Bioinformatics and Computational Biology

Undergraduate study

Undergraduate study in BCBio is jointly administered by the Department of Computer Science, the Department of Genetics, Development, and Cell Biology, and the Department of Mathematics. The undergraduate B.S. degree is offered through the College of Liberal Arts and Sciences.

Bioinformatics and Computational Biology is an interdisciplinary science at the interfaces of the biological, informational and computational sciences. The science focuses on a variety of topics. These include gene identification, expression, and evolution; RNA, protein, and genome structure; and molecular and cellular systems and networks. The large group of participating faculty provides students with a multidimensional perspective on bioinformatics and computational biology and presents them with broad range of possibilities to get involved in research.

This major will prepare students for careers at the interfaces of biological, informational and computational sciences. BCBio graduates with a B.S. seeking direct employment will find ready markets for their talents in agricultural and medical biotechnology industries, as well as in academia, national laboratories, and clinics. Although some students find employment directly after their baccalaureate training, many students will continue their education in one of the many excellent graduate programs in bioinformatics and computational biology that now exist.

Participation in this field requires that students achieve a high level of competence not only in biology, but also in mathematics, computer science, and statistics. As a result, the program includes required courses from many different disciplines. Graduates demonstrate an above-average ability to synthesize methods from these different disciplines to solve problems.

In addition to basic degree requirements listed in the Curriculum in Liberal Arts and Sciences, BCBio majors must satisfy the following requirements:

A. Complementary Courses for the BCBio Major

Choose from:

- CHEM 163 College Chemistry
- CHEM 163L and Laboratory in College Chemistry

or

- CHEM 177 General Chemistry I
- & 177L and Laboratory in General Chemistry I
- CHEM 178 and General Chemistry II

or

- CHEM 201 Advanced General Chemistry
- & 201L and Laboratory in Advanced General Chemistry
- CHEM 231 Elementary Organic Chemistry
- & 231L and Laboratory in Elementary Organic Chemistry

or

- CHEM 331 Organic Chemistry I
- & 331L and Laboratory in Organic Chemistry I
- CHEM 332 and Organic Chemistry II
- & CHEM 332L and Laboratory in Organic Chemistry II
- PHYS 111 General Physics
- PHYS 221 Introduction to Classical Physics I
- PHYS 115 Physics for the Life Sciences
- & 115L and Laboratory in Physics for the Life Sciences

Note: The following other STAT courses may be substituted for STAT 330 and STAT 430, with permission of the BCBio Major.

- STAT 330: STAT 101, 104, 105, 201, 231, 305, or 341
- STAT 430: STAT 301, 401, or 432

B. Core Courses Within the BCBio Major

GEN 313 & 313L Principles of Genetics and Genetics Laboratory

one of the following combinations:

- COM S 227 & COM S 228 Introduction to Object-oriented Programming and Introduction to Data Structures
- COM S 207 & COM S 208 Fundamentals of Computer Programming and Intermediate Computer Programming
- COM S 330 Discrete Computational Structures
- or CPR E 310 Theoretical Foundations of Computer Engineering
- COM S 311 Design and Analysis of Algorithms
- MATH 165 Calculus I
- & MATH 166 and Calculus II
- or
- MATH 181 & MATH 182 Calculus and Mathematical Modeling for the Life Sciences I and Calculus and Mathematical Modeling for the Life Sciences II
- or
- BCBIO 110 BCBio Orientation
- BCBIO 211 Introduction to Bioinformatics and Computational Biology
- BCBIO 401 Fundamentals of Bioinformatics and Computational Biology I
- BCBIO 402 Fundamentals of Bioinformatics and Computational Biology II
- BCBIO 490 Independent Study
- or
- BCBIO 491 Team Research Projects.

Total Credits 34.5-39.5

C. Support Electives

3-9 credits to be chosen from the following list:

- BBMB 404 Biochemistry I
- BBMB 405 Biochemistry II
- BBMB 461 Molecular Biophysics
- BIOL 328 Molecular and Cellular Biology of Human Diseases
- BIOL 423 Developmental Biology
- BIOL 451 Plant Evolution and Phylogeny
- BIOL 462 Evolutionary Genetics
- BIOL 465 Morphometric Analysis
- BIOL 487 Microbial Ecology
- COM S 252 Linux Operating System Essentials
- COM S 309 Software Development Practices
- COM S 319 Software Construction and User Interfaces
- COM S 327 Advanced Programming Techniques
- COM S 363 Introduction to Database Management Systems
- COM S 425 High Performance Computing for Scientific and Engineering Applications
- COM S 426 Introduction to Parallel Algorithms and Programming
- GEN 340 Human Genetics
- GEN 410 Analytical Genetics
- MATH 207 Matrices and Linear Algebra
- or MATH 317 Theory of Linear Algebra
- MATH 265 Calculus III
- or MATH 266 Elementary Differential Equations
- or MATH 267 Elementary Differential Equations and Laplace Transforms
- MATH 304 Combinatorics
- MATH 314 Graph Theory
- MATH 373 Introduction to Scientific Computing
- MICRO 402 Microbial Genetics and Genomics
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: 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 "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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH 265: Calculus III</td>
<td>4</td>
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<tr>
<td>STAT 341: Introduction</td>
<td>3</td>
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<tr>
<td>STAT 307: Fundamentals</td>
<td>3</td>
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<tr>
<td>STAT 308: Intermediate</td>
<td>3</td>
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<tr>
<td>STAT 330: Discrete</td>
<td>3</td>
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<tr>
<td>CPR E 310: Theoretical</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 163: College</td>
<td>4</td>
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<tr>
<td>CHEM 231: Elementary</td>
<td>3</td>
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<tr>
<td>BIOL 313: Principles</td>
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<tr>
<td>BIOL 315: Biological</td>
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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:

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<th>Course</th>
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<td>BCB 567: Bioinformatics</td>
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<tr>
<td>BCB 568: Bioinformatics</td>
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<tr>
<td>BCB 569: Bioinformatics</td>
<td>3</td>
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<tr>
<td>BCB 570: Bioinformatics</td>
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And also should include

<table>
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<th>Course</th>
<th>Credits</th>
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<tr>
<td>GDCB 511: Molecular</td>
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<tr>
<td>BCB 690: Student Seminar</td>
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<tr>
<td>BCB 691: Faculty Seminar</td>
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<tr>
<td>BCB 593: Workshop</td>
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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:

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<th>Course</th>
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<tr>
<td>BCB 444: Introduction</td>
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Courses primarily for graduate students, open to qualified undergraduates:

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<td>BCB 544: Introduction</td>
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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 598. Cooperative Education. Cr. R. Repeatable. F.S.S.S. 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.S.S. 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.S.S. Graduate research projects performed under the supervision of selected faculty members in the Bioinformatics and Computational Biology major.


Courses primarily for undergraduates:

BCBIO 110. BCBIO Orientation. (1-0) Cr. 0.5. F. First 8 weeks. Orientation to the area of bioinformatics and computational biology. For students considering a major in BCBIO. Specializations and career opportunities. Offered on a satisfactory-fail basis only.

BCBIO 211. Introduction to Bioinformatics and Computational Biology. (3-0) Cr. 3. S. Perl programming, molecular biology, biological databases, sequence alignment, homology search, identification of sequence patterns, construction of phylogenetic trees, gene function prediction, gene structure prediction, genomic annotation and comparative genomics.

BCBIO 401. Fundamentals of Bioinformatics and Computational Biology I. (3-0) Cr. 3. F. Prereq: BCBIO 211 and basic programming experience (e.g. COM S 207, COM S 208, COM S 227 or permission of instructor). Application of computer science to molecular biology. String algorithms, sequence alignments, indexing data structures, homology search methods, pattern recognition, fragment assembly, genome annotation, construction of bioinformatics databases, and gathering and distribution of biological information with the Internet.


BCBIO 442. Bioinformatics and Computational Biology Techniques. (0.2-0.5) Cr. 0.5. Repeatable, maximum of 2 credits. S.S.S. Prereq: BIOL 314 recommended. Modular minicourses consisting of guided tutorials and hands-on computer software exercises focused on fundamental problems, approaches, and software applications in bioinformatics and computational biology. Offered on a satisfactory-fail basis only.

BCBIO 442A. Bioinformatics and Computational Biology Techniques: Sequence Database Searching. (0.2-0.5) Cr. 0.5. Repeatable, maximum of 2 credits. S.S. Prereq: BIOL 314 recommended. Modular minicourses consisting of guided tutorials and hands-on computer software exercises focused on fundamental problems, approaches, and software applications in bioinformatics and computational biology. Offered on a satisfactory-fail basis only.

BCBIO 442B. Bioinformatics and Computational Biology: Protein Structure Databases, Visualization, and Prediction. (0.2-0.5) Cr. 0.5. Repeatable, maximum of 2 credits. S.S. Prereq: BIOL 314 recommended. Modular minicourses consisting of guided tutorials and hands-on computer software exercises focused on fundamental problems, approaches, and software applications in bioinformatics and computational biology. Offered on a satisfactory-fail basis only.

BCBIO 442C. Bioinformatics and Computational Biology Techniques: Phylogenetic Analysis. (0.2-0.5) Cr. 0.5. Repeatable, maximum of 2 credits. S.S. Prereq: BIOL 314 recommended. Modular minicourses consisting of guided tutorials and hands-on computer software exercises focused on fundamental problems, approaches, and software applications in bioinformatics and computational biology. Offered on a satisfactory-fail basis only.

BCBIO 442D. Bioinformatics and Computational Biology Techniques: Microarray Analysis. (0.2-0.5) Cr. 0.5. Repeatable, maximum of 2 credits. S.S. Prereq: BIOL 314 recommended. Modular minicourses consisting of guided tutorials and hands-on computer software exercises focused on fundamental problems, approaches, and software applications in bioinformatics and computational biology. Offered on a satisfactory-fail basis only.
BCBIO 444. Introduction to Bioinformatics.  
(Cross-listed with BCB, BIOL, 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. 

BCBIO 490. Independent Study. 
Cr. 1-5. Repeatable, maximum of 9 credits. F.S.S.S. Prereq: BCBIO 211, junior or 
senior classification, permission of instructor 
Students in the College of Liberal Arts and Sciences may use no more than 9 
credits of BCBIO 490 and 491 toward graduation. 

BCBIO 491. Team Research Projects. 
Cr. 1-5. Repeatable, maximum of 9 credits. Prereq: BCBIO 211, junior or senior 
classification, permission of instructor 
Research projects in bioinformatics and computational biology done by teams of 
students. Students in the College of Liberal Arts and Sciences may use no more 
than 9 credits of BCBIO 490 and 491 toward graduation.