THE BIOLOGY DEPARTMENT AT HOLY CROSS – A HISTORICAL PERSPECTIVE

This handbook summarizes the resources available in the Department of Biology for the education of Holy Cross students. Included are descriptions of the curriculum, extracurricular opportunities, and suggestions for informal study.

The first biology courses were offered at Holy Cross in 1914 by Dr. Joseph O'Connor, a local physician. In 1915 John A. Frisch, a young Jesuit scholastic, established the department. By the 1930's the faculty had grown to a nucleus of four legendary professors who remained until their retirement in the 1960's: Thomas Malumphy, Robert Crowe, William Campbell, and Fr. Joseph Busam. By that time the department, originally housed in Beaven Hall, had moved to O'Neil Hall, whose classrooms, laboratories, and offices were dedicated in 1951 with a speech by the department founder, Father Frisch.

The facilities expanded over the next three decades. O'Neil Hall was extensively modified to accommodate microbiology, biochemistry, electron microscopy and a computer laboratory. In 1985 the opening of Swords Hall provided laboratories for biochemistry, physiology, cell culture, and histology, greenhouses, computer and dark room facilities, warm and cold rooms, environmental chambers and an animal room. By the turn of the century the requirements of modern life science education had outstripped even those facilities. O’Neil Hall underwent a complete renovation and addition of a new wing to house molecularly based instructional and research laboratories and faculty offices. Recent grants have provided major equipment for protein purification and a laser scanning confocal microscope.

The human resources expanded, too. With the appointment in 2006 of the College’s first geologist, the department now numbers thirteen faculty members, three laboratory supervisors, an administrative assistant, and a departmental assistant. Their names, scientific specialties, campus addresses and phone numbers are listed below together with the year faculty members are next eligible for sabbatical or junior leave. Numerous student teaching assistants also participate in laboratory instruction each semester.

Faculty	Scientific Specialty	Office	Phone	Next Leave
Dr. Robert M. Bellin	Biochemistry	O’Neil 331	3422	2015-16
Dr. Robert I. Bertin **(Chair)**	Ecology, Botany	O'Neil 316	2352	2011-12
Dr. Leon P. Claessens	Vertebrate Morphology, Paleontology	O'Neil 315	2594	2011-12
Dr. George R. Hoffmann	Genetics, Toxicology, Botany	O'Neil 107	3416	2015-16
Dr. Mary Lee S. Ledbetter	Cell and Molecular Biology	O'Neil 335	3418	2014-15
Dr. Sara G. Mitchell	Geology, Geomorphology	Swords 234	3420	2013-14
Dr. Karen A. Ober	Evolution, Entomology	O'Neil 227	3046	2011-12
Dr. Kenneth N. Prestwich	Physiology, Invertebrate Zoology	O'Neil 107	2578	2011-12
Dr. Ann M. Sheehy	Immunology, Virology	Swords 235	2255	2011-12
Dr. William V. Sobczak	Freshwater Ecology	O’Neil 207	3752	2015-16
Dr. Madeline Vargas	Microbiology	O'Neil 333	3036	2009-10
Dr. Sarah M. Webster	Neurobiology	Swords 233	2212	2011-12

Staff	Title	Office	Phone
Mrs. Darlene A. Colonna	Departmental Assistant	O'Neil 121B	2757
Mr. James M. Doyle	Senior Laboratory Supervisor	O’Neil 217	2588
Mrs. Catherine Dumas	Laboratory Supervisor	O'Neil 214	2579
Mr. Peter J. Lemay	Laboratory Supervisor	O'Neil 314	3415
Mrs. Linda A. Walsh	Administrative Assistant	O'Neil 120	2656

THE BIOLOGY MAJOR

REQUIREMENTS FOR THE BIOLOGY MAJOR

A student intending to major in biology should begin to satisfy the departmental requirements early in his or her career at Holy Cross, since advanced courses frequently have prerequisites. While it is possible to complete the biology major without having satisfied any of the requirements before the sophomore year, prospective biology majors are encouraged to take both chemistry and biology in their first year. Biology majors are required to take the following courses:

Biology (8 courses, 6 with lab): All majors take Biology 131, 132 with lab and 261 or 262. All majors must also take at least one course from each of three areas of biology (see below) to meet the departmental distribution requirement. Students must earn the grade of C or better in Biology 131 and 132 to continue in the major.
Mathematics: Mathematics through Math 132, 134, or 136.
Chemistry (4 courses with lab): Chemistry 181, 221, 222*, 231.
Physics (2 courses with lab): Physics 111 & 112* or 115 & 116*

Courses that fulfill the departmental distribution requirement are as follows:

1. **Molecular and Cellular**

Biology 223	Microbiology
Biology 266	Cell Biology
Biology 301	Biochemistry I
Biology 302	Biochemistry II
Biology 341	Virology
Biology 392	Immunology

2. **Organismal**

Biology 213	Comparative Vertebrate Morphology
Biology 220	Entomology
Biology 250	Field Botany
Biology 255	Vertebrate History
Biology 361	Toxicology
Biology 390	Animal Physiology

3. **Ecological and Evolutionary**

Biology 233	Freshwater Ecology
Biology 280	General Ecology
Biology 283	Evolution
Biology 287	Ethology & Behavioral Ecology
Biology 331	Ecosystem Ecology
Biology 381	Conservation Biology

Additional department electives include:

Biology 275	Biological Statistics
Biology 299	Geomorphology

*Students interested in ecological or paleontological aspects of biology may substitute Biology 150 – Introduction to Geology for either Chemistry 222 or Physics 112 or 116 after consulting with their advisor and with the permission of the Chair. However, both the chemistry and physics courses are still required for students in the premedical program, biochemistry concentrators, or those intending graduate study in areas of functional biology. Students should also seek permission from the Chair of Chemistry to waive the prerequisite of Chemistry 222 for Chemistry 231.

A score of 4 or 5 on the Advanced Placement earns a student 1.25 units of credit unless she or he takes Biology 131. All biology majors are expected to take Biology 131.

Biology majors are required to take a minimum of 6 of their 8 biology courses at Holy Cross. Transfer students must take a minimum of 6 of their biology courses at either Holy Cross or the institution from which they transferred.

Premedical biology majors must also take two courses in English to satisfy the requirements of the premedical program.

Problems in Biology (Biology 311, 312) courses apply to distribution requirements appropriate to the subject. Inquire in the Department Office regarding the classification of specific Problems courses.

Majors may enroll in certain sections of **Biological Principles (Biology 114)** but do not receive credit toward the major.

Undergraduate or Honors Research (Biology 401, 407, 408), Problems in Biology (Biology 311, 312), and Directed Readings (Biology 405) may be taken for college credit. One semester may be counted for credit toward the requirements of the major. Application of these courses to the departmental distribution requirement is by approval before the course is taken; consult with the Chair on specific cases.

BIOCHEMISTRY CONCENTRATION

The Departments of Biology and Chemistry jointly offer a concentration that focuses on the study of the chemistry underlying biological structure and function. Concentrators must be enrolled as either biology or chemistry majors. Participants take Biology 131 (or Biology 120), 301, and 302 with laboratories; Chemistry 181, 221, 222, 231 and 255; and one additional biology course with an associated biochemistry-oriented laboratory, in addition to the usual courses required of their major. Furthermore, concentrators complete a two-semester thesis project in their fourth year involving research in some aspect of biochemistry. Admission to the Concentration is competitive and occurs in the second semester of the second year. Interested students should contact the chair of either department.

BIOLOGICAL PSYCHOLOGY CONCENTRATION

The Departments of Biology and Psychology jointly offer an interdisciplinary concentration that concerns the study of neuroscience and behavior. Concentrators major in either biology or psychology and take courses in both departments in fulfillment of the concentration requirements. Students are exposed to original research throughout the concentration and may elect to spend a portion of their fourth year engaged in a thesis project. Admission to the concentration is competitive and is limited to eight students per class year. Interested students should consult with the Concentration Director or the Chair of the Biology or Psychology Department prior to registering for second-year courses.

ENVIRONMENTAL STUDIES CONCENTRATION

Students with any major can elect a concentration in Environmental Studies. This is a multidisciplinary program administered by the Center for Interdisciplinary and Special Studies. Students must take seven courses approved for the concentration, including an appropriate balance of courses inside and outside the natural sciences. More details are available in the Center for Interdisciplinary and Special Studies, or from the Coordinator of Environmental Studies.

COURSES OFFERED

BIOLOGY 114: BIOLOGICAL PRINCIPLES (Fall and Spring)

These courses are offered by members of the department on topics of general interest. They are designed for nonmajors, but biology majors may enroll in some sections. Biological Principles courses may not be applied for credit toward the major. The following list is subject to change depending on staff availability.

BIOLOGICAL PRINCIPLES-Biological Chemistry of Health & Disease
Professor Bellin

This course deals with concepts of biological chemistry in the context of topics related to human health and disease. Possible topics include nutrition, the immune system, heart disease, cancer, and infectious disease. Material in the course will be covered through a combination of lecture and discussion, therefore requiring students to keep up with out-of-class reading assignments in order to participate in class adequately.

BIOLOGICAL PRINCIPLES-Conservation Biology
Professor Prestwich

This course deals with biological aspects of the use and preservation of our natural biological resources. We will focus on biological diversity – what it is, how it is measured and how it is maintained. We will discuss different aspects of diversity such as genetic diversity within species, species diversity within ecological communities and finally, ecosystem diversity. As part of this discussion, we will consider threats to diversity and management techniques. Major issues will be illustrated through a number of case studies. This course is suitable for Environmental Studies Concentrators.

BIOLOGICAL PRINCIPLES-Environmental Biology
Professors Bertin and Sobczak

The course begins with an introduction to the ecosystem perspective, covering such topics as food webs, energy flow, nutrient cycling and ecological succession. It continues with a consideration of population growth and regulation and human population issues. The ability of ecosystems to sustain this growing population is examined in units on agriculture, pest control and biological resources. Environmental effects of humans are considered in units on energy, water and air pollution and global climate change.

BIOLOGICAL PRINCIPLES-Evolution
Professor Ober

This lecture course is an introduction to the concept of evolution, the major paradigm used to interpret modern biology, which has been hailed as one of our species' greatest intellectual achievements. The material covered includes evaluation of evidence for evolution, discussion of the central importance of genetics for understanding evolution and an explanation of the role of natural selection in causing evolution. How evolutionary thinking relates to religion and the implications of a dynamic worldview for modern society are emphasized.

BIOLOGICAL PRINCIPLES-Global Change Biology
Staff

The goal of this course is to develop an understanding of the key aspects of global environmental change and the biological effects of those changes. Much of the course focuses on atmospheric and climate change, but additional topics include ozone depletion, air pollution, changes in the nitrogen cycle, preservation of biodiversity, invasive species, and land-use change.

BIOLOGICAL PRINCIPLES-Molecular Biology and the HIV Pandemic
Professor Sheehy

This course emphasizes biological aspects of the HIV pandemic. It will focus especially on the nature of the human immunodeficiency virus, its effects on host cells and interactions with the host immune system. It will also consider the epidemiology of AIDS and the specific challenges of developing an effective vaccine. Limited emphasis is given to pertinent ethical and social concerns of the pandemic.

BIOLOGICAL PRINCIPLES-Plant Life
Professor Hoffmann

This course provides a survey of biological principles as revealed through the study of plants. It introduces the chemistry of living systems, cell structure and function, cell division processes, life cycles, genetics, and the classification of organisms. It also surveys organisms that are typically studied as part of the science of botany, including algae, fungi, mosses, ferns, conifers, and flowering plants. The survey has three main emphases: biological diversity, evolution, and the ecological and economic importance of the organisms. The flowering plants are studied in detail, focusing on plant tissues and organs (roots, stems, leaves, and flowers). Plant anatomy is related to function through such physiological topics as water relations, mineral nutrition, photosynthesis, food translocation and storage, plant hormones, and development. An introduction to plant ecology includes a discussion and slide show on the local flora. The course concludes with consideration of such specialty topics as plant biotechnology, propagation, and edible and poisonous plants.

BIOLOGICAL PRINCIPLES-Toxicants & Radiation
Professor Hoffmann

This course explores principles of biological, physical, and mathematical sciences through the study of toxic substances and radiation. Topics covered include: 1) general principles of toxicology and radiation biology; 2) how toxicants and radiation affect cell structure and function; 3) effects on each of the major body systems; 3) carcinogens, mutagens, and agents that adversely affect prenatal development; 4) environmental toxicology; 5) policies for the protection of public health.

