

BIOLOGY, BACHELOR OF SCIENCE (B.S.)

The four-year curriculum in biology prepares students for graduate study in biology, for employment in laboratory or field programs in private industry or government agencies and for teaching in secondary schools. This curriculum also prepares students for admission into schools of medicine, dentistry and veterinary medicine, and into allied health programs.

Student learning outcomes

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

Knowledge base

Students will demonstrate knowledge of evolutionary processes and the functions and interactions of cells, organisms and species.

Communication skills

Students will demonstrate oral and written communication skills needed for professional careers in the field of biology.

Critical-thinking skills

Students will demonstrate critical thinking, problem-solving and analytical skills.

Method and inquiry

Students will demonstrate knowledge in the methods of inquiry and research in biology.

Transfer students

Transfer students intending to major in biology must satisfy all biology major course requirements and complete a minimum of 15 credits of VCU biology courses at the 300-, 400- or 500-level.

Extended Teacher Preparation Program

Biology majors interested in teaching careers in secondary education can enroll in the Extended Teacher Preparation Program, which simultaneously awards a bachelor's degree in biology and a master's degree in teaching. For more information about this program, jointly administered by the College of Humanities and Sciences and the School of Education, contact the School of Educations Student Services Center.

Honors in biology

Biology majors may graduate with honors in biology. To qualify, students must have overall and biology GPAs of at least 3.5 and must complete the following courses in this sequence: BIOL 392, at least four credits of BIOL 495 and BIOL 490. Grades of A or B must be earned in each of the listed courses. Students who qualify will have the notation "Honors in Biology" placed on their transcript. Students must meet all Department of Biology requirements for graduation. Students should consult with their academic advisers to create a program suitable to their particular needs and interests.

Special requirements

The curriculum for a Bachelor of Science in Biology requires a minimum of 120 credits, with at least 40 of those credits in biology or other approved courses. A cumulative GPA of 2.0 for biology courses is required. At least five laboratory experiences must be taken from

all biology courses, including BIOZ 151 and BIOZ 152; up to two laboratory experiences can be selected from BIOZ 395, BIOL 451, BIOL 453, BIOL 492 or BIOL 495. Topics courses (BIOL 391, BIOZ 391, BIOL 491 and BIOZ 491) may count as laboratory experiences only when approved in advance by the Department of Biology undergraduate academic committee. Registration in BIOZ 395, BIOL 492 or BIOL 495 must be for a minimum of two credit hours to count as one of the five required laboratory experiences. A maximum total of six credits for all undergraduate research and internships in biology (BIOZ 395, BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493 and BIOL 495) 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 maximum of four combined credits from BIOL 496 and BIOL 499 may be applied to degree requirements. While BIOL 496 may be repeated for credit toward degree requirements when serving as a preceptorship for different courses, it may not be repeated with the same course for credit toward the degree. No more than five credits of the 100-level (or introductory level) biology courses can be applied to the major.

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 Biology.

Course	Title	Hours
BIOL 151	Introduction to Biological Sciences I	3
BIOZ 151	Introduction to Biological Science Laboratory I	1
BIOL 152	Introduction to Biological Sciences II	3
BIOZ 152	Introduction to Biological Science Laboratory II	1
BIOL 200	Quantitative Biology	3
BIOL 300	Cellular and Molecular Biology	3
BIOL 310	Genetics	3
BIOL 317	Ecology	3
BIOL 318	Evolution	3

Degree requirements for Biology, Bachelor of Science (B.S.)

