Science, Bachelor of Science (B.S.) with a concentration in biology

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

• Demonstrate broad and core science proficiency
• Demonstrate competency in at least two sciences or in a non-science area
• Apply learning to selection and pursuit of professional or graduate career objective
• Demonstrate proficiency in communication of scientific or research findings
• Demonstrate ability to apply the scientific method/approach to professional problems
• Demonstrate appreciation of the interrelation of core sciences to interdisciplinary problems

Special requirements
The Bachelor of Science in Science requires a minimum of 120 credits.

Along with the general education requirements of the undergraduate programs and the College of Humanities and Sciences for a Bachelor of Science degree, this curriculum requires 28 to 33 credits in foundation science and mathematics courses and 36 to 38 credits in supplemental courses in the concentration. In preparation for the required mathematical sciences courses, all students must take the Mathematics Placement Test. Science majors are strongly encouraged to select a minor in an area different from their area of concentration that will complement their career interests and contribute additional upper-level credits to their curriculum.

Science majors declaring the biology concentration may not simultaneously declare a major or minor in biology.

Grade requirements
A minimum grade of C is required in each prerequisite course:

Course | Title | Hours
---|---|---
CHEM 100 | Introductory Chemistry (if required through placement test) | 3
CHEM 101 | General Chemistry I | 3
CHEM 102 | General Chemistry II | 3
CHEM 301 | Organic Chemistry | 3
CHEM 302 | Organic Chemistry | 3

A minimum grade of C is required in the following courses before enrollment in advanced BIOL courses:

Course | Title | Hours
---|---|---
BIOL 152 & BIOZ 152 | Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II | 4
BIOL 300 | Cellular and Molecular Biology | 3

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

Course | Title | Hours
---|---|---
BIOL 152 & BIOZ 152 | Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II | 4
BIOL 300 | Cellular and Molecular Biology | 3

Ancillary requirements

Course | Title | Hours
---|---|---
BIOL 151 | Introduction to Biological Sciences I | 3
BIOL 151 | Introduction to Biological Science Laboratory I | 1
CHEM 101 & CHEZ 101 General Chemistry I and General Chemistry Laboratory I (both satisfy general education BOK for natural sciences and AOI for scientific and logical reasoning) 4

HUMS 202 Choices in a Consumer Society 1

MATH 151 Precalculus Mathematics (or placement; satisfies general education quantitative foundations) 4

PHYS 201 General Physics I (either satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning) 4-5 or PHYS 207 University Physics I

These courses include laboratory hours and may be used to satisfy laboratory requirements.

### Natural science electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFSC 301</td>
<td>Integrative Life Sciences Research</td>
<td>3</td>
</tr>
<tr>
<td>LFSC 401</td>
<td>Faith and Life Sciences</td>
<td>3</td>
</tr>
<tr>
<td>PHTX 400</td>
<td>Drugs and Their Actions</td>
<td>3</td>
</tr>
</tbody>
</table>

Any 200-level or higher BIOL, BNFO, CHEM, CLSE, EGRB, ENVS, FRSC, INSC or PHYS course, except:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 392</td>
<td>Introduction to Research</td>
</tr>
<tr>
<td>BIOL 475</td>
<td>Biology Capstone Seminar: ____</td>
</tr>
<tr>
<td>BIOL 477</td>
<td>Biology Capstone Experience</td>
</tr>
<tr>
<td>BIOL 489</td>
<td>Communicating Research</td>
</tr>
<tr>
<td>BIOL 490</td>
<td>Presenting Research</td>
</tr>
<tr>
<td>BIOL 492</td>
<td>Independent Study</td>
</tr>
<tr>
<td>BIOL 493</td>
<td>Biology Internship</td>
</tr>
<tr>
<td>BIOL 495</td>
<td>Research and Thesis</td>
</tr>
<tr>
<td>BIOL 496</td>
<td>Biology Preceptorship: ____</td>
</tr>
<tr>
<td>BNFO 292</td>
<td>Independent Study</td>
</tr>
<tr>
<td>BNFO 492</td>
<td>Independent Study</td>
</tr>
<tr>
<td>BNFO 496</td>
<td>Undergraduate Teaching Assistantship in Bioinformatics</td>
</tr>
<tr>
<td>CHEM 392</td>
<td>Directed Study</td>
</tr>
<tr>
<td>CHEM 492</td>
<td>Independent Study</td>
</tr>
<tr>
<td>CHEM 493</td>
<td>Chemistry Internship</td>
</tr>
<tr>
<td>ENGR 490</td>
<td>Engineering Seminar</td>
</tr>
<tr>
<td>ENGR 492</td>
<td>Independent Study in Engineering</td>
</tr>
<tr>
<td>ENVS 490</td>
<td>Research Seminar in Environmental Studies</td>
</tr>
<tr>
<td>ENVS 492</td>
<td>Independent Study</td>
</tr>
<tr>
<td>ENVS 493</td>
<td>Environmental Studies Internship</td>
</tr>
<tr>
<td>FRSC 490</td>
<td>Professional Practices in Forensic Science</td>
</tr>
<tr>
<td>FRSC 492</td>
<td>Forensic Science Independent Study</td>
</tr>
<tr>
<td>FRSC 493</td>
<td>Forensic Science Internship</td>
</tr>
<tr>
<td>INSC 490</td>
<td>Capstone Research Experience in Interdisciplinary Science</td>
</tr>
<tr>
<td>PHYS 490</td>
<td>Seminar in Conceptual Physics</td>
</tr>
<tr>
<td>PHYS 492</td>
<td>Independent Study</td>
</tr>
</tbody>
</table>