BIOLOGICAL PRINCIPLES-Unseen World of Microbes
Professor Vargas

This course introduces students to scientific methodology and biological principles through the study of microorganisms. Bacteria, fungi, viruses, and other microbes have a profound impact on human activities. Some microbes cause disease in humans, animals, and plants. Other microbes play useful roles in the production of drugs, foods, and other products. In our brief tour of the microbial world, we use the biology of microorganisms as a focus for examining the nature of modern science. In doing so, we also explore the diverse ways that microbes affect our lives.

BIOLOGY 120: GENERAL BIOLOGY 1 (Fall)
Professor Webster

Prerequisite or Corequisite: Chemistry 222.

This course is designed for nonbiology major premedical students. Together with General Biology 2, it is intended to satisfy the biology requirements for medical school admission and the MCAT. If space permits, others satisfying the prerequisites may enroll. Students who have completed Biology 131 or 132 may take only one of the courses, Biology 120 or Biology 121, for credit. They and others are, however, welcome to audit the course.

Since the course is designed for juniors who have completed organic chemistry, it is a fairly rigorous study of biology at the lower levels of organization: molecules, macromolecules, subcellular organelles, and cells. In the process the student is introduced to disciplines customarily taught as biochemistry, cell biology, molecular biology and genetics. We use a standard introductory textbook, such as Campbell's *Biology,* but selected topics are considered in more detail, using more advanced textbooks and journal articles as sources.

The laboratory exercises are integrated with the material offered in lecture, and are designed to fill only the scheduled laboratory period. Occasional exceptions require additional time, but they can be scheduled at the convenience of the student.

Evaluation is based on the examinations (2 to 3 midterms, 1 final), weekly lab reports, and an analytical paper based on library research. The work load is heavy and the pace rapid, but effort is generally rewarded.

BIOLOGY 121: GENERAL BIOLOGY 2 (Spring)
Professor Claessens

Prerequisite: Biology 120.

This course is designed to acquaint nonbiology majors who are pre-medical students with the basic principles of biology and diversity of life at the organismal level and above. A survey of the topics covered is given in the course guide. Lecture examinations consist of essay and short-answer questions.

The laboratory exercises generally follow the lecture topics closely, thus giving the student a practical familiarity with the material. The laboratory includes dissections of preserved fetal pigs, histology, and examination of animal taxonomy and diversity. Laboratory grades are determined by practical exams, dissections, and a few short exercises.

BIOLOGY 131: INTRODUCTION TO BIOLOGY 1 (Fall)
Professors Prestwich and Sheehy

This course is required of biology majors and is usually taken in the first semester.

Biology is a fragmented discipline subdivided into a myriad of specializations. Biology 131 attempts to provide a coherent, unified picture of biology by ordering principles around structural levels of organization from macromolecules to ecosystems. Emphasis is placed upon interrelationships among the structural levels, and topics discussed are chosen to illustrate the correlation of structural and functional properties at each level. In addition, the basic principles of genetics, development, behavior, and evolution are discussed.

INTRODUCTION TO BIOLOGY 1 - LABORATORY (Fall)
Staff

The primary goal of the laboratory is to acquaint students with the practical application of scientific thinking to biology. Exercises are designed to provide the student with a large amount of factual information, but only through rigorous application of the scientific method. During the early part of the semester, data gathering is dependent on direct observation, and is thus relatively straightforward. Later exercises are increasingly complex, ultimately presenting the student only with the problem, leaving the experimental design, results, and conclusions to be worked out independently.

Topics covered using this approach include histology, anatomy, physiology, genetics, biochemistry, and ecology. A formal lab report is required. Quizzes, other assignments, and practical exams are also given.

BIOLOGY 132: INTRODUCTION TO BIOLOGY 2 (Spring)

Biology 132 covers plant and animal diversity and is required of all biology majors. Half of the course is devoted to botany and the other half to invertebrate zoology.

Botany
Professor Hoffmann

The botanical portion of the course includes a phylogenetic survey and selected topics in plant physiology. The emphasis in the survey is on comparative morphology, life cycles, systematics, and evolution. Organisms studied include plants in the common sense of the word; green, red, and brown algae; other algal groups that are sometimes considered as protozoans or protists (*e.g.*, euglenoids, diatoms, and dinoflagellates); myxomycetes; and fungi. Physiological topics include water relations, mineral nutrition, photosynthesis, carbohydrate translocation and storage, nitrogen metabolism, plant hormones, and development. Laboratory sessions involve the study of algae, fungi, bryophytes, ferns, conifers, and flowering plants and experiments in plant physiology. Evaluations include laboratory quizzes, a laboratory notebook, and two examinations based on the lectures, the laboratory, and reading assignments.

Invertebrate Zoology
Professors Bertin and Ober

The zoological portion of the course includes a survey of selected groups of animal-like protists and invertebrate animals. The emphasis of the subject matter varies from group to group and includes comparative morphology and physiology, life history, ecology, behavior and special topics. Labs emphasize taxonomy and morphology of major groups. Evaluations include two lecture exams, laboratory quizzes, and a laboratory notebook.

BIOLOGY 150: INTRODUCTION TO GEOLOGY (Fall)
Professor Mitchell

Introduction to Geology is an introduction to the physical processes operating on the earth and the history of the earth. This course will introduce topics including the formation and physical properties of rocks and minerals, plate tectonics, geologic time, weathering and erosion, geologic hazards including volcanoes, earthquakes, flooding, and landslides, global climate change, and the geology of mineral and energy resources.

Laboratory sessions including field trips to local geologic sites will provide students with hands-on experience using classic and modern approaches to investigating the earth and its history. The course includes one required Saturday field trip to the Connecticut River Valley.

This course is appropriate for science and non-science students interested in the geologic history, processes, and materials of the earth.

BIOLOGY 199: ENVIRONMENTAL GEOLOGY (Fall)
Professor Mitchell

This non-lab course will introduce students to the relationship between humans and the Earth. We will focus on understanding the geologic processes that shape the surface of the Earth, and how these processes affect and are affected by human activity. We will also discuss how the scientific method allows us to study, predict, and mitigate environmental problems. Specific topics may include: plate tectonics, earth materials, natural hazards such as earthquakes, volcanoes, and floods, surface water dynamics, groundwater systems and pollution, natural resources, and global climate change. This course will include lectures, discussions, in-class activities, problem sets, exams, and a final project involving environmental case studies. Readings will come from textbooks, scientific literature, and popular literature.

This course is suitable for Environmental Studies majors and concentrators. Students may not take both Environmental Geology and Introduction to Geology (BIOL 150).

BIOLOGY 210: GEOMORPHOLOGY (Spring)
Professor Mitchell

Geomorphology is the study of the landforms and processes that shape and modify the Earth's surface. Because we also reside on the Earth's surface, geomorphic processes are often relevant to human and environmental concerns. This intermediate-level course focuses on topics including the relationships between tectonics and landforms, rivers, glaciers, and hillslope processes. In addition to the text, students will read and discuss several articles from the primary literature. Laboratory sessions will include field trips to observe, measure, and analyze various geomorphic features and processes. Many labs have a significant quantitative component, requiring use of Microsoft Excel and/or ArcGIS computer software (instruction will be provided). Grading is based on weekly laboratory assignments, one or two midterm exams, a comprehensive final exam, an independent research project, participation in class discussions, and other assignments.

This course is particularly relevant for biology students interested in ecology and Environmental Studies students interested in the scientific study of our physical environment. Prior completion of Introduction to Geology (BIOL 150) or Environmental Geology (BIOL 199) is recommended, though not a prerequisite, for Geomorphology.

BIOLOGY 213: COMPARATIVE VERTEBRATE MORPHOLOGY (Fall)
Professor Claessens

Prerequisite: Biology 131

Lectures cover the morphology and evolution of the vertebrate body, using embryos and adults of living forms, as well as the fossil record. Primary objectives include:

1. an understanding of both functional and phylogenetic factors contributing to morphological similarities and differences among vertebrates,
2. a comprehension of evolutionary principles, as elucidated by vertebrate history, and
3. a general understanding of the systematics and diversity of living vertebrates.

The laboratory consists of a rigorous, detailed consideration of vertebrate anatomy, including a study of the skeletal system in representatives of all vertebrate classes, and dissections of preserved sharks and cats. The course includes one Saturday field trip to the Harvard Museum of Comparative Zoology in Cambridge. The laboratory accounts for approximately forty percent of the course grade.

BIOLOGY 220: ENTOMOLOGY (Fall)
Professor Ober

Prerequisites: Biology 131 and 132.

A general introduction to insects covering diversity, morphology, physiology, ecology and behavior, as well as considerations of the economic and medical importance of insects. Specific topics include metamorphosis, complex life cycles, flight, dispersal, sensory systems, thermoregulation and adaptations to special conditions, as well as ecological and evolutionary issues, including population dynamics, coevolution, plant-insect relationships, sociality, and parasitism. Labs investigate insect internal and external anatomy, structure, and behavior, as well as taxonomy and systematics of insect orders. Readings are from the textbook and supplementary sources.

BIOLOGY 223: MICROBIOLOGY (Fall)
Professor Vargas

Prerequisites: Biology 131, 120 or the equivalent and Chemistry 181.

General topics covered in this course include the history and development of microbiology, microbial metabolism, the role of microbes in disease, and microbial evolution. The biology of viruses and of prokaryotic and eukaryotic microorganisms is explored with special reference to bacteria and fungi. The course provides an overview of bacterial taxonomy and diversity, catabolic and biosynthetic pathways, microbial growth, genetics, symbiosis, and industrial and environmental microbiology. The laboratory emphasizes pure culture methods and diagnostic microbiology. It offers an exposure to modern instruments and techniques (*e.g.*, microscopy, spectrophotometry, chromatography, and electrophoresis).

BIOLOGY 233: FRESHWATER ECOLOGY (Fall)
Professor Sobczak

Prerequisites: Biology 131 and 132.
Some background in chemistry, ecology and statistics is helpful, but not required.

Freshwater Ecology provides students with a comprehensive introduction to the physical, chemical, and biological attributes of freshwater ecosystems. Field trips and exercises are designed to expose students to the importance and complexity of a wide diversity of aquatic ecosystems. Instruction covers the hydrology, chemistry, and ecological characteristics of streams, rivers, lakes, and wetlands, and provides students with a solid foundation in this complex multidisciplinary field of ecology.

BIOLOGY 250: FIELD BOTANY (Fall of every second year)
Professor Bertin

Prerequisites: Biology 132 or permission of instructor.

This course introduces the vascular flora of New England, emphasizing woody species and fall-flowering herbaceous species. Habitats examined include fields, forests, wetlands, and coastal and montane communities. It includes an introduction to plant taxonomy and nomenclature and a review of major plant families. The course includes training in the use of field guides, the use and construction of technical keys, and the preparation of herbarium specimens. Much course time will be spent in the field.

BIOLOGY 255: VERTEBRATE HISTORY (Spring)
Professor Claessens

Prerequisites: Biology 131 and 132.

This course provides students with a survey of vertebrate history, with emphasis on the anatomical and physiological transformations that occurred at the evolutionary originations of the major vertebrate groups. The structure and function of both extant and extinct taxa is explored, as documented by modern fauna and the fossil record. Laboratories will focus on the detailed osteology of living forms and various types of fossil material to elucidate vertebrate evolution. Laboratories will examine systematics, structure, and function as it can be deduced from skeletal and fossil specimens. The course includes one Saturday field trip to the Harvard Museum of Comparative Zoology in Cambridge. Grading is based on lecture and laboratory exams, plus a team-written paper based on a large project assigned in laboratory mid-semester.

BIOLOGY 261: GENETICS (Fall)
Professor Hoffmann

This course is required of all biology majors. Other genetics courses, with or without laboratory, may be substituted to fulfill the requirement if the prerequisites and content are equivalent.

Prerequisites: Biology 131 and 132; Chemistry 221.

The genetics course provides an understanding of mechanisms of heredity and genetic analysis. It covers the transmission of genetic characteristics between generations, the cellular basis of heredity, the molecular basis of heredity, and the behavior of genes in populations. Interrelationships among these broad areas are emphasized in the treatment of such topics as genetic mapping, mutation, applied molecular genetics, physiological genetics, quantitative inheritance, immunogenetics, and genetic regulation. Examples that illustrate genetic principles are selected from organisms that range from bacteria to humans. The relationship of genetic principles to human heredity, agriculture, medicine, and evolution is explored.

