

REPORT OF SCIENCE

AT

WILLIAMS COLLEGE

2010-2011

**A RECORD OF THE PROFESSIONAL ACTIVITIES OF FACULTY AND
STUDENTS IN THE NATURAL SCIENCES**

**Williamstown, Massachusetts
2011**

Cover:

“715 molecules” is a stone table and benches engraved with the formulae of 715 molecules. It was donated in 2011 to the college in memory of J. Hodge Markgraf⁵² Ebenezer Fitch Professor of Chemistry, Emeritus and was installed on the science quad in May.

This photo was taken during the official unveiling of the piece and depicts a student reaching out to touch the polished stone surface of one of the benches.

715 molecules, 2011

sandblasted diorite table and benches

20 x 7.5 x 2.5 ft./6.1 x 2.3 x .8 m

Williams College, Williamstown, Massachusetts, USA

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Photo: Arthur Evans

The Science Executive Committee wishes to express its gratitude to the extensive efforts of all the science departmental executive assistants in preparing contributions for this publication, and to Chanda Shepardson, administrative assistant at the Science Center, for assembling this material in its final form.

Editor: Norman Bell

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SCIENCE PROGRAMS AT WILLIAMS COLLEGE

Students learn science best when they formulate and test their own hypotheses, using methods capable of producing convincing evidence. This is true at the elementary level, where students become interested in further study by encountering science as discovery rather than rote facts. It is even more important at advanced levels, where students are most likely to become interested in science careers by working as fully involved junior colleagues with professionally active faculty on research projects that develop new science. The ability to conduct competitive research at Williams helps to attract talented scientists as faculty and keeps them current, so that the diverse range of science courses reflects new results and perspectives. For faculty to involve students in research, to produce publishable results, to compete for research funding, to teach effectively in a formal classroom setting, and to continually bring modern ideas into course laboratories, requires substantial support in the way of modern facilities, instrumentation, supplies and technical support. Williams College long ago recognized this need. With the construction of the Bronfman Science Center in 1967, we established the kind of facilities and support programs recommended by studies such as the 1986 National Science Board Task Committee on Undergraduate Science and Engineering Education. As our science buildings have been upgraded to provide modern facilities for teaching and student-faculty research, the model of the entire science division as a programmatic unit has flourished. Funds for major equipment, for individual student-faculty research projects, and for stipend support of students doing research with faculty are coordinated on a division-wide basis by the Science Executive Committee and the Divisional Research Funding Committee. By working together, we are able to share not only facilities and equipment, but also ideas and enthusiasm, and so provide a “critical mass” of activity that might not be possible within an individual department at a small institution.

In the late 1980s, Williams College affirmed its commitment to training future scientists by identifying applicants with an expressed interest in pursuing a Ph.D. in science. Since then, about 15% of students in each class have expressed interest in careers in scientific research. The quality of the College’s science programs has nurtured this interest and nearly all of those students continue in science. Williams College has become a leader in the training of future scientists with more than 50 students going on to Ph.D. programs in science each year. As a result of this commitment, Williams has ranked first among predominantly undergraduate institutions in students receiving NSF pre-doctoral fellowships, averaging about 7 per year over the past ten years. We attribute this success to an energetic faculty and staff dedicated to providing an excellent educational experience and to the many research opportunities available to Williams students at both advanced and introductory levels. It has long been recognized that a positive undergraduate research experience is the single most important inspiration for future scientists. As documented in this report, more than 250 students were engaged in science research with Williams faculty this year. More than 85 students conducted independent research projects during the academic year and 166 students were engaged in full-time research with Williams science faculty during the summer. Dozens of Williams students participated in conferences where they presented the results of their research, and many Williams students co-authored publications in peer-reviewed journals.

Concurrent with the increased student involvement in science, Williams has attracted talented and vibrant science faculty engaged in competitive research and dedicated to teaching undergraduates. As a result, the number of external grants awarded to support faculty research or curricular innovation has increased significantly. With 24 active NSF grants this past year, Williams College ranks second among undergraduate institutions in the number of NSF grants awarded to science faculty. The large number of individual faculty grants, together with grants from the Sherman Fairchild Foundation, the Essel Foundation, the Kresge Foundation, the Keck Foundation, and other sources, has enabled us to purchase and maintain sophisticated equipment for teaching and research. Emphasizing close student-faculty interactions, the opportunities in undergraduate science education at Williams are exciting, diverse, and progressive. After years of careful planning by science faculty, a \$47 million science facility was completed in fall 2000. This facility unifies all science departments in a single complex surrounding a central science library. The new Science Center, ensures Williams’ place as a leader in undergraduate science education in the 21st century

Freshman and Sophomore Discovery Courses

Launched under a five-year grant from the Ford Foundation Initiative for Undergraduate Science Education, “discovery” courses in the sciences have become an integral part of our curriculum. Although the grant has expired, most of these special introductory science courses (described below) have become integral parts of our curriculum. Designed to excite the interest of beginning students through hands-on experiences, the discovery courses are taught in a manner that requires students to take a greater responsibility for their own education. They are expected to make observations, formulate hypotheses, gather data, conduct analyses, and evaluate outcomes without the faculty providing them with the anticipated results in advance. The success of these courses has led to the incorporation of the discovery approach to teaching science in upper-level courses as well.

CHEM 255 Organic Chemistry: Intermediate Level Special Laboratory Section

While covering the same lecture material as other introductory chemistry classes, a special, enriched laboratory program includes activities that more closely resemble the unpredictable nature and immediacy of true chemical research. Students synthesize, isolate, and characterize a family of unknown materials in a series of related experiments constituting an integrated, semester-long investigation.

ENVI 102 Introduction to Environmental Science

ENVI 102 is course with a hands-on approach to learning environmental science by going out and collecting data locally. It has been taught by professors Hank Art (Biology), Dieter Bingemann (Chemistry), and Mea Cook (Geosciences) with help from Jay Racela (Environmental Studies). This project-centered approach looks at local analogues of five themes of global importance: climate change and the carbon cycle, acid deposition, metals in the environment, water quality, and waste treatment and remediation. This year we again completed a biomass census in a permanent plot in Hopkins Forest to estimate the amount of CO₂ taken up by forest re-growth in Williamstown, analyzed chemical processes in conventional and Living Machine sewage treatment facilities, measured heavy metals in soils from various locations in Williamstown, and evaluated water quality in local streams and ponds. Students in the course undertook a diversity of independent field/lab projects, ranging from a chemical and gustatory drinking water comparison and the design of an environmental discovery trail to maple syrup from the Hopkins Forest and the in-depth study of local ponds and rivers stressed by human impacts.

GEOS 105 Geology Outdoors

An introduction to geology through student field projects – the mountains, lakes, rivers, and valleys of the Williamstown area provide unusual opportunities for learning geology in the field. Guided by Paul Karabinos (Geosciences), student projects include the study of streams as active agents of erosion and deposition, the effects of glaciation on the New England landscape, and the history of mountain building in the Appalachians. Following several group projects introducing the techniques of field geology, students pursue independent projects on subjects of particular interest to them.

Kresge Foundation Equipment Grant

Williams was awarded a grant from the Kresge Foundation in 1990 to replace and update major items of scientific equipment and instrumentation. This three-part grant is used not only to purchase new equipment, but also to support maintenance contracts and the repair of existing instruments. One aspect of the grant is that the College sets aside endowment funds for the depreciation and eventual replacement of items purchased under the grant.

Through this grant the college has purchased and maintains a 24-inch optical telescope, a gas chromatograph mass spectrometer, a transmission electron microscope, a UV/Vis/NIR spectrophotometer, and an x-ray diffraction instrument. In recent years, Kresge endowment funds were used to replace earlier models of a scanning electron microscope, a nuclear magnetic resonance spectrometer, an atomic absorption spectrometer and an ion chromatograph. These expensive pieces of core equipment are heavily used by faculty and students in collaborative research projects and in teaching laboratories associated with courses ranging from introductory to advanced levels.

Sherman Fairchild Foundation Grant

In January 2005, the Sherman Fairchild Foundation awarded a \$500,000 grant to Williams College for the development of an interdisciplinary program in bioinformatics, genomics, and proteomics (BiGP) at Williams College. This grant was used to purchase a MALDI-TOF mass spectrometer, an HPLC-ESI mass spectrometer, a flow cytometer and qPCR instrument for the capstone BiGP laboratory course. The instruments have also been used in biochemistry, biophysical biochemistry, and organic chemistry courses as well as several student-faculty research projects.

SMALL

SMALL is a summer research program in mathematics funded by the National Science Foundation and the Science Center, now in its twenty-third year. Between 20 and 32 students split into groups of about four and work on solving open problems of current research interest. Each group has a faculty advisor. Students publish their results in mathematics research journals and give talks at math conferences around the country. In the summer of 2011, thirty one students are working in Commutative Algebra, Ergodic Theory, Geometric Origami, Geometry, Multidimensional Continued Fractions, and Number Theory and Probability, with six faculty members.

Major Programs

The **Astronomy Department** offers courses for students interested in studying and learning about the universe, and who would like to be able to follow new astronomical discoveries as they are made. Students can choose between broad non-mathematical survey courses (ASTR 101, 102 or 104) and a more intensive introductory course (ASTR 111) designed for those planning further study in astronomy or another science. All students in the introductory courses use the 24-inch telescope and other telescopes and instruments on the observing deck to study astronomical objects. The astrophysics major, administered jointly with the Physics Department, is designed primarily for students who plan graduate study in astronomy, astrophysics or a related field. The major emphasizes the structure of the universe and its constituents – including the Sun, stars and star clusters, galaxies and galaxy clusters, quasars and active galaxies, and the cosmic background radiation – in terms of physical processes. Majors in astrophysics usually begin their program with *Introduction to Astrophysics* (ASTR 111) as well as introductory physics courses. Intermediate and advanced level seminars introduce majors to current research topics in astronomy, while parallel study of physics completes their preparation for graduate work in astronomy or employment in a related field. The astronomy major is designed for students with a serious intellectual interest in learning about modern astronomy, but who do not wish to undertake all of the physics and math required for the more intensive astrophysics major. The astronomy major emphasizes understanding the observed properties of the physical systems that comprise the known universe. Students that are considering a major in the Astronomy Department, or a double major including Astronomy or Astrophysics, should consult with members of the Department about appropriate beginning courses. Independent research, extensive use of observational and image processing computer facilities, fieldwork at remote observatories or on eclipse expeditions and close working relationships with faculty are hallmarks of the Astronomy and Astrophysics majors.

The biological sciences are in a constant state of flux that is reforming our entire view of living systems. Significant breakthroughs are occurring at all levels; from the theoretical to the practical, from health related fields to environmental studies, from animal behavior to molecular biology and bioinformatics. In response to these needs the Williams College **Biology Department** curriculum has been designed not only to keep pace with new developments in the field, but also to afford students as broad a base as possible for understanding the principles governing life processes. Four courses, *The Cell* (BIOL 101), *The Organism* (BIOL 102), *Genetics* (BIOL 202) and a 400 level senior seminar, are required for the major. In addition, five electives may be selected from a range of courses including those in cellular biology, immunology, biochemistry, molecular biology, developmental biology, physiology, animal behavior, neurobiology, ecology and evolution. New courses have been added to our curriculum in recent years: *Integrative Bioinformatics, Genomics and Proteomics* (BIOL 319), a new literature-based senior-level course dealing with topics of current research interest including developmental and genomic evolution of animal design and two 400-level tutorials, *Frontiers in Muscle Physiology: Controversies* (BIOL 426T)

and *Evolutionary Ecology* (BIOL 428T). These courses change from year to year to emphasize the latest concepts and to introduce techniques and instrumentation used in modern biological research. To support our teaching objectives, the department continues to integrate state-of-the-art techniques and instrumentation into our courses. Although the biology major is specifically designed to provide a balanced curriculum in the broader context of the liberal arts for any interested student, it is also an excellent preparation for graduate studies in medicine and life sciences.

The **Biochemistry and Molecular Biology (BiMo) Program** is designed to provide students with an opportunity to explore living systems on the molecular level. Biochemistry and molecular biology are dynamic fields that lie at the interface between biology and chemistry. Current applications range from the diagnosis and treatment of disease to enzyme chemistry, developmental biology, and the engineering of new crop plants. After completing the introductory biology and chemistry courses and organic chemistry, a student would normally take the introductory course in the program: *Biochemistry I – Structure and Function of Biological Molecules* (BIMO 321) and *Biochemistry II- Metabolism* (BIMO 322). These courses, taken in conjunction with courses in genetics and molecular genetics, establish a solid background in biochemistry and molecular biology. The advanced courses and electives available from the chemistry and biology department offerings encourage students' exploration of individual interests in a wide variety of topics. A senior capstone course, *Topics in Biochemistry and Molecular Biology* (BIMO 401), gives students the chance to explore the scientific literature in a variety of BIMO-related research areas. Completion of the BIMO Program provides exceptional preparation for graduate study in all aspects of biochemistry, molecular biology, and the medical sciences.

Through a variety of individual courses and sequential programs, the **Chemistry Department** provides an opportunity for students to explore chemistry, an area of important knowledge about ourselves and the world around us. For those who elect to major in chemistry, the introductory course, *Introductory Concepts of Chemistry* (CHEM 151, or for those who qualify, CHEM 153 or CHEM 155), is followed by intermediate and advanced courses in organic, inorganic, physical, and biological chemistry. These provide a thorough preparation for graduate study in chemistry, chemical engineering, biochemistry, environmental science, materials science, medicine and the medical sciences. Advanced independent study courses focus on the knowledge learned in earlier courses and provide the opportunity to conduct original research in a specific field. For those in other majors who wish to explore the science of chemistry, the Chemistry Department offers courses that introduce the fundamentals of chemistry in a context designed to provide students with an enriching understanding of our natural world. Chemistry courses for non-majors include: *Chemistry and Crime: From Sherlock Holmes to Modern Forensic Science* (CHEM 113); *AIDS: The Disease and Search for a Cure* (CHEM 115); and *Applying the Scientific Method to Archaeology and Paleoanthropology* (CHEM 262T).

Computers and computation are pervasive in our society. They are enormously important in areas as diverse as education, business, industry, and the arts. The **Computer Science Department** seeks to provide students with an understanding of the nature of computation and the ability to explore the great potential of computers. The Department recognizes that students' interests in computer science vary widely, and attempts to meet these varied interests through 1) its major program; 2) a selection of courses intended for those who are interested primarily in an introduction to computer science; 3) recommended course sequences for the non-major who wants a more extensive introduction to computer science in general or who seeks to develop some specific expertise in computing for application in some other discipline. A major in computer science equips students to pursue a wide variety of career opportunities. It can be used as preparation for a career in computing, for graduate school, or to provide important background for students whose future careers will extend outside of computer science. The first course for majors and others intending to take more than a single computer science course is *Introduction to Computer Science* (CSCI 134). Upper-level courses include computer organization, algorithm design and analysis, principles of programming languages, computer networks, distributed systems, theory of computation, computer graphics, artificial intelligence, operating systems, and compiler design. For those students interested in learning more about new ideas and developments in computer science, but who are not necessarily interested in developing extensive programming skills, the department offers three courses. CSCI 107 introduces concepts in computer science through the design and analysis of games. CSCI 108

provides an introduction to artificial intelligence, and CSCI 109 introduces students to the techniques of computer graphics.

The **Program in Environmental Studies** commenced in 1970, after the 1967 establishment of The Center for Environmental Studies (CES) at Williams. The Major in Environmental Science was approved by the faculty in 2010. The ENVI Program allows students to major in traditional departments while taking a diverse series of courses in an integrated, interdisciplinary examination of the environment. Environmental Science majors can choose one of three tracks (Environmental Biology, Environmental Geoscience, or Environmental Chemistry) while taking a diversity of required methodological and project courses that represent the breadth and depth of a major. Both the ENVI Program and the ENVS Major are designed to help students understand the complexity of issues and perspectives and to appreciate that many environmental issues lack distinct boundaries. The goal is to help students become well-informed, environmentally literate citizens of the planet who have the capacity to become active participants in their communities from the local to the global scale. The major and program seek to develop abilities to think in interdisciplinary ways and to use holistic-synthetic approaches in solving problems while incorporating the knowledge and experiences they have gained as undergraduates at the College. For more information on the ENVS major and ENVI program, please visit: <http://catalog.williams.edu/catalog.php?&subjinfo=envs>

The CES maintains and operates the 2600-acre Hopkins Memorial Forest and its Rosenberg Center Field Station, 1.5 miles from campus, and is in the final phase of adding lands of the old Wire Bridge Farm along the Hoosic River near the Vermont border. The Environmental Science Laboratory in the Morley Science Laboratory is a joint venture between the CES and the science division at Williams and is overseen by Technical Assistant Jay Racela.

Professor David Dethier serves as chair of the Hopkins Memorial Forest Users Committee and continues to supervise activities in the Environmental Science Laboratory. Professor Hank Art is the Principal Investigator on a 5-year grant from the Luce Foundation Environment and Policy Program to incorporate renewable energy and sustainability into the environmental studies curriculum. He, along with the Hopkins Forest Manager Drew Jones, continued their collaboration with faculty and students from Massachusetts College of Liberal Arts and Berkshire Community College monitoring amphibian and reptile utilization of two vernal pools near Hopkins Forest.

The study of vegetation and landscape changes in the Hopkins Memorial Forest and on-going meteorologic and hydrologic measurement have led to the designation of the Hopkins Memorial Forest as a gradient site in the National Ecological Observatory Network (NEON). Williams College is a founding member of NEON with David Dethier as our institutional representative.

The **Geosciences** major is designed to provide an understanding of the physical and biological evolution of the earth and its surrounding ocean and atmosphere. Dynamic internal forces drive the development of mountain ranges and ocean basins. Waves, rivers, glaciers and wind shape the surface of the earth, providing the landscapes we see today. Fossils encased in sedimentary rocks supply evidence for the evolution of life and record the history of the earth, including a unique record of changing climates. Four introductory courses open to all students include *Biodiversity in Geologic Time* (GEOS 101), *An Unfinished Planet* (GEOS 102); *Global Warming and Natural Disasters* (GEOS 103); and *Oceanography* (GEOS 104). A special course limited to ten first-year students, *Geology Outdoors* (GEOS 105), presents geology through fieldwork and small group discussions. *Evolution of and on Volcanic Islands* (GEOS 220T) will be offered in the spring and is linked to a two-week trip to Hawaii during spring break. Courses in the major are designed to provide a foundation for a professional career in the earth sciences, a background for commercial activity such as the marketing of energy or mineral resources, or simply an appreciation of our human heritage and physical environment as part of a liberal arts education. Students often choose electives so as to concentrate in a particular field: for example, environmental geology, oceanography, stratigraphy and sedimentation, or petrology and structural geology. In addition, *Remote Sensing and Geographic Information Systems* (GEOS 214); *Climate Changes* (GEOS 215); and *Renewable Energy and the Sustainable Campus* (GEOS 206) offer surveys of these areas for both non-majors and majors, and especially for students interested in environmental studies.

History of Science, fundamentally an interdisciplinary subject, traces the historical development of the social relations between science and society as well as the development and mutual influence of scientific concepts. The “external” approach emphasizes the relations between science and society, attempting to relate changes and developments in each to the other. The “internal” approach concerns primarily the ways in which technical ideas, concepts, techniques, and problems in science developed and influenced each other. Courses offered in the History of Science Program introduce students who do not major in a science to the content and power of the scientific and technological ideas and forces which have in the past transformed western civilization and which are today transforming cultures the world over. Science majors are introduced to the historical richness and variety of scientific activity, as well as to how that activity reflects upon the changing nature of science itself and upon science’s relationship to society as a whole.

The major program in The **Department of Mathematics and Statistics** is designed to meet two goals: introducing some of the central ideas in mathematics, and developing problem-solving ability by teaching students to combine creative thinking with rigorous reasoning. The department has recommended coursework for students interested in applied mathematics or other sciences, engineering, graduate school in mathematics, statistics, actuarial science, and teaching. The major requires calculus, linear algebra, a course in applied/discrete mathematics or statistics, two core courses in algebra and analysis, two electives, a senior seminar, and participation in the undergraduate colloquium.

Neuroscience is a rapidly growing field concerned with understanding the relationship between brain, mind, and behavior. The study of the brain, a remarkably complex organ, requires a unique interdisciplinary approach ranging from the molecular to the clinical levels of analysis. The Neuroscience Program draws faculty members from the Psychology and Biology Departments and designs its courses to provide students the opportunity to explore these approaches with an emphasis on hands-on learning. The curriculum consists of five courses, including an introductory course, three electives, and a senior seminar. In addition, students are required to take two courses, BIOL 101, and PSYC 101, as prerequisites for the program. *Introduction to Neuroscience* (NSCI 201) is the basic course and provides the background for other neuroscience courses. Ideally, this will be taken in the first or second year. Electives provide in-depth coverage of areas such as hormones and behavior and developmental neuroscience, and include laboratory experiences that incorporate independent projects. *Topics in Neuroscience* (NSCI 401) offers an integrative culminating experience in for seniors. This past year 12 Neuroscience concentrators graduated, and three completed senior theses. The Neuroscience Program also sponsored or co-sponsored a number of speakers in the Class of 1960 Scholars colloquium series.

The **Physics Department** offers two majors, the standard physics major and, in cooperation with the Astronomy department, an astrophysics major. Either route serves as preparation for further work in pure or applied physics, astronomy, other sciences, engineering, medical research, science teaching and writing, and other careers requiring insight into the fundamental principles of nature. Physics students experiment with the phenomena by which the physical world is known, and the mathematical techniques and theories that make sense of it. They become well grounded in the fundamentals of the discipline: classical mechanics, electrodynamics, optics, statistical mechanics, and quantum mechanics. We offer a variety of summer research opportunities in theoretical and experimental physics, and invite interested students at all stages of their Williams careers to participate. Physics offers several tutorial courses each year, and nearly all of our majors take more than one. Many majors do senior honors projects, in which the student works together with a faculty member in either experimental or theoretical research.

The 15 faculty members of the **Psychology Department** offer a wide variety of curricular and research opportunities to both major and non-major students. Courses are grouped into the areas of behavioral neuroscience, cognitive psychology, developmental psychology, social psychology, clinical psychology, and psychology of education. After completing *Introductory Psychology* (PSYC 101), majors take *Research Methods and Statistics* (PSYC 201), in which they learn the tools used to generate knowledge in psychology, and at least three 200-level courses, which are comprehensive surveys of each of the subfields. They then take the 300 level courses, which are advanced seminars; many of these are lab courses in which students do an original empirical study, others are discussion seminars, and some are also tutorials or writing intensive courses. In each, the professors expose students in depth to their specialty

areas, and students read and discuss primary literature. The major sequence ends with a capstone course, *Perspectives on Psychological Issues* (PSYC 401), a discussion/debate-oriented seminar. A variety of research opportunities are offered through research assistantships, independent study, senior thesis work and the Bronfman Summer Science Program. The psychology major provides an opportunity for liberal arts students to consider the nature of mind and behavior from different perspectives. It provides sound preparation for graduate study in both academic and professional fields of psychology and is relevant to careers in education, business, law, and medicine. A recent external review of the department highlighted the “rigorous curriculum that exposes students to the core areas of the discipline; provides training in the methods and writing of psychologists; engages students in the development of research ideas, hypothesis testing, data collection and analysis; and provides an opportunity to get senior majors engaged in cross disciplinary discussion and writing.” The reviewers found that the depth and breadth of these activities, particularly our 300-level lab courses, “set Williams apart from even the best undergraduate programs in psychology” as well as undergraduate programs at major universities, and “are likely contributors to the success of Williams in producing students who are coveted by the finest Ph.D. programs in the sciences.” In addition to the psychology major curriculum, our students often become concentrators in related programs across the college including Cognitive Science, Leadership Studies, Legal Studies, Public Health, and Neuroscience.

Science and Technology Studies (STS) is an interdisciplinary program concerned with science and technology and their relationship to society. Less concerned with historical development and philosophical understanding of the ideas and institutions of science and technology, the STS program focuses on current ethical, economic, social and political implications. Although many acknowledge that science and technology has played a major role in shaping industrial societies, few, including scientists and engineers, possess a critical, informed understanding of how that process has occurred. We have little knowledge of the technical and social interactions that direct change in science or society. The STS program is intended to help students create a coherent course of study from a broad range of perspectives in different departmental curricula. Courses examine the history and philosophy of science and technology, the sociology and psychology of science, the economics of R&D and technological change, science and public policy, technology assessment, technology and the environment, scientometrics and ethical value issues. To fulfill the requirements of the program, students must complete six courses. The introductory course and senior seminar are required and three elective courses are chosen from the list of designated electives. Students may choose to concentrate their electives in a single area such as technology, American studies, philosophy, history of science, economics, environment, current science or current technology, but are encouraged to take at least one elective in history, history of science or philosophy. The sixth course necessary to complete the program is one semester of laboratory or field science in addition to the College’s three-course science requirement.

Williams-Mystic Maritime Studies Program is an interdisciplinary, cross-divisional program that examines the literature, history, policy issues, and science of the ocean. Because of the interdisciplinary nature of the course of study, the professors and concentrators have a variety of majors and primary areas of study, ranging from theatre to economics to geology to history. All share, however, a deep respect for the world’s oceans. In 1975-1976 the Williams faculty and the Mystic Seaport’s board of directors voted to establish the Williams-Mystic Program in American Maritime Studies. In 2002- 2003 Professor Ronadh Cox and several other Williams faculty wrote a proposal for a concentration in maritime studies. In the fall 2003, the faculty voted almost unanimously to establish the Maritime Studies concentration. This new concentration is designed to utilize the Williams-Mystic program, but requires courses both before and after the Mystic semester at Williams. Candidates for the concentration in Maritime Studies must complete a minimum of seven courses: the interdisciplinary introductory course, GEOS 104 *Oceanography*, four intermediate core courses at Williams-Mystic, an elective, and the senior seminar.

Winter Study Science Offerings

The January Winter Study Period (WSP) at Williams offers a unique opportunity for concentrated study and research in science. It is particularly valuable for senior thesis research students who are able to devote

their full time for a month to their developing projects. Many departments also offer research opportunities to sophomores and juniors during WSP. Projects of lesser complexity than senior thesis projects also are undertaken, often with guidance from more experienced students as well as the supervising faculty member. In addition, the science departments offer many interesting and unusual opportunities to students regardless of whether they intend a science major. Full descriptions of science WSP offerings can be found in the Williams College Bulletin. A few highlights of the 2011 WSP science offerings are given below:

ASTR 12 Mars! A Passion for the Red Planet

This course, meant for non-majors, will deal with the scientific, historical, and literary aspects of the planet Mars. It will be based on the content of the instructor's 2008 book, *A Passion for Mars: Intrepid Explorers of the Red Planet*. Dreamers and space scientists, engineers and biologists, backyard astronomers and artists have devoted their lives - sometimes at the expense of their careers - to the quest for Mars. Over half a century, they have transformed the Red Planet from a projection of our wildest fantasies into an even more amazing *real* place of spectacular landscapes, beguiling mysteries, and fantastic possibilities - as an abode for life, and even as a second home for humanity. In *A Passion for Mars*, Andrew Chaikin, who covered Mars exploration as a science journalist and took part in the first Mars probe landing, chronicled this epic quest and the enduring dream of going there. Based on first-person interviews and animated by the author's own passion, this course will deal with the story of Earthbound humans and their robotic surrogates caught in the irresistible pull of the Red Planet. The humans include astronomer Carl Sagan, fierce champion of the search for life; rocket scientist Wernher von Braun, who envisioned human Mars expeditions years before the space age; and science-fiction titan Ray Bradbury, standard-bearer for Mars as human destiny. The course will discuss four decades of photographs and other observations sent back by robotic explorers as well as visionary artwork that renders our Martian future.

BIOL 11 Project BioEyes

Project BioEyes brings tropical fish to 4th and 11th grade classrooms in Williamstown and beyond, in a science teaching workshop. Elementary and high school students will breed fish in the classroom, then study their development and pigmentation during one week per school. Williams students will write lesson plans that adapt the project to the science curriculum for the grades we visit, work with classroom teachers to introduce concepts in genetics and development, help the K-12 students in the classroom, and assess student learning. A final eight-page paper describing the goals and outcomes for each grade level is required. No zebrafish experience is necessary; during the first week students will learn to set up fish matings, and learn about embryonic development and the genetics of fish pigmentation, as well as about supporting the K-12 curriculum with hands-on experiments using living animals. In the subsequent two weeks we will work at the schools, and in the final week, students will write up the assessment data.

CHEM 16 Glass and Glassblowing

This course provides an introduction to both a theoretical consideration of the glassy state of matter and the practical manipulation of glass. We do flameworking with hand torches for at least 12 hours per week. While no previous experience is required, students with patience, good hand-eye coordination, and creative imagination will find the course most rewarding. The class is open to both artistically and scientifically oriented students.

CSCI 14 LEGO Robotics

In this course, students will explore the theory and practice behind the construction of autonomous robots. Working in small teams, students will construct robots from battery powered microprocessor control boards, assorted sensors and motors, and LEGO components, and will then program them. Control programs will be written in a subset of the C programming language. The majority of class time will be spent in the laboratory. Students will be expected to complete appropriate structured exercises to develop basic skills in robot construction and programming. By the conclusion of the course, each team will be required to construct a robot designed to perform a pre-determined task such as obstacle avoidance, maze navigation, etc. Each team's project goals will be selected with both the interests and prior backgrounds of

the team members in mind. Each team will give a brief presentation describing their final project (including a demonstration of their robot's performance) and submit a written report summarizing the design process.

GEOS 012 Landscape Photography

This class will broaden students' appreciation for the appearance and history of the landscape and teach the skills of making a successful photograph. Williamstown, situated in a valley between the Green and Taconic Mountains and bisected by the Green and Hoosic Rivers, is a place of great natural beauty. The local landscape is a subject that inspires both professional and amateur photographers alike. While Williamstown will be the subject of most of our work, we will use it to learn principles of universal application. Students will discover the importance of light in making a photograph. They will also learn camera skills and the mechanics of digital photography, which will be reviewed at biweekly class meetings. In addition to photographing and critiquing images, the class will visit collections at the Clark Art Institute and WCMA to see original work and examine and discuss books on reserve at Sawyer Library. An overview of the history of landscape photography will be provided with an emphasis on American workers such as Carlton Watkins, Eadweard Muybridge, Alfred Stieglitz, Eliot Porter and Ansel Adams. We will also demonstrate examples of different cameras such as medium format, view cameras, and panorama cameras. Students will produce a body of successful photographs that will be projected at the Winter Study presentation day and on display at <http://drm.williams.edu/projects/>. Students will submit short written explanations with each of their photographic assignments.

STAT 10 Displaying Multivariate Data

Ever wished you could go beyond the capabilities of your current software and actually create the graph you had in mind for a particular data set? We are going to introduce the free software program R (just google "R") and then use a very powerful add-on called Lattice to create beautiful (and correct!) graphs, starting with simple histograms and barcharts for one-dimensional data and scatterplots and time series plots for two-dimensional data. We will finish with three-dimensional surface plots or plots that show the distribution of a variable over a map (the states) of the US. Examples of graphs can be found at <http://lmdvr.r-forge.r-project.org/figures/figures.html>. In the first two weekly meetings, we will use the textbook by the author of Lattice to introduce the many ways (multivariate) data can be displayed effectively and how this is coded in R. The third meeting each week is dedicated to student presentations, where students present their "graph of the week" (and the corresponding R coding steps) based on a dataset of their interest.

PHYS 010 Light and Holography

This course will examine the art and science of holography. It will introduce modern optics at a level appropriate for a non-science major, giving the necessary theoretical background in lectures and discussion. Demonstrations will be presented and students will make several kinds of holograms in the lab. Thanks to a grant from the National Science Foundation, we have seven well-equipped holography darkrooms available for student use.

PSYC 10 Introduction to Complex Skill Acquisition

Come learn how to juggle. Beginners welcome. Learning to juggle is fun, but it is also a highly complex procedural learning task. We will talk about factors that affect skill learning and design experiments, which we will conduct on ourselves, to learn more about what makes skill acquisition effective. There might also be unicycle access.

Science Center Programs

The Science Center links the Bronfman Science Center with the Thompson Biology, Chemistry, and Physics Laboratories, Schow Library, and the Morley Science Laboratory wing; Clark Hall completes the Science Center complex. Serving as the home for astronomy, biology, chemistry, computer science, geosciences, history of science, mathematics and statistics, physics, and psychology, this facility fosters interdisciplinary interaction among all members of the Science Division. This interaction is facilitated through the sharing of core research equipment and services; through interdepartmental programs; and, to a great extent, by the spatial juxtaposition of faculty with common interests regardless of their departmental affiliation. Several Science Center activities promote this further by specifically encouraging discourse among scientists at Williams. This is carried out in a number of ways, including informal faculty presentations at Tuesday lunches (during both the summer and academic year), the maintenance of a weekly science calendar, the publication of the Report of Science at Williams, and the faculty lectures sponsored each semester by the local Sigma Xi chapter.

The programs based in the Science Center encompass the coordination of grant proposals to federal agencies and private foundations, the distribution of more than \$400,000 of research funds annually, and the allocation of space within the science division. In 2010-2011, individual Williams College science faculty received over \$1,000,000 from active federal grants for the purchase of equipment and support of research projects. Faculty and student research projects and summer research opportunities supported by internal divisional funds, as well as those supported by external grants, are detailed below and in the various departmental reports.

Summer Student Research Participation

Summer Research Fellowships were awarded to 166 individuals at Williams in 2011. Many of the summer research students are entering their senior year and beginning work that will lead to senior honors research. A large number of research fellowships were awarded to rising sophomores and juniors who were getting their first taste of independent research. The summer research program also included students from outside Williams. Students from a variety of other institutions were sponsored by an NSF/REU site grant to the mathematics and statistics department and worked with Williams College faculty members. As participants in a chemistry department exchange program, one student from the University of Leiden worked with chemistry professors at Williams while one Williams College chemistry major worked with professors at the University of Leiden.

The summer is a relaxed yet focused time for research, without the competition of course work to interrupt collaborative efforts between students and faculty. In addition to the actual research experience, the Science Center sponsors a weekly Tuesday luncheon featuring a member of the faculty lecturing on current research, an annual science division picnic, and a poster session at the end of the summer where summer research students present their results.

Support for summer research, a \$3800 stipend for 10 weeks plus housing, comes from a variety of sources including College funds, external grants to individual faculty, foundation grants, and endowed fellowships provided by generous donations from alumni and friends of the sciences. The Wege-Markgraf endowment, gifts from Peter Wege and the Class of 1952 in honor of J. Hodge Markgraf '52, Emeritus Professor of Chemistry, supports summer research fellowships in chemistry. The John A. Lowe III 1973 fund also supports summer research fellowships in chemistry. The Betty and Lewis Somers '48 Student Summer Internships Fund and the Thomas Synnott Fund support summer research fellowships in physics. The Williams Bicentennial Psychology Scholarship Fund supports summer research fellowships in psychology. The Whitehead Scholarship Fund, a gift from John Whitehead '67 to provide an opportunity for Williams students and faculty to interact with scientists at the prestigious Whitehead Institute, supports summer research fellowships for Williams biology students to spend the summer doing research at the Whitehead Institute. The Arnold Bernhard Foundation Endowed Summer Science Fellows Program, made possible by the generosity of Jean Buttner, Williams Trustee from 1982-1997, and the Class of 1951 Summer Research Fellowship fund supports summer research fellowships across the division.

Full or partial federal, foundation and alumni support for summer student stipends was provided by the following sources:

Funding Source*	Students	Funding Source*	Students
College funds	65	Mellon Foundation	8
NSF grants to individual faculty	34	Rensselaer Polytechnic Institute	2
Arnold Bernhard Foundation			
Fellowships	19	Somers Fellowship	2
NSF/REU	3	Whitehead Scholarship	2
American Physiological Society	1	Keck Geoscience	1
Wege/Markgraf Fellowships	9	Petroleum Research Fund	2
Bradbury-Seiler Fellowships	4	American Chemical Society	2
Lowe Fellowships	10	Bicentennial Psychology Scholarships	1
Markgraf Fellowships	6	Center for Environmental Studies	2
Keck Northeast Astronomy Consortium	3	Dreyfus Foundation	1
NIH grants to individual faculty	2	NASA	1
Class of 1951	5	Synnott Fellowship	1
National Institute of Standards and Technology	2		

* Some students are supported by multiple grants.

2010 Summer Science Students and their Faculty Advisors

Astronomy

David Amrhein	Jay Pasachoff	Shphanga Pandey	Jay Pasachoff
Allen Davis	Steven Souza	Alice Sady	Karen Kwitter
Matthew Hosek	Karen Kwitter	Yaron Teich	Steven Souza
Aven King	Karen Kwitter		

Biology

Michael Abrams	William DeWitt	Adena Hernandez	Claire Ting
Sameer Aryal	Tim Lebestky	Joy Jing	Luana Maroja
Amlak Bantikassegn	Luana Maroja	Audrey Kwon	Lois Banta
Francesca Barrett	Dan Lynch	Son Le	Steve Swoap
Ellen Beauchamp	Claire Ting	Emily Levy	Joan Edwards
Ryan Buchanan	Heather Williams	Geordie Lonza	Jonathan Snow
Claudia Corona	Hank Art	Nicole Lou	Lois Banta
Wade Davis	Hank Art	Julio Lunquin	Hank Art
Connor Dempsey	Lois Banta	Mark Lyons	Hank Art
Katherine DiAngelo	Hank Art	Abigail Martin	Hank Art
Katelyn Foley	Heather Williams	Gregory McElroy	Lois Banta
Julianne Fontana	Hank Art	Zachary McKenzie	Luana Maroja
Melany Funes	Claire Ting	Stanislas Monfront	Luana Maroja
Kelsey Ham	Jonahtan Snow	Daniel Nachun	Derek Dean
Eric Outtersson	Hank Art	Felix Sun	Jonathan Snow
Bonnie Patchen	Steve Swoap	Marissa Thiel	Jonathan Snow
Clint Robins	Heather Williams	Ai Tran	Heather Williams
Sarah Rowe	Hank Art	Emily Ury	Joan Edwards
Rebecca Shoer	Joan Edwards	Jonathan Wickman	Dan Lynch
Amelia Simmons	Hank Art	Hannah Wilson	William DeWitt
Meera Sivalingam	Jonathan Snow	Rachel Zipursky	Steve Swoap
Gordon Smith	Hank Art		

Chemistry			
Liam Abbott	Jay Thoman	Natalia Loewen (Leiden)	Anne Skinner
Michael Alcalá	Peacock-Lopez/ Gehring	Matthew Madden	Amy Gehring
Grace Babula	Lee Park	Lovemore Makusha	Chip Lovett
Craig Burt	Sarah Goh	Erin McGonagle	Amy Gehring
Ariana Chaipella	Richardson/ Thoman	Michelle McRae	Sarah Goh
Tiffany Chang	Enrique Peacock- Lopez	Steve Mendoza	Enrique Peacock- Lopez
Peter Clement	Lee Park	Jessica Monterrosa Mena	Amy Gehring
Christopher Corbett	Lee Park	Anna Moriondo	Jay Thoman
Chaira Del Piccolo	Dieter Bingemann	Asvelt	Chip Lovett
		Nduwumwami	
Laura Dos Reis	Enrique Peacock- Lopez	Julia Nguyen	Sarah Goh
Roop Dutta	Chip Lovett	Emily Niehaus	Chip Lovett
Bryn Falahee	Dieter Bingemann	Johan Postema (Leiden)	Park/ S.Goh
Olivia Foley	Sarah Goh	Hetal Ray	Amy Gehring
Olivia Gannon	Richardson/ Thoman	Jennifer Rodriguez	Amy Gehring
Daniel Gross	Lee Park	Jon Hung Seong	Lee Park
Elizabeth Hwang	Sarah Goh	Kassandra Spiller	Anne Skinner
Sora Kim	Amy Gehring	Nicole Wise	Anne Skinner
Willis Koomson	Chip Lovett	Erica Wu	Lee Park
Andrew Kung	Chip Lovett	Nai Chien Yeat	Sarah Goh
Zebulon Levine	David Smith	Peter Young	Chip Lovett
Computer Science			
Jennifer Gossels	Duane Bailey	Antal Spector- Zapusky	Stephen Freund
Alexander Lockwood	Tom Murtagh		
Geoscience			
Miranda Bona	Mea Cook	Nari Miller	Mea Cook
Miranda Bona	Ronadh Cox	Elizabeth Moncure	Lisa Gilbert
Galen Corey	Mea Cook	David Rapp	Ronadh Cox
Zara Currimjee	Mea Cook	Harley Stevens	Lisa Gilbert
Christopher Elliot	Mea Cook	Herrick Sullivan	Lisa Gilbert
Daniel Gross	Lisa Gilbert	Ny Riavo Voarintsoa	Ronadh Cox
Kathryn Kumamoto	Bud Wobus		
Mathematics/Statistics			
Ji Won Ahn	Susan Loepp	Oleg Lazarev	Steve Miller
Nadine Amersi	Steve Miller	Chansoo Lee	Tom Garrity
Thealexa Becker	Steve Miller	Brian Li	Satyan Devadoss
Olivia Beckwith	Steve Miller	Lucas Manuelli	Cesar Silva
Ke Cai	Cesar Silva	Zane Martin	Cesar Silva
Howard Cheng	Satyan Devadoss	Cornelia Mihaila	Tom Garrity
Ping Ngai Chung	Frank Morgan	Sarah Peluse	Tom Garrity
Krishna Dasaratha	Tom Garrity	Andrej Risteski	Satyan Devadoss
Elizabeth Ferme	Susan Loepp	Ryan Ronan	Steve Miller
Miguel Fernandez Flores	Frank Morgan	Niralee Shah	Frank Morgan

Laure Flapan	Tom Garrity	Karen Shen	Steve Miller
Alexander Greaves-Tunnell	Steve Miller	Luis Sordo Vieira	Frank Morgan
Jared Hallett	Cesar Silva	Matthew Stoffregen	Tom Garrity
Hannah Hausman	Bernhard Klingenberg	Wei Sun	Cesar Silva
Geoffrey Iyer	Steve Miller	Giang Thi Huong	Susan Loepp
Feiqi Jiang	Susan Loepp	Liyan Zhang	Steve Miller
Physics			
Victoria Borish	Bill Wootters	Cristina Lopez	Michael Taylor
Nathan Bricault	Michael Taylor	Margot Robinson	Dave Tucker-Smith
Joel Clemmer	Daniel Aalberts	Takuto Sato	Bill Wootters
Dylan Gilbert	Dave Tucker-Smith	Nathan Schine	Tiku Majumder
Julian Hess	Daniel Aalberts	Anders Schneider	Tiku Majumder
David Kealhofer	Kevin Jones	Roshan Sharma	Bill Wootters
Christina Knapp	Kevin Jones	Taryn Siegel	Tiku Majumder
Murat Kologlu	Dave Tucker-Smith		
Psychology			
James McKinsey	Jennifer Crosby	Aaron Lim	Noah Sandstrom
Brian Thomas	Jennifer Crosby	Thomas Kuczarski	Ken Savitsky
Jessica De La Cuesta	Steve Fein	Nikola Mirkovic	Paul Solomon
Chelsey Barrios	Amie Hane	Katherine O'Leary	Paul Solomon
Amber Cardoos	Amie Hane	Jeffrey Fossett	Safa Zaki
Emmanuel Whyte	Laurie Heatherington	Sierra Germayan	Betty Zimmerberg
Katrina Flanagan	Nate Kornell		

Summer Research Colloquia 2011

A luncheon is provided every Tuesday for participants in the Summer Science Research Program. Faculty members from the science departments give talks on their research at these lunches, with opportunity for discussion afterwards. The speakers this summer were:

Dr. Anne Skinner, Chemistry	Laboratory Safety
Professor Frank Morgan, Mathematics and Statistics	Minimal Tilings
Professor Daniel Aalberts, Physics	Somewhere Over the RNAbow
Professor Jay Pasachoff, Astronomy	Transits of Venus and Mercury
Professor Jonathan Snow, Biology	Blended Families and Bellyaches: Genetic Diversity and Honey Bee Immunity
Professor Paul Karabinos, Geosciences	How Geology Controls Topography in the Berkshires
Professor Lee Park, Chemistry	Self-Assembly in Designing Nanoscale Materials
Professor Duane Bailey, Computer Science	In Search of a Programmable Tattoo

Academic Year Science Lunch Colloquia

During the academic year, the science faculty and staff meet for lunch on Tuesdays in the Science Center to discuss matters of interest to the sciences as a whole, and to hear informal reports on faculty research and other science developments. The following talks or discussions were held during 2010-2011.

Presenter	Title
Dieter Bingemann, Chemistry	Why Glasses Don't Flow Like a Liquid
Paul Karabinos, Geosciences	Adding Structures to 3-D Geologic Maps: An Example of Using Google SketchUp in Teaching
Jay Thoman, Chemistry	5000 Pounds of Diorite
Hank Art, Biology	75 Years In the Life of an Old-Growth Woodlot
Bill Wootters, Physics	Keeping it Real: Quantum Mechanics Without Complex Numbers
Mea Cook, Geosciences	Tracing Ocean Circulation and Climate Change with Radiocarbon
Cesar Silva, Mathematics and Statistics	Fractals Representing Natural Shapes
Elizabeth Townsend Beazley, Mathematics and Statistics	Several Partial Orderings on the Set of Permutations
Michael Taylor, Design Engineer/ Model Maker	Recent Projects and New Capabilities in the Science Shop
Luana Maroja, Biology	On Crickets and Butterflies
Enrique Peacock-Lopez, Chemistry	To Bet or Not to Bet in Parrondian Games
Tom Garrity, Mathematics and Statistics	Beyond Pascal's Triangle
Martha Marvin, Neuroscience/ Biology	Hearts in the Wrong Place: Left-Right Asymmetry in Zebrafish
Fred Strauch, Physics	Quantum Routing and Beyond with Superconducting Resonators
Andrea Danyluk, Computer Science	Identification of Individual Spotted Salamanders from Digital Images: An Update
Jonathan Snow, Biology	Maintenance of Inducible Immunity in Honey Bee Foragers
Christopher Goh, Chemistry	Catalysis Efforts Using Renewable Resources
Amie Hane, Psychology	Beyond Licking and Grooming: Maternal Regulation of Infant Stress in the Caregiving Context
Sarah Goh, Chemistry	Stealth Polymers and Protein PEGylation
Courtney Wade, Office of Information Technology	Web-Based Instrument Sign-Up System

Pre-First Year Summer Science Program

In its twenty-fourth summer in 2011, the Summer Science Program (SSP) provides an enriching and intensive five-week immersion in science, mathematics, and English for a talented group of science-oriented incoming Williams students. SSP targets members of groups that have been historically underrepresented in the sciences, and the goal of the program is to promote and encourage continuing participation by SSP students in science and science related studies at Williams and ultimately careers in research science and science education.

Twenty-three students took classes in chemistry (including a major laboratory component), biology, mathematics and English (literature and expository writing). Although not replicas of Williams academic year offerings, the Summer Science Program classes are taught at a college level, thus introducing participants to the rigors and demands of college academics. In addition to the regular classes, the students participated in geology laboratory and field experiments. They also engaged in a variety of extracurricular activities including the Williamstown Theatre Festival and a weekend trip to Woods Hole Oceanographic Institution.

Enthusiasm for the program has been high. Participants have taken full advantage of the opportunity to study at Williams in the summer. As a result of the Summer Science Program, their academic year experiences have been successful and many of the students have continued their studies in science or mathematics. A significant number of former participants have returned to campus in the summer as full-time research students in science and mathematics, have become tutors for the Summer Science Program, or have secured positions elsewhere in science research institutes.

Professor Charles M. Lovett, Director of the Summer Science Program, taught the chemistry lectures and Professor David P. Richardson conducted the laboratory sessions. Professors Olga R. Beaver and Cesar Silva taught the mathematics component. Professor Wendy Raymond taught the biology lectures. Professor Paul Park taught the English sessions and Professor David Dethier conducted the geology in-the-field laboratory.

The Summer Science Program has been funded primarily by Williams College as part of its commitment to encourage the participation of traditionally underrepresented groups in the sciences. Since 1991, SSP has received additional funding from a biological sciences grant from the Howard Hughes Medical Institute. This grant contributed support for several SSP components, and has provided summer research stipends for SSP students after their first year at Williams. Special thanks go to the many science faculty and students of Williams College who, during the summer as well as during the academic year, have contributed to the success of the program and of its participants.

Pre-First Year Summer Science Program Participants

Students		Faculty
Elizabeth Berggren	Juan Mena	Charles M. Lovett, Director
Christie Black	Jared Nowell	Olga R. Beaver
Chelsea Boydston	Kimberly Oliva	David Dethier
Guedis Cardenas	Ashini Patel	Paul Park
Julia Carroll	Naomi Patterson	Wendy Raymond
Paul Deaderick	Cody Remillard	David Richardson
Moses Flash	Khan Shairani	Cesar Silva
Jennifer Galaviz	Shelby Shote	
Racquel Gibson	Michael Williams	Tutors
Ashley Graves	Daniela Zarate	Amlak Bantikassegn
Grace Kim		Craig Corsi
Vero Ignace		Jessica Monterrosa-Mena
Aaron Jordan		Yolkys Morales

Williams College Sigma Xi Chapter

The Williams College Sigma Xi Chapter has played an active role on the Williams Campus since it was founded as the Sigma Xi Club in 1969. Sigma Xi is a national society honoring and encouraging research in science. The officers for 2010-2011 were Professor Jay M. Pasachoff of the Astronomy Department, President, and Associate Professor Lois Banta of the Biology Department, Secretary/Treasurer.

This year, as usual, the local Sigma Xi chapter sponsored two excellent sets of talks directed to broad community audiences. In November, we were honored to have Professor Marlene Sandstrom of the Psychology Department at Williams College present two colloquia on how children's social relationships can be studied empirically. Her first talk focused on what is known about the emergence, stability, and

long-term trajectories of peer rejection: the second highlighted some of Sandstrom's own research examining how children perceive and respond to negative feedback from peers.

In April, Karen Kwitter, the Ebenezer Fitch Professor of Astronomy, presented her research about what planetary nebulae (the glowing gas shells ejected by low- to intermediate-mass dying stars) tell us about the evolution of these stars and how this evolution affects the chemical enrichment of their host galaxies. Both sets of lectures were followed by the usual lively and well-attended receptions in the Science Center Atrium.

The Williams College Sigma Xi Chapter sponsors a High School Science Award for a student at Mount Greylock Regional High School, Williamstown, MA, in recognition of a high level of motivation and accomplishment in science courses. This year the award was given to Sophia Santore.

One of the primary purposes of Sigma Xi is to recognize graduating science students who have demonstrated exceptional ability and promise for further contributions to the advancement of scientific research. These students are elected as associate members of Sigma Xi and are inducted into the society at a ceremony during commencement weekend. On Class Day, the chapter honored 53 newly elected associate members from the class of 2011 in a ceremony in the '62 Center for Theatre and Dance. The names of this year's honorees are listed below and detailed descriptions of their research projects are presented in the student abstracts section of this report.

Associate Sigma Xi members from the Class of 2011

Astronomy

Sara M. Dwyer

Biology

Michael J. Abrams

Joshua A. Blanco

Jillian E. Hancock

Ang Li

Mari M. Lliguicota

Beryl L. Manning-Geist

Anexandra M. Peruta

Clint W. Robins

Jonah P. Zuflacht

Chemistry

Mary E. Daub

Marian M. Deuker

Zebulon G. Levine

Colin W. Platt

Charles A. Seipp

Sara A. Turner

Cognitive Science

Patricia J. Klein

Computer Science

Nicholas A. Arnotsi

Yuxing Huang

Steven S. Rubin

Geosciences

Aaron W. Bauer

Evan N. Dethier

Caleb O. Lucy

James A. McCarthy

David O. Oakley

Daniel R. Walsh

Mathematics/Statistics

Jake A. Levinson

Sean C. Pegado

Thuy V. Pham

Ville A. Satopää

Robert A. Silversmith

Philip V. Vu

Jacob G. Wagner

Zhaoning Wang

Wentao Xiong

Neuroscience

Wilmer A. Del Cid

Kylie A. Huckleberry

Fhatarah A. Zinnamon

Physics

Antoniya Aleksandrova

Peter K. Gottlieb

Leah L. Hurwich

Nathaniel J. Lim

Antonio T. Lorenzo

Yuzhong Meng

Samyam Rajbhandari

Rebecca C. Sullivan

Psychology

Janna R. Gordon

Joshua M. Wilson

Johannes M. Wilson

Veronica C. Rabelo

ASTRONOMY DEPARTMENT

Faculty of the Astronomy Department included Jay M. Pasachoff, Field Memorial Professor of Astronomy, Chair, and Director of the Hopkins Observatory; Karen B. Kwitter, Ebenezer Fitch Professor of Astronomy (on sabbatical leave); Marek Demianski, Visiting Professor of Astronomy; and Steven P. Souza, Instructor in Astronomy and Observatory Supervisor. Bryce A. Babcock, recently retired as Staff Physicist and Coordinator of Science Facilities, was appointed Associate of the Hopkins Observatory.

Pasachoff and Souza participated with MIT colleagues in observations of the occultation of a star by Pluto on July 3, 2010, from Santiago, Chile, working with Muzhou Lu'12 and Keck Northeast Astronomy Consortium (KNAC) Summer Fellow Craig Malamut (Wesleyan'12) [Souza operated the camera remotely from Williamstown]. Pasachoff had arranged other telescopes in Chile to participate in the observations. The Williams-MIT collaboration attempted observations of the Kuiper-belt object Ixion on July 18, 2010 from Williamstown and other sites in the Northeast, though no occultation was seen. Pasachoff and Babcock, in collaboration with their MIT colleagues, prepared for, arranged, and observed from two telescopes in Hawaii in February 10, 2011, to try to capture an occultation of a star by the Kuiper-belt object Varuna, also



On the steps of the President's House before the Weinberg lecture. (left to right) Naomi Pasachoff, Jay Pasachoff, Frederic Strauch, Adam Falk, Marek Demianski, Louise Weinberg, Steven Weinberg, Karen Kwitter, Steven Souza, Daniel Aalberts, Jefferson Strait

one of the trans-Neptunian objects. On May 22, 2011, Souza used the on-campus 0.6-m telescope with a POETS (Portable Occultation, Eclipse, and Transit System), one of three that Williams College has through a NASA equipment grant, to successfully observe an occultation of a star by Pluto, showing a diminution of the total intensity of the star + Pluto by about 20% for about 100 seconds. Also present for the observations were Pasachoff, Babcock, Matt Hosek'12 and Shubhanga Pandey'13. The results are being used to refine the model of Pluto's and Charon's orbits and will improve the predictions of the currently planned observations from two telescopes in Hawaii of the June 22/23, 2011, occultation of both Pluto and Charon and the June 26/27 occultation of Pluto with the possibility of an additional occultation by its moon Hydra. The work is supported by a research grant from NASA. Caroline Ng'11 during the summer of 2010 prepared a Website at <http://www.stellaroccultations.info> to gather links to the various work the Williams faculty and students have carried out to study the outer solar system through observing those objects occulting distant stars.

Pasachoff with former KNAC Summer Fellow Evan Tingle (Wesleyan '08) published their analysis of the fine structure of the solar chromosphere, supported in part by a grant from NASA's Marshall Space Flight Center. Ingolf Dammasch of the Royal Observatory Belgium, and Alphonse Sterling from NASA's Marshall Space Flight Center, were collaborators. The observations were taken in conjunction with simultaneous observations of the same features in the ultraviolet from NASA's *Transition Region and Coronal Explorer (TRACE)* spacecraft. Tingle used Pasachoff's Solar Ultraviolet Measurement of Emitted Radiation (SUMER) observations of chromospheric motions spectroscopically, and tied them in with TRACE observations that showed an overlapping chromospheric loop, with the material held in place by solar magnetism. Pasachoff, Tingle, Sterling and Dammasch, had their paper appear in the journal *Solar Physics*.

Pasachoff observed the total solar eclipse of July 11, 2010, from Easter Island, working with Muzhou Lu'13 and KNAC Summer Fellow Craig Malamut (Wesleyan'12). They had previously observed the July 3 Pluto occultation from Santiago, Chile. In the analysis of the results, which include a comparison with observations made from Tatakoto in French Polynesia 83 minutes earlier, they worked with Hana Druckmüllerová and Miloslav Druckmüller of the Brno Technical University, Czech Republic, and Vojtech Rusin and Metod Saniga of the Astronomical Institute in Tatranská Lomnica, Slovakia. They compared with space observations from NASA's *Solar Dynamics Observatory*, the European Space Agency's *PROject for Onboard Autonomy (PROBA2)*, ESA's and NASA's *Solar and Heliospheric Observatory*, and NASA's *Solar Terrestrial Relations Observatory (STEREO)*, and included colleagues Leon Golub and Alec Engell of the Harvard-Smithsonian Center for Astrophysics, Daniel B. Seaton '01 of the Royal Observatory of Belgium, Steele Hill of NASA's Goddard Space Flight Center, and Rob Lucas of the University of Sydney, Australia, as co-authors of the paper for *The Astrophysical Journal*. They described two coronal mass ejections as they moved through space during the interval between observations at the two eclipse island sites, as well as changes in a polar plume. See also Pasachoff's podcast about the total eclipse of July 11: <http://365daysofastronomy.org/2010/07/10/july-10th-total-solar-eclipse-in-easter-island>. Pasachoff had an Op-Ed piece in *The New York Times* on eclipse day, "Why I Never Miss a Total Eclipse."

Pasachoff worked with John Seiradakis and Aris Voulgaris of the Aristotle University of Thessaloniki, Greece, on papers for *Solar Physics* about chromospheric and coronal spectra taken at the total eclipses. The spectra show the decline in overall coronal temperature with the sunspot cycle, and provide a new way of determining the length of totality and of the flash spectrum through such spectral observations.

A film crew accompanied the team on Easter Island from *Naked Science* on the National Geographic Channel that made the *Easter Island Eclipse* program. It aired the evening of eclipse day, July 11, 2010; clips are available on YouTube in 5 parts at:

http://www.youtube.com/view_play_list?p=9748EB4F9967520F

Pasachoff continued his work on transits of Mercury and Venus across the face of the sun, collaborating with Glenn Schneider of the Steward Observatory of the University of Arizona. In additional collaboration with Thomas Widemann of l'Observatoire de Paris, they published a detailed analysis of their observations of the 2004 transit of Venus from NASA's *TRACE* spacecraft in *The Astronomical Journal*. Venus's atmosphere appeared as refracted light during the second half of ingress and the first half of egress, each lasting about 25 minutes of visibility. Widemann and Paolo Tanga at the l'Observatoire de Côte d'Azur in Nice related the transit observations to *Venus Express* spacecraft observations of the Cytherean atmosphere's circulation. See our Website at <http://www.transitofvenus.info>, which includes both historical information and information about current research at Williams College about transits of Venus and Mercury.

Pasachoff and Schneider, in collaboration with Babcock, Kevin Reardon '82, Widemann, and Tanga planned observations for the June 5, 2012, transit of Venus, the last such transit to be seen until the year 2117. They obtained commitments of telescope time at Haleakala, Hawaii, at Sacramento Peak Observatory, New Mexico, and at Kitt Peak, Arizona, and with spacecraft including NASA's new *Solar Dynamics Observatory*, the American Solar Optical Telescope, on the Japanese *Hinode* spacecraft, and NASA's *ACRIMsat (Active Cavity Radiometer Irradiance Measurement satellite)* and *SORCE/TIM (Solar Radiation and Climate Experiment/Total Irradiance Measurement)*.

Pasachoff continued work on the interstellar medium, especially through considerations of the cosmic deuterium abundance. He works in collaboration with Donald Lubowich of Hofstra University.

Pasachoff continued his work with art-historian Roberta J. M. Olson of the New-York Historical Society. They delivered a paper at the seventh meeting on *The Inspiration of Astronomical Phenomena, INSAP7*, held in Bath, England. See <http://www.insap.org>. They discussed the comets discovered in the 18th century by Caroline Herschel who, with her brother William, started observing from Bath.

Pasachoff observed the partial solar eclipse of January 5, 2011, from Tel Aviv, Israel, and the partial solar eclipse of June 1, 2011, from Reykjavik, Iceland. They were his 52nd and 53rd solar eclipses. Descriptions and images appear at <http://www.williams.edu/astronomy/eclipse>. He received a research grant from the

National Science Foundation for himself, Babcock, and students to study the sun at the two 2012 solar eclipses in Australia and the Western United States.