### Natural science laboratory electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 205</td>
<td>Basic Human Anatomy</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 309</td>
<td>Entomology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 320</td>
<td>Biology of the Seed Plant</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 402</td>
<td>Comparative Vertebrate Anatomy</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 417</td>
<td>Mammalogy</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 435</td>
<td>Herpetology</td>
<td>1</td>
</tr>
</tbody>
</table>

### Animal and plant courses

#### Animal group

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 309</td>
<td>Entomology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 312</td>
<td>Invertebrate Zoology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 312</td>
<td>Invertebrate Zoology Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>BIOL 313</td>
<td>Vertebrate Natural History</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 313</td>
<td>Vertebrate Natural History Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>BIOL 391</td>
<td>Topics in Biology (as approved)</td>
<td>1-4</td>
</tr>
<tr>
<td>BIOL 391</td>
<td>Topics in Biology Laboratory (as approved)</td>
<td>1-4</td>
</tr>
<tr>
<td>BIOL 402</td>
<td>Comparative Vertebrate Anatomy</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 416</td>
<td>Ornithology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 416</td>
<td>Ornithology Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 417</td>
<td>Mammalogy</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 435</td>
<td>Herpetology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 445</td>
<td>Neurobiology and Behavior</td>
<td>1</td>
</tr>
<tr>
<td>BIOL 503</td>
<td>Fish Biology</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Plant group

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 320</td>
<td>Biology of the Seed Plant</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 320</td>
<td>Plant Development</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 321</td>
<td>Plant Development Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 322</td>
<td>Plants, People and Culture</td>
<td>3</td>
</tr>
</tbody>
</table>
Science, Bachelor of Science (B.S.) with a concentration in biology

BIOL 445  Neurobiology and Behavior 1  4
BIOL 503  Fish Biology 1  4
BIOZ: any 200-level or higher course
BNFO 380  Introduction to Mathematical Biology 1  4
BNFO 420  Applications in Bioinformatics 1  3
BNFO 440  Computational Methods in Bioinformatics 1  3

CHEZ: any 200-level or higher course
EGRB 307  Biomedical Instrumentation 1  4
EGRB 308  Biomedical Signal Processing 1  4
EGRB 310  Biomechanics 1  4
ENVZ 335  Environmental Geology Laboratory 1

BNFO 380  Introduction to Mathematical Biology 1  4
BNFO 420  Applications in Bioinformatics 1  3
BNFO 440  Computational Methods in Bioinformatics 1  3

Courses have a combined lecture and lab and will satisfy both natural science lecture and laboratory requirements.

Health science electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFAM/ANTH/INTL/ GSWS 309</td>
<td>Gender and Global Health</td>
<td>3</td>
</tr>
<tr>
<td>AFAM 310</td>
<td>Black Health Matters: Social Determinants of Health in the African American Community</td>
<td>3</td>
</tr>
<tr>
<td>GSWS 392</td>
<td>Gender and Health Across the Life Span</td>
<td>3</td>
</tr>
<tr>
<td>HPEX 325</td>
<td>Pathology and Pharmacology in Athletic Training</td>
<td>3</td>
</tr>
<tr>
<td>HPEX 345</td>
<td>Nutrition for Health and Disease</td>
<td>3</td>
</tr>
<tr>
<td>HPEX 350</td>
<td>Nutrition</td>
<td>3</td>
</tr>
<tr>
<td>HPEX 353</td>
<td>Disease Trends, Prevention and Control</td>
<td>3</td>
</tr>
<tr>
<td>HPEX 373</td>
<td>Structural Kinesiology</td>
<td>3</td>
</tr>
<tr>
<td>HPEX 374</td>
<td>Musculoskeletal Structure and Movement</td>
<td>4</td>
</tr>
<tr>
<td>HPEX 375</td>
<td>Physiology of Exercise</td>
<td>3</td>
</tr>
<tr>
<td>HPEX 440</td>
<td>Chronic Disease and Exercise Management</td>
<td>3</td>
</tr>
<tr>
<td>PSYC 401</td>
<td>Physiological Psychology</td>
<td>3</td>
</tr>
<tr>
<td>PSYC 412</td>
<td>Health Psychology</td>
<td>3</td>
</tr>
<tr>
<td>PSYC/GSWS 414</td>
<td>Psychology of Women’s Health</td>
<td>3</td>
</tr>
<tr>
<td>SCTS 300</td>
<td>Introduction to Science and Technology Studies</td>
<td>3</td>
</tr>
<tr>
<td>SCTS 301</td>
<td>Illness Narratives</td>
<td>3</td>
</tr>
<tr>
<td>SCTS 392</td>
<td>Revolutions in Science I</td>
<td>3</td>
</tr>
<tr>
<td>SCTS 393</td>
<td>Revolutions in Science II</td>
<td>3</td>
</tr>
<tr>
<td>SCTS 397</td>
<td>Genetics and Society: 1865 to the Present</td>
<td>3</td>
</tr>
</tbody>
</table>