Course	Title	Hours
General education (http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/)		
Select 12-13 credits from general education foundations and 17-18 credits from areas of inquiry.		30

Major requirements

• Major core requirements		
BIOL 152	Introduction to Biological Sciences II	3
BIOL 200	Quantitative Biology	3
BIOL 300	Cellular and Molecular Biology	3
BIOL 310	Genetics	3
BIOL 317	Ecology	3
BIOL 318	Evolution	3
BIOZ 151	Introduction to Biological Science Laboratory I ¹	1
BIOZ 152	Introduction to Biological Science Laboratory II ²	1

• Additional major requirements (20 credits total)

Capstone requirement - select one of the following: 0-3

BIOL 475 Biology Capstone Seminar. _

BIOL 477 Biology Capstone Experience (to denote department approved capstone course or experience)

BIOZ 476 Molecular Capstone Laboratory

Major electives

Select from all biology (BIOL and BIOZ) courses applicable to the biology major and biochemistry (CHEM 403) to satisfy the 40 biology credits required for the major. All majors must complete at minimum three additional upper-level biology lab courses. The laboratory experiences may be fulfilled by a separate laboratory section (BIOZ) or by laboratory hours included in a lecture-based (BIOL) course. Not all courses are offered each semester. BIOL courses at the 500 level are available to seniors and graduate students only. 17-20

Ancillary requirements

BIOL 151 Introduction to Biological Sciences I 3

CHEM 101 & CHEZ 101 General Chemistry I and General Chemistry Laboratory I (both satisfy general education BOK for natural science and AOI for scientific and logical reasoning) 4

CHEM 102 & CHEZ 102 General Chemistry II and General Chemistry Laboratory II 4

CHEM 301 & CHEZ 301 Organic Chemistry and Organic Chemistry Laboratory I 5

CHEM 302 & CHEZ 302 Organic Chemistry and Organic Chemistry Laboratory II 5

HUMS 202 Choices in a Consumer Society 1

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

MATH 200 Calculus with Analytic Geometry I (or STAT 314 or higher numbered statistics course) 4

PHYS 201 General Physics I (satisfies general education AOI for scientific and logical reasoning) 4-5

or PHYS 207 University Physics I

PHYS 202 General Physics II 4-5

or PHYS 208 University Physics II

STAT 210 Basic Practice of Statistics 3

Experiential fine arts³ 1-3

Foreign language through the 102 level (by course or placement) 0-6

Open electives

Select any course. 10-20

Total Hours 120

1

BNFO/LFSC 251 approved course substitute

2

BNFO/LFSC 252 approved course substitute

3

Course offered by the School of the Arts

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

Biology electives

Course	Title	Hours
BIOL 291	Topics in Biology	1-4
BIOL 303	Microbiology	3
BIOZ 303	Microbiology Laboratory	2
BIOL 304	Biology Skills ¹	2
BIOL 307	Aquatic Ecology	3
BIOZ 307	Aquatic Ecology Laboratory	1
BIOL 308	Vertebrate Histology ¹	4
BIOL 309	Entomology ¹	4
BIOZ 310	Laboratory in Genetics	2
BIOL 312	Invertebrate Zoology	3
BIOZ 312	Invertebrate Zoology Laboratory	1
BIOL 313	Vertebrate Natural History	3
BIOZ 313	Vertebrate Natural History Laboratory	1
BIOL 314	Animal Reproduction	3
BIOZ 317	Ecology Laboratory	2
BIOL 320	Biology of the Seed Plant ¹	4
BIOL 321	Plant Development	3
BIOZ 321	Plant Development Laboratory	2
BIOL 322	Economic Botany	3
BIOL 324	Medicinal Botany	3
BIOZ 324	Medicinal Botany Laboratory	1
BIOL 325	Fungal Biology ¹	3
BIOL 330	Community Science: ____ ¹	3
BIOL 333	Evolution of the Angiosperms	3
BIOL 335	Global Change Biology	3
BIOL 340	Development and Stem Cells	3
BIOL 341/ANTH 301	Human Evolution ¹	4
BIOL 391	Topics in Biology (as approved)	1-4
BIOZ 391	Topics in Biology Laboratory (as approved)	1-4
BIOL 392	Introduction to Research	2
BIOL 395	Directed Study	1-2
BIOZ 395	Directed Study	1-2
BIOL 401	Applied and Environmental Microbiology	3
BIOZ 401	Applied and Environmental Microbiology Laboratory	2
BIOL 402	Comparative Vertebrate Anatomy ¹	5
BIOL/ANTH 403	Primateology ¹	4
BIOL 405	Gross Anatomy Laboratory	2
BIOL 411	Physiology	3
BIOL 413	Parasitology	3
BIOL 415	Mangrove Avian Field Ecology ¹	4
BIOL 416	Ornithology	3
BIOZ 416	Ornithology Laboratory	2
BIOL 417	Mammalogy ¹	4
BIOZ 418	Integrative Physiology Laboratory	3

