Bioinformatics & Computational Biology Handbook

For more information regarding IGPI, please visit informatics.uiowa.edu or refer to the Interdisciplinary Graduate Program in Informatics Handbook.
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Mission - Bioinformatics and Computational Biology
Subprogram

The mission of the Bioinformatics and Computational Biology subprogram is to:

1. Prepare students to become leading primary investigators (Ph.D.s) or Bioinformatics professionals (M.S.s) in academic or industrial roles.
2. Provide supplemental training to students in fields closely aligned to Bioinformatics and Computational Biology.

Subprogram Description and Training – Bioinformatics and Computational Biology

As the cost of reading DNA sequencing drops below the cost of analyzing and storing the data, the fields of bioinformatics and computational biology are poised to transform research and healthcare. **Bioinformatics** is the application of "informatics sciences" to problems in biological sciences. This includes using software, algorithms, statistics, database sciences, and machine learning to resolve problems associated with biology, genetics, and genomics. **Computational Biology** is the application of computing and statistics to model biology, genetics, and genomics. This subprogram provides training in topics associated with bioinformatics and computational biology, including software, algorithms, biology, genetics, genomics, statistics, machine learning, and databases.

The subprogram of Bioinformatics and Computational Biology can also supplement the training of graduate students in existing degree-granting programs (Engineering, Genetics, Biology, Computer Science, Mathematics, Geography, Biosciences, Anatomy and Cell Biology, Biochemistry, Chemistry, Free Radical & Radiation Biology, Human Toxicology, Immunology, Microbiology, Molecular & Cellular Biology, Molecular Physiology and Biophysics, Neuroscience, Pharmacology, Physical Therapy and Rehabilitation Science, Physics and Astronomy, Speech & Hearing Science, etc.).
Application Prerequisites

Applicants are expected, but not required, to have approximately 6 hours of undergraduate work in computer science and/or informatics, and 6 hours of biology, covering genetics, molecular biology and evolution. Both graduate programs have been designed to provide flexible entry points to provide appropriate remedial training depending on the students’ prior training and experience. See the Prerequisite Requirements section for further information.

Requirements for the M.S. and Ph.D. include:

- A bachelor’s degree from a regionally accredited American college or university, or an equivalent degree from another country as determined by the Office of Admissions.
- A minimum grade-point average (GPA) of 3.00, or the foreign equivalent as determined by the Office of Admissions.
- Your official GRE General Test scores from the Educational Testing Service (the University's Institutional code is 6681)
- For applicants whose native language is not English and who do not hold a degree from a US college or university, a score of 563 or higher on the paper-based (223 on the computer-based or 85 on the Internet based) Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). The University's Institutional code is 6681. All students submitting IELTS scores must earn a minimum score of 7.0, with no subscore lower than 6.0, and must take the on-campus English Proficiency Evaluation prior to registration. For more information about English proficiency testing, please visit the Graduate College webpage: http://www.grad.uiowa.edu/manual-part-1-section-i-admission-to-the-graduate-college

Additionally, applicants must meet all of the admissions requirements outlined in the general Interdisciplinary Graduate Program in Informatics Handbook.

Doctoral (Ph.D.) Program in Bioinformatics

Please check the Manual of Rules and Regulations of the Graduate College for a complete description of the Ph.D. guidelines and requirements of the Graduate College. The requirements described here, specific to the Bioinformatics Ph.D. program, are in addition to the University-wide requirements for doctoral degrees.
The Ph.D. program in the Bioinformatics subprogram inherits all course requirements of the Informatics Ph.D. program, that is, a total of 72 semester hours (42 semester hours of coursework) beyond the bachelor’s degree, consisting of 21 semester hours in core coursework (Bioinformatics, Genetics, Biology, and Informatics), 6 seminar hours in Bioinformatics, and 6 hours in upper-level Bioinformatics coursework. The remaining 6 hours consist of electives selected in consultation with the student’s advisor.

The Ph.D. also requires satisfactory performance on the comprehensive exam, and the production and formal defense of a dissertation that describes original research results.

Students not already holding a University of Iowa M.S. degree may request that one be granted at the comprehensive exam. The M.S. degree is normally awarded upon successful completion of the comprehensive exam, but may also be awarded even if the student does not pass the exam (at the examination committee’s discretion and dependent on the student having met the requirements for the M.S).