SCTS 398  History of Medicine and Public Health: 3
SOCY 344  Medical Sociology 3

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

MATH 151  Precalculus Mathematics (or placement) (satisfies general education quantitative foundations) 4
STAT 208 or STAT 210  Statistical Thinking or Basic Practice of Statistics 3
UNIV 101  Introduction to the University 1
UNIV 111  Play course video for Focused Inquiry I 3
General education course (select racial literacy foundations) 3

Term Hours: 14

Spring semester

CHEM 101  General Chemistry I and General Chemistry Laboratory I (both satisfy general education BOK for natural sciences and AOI for scientific and logical reasoning) 4
HUMS 202  Choices in a Consumer Society 1
MATH 200 or SCMA 212 or STAT 314  Calculus with Analytic Geometry I or Differential Calculus and Optimization for Business or Applications of Statistics 3-4
UNIV 112  Play course video for Focused Inquiry II 3
General education course (select BOK to satisfy breadth of knowledge requirement and AOI for diversities in the human experience) 3

Term Hours: 14-15

Sophomore year

Fall semester

BIO 151  Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I 4
CHEM 102  General Chemistry II and General Chemistry Laboratory II 4
PHYS 201 or PHYS 207  General Physics I (satisfies general education AOI for scientific and logical reasoning) or University Physics I 4-5

Term Hours: 14-15
The minimum number of credit hours required for this degree is 120.

### BIOL 101. Biological Concepts. 3 Hours.
Semester course; 3 lecture hours (delivered online, face-to-face or hybrid). 3 credits. A topical approach to basic biological principles. Topics include molecular aspects of cells, bioenergetics, photosynthesis, cellular respiration, cellular and organismal reproduction, genetics and evolution, and ecology. Not applicable for credit toward the major in biology.

### BIOL 103. Global Environmental Biology. 3 Hours.
Semester course; 3 lecture hours (delivered online). 3 credits. This course engages students in understanding biological systems through aspects of global change in the Earth's environment. Global change is explored through the perspective of a biologist in association with social and economic concepts. Topics include climate change, population biology, ecosystems, urbanization, renewable and nonrenewable energy, air and water resources and sustainability goals. Assessments and applied activities reinforce major course concepts. Not applicable as a prerequisite for any biology course at the 200 level or higher nor for credit toward the B.S. in Biology.

### BIOL 151. Introduction to Biological Sciences I. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 139, MATH 141, MATH 151, MATH 200, MATH 201 or a satisfactory score on the math placement exam; and CHEM 100 with a minimum grade of B, CHEM 101 with a minimum grade of C or a satisfactory score on the chemistry placement exam. Introduction to core biological concepts including cell structure, cellular metabolism, cell division, DNA replication, gene expression and genetics. Designed for biology majors.

### BIOL 152. Introduction to Biological Sciences II. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and CHEM 101, both with a minimum grade of C. Focuses on evolutionary principles, the role of natural selection in the evolution of life forms, taxonomy and phylogenies, biological diversity in the context of form and function of organisms, and the basic principles of ecology. Designed for biology majors.

### BIOL 200. Quantitative Biology. 3 Hours.
Semester course; 3 lecture hours (delivered online or hybrid). 3 credits. Prerequisites: BIOL 151 and BIOZ 151 with minimum grades of C, and MATH 151, MATH 200, MATH 201, STAT 210 or satisfactory score on the VCU Mathematics Placement Test within a one-year period immediately preceding the beginning of the course. Enrollment is restricted to biology majors and biology minors. An introduction to the application of the scientific method, experimental design and quantitative aspects of biology.

### BIOL 201. Human Biology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 101, 151, or 152, or BIOL/ENVS 103. Fundamentals of human biology, including the structure, function and disorders of human body systems, principles of human genetics and inheritance, human evolution, and the interaction of humans with the environment. Not applicable for credit toward the B.S. in Biology.
BIOL 205. Basic Human Anatomy. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours (plus online component). 4 credits. Prerequisites: BIOL 101 and BIOZ 101, BIOL 151 and BIOZ 151, or BIOL 152 and BIOZ 152, each with a minimum grade of C. Enrollment is restricted to students majoring in communication arts, health and physical education, health, physical education and exercise science; pre-health majors in medical laboratory sciences, clinical radiation sciences, dental hygiene and nursing; students enrolled in the health sciences certificate program; and students in the advising tracks for pre-occupational therapy, pre-physician assistant, pre-pharmacy and pre-physical therapy. Additionally, students in the pre-dentistry or pre-optometry advising tracks or those pursuing application to the accelerated nursing program must speak with a pre-professional health adviser prior to enrolling in the class. Human specimens, models and interactive software are used to study human body structures; emphasis is on the skeleto-muscular aspects. Not applicable for credit toward the B.S. in Biology.

