Ph.D. in Bioinformatics and Computational Biology Degree Requirements

Credits

Students pursuing the doctoral degree in BCB must complete a minimum of 90 credits of relevant work beyond the bachelor’s degree; or a minimum of 60 credits beyond the M.S. degree if the student possesses a relevant M.S. degree in Bioinformatics, Computational Biology, or a closely related field.

For students proceeding directly from the B.S. degree to the Ph.D. degree, the 90 credits must be distributed as follows:
- 30 graduate credits in coursework, as described below;
- 30 graduate credits in BCB 699 Dissertation Research; and
- 30 graduate credits in additional coursework and additional research (BCB 699 Dissertation Research or BCB 597 Directed Research).

For students with a relevant M.S. degree, the 60 credits must be distributed as follows:
- 30 graduate credits in BCB 699 Dissertation Research; and
- 30 graduate credits in coursework and additional research (BCB 699 Dissertation Research or BCB 597 Directed Research). Student must fulfill the Course Work Requirement described below. Student may substitute additional research work for course work requirements already fulfilled during their M.S. work, with the permission of the BCB program’s Review Committee.

Course Work Requirement (30 credits)

Students must take courses to satisfy each of the following requirements. Only courses in which the student has obtained an A or a B grade can be used to satisfy this requirement. If a course is listed below as satisfying more than one requirement, a student can only count such course towards one of his/her course work requirements.

1. Foundational knowledge (12 credits): All BCB Ph.D. students must gain core knowledge of biology, computer science, mathematics/statistics, and bioinformatics and computational biology. To achieve this requirement, students must complete one 3-credit foundational course in each of these four areas. To provide students with maximum flexibility in this fast-moving field, students work with their Advisory Committee to determine the most relevant courses for their areas of interest. For example, a student focusing on bioinformatics who is interested in studying the effects of mutations on protein interaction networks may take completely different courses from a student focusing on computational biology who is interested in developing computational simulations of ecological systems.

1.1. Foundational knowledge in mathematics/statistics (3 credits):
   - MA 511 Applied Statistics for Engineers and Scientists
   - DS 502 / MA 543 Statistical Methods for Data Science
   - MA 501 Engineering Mathematics
   - MA 510 / CS 522 Numerical Methods
1.2. Foundational knowledge in computer science (3 credits):
   - CS 5084 Algorithms
   - CS 584 Algorithms: Design and Analysis

1.3. Foundational knowledge in biology (3 credits):
   - BB 561 Model Systems: Experimental Approaches and Applications
   - BB 575 Advanced Genetics and Cellular Biology
   - BBS 612 Biomedical Sciences Block II Molecular Genetics (UMMS course)

1.4. Foundational knowledge in bioinformatics and computational biology (3 credits):
   - BCB 501 Bioinformatics
   - MA 508 Mathematical Modeling

2. Interdisciplinary work (6 credits):
   - BCB 501 Bioinformatics
   - BCB 502 Biovisualization
   - BCB 503 Biological and Biomedical Database Mining
   - BCB 504 Statistical Methods in Genetics and Bioinformatics
   - BCB 590 Special Topics
   - BBS 741 Advanced Topics in Bioinformatics (UMMS course)
   - BBS 785 Quantitative Informatics in Biology and Medicine (UMMS course)

3. Social implications or bioethics (1 credit):
   - BB 551 Research Integrity in the Sciences
   - BBS 601 Responsible Conduct in Research (UMMS course)

4. Proposal writing (2 credits):
   - BB 552 Scientific Writing and Proposal Development
   - BBS 602 Communicating Science (UMMS course)

5. Program electives (9 credits):
   - Courses chosen in consultation with the student’s Advisory Committee. An elective can be any graduate course on the approved list for the BCB Ph.D. degree (see Appendix). Other graduate courses, graduate research credits, or ISGs may also be used with prior approval of the BCB program's Review Committee.