During the academic year 2010/ 2011 Marek Demianski continued his study of the process of condensation of matter that leads to formation of galaxies and clusters of galaxies leaving large regions of space almost devoid of galaxies. This process critically depends on the amount of dark matter and dark energy in the universe. To study the influence of dark energy on the process of formation of structure Demianski in collaboration with Ester Piedipalumbo from the Federico Secondo University of Naples, Italy used the very distant gamma-ray bursts to study the expansion rate of the universe up to redshift of about 9. Results of their investigations were published in the *Monthly Notices of the Royal Astronomical Society*. In collaboration with A. Doroshkevich and S. Pilipenko from the Astro Space Center of the Russian Academy of Sciences in Moscow and S. Gotlloeber from the Astrophysical Institute in Potsdam, he analyzed evolution of the basic properties of simulated large scale structure elements formed by dark matter. The observed time dependence of the basic characteristics of structure elements and probability distributions supports the self-similar character of the process of structure formation. Results of this analysis were published recently in the *Monthly Notices of the Royal Astronomical Society*. In October 2010 Demianski participated in an international conference in Napoli where he delivered an invited talk “The Universe as a simple dynamical system.”

Kwitter continued her research into the chemical composition of planetary nebulae – the ejected shells of dying sun-like stars. These clouds, which contain results of nuclear processing inside the parent star, are valuable probes into the chemical enrichment of the Milky Way and other galaxies. Kwitter, Anne Jaskot’10 (now in graduate school at the University of Michigan), Dick Henry (University of Oklahoma) and Bruce Balick (University of Washington) completed their study of the oxygen abundance gradient in the Milky Way, concluding that uncertainties in distances, plus natural scatter in the oxygen abundances, leads to a final uncertainty in the gradient value that encompasses the range in the gradient that is predicted by different theorists; improvement will require better distances and a deeper understanding of the source of the scatter.

In the summer of 2010 Kwitter supervised three students: Connor Dempsey’13 and two students sponsored by KNAC, Vivienne Baldassare (Hunter’12) and Brian Kirk (Villanova’11). A large part of their summer was devoted to entering more than 10,000 emission line strengths and uncertainties for our sample of 164 planetary nebulae into a “master” spreadsheet. This spreadsheet is proving to be immensely valuable as they examine her sample of objects for trends and correlations that will help uncover physical underpinnings of observed behavior. Also, the students developed a morphological classification scheme to classify planetary nebulae according to their shapes and brightness characteristics. The classification is available, along with nebular images, at Bruce Balick’s *Planetary Nebula Image Catalog* site: <http://www.astro.washington.edu/users/balick/PNIC/>. These students accompanied Kwitter to a collaboration meeting with Henry and Balick at Apache Point Observatory in Sunspot, NM.

Kwitter, Henry and Balick (KHB) are now in the midst of studying planetary nebulae in the disk of M31, the Andromeda Galaxy. M31, located 2.5 million light-years away, is a twin to our own Milky Way. They obtained data for 16 planetary nebulae; Emma Lehman’10 participated in observing at the 8.1-meter *Gemini-North* telescope on Mauna Kea and in the data analysis. KHB have submitted proposals to use the *Keck 10-meter telescope* on Mauna Kea to observe 17 additional nebulae, which will help in defining M31’s oxygen gradient. KHB and additional colleagues have also submitted proposals to use the *Hubble Space Telescope* to observe planetary nebulae in both the Milky Way and M31 in the ultraviolet part of the spectrum to detect bright emission lines from the element carbon, which emits only feebly in the optical region. The ratios of carbon to nitrogen and to oxygen form important constraints on the evolution and nucleosynthesis inside planetary nebula parent stars. Finally, KHB and another set of colleagues have obtained spectra of H II regions (ionized gas clouds surrounding young stars) very near the center of the spiral galaxy M83, observed at McDonald Observatory of the University of Texas. Kwitter will determine the chemical composition in these regions, which are expected to be very metal-rich compared with the region in our Galaxy near the Sun.

In July Kwitter organized and attended the KNAC Faculty Meeting here at Williams; in November, she attended the KNAC Student Research Symposium at Colgate University. In January, she attended the 217th meeting of the American Astronomical Society (AAS) in Seattle, where she was a coauthor on three poster presentations; in April she gave a talk at the University of Washington in Seattle; also in April she spoke at the Midamerican Regional Astrophysics Conference in Kansas City; and in May she gave a talk at the Boston meeting of the American Astronomical Society. Finally, Kwitter was invited to give the review talk in on chemical abundances in planetary nebulae, "Cosmic Recycling: The Planetary Nebula Connection," at the July 2011 Symposium #283 of the International Astronomical Union, with the theme *Planetary Nebulae: An Eye to the Future*.

Kwitter, who was on sabbatical for the academic year, presented the spring 2011 Sigma Xi Research Lecture on April 28, with a talk entitled, "Planetary Nebulae as Narrators of Stellar and Galactic Evolution."

Pasachoff continued as Chair of the Working Group on Eclipses of the International Astronomical Union's solar commissions and as a member of the Johannes Kepler Working Group of the History of Astronomy commission. He was elected Vice-Chair (2011-2014) and Chair-Elect (2014-2017) of the Historical Astronomy Division of the American Astronomical Society. He continues as U.S. National Liaison to Commission 46 on Education and Development of the International Astronomical Union, of which he is a past president. He is also head of the Program Group on Public Education at the Times of Eclipses and Transits of the Commission on Education and Development. See <http://www.eclipses.info> and <http://www.transitofvenus.info>. Pasachoff continues as representative of the AAS to the American Association for the Advancement of Science's Astronomy Division, of which he was twice chair.

In July Pasachoff attended the KNAC Faculty Meeting at Williams. In January, he attended the 217th meeting of the AAS in Seattle and in May, he attended the 218th meeting in Boston. He attended the AAS Division of Planetary Sciences meeting in October in Pasadena and the Solar Physics Division's meeting in June in Las Cruces, NM, presenting papers at each.

Pasachoff participated as on-campus thesis supervisor of the work of Sara Dwyer'11, with her thesis being a continuation of her KNAC Fellowship at Wesleyan under the guidance of Prof. William Herbst there. She worked on identifying stars and comparing star catalogues in the Orion Nebula region.

Pasachoff continued his K-12 education work with PROM/SE (Promoting Rigorous Outcomes in K-12 mathematics and Science Education), an NSF-funded organization based at Michigan State University. He attended their meetings in New York City in November and in Washington, DC, in June. (www.promse.msu.edu)

Pasachoff continues as astronomy consultant for the *McGraw-Hill Encyclopedia of Science and Technology* and its yearbooks. He also continues on the Physical Science Board of World Book. He is on the Council of Advisors of the *Astronomy Education Review* electronic journal. See <http://aer.noao.edu/>. Pasachoff continues as science book reviewer for *The Key Reporter*, the Phi Beta Kappa newsletter. He continues as advisor to the children's magazine *Odyssey*, where he was guest editor of the May 2011 special issue about the Sun, to which he also contributed articles on eclipses and on transits of Venus.

Pasachoff was elected Fellow of the Society for Skeptical Inquiry. In a related course at Williams, he again gave his seminar on *Science, Pseudoscience, and the Two Cultures* in spring 2011.

Souza conducts the astronomy observing program, and all indoor labs and daytime observing. He hosted numerous observatory visitors, including planetarium groups, alumni, Family Days attendees, the Five College Astronomy Club, Summer Science Program students, the Massachusetts Teachers Association, and student previews and prospective students.

Souza continues to maintain and improve the observatory. He modified the control system of our 24" telescope so that the camera software communicates with the telescope software. With Larry Mattison of the Science Shop, he motorized the shutter of the small dome of our widefield imaging system as a first step toward partial automation of the telescope. He acted as liaison with Williams's Office of Information Technology, and worked with Facilities on maintenance issues.

Souza gave a guest lecture on Magnetic Resonance Imaging in CHEM 364. He attended the KNAC Faculty Meeting in July 2010 and the KNAC Student Symposium in September 2010. He also attended the American Astronomical Society (AAS) meetings in January 2011 (Seattle) and May 2010 (Boston).

In July 2010 Souza remotely observed an occultation of a star by Pluto, using a POETS system brought to a telescope in Santiago, Chile by Jay Pasachoff and students Muzhou Lu'13 and Craig Malamut (Wesleyan'12). In May 2011 he made, with Jay Pasachoff, Bryce Babcock, Matt Hosek'12, and Shubhanga Pandey'13, a similar observation of a Pluto occultation using POETS at our 24" telescope in Williamstown.

Souza's new research effort to monitor variations in H-alpha emission in massive stars continued in the summer of 2010, with Sarah Wilson'13 and Erin Boettcher (Haverford'12) working to evaluate the feasibility of the project and establish observing procedures. Matt Hosek'12 undertook a Winter Study 99 to develop a data-processing pipeline for the project. He presented the first publication resulting from this project as a poster at the Boston AAS meeting.

Class of 1960 Scholars in Astronomy

Sara M. K. Dwyer

Department Colloquia

[Colloquia are held jointly with the Physics Department. Listings can be found in the Physics section.]

Off-Campus Colloquia

Demianski, Marek

"The Universe as a simple dynamical system,"

International conference on The Universe as a Simple Mechanical System in Napoli, Italy, invited talk
October 2010

Karen B. Kwitter

"Abundances in Planetary Nebulae in M31, The Andromeda Galaxy"

Department of Astronomy, University of Washington, Seattle, WA

"Planetary Nebulae as a Teaching Tool"

41st Meeting of the Midamerican Regional Astrophysics Conference, Kansas City, MO

"Using Planetary Nebulae to Teach Physics"

in Special Session, Using Astronomy to Teach Physics, at the 218th meeting of the American
Astronomical Society, Boston, MA

Olson, Roberta J. M., and Jay M. Pasachoff

"The Comets of Caroline Herschel (1750-1848), Sleuth of the Skies at Slough"

The Inspiration of Astronomical Phenomena VII (insap.org), Bath (2010)

Pasachoff, Jay M., and Roberta J. M. Olson,

"Report of Some Comets: The Discovery of Uranus and Comets by William, Caroline, and John
Herschel"

217th meeting of the American Astronomical Society meeting, Seattle, January 2011

Pasachoff, J.M., Elliot, J.L., Souza, S.P., Person, M.J., Zuluaga, C., Bosh, A.S., Zangari, A.M.,
Jensen-Clem, R., Lockhart, M., Gulbis, A.A.S., Rojo, P., Lu, M., Malamut, C., Ng_Tam, Y.H.,
Levine, S., Ivarsen, K.M., Reichart, D.E., LaCluyze, A.P., Nysewander, M.C., Haislip, J.B.,
MacDonald, R.K.D., Bailyn, C.D., Rabinowitz, D., Emilio, M., Jehin, E., Gillon, M.,
Manfroid, J., Chantry, V., Magain, P. Hutsemekers, D., and Queloz, D

"The 3 / 4 July 2010 Pluto Stellar-Occultation Observations"

42nd Meeting, Division for Planetary Sciences, American Astronomical Society
Pasadena, October 2010

Pasachoff, Jay M., B. A. Babcock, J. L. Elliot, M. J. Person, A. A. S. Gulbis, C. Zuluaga, A. Zangari, W. Rosing, F. Bianco, J. E. Ciotti, S. W. L. Plunkett, Jr., M. R. Kessler, N. D. Niraoka, K. Mohanan, E. Pilger, T. George, D. Breit, S. Preston, K. Lonergan, S. Menaker, J. Egger, M. Lockhart, M. Gutoski, P. Rulon, D. Hampton, X. Jiang, J. Bai, W. P. Chen, M. Lehner, N. Tokimasa

“Attempted Stellar-Occultation Observations for KBO (20000) Varuna on February 10 2011”

218th meeting of the American Astronomical Society meeting, Boston, May 2011

Pasachoff, Jay M., Michael E. Brown (Caltech), Michael J. Person (MIT), and Yung Hsien Ng Tam’12

“Pluto and Beyond: Stellar-Occultation Web Pages for Education and Observation Planning,”

Pasadena meeting of the Division of Planetary Sciences, American Astronomical Society, 2010

Person, M.J., Elliot, J.L., Bosh, A.S., Gulbis, A.A.S., Jensen-Clem, R., Lockhart, M.F., Zangari, A.M., Zuluaga, C., Levine, S.E., Pasachoff, J.M., Souza, S.P., Lu, M., Malamut, C., Rojo, P., Bailyn, C.D., Rabinowitz, D., MacDonald, R.K.D., Ivarsen, K.M., Reichart, D.E., LaCluyze, A.P., Nysewander, M.C., and Haislip, J.B

“Pluto’s Atmosphere from the July 2010 Stellar Occultation”

42nd Meeting, Division for Planetary Sciences, American Astronomical Society

Pasadena, October 2010

Elliot, J.L., Person, M.J., Zuluaga, C.A., Bosh, A.S., Adams, E.R., Brothers, T.C., Gulbis, A.A.S., Levine, S.E., Lockhart, M., Zangari, A.M., Babcock, B.A., DuPré, K., Pasachoff, J.M., Souza, S.P., Rosing, W. and Secrest, N.

“Size and albedo of Kuiper belt object 55636”

42nd Meeting, Division for Planetary Sciences, American Astronomical Society

Pasadena, October 2010

Rebecca Jensen-Clem, J. L. Elliot, M. J. Person, C. A. Zuluaga, A. S. Bosh, E. R. Adams, T. C. Brothers, A. A. S. Gulbis, S. E. Levine, M. Lockhart, A. M. Zangari, B. A. Babcock, K. DuPre, J. M. Pasachoff, S. P. Souza, W. Rosing, N. Secrest, L. Bright, E. W. Dunham, M. Kakkala, T. Tilleman, S. Rapoport, L. Zambrano-Marin, J. Wolf, and K. Morzinski

“A Search for Satellites of Kuiper Belt Object 55636 from the 2009 October 9 Occultations”

217th Meeting of the American Astronomical Society

Seattle, WA, January 2011

Pasachoff, Jay M.

“The Sun and Solar Eclipse,”

Sydney Observatory, Australia, December 2010

“Solar Eclipses Linked with Space Observations”

Royal Observatory of Belgium, Brussels, February 2011

“Transits of Venus and Mercury,”

Observatoire de Paris, March 2011

“The Sun and Solar Eclipses”

Amateur Astronomical Society of Seltjarnnes, University of Iceland, May 2011

S. P. Souza, E. Boettcher, S. Wilson, and M. Hosek

“H α Monitoring of Early-Type Emission Line Stars”

218th Meeting of the American Astronomical Society, Boston, MA, May 2011

Postgraduate Plans of Department Majors

Bradley Culley	Starting with tutoring chemistry
Sara M. K. Dwyer	Consultant, Booz Allen Hamilton, Washington, DC
Yung Hsien (Caroline) Ng Tam	Williams College Teaching Fellowship at Chinese University of Hong Kong
David Oakley	PhD program in GeoSciences, Penn State
Hillary A. Walker	PhD program in English, UC Davis, after a year’s break

BIOLOGY DEPARTMENT

Working closely with the many interdisciplinary programs on campus: The BIMO Program, the Neuroscience Program, the Environmental Studies Program and the BiGP Program, the Biology Department's goal is to provide students with the opportunity to do hands-on, one-on-one research with a professor in addition to offering state of the art academic courses. To that end the department had 20 honors students working in faculty labs this past year. Of these, 9 were inducted into the Sigma Xi Honors Society. For the academic year 2011-2012, the department has 21 students who will be doing honors work. The department is committed to providing a positive research and learning experience for all biology students. As a result of this commitment, several of our students were awarded grants or fellowships to pursue their studies after graduation. Shvion Robinson received a Stratton Fellowship to further her studies. The department also has approximately 34 students doing summer research, either here at Williams or off campus. Francesca Barrett and Jonathan Wosen will be working at the Whitehead Institute. Funding for summer research comes from various sources including individual research grants and Division funding. At least half of the biology faculty has outside research funding from either NSF or NIH. This funding allows many students to travel to professional meetings throughout the year giving poster presentations on their research at Williams. At the Experimental Biology meetings in California in April of this year, one of Professor Swoap's students, Beryl Manning-Geist '11 won the prestigious David Bruce Award for the best undergraduate physiology research project. The David S. Bruce Awards are given to recognize excellence in undergraduate research. These awards honor Dr. Bruce's commitment to promoting undergraduate involvement in research, in the American Physiological Society annual meeting, and, ultimately, in research careers. The American Physiological Society's annual meeting is called Experimental Biology, and consists of physiologists, young and old, totaling about 12,000+ scientists, including MDs, PhDs, graduate students and undergraduates. A number of alumni returned to campus this year to share their post-graduate experiences with students in the form of a poster presentation. This is an opportunity for students to learn firsthand about life as a graduate student.

Each year at graduation, the Biology Department awards prizes to several outstanding majors, Timothy Hickey-LeClair and Beryl Manning-Geist each received the Benedict Prize in Biology. Jillian Hancock received the Dwight Botanical Prize. Ang Li received the Conant-Harrington Prize for exemplary performance in the biology major, and Hilary Dolstad received the William C. Grant, Jr. Prize for demonstrating excellence in a broad range of areas in biology.

The Biology Department would like to welcome a new faculty member – Assistant Professor Timothy Lebestky. Tim comes to us from the School of Medicine at the University of California, Los Angeles where he received his Ph.D. in Molecular Biology, specializing in Developmental Biology.

The Biology Department continued to participate in the Class of 1960 Scholars program. In addition to the returning alumni who were sponsored by the Class of 1960 Scholars program, the department invited Dr. Andy Bass from Cornell University to be a Class of 1960 Scholar speaker.

Class of 1960 Scholars in Biology

Francesca Barrett	Karyn Moss	Samantha Teng
Olivia Delia	Thomas Kuriakose	Seth Ari Tobolsky
Katelyn Foley	Mark Springel	Chalita Washington

Professor Marsha Altschuler continued her research on chromosome copy number control in the ciliate *Tetrahymena thermophila*. During the Summer semester 2010 she was assisted by Anh Nguyen '12, Brian Shepherd '11, and Ang Li '11. Ang Li continued his research during the academic year as an honors thesis project. Professor Altschuler attended a ciliate molecular biology symposium in August 2010 at the University of Rochester in honor of Dr. Martin Gorovsky. During Fall semester 2010 she taught BIOL202 *Genetics* and in the Spring semester 2011 she taught a tutorial BIOL218T *DNA, Life, and Everything* and a capstone seminar course BIOL416 *Epigenetics*.

During the 2010-11 academic year, Professor Hank Art taught **BIOL/ENVI 220 – Field Botany & Plant Natural History** fall 2010 semester. In the Spring semester 2011 Professor Art co-taught **ENVI 102 – Introduction to Environmental Science** with Mea Cook and Dieter Bingemann and taught a senior tutorial

BIOL/ENVI 422 Ecology of Sustainable Agriculture. During Winter Study, Professor Art co-taught a course with Drew Jones, Hopkins Forest Manager titled *Winter!?*.

Professor Art also was the Williams College Faculty lecturer on two Alumni Travel Courses in 2010: a 2-week safari to Tanzania and a 1-week trip exploring the ecology of the Everglades and South Florida.

In fall 2010 Professor Art started the supervision of Abby Martin'11 Contract Major thesis on "Environmental Determinism on Mt. Greylock" and serving as an assistant supervisor of Rooney Charet'11 on her thesis on "Regional Farms and Agriculture."

The summer of 2010 marked the start of re-inventorying the permanent plot system in the Hopkins Memorial Forest. This was a research collaboration with a group of 10 undergraduates and essentially was summer teaching activity. Matthew Cranshaw'11, David Hansen'11, Nick Lee'11, Mari Lliguicota'11, Eric Outtersen'12, Dan Nachun'12, Alex Peruta'11, Jackie Pineda'12, Sarah Rowe'13, and Jennifer Turner'13 who each worked 10 weeks on the project. This research was facilitated through a grant obtained from the Holloman-Price Foundation. In addition to research in the Hopkins Forest, Professor Art continues to be a member of the team producing an interpretive infrastructure on the Mount Greylock State Reservation.

Associate Professor Lois Banta continued her research on the soil bacterium *Agrobacterium tumefaciens*. This plant pathogen is best known for its unique ability to deliver DNA and proteins to host plant cells, thus stably altering the genetic makeup of the plant and causing crown gall tumors ("plant cancer") to form at the infection site. One major goal of the lab's current research is to characterize the host defense responses elicited by the bacterium. Honors student Helen Cha ('11) and post-doctoral fellow Janis Bravo pursued this line of investigation, which is funded by a \$415,000 grant from the National Science Foundation (NSF) awarded to Professor Banta. During Winter Study, Lauren Goldstein-Kral ('12) and Connor Dempsey ('13) also contributed to this research. Honors student Josh Blanco ('11) and senior Maddy Haff ('11) continued to explore the lab's recent discovery by David Rogawski ('08) that a newly identified Type VI Secretion System (T6SS) in *A. tumefaciens* influences the formation of biofilms, large aggregates of bacterial cells that are resistant to antibiotics, antibody attack, and even chlorox bleach. Kate Dusenbury ('13) worked both semesters in the lab, using site-directed mutagenesis to create new T6SS mutants. Nicole Lou ('13), Chalita Washington ('13), and Janis Bravo used genetic screens and scanning electron microscopy to study the role of several groups of proteins in mediating attachment of *Agrobacterium* to host plant tissue. At the annual international Crown Gall Conference, held this year in Berkeley, CA, Josh Blanco, Maddy Haff, Helen Cha, and Janis Bravo presented posters, and Lois Banta presented a talk on this research.

During the fall semester, Professor Banta spent part of her research leave in the lab of collaborator Rosalia Deeken in Wuerzburg, Germany. She was also one of 20 participants invited to a think-tank convened by the Carnegie Corporation, the Hewlett Foundation, and the Teagle Foundation to brainstorm on "Accelerating the Adoption of Evidence-Based Improvement of Teaching and Learning in Higher Education" in Palo Alto, CA, where she discussed the findings of a 3-year, multi-college Genomics Curriculum Development project for which she was Program Director. In Professor Banta's spring course, Cellular Regulatory Mechanisms (Biology 306), the 14 students in the class carried out original research, using quantitative reverse-transcriptase PCR to test the hypothesis that the T6SS mutant bacteria have an altered capability to trigger and/or dampen the host plant's response to *A. tumefaciens*. They then designed independent projects, applying their knowledge from the discussion/literature component of the course to investigate the innate immune defenses mounted by mammalian cells against bacterial cell surface material.

During this academic year, Professor Banta served as a reviewer for the National Science Foundation, *Journal of Bacteriology*, and *Molecular Plant Physiology*. Within Williams, she served on the Biochemistry/Molecular Biology advisory committee, the Bioinformatics, Genomics and Proteomics advisory committee, the Environmental Studies advisory committee, and the International Educational Initiatives committee; she also served as coordinator for the Global Health track of the International Studies Area of Concentration and for a new college-wide program in Public Health. Finally, she is Secretary/Treasurer of the Williams College Chapter of the national science honor society Sigma Xi.

Derek Dean continues to work as a lecturer for the BIOL101, 102, and Genetics laboratory sections. He has also been updating the laboratory curriculum and creating new, investigative lab exercises. For example, he and Jason Wilder (a former Assistant Professor at Williams who has since moved on to Northern Arizona

University) have developed a recombinant DNA laboratory exercise for the Genetics course. In this exercise, students cut up two different DNA molecules, mix them together in the same solution, and splice the DNA together, generating a number of different combinations, much like stacking building blocks randomly. Students then select one of these combinations and use molecular biology techniques to deduce the arrangement of their particular DNA molecule. Over the past four years, the lab has been optimized so that each step works for virtually every student, and backups were put in place so that regardless, everyone has their own data to analyze at the conclusion of the three week exercise. Assignments indicated that students had learned the concepts behind techniques quite nicely, and in evaluations, they expressed appreciation for the chance to take ownership of their own “puzzle”, solving their unique combination of DNA fragments. This exercise will be published in *Biochemistry and Molecular Biology Education* this fall, and we hope that other schools will take interest.

In addition, Dean has been researching the genetics of seizure disorders, using the fruit fly, *Drosophila melanogaster*. His lab is interested in how insulin signaling affects the sensitivity of the fly to seizures. This line of inquiry could serve to help us understand a similar phenomenon in humans, as diabetes and hyperglycemia can cause seizures under certain conditions. Dean’s students Daniel Nachun (’12) and Jingyi Liu (’14) presented a poster at the most recent International *Drosophila* Meeting in San Diego, and Dean and Nachun are continuing this work at Cornell University this summer with a collaborator (David Deitcher, Associate Professor of Neurobiology and Behavior). Through generous support from the Williams Division III and Psychology Discretionary Funds, Nachun will have a great opportunity to start off his Honors thesis early and to get a preview of graduate school at a research institution.

In addition to teaching Biology 101 and his senior seminar course, *The Molecular Basis of Biological Clocks*, this year Professor Bill DeWitt began an entirely new research project conceived by his Honors student, Mike Abrams’11. Its ultimate aim is to biologically generate high levels of hydrogen gas, which can be used as a renewable, carbon-neutral energy source. We are using the photosynthetic cyanobacterium *Synechocystis* that possesses an enzyme complex, hydrogenase, which catalyzes the production of hydrogen gas under certain defined growth conditions. However, the hydrogenase enzyme is inactivated in the presence of molecular oxygen, which is synthesized in all cyanobacteria as a byproduct of photosynthesis. Consequently, we initiated experiments designed to limit oxygen concentrations within the photosynthesizing cells. Our approach has been two-fold: (1) to modify *Synechocystis* genetically in order to insert genes that will bind molecular oxygen, and (2) to develop a unique growth regime that will favor hydrogen production. This academic year, we were able to make three different genetic constructs with which we have transformed *Synechocystis* and obtained three novel strains. We have also constructed an apparatus in which we can grow the *Synechocystis* under conditions that exclude molecular oxygen from the air while still allowing us to assay for the production of even low levels of hydrogen using gas chromatography. This summer and during the next academic year, we will test the transformed *Synechocystis* strains in order to determine the levels of hydrogen they produce and then attempt a series of experiments to optimize growth conditions for hydrogen production.

Professor Joan Edwards taught Ecology (Biology 203) fall term and was on leave in the spring. During summer 2010 Gregory McElroy’12 and Gordon Smith’13 assisted with her research on pollination networks and arctic plants at Isle Royale National Park, Michigan. Kelsie Meehan’11 and Holly Dwyer’12 assisted with studies of rapid plant movements and the long-term studies of garlic mustard in Hopkins Forest. In August, Jillian Hancock started her thesis work with Prof. Edwards. Jillian’s research focused on the conservation of the fall blooming asters and goldenrods and their pollinators. These are of particular concern because they form an important component of the New England’s biodiversity and they are all in decline—partly due to habitat loss, partly due to management practices, and partly due to other reasons (e.g. diseases and parasites). Jillian’s study showed that simple changes in mowing practices could increase the biodiversity of all of these species.

Prof. Edwards continues to study ultra-rapid movements in plants. Last summer the work she did with Prof. Dwight Whitaker (Physics, Pomona College) on the explosive capsules of *Sphagnum* moss was published in *Science* (Whitaker and Edwards. 2010. *Sphagnum* moss disperses spores with vortex rings. *Science* 329: 406). This moss has tiny capsules (about the size of a small pepper grain). They build up internal pressure and eventually explode releasing their spores in a miniature mushroom cloud (vortex ring), which allows the tiny spores to achieve enough height where they can remain aloft and be carried many kilometers by turbulent winds. This paper was also covered by a *Science* perspectives article (van Leeuwen, J.L. 2010.

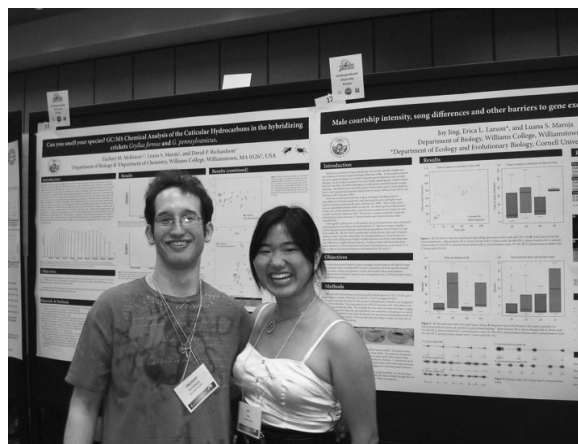
Launched at 36,000g. Science 329:395-396). Prof. Edwards also published a paper with colleagues based on a symposium on “Mechanics Without Muscle: Evolutionary Design of Macrophytes at the 2010 meeting of the Society for Integrative and Comparative Biology (Martone et al. 2010. Mechanics without muscle: biomechanical inspiration from the plant world. Integrative and Comparative Biology 50: 888-908). She gave invited talks at Isle Royale National Park and for the Distinguished Lecture Series of the Lenox library, and at Skidmore College. She also gave talks on botanical explosions to 4th graders at the Williamstown Elementary School.

Prof. Edwards is collaborating with Prof. Maroja on a project examining the origins and population structure of the arctic plants on Isle Royale.

During this past year Professor Dan Lynch taught BIOL 101 *The Cell* in the fall semester, and he taught BIMO/BIOL/CHEM 322 *Biochemistry II Metabolism* in the spring semester.

Professor Lynch continued his research on plant sphingolipid biochemistry. Students working in the lab included Sophia Kim, a thesis research student in the biology department who characterized mutants of *Arabidopsis thaliana* having a disruption in one of the three ceramidase genes; and Elizabeth Kalb, a thesis research student in the chemistry department who characterized mutants having the lone ceramide kinase gene disrupted. Since mutations knocking out the activities of these two gene products would be predicted to increase levels of ceramides in the plant tissues, and ceramides are associated with programmed cell death, the results of these projects permit us to better assess the respective roles of these genes in plants. In addition, Karyn Moss completed an independent study project working with professors Lynch and Swao to characterize the lipid profiles in selected tissues of calorically restricted mice. Lynch also served as a reviewer for manuscripts submitted to several scientific journals.

In her first year as an assistant professor in Evolutionary Genetics, Luana Maroja set up a new lab and advised three summer students (Amlak Bantikassegn’ 12, Joy Jing’ 13 and Zach McKenzie’ 14) who conducted research on genetic divergence and speciation in crickets and butterflies. The work of these students together with a winter student (Stanislas Monfront’ 13) will be presented at the annual Society for the Study of Evolution conference in June 2011. Jing and McKenzie were awarded an NSF Evolution undergraduate diversity grant and will participate in a special program during the Evolution conference.



Joy Jing'13 and Zachary McKenzie'14 present their research in the "International Evolution Meeting 2011" in Norman, Oklahoma.

Maroja has submitted two papers related to her work on butterfly genetics, one was published in BMC Genomics and the other is under review in BMC Biology. Another paper is in preparation with the independent student Rebecca Alshuler’ 11. Maroja also developed a new human mitochondrial DNA lab for BIOL 305 (Evolution) where the students sequenced their own DNA and that of professors to find where in the world their maternal lineage came from.

Last summer, Maroja attended a symposium at Cornell University (Genetics and the Origin of Species: The Continuing Synthesis) and in March 2011, she gave an invited lecture at the University of Vermont on co-evolution. For the summer of 2011, Maroja is starting a new project on the population genetics of plants on Isle Royale in collaboration with Joan Edwards and will also advise six summer research students working in various projects (Bantikassegn, Jing, McKenzie, Monfront, Oscar Calzada’ 12 and Hannah Matheny’ 12).

Martha Marvin, Essel Fellow in Neuroscience, taught the laboratories for NSCI 201/BIOL 212/PSYC 212 *Introduction to Neuroscience* in the fall and as a Visiting Assistant Professor in the spring, taught NSCI 401, *Neuroscience Senior Seminar* on the topic “Adult Neurogenesis and Plasticity”.

Dr. Marvin's research is focused on the environmental influences that cause birth defects in the developing heart, using zebrafish as a model organism. This project began as a collaboration with former Williams Professor Lara Hutson (University at Buffalo) to investigate the cardiovascular function of a class of small heat shock proteins, which protect animals from environmental stress. A previous honors student, Jamie Lahvic'10, demonstrated that two of the cardiovascular small heat shock proteins are necessary for normal left-right asymmetry of the heart and visceral organs, showing a role for these proteins even before heart formation. During the Summer semester 2010, Dr. Marvin mentored four research students. Mark Springel'12 and Jonathan Wosen'13 concentrated on the requirement for heat shock proteins and the role of heart rate in forming the cardiac valves. While Jonathan analyzed changes in gene expression through quantitative PCR, Mark worked on visualizing the changes in valve structure with the scanning confocal microscope. Jackline Odhiambo'13 surveyed the expression of heat shock proteins in the pre-gastrulation embryo by quantitative PCR and in situ hybridization, searching for other members of the small heat shock protein family that might influence very early development. Jackline and Paloma Marin'12 also investigated whether the disruption of global left-right asymmetry leads to asymmetry in normally symmetric organs, but found that it does not. All the summer students continued to work in the lab for the rest of the year. During the academic year, Honors student Jonah Zuflacht'11 investigated the mechanism by which the small heat shock proteins disrupt embryonic asymmetry. He found that hspb7 and hspb12 have partially overlapping roles in determining laterality. Normal laterality depends on the function of cilia in a transient organ, in fish called Kupffer's vesicle. Using transmission electron microscopy, he found evidence that the structure of cilia in embryos with reduced expression of hspb7 may be defective. Additionally, Mark Springel expanded the work of the summer by spending Winter study in the lab of Didier Stainier at University of California, San Francisco, to learn how to image living, beating hearts in the transparent zebrafish embryo. He brought back these skills to Williams, and in an independent project in spring 2011, demonstrated that reduced hspb7 indeed causes stiff and thickened heart valves, a condition that leads to valve degeneration in humans.

Dr. Marvin served as an advisor to Jennifer Swoap's Winter Study course BIOL11, *Project BioEyes: Zebrafish Genetics and Development in the K-12 classroom*, which brought the zebrafish back to 4th grade classrooms at Williamstown Elementary School for a second year. Eight Williams students learned about zebrafish genetics, habitat and care, and then taught the 4th graders how to set up matings between fish, make predictions and observations about the pigmentation of the babies, collect fish embryos and watch them develop during the course of a week. It was a unique experience for both the elementary and the college students, many of whom are interested in teaching careers. Retired elementary teachers Diane and Art Fuleihan again volunteered to join us in the classrooms. Art composed new verses for his song about zebrafish going to school, which is always a real high point. Despite snow days and fire alarms, everyone was able to see the fish embryos' hearts beating and learned why some fish were striped and some were not.

Professor David C. Smith taught the Biology and Social Issues of the Tropics (Biology 134) in the fall and was on leave in the spring. During the summer Gregory McElroy'12 and Gordon Smith'13 assisted with his research at Isle Royale National Park, Michigan—research that is now in its 31st field season.

Professor Smith continues to work on the long-term population dynamics and the plasticity and genetic structure of the boreal chorus frog populations at the northeastern end of Isle Royale. Previously he collaborated with Josh Van Buskirk and colleagues in Switzerland to identify microsatellite markers for these specific populations. Over the past few years Prof. Smith has worked with Chris Himes, a postdoctoral scholar, and his honors students to look at patterns of microsatellite variation among the Isle Royale Chorus frogs. Prof. Smith and Dr. Himes are collaborating on a paper that reports that the Isle Royale population originated from a population along the north shore of Lake Superior. Along with Emily Behrman '09 Prof. Smith is working on a paper describing the genetic structure of the population on Isle Royale.

Jonathan Snow has set up a new lab characterizing the immune mechanisms used by the honey bee to combat infectious agents targeting them through their gastrointestinal tract. Snow attended the Honey Bee Genome Conference at Cold Spring Harbor in May and presented work on honey bee immunity performed by thesis students Hilary Dolstad'11 and Jamal Jefferson'11. In addition, Jefferson'11 presented a poster on his thesis work at the New England Science Symposium in April. Prior to transitioning to research on honey bee immune function, Snow worked on blood and immune cell development in mammals at

Children's Hospital in Boston. He published a number of papers this year dealing with results from this previous work.

Associate Professor Claire Ting taught *Integrative Plant Biology: Fundamentals and New Frontiers* (BIOL 308) in the fall semester and offered a new capstone course on *Genome Sciences: At the Cutting Edge* (BIOL 430T) in the spring semester. In this tutorial, students explored how developments in metagenomics (genomic studies of entire communities of microorganisms in natural environments, such as the open oceans and mammalian gut), metatranscriptomics (studies of genome wide changes in expression and mRNA levels in natural communities of organisms), and proteomics have integrated and revolutionized the field of biology.

During the year, Professor Ting continued to pursue her National Science Foundation funded research on photosynthesis in the ecologically important marine cyanobacterium *Prochlorococcus*, and her laboratory has continued to work with the Sargasso Sea bacteriophytoplankton samples they recently collected for metagenomic and metatranscriptomic analyses. *Prochlorococcus* is one of the most abundant photosynthetic organisms on the planet and is an important carbon sink. One of the ongoing projects in the laboratory focuses on the *Prochlorococcus* carboxysome, which is a cellular microcompartment that functions in the fixation of carbon dioxide. Research in her laboratory aims specifically to establish how differences at the genomic level translate into physiological advantages in photosynthetic capacity and in tolerance to environmental stress. Undergraduate students who participated in research in her laboratory this past year included Aimee Weber'11 (NSF summer research assistant, honors thesis research), Charlene Thomas'11 (NSF summer research assistant, BIOL 297 Independent Study student), Ai Tran'12 (summer research), Ellen Beauchamp'12 (research assistant), Donna Lee'12 (research assistant), Melany Funes'14 (research assistant), and Alyson Barrett'14 (BIOL 22 Winter Study research student, research assistant). Kris Anderson also joined her laboratory for the first time in August 2010 as an NSF-funded research technician. Professor Ting was invited to give an oral presentation of her laboratory's research at the 10th Cyanobacterial Molecular Biology Workshop in Lake Arrowhead, California, and was also invited to participate on the NSF Climate Change panel. She was also selected to participate in the NSF-BBSCR Ideas Lab on Surpassing Evolution: Transformative Approaches to Enhance the Efficiency of Photosynthesis in Asilomar, California.

Professor Heather Williams taught two courses in the fall. Neuroscience, a large 200-level course that she co-taught with Betty Zimmerberg of the Psychology Department, introduces students to the principles of neuronal function and how these principles relate to complex brain phenomena such as visual processing, consciousness, and language. Sensory Biology was taught as a literature-based seminar and covered a variety of systems - from bacterial stretch receptors and their relationship to touch and pain in humans to the details of how the retina functions and implications for how light-sensing chips can be implanted and used as prostheses. In the spring, she taught a section of the second-semester course in the introductory Biology sequence.

Two honors students spent the summer doing research and also completed theses in Professor Williams' lab. Leigh Davis'11 investigated the role of changing connections in allowing the adult songbird brain to adjust its song after the critical period for learning is over, and Clint Robins'11 investigated the roles of morphology (beak shape), physiology (use of the beak to adjust volume and resonance), and culture (learned preferences and behavioral responses) in defining the structure of songs of wild sparrows from two different populations.

Prof. Williams served as a reviewer for the N.I.H., the N.S.F., and several journals.

During the fall semester, Professor Steve Zottoli taught BIOL 304 Neurobiology. In the spring he was on leave. A long term goal of the Zottoli laboratory is to understand the neuronal basis of behavior and the recovery of behavior after spinal cord injury. He uses identified neurons in the goldfish as a 'model system'. Professor Zottoli continues to spend summers at the Marine Biological Laboratory in Woods Hole, MA where he conducts research and is faculty member in the SPINES (Summer Program in Neuroscience, Ethics and Survival) course. In work performed with Mark Agostini, Jason Meyers '97 and Tina Wong '08, Professor Zottoli published a paper on "Axon cap morphology of the sea robin (*prionotus carolinus*) mauthner cell is correlated with the presence of 'signature' field potentials and a C-type startle response." Professor Zottoli continues as a Life Trustee of The Grass Foundation.

Department Colloquia

Thomas Kunz, Boston University

“Aeroecology – An Emerging Frontier”

Amy Gladfelter, Dartmouth College

“Nuclear Anarchy and Cortical Order in a Filamentous Fungus”

Doron Greenbaum, University of Pennsylvania

Co-sponsored with BIMO

“A Chemical Biology Approach to Understand Host-Parasite Interactions”

Jacques Dumais, Harvard University

“Nature’s Catapults: Their Evolution and Mode of Action in Plants and Fungi”

Heather Mattila, Wellesley College

“How Do Promiscuous Honey Bee Queens Generate Productive Colonies?”

Gerry Borgia, University of Maryland

“Exploring the Unique Courtship Behaviors of Bowerbirds: The Design of Bower Decoration Displays”

Phil Zamore, University of Massachusetts Medical School

Co-sponsored with BIMO

“What Fruit Flies Teach Us About RNA Silencing”

Greg Ball, Johns Hopkins University

“Adult Neuroplasticity: Lessons from the Birds”

Andy Bass, Cornell University

Biology Class of 1960 Scholar Speaker

“Getting Ready to Talk: Evo-Devo of Novel Pattern Generators”

Department Colloquia

Hank Art

The Pros and Cons of Burning Biomass for Electricity: Ecological Considerations Panel Discussion – October, 2010

Off-Campus Colloquia

Hank Art

NE Old Growth Forest Conference – “The Beinceke Stand” – Holyoke Comm. College - October, 2010

Empirical Sustainability Education at Williams - Luce Foundation Conference on Sustainability - Brown University, November 2010

Tower Hill Botanic Garden - “Ecology for Landscape Designers.” February 2011.

Lois Banta, Joshua A. Blanco’11, Janis E. Bravo, Catherine R. Hoover’09, Annie Knox, Annie S. Park’10, and R.Deeken.

Mechanisms Mediating Attenuated Virulence Associated with Type 6 Secretion System Deficiency in *A. tumefaciens*. 31st Annual Crown Gall Conference (Berkeley, CA)-Oral Presentation (2010)

Janis E.Bravo, Joshua A.Blanco’11, Annie Knox, R.Deeken, and Lois Banta

Pathogenesis-Related Gene Expression in *Arabidopsis thaliana* is Altered in Response to *A. tumefaciens* Lacking a Type 6 Secretion System. 31st Annual Crown Gall Conference (Berkeley, CA)-Poster presented by student and post-doc (2010)

Derek M. Dean, Ma Khin Pyi Son’10, Cynthia Cortes’10, Daniel Nachun’12, and Jun Liu’10

PI3K signaling modulates the bang sensitivity of *slamdance* mutants. 51st Annual Drosophila Research Conference (2011), Genetics Society of America

Madeleine G.Haff’11, A.D.Tomlinson, Janis E.Bravo, Lauren E.Sinnenberg’10, Helen J.Cha’11, C.Fuqua, and Lois Banta

IcmF (ImpL) Regulates Biofilm Formation and Host Cell Adhesion in *A. tumefaciens*. 31st Annual Crown Gall Conference (Berkeley, CA)-Poster presented by student (2010)

Luana Maroja

Genetics of Speciation, Co-evolution and its consequences. The University of Vermont, March 21, 2011

External evaluator of Master Thesis. "Microsatellite variation in the Mountain Pine Beetle (*Dendroctonus ponderosae* Hopkins) in Western Canada; Spatial genetic analysis of Neutral variation and development of genetic markers". By G. D. N. Gayathri Samarasekera. University of Northern British Columbia. April 26, 2011

Claire Ting

Cyanobacterial Photosynthesis in the Open Oceans: Insights from *Prochlorococcus* Genomics, Structure, Physiology. 10th Cyanobacterial Molecular Biology Workshop, UCLA Conference Center, Lake Arrowhead, California (2011)

Postgraduate Plans of Biology Department Majors

Michael Abrams	Working at a biotechnology firm, before attending graduate school in biology.
Rebecca Alschuler	Going to California and applying to graduate schools for next year.
Katherine Anderson	Working as a teacher in Denver, Colorado.
Jacqueline Berglass	Unknown
Joshua Blanco	Working as a research assistant at Harvard Medical School.
Brian Borah	Unknown
Kim Bui	Aide in Radiology, Assistant to Hugh Hawkins, MD, at the Atrium Medical Center in Middletown, Ohio
Olivia Card-Childers	Working as a Research Assistant at the Hospital for Special Surgery in New York while applying to medical school.
Helen Cha	Post-baccalaureate research at the National Institute of Health
Brian Cole	Unknown
Matthew Cranshaw	Unknown
Barbara Cymring	Working as a Research Assistant while applying to medical school.
Leigh Davis	Traveling in Europe and New Zealand and staying at different organic farms to learn cheese making techniques while applying to veterinary schools.
Cecilia Davis-Hayes	Teaching English in a French public school while applying to medical school.
Marijke DeVos	Working as a Research Assistant at the Hospital for Special Surgery in New York while applying to medical school.
Hilary Dolstad	Unknown
Justin Guttek	Unknown
Madeleine Haff	Working at Harvard Medical School as a research assistant in an immunology lab.
Jillian Hancock	Working as the Assistant Swim Coach at Bucknell University and taking graduate courses in Environmental Sciences
David Hansen	Unknown
Timothy Hickey-LeClair	Unknown
Kylie Huckleberry	Entering the Ph.D. program at the University of Texas at Austin.
Sa-Kiera Hudson	Unknown
Jamal Jefferson	Aide in Radiology, Assistant to Hugh Hawkins, MD, at the Atrium Medical Center in Middletown, Ohio
Robert Kim	Working in Marketing in New York City.
Sophia Kim	Unknown
Nicholas Lee	Unknown
Ang Li	Entering the Ph.D. program at Columbia University Medical School.

Leanne Lin	Taking postgraduate courses in NYC to prepare for medical school.
Mari Lliguicota	Working for OIT while applying to graduate schools in Biology.
Beryl Manning-Geist	Unknown
Geoffrey McCrossan	Unknown
Julia McGuinness	Attending Baylor College of Medicine pursuing an MD.
Kelsie Meehan	Work on an organic farm (Butterfield Beef and Berry Farm) near Montpelier, VT.
Lisa Merkhofer	Unknown
Alexandra Peruta	Working as a Research Associate in the Boyer Center for Molecular Medicine at Yale University.
Bhuvaneswari Reddy	Traveling to India to research indigenous medicine.
Sabrina Reid	Unknown
Joshua Rim	Unknown
Clint Robins	Working as a research assistant while applying to graduate school.
Shivon Robinson	Entering the Ph.D. program at the University of Pennsylvania.
Geoffrey Rodriguez	Studying Spanish in Guatemala before applying to medical school.
Victoria Sheng	Unknown
Kenneth Sluis	Medical School
Annelise Snyder	Working for two years as a research assistant in pathology at UPenn Vet school, then applying to DVM/PhD programs afterwards.
Andrea St. Cyr	Unknown
Charlene Thomas	Unknown
Aimee Weber	Unknown
Ariel White	Unknown
Robert Wilechansky	Teaching middle school in the Boston area for Teach for America while applying to medical school
Xin Zeng	Training as a dental assistant at a private prosthodontics office in Boston for a year, then dental school.
Jonah Zuflacht	Working for 2 years as a clinical research assistant in the Vascular Center at Brigham and Women's Hospital before attending medical school.
Lauren Zurek	Attending the University of Minnesota Medical School.

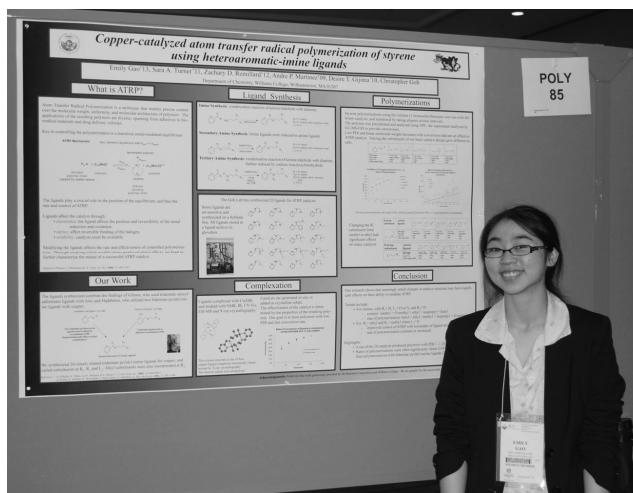
CHEMISTRY DEPARTMENT

The 2010-2011 academic year has been another full and eventful one for the Chemistry Department. Our classrooms were full of lively and capable students, with 26 senior majors, 15 of whom completed senior independent thesis projects. A critically important development in the Chemistry Department was the promotion of Professor Sarah Goh to Associate Professor with tenure. We congratulate Sarah on her accomplishments and look forward to her future contributions to the Department and to the College. At the close of the year we were sad to say goodbye to two valuable colleagues. Assistant Professor Oyindasola Oyelaran departed to begin an appointment at Northeastern University. We wish Oyinda good fortune in all her future endeavors. On July 1, Dr. Anne Skinner, Senior Lecturer in Chemistry and long time member of the Department, officially retired from her teaching duties and from her long and valued service as Campus Safety Officer. We are pleased, however, that Dr. Skinner has agreed to stay on as Campus Radiation Officer and that she will continue her very active research program in archeometry for the next several years.

We are particularly proud of our students and their accomplishments. Each year, individual students are recognized with departmental awards. In the class of 2011, the John Sabin Adriance prize went to Yuzhong (Jeff) Meng for his outstanding work throughout her chemistry career and Mary Beth Daub was awarded the American Institute of Chemists Student Award for outstanding scholastic achievement. The James F. Skinner prize was awarded to Zebulon Levine for his distinguished achievement in chemistry and his future promise as a researcher, and the Leverett Mears prize went to Elizabeth Kalb in recognition of both her abilities in chemistry and future in medicine. Colin Platt was awarded the American Chemical Society Connecticut Valley Section Award for his sustained scholastic excellence. Sara Turner was the recipient of the ACS Division of Inorganic Chemistry Undergraduate Award in Inorganic Chemistry and Charles Seipp was awarded the American Chemistry Society Analytical Division Award.

Over the course of the academic year, a number of awards were presented to chemistry students for outstanding scholarship. Thomas Daubert'13, Emma Rickles'14, and Chau D. Vo'14 received the CRC Awards as the outstanding students in CHEM 151, CHEM 153, and CHEM 155, respectively. Recognized for their achievement in organic chemistry, Peter Clement'13 received the Polymer Chemistry Award and Michael Girouard'13 was the recipient of the Harold H. Warren Prize.

This year we continued to participate in the Class of 1960 Scholars Program. Two distinguished scientists were invited to campus to meet with our students and present a seminar. Professor Bob Crabtree from Yale University and Professor Chris Chang from the University of California-Berkeley were the 1960 Scholar speakers this year. Sixteen students were selected by the faculty to be Class of 1960 Scholars during 2011 and to participate in the seminar program which includes: a preliminary meeting of the Scholars with a Chemistry Department faculty member to discuss some of the papers of the seminar speaker, attendance at the seminar/discussion, and an opportunity for further discussion with the seminar speaker at an informal reception or dinner. The students selected for 2011 are:



Emily Gao'13 presenting her poster at the American Chemical Society Conference in Anaheim, CA, March 2011.

Class of 1960 Scholars in Chemistry

Grace Babula
Andrew Kung
Matthew Madden
Erin McGonagle
Michelle McRae
Kenneth Murgo

Emily Niehaus
Rachel Patel
Emma Pelegri-O'Day
Zachary Remillard
Jennifer Rodriguez

Cameron Rogers
Tarjinder Singh
Christian Torres
Norman Walczak
Matthew Zhou

During the summer of 2011, approximately 40 Williams College chemistry students were awarded research assistantships to work in the laboratories of departmental faculty. We gratefully acknowledge support from the American Chemical Society, the College Divisional Research Funding Committee, the Camille & Henry Dreyfus Foundation, Lowe JA III 1973, the J. Hodge Markgraf '52 summer research fund, the National Institutes of Health, the National Science Foundation, Research Corporation, Summer Science Program funds, and the Wege-Markgraf fund.

After returning from his productive sabbatical year abroad, Associate Professor Dieter Bingemann, along with the help of work-study student Ji Won Ahn'12, applied new-found insight to data taken previously in his own laboratory. With a newly developed statistical analysis routine they showed that single molecule spectroscopy allows to follow the relaxation at the glass transition in unprecedented detail, individually observing fast and slow polymer domains at the molecular level. These results have since been published in the *Journal of Chemical Physics* and are setting the stage for research with summer research students Bryn Falahee'13 and Chiara Del Piccolo'14.

Building on the experience gained during his sabbatical, Bingemann expanded his research field to now also include molecular dynamics simulations performed on high-speed parallel computers. With work-study student Chansoo Lee'12 the lab identified the times between local rearrangement events in simulations on a model glass former and found amazing similarities to simulations on polymers and results from their own single molecule experiments. Bingemann will present results from both the single molecule experiments and the computer simulations at the Gordon Conferences "Chemistry and Physics of Liquids" and "Soft Condensed Matter Physics" in August.

Back in the classroom, in the fall Bingemann taught *Physical Chemistry: Structure and Dynamics* (CHEM 361), one of the upper-level chemistry courses, using a new project-based approach, which borrows heavily from tutorials, and was favorably received by the students. In the spring he team-taught *Introduction to Environmental Sciences* (ENVI 102) with Professor Mea Cook, Geosciences Department, and Professor Henry Art, Biology Department. He also supported *Foundations of Modern Chemical Science* (CHEM 256) as lab instructor.

Associate Professor Amy Gehring returned to teaching this year following her sabbatical semester. She was thrilled to be back teaching in our biochemistry offerings including *Biochemistry I – Structure and Function of Biological Molecules* (CHEM 321) in the fall and *Enzyme Kinetics and Reaction Mechanisms* (CHEM 324) in the spring. She also enjoyed working with a great group of students in the Biochemistry and Molecular Biology (BIMO) senior seminar program this past spring, *Topics in Biochemistry and Molecular Biology* (BIMO 401). Gehring is currently serving as chair of the BIMO program.

Research continued in the Gehring lab to understand the molecular details of the life cycle of the important antibiotic-producing soil bacterium, *Streptomyces coelicolor*. During the summer of 2010, Gehring was joined in this work by Nancy Dong'11, Moyukh Ghosh'11, Ariel White'11, and Sora Kim'13. Moyukh and Ariel continued on during the academic year as thesis students, studying genetic conditions that cause overproduction of antibiotics and secreted hydrolytic enzymes that potentially influence the life cycle of this bacterium, respectively. Also participating in research at various times during the academic year were Nancy Dong'11, Donna Lee'12, Matt Madden'12, Sora Kim'13, Sola Haye'14, Jessica Monterrosa Mena'14, and Aura Perezbanuet'14. For both the summer and academic year, Mike Alcalá'12 pursued a collaborative project with Professor Peacock-López using fluorescence microscopy to visualize oscillations in gene expression in the model bacterium *E. coli*. In addition to pursuing her research program, Gehring served as a reviewer for several journals throughout the year including *Applied and Environmental*

Microbiology, FEMS Microbiology Letters, Journal of Bacteriology, Journal of Molecular Biology and PLoS ONE.

Research on homogeneous metal catalysts continued to progress in the laboratory of Assistant Professor Christopher Goh thanks to thesis students Matt Everhart'11 and Sara Turner'11, fellow student researchers Emily Gao'13, Lovemore Makusha'14, Zac Remillard'12, Pedro Roque and John van Paridon, an exchange student from the University of Leiden, Netherlands. Through the generous support of the Chemistry Department, the Bronfman Science Center and the Division of Inorganic Chemistry, Sara and Emily both presented their work on combinatorial approaches to the discovery and systematic study of Atom Transfer Radical Polymerization (ATRP) catalysts using copper complexes at the national American Chemical Society conference in Anaheim, CA, in March 2011.

Professor Goh taught *Current Topics in Chemistry* (CHEM 155) in the fall semester, and *Instrumental Methods of Analysis* (CHEM 364) in the spring. He also served as a reviewer for the Petroleum Research Fund and the journals *Macromolecules* and *The Journal of Materials Chemistry*.

The summer of 2010 was quite productive for Professor Sarah Goh. The group submitted two manuscripts. Elizabeth Hwang'13, Taylor Wilson-Hill '09, Ji Won Ahn'12, Andrew Platt '07, and Kate Rutledge '05 all contributed to a lengthy project of synthesizing self-assembled peptide-poly(ethylene glycol) (PEG) copolymers. This *Journal of Polymer Science* paper described these micelles' characteristics (size, CMC, solvent/temperature stability) and encapsulation behavior using fluorescein as a model drug. A *Biomacromolecules* article featured the work of Karen Chiu'10, Lauren Agoubi'13, Iris Lee '09, Matt Limpar '09 and Jim Lowe '09. The paper explored the effects of PEGylation on trypsin's enzymatic activity and stability.

Charles Seipp'11 and Colin Platt'11 completed senior theses, developing polymers using peptide-based monomers and active cell-targeting moieties, respectively. They were joined by Michelle McRae'12 and Matt Zhou'12 in February, who began calendar year theses. Also in the lab this year were Ben Fischberg'14, Chris Corbett'13, and Nari Miller'12, as part of their winter study course *Introduction to Research in Organic Chemistry* (CHEM 23). Bryn Falahee'13, Elizabeth Hwang'13, and Julia Nguyen'14 were also active in research.

Professor Goh and students traveled to two conferences this year. Charles, Elizabeth, and she attended the National American Chemical Society meeting in Anaheim, CA over spring break, where Elizabeth won Best Poster in the Undergraduate Polymer Symposium. Bryn, Chris, and Elizabeth represented the Goh lab at the local ACS Connecticut Valley Undergraduate Symposium in April at Trinity College.

In the fall semester, Professor Goh taught *Physical Organic Chemistry* (CHEM 344T) as a tutorial. The students had a great time putting all of their mechanistic knowledge together for their final independent laboratory project. In the spring, Professor Goh taught a new course entitled *Polymer Chemistry* (CHEM 348). She also continues to serve a member of the Proposal Study Panel for the Molecular Foundry, a Department of Energy Nanoscale Science Research Center at Lawrence Berkeley National Laboratory.

Professor Lawrence J. Kaplan was on a sabbatical for the 2010-2011 academic year, which he spent at the University of Central Florida working with colleagues in the Chemistry Department and the Forensic Science Program.

He continues to administer the Center for Workshops in the Chemical Sciences with his colleagues Professors Jerry Smith of Georgia State University, David Collard of Georgia Institute of Technology and Patricia Hill of Millersville University. Since its founding ten years ago, the CWCS has received major grants from the National Science Foundation and was informed in the fall of 2010 that the latest grant application was reviewed favorably and the grant awarded. This year, collaborative proposals were submitted so that the major grant was made to Georgia State University for \$3,908,665 for five years and the collaborative grant was award to Williams College for \$204,260 for five years. The CWCS sponsors workshops related to the chemical disciplines including Food Chemistry, Chemistry and Art, Environmental Chemistry, Material Science and Nanotechnology, Fundamentals of Proteomics, Biomolecular Crystallography, and Forensic Science. In addition to offering workshops, the CWCS continues to develop a series of Communities of Scholars. With the workshops and their alumni serving as

the nucleus, the Communities will continue to develop high-quality course content and pedagogy; propagate the use of successful teaching strategies; and provide discussion venues such as online discussion boards and video conferencing. This past year, the website for the Forensic Science Scholars Community was launched.

Kaplan taught a weeklong CWCS workshop in forensic science during the summer of 2010 at Williams. Sixteen participants from colleges and universities as well as community colleges became criminalists for the week. They processed crime scenes and analyzed evidence such as glass and soil, fibers and fingerprints, drugs and alcohol, blood and bullets, and, of course, DNA. Ms. Deborah Morandi, Administrative Assistant and Dr. Tony Truran, Lecturer/Technical Assistant, both in the Chemistry Department, assisted Kaplan in the organization and instruction of the workshop.

Kaplan organized and presided at a daylong symposium and a daylong forensic workshop sponsored by CWCS at the 21st Biennial Conference of Chemical Education at the University of North Texas in Denton, Texas in August 2010. The symposium provided an opportunity for workshop alumni to present their accomplishments based upon their participation in previous workshops. A number of colleagues assisted Kaplan in the instruction of the mini-workshops. Professor John Woolcock, Chemistry Department, Indiana University of Pennsylvania introduced the participants to ballistic analysis of both bullets and cartridge casings; Professor Deirdre Belle-Oudry, Department of Chemistry and Biochemistry, University of Arizona, presented an activity involving the principles and forensic applications of Attenuated Total Reflectance, Fourier Transform Infrared Spectroscopy; Professor Carmen Valdez-Gauthier, Department of Chemistry, Florida Southern College coordinated a series of experiments involving the analysis of suspected powdered drug material and drugs in urine and the detection of alcohol in saliva; and Professor Eric Schurter, Department of Chemistry, Muskingum University showed the participants how to detect nitrated explosives using a fluorescence quenching technique.

Kaplan organized a daylong forensic science symposium at the 240th American Chemical Society national meeting in August 2010 in Boston. Entitled “Forensic Science: Its Impact on the Education of Recent Generations of Undergraduate Students,” the symposium brought together some of the major figures in the world of forensic science - Barry A. J. Fischer, Director, Los Angeles County Sheriff's Department, Crime Laboratory, past president of the American Academy of Forensic Science; Dr. Richard Saferstein, Forensic Science Consultant, Mt. Laurel, New Jersey; Professor Howard Harris, Department of Forensic Science, University of New Haven; Professor Jay A. Siegel, Director, Forensic and Investigative Sciences Program, Indiana University Purdue University – as well as a number of alumni from Kaplan's forensic science workshop.