BIOL 209. Medical Microbiology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 101 and BIOZ 101, BIOL 151 and BIOZ 151, or BIOL 152 and BIOZ 152, each with a minimum grade of C. General principles of microbiology and immunology to provide a thorough understanding of the host-microbe relationship in disease. Not applicable for credit toward the B.S. in Biology.

BIOL 217. Principles of Nutrition. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 101, 151 or 152 with a minimum grade of C, or BIOL/ENV 103 with a minimum grade of C. An introduction to basic principles of nutrition and their application in promoting growth and maintaining health throughout the life cycle. Not applicable for credit toward the B.S. in Biology.

BIOL 284. Laboratory Assistant Experience. 0 Hours.
Semester course; 0 hours. 0 credits. Enrollment is restricted to students with permission of the departmental chair and limited to students for whom a laboratory supervisor has agreed to mentor their laboratory assistants. Helps facilitate student involvement in research laboratories within the Department of Biology. Students will assist with components of the laboratory's operation and gain experience working in a laboratory setting. Students will gain hands-on experience in performing tasks related to specific research areas based on the laboratory in which they are accepted to work. Graded as pass/fail.

BIOL 291. Topics in Biology. 1-4 Hours.
Semester course; variable hours. Variable credit. Prerequisites: BIOL 151, 152 and BIOZ 151, 152, with minimum grades of C. A study of a selected topic in biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

BIOL 300. Cellular and Molecular Biology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOZ 151 or LFSC/BNFO 251; BIOZ 152 or LFSC/BNFO 252; CHEM 101 and CHEZ 101, all with a minimum grade of C; BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. Pre- or corequisites: CHEM 102 and CHEZ 102. A study of the molecular biology of the cell as it relates to gene expression, cell signaling, and cell growth and differentiation.

BIOL 303. Microbiology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. The morphological, biochemical, taxonomic, genetic and evolutionary characteristics of microorganisms with a primary focus on bacteria. Focuses on the structural, mechanical and biochemical adaptations employed by microorganisms in their interactions with host cells and substrates.

BIOL 304. Biology Skills. 3 Hours.
Semester course; 1 lecture hour (delivered online), 1 recitation hour and 3 laboratory hours. 3 credits. Prerequisites: BIOL 151 and BIOZ 151. Enrollment requires permission of the instructor. This course provides hands-on experience in laboratory-based research using current biological and/or biomedical research topics to aid in development of critical thinking and problem-solving.

BIOL 307. Aquatic Ecology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 317, CHEM 102 and CHEZ 102, with minimum grades of C. The physical, chemical and especially the biological aspects of freshwater ecosystems.

BIOL 308. Vertebrate Histology. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 300 with a minimum grade of C. Microanatomy of vertebrate cells, tissues and organs and the relationship of structure to function. Laboratory work involves an in-depth study of vertebrate microanatomy at the light microscope level as well as an introduction to techniques used for the preparation of materials for histological study.

BIOL 309. Entomology. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152, all with minimum grades of C. A field-based course that focuses on insect diversification, identification, natural history and basic biology.

BIOL 310. Genetics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOZ 151 or LFSC/BNFO 251; BIOZ 152 or LFSC/BNFO 252; BIOZ 300; CHEM 101; and CHEZ 101, each with a minimum grade of C; and BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. Pre- or corequisites: CHEM 102 and CHEZ 102. The basic principles of molecular and applied genetics of plants, animals and microorganisms.

BIOL 312. Invertebrate Zoology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152, all with minimum grades of C. An integrative survey of the invertebrate animals with emphasis on systematics and natural history.

BIOL 313. Vertebrate Natural History. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, 152 and BIOZ 151, 152, with minimum grades of C. The natural history of vertebrates with emphasis on the species native to Virginia.

BIOL 314. Animal Reproduction. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL and BIOZ 151, BIOZ and BIOZ 152, and BIOZ 300, each with a minimum grade of C. Introduction to basic reproductive anatomy and physiology. Examination of the basic factors that affect reproductive performance and how these factors are used to regulate the reproductive processes of domestic animals and humans.

BIOL 317. Ecology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOZ 151 or LFSC/BNFO 251; BIOZ 152 or LFSC/BNFO 252; CHEM 101 and CHEZ 101, all with a minimum grade of C; BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. An introduction to the basic principles of ecology, including interactions among organisms and influences of the physical environment.
BIOL 318. Evolution. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOL 151 or LFSC/BNFO 251; BIOL 152 or LFSC/BNFO 252; CHEM 101 and CHEZ 101, all with a minimum grade of C; BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. An exploration of the theoretical and empirical foundations of evolutionary biology with a focus on the processes driving evolutionary change across all of life.

