Stanford University

Biomedical Informatics Distance Education Programs

Overview

Biomedical informatics is an interdisciplinary field that combines ideas from computer science and quantitative disciplines to solve challenging problems in biology and medicine.

Stanford's program is particularly strong in methods development, drawing heavily on quantitative and computational approaches. Note that our prerequisites include mathematics, probability and statistics, and computer programming. Many other programs are more applied in nature.

Our distance education program offers individual courses, a three-course certificate, and a distance education masters degree. Students receive course content and interact via the Stanford Center for Professional Development (SCPD, `http://scpd.stanford.edu`). Students enrolled in the MS degree program are also allowed to attend class on campus if they desire.

Certificate in Biomedical Informatics

Prerequisites

The following are required for entry into the Certificate Program. Note that these prerequisite courses do not count towards the Certificate, even if taken at Stanford.

1. A bachelor's degree with a 3.0 (B) grade point average or better.
2. One year of computer programming or software engineering coursework or equivalent experience. We recommend that students take the equivalent of Stanford's CS 106A and 106B prior to entering the Certificate Program.
3. At least some college biology, preferably one year.
4. One year of calculus is required for some classes, and is strongly recommended so that a student is able to take any of the certificate courses.
5. Classwork in probability and statistics is a prerequisite for some classes.

Tuition

The cost of the certificate depends on the number of units taken. The current tuition is $1,200 per unit. Details are at `http://scpd.stanford.edu/admissions/tuition-fees`.

How to Apply

You apply to take individual courses or courses for the Certificate programs through SCPD (`http://scpd.stanford.edu`).

Certificate courses

Three courses are required for the Biomedical Informatics Certificate. These courses, which are described in detail later in this brochure, are chosen from the following list:

- BIOMEDIN 210: Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
- BIOMEDIN 214: Representations and Algorithms for Computational Molecular Biology
- BIOMEDIN 215: Data Driven Medicine
- BIOMEDIN 217: Translational Bioinformatics
- BIOMEDIN 260: Computational Methods for Biomedical Image Analysis

Masters Degree Program

Stanford BMI has a distance education MS program. It is offered through SCPD under the Honors Cooperative Program, or Professional Science

Masters model. It is designed for employed professionals working in the general area of biomedical informatics, who want further training leading to a degree. The HCP MS degree is fully equivalent to a regular Stanford MS degree. You can learn more about the HCP program and employment requirements at the SCPD website.

Prerequisites

The prerequisites are shown, along with the equivalent Stanford courses. Note that these are the minimum requirements needed to be able to begin graduate-level coursework in our program and that many applicants exceed them.

1. One year of calculus. Further coursework in multivariate calculus (MATH 51 and MATH 52) is strongly recommended.
2. Coursework in probability and statistics (STATS 116), and linear algebra (MATH 104 or MATH 113).
3. One year of computer programming/computer science coursework (CS 106A and CS 106B). The focus should be fundamentals of computer science and software engineering principles, including abstraction, modularity, and object-oriented programming, not merely the syntax of a programming language, scripting, or web programming.
4. One year of college biology at the level required of biology majors (BIO 41, BIO 42, and corresponding laboratory BIO 44X).

Tuition

Stanford requires 45 units for an MS degree. The current rate set by SCPD is $1,400 per unit, so the total would be $63,000. Details are at `http://scpd.stanford.edu/admissions/tuition-fees`.

How to Apply

You apply to the MS program through BMI at `http://bmi.stanford.edu/prospective-students/`.

Curriculum

The course requirements for the MS degree are listed at `http://exploredegrees.stanford.edu/schoolofmedicine/biomedicalinformatics/#masterstext`. In summary, the required coursework is:

1. Core Biomedical Informatics (15 or more units). Students complete the core: BIOMEDIN 212, and four courses chosen from BIOMEDIN 210, BIOMEDIN 214, BIOMEDIN 215, BIOMEDIN 217, and BIOMEDIN 260.
2. Computer Science, Statistics, Mathematics and 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. CS 161 Design and Analysis of Algorithms, and STATS 200 Introduction to Statistical Inference are required. These two courses, or some of their prerequisites, may not be available through SCPD. You should design a course plan with next best alternatives: these may include similar courses at Stanford, or courses at other institutions (outside courses would not count towards the required 45 units). Alternatively, you could take the courses on-campus if you live nearby.
3. Social and Ethical Issues (4 units)
4. Unrestricted Electives at the graduate level to complete the required 45 units.

Transfer Credits

Stanford does not allow transferring credits from outside institutions towards the MS degree. However, up to 15 units of Stanford coursework, either individual courses, or those taken for the certificates, can be counted towards the MS degree.

Course List

The follow is a list of the courses for the certificate and the MS core. A complete list of Stanford

courses is at: http://explorecourses.stanford.edu.

