BIOINFORMATICS, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN COMPUTATIONAL SCIENCES

This bioinformatics program consists of a core curriculum that provides immersion in the field of bioinformatics as well as foundational courses in biology, chemistry, computer science and statistics. The bachelor’s program in bioinformatics requires breadth of training via the VCU ConnectED general education requirements, a bioinformatics core with ancillary scientific course work and focused training in the areas of biological/genomic sciences, computational sciences or quantitative/statistical sciences through the concentration-specific courses.

Students wishing to pursue the bioinformatics major must apply for admission into the program. High school seniors as well as students transferring to VCU should follow the regular VCU admissions process and deadlines, being sure to indicate clearly in their application that they wish to apply to the bioinformatics program. Continuing VCU students wishing to apply to the program may contact the bioinformatics academic adviser at (804) 828-0825.

Transfer students and continuing VCU students with at least 15 college credits should present a suggested college GPA of 3.0 including relevant course work in science, math or computer science.

Learning outcomes

Upon completing this program, students will know and know how to do the following:

• Present scientific results, both orally and in writing, in a way that makes clear to an appropriate target audience the distinction between what is known (and how) and what is merely suspected between an observation and a conclusion in a way that tells a compelling story
• Will have demonstrated fundamental knowledge of the basic concepts of biology (particularly molecular biology), the physical sciences, mathematics, statistics and computational science and the ability to apply that knowledge within the context of bioinformatics
• Will have demonstrated an ability to identify and analyze bioinformatics problems and strategies to solve said problems
• Will possess an appropriate level of technical knowledge and ability necessary to address a scientific problem by exploiting biological software and datasets and creating simple bioinformatics tools
• Will have demonstrated an ability to identify and access relevant scientific literature and draw from it in a meaningful and critical manner

Special requirements

A minimum grade of C in the following courses is required for enrollment in all courses for which they are prerequisites and to successfully complete the B.S. in Bioinformatics with a concentration in computational sciences.

Degree requirements for Bioinformatics, Bachelor of Science (B.S.) with a concentration in computational sciences

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 151</td>
<td>Introduction to Biological Sciences I</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 152</td>
<td>Introduction to Biological Sciences II</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 300</td>
<td>Cellular and Molecular Biology</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 101</td>
<td>Introduction to Scientific Computing</td>
<td>1</td>
</tr>
<tr>
<td>BNFO 201</td>
<td>Computing Skills and Concepts for Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 251</td>
<td>Phage Discovery I</td>
<td>2</td>
</tr>
<tr>
<td>BNFO 252</td>
<td>Phage Discovery II</td>
<td>2</td>
</tr>
<tr>
<td>BNFO 301</td>
<td>Introduction to Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 411</td>
<td>Ethical Issues in Life Sciences</td>
<td>2</td>
</tr>
<tr>
<td>BNFO 420</td>
<td>Applications in Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 101</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEZ 101</td>
<td>General Chemistry Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>CMSC 255</td>
<td>Introduction to Programming</td>
<td>4</td>
</tr>
<tr>
<td>CMSC 256</td>
<td>Data Structures and Object Oriented Programming</td>
<td>4</td>
</tr>
<tr>
<td>CMSC 302</td>
<td>Introduction to Discrete Oriented Programming</td>
<td>3</td>
</tr>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I</td>
<td>4</td>
</tr>
</tbody>
</table>

Select 30 credits of general education courses in consultation with an adviser.¹

Major requirements

• Major core requirements
  - BIOL 152 Introduction to Biological Sciences II 3
  - BIOL 300 Cellular and Molecular Biology 3
  - BIOL 310 Genetics 3
  - BNFO 101 Introduction to Scientific Computing 1
  - BNFO 201 Computing Skills and Concepts for Bioinformatics 3
  - BNFO 251 Phage Discovery I 2
  - BNFO 252 Phage Discovery II 2
  - BNFO 301 Introduction to Bioinformatics 3
  - BNFO 411 Ethical Issues in Life Sciences 2
  - BNFO 420 Applications in Bioinformatics 3
  - CHEM 102 General Chemistry II 3
  - CHEZ 102 General Chemistry Laboratory I 1
  - CMSC 255 Introduction to Programming 4
  - STAT 321 Introduction to Statistical Computing 3

• Concentration requirements
  - CMSC 256 Data Structures and Object Oriented Programming 4
  - CMSC 302 Introduction to Discrete Structures 3
  - CMSC 355 Fundamentals of Software Engineering 3
  - CMSC 401 Algorithm Analysis with Advanced Data Structures 3

Select concentration electives from list below. 11

¹ Some courses may satisfy both major and general education requirements.
The ancillary courses fulfill 12 of the required 30 credits of general education, including fulfillment of the quantitative foundations requirement, the natural sciences breadth of knowledge requirement and the maximum allowable nine credits of scientific and logical reasoning area of inquiry.