Advising
Every Ph.D. student must have a faculty advisor with an appointment in the Bioinformatics program. Upon admission, each student is assigned a temporary academic advisor who can assist in guiding the individual’s curriculum and plan of study. During their first year in the program, it is expected that the student will choose a faculty member whose research interests align with their own to serve as academic and research advisor, and chair of the student’s thesis committee. The advisor / advisee relationship requires the consent of both parties and can be terminated by either upon notice. It is required that a student will complete a Plan of Study form in consultation with his/her advisor every semester, and submit the completed form to the IGPI office for approval. The Plan of Study form can be downloaded from the IGPI website at: http://informatics.grad.uiowa.edu/prospective-students/how-to-apply.

Committee
Examination committees must be composed of a minimum of five faculty members, per graduate college guidelines. IGPI-BCB students’ committees must include their research Advisor and at least 2 program-affiliated faculty from any of the following disciplines: Engineering, Genetics, Biology, Biosciences, and IGPI. At minimum, two committee members must have never coauthored a peer-reviewed journal article with the student.
**Ph.D. Guidelines & Milestones**

**Qualifier**

- Complete by fall of Year 02
- Minimum committee of 5 professors, including the advisor
- Format: Research or project in the form of a paper with a presentation – pass or fail

Students must choose **one** of the following qualifier formats:

**A) An NIH-style proposal** (typically proposed by the student and advisor; may also be assigned by the committee). Students are encouraged to submit the proposal as a pre-doctoral NIH Fellowship (F31). The purpose of this individual pre-doctoral research training fellowship is to provide support for promising doctoral candidates who will be performing dissertation research and training in scientific health-related fields relevant to the missions of the participating NIH Institutes and Centers (ICs) during the tenure of the award. These fellowships allow a student to develop a research idea and provide support for typically 2-3 years. The advisor and/or committee may decide to have on- or off-topic proposals. The committee (which includes the advisor), has final say regarding on- or off-topic proposals by majority vote. The format gives students a year to polish and improve the proposal for submission to the NIH (http://grants.nih.gov/training/F_files_nrsa.htm).

**B) Open-ended research question:**

Students who select this qualifier option will be assigned, by their examining committee, an open-ended problem in the area of the student’s intended thesis research. Ideally, the student will be presented with this problem no later than the end of the spring semester of the first year of study, along with a designated date/time for the examination (typically at the beginning of the fall semester), and the student will be expected to develop a solution during the summer. On the assigned examination date, the student will submit a written response to the assigned problem. The student will be expected to defend this response at an oral examination during the fall semester before the Examining Committee. The actual format of the response will depend on the specific problem assigned and specified by the Committee in the problem description, but is expected to involve the application of bioinformatics techniques towards the solution of a specific problem within the student's research area. Under certain circumstances, these guidelines, with respect to the problem due date and oral examination, might require modification to suit extenuating circumstances of the student or the Committee.
Successful completion of the Ph.D. Qualifying Exam is required before a student is to be considered a Ph.D. graduate student. Students will have two chances to pass the Ph.D. Qualifying Exam. If students receive an evaluation of “unsatisfactory” on their first Qualifying Exam attempt, a different topic will be selected for the open-ended problem. The student will then conduct a small-scale research project and present this to the committee. As an example, the research project could replicate work done in a paper of interest, optionally, with a few extensions. The Qualifying Exam is milestone is designed to ensure that the student starts early in gaining research experience; it also ensures that the student has the potential to conduct doctoral-level research. The student may retake the qualifier once. A second failure will result in termination from the program.

Comprehensive Exam

- Expected in Fall Year 03, allowing flexibility to accommodate scheduling of specific courses
- Format: On-topic thesis proposal
- Committee: Minimum of five professors, two of whom are affiliated IGPI faculty.

*Note: This examination satisfies the University’s comprehensive exam requirement.*

After 2-3 years of working in conjunction with a research advisor on a problem in Bioinformatics, the size and scope of the research project becomes evident to the student, as well as the advisor. To clearly define a problem or hypothesis under examination and describe a clear, logical process to solve that problem or test the hypothesis, the student will develop a written document describing the problem/hypothesis and solution/experiments. This document represents the Ph.D. Comprehensive Exam. The Ph.D. Comprehensive Examination consists of a proposal, formatted in the style of an NIH grant proposal, outlining the student's Ph.D. research. It is expected that the Ph.D. Comprehensive Exam will be completed one year after the Ph.D. Qualifying Exam, but might be completed later, at the discretion of the student's examining committee. The quality of the proposal will be determined through its assessment by the Examining Committee, and a formal oral presentation is required. The final document will consist of a 12-page NIH-style grant application on the thesis, plus a comprehensive literature review (no page limit).