Professor Charles Lovett stepped down as Director of the Science Center in July of 2010 after 16 years in the position. During the past year he continued to serve as Chair of the Bioinformatics, Genomics, and Proteomics Program and Director of the Summer Science Program for Students from backgrounds traditionally underrepresented in the sciences.

Professor Lovett continued his research on the *Bacillus subtilis* SOS response to DNA damage, which comprises a set of DNA damage-inducible genes i.e., SOS genes that code for DNA repair and cellular survival functions. During the past 26 years Lovett and Williams' students working in his lab have discovered more than 30 SOS genes and characterized their genetic regulation in response to DNA damage. NIH Funding \$214,050 for Lovett's project entitled, “The binding of the LexA protein to the RecA protein nucleoprotein filament,” which involves characterizing the molecular details of SOS induction, began in June of 2010. In the past year Williams students have worked on various aspects of this project during the summer of 2010, during winter study, and during the academic year. Several summer students worked as full time research assistants including Lucas Bruton'11, Pacifique Irankunda'13, Bianca Martinez'12, Asvelt Nduwumwami'12, and Henry Su'13. Lucas Bruton continued as an honors thesis student during the academic year. Professor Lovett also supervised independent research student Roop Dutta'13 during the spring semester of 2011, winter study research student Jackline Odhiambo'13, work study students Bianca Martinez'12, Lara Roche-Sudar'14, and Bianca Ulloa'14.

Last summer, Professor Lovett taught the Chemistry lectures component of the Williams College Summer Science Program. Together with Professor David Richardson, he also taught in the eighth year of science camp for elementary school students and teachers.

Professor Lovett also served as a reviewer for the *Journal of Bacteriology*, and as a consultant for the Sherman Fairchild Foundation's Scientific Equipment Grant Program.

Park's work on the design of new materials for use in organic photovoltaic cells continued this year with the help of a large group of students. Between summer 2010 and summer 2011, the following students helped out in the lab, participating in summer research, independent study work during the academic year, Winter study research, or simply by volunteering time in lab: Grace Babula'12, Gordon Bauer'13, Heather Burrell'12, Peter Clement'13, Chris Corbett'13, Dan Gross'12, Tracy Hu'13, Mindy Lee'12, Trey Meyer'13, Emma Pelegri-O'Day'12, Jennifer Rodriguez'13, Cameron Rogers'12, Joon-Hun Seong'14, Seth Tobolsky'13, Katrina Tulla'11, Erica Wu'13, Nai-Chien Yeat'13 and Johan Postema, an exchange student from the University of Leiden. This group of students has been working on the design and synthesis of new conductive materials that will be used in prototype organic solar cells. Over the year they successfully made a series of new partially fluorinated polymers and begun studying the self-assembly properties (via AFM) of thin films of those polymers cast onto silicon. They've also begun exploratory work on the design and preparation of some small molecule species that can be used in organic photovoltaic devices, including oligo-phenylenevinylenes as well as other borane and amine based compounds. We're looking forward to a productive 2011!

Park taught *Materials Chemistry* (CHEM 336) and *Foundations of Modern Chemical Science* (CHEM 256) this year. For the Materials Chemistry course, she developed and offered a lab program for the first time this year. The lab program focused on various strategies in nanofabrication, and made heavy use of the new AFMs on campus, as well as of the refurbished evaporator (for deposition of metals) in the Park lab. This lab program is highly unusual at small liberal arts colleges; it was exciting to be able to offer it this year, and we're looking forward to making some improvements for the next time it's offered (spring 2012).

Park also finished her service as vice-chair (continuing as a regular member of the committee) of the Committee on Professional Training for the American Chemical Society, a committee that oversees curricular development at all approved chemistry programs in the country as well as numerous other aspects of the professional training of chemists at all levels. In addition, she continued her service reviewing proposals for various funding agencies (NSF, Research Corporation, the Petroleum Research Fund) as well as manuscripts for various journals. She also served as an external reviewer for the Carleton College Chemistry Department in January 2011, and was an invited participant (representing CPT) at an Education Summit hosted by the American Chemical Society, and was an invited participant at two NSF sponsored workshops, one focusing on future directions in macromolecular, supramolecular and nanoscale chemistry and another focusing on issues in career development for women in chemistry and physics. Closer to home she continued her service on the Committee for Appointments and Promotions, and served on two successful college-wide search committees, one for the new athletic director and one for the new vice-president of finance administration.

During the academic year, 2010-2011 Professor Peacock-López spent part of his sabbatical as a visiting professor at the University of Cape Town. During the year, Steve A. Mendoza'13 and Erik Levinsohn'12 worked on discrete dynamic systems, and in particular, considered seasonality models and simple genetic networks. Related to the latter project and in collaboration with Professor Amy Gehring, Professor Peacock-López extended his research in complex dynamical chemical and biochemical mechanisms to include transcriptional regulatory networks. In collaboration with Professor Gehring, the so-called repressilator plasmid, which was designed originally by M. B. Elowitz and S. Leibler to include three particular genes, and a green fluorescent protein (GFP) reporter was investigated. In this network, the LacI protein, from *E. coli*, represses the transcription of a second gene, tetR, from the tetracycline-resistance transposon, Tn10. The protein product TetR inhibits a third gene cI, from Lambda phage. Closing the loop, protein product CI represses the lacI gene. The system also includes a compatible reporter plasmid containing the tet-repressible promoter PLtetO1 fused to a variant of gfp. Up to date the repressilator is the smallest oscillatory transcriptional network. Motivated by the repressilator dynamics, Michael Alcalá'12

has considered a relatively simple synthetic transcriptional network in *E. coli* and has developed a two-gene plasmid, which represents the smallest artificial gene network. This simple network has been modeled by Mimi Lu '09 and Steve A. Mendoza'13, predicting complex dynamics.

During the academic year, Ang Li'11 considered two extensions of the Higgins Model used to model metabolite concentrations in glycolysis. In his work, Ang Li'11 developed and studied a two variable and a three variable model, where he considered glucose transport and hexokinase inhibition by gluco-6-phosphate. For the three variable model, we found complex oscillation including bursting and mixed modes, as well as chaos.

While continuing with his research, Professor Peacock-López, Ms. Gisela Demant, and instructors Mr. Kevin M. Hartmann (Drury High School: 28 students) and Ms. Cheryl Ryan (Hoosac Valley High School: 14 students) organized and taught chemistry labs at Williams College. As in previous years, Professors Sarah Goh and Christopher Goh, as well as Dr. Tony Truran helped with running the experiments. These honors chemistry students came five times during the year to perform some of the labs from the Williams introductory chemistry lab program and a newly developed organic synthesis lab. The latter experiment was implemented and adapted by Ms. Gisela Demant to include the synthesis of aspirin from salicylic acid and include the characterization of the purity of the product by TLC and melting point determination. This outreach chemistry effort has now been supported entirely by the National Science Foundation through an RUI grant to professor Peacock-López.

Finally, he has served as reviewer for *Chaos, Mathematical and Computing Modeling, Solutions and Fractals, Journal of Chemical Physics, Catalysis Letters, Journal of Applied Mathematics, and Physical Chemistry Chemical Physics*.

In 2010-2011, Professor David Richardson pursued another full year of teaching and research and completed the final year of a two-year stint as department chair. On the research front, he supervised the work of several students throughout the year. He supervised the senior honors thesis research of Christina Meade'11 and Mara Shapero'11 who continued the Richardson lab's collaboration with Dr. Andria Agusta of the Indonesian Institute of Biological Sciences and with Professor Chip Lovett of the Chemistry Department. This project is directed at the isolation of new antibiotics from medicinally active South East Asian plants. Clarissa Andre'12 also contributed to this project as a work-study student. Collaborating with Professor Jay Thoman, he supervised Mika Nagashige'13, a work-study student, and summer students Emily Ury'13 and Alex Lou'13 with research directed at measuring PCB levels in sediments and macro-invertebrates from the Hoosic River. Finally, in a new research collaboration with Professor Luana Maroja of the Biology Department, he supervised the research of Zachary MacKenzie'14 (work-study student) and also provided extensive technical support to a new research project being conducted by Professor Bill DeWitt with his senior honors thesis student, Michael Abrams'11.

He continued his supervision and maintenance of the department's 500 MHz nuclear magnetic resonance spectrometer (overseeing a rebuild of the instrument's magnet after it spontaneously quenched), and he supervised the upgrade and refurbishment process for our high-pressure liquid chromatography-mass spectrometer. He also served as a reviewer for *Steroids, The Journal of Natural Products, Magnetic Resonance in Chemistry, The Journal of Heterocyclic Chemistry, The Journal of Organic Chemistry, and Natural Products Communications*. He served on the review committee evaluating Massachusetts College of Liberal Arts' application to the Massachusetts Department of Higher Education to reinstate a chemistry major, and on the Science Building Steering Committee advising MCLA on the design of their new science building.

Professor Richardson's teaching responsibilities for the year included two laboratory sections of *Organic Chemistry: Intermediate Level* (CHEM 251) and *Organic Chemistry: Intermediate Level-Special Laboratory Section* (CHEM 255) in the fall semester, and a laboratory section of *Organic Chemistry: Introductory Level* (CHEM 156) in the spring semester. In the month of July he taught the Chemistry laboratory portion of the Williams College Summer Science Program for traditionally underrepresented groups in the sciences and, together with Professor Chip Lovett, he hosted the Department's Summer Science Camp program for local 4th and 5th graders. Professor Richardson also served as chair of the

Olmsted Committee, served on Boards of the New England Tropical Conservatory and the South Williamstown Community Association, and as the Tutor Coordinator for the Williamstown ABC Program.

Anne Skinner, who taught her first class in the fall of 1967, retired from teaching this year. She will continue her research program, with the help of students. In the fall of 2010 she gave a keynote address, "Current Topics In ESR Dating," at EPRBiodose 2010, a conference dosimetry through electron spin resonance and complementary biological techniques, in Mandelieu La Napoule, France. She also presented a series of posters on dating topics ranging from deep-sea foraminifera to desert molluscs. In January she was invited to participate in an expedition to the oases of the southwestern desert of Egypt, from which she brought back numerous samples for student projects. In March, with Natalia Loewen'12, she attended the annual meeting of the Society for American Archaeology in Sacramento where she gave an oral presentation on new ways of calculating ages and a poster on samples from Tanzania. At the conference she learned that a grant on which she is a co-Principal Investigator has been received for more work in Tanzania. Natalia presented a poster on her work in Ethiopia. During this year Dr. Skinner has also served as guest editor for *Radiation Measurements*, preparing the proceedings for the EPRBiodose 2010 conference.

Professor Tom Smith spent his thirteenth year at Williams pursuing his research in organic synthesis and methods development, *Asymmetric Methods for the Synthesis of Pyran-Based Anticancer Natural Products*, under an NIH Academic Research Enhancement Award (AREA) grant and a Henry Dreyfus Teacher-Scholar Award. Senior honors student Zebulon Levine'11 made significant progress toward the complex marine natural product, tedanolide C, Mark Johnson'11 developed methods for the synthesis of a,b-unsaturated lactones including the natural product, goniothalamin, Mary Beth Daub'11 developed the key step in the synthesis of jerangolid D, and Marian Deuker'11 worked toward the synthesis of a new marine natural product, enigmazole A.

In the classroom this fall, Professor Smith taught *Synthetic Organic Chemistry* (CHEM 342) to five dedicated chemistry majors. The final project, an analysis of a recent total synthesis published in the chemical literature was, again, the high point of the course. In the spring semester, Smith taught *Organic Chemistry: Introductory Level* (CHEM 156) to a group of 120 aspiring chemistry majors and premedical students.

In December, Professor Smith and all four of his senior thesis students traveled to Honolulu, HI to attend Pacificchem 2010: The International Congress of Pacific Basin Societies.

Jay Thoman taught *Concepts of Chemistry: Advanced Section* (CHEM 153) in the fall and *Physical Chemistry: Thermodynamics* (CHEM 366) in the spring. During January, Thoman taught *Glass and Glassblowing* (CHEM/ARTS 16) and sponsored an independent study in flameworking. With David Dethier, he served as thesis co-advisor to J.J. Augenbraun'11, who completed one of the first theses in Environmental Science. A focus of Augenbraun's thesis was to analyze data from the sensors on the unique solar thermal collection system on Thoman's home. The collection system includes a 20-m² reflector, which is angled such that it functions as a shade in the summertime and a mirror in the winter. In service outside of the college, Thoman was on the external review committee for the Chemistry and Biochemistry Department at Middlebury College. He continues to serve as Chair of the Review Committee for the Chemistry GRE.

During summer 2010, Thoman worked with Dave Richardson, Alex Lou'13, and Emily Ury'13 examining the distribution of PCB pollutants in the Hoosic River between North Adams and Williamstown. They took advantage of the new gas chromatograph – mass spectrometer to quantify PCBs in parts per million concentrations in the sediment. Ury was particularly successful at catching crayfish; mapping the concentration of PCBs in crayfish is a goal for the project continuing in summer 2011. During the academic year, Thoman was joined by Rick Eiselen'14 on his continuing research into the structure and dynamics of hydrofluorocarbons. At the Pacificchem 2010 conference in Honolulu, Thoman presented a poster on this project, based in large part on the thesis work of Tina Motazedizadeh'10 and Dan Suess '07.

Thoman also enjoyed working with the artist Jenny Holzer and her studio on her piece *715 molecules*, a sandblasted diorite table and benches that has been installed in the science quad. The table is a gift from

friends of the late J. Hodge Markgraf '52, who was a Professor of Chemistry at Williams starting in 1959 through to his retirement in 1998, and who taught a lab section or a course almost every year after his retirement. Numerous students, faculty, and alumni, contributed ideas, drawing, and proofreading to the project. Charles Seipp'11, Karen Chiu'10, Rachel Patel'12, Mindy Lee'12, Scott Snyder '94, and Dave Vosburg '97 provided chemical help to the team of dozens.

Chemistry Colloquia

Professor Simon Blakey, Emory University

“Metallonitrene/Alkyne Metathesis and Beyond: Transition Metal Catalyzed Oxidative□ Amination for Organic Synthesis”

Professor Christopher Chang, University of California-Berkeley, Class of 1960 Scholars Program

“Molecular Imaging Approaches to Understanding Metal and Oxidation Chemistry in the Brain”

Professor Robert Crabtree, Yale University, Class of 1960 Scholars Program

“Climate Change, Our Energy Future and Water Oxidation Catalysis”

Professor Danielle H. Dube, Bowdoin College

“Chemical Tools to Discover and Target Bacterial Glycoproteins”

Dr. Edward Grabowski, Merck Laboratories (Retired), Charles Compton Lectureship

“Recent Applications of Catalytic Processes in the Pharmaceutical Industry: The Importance of Asymmetric Hydrogenation”

Professor Gavin Sacks, Cornell University

“The Flavor Chemistry of Wines and Grapes”

Dr. Doron Greenbaum, Penn Genome Frontier Institute, BIMO Class of 1960 Scholars Program

“Chemical Biology Approach to Understand Host-Parasite Interactions”

Professor Jay Thoman, Williams College

“*715 Molecules*, Jenny Holzer, American 2010”

Professor Dhandapani Venkataraman, University of Massachusetts-Amherst

“Plastic Photovoltaics: Promise, Progress and Prognosis”

Dr. Phil Zamore, University of MA Medical School, BIMO Class of 1960 Scholars Program

“What Fruit Flies Teach Us About RNA Silencing”

Off-Campus Colloquia

Dieter Bingemann

“The Glass Transition Using the Example of the Molecular Dynamics Simulation of a Model Polymer”

Technical University Darmstadt, Darmstadt, Germany, June 2010

Christopher J. Corbett'13, Bryn E. Falahee'13, Elizabeth E. Hwang'13, Williams H. Parsons '07,, Charles A. Seipp'11, and Sarah L. Goh

“Synthesis of Amino Acid Containing Self-Assembling Polymers”

Connecticut Valley Section of the American Chemical Society Undergraduate Symposium, Trinity College, Hartford, CT, April 2011

Emily Gao'13, Sara Turner'11, Zachary Remillard'12, Andre Martinez '09, Desire Gijima'10, and Christopher Goh

“Copper-Catalyzed Atom Transfer Radical Polymerization of Styrene Using Heteroaromatic-imine Ligands”

241st ACS National Meeting and Exposition, Anaheim, CA, March 2011, POLY-85

Elizabeth E. Hwang'13, Taylor R. Wilson-Hill '08, Ji Won Ahn'12, Andrew P. Platt '07, and Katherine E. Rutledge '05, and Sarah L. Goh

“Self-Assembled Di- and Tri-block PEG-pentavaline Copolymers”

241st ACS National Meeting and Exposition, Anaheim, CA, March 2011, POLY-84

Connecticut Valley Section of the American Chemical Society Undergraduate Symposium, Trinity College, Hartford, CT, April 2011

Lawrence J. Kaplan

“Forensic Science: An Advanced CWCS Workshop”

“Issues Confronting the Education and Training of Future Forensic Scientists”

“Center for Workshops in the Chemical Sciences (CWCS): Professional Development Opportunities Through Workshops and Community Building”

21st Biennial Conference of Chemical Education, The University of North Texas, Denton, TX, August 2010

“Forensic Science: Its Impact on the Education of Undergraduate Science Students”

240th American Chemical Society National Meeting, Boston, MA, August 2010

Lee Y. Park

“Guiding Morphology Development in Polymer/PCBM Films for Organic Photovoltaic Applications via Surface Patterning and Polymer Design”

University of West Florida, January 2011

“Practices and Policies that Foster Excellence in the First Two Years”

21st Biennial Conference of Chemical Education, The University of North Texas, Denton, TX, August 2010

Enrique Peacock-López

“Minimal Model of Chemical Self-Replication and Its Dynamic Consequences”

Department of Chemistry, University of Cape Town, Cape Town, South Africa, July 2010

David P. Richardson

“Organic Pollutants in Local Waters: PCBs in the Hoosic River Watershed: A Snapshot”

Massachusetts College of Liberal Arts, North Adams, MA

David P. Richardson, Zachary M. McKenzie’14, and Luana S. Maroja

“Can You Smell Your Species? GC/MS Chemical Analysis of the Cuticular Hydrocarbons in the Hybridizing Crickets *Gryllus firmus* and *G. pennsylvanicus*”

Evolution 2011, The University of Oklahoma, Norman, OK, June 2011

Charles A. Seipp’11, Elizabeth E. Hwang’13, Christopher J. Corbett’13, Bryn E. Falahee’13, Bianca Martinez’13, William H. Parsons ’07, and Sarah L. Goh

“Synthesis of Amino Acid Containing Self-Assembling Polymers”

241st ACS National Meeting and Exposition, Anaheim, CA, March 2011, POLY-87

Anne R. Skinner

“Current Topics in ESR Dating”

EPRBiodose 2010, Mandelieu La Napoule, France, October 2010

“Thinking Inside the Sphere: Calculating External Radiation Dose Rates for ESR and TL Dating at Roc de Marsal, France, and Grotte des Contrebandiers, Morocco”

“ESR Dating of Mollusc Shells from the Iringa Region, Tanzania”

76th Annual Meeting of SAA, Sacramento, CA, April 2011

Anne R. Skinner and Natalia Loewen’12

“Blue Highways: Dating Shifra River sites, Ethiopia, with ESR”

76th Annual Meeting at SAA, Sacramento, CA, April 2011

Thomas E. Smith

“Asymmetric Methods for the Synthesis of Pyran-Based Anticancer Natural Products”

Camille and Henry Dreyfus Teacher-Scholar Symposium, New York, NY, October 2010

Thomas E. Smith, Zebulon G. Levine’11 Sarah J. Fink ’08, Adrian A. Zackheim ’09, Kerani A. McClelland’10, and Mary Beth Daub’11

“Synthetic and Stereochemical Studies on Tedanolide C”

Pacificchem, Honolulu, HI, December 2010

Thomas E. Smith, Jennifer L. Green, Mary Beth Daub'11, Cale D. Weatherly '09, Edwin T. Layng'10, Zebulon G. Levine'11, Amanda Huey'10, Pamela M. Choi '05, Marian M. Deuker'11, Rachel C. Patel'12
 "Asymmetric Methods for the Synthesis of Pyran-Based Natural Products"
 Pacifichem, Honolulu, HI, December 2010

John W. Thoman, Jr., Daniel L. M. Suess '07, Christopher A. Chudzicki'10, Tina Motazed'i'10, and David P. Richardson
 "Dynamics of Deuterofluorocarbons Probed by Overtone Spectroscopy"
 Poster presentation at Pacifichem 2010, Honolulu, December 2010

Sara Turner'11, Emily Gao'13, Desire Gijima'10, Andre Martinez '09, Zachary Remillard'12, and Christopher Goh
 "Copper Complexes of Tridentate Pyridine-imine Ligands as Catalysts of Atom Transfer Radical Polymerizations"
 241st ACS National Meeting and Exposition, Anaheim, CA, March 2011, INOR-57

Postgraduate Plans of Chemistry Department Majors

Josef Brewster	Associate Consultant, Clarion Healthcare, Boston, MA
Lucas Bruton	Research Technician/Associate, UCLA, then medical school
Heather Burrell	Clinical Research Coordinator, Center for Addiction Medicine, Massachusetts General Hospital, Boston, MA, then medical school
Mary Beth Daub	Ph.D. in Chemistry, University of California-Irvine
Marian Deuker	Ph.D. in Chemistry & Chemical Biology, University of California-San Francisco
Nancy Dong	Teach for America, LA Corps
Susannah Eckman	Working as an EMT, then to medical school
Matthew Everhart	M.S. in Chemistry, California Institute of Technology
Michael Geary	M.D., University of Rochester
Moyukh Ghosh	Unknown
Mark Johnson	Applying to medical school
Elizabeth Kalb	Applying to medical school
Leah Landsdowne	Unknown
Zebulon Levine	M.Phil. in Chemistry, Herschel Smith Fellowship, University of Cambridge
Ang Li	Unknown
B. Casey Lyons	Unknown
Christina Meade	Clinical Research Coordinator, Massachusetts General Hospital, Boston, MA
Yuzhong (Jeff) Meng	Research Assistant, Whitehead Institute, Cambridge, MA, then to medical school
Alexandra Peruta	Research Associate, Boyer Center for Molecular Medicine, Yale University
Colin Platt	Internship, National Cancer Institute, then to graduate school
Charles Seipp	Ph.D. in Chemistry, University of Texas at Austin
Mara Shapero	Unknown
Annelise Snyder	Research Assistant, School of Veterinary Medicine, University of Pennsylvania, then V.M.D./Ph.D.
Laura Ting	Research Assistant, Brigham and Women's Hospital, Boston, MA
Katrina Tulla	Unknown
Sara Turner	Unknown

COMPUTER SCIENCE DEPARTMENT

Several members of our department's faculty have moved in and out of administrative positions over the course of this year. At the beginning of the year, Andrea Danyluk concluded a year of service as the Acting Dean of Faculty for the college. She was excited to return to the classroom, teaching a diverse set of courses ranging from our introductory course to a tutorial on Machine Learning (her research area) to the senior seminar in Cognitive Science. At the end of the year, Prof. Bill Lenhart completed six years of service as Provost of the College, where he helped guide the College through the financial difficulties of the last few years. Bill begins a well-deserved sabbatical leave this fall. The department looks forward to his return to teaching. Finally, Prof. Tom Murtagh completes his term as Chair of the Computer Science Department at the end of this year. Prof. Steven Freud will assume this position. We appreciate the service all of these members of our department have provided.



(left to right) Diogenes Nunez '12, April Shen '12 and T. Andrew Lorenzen '12 viewing a research poster at the end of the Summer Science Research Session in August 2010.

Each year the department participates in a special lectureship program funded through the generosity of the Class of 1960. This fall, we welcomed Prof. Lance Fortnow from Northwestern University McCormick School of Engineering. His research spans computational complexity and its applications, most recently to micro-economic theory. His works on interactive proof systems and time-space lower bounds for satisfiability have led to his election as a 2007 ACM Fellow. In the spring, Prof. Luis von Ahn of Carnegie Mellon University visited our department. His research interests include encouraging people to do work for free, as well as catching and thwarting cheaters in online environments. He is most widely known for his contributions to the development of the captcha, those images of distorted letters you have to read and

type to access certain web sites. He is the recipient of a MacArthur Fellowship. During their visits, each of these distinguished guests gave several talks and met with faculty and students. As part of the Class of 1960 scholars program, several students were invited to participate in special events. This year's scholars were:

Class of 1960 Scholars in Computer Science

Nicholas Arnosti
Aaron Bauer
Ji Chuan
Zina Cigolle
Yuxing Danny Huang
Donny Huang
Matthew Lea

T. Andrew Lorenzen
Diogenes Nunez
Steven Rubin
Erdem Sahin
Ville Satopää
April Shen

Antal Spector-Zabusky
Lee Wang
Katherine Weyerhaeuser
Alexander Wheelock
James Wilcox
Emily Yu

We were able to provide some of our students with another opportunity to interact with computer scientists outside our department in October when Kaylee Weyerhaeuser'11, Emily Yu'11, April Shen'13, and Lorraine Schmitt'13 attended the Grace Hopper Celebration of Women in Computing in Atlanta, Georgia along with Prof. Danyluk. This trip was made possible by funding we received from both the college and the Anita Borg Institute for Women in Technology. We are grateful for this support.

After spending the fall semester on maternity leave, Prof. Jeannie Albrecht spent the spring semester on sabbatical at the University of Massachusetts, Amherst. There she continued to develop Gush, which is a

framework for configuring and controlling distributed applications (<http://gush.cs.williams.edu>). Gush is part of a National Science Foundation (NSF) funded project for creating GENI—a Global Environment for Network Innovations (<http://www.geni.net>). Kaylee Weyerhaeuser ('11) and April Shen ('13) worked with Albrecht last summer on a graphical user interface for Gush, which originally began four years ago as an extension of Albrecht's thesis work on Plush. A journal article on Plush was recently accepted for publication in the Association for Computing Machinery's *Transactions on Internet Technology* (TOIT) journal, and will appear sometime in the next year.

Also as part of her work with GENI, Albrecht traveled to Washington, D.C. in November for the GENI Engineering Conference and demonstrated how Gush and GENI can be used to enhance undergraduate computer science curriculums. In addition, Albrecht began working on extensions to her previous work on distributed application management that focused on the challenges that arise in mobile applications. Specifically, this new project aims to make applications that run in volatile mobile networks more reliable. Danny Y. Huang ('11) worked with Albrecht on this task for his senior thesis this year. Danny will join University of California at San Diego in pursuit of a Ph.D. this fall.

Albrecht recently had a paper accepted at Simplex, a workshop that focuses on Simplifying Complex Networks for Practitioners. The paper describes a new algorithm for automatically detecting “knees” in performance curves. Knees typically represent the point of diminishing returns, and many systems have developed ad hoc methods for finding these knees. Albrecht's work aims to provide a general-purpose method for detecting knees in a way that is not application-specific. Albrecht will travel to Minneapolis in June and present her results. This project is joint work with Barath Raghavan of ICSI, David Irwin of University of Massachusetts, Amherst, and Ville Satopää ('11). Ville will attend the University of Pennsylvania in pursuit of a Ph.D. in Statistics this fall.

Aside from distributed and mobile application management, Albrecht also began working on a new green computing project at the University of Massachusetts, Amherst this spring. The project aims to lower the peak energy usage of homes by scheduling “background” appliances (e.g., refrigerators, dehumidifiers, etc.) in a way to avoid high peaks in energy usage. Albrecht recently submitted a paper to the International Conference on Ubiquitous Computing documenting her results. As a next step, Albrecht and her colleagues plan to experiment with the use of renewable energy sources and batteries to further reduce the strain put on the electric grid. The project is joint work with Prof. Prashant Shenoy, David Irwin, and Sean Barker ('09) at the University of Massachusetts, Amherst.

Prof. Duane Bailey worked with two seniors this year on independent research. Steve Rubin '11 completed honors work with Bailey, developing a new approach to visualizing the very large communication structures that are often associated with highly parallel programs. The approach makes use of the information that programmers often provide when they increase the number of processors used by a parallel program. Jack Wadden '11 worked with Bailey on a design for a time-sliced field programmable gate array (FPGA) that might be used in conjunction with traditional processors. The approach would allow programmers to bundle alternative hardware implementations of computationally intensive algorithms with software.

Bailey begins a new project with Jennifer Gossels '13 this summer, modifying a technique called "literate programming," that will support the process of writing about programs. The immediate goal of the system will be the development of a new text on data structure design for Python.

Bailey continues to work with Pittsfield High physics teacher Brad Whateley, who teaches Principles of Engineering. Whateley and Bailey co-designed a number of hardware experiments that demonstrate the use of logic in computer engineering.

Bailey continued as a member of the NSF advisory panel on the redesign of the Advanced Placement exam in Computer Science. The curriculum is part of a national effort to boost participation in Computer Science. Bailey continued as a member of the national panel of readers for the Goldwater, a congressional scholarship that recognizes the nation's best undergraduate students. He is also a reviewer for the National Science Foundation.

Prof. Andrea Danyluk returned to the department after a year of administrative work. She was excited to teach a diverse set of courses ranging from our introductory course to a tutorial on Machine Learning (her research area) to the senior seminar in Cognitive Science.

Danyluk supervised two honors theses this year, one in Computer Science and the other in Cognitive Science. In Computer Science she worked with Nick Arnosti'11. Nick's work addressed two related issues: fast training of linear Support Vector Machines (SVMs) and feature selection. Research has demonstrated that SVMs for classification purposes can be learned and applied effectively across a wide set of domains. Nick was able to significantly improve upon techniques for fast training of linear SVMs, and demonstrated that his techniques worked best on data sets with a high example-to-feature ratio. Nick then developed a new method for feature selection based on the work of Shen et al. as well as a theoretical framework for the analysis of his method and Shen's. This framework relates Shen's method to the Bayes-optimal classifier and makes predictions about situations in which his method or Shen's would be best to use.

In Cognitive Science, Danyluk co-advised the thesis of Patricia Klein'11 together with Prof. Nate Kornell in the Psychology Department. Patricia's work focused on the testing effect, which refers to the phenomenon that active retrieval of information tends to lead to greater learning than re-presentation. Together Patricia and Prof. Danyluk developed a computational model to explore two possible causes of the testing effect: mediation and inhibition.

Danyluk continued her work as a board member of the CRA-W, the Computing Research Association's Committee on the Status of Women in Computing Research, where her primary role is to administer an undergraduate research grant program. This year she also developed an extensive set of resources on undergraduate research mentoring and ran a workshop on the same topic. She has also begun work as a member of the steering committee for the ACM/IEEE Computer Science Curriculum 2013, whose goal is to develop international curriculum guidelines for undergraduate programs in computer science. She continues her work with the Liberal Arts Computer Science Consortium.

Prof. Stephen Freund has continued his work on tools to help programmers more easily find defects in software. As part of this work, he published the paper "FastTrack: Efficient and Precise Happens Before Race Detection" in Communications of the ACM. The paper describes a new technique for finding race conditions, a particularly pernicious type of bug caused when multiple parts of a program try to access a shared resource (such as a file or printer) at the same time.

In addition, he presented his work at several venues, including Harvard University and Cornell University. He also presented an overview of his research at Williams in a talk entitled "Stopping the Software Bug Epidemic," which was part of the Williams College Faculty Lecture Series this spring.

Last summer, Freund worked with Diogenes Nunez'12 on a summer science research project entitled "Statistical Sampling for Dynamic Concurrency Analyses." The goal of this work was to reduce the overhead of monitoring programs for defects caused by checking every operation performed by the processor. Instead, we examined the effectiveness of statistically sampling the operations in a way that still enables the monitor programs with a lower run-time overhead while still catching defects with a fairly high probability.

Freund served on the program committee for several workshops and conferences this past year, including the ACM Conference on Principles of Programming Languages. He is also currently serving on the Programming Languages Education Board, the national committee in his research community that focuses on issues surrounding undergraduate education.

Prof. Brent Heeringa completed his fifth year as Assistant Professor in the Computer Science Department at Williams College. Heeringa taught Theory of Computation in the fall and Algorithm Design and Analysis in the spring.

Heeringa advised one senior honors thesis. Erdem Sahin'11 developed, adapted and analyzed a suite of minimum spanning tree algorithms for the increasingly relevant MapReduce paradigm of computation.

Based on work from his sabbatical at BU, Heeringa, in collaboration with John Byers (BU), Giorgos Zervas (BU) and Michael Mitzenmacher (Harvard University), published *Heapable Sequences and Subsequences*

at the 2011 *Workshop on Analytic Algorithmics and Combinatorics*. The work is motivated by the classic *secretary problem* where a committee sequentially interviews candidates for a secretarial position. When interviewing a candidate, the committee learns the candidate's rank relative to all the previously interviewed candidates. Immediately following the interview, the committee can either offer the job to the candidate (which he will always accept) or pass on the candidate, in which case the committee considers the next person. Perhaps surprisingly, the optimal hiring strategy samples the first 37% of the candidates and then offers the job to the first candidate in the remaining 63% that exceeds the best candidate seen so far. Heeringa and his colleagues extended these problems to scenarios where the committee is interested in hiring *an organization* with the constraint that a candidate will only work under someone who is ranked higher.

Heeringa also continued his research on data structures and approximation algorithms. Working with Gordon Wilfong (Bell Labs) and Glencora Borradaile (Oregon State University), Heeringa published the *I-Neighbour Knapsack Problem* at the 2011 *International Workshop on Combinatorial Algorithms*. Building on M. Catalin Iordan's '09 (Stanford University) honors thesis, Heeringa together with Iordan and Louis Theran (Temple University) developed the *Line-Leaf Tree*—a new data structure for maintaining a dynamic partial order. The research will appear at the 2011 *Algorithms and Data Structures Symposium*. This work includes experiments based on T. Andrew Lorenzen's '12 implementation of the Line-Leaf Tree.

A \$200,000 National Science Foundation award supports all of Heeringa's research.

This past year Heeringa was selected as the University of Minnesota, Morris (UMM) 2010-11 *Latterell Visiting Alumnus* which provides "a unique opportunity to expose UMM students to the enormous breadth of career options that exist for well prepared and articulate graduates of Morris's science and mathematics programs." Heeringa traveled to Minnesota in November to give a series of public lectures and talks.

Heeringa reviewed papers for Information Processing Letters, Discrete Applied Mathematics, and the 2011 Symposium on Discrete Algorithms. He attended the 2010 Foundations of Computer Science (FOCS) conference held in Las Vegas, NV, the 2011 Symposium on Discrete Algorithms (SODA) and 2011 Workshop on Analytic Algorithmics and Combinatorics held in San Francisco, the 2011 Conference on Implementation and Application of Automata held in Winnipeg, and 2011 International Workshop on Combinatorial Algorithms held in Victoria, BC. Heeringa also traveled to Swarthmore College this past spring as an external honors examiner.

Prof. Morgan McGuire collaborated with NVIDIA Research and the Vicarious Visions game studio on massively-parallel Monte Carlo methods for computer graphics throughout the year. Their work directly affects consumer products such as film and video games today and has significant implications for how financial, medical and scientific modeling will be done in the future.

From the shading on the leaves of the jungle in the film *Avatar* to tracking the interactions of individual drug molecules in a pharmaceutical study, there are many problems for which computing a result every element of truly massive data is impossible. This isn't just a limitation of today's computers—even on the fastest computers that we might *ever* build we could not solve many of these problems by brute force. The only approach is to carefully sample millions of individual data in a representative way and then estimate the net impact of trillions elements. This process is called stochastic sampling and reconstruction, and it is how most scientific simulation is performed today. Prof. McGuire invented several new methods at Williams for increasing the quality of the result while reducing the number of samples. This year that work led to several new solutions for classic problems in computer graphics: shadowing from nearby objects, proper rendering of translucent surfaces, and aliasing that appears as jagged edges on lines in computer images.

Looking forward, he is currently collaborating on separate projects with Kefei Lei'10 (at Brown University) and Marc Blackstein '99 (NVIDIA), as well as advancing stochastic methods in the graphics lab on campus. He is particularly excited to join the leading researchers on the antialiasing problem across industry and academia to teach a course for researchers at this year's SIGGRAPH conference in Vancouver, CA.

Prof. McGuire travelled to present work at several conferences and gratefully accepted first and second place research awards in the *High-Performance Graphics* conference with his coauthors for their two papers in that venue last summer.

He edited the Special Section on the Symposium on Interactive 3D Graphics and Games in the *IEEE Transactions on Visualization and Computer Graphics* journal, the *Journal of Graphics, Game, and GPU Tools*, and the *Proceedings of the ACM SIGGRAPH Symposium on Non-Photorealistic Animation and Rendering*.

Prof. Tom Murtagh continued his work investigating congestion control mechanisms for Internet protocols. During the summer of 2010, Murtagh worked with Michael Dinku'11 on the analysis of traces of Internet traffic. The goal of this work is to identify techniques that might be used within an Internet router to efficiently distinguish different types of data flows in order to design routers that more effectively allocate available bandwidth.

Murtagh also began a new project on improved contention resolution in broadcast networks like Ethernets and WiFi networks. He worked with Katherine Stevenson'12 on the construction of a simulator to support experimental evaluation of contention resolution schemes. In addition to its research goals, this project provided the framework for a new, simulation-based project in the tutorial course on computer networks that Murtagh offered in the fall.

Murtagh attended the USENIX Networked Systems Design and Implementation conference in June 2010.

Department Colloquia

Prof. Morgan McGuire, Williams College
“Ambient Occlusion Volumes”

Prof. Duane Bailey, Williams College
“In Search of the Programmable Tatoo”

Computer Science Faculty
“Everything you need to know about graduate schools and more”

Giogos Zervas, Ph.D. Candidate, Boston University
“Information Asymmetries in Pay-Per-Bid Auctions: How Swoopo Makes Bank”

Prof. Andrew McGregor, University of Massachusetts, Amherst
“Data Streams, Dyck Languages, and Detecting Dubious Data Structures”

David Luebke, Ph.D., Director of Research, NVidia Research
“Democratizing Supercomputing: the surprising story of GPU computing”

Prof. Hannah Wallach, University of Massachusetts, Amherst
“P versus NP: An Epic Struggle”

Hanspeter Pfister, Gordon McKay Prof. of the Practice, Harvard University
“High-Throughput Science”

Prof. Audrey Lee St. John, Mount Holyoke College
“Rigidity Theory: from Foundations to Applications”

A.J. Brush '96, Researcher, Microsoft
“Everyday Technology for Families”

Robin Stewart '06, The Omni Group
“Direct Manipulation 2.0: Why scientific software should also be fun for 3-year-olds”

Prof. Kevin Fu, University of Massachusetts, Amherst
“Trustworthy Medical Device Software”

Prof. Richard Wicentowski, Swarthmore College
“Computational Semantics and Lexical Substitution”

Prof. Stephen Freund, Williams College
“FastTrack: Efficient and Precise Dynamic Race Detection”

Computer Science Faculty

“Graduate School - How to Apply and What to Expect”

Prof. Douglas Turnbull, Swarthmore College

“Combining Audio Content and Social Context to Improve Music Discovery”

Computer Science Alumni Panel

“Beyond Williams – Life After Williams”

Prof. Kristina Striegnitz, Union College

“Evaluating Natural Language Generation Systems in Online Virtual Environments”

Department Student Colloquia

Ville Satopää’11	“Simultaneous Confidence Intervals for Comparing Margins of Multivariate Binary Data”
Steve Rubin’11	“Tiptoes into Industry - My Summer at Adverplex”
Aaron Bauer’11	“Automatic Detection of Lunar Craters from Global Topography”
Nicholas Arnosti’11	“CS REU in Colorado”
Erdem Sahin’11	“My Summer at Goldman Sachs”
Y. Danny Huang’11	“Masking Network Heterogeneity with Shims”
Lee Wang’11	“A summer of programming with the Facebook API”
Hai Zhou’11	“My WIT Experience”
April Shen’13	“My summer at Carleton and Williams College”
T. Andrew Lorenzen’12	“AIT in Budapest, Hungary”
Jack Wadden’11	“Heterogeneous CPU Architectures”

Off-Campus Colloquia

Jeannie Albrecht

“GENI in the Classroom,” GENI Engineering Conference 9, November 2010

“Finding a ‘Kneedle’ in a Haystack: Detecting Knee Points in System Behavior,” Simplex Workshop, June 2011

Andrea Danyluk

“Identification of Individual Spotted Salamanders”

Willamette University, Salem, OR

Union College, Schenectady, NY

“How do I start my own research program?”

Grace Hopper Celebration of Women in Computing, Atlanta, GA

“Making the Most of Undergraduate Research”

“Time Management”

SIGCSE 2011, The 42nd ACM Technical Symposium on Computer Science Education, Dallas, TX

“Balancing Graduate School and Personal Life”

“Academic Career Paths: Research and Teaching”

CRA-W Graduate Cohort Workshop, Boston, MA

Stephen Freund

“FastTrack and Jumble: Efficient and Precise Dynamic Detection of Destructive Races”

Harvard University, November 2010

“FastTrack and Jumble: Efficient and Precise Dynamic Detection of Destructive Races”

Cornell University, March 2011

Brent Heeringa

“Searching in Dynamic Partial Orders”

Invited talk at the University of Minnesota, Morris

“From Startups to Scholarship: Life in the Liberal Arts after UMM”

Invited talk at the University of Minnesota, Morris

“Minimum Reset Sequences”

Conference on Implementation and Application of Automata

“Heapable Sequences and Subsequences”

Workshop on Analytic Algorithmics and Combinatorics

Morgan McGuire

“The Big Picture: The Science of Computation for Visual Communication”

Harvard University, Cambridge, MA, December 1, 2010

“A New Analytic Solution for the Ambient Occlusion Problem”

University of Toronto, Toronto, Ontario, Canada, July 15, 2010

University of Iowa, Iowa City, IA, November 19, 2010

“Real-Time Stochastic Rasterization”

University of Waterloo, Waterloo, Ontario, Canada, July 13, 2010

Postgraduate Plans of Computer Science Majors

Nicholas A. Arnosti	Graduate school of Management Science and Engineering, Stanford University, CA
Aaron Bauer	Graduate school in Computer Science at the University of Washington, Seattle, WA
Christopher Brauchli	Traveling the Trans-Siberian Railroad
Elisa Chang	Undecided
Michael T. Dinku	Undecided
Yuxing Danny Huang	Graduate school in Computer Science and Engineering at the UCSD, San Diego, CA
Joseph Kiernan	Strategic Consulting, Bain & Co., Boston, MA
Matthew Lea	Undecided
Nathaniel Lim	Graduate school in Mechanical Engineering at Boston University
Samyan Rajbhandari	Graduate school in Computer Science at Ohio State University
Steven Rubin	Graduate school in Computer Science at University of California Berkeley, CA
Erdem Sahin	Technology Analyst, Goldman Sachs, NY
Ville Satopää	Graduate school in Statistics at the Wharton School, University of Pennsylvania
John P. Wadden	Graduate school in Computer Science at the University of Virginia, VA
Lee Wang	Undecided
Daniel L. Waters	Undecided
Katherine Weyerhaeuser	Fisku Inc., Boston, MA
Jesse Youngman	Travel and undecided
Emily Yu	Epic Systems, Verona, WI
Hai Zhou	Seeking employment in Boston, MA

GEOSCIENCES DEPARTMENT

Assistant Professor Mea Cook, a paleo-oceanographer, attended the 10th International Conference on Paleooceanography in San Diego, California. Seven students worked in her lab during the summer and academic year reconstructing climate during the end of the last glacial period in the Bering Sea, New Zealand, and Brazil.

Professor Rónadh Cox continued her field research on enigmatic boulder ridges on shore-hugging cliffs in the Aran Islands with Nari Miller'12 and Brian Kirchner'12. She and her students also used Geographic Information System analysis to track movement of the boulder ridges since a detailed 1839 Ordnance Survey map was made. She and Aaron Bauer'11 continued numerical modeling of impacts onto ice crusts to improve understanding of structures on Europa.

Prof. David Dethier continued his NSF-funded investigation of weathering and erosion rates in the Colorado Front Range with Evan Dethier'11, Keith Kantack'11, and James McCarthy'11, in collaboration with University of Vermont Prof. Paul Bierman '85 and University of Connecticut Prof. Will Ouimet '01. Dethier is also the coordinator of data collection for weather, stream flow, and precipitation chemistry in Hopkins Memorial Forest.

Assistant Professor Lisa Gilbert, at Williams-Mystic, led a field study of marsh accretion, historic hurricanes, and sea-level rise in coastal Connecticut involving eleven students. Three of the students, Abigail Martin'11, Anna Syzmanski'12, and Herrick Sullivan'13, are from Williams College. She also collaborated with other scientists in the Integrated Ocean Drilling Program and worked with Daniel Gross'12 to measure permeability in gabbro.



Participants in *Gulf of California Tectonics and Coastal Ecosystems* (GEOS 254T) on a Pleistocene coral reef (Isla Coronados) led by Prof. Markes Johnson during the spring break field excursion to the Gulf of California (Mexico).

Professor Markes Johnson worked with Dan Walsh'11 in the Oscar Range of Western Australia on a project funded by the National Geographic Society. During the spring semester he taught a new tutorial on the tectonics and coastal ecosystems of the Gulf of California. The course included a ten-day field trip to the Loreto area on Baja California funded by the Freeman Foote Field Trip Fund for the Sciences.

Professor and Chair Paul Karabinos continued fieldwork in New England and devoted much of his research to improving the three-dimensional visualization of the geology and topography in the Appalachians.

Professor Wobus celebrates the 30th anniversary of the Williams Alumni College in the Rockies, a Colorado-based week of geology and natural history field trips. He started this program in 1981 and has hosted more than 400 alumni, faculty, spouses, and friends. This field-based alumni program led to the extensive Alumni Travel-Study program that exists today.

The Geosciences Department continued to participate in the Class of 1960 Scholars Program. The lecture series was organized by Mea Cook and Markes Johnson and brought speakers to campus to describe their work on climate science and tectonics and ecosystems in Baja California, and the speakers' talks were integrated with tutorials offered by both Professors Cook and Johnson.

Geosciences faculty, students, and alumni published widely in scientific journals and presented numerous talks at the National Geological Society of America meeting in Denver, Colorado, the American Geophysical Union Meeting in San Francisco, California, and the Northeastern Sectional Meeting of the Geological Society of America in Buffalo, New York. Evan Dethier, Keith Kantack, Caleb Lucy, James McCarthy, and David Oakley, all class of '11, also gave research presentations at the Keck Symposium hosted by Union College.

The David Major Fund in Geology offered field camp scholarships to two of our majors during the summer of 2010. Daniel Perez'10 and Peter Tierney'10 attended the Albion College field camp. The Keck Geology Consortium supported fieldwork by Evan Dethier, Keith Kantack, and James McCarthy in Colorado; Caleb Lucy in Montana; and David Oakley in Wyoming. The Sperry Family Fund supported the summer research and thesis work of Dan Walsh'11, who worked in Western Australia with Markes Johnson. Clara Noomah'13 was the recipient of the Lauren Interest Fellowship. Clara traveled to Chile to study the environmental impact of salmon farming. The McAleenan Family Fund in Geology supported Dan Walsh and Lisa Merkhofer to attend the National Meeting of the Geological Society of America in Denver, Colorado. Lisa presented a talk based on her thesis research with Paul Karabinos as co-author.

Seven honors students presented their research results on May 16, and Dan Walsh won the Freeman Foote prize for the best thesis presentation. David Oakley won the Mineralogical Society of America prize, and James McCarthy received the David Major Prize in Geology. Evan Dethier, Caleb Lucy, James McCarthy, Lisa Merkhofer, David Oakley, and Dan Walsh were inducted into Sigma Xi.

Mea Cook attended the 10th International Conference on Paleoceanography in San Diego, CA, in August and presented her work reconstructing ocean circulation and the carbon cycle in the northwest Pacific during the transition out of the last glaciation using radiocarbon. She had an active lab this year, with seven students working on projects reconstructing climate over ice age cycles from Bering Sea, New Zealand, and Brazil Margin. Two of the students, Nari Miller'12 and Ian Nesbitt'13, traveled with Mea to UC Santa Cruz and Oregon State University in January to analyze marine microfossils with isotope-ratio mass spectrometry. Mea published a study on methane and climate in the journal *Paleoceanography* and gave a seminar on the project at the College of Oceanic and Atmospheric Sciences at OSU.

Rónadh Cox spent much of the summer in 2010 on Inis Meáin, one of the Aran Islands off the west coast of Ireland, measuring boulders and piles of boulders with Brian Kirchner'12 and Nari Miller'12. They looked at the relationships between the boulder ridges, the coastal geometry, and the offshore bathymetry as part of the continuing investigation of how these deposits were emplaced. The largest single boulder they measured was 11.5 m long, with estimated mass of 78 tons, and local people told the group that this boulder had appeared in its present position after a large winter storm in 1991. Back at Williams, GIS comparison between modern orthophotos of the island and a detailed Ordnance Survey map made in 1839 showed that the boulder ridges have migrated inland over time, in places over-running old field boundaries. In summer 2011, Rónadh will return to the Aran Islands with Miranda Bona'13 and David Rapp'13, to collect more measurements and to re-photograph reference sites to investigate which boulders have moved over the last few years.

Aaron Bauer'11 continued his work on numerical modeling of impacts onto ice crusts, and he and Rónadh presented results at the Geological Society of America meeting in October 2010 and at the Lunar and Planetary Science meeting in March 2011. After 3.5 years of work, this project has yielded a comprehensive set of excellent results, which Rónadh plans to write up for publication during her sabbatical semester this fall.

Geosciences hosted a student from Madagascar this year, Ny Riavo (Voary) Voarintsoa, who worked with Rónadh to investigate the relationships between local slope, lithology, and the abundance of lavakas (gullies). Voary will continue to work on the project this summer, prior to fieldwork in Madagascar this August.

David Dethier continued his NSF-sponsored research in the Colorado Front Range, focused mainly on the measurement of processes in the Boulder Creek "critical zone" (CZO), which includes the mantle of soil and weathered material above fresh bedrock. In cooperation with the NSF CZO project, during July and

August he supervised (with Will Ouimet '01) a Keck Geology Consortium Project involving 10 students in the Boulder Creek area. Williams students on the project included Evan Dethier'11, Keith Kantack'11 and James McCarthy'11, all of whom subsequently did honors thesis work in Geosciences with Dethier. Paul Bierman '85 (University of Vermont), Will Ouimet and Dethier continued investigations of Front Range weathering and erosion rates using meteoric and in-situ cosmogenic ¹⁰Be techniques. Dethier worked in the City of Boulder watershed with Matthias Leopold and other colleagues from the Technical University of Munich, using seismic refraction, resistivity and ground-penetrating radar to non-destructively image the shallow subsurface in a suite of study areas. Dethier also helped to supervise the honors thesis work (in Environmental Science) of JJ Augenbraun'11 on "Residential Solar Thermal Energy in Williamstown, Massachusetts."

Dethier helps to coordinate ongoing collection of weather, streamflow, precipitation chemistry and other environmental data from Hopkins Memorial Forest and their analysis in the Environmental Science Lab in the Morley Science Center. Real-time weather and groundwater data and archived weather data from 25 years of monitoring are available at <http://web.williams.edu/Geoscience/weather>; archived watershed data (streamflow and temperature, stream chemistry and bulk precipitation chemistry) are at: <http://web.williams.edu/Geoscience/weather/watershed/>.

Lisa Gilbert led a team studying marsh accretion, historic hurricanes, and sea level rise in southeastern Connecticut. In the summer of 2010, they used a vibracore to recover peat and sediment cores up to 7 meters long at Barn Island Marsh, in Pawcatuck, CT. During the summer of 2011, they continued the work with an intense mapping effort. Among the eleven Williams-Mystic students participating in the Barn Island Marsh project this year were Abigail Martin'11, Anna Syzmanski'12, and Herrick Sullivan'13. Gilbert also continues her involvement in the Integrated Ocean Drilling Program as a shore-based participant for Expedition 335, an attempt to deepen the first hole drilled to gabbro in normal oceanic crust at Hole 1256D. For part of that study, Daniel Gross'12 examined the permeability of some of the rocks as an indicator of crack size and hydrothermal fluid flow. This year Gilbert traveled to Macalester College in Minnesota to collaborate on an NSF-funded research project examining the importance of the affective domain in introductory geoscience courses; some of the initial findings of the research were presented at the Geological Society of America Annual Meeting in Denver.

Professor Markes Johnson returned to teaching in the Geosciences Department, after a richly rewarding sabbatical year of travel and research on modern and ancient rocky shores with a focus on Europe, Asia, and Australia. The last phase of research entailed a month of fieldwork in the Oscar Range of Western Australia along the Devonian Great Barrier Reef (June/July 2010) under a grant from the National Geographic Society. With additional support from the Sperry Fund, Dan Walsh'11 participated in this project and took on many aspects to launch his senior honors thesis for the ensuing academic year. During the fall semester, Markes revised manuscripts on Miocene rocky shores from the Balearic Islands (Spain) in the western Mediterranean and the Madeira Islands (Portugal) in the North Atlantic. The Iberian research group, to which he and spouse Gudveig Baarli (Williams Research Scientist) belong, was awarded a grant from the Spanish Ministry of Science and Technology to expand research on island rocky shores to the Canary Islands (Spain) and Cape Verde Islands (former possession of Portugal) over the next three years. Fieldwork on those islands will be initiated during the summer of 2011, to include ongoing studies in the Madeira Islands.

During the spring semester, Prof. Johnson offered a new tutorial course on the tectonics and coastal ecosystems of the Gulf of California (GEOS 254T). The 10 students in the course joined Markes and David Backus (Williams Research Scientist) on a 10-day excursion to the Loreto area on the Baja California peninsula during spring break. The trip was supported by a grant from the Freeman Foote Field Trip Fund for the Sciences. Students visited geological sites on Isla Coronados and Isla del Carmen and began a new mapping project at San Basilio, north of Loreto.

During the course of the academic year, Prof. Johnson wrote peer reviews on manuscripts submitted to *Palaeogeography*, *Palaeoclimatology*, *Palaeoecology*; *International Journal of Earth Sciences*; *Geologica Acta* (Spain); and the *Geological Journal*. He also joined the editorial board as Associate Editor for the *Journal of Coastal Research*.

At the conclusion of the academic year, Prof. Johnson was awarded a Nelson Bushnell Prize from The College for excellence in scholarship and teaching.

Professor and Chair Paul Karabinos, along with R.Tollo, M. Bartholomew, and J. Hibbard, edited a Geological Society of America Memoir entitled *From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region*. At 956 pages, it contains thirty-six original articles tracing the geologic history of eastern North America from 1200 to 200 million years ago.

Karabinos continued research on a three-year \$144,000 grant from the National Science Foundation to support an educational initiative visualizing strain in rocks with interactive computer programs. This project, in collaboration with Chris Warren from the Office of Information Technology, aims to create new computer programs written in Java, and accompanying modules for classroom and laboratory use, to enhance student learning of fundamental concepts of strain analysis in rocks. Lisa Merkhofer'11 also worked on this project during the summer of 2010 and used her research for her senior thesis in the Geosciences Department.

Karabinos attended the National Meeting of the Geological Society of America in Denver, Colorado, in October 2010 where he gave an invited presentation at a theme session titled *Virtual Tectonics*, and was co-author on another presentation with Lisa Merkhofer'11 in the same session. He gave another presentation in a theme session called "Garnet and its Use in Unraveling Metamorphic and Tectonic Processes." In January 2011, Karabinos attended a Penrose Conference in Mountain View, California, at Google Headquarters on "Google Earth: Visualizing the Possibilities for Geoscience Education and Research" where he gave a presentation on using Google SketchUp for teaching and research applications. He also attended the Geological Society of America joint Northeastern/North-Central Section meeting in March 2010 in Pittsburgh, Pennsylvania, where he organized a theme session called "Devonian Orogenesis in the Appalachian-Caledonian Mountain Belt—Where, When, and What Caused It" and gave a presentation on his recent research in western Massachusetts.



Nari Miller '13 and Brian Kirchner '13 measuring cliff-top boulder deposits on Inis Meáin, Aran Islands,

Professor Reinhard A. (Bud) Wobus celebrates this year the 30th anniversary of the Williams Alumni College in the Rockies, a Colorado-based week of geology and natural history field trips he organized in 1981 that led to the extensive Alumni Travel-Study program that exists today. The Rockies week has hosted more than 400 alumni, faculty, spouses, and friends in the twenty-some offerings; the 30th anniversary gala will be in July this summer. Wobus has run similar field programs in the Pikes Peak region for many other groups, particularly those from the Geological Society of America. Most recently he led a two-day trip for two dozen geologists through the Pikes Peak region after GSA's annual meeting in Denver in early November.

While at the GSA conference Wobus represented the college for the 24th year at the fall meeting of the governing board of the Keck Geology Consortium. He organized a gathering of about 25 Williams geology alumni at the GSA meeting, and was co-author of a poster presented by his honors student last year, Allie Goldberg'10, on young pyroclastic deposits at Makushin Volcano in the Aleutians.

At the December meeting of the American Geophysical Union in San Francisco he attended an oral presentation by his honors student for next year, Katie Kumamoto'12, based on her petrologic internship at the Geophysical Lab of the Carnegie Institute the previous summer. As in previous years, he organized a noontime reunion of some 20 Williams alumni who were attending the meeting and/or working in the Bay area.

In April he, Prof. David Dethier, and five Williams seniors participated in the 24th Keck Geology symposium hosted by Union College. His honors student, Caleb Lucy'11, presented a poster giving the results of his research on Precambrian meta-igneous rocks in the Henrys Lake Mountains on the Montana-Idaho border west of Yellowstone. Wobus visited that field site for several days last summer.

The Keck Consortium, now 18 geology departments at liberal arts colleges coast-to-coast, received notification in April of the renewal of its NSF-REU grant for three more years for \$783,894. The grant, along with contributions from the member colleges and Exxon-Mobil, will enable the Consortium to continue its direction of intercollegiate student-faculty research collaboration on projects worldwide. The Consortium was founded in 1987 in response to a proposal to the W.M. Keck Foundation of Los Angeles, submitted by Wobus and Prof. Emeritus Bill Fox. Since then more than 1100 geology students, including 80 from Williams, have been part of some 150 research projects.

Class of 1960 Scholars in Geosciences

Alexandra Ambros	Peter Clement	Mika Nakashige
Ty Aveni	Thomas Gaidus	Sarah Rowe
Jeffrey Bak	Kristina Krone	Carly Shulman
Miranda Bona	James McCarthy	Gordon Smith
Leo Brown	Lisa Merkhofer	Daniel Walsh
Taylor Cherytkov		

Geosciences Colloquia

Dr. Joann Stock, California Institute of Technology

Sperry Lecture Speaker and Geosciences Class of 1960 Scholar Speaker

“The Continent-Ocean Transition in the Gulf of California Region”

“Tectonic Evolution of the Northern Gulf of California”

Dr. Markes Johnson, Williams College

“Miocene Orange-Hill Deposits on Porto Santo (Madeira Archipelago) Compared with Pliocene Rhodoliths of Baja California Sur”

Dr. Lee Kump, Pennsylvania State University

Geosciences Class of 1960 Scholar Speaker

“The Last Great Global Warming Event”

Dr. Ken MacLeod '86, University of Missouri

Geosciences Class of 1960 Scholar Speaker

“Cretaceous/Paleogene (K/T) Boundary in Ocean Drilling Program Cores”

Dr. Jochem Halfar, University of Toronto

Geosciences Class of 1960 Scholar Speaker

“Global Occurrences of Rhodolith Facies with a Special Emphasis on the Gulf of California, Mexico”

Dr. Richard Busca, Arizona-Sonora Desert Museum, Tucson, Arizona

Geosciences Class of 1960 Scholar Speaker

“Biodiversity and Conservation Issues in the Gulf of California”

Geosciences Student Colloquia

Clara Noomah '13 Lauren Interest Fellow in Geosciences	"A Slippery Harvest: The Farmed Salmon Industry in Chile"
Evan Dethier '11	"Examining Knickpoints in the Middle Boulder Creek Catchment, Colorado"
Keith Kantack '11	"Reconstructing Pinedale Ice in the Green Lakes Valley and Adjacent Areas, Colorado"
Caleb Lucy '11	"Petrogenesis of Precambrian Igneous and Meta-Igneous Rocks South of the Madison Mylonite Zone, Henrys Lake Mountains, SW Montana & Idaho"
James McCarthy '11	"Assessing Eolian Contributions to Soils in the Boulder Creek Catchment, Colorado"
Lisa Merkhofer '11	"Pre-Tectonic Fabric in Unstrained Conglomerates and Implications for the Rf-phi Strain Analysis of Their Deformed Counterparts"
David Oakley '11	"Linking Minor Basement Faults to the Laramide Bighorn Arch, Wyoming"
Daniel Walsh '11	"Paleogeography of a Devonian Island Reef System"

Off-Campus Colloquia

Mea Cook "Methane Release from Bering Sea Sediments During the Last Glacial Period" Oregon State University College of Oceanic and Atmospheric Sciences	
Rónadh Cox "Boulder Ideas, Some Far-Fetched: Cliff-Top Deposits on the Aran Islands, Ireland" Smith College Williams-Mystic, Mystic Seaport "Hydrocode Modeling of Impacts at Europa" 42 nd Lunar and Planetary Science Conference "Geomorphology of Chaos Areas on Europa" 42 nd Lunar and Planetary Science Conference	
R. A. Wobus Leader of a two-day field trip through the Pikes Peak Region, Colorado, for two dozen geologists	

Postgraduate Plans of Geoscience Majors

Alexandra K. Ambros	Working in Denali National Park guiding hikes and becoming involved with outdoor education
Evan N. Dethier	Coaching and teaching at Green Mountain Valley School, VT, then graduate school
Keith M. Kantack	Undecided
Jeffrey M. Lauer	Undecided
Caleb O. Lucy	Indiana University Field Camp summer of 2011
James A. McCarthy	Indiana University Field Camp summer of 2011
Lisa M. Merkhofer	YBRA field camp in Montana; road trip around western U.S.
David O. Oakley	Graduate School in geology at Pennsylvania State University
David M. Roth	Undecided
Daniel R. Walsh	Fellowship at Piedmont Environmental Council of Northern Virginia; work in national parks in Montana; graduate school in geology fall of 2012

MATHEMATICS AND STATISTICS DEPARTMENT

The Mathematics and Statistics department had another great year. Professor Edward Burger was appointed Lissack Professor of Social Responsibility and Personal Ethics.