The minimum number of credit hours required for this degree is 120.

**Course**  | **Title**                              | **Hours** |
---         | ---                                   | ---       |
BIOL 151   | Introduction to Biological Sciences I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning) | 3         |
CHEM 101   | General Chemistry I (satisfies general education AOI for scientific and logical reasoning) | 3         |
CHEZ 101   | General Chemistry Laboratory I (satisfies general education AOI for scientific and logical reasoning) | 1         |
MATH 200   | Calculus with Analytic Geometry I      | 4         |
PHYS 207   | University Physics I (either course satisfies general education AOI for scientific and logical reasoning) | 4-5       |
PHYS 201   | General Physics I                      | 1         |
STAT 212   | Concepts of Statistics (satisfies general education quantitative foundations) | 3         |

**Open electives**
Select any course. 23-24

**Total Hours**  120

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1

May be taken only with adviser's permission

2

No more than 8 combined credits of BNFO 391, BNFO 393, BNFO 491, BNFO 493, BNFO 591, and BNFO 593 may apply toward concentration elective requirements.

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

**Freshman year**

**Fall semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 151</td>
<td>Introduction to Biological Sciences I</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 251</td>
<td>Phage Discovery I</td>
<td>2</td>
</tr>
<tr>
<td>CHEM 101</td>
<td>General Chemistry I (satisfies general education AOI for scientific and logical reasoning)</td>
<td>3</td>
</tr>
<tr>
<td>CHEZ 101</td>
<td>General Chemistry Laboratory I (satisfies general education AOI for scientific and logical reasoning)</td>
<td>1</td>
</tr>
<tr>
<td>UNIV 111</td>
<td>Play course video for Focused Inquiry I</td>
<td>3</td>
</tr>
</tbody>
</table>

**Term Hours:**  15

**Spring semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 152</td>
<td>Introduction to Biological Sciences II</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 251</td>
<td>Phage Discovery II</td>
<td>2</td>
</tr>
<tr>
<td>CHEM 102</td>
<td>General Chemistry II (satisfies general education AOI for scientific and logical reasoning)</td>
<td>3</td>
</tr>
<tr>
<td>UNIV 112</td>
<td>Play course video for Focused Inquiry II</td>
<td>3</td>
</tr>
</tbody>
</table>

**Term Hours:**  15

**Sophomore year**

**Fall semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 300</td>
<td>Cellular and Molecular Biology</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 201</td>
<td>Computing Skills and Concepts for Bioinformatics</td>
<td>3</td>
</tr>
</tbody>
</table>

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1

May be taken only with adviser's permission

2

No more than 8 combined credits of BNFO 391, BNFO 393, BNFO 491, BNFO 493, BNFO 591, and BNFO 593 may apply toward concentration elective requirements.
The minimum number of credit hours required for this degree is 120.

### Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows qualified students to earn both the B.S. and M.S. in Bioinformatics in a minimum of five years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count up to 12 hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 142 credits rather than the 154 credits necessary if the two degrees are pursued separately.

Students holding these degrees will have a head start for pursuing careers in industry or continuing in an academic setting. The M.S. degree provides two tracks: (1) a thesis track with formal research experience and (2) a nonthesis (professional science master's) track combining business skills with an externship experience. This degree can lead to expanded job opportunities, greater potential for job advancement and higher starting salaries.

### Entrance to the accelerated program

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit (no later than two semesters prior to graduating with a baccalaureate degree, that is, before the end of the spring semester of their junior year) an Accelerated Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program include completion of 90 undergraduate credit hours; an overall GPA of 3.0; and a GPA of 3.0 in bioinformatics degree course work. Applicants should have completed a substantial amount of course work toward the B.S. degree and maintained a strong academic record. Students who are interested in the accelerated program should consult with the program director to the M.S. in Bioinformatics program during their junior year after they have completed 75 credits and before they have completed 90 credits toward the B.S. degree. Applicants to this accelerated program must have junior or senior status in VCU's B.S. in Bioinformatics program. Successful applicants would enter the accelerated program in the first semester of their senior year.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the “Satisfactory academic progress” section of the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students admitted to the accelerated program is provided by both the undergraduate bioinformatics adviser and the program director of the bioinformatics graduate program.

