



BIOLOGY

STUDENT HANDBOOK

2019-2020



Clarkson™

BIOLOGY HANDBOOK

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Department of Biology – Clarkson University

I. General Information

Web Site: <http://www.clarkson.edu/academics/arts-sciences/biology>

Administrative Secretary: Vicki Wilson (ywilson@clarkson.edu)
Diana Richardson (drichard@clarkson.edu)

Phone: 1-800-527-6577 and ask for the Biology Department, or call 315-268-2342

Faculty: **Biology Department Chair:** Tom Langen
Professors: Alan Christian, Tom Langen, Thomas Lufkin, Michael Twiss
Associate Professors: Damien Samways, Kenneth Wallace
Assistant Professors: Susan Bailey, Andrew David, Beatrice Hernout, Ginger Hunter, Petra Kraus, Stefanie Kring, Shantanu Sur, Michelle Yoo
Professor Emeritus: Craig Woodworth
Adjunct Professors: Deborah Brown, Ali Boolani
Laboratory Coordinator: Stefanie Kring
Bayard & Virginia Clarkson Endowed Chair of Biology: Thomas Lufkin
Director of Graduate Studies: Thomas Lufkin
Premedical and Health Professions Advisor: Damien Samways

II. Mission:

As teachers of Biology, our goal is to convey a deep understanding of the natural world and the workings of life to our students. We aim to help students learn through instructor-guided mastery of information and by teaching them to be independent thinkers. As life scientists, we strive to advance the frontier of knowledge in biology through original research that generates new insights and leads to discoveries that benefit humanity and preserve the environment. We are privileged to work as scholar-scientists and strive to be generous in serving our institution, our profession, and our community. We aim to train and graduate well-prepared students who have the ability and experience necessary to succeed and advance to the next level, whether the next level is graduate school, professional school in a health-related field, environmental work, employment in the biotechnology sector, or any other worthwhile goal that they wish to pursue. In pursuing a combined mission of education, research, and service, we hope to foster productive interpersonal interactions that inspire faculty, staff, and students alike to excel and accomplish great things.

III. Vision of a Biology Education:

Clarkson Biology students will

- Become proficient in biology by mastering the core knowledge curriculum and specializing in various subfields of the life sciences represented by a wide array of course electives.
- Be active participants in acquiring knowledge and scientific skills through inquiry-based laboratories and a variety of practical learning experiences that include directed study and thesis-based courses.
- Develop the ability to think critically and solve problems through exposure to quantitative laboratory- and field-based research, the history of biological science, and the primary research literature.
- Learn how to use appropriate technology, methodology, and informational tools that accelerate progress in the workplace, field, and laboratory such as computer software, bioinformatics, genetic engineering, cell culture, microscopy, etc.
- Acquire oral and written communication skills essential for work in all fields of biology and the health professions.
- Develop social skills of interpersonal interaction including an awareness and appreciation of cultural diversity that enhances progress and enriches the pursuit of scientific endeavors.
- Gain an appreciation of the fundamental importance of professional ethical behavior in society and the workplace.
- Develop personal insight to current issues of bioethical concern ranging from preservation of global biodiversity to the improvement of human health through modern advances in biotechnology.
- Learn about career opportunities in the life sciences in preparation for seeking job opportunities and professional work after graduation.

Clarkson Biology faculty

- Strive for excellence in teaching and research through personal interactions with students and colleagues.
- Serve as mentors and advocates of our students as they journey through their undergraduate education and mature toward readiness to engage in fulfilling careers.
- Inspire students with a sense of the significance of knowledge, the excitement of research, and the thrill of scientific discovery.
- Foster an appreciation of the dynamism and beauty of living systems through our enthusiasm for the discipline of Biology.
- Share our scientific expertise in service to the campus community and society at large.

Objectives

All students graduating from our program will

- Have an introductory general understanding of Biology's five core concepts (evolution; structure and function; information flow, exchange and storage; pathways and transformations of energy and matter; and systems-thinking) as applied across all levels of biological organization.

- Have an advanced, in-depth understanding of concepts, content, and competencies in one sub-discipline of biology.
- Have an understanding and be able to apply sound methods of scientific inquiry to answer a biological question.
- Follow protocols and safety procedures, and know how to learn to use unfamiliar bioscience technologies and methodologies.
- Be able to use quantitative reasoning and analytical methods to interpret and analyze data.
- Be able to work effectively as a member of a team to complete a research project.
- Be able to communicate scientific research results effectively via written technical reports and oral presentations.
- Know how to present themselves professionally.
- Know and practice ethical professional behavior.
- Understand that bioscience technologies and research findings affect society, and how decisions about the application of bioscience knowledge are made.
- Be familiar with and be prepared to meet the requirements of a profession they chose to pursue.

Outcomes

Students who have received a Clarkson B.S. degree in Biology will

- Be confident and proficient in their mastery of bioscience concepts, content, and competencies.
- Be hired into a career-track position, or matriculate into a graduate research or professional program.
- Be effective communicators.
- Be ethical professionals.
- Have a growth mindset and motivation to be life-long learners.
- Make a positive contribution to their communities and society.

How the Objectives are Accomplished:

- Core course requirements (Biology, affiliated math and science, and Common Experience courses).
- Upper-level bioscience course electives.
- Bioscience (and affiliated science) laboratory course requirements.
- Faculty advisor, pre-professional advisor, and career center mentoring.
- Professional experience requirement.
- Opportunities for research and teaching.
- Seminar series.
- Student professional societies and clubs.

How the Outcomes are Evaluated:

- Biology Mastery Field Test.
- National Survey of Student Engagement.
- University retention and completion statistics.
- Biology Department faculty self-study.
- Biology Department strategic plan.
- Record of performance on standardized graduate/professional tests (MCAT, GRE etc.).
- Record of alumni careers.
- Feedback from employers & professional program directors.
- Alumni feedback.

IV. REQUIREMENTS FOR A BIOLOGY DEGREE AT CLARKSON UNIVERSITY

1. Biology Core Requirements (17-19 credits)
2. Biology Elective Requirements (21-23 additional credits, to a total of 40 biology credits)
3. Clarkson Common Experience Requirements (22 credits)
 - First Year Seminar (1 credit)
 - The Clarkson Seminar (3 credits)
 - Knowledge Area/UC (15 credits)
 - Technology (3 credits)
 - Professional Experience in Biology
4. Physical Sciences (25 – 27 credits)
 - Chemistry (17 – 19 credits)
 - Physics (8 credits)
5. Mathematics/Computer Science: Includes calculus, statistics, and one additional math, statistics, or computer science course (9-10 credits)
6. Free electives (additional courses up to 120 overall credits)

V. REQUIRED AND ELECTIVE BIOLOGY COURSES

Core Biology Courses: 17-19 credits

These courses are required for all Biology majors:

- BY140/142 Biology I - Inheritance, Evolution, and Diversity (3 cr.)/Biology I Laboratory (2 cr.)
- BY160/162 Biology II - Cellular and Molecular Biology (3 cr.)/Biology II Laboratory (2 cr.)
- BY214 Genetics
- BY401 Professional Assessment
- Two BY lab courses numbered 200 or above not including BY405 or BY 410 (4-6 cr.)

Biology Electives: *a minimum of 40 total credits of BY courses are required. 17-19 of these are covered in the core Biology courses, listed above. Therefore, a minimum of 21-23 additional Biology Elective credits are needed. No more than 6 credits of directed research can count toward these 40 credits (students may enroll for additional directed research credits in place of Free Elective credits).*

Professional Experience and Directed Studies

Completion of one of the following:

- BY405 Undergraduate Research in Bioscience
- BY410 Undergraduate Thesis Research in Bioscience
- BY495 Undergraduate Teaching Assistantship in Bioscience
- BY498 Internship in Bioscience
- BY499 Professional Experience in Bioscience

Additional Required and Recommended Courses for Certain Concentrations

Courses, beyond those required for a Clarkson Biology degree, for students with defined career goals. Those listed as required are not required for a Clarkson degree, but may be required for acceptance into a professional program. Please see your pre-professional advisor to confirm specific requirements / recommended courses for each professional program

Pre-Medical School:

English Literature and/or Composition (two courses)
PY 151 Introduction to Psychology
SOC 201 Introduction to Society

Additional recommended courses:

BY 471/BY 473, BY 472/BY 474 Anatomy & Physiology I and II
BY 320 or 448 Microbiology or Medical Microbiology

Pre-Physical Therapy School:

BY 471/BY 473, BY 472/BY 474 Anatomy & Physiology I and II
PY 151 Introduction to Psychology
PY 370 Developmental Psychology
Medical Terminology

Pre-Occupational Therapy School:

BY 471/BY 473, BY 472/BY 474 Anatomy & Physiology I and II
PY 151 Introduction to Psychology
PY 370 Developmental Psychology
PY 462 Abnormal Psychology
Social Sciences (two courses, e.g. SOC 201 Introduction to Society)

Additional recommended courses:

COMM 217 Introduction to Public Speaking
English Composition/Critical Thinking (two courses)
Scientific writing
3D skill/craft*

* Example: Knitting, woodwork, sculpting, loom work, ceramics, sewing, beading

Pre-Physicians Assistants School:

Additional recommended courses:

BY 471/BY 473, BY 472/BY 474 Anatomy & Physiology I and II
BY 320/BY 322 Microbiology or BY 448 Medical Microbiology

Pre-Vet Students:

Most veterinarian schools require the following:

English Composition (2 semesters)
BY450 Biochemistry

Some veterinarian schools require:

Microbiology (BY 320/BY 322 Microbiology or BY 448 Medical Microbiology)

A few veterinarian schools (7 out of 53 US and Canadian schools) require:

Nutrition, Physiology, and Animal Science

Pre-Dentistry Students:

English Literature and/or Composition (2-3 courses)

Additional recommended courses (check with specific school for requirements):

BY 471/BY 473, BY 472/BY 474 Anatomy & Physiology I and II

BY 320/BY 322 Microbiology or BY 448 Medical Microbiology

BY450 Biochemistry

VI. REQUIREMENTS FOR A BIOLOGY SENIOR THESIS

The biology senior thesis provides an opportunity for you to work on a research problem with a member of the biology faculty. You will be expected to design experiments in consultation with your faculty advisor, and to perform and evaluate the results of these experiments. You will prepare a thesis describing the results of your research, and to present the results to biology faculty and students at the annual Clarkson Symposium for Undergraduate Research in the spring. The senior thesis can be a valuable experience. It will give you some appreciation of what biological research involves and illustrate how various skills can be used to solve real problems. Senior thesis work can be particularly helpful if you plan to enter professional or graduate school after you graduate from Clarkson.