We were joined by Assistant Professor Elizabeth Beazley, who came to us after a post-doctoral position at the University of Michigan. Two members of our department were on leave this past year. Edward Burger spent the fall at Baylor University as Robert Foster Professor for Great Teaching, and the spring at the University of Texas, and next year he will also be on leave at Baylor University. Frank Morgan spent the fall at the University of Toronto and in the spring he undertook an extensive speaking tour of Asia. We look forward to the return of Frank Morgan in fall 2011 and Ed Burger in fall 2012. Next year Professors Bernhard Klingenberg and Susan Loepp will be on leave for the year, and Professors Carsten Botts, Ollie Beaver and Allison Pacelli will be on leave in the fall.

Andrey Glubokov will join us as Visiting Assistant Professor of Statistics. Also, Lori Pedersen will join us again as a visiting lecturer.

In December, we learned the happy news that Professor Mihai Stoiciu was promoted to Associate Professor with tenure.

We are very proud of the accomplishments of our majors. The Rosenberg Prize for outstanding senior was awarded to Jake Levinson'11. Yuzhong "Jeff" Meng'11 and Thelonious "T. Sam" Jensen'11 received the Goldberg Prize for the best colloquia. Patricia Klein'11 was awarded the Morgan Prize for teaching in its broadest sense. Ville Satopaa'11 received the Robert M. Kozelka Award for outstanding students of statistics. Nicholas Arnosti'11 received the Witte Problem Solving Prize. James Wilcox'13, first, and Carlos Dominguez'13, second, were awarded the Benedict Prize for outstanding sophomore. Patrick Aquino'12 was awarded the Wyskiel Prize for a student who chooses a career in teaching. Finally, Nicholas Arnosti'11 and Jake Levinson'11 were awarded the colloquium attendance prize.

The members of our student advisory board, SMASAB (Students of Mathematics and Statistics Advisory Board), were JiWon Ahn'12, Carlos Dominguez'13, Hannah Hausman'12, Patricia Klein'11, Christina Knapp'13, Jake Levinson'11, Sean Pegado'11. They provided sage advice, in addition to organizing the department's ice cream socials. This year one of our majors, Robert Silversmith'11 was awarded a National Science Foundation graduate fellowships in mathematics.

Last summer, Colin Adams served as director of the SMALL program, and advised five students in a group investigating lattice stick numbers for knots. The paper they wrote has been accepted for publication in the *Journal of Knot Theory and its Ramifications*. A paper from the previous summer was also submitted and will appear in the same journal.

Over the academic year, Adams served as the advisor for Jacob Wagner'11, who wrote a thesis on superbridge index and geometric degree of two-bridge knots. After a few more results are completed, they will publish the work.

Adams submitted several other papers for publication and gave a variety of talks over the year. He served as a co-principal investigator on a grant that funds undergraduate math conferences around the United States. In the spring, he taught graph theory to a mix of math and computer science students.

In summer 2010, Professor Ollie Beaver taught in and coordinated the mathematics component of the Summer Science Program. During the academic year, Beaver continued her involvement in the Quantitative Studies program at Williams. She was again chair of the Winter Study Committee. In January Beaver attended the Joint Mathematics Meetings and in February she was an invited panelist on the National Science Foundation Panel for Graduate Fellowships in Mathematical Sciences.

Professor Elizabeth Beazley completed her first year at Williams this year, and has been blown away by the level of scientific activity in the department. Her research interests have typically been in algebraic geometry, but grew this year to include related subfields of algebraic combinatorics, coming off the heels of an RTG Hildebrandt postdoc in the combinatorics group at the University of Michigan. She had one

paper accepted this year to the *Journal of Algebra* on her work with affine Deligne-Lusztig varieties, and she gave many invited research talks around the eastern part of the continent, including at the workshop on "Affine Schubert Calculus" at the Fields Institute in Toronto. She also attended a workshop at the Banff International Research Station in Alberta, Canada, where she initiated a research collaboration in the area of quantum Schubert calculus.



A group of Math seniors at the start of the fall semester colloquium

Professor Edward Burger was awarded the endowed chair of *Lissack Professor of Social Responsibility and Personal Ethics* by Williams in July 2010. For the 2010–2011 academic year he was the Robert Foster Cherry Professor for Great Teaching at Baylor University. The Korean edition of his book *Coincidences, Chaos and All That Math Jazz* was awarded an Excellence Certification by The National Research Foundation of Korea. In October, the Huffington

Post named Burger a 2010 Game Changer ("HuffPost's Game Changers salutes 100 innovators, visionaries, and leaders who are reshaping their fields and changing the world."). In fall 2011, Burger will return to Baylor University as Vice Provost for *Strategic Educational Initiatives*, a position that was created for him.

Professor Burger's G-Option Initiative was highlighted in the September 2010 issue of the Williams Alumni Review in a story entitled, *The Gaudino Option: Enabling students to enroll in courses they really want to take—but that seem risky*. Burger was the subject of several other articles including a profile in The Chronicle of Higher Education (October 4, 2010) entitled, *Teaching Math as Narrative Drama*; a feature in Baylor Arts and Science Magazine (Fall 2010) entitled, *Disciple of Creativity*; and a story in the Winter 2010–2011 issue of Baylor Magazine entitled, *Making math magical*.

In the summer of 2010, Burger was a faculty member of Williams' Summer Humanities and Social Sciences Program, as well as a SMALL NSF-REU faculty advisor for a group of four undergraduates including Gea Shin'11 and Nancy Wang'11. They are currently completing several manuscripts based on their work. In 2010 he published *Arithmetic from an advanced perspective: An introduction to the adeles* in *Pro Mathematica* **24** (2010) pp 9–54. Also in 2010, the Italian, Japanese, and Portuguese translations of his book, *Coincidences, Chaos, and All That Math Jazz: Making light of weighty ideas* (co-authored with Michael Starbird), were published. In addition, he is the author of *Fuse Algebra 1*, the first app math textbook developed exclusively for the Apple iPad, published by Houghton Mifflin Harcourt.

Burger delivered 28 addresses in the past year including the Battles Lecture at the Spring Conference of the NES MAA, a Fulbright Workshop at Harvard University, three mathematics workshops in the United Arab Emirates, and the Parsons Lectures at The University of North Carolina–Asheville. In addition, Burger was the moderator of "Williams Today and Tomorrow" as part of the Williams presidential induction in September. On June 26, he was a guest on the television program *207* on WCSH (NBC-TV) in Portland, ME.

Professor Satyan Devadoss returned from sabbatical this year, once again enjoying the sun and the snow of Williams, having a grand ol' time. His research is in the areas of discrete topology and geometry, on which he gave several invited talks from coast-to-coast. Two of his papers appeared in print this year: One was in the *Journal of Combinatorial Theory* on his work on graphs and polytopes, and the other, co-written with students of SMALL, appeared in the *Notices of the American Mathematical Society*, which was somewhat of a big deal to him. Professor Devadoss also had his first book appear in print, *Discrete and Computational Geometry*, published by Princeton University Press.

On the Williams front, Devadoss gave several talks, including the *Veritas Forum* and the *Latke vs Hamentashen Debate*. Moreover, after several years as faculty program director of the Dodd Cluster, Professor Devadoss will be stepping down and the department's own Professor Morgan will be taking the mantle. This seems fitting as Dodd House was built by Cyrus Dodd '55, Professor of Mathematics.

Professor Richard De Veaux continued his work in data mining and gave a variety of invited talks, keynote addresses and workshops on teaching and data mining throughout the United States and Europe. His book *Business Statistics 2nd Edition* written with Norean Sharpe (Georgetown University) and Paul Velleman (Cornell) and *Stats: Data and Models 3rd Edition* were published in December by Pearson. He also supervised the thesis of Ville Satopää entitled, "Robust Regression Boosting."

Professor Thomas Garrity has continued his research in number theory. On September 30, 2010, with Colin Adams, he gave the debate "Derivative vs. Integral: The Final Smackdown." They also gave this debate in January 2011 at the National Joint Meeting of the American Mathematical Society and the Mathematical Association of America in New Orleans. Also at the National Joint Meeting he spoke on "Generalizing Stern's Diatomic Sequences via Multidimensional Continued Fractions" in a special session. Also in January he gave a colloquium at the College of Wooster titled "On Writing Numbers." He gave a similar talk to the students at the Hampshire College Summer Studies in Mathematics in July 2010. He continues being the co-director of Williams' Project for Effective Teaching (Project PET).

Professor Stewart Johnson continues his research in dynamical systems, modeling, and optimal control with a focus on systems that exhibit continuous and discrete behavior. He is currently developing computational methods for delicate optimal control problems.

Prof. Johnson organized a mini-symposium and presented his work on rapidly switching control systems at the 2011 Society for Industrial and Applied Mathematicians Conference on Applications of Dynamical Systems.

Professor Johnson remains active in the college wide Quantitative Studies program which provides early identification and intervention for students with quantitative challenges.

Professor Bernhard Klingenberg with the help of Ville Satopää'11, worked on analyzing multivariate binary data which arise in toxicology or drug and vaccine safety studies when comparing measurements taken on subjects that are exposure to a toxin/drug/vaccine to measurements taken on subjects in a control group. A first paper on this subject recently appeared in *Computational Statistics and Data Analysis*. A second topic that is currently under research is on statistical methods for multiple comparisons from cross-over clinical trials with a binary response. Prof. Klingenberg gave several invited and contributed talks on these and related topics, among them at the Institute of Medical Statistics at the Medical Univ. of Vienna, Austria, at the Dept. of Biostatistics, Karolinska Institute, Stockholm, Sweden and at Biostatistics conferences in Montpellier, France and Miami, FL. At Williams, Prof. Klingenberg provided statistical consulting services to students and faculty from a wide variety of disciplines.

In 2010 a research paper written by the 2007 SMALL Commutative Algebra group, advised by Susan Loepp, appeared in the *Canadian Journal of Mathematics*. In addition, a paper written by the 2009 SMALL Commutative Algebra group was accepted for publication in the *Journal of Commutative Algebra*. Loepp advised the senior honors theses of Sean Pegado'11 and Philip Vu'11. Both students presented their thesis results at the Undergraduate Research Poster Session at the National Math meetings in New Orleans in January 2011.

In February, Loepp concluded her service as the chair of the American Mathematical Society's Committee on the Profession. She was also the chair of the 2011 AMS committee on Programs that Make a Difference and is currently on the AMS search committee for a new Secretary, and the AMS Committee on Committees. In November, Loepp served on a panel for the National Science Foundation. The panel reviewed grants and made recommendations for funding to the Program Officers.

Professor Steven Miller received a three year NSF grant to continue his investigations in number theory and probability. Last year he wrote 10+ papers (many with students), gave 20 talks and jointly organized two AMS special sessions. He also worked with three WIT students (Jennifer Gossels, Kushatha Fanikiso

and Mike Ormsbee) and two summer science students (Craig Corsi and Stewart Stewart) to revise his math riddles website <http://mathriddles.williams.edu/> (which is in the top 5 when googling ‘math riddles’), six students in SMALL (with Williams students Carlos Dominguez and Murat Kologlu), advised high school students in research projects at PROMYS at BU over the summer, and gave continuing education lectures on cryptography and Benford’s law to middle and high school teachers. He supervised three math theses (Ari Binder, Jake Levinson and Wentao Xiong), and was a secondary advisor for one in economics (Dan Costanza). He is currently working on three books (on Benford’s law, on cryptography and on probability, the last two with Williams students).

As Vice-President of the American Mathematical Society, Professor Frank Morgan spent two months of his sabbatical giving some 40 talks across Asia: Pakistan, just 35 miles from Osama Bin Laden; Vietnam, with a talk to a thousand students, covered on Vietnam TV; Thailand; Singapore; Malaysia; and the Philippines. In Ho Chi Minh City one former student—Chung Truong—appeared at his talk and alerted three more former students in Bangkok—Wisa “Aom” Kitichaiwat, Pakinee “Ta” Banchuin, and Harit Rodpraser—who took him to dinner and talked about their work at the Bank of Thailand. He spent the fall at the Fields Institute in Toronto and January-February at Brigham Young University in Utah. Last summer he taught a short course on geometric measure theory in Sao Paulo, Brazil. Altogether he gave some 66 talks.

Morgan is continuing his study of minimal surfaces and densities with a number of collaborators and his undergraduate research Geometry Group. Publications include a joint note with a Walter Filkins, a student in his Investment Mathematics class.

Professor Allison Pacelli was on leave during the fall semester, and continued her research in algebraic number theory. She advised the Algebraic Number Theory group as part of SMALL 2010; the group’s results on Galois groups of iterated Rikuna polynomials have been submitted for publication.

During the summer of 2010, Pacelli co-directed an MAA Professional Enhancement Program on teaching algebraic number theory at the undergraduate level for college faculty around the country. During the past year, she gave talks at Wellesley College, Siena College, Brown University, George Washington University, Acadia University, Canadian Number Theory Conference IX, and Williams College. She served as a grant reviewer for the National Science Foundation Division of Undergraduate Education, and continued to serve on the Steering Committee for the Hudson River Undergraduate Mathematics Conference.

Professor Cesar Silva continued his research in ergodic theory. He taught Real Analysis in the fall, where he used a preliminary version of the book he is writing. He was awarded a grant from the National Science Foundation to organize a conference on the occasion of John Oxtoby’s Centennial. The conference took place at Bryn Mawr College, October 30 – 31, 2010.

Silva attended the Dynamics Workshop in Pingree Park of Colorado State University during August 2 - 7, 2010 and the annual AMS Meeting in New Orleans, Louisiana, January 6 – 9, 2011. He was invited to give a series of lectures in ergodic theory at the CIMPA – UNESCO conference in Lima, Peru in July 2010. In the spring, Silva offered five lectures on fractals for the Osher Lifelong Learning Institute. He was invited to participate in a panel at The Hotchkiss Symposium on International Student Secondary and Post-Secondary Experiences on June 15, 2011. Silva published three papers coauthored with his students based on research in the SMALL program.

Professor Mihai Stoiciu taught two sections of Linear Algebra in the Fall Semester of the Academic Year 2010-2011. During the Spring Semester he taught two sections of “Abstract Algebra and Numerical Problem Solving”, a 300-level tutorial cross-listed between Mathematics and Computer Science. Also, Stoiciu supervised Zhaoning (Nancy) Wang’11, who wrote an undergraduate thesis titled “Sturm-Liouville Oscillation Theory for Differential Equations and Applications to Functional Analysis.” In her thesis, Nancy studied connections between second-order differential equations and their corresponding difference equations, as well as applications of the Sturm-Liouville Oscillation Theory to spectral theory. Stoiciu also supervised the SMALL 2010 Mathematical Physics Group, which investigated spectral properties of non-Hermitian matrices and operators.

During the year, Stoiciu continued his research on spectral properties of random and deterministic operators, working with collaborators from the UK and US. He was invited to present his research at Rice University, Cuernavaca Mathematics Institute, Mexico, at two AMS Special Sessions in Iowa City, IA and in Worcester, MA and at a SIAM workshop at the University of North Carolina at Charlotte. Stoiciu was also invited to give a graduate mini-course on topics related to his research at Universidad Nacional Autónoma de México in Mexico City, Mexico. At Williams College, Stoiciu gave two talks in the Mathematics and Statistics Faculty Seminar, a Tuesday Science Talk, and two Mathematics Colloquia for students.

Mathematics Colloquia

Colin Adams, Williams College

“Geometry of Knots”

“Stick Numbers of Knots”

Elizabeth Beazley

“Maximal Newton Polygons Via the Quantum Bruhat Graph”

“A Graph Encoding an Order on the Affine Symmetric Group”

Arthur Berg, Pennsylvania State University

“Standing Between A Bayesian and A Frequentist: An Empirical Bayes Exploration of Movies, Baseball, and Williams College”

Carsten Botts, Williams College

“Producing an Exact Sample from a Posterior Distribution”

“Transformed Density Rejection with Inflection Points”

Edward Burger, Williams College

“Conjugate Coupling: The Romantic Adventure of the Quintessential Quadratic”

David Demanik, Rice University

“An Introduction to the Mathematics of Aperiodic Order”

Satyan Devadoss, Williams College

“Deformations of Bordered Riemann Surfaces”

John Emerson '92, Yale University

“Statistical Sleuthing by Leveraging Human Nature: A Study of Olympic Figure Skating”

Thomas Garrity, Williams College

“On Writing Numbers: The Hermite Problem and Multi-dimensional Continued Fractions”

“On Pascal with Memory for Triangles, or, on Sterns’ Triatomic Sequences”

Sandra Eckel, University of Southern California

“Statistical Issues in Quantifying the Health Effects of Air Pollution in Children”

Kari Hart, Emory University

“A Robust Extension of Latent Class Analysis for Longitudinal Data”

Bernhard Klingenberg, Williams College

“Comparing Margins of Multivariate Binary Data”

“Confidence Intervals for Contrasts of Binomial Proportions”

“Crossover Studies”

Kari Lock, Harvard University

“Rerandomization in Randomized Experiments”

Susan Loepp, Williams College

“Semilocal Formal Fibers of Prime Ideals with Large Heights”

“Excellent Integral Domains of Prime Characteristic”

Kelly McConville, Colorado State University

“I Count Trees: How a Survey Statistician Estimates a Finite Population Total”

Xiao-Li Meng, Harvard University

“Trivial Mathematics but Deep Statistics: Simpson’s Paradox and Its Impact on Your Life”

Steven Miller, Williams College
 “Benford’s Law, or Why the IRS Cares About Number Theory!”
 “Cookie Monster Meets the Fibonacci Numbers. Mmmmmm – Theorems!”

Frank Morgan, Williams College
 “Ideal Shapes”

Joseph O’Rourke, Smith College
 “Unfolding Convex Polyhedra: New Methods”

Allison Pacelli, Williams College
 “Algebraic Number Theory, an “Ideal” Subject”

Shawn Rafalski, Fairfield University
 “Small Hyperbolic Polyhedra”

Karl Rohe, University of California, Berkeley
 “An Introduction to Clustering and the Spectral Clustering Algorithm”

Cesar Silva, Williams College
 “Mu-Compatible Metrics and Measurable Sensitivity”

Mihai Stoiciu, Williams College
 “Spectra of Non-Hermitian Operators”
 “The Asymptotic Behavior of the Pseudospectrum of a Square Matrix”
 “Sturm Oscillation Theory for Unitary Matrices”

Andrew Womack, Washington University in St. Louis
 “Information Theory and Invariance in Bayesian Statistics”

Mathematics Student Colloquia by 2011 Graduates

Antoniya Aleksandrova	“Random Matrices and Wigner’s Semicircle Law”
Nicholas Arnosti	“Continued Fractions and Diophantine Approximation”
Benjamin Atkinson	“Phylogenetic Trees: A Geometric and Combinatorial Approach”
Nicole Ballon-Landa	“Check Digit Schemes”
Ran Bi	“From the Unit Interval to Much More: Space-Filling Curves”
Ariel Binder	“Love Mathematically”
Christine Bowman	“Cryptographic Hash Functions”
Camille Chicklis	“Firefly Synchronization”
Daniel Costanza	“Statistical Limbo: How Low Can You Go?”
Sara Dwyer	“Non-Parametric Statistics and the Search for Extrasolar Planets”
Aaron Ford	“Optimal Pricing with Loyalty”
Daniel Franck	“German Tank Problem”
Robert Hannigan	“Statistical Quality Control as an Investment Strategy”
Katherine Hunter-Smith	“Methods of Approximation”
Leah Hurwich	“The Shape of Irrationality”
Michael Ives	“Cayley and Catalan Count Trees, in Space and On A Plane”
Thelonious Jensen	“The Beauty Contest Problem: Choosing the Maximum of a Sequence”
Daniel Kenefick	“Continuous Functions with Divergent Fourier Series”
Patricia Klein	“Finding Algebraically Closed Fields”
Jake Levinson	“Groebner Bases: An Ideal Way to Color Graphs”
Ang Li	“Cancer Stem Cell, Niche and Proliferative Signalling on Tumor Development and Treatment Response: A Mathematical Model”

Andrew Liu	“Generating Random Variables”
Meredith McClatchy	“Have a Hat?”
Nancy McInerney	“Robot Motion Planning”
Alex Mendels	“Chaos and the Lorenz Water Wheel”
Yuzhong Meng	“Differentiating the Undifferentiable and Solving PDEs”
Brendan Munzar	“Surreal Numbers and Their Applications in Combinatorial Game Theory”
Connor Olvany	“Probability and Graph Theory: An Unlikely Marriage”
William Palmer	“Hamming Codes: The Perfect Way to Send a Message”
Sean Pegado	“Elliptic Curves and Mordell’s Theorem”
Jay Petricone	“Optimal Sports Draft Strategies”
Thuy Pham	“Stochastic Linear Programming”
David E. Phillips	“Balls to the Wall: Pushing the Combinatorial Limits of Juggling”
Laura Pickel	“Constructing Regular n-gons Using Compass and a Straightedge”
Ellen Ramsey	“The ABC Conjecture”
Steven Rubin	“Tiling Your Bathroom Floor With Rectangular Tiles”
Ville Satopaa	“Simultaneous Confidence Interval Estimation – Part I”
T. Elliott Schrock	“Dirichlet’s Theorem on Arithmetic Progressions: L-Functions and Primes”
Meghan Shea	“From Peace Treaties to Divorce Settlements: Does Someone Always Get the Better Deal?”
Hyun Gea Shin	“Hathaway’s Circular Pursuit Problem”
Robert Silversmith	“Dynamics in the p-adic Numbers”
Evan Skorpen	“Forecasting with Autoregressive Functions”
Anna Soybel	“I Don’t Want to Do the Dishes”
Catalina Stoica	“Misuse of Statistics in the Court: The Case of Lucia de Berk”
Ashley Taylor	“The Conway Napkin Problem”
David Thompson	“Group Theory and the Rubik’s Cube”
Rebecca Tyson	“Latin Squares”
Philip Vu	“The In-Between Worlds: Understanding Non-integer Dimensions with the Hausdorff Measure”
Jacob Wagner	“Cellular Automaton Models for Traffic Flow”
Zhaoning Wang	“Fibonacci Nim: How Number Theory Allows you to Always be a Winner”
Daniel Waters	“The Weierstrass Approximation Theorem”
Stephen Webster	“Choose Wisely: The Polyhedral Geometry of University Rankings”
Dean Weesner	“Optimizing Auctions”
Elena Wikner	“Conics in the Projective Plane”
Wentao Xiong	“An Introduction to Surfaces, Polygons, and Fundamental Groups”

Off-Campus Colloquia

Colin Adams
 “Making Math Fun”
 University of Texas at Tyler
 “The Great Calculus Debate”
 with Thomas Garrity, Siena College
 Joint Mathematics Meetings, New Orleans, LA

“Blown Away: What Knot to Do When Sailing”
Hampshire College
Ohio State Young Mathematician’s Conference, Columbus, OH
University of California, Irvine
Iona College
Loyola Marymount University
Eastern Kentucky University
University of Texas at Tyler

Elizabeth Beazley

“Maximal Newton Polygons and the Quantum Bruhat Graph”
University of Pennsylvania
“Several Partial Orderings on the Set of Permutations”
Swarthmore College
“Affine Deligne-Lusztig Varieties in the Affine Flag Variety”
University of Massachusetts, Amherst
“Quantum Schubert Calculus and Maximal Newton Polygons”
Affine Schubert Calculus Workshop, Fields Institute

Satyan Devadoss

“Colloquium”
AMS Section Meeting at Syracuse, NY
Central Connecticut State University
Pomona College
“Martin Lecture Series”
Johns Hopkins University
“Pi-Mu-Epsilon Lecture”
Siena College
“Veritas Forum”
Caltech

Richard De Veaux

“Successful Data Mining in Practice” Workshop
Abbott Laboratories, Chicago, IL
American Statistical Association Chapter, Kentucky
American Statistical Association Chapter, Honolulu, HI
New York State Comptroller’s Office, Albany, NY
New York State Comptroller’s Office, New York, NY
“The Seven Deadly Sins of Data Mining”
JMP Discovery 2100, Cary, NC
Federal Reserve Bank of Philadelphia
M2010 Conference (SAS), Las Vegas, NV
Mathematics Association of America, NJ Chapter, Newark, NJ
ICI Conference, Cavtat, Croatia
“What’s That in the Road? A Head?”
The Lawrenceville School, Lawrenceville, NJ
“Teaching Statistics via Story Telling”
Decision Sciences Institute Conference, San Diego, CA
Decision Sciences Institute Conference, Savannah, GA
“Play it Again, Sam: Resampling and Simulation in Intro Stats”
International Conference on Technology for College Mathematics (ICTCM), Denver, CO
“Data Mining: Fool’s Gold? Or the Mother Lode?”
“Data Mining Under the Hood: Bagging and Boosting”
St. Olaf College, Northfield, MN

“JMP Explorers’ Series: Exploring Interactive and Visual Data Mining”

Atlanta, GA, (July 2010 & June 2011)

Carlsbad, CA

Baltimore, MD

London, England, (November 2010 and March 2011)

Paris, France, (November 2010 and March 2011)

Frankfurt, Germany

Milan, Italy

Pittsburgh, PA

Boulder, CO

“Data Mining Workshop for High School Teachers”

Mass Insight, Bentley, MA

Thomas Garrity

“On Writing Numbers”

Hampshire College

College of Wooster

“Derivative vs. Integral: The Final Smackdown”

with Colin Adams, Siena College

“Derivative vs. Integral: The Final Smackdown”

Annual MAA Meetings, New Orleans, LA

“Generalizing Stern’s Diatomic Sequences via Multidimensional Continued Fractions”

AMS Special Session, New Orleans, LA

Bernhard Klingenberg

“Comparing Margins of Multivariate Binary Data”

ENAR Spring Conference, Miami, FL

“Exchangeability for Multivariate Binary Observations”

International Society for Clinical Biostatisticians, Montpellier, France

“Simultaneous Score Bounds for Risk Differences”

Karolinska Institute, Sweden

Medical University of Vienna, Austria

Susan Loepf

“These are a Few of my Favorite Rings: Ideas for Inspiring Students to Like Abstract Algebra”

MAA Northeastern Section Fall Meeting

“The Key to Sending Secret Messages”

“Protecting your Personal Information: An Introduction to Encryption”

St. John Fisher College

Steven Miller

“Sage Days 21: Progress Report on Statistics in Function Fields, Sage Days 21”

Seattle, Washington

“Cookie Monster meets the Fibonacci Numbers. Mmmmmm – Theorems!”

CUNY Graduate Center, New York, NY

Hampshire College

Smith College

Pi Mu Epsilon Induction Ceremony, College of the Holy Cross

Workshop on Combinatorial and Additive Number Theory (CANT 2010), CUNY Graduate Center,
New York, NY

“Eigenvalue Statistics for Toeplitz Ensembles”

Bangalore, India

“From the Manhattan Project to Elliptic Curves”

Smith College

“From Cookie Monster to the IRS: Some Fruitful Interactions Between Probability, Combinatorics and Number Theory”

University of North Carolina

“Pythagoras at the Bat: An Introduction to Mathematical Modeling”

Virginia Tech

“Painleve VI and Tracy-Widom Distributions in Random Graphs, Random Matrix Theory and Number Theory”

AMS Special Session, Worcester, MA

“Mentoring Undergraduate Research”

AMS Special Session, College of the Holy Cross

“An Introduction to Matlab in Mathematics”

IAS Women in Mathematics Conference

Frank Morgan

“Densities from Geometry to Poincaré”

Canadian Undergraduate Mathematics Conference, Toronto

Kent State University

Fields Institute of Mathematics

Mahidol University, Bangkok

“Geometric Measure Theory Course”

San Paulo, four lectures

“New Isoperimetric Theorems”

Hampshire College

“Baserunner’s Optimal Path”

Mathfest, Pittsburgh, PA.

Abdus Salam School of Mathematical Sciences, Lahore, Pakistan, four lectures on Geometric Measure Theory

National University, Hanoi

Universiti Malaya, Malaysia

“Geometric Measure Theory, Densities, and Soap Bubbles”

Fields Institute

“Log Convex Density Conjecture”

University of California, Los Angeles

“Pentagonal Tilings and Other Partition Problems”

University of Toronto

“Double Bubbles from Euclidean to Gauss Space”

University of Toronto

“Isoperimetric Problems with Density”

New Orleans Joint Mathematics Meetings

Center for Advanced Mathematic and Physics, Islamabad, Pakistan

“Soap Bubble Geometry Contest”

Westside High School, Provo, Utah

“Double Soap Bubble Theorem”

Brigham Young University

Quaid-i-Azam University, Islamabad, Pakistan

“Isoperimetry and the Log-Convex Density Conjecture”

Centennial Congress RSME, Avila, Spain

“My Math Chat Live Call-In Show”

Brigham Young University

“Double Soap Bubble Theorem” and hands-on activities at Flandreau Planetarium Theater

University of Arizona, Tucson

“AMC Recognition Program”

Brigham Young University

“Soap Bubble Clusters”

University of Connecticut, Storrs

“Soap Bubbles and Mathematics”

For teachers of All Pakistan Mathematical Association at Pakistan Academy of Sciences

Punjab University, Lahore, Pakistan

Thai Nguyen, Vietnam

Math. Assn., Thailand

National University of Singapore High School

National Science Center (PSN), Malaysia

Al-Amin School, Malaysia

“Densities from Geometry to the Poincaré Conjecture”

Institute of Mathematics, Hanoi

Inst. Math. University of the Philippines

“Isoperimetric Problems”

“Students and Current Research”

“Soap Bubbles and Soap Films”

Hue, Vietnam

“Proof of the Double Bubble Conjecture”

Hochiminh City

Chulalongkorn U., Bangkok

“Isoperimetric Problems”

Thammasat U., Bangkok

2nd Singapore Mathematical Symposium, Nanyang Technological University, Singapore

“Teaching Geometry by Guessing What Soap Bubbles Will Do”

Clementi Town Secondary School, Singapore

“Students and Current Research”

National Institute of Education, Singapore

“Soap Bubbles and Mathematics, Popularization of Mathematics and MathChat TV”

Universiti Malaysia Terengganu

“Innovative Teaching in Mathematics, Soap Bubbles and Mathematics”

Universiti Putra Malaysia

“Soap Bubbles and Mathematics, Current Research and Innovation in Mathematics”

Universiti Teknologi Mara, Malaysia

“Popularization of Mathematics and MathChat TV”

National Science Center, Malaysia

“Innovative Teaching of Calculus: Max-Min Problems, Soap Bubbles and Mathematics”

Universiti Kebangsaan Malaysia

“Soap Bubbles”

University of the Philippines

“The Double Soap Bubble Theorem”

Ateneo de Manila University, Philippines

“Soap Bubbles and Mathematics: The Amazing Shapes of Minimal Surfaces”

Museum of Mathematics, New York City

Allison Pacelli

“Algebraic Number Theory: An “Ideal” Subject”

Wellesley College

Summer Program for Women in Mathematics, George Washington University

“Algebraic Number Theory & Fermat’s Last Theorem”

Siena College

“Class Number Indivisibility”

Brown University

“Indivisibility of Class Numbers in Global Function Fields”

Canadian Number Theory Conference

“Math and Politics in the Undergraduate Colloquium”

Arcadia University

Cesar Silva

“Ejemplos y contraejemplos en teoría ergódica”

series of five talks, International School CIMPA-UNESCO, IMCA, Lima, Peru

Mihai Stoiciu

“Mathematics Colloquium”

“Analysis and Geometry Seminar”

Rice University

“Probability Seminar”

University of Toronto

“Orthogonal Polynomials on the Unit Circle, CMV Matrices, and the Distribution Theory”

Universidad Nacional Autónoma de México, Mexico City

“Mathematics Colloquium”

Mathematics Institute, Cuernavaca, Mexico

“Spectral Theory”

AMS Central Sectional Meeting, Iowa City, IA

“Spectral Theory and Wave Processes in Periodic and Random Media”

University of North Carolina, Charlotte

“Random Processes”

AMS Special Session, College of the Holy Cross

Postgraduate Plans of Mathematics Majors

Nicholas Arnosti	Pursuing a Ph.D. in Operations Research in the Department of Management Science and Engineering at Stanford University
Ariel Binder	Research Assistant at International Monetary Fund in Fiscal Operations Division in Washington, DC then pursuing a PhD. in economics
Christine Bowman	Attending Emory University School of Medicine
Aaron Ford	Working as an Investment Banking Analyst at JP Morgan in the Tech, Media, Telecom group.
Daniel Franck	Consultant for Booz Allen Hamilton
Robert Hannigan	Analyst at a boutique investment bank specializing in M&A advisory and related financing
Leah Hurwich	Working for Raytheon
Jake Levinson	Pursuing a Ph.D. in Mathematics at the University of Michigan
Ang Li	Pursuing a MD/Ph.D. at Columbia Medical School
Andrew Liu	Investment Fellowship with T. Rowe Price in Baltimore, Maryland
Yuzhong Meng	Research Assistant in cancer biology lab at the Whitehead Institute for Biomedical Research in Cambridge, MA, while applying to medical school.
Sean Pegado	Working as an Analyst at Cornerstone Research, an economic consulting firm in NYC
Jay Petricone	Working at Audax Group, a private equity firm in Boston
David E. Phillips	Working in consulting with Deloitte Consulting in Boston
Ellen Ramsey	Working as an analyst at Promontory Financial Group in New York

Steven Rubin	Pursuing a Ph.D. in Computer Science at University of California, Berkeley
Ville Satopaa	Traveling a lot this summer: Spain, Denmark, England, Finland (home), and Lapland (northern parts of the Northern Europe). Fall 2012 pursuing a Ph.D. in statistics at the Wharton School, University of Pennsylvania.
Meghan Shea	Working as a analyst for Compass Lexecon, an economic consulting firm
Robert Silversmith	Pursuing a Ph.D. in Pure Mathematics at the University of Michigan
Evan Skorpen	Working at Bain Consulting in New York
David Thompson	Working at Bain & Company as an associate consultant
Philip Vu	Taking a gap year, then attending graduate school in mathematics
Jacob Wagner	Investment banking at GS
Zhaoning Wang	Pursuing a Ph.D. in Economics at Harvard University
Stephen Webster	Working as a consultant at Booz Allen Hamilton
Dean Weesner	Economic consulting in Menlo Park, California

PHYSICS DEPARTMENT

The Physics Department has had a very exciting year. The American Physical Society presented Christopher Chudzicki'10 with the annual Leroy Apker Award for outstanding American undergraduate research. Williams Physics has won four of the past twelve Apker Awards, an amazing and unprecedented achievement.

A Fall 2010 external visiting committee described the Physics Department as "one of the top physics programs in the Nation" and "one of the most brilliant jewels of Williams College." Another remarked, "It is not a coincidence that year after year Williams College is the top choice for a disproportionately large number of high school seniors who want to major in physics. The Department of Physics at Williams College offers one of the very best undergraduate programs in the country."

Thirteen Physics and Astrophysics majors graduated in June. Seven are starting graduate work in science or engineering this fall. Others plan to work as a NYC teaching fellow, a lab instructor at Williams, a research technician at Raytheon, and an analyst at Bain & Company, proving again that physics is a great preparation for many professions.

The Physics and Astronomy colloquium program was excellent this year, headlined by Nobel Laureate Steven Weinberg's presentation "The Dark Side of the Universe." We were also delighted to have four alumni (Brian Wecht '97, Justin Brown '05, Ned Ladd '86, and Laura Brenneman '99) return to give presentations and to meet with students to talk about the paths they've taken in their careers.

Finally, the Department is excited to welcome Visiting Assistant Professor Michael Seifert who will join us during Sarah Bolton's term as Dean of the College, Administrative Assistant Michele Rech, Assistant Lab Instructor Tony Lorenzo'11, and Postdoctoral Research Fellow Gambhir Ranjit.

In the Aalberts Lab, thesis students Jeff Meng'11 created a polymer-physics model for stretched loops related to small RNA-mRNA binding and Becca Sullivan'11 described the importance of including thermal fluctuations around consensus RNA structures. He also worked with Scientific Programmer Bill Jannen '09 on an algorithm to cluster related RNA structures. Collaborations with Joel Clemmer'12 and Julian Hess'13 begin this summer.

Emeritus Professor Stuart Crampton presented some ideas about how physics may suggest ideas about God to a forum at a local church and followed that up in an article in the student publication Telos. He continues to serve as a scientific consultant to the Murdock Trust, a foundation supporting science in the five northwest states, and is an Emeritus Director of Research Corporation, America's oldest foundation devoted exclusively to science.

Professor Kevin Jones coordinated a successful grant application to the Summer Undergraduate Research Fellowship program of the National Institute of Standards and Technology (NIST). The grant is supporting two students, Christina Knapp'13 and David Kealhofer'13, to do research at the Gaithersburg Maryland NIST campus for 11 weeks during summer 2011. In addition, Jones has a separate grant enabling him to be a Guest Researcher at NIST. Jones and the two students are working with Dr. Paul Lett in the Laser Cooling and Trapping Group headed by Dr. William Phillips. They are building a diode laser system to produce light suitable for interacting with cesium atoms. If all goes well, they will be using the non-linear optical properties of cesium atoms to modify the laser light and produce non-classical, quantum entangled, beams of light. This work, if successful, will extend the NIST group's previous scheme for "twin beam" generation in atomic vapors to a new wavelength regime. As a side project, Christina and David are designing a magnet for use in a quantum memory experiment.

In addition to the project with the two students, Jones is also working with post-docs and graduate students at NIST on other projects begun during prior visits to NIST. All of the work is related in one way or another to producing and manipulating non-classical states of light. Such states are of interest for quantum information processing and enhanced imaging techniques. Jones and his colleagues are preparing a manuscript describing their recent results on single beam "squeezed vacuum" produced by a non-linear

interaction between light and Rubidium atoms. In the lab they are working to extend these initial results to construct and characterize a “noiseless” image amplifier.

Research in Assistant Professor, Ward Lopes’s lab continued with the themes of studying the self-assembly of organic molecules and using holographic control of light for micromanipulation.

Leah Hurwich’11 continued work begun by Scott Olesen’10 to investigate a common assumption that the microscopic mechanisms by which materials become more ordered depend only upon the fundamental symmetries of the material in question. Both Leah and Scott studied a class of organic molecules, which self-assemble to form stripes. Defects in the striped pattern are free to move when the sample is heated and they tend to annihilate in order to reduce the energy of the sample. The mechanisms by which defects in striped samples annihilate are well studied and it is believed that all striped samples behave the same way. Scott, however, observed many annihilation events, which run counter to the previously observed annihilation mechanisms. Leah’s data also came to the same conclusion.

On the optical side of the lab, Peter Gottlieb’11 continued Joseph Skitka’s’10 work investigating algorithms for calculating phase-only holograms. Holographic Optical Trapping (HOT) is a method for optical micromanipulation. For various historical and practical reasons, the holograms used in HOT use only the phase degrees of freedom of the light used in optical micromanipulation. This greatly increases the difficulty and time to calculate appropriate holograms. Joe discovered and numerically tested a couple of algorithms which give improved theoretical performance in less computational time than well established algorithms used for calculating phase only holograms. Peter tested and characterized how well these algorithms operate in a laboratory environment as part of his thesis work. Peter was awarded Highest Honors in Physics for his thesis.

This summer Ward starts his Assistant Professor Leave. During his sabbatical, he will travel to the University of Illinois at Urbana-Champaign to work on imaging problems in Biophysics, which use holographic techniques. With the balance of his time, he will be working in his lab in Williamstown to finish off the projects started by the students in his lab.

During the 2010-2011 academic year Professor Tiku Majumder began his term as Director of the Science Center and Chair of the Science Executive committee. In his administrative role, he has supervised and supported faculty research funding, the student research program, as well as numerous projects related to facilities, development, and admissions, which relate to the Science Center. He also taught Quantum Mechanics, PHYS 301, and its associated advance laboratory, to a record number of 23 students in the fall of 2010. He continued to pursue diode laser and atomic physics experiments in his research lab, teaming up with senior thesis student Antonio (Tony) Lorenzo’11, and newly hired post-doc Dr. Gambhir Ranjit. Gambhir was hired with funds from Majumder’s new \$300,000 NSF grant which will also supports purchase of numerous new pieces of scientific equipment over the next three years.

The Majumder lab continues to pursue very high precision measurements of atomic structure of heavy metal elements such as thallium and indium. These measurements test state-of-the-art calculations of atomic structure in these multi-electron atoms, and are useful in providing ‘table-top’ tests of fundamental physics of the sort normally associated with elementary particle theory and high-energy accelerators. Two recent senior thesis students, Charles Cao ‘09 (now at Princeton) and Paul Hess ‘08 (now at Harvard) helped to complete the group’s first spectroscopy experiment in indium, using a stabilized 410 nm diode laser and a sealed, heated quartz vapor cell. This work was published in the journal Physical Review A, with these students as co-authors. Tony Lorenzo is now using this same laser system to study indium in the confines of a high-vacuum chamber by producing a high-flux atomic beam of indium. Tony, with help from our new model-maker, and design engineer Michael Taylor, designed, tested and installed a new source oven capable of reaching 1000 degrees C under vacuum. Using a very sensitive frequency-modulation spectroscopy technique, he has measured, for the first time, absorption signals in the atomic beam environment, demonstrating the feasibility of this experiment.

Incoming thesis student Andy Schneider’12 will build upon Tony’s work, and complete an atomic beam measurement of the Stark shift (by applying electric fields of 30,000 V/cm to the atoms) in indium beginning in June 2011. Andy will be joined this summer by Taryn Siegel’12, who will be working on

thallium spectroscopy using a UV diode laser, and Nathan Schine'13 who has already spent a very productive WSP month working in the Majumder lab. Finally, Prof. Majumder will be giving an invited talk and serving as a discussion leader at this year's biennial Atomic Physics Gordon Research Conference at the end of June.

Professor Jefferson Strait and his students have built and are studying an optical fiber laser that produces pulses of light about one picosecond long. Unlike most lasers, which use mirrors to confine light to the laser cavity, an optical fiber laser uses a loop of fiber as its cavity. A section of fiber doped with erbium acts as the gain medium. It lases at 1.55 microns, conveniently the same wavelength at which optical fiber is most transparent and therefore most suitable for telecommunications. This laser functions as a test bed for short pulses of light propagating in fiber.

During the summer of 2010 Takuto Sato'12 and Nathaniel Lim'11 worked with Strait testing the laser and refining a model describing pulse formation in it. The polarization of light in the laser cavity plays an important role, so they carefully measured the transmission of the laser cavity as a function of polarization. Nathaniel continued to work with Strait during the academic year and wrote his honors thesis on these experiments.

During the fall semester Strait taught 108, Energy Science and Technology for the third time. This course aimed to give non-natural science majors a quantitative approach to issues in energy supply and use. After an introduction to some basic physical principles, the course covered electric power generation (fossil fuels, nuclear, photovoltaic solar cells, wind turbines), transportation (internal combustion engines, electric cars, hybrid cars, hydrogen fuel cell cars) and energy efficient building technologies.

Strait serves as pre-engineering advisor, department webmaster, and College Marshal, the faculty member responsible for coordinating the Convocation and Commencement ceremonies. In September 2010 Strait organized the induction of Adam Falk as the College's new president.

Assistant Professor, Frederick Strauch continued his theoretical work in superconducting quantum circuits, quantum algorithms, and other applications to quantum information processing. His recent work on quantum routing with Chris Chudzicki'10 (now at MIT) was published in Physical Review Letters, one of the top journals in physics, and Chris's senior thesis was honored by the national Leroy Apker Award for undergraduate achievement in physics from the American Physical Society (APS). Chris presented his work at a special invited talk at the APS March Meeting in Dallas, where fellow research Steven Jackson'10 (now at Princeton) also contributed a talk based on his senior thesis.

The quantum routing research was supported by a grant from the Research Corporation for Science Advancement, and was continued in the summer of 2010 with Praphruetpong (Ben) Athiwaratkun'12 and Qiao Zhang'13. Ben verified theoretical predictions for quantum routing with decoherence, while Qiao developed a method to visualize the dynamics of quantum state transfer.

Strauch continued collaboration with Kurt Jacobs at the University of Massachusetts Boston to study quantum control and measurement of superconducting resonators using high-performance parallel computing. Their first work was published in Physical Review Letters, in collaboration with Ray Simmonds of the National Institute of Standards and Technology, and is now supported by a continuing grant of \$233,186 from the National Science Foundation. This work was continued during 2010-2011 year by independent research by Douglas Onyango'11 (who is heading to Columbia University next year). Finally, Samyam Rajbhandari'11 completed a senior honors thesis on decoherence and encoding of quantum walks, and will be studying computer science at Ohio State University next year.

Strauch taught PHYS 411 in Fall semester 2010, an advanced tutorial on Classical Mechanics, for which he developed a number of new computer simulations. In Spring semester 2011, he taught PHYS 132, Electromagnetism and the Structure of Matter, the second of the department's introductory physics sequence for non-majors, for which he incorporated the PhET physics simulations developed by Nobel Prize physicist Carl Wieman. This latter was inspired by a workshop he attended in Summer semester 2010 by the American Association of Physics Teachers on innovations in undergraduate teaching of physics.

During the 2010-2011 academic year, Associate Professor David Tucker-Smith was on sabbatical as a visiting researcher at NYU's Center for Cosmology and Particle Physics and at the Institute for Advanced Study at Princeton. Tucker-Smith collaborated with colleagues on projects in theoretical particle physics, focusing on how models can be tested at Fermilab's Tevatron and at the Large Hadron Collider. Tucker-Smith also participated in the workshop embarking on a New Era of Discovery: LHC, dark matter, and their interplay, at the Berkeley Center for Theoretical Physics, and reviewed proposals for NSF.

In the summer of 2011 will work with Dylan Gilbert'13, Murat Kologlu'12, and Margot Robinson'12 on particle physics models and their experimental signatures. Murat and Margot will continue their research during the academic year as senior honors thesis students. In the fall semester of 2011 Tucker-Smith will teach Newton, Einstein and Beyond (PHYS 107), a course intended for non-scientists, and in the spring semester he will teach Mathematical Methods for Scientists (PHYS 210), and an introduction to Einstein's general relativity, Gravity (PHYS 418).

Professor Bill Wootters worked this year with Antoniya Aleksandrova'11 on a project investigating a version of quantum mechanics based on real numbers instead of the usual complex numbers. They found that the real-number theory agrees with ordinary quantum mechanics in a certain limit but that the two theories diverge subtly from each other as one moves away from the limiting case. It remains for future research to determine how one might test the alternative theory experimentally. In the summer of 2011 Prof. Wootters will work with Victoria Borish'12 and Roshan Sharma'13.

Prof. Wootters participated in a few conferences this year, including the American Physical Society's March meeting, where he was pleased to attend talks by a number of former students. He gave the keynote address at a meeting of the Anacapa Society, an organization that supports research in theoretical physics at undergraduate institutions.

Class of 1960 Scholars in Physics

Antoniya A. Aleksandrova
Peter K. Gottlieb
Leah Hurwich

Nathaniel Lim
Antonio Lorenzo
Yuzhong Meng

Samyam Rajbhandari
Rebecca Sullivan

Department Colloquia

[Colloquia are held jointly with the Astronomy Department.]

Prof. Sarah Demer, Yale University
"Hunting for New Physics with CERN's Large Hadron Collider"

Prof. Courtney Lannert, Wellesley College
"Studying Quantum Dynamics with Ultracold Atomic Gases"

Prof. Pan Li, University of Albany
"Effect of Mg²⁺ Ions on Mechanical Unfolding of a Hairpin"

Prof. Luis Orozco, University of Maryland
"Grand State Quantum Beats"

Prof. Ophelia Tsui, Boston University
"Glass Transition Temperature of Polymer Films"

Dr. Brian Wicht '97, University of Michigan
"Supersymmetry as a Theoretical Toolbox"

Dr. Meg Schwamb, Yale University
"The Solar System Beyond Sedna"

Justin Brown '05, Princeton University
"A New Limit on Lorentz – and CPT – Violating Neutron Spin Interactions"

Prof. Bill Wootters, Williams College
"Physics in Rwanda"

Prof Ned Ladd '86, Bucknell University & Harvard /Smithsonian Center for Astrophysics
 “Why aren’t There More Stars? The Battle Against Gravity in our Galaxy’s Nurseries ”

Dr. Laura Brenneman '99, Harvard/Smithsonian Center for Astrophysics
 “Spinning Black Holes”

Prof. Graziano Vernizzi, Siena College
 “RNA Folding and Random Matrix Theory”

Prof. Steven Weinberg, Nobel Laureate, University of Texas
 “The Dark Side of the Universe”

Prof. Steven Girvin, Yale University
 “The Race to Build a Quantum Computer”

Other on Campus Presentations

Frederick Strauch
 “From cuckoos to qubits: Quantum Computing by Exciting Oscillators”
 Summer Science Program Talk, Williams College (July 20, 2010)

Bill Wootters
 “Keeping It Real: Quantum Mechanics without Complex Numbers”
 Bronfman faculty lunch talk, November 9, 2010

Off-Campus Colloquia

Daniel P. Aalberts
 “RNAbows: an intuitive tool for visualizing RNA structures”
 poster presentation at the Biology of Post-Transcriptional Gene Regulation Gordon Research Conference (with Bill Jannen '09)

Tiku Majumder
 “Precise Measurement of the Stark Shift within the $5P_{1/2} - 6S_{1/2}$ Transition in Indium -115”
 poster presentation at Division of Atomic, Molecular, and Optical Physics conference, Atlanta, GA
 (with Antonio Lorenzo'11 and Gambhir Ranjit, Post-doc)

Frederick Strauch
 "Arbitrary Control of Entanglement between Two Superconducting Resonators"
 QUEST Workshop sponsored by Los Alamos National Laboratory, Santa Fe, NM (August 23, 2010)

"Arbitrary Control of Entanglement between Two Superconducting Resonators"
 Bits and Waves Laboratory Seminar, BBN, Cambridge, MA (September 30, 2010)

"Quantum Logic Gates for Coupled Superconducting Resonators"
 American Physical Society March Meeting, (March 21, 2011)

David Tucker-Smith
 “An Effective Z”
 University of Maryland particle theory seminar, April 2011
 Boston University particle theory seminar, May 2011
 UC Berkeley particle theory seminar, May 2011
 SLAC particle theory seminar, May 2011

Bill Wootters
 “Introduction to Mutually Unbiased Bases” and “States that Look the Same in Each Basis of a Complete Unbiased Set”
 Workshop on Quantum Theory in Higher Dimensions, Traunkirchen, Austria, July 2010

“Doing Physics with Undergraduates in Williamstown and Kigali”
 meeting of the Anacapa Society, Pomona, CA, December 2010

“Isotropic States in Discrete Phase Space”
 APS March meeting, Dallas, TX, March 2011

Postgraduate Plans of Department Majors

Antoniya A. Aleksandrova	Herchel Smith fellow, PhD program in physics, University of Cambridge, England
Peter K. Gottlieb	M.S. program in mechanical engineering, Stanford University
Leah L. Hurwich	Employed at Raytheon, Waltham, MA
Nathaniel J. Lim	M.S./PhD program in mechanical engineering, Boston University
Antonio T. Lorenzo	Laboratory instructor, Williams College
Douglas O. Onyango	4/2 program in mechanical engineering, Columbia University
Samyam Rajbhandari	PhD program in computer science, Ohio State University
Todd Elliott Schrock	Graduate school in math at NYU
Rebecca C. Sullivan	NYC Teaching Fellow, New York, NY
David A. Thompson	Consulting at Bain & Co., Boston, MA
Hai Zhou	Seeking employment in Boston, MA

PSYCHOLOGY DEPARTMENT

The psychology major at Williams College attracts a very large number of students with diverse interests, goals, and backgrounds. Our students follow a curriculum that teaches them not only about what we know about mind and behavior, but also about how we know it, using experiential teaching as our core pedagogy. Students learn how to use the methods of scientific inquiry to critically evaluate information, generate new knowledge and imagine its implications and applications in the world. Students take a range of courses spanning the sub-disciplines of neuroscience, cognitive, clinical, developmental, and social psychology, as well as the psychology of education.

Psychology students have multiple opportunities to conduct research collaboratively with professors. Some of these are empirical projects conducted within required 300-level lab courses, and others are in work-study or research assistant positions or as more formal independent studies. Also, in 2010-2011, nine students completed year-long senior honors thesis research under the direction of Psychology faculty, on topics such as “My Wish is Your Command: Associations between Subclinical Narcissism and Impression Management,” “Temperamental Fearfulness and Proneness to Anger and Physiological Response to Loss of Social Contingency in Infants and Preschoolers,” “The Magnitude Effect on the Discounting of the Utility of Delayed Rewards,” and “Let’s Not, and Say We Would: The Discrepancy between Imagined and Real Responses to Homophobia.” Their projects are listed in the Student Abstracts section of this report.

Department events this year included student/faculty/family picnics, an evening program on “Graduate Study in Psychology”, and a wine and cheese reception to celebrate honors thesis presentations in the Psychology Lounge. A group of our majors organized a new club, P.S.Y.K. (“Psychology Students Yearning for Knowledge”), and had frequent meetings this spring to discuss recent journal articles. To encourage students to explore careers in psychology, the Class of 1960 Scholars Program brought accomplished researchers from other colleges and universities to campus to give colloquia. In advance of the colloquia, the group of 1960 Scholars read and discussed the speakers’ work with a faculty member and then joined the speaker and faculty for dinner afterward. A highlight this year was the visit of Daniel Schacter from Harvard. The 2010-2011 Class of 1960 Scholars are listed below. This year marked the fourth year of the G. Stanley Hall Prize in Psychology, funded by a generous gift from the Chuzi family, parents of Sarah Chuzi ’07, and given at graduation to a student who has demonstrated exceptional achievement in psychology. We were happy to award the prize to our two top students, who shared the prize: Joshua Wilson’11 and Johannes Wilson’11.

Class of 1960 Scholars in Psychology

Erin Altenburger	Sa-Kiera Hudson	Marissa Pilger
Chelsey Barrios	Aaron Lim	Veronica Rabelo
Quaneece Calhoun	Su-Mai Lin	Gary Roberson
Tasha Chu	Jackson Lu	Shivon Robinson
Laura Corona	Stephen Maier	Sarah Weber
Janna Gordon	Cam Nguyen	Stephanie Wren
Elizabeth Greiter	Laura Pickel	Fhatarah Zinnamon

The faculty of the Psychology Department continued their varied and productive teaching and research programs, as detailed below. We note with pride Laurie Heatherington’s winning the Distinguished Contribution to Family Systems Research Award from the American Family Therapy Association. We were happy to welcome back our colleague Ari Solomon as a visitor. Ari introduced a new course this year, Advanced Topics in Personality, which will be offered again next year. Also arriving next year will be Kate Stroud, a clinical psychologist coming to us from her postdoctoral training at Northwestern University. Kate’s research on depression in adolescence will be an important contribution to the range of our teaching in the clinical psychology subfield. Also joining us next year will be Carin Perilloux from the University of Texas at Austin. Carin’s area of research is evolutionary psychology, and she will be teaching that approach to psychological issues as well as contributing to the social psychology subfield. Through all of these activities as well, we could not function without the invaluable help of C.J. Gillig, Psychology Department Technical Assistant, and Beth Stachelek, Department Administrative Assistant. Their wisdom

and cheerfulness, as well as ability to step in, often at the last minute, to support our work, is well-known to students from Introductory Psychology through senior honors thesis students, and they help keep our large department feeling friendly and accessible. It is deeply appreciated by faculty as well.

Professor Phebe Cramer attended the national meeting of the Society for Personality Assessment in Boston, Massachusetts in March, where she presented a paper “Longitudinal Personality Change: The Role of Defense Mechanisms and IQ.” She also served as a discussant for the Symposium “TAT Defense Mechanisms with Diverse Samples and Methods”, and attended a meeting of the Consulting Editors for the *Journal of Personality Assessment*.

Professor Cramer continues her research on life-span development of personality, with a special interest in defense mechanisms and narcissism. In this area, she has published two new papers: “Attachment Styles and Defense Mechanisms in Parents who Abuse their Children” (with Francis Kelly), and “Young Adult Narcissism: A 20 Year Longitudinal Study of the Contribution of Parenting Styles, Preschool Precursors of Narcissism, and Denial.” She has recently begun a collaborative research project with Dr. Lily Rothschild (Univ. of Haifa) to study the use of defense mechanisms in anorexic patients and a matched control group.

Jennifer Randall Crosby explored several aspects of intergroup interaction with a growing lab that included three thesis students, an independent study student, and 13 undergraduate research assistants who acted as experimenters, research confederates, and data coders. With thesis student Johannes Wilson’11, Professor Crosby examined the divide between how people think they will respond to anti-gay discrimination, and how they actually respond. With thesis student Madeline King’11 and Professor Ken Savitsky, Professor Crosby explored the experience of minority individuals in situations where they are the only member of their group, and when the conversation topic is related to their group membership (such as Black students in a conversation about affirmative action), finding that minority individuals in these situation experienced a sense of being “in the spotlight.” With thesis student Sa-Kiera Hudson’11, Professor Crosby explored how power and group membership affect the ability of individuals to make predictions about the preferences of others. In an Independent Study project with Su-Mai Lin ’2011, Professor Crosby investigated the influence of Black and White individuals in conversations about affirmative action.

In addition to on-campus research activities, Professor Crosby was chosen to present her research at the Franklin & Marshall Emerging Scholars Symposium on Identity in February of 2011. Professor Crosby acted as a reviewer for *Psychological Science*, *Journal of Experimental and Social Psychology*, and *Personality and Social Psychology Bulletin*, and attended the meeting of the Society for Personality and Social Psychology (SPSP) in San Antonio, TX.

This past year, Senior Lecturer Susan Engel published three more op-ed pieces in the New York Times, one of them with Marlene Sandstrom. She also published a piece in the Teachers College Record on new ways to measure what children learn in school. She made a presentation to Arne Duncan’s senior staff at the Department of Education in Washington DC on the educational needs of young children. She gave a series of lectures and readings in conjunction with her new book, *Red Flags or Red Herrings: Predicting Who Your Child Will Become*, published in February 2011 by Simon and Schuster, including an appearance on Good Morning America.

Professor Engel organized a conference which met in October 2011, in Chicago and was funded by the Spencer Foundation. Sixteen developmental psychologists gathered to devise new ways to measure what children learn in school. Madeline Wendt’11 helped coordinate and attended the meeting. Susan supervised Laura Corona’s honors thesis, in which they examined the dinner table conversations of families with children ages five and nine, to find out what kinds of questions children ask and hear when they are at home. She also supervised research by Maddy Wendt looking at how parental ambitions for children change as their children age.

During her fall 2011 sabbatical, Professor Engel served as the Director of Learning and Teaching for a public school district in Western Massachusetts. In the spring, the Program in Teaching hosted visits by Peter Dillon, Ed.D. and Sam Intrator, Ph.D. The program also held a roundtable discussion of the new National Core Curriculum.