### Admission to the graduate program

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degrees. However, entry into an accelerated program via an approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application to the master's program, which is submitted through Graduate Admissions no later than a semester prior to graduation with the baccalaureate degree, that is, before the end of the first semester of the senior year. In order to continue pursuing the master's degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin. Two reference letters (at least one from a bioinformatics faculty member) must accompany the application.

### Degree requirements

The Bachelor of Science in Bioinformatics degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion...
Bioinformatics, Bachelor of Science (B.S.) with a concentration in computational sciences

of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits may substitute for bioinformatics requirements for the undergraduate degree, and are planned in consultation with the undergraduate academic adviser and the graduate program director. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements. For best alignment of these credits, students must plan ahead.

Examples of bioinformatics degree courses that may be taken as an undergraduate, once a student is admitted to the program, are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 543</td>
<td>Graduate Research Methods I</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 540</td>
<td>Fundamentals of Molecular Genetics</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 541</td>
<td>Laboratory in Molecular Genetics</td>
<td>2</td>
</tr>
<tr>
<td>BNFO 592</td>
<td>Independent Study</td>
<td>1-9</td>
</tr>
<tr>
<td>BNFO 620</td>
<td>Bioinformatics Practicum</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 621</td>
<td>Business and Entrepreneurship Essentials for Life Scientists</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 653</td>
<td>Advanced Molecular Genetics: Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 692</td>
<td>Independent Study</td>
<td>1-9</td>
</tr>
<tr>
<td>CMSC 508</td>
<td>Database Theory</td>
<td>3</td>
</tr>
</tbody>
</table>

Recommended course sequence/plan of study

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL 300</td>
<td>Cellular and Molecular Biology</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 411</td>
<td>Ethical Issues in Life Sciences</td>
<td>2</td>
</tr>
<tr>
<td>Required B.S. course work</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Term Hours:</td>
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<td>15</td>
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<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNFO 541</td>
<td>Laboratory in Molecular Genetics</td>
<td>2</td>
</tr>
<tr>
<td>PHYS 207</td>
<td>University Physics I</td>
<td>5</td>
</tr>
<tr>
<td>STAT 321</td>
<td>Introduction to Statistical Computing</td>
<td>3</td>
</tr>
<tr>
<td>Required B.S. course work</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Term Hours:</td>
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<td>15</td>
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<tr>
<td>Senior year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNFO 540</td>
<td>Fundamentals of Molecular Genetics</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 256</td>
<td>Data Structures and Object Oriented Programming</td>
<td>4</td>
</tr>
<tr>
<td>Required B.S. course work</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Term Hours:</td>
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<td>Spring semester</td>
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</tr>
<tr>
<td>Required B.S. course work</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>BNFO 601</td>
<td>Integrated Bioinformatics</td>
<td>4</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fifth year

Fall semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNFO 563</td>
<td>Advanced Molecular Genetics: Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>BNFO 700</td>
<td>Externship in Bioinformatics</td>
<td>2</td>
</tr>
<tr>
<td>Graduate electives (500 and 600 level)</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>15</td>
</tr>
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</table>

Spring semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNFO 653</td>
<td>Advanced Molecular Genetics: Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>OVPR 601</td>
<td>Scientific Integrity</td>
<td>1</td>
</tr>
<tr>
<td>Graduate electives (500 and 600 level)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

For example: 500-level (or higher) BIOL, BIOC, BIOS, BNFO, CMSC, ENVS, HGEN, LFSC, STAT courses

Students interested in the accelerated B.S. and M.S. program can contact the individuals listed below who will explain the program and coordinate the curriculum.

Undergraduate adviser
Lian Currie
lcurrie@vcu.edu
Grace E. Harris Hall, Room 3116a

Graduate program director
Allison Johnson
aajohnson@vcu.edu
Grace E. Harris Hall, Room 3115

- Bioinformatics (BNFO) (p. 4)
- Life sciences (LFSC) (p. 6)

Bioinformatics

BNFO 101. Introduction to Scientific Computing. 1 Hour.

