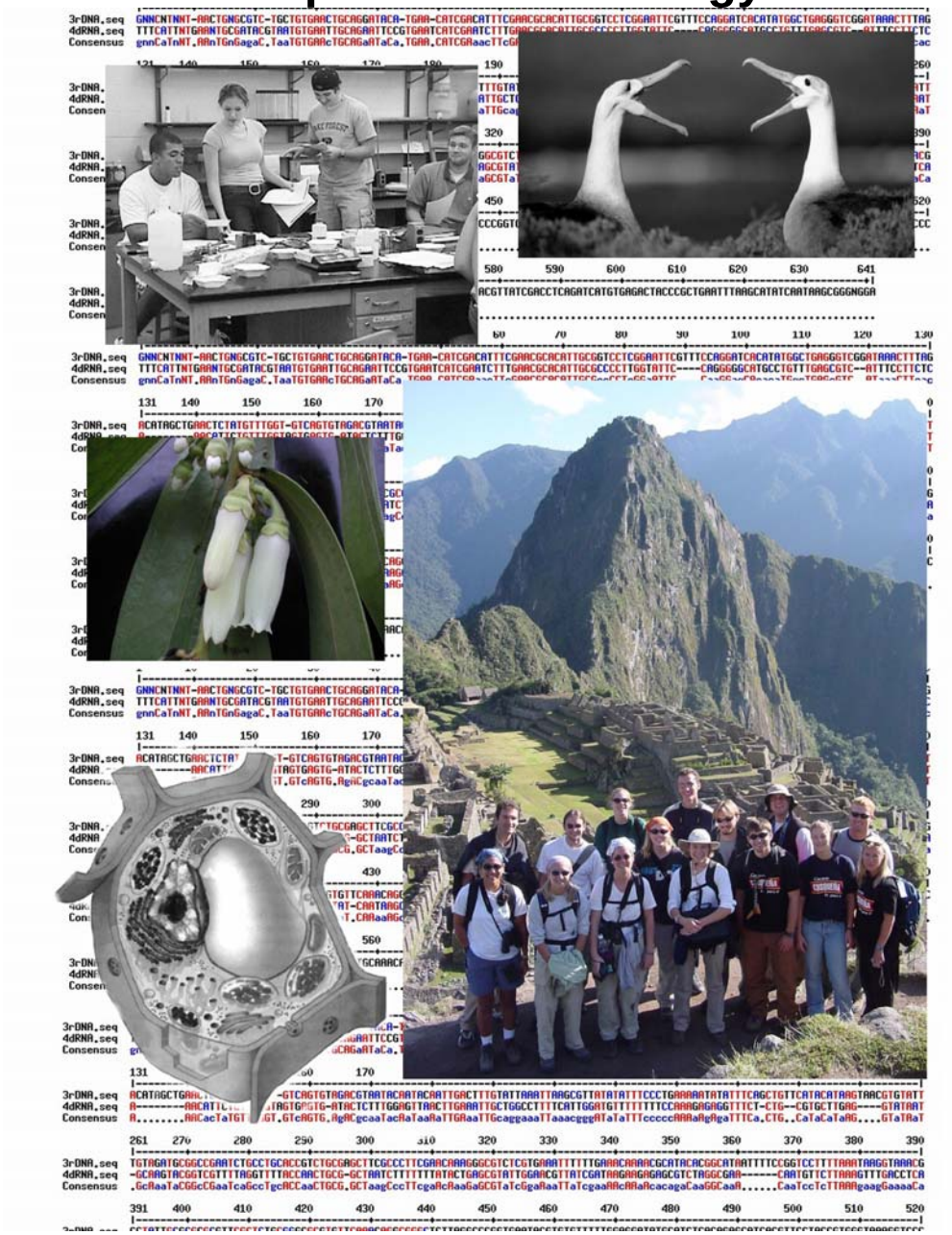
BIOLOGY MAJOR HANDBOOK
Fall 2009 Edition

WAKE FOREST UNIVERSITY
Department of Biology



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The Biology Major At Wake Forest

The core curriculum in biology is composed of 4 introductory courses which are required for the major: Bio 112 - Comparative Physiology; Bio 113 - Ecological and Evolutionary Biology, Bio 213 – Genetics and Molecular Biology and Bio 214 - Cellular Biology. The major requires an additional 18 hours of biology which may be selected from nearly 50 300- level courses, the only restriction being that at least two of these additional courses must have a laboratory component. ***Students majoring in Biology may elect to earn either a B.S. or B.A. degree, which differ in co-requirements (see below), and in the requirement for a research experience for the B.S. degree.***

****The requirements for the Biology major (BA or BS) are those that are in effect when the student declares Biology as their major.****

Bio 111, Principles of Biology, and Bio 101, Biology and the Human Conditions, are introductory courses for non-majors. A prospective student who earns a 4 or 5 on the AP exam will receive elective credit for Biology 111. However, neither this course nor Bio 101 counts for credit towards the major or minor in biology

A minimum overall grade average of 2.0 must be earned on all Wake Forest biology courses taken to complete a major.

A maximum of four hours of research in biology may be applied toward the major, but an additional four hours (Bio 393 and/or 394) may be taken and applied towards graduation as elective hours.

For students declaring biology as their major in Spring 2005 or later

COURSES REQUIRED FOR THE BA DEGREE IN BIOLOGY

Biology 112: Comparative Physiology (4 hours)
Biology 113: Evolutionary and Ecological Biology (4 hours)
Biology 213: Genetics and Molecular Biology (4 hours)
Biology 214: Cellular Biology (4 hours)

2 300-level lab courses (8 hours)
Additional hours of 200- or 300-level biology for a total of 34 biology hours

Co-requirements:
Chem 111 and 122 and one additional course in math or the physical sciences

COURSES REQUIRED FOR THE BS DEGREE IN BIOLOGY

Biology 112: Comparative Physiology (4 hours)
Biology 113: Evolutionary and Ecological Biology (4 hours)
Biology 213: Genetics and Molecular Biology (4 hours)
Biology 214: Cellular Biology (4 hours)

2 300-level lab courses (8 hours)
Bio 391 or equivalent research experience (Bio 500E – no credit)
Additional hours of 200- or 300-level biology for a total of 34 biology hours

Co-requirements:
Chemistry 111, 122, and 120 (or 223)
Physics 113 and 114
One additional 200- or 300-level course in math or the physical sciences

Undergraduate Enrollment In Graduate Courses

In addition to the regular undergraduate courses, selected graduate level courses are also available to undergraduates. These appear as 700-level graduate courses on a student's transcript, but the student receives undergraduate credit. Such courses may be used to satisfy the requirements for the major. Permission of the instructor and the department chair are required to enroll in graduate level courses. Students should consult a current course schedule to determine the availability of graduate level courses.