BIOL 420	Yeast and Fermentation ¹	3	BIOL 541	Laboratory in Molecular Genetics ¹	2
BIOL 422	Forest Ecology ¹	4	BIOL 545/LFSC 510	Biological Complexity	3
BIOL 423	Plant Physiology	3	BIOL 548/LFSC 520	Bioinformatic Technologies	2
BIOL 425 Play course video for Field Botany	Field Botany ¹	3	BIOL 550	Ecological Genetics	3
BIOL 430	Invasion Biology	3	BIOL 560	Conservation Medicine	3
BIOL 431	Introduction to Marine Biology	3	BIOL 565	Advances in Cell Signaling	3
BIOL 435	Herpetology	3	BIOL 580	Eukaryotic Biotechnology	3
BIOL/FRSC 438	Forensic Molecular Biology	3	BIOL 591	Special Topics in Biology	1-4
BIOZ/FRSZ 438	Forensic Molecular Biology Laboratory	2	BNFO 301/BIOL 351	Introduction to Bioinformatics	3
BIOL 440	Developmental Biology	3	CHEM 403	Biochemistry I	3
BIOL 445	Neurobiology and Behavior ¹	4	ENVS 330	Environmental Pollution	3
BIOL 448	Neuroscience	3	LFSC 301	Integrative Life Sciences Research	3
BIOL 449	Stem Cells in Disease and Therapy	3	MATH/BNFO 380	Introduction to Mathematical Biology	4
BIOL 450	Biology of Cancer I	3			
BIOL 451	Biology of Cancer II ¹	4	¹		
BIOL 453	Cancer Biology Thesis ¹	4	This course includes laboratory hours and may be used to satisfy laboratory requirements.		
BIOL 452	Biology of Drugs	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.		
BIOL 455	Immunology	3			
BIOL 456	Virology	3	Freshman year		
BIOL 459	Infectious Disease Ecology	3	Fall semester		Hours
BIOL 460	Human Evolutionary Genetics	3	BIOL 151	Introduction to Biological Sciences I	3
BIOL 480	Animal-Plant Interactions	3	BIOZ 151	Introduction to Biological Science Laboratory I	1
BIOL 489	Communicating Research	1	CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I (both satisfy general education AOI for scientific and logical reasoning)	4
BIOL 490	Presenting Research	1	MATH 151	Precalculus Mathematics (satisfies general education quantitative foundations)	4
BIOL 491	Topics in Biology	1-4	UNIV 101	Introduction to the University	1
BIOZ 491	Topics in Biology Laboratory	1-4	UNIV 111	Focused Inquiry I (satisfies general education UNIV foundations)	3
BIOL 492	Independent Study	1-4	Play course video for Focused Inquiry I		
BIOL 493	Biology Internship	1-3	Term Hours:		16
BIOL 495	Research and Thesis	1-4	Spring semester		
BIOL 496	Biology Preceptorship: ____	2	BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	4
BIOL 497	Ecological Service Learning	1	BIOL 200	Quantitative Biology	3
BIOL 498	Insects and Plants Service-learning	2	CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
BIOL 499	Biology Lead Preceptorship	2	HUMS 202	Choices in a Consumer Society	1
BIOL 502	Microbial Biotechnology	3	UNIV 112	Focused Inquiry II (satisfies general education UNIV foundations)	3
BIOL 503	Fish Biology ¹	4	Play course video for Focused Inquiry II		
BIOL 507	Aquatic Microbiology	4	Term Hours:		15
BIOL 508	Barrier Island Ecology	3	Sophomore year		
BIOL 509	Microbial Ecology	3	Fall semester		
BIOL 510	Conservation Biology	3			
BIOL 514	Stream Ecology	4			
BIOL/HGEN 516	Population Genetics	3			
BIOL 518	Plant Ecology	4			
BIOL 519	Forest Ecology ¹	4			
BIOL 520	Population Ecology	3			
BIOL 521	Community Ecology	3			
BIOL 522	Evolution and Speciation	3			
BIOL 524	Endocrinology	3			
BIOL 530/HGEN 501	Introduction to Human Genetics	3			
BIOL 535	Wetlands Ecology ¹	4			
BIOL/BNFO 540	Fundamentals of Molecular Genetics	3			

