BIOINFORMATICS

Director: Debra T. Burhans, PhD

Introduction

Bioinformatics is an exciting field that involves the application of techniques from computer science, mathematics, statistics and information technology to problems in biology. Bioinformatics is a truly interdisciplinary science that teaches students both practical and conceptual tools for the understanding of biological information. Bioinformatics is important in all areas of biology, from human genetics to ecology, evolutionary biology, epidemiology and structural biology. Bioinformatics is transforming drug discovery, medical diagnostics and other biotechnology related areas. This major is academically rigorous, requiring challenging course work in biology, chemistry, mathematics and computer science. The major is ideal for students interested in learning about and applying mathematical and computational techniques to problem solving in biology.

A degree in bioinformatics from Canisius College provides you with the experience and background required for graduate study or employment in bioinformatics or computer science. Graduates of the program have pursued advanced degrees in bioinformatics, biology, biostatistics, and computer science as well as going on to medical school. They have also found employment in academic and industrial settings. The foundational courses in the major provide a strong general background in computing, biology, and chemistry. Elective courses in the major allow students to specialize in the area of greatest interest to them, whether it is computer science, mathematics, or biology.

For a more detailed description of the program, faculty, facilities, academic and co-curricular opportunities please go to the Bioinformatics website (https://www.canisius.edu/academics/programs/bioinformatics).

Qualifications

Students must maintain a 2.0 GPA in their major and a 2.0 overall average to graduate with a degree in Bioinformatics. In order to proceed in the computer science course sequence students must earn a C or better in CSC 111/CSC 111L. Similar requirements are found for the introductory biology and chemistry sequences.

Advisement

All students should have an advisor in the major and should contact the department directly to have an advisor assigned if they do not already have one. Meetings with academic advisors are required prior to students receiving their PIN for course registration each semester. All majors should work closely with their advisor in discussing career expectations, choosing their major electives, developing their entire academic program and planning their co-curricular or supplemental academic experiences.

Dual Majors

Students who wish to expand their educational opportunities may decide to declare a dual major. The decision may be based on career goals or planned graduate studies. Before a student declares a dual major, it is important to meet with the appropriate academic departments for advisement. Some dual major combinations can be completed within the minimum 120 credit hour degree requirement, but in some cases additional course work may be required. In order to declare a dual major, the student must complete the appropriate dual major request form and get the signature of each department chairperson and the appropriate associate dean.

Some bioinformatics majors have elected a second major in Computer Science. If all bioinformatics elective courses are taken in computer science, students will need an additional 4 courses in Computer Science for the double major. Careful consultation with the advisor is important if this is of interest.

Minors in other dISCIPLINES

Minors provide students the opportunity to pursue additional interests but generally do not require as many courses as a major. Minors generally range from five to eight required courses. The minors page (http://catalog.canisius.edu/undergraduate/minors) provides a complete list of minors and provides links to each minor. Some majors and minors can be completed within the minimum 120 credit hour degree requirement, but in some cases additional coursework may be required. Students must complete the appropriate minor request form.

Students with a strong background in mathematics are encouraged to consider a math minor. Please consult as soon as possible with your advisor regarding course selections if you are interested in this possibility. Minimally, students will elect MAT 230 instead of MAT 191 and MAT 351 instead of MAT 141. This major is most suitable for students with AP credit for calculus.

Curriculum

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All undergraduate students must complete either the Canisius Core Curriculum (http://catalog.canisius.edu/undergraduate/academics/curricular-information/core-curriculum) or the All-College Honors Curriculum (http://catalog.canisius.edu/undergraduate/academics/curricular-information/all-college-honors-program). Many schools refer to their college-wide undergraduate requirements as "general education" requirements. We believe that the core curriculum and the honors curriculum are more than a series of required classes, they provide the basis for a Jesuit education both with content and with required knowledge and skills attributes that are central to our mission.

Free Electives

Students may graduate with more but not less than 120 credit hours. Free electives are courses in addition to the Core Curriculum or Honors Curriculum and major requirements sufficient to reach the minimum of 120 credit hours required for graduation.