Undergraduate Research

Biology 391-394: Research in Biology: Students may receive academic credit for work in any of the research laboratories of the Biology Department or in one of a select group of laboratories at Bowman Gray School of Medicine. Credit for such work is received by registering for Research in Biology, Bio. 391 and/or 392, which are offered for two hours each. A maximum of four hours of research in biology credits may be applied toward the major, but an additional four hours (Bio. 393 and/or 394) may be taken and applied towards graduation as elective credits. Students who choose this course are then directed in their studies in the laboratory by a faculty member, who, working with the student, designs an original research project for independent study by the student. Many of our students have completed research projects very successfully, and have gone on to present the results of their research at regional, and occasionally even national, scientific meetings. Wake Forest undergraduates often bring home prizes for excellence in research and presentation from these meetings. A number of students have also published their research in scientific journals.

Other opportunities for research: The B.S. degree requires that students complete Bio 391 or an approved research equivalent (Bio 500E). To have a research experience (other than 391) to fulfill the research requirement, students must obtain approval from the major advisor **PRIOR** to participation in the research project. Then after completing the research project, a student must complete a research equivalency form (obtained from major advisor) and include a written description of their research project clearly stating the student's role in the research. The student's major advisor will then sign the form and turn it in to the biology office for the student to fulfill their research requirement.

But where can you find such an alternative? There are a number of opportunities to conduct research outside of the biology department, particularly in the summer. Several members of the department involve undergraduates in summer research programs for which the students can receive either credit or a stipend. These include research sponsored through the Wake Forest Research Fellowship program, and programs at the Duke Marine Laboratory, the Marine Biological Laboratory, the Archbold Biological Station in south central Florida, and field stations in Cocha Cashu, Peru and the Galápagos Islands. Students may also arrange research internships through the Environmental Studies Program. Also, each year the department provides students with information about REU and other programs nationwide at a Summer Research Opportunities Workshop organized in conjunction with the Women in Science Program. REU programs are Research Experiences for Undergraduates, funded by the National Science Foundation, and held at research sites throughout the US. You may find a description of all REU programs at http://www.nsf.gov/index.jsp then Search REU.

SUPPORT FOR RESEARCH

Wake Forest Research Fellows Program

The Wake Forest Research Fellows Program (WFRFP) is designed to encourage collaborative research between faculty and students. While improving opportunities for mentoring and helping students progress into advanced work, these are also a means of supporting successful and dedicated students with financial scholarships. Up to 150 fellowships are available per year. Scientific research done through the WFRFP will satisfy the requirement for a research experience for those students earning the BS degree in biology.

The value of the fellowship is $2,000 if used to support research during the academic year, in which case it is applied to student loans, or if there are no outstanding loans, to either fall or spring tuition. If the fellowship supports summer research, it is given as a $3,000 stipend directly to the student. An expense budget of up to $500 may accompany the fellowship.

Applications for the WFRFP may be obtained from the Dean's Office, or from the program director, Toby Hale, Dean of the Summer School. Acceptance to the program is on a rolling admissions basis. For more information and application forms:
Dr. Toby Hale, x5311
e-mail to haleta@wfu.edu

Sullivan Scholarship for Expanding Biological Horizons

Undergraduate students who are interested in pursuing biological studies beyond the classroom at Wake Forest may wish to apply for funds to support activities with the following goals:

1) Summer experiences at a research laboratory or field station.
2) Independent biological studies projects away from Winston-Salem in laboratories or the field.
3) Present scientific papers at national, regional and/or state meetings.
4) Attend scientific meetings.
5) Participate in organized field trips during the summer under the direction of a faculty member.

Proposals will be reviewed by the Department of Biology and grants awarded according to financial need and scientific merit. The amount of funds awarded per proposal is usually less than $2,500.

Interested students should request an application form from the office of the Biology Department. Grants will be awarded twice a year in October and March.

Richter Scholarships

The Richter Scholarship is a competitive, independent study scholarship awarded to students proposing an independent study project requiring travel away from Winston-Salem. International projects are especially encouraged. Most projects are expected to occur in the summer, and are expected to be enriching and potentially life-changing. The Richter Scholar awards are for up to $5,000. Each student is required to have a faculty mentor for his or her project. Deadlines for applications are November 15th and March 15th. For further information, contact Associate Dean Toby Hale, 126 Reynolda Hall, x5311.

Environmental Studies Grants

Biology majors are eligible for grants of up to $3000 from the Wake Forest Environmental Studies Program. These grants support undergraduate students for environmental activities including:

Environmental work with non-profit, governmental, and industrial organizations, including internships

Environmental research of one's own design

Environmental research with Wake Forest faculty or faculty at other institutions

Participation in programs which have a significant environmental component such as School for Field Studies, Sea Education Association, School for International Training, and Oxford University Environmental Program

Funds are available for students of ALL majors, including interdisciplinary activities. The application consists of a one-page description of the project, a proposed budget and a letter of recommendation (from the project or program director if applicable). Application review occurs every month. For additional information, contact Dr. Robert Browne, Environmental Studies Program Coordinator, Ext. 5569, 243 Winston Hall.

HONORS IN BIOLOGY

The Honors Program in Biology is designed to recognize the accomplishments of students in research and independent study - activities perhaps growing out of, but distinctly different from most classroom work. A student graduating with Honors in Biology has committed himself/herself to pursuing ideas in depth and over an extended period in the laboratory or field while working closely with a faculty advisor. Such an experience not only may lead to new knowledge in a chosen field but, perhaps more importantly, gives the student a real appreciation of the diverse ways in which science confronts and explores the natural world.

The Honors Program in Biology is run under the following guidelines: A student wishing to graduate with honors in Biology must inform the Undergraduate Studies Committee (USC) of that intention during the first semester of the senior year by completing an application to pursue honors in biology. This application must include honors advisor signature, major advisor signature, title of research project and advisory committee. The research that the student chooses to submit for consideration for honors need not be completed in the senior year. The work could have been completed before the senior year.

Suggested deadlines for the honors program might be:

September	Choose honors advisor with major advisor consultation.
November	Select an honors advisory committee and meet with its members to discuss research plans; complete Honors in Biology form (see form next page) and submit to Undergraduate Studies Committee chairperson.
Mid-February	Schedule thesis defense
April	Defend thesis.

What are the *absolute* deadlines? The registrar's office must be notified of which students intend to graduate with honors by the middle of February, and the student must defend the thesis, by the last regular day of classes before graduation.