BIOMEDIN 210. Modeling Biomedical Systems: Ontology, Terminology, Problem Solving. 3 units, *Winter*. Methods for modeling biomedical systems and for making those models explicit in the context of building software systems. Emphasis is on intelligent systems for decision support and Semantic Web applications. Topics: knowledge representation, controlled terminologies, ontologies, reusable problem solvers, and knowledge acquisition. Prerequisites: CS106A, basic familiarity with biology.

BIOMEDIN 212. Introduction to Biomedical Informatics Research Methodology. 3 units, *Spring, available to HCP students on experimental basis*. Hands-on software building. Student teams conceive, design, specify, implement, evaluate, and report on a software project in the domain of biomedicine. Creating written proposals, peer review, providing status reports, and preparing final reports. Guest lectures from professional biomedical informatics systems builders on issues related to the process of project management. Software engineering basics. Prerequisites: BIOMEDIN 210 or 211 or 214 or 217. Preference to BMI graduate students. Consent of instructor required.

BIOMEDIN 214. Representations and Algorithms for Computational Molecular Biology. 3–4 units, *Autumn*. Topics: introduction to bioinformatics and computational biology, algorithms for alignment of biological sequences and structures, computing with strings, phylogenetic tree construction, hidden Markov models, Gibbs Sampling, basic structural computations on proteins, protein structure prediction, protein threading techniques, homology modeling, molecular dynamics and energy minimization, statistical analysis of 3D biological data, integration of data sources, knowledge representation and controlled terminologies for molecular biology, microarray analysis, machine learning (clustering and classification), and natural language text processing. Prerequisite: CS 106B; recommended: CS161; consent of instructor for 3 units.

BIOMEDIN 215. Data Driven Medicine. 3 units, *Autumn*. With the spread of electronic health records and increasingly low cost assays for patient molecular data, powerful data repositories with tremendous potential for biomedical research, clinical care and personalized medicine are being built. But these databases are large and difficult for any one specialist to analyze. To find the hidden associations within the full set of data, we introduce methods for data-mining at the internet scale, the handling of large-scale electronic medical records data for machine learning, methods in natural language processing and text-mining applied to medical records, methods for using ontologies for the annotation and indexing of unstructured content as well as semantic web technologies. Prerequisites: CS 106A; STATS 216. Recommended: one of CS 246, STATS 305, or CS 229

BIOMEDIN 217. Translational Bioinformatics. 4 units, *Winter*. Analytic, storage, and interpretive methods to optimize the transformation of genetic, genomic, and biological data into diagnostics and therapeutics for medicine. Topics: access and utility of publicly available data sources; types of genome-scale measurements in molecular biology and genomic medicine; analysis of microarray data; analysis of polymorphisms, proteomics, and protein interactions; linking genome-scale data to clinical data and phenotypes; and new questions in biomedicine using bioinformatics. Case studies. Prerequisites: programming ability at the level of CS 106A and familiarity with statistics and biology.

BIOMEDIN 224: Principles of Pharmacogenomics. 3 units, *Spring*. This course is an introduction to pharmacogenomics, including the relevant pharmacology, genomics, experimental methods (sequencing, expression, genotyping), data analysis methods and bioinformatics. The course reviews key gene classes (e.g., cytochromes, transporters) and key drugs (e.g., warfarin, clopidogrel, statins, cancer drugs) in the field. Resources for pharmacogenomics (e.g., PharmGKB, Drugbank, NCBI resources) are reviewed, as well as issues implementing pharmacogenomics testing in the clinical setting. Reading of key papers, including student presentations of this work; problem sets; final project selected with approval of instructor. Prerequisites: two of BIO 41, 42, 43, 44X, 44Y or consent of instructor.

BIOMEDIN 260. Computational Methods for Biomedical Image Analysis and Interpretation. 3–4 units, *Spring*. The latest biological and medical imaging modalities and their applications in research and medicine. Focus is on computational analytic and interpretive approaches to optimize extraction and use of biological and clinical imaging data for diagnostic and therapeutic

translational medical applications. Topics include major image databases, fundamental methods in image processing and quantitative extraction of image features, structured recording of image information including semantic features and ontologies, indexing, search and content-based image retrieval. Case studies include linking image data to genomic, phenotypic and clinical data, developing representations of image phenotypes for use in medical decision support and research applications and the role that biomedical imaging informatics plays in new questions in biomedical science. Includes a project. Enrollment for 3 units requires instructor consent. Prerequisites: programming ability at the level of CS 106A, familiarity with statistics, basic biology. Knowledge of Matlab or Python highly recommended.

Contact Information

For questions about courses and degrees requirements, review the relevant sections of `http://bmi.stanford.edu`, and send remaining questions via email to `bmi-contact@lists.stanford.edu`.

For questions about receiving the course video over the Internet, employment requirements, and tuition, please review the relevant sections of `http://scpd.stanford.edu`, and send remaining questions to SCPD at: `scpd-gradstudents@stanford.edu`.

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