Eligibility Requirements for Biology Senior Thesis Candidacy

- Biology Major
- Biology GPA and Overall GPA 3.0 or better
- Approved thesis proposal, signed by the candidate, the candidate's advisor, and the senior thesis director

Requirements for Completion of the Biology Senior Thesis

- Completion of the Biology Major
- An equivalent of at least 6 credit hours of research, including at least 1 credit BY410 Undergraduate Thesis. (*Summer research experience = 6 credit hour equivalents 1 credit hour equivalent = 4 hours research per week for 16 weeks = 64 hours research*)
- Public presentation of the thesis research (e.g. SURE or RAPS Conference)
- Approved thesis, signed by the candidate, the candidate's advisor, a second thesis reader, and the senior thesis director

VII. REQUIREMENTS FOR A BIOLOGY MINOR (at least 19 credits)

1. Core courses (9 credits)
Students must take BY140 Biology I (3 credits) and BY160 Biology II (3 credits) and at least one of the following:
 - BY214 Genetics (3 credits)
 - BY222 Ecology (3 credits)
 - BY320 Microbiology (3 credits)
 - BY360 Physiology (3 credits)
2. Elective courses (9 credits)
Students must take at least 9 credits of Biology courses numbered 300 or above. Examples in Section V.
3. Laboratory requirement (2 credits): Students must take at least 1 of the following laboratory courses:
 - BY224 General Ecology Laboratory (2 credit)
 - BY142 Biology I Lab (2 credits)

BY162 Biology II Lab (2 credits)
BY322 Microbiology Laboratory (2 credit)
BY362 Physiology Laboratory (2 credit)

VIII. REQUIREMENTS FOR A MEDICINE AND HEALTH CARE MINOR

A minor in *Medicine and Healthcare* is available to students in all degree programs. To obtain a minor, students must complete 23 credits:

Required courses (14 credits):

1. BY 471 Anatomy and Physiology I [Fall]
2. PY463 Health Psychology [C1, Fall]
3. *Either* PHIL 241 Medical Ethics [UNIV/CGI/IG, Odd Springs]
Or BIE 400 Responsible Conduct of Research [STS, Spring]
4. *Either* HIST 335 History of Medicine in Europe and North America [UNIV/CGI/STS, C1, Fall]
Or HIST 321 History of Public Health in America [UNIV/CSO/STS, C1, Spring?]
5. HS 220 Medicine & Healthcare Profession Seminar (new course, 1 credit, Spring?)
6. HS 405 Experiential Learning in Healthcare (new course, 1 credit, every semester)

Electives (9 credits): *Electives include at least three credits from each of the three categories:*

Category 1 Electives – Biomedical Science & Engineering

BY 315 Bioinformatics for Disease Research [TECH]
BY 324 Parasitology
BY 383 Molecular Genetics & Human Disease
BY 416/ EHS 415 Principals of Toxicology & Epidemiology
BY 419 Immunology [C1]
BY 363 Pharmacology of Infectious Disease
BY 440 Introduction to Biomedical Rehabilitation Engineering & Science
BY 448 Medical Microbiology [C1]
BY 452 Pharmacology
BY 455 Cell & Molecular Biology of Cancer [C1]
BY 472 Anatomy and Physiology II
BY 473 Anatomy and Physiology I Lab
BY 474 Anatomy and Physiology II Lab [TECH]
BY 476 Current Topics in Biology & Medicine [C1]
BY 485 Neural Engineering
BY 488 Stem Cells & Regenerative Medicine
BR 200 Intro to Biomedical & Rehabilitation Engineering [STS/C2]
CM 444 Medicinal Chemistry
CM 453 Introduction to Biomaterials
CM 460 Biochemistry I
PY 462 Abnormal Psychology

Category 2 – Healthcare & Social Sciences

HS 200 Health Coaches I
PY 310 Human Sexuality [UNIV/CGI/IG]
PY 317 Psychology of Psychoactive Drugs [UNIV/CGI/IG]
PY 363 Judgment and Decision Making for the Biomedical Sciences
PY 411 Counseling Psychology: Theory and Practice
SOC 330 Health, Wealth, Inequality and the Environment [UNIV/CGI/STS, C1]
POL 431 Health Care Policy [UNIV/EC/STS C1]

Category 3 – Healthcare & the Humanities

ANTH 330 Men and Masculinities [CSO]
Either PHIL 241 Medical Ethics [UNIV/CGI/IG, Odd Springs]
Or BIE 400 Responsible Conduct of Research [STS, Spring] – *whichever not used to fulfill the required course.*

HIST 270 Introduction to Society, Culture & Biology [UNIV/CSO/STS]
 HIST 338 Women, Gender and Science in American History [UNIV/CSO/STS C1]
 HIST 353 Medicine & Ethics, 3rd Reich [UNIV/IG/STS C1]
 HIST 331 Ancient Medicine and Magic [STS]
 HIST 459 Neuroscience & Society [STS C1]
Either HIST 335 History of Medicine in Europe and North America [UNIV/CGI/STS, C1]
Or HIST 321 History of Public Health in America [UNIV/CSO/STS, C1] – *whichever not used to fulfill the required course.*
 POL/PHIL 380 The Law and Bioethics [CGI, C1]
 SS 221 Introduction to Sexuality [UNIV/CSO/IG C1]

IX. MINOR IN COGNITIVE NEUROSCIENCE

Cognitive neuroscience is the study of the physiological and biochemical mechanisms underlying higher order human cognitive processes, such as attention, memory, perception, and emotion. The Cognitive Neuroscience minor will be of interest to students pursuing careers in the clinical health sciences (medicine, physical therapy, clinical psychology, neuropsychology) and those wishing to do basic and applied research on the central nervous system.

REQUIREMENTS (*beyond requirement for the Clarkson Biology degree*)

Required Basic Science Courses

PY151 Introduction to Psychology (3 cr)
 BY140 Biology I: Inheritance, evolution and diversity (3 cr)
 BY142 Biology I Laboratory (2 cr)
 BY160 Biology II: Cellular and Molecular Biology (3 cr)
 BY162 Biology II Laboratory (2 cr)
 CM131 General Chemistry I (4 cr)¹
 CM132 General Chemistry II (4 cr)¹
 PH141 Physics for Life Sciences I (4 cr)²
 PH142 Physics for Life Sciences II (4 cr)²

Required Cognitive Neuroscience Courses (9 credits)

PY458 Cognitive Neuroscience (3 cr)
 BY/PY454 Physiological Psychology¹ (3 cr)
 BY/PY460 Neurobiology (3 cr)

Elective Psychology Courses: 2 courses (6 credits) chosen from the following:

PY317 Psychology of Psychoactive Drugs (3 cr)
 PY/BY357 Human Cognitive Evolution (3 cr)
 BY/PY358 Animal Learning and Cognition (3 cr)
 PY359 Perception (3 cr)
 PY360 Learning and Memory (3 cr)
 PY462 Abnormal Psychology (3 cr)
 PY463 Health Psychology (3 cr)

Elective Biology Courses: 2 courses (6 cr) chosen from the following:

BY360 Physiology (3 cr)
 BY214 Genetics (3 cr)
 BY310 Developmental Biology (3 cr)
 BY350 Comparative Anatomy (3 cr)
 BY471 Anatomy and Physiology I (3 cr)
 BY472 Anatomy and Physiology II (3 cr)

¹Biology majors taking the cognitive neuroscience minor cannot use PY/BY454 as one of their Biology elective courses

X. 4+1 PLAN FOR MASTERS OF BASIC SCIENCE (MBS) & INTERDISCIPLINARY BIOSCIENCE & BIOTECHNOLOGY (IBB-MS) M.S. DEGREE PROGRAMS

OBJECTIVES: Provide academically-strong Clarkson undergraduates a head-start and rapid track to a bioscience M.S. degree.

OUTCOMES:

4+1 M.S. Degree Students will

- 1) Complete all of the requirements and meet the outcomes of the M.S. graduate program in which they matriculate.
- 2) Complete the M.S. degree after one year of additional classwork beyond the B.S. degree.

PROGRAM PREREQUISITE:

Students will apply in the junior year (5th or 6th semester) at Clarkson University.

Requirements:

- 1) Either a Clarkson University Biology or Biomolecular Science Major or else another Clarkson University major that has taken the introductory biology core (BY 140, 142, 160, 162) and genetics (BY 214).
- 2) GPA minimum of 3.25 overall and for Biology courses.
- 3) Likelihood of completing undergraduate degree requirements plus two additional graduate courses during the senior year (7th and 8th semesters).
- 4) Short essay explaining why the student is motivated to pursue a MS degree.
- 5) Specification of which M.S. program the student plans to pursue.

PROGRAM:

During the senior year (7th and 8th semesters), a student in the 4+1 MS program will take minimally three-credits (typically one course) graduate-level bioscience coursework each semester (500 or 600 level course with a BY designator). This graduate coursework will not count toward the undergraduate degree; it is in addition to the required 40 credits of BY designated coursework for the undergraduate degree. At the end of the senior year (upon graduation) the student will have completed at least 6 credits of the 30 credits required for a M.S. degree.

If the student has made adequate progress in the graduate coursework (grades B or better), the student will be immediately matriculated into the M.S. degree program and be granted graduate student status. During the 5th year (9th and 10th semesters) the student will be expected to complete all additional coursework and research / project requirements of the graduate program (MBS or MS-IBB). This will require 12 credit hours each of the two semesters to complete the degree requirements.

XI. BIOLOGY SAMPLE CURRICULUM

Biology Major – Clarkson Common Experience

<i>Fall 1</i>	<i>Cr</i>	<i>Spring 1</i>	<i>Cr</i>
BY140 Biology I	3	BY160 Biology II	3
BY142 Biology II Lab	2	BY162 Biology II Lab	2
CM131 General Chemistry I or (CM103/CM105 Structure & Bonding)	4	CM132 General Chemistry II or(CM104 Equilibrium/CM106 Chemistry II lab)	4
MA180 Intro to College Math (or MA131 Calculus I) 3	4	MA181 Basic Calculus (or MA132 Calculus II) 3	3
UNIV190 Clarkson Seminar	3	Knowledge Area Elective	3
FY100 First Year Seminar	1		
	17		15
<i>Fall 2</i>		<i>Spring 2</i>	
Biology Elective	5	BY214 Genetics	3
CM 241 Organic Chem I	3	CM242 Org Chem II	3
PH 141 Physics Life Sci I (or PH 131 Physics I)	4	CM244 Org Chem Lab	3
Knowledge/UC Elective	3	STAT318 Biostatistics	4
		PH142 Physics for Life Sci II (or PH132 Physics II)	4
	15		17
<i>Fall 3</i>		<i>Spring 3</i>	
BY Biology Elective	6	BY Biology Elective	8
Knowledge / UC Elective	3	Technology Elective	3
Free Elective	6	Free Elective	3
	15		14
<i>Fall 4</i>		<i>Spring 4</i>	
BY Biology Elective	5	BY Biology Elective	6
Knowledge / UC Elective	3	Knowledge/UC Elective	3
Free Elective	6	Free Elective	3
Prof Exp in Biology	1	BY401 Professional Assessment	0
	15		12
Total Credits			120

XII. The Clarkson Trudeau Biomedical Scholars Program

The Clarkson Trudeau Biomedical Scholars Program is an intensive semester-long living and learning experience (the “Trudeau Semester”) and a separate summer research program that both take place off campus at the renowned Trudeau Institute in Saranac Lake, New York.

The 15-credit program Trudeau Semester is an undergraduate program designed to provide a select group of undergraduate students the opportunity to learn multidisciplinary aspect of bioscience related to the human health field. The program is specifically designed for students from the majors of Biology, Biomolecular Science, Chemistry and Chemical & Biomolecular Engineering, and also serves as a professional experience. The Trudeau Semester is taught by Clarkson and Trudeau Institute faculty who are experts in their field. The academic program provides a range of disciplines that by design will each contribute to a related topic that is the focus of a semester-long, integrative project that aims to demonstrate how technology serves humanity, a core Clarkson value

Students study and conduct a research project at the Trudeau Institute located near their townhouse residences in Saranac Lake. At the Trudeau Institute there is dedicated laboratory space for instruction and study offices. Each course is 3 weeks in duration, with the exception of the Term Integrated Research Project, which the students are involved with the entire semester. Students present their research findings at the Spring Research & Project Showcase (RAPS) conference that takes each semester on the Clarkson University Campus, in addition to a public presentation.

For additional information see the Trudeau Semester web site at

<http://www.clarkson.edu/trudeauscholar/>.

XIII. HEALTH-RELATED CAMPUS ORGANIZATIONS

Animal Science Club

Advisor: Andrew David

Doctors Without Borders

Advisor: Dr. JoAnn Rogers

EMS Club

Advisor: David Delisle

Humane Society Club

Advisor:

Minority Association of Premedical Students (MAPS)

Advisor:

Phi Delta Epsilon (Medical Fraternity)

Advisors: Dr. Stephen Casper

Pre-PA Club

Advisor: Terri Joyce

Pre-PT Club

Advisor: Dr. Vicki LaFay

Tri-Beta Biological Honor Society

Advisor: Dr. Shantanu Sur

XIV. Awards for Biology Undergraduates

Biology Department Outstanding Senior Award: This award is presented to an outstanding senior biology major. It is the most prestigious award that the department provides and the recipient is chosen by a vote of faculty in the Biology Department. The criteria considered for this award includes; high GPA, participation in undergraduate research or corresponding professional experience, involvement in extracurricular activities and community service, and demonstration of leadership skills. The recipient is expected to excel in more than one of these areas.

Biology Department Outstanding Research Award: The recipient of this award is chosen by a panel of faculty from the Biology Department who evaluate undergraduate senior and Honors Program research projects. The recipient should have conducted original research and should be in the process of synthesizing a thesis.

Biology Department Undergraduate Teaching Award: This award is presented to an undergraduate biology major who has demonstrated excellence in teaching or tutoring biology. The recipient of this award will be chosen by the Director of Freshman Biology in consultation with other biology faculty.