To be graduated with the distinction “Honors in Biology”, a student must have a minimum GPA of 3.0 in all courses and a 3.3 in biology courses. In addition, the student must submit an honors paper (written in the form of a scientific paper) describing the research which must be defended before the Advisory Committee. If the paper is approved and the defense is passed by the Advisory Committee and minimum GPA requirements are met, the Honors Advisor will then notify the Chair of the Undergraduate Studies Committee and the student will graduate with honors in Biology.

Department of Biology
Wake Forest University
Application to Pursue Honors in Biology

To graduate with Honors in Biology, the student must complete this form in consultation with both the student's Honors research advisor and the student's major advisor. The form is due by November of a student's senior year. Once completed, the form should be sent to the chairperson of the Undergraduate Studies Committee.

Student's Name:_____

Student's ID number:_____

Current Biology GPA: _____ (minimum 3.300 at graduation required)

Current overall GPA: _____ (minimum 3.000 at graduation required)

Honors research advisor: _____

Honors advisor's signature:_____

Major advisor's signature:_____

Title of research project:_____

_____

Advisory committee (Honors research advisor plus 2 more members; at least 2 committee members must come from the Biology Department):

_____

Name Signature

_____

Name Signature

_____

Name Signature

Date of preliminary advisory committee meeting: _____

Date of thesis defense: _____

Other Programs Of Interest

Interdisciplinary Minor in Environmental Science: The Wake Forest Environmental program offers an environmental science minor or an environmental studies minor. The environmental program provides an interdisciplinary approach to the study of human-environmental interaction. The environmental science or the environmental studies minor, coupled with a liberal arts major, is designed to prepare students for careers in the environmental sciences, law, public health, public policy, and public administration, and to develop attitudes and values consistent with a sustainable environmental future.

Please consult a current copy (or online version) of the Wake Forest bulletin for course requirements. There is some overlap between the requirements of a Biology major and Environmental Sciences minor. The Environmental Program currently has some funding to support student research projects locally and in Latin America, and to participate in a joint environmental program with the University of Oxford. For more information contact Dr. Robert Browne.

The Neuroscience Minor: Wake Forest offers a minor in Neuroscience. Neuroscience is a rapidly growing interdisciplinary field that encompasses the study of the nervous system and its role in regulating behavior. Neuroscientists examine subjects ranging from the molecular pharmacology of brain function to the mind-body problem. Information about the minor, including requirements can be found at http://www.wfu.edu/Academic-departments/neuroscience/ or by contacting Dr. Wayne Silver in the Department of Biology (silver@wfu.edu), EXT. 5920

Sea Education Association: Wake Forest has recently affiliated with the Sea Education Association (SEA). Wake Forest undergraduates can earn a full semester of academic credit through the department of Biology and the Environmental Studies Program for participation in SEA's college programs. SEA Semester and SEA Summer Session are the only full-term programs in the U.S. that offer a deep-sea oceanographic research component at the undergraduate level. In the SEA semester, students work with an array of faculty—scientific researchers, experienced master mariners, historians, and literary scholars. The six-week shore component is held in in Woods Hole, MA, and combines lectures, hands-on workshops, small-group discussions and field excursions in an intensive, focused, interdisciplinary curriculum. Then, during the subsequent SEA component, students sail on board one of SEA's sailing research vessels and put into practice the knowledge learned ashore. SEA's shore component is in the oceanographic community of Woods Hole. Working with the crew, students, sail, navigate, and conduct research in the waters of the Atlantic Ocean and Caribbean. Work in oceanography and in the shipboard lab gives new insights into the scientific process, and an understanding of the interrelationships between earth, ocean and atmosphere. By the end of the program, students have completed an original research project. For more information on SEA, contact Dr. Robert Browne in the Biology Department. Prerequisite for the Admission to the Sea Education Association program is approval of department chair and/or his designate.

Wake Forest Summer Slovenia Program University of Ljubljana: Beginning in the summer of 2005, Wake Forest will begin an academic program at the University of Ljubljana in Ljubljana, Slovenia.

The purpose of the program is to provide Biology and/or Psychology students with an opportunity to study abroad and at the same time receive WFU credits which would count towards the major.

A WFU biology (or psychology) professor will teach his/her WFU course in Ljubljana for four weeks in July. The class will meet M-Th, 10AM – 1PM. In addition, students take a Slovenia culture and history course taught by Slovenian Professor. This course will meet M-W 2PM-3PM.

Students will pay WFU tuition and live in dorms at the University of Ljubljana. Current estimate for cost of the program is between $5,000 and $6,000. That includes airfare, meals, tuition, room, books, etc.

Slovenia is a fascinating country which was part of the former Yugoslavia. It will become a European Union member in 2005. Its western border is Italy and its northern border is Austria. Students will be encouraged to travel throughout the region.

STUDY ABROAD IN BIOLOGY

In today's world students need to have a global perspective with respect to geopolitical issues, economic issues, social and human rights issues and environmental issues. This is no less true for their major disciplines. Many biology majors study abroad. As with any other major, most tend to seek programs that offer a new cultural experience while at the same time offering them an opportunity to take courses in their major taught under a different educational system. We encourage our majors to take advantage of this great opportunity, but they must plan their schedule early to allow for such an opportunity.

Any student wishing to study abroad should first contact the Center for International Studies Office to get course information about the program to which he/she wants to apply. Then the student should bring the course information including syllabus, if possible, to the Department Chair who will advise the student regarding whether or not his/her selection of courses meets the department's requirements for transfer credit. If approved, courses taught in non-Wake Forest programs come in as transfer courses and may be applied to the major. Courses taught in Wake Forest programs are considered regular Wake Forest courses, thus automatically count toward the major (Biology majors may also take courses in other Wake Forest and non Wake Forest programs that do not have a biology component).

Most biology majors choose to study abroad during the fall semester of their junior year, although any semester following the completion of the sophomore year can work with careful planning. Once a major has completed the core (Biology 112, 113, 213 and 214) he/she should be able to handle most courses taught in an overseas program (levels 2 and 3). Our majors have studied in a variety of locations around the world, including:

Semester Programs

- London
- Venice
- Vienna
- Australia
- Denmark
- Bristol (UK)
- New Zealand
- Chile
- Scotland (UK)
- France (Dijon)
- School for Field Studies (Africa, Costa Rico, Spain, Caicos Islands)
- Barcelona, Spain
- Ireland
- Westminster (UK)
- Salamanca, Spain

Summer Programs

- Benin
- Colombia

Summer Programs offered by faculty in the Department of Biology

- Peru (Tropical Biodiversity)
- Jamaica (Tropical Marine Ecology)
- Slovenia (course offered changes with Director)

GRADUATE SCHOOL ADVISOR

Students who are interested in attending graduate school after graduation from Wake Forest should see the department's Graduate School Advisor, whose role is to act as an advisor to majors considering graduate school in all areas outside of the health professions. Dr. Brian Tague is the Graduate School Advisor. He can be found in room 049 Winston Hall. Call him at x5016 or e-mail him at tague@wfu.edu to set up an appointment. Also, enroll in the BlackBoard site to get on an emailing list and to access information about applying to graduate school. The course title is "Graduate School Advising – Biology". During the year the Graduate School Advisor will coordinate various programs to assist students in planning for graduate study.