BIOL 300	Cellular and Molecular Biology	3
CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5
STAT 210	Basic Practice of Statistics	3
UNIV 200	Inquiry and the Craft of Argument (satisfies general education UNIV foundations)	3
Experiential fine arts		1-3
Term Hours:		15-17

Spring semester

BIOL 310 or BIOL 317 or BIOL 318	Genetics or Ecology or Evolution	3
CHEM 302 & CHEZ 302	Organic Chemistry and Organic Chemistry Laboratory II	5
MATH 200 or STAT 314	Calculus with Analytic Geometry I or Applications of Statistics	4
General education course (select AOI for creativity, innovation and aesthetic inquiry)		3
Term Hours:		15

Junior year**Fall semester**

PHYS 201 or PHYS 207	General Physics I (either satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning) or University Physics I	4-5
Select the two courses not previously taken from BIOL 310, BIOL 317 and BIOL 318.		6
Foreign language 101		3
General education course (select BOK to complete breadth of knowledge requirement and AOI for diversities in the human experience)		3
Term Hours:		16-17

Spring semester

PHYS 202 or PHYS 208	General Physics II or University Physics II	4-5
Biology elective		3
Biology laboratory elective		1-2
Foreign language 102		3
General education course (select BOK to complete breadth of knowledge requirement and AOI for global perspectives)		3
Term Hours:		14-16

Senior year**Fall semester**

Biology electives		5-6
Biology laboratory elective		1-2
Open electives		9
Term Hours:		15-17

Spring semester

Select one of the following (capstone):		0-3
BIOL 475 Biology Capstone Seminar: ____		-

BIOL 477 Biology Capstone Experience (to denote department approved capstone course or experience)	-
BIOZ 476 Molecular Capstone Laboratory	-
Biology electives	6
Biology laboratory elective	1-2
Open electives	7
Term Hours:	14-18
Total Hours:	120-131

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 academically talented students to earn both the B.S. in Biology and M.S. in Forensic Science with a concentration in forensic biology in a minimum of five and a half 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 150 credits rather than the 162 credits necessary if the two degrees are pursued separately.

Students holding these degrees will have foundational work in biology, followed by advanced training in forensic science through a combination of laboratory and classroom work and will gain important professional development skills. The goal of the accelerated program is to significantly enhance the student's qualifications to pursue a career in the forensic science field. Alternatively, students who distinguish themselves may be able to pursue advanced study in doctoral or professional programs on an accelerated timetable.

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 60 undergraduate credit hours including CHEM 301, CHEZ 301, CHEM 302, CHEZ 302, CHEM 403 and BIOL 310; an overall GPA of 3.3; and a GPA of 3.0 in biology course work. Two reference letters (at least one from a biology or forensic science faculty member) must accompany the Accelerated Program Declaration Form.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the "Satisfactory academic progress (<http://bulletin.vcu.edu/about:blank>)" section of Bulletin, including maintaining a 3.0 GPA. Guidance to students in an accelerated program is provided by both the undergraduate biology adviser and the forensic science graduate program director.

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. 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.