Assistant Professor Amie Ashley Hane's research examines social and emotional development from infancy through middle childhood and integrates multiple levels of analysis, including behavioral, electrophysiological, and neuroendocrine methodologies. She conducted several studies in her laboratory this year in conjunction with students Julia Bender-Stern'13, Kaitlin Dinert'13, Chelsey Barrios'12, Cam Nguyen'12, Anna Szymanski'12, Ashley Turner'12, Erin Altenburger'11, Ian Murphy'11, Ellen Ramsey'11, and Sarah Weber'11. Professor Hane worked together with honors thesis student Ellen Ramsey on a study examining temperament and preschoolers' physiological responses to the loss of social contingency.

Professor Hane submitted two grants to the NIH this year, which are currently under review. She has continued to work in conjunction with colleagues at the University of Maryland where she is a co-investigator of a longitudinal project examining continuity in temperament from infancy through childhood. She also continued to work collaboratively with colleagues from the Department of Child and Adolescent Psychiatry at Columbia University on research examining maternal depression, mother-infant interaction, and infant self regulation. She is a co-investigator in an ongoing study at Columbia examining the effects of an intervention program for parents of infants admitted to a neonatal intensive care unit.

This year Professor Hane published original research in *Developmental Psychology*, *Developmental Psychobiology*, *Journal of Abnormal Child Psychology*, *Journal of Family Psychology*, and *Social Development*. Her research team presented peer-reviewed posters and papers at the biennial meeting of the Society for Research in Child Development in Montreal. Professor Hane gave invited talks this year at the University of Toronto and the University of Massachusetts, Amherst. Professor Hane became an Associate Editor of the *International Journal of Behavioral Development* and served as an ad-hoc reviewer for several other journals, including *Child Development*, *Developmental Psychology*, *Early Human Development*, *Emotion*, *Journal of Child Psychology and Psychiatry*, *Journal of Early Adolescence*, and *Journal of Reproductive and Infant Psychology*.

During the fall term and a spring semester sabbatical at Duke University, Professor Laurie Heatherington and her students continued research on change processes in psychotherapy, including ongoing research on the therapeutic alliance in couple and family therapy (in collaboration with colleagues at SUNY Albany and Universidad de La Coruña, Spain), predictors of retention and outcome in group CBT treatment for anxiety disorders (in collaboration with psychologists at the Brien Center and Berkshire Medical Center in Pittsfield, MA), and outcomes of residential treatment for major mental illness. They also studied the outcomes of a NAMI-directed training for Berkshire County police officers in handling cases involving emotionally disturbed persons. Her students pursued their own thesis and independent study research projects as well, on the role of social cognitive factors in interpersonal relationship difficulties, the predictors of stigma and other judgments of children with ADHD, and international psychology.

Professor Heatherington attended the 2010 International Society for Psychotherapy Research Conference in June in Asilomar, CA, where she presented a paper, "Corrective Experiences and Perceived Mechanisms of Change." Also in June she was awarded the Distinguished Contribution to Family Systems Research Award at the American Family Therapy Association conference in Boulder, Colorado. She was elected President of the North American chapter of the Society for Psychotherapy Research, for a term 2011-2013. With colleagues, she published a meta-analysis and chapter on the alliance in couple and family therapy, in *Psychotherapy Relationships that Work: Evidence-based Practice (2nd ed)*, and two journal articles. And with Williams colleague Marlene Sandstrom, she wrote a successful AALAC/Mellon 23 Collaborative Workshop Grant, "Clinical Psychology in the Liberal Arts College: Surviving and Thriving in the 21st Century."

Professor Heatherington continued to serve on the editorial boards of *Psychotherapy Research*, *Journal of Family Psychology*, *Journal of Marital and Family Therapy*, and *Psychotherapy: Theory, Research, Practice, and Applications*, was newly appointed to the editorial board of *Journal of Counseling Psychology*, and did ad-hoc reviewing for several other journals and publishers. She served on the Associates Board of the Gould Farm (Monterey, MA), a treatment center/working farm serving people with schizophrenia and other major mental illnesses and directs an ongoing twelve year program evaluation and outcomes study there.

Professor Saul Kassin is currently on leave while serving as a Distinguished Professor at the John Jay College of Criminal Justice in New York. Focused on policy reform on matters concerning wrongful convictions, Kassin worked this past year with the American Psychological Association in writing several amicus briefs to state supreme courts. He also appeared before criminal justice task forces in New York and Pennsylvania. He has contributed chapters to three scholarly books and has presented talks at colleges, universities, law schools, conferences, and the Vera Institute of Justice. In 2011, he published the eighth edition of the textbook *Social Psychology* coauthored by Steven Fein and Hazel Markus. He has also written an op-ed article for CNN.com and has appeared on NBC *Dateline*, CBS *48 Hours*, and a *New York 1* story on the Central Park jogger case. This past year, Kassin served as Consulting Editor for *Law and Human Behavior*, Research Advisory Board of the Innocence Project, Advisory Board member of the Social Science Research Network (SSRN), external faculty for the International Centre for Research in Forensic Psychology at the University of Portsmouth, and reviewer for the National Science Foundation. He has also served as a consultant in several cases.

Professor Kris Kirby published one paper during this past year, which reported the results of seven experiments on the curvature of utility functions, conducted under the auspices of a grant from the National Science Foundation. He also supervised the honors thesis of Tasha Chu'11, on the discounting of the utility of delayed rewards. Professor Kirby joined the editorial board of the *Journal of Behavioral Decision Making*, and in addition to serving as a reviewer for NSF grant applications, he served as an ad hoc reviewer for *Behavioral Research Methods*, *Journal of Decision Making*, and *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

Assistant Professor Nate Kornell continues to research the interaction between learning, memory, education, and self-monitoring. He published six journal articles and two book chapters in the past year. His research was featured in the New York Times, the Globe and Mail, NPR, Education Week, and other media outlets. He began blogging for Psychology Today and writing a column for Miller-McCune in an effort to disseminate research on cognition and learning more broadly.

Professor Marlene Sandstrom's research focuses on socially vulnerable children. She is particularly interested in victimization, bullying, bystander behavior, and social influence. This fall, she presented the Sigma Xi Lectures, titled *They like me, they like me not: Peer relations in childhood*. In the spring, Professor Sandstrom co-chaired a symposium at the Biennial Meeting of the Society for Research in Child Development, titled *Bearing witness to bullying: How can bystanders be empowered to protect their victimized classmates*. At this same meeting, Professor Sandstrom also presented papers on bystander behavior, and the association between self-esteem and aggression. Over the past year, Professor Sandstrom published a chapter on peer influence for a book titled *Popularity in the Peer System*. In addition, she has served as an ad hoc reviewer for *Developmental Psychology* and *Developmental Science*.

Associate Professor Noah Sandstrom continues to explore the behavioral and neuroanatomical consequences of global ischemia and interventions that may influence these outcomes. He and Marijke DeVos'11 explored how the steroid hormone estradiol administered after an ischemic event influences neuronal survival. Working with Kylie Huckleberry'11, he examined how voluntary exercise impacts performance on learning and memory tasks following ischemic insults. In July, Sandstrom, Jennah Durham'10, and Katherine Jordan '09 presented their work on neuroprotective effects of estradiol at the annual meeting of the Society for Behavioral Neuroendocrinology (SBN) held in Toronto, Canada. Sandstrom has also served as a reviewer for several journals and as a member of the review panel for the Behavioral Neuroscience Fellowship study section at the National Institutes of Health.

Professor Kenneth Savitsky continued his research on egocentrism in everyday social judgment and published an article based on this work in the *Journal of Experimental Social Psychology*. He supervised the thesis research of Janna Gordon'11.

Professor Betty Zimmerberg continued her research on the epigenetics of anxiety behavior as well as starting her term as chair of the Psychology Department. Shiyon Robinson'11 conducted her senior honors thesis on the epigenetic effects of communal nesting on object recognition memory in rats selectively bred for high and low rates of distress calls. Another senior thesis student, Fhatarah Zinnamon'11, started a new line of research in our lab on empathy and mirror neurons. Students in the lab helping on these projects

were Amber Cardoos'12, Sierra Germeyan'13, Alexandra Berg'14 and Manasi Iyer'14. Traveling to the beautiful island of Sardinia to attend the annual meeting of the International Behavioral Neuroscience Society last June, Zimmerberg presented the results of her research on the anxiolytic effects of socially housing during pregnancy, led a workshop for new investigators on grant writing and served on the Program Committee for the meeting. Other professional activities included serving on the Editorial Board of *Developmental Psychobiology* as well as reviewing for several journals and for the National Science Foundation.

Psychology Department Colloquia

Amie A. Hane, Williams College

“Beyond Licking and Grooming: Maternal Regulation of Infant Stress in the Caregiving Context”

Sarah Nelson, Harvard Medical School

“Under the Influence: How Our Understanding of Addiction Influences Our Approach to One of the Country's Leading Public Health Threats, DUI”

Marlene Sandstrom, Williams College

“They Like Me, They Like Me Not: Peer Relations in Childhood,” Sigma Xi Lectures

Daniel Schacter, Harvard University

“Constructive Memory: Remembering the Past to Imagining the Future”

Catherine Monk, Columbia University

“Development Begins before Birth: Psychological Functioning during Pregnancy & Infant Neurobehavioral Trajectories”

Heather Cameron, National Institutes of Health

“Maturation and Function of New Neurons in the Adult Hippocampus”

Jennifer Randall Crosby, Williams College

“Targets of Prejudice”

Off-Campus Colloquia

Phebe Cramer

“Longitudinal Personality Change: The Role of Defense Mechanisms and IQ”

Paper presented at the national meeting of the Society for Personality Assessment, Boston, MA

“TAT Defense Mechanisms with Diverse Samples and Methods”

Symposium at the national meeting of the Society for Personality Assessment, Boston, MA

Jennifer Randall Crosby

“Good Intentions and Unexpected Consequences: The Effects of Social Identity on Intergroup Interactions”

Emerging Scholars Symposium, Franklin & Marshall College

Amie Ashley Hane

“Beyond Licking and Grooming: Maternal Regulation of Infant Stress in the Caregiving Context”

Invited presentation for the colloquium series for the Department of Psychology, University of Massachusetts, Amherst

Invited presentation given at the Centre for Research in Parenting: Social and Biological Determinants of Parenting. University of Toronto

“The Moderating Role of Maternal Expressed Emotion on Behavioral Inhibition in the Emergence of Anxious Behaviors”

Paper presented in the symposium chaired by K. Buss entitled *Moderators and Mediators of Fearful Temperament Trajectories* at the biennial meeting of the Society for Research in Child Development, Montreal, Quebec, Canada with W. Marquis & N. A. Fox

“Maternal Regulation of Infant Stress in the Context of Routine Caregiving Tasks”

Paper presented in the symposium chaired by J. Mesman entitled *New Approaches to Parental Sensitivity and Its Outcomes* at the biennial meeting of the Society for Research in Child Development, Montreal, Quebec, Canada with L. E. Philbrook

“Maternal and Child Behavior and Child Physiology During Discussion of Ambiguous Situations”
Poster presented at the biennial meeting of the Society for Research in Child Development, Montreal, Quebec, Canada with E. Barrios

“Will I Get a Turn?” Anticipation of Peer Exclusion and Cardiac Reactivity and Regulation in School-Age Children”

Poster presented at the biennial meeting of the Society for Research in Child Development, Montreal, Quebec, Canada with M. J. Sandstrom & A. Hoff

Laurie Heatherington

“Corrective Experiences and Perceived Mechanisms of Change”

2010 International Society for Psychotherapy Research Conference in Asilomar, CA

Saul Kassin

Colloquia and Guest Lectures

New York State Justice Task Force

Vera Institute of Justice

Cornell University Psychology Department

Cornell University Law School

New York University

Fordham University

Pennsylvania State Advisory Committee to Study Wrongful Convictions

Albany Law School Symposium on Wrongful Convictions

“Why Innocent People Confess -- and How Their Confessions Corrupt Judgments”

Keynote speech presented at the Meeting of the International Investigative Interviewing Research Group, Dundee, Scotland

“When Confessions Trump DNA: Relative Impacts of Self-Report and DNA Evidence on Juror Decisions”

Paper presented at the Meeting of the American Psychology-Law Society, Miami, FL with S. Appleby

“ ‘I Would Never Do That!’ ...And Then They Do: Exploring Predicted and Actual Behavior During Interrogation Situations”

Paper presented at the Meeting of the American Psychology-Law Society, Miami, FL with J. Schell, H. Merckelbach, & H. Hospers

“Perpetrator Memory: Better than the Eyewitness?”

Paper presented at the Meeting of the American Psychology-Law Society, Miami, FL with J. Perillo

“Juror Perceptions of Confessions: Effects of Perceived Coercion and Guilty Knowledge”

Paper presented at the Meeting of the American Psychology-Law Society, Miami, FL with C. Crocker

“Predicting Malintent Targets with Eye-Tracking”

Paper presented at the Meeting of the American Psychology-Law Society, Miami, FL with D. Wallace & M. Hartwig

“The Corruptive Power of Confessions”

Keynote speech at the European Association of Psychology and Law, Gothenburg, Sweden

Nate Kornell

“Interleaving as the Friend of Induction”

Poster presented at the 91st annual meeting of the Western Psychological Association, Los Angeles, CA with M. S. Birnbaum & R. A. Bjork

“Difficult Ruled-based Category Learning Benefits From Massed Practice ”

Poster presented at the Symposium of the Science of Learning in Medical Education, UCLA, Los Angeles, CA with M. Garcia & R. A. Bjork * Winner of Best Poster, Research Category

Marlene Sandstrom

“Bearing Witness to Bullying: How Can Bystanders be Empowered to Protect their Victimized Classmates?”

Co-chair of paper symposium at the Biennial Meeting of the Society for Research in Child Development, Montreal with M. Bartini

“Changing Bystanders to Defenders: A Norms-based Approach

Paper presented at the Biennial Meeting of the Society for Research in Child Development, Montreal with M. Bartini

“The Fragile Bully: Defensive Self-Esteem and Aggression in Early Adolescence’

Paper presented at the Biennial Meeting of the Society for Research in Child Development, Montreal with J. Jordan

“Cross-contextual Consistency of Children's Aggression: An APIM Analysis”

Poster presented at the Biennial Meeting of the Society for Research in Child Development, Montreal with A. H. N. Cillessen

“Will I Get a Turn? Anticipation of Peer Exclusion and Cardiac Reactivity and Regulation in School-Age Children”

Poster presented at the Biennial Meeting of the Society for Research in Child Development, Montreal with A. A. Hane and A. L. Hoff

Noah Sandstrom

“Estradiol Protects Against Hippocampal Damage and Impairments in Fear Conditioning Resulting from Transient Global Ischemia in Mice”

Annual Meeting of the Society for Behavioral Neuroendocrinology, Toronto, Canada with K. A. Jordan and J. L. Durham

Betty Zimmerberg

“Epigenetic Influences on Affective and Social Behavior in Rats Selectively Bred for an Infantile Trait”

International Behavioral Neuroscience Society meeting, Sardinia, Italy

Postgraduate Plans of Psychology Majors

James A. Allison	Teaching high school math in Baltimore City through the Teach For America program
Erin M. Altenburger	Working as a research coordinator at Massachusetts General Hospital in the OCD and Related Disorders Program
Joseph J. Augenbraun	Pursuing work in the environmental consulting field
Andrei Baiu	Working as a Project Manager for a medical software company, Epic Systems in Madison, WI
Nicole C. Ballon-Landa	Working in New York City as an analyst at Goldman Sachs, in the leveraged finance group
Elizabeth A. Barcay	Working in the Teacher Training Internship Program at The Learning Project, an elementary school in Boston
Katerina Belkin	Working at the Division on Addictions at Harvard Medical School for two years before graduate school for clinical psychology
Elizabeth W. Bingham	Attending Dental School at Tufts University
Matthew J. Blake	Working at the Qatar Leadership Academy, a school in Doha, Qatar as a boarding supervisor, which is part tutor and part sports/games/outward bound type activities leader
Anne Marie Burke	Unknown
Quaneece O.S. Calhoun	Unknown
Tasha Chu	Hoping to find a research position in clinical psychology and attend grad school in the next couple years
Christine Y. Chung	Teaching English in Korea
Julia C. Cohan	Unknown
Alexandra S.M. Coleman	Unknown
Benjamin C. Coleman	Working as an investment banking analyst at Citigroup
Laura L. Corona	Hoping to do psychology research in Boston as a research assistant
Robert W. Cuthbert	Unknown
Lindsay H. Davies	Unknown

Amanda M. Davis	Unknown
Elizabeth A. Dawson	Unknown
Wilmer A. DelCid	Participating in a year-long post-bac program called UNC PREP doing neurobiological research and acquiring other professional skills to then apply to a neuroscience PhD program for fall 2012
Matthew K. Farley	Taking the semester off next fall and then pursuing a masters in counseling
Christopher J. Fox	Serving as an Alumni Mentor at Regis High School in New York for the 2011-2012 academic year
Janna R. Gordon	Working as a Clinical Research Assistant at Massachusetts General Hospital in Boston, in the Department of Behavioral Medicine
Amy L. Harris	Unknown
Lisa M. Holub	Working in a law firm in New York as a paralegal/legal assistant
Kylie A. Huckleberry	Attending the University of Texas at Austin to obtain a PhD in Neuroscience
Sa-Kiera T. Hudson	Unknown
Madeline J. King	Working at Goodman Research Group, a private research firm in Cambridge, MA that focuses on education
Su-Mai Lin	Unknown
Ryan A. Lupo	Unknown
Brian C. Malchoff	Hoping to play professional hockey in Europe or going to fishing guide school
Dale E. Markey	Unknown
Briana M. Marshall	Working at Booz Allen Hamilton in Washington, DC
Tarra N. Martin	Working at the Huntington Theatre Company in Boston as a General Management Professional Intern
Mary R. McChesney	Unknown
Kimberly A.M. Middleton	Unknown
Ian C. Murphy	Unknown
Thomas I. Murray	Unknown
Anne E. Neil	Planning on going into the marketing field, preferably in sports marketing
Isaac M. Nicholson	Unknown
Jennifer M. Oswald	Hoping to do psych research next year, and eventually go to grad school for a PhD in Clinical Psychology
Zachary J. Padovani	Working part time, volunteering in the field of mental health, helping out significantly at home, and applying to graduate school for clinical psychology
Ashley S. Parsons	Unknown
Laura M. Pickel	Working as a math teacher at CITYterm at The Masters School next year. The school promotes exploratory learning using New York City as a classroom.
Marissa L. Pilger	Hoping to move to the Bay Area and do clinical psych research and/or work with autistic kids
Veronica C. Rabelo	Entering a joint PhD program in Psychology (Social & Personality Contexts) and Women's Studies at the University of Michigan this fall
Tyler L. Rainer	Unknown
Ellen S. Ramsey	Working as an analyst at Promontory Financial Group, a financial consulting firm in New York
Gary R. Roberson	Leading an Overland Summer Programs biking trip across the country, and following the summer, hoping to join a neuroscience lab as a research assistant
Shivon A. Robinson	Attending the University of Pennsylvania to obtain a PhD in Neuroscience
Sophie S. Robinson	Moving to Nashville, TN in the fall to work part time teaching and part time at a health food store; also doing a lot of traveling, including a month in southern France, WWOOFing at a cheese farm
Gina R. Rodriguez	Unknown

Jacqueline R. Russo	Attending Yeshiva University's Ferkauf Graduate School of Psychology to obtain a PsyD in Clinical Child and School Psychology
Diane S. Saint-Victor	Attending Emory University Rollins School of Public Health for an MPH in Global Health - Infectious Diseases
Julia L. Schreiber	Unknown
Taylor J. Shea	Unknown
Taylor J. Stevens	Going to Smith College Graduate School for a Master of Arts in Teaching and doing the fellowship program with Project Coach
Emily M. Studenmund	Hoping to be in Boston doing nonprofit work with kids
Matthew C. Sullivan	Working as a research assistant at the Tufts Medical Center Mood Disorder Program in Boston
Joseph L. Vella	Working as a Marketing Analyst at American Express in Manhattan
Sarah R. Weber	Doing clinical research on Crohn's Disease and Ulcerative Colitis at Children's Hospital Boston
Madeline H. Wendt	Teaching and being a camp counselor at Wolfeboro Summer Boarding School in New Hampshire; hoping to teach and/or coach for a few years and then go back to graduate school in either educational or social psychology
Katherine L. Weyerhaeuser	Unknown
Laura C. White	Unknown
Brandon T. Whittington	Unknown
Johannes M. Wilson	Working at the Behavioral Medicine Service of Massachusetts General Hospital for two years as a Research Assistant on studies examining cognitive processing therapy and HIV prevention for men who have sex with men and are also survivors of child abuse. After this, planning to apply for a PhD in clinical psychology, community psychology, or a degree that combines both
Joshua M. Wilson	Moving to Boston to find work as a research assistant in clinical psychology and applying to graduate school
Stephanie E. Wren	Attending graduate school for clinical psychology in the fall at Nova Southeastern University in Fort Lauderdale, FL
Fhatarah A. Zinnamon	Attending University College London to obtain an MSc in Neuroscience and hoping to go on to obtain a PhD and do clinical research in neuroscience and health policy

ABSTRACTS FROM STUDENT THESES

Astronomy

Data Compilation and Analysis of Stars in the Orion Nebula Cluster

Sara M. K. Dwyer

I took nine surveys of the Orion Nebula cluster and combined them into one master catalog. Using this catalog, I examined I-magnitude data to see how the cluster has changed over time in terms of magnitude variability. I found that large and small amplitude variable stars have different positional distributions in the cluster.

Biology

Molecular Strategies for Augmenting Hydrogen Production by *Synechocystis* 6803

Michael J. Abrams

The cyanobacterium *Synechocystis* PCC 6803 is an excellent model organism for the production of biologically-produced hydrogen gas (H₂) for use as a fuel source. In order to maximize H₂ production, we have sought to culture *Synechocystis* under conditions in which it is actively photosynthesizing – and consequently evolving O₂ – in order to stimulate the production of NADPH, the reducing power of which is used by the bidirectional hydrogenase enzyme of *Synechocystis* to produce H₂. However, the hydrogenase enzyme is acutely inhibited by O₂. To overcome this problem, we identified two genes involved in the natural symbiotic relationship between legumes and rhizobium bacteria, which function to protect nitrogenase from O₂ inactivation in a manner similar to that encountered in hydrogenase. Using these genes, we engineered two genetic constructs with which to transform *Synechocystis*. One gene encodes the O₂-binding protein leghemoglobin (Lb), which has an extremely fast O₂ association rate and supplies O₂ to oxidative respiration or exports it from the cell. The other gene, encoding the protein ferric leghemoglobin reductase (FLbR), catalyzes the NADH-dependent reduction of ferric to ferrous Lb. We made one construct to express Lb alone and a second, using PCR SOEing, to express both Lb and FLbR. We have also designed a reaction chamber that allows us to test the two transformed strains of *Synechocystis* for H₂ accumulation. We have yet to test our transformed strains, but we have determined basal levels of H₂ and O₂ evolution in wild type (untransformed) *Synechocystis*.

Small Heat Shock Proteins and Zebrafish Left-Right Asymmetry: Exploring the Functional Roles of *hspb7* and *hspb12* in Cardiogenesis

Jonah Zuflacht

The small heat shock proteins (sHsps) *hspb7* and *hspb12* have unique, unprecedented roles in the establishment of visceral left-right (LR) asymmetry. Morpholino (MO) knockdown of these genes randomizes cardiac laterality and perturbs normal *southpaw*, *lefty-1*, and *lefty-2* expression (Lahvic, 2010). The mechanism through which *hspb7* and *hspb12* affect asymmetry, however, has yet to be determined. Here we present insight into the functional roles of these sHsps on a cellular level. Through transmission electron microscopy, we demonstrate that *hspb7* morphants exhibit perturbed ciliary ultrastructure and propose that these microtubule defects could underlie the randomization of visceral situs. Previous work has demonstrated that *hspb7* and *hspb12* are expressed specifically in cardiac tissue (Lahvic, 2010). We have repeated in situ hybridization for these genes and observe far earlier expression in the yolk syncytial layer, a transient extra-embryonic tissue with important roles in developmental patterning and heart migration. The expression patterns of *southpaw*, *lefty-1*, and *lefty-2* in double morphants suggests that *hspb7* and *hspb12* work together to influence laterality. We also show that *hspb7* is important for normal cardiac morphogenesis and heart function in addition to laterality.

Regenerative Effects of Exercise Following Global Ischemia

Kylie Huckleberry

Studies from animal models such as rats and gerbils have provided evidence that post-injury exercise can be neuroprotective and reduce damage resulting from ischemia. Exercise alone has also been shown to improve performance on the same tasks that ischemia impairs. The present study sought to explore the effects of exercise following global ischemia. Adult male mice were subjected to either global ischemia via a two-vessel occlusion (2VO) or a sham surgery. Twenty-four hours post-injury, animals were given either

a running or stationary wheel for two weeks, during which period they were injected with 5-bromo-2-deoxyuridine (BrdU) three and four days post-injury. At the end of the two-week period, mice were behaviorally tested on the rotarod, the Morris Water Maze (MWM), and Contextual and Cue Fear Conditioning (CCFC) to assess motoric function as well as spatial and contextual learning and memory. Hippocampal slices were stained with Cresyl Violet (CV), Fluorojade (FJ), and BrdU. There were some minor motoric differences between the conditions, and all groups performed comparably on the tests of learning and memory. However, there is reason to suspect that some of the conditions used alternative strategies during the tasks that were not hippocampally-dependent such as knowing the distance from the platform to wall and swimming in a circle. Only the CV stain reliably worked, but no significant results were found. It is possible that this is due to a measure that was not sensitive to the cell death. In summary, I found no detectable differences resulting from surgery and therefore also found no evidence supporting the idea that running is protective.

An acute dose of estradiol immediately after transient global ischemia does not protect against hippocampal structural and functional damage

Marijke J. Devos

Both focal and global occlusion of blood flow to the forebrain leads to a variety of negative behavioral effects including declines in executive function, memory, language, speed of processing, and visuospatial/constructional abilities. The hippocampus, a structure in the forebrain implicated in learning and memory, is severely affected by transient global ischemia, and infarct is associated with neurodegeneration in the CA1 and neurogenesis in the dentate gyrus in rodent models. Pretreatment with estradiol in rodent models protects against cell death in the CA1, increases neurogenesis in the dentate gyrus, and improves deficits in hippocampally dependent learning and memory. However, controversy surrounds the use of estrogen therapy in women as a method of decreasing the negative effects of stroke, as estrogen therapy may actually increase the incidence of stroke in women. If an acute dose of estradiol could be administered immediately after an ischemic event, in a therapeutic manner, the negative consequences of both stroke and long term treatment with estradiol could be avoided.

Here, an acute dose of estradiol (4 mg/Kg) was administered to C57BL/6J mice immediately after 15 minutes of transient global ischemia and the structural and functional effects on the hippocampus were examined.

Histological sections were stained with cresyl violet for healthy cells and fluoro- jade B (FJB) for degenerating neurons, and labeled with bromodeoxyuridine (BrdU) for dividing cells. Motor coordination, spontaneous activity and anxiety, and learning and memory, were assessed with the roto-rod task, the open field task, and the context cue fear conditioning task.

Estradiol had no effect on hippocampally-dependent learning and memory, but marginally improved hippocampally-independent learning and memory after stroke. Estradiol decreased spontaneous activity, increased anxiety behavior, and a trend was observed where estradiol seems to decrease mortality immediately after stroke as compared to oil-treated animals.

Although no differences in FJB staining were evident between groups in the CA1, 2VO marginally increased FJB+ cells in the dentate gyrus and estradiol marginally decreased neurogenesis in the dentate gyrus.

To conclude, an acute dose of estradiol immediately after transient global ischemia does not affect hippocampally-dependent learning and memory, does not protect against neurodegeneration in the dentate gyrus, and decreases neurogenesis in the dentate gyrus. However, mortality after stroke was marginally decreased by estradiol treatment, suggesting that estradiol's known immediate effects on neural plasticity may provide protection to the brain overall following occlusion of blood flow. Further, the marginal increase in anxiety in the estradiol group may have been caused by withdrawal from estradiol, which is known to increase anxiety and depression in both humans and rats. In the future, a shorter duration of occlusion, namely 10 minutes, should be used to prevent selective effects of the occlusion from affecting the results, and chronic estradiol treatment, for a week after ischemia, should be used to rule out withdrawal effects from estradiol in the behavioral result.

The Influence of Land Management Practices on the Abundance of Aster, Goldenrod, and their Pollinators in Williamstown, MA, USA

Jillian Hancock

Asters, goldenrods, and their pollinators form an important and delicate ecological relationship. Asters and goldenrods rely on pollinators to visit and cross-pollinate between plants so that they can reproduce. Pollinators need the pollen and nectar resources provided by these late blooming flowers in order to survive the cold New England winter. This relationship is in jeopardy due to declines in abundance and diversity of both plants and their pollinators. Numerous factors including loss of habitat, competition with nonnative species, disease, and maladaptive land management practices contribute to these declines. My study examines the influence of mowing schedules on abundance and diversity.

A field last mowed in October 2008 had significantly greater flower visitation than a field mowed in August 2010 (Paired t-test, $t = 4.317$, d.f. = 9, $N=10$, $p = .001942$). The unmowed field had a significantly more diverse pollinator species sample with Shannon Diversity Index of $H = 1.09 \pm 0.12$ SE compared to the mowed field's index of $H = 0.29 \pm 0.15$ SE. The unmowed field had significantly greater number and diversity of blooming stems of asters and goldenrods than the mowed field. The unmowed field had 11,718 stems including 7 different species of asters and goldenrods and the mowed field only had 2,154 stems including 5 different species of asters and goldenrods.

Our local survey of Williamstown, MA, USA sampled 43 properties that included 1,066.5 acres of open land. Results showed that most (62% or 681.5 acres) open land in Williamstown is committed to agriculture that requires two to three mows per year. Eight-hundred thirteen (813) acres have mowing schedules dedicated for specific purposes such as haying or ground-nesting bird conservation. Of the lands without committed mowing schedules (253.5 acres), caretakers and

property owners of 180 acres indicated they were willing to delay mowing until October or later to promote the growth of aster, goldenrod, and pollinator populations. Thus there is potential to increase the success of asters, goldenrods, and their pollinators in Berkshire County, MA.

The Role of the *Agrobacterium tumefaciens* T6SS in Modulating Host Defense Responses

Helen Cha

Agrobacterium mutants lacking the recently discovered Type VI Secretion System (T6SS) exhibit attenuated virulence; we hypothesized that this defect may be attributable to a diminished ability to dampen host defenses. In the *A. thaliana* ecotype Landsberg erecta, no transgene expression was found in seedlings infiltrated with T6SS-deficient bacteria, whereas all the seedlings infected with the wild-type bacteria strongly expressed the transgene. In contrast, a low level of expression was found with both wild type and T6SS-mutant infected seedlings of the Col-0 ecotype. Furthermore, infiltration with wild-type but not mutant bacteria inhibited growth of the seedlings, in the same way as exposure to known bacterial elicitors. We are currently testing the possibility that T6SS effectors are necessary to dampen siRNA-mediated silencing of transgenes delivered by the bacterium. This anti-silencing function may promote virulence by allowing expression of the oncogenes, but at the expense of triggering primary lines of defense. The apparent reduced susceptibility of the Col-0 ecotype to *Agrobacterium* transformation, coupled with marked growth inhibition of this line upon exposure to bacteria, may reflect its ability to perceive and respond effectively to pathogen-associated elicitors other than T6SS substrates. In contrast, the lack of the ERECTA kinase in the Landsberg ecotype may make it more prone to transformation as long as the pathogen can dampen other defenses via delivery of T6SS effector(s). Preliminary data suggest the Landsberg ecotype of *A. thaliana* is more prone to bacterial transformation than Col-0, which is consistent with the greater susceptibility of Landsberg to other pathogens.

Characterization of Chicken Ovalbumin Upstream Promoter-Transcription Factor in *Helobdella* sp. (Austin)

Mari M. Lliguicota

Our lab investigates segmental pattern formation in annelid, the segmented worm. Developmental mechanisms are poorly understood in this group; therefore the goal of my research project was to identify potential regulators that function during early annelid development. An unbiased search for gene products expressed in annelid segmentation has been conducted and a number of genes have been identified as potential candidate segmentation genes. One of the gene products was *HauCOUP*, which was identified as

a member of the chicken ovalbumin upstream promoter transcription factor family due to high-shared amino acid sequence identity found through sequence analysis. In this thesis, I used *in situ* hybridization to characterize the spatial and temporal expression pattern of *HauCOUP* in the leech *Helobdella* sp. (Austin). Although the function of *HauCOUP* was not investigated, it is apparent *HauCOUP* is expressed all through out development, primarily enriched in mesoderm precursors. The expression pattern of *HauCOUP* suggests it is an early mesoderm marker. The understanding of developmental mechanisms of annelids still remains poorly understood but the expression profile of *HauCOUP* suggests *HauCOUP* is present for mesoderm segmentation.

Neuroscience Thesis: Mirror Neurons and Emotions in Motion

Fhatarah A. Zinnamon

When we observe someone performing an action, mirror neurons enable our brains simulate that same motion. One way to study this system of mirror neurons is to compare people who have and haven't learned a certain repertoire of movement. The mirror neuron system has also been proposed as the neural basis of empathy. In this study, we examined the responses to emotional modern dance pieces in modern dancers and non-dancers. Participants were Williams College students, who completed measures of empathy and questionnaires about their responses to Martha Graham performance pieces. Results indicated that dancers had increased Empathy Quotient (EQ) scores and stronger connections to the piece rated as most emotional compared to non-dancers. All participants with higher EQ scores rated the most emotional piece as more emotional than participants with lower EQ scores. Attempts to quantify mirror neuron activation through electroencephalography failed due to high impedances and results were not recorded. This study extended previous action observation studies to modern dance stimuli and showed that modern dancers have higher empathy scores than non-dancers. Clinical implications of these findings are discussed, as are directions for future research.

Are We Singing The Same Song? Culture-Based Behavioral Differences in Savannah Sparrows

Clint Robins

The importance of dialect differences in songbirds and the origin of those differences was investigated by studying beak gape patterns and behavioral responses to playbacks of the buzz section of song in two populations of Savannah sparrows (*Passerculus sandwichensis*). Males from both populations exhibited more variability in beak gape patterns in the buzz section of song than in other song sections. However, beak gape patterns did not vary significantly across populations. This result suggests that either beak gape patterns were difficult to maintain during buzzes or that beak gape was adjusted to compensate for variability in other vocal parameters. Such song-to-song variability in acoustic parameters in beak gape patterns may allow the buzz to carry information about a male's motivational or physiological state. Playback responses demonstrated that males from both populations discriminated between the buzzes of local and foreign dialects. Males in each population responded longer when the buzz stimulus was drawn from the local dialect. The stronger responses to playbacks of local buzz stimuli indicate that males perceive the local dialect to be more threatening. Taken together, these results suggest that *a*) the buzz carries information about dialect, and *b*) differences in the buzz portion of the song are not due to differences in the way the vocal instrument is used, but rather are subject to cultural influences mediated by learning.

Searching for Candidate Barrier Genes Related to Wing Coloration in *Heliconius* Butterflies

Leanne Lin

Speciation is a fundamental process in evolutionary biology. It is the main source of biodiversity, a remarkable claim considering the countless forms of life on Earth. However, as an evolutionary process occurring over long periods of time, speciation is difficult to study by direct observation. Therefore, to determine how new species evolve, a deeper understanding of barriers to gene exchange is crucial. These barriers lead to reproductive isolation, genetically and physiologically preventing new species from mating with one another. Sequence comparisons of the *Cr/Yb* locus were performed for three F2 broods of *Heliconius* butterflies derived from pure parental populations. Restriction enzymes were designed based on nucleotide sites that differed consistently for black, shadow, and yellow individuals. This approach of correlating specific restriction digest patterns with hindwing phenotypes allowed for 5th instar larvae, early pupae, and ommochrome only pupae individuals to be genotyped. Based on these results, further analysis can be done using methods such as qPCR and next-generation sequencing to determine the RNA

expression patterns in different stages of development. These subsequent steps will reveal how gene expression determines wing color, and hence which gene in the *Cr/Yb* locus may function as a barrier gene.

Characterization of an Orthopedia Homolog in *Helobdella* sp (Austin)

Alexandra M. Peruta

What molecular mechanisms operate in segmentation of the annelid phylum are important questions within developmental biology. Candidate gene products expressed during annelid segment formation in the leech *Helobdella* sp (Austin) were identified through a novel, unbiased approach. One candidate EST possessed high sequence similarity to the insect Orthopedia (Otp) gene, termed Hau-Otp. The comparative sequence data support the theory that leech Otp and fly Otp belong to a subfamily of homeobox genes. Multiple amino acid sequence alignments and a molecular phylogeny independently confirmed Hau-Otp's identity. Whole mount in situ hybridization was carried out in *Helobdella* sp (Austin) embryos and juveniles to determine the spatiotemporal expression pattern of Hau-Otp. The differential and restricted spatiotemporal expression patterns implicate Hau-Otp in ectoderm, mesoderm, and cell fate specification. This is the first reported role of Orthopedia in early developmental patterning of the mesoderm. The phylogenetic and immunohistochemical data indicate that Orthopedia is present in multiple members of the annelid phylum as well as other protostomes and even deuterostomes. Therefore, the presence of Orthopedia in the molecular mechanism of development in the early Bilateria *Helobdella* sp (Austin) continues through evolution.

Chemistry

Exploring the Binding Mechanism of the LexA and RecA Proteins Through the Use of Cross-Linking Studies

Lucas Bruton

The mechanism underlying the regulation of the bacterial SOS response to DNA damage, the RecA-mediated autocleavage of LexA, is not well understood, due, in part, to the lack of knowledge regarding the interaction between the RecA and LexA proteins. Recent work in the Lovett laboratory has produced fourteen *Bacillus subtilis* LexA mutants in which conserved amino acid residues in the putative RecA binding domain were replaced with cysteine. The goal of this research was to use these LexA mutants to identify the corresponding binding sites on RecA using the bifunctional cross-linker 2-{N2-[N6-(4-Azido-2,3,5,6-tetrafluorobenzoyl-6-amino-caproyl)-N6-(6-biotinamidocaproyl)-L-lysinylamido]}ethyl methanethiosulfonate (Mts-Atf-LC-Biotin), which contains a sulfhydryl-specific group and a non-specific azido group.

After purifying the fourteen LexA cysteine mutants, I successfully attached Mts-Atf-LC-Biotin to thirteen of the mutants as evidenced by Western analysis with streptavidin. Appropriate LexA mutant conjugates were chosen for cross-linking trials with RecA based on their ability to bind RecA in LexA cleavage assays. Unfortunately, no RecA attachment was observed with any mutant. After determining that RecA cross-linking conditions were optimal in LexA dimer cross-linking studies, I hypothesized that LexA autocleavage may have interfered with the cross-linking reaction. As a result, I used site-specific mutagenesis to change the catalytic serine residue on each cysteine mutant to an alanine to block the cleavage of these mutants. These mutants are now ready for future cross-linking studies.

Toward the Asymmetric Total Synthesis of Jerangolid D

Mary Beth Daub

Progress towards the asymmetric total synthesis of the natural product jerangolid D is described. Jerangolid D is a secondary metabolite produced by the myxobacterium *Sorangium cellulosum* and a potential antifungal agent. Jerangolid D bears a strong structural similarity to the better-known metabolite ambruticin; the two molecules have identical right halves. The key structural features of jerangolid D include a *cis*-dihydropyran, an α,β -unsaturated δ -lactone, and a doubly allylic isolated stereogenic center. The *cis*-dihydropyran has been constructed in eight steps from commercially available materials using the method for the elaboration of thiazolidinethione aldol adducts developed in our lab and a reductive carbon-Ferrier rearrangement, which intercepts a key intermediate in Jacobsen's ambruticin synthesis. Although the reductive carbon-Ferrier rearrangement still requires optimization, the product structure has

been verified by comparison to published spectral data. The doubly allylic stereogenic center will be established using the exact asymmetric hydroformylation reaction utilized by Jacobsen. Our route will then diverge toward the asymmetric total synthesis of jerangolid D where the α,β -unsaturated δ -lactone will be prepared using chemistry previously developed in our lab for the synthesis of the kavalactones.

**Toward the Total Synthesis of Enigmazole A:
Model Studies Directed to C₃ Hydroxyl Deoxygenation**

Marian Deuker

Enigmazole A is a phosphorylated 18-membered macrolide natural product with seven chiral centers, isolated from the marine sponge *Cinchyrella enigmatica*. The molecule has emerged as a captivating synthetic target because enigmazole A exhibits novel architecture, and also because although enigmazole A possesses anticancer activity, its biological target remains enigmatic. We envision inducing asymmetry into the synthesis with a chiral auxiliary, and then using the tin-promoted Evans β -keto imide aldol reaction to increase molecular complexity through the modular installation of three stereogenic centers. However, the highly efficient Evans β -keto imide aldol method will introduce an unnecessary hydroxyl at the C₃ position. Herein we present research efforts to build a model system with a sterically crowded C₃ hydroxyl that mimics the actual system, in order to test the radical Barton-McCombie deoxygenation as a tactic to reduce the C₃ hydroxyl to a methylene.

**The Iron-Catalysis of the Epoxidation of Plant-Based Fatty Acid Derivatives
and Other Acid-Containing Alkene Substrates**

Matthew Everhart

[Fe(BPMEN)](OTf)₂ (**2**, BPMEN = *N,N'*-dimethyl-*N,N'*-bis(2-pyridylmethyl)-ethane-1,2-diamine), was used to catalytically oxidize a number of plant-based fatty acid derivatives and other acid-containing alkene substrates. Reaction conditions were explored and optimized with respect to reaction time, temperature, atmosphere, solvent, reagent ratios, and oxidant using oleic acid as a model substrate. A 6 minute reaction time, an inert Ar atmosphere, 25mL of solvent MeCN, 600 eq. of oxidant H₂O₂, and 1 eq. of **2** led to 76% substrate consumption and 82% epoxide selectivity with 200 eq. of oleic acid. The addition of acetic acid, an additive crucial for achieving favorable selectivities and yields in previously-reported systems, was not required. Additionally, consumption appeared to peak between 25°C and 50°C and to drop at 60°C. Choice of solvent significantly impacted consumption but did not affect selectivity. With ethyl oleate, diminished consumption and selectivity were observed, confirming the importance of the carboxylic acid functionality in oleic acid. Catalyst composition and the role of acetic acid were also investigated. Specifically, [Fe(bipy)₃](OTf)₂, [Fe(phen)₃](SO₄), and [Fe(iso-BPMEN)](OTf)₂ were inferior catalysts relative to **2**. While increasing oleic acid consumption to 100%, acetic acid did not improve selectivity. Epoxidations of 4-pentenoic acid and 5-hexenoic acid produced two useful lactone synthons with 100% and 93% selectivity, respectively. Finally, promising results of 65% consumption and 100% selectivity were achieved for the epoxidation of acrylic acid.

Undecylprodigiosin Production in *Streptomyces coelicolor* A3(2)

Moyukh Ghosh

The genus *Streptomyces* is a group of soil dwelling, gram positive, bacteria that are prolific producers of secondary metabolites including many of the clinically significant antibiotics used today. As such, understanding and maximizing antibiotic production in *Streptomyces* is essential to the medical field. The model organism *Streptomyces coelicolor* produces 4 well characterized antibiotics, and essential to the biosynthesis of these antibiotics are phosphopantetheinyl transferases (PPTases) which catalyze a necessary posttranslational modification of their biosynthetic enzyme. Previous studies have attempted to characterize the three PPTase encoded in the *S. coelicolor* genome. In characterizing the SCO6673 PPTase, researchers found that a SCO6673 PPTase knockout mutant had an unexpected 5 fold increase in undecylprodigiosin production relative to wild type.

The intent of this study was to first, elucidate the molecular mechanism behind the increase in undecylprodigiosin production in the SCO6673 PPTase mutant, and second, to further maximize the biosynthesis of this antibiotic in this strain. Towards the first goal, studies into activity of glycolytic and

pentose phosphate pathway enzymes in the mutant, as well as quantitative real time PCR (qPCR) assessment of the expression of antibiotic regulatory and biosynthetic genes were performed. While the metabolic enzyme activity data remains preliminary, it suggested perhaps minor alterations in activity of glycolytic enzymes in the SCO6673 mutant. qPCR revealed that the increased undecylprodigiosin production in the SCO6673 mutant is, at least in part, due to the up-regulation of expression of undecylprodigiosin regulatory and biosynthetic genes. The expression of the *redD* regulatory gene was observed to be elevated as much as 8 fold in the SCO6673 PPTase mutant as compared to the WT and corresponded to an approximate 10 fold elevated expression of the biosynthetic genes *redF* and *redN*. Additionally, the SCO6673 mutant, which hyper-produces undecylprodigiosin, was further engineered in order to maximize undecylprodigiosin biosynthesis. Overexpression of *redD* in the SCO6673 mutant was successful in increasing undecylprodigiosin production by 25-50%. However, addition of a *pfKA2* mutation to the strain actually decreased undecylprodigiosin production.

Efficient Asymmetric Synthesis of α,β -Unsaturated γ -Lactones and Direct Refunctionalizations of *N*-acyl Thiazolidinethiones

Mark Johnson

A versatile and efficient asymmetric synthesis of α,β -unsaturated γ -lactones, a common structural moiety to many biologically active natural products, is described using a single-flask reaction involving three stages: 1) base catalyzed lactonization, 2) triflation, and 3) hydride reduction via conjugate addition and α -elimination. Ultimately, a range of α,β -unsaturated γ -lactones were produced in excellent enantiomeric excesses (>95% *ee*) and good yields over the three steps (54–58%) from aldehyde starting materials. Additional work is reported on direct refunctionalizations of *N*-acyl thiazolidinethiones through acylation reactions involving benzotriazole and mildly-generated enolates of ketones and thioesters.

The Characterization of *Arabidopsis thaliana* Mutants Deficient in Ceramide Kinase

Elizabeth Kalb

Sphingolipids are a ubiquitous class of lipids that function as integral structural components of eukaryotic endomembrane systems and, more interestingly, serve as signaling molecules in diverse pathways. Sphingolipids and their complex derivatives mediate plant responses to drought stress and pathogen infection. Moreover, it has been demonstrated that ceramide, one sphingolipid species, initiates programmed cell death in *Arabidopsis thaliana*. Ceramide kinase appears to be particularly important for regulating the abundance of free ceramide and, consequently, moderates programmed cell death in plants.

Through characterizations of *A. thaliana* mutants deficient in ceramide kinase, we may better understand how ceramide accumulation affects plant fate. Although the naturally occurring ceramide kinase missense mutant *accelerated cell death 5* (*acd5*) has been previously studied, we must corroborate these findings in other mutant lines to demonstrate that the results are not unique to *acd5* plants. Here we study four mutant plants containing insertions in the *CERK1* locus in addition to *acd5*. We quantify the ceramide kinase activity of these mutants relative to wild-type. More importantly, we provide confirmatory evidence that mutants deficient in ceramide kinase are more susceptible to cell death following exposure to abiotic stresses, including heat shock and dark-induced senescence. The objective of this is not only to confirm that ceramide kinase deficient mutants are predisposed to precocious cell death, but also to provide avenues for future research that might elucidate the pathways linking ceramides to programmed cell death.

Synthesis of the C₁–C₁₂ Fragment of Tedanolide C and Initial Efforts Towards the C₁₃–C₁₇ Fragment

Zebulon Levine

The marine natural product tedanolide C has some ambiguity associated with its stereochemical assignment. To resolve this ambiguity, we propose to build four macrolide models without the epoxide side chain that could encompass all stereochemical configurations that fit the available data. Spectral comparison between these models and the natural product should allow the elucidation of the true structure of tedanolide C. Herein, we report the completion of both methyl ketone fragments that form the C₁–C₁₂ portion of the macrolide models. The (*R*) C10 methyl epimer is available in 16.0% overall yield over nine

steps from *N*-propionyl-(*S*)-isopropyl thiazolidinethione; the (*S*) C10 methyl epimer is available in 9.0% unoptimized yield in nine steps from the same precursor. The initial efforts to synthesize the C₁₃–C₁₇ fragment are also reported; modifications to improve the synthetic strategy towards this fragment are discussed in detail.

Mathematical Modeling of Glycolysis Based on the Higgins Model

Ang Li

Glycolysis is a fundamental and ubiquitous metabolic pathway, and glycolytic oscillations have been observed in a range of organisms and cell types both in vivo and in vitro. The Higgins Model, proposed in 1964, describes glycolytic oscillations with two differential equations that focus on the positive allosteric control on the enzyme, phosphofructokinase-1. To incorporate more molecular mechanisms of glycolysis into the model and build a more accurate model that exhibits richer dynamic behaviors, we modify the original Higgins Model by adding the glucose transporters on the cell membrane and the allosteric control of hexokinase into the model. For the modified model including the glucose transporters, we can find oscillations that are similar to those found in the original Higgins Model but without the point at infinity with physical parameter values. This model also exhibits Canard explosion. For the model that further includes the regulation on hexokinase in addition to the glucose transporters, we find a range of dynamic behaviors including simple oscillations, complex oscillations, chaos, bursting oscillations, and mixed mode oscillations. Our work has expanded the repertoire of existing glycolytic models and may suggest new directions for experimental research to discover new modes of glycolytic oscillations.

Isolation and Identification of Bioactive Materials

Present in H2-22 (*Sageraea* sp.)

Christina Meade

Over the course of the 2010-2011 academic year, research was conducted in collaboration with Dr. Andria Augusta and the Indonesian Institute for Science in order to explore antibiotic activity in native Indonesian plant extracts, specifically *Sageraea* sp. (“H2-22”). The two main goals of this thesis were to develop High Performance Liquid Chromatography/Mass Spectrometry (HPLC-MS) analysis methods, for general analytical use, and to isolate and identify the source of antibiotic activity of the aqueous methanol fraction of the crude H2-22 plant extract. Conditions were determined for effective HPLC gradient analysis. Samples were subjected to a solvent gradient of water and acetonitrile in order to elute components that could be detected by the UV-Vis detector (190-350 nm) in the HPLC system. MS analysis was conducted under positive ionization conditions with 0.1% formic acid as a solvent additive in order to protonate the samples and produce ions that could be detected by the MS detection.

The extraction and subsequent fractionation of H2-22 resulted in the isolation of bioactive material at an *R_f* value of 0.35, I-CMM-IndoAnti-56a and 56b. HPLC-MS analysis did not provide definitive information regarding the identity of these samples. The absence of a UV-Vis chromophore in the most pure bioactive H2-22 samples produced very weak HPLC peaks, and experimentation with MS analysis was inconclusive, suggesting that the solvent conditions should be developed to convert the neutral components to their corresponding anionic forms. ¹H-NMR analysis indicated that the biologically active components isolated were likely long chain unsaturated fatty acids. The samples isolated were likely the same as those isolated from the hexane layer during the preceding thesis research by Jacob Kravetz¹⁰, which were tentatively identified as oleic and palmitic acid.

The Free Energy of a Stretched RNA Chain, with Applications to Small RNA-mRNA Binding

Yuzhong Meng

Small RNA-mRNA binding is involved in an important cellular regulatory process called RNA interference (RNAi). Previous calculations of the binding free energy, used in binding site prediction, neglect the cost of mRNA stretching by the rigid small RNA-mRNA duplex. Here, using both polymer physics theory and random-walk simulations, we estimate the free energy of a stretched RNA chain. We then use this estimate to calculate the free energy of small RNA binding to mRNA hairpin loops. Our calculation shows that chain stretching significantly increases the free energy of seed+3' miRNA binding and siRNA binding to mRNA hairpins. We also make the important observation that 3' supplementary miRNA has two binding

modes: seed-only and seed+3', and that the former is often more favorable in mRNA hairpins. The stretching effect is insignificant in seed-only miRNA binding and when binding to mRNA bulges, internal loops, or multibranch loops.

Towards Folate-Targeted Polymer-Enzyme Conjugates for Chemotherapy

Colin Platt

The advent and development of chemotherapy has given a new lease on life to thousands of cancer patients, delaying progression or even inducing full remission in many cancer types. However, most chemotherapeutic agents are plagued by severe systemic toxicity due to their untargeted killing of all rapidly-dividing cells, both healthy and neoplastic. In an effort to direct the delivery of these highly toxic agents specifically to neoplastic cells, researchers have taken advantage of the leaky vasculature of solid tumors by use of polymer-conjugated enzymes and prodrugs, which due to their macromolecular size extravasate and accumulate preferentially in tumors. This strategy is known as polymer directed enzyme prodrug therapy (PDEPT).

In this work, we sought to enhance the passive accumulation of current PDEPT conjugates within tumors through the addition of active targeting. As a first step towards the development of a novel, actively-targeted PDEPT system, we synthesized polymers incorporating folic acid. Incorporation of folic acid moieties provides targeting to folic acid receptors known to overexpressed in several cancer types, particularly ovarian carcinomas. These polymers were also fluorescently labeled so that they could be tracked during *in vitro* cell studies and their receptor-specific targeting assayed.

Our polymers were found to display minimal cytotoxicity, even at concentrations as high as 3 mg/mL, and the results of initial *in vitro* binding studies are suggestive of folate-receptor-specific targeting. Conditions for the synthesis of our polymers using reversible addition-fragmentation chain transfer (RAFT) polymerizations were also evaluated. A moderately successful RAFT technique was developed which will allow future synthesis of our polymers with high control of molecular weight and introduction of functional end-groups that will allow our polymers to be conjugated to prodrug activating enzymes such as β -lactamas.

Towards the Synthesis of Amino Acid Based Thermoresponsive Polymers

Charles Seipp

The development of new thermoresponsive and self-assembling copolymers has the potential to profoundly affect modern medicine due to their usage in selective targeting of therapeutic agents. To this aim, the amphiphilic diblock copolymer poly((N-acryloyl-valine-N-isopropylamine)-co-poly(acrylic acid)) was synthesized at three different molecular weights (26000, 13000, 6800 Da) with nearly identical block length ratios. While none of the copolymers demonstrated thermoresponsive behavior all three showed self-assembling properties. These copolymers exhibited low critical micelle concentrations of 3.4, 2.6, 2.5 [M] respectively. DLS confirmed the presence of micelles ranging in diameter from 16 to 33 nm. Due to their self-assembling nature, these polymers have promise for drug delivery applications.

The Isolation and Structural Characterization of a Bioactive Compound in Crude *Irvingia malayana* Extract

Mara Shapero

The Indonesian medicinal plant, *Irvingia malayana*, possesses bioactive components that have the potential to be of great use in our race against growing antibacterial resistance. Dr. Andria Augusta from the Indonesian Institute of Sciences (LIPI) generously provided our lab with crude *Irvingia* extract, and from this extract we have worked to isolate and identify the structure of its bioactive components. The bioactive compound we are pursuing and the bioassay-guided fractionation procedure we followed were established by Andrew Yoo in 2009-2010. This year was aimed at isolating more of this bioactive compound, AEY-IndoAnti-94a, in a pure form, and to use a wide variety of analytical instruments to investigate its structure.

From a cumulative total of 34 g of crude extract, we were able to isolate 7.2 mg of this bioactive material, MNS-IndoAnti-90a. 1D- and 2D-NMR spectroscopic analysis was used, in addition to UV-Vis and IR spectroscopy, to further our knowledge of this component's structure. Because of the enhanced level of

purity in our sample relative to Yoo's, we were able to obtain cleaner, less ambiguous spectra that led us to several more refined structural conclusions. We now conclude that MNS-IndoAnti-90a has 30 carbons, 44-48 hydrogens, and 2-3 oxygens, and includes a terminal methylene group, a carboxylic acid or ester carbonyl, and a functional group containing a carbon-oxygen single bond. Further spectral analysis is necessary before the structure of MNS-IndoAnti-90a can be completely assigned.

The Synthesis and Analysis of Copper(I) Complexes of Tridentate Pyridine-Imine Ligands Used as Catalysts for Atom Transfer Radical Polymerization

Sara Turner

Atom transfer radical polymerization is mediated by a transition metal catalyst, which must provide for an accessible one electron redox couple, readily reversible halogen atom transfer, and full catalyst solubility. Catalyst structure heavily influences the efficiency of ATRP; even subtle changes in catalyst structure can have a large effect on the control of the radical polymerization. Here we investigate copper(I) complexes of a family of closely related tridentate ligands based on a pyridine-imine framework with a third N or O electron donor. We have generated 19 such ligands using a combinatorial building block approach to synthesis, and complexed them to copper. Structural characterizations of the complexes are presented here, and include single crystal XRD, NMR, IR, and ESI-MS analyses. In addition, polymerization data are presented and discussed with respect to catalyst structure. Multiple lines of evidence indicate the facile chelation of one ligand per copper. This chelation causes a change in the bonding of that ligand, as evidenced by NMR and IR analyses. In the catalysts studied here, copper(I) prefers a pseudotetrahedral coordination environment in the solid state. Three of the structurally characterized complexes are dinuclear, and one is mononuclear. A catalyst's preference for a dinuclear structure may be caused by the strain associated with two chelate rings to the same copper atom.

Computer Science

Support Vector Machines: Efficient Training Algorithms and Applications to Feature Selection

Nicholas A. Arnosti'11

This analyzed several feature selection algorithms that score features according to their impact on estimated class probabilities. In it, we presented a theoretical approach that clarifies the quantities estimated by each scoring system and allowed us to make several predictions about their performance. We validated our predictions with tests on synthetic data.

Developing Mobile Applications with Shims

Yuxing Danny Huang'11

By preserving the programming model of the operating system's networking interface, we developed a framework through which applications can be adapted for mobile networks without changing the source code, in a way that is automatic, dynamic and flexible.

Visualizing Large Communication Graphs

Steven S. Rubin'11

Communication graphs from parallel programs, which are useful for debugging, can be difficult to visualize. We first showed methods of creating and describing the symmetric structure of these graphs using graph grammars and procedural methods. Finally, we presented several techniques for visualizing these graphs, included a generalized algorithm for finding contextual subgraphs around important nodes.

Minimum Spanning Tree Algorithms in MapReduce

Erdem Sahin'11

This thesis investigates MST algorithms for the MapReduce framework of distributed computation. We consider MST algorithms designed for MapReduce, CRCW PRAM, and RAM models of computation. We implement each algorithm on the Hadoop MapReduce platform, and analyze our implementation's run-time and space complexity with respect to MapReduce. We run our algorithms on massive graphs consisting of millions of nodes and billions of edges. The performance of our algorithms follow theory, but all except our adaptation of Boruvka's MST algorithm fail to process very large graph instances due to unrealistic reducer

memory assumptions. We conclude that the streaming model used by our adaptation of Boruvka's is preferable for MST computations on the MapReduce framework, as it makes no assumptions about what can be held in memory, harnesses the power of the distributed framework well on massive graphs, and features desirable scalability.

Geosciences

Examining Knickpoints in Middle Boulder Creek, Colorado

Evan N. Dethier

The apparent stasis of our current landscape belies the constant change it has undergone for millions of years before the present. The earth's surface continues to transform as denudation balances slow uplift of rock material removed from slopes and by channels, which transmit climatic and tectonic signals through the landscape. In postorogenic terrains such as the Colorado Front Range, knickpoints—steep channels bounded by relatively shallower reaches—may reflect the influence of rock strength or slow, complex response to external forcing.

Most knickpoint research has focused on regions with high uplift rates, weak rock, and rapid landscape evolution. In contrast, the Front Range in Colorado—in the interior of the North American continent—is a region with low rock uplift and low precipitation, relatively strong rock, and thus comparatively low rates of incision. Knickpoints are found in all channel orders in the Middle Boulder Creek catchment, likely the result of increased precipitation and channel mouth lowering initiated between 7 and 3 Ma.

This study focused on the Middle Boulder Creek catchment west of Boulder, CO. Middle Boulder Creek has a drainage area of roughly 350 km², an area that includes the other two study areas: Gordon Gulch (~4 km²) and Betasso Gulch (~0.45 km²). In the field, we surveyed channel profiles and recorded width, depth, and grain size measurements. We described the character of the hillslopes, surveying transects perpendicular to the channel and measuring rock strength using a Schmidt hammer. We supplemented these field data with LIDAR DEM observations with a pixel size of 1 m². We calculated relationships between spatial data, comparing downstream distance, channel slope, mean hillslope angle, rock strength, and stream power. In these channels, knickpoints are roughly twice as steep as the mean channel slope, producing local convexity in channel profiles that would be concave-up in steady state. In Middle Boulder Creek, the knickpoint slopes average 7.4%, higher than the 4.2% channel average. A second, minor knickpoint is preserved upstream in a reach where average stream slope is only 4%. Rock type is uniform along Middle Boulder Creek, but rock strength is highest in the middle of the lower knickpoint and at the second knickpoint. In those zones, Schmidt Hammer values range between 50 and 65, considerably higher than the values of 35–45 that characterize the rest of the basin. Gordon Gulch has two knickpoints, with mean slopes of 15.3%, compared to the 10.8% channel average. These knickpoints are located in Silver Plume Granite that is harder than the metasedimentary basement rock that underlies the rest of the basin. Schmidt hammer values average between 45–50 in the knickpoints, compared to values between 0 and 40 upstream. Betasso has three small knickpoints that do not dramatically disrupt the channel concavity, but instead appear as bedrock steps in the channel. These steps correspond to areas of hard rock in the channel and on the adjacent hillslopes and have Schmidt hammer values of >45. Schmidt hammer values elsewhere in the catchment are between 5 and 40, and are <5 above the third knickpoint, where a thick layer of colluvium and saprolite covers the bedrock.