The proposal should include the following:

1. TITLE PAGE

   Student name
   Committee members and their academic departments
   Committee chair (research adviser)
2. RESEARCH PROPOSAL

Provide a detailed description of the research, including:
Specific Aims
Background and Significance
Preliminary Studies (optional, but recommended)
Research Plan (include expected results and their significance, and a discussion of potential pitfalls / workarounds)

3. TIMELINE

Provide a specific schedule for the completion of the proposed studies, with explicit reference to the work proposed in the Research Plan.

4. BIBLIOGRAPHY

A complete list of cited references.

Proposal Defense

The proposal defense is part of the Comprehensive Exam.

Final Oral Defense/ Final Examination (Thesis Defense)

- Format: Written thesis and presentation
- Committee: Minimum of five professors, with at least two affiliated with the IGPI.

Upon satisfactory completion of the Ph.D. thesis, the student will submit a final draft of the dissertation to the members of their Examining Committee. Following an assessment of the dissertation by the student's Examining Committee, the student will defend it orally in an open and public forum. The Examination Committee may then ask additional questions in a meeting between the candidate and the committee. Satisfactory performance in this final examination will result in a recommendation by the Committee to the Graduate College that the student be awarded a Ph.D. in Interdisciplinary Graduate Program in Bioinformatics and Computational Biology.

In addition to the formal examination process, students in the Ph.D. program are evaluated on a yearly basis to ensure that they are making satisfactory academic progress. By September 15th, each student and the student’s advisor are required to submit an evaluation assessment of the student’s progress, outlining past year accomplishments and plans for the current year, including Ph.D. milestones. The Advisory Board reviews these summaries and sends the student a letter summarizing their status in the program. Students who are failing to make satisfactory progress are expected to correct any deficiencies and move to the next milestone within one year. Failure to do so will result in dismissal from the program.
Master of Science (M.S.) Program in Bioinformatics

Please check the Manual of Rules and Regulations of the Graduate College for a complete description of the M.S. guidelines and requirements of the Graduate College. The requirements described here are in addition to the university-wide requirements for master’s degrees.

The M.S. program in the Bioinformatics subprogram offers an M.S. non-thesis option and requires completion of a minimum of 30 course semester hours beyond the bachelor’s degree, consisting of 12 hours of core Bioinformatics coursework, 1 seminar hour in Bioinformatics, 2 hours in Independent Study (Capstone) coursework, and 6 hours in upper-level Bioinformatics coursework. The remaining 6 hours consist of electives selected in consultation with the student’s advisor.

**Advising:** Students will be assigned an academic faculty advisor upon admission to the program.

**Committee:** A 3-member committee will consist of the academic faculty advisor and 2 other program-affiliated members selected by the advisor.

**M.S. – Final Exam Procedures (Non-Thesis)**

The committee will assign 3 papers, 4 weeks before the exam. The student provides a written review of each paper and an oral presentation. Demonstration of comprehension of methods and scientific goals in the papers is required to pass the exam. The exam must be completed no later than 8th week of the semester of graduation. Students, in consultation with their advisor, are eligible to take the final exam after completing 15 semester hours of course work. Students are required to graduate no later than 3 semesters after completing the final exam.

**Graduate Certificate in Informatics – Bioinformatics and Computational Biology**

The Certificate in Informatics with an emphasis in Bioinformatics and Computational Biology is open to graduate students in good standing, and applicants to the non-degree program, who wish to complement their own disciplinary studies with foundational and applied knowledge in informatics. Students must complete a minimum of 18 semester hours (or up to 24 hours, depending on the background of the student).
Students entering this program come from many diverse areas of science with grounding in engineering, the physical sciences, mathematics, or biological/life sciences. Independent of prior degree and specialization, it is essential that students pursuing the Certificate in Informatics with an emphasis in bioinformatics and computational biology have an appropriate background in mathematics and statistics.