Degree requirements

The Bachelor of Science in Biology degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion 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 satisfy required major electives for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

The graduate forensic science courses that may be taken as an undergraduate, once a student is admitted to the program, are:

Course	Title	Hours
BIOL 540	Fundamentals of Molecular Genetics (satisfies undergraduate biology elective)	3
BIOS 543 or STAT 543	Graduate Research Methods I (satisfies elective (upper-level)) Statistical Methods I	3
FRSC 673 & FRSZ 673	Forensic Microscopy and Forensic Microscopy Laboratory (satisfies undergraduate biology elective and biology laboratory elective)	3
FRSC 675 & FRSZ 675	Forensic Serology and DNA Analysis and Forensic Serology and DNA Analysis Laboratory (satisfies undergraduate biology elective and biology laboratory elective)	3
Total Hours		12

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.

Course	Title	Hours
Junior year		
Fall semester		
BIOL 317 or BIOL 318	Ecology Evolution	3
CHEM 403	Biochemistry I	3
PHYS 201 or PHYS 207	General Physics I University Physics I	4-5
Foreign language 101		3
General education course		3
Term Hours:		16-17
Spring semester		

BIOL 317 or BIOL 318	Ecology Evolution	3
PHYS 202 or PHYS 208	General Physics II University Physics II	4-5
Biology elective		3
Foreign language 102		3
Open elective		2
Term Hours:		15-16
Senior year		
Fall semester		
FRSC 673 & FRSZ 673	Forensic Microscopy and Forensic Microscopy Laboratory	3
FRSC 675 & FRSZ 675	Forensic Serology and DNA Analysis and Forensic Serology and DNA Analysis Laboratory	3
Biology elective		3
Open electives		5
Term Hours:		14
Spring semester		
BIOS 543 or STAT 543	Graduate Research Methods I Statistical Methods I	3
BIOL 540	Fundamentals of Molecular Genetics	3
BIOZ 476	Molecular Capstone Laboratory	2
General education course		3
Open elective		3
Term Hours:		14
Fifth year		
Fall semester		
FRSC 565	Scientific Crime Scene Investigation	3
FRSC 570	Forensic Science Seminar	1
FRSC 670	Forensic Evidence and Criminal Procedure	3
FRSC 671	Instrumentation in Forensic Chemistry	2
Term Hours:		9
Spring semester		
BIOL 516	Population Genetics	3
FRSC 570	Forensic Science Seminar	1
FRSC 676	Advanced Forensic DNA Analysis	3
FRSC 677	Professional Practices and Expert Testimony	3
FRSC 793	Directed Research in Forensic Science	1
Term Hours:		11
Sixth year		
Fall semester		
FRSC 570	Forensic Science Seminar	1
FRSC 660 or FRSC 661 or FRSC 662	Toolmark Examinations Analysis of Pattern Evidence Firearm Identification	3
FRSC 686	Emerging Molecular Applications for Forensic Biology	3
FRSC 793	Directed Research in Forensic Science	2

FRSC elective	1
Term Hours:	10

Courses not applicable to the major

The following courses are not applicable toward the biology major requirements, but may be used as general electives toward the bachelor's degree:

Course	Title	Hours
BIOL 101	Biological Concepts	3
BIOZ 101	Biological Concepts Laboratory	1
BIOL 103	Global Environmental Biology	4
BIOL 201	Human Biology	3
BIOZ 201	Human Biology Laboratory	1
BIOL 205	Basic Human Anatomy	4
BIOL 209	Medical Microbiology	3
BIOZ 209	Medical Microbiology Laboratory	1
BIOL 217	Principles of Nutrition	3
PHIS 206	Human Physiology	3
PHIZ 206	Human Physiology Laboratory	1

Jump to biology lab courses. (p. 12)

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. 4 Hours.

Semester course; 3 lecture and 2 laboratory hours (delivered mostly online). 4 credits. Online presentations, assignments, debates and exams require students to understand situations and ideas that involve scientific, social and economic concepts associated with Earth's environment. Laboratory exercises reinforce major course concepts. Integrates aspects of biology, chemistry, geology, physics and sociology. Topics include ecology, evolution, natural resources, air and water resources, energy and recycling, population biology, and sustainable global societies. Not applicable as a prerequisite for any biology course at the 200 level or above, 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 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/ENVS 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 assistantship. 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. 2 Hours.