Biology Department Outstanding Leadership and Service Award: The recipient of this award will be chosen by faculty from the Biology department based on the candidate's participation in departmental events (Open House, Tri-Beta, teaching assistant or tutoring) and by demonstration of leadership in campus organizations including clubs, fraternities and athletic teams.

Biology Department Sophomore Award: Given to the sophomore biology major who has attained the highest overall GPA in their first three semesters at Clarkson.

XV. COURSE DESCRIPTIONS

BY110 Biology and Society - Credits (3)

Definition of science, the scientific method, overview and scope of modern biology, introduction to biomolecules and cell structure, Mendelian inheritance and genetics, human physiology, evolution, and ecology. Course topics are presented from the perspective of current issues in biotechnology, medicine, and human impact on the biosphere. This course is intended for students who are not majoring in the biological sciences and may not be taken by biology majors or minors with credit for BY100 or BY140.

BY112 Laboratory for Biology and Society - Credits (1)

Companion laboratory course to BY110 introducing students to the scientific method of laboratory and field experimentation used by contemporary biologists. Co-requisite: BY110.

BY115 Introduction to Environmental Sustainability-Credits (3)

This course will provide students with a basic understanding of environmental science and sustainability concepts. Students will gain an understanding of the impacts that humans have on atmosphere, lithosphere, and hydrosphere. The course will also focus on sustainability concepts that are particularly relevant to business practices and engineering. Specific case studies will also be used to increase understanding of how businesses are tailoring their practices to meet sustainability goals. The course will be lecture based, and active learning exercises will be implemented to enhance understanding of sustainability concepts. Students will be evaluated through homework, examinations, and a group project.

BY120 Introduction to Biotechnology Sciences and their Applications- Credits (3)

Students in today's competitive market often need to possess multifaceted knowledge and skills. The interdisciplinary structure of BY120 encourages collaborations across schools and fields. The syllabus is designed to meet the needs and spark the interest of non-biology majors in biotechnology. By creating a stimulating, lecture-based, solid foundation in basic molecular biology and providing insight into the innovative discipline of biotechnology, students will be inspired and encouraged to apply their own academic backgrounds in a creative manner to drive innovations and applications in this field forward and to investigate possible employment niches for themselves. Aside from covering the fundamentals, the lectures will venture into bioinformatics, DNA amplification and sequencing technologies, genetic engineering and gene expression systems, large scale production, molecular diagnostics, personalized medicine, commercial products, gene therapy, stem cells, transgenic animals and plants, synthetic biology, patenting, as well as societal and ethical impacts. Extra credit opportunities will be offered for students who would like to deepen their knowledge on specific topics.

BY130 Contemporary Issues in Environmental Sciences for Non-Majors - Credits (3)

This course examines how human activity impacts the environment. Topics include air and water pollution, environmental systems management, industrial ecology and environmental policy with emphasis on the multidimensional aspects of currently environmental issues. Case studies of chemical exposures, life cycle assessments, and integrated resources management will be used to discuss the process of environmental decision making.

BY140 Biology I – Inheritance, Evolution, and Diversity - Credits (3)

Corequisites: BY142.

Introduction to the scientific method, mitotic and meiotic cell division, genetic inheritance, evolution of species, phylogenetics, systematics, paleobiology, survey of the tree of life, population biology, ecology and behavior.

BY142 Biology I Laboratory - Credits (2)

Corequisites: BY140

Companion laboratory course to BY140 providing practical exposure to the scientific method of hypothesis testing, presentation and statistical analysis of biological data, writing scientific reports and papers in the context of field and laboratory experimentation related to BY140. Offered fall semester.

BY160 Biology II – Cellular and Molecular Biology (Sci) - Credits (3)

Corequisite: BY162

Introduction to biomolecules, organelles, and cytoarchitecture of cells, energy metabolism and photosynthesis, DNA replication, transcription of RNA, protein synthesis, gene regulations, development and differentiation with a view towards biotechnology.

BY162 Biology II Laboratory - Credits (2)

Corequisite: BY160

Companion laboratory course to BY160 providing a hands-on experience to put your knowledge to the test. Here you will be introduced to the scientific method and you will be describing, analyzing, and reporting your results the way a scientist would in a real laboratory setting. Experiments include chemical properties of the molecules of life, enzymatic analyses, microscopy and micro-dissections, photosynthesis and respiration, mitosis and meiosis, *Drosophila* genetics, molecular biology of nucleic acids and bacteriology. You will be presenting your results both orally and in writing.

BY214 Genetics – (STS) Credits (3)

Prerequisites: BY160 or consent of the instructor

The overall goal of this course is to provide a comprehensive introduction to the science of genetics. Classical principles of Mendelian genetics will be covered, however, the emphasis will be placed on fundamentals of molecular genetics and recent advances. Major topics include gene structure and function, genetic recombination, genetic engineering, genomics, gene and chromosome mutations, regulation of gene transcription, cell cycle and cancer genetics, developmental genetics, and an introduction to population genetics.

BY216 Classical Genetics Laboratory Theory and Practice-Credits (4)

Hands-on experimental testing of genetic concepts using *D. melanogaster* as a model organism.

Objectives: to learn how to develop testable hypotheses and use the scientific method to interpret and analyze data and write a scientific manuscript of experimental findings. Outcomes: students will become proficient in using their knowledge from previous biology courses, especially BY214 (required) as well as newly acquired knowledge from lectures and literature searches to design experiments, include proper controls, objectively analyze data, use statistical methods to evaluate their results, and gain experience in presenting their findings both orally and in written form.

BY222 Ecology – (C1) Credits (3)

Prerequisite: BY140 or Corequisite: BY140

Ecology is the study of factors that control the distribution and abundance of species in nature. Ecological interactions will be explored at the individual through ecosystem level in terrestrial, freshwater, and marine habitats. Emphasis will be on fundamental ecology, but applications to human-related problems will be explored.

BY224 Ecology Lab – (C1) Credits (2)

Corequisite: BY222.

Field and laboratory exploration of physical, chemical, and biological factors influencing animal and plant species, populations, and communities in upstate New York. Students will learn field and laboratory techniques in ecology and general identification of some organismal groups. Course will include required field trips to surrounding habitats and laboratory experiments.

BY280 (EV280) Environmental Science-Credits (3)

Prerequisites: Sophomore standing, CM131/CM132 or CM103/CM104 or consent of the instructor.

This course will investigate the key concepts and principles of environmental science, emphasizing human impacts to the earth. The themes will include, energy flows through nature, and biogeochemical systems and how they have been perturbed by human activities. Technology and population growth have enabled humans to increase both the rate and scale of their impact on the environment. Quantitative analysis of air, soil, and water quality on local, regional, and global scales will be a significant component of the course. Emerging principles in environment science, including sustainability, industrial ecology, risk assessment, and the precautionary principle will be introduced. The course will prepare students to qualitatively and quantitatively analyze fluid and contaminant flow in varied biological and geologic systems.

BY300 Recent Advances in Biological Research – (C1) Credits (1)

Prerequisites: BY140 and BY160

The objective of this course is to present recent advances in biological and biomolecular research, and to describe opportunities for graduate study and undergraduate summer research. Students will receive one credit for attending biology seminars (6 per semester), reading a journal article prior to each presentation, writing short review of each seminar, and participating in discussions. This course can be taken for credit more than once.

BY 302 Plant Science of Northern New York-Credits (3)

Prerequisites: BY140/142 and BY160/162, or consent of the instructor.

In this course we will undertake a comparative survey of the major groups of fungi, nonvascular and vascular plants present in our local environment. Emphasis is placed on the structure, function and ecology of various groups. The role of plants in the northern New York biosphere as well as the reciprocal interactions with human activities will be addressed.

BY304 Introductory Zoology- Credits (3)

Prerequisites: BY 140/142 and BY 160/162, or consent of the instructor

In this course, we will conduct a diversity survey of animal life with emphasis on invertebrates. Course content will primarily consist of comparing the major animal phyla emphasizing integration of form, function, ecology, and phylogeny.

BY312 (EV 312) Adirondack Ecology and Environmental Science-(TECH) Credits (3)

Prerequisites: Enrollment is limited to those students participating in the Adirondack Semester Program.

This course introduces ecological and environmental science concepts relevant for understanding the structure and function of terrestrial, aquatic, and human systems in the Adirondack Park. Students will learn to identify important plant and animal species representative of the Adirondack Mountains, and learn major features of ecological systems in the Park. The course will also provide the students an assessment of human impacts on the ecology of the Adirondack Park.

BY313 (EV 313) Biogeochemical Earth Systems Science- (TECH) Credits (3)

Prerequisites: CM132 (or CM104), or consent of the instructor

This course will investigate the key concepts and principles of environmental science emphasizing the earth's biogeochemical cycles and how they have been perturbed by human activities. Quantitative analysis of air, soil and water quality on local, regional and global scales will be a significant component of the course. Emerging principles in environmental science, including sustainability, industrial ecology, risk assessment and the precautionary principle will be introduced. In addition to the quantitative aspects, the course will consider the historical, social, and political contexts in which the practice of environmental science takes place.

BY314 (CM314) Bioinformatics – (TECH) Credits (4)

Prerequisites: BY160 and BY214

This course and companion lab provides students with an introduction to the theory and methods of DNA and protein sequence analysis. Students receive experience retrieving information from sequence and genome databases. Methods of sequence alignments include dynamic programming and statistical methods of molecular evolutionary change are outlined. Emphasis is also placed on calculating the statistical significance of results. Protein structural alignments and displays, and structural prediction are covered. Gene prediction algorithms, methods of phylogenetic analysis and database similarity searching are explained. The course introduces students to the analysis of genomes for protein families and domains and to the analysis of gene expression patterns.

BY315 Bioinformatics for Disease Research-(TECH, STS) Credits (3)

This course will provide students with an introduction to the theory and methods of DNA, RNA, and protein sequence analysis in the context of disease biology. Integrated computer laboratory exercises will give students significant experience retrieving, manipulating, and analyzing information from sequence and genome databases. Enrollment is limited to students participating in the Trudeau Semester.

BY319 Current Readings in Animal Behavior- Credits (1)

Prerequisites: BY222 or PY151

The field of animal behavior is a rapidly advancing one, especially at the interface of neurobiology and cognition, and the interface of cognition and functional analysis of behavior (behavioral ecology and sociobiology). This one credit hour course is designed as a 'journal club' with a focus on the latest developments in theory and empirical research on animal behavior. The course is intended for any student who has a sincere interest in integrative animal behavior.

BY320 Microbiology - Credits (3)

Pre-requisites: BY160, BY214 and CM132 or CM104, or consent of instructor.

The diverse biology of microbial life forms will be reviewed and application to human health and society, the natural environment, and biotechnology will be emphasized. Upon completion of the course, students will be capable of assessing microbial growth and metabolism and understand its applications in natural and engineered environments.

BY322 Microbiology Laboratory –(C2) Credits (2)

Pre-requisites: BY162, CM132 or CM104, or consent of instructor.

Laboratory exercises stress the classical techniques for handling bacteria and demonstrate concepts presented in the lecture series: both clinical and environmental aspects of applied microbiology will be explored. Upon completion of the course, students will be capable of safely manipulating microbes in a laboratory setting, as well as competent in techniques used to observe and culture microbes.

BY324 Parasitology-Credits (3)

The natural history, ecology and molecular biology of parasites are explored with an emphasis on life cycles, host/parasite interactions and evolution of parasitism. Basic principles of epidemiology, transmission, diagnosis, treatment and prevention are examined in parasites of medical, veterinary, and economic importance. Lectures will be supplemented by demonstrations of fixed materials and by exercises in identification and diagnoses.

BY328 Conservation Biology - Credits (3)

Prerequisites: BY222 or consent of the instructor.

Conservation biology is about how human-provoked environmental changes impact biodiversity, and what can be done to ameliorate these impacts. Major topics of this course will include the problems of small population size on the long-term persistence of a species, habitat fragmentation and nature reserve design, invasive species, consequences of extinctions on ecosystem processes and community structure, and the possible effects on biodiversity of global climate change.