HEALTH PROFESSIONS ADVISING

The Health Professions Advisors, Dr. Lane and Dr. Miller, Dept of Health and Exercise Science, have the task of assisting any health professions student with advice about course selection and academic as well as social suggestions to enhance successful application to the health professions school of his/her choice. Dr. Lane primarily advises students interested in the health professions (medical, dental, veterinarian) and Dr. Miller primarily advises students interested in the allied health sciences (physician's assistant, physical therapy, nursing, and occupational therapy). This is predicated on the knowledge that medical schools in particular search for students who are able to perform academically at a high standard under normal academic load and who have good interpersonal and social skills.

Programs to assist in this application include orientation seminars for freshmen and transfer students and for juniors. Freshmen and transfer students need to ensure that their course selection leads to completing a selected number and type of science courses so that they will be ready to take the MCAT as second semester juniors.

The Health Professions Advisor is chairman of the HEALTH PROFESSIONS COMMITTEE. The committee has the task of assembling and assessing information about Wake Forest candidates of the health professions schools so that the health professions advisor may write a composite letter of evaluation that medical schools admissions committees have come to expect. This process is initiated by the candidate by logging on to the Health Professions Program web site (www.wfu.edu/~lane/hpp\) and downloading the application packet.

UNDERGRADUATE STUDY LOUNGE

The Department of Biology provides a room on the basement level of Winston Hall, Room 053, for undergraduate to use as a study lounge. The space is located beneath the greenhouse in the south (east) wing of the building next to Dr. Tague's office. This lounge is for all majors and to use and is equipped with a table, chairs, a file cabinet, a telephone and a chalk board. The two biology honor societies, AED and BBB, also have mailboxes in this lounge. We encourage all majors to make use of this space. Our intention in providing this space is to foster a sense of community and collegiality among our majors.

AED

The North Carolina Gamma chapter of Alpha Epsilon Delta, the pre-medical honor society, has about 50 members. Membership is open to any Wake Forest student, regardless of major, who fulfills the entry requirements. Applicants for membership must be at least second semester sophomores who have completed at least than three science and/or mathematics courses. An overall college GPA of 3.0 and a science GPA (biology, chemistry, physics and mathematics) of 3.0 are the only scholastic requirements. Application forms can be downloaded from the chapter's web page (www.wfu.edu/Student-organizations/AED/)

The objectives of AED are to "encourage excellence in premedical scholarship, to stimulate appreciation of the importance of premedical education in the study of medicine, to promote education in the study of medicine, to promote cooperation and contacts between medical and premedical students and educators in developing an adequate program of premedical education , and to bind together similarly interested students." AED is a forum for students interested in, or committed to, the health professions. Meetings aim to inform the membership of the procedures, requirements and steps necessary to being a successful candidate for health professions school (medical, dental, veterinary and allied health programs). Speakers from specialized areas of the health professions are invited to describe their area of expertise and lifestyle. The medical student panel brings four to five medical students to the membership to share their experiences in applying to, and attending, medical school. Other programs of AED include an important volunteer program and a large mentoring program. AED is affiliated with the Collegiate Academy of the North Carolina Academy of Science and participates in its field trips, research workshop.

Beta Beta Beta

Beta Beta Beta Biological Society is a national honor society for undergraduate students in the biological sciences. It seeks to encourage scholarly attainment in this field of learning by reserving its active membership for those who achieve superior academic records and who indicate special aptitude for and major interest in the life sciences. It desires to cultivate intellectual interest in the natural sciences and to promote a better appreciation of the value of biological study, and thus welcomes into associate membership all those students who are interested in Biology. Beta Beta Beta endeavors also to extend the boundaries of man's knowledge by encouraging new discoveries though scientific investigation and to this end encourages undergraduate students to begin research work and report their findings in the Journal of the Society, *BIOS*. It emphasizes, therefore, a three-fold program: stimulation of scholarship, dissemination of scientific knowledge, and promotion of biological research.

The chapter at Wake Forest meets semi-monthly for chapter business and programs originating with its own members of with occasional outside speakers. In addition to its meeting, the chapter carries on several projects of educational or scientific value and participates in one or more activities sponsored by the national organization. All members will be required to attend the initiation meeting and one additional meeting per semester. Failure to comply will result in suspension of membership.

BBB Memberships are of two types: Active members must be an undergraduate major or potential major in Biology, have completed at least three term courses in Biology with a GPA of at least 3.0 in these courses, and have an overall GPA of at least 3.0 in all courses taken. Associate members: must have completed two term courses in Biology with a GPA of at least 3.0 in these courses, have an overall GPA of at least 3.0 in all courses taken, and show a high degree of interest in Biology. Associate members are elevated to active membership status when they have met the requirements for active membership.

Upon acceptance to the Society students are required to pay a one time membership fee of $90.00 (Associate), $80.00 (Active) or $10 (promoted from Associate to Active), Graduate, Honorary and Alumni membership dues are $30 each.

BBB sponsors a number of functions each year, including speakers, dinners, picnics, fund raising projects, monthly meetings, special programs, and the opportunity to present reports on one's scientific research. As members of the North Carolina Collegiate Academy of Science, students can participate in field trips, research presentations, projects and workshops. The district and regional BBB chapters also sponsor an annual convention, symposial dinners, and socials. Nationally there is a biennial convention, offering additional opportunities for research presentations, field trips, speakers, socials, symposia, and banquets. The national office helps defray travel costs of members through grants to chapters that send delegates to the national meeting. The local chapter and the department have in the past been able to pay all expenses for those presenting papers, although this is not guaranteed. The local chapter and department have paid full expenses for district and regional meetings as well for those students presenting papers.

The Biology Department

There are 22 full-time, one permanent part-time and one adjunct faculty members in the Department of Biology, each having expertise in a different area of biology. This allows us to offer a diversity of courses. Students interested in cellular, ecological, physiological, or more classical courses of study will find numerous courses available in each of these areas. In addition, some courses offered by the Departments of Physics and Anthropology may also be taken for credit towards the major in Biology.

