Bioinformatics and Computational Biology Graduate Program

Undergraduate Study

Undergraduates seeking a B.S. in Bioinformatics and Computational Biology should enroll in the undergraduate major BCBio, which is described in a separate section of this catalog. See Index, BCBio.

Undergraduates wishing to prepare for graduate study in Bioinformatics and Computational Biology should consider the undergraduate major in BCBio. Alternatively, they should obtain solid undergraduate training in at least one of the foundation disciplines: molecular biology, computer science, mathematics, statistics, and physics. They should also elect courses in basic biology, basic transmission and molecular genetics, chemistry, physics, mathematics at least through calculus, statistics, and computer programming.

Graduate Study

Work is offered for the master of science and doctor of philosophy degrees with a major in Bioinformatics and Computational Biology (BCB). Faculty are drawn from several departments: Agronomy; Animal Science; Astronomy and Physics; Biochemistry, Biophysics and Molecular Biology; Biomedical Sciences; Chemical and Biological Engineering; Chemistry; Computer Science; Ecology, Evolution, and Organismal Biology; Electrical and Computer Engineering; Entomology, Genetics, Development and Cell Biology; Materials Science and Engineering; Mathematics; Plant Pathology; Statistics; Veterinary Microbiology and Preventive Medicine; and Veterinary Pathology.

The BCB program emphasizes interdisciplinary training in nine related areas of focus: Bioinformatics, Computational Molecular Biology, Structural and Functional Genomics, Macromolecular Structure and Function, Metabolic and Developmental Networks, Integrative Systems Biology, information Integration and Data Mining, Biological Statistics, and Mathematical Biology. Additional information about research areas and individual faculty members is available at: http://www.bcb.iastate.edu .

BCB students are trained to develop an independent and creative approach to science through an integrative curriculum and thesis research projects that include both computational and biological components. First year students are appointed as research assistants and participate in BCB 697 Graduate Research Rotation, working with three or more different research groups to gain experience in both “wet” (biological) and “dry” (computer) laboratory environments. In the second year, students initiate a thesis research project under the joint mentorship of two BCB faculty mentors, one from the biological sciences and one from the quantitative/computational sciences. The M.S. and Ph.D. degrees are usually completed in two and five years, respectively.

Before entering the graduate BCB program, prospective BCB students should have taken courses in mathematics, statistics, computer science, biology, and chemistry. A course load similar to the following list would be considered acceptable:

MATH 265	Calculus III	4
STAT 341	Introduction to the Theory of Probability and Statistics I	3
COM S 207	Fundamentals of Computer Programming	3
COM S 208	Intermediate Computer Programming	3
COM S 330	Discrete Computational Structures	3
CPR E 310	Theoretical Foundations of Computer Engineering	3
CHEM 163	College Chemistry	4
CHEM 231	Elementary Organic Chemistry	3
BBMB 301	Survey of Biochemistry	3
BIOL 313	Principles of Genetics	3
BIOL 315	Biological Evolution	3

During the first year, BCB students are required to address any background deficiencies in calculus, molecular genetics, computer science, statistics and discrete structures, with specific courses determined by prior training. Among the total course requirements for Ph.D. students are four core courses in Bioinformatics:

BCB 567	Bioinformatics I (Fundamentals of Genome Informatics)	3
BCB 568	Bioinformatics II (Advanced Genome Informatics)	3
BCB 569	Bioinformatics III (Structural Genome Informatics)	3
BCB 570	Bioinformatics IV (Computational Functional Genomics and Systems Biology)	3

And also should include

GDCB 511	Molecular Genetics
BCB 690	Student Seminar in Bioinformatics and Computational Biology
BCB 691	Faculty Seminar in Bioinformatics and Computational Biology
BCB 593	Workshop in Bioinformatics and Computational Biology

M.S. students take the above background and core courses, take at least 6 credits of advanced coursework, and may elect to participate in fewer seminars and workshops. Additional coursework may be selected to satisfy individual interests or recommendations of the Program of Study Committee. All graduate students are encouraged to teach as part of their training for an advanced degree. (For curriculum details and sample programs of study, see: www.bcb.iastate.edu .)

Courses primarily for undergraduates:

BCB 444. Introduction to Bioinformatics.
(Cross-listed with BIOL, BCBIO, COM S, CPR E, GEN). (4-0) Cr. 4. F. *Prereq: MATH 165 or STAT 401 or equivalent*
Broad overview of bioinformatics with a significant problem-solving component, including hands-on practice using computational tools to solve a variety of biological problems. Topics include: database searching, sequence alignment, gene prediction, RNA and protein structure prediction, construction of phylogenetic trees, comparative and functional genomics, systems biology. Nonmajor graduate credit.