BY330 Great Lakes Water Protection- (C1, UNIV: CGI,STS) Credits (3)

Prerequisite: sophomore or greater standing

The Laurentian Great Lakes contain 20% of the world's surface fresh water and serve both water supply and waste disposal services for over 30 million residents in the United States and Canada. Technological advances have controlled the outflow of the Great Lakes at the St. Lawrence River system and this has brought with it social benefits and environmental costs. The United States and Canada share the management of this resource and have shared notable success controlling environmental consequences of development yet are faced with emerging issues. The system will be examined from a multidisciplinary, multinational perspective to illustrate that a shared resource can be maintained. Students will be able to understand the forces (geomorphic, biological, chemical, social, economic, and political) that have shaped and impacted a globally significant resource.

BY340 (PY340) Behavioral Ecology and Sociobiology- (IG) Credits (3)

Prerequisites: BY140 or PY151 or consent of instructor.

This course is concerned with the adaptive functions of animal behavior, emphasizing ecological and evolutionary perspectives. Topics covered include foraging behavior, sexual selection, social systems, parental care, and cooperation and conflict. One major focus will be on evaluating the arguments of proponents and critics of sociobiology on whether the fields are useful at explaining human behavior.

BY350 Comparative Vertebrate Anatomy- Credits (3)

Pre-requisites: BY160 or consent of instructor.

Co-requisite: BY 352

This course compares anatomical structures throughout different classes of vertebrates. We begin by defining anatomical terms and identifying what constitutes a vertebrate. We will also learn how vertebrate organ systems develop and the physical constraints placed on development of these systems. The anatomical study will be broken down into major organ systems that will be discussed one at a time. For each of the organ systems, there will be a discussion of relevant structure and function followed a description of the major changes in form and function throughout vertebrate evolution. Since there are numerous classes of vertebrates, we will concentrate on representatives from some of the better studied examples.

BY352 Comparative Vertebrate Anatomy Laboratory-Credits (2)

Pre-requisites: BY160 or consent of instructor.

Co-requisite: BY 350

Through the use of dissection and histological observation, we will observe and make direct

comparisons of anatomical structures from representative vertebrates. The organ systems that are dissected in this course will follow the topics presented in BY350. After the first two introductory labs, you will dissect specific organ systems one at a time in each of your specimens. This will allow you to make direct comparisons between comparable structures in different vertebrates. The animals that will be dissected (*Necturus*- Mud Puppy, Dogfish shark, pigeon, and cat) are representative vertebrates chosen to illustrate changes to the organ systems as vertebrates became more complex.

BY 357 (PY 357) Human Cognitive Evolution- Credits (3)

Prerequisites: PY 151 or junior or senior standing

Evolutionary psychology is concerned with the adaptive problems and selective pressures our ancestors encountered in their environments, the psychological mechanisms that evolved to help them solve those problems, and the way those evolved mechanisms function in current environments. This way of thinking about the brain, mind, and behavior is changing how scientists approach old topics, and is opening up new ones. This course will focus on current developments and selected topics in evolutionary psychology (e.g., foraging, mate choice, parental investment, cooperation and culture) and explore the evolution of cognition from a broad comparative perspective.

BY358 (PY358) Animal Learning and Cognition- Credits (3)

Prerequisites: BY140 or PY151 or consent of the instructor

This course focuses upon how animals acquire, process, store and recall information about their environment and social partners. Topics that will be examined include how animals perceive and classify stimuli; how they learn and remember; how they orient and navigate; how they measure time, number, and amount; how they acquire abstract concepts; how they perceive social relationships; and how they communicate. A diversity of in-vertebrate and vertebrate organisms will be included (sea slugs to primates!), and there will be an emphasis on understanding taxon-specific specializations as well as general patterns across animals.

BY/PY 359 Perception-Credits (3)

Prerequisites: PY 151 or junior or senior standing

Perception deals with our conscious experience of the world, ourselves and each other. This course will examine how perceptions are measured (psychophysics); how visual, auditory, touch and pain sensory stimulation is actively organized into conscious perceptions; developmental aspects of perception; the role of cognitive factors, such as attention; and how altered conscious states (e.g., achieved through meditation, hallucinogenic drugs) affect perception. Fundamental principles of perception discussed in this course will be used to explain how we experience the world, ourselves, and each other.

BY360 Comparative Physiology- Credits (3)

Prerequisites: BY160 or consent of the instructor.

Physiology is concerned with the vital functions of living organisms. The central question of this course is: How does the human body work? We will attempt to answer this question through an exploration of the major organ systems. An examination of physiological processes at the cellular and molecular level will be used to elucidate the basis of various human diseases.

BY362 Comparative Physiology Laboratory- (C1) Credits (2)

Corequisite: BY360.

Laboratory exercise designed to provide practical exposure to basic physiological research techniques and clinical applications. Examples of class activities include: microscopy of vertebrate tissues, computer modeling of action potentials, electromyography, electrocardiogram, blood pressure, pulse monitoring and physiological effects of exercise.

BY363 Pharmacology of Infectious Disease-Credits (3)

Prerequisites: BY160

This course will introduce students to the basic principles of immunology and pharmacology with an emphasis on current treatment strategies employed to combat infectious disease. Students will learn how vaccines are used to prevent infection, in addition to the deployment of small molecule drugs and newer antibody-based therapies for the treatment of existing infectious disease. Course information will be disseminated to students in the form of lectures, readings from review and original research articles, and through group discussion that involves case studies and problem-based learning.

BY368 Mathematical Biology Seminar- Credits (1)

Prerequisites: BY140 and BY160; MA181 or MA131 (or equivalent), or consent of the instructor

The objective of this course is to present recent advances in research that combines biological and mathematical analysis, and to describe opportunities for interdisciplinary summer research in biology and mathematics. Students will receive one credit for attending seminars (6 per semester), reading a journal article prior to each presentation, writing a short review of each seminar, and participating in discussions. This course can be taken for credit more than once.

BY380 Techniques in Immunological Research-(TECH) Credits (3-6)

This course will provide students with a basic understanding of molecular, cellular and imaging techniques used at the Trudeau Institute to help researchers study the immune system. Students will learn principles and procedures relating to molecular biology, cellular biology, histology, flow cytometry, light microscopy, and cell sorting. The course will cover basic quantification of gene expression at the transcriptional and post-translational level. The course will also cover basic quantification of cell populations using flow cytometers to collect and analyze subpopulations of cells from tissues. Histology and light microscopy techniques will be used to locate similar cell populations within a tissue section. Students will gain confidence in the selection and application of the appropriate cell imaging techniques required to assess mammalian cell tissues.

BY383 Molecular Genetics and Human Disease-Credits (3)

Prerequisites: BY160 and BY214

The goal of this course is to learn detailed information related to the structure, packaging and expression of genes within the genome of both prokaryotic and eukaryotic organisms. Not only will the material be discussed in class, but there will be discussion about how the research was performed with critical analysis of current biotechnological techniques and results. A textbook will be used for the course but this there will also be regularly spaced journal articles related to the topic. We will also discuss health related issues caused by defects in each of these processes.

BY400 Directed Study in Bioscience- Credits (1-4)

Prerequisites: consent of instructor.

Students study specialized topics in bioscience not otherwise available in formal courses. Under supervision of a faculty member, a semester-long course of study tailored to professional interests is designed based on reading from relevant texts and primary literature.

BY 401 Professional Assessment – Credits (0)

Pre-requisite: Senior standing or consent of the Biology Department Chair.

This course is designed to assess the professional development of biology majors by (1) completion of a standardized test to assess their level of knowledge in the field of biology, (2) submission of a professional resume, and (3) submission of a personal statement for graduate/professional school or employment.

BY405 Undergraduate Research in Bioscience- Credits (0-6)

Prerequisites: consent of instructor

Students conduct and original bioscience research project based on investigation of a specific problem related to areas of faculty expertise. Research methodology may involve field, laboratory, computational, or theoretical approaches. Presentation of research results at a scientific meeting or local symposium is strongly encouraged.

BY410 Undergraduate Thesis Research in Bioscience -Credits (1-6)

Prerequisites: consent of instructor.

A formal thesis project is arranged under supervision of a faculty member who guides the student in planning and execution of original research work and preparation of a written thesis. This course is primarily intended for junior or senior biology majors who wish to pursue graduate or professional studies in bioscience. Work done in satisfaction of the requirements for a degree will be assigned a grade when the thesis is submitted and approved.

BY412 Molecular Biology Laboratory - (TECH, C1) Credits (4)

Pre-requisites: BY214 or consent of instructor.

This course will provide students with a hands-on introduction to modern molecular biology techniques. Students will learn techniques such as bacterial transformation and plasmid DNA purification, restriction digest and gel electrophoresis, isolation of DNA and RNA from eukaryotic cells, Southern hybridization, reverse transcription, polymerase chain reaction, and cloning PCR products, and web-based analytical programs. The lectures and reading will cover the theory and applications of these molecular techniques.

BY416 (EHS416) Principles of Toxicology and Epidemiology- Credits (3)

Prerequisites: IH309 or consent of instructor.

See IH416 Principles of Occupational Health for description.

BY419 Immunology- (C1) Credits (3)

Prerequisites: BY140, BY160 or BY214 or consent of instructor

An overview of the immune system, with emphasis on current concepts and literature. Topics covered include: cells and tissues of the immune system; structure and function of antibodies; genetic basis of antibody diversity; humoral and cellular immunity; cellular interactions; major histocompatibility complex; the complement system; transplantation; tumor immunity.

BY420 Evolution Credits (3)

Prerequisites: BY214.

This course is organized into three sections: History of Life, which covers abiogenesis and the fossil record; Development of Evolutionary Theory, which reviews the origin of evolutionary thought, emphasizing Darwin and the synthesis of genetics and natural history; and Population Biology, which covers the mechanisms by which populations adapt to environmental change.

BY 424 Experimental Evolution Laboratory Credits (2)

Prerequisites: BY420

An introduction to experimental approaches used in evolutionary biology. Students will conduct lab experiments using microbes to investigate a range of topics in experimental evolution, observing and exploring evolution as it happens in real time. Topics explored will include adaptive diversification, the evolution of fitness trade-offs, evolutionary loss of redundant traits, and evolutionary rescue.

BY425 Biological Systems and Environmental Change- (UNIV: CGI, STS) Credits (3)

Prerequisites: BY222 or graduate standing

Human activities are resulting in dramatic global environmental change, in the forms of biodiversity loss, altered biogeochemical cycles, introduced invasive species, chemical toxification of the environment, climate change, unsustainable exploitation of natural resources, and habitat loss, degradation, and fragmentation. In this course, we will examine how these forms of environmental change disturb biological systems by critically reading key research papers, and discussing their implications for future research and policy action.

BY430 Developmental Biology - Credits (3)

Prerequisites: BY160 or consent of the instructor.

The course will focus on how an organism develops into a complex multicellular organism from a single cell. We will begin with the genetics of development and discuss mechanisms by which genes become sequentially activated as embryogenesis proceeds. The mechanics and genetics of both invertebrate and vertebrate development will be discussed beginning with fertilization and ending as embryogenesis is completed. We will also discuss some of additional developmental events that occur during embryogenesis and later in adults. Because of technological advances in developmental biology, topics in this field have also become important societal issues. Throughout the semester, we discuss the ethical implications of using these advances and their impact on society.

BY431 Limnology – Credits (3)

Pre-requisites: BY222, CM 132 (or CM 104)

Co-requisite: BY432

Limnology (aquatic science) is the study of physical, chemical, and biological properties of fresh water bodies, e.g. lakes, rivers, reservoirs, and wetlands. This introductory course will provide an array of topics that will, by the multi-disciplinary nature of limnology, call upon students' knowledge of biology, chemistry and physics and place them within the context of aquatic science. The focus of the instruction will be aquatic ecology at all levels of biological organization. Upon completion of the course, the student will be able to characterize the physical, chemical and biological/ecological properties of a freshwater through the selection and application of appropriate sampling methods.

BY432 Limnology laboratory – Credits (2)

Co-requisite: BY431

This co-requisite of Limnology (aquatic science) will provide students the opportunity to engage in water sampling of regional lakes and rivers, analysis of samples in the laboratory, introduction to data synthesis, and report writing. Some fieldwork will be required.

BY440 Introduction to Biomedical Rehabilitation Engineering and Science- Credits (3)

Prerequisites: MA131/132, PH131/132, junior or senior standing

This interdisciplinary course will introduce students to basic principles of biomedical rehabilitation engineering. The course will present principles of disability and the diverse roles of engineering in medicine and rehabilitation. Students will use engineering methods to study anatomical and physiological systems including applications in rehabilitation engineering, bioinstrumentation, biosignal and image processing, biomechanics, and biomaterials.