Semester course; 1 lecture hour. 1 credit. Enrollment is restricted to bioinformatics majors. This course will introduce students to basic principles and skills for using a computer to solve scientific problems. It is hands-on course and does not assume any special prior knowledge or skill with computers. Students completing the course will become familiar with and develop skills and practical knowledge of how to use common computer-based command-line tools and systems critical for effective scientific computing.
BNFO 125. Disease and Human Ancestry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course introduces
the role that disease has played in human existence. A key part of this
understanding comes from new DNA sequencing and genomic data
analysis tools that provide information about our ancestry and origin,
as well as about the ancestry and history of disease organisms that
have co-evolved with us. The vast amount of new data has opened
controversial doors to social and ethical implications, such as questions
of race and discrimination, and teach us how to fight emerging disease
at local and global levels. This course will discuss these topics through
case examples of different diseases from parasites (e.g., malaria),
bacteria (e.g., bubonic plague, tuberculosis and syphilis) and viruses (e.g.,
smallpox, influenza and AIDS).

BNFO 191. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for
a maximum total of nine credits, with the provision that no more than
nine combined credits of BNFO 191 and BNFO 193 can apply toward
graduation. An introductory, detailed study of a selected topic in
bioinformatics unavailable as an existing course. If multiple topics are
offered, students may elect to take more than one. Adviser's approval is
required for counting each special topics course toward meeting specific
requirements of the B.S. program.

BNFO 193. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for
a maximum total of nine credits, with the provision that no more than
nine combined credits of BNFO 191 and BNFO 193 can apply toward
graduation. An introductory, detailed study of a selected topic in
bioinformatics unavailable as an existing course. If multiple topics are
offered, students may elect to take more than one. Adviser's approval is
required for counting each special topics course toward meeting specific
requirements of the B.S. program. Graded as pass/fail.

BNFO 201. Computing Skills and Concepts for Bioinformatics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 151
or 200 with a minimum grade of C, or satisfactory score on the VCU
Mathematics Placement Test within the one-year period immediately
preceding the beginning of the course. An introduction to computation
in bioinformatics, including basics of data representation, and computer
organization, as well as programming in Python or other appropriate
scripting language. Bioinformatics applications in the literature will be
discussed. Guest speakers will share bioinformatics career experiences
and opportunities.

BNFO 251. Phase Discovery I. 2 Hours.
Semester course; 4 laboratory hours. 2 credits. Corequisite: BIOL 151 or
152. An exploratory laboratory where students will purify phage from soil,
visualize phage using electron microscopy and isolate genomic material
for nucleic acid sequencing. Registration by override only.

BNFO 252. Phase Discovery II. 2 Hours.
Semester course; 4 laboratory hours. 2 credits. Corequisite: BIOL 151 or
152. An exploratory laboratory where students will learn about
the genomes of viruses infecting bacteria. Students will be given the
genome sequence of a novel virus, which will be the basis for a series of
computer-based analyses to understand the biology of the virus and to
compare it with other viruses that infect the same host. Registration by override only.

BNFO 291. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for
a maximum total of nine credits, with the provision that no more than
nine combined credits of BNFO 291 and BNFO 293 can apply toward
graduation. An introductory, detailed study of a selected topic in
bioinformatics unavailable as an existing course. If multiple topics are
offered, students may elect to take more than one. Adviser's approval is
required for counting each special topics course toward meeting specific
requirements of the B.S. program.

BNFO 292. Independent Study. 1-2 Hours.
Semester course; variable hours. 1-2 credits. May be repeated for a
maximum total of 6 credits. Prerequisite: permission of instructor. A
course designed to provide an opportunity for independent readings of the
bioinformatics literature under supervision of a staff member.

BNFO 293. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for
a maximum total of nine credits, with the provision that no more than
nine combined credits of BNFO 291 and BNFO 293 can apply toward
graduation. An introductory, detailed study of a selected topic in
bioinformatics unavailable as an existing course. If multiple topics are
offered, students may elect to take more than one. Adviser's approval is
required for counting each special topics course toward meeting specific
requirements of the B.S. program. Graded as pass/fail.

BNFO 300. Molecular Biology Through Discovery. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The course aims to
expand students' "ignorance," a prerequisite for success in science, by
confronting them with the interface between the known and the unknown,
stressing the process by which the boundary is traversed. It will do so
using as the raw material the study of molecular biology, an essential
groundwork for bioinformatics.