The laboratory component of the course involves experimental work with bacteria, fungi, plants, fruit flies, and isolated DNA. It includes interpretive studies in human genetics and cytogenetics. The central theme of the laboratory is genetic analysis, but it also provides experience in basic laboratory techniques and illustrates genetic principles discussed in the lectures. In addition to attending scheduled laboratory sessions, students must come to the laboratory at other times in order to maintain experiments or record results.

Grading is based on laboratory assignments and quizzes, a laboratory notebook, two major examinations during the semester, and a comprehensive final examination. The examinations draw on the lectures, laboratory, and readings. Besides reading text assignments, students are required to read primary scientific literature; citations to journal articles that relate to the lectures are distributed in class.

BIOLOGY 262: GENETIC ANALYSIS (Every third year in Spring)
Professor Hoffmann

Prerequisites: Biology 131 and 132; Chemistry 221.

This course covers the mechanisms of heredity and genetic analysis. Topics include Mendelian inheritance, chromosome structure and function, genetic mapping, molecular genetics, mutation, physiological genetics, genetic regulation, quantitative inheritance, interactions between heredity and environment, and population genetics. This course is a nonlaboratory equivalent of Biology 261.

BIOLOGY 266: CELL BIOLOGY (Spring)
Professor Ledbetter

Prerequisites: Biology 131 or Biology 120; Chemistry 221.

The course involves the study of the structure and function of the generalized cell of higher organisms, both animal and plant, and its parts. This includes consideration of metabolism and enzyme action. The textbook is a standard one such as Alberts, et al., *Molecular Biology of the Cell*.

If time permits, there is discussion of special topics and presentation of reports of library or laboratory research projects by the students. This part is flexible and may vary from year to year, depending on the interests of the students enrolled and the size of the class.

Throughout, we emphasize the experimental approach, and the critical evaluation of experimental evidence. To that end, the laboratory exercises include experience with enzyme assays, protein and nucleic acid analyses, cell fractionation, microscopy, cell culture and transport techniques, among others. Some experiments may require time in addition to scheduled laboratory periods. There may be the opportunity for independent laboratory projects in years when enrollment is low.

BIOLOGY 275: BIOLOGICAL STATISTICS (Spring)
Professor Bertin

Prerequisites: Biology 131 or permission of instructor.

This course examines the nature, handling and analysis of biological data. It covers descriptive statistics, probability distributions, estimation and hypothesis testing, analysis of variance, regression, correlation, nonparametric tests and resampling procedures. This course is particularly appropriate for those majors planning to go on in biological or medical research.

BIOLOGY 280: GENERAL ECOLOGY (Fall of every second year)
Professor Bertin

Prerequisite: Biology 131 or permission of instructor.

Ecology is the study of interactions between organisms and their environments, examining biology at the levels of the individual, population, community, and ecosystem. Major topics include population growth and regulation, competition, predation, mutualism, community structure, succession, energy flow, nutrient cycling, and biogeography. We also review the major features of terrestrial, freshwater, and marine ecosystems. The laboratory involves both indoor work and field trips and is intended to 1) introduce several different habitats, 2) familiarize students with various techniques commonly used in ecology, and 3) engage students in collecting, analyzing and evaluating ecological data. A paper and/or lab reports emphasize critical evaluation of ecological concepts and data, and effective scientific communication. Students considering ecological research or graduate study in ecology should try to take this course before their senior year.

BIOLOGY 283: EVOLUTION (Spring)
Professor Ober

Prerequisites: Biology 131 and 132.

This course is an introduction to the study of evolutionary processes. Students will examine the basic mechanisms for evolution, including processes that are adaptive and neutral with respect to adaptation. Evolution will be examined at a variety of scales, from molecular to ecological, and from changes in populations over a few generations to patterns over millennia. Natural selection is examined in detail and related to the evolution of such diverse phenomena as life history strategies, sex, altruism and human and cultural evolution. Along with these topics students will explore the ways that questions about evolution are answered. Students will be asked to read and evaluate original literature so that they have direct access to new developments in the field of evolution.

BIOLOGY 287: ETHOLOGY & BEHAVIORAL ECOLOGY (Spring)
Professor Prestwich

Prerequisites: Biology 131 and 132 or permission.

This course is a comparative look at animal behavior and the evolutionary forces that shape it. Topics include physiological mechanisms of behavior, behavioral genetics and heritability, learning and cognitive processes, communication, foraging, competition and cooperation, mating and parenting systems, and social behavior. The importance of good experimental design and the proper role of modeling in behavioral studies are emphasized throughout the course. Field projects provide an experiential component. Prerequisite Biology 131 and 132 or permission.

BIOLOGY 299: NEUROBIOLOGY (Spring)
Professor Webster

Prerequisites: Biology 120 or 131

Neurobiology is the study of the nervous system at multiple levels, from molecular to the systems level. Major topics cover the range of these levels and include: structure of the nervous system, generation of electric signals, synapses, sensory and motor systems, development and plasticity. Laboratory exercises will give students an opportunity to investigate the structure and function of the nervous system through dissection, simulation, and behavioral assays.

BIOLOGY 301: BIOCHEMISTRY 1 (Fall)
Professor Bellin

Prerequisites: Chemistry 181, 221 and 222.

Objectives: To acquaint the student with the detailed chemistry of bioorganic and bioinorganic molecules in biological systems. This course features a detailed consideration of buffers, protein structure, enzyme catalysis, intermediary metabolism and the bioenergetics and thermodynamics pertinent to these topics. More specifically, we study:

1. calculations for preparing biological buffers,
2. an overview of cell structure and its relationship to cell function,
3. the concept of active sites in enzyme molecules as well as the derivation and application of Michaelis-Menten kinetics,
4. amino acid chemistry as it relates to the structure and function of protein molecules,
5. the detailed biochemistry and bioenergetics involved in:
    a. the conversion of glucose to carbon dioxide and water (glycolysis, pyruvate dehydrogenase and Krebs cycle),
    b. the oxidation of fatty acids to carbon dioxide and water(beta-oxidation and Krebs cycle), and
    c. the synthesis of ATP via oxidative phosphorylation.

The grade in the course is determined by three unit exams, a comprehensive final, a library research paper and class participation.

BIOLOGY 302: BIOCHEMISTRY 2 (Spring)
Professor Bellin

Prerequisite: Biology 301.

This is a continuation of Biochemistry 1. Specifically, we review:

1. the light and dark reactions of photosynthesis,
2. the pentose phosphate shunt,
3. glycogen synthesis and degradation and its regulation,
4. carbohydrate synthesis,
5. fatty acid, phospholipid and cholesterol synthesis,
6. amino acid metabolism,
7. nucleotide structure and biosynthesis,
8. DNA structure and replication,
9. the molecular biology of transcription and translation.

The grade in the course is determined by two unit exams, a comprehensive final, an integrative metabolism project and class participation.

BIOLOGY 303: BIOCHEMISTRY 1 LABORATORY (Fall)
Professor Bellin

Prerequisite or corequisite: Biology 301.

Objectives: To acquaint the student with modern biochemical laboratory techniques. Lab exercises include several of the following:

1. making biological buffers and utilizing a pH meter
2. production of synthetic liposomes (lipid membranes)
3. protein chromatography
4. methods of protein quantitative determination
5. purification of an enzyme
6. enzyme kinetics (measuring V_{max} and K_m)
7. polyacrylamide gel electrophoresis
8. Western blotting

These experiments provide each student with hands on experience in these areas. The grade is determined primarily from weekly lab write-ups, as well as a final comprehensive lab report.

BIOLOGY 304: BIOCHEMISTRY 2 LABORATORY (Spring)
Professor Bellin

Prerequisite or corequisite: Biology 302.

The Biochemistry 2 labs provide students with hands-on experience with techniques in molecular biology currently used by researchers worldwide. General areas of research covered include restriction endonucleases, DNA isolation, PCR, DNA sequencing, and the use of computational tools for molecular biology. The emphasis in lab includes the principles behind modern molecular techniques and the reasons for selecting one approach over another to answer a given set of questions. The grade is determined primarily from weekly lab write-ups, as well as a final comprehensive lab report.

BIOLOGY 331: ECOSYSTEM ECOLOGY (Spring)
Professor Sobczak

Prerequisites: Biology 131 and 132

Ecosystem Ecology is the scientific study of the physical, chemical, and biological processes influencing the distribution and abundance of organisms, the interactions among organisms, and the interactions between organisms and the transformation and flux of energy and matter. This upper-level, seminar covers the concepts, theories and history of ecosystem ecology, biogeochemical cycles and budgets, ecosystem energetics and trophic structure, and the response of ecosystems to stress and disturbance. The course emphasizes contemporary research and scholarship that contributes to the conceptual framework underlying the restoration and conservation of diverse ecosystems. ~75% of the course is structured around the discussion of recent primary literature.

BIOLOGY 341: VIROLOGY (Fall)
Professor Sheehy

Prerequisites: Biology 261or 262 or 266.

The goal of this course is to introduce students to the incredible world of viruses. It is taught as a survey course, using specific viruses as representatives of the virus families. The molecular events surrounding the individual stages of the viral lifecycle, as well as the interplay between viruses and their hosts (specifically the defenses an invading pathogen must evade), will be examined. "Hot" topics such as H5N1 (avian flu), "mad cow" disease and the HPV vaccine will be included in the lectures.

BIOLOGY 361: TOXICOLOGY (Spring)
Professor Hoffmann

Prerequisites: Chemistry 222 and Biology 261, Biology 262 or Biology 120.

This course provides a comprehensive introduction to toxicology for biology majors. Its content includes a historical introduction; measurement of toxicity; dose-response relationships; interactions among toxicants; the absorption, distribution, and excretion phases of toxicant disposition; phase 1 metabolism of toxicants (oxidation, reduction, hydrolysis, hydration, dehalogenation); phase 2 metabolism (conjugation); targets of toxicity (blood, immune system, liver, kidney, lungs, nervous system, skin, reproductive systems, eye, endocrine system); genetic toxicology; carcinogenesis; developmental toxicity; human and veterinary toxicants; toxins; environmental toxicology; forensic toxicology; and regulatory toxicology. The emphasis is on the basic science underlying the adverse effects of chemicals on biological systems, but social, ethical, political, and legal aspects of toxicology are also considered.

Grading is based on three examinations during the semester, a term paper, and a comprehensive final examination. Students are expected to participate in class discussions and make a brief (10 minute) presentation to the class. The term paper is on the topic of the student's oral presentation and requires critical reading of primary scientific literature.

BIOLOGY 381: CONSERVATION BIOLOGY (Spring)
Professor Prestwich

Prerequisites: Biology 261 or 262 or 233 or 280 or 331.

This is the study of the effects of human activity on biological diversity at the population and system levels. Topics include the underlying philosophical approaches to conservation, techniques for measuring biological diversity, for assessing and predicting changes, the principles of management and restoration and the use of mathematical models in management. Classes will be a mix of lecture on general principles plus student-led discussion of case studies and of the recent conservation literature.

Students interested in environmental biology and veterinary medicine may find this course especially valuable.

BIOLOGY 390: ANIMAL PHYSIOLOGY (Fall)
Professor Prestwich

Prerequisites: Biology 131 or equivalent, Chemistry 231.
Prerequisite or corequisite: Physics 111 or 115.

Physiology is the study of the function of organisms. It can be approached on many levels from the subcellular to organismal. The approach to the study of function can emphasize either the chemical or physical basis of life processes. In order to give the student a unique view of physiology, Biology 390 dwells on levels of organization primarily at the whole organism or organ level (as compared to the cellular level stressed in other courses). It takes a strongly physical (or engineering) view of physiological processes as compared to the chemical view of life presented in other courses. As a result, the course is very mathematical (and requires a good knowledge of algebra and some simple calculus). Finally, the course exposes the students to the three main approaches to physiology: physiological ecology (the study of how an animal's unique physiological adaptations allow it to survive in a certain habitat), comparative physiology (the evolution of physiological systems) and medical physiology (physiology of normal and abnormal humans).

Topics covered in lecture include:

1. control systems in organisms,
2. temperature regulation,
3. metabolism in reference to rest, exercise, and temperature,
4. respiratory physiology,
5. cardiovascular physiology,
6. renal function,
7. muscle physiology,

Course grading is based on three midterms and a comprehensive final exam, a lab exam, two oral presentations in lab, participation in discussion, and a series of problems.