The Graduate Certificate in Bioinformatics is built on a flexible curriculum and includes the study of core and elective courses in the biological sciences, informatics, and bioinformatics which augment the coursework in a primary disciplinary Ph.D. Degree Program.

Depending on the disciplinary orientation of the student, courses selected for the certificate should be made in consultation with the appropriate curricular committee.

Plans for the Certificate in Informatics may not completely substitute for coursework or examinations required within the requirements of the disciplinary degree program. A minimum of 9 semester hours of coursework must be completed independently from other degree requirements.

**T-32 Training Grant**

Students applying to a Ph.D. program (or currently enrolled) in a primary discipline, (e.g., Biological Sciences, Computer Science, Biomedical or Electrical Engineering, Molecular and/or Cellular Biology, etc.) or Bioinformatics, are eligible to apply for the T-32 Training Grant. For more information on the T-32: [http://informatics.grad.uiowa.edu/content/nih-t32-training-grant](http://informatics.grad.uiowa.edu/content/nih-t32-training-grant).

Students receiving funding under the T-32 Training Grant are automatically enrolled in the Bioinformatics Certificate Program and do not need to make application to the certificate program at this time.

**Additional Requirements for T-32 Certificate Students Only**

- Co-advisors: Students in the T-32 certificate program need a Bioinformatics advisor and a Biosciences advisor.

- Rotations: Students in the T-32 certificate program are required to perform one dry-lab (Bioinformatics) and one wet-lab (Biosciences) rotation.

- Thesis: Your thesis topic needs to have a significant focus on Bioinformatics.

Requirements may be adjusted based on student experience and training.
Program Prerequisites for the Bioinformatics Programs

Applicants are expected to have 6 hours of undergraduate work in computer science and/or informatics, and 6 hours in biology (covering genetics, molecular biology and evolution). Following are preferred prerequisites to application for the program:

**Prerequisites (undergraduate course semester hours or equivalent in)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory Programming</td>
<td>3</td>
</tr>
<tr>
<td>Intermediate Programming</td>
<td>3</td>
</tr>
<tr>
<td>Basic Biology</td>
<td>6</td>
</tr>
<tr>
<td>Introductory Genetics</td>
<td>3</td>
</tr>
<tr>
<td>Intro to Physics</td>
<td>3</td>
</tr>
<tr>
<td>Calculus</td>
<td>3</td>
</tr>
<tr>
<td>Statistics</td>
<td>3</td>
</tr>
</tbody>
</table>

Students may take all or some of these prerequisite courses to make up for any deficiencies in undergraduate preparation. Work experience may be considered as meeting some of these prerequisite requirements, as determined by the UI Academic Affairs Committee.

After admission, students lacking 6 hours of programming coursework are required to take **6 hours from the following courses**:

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS:3110/022C:104</td>
<td>3</td>
</tr>
<tr>
<td>CS:3210/022C:109</td>
<td>3</td>
</tr>
<tr>
<td>ECE:3330/055:033</td>
<td>3</td>
</tr>
</tbody>
</table>

*Please note: These courses do not count towards the degree program. A grade of B- or better is required.*

After admission, students lacking 6 hours of bioscience coursework are required to take the **following courses**:

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL:1411/002:031</td>
<td>3</td>
</tr>
<tr>
<td>BIOL:5211/002:202</td>
<td>3</td>
</tr>
</tbody>
</table>

*(undergraduate level course; no graduate credit awarded)*
Course Requirements for the Ph.D. and M.S. Programs

Ph.D. students are required to complete 72 semester hours (42 semester hours of coursework); M.S. students are required to have 30 semester hours of coursework.

Please note: Students wishing to pursue an independent study (IGPI:5015, IGPI:6515 or IGPI:6510) with a University of Iowa faculty member may refer to the Independent Study guidelines on the Informatics website.