Major Requirements

Code	Title	Credits
Bioinformatics		
BIF 101L	Introduction to Bioinformatics	1
BIF 400	Bioinformatics Senior Seminar	3
Computer Science		
CSC 111 & 111L	Introduction to Programming and Introduction to Programming Laboratory	4
CSC 112 & 112L	Data Structures and Data Structures Laboratory	4
CSC 213 & 213L	Large Scale Programming and Large Scale Programming Laboratory	4
CSC 310 & 310L	Information Organization and Processing and Information Organization and Processing Laboratory	4
Mathematics		
MAT 111	Calculus I	4

MAT 141	Inferential Statistics and Computers for Science	4
MAT 191	Introduction to Discrete Mathematics	4
Biology		
BIO 111 & 111L	Introductory Biology I and Introductory Biology Laboratory I	4
BIO 112 & 112L	Introductory Biology II and Introductory Biology Laboratory II	4
BIO 211 & 211L	Biochemistry and Cell Biology I and Biochemistry and Cell Biology Lab I	4
BIO 212 & 212L	Biochemistry and Cell Biology II and Biochemistry and Cell Biology Lab II	4
Chemistry		
CHM 111 & 111L	General Chemistry I and General Chemistry I Laboratory	4
CHM 112 & 112L	General Chemistry II and General Chemistry II Laboratory	4
CHM 227 & 227L	Organic Chemistry I and Organic Chemistry I Laboratory	4
Total Credits		60

Note: The BIF 400 course is offered once every two years, and students should plan accordingly. The BIF 400 course carries the Advanced Writing-intensive attribute. If all of the other core courses elected by students have no overlap of attributes students will need to elect 11 additional core courses after taking the four foundational courses. With this in mind, it is important to plan schedules carefully to ensure timely completion of the program. Upper-level Computer Science courses are offered once every other year, and students must ensure that they take CSC 310 as soon as it is offered after their sophomore year.

Elective Courses

Students choose 3 elective courses for the major at the 300-400 level from the list below. Note that as new courses are developed this list may be revised to include additional courses, and that additional courses may be approved on a case by case basis by the program director. Note also that some of these courses may have additional prerequisites not included in the required BIF courses.

Code	Title	Credits
Biology		
BIO 404	Genetics	3
BIO 408	Biotechnology, Theory in Practice	4
BIO 419	Cell Biology	3
BIO 432	Developmental Biology	3
BIO 450	Molecular Biology	3
Chemistry		
CHM 301 & 301L	Fundamental Physical Chemistry and Fundamental Physical Chemistry Laboratory	4
CHM 302 & 302L	Modern Physical Chemistry and Modern Physical Chemistry Laboratory	4
Computer Science (all courses with lab)		
CSC 330 & 330L	Distributed Computing and Distributed Computing Laboratory	4
CSC 351 & 351L	Comparative Programming Languages and Comparative Programming Languages Laboratory	4
CSC 360 & 360L	Intelligent Systems and Intelligent Systems Laboratory	4
CSC 380 & 380L	Web Development and Web Development Laboratory	4
CSC 395 & 395L	Software Engineering and Software Engineering Lab	4
Mathematics		
MAT 341	Numerical Analysis	3
MAT 351 & MAT 352	Probability & Statistics I and Probability & Statistics II	6
MAT 354	Experimental Design and Statistical Computing	3

Additional Course Considerations

Students interested in medical or dental school or in advanced study in biology should take the second semester of organic chemistry and a year of physics.