BCB 490. Independent Study.
Cr. 1-5. Repeatable, maximum of 9 credits. F.S.SS. *Prereq: Permission of instructor*

Courses primarily for graduate students, open to qualified undergraduates:

BCB 544. Introduction to Bioinformatics.
(Cross-listed with GDCB, CPR E, COM S). (4-0) Cr. 4. F. *Prereq: MATH 165 or STAT 401 or equivalent*
Broad overview of bioinformatics with a significant problem-solving component, including hands-on practice using computational tools to solve a variety of biological problems. Topics include: database searching, sequence alignment, gene prediction, RNA and protein structure prediction, construction of phylogenetic trees, comparative, functional genomics, and systems biology.

BCB 567. Bioinformatics I (Fundamentals of Genome Informatics).
(Cross-listed with COM S, CPR E). (3-0) Cr. 3. F. *Prereq: COM S 208; COM S 330; STAT 341; credit or enrollment in BIOL 315, STAT 430*
Biology as an information science. Review of algorithms and information processing. Generative models for sequences. String algorithms. Pairwise sequence alignment. Multiple sequence alignment. Searching sequence databases. Genome sequence assembly.

BCB 568. Bioinformatics II (Advanced Genome Informatics).
(Cross-listed with GDCB, STAT, COM S). (3-0) Cr. 3. S. *Prereq: BCB 567, BBMB 301, BIOL 315, STAT 430, credit or enrollment in GEN 411*
Advanced sequence models. Basic methods in molecular phylogeny. Hidden Markov models. Genome annotation. DNA and protein motifs. Introduction to gene expression analysis.

BCB 569. Bioinformatics III (Structural Genome Informatics).
(Cross-listed with BBMB, COM S, CPR E). (3-0) Cr. 3. F. *Prereq: BCB 567, GEN 411, STAT 430*
Algorithmic and statistical approaches in structural genomics including protein, DNA and RNA structure. Structure determination, refinement, representation, comparison, visualization, and modeling. Analysis and prediction of protein secondary and tertiary structure, disorder, protein cores and surfaces, protein-protein and protein-nucleic acid interactions, protein localization and function.

BCB 570. Bioinformatics IV (Computational Functional Genomics and Systems Biology).
(Cross-listed with CPR E, COM S, GDCB, STAT). (3-0) Cr. 3. S. *Prereq: BCB 567, BIOL 315, COM S 311 and either 208 or 228, GEN 411, STAT 430*
Algorithmic and statistical approaches in computational functional genomics and systems biology. Elements of experiment design. Analysis of high throughput gene expression, proteomics, and other datasets obtained using system-wide measurements. Topological analysis, module discovery, and comparative analysis of gene and protein networks. Modeling, analysis, simulation and inference of transcriptional regulatory modules and networks, protein-protein interaction networks, metabolic networks, cells and systems: Dynamic systems, Boolean, and probabilistic models. Multi-scale, multi-granularity models. Ontology-driven, network based, and probabilistic approaches to information integration.

BCB 590. Special Topics.
Cr. arr. Repeatable. *Prereq: Permission of instructor*

BCB 593. Workshop in Bioinformatics and Computational Biology.
(1-0) Cr. 1. Repeatable. F.S.
Current topics in bioinformatics and computational biology research. Lectures by off-campus experts. Students read background literature, attend preparatory seminars, attend all lectures, meet with lecturers.

BCB 596. Genomic Data Processing.
(Cross-listed with COM S, GDCB). (3-0) Cr. 3. F. *Prereq: Some experience in computation*
Study the practical aspects of genomic data processing with an emphasis on hands-on projects. Topics include base-calling, sequence cleaning and contaminant removal; fragment assembly procedures and EST clustering methods; genome closure strategies and practices; sequence homology search and function prediction; and annotation and submission of GenBank reports. Next-generation sequencing topics like model genome resequencing, short-read assembly and transcriptome abundance measurement will also be covered.

BCB 598. Cooperative Education.
Cr. R. Repeatable. F.S.SS. *Prereq: Permission of the program chair*
Off-campus work periods for graduate students in the field of bioinformatics and computational biology.

BCB 599. Creative Component.
Cr. arr.

Courses for graduate students:

BCB 660. Selected Topics in Bioinformatics and Computational Biology.
(3-0) Cr. 1-4. Repeatable, maximum of 4 times. F.S.SS. *Prereq: Permission of Instructor*
Topics of interest in the major research areas of computational molecular biology, including genomics, structural genomics, functional genomics, and computational systems biology.

BCB 690. Student Seminar in Bioinformatics and Computational Biology.
Cr. 1. Repeatable. S.
Student research presentations.

BCB 691. Faculty Seminar in Bioinformatics and Computational Biology.
(1-0) Cr. 1. Repeatable.
Faculty research series.

BCB 697. Graduate Research Rotation.
Cr. arr. Repeatable. F.S.SS.
Graduate research projects performed under the supervision of selected faculty members in the Bioinformatics and Computational Biology major.

BCB 699. Research.
Cr. arr. Repeatable.