Semester course; 1 lecture hour (delivered online) and 3 laboratory hours. 2 credits. Prerequisites: BIOL 151 and BIOZ 151 and permission of instructor. This course provides a hands-on experience in laboratory techniques, emphasizes the development of library and informational fluency skills, and uses current biological and/or biomedical research topics to aid in development of critical-thinking and problem-solving skills.

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, 152 and BIOZ 151, 152, 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; BIOL 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, 152 and BIOZ 151, 152, with minimum grades of C. A survey of the invertebrate animals with emphasis on environmental interactions. A weekend trip to a marine environment is required.

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, BIOL and BIOZ 152, and BIOL 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; 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 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 and BIOZ 151 and BIOL and BIOZ 152, each with a minimum grade 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. Economic Botany. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152 and BIOZ 151 and 152, or equivalents, with minimum grades of C. This class focuses on plant morphology, anatomy, phytochemistry, growth and reproduction through an examination of the biology of economically and culturally important plants, including crops used for foods and beverages, medicines and drugs, fibers, and timber.

BIOL 324. Medicinal Botany. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 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/ailments 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, BIOZ 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 333. Evolution of the Angiosperms. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, 152 and BIOZ 151, 152, all with minimum grade of C. Application of evolutionary concepts to flowering plants. Topics include speciation concepts, evolution of vegetative and sexual characteristics and an overview of angiosperm diversity to the level of family.

BIOL 335. Global Change Biology. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOL 152, BIOZ 151 and BIOZ 152, all with minimum grade of C. Examines how humans influence biological systems and explores what can be done to adapt to or to mitigate future global change, emphasizing anthropogenic climate change.

BIOL 340. Development and Stem Cells. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and CHEM 102, each with a minimum grade of C. Basic principles of developmental biology and stem cells of vertebrates, pinpointing the underlying cellular and molecular mechanisms that guide development and stem cell biology. Significant emphasis on medical aspects of development such as human birth defects, cloning, properties of stem cells and their medical uses, and careers in developmental and stem cell biology.

BIOL 341. Human Evolution. 4 Hours.

Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisite: UNIV 200 or HONR 200 with a minimum grade of C. Introduces the range of human diversity as well as a broad understanding of evolution and evolutionary biology, particularly as it applies to hominid evolution. Specific topics include basic genetics, primatology, paleontology and the hominin fossil record. Crosslisted as: ANTH 301.

BIOL 351. Introduction to Bioinformatics. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: BNFO 201 and BNFO 300 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. Crosslisted as: BNFO 301.

BIOL 391. Topics in Biology. 1-4 Hours.

Semester course; 1-4 lecture hours. 1-4 credits. Prerequisites: BIOL 152 and BIOZ 152; and BIOL 300, BIOL 310, BIOL 317 or BIOL 318, each with a minimum grade 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 392. Introduction to Research. 2 Hours.

Semester course; 1 lecture and 1 demonstration hour. 2 credits. Prerequisite: BIOL 300, BIOL 310, BIOL 317 or BIOL 318 with a minimum grade of C. An introduction to the scientific process, including the mechanics of problem definition, information gathering and experimental design. Experimentation is discussed in context with methods of data collection and analysis. Aims are to prepare the student for future research experiences and to have the student write detailed research proposals.

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, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 495 and/or BIOZ 395) may be applied to the 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. Mangrove 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. 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; BIOL 152 and BIOZ 152; and BIOL 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 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 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 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 immune system of higher animals, emphasizing the molecular and cellular basis for antibody-mediated immunity.

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: BIOZ 151 and BIOZ 152, each with a minimum grade of C; and 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 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. 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, BIOZ 151, BIOL 152 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 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. 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.

Biology labs

BIOZ 101. Biological Concepts Laboratory. 1 Hour.