BIOL 320. Biology of the Seed Plant. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: BIOL 151 and BIOL 152; and BIOL 152 and BIOL 152, all with minimum grades of C. The physiology, structure and adaptation of seed plants.

BIOL 321. Plant Development. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. This course will discuss the mechanisms underlying plant development. Lectures and readings will explain the patterns in plant development from a morphological and molecular standpoint.

BIOL 322. Plants, People and Culture. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOL 151, BIOL 152 and BIOL 152, or equivalents, with minimum grades of C. Plant-human interactions are deeply intertwined and have significant impact on our societies, environment and future. Plants are harnessed to provide us with clothing, food, housing, medicine, recreation, jobs, clean air, clean water, etc. This course provides basic understanding of plant morphology, anatomy and growth by examining the biology, ecology, history and current events of economically useful plants. Students read primary literature, communicate scientific findings and synthesize information from multiple sources verbally and in written format.

BIOL 324. Medicinal Botany. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and BIOL 151; BIOL 152 and BIOL 152; and BIOL 300, all with a minimum grade of C. Topics include plant anatomy, morphology and reproduction; traditional plant medicine such as Ayurveda and traditional Chinese medicine; plant defense systems and secondary metabolites; and plant-derived drugs for various illnesses/aillments including cancer, arthritis, depression and diabetes.

BIOL 325. Fungal Biology. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. The basic biology of fungi, including growth, structure, genetics, diversity, the commercial uses of fungi and their importance as model organisms. Also discusses the interactions between fungi and plants and fungi and humans.

BIOL 330. Community Science: ____. 3 Hours.
Semester course; 1 lecture hour (delivered online) and 4 laboratory hours. 3 credits. May be repeated with a different topic for a maximum of six credits. Prerequisites: BIOL 152, BIOL 152 and BIOL 200, each with a minimum grade of C. A comprehensive study of select topics that is integrated with community science. Students will contribute to local, national and/or global community science projects while gaining experience in data collection, data analysis and topic-specific protocols.

BIOL 332. Environmental Pollution. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: eight credits in biology. The study of pollution in the environment with emphasis on the procedures for detection and abatement. Crosslisted as: ENVS 330.
BIOL 395. Directed Study. 1-2 Hours.
Semester course; 1-2 independent study hours. 1-2 credits. Prerequisites: BIOZ 151 and BIOZ 152 with minimum grades of C, permission of the Department of Biology and research mentor. A maximum of two credits may be earned between BIOL 395 and BIOZ 395; maximum total of six credits for all research and internship courses (BIOL 395, BIOI 451, BIOZ 453, BIOZ 492, BIOZ 493, BIOZ 495 and/or BIOZ 395) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. Mentors are not limited to faculty members within the Department of Biology, but the context of the research study must be applicable to the biological sciences as determined by the department. Studies should include directed readings, directed experimentation or advanced guided inquiry – all under the direct supervision of a faculty member. A minimum of three hours of supervised activity per week per credit hour is required. This course may not apply as a laboratory experience. Graded as pass/fail.

BIOL 401. Applied and Environmental Microbiology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 300, each with a minimum grade of C. Introduction to the diversity of microorganisms in natural environments and the ways they can be manipulated and controlled for human advantage. Students gain foundational knowledge of microbial energetics, growth and community dynamics, which is then applied to understanding microbial roles in biogeochemical cycling, climate change, agriculture, public health, wastewater treatment and landfills. The course also covers applied topics such as biotechnology, pollution control and food production.

BIOL 402. Comparative Vertebrate Anatomy. 5 Hours.
Semester course; 3 lecture and 4 laboratory hours. 5 credits. Prerequisites: BIOL 300 and BIOL 318, each with a minimum grade of C. The evolution of vertebrate forms as demonstrated by anatomical studies of selected vertebrate types.

BIOL 403. Primatology. 4 Hours.
Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisite: ANTH 210 or ANTH 301/BIOL 341. Primatology investigates the taxonomic relationships among primates through comparative anatomy, comparative behavior and comparative biochemistry. Study of primate evolution, demography, subsistence, reproduction, social organization, communication systems and ecology. Crosslisted as: ANTH 403.

BIOL 411. Physiology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and CHEM 301, each with a minimum grade of C. Focuses on the characterization and understanding of the function and mechanisms of major physiological systems, primarily using human physiology as a model. Emphasis is placed on understanding how different physiological systems work together to maintain homeostasis and predicting the consequences of damaging or deleting system components that can occur in diseases and injuries.

BIOL 413. Parasitology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. The epidemiology and pathological effects of eukaryotic parasites, including parasite life cycles and host-parasite relationships.