BNFO 301. Introduction to Bioinformatics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BNFO 201
or permission of instructor. The course will present a practical and
theoretical introduction to the tools and techniques needed to obtain
and interpret a variety of genome-related data types. The course will
include several bioinformatic methods underlying nucleotide and protein
sequence alignment, statistical methods for data visualization in R, the
types of experimental results commonly encountered in bioinformatics
data analysis and the public databases where these data can be
accessed.

BNFO 315. Effective Communication in the Sciences. 3 Hours.
Semester course; 3 lecture hours. 3 credits. How do we tell our science as a story? This course will explore ways to share science with fellow
scientists and the public, including best practices for presenting data,
simplifying complex ideas for presentations and sharing science in an
accurate and ethical way in different media. Students will experience a
hands-on approach to scientific writing and storytelling and hear from
guest speakers from varying backgrounds in scientific communication.
Communicating about science is an important part of being published,
securing funding and building awareness around interests and this
course is a first step to honing those skills.

BNFO 380. Introduction to Mathematical Biology. 4 Hours.
Semester course; 3 lecture and 2 laboratory hours. 4 credits.
Prerequisites: MATH 200 and BIOL 151, both with a minimum grade of
C, or permission of instructor. An introduction to mathematical biology.
Various mathematical modeling tools will be covered and implemented
in a range of biological areas. Additionally, the collaborative research
process will be presented and discussed. Crosslisted as: MATH 380.
BNFO 391. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for a maximum total of nine credits, with the provision that no more than nine combined credits of BNFO 391 and BNFO 393 can apply toward graduation. A detailed study of a selected topic in bioinformatics unavailable as an existing course. If multiple topics are offered, students may elect to take more than one. Adviser's approval is required for counting each special topics course toward meeting specific requirements of the B.S. program.

BNFO 393. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for a maximum total of nine credits, with the provision that no more than nine combined credits of BNFO 391 and BNFO 393 can apply toward graduation. An introductory, detailed study of a selected topic in bioinformatics unavailable as an existing course. If multiple topics are offered, students may elect to take more than one. Adviser's approval is required for counting each special topics course toward meeting specific requirements of the B.S. program. Graded as pass/fail.

BNFO 411. Ethical Issues in Life Sciences. 2 Hours.
Semester course; 2 lecture hours. 2 credits. This course will introduce fundamentals in ethical conduct with a focus on interdisciplinary application to the life sciences, with attention paid to the design, collection, analysis and dissemination of bioinformatic datasets. Graded as pass/fail.

BNFO 420. Applications in Bioinformatics. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisites: CMSC 245 or 255 and BNFO 301. Capstone course. Students will integrate biological, computational and quantitative skills to complete bioinformatics projects in a professional team-problem-solving context. Course includes explicit instruction in the conduct of research as well as a review of applicable strategies, methods and technologies. Written and oral presentation is emphasized, with systematic feedback and practice opportunities provided.

BNFO 440. Computational Methods in Bioinformatics. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisites: CMSC 255 and 256, BNFO 301, or permission of instructor. An introduction to mathematical and computational methods in bioinformatics analysis. Topics include but are not limited to operating systems, interfaces, languages, SQL, search algorithms, string manipulation, gene sequencing, simulation and modeling, and pattern recognition. Students will be exposed to Maple, Matlab, SPSS, E-cell, BioPerl, Epigram and C as part of the requirements of this course.

BNFO 451. Genomic Medicine. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300. Genomic medicine is a clinical approach to diagnose and treat patients based on testing that includes an individual's genomic information. This course will provide an introduction to this emerging field and its potential to improve the diagnosis, prevention and treatment of disease. Topics will include key genomic technologies and the computational approaches used to probe genomic data as applied to real clinical examples. The ethical, legal and societal issues in genomic medicine will be explored. This course is geared toward students with a general biology background.

BNFO 491. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for a maximum total of 12 credits, with the provision that no more than 12 combined credits of BNFO 491 and BNFO 493 can apply toward graduation. A detailed study of a selected topic in bioinformatics unavailable as an existing course. If multiple topics are offered, students may elect to take more than one. Adviser's approval is required for counting each special topics course toward meeting specific requirements of the B.S. program.

BNFO 492. Independent Study. 1-4 Hours.
Semester course; variable hours. A minimum of three hours of supervised activity per week per credit is required. 1-4 credits. May be repeated for a maximum total of 6 credits. Prerequisite: BIOL 218. Projects should include data collection and analysis, learning bioinformatics-related research techniques, and mastering experimental procedures, all under the direct supervision of a faculty member. A final report must be submitted at the completion of the project. Graded as pass/fail.

