier (Associate Professor), Andrew Gentles (Assistant Professor), Olivier Gevaert (Assistant Professor), Mary Goldstein (Professor), Summer Han (Assistant Professor), Tina Hernandez-Boussard (Associate Professor), Michael Higgins (Adjunct Associate Professor), Mark Hlatky (Professor), Hanlee P. Ji (Associate Professor), Purvesh Khatri (Associate Professor), Teri Klein (Professor), Lianne Kurina (Associate Professor, Teaching), Curtis Langlotz (Professor), Henry Lowey (Associate Professor), Mark A. Musen (Professor), Douglas K. Owens (Professor), Natalie Pageler

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