Advisor and Advisory Committee Selection

Upon acceptance to the doctoral program, students will be assigned a temporary Academic Advisor. In consultation with the Academic Advisor, the student must prepare a Plan of Study outlining the course selections and rotations that the student will pursue for the first year. This Plan of Study must then be approved by the BCB program's Review Committee, which consists of faculty members from each of the three participating WPI departments.
Students are required to complete rotations with at least two program faculty members in the first year of the program (at least 2 credits each, BCB 597). A rotation is typically a semester-long research or laboratory experience conducted under the guidance of a faculty member affiliated with the BCB program. After completing his/her rotations, the student will ask one of the rotation faculty members to be their Advisor, replacing the temporary Academic Advisor. Students are encouraged to ask faculty from two different participating departments to co-advice their research. In consultation with the Advisor(s), the student will select an Advisory Committee. The Advisory Committee must be constituted as follows:

- The Advisory Committee must consist of at least three members (four members if there are two co-Advisors).
- At least two Advisory Committee members must be BCB affiliated faculty members from two different participating WPI departments (BBT, CS, MA).
- At least one Advisory Committee member must be a full-time, WPI tenured / tenure-track faculty member.
- At least one Advisory Committee member must be from outside the BCB program, or from outside of WPI.

The Advisory Committee will meet with the student once per semester to monitor research and coursework progress.

**Research presentation skills**

Students are required to register for 1 credit per semester in the BCB seminar series (BCB 510 BCB Seminar). This series includes research seminars from invited external speakers as well as student presentations of their research. Students must present a seminar on their work once each year. In addition, all doctoral students are encouraged to present their research at appropriate professional conferences.

**Teaching and mentoring experience**

Recent studies show that teaching experience enhances graduate students’ research skills. In addition, particularly for students preparing for academic careers, teaching and mentoring experience is an invaluable asset. Thus, all BCB doctoral students must acquire teaching and mentoring experience. Students may fulfill this requirement in one of several ways. While at least one such experience is required, students are encouraged to pursue more than one teaching and mentoring opportunity during their graduate work.

Students must choose at least one of the following options:
- Work with a faculty member to design lectures, classroom activities, or problem sets, and to lead problem sessions or discussion sections for the students. This experience may be fulfilled as part of a Teaching Assistantship, but is not fulfilled by simply acting as a grader for a course. Credit is obtained by registering for BB 556 Mentored teaching experience (1 credit).
- Work with a faculty member to mentor undergraduate students in a research project. The undergraduate research project will typically be related to the graduate student’s research,
resulting in a vertical integration of the research experience for all of the students. Credit is obtained by registering for BB 556 Mentored teaching experience (1 credit).

- Take a course related to teaching with prior advisor approval. The Higher Education Consortium of Central Massachusetts (HECCMA) offers coursework that can lead to a Certificate in College Teaching.

**Graduate Internships**

Students will have the opportunity to undertake a Graduate Internship to fulfill credit toward their degree (BCB 589 Graduate Internship). A graduate internship is carried out in cooperation with a sponsor or industrial partner. It must be overseen by a faculty member affiliated with the Bioinformatics and Computational Biology Program. The internship will involve development and practice of technical and professional skills and knowledge relevant to Bioinformatics and Computational Biology. At the completion of the internship, the student will produce a written report, and will present his/her work to BCB faculty and internship sponsors. Students may use up to 6 coursework credits of BCB 589 Graduate Internship towards their Ph.D. degrees.

**Ph.D. Qualifying Examination**

The Qualifying Examination will be comprised of researching, writing, and defending a research proposal. The student is required to successfully complete the Qualifying Examination no later than the first semester of his/her third year in the program. If the Qualifying Examination is successfully completed, the proposed work may constitute the basis of the student’s dissertation research.

The student will present his/her research proposal publicly. The student will then be examined privately by the Advisory Committee, who will assign the student one of four outcomes:

- Fail, which results in dismissal from the BCB Ph.D. program.
- Repeat, which requires the student to retake the examination within six months of the date of the initial Qualifying Examination. Students may only Repeat once.
- Pass with Conditions, which requires the student to complete additional work, such as coursework or independent study.
- Pass.