Semester course; 2 laboratory hours. 1 credit. Pre- or corequisite: BIOL 101, 151 or 152. Laboratory exercise correlated with BIOL 101. Not applicable for credit toward the B.S. in Biology.

BIOZ 151. Introduction to Biological Science Laboratory I. 1 Hour.

Semester course; 3 laboratory hours. 1 credit. 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. Corequisite: BIOL 151. Laboratory investigation of cellular metabolism, genetics and molecular biology, with an emphasis on formation and testing of hypotheses. Laboratory exercises will elaborate themes discussed in BIOL 151.

BIOZ 152. Introduction to Biological Science Laboratory II. 1 Hour.

Semester course; 3 laboratory hours. 1 credit. Prerequisites: BIOL 151, BIOZ 151 and CHEM 101, each with a minimum grade of C. Corequisite: BIOL 152. Laboratory investigation of evolutionary concepts, evolution of organisms, biological diversity and ecology, with an emphasis on formation and testing of hypotheses. Laboratory exercises will elaborate themes discussed in BIOL 152.

BIOZ 201. Human Biology Laboratory. 1 Hour.

Semester course; 2 laboratory hours. 1 credit. Pre- or corequisite: BIOL 201. Laboratory exercises correlated with BIOL 201 Human Biology. Exercises emphasize the structure, function and disorders of human body systems, principles of human genetics and inheritance, and human evolution and ecology. Not applicable for credit toward the B.S. in Biology.

BIOZ 209. Medical Microbiology Laboratory. 1 Hour.

Semester course; 2 laboratory hours. 1 credit. Pre- or corequisite: BIOL 209. Techniques to culture, isolate and identify microbes with related topics such as water coliform tests, and antibiotics and disinfectant sensitivity testing. Not applicable for credit toward the B.S. in Biology.

BIOZ 303. Microbiology Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Pre- or corequisite: BIOL 303. Laboratory application of techniques and concepts in microbiology. Emphasis is placed on techniques to isolate, culture and identify bacteria; genetics and molecular biology of bacteria; safety and aseptic protocols; assays for antibiotic and disinfectant susceptibility.

BIOZ 307. Aquatic Ecology Laboratory. 1 Hour.

Semester course; 3 laboratory hours. 1 credit. Prerequisites: BIOL 317, CHEM 102 and CHEZ 102, with minimum grades of C. Pre- or corequisite: BIOL 307. Laboratory and field studies of the biota of aquatic habitats and their relationship with the environment.

BIOZ 310. Laboratory in Genetics. 2 Hours.

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisites: UNIV 200 or HONR 200; and BIOL 152 and BIOZ 152, each with a minimum grade of C. Pre- or corequisite: BIOL 310. Demonstrates the laws and molecular basis of heredity through exercises and experiments that use a variety of organisms.

BIOZ 312. Invertebrate Zoology Laboratory. 1 Hour.

Semester course; 3 laboratory hours. 1 credit. Prerequisites: BIOL and BIOZ 151 and 152, with minimum grades of C. Pre- or corequisite: BIOL 312. A laboratory survey of the invertebrate animals, with emphasis on environment interactions. A weekend trip to a marine environment is required.

BIOZ 313. Vertebrate Natural History Laboratory. 1 Hour.

Semester course; 3 laboratory hours. 1 credit. Prerequisites: BIOL and BIOZ 151 and 152, with minimum grades of C. Pre- or corequisite: BIOL 313. Laboratory exercises focusing on the natural history of vertebrates, with emphasis on the species native to Virginia.

BIOZ 317. Ecology Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: BIOL and BIOZ 151 and 152, and UNIV 200 or HONR 200; all with minimum grades of C. Pre- or corequisite: BIOL 317. A field-oriented course that provides experience in ecological research, including experimental design, instrumentation, data collection and data analysis.

BIOZ 321. Plant Development Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Pre- or corequisite: BIOL 321. An experimental approach applied to a phylogenetic survey of developmental model systems. Observational and experimental protocols will be used to collect data and gather information. Problem-solving skills will be utilized to analyze and present experimental results.