BIOL 415. Mangoave Avian Field Ecology. 4 Hours.
Semester course; two weeks abroad in Panama (or other tropical location with mangrove forests) followed by class meetings two days per week throughout most of spring semester. 4 credits. Prerequisite: BIOL 317. An immersive study of tropical ecology with a focus on bird ecology and conservation of mangrove ecosystems through a unique blend of rigorous science and community engagement. Two weeks of study abroad, including engagement with local conservation organizations and participation in education outreach with local schools, followed by discussion, data analysis and presentation of progress and research in a public symposium on campus.

BIOL 416. Ornithology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 with a minimum grade of C. Provides an integrative study of birds, including avian evolution and diversity, general anatomy and physiology, behavior, and ecology.

BIOL 417. Mammalogy. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: BIOL 218 and 317 with minimum grades of C. Study of the characteristics, adaptive radiation and distribution of mammals, with emphasis on North American forms.

BIOL 420. Yeast and Fermentation. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. Pre- or corequisites: BIOL 303 and BIOL 310. Addresses the basic biology of yeast used in brewing beer and briefly in wine production. Topics will include yeast properties such as growth, structure, genetics, biodiversity and natural habitats. The process of wine and beer production will be discussed. Laboratory sessions include basic microbiology techniques, yeast isolations and characterization using DNA and biochemical methods, as well as the study of factors that affect fermentation. At the end of the course the students will give a presentation on other fermentation products of their interest such as vinegar, bread, etc., providing an expanded version of this important process.

BIOL 422. Forest Ecology. 4 Hours.
Semester course; 3 lecture hours and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317 with a minimum grade of C. Covers the fundamentals of forest ecology, with a particular emphasis on Virginia’s diverse forest ecosystems. Students gain an understanding of the principal controls on forest structure, growth and distribution and relate these principles to sustainable forest management.

BIOL 423. Plant Physiology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOZ 152 and BIOZ 152; and BIOZ 300 or equivalents, all with minimum grades of C. Physiology of higher plants at molecular, cellular and organism level. Topics include transport processes, metabolism, growth, stress responses and plant-soil interactions.

BIOL 425. Field Botany. 3 Hours.
Semester course; 1 lecture hours and 4 laboratory hours (40 percent online, 60 percent field/laboratory). 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 200; and BIOL 300, BIOL 310, BIOL 317 or BIOL 318. Online discussions, reflections and assessments in conjunction with field experience. Explores the effects of environmental conditions on plant morphology and adaptations, with emphasis on plant anatomy, plant physiology and plant diversity.
BIOL 430. Invasion Biology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOL 152, BIOZ 151, BIOZ 152 and BIOL 317, all with minimum grade of C. A comprehensive view of the ecology and impacts of invasive species. Integrates the effects of historical human demography, ecological disturbance, natural history, species interactions, barriers to invasion, invasive species management and impacts on natural communities and ecosystems.

BIOL 431. Introduction to Marine Biology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 317, CHEM 102 and CHEZ 102, with minimum grades of C. An introduction to physical, chemical and geological oceanography and a more detailed treatment of the organisms and ecological processes involved in the pelagic and benthic environments of the world's oceans and estuaries.

BIOL 435. Herpetology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 with a minimum grade of C. The evolution, ecology, structure, taxonomy and behavior of reptiles and amphibians.

BIOL 438. Forensic Molecular Biology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 310 with a minimum grade of C. Provides an understanding of molecular biology testing methodologies as applied to analysis of forensic samples. Current topics in forensic DNA analysis will include quality assurance, DNA databanking, contemporary research and population genetics. Crosslisted as: FRSC 438.

BIOL 440. Developmental Biology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and 310, each with a minimum grade of C. Basic principles of developmental biology focused on vertebrate model organisms with an emphasis on the underlying cellular and molecular mechanisms that guide development.

BIOL 445. Neurobiology and Behavior. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317 with a minimum grade of C. The study of animal behavior stressing ecological, evolutionary and neurobiological approaches.

BIOL 448. Neuroscience. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. Pre- or corequisite: BIOL 310. An examination of the basic structure of the nervous system, nervous system operation on a cellular and molecular level and the formation of the nervous system during development.

BIOL 449. Stem Cells in Disease and Therapy. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 300, each with a minimum grade of C. BIOL 310 and BIOL 340 recommended. Advanced stem cell biology with emphasis on the role of stem cells in human disease and regenerative medicine. Topics include the history of stem cell research; the generation of pluripotent stem cells; the role of adult stem cells in disease and genetic disorders; the use of genetic engineering in stem cell-based curative gene therapy; and discussions of the ethical issues related to stem cell use in regenerative medicine.

BIOL 450. Biology of Cancer I. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 with a minimum grade of C or PHIS 309. An examination of the cellular, molecular and clinical aspects of cancer development, progression and treatment.

BIOL 451. Biology of Cancer II. 4 Hours.
Semester course; 1 lecture and 12 laboratory hours. 4 credits. Prerequisites: BIOL 450 and instructor's permission. A maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 495 and/or BIOZ 395) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. An examination of the cellular, molecular and clinical aspects of cancer development, progression and treatment.