In each catchment, knickpoints mark the boundary between steady state and adjusting landscapes. Below and perpendicular to knickpoints, hillslopes are steep and rough relative to smoother and flatter hillslopes above. Steepening is a result of knickpoint-driven baselevel lowering. Where the hillslopes are steepened past the angle of repose, mass-wasting events hinder the adjustment process, overwhelming the ability of the channel to transport material downstream. Less dramatic baselevel lowering can accelerate hillslope processes, but rock strength, stream power, and continued channel disruption inhibit this adjustment and prevent a return to steady-state processes.

Bedrock strength plays a major role in knickpoint dynamics. In the Middle Boulder Creek and Betasso Gulch catchments, basins without local change in lithology nonetheless contain knickpoints that mark the transition between resistant and nonresistant bedrock. The strongest rock is at the knickpoint, and the lower

margin of weaker rock lies immediately above. This localized hardness likely results from the removal of weak rock by highly erosive flows within the knickpoint, exposing the fresh unweathered rock beneath. Weakness above the knickpoint—where stream power is low—is produced by the absence of effective removal and transport in those reaches. The stasis of this untransported rock makes it susceptible to weathering processes, and low rock strength could be the result of longer exposure. Where bedrock in a catchment is non-uniform, knickpoints form in the zones of higher rock strength. In Gordon Gulch, incision has been less effective in resistant rock, and the resulting disparity in baselevel lowering has localized the steepest reaches at the contact between less- and more-resistant rock.

Knickpoint migration in post-orogenic landscapes is difficult. Incision is not accelerated by rapid uplift, and must be driven by other forcing. The presence of resistant rock, low stream power, and the aggradation of sediment in the channel further hinder incision in the Front Range. Evidence for continued knickpoint migration is absent from this landscape and tentative evidence shows that the knickpoints may have stalled in each catchment. We must conclude that incision in the Middle Boulder Creek requires a synergy of many erosive processes in order to effectively incise the channels. This synergy is currently missing several key components, and knickpoint migration is likely to remain stalled until conditions change in the Front Range. Various climatic forcings or the renewal of tectonic action in the Rocky Mountains could reinitiate knickpoint migration in the Middle Boulder Creek catchment.

Reconstructing Pinedale Ice in the Green Lakes Valley and Adjacent Areas, Colorado

Keith M. Kantack

During the Pinedale Glaciation (~32-15 kya) alpine glaciers filled cirques and valleys extending from the crest of the Colorado Front Range. These glaciers are small remnants today, but their erosion over time dominates the landscape. Using field evidence, modeling techniques based on glacial flow rules, and Lidar imagery, I determined glacier size and local ice-flow direction and estimated volumes of sediment deposited during late Pinedale time. The volume estimates help constrain how rapidly those glaciers cut their cirques and valleys.

At glacial maximum, ice flowing out of the Green Lakes and Arapaho valleys joined and covered 22.3 km², but was only 83 m thick on average. Between 21 and about 15 kya, the glacier deposited morainal debris with a volume between 67 and 90 x10⁶ m³, which equates to a bed-lowering rate between 0.5 and 1.35 mm yr⁻¹. Moraine volumes suggest that cutting the Arapaho and Green Lakes Valleys required as few as 11 glacial events of size similar to the late Pinedale. Results from the Horseshoe and Rainbow Cirques to the south suggest respective bed-lowering rates of 0.25 to 2.98 mm yr⁻¹ and 0.15 to 1.37 mm yr⁻¹. Calculated erosion rates are similar to those measured for glaciers in the Swiss Alps. Late Pinedale cirque glaciers in the Front Range eroded at a moderate rate - far greater than polar ice sheets (0.01 mm yr⁻¹), but well below rates of glaciers in southeastern Alaska that lower their beds on the order of 1 to 10 cm yr⁻¹.

Petrogenesis of Precambrian Igneous and Metagneous Rocks South of the Madison Mylonite Zone, Henrys Lake Mountains, SW Montana and Idaho

Caleb O. Lucy

In their geologic map of the Hebgen Lake Quadrangle, O'Neill and Christiansen (2004) show units of Middle Archean tonalite and diorite gneiss along with Late Archean amphibolite in the middle of the Henrys Lake Mountains, SW Montana and Idaho. These bodies appear to be plutonic components along the western edge of the Wyoming province and broadly trend southwest to northeast, but they have not been studied in detail. After ascertaining the nature of the protoliths of these rocks, my project seeks to determine their metamorphic history, establish their original tectonic setting, and relate their history to that of southwest Montana, the northwestern Wyoming province and potentially the Big Sky orogeny.

Upon close inspection, the igneous rocks found in the Henrys Lake Mountains mapped by O'Neill and Christiansen as tonalite and diorite are petrographically and chemically indistinguishable. Geochemical analysis confirms their original mafic to intermediate igneous character; field relationships and petrography suggest an intrusive origin, although petrography also indicates that since crystallization, the rocks have experienced extensive hydrothermal alteration or low greenschist facies metamorphism. Because of their similarity and subsequent history, the "tonalite" and "diorite" of the Henrys Lake Mountains should be

considered one unit, ranging in composition from metagabbro to metadiorite. The amphibolite is more mafic, with a protolith composition of subalkaline basalt.

Geochemical evidence suggests the metagabbro, metadiorite and amphibolite are associated with arc volcanism and may have been part of a continental margin arc or a mature island arc that docked on the western edge of the Wyoming province. A cryptic, low greenschist facies metamorphic or extensive hydrothermal alteration event affected the rocks after their crystallization. The crystallization age for the metaigneous rocks of the Henrys Lake Mountains remains undecided.

Assessing Eolian Contributions to Soils in the Boulder Creek Catchment, Colorado

James A. McCarthy

In high-relief environments, soil geochemistry and morphology reflect the weathering of both parent material and materials added to weathering profiles by downslope transport and dustfall. In the Colorado Front Range, transport is limited in alpine soils developed on stable surfaces. In the montane zone, soils and regolith on hillslopes are mobile and mix during downslope transport. In this study, measurement of soil texture, citrate-buffered dithionite-extractable iron (Fe_d), and bulk geochemistry permitted evaluation of weathering, downslope transport, and eolian deposition in the Critical Zone of the Boulder Creek catchment. The accumulated mass of Fe_d and clay are positively correlated with deposit age in the catchment. Stable alpine soils form from Pinedale age till and the cool, moist climate generates sufficient acidity to develop strong horizonation. Soil morphology in the upper montane Gordon Gulch is controlled mainly by downslope transport; soils on the north-facing slope thicken downslope and have complex morphology. Soils on the south-facing slope are thin and overlie saprolite at a maximum depth of 53 cm. Soils on the north-facing slope have higher clay and Fe_d contents than those that face south, indicating more rapid erosion of the south-facing slope and greater weathering on the north-facing slope. On older surfaces of low relief, soils with thick Bt horizons develop from deeply weathered saprolite and regolith, and locally contain buried sequences and features that suggest periglacial mass movement and slope instability in pre-Holocene time.

In soils throughout the catchment, enrichment of fine particles and low concentrations of Fe_d in surface horizons suggests eolian sedimentation. Enrichment of fines is most apparent at stable sites, but soils on lower positions on slopes are also enriched. The amount of clay and fine silt produced in situ and the amount added from dustfall is poorly constrained, but the dustfall rate is less than $60 \text{ g cm}^{-2} 100 \text{ kyr}^{-1}$. Immobile element geochemistry indicates that surface enrichment in high field strength elements (HFSE) is not uniform throughout the study area, suggesting that the dust deposition may vary spatially and/or temporally. Ratios of the immobile elements Ti, Zr, and Nb, suggest that surface fines are geochemically distinct from the dominant parent materials in the catchment; however, elemental ratios may also reflect increased fines in the surface horizons released by weathering, because Zr and Nb are preferentially enriched in fine fractions of parent rocks in the study area. The composition of fine sediments in surface horizons are similar to silt mantles in other basins in the Indian Peaks Wilderness Area and to silt-sized alluvium in North Park and Middle Park to the west of the study area. Surface enrichment of fines with low Fe_d and distinct immobile element ratios of low compositional variability suggest that a substantial portion of the fine fraction of soils examined in this study originate as dustfall, potentially derived from North Park and Middle Park.

Pre-Tectonic Fabric in Unstrained Conglomerates and Implications for the Rf-phi Strain Analysis of Their Deformed Counterparts

Lisa M. Merkhofer

The Rf- ϕ method of strain analysis is based on the assumption that sedimentary rocks will have initially random fabrics before the onset of strain (Ramsay, 1967). In random fabrics, clasts are unaligned, such that their long axes are uniformly distributed across all orientations. Alternatively, the clasts of aligned fabrics are non-random, with a preferred orientation of clast long axes.

While assuming an initially random state is necessary to quantify strain, clasts of sedimentary rocks may be aligned and frequently such alignments are strong. It is therefore difficult to disentangle tectonic alignment

from that of prior depositional or diagenetic alignment. When such pre-tectonic alignment exists and is not recognized in a strained rock, Rf- ϕ analysis can result in significant strain errors (Patterson & Yu, 1994).

The large size of conglomerate clasts makes them common subjects for strain analysis. However, although the effects of pre-tectonic fabric on strain have been studied for many sedimentary rocks, including sandstone, tuff, and oolitic limestone, little work has been done for conglomerate. In this study, I conduct analysis by digitizing clasts from unstrained alluvial-fan conglomerates using high-resolution GigaPan photography. From the analysis of both Cartesian and polar plots, I characterize how strongly conglomerate initial fabrics deviate from random fabrics. Secondly, by simulating strain on undeformed conglomerate, I calculate the error aligned initial fabrics impose on strain estimates and assess prospects for detecting the traces of initial fabric after strain.

The conglomerates studied in Deerfield Basin, Massachusetts, show random fabrics on bedding-parallel faces and non-random fabrics on bedding perpendicular faces. Non-random fabrics are aligned consistently imbricate to bedding trace. The magnitude of clast alignment in non-random fabrics can be described by an average apparent strain aspect ratio of 2.0 and consistency ratios above 0.40, indicating strongly preferred fabrics. Three-dimensional fabric is described by an oblate apparent strain ellipsoid with maximum dimensions of 2.5:1.9:1.0, far greater than those found in other sedimentary rocks (Holst, 1982). Within fabrics, quartz vein or quartzite clasts are the least likely to be preferred.

Strain simulations performed on conglomerate fabrics assuming a random fabric demonstrate that strain magnitudes can be overestimated by 50%, when stretching is parallel to the initial preferred orientation. Errors of this scale occur even at small strains of an $R_s=1.5$.

Basement Faults of the Edelman Lineament, Bighorn Mountains, Wyoming

David O. Oakley

The Bighorn Mountains are a basement-cored arch in north-central Wyoming formed during the Laramide orogeny (70-45 Ma). The range and orogeny are exemplary of mid-continent deformation distant from a plate boundary, but many unanswered questions remain about the structures involved. The Archean crystalline basement rocks at the core of the Bighorn arch and the series of topographic lineaments of likely structural significance within them (Hoppin, 1974) are particularly understudied parts of the range. I conducted stereographic analysis of faults and fractures, calculated paleostresses, and did petrographic study of fault materials from within the Edelman Creek lineament, a narrow valley trending approximately 040°. My goal was to determine whether the structures were active during Laramide arch formation, to assess the significance of fault mineralization, and to determine the structural role of the lineament.

My results suggest that the Archean basement rocks of the Bighorn Mountains record a long history of deformation. Field observations and paleostress analysis indicate some Laramide deformation, but the majority of faults appear to be non-Laramide. Many faults have been reactivated under changed stress conditions subsequent to their formation. Chlorite and epidote fault mineralization correlate roughly with fault orientation and more closely with different microscopic characteristics, indicating different conditions and thus ages of formation. Epidote mineralization appears to be pre-Laramide and to predate chlorite, but otherwise the timing of mineralization and fault movement remains mostly uncertain. Evidence suggests that a regional scale strike-slip fault underlies the Edelman lineament. Absolute, and in many cases relative, ages remain as crucial unknowns and a potential topic for future work.

Paleogeography of a Devonian Island-Reef Complex, Canning Basin, Western Australia

Daniel R. Walsh

The Devonian island-reef complex of the Canning Basin in Western Australia provides a unique opportunity for paleoecologists and geomorphologists to explore an intact biophysical system preserved in three dimensions. The burial of the currently exposed Devonian reefs by 2,500 m of carbonates after the Frasnian-Famminian boundary and subsequent geological quiescence allowed structures such as skerrys, islands, lagoons, and clastic deposits, as well as the associated invertebrate faunas, to be preserved in detail despite the 375 million years separating us from the living reef. This study aims to reconstruct the paleogeography of the island reef system in a holistic sense.

The island-reef complex consists of two parts: the highly folded quartzite-phyllite Oscar Range, which formed a chain of islands in Devonian times, and the stromatoporoid reef structure, which includes a classic reef-front to reef-flat sequence as well as an inner and outer lagoon, which are separated by the Oscar Range. Fieldwork focused on the far eastern end of the range, where the Tunnel Creek Road provides access to a wide variety of facies including siliciclastic deposits sourced from the Oscar Range. Studies in three different phases of the various aspects of the island-reef system provide insights into the paleoecology, geomorphology, and stratigraphic history of the region.

The 2005 discovery of a fan-delta deposit composed of siliciclastics apparently sourced from the Oscar Range (Johnson and Webb, 2007) spurred a return trip to the region to map in the deposit and surrounding bio-facies. The first stage of this study involved the creation of a detailed map and stratigraphic section for the fan-delta and overlying carbonates, which are located in the distal outer lagoon. The stratigraphy reveals a sequence of episodic siliciclastic sedimentation events with provenance in the Oscar Range that decrease in magnitude with time. A transition to active reef growth indicated by a massive stromatoporoid fauna and the stabilization of oncoids is diagnostic of a rise in sea level near the close of Frasnian time.

The second stage of the study focuses on the paleogeographic relationship between the fan-delta deposit and the paleoislands of the Oscar Range. This relationship suggests that the stream channels that now converge and pass immediately alongside the fossil fan-delta are inherited from those which originally delivered sediments from the Oscar Range to the fan-delta in Frasnian times. Quantitative assessment of this possibility reveals that differential erosion rates between quartzite and limestone, derived from studies of landscape denudation in arid Australia, would not result in enough erosion within the Oscar Range to override structural controls on stream erosion. Channel quantification shows that stream flow is controlled almost entirely by folds in Proterozoic quartzite and phyllite, therefore demonstrating that modern stream channels are likely to be very similar in location to those active during the Devonian. Study of the ancient landforms reveals that geomorphological techniques can be extended into the past under very specific circumstances.

The third stage of the project focuses on a small paleoisland located in the inner lagoon just north of the Oscar Range. Detailed reconstruction of an invertebrate community rich in gastropods, stromatoporoids, and bivalves is possible due to incredible in situ preservation. Determination of species zones and regions of siliciclastic deposition allows for reconstruction of paleoenvironmental conditions such as wind and water circulation. Analogs in modern reefs show that species with similar morphologies have filled specific niches since Devonian times. A diverse gastropod fauna in the lagoon near the island allows for a similar analysis in a different setting.

The spectacularly preserved biophysical systems of the island-reef tract allow for reconstruction of an ancient geography with an incredible level of detail. This location is therefore ideal for the creation of a geopark – a conservation framework that would ensure protection of this geologic resource and education of the public about its value. The last phase of the project was to make recommendations as to how a geopark could be implemented in the field area from a practical and educational standpoint.

The division of paleogeographic reconstruction into several small-scale projects allows for a well-constrained and detail-oriented interpretation. Much fruitful research remains to be done in the eastern Oscar Range alone; the analysis contained herein provides a firm basis for such work.

Mathematics and Statistics

A Study of Hitting Times for Random Walks on Finite, Undirected Graphs

Ariel Joseph Binder

This thesis applies algebraic graph theory to random walks. Using the concept of a graph's fundamental matrix and the method of spectral decomposition, we derive a formula that calculates expected hitting times for discrete-time random walks on finite, undirected, strongly connected graphs. We arrive at this formula independently of existing literature, and do so in a clearer and more explicit manner than previous works. Additionally we apply primitive roots of unity to the calculation of expected hitting times for random walks on circulant graphs. The thesis ends by discussing the difficulty of generalizing these results to higher

moments of hitting time distributions, and using a different approach that makes use of the Catalan numbers to investigate hitting time probabilities for random walks on the integer number line.

n-Level Densities of the Low-Lying Zeroes of Quadratic Dirichlet L-Functions

Jake Levinson

The statistical distributions of zeros of L-functions can be used to study prime numbers, elliptic curves and even the ideal class groups of number fields. L-functions have been studied in connection with random matrix theory, which provides easier methods of computing these distributions. One statistic, the n-level density of low-lying zeros for a family of L-functions, measures the distribution of zeros near the central point $s = 1/2$. The Density Conjecture of Katz and Sarnak states that the n-level density for an L-function family depends on a classical compact group associated to the family. We extend previous work by Gao on the n-level densities of quadratic Dirichlet L-functions. Our main result is to confirm up to $n = 6$ that, for test functions of suitable support, the density is as predicted by random matrix theory. We also consider a (conjectural) combinatorial identity for certain Fourier transforms of the test functions which, if true, would help in extending the result to all n .

Chains of Rings with Local Formal Fibers

Sean Carlos Pegado

Let R be a local (Noetherian) commutative ring with unity. If R is complete, its structure is understood; however, less is known if R is not complete, and thus the relationship between a ring and its completion is a subject of current research. To this end, previous work has begun to investigate the relationship between prime ideals of a ring and the prime ideals of its completion. We generalize these results to chains of rings that share the same completion.

Optimal Control of the Generalized Moving Point Mass Dynamic

Thuy Vinh Pham

We study the generalized time-optimal control problem where the underlying dynamic is a moving point mass under Newtonian mechanics with acceleration and velocity constraints. The optimal control of this control problem coincides with the viscosity solution of a specific partial differential equation of Hamilton-Jacobi type. Using the dynamic programming approach, we derive the associated Hamilton-Jacobi-Bellman equation and obtain its numerical solution with a semi-Lagrangian discretization scheme.

Robust Regression Boosting

Ville Satopaa

In 2010 Long and Servedio suggested that boosting algorithms that are based on convex loss functions are flawed in a sense that they cannot tolerate outliers. Inspired by Long and Servedio's observation, this undergraduate thesis introduces a novel regression boosting algorithm that is based on a non-convex loss function. First, several properties of this algorithm are stated and proven. Second, experimental evidence showing that this algorithm is highly robust in the presence of outliers is given.

Generic Formal Fibers

Philip Vu

Let T be a complete local ring. We present necessary and sufficient conditions for which there exists a local integral domain A , a subring of T , whose completion is T with a generic formal fiber that has countably many maximal elements. We also present results on the elements we can adjoin to this integral domain A .

Geometric Degree of 2-Bridge Knots

Jacob Wagner

In 1987, Kuiper introduced geometric degree alongside superbridge index, but degree has been studied far less than superbridge. In this thesis, we calculate degree for all 2-bridge, 4-superbridge knots. Then, we modify the definitions of degree and a related invariant, thin position, to generate new measures.

Sturm-Liouville Oscillation Theory for Differential Equations and Applications to Functional Analysis

Zhaoning Wang

We study the connection between second-order differential equations and their corresponding difference equations. With this connection in mind, we investigate quantitative and qualitative properties of the zeros of the solutions of differential/difference equations and of the eigenvalues of the associated Jacobi matrices. In particular, we study various applications of the Sturm-Liouville Oscillation Theory to differential equations and spectral theory.

The Limiting Spectral Measure for the Ensemble of Generalized Real Symmetric Block m-Circulant Matrices

Wentao Xiong

Given an ensemble of $N \times N$ random matrices with independent entries chosen from a nice probability distribution, a natural question is whether the empirical spectral measures of typical matrices converge to some limiting measure as N tends to infinity. It has been shown that the limiting spectral distribution for the ensemble of real symmetric matrices is a semi-circle, and that the distribution for real symmetric circulant matrices is a Gaussian. As a transition from the general real symmetric matrices to the highly structured circulant matrices, the ensemble of block m -circulant matrices with toroidal diagonals of period m exhibits an eigenvalue density as the product of a Gaussian and a certain even polynomial of degree $2m-2$. This paper generalizes the m -circulant pattern and shows that the limiting spectral distribution is determined by the pattern of the i.i.d.r.v. elements within an m -period, depending on not only the frequency at which each element appears, but also the way the elements are arranged. For an arbitrary pattern, the empirical spectral measures converge to some nice probability distribution as N tends to infinity.

Physics

The Ubit: An Exploration of Real-Vector-Space Quantum Mechanics

Antoniya Aleksandrova

In 1960, Stueckelberg showed that if the real-vector-space version of quantum theory is supplemented by a specific "super selection rule" limiting the set of allowed observables, then the theory is mathematically equivalent to ordinary quantum mechanics. We give an information-theoretic interpretation of this rule by proposing a model in which all real quantum objects can interact with a universal binary object called the ubit. In addition, we use our model to investigate whether the rule can be achieved through a generic dynamics rather than being assumed.

Experimental Characterization of Algorithms for Holographic Optical Trapping

Peter K. Gottlieb

Tightly focused light can be used to manipulate objects on a very small scale. My thesis looks at the merits and difficulties of using a phase-modulated laser beam to simultaneously manipulate an arbitrary number of objects.

Observation of Dynamic Processes in Weakly Segregated Diblock Copolymer Films

Leah L. Hurwich

This thesis studied the dynamic processes of weakly segregated diblock copolymer films to better understand the behavior of smectic systems. Thin films samples of polystyrene-block-polymethylmethacrylate (PS-*b*-PMMA) were cast atop silicon substrates and imaged under an atomic force microscope (AFM) while heating to determine the annihilation processes prevalent in the system. Preliminary findings show these annihilations differ greatly from those of strongly segregated diblock copolymers, thus suggesting not all smectic systems evolve through similar processes.

Study of a Modelocked Optical Fiber Laser

Nathaniel J. Lim

Research includes evaluation of the birefringence properties of a non-linear optical mirror and its ability to mode-lock an Erbium-doped fiber laser. Pulses with an estimated duration of about three picoseconds were generated. A solution on how to engineer the non-linear optical loop mirror to generate shorter pulses was proposed.

Measurement of the Stark Shift in an Indium Atomic Beam using Frequency Modulation Spectroscopy

Antonio Lorenzo

We have made progress towards a precise measurement of the Stark shift in the $5P_{1/2}$ to $6S_{1/2}$ transition at 410 nm in atomic indium to test ab initio atomic theory calculations. We have designed and constructed an oven capable of reaching over 1000 degrees Celsius in order to produce an atomic beam of indium. Additionally, we have shown the feasibility of using frequency modulation spectroscopy in measuring the Stark shift in this atomic beam.

The Free Energy of a Stretched RNA Chain, (mRNA pronounced messenger RNA) with Applications to Small RNA Binding to mRNA

Yuzhong Meng

Using both polymer physics theory and random walk simulations, we estimate the free energy of a stretched RNA chain. We then use this estimate to calculate the free energy of small RNA binding to mRNA hairpin loops. Our calculation shows that mRNA chain stretching significantly increases the free energy of seed+3' miRNA binding and siRNA binding to mRNA hairpins. We also make the important observation that 3' supplementary miRNA has two binding modes: seed-only and seed+3', and that the former is often more favorable in mRNA hairpins.

Robust Encodings for Dephased Quantum Walks on Rings

Samyam Rajbhandari

In my research I found an exact solution to the quantum walk on a ring graph under dephasing. I also proved that unary encoding is the most robust encoding within a factor of two of the dephasing rates for a quantum walk on a ring graph.

Accounting for Thermal Fluctuations in RNA Secondary Structure

Rebecca C. Sullivan

Our lab has shown that the probability of any single RNA secondary structure state occurs with very small probability, but currently secondary structure databases provide one "correct" state. We have produced a new kind of set of reference structures that include typical thermal fluctuations. The resulting database lists the thermally averaged base pair probabilities to replace the single-state reference structures.

Psychology

The Magnitude Effect on the Discounting of the Utility of Delayed Rewards

Tasha Chu

Individuals tend to value a reward less as the delay to the reward increases. This decrease in value due simply to an increase in delay is known as *delay discounting*. Larger amounts tend to be discounted less than smaller amounts, a phenomenon known as the *magnitude effect*. There is no satisfactory theoretical account for the magnitude effect, which may be due to inaccurate estimates of the way in which discounting rates change with reward magnitude through the use of raw amounts, rather than the utility of those amounts. In Experiment 1 ($n = 36$), we assessed utility with the gamble-tradeoff method, which was proposed by Wakker and Deneffe (1996), using real money to attain three pairs of values for which the participant's utility ratio is 2-1. Participants then chose between the larger reward at some delay and the smaller reward immediately, and delays were adjusted until participants were indifferent between the two rewards. We then compared the use of amounts and the use of utility values in estimating the magnitude effect. The procedure for Experiment 2 ($n = 39$) was identical, except that we used a 1.5-1 ratio of utility

values. For both Experiments 1 and 2, the utility functions of many of the participants, as assessed by the gamble-tradeoff task, were linear or very nearly so. In Experiment 1, 11 of 33 (33%) participants had linear utility, and in Experiment 2, 13 of 39 (33%) participants had linear utility. Consequently, the use of raw amounts and of utilities gave very similar estimates of the magnitude effect. Log k was a decreasing, and approximately linear, function of log amount and of log utility.

Family Dinner Time: Examining Children's Questions in Context

Laura Corona

This study examines the questions children hear and ask in the context of family dinner time. Six families with a child in kindergarten and six families with a child in third grade were provided with tape recorders with which to record five family dinners within a period of two weeks. Questions were coded for type and content. Responses to children's questions were also coded. Children asked an average of six questions per dinner, many of which were about family experience and many of which requested novel information about the world. There was no significant difference between age groups in the number of informational questions children asked. Children's information-seeking questions were positively associated with maternal information-seeking questions. Differences in the kinds of questions children asked were examined, as well as individual patterns within families. Children of both ages asked more questions than research suggest they ask at school. This adds to the picture of why so little curiosity has been identified in classroom settings, providing clues about why there might be a difference between children's question-asking at school and at home. Educational implications are discussed.

“The Money is Yours to Keep”: The Effect of Automatic vs. Contingent Compensation on Research Participation

Janna Gordon

How does a research study's compensation policy influence individuals' decisions about whether or not to participate? In order to limit coercive pressure on participants, IRB guidelines stipulate that compensation should be automatic rather than contingent on study completion—i.e., that participants are entitled to their payment even if they decide to discontinue their participation in a study. Although this policy suggestion is well-intentioned, it does not take into account the norm of reciprocity, the widely held social expectation that individuals have an implicit obligation to respond to one another in kind, such as returning a favor with a favor. In four studies, I show that individuals who receive automatic payment actually felt more pressure to participate in a psychology study, and were generally more likely to do so, than those receiving contingent payment. Implications of these findings and possible avenues for future research are addressed.

Differences in Prediction Accuracy between Minority and Majority Groups: An Exploration of the Intersection of Power, Status, and Perspective-taking

Sa-Kiera Hudson

Majority groups usually occupy senior positions in modern companies and by dint of their position make company decisions that affect minorities. There has not been much research on whether majority groups such as Whites and men have an accurate sense of what minority groups like women and ethnic minorities believe and want, especially within a company setting. We predict that ethnic minorities and women will be relatively more accurate than whites and men at predicting for others. Study One found job factors that differed in the amounts of money given up between men and women and between Whites and Minorities. In Study Two participants were asked to predict what they thought Black and White men and women would respond to questions about the importance of various job factors. Ethnic minorities are more accurate at predicting for others than Whites are, however women are not more accurate than men. We found little support in Study Three that underlying power dynamics caused this difference in accuracy between Whites and Minorities. Implications and future studies are discussed.

The Minority Spotlight Effect

Madeline King

The present study examined whether social referencing and solo status interact to create a minority spotlight effect. White and minority participants listened to opinions about either a race-relevant or race-neutral topic in the presence of two confederates, whose behavior was standardized across conditions.

Minority participants listening to opinions about a race-relevant topic felt they were the targets of attention significantly more than minority participants in the race-neutral condition, and significantly more than White participants in either condition. Furthermore, minority participants were more likely to report feeling “in the spotlight” and feeling negative emotions when the topic was race relevant. These findings have implications for the experience of underrepresented minorities in academic and workplace settings.

My Wish is Your Command: Associations between Subclinical Narcissism and Impression

Management

Veronica Rabelo

The present study examined the associations between subclinical narcissism and perceptions of noticeability for positive and negative traits and behaviors. We speculated that narcissism would be associated with a tendency to believe that positive traits and behaviors would be highly noticeable to others, while negative characteristics and actions would be cloaked by invisibility. In Phase 1 of the study, participants rated how noticeable they believed a variety of positive and negative traits, past behaviors, and actions in hypothetical scenarios would come across to others. As predicted, participants rating higher in narcissism were more likely to think others noticed their positive traits and behaviors, and less likely to think this about their negative traits and behaviors. Phase 2 of the study explored four potential mechanisms that could help explain the observed relationship between narcissism and noticeability: paying differential attention to positive feedback, disproportionate memory to favor positive feedback, sheer skill at deception, and self-serving interpretation of ambiguous feedback. Of the four proposed mechanisms, we found support for skill at deception, but only among men. These findings are discussed within the framework of a self-regulatory model of narcissism.

Temperamental Fearfulness and Proneness to Anger and Physiological Response to Loss of Social Contingency in Infants and Preschoolers

Ellen Ramsey

Previous research on infants’ individual differences in response to a loss of social contingency has focused on maternal characteristics including stress, depression, and sensitivity, but considerably less is known about infant contributions. Additionally, little is known about how children respond physiologically to a loss of social contingency. This thesis sought to extend previous research by first examining the associations between individual differences in infant temperament, including fearfulness and anger, and infant physiological responding to a modified, double Still-Face Paradigm (SFP). Preschoolers’ physiological response to a modified SFP was then examined to see if similar patterns in response to a loss of social contingency as that seen in infants would emerge. Finally, individual differences in fearfulness and anger were explored in preschoolers to examine if temperamental variables have similar influences in older children during the loss of contingency. Physiological responding (heart rate and vagal tone) during the SFP and maternal report of fearfulness and anger were examined in 22, 6-month old infants. Physiological responding during a modified loss of contingency paradigm and during anger- and fear-eliciting tasks, and maternal report of fear and anger was collected in a sample of 14 preschool-aged children. Results showed that physiological reactivity in response to a loss of social contingency follow similar patterns for both infants and preschool aged children. Temperamental measures of fear and anger were significantly related to individual differences in physiological arousal in both infants and preschool-aged children, demonstrating that temperamental fearfulness in particular may be of central importance to individual differences in sensitivity to loss of social contingency.

Let’s Not, and Say We Would: The Discrepancy between Imagined and Real Responses to

Homophobia

Johannes Wilson

This study examined participants’ imagined affective and behavioral responses to witnessing a homophobic slur in comparison with the responses of participants who actually witnessed a homophobic slur. Participants were assigned to one of two roles: Experiencers, who witnessed a heterosexual confederate utter a homophobic slur targeted toward a gay confederate who had just left the room, and Forecasters, who imagined the scenario that Experiencers went through. Within both Forecasters and Experiencers, there was also a control condition in which the heterosexual confederate did not utter a slur. All participants reported

their affect, selected one of the two confederates for an upcoming task, and recommended each confederate for a pleasant or unpleasant task. It was found that, upon hearing the slur, Forecasters reported much higher levels of negative affect than Experiencers did, and half of them reported that they would assertively confront the straight confederate whereas no Experiencers actually confronted. Individual differences were virtually unrelated to affective and behavioral responses to the slur. These findings indicate that there is a discrepancy between imagined and real affective and behavioral responses to homophobia.

Rumination, Attribution, and Contingent Self Esteem in Romantic Relationships

Joshua Wilson

Two studies were conducted to examine the interacting effects of rumination, negative attribution, and contingent-self esteem in the domain of romantic relationships. Specifically, the studies examined the role of rumination and its subtypes (brooding and reflection) in dynamic interaction with negative attribution across time in the maintenance of negative mood. In Study 1, brooding and reflection were experimentally induced in a sample of 67 college students used a rumination induction to determine their subsequent effects on affect, causal attributions, and social problem-solving in the context of romantic relationships. Relationship-contingent self esteem (RCSE) was included as a possible moderator, on the basis of contingent self-worth theory. Results were consistent with the classic depressogenic effects of rumination: after rumination, positive affect and social problemsolving skills were both lower, with more mixed results for attribution. There were no differences between brooding and reflection, and the moderating role of relationship-contingent self esteem was supported only for blame attributions. In Study 2, a daily diary methodology was used to examine the effects of brooding and reflection on affect and attribution over a 14 day period in 39 college students. Specifically, it assessed whether brooding was associated with negative causal attributions in response to negative relationship events. Relationship-contingent self esteem was expected to predict more frequent brooding response to negative events. Overall, this study found that rumination of both types was associated with more negative attributions both on the same day as the brooding as well as in the future, with no moderating role of relationship-contingent self esteem. Both brooding and reflection were associated with increases in negative affect. Furthermore, participants with high RCSE brooded more than those with low RCSE, but only on days when no negative event occurred. There is minimal evidence that contingent-self esteem moderates the effects of rumination, but further study is needed to confirm this. Methodological issues, clinical implications, and implications for the theoretical distinctions between the subtypes of rumination, as well as directions for future research, are discussed.

FACULTY PUBLICATIONS AND PRESENTATIONS

Astronomy

The Universe as a Simple Mathematical System

Marek Demianski, Doroshkevich, S. Pilipenko and S. Gottlöber

Monthly Notices of the Royal Astronomical Society, 1 June, DOI: 10.1111/j.1365-2966.2011.18265.x, 14 pp. (2010)

We analyze the evolution of the basic properties of the simulated elements of the large-scale structure of the Universe (LSS) formed by dark matter (DM), and we confront it with the observed evolution of the Lyman α forest. In three high-resolution simulations, we have selected samples of compact DM clouds of moderate overdensity. Clouds are selected at redshifts $0 \leq z \leq 3$ with the minimal spanning tree technique. The main properties of the clouds selected in this way are analyzed in three-dimensional space and with the core-sampling approach. This allows us to compare estimates of the DM LSS evolution obtained with two different techniques, and to clarify some important aspects of the LSS evolution. In both cases, we find that regular redshift variations of the mean characteristics of the DM LSS are accompanied only by small variations of their probability distribution functions (PDFs), which indicates the self-similar characteristic of the DM LSS evolution. A high degree of relaxation of DM particles, compressed within the LSS, is found along the shortest principal axis of the clouds. We see that the internal structure of the selected clouds depends upon the mass resolution and scale of the perturbations achieved in the simulations. It is found that the low-mass tail of the PDFs of the LSS characteristics depends upon the procedure of cloud selection.

The Gamma Ray Bursts Hubble Diagram in Quintessential Cosmological Models

Marek Demianski, E. Piedipalumbo, and C. Rubano

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It has been recently empirically established that some of the directly observed parameters of gamma-ray bursts (GRBs) are correlated with their important intrinsic parameters, such as the luminosity or the total radiated energy. These correlations were derived, tested and used to standardize GRBs, i.e. to derive their luminosity or radiated energy from one or more observables, in order to construct an estimated fiducial Hubble diagram (HD), assuming that radiation propagates in the standard Λ cold dark matter cosmological model. We extend these analyses by considering more general models of dark energy and an updated data set of high-redshift GRBs. We show that the correlation parameters only weakly depend on the cosmological model. Moreover we apply a local regression technique to estimate, in a model-independent way, the distance modulus from the recently updated Type Ia supernova (SNIa) sample containing 307 SNIa, in order to calibrate the GRBs 2D correlations, by considering only GRBs with $z \leq 1.4$. The derived calibration parameters are used to construct a new GRBs HD, which we call the calibrated GRBs HD. We also compare the estimated and calibrated GRBs HDs. It turns out that for the common GRBs they are fully statistically consistent, thus indicating that both of them are not affected by any systematic bias induced by the different standardizing procedures. We finally apply our methods to calibrate 95 long GRBs with the well-known Amati relation and construct the estimated and calibrated GRBs HD that extends to redshifts $z \sim 8$. Even in this case there is consistency between these data sets. This means that the high-redshift GRBs can be used to test different models of dark energy. We used the calibrated GRBs HD to constrain our quintessential cosmological model and derived the likelihood values of Ω_m and $w(0)$.

Abundances of Oxygen in Anticenter Planetary Nebulae and the Oxygen Abundance Gradient in the Galactic Disk

R.B.C. Henry, Karen B. Kwitter, Anne E. Jaskot '08, B. Balick, M. Morrison and J.B. Milingo

Astrophysical Journal, **724**, 748-761 (2010)

We have obtained spectrophotometric observations of 41 anticenter planetary nebulae (PNe) located in the disk of the Milky Way. Electron temperatures and densities, as well as chemical abundances for He, N, O, Ne, S, Cl, and Ar were determined. Incorporating these results into our existing database of PN abundances

yielded a sample of 124 well-observed objects with homogeneously determined abundances extending from 0.9 to 21 kpc in galactocentric distance. We performed a detailed regression analysis which accounted for uncertainties in both oxygen abundances and radial distances in order to establish the metallicity gradient across the disk to be $12 + \log(\text{O}/\text{H}) = (9.09 \pm 0.05) - (0.058 \pm 0.006) \times R_g$, with R_g in kpc. While we see some evidence that the gradient steepens at large galactocentric distances, more objects toward the anticenter need to be observed in order to confidently establish the true form of the metallicity gradient. We find no compelling evidence that the gradient differs between Peimbert Types I and II, nor is oxygen abundance related to the vertical distance from the galactic plane. Our gradient agrees well with analogous results for H II regions but is steeper than the one recently published by Stanghellini & Haywood over a similar range in galactocentric distance. A second analysis using PN distances from a different source implied a flatter gradient, and we suggest that we have reached a confusion limit which can only be resolved with greatly improved distance measurements and an understanding of the natural scatter in oxygen abundances.

The Galactic Disk Oxygen Gradient and the Limit of Confusion

R.B.C. Henry, Karen B. Kwitter, Anne E. Jaskot '08, B. Balick, M. Morrison and J.B. Milingo

Bulletin of the American Astronomical Society, **256.07** (2011)

We have obtained spectrophotometric observations of 41 anticenter planetary nebulae (PNe) located in the disk of the Milky Way. Oxygen abundance results of these objects plus those in our pre-existing database yield a sample of 124 PNe with which to study the oxygen abundance gradient in the disk of the Galaxy between 0.9 and 21 kpc in galactocentric distance. Accounting for both abundance and distance uncertainties, we find an oxygen gradient of -0.058 ± 0.006 dex/kpc. We see some evidence that the gradient may steepen at large galactocentric distances but no compelling evidence that the gradient differs between Peimbert Types I and II nor that the oxygen abundance is related to the vertical distance from the Galactic plane. A second analysis using PN distances from Stanghellini et al. (ApJ, 689, 194, 2008) implies a flatter gradient, and we suggest that we have reached a confusion limit which can only be resolved with greatly improved distance measurements and an understanding of the natural scatter in oxygen abundances. RBCH, KK, and BB gratefully acknowledge support from NSF Grants AST-0806577, AST-0806490, and AST-0880201, respectively.

Abundances in a Sample of Halo/Thick Disk Planetary Nebulae in M31

Karen B. Kwitter, Emma M. M. Lehman '10, B. Balick and R.B.C. Henry

Bulletin of the American Astronomical Society, **256.08** (2011)

We present preliminary abundances for 16 planetary nebulae in M31 identified by Merrett et al. (MNRAS, 369, 120, 2006). Our objects are the brightest 16 in a $\lambda 5007$ flux-ranked subsample (m_{5007} between 20.45 and 20.88) whose distances from the major axis of M31, measured parallel to the minor axis, are between 15 and 50 arcminutes. This group presumably includes non-thin-disk objects, i.e., members of the thick disk and halo of M31, but may also sample possible tidal streams. Spectroscopic data were obtained with the DIS instrument on the 3.5-m ARC telescope at Apache Point Observatory (3700-9600 Å) and with GMOS on the Gemini North 8.1-m telescope (3700-6400 Å). Abundances were derived using our ELSA package (Johnson et al., IAU Symp. #234, 439, 2006). The resulting preliminary average abundances based on observations to date are as follows: $\text{He}/\text{H} = 0.107 (\pm 0.010)$, $\text{O}/\text{H} = 4.29 (\pm 1.24) \times 10^{-4}$, $\text{N}/\text{O} = 0.703 (\pm 0.618)$, and $\text{Ne}/\text{O} = 0.212 (\pm 0.019)$. There remain six PNe for which we have only Gemini spectra; in the fall of 2010 we plan to complete our observations and obtain companion red spectra at APO, allowing an improved analysis. For now, we note that the average He/H ratio is similar to the average of Milky Way halo PNe (Henry, Kwitter & Balick, A.J., 127, 2284, 2004), and below that for a similar-sized sample of mostly bulge PNe in M31 reported by Jacoby & Ciardullo (Ap.J., 515, 169, 1999). Our O/H ratio is well above the Milky Way halo PN value, and slightly above that of the Jacoby & Ciardullo sample.

KBK, RBCH and BB are grateful to their respective institutions and to the NSF for support under grants #AST-0806490, AST-0806577, and AST-0880201, respectively. KBK and EML thank NOAO for their generous travel support.

Spectra of 12 New Planetary Nebulae in the Milky Way Galaxy
J. McKeever, T. Gomez, B. Balick, J. Lutz, *Karen B. Kwitter*, and S. Snedden

Bulletin of the American Astronomical Society, **256.09** (2011)

There are many planetary nebulae known in our own galaxy but the vast majority are located close to the plane. However studies of M31 show thousands of PN in its thick disk and halo, so we surmise that there are more halo PN to be discovered for the MWG. Halo PN are important for studying the chemical evolution of the MWG, since they reflect the composition of the galaxy when the first generation of stars formed. We have been searching for PN within the galactic halo, and have found three new PN that may be classified as "halo" PN. We have also discovered nine other new PN within the thick disk and plane of the galaxy. Candidates for our spectral observations were chosen through a multi-step process. First, colors within SDSS and 2MASS were compared to find initial targets, which were then followed up with imaging in g' and [OIII] filters to pick out [OIII] bright candidates. Apache Point Observatory DIS spectroscopy of our candidates has resulted in identification of twelve likely new PN, based on the observed emission lines, and ratios of these lines. We present spectra and images of some for these targets.

A Comparison of the Red and Green Coronal Line Intensities at the 29 March 2006 and the 1 August 2008 Total Solar Eclipses: Considerations of the Temperature of the Solar Corona

A. Voulgaris, T. Athanasiadis, J. H. Seiradakis, and *Jay M. Pasachoff*

Solar Physics **264**, #1, 45-55. DOI 10.1007/s11207-010-9575-7. (2010)

During the total solar eclipse at Akademgorodok, Siberia, Russia, on 1 August 2008, we imaged the flash spectrum with a slitless spectrograph. We have spectroscopically determined the duration of totality, the epoch of the 2nd and 3rd contacts and the duration of the flash spectrum. Here we compare the 2008 flash spectra with those that we similarly obtained from the total solar eclipse of 29 March 2006, at Kastellorizo, Greece. Any changes of the intensity of the coronal emission lines, in particularly those of [Fe X] and [Fe XIV], could give us valuable information about the temperature of the corona. The results show that the ionization state of the corona, as manifested especially by the [Fe XIV] emission line, was much weaker during the 2008 eclipse, indicating that following the long, inactive period during the solar minimum, there was a drop in the overall temperature of the solar corona.

An Old World with a Fresh Surface

J. L. Elliot, M. J. Person, C. A. Zuluaga, A. S. Bosh, E. R. Adams, T. C. Brothers, A. A. S. Gulbis, S. E. Levine, M. Lockhart, A. M. Zangari, *Bryce A. Babcock*, *Katherine DuPré '10*, *Jay M. Pasachoff*, *Stephen P. Souza*, W. Rosing, N. Secrest, L. Bright, E. W. Dunham, S. S. Sheppard, M. Kakkala, T. Tilleman, B. Berger, J. W. Briggs, G. Jacobson, P. Valleli, B. Volz, S. Rapoport, R. Hart, M. Brucker, R. Michel, A. Mattingly, L. Zambrano-Marin, A. W. Meyer, J. Wolf, E. V. Ryan, W. H. Ryan, K. Morzinsky, B. Grigsby, J. Brimacombe, D. Ragozzine, H. G. Montano, and A. Gilmore

Nature, June 17 (2010)

The Kuiper belt is a collection of dwarf planets and other small bodies that lie beyond the orbit of Neptune. Believed to have formed contemporaneously with the planets (or soon thereafter), Kuiper belt objects (KBOs) offer clues, through their spatial distribution and physical properties, to conditions during the formation of the solar system. Unfortunately, due to their small size and great instance, few methods allow detailed investigations of these frigid bodies. Here we report the first multi-chord observations of a KBO stellar occultation, which occurred on 2009 October 9 (UT). We find that the KBO 55636 (2002 TX300), which is a member of the water-ice rich Haumea KBO collisional family, has a mean radius of 143 ± 5 km (circular solution). Allowing for possible elliptical shapes we find a geometric albedo $0.88 (+0.06, -0.14)$ in the V photometric band, which firmly establishes that 55636 is smaller than previously thought and, like its parent body Haumea, is among the most highly reflective objects in the Solar System. Dynamical calculations by two groups indicate that the collision that created 55636 occurred at least 1 Gyr ago, which raises the question of how such a small, ancient body can have a highly reflective surface.

Resource Letter SP-1 on Solar Physics

Jay M. Pasachoff

American Journal of Physics, **78**, September, 890-901 (2010)

This Resource Letter provides a guide to printed literature and online resources about scientific and cultural references to the sun and related topics such as solar spectroscopy. Items in the Resource Letter below are labeled with the letter E to indicate elementary level or material of general interest to persons seeking to become informed in the field, the letter I to indicate intermediate level or somewhat specialized material, or the letter A to indicate advanced or specialized material.

At the turn of the 20th century, much of astronomy was positional. Studies of the Sun played a major role in bringing astronomy to the astrophysical position that it enjoys today. The 21st-century solar physics is a vibrant science, with solar telescopes on the ground, including soon the Advanced Technology Solar Telescope about to be erected on Maui, joining dozens of spacecraft studying the Sun. NASA's Living with a Star program positions the Sun as a major influence on space weather and thus on the Earth. This Resource Letter does not include solar energy as an energy resource.

The Origin and Diffusion of the H and K Notation

Jay M. Pasachoff and T.A. Suer

Journal of Astronomical History and Heritage, **13** (2), 121-127 (2010)

Though many or most astronomers and astronomy students may think that H and K, as in the Ca II "H and K lines," were named by Fraunhofer, actually only the H line was in Fraunhofer's original notation. He also used "I" to indicate the end of the spectrum in his widely reproduced 1814 drawing, of which an engraved version was published in 1817. We have searched references from 19th-century books and journals to find the first use of "K" to indicate the ionized-calcium spectral line at 393.3 nm and located the probable first use and eventually the reuse of the notation.

Simultaneous Observations of the Chromosphere with TRACE and SUMER

Jay M. Pasachoff, E. Tingle, I. E. Dammasch, and A. C. Sterling

Solar Physics **268**, No. 1, 151-163; <http://dx.doi.org/10.1007/s11207-010-9673-6> (2010)

Using the 1600 Å continuum and 1216 Å Lyman-alpha filters aboard the TRACE satellite, we observed the short yet complete lifetime of a transient, bright chromospheric loop. Simultaneous observations with the SUMER instrument aboard the SOHO spacecraft revealed interesting material velocities existing above the chromospheric loop imaged with TRACE, possibly corresponding to extended non-visible loops, or the base of an X-ray jet.

High-resolution Satellite Imaging of the 2004 Transit of Venus and Asymmetries in the Cytherean Atmosphere

Jay M. Pasachoff, G. Schneider, and T. Widemann

Astron. J., **141**, #3, 112-120 (March). doi: 10.1088/0004-6256/141/4/112 (2011)

The paper presents the only space-borne observations of the 8 June 2004 transit of Venus, the first such transit visible from Earth since AD 1882. The high-resolution, high-cadence satellite images we arranged from NASA's Transition Region and Coronal Explorer (TRACE), reveal the onset of visibility of Venus's atmosphere and give further information about the black-drop effect, whose causes we previously demonstrated from TRACE observations of a transit of Mercury (Pasachoff et al. 2003, 2004). The atmosphere is gradually revealed before second contact and after third contact, resulting from the changing depth of atmospheric layers refracting the photospheric surface into the observer's direction. We use Venus Express observations to relate the atmospheric arcs seen during the transit to the atmospheric structure of Venus. Finally, we relate the transit images to current and future exoplanet observations, providing a sort of ground-truth showing an analogue in our solar system to effects observable only with light curves in other solar systems with the Kepler and CoRoT missions and ground-based exoplanet-transit observations.

Size and Albedo of Kuiper Belt Object 55636 from a Stellar Occultation

J.L. Elliot, M.J. Person, C.A. Zuluaga, A.S. Bosh, E.R. Adams, T.C. Brothers, A.A.S. Gulbis, S.E. Levine, M. Lockhart, A.M. Zangari, *Bryce A. Babcock, Katherine DuPré '10, Jay M. Pasachoff, Steven P. Souza, W. Rosing, N. Secrest, L. Bright, E.W. Dunham, S.S. Sheppard, M. Kakkala, T. Tilleman, B. Berger, J.W. Briggs, G. Jacobson, P. Valletti, B. Volz, S. Rapoport, R. Hart, M. Brucker, R. Michel, A. Mattingley, L. Zambrano-Marin, A.W. Meyer, J. Wolf, E.V. Ryan, W.H. Ryan, K. Morzinski, B. Grigsby, J. Brimacombe, D. Ragozine, H.G. Montano, and A. Gilmore*

Nature, **465**, 897-900, June 17 (2010)

The Kuiper belt is a collection of small bodies (Kuiper belt objects, KBOs) that lie beyond the orbit of Neptune and which are believed to have formed contemporaneously with the planets. Their small size and great distance make them difficult to study. KBO 55636 (2002 TX300) is a member of the water-ice-rich Haumea KBO collisional family. The Haumea family are among the most highly reflective objects in the Solar System. Dynamical calculations indicate that the collision that created KBO 55636 occurred at least 1 Gyr ago. Here we report observations of a multi-chord stellar occultation by KBO 55636, which occurred on 9 October 2009 UT. We find that it has a mean radius of 143 ± 5 km (assuming a circular solution). Allowing for possible elliptical shapes, we find a geometric albedo of 0.88 in the V photometric band, which establishes that KBO 55636 is smaller than previously thought and that, like its parent body, it is highly reflective. The dynamical age implies either that KBO 55636 has an active resurfacing mechanism, or that fresh water-ice in the outer Solar System can persist for gigayear timescales.

PICO: Portable Instrument for Capturing Occultations

M. Lockhart, M.J. Person, J.L. Elliot and *Steven P. Souza*

Publications of the Astronomical Society of the Pacific, **122**, 1207-1213 (2010)

We describe a portable imaging photometer for the observation of stellar occultation events by Kuiper Belt objects (KBOs) and other small bodies. The system is referred to as the Portable Instrument for capturing Occultations (PICO). It is designed to be transportable to remote observing sites by a single observer. A GPS timing system is used to trigger exposures of a Finger Lakes Instrumentation ML261E-25 camera to facilitate the combination of observational results from multiple sites. The system weighs a total of 11 kg when packed into its single rigid $55.1 \times 35.8 \times 22.6$ cm container, meeting current airline size and weight limits for carry-on baggage. Twelve such systems have been constructed. Nine systems were deployed for observation of a stellar occultation by Kuiper Belt object 55636 in 2009 October. During the same month, one system was used to record a stellar occultation by minor planet 762 Pulcova.

Biology

Axon cap morphology of the sea robin (*prionotus carolinus*) mauthner cell is correlated with the presence of 'signature' field potentials and a C-type startle response"

Steven J. Zottoli, Tina W. Wong '08, M.A. Agostini, Jason R. Meyers '97

Journal of Comparative Neurology, **10**, 1979-98. doi: 10.1002/cne.2261 (2011)

Studies on the Mauthner cell (M-cell) of goldfish, *Carassius auratus*, have facilitated our understanding of how sensory information is integrated in the hindbrain to initiate C-type fast startle responses (C-starts). The goldfish M-cell initial segment/axon hillock is surrounded by a composite axon cap consisting of a central core and a peripheral zone covered by a glial cell layer. The high resistivity of the axon cap results in "signature" field potentials recorded on activation of the M-cell, allowing unequivocal physiological identification of the M-cell and of its feedback and reciprocal inhibitory networks that are crucial in ensuring that only one M-cell is active and that it fires only once. Phylogenetic mapping of axon cap morphology to muscle activity patterns and behavior predicts that teleost fishes that have a composite axon cap, like that of the goldfish, will perform C-start behavior with primarily unilateral muscle activity.

We have chosen to study these predictions in the northern sea robin, *Prionotus carolinus*, a percomorph fish. Although sea robins have a very different phylogenetic position, body form, and habitat compared with the goldfish, they display the correlation of axon cap morphology to physiology and C-start behavior. Differences in response parameters suggest some evolutionary trade-offs in sea robin C-start behavior

compared with that of the goldfish, but the correlations in morphology, physiology, and behavior are common features of both otophysan and nonotophysan teleosts. The M-cell will continue to provide an unprecedented opportunity to study the evolution of a neural circuit in the context of behavior.

***Sphagnum* moss disperses spores with vortex rings**

D.L. Whitaker and Joan Edwards,

Science, **329**, 406 (2010)

Sphagnum spores, which have low terminal velocities, are carried by turbulent wind currents to establish colonies many kilometers away. However, spores that are easily kept aloft are also rapidly decelerated in still air; thus, dispersal range depends strongly on release height. Vascular plants grow tall to lift spores into sufficient wind currents for dispersal, but nonvascular plants such as *Sphagnum* cannot grow sufficiently high. High-speed videos show that exploding capsules of *Sphagnum* generate vortex rings to efficiently carry spores high enough to be dispersed by turbulent air currents. Spores launched ballistically at similar speeds through still air would travel a few millimeters and not easily reach turbulent air. Vortex rings are used by animals; here, we report vortex rings generated by plants.

Mechanics without muscle: biomechanical inspiration from the plant world

P.T.Martone, M.Boller, I.Burgert, J.Dumais, Joan Edwards, K.Mach, N.Rowe, M.Rueggeberg, R.Seidel and T.Speck

Integrative and Comparative Biology, **50**, 888-908 (2010)

Plant and animal biomechanists have much in common. Although their frame of reference differs, they think about the natural world in similar ways. While researchers studying animals might explore airflow around flapping wings, the actuation of muscles in arms and legs, or the material properties of spider silk, researchers studying plants might explore the flow of water around fluttering seaweeds, the grasping ability of climbing vines, or the material properties of wood. Here we summarize recent studies of plant biomechanics highlighting several current research themes in the field: expulsion of high-speed reproductive projectiles, generation of slow movements by shrinking and swelling cell walls, effects of ontogenetic shifts in mechanical properties of stems, flexible reconfiguration and material properties of seaweeds under crashing waves, and the development of botanically-inspired commercial products. Our hope is that this synopsis will resonate with both plant and animal biologists, encourage cross-pollination across disciplines, and promote fruitful interdisciplinary collaborations in the future.

An *Agrobacterium* VirB10 Mutation Conferring a Type IV Secretion System Gating Defect

Lois M.Banta, J.E.Kerr, E.Cascales, Megan E.Giuliano '05, Megan E.Bailey '08, C.McKay, V.Chandran, G.Waksman, P.J.Christie

Journal of Bacteriology 193(10):2566-74 (2011).

Agrobacterium VirB7, VirB9, and VirB10 form a “core complex” during biogenesis of the VirB/VirD4 type IV secretion system (T4SS). VirB10 spans the cell envelope and, in response to sensing of ATP energy consumption by the VirB/D4 ATPases, undergoes a conformational change required for DNA transfer across the outer membrane (OM). Here, we tested a model in which VirB10 regulates substrate passage by screening for mutations that allow for unregulated release of the VirE2 secretion substrate to the cell surface independently of target cell contact. One mutation, G272R, conferred VirE2 release and also rendered VirB10 conformationally insensitive to cellular ATP depletion. Strikingly, G272R did not affect substrate transfer to target cells (Tra-) but did block pilus production (Pil-). The G272R mutant strain displayed enhanced sensitivity to vancomycin and SDS but did not nonspecifically release periplasmic proteins or VirE2 truncated of its secretion signal. G272 is highly conserved among VirB10 homologs, including pKM101 TraF, and in the TraF X-ray structure the corresponding Gly residue is positioned near an α -helical domain termed the antenna projection (AP), which is implicated in formation of the OM pore. A partial AP deletion mutation (Δ AP) also confers a Tra- Pil- phenotype; however, this mutation did not allow VirE2 surface exposure but instead allowed the release of pilin monomers or short oligomers to the milieu. We propose that (i) G272R disrupts a gating mechanism in the core chamber that regulates substrate passage across the OM and (ii) the G272R and Δ AP mutations block pilus production at distinct steps of the pilus biogenesis pathway

Model selection analysis of temporal variation in benefit for an ant-tended treehopper.

Morales, Manuel A

Ecology 92:709–719. [doi:10.1890/10-1154.1] (2011)

Recent studies of mutualism have emphasized both that the net benefit to participants depends on the ecological context and that the density-dependent pattern of benefit is key to understanding the population dynamics of mutualism. Indeed, changes in the ecological context are likely to drive changes in both the magnitude of benefit and the density-dependent pattern of benefit. Despite the close linkage between these two areas of research, however, few studies have addressed the factors underlying variation in the density-dependent pattern of benefit. Here I use model selection to evaluate how variation in the benefits of a mutualism drives temporal variation in the density-dependent pattern of net benefit for the ant-tended treehopper *Publilia concava*. In the interaction between ants and treehoppers in the genus *Publilia*, ants collect the sugary excretions of treehoppers as a food resource, and treehoppers benefit both directly (e.g., by feeding facilitation) and indirectly (e.g., by predator protection). Results presented here show that temporal changes in the relative magnitude of direct and indirect benefit components of ant tending, especially the effectiveness of predator protection by ants, qualitatively change the overall pattern of density-dependent benefit between years with maximum benefit shifting from treehoppers in small to large aggregations. These results emphasize the need for empirical studies that evaluate the long-term dynamics of mutualism and theoretical studies that consider the population dynamics consequences of variation in the density-dependent pattern of benefit.

Context-Dependent Function of “GATA Switch” Sites In Vivo

Jon W.Snow, J.J.Trowbridge, K.D.Johnson, T.Fujiwara, N.R.Emambokus, J.A.Grass, S.H.Orkin, and E.H.Bresnick

Blood (18):4769-72 (2010).

Master transcriptional regulators of development often function through dispersed cis elements at endogenous target genes. While cis-elements are routinely studied in transfection and transgenic reporter assays, it is challenging to ascertain how they function in vivo. To address this problem in the context of the locus encoding the critical hematopoietic transcription factor Gata2, we engineered mice lacking a cluster of GATA motifs 2.8 kb upstream of the Gata2 transcriptional start site. We demonstrate that the -2.8 kb site confers maximal Gata2 expression in hematopoietic stem cells and specific hematopoietic progenitors. By contrast to our previous demonstration that a palindromic GATA motif at the neighboring -1.8 kb site maintains Gata2 repression in terminally differentiating erythroid cells, the -2.8 kb site was not required to initiate or maintain repression. These analyses reveal qualitatively distinct functions of 2 GATA motif-containing regions in vivo.

Separable Core Pluripotency and Myc Network Modules in Embryonic Stem Cells and Cancer

J.Kim, A.J.Woo, J.Chu, Jon W.Snow, Y.Fujiwara, C.G.Kim, A.B.Cantor, and S.H.Orkin

Cell 143(2):313-24 (2010).

c-Myc (Myc) is an important transcriptional regulator in embryonic stem (ES) cells, somatic cell reprogramming, and cancer. Here, we identify a Myc-centered regulatory network in ES cells by combining protein-protein and protein-DNA interaction studies and show that Myc interacts with the NuA4 complex, a regulator of ES cell identity. In combination with regulatory network information, we define three ES cell modules (Core, Polycomb, and Myc) and show that the modules are functionally separable, illustrating that the overall ES cell transcription program is composed of distinct units. With these modules as an analytical tool, we have reassessed the hypothesis linking an ES cell signature with cancer or cancer stem cells. We find that the Myc module, independent of the Core module, is active in various cancers and predicts cancer outcome. The apparent similarity of cancer and ES cell signatures reflects, in large part, the pervasive nature of Myc regulatory networks.