BY 445 Biological Oceanography- Credits (3)

Prerequisites: BY140, BY160, and MA180

The goal of this course is to introduce students to the fundamentals of ocean science through an integrative approach that emphasizes physical (circulation, tides & waves), chemical (biogeochemistry) and biological (marine life) principles. Through a series of inquiry based and computational exercises, an exploration of the scientific literature and the use of flipped classrooms, we will consider the future of

the world's oceans in light of the contemporary challenges they face such as global climate change, pollution and an ever expanding aquaculture trade.

BY 448 Medical Microbiology- (C1) Credits (3)

Prerequisites: BY 160 and BY 214 (or instructor approval)

This course will systematically examine human pathogens with a focus on why the biologic properties of organisms are important to disease in humans, including the basic principles of the host immune response, laboratory diagnosis, bacteriology, virology, mycology and parasitology. This class will emphasize basic science with clinical practice to understand the clinical relevance of the organisms examined using clinical cases from literature reports to illustrate the epidemiology, diagnosis, and treatment of infectious diseases. The course will emphasize student interaction and exploration of the scientific literature.

BY450 (CM460) Biochemistry I- Credits (3)

Prerequisites: CM241 or consent of instructor.

This course is a one semester introduction to the molecular basis of biological processes. The first part of the course will cover the structure and function of the four major classes of biomolecules – proteins, carbohydrates, lipids, and nucleic acids. The second part covers the organization and regulation of the major energy generating and biosynthetic pathways.

BY451 (CM461) Biochemistry II -Credits (3)

Prerequisites: BY450.

A continuation of Biochemistry I focusing on autotrophic and anabolic metabolism.

BY452 Pharmacology- Credits (3)

Prerequisites: BY160 and CM241 or consent of instructor

The science of Pharmacology concerns the molecular mechanisms by which drugs act on the human body and the applications of drugs in clinical therapy. This course will introduce students to general principles of drug action and survey selected classes of drugs according to their physiological effects and uses in the treatment of certain diseases.

BY453 Pharmacology Lab-Credits 2

The goal of this course is to facilitate a greater understanding of key concepts in pharmacodynamics, pharmacokinetics that are discussed in the lecture component and observe how they are applied in the context of the clinical environment. The lab will be simulation based, employing virtual organ bath experiments to derive and interpret dose-response curves, and virtual patient software to investigate drug pharmacokinetics and dosing strategies.

BY454 (PY454) Physiological Psychology- Credits (3)

A comprehensive investigation of the physiological foundation of behavior. Topics include: perception, motivation, emotion, states of consciousness, learning, memory and mental illness. Only one course with this designator may be used as a Foundation Curriculum Science course.

BY455 Cell and Molecular Biology of Cancer- (C1) Credits (3)

Prerequisites: BY160 and BY214 or consent of the instructor.

This course will focus on the cellular and molecular alterations that cause human cancer. Topics include cell cycle regulations, oncogenes and tumor suppressor genes, cancer viruses, multi-step tumorigenesis, invasion and metastasis, and new developments in cancer diagnosis and therapy. Emphasis will be placed on student interaction and exploring the scientific literature.

BY458 Cognitive Neuroscience- Credits (3)

Prerequisites: PY151 or junior or senior standing

This course introduces a sampling of the theories and research concerning how various mental processes are accomplished within the brain. Emphasis will be placed on developing an understanding of both the physiological bases of the techniques and the issues involved in relating measures of brain activity to cognitive functioning. Students will be exposed to current topics of study in a number of areas of cognition: perception, language, memory, among others. In this course we will study a number of different techniques for studying the brain, including electrophysiological recording techniques, functional imaging techniques, and methods that involve brain lesions and disrupting neural activity.

BY460 (PY460) Neurobiology- Credits (3)

Prerequisites: BY160 or BY360 or consent of the instructor.

Neurons are electrically excitable cells that initiate or control many complex functions such as sensory perception, locomotion, memory, and learning. This course introduces the study of neuronal mechanisms at the cellular and molecular level. Topics include: membrane biophysics, ion channels, electrical signaling, synaptic transmission, glia, sensory transduction, neuromodulation, and neuronal plasticity.

BY 465 Molecular and Genome Evolution

Prerequisites: BY420

An overview of the molecular underpinnings of evolution, and how those molecular changes can be used to characterize and understand the evolutionary history of genes, proteins and organisms. Topics include how and why DNA sequences and genomes change, molecular phylogenetics and evolutionary models, gene duplication and the evolution of gene families, and horizontal gene transfer. For BY 565, additional readings and an additional written and oral report will be required.

BY470 (CM470) Biochemistry & Biotechnology Laboratory-(C2) Credits (3)

Prerequisites: BY312 or BY450/CM460 or consent of the instructor.

This course is a one semester course in the fundamental laboratory approaches for biochemistry and biotechnology. While largely a hands-on course, laboratory experiments will be supplemented with lectures that integrate the theoretical and practical principals covered in the exercises. Topics include protein purification, characterization and analysis, enzyme kinetics and molecular modeling.

BY 471 Anatomy and Physiology I – Credits (3)

Pre-requisites: BY140, BY160, and CM104 or CM132. In addition, must be of junior or senior standing, or with permission of the instructor.

This course is the first course in a two semester sequence that studies the anatomy and physiology of the human body in detail. Topics covered in this semester include basic cellular activities, anatomy and physiology of skeletal, muscular, circulatory and lymphatic systems. This course is appropriate for students in the pre-PT program as well as pre-health majors in any other health-related fields that require a two-semester Anatomy and Physiology sequence.

BY 472 Anatomy and Physiology II – Credits (3)

Pre-requisites: BY471 and BY473, or consent of the instructor. Co-requisite: BY474.

This course is the second course in a two semester sequence that studies the anatomy and physiology of the human body in detail. Topics covered in this semester include the anatomy and physiology of major organ systems as well as homeostasis. This course is appropriate for students in the pre-PT program as well as pre-health majors in any other health-related fields that require a two-semester Anatomy and Physiology sequence.

BY473 Anatomy and Physiology I Laboratory-Credits (2)

Pre-requisites: BY140, BY160, and CM104 or CM132. In addition, must be of junior or senior standing, or with permission of the instructor.

BY474 Anatomy and Physiology II Laboratory- (TECH) Credits (2)

Prerequisite: BY471 and BY473, or consent of the instructor

Corequisite: BY472

Companion laboratory course to Anatomy and Physiology II, introducing students to anatomical terminology and histology. The student will focus on human physiology of the major organ systems.

BY 476 Current Topics in Biology and Medicine-(C1) Credits (3)

Prerequisites: BY160 or BY214 or consent of instructor.

This is a discussion-based seminar course that broadly examines advances and implications of modern biology of interest to society, scientists, and students planning a career in medicine, research, or teaching. Students are required to read a variety of current texts, participate in class discussions, and write a substantive essay. Example topics include the discovery of DNA, genome sequencing, applications of bioinformatics, the revolution in applied biotechnology, human physiology under extreme conditions, intellectual history of biology and medicine as explored by prominent science writers, the prognosis for life on earth.

BY480 Advanced Cell Biology – (C1) Credits (3)

Prerequisites: BY160/162 and BY214 or consent of instructor.

This course will focus on understanding how cells function normally, and how cell dysfunction can cause human disease. Topics include DNA replication and repair, cell cycle control and cancer, cell communication and intracellular signaling, regulation of gene expression, the cell surface and the cytoskeleton. Current methods used in cell and molecular biology research will be discussed. The course will emphasize student interaction and exploration of the scientific literature.

BY482 Molecular Genetics- Credits (3)

Prerequisites: BY160, BY214, BY450, CM103 or 131, and CM104 or 132.

This course will provide students with detailed information on the structure, packages, and expression of genes within the genome of both prokaryotes and eukaryotes. Topics will include chromatin packaging and structure; DNA replication mutation and repair; transcription; RNA splicing; translation; and control of gene expression. Included with each of these topics will be primary research papers, which will be discussed during class. During discussions, experiments in the papers will be analyzed as to how they work (focusing on current biotechnology) and critical analysis of the conclusions. Evaluation will involve exams based on material presented during the course as well as participation in discussions and written analysis of presented research papers. This course contains advanced topics and is designed primarily for graduate or advanced undergraduate students.

BY485 Neural Engineering-Credits (3)

Cross-listed with EE 485, ES 485] This course applies engineering principles to the study of neuroscience and to the design of devices or techniques intended to replace missing or augment existing functions such as seeing, hearing, speaking, and walking. The course provides a detailed overview of sensorimotor systems, neurophysiology, neuroanatomy, neuropathology and clinical neurology. The class sequences through the various sensory and movement systems, providing a quantitative basis for how the nervous systems works for these systems, for how it dysfunctions, for the disability produced, and finally for how function can be restored by neuroprostheses. Students will prepare and present a paper on a neural engineering topic.

BY486 Molecular Biotechnology- Credits (3)

Molecular biotechnology is a rapidly evolving scientific discipline impacting on many aspects of our daily life. This course will review basic concepts and methodologies in recombinant DNA technology, cover the use of molecular biotechnology for the production of useful products in areas of microbial, plant and animal biotechnology and address social and economic issues rising with the availability of these technologies.

BY488 Stem Cells and Regenerative Medicine-Credits 3

This course will cover biological and medical perspectives of stem cells from their fundamental basic biology and mechanisms of organ regeneration through the use of induced-pluripotent stem cells (iPSCs) for therapeutic benefit. It will deal with mammalian and human embryonic stem cells (hESCs) and focus on how iPSCs generate distinct fates during human development and how this can be used for regenerative therapy of common human diseases.

BY495 Undergraduate Teaching Assistantship in Bioscience- Credits (1-2)

Prerequisites: Consent of instructor

Students obtain teaching experience by assisting a faculty member in teaching a lecture or laboratory course. Pedagogical activities may include leading laboratory or discussion sections, designing and testing laboratory exercises, and assisting in student assessment.

BY498 Internship in Bioscience- Credits (0 cr., P/NP)

Prerequisites: Consent of instructor

During the fall semester, spring semester, or summer break, students may receive credit for an approved internship or co-op work experience with a private organization or company with a mission related to bioscience. Typical examples include internships at a hospital or medical clinic, work at a biotechnology company, and field or office work at an ecological conservation society. Internships are expected to involve a minimum of 120 hours of work and must be pre-approved in consultation with a faculty member. A formal report upon completion of the internship is required.

BY499 Professional Experience in Bioscience- Credits (0 cr, P/NP)

This course is used to assign credit for alternative experimental learning activities that meet the requirement of undergraduate Biology majors to complete a professional experience in their major under the Clarkson Common experience curriculum. Examples of appropriate activities include participation in a summer undergraduate research program or training course at other institutions such as a national or foreign bioscience laboratory, field station, or research institute. The program experience must be pre-approved in consultation with a faculty member and a formal report is required upon completion.