Core Bioinformatics (9 s.h. for Ph.D., choose 12 s.h. for M.S.)
*CS:3110/22C:104 Introduction to Informatics OR 3
BIOL:4213/002:170 Bioinformatics 3
BME:5320/051:123 Bioinformatics Techniques 3
BIOL:5320/002:174 Computational Genomics 3
*BIOI:5211/002:202 Genes, Genomes & Human Cond Grad Lect(or equiv.) 3

Core Genetics (3 s.h. required for Ph.D.; possible elective for M.S.)
BIOL:5412/002:128 Fundamental Genetics 3

Core Biology (3 s.h. required for Ph.D.; possible elective for M.S.)
BIOL:3713/002:171 Molecular Genetics 3
BIOL:4373/002:160 Molecular Phylogenetics 3

Core Informatics (3 s.h. required for Ph.D. only)
ECE:5330/055:133 Graph Algorithms & Combinatorial Optimization 3

Required (6 s.h. for Ph.D. students; 1 s.h. for M.S. students)
BME:5020/051:192 Seminar in Bioinformatics (minimum 6 s.h.) 1

Required Independent Study (2 s.h. for M.S. Only)
IGPI:5015/200:205 Independent study (capstone project) 2
The capstone project consists of the development of a bioinformatics computer program or analysis development, and replication of paper analysis and results.

Upper-Level Bioinformatics (6 s.h. for Ph.D. and M.S.)
BIOS:5110/171:161 Introduction to Biostatistics 3
*BIOI:5510/171:178 Biostatistical Computing 3
*BIOS:7600/171:290 Advanced Biostatistics Seminar 3
IE:6760/056:275 Statistical Pattern Recognition 3
BIOS: XXXX/XXX:XXX Structural Biophysics (new in 2015) 3
BIOS: 5120/171:162 Design and Analysis of Biomedical Studies 3

Electives (9 s.h. for Ph.D. and M.S.)
Choose from any upper-level Bioinformatics classes (3 s.h. each)
GENE:7191/127:191 Human Molecular Genetics 3
**BIOI:5211/002:202 Genes, Genomes, & Human Cond Grad Lecture 3
BIOS:3314/002:178 Genomics 3
Course Requirements for the Bioinformatics Certificate Program

Certificate students are required to have 18-21 semester hours of coursework, depending on background, comprised of the following courses:

**Core Courses (9 s.h.)**
- CS:3110/022C:104 Intro to Informatics (Informatics core) 3
- BIOL:4213/002:170 Intro to Bioinformatics (Bioinformatics core) 3
- BIOL:5412/002:128 Fundamental Genetics (Biosciences core) 3

**Bioinformatics Courses (6 s.h.)**
- BME:5320/051:123 Bioinformatics Techniques 3
- BME:5330/051:122 Computational Genomics 3

**Bioinformatics Seminar Series (attendance required)**

**Electives (ONE (or TWO) required courses – 3 (or 6) s.h.***

Please note: Advisors may require TWO electives (one informatics elective AND one bioscience elective).

- Informatics Elective (see the following list) 3
- Bioscience Elective (see the following list) 3
Informatics Electives

CS:3210/022C:109 Programming Languages and Tools
CS:4400/022C:144 Database Systems
CS:4340/022C:131 Limits of Computation
CS:4420/022C:145 Artificial Intelligence
CS:4720/022C:174 Optimization Techniques
CS:4700/022C:177 High Performance and Parallel Computing
CS:5800/022C:180 Fundamentals of Software Engineering
CS:5810/022C:181 Formal Methods in Software Engineering
CS:5820/022C:182 Software Engineering Languages and Tools
CS:4980/022C:196 Topics in CS I/II (graduate courses)
CS:5350/022C:231 Design and Analysis of Algorithms
CS:4980/22C:196 Topics in Computer Science II
SLIS:6100/021:124 Database Systems
BIOS:5110/171:161 Introduction to Biostatistics
STAT:3120/22S:120 Probability and Statistics
STAT:3100/22S:130 Intro to Mathematical Statistics I
STAT:3101/22S:131 Intro to Mathematical Statistics II
STAT:3200/22S:152 Applied Linear Regression
STAT:4100/22S:153 Mathematical Statistics I
STAT:4101/22S:154 Mathematical Statistics II
STAT:5200/22S:164 Applied Statistics I
STAT:5400/22S:166 Computing in Statistics
GEOG:3540/044:109 Introduction to Geographic Visualization

Biosciences Electives

BIOL:3172/002:131 Evolution
BIOL:4273/002:162 Population Genetics and Molecular Evolution
GENE:6150/127:150 Genetic Analysis of Biological Systems
GENE:7191/127:191 Human Molecular Genetics
BISC:5201/156:201 Fundamentals of Gene Expression