The Biology faculty is actively engaged in research. The Department is productive in terms of publications generated from these activities and in acquiring extramural grant funds in support of research. The faculty currently receives grant support from the National Institute of Health, National Science Foundation, National Aeronautics and Space Administration, Whitehall Foundation, North Carolina Biotechnology Center, National Park Service, U.S. Fish and Wildlife Service, and National Geographic Society. Faculty members routinely publish in leading scientific journals and have been invited to lecture in Europe, Asia, and South America, as well as throughout North America. Students benefit from faculty research programs in two ways: Research laboratories provide undergraduate students with a means of participation in research, a valuable experience for any student considering a career in the sciences; equally important, however, is the sense of purpose and excitement generated by the research environment which is often carried into the classroom. As a result, biology is presented not as a collection of facts as much as a pathway of discoveries leading to unanswered questions and future research.

The Department of Biology is equipped with a variety of research-quality instrumentation for conducting scientific studies at all levels of biological organization, from the subcellular to population and a variety of community phenomena. An assortment of equipment, including a laser scanning confocal microscope, a scanning electron microscope, a video-microscopic facility, gas chromatographs, liquid scintillation counter, ultracentrifuge, ultrasound recording equipment and spectrophotometers, enables the department to investigate a number of biochemical and cellular phenomena. The availability of oxygen analysis systems, calorimetric equipment, instrumentation for ionic and osmotic determinations, and electrophysiological apparatus provides for detailed studies of organismal phenomena.

In addition to a complement of instrumentation for making various field collections and measurements, the department maintains a field station on Belews Lake, a man-made reservoir about twenty-five miles from Winston-Salem. The field station is located on a l00-acre tract bordering Belews Lake and is available for a variety of research involving either aquatic or terrestrial ecosystems. The department has a fully equipped electrofishing boat to supplement ichthyological research.

Wake Forest is a member of the Highlands Biological Association and uses the Highlands Biological Station in the mountains of Western North Carolina. Through several faculty and graduate students, the department also has access to the facilities of the Duke University Marine Laboratory on the North Carolina coast, the Bermuda Biological Station, and the Marine Biological Laboratory at Woods Hole, MA. Current research programs are also being conducted at the Savannah River Ecology Laboratory in Aiken, SC. These associations provide research opportunities covering the spectrum from marine biology to terrestrial and aquatic studies.

FACULTY PROFILES

David J. Anderson
Professor of Biology

B.A. Denison University (1980), M.S. University of Michigan (1986), Ph.D. University of Pennsylvania (1989)
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Areas of Interest
Behavioral and Evolutionary Ecology, Avian Siblicide, Evolution of Reproductive Rates, Sex Allocation, Conservation Biology in the Galápagos Islands

Research

My laboratory's research is on the evolutionary and behavioral ecology of birds. Of particular interest is the evolution of reproductive life histories. We ask questions about the influence of variables such as costs of reproduction, genetic conflicts of interest, and phylogenetic constraints on the evolution of characters like clutch size, offspring sex ratio, and sibling competition. Since 1984 we have pursued a major field research effort in the Galápagos Islands, Ecuador on boobies. These birds provide excellent opportunities for experimental approaches to issues in evolutionary and behavioral ecology because they are fearless of humans. They are also great for comparative studies since closely related species have different life histories.

We are using satellite tracking to study the influence of foraging biology on evolution of reproductive traits in Laysan and black-footed albatrosses in the Northwest Hawaiian Islands. In a laboratory emphasis, we are using molecular sexing techniques to test hypotheses dealing with the evolution of sex ratio in birds of prey and a variety of other taxa. We have also been involved in conservation issues in the Galápagos, through studies of the demography and genetics of threatened and endangered bird species.

Miriam A. Ashley-Ross
Associate Professor of Biology

B.S., Northern Arizona University, 1988, Ph.D., University of California, Irvine, 1994

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Areas of Interest
Functional morphology, comparative physiology, biomechanics

Research Interests

My laboratory is interested in the mechanistic basis of animal behavior. A variety of animal species from diverse groups serve as models. Currently, my lab has two main research tracks. First, we are investigating the evolution of tetrapod (four-footed land animals: mammals, birds, reptiles, amphibians) locomotion by quantifying underwater locomotion using the limbs in salamanders. This may sound odd, but the fossil evidence indicates that the appearance of the tetrapod limb and foot pre-dated the move to land. Thus, one wants a model that approximates the posture of early tetrapods, and salamanders are our best available match. Second, we are examining the biomechanics of prey capture in tarantulas. These large, hairy, ground-dwelling spiders can capture small arthropods (such as crickets) in less than one-tenth of a second. Just how they detect and capture their prey is our current interest. My graduate students are working on such diverse projects as the function of the median fins during the escape response in fish, and the development of feeding biomechanics in a blind cave salamander. Techniques that we use are high-speed video, electromyography (recording patterns of muscle activity), sonomicrometry, and *in vitro* measures of muscle work and power output.

Carole L. Browne
Professor of Biology

B.S., University of Hartford, 1972, Ph.D., Syracuse University, 1977

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Research Area
Cell and Developmental Biology

Research Interests

Working in collaboration with Dr. Michael Tytell of the Wake Forest University School of Medicine, we have been using the sea urchin egg as a model system for studying the effect of exogenous heat shock protein (Hsp) on cells. Hsps are molecular chaperones involved in protein folding and translocation in response to physical stresses and during immune and inflammatory responses. Recently it has become clear that they also play a role in regulating the cell cycle. Although Hsps are best understood in the context of their intracellular actions, evidence suggests that they can be passed from cell to cell, expressed on plasma membranes, and taken up from the extracellular medium. Thus exogenous application of Hsps might have clinical benefits. Exogenous Hsp is taken up by fertilized eggs of the sea urchin *Lytechinus variegatus*, leading to a shortening of the first cell cycle after fertilization. The ability of Hsp to decrease cell cycle time is correlated with their ability to protect proteins against heat-induced denaturation.

The coelomic fluid of sea urchins contains motile, phagocytic cells called coelomocytes that undergo a dramatic spreading reaction when physically stressed or placed in hypotonic medium. The ability of coelomocytes to rapidly and extensively remodel their cytoskeleton in response to external stimuli suggested this as another model for testing the functional effects of exogenous Hsp. We have demonstrated that Hsp 70 inhibits the injury response of sea urchin coelomocytes, suggesting that it acts at the cell surface or is internalized in such a way as to inhibit signals regulating the polymerization of the cytoskeleton.

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B.S., M.S. University of Dayton, 1972, 1974, Ph.D., Syracuse University, 1977

Research Interests
The field of evolutionary ecology encompasses the fields of ecology, evolution and genetics. We are interested in exploring further aspects of the evolutionary ecology of both laboratory and wild organisms. Recently this has focused on two major areas: Conservation Genetics. We assay genetic diversity of isolated populations that are often rare and/or endangered. Recent projects include studies on Hawaiian ducks, the Cape Cod redbelly turtle, dark-rumped petrels of Hawaii and the Galápagos, and mountain-top populations of mice, voles, flying-squirrels and salamanders. Projects are often collaborative. Life-history and Reproductive Strategies. We are interested in how organisms adapt to their abiotic and biotic environment and the trade-offs that often occur in reproduction and lifespan. The majority of this work has occurred using the brine shrimp Artemia as the model organism. An especially interesting aspect of this work involves sexual and asexual reproduction.