A single cis element maintains repression of the key developmental regulator Gata2

Jon W.Snow, J.J.Trowbridge, T.Fujiwara, J.A.Grass, N.R.Emambokus, S.H.Orkin, and E.H.Bresnick

PLoS Genetics 6(9):e1001103 (2010).

In development, lineage-restricted transcription factors simultaneously promote differentiation while repressing alternative fates. Molecular dissection of this process has been challenging as transcription factor loci are regulated by many trans-acting factors functioning through dispersed cis elements. It is not understood whether these elements function collectively to confer transcriptional regulation, or individually to control specific aspects of activation or repression, such as initiation versus maintenance. Here, we have analyzed cis element regulation of the critical hematopoietic factor Gata2, which is expressed in early precursors and repressed as GATA-1 levels rise during terminal differentiation. We engineered mice lacking a single cis element -1.8 kb upstream of the Gata2 transcriptional start site. Although Gata2 is normally repressed in late-stage erythroblasts, the -1.8 kb mutation unexpectedly resulted in reactivated Gata2 transcription, blocked differentiation, and an aberrant lineage-specific gene expression pattern. Our findings demonstrate that the -1.8 kb site selectively maintains repression, confers a specific histone modification pattern and expels RNA Polymerase II from the locus. These studies reveal how an individual cis element establishes a normal developmental program via regulating specific steps in the mechanism by which a critical transcription factor is repressed.

Sumoylation regulates interaction of FOG1 with CTBP

Jon W.Snow, J.Kim, C.Currie, J.Xu, and S.H.Orkin

Journal of Biological Chemistry 285(36):28064-75 (2010).

Erythropoietic and megakaryocytic programs are specified from multipotential progenitors by the transcription factor GATA1. FOG1, a GATA1-interaction partner, is critical for GATA1 function in several contexts by bringing multiple complexes into association with GATA1 to facilitate activation or repression of target genes. To further elucidate regulation of these associations by cellular and extracellular cues, we examined FOG1 for post-translational modifications. We found that FOG1 is SUMOylated and phosphorylated in erythroid cells in a differentiation-dependent manner. Removal of the SUMOylation sites in FOG1 does not impair nuclear localization, protein stability, or chromatin occupancy. However, SUMOylation of FOG1 modulates interactions with C-terminal binding protein family members, specifically promoting CTBP1 binding. Phosphorylation of FOG1 modulates SUMOylation and, therefore, indirectly regulates the CTBP interaction. Post-translational modification of FOG1 may contribute to control of co-occupancy by CTBP family members, the NuRD complex, and GATA1 at differentially regulated genes.

Characterisation and expression of microRNAs in developing wings of the neotropical butterfly *Heliconius melpomene*

A.K.Surridge, S.Lopez-Gomollon, S.Moxon, Luana S.Maroya, T.Rathjen, J.Nadeau n, T.Dalmay and C.D.Jiggins

BMC Genomics 12: 62doi:10.1186/1471-2164-12-62 (2011)

Background

Heliconius butterflies are an excellent system for studies of adaptive convergent and divergent phenotypic traits. Wing colour patterns are used as signals to both predators and potential mates and are inherited in a Mendelian manner. The underlying genetic mechanisms of pattern formation have been studied for many years and shed light on broad issues, such as the repeatability of evolution. In *Heliconius melpomene*, the yellow hindwing bar is controlled by the *HmYb* locus. MicroRNAs (miRNAs) are important post-transcriptional regulators of gene expression that have key roles in many biological processes, including development. miRNAs could act as regulators of genes involved in wing development, patterning and pigmentation. For this reason we characterised miRNAs in developing butterfly wings and examined differences in their expression between colour pattern races.

Results

We sequenced small RNA libraries from two colour pattern races and detected 142 *Heliconius* miRNAs with homology to others found in miRBase. Several highly abundant miRNAs were differentially represented in the libraries between colour pattern races. These candidates were tested further using

Northern blots, showing that differences in expression were primarily due to developmental stage rather than colour pattern. Assembly of sequenced reads to the *HmYb* region identified hme-miR-193 and hme-miR-2788; located 2380 bp apart in an intergenic region. These two miRNAs are expressed in wings and show an upregulation between 24 and 72 hours post-pupation, indicating a potential role in butterfly wing development. A search for miRNAs in all available *H. melpomene* BAC sequences (~ 2.5 Mb) did not reveal any other miRNAs and no novel miRNAs were predicted.

Conclusions

Here we describe the first butterfly miRNAs and characterise their expression in developing wings. Some show differences in expression across developing pupal stages and may have important functions in butterfly wing development. Two miRNAs were located in the *HmYb* region and were expressed in developing pupal wings. Future work will examine the expression of these miRNAs in different colour pattern races and identify miRNA targets among wing patterning genes.

Genomic Hotspots for Adaptation: The Population Genetics of Müllerian Mimicry in the *Heliconius melpomene* Clade

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PLoS Genetics 6(2): e1000794. doi:10.1371/journal.pgen.1000794 (2010)

Wing patterning in *Heliconius* butterflies is a longstanding example of both Müllerian mimicry and phenotypic radiation under strong natural selection. The loci controlling such patterns are “hotspots” for adaptive evolution with great allelic diversity across different species in the genus. We characterise nucleotide variation, genotype-by-phenotype associations, linkage disequilibrium, and candidate gene expression at two loci and across multiple hybrid zones in *Heliconius melpomene* and relatives. Alleles at *HmB* control the presence or absence of the red forewing band, while alleles at *HmYb* control the yellow hindwing bar. Across *HmYb* two regions, separated by ~100 kb, show significant genotype-by-phenotype associations that are replicated across independent hybrid zones. In contrast, at *HmB* a single peak of association indicates the likely position of functional sites at three genes, encoding a kinesin, a G-protein coupled receptor, and an mRNA splicing factor. At both *HmYb* and *HmB* there is evidence for enhanced linkage disequilibrium (LD) between associated sites separated by up to 14 kb, suggesting that multiple sites are under selection. However, there was no evidence for reduced variation or deviations from neutrality that might indicate a recent selective sweep, consistent with these alleles being relatively old. Of the three genes showing an association with the *HmB* locus, the *kinesin* shows differences in wing disc expression between races that are replicated in the co-mimic, *Heliconius erato*, providing striking evidence for parallel changes in gene expression between Müllerian co-mimics. Wing patterning loci in *Heliconius melpomene* therefore show a haplotype structure maintained by selection, but no evidence for a recent selective sweep. The complex genetic pattern contrasts with the simple genetic basis of many adaptive traits studied previously, but may provide a better model for most adaptation in natural populations that has arisen over millions rather than tens of years.

Chemistry

Single Molecules Reveal the Dynamics of Heterogeneities in a Polymer at the Glass Transition

Dieter Bingemann, Rachel M. Allen '08, and Scott W. Olesen '10

Journal of Chemical Physics **134**, 024513 (2011)

The notion of heterogeneous dynamics in glasses, that is, the spatial and temporal variations of structural relaxation rates, explains many of the puzzling features of glass dynamics. The nature and the dynamics of these heterogeneities, however, have been very controversial. Single rhodamine B molecules in poly(vinyl acetate) at the glass transition reorient through sudden jumps. With a statistical search for the most likely break points in the logarithm of the ratio of the two perpendicular fluorescence polarizations, we determine the times of these angular jumps. We interpret these jumps as an indication for individual glass rearrangements in the vicinity of the probe molecule. Time-series analysis of the resulting sequence of

waiting times between jumps shows that dynamic heterogeneities in the matrix exist, but are short lived. From the correlation of the logarithm of the waiting time between subsequent jumps, we determine an upper limit for the lifetime of heterogeneities in the sample. The correlation time of $\tau_{het} = 32$ s is three times shorter than the orientational correlation time of the probe molecule, $\tau_{orient} = 90$ s, in the sample at this temperature, but 13 times longer than the structural relaxation time, $\tau_{\alpha} = 2.5$ s, estimated for this sample from dielectric experiments. We present a model for glass dynamics in which each rearrangement in one region causes a random change in the barrier height for subsequent rearrangements in a neighboring region. This model, which equates the dynamics of the heterogeneities with the dynamics of the glass itself and thus implies a factor of one between heterogeneity lifetime and structural relaxation time, successfully reproduces the statistics of the experimentally observed waiting time sequences.

Effects of Polymer Molecular Weight on the Size, Activity, and Stability of PEG-functionalized Trypsin

K. Chiu '10, L. Agoubi '13, I. Lee '09, M. T. Limpar '09, J. W. Lowe Jr. '09, and Sarah L. Goh

Biomacromolecules **11**, 3688-3692 (2011)

Polymer conjugation increases an enzyme's circulation time and stability for use as a therapeutic agent, but this attachment indubitably affects its properties. Covalent attachment of multiple polyethylene glycol chains with sizes of either 2, 5, 10, or 20 kDa increases the molecular weight and hydrodynamic radius of the model enzyme trypsin. The sizes of these polymer-enzyme conjugates are increased to be within the recommended limits for PDEPT applications. The Td increases from 49 to 60 °C to expand the enzyme's workable range of conditions. This functionalization with PEG polymers of varying lengths maintains trypsin's enzymatic activity. Conjugate activities are 79–120% that of native trypsin at room temperature and 221–432% that of trypsin at 37 °C.

Self-Assembly of Di- and Tri-Block PEG-Pentavaline Amphiphiles

E. Hwang '13, T. Wilson-Hill '09, J. W. Ahn '12, A. Platt '07, K. Rutledge '05, and Sarah L. Goh

Journal of Polymer Science Part A: Polymer Chemistry **49**, 871-878 (2011)

Nanoparticles formed from amphiphilic block copolymers can be used as drug delivery vehicles for hydrophilic therapeutics. Poly(ethylene glycol) (PEG)-peptide copolymers were investigated for their self-assembling properties and as consequent potential delivery systems. Mono- and dihydroxy PEGs were functionalized with a pentavaline sequence bearing Fmoc end groups. The molecular weight of the PEG component was varied to evaluate copolymer size and block number. These di- and tri-block copolymers readily self-assemble in aqueous solution with critical aggregation concentrations (CACs) of 0.46–16.29 [M. At concentrations above the CAC, copolymer solutions form spherical assemblies. Dynamic light scattering studies indicate these aggregates have a broad size distribution, with average diameters between 33 and 127 nm. The copolymers are comprised α -conformations that are stable up to 80 °C, as observed by circular dichroism. This peptide secondary structure is retained in solutions up to 50% MeOH as well. The triblock copolymers proved to be the most stable, with copolymers synthesized from 10 kDa PEG having the most stable particles. Loading of carboxyfluorescein at 2–5 mol % shows that these copolymers have the potential to encapsulate hydrophilic drugs for delivery applications.

Particle in a One-Dimensional Finite and Semi-Infinite Well Revisited

Enrique Peacock-López

The Chemical Educator **16**, 148-154 (2011)

For the quantum particle in a finite and semi-infinite well, we scale space and energy to consider a dimensionless Schrödinger equation that can be solved for the allowed energy levels. In contrast to traditional approaches that determine the energies from dimensional transcendental equations associated with the boundary conditions, we solve for the square root of the dimensionless energies, which are also solutions of dimensionless transcendental equations. Our ability to define classes of wells depends on the value of the square root of the dimensionless well depth. We are also able to determine the maximum number of energy levels quite easily, and, besides deriving the relevant transcendental equations, we obtain

a simple expression for the corresponding wave functions, which can be plotted using the numerical values of the allowed energies.

The Relevance of Cross-Diffusion in the Formation of Turing Patterns

Enrique Peacock-López

Nonlinear Dynamics, Psychology, and Life Sciences **15**, 1-10 (2011)

Over the years, the Rosenzweig-MacArthur (RM) model has been used to study simple prey-predator systems. It has been observed, however, that the RM model cannot sustain Turing patterns when using a diagonal diffusion tensor. As a result, researchers have introduced changes to the RM model that induce stable Turing patterns. In most cases, the changes have been made to the so-called response function, changing the interspecies interaction, or by adding an intraspecies interaction to the model. In this communication, we study the original RM model but we include cross-diffusion, which considers off diagonal elements in the diffusion tensor. Although cross-diffusion is well characterized in multicomponent solutions, including electrolytes, it has an apparent counterintuitive meaning in predator-prey systems. We observe, however, that in plant and fish systems, the lack of predator mobility is compensated by their ability to camouflage and attract their prey, which yields a negative cross-diffusion coefficient. We show that negative cross-diffusion is enough to trigger stable Turing patterns in the RM model.

Current Topics in ESR Dating

Anne R. Skinner

Radiation Measurements (2011)

After over 25 years, the use of electron spin resonance (ESR) is well-established in dating sites of geological, paleontological and archaeological interest. Like any scientific technique, there have been changes in understanding and in methodology. Improvements have not, however, changed the observation that external dose calculations are still a significant source of uncertainty in ages. Examples from Europe, Africa and the Americas illustrate this point. For Pradayrol Cave (France), the occupation age, 330 ka, is unchallenged, making this the oldest known Neanderthal site in France. For Roc de Marsal, also in France, on the other hand, discrepancies between TL and sedimentary dose rates imply substantial differences in interpretation. In the Western Egyptian Desert, where artifacts and datable material are not well-correlated, the dating results show consistency with expectations based on global climate change, even in deflated sites. Climate change is also the question in geological studies in the Bahamas where, despite concerns about cosmic dose history, ESR dates confirm other evidence for sealevel changes. We show that an uncertain age is not the same as an impossible one.

Testing Cosmic Dose Rate Models for ESR: Dating Corals and Molluscs on San Salvador, Bahamas

Anne R. Skinner, A.E. Deely, B.A.B. Blackwell, J.E. Mylroie, J.L. Carew, and J.I.B. Blickstein

Radiation Measurements (2011)

Sealevel curves are best developed on tectonically stable coastlines like San Salvador, where eolianites preserve transgressive and regressive phases associated with Quaternary high seastands, while reef facies mark the highstands. At 11 locations around San Salvador, terrestrial mollusks (*Cerion*) from the eolianites, lagoonal bivalves (*Codakia*), and corals from the highstand deposits were dated by ESR. Volumetrically averaged sedimentary dose rates were calculated from sedimentary geochemistry and time-averaged cosmic dose rates from each sample's current and past geologic contexts. Rice Bay Formation corals dated at 3.9 ± 0.3 to 7.1 ± 0.4 ka (OIS 1). Minimum ages for the Cockburn Town Member's regressive phase ranged from 49 ± 6 to 75 ± 8 ka, correlating with OIS 3-4. *Codakia* dates showed that an OIS 5a sealevel approached modern levels at 91-78 ka. In situ corals from the Cockburn Town Reef averaged from 127 ± 6 to 138 ± 10 ka, correlating well with OIS 5e. Ages from the Reef's rubble zones hint that some coral reefs grew as early as OIS 7, but were likely reworked during OIS 5. San Salvador preserves deposits from three mid to late Quaternary highstands above, and as many as three that closely approach, modern sealevel.

Who Used Fire 1,500,000 Years Ago?

Anne R. Skinner

Electron Paramagnetic Resonance: From Fundamental Research to Pioneering Applications, 196-197 (2009)

While many aspects of an archaeological or geological project are essential to understanding human and environmental developments, the date of a site is frequently one of the most important factors. There are several methods to determine material ages. Most people have heard of the carbon-14, ^{14}C , method. It is based on determining the relative amount of the radioactive isotope ^{14}C compared to the non-radioactive isotope, ^{12}C . Unfortunately for investigators interested in human evolution, to the relatively short half-life of ^{14}C , 5730 ± 40 years, means that this method is reliable results only for samples younger than about 40,000 years. Another radiometric dating method uses the ratio of argon isotopes, $^{40}\text{Ar}/^{39}\text{Ar}$, found in volcanic lava. While this method can date materials in the millions of years, it is, of course, limited to sites with volcanic deposits. Electron paramagnetic resonance (EPR) dating is one of the newest dating methods. The paper by Ikeya on the dating of a stalagmite (1975) is considered the first example. Currently, depending on the material being used, EPR can provide chronometric ages as young as a few thousand years and as old as several million. Therefore it assists in studies older than the ^{14}C limit, and at sites that lack volcanic materials. Overall, the variety of materials and time periods whose chronology can be determined make EPR a significant tool in the archaeological and paleontological dating kit.

Computer Science

Distributed Application Configuration, Management, and Visualization with Plush

Jeannie Albrecht, C. Tuttle, R. Braud, D. Dao, N. Topilski, A. C. Snoeren, and A. Vahdat

ACM Transactions on Internet Technology (TOIT)

Support for distributed application management in large-scale networked environments remains in its early stages. Although a number of solutions exist for subtasks of application deployment, monitoring, and maintenance in distributed environments, few tools provide a unified framework for application management. Many of the existing tools address the management needs of a single type of application or service that runs in a specific environment, and these tools are not adaptable enough to be used for other applications or platforms. To this end, we present the design and implementation of Plush, a fully configurable application management infrastructure designed to meet the general requirements of several different classes of distributed applications. Plush allows developers to specifically define the flow of control needed by their computations using application building blocks. Through an extensible resource management interface, Plush supports execution in a variety of environments, including both live deployment platforms and emulated clusters. Plush also uses relaxed synchronization primitives for improving fault tolerance and liveness in failure-prone environments. To gain an understanding of how Plush manages different classes of distributed applications, we take a closer look at specific applications and evaluate how Plush provides support for each.

Finding a “Kneedle” in a Haystack: Detecting Knee Points in System Behavior

Ville Satopää’11, Jeannie Albrecht, D. Irwin, and B. Raghavan

Proceedings of the Third IEEE Workshop on Simplifying Complex Networks for Practitioners (Simplex), June 2011

Computer systems often reach a point at which the relative cost to increase some tunable parameter is no longer worth the corresponding performance benefit. These “knees” typically represent beneficial points that system designers have long selected to best balance inherent trade-offs. While prior work largely uses ad hoc, system-specific approaches to detect knees, we present Kneedle, a general approach to online and offline knee detection that is applicable to a wide range of systems. We define a knee formally for continuous functions using the mathematical concept of curvature and compare our definition against alternatives. We then evaluate Kneedle’s accuracy against existing algorithms on both synthetic and real data sets, and evaluate its performance in two different applications.

Enjoying Python, processing, and Java in CS1

O.Bälter and *Duane A.Bailey*

ACM Inroads 1(4): 28-32 (2010)

Here we describe an introductory course in computer science where we combined Python, Processing, and core Java. The main reason for this structure was to make the initial contact with programming as gentle, enjoyable, and understandable as possible, while still having the power of graphics and sufficient Java knowledge for more advanced courses in computer science. This course was designed with a few informal pedagogical principles that facilitated the students' abilities to learn how to learn on their own. Informal results suggest that students may be interested in a greater diversity of programming assignments.

Efficient and Precise Happens Before Race Detection

C.Flanagan and *Stephen N.Freund*

Communication of the ACM, 53(11), pages 93-101 (2010)

Multithreaded programs are notoriously prone to race conditions. Prior work developed precise dynamic race detectors that never report false alarms. However, these checkers employ expensive data structures, such as vector clocks (VCs) that result in significant performance overhead. This paper exploits the insight that the full generality of VCs is not necessary in most cases. That is, we can replace VCs with an adaptive lightweight representation that, for almost all operations of the target program, requires constant space and supports constant-time operations. Experimental results show that the resulting race detection algorithm is over twice as fast as prior precise race detectors, with no loss of precision.

The 1-Neighbour Knapsack Problem

G.Boradaille, *Brent Heeringa*, and G.Wilfong

Proceedings of the 2011 International Workshop on Combinatorial Algorithms

We study a constrained version of the knapsack problem in which dependencies between items are given by the adjacencies of a graph. In the 1-neighbour knapsack problem, an item can be selected only if at least one of its neighbours' is also selected. We give approximation algorithms and hardness results when the nodes have both uniform and arbitrary weight and profit functions, and when the dependency graph is directed and undirected.

Heapable Sequences and Subsequences

J.Byers, *Brent Heeringa*, M.Mitzenmacher, and G.Zervas

Proceedings of the 2011 Workshop on Analytic Algorithms and Combinatorics

Let us call a sequence of numbers heapable if they can be sequentially inserted to form a binary tree with the heap property, where each insertion subsequent to the first occurs at a leaf of the tree, i.e. below a previously placed number. In this paper we consider a variety of problems related to heapable sequences and subsequences that do not appear to have been studied previously. Our motivation for introducing these concepts is two-fold. First, such problems correspond to natural extensions of the well-known secretary problem for hiring an organization with a hierarchical structure. Second, from a purely combinatorial perspective, our problems are interesting variations on similar longest increasing subsequence problems, a problem paradigm that has led to many deep mathematical connections.

We provide several basic results. We obtain an efficient algorithm for determining the heapability of a sequence, and also prove that the question of whether a sequence can be arranged in a complete binary heap is NP-hard. Regarding subsequences we show that, with high probability, the longest heapable subsequence of a random permutation of n numbers has length $(1-o(1))n$, and a subsequence of length $(1-o(1))n$ can in fact be found online with high probability. We similarly show that for a random permutation a subsequence that yields a complete heap of size $c*n$ for a constant c can be found with high probability. Our work highlights the interesting structure underlying this class of subsequence problems, and we leave many further interesting variations open for future work.

Searching in Dynamic Tree-Like Partial Orders

Brent Heeringa, M.C.Iordan '09, and L.Theran

Proceedings of the 2011 Algorithms and Data Structures Symposium

We give the first data structure for the problem of maintaining a dynamic set of n elements drawn from a partially ordered universe described by a tree. We define the Line-Leaf Tree, a linear-sized data structure that supports the operations: insert; delete; test membership; and predecessor. The performance of our data structure is within an $O(\log w)$ -factor of optimal. Here $w \leq n$ is the width of the partial-order—a natural obstacle in searching a partial order.

Approximating Optimal Binary Decision Trees

M.Adler and Brent Heeringa

Algorithmica, April 2011- <http://dx.doi.org/10.1007/s00453-011-9510-9>

We give a $(\ln n + 1)$ -approximation for the decision tree (DT) problem. An instance of DT is a set of m binary tests T and a set of n items X . The goal is to output a binary tree where each internal node is a test, each leaf is an item and the total external path length of the tree is minimized. Total external path length is the sum of the depths of all the leaves in the tree. DT has a long history in computer science with applications ranging from medical diagnosis to experiment design. It also generalizes the problem of finding optimal average-case search strategies in partially ordered sets. This includes several alphabetic tree problems. Our work decreases the previous upper bound on the approximation ratio by a constant factor. We provide a new analysis of the greedy algorithm that uses a simple accounting scheme to spread the cost of a tree among pairs of items split at a particular node. We conclude by showing that our upper bound also holds for the DT problem with weighted tests

Filtering Approaches for Real-Time Anti-Aliasing

J.Jimenez, D.Guiterrez, J.Yang, A.Reshetov, P.Demoreuille, T.Berghoff, C.Perthis, H.Yu, Morgan McGuire, T.Lottes, H.Malan, D.Andreev, and T.Sousa

ACM SIGGRAPH Course Notes (Proceedings of SIGGRAPH 2011), August 2011

For more than a decade, Supersample Anti-Aliasing (SSAA) and Multisample Anti-Aliasing (MSAA) have been the gold standard antialiasing solution in games. However, these techniques are not well suited for deferred shading or fixed environments like the current generation of consoles. In the last years, Industry and Academia have begun to explore alternative approaches, where anti-aliasing is performed as a post-processing step. The original, CPU-based Morphological Anti-Aliasing (MLAA) method gave birth to an explosion of real-time anti-aliasing techniques that rival MSAA. This course will cover the most relevant techniques, from the original MLAA to the latest cutting edge advancements.

The Alchemy Screen-Space Ambient Obscurance Algorithm

Morgan McGuire, B.Osman, M.Bukowski, and P.Hennessy

Proceedings of ACM SIGGRAPH and Eurographics High Performance Graphics, August 2011

Ambient obscurance (AO) produces perceptually important illumination effects such as darkened corners, cracks, and wrinkles; proximity darkening; and contact shadows. We present the AO algorithm from the Alchemy engine used at Vicarious Visions in commercial games. It is based on a new derivation of screen-space obscurance for robustness, and the insight that a falloff function can cancel terms in a visibility integral to favor efficient operations. Alchemy creates contact shadows that conform to surfaces, captures obscurance from geometry of varying scale, and provides four intuitive appearance parameters: world-space radius and bias, and aesthetic intensity and contrast. The algorithm estimates obscurance at a pixel from sample points read from depth and normal buffers. It processes dynamic scenes at HD 720p resolution in about 4.5 ms on Xbox 360 and 3 ms on NVIDIA GeForce580.

Colored Stochastic Shadow Maps

Morgan McGuire and E.Enderton

Proceedings of the ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games, February 2011

This paper extends the stochastic transparency algorithm that models partial coverage to also model wavelength-varying transmission. It then applies this to the problem of casting shadows between any combination of opaque, colored transmissive, and partially covered (i.e., α -matted) surfaces in a manner compatible with existing hardware shadow mapping techniques. Colored Stochastic Shadow Maps have a similar resolution and performance profile to traditional shadow maps, however they require a wider filter in colored areas to reduce hue variation.

Subpixel Reconstruction Antialiasing

M.Chajdas, Morgan McGuire, and D.Luebke

Proceedings of the ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games, February 2011

Subpixel Reconstruction Antialiasing (SRAA) combines single-pixel (1x) shading with subpixel visibility to create antialiased images without increasing the shading cost. SRAA targets deferred-shading renderers, which cannot use multisample antialiasing. SRAA operates as a post-process on a rendered image with super resolution depth and normal buffers, so it can be incorporated into an existing renderer without modifying the shaders. In this way SRAA resembles Morphological Antialiasing (MLAA), but the new algorithm can better respect geometric boundaries and has fixed runtime independent of scene and image complexity. SRAA benefits shading-bound applications. For example, our implementation evaluates SRAA in 1.8 ms (1280x720) to yield antialiasing quality comparable to 4-16x shading. Thus SRAA would produce a net speedup over super sampling for applications that spend 1 ms or more on shading; for comparison, most modern games spend 5-10 ms shading. We also describe simplifications that increase performance by reducing quality.

A Local Image Reconstruction Algorithm for Stochastic Rendering

P.Shirley, T.Aila, J.Cohen, E.Enderton, S.Laine, D.Luebke, and Morgan McGuire

Proceedings of the ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games, February 2011

Stochastic renderers produce unbiased but noisy images of scenes that include the advanced camera effects of motion and defocus blur and possibly other effects such as transparency. We present a simple algorithm that selectively adds bias in the form of image space blur to pixels that are unlikely to have high frequency content in the final image. For each pixel, we sweep once through a fixed neighborhood of samples in front to back order, using a simple accumulation scheme. We achieve good quality images with only 16 samples per pixel, making the algorithm potentially practical for interactive stochastic rendering in the near future.

Stylized Rendering in Games

Morgan McGuire, H.Halen, J.F.St-Amour, A.Thibault, and B.Martel

ACM SIGGRAPH Course Notes (Proceedings of SIGGRAPH 2010), August 2010

Games like Prince of Persia and Battlefield Heroes deliver artistic visions beyond standard photo-realistic 3D. In this course, game developers teach the challenges of creating distinctive visual styles for interactive environments and some of their own solutions. Topics include the art pipeline, rendering algorithms, and integrating visuals with gameplay.

Why stylized rendering? As they matured, the visual arts (painting, sculpture, photography, and architecture) all developed new visual-abstraction mechanisms to go beyond "realism". Recent advances in visual effects have put film and games into this transitional state. In a sense, we're like artists at the end of the Renaissance: we've nearly mastered photorealism, but are only at the beginning of our discoveries about expression and perception.

Some effects are subtle, like the color shifts and post-processing in Mirror's Edge. Others, such as the graphic-novel look of Mad World, dominate the entire rendering style. In games, real-time and interactive constraints require more efficient and robust solutions than are employed elsewhere in computer graphics.

And to be successful, a stylized renderer must integrate with appropriately stylized models, animation, and audio to form a coherent virtual world and ultimately enhance game play.

Geosciences

Repeated Pulses of Vertical Methane Flux Recorded in Glacial Sediments from the Southeast Bering Sea

Mea Cook, L.D.Keigwin, D.Birgel, and K-U.Kinrichs

Paleoceanography **26**, 2210 (2011)

There is controversy over the role of marine methane hydrates in atmospheric methane concentrations and climate change during the last glacial period. In this study of two sediment cores from the southeast Bering Sea (700 m and 1467 m water depth), we identify multiple episodes during the last glacial period of intense methane flux reaching the seafloor. Within the uncertainty of the radiocarbon age model, the episodes are contemporaneous in the two cores and have similar timing and duration as Dansgaard-Oeschger events. The episodes are marked by horizons of sediment containing ^{13}C -depleted authigenic carbonate minerals, ^{13}C -depleted archaeal and bacterial lipids, which resemble those found in ANME-1 type anaerobic methane oxidizing microbial consortia, and changes in the abundance and species distribution of benthic foraminifera. The similar timing and isotopic composition of the authigenic carbonates in the two cores is consistent with a region-wide increase in the upward flux of methane-bearing fluids. This study is the first observation outside Santa Barbara Basin of pervasive, repeated methane flux in glacial sediments. However, contrary to the “Clathrate Gun Hypothesis” [Kennett et al., 2003], these coring sites are too deep for methane hydrate destabilization to be the cause, implying that a much larger part of the ocean’s sedimentary methane may participate in climate or carbon cycle feedback at millennial time scales. We speculate that pulses of methane in these opal-rich sediments could be caused by the sudden release of overpressure in pore fluids that builds up gradually with silica diagenesis. The release could be triggered by seismic shaking on the Aleutian subduction zone caused by hydrostatic pressure increase associated with sea level rise at the start of interstadials.

Well-Ventilated Intermediate Water and Pulses of High Export Production in the NW Pacific During the Last Glaciation

Mea Cook and L.D.Keigwin

10th International Conference on Paleoceanography (2010)

There is a sequence of laminated or dysoxic sediments observed at intermediate depth in the North Pacific from the Bolling-Allerod and the early Holocene. It is unclear whether the sediments represent an increase in export production, a decrease in ventilation of intermediate water or a combination. The timing and intensity of the oxygen depletion are spatially variable, probably as local differences in primary productivity. However, this pattern is observed in a variety of depositional settings from the Mexican margin to the Bering Sea to the Japan margin, which suggests a basin-wide mechanism at work. In a depth transect of sediment cores (939 to 4155 m water depth) from the Okhotsk Sea and Emperor Seamounts, we have measured the absolute abundance of benthic foraminifera from the LGM to the Holocene. There are narrow peaks in the abundance of *Uvigerina peregrina* and *U. auberiana* that rise an order of magnitude higher than background values. These abundance peaks probably represent times of high organic carbon flux to the seafloor, caused by either greater export production or greater preservation of exported organic carbon due to reduced ventilation. We observe peaks in *Uvigerina* abundance in all ten cores of this study that are radiocarbon dated with planktonic foraminifera to the very beginning of the Bolling- Allerod, $14,500 \pm 200$ cal BP. We observe another peak in cores from 939 to 1761 m water depth in the early Holocene, just after the end of the Younger Dryas, $11,600 \pm 200$ cal BP. The synchrony of the peaks and the high abundance of benthic foraminifera allow us to reconstruct the $\Delta^{14}\text{C}$ of the water column in a snapshot at these two times by radiocarbon dating pairs of benthic and planktonic foraminifera. We find that at the beginning of the Bolling-Allerod, the water column at 1–2 km and deeper than 3 km was enriched in ^{14}C compared to what it would have been with a modern circulation. At the beginning of the Holocene, the water column at 1–2 km is also significantly enriched in ^{14}C , though to a lesser extent. This

suggests that during the early Bolling-Allerod and early Holocene, there were pulses of high export production at times of greater ventilation of intermediate water than today.

Bering Sea Paleooceanography

Mea Cook, K. Takahashi, A.C. Ravelo, C.A. Alvarez-Zarikian, and 323 Expedition Scientists

Proceedings of the Integrated Ocean Drilling Program **323**, 201 p. (2011)

Paleoclimate and paleoceanography studies present opportunities to study the dynamics of the climate system by examining how it responds to external forcing (e.g., greenhouse gases and solar radiation) and how its interacting components generate climate oscillations and abrupt changes. Paucity of data in critical regions of the Pacific such as the Bering Sea has prevented an evaluation of the role of North Pacific processes in global climate change over the last 5 million years. The Integrated Ocean Drilling Program Expedition 323 was dedicated to elucidate the history of climate and surface ocean conditions since the earliest Pliocene; characterize the history of deep ocean circulation, continental glaciation, river discharge, and sea ice; investigate linkages between this marginal sea and global processes; and constrain biogeochemical models of sub-seafloor biomass and respiration. During Expedition 323, 5741 m of sediment were drilled at seven sites in three areas: Umnak Plateau, Bowers Ridge and the Bering Sea continental slope. Water depths of coring locations ranged from 818 to 3174 m and sediment age spans 0 to 5 million years. Preliminary findings include the intensification of seasonal sea ice production 1 million years ago at the mid-Pleistocene transition, evidence of episodes of low-oxygen conditions in the Bering Sea throughout the last 5 million years, strong climate and sea level control of siliciclastic deposition, and a very large range of microbial activity as deep as 700 m below the sea floor, with notable site-to-site variations.

Hydrodynamic Fractionation of Zircon Age Populations

Ronadh Cox, R.L. Lawrence, R.W. Mapes, and D.S. Coleman

Geological Society of America Bulletin **123**, 295-305 (2011)

Zircons in transport in the modern Amazon River range from coarse silt to medium sand. Older grains are smaller on average: Mesozoic and Cenozoic grains have average equivalent spherical diameter (ESD) $122 \pm 42 \mu\text{m}$ (lower fine sand), whereas grains $>2000 \text{ Ma}$ have average ESD $67 \pm 14 \mu\text{m}$ (upper coarse silt). As a full Wentworth size class separates the two values, zircons in these age populations are hydraulically distinct. Five samples representing different hydrodynamic microenvironments of a single dune present significantly different detrital zircon age spectra, apparently the result of hydraulic processes. Peak mismatch (age peaks failing to overlap at 2σ level), is the most common disparity; but age populations present in some samples are missing from other samples. The lack of correspondence among the samples appears to exceed that attributable to random sampling. We conclude that hydrodynamic fractionation of zircons and zircon age populations does occur. Zircon size should therefore be taken into consideration in detrital zircon provenance analysis.

Hydrocode Modeling of Impacts at Europa

Ronadh Cox and A.W. Bauer¹¹

42nd Lunar and Planetary Science Conference, abstract 1123 (2011)

Previous hydrocode simulations (e.g. [1]) have shown that impacts of sufficient energy could break through Europa's ice crust to the water layer that probably underlies it [2], and this provides limiting criteria for formation of first-order (non-penetrating) craters [3]. But as the first-order crater population on Europa is small (24 known $\geq 10 \text{ km}$ [4]), and as estimates of ice thickness ($< 1 \text{ km}$ to a few 10s of km [5, 6]) intersect with the penetration capabilities of likely impactors [3], it's necessary to think broadly about a range of possible impact outcomes, and especially about the potential effects of large impacts or impacts into areas of thinner crust. We report here results of hydrocode simulations that provide constraints on ice penetration—both second and third order—for crust thicknesses and impact energies within the range of those expected at Europa.

Geomorphology of Chaos Areas on Europa

Ronadh Cox and Andrew T. Mikell '09

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Chaos areas on Europa—regions where the surface has been disrupted, with blocks of remnant crust set in a hummocky matrix of slushy appearance—are poorly understood, and no satisfactory explanation for their formation has yet been presented. One of the proposed interpretations is that impact penetration could create holes in the ice layer, exposing underlying water; and while it's clear that not all questions can be answered with current data, ongoing analysis and simulations continue to suggest that this may be a viable hypothesis. We present here GIS analysis of chaos area geomorphology. The geometry of chaos areas on Europa matches predictions from impact experiments, and their distribution corresponds to that expected for an ecliptic impactor population.

Hydrocode Modeling of Ice-Penetrating Impacts on Jupiter's Moon, Europa

Ronadh Cox, Aaron W. Bauer '11, and V.J. Bray

Geological Society of America Abstracts with Programs **42**, 304 (2010)

Geological, gravitational, and magnetic-field evidence indicates a subsurface water ocean at relatively shallow depth beneath Europa's ice crust. If ice thickness is ≤ 20 km (indicated by crater depth:diameter ratios and lithostatic stress constraints), impacts of sufficient energy could break through to the underlying water. Using the iSALE hydrocode, we have produced 2-D numerical simulations of impacts at Europa to assess the likelihood of impact penetration of the ice crust. Preliminary results indicate that a 620 m diameter comet at 15 km/s penetrates crust up to 6 km thick, and a 2.9 km bolide at 15 km/s penetrates 20 km thick crust. These impacts are energetically equivalent to 26 km/s impacts of bolides 430 m and 2 km, respectively. Penetrating impacts produce a water-filled breach extending fully through the ice, with the water comprising both impact-melted crust and exposed water under-layer. In some cases unbelted blocks of ice—ejecta that have fallen back into the opening cavity—persist as rafts in the water. Calculated recurrence intervals at Europa (from equations of Zahnle et al. 2003; Icarus, v. 163) are ≈ 2 m.y. for a 420 m and ≈ 10 m.y. for a 2 km comet. So even if ice thicknesses are substantial (≈ 20 km), our simulations suggest that impact penetration at Europa is likely, and may be a regular occurrence. Chaos terrain—where crust has been destroyed and underlying water appears to have been exposed—is unique to Europa, and may be the geomorphologic expression of such events.

Cosmogenic ^{10}Be Analysis of River Sands Provides Background Erosion Rates for Madagascar

Ronadh Cox, P. Bierman, E.O. Perry, and A.F.M. Rakotonirafy

Geological Society of America Abstracts with Programs **42**, 418 (2010)

Madagascar is considered one of the world's most ravaged landscapes, with inferred erosion rates 100-1000 m/m.y. Lavakas—saprolite gullies of the central highlands—are cited as evidence of catastrophic anthropogenic degradation. But this picture is based on few data, mostly from bare-plot runoff and short-term estuary sedimentation records. There are no long-term (>1 yr) stream-sediment gauge data. Cosmogenic ^{10}Be in quartz sand from rivers provides quantitative constraints on regional erosion rates at millennial timescales for specific geomorphologic settings. Data from 32 rivers spanning Madagascar from W to E indicate variable erosion rates of 3-76 m/m.y. The results challenge conventional interpretations of the role of lavakas in Malagasy erosion. Perhaps most surprising is the result that rates from lavaka-hosting watersheds are all <20 m/m.y. In strong contrast, the 6 highest erosion rates (30-76 m/m.y.) are all measured from zero-lavaka watersheds: i.e. high natural erosion rates occur in the absence of lavakas. These data provide a time-integrated background from which to interpret erosion in Madagascar's varied environments, and show that erosion—although most dramatically expressed in the lavaka-bearing highlands—may be greatest in coastal lowlands.

Quaternary Slope Sediments and Paleosoils in the Colorado Front Range - Process and Age

David P.Dethier, J.Voelkel, J.Huber, and M.Leopold

Geological Society of America Abstracts with Programs **42(5)**, 469 (2010)

The subalpine to montane zones of the Colorado Front Range, U.S.A., are characterized by the abundance of stratified slope deposits exhibiting depths > 1 m and recurring sediment characteristics within the respective strata complexes. Apart from the initial description by Leopold et al. (2008a), they have not been investigated up to now in terms of either their genesis or age. First OSL dating attempts demonstrate the general applicability of the dating method in this context and render last glacial ages ranging between 40 and 12 ka. Across a landscape transect stretching W-E from the subalpine zone east of the Continental Divide (tree line at Niwot Ridge) to the zone of the Foot Hills at the border with the Great Plains (Boulder), representative profiles are investigated with regards to hypsometric differences in stratification, sediment characteristics and morphodynamics. Most notably the montane zone of the Colorado Front Range is characterized by a lack of a considerable number of paleoclimatically interpretable geoarchives due to its semiarid climatic conditions. Additionally the slope sediments provide a basis for discussing the position of the permafrost line during the LGM. Therefore the state of the art project contributes a novel approach to the reconstruction of paleoenvironments and paleoclimates across the various altitudinal zones of the Colorado Front Range.

Using the Accumulation of CBD-Extractable Iron and Clay to Estimate Soil and Landform Age, Front Range, Colorado

David P.Dethier and P.Birkeland

Geological Society of America Abstracts with Programs **42(5)**, 364 (2010)

In transport-limited environments, the color (oxidized Fe) and clay content of regolith, particularly soil horizons, provide a basis for estimating the exposure age of surficial deposits and associated landforms. We were interested in quantifying soil properties at several classic Front Range glacial and hillslope localities; here we use extractable iron and clay content to estimate soil age or residence time at undated sites. We measured citrate-buffered dithionite (CBD)-extractable Fe (Fe_d) concentrations in ~ 140 samples of fresh rock, saprolite, morainal and colluvial materials and soil horizons from the Boulder Creek catchment and nearby areas; clay content was measured on ~90 samples. Fresh rocks contain < 1% Fe_d and < 5% clay. As bedrock and surficial deposits age, Fe_d and clay accumulate from weathering and dustfall. Holocene regolith contains small amounts of Fe_d and clay; soils developed on early Holocene cirque deposits locally contain 1.5% Fe_d and 8% clay. Concentrations mainly are higher in soils on older glacial deposits (Pinedale and Bull Lake age) and are still higher on hillslopes beyond the glacial limit, where colluvium may be >130 kyr. Clay and Fe_d contents are positively correlated ($r^2=0.46$), but scatter in the data likely reflects the influence of variable parent material, local climate, dustfall and landscape stability. Maximum profile concentration and the total mass of Fe_d in soil and in an underlying buried soil in Lefthand Canyon suggest that colluvium has accumulated episodically over >100 kyr. Another red soil developed in colluvium on an old surface near Ward appears even older. In contrast, at Gordon Gulch, one of the Boulder Creek CZO catchments developed on what appears to be a stable surface, Fe_d and clay concentrations suggest that soils mainly are of Pinedale age. In the absence of radiometric ages, the accumulation of Fe_d and clay in various soils provides a useful chronofunction for 10^3 to $\sim 10^6$ yrs with a strong dependence on climate.

Assessing the Hydrologic Impact of Land-Use Change in Upper Gordon Gulch, a Small Upland Catchment in the Arapaho National Forest, Colorado

David P.Dethier and Eirik M.Buraas '09

Geological Society of America Abstracts with Programs **42(5)**, 351 (2010)

Assessing the hydrologic impacts of future land management on National Forest land is important because increases in low-permeability areas (roads, trails, logged areas) produce higher peak discharges during high intensity precipitation events. The cumulative impact of such land-use changes is significant in areas such as the upland catchments of the Front Range, where forested land helps to buffer the effects of intense summer thunderstorms. We used the upper Gordon Gulch catchment (0.94 km^2), part of the Boulder Creek

Critical Zone Observatory in Arapaho National Forest, to measure and model the effect of precipitation intensity and land-use change on peak discharge.

We measured soil infiltration rates and soil compaction (dynamic cone penetrometer), analyzed soil samples, and estimated 1-hr precipitation intensities for recurrence intervals ranging from 0.5 to 500 years using local precipitation data. Infiltration rates reflect regolith properties and recent human impacts. Our measurements show that rates are correlated (p -value < 0.05) with field values for soil compaction and with laboratory values for soil texture and loss-on-ignition (LOI). Estimated precipitation intensities and measured infiltration rates show that precipitation in most areas of the catchment will flow through soil layers and sandy regolith and as groundwater toward surface channels.

We modeled peak flows for upper Gordon Gulch using KINEROS 2, a GIS-based, distributed property runoff model (Sammens et al., 2008) and the Rational Runoff Technique. Model runs suggest that a substantial fraction of peak discharge originates from roads and trails, logged areas and rock outcrops, which collectively comprise $< 10\%$ of the catchment. Peak discharge values modeled using KINEROS 2 exceed $1 \text{ m}^3 \text{ s}^{-1} \text{ km}^{-2}$ for the 100-year storm only if basin impermeable area increases to $> 10\%$ or if large portions of the basin burn. Our results suggest that planners should carefully consider and model possible hydrologic effects from cumulative land-use change in the National Forest. The local variation and range in soil properties also indicate that catchment-scale hydrologic models require detailed, locally measured data to contribute useful information to planners of National Forest land.

Internal Structure of the Green Lake 5 Rock Glacier, Colorado Front Range, USA

David P. Dethier, M. Leopold, M. W. Williams, N. Caine, and J. Völkel

Permafrost and Periglacial Process **22(2)**, 107-119 (2011)

Information about the internal structure of rock glaciers is needed to understand their reaction to ongoing climate warming. Three different geophysical techniques — shallow seismic refraction, ground-penetrating radar (GPR) and electrical resistivity tomography — were used to develop a detailed subsurface model of the Green Lake 5 rock glacier in the Colorado Front Range, USA. Below a thin zone of fine sediments and soils (0.7 – 1-m thickness; $0 - 20 \text{ k}\Omega\text{m}$ and $320 - 370 \text{ ms}^{-1}$), a 1 – 3-m thick zone with low p -wave velocities ($790 - 820 \text{ ms}^{-1}$) and high electrical resistivity ($20 - 100 \text{ k}\Omega\text{m}$) is interpreted as the ice-free, blocky active layer with large void spaces. The data corroborate strong reflections of the GPR signals, which travel at this depth at 0.11 m ns^{-1} . A third layer that extends from depths of 1 – 3 m to about 5 m is characterized by lower electric resistivities ($5 - 20 \text{ k}\Omega\text{m}$) and has lower electromagnetic wave velocities (0.65 m ns^{-1}), representing unfrozen, finer and wetter sediments. At around 5-m depth, the measured physical parameters change drastically ($v_p = 3200 - 3300 \text{ ms}^{-1}$, $50 - 150 \text{ k}\Omega\text{m}$, $v_{\text{GPR}} = 0.15 \text{ m ns}^{-1}$), showing an ice-rich permafrost zone above the bedrock. This model of the internal structure was used to evaluate an existing hydrological flowpath model based on the hydrochemical properties of water outflow from the rock glacier.

Mineralogic and Geochemical Changes from Alteration of Granitic Rocks, Boulder Creek Catchment, Colorado

David P. Dethier and D. J. Bove

Vadoze Zone Journal (in press, 2011)

In the critical zone of the upland Boulder Creek (Colorado) catchment, a weathered mantle consisting of 3 to 10 m of oxidized bedrock, saprolite, and mobile regolith (grus and soil), overlies fresh and locally hydrothermally altered bedrock that is exposed beneath a low-relief surface. Saprolite forms from isovolumetric alteration of primary rock materials to secondary minerals by percolating water; mobile regolith includes rock materials in transport downslope, mixed by a variety of biologic and physical processes. Analysis of vadose-zone samples by petrographic, ICP-MS and XRD techniques demonstrates that weathering of Precambrian Boulder Creek Granodiorite and Silver Plume Granite has formed small amounts of clay and iron oxides. Bulk geochemical changes during alteration are minor except in the transformation of saprolite to regolith, which is enriched in neoformed minerals. In saprolite, the alteration sequence is plagioclase \rightarrow biotite \rightarrow microcline \rightarrow quartz. Quantitative XRD analysis shows that smectite + kaolinite form $< 10\%$ of the rock in weathered samples and that smectite is absent and kaolinite + illite

comprise >15 percent of the rock at several hydrothermally altered sites. Iron oxide and hydroxide minerals such as goethite and hematite have formed by weathering and by hydrothermal alteration. Hydrothermal alteration of granodiorite to saprolite at the Hurricane Hill site resulted in substantial losses of CaO, MgO and Na₂O, Sr and metals such as Cd and Pb, and enrichment in K₂O and the trace elements Cs, Sb and W. At four critical- zone profiles studied in detail: (1) increases in kaolinite, smectite and Fe-oxides and decreases in magnetite concentration due to weathering are significant if fresh rock is compared to regolith; (2) illite is enriched in soil; (3) minor amounts of clay minerals are inherited from fresh rock; and (4) clay minerals and Fe-oxides are abundant only in hydrothermally altered saprolite. Some of the apparent enrichment of secondary minerals in weathered profiles likely results from dustfall and from material mixed into mobile regolith from heterogeneous bedrock sources. If some portion of the clay minerals in regolith and some fraction of dissolved material leaving Boulder Creek catchments are exotic, rates of clay and Fe-oxide formation in the Boulder Creek area must be slow and the alteration of granitic rocks during the conversion of saprolite to regolith may be driven mainly by volume expansion in this cool, continental climate.

Self-Efficacy Rocks! A Comparison of Student Affect and Performance in Physical Geology Courses

Lisa A. Gilbert and others

Geological Society of America Abstracts with Programs **42(5)**, 191 (2010)

The GARNET (Geoscience Affective Research Network) project examines the connection between student learning and the affective domain, which includes student motivations, values, attitudes and learning strategies. A key question is the influence of the affective domain on course grade. In 2008-2009, nine participating instructors at four institutions administered the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1993) at the beginning and end of the course. A total of 326 students fully participated and consented to use of their data. We compared the students' course grades to their MSLQ results and found that three of the MSLQ subscales were significantly correlated to students' percentile rankings within their classes: Self-Efficacy (positive correlation), Time and Study Environment (positive correlation), and Rehearsal (negative correlation), with Self-Efficacy being the most important. All of these correlations held true for both pre-course and post-course MSLQ scores, although the correlations were stronger for the post-course scores.

In 2009-2010, we repeated the procedure with 14 instructors at seven institutions. The grade distributions were statistically identical for four of these instructors, so we focused on these instructors and used grade rather than percentile rank as our measure of student performance. A total of 351 of these instructors' students completed both pre- and post-course surveys and consented to use of their data. We again found a strong correlation between Self-Efficacy and student grade. Other subscales showed significant but weaker correlations. On the pre-course survey, students' scores on the Effort Regulation scale showed a positive correlation with their grades. On the post-course survey, students' scores on the Intrinsic Goal Orientation scale and the Test Anxiety scale were negatively correlated with their course grades.

Students with high self-efficacy are confident that they can understand class material, do well on assignments and exams, and master the skills taught in the course. Instructors striving to improve student performance in introductory geology classes may wish to try to improve students' self-efficacy.

Retention in Geosciences: What Influences Students to Continue Beyond an Introductory Undergraduate Course?

Lisa A. Gilbert and others

Geological Society of America Abstracts with Programs **42(5)**, 584 (2010)

Students decide to enroll in introductory geoscience courses for a variety of reasons, most commonly to fulfill a general education requirement. At the conclusion of their introductory geoscience course, we asked students whether they planned to take another geology course. Over 800 students were surveyed from 7 institutions and 14 different instructors (public and private universities and colleges) for demographic and affective characteristics. We used the Motivated Strategies for Learning Questionnaire (Pintrich et al., 1993) as part of GARNET Project (Geoscience Affective Research Network) to determine student motivations (e.g., goal orientation and control beliefs) and learning strategies (e.g., study methods, critical

thinking, and metacognition). We also collected demographic, performance, and interest information from the students, both at the beginning and end of the semester.

Preliminary analysis indicates that students from under-represented race/ethnicity groups and female students tend to have a lower interest in continuing with another geology course. Students with a low prior interest in science and those enrolling to fulfill a general education requirement are less likely to continue. In addition, those students who perceive it will be an easy course are less likely to plan to take another geology course. Students who enter the course with high intrinsic motivation and task value leave the course with a higher likelihood of taking another geoscience course. Additionally, students who show the largest drop in motivational scores during the introductory course also leave with a low interest for continuing. Students at the beginning of the semester who are hesitant to commit to a science degree are somewhat more likely to indicate interest in pursuing a science degree after taking introductory geology. Further, undecided majors were more likely to say they planned to take another geology course than students who had declared any major, even more than students from other STEM fields. Our initial results suggest that geoscience majors may more likely come from students with initial high scores in motivation and those that have not yet declared a major.

The Little Engine that Could—Less Prior Knowledge but High Self-Efficacy is Equivalent to Greater Prior Knowledge and Low Self-Efficacy

Lisa A. Gilbert and others

Geological Society of America Abstracts with Programs **42(5)**, 191 (2010)

Does a student entering a geology course at a specific ability level (on the basis of past performance and prior knowledge) but greater confidence in their capability to be successful, end up with a higher score in class than a student who has similar ability but lower initial self-confidence? We analyzed survey results from students in introductory physical geology classes in regard to prior knowledge, records of student success, self-efficacy, and performance (grade). Based on previous findings, we hypothesized that regardless of ability, the students who entered the class with higher self-efficacy (belief in their ability to be successful in the course) would earn higher grades than those with low self-efficacy.

We administered pre- and post-course Motivated Strategies for Learning Questionnaires (MSLQ; Pintrich et al, 1993) in introductory geology classes taught by 14 instructors at seven colleges and universities as part of a larger study of student affect (GARNET). We compared the MSLQ scores for more than 800 students to final class scores. Self-efficacy was measured by one of 15 subscales that make up the MSLQ. A step-wise multiple regression of matched pairs of student responses reveals that student performance is most strongly correlated with their score on the self-efficacy subscale on this larger database.

One could argue that high self-efficacy may simply reflect a student's previous knowledge. In an effort to determine whether our data merely showed that more capable students do better than less capable students, we analyzed data from groups of students with similar prior knowledge. Students in this mini-study were almost exclusively freshmen who were members of two 95-person classes at a large public university in the Southeastern U.S. Student aptitude was measured on the basis of their GPA scores, and their results on a standard entry exam (GCI) and students were divided into groups of high (upper quartile), medium, and low (lower quartile) scores. We further divided these groups on the basis of self-efficacy. In individual aptitude groups, the high self-efficacy students earned higher grades than students with low self-efficacy scores. Further, students with low GCI or GPA scores but high self-efficacy earned the same grade as students with high GCI or GPA scores and low self-efficacy.

The Influence of Instructional Methods on Student Motivation, Attitudes, Values, Self Confidence and Work Effort

Lisa A. Gilbert and others

Geological Society of America Abstracts with Programs **42(5)**, 584 (2010)

Student motivation, values, attitudes, learning regulation and other components of the affective domain both promote and limit learning. For example, multiple studies have demonstrated that some aspects of student motivation have more significant influences on college student learning (reflected by grades and

concept inventories) than does student ability measured by standardized test results. Different approaches to instruction may (1) directly promote different amounts of learning, and (2) change student affect, further promoting or limiting learning.

The GARNET study investigated the influence of the affective domain on >800 students in introductory geology classes taught by 14 instructors at 7 colleges/universities. The most significant affective characteristics that predict student success upon entering a course are student confidence (self-efficacy) and willingness to work hard and persist (effort regulation). During a semester, both of these change, almost always in a negative direction regardless of the specific school/class/instructor.

Results from two sections of Introductory Geology at the University of North Dakota show profound effects of different teaching styles on similar groups of students. One class (A) was a traditional lecture class with student grades primarily based on two one-hour exams and a final. The other (B) was more learner centered, involving in-class group activities, projects, homework, and significantly less emphasis on lecture and exams. Although final letter grade distribution was about the same for both classes, numerical scores differed (max=80, avg=68 for A; max=100, avg=86 for B). For students in class A, confidence and work habits declined markedly during the semester, and test anxiety grew. For students in class B, confidence and habits declined only slightly, and test anxiety decreased.

The ways we teach our class, evaluate student learning, and assign grades have significant impact on student affect and may have implications beyond our immediate classroom. Students have greater self-efficacy, work harder and persist in the face of difficulty, and have less test anxiety in student-centered classes. Consequently they have the potential to learn more, and have better motivation, values, attitudes, and learning regulation when they leave the classroom.

Examination of the Motivation and Learning Strategies of Underrepresented Students in Introductory Geosciences

Lisa A. Gilbert and others

Geological Society of America Abstracts with Programs **42(5)**, 338 (2010)

The GARNET (Geoscience Affective Research Network) project examines the connection between student affect (attitudes, motivation, values, and regulation of learning) and geoscience learning outcomes. We examined how demographic characteristics relate to the motivation and learning strategies of under-represented students entering introductory geology courses at different institutions. Participating instructors used the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1993) to investigate how aspects of the affective domain varied for students from under-represented populations.

One obstacle to understanding how to address increasing diversity in the geosciences is the dearth of data about the experience of students in introductory geoscience classes. Introductory courses are considered a gateway to recruiting majors. Student affect can influence ongoing student learning, enrollment in subsequent classes, and the potential for a student to select a geoscience major. Affect may be more critical for under-represented students due to stereotype impressions.

Students from under-represented populations reported lower intrinsic and extrinsic motivation when entering our classes. The implication of this finding is that under-represented students begin with a lower motivation to achieve and learn the content. In this analysis, we examine a larger number of under-represented students across a more diverse transect of institutions (large university, community college and private colleges) from beginning to the end of the semester. Preliminary results indicate that many of the factors that affect Caucasian students also affect under-represented students, however they start the course as distinctly different statistical populations. Across different student demographic groups a decline in self-efficacy (confidence in learning) during a semester occurs. Under-represented students begin the semester with a lower average self-efficacy than the Caucasian students. The amount of effort that students are willing to put into a class displays a similar trend, with under-represented students entering with lower scores. These findings have important implications for their success in the course as well as their decisions to enroll in future geoscience classes.

Role of Gender in Student Affect in Introductory Physical Geology Courses at Multiple Institutions

Lisa A. Gilbert and others

Geological Society of America Abstracts with Programs **42(5)**, 191 (2010)

Are female students in your class more motivated, more confident, or more anxious about their performance than male students? As a part of the GARNET (Geosciences Affective Research NETwork) project we identify differences between the genders regarding incoming motivation, attitudes, values and learning strategies, and how those components change during the course of semester in introductory physical geology class.

GARNET collected student responses to the MSLQ (Motivated Strategies for Learning Questionnaire; Pintrich et al., 1993) at the beginning and end of the semester for the 2009/2010 academic year. Respondents represent 539 males and 607 females from 14 classes in 7 institutions ranging from research universities to community colleges. Responses in the 15 subscales of the MSLQ and various demographic data were statistically analyzed to characterize pre-instruction affect and the shift in affect during the course of the semester.

Incoming attitudes between the genders are significantly different in cognitive and metacognitive strategies (e.g. memorization, critical thinking), self-efficacy, test anxiety, time and study environment, and effort regulation. Females report less confidence (self-efficacy) in their ability to succeed in the course, have higher test anxiety, but record higher scores on most learning/cognitive strategies than their male peers at the beginning of semester. Shifts in value components (e.g. intrinsic goal orientation), self-efficacy, critical thinking, metacognition and elaboration strategies were significantly different between the genders. Female students recorded negative shifts in multiple scales (e.g., self-efficacy, task value, critical thinking). In contrast, males showed some negative shifts (e.g., self-efficacy) but increased their scores in several subscales (e.g., intrinsic goal orientation, critical thinking).

The differences in attitudinal shifts between the genders throughout the course of a single semester could have implications on the likelihood of recruiting female students into geology. Despite similar course grades, female students reported that they were statistically less likely to take additional classes beyond the introductory geology course compared to the male peers.

Geoscience Affective Research Network: Researching Student Attitudes, Motivations, Values and Regulation of Learning in Introductory Geoscience Courses

Lisa A. Gilbert and others

Geological Society of America Abstracts with Programs **42(5)**, 585 (2010)

Concerns about ensuring a scientifically literate society and the continued supply of able scientists are particularly relevant to the geosciences. At a time when college and university enrollments are climbing, geoscience enrollments are in decline. Though there are many resources available to instructors for improving student cognitive strategies (e.g., analytical and critical thinking), there is relatively little guidance available for addressing student affect (personal characteristics that influence student learning and attitudes toward science). Few previous studies have explored the relationship between student cognition and affect in college science classrooms, especially in the geosciences. The Geoscience Affective Research NETwork (GARNET) is an NSF-funded study that aims to explore the connections between instruction, student affect (attitudes, motivations, values, and regulation of learning) and geoscience learning. Results to date have documented significant differences in student affect and learning gains in introductory geoscience courses at multiple institutions; both have important implications for how we teach. Best practices that have the potential to improve student affect and learning outcomes have also been identified.

GARNET seeks broad participation by introductory geoscience instructors from community colleges, private liberal arts colleges, and public universities to investigate student affect and learning. Students enrolled in participating courses will complete some or all of the Motivated Strategies for Learning Questionnaire (MSLQ). Additionally, in some cases, student learning gains may be measured using the Geoscience Concept Inventory (GCI) and the learning environment may be characterized using the Reformed Teaching Observation Protocol (RTOP). Instructors will also have materials and guidance for

using a range of teaching interventions that can improve student learning and affect in their classes. Instructors will receive information about student learning gains, affective characteristics, and the learning environment, all with the goal of promoting better student learning, retaining students in the geosciences, and improving instructor satisfaction.