XVI. Clarkson University Biology Major – Clarkson Common Experience

120 Total Credits Minimum to Graduate / Average Course Load 15 credits per semester

Biology – Required Core Courses – 17-19 Credits		
BY140/BY142 fall	Biology I: Inherit, Evol, Diversity / Lab	3/2
BY160/BY162 spring	Biology II: Cell and Mol Bio / Lab	3/2
BY214 spring	Genetics	3
BY401 spring	Professional Assessment	0
Two Biology Lab Courses numbered 200 or above not including BY405 or BY410 – (4-6 Credits)		
Biology Electives – additional BY credits (21-23)		
A minimum of 40 total credits of BY courses are required. 17-19 of these are covered in the core Biology courses, listed above. Therefore, a minimum of 21-23 additional biology elective credits are needed. No more than 6 credits of directed research can count toward these 40 credits. (Students may enroll for additional directed research credits in place of Free Elective credits).		
BY 115 spring	Introduction to Environmental Sustainability	3
BY 120 spring	Introduction to Biotechnology Sciences and their Applications	3
BY240 when needed	Environmental Science and Policy of American Rivers	3
BY 280 fall	Environmental Science	3
BY300 fall and spring	Advances in Biology Research	1
BY304 Given when needed	Introductory Zoology	3
BY312 Given when needed	Adirondack Ecology and Natural History	3
BY313 fall	Biogeochemical Earth Systems Science	3
BY314 spring	Bioinformatics/ Lab	4
BY315 Given when needed	Bioinformatics for Disease Research	3
BY319 fall	Current Readings in Animal Behavior	1
BY324 even fall	Parasitology	3
BY328 alt spring	Conservation Biology	3
BY330 alt falls	Great Lakes Water Protection	3
BY340 alt spring	Behavioral Ecology/ Sociobiology	3
BY357 alt falls	Human Cognitive Evolution	3
BY358 alt spring	Animal Learning and Cognition	3
BY359	Perception	3
BY363 even springs	Pharmacology of Infectious Disease	3
BY368 fall	Mathematical Biology Seminar	1
BY369 spring	Conducting Interdisciplinary Research in Biology and Mathematics	1
BY383 odd falls	Molecular Genetics and Human Disease	3

BY400 fall & spring	Directed Study in Bioscience	1-4
BY412 fall	Molecular Biology Laboratory	4
BY416 spring	Principles of Toxicol & Epidemiology	3
BY419 alt falls	Immunology	3
BY420 fall	Evolution	3
BY 424 fall	Experimental Evolution Laboratory	2
BY425 alt spring	Bio Systems & Environmental Change	3
BY 430 odd spring	Developmental Biology	3
BY440 fall	Biomedical Engineering Fundamentals	3
BY 445 even springs	Biological Oceanography	3
BY448 spring	Medical Microbiology	3
BY450 & BY451 fall/spring	Biochemistry I & Biochemistry II	3/3
BY452 & BY 453 fall	Pharmacology/Lab	3/2
BY 454 even springs	Physiological Psychology	3
BY455 alt spring	Cell & Mol Biology of Cancer	3
BY458 alt spring	Cognitive Neuroscience	3
BY460 fall	Neurobiology	3
BY 465 spring	Molecular and Genome Evolution	3
BY470 spring	Biochemistry & Biotechnology Lab	3
BY 476 spring	Current Topics in Biology and Medicine	3
BY480 fall	Advanced Cell Biology	3
BY482 spring	Molecular Genetics	3
BY485 fall	Neural Engineering	3
BY486 fall	Molecular Biotechnology	3
BY488 fall	Stem Cells and Regenerative Medicine	3
Professional Experience Courses		
BY405 fall & spring	Undergrad Research in Bioscience	0-6
BY410 fall & spring	Undergrad Thesis in Bioscience	1-6
BY495 fall & spring	Undergrad Teaching Asst in Bioscience	1-2
BY498 fall & spring	Internship in Bioscience	0, P/ NP
BY499 fall & spring	Professional Experience in Bioscience	0, P/ NP
Chemistry – 17-19 Credits		
CM131 fall	General Chemistry I	4
CM103/105 (alternative to above)	Structure and Bonding/Lab	3/2
CM132 spring	General Chemistry II	4
CM104/106 (alternative to above)	Equil and Dynamics/Lab	3/2

CM241 fall	Organic Chemistry I	3
CM242 spring	Organic Chemistry II	3
CM244 spring	Organic Chemistry Lab	3
<i>Physics – 8 Credits</i>		
PH141 fall (or PH131)	Phys Life Sci I (Physics I)	4
PH142 spring (or PH132)	Phys Life Sci II(Physics II)	4
<i>Mathematics – 9-10 Credits (includes calculus, statistics, and one additional math, statistics, or computer science course numbered 100 or above)</i>		
MA180 (optional precursor course)	Intro College Math	4
MA181 (or MA131 spring)	Basic Calc (orCalculus I)	3
MA132 Calculus II, MA239 Linear Algebra or other MA or CS elective	Math / Comp Sci elective	3
STAT318 Biostatistics (or STAT282/383 General/Appl Statistics)	Statistics requirement	4/3
<i>CCE Requirements – 22 Credits</i>		
FY100	First Year Seminar	1
UNIV190	The Clarkson Seminar	3
Knowledge Area / UC Courses	5 elective courses covering 4 KA	15
Technology Course	BY412, IS/CS110,BY315, BY474	3
<i>Free Electives – additional courses up to 120 overall credits</i>		
Special topics of personal interest	~7 elective courses	21
Notes: Student must also meet CCE communication requirement of 6 total points (C1 or C2 courses) and fulfill Dept of Biology Professional Experience Requirement.		

XVII. Faculty Expertise

Bioinformatics

Susan Bailey
Andrew David
Michelle Yoo

Biotechnology

Petra Kraus
Damien Samways
Shantanu Sur
Kenneth Wallace
Michelle Yoo

Biology Education

Deborah Brown
Andrew David
Stefanie Kring
Tom Langen
Damien Samways

Developmental Genetics

Ginger Hunter
Thomas Lufkin
Kenneth Wallace
Michelle Yoo

Environmental Science & Ecology

Alan Christian
Beatrice Hernout
Tom Langen
Stefanie Kring
Michael Twiss

Evolutionary Biology

Susan Bailey
Andrew David
Tom Langen
Michelle Yoo
Alan Christian

Organismal Biology (Zoology & Botany)

Alan Christian
Andrew David
Beatrice Hernout
Tom Langen
Michael Twiss
Michelle Yoo

Physiology & Biomedical Science

Ali Boolani
Beatrice Hernout
Thomas Lufkin
Damien Samways
Shantanu Sur

XVIII. Laboratory Facilities

Cell Receptor Signaling Lab (Associate Prof. Damien Samways; Science Center 105): Our laboratory is interested in how cells use surface receptors, particularly ion channels and G protein-coupled receptors, to sense and respond to extracellular neurotransmitters, hormones and drugs. We have a particular focus on those cell signaling mechanisms that involve the ubiquitous cytosolic second messenger, Ca²⁺, which plays a key role in regulating numerous cellular processes including secretion, muscle contraction, cell migration, and gene regulation. Our laboratory is equipped to use patch clamp electrophysiology, including patch clamp photometry, to study plasma membrane ion channel function. We also employ a time-lapse fluorescence imaging system to investigate Ca²⁺ signaling dynamics and membrane potential fluctuations in intact cells.

Developmental Genetics and Stem Cell Regulation Lab (Associate Professor Kenneth Wallace; Science Center SC172): The lab facility is designed to support research activity in the area of vertebrate intestinal development using the zebrafish model system. Specifically, we are investigating control of the developing intestinal stem cell compartment before the mature structure forms. We have a fish facility with three independently circulating racks from Aquatic Habitats. Each of the fish racks have a mix of ten, three and 1.5 liter tanks. The fish racks have automated conductivity and pH monitoring and draws water from a reverse osmosis system. We have a variety of stereomicroscopes, an epifluorescent microscope to image immunohistochemistry and RNA in situ hybridizations. We have a microinjection apparatus for embryo injections. We are equipped for genetic and molecular biology work with PCR machines, qPCR (Biorad), electrophoresis equipment, incubators and hybridization ovens.

Bioimaging rooms (SC108 and SC102): Fluorescent imagery is performed on two different inverted microscopes (Nikon and Zeiss). We have an upright Zeiss light microscope for histological observations and a stereomicroscope with both transmitted and reflected light capabilities. In SC102 we have the Leica Confocal microscope with an automated inverted DMI8. It is equipped with four solid state scanning lasers 405/488/561/635 nm. The objectives are 10x, 20x, 40x dry and oil, 63x oil. Each lens is equipped with differential interference contrast (DIC). The scope has epi-fluorescence to identify samples before scanning. Driver/analysis software is LAS SPE 3D Visualization Basic for reconstruction and processing of 3D data.

The Limnology Laboratory (Prof. Michael Twiss, Science Center 176B): The Limnology Laboratory is designed to support student research activity in the subject area of freshwater science, which encompasses measurements of physical, chemical, and biological conditions in surface fresh waters (rivers, lakes, and wetlands). Both classical (e.g., water sampling bottles, microscopy, filtration apparatus) and advanced instrumentation (e.g. pigment-specific fluorometers, electronic water quality sensors) is available in this laboratory that is also equipped as a staging point for field work using coastal research vessels (<https://www.clarkson.edu/great-rivers-center>).

Cell-Materials Interaction Lab (Asst. Professor Shantanu Sur; Science Center 207): : This lab focuses primarily on the study of biomaterials-cell interactions using in vitro models for the development of tissue engineering scaffolds and targeted drug delivery systems. The lab has a BSL2 mammalian tissue culture set-up and a live-cell imaging facility (Nikon Biostation). Thermocyclers and gel electrophoresis equipment are available for routine gene and protein expression analysis (PCR and western blot). A multi-mode microplate detection platform with an attached imaging cytometer (SpectraMax i3x with Minimax imaging cytometer) is used for colorimetric, fluorescence, and microscopy-based assays for high throughput assessment of cell response such as viability and proliferation.

Experimental Evolution and Bioinformatics Lab (Asst. Professor Susan Bailey; Science Center 107): We use experiments with bacteria to study evolutionary dynamics, and analyze genome sequence data to identify the underlying genetic changes that drive adaptation. In the lab, we culture bacteria in different types of media, using our biological safety cabinet for safe and sterile transfer of bacteria (bio safety levels 1 and 2). Bacteria are grown in our shaking incubators, and quantified using Petri dish plating, and optical density measures

obtained with our Epoch 2 Microplate Spectrophotometer. For preservation of bacterial cultures we have an ultra-low-temperature freezer and for DNA extraction and quantification, we have a micro-centrifuge, and a nano-drop spectrophotometer.

Stem Cell Biology and Regenerative Medicine Lab (Prof. Thomas Lufkin, Asst. Professor Petra Kraus; Science Center 203, 205): Our research is in the area of **Developmental Genomics and Regenerative Medicine** with a focus on the molecular mechanisms controlling vertebral column development and an emphasis on stem cell commitment to specific differentiation pathways leading to the adult organ, but from a Systems Biology point of view. In particular we are working on understanding the gene regulatory networks (GRNs) that govern normal development of the vertebral column and intervertebral disc (IVD). We are investigating the role of transcriptional regulators in the restriction of pluripotent stem cells into specific lineages that in turn comprise functional pre and postnatal vertebral elements with the goal of applying this knowledge to regenerative medicine in humans using patient-specific induced pluripotent stem (iPS) cells and adult mesenchymal stem cells.

Developmental Genetics lab (Asst. Professor Ginger Hunter; Science Center 113): This lab facility is equipped for performing experiments in developmental genetics using the fruit fly *Drosophila melanogaster*. We have two fly stations for routine fly pushing as well as live documentation of adult phenotypes and fluorescence sorting of genetic markers. In support of this, part of the lab space is dedicated to a small 'fly kitchen' where we prepare everything we need to keep the flies going and experiments running. We have all the support equipment to perform molecular biology based analysis (DNA analysis, protein analysis, other cloning) which we use to screen flies for new mutations and changes in protein expression, in addition to assembling DNA constructs for making transgenic flies. There is a computer workstation for data analysis and plenty of student workspace. The lab is equipped with the hood and incubators necessary to maintain and perform experiments in insect cell culture.

Ecology & Behavior lab (Professor Tom Langen; Science Center 170G): This lab facility serves as a base for fieldwork on terrestrial and wetland ecology and animal behavior research. It is fully equipped with field equipment for wildlife observation, radiotelemetry, capture and marking animals, camera-trapping, and vocal playback surveys. It has a computer work station for geospatial analysis using ArcGIS and other geospatial applications, and other work stations for data analysis. It has an extensive library for identifying organisms and planning biological surveys.

Aquatic Ecology lab (Asst. Professor Andrew David; Science Center 132C): This lab facility is designed to support research in experimental marine and freshwater ecology and molecular taxonomy and ecology of aquatic invertebrates including DNA barcoding. It is equipped with four 10-gallon aquaria fitted with automatic CO₂ injectors and water quality sensors for non-flow through acidification experiments. For genetic work, we have the latest Thermal Cycler from ABI (MiniAmp) for accurate amplification, along with all the standard equipment for DNA extraction (microcentrifuges, vortexer, heating blocks and materials for gel electrophoresis). There is a computer workstation for Bioinformatics analyses along with premium DNA alignment and editing applications installed included Geneious. There are also two Linux based laptops available as loaners for undergraduates working in the lab. The lab has extensive storage space for voucher specimens collected in the field.

First Year Biology Lab (Stefanie Kring; SC 170D): This lab facility accommodates 16 students (4 desks x 4 seats/desk). All desks are equipped with computers that students can use for data analysis and research. Each desk has gas, water, and air for a variety of biological experiments. The lab is used for a wide range of applications from ecological studies to molecular manipulations.