BIOL 452. Biology of Drugs. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. Explores how drugs modulate biological signaling pathways to study, cure, enhance and intoxicate organisms. An introduction to basic pharmacology that largely focuses on human pathways and diseases. Topics include major drug classes (cardiovascular, gastrointestinal, etc.) and drugs of abuse (alcohol, marijuana, etc.).

BIOL 453. Cancer Biology Thesis. 4 Hours.
Semester course; 1 recitation and 12 laboratory hours. 4 credits. Prerequisite: BIOL 451. A maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 495 and/or BIOZ 395) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. Enrollment is restricted to students with permission of the instructor and research mentor. Students will benefit from invaluable learning opportunities in cancer research including hands-on learning, direct mentorship from a VCU faculty member, scientific writing skills, time and research project management, and exposure to and training in various laboratory techniques. In addition, students will gain experience in preparation of a cancer research proposal and thesis.

BIOL 454. Biology of Aging and Diseases. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and BIOL 310 each with a minimum grade of C. A study of the molecular biology of aging as it relates to evolution of life span, model organisms, diseases and genetic regulation of aging.

BIOL 455. Immunology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C or PHIS 309. A comprehensive introduction to the vertebrate immune system emphasizing the molecular and cellular basis of innate and adaptive immune mechanisms, interactions and regulation.

BIOL 456. Virology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 300, each with a minimum grade of C. BIOL 310 is recommended. Exploration of concepts related to the basic molecular and cellular biology of viruses with emphasis on the structure, genetic material and replication strategies of viruses, and the different mechanisms of infection and prevention measures. Importance of viruses as agents of evolution and their role in ecosystems and geological processes will also be discussed.
BIOL 459. Infectious Disease Ecology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOL 152, BIOZ 151, BIOZ 152 and BIOL 317, all with minimum grade of C. A comprehensive and up-to-date overview of the causes and consequences of infectious disease at levels from individual organisms to global scale. Examines the history of infectious disease ecology in human and nonhuman populations. Students learn about the roles of transmission and coevolution in infectious disease ecology and how population models are used to inform management of epidemics and emerging infectious diseases.

BIOL 460. Human Evolutionary Genetics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 318 or BIOL 341 with a minimum grade of C. The origin and genetic history of modern humans, our historic colonization and migration, the utility of the Human Genome Project, our differences from other primates, adaptation to our environment and disease, and the ethical implications of genetic research in our society.

BIOL 475. Biology Capstone Seminar. 1-3 Hours.
Semester course; 1-3 seminar hours. 1-3 credits. Prerequisites: BIOL 300, BIOL 310, BIOL 317 and BIOL 318, each with a minimum grade of C. Enrollment is restricted to biology majors with senior standing. Students read assigned topical papers before class, prepare critical analyses, discuss and debate selected positions. See Schedule of Classes for specific topics.

BIOL 477. Biology Capstone Experience. 0 Hours.
Semester course; variable hours. 0 credits. Prerequisites: BIOL 300, BIOL 310, BIOL 317 and BIOL 318, each with a minimum grade of C; and 90 hours of undergraduate course work. The following courses qualify as a capstone experience if taken concurrently with this course: BIOL 492, BIOL 493, BIOL 495, BIOL 497 or other courses, including topics courses, which include the core competencies required for a capstone experience and are approved by the chair of the Department of Biology. Graded as pass/fail.

BIOL 480. Animal-Plant Interactions. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 or BIOL 318 with a minimum grade of C, or permission of the instructor. Ecological and evolutionary consequences of interactions among animals and plants.

BIOL 482. Preceptor Experience. 0 Hours.
Semester course; 0 hours. 0 credits. Enrollment is restricted to students who have completed the relevant course for which they will be a teaching assistant with a minimum grade of B and who have a minimum cumulative GPA of 3.0. Permission of instructor and departmental chair also required prior to registration. Teaching assistants will enhance their knowledge of course content and develop skills that are natural to an instructional role, an understanding of the learning process within a discipline and the ability to explain the importance and value of course content to a novice audience. Graded as pass/fail.

BIOL 484. Research Assistant Experience. 0 Hours.
Semester course; 0 hours. 0 credits. Enrollment is restricted to students with permission of the departmental chair and limited to students for whom a research supervisor has agreed to be a mentor. Helps facilitate student involvement in research laboratories within the Department of Biology. Students will gain hands-on experience including data collection and analysis, learning field and/or laboratory techniques, and/or mastering experimental procedures, all under the direct supervision of a faculty member. Graded as pass/fail.

BIOL 489. Communicating Research. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Prerequisite: Completion of the Biocore with minimum grades of C. Corequisite: BIOL 495, senior standing. An opportunity for students to develop skills necessary for effective communication of their research in writing. Includes a variety of seminar discussions and activities including preparation of figures for publication and the crafting of a research paper with correct usage of the primary literature. Students will use this as an opportunity to aid the writing of their thesis for BIOL 495.