**Dissertation Defense**

All Ph.D. students must produce and orally defend a dissertation. The research must constitute a contribution to knowledge in the field of Bioinformatics and Computational Biology and must be of publication quality. Students must defend the dissertation orally in a public presentation, followed by a private defense to the Advisory Committee. The Advisory Committee will assign the student one of three outcomes:

- Fail, which results in dismissal from the BCB Ph.D. program.
- Repeat, which requires the student to complete additional work, and repeat the defense.
- Pass, with or without additional work and revisions to the document.
Admission

Students applying to the doctoral degree program in BCB are expected to have a bachelor's or master’s degree in bioinformatics, biology, computer science, mathematics/statistics, or a related field, and to have taken introductory courses in each of the three disciplines of biology, computer science, and mathematics. For example, a student with a degree in biology is expected to have also completed basic coursework in programming, data structures, calculus, and statistics prior to submitting an application.

All applicants are required to submit a Statement of Purpose. Applicants who are not WPI students or alumni must submit Graduate Record Exam (GRE) scores. GRE Subject tests in relevant disciplines are encouraged but not required. All other WPI graduate application requirements, including transcripts, letters of recommendation and TOEFL/IELTS, apply.

Appendix: Approved electives for the BCB Ph.D. degree

Relevant Bioinformatics and Computational Biology Interdisciplinary Courses
BCB 501 Bioinformatics
BCB 502 Biovisualization
BCB 503 Biological and Biomedical Database Mining
BCB 504 Statistical Methods in Genetics and Bioinformatics
BCB 590 Special Topics
UMMS Advanced Topics in Bioinformatics
UMMS Quantitative Informatics in Biology and Medicine
Other UMMS courses with approval of the program's Review Committee.

Relevant Biology, and Chemistry and Biochemistry Graduate Courses:
BB 515 Environmental Change: Problems and Approaches
BB 561 Model Systems: Experimental Approaches and Applications
BB 562 Cell Cycle Regulation
BB 565 Virology
BB 570 Special Topics
BB 575 Advanced Genetics and Cellular Biology
CH 540 Regulation of Gene Expression
CH 554 Molecular Modeling
CH 561 Functional Genomics
UMMS Core Block I (Molecular Biophysics)
UMMS Core Block II (Molecular Genetics)
UMMS Core Block III (Cell Biology)
Other UMMS courses with approval of the program's Review Committee.

Relevant Computer Science Graduate Courses:
CS5084 Introduction to Algorithms: Design and Analysis
CS504 Analysis of Computation and Systems
CS509 Design of Software Systems
CS 522 / MA 510 Numerical Analysis
CS525 Special Topics
CS531 System Simulation
CS534 Artificial Intelligence
CS539 Machine Learning
CS542 Database Management Systems
CS561 Advanced Topics in Database Systems
CS548 Knowledge Discovery and Data Mining
CS584 Algorithms: Design and Analysis
CS 585/DS 503. Big Data Management
CS 586/DS 504. Big Data Analytics
(Note: Students cannot receive credit for both CS5084 and CS584.)

**Relevant Mathematics Graduate Courses:**
MA 508 Mathematical Modeling MA 510 / CS 522 Numerical Analysis
MA 511 Applied Statistics for Engineers and Scientists
MA 528 Measure Theoretic Probability Theory
MA 529 Stochastic Processes
MA 540/4631 Probability and Mathematical Statistics I
MA 541/4632 Probability and Mathematical Statistics II
MA 542 Regression Analysis
MA 546 Design and Analysis of Experiments
MA 547 Design and Analysis of Observational and Sampling Studies
MA 549 Analysis of Lifetime Data
MA 550 Time Series Analysis
MA 552 Distribution-Free and Robust Statistical Methods
MA 554 Applied Multivariate Analysis
MA 556 Applied Bayesian Statistics
MA 543/DS 502. Statistical Methods for Data Science

**Relevant Data Science Graduate Courses:**
DS 501. Introduction to Data Science.
DS 503 / CS 585 Big Data Management.
DS 504 / CS 586. Big Data Analytics.