Tracking Silurian Eustasy: Alignment of Empirical Evidence or Pursuit of Deductive Reasoning?

Markes E. Johnson

Palaeogeography, Palaeoclimatology, Palaeoecology **296**, 276-284 (2010)

Sea level is not static, but liable to fluctuations due to addition or subtraction of water in the world's oceans, as well as changes to the shape and holding capacity of ocean basins. Relative changes in sea level are well supported by the rock record on a regional scale. Whether or not global (eustatic) changes are evident and how frequently they occurred during any given interval of time is a matter of contention among stratigraphers. Opinions have evolved over the last century with arguments based on refinements in biostratigraphy, chemostratigraphy, radiometric dating, and conceptual advances in sequence stratigraphy derived from technological advances in seismic stratigraphy. In 1936, the Pulsation Theory of A.W. Grabau attributed to Paleozoic strata a global history of 11 highstands distributed through a sequence with 21 subdivisions. In 1977, Peter Vail and associates from the Exxon Production Research Company independently interpreted a similar Paleozoic history showing 10 second-order highstands but distributed over 19 subdivisions. Vail's approach was model-based and followed a deductive path, while Grabau's was based on inductive reasoning. Recent refinements in a Paleozoic sea-level curve by Haq and Schutter are based on the same deductive approach taken by the Vail group, but pinned to patterns in sequence stratigraphy. Drawing on the Silurian System as a Paleozoic sample, the timing, frequency, and magnitude of sea-level highstands deduced by Haq and Schutter are compared with those promulgated by the author from the mid-1980s onward using empirical evidence more in line with Grabau's methodology. Both apply the concept of geographic reference areas, but Haq and Schutter identify 50% more Silurian highstands over an interval lasting 27.7 million years. Eight out of 10 Silurian highstands identified by this author match or overlap 8 out of 15 highstands recognized by Haq and Schutter. At issue is which, if any, qualify as eustatic signals with respect to current databases for biostratigraphic correlation. Evaluation is based on evidence reviewed from Iowa, New York, Norway, Estonia, and Austria in the paleogeographic context of three independent Silurian continents.

Ichnofacies and Microbial Build-Ups on Late Miocene Rocky Shores from Minorca (Balearic Islands), Spain

Markes E. Johnson, B.G. Baarli, A. Santos, and E. Mayoral

Facies **57**, 255-265 (2011)

Angular unconformities between Jurassic and Miocene strata are exposed in the sea cliffs of Cala Cigonya on the northwest coast of Menorca in the Balearic Islands of Spain. The geological discontinuities represent rocky shores on opposite sides of a former headland with 15 m of topographic relief. On the east flank, Jurassic dolomite is overlain by Upper Miocene (Tortonian to Messinian) breccia and laminated limestone. Here, a partially exhumed dolomite surface records Miocene bivalve borings of the ichnospecies *Gastrochaenolites torpedo* and *G. lapidicus* that achieved a density of >1,000 borings/m². Other associated traces include sponge borings (*Entobia* isp.) and polychaete borings (*Caulostrepsis* isp.). A breccia deposit 0.8 m thick was derived from the underlying dolomite and angular clasts still retain evidence of bivalve borings. Above follows a succession of laminated limestone beds more than 5 m thick, including some levels with dome-shaped stromatolites and other horizons with reworked dolomite clasts. Thin-section analysis of the laminated limestone reveals dark and light couplets 0.2 mm thick consistent with microbial origins. In contrast, the west flank was buried by coarse sandstone and laminated sediments. Here, dwelling structures of regular echinoids (*Circolites kotoncensis*) are the dominant traces preserved on the dolomite surface, reaching a maximum density of 66 borings/m². Associated borings include *Entobia geometrica* as well as rare traces of *Gastrochaenolites* isp. and *Trypanites* isp. Notable for the absence of a basal Miocene breccia, the west flank is interpreted as a sheltered rocky shore coeval with an exposed rocky shore on the east flank. Today, heavy surf on the north coast of Menorca is related to the Tramontana winds that blow out of Spain during winter months. Similar atmospheric circulation patterns must have prevailed during the

Late Miocene, but the replacement of ichnofacies by microbial build-ups resulted from increased salinity during the Messinian crisis.

Rhodolith Transport and Immobilization on a Volcanically Active Rocky Shore: Middle Miocene at Cabeço das Laranjas on Ilhéu de Cima (Madeira Archipelago, Portugal)

Markes E.Johnson, C.M.da Silva, A.Santos, B.G.Baarli, M.Cachão, E.J.Mayoral, A.C.Rebelo and J.Ledesma-Vázquez

Palaeogeography, Palaeoclimatology, Palaeoecology **300**, 113-127 (2011)

Extraordinary deposits of fossil rhodoliths occur at the Cabeço das Laranjas (Portuguese ~ Hill of the Oranges) in a small fault block at the northwest end of Ilhéu de Cima off Porto Santo in the Madeira Archipelago. Stratigraphic repetitions of densely packed rhodolith beds up to 2.6 m thick are associated with a receding rocky shoreline, and are interpreted as the result of hurricanes. The initial storm deposit sits unconformably on basalt and eroded basalt boulders associated with tuff and volcanoclastic breccia. Approximately 90,000 rhodoliths of Middle Miocene age (14 - 15 Ma) are exposed on the upper surface of the initial deposit over a 450-m² shelf exhumed from the hill's southeast side. Ranging in diameter from ≤ 3 cm to 20 cm, many of the rhodoliths generated by crustose coralline red algae are now iron stained and resemble a mass of oranges in gross appearance. Sea stacks and large boulders rise through the thick basal rhodolith bed to form small catchment areas that held the deposit in place after the storm's passage. The succeeding rhodolith deposits are variably separated by layers with mixed carbonate and volcanic sand, pure volcanic lapilli, and volcanoclastic tephra mixed with tuff showing swaley cross-stratification. Three out of four rhodolith beds are truncated against the flank of the adjoining rocky shore. Only the youngest (fourth) rhodolith layer is fully exposed around the perimeter of the hill and can be shown to cross a basalt barrier that is traceable for 70 m in cross section as an erosional ramp dipping from 6° to 8° southeast. The entire fossil-rich sequence is capped by a basalt flow showing columnar disjunction. Based on thin-section analysis, three genera of coralline red algae are recognized in the basal rhodolith deposit: *Sporolithon*, *Lithothamnion*, and *Neogoniolithon*. Associated biodiversity is low, represented by 16 kinds of marine invertebrates dominated by encrustations and borings on the rhodoliths and very few free body fossils. The Madeira region of the North Atlantic may have been susceptible to major cyclonic storms immediately after the Middle Miocene Climate Optimum, when a northward shift of the Inter-tropical Convergence Zone was stimulated by a steeper temperature gradient in the southern hemisphere related to expansion of continental glaciers on Antarctica.

Miocene Intertidal Zonation on a Volcanically Active Shoreline: Porto Santo in the Madeira Archipelago (Portugal)

Markes E.Johnson, A.G.Santos, E.J.Mayoral, C.M.da Silva, M.Cachão, and B.G.Baarli

Lethaia **44**, 26-32 (2011)

Short-term biological colonization on hardgrounds perturbed by volcanic and local tectonic events is a topic, as yet, poorly explored on basaltic shorelines of oceanic islands. A Miocene sea cliff on Ilhéu de Cima off Porto Santo in the Madeira Archipelago of Portugal provides a case study showing intertidal zonation with two types of barnacles, serpulid worm tubes, two coral species, epifaunal bivalves, and the traces of endolithic bivalves. Large barnacles (*Balanus* sp.) and serpulids are limited to the upper 40 cm of a 160-cm high basalt cliff. Small barnacles, possibly the same species, extend to the base. The upper half includes the corals *Isophyllastrea orbignyana* and *Tarbellastraea reussiana*, to which many small, coral-inhabiting barnacles of *Ceratoconcha costata* are fixed. Borings identified as *Gastrochaenolites torpedo* appear through the bottom two-thirds of the cliff face. Rarely, *G. lapidicus* is exposed in longitudinal section with borings up to 4.5 cm deep in solid basalt. Epifaunal bivalves, such as *Spondylus* sp., are limited to a middle zone. Associated with the sea cliff is an outer platform on which a multitude of *T. reussiana* colonies occur in growth position. The corals exhibit planar erosion over a 180-m² area. The shelf was faulted and cut by a basalt dike prior to the brief recolonization of *I. orbignyana*, found attached to low fault scarps. Habitation of the sea cliff was facilitated by rising sea level, but abruptly terminated by burial under volcanoclastic ejecta.

Adding Structures to 3-D Geologic Maps

Paul Karabinos

Geological Society of America, Abstracts with Programs **42(5)**, 208 (2010)

Combining geologic maps and cross-sections into traditional block diagrams is a time-tested and effective way to portray the structure of a region and to illustrate how maps and cross-sections work together; block diagrams are especially valuable for non-specialists. The inherent power of block diagrams is dramatically increased by software that can create interactive 3-D models of a region, which can be rotated, panned, and zoomed by the user. Particularly useful software options include Midland Valley's MOVE 2010 powerful modeling package, ESRI's GIS-based applications, Google Earth, and Google SketchUp. The best way to create virtual block diagrams is to combine the individual strengths of two or more applications, and merge the results into a single 3-D model.

The most effective 3-D models drape geologic maps on topography and show how the maps and cross-sections connect at the topographic surface. Creating models in segments gives the user flexibility to 'turn off' individual portions of the surface to sequentially reveal multiple cross-sections. Such models help students and non-specialists visualize geologic structures, and provide geologists with a valuable tool for assessing the validity of geologic interpretations.

Even the best 3-D virtual block diagrams can be challenging for a non-specialist to interpret and understand. Basic concepts such as bedding and strike and dip are unfamiliar to most non-geologists. Adding structures and textures to geologic maps can clarify these fundamental concepts. For example, ArcGlobe can portray the strike and dip of bedding of different units as color-coded 3-D 'wafers' that protrude above the surface and are precisely oriented to match the orientation of beds. Structures such as plunging folds become readily apparent using this technique.

Another approach is to use the astonishing flexibility and power of Google SketchUp to accurately model geologic structures in real-world coordinates and export the results to either Google Earth or ArcGlobe. These accurately constructed and located models of geologic structures can be integrated with geologic maps, and are particularly effective for showing how bedrock geology affects the topography of a region.

Evidence for Complex Mid-Crustal Flow in the Northern Appalachians from Regional Garnet Inclusion and Zoning Patterns

Paul Karabinos

Geological Society of America, Abstracts with Programs **42(5)**, 237 (2010)

Garnet-bearing pelitic and mafic schists are common in VT. Rosenfeld (1968) described garnets with two-stage growth histories from the Neoproterozoic Gassetts Schist in the Chester dome, and argued that the first-stage cores were Taconic and that the second-stage rims were Acadian. Thompson et al. (1977) suggested that both stages could have grown during a single prograde event that included an intermediate garnet-consuming reaction.

Garnets that grew in two stages are widespread in VT. Many contain zoning reversals indicating that garnet was partially resorbed during the growth hiatus. Rutile inclusions are common in garnet cores but absent in the rims and matrix indicating that the first growth stage occurred under higher pressure conditions than the second.

The hiatus in garnet growth is texturally linked to the formation of a new cleavage and does not correlate with metamorphic grade. The wide variation in grade of rocks containing two-stage garnets indicates that the hiatus cannot be attributed to an intermediate garnet consuming reaction during a single event. Two isograd maps, one for each stage of garnet growth, show that the grade during the second growth stage is consistently higher than the first, but there is a striking spatial correlation between the highest-grade areas during each stage. This suggests that both growth episodes occurred during a single orogeny, rather than separated by 80 m.y. The age of peak metamorphism is well constrained to be 380 Ma. Further, inclusions patterns and mineral chemistry indicate ca. 3 kbars of decompression during garnet growth. Thus, the hiatus in garnet growth was triggered by a tectonic event that altered the P-T conditions at a particular mid-crustal level.

In contrast, Sil. and Dev. pelitic and mafic schist samples contain garnets with simple zoning patterns and no evidence for two stages of growth. Metamorphism in these rocks occurred during increasing P. The spatial distribution of distinctive garnet zoning and inclusion patterns is consistent with structural evidence for a high-strain zone with normal displacement that separates structurally lower rocks with complex garnets from higher rocks with simple garnets. Structurally lower rocks were extruded northward and upward into Sil. and Dev. nappes that were transported westward during the Acadian orogeny.

Preferred Orientation of Cobbles and Boulders in Unstrained Alluvial Fan Deposits: Implications for Rf-Phi Analysis of Deformed Conglomerates

Paul Karabinos and Lisa Merkhofer '11

Geological Society of America, Abstracts with Programs **42(5)**, 208 (2010)

Deformed conglomerates are commonly used for strain analysis because clasts can be approximated as ellipses. The Rf- ϕ method uses the orientation and axial ratio of elliptical objects to estimate finite strain, but it assumes an initially random orientation of clast long axes. This assumption has been tested in sandstones, but not in cobble and boulder-sized conglomerates. In sandstones, initially preferred orientations of long axes can significantly affect estimated strain values and can be difficult to detect (Patterson and Yu, 1993).

Our work focused on undeformed conglomerates in the Deerfield Basin in MA. The Jurassic Sugarloaf Arkose and Mount Toby Conglomerate were deposited near a normal fault at the eastern margin of the basin. We measured 13 joint faces from 3 large outcrops. Exposures include both clast and matrix supported fabrics. Clast size ranges from pebble to boulder, and clasts are angular to well rounded. Each outcrop contains one or two joint faces parallel to bedding and two to four faces approximately perpendicular to bedding.

We used a Gigapan mount to take high-resolution photographs of the joint faces. We included a 2x1 m grid to correct for image distortion using Photoshop. We imported the photos into Geoshear, a strain analysis program (Karabinos and Warren, 2010). Using Geoshear, clasts are digitized and both Cartesian and polar Rf- ϕ plots created. We measured an average of 247 clasts on each surface, ranging from 85 to 955 clasts.

In faces perpendicular to bedding, Rf- ϕ plots show an initially preferred orientation of long axes parallel to bedding, and clasts with higher axial ratios are more likely to be oriented parallel to bedding; this is the so-called 'delta' configuration of Elliott (1970). Rf- ϕ plots for faces parallel to bedding showed no preferred orientation of clast long axes. The virtual tools allowed us to measure numerous clasts directly from rock faces, and to create a visual record of our measurements readily available for review by other geologists. Geoshear also allows us to run deformation "experiments" to evaluate how accurately we can estimate strain imposed on samples with an initially preferred orientation, and thereby assess the importance of preferred orientations in typical conglomerates.

Integrating Geologic Maps and Cross Sections in an Interactive 3-D Environment

Paul Karabinos

Geological Society of America Penrose Conference, 2011

Traditional geologic maps and cross sections are common, time-tested, and effective ways to portray the structure of a region, but are best appreciated by experienced geologists. Textbooks integrate maps and cross sections into static perspective block diagrams to help students visualize basic concepts in structural geology. The inherent power of block diagrams, however, is dramatically increased by software that can create interactive 3-D models of a region, which can be rotated, panned, and zoomed by the user. The best way to create virtual block diagrams is to combine the individual strengths of dedicated GIS software with Google SketchUp and Earth, and merge the results into a single 3-D model.

Effective 3-D models drape geologic maps on topography and show how the maps and cross-sections connect at the topographic surface. Creating models in segments gives the user flexibility to 'turn off' individual portions of the surface to sequentially reveal multiple cross-sections. Such models help students and non-specialists visualize geologic structures, and provide geologists with a valuable tool for assessing

the validity of geologic interpretations. It is even possible to construct cross sections in a 3-D environment using SketchUp.

Even the best 3-D virtual block diagrams can be challenging for students to interpret and understand. Basic concepts such as bedding and strike and dip are unfamiliar to most non-geologists. SketchUp can be used to add visual cues to maps and show the intersection of unconformities, faults, and plunging folds with the topographic surface. These accurately constructed and located models of geologic structures can be exported to Google Earth, and are particularly effective for showing how bedrock geology affects the topography of a region.

An Emsian Age for the Goshen Formation in the Connecticut Valley-Gaspe Trough in Massachusetts
Paul Karabinos

Geological Society of America, Abstracts with Programs **43**, 160 (2011)

The Devonian Goshen Formation is the westernmost unit in the Connecticut Valley-Gaspe Trough (CVGT) in MA. Equivalent rocks in VT are called the Northfield Formation. The Goshen Formation is the only Devonian unit in MA in contact with Ordovician rocks west of the CVGT and around the Shelburne Falls, Goshen, Granville, and Woronoco domes. This contact relationship suggested to Hatch et al. (1988) that the Goshen Formation is predominantly older than the Waits River Formation. However, they noted the lithologic similarity between the Goshen Formation and the Royalton belt of the Devonian Gile Mountain Formation in VT, which is demonstrably younger than the Waits River Formation. The age range of the Waits River Formation is approximately 423 Ma (Aleinikoff and Karabinos, 1990) to at least 415 Ma (McWilliams et al., 2010).

The Goshen Formation commonly contains graded beds that delineate numerous upright folds in the central part of the outcrop belt, where a younger member (Dgq) is defined by a greater percentage of micaceous quartzite beds. We discovered several beds within the Dgq member of the Goshen Formation near Cummington, MA, that we interpret as volcanic in origin. Prismatic, colorless zircons extracted from a 1.5 m thick felsic layer yield a SHRIMP Concordia Age of 405 ± 4 Ma (11 of 15 analyses). This age is indistinguishable from ages of 407 ± 3 Ma from a metarhyolite in the Meetinghouse Slate Member of the Gile Mountain Formation (Rankin and Tucker, 2009) and 409 ± 5 Ma from volcanic zircons extracted from a quartzite bed in the Royalton belt of the Gile Mountain Formation (McWilliams et al., 2010).

Our data show that the Dgq member of the Goshen Formation is the same age as the Royalton belt and the Meetinghouse Slate Member of the Gile Mountain Formation, and that they are all younger than the Waits River Formation. Assuming that the older part of the Goshen Formation in MA and the equivalent Northfield Formation in VT are not significantly older than the volcanic bed we dated, the youngest units in the CVGT occur along both the western and eastern margins, and the older Waits River Formation occupies the central part of the trough. Also, sedimentation in the CVGT appears to have been active from ca. 423 to at least 405 Ma, which constrains tectonic models of terrane accretion in the northern Appalachians.

Quaternary Intertidal Deposits Intercalated with Volcanic Rocks on Isla Sombrero Chino in the Galápagos Islands (Ecuador)

Paul Karabinos, Markes E. Johnson, and V. Mendiola

Journal of Coastal Research **26(4)**, 762-768 (2010)

A stratigraphic succession composed of limestone intercalated with volcanic ash and basalt capped by a conglomerate of mixed limestone and basalt cobbles was deposited in a trough-shaped depression approximately 25 m wide and 50 m long to a thickness of 1.62 m on the southwest side of Isla Sombrero Chino in the Galápagos Islands of Ecuador. Two layers of well-cemented calcarenite up to 20 cm thick accumulated as beach deposits with bioclasts of gastropods dominated by the Galápagos Periwinkle (*Nodilittorina galapagensis*), a representative of the Beaded Hoofshell (*Hipponix grayanus*), broken crab fragments, and bird bones. Crustacean remains most likely belong to the Sally Lightfoot Crab (*Grapsus grapsus*). The bird bones are attributed to Audubon's Shearwater (*Puffinus iherminieri*). Distinctly intertidal in origin, such a mixed assemblage of invertebrates and vertebrates is unusual, and the association with basalt flows is seldom met in the rock record. The pristine state of the volcanic cone on Sombrero Chino is

consistent with a ^3He exposure age of 13 ± 0.8 ka. The age of the basalt-limestone sequence is unknown but must be younger than the ^3He exposure age. The basalt-limestone sequence is elevated approximately 3 to 4 m above current sea level. This implies that the intertidal limestone was deposited during an interval of higher sea level or, more likely, was uplifted by magmatic inflation. Such intertidal deposits, in conjunction with more precise dating, have the potential to constrain the history of relative sea-level change during island growth and isostatic subsidence related to volcanism and lithospheric cooling. Intertidal deposits of the kind reported here also help to distinguish between monogenetic as opposed to polygenetic history for volcanic islands.

From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region

Paul Karabinos, R.P.Tollo, M.J.Bartholomew, and J.P.Hibbard, editors

Geological Society of America Memoir **206**, 956 p. (2010)

The Appalachians constitute one of Earth's major tectonic features and have served as a springboard for innovative geologic thought for more than 170 years. This volume contains 36 original papers reporting the results of research performed throughout nearly the entire length and breadth of the Appalachian region, including all major provinces and geographical areas. Memoir 206 was designed to commemorate the (near-) fortieth anniversary of the publication of the classic *Studies of Appalachian Geology* volumes that appeared just prior to the application of plate tectonic concepts to the region. Contributions concerning structural evolution, sedimentation, stratigraphy, magmatic processes, metamorphism, tectonics, and terrane accretion illustrate the wide range of ongoing research in the area and collectively serve to mark the considerable progress in scientific thought that has occurred during the past four decades.

Mathematics and Statistics

The Spiral Index of Knots

Colin Adams, W.George, R.Hudson, R.Morrison, L.Starkston, S.Taylor, and O.Turanova

Mathematical Proceedings of the Cambridge Philosophical Societ, **149(2)**, 297-315 (2010)

In this paper, we introduce two new invariants that are closely related to Milnor's curvature-torsion invariant. The first, a particularly natural invariant called the spiral index of a knot, captures the number of local maxima in a knot projection that is free of inflection points. This invariant is sandwiched between the bridge and braid index of a knot, and captures more subtle properties. The second invariant, the projective superbridge index, provides a method of counting the greatest number of local maxima that occur in a given projection. In addition to investigating the relationships among these invariants, we use them to classify all those knots for which Milnor's curvature-torsion invariant is 6π .

Looking Backward

Colin Adams

Mathematical Intelligencer **32(3)**, (2010)

What happens to someone who is hypnotized to sleep and reawakens 100 years later in their expectation of the present day world, and finds a mathematical paradise?

A Forgivably Flat Classic, review of Flatland

Colin Adams

American Scientist **98(6)**, 498-500 (2010)

A review of the classic book "Flatland" in a new edition

Group Therapy

Colin Adams

Mathematical Intelligencer **32(4)**, (2010)

How does group therapy work for a group of mathematicians who know group theory?

Hardy and Ramanujan

Colin Adams

Mathematical Intelligence **33(1)**, (2011)

A more detailed account of the enigmatic relationship between Hardy and Ramanujan

Leonhard Euler and Seven Bridges of Königsberg

Colin Adams

Mathematical Intelligencer **33(2)**, (2011)

The true story of how Leonhard Euler became the greatest bridge stroller problem solver in history

Arithmetic from an Advanced Perspective: An Introduction to the Adeles

Edward B. Burger

Pro Mathematica **24**, 9-54 (2010)

Here we offer an introduction to the adèle ring over the field of rational numbers \mathbf{Q} and highlight some of its beautiful algebraic and topological structure. We then apply this rich structure to revisit some ancient results of number theory and place them within this modern context as well as make some new observations. We conclude by indicating how this theory enables us to extend the basic arithmetic of \mathbf{Q} to the more subtle, complicated, and interesting setting of an arbitrary number field k .

Deformations of Bordered Surfaces and Convex Polytopes

Satyan Devadoss, T. Heath and C. Vipismakul

Notices of the American Mathematical Society **58**, 530-541 (2011)

We provide a combinatorial framework to understand how surfaces with boundary can deform, and then proceed to classify all such deformations which have polytopal structures.

Pseudograph Associahedra

Satyan Devadoss, M. Carr and S. Forcey

Journal of Combinatorial Theory, Series A **118**, 2035-2055 (2011)

Given an arbitrary finite graph (with loops and multiple edges), we construct a polytope which captures the connectedness of the graph.

Discrete and Computational Geometry

Satyan Devadoss and J. O'Rourke

Princeton University Press (2011)

This textbook bridges the gap between discrete geometry of pure mathematics and computational geometry of data-driven computer science, at an undergraduate level. It includes traditional topics such as convex hulls, triangulations, and Voronoi diagrams, as well as advanced material such as curve reconstruction, quasisgeodesics, and Dehn invariants.

Stats: Data and Models, 3rd Edition

Richard DeVeaux, P. Velleman and D. Bock

Pearson Education (2010)

Simultaneous Confidence Bounds for Relative Risks in Multiple Comparisons to Control

Bernhard Klingenberg

Statistics in Medicine **29**, 3232-3244 (2010)

We discuss the construction of asymptotic simultaneous upper confidence limits that jointly bound relative risks formed by comparing several treatments to a control. Motivated by a vaccine study, we investigate the performance of several methods under such settings. Inverting the minimum of score statistics, together with estimating the correlation matrix of these statistics under the null gives simultaneous coverage rates

closest to the nominal level. In typical settings of vaccine studies, this method proves to be the most powerful of the ones considered, but computationally simpler alternatives are also worth exploring when the number of comparisons is large. Simultaneous lower and two-sided confidence intervals are also considered. All procedures can be implemented and evaluated using freely available and general R code.

Formal Fibers of Unique Factorization Domains

Susan Loepp, A.Boocher, M.Daub, R.Johnson, H.Lindo, and P.Woodard

Canadian Journal of Mathematics **62**, 721-736 (2010)

In this paper, the authors construct unique factorization domains such that most of the formal fibers of these integral domains are geometrically regular. In addition, they construct unique factorization domains containing many ideals for which tight closure and completion do not commute.

A Unitary Test of the L-Functions Ratios Conjecture

Steven J.Miller, J.Goes, S.Jackson '10, D.Montague, K.Ninsuwan, R.Peckner and Thuy Pham '11

Journal of Number Theory **130**, 2238-2258 (2010)

We verify the L-function Ratios Conjecture's predictions for the unitary family of all Dirichlet L-functions with prime conductor; we show square-root agreement between prediction and number theory if the support of the Fourier transform of the test function is in $(-1, 1)$, and for support up to $(-2, 2)$ we show agreement up to a power savings in the family's cardinality. The interesting feature in this family (which has not surfaced in previous investigations) is determining what is and what is not a diagonal term in the Ratios recipe.

Towards an Average Version of the Birch and Swinnerton-Dyer Conjecture

Steven J.Miller and J.Goes

Journal of Number Theory **130**, 2341-2358 (2010)

We find non-trivial upper and lower bounds for the average number of normalized zeros in intervals on the order of $1/\log N_E$ (which is the expected scale). Our results may be interpreted as providing further evidence in support of the Birch and Swinnerton-Dyer conjecture, as well as the Katz-Sarnak density conjecture from random matrix theory (as the number of zeros predicted by random matrix theory lies between our upper and lower bounds).

Explicit Constructions of Infinite Families of MSTD Sets (with Dan Scheinerman) Additive Number Theory: Festschrift in Honor of the Sixtieth Birthday of Melvyn B. Nathanson

Steven J.Miller, D.Chudnovsky and G.Chudnovsky, eds.

Springer-Verlag (2010)

We present a new construction that yields a family of sum-dominated sets in $\{1, 2, \dots, r\}$ of size $C 2^r / r^4$ for a fixed, non-zero constant C ; our family is significantly denser than previous constructions.

The Lowest Eigenvalue of Jacobi Random Matrix Ensembles and Painleve VI

Steven J.Miller, E.Duenez, D.K.Huynh, J.Keating and N.Snaith

Journal of Physics A: Mathematical and Theoretical **43**, 405204 (27 pp) (2010)

We present two complementary methods, each applicable in a different range, to evaluate the distribution of the lowest eigenvalue of random matrices in a Jacobi ensemble.

An Orthogonal Test of the L-Functions Ratios Conjecture, II

Steven J.Miller and D.Montague

Acta Arithmetica **146**, 53-90 (2011)

We prove the accuracy of the Ratios Conjectures prediction for the 1-level density of families of cuspidal newforms of constant sign (up to square-root agreement for support in $(-1, 1)$, and up to a power savings in $(-2, 2)$), and discuss the arithmetic significance of the lower order terms. This is the most involved test of the Ratios Conjectures predictions to date, as it is known that the error terms dropped in some of the steps do not cancel, but rather contribute a main term! Specifically, these are the non-diagonal terms in the

Petersson formula, which lead to a Bessel-Kloosterman sum which contributes only when the support of the Fourier transform of the test function exceeds $(-1, 1)$.

Effective Equidistribution and the Sato-Tate Law for Families of Elliptic Curves

Steven J. Miller and R. Murty

Journal of Number Theory **131(1)**, 25-44 (2011)

We provide effective bounds on the family of all elliptic curves and one-parameter families of elliptic curves modulo p (for p prime tending to infinity) obeying the Sato-Tate Law.

Isoperimetric Sets of Integers

Steven J. Miller, F. Morgan, Edward Newkirk '09, Lori Pedersen, Deividas Seferis '09

Mathematics Magazine **84**, 37-42 (2011)

The celebrated isoperimetric theorem says that the circle provides the least-perimeter way to enclose a given area. In this note we discuss a generalization.

An Elliptic Curve Family Test of the Ratios Conjecture

Steven J. Miller, D.K. Huynh and Ralph Morrison '10

Journal of Number Theory **131**, 1117-1147 (2011)

We compare the L-Function Ratios Conjectures prediction with number theory for the family of quadratic twists of a fixed elliptic curve with prime conductor, and show agreement in the 1-level density.

Demand-Driven Scheduling of Movies in a Multiplex

Steven J. Miller, J. Eliashberg and C.B. Weinberg

Newsletter of the European Marketing Academy (October 2010)

Summary of Silver-Scheduler paper in honor of it receiving the IJRM Best Paper Award for 2009

Stable Constant Mean Curvature Hypersurfaces are Area Minimizing in Small L^1 Neighborhoods

Frank Morgan and A. Ros

Interfaces Free Boundaries, 151-155 (2010)

We prove that a strictly stable constant-mean-curvature hypersurface in a smooth manifold of dimension less than or equal to 7 is uniquely homologically area minimizing for fixed volume in a small L^1 neighborhood.

Isoperimetric Sequences

Frank Morgan, Steven J. Miller, Edward Newkirk '09, Lori Pedersen, Deividas Seferis '09

Math Magazine **84**, 37-42 (2011)

We generalize the isoperimetric problem from geometry to numbers.

Rebalance Every $(15000/V)^{1/3}$ Years

Frank Morgan and W. Filkins

SSRN (2010)

An original formula for how often to rebalance investments

The Log-Convex Density Conjecture

Frank Morgan, C. Houdré, M. Ledoux, E. Milman, and M. Milman, eds.

Concentration, Functional Inequalities and Isoperimetry (Proc. Intl. Wkshp., Florida Atlantic Univ., Oct./Nov. 2009) Contemporary Mathematics **545**, Amer. Math. Soc. (2011)

A short exposition of a conjecture on when balls about the origin are isoperimetric in \mathbb{R}^n with density

Mixing on Rank-One Transformations

Cesar E.Silva and D.Creutz '03

Studia Mathematica **199(1)**, 43-72 (2010)

We prove mixing on rank-one transformations is equivalent to “the uniform convergence of ergodic averages (as in the mean ergodic theorem) over subsequences of partial sums.” In particular, all polynomial staircase transformations are mixing.

Dynamics of the p-adic Shift and Applications

Cesar E.Silva, J.Kingsbery '06, A.Levin, and A.Preygel

Discrete and Continuous Dynamical Systems **30(1)**, 209-218 (2011)

There is a natural continuous realization of the one-sided Bernoulli shift on the p-adic integers as the map that shifts the coefficients of the p-adic expansion to the left. We study this map's Mahler power series expansion. We prove strong results on p-adic valuations of the coefficients in this expansion, and show that certain natural maps (including many polynomials) are in a sense small perturbations of the shift. As a result, these polynomials share the shift map's important dynamical properties. This provides a novel approach to an earlier result of the authors.

Digraph Representations of Rational Functions Over the p-adic Numbers

Cesar E.Silva and H.Diao

P-adic Numbers, Ultrametric Analysis, and Applications **3(1)**, 23-38 (2011)

In this paper, we construct a digraph structure on p-adic dynamical systems defined by rational functions. We study the conditions under which the functions are measure-preserving, invertible and isometric, ergodic, and minimal on invariant subsets, by means of graph theoretic properties.

Physics

A Two Length Scale Polymer Theory for RNA Loop Free Energies and Helix Stacking

Daniel P.Aalberts and Nagarajan Nandagopol '09

RNA, **16**, 1350-1355 (2010)

The reliability of RNA secondary structure predictions is subject to the accuracy of the underlying free energy model. Mfold and other RNA folding algorithms are based on the Turner model, whose weakest part is its formulation of loop free energies, particularly for multibranch loops. RNA loops contain single-strand and helix-crossing segments, so we develop an enhanced two-length freely jointed chain theory and revise it for self-avoidance. Our resulting universal formula for RNA loop entropy has fewer parameters than the Turner/Mfold model, and yet simulations show that the standard errors for multibranch loop free energies are reduced by an order of magnitude. We further note that coaxial stacking decreases the effective length of multibranch loops and provides, surprisingly, an entropic stabilization of the ordered configuration in addition to the enthalpic contribution of helix stacking. Our formula is in good agreement with measured hairpin free energies. We find that it also improves the accuracy of folding predictions.

A Vision for Photoisomerization

Daniel P.Aalberts and H.F.Stabenau '02

Physica A **389**, 2981-2986

We propose a simple physical mechanism to explain the ultrafast first step of vision, a photoinduced cis to trans rotation of retinal. In the ground state, the torsional stability of π bonds is countered by Coulomb interactions acting between the π lobes; the torsional dependence for Coulomb interactions is absent in the often-used Ohno approximation, but restored with our formula. After photoexcitation, the bonding weakens causing the destabilizing terms to dominate. The twist in the ground state due to steric interactions surrounding the 11-cis bond increases the initial torque and thus the speed of the reaction.

Arbitrary Control of Entanglement between Two Superconducting Resonators

Frederick W. Strauch, K. Jacobs, and R. W. Simmonds

Physical Review Letters 105, 050501 (July 27, 2010)

We present a method to synthesize an arbitrary quantum state of two superconducting resonators. This state-synthesis algorithm utilizes a coherent interaction of each resonator with a tunable artificial atom to create entangled quantum superpositions of photon number (Fock) states in the resonators. We theoretically analyze this approach, showing that it can efficiently synthesize NOON states, with large photon numbers, using existing technology.

Parallel State Transfer and Efficient Quantum Routing on Quantum Networks

Christopher Chudzicki '10 and Frederick W. Strauch

Physical Review Letters 105, 260501 (December 22, 2010)

We study the routing of quantum information in parallel on multidimensional networks of tunable qubits and oscillators. These theoretical models are inspired by recent experiments in superconducting circuits. We show that perfect parallel state transfer is possible for certain networks of harmonic oscillator modes. We extend this to the distribution of entanglement between every pair of nodes in the network, finding that the routing efficiency of hypercube networks is optimal and robust in the presence of dissipation and finite bandwidth.

Neutrino mass, sneutrino dark matter, and signals of lepton flavor violation in the MRSSM

A. Kumar, David Tucker-Smith, and N. Weiner

JHEP 1009, 111 (2010)

We study the phenomenology of mixed-sneutrino dark matter in the Minimal R-symmetric Supersymmetric Standard Model (MRSSM). Mixed sneutrinos fit naturally within the MRSSM, as the smallness (or absence) of neutrino Yukawa couplings singles out sneutrino A-terms as the only ones not automatically forbidden by R-symmetry. We perform a study of randomly generated sneutrino mass matrices and find that (i) the measured value of Ω_{DM} is well within the range of typical values obtained for the relic abundance of the lightest sneutrino, (ii) with small lepton-number-violating mass terms for the right-handed sneutrinos, random matrices satisfying the Ω_{DM} constraint have a decent probability of satisfying direct detection constraints, and much of the remaining parameter space will be probed by upcoming experiments, (iii) the lepton-number-violating mass terms radiatively generate appropriately small Majorana neutrino masses, with neutrino oscillation data favoring a mostly sterile lightest sneutrino with a dominantly μ/τ -flavored active component, and (iv) a sneutrino LSP with a significant μ component can lead to striking signals of $e-\mu$ flavor violation in dilepton invariant-mass distributions at the LHC.

Muonic hydrogen and MeV forces

David Tucker-Smith and I. Yavin

Phys. Rev. D 83, 10172(R) (2011)

We explore the possibility that a new interaction between muons and protons is responsible for the discrepancy between the CODATA value of the proton radius and the value deduced from the measurement of the Lamb shift in muonic hydrogen. We show that a new force carrier with roughly MeV mass can account for the observed energy shift as well as the discrepancy in the muon anomalous magnetic moment. However, measurements in other systems constrain the couplings to electrons and neutrons to be suppressed relative to the couplings to muons and protons, which seems challenging from a theoretical point of view. One can nevertheless make predictions for energy shifts in muonic deuterium, muonic helium, and true muonium under the assumption that the new particle couples dominantly to muons and protons.

Entanglement cost of two-qubit orthogonal measurements

S.Bandyopadhyay, R.Rahaman, and *William K.Wootters*

Journal of Physics A: Mathematical and Theoretical **43**, 455303 (2010)

The “entanglement cost” of a bipartite measurement is the amount of shared entanglement two participants need to use up in order to carry out the given measurement by means of local operations and classical communication. We numerically investigate the entanglement cost of generic orthogonal measurements on two qubits. Our results strongly suggest that for almost all measurements of this kind, the entanglement cost is strictly greater than the average entanglement of the eigenstates associated with the measurements, implying that the nonseparability of a two-qubit orthogonal measurement is generically distinct from the nonseparability of its eigenstates.

Entanglement Sharing in Real-Vector-Space Quantum Theory

William K.Wootters

Foundations of Physics, Online First, 16 July 2010

The limitation on the sharing of entanglement is a basic feature of quantum theory. For example, if two qubits are completely entangled with each other, neither of them can be at all entangled with any other object. In this paper we show, at least for a certain standard definition of entanglement, that this feature is lost when one replaces the usual complex vector space of quantum states with a real vector space. Moreover, the difference between the two theories is extreme: in the real-vector-space theory, there exist states of arbitrarily many binary objects, “rebits,” in which every rebit in the system is maximally entangled with each of the other rebits.

Geometric local invariants and pure three-qubit states

M.S.Williamson, M.Ericsson, M.Johansson, E.Sjöqvist, A.Sudbery, V.Vedral, and *William K.Wootters*

Physical Review A **83**, 062308 (2011)

We explore a geometric approach to generating local $SU(2)$ and $SL(2,C)$ invariants for a collection of qubits, inspired by lattice gauge theory. Each local invariant or “gauge” invariant is associated with a distinct closed path (or plaquette) joining some or all of the qubits. In lattice gauge theory, the lattice points are the discrete space-time points, the transformations between the points of the lattice are defined by parallel transporters, and the gauge invariant observable associated with a particular closed path is given by the Wilson loop. In our approach the points of the lattice are qubits, the link transformations between the qubits are defined by the correlations between them, and the gauge invariant observables, the local invariants associated with a particular closed path, are also given by a Wilson looplike construction. The link transformations share many of the properties of parallel transporters, although they are not undone when one retraces one’s steps through the lattice. This feature is used to generate many of the invariants. We consider a pure three-qubit state as a test case and find we can generate a complete set of algebraically independent local invariants in this way; however, the framework given here is applicable to generating local unitary invariants for mixed states composed of any number of d-level quantum systems. We give an operational interpretation of these invariants in terms of observables.

Psychology

Attachment Styles and Defense Mechanisms in Parents who Abuse their Children

Phebe Cramer and *F.D.Kelly*

Journal of Nervous and Mental Disease **198**, 619–627 (2010)

Adult attachment style, defense mechanisms, and personal history of abuse were studied in a group of abusive parents. As a group, these parents made unusually high use of the defense of denial; this was especially true of those with a Fearful attachment style. However, the use of Identification was characteristic of those with a Preoccupied attachment style. Further, personal abuse history was related to adult attachment style. Those who reported having been abused as a child were less likely to have a Secure attachment style, and a history of physical or sexual abuse was associated with a Preoccupied style. In

general, these findings support the deactivating/hyperactivating defensive theory of Mikulincer et al. (2006).

Young Adult Narcissism: A 20 Year Longitudinal Study of the Contribution of Parenting Styles, Preschool Precursors of Narcissism, and Denial

Phebe Cramer

Journal of Research in Personality **45**, 19-28 (2011)

The role of parenting in the development of young adult narcissism was investigated with individuals from the Block and Block (1980) longitudinal study. At age 3, participants were assessed for the presence of narcissism precursors, and mothers and fathers provided information about their parenting styles. At age 23, the presence of both healthy and maladaptive narcissism was assessed, along with the use of denial. The results showed that parenting styles had a direct effect on the development of healthy narcissism, but the effect on the development of maladaptive narcissism depended on the child's initial proclivity towards narcissism. Also, the use of denial was positively associated with the presence of maladaptive narcissism, but not with healthy narcissism.

Ordinary Variations in Human Maternal Caregiving in Infancy and Biobehavioral Development in Early Childhood: A Follow-Up Study

Amie A.Hane, H.A.Henderson, N.A.Fox, B.C.Reeb-Sutherland

Developmental Psychobiology **52**, 558-567 (2010)

Rodent models of early caregiving find that pups reared by dams providing low levels of early stimulation subsequently display heightened stress reactivity and social aggression. We examined these effects in humans by investigating the effects of early caregiving on markers of biobehavioral development at ages 2 and 3 years. This study extended the findings reported by Hane and Fox (Hane and Fox [2006] Psychol. Sci. 17: 550–556) in which 185 mothers and infants were observed and scored for variations in maternal caregiving behavior (MCB) at age 9 months. Relative to young children who received high-quality MCB in infancy, those who received low-quality MCB showed significantly higher socially inhibited behavior with adults, right frontal electroencephalogram (EEG) asymmetry, aggressive play, and maternal reported internalizing behavior problems and anger proneness. These effects were independent of early temperamental reactivity. Results parallel rodent models and demonstrate that ordinary variations in MCB influence stress reactivity and social behavior in young children.

Longitudinal Stability of Temperamental Exuberance and Social-Emotional Outcomes in Early Childhood

K.A.Degnan, Amie A.Hane, H.A.Henderson, O.L.Moas, B.C.Reeb-Sutherland & N.A.Fox

Developmental Psychology **47** 765-80 (2011)

The goals of the current study were to investigate the stability of temperamental exuberance across infancy and toddlerhood and to examine the associations between exuberance and social-emotional outcomes in early childhood. The sample consisted of 291 4-month-olds followed at 9, 24, and 36 months and again at 5 years of age. Behavioral measures of exuberance were collected at 9, 24, and 36 months. At 36 months, frontal electroencephalogram (EEG) asymmetry was assessed. At 5 years, maternal reports of temperament and behavior problems were collected, as were observational measures of social behavior during an interaction with an unfamiliar peer in the laboratory. Latent profile analysis revealed a high, stable exuberance profile that was associated with greater ratings of 5-year externalizing behavior and surgency, as well as observed disruptive behavior and social competence with unfamiliar peers. These associations were particularly true for children who displayed left frontal EEG asymmetry. Multiple factors supported an approach bias for exuberant temperament but did not differentiate between adaptive and maladaptive social-emotional outcomes at 5 years of age.

Alliance in Couple and Family Therapy

M.L.Friedlander, V.Escudero, Laurie Heatherington, and G.M.Diamond

In J.Norcross (Ed.), *Psychotherapy Relationships that Work: Evidence-based Practice (2nd ed)*. Oxford University Press (2011)

This chapter is included in the second edition of Norcross' volume *Psychotherapy Relationships That Work* (2011, Oxford University Press), on the empirical evidence for the importance of the therapy relationship (in addition to the therapy technique itself) as a factor in therapeutic outcomes. Our chapter provides a meta-analysis and critical review of contemporary empirical studies of the therapeutic alliance in family therapy outcomes.

Using the e-SOFTA for Video Training of Alliance-related Behavior

M.L.Friedlander, V.Escudero, and Laurie Heatherington

Psychotherapy 48, 138-147 Special issue: Technology and Training (2011)

In this article, we describe a specific technology for training/supervision and research on the working alliance in either individual or couple/family therapy. The technology is based on the System for Observing Family Therapy Alliances (SOFTA; Friedlander, Escudero, & Heatherington, 2006), which contains four conceptual dimensions (*Engagement in the Therapeutic Process*, *Emotional Connection with the Therapist*, *Safety within the Therapeutic System*, and *Shared Sense of Purpose within the Family*), observational rating tools (SOFTA-o), and self-report measures (SOFTA-s) shown to be important indicators of therapeutic progress. The technology, e-SOFTA, is a computer program (available for PC downloading free of charge) that can be used to rate client(s) and therapist on the specific SOFTA-o behaviors that contribute to or detract from a strong working alliance in each dimension. In addition to providing time-stamped frequencies of alliance-related behaviors, e-SOFTA allows users to link the observed behaviors to qualitative comments and to compare one person's rating of a session to that of another person. Suggestions are provided for using e-SOFTA in research, in didactic training, and in supervision, including a specific training module for introducing students to the working alliance and assessing their observational and executive skills.

Alliance in Couple and Family Therapy

M.L.Friedlander, V.Escudero, Laurie Heatherington, and G.M.Diamond

Psychotherapy 48, 25-33 Special issue: Evidence-Based Psychotherapy Relationships (2011)

Couple and family therapy (CFT) is challenging because multiple interacting working alliances develop simultaneously and are heavily influenced by preexisting family dynamics. An original meta-analysis of 24 published CFT alliance-retention/outcome studies ($k = 17$ family and 7 couple studies; $N = 1,416$ clients) showed a weighted aggregate $r = .26$, $z = 8.13$ ($p < .005$); 95% CI = .33, .20. This small-to-medium effect size is almost identical to that reported for individual adult psychotherapy (Horvath Del Re, Flückiger, & Symonds, this issue, pp. 9–16). Analysis of the 17 family studies ($n = 1,081$ clients) showed a similar average weighted effect size ($r = .24$; $z = 6.55$, $p < .005$; 95% CI = .30, .16), whereas the analysis of the 7 couple therapy studies ($n = 335$ clients) indicated $r = .37$; $z = 6.16$, $p < .005$; 95% CI = .48, .25. Tests of the null hypothesis of homogeneity suggested unexplained variability in the alliance-outcome association in both treatment formats. In this article we also summarize the most widely used alliance measures used in CFT research, provide an extended clinical example, and describe patient contributions to the developing alliance. Although few moderator or mediator studies have been conducted, the literature points to three important alliance-related phenomena in CFT: the frequency of “split” or “unbalanced” alliances, the importance of ensuring safety, and the need to foster a strong within-family sense of purpose about the purpose, goals, and value of conjoint treatment. We conclude with a series of therapeutic practices predicated on the research evidence.

Social Psychology (8th edition)
Saul Kassin, Steven Fein, and H. Markus

Cengage Learning (2011)

Distinguished by its current-events emphasis, strong diversity coverage, and engaging connections drawn between social psychology and students' everyday lives, *Social Psychology, Eighth Edition*, remains one of the most scholarly and well-written texts in its field. Integrating classic and contemporary research, the text also includes comprehensive coverage of social cognition and evolutionary psychology, and features authoritative material on social psychology and the law. In addition, coverage of culture and diversity are integrated into every chapter by Hazel Rose Markus, a leader and respected researcher in the study of cultural psychology.

The “Messenger Effect” in Persuasion
Saul Kassin

In R. Arkin (Ed.), *Most Underappreciated: 50 Prominent Social Psychologists Talk About Hidden Gems*, New York: Oxford University Press (2011)

Deconstructing Confessions - The State of the Literature
Saul Kassin

In G.D. Lassiter & C.A. Meissner (Eds.), *Police Interrogations and False Confessions: Current Research, Practice, and Policy Recommendations*, Washington, DC: American Psychological Association (2010)

False Confessions
L.E. Hasel and *Saul Kassin*

In B. Cutler (Ed.), *Conviction of the Innocent: Lessons from Psychological Research*. Washington, DC: American Psychological Association (2011)

The Psychology of a Jared Loughner
Saul Kassin

CNN.com, January 18, 2011

<http://www.cnn.com/2011/OPINION/01/17/kassin.profile.tucson/index.html?iref=allsearch>

Harmless Error Analysis: How Do judges Respond to Confession Errors
D.B. Wallace and *Saul Kassin*

Law and Human Behavior, 2011 Jan 12. [Epub]

In *Arizona v Fulminante* (1991), the U.S. Supreme Court opened the door for appellate judges to conduct a harmless error analysis of erroneously admitted, coerced confessions. In this study, 132 judges from three states read a murder case summary, evaluated the defendant's guilt, assessed the voluntariness of his confession, and responded to implicit and explicit measures of harmless error. Overall, results indicated that judges found a high-pressure confession to be coerced and hence improperly admitted into evidence. As in mock jurors, however, the improper confession significantly increased their conviction rate in the absence of other evidence. On the harmless error measures, judges successfully overruled the confession when required to do so, indicating that they are capable of this analysis.

Inside Interrogation: The Lie, The Bluff, and False Confessions
J.T. Perillo and *Saul Kassin*

Law and Human Behavior, 2010 Aug 24. [Epub]

Using a less deceptive variant of the false evidence ploy, interrogators often use the bluff tactic, whereby they pretend to have evidence to be tested without further claiming that it necessarily implicates the suspect. Three experiments were conducted to assess the impact of the bluff on confession rates. Using the Kassin and Kiechel (1996) computer crash paradigm, Experiment 1 indicated that bluffing increases false confessions comparable to the effect produced by the presentation of false evidence. Experiment 2 replicated the bluff effect and provided self-reports indicating that innocent participants saw the bluff as a

promise of future exoneration which, paradoxically, made it easier to confess. Using a variant of the Russano, Meissner, Narchet, and Kassin (2005) cheating paradigm, Experiment 3 replicated the bluff effect on innocent suspects once again, though a ceiling effect was obtained in the guilty condition. Results suggest that the phenomenology of innocence can lead innocents to confess even in response to relatively benign interrogation tactics.

An Empirical Assessment of the Form of Utility Functions

Kris N. Kirby

Journal of Experimental Psychology: Learning, Memory, and Cognition **37**, 461–476 (2011)

Utility functions, which relate subjective value to physical attributes of experience, are fundamental to most decision theories. Seven experiments were conducted to test predictions of the most widely assumed mathematical forms of utility (power, log, and negative exponential), and a function proposed by Rachlin (1992). For pairs of gambles for real monetary gains, undergraduate and nonstudent subjects either reported an *equalizing amount* for 1 outcome that made the gambles subjectively equal or chose between gambles where the amounts were varied across trial, which allowed the equalizing amount to be estimated from their pattern of choices. Using a novel method that eliminates several limitations of previous research, I manipulated the outcomes across trials such that each type of utility function predicted a linear relationship between the equalizing amounts and the amounts of the other outcomes, and made point predictions for either the slope or intercept of that relationship. In a meta-analysis across experiments, systematic departures from the point predictions were observed for each type of utility function. Thus, the data imply that despite their historical importance and incorporation in many psychological and economic decision theories, the most widely assumed models of utility are incorrect.

Benefits of Accumulating versus Diminishing Cues in Recall

J.R. Finley, A.S. Benjamin, M.J. Hays, R.A. Bjork, and Nate Kornell

Journal of Memory and Language **64**, 289–298 (2011)

Optimizing learning over multiple retrieval opportunities requires a joint consideration of both the probability and the mnemonic value of a successful retrieval. Previous research has addressed this trade-off by manipulating the schedule of practice trials, suggesting that a pattern of increasingly long lags—“expanding retrieval practice”—may keep retrievals successful while gradually increasing their mnemonic value (Landauer & Bjork, 1978). Here we explore the trade-off issue further using an analogous manipulation of cue informativeness. After being given an initial presentation of English-Inupiaq word pairs, participants received practice trials across which letters of the target word were either accumulated (AC), diminished (DC), or always fully present. Diminishing cues yielded the highest performance on a final test of cued recall. Additional analyses suggest that AC practice promotes potent (effortful) retrieval at the cost of success, and DC practice promotes successful retrieval at the cost of potency. Experiment 2 revealed that the negative effects of AC practice can be partly ameliorated by providing feedback after each practice trial.

Why Tests Appear to Prevent Forgetting: A Distribution-Based Bifurcation Model

Nate Kornell, R.A. Bjork, and M.A. Garcia

Journal of Memory and Language **65**, 85–97 (2011)

Retrieving information from memory produces more learning than does being presented with the same information, and the benefits of such retrieval appear to grow as the delay before a final recall test grows longer. Recall tests, however, measure the number of items that are above a recall threshold, not memory strength per se. According to the model proposed in this paper, tests without feedback produce bifurcated item distributions: Retrieved items become stronger, but non-retrieved items remain weak, resulting in a gap between the two classes of items. Restudying items, on the other hand, strengthens all items, though to a lesser degree than does retrieval. These differing outcomes can make tested items appear to be forgotten more slowly than are restudied items—even if all items are forgotten at the same rate—because the test-induced bifurcation leaves items either well above or well below threshold. We review prior evidence and present three new experiments designed to test the bifurcation interpretation.

The Ease of Processing Heuristic and the Stability Bias: Dissociating Memory, Memory Beliefs, and Memory Judgments

Nate Kornell, M.G.Rhodes, A.D.Castel, and S.K.Tauber

Psychological Science **22**, 787-794 (2011)

Judgments about memory are essential in promoting knowledge; they help identify trustworthy memories and predict what information will be retained in the future. In the three experiments reported here, we investigated the mechanisms underlying predictions about memory. In Experiments 1 and 2, single words were presented once or multiple times, in large or small type. There was a double dissociation between actual memory and predicted memory: Type size affected predicted but not actual memory, and future study opportunities affected actual memory but scarcely affected predicted memory. The results of Experiment 3 suggest that beliefs and judgments are largely independent, and neither consistently resembles actual memory. Participants' underestimation of future learning--a stability bias--stemmed from an overreliance on their current memory state in making predictions about future memory states. The overreliance on type size highlights the fundamental importance of the ease-of-processing heuristic: Information that is easy to process is judged to have been learned well.

Four Principles of Memory Improvement: A Guide to Improving Learning Efficiency

B.L.Schwartz, L.K.Son, Nate Kornell, and B.Finn

International Journal of Creativity and Problem Solving **21**, 7-15 (2011)

Recent advances in memory research suggest methods that can be applied to enhance educational practices. We outline four principles of memory improvement that have emerged from research: 1) process material actively, 2) practice retrieval, 3) use distributed practice, and 4) use metamemory. Our discussion of each principle describes current experimental research underlying the principle and explains how people can take advantage of the principle to improve their learning. The techniques that we suggest are designed to increase efficiency—that is, to allow a person to learn more, in the same unit of study time, than someone using less efficient memory strategies. A common thread uniting all four principles is that people learn best when they are active participants in their own learning.

The Costs and Benefits of Providing Feedback During Learning

M.J.Hays, Nate Kornell, and R.A.Bjork

Psychonomic Bulletin & Review **17**, 797-801(2010)

It seems uncontroversial that providing feedback after a test, in the form of the correct answer, enhances learning. In real-world educational situations, however, the time available for learning is often constrained--and feedback takes time. We report an experiment in which total time for learning was fixed, thereby creating a trade-off between spending time receiving feedback and spending time on other learning activities. Our results suggest that providing feedback is not universally beneficial. Indeed, under some circumstances, taking time to provide feedback can have a negative net effect on learning. We also found that learners appear to have some insight about the costs of feedback; when they were allowed to control feedback, they often skipped unnecessary feedback in favor of additional retrieval attempts, and they benefited from doing so. These results underscore the importance of considering the costs and benefits of interventions designed to enhance learning.

Failing to Predict Future Changes in Memory: A Stability Bias Yields Long-Term Overconfidence

Nate Kornell

In A. S. Benjamin (Ed.), *Successful Remembering and Successful Forgetting: A Festschrift in Honor of Robert A. Bjork*. New York, NY: Psychology Press (2010)

Human memory is anything but stable. We constantly forget old information and form new memories. Yet recent research has demonstrated a stability bias in human memory: People act as though their memories will remain stable in the future. They fail to predict future forgetting (Koriat, Bjork, Sheffer, & Bar, 2004) and future learning (Kornell & Bjork, 2009). In this chapter, I discuss the importance of assessing one's memory in everyday life, draw a distinction between predicting future remembering versus predicting

future changes in remembering, and review evidence substantiating the stability bias. I then describe an experiment examining the cause of the stability bias. I asked participants (n = 430) to predict their ability to remember word pairs they would study once or four times and would be tested on in 5 minutes or one week. Participants predicted significant learning and forgetting, but vastly under-predicted both effects, demonstrating a stability bias. Asking participants to imagine the test situation had little or no effect. The results demonstrated long-term overconfidence: Relatively modest immediate overconfidence transformed into enormous overconfidence as the test delay increased.

Metacognition

Nate Kornell

In D. Mills (Ed.), *The Encyclopedia of Applied Animal Behaviour & Welfare*. Wallingford, Oxon, UK: CABI Publishing (2010)

The study of animal metacognition revolves around the concept of uncertainty--that is, discriminating between situations in which one is certain, versus uncertain, of what to do. Animals frequently appear to be uncertain, as when a horse hesitates before jumping a hurdle that it may not be able to clear. But, by itself, appearing uncertain is not evidence of metacognition. The question, which has been addressed over the past dozen years, is can animals report that they are uncertain? And can they report uncertainty about their memories?

Spacing as the Friend of Both Memory and Induction in Young and Older Adults

Nate Kornell, A.D.Castel, T.S.Eich, and R.A.Bjork

Psychology and Aging **25**, 498-503 (2010)

We compared the effects of spaced versus massed practice on young and older adults' ability to learn visually complex paintings. We expected a spacing advantage when one painting per artist was studied repeatedly and tested (repetition), but perhaps a massing advantage, especially for older adults, when multiple different paintings by each artist were studied and tested (induction). Surprisingly, spacing facilitated both inductive and repetition learning by both younger and older adults, even though the participants rated massing superior to spacing for inductive learning. Thus, challenging learners of any age appears to have unintuitive benefits for both memory and induction.

The Virtues of Ignorance

L.K.Son and Nate Kornell

Behavioral Processes **83**, 207-212 (2010)

Although ignorance and uncertainty are usually unwelcome feelings, they have unintuitive advantages for both human and non-human animals, which we review here. We begin with the perils of too much information: Expertise and knowledge can come with illusions (and delusions) of knowing. We then describe how withholding information can counteract these perils: Providing people with less information enables them to judge more precisely what they know and do not know, which in turn enhances long-term memory. Data are presented from a new experiment that illustrates how knowing what we do not know can result in helpful choices and enhanced learning. We conclude by showing that ignorance can be a virtue, as long as it is recognized and rectified.

The Power of Popularity: Influence Processes in Childhood and Adolescence

Marlene Sandstrom

In A.H.N. Cillessen, D. Schwartz, & L. Mayeux (Eds), *Popularity in the Peer System*. New York: Guilford Press (2011)

This chapter explores peer influence processes in childhood and adolescence. In particular, it explores what we know about the extent to which popularity is associated with being persuasive, as well as being susceptible to the sway of others.

The Closeness-Communication Bias: Increased Egocentrism among Friends versus Strangers

Kenneth Savitsky, B.Keysar, N.Epley, T.Carter, and A.Swanson

Journal of Experimental Social Psychology **47**, 269-273 (2011)

People commonly believe that they communicate better with close friends than with strangers. We propose, however, that closeness can lead people to overestimate how well they communicate, a phenomenon we term the closeness-communication bias. In one experiment, participants who followed direction of a friend were more likely to make egocentric errors—look at and reach for an object only they could see—than were those who followed direction of a stranger. In two additional experiments, participants who attempted to convey particular meanings with ambiguous phrases overestimated their success more when communicating with a friend or spouse than with strangers. We argue that people engage in active monitoring of strangers' divergent perspectives because they know they must, but that they “let down their guard” and rely more on their own perspective when they communicate with a friend.

Developmental Effects of Breeding for an Infant Trait

S.A.Brunelli, Betty Zimmerberg, and M.A.Hofer

In K. E. Hood, C. T. Halpern and G. Greenberg (Eds.), *Handbook of Developmental Science, Behavior, and Genetics*, Chichester: Wiley-Blackwell (2010)

This chapter describes the results of selective breeding over many generations for an infant affective trait, ultrasonic vocalization responses to isolation. We report that this long-term selection resulted in populations with two “paths” that appear to recruit a variety of physiological systems and behaviors to produce lifelong differences in temperament. The High and Low vocalization lines express consistent behavioral phenotypes of high anxiety/depression compared to low anxiety/aggression, respectively. We also considered the environmental contributions to the development of these systems, revealing epigenetic effects at sensitive periods early in life.