BIOZ 324. Medicinal Botany Laboratory. 1 Hour.

Semester course; 3 laboratory hours. 1 credit. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152; and BIOL 300, all with a minimum grade of C. Pre- or corequisite: BIOL 324. Introduces basic plant biology concepts, plant diversity and systematics, and various medicinal plant species, compounds and properties.

BIOZ 341. Human Evolution Lab. 1 Hour.

Semester course; 2 laboratory hours. 1 credit. Corequisite: BIOL 341/ ANTH 301. Laboratory exercises correlated with BIOL 341/ANTH 301. Exercises emphasize comparative primate and fossil anatomy, morphology and behavior, as well as practice in recognizing and applying evolutionary principles in human evolution. Crosslisted as: ANTZ 301.

BIOZ 391. Topics in Biology Laboratory. 1-4 Hours.

Semester course; 1-4 laboratory hours. 1-2 credits. Prerequisite: BIOL 300, BIOL 310, BIOL 317 or BIOL 318, with a minimum grade of C. Laboratory investigations in a selected topic of biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

BIOZ 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, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 495 and/or BIOZ 395) may be applied to the 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. 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. Graded as pass/fail.

BIOZ 401. Applied and Environmental Microbiology Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisite: BIOL 303, BIOL 401 or permission of instructor. Offers students the opportunity to gain skills and experience necessary to perform a variety of microbiology analyses including both cultivation-based approaches and cultivation-independent methods. Students will apply these techniques and concepts to conduct experiments in soil and aquatic ecology, drinking water quality, wastewater treatment, food production and other environmental applications.

BIOZ 405. Gross Anatomy Laboratory. 2 Hours.

Semester course; 1 recitation and 3 lab hours. 2 credits. Prerequisite: BIOL 205 or BIOL 402 with a minimum grade of B. Enrollment requires permission of the instructor. Lab-based advanced human anatomy course utilizing regional-based cadaver dissection to focus on integrative functions of anatomical structures. Anatomical anomalies, clinical application and relevant advances are applied in the context of exploratory learning and emergent topics. Enrollment is intended for pre-health and biology majors.

BIOZ 416. Ornithology Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisite: BIOL 317 with a minimum grade of C. Pre- or corequisite: BIOL 416. A field-oriented course that develops basic skills in bird identification by sight and sound for a variety of regional taxa with emphasis on avian anatomy and adaptations for flight. Students conduct an independent or small-group research project on a question of their choice relating to avian ecology or behavior, including experimental design, data collection and analysis, and a final project presentation.

BIOZ 418. Integrative Physiology Laboratory. 3 Hours.

Semester course; 2 recitation and 3 laboratory hours (hybrid course taught mostly on campus). 3 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152; and BIOL 300; or equivalents, all with minimum grades of C. Corequisite: BIOL 411 or BIOL 423. A comparative laboratory investigation of physiological responses across plant and animal taxa, with application to changing environmental conditions and ecological interactions. Topics include metabolism, water balance, gas exchange, resource allocation and chemical signaling.

BIOZ 438. Forensic Molecular Biology Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Pre- or corequisite: BIOL/FRSC 438. Provides comprehensive coverage of the various types of DNA testing currently used in forensic science laboratories. Students will have hands-on experience with the analytical equipment employed in forensic science laboratories and the techniques for human identification in forensic casework. Students also will explore and practice both scientific writing and writing of DNA case reports. Crosslisted as: FRSZ 438.

BIOZ 476. Molecular Capstone Laboratory. 2 Hours.

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisites: BIOL 300 and BIOL 310, each with a minimum grade of C; and 90 credit hours of undergraduate course work. Application of basic methods used in cellular and molecular biology to the investigation of topics of current biological interest. Emphasis on experimental design, data collection and analysis, communication skills, critical thinking, and ethical and social responsibility.

BIOZ 491. Topics in Biology Laboratory. 1-4 Hours.

Semester course; variable hours. Variable credit. Prerequisites: BIOL 300 with a minimum grade of C. Laboratory investigations in a selected topic of biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.