Upper Level Teaching Lab (SC 134A): This lab facility accommodates 20 students (2 desks x 10 seats/desk). All desks are equipped with gas, water, and air for a variety of biological experiments. This room is also equipped with compound and stereomicroscopes. Various equipment for molecular biology and biochemistry labs can be found here (NanoDrop, thermal cycler, water baths, centrifuges, vortexes, incubators, ice machine,

gel apparatus, etc.) There is also a separate facility within this teaching lab that can be used for cell culture, with microscopes, a CO₂ incubator, and two laminar flow hoods. This room also contains a water purification system.

Upper Level Teaching Lab (SC 134B): This lab facility accommodates 24 students (6 desks x 4 seats/desk). Computers are equipped with AD Instruments software, for various anatomy and physiology experiments. Each desk is equipped with a dissection hood that can be used to dissect small animals. The lab is also used for a wide range of ecological studies.

XIX. Research Currently in Progress 2019-2020

Tom Langen, PhD (UC San Diego)

Department Chair of Biology and Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Environment

Aim: To use science to improve conservation and management of nature in human-dominated landscapes.

Methods: Fieldwork on species, habitat assessments, computer modeling using Geographical Information Systems (GIS).

Applications: Adaptive Management of natural resources, conservation of threatened species and habitats, infrastructure design.

Broader impacts: Environmental quality, conservation of threatened species, improved infrastructure design and management, conservation education and capacity building.

Dr. Langen conducts research on the environmental impact of roads, on the effectiveness of public-private partnerships for wetland restoration, and on habitat management and conservation of birds and other animals. His road-related research has included the impacts of winter road management on roadside vegetation and lakes in the Adirondack Park, predictive modeling of hotspots of road mortality of amphibians and reptiles, design and functioning of wildlife barriers and passageways for turtles, and the impact of highways on habitat connectivity in Costa Rican National Parks. He leads professional development workshops in Latin America and North America on the environmental impact of roads and other infrastructure. Dr. Langen's wetland research focuses on the environmental, economic, and social benefits and costs of wetland restoration to private landowners. His research on habitat management in birds focuses on cooperative projects between landowners and conservationists for threatened species such as the golden-winged warbler or spruce grouse. Dr. Langen's teaching interests include how to best apply problem-based learning and inquiry approaches to improve teaching in ecology and conservation biology, and how to design undergraduate summer research internship programs to best achieve program objectives.

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Michael Twiss, PhD (Université du Québec, Canada)

Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Environment (Water)

Aim: To conduct fundamental research that addresses water quality issues in the Great Lakes and St. Lawrence River during all seasons of the year.

Methods: Involve field work working on coastal research vessels and ships, as well as remote water quality sensing stations.

Applications: Adaptive Management of water resources, refinement of water quality criteria, understanding long-term changes in surface water quality.

Broader impacts: Water security, graduate student education, international (Canada/USA) relations, environmental policy.

Twiss focusses on interactions of microbes with chemicals (nutrients, toxic substances) in the water column of lakes, rivers, and wetlands and the use of advanced technologies for assessing phytoplankton community structure and health. Studies focus on the Laurentian Great Lakes and St. Lawrence River ecosystems, and involves research both in the field and laboratory. Connections to government policy and constituencies is made possible by direct participation in scientific societies (International Association for Great Lakes Research) and science advisory boards (International Joint Commission).

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Thomas Lufkin, PhD (Cornell University)

Clarkson Chair and Professor of Biology, Clarkson University Department of Biology

Clarkson Strategic Theme: Biotechnology

Aim: Understand how human stem cells can be used for tissue and organ regeneration.

Methods: Human somatic cells are reprogrammed to cells of the intervertebral disc in cell culture.

Applications: Regenerative medicine of degenerated or injured intervertebral discs.

Broader impacts: Development of methods of regenerating spinal discs to treat vertebral column degeneration associated with aging.

Our research is in the novel area of Regenerative Medicine and Stem Cell Biology with a focus on the molecular mechanisms controlling vertebral column development and an emphasis on early embryogenesis and embryonic stem cell commitment to specific differentiation pathways, but from a novel Systems Biology point of view. We are committed to understanding how the vertebral column degenerates with aging, and how this process can be reversed using stem cell based approaches. We use both mouse and zebrafish as model animals. In particular we are working on understanding the gene regulatory networks (GRNs) that govern normal embryonic development of the vertebral column and intervertebral disc (IVD). We are investigating the role of transcriptional regulators in the restriction of pluripotent embryonic stem cells into specific lineages that in turn comprise functional pre and postnatal vertebral elements with the goal of applying this knowledge to regenerative medicine using patient- specific induced pluripotent stem (iPS) cells and adult mesenchymal stem cells.

Damien Samways, PhD (University of Bristol, United Kingdom)

Associate Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Biotechnology

Aim: To understand how ion channel proteins conduct the movement of ions into and out of cells, and examine the potential for using these receptor proteins as endogenous drug transporters for the targeted delivery of therapeutics

Methods: I use patch clamp electrophysiology and fluorescence cell imaging to monitor the movement of ions across the cell's outer plasma membrane.

Applications: Identification of new therapeutic targets for rational drug design

Broader impacts: Better understanding of how the structure of proteins impart their function, identification of novel drug targets, improved drug design, improve drug delivery

Dr. Samways works on the role of ion channels in regulating cell signaling processes in response to neurotransmitters and other chemical mediators. Traditionally, the focus of his research has been the structure and function of ion channels largely expressed in neurons, and here he has made valuable contribution to the understanding of how a number of these proteins open and conduct cations, particularly Ca^{2+} , into cells. More recently, the presence of certain ion channel types in cancer cells, and their potential capacity to carry therapeutic drugs, has encouraged Dr. Samways to consider the function of these proteins in a broader context. Dr. Samways' teaching interests are in the sphere of cellular and molecular physiology and pharmacology. Much of Dr. Samways research has involved investigating how individual amino acid alterations affect the function of ion channels. Relating to this, he is currently building the first exhaustive graphical database of all amino acid alterations tested for an entire ion channel family, the P2X receptors. In addition to serving as a fun and intuitive tool for instructors teaching molecular pharmacology, the database will also provide a much needed and efficient means for researchers to navigate the enormous body of mutational data available for these ion channels.

Kenneth Wallace PhD (Ohio State U.)

Associate Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Biotechnology

Aim: To understand the role of regulatory cells within the developing intestinal stem cell compartment and the impact of nanoparticles on development of the digestive system and whole organism.

Methods: Molecular genetics, cell biology, Developmental biology, proteomics, microscopy

Applications: Regulation of stem cells and methods to produce biologically compatible nanoparticles.

Broader impacts: Repair and protection of digestive organs damaged by disease or environmental insults.

Project 1: Dr. Kenneth Wallace (Biology) works to develop an understanding of control of stem cells within the developing digestive system. Throughout the life of the digestive system, there is rapid turnover of cells that line the opening where food passes to be digested. Within humans, cells divide move up the folds and die within three to five days. Dr. Wallace is investigating development of cells that play a role in controlling the rapid division. Control of cell division needs to be tightly controlled or tumors and cancer may result. Also during cancer development, new cancer cells develop that function to control proliferating cells similar to normal cells. Understanding how and when normal control cells develop will allow for identification of cancer cells controlling proliferation and provide information as how to interrupt their development and function. Dr. Wallace utilizes the zebrafish vertebrate model system to investigate the role of digestive epithelial cells that regulate proliferation.

Project 2: Nanoparticles are currently being used in a multitude of commercial products and are also being manufactured for a number of additional industrial processes. This results in a substantial increase in exposure of all types of organisms to manufactured nanoparticles including humans. While we are experiencing increased exposure, less is known about health affects. Dr. Kenneth Wallace (Biology), in collaboration with Dr. Silvana Andreescu (Chemistry) is investigating the affects of nanoparticle exposure using the high throughput vertebrate model system of zebrafish embryos to rapidly screen and assay biological affects of a number of manufactured nanoparticles within the whole organism. Similarities in response to toxic chemicals between zebrafish and mammals allows for faster and less costly screening of a number of combinations of nanoparticles. Previous exposure studies use high concentrations of nanoparticles to see an affect on the whole organism. Electrochemical probes developed in this investigation will enable determination of more subtle physiological changes occurring at more relevant environmental nanoparticle exposure. One outcome of this work will be a better understanding of how to modify nanoparticles to minimize their toxicity in biological systems.

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Alan Christian, PhD (Miami University)

Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Environment

Aim: Investigate pure and applied life history, ecology, evolution research in freshwater ecosystems, especially freshwater mussels, and to investigate the effects of natural and anthropogenic perturbations (e.g. land use land cover change, urbanization, restoration) on freshwater organisms, populations, communities, and ecosystems.

Methods: Population genetics/molecular ecology/conservation genetics, microbial community structure, ecological stoichiometry, geochemistry and biogeochemistry analysis including stable isotopes and water chemistry, field monitoring, surveys, and experiments, stream habitat geomorphological and habitat characterization and assessment, Geographic Information Systems analyses, and parametric and non-parametric statistical techniques.

Applications: Conservation biology and environmental impact assessments of aquatic ecosystems and restoration projects

Broader impacts: My research spans local, state, regional, and international borders and is relevant, timely, contributes new knowledge, and helps move both science and conservation management forward. While maintaining a focus freshwater mussel ecology and conservation, my work and that of my students contributes, locally and internationally, in the study of pure and applied watershed environmental issues. My research portfolio is aligned with the mission of generating, communicating, and activating knowledge to solve environmental problems while integrating human, natural, and built system impacts on watersheds. As is expected, my research is translated to practice supporting best management practices and the evolution of new modalities for restoration and aquatic system monitoring. In sum my research addresses critical issues of aquatic ecosystem function in urbanized and rural communities facing emerging threats of global change as well as loss of ecosystem services such that my research also acts to ensure a more sustainable, just, and equitable future.

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Shantanu Sur MBBS, PhD (Indian Institute of Technology)

Assistant Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Biotechnology, Materials Science

Aim: (a) Study cell-biomaterials interactions with a goal to develop novel materials for biomedical applications. (b) Airborne pathogen detection from a portable real-time air quality monitoring system.

Methods: Study molecularly designed biomaterials on *in vitro* model systems; assay methods include spectroscopy, molecular biology techniques (western blot and PCR, transfection), fluorescence microscopy (confocal), live-cell imaging, calcium imaging, flow cytometry, *in situ* hybridization; materials characterization by mass spectroscopy, circular dichroism, X-ray scattering, electron microscopy; develop mathematical models to understand cell dynamics; quantitative PCR and next generation sequencing for identification and quantification airborne pathogens.

Applications: Designed materials for regenerative or cancer therapy; targeted delivery of proteins and drugs in the lungs using microparticles; air quality monitoring to predict the risk for airborne infections.

Broader Impacts: Advancement in health by development of novel diagnostic and therapeutic strategies.

One major goal in our lab is to find out design principles to tune supramolecular biomaterials for specific biomedical applications, focusing mainly at the interactions at the cell-biomaterials interface. We are especially interested in tailoring the biophysical properties of the supramolecular assemblies such as stiffness, nanostructure, molecular arrangement and cohesion to elicit desired cell response. On a collaborative endeavor, we are studying how the properties of peptide-based materials control cell proliferation, differentiation, migration, response to growth factors, and programmed cell death. Taking advantage of this materials platform and using live imaging studies, we seek to extend our fundamental understanding on the dynamic behavior of cells, especially how the microenvironment partakes in tumor cell invasion. We are also interested to understand how the supramolecular properties can be harnessed to target cancer cells and deliver chemotherapeutic agents. Targeted drug delivery to lungs using microparticles is another area of interest in our lab. We are currently working in collaboration to develop core-shell microparticles for tuberculosis (TB) therapy that will be deliverable via respiratory route to deep lung tissue and target macrophages to deliver anti-TB drugs to reduce bacterial load in these cells. On a different direction our lab has started a collaborative venture to build and characterize a portable aerosol biosampler that will provide information on the airborne pathogen load along with a real-time data of particle size distribution in air. Our lab's primary objective here is to optimize techniques for DNA extraction, qPCR, and next-generation sequencing (NGS) data analysis to develop a sensitive and reliable method to identify and

determine relative abundance of pathogens in aerosol samples. We are currently working on deploying this system in hospital environment where the pathogen analysis of collected aerosol particles is expected help in the risk assessment for healthcare-acquired infections transmitted or dispersed through air.