BIOLOGY 392: IMMUNOLOGY (Spring)
Professor Sheehy

Prerequisites: Biology 261 or 262 or 266.

The focus of this course is to provide students with an introduction to the immune system with the primary focus on the molecular aspects of the system. The immune system is our defense against a vast array of pathogenic invaders and foreign insults. The molecules, organs and networks of the immune system are engaged in a constant battle to eliminate viruses, bacteria, parasites, etc. An understanding of the immune system is critical to a range of scientific fields from issues of donor-matching for transplantation to questions of vaccine design. Unfortunately, the immune system also can and does fail us, leading to both diseases of immunodeficiency and immunosuppression; both of these will be discussed.

This course is taught as a lecture-based course with a lab component. Students will also read and present primary literature (journal articles) to explore the most recent advances in the field.

BIOLOGY 401: UNDERGRADUATE RESEARCH
Staff

Prerequisite: Permission of instructor.

Undergraduate research involves individual experimental investigation and associated study of the scientific literature under the direct supervision of a member of the faculty. The number of positions is limited; students contemplating research should make inquiries early in the year preceding the term in which research is to be initiated. Only one semester of Undergraduate Research may be counted toward the biology major. Students may apply additional credits for Undergraduate Research to the 32-course graduation requirement, however. One and one-quarter units each semester.

BIOLOGY 405: DIRECTED READING
Staff

Prerequisite: Permission of instructor.

An in-depth literature study of a biological subject of interest to the student is conducted under the tutorial supervision of a member of the faculty. Directed Reading courses count toward the biology major; the distribution area depends on the subject. One unit each semester.

BIOLOGY 407, 408: HONORS RESEARCH
Staff

Requirement: Student must be a member of the College Honors Program.

Individual experimental investigation, associated study of the scientific literature, and the writing of a thesis is conducted under the direct supervision of a faculty member. Students contemplating Honors Research should make inquiries early in the year preceding the term in which research is to be initiated. Honors Research counts toward the completion of the biology major. One and one-quarter units each semester.

ADDITIONAL COURSES:

Holy Cross students may enroll in courses at the other institutions of the Worcester Consortium as part of their regular schedule during the academic year. Diverse courses in the basic and applied biological sciences are available through the Consortium. For some post-graduate studies, courses are required that we do not offer, e.g. Physician's Assistant or Physical Therapy require Human Anatomy & Physiology. This course is available at Worcester State College or Quinsigamond Community College. Listings of Consortium courses are available through the Office of the Registrar. Students who would like to count a course taken elsewhere in the Consortium toward the biology major must seek approval of the Chair of the Biology Department before taking the course. Students may also take courses at other institutions during summer sessions, provided that the courses are approved in advance by the Chair.

OPPORTUNITIES FOR PURSUIT OF SPECIAL INTERESTS

Undergraduate Research in Biology

Undergraduate Research (Biology 401) is a special course that provides well qualified students with exposure to the concepts and methodologies of independent investigation. It is an important experience for students who anticipate a career in the life sciences. Facilities and resources are limited, so faculty permission is required for registration. The faculty exercises care in ensuring that only highly motivated students who will substantially benefit from the course are enrolled.

Guidelines have been adopted by the departmental faculty to maximize the benefits a student may obtain in research and to ensure a high caliber of teaching and learning. Enrollment in Biology 401 carries with it the student's acceptance of these guidelines:

1. The project undertaken by the student should be directly within the scope of the instructor's research and expertise to maximize benefits to the student. Projects beyond the resources of the department are often possible through the Center for Interdisciplinary and Special Studies as an Academic Internship, or may be arranged independently at the University of Massachusetts Medical School.

2. Students should complete at least four Biology courses prior to doing undergraduate research for credit. They may then take Undergraduate Research for a maximum of four semesters. Normally successful completion of a research project requires at least two semesters. Exceptions are possible if a student has sufficient background in the subject matter or adequate technical expertise to complete a project in a single term. Such a determination is made by the supervising staff member. Each semester of enrollment carries 1.25 units and is considered a laboratory course.

3. Only one semester of Undergraduate Research may be counted toward the eight courses required by the department for the major. Students may apply additional credits for Undergraduate Research to the 32-course graduation requirement, however.

4. Considerable latitude is allowed for the student and faculty member to design a project that has both academic merit and flexibility. The student must anticipate that he or she will be held accountable for progress through the presentation of written and/or oral reports, papers, etc. Some faculty may likewise require a prospectus before the research is begun or similarly prescribe preparation through independent reading or specific course work. The details of expectation and evaluation are left to the discretion of the instructor.

Students are urged to make arrangements with the appropriate faculty member well in advance of the semester in which enrollment is anticipated, since spaces are limited.

Summer Research Opportunities

Many opportunities are available for students to carry out directed research during the summer months. Students are paid a stipend that usually covers their travel and living expenses. They spend eight to ten weeks working under the supervision of a scientist in settings that can range from a biochemical laboratory at a college, university or hospital to an ecological field station in the United States or overseas. Though this work is not taken for course credit, it offers valuable experience for students considering graduate school. Others will also find their increased skill helpful in qualifying for employment or other kinds of professional training. Usually preference is given to rising seniors, then to rising juniors. Some of the programs to which our students apply are as follows:

1. Opportunities for summer research at Holy Cross are supported by grants to the College and its faculty. Procedures for application are publicized in the Biology Department and elsewhere in the College.

2. Research Experiences for Undergraduates (REU and SURF). These programs, funded by the National Science Foundation, are in place at various colleges and universities. They are intended to serve students from outside the host institution as well as its own students. In recent years Holy Cross students have participated in REU programs at Wellesley College and Hope College, and in SURF programs at Pepperdine University and University of North Carolina at Chapel Hill. Announcements of application procedures and deadlines are sent to the Biology Department each year.

3. Various hospitals, universities, research institutes and industries run their own summer research programs. Among these are Hartford Hospital, University of Connecticut Health Center, University of Massachusetts Medical Center, Harvard School of Public Health, the New England Primate Center, and others. Announcements of application procedures and deadlines are posted in the Biology Department each year.

4. Several scientific societies and industries offer fellowships for undergraduates to conduct research at their own or other institutions. Among these are the Genetics Society of America, the Council on Undergraduate Research, the Pfizer Pharmaceutical Company and others. The student and the faculty sponsor together prepare a description of the proposed project. Announcements of application procedures and deadlines are sent to the Biology Department each year.

5. Wildlife sanctuaries, oceanographic institutions, and other field-oriented organizations often have openings for college students to assist in research or lead nature-study programs for high school or younger students.

6. Two students are selected each summer to do research at the world-renowned Salk Institute in La Jolla, California. Applications are handled by the Science Coordinator.

7. Many individual scientists or departments in colleges, universities, and medical schools have funds in their research grants that could be used to support a summer research student. In such cases students need to take the initiative to contact the scientist with whom they would like to work, describe their qualifications, and ask the scientist whether he/she (or his/her colleagues) might be able to use their services.

Ms. Dumas collects announcements of all such opportunities and circulates them to interested students. If you are interested, get your name on the list.

Internships

Academic internships provide the opportunity to gain "on-the-job" experience as well as personal insight into the workings of a particular profession. The internship program presents an alternative to traditional classroom instruction and the chance for eager students to demonstrate imagination and resourcefulness. The intern benefits not only through educational growth, but also by the development of special skills, the assessment of personal commitments and the exploration of potential careers. Internships are available in a wide area of the biological and medical sciences. Information on internships is available from the Center for Interdisciplinary and Special Studies.

Lists of internship positions are published twice a year by the Center for Interdisciplinary and Special Studies. Applications are accepted in early November and mid-March from students who will be juniors or seniors in the following semester. Those who are accepted for internships must select a faculty advisor from the field of study that the internship encompasses or enroll in one of the internship seminars offered through the Center for Interdisciplinary and Special Studies. The internship is considered as one of the student's four academic courses and receives credit accordingly, but does not count towards the biology major.

Honors Program

The College Honors Program is open to a limited number of highly qualified students who wish to combine advanced work in their major with a broader range of serious intellectual interests. Participating students meet in colloquia during their junior and senior years, enroll in at least two specially designed Honors Seminars (each limited to 10 students) in areas outside their major, and devote one-fourth of their time in their senior year preparing a comprehensive thesis based on a directed research project, usually in their major field. Biology majors doing a laboratory based Honors Thesis should enroll in Biology 407, 408: Honors Research in Biology. One of these courses counts toward the requirements of the major. Otherwise the thesis work is registered through the Center for Interdisciplinary and Special Studies. The Honors Thesis is prepared with the guidance of a faculty adviser and one or two faculty readers. It is presented orally at the end of the year (often in the context of the annual Academic Conference or the Undergraduate Research Symposium) and as a formal paper.

To be considered for the Honors Program, the student must apply to the Director of the Honors Program in the fall of sophomore year. The application includes a statement of student interest in and qualification for such study.

Fenwick Scholar

This program is typically open to one Holy Cross student per year. It is one of the highest academic honors the College bestows. Students are nominated by their departments, and the Fenwick Scholar is then chosen by the Committee for Special Studies. During the senior year, the Fenwick Scholar is free to design, with an advisor, the academic program that will complete his or her undergraduate education in the most profitable way. Scholars are free to take courses or not, to do independent study, or to undertake a combination of courses and independent study. The Committee seeks a student who will put this unusual opportunity to best use. At the end of the senior year, the Fenwick Scholar usually makes a public presentation of a major piece of work, a scholarly essay, a group of experiments, or a demonstration of substantial accomplishment in the creative arts. Application deadline is in the spring of the junior year. Biology majors interested in this opportunity are urged to express their interest to members of the faculty so that their nomination may be considered.

The Consortium

The Worcester Consortium for Higher Education represents the collaboration of Worcester colleges in the advancement of academic growth and the pooling of individual resources. Anna Maria College, Assumption College, Becker College, Clark University, Holy Cross College, Quinsigamond Community College, University of Massachusetts Medical Center, Worcester Polytechnic Institute, and Worcester State College form the Consortium program. The Consortium coordinates sharing arrangements in curriculum, administration, and community service through cross-registration, joint faculty appointments, and curriculum projects. The Consortium explores ways of broadening academic programs for faculty and students as well as expanding continuing education opportunities.

A Holy Cross student may enroll in one course per semester at a Consortium institution provided the course has been approved by the appropriate department chair at Holy Cross. In special circumstances, and with the approval of the Dean of the College, a student may be permitted to enroll in two Consortium courses in one semester. Written application for the approval is filed in the Office of the Assistant Dean.

A free shuttle bus provides inter-campus transportation. The Consortium also provides an interchange of library resources from 14 collections, amounting to over 3 million items.

Several Consortium programs are especially noteworthy. The Consortium Health Studies Option and the Gerontology Studies Option are of particular interest to premedical students. These programs, operated from the University of Massachusetts Medical Center, enable liberal arts students to sample health careers through courses and internships, as well as providing the availability of career counseling. The Consortium Water Quality Research Group is an interdisciplinary effort with the Worcester Public Health Department. Faculty and students undertake projects aimed at preserving the quality of the region's water supply.

In addition to the Consortium Members, a group of Associates further broadens local opportunities for interesting experiences and academic enrichment. The Associates include American Antiquarian Society, the Craft Center, International Center of Worcester, Old Sturbridge Village, Worcester Art Museum, Worcester County Horticultural Society, Worcester Foundation for Experimental Biology, Worcester Historical Society, radio station WICN, and the Ecotarium.

EXTRACURRICULAR ACTIVITIES FOR STUDENTS OF BIOLOGY

Student Advisory Committee

The Student Advisory Committee (SAC) is responsible for the administration of Course Evaluation Forms and participates in the evaluation of teaching effectiveness. The Committee ordinarily consists of seven members who must be majors in the department. SAC elections are held during the spring semester. Sophomores are elected to two-year terms to fill the seats being vacated by graduating seniors. Each spring all members of the new SAC elect a chair from among those incumbent members who have already served a year on the SAC.

During the last three weeks of each semester, the SAC administers a Course Evaluation Form to all classes of its department. This form is uniform for all departments. Copies of the form are given to the teacher and to the department chair at the end of the semester after grades have been submitted to the Registrar. These evaluations are significant components of decisions regarding faculty compensation, retention, and promotion.