Code	Title	Credits
CHM 228 & 228L	Organic Chemistry II and Organic Chemistry II Laboratory	4
Select one of the following:		4
PHY 201 & PHY 202	College Physics I and College Physics II (does not require calculus)	
PHY 223 & PHY 224	General Physics for Physical Science Majors I and General Physics for Physical Science Majors II (requires Calculus I)	

Additional recommended math courses for majors include

Code	Title	Credits
MAT 112	Calculus II	4
MAT 211	Calculus III	4
MAT 219	Linear Algebra	4
MAT 222	Differential Equations	3

Roadmap

Recommended Semester Schedule for Major Course Requirements

Freshman

Fall	Spring
BIF 101L	CSC 112 & 112L
CSC 111 & 111L	BIO 112 & 112L
BIO 111 & 111L	CHM 112 & 112L
CHM 111 & 111L	

Sophomore

Fall	Spring
CSC 213 & 213L	MAT 111
BIO 211 & 211L	BIO 212 & 212L

CHM 227 & 227L	MAT 191
Junior	
Fall	**Spring**
MAT 141	BIF 400 (or BIF elective)
BIF elective	CSC 310 & 310L
Senior	
Fall	**Spring**
BIF elective	BIF elective (or BIF 400 if not taken in junior year)

Learning Goals & Objectives

Student Learning Goal 1

Majors will effectively develop and implement computational solutions to problems.

Students will:

- Specify and design acceptable computational solutions;
- Implement and test acceptable computational solutions;
- Describe which data structures would be appropriate to use and explain why, given a problem;
- Describe which algorithms would be appropriate to use and explain why, given a problem;
- Design effective data representations for the storage and manipulation of large datasets where needed;
- Utilize and understand statistical methods for the analysis of large datasets where appropriate.

Student Learning Goal 2

Majors will be competent with respect to biology and biotechnology:

Students will:

- Describe information transfer within cells and between generations;
- Understand high-throughput laboratory technologies used in biology to generate large datasets.

Student Learning Goal 3

Majors will analyze legal, social, and ethical considerations related to bioinformatics.

Students will:

- Understand and analyze issues using different ethical frameworks;
- Understand social, legal, and privacy implications of electronic storage and sharing of biological information.

Minor

A minor in Bioinformatics is offered. There are 6 required courses (20 credits) that will also meet the Field 6 and Field 7 (BIO and CSC courses) requirements in the Core Curriculum. The courses are listed below. All of the following courses must include the accompanying laboratory section:

Minor Courses

Code	Title	Credits
BIF 101L	Introduction to Bioinformatics	1
BIO 111 & 111L	Introductory Biology I and Introductory Biology Laboratory I	4
BIO 112 & 112L	Introductory Biology II and Introductory Biology Laboratory II	4
CSC 111 & 111L	Introduction to Programming and Introduction to Programming Laboratory	4
CSC 112 & 112L	Data Structures and Data Structures Laboratory	4
BIF 400	Bioinformatics Senior Seminar	3
Total Credits		20

Courses

BIF 101L Introduction to Bioinformatics **1 Credit**

This 1 credit course provides an introduction to the field of bioinformatics. Web sites, tools, video, discussions, and visiting speakers will help students learn about the major and current opportunities in terms of jobs and research.

Offered: fall.

BIF 400 Bioinformatics Senior Seminar **3 Credits**

This course provides a culminating experience for bioinformatics majors. Students work on several projects where they learn about and use a variety of bioinformatics software as well as building their own tools and pipelines. Students will contribute to a bioinformatics research project about which they will write a scientific article. The writing component introduces skills such as reading primary literature, the development of writing skills appropriate to the field and information literacy techniques.

Restriction: must be junior or senior bioinformatics major.

Fulfills College Core: Advanced Writing-Intensive

Offered: spring of even-numbered years.

BIF 400L Bioinformatics Senior Seminar Lab **1 Credit**

This course provides a culminating experience for bioinformatics majors. Students work on several projects where they learn about and use a variety of bioinformatics software as well as building their own tools and pipelines. Students will contribute to a bioinformatics research project about which they will write a scientific article. The writing component introduces skills such as reading primary literature, the development of writing skills appropriate to the field and information literacy techniques. Instruction is carried out through both lecture and lab components.

Restriction: must be junior or senior bioinformatics major.

Offered: spring of even-numbered years.

BIF 499 Bioinformatics Internship **3-4 Credits**

Students are strongly encouraged to take part in a bioinformatics internship, which typically would take place in a research laboratory or biotechnology firm. Application and faculty advisor approval required. Note that this course cannot count as a bioinformatics elective for the major.