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Susan Bailey, PhD (University of Ottawa, Canada)

Assistant Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Environment, Biotechnology

Aim: To understand fundamental processes driving variation in evolutionary adaptation and diversification across organisms and environments.

Methods: Mathematical and statistical modelling, bioinformatics, microbial experimental evolution.

Applications: Predicting how and when species of interest will evolve in response to environmental changes; modelling the evolutionary dynamics of human pathogens and cancers.

Broader impacts: Inferring evolutionary history of populations and communities and predicting future evolutionary dynamics in a changing world.

Dr. Bailey's research aims to understand the fundamental processes driving evolutionary adaptation and diversification. She uses a combination of mathematical/ statistical models and microbial lab experiments with two current focuses: 1) investigating the dynamics of adaptation and diversification in spatially heterogeneous environments, and 2) identifying potential factors driving parallel or convergent evolution. By evolving the bacteria *Pseudomonas fluorescens* in varied environments in the lab, Dr. Bailey tests the effects of a range of genetic and environmental factors that play potentially important roles in populations living in the complex natural world, but are difficult to tease apart without controlled experiments. Replication of these kinds of evolution experiments and characterization of the varied outcomes, then allows for exploration of if, and when, evolution is predictable. Dr. Bailey uses comparative genomics to explore resulting genetic changes in her experimental bacteria populations, and other natural populations, and builds mathematical and statistical models to generate and test hypotheses describing the evolutionary dynamics underlying the observed genetic changes.

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Andrew A. David, PhD (Universiteit van Stellenbosch, South Africa)

Assistant Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Environment

Aim: To understand the scope of biological invasions through an integrative approach that spans all levels of biology; from the genetic to the ecosystem level.

Methods: Designing and maintaining experimental larval cultures, Light and Scanning Electron Microscopy, Field sampling and water quality measuring, Polymerase Chain Reaction and genotyping of specimens, bioinformatics, oceanographic modelling

Applications: Management of invasive species, coastal conservation, design of aquaculture farms,

Broader impacts: Improving the design of marine protected areas (MPAs), prioritizing localities for the management of invasive species, informing aquaculture farmers and shareholders on best practices for farm operations, contributing to the natural history of benthic invertebrates

Dr. David works on a widely researched area in marine ecology; understanding dispersal and range expansion of invasive species. Anthropogenic disturbances such as introductory events and climate change are expected to significantly alter species ranges on a global scale and developing methods to predict these changes are crucial for conserving marine biodiversity. His research involves designing culture methods to rear non-model organisms (e.g. obligate symbiotic polychaetes) in the laboratory and investigating the effects of changing temperature and salinity regimes, (as predicted by climate change models) on their development. Furthermore, his research uses population genetics to measure larval connectivity and gene-flow among spatially separated populations. This method is often used to detect evolutionary significant units, which are the targets of many conservation programs. His most recent research involves developing an integrated approach that combines genetic studies with high resolution transport/circulation models to predict the spread of invasive species. This method is expected to be a more powerful measure of estimating connectivity as the model rules out human-mediated movement, and therefore acts as a control for anthropogenic influences. The study is an ongoing collaborative effort with researchers from both South Africa and the United Kingdom. Dr. David's teaching interests involve the use of active learning instruments such as data nuggets and case-based studies as a method of increasing student engagement in freshman Biology courses.

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Ginger Hunter, PhD (Duke)

Assistant Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Biotechnology

Aim: To understand how local signals are integrated across developmental space and temporal scales during patterning.

Methods: Molecular genetics, cell biology, developmental biology, microscopy, biophysical manipulations.

Applications: Organismal development.

Broader impacts: Development of new tools to study the dynamics of cell fate decision making, experimental and theoretical approaches to cell signaling and pattern formation.

Dr Hunter's research focuses on how local cell behaviors and interactions are integrated across tissues during successful developmental patterning, using the fruit fly model system, *Drosophila melanogaster*. Specifically, this research takes an experimental approach towards understanding the mechanisms of signaling filopodia-mediated lateral inhibition; initially considering the regulation of the filopodia structure as well as the dynamics of Notch-mediated cell fate change during lateral inhibition. Collaborative efforts have helped to develop a mathematical model of long-range lateral inhibition, which contributes to guiding the experimental framework focussed on understanding the molecular mechanisms at the interface of cell shape and signaling. Dr Hunter takes genetic, cell biological, and biophysical approaches to ask (1) how cells engage in lateral inhibition via filopodia; (2) what are the dynamic cell responses as a function of distance; (3) what is the role of cell shape and behavior during lateral inhibition.

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Stefanie Kring, PhD (Clarkson University)

Assistant Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Environment

Aim: To increase the understanding of the St. Lawrence River ecosystem, and understanding the role of phytoplankton and zooplankton role in the algal biofuel industry

Methods: Fieldwork that involves the measurement of phytoplankton, zooplankton, nutrients, and other water quality parameters. Laboratory experiments include the use of phytoplankton and zooplankton cultures to conduct controlled experiments that include the measurement of lipids and growth rates.

Broader Impacts: Dr. Kring conducts research on water quality and the sustainability of algal biofuels. Phytoplankton dynamics is the common theme in all of Dr. Kring's research. She has studied wastewater lagoons as a potential biofuel source due to their phytoplankton and zooplankton populations. She has also examined the accuracy of an in situ fluorometer for measuring phytoplankton biomass in freshwater ecosystems. Dr. Kring is currently assessing the fate and transport of mercury and methyl mercury on the north and south shores of fluvial Lake St. Francis (St. Lawrence River).

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Beatrice Hernout, PhD (University of York, England)

Assistant Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Environment

Aim: Assessing the effects of anthropogenic contaminants in wildlife species.

Methods: Molecular toxicology, analytical chemistry, spatial analyses, ecological monitoring and computational biology techniques.

Applications: Predicting the potential risks and improving environmental risk assessment for regulatory purposes.

Broader impacts: Helping in mitigating risks and contributing to the conservation of wildlife species.

My main research aims focus on 1) assessing the exposure and bioaccumulation of chemicals in wildlife; 2) evaluating the potential adverse effects and predicting the associated risks; and 3) extrapolating risk predictions from individual to populations or communities. I have previously investigated the effects of trace metals and organic pollutants in several taxa: bats, birds, reptiles and fish.

Current research involves the monitoring of body burdens of PAHs (Polycyclic aromatic hydrocarbons), and PCBs (Polychlorinated biphenyls) in fish from the Gulf of Mexico (using GC-MS techniques). These pollutant body burdens will be associated with the activities of hepatic enzymes (involved in the biotransformation and biodegradation of organic contaminants). These monitoring data will provide a deep insights into the effects of marine pollutants in fish from the Gulf.

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Petra Kraus, PhD (University of Ulm, Germany)

Assistant Professor, Clarkson University Department of Biology

Clarkson Strategic Theme: Biotechnology

Aim: Develop quality control measures for the use of human stem cells and reprogrammed pluripotent cells in regenerative medicine therapy with a focus on intervertebral disc disease.

Methods: We have established the bovine intervertebral disc (IVD) as suitable human-related experimental animal model system for the identification of markers of the different cell lineages of the IVD and for the development of much needed quality control assays at single cell resolution to improve culture conditions towards the derivation of the different IVD cell lineages for clinical applications.

Applications: Quality control of human cells generated for regenerative medicine based therapeutic approaches with a focus on cells of degenerated or injured intervertebral discs.

Broader impacts: Development of gene and protein markers for quality control assays with single cell resolution to ensure homogeneity of cell lineages and patient safety when receiving therapeutic cell and tissue transplants. We are committed to identifying and characterizing the different cell lines present in the adult IVD. Using advanced gene editing methodologies we are engineering visible markers for the different IVD cell lineages to establish conditions for the isolation and maintenance of homogeneous cell lines. This will help understand their individual contributions to the mature IVD and their response to transcriptional regulators in order to develop robust and safe clinical protocols for culturing these cell lines for use in human cell and tissue based regenerative medicine therapies.

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Michelle Mi-Jeong Yoo, PhD (University of Florida)

Clarkson Strategic Theme: Environment, Biotechnology

Aim: To understand the impact of polyploidy on plant speciation/diversification and crop domestication.

Methods: Evolutionary “-omics” tools of genomics, transcriptomics, proteomics, and metabolomics, bioinformatics, physiological response to environmental stress, phylogenomics using target enrichment method

Applications: crop improvement, development of conservation program

Broader impacts: Predicting the target genes and networks in crop species which lead to improved yields and increased stress-tolerance capabilities; development of conservation program based on a population structure and species diversity

Dr. Yoo’s research have encompassed diverse areas of biology, including molecular evolution, phylogenetics, evolutionary developmental biology, evolutionary genomics, proteomics, metabolomics, physiology, and genetics. The primary focus of her research is on how plants adapted to their environment and how evolutionary processes, such as polyploidy, hybridization and domestication, contributed phenotypic modification and diversification of higher plants. Dr. Yoo tries to address the following questions using comparative and integrative approaches with omics technologies: **1)** how human selection has shaped the evolution of spinnable cotton fibers?, **2)** how polyploidy or whole genome duplication triggered the diversification of flowering plants, focusing on two model systems, cotton and *Tragopogon*?, **3)** how polyploids better cope with environmental stresses than their diploid parents using *Brassica* polyploid system?, and **4)** what evolutionary and molecular processes have shaped the plant diversity and trait evolution in flowering plant lineages?. The improved understanding of plant genome evolution and plant adaptation to the environment may provide effective biotechnology targets and strategies for the improvement of crop species.

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Ali Boolani, Ph.D. (Oklahoma State University)

Adjunct Associate Professor, Clarkson University Physical Therapy Program

Clarkson Strategic Theme: Health

Aim: To use science to better understand how physiology influences how we feel and our cognitive decline and how our moods and cognitive decline influence how we move.

Applications: To create systems to help identify people who have mood disturbances or cognitive decline.

Broader Impact: Identifying sub-clinical mood changes through human movement, creating interventions to reduce the onset of clinical mood changes, creating better objective measures to identify sub-clinical mood states, identifying sub-clinical mood changes through changes in human physiology, identify cognitive decline through human movement and human physiology

The research in the Boolani lab is four fold: 1) Understand how human physiology influences mood and how those moods manifest themselves in human movement; 2) Develop interventions to improve moods; 3) Identify the physiological mechanisms behind cognitive decline and how they influence human movement; 4) Develop interventions to reduce cognitive decline. Currently our lab is trying to understand the influence of mitochondrial function, heart rate variability and pulmonary function on moods and cognitive decline and how these moods and this cognitive decline influences human movement. Additionally, we are trying to develop interventions to improve moods and reduce cognitive decline.

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Deborah M. Brown, PhD (University of Rochester Medical Center)

Adjunct Associate Professor, Trudeau Institute

Clarkson Strategic Theme: Biotechnology/Health

Aim: To understand the immune response to viral infection in order to improve vaccines for influenza.

Methods: Mouse models of infection and immunity, flow cytometry, ELISA, influenza infection

Applications: Vaccine design, generation of immune memory, T cell biology

Broader impacts: Better understanding of the immune response to vaccination, improved vaccine design and development for influenza vaccines, preparing undergraduates for research careers

The overall goal of Dr. Brown's research program is to understand how T cells are activated, differentiate into memory and provide protection against viral infections.

We aim to understand how the innate immune response shapes the development of resident T and B cell memory as a prerequisite for developing vaccine strategies that induce broad protection against influenza infection. protection against infection in order to facilitate novel vaccine designs for emerging infectious disease. Project 1 utilizes synthetic small molecule activators of innate immunity as vaccine adjuvants to promote protection against lethal, highly pathogenic influenza infection. Dr. Brown's group has demonstrated that using small molecules in combination can provide dose sparing effects of both vaccine and adjuvant and promotes an immune state that more resembles infection, unlike current vaccine strategies for influenza. Project 2 involves understanding the signals required for differentiation of distinct T cell subsets that provide anti-viral, anti-bacterial or homeostatic immune responses, while at the same time, avoiding autoimmunity.

Dr. Brown's teaching interests include using innovative and student based learning techniques to make a complex subject like Immunology accessible for undergraduate Biology students. In addition, Dr. Brown is actively involved in creating unique laboratory experiences and career development training for undergraduates interested in a biomedical research career.