The SAC also prepares advisory reports to faculty and participates in the evaluation of faculty for reappointment, tenure or promotion. Through this process, the students present their views of a faculty member's effectiveness as a teacher, as represented by the Course Evaluation Forms. These reports are very serious matters and demand quality of analysis, fairness of judgment, and accuracy of presentation.

SAC members attend department meetings to represent the student voice. They also assist the department in hiring by meeting with candidates and conveying their impression to the department.

Biology Society

The Biology Society is an organization of students who are interested in working together to offer activities of educational and recreational value to Holy Cross biologists. The activities are directed by four officers: President, Vice President, Secretary, and Treasurer, who are elected each April for the following school year, with the guidance of a faculty advisor.

The Society is involved in several activities: serving as a communication pathway between faculty and students, and promoting a close student-faculty rapport through social events; sponsoring films and lectures by Holy Cross faculty and students and by visiting lecturers; sponsoring recreational activities including hikes and museum trips; and occasionally arranging outreach programs such as Hogwarts at Holy Cross.

Overall, the Society realizes that most people are interested in some aspects of biology It is possible to bring these people closer to their interests, and the best approach is to combine the educational aspects with the social and recreational. It is the purpose of the Biology Society to make the field of biology an interest to all students at Holy Cross.

Night Labs

Night labs make available the facilities of O'Neil and Swords Halls during evening hours for students who wish to complete laboratory assignments or find a quiet place to study.

The building is presently open on Monday through Thursday evenings from 7:00 PM until 10:00 PM with all the labs and the lounge available for use. Any Holy Cross student enrolled in a biology course may use the building provided that they sign in and leave an ID upon entering. This is for purposes of security, and the students can pick up their ID's when they sign out and leave the building.

Should there not be enough volunteers to cover the building adequately for a particular evening, the building will remain closed. Volunteers should contact the Biology Society or the Department's laboratory supervisors.

The night labs are an important resource of the Biology Department, and it is expected that students will not abuse this privilege.

Phi Beta Kappa

Phi Beta Kappa is a national honor society. It elects to membership individuals who have distinguished themselves intellectually in pursuing education in the liberal arts and sciences. The society's objectives include intellectual honesty and tolerance, a range of intellectual interests, and understanding---not merely knowledge.

On May 8, 1974, the Phi Beta Kappa Massachusetts Chapter, Pi, was chartered at Holy Cross and the first group of Holy Cross undergraduates was initiated. Each year since then, students of high academic achievement are considered for election, and some of them join the fraternity. Criteria for election include broad cultural interests, scholarly achievement, and good character. Juniors and seniors who are enrolled at Holy Cross and are candidates for the Bachelor of Arts degree are eligible for consideration if their undergraduate records fulfill the following minimum requirements:

The candidate must have completed at least 3 semesters of work in residence at Holy Cross and be registered for a fourth semester.

To be considered for election as a junior, the candidate must have completed at least 20 semester courses of college work with a record of exceptional distinction (GPA=3.80). The minimum GPA for election as a senior is at least 3.50. Weight is given to the breadth of the program of each candidate as shown by the number and variety of courses taken outside the major, and the balance and proportion of the degree program as a whole. The minimum requirements for breadth are as follows: natural sciences (one course), mathematics (one course)*, language (completion of a second-year level course)*, humanities (two courses), and social sciences (two courses). The mathematics and language requirements may be met by sufficiently high College Board achievement examination scores.
*These two requirements are not the same as the College’s common area requirements.

Biology Seminar Series

Several times each semester visiting scientists are invited to speak by the Biology Department on a subject of their expertise. These seminars are opportunities for the student to be stimulated by an encounter with the world beyond the textbook. The lectures themselves and refreshments afterward offer the chance for informal contact with the speaker, faculty, and fellow students.

Undergraduate Research Symposium

At the end of the spring semester a symposium is held where undergraduate research students present their results in the form of posters. For some the opportunity is a requirement of their research program; for all it is a chance to summarize their experiences and learn those of others. This is one of the year's intellectual highlights and is well attended by students, faculty and friends.

FACULTY RESEARCH INTERESTS

Professor Bellin

My research focuses primarily on the biochemistry of the proteins that compose, or are associated with, the cell cytoskeleton. The cytoskeleton in higher animal cells is generally thought to be composed of three classes of protein-based filaments, the microfilaments, the microtubules and the intermediate filaments. In recent years, the cytoskeleton has become the focus of much disease-related research because it is thought to be involved in a multitude of essential cellular processes including cell division, cell migration, transport of intracellular material, the maintenance of cell integrity and the overall integration of cellular space. Through a multi-faceted approach involving protein purification, cell culture, microscopy and molecular interaction assays, studies in my lab focus on examining the protein-based linkages that tie cytoskeletal filament proteins to each other, and to other cellular proteins to which filaments are linked. Current studies in the lab are specifically focused in two areas: (1) understanding the mechanism of linkage between intermediate filaments and specific cellular structures, such as focal adhesions and organelles, and (2) determining the nature of the linkages between the cytoskeleton and a specific class of transmembrane proteoglycans known as the syndecans.

Students with an interest in biochemistry who would like to consider pursuing a research project in my laboratory are encouraged to contact me at their earliest convenience.

Selected publications include:

Bellin, R.M. and K.V. Mills. 2007. The Holy Cross Biochemistry Concentration: An Integrated Four-Year Program to Develop Undergraduate Research Scholars in Designing, Implementing, and sustaining a Research-Supportive Undergraduate Curriculum (K.K. Karukstis and T.E. Elgren, eds.), pp. 394-396, Council on Undergraduate Research.

LeDuc, P.R. and R.M. Bellin. 2006. Nanoscale intracellular organization and functional architecture mediating cellular behavior. *Ann. Biomed. Eng.* **34**:102-113.

Lee, H.-S., R.M. Bellin , D.L. Walker, B. Patel, P. Powers, H. Liu, B. Garcia-Alvarez, J.M. de Pereda, R.C. Liddington, N. Volkmann, D. Hanein, D.R. Critchley and R.M. Robson. 2004. Characterization of an actin-binding site within the talin FERM domain. *J. Mol. Biol.* **343** : 771-784.

Robson, R.M. , T.W. Huiatt, and R.M. Bellin. 2004. *Muscle Intermediate Filament Proteins* in *Methods in Cell Biology Vol. 78* (M.B. Omary and P.A. Coulombe, eds.), pp. 519-553, Elsevier Science, USA.

Bellin, R.M., I. Capila, J. Lincecum, P.W. Park, O. Reizes and M.R. Bernfield. 2003. Unlocking the secrets of syndecans: transgenic organisms as a potential key. *Glycoconjugate J.* **19:** 295-304.

Bellin, R.M., T.W. Huiatt, D.R. Critchley, and R.M. Robson. 2001. Synemin may function to directly link muscle cell intermediate filaments to both myofibrillar Z-lines and costameres. *J. Biol. Chem.* **276**: 32330-32337.

Bellin, R.M., S.W. Sernett, B. Becker, W. Ip., T.W. Huiatt, and R.M. Robson. 1999. Molecular characteristics and interactions of the intermediate filament protein synemin: Interactions with α-actinin may anchor synemin-containing heterofilaments. *J. Biol. Chem.* **274**: 29493-29499.

Bellin, R.M., S.W. Sernett, and R.M. Robson. 1999. *Synemin* in *Guidebook to the Cytoskeletal and Motor Proteins, Second Edition* (T. Kreis and R. Vale, eds.), pp. 322-324, Oxford Univ. Press, UK.

Hemken, P.M., R.M. Bellin, S.W. Sernett, B. Becker, T.W. Huiatt, and R.M. Robson. 1997. Molecular characteristics of the novel intermediate filament protein paranemin: sequence reveals EAP-300 and IFAPa-400 are highly homologous to paranemin. *J. Biol. Chem.* **272**: 32489-32499.

Professor Bertin

My recent research has examined the flora and natural history of New England, the ecology of invasive species, and the reproductive biology of flowering plants.

My major current research is a detailed examination of the flora of Worcester County, Massachusetts. This largest of Massachusetts counties extends from the New Hampshire border to the Rhode Island border and also varies substantially in elevation. Despite the fact that central Massachusetts is generally considered less botanically interesting than the coastal plain or the limestone areas of western Massachusetts, my field work has uncovered dozens of species new to the county, including several that are rare or new to Massachusetts. One goal of this work is to understand the ranges and ecological affinities of our native and introduced plants. Because Worcester County received exceptionally detailed botanical studies in the mid 1900s, I also plan detailed comparisons of the past and present flora, examining and attempting to interpret patterns of change in native and non-native species. This interest in changes in the local flora has led to additional work in two areas. Working with several students, I examined the abundance and distribution of introduced tree species in urban woodlands, with special emphasis on Norway maple. Our work on this species, which is widely planted as a street and back yard ornamental, was published in 2005 and contributed to a decision to ban its import and sale in Massachusetts. Another aspect of floristic change involves potential impacts of climate change on plant ranges and flowering times. This interest led to a recent review paper and to investigations of changes in flowering time in the local flora.

My interests in reproductive biology lie in understanding the ecological function and adaptive basis of reproductive traits. My current work is an attempt to understand the functional significance of having two different sexual types of flowers on a plant. Together with several research students, I have published papers examining the possibility that the presence of two flower types (male and female or female and bisexual) permits plants to be flexible in their allocation of resources to male and female functions. This work, with asters, goldenrods and sedges, was published in 1998, 2002 and 2007, but found little evidence to support the flexible allocation hypothesis. Current research is evaluating an alternate hypothesis in gynomonoecious composites (i.e. those with female and bisexual flowers), namely that sex-specific herbivory may have contributed to the evolution of this sexual system.

Recent publications (with student co-authors in bold) include:

Bertin, R. I. 2008. Plant phenology and distribution in relation to recent climate change. *Journal of the Torrey Botanical Society* 135:126-146.

Bertin, R. I. 2007. Sex allocation in *Carex* (Cyperaceae): effects of light, water and nutrients. *Canadian Journal of Botany* 85:377-384.

Zhou, Q., R. I. Bertin and D. Fu. 2006. Gender dimorphism in *Tetradium daniellii* (Rutaceae): floral biology, gametogenesis and sexual system evolution. *International Journal of Plant Sciences* 167: 201-212.

Bertin, R. I., **B. G. DeGasperis and J. M. Sabloff**. 2006. Land use and forest history in an urban sanctuary in central Massachusetts. *Rhodora* 108: 119-141.

Bertin, R. I., **M. E. Manner, B. F. Larrow, T. W. Cantwell and E. M. Berstene**. 2005. Norway maple (*Acer platanoides*) and other non-native trees in urban woodlands of central Massachusetts. *Journal of the Torrey Botanical Society* 132:225-235.

Routley, M. B., R. I. Bertin and B. C. Husband. 2004. Correlated evolution of dichogamy and self-incompatibility: a phylogenetic perspective. *International Journal of Plant Sciences* 165:983-993.

Bertin, R.I. 2002. Losses of native plant species from Worcester, Massachusetts. *Rhodora* 104:325-349.

Bertin, R.I. and **G. M. Gwisc**. 2002. Floral sex ratios and gynomonoecy in *Solidago* (Asteraceae). *Biological Journal of the Linnaean Society* 77:413-422.

Bertin, R.I. 2001. Life cycle, demography, and reproductive biology of herb Robert (*Geranium robertianum*). *Rhodora* 103:96-116.

Bertin, R.I. 2000. Vascular flora of Worcester, Massachusetts. Special Publication: New England Botanical Club.

Bertin, R.I. and **M.A. Kerwin**. 1998. Floral sex ratios and gynomonoecy in *Aster* (Asteraceae). *American Journal of Botany* 85:235-244.

Professor Claessens

One of my main research interests is the evolution of the respiratory system in the Archosauria. Birds and crocodylians are the only living representatives of the Archosauria, a once-diverse group that includes dinosaurs, pterosaurs, and other fossil forms exhibiting an enormous range of anatomical diversity. Because crown-group archosaurs offer examples of highly specialized respiratory systems serving both cold-blooded (ectothermic) and warm-blooded (endothermic) metabolic physiologies, the clade presents an unparalleled opportunity to examine evolutionary pathways in respiratory design and function.