BIOL 490. Presenting Research. 1 Hour.
Semester course; 1 credit. Prerequisite: Completion of the Biocore with minimum grades of C. Pre- or corequisites: BIOL 492 or 495, and senior standing. Opportunity for students to develop skills necessary for effective oral presentation of their research work. Includes a variety of seminar discussions and activities such as preparation of visual materials and statistical analysis of data. Students will make several oral presentations directly related to their specific BIOL 492 or 495 projects.

BIOL 491. Topics in Biology. 1-4 Hours.
Semester course; variable hours. Variable credit. Prerequisite: BIOL 300. A study of a selected topic in biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

BIOL 492. Independent Study. 1-4 Hours.
Semester course; 1-4 independent study hours. 1-4 credits. Prerequisites: BIOL 151 and BIOZ 152, each with a minimum grade of C; permission of the chair of the Department of Biology. May be repeated for credit. A maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 495 and/or BIOL 395) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. A minimum of two credits is required for the course to count as a laboratory experience. Projects should include data collection and analysis, learning field and/or laboratory techniques, and/or mastering experimental procedures, all under the direct supervision of a faculty member. A minimum of three hours of supervised activity per week per credit hour is required. A final report must be submitted at the completion of the project.

BIOL 493. Biology Internship. 4 Hours.
Semester course; 0-4 field experience hours. 0-4 credits (one credit per 50 hours of supervised work experience). May be repeated for credit. Prerequisites: BIOL 151, BIOL 152, BIOZ 151 and BIOZ 152, each with minimum grade of C; and permission of the chair of the Department of Biology and the institution where the internship will be performed. Students may take a maximum of four credits per semester; maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 495 and/or BIOL 395) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. BIOL 493 taken for 0 credit does not qualify for BIOL 477 capstone experience. Internship is designed to provide laboratory, field or work experience in an off-campus professional biology setting. In addition to an internship proposal and professional practices/reflection assignments, a final report/reflection must be submitted during the course of the internship.
BIOL 495. Research and Thesis. 1-4 Hours.
Semester course; 1-4 research hours. 1-4 credits. Prerequisites: BIOL 392, permission of the supervising faculty member and a research proposal acceptable to the departmental chair. Corequisite: BIOL 489 or BIOL 490. May be repeated for a maximum of eight credits. Students may take a maximum of four credits per semester; maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 495 and/or BIOZ 395) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. A minimum of two credits is required for the course to count as a laboratory experience. A minimum of four credits is required for honors in biology. Activities include field and/or laboratory research under the direct supervision of a faculty mentor. A minimum of three hours of supervised activity per week per credit hour is required. Research projects must include experimental design and analysis of data. This course must be taken for two consecutive semesters starting in the fall. A written thesis of substantial quality is required upon completion of the research.

BIOL 496. Biology Preceptorship: _____, 2 Hours.
Semester course; 2 practicum hours. 2 credits. May be repeated with a different course for credit. Enrollment restricted to students who have completed the relevant course with a minimum grade of B and who have a minimum cumulative GPA of 3.0. Permission of instructor is required prior to registration. Preceptors assist instructors in lecture (BIOL) or laboratory (BIOZ) courses. Responsibilities vary and may include, but are not limited to, attending class, conducting review sessions and preparing course study/review materials. Graded as pass/fail. A maximum of four combined credits from BIOL 496 and BIOL 499 may be applied to degree requirements.

BIOL 497. Ecological Service Learning. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Prerequisite: BIOL 317 with a minimum grade of C. A service-learning course coupled to course content and material taught in BIOL 317. Students will seek out ecologically relevant opportunities with local, state and federal community partners who will provide experiences to enhance academic enrichment and personal growth and will help foster a sense of civic responsibility. Students must complete a minimum of 20 service-learning hours with community partner(s).

BIOL 498. Insects and Plants Service-learning. 2 Hours.
Semester course; 2 field experience hours. 2 credits. Prerequisites: BIOL 317 or BIOL 318 with a minimum grade of C, and permission of the instructor. A service-learning course related to insect-plant interactions. Field experience with community partners, including public parks, botanical gardens and organic farms. Designed to expand academic instruction, enhance personal growth and foster a sense of civic responsibility. Students must complete a minimum of 40 service-learning hours with a community partner.

BIOL 499. Biology Lead Preceptorship. 2 Hours.
Semester course; 2 practicum hours. 2 credits. Prerequisite: BIOL 496 in the same course with a grade of Pass. Enrollment is restricted to students who have completed the relevant course with a minimum grade of B and who have a minimum cumulative GPA of 3.0. Permission of the instructor is required prior to registration. Lead preceptors assist instructors in lecture (BIOL) or laboratory (BIOZ) courses. Responsibilities cumulate beyond those required in the prerequisite course. Responsibilities vary and may include, but are not are limited to, organizing preceptor teams for large enrollment courses, preceptor mentorship, data entry of course materials, execution of group work, etc. Graded as pass/fail. A maximum of four combined credits from BIOL 496 and BIOL 499 may be applied to degree requirements.