BNFO 493. Special Topics in Bioinformatics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for a maximum total of 12 credits, with the provision that no more than 12 combined credits of BNFO 491 and BNFO 493 can apply toward graduation. A detailed study of a selected topic in bioinformatics unavailable as an existing course. If multiple topics are offered, students may elect to take more than one. Adviser's approval is required for counting each special topics course toward meeting specific requirements of the B.S. program. Graded as pass/fail.

BNFO 496. Undergraduate Teaching Assistantship in Bioinformatics. 1-2 Hours.
Semester course; 1-2 field experience hours. 1-2 credits. May be repeated for a maximum total of two credits. Enrollment requires permission of instructor and a minimum grade of B in the course the student will TA. Student will work with course instructor to implement course objectives. Typical duties involve media preparation, answering questions, providing feedback on course assignments and peer mentoring. Provides exposure to the practice, possibilities, rewards and responsibilities of the act of teaching. Graded as pass/fail.

BNFO 497. Research and Thesis. 1-4 Hours.
Semester course; variable hours. A minimum of three hours of supervised activity per week per credit is required. 1-4 credits. May be repeated for a maximum total of 6 credits. Prerequisite: BIOL 218. Junior or senior status. Projects should include data collection and analysis, learning bioinformatics-related research techniques, and mastering experimental procedures, all under the direct supervision of a faculty member. A written thesis of substantial quality is required at the completion of the research. Graded as pass/fail.

Life Sciences

LFSC 101. Academic and Career Options in Life Sciences. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Students interested in the life sciences at VCU are faced with an enormous variety of academic options from bioinformatics and biomedical engineering to exercise science and nursing. Students outside of these programs have post-graduate opportunities in the life sciences, such as health care administration and government policy. This course will introduce students to an overview of all of the academic programs in life sciences available at VCU and their associated potential career options. Graded as pass/fail.
**LFSC 191. Special Topics in Integrative Life Sciences. 1-4 Hours.**
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for credit with different topics. A 100-level study of a selected topic in integrative life sciences. Students will find specific topics and prerequisites for each special topics course listed in the Schedule of Classes. If multiple topics are offered, students may elect to take more than one.

**LFSC 301. Integrative Life Sciences Research. 3 Hours.**
Semester course; 2 lecture and 1 recitation hours. 3 credits. Pre- or corequisite: UNIV 200 or HONR 200. Students will leave this course knowing enough about science and the process of science to feel confident in critically evaluating scientific information and/or embarking on their own process of discovery with a faculty mentor. They will gain an appreciation of the interdisciplinary and complex nature of life sciences and will hone their critical thinking about how science interacts with and informs society.

**LFSC 307. Community Solutions: Multiple Perspectives. 3 Hours.**
Semester course; 3 lecture hours. 3 credits. Prerequisite: PSYC 101. Explores possibilities for addressing social concerns of the Richmond community by understanding the complex nature of social issues as essential to their successful amelioration via perspectives of life and social sciences. Toward this end, expertise from the social sciences, the life sciences and the community are integrated. Includes a service-learning experience (a 20-hour volunteer requirement). Crosslisted as: PSYC 307.

**LFSC 391. Special Topics in Integrative Life Sciences. 1-4 Hours.**
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for credit with different topics. A 300-level study of a selected topic in integrative life sciences. Students will find specific topics and prerequisites for each special topics course listed in the Schedule of Classes. If multiple topics are offered, students may elect to take more than one.

**LFSC 401. Faith and Life Sciences. 3 Hours.**
Semester course; 3 lecture hours. 3 credits. Prerequisite: UNIV 200 or HONR 200. Open to students of any school or program. Explores the complex relationships between faith traditions and the life sciences. Topics include epistemology, impact of life sciences on ideas of fate and responsibility, limits of science and technology, and scientific and religious perspectives on human origins, consciousness, aggression, forgiveness, health, illness and death. Crosslisted as: RELS 401.

**LFSC 491. Special Topics in Integrative Life Sciences. 1-4 Hours.**
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated for credit with different topics. A 400-level study of a selected topic in integrative life sciences. Students will find specific topics and prerequisites for each special topics course listed in the Schedule of Classes. If multiple topics are offered, students may elect to take more than one.