Projects in the Claessens lab combine traditional anatomical investigations with state of the art imaging and modeling techniques such as 3-D laser scanning and animation, facilities for which are available in my laboratory, and cineradiography (x-ray filming) and magnetic resonance imaging (MRI), which is done off-site. Ongoing projects in the laboratory include studies of:

1) the functional anatomy and ecomorphology of the avian musculoskeletal system
2) the morphology and evolution of the respiratory system of pterosaurs, extinct flying reptiles that roamed the Mesozoic skies (in collaboration with Professor Patrick O'Connor from Ohio University and Dr. David Unwin from the University of Leicester)
3) the anatomy and systematics of ornithomimid dinosaurs

Most students working in my laboratory take part in the Aves 3D project, an NSF funded biological database of three-dimensional avian skeletal anatomy (www.Aves3D.org). In addition, there are opportunities for paleontological fieldwork in Triassic and Cretaceous rock deposits in Grand Staircase-Escalante National Monument in Utah and surrounding areas each summer. These expeditions are run in collaboration with the Yale University Peabody Museum of Natural History and the Utah Museum of Natural History, respectively. Fieldwork involves strenuous labor under difficult conditions, and requires the ability to do long hours of manual labor outdoors in all types of climatic conditions, long daily hikes in rugged terrain while carrying heavy equipment, and extended periods of time living in a tent with only rudimentary sanitary provisions. However, fieldwork is very rewarding, and there's nothing like digging for dinosaurs out West. Coursework experience in chordate morphology (213), vertebrate history (255), or geology preferred.

Students with an interest in vertebrate morphology or paleontology who would like to consider pursuing a research project in my laboratory or fieldwork are encouraged to contact me at their earliest convenience. Sophomores are especially encouraged to apply. More information regarding research in the Claessens lab can be found at:
http://college.holycross.edu/faculty/lclaesse/ClaessensLab.htm
http://www.Aves3D.org

Selected Publications:

Claessens, L.P.A.M**.** 2009. A cineradiographic study of lung ventilation in *Alligator mississippiensis*. *Journal of Experimental Zoology A*. **311** (8).

Claessens, L.P.A.M. 2009. The skeletal kinematics of lung ventilation in three basal bird taxa (emu, tinamou, and guinea fowl). *Journal of Experimental Zoology A.* **311** (8).

Claessens L.P.A.M., O'Connor P.M., Unwin D.M. 2009. Respiratory Evolution Facilitated the Origin of Pterosaur Flight and Aerial Gigantism. *PLoS ONE* **4**(2): e4497. doi:10.1371/journal.pone.0004497.

O'Connor, P.M. and L.P.A.M. Claessens. 2005. Basic avian pulmonary design and flow-through ventilation in non-avian theropod dinosaurs. *Nature* **436**: 253-256.

Claessens, L.P.A.M. 2004. Archosaurian respiration and the pelvic girdle aspiration breathing of crocodyliforms. *Proceedings of the Royal Society of London B: Biological Sciences* **271** (1547): 1461-1465.

Claessens, L.P.A.M. 2004. Dinosaur gastralia; origin, morphology, and function. *Journal of Vertebrate Paleontology* **24** (1): 89-106.

Claessens, L.P.A.M. 1997. Gastralia. In: *Encyclopedia of Dinosaurs*. Currie, P.J., and Padian, K. (Eds.), Academic Press, San Diego, pp. 269-270.

Professor Hoffmann

My primary research interests are in mutation research and genetic toxicology. My students and I study the induction of point mutations, genetic recombination, and chromosomal damage using methods based in microbial genetics and human cytogenetics. The focus is on mechanisms by which mutagenic and carcinogenic chemicals and radiation cause genetic damage. Related interests include relationships between chemical structure and biological activity, the analysis of dose-response relationships, and applications of microbial and cytogenetic assays as models for predicting and interpreting genotoxic effects. Recent research projects concern the induction of mitotic recombination in yeast, mechanisms of mutagenesis in bacteria, the induction of chromosomal damage in human lymphocytes by the cancer chemotherapy drug bleomycin, and interactions among mutagenic treatments.

Selected publications (* indicates student coauthors):

Hoffmann, G.R., M.V. Ronan*, K.E. Sylvia*, and J.P. Tartaglione*. 2009. Enhancement of the recombinagenic and mutagenic activities of bleomycin in yeast by intercalation of acridine compounds into DNA. Mutagenesis 24: 317-329.

Hoffmann, G.R. 2009. A perspective on the scientific, philosophical, and policy dimensions of hormesis. Dose-Response 7: 1-51.

Preston, R.J., and G.R. Hoffmann. 2008. Genetic Toxicology. In "Casarett and Doull's Toxicology: The Basic Science of Poisons," C.D. Klaassen, ed., McGraw-Hill, New York, 7th Edition, Chapter 9, pp. 381-413.

Hoffmann, G.R. and W.E. Stempsey. 2008. The Hormesis concept and risk assessment: Are there unique ethical and policy considerations? Hum. Exper. Toxicol. 27:613-620 (http://www.belleonline.com/newsletters/volume14/vol14-3.pdf).

Hoffmann, G.R., G.S. Gessner*, J.F. Hughes*, M.V. Ronan*, K.E. Sylvia* and C.J. Willett*. 2007. Modulation of the genotoxicity of bleomycin by amines through noncovalent DNA interactions and alteration of physiological conditions in yeast. Mutat. Res., 623: 41-52.

Freeman*, K.M. and G.R. Hoffmann. 2007. Frequencies of mutagen-induced coincident mitotic recombination at unlinked loci in Saccharomyces cerevisiae. Mutat. Res., 616: 119-132.

Hoffmann, G.R., C.C. Yin*, C.E. Terry*, L.R. Ferguson, and W.A. Denny. 2006. Frameshift mutations induced by four isomeric nitroacridines and their des-nitro counterpart in the *lacZ* reversion assay in *Escherichia coli*. Environ. Mol. Mutagen., 47:82-94.

Calabrese, E.J., J.W. Staudenmayer, E.J. Stanek III, and G.R. Hoffmann. 2006. Hormesis outperforms threshold model in NCI anti-tumor drug screening database. Toxicol. Sci., 94: 368-378.

Hoffmann, G.R., M.A. Calciano*, B.M. Lawless*, and K.M. Mahoney*. 2003. Frameshift mutations induced by three classes of acridines in the *lacZ* reversion assay in *Escherichia coli*: Potency of responses and relationship to slipped mispairing models. Environ. Mol. Mutagen., 42:111-121.

Hoffmann, G.R., D.J. Crowley*, and P.J. Theophiles*. 2002. Comparative potencies of induction of point mutations and genetic duplications by the methylating agents methylazoxymethanol and dimethyl sulfate in bacteria. Mutagenesis, 17:439-444.

Hoffmann, G.R., A.M. Sayer, and L.G. Littlefield. 2002. Higher frequency of chromosome aberrations in late-arising first-division metaphases than in early-arising metaphases after exposure of human lymphocytes to X-rays in G_0. Int. J. Radiat. Biol., 78:765-772.

Hoffmann, G.R., J. Buccola*, M.S. Merz*, and L.G. Littlefield. 2001. Structure-activity analysis of the potentiation by aminothiols of the chromosome-damaging effect of bleomycin in G_0 human lymphocytes. Environ. Mol. Mutagen., 37:117-127.

Hoffmann, G.R., A.M. Sayer, E.E. Joiner, A.F. McFee, and L.G. Littlefield. 1999. Analysis by FISH of the spectrum of chromosome aberrations induced by x rays in G_0 human lymphocytes and their fate through mitotic divisions in culture. Environ. Mol. Mutagen., 33:94-110.

Hoffmann, G.R., R.A. Shorter*, J.L. Quaranta*, and P.D. McMaster. 1999. Two mechanisms of antimutagenicity of the aminothiols cysteamine and WR-1065 in *Saccharomyces cerevisiae. Toxicol. In Vitro.,* 13:1-9.

Hoffmann, G.R. and R.P.P. Fuchs. 1997. Mechanisms of frameshift mutations: Insight from aromatic amines. *Chem. Res. Toxicol.*, 10:347-359.

Hoffmann, G.R., S.M. Deschênes*, T. Manyin*, and R.P.P. Fuchs. 1996. Mutagenicity of acridines in a reversion assay based on tetracycline resistance in plasmid pBR322 in *Escherichia coli. Mutation Res.*, 351:33-43.

Hoffmann, G.R., J.L. Quaranta*, R.A. Shorter*, and L.G. Littlefield. 1995. Modulation of bleomycin-induced mitotic recombination in yeast by the aminothiols cysteamine and WR-1065. *Molec. Gen. Genet.*, 249:366-374.

Professor Ledbetter

Through my research I am trying to understand the biochemical mechanisms regulating growth and gene expression in mammalian cells. The principal techniques used are cell culture, isotopic tracer studies, spectrophotometry, fluorimetry, microscopy and molecular biology. Substantial computer work is done to analyze microscopic images and to mine genomic and microarray data bases. Usually I work with established cell lines and strains, both normal and tumorigenic, that have been in continuous culture for extended periods. If necessary, though, I have the capability of establishing new cell strains directly from tissue specimens or doing short-term experiments in organ culture.

My current work involves a phenomenon whose function is not well understood: cell communication through gap junctions. Briefly, cells, both in tissues and in culture, can form junctions with other cells, and materials can then pass among the cytoplasms of all cells communicating in this way. A physiological role for cell communication is suggested for cells whose growth is regulated. Tumor cells or actively dividing embryonic cells frequently show altered communication. Thus one hypothesis is that cell communication is necessary for growth control. Using several kinds of assays for cell communication in cultured cells, I measure the effects of various agents known to promote or suppress growth. Where possible I also attempt to discover the mechanism underlying the activity of those agents that affect cell communication. The correlations obtained carry implications for the normal function of cell communication.

Recent work has revealed effects on cell communication of agents that influence ion transport across the cell membrane. Steroid hormones also influence communication among cultured kidney cells. These observations are the basis for current studies. We interfere with ion transport by treating cells with ouabain, a drug that blocks the membrane sodium pump. We then monitor the behavior of the treated cells:

- Their ability to share small fluorescent molecules (a measure of their cell-to-cell communication);
- Their ability to form gap junctions between adjoining cells.
- The distribution of the gap junction constituent, connexin-43, in various cellular compartments, studied by immunohistochemistry;
- The amount of connexin-43 in cell extracts, detected by electrophoresis and immunoblotting;
- The level of expression of the genes from connexin-43 and other proteins, monitored by extraction of RNA and analysis by polymerase chain reaction, Northern blotting, and microarray analysis.

My students and I use these methods to see how agents that influence cell communication modify expression of gap junction genes. A grant from the National Science Foundation allowed us to enhance our expertise at the interface between biology and computer science, the emerging discipline of bioinformatics.

Cell culture is an exacting technique requiring at least six weeks to learn. Therefore, students intending to work with me must be prepared to commit at least two semesters to the project, to justify the training. Between 8 and 12 hours a week in lab and 4 to 8 hours outside lab will be necessary. I can accommodate 2 to 3 students at a time. The best preparation includes courses in Cell Biology, Biochemistry, and/or Physiology.

Selected publications, with undergraduate co-authors indicated with an *, are as follows:

Ledbetter, M.L.S. and Gatto, C.L.* 2003. Concentrations of ouabain that prevent intercellular communication do not affect free calcium in cultured fibroblasts. *Cell Biochemistry and Function* 21:363-370.

Ledbetter, M.L.S. and Lippert, M.J. 2002. Glucose transport in cultured animal cells: An exercise for the undergraduate cell biology laboratory. *Cell Biology Education* 1:76-86.

Ledbetter, M.L.S. and S.L. Valentine*. 1997. Furosemide protection of Balb/c 3T3 cells from reduction of connexin43 levels induced by ouabain. *Mol. Biol. Cell* 8:93a.

Ledbetter, M.L.S., C. Clark*, A. Comi*, C. Leo*, R. Lue*, R. Morasco*, and A. Tremblay*. 1995. Ouabain inhibition of cell communication may be associated with mobilization of cell calcium. *Prog. Cell Res.* 4:367-370.

Berthoud, V.M., M.L.S. Ledbetter, E.L. Hertzberg, and J.C. Saez. 1992. Connexin 43 in MDCK cells: regulation by a tumor promoting phorbol ester and Ca^{2+}. *Eur. J. Cell Biol.* 57:40-50.