Our work involves molecular tools such as mitochondrial DNA analysis and allozymic variation detected by electrophoresis. In addition, demographic parameters are examined via classical life-history trait analysis. Field work has been conducted in the American west, North Africa, Tibet and especially southern France.

William E. Conner
Professor of Biology
Scott Family Fellow

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Areas of Interest
Animal Communication, Chemical Ecology, Insect Physiology and Behavior, Bioacoustics

Reasearch Interests

My laboratory studies the sex pheromones and chemical defenses of moths. We are interested in how chemical signals are released, how they travel through the environment, how they are detected, how the receiver responds to them, and ultimately how they have evolved. The colorful arctiids on which we concentrate provide a diversity of interaction with which to work and allow a comparative approach to many evolutionary questions. My students and I combine analytical chemical techniques, electrophysiological techniques, infrared videography, and cladistic analyses in exploring communication systems that are well beyond are own sensory capabilities.

Because communication often involves multiple modalities, we occasionally work with other sensory signals, most notably ultrasound. It is well known that some insects have the ability to hear ultrasound in the form of bat echolocation signals, but we have discovered that some arctiid moths also utilize ultrasound in intraspecific communication. Our field studies are carried out in North Carolina, Florida and in the cloud forests of eastern Ecuador.

James F. Curran
Professor and Chair of Biology

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Research Interests

Protein synthesis. The ribosomal translation of the genetic code is a fundamental biological process. Cells are composed mostly of protein, and cellular well-being depends on the accurate and efficient production of that biomass. In addition, there are specific mRNA sites in which errors occur at very high frequencies to generate active proteins. For example, a very high frequency frameshift occurs at a specific site in the AIDS virus mRNA. If we could prevent this "programmed frameshift," then the AIDS virus could not grow. We have ongoing projects that explore the molecular mechanisms of programmed frameshifting, translational accuracy, and the evolution of the genetic code.

DNAs as biotech tools. For many years, antibodies have been used as specific reagents for the detection of pathogens or the quantification of key biological markers of human health. Antigen specificity is the fundamental feature of antibodies that permit these uses. It has recently been shown that synthetic nucleic acids can be created that have binding affinities and specificities as great as those of antibodies. Furthermore, the technologies needed to develop nucleic acid based reagents are much simpler and cheaper than those needed to develop antibody reagents. We exploit these characteristics to develop synthetic DNAs as biotech reagents.

Ronald V. Dimock, Jr.
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Areas of Interest
Invertebrate Zoology, Physiological Ecology

Research Interests

I am broadly interested in the behavioral and physiological ecology of invertebrates, especially marine and freshwater species, and the mechanisms by which these organisms are affected by significant environmental factors. Recent projects include host/symbiont interactions between bivalve molluscs and aquatic (unionicolid) mites, dynamics of filter-feeding and respiration of adult bivalves, and the behavior and physiology of juvenile freshwater mussels. Our work on mussels has implications for conservation of this seriously threatened group of animals.

Gerald W. Esch
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Areas of Interest
Parasitology, Aquatic Biology

Research Focus

Over the years, my research interests have focused on host/parasite relationships in aquatic ecosystems. In general, these studies have centered on the population and community dynamics of parasitic helminths in both vertebrate and vertebrate hosts. In more recent times, our work has involved snail-trematode interactions in a small farm pond located near the Wake Forest University campus. Specificially, we have attempted to identify those factors which structure infra- and component trematode communities in two species of pulmonate snails. Our studies have also been aimed at relating these factors to the transmission dynamics of allogenic and autogenic species that infect these snails and their vertebrate definitive hosts in the pond. These efforts have employed standard field procedures as well as modern biochemical and molecular techniques in the laboratory.

Herman E. Eure
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Research Interests

Host parasite interactions are the primary focus of my research. How these parasite interact with their hosts and the various factors that impact on that relationship is studied in vertebrate organisms ranging from frog, toad, turtles to fish. I am interested in determining how factors such as host diet, temperature, availability of infective intermediate host, host sex and age influence the seasonality of parasite populations. An additional interest lies in how these populations are regulated, both at the intermediate and definitive host levels.

Susan E. Fahrbach
Reynolds Professor of Neuroscience

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Research Interests

The Fahrbach laboratory is interested in the development of the nervous system and uses two insect model systems to study metamorphosis and learning. Projects on the tobacco hornworm, a moth, focus on the responses of glial cells to hormones when caterpillars pupate. In honey bees, I study the mushroom bodies, which are the main insect brain centers for learning. These neuroanatomical projects use immunostaining, stereology, and in situ hybridization to study the bee brain. I am also conducting studies that seek to identify nerve cells that function as the master "clock" of the bee brain.

A. Daniel Johnson
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Research Interests

I am interested in normal and pathological responses of vascular smooth muscle cells (SMCs) to injury. In normal blood vessels, SMCs are highly differentiated, non-mitotic, contractile cells. If a vessel is injured, SMCs will de-differentiate, multiply, and migrate into the damaged area. Next, they lay down extracellular matrix and repair the injured area. Yet in chronic vascular diseases like atherosclerosis (hardening of the arteries), SMCs often die before an injury is fully repaired, leaving a weak spot in the arterial wall. These weak spots can rupture suddenly, causing a myocardial infarction (heart attack) or stroke. At large mass of cells and extracellular matrix that slowly cuts off blood flow. This causes chronic ischemia, that can damage the heart or brain as badly as a stroke or heart attack. My collaborators and I are working to understand when, how, and why SMC survival and repair mechanisms go awry.

At present, I am interested in two major questions: Why do SMCs die in late stage atherosclerosis? And why do SMCs proliferate excessively after some kinds of vascular injury? I am using cultured SMCs and transgenic mice to determine which transcription factors specifically control SMC growth and repair during atherosclerosis.

Erik C. Johnson
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Research Interests

I am broadly interested in the mechanisms involved in neuronal signaling and communication. Specifically, I focus on neurotransmitters and the receptors that recognize these factors and attempt to link these to specific aspects of behavior, physiology, and development. I use the fruit fly, *Drosophila melanogaster*, to address questions regarding how these neuropeptides and other transmitters function within the nervous system, because the advanced genetic tools of *Drosophila* allows for targeted manipulations of these signaling systems.