Professor Mitchell

I am a geologist who specializes in the long- and short-term evolution of landscapes. My current research focuses on the relationships between climate, tectonics, and erosion in the topographic development of mountain ranges. In particular, I am interested in the effects of glacial erosion on the height and morphology of young mountain ranges. The techniques and methods I use include field observations, geographic information system (GIS) analysis of digital topography, and isotopic and geochemical measurements. These techniques allow me to investigate rates of surface processes, landform ages, and erosion patterns in mountainous regions. I am currently involved in new projects studying the relationship between topography, climate, and evolution patterns in southeastern Arizona and glacial erosion in the Swiss Alps. I am also interested in the effects of urbanization on river systems. I have initiated a project investigating the geomorphology of the streams in Worcester, with a focus on the rates of erosion, sedimentation, and sediment transport on these highly impacted streams. I encourage students with an interest in surface processes, the environment, or using GIS to analyze spatial data to contact me regarding potential independent research projects.

Selected publications (*indicates an undergraduate co-author):

Mitchell, S.G., Montgomery, D.R., and Greenberg, H. 2009. Erosional unloading, hillslope geometry, and the height of the Cascade Range, Washington State, USA. *Earth Surface Processes and Landforms*, v. 34, iss. 8, p. 1108-1120.

*Harkins, R. and Mitchell, S.G. 2009. Grain size characteristics and potential mobility of road traction sand in Worcester, Massachusetts. *Geological Society of America, Abstracts with Programs*, 2009 National Meeting.

*Shea, N.S. and Mitchell, S.G. 2009. No glacial buzzsaw at Glacier National Park, Montana USA. *Geologiacal Society of America, Abstracts with Programs*, v. 41, no. 3, p. 25.

Tomkin, J.H., Mitchell, S.G., Anders, A.M., *Reynout, S. 2008. Spatial gradients of precipitation and erosion in the Swiss Alps: Direct evidence and mechanistic explanation for the glacial buzzsaw. *Eos Transactions, AGU,* v. 89, Fall Meeting Supplement.

Mitchell, S.G. and *Dagley, V. 2008. Sediment transport in a cobble- and boulder-bed urban headwater channel, preliminary results from Worcester, MA. *Geological Society of America, Abstracts with Programs,* v. 40, no. 3.

Mitchell, S.G. and Montgomery, D.R. 2006. Polygenetic topography of the Cascade Range, Washington State, USA. *American Journal of Science,* v. 306, p. 736-768.

Mitchell, S.G. and Montgomery, D.R. 2006. Influence of a glacial buzzsaw on the height and morphology of the Cascade Range in central Washington State, USA. *Quaternary Research*, v. 65, no. 1, p. 96-107.

Reiners, P.W., Ehlers, T.A., Mitchell, S.G., Montgomery, D.R. 2003. Coupled spatial variations in precipitation and long-term erosion rates across the Washington Cascades. *Nature*, v. 426, p. 645-647.

Mitchell, S.G. and Reiners, P.W. 2003. Influence of wildfires on apatite and zircon (U-Th)/He ages. *Geology*, v. 31, no. 12, p. 1025-1028.

Reiners, P.W., Ehlers, T.A., Garver, J.I., Mitchell, S.G., Montgomery, D.R., Vance, J.A., and Nicolescu, S. 2002. (U-Th)/He and fission-track thermochronometry of the Washington Cascades. *Geology*, v. 30, no. 9, p. 767–770.

Mitchell, S.G., Matmon, A., Bierman, P.R., Enzel, Y., Caffee, M., and Rizzo, D. 2001. Displacement history of the Nahef East fault, northern Israel, using cosmogenic ^{36}Cl. *Journal of Geophysical Research*, v. 106, no. B3, p. 4247-4264.

Gran, S.E. (now Mitchell, S.G.), Nichols, K.K., and Bierman, P.R. 1999. Teaching winter geohydrology in Vermont using frozen lakes and snowy mountains. *Journal of Geoscience Education*, v. 47, no. 5, p. 420-437.

Professor Ober

My primary interest is exploring molecular and morphological diversity in insects. Evolutionary history, molecular evolution, and developmental biology are critical in investigating the patterns and processes of morphological change and adaptations in groups of insects. Fundamental to my investigation of diversity and morphological and ecological change is seeking the evolutionary history of organisms. Beetles, in particular, offer a spectacular example of evolutionary success and diversification. They are a particularly good group of insects to examine the patterns and processes of morphological ecological, and molecular change. My research interests fall into two major areas: understanding evolution and relationships of major groups of beetles at deeper levels and understanding processes producing patterns of morphological diversity in insects. Insects are incredibly diverse, and they offer good models to study evolution and morphological adaptation. The broad array of adult insect morphologies is a direct result of the developmental pathways expressed in embryonic and larval development, and the timing and mode of this development.

Representative publications include:

Ober, K.A. and L. Jockusch. 2006. The roles of wingless and decapentaplegic in axis and appendage development in the red flour beetle, *Tribolium castaneum*. *Developmental Biology* 294:391-405.

Jockusch, E. and Ober, K. 2004. Hypothesis Testing in Evolutionary Developmental Biology: A Case Study from Insect Wings. *Journal of Heredity* 95:382-396.

Ober, K. 2003. Arboreality and morphological evolution in ground beetles (Carabidae: Harpalinae): testing the taxon pulse model. *Evolution* 57:1343-1358.

Ober, K. 2002. Phylogenetic relationships of the carabid subfamily Harpalinae based on molecular sequence data. *Molecular Phylogenetics and Evolution* 24: 227-247.

Jockusch, E. and Ober, K. 2000. Phylogenetic analysis of the *Wnt* gene family and discovery of an arthropod *Wnt-10* orthologue. *Journal of Experimental Zoology Molecular and Developmental Evolution* 288:105-119.

Maddison, D., Baker, M., Ober, K. 1999. Phylogeny of Carabid Beetles as Inferred from 18S Ribosomal DNA (Coleoptera: Carabidae) *Systematic Entomology* 24:1-36.

Maddison, D., Baker, M., Ober, K. 1998. A Preliminary Phylogenetic Analysis of 18s Ribosomal DNA of Carabid Beetles (Coleoptera: Carabidae). In "Phylogeny and Classification of Caraboidea (Coleoptera: Adephaga). Proceedings of a Symposium (28 August, 1996, Florence Italy) XX International Congress of Entomology" (G.E. Ball, A. Casale and A.V. Taglianti, Eds.), pp.229-250.

Professor Prestwich

Over the past several years my work has taken two directions. The first involves the studies of the limitations on running in spiders. Spiders are superbly adapted predators. Their hunting styles vary from ambush, to cornering prey in burrow, to active pursuit and, of course, to the use of a bewildering variety of webs. Each species has its own particular morphological, physiological and behavioral traits that correlate the type of prey capture it uses. In my lab we look at the energetic consequences of these different approaches to prey capture. For instance, we have studied the amount of energy required to build different types of webs. We have tried to estimate the amount of energy required to capture different types of prey using different methods. And we have been very interested in understanding the limits (constraints) imposed on a spider's ability to move about rapidly by the particular physiological systems a given species possesses We compare species in terms of the their oxygen consumption, heart rates, and anaerobic and phospagen metabolism during different types of exercise and recovery from that exercise. The ultimate goal of these studies are to (i) better understand some of the adaptations that spiders possess and relate these to similar predators in an attempt to understand the selective factors associated with various predatory patterns, and, (ii) come to a better understanding of the evolution of locomotory systems.

My other area of research involves the energetics of acoustic communication and in particular in the production of mating calls. In animals where the males call to attract females, the calls are often very loud and are produced at a high rate over a long period of time. I have been able to show that such calls are very expensive energetically and in ectothermic animals such as frogs and many insects the expense of producing these calls rivals or exceeds that of terrestrial locomotion. Besides looking at the metabolic energy required to produce such calls, I have also looked at the acoustic energy in the call and have been able to determine that animals do not change their metabolic energy into sound very efficiently. For instance, efficiency of locomotion such as walking, running, swimming or flying is typically about 20% while the efficiency of sound production is generally less than 5% and often less than 1%. This discovery has led me to investigate factors which actually determine the efficiency of sound production -- for instance features of the wings and thorax in crickets and the vocal pouch in frogs. The importance of this work to biologists lies mainly in improving our understanding of factors relating to mating behavior -- especially those that might relate to what is known as sexual selection.

Selected publications include:

Prestwich, K.N. 2007. Measuring the efficiency of sound production. *Physiol Biochem Zool.* 80:157-165.

Prestwich, K.N. 2006. Anaerobic Metabolism and Maximal Running in the Scorpion *Centruroides hentzi* (Banks) (Scorpiones, Buthidae). *J. Arachnology* 34:351-356.

Prestwich, K.N. and O'Sullivan, K. 2005. Simultaneous measurement of metabolic and acoustic power and the efficiency of sound production in two mole cricket species (Orthoptera: Gryllotalpidae). *J. Exp. Biol.* 208:1495-1512.

Hung, Y.P. and K.N. Prestwich. 2005. Is significant acoustic energy found in audible and ultrasound harmonics of the carrier frequency in ensiferan calling songs? *J. Orthoptera Res.* 13:63-71.

Prestwich, K. N., Lenihan, K. M., and Martin, D. M. 2000. The control of carrier frequency in cricket calls: a refutation of the subalar-tegminal resonance/auditory feedback model. *J. Exp. Biol*. 203:585-596.

Prestwich, K.N. 1994. Energy and constraints on acoustic communication in insects and anurans. *American Zoologist* 34(6):625-643.

Prestwich, K.N., K. E. Brugger, and M. Topping. 1989. Energy and communication in three species of hylid frogs: power input, power output and efficiency. *J. Exp. Biol.* 144:53-80.

Prestwich, K.N. 1988a. The constraints on maximal activity in spiders, I. Evidence against the hydraulic insufficiency hypothesis. *J. Comp. Physiol. B.* 158:437-447.

Prestwich, K.N. 1988b. The constraints on maximal activity in spiders, II. Limitations imposed by phosphagen depletion and anaerobic metabolism. *J. Comp. Physiol. B.* 158:449-456.

Anderson, J.F., and K. N. Prestwich. 1985. The physiology of exercise at and above maximal aerobic capacity in a theraphosid (tarantula) spider *Brachypelma smithii*. *J. Comp. Physiol.* 155:529-539.

Professor Sheehy

Currently, my research focuses on the interplay between a human protein, APOBEC3G, and the HIV (human immunodeficiency virus) viral protein, Vif. APOBEC3G is a recently-cloned cellular protein that is highly expressed in T lymphocytes and has potent anti-HIV activity. The possibility of manipulating the APOBEC3G protein as a point of therapeutic intervention is a novel and exciting line of investigation. However, we must first understand both the interaction between Vif and APOBEC3G, and how the cell regulates the expression and function of APOBEC3G. The projects in my lab are geared toward understanding the regulation of APOBEC3G and whether ultimately manipulating this regulation can significantly enhance and strengthen APOBEC3G anti-viral activity.

We are currently working to precisely identify and characterize the promoter and putative enhancer elements of the APOBEC3G gene. The successful identification of these regions will lend valuable insight into the specific regulation of this cellular gene that is capable of suppressing HIV infection. We hope that dissection of the specific molecular details of cellular control of APOBEC3G gene expression will allow us to intelligently predict possible routes of therapeutic manipulation. Recent clinical investigation from a number of groups has suggested that endogenous overexpression APOBEC3G may impart a significant restriction of HIV replication. If we can manipulate APOBEC3G, we may be able to boost the cell's ability to defend itself against HIV invasion.

A second project in my lab focuses on the mutageneis of the APOBEC3G in an effort to delineate and understand the different domains of the protein. Using an unbiased, alanine-scan mutagenesis technique, we have introduced mutations across the full-length protein, creating a library of 135 mutants. Each of these mutants is currently being evaluated in its ability to function as a viral restriction factor and participate in characterized cellular processes. This global approach is expected to reveal regions of APOBEC3G that have not been previously identified as critical to antiviral function.

Selected publications:

Farrow, M.A. and Sheehy, A.M. 2008. Vif and Apobec3G in the innate immune response to HIV: a tale of two proteins. Future Microbiol. 3: 145-54.

Sheehy, Ann M. 2008. "Antiviral function of APOBEC3 Cytidine Deaminases." RNA and DNA Editing Molecular Mechanisms and Their Integration into Biological Systems. Ed. Harold C. Smith. Wiley-Interscience. 231-254.

Newman, Edmund N.C., Holmes, Rebecca K., Craig, Heather M., Klein, Kevin C., Lingappa, Jaisiri R., Malim, Michael H., and Sheehy, Ann M. 2005. Anti-Viral Function of APOBEC3G can be Dissociated from Cytidine Deaminase Activity. Curr. Biol. 15: 166-70.

Bishop, Kate N., Holmes, Rebecca K., Sheehy, Ann M., Davidson, Nicholas O., Cho, Soo-Jin, and Malim, Michael H. 2004. Cytidine Deamination of Retroviral DNA by Diverse APOBEC Proteins. Curr. Biol. 14: 1392-96.

Sheehy, Ann M., Gaddis, Nathan C., and Malim, Michael H. 2003. The antiretroviral enzyme APOBEC3G is degraded by the proteasome in response to HIV-1 Vif. Nat. Med. 9: 1404-7.

Harris RS, Bishop KN, Sheehy AM, Craig HM, Petersen-Mahrt SK, Watt IN, Neuberger MS, Malim M.H. 2003. DNA deamination mediates innate immunity to retroviral infection. Cell113: 803-9.

Sheehy, Ann M., Gaddis, Nathan C., Choi, Jonathan D. and Malim, Michael H. 2002. Isolation of a human gene that inhibits HIV-1 infection and is suppressed by the viral Vif protein. Nature418: 646-650.

Simon, James, H.M., Sheehy, Ann M., Carpenter, Elise A., Fouchier, Ron A.M., and Michael H. Malim. 1999. Mutational Analysis of the Human Immunodeficiency Virus Type-1 Vif Protein. J. Virol.73(4): 2675-2681.

Professor Sobczak

I have diverse research interests in freshwater ecology, ecosystem ecology, and restoration ecology. My previous research has encompassed a wide variety of aquatic ecosystems, including shallow groundwaters, mountain streams, lowland rivers, freshwater wetlands, tidal marshes, and large estuaries.

Recent research has examined stream ecosystem responses to regional hemlock mortality. Eastern hemlock dominates many New England forests and stream-side riparian areas, thus influencing the supply of detritus and availability of light to many regional streams. Regional declines of hemlock have been documented following the invasion of the woolly adelgid, an exotic forest pest. The continued expansion of the woolly adelgid range into New England and subsequent loss of eastern hemlock from New England forests will result in an array of ecological consequences. Terrestrial ecosystem responses are just now being documented, yet aquatic ecosystem responses to regional changes in riparian forest composition are less certain. My research aims to understand how the ecology and biogeochemistry of New England stream ecosystems (and linked downstream ecosystems) will be altered as riparian forests change. The proposed research will help identify ecological effects of a regional landscape disturbance (the woolly adelgid invasion) on neighboring aquatic ecosystems and help scientists and managers forecast future environmental change.

Selected publications include (* denotes student coauthors):

Rainey*, J.D., W.V. Sobczak, and S.C. Fradkin. 2007. Zooplankton diel vertical distributions in Lake Crescent, a deep oligotrophic lake in Washington (USA). *Journal of Freshwater Ecology* 22:469-476.

Collins*, B.M., W.V. Sobczak, and E.A. Colburn. 2007. Subsurface flowpaths in a forested headwater stream harbor a diverse macroinvertebrate community. *Wetlands* 27:319-325.

Sobczak, W.V., J. E. Cloern, A. D. Jassby, B. E. Cole, T. S. Schraga, and A. Arnsberg. 2005. Detritus fuels metabolism but not metazoan food webs in San Francisco Estuary's freshwater delta. *Estuaries* 28:124-137.

Findlay, S., R.L. Sinsabaugh, W.V. Sobczak, and M. Hoostal. 2003. Metabolic and structural response of hyporheic microbial communities to variations in supply of dissolved organic matter. *Limnology and Oceanography* 48: 1608-1617.

Sobczak, W.V., J.E. Cloern, A.D. Jassby, and A. Mueller-Solger. 2002. Bioavailability of organic matter in a highly disturbed estuary: The role of detrital and algal resources. *Proceedings of the National Academy of Sciences* 99:8101-05.

Sobczak, W.V. and S. Findlay. 2002. Variation in bioavailability of dissolved organic carbon among stream hyporheic flowpaths. *Ecology* 83:3194-3209.

Sobczak, W.V., S. Findlay, and S. Dye. 2002. Relationships between DOC bioavailability and nitrate removal in an upland stream: An experimental approach. *Biogeochemistry* 62:309-327.

Lovett, G.L., K.W. Weathers, and W.V. Sobczak. 2000. Nitrogen saturation and retention in forested watersheds of the Catskill Mountains, New York. *Ecological Applications* 10:73-84.

Findlay, S. and W.V. Sobczak. 2000. Microbial communities in hyporheic sediments. In "Streams and Ground Waters," Jones, J. & P. Mulholland, eds., Academic Press, New York.

Sobczak, W.V., L.O. Hedin, and M.J. Klug. 1998. Relationships between bacterial productivity and organic carbon at a soil-stream interface. *Hydrobiologia* 386:45-53.

Findlay, S., R.O. Hall, and W.V. Sobczak. 1998. Book Review: Methods in Stream Ecology (R. Hauer & G. Lamberti eds.). *Limnology and Oceanography* 43:1021-1022.

Sobczak, W.V. 1996. Epilithic bacterial responses to variations in algal biomass and labile DOC during biofilm colonization. *Journal of the North American Benthological Society* 15:143-154.

Sobczak, W.V. and T.M. Burton. 1996. Epilithic bacterial and algal colonization among a stream run, riffle, and pool: a test of co-variations. *Hydrobiologia* 332:159-166.

Findlay, S. and W.V. Sobczak. 1996. Variability in removal of dissolved organic carbon in hyporheic sediments.

Journal of the North American Benthologial Society 15:35-41.

Professor Vargas

My lab is interested in the biochemical mechanisms of iron respiration in microorganisms inhabiting unique environments. Iron respiration is a metabolic process whereby microbes generate energy by oxidizing organic or inorganic substrates and using Fe(III) as the terminal electron acceptor. The cycling of organic matter in anaerobic, freshwater and marine environments, submerged soils, and the terrestrial (deep) subsurface is greatly influenced by bacterial reduction of Fe(III).

My lab actively researches the physiology of microorganisms that inhabit hyperthermophilic (>90°C) environments. Our laboratory was the first to describe iron respiration in hyperthermophiles (heat lovers) belonging to ancient lineages from the Bacteria and Archaea domains, including the genera *Thermotoga*, *Pyrococcus* and *Pyrobaculum.* The phylogenetic positions of these organisms near the common ancestor to all life led to the hypothesis that iron respiration is a process that arose very early in evolution. Subsequent work has focused on characterizing, at the molecular level, the iron reducing activity in cell-free extracts of *Thermotoga maritima*.

My lab has also discovered iron reduction in the clinically important organisms *Helicobacter pylori* and *Campylobacter jejuni*. Both are pathogens of the gastrointestinal (GI) tract with *H. pylori* being the causative agent in gastric and duodenal ulcers and associated with gastric cancer; *C. jejuni* causes bloody diarrhea and dehydration. Thus, iron respiration may be an important factor in colonization of the GI tract. I am especially interested in purifying the ferric reductase enzyme/enzyme complex in both *Thermotoga* and *Campylobacter* and in characterizing, at the molecular level, the iron reducing activity in *Helicobacter*.

Selected Publications:

Yu, J.S., Vargas, M., Mityaf, C., and Noll, K.M. 2001. Liposome-mediated DNA uptake and transient expression in *Thermotoga.* Extremophiles 5:53-60.

Lovley, D.R., Kashefi, K., Vargas, M. Tor J.M. and Blunt-Harris, E.L. 2000. Reduction of humic substances and Fe(III) by hyperthermophilic microorganisms. Chem. Geol. 169-289-298..

Vargas, M., Kashefi, K., Blunt-Harris, E.L., and Lovley, D.R. 1998. Microbiological evidence for Fe(III) reduction on early earth. Nature 395:65-67.

Noll, K.M. and M. Vargas. 1997. Recent advances in genetic analyses of hyperthermophilic archaea and bacteria. Arch. Microbiol. 168:73-80.

Vargas, M. and K.M. Noll. 1996. Catabolite repression in the hyperthermophilic bacterium *Thermotoga neapolitana* is independent of cAMP. Microbiol. 142: 139-144.

Vargas, M. and K.M. Noll. 1994. Isolation of auxotrophic and antimetabolite-resistant mutants of the hyperthermophilic bacterium *Thermotoga neapolitana*. Arch. Microbiol. 162:357-361.

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Professor Webster

My primary interests are in the molecular and cellular functions of neurons. I use the fruit fly, *Drosophila melanogaster* because they have a simple nervous system, and their neurons are structurally and functionally homologous to neurons of higher organisms. In particular my current work focuses on *Drosophila* mechanosensitive neurons as a model system for mechanosensory perception which underlies the senses of touch, hearing, and balance.

The sensory neuron that innervates the bristles of the fly is similar in structure and function to the neurons in the inner ear. These neurons allow the fly to perceive changes in the bristle position in response to touch or air motion. Using a genetic screen based on a behavioral touch assay, I hope to identify new molecules that are involved in the process of converting the movement of the bristle into the electrical response of the neuron.

In addition, I will study the interactions between proteins in the pathway using molecular and biochemical approaches in an effort to further understand the relationship between the structure and function of these proteins. By studying the signaling systems, I seek to understand how these proteins shape the response of these neurons at the molecular, cellular, and electrophysiological levels.

Students can choose from projects that combine genetic, molecular, cellular, or neurophysiological techniques to investigate aspects of mechanotransduction in the fly.

Representative publications from previous work:

Webster, S.M., D. del Camino, J.P. Dekker, and G. Yellen. 2004. Intracellular gate opening in Shaker K+ channels defined by high-affinity metal bridges. *Nature* 428: 864-868.

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Konig, G., P. Graham, A. Bushnell, S. Webster, D. Wunderlich, and L.S. Perlmutter. 1996. Development and characterization of a monoclonal antibody 369.2B specific for the carboxyl-terminus of the beta A4 peptide. *Ann. NY Acad. Sci.* 777:344-55.

SUGGESTED READINGS FOR STUDENTS OF BIOLOGY

The following is an informal compilation of books that various faculty members have found rewarding. Many are available either in the O'Callahan Science Library or in the Dinand Main Library. The bookstore can also order any that you would like to buy.

Attenborough, D., 1990, The Trials of Life--A Natural History of Animal Behavior, Little, Brown & Co. [O'Callahan: QL751.A77.1990]

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Darwin, C.,1845, Voyage of the Beagle, Paperback editions from Signet, Mentor, or Penguin. [Dinand: AC1.H32.V.29.C1; O'Callahan: QH11.D22]

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Diamond, J.M., 1997, Guns, germs, and steel: the fates of human societies, W.W. Norton. [Dinand HM206.D48]

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Gould, S.J., 1981, The Mismeasure of Man, W.W. Norton & Co. [Dinand: BF431.G68.1981]

Hauser, M., 2001, Wild Minds: What Animals Really Think, Owl Books. [O'Callahan: QL785.H359]

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Jacob, F., 1988, The Statue Within, Basic Books, New York. [O'Callahan: QH429.2.J33.A313.1988]

Jorgensen, N., 1971, A guide to New England's landscape, Barre. [Dinand: GB124.N4.J82]

Keller, E.F., 1983, A Feeling for the Organism: The Life and Work of Barbara McClintock, W.H. Freeman, New York. [O'Callahan: QH429.2.M38.K44.1983]

Kumar, S. and P.J. Bentley, 2003, On Growth, Form and Computers, Elsevier Academic Press [O'Callahan: QH491.0583]

Leopold, A., 1987, Sand County Almanac, Oxford Univ. Press. [O'Callahan: QH81.L56.1987]

Medawar, P.B., 1979, Advice to a Young Scientist, Harper and Row. [O'Callahan: Q147.M38.1979]

Nesse, R.M. & G.C. Williams, 1996, Why We Get Sick: The New Science of Darwinian Medicine, Vintage.

Plotkin, M.J., 1993, Tales of a Shaman's Apprentice: An Ethnobotanist Searches for New Medicines in the Amazon Rain Forest, Viking Penquin.

Pollan, M., 2001, The botany of desire: a plant's-eye view of the world, Random House. [O'Callahan: QK46.5.H85.P66.2001]

Schmidt-Nielsen, K., 1972, How Animals Work, Cambridge Univ. Press.

Thomas, L., 1974, Lives of a Cell, Viking Press. [O'Callahan: QH307.2.T45]

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Walters, M.J., 2003, Six Modern Plagues: And How We Are Causing Them, Shearwater Books. [O'Callahan: RA653.W34]

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