Initial experiments are aimed at assigning specific ligands (neuropeptides or neurotransmitters) for novel or "orphan" receptors. I have adopted a functional genomic approach in which DNA sequences are identified as encoding a receptor and then are subsequently cloned and expressed in a heterologous system. These preliminary experiments offer insight into the consequences of receptor activation and are used to frame future experiments aimed at dissecting receptor signaling in native tissues. Current studies also focus on addressing potential influences that specific cellular contexts have on receptor function and signaling. Additionally, other experiments are aimed at determining the functional significance of manipulating specific structural features of neuropeptide receptors.

Kathleen A. Kron
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Research Interests

My general area of research interest is the phylogenetic relationships of flowering plants. In my lab we use molecular and morphological data to study the evolution of members of the blueberry family (Ericaceae) and, more recently, the buckwheat family (Polygonaceae). Currently we have several research projects in progress. These include: the phylogeny and biogeography of the South African genus Erica and its European relatives, evolutionary relationships of Rhododendron, molecular systematics of Gaultheria (wintergreens) and temperate and tropical blueberries, and molecular systematics of the family Polygonaceae (buckwheat and rhubarb relatives).

In addition to family and generic level studies, we are also interested in the major clades within the large and diverse order Ericales using combined data sets. These taxa can be studied from a variety of perspectives such as biogeography, evolution of leaf morphology/physiology (in the heathers) or patterns of diversification (in Rhododendron).

Raymond E. Kuhn
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Area of Interest
Immunobiology of Host-Parasite Relationships

Research Focus

Our research focuses on the immune response of mammalian hosts infected with metazoan or protozoan parasites. We are particularly interested in determining which immune effector mechanisms are most effective in rejection and elimination of these parasites. Evolutionarily, however, parasites have developed their own adaptive responses to evade or avoid immune rejection mechanisms and can often survive for years or decades in immune hosts. In many cases, it has been shown that concomitant with parasitic infection, the host's immune response becomes down-regulated or is driven in a less effective direction. Our studies on *Trypanosoma cruzi* infection in mice has shown that the immune response becomes severely suppressed shortly after infection and that this suppression down-regulates responses not only to the parasite but also to other unrelated antigens. Recently, we have shown that the metazoan parasite, *Taenia crassiceps*, secretes a substance which inhibits the part of the immune response which would be expected to reject a multcellular foreign material. Our studies to further examine potential evasive mechanisms used by *T. cruzi* and *T. crassiceps* are continuing and include examining the cellular and molecular basis of their immunosuppressive activities in infected mammalian hosts.

Hugo C. Lane
Professor of Biology

Licenciate of Biological Sciences 1967 University of Geneva, Doctorate of Biological Sciences 1972 University of Geneva, Switzerland

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Research Interests
Physiology, endocrinology, biomedical ethics

Research Focus

I have been interested in the forces that affect the oxygen-carrying capacity of the blood of rainbow trout. This capacity is a function, not only of the total number of circulating red cells, but also of the proportions and oxygen-binding nature of the hemoglobin isomorphs in the cells of different age classes. Some trout farmers in North Carolina use the practice of injecting liquid oxygen into raceways, especially in summer, to raise the yield of fish by raising oxygen to supersaturated levels. Our attention has been directed to the influence of oxygen supersaturation on the red cell life cycle in the animal as it attempts to maintain oxygen-carrying capacity.

Pat C. Lord
Lecturer in Biology

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Areas of Interest
Developmental Biology, Muscle Development in *Drosophila melanogaster*; Genetics, Science Education for the Non-Scientist

Research Interests

In developmental biology, the goal is to determine the molecular events that regulate growth and development of a fertile egg into a multicellular organism. One part of this development is the differentiation of mesoderm into muscle. During *Drosophila* embryogenesis, mesoderm formation starts at gastrulation in the ventral furrow cells. Eventually, a subsequent mesodermal cells will give rise to the somatic body wall muscles, which is organized into 30 separate and distinct muscle repeated within each segment of the embryo. I have isolated and studied a homoeobox gene, *muscle segment homeo (msh)* expressed during *Drosophila* embryogenesis. The *msh* gene is expressed in developing neuroblasts early in embryogenesis. Later in embryogenesis, *msh* is expressed dorsal lateral cells in each thoracic and abdominal segment which will form body wall muscles. As embryogenesis continues, the *msh*-expressing cells are expanded as myoblasts form muscle fibers. *Msh* expression is reduced or absent in *twist* or *snail* mutants, which do not form the mesodermal layer, confirming that *msh* expression is in the mesoderm. Ectopic expression of *msh* in the mesodermal cells leads to defects in the developing musculature suggesting that muscle defects are at the level of recruitment and/or formation muscle precursor cells. Since *msh* is a homeobox gene, the *msh* protein acts as a transcription factor and "turns on" genes, which are important in muscle differentiation.

Anita McCauley
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Research Interests:
Sensory Systems Neuroscience; Visual System Development; Anatomy and Function of the Thalamus; Nitric Oxide-Mediated Neurotransmission

Research Focus:
The thalamus is a sub-cortical brain structure that is essential for both sensory information processing and the modulation of sleep and waking states. The complex neural circuitry of the thalamus allows this structure to transform and gate sensory information that is relayed from the periphery to the cerebral cortex. My research has focused on the development of the thalamic circuitry associated with the visual pathway, and in particular, the contributions of the neurotransmitter nitric oxide to the development and function of this circuitry. In collaboration with Dr. Dwayne Godwin of Wake Forest University School of Medicine, we have determined the cellular pattern of expression of nitric oxide synthase (the synthesizing enzyme for nitric oxide) during development and in the adult visual thalamus. My current research efforts utilize many complementary anatomical techniques to determine the synaptic contacts onto nitric oxide synthase containing cells, to characterize the nitric oxide synthase containing brainstem input to the visual sectors of the thalamus, and to understand the mechanisms responsible for stimulating nitric oxide release. This research will provide important basic science and clinical information related to the development and plasticity of the visual pathway, mechanisms of information processing, and factors that may be associated with neurological disorders such as epilepsy and Parkinson's disease.

Gloria Kressin Muday
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Research Interests
Plant Physiology and Biochemistry, Molecular Biology

Research Focus

The emphasis of research in my laboratory is the understanding of the role of the hormone, auxin, in plant growth, development, and response to the environment though characterization of the biochemical mechanisms of auxin transport. Auxins reach plant tissues by a unique cell to cell polar transport system. Regulation of auxin transport is carefully modulated to allow growth, development, and responses to light and gravity to be precisely controlled. The biochemical mechanisms of auxin transport and the role of transport in plant growth are the focus of research in the laboratory. We are specifically interested in a protein which regulates the efflux of auxin from cells. This regulatory protein is associated with the auxin efflux carrier and is believed to be localized to the base of plant cells and to thereby drive the polarity of auxin transport. Recent evidence suggests that this regulatory protein is associated with the actin cytoskeleton. The actin cytoskeleton is a dynamic structure which may allow growth and developmental signals to be communicated to this regulatory protein and may allow rapid modulation of auxin transport. Our efforts are now directed toward understanding the regulation of polar auxin transport through isolation of this regulatory protein and the gene which encodes it. The isolation of these molecular probes will allow elucidation of the regulatory processes which control auxin transport and influence plant growth and development.

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Research Focus

My research focuses on population and community dynamics, most recently focussing on trees. By using ecological, geological, and paleobotanical techniques, I seek to understand the distribution and abundance of tree species, and particularly the composition and dynamics of tropical tree communities. This approach combines rigorous experimental design and analysis with an understanding of the natural history of both the forest ecosystem and the component species in order to test the causes of patterns found in nature. My research is very field oriented. Current research projects include: the role of life history in the structure and diversity of tropical tree communities in Manu National Park, Peru, a paleoecological investigation into the composition and stability of tropical tree communities over time, and, closer to home, a long-term project on sex-switching and population dynamics in striped maple (Acer pensylvanicum L.) at Mountain Lake Biological Station, Virginia.

Wayne L. Silver
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Areas of Interest:
Comparative physiology of the chemical senses; chemesthesis

Research

My research involves the neurophysiology of the chemical senses, including taste, smell, and trigeminal chemoreception (chemesthesis). My present focus is the characterization of nasal trigeminal chemoreceptors as well as the assessment of the role of these receptors in the detection of odors. I am particularly interested in the effects of odorants on physiological function. Chemical stimuli entering the nasal cavity stimulate both trigeminal and olfactory receptors (as well as vomeronasal receptors). Trigeminal chemoreceptors, usually associated with irritating stimuli, are a class of pain receptors and do not constitute a separate chemical sense. In addition to their role as affectors, signaling the presence of irritating stimuli, these receptors have an effector role, initiating processes which tend to keep the irritating compound from potentially damaging the body. Examples of chemesthesis include the stinging of ammonia and the burning of horseradish and chili peppers.

William K. Smith
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Area of Interest
Adaptations of plants to harsh or unusual environments; plant physiological ecology and environmental biophysics; photosynthesis, water and nutrient relations; microclimate measurements in the field; natural isotopes

Research

The research in my laboratory ranges from the cell to the landscape and ecosystem levels, but with an emphasis on the whole-organism. A primary focus concerns how plants are adapted to their respective habitats and the development of mechanistic explanations for the observed distribution patterns of different species. Unusually harsh or extreme environments (e.g. deserts, alpine, forest understory) are often excellent choices for understanding plant adaptation and distribution. Measurements of photosynthesis, temperature, water and nutrient relations, and natural isotopes provide the foundation for understanding adaptations in physiological processes, as well as structural/functional relationships at the leaf, crown, canopy and stand levels.

Current projects are evaluating stress factors at the alpine treeline, in snow algae, conifer tree seedlings, and snowbank plants; determination of sources and sinks for CO2 exchange across mountain/plain landscapes; effects of elevated CO2 on the form and function of alpine plants, and impacts of leaf form (anatomy, morphology, and orientation) on photosynthetic performance; the influence of leaf surface wetness (e.g. dewfall) on gas exchange and ecophysiology; winter photosynthesis in evergreen species; and effects of air pollution on high elevation conifers.

Brian W. Tague
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Director, Graduate Program
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Area of research
Plant Molecular and Cellular Biology

Research Interests

Dr. Tague uses molecular genetic techniques to study plant cell biology and development. The organism studied is Arabidopsis thaliana, a member of the mustard family that has become an important model system for plant molecular biology. One area of this research concentrates on the functional analysis of a family of genes encoding zinc finger proteins. The zinc finger motif is a DNA-binding domain found in transcription factors from a variety of plants and other non-green organisms. A second area of research concerns the analysis of morphological mutants altered in leaf development and the isolation of the mutant genes involved in those alterations. This research should result in a more basic understanding of the cellular basis of plant development.

Peter D. Weigl
Professor of Biology

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Research Interests
My interests include the fields of ecology, behavior, comparative physiology and evolutionary biology. Most of my research and that of my students involves wild vertebrates, combines field and laboratory approaches and concentrates on energetic aspects of adaptations to different environments. In the past few years our work has included foraging behavior in squirrels, investigations of endangered species of mammals, locomotion in frogs, thermoregulation in screech owls, parasite mediated competition in flying squirrels, the coevolutionary relationships of tree squirrels and certain species of conifers and fungi and the possible role of megaherbivores in maintaining grassland habitats.

Clifford Zeyl
Associate Professor
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Research Area:
Experimental Evolutionary Genetics

Research Interests
My lab uses populations of budding yeast, Saccharomyces cerevisiae, to study fundamental questions of evolutionary and population genetics. I am particularly interested in the effects of sex, and of variation in mutation rates, on the ways that eukaryotic populations respond to natural selection. I am also interested in the genetic mechanisms and population dynamics of adaptation in long-term yeast cultures.

Yeast cells may be haploid or diploid. Both types reproduce by budding and mitosis. Haploid cells are either mating type a or mating type alpha. Adjacent haploid cells of opposite mating types mate by growing towards each other and fusing. This produces a diploid cell that can then reproduce by budding. Yeast populations in the lab can therefore be haploid or diploid, sexual or asexual. Because they undergo up to 16 generations per day, their evolution can be studied as it occurs, in controlled experiments. We can experimentally test a great deal of population genetic and evolutionary theory that so far has been studied mostly by mathematical modeling and simulation. The recently completed sequencing of the entire yeast genome, and the ongoing study of the functions of each gene, will make it possible to manipulate the genetic makeup of experimental populations, and to analyze the outcome of selection, in great detail.
Here are two examples of the kinds of questions that interest me

1) The roles of chance and historical contingency in adaptation: Biologists have often wondered whether evolutionary history would repeat itself given identical starting conditions, or whether every outcome is unique. More precise genetic theories about adaptation also lead to contrasting predictions about the repeatability of evolutionary history. These can be tested by experiments in which cryogenically preserved samples taken from evolving yeast populations over hundreds of generations are revived and used to start parallel evolving populations. Will they repeat the evolutionary changes observed the first time?

2) Sex and co-operation within genomes: Most genomes contain sequences which appear to be molecular parasites, such as plasmids, transposons, and mobile introns. Over many generations of co-evolution, initially parasitic associations may become commensal or even mutualistic. By breaking up such co-evolving associations, sex may hinder the evolution of co-operation within genomes. Asexual and sexual yeast populations carrying initially harmful plasmids